ELECTRONICS MECHANIC

NSQF LEVEL - 4

2nd Year

TRADE THEORY

SECTOR: ELECTRONICS & HARDWARE

(As per revised syllabus July 2022 - 1200 Hrs)

Directorate General of Training

DIRECTORATE GENERAL OF TRAINING
MINISTRY OF SKILL DEVELOPMENT & ENTREPRENEURSHIP
GOVERNMENT OF INDIA

NATIONAL INSTRUCTIONAL MEDIA INSTITUTE, CHENNAI

Post Box No. 3142, CTI Campus, Guindy, Chennai - 600 032

Sector : **Electronics & Hardware**

Duration : **2 Years**

Trades : **Electronics Mechanic - 2nd Year - Trade Theory - NSQF Level - 4 (Revised 2022)**

Developed & Published by

National Instructional Media Institute
Post Box No.3142
Guindy, Chennai - 600 032
INDIA
Email: chennai-nimi@nic.in
Website: www.nimi.gov.in

First Edition : December 2023 Copies: 1000

Rs.470/-

FOREWORD

The Government of India has set an ambitious target of imparting skills to 30 crores people, one out of every four Indians, by 2020 to help them secure jobs as part of the National Skills Development Policy. Industrial Training Institutes (ITIs) play a vital role in this process especially in terms of providing skilled manpower. Keeping this in mind, and for providing the current industry relevant skill training to Trainees, ITI syllabus has been recently updated with the help of Media Development Committee members of various stakeholders viz. Industries, Entrepreneurs, Academicians and representatives from ITIs.

The National Instructional Media Institute (NIMI), Chennai, has now come up with instructional material to suit the revised curriculum for **Electronics Mechanic - 2nd Year - Trade Theory NSQF Level - 4 (Revised 2022) in Electronics & Hardware** Sector under Yearly Pattern**.** The NSQF Level - 4 (Revised 2022) Trade Practical will help the trainees to get an international equivalency standard where their skill proficiency and competency will be duly recognized across the globe and this will also increase the scope of recognition of prior learning. NSQF Level - 4 (Revised 2022) trainees will also get the opportunities to promote life long learning and skill development. I have no doubt that with NSQF Level - 4 (Revised 2022) the trainers and trainees of ITIs, and all stakeholders will derive maximum benefits from these Instructional Media Packages IMPs and that NIMI's effort will go a long way in improving the quality of Vocational training in the country.

The Director General of Training, Executive Director & Staff of NIMI and members of Media Development Committee deserve appreciation for their contribution in bringing out this publication.

Jai Hind

Athul Kumar Tiwari, ***I.A.S***
Secretary
Ministry of Skill Development & Entrepreneurship,
Government of India.

December 2023
New Delhi - 110 001

PREFACE

The National Instructional Media Institute (NIMI) was established in 1986 at Chennai by then Directorate General of Employment and Training (D.G.E & T), Ministry of Labour and Employment, (now under Directorate General of Training, Ministry of Skill Development and Entrepreneurship) Government of India, with technical assistance from the Govt. of Federal Republic of Germany. The prime objective of this Institute is to develop and provide instructional materials for various trades as per the prescribed syllabus under the Craftsman and Apprenticeship Training Schemes.

The instructional materials are created keeping in mind, the main objective of Vocational Training under NCVT/NAC in India, which is to help an individual to master skills to do a job. The instructional materials are generated in the form of Instructional Media Packages (IMPs). An IMP consists of Theory book, Practical book, Test and Assignment book, Instructor Guide, Audio Visual Aid (Wall charts and Transparencies) and other support materials.

The trade practical book consists of series of exercises to be completed by the trainees in the workshop. These exercises are designed to ensure that all the skills in the prescribed syllabus are covered. The trade theory book provides related theoretical knowledge required to enable the trainee to do a job. The test and assignments will enable the instructor to give assignments for the evaluation of the performance of a trainee. The wall charts and transparencies are unique, as they not only help the instructor to effectively present a topic but also help him to assess the trainee's understanding. The instructor guide enables the instructor to plan his schedule of instruction, plan the raw material requirements, day to day lessons and demonstrations.

IMPs also deals with the complex skills required to be developed for effective team work. Necessary care has also been taken to include important skill areas of allied trades as prescribed in the syllabus.

The availability of a complete Instructional Media Package in an institute helps both the trainer and management to impart effective training.

The IMPs are the outcome of collective efforts of the staff members of NIMI and the members of the Media Development Committees specially drawn from Public and Private sector industries, various training institutes under the Directorate General of Training (DGT), Government and Private ITIs.

NIMI would like to take this opportunity to convey sincere thanks to the Directors of Employment & Training of various State Governments, Training Departments of Industries both in the Public and Private sectors, Officers of DGT and DGT field institutes, proof readers, individual media developers and coordinators, but for whose active support NIMI would not have been able to bring out this materials.

Chennai - 600 032 **EXECUTIVE DIRECTOR**

ACKNOWLEDGEMENT

National Instructional Media Institute (NIMI) sincerely acknowledges with thanks for the co-operation and contribution extended by the following Media Developers and their sponsoring organisation to bring out this IMP **(Trade Theory)** for the trade of **Electronics Mechenic** under the **Electronics & Hardware** Sector for ITIs.

MEDIA DEVELOPMENT COMMITTEE MEMBERS

Smt. S. Gowri	-	Assistant Training Officer, Govt. ITI, Thiruvanmiyur.
Smt. P.R. Nancy	-	Junior Training Officer, Govt. ITI, Guindy.
Shri. A. Sunderesan	-	Junior Training Officer, Govt. ITI, Hosur.

NIMI CO-ORDINATORS

Shri. Nirmalya nath	-	Deputy Director of Training, NIMI, Chennai - 32.
Shri. S. Gopalakrishnan	-	Assistant Manager, NIMI, Chennai - 32.

NIMI records its appreciation of the Data Entry, CAD, DTP Operators for their excellent and devoted services in the process of development of this Instructional Material.

NIMI also acknowledges with thanks, the invaluable efforts rendered by all other staff who have contributed for the development of this Instructional Material.

NIMI is grateful to all others who have directly or indirectly helped in developing this IMP.

INTRODUCTION

TRADE PRACTICAL

The trade practical manual is intented to be used in practical workshop. It consists of a series of practical exercises to be completed by the trainees during the course of the **Electronics Mechanic** trade supplemented and supported by instructions/ informations to assist in performing the exercises. These exercises are designed to ensure that all the skills in compliance with NSQF LEVEL - 4 (Revised 2022) syllabus are covered.

This manual is divided into sixteen modules. The sixteen modules are given below

Module 1	**Electronic Cables & Connectors**
Module 2	**Computer Hardware, OS, MS Office and Networking**
Module 3	**Basic SMD (2,3,4 terminal components), soldering and desoldering**
Module 4	**PCB Rework**
Module 5	**Protection Devices and Electrical Control Circuits**
Module 6	**Communication Electronics**
Module 7	**Microcontroller (8051)**
Module 8	**Sensors, Transducers and Applications**
Module 9	**IoT Applications**
Module 10	**Fiber Optic Communication**
Module 11	**Digital Panel Meter**
Module 12	**SMPS & Inverters, UPS**
Module 13	**Solar Power (Renewable Energy System)**
Module 14	**Cell phones**
Module 15	**LED Lights**
Module 16	**LCD & LED TV**

The skill training in the shop floor is planned through a series of practical exercises centred around some practical project. However, there are few instances where the individual exercise does not form a part of project.

While developing the practical manual a sincere effort was made to prepare each exercise which will be easy to understand and carry out even by below average trainee. However the development team accept that there is a scope for further improvement. NIMI, looks forward to the suggestions from the experienced training faculty for improving the manual.

TRADE THEORY

The manual of trade theory consists of theoretical information for the Course of the **Electronics Mechanic 2nd Year NSQF Level - 4 (Revised 2022) in Electronics & Hardware**. The contents are sequenced according to the practical exercise contained in NSQF Level - 4 (Revised 2022) syllabus on Trade Theory attempt has been made to relate the theoretical aspects with the skill covered in each exercise to the extent possible. This correlation is maintained to help the trainees to develop the perceptional capabilities for performing the skills.

The trade theory has to be taught and learnt along with the corresponding exercise contained in the manual on trade practical. The indications about the corresponding practical exercises are given in every sheet of this manual.

It will be preferable to teach/learn trade theory connected to each exercise at least one class before performing the related skills in the shop floor. The trade theory is to be treated as an integrated part of each exercise.

The material is not for the purpose of self-learning and should be considered as supplementary to class room instruction.

CONTENTS

LEARNING / ASSESSABLE OUTCOME

On completion of this book you shall be able to

S.No	Learning Outcome	Ref. Ex.No.
1	Prepare, crimp, terminate and test various cables used in different electronics industries. **(Mapped NOS: ELE/N6307)**	2.1.135 - 139
2	Install, configure, interconnect given computer Install, onfigure,interconnect given computer system(s) and demonstrate & utilize application packages for different application. **(Mapped NOS: ELE/N4614)**	2.2.140 - 154
3	Identify, place, solder and desolder and test different SMD discrete components and ICs package with due care and following safety norms using proper tools/ setup. **(Mapped NOS: ELE/N5102)**	2.3.155 - 164
4	Rework on PCB after identifying defects from SMD soldering and desoldering. **(Mapped NOS: ELE/N5102)**	2.4.165 - 166
5	Construct different electrical control circuits and test for their proper functioning with due care and safety. **(Mapped NOS: ELE/N9407)**	2.5.167 - 173
6	Assemble and test a commercial AM/ FM receiver and evaluate performance. **(Mapped NOS: ELE/N9408)**	2.6.174 - 180
7	Test, service and troubleshoot the various components of different domestic/ industrial programmable systems. **(Mapped NOS: ELE/N9802)**	2.7.181 - 188
8	Execute the operation of different sensors, identify, wire & test various transducers of IOT Applications **(Mapped NOS: ELE/N9409)**	2.8.189 - 193
9	Identify different IoT Applications with IoT architecture. **(Mapped NOS: ELE/N3102)**	
	Plan and carry out the selection of a project, assemble the project and evaluate performance for a domestic/ commercial applications. **(Mapped NOS: ELE/N9802)**	2.9.194 - 198
10	Prepare fibre optic setup and execute transmission and reception. **(Mapped NOS: ELE/N5902)**	2.10.199 -204
11	Plan and Interface the LCD, LED, DPM panels to various circuits and evaluate performance. **(Mapped NOS: ELE/N8107)**	2.11.205 -210
12	Detect the faults and troubleshoot SMPS, UPS and inverter. **(Mapped NOS: ELE/N7202)**	2.12.211 - 229
13	Identify, Test and verify characteristics of Photovoltaic cells, Modules, Batteries and Charge controllers. Install a solar panel, execute testing and evaluate performance by connecting the panel to the inverter. **(Mapped NOS: ELE/N5902)**	2.13.230A - 234
14	Dismantle, identify the various parts and interface of a cell phone to a PC. Estimate and trouble shoot. **(Mapped NOS: ELE/N8107)**	2.14.235 - 242
15	Check the various parts of a LED lights & stacks and troubleshoot. **(Mapped NOS: ELE/N9302)**	2.15.243 - 247
16	Identify, operate various controls, troubleshoot and replace modules of the LCD/LED TV & its remote. **(Mapped NOS: ELE/N3102)**	2.16.248 - 255

SYLLABUS FOR ELECTRONICS MECHANIC

Duration	Reference Learning Outcome	Professional Skill (Trade Practical) (With indicative hour)	Professional Knowledge (Trade Theory)
Professional Skill 25 Hrs; Professional Knowledge 06 Hrs	Prepare, crimp, terminate and test various cables used in different lectronics industries. **(Mapped NOS: ELE/N6307)**	**Electronic Cables & Connectors** 135. Identify various types of cables viz. RF coaxial feeder, screened cable, ribbon cable, RCA connector cable, digital optical audio, video cable, RJ45, RJ11, Ethernet cable, fibre optic cable splicing, fibre optic cable mechanical splices, insulation, gauge, current capacity, flexibility etc. used in various electronics products, different input output sockets. (05 Hrs.) 136. Identify suitable connectors, solder/ crimp /terminate & test the cable sets. (05 Hrs.) 137. Check the continuity as per the marking on the connector for preparing the cable set. (05 Hrs.) 138.Identify and select various connectors and cables inside the CPU cabinet of PC. (05 Hrs.) 139. Identify the suitable connector and cable to connect a computer with a network switch and prepare a cross over cable to connect two network computers. (05 Hrs.)	Cable signal diagram conventions Classification of electronic cables as per the application w.r.t. insulation, gauge, current capacity, flexibility etc. Different types of connector & their terminations to the cables. Male / Female type DB connectors. Ethernet 10 Base cross over cables and pin out assignments, UTP and STP, SCTP, TPC, coaxial, types of fibre optical Cables and Cable trays. Different types of connectors Servo 0.1" connectors, FTP, RCA, BNC, HDMI Audio/video connectors like XLR, RCA (phono), 6.3 mm PHONO, 3.5 / 2.5 mm PHONO, BANTAM, SPEAKON, DIN, mini DIN, RF connectors, USB, Fire wire, SATA Connectors, VGA, DVI connectors, MIDI and RJ45, RJ11 etc. (06 Hrs.)
Professional Skill 80 Hrs; Professional Knowledge 34 Hrs	Install, configure, interconnect given computer Install, onfigure,interconnect given computer system(s) and demonstrate & utilize application packages for different application. **(Mapped NOS: ELE/N4614)**	**Computer Hardware, OS, MS office and Networking** 140. Demonstrate various parts of the system unit and motherboard components. (06 Hrs.) 141. Identify various computer peripherals and connect it to the system. (04Hrs.) 142. Disable certain functionality by disconnecting the concerned cables SATA/ PATA. (05 Hrs.) 143. Replace the CMOS battery and extend a memory module. (06 Hrs.) 144. Test and Replace the SMPS. (05 Hrs.) 145. Replace the given DVD and HDD on the system. (06 Hrs.) 146. Dismantle and assemble the desktop computer system. (07 Hrs.) 147. Boot the system from Different options. (07 Hrs.)	Basic blocks of a computer, Components of desktop and motherboard. Hardware and software, I/O devices, and their working. Different types of printers, HDD, DVD. Various ports in the computer. Windows OS MS widows: Starting windows and its operation, file management using explorer, Display & sound properties, screen savers, fontmanagement, installation of program, setting and using of control panel, application of accessories, various IT tools and applications. Concept of Internet, Browsers, Websites, search engines, email, chatting and messenger service. Downloading the Data and program files etc.

		148. Install OS in a desktop computer. (05 Hrs.) 149. Install a Printer driver software and test for print outs. (05 Hrs.) 150. Install antivirus software, scan the system and explore the options in the antivirus software. (05 Hrs.) 151. Install MS office software. (05 Hrs.) 152. Browse search engines, create email accounts, practice sending and receiving of mails and configuration of email clients. (08 Hrs.) 153. Prepare terminations, make UTP and STP cable connectors and test. (08 Hrs.) 154. Configure a wireless Wi-Fi network. (10 Hrs.)	**Computer Networking:-** Network features - Network medias Network topologies, protocols- TCP/IP, UDP, FTP, models and types. Specification and standards, types of cables, UTP, STP, Coaxial cables. Network components like hub, Ethernet switch, router, NIC Cards, connectors, media and firewall. Difference between PC &Server. (34 Hrs.)
Professional Skill 70 Hrs; Professional Knowledge 20 Hrs	Identify, place, solder and desolder and test different SMD discrete components and ICs package with due care and following safety norms using proper tools/setup. **(Mapped NOS: ELE/N5102)**	**Basic SMD (2, 3, 4 terminal components)** 155. Identification of 2, 3, 4 terminal SMD components. (05 Hrs.) 156. De-solder the SMD components from the given PCB. (05 Hrs.) 157. Solder the SMD components in the same PCB. (05 Hrs.) 158. Check for cold continuity of PCB. (05 Hrs.) 159. Identification of loose /dry solder, broken tracks on printed wired assemblies. (05 Hrs.)	Introduction to SMD technology Identification of 2, 3, 4 terminal SMD components. Advantages of SMD components over conventional lead components. Soldering of SM assemblies - Reflow soldering. Tips for selection of hardware, Inspection of SM. (05 Hrs.)
		SMD Soldering and Desoldering 160. Identify various connections and setup required for SMD Soldering station. (05 Hrs.) 161. Identify crimping tools for various IC packages. (05 Hrs.) 162. Make the necessary settings on SMD soldering station to de-solder various ICs of different packages (at least four) by choosing proper crimping tools. (07 Hrs.) 163. Make the necessary settings on SMD soldering station to solder various ICs of different packages (at least four) by choosing proper crimping tools. (8 Hrs.) 164. Make the necessary setting rework of defective surface mount component used soldering / de-soldering method. (8 Hrs.)	Introduction to Surface Mount Technology (SMT). Advantages, Surface Mount components and packages. Introduction to solder paste (flux). Soldering of SM assemblies, reflow soldering. Tips for selection of hardware, Inspection of SM. Identification of Programmable Gate array (PGA) packages.Specification of various tracks, calculation of track width for different current ratings. Cold/ Continuity check of PCBs. Identification of lose / dry solders, broken tracks on printed wiring assemblies. Introduction to Pick place Machine, Reflow Oven, Preparing stencil,& stencil printer (15 Hrs.)

Professional Skill 20 Hrs; Professional Knowledge 10 Hrs	Rework on PCB after identifying defects from SMD soldering and desoldering. **(Mapped NOS: ELE/N5102)**	**PCB Rework** 165. Checked and Repair Printed Circuit Boards single, Double layer and important tests for PCBs. (10 Hrs.) 166. Inspect soldered joints, detect the defects and test the PCB for rework. (10Hrs.)	Introduction to Static charges, prevention, handling of static sensitive devices, various standards for ESD. Introduction to non-soldering interconnections. Construction of Printed Circuit Boards (single, Double, multilayer), Important tests for PCBs. Introduction to rework and repair concepts. Repair of damaged track. Repair of damaged pad and plated through hole. Repair of solder mask. (10 Hrs.)
Professional Skill 30 Hrs; Professional Knowledge 10 Hrs	Construct different electrical control circuits and test for their proper functioning with due care and safety. **(Mapped NOS: ELE/ N9407)**	**Protection devices** Identify different types of fuses along with fuse holders, overload (no volt coil), current adjust (Biometric strips to set the current). (06 Hrs.) 167. Test the given MCBs. (03 Hrs.) 168. Connect an ELCB and test the leakage of an electrical motor control circuit. (05 Hrs.)	Necessity of fuse, fuse ratings, types of fuses, fuse bases. Single/ three phase MCBs, single phase ELCBs. Types of contactors, relays and working voltages. Contact currents, protection to contactors and high current applications. (05 Hrs.)
		169. Test DC motor and its operating voltage. (03 Hrs.) 170. Test DC motor control signal. (03 Hrs.) 171. Test various Low potential motors. (03 Hrs.) **Stepper Motor** 172. Test stepper motor. (03 Hrs.) 173. Demonstrate working process of stepper motor in various Equipment. (04 Hrs.)	**1.LOW VOLTAGE DC MOTOR** (Low Potential motor) Introduction of DC motor. Types of DC motor .Types of DC motor controller. DC Motor power. Types of DC Motor power regulation. Application area of DC motor controller. 2.What is a Stepper motor and its types. Stepper Motor working Principal. How to select a stepper motor Types of wiring of stepper motor. Stepper motor control by varying clock pulses. Advantage of stepper motor. (05 Hrs.)
Professional Skill 60 Hrs; Professional Knowledge 15 Hrs	Assemble and test a commercial AM/ FM receiver and evaluate performance. **(Mapped NOS: ELE/N9408)**	**Communication electronics** 174. Modulate and Demodulate various signals using AM and FM on the trainer kit and observe waveforms. (08 Hrs.) 175. Test IC based AM Receiver (08 Hrs.) 176. Test IC based FM transmitter. (06 Hrs.) 177. Test IC based AM transmitter and test the transmitter power Calculate the modulation index. (08 Hrs.) 178. Dismantle the given FM receiver set and identify different stages (AM section, audio amplifier section etc). (10 Hrs.)	Radio Wave Propagation – principle, fading. Need for Modulation, types of modulation and demodulation. Fundamentals of Antenna, various parameters, types of Antennas & application. Introduction to AM, FM & PM, SSB-SC & DSB-SC. Block diagram of AM and FM transmitter. FM Generation & Detection. Digital modulation and demodulation techniques, sampling, quantization & encoding. Concept of multiplexing and de multiplexing of AM/ FM/ PAM/ PPM /PWM signals. A simple block diagram approach to be adopted for explaining the above mod/demod techniques. (15 Hrs.)

		179. Modulate two signals using AM kit draw the way from and calculate percent (%) of modulation. (10 Hrs.) 180. Modulate and Demodulate a signal using PAM, PPM, PWM Techniques. (10 Hrs.)	
Professional Skill 60 Hrs; Professional Knowledge 15 Hrs	Test, service and troubleshoot the various components of different domestic/ industrial programmable systems. **(Mapped NOS: ELE/N9802)**	**Microcontroller (8051)** 181. Identify various ICs & their functions on the given Microcontroller Kit. (07 Hrs.) 182. Identify the address range of RAM & ROM. (07 Hrs.) 183. Measure the crystal frequency, connect it to the controller. (07 Hrs.) 184. Identify the port pins of the controller & configure the ports for Input & Output operation. (07 Hrs.) 185. Use 8051 microcontroller, connect 8 LED to the port, blink the LED with a switch. (08 Hrs.) 186. Perform the initialization, load & turn on a LED with delay using Timer. (08 Hrs.) 187. Perform the use of a Timer as an Event counter to count external events. (08 Hrs.) 188. Demonstrate entering of simple programs, execute & monitor the results. (08 Hrs.)	Introduction Microprocessor & 8051Microcontroller, architecture, pin details & the bus system. Function of different ICs used in the Microcontroller Kit. Differentiate microcontroller with microprocessor. Interfacing of memory to the microcontroller. Internal hardware resources of microcontroller. I/O port pin configuration. Different variants of 8051 & their resources. Register banks & their functioning. SFRs & their configuration for different applications. Comparative study of 8051 with 8052. Introduction to PIC Architecture (15 Hrs.)
Professional Skill 60 Hrs; Professional Knowledge 15 Hrs	Execute the operation of different sensors, identify, wire & test various transducers of IOT Applications **(Mapped NOS: ELE/N9409)**	**Sensors, Transducers used in IoT Applications** 189. Identify sensors used in process industries such as RTDs,temperature ICs, Thermocouples, proximity switches (inductive, capacitive and photo electric), load cells, strain gauge. LVDT PT 100 (platinum resistance sensor), water level sensor, thermostat float switch, float valve by their appearance. (15 Hrs.) 190. Measure temperature of a lit fire using a Thermocouple and record the readings referring to data chart. (10 Hrs.) 191. Measure temperature of a lit fire using RTD and record the readings referring to data. (10 Hrs.) 192. Measure the DC voltage of a LVDT. (10 Hrs.) 193. Detect different objectives using capacitive, inductive and photoelectric proximity sensors. (15 Hrs.)	Basics of passive and active transducers. Role, selection and characteristics. Sensor voltage and current formats. Thermistors/ Thermocouples - Basic principle, salient features, operating range, composition, advantages and disadvantages. Strain gauges/ Load cell – principle, gauge factor, types of strain gauges. Inductive/ capacitive transducers - Principle of operation, advantages and disadvantages. Principle of operation of LVDT, advantages and disadvantages. Proximity sensors – applications, working principles of eddy current, capacitive and inductive proximity sensors. (15 Hrs.)

Professional Skill 20 Hrs.; Professional Knowledge 06 Hrs.	Identify different IoT Applications with IoT architecture. **(Mapped NOS: ELE/ N3102)**	194 Connect and test microcontroller to computer and execute sample programs. (04hrs.) 195. Upload computer code to the physical board (Microcontroller) to blink a simple LED. (02hrs.) 196. Write and upload computer code to the physical Micro controller to sound buzzer. (02hrs.) 197. Circuit and program to Interface light sensor – LDR with Microcontroller to switch ON/OFF LED based on light intensity. (03hrs.) 198. Set up & test circuit to interface potentiometer with Microcontroller and map to digital values for e.g. 0-1023. (03hrs.)	Introduction to Internet of Things applications environment, smart street light and smart water & waste management. What is an IOT? What makes embedded system an IOT? Role and scope of IOT in present and future marketplace. Smart objects, Wired – Cables, hubs etc. Wireless – RFID, WiFi, Bluetooth etc. Different functional building blocks of IOT architecture. (06 hrs.)
Professional Skill 90 Hrs; Professional Knowledge 18 Hrs	Plan and carry out the selection of a project, assemble the project and evaluate performance for a domestic/ commercial applications. **(Mapped NOS: ELE/N9802)**	**Analog IC Applications** Make simple projects/ Applications using ICs 741, 723, 555, 7106, 7107 **Sample projects:** • Laptop protector • Mobile cell phone charger • Battery monitor • Metal detector • Mains detector • Lead acid battery charger • Smoke detector • Solar charger • Emergency light • Water level controller • Door watcher (Instructor will pick up any five of the projects for implementation) (45 Hrs.)	Discussion on the identified projects with respect to data of the concerned ICs. Components used in the project. (09 Hrs.)
		Digital IC Applications Make simple projects/Applications using various digital ICs (digital display, event counter, stepper motor driver etc) • Duty cycle selector • Frequency Multiplier • Digital Mains Resumption Alarm • Digital Lucky Random number generator • Dancing LEDs	Discussion on the identified projects with respect to data of the concerned ICs. Components used in the project. (09 Hrs.)

		• Count down timer • Clap switch • Stepper motor control • Digital clock • Event counter • Remote jammer (Instructor will pick up any five of the projects for implementation) (45 Hrs.)	
Professional Skill 15 Hrs; Professional Knowledge 05 Hrs	Prepare fibre optic setup and execute transmission and reception. **(Mapped NOS: ELE/N5902)**	**Fiber optic communication** 199. Identify the resources and their need on the given fiber optic trainer kit. (02 Hrs.) 200. Make optical fiber setup to transmit and receive analog and digital data. (02 Hrs.) 201. Set up the OFC trainer kit to study AM, FM, PWM modulation and demodulation. (02 Hrs.) 202. Perform FM modulation and demodulation using OFC trainer kit using audio signal and voice link. (03 Hrs.) 203. Perform PWM modulation and demodulation using OFC trainer kit using audio signal and voice link. (03 Hrs.) 204. Perform PPM modulation and demodulation using OFC trainer kit using audio signal and voice link. (03 Hrs.)	Introduction to optical fiber, optical connection and various types optical amplifier, its advantages, properties of optic fiber, testing, losses, types of fiber optic cables and specifications. Encoding of light. Fiber optic joints, splicing, testing and the related equipment/ measuring tools. Precautions and safety aspects while handling optical cables. (05 Hrs.)
Professional Skill 35 Hrs; Professional Knowledge 05 Hrs	Plan and Interface the LCD, LED, DPM panels to various circuits and evaluate performance. **(Mapped NOS: ELE/N8107)**	**Digital panel Meter** 205. Identify LED Display module and its decoder/driver ICs. (05 Hrs.) 206. Display a word on a two line LED. (06 Hrs.) 207. Measure/current flowing through a resistor and display it on LED Module. (06 Hrs.) 208. Measure/current flowing through a sensor and display it on a LED module (DPM). (06 Hrs.) 209. Identify LCD Display module and its decoder/driver ICs. (06 Hrs.) 210. Measure/current flowing through a resistor and display it. (06 Hrs.)	Different types of seven segment displays, decoders and driver ICs. Concept of multiplexing and its advantages. Block diagrams of 7106 and 7107 and their configuration for different measurements. Use of DPM with seven segment display. Principles of working of LCD. Different sizes of LCDs. Decoder/ driver ICs used with LCDs and their pin diagrams. Use of DPM with LCD to display different voltage & current signals. (05 Hrs.)
Professional Skill 120 Hrs; Professional Knowledge 40 Hrs	Detect the faults and troubleshoot SMPS, UPS and inverter. **(Mapped NOS: ELE/N7202)**	**SMPS and Inverter** 211. Identify the components/devices and draw their corresponding symbols. (03 Hrs.) 212. Dismantle the given stabilizer and find major sections/ ICs components. (06 Hrs.)	Concept and block diagram of manual, automatic and servo voltage stabilizer, o/p voltage adjustment. Voltage cut-off systems, relays used in stabilizer. Block Diagram of different types of Switch mode power supplies and their working principles.

		213. List the defect and symptom in the faulty SMPS. (05 Hrs.) 214. Measure / Monitor major test points of computer SMPS. (07 Hrs.) 215. Troubleshoot the fault in the given SMPS unit. Rectify the defect and verify the output with load. Record your procedure followed for trouble shooting the defects. (08 Hrs.) 216. Use SMPS used in TVs and PCs for Practice. (05 Hrs.) 217. Install and test the SMPS in PC. (05 Hrs.) 218. Install and test an inverter. (05 Hrs.) 219. Troubleshoot the fault in the given inverter unit. Rectify the defects and verify the output with load. (08 Hrs.) 220. Construct and test IC Based DC-DC converter for different voltages. (08 Hrs.) 221. Construct and test a switching step down regulator using LM2576. (08 Hrs.) 222. Construct and test a switching step up regulator using MC 34063. (08 Hrs.)	Inverter; principle of operation, block diagram, power rating, change over period. Installation of inverters, protection circuits used in inverters. Battery level, overload, over charging etc. Various faults and its rectification in inverter. Block diagram of DC-DC converters and their working principals. (20 Hrs.)
		UPS 223. Connect battery stack to the UPS. (07 Hrs.) 224. Identify front panel control & indicators of UPS. (05 Hrs.) 225. Connect Battery & load to UPS & test on battery mode. (06 Hrs.) 226. Open top cover of a UPS; identify its isolator transformers, the UPS transformer and various circuit boards in UPS. (08 Hrs.) 227. Identify the various test point and verify the voltages on these. (05 Hrs.) 228. Identify various circuit boards in UPS and monitor voltages at various test points. (05 Hrs.) 229. Perform load test to measure backup time. (08 Hrs.)	Concept of Uninterrupted power supply. Difference between Inverters and UPS. Basic block diagram of UPS & operating principle. Types of UPS : Off line UPS, On line UPS, Line interactive UPS & their comparison UPS specifications. Load power factor & types of indications & protections Installation of single phase & UPS. (20 Hrs.)
Professional Skill 60 Hrs; Professional Knowledge 15 Hrs	Identify, Test and verify haracteristics of Photovoltaic cells, Modules, Batteries and Charge controllers. Install a solar panel, execute testing and evaluate performance by connecting the panel to the inverter. **(Mapped NOS: ELE/ N5902)**	230A. Identify and Test an LED and a Photodiode to verify the photo emitting effect and light sensitivity. (04 hrs) 230B.Test a Photo voltaic cell for different illumination levels and verify photovoltaic property. (04 hrs) 230C. Plot I-V curve for photovoltaic cell based on the illumination at constant temperature. (04hrs) 230D. Plot I-V curve for photovoltaic cell based on temperature at constant illumination. (04 hrs)	Semiconductor properties and types. P-type and N-type semiconductors, PN junction, etc. Conversion of solar radiation to electricity. Main materials used to develop solar cells (Silicon, Cadmium tellurides, etc.) Light sensitive properties of PN junction. Difference of photo electric and photo voltaic effects of a PN junction. PV cell characteristics, I–V curve, effects of temperature.

		230E Test photovoltaic cell in sunlight at various angles of inclination and direction. (04 hrs)	Photovoltaic effect. Photo voltaic module: minimal functional specification, cells per module, max watts per module, maximum voltage at max power, maximum current at max power. (05)
		Solar Power (Renewable Energy System) 230F. Wire a solar controller to a battery storage station. (08 Hrs.) 231. Connect storage batteries to a power inverter. (08Hrs.) 232. Connect and test solar panel to the Inverter and run the load. (08Hrs.) 233. Install a solar power to charge a rechargeable 12 V DC battery and find out the charging time. (08 Hrs.) 234. Install a Solar Inverter. (08 Hrs.)	Need for renewable energy sources, Solar energy as a renewable resource. Materials used for solar cells. Principles of conversion of solar light into electricity. Basics of photovoltaic's cell. Module, panel and Arrays. Factors that influence the output of a PV module. SPV systems and the key benefits. Difference between SPV and conventional power. Solar charge controller or regulator and its role. Safety precautions while working with solar systems. (10 Hrs.)
Professional Skill 30 Hrs; Professional Knowledge 10 Hrs	Dismantle, identify the various parts and interface of a cell phone to a PC. Estimate and trouble shoot. **(Mapped NOS: ELE/N8107)**	**Cell phones** 235. Dismantle, identify the parts and assemble different types of smart phones. (04 Hrs.) 236. Dismantle the cell phone/smart phone remove the key pad and clean it, test for the continuity of the matrix/ tracks. (04 Hrs.) 237. Interface the cell phone/smart phone to the PC and transfer the data card. (03 Hrs.) 238. Flash the various brands of cell phone/smart phone (at least 3). (03 Hrs.) 239. Format the cell phone/ smart phone for virus (approach the mobile repair shop/ service centre). (04 Hrs.) 240. Perform the interfacing of cell phone/ smart phone to the PC and dismantle the cell phone and identify the power section and test its healthiness. (04 Hrs.) 241. Find out the fault of basic cell phone system. Rectify the fault in ringer section and check the performance. (04 Hrs.) 242. Replace various faulty parts like mic, speaker, data/ charging/ audio jack etc. (04 Hrs.)	Introduction to mobile communication.Concept cell site, hand off, frequency reuse, block diagram and working of cell phones, cell phone features. GSM and CDMA technology. Use IEMI number to trace lost/ misplaced mobile phone. (10 Hrs.)

Professional Skill 15 Hrs; Professional 05 Hrs Knowledge	Check the various parts of a LED lights & stacks and troubleshoot. **(Mapped NOS: ELE/N9302)**	**LED Lights** 243. Dismantle the LED light, identify the connections of LEDs stacks, protection circuits, regulator. (03 Hrs.) 244. Identify the rectifier, controller part of LED lights. (03 Hrs.) 245. Make series string connection of six LED's and connect four Series strings in parallel. (03 Hrs.) 246. Connect to such parallel sets in Series to create a matrix of LED's. (03 Hrs.) 247. Apply suitable voltage and check Voltage across series strings. (03 Hrs.)	Types of LED panels used in various lighting applications. Stacking of LEDs.
Professional Skill 50 Hrs; Professional Knowledge 15 Hrs	Identify, operate various controls, troubleshoot and replace modules of the LCD/LED TV & its remote. **(Mapped NOS: ELE/N3102)**	**LCD and LED TV** 248. Identify and operate different Controls on LCD, LED TV. (05 Hrs.) 249. Identify components and different sectors of LCD and LED TV. (05 Hrs.) 250. Dismantle; Identify the parts of the remote control. (05 Hrs.) 251. Dismantle the given LCD/LED TV to find faults with input stages through connectors. (05 Hrs.) 252. Detect the defect in a LED/LCD TV receiver given to you. Rectify the fault. (10 Hrs.) 253. Troubleshoot the faults in the given LED/LCD TV receiver. Locate and rectify the faults. (10 Hrs.) 254. Test LED/LCD TV after troubleshooting the defects. (05 Hrs.) 255. Identify various connectors and connect the cable operators external decoder (set top box) to the TV. (05 Hrs.)	Driving of LED stacks. (05 Hrs.) Difference between a conventional CTV with LCD & LED TVs. Principle of LCD and LED TV and function of its different section. Basic principle and working of 3D TV. IPS panels and their features. Different types of interfaces like HDMI, USB, RGB etc. TV Remote Control –Types, parts and functions, IR Code transmitter and IR Code Receiver. Working principle, operation of remote control. Different adjustments, general faults in Remote Control. (15 Hrs.)

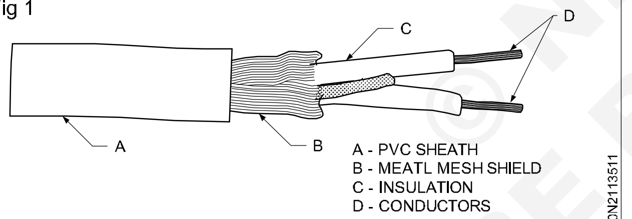
Audio and Video/RF Cables

Objectives: At the end of this lesson you shall be able to
- **construction of audio cable**
- **types and applications of audio cable**
- **construction of video cable**
- **types of applications of video cable.**

Audio Cables: Audio frequencies range from 20 Hz to 20kHz. In other words frequencies from 20Hz to 20kHz are audible by human ear. Any information conveyed at these frequencies are wanted signals. Any other disturbances like noise cross talk and hum are unwanted signals. The audio equipments are designed and assembled to handle only wanted signals and reject unwanted signals. Similarly the audio cables used inside the audio equipments and also cables used for connecting two or more equipments and devices should also be such that they reject unwanted signals. For this purpose the audio cables are provided with a shield which is grounded at both ends of the cable. This shield acts as a screen and prevents induction of noise. This shield surrounding the live leads runs throughout the length of the cable in the form of a metal (copper) mesh.

The general construction of an audio cable is shown in the Fig 1.

Fig 1



AUDIO CABLE

The details of various types of commonly used Audio cables are as follows.

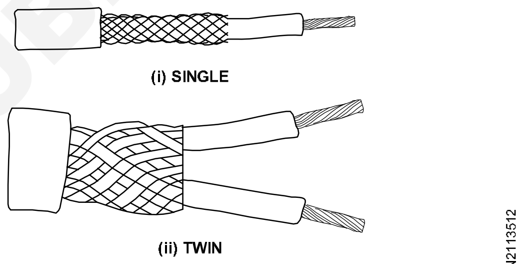
Standard Round: Fig. 2 shows standard type braided screen cables. They offer low noise for use in low-level signal circuits.

16/0.2mm tinned copper stranded conductors, PVC insulated, braided screen and grey PVC sheath.

Cores: red (single), blue and red (twin).

Capacitance: 360 pF/m (single); core to screen 288 pF/m and core to core 171 pF/m (twin). Twin type has twisted cores for hum reduction.

Fig 2



STANDARD ROUND

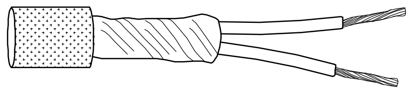
Given below is a list of common audio cables, their types, specifications and applications.

Types of Audio cables

Sl.No.	Type	Specification	Application
1	Microphone cable 10 x 0.2mm	Low noise single core Amplifiers (Unbalanced)	Microphones, Pre-Amplifiers Programme shielded
2	Microphone cable	Low noise Two core 26 x 0.1mm Flexible, Shielded	Microphones, Pre-Amplifiers Programme Amplifiers (Balanced)
3	Standard Audio cable	Two core 14 x 0.2mm cotton braided shielded	Line Amplifiers, Audio consoles, Tape recorders, Programme Amplifiers
4	General purpose Audio cable	Two core 26 x 0.1mm cotton braided shielded	For any indoor and outdoor applications
5	Heavy duty Audio cables	Two core individually screened 7 x 0.2mm	Data Transmission
6	Heavy duty Audio cable	Four core Individually screened 7 x 0.2mm	Data Transmission

Microphone Cables: Fig 3 shows a 2-core standard type Microphone cable. This is a low noise screened cable. Construction ensures good transmission properties desirable in many professional audio & low level programme circuits. Two 55/0.1 mm plain copper stranded conductors PVC insulated and twisted together.

Fig 3



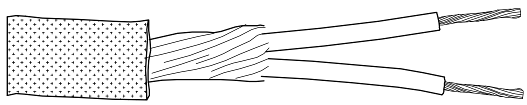
EM20N2113513

MICROPHONE CABLE

Fig 4 shows a 2 core flexible type Microphone cable. This cable is designed to fulfill the conflicting requirements of flexibility and good screening properties, thus making it suitable for hand-held or free-standing microphone applications. Two 28/0.1mm plain annealed copper stranded conductors, PVC insulated with a single lap screen constructed from plain annealed copper with a grey PVC outer sheath.

Capacitance 273pF/m Dia.5.4mm

Fig 4

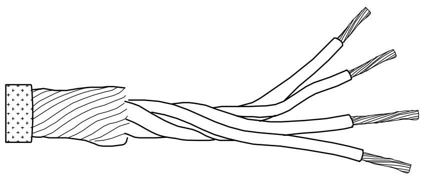


EM20N2113514

MICROPHONE CABLE

Fig 5 shows a 4-core standard type Microphone cable.

Fig 5



EM20N2113515

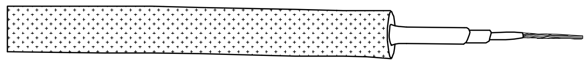
4 CORE CABLE

This cable comes with four 14/0.12 mm tinned copper stranded conductors, PVC insulated and wrapped with polythene tape. Capacitance 125 PF / m.

This is also a High-grade, low-noise, screened cables and the construction ensures good transmission properties desirable in many professional audio and low noise level.

Patch/instrument Cable: It is shown in the Fig 6.

Fig 6



EM20N2113516

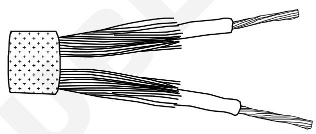
PATCH/INSTRUMENT CABLE

An instrument/patch cable which has been developed with the emphasis on mechanical stability and consistent electrical performance. This black 6mm cable is ideal for stage use where mechanical strength is the prime consideration.

Specifications : Strand / conductor : 7 x 0.202 mm shield : Double shield of lapped copper screen, Capacitance 110 PF/m, resistance : 78.2 W / km.

Heavy Duty Twin: Fig.7 shows 2 core Heavy duty twin with individually lapped screen.

Fig 7



EM20N2113517

HEAVY DUTY TWIN

Speaker cable : Speaker wire is used to make the electrical connection between loudspeakers and audio amplifiers. Modern speaker wire consists of two electrical conductors individually insulated by plastic (such as PVC, PE or Teflon) or, less commonly, rubber. The two wires are electrically identical, but are marked to identify the correct audio signal polarity. Most commonly, speaker wire comes in the form of zip cord.(Fig 8)

Types of RF cables

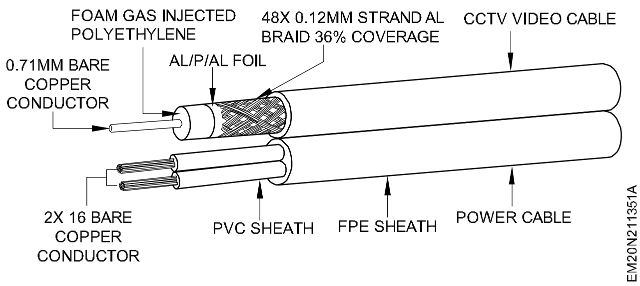
		Specifications			
		Characteristic impedance in Ohms	**Attenuation for 10m at 100** MHZ	**Thickness**	
1	RG58C/U	50	3 db	5mm	Short length RF cabling
2	RG214/U	50	0.76 db	10.8mm	RF Transmission line
3	RG223/U	50	1.41 db	5.5mm	Short length RF cabling
4	RG213/U	50	0.62 db	10.3mm	RF Transmission line
5	RG18A/U	50	0.3 db	24mm	Long length RF Transmission line
6	RG174/U	50	2 db	2.5mm	For wiring inside RF equipments
	RG59B/U	75	1.9 db	6.15mm	General purpose video cabling
	RG179B/U	75	3.2 db	2.5mm	Short length video cabling
	CT167	75	3.7 db	10.1mm	Cable TV
	CT100	75	3.9 db	6.65mm	
	CT125	75	4.9 db	78mm	
	RG6U	75		6.96	Cable TV - long lines
	RG11U	75	0.6 db	10.29mm	Closed circuit TV (video) cabling

Other types of video cables come with power supply line along the coaxial cable are given below.

RG59 Coaxial Cable + 2 Core Power CCTV cable

RG59+2 composite cable. (Fig 10)

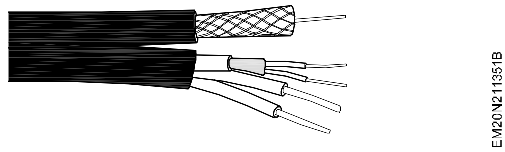
Fig 10



This cable is also called as shotgun cable, is more economical in saving your installation time and money fitting 1 cable instead of 2. It allows you to send power in the two cores and a video signal in Coaxial cable down just the one cable. The two cables run in shotgun style can easily be separated to allow the power cores to be taken to a power source leaving the RG59 to be crimped for connection to a Digital Video Recorder (DVR), Video camera, or monitor.

PTZ combo cable- The PTZ combo cable. (Fig 11)

Fig 11



This heavy duty Pan Tilt Zoom- (PTZ) cable is an ideal choice for applications with pan, tilt and zoom security cameras. PTZ Combo cable is a 3 in 1 cable which supports the data, power and video signal. The power cores are 0.15 x 30 stranded to prevent interruptions and are colour coded red 12V and black 0V to avoid any errors in connection. These power cores can also be used to run 24V AC, ideal for most PTZ installations.

Types of audio and video connectors

Objectives: At the end of this lesson you shall be able to
- **list the different types of Audio and Video connectors**
- **explain the construction of Audio and Video connectors**
- **explain the applications of connectors.**

Introduction: The various types of equipments used in the field of communications and broadcasting are in the form of cabinets closed on all sides by metal plates. The input-output connections, Auxiliary inputs and outputs and other connections to the equipment are brought out in the form of connectors mounted normally on the rear side of the equipment. So connections to the equipments by cables cannot be done with open ended cables. The cable ends should also have suitable mating connectors for giving input or taking the output from the equipments.

The use of such connectors makes it easy to remove equipment or replace the equipment whenever necessary. The cable connections can easily be changed to other equipments when cables and equipments are provided with connectors. Also the use of such connectors are helpful in making firm and reliable connections. In addition, in many cases the usage of connectors helps for fool proof operation avoiding errors due to wrong connections.

Audio Connectors

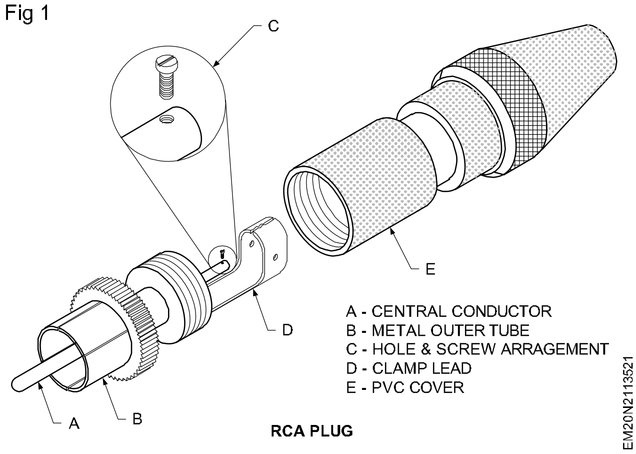
The details of some of the Audio connectors which are mostly in use are as follows.

RCA plug and sockets: The exploded view of the RCA connector plug is given in Fig 1.

The RCA plugs and sockets are invariably used in commercial equipments like audio consoles, recorders, TV receivers, video cassette recorders/players and some commercial amplifiers. These connectors can be used only with unbalanced audio cables. They are normally used for connecting high impedance inputs and outputs.

The exploded view of RCA plug is shown in fig.1. The RCA plug consists of metal outer tube (B) and an inner central conductor (A) insulated from one another by foam or styroflex spacer. The cable side of the inner conductor is in the form of a small cylindrical rod with a hole and screw arrangement (C) for connecting the centre conductor of the unbalanced cable. There is also a clamp like lead (D) fixed to the outer tube to which the shield of the unbalanced cable is to be connected using a crimp tool or a nose plier.

Fig 1



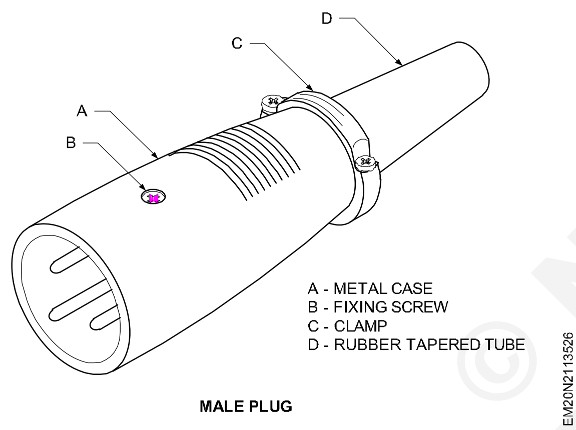
The entire rear portion of the connector (cable end) is protected by a strong PVC cover (E) which is screwed to the metal connector. A sleeving of suitable diameter may be used at the cable connection to prevent the strands of the shield touching the inner conductor.

The RCA plugs can also be used with video cables (RG58/59) to connect video inputs and outputs in commercial equipments.

RCA sockets (female) are available in different styles; The construction of these sockets is more or less similar as PCB mount type and panel mount type as shown in Fig 2A & 2B. The central conductor is the inner tube separated from the outer tube by a plastic or foam spacer. The dimensions of the inner tube and outer tube are such that the male plug tightly sits making firm contact.

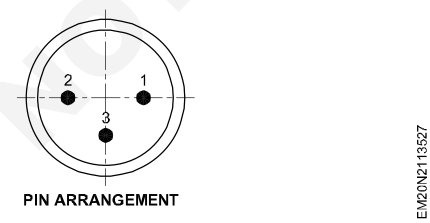
XLR Male plug (cable type): It consists of a metal case with an insulator disc inside holding the three pins in precise position. The cable ends of the pins have curved edges to enable easy soldering. The clamp provided at the cable end of the connector helps to hold the audio cable tightly so that movement or shaking of the cable will not affect the soldering connection at the pins. A thick rubber tapered tube is provided for leading the cable inside and helps to give right flexibility at the connector. A typical XLR male plug shown in Fig 6.

Fig 6



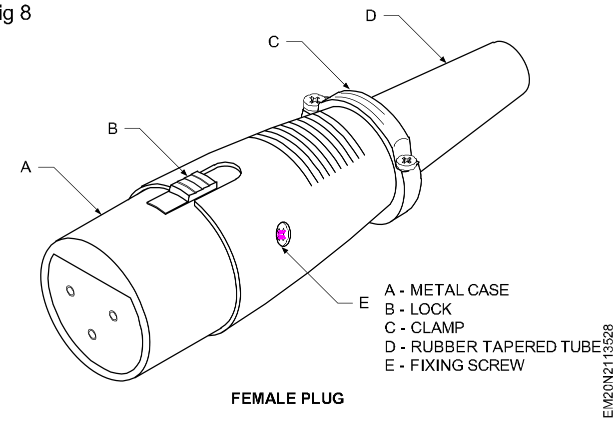
The arrangement of pins in a XLR male plug is shown in Fig 7. The three leads of the Audio cable namely two live leads and shield can be connected to any pin in any sequence. But a standard sequence should be followed to avoid wrong inter-connections between various equipments. The international standard is to connect the screen (ground) to pin 1 and the live leads of the cable to pin 2 & pin 3. This standard should be followed in connecting any XLR connector.

Fig 7



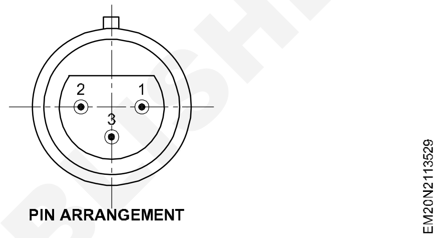
XLR Female plug (cable type) : XLR Female plug (cable) is shown in Fig 8. The XLR female plug consists of a metal case with three sockets held in position by fibre spacer. The metal case is provided with a locking arrangement which helps to hold the connector in locked position. While removing the plug, the lock pin should be pressed slightly while pulling out the plug. The cable end of the connector is similar to that of the male connector described above.

Fig 8



The standards used for connecting audio cable to XLR connectors should be followed here also. The screen (ground) should be connected to Pin No.1 and the live leads to pins 2 & 3. The pin configuration is shown in Fig 9.

Fig 9



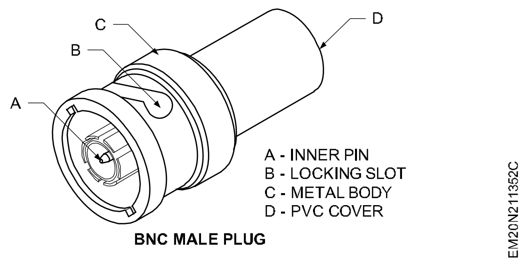
XLR female plugs (cable) should be used for feeding the input to the equipment by inserting it to the male panel mounted connector fixed in the equipment.

Video Connectors

The details of some of the common video connectors are as follows.

BNC (Male plugs) : The BNC male plugs are very common in video systems and equipments. It consists of an inner conductor in the form of a pin and outer metal housing as shown in Fig 12. The inner pin is gold plated normally for providing good electrical contact. The inner pin is kept insulated from the outer housing by a styroflex or foam spacer. The outer housing has a turntable locking arrangement. The plug is pushed into the female receptacle and when turned clockwise the connector gets locked. While removing, the housing is gently turned anti-clockwise and pulled.

Fig 12



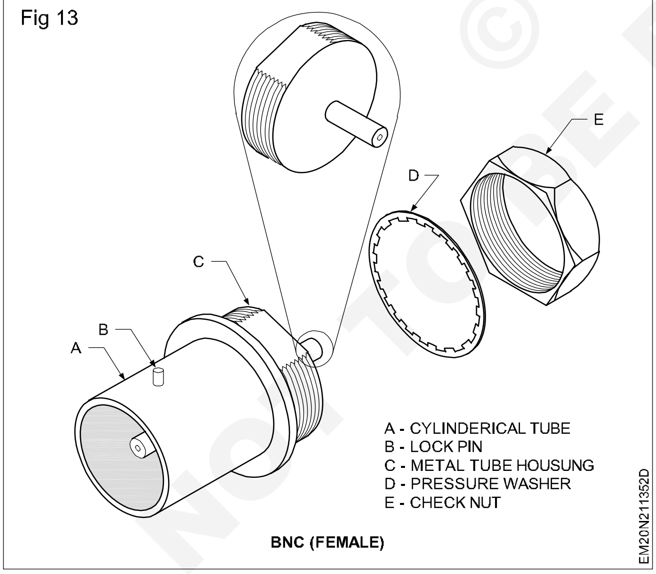
The cable side of the connector is in the form of a tube through which the inner conductor of the cable is connected to the central pin. The outer shield of the cable is expanded and spread over the knurled portion of the tube. Another cylindrical tube is run over this bed and crimped. Now the inner pin and the outer metal housing act as two leads of the video cable. A protective PVC cover is provided at the rear of the connector to reduce strain at the cable connection.

The BNC plugs are used along with the following types of co-axial cables in video circuits.

RG58	RG59	BNC connectors are
RG174A	RG223/U	used both for 50 and
RG8A/U	RG55B/U	75 ohms cables.
RG142B/U	RG188A/U	
RG213/U	RG400/U	
RG179B/U	RG214/U	

BNC (Female) connectors: BNC female connectors can be either of cable type or panel mount type. Mostly they are of panel mount type fixed as input and output ports of various video equipments. Fig 13 illustrates the panel mount BNC connector. It consists of an inner thin cylindrical tube fixed centrally inside a larger outer metal tube housing. Styroflux or foam is used as the spacer between the two. The outer housing has two short pins used for locking the male plug.

Fig 13



In the rear portion of the connector the leads from the inner conductor is brought out to which the centre lead of the cable is soldered. The shield of the cable is connected to the chassis (ground) at a point nearest to the connector. Since the outer frame of connector is fixed to the panel, it gets grounded.

In the cable type BNC female connector, the rear portion (cable side) is similar to that of the male plug and the procedure for giving cable connection is also same.

HDMI connector

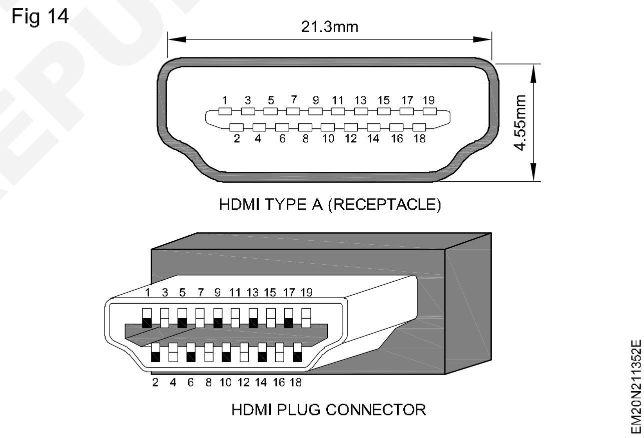
HDMI (High-Definition Multimedia Interface) is a proprietary audio/video interface for transferring uncompressed video data and compressed or uncompressed digital audio data from an HDMI-compliant source device, such as a display controller, to a compatible computer monitor, video projector, digital television, or digital audio device. HDMI is a digital replacement for analog video standards.

No signal conversion is necessary, nor is there a loss of video quality when a DVI-to-HDMI adapter is used. The CEC (Consumer Electronics Control) capability allows HDMI devices to control each other when necessary and allows the user to operate multiple devices with one remote control handset.

Several versions of HDMI have been developed and deployed since initial release of the technology but all use the same cable and connector. Other than improved audio and video capacity, performance, resolution and color spaces, newer versions have optional advanced features such as 3D, Ethernet data connection, and CEC (Consumer Electronics Control) extensions.

The HDMI specification defines 5 connector types. The normal full-size single-link Type A is shown in Fig.14a & 14b.

Fig 14



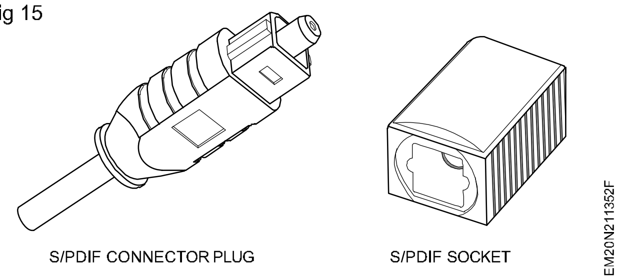
S/PDIF connector

S/PDIF (Sony/Philips Digital Interface Format) connector plug is shown in Fig 15a & 15b is a type of digital audio interconnect used in consumer audio equipment to output audio over reasonably short distances. The signal is transmitted over a fiber optic cable with TOSLINK connector. S/PDIF interconnects components in home theatres and other digital high fidelity systems.

S/PDIF is based on the professional AES3 interconnect standard. S/PDIF can carry two channels of uncompressed PCM audio or compressed 5.1 or 7.1 surround sound (such as DTS audio codec) it cannot support lossless formats (such as Dolby True HD and DTS-HD Master Audio) which require greater bandwidth like that available with HDMI .

This mode is used to connect the output of a DVD player or computer, via optical to a home-theatre amplifying receiver that supports Dolby Digital or DTS. Another common use is to carry two channels of uncompressed digital audio from a CD player to an amplifying receiver.

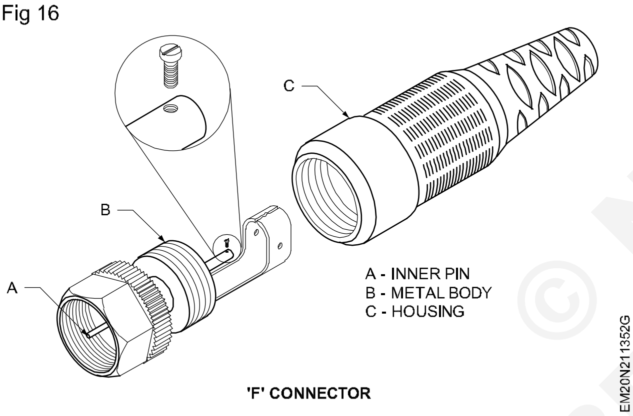
Fig 15



'F' connectors: The general view of the F connector is given in Fig 16. It consists of an inner pin and outer separated and insulated from one another. The outer is hexagonal in the outside and cylindrical and threaded inside. The threading is used for tightening the connector after pushing it to the female receptable. The leads on the cable side are similar as in the case of RCA plug where the inner and outer leads of the cable are connected.

'F' connectors are invariably used in cable TV circuits and equipments with cables of 75 ohm impedance.

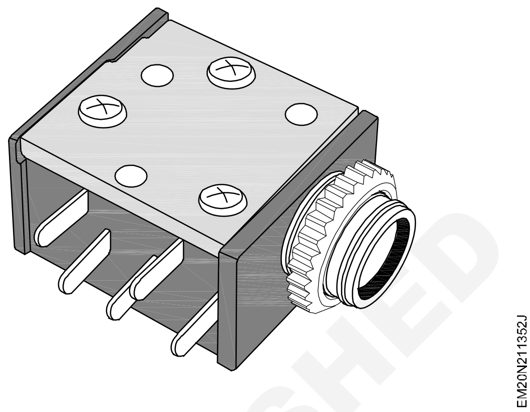
Fig 16



Jack connectors

Stereo 3.5 mm Plugs: These are shown in Fig 17. Available in two versions, insulated plug or screened plug. The insulated type has a moulded body with a cable strain relief sleeve and the screened type has a metal body with a moulded cable strain relief sleeve. Miniature 2.5 mm plugs also are in use.

Fig 17



Chassis Socket: This is shown in Fig 18. Enclosed chassis socket with silver-plated closed circuit contacts (single circuit). Plated mounting bush. Earth contact connected to bush.

Fig 18

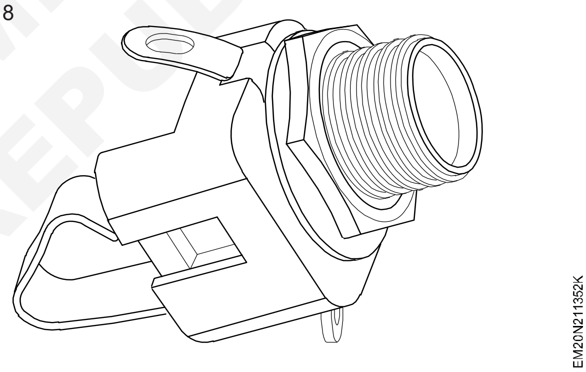
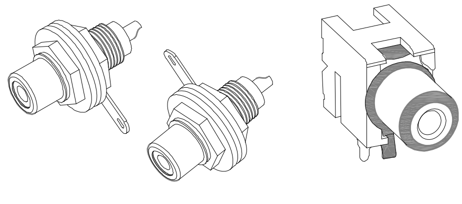
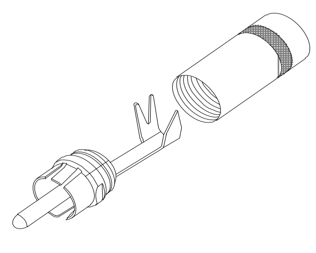
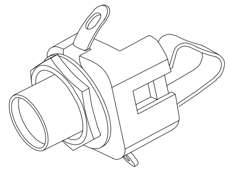
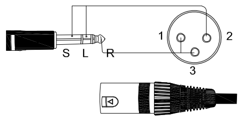
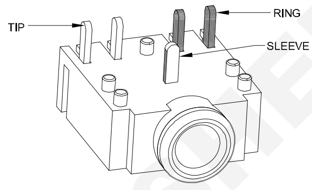
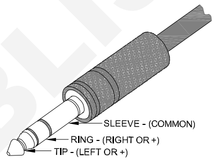
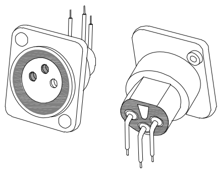
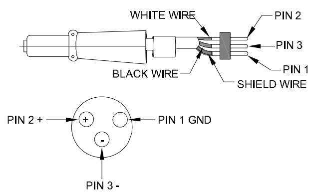
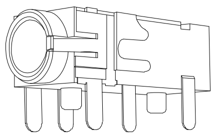
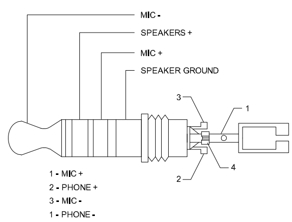
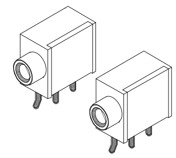
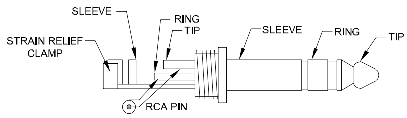
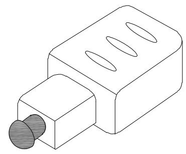
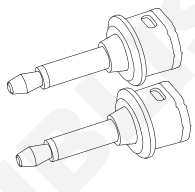
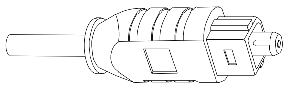
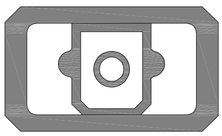
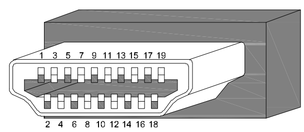
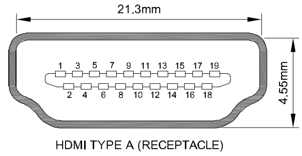
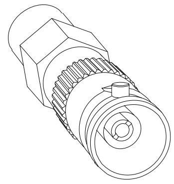
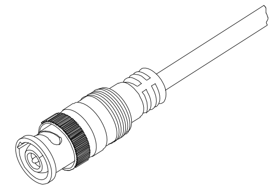
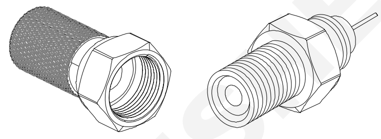
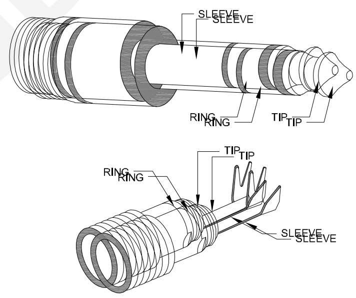
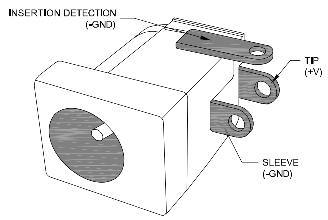


Chart showing various types of sockets/jacks and plugs used for Audio/Video and DC power connectors

Sl.No.	Socket / connector Name	Socket / connector Image
1	RCA socket -Female	
2	RCA plug- Male	

3	TRS-Jack- Female (6.35mm)	
4	TRS plug - Male(6.35mm)	
5	TRS Jack- Female (6.35mm)	
6	TRS plug - Male (6.35mm)	
7	XLR connector- female	
8	XLR connector- Male	
9	TRRS jack- Female	
10	TRRS plug- male	

11	Headphone Jack- Female	
12	Headphone plug- Male	
13	TOS Link -optical Jack -female	
14	TOS link - optical plug- male	
15	S/PDIF connector- male	
16	S/PDIF connector female	
17	HDMI Female Connector	
18	HDMI male connector	

19	BNC Female connector	
20	BNC Male Connector	
21	F - Connector	
22	Barrel DC connector- plug	
23	Barrel DC connector -jack	

Termination of cable ends of crimping and soldering

Objectives: At the end of this lesson you shall be able to
- **state the application of BNC plug**
- **state the application of 'N' male connectors**
- **state the application of 'F' connectors**
- **describe the crimping process used in co-axial cables and connectors**
- **describe the stripping process using a cable stripper**
- **state the advantage and disadvantages of crimping.**

Selection of cable with BNC connector: A BNC connector of 75 ohms characteristic impedance (Zo) connected to a RG59 cable (whose Zo is also 75 ohms) is suitable for wiring in video circuits. All video circuits invariably use 75 ohms as the standard in their design. BNC connectors of Zo 50 ohms should not be used with co-axial cable of Zo 75 ohms. This will cause mismatch, reflections and heating of components.

Selection of co-axiable with N type connectors: Similarly in the case of 'N' connectors, the characteristic impedance of 'N' connectors is 50 ohms only. They should be used only with co-axial cables having Zo as 50 ohms. The impedance of the connector must match the impedance of the cable used. Also the impedance of the cable connector assembly must match the impedances of the equipments where they are used for inter-connectivity.

Table 1 gives the types of cables suitable for BNC connectors of both types.

Some of the types of co-axial cables having Zo as 50 ohms to be used a long with 'N' connectors are given in table 2. The outer diameter of these cables are such that they fit into the connector. These co-axial cables are also meant for more power handling capacity.

Table 1

Cables with 75 ohms BNC connectors	Application
RG59B/U RG179B/U RG6	Video circuits and cabling Closed circuit TV

Cables with 50 ohms BNC connectors	Application
RG58C/U RG174A/U RG8A/U RG213/U RG214/U RG188/U RG223/U	Low power RF circuits and interconnecting low power RF equipments

Selection of co-axial cable with F connectors : In the case of F connectors, the impedance of these connectors is 75 ohms. Hence they should be used only with co-axial cables having characteristic impedance of 75 ohms.

The co-axial cables commonly used with 'F' connectors are given in table 3.

Table 2

Co-axial cable type	Overall outer diameter (inch)	Characteristic impedance	Application
RG8A/U	0.285	50	Short and medium length
RG9	0.280	50	transmission lines and
RG9A	0.280	50	inter-connecting cables.
RG55B	0.116	50	Used in medium power
RG400	0.116	50	RF equipments (upto 100W)
RG213	0.285	50	
RG214	0.285	50	

Table 3

Type of cable	Overall outer dia	Zo Nominal impedance in ohms	Applications
RG6	0.185	75	Short length out-door and cabling in cable TV field.
RG59	0.146	75	Example: LNBC to satellite receiver, modulator - amplifier
CT100	0.25	75	connections, Roof top to TV receivers tap off connections etc.

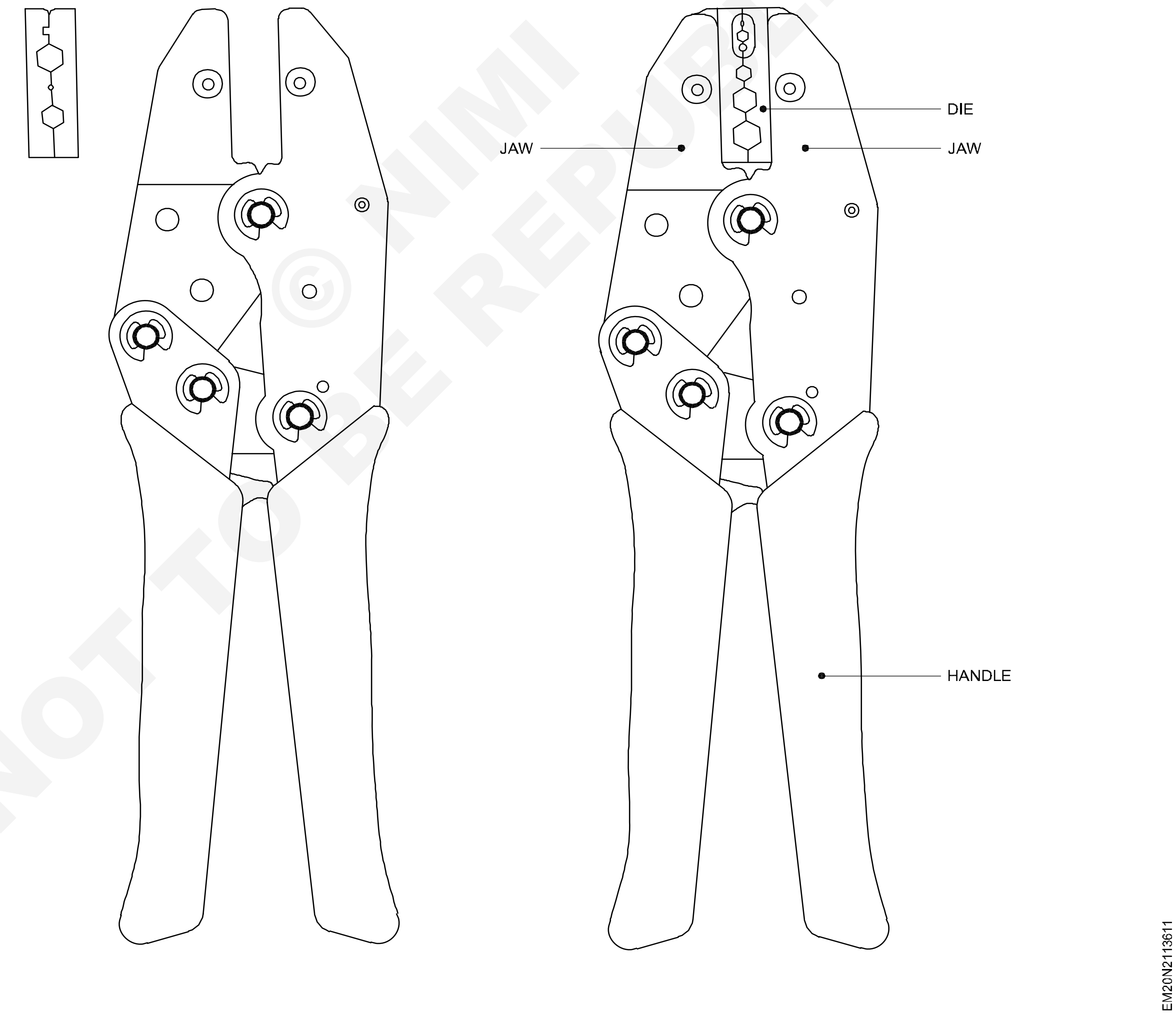
While making co-axial cable-connector assemblies there is a possibility of some thin strands of the shield of the cable touching the inner at the connector end. This should be carefully avoided. Also while checking the continuity during testing shake the connector ends of the cable while holding multimeter prods. The centre pin and the outer of the connector should not show continuity even while shaking the cable.

The Crimping tool : We have come across crimping tools used with power cables where the cable ends are connected to lugs and crimped for firm contact. Similarly we have crimping tools used for co-axial cable connections. Crimping ensures very good contact and also avoids breaking of the cable leads which is normal in soldered connections.

The crimping tool type HT 301C is used for crimping common types of video and RF connectors. HT 301C is useful for crimping BNC connectors while making co-axial cable connector assembly.

Fig 1 shows the crimping tool. It is 8.7" professional Hexagon/Oval type Ratchet and useful for F, BNC, TNC, N, Fiber optic thinnet - PVC & Thinnet Teflon connectors.

Fig 1



It consists of a pair of jaws with a set of DIE in between the jaws. The DIE set consists of three or four hexagonal holes.

The jaws can be opened and closed by the two handles. The frame is made up of carbon steel and hardened so that it can withstand heavy pressure.

The handles are sufficiently long to give good leverage. The handles get locked automatically when the jaws are fully closed. Slight pressure on the handles releases the lock and causes the jaws to open. As detailed in the figure, the die can be replaced depending upon the requirement.

The specification are given in table 4. It explains clearly the dimensions of various dies in the tool and also gives the types of cables that can be used for crimping. For example HT 301C has four dies 8.1mm, 6.5mm, 5.41mm and 1.72mm.

Table 4

A specification of all dimension and RG size

HT					PIN	SQ PIN	FOR CRIMPING RG TYPE CABLE
301A		.256" 6.5 mm	.213" 5.41 mm		.698" 1.72 mm		59, 62, 140, 210, BELDEN 8279 55,58,141,142,223,303,400, Fiber Optic
301B	.319" 8.1mm		.213" 5.41mm		.187" 4.75mm		6, 55, 58, 141, 142, 223, 303, 400 174, Fiber Optic
301C	.319" 8.1mm	.256" 6.5mm	.213" 5.41mm		.068" 1.72mm		6, 59, 62, 140, 210, BELDEN 8279 55, 58, 141, 142, 223, 303, 400, Fiber Optic
301D	.324" 8.3mm	.256" 6.5mm	.213" 5.41mm		.068" 1.72mm		5, 6, 58, 59, 62, 140, 141, 142, 212, 222, 303 Fiber Optic BELDEDN 8281, 8279, 9231, 9141

The advantages of using crimping are

a Crimping ensures firm mechanical and electrical contact.

b It avoids breaking of leads which we normally experience in soldered connection.

c The crimping saves a lot of time. The process is very quick.

The only disadvantages in crimping is, the connector once used for crimping, cannot be re-used. It should be thrown out only. This is the reason why precaution should be taken to cut the cable end to correct dimensions and positioned properly before crimping.

Different types of cable and connectors used in LAN

Objectives: At the end of this lesson you shall be able to
- **list different types of cables used in networking**
- **explain the construction of a twisted pair cable**
- **explain the construction of a coaxial cable.**

Cables or Transmission media

Network computers must have a pathway to contact other computers. The physical path through which the electrical signals travel is called transmission media or cables.

Cable media are wires that conduct electricity/signal. The following types of cables are used in LAN.

1 Twisted pair cable

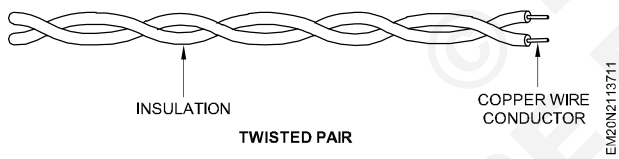
2 Co-axial cable

1 Twisted pair cable

Twisted pair is a common scheme for using copper wire as telecommunication cable because copper is a good conductor of electrons. Twisted copper wires reduces cross talk and signal emissions.

Twisted pairs are formed by two insulated 22 to 26 gauge copper wires that are twisted about each other as in Fig 1. These twisted cables are available in two types.

Fig 1



The two types of cables are:

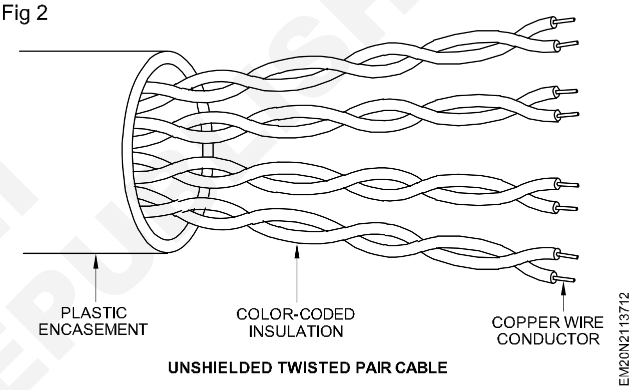
– Unshielded twisted pair cable.

– Shielded twisted pair cable.

Unshielded twisted pair cable (UTP)

Unshielded twisted pair cable is composed of a set of twisted pairs with a simple plastic encasement as in Fig 2.

Fig 2



It is commonly used in telephone systems and has been largely standardized.

Twisted pair network cables are rated in terms of their capability to carry network traffic. They are referred as category 3, 4 5e and cat 6.

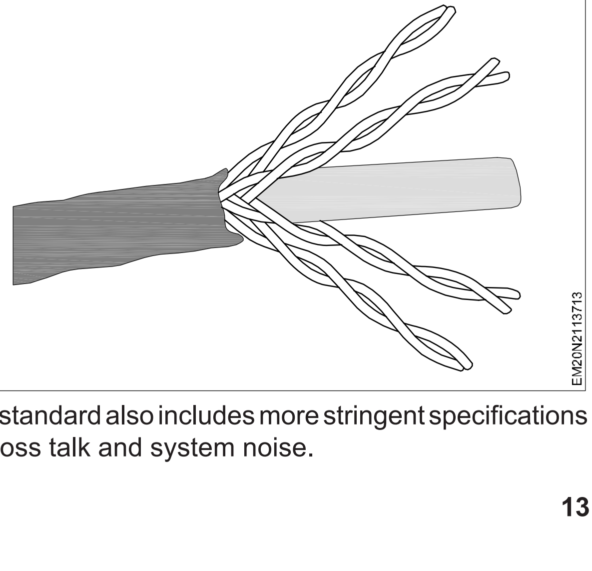
Category 3/Cat 3	-	10 Mbps	-	used for voice grade telephone or 10 mbps ethernet
Category 4/Cat 4	-	16 Mbps	-	Token ring network
Category 5/Cat 5	-	100 Mbps	-	For 100 Mbps Ethernet
/ECat 5	-	100/1000 Mbps		

CAT 6 cable: Cat 6 is a "twisted pair" network cable used for carrying data signals at speeds of up to 550MHz of Bandwidth. This cable is preferred for more advanced networking installations where a higher bandwidth than normal is required.

With Gigabit Ethernet, Broadband, Audio/Video and Security capabilities, Cat6 is ideal for any critical network installation. Whether it's for wiring a home, office or entire campus, we have the solution that's right for the installation.

Cat6 is backward compatible with the CAT 3, 5, 5e cable standards. As with Cat5 and Cat5e cabling, Cat6 cables consists of 4 unshielded twisted pairs(UTP) of copper wires with a soft supporting member in the center of the cable (Fig 3)

Fig 3



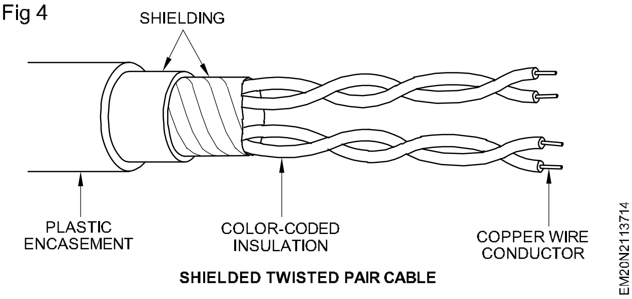
Cat6 standard also includes more stringent specifications for cross talk and system noise.

E Category 5 and category 5 UTP are commonly used in computer networking.

UTP cables are limited to a length of 100 meters (328 feet) for each node to Hub connection.

Shielded twisted pair cable: Today, the mostly used cable is UTP. But some forms of shielded twisted pair (STP) still exist. The below Fig. 4 shows the STP cable. It is used in places where electromagnetic interference caused by electric motors, power lines and other sources.

Fig 4

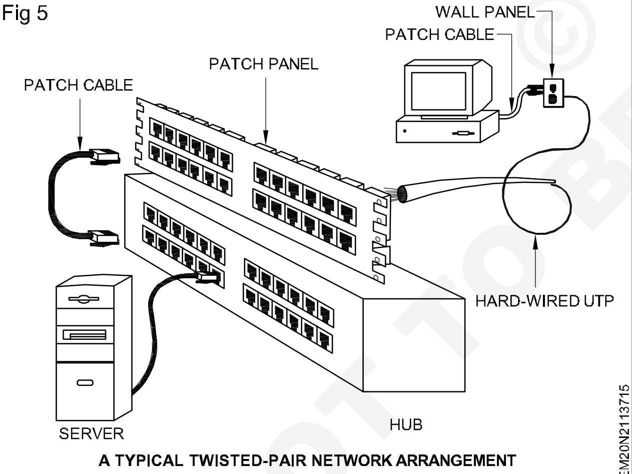


SHIELDED TWISTED PAIR CABLE

The STP is insulated cable which includes bundled pair wrapped in a foil shielding.

UTP: UTP is a popular choice for structured cabling systems used widely in office network environments. Structured cabling system is a network cabling pattern which follows strict engineering design rules. It allows voice, data and video to be transmitted/received on the same cabling system. It allows shifting, adding and replacing the nodes easily. The arrangement is as shown in Fig. 5.

Fig 5



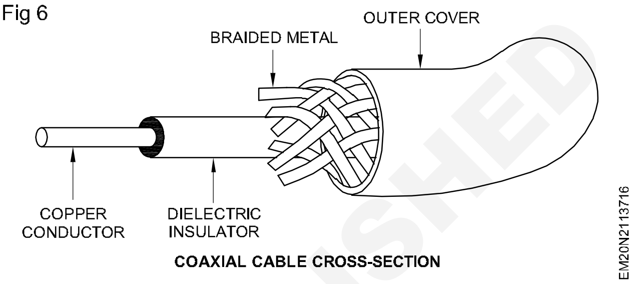
A TYPICAL TWISTED-PAIR NETWORK ARRANGEMENT

The cabling starts from the Hub or switch which is placed in a Rack centrally. A patch cable (usually 6-10 feet long) connects a port on the hub to a patch panel which is also in the Rack using RJ-45 connectors on each end. On the back side of the patch panel, the UTP cable is hard-wired or crimped to the panel connector. From the patch panel, the UTP cable runs continuously to a wall jack or information outlet (I/O). The information outlet contains a RJ-45 jack called I/O jack in it.

The UTP cable is crimped to the information outlet. Another patch cable connects to the RJ-45 jack in the information outlet and the other end gets connected to the NIC of the computer. Note that the distance from the connector on the hub to the connector on the computer's NIC cannot exceed 100 meters of cable length.

2. Co-axial cable: Co-axial cable commonly called ("Coax") is made of two conductors that share a common axis, hence the name ("co", "axis"). typically, the centre of the cable is relatively stiff solid copper wire or stranded wire surrounded by an insulating plastic foam. The foam is surrounded by the second conductor, a wire mesh tube as in Fig 6.

Fig 6



COAXIAL CABLE CROSS-SECTION

Several co-axial cable standards are in common use for computer networking. The most common types meet one of the following ohm and size standards.

– 50 ohm RG-8 and RG-11 (used in thick Ethernet specifications.)

– 50 ohm RG-58 (used in thin Ethernet specifications).

- 75 ohm RG-59 (used for low power video and RF

– 75 ohm RG-62 (used for ARC net specifications)

The co-axial cable can handle a speed of only 10 Mbps maximum and the distance it can drive is only 185 m maximum.

Types of Co-axial cable:

There are two types of co-axial cable

– Thin (Thinnet)

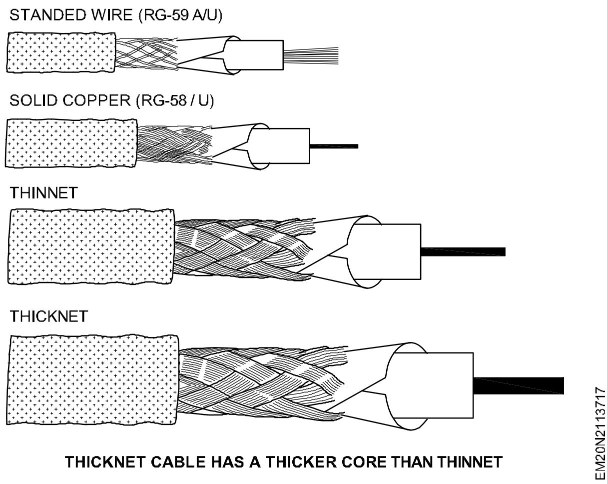
– Thick (Thicknet)

Thinnet: Thinnet is a flexible coaxial cable about 0 .25 inch thickness. Because this type of coaxial is flexible and easy to work with, it can be used in almost any type of network installation. as shown in fig.7

Thicknet : Thicknet is relatively rigid co-axial cable about 0.405 inches in diameter. The copper core is thicker than a thinnet.

RJ45 Cable Wiring: RJ stands for Registered Jacks. These are used in telephone and data jack wiring.RJ-45 is a 8-position, 8-conductor jack used in 10BaseT and 100BaseT Ethernet wiring.

Fig 7



RJ-45 conductor data cable contains 4 pairs of wires each consists of a solid colored wire and a strip of the same color. There are two wiring standards for RJ-45 wiring: T-568A and T-568B.   Although there are 4 pairs of wires, 10BaseT/100BaseT Ethernet uses only 2 pairs: Orange and Green.

The other two colors (blue and brown) may be used for a second Ethernet line or for phone connections. The two wiring standards are used to create a cross-over cable (T-568A on one end, and T-568B on the other end), or a straight-through cable. as shown in Fig 8 & 9.

Fig 8

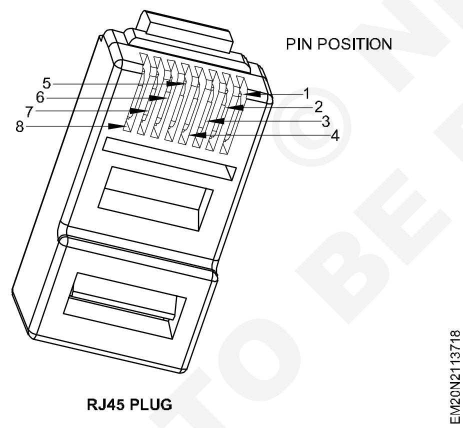


Fig 9

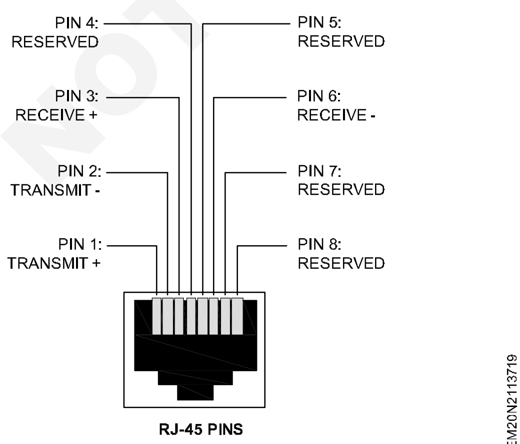


Fig 10 Colours of wires & pin numbers for T568A cable end

Fig 10

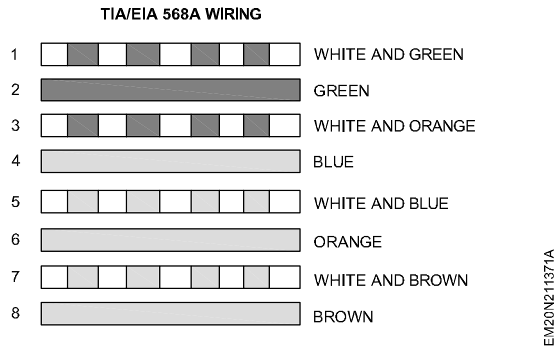
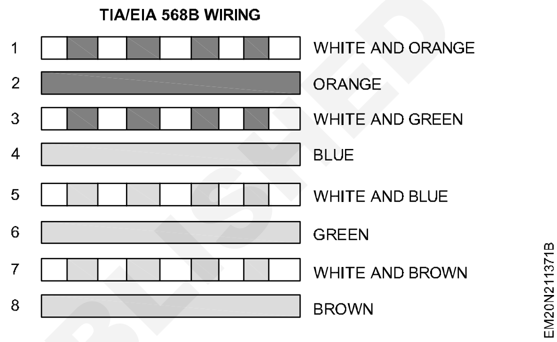


Fig 11 Colours of wires & pin numbers for T568B cable end

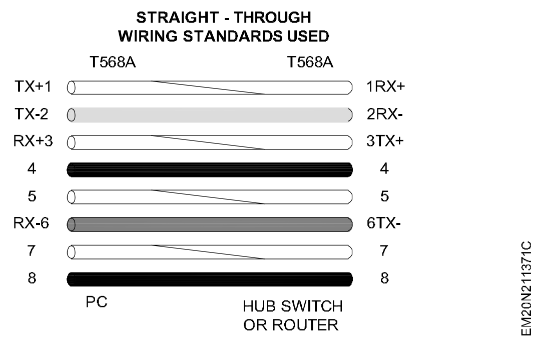
Fig 11



The straight-through cables are used when connecting Data Terminating Equipment (DTE) to Data Communications Equipment (DCE), such as computers and routers to modems (gateways) or hubs (Ethernet Switches).

To create a straight-through cable, you'll have to use either T-568A or T-568B on both ends of the cable. (Fig 12)

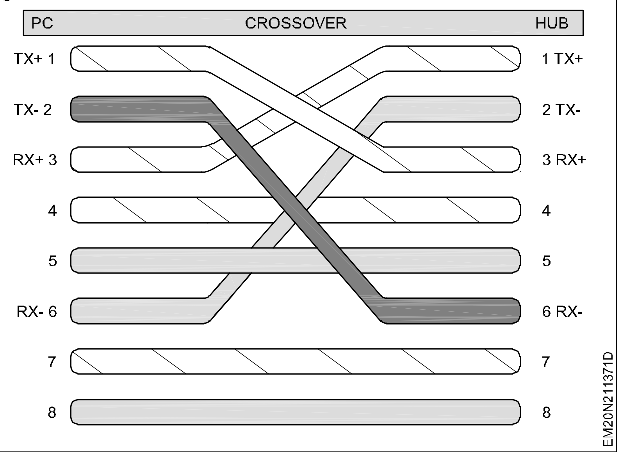
Fig 12



The cross-over cables are used when connecting DTE to DTE, or DCE to DCE equipment; such as computer to computer, computer to router; or gateway to hub connections.To create a cross-over cable, you'll have to use T-568A at one end and T-568B at another end of the cable.(Fig.13)

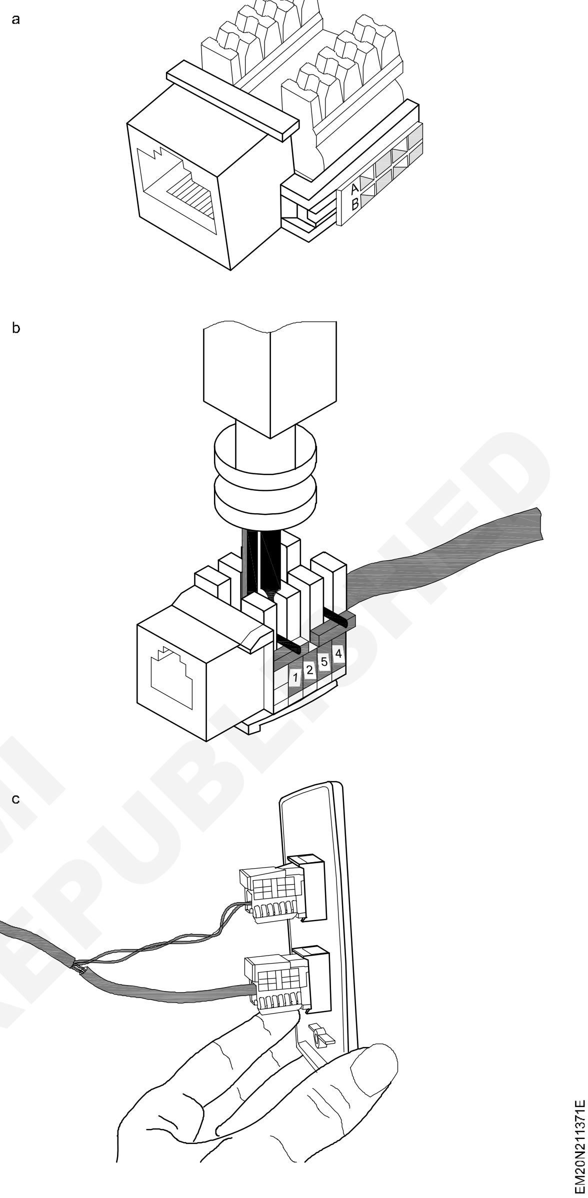
RJ45 Input / Output box (I/O Box) is a preparatory cable with both ends terminated by RJ45 keystone jacks for LAN network; it is also called as wall jack. The keystone jack is shown in Fig 14(a). Keystone jack has color code running down A and B standards on both sides of the jack to be followed with the colours of wires. Using a punch down tool the wires are punched down into the blades designed to work with solid conductors into the keystone jack as shown in Fig 14 b. It is prepared as a straight through cable terminated at both ends with RJ45 sockets. It is used to connect the router to personal computer and printer etc in the networking. It consists of one or more number of RJ45 keystone sockets fitted onto a face plate and it is wired internally by punching down the wires of the CAT cable into respective terminals as shown in Fig 14 c

Fig 13



It is prepared as a straight through cable terminated at both ends with RJ45 sockets. This I/O Box is used for extending the network connectivity for a maximum allowable distance of 100meters.

Fig 14



Cables and Connectors of a PC system

Objectives: At the end of this lesson you shall be able to
- **establish the need for cables and connectors in a PC system**
- **list the types of cables/connectors used to interconnect PC peripherals**
- **list the types of cables/connectors used to interconnect mother board with devices.**

Cables and connectors

Different types of cables used in the computer are multicored round shielded cable, unshielded cables and multicored flat cable as per the international standards. Chart -1 shows various types of connectors used in PC. Mouse, key board and monitor comes with a cable, terminated with connectors at one end . Hard disk, FDD, CD-ROM and other such devices are terminated with a 40 pin/50pin/ 34 pin FRC connectors. Power supply to HDD, FDD and CD-ROM units also fed through the hard plastic connectors.

HDD, is connected to the Mother Board with a flat cable (40 pin) for data transmission and 4 pin hard plastic connector for the Power. These cables are made in such away that we can connect two devices at a time (one master and the other slave). In a typical system the connection may be any of the following type

i M/B to HDD and CD drive

ii M/B to two HDDs

ii M/B to two CD drive

FDD is connected to the MB with a 34 pin flat cable for data transfer and 4 pin hard plastic Molex connector for power. We can connect two floppy disks at a time using the cable. They can be either two "5 1/4 "or two "3 1/2" or combination of both. But nowadays only "3 1/2 " i.e. 1.44MB drives are used and the "5 1/2" are out dated

The rear panel connectors are identified by their standard types such as D type, DIN type, mini DIN type or PS/2 type, RJ type, BNC, RCA and USB. All these types have male and female connectors. Chart 1 at the end of this lesson provides details on various connectors and cables.

DB-9 is a D-type subminiature connector or D- sub type of connector. It has items for male connector and I holes for female connector. Today DB 9 has mostly been replaced by USB, PS-2, fire wire and others. Still many devices are using DB9 interface for serial communication D type 25 pin male connectors are located on the rear side of the cabinet usually denoted as COM-1 & COM -2 are used for serial communication. These are connected to mother board using two 10 core cables. A D type 25 pin (female) parallel port is located on the rear side of the cabinet is used for parallel communication. This is also called as printer port or asynchronous port which is connected to the mother board using a 25 core flat cable. Printers are connected to the parallel port. A general mouse comes with a 9 pin D type female connector which is connected to the serial port.

Universal Serial Bus (USB) is also a communication port similar to serial port used to connect modem, scanners and Web-cameras etc. USB ports are used to connect the peripherals having the USB connectors. Two 5 core or 4 core cables are connected between the Mother Board and the USB terminations on the rear side of the PC.

Mini jack connectors are used to connect Audio IN and OUT of external audio sources. Computers with sound card are provided with female mini jack connectors at the rear side. Allows to attach microphone or external sound source, speakers . The PCs CD-ROM drive audio is connected to the sound card internally.

RCA connectors are used for video IN and OUT to external video sources. Computers with TV tuner card/ video digitizer card are provided with female type RCA connectors at the rear side.

Game port is a 15 pin D type (normal) connector provided at the rear side of the computer to connect JOY stick which is a popular multi directional pointing device used for playing computer games.

Monitors come with a cable terminated with a 15 pin D type male connector. It is connected to the CPU through a 15 pin D type female video connector located at the rear side of the cabinet. This connector is a high density connector, packed in a 9 pin D type shell construction.

Registered Jack (RJ) connectors are available as two wire, 4 wire and 8 wire terminations. They are denoted as RJ 11(4 pin) and RJ 45 (8 pins) etc. RJ-female connectors are located at the rear side of a computer if the computer is fitted with a modem or network card. RJ 11 is used to interface telephone connection (for modem). RJ 45 for network interface connection - (for net work). BNC - "Baynet Naur Connector" is used for coaxial cable termination.

The BNC connectors are also used in networking computers using coaxial cable.

Normal Key boards are terminated with a DIN type male connector. A DIN type female connector is provided at the rear side of the PC through which the key board is connected to the PC. A miniature DIN connector is also provided on the PC for connecting keyboards terminated with PS/2 connector or mouse terminated with PS/2.

Connector /converters

Usually connectors are matched properly between cabinet and devices. Sometimes the connectors may not match. Convertors are available to match these devices. For example - a PS/2 (mini DIN) mouse can be converted to match 9 pin serial connector, if the mother board does not have PS/2 connector (mini DIN). In this way we can use the device with unmatched connector saving cost of a new device. Converters are available for Modem, Keyboard, mouse.

HDMI (High-Definition Multimedia Interface) is a proprietary audio/video interface for transferring uncompressed video data and compressed or uncompressed digital audio data from an HDMI-compliant source device, such as a display controller, to a compatible computer monitor, video projector, digital television, or digital audio device. HDMI is a digital replacement for analog video standards.

FireWire: The IEEE 1394 High Performance Serial Bus (HPSB), FireWire is a high-speed interface mostly developed and promoted by Apple for video transmission. Introduced in 2000, FireWire was added to camcorders and a variety of A/V equipment. Even early iPods could connect via FireWire. Still included on Mac laptop and desktop computers, modern camcorders have replaced FireWire with USB, HDMI and other video outputs. There are two types as FireWire 400 and 800.

USB 3.0 is the third major version of the Universal Serial Bus (USB) standard for interfacing computers and electronic devices. Among other improvements, USB 3.0 adds the new transfer mode SuperSpeed (SS) that can transfer data at up to 5 Gbit/s (625 MB/s), which is about ten times faster than the USB 2.0 standard.

Digital Visual Interface (DVI) is a video display interface developed by the Digital Display Working Group (DDWG). The digital interface is used to connect a video source, such as a display controller to a display device, such as a computer monitor. It was developed with the intention of creating an industry standard for the transfer of digital video content.

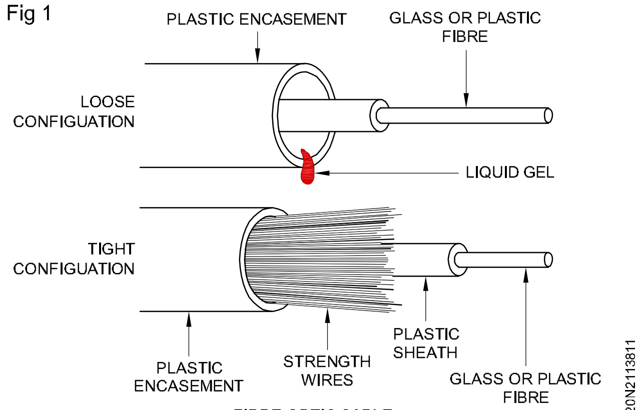
The interface is designed to transmit uncompressed digital video and can be configured to support multiple modes such as DVI-D (digital only), DVI-A (analog only), or DVI-I (digital and analog). Featuring support for analog connections, the DVI specification is compatible with the VGA interface.

Fiber optic cable

Fiber optic cable is made of light- conducting glass or plastic core surrounded by more glass and a tough outer sheath as in Fig 1 The center core provide the light path or wave guide while the glass or cladding is composed of varying layers of reflective glass. The glass or cladding is composed of varying layers of reflective glass. The glass cladding is designed to refract light back into the core. Each core and cladding strand is surrounded by a tight or loose sheath in tight configurations, the strand is completely surrounded by the outer plastic sheath. Loose configuration use a liquid gel or other material between the strand and the protective sheath.

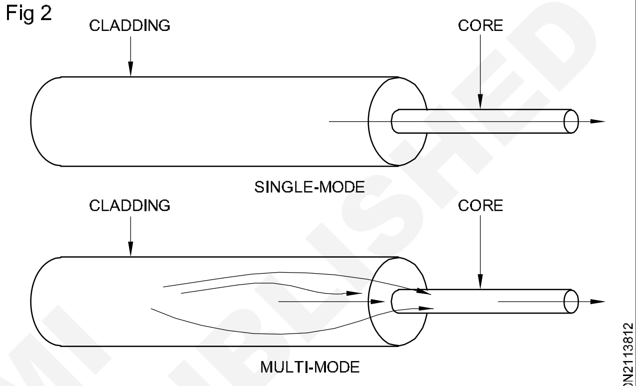
The Optical fibers may be multimode or single mode in nature. single mode fiber has been optimized to allow only one light path while multimode fiber allows various paths. The following figure explains single mode and multimode fibers. (Fig 2)

Fig 1



FIBRE OPTIC CABLE

Fig 2



FIBRE OPTIC CABLE

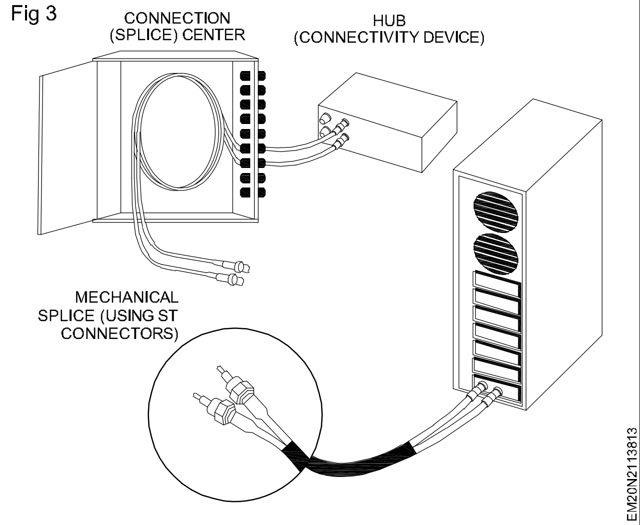
Single mode fiber cable can be used for distance upto 10kms. and multimode cable foe upto 2.5km. The typical speeds are 100/1000 Mbpz. The types of optic cable are differentiated by mode, composition (glass or plastic) and core/cladding size.

Common types of fiber optical cables:

- 8.3 micron core/125 micron cladding single mode
- 62.5 micron core/125 micron cladding multimode
- 50 micron core/125 micron cladding multimode
- 100 micron core/140 micron cladding multimode

The common fiber optic cables installation is given in the following Fig 3

Fig 3

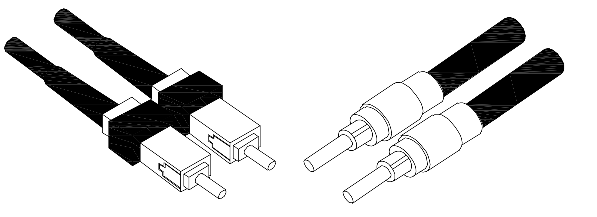


The single carried by a single mode cable is generated by a laser source and that of a multimode by light emitting diode (LED). Together, these qualities allow single mode cable to operate at higher bandwidths than multimode and traverse distance upto 50 times longer. single mode cable is cheaper than multimode and has a relatively high bend radius, which makes it mode difficult to work with. MMF is most commonly used.

Fiber optic connectors

The connector used fiber optic cables is called an ST (straight tip) connection. (Fig 4)

Fig 4



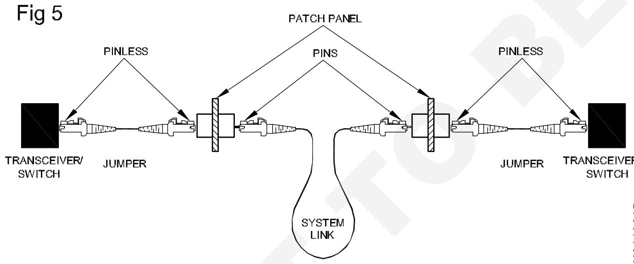
FIBRE-OPTIC SC (LEFT) AND ST (RIGHT) CONNECTORS

EM20N2113814

One more connector type is SC (subscribe connector) is coming up popularly. It has a square body and locks by simply pushing into the socket.

The MTRJ is a new fiber optic connector being used widely. it can operate at Gigabit ethernet speeds (1000 Mbps) easily. The MT-RJ has a latching mechanism similar to the RJ-45 UTP connector. A standard MT-RJ connection consists of 3 components: a male connector (with pins), a female MT-RJ (with guide holes) and as MTRJ adapter. it is easily to install and maintain and should be considered for any new installation. The Figs 5 & 6 show the MTRJ connectors and connections in use.

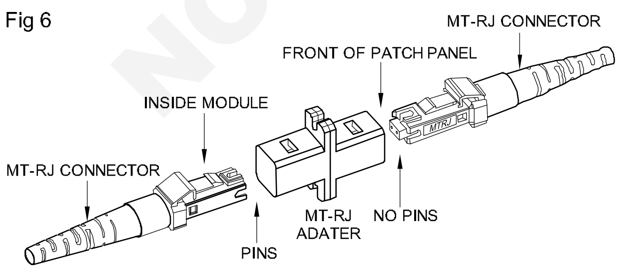
Fig 5



TYPICAL PATCH PANEL TO PATCH PANEL SYSTEM WITH MT-RJ CONNECTORS

EM20N2113815

Fig 6



MATING OF A PINNED MT-RJ CONNECTOR TO PINLESS MT-RJ CONNECTOR

EM20N2113816

Fiber-Optic connectors can attach to the cable in several ways, using either a crimped compression fitting or an epoxy glue.

Fiber cables are main used for backbone connectivity across the floors or when the distance cannot be covered by UTP cable limitation or when the network path to be connected is exposed to sky.

Fiber cables come in three varieties depending on the place of usage.

1 Indoor cables-for in -house usage within buildings.

2 outdoor cables/Armoured cable-to be used in areas which are exposed to sky. Has an additional hard shield to prevent any occasional damage.

3 Indoor/outdoor cable can be used inside and outside buildings. Does not carry heavy shield as in outdoor cable, but better than indoor cable.

Different types of network connectivity hardware

In s network number of hardware devices are used to connect each computer to a media segment. These devices are:

1 Transmission media connectors

2 Network interface boards

3 Modems

We can also connect multiple separate segments of transmission media to form one large network. For this purpose we use the following networking devices.

1 Repeaters

2 Hubs

3 Bridges

4 Multiplexers

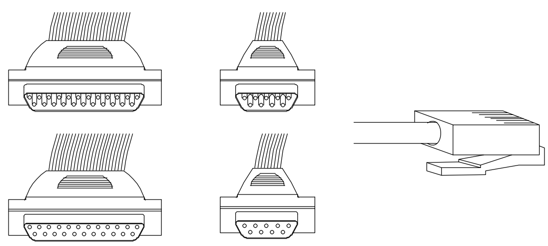
5 Transceiver

6 Routers

1 Transmission media connectors:

Every medium has one or more physical connectors to which you can attach various devices (Fig 7)

Fig 7

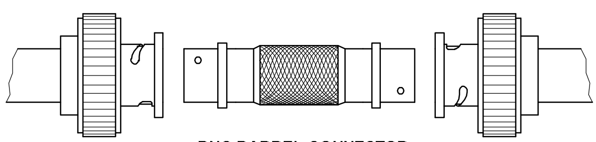


EM20N2113817

BNC (Bayonet nut connector)

It is a connector for co-axial cable that locks when one connector is inserted into another and is rooted 90 degree as in Fig 8

Fig 8



BNC BARREL CONNECTOR

EM20N2113818

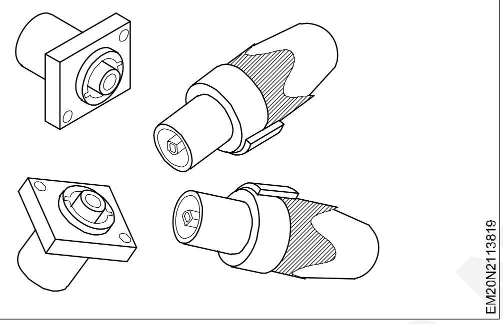
Speaker connector

The Speaker is an electrical connector used in professional audio systems for connecting loudspeakers to amplifiers. Speaker connectors are rated for 40 A RMS continuous current, higher than 1/4-inch TS phone connectors, two-pole twist lock, and XLR connector for loudspeakers

The speaker connector (male) shown in Fig 9

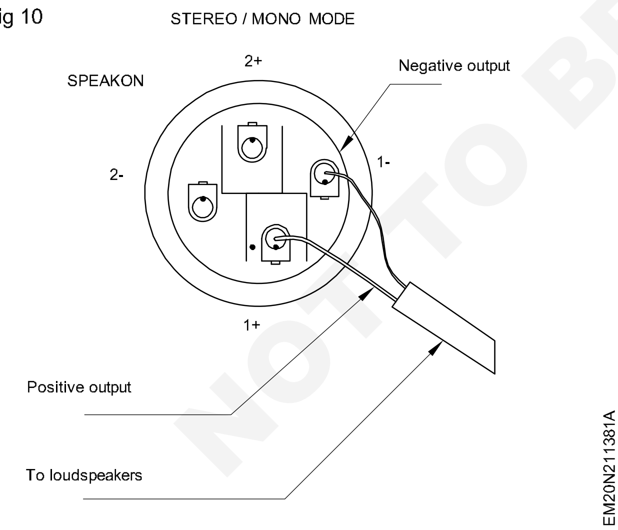
A speaker connector is designed with a locking system that may be designed for soldering or screw-type connections. Line connectors (female) mate with (male) panel connectors at both ends, Recently the manufacture has introduced new series called STX which include also male line connectors and female panel Speaker connectors are designed for use in speaker cables. With 1/4' speaker jacks and XLR connections. It is possible for users to erroneously use low-current shielded microphone or instrument cables are intended solely for use in high current audio applications.

Fig 9



The connection diagram of speaker female socket is shown in Fig 10

Fig 10



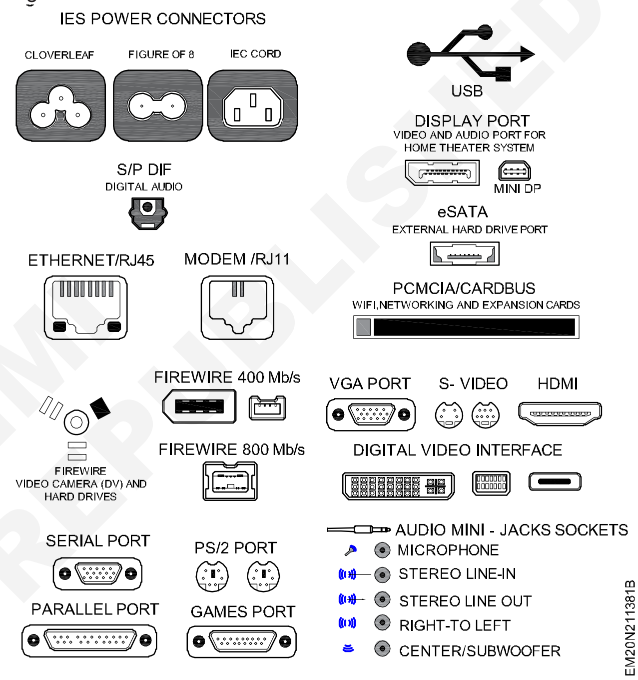
Connector arrange their contacts in two concentric rings with the inner contacts named +1,+2, etc. and the outer contacts connectors (in the four-pole and eight-pole version only). named -1, -2, etc. [5] The phase conventions is that positive voltage on the + contact causes air to be pushed away form the speakers.

Speaker connectors are made in two, four and eight-pole configurations. The two-pole line connector will mate with the four -pole panel connector, connecting to +1 and -1: but the reverse combination will not work. The eight-pole connector is physically larger to accommodate the extra poles. The four-pole connector is the most common at least from the availability of ready-made leads, as it allows for things like bi-amping(two of the four connections for the higher-frequency signal, With the other two for the lower-frequency signal) without two separate cables.

Fiber optic trays

Fiber trays are designed to provide a place to store the fiber cables and splices and prevent them from becoming damages or being misplaced.

Fig 11



Types of optic trays

1 Ladder - Type

2 Perforated type

3 Solid bottom type

4 Wire mesh

5 Channel type

Ports

A port is a physical docking point using which an ex termal devices can be connected to the computer. It can also be programmatic docking point through which information flows from a program to the computer or over the internet. Different types ports used in computer.

Characteristics of ports

A port has the following characteristics-

- External devices are connected to a computer using cables and ports.
- Ports are slots on the motherboard into which a cable of external devices is plugged in.

- Examples of external devices attached via ports are the mouse, keyboard, monitor, microphone, speakers, etc.

Important Types Of Ports

Serial port

- Used for external modems and older computer mouse
- Two versions: 9 pin, 25 pin model
- Data travels at 115 kilobits per second

Parallel port

- Used for scanners and printers
- Also called printer port
- 25 pin model
- IEEE 1284-complaint Centronics port

PS/2 Port

- Used for old computer keyboard and mouse
- Also called mouse port
- Most of the old computers provide two PS/2 port, each for the mouse and keyboard
- IEEE 1284-complaint Centronics port

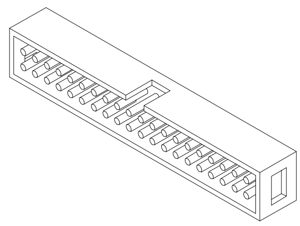
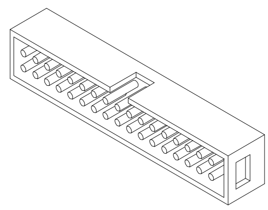
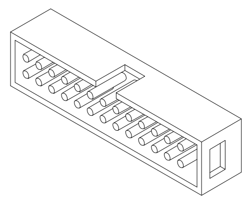
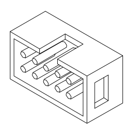
Universal Serial Bus (or USB) Port

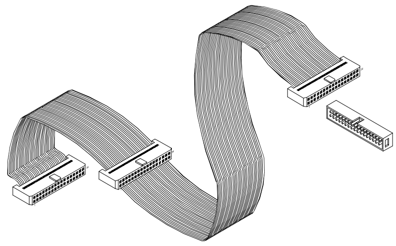
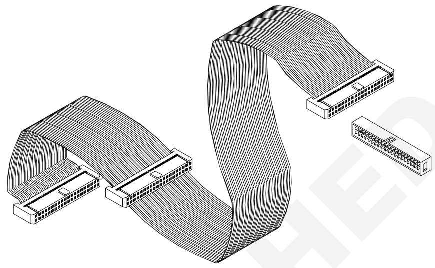
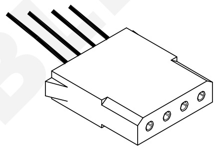
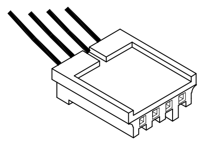
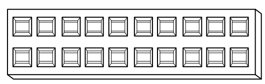
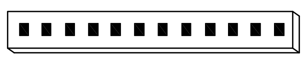
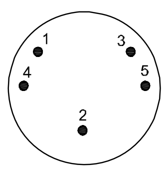
- It can connect all kinds of external USB ports as minimum.
- It was introduced in 1997.
- Most of the computers provide two USB port.

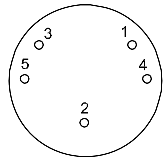
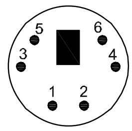
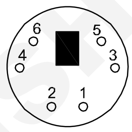
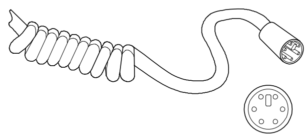
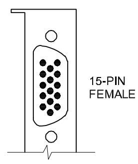
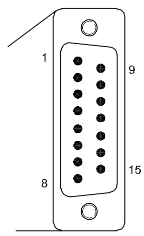
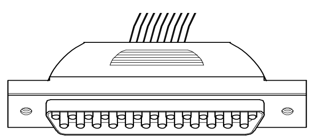
VGA Port

- Connects monitor to a computer's video card.
- It has 15 holes.
- Similar to the serial port connector. However, serial port connector has Pins, VGA port has holes.

Chart 1

Description	Application	Cable/connector
40 pin FRC male connector located on M/B	To connect MB with HDD	 40 PIN FRC CONNECTOR
34 pin FRC male connector located on M/B	To connect MB with FDD	 34 PIN FRC CONNECTOR
25 pin FRC male connector located on M/B	To connect MB with Parallel port provided on the rear side of the PC	 26 PIN FRC CONNECTOR
10 pin FRC male connector located on M/B	To connect MB with serial port "D" connector provided on the rear side of the PC	 10 PIN FRC CONNECTOR

Description	Application	Cable/connector
FDD cable (data) located inside the PC	To connect MB with FDD	 FLOPPY DISK CABLE
HDD cable (data) located inside the PC	To connect MB with HDD	 HARD DISK CABLE
4 pin Molex connector from SMPS unit	SMPS to HDD,FDD,DVD- ROM	 MOLEX CONNECTOR
4 pin Berg connector from SMPS unit	SMPS to FDD (3 1/2'')	 BERG CONNECTOR
20 pin Berg connector from SMPS unit	SMPS (ATX) to MB	ATX  20 PIN BERG CONNECTOR
12 pin Berg connector	SMPS (AT) to MB	AT  12 PIN BERG CONNECTOR
5 pin DIN plug on key board cable	Key board to MB	 5-PIN DIN PLUG

Description	Application	Cable/connector
5 pin DIN socket provided on the rear side of the PC	MB to key board	 5-PIN DIN SOCKET
5 pin Miniature DIN plug on keyboard cable	Key board to MB	 5-PIN MINI-DIN PLUG
5 pin Miniature DIN socket provided on the rear side of the PC	MB to key board	 5-PIN MINI-DIN SOCKET
PS/2 Key board connectors	Mouse to MB	 NEW STYLE PS/2 MINI DIN KEYBOARD CONNECTOR WITH SIX PINS
15 pin High density VGA connector on the rear side of PC	MB to Monitor	 HIGH DENSITY CONNECTOR
15 pin D type connector	To connect Joy stick	 15-PIN D-SHELL CONNECTOR
D-25 pin male connector on the rear side of the PC	Serial port (Com-port)	 25 PIN MALE CONNECTOR

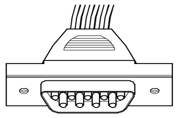
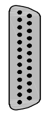
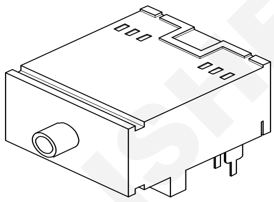
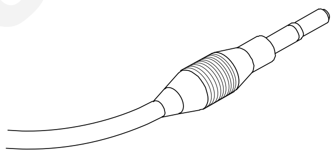
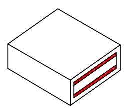
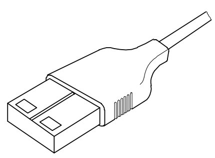
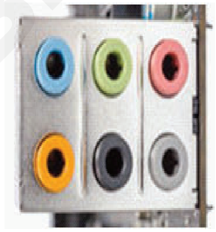
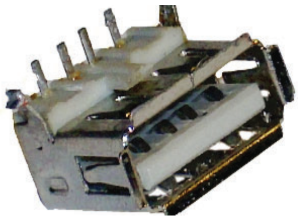
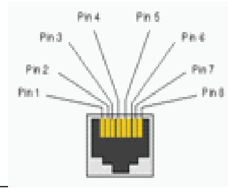
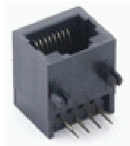
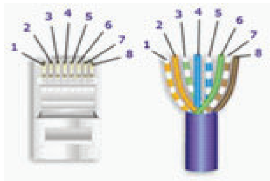
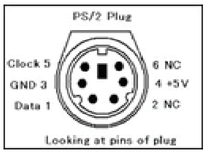
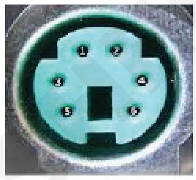
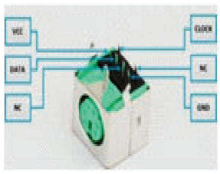
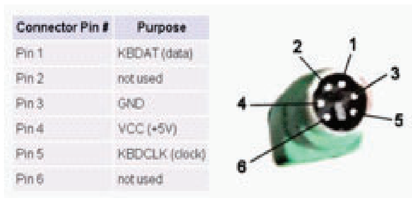
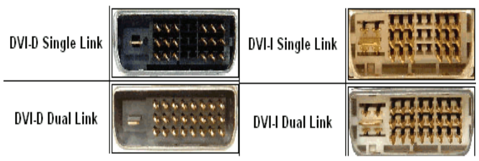
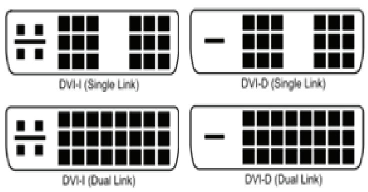
Description	Application	Cable/connector
D-9 pin male connector on the rear side of the PC	Serial port (Com-port)	 9 PIN MALE CONNECTOR
D-25 pin female connector on the rear side of the PC	Parallel port (Printer port)	 25-PIN FEMALE CONNECTOR
Mini Jack socket on the rear side of the PC	Audio IN /MIC	 MINI JACK SOCKET
Mini Jack from external audio device	External Audio Devices to Sound card	 MINI JACK
USB female connector provided on the rear side of the PC	MB to USB peripherals	 FEMALE USB CONNECTOR
USB male connector from the USB device	USB peripherals to MB	 MALE USB CONNECTOR

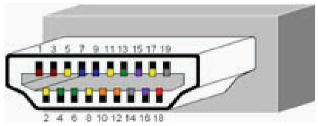
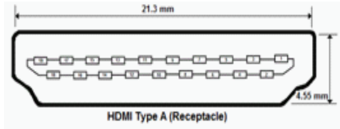
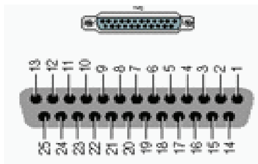
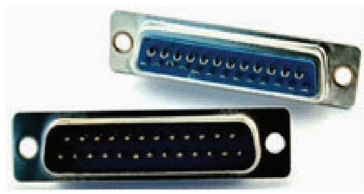
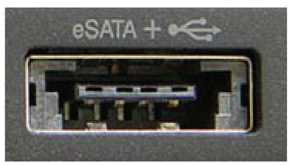
Chart showing various types of sockets /ports and plugs used for Computer Rear Panel & Mother board

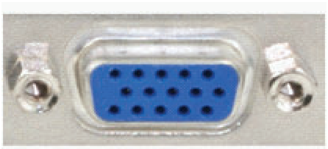
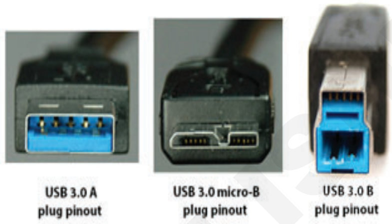
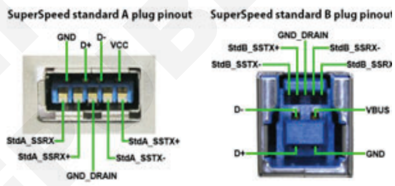
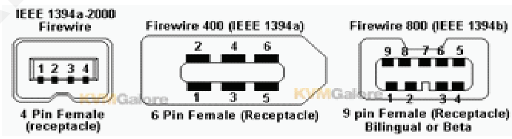
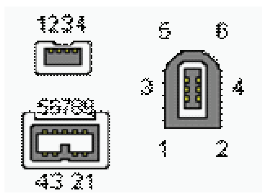
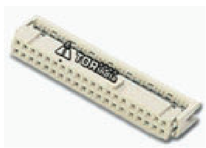
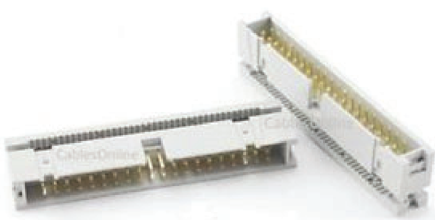
Sl.No	Port/Socket &plug Name	Port/Socket &plug Image
1	Mains Power supply Connector and plug	 
2	Mains Power supply adaptor and plug	
3	Audio jack (3.5mm)	
4	Audio plug (3.5mm)	
5	USB -2.0- female	
6	USB-2.0- male	

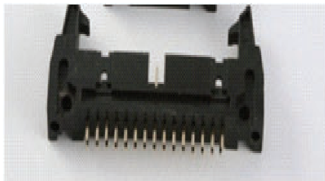
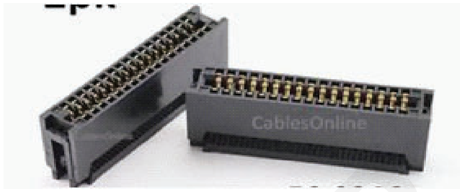
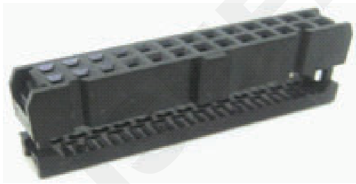
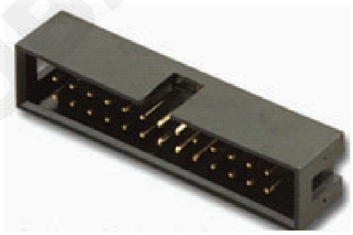
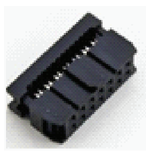
<table>
<tr><th>Sl.No</th><th>Port/Socket &plug Name</th><th>Port/Socket &plug Image</th></tr>
<tr><td>7</td><td>RJ-45jack- Female</td><td>

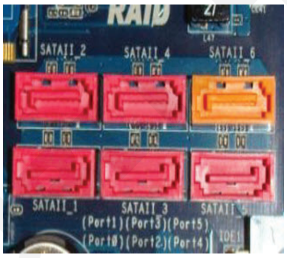
</td></tr>
<tr><td>8</td><td>RJ-45 plug-Male</td><td></td></tr>
<tr><td>9</td><td>PS-2 mouse port</td><td>

</td></tr>
<tr><td>10</td><td>PS-2 mouse plug</td><td></td></tr>
<tr><td>11</td><td>PS-2 keyboard port</td><td></td></tr>
<tr><td>12</td><td>PS-2 keyboard plug</td><td>
</td></tr>
<tr><td>13</td><td>DVI male connector</td><td>
</td></tr>
<tr><td>14</td><td>DVI port</td><td>
</td></tr>
</table>

Sl.No	Port/Socket &plug Name	Port/Socket &plug Image
15	HDMI plug	
16	HDMI Port	
17	DP9-Serial female plug	
18	DP9-Serial male port	
19	DP-25 Parallel plug	
20	DP-25 Parallel port	
21	eSATA -female	
22	eSATA - Port	

Sl.No	Port/Socket &plug Name	Port/Socket &plug Image
23	VGA port (DP-15)	
24	VGA male plug (DP-15)	
25	USB -3.0 port -male	
26	USB-3.0 port - female	
27	IEEE 1394(fire wire)- Female	
28	IEEE 1394 (fire wire)- male	
29	40 Pin FRC Female connector	
30	40 pin FRC Male connector	

Sl.No	Port/Socket &plug Name	Port/Socket &plug Image
31	34 pin FRC male connector	
32	34 Pin FRC female connector	
33	26 Pin FRC Female Connector	
34	26 pin FRC Male Connector	
35	10 pin FRC Male Connector	
36	10Pin FRC female Connector	
37	S/PDIF connector- male	

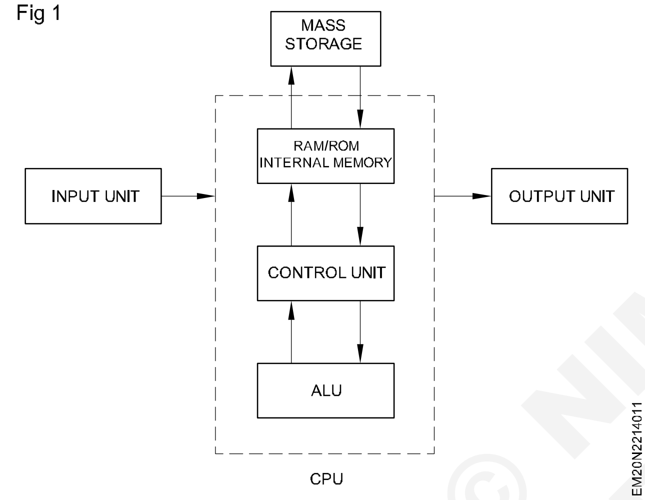
Sl.No	Port/Socket &plug Name	Port/Socket &plug Image
38	S/PDIF connector- female	
39	SATA cable	
40	SATA port	

Computer, parts and their working

Objectives : At the end of this lesson you shall be able to
- **explain the basics of computer**
- **identify various peripheral devices.**
- **identify and explain computer connection and ports**
- **explain the main components on the mother board**
- **explain the CPU and memory.**

What is a computer?: The term computer is used to describe a device made up of electronic and electro mechanical components. The computer itself cannot perform any task and is referred to as hardware. (Fig 1)

Fig 1



A computer system consists of three elements.

1 Hardware

2 Software

3 People

Hardware : The physical components which you can see, touch and feel in the computer system are called hardware Eg monitor, keyboard, mouse etc.

Software : Software is used to describe the instructions that tells the computer how to perform a task. Software is categorized as

1 System software (eg . operating systems, compilers, editors, etc)

2 Application software (MS-word, excel, accounting packages, etc)

People : People who operate the computer and also create computer software instructions.

Computer hardware

Basic components in a computer system are central processing unit (CPU), memory, the input device and output device.

Computer systems – Micros, Minis and Mainframes.

Micro computer : Micro computer is also called as personal computer or PC. It has a processor based on a single silicon chip. Personal computers come in three different physical sizes, pocket pc's, lap pc's and desktop pc's. Pocket pc's and lap pc's belong to portable category. Microcomputer is used in small businesses.

Ex : IBM compatible or IBM clone and Apple Macintosh systems.

Multiuser microcomputers. Until recently microcomputers were personal

computers for individual use only. But now days several microcomputers can be networked together for simultaneous use by several people.

Mini computers: Mini computer is simply a small mainframe computer. It is a reduced version of mainframe. Attached printers are not so fast. So it has less storage capacity less processing speed of that of mainframe computers. They are usually used by small businesses. For example research groups, engineering firms, colleges etc. use mini computers.

Mainframe computers: A mainframe computer is a large expensive machine whose processing speed is very high and has large amount of secondary storage and fast printers. A large mainframe computer may be used to meet the data processing requirements of the entire organization.

Examples: airline booking systems, Railway booking systems , weather forecast etc.

System types

We can classify systems into the following categories :

8-bit, example : 8085 microprocessor

16-bit, example : 8086, 286, 386 processor

32-bit , example : 486

64-bit, example : Pentium - II

This gives us two basic system types or classes of hardware.

8-bit (PC/XT) class systems

16/32/64 (AT) class systems

PC stands for personal computers, XT stands for extended PC, and AT stands for an advance technology PC.

The XT basically was a PC system that included a hard disk for storage in addition to the floppy drive found in the basic PC system. These systems has an 8-bit processor and an 8-bit INDUSTRY STANDARD ARCHITECTURE

(ISA) bus for system expansion. Bus is the name given to expansion slots in which additional plug in circuit board can be installed.

16-bit and greater systems are said to be AT class. 16-bit (and latter 32 and 64 bit) processors and expansion slots are included. The first AT class systems had a 16-bit version of the ISA bus which is an extension of the original 8-bit ISA bus found in the PC/XT class systems. Afterwards several expansion slots were developed for AT class systems.

Example

16/32 bit PS/2 microchannel architecture (MCA) bus.

16-bit PC card (PCMCIA) bus

16 bit ISA bus

16/32 bit Extended ISA(EISA) bus

32/64 - bit card Peripheral Component Interconnect (PCI) bus.

The easiest way to identify a PC/XT system is by the 8-bit ISA expansion slots regardless of the processor present in the system. AT systems can be similarly identified by having 16-bit of greater slots of any type (ISA, EISA, PCI) slots.

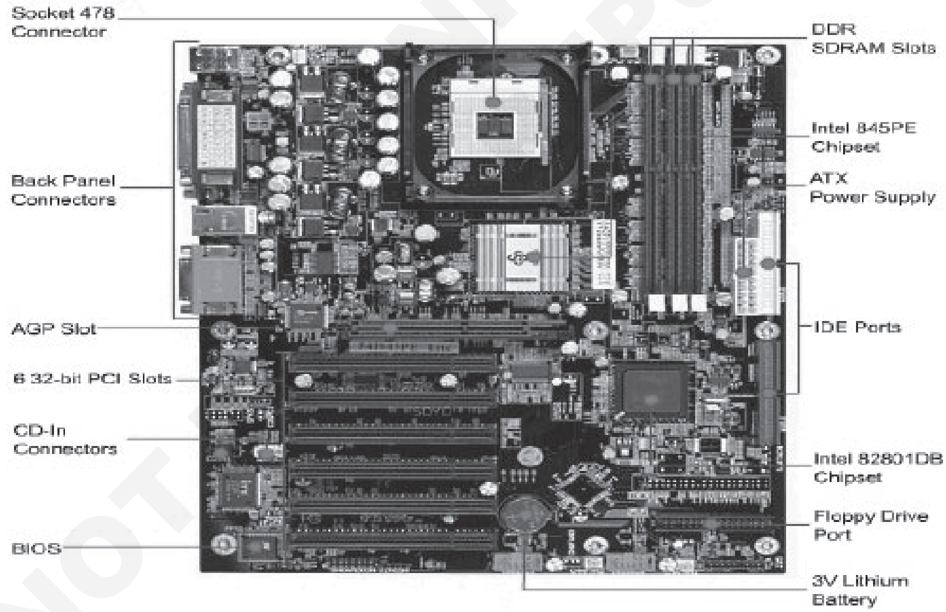
System components

Component needed to assemble a basic modern PC system.

- Motherboard
- Processor
- Memory (Primary)
- Hard disk
- CD-ROM
- Floppy Drive
- Keyboard
- Mouse
- Monitor
- Power Supply
- Cabinet

Motherboard : Motherboard is the important component of the computer as everything else is connected to it. And it controls everything in the system. Motherboard are available in several different shapes. Motherboard usually contain the following individual components shown in Fig 2.

Fig 2



1 Processor slot

2 Processor voltage regulators

3 Motherboard chipset

4 Level 2 cache

5 Memory SIMM or DIMM sockets

6 Bus slots

7 ROM BIOS

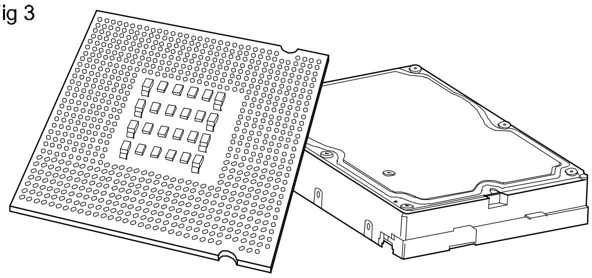
8 Clock / CMOS battery

9 Super I/O chips

Processor (Fig 3)

The processor is often thought as the engine of the computer shown in Fig 3. Then the processor reads the commands from the memory and then executes them. The processor is one of the most expensive parts of the computers and is also one of the smallest parts.

Fig 3



Primary Memory

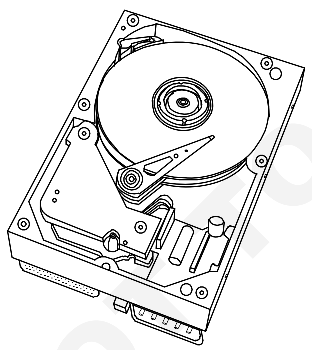
Memory: Is used to hold programs and data during execution.

Primary memory is often called as RAM(Random Access Memory). It holds all the programs and data the processor is using at a given time. RAM is volatile because its contents are erased when power is switched off. The other type of system memory is ROM(Read only Memory)which is permanent because it contents are not erased even when power is switched off. It is usually used to load an operating system.

Hard disk drive (Fig 4)

A hard drive consists of spinning platters made up of aluminum or ceramic that is coated with magnetic media shown in Fig 4. The platters come in various sizes. The hard drive with many different storage capacities can be created depending upon the density, size and number of platters. This is also called as Secondary memory. There can be several programs in the system, which cannot be stored in RAM, so we need a very huge non-volatile memory, which can be used for storing all the programs, and data when the system is not in use are called as Hard disks.

Fig 4



CD-ROM drive: CD-ROM stands for compact disk read only memory. It consists of small disks similar to the gramophone records to hold digital information. As the name applies they are read only medium. With the advancement in technology writable CD's are also available.

Floppy Disk Drive: Floppy disks are the slowest and the smallest form of secondary storage. They provide a simple way to carry information from one place to another, and backup small amount of files. In modern days floppy drive component is not as important as it was years ago. All PC's made in the last 10 years use a standard 3 ½ inch, 1.44 MB capacity floppy drive.

Keyboard: The keyboard is the main input device for most computers. It is used to input text or enter commands into the PC. Nowadays keyboards with additional features are available like multimedia keyboard, wireless keyboard.

Mouse: With the invention of graphical user interface mouse is used to input information into the computer. Users simply point and click to enter information. The main advantage of mouse over keyboard is simplicity. And there are many operations that are much easier to perform with a mouse than a keyboard.

Monitor: The monitor is the specialized high-resolution screen similar to a television. The video card sends the contents of its video memory to the monitor at a rate of 60 or more time per second. The actual display screen is made up of red, green and blue dots that are illuminated by electron beam from behind. The video card DAC chip controls the movement of the electron beam, which then controls what dots are turned on and how bright they are. Which then determines the picture you see on the screen.

Power supply

SMPS (Switch Mode Power Supply): The power supply provides power to every part in the PC. The main function of the power supply is to convert the 230 V AC into 3.3 V, 5 V and 12 V DC power that the system requires for the operations. In addition to supplying power to run the system, the power supply also ensures that the system does not run unless the power supplied is sufficient to operate the system properly. The power supply completes internal checks and tests before allowing the system to start. If the tests are successful, the power supply sends a special signal to the motherboard called **Power Good.** If this signal is not present continuously, the computer does not run. Therefore, when the AC voltage dips and the power supply becomes stressed or overheated, the **Power Good** signal goes down and forces a system reset or complete shutdown.

Cabinet: The box or outer shell that houses most of the computers. The cabinet actually performs several important functions for your PC including protection to the system components, directing cooling airflow, and allowing installation access to the system components. The cabinet often includes a matching power supply and must also be designed with shape of the motherboard and other system components in mind.

Peripheral Devices: Any external device, which is not necessary to perform the basic operation of computer, is called as peripherals. They provide additional computing capabilities. For ex : Printers, Modems, Speakers etc.

Modem: Modem (Modulator and Demodulator) is typically used to send digital data over a phone line . The sending modem converts digital data into analog data, which can be transmitted over telephone lines, and the receiving modem converts the analog data back into digital form. This is used to connect to Internet.

Modems are available in different capacities.

- 300 bps - 1960s through 1983 or so
- 1200 bps - Gained popularity in 1984 and 1985

- 2400 bps
- 9600 bps - First appeared in late 1990 and early 1991
- 19.2 kilobits per second (Kbps)
- 28.8 Kbps
- 33.6 Kbps
- 56 Kbps - Became the standard in 1998
- ADSL, with theoretical maximum of up to 8 megabits per second (Mbps)

  Gained popularity in 1999

Printers: The capability to produce a printed version often called a hard copy of a document is the primary function of a printer. Different types of printers are 1) Laser 2) Inkjet 3) Dot-Matrix.

Network Connector: The Network Connector, also referred to as a NIC card, is how your CPU talks to the network. A network cable is plugged into the back of the computer in this location . The other end of the network cable is plugged into a network jack in the wall. If the wall jack is “live”, meaning it has been wired to talk to the network, then your computer will connect to the network

USB Ports: The USB ports are present on newer machines and most often require Windows 98 or higher. If you have Windows95, the USB ports may not work. USB ports allow you to connect an external device, such as a printer, camera, scanner, or other device to your computer.

USB ports transfer information from the connected device to your computer.

Monitor Connector: The monitor connector is a 15 pin female connector. This is how the monitor is connected to the computer. On the back of the monitor, there is a 15 pin male connector. The monitor cable gets plugged into the back of the computer in this location.

Keyboard Connector: The PS/2 Keyboard connector is where the keyboard gets connected to the computer. The keyboard cable, has a round connection with one flat side.

Mouse Connector: The PS/2 Mouse connector is where the mouse gets connected to the computer. Although the keyboard connector and the mouse connector look the same, they are not interchangeable. In newer PC’s, the components are color coded and it is clear where the mouse and keyboard go. In older models, the keyboard connector comes first.

Com Port 1 & 2

Com Port 1 Com Port 2

Com Ports are usually have 9 pins and are male connectors. Com Port stands for communication port and is how your computer talks to external devices such as modems, scanners or digital cameras.

Parallel Port: The parallel port is sometimes referred to as a printer port (or LPT1) because that is the typical device that is attached to this port. The parallel port is a 25 pin female connector. If you have a direct connect printer, the male end of the printer cable (pictured later in this manual) is connected here.

Game Stick Port: The game stick port is where you would connect an external device like a game stick or joystick. It is a 15 pin female connector.

Sound Card

Sound Card – Speaker Connector

Sound Card – Audio Out Connector

Sound Card – Microphone Connector

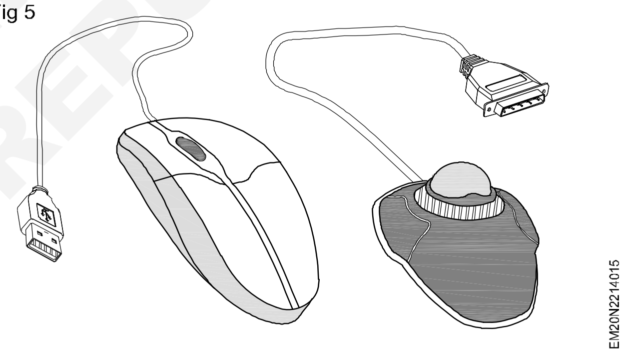
A sound card allows you to hear sounds from a CDROM or audio file. The connectors allow you to attach speakers, microphones or headphones. If your computer does not have these connectors, you will not be able to hear sound.

CPU Power Cord: The CPU power cord connects the CPU to the electrical supply.

Keyboard: The illustration above shows two examples of keyboard connectors – the left is the larger connector and the right is the smaller. On the larger connector, there is an arrow that should face up when you are connecting it to the CPU. On the smaller connector, there is a flat side that should face up when connecting it to the CPU.

Mouse (Fig 5): The illustrations above (Fig 5) show two examples of mouse connectors. The left is a PS/2 mouse connector (circle) and the right is a serial connector that would plug into one of your com ports

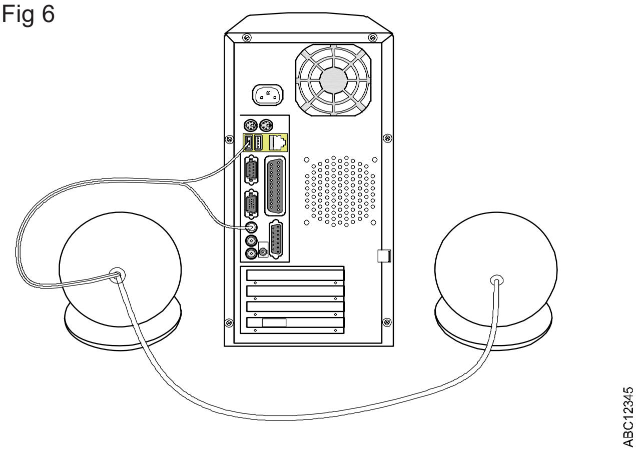
Fig 5



Speakers (Fig 6): The following cords are connected to a set of speakers

The following cords are connected to a set of speakers shown in Fig 6

Fig 6



- Power cord – connecting one speaker to the power source
- Left to Right speaker connector – connecting one speaker to the other
- Speaker to CPU connector – connecting speakers to the CPU

Monitor: There are two cords attached to the back of the monitor. The first is a power cord that connects the monitor to the power source. The second is a monitor cable.

The monitor cable is a 9 pin male connector that gets connected to the monitor connector on the back of the CPU

Network Cable and Network Jack: The network cable can be blue, purple or off-white. One end is connected to the back of the computer (in location A) and the other end is plugged into the network jack on the wall.

Parallel Printer Cable: The parallel printer cable has one connector on each end. The 25 pin male connector gets connected to the back of the CPU in location G and the other end is connected to the local printer.

USB Printer Cable: Newer computers and printers will support the use of a USB printer cable. A USB cable will transfer information more quickly than a parallel cable. The flat end of the USB cable gets connected to the back of the CPU in location B. The square end is connected to the local printer.

The following should help you put the pieces together.

1 Position the CPU in the desired location
2 Connect one end of the **network cable** to the back of the CPU (location A) and the other to the wall jack.
3 Connect the **keyboard** to the back of the CPU (location D)
4 Connect the **mouse** to the back of the CPU (location E)
5 Connect the **monitor cable** to the back of the CPU (location C)
6 Connect the monitor power cable to the power source
7 If you have speakers, connect the speaker power cord to the power source, connect the left and right speaker and connect the speaker to the sound card on the back of the CPU (location J) – note, some speakers are color coded to assist in the set-up, if yours are, follow the color codes.
8 If you have a local printer, connect one end of the parallel printer cable or USB Printer Cable to the back of the CPU (location G or location B) and the other end to the printer
9 Connect one end of the power cord to the back of the CPU and the other end to the power source.

Mother board and CPU

1 **Memory**: This is the area used by the processor to store raw data and instructions
2 **Microprocessor**: This is the CPU, which is the main component in a computer that does all the processing work of the data fed into the computer.

It contains three units viz.,

1 Memory units (internal , called as registers)
2 Arithmetic Logic Unit (ALU)
3 Control Unit

Memory Unit: It is the nervous system of the computer. It controls arithmetic operations to be performed. These unit co-ordinates the activities of all other units in the system. It has two main functions. They are:

1 To control the transfer of data and information between various units
2 To indicate appropriate functions by the arithmetic unit

3 Bus: These are the pathways through which data and instructions pass from one area to another within the computer. The bus carries the signals to various devices that are attached to the computer. There are three buses: Address bus, Control Bus and Data bus.

Arithmetic Logic Unit (ALU): This unit does arithmetic calculations and logical operations involved in the program, such as addition, multiplication, comparison etc.,

The CPU uses the address bus to select the memory address of the device in order to read and write data. The actual data is sent using the data bus. Control bus carries the control information like instructing the ALU which operation to perform. Out of these buses the address and control buses are unidirectional whereas the data bus is bidirectional.

4 Storage Devices: These are the floppy drives and hard disk drives, both of which we would discuss in detail in the lesson on secondary memory devices.

5 Motherboard: The motherboard is the primary component of the entire system. Without the support circuitry and functions that this device provides, even the CPU is unable to function. The detailed diagram of a mother – board is given below.

RAM Modules: These memory modules can be seen as small PCB strips (much smaller than add –on cards) plugged into lengthy slots (DIMM-168-pin) (SIMM-72 pin) (SIMM-30 pin) perpendicularly on the motherboard as shown in Fig 8.You may see only one RAM module strip or more than one. Each RAM module strip may have capacity ranging from 4 MB to more than 128 MB .

You will generally see two small plastic card extractors on the edges of the connector.

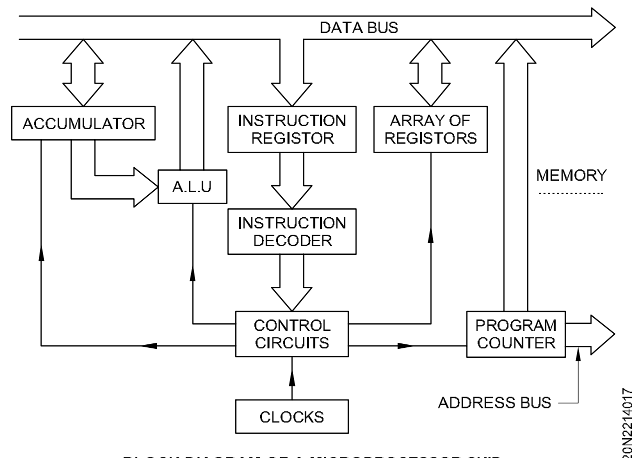
7 Store the PC cabinet in a safe place.
8 Keep the working table clean and place the mother board for studying.
9 Record the jumper and switch setting on the motherboard.

Tips for identifying the major components on the mother board

CPU: The Central Processing Unit or CPU ,is an integrated Circuit(IC).This will be biggest IC which you can easily identify. This IC can be of two basic types:

1 A super socket-7 or socket 370 types.
2 A socket -1 type.
3 **ROM BIOS Chip:** This means Read Only Memory Basic input-output System. These Chips contain permanent code that the PC uses when the PC is first turned-On.

Fig 7



BLOCK DIAGRAM OF A MICROPROCESSOR CHIP

Most ROM Bios Chips will have a glass window at its center. Some times this window is closed using a adhesive glossy paper slip on which it would be marked the marker of this Bios such as AWARD or AMI or PHOENIX and like. On this glossy paper slip ,a few other details including the year will be printed. This is an important data to be recorded.

4 **Battery:** A round shining big coin like thing ,held in a plastic enclosure with a '+' mark can be seen on the mother board. This is technically called as a button cell. This is actually a Lithium ion battery. This provides power supply to the CMOSRAM for maintenance of Real Time Clock(RTC) and BIOS settings.

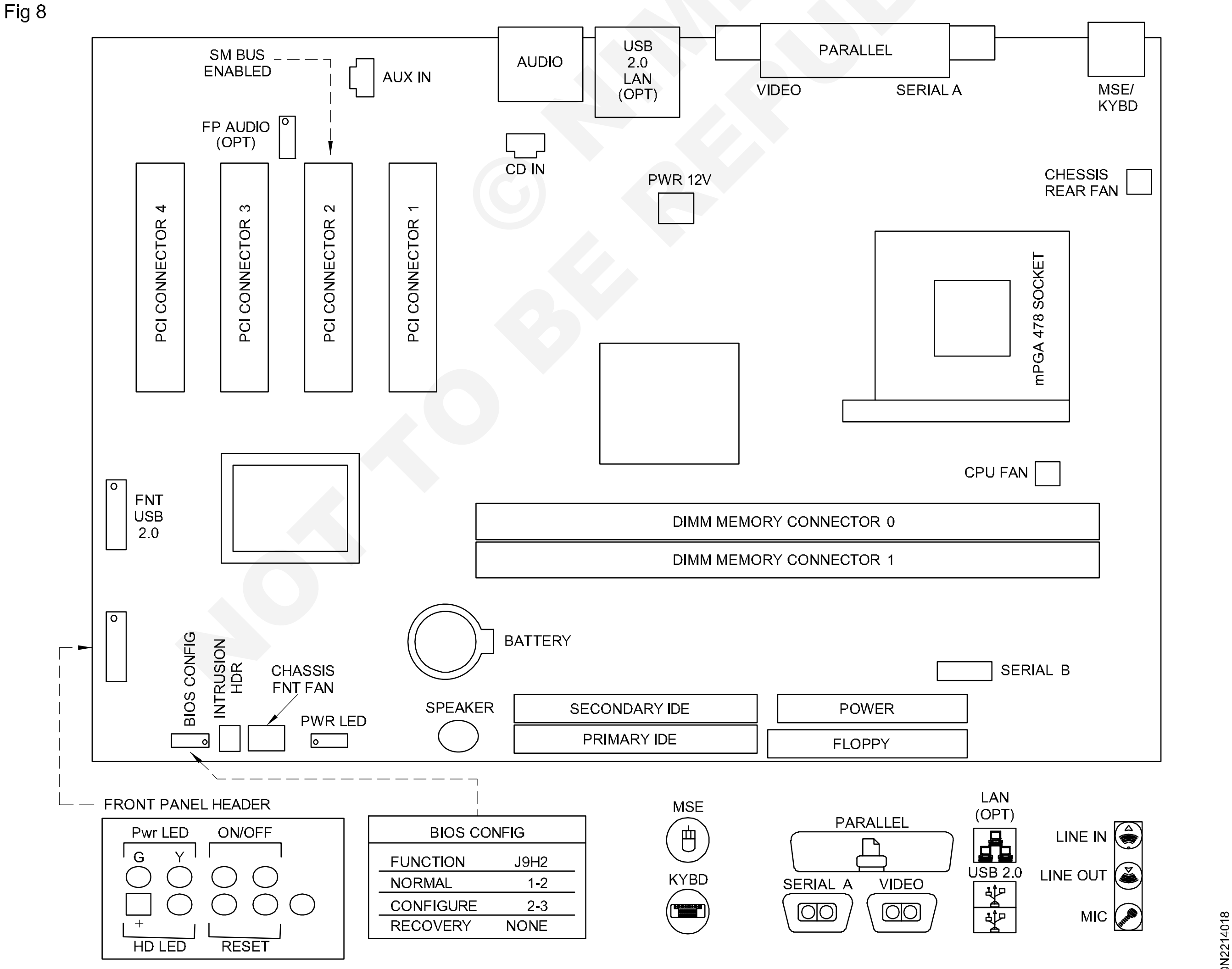
Also shows a connector with lot of pins, generally in pairs. These provide necessary signal for the LED's and switches mounted on the front panel of the PC. Right by the sides of this connectors, markings can be seen as to which it should be connected, such as, LED,SPK, RST, etc.

5 ADD-ON Cards/Expansion Card SLOTS: There will generally be three different types of slot female edge connectors.

ISA slots: ISA means Industry Standard Architecture. This type of connector will be Black in color and is the longest of the three types. This slot is called as the ISA slots. These are the old versions and hence your PC mother board may have just one slot of this type or more. Note that your mother board may not have this type of slot also. If so, don't be worried as ISA is an old type and not very essential.

PCI slots: PCI means Peripheral Component Interconnect. These are more recent type compared to ISA and are very

Fig 8



A TYPICAL MOTHERBOARD LAYOUT

popular. These slots are generally white in color and smaller in size compared to ISA slots. A PC Motherboard will definitely have one PCI slot but generally more than one.

AGP slots: AGP means Accelerated Graphics Port. This slot is much more recent than the PCI slot and this slot holds the add-on graphic card to enhance the graphic capabilities of your PC. This slot is generally brown in color and there will be only one such slot on the mother board. If the AGP control circuit is integrated on the mother board itself, then you may not find an AGP on the mother board.

L2 Cache Slot: Some mother board will have small slots for placing cache memory chip modules. These slots are generally white in color . Not all mother boards will have this slot.

IDE/EIDE Connectors: Most motherboards will have two such connectors, one slot marked as IDE1 or Primary and other as IDE2 or Secondary. Through these connectors IDE/EIDE devices such as HDD's and CD ROM drives are connected to the motherboard.

Floppy Diskette Drive Connector: This is a 34 pin mate black plastic connector. On most motherboards there will be only one such connector. The cable used with connector will have facility to connect two floppy diskette drivers.

Power supply connector on the Motherboards: This will generally be a plastic male Molex connector will be one connector strip of 12 pins in single line .In case of ATX models, there will two rows of 10 pin connectors.

Keyboard port, Mouse Port, On Board Serial and Parallel Port: Keyboard Port is one which is always on the Mother. The key board port can be of these types listed below.

1 The olden type-5 pin –DIN connector

2 The more recent type -6 pin P/S -2 connector.

3 The most modern USB port

These motherboards having only the 5-pin DIN port can also use P/S 2-keyboards using a cross adapter cable.

Those motherboard not having USB(Universal Serial Bus) circuitry on board can place a USB adapter card in one of the PCI slots. Then use the USB connector for connecting a USB keyboard.

Serial ports are generally a 9 pin male mini D shell type(DB- 9) connector. Generally any motherboard will have at least two serial ports. All motherboard may not have the serial port connectors mounted right on the motherboard at its edge as shown in figure above. But there will be a two 9 pin connector on the motherboard some where, using which, you have to run 9 wire flat cables to the ports mounted on a metal plate and fixed at one of the metal slots found at the rear of the cabinet.

Some devices need a 25 pin serial port(DB-25). However there will be only 9 pin connections at it. These DB-25 serial port can be easily identified because, this 25 pin slot is a male connector(Whereas a DB-25 pin female is a parallel port).

Mouse is connected to any one of the DB-9 serial port or a P/S-2.6 pin mini DIN connector or a USB port. Where is the mouse to be connected depends upon the type of connector your mouse has. However, you can use cross adapter cable to connect a mouse to a P/S-2 port or vice versa.

CPU Architecture: The basic function performed by a computer is execution of a program, which is a set of instructions stored in memory. The processor does the actual work by executing instructions specified in the program. The instruction execution takes place in the CPU registers, which are:

Memory Address Register (MAR): It specifies the address of memory location from which data or instruction is to be accesses (for read operation) or to which the data is to be stored (for write operation).

Program Counter (PC): It keeps track of the instruction which is to be executed next, after the execution of an on-going instruction.

Instruction Register(IR): Here the instructions are loaded before their execution.

Instruction Execution: The simplest model of instruction processing can be a two step process. The CPU reads (fetches) instructions (codes) from the memory one at a time, and executes or performs the operation specified by the instruction. Instruction fetches involves reading of an instruction from a memory location to the CPU register. The execution of this instruction may involve several operations depending on the nature of the instruction.

The processing needed for a single instruction (fetch and execution) is referred to as instruction cycle. The instruction cycle consist of the fetch cycle and the execute cycle. Program execution terminates if the electric power supply is discontinued or some sort of unrecoverable error occurs, or by a program itself.

Fetch Cycle: For fetch cycle, typically the program counter is used. Program counter keeps track of the instructions which is to be fetched next. The fetched instructions is in the form of binary code and is loaded into an instruction register in the CPU.

Execute Cycle: The CPU interprets the instructions in the instruction register and does the required action. In general, these action can be divided into the following categories.

1 Data may be transferred from processor to memory or from memory to processor.

2 Data may be transferred to or from a peripheral device and an I/O module.

Following are few of the important output devices, which are used in Computer Systems

Computer - Memory

A memory is just like a human brain. It is used to store data and instruction. Computer memory is the storage space in computer where data to be processed and instructions required for processing are stored.

The memory is divided into large number of small parts. Each part is called cell. Each location or cell has a unique address, which varies from zero to memory size minus one.

For example, if computer has 64k words, then this memory unit has 64* 1024 = 65536 memory locations.

Memory is primarily of three types:

1 Cache Memory

2 Primary Memory/Main Memory

3 Secondary Memory

Computer - RAM

A RAM constitutes the internal memory of the CPU for storing data, program result. It is read/write memory. It is called random access memory (RAM).

Since access time in RAM is independent of the address to the world that is, each storage location inside the memory is as easy to reach as other location & takes the same amount of time. We can reach into the memory at random & extremely fast but can also be quite expensive.

RAM is volatile i.e. data stored in it is lost when we switch off the computer or if there is a power failure. Hence, a backup uninterruptible power system (UPS) is often used with computers. RAM is small, both in terms of its physical size and in the amount of data it can hold.

RAM is of two types

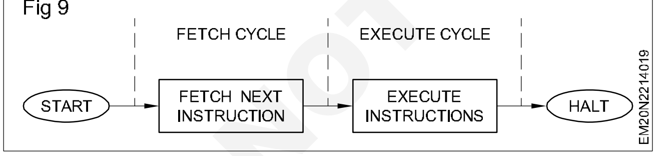
1 Static RAM (SRAM)

2 Dynamic RAM (DRAM)

Computer - ROM: ROM stands for Read Only Memory. The memory from which we can only read but cannot write on it. This type of memory is non-volatile. The information is stored permanently in such memories during manufacture.

A ROM stores such instructions as are required to start computer when electricity is first turned on, this operation is referred to as bootstrap. ROM chip are not only used in the computer but also in other electronic items like washing machine and microwave oven.

Fig 9



Computer - Motherboard: The motherboard serves as a single platform to connect all of the parts of a computer together. A mother board connects CPU, memory, hard drives, optical drives, video card, sound card and other ports and expansion cards directly or via cables. It can be considered as the backbone of a computer

Features

1 Motherboard varies greatly in supporting various types of components

2 Normally, a motherboard supports a single type of CPU and few types of memories

3 Video Cards, Hard disks, Sound Cards have to compatible with motherboard to function properly

4 Mother boards, cases and power supplies must be compatible to work properly together

Computer - Memory Units

1 It is the amount of data that can be stored in the storage unit.

2 The storage capacity are expressed in terms of Bytes

Computer - Ports

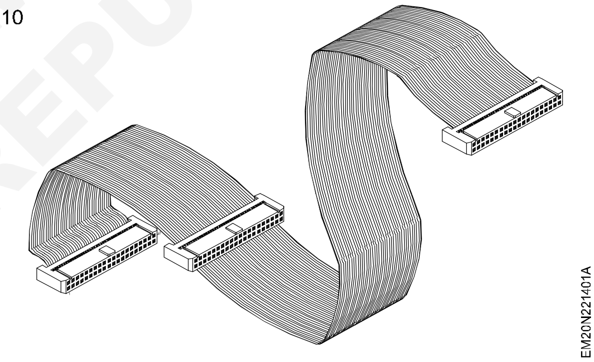
1 A computer port is a physical docking point using which an external device can be connected to the computer

2 A computer port can also be programmatic docking point through which information flows from a program to computer or over the internet.

PATA Cable

PATA, short for Parallel ATA, is an IDE standard for connecting storage devices like hard drives and optical drives to the motherboard. It's important to note that the term Parallel ATA used to simply be called ATA. ATA was retroactively renamed to Parallel ATA when the newer Serial ATA (SATA) standard came into being. PATA cables are long, flat cables with 40-pin connectors (in a 20x2 matrix) on either side of the cable. (Fig 10)

Fig 10



One end of the PATA cable plugs into a port on the motherboard, usually labeled IDE, and the other into the back of a storage device like a hard drive.

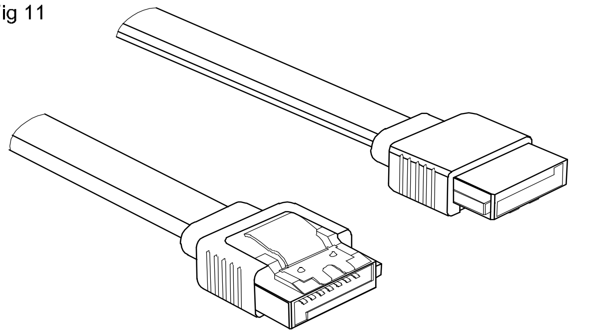
Some PATA cables have an additional connector midway through the cable for connecting yet another storage device.

PATA cables come in 40-wire or 80-wire designs. Newer PATA storage devices require the use of the more capable 80-wire PATA cable to meet certain speed requirements. Both types of PATA cables have 40-pins and look nearly identical so telling them apart can be difficult.

SATA Cable

SATA, short for Serial ATA, is an IDE standard for connecting devices like optical drives and hard drives to the motherboard. Serial ATA replaces Parallel ATA as the IDE standard of choice for connecting storage devices inside of a computer. SATA storage devices can transmit data to and from the rest of the computer over twice as fast as an otherwise similar PATA device. (Fig 11)

Fig 11

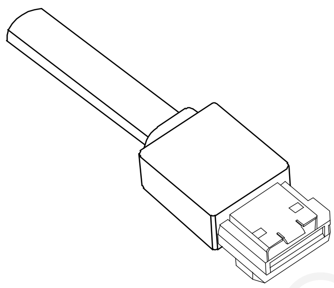


eSATA Cables

While SATA cables are used internally for connecting the hard drive to the computer's motherboard, eSATA cables are designed for portable hard drives, and can transfer data faster than USB or FireWire.

However, the eSATA cable cannot transmit power, so unlike USB, you cannot power an external hard drive with eSATA. The eSATA cable is somewhat different from the internal SATA cable; it has more shielding, and sports a larger connector. (Fig 12)

Fig 12

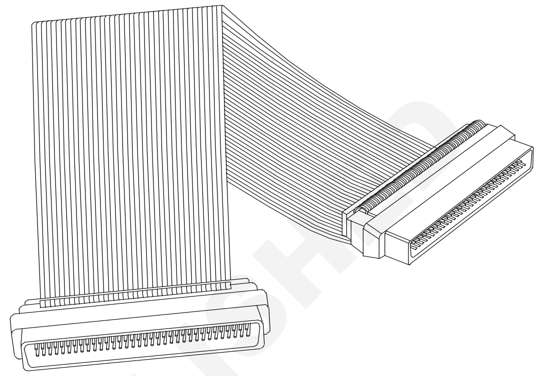


SCSI Cable

SCSI, is a type of connection for storage and other devices in a PC. Generally, it refers to the types of cables and ports used to connect certain types of hard drives, optical drives, scanners, and other devices to a computer. (Fig 13)

SCSI interfaces can be used internally to connect these types of hardware devices directly to a motherboard or storage controller card. External connections are also common for SCSI and typically connect via an external port on a storage controller card.

Fig 13



CMOS setup and extend a memory module

Objectives : At the end of this lesson you shall be able to
- **state the purpose of CMOS**
- **state the CMOS battery's life**
- **describe the functions of BIOS.**

CMOS may refer to any of the following:

Alternatively referred to a real-time clock (RTC), Non-Volatile RAM (NVRAM) or CMOS RAM, CMOS is short for complementary metal-oxide semiconductor. CMOS is an on-board, battery powered semiconductor chip inside computers that stores information. This information ranges from the system time and date to system hardware settings for your computer. The fig shows an example of the most common CMOS coin cell battery (Panasonic CR 2032 3V) used to power the CMOS memory.

The Motorola 146818 chip was the first RTC and CMOS RAM chip to be used in early IBM computers; capable of storing a total of 64 bytes of data. Since the system clock used 14 bytes of RAM, this left an additional 50 bytes for storing system settings. Today, most computers have moved the settings from CMOS and integrated them into the southbridge or super I/O chips.

Life of battery

The standard lifetime of a CMOS battery is around 10 years. However, this can vary depending on the use and environment in which the computer resides.

CMOS are used in the following

- Digital logic circuits
- Static RAM (SRAM)
- Micro processors
- Micro controllers

The Basic Input/ Output System (BIOS), also known as System BIOS, ROM BIOS or PC BIOS is a generally accepted standard defining a firmware interface.

The fundamental purpose of the BIOS is to initialize and test the system hardware components and load an operating system from a mass memory device. The BIOS is special software that interfaces the major hardware components of the computer with the operating system. It is usually stored on a Flash memory chip on the motherboard, but sometimes the chip is another type of ROM. The BIOS is a firmware (software instructions permanently recorded on a chip located on your motherboard).

Functions of BIOS

The BIOS software has a number of different roles, but its most important role is to load the operating system. The BIOS checks and initializes the PC hardware each time the system powers up or restarts before handing over control to the operating system. Some of the other common tasks that the BIOS performs include:

- A power-on self-test (POST) for all of the different hardware components in the system to make sure everything is working properly
- Activating other BIOS chips on different cards installed in the computer - For example the graphics cards often have their own BIOS chips.
- Providing a set of low-level routines that the operating system uses to interface to different hardware devices. They manage things like the keyboard, the screen, and the ports, especially when the computer is booting.
- Managing a collection of settings for the hard disks, clock, etc.

CMOS Setup

The first thing the BIOS will do is check the information stored in a tiny (64 bytes) amount of RAM located on a complementary metal oxide semiconductor (CMOS) chip. The CMOS Setup provides detailed information particular to your system and can be altered as your system changes. The BIOS uses this information to modify or supplement its default programming as needed.

Configuring BIOS

The BIOS checks the CMOS Setup for custom settings. To change the CMOS settings we need to enter the CMOS setup. To enter the CMOS Setup, a certain key or combination of keys must be pressed during the initial startup sequence. Most systems use "Esc," "Del," "F1," "F2," "Ctrl-Esc" or "Ctrl-Alt-Esc" to enter setup. There is usually a line of text at the bottom of the display that tells "Press ___ to Enter Setup."

The BIOS setup shows a set of text screens with a number of options. Some of these are standard, while others vary according to the BIOS manufacturer. Common options include:

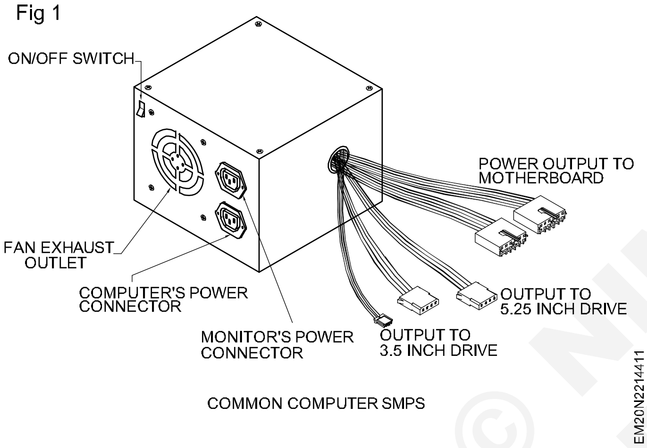
- System Time/Date - Set the system time and date
- Boot Sequence - The order that BIOS will try to load the operating system
- Plug and Play - A standard for auto-detecting connected devices; should be set to "Yes" if your computer and operating system both support it
- Mouse/Keyboard - "Enable Num Lock," "Enable the Keyboard," "Auto-Detect Mouse"...

Switch Mode Power Supply for PC

Objectives: At the end of this lesson you shall be able to
- **explain the parts of SMPS**
- **explain with block diagram and working principle of an SMPS**
- **explain the precautions to be taken while testing and troubleshooting of different SMPS.**

Switch Mode Power Supply of a PC is housed in a metal box. SMPS consists of an electronic circuit board, a fan, AC power sockets, power supply interface connectors for motherboard, hard disk drive and floppy disk drive. AC power switch connected to the power cable from the SMPS. The connectors are polarised and standards are followed so that any PC SMPS can be interchanged. A typical SMPS is shown in Fig 1.

Fig 1



COMMON COMPUTER SMPS

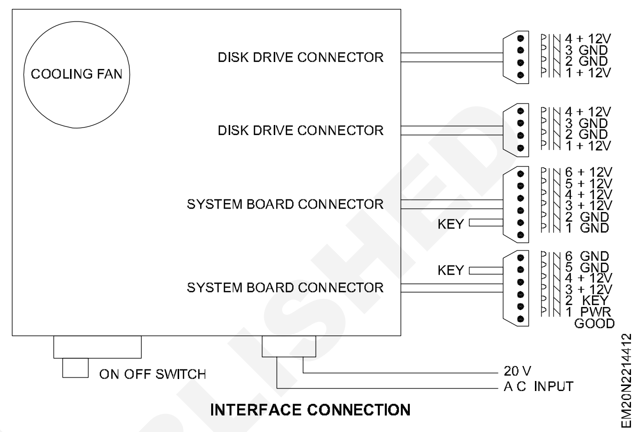
The SMPS comes in various capacities for PCs. The capacities are 80W, 150W, 200W, 230W, 250W and 280W. For PC nodes/ unix terminals 80W supply is used. The connector details are printed on the cover of the SMPS as shown in Fig 2. Table 1 gives the colour of wire for different voltages and the current ratings.

Table 1

DC outputs				
Red	+5V	20A max	Total power	200W
Yellow	+12V	8A max	AC Input	220-240V
White	-5V	0.5A max		
Orange	PG			

A 12V DC fan is used for removing the heat generated inside the power supply. The fan blows out air from the SMPS. The fan also helps in air circulation inside the cabinet. Proper working of fan is ensured by periodic cleaning. Whenever the fan is working intermittently the fan should be cleaned for dust near the motor. A failed fan can result in the failure of the SMPS because of excess heat.

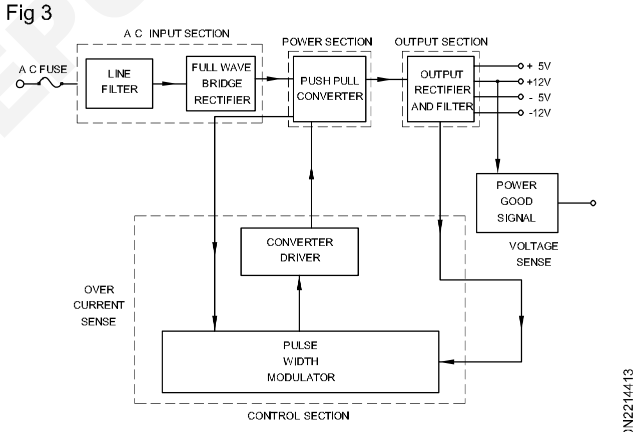
Fig 2



INTERFACE CONNECTION

Block diagram of SMPS: The block diagram in Fig 3 shows the various functional sections in SMPS.

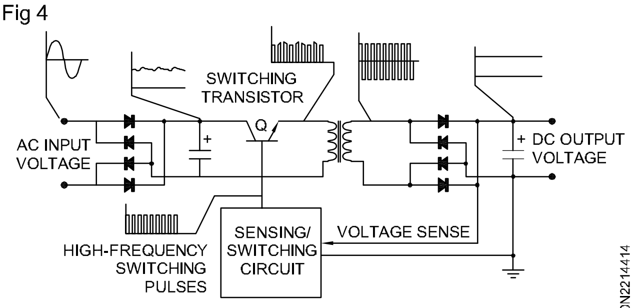
Fig 3



BLOCK DIAGRAM OF SMPS

Working principle of SMPS: AC line input is rectified and converted to DC voltage. The DC voltage is switched at high frequency nearly 20 kHz. The switched voltage is fed to the high frequency step down transformer. The output of the transformer is rectified and energy is stored in an inductor and smoothened by a capacitor. The switching period (pulse width) is controlled by the feed back given to the controller section. Power switching transistors ON time is varied according to the load. When the load increases the output voltage tends to drop. This drop in voltage is fed as the error signal to power controller which increases the ON period of switching pulses. When the load decreases the output goes high. The error voltage is fed to the controller which reduces the ON period of switching pulses. Since there are many outputs in a PC SMPS i.e. 12V, -12V, -5 only the main 5 volts which supplies maximum current is sensed and regulated. The transformer winding is designed taking care of this aspect. A simplified diagram of a switching power supply is shown in Fig 4.

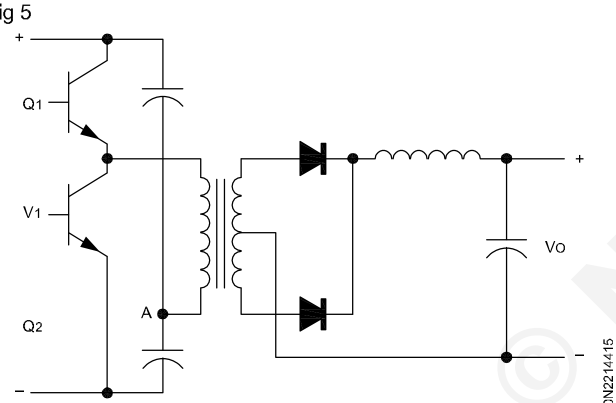
Fig 4



SIMPLIFIED DIAGRAM OF A SWITCHING POWER SUPPLY

Most widely used configuration in PC SMPS is half bridge converter circuit as shown in Fig 5. Power transistors Q1 and Q2 switch the DC voltage through the windings in a push pull manner.

Fig 5



MOST WIDELY USED HALF-BRIDGE CONVERTER CIRCUIT

In most of PC SMPS there is no separate step down transformer used for the power supply of the PWM IC. It is derived from the main ferrite core transformer output. Primary winding of the transformer with a capacitor and resistor along with part of driver transformer form a self oscillating circuit. This oscillation produces secondary output. The 12V winding output is used to power the PWM IC. Once powered the PWM IC takes over the switching operation. Thus the need for separate power supply for the IC is eliminated.

Power ON and OFF

On ATX and most of the other later from factors, the motherboard can turn the power supply on or off. This is done through the PS-ON (power supply on) signal that passes between the motherboard and the power supply. If your PC powers off when windows is finished shutting down, you have this feature.

Another indicator that your power supply supports PS-ON is the use of Momentary On or Always On power switches that are connected to the motherboard in place of an exterior switch connected to the power supply. When this signal line is pulled to a low voltage signal, the +12V DC, +5V DC, +3.3V DC, -5V DC and -12V DC power lines are turned on. When it is pulled to a high-voltage signal, or open-circuited, the DC output lines should no longer have current. The +5V DC output is always on as long as the power supply is receiving AC power. Because the ATL, NLX, LTX and other form factor motherboards have some power running to them at all times, you will always want to unplug the PC before working on it.

Advantages and disadvantages of SMPS

SMPS for the power rating is smaller in size. A conventional power supply for similar power rating will be heavy and big in size.

SMPS efficiency is very high so heat dissipation is low. A conventional power supply efficiency is less and heat generated is more.

SMPS output has high frequency noise. So cannot be used for critical applications. In conventional power supply the noise is very minimal

Servicing of SMPS is difficult because of interdependance of circuits and components.

Servicing of linear power supply is relatively straight forward.

Difference between AT and ATX power supply

AT power supply does not have soft start option.

AT power supply does not generate 3.3V DC.

AT motherboard supply connectors come with 2x6 pin connection.

ATX power supply has a soft start.

ATX power supply does not shut down completely. Always the ATX power supply gives 5 volt to the mother board.

ATX power supply generates a 3.3V DC for the processor core voltage.

Precaution to be taken while testing and servicing an SMPS

Since the SMPS is operating directly from rectified 220V AC, potentially hazardous DC voltage exist inside. So care should be taken while opening and testing.

High voltage capacitors must be discharged safely using a resistor.

When using any AC powered instrument to test an SMPS the instrument must be isolated. To isolate use isolation transformer.

Some SMPS start with sufficient load only.

Hard disk drives

Objectives: At the end of this lesson you shall be able to
- **explain the basic components of a hard disk**
- **explain boot process**
- **explain Windows OS desk top shortcuts and various options.**

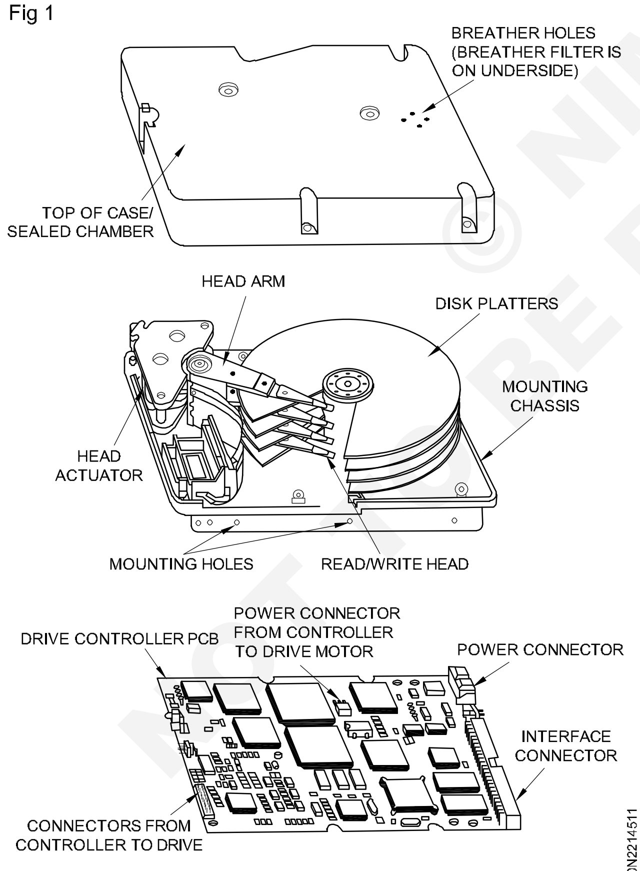
Introduction

Magnetic disks are the most common form of permanent data storage. Their capacities may range from a few kilobytes to several Gigabytes. An aspect common to all magnetic drives is the scheme that determines how the data on the disk is organised. The operating system determines this scheme before any information can be stored on a magnetic disk, provided the disk is formatted. Formatting allows the drive to store and retrieve data in an orderly manner.

The basic parts of Hard disk

The basic hard disk drive components are as shown in the Fig 1.

Fig 1



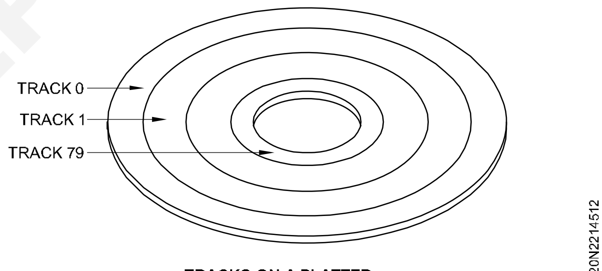
HARD DISK DRIVE COMPONENTS

Disk platters, Logic board, Read/write head, Head - actuate mechanism, connectors, Spindle motor, spindle, platter motor, heads and Actuator are assembled inside a sealed chamber. Drive electronics (PCB) is located outside the chamber.

Hard Disk has one or more platters. Platter is made of aluminium or glass, coated with magnetic media to store information. A read/write head is placed on a spring loaded arm. The arm is moved along the radius by actuator mechanism. Motor that spins the platter is called spindle motor. It rotates at 3600 to 7200 rpm. Logic board controls the drive motor and head actuator mechanism. Data is transferred to and from the platter in a standard format. Hard disk has a FRC connector for data cable and molex connector for power. Power supply requirements are +12V 1 amp, +5V, 500 mA

Hard disk platter is divided into tracks of a particular width as shown in Fig 2. Each track is dived into sectors. Outermost track is numbered ‘0 ‘. Similar numbered track on each platter is combined to form a cylinder. Capacity of the hard disk is determined by number of cylinders, number of heads, sectors and data storage mode.

Fig 2



TRACKS ON A PLATTER

Boot process

Computer initialisation is a process from the time a PC is switched on until the PC displays A>:\C:> or windows Desk top, is called boot process. Number of steps are involved in this process.

When power is applied, the power good signal (PG) resets the CPU into its process. Program starts by fetching an instruction from ROM BIOS. The BIOS programme as explained earlier does the POST and looks for the operating system from drive A. If booting programme is not found in drive A, automatically it looks for a boot program in C:. In BIOS setup one can alter the sequence C to A or A to C.

Once operating system is found, the boots trap loader programme loads the operating system components into the memory and hands over the control to the operating system. When the process is complete, the monitor displays A>:/,C:> or windows desktop.

Handling hard disk

Hard disk should not be dropped. It will permanently damage the platter. Hard disk electronics should not be handled with bare hands as it is more sensitive to static charges. Hard disk interface cable and power supply should be connected/removed only after switching off mains power. No magnetic material should be placed near HDD.

Control Panel: It is presented as a folder full of icons. To view Control panel, click the Start button, point the settings and then click Control panel (Fig 3) shows the contents of Control panel.

Accessibility options: Change your computer screen, mouse, keyboard, features, and sound to make windows more accessible for people with disabilities.

Add / Remove programs: Install and remove software automatically, and add or remove installed components in windows NT.

Console: Change the appearance of your MS-DOS screen by changing screen colors, screen size and position, fonts, cursor size and more.

Date / Time: Change the system date, time, and time zone.

Devices: Start, stop and configure the start up type for device drivers.

Display: Change the appearance of your screen by changing screen, colors, fonts, the appearance and size of windows, background design, icons and other visuals.

Fonts: Add or remove screen, vector, True type, and Type1 fonts, some printer fonts are installed automatically when you install a printer. Other printer fonts must be installed using a font installation program provided by the font manufacturer.

Keyboard: Adjust the keyboard delay and repeat rate, and add keyboard symbols that are exclusive to other languages.

Modems: Add modems using the Add modem wizard, a step-by-step modem set up program.

Multimedia: Adjust audio, video, CD (music), and MIDI, and add or remove multimedia devices.

Network: Configure network adapter cards, network services and protocols, and join a workgroup or a domain.

PC Card (PCMCIA): Display resources used by any PC cards, if you have these devices.

Ports: Set parameters for, and add and remove serial communications ports.

Printers: Add and remove printers and remove, control and create share access to printers using the Add printer wizard, a step-by-step printer set up program.

Regional Settings: Change sort dates, time currency and numbers to reflect regional standards.

SCSI Adapters: Display adapters and devices connected to your computer.

Server: Display user and share information.

Services: Start, Stop, Pause, or continue the services available on the computer, and configure start up options.

Sounds: Assign sounds to system and application events, and turn on or off the warning beep and system sounds.

System: Specify the default operating system for startup, change user environment variables and define paging file size.

Tape Devices: Display, add and remove tape devices.

Telephony: Display, add, and remove telephony drivers change telephony properties. Adjust telephony conditions depending on whether the computer is docked or undocked.

UPS: Create settings for uninterrupted power supply.

The control panel is thus the place where most of the system working can be controlled. The following are the various settings that can be done:

Date and Time properties: The date and time properties dialog is used to change the systems date and time which is shown in the system tray at the right end corner of the task bar.

Changing the date.

- Day
- Month
- Year

Changing the time

- Hour
- Time
- Seconds

The spinner button  is used to change the meridians , i.e. AM. and PM.

There is one more tab in the Date & Time properties i.e. Time Zone that is used to set the local time in tune with the Greenwich Meridian Time (GMT) as shown in Fig 5.

Click on the down arrows button in the box indicated in above figure and change it to Colombo GMT+6:00. Watch how the World map shifts itself towards left.

Also observe time now in the system tray. It will be changed now.

Changing the Wall Paper and screen savers: Wallpapers are the screen patterns that can be set as the background of the desktop. There are built in wallpapers available that can be selected in the Background tab of the Display property dialog.

Appearance of Window : The look and feel of windows can be changed using the Appearance Tab of the Display property dialog. This tab can be used to change the whole appearance of windows like the color, size of icons, fonts that are used in the menus and title bars etc. each type of these appearance is presented as a set of schemes.

Click in the Scheme list box and select the Windows standard as the type of the appearance for the windows.

– Watch how immediately the window in the top box appears.

– Clicking on the respective items individually can change the appearance of each individual item. For instance clicking on the active window in the box can change the appearance of the active.

The Save as button is used to save your own scheme of colors, fonts, size etc under a different name. Delete button is used to remove the schemes.

Regional Settings: The Regional settings properties sheet controls a variety of features that can be used by your programs to adjust the way they behave. Double clicking on the Regional Settings icon allows you to examine these regional settings.

If you are going to change this setting, we suggest changing the region first. The map changes to highlight the region of the world that you have selected, and the choices available on the other four pages are changed to ones appropriate to that region.

The Number card includes settings for what should be used for the Decimal Symbol, the No. of digits after decimal, the symbol that should be used to group digits (in the U.S. this is referred to as the "thousands separator"), and the Number of digits in group.

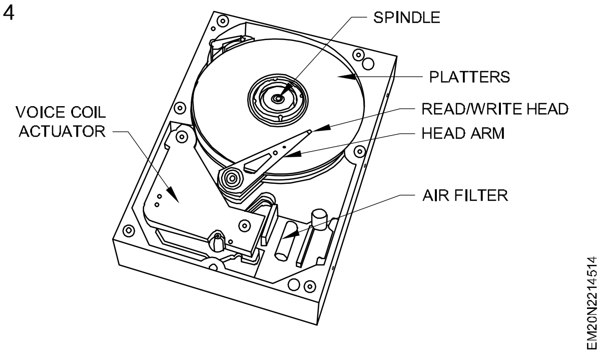
The Currency pages allows you to set some characteristics specific to currency such as the Currency symbol, the Position of currency symbol, the Negative number format, as well as the features just mentioned for use in the Number pages.

The formats for time and date information allow you to select from a drop-down list of features. The choices for time include the Time style; the Time separator between hours, minutes, and seconds; and the choice for AM symbols and for PM symbols.

Hard drives

A Hard drive is a data storage device used for storing and retrieving digital information using one or more rigid "hard" rapidly rotating disks (platters) coated with magnetic material. The platters are paired with magnetic heads arranged on a moving actuator arm, which read and write data to the platter surfaces. Data is accessed in a random-access manner, meaning that individual blocks of data can be stored or retrieved in any order rather than sequentially. A typical hard disk drive consists of a motor, spindle, platters, read/write heads, actuator and electronics as shown in Fig 4.

Fig 4



The primary characteristics of an HDD are its capacity and performance. Capacity is specified in powers of 1000: a 1-terabyte (TB) drive has a capacity of 1,000 gigabytes (GB; where 1 gigabyte = 1 billion bytes). Performance is specified by the time required to move the heads to a track or cylinder (average access time) plus the time it takes for the desired sector to move under the head (average latency, which is a function of the physical rotational speed in revolutions per minute), and finally the speed at which the data is transmitted (data rate).

A HDD records data by magnetizing a thin film of ferromagnetic material on a disk. Sequential changes in the direction of magnetization represent binary data bits. The data is read from the disk by detecting the transitions in magnetization. User data is encoded using an encoding scheme, such as run-length limited encoding, which determines how the data is represented by the magnetic transitions.

Different types of printers

Objectives : At the end of this lesson you shall be able to
- **state different types of print technologies and printers**
- **explain the impact printers/dot matrix printers**
- **state non-impact printers, inkjet printers & laser jet printers.**

Printers are electro-mechanical devices that enable a user to print whatever is displayed by the monitor - letters, contracts, business documents, images.

Printers can be divided into two categories

- Impact
- Non-Impact

Printer
- Impact Printer
  - Daisy wheel
  - Dot - Matrix
- Non - Impact Printer
  - Inkjet
  - Thermal
  - Laser

Impact: The impact printers incorporate a built-in mechanism to print images on paper using a series of pins or hammers which strike on an inked ribbon to create the image. For Example: Dot matrix, Daisy Wheel, etc.

Non-Impact: The non-impact printers include those printers that do not have any kind of contact with the paper while printing either text or image. For Example: Inkjet, Laser, Bubble Jet, etc.

These printers use different technology to print an image. For Example, a laser printer uses heat to attach microscopic particles of dry toner to specific parts of the page. An Inkjet printer has tiny nozzles through which it sprays droplets of ink on to the page.

Impact Printers: In this hammers or pins strike against a ribbon and paper to print the text. This mechanism is known as electro-mechanical mechanism. They are of two types.

1 Character Printer

2 Line Printer

Character Printer: It prints only one character at a time. It has relatively slower speed. Eg. Dot Matrix Printers

Dot Matrix Printer: It prints characters as combination of dots. Dot matrix printers are the most popular among serial printers. These have a matrix of pins on the print head of the printer which form the character. The computer memory sends one character at a time to be printed by the printer. There is a carbon between the pins & the paper. The words get printed on the paper when the pin strikes the carbon. There are generally 24 pins.

Non-Impact Printers: These printers use non-Impact technology such as ink-jet or laser technology. These printers provide better quality of O/P at higher speed. These printers are of two types :

Ink-Jet Printer: It prints characters by spraying patterns of ink on the paper from a nozzle or jet. It prints from nozzles having very fine holes, from which a specially made ink is pumped out to create various letters and shapes. The ink comes out of the nozzle in a form of vapors. After passing through a reflecting plate, it forms the desired letter/shape at the desired place.

Laser Printer is a type of printer that utilizes a laser beam to produce an image on a drum. The light of the laser alters the electrical charge on the drum wherever it hits. The drum is then rolled through a reservoir of toner, which is picked up by the charged portions of the drum. Finally, the toner is transferred to the paper through a combination of heat and pressure.

This is also the way copy machines work. Because an entire page is transmitted to a drum before the toner is applied, laser printers are sometimes called page printers. There are two other types of page printers that fall under the category of laser printers even though they do not use lasers at all. One uses an array of LEDs to expose the drum and the other uses LCDs. Once the drum is charged, however, they both operate like a real laser printer. One of the chief characteristics of laser printers is their resolution - how many dots per inch (dpi) they lay down.

The available resolutions range from 300 dpi at the low end to 1,200 dpi at the high end. In addition to text, laser printers are very adopt at printing graphics, so you need significant amounts of memory in the printer to print high-resolution graphics. To print a full-page graphic at 300 dpi, for example, you need at least 1 MB (megabyte) of printer RAM. For a 600 dpi graphic, you need at least 4 MB RAM.

Because laser printers are non-impact printers, they are much quieter than dot-matrix or daisy-wheel printers. They are also relatively fast, although not as fast as some dot-matrix or daisy-wheel printers. The speed of laser printers ranges from about 4 to 20 pages of text per minute (ppm). A typical rate of 6ppm is equivalent to about 40 characters per second (cps).

Internet websites text/images & use of E- mails

Internet

The internet is a world wide collection of network, servers, gateways and computers using a common set of telecommunication protocol to link and inter operate them together.

The internet provides world wide access to information and resources. It is possible to find information about almost any subject imaginable from universities, government organisations, the military or libraries which may be in any part of the world.

The internet evolved from a US department of defense project. The advanced Research Projects Agency (ARPA) of the department funded a project to connect university computer scientists and engineers together via their computers and telephone lines. This project called ARPANET, allowed researchers to share each others computer facilities over long distances. It was also used to exchange electronic mail (e-mail) with other users. The network protocol used by the project was TCP/IP which continues to be used on the Internet today. With the combination of electronic mail, file transfers and mailing lists this network of networks called internet began to take shape.

The simplest definition of internet is that its the longest computer network in the world. A study in 1997 estimated that the internet has 16.1 million hosts or computers connected to it.

Technically, the internet is actually a network which is made up of many smaller networks that exist all over the world, but this is as invisible to the user as the telephone network which provides national to international calls (STD/ ISD). There is no particular person or company who controls the internet. It can be considered as a vast and growing online library in which anyone can publish anything they want.

Some of the best known services available on the internet are

- WWW or World Wide Web
- FTP or File Transfer Protocol
- E-mail or Electronic mail
- Mailing lists
- Newsgroups
- Search engines
- Telnet
- Telephony
- VPN

World Wide Web

It is the internets multimedia service. It is also the widely used part of internet. It is a vast storehouse of documents known as hyper text documents. These documents are written using the hypertext markup language (HTML). Hypertext is a method for presenting text, images, sound and videos that are linked together in a document. It allows a user to browse through topics in any order. It also includes dynamic links or connections which will take you to access those pages. Using WWW, you have access to millions of pages of information.

The sum of all the hyper text and connecting links connected via the internet form is known as the world web wide or WWW or the web. The web allows you to move among linked documents stored on host computers that may be physically very distant from one another.

You can read a hyper text file, look at its illustrations and even listen any audio in it and also follow its links. Certain words or phrases appear in text of a different colour than the text and is also underlined. When you move the cursor and point it on these words a small hand appears which indicates that it is a link. You click this word and a new hypertext document gets opened.

Website

A website is a collection of hypertext documents. A document on the site is called a web page. The first page in a series of related documents or a site is called a home page. The first document you access at any site is called the home page. Many individuals on the internet have their own home page - a document about them and their interests - that anyone on the internet can access. This is a very useful way to represent a company or individual.

The web combines TCP/IP, the protocol for sending documents across network, with an entirely new method of locating and accessing documents on different networks. It involves a simple coding mechanism around a string of characters called a URL or a Universal Resource Locator. The URL identifies the name and address of each document available to the web.

The URLs specify the server to access as well as the access method and the location. Each website on the internet has its own URL.

An URL consists of

1 The server protocol to be used where the document is located. A server setup specifically for web documents uses hypertext transfer protocol (HTTP).

2 A colon

3 The type of site generally world wide web (WWW), file transfer protocol (FTP), a protocol used specifically to transfer files from one computer to another or Gopher, a client server application that organizes the files on a server, so users need not know or enter the exact file name.

4 The address of the host computer. Also known as domain address. The address begins with two forward slashes. It consists of the name of server or site, the network, university or computer name and the domain (two or three letter designation of the type of institution). The specific location of the document on that computers network

Example:

1. http://www.microsoft.com/home.htm

http	- Server protocol
www	- Type of site
Microsoft	- Company name
com	- Domain name
home.htm	- Location of the document

2. ftp://ftp.microsoft.com

3. gopher://gopher.microsoft.com

Domain name system

In addition to URLs every computer on the internet has a unique IP address. The IP address is four sets of digits separated by dots. (198.64.3.20)

Because these numbers are hard to remember and difficult to type, the domain name system was created. Domain names enable short, alphabetical names to be assigned to IP addresses to describe where a computer is located. In the e.g. http://www.microsoft.com, www.microsoft.com is the domain name.

The last three characters of DNS or URL address indicate the type of domain. Some common domain names used in US are

com	- commercial organisations
edu	- educational institutions
gov	- government organisations
mil	- military
net	- network, companies and groups who ad minister the internet
org	- organisation

Countries outside the US use a two letter country code as their domain name.

Au - Australia

In - India

Fr - France

Uk - United kingdom

Browser

To view the web sites/pages you need a graphical user interface, called a web browser. It is a piece of software, that lets you visit different web sites on the internet and display their pages on your own computer. You can visit the site by supplying the browser with an address or URL.

A browser displays a document from the internet on the computer screen. Like any windows based program, a browser has a number of features - buttons, menus, scroll bars, toolbars etc, that let you control its operation. The latest version of the browser is recommended, since the technologies involved in publishing information on the internet are constantly changing.

Once you have your browser and a internet connection, accessing the internet is fairly straight forward. Commonly used browsers are Netscape Navigator and Microsoft Internet Explorer.

Page 1 gives the home page of Microsoft internet explorer.

Title bar: Shows the name of the page you are currently viewing on the documents file name if it is not a web page.

Menu bar: Provides with drop down menus contains almost all the commands you will need in the browser.

Navigation toolbar: Provides command action buttons. Click the icon for the specified action to occur. If you point at a button for a few seconds, without clicking, a tool tip will appear describing the action of the button.

Location tool bar: Type the URL you want to connect in the “document URL” area of the location toolbar. On the right side of the window a small arrow appears. Click the arrow and the URLs most recently visited will pop up as a list.

Internet options: Select view on the menu bar and select internet options to edit internet explorers default settings.

Computer Viruses and protection

Objectives : At the end of this lesson you shall be able to
- **describe the computer virus**
- **explain how viruses spread in computer**
- **protect the computer from viruses**
- **explain the Anti-Virus software.**

What is a Virus?

A computer virus is one of thousands of programs that can invade computer systems (both IBM PC and Macintosh) and perform a variety of functions ranging from annoying (e.g., popping up messages as a joke) to dangerous (e.g., deleting files or destroying your hard disk). Trojan horses or worms are specific types of clandestine programs (loosely categorized as viruses) and can be just as dangerous. For simplicity's sake, future mention of viruses in this document will refer to viruses, Trojan horses, and worms taken as a whole.

How Do Viruses Spread?

Computer viruses are programs that must be triggered or somehow executed before they can infect your computer system and spread to others. Examples include opening a document infected with a "macro virus," booting with a diskette infected with a "boot sector" virus, or double-clicking on an infected program file. Viruses can then be spread by sharing infected files on a diskette, network drive, or other media, by exchanging infected files over the Internet via e-mail attachments, or by downloading questionable files from the Internet.

How Can Protect computer

With dangerous viruses on the network, what can computer users do to protect their systems? Here are just a few hints:

- Be sure to install an anti-virus software program to guard against virus attacks. Also, be sure you turn on the scanning features. It can't protect if it's not enabled.
- Practice caution when working with files from unknown or questionable sources.
- Do not open e-mail attachments if do not recognize the sender. Scan the attachments with anti-virus software before opening them.
- Download files only from reputable Internet sites, and be wary when exchanging diskettes or other media with friends.
- Scan the hard drive for viruses monthly. Even with these precautions, new viruses may find ways to enter the computer system.

Getting Anti-virus Software

Anti-virus software are programs that are installed onto your computer and can scan and remove known viruses which you may have contracted. The software can also be set to automatically scan diskettes when inserted into the disk drive, scan files, downloaded from the Internet, or scan e-mail when received.

> **Be sure to have only one anti-virus program running on your system. Multiple programs may cause conflicts and system instability. Keeping it Current**

Even with active monitoring of computer systems, anti-virus software can only protect against viruses that it knows about. For this reason, update files (generally called Definition Files) for anti-virus software are needed every time there is a new virus release. On the Windows platform, this means an update roughly every week; the Macintosh has fewer new viruses to worry about so updates are usually done monthly. The software that ITS distributes has an "Auto Update" feature to automatically connect to a Web site and download the latest Definition Files. Refer to the documentation to turn this feature on and receive the maximum protection against viruses on computer. Be sure to keep the Definition Files current!

How to remove virus?

If computer becomes infected with a virus, don't panic! For most viruses, can simply use anti-virus program to scan and remove the virus. If your Definition Files are up-to-date, the program should be able to clean off all but the most recent viruses. In the case of rather nasty viruses, some damaged files that cannot be fixed. Restore these from backups.

MS Office Applications & its Functions

Objectives : At the end of this lesson you shall be able to
- **define MS office**
- **describe formatting, documents, spacing and headers.**

MS Office

MS Office (or simply Office) is a family of server software, and services developed by Microsoft. It was first announced by Bill Gates on August 1, 1988, in Las Vegas. The first version of Office contained Microsoft Word, Microsoft Excel, and Microsoft PowerPoint. Over the years, Office applications have grown substantially closer with shared features such as a common spell checker, data integration etc. Office is produced in several versions targeted towards different end-users and computing environments. The original, and most widely used version, is the desktop version, available for PCs running the Windows, Linux and Mac OS operating systems. Office Online is a version of the software that runs within a web browser, while Microsoft also maintains Office apps for Android and iOS.

1 MS Word

- First released on October 25, 1983
- Extension for Doc files is ".doc"
- It is useful in creating text documents
- Templates can be created for Professional use with the help of MS Word
- Work Art, colours, images, animations can be added along with the text in the same file which is downloadable in the form of a document
- Authors can use for writing/ editing their work

To read in detail about Microsoft Word, its features, uses and to get some sample questions based on this program of Office suite, visit the linked article.

2 MS Excel

- Majorly used for making spreadsheets
- A spreadsheet consists of grids in the form of rows and columns which is easy to manage and can be used as a replacement for paper
- It is a data processing application
- Large data can easily be managed and saved in tabular format using MS Excel
- Calculations can be done based on the large amount of data entered into the cells of a spreadsheet within seconds
- File extension, when saved in the computer, is ".xls"

Also, visit the Microsoft Excel page to get more information regarding this spreadsheet software and its components.

3 MS PowerPoint

- It was released on April 20, 1987
- Used to create audiovisual presentations
- Each presentation is made up of various slides displaying data/ information
- Each slide may contain audio, video, graphics, text, bullet numbering, tables etc.
- The extension for PowerPoint presentations is ".ppt"
- Used majorly for professional usage
- Using PowerPoint, presentations can be made more interactive

In terms of Graphical user interface, using MS PowerPoint, interesting and appealing presentation and documents can be created. To read more about its features and usage, candidates can visit the linked article.

4 MS Access

- It was released on November 13, 1992
- It is Database Management Software (DBMS)
- Table, queries, forms and reports can be created on MS Access
- Import and export of data into other formats can be done
- The file extension is ".accdb"

5 MS Outlook

- It was released on January 16, 1997
- It is a personal information management system
- It can be used both as a single-user application or multi-user software
- Its functions also include task managing, calendaring, contact managing, journal logging and web browsing
- It is the email client of the Office Suite
- The file extension for an Outlook file is ".pst"

6 MS OneNote

- It was released on November 19, 2003
- It is a note-taking application
- When introduced, it was a part of the Office suite only. Later, the developers made it free, standalone and easily available at play store for android devices
- The notes may include images, text, tables, etc.
- The extension for OneNote files is ".one"
- It can be used both online and offline and is a multi-user application

Apart from the applications mentioned above, various other applications are included in the MS Office suite but these are most commonly used ones and questions based on the same may be asked in the upcoming exams as well.

Aspirants can also learn more about Microsoft Office through the video given below, specially curated for candidates assistance:

Search Engine and Email Accounts

Objectives : At the end of this lesson you shall be able to
- **explanation about search engine**
- **creating email, sending and receiving messages.**

What is a search engine?

A search engine is a searchable database which collects information on web pages from the Internet, and indexes the information and then stores the result in a huge database where it can be quickly searched. The search engine then provides an interface to search the database.

Examples : Google, Alta Vista, Exite

A Search engine has **three** parts.

- **Spider:** Deploys a robot program called a spider or robot designed to track down web pages. It follows the links these pages contain, and add information to search engines' database. Example: **Googlebot** (Google's robot program)
- **Index:** Database containing a copy of each Web page gathered by the spider.
- **Search engine software :** Technology that enables users to query the index and that returns results in a schematic order.

How does a search engine work?

Types of search engines

In broad sense, search engines can be divided into two categories.

1. Individual search engines

An individual search engine uses a spider to collect its information regarding websites for own searchable index. There are two types of individual search engines.

i . General search engines

Examples: Google, AltaVista, HotBot, Lycos

ii. Subject specific search engines

Examples: MetaPhys, Chritech, ReligionExplorer, Chordie, ChemFinder

2. Meta search engines

A Meta search engine searches multiple individual engines simultaneously. It does not have its own index, but uses the indexes collected by the spiders of other search engines.

Example: metacrawler, Ixquick, mamma

Advantages of using search engines

Search engines are best at finding unique keywords, phrases, quotes, and information buried in the full-text of web pages since they normally index WWW documents word by word. Search engines allow the user to enter keywords, and then they are searched against its database. Users can use advanced search techniques such as phrase searching, truncation/wildcard searching, as well as for Boolean operators (AND, OR, NOT combinations). With comparison to web directories, search engines are huge databases and contain a large amount of materials. Also, the database is updated at a variable rate.

Download content

Downloading content from internet has become a commonplace activity for all internet users – in the home, in business and in schools. All internet users download content from time to time – typically programs, games, pictures, music, video and documents. Downloading content can be troublesome. Downloads can fail. Downloads can take excessive time. Downloads can be password-protected. Some content cannot be downloaded using your web browser. A download manager is a utility designed to fix all the problems you may be having downloading content from the internet. They have quickly become a must-have utility for all internet users. Download managers can accelerate your downloads, allow you to resume broken downloads and contain numerous features that allow to you get hard-to-get files from the internet.

Key terms

URL

A URL (or Uniform Resource Locator) is the location of a resource on the internet. The format of a URL includes the protocol (e.g. http://, https://, ftp://, mms://, etc.), the domain name (or IP address), and additional path information (or folder & file name). A URL may address a web page file, a program file, an image file, a CGI file, or any other type of file, folder or program. Download managers use URLs to find the location of files, web sites and FTP sites that you want to download. You input URLs when download content from the internet.

Examples of URLs are:

- http://www.conceiva.com/downloads/downloadstudio2200.exe
- ftp://ftp.microsoft.com/pub/msoffice.zip
- http://www.google.com
- http://www.itunes.com/hiphop/newtrack.mp3

Servers, Domains and Groups

A server name represents a single web server. For example, "www.conceiva.com" and "www.google.com" are examples of server names. Even "google.com" counts as a different server name since it is not the same as "www.google.com" – even though if you visit "http://www.google.com" and "http://google.com" in your web browser you may see the same content. A domain name is the most general part of a server name. For example, "conceiva.com", "google.com" and "zdnet.co.uk" are examples of domain names. When downloading files, if you set the download job to span across Domains, it will download files from any servers that share the same domain name. For example, "www.conceiva.com", "images.conceiva.com" and "downloads.conceiva.com" all belong to the same domain "conceiva.com".

A group name refers to any number of servers that share the same name regardless of the country-specific part of the name. For example, "www.conceiva.net", "ftp.conceiva.org.au" and "images.conceiva.co.jp" would all be part of the same group, because they all contain the word "conceiva" directly before the country specific part of the name.

Using the URL "http://www.conceiva.com/images/logo.gif" as an example:

- "www.conceiva.com/images" is the folder name
- "www.conceiva.com" is the server name
- "conceiva.com" is the domain name
- "conceiva" is the group name

Data files.
An increasing number of businesses download data files from the internet on a daily basis – often as a regular scheduled backup of their online data or to simply get the latest up-to-date data for their business. Data files can be any type of file and can be large in size, requiring significant bandwidth and time to download.

Email

Most people will be familiar with the term email (electronic mail) in this day and age. It basically covers all messages sent over the Internet, normally between computer users, but also is now used with other internet-connected devices such as mobile phones. Email messages can be just text based or can also contain graphical or other multimedia information. One common misconception with email is that messages will always arrive immediately or at least very quickly (within minutes). Whilst this is often the case, any email relies on many computers and networks to be working, therefore emails are at risk of delays at any stage. However, sending messages within one system (such as the SHU First Class email service) should be immediate. To send email messages all you need to know is a valid address of the recipient - see addressing below. Messages can either be like formal letters or increasingly they are much more "conversational" where the emotions of the writer are expressed as emoticons (also called "smilies").

Other Email Features

Other features you will commonly find when using email:

Cc: This stands for "carbon copy" or "courtesy copy" and is the field where you can put extra addresses in to send to other mailboxes if not the main recipient.

Bcc: Like c:, but the mailbox address entered in this field is not visible to the main recipient of the mail.

Attachment: Any file being sent along with the main message; eg a Word file, a picture etc.

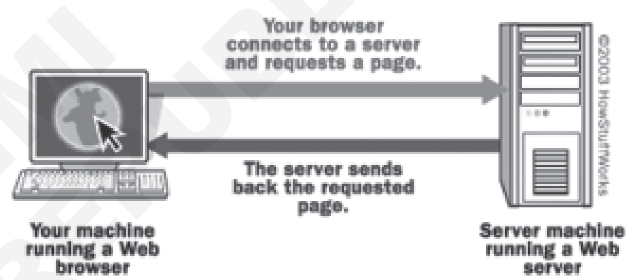
SPAM: Any unwanted and often malicious unsolicited emails. At SHU we try and detect these and mark them appropriately so that they can be deleted by the user without needing to open them.

How E-mail Works

A Simple E-mail Server

Given that you have an e-mail client on your machine, you are ready to send and receive e-mail. All that you need is an **e-mail server** for the client to connect to. Let's imagine

Fig 1



what the simplest possible e-mail server would look like in order to get a basic understanding of the process shown in Fig 1. Then we will look at the real thing.

If you've read How Web Servers Work, then you know that machines on the Internet can run software applications that act as **servers**. There are Web servers, FTP servers, telnet servers and e-mail servers running on millions of machines on the Internet right now. These applications run all the time on the server machine and they listen to specific **ports**, waiting for people or programs to attach to the port. The simplest possible e-mail server would work something like this:

1 It would have a list of e-mail accounts, with one account for each person who can receive e-mail on the server. My account name might be **MBRAIN**, John Smith's might be **JSMITH**, and so on.

2 It would have a text file for each account in the list. So, the server would have a text file in its directory named MBRAIN.TXT, another named JSMITH.TXT, and so on.

Computer networking, Network Cable Components, and Servers

Objectives : At the end of this lesson you shall be able to
- **explain the network**
- **state the components of a network**
- **explain the type of network topology**
- **state the types of cables and connectors used in network**
- **explain P.C. server and webserver.**

Introduction

If there is one concept that facilitates a global community, it is networking. A network by definition is a collection of two or more computers connected together. Through these networked computers, people can share almost anything that include:

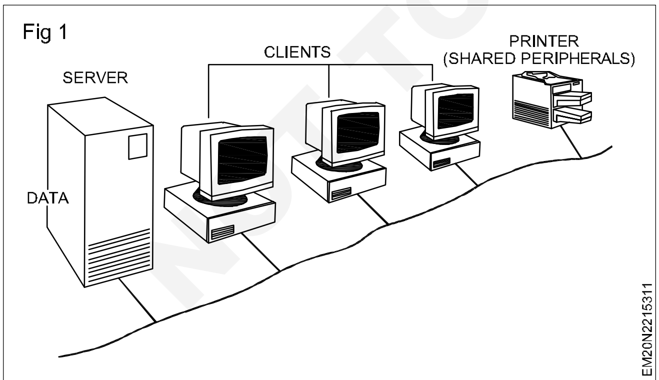
- **Data files:** Word processing, electronic spread sheet or presentation documents.
- **Peripheral devices:** Printers, monitors, scanners etc.
- **Software applications:** Bundled PC software such as MS-Office or Lotus Smart suite, Financial accounting software, database software etc.
- **An internet connection:** Going On line to connect to another network or to send e-mail to another person.

In essence a network is a group of computers, printers and other devices that are connected together with cables. Information travels over the cables, allowing network users to share any hardware or software that is connected to the network.

Components of a network: All networks have certain components in common. They are:

Servers - computers that provides shared resources. Fig 1

Fig 1



Shared resources: Files, directories, applications, printers, CD rom drives, and other peripherals which are accessed by the users on the network.

Clients: Computers that access or use shared resources from server

Media: The physical cable that connects the computers in a network.

Network interface card: To convert a standalone computer to be connected to a network, first a network interface card has to be plugged into the PCs expansion slot and configured.

Network topology

The term network topology refers to the arrangement or physical layout of computers, cables and other components on the network. The term Topology is also commonly used to refer to the network's basic design. Topology is an important issue when you plan for a network. It depends on the type of cable and protocol to be used in the network.

The most common topologies are:

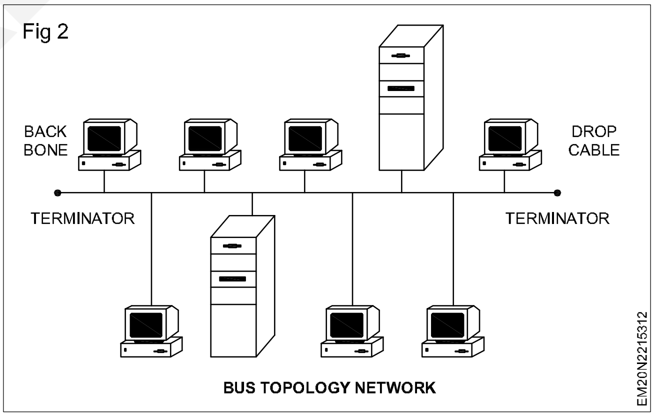
1 Bus

2 Star

3 Ring

Bus Topology:

Fig 2



In this type of arrangement as shown in Fig 2, computers are connected in a row. This is the simplest and most common method of networking computers. The cable that is used to connect all the computers is also called as backbone. Bus topology networks use coaxial cable. They use BNC connectors to connect all the individual cables. Each computer is connected to the network through the use of a BNC. This connection allows the backbone cable to be continued to the next computer. To make a longer piece of cable, a component called a barrel connector is used.

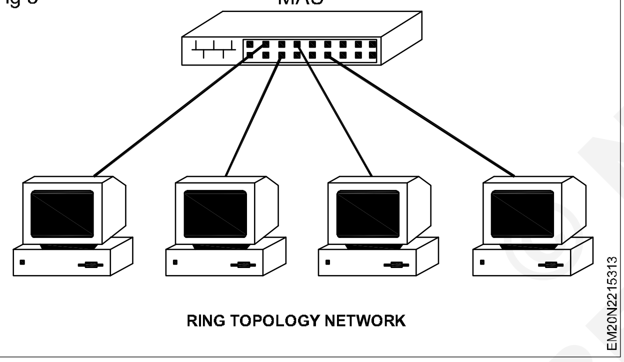
In this topology, the network data is sent in the form of an electronic signal along with the MAC (Manufacturer address code) address of the machine to which data has to be sent. All the computers on the network receive this data. But only the computer whose address matches the address in the data sent over the network will accept the information. Only one computer at a time can send messages over the network.

Because the data, or electronic signal, is sent to the entire network, it will travel from one end of the cable to the other. If the signal were allowed to continue uninterrupted, it would keep bouncing back and forth along the cable and prevent other computers from sending signals. Therefore, the signal must be stopped after it has reached the proper computer. To stop the signal from bouncing, a component called Terminator is placed at each end of the cable to absorb free signals. Absorbing the signal clears the cable so that other computers can send data. The protocol that is used in bus topology is Ethernet.

If the cable is physically cut or if any one end of the cable gets disconnected from the terminator or T-connector, the entire network is down. Then the computers will not be able to communicate with each other.

Ring Topology: The ring topology connects computers on a single circle of cable. There are no terminators at the end of cable like in bus topology. Refer to the Fig 3 shown below.

Fig 3



RING TOPOLOGY NETWORK

he signals travel around the loop in one direction and pass through each computer. Each computer boosts the signal and sends it to next computer. Because the signal passes through each computer in the ring, the failure on one computer effect the entire network.

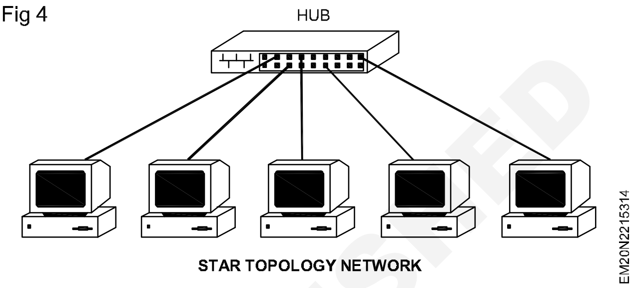
Though the computers are logically connected in a ring fashion, the actual cables from the NIC of the computer gets connected to the MAU or Multistation Access Unit centrally. The function of the MAU is to accept signals transmitted from one computer and direct the signals to the computer to which it is addressed.

One method of transmitting data around a ring is called token passing. A token is passed from one computer to the next and so on. When a station wants to transmit on the ring, it waits for a free token to pass by. The sending computer takes the token. It modifies by putting an electronic address of the computer to which it has to transmit. Then it sends the token out on the rings. As the busy token passes by, each computer on the ring checks the token's address. If the address does not match with its own address, it sends the token to the next computer. If the address matches, the computer copies the data from the token. It also returns a message on the token to the sending computer indicating that the data has been received. After verification, the sending computer creates a new token and releases it on the network.

Token ring topology uses category 3/4/5 UTP or fibre optic cable. Though originally 4 Mbps speed was used, the typical speed used now is 16Mbps. A newer version of fast token ring standard also exists that enhances the speed to 100 Mbps.

Star Topology: In this type, computers are connected by cables to a centralised component, called a hub. Signals are transmitted from the sending computer through the Hub to all the computers on the network as shown in Fig 4.

Fig 4



STAR TOPOLOGY NETWORK

Star topology is easy to install. You must install a separate cable from the Hub to the computer. So it may require more cabling than other topologies. Shifting, adding and removal of nodes are very simple. Even if one cable breaks down, only that computer gets affected on the network and the rest is operational. UTP or FTP cables Cat5 or Ecat5 may be used for achieving speeds upto 100/1000 Mbps. They are limited to a length of 100 meters (328 feet) for each node connection.

There is no limitation in the number of nodes in a segment. Uses RJ-45 connectors for all connections.

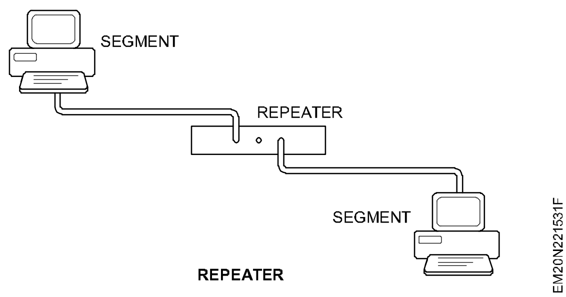
Network Architecture

Network architecture combines standards, topologies and protocols to produce a working network. Ethernet is currently the most popular network architecture. It uses a bus topology, it follows the IEEE's 802.3 specification.

The Ethernet media draws power from the computer and this will not fail unless the media is physically cut or improperly terminated. The transfer speed is 10/100 Mbps. It supports Thin, Thick coaxial cables and UTP.

Repeaters: Electro magnetic waves become weaker as they pass through transmission medium. Each transmission medium can only be used for a certain distance. One can exceed the physical mediums maximum effective distance by using an amplification device called repeater. Repeater is shown in Fig 5.

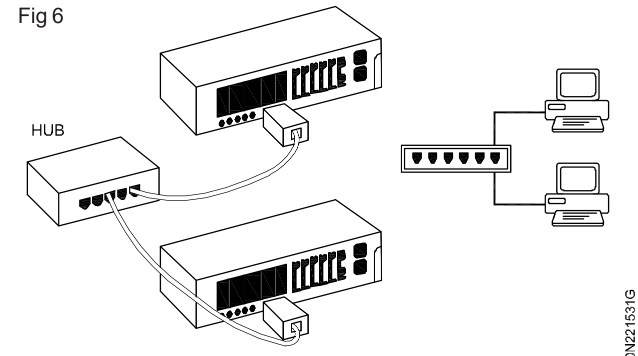
Fig 5



REPEATER

Hubs: Some networks require a central point of connection between media segments. These central points are referred to as hubs is shown in Fig 6.

Fig 6



HUBS

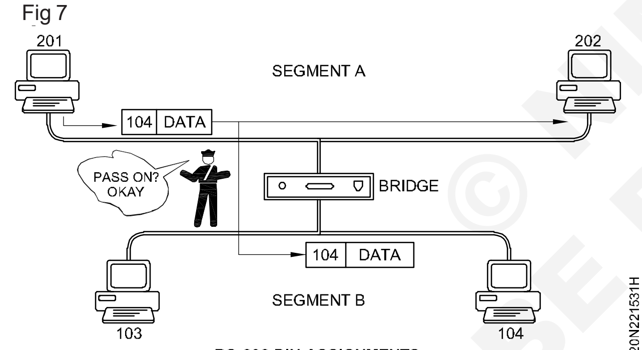
Bridges: A bridge extends the maximum distance of your network by connecting separate network segments. Bridges selectively pass signals from one medium segment to another as in below Fig 7.

The above figure explains that

– Receive all signals sent on segment A.

– Discard signals addressed to other nodes on segment A.

Fig 7



RS-232 PIN ASSIGNMENTS

– Retransmit all other signals out of the appropriate ports

– Perform the same functions for data on other connected segments.

Multi plexers: A multiplexer combines two or more separate signals on a single transmission media segments i.e. to efficiently use the entire transmission media band width, we can use multiplexers.

Routers: Routers connect two or more logically separate networks (consisting of several network segments with different protocols and architectures) is called router.

PC-Server: The term client-server can describe hardware, in which case it is referring to network servers and client computers, or it can refer to a way of organising software applications and services on a network. Client server computing is a powerful way of constructing programs on a network. In order to describe its advantage and how it works, we will first describe two alternatives to client-server computing:

– Centralised computing

– Client computing with central file storage

Centralized computing : Centralized computing originated with mainframe computers and time-sharing. The principle behind centralized computing is that a central computer executes a program, such as a database or a transaction-processing program (for instance, an airline reservations system or a bank records program) and remote terminals merely display data on a screen and convey keyboard data back to the central computer.

In modern networks, personal computers can perform the role of dumb terminals. With Windows software, the PC can appear to the central computer as many terminals, each virtual terminal accessing different data or performing a separate transaction on the mainframe.

In centralized computing it is the central computer that does all the work. The data resides on the central computer and the program executes on the central computer. The personal computer or dumb terminal only display screen data and accepts keystrokes for the central computer to process. Centralized computing does not fully use the capabilities of today's powerful network clients.

Client computing with Central file storage : At the opposite end of the spectrum from centralized computing is client computing with central file storage (see Fig 40). In this way of organizing an application, the client computer does all the work. A central file server stores, but that is all.

Client computers cooperate to ensure that central files are not corrupted by attempts by several computers to access them at the same time. When a client computer needs to perform an operation, the file is transferred to the client computer to perform the operation. Two examples of this type of application are networked database programs that do not use a SQL. (Structured Query Language) server and any network-aware application that does not communicate with a special program executing on the server, such as network scheduling programs and groupware.

While it is fully exploits the capabilities of client computers and provides a richer and more customizable environment for the user, this type of program can place heavy demands on the network if the data files in which program works with are large. It also takes time to transmit data from the server to the client, process the data, and transfer it back to the server so other network programs can access the data.

The Client-Server Model : The Client-server model combines the advantages of both the centralized computing model and the client model of computing. It does this by performing the operations that are best executed by a central computer on the file server and performing those operations that are best done close to the user on the client computer. The client-server model works best when many people need access to large amounts of data. Simply stated, a client-server system is any system in which the client computer makes a request over a network to a server computer that then satisfies the request.

The Client : When you use a client-server system, what you see is the client, or front end. It presents the interface to manipulate or search for data. The request you make by manipulating windows, menu, check boxes and so on, is translated into a compact form that the client transmits over the network for the server to perform.

One example of a front end is Microsoft Access when it is used with a SQL back end. Access displays tables in windows or in forms you can browse. It allows you to modify and search the tables in an easy-to-use graphical environment. All the actual data manipulation, however, occurs on the SQL server. Access translates all the data-base operations into SQL for the server to perform. The results of the operations are transmitted back to Access to display in an intuitive, graphical form.

SQL is not limited to database programs such as Microsoft Access. User programs such as Microsoft Excel can use SQL to query the back-end data-base server for values to use in spreadsheet calculations. Program tools allow custom programs to store and retrieve data in server-based databases. Query tools provide direct access to the SQL data.

The Server : The server is where data operations in a client-server system occur. The central computer can service many client requests quickly and efficiently, which is the traditional advantage of centralized computing. The central computer can also provide enhanced security by performing only authorized operations on the data.

Back-end database software is optimized to perform searches and sorts and the back-end computer is often more powerful than the front-end computer.

Web server : A web server is a program using the client/server model and the World Wide Web's Hyper Text Transfer Protocol (HTTP) serves the files that form web pages to web users.

Every computer on the internet that contains a web site must have a web server program. The most popular web servers are: The Microsoft's Internet Information Server (IIS) which comes with the Microsoft's Windows NT Server; Netscape Fast Track and Enterprises Servers and Apache, a web server for Unix-based operating systems. Other web servers include Novell's Web Server for users of its Netware Operating System and IBM's family of Lotus Domino Servers. Primarily for IBM's OS/390 and AS/400 customers.

Web servers often come as a part of a larger package of Internet related programs for serving e-mail, downloading requests for File Transfer Protocol (FTP) files and building and publishing web pages. Consideration in choosing a web server include how well it works with the operating system and other servers, its ability to handle server side programming and publishing, search engine and site building tools that may come with it.

Wi-Fi Network

Objective: At the end of this lesson you shall be able to
- **explain the bluetooth device**
- **explain wi-fi and network protocols.**

Wireless network

Connecting to a network using wires has become nowadays outdated as most times availability of wireless networks is there in public places.

Wireless network uses the connections through wi-fi devices and bluetooth devices.

Bluetooth device

Bluetooth device are installed inside devices like mobile phones laptops and on a separate adapters in desktops. It connects devices by identification using machine id and one-to-one basic paired connections. The date shared between paired devices are about Mbps in normal USB mode. Sharing internet is also available in bluetooth networks. The only restriction is its connecting area and speed of transmission.

Wi-Fi device

Compared to bluetooth the wi-fi devices are very fast in transmitting data and area of coverage and connecting devices are also more. Wi-fi also used to connect a LAN using TCP/IP settings. Unlike bluetooth, wi-fi is secured with connection. Key as passwords, which restricts unauthorised accessing of network and sharing internet connections. Configuring wi-fi network using a mobile phone is very easy as just select '"wi-fi hotspot" to share its internet connectivity and access from other devices by providing pass key. Also when DHCP mode is enabled in a wifi modem, systems can easily be connected to the network as configured.

Wi-Fi

Wi-Fi or WiFi (/'waifai/') is technology for radio wireless local area networking of devices based on th IEEE 802.11 standards. Wi-Fi is a trademark of the Wi-Fi Alliance, which complete interoperability certification testing.

Devices that can be Wi-Fi technology include personal computers, video-game consoles, smartphones and tablets, digital cameras, smart TVs, digital audio players and modern printers. Wi-Fi compatible devices can connect to the internet via a WLAN and a wireless access point. Such an access point (or hotspot) has a range of about 20 meters (66 feet) indoors and a greater range outdoors. Hotspot coverage can be as small as a single room with walls that block radio waves, or as large as many square kilometers achieved by using multiple overlapping access points.

Depiction of a device sending information wirelessly to another device, both connected to the local network, in order to print a document.

Wi-Fi most commonly uses the 2.4 gigahertz (12 cm) UHF and 5.8 gigahertz (5cm) SHF ISM radio bands, these bands are subdivided into multiple channels. Each channel can be time-shared by multiple networks. These wavelengths work best for line-of sight. Many common materials absorb or reflect them, which further restricts range, but can tend to help minimize interference between different networks in crowded environments. At close range, some versions of Wi-Fi, running on suitable hardware can achieve speeds of over 1 Gbps.

Anyone within range with a wireless network interface controller can attempt to access a network; because of this, Wi-Fi is more vulnerable to attack (called eavesdropping) than wired networks. Wi-Fi protected access is a family of technologies created to protect information moving across Wi-Fi networks and includes solutions for personal and enterprise networks. Security features of Wi-Fi protected Access have included stronger protections and new security practices as the security landscape has changed over time.

Network Protocol

Rules of Network Protocol include guidelines that regulate the following characteristics of a network: access method, allowed physical topologies, types of cabling, and speed of data transfer.

Types of Network Protocols

The most common network protocols are:

- Ethernet
- Local Talk
- Token Ring
- FDDI

ATM

The followings are some commonly used network symbols to draw different kinds of network protocols.

Ethernet

The Ethernet protocol is by far the most widely used one. Ethernet uses an access method called CSMA/CD (Carrier Sense Multiple Access/Collision Detection). This is a system where each computer listens to the cable before sending anything through the network. If the network is clear, the computer will transmit. If some other nodes have already transmitted on the cable, the computer will wait and try again when the line is clear. Sometimes, two computers attempt to transmit at the same instant. A collision occurs when this happens. Each computer then backs off and waits a random amount of time before attempting to retransmit. With this access method, it is normal to have collisions. However, the delay caused by collisions and retransmitting is very small and does not normally effect the speed of transmission on the network.

The Ethernet protocol allows for linear bus, star, or tree topologies. Data can be transmitted over wireless access points, twisted pair, coaxial, or fiber optic cable at a speed of 10 Mbps up to 1000 Mbps.

Fast Ethernet

To allow for an increased speed of transmission, the Ethernet protocol has developed a new standard that supports 100 Mbps. This is commonly called Fast Ethernet. Fast Ethernet requires the application of different, more expensive network concentrators/hubs and network interface cards. In addition, category 5 twisted pair or fiber optic cable is necessary. Fast Ethernet is becoming common in schools that have been recently wired.

Local Talk

Local Talk is a network protocol that was developed by Apple Computer, Inc. for Macintosh computers. The method used by Local Talk is called CSMA/CA (Carrier Sense Multiple Access with Collision Avoidance). It is similar to CSMA/CD except that a computer signals its intent to transmit before it actually does so. Local Talk adapters and special twisted pair cable can be used to connect a series of computers through the serial port. The Macintosh operating system allows the establishment of a peer-to-peer network without the need for additional software. With the addition of the server version of AppleShare software, a client/server network can be established.

The Local Talk protocol allows for linear bus, star, or tree topologies using twisted pair cable. A primary disadvantage of Local Talk is low speed. Its speed of transmission is only 230 Kbps.

FDDI

Fiber Distributed Data Interface (FDDI) is a network protocol that is used primarily to interconnect two or more local area networks, often over large distances. The access method used by FDDI involves token-passing. FDDI uses a dual ring physical topology. Transmission normally occurs on one of the rings; however, if a break occurs, the system keeps information moving by automatically using portions of the second ring to create a new complete ring. A major advantage of FDDI is high speed. It operates over fiber optic cable at 100 Mbps.

ATM

Asynchronous Transfer Mode (ATM) is a network protocol that transmits data at a speed of 155 Mbps and higher. ATM works by transmitting all data in small packets of a fixed size; whereas, other protocols transfer variable length packets. ATM supports a variety of media such as video, CD-quality audio, and imaging. ATM employs a star topology, which can work with fiber optic as well as twisted pair cable.

ATM is most often used to interconnect two or more local area networks. It is also frequently used by Internet Service Providers to utilize high-speed access to the Internet for their clients. As ATM technology becomes more cost-effective, it will provide another solution for constructing faster local area networks.

Internet Protocol (TCP/IP)

Definition

Transmission Control Protocol/Internet Protocol (TCP/IP)

Transmission Control Protocol/Internet Protocol (TCP/IP) is the language a computer uses to access the internet. It consists of a suite of protocols designed to establish a network of networks to provide a host with access to the internet.

TCP/IP is responsible for full-fledged data connectivity and transmitting the data end to end by providing other functions, including addressing, mapping and acknowledgment. TCP/IP contains four layers, which differ slightly from the OSI model.

The technology is so common that one would rarely use the full name. In other words, in common usage the acronym is now the term itself.

Techopedia explains Transmission Control Protocol/ Internet Protocol (TCP/IP)

Nearly all computers today support TCP/IP. TCP/IP is not a single networking protocol - it is a suite of protocols named after the two most important protocols or layers within it - TCP and IP.

As with any form of communication, two things are needed: a message to transmit and the means to reliably transmit the message. The TCP layer handles the message part. The message is broken down into smaller units, called packets, which are then transmitted over the network. The packets are received by the corresponding TCP layer in the receiver and reassembled into the original message.

The IP layer is primarily concerned with the transmission portion. This is done by means of a unique IP address assigned to each and every active recipient on the network.

TCP/IP is considered a stateless protocol suite because each client connection is newly made without regard to whether a previous connection had been established.

File Transfer Protocol (FTP)

File Transfer Protocol(FTP) is an application layer protocol which moves files between local and remote file systems. It runs on the top of TCP, like HTTP. To transfer a file, 2 TCP connections are used by FTP in parallel: control connection and data connection

,

Electronics Mechanic - Basic SMD (2,3,4 terminal components), Soldering and Desoldering

Surface Mount Technology and Surface Mount Devices

Objectives : At the end of this lesson you shall be able to
- **explain briefly SMT & SMD**
- **state the need for SMD**
- **list the advantages of SMDs**
- **state the safety precautions required while handling SMDs**
- **list the tools and equipments used in SMT**
- **understand to perform test and measurement of the circuit.**

Introduction

Surface Mount Devices (SMDs) are used in a growing number of commercial and industrial products. Due to their small size, prototype manufacturing, rework and repair can be difficult and are best performed using specialized techniques specific to this technology. Learning these techniques will help you succeed when working with these small components. The SMT technique opens advantages and new applications through miniaturizing of the components and increasing of reliability.

Surface Mounted Devices (SMD) are active and passive electronic components without conventional connecting wires.

In the conventional through - hole technology (THT) the components are placed on the "components side" of the printed circuit board (PCB), wires inserted into holes, and soldered to the copper pads on the opposite, "solder side" of the PCB.

Need of surface mount technology

SMDs have improved performance over through-hole components due to their smaller size, shorter internal leads, and smaller board layouts. These factors reduce the circuit's parasitic inductance and capacitance. SMDs can also be more cost effective than traditional through - hole components due to the smaller board size, fewer board layers, and fewer holes. SMDs can be challenging to solder, so it is best to learn general soldering skills on larger components before attempting to work with SMDs.

Advantages of SMDs are given below

1 PCBs area much smaller than by conventional through - hole components

2 Since the both layers of the PCB could be used for assembling, the final PCBs area for the same circuits could be decreased by 50%.

3 Simple assembling-no bending and cutting of the wires.

4 Automatic assembling very easy. Low cost of the assembling.

5 Small size of components makes very high packing density possible. For the same circuits a volume of a module assembled with SMD could be reduced to 30% of the device assembled with the conventional technique. Therefore a size of the whole instrument decreases, too.

6 Very high resistance to mechanical shock and vibration.

7 Low store and transport cost. Low store area and volume.

8 Lack of hole's drilling and metallization.

9 Thin pads.

10 For larger volumes, low manufacturing cost.

SMD safety precautions

Surface mount components are very small, and therefore special precautions (in addition to those required when working with through - hole components) must be taken

- Do not eat or drink when working with surface mount components.
- Do not use cups, plates, or any food related items to hold or store surface mount components.
- Keep surface mount components away from children and pets.
- Always wear safety goggles.
- Work away from the edge of a desk or workbench to ensure that components will not fall on the floor.
- Keep a strong light and magnet available to search for components that have dropped on the floor.

Work area for dealing with SMD

Because SMDs are very small, it is important to make them "look" bigger. This can be accomplished by illuminating the work surface with a very bright light. A swing - arm desk lamp with a 100-watt frosted bulb positioned close to the work surface works very well. The lamp should be adjustable from 6 to 24 inches above the desktop. Regular room lighting or shop lights just are not bright enough. The second trick is to work on an absolutely clean, bright white surface. The SMD work tray works very well. The white paper gives contrast to the components and the small sides help prevent the SMDs from getting lost.

Tools and Equipment required for SMD

The tools and equipment required for SMD used are self - locking tweezers which work much better than regular tweezers. Vacuum pick-up tools can also be used, but are considerably more expensive. Select a low wattage (15 or 25 watt) or temperature controlled (600^0F) pencil soldering iron with a pointed tip.

List of tools & equipments

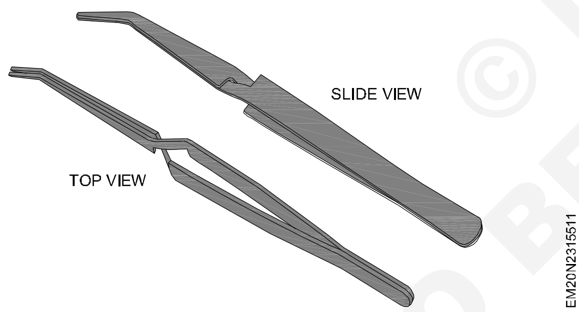
1 Safety Goggles
2 Self locking tweezers (Fig.1)
3 600°F or low wattage soldering gun with sharply pointed tip
4 Small diameter solders wire (63/37)
5 RMA solder paste
6 Desoldering braid
7 Plastic scouring pads
8 Deco cement
9 Magnet
10 Flexible neck lamp with 100w frosted bulb.
11 Magnifying glass.

To clean the circuit board before soldering you will need a nonconductive abrasive pad. Don't use steel wool or a steel wool scouring pad, since they may leave small (almost microscopic) steel wires behind. A strong magnet is useful for finding dropped components. You will also need a magnifying glass. Use this to read the component markings on chip resistors and electrolytic capacitors.

Types of SMD components

Now a days, almost all active components are available in SMD packages for example diodes, transistors, FET, Triac etc. But in passive components only resistor and capacitors are available in different sizes and values. Due to size and mounting limitations -inductors and transformers are not available in SMDs. In active devices, some power electronic components are available in limited varieties due to large

Fig 1



current drawing and problems for mounting heat sink on SMDs. Large surface space is required for mounting the heat sinks whereas SMDs are in small size.

SMD resistors

SMD resistors are in shape of rectangle with metalized in both ends of body for convenient to solder on PCBs.

SMD resistors are constructed with use of the thick film technique on a ceramic substrate. They have metallic areas on the narrow ends of the chip, which allows soldering. The resistive path is covered with a protective glaze. Chip resistors could be soldered with all common soldering techniques : reflow, wave and solder iron. A sample of SMD resistor is shown in Fig 2.

Case forms of same SMD components ae tabulated table1.

SMD resistor packages

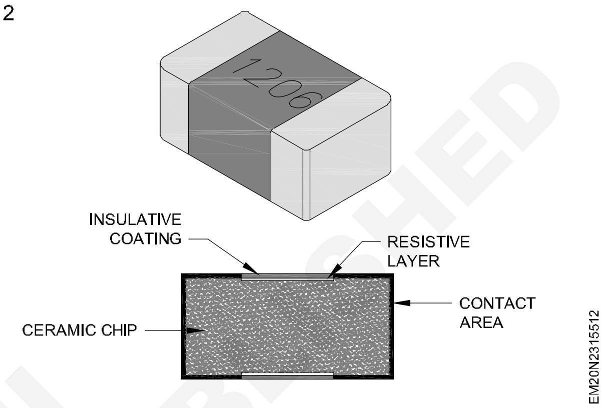
SMD resistors are available in different types of packages and they are mostly differ some part of specifications from manufacturer to manufacturer. The size of resistors are also reduced day by day due to technological enhancement. The most common packages and their sizes are shown in table 1.

SMD resistor specifications

SMD resistor specifications differ from one manufacturer to other. For selecting a SMD resistor, one needs to refer to manufacturer ratings.

Some most important specifications are shown below.

Fig 2



a Power rating: The size of the resistor will increase by power rating and current drawn by it. The power rating of resistor should be always smaller than PCB layer current rating. Some power ratings are shown in table.

b Tolerance: SMD resistors are mostly metal oxide film resistor which are having more accurate values. So they mostly having tolerance of 1% to 5%. But in some special applications they may available in less than 1% tolerance.

c Temperature coefficient: SMD are having very good temperature coefficient than normal resistors due metal oxide film material. Generally they may available in 25 to 100 ppm/c.

SMD capacitors

SMD capacitors are mostly used components after SMD resistors in practical electronic circuits. SMD capacitors are similar to general capacitors in construction and the only difference is that instead of leads SMD capacitors have metalized connections at their both ends.

Advantages of SMD over a general capacitors

1. Due no leadless, manufacturers are using different techniques and they are available in small in size.
2. Easy to assemble and mount in automated manufacturing techniques.
3. Less effected by static field and electro-magnetic effects.

Types of SMD capacitors

1. SMD Ceramic capacitors
2. SMD tantalum capacitors
3. SMD electrolytic capacitors

SMD tantalum capacitors

SMD tantalum capacitors are available in different case forms, partly without printed values. The + polarity is marked by white line, or white "M". The case forms depend of capacitance value and nominal voltage.

SMD tantalum capacitors standard sizes are:

3.2 x 1.8 mm

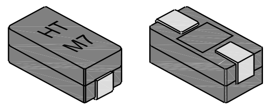
3.5 x 2.8 mm

6.0 x 3.2 mm

7.3 x 4.3 mm

The values are coded with digits, or with alphanumerical characters.

Fig 3



EM20N2315514

They are low cost and smaller size than general capacitors.

Electrolytic capacitors are now being used increasingly in SMD designs. SMD capacitors are available in two types are value marking

1 Direct value printing

2 Coding technique

Generally, SMD ceramic and tantalum capacitors are having coding technique for reading values and they may differ from one manufacturer to other. Most of Electrolytic capacitors are having values with their working voltage printed on their surface because of their large surface area.

SMD diodes and transistors

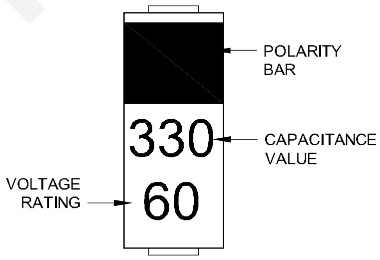
SMD diodes and transistors are available mostly in similar packages. Diodes are available in mainly two forms as shown in below Fig.

Those are

1 Single diode form

a Simple diode b Dual anode c Dual cathode

Fig 4

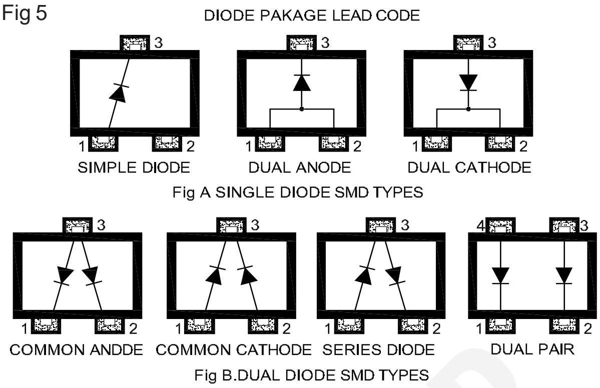


EM20N2315515

2 Dual diode form

a Common anode b Common cathode
c Series diodes d Dual pair

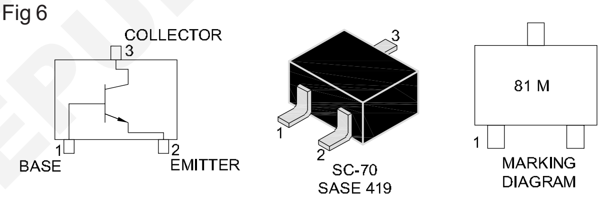
Fig 5



EM20N2315516

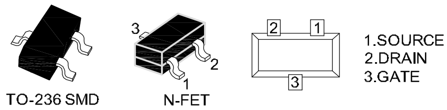
Almost all standard diodes and transistors are available as SMD components in SOT - 23, SOT - 89 and SOT - 143 cases. In general electrical parameters of SMD diodes and transistors are the same as comparable standard types in conventional cases. SOT - 23, and SOT - 143 cases are used for components with power dissipation 200 to 400 mW. SOT - 89 cases are used for power dissipation 500 mW to 1W. SMD LEDs are available in SOT - 23 cases. All SMD transistors are marked with codes.

Fig 6



EM20N2315517

Fig 7



EM20N2315518

Note:

The same mark does not means the same component!

If SMD transistors with the same marks have different case forms their technical specifications are different as well!

SMD Integrated circuits

The first SMD ICs were manufactured on begin 70' for hybrid technique. Nowadays (February 1999) are many of new ICs design manufactured in SMD only.

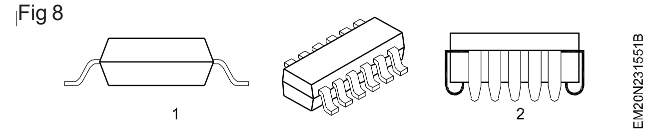
ICs in SMD cases are electrically fully compatible to types in DIL cases therefore both of them have the same marking. The different for SMD (SO-xx case)is only the last character of the mark; i.e. LM 324 N (DIL) = LM 324 D (SO).

SO cases are produced with two different pin forms:

1. pins bent outside of the case

2. pins bent under the case

Fig 8



Pin 1 is marked by a white line on atop of the case or a cut on a front of the case.

Abbreviate the full form of term used in surface Mount technology

SMD **S**urface **M**ounted **D**evices

(active, passive and electromechanical components)

SMT **S**urface **M**ounted **T**echnology

(assembling and montage technology)

SMA **S**urface **M**ounted **A**ssembly.

Solder paste and its Application in SMT

Solder paste or solder cream is simply a suspension of fine solder particles in a flux vehicle. In electronic industry, solder paste is used in surface mount technology (SMT) to solder SMDs on to the printed circuit board, The composition of the particles can be tailored to produce a paste of the desired melting range. Additional metals can be added to change paste compositions for specialized applications. Particle size and shape, metal content and flux type can be varied to produce pastes to varying viscosity. Availability of solder paste

Solder paste is available in both leaded (with lead) and lead-free (with no lead) forms. It can be no-clean or water soluble. With no-clean solder paste, there is not need to clean the board after soldering. Water soluble solder paste is easily soluble in water with no harm.

Reflow solder process Description

The basic reflow solder process consists of: Application of a solder paste to the desired pads on a printed circuit board (PCB) Placement of the parts in the paste. Applying heat to the assembly which causes the solder in the paste to melt (reflow). wet to the PCB and the part termination resulting in the desired solder fillet connection.

A Solder paste the solder paste mixes are improving as the demands of reflow soldering of SMT increase. Selection and specification of the optimum paste is a key item in the reflow solder process.

Explanation about different types of tools & equipments required for SMD soldering and desoldering work

Objectives : At the end of this lesson you shall be able to
- **trainees will be familiar to use the tools and raw materials used to avoid the damage of costly SMD devices and components and ICs due to electrostatic discharge**
- **trainees will be familiar to use tools and equipments and raw materials required to do soldering and desoldering work of SMD components and ICs.**

Tools and equipments required for SMD soldering

Hot air station solder blower

Hot air gun soldering station iron tool solder

It is used to solder and de solder the fine and narrow terminals of SMD components, by setting the suitable temperature and air pressure of hot air blower as per the pad size of the PCB and package size of SMD components. shown in Fig. 1 & 2

Fig 1

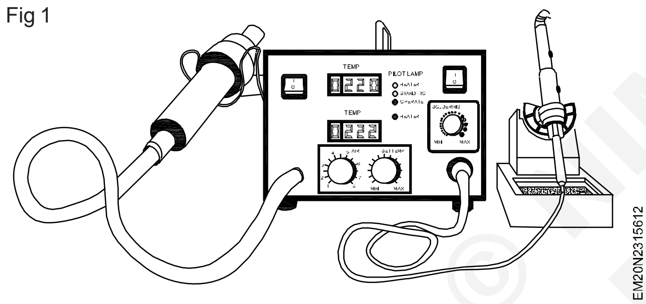
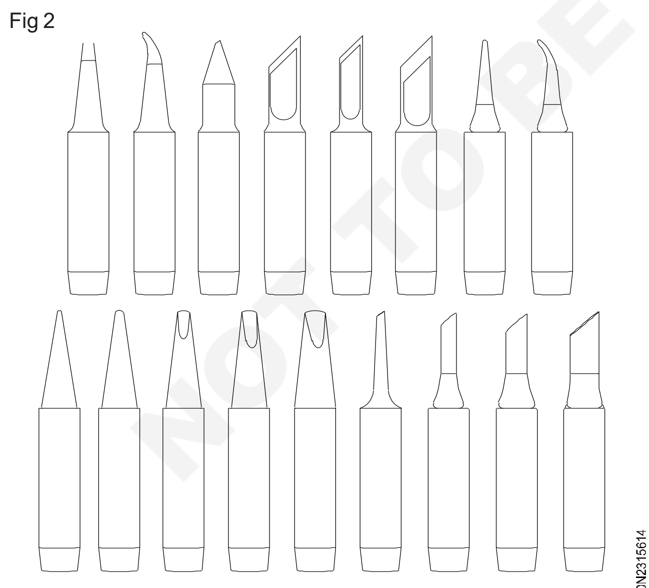


Fig 2

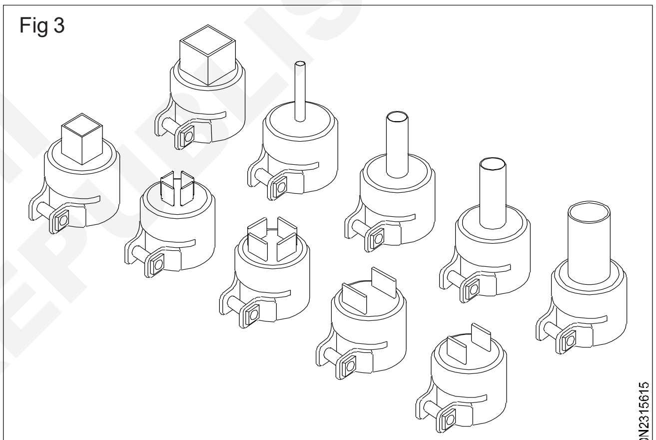


VARIOUS SOLDERING TIPS

Working of SMD Rework station

Rework station is an antistatic soldering station with soldering iron and hot air gun. Rework station recommended. Thermal sensitive electronic component like (QFP, PLCC, SOP etc) Air compressor is located in side the station etc.,) It is useful for the soldering and desoldering the SMD components. shown in Fig.3

Fig 3



DIFFERENT SHAPES OF HOT AIR TIPS

SMD rework system with different temperature profiles and digital display

The hot air pencil has many advantages of the traditional soldering iron : First and foremost, the hot air pencil is completely non - invasive providing precision, pin- pointed, non - contact, low- velocity hot air directly to the individual components leads. as show in Fig. 4

Optional : 5 Distinct stainless steel air tip styles are available for all SMD's

Heated Tweezers : (Optional)

Heated tweezers have more targeted heat transfer than the hot - air rework stations. They provide a fast and efficient method to solder and de-solder SMDs such as chip resistors, chip capacitors, SOTs, flat packs and DIP ICs. as shown in Fig. 5

Fig 4

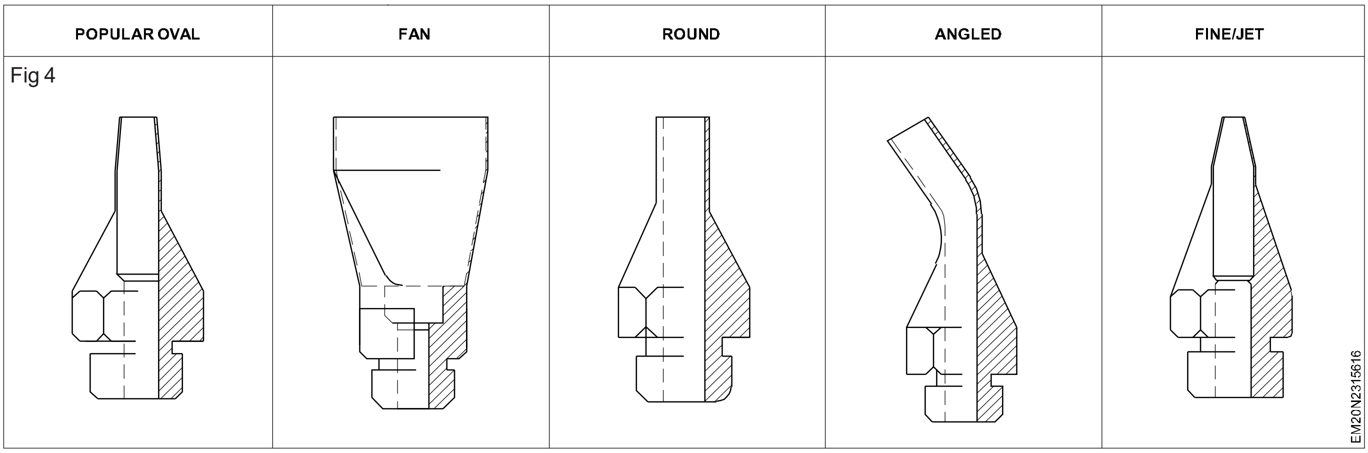
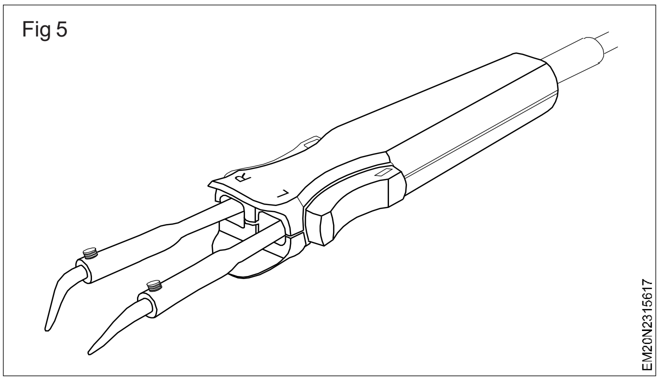


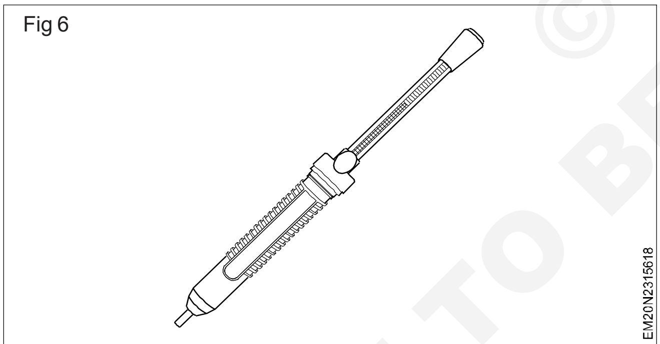
Fig 5



Solder suckers de - soldering pumps

A 'desoldering pump' or more generically referred to as a "solder sucket", is a tool that vacuums molten solder from circuit board assemblies during circuit repairs or component removal. shown in Fig. 6

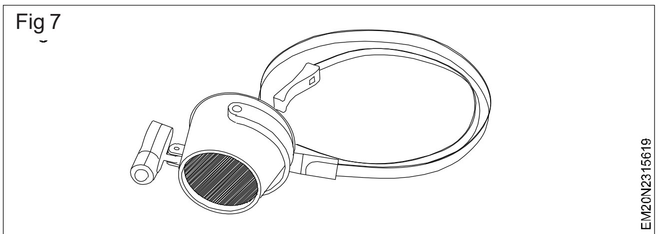
Fig 6



Monocle Magnifier -Illuminated

This loop magnifier set itself apart in your eyes because of the little LED on the side. Trying to view SMD connections is hard enough - the LED on the side is huge help for those want to inspect the connections very closely for proper solder connection. shown in Fig. 7

Fig 7



90° forming tool

Tool cut kink forming

Special tool that cuts and pre-form the component wire in one operation. Length setting is carried out by means of a sliding stop. as shown in Fig.8

90° SMD tweezer

Parallel blades ideal to lift & align chips. Also winding coils & hairsprings. as shown in Fig 9

Fig 8

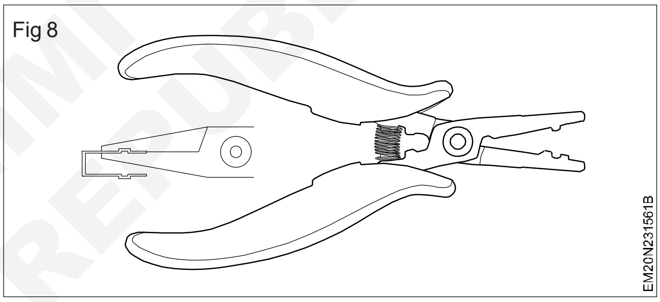
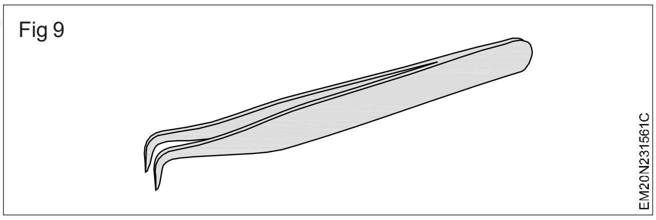


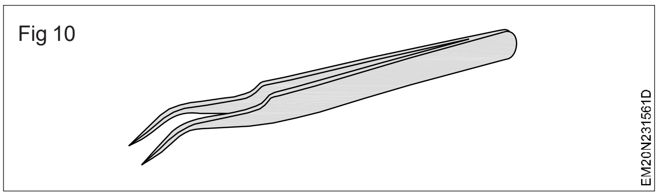
Fig 9



Curved tweezer

Curved (eagle) tweezer for general assembly, permits resting hand on bench. Fine points. as shown in 10

Fig 10



Reverse action tweezer grips and hold parts with less pressure than traditional tweezers. shown in Fig.11.

Parallel paddle tweezer

Smooth, flat, angled parallel paddle tweezer. Great at gripping and lifting IC's & small parts. as shown in Fig.12

Fig 11

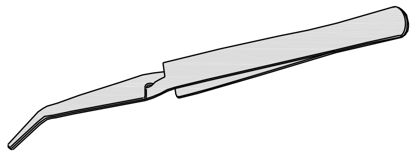
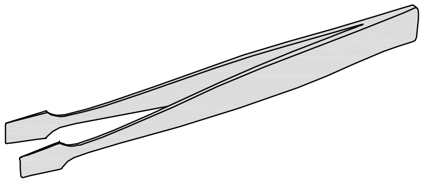


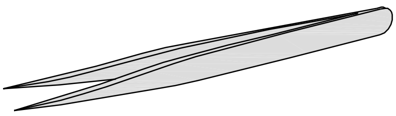
Fig 12



Rounded points tweezer

Round points prevent scratch to delicate parts silicon, crystal & germanium water chips. as shown in Fig. 13

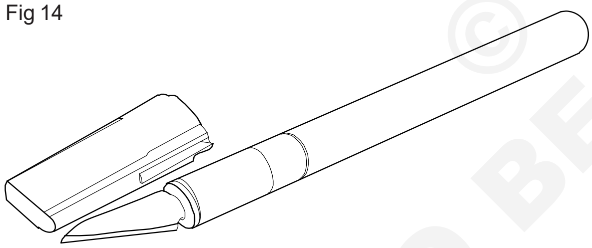
Fig 13



Hobby knife

We use these extensively when working with PCBs. These small knife work well for cutting traces, scraping ground pours, and guiding hair - like wires into their proper place. Excel knife comes with aluminum handle, one ultra - sharp blade, and safety cap. as shown in Fig. 14

Fig 14



Digital multimeter

Smart tweezer (optional) : Measure accurately and easily your SMT components. LCR measurement using smart tweezers. Measure resistance from 0.05 ohm to 10 mega ohm, capacitance 10pF to 5 mF and inductance 1 uH to 1H. It automatically recognize for LCR measure mode. Continuity or open test, Diode test. DC/AC voltage upto +/- 8 volt, reading of main and parasitic impedance components. Measurement of dissipation and quality factors. as shown in Fig. 15

Soldering and desoldering tip temperature thermometer (Optional)

Measure tip temperature quickly, with high accuracy. as shown in Fig.16

Bench fume absorber (optional) as shown in Fig.17

Help to remove harmful fume in soldering area

Fig 15

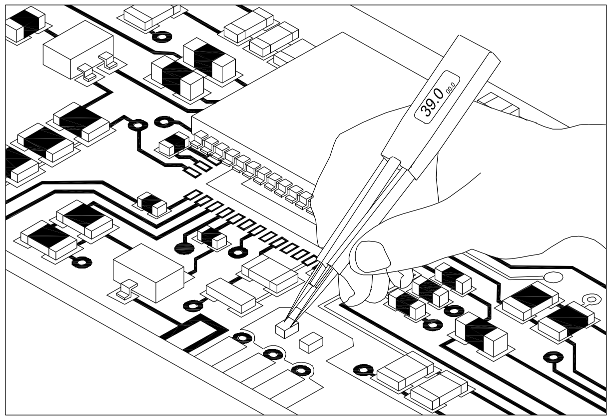


Fig 16

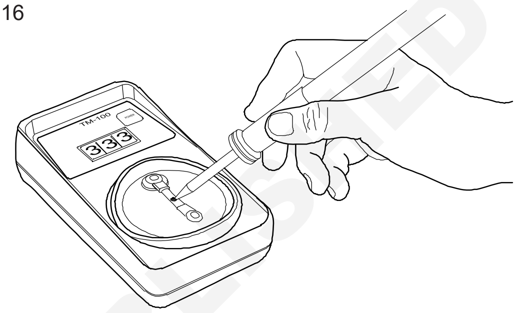
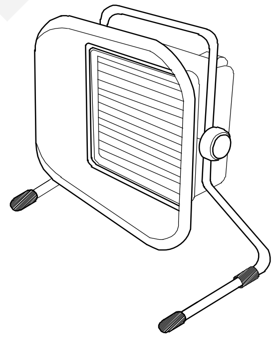


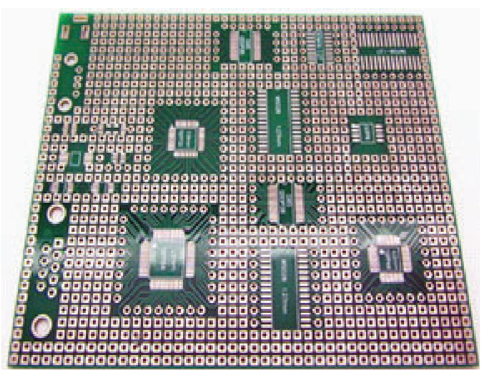
Fig 17



Raw materials

SMD PCB board (single sided and double sided) as shown Fig. 18 & 19

Fig 18



This prototype board supports most kinds of SMD IC package.

TQFP 32 (0.65 mm)

TQFP 48 (0.5 mm)

TQFP 64 (0.5 mm)

SOP 28, SO- 8, SO-14, SO- 16, SOT - 25

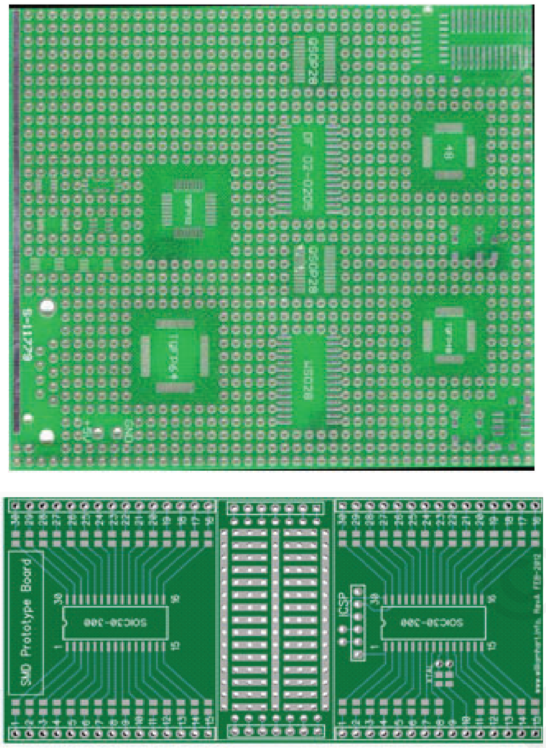
QSOP - 28 (0.65 mm)

DB 9

MSOP - 8, etc

Size : 90 * 110* 1.5 mm

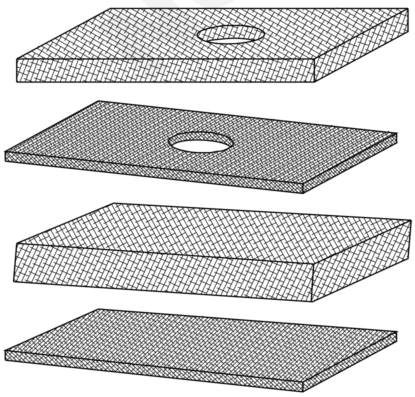
Fig 19



Damp sponge with a hole

A hole in the middle gives you an edge to wipe the iron tip on, and also a place for the used solder to fall into so you are not trying to clean the tip on older debris. We should wet the sponge using distilled water to avoid corrosion of the soldering iron bit. as shown in Fig.20

Fig 20



EM20N231561Z

Dry tip cleaner

A sponge replacement, these soft, metal coils are coated with flux and clean soldering iron tips without thermally shocking them like a wet sponge does. This helps to prolong tip life. Also, this cleans more effectively than a sponge. To clean, thrust the iron into the coils a few times. as shown in Fig. 21

Do not scrape the tip on the coils because this can fling molten solder.

Flux : The key to surface mount soldering

Flux removes oxides from metal that prevent solder from bonding to it, and also helps to distribute heat. During typical soldering with flux - cored, solder wire, all the flux you need is contained in the solder. When the wire touches a hot connection, the flux flows out, cleans the joint and prevents further oxidation. However, in surface mount soldering, (brace yourself) oftentimes solder is melted on the iron, and then transferred to the joint. During this time, the flux quickly boils off and becomes useless, so additional flux is needed on the connection. If transferring solder in this manner seems questionable, bare in mind that a common process in industry, called wave soldering, is similar. Fluxed boards are slowly passed over a giant wave of molten solder that wicks into the connections.

Fig 21

Flux comes in a large variety of different types and applications. It is recommend using a rosin based, RMA (Rosin Mildly activated), clean the flux soon after soldering because the residues quickly harden. “No - clean” fluxes have very low activation levels, and are therefore less effective than activated fluxes, but will work fine on clean parts. as shown in Fig. 22.

Use no - clean flux if you are making circuits space applications or if you use water soluble flux, the residues are corrosive, and should be removed with warm water.

Solder wire spool holder, soldering wire rack, solder wire dispenser

No clean solder wire has a no - clean flux core and is terrific for all your PCB soldering including both through-hole and surface mount. Ideal for prototyping, low - volume runs, and printed circuit board rework at the bench.

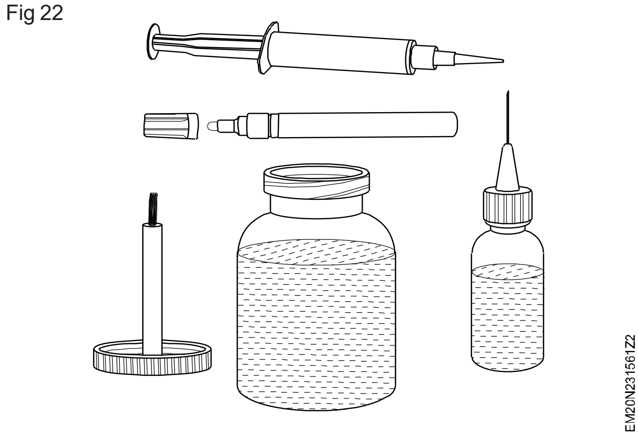


Fig 22

Solder paste with lead

Zero lead - solder paste is your Rohs compliant, as shown in Fig. 23 lead - free solder paste perfectly harmonizing its rich tin, silver and copper alloy with an effective no - clean flux 'carrier' yielding simply superb wetting characteristics and premium solder joints with an attractive satin finish.

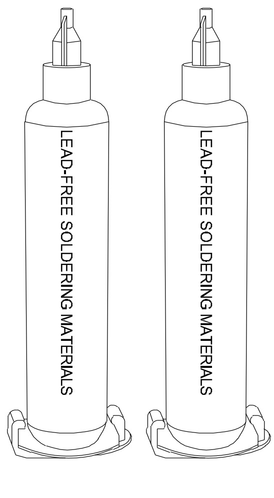


Fig 23

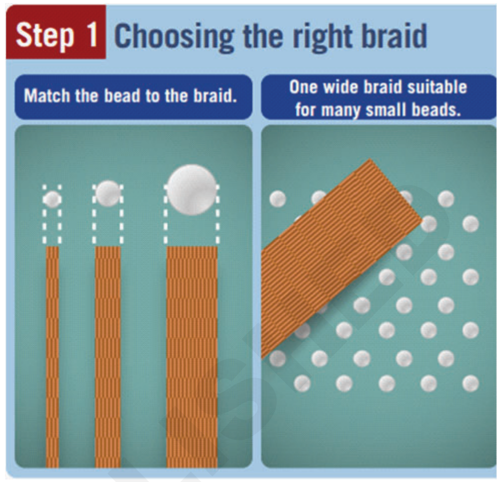
Zero lead solder paste was developed specifically for the electronic bench top and is ideal for rework, low volume production. This consists of tiny solder balls floating in gel - like flux. Once paste is applied to the pads, chips are placed on top, and the board is "reflowed" (paste melted) in a toaster oven or with hot air. Paste can be applied using the syringes shown or with a squeegee and stencil. Note that paste in syringes usually has slightly less metal content to help it flow through small needles. Get paste in a air if you are using a stencil. The main choice to make is between no - clean or water soluble paste. No clean flux is recommended unless you have reason to believe your components are difficult to solder old and possibly corroded. The residues from water - soluble paste are corrosive, so be sure to clean them with warm water.

If you get a syringe, you will likely have to buy a needle and plunger, too A 22 gauge needle is a good starting place, and you can always lay a thicker bead of paste just by pushing more out.

Desoldering braid

De - soldering is required when electronic components need to be removed from a circuit, usually because they are faulty. It may sometimes be necessary during testing or assembly, if a wrong parts has been fitted or a modification has to be made. To professionally remove solder from a circuit, you will need for the following materials. as shown in Fig. 24

Fig 24



1 De -soldering barid

2 Soldering iron

Step 1 : Choosing the right braid

- Choose a braid width the matches the size of the solder bead to be removed.
- If there are many small beads, choosing a wider braid will also speed up the desoldering process.

Step 2 : Using the braid

a. Heat up soldering iron as shown in Fig. 25

b. Place super wick on to solder bead

c. Place heated solder iron on to braid

Fig 25

Molten solder is drawn up by capillary action into the braid. Careful not to overheat, or 'drag whiskers' of solder over the board, not let the braid solidity on the joint. Always remove braid and solder iron together in a vertical motion.

a) Heat up soldering iron

b) Place super wick on to solder bead

c) Place heated solder iron on to braid

- The desoldering braid is treated with a flux coating that once used will no longer draw in the molten solder, so you will need to unspool new braid as you desolder several joints.
- Always hold the braid by the bobbin on which it is spooled because the copper does conduct heat and can cause burns if handled directly.

Soldering guns and its types

Objectives : At the end of this lesson you shall be able to
- **explain soldering guns and its types**
- **describe the selection of soldering guns**
- **define tips and its types.**

Soldering guns

A **soldering gun** is an approximately pistol-shaped, electrically powered tool for soldering metals using tin-based solder to achieve a strong mechanical bond with good electrical contact. The tool has a trigger-style switch so it can be easily operated with one hand. The body of the tool contains a transformer with a primary winding connected to mains electricity when the trigger is pressed, and a single-turn secondary winding of thick copper with very low resistance. A soldering tip, made of a loop of thinner copper wire, is secured to the end of the transformer secondary by screws, completing the secondary circuit. When the primary of the transformer is energized, several hundred amperes of current flow through the secondary and very rapidly heat the copper tip. Since the tip has a much higher resistance than the rest of the tubular copper winding, the tip gets very hot while the remainder of the secondary warms much less. A tap on the primary winding is often used to light a pilot lamp which also lights the work piece.

Soldering iron types

- Simple iron
- Cordless iron
- Temperature-controlled soldering iron
- Soldering station
- Soldering tweezers

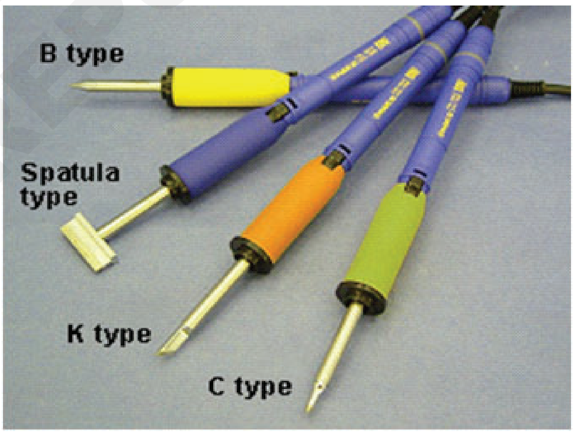
Simple iron

For electrical and electronics work, a low-power iron, a power rating between 15 and 35 watts, is used. Higher ratings are available, but do not run at higher temperature; instead there is more heat available for making soldered connections to things with large thermal capacity, for example, a metal chassis Some irons are temperature-controlled, running at a fixed temperature in the same way as a soldering station, with higher power available for joints with large heat capacity. Simple irons run at an uncontrolled temperature determined by thermal equilibrium; when heating something large their temperature drops a little, possibly too much to melt solder.

Cordless iron

Small irons heated by a battery, or by combustion of a gas such as butane in a small self-contained tank, can be used when electricity is unavailable or cordless operation is required. The operating temperature of these irons is not regulated directly; gas irons may change power by adjusting gas flow. Gas-powered irons may have interchangeable tips including different size soldering tips, hot knife for cutting plastics, miniature blow-torch with a hot flame, and small hot air blower as shown in Fig 1 for such applications as shrinking heat shrink tubing.

Fig 1



DIFFERENT TYPES OF GAS FLOW IRON

Temperature-controlled soldering iron

Simple irons reach a temperature determined by thermal equilibrium, dependent upon power input and cooling by the environment and the materials it comes into contact with. The iron temperature will drop when in contact with a large mass of metal such as a chassis; a small iron will lose too much temperature to solder a large connection. More advanced irons for use in electronics have a mechanism with a temperature sensor and method of temperature control to keep the tip temperature steady; more power is available if a connection is large. Temperature-controlled irons may be free-standing, or may comprise a head with heating element and tip, controlled by a base called a soldering station, with control circuitry and temperature adjustment and sometimes display is as shown in the Fig. 2.

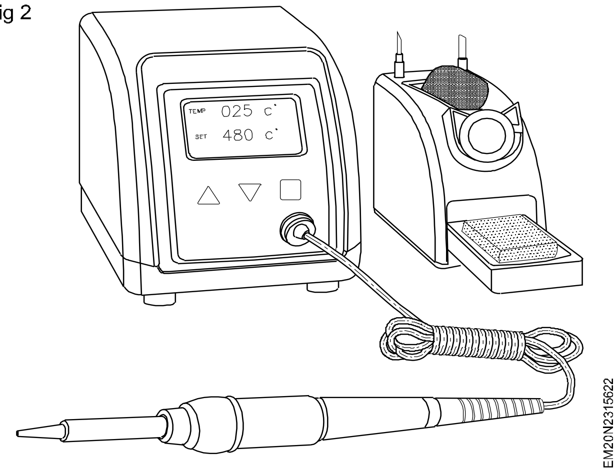


Fig 2

A variety of means are used to control temperature. The simplest of these is a variable power control, much like a light dimmer, which changes the equilibrium temperature of the iron without automatically measuring or regulating the temperature. Another type of system uses a thermostat, often inside the iron's tip, which automatically switches power on and off to the element. A thermal sensor such as a thermocouple may be used in conjunction with circuitry to monitor the temperature of the tip and adjust power delivered to the heating element to maintain a desired temperature.

Soldering station

A soldering station (Fig. 3), invariably temperature-controlled, consists of an electrical power supply, control circuitry with provision for user adjustment of temperature and display, and a soldering iron or soldering head with a tip temperature sensor. The station will normally have a stand for the hot iron when not in use, and a wet sponge for cleaning. It is most commonly used for soldering electronic components. Other functions may be combined; for example a rework station, mainly for surface-mount components may have a hot air gun, vacuum pickup tool, and a soldering head; a desoldering station will have a desoldering head with vacuum pump for desoldering through-hole components, and a soldering iron head.

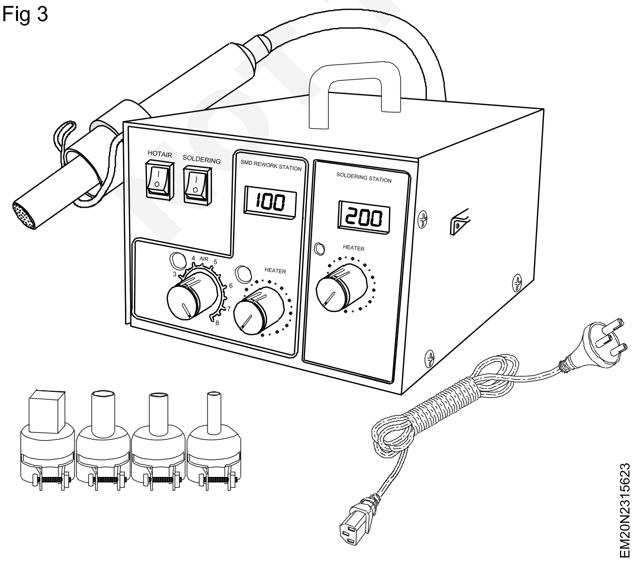
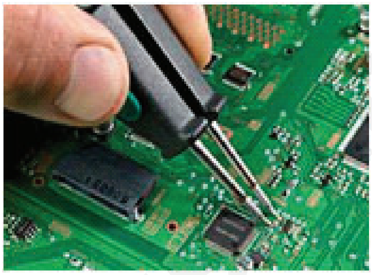


Fig 3

Soldering tweezers

For soldering and desoldering small surface-mount components with two terminals, such as some links, resistors, capacitors, and diodes, soldering tweezers can be used; they can be either free-standing or controlled from a soldering station. The tweezers (Fig. 4) have two heated tips mounted on arms whose separation can be manually varied by squeezing gently against spring force, like simple tweezers; the tips are applied to the two ends of the component. The main purpose of the soldering tweezers is to melt solder in the correct place; components are usually moved by simple tweezers or vacuum pickup.

Fig 4



Soldering tweezers

Selection of soldering guns

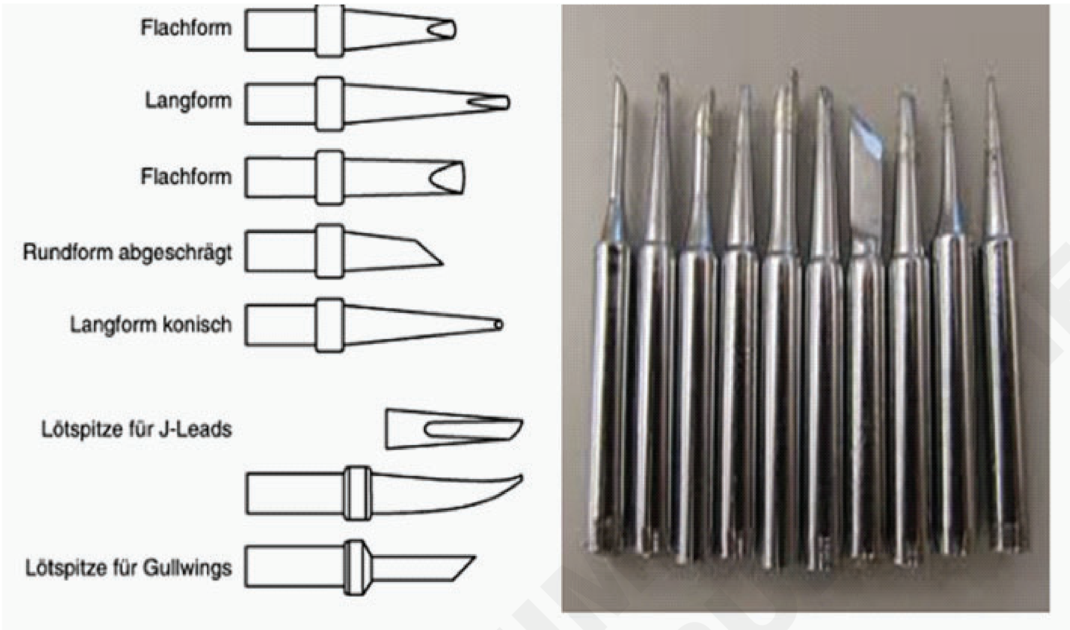
Most soldering "guns" are vastly overpowered for electronics soldering and can easily overheat components or expose them to harmful voltages. However, some people cleverly use them to solder multiple leads on surface mount devices. Soldering "guns" are for plumbing and much heavier duty applications, and are usually over 100 Watts. The "guns" work by passing high currents through the tips, and these currents can generate voltages that damage electronic components. Also, magnetic fields from guns with transformers can damage some electronics. By forming the heating element in the shape of the chip, a soldering gun can be used to heat many leads simultaneously.

Tips and types

Most soldering irons for electronics have interchangeable tips, also known as bits that vary in size and shape for different types of work. Pyramid tips with a triangular flat face and chisel tips with a wide flat face are useful for soldering sheet metal. Fine conical or tapered chisel tips are typically used for electronics work. Tips may be straight or have a bend. Concave or wicking tips with a chisel face with a concave well in the flat face to hold a small amount of solder are available. Tip selection depends upon the type of work and access to the joint; soldering of 0.5mm pitch surface-mount ICs, for example, is quite different from soldering a through-hole connection to a large area. A concave tip well is said to help prevent bridging of closely spaced leads; different shapes are recommended to correct bridging that has occurred. Due to patent restrictions not all manufacturers offer concave tips everywhere; in particular there are restrictions in the USA.

Older and very cheap irons typically use a bare copper tip, which is shaped with a file or sandpaper. This dissolves gradually into the solder, suffering pitting and erosion of the shape. Copper tips are sometimes filed when worn down. Iron-plated copper tips have become increasingly popular since the 1980s. Because iron is not readily dissolved by molten solder, the plated tip is more durable than a bare copper one, though it will eventually wear out and need replacing. This is especially important when working at the higher temperatures needed for modern lead-free solders. Solid iron and steel tips are seldom used because they store less heat, and rusting can break the heating element. (Fig.5)

Fig 5

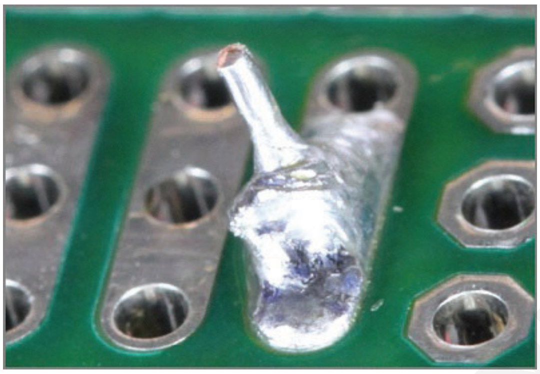


Testing of Cold Continuity of PCB

Objectives : At the end of this lesson you shall be able to
- **cold solder joint/cautions**
- **loose and dry solder, broken tracks repairing.**

A cold solder joint occurs when solder fails to melt entirely to form a proper joint. A cold solder joint or an improperly formed joint can be the trigger for reliability problems of an electronic assembly. Cold solder joints increase the electrical resistance of the solder joints, and hence reduce the reliability of the solder joints. (Fig 1)

Fig 1

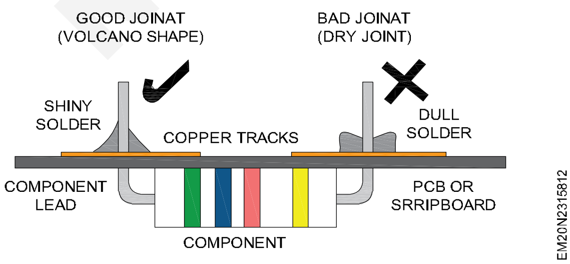


There are a number of factors that can cause cold solder joints. These include:

- Improper melting or reflow or wetting of solder at the joints
- Disturbances such as vibrations while the solder is cooling
- Too high a process temperature causes the flux to break down prematurely
- Too low a process temperature at the solder joint - can lead to incomplete wetting
- Unmatched geometry of the components

Cold solder joints can be detected by visual checking or using a magnifying glass. Primarily, a cold solder joint could look dull, whitish, and convex, or deformed, which is very different from a proper solder joint. (Fig 2)

Fig 2



Another way to detect a cold solder joint is by using a multimeter. Since one of the effects of a cold solder joint is an increase in resistance. A multimeter can be used to test for this - it can be used to test for an increase in electrical resistance or test the continuity of the circuit.

However, the detection of cold solder joints gets more challenging when a lead-free soldering process is used. So it is best to try and avoid these cold solder joints from arising.

Here are a few things that you can do to avoid cold solder joints:

- Use an appropriate reflow profile as per the solder manufacturers specification.
- The peak temperature must be set of at least 15°C above the melting point of the solder alloy for more than 45 seconds.
- Try to identify any vibration sources that can cause the solder to spread unevenly.
- Use a good quality solder paste-alloy analysis should be done to check for contaminants. He cold solder joints can be detected by visual checking or using a magnifying glass. A cold solder joint usually looks dull, whitish, and convex, or deformed, which is very different from a proper solder joint.

This how different a cold solder joint from a proper solder joint.

Fig 3 shows a properly soldered joint that is shining, bright, and concave in shape.

Fig 3

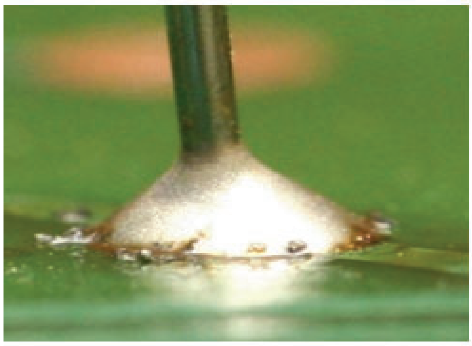
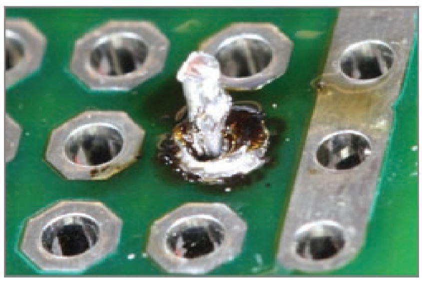


Fig 4 shows a cold solder joint that is dull looking, whitish, convex, and deformed in shape.

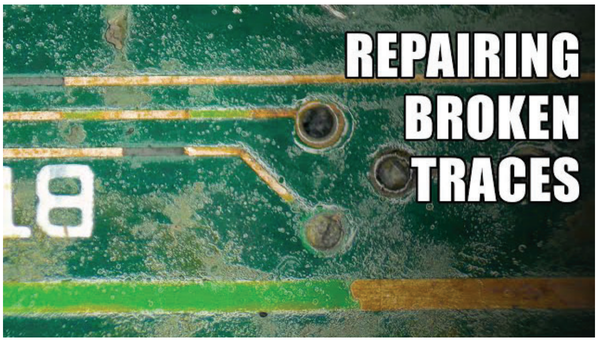
Fig 4



Identification of loose and dry solder, broken PCB

1 How to identify the broken PCB trace?

Fig 5



The traces on a printed circuit board are pathways that conduct electricity and consist of either copper or silver. PCB trace damage that occurs as a result of physical breakdowns or ongoing use can lead to major problems that affect the parts and conductivity of the printed circuit board and the actual device.

There are different causes of trace damage and these include regular wear and tear, overheating, dust, power surges and lightning. If the trace is not hard to see due to being extremely thin, it is generally possible to identify the damage by examining the pathway.

Since silver and copper are naturally bright and conspicuous elements, they are easy to detect when there is a problem. Fixing damaged or defective pathways involves using the right material to solder the board in order to restore the damaged circuit and enable electricity to flow without disruption through the circuit board.

2 How to bridging broken PCB traces with wire?

You won't be angle to solder directly over the broken traces. There's an epoxy coating over most of the metal that solder won't adhere to. You can scrape away the epoxy with an awl or a pick until you get down to bare copper. You'll know when you reach copper, as the color changes from the tint of the PCB to bright, shiny copper like a new penny. Expose a good 1/8 inch or 3mm of the trace, if not a bit more. Clean the area, then apply a bit of flux to the bare copper.

Strip a bit of wire tin the end, then solder the wire to one side of the trace. Cut the wire to length, then strip and tin the other end. Position the wire on the board and apply a bit of tape to hold the wire in place if you need to. Solder the other end, then remove the tape. Let the solder cool, then check to make sure the wire stays in place. You want bright, shiny solder joints, not dull ones. Dull joints indicate both a weak electrical and mechanical bond.

3 What is the process of fixing broken PCB traces?

Mix the epoxy according to the manufacturer's instructions, and apply it sparingly to one side of the PCB Press the two halves of the broken board together, and hold them until the epoxy takes hold““Cut through the broken copper traces using a razor knife Remove all of the““loose traces, and then carefully use the emery cloth to sand the traces from which you removed the loose sections Plug the soldering pencil into a 110-volt receptacle and wait for it to get hot Clean the hot soldering tip by wiping it on a wet soldering sponge““Apply a fresh "Linning coat of rosin-core solder to the clean soldering pencil““tip. A properly tinned tip will be a bright silvery color““Apply the rosin-core solder to the bared copper traces on the printed circuit““board. Use care to apply no more heat than is necessary to melt the solder • Cut pieces of the 18-gauge copper wire that are long enough to span the cut traces, and tin these short lengths of wire with rosin-core solder““• Pick up a piece of tinned wire with the tweezers and lay it carefully across one of the traces where you removed a loose section.““• Reassemble the device and test it to see if it works properly.““

4. How to prepare the soldering for broken PCB traces?

““Next, you will have to prepare the printed circuit board for soldering to reestablish the wired connection between the boards. For this, at first, find a 110V receptacle (power source) and plug in the soldering pencil in it.““Then wait until the soldering pencil becomes hot. When the soldering tip gets hot,““wipe it using a wet soldering sponge. Make sure to plug off the soldering pencil““before wiping it on the sponge. Also, ensure that the tip is free from every dirt and““oxidation for fine soldering later““5. How to layer the wiring of broken PCB traces?““Use tweezers to pick the tinned wires one after one carefully. Then lay the picked wiring right on the traces from where you have removed the loose traces lately After you have layered the copper wining on the traced gaps, you will require““soldering them properly For this, use the soldering pencil tip and fuse the 18-gauge copper wiring accurately in the holes. You will have to repeat the wiring procedure to fill up each loose trace and link the wiring appropriately.

5 How to locate the broken PCB traces?“

Use tweezers to pick the tinned wires one after one carefully. Then lay the picked wiring right on the traces from where you have removed the loose traces lately.

After you have layered the copper wiring on the traced gaps, you will require soldering them properly. For this, use the soldering pencil tip and fuse the 18-gauge copper wiring accurately in the holes. You will have to repeat the wiring procedure to fill up each loose trace and link the wiring appropriately.

How to locate the broken PCB traces?

Use the free millimeter's probe to touch a single spot on the board. Then use your finger with the foil move it over the components touching the soldered part. Thus you will cover more area quicker and when you hear the millimeter beeping - you have found your track on the PCB““

6 How to text he broken PCB traces?

The A stands for the amp which is the unit for electrical current. Test all devices on the circuit board, one at a time, by touching the red and black probes of the millimeter to either side of the device. A zero current reading indicates a short ci.

Surface Mount Technology (SMT)

Objectives : At the end of this lesson you shall be able to
- **explain surface mount technology**
- **describe advantages and disadvantages surface mount components.**

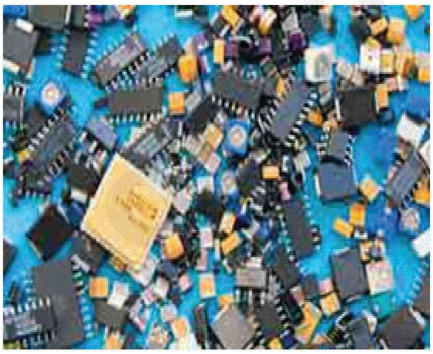
Surface-mount technology (SMT) is a method for producing electronic circuits in which the components are mounted or placed directly onto the surface of printed circuit boards (PCBs). An electronic device so made is called a surface-mount device (SMD). In the industry it has largely replaced the through-hole technology construction method of fitting components with wire leads into holes in the circuit board. Both technologies can be used on the same board for components not suited to surface mounting such as large transformers and heat-sinked power semiconductors.

An SMT component as shown in Fig.1 is usually smaller than its through-hole counterpart because it has either smaller leads or no leads at all. It may have short pins or leads of various styles, flat contacts, a matrix of solder balls (BGAs), or terminations on the body of the component.

Virtually all of today's mass produced electronics hardware is manufactured using surface mount technology, SMT. The associated surface mount devices, and SMDs provide many advantages over their leaded predecessors in terms of manufacturability and often performance.

It was not until the 1980's that surface mount technology, SMT became widely used. Once SMT started to be used, the change from conventional leaded components to surface mount devices, SMDs took place quickly in view of the enormous gains that could be made using SMT.

Fig 1



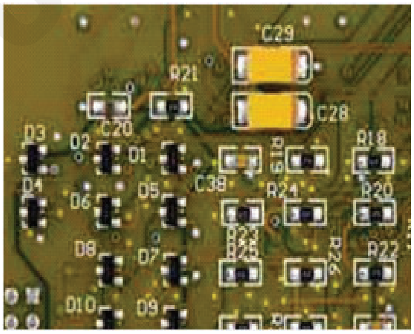
SMT COMPONENT

Mass produced electronic circuit boards need to be manufactured in a highly mechanized manner to ensure the lowest cost of manufacture. The traditional leaded electronic components do not lend themselves to this approach. Although some mechanisation was possible, component leads needed to be pre-formed. Also when the leads were inserted into boards automatically problems were often encountered as wires would often not fit properly slowing production rates considerably.

It was reasoned that the wires that had traditionally been used for connections were not actually needed for printed circuit board construction. Rather than having leads placed through holes, the components could be soldered onto pads on the board instead. This also saved creating the lead holes in the boards which added cost to the production of the bare PCBs.

As the components were mounted on the surface of the board, as shown in the Fig. 2, rather than having connections that went through holes in the board, the new technology was called surface mount technology or SMT and the devices used were surface mount devices, SMDs. The idea for SMT was adopted very quickly because it enabled greater levels of mechanisation to be used, and it considerably saved on manufacturing costs.

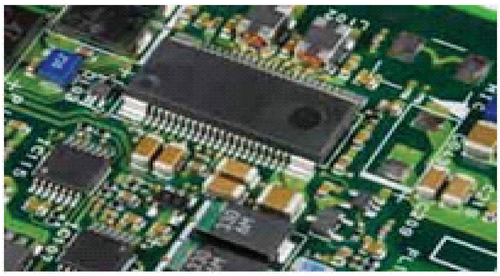
Fig 2



TYPICAL SMT BOARD WITH TRANSISTORS, AND PASSIVE COMPONENTS

To accommodate surface mount technology, SMT, a completely new set of components was needed. New SMT outlines were required, and often the same components, e.g. ICs were sold as shown in Fig. 3 in both traditional leaded packages and SMT packages. Despite this, the gains of using SMT proved to be so large that it was adopted very quickly.

Fig 3



ICS WERE SOLDERED IN PCB BOARD

Transistors and diodes: These components are often contained in a small plastic package. The connections are made via leads which emanate from the package and are bent so that they touch the board. Three leads are always used for these packages. In this way it is easy to identify which way round the device must go.

Integrated circuits: There is a variety of packages which are used for integrated circuits. The package used depends upon the level of interconnectivity required. Many chips like the simple logic chips may only require 14 or 16 pins, whereas other like the VLSI processors and associated chips can require up to 200 or more. In view of the wide variation of requirements there is a number of different packages available.

Advantages

The main advantages of SMT over the older through-hole technique are:

- Smaller components. As of 2012 smallest was 0.4 × 0.2 mm (0.016 × 0.008 in: 01005). Expected to sample in 2013 are 0.25 × 0.125 mm (0.010 × 0.005 in, size not yet standardized)
- Much higher component density (components per unit area) and many more connections per component.
- Lower initial cost and time of setting up for production.
- Fewer holes need to be drilled.
- Simpler and faster automated assembly. Some placement machines are capable of placing more than 136,000 components per hour.
- Small errors in component placement are corrected automatically as the surface tension of molten solder pulls components into alignment with solder pads.
- Components can be placed on both sides of the circuit board.
- Lower resistance and inductance at the connection; consequently, fewer unwanted RF signal effects and better and more predictable high-frequency performance.
- Better mechanical performance under shake and vibration conditions.
- Many SMT parts cost less than equivalent through-hole parts.
- Better EMC performance (lower radiated emissions) due to the smaller radiation loop area (because of the smaller package) and the smaller lead inductance

Disadvantages

- Manual prototype assembly or component-level repair is more difficult and requires skilled operators and more expensive tools, due to the small sizes and lead spacing of many SMDs.
- SMDs cannot be used directly with plug-in breadboards (a quick snap-and-play prototyping tool), requiring either a custom PCB for every prototype or the mounting of the SMD upon a pin-leaded carrier. For prototyping around a specific SMD component, a less-expensive breakout board may be used. Additionally, strip board style proto boards can be used, some of which include pads for standard sized SMD components. For prototyping, "dead bug" bread boarding can be used.
- SMDs' solder connections may be damaged by potting compounds going through thermal cycling.
- Solder joint dimensions in SMT quickly become much smaller as advances are made toward ultra-fine pitch technology. The reliability of solder joints becomes more of a concern, as less and less solder is allowed for each joint. Voiding is a fault commonly associated with solder joints, especially when re- flowing a solder paste in the SMT application. The presence of voids can deteriorate the joint strength and eventually lead to joint failure.
- SMT is unsuitable for large, high-power, or high-voltage parts, for example in power circuitry. It is common to combine SMT and through-hole construction, with transformers, heat-sinked power semiconductors, physically large capacitors, fuses, connectors, and so on mounted on one side of the PCB through holes.
- SMT is unsuitable as the sole attachment method for components that are subject to frequent mechanical stress, such as connectors that are used to interface with external devices that are frequently attached and detached.

Classification of SMD IC packages

Objective : At the end of this lesson you shall be able to
- **identify different types SMD IC packages depends upon their size & pin details.**

Package classifications

Packaging trends

Integrated circuits are classified into LSI, VLSI and ULSI is recent years

With increased functions and pin counts, IC packages have had to change significantly in the last few years in order to keep - up with the advancement in semiconductor development.

Functions required for conventional IC packages are as follows.

1 To protect IC chips from the external environment
2 To facilitate the packaging and handling of IC chips
3 To dissipate heat generated by IC chips
4 To protect the electrical characteristics of the IC

Standard dual - in - line packages (DIP), which fulfill these basic requirements, have enjoyed wide usage in the electronics industry for a number of years

With increasing integration and higher speed ICs, and with the miniaturization of electronic equipment, newer packages have been requested by the industry which incorporate the functions listed below.

1 Multi- pin I/O
2 Ultra- miniature packages
3 Packages suited to high density ICs
4 Improved heat resistance for use with reflow soldering techniques.
5 High through put speed
6 Improved heat dissipation
7 Lower cost per pin

Classification of ICS by the mounting method

Through - hole mount packages

Through hole packages have a structure in which the lead pins are inserted and soldered into holes (0.8 to 1.0 mm in diameter) drilled through the printed circuit (PC) board, and find wide applications in electronic equipment where board space is not at a premium or where costs are a constraint.

DIPs, and PGAs (pin grid array) are typical packages in this group.

Surface mount packages

Surface mount packages have a flat structure in which the lead pins are soldered directly to the soldered pattern (called the mount pad) provided on the PC board, and are used in high - pin - density IC package situations because devices can be mounted on both sides of the PC board. QFPs and QFJs (PLCC) are typical packages in this group.

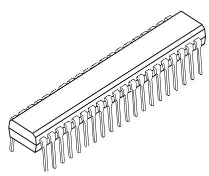
Custom packages

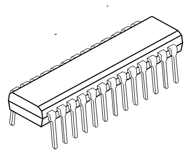
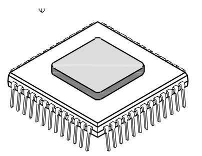
Memory modules are packages which have several memory ICs mounted on a PC board, Tape carrier packages (TCP) using tape automated bonding (TAB) techniques, chip on board (COB) packages, or IC cad packages. TCP and COB packages are custom designs conforming to the customer's specifications.

Classification by package materials

Packages are broadly classified into ceramic and plastic packages. Package materials can be selected according to their application or operating environment.

Ceramic packages are known for their high reliability, but plastic packages are becoming more popular due to their low cost (when compared to ceramic packages). Reliability has improved considerably in the last few years marking plastic a very attractive alternative to ceramic.

Type		Package types		Package symbol		Pin count
				Old	New	
Through hole mounting type	Ceramic	Standard DIP		AS	AA	16, 16, 18, 20, 22, 24, 28, 40, 42, 48

		CER- DIP		AS	AB	8, 14, 16, 18, 22, 24,, 28, 32, 40, 42
		PGA		AS	BA	73^{+2},88133^{+2},177^{+2}, 209^{+2}, 257^{+2}_{+1},301^{+2}, 240,365^{+2}, 400

The PGA pin count includes a pin for preventing incorrect insertion.

Package Name	Characteristics
Dual in - line package	DIP packages are hermetic ceramic package. The lead pitch is 2.54mm (100 mil) and the package body is made of ceramics. Metal or glass may be used as a sealing material.
Dual in - line package (Glass sealed)	Dual in - line package are called “CER-DIP” package. The lead pitch is 2.54 mm (100 mil) and the package body is molded with powder ceramics. The sealing materials is glass.
Pin grid array	PGA packages are featured by the leads which are drawn out vertically from each package body and arranged on the spcified grid. The package body is made of ceramic, and the standard lead pitch is 2.54 mm (100 mil). PGA packages are suited to multi pin packaging.

SMD integrated circuits family

Packages type for surface mount integrated circuits can be grouped into families.

The flat pack is old technology.

The QUAD flat pack and TSOP use newer technology.

Each family has certain characteristics in common such as lead style, lead pitch, body size and case materials. as shown in Fig. 1 & 2

SMD IC family overview

Package classifications

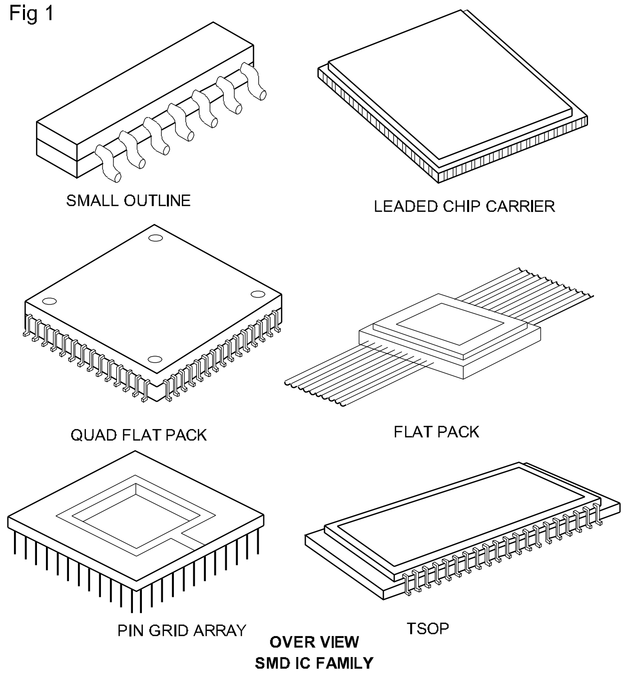
Lead styles

SMD integrated circuits have three types of basic leads. They have their name depends upon their shape.

Gull - wing leads are small and quite fragile. They can easily be damaged and must be handled with great care.

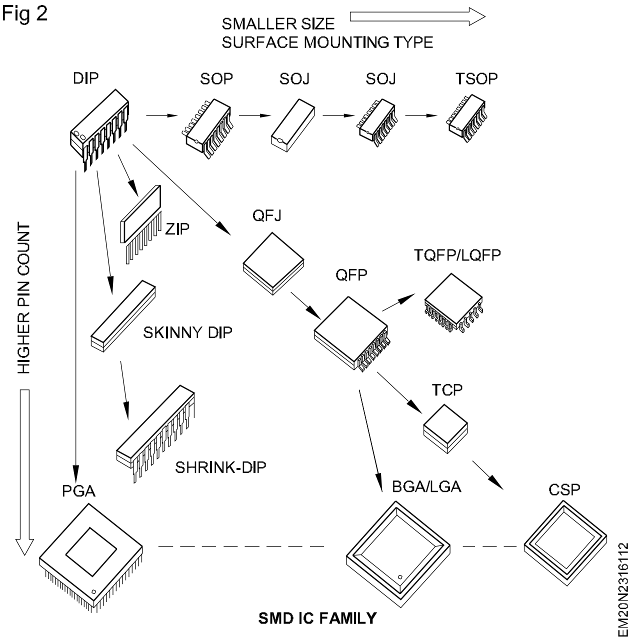
Gull - wing leads are used to get the highest number of leads onto an IC. It is possible to get 40 to 80 leads per linear inch (15 to 33 leads per cm) onto an IC using gull-wing leads. Gull - wing leads are easy to inspect after soldeirng.

Fig 1



OVER VIEW
SMD IC FAMILY

Fig 2

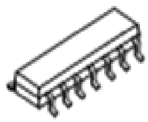
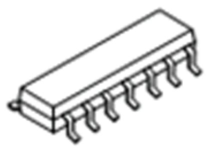
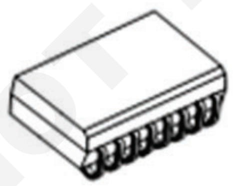


J - leads are more sturdy than gull - wing leads, however, they take up more space. With J- leads, you can only get 20 leads per linear inch (8 leads per cm) on an IC package.

Flat leads are also used on ICs. Flat leads must be stored in special carriers to prevent lead damage.

Just prior to use, IC's with flat leads are cut and bent into gull - wings by using lead forming equipment. Lead forming equipment is an extra expenses. Therefore, flat leads are the least popular type of IC lead.

The words lead pitch are synonymous with lead space

Small outline, Integrated circuit				
Drawing		**Nomenclature**	**Body width**	**Lead type**
8-16 PIN		SO = Smal outline	156 mil	
8-16 PIN		SOM = Medium outline	220 mil*	Gull 50 mil pitch
16-32 PIN		SOL = "Large" outline SOP = "Small" outline package	300 mil	
16-40 PIN		SOJ or SOL - J = "J" - Lead large outline	300 mil*	J- Lead 50 mil
32-56 PIN		VSOP = Very small outline package	300 mil	Gul wing 25 mil

8-30 PIN		SSOP= Shrink small outline package	208 mil	Gull wing 25 mil
20-56 PIN		QSOP = Quarter small outline package	156 mil	Gull wing 25 mil

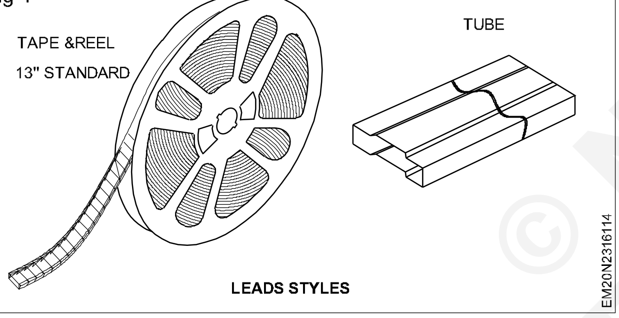
Note : The length of the body is determined by the number of leads.

SOIC packaging

13 inch (330 mm) reels are standard for SOICs. The carrier tape is always plastic and measures 12 mm to 32 mm in width depending on the IC package size.

SOIC's are also readily available in plastic tubes. These tubes are sometimes called magazines or sticks. as shown in Fig. 4

Fig 4



Tape & Reel 13" standard

Tube

TSOP thin small outline package

The TSOP (Thin small outline package) combines a low profile package (1.0 mm high) with fine - pitch 19.7 mils (.5mm) leads.

The TSOP provides a package which accommodates a large silicon chip in a high density package.

TSOP's are usually shipped in trays; however, tape and reel and tubes are available on special request.

The overall dimensions of TSOPs include the leads (total footprint). as shown in Fig. 5 & 6.

Fig 5

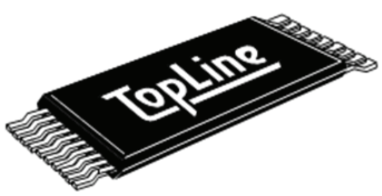
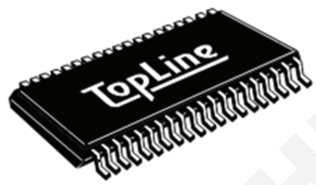


Fig 6



Type 11 20 to 56 lead 0.5 mm pitch

Type 12 20 leads 1.27 mm pitch

PLCC leaded chip carrier

The plastic body PLCC is the most popular leaded chip carrier. Its J - leads are always 50 mil (1.27 mm) pitch. They are commonly available from 18 to 100 leads. PLCC's are usually supplied in tubes or on tape and reel.

As an alternative to the plastic case, leaded chip carriers are available in ceramic, known as CLCC, and metal, known as MLCC.

PLCCs fit into IC sockets and can be easily replaced in the field.

PLCCs have been in use for over a decade and are now a common item. as shown in Fig.7

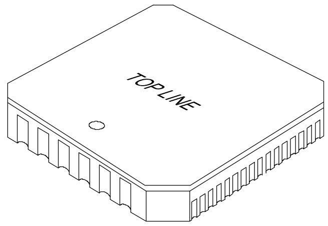
Fig 7

- Fits into IC sockets
- T & R or tubes
- Trends - PLCC is common item to new development

LCC (leadless chip carrier)

The ceramic LCC is one of the most rugged packages since it has no leads. LCCs are soldered directly to PC boards by their solder pads, known as castellations. Most LCCs come with 50 mil pitch gold castellations which must be pre - coated with solder before mounting. as shown in Fig. 8

Fig 8



LEADS STYLES

EMN3218448

LCCs are usually designed for mill spc, aerospace and high temperature applications.

LCC's are shipped in either trays or tubes.

Sometimes LCC's are called LCCC (Leadless ceramic chip carrier)

- LCC
- Solderable castellation pads
- 16 Pin to 44 pin (up to 124 pin)
- Rugged, no leads to bend
- Ceramic body
- High temp & mil spec. applications
- Usually tubes or trays

Quad flat pack nomenclature

There are many variations of quad flat packs depending on package materials (plastic, ceramic or metal) and other standards.

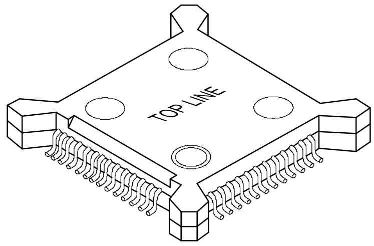
Nomenclature

- QFP - Quad Flat Pack
- PQFP - Plastic Quad Flat Pack
- CQFP - Ceramic Multilayer QFP
- CERQUAD - Ceramic Quad Flat Pack
- MQUAD - Metal Quad Flat Pack
- MQFP - Metric Quad Flat Pack
- TQFP - Thin Quad Flat Pack
- TAPEPAK - Molded Carrier Ring
- BQFP - Bumpered Quad Flat Pack
- LQFP - Low Quad Flat Pack

BQFP - Bumpered Quad Flat Pack

The bumpered quad flat pack is built to American JEDEC standards using true inch measurements. This means that 25 mil lead pitch is truly 5 mils (.636 mm not .65 mm) as shown in Fig. 9.

Fig 9



LEADS STYLES

EMN3218449

The purpose of the bumpered corners is to protect the leads during shipping, handling and assembly.

BQFPs are constructed in a plastic package; however, they are also available with metal case, known as the BMQUAD.

BQFPs always have gull - wing leads and are shipped in trays, tubes or on tape and reel.

- JEDEC standard (USA)
- Bumpered corners - Protects leads
- Gull - wing
- Up to 196 leads
- Package options - Trays, tubes and T & R
- True 25 mil (.636 mm) pitch

Flip chips

Flip chips are bare die with small solder bumps on the bottom which serve as "leads".

The flip chip is soldered directly to a PC board (FR4 or ceramic) by placing the component on the board and applying heat. The solder bumps melt to corresponding pads on the PC board.

The following solder type (Eutectic) is used for the bumps:

FR4 boards 63% - 37% low melt (183°C)

Ceramic boards : 95% - 5% requires high temp.

Bump on the die are around the perimeter and also in the middle.

Since the parts are small, dimensions are specified in "microns" not millimeters.

100μm = 1 millimeter

Important package specifiers

A Die size

B Number bumps

C Diameter of bumps

D Solder composition of bumps

E Bump pitch

Package symbols and codes

1) Package code (New package code)

The package codes given on the outline view are those specified in ED - 7303 (General rules for integrated circuits package name and code) established by electronic industries association of Japan (EIAJ) as shown below

□-□□□ □□□ □□□□-□□□□x □□□□-□□□□-□□□

1 2 3 4 5 6 7

1 Package material

2 Package structure characteristics

3 Package name

4 Number of package leads

5 Reference package dimensions

6 Lead pitches

Examples

1 P-HQFP 208-40 x 40-0.65 - K (HQFP 208- P-4040-0.65-K) this indicates a plastic QFP type package with a heat sink, consistingof 208 leads with a package body size of 40 mm x 40 mm and a normal bending lead pitch of 0.65 mm.

2 P-DIP 42-13.7 x 51.98-2.54 (DIP42-P-600-2.54) This indicates a plastic DIP type package consisting of 42 leads with package body width of 13.7mm package body length of 51.98 mm and a lead pitch of 2.54 mm.

Package Names

Code	Package Name
QFP	Quad Flat Package
QFJ	Quad Flat J-Leaded Package
DIP	Dual in -line Package
SOP	Small Out-Line Package
SOJ	Small Out-line J-Leaded Package
ZIP	Zigzag in- line Package
PGA	Pin Grid Array
BGA	Ball Grid Array
LGA	Land Grid Array

Number of Package Leads (Typical Example)

Code	Package Name
0008	8
0014	14
0064	64
0144	144
0256	256

Package Material

Code	Material	Applicable Package
C	Ceramic	Multi-layer ceramic package
G	Ceramic	Hermetic ceramic package sealed with glass
P	Plastic	Package molded with resin

QFN - Quad flat no leads

The Quad flat no leads package, or QFN is a very small square - shaped or rectangular surface - mount plastic package with no leads. It is basically a quad flat package, except for the absence of leads protruding from its sides. Meta pads or lands around the periphery of the bottom of the QFN package service as electrical connection points to the outside world. Because the QFN has no leads an has shorter bond wire lengths, it exhibits less inductance than leaded packages and therefore provides a higher electrical performance. The QFN package also includes an exposed thermal pad at the package bottom to facilitate heat dissipation from the die. as shown in Fig. 10a & 10b.

Fig 10a

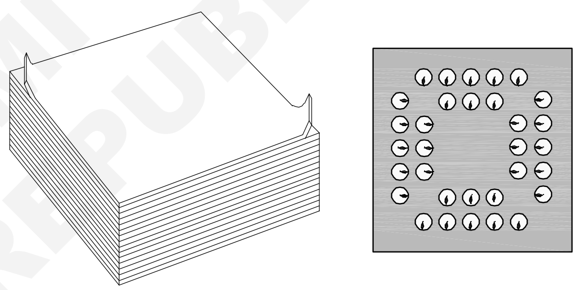
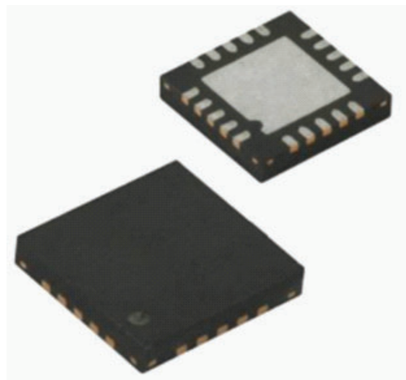


Fig 10b



Ceramic package, or cerpack

The ceramic package, or cerpack, is a hermetically sealed rectangular ceramic package that has leads extending from both of its longer sides, thus forming two sets of in - line pins. It is therefore a type of dual -in-line package (DIP) like the CerDIP. as shown in Fig.11.

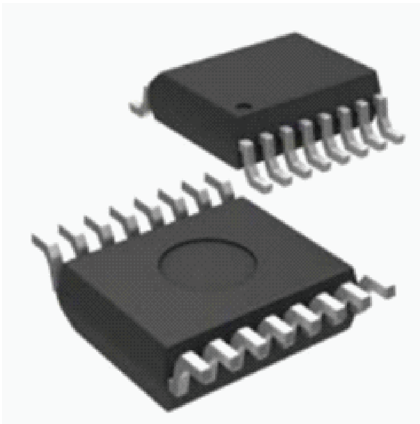
QSOP Quarter size outline package

The quarter size outline package, or QSOP is a small rectangular surface - mount plastic package with gull wing leads protruding out of its longer sides. The QSOP

Fig 11

comes in two standard body widths; the narrow body QSOP which has a nominal body thickness of 150 mils and the wide body QSOP which has a nominal body thickness of 300 mils. Typical QSOP lead counts range from 16 to 28 leads for the narrow body and 36 to 44 leads for the wide body. The QSOP lead pitch is typically 25 mils. as shown in Fig. 12.

Fig 12

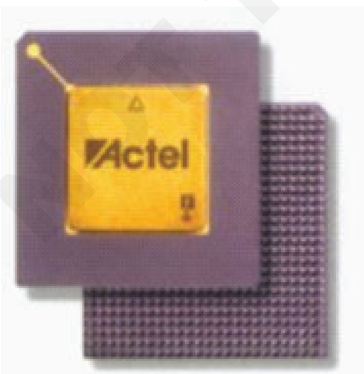


General notes on IC packages

Ceramic column grid array, or CCGA

The Ceramic column grid array, or CCGA is a square - shaped or rectangular ceramic package that uses solder columns for external electrical connection instead of leads or solder balls. These solder columns are arranged in a grid or array at the bottom of the ceramic package body, hence the name 'ceramic column grid array. The CCGA is basically just a CBGA package that has solder columns instead of solder balls. as shown in Fig. 13

Fig 13



PSOP - Power small outline package

The power small outline package, or PSOP is a rectangular small outline IC package developed by amkor that integrates a copper heat slug in its plastic body. The die is attached to this heat slug, increasing the chip's ability to dissipate heat and thus handle more power. as shown in Fig. 14

CLCC or LCC - Ceramic leadless chip carrier

The ceramic leadless chip carrier, or CLCC or LCC, is a square or rectangular surface mount ceramic package that has no leads. For electrical connection to the outside world, the LCC instead uses flat metal contacts (or metallized castellations) known as pads around the four sides of the package bottom. as shown in Fig. 15

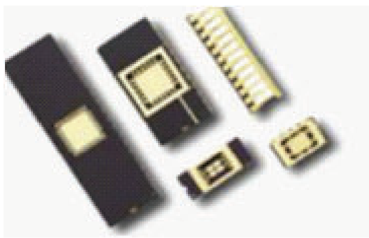
Fig 14

Fig 15

Side braze package

The side braze package, is one of the most mature IC packages still in use today. It is a rectangular ceramic package that has leads extending from both of its longer sides, thus forming two sets of in-line pins. It is therefore a type of dual - in line package (DIP). Two other widely used DIP's are the PDIP and the CerDIP. as shown in Fig. 16.

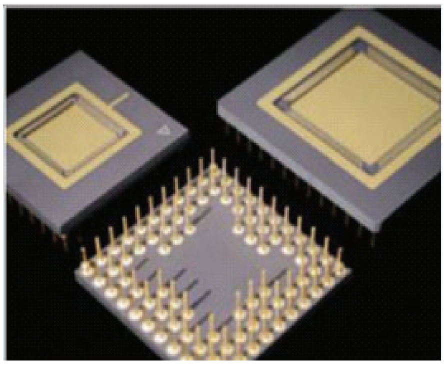
Fig 16



CPGA Ceramic pin grid array

The ceramic pin grid array, or CPGA is a square or rectangular through- hole ceramic package whose pins or leads are arranged in a square array at the bottom of the package body. The CPGA can either have a first - sealed ceramic lid or a solder - sealed metal lid. The CPGA is just one of several types of the PGA package. The PGA is a popular choice for devices with high I/O counts such as microprocessors because of its high pin density. as shown in Fig. 17.

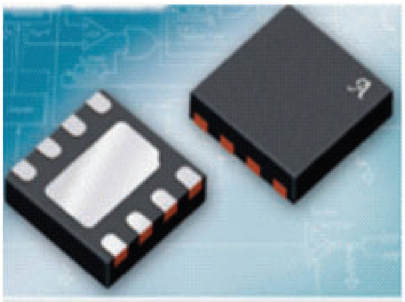
Fig 17



DFN- Dual flat no leads

The Dueal flat no leads package, or DNF is a very small square - shaped or rectangular surface - mount plastic package with no leads. Metal pads or lands along two sides of the bottom of the DFN package serve as electrical connection points to the outside world. The DFN is similar to the QFN, except that the latter has lands all around the periphery of the package instead of just two sides like the DFN. as shown in Fig. 18.

Fig 18



DPAK - Decawatt package

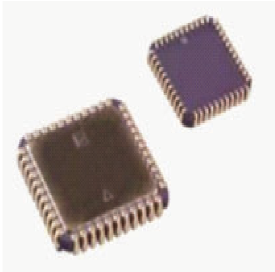
The Decawatt package, or DPAK is an IC package developed by motorola to encase discrete high - power devices. The DPAK is also known as the TO-252. The acronym 'DPAK' can also stand for the term 'Discrete package' DPAKs can have 3 or 5 terminals. as shown in Fig. 19.

Fig 19

JLCC- J-Leaded ceramic chip carrier

The J-leaded ceramic chip carrier, or JLCC, is a square or rectangular surface - mount ceramic package that has J-formed leads around its periphery. The plastic molded equivalent of the JLCC is the PLCC. as shown in Fig. 20.

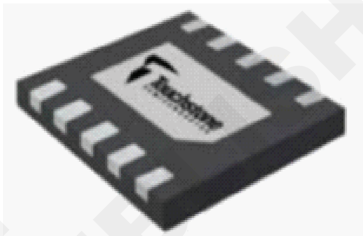
Fig 20



TDFN- Thin Dual flat no leads

The thin dual flat no leads package, or TDFN, is a very small and thin square - shaped or rectangular surface - mount plastic package with no leads. Instead of leads, it uses metal pads along two sides of the package body for electrical connection to the outside world. It is basically a thinner version of the dual flat no leads (DFN) package. as shown in Fig. 21.

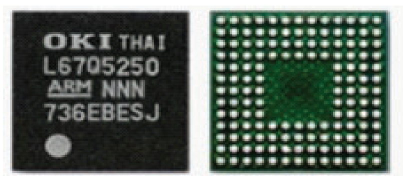
Fig 21



LFBGA - Low profile fine- pitch ball grid array

The low profile fine pitch ball grid array, or LFPBGA, is a smaller version of the ball grid array (BGA) package. It is basically an FBGA package that has a package height ranging from 1.2 mm and 1.7 mm. It is therefore thicker than the TFBGA and the VFBGA. as shown in Fig. 22

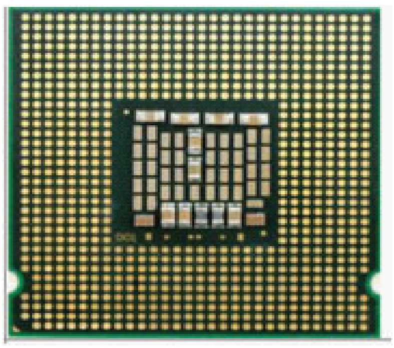
Fig 22



LGA - Land grid array (Fig.23)

The land grid array or LGA is a package that uses metal pads for external electrical connection instead of leads (as in the pin grid array) or solder balls (as in the ball grid array). These metal pads, which are called 'lands' are

Fig 23

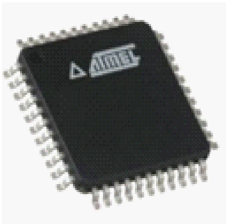


arranged in a grid or array at the bottom of the package body hence the name land grid array. The grid arrangement of the lands of the LGA package allows it to have a high land count, making it a popular packaging option for devices with high I/O requirements.

TQFP Thin quad flat pack

The thin quad flat pack, or TQFP is a surface - mount IC package with gull wing leads on all foru sides of the package body. It is basically a thinner version of the MQFP and LQFP. as shown in Fig. 24

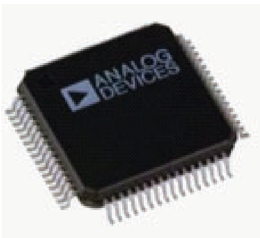
Fig 24



LQFP - Low profile quad flat pack

The low profile quad flat pack or LQFP, is a surface - mount IC package with leads extending from all four sides of the package body. as shown in Fig. 25.

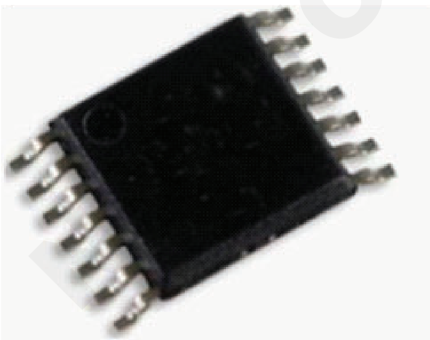
Fig 25



TSSOP - Thin shrink small outline package

The thin shrink small outline package, or TSSOP, is a rectangular surface mount plastic package with gull wing leads. It has a smaller body and smaller lead pitch than the standard SOIC package. It is also smaller and thinner than a TSOP with the same lead count. as shown in Fig. 26

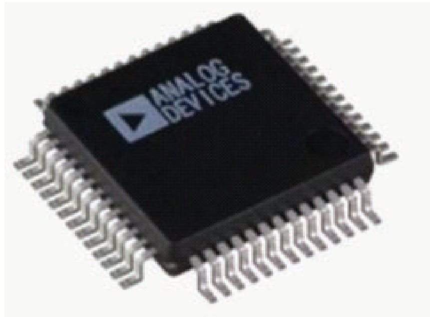
Fig 26



MQFP- Metric quad flat pack

The metric quad flat pack, or MQFP is a surface - mount IC package with gull wing leads on all four sides of the package body. as shown in Fig. 27

Fig 27



TSOP -Thin small outline package

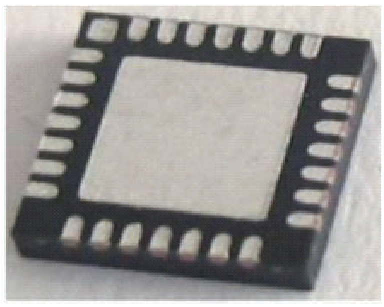
The thin small outline package, or TSOP is a rectangular IC package with a thickness of 1.0 mm. There are two types of TSOPS. The type I TSOP has its leads protruding from the shorter edges of the package. The type II TSOP has its leads protruding from the longer edges of the package. as shown in Fig. 28

Fig 28

MLP- Micro lead frame package

The micro lead frame package, or MLP is a JEDEC compliant, very thin, near - CSP square - shaped or rectangular surface - mount plastic package uses metal pads instead of leads for the electrical connection to the outside world. The MLP belongs to the same 'no leads' package family as the QFN and the DFN. as shown in Fig. 29

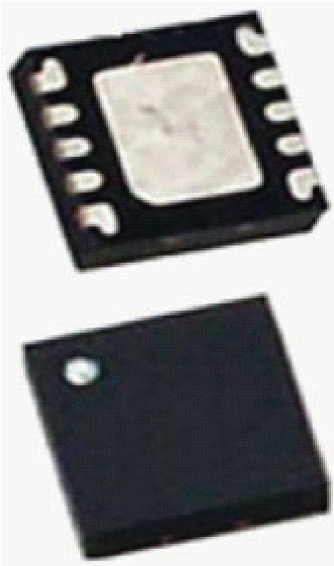
Fig 29



UTDFN - Ultra thin dual flat no leads

The ultra thin dual flat no leads package, or UTDFN is a very small and thin square - shaped or rectangular surface - mount plastic package with no leads. Instead of leads, it uses metal pad as long two sides of the package body for electrical connection to the outside world. It is basically a thinner version of the thin dual flat no leads (TDFN) package. as shown in Fig. 30.

Fig 30



MSOP - Micro small out line package

The micro small outline package, or micro- SOP or MSOP, is a very small rectangular plastic package with gull wing leads protruding out of its longer sides. The MSOP is a miniaturized version of the SSOP package, having a smaller footprint than the latter. as shown in Fig. 31.

UTQFN- Ultra thin quad flat no leads

The ultra thin quad flat no leads package, or UTQFN is every small and thin square- shaped or rectangular surface - mount plastic package with no leads. Instead of leads, it uses metal pads around the periphery of the package body for electrical connection to the outside world. It is basically a thinner version of the thin quad flat no leads (TQFN) package. as shown in Fig.32.

Fig 31

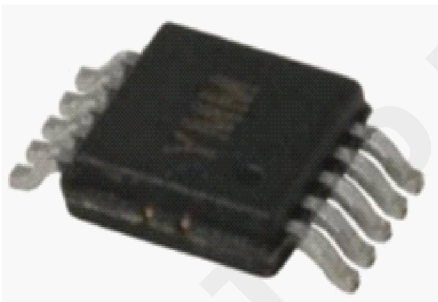
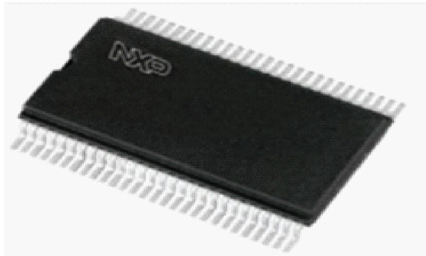


Fig 32

VSOP- Very small outline package

The very small out line package, or VSOP is one of several smaller versions of the SOIC package, having a compressed body and a tightened pitch for its gull wing leads. Another smaller version of the SOIC is the SSOP. as shown in Fig. 33

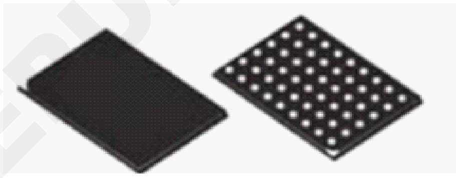
Fig 33



TFBGA - Thin profile fine pitch ball grid array

The thin profile fine pitch ball grid array or TFBGA, is a thinner version of the FBGA package like all BGA packages. TFBGA's use solder balls that are arranged in a grid or array at the bottom of the package body for external electrical connection. The TFBGA is near - chip - scale in size and features ball pitch values that are even tighter than those of the FBGA. as shown in Fig. 34.

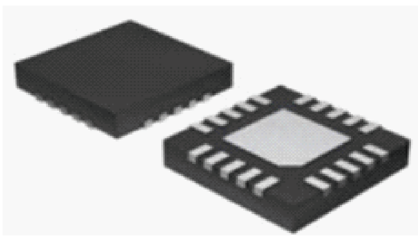
Fig 34



TQFN - Thin quad flat no leads

The thin quad flat no leads package, or TQFN is a very small and thin square - shaped or rectangular surface mount plastic package with no leads. Instead of leads, it uses metal pads around the periphery of the bottom of the package body for electrical connection to the outside world. It is basically a thinner version of the quad flat no leads (QFN) package. as shown in Fig. 35

Fig 35



FBGA- Fine pitch ball grid array

The fine pitch ball grid array, for FPBGA or FBGA is a smaller version of the ball grid array (BGA) package. As in all BGA packages, FBGA's use solder balls that are arranged in a grid or array at the bottom of the package body for external electrical connection. However, the FBGA is near chip -scale in size, with a smaller and thinner body than the standard BGA package. As its name implies, it also features a finer ball pitch (smaller distance between balls) as shown in Fig. 36.

SSOP-Shrink small outline package

The shrink small outline package or SSOP is a smaller or 'shrunk' version of the SOIC package having a compressed body and a tightened lead pitch. as shown in Fig. 37.

Fig 36

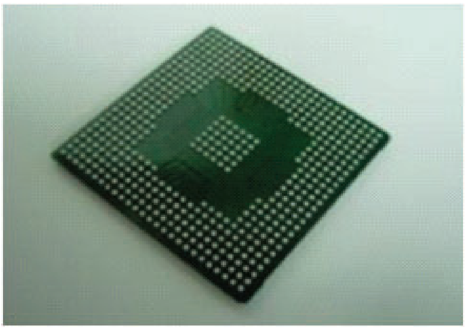


Fig 37

D3PAK - Decawatt package 3

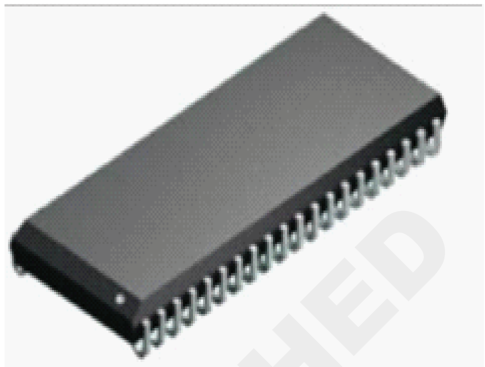
The decawatt package 3 or D3PAK is a bigger version of the D2PAK package. Just like the D2PAK (and the DPAK the D2PAK's predecessor) the D3PAK is a surface - mount plastic - molded package intended for high - power discrete devices. The D3PAK is also known by other names such as 'TO-268' and discrete package 3. as shown in Fig. 38

Fig 38

SOJ : Small outline J- lead package

The small outline J-lead package or SOJ is a small rectangular surface - mount plastic molded integrated circuit package with J-formed leads. The leads protrude from the longer edge of the package. The SOJ is also sometimes referred to as SOJ or J- leaded small outline IC package. as shown in Fig. 39

Fig 39



D2PAK or DDPAK- Double decawatt package

The Double decawatt package, or D2PAK or DDPAK is the successor to the DPAK package which was designed by Motorola to encase discrete high power devices. The D2PAK is bigger than the DPAK and comes in several versions with different terminal counts. The D2PAK which has a flat heat sink at the back is basically the surface - mount equivalent of the TO-220 through- hole package and its therefore sometimes referred to as 'SMD-220'. The D2PAK is also known as 'TO-263'. as shown in Fig. 40.

Fig 40

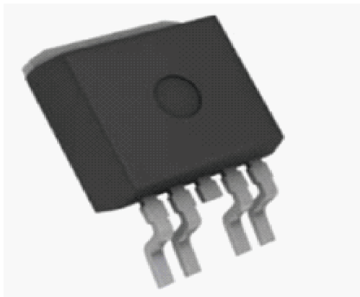


Fig 41

SOIC - Small outline integrated circuit

The small outline integrated circuit or SOIC is a small rectangular surface mount plastic molded integrated circuit package with gull wing leads. The leads protrude from the longer edge of the package. It is one of the most commonly used surface mount packages today as show in Fig. 41

Small outline Transistor (SOT) package

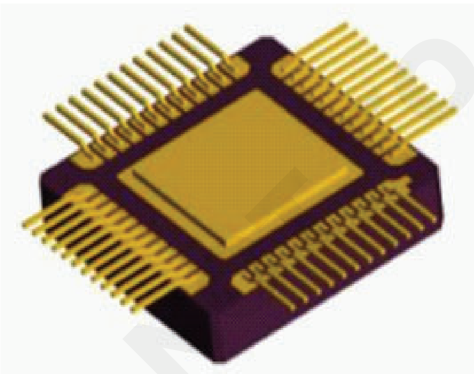
Small outline transistor (SOT) packages are very small, inexpensive surface mount plastic - molded packages with leads on their two long sides. Due to their low cost and low profile. SOT's are widely used in consumer electronics. The SOT - 23 and the SC-70 packages are two of the most widely used SOT packages today. Note that a side from these two, there are many other SOT package types used in the IC industry. as shown in Fig. 42

Fig 42

CQFP - Ceramic quad flat pack

The ceramic quad flat pack, or CQFP is a ceramic IC package with leads extending from all four sides of the package body. CQFP's are predominantly square in shape, although rectangular variants do exist. The CQFP is just one of the many types of the quad flat pack (QFP) package. as shown in Fig. 43

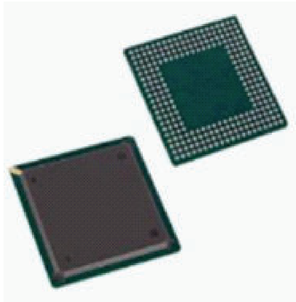
Fig 43



Ball grid array aka BGA

BGA packages are used to permanently surface mount devices such as microprocessors. A BGA can provide more interconnection pins than can be put on a dual in - line or flat package. The whole bottom surface of the device can be used, instead of just the perimeter. The leads are also one average shorter than with a perimeter only type, leading to better performance at high speeds. soldering of BGA devices requires precise control and is usually done by automated processes. A BGA device is never mounted in socket in use. as shown in Fig.44

Fig 44



Plastic quad flat package aka PQFP

The plastic quad flat pack, or PQFP is an IC package with leads extending from all four sides of the package body. PQFP's are predominantly square in shape, although rectangular variants do exist. The PQFP is just one of the many types of the quad flat pack (QFP) package. as shown in Fig. 45.

PLCC- Plastic leaded chip carrier

The plastic leaded chip carrier, or PLCC is a four - sided plastic package that has "J" leads around its periphery. These "J" leads, occupy less board space than the gull - wing leads that other packages like the SOIC have. PLCC lead counts range from 18 to 84. PLCC packages can either be square or rectangular in shape. The ceramic equivalent of the PLCC is the JLCC. as shown in Fig. 46

Fig 45

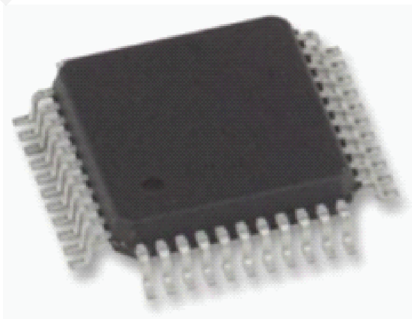


Fig 46

Identification of Pin 1 marking in various SMD IC packages

Objectives : At the end of this lesson you shall be able to
- **to identify the pin 1 marking of various SMD IC packages which is indicated in different methods**
- **how to differentiate the orientation of IC package pin details in order to avoid wrong soldering and to avoid economic loss without damaging costly IC package like motherboard ICs.**

Pin 1 marking in a DIP SMD IC

Fig 1

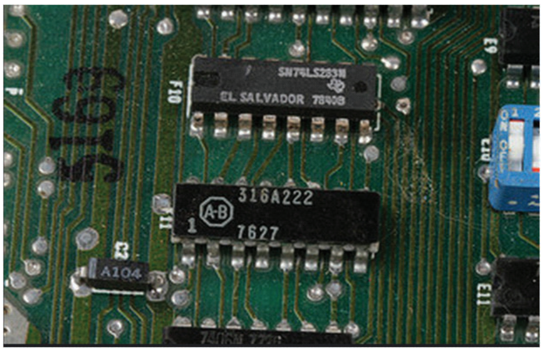
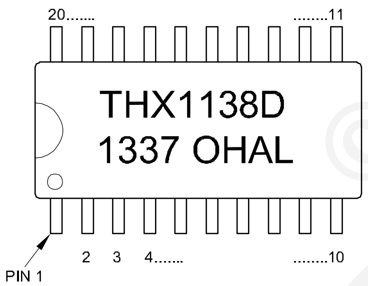


Fig 2



EMN3218472

Here is a basic rule that applies for most integrated circuits. There is a polarity mark somewhere. From that polarity mark, move counterclockwise around the chip, and number the pins starting at 1. as shown in Fig 1

A common polarity marker is a half - moon shape at one end of the chip. Another is a small dot by pin 1, or sometimes a small triangle or tab instead. Sometimes several of these marks can appear. as shown in Fig 2

Often pin 1 is in a corner of the chip, and its only that corner - not the pin itself - that is marked by the small circle or triangle.

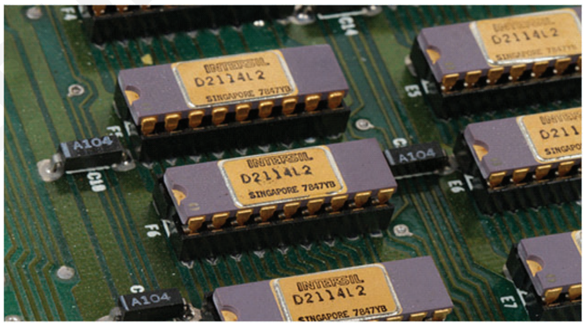
In the above IC part number "THX1138D," manufactured in week 37 of 2013, and it has a mysterious lot or internal code "OHAI" that may or may not be explained in the datasheet. The polarity marks are a half - moon indentation on the left hand side as well as a dot by pin 1. This device has 20 pins, numbered counterclockwise along the two edges from 1 to 20.

As well see, there are plenty of examples of this, or close variations on it. But there are also cases where there are "no" direct marks, but you can instead rely on the orientation of the text to understand the numbering. The text orientation is consistent, and for chips of this shape (with pins on two opposite sides), you can reliably assume that the polarity mark goes to the left of the text.

Here are some classic and beautiful examples of chips with well - marked polarity. These are "ceramic DIP" integrated circuit packages.

Each has a molded half - moon shape as well as a more subtitle dot by pin 1. as shown in Fig 3

Fig 3



This is a modern higher - density variation on the same design. It is a wide, low - profile plastic package called a 66-pin TSSOP (and a 128 M bit DDR SDRAM, if you are curious). The orientation is given by the half - moon shape on the left hand side and by the dot in the lower left corner. Now, that dot actually looks like it's closer to pin 2 than to pin 1 - Again, the maker often labels the corner where pin 1 lives, not the individual pin. as shown in Fig 4 & 5.

Fig 4

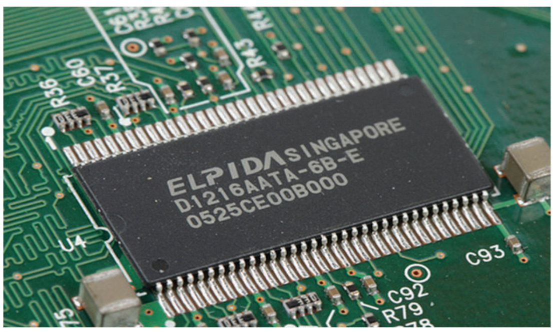
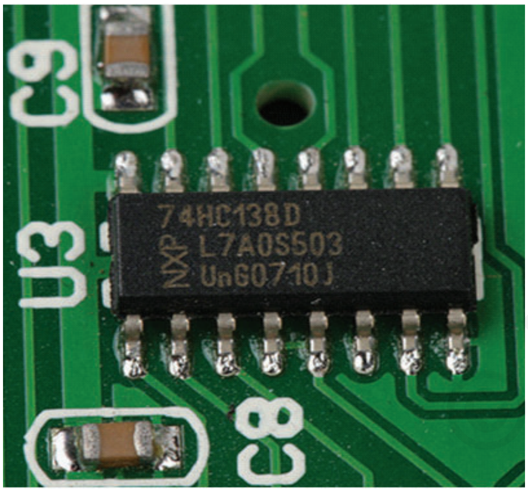


Fig 5

This 74 HC245D " as shown in Fig. 6 octal bus transceiver" chip from NXP has the half - moon shape on the left hand side, plus a slightly more unusual polarity marking feature. The entire front edge of the chip - the edge containing pin 1 - is slightly beveled.

Fig 6



And now here is a chip that has less of a "direct" indication of its orientations - no dot or half moon shape. As we discussed earlier, you can really on the orientation of the text in cases like this, and imagine an effective polarity mark on the left hand side of the chip. Pin 1 is on the power left hand side.

If you look very closely, as shown in Fig 7 you will see that there is one additional polarity marking feature, in that this chip also has a very slightly beveled front edge.

His is a some what unusual seven - yes- seven pin DIP chip. It is a neat little solid - state relay capable of switching small loads on AC line voltage (0.9 A at up to 240 VAC) from a low - voltage digital input. Presumably, it has seven pins so that you can not put in backwards. This chip also relies on a combination of text orientation and level at the side with pin 1. as shown in Fig 8

Careful : That apparent "dot' is not a polarity indicator ; pin 1 is still at the corner of the chip. as shown in Fig 9

Here is one more variation. There is printed bar on the left hand side of this chip to act as a polarity indicator, taking the place of the half - moon shape.

Fig 7

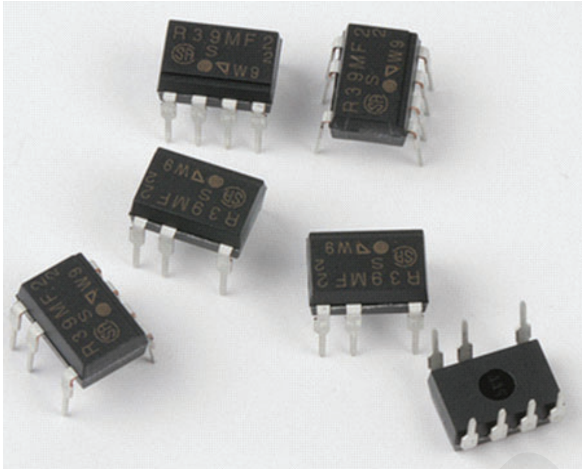


Fig 8

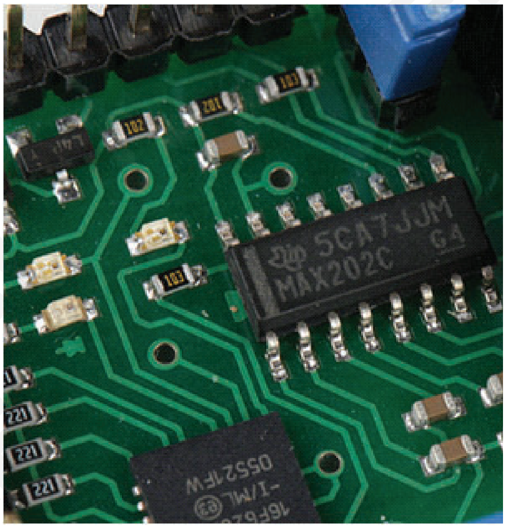


Fig 9

Some times you will come across very different looking chips with very obvious polarity markers. This chip from agilent has a gold stripe on the upper left hand corner. as shown in Fig 10

Pin 1 identification

Sometimes a chip has a notched corner to indicate where pin 1 lives as shown in Fig 11. The white silkscreen on the circuit board shows an exaggerated picture of this notching, by the lower - left corner.

Fig 10

Fig 11

The 486 is a good example of a chip with a notched corner, while the 68030 has a gold stripe to indicate pin 1

This broadcom chip has a dot by the corner with pin 1, as shown in Fig 12 but that is a pretty suitable mark . If you chip already mounted to a board, that can provide some better information to verify the orientation. For example, pin 1 of this chip is also marked by a white do on the circuit board, and the other three corners have a mark, as though those corners were un-noticed.

Here is another chip that is some what ambiguous. Pin 1 is clearly marked with an arrow on the circuit board. If the chip were loose it would be a little less clear because not only is there a dot by pin 1, as shown in Fig 13 & 14 but there is also apparently a dot by the opposite corner. It may be just a coincidental mold mark, but it's still potentially confusing.

This is far from an exhaustive list, but is meant to show off some of the common ways that chip orientation is differentiated.

Fig 12

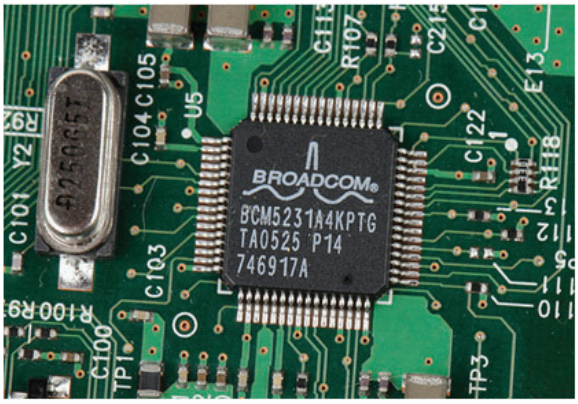


Fig 13

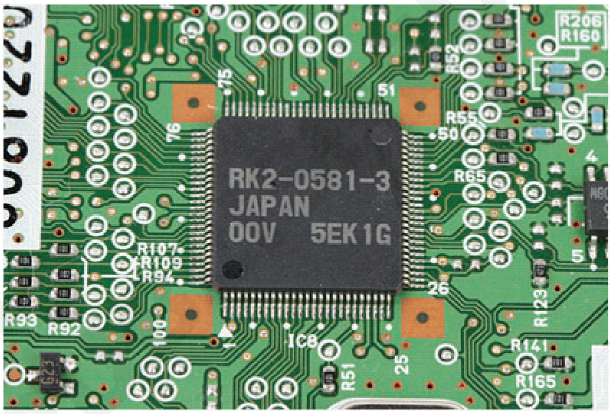
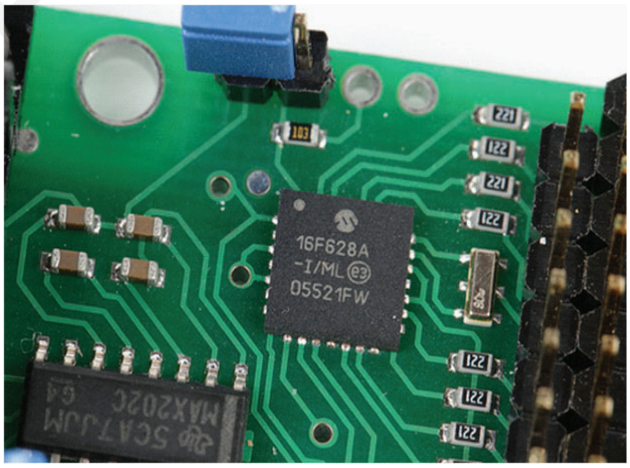


Fig 14

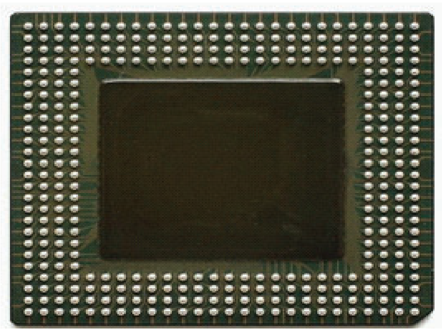


Ball grid array and pin grid array components

Objectives : At the end of this lesson you shall be able to
- **study the structural details of ball grid array SMD ICs**
- **study the advantages and disadvantages of BGA package**
- **study the structural details of pin grid array package.**

A ball grid array (BGA) is a type of surface mount packaging (a chip carrier) used for integrated circuits. BGA packages are used to permanently mount devices such as microprocessors. A BGA can provide more interconnection pins than can be put on a dual in-line or flat package. The whole bottom surface of the device can be used, instead of just the perimeter. The leads are also on average shorter than with a perimeter - only type, leading to better performance at high speeds. as shown in Fig. 1

Fig 1



Soldering of BGA devices requires precise control and is usually done by automated processes. BGA devices are not suitable for socket mounting.

With the increasing component density of today's electronics printed circuit boards and the very high track densities that result, connectivity on many boards has become a problem. Even migrating to greater numbers of layers for the PCB cannot overcome many of the problems. To assist in resolving this problem an integrated circuit package known as the ball grid array, BGA was introduced. The BGA components provide a far better solution for many boards, but care is required when soldering BGA components to ensure that the BGA solder process is correct and that the reliability is at least maintained or preferably improved.

The ball grid array of BGA, is a very different package to those using pins, such as the quad flat pack. The pins of the BGA package are arranged in a grid pattern and this gives rise to the name. In addition to this, rather than having the more traditional wire pins for the connections, pads with balls of solder are used instead. On the printed circuit board, PCB, on to which the BGA components are to be fitted there is a matching set of copper pads to provide the required connectivity.

BGA packages offer many advantages over their quad flat pack rivals and as a result they are being used increasingly for the manufacture of electronic circuits.

Advantages of BGA

High density

The BGA is a solution to the problem of producing a miniature package for an integrated circuit with many hundreds of pins. Pin grid arrays and dual-in-line surface mount (SOIC) packages were being produced with more and more pins, and with decreasing spacing between the pins, but this was causing difficulties for the soldering process. As package pins got close together, the danger of accidentally bridging adjacent pins with solder grew. BGAs do not have this problem if the solder is factory - applied to the package.

Heat conduction

A further advantage of BGA packages over packages with discrete leads (i.e packages with legs) is the lower thermal resistance between the package and the PCB. This allows heat generated by the integrated circuit inside the package to flow more easily to the PCB, preventing the chip from overheating.

Low - inductance leads

The shorter an electrical conductor, the lower its unwanted inductance, a property which causes unwanted distortion of signals in high - speed electronic circuits. BGAs with their very short distance between the package and the PCB, have low lead inductances, giving them superior electrical performance to pinned device.

Improved PCB design as a result of lower track density : Track densities around many packages such as the quad flat pack become very high because of the very close proximity of the pins. A BGA spreads the contacts out over the full are of the package greatly reducing the problem.

The BGA package is robust :

Packages such as the quad flat pack have very fine pins, and these are easily damaged by even the most careful handling. It is almost impossible to repair them once the pins are bent wing to their very fine pitch. BGAs do not suffer from this as the connections are provided by pads with the BGA solder balls on them which are very difficult to damage.

Lower thermal resistance : BGAs offer a lower thermal resistance between the silicon chip itself then quad flat pack devices. This allows heat generated by the integrated circuit inside the package to be conducted out of the device onto the PCB faster and more effectively.

Improved high speed performance : As the conductors are on the underside of the chip carrier. This means that the leads within the chip are shorter. Accordingly unwanted lead inductance levels are lower, and in this way, Ball grid array devices are able to offer a higher level of performance than their QFP counterparts.

BGA solder process

One of the initial fears over the use of BGA components was their solder ability and whether traditional forms of connection. As the pads are under the device and not visible it is necessary to ensure the correct process is used and it is fully optimized. Inspection and rework were also concerns.

Fortunately BGA solder techniques have proved to be very reliable, and once the process is set up correctly BGA solder reliability is normally higher than that for quad flat pack. This means that any BGA assembly tends to be more reliable. Its use is therefore now widespread in both mass production PCB assembly and also prototype PCB assembly where circuits are being developed.

> **For the BGA solder process, reflow techniques are used. The reason for this is that the whole assembly needs to be brought up to a temperature whereby the solder will melt underneath the BGA components themselves. This can only be achieved using reflow techniques.**

For BGA soldering, the solder balls on the package have a very carefully controlled amount of solder, and when heated in the soldering process, the solder melts. Surface tension causes the molten solder to hold the package in the correct alignment with the circuit board, while the solder cools and solidifies. The composition of the solder alloy and the soldering temperature are carefully chosen so that the solder does not completely melt, but stays semi-liquid, allowing each ball to stay separate from its neighbors.

BGA solder joint inspection

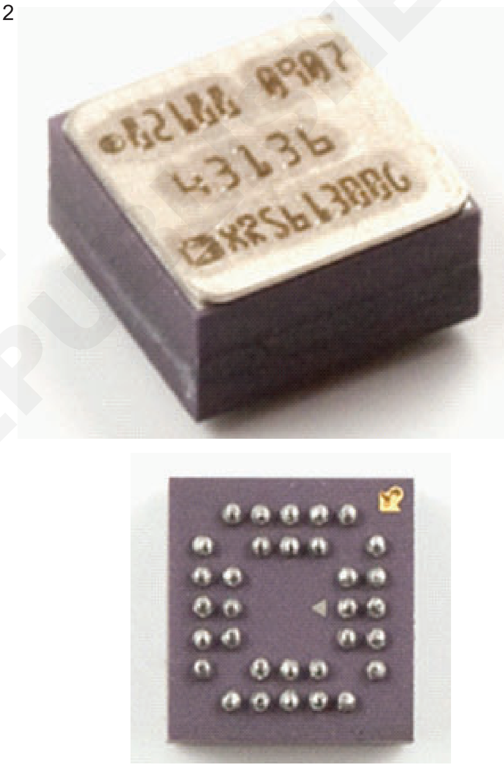
BGA inspection is one are of the manufacturing process that has raised a considerable amount of interest since the introduction of the first BGA components. BGA inspection cannot be achieved in the normal way using straight forward optical techniques because, quite, obviously the solder joints are underneath the BGA components and they are not visible. This creates problems for BGA inspection. It also created a considerable degree of unease about the technology when it was first introduced and many manufactures undertook tests to ensure that they were able to solder the BGA components satisfactorily. The main problem with soldering BGA components is that sufficient heat must be applied to ensure that all the balls in the grid melt sufficiently for every BGA solder joint to be satisfactorily made.

The solder joints cannot be fully tested by checking the electrical performance. While this form of test of the BGA solder process will reveal conductivity at that time, it does not give a full picture of how the BGA solder process has succeeded. It is possible that the joint may not be adequately made and that over time if will fall. For this the only satisfactory means of test is a form of BGA inspection using x-rays. This form of BGA inspection is able to look through the device at the soldered joint beneath. Fortunately, it is found that once the heat profile for the solder machine is set up correctly, the BGA components solder very well and few problems are encountered with the BGA solder process.

BGA rework

As might be anticipated, it is not easy to rework BGA assemblies unless the correct equipment available. If a BGA components is suspected as being faulty, then it is possible to remove the device. This is achieved by locally heating the BGA component to melt the solder underneath it. as shown in Fig 2

Fig 2



In the BGA rework process, the heating is often achieved in a specialized rework station. This comprises a jig fitted with infrared heater, a thermocouple to monitor the temperature and a vacuum device for lifting the package. Great care is needed to ensure that only the BGA is heated and removed. Other devices nearby need to be affected as little as possible otherwise they maybe damaged.

BGA technology in general and in particular the BGA soldering process have proved themselves to be very successful since they were first introduced. They are now an integral part of the PCB assembly process used in most companies for mass production and for prototype PCB assembly.

Pin grid array package

A pin grid array, often abbreviated PGA, is a type of integrated circuit packaging. In a PGA the package is square or rectangular, and the pins are arranged in a regular array on the underside of the package. The pins are commonly spaced 2.54 mm (0.1”) apart, and may to may not cover the entire underside of the package. as shown in Fig. 3 & 4.

Fig 3

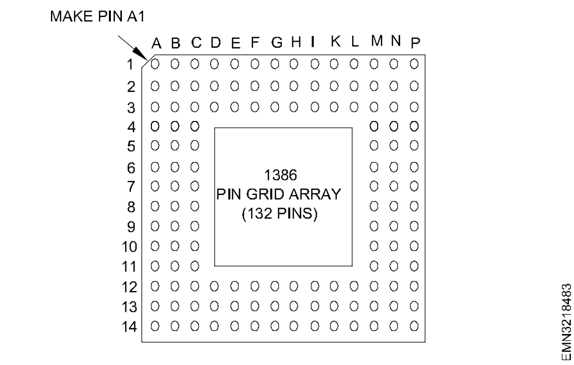
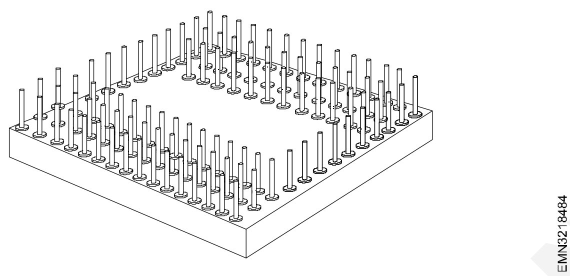


Fig 4



PGAs are often mounted on printed circuit boards using the through hole method of inserted into a socket. PGAs allow for more pins per integrated circuit than older packages such as dual in line package (DIP)

The familiar dual in line (DIL) package can have up to 68 leads with a spacing between pins of 2.54 mm. The chip carrier family has a pin count that ranges from 20 to 84, with pin spacing of 1.274 mm; although pin counts above 84 can be produced, the problems of handling become severe above 84 pins (the 84 pin chip carrier is approximately 30 x 30 mm). The PGA (Pin grid array) package allows up to 144 pins (spacing 2.54 mm). It has an high power dissipation capability and it is now being extended to a low cost plastic version. However the route interconnection on the PC board is difficult and the connections are difficult to inspect. Surface mounting technique also offers a large number of pins. The placement of the IC must be automatic and the soldering technique not conventional. However, the quad flat pack has from 36 to 128 pins with spacing from 1 mm to 0.65 mm. It has potentially a low cost but the number of suppliers is very limited.

Pin grid array and variations (PGA/SPGA/CPGA/PPGA)

Pin grid array or PGA packaging is the standard used for most fifth generation processors, starting with the intel 80286 over a decade ago. PGA packages are square or rectangular and have two or more rows of pins going around their perimeter. They are inserted into a special socket on the mother board or daughter card. PGA packaging was invented because newer processors with wider data and address buses required a large number of interface pins to the motherboard, and DIP packaging just was not up to the task.

PGA comes in two different main material types. The standard PGA used on most processors until recently is made from a ceramic material, and is also called CPGA for that reason. Some newer processors use a plastic package, called PPGA. The plastic package is both less expensive and thermally superior to the CPGA. It has a raised metal square area on is surface for heat transfer to the heat sink that works better than the CPGA.

Eventually, as the number of connections for Pentium and later processors exceeded 200 and approached 300, intel needed to be able to pack even more pins into the same amount of space. To do this, intel staggered the pin layout so that they could be compressed more tightly. (The idea is similar to how a wine rack stacks bottles.) This is sometimes called SPGA. Pentium and later chips are made with this design.

Finally, the Pentium pro processor uses a special from of PGA called a “dual pattern PGA”. This is of course because the pentium pro has a dual - chip package containing both the chip itself and its miniaturized, integrated secondary cache.

Re-flow soldering

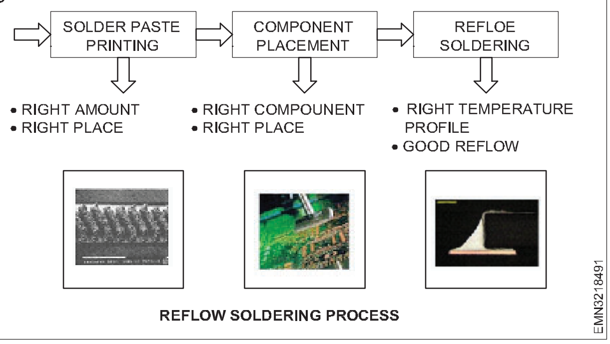
Objective : At the end of this lesson you shall be able to
- **explain the Reflow soldering and working principle.**

Reflow soldering and working principle

Reflow soldering is a process in which a solder paste (a sticky mixture of powdered solder and flux) is used to temporarily attach one or several electrical components to their contact pads, after which the entire assembly is subjected to controlled heat, which melts the solder, permanently connecting the joint. Heating may be accomplished by passing the assembly through a reflow oven or under an infrared lamp or by soldering individual joints with a hot air pencil as shown in Fig. 1 reflow soldering process.

Reflow soldering is the most common method of attaching surface mount components to a circuit board, although it can also be used for through-hole components by filling the holes with solder paste and inserting the component leads through the paste. Because wave soldering can be simpler and cheaper, reflow is not generally used on pure through-hole boards. When used on boards containing a mix of SMT and THT components, through-hole reflow

Fig 1



REFLOW SOLDERING PROCESS

allows the wave soldering step to be eliminated from the assembly process, potentially reducing assembly costs.

The goal of the reflow process is to melt the solder and heat the adjoining surfaces, without overheating and damaging the electrical components. In the conventional reflow soldering process, there are usually four stages, called "zones", each having a distinct thermal profile: preheat, thermal soak (often shortened to just soak), reflow, and cooling.

Preheat zone

Maximum slope is a temperature/time relationship that measures how fast the temperature on the printed circuit board changes. The preheat zone is often the lengthiest of the zones and often establishes the ramp-rate. The ramp-up rate is usually somewhere between 1.0 °C and 3.0 °C per second, often falling between 2.0 °C and 3.0 °C (4 °F to 5 °F) per second. If the rate exceeds the maximum slope, damage to components from thermal shock or cracking can occur. Solder paste can also have a spattering effect. The preheat section is where the solvent in the paste begins to evaporate, and if the rise rate (or temperature level) is too low, evaporation of flux volatiles is incomplete.

Thermal soak zone

The second section, thermal soak, is typically a 60 to 120 second exposure for removal of solder paste volatiles and activation of the fluxes (see flux), where the flux components begin oxide reduction on component leads and pads. Too high a temperature can lead to solder spattering or balling as well as oxidation of the paste, the attachment pads and the component terminations. Similarly, fluxes may not fully activate if the temperature is too low. At the end of the soak zone a thermal equilibrium of the entire assembly is desired just before the reflow zone. A soak profile is suggested to decrease any delta T between components of varying sizes or if the PCB assembly is very large. A soak profile is also recommended to diminish voiding in area array type packages.

Reflow zone

The third section, the reflow zone, is also referred to as the "time above reflow" or "time above liquidus" (TAL), and is the part of the process where the maximum temperature is reached. An important consideration is peak temperature, which is the maximum allowable temperature of the entire process. A common peak temperature is 20-40 °C above liquidus. This limit is determined by the component on the assembly with the lowest tolerance for high temperatures (the component most susceptible to thermal damage). A standard guideline is to subtract 5 °C from the maximum temperature that the most valuable component can sustain to arrive at the maximum temperature for process. It is important to monitor the process temperature to keep it from exceeding this limit. Additionally, high temperatures (beyond 260 °C) may cause damage to the internal dies of SMT components as well as foster intermetallic growth. Conversely, a temperature that isn't hot enough may prevent the paste from reflowing adequately.

Time above liquidus (TAL), or time above reflow, measures how long the solder is a liquid. The flux reduces surface tension at the junction of the metals to accomplish metallurgical bonding, allowing the individual solder powder spheres to combine.

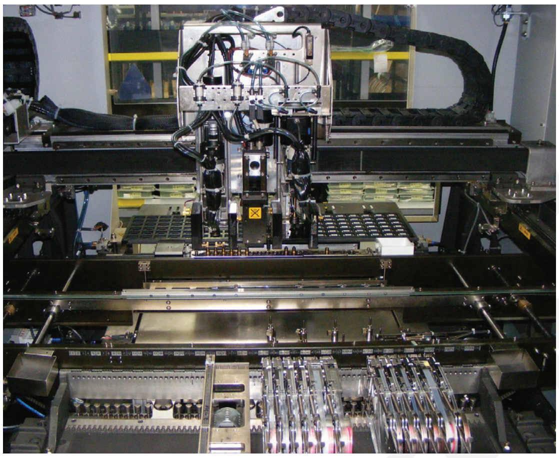
Pick and place machine

Objective : At the end of this lesson you shall be able to
- **working of pick and place machine**
- **stencil and stencil printer working.**

Pick-and-place machine

Surface-mount technology placement systems, commonly called pick-and-place (SMT) component machines or P&Ps, are robotic machines which are used to place surface-mount devices (SMDs) onto a printed circuit board (PCB). They are used for high speed, high precision placing of a broad range of electronic components, like capacitors, resistors, integrated circuits onto the PCBs which are in turn used in computers, consumer electronics as well as industrial, medical, automotive, military and telecommunications equipment. Similar equipment exists for through-hole components.[1][2] This type of equipment is sometimes also used to package microchips using the flip chip method.

Fig 1



Operation

The placement equipment is part of a larger overall machine that carries out specific programmed steps to create a PCB assembly. Several sub-systems work together to pick up and correctly place the components onto the PCB. These systems normally use pneumatic suction cups, attached to a plotter-like device to allow the cup to be accurately manipulated in three dimensions. Additionally, each nozzle can be rotated independently.

Component feeds

Surface mount components are placed along the front (and often back) faces of the machine. Most components are supplied on paper or plastic tape, in tape reels that are loaded onto feeders mounted to the machine. Larger integrated circuits (ICs) are sometimes supplied arranged in trays which are stacked in a compartment. More commonly used ICs will be provided in tapes rather than trays or sticks. Improvements in feeder technology mean that tape format is becoming the preferred method of presenting parts on an SMT machine.

Conveyor belt

Through the middle of the machine there is a conveyor belt, along which blank PCBs travel, and a PCB clamp in the center of the machine. The PCB is clamped, and the nozzles pick up individual components from the feeders/ trays, rotate them to the correct orientation and then place them on the appropriate pads on the PCB with high precision.

Inspection and visual system

The part being carried from the part feeders on either side of the conveyor belt to the PCB, it is photographed from below by using high resolution camera and lighting system. Its silhouette is inspected to see if it is damaged or missing (was not picked up), and the inevitable registration errors in pickup are measured and compensated for when the part is placed. For example, if the part was shifted 0.25mm and rotated 10° when picked up, the pickup head will adjust the placement position to place the part in the correct location.

Stencil and stencil printer

Solder paste printing is the first process of the SMT process, and it is a key process to ensure the quality of SMT It directly affects the soldering quality a reliability of the surface assembly. At present, the most widely used is the automatic printing machine metal mesh solder paste process. The automatic s paste printing machine is mainly composed of the main body of the equipment, the PCB transfer mechanism, the squeegee device, the printing (work) t optical vision system, the computer control system, and the power it is composed of driving device, off-grid mechanism and stencil cleaning mechanism basic working principle of the solder paste printer is that after the PCB is sent to the solder paste printer from the conveyor belt, the clamping device fix the XY-8 platform, and the vision system is based on the two (or more) of the PCB and the screen. Multi) Deviation of the coordinate value of the mark recognition point, and correct the deviation. The X-Y-8 platform is adjusted by the drive motor, and the PCB is accurately aligned with the stencil by the three directions of X-Y-8, and finally the solder paste is printed on the PCB pad through the special opening of the stencil.

Solder paste printing is the first process of the SMT process, and it is a key process to ensure the quality of SMT. It directly affects the soldering quality and reliability of the surface assembly. At present, the most widely used is the automatic printing machine metal mesh solder paste process. The automatic solder paste printing machine is mainly composed of the main body of the equipment, the PCB transfer mechanism, the squeegee device, the printing (work) table, the optical vision system, the computer control system, and the power it is composed of driving device, off-grid mechanism and stencil cleaning mechanism. The basic working principle of the solder paste printer is that after the PCB is sent to the solder paste printer from the conveyor belt, the clamping device fixes it on the XY-8 platform, and the vision system is based on the two (or more) of the PCB and the screen. Multi) Deviation of the coordinate value of the mark recognition point, and correct the deviation. The X-Y-8 platform is adjusted by the drive motor, and the PCB is accurately aligned with the stencil by moving in the three directions of X-Y-8, and finally the solder paste is printed on the PCB pad through the special opening of the stencil.

Computer control system: The computer control interface is shown in the Fig below. The operator uses it to understand the status of the printing press, perform file management machine operations. The mouse is used to move the cursor on the screen, and each button (select, next, exit) on the mouse is used to set parameters operate the printing press.

Second, the preparation before the operation of the solder paste printing machine

Make preparations before solder paste printing, craftsmen and technicians should do the following:

Familiar with the process requirements of the product

According to the product process documents, receive the PCB that has passed the inspection

Choose the correct solder paste material, printing machine screen and squeegee, etc.,

Determine the reliable process, such as good positioning, cleaning and wiping etc.,

Make visual images of mark points etc.,

And while understanding the product structure process characteristics in depth, the best design plan should be optimized and selected, for different on set the corresponding printing parameters in the printing program, such as working temperature, squeegee pressure and speed, automatic cleaning cycle screen etc. At the same time, it is necessary to formulate strict process management and process procedures to ensure solder paste printing finished smoothly and well.

Introduction to ESD and PCB Rework

Objectives : At the end of this lesson you shall be able to
- **the trainees will be able to acquire the knowledge on general safety precautions to be followed in a SMD soldering lab**
- **the trainee will be able to acquire the knowledge about the precautions to be followed to avoid the damage of SMD components due electrostatic discharge (ESD).**

General safety precautions to be followed while performing soldering and desoldering work in a laboratory or work place

- Never touch the element or tip of the soldering iron. They are very hot (above 300°C) and will give you a nasty burn.
- Take great care to avoid touching the mains cable with the tip of the iron. The iron should have a heat proof cable for extra protection. Ordinary plastic cable melts immediately if touched by a hot iron and there is a risk of burns and electric shock.
- Always return the soldering iron to its stand when not in use. Never put it down on your workbench, even for a moment. Normally the trainees used to follow the bad practice of keeping the hot soldering iron on the top of work bench and burn the work bench and burn the power supply cable of CROs or function generator, and other costly equipments. So instructor should train the trainees from the beginning to follow the safe work habits
- Allow joints a minute or so to cool down before you touch them.
- Work in a well - ventilated area. The smoke formed as you melt solder is mostly from the flux and quite irritating. Avoid breathing it by keeping you head to the side of, not above, your work.
- Wash your hands after using solder. Solder contains lead.

Preparing the soldering iron

- Place the soldering iron in its stand and plug in. The iron will take a few minutes to reach its operating temperature of above 300°C.
- Dampen the sponge in the stand. The best way to do this is to lift it out the stand and wet it by using distilled water to avoid corrosion of soldering iron tip, and squeeze to remove excess water. It should be damp, not dripping wet.
- Wait a few minutes for the soldering iron to warm up. You can check if it is ready by trying to melt a little solder on the tip.
- Wipe the tip of the iron on the damp sponge. This will clean the tip.
- Melt a little solder on the tip of the iron. This is called 'tinning' and it will help the heat to flow from the iron's tip to the joint. It only needs to be done when you plug in the iron, and occasionally while soldering if you need to wipe the tip clean on the sponge.
- You are now ready to start soldering.

ESD protection

- Proper precautions in handling SMDs should also be observed to avoid ESD (Electrostatic - Discharge)
- Electronics components are becoming smaller and faster but they are also becoming more sensitive towards ESD.
- Electrostatic discharge (ESD) is the release of static electricity when two objects come into contact. Familiar examples of ESD include the shock we receive when we walk across a carpet and touch a metal door knob and the static electricity we feel after drying clothes in a clothes dryer. A more extreme example of ESD is a lightning bolt. Most ESD events are harmless, it can be an expensive problem in many industrial environments.
- ESD first requires a build - up of an electrostatic charge. This occurs when two different materials rub together. One of the materials becomes positivity charged; the other becomes negatively charged. The positively - charged material now has an electrostatic charge. When that charge comes into contact with the right material, it is transferred and we have an ESD event. The heat from the ESD event is extremely hot, although we do not feel it when we are shocked. However, when the charge is released onto an electronic device such as an expansion card, the intense heat from the charge can melt or vaporize the tiny parts in the card causing the device to fail. Sometimes an ESD event can damage a device, but it continues to function. This is a called a latent defect, which is hard to detect and significantly shortens the life of the device.
- Synthetic carpeting - one can hardly move without generating a charge - avoid carpeting in your work area.
- Cathode ray tubes (oscilloscopes or monitors) can be dangerous sources of ESD- keep static sensitive components a safe distance away from the screen and avoid touching the screen.

- Many electronic devices are susceptible to low voltage ESD events. For example , hard drive components are sensitive to only 10 volts. For this reason, manufacturers of electronics devices incorporate measures to prevent ESD events throughout the manufacturing, testing, shipping, and handling processes. For example, an employee may wear a wrist strap when working with devices or many wear ESD control footwear and work on an ESD floor mat that causes the electrostatic charge to go into the ground instead of into the device. Sensitive devices can be packaged with materials that shield the product from a charge.
- The rework station needs to be specifically designed to minimise the effect of ESD, especially when various studies around the world have revealed that 60-90 percent of defective devices are damaged due to ESD, and 70 percent of these failures can be attributed to damage caused by ungrounded workers. So it becomes really important that you take ESD - control systems seriously, or otherwise, the losses can be astonishingly high.
- A basic ESD control rule is ground all conductors including workers at the rework station. Ground works very efficiently in ESD - control systems and reliably removes ESD to ground. For such a grounding system, it is important that the electrical wiring system of our lab should be correct. All electrical outlets in our lab need to be evaluated for correct wiring of live, neutral and ground wires.

A wrist strap is an effective method for ground the workers. The electrostatic discharge association's standard ANSI/ ESD SI.1-2006 defines a wrist strap as an assembled device consisting of a wrist cuff and ground cord that provides electrical connection of a pension's skin to the ground. The standard document completely describe the parameters for evaluation, acceptance and functional testing of wrist straps. While the document describes the whole set of mechanical and electrical parameters over which a wrist strap needs to be evaluated and accepted, the most important parameter amongst all is the wrist strap continuity and resistance, which should be 1 meg - ohm 20 percent, for acceptance. The document also suggests the testing procedure for the same. While you are buying grounding materials, do check if they comply with the above - mentioned standard and specification.

When you are working with sensitive electronics components you should consider buying all the equipment for your workstation that is tagged as anti- static or ESD - safe. The materials mentioned below are optional but can be used for better electrostatic protected area (EPA).

1 ESD- tables, chairs and stools

2 ESD- safe toll kit (cutter, plier, desoldering pump, etc)

3 ESD- safe equipment like soldering iron

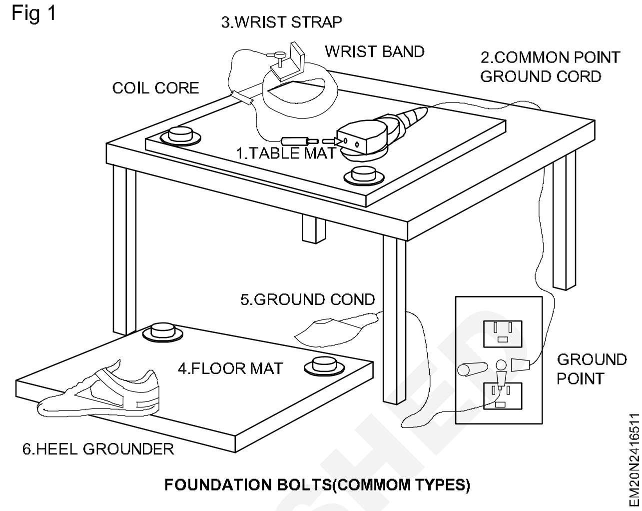
4 ESD- safe brush

5 ESD -safe trays, bins and cabinets

ESD safe workstation layout

An ESD workstation is defined as work area with materials and equipment that limit electrostatic voltages and ESD (Electrostatic discharge) shown in Fig.1.

Fig 1



FOUNDATION BOLTS(COMMOM TYPES)

Table Mat

A work surface that dissipates static from conductive items placed on it shown in Fig. 2.

Fig 2

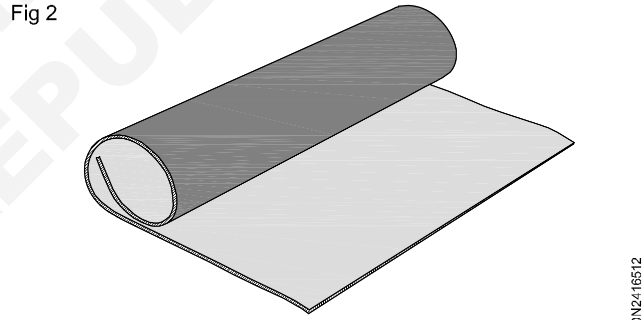


TABLE MAT

Common point ground cord

A cable and connector that connect a table mat and one or two wrist straps to ground. shown in Fig. 3 & 4.

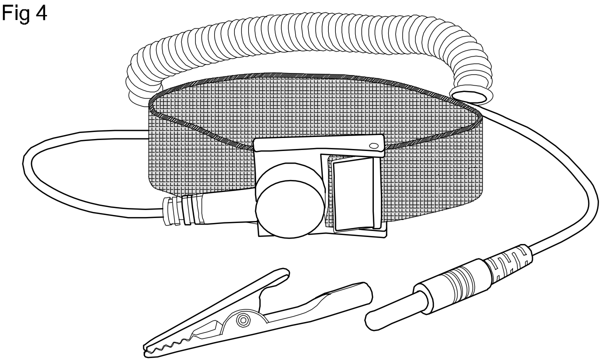
Fig 3

COMMON POINT GROUND CORD

Wrist strap

A two part device including a wrist band and a coil cord that connects a person's skin to ground. ESD wrist straps, also known as anti static wrist straps as show in Fig.4, are used to prevent electrostatic discharge (ESD) by safety grounding a person working with electronics equipment or at an electronic assembly facility. It consists of a bend of fabric with fine conductive fibers woven into it. The fibers are usually made of carbon or carbon - filled rubber, and the strap is bound with a stainless steel clasp or plate. They are usually used in conjunction with an ESD table mat on the workbench, or a special static dissipating plastic laminate on the workbench surface.

Fig 4



COMMON POINT GROUND CORD

EM20N2416514

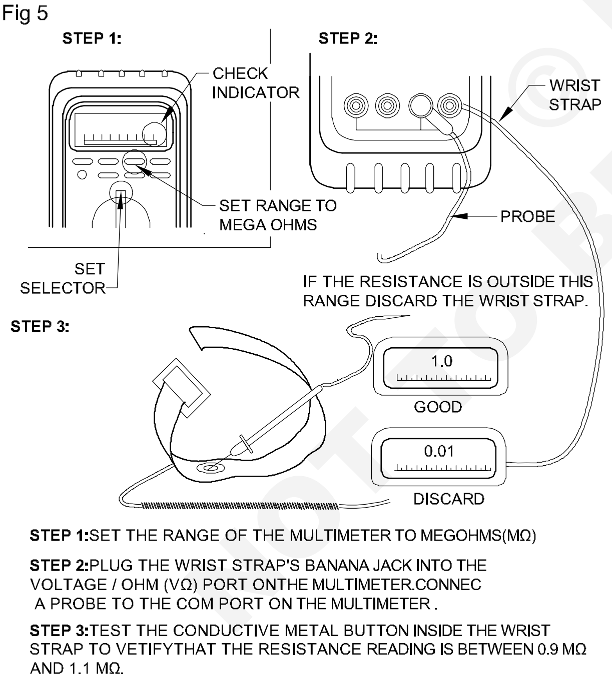
ESD wrist strap testing using a multimeter

Step 1 : Set the range of the multimeter to mega ohms (M)

Step 2 : Plug the wrist strap's banana jack into the voltage /ohm (V) port on the multimeter. Connect a probe to the COM port on the multimeter.

Step 3 : Test the conductive metal button inside the wrist strap to verify that the resistance reading is between 0.9 M and 1.1 M as shown in Fig. 5.

Fig 5



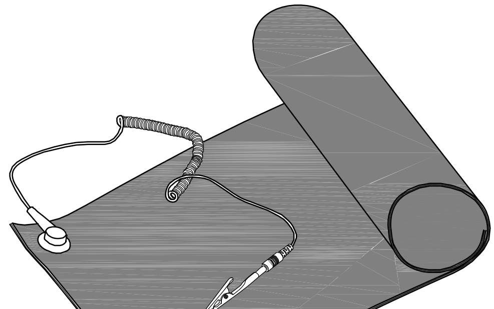
ESD WRIST STRAP TESTING USING A MULTIMETER

EM20N2416515

Floor Mat

A walking surface that dissipates static charge from conductive items placed on it. shown in Fig 6

Fig 6



COMMON POINT GROUND CORD

EM20N2416516

ESD anti fatigue floor mats are made of 3/8" thick closed - cell expanded polyvinyl chloride designed to provide comfort and reduce worker fatigue when used in static sensitive environment. Surface resistivity is 10^9-10^{10} Ohm. The construction design of the ESD floor mat allows for effective static charge removal at a non - damaging flow rate and emboss pattern make slip resistant. At the same time the ESD anti fatigue mat is known to maintain a consistent discharge throughout the life of the mat with no noticeable deterioration of effectiveness. Resistant to degradation by inorganic acid, organic acids, detergent solutions, alcohol and mineral oil. Suggested service temperature of -20°F to +160°F.

Floor mat ground cord

A cable and connector that connect a floor mat to ground

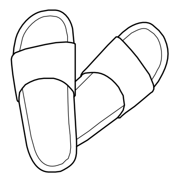
Heel grounder

A device for connecting a walking or standing person to ground by using the moisture in the shoe as a body connection and a conductive rubber tread as a connection to a grounded mat or floor.

ESD Heel grounders

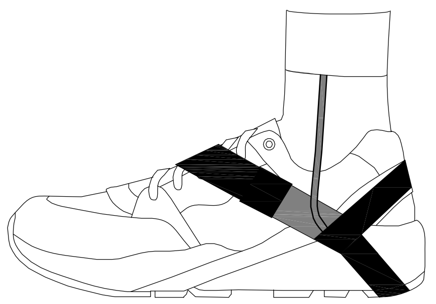
ESD heel grounders provide a continuous ground path between the operator and properly grounded ESD protected flooring. They are designed for use in applications where user mobility is required, such as wave solder, kitting and quality control. "ESD protective flooring used with approved footwear, may be used as an alternative to the wrist strap system for standing operations." Heel grounders quickly and effectively drain the static charges that are collected by the personnel during normal everyday activities. ESD heel straps help protect your electronic assembly plant. shown in Fig. 7 & 8.

Fig 7



EM20N2416517

Fig 8

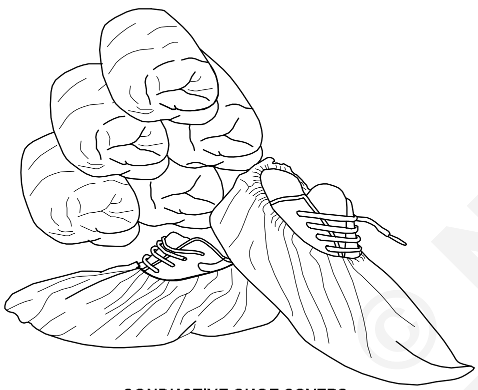


Durable ESD slipper & Heel grounder

Conductive shoe covers

Conductive shoe covers also known as polypropylene shoe covers, are non woven, spun bond fabric that helps filter particulates. They have a conductive strip that protects electronic devices from static charge. Covers are extra lightweight. For added safety, choose skid - free soles for improved traction. They are packaged as 100 pieces per bag and 3 bags per case. shown in Fig.9

Fig 9

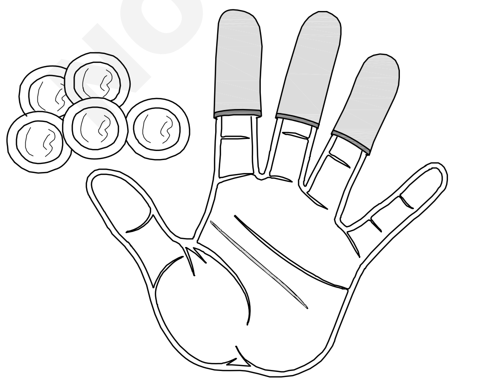


CONDUCTIVE SHOE COVERS

ESD Finger cots

ESD finger cots or pink ESD finger cots are commonly used in electronic assembly, photonics, medical and pharmaceutical manufacturing. Anti static finger cots are powder free and are made of 100% latex material. These finger cots meet MIL -STD - 105E for holes, tear, stains and electrostatic properties. Pink in color. Style is rolled. shown in Fig. 10 & 11.

Fig 10



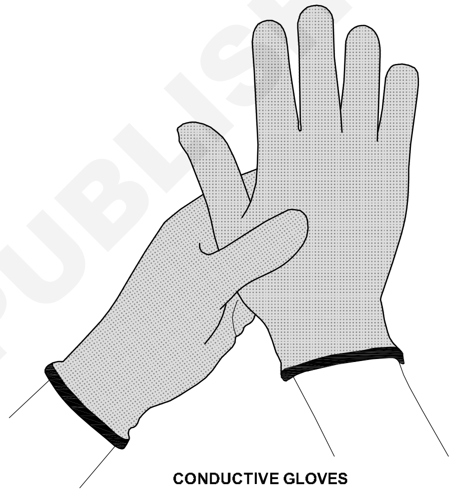
ESD FINGER COTS

Fig 11

Conductive gloves (shown in Fig.12)

Conductive gloves are made of seamless knit nylon and copper fiber yarns with urethane coating. The surface resistivity is below 7.5 x 10^7. Electrostatic dissipative (ESD) fiber yarns blended with low lint nylon which reduces static build - up on the glove surface for improved performance in electronics assembly.

Fig 12



CONDUCTIVE GLOVES

ESD Aprons

ESD jackets, also known as ESD smocks, are lightweight and provide durable static shielding for use where electrostatic charge is a concern. It has a lapel style collar and is 3/4 length with 3 pockets. New ECX -500 fabric gives low cost static - shielding during electronics assembly process. Available in blue and white color. shown in Fig.13

Fig 13

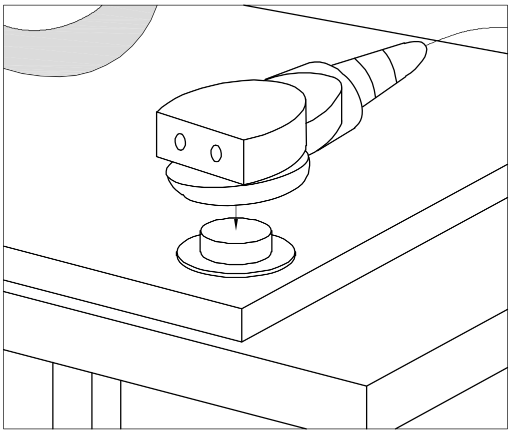
ESD APRONS

To install ESD workstation

1 Lay the table mat flat on the workbench with the snaps toward the operator. TIP. Mild heat (sun light) will remove creases caused by shipping.

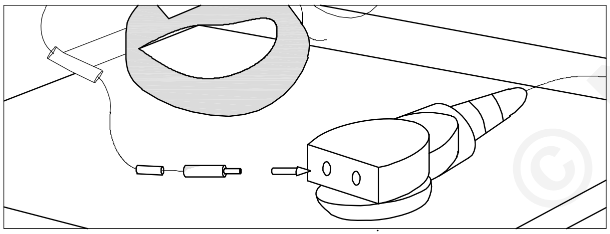
2 Connect the common point ground cord to the table mat by snapping it to the left or right snap. shown in Fig.14

Fig 14



3 Connecting the coil cord to the common point ground cord by plugging the banana plug into one of the ground cord's . shown in Fig.15

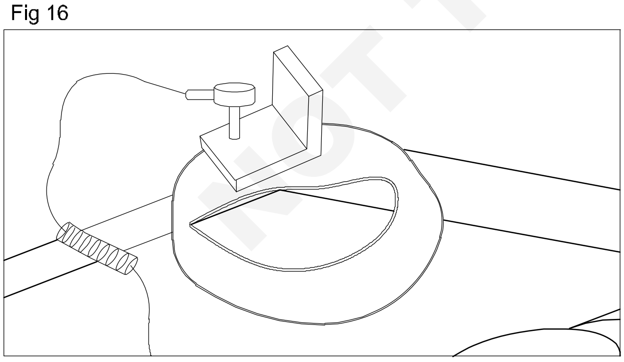
Fig 15



FOUNDATION BOLTS(COMMOM TYPES)

4 Snap the wrist band to the coil cord. TIP : Make sure that the operator wears the wrist band on bare skin and tightens the band so that no gap exists between the skin and the band. shown in Fig.16

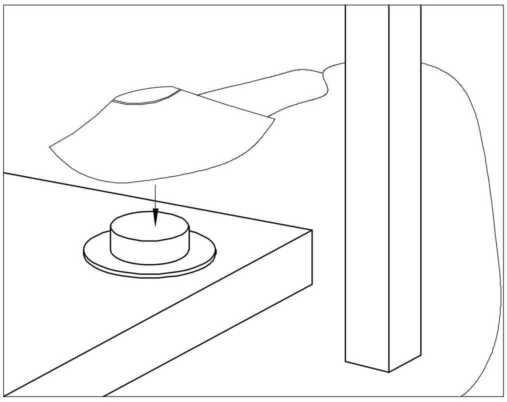
Fig 16



5 Lay the floor mat on the floor in front of the workbench with the snaps toward the bench.

6 Connect the floor mat ground cord to one snap on the floor mat. shown in Fig.17

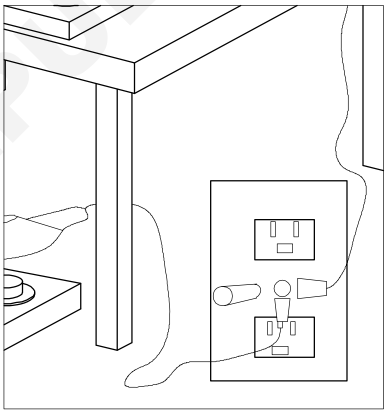
Fig 17



FOUNDATION BOLTS(COMMOM TYPES)

7 Connect the common point ground cord and floor mat ground cord to ground. Use the green wire building ground point as specified in EOS/ESD standard 6. Connection to this ground point most easily accomplished by removing the center AC outlet plate cover screw, placing the screw through the eyelets from both ground cords, and replacing the screw. The wires can be moved to the left and right sides of the screw so that they do not obstruct the outlet. shown in Fig.18

Fig 18



FOUNDATION BOLTS(COMMOM TYPES)

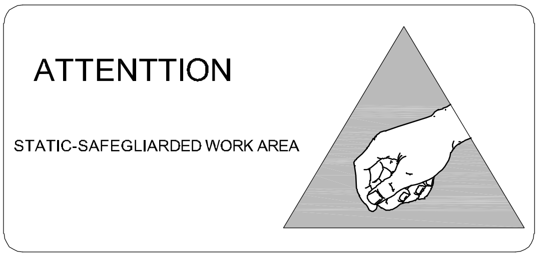
Cautionary notices

Warning : only qualified personnel should work with exposed AC outlets. Consult with a qualified electrician to make ground connection if necessary. AC voltage is dangerous.

Caution : Exercise extreme care when using energized equipment at an ESD workstation. Ground fault current interrupters should be considered to avoid shock. Most static control equipment is not designed to be used near voltages greater than 250 volts.

8 Mount the ESD awareness sign above the work area where it is clearly visible to both the operator and anyone approaching the work area. Before hanging the sign, clean any dust or oil from the wall before application for better adhesion. Next, remove the cover tape from the back of the adhesive strips, place the sign on the wall, and press firmly across the entire sign so that all of the adhesive contacts the wall. shown in Fig.19

Fig 19

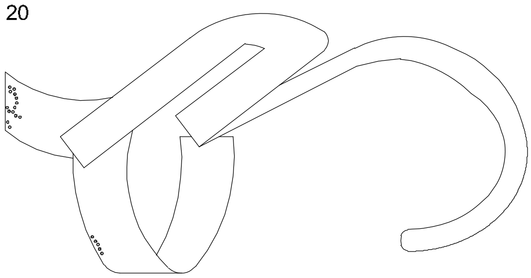


FOUNDATION BOLTS(COMMOM TYPES)

EM20N241651J

9 **Heel grounders :** Open the velcro strap. Remove foot from shoe and insert tab. Trim excess tab material with scissors if necessary. Place foot back into shoe and slip rubber cup onto the shoe's hell. Close velcro strap. Repeat procedure for other shoe. shown in Fig.20

Fig 20



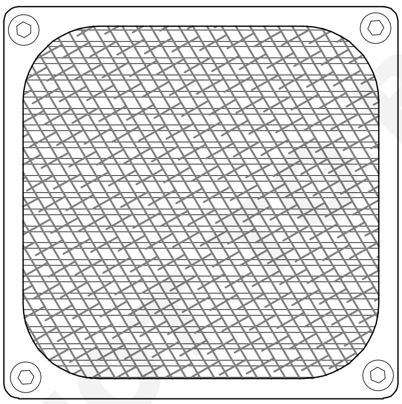
FOUNDATION BOLTS(COMMOM TYPES)

EM20N241651K

Newly installed work stations should be tested for continuity. A surface resistivity meter with a "resistance to ground" function can be used to test continuity from the ground point to all part of the workstation.

Ionizers (shown in Fig.21)

Fig 21



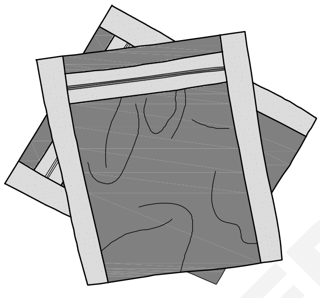
EM20N241651L

Bench top Ionizers are used in many high tech manufacturing programs to control ESD (Electro Static Discharge) in the work environment. EDS ionizers neutralize a static charge via balancing the ions between the molecules in the gasses of the surrounding air. They are typically used to control static on isolated conductors that can't be grounded and isolated objects (like standard plastics). ESD ionizers are perfect for removing contaminant attraction caused by static as well as neutralizing static charges from wide, focused or hard to reach areas. Ionization is ideal when working with delicate electronic products or large more robust assemblies.

The required limit according to ANSI/ESD S20.20 is less than ± 50V offset voltage (balance). In addition to that, the discharge time to reduce + 1000V to +100 V and to reduce -1000V to - 100 V should also be measured. Faster the static elimination time, the better it is. Do look for one that strictly complies with the ANSI /ESD S20.20 standard.

ESD bags (as shown in Fig. 22)

Fig 22



ESD BAGS

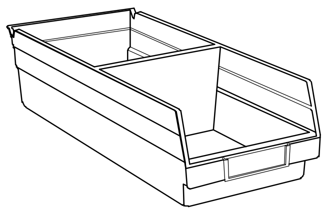
EM20N241651M

ESD bags, also known as general purpose ESD bags or static shielding bags, have buried metal shielding that offers superior durability at a low cost. These ESD bags are recognized as the consistently reliable, readily available and most competitively priced static shielding bags in the electronics industry. General purpose antistatic bags are available in regular open top or zip lock. Light transmission of better than 50% allows for easy identification of static devices without removal.

ESD bags are constructed from an alloy electrostatic shield with a tough layer of polyester protection, providing a level of abrasion and puncture resistance never before possible in a transparent shielding bag.

ESD Bins and containers (shown in Fig. 23 to 29)

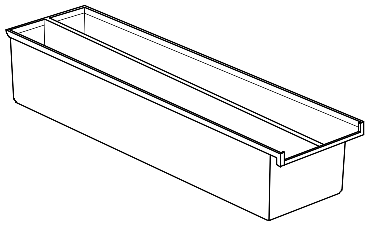
Fig 23



ESD SHELF BIN WITH CORRUGATED BASE

EM20N241651N

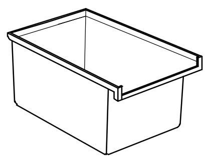
Fig 24



ESD SHELF BIN

EM20N241651O

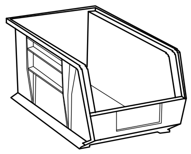
Fig 25



ESD SHELF PARTS DRAWERS

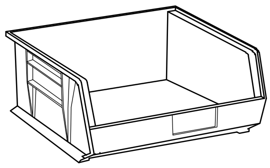
EM20N241651P

Fig 26



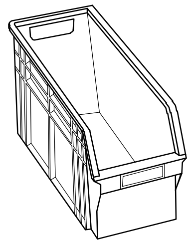
ESD STACKING BINS

Fig 27



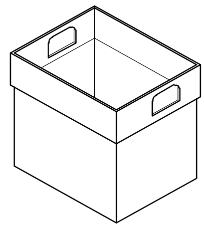
ESD PICKING BINS

Fig 28



LARGE ESD STACKING BIN

Fig 29



ESD STORAGE BOXES

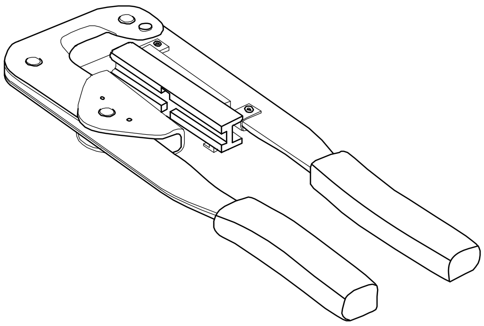
Introduction to non-soldering interconnection and printed circuit boards

Objectives : At the end of this lesson you shall be able to
- **define crimping, wire wrapping, conductive adhesives, chip on board and tape automated bonding**
- **define printed circuit board and its types.**

Crimping

A crimping tool is a device used to join two pieces of metal by deforming one or both of them in a way that causes them to hold each other. The result of the tool's work is called a crimp. A good example of crimping is the process of FRC connector to the end of a cable as shown in the Fig.1.

Fig 1

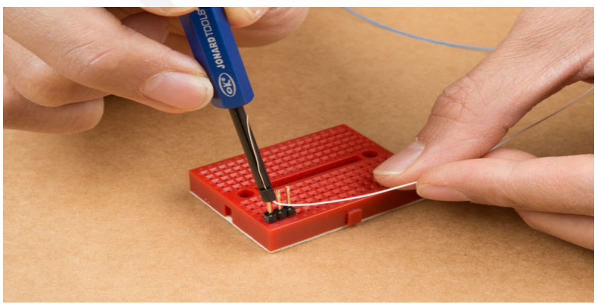


FRC CRIMPING TOOLS

Wire wrapping

Wire wrap is a method to construct electronic circuit board as shown in Fig 2. Electronic components mounted on an insulating board are interconnected by lengths of insulated wire run between their terminals, with the connections made by wrapping several turns around a component lead or a socket pin. Wires can be wrapped by hand or by machine, and can be hand-modified afterwards. It was popular for large-scale manufacturing in the 60s and early 70s, and continues to be used for short runs and prototypes. The method eliminates the design and fabrication of a printed circuit board. Wire wrapping is unusual among other prototyping technologies since it allows for complex assemblies to be produced by automated equipment, but then easily repaired or modified by hand.

Fig 2

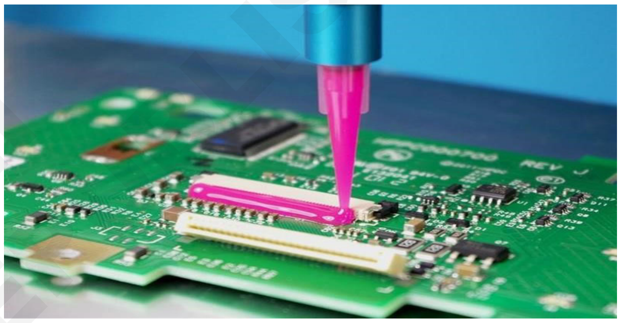


WIRE WRAPPING AND TOOL

Conductive adhesives

An electrically conductive adhesive is glue that is primarily used for electronics as shown in Fig.3. The electric conductivity is caused by a component that makes 80% of the total mass of an electrically conductive adhesive. This conductive component is suspended in a sticky component that holds the electrically conductive adhesive together. The particles of the conductive component are in contact to each other and in this way make electric current possible.

Fig 3



CONDUCTIVE ADHESIVES

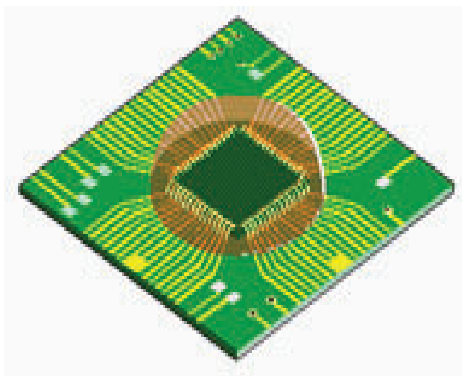
Chip on Board

Chipboard may refer to

A type of paperboard generally made from reclaimed paper stock; as shown in the Fig. 4

- White lined chipboard, a grade of paperboard
- Particle board, a type of engineered wood known as "chipboard" in some countries

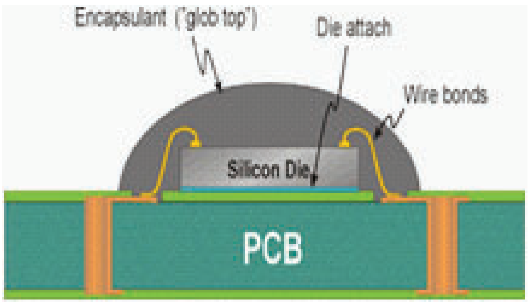
Fig 4



CHIP ON BOARD

The bare chip is adhered and wire bonded to the board, and an epoxy is poured over it to insulate and protect it. For illustrative purposes only, this picture shows a clear epoxy. This side view shows how the wires connect the chip to the printed circuit board (PCB) as shown in Fig.5.

Fig 5



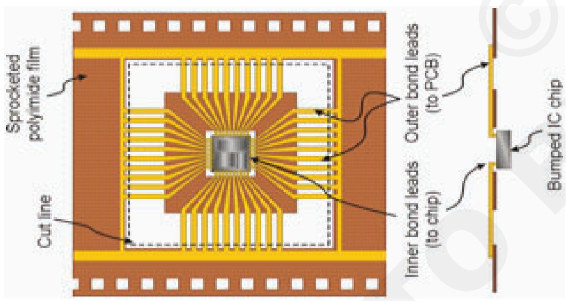
CHIP ON BOARD SIDE VIEW OF PCB

Tape automated bounding

Tape-automated bonding (TAB) is a process that places bare integrated circuits onto a printed circuit board (PCB) by attaching them to fine conductors in a polyamide or polyimide film, thus providing a to directly connect to external circuits as shown in Fig.6.

Process that places bare chips onto a printed circuit board (PCB) by first attaching them to a polyimide film, the film is moved to the target location, and the leads are cut and soldered to the board. This is also called a "tape carrier package" (TCP), the bare chip is then encapsulated ("glob topped") with epoxy or plastic.

Fig 6



TAPE AUTOMATED BONDING

Printed Circuit Board

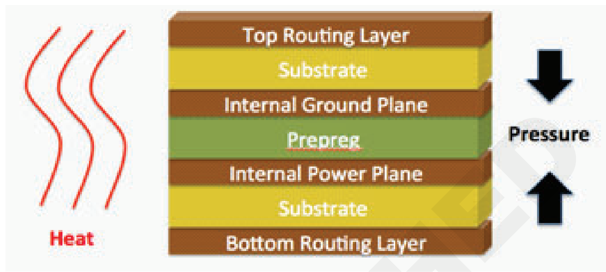
A printed circuit board (PCB) mechanically supports and electrically connects electronic components using conductive tracks, pads and other features etched from copper sheets laminated onto a non-conductive substrate. PCBs can be single sided (one copper layer), double sided (two copper layers) or multi-layer (outer and inner layers). Multi-layer PCBs allow much higher component density. Conductors on different layers are connected with plated-through holes called vias. Advanced PCBs may contain components - capacitors, resistors or active devices - embedded in the substrate.

The PCBs are manufactured with "1 oz copper" (~35µm thick or 1.4 mils) on the outer layers. If there are inner layers, they are almost always manufactured with "1/2 ounce copper"(~17.5µm thick or 0.7 mils)

The thickness of the copper layer on the PCB measured in ounces per square foot or ounces. It can also be given in micrometers, inches or mils.

FR-4 glass epoxy is the primary insulating substrate upon which the vast majority of rigid PCBs are produced. A thin layer of copper foil is laminated to one or both sides of an FR-4 panel. Circuitry interconnections are etched into copper layers to produce printed circuit boards. Complex circuits are produced in multiple layers as shown in Fig. 7.

Fig 7



CONSTRUCTION OF MULTI LAYER PCB

Printed circuit boards are used in all electronic products. Alternatives to PCBs include wire wrap and point-to-point construction. PCBs require the additional design effort to lay out the circuit, but manufacturing and assembly can be automated. Manufacturing circuits with PCBs is cheaper and faster than with other wiring methods as components are mounted and wired with one single part. Furthermore, operator wiring errors are eliminated.

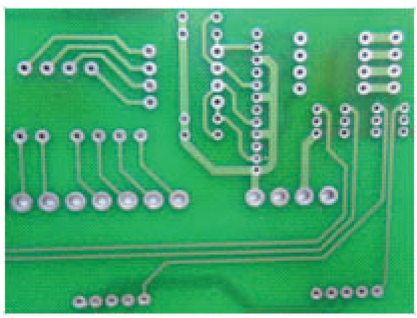
Types of PCBs

- Single side PCB
- Double side PCB
- Multi layer PCB

Single side PCB

Single-sided printed circuit boards are easily designed and quickly manufactured as shown in Fig.8. Single sided boards are available with surface finishes including Organic surface protectant (OSP), Immersion Silver, Tin, and Gold plating along with both leaded and lead-free Hot Air Solder Level (HASL).

Fig 8



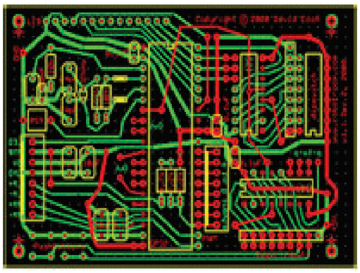
SINGLE SIDE PCB

Ex: Power supplies, Relays (automotive and industrial), Timing circuits, Sensor products

Double Side PCB

Double Sided PCBs (also known as Double-Sided Plated Thru or DSPT) as shown in Fig. 9 circuits are the gateway to higher technology applications. DSPT the advantage of the plated through-hole is quickly adapted and allowed electronic designs to expand in capability and shrink in physical size. Today the double sided printed circuit board technology remains the workhorse of the assembly industry. There are limitless applications for old and new designs.

Fig 9



DOUBLE SIDE PCD BOARD

Ex: Industrial controls, Power supplies, Converters, Control relays

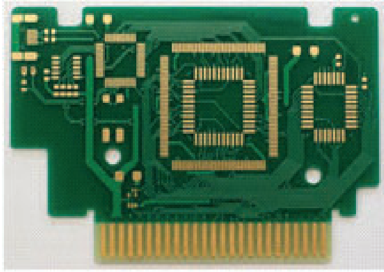
Multi- layer PCB

Multilayer printed circuit boards (PCBs) representes the next major evolution in fabrication technology as shown in Fig. 10. From the base platform of double sided plated thru came a very sophisticated and complex methodology that would again allow circuit board designers a dynamic range of interconnects and applications.

Multilayer circuit boards were essential in the advancement of modern computing. The multilayer PCB basic construction and fabrication are similar to micro chip fabrication on a macro size. The range of material combinations is extensive from basic epoxy glass to exotic ceramic fills. Multilayer can be built on ceramic, copper, and aluminum. Blind and buried vias are commonly produced, along with pad on via technology.

EX: Computers, File servers, Cell phone

Fig 10

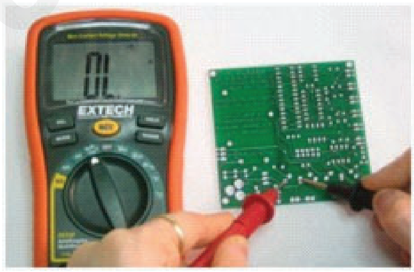


MULTI LAYER PCB

Test of PCB

In this blog some basic procedures for finding faults with PCBs and fixing those faults. Though there are many circuit testing programs and probes available in the market for skilled technicians and test engineers there are no general guidelines. If you face some problems like when you end up removing an entire track (connection from one component to another) on the PCB you can use a simple piece of wire to imitate the connection. Solder the two ends of the wire where you think the connection should be present on the PCB as shown in Fig. 11.

Fig 11



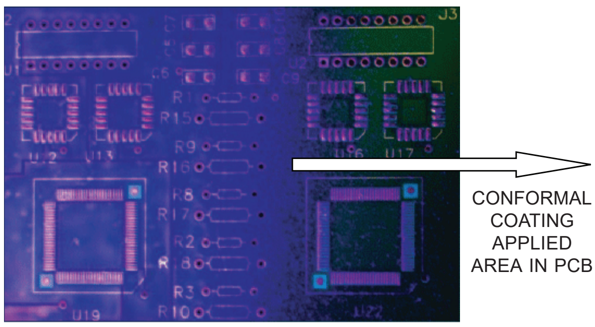
TESTING OF PCB

Types of conformal coating and its removal methods

Objectives : At the end of this lesson you shall be able to
- **define conformal coating & its types**
- **explain how to coat the conformal coating**
- **describe various method of removal of conformal coating.**

Conformal coating is a protective chemical coating or polymer film 25-75µm thickness that is applied onto the printed circuit board. It is used to protect PCB from damages due to contamination, salt spray, moisture, fungus, dust and corrosion and also a physical barrier. When coated, it is clearly visible as a clear and shiny material as shown in Fig. 1.

Fig 1

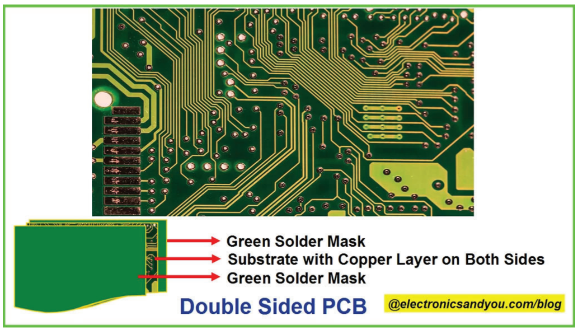


CONFORMAL COATING APPLIED AREA IN PCB

Construction of printing circuit board (Single Double, Multiple)

A PCB (Printed circuit board) or PWB (Printing wring Board) is a complex circuitry of copper tracks on a heat resistant material called PCB substrate. Electronic components are soldered on this Circuit Board to control flow of electricity in a preset matter for the electronic device to work in a manner that it was designed for.

Fig 2



Different Types of PCB

1 Single Sided PCB or Single Layer PCB

2 Double Sided PCB or Double Layer PCB

3 Multiplayer PCB

4 Rigid PCB

5 Fixed PCB or Flexible PCB

6 Rigid-Flex PCB or Rigid-Flexible PCB

Single sided PCB

A single-side PCB, Also known as a single-layer PCB, is manufacturer begins with a base core material such as

Copper on it. This copper material makes the board conductive

Then they add a solder mask that insulates the conductive copper sheet below.

Rest of the layers with a silkscreen print that indicates the location for each part. When creating a single sided board, the manufacturer adds these layers to one side only.

Single –sided boards may not have the same complexity as their counterparts, but they power a wide range of everyday electronics. Since they cost so little to make, you can find them in bulk-manufactured

Devices like:

1 cameras

2 Audio equipment

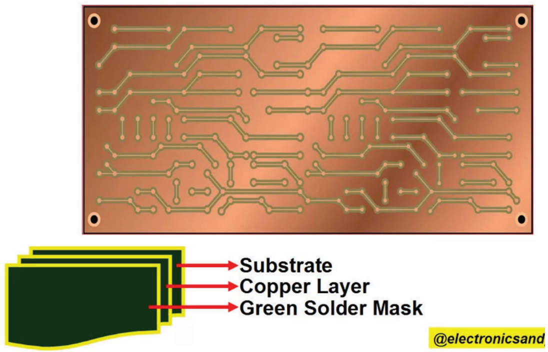
3 Power supplies

4 Calculators

5 solid state drives

6 prints

Fig 3



Double sided PCBS

Making double-sided PCBs involves the same kind of layers as a single- sided board. The difference between double sided and single sided PCBs is that instead of using a single sided copper core, the manufacture will start a core with copper on both sides. During production, they also drill holes called vias that they can plate or fill with a conductive, ore nonconductive material. The electrical current travels from one side of the board to the other though these vias. Double-sided PCBs have a higher cost than single sided boards, but they provide twice as much space for components.

Electronics that need an intermediate level of circuit complexity use double sided PCBs to operate. Double-sided boards power more complicated devices than single-sided PCBs, but they can't handle advanced applications like computers or smartphones. They appear in electronic such as:

1 LED lighting

2 Vending machines

3 Car dashboards

4 Phone systems

5 Industrial controls

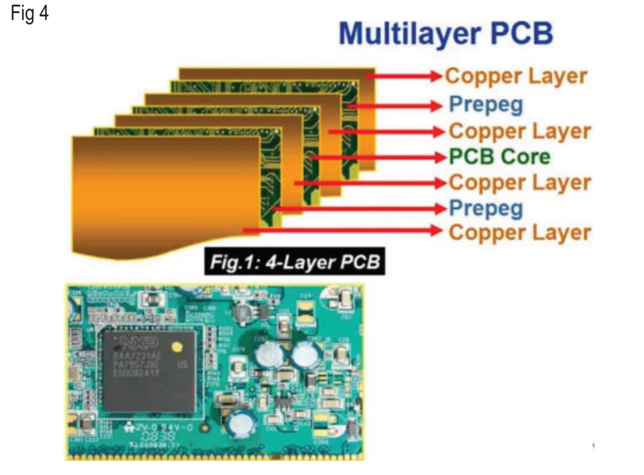
Multilayer printed circuit boards

Multilayer PCBs can support a high level of circuit complexity because they consist of three or more copper layers laminated together. The manufacturer starts a core that has the same materials as a typical single sided or double sided PCB. After etching the inner core, they add layers of prepreg, a soft fiberglass. This material keeps the layers together and becomes hard fiberglass after the board goes though the hot press. As a result of the curing process, multilayer PCBs are tough and durable. If the manufacture is building a 4 Layer pcb they typically will use one core, prepreg and they copper foil for the top and bottom layers.

We have complex technology like computers and data severs thanks to the high capacity of multilayer PCBs. Other examples of devices powered by multilayer PCBs include:

1 Fiber optics
2 Smartphones
3 GPS system
4 Scientific and space equipment
5 Heart monitors
6 Atomic accelerators

Fig 4



Repair and damage track in PCB :

Repair Pen: For minor scratches or small cracks, you can use a solder mask repair pen or paint to fill in the damaged area. Follow the manufacturer's instructions for applying the repair material. Typically, you would carefully apply the repair pen over the damaged section and allow it to dry or cure.

UV Curable Mask: Another option is to use a UV curable solder mask material. Apply a thin layer of the UV curable mask over the damaged area, ensuring it covers the entire affected section. Use a UV light source to cure the mask according to the manufacturer's instructions. Larger Damaged Sections:

Masking Tape: If the damaged area is relatively large, you can use masking tape to create a temporary barrier around the damaged section. Apply the tape around the perimeter ensuring it covers the unaffected areas. Then, carefully fill in the damaged section with solder mask material using a brush or syringe. Once the mask material has cured, remove the masking tape.

Professional Repair: In cases where the damage is extensive or involves intricate patterns, it is recommended to seek professional assistance or specialized PCB repair services. They can use advanced techniques such as laser ablation or screen printing to accurately restore the solder mask.

Curing and Finishing: After applying the solder mask repair material, ensure that it is fully cured according to the manufacturer's instructions. Once cured, inspect the repaired area for any imperfections or inconsistencies. If necessary, you can lightly sand or polish the repaired section to achieve a smoother surface finish.

It's worth noting that the repaired solder mask may not match the original color or texture perfectly. Additionally, the repaired section may have slightly different electrical or thermal characteristics compared to the surrounding solder mask. Therefore, it's important to thoroughly test the PCB after the repair to ensure its functionality and performance.

Again, for precise and professional solder mask repairs, it is advisable to consult experts or specialized PCB repair services who have the necessary tools and experience.

Introduction to rework and repair concepts

Objective : At the end of this lesson you shall be able to
- **explain the solder mask, solder joints, tracks, pads and plated through hole.**

Solder mask

Solder mask or solder stop mask or solder resist is a thin layer of polymer applied to the copper traces of a printed circuit board (PCB) for protection against oxidation short circuits, corrosion, and other problems. Solder mask is a thin layer of polymer and to prevent solder bridges from closely spaced solder pads. A solder bridge is an unintended electrical connection between two conductors by means of a small blob of solder. Once applied, openings must be made in the solder mask wherever components to be soldered. This is done by photolithography. Solder mask is mostly green in color, but is now available in many colors.

- Green
- Matte Green
- Red
- Blue
- Yellow
- White
- Black
- Matte Black

Mostly Green colours used as solder mask as shown in Fig.1a & 1b.

Solder mask as shown in Fig. 2a & 2b comes in different media depending upon the demands of the application.

The lowest-cost solder mask is epoxy liquid that is silkscreened through the pattern onto the PCB. Other types are,

Liquid photoimageable solder mask (LPSM) inks.

Dry film photoimageable solder mask (DFSM).

LPSM are silkscreened and sprayed on the PCB, exposed to the pattern and developed to provide openings in the pattern for parts to be soldered to the copper pads.

DFSM is vacuum laminated on the PCB then exposed and developed.

All three processes go through a thermal cure after the pattern is defined.

Solder joints

The solder joints are very much important in construction of PCB as shown in Fig.3a & 3b.

Fig 1a

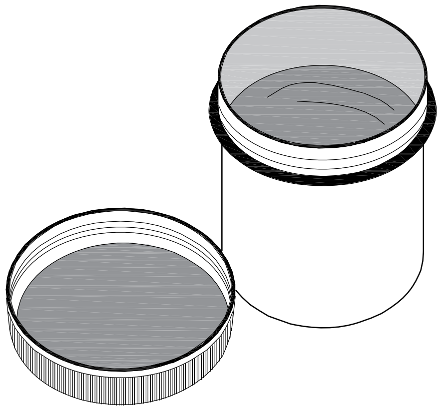


Fig 1b

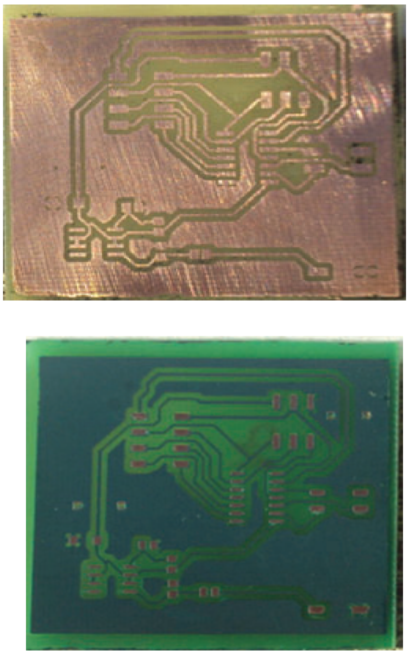


Fig 2a

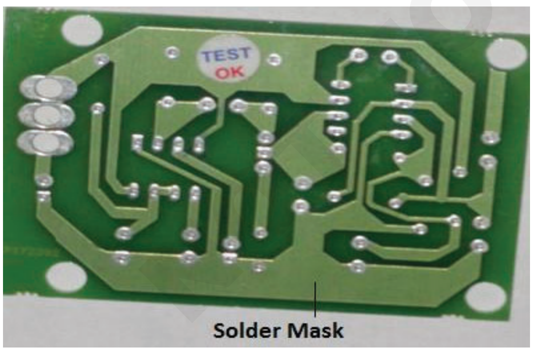
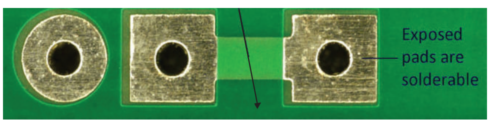


Fig 2b



SOLDER MASK COVERS UP THE SIGNAL TRACES BUT LEAVES THE PADS TO SOLDER.

Fig 3a

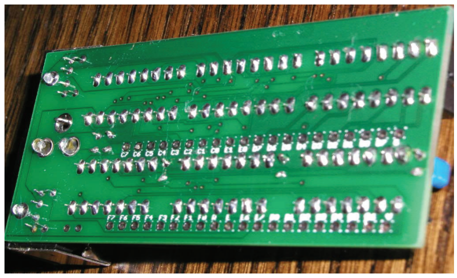
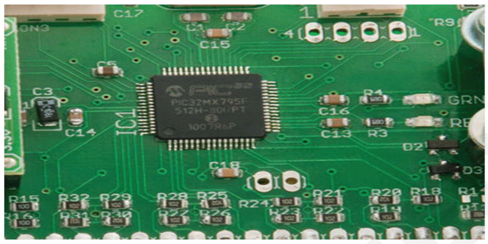


Fig 3b



- If the solder joints are poor
- It will cause the equipment to not to work.
- There is a possibility that the solder joint could fail intermittently.
- It will introduce noise into the circuit.

Fig.4 Shows the method of solder joints on PCB

Good solder joint

Most solder joints are good and do not cause any problems. A good solder joint will have a shiny finish to it, and it should not have too much solder as shown in Fig.5. The contour of the solder around the joint should be slightly concave.

Fig 4

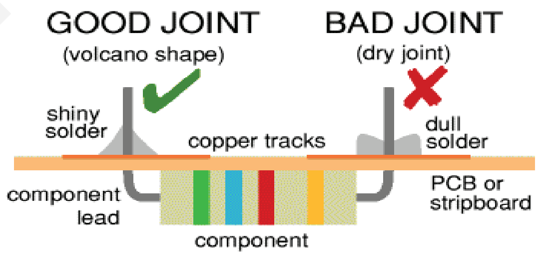


Fig 5

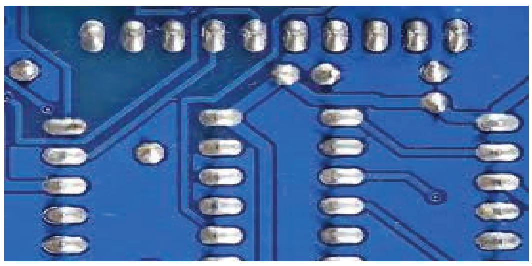


Fig 6a

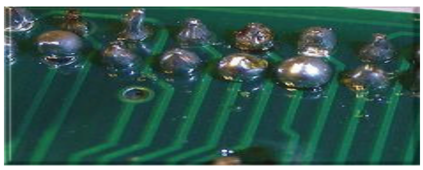
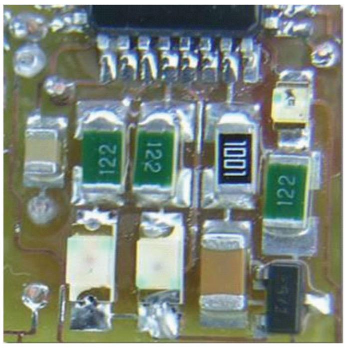


Fig 6b

Fig 6c



Poor solder joints

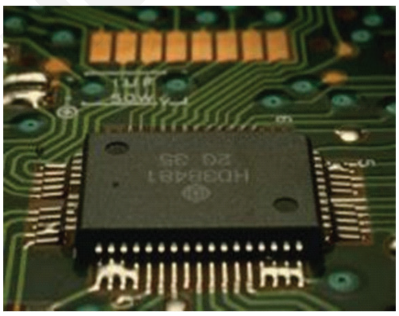
Too much solder on a joint may lead to poor joints as shown in Fig. 6a, 6b, 6c

Excess solder on joints

On printed circuit boards if too much solder is used then it could spill over onto another track, causing a short circuit as shown in Fig.7a & 7b.

Fig 7a

Fig 7b



Dry joints

Dry joints are the main problem of solder joint. These solder joints may be completely open circuit, or they may be intermittent, high resistance or noisy. Therefore it is essential that no dry solder joints are present in any electronics equipment.

It is easy to identify dry joints as shown in Fig.8a & 8b. Good solder joints are shiny, where as dry joints have a dull or matt finish.

Fig 8a

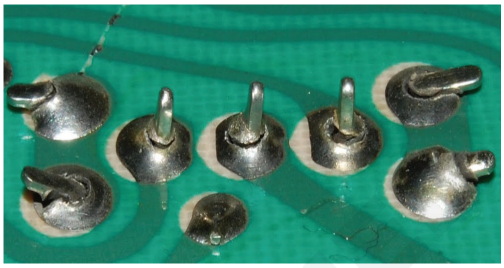
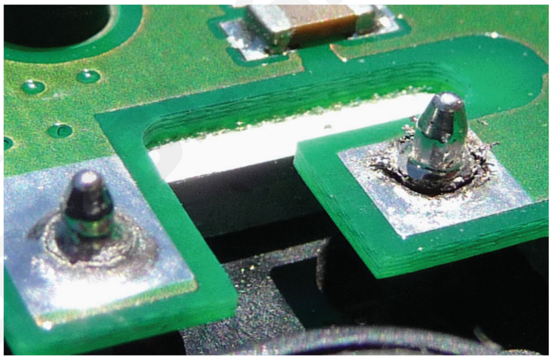


Fig 8b



When a dry joint is found, the solder on the joint should be removed and care to be taken when re-soldering it, to ensure that a good joint is made.

Tracks

Commonly there is no recommended standard for track sizes. Size of track will depend upon the requirements of the design, the routing space and clearance. Every design will have a different set of electrical requirements which can vary between tracks on the board. As a general rule bigger the track width is better. Bigger tracks have lower DC resistance, lower inductance, can be easier and cheaper for the manufacturer to etch, and also easier to inspect and rework. The lower limit of track width will depend upon the “track/space” resolution. For example, a manufacturer may quote a 10/8 track /space. This means that tracks can not be less than 10 thou wide, and the spacing between tracks, or pads, or any part of tracks are the copper, can not be less than 8 thou. Always quoted in thou’s, with track width first and then spacing. IPC standard recommends 4 thou as being a lower limit.

A “thou” is 1/1000th of an inch = 1 thou (0.001 inch)

Fig.9 shows the tracks on the PCB.

Fig. 10 shows the damaged track on PCB which is to be repaired.

Pads

Fig. 11 shows the pads of PCB

Pad sizes, shapes and dimensions will depend upon the component used to assemble the board. There is an important parameter known as the pad/hole ratio. This is the ratio of the pad size to the hole size. The pad should be at least 1.8 times the diameter of the hole, or at least 0.5 mm larger. This is to allow for alignment tolerances on the drill and the artwork on top and bottom layers. This ratio gets more important the smaller the pad and

Fig 9

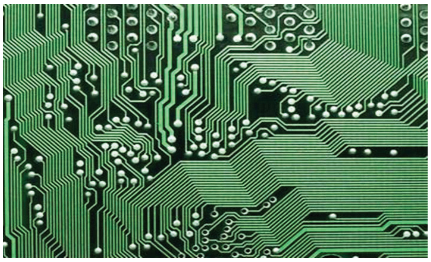


Fig 10

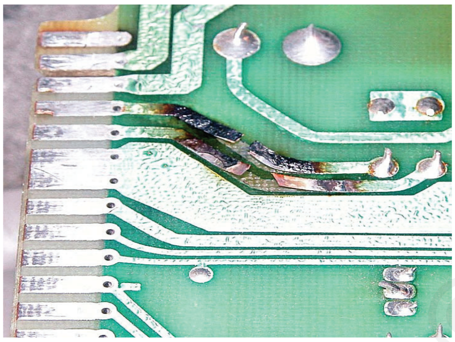
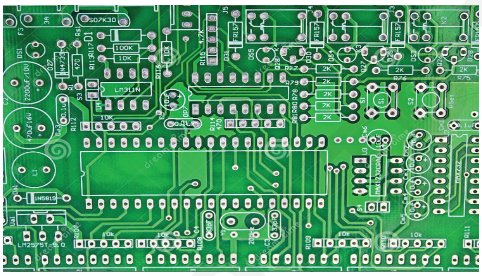


Fig 11



hole become, and particularly relevant to vias. Pads for components like resistors, capacitors and diodes should be round, with around 70 thou. diameter being common. Dual in line (DIL) components like IC's are oval shaped pads.

Pin.1 of the chip should be rectangular shape and other pins are circular or oval.

Fig.12 shows the damaged pad which is to be reworked.

Plated-Through Hole

"Through-hole technology", refers the mounting system used for electronic components inserted into holes in PCBs and soldered to pads on the opposite side either by manual assembly or automated insertion mount machines. PCBs are initially had tracks printed on one side only. Later two sides are used, and then multi-layer boards are using now a days. Similarly, through holes became plated-through holes (PTH), Fig.13. is a Plated-Through Hole in a ten layer board.

Plated-through holes are used to make the components contact with required conductive layers and making interconnections between the layers called vias.

In PTH electrolysis deposition are done after the holes are drilled, then copper is electroplated to build up the thickness, Finally the boards are screened, and plated with metal. The amount of plating used in the hole depends on the number of layers in the printed circuit board, however only the least amount of metal is used for this process. Holes through a PCB are typically drilled with small-diameter, drill bits are made up of solid coated tungsten carbide. Fig.14 shows the eyelets, which can be used to repair if PTH or vias are damaged.

Fig 12

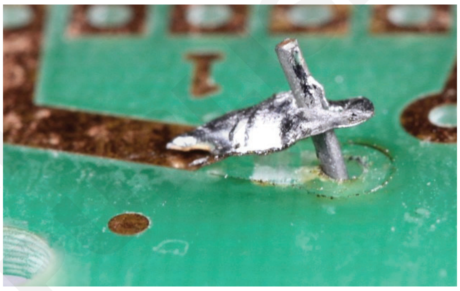


Fig 13

Fig 14

Fuses-terminology-types-uses

Objectives : At the end of this lesson you shall be able to
- **explain the purpose of the fuse in a circuit**
- **explain the types of fuse bases**
- **classify the different types of fuses and their uses.**

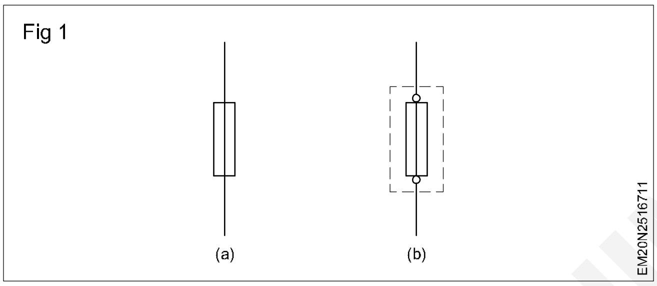
Purpose of fuses : A fuse is a safety device used for the purpose of protecting a circuit against excess current. In the event of excessive current, the fuse element melts and opens up the circuit thereby protecting it from damage.

Symbols : These are the graphical symbols used to illustrate an electrical fuse in electro - technical diagrams.

General symbols of a fuse (Fig. 1a)

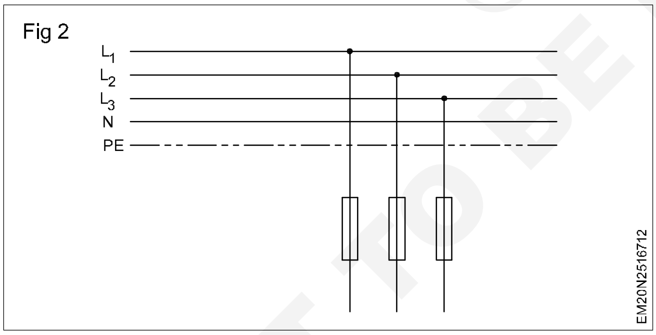
Fuse with terminals and protective housing (Fig. 1b)

Fig 1



Placement of fuses : In electrical installations, the fuses are always connected into the live wires (L_1, L_2 and L_3 as shown in Fig. 2) and never into the neutral N or the protective earth line (PE).

Fig 2



Terminology

Fuse element : The part of the fuse which is designed to melt and open up a circuit.

Fuse - carrier : The removable portion for carrying the fuse element.

Fuse base : The fixed part of the fuse provided with terminals for connection to the circuit which is suitable for the reception of the fuse - carrier.

Current rating : Safe maximum current that can pass continuously without overheating.

Fusing current : The current at which the fuse element melts

Cut - off factor : Time (period) taken a fuse to interrupt the circuit in the event of a fault.

Fusing factor : Ratio between minimum fusing current and current rating.

$$\text{Fusing factor} = \frac{\text{Minimum fusing current}}{\text{Rated current}}$$

The fusing factor for a re-wireable fuse varies between 1.4 to 1.7 and may go up to 2.0, but for a HRC fuse it is 1.1

However, a fuse selected for over - current protection should not have a fusing factor of more than 1.4.

The fusing factor for a re-wirable fuse varies between 1.4 to 1.7 and may go up to 2.0, but for a HRC fuse it is 1.1

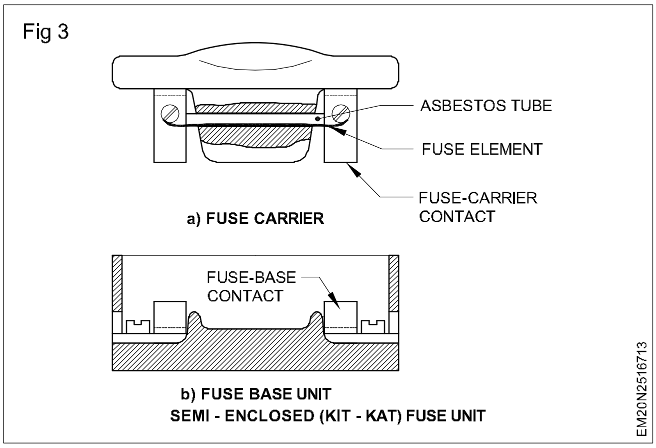
However, a fuse selected for over-current protection should not have a fusing factor of more than 1.4.

Types of fuses used in domestic wiring:

- Re-wirable type (up to 200A)
- Cartridge type (up to 1250A)

Rewirable type fuse (Fig. 3): The fuse element in this type of fuse consists of a wire which may be replaced when necessary. These fuses are simple in construction and the initial cost as well as the renewal cost is very low.

Fig 3



The fuse elements used in this type are tinned copper wire, lead and tin alloy. Approximate sizes of fuse elements of tinned copper wire or aluminium wire for use in semi-enclosed fuses are shown in Table 1.

The fuse element will melt after approximately 2 minutes when carrying a current equal to twice the current rating. However, the cut-off time factor varies in rewirable fuses due to:

- the construction of the carrier (design of fuse-carrier/ base)
- the manner in which the fuse wire has been fitted
- the length of time the fuse was in service
- ambient temperature
- the amount of current etc.

Small fuse wires in parallel in a carrier to carry a large current should be avoided, as far as possible. The actual rating becomes less than the sum of the ratings of the individual strands. A paralleling factor of 0.7 to 0.8 is used to multiply the sum of the rating of individual strands to get the actual current rating.

Example: 35 SWG - copper wire has a fuse rating of 5 amps, and 3 strands in parallel together will a have current rating equal to 5x3x0.8=12 amps when 0.8 is taken as the paralleling factor.

Disadvantages of rewirable type fuse:

- Deterioration of the fuse element by oxidation due to heating.
- Lack of discrimination.

Table 1

Current rating for	Approximate fusing current Amp.	Tinned copper wire		Aluminium wire dia. in mm
		S.W.G.	Diameter in mm	
1.5	3	40	.12192	--
2.5	4	39	.13208	–
3.0	5	38	.1524	.195
4.0	6	37	.17272	–
5.0	8	35	.21336	–
5.5	9	34	.23368	–
6.0	10	33	.254	.307
7.0	11	32	.27432	–
8.0	12	31	.29464	–
8.5	13	30	.31496	–
9.5	15	–	—	.400
10.0	16	29	.34544	–
12.0	18	28	.37592	–
13.0	20	–	—	.475
13.5	25	–	—	.560
14.0	28	26	.4572	–
15.0	30	25	.508	.630
17.0	33	24	.5588	–
18.0	35	–	—	.710
20.0	38	23	.6096	–
21.0	40	–	—	–
22.0	45	–	—	.750
24.0	48	22	.7112	.850
25.0	50	–	—	.90
29.0	58	21	.8128	–
30.0	60	–	—	1.00
34.0	70	20	.9144	1.22
37.5	80	–	—	1.25
38.0	81	19	1.016	--
40.0	90	–	—	1.32
43.0	98	–	1.1176	–
43.5	100	–	—	1.40
45.0	106	18	1.2192	–
55.0	120	–	—	1.60
62.0	130	–	—	1.70
65.0	135	17	1.4224	–
66.0	140	–	—	1.80
69.0	150	–	—	1.85
73.0	166	16	1.6256	–
75.0	175	–	---	2.06
78.0	197	15	1.8288	–
80.0	200	–	—	2.24
102.0	230	14	2.032	–
130.0	295	13	2.3368	–

- Effected by the fluctuation of the ambient temperature.
- Premature failure due to deterioration under normal load.
- Low speed operation (poor cut-off factor)
- External flash or arc on blowing.
- Poor rupturing capacity (under short-circuit condition).
- Wrong rating possible by human error.

Rewirable-type fuses up to 16A rated current should not be used in locations where short circuit level exceeds 2 KA, and those of higher ratings in locations where the S.C. level exceeds 4 KA. (I.S. 2086-963)

Cartridge fuses: Cartridge fuses are developed to overcome the disadvantages of the rewirable fuses. Due to high temperature, prolonged use and oxidation, rewirable fuses deteriorate and interrupt the supply even when carrying normal current. As cartridge fuse elements are enclosed in an air tight chamber, deterioration does not take place. Further the rating of a cartridge fuse could be accurately determined from its marking. However, the cost of replacement of cartridge fuses is more than that of rewirable fuses.

Cartridge fuses can be grouped as those with a:

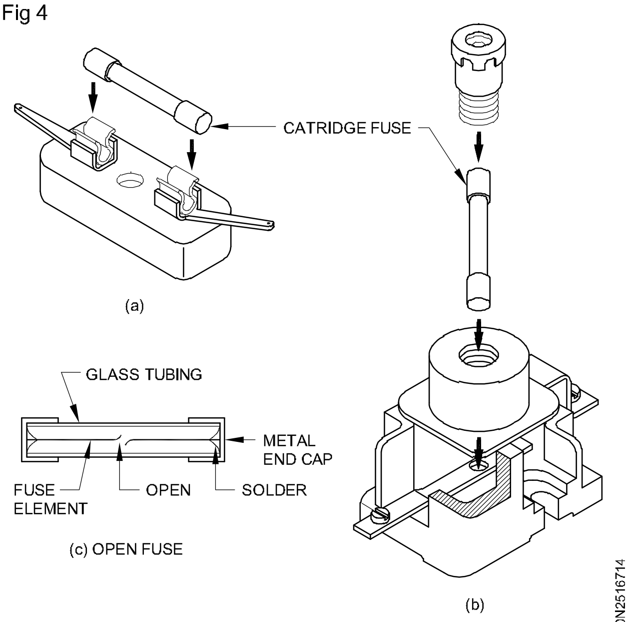
- low rupturing capacity (Say rupturing capacity up to 50 KA.)
- high rupturing capacity. (Say rupturing capacity above 80 KA.)

Rupturing capacity is the ability of a fuse to open the faulty circuit without much arcing or damage to itself. For domestic installations, low rupturing capacity fuses are used whereas for high power factory installations, and for installations connected from high power sources, high rupturing capacity (HRC) fuses are used.

Low rupturing capacity cartridge fuses can be further divided into:

- Ferrule-contact cartridge fuses.(Fig. 4)

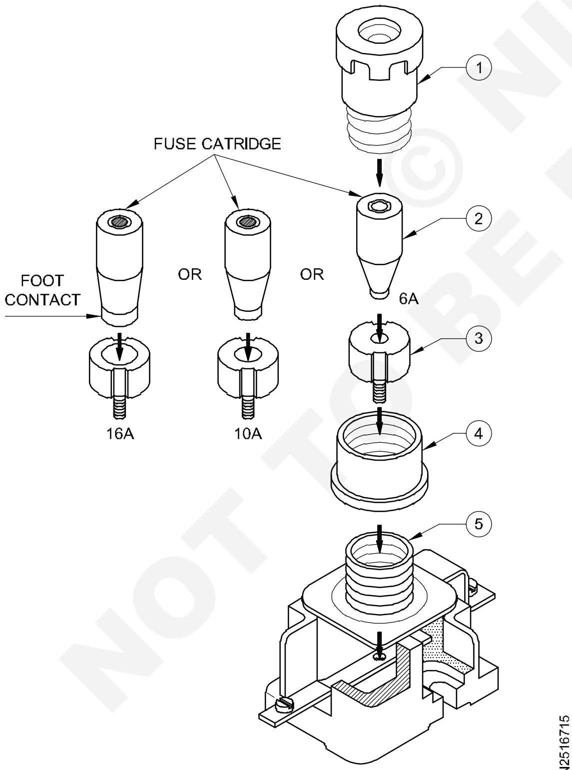
Fig 4



FERRULE - CONTACT CATRIDGE FUSE UNIT

- diazed screw-type cartridge fuses.(Fig. 5)

Fig 5



DIAZED SCREW TYPE CATRIDGE FUSE UNIT

Ferrule-contact cartridge fuses: This type, shown in Fig. 4, is used for protecting electrical and electronic circuits. These are available in 25, 50, 100, 200, 250, 500 milliamperes, and also in 1,2,5,6,10,16 & 32 amperes capacity. Normally the current rating is written on one side of the cap, and while replacing, the same capacity fuse should be used. Its body is made of glass and the fuse wire is connected between two metallic caps.

This fuse can be plugged into the fuse socket as shown in Fig 4a or it can be fitted into a fuse base with a screw, in a fuse- holder of the type shown in Fig. 4b.

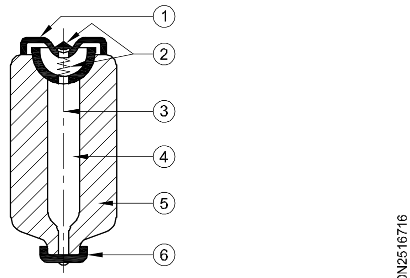
Diazed screw-type cartridge fuses: This is shown in Fig. 5. It is also not of a rewirable type. This type of fuse is commonly used in domestic and industrial electrical installations in many countries. It consists of the following parts as shown in Fig. 5.

- Screw cap or fuse cartridge-holder (1)
- Fuse cartridge (2)
- Fitting screw or contact screw (3)
- Protective plastic or ceramic ring (4)
- Fuse base or fuse socket (5)

Fuse cartridges are available for rated electric currents of: 2, 4, 6, 10, 16, 20, 25, 35, 50 and 63 amperes. To prevent the insertion of a fuse cartridge having a larger current rating than intended, the foot contacts of the fuse cartridges have different diameters for each rated current(the smaller the current the smaller the diameter of the foot contact). As there is also a separate fitting screw for each type of cartridge, it is not possible to insert, let's say, a 35 amp. fuse cartridge into the fitting screw of a 25 amp fuse cartridge.

Fig. 6 shows the inside of one of the afore-mentioned fuse cartridges. It shows the ceramic body of the cartridge with its foot and head contacts. The two contacts are linked by a fuse wire which is embedded in sand. Each cartridge has a break indicator which will be ejected from the cartridge if the fuse wire is burnt out. The parts of this cartridge, shown in Fig. 6, are:

Fig 6

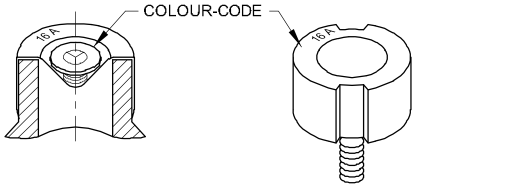


FUSE CATRIDGE

- head contact(1)
- break indicator(2)
- fuse wire(3)
- sand filling(4)
- ceramic fuse body(5)
- foot contact. (6)

For easy identification of the fuse cartridges and the corresponding fitting screws, they are marked with various colours at the places shown in Fig. 7. For each current rating, a different colour is used.

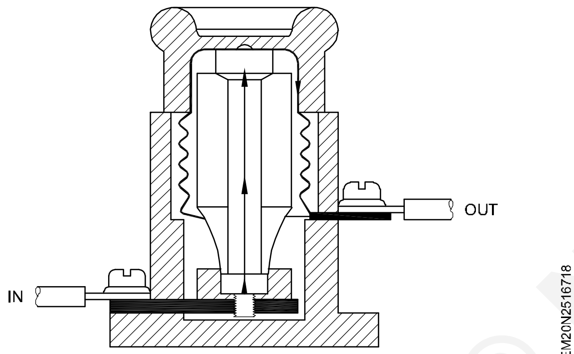
Fig 7



Pink	- 2 amperes	Blue	- 20 amperes
Brown	- 4 amperes	Yellow	- 25 amperes
Green	- 6 amperes	Black	- 35 amperes
Red	- 10 amperes	White	- 50 amperes
Grey	- 16 amperes	Copper	- 63 amperes

Fig 8 shows the flow of the electric current through the fuse base and the fuse. In order to prevent the accidental touching of a live line, the electrical supply must be connected to the terminal which is connected to the fixing screw at the bottom of the base.

Fig 8

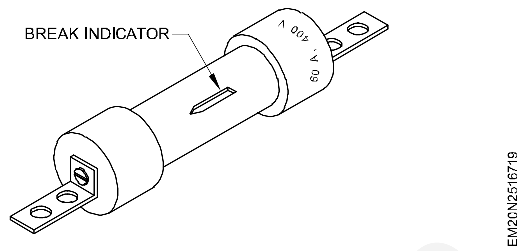


Diazed type fuses are available in two categories,

a) quick-response type and b) delayed-action type. The quick-response type is used for heating circuits and normal loads whereas the delayed- action type is used for motor circuits and highly inductive circuits.

High rupturing capacity fuses (Fig. 9): They are cylindrical in shape and are made of a ceramic body filled in with a chemically treated filling powder or silica to quench the arcing quickly without any fire hazard.

Fig 9



Normally a silver alloy is used as the fusing element and when it melts due to the excessive current, it combines with the surrounded sand/powder, and forms small globules without making an arc, spark or gas. HRC fuses can open a short-circuited circuit within 0.013 second. It has an indicator to show the fuse has blown. The rupturing capacity of the fuse could be calculated from the following formula.

$$\text{Rupturing capacity in MVA} = \frac{\begin{matrix}\text{Fault current} \\ \text{in amperes}\end{matrix} \times \begin{matrix}\text{Circuit} \\ \text{voltage}\end{matrix}}{10^6}$$

As HRC fuses are capable of opening circuits having very high faulty currents, these are preferred in high power circuits even though the replacement cost is high.

Miniature circuit breaker (MCB)- types- construction- working- specification

Objectives: At the end of this lesson you shall be able to
- **explain the types, working principle and parts of a miniature circuit breaker.**
- **state the advantages and disadvantages of MCB**
- **explain the working of combination circuit breaker (ELCB + MCB)**
- **state the categories of MCB's**
- **state the applications of MCBs.**

Circuit Breaker

A circuit breaker is a mechanical switching device capable of making, and breaking currents under normal circuit condition and also making, carrying current under normal condition and breaking currents under abnormal circuit conditions like a short circuit.

Miniature circuit breaker (MCB)

A miniature circuit breaker is a compact mechanical device for making and breaking a circuit both in normal condition and in abnormal conditions such as those of over current and short circuit.

Types of MCB's

MCBs are manufactured with three different principles of operation namely

a Thermal Magnetic

b Magnetic hydraulic and

c Assisted bimetallic

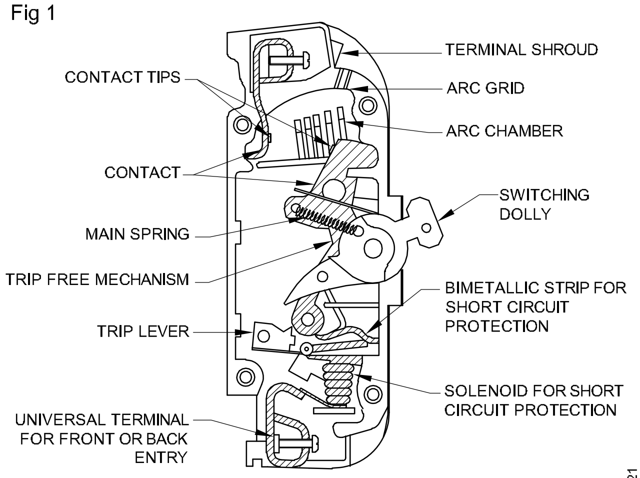
Thermal magnetic MCB

As shown in Fig. 1, the switching mechanism is housed in a moulded housing with phenolic moulded high mechanically strong switching dolly. This type of MCB is also provided with bimetallic over load release.

The electric current gets through two contact tips one each on moving and fixed contact of silver graphite.

An arcing chamber incorporating de-ionising arc chutes for control and quick suppression of the arc is provided in the gap between two contacts. It has a ribbed opening

Fig 1



NOTE: THE HATCHED PORTION SHOWS THE PATH OF CURRENT FROM TOP TERMINAL TO BOTTOM

THERMAL MAGNETIC TYPE MCB

closed by metal grid which allows ventilation and escape of gases.

For protection against over-load and short circuit, MCB's have thermal magnetic release unit. The overload is taken care of by bimetallic strip, short circuit currents and over loads of more than 100% are taken care by solenoid.

Working

The bimetallic strip when flexing due to temperature rise caused by increasing normal rated current beyond 130% rotates a trip lever carrying an armature to which it is to brought into field of a solenoid. The solenoid is designed to attract the armature to full position at about 700% overload or instantaneous short circuit current.

For initial portion of current wise (130% to 400%) tripping of circuit breaker is due to thermal action, between 400 to 700% tripping is due to combined thermal and magnetic action and beyond 700% due to fully magnetic action.

Magnetic hydraulic MCB

Magnetic hydraulic circuit breaker operates on the principle of a solenoid and hydraulically damped plunger.

Construction and working

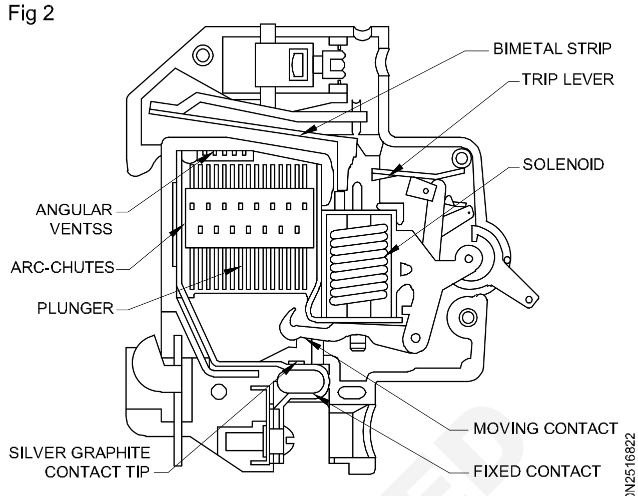
A movable ferrous plunger is held against a non-ferrous tube containing polysiloxane liquid which have flat temperature viscosity characteristic in temperature range of 20 to 60°C. The solenoid is a series coil in the circuit of MCB. As the plunger moves towards a pole piece, the reluctance of magnetic path.

Containing the armature is cumulatively reduced leading to some magneto motive force producing a progressively increasing flux. The armature is then attracted causing the mechanism to trip and open the controls on overload or short circuit. Instantaneous tripping occurs on very large currents 7 to 8 times the full load current. The construction of magnetic hydraulic tripping mechanism is as shown in Fig. 2.

Assisted Bimetal Tripping MCB (Fig. 3)

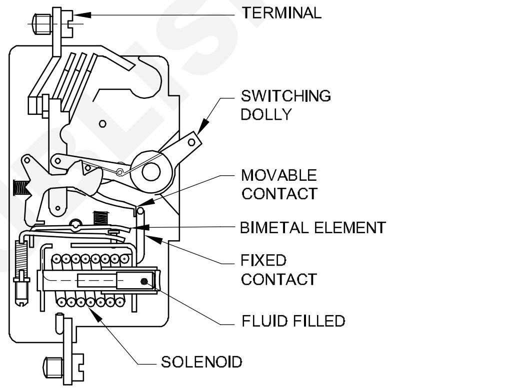
In the assisted bimetal form of construction, the time delay characteristic is provided by a thermally operated bimetal element which may be either directly or indirectly heated. Instantaneous tripping in short circuit condition is achieved by arranging a powerful magnetic pull to deflect the bimetal as shown in Fig. 4.

Fig 2



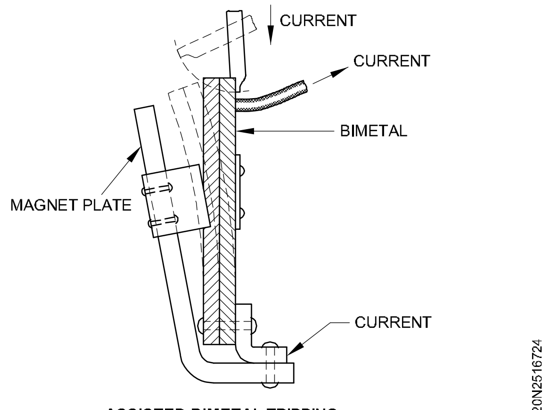
MAGNETIC HYDRAULIC MCB

Fig 3



ASSISTED BIMETAL TRIPPING MCB

Fig 4



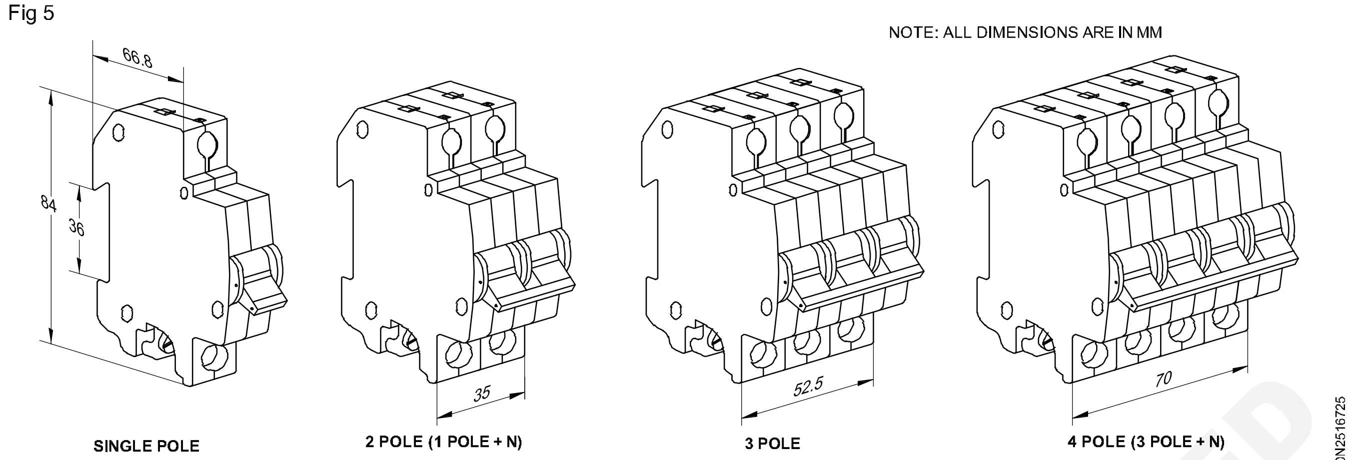
ASSISTED BIMETAL TRIPPING

This method utilises the magnetic field which is produced when a current flows through the conductor. By locating the bimetal near to a substantial section of ferrous material, the magnetic field associated with current flowing in the bimetal will cause a sideways pull to be applied to the bimetal element, attracting the bimetal towards the ferrous material. This sideways pull is arranged to coincide in direction with the normal direction of movement of the bimetal, which is powerful enough to deflect the bimetal (in heavy over load or short circuit condition) sufficiently to trip the breaker.

Design and rating of MCBs

MCBs are normally rated for 25°C ambient temperature and are available in the following various combination of poles and current ratings. (Fig. 5)

Fig 5



DIFFERENT TYPES OF MCB'S

Sl.No.	No. of poles	Current
1	Single pole MCB	0.5 to 60A
2	Double pole MCB (ie. 2 MCBs with common trip bar)	5 to 60A
3	Triple pole MCB	5 to 60A
4	Four pole MCB	5 to 60A

Isolators

An isolator is a switch only. These cannot be used for automatic tripping. Isolators are not meant for either closing or breaking the circuit on load or short circuit. Isolators have the same physical dimensions of MCBs and are available in the following configurations and ratings.

No. of poles	Current rating
Single pole	30, 60, and 100A
Single pole and Neutral	30, 60, and 100A
Double pole	60, and 100A
Triple pole	60, and 100A
Four pole	60 and 100A

Breakers with neutral

Breakers are available with switched neutral for applications where the neutral is to be disconnected when the mains are switched off. They are available in current ratings from 5 to 60 amp and in the following configurations.

1 Single pole and neutral

2 Double pole and neutral

3 Triple pole and neutral

ELCB + MCB combination circuit breaker

Now a days some manufacturers have introduced an ELCB + MCB combination circuit breaker which can be used instead of using separate MCB and ELCB (earth leakage circuit breaker). This combination not only allows reduction in costs, but also ensures extremely efficient protection from all low voltage and medium voltage electrical hazard of shock and fire caused by

1 over current

2 short circuit

3 earth leakage

4 earth fault.

> **Earth leakage circuit breakers are now generally called Residual Current (RC) circuit breakers.**

Working

The RC + MCB combination employs a modular concept for efficient operation. The MCB module consists of a thermal trip (bimetallic) for overload protection and a hammer trip (magnetic) for short circuit.

Operating system

The thermostatic bimetal has close calibration to provide reliable protection without nuisance tripping.

The hammer trip active current limiting system provides high rupturing capacity during short circuits. The typical trip time for clearing short circuits is only 2 to 3 millisecond. Specially designed arc chutes, arc runner and silver graphite contact system ensures high reliability and a long maintenance free operating life.

The residual current module works on the core balance transformer principle. It includes high permeability magnetic core and temperature resistant insulated copper wire wound with high degree of symmetry to eliminate nuisance tripping. The residual current signal from the core balance transformer is fed to a super sensitive permanent relay. This relay is calibrated to operate at about 100 micro volt Amp directly on the residual current energy. The relay operates when the leakage power threshold is crossed and activates the MCB tripping mechanism internally. All tripping mechanisms are truly current operated. They do not require any auxiliary power source other than the fault leakage current energy itself.

The rated load currents of the RC + MCB combination are 6A, 10A, 16A, 20A, 25A, 32A and 35A. The bimetal trip is so adjusted that no tripping will occur upto 1.3 times the rated current.

Categories of MCBs

Certain manufacturers like Indo Kopp manufacture MCBs in three different categories namely 'L' series, 'G' series, and 'DC' series.

'L' series MCBs

'L' series MCBs are designed to protect circuits with resistive loads. The tripping factor for current ratings upto 10 A is 1.6 I_n and for current ratings above 10 A is 1.35 I_n. They are ideal for protection of equipment like Geysers, ovens and general lighting systems.

'G' series MCBs

'G' series MCBs are designed to protect circuits with inductive loads. The over load tripping factor for all current ratings is above 1.1 I_n. The magnetic tripping commences above 7 times the rated current. G series MCBs are suitable for protection of motors, air conditioners, hand tools, halogen lamps etc.,

'DC' series MCBs

'DC' series MCBs are suitable for voltage upto 220V DC and have a breaking capacity up to 6kA.

The tripping characteristics are similar to 'L' an 'G' series. They find extensive application in DC controls, locomotives, diesel generator sets etc.,

Advantages of MCB

1 Tripping characteristic setting can be done during manufacture and it cannot be altered.
2 They will trip for a sustained overload but not for transient overload.
3 Faulty circuit is easily identified
4 Supply can be quickly restored
5 Tamper proof
6 Multiple units are available.

Disadvantages

1 Expensive
2 More mechanically moving parts
3 They require regular testing to ensure satisfactory operation.
4 Their characteristics are affected by the ambient temperature.

Moulded case circuit breakers (MCCB)

Moulded case circuit breakers are similar to thermo magnetic type MCBs except that these are available in higher ratings of 100 to 800amp at 500V 3-phase.

In MCCB, thermal and magnetic releases are adjustable. A shunt release is also incorporated for remote tripping and interlocking at MCCB. MCCBs are provided with under voltages release. There are two types of MCCB.

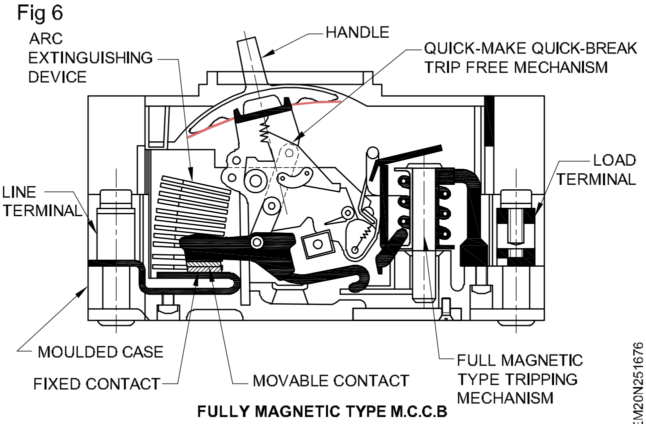
1 Thermal magnetic type
2 Fully magnetic type

The constructional feature of a fully magnetic MCCB design is shown in Fig. 6.

Advantages of MCCB

1 MCCBs occupy much less space in comparison to fuse switch units or switch fuse units.

Fig 6



FULLY MAGNETIC TYPE M.C.C.B

2 MCCBs provide equal amount of protection against high faults as switch gears having HRC fuses.

Disadvantages

1 MCCBs are much costlier.

Application of (RC + MCB) combination circuit breakers

1 All residential premises can have incoming protection after energy meter instead of fixing fuse and main switch.
2 All domestic equipments like water heaters, washing machines, electric iron, pump sets etc.,
3 All construction and outdoor electrical equipments such as lifts, hosts, vibrators, polishing machines etc.,
4 All industrial distribution and equipments
5 All agriculture pump sets.
6 Operation theaters and electrically operated medical equipment such as X-ray machines.
7 All neon sign installations
8 All low and medium voltage electrical distributions.

Technical specification of MCBs

Related voltage	240/ 415V AC 50Hz Up to 220V DC
Current rating	0.5, 1, 1.6, 2, 2.5, 3, 4, 5, 6, 7.5, 10, 16, 20, 25, 32, 35, 40 and 63A.
No. of poles	1,2,3
Types	'L' 'G' and 'DC' series
Breaking capacity	Upto to 9kA
Mechanical life	1,00, 000 operations
Electrical life	50,000 operations
Overload capacity	15% over load
Housing	Glass fiber reinforced polyester
Fixing	Snap fixing on 35 mm DIN channel
Types of terminals	25mm² box type terminal at the incoming and outgoing.

Definition of Breaking capacity of MCB

The short circuit breaking capacity of the circuit breaker is the current more than the prospective fault current at the point of installation of circuit breaker. Prospective fault current is the maximum fault current which may have to be interrupted by the circuit breaker.

ELCB-types-working principle-specification

Objectives : At the end of this exercise you shall be able to
- **explain the working principle, different types and construction of an Earth Leakage Circuit Breaker (ELCB)**
- **explain the technical specifications of ELCB's.**

Earth Leakage Circuit Breakers

The sensation of electric shock is caused by the flow of electric current through the human body to earth. When a person comes in contact with electrically live objects like water heaters, washing machines electric iron etc., the extent of damages caused by this current depends on its magnitude and duration.

This kind of current is called the leakage current which comes in milli-amps. These leakage current being very small in magnitude go undetected by the fuses/MCBs are the major cause for the fires due to electricity.

The leakage current to earth also results in the wastage of energy and excessive billing for electricity not actually used.

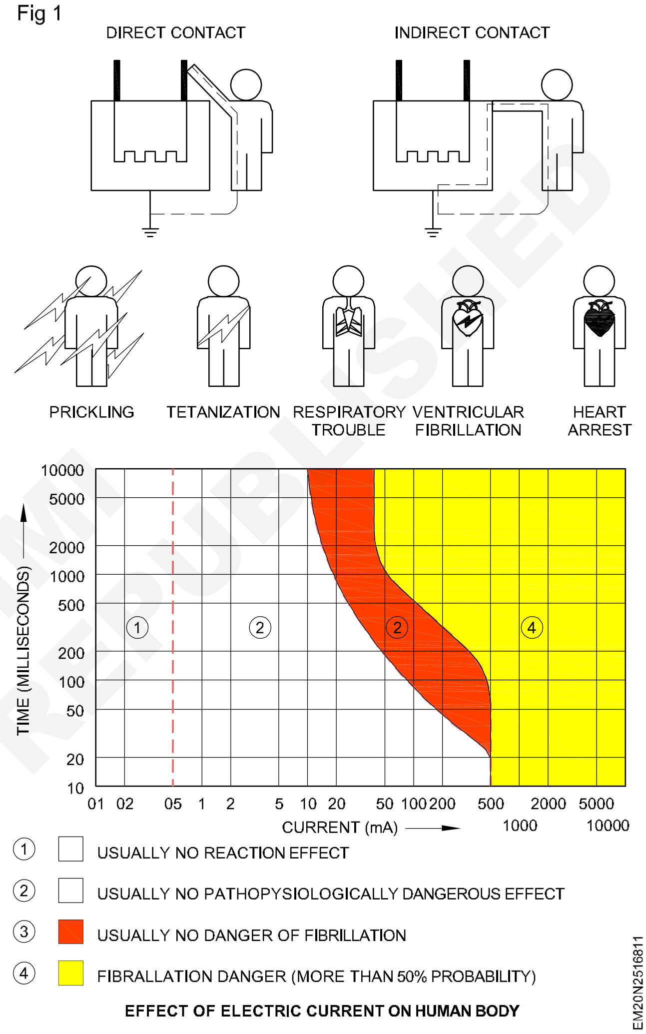
Residual current operated circuit breakers are internationally accepted means of providing maximum protection from electric shocks and fires caused due to earth leakage current and also prevents the waste of electrical energy. These residual current circuit breakers (RCCB) are popularly called as Earth leakage circuit breakers (ELCB). Fig 1 shows the effect of electric current on human body in various levels represented in graph.

Basically ELCBs are of two types namely voltage operated ELCBs and the current operated ELCBs.

Voltage operated ELCB (Fig 2)

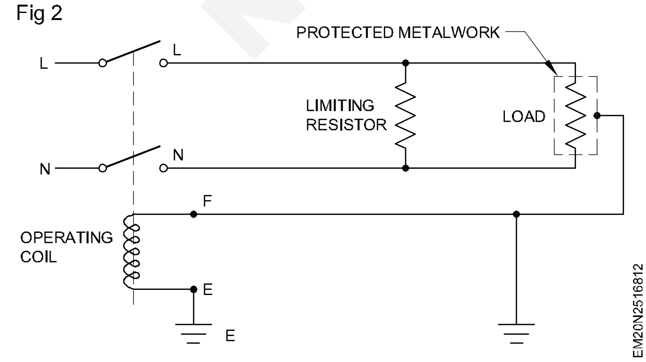
This device is used for making and breaking a circuit. It automatically trips or breaks the circuit when the potential difference between the protected metal work of the installation and the general mass of earth exceeds 24V. This voltage signal will cause the relay to operate. Voltage operated ELCBs are meant to be used where it is not practicable to meet the requirements of IEE wiring regulation by direct earthing or where additional protection is desirable. (Fig 2)

Fig 1



EFFECT OF ELECTRIC CURRENT ON HUMAN BODY

Fig 2



The above circuit shows the principle of operation of a voltage operated ELCB.

Current operated ELCB

This device is used for making and breaking a circuit and for breaking a circuit automatically when the vector sum of current in all conductors feeding the circuit controlled by the circuit breaker differs from zero by a predetermined amount. Current operated ELCBs are much more reliable in operation, easier to install and maintain.

Construction of ELCB

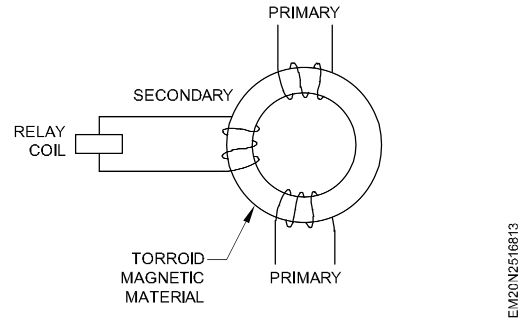
It consists of a Toroid ring made of high permeability magnetic material. It has two primary windings each carrying the current flowing through phase and neutral of the installation. The secondary winding is connected to a highly sensitive electron magnetic trip relay which operates the trip mechanism.

Working principle of ELCB (RCD breaker)

The residual current device is a circuit breaker which continuously compares the current in the phase with that in the neutral. The difference between the two is called as the residual current which is flowing to earth.

The purpose of the residual current device is to monitor the residual current and to switch off the circuit if it rises from a preset level. The arrangement of RCD is shown in Fig. 3.

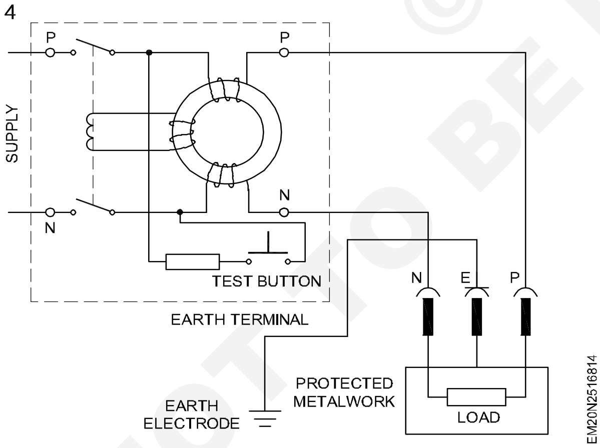
Fig 3



The main contacts are closed against the pressure of a spring which, provides the energy to open them when the device trips. Phase and neutral current pass through identical coils wound in opposing direction on a magnetic circuit, so that each coil will provide equal but opposing numbers of ampere turns when there is no residual current. The opposing ampere turns will cancel and no magnetic flux will be set up in the magnetic circuit.

Fig 4 shows a 4 pole Residual current circuit breaker being connected in a 3-phase 4 wire system load circuit.

Fig 4



Test Switch

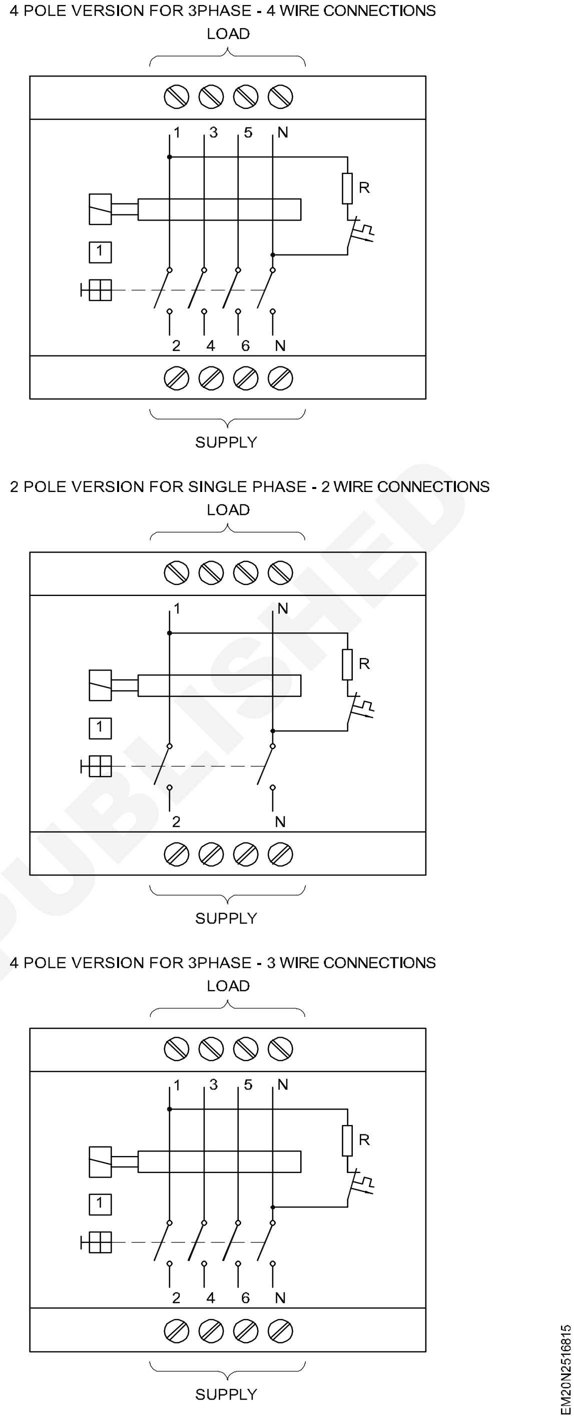
As shown in Fig 5 test switch is a requirement of BS842. It is used to test the functioning of ELCB. When the test button is pressed it circulates additional current through neutral coil which is determined by the value of current limiting resistor R. As a result there exists a difference in current flowing through phase and neutral coils and hence the ELCB trips off.

Technical specification

The current ratings of ELCB are 25A, 40A and 63A.

No. of poles - 2 and 4

Fig 5



Nominal voltage - 240/415V 50Hz.

Sensitivities: ELCBs are designed to trip at leakage currents of 30mA, 100mA, and 300mA.

Electrical life: More then 10,000 operations.

Mechanical life: 20000 to 100000 operations.

Tripping time - < 30ms.

Time delayed RCCB

There are cases, where more than one RCCB is used in an installation, for example a complete installation may be protected by an RCCB rated at 100mA, while a socket intended for equipment may be protected by 30mA device. Discrimination of the two devices then becomes important.

For example an earth fault occurs in the equipment giving an earth fault current of 250mA. Since the fault current is higher, than the operating current of both devices both will trip. It does not follow, that the device with smaller operating current will trip first. This is a lack of discrimination between the two devices. To ensure proper discrimination, the device with a larger operating current, has a deliberate time delay built into its operation. It is called time-delayed RCCB.

Calculation of Earth fault loop impedance

Earth wire from an equipment to the earth electrode is called earth loop. Its impedance should not be more than 50 earth fault loop impedance in ohm, multiplied by the rated tripping current of the R.C.C.B.(ELCB) in ampere should not exceed 50 (i.e) $Z_E \times I_t < 50$.

Where Z = Earth wire loop impedance

I_t = Rated tripping current in Ampere

Example

An ELCB with a rated tripping current of 30mA, the maximum possible Earth fault loop impedance will be

$$Z_E\ (\text{max}) = 50/I_t = \frac{50}{0.03} = 1666 \text{ ohm}$$

Contactors-parts-functions-troubleshooting-symbols

Objectives: At the end of this lesson you shall be able to

- **explain the basic contactor circuit with a single push-button station for start and stop**
- **state the function of a no-volt coil, its rated voltage, position of operation, its common troubles, their causes and remedies.**

i) Contactors: The contactor forms the main part in all the starters. A contactor is defined as a switching device capable of making, carrying and breaking a load circuit at a frequency of 60 cycles per hour or more. It may be operated by hand (mechanical), electromagnetic, pneumatic or electro-pneumatic relays.

The contactors shown in Fig. 1 consist of main contacts, auxiliary contacts and no-volt coil. As per Fig 1, there are three sets of normally open, main contacts between terminals 1 and 2, 3 and 4, 5 and 6, two sets of normally open auxiliary contacts between terminals 23 and 24, 13 and 14, and one set of normally closed auxiliary contact between terminals 21 and 22. Auxiliary contacts carry less current than main contacts. Normally contactors will not have the push-button stations and O.L. relay as an integrated part, but will have to be used as separate accessories along with the contactor to form the starter function.

The main parts of a magnetic contactor are shown in Fig. 1, and Fig. 2 shows the schematic diagram of the contactor when used along with fused switches (ICTP), push-button stations and OL relay for connecting a squirrel cage motor for starting directly from the main supply. In the same way the direct on-line starter consists of a contactor, OL relay and push-button station in an enclosure.

Fig 1

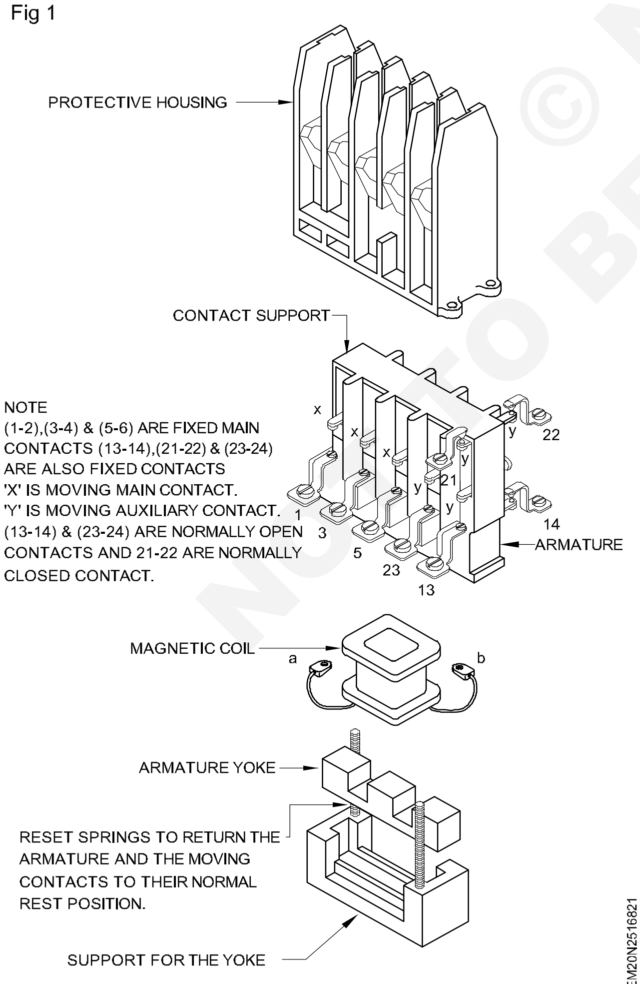
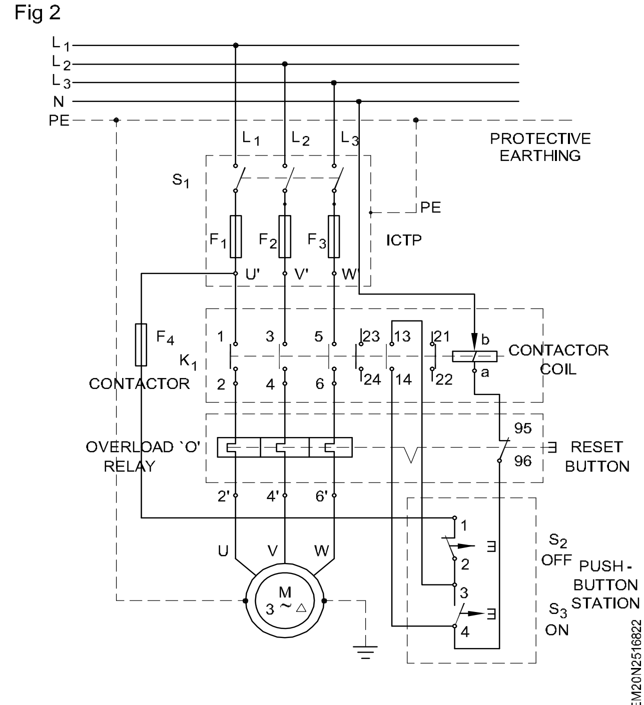


Fig 2



Functional description

Power circuit: As shown in Fig.2, when the main ICTP switch is closed and the contactor K_1 is operated, all the three windings U V & W of the motor are connected to the supply terminals R Y B via the ICTP switch, contactor and OL relay.

The overload current relay (bimetallic relay) protects the motor from overload (`motor protection'), while the fuses F1/F2/F3 protect the motor circuit in the event of phase-to-phase or phase-to-frame short circuits.

Control circuits

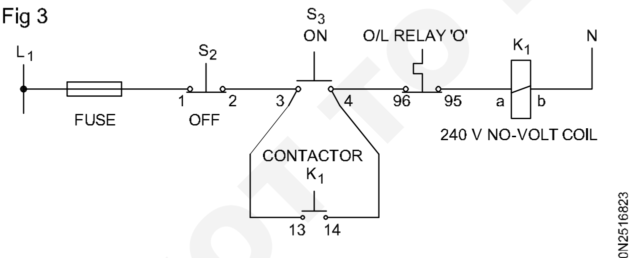
Push-button actuation from one operating location: As shown in the complete circuit Fig. 3, and the control circuit Fig. 3, when the `ON' push-button S_3 is pressed, the control circuit closes, the contactor coil is energised and the contactor K_1 closes. An auxiliary, a normally open contact 13,14 is also actuated together with the main contacts of K_1. If this normally open contact is connected in parallel with S_3, it is called a self-holding auxiliary contact.

After S_3 is released, the current flows via this self-holding contact 13,14, and the contactor remains closed. In order to open the contactor, S_2 must be actuated. If S_3 and S_2 are actuated simultaneously, the contactor is unaffected.

In the event of overloads in the power circuit, the normally closed contact 95 and 96 of overload relay `O' opens, and switches off the control circuit. Thereby $K_1$ switches `OFF' the motor circuit.

Once the contact between 95 and 96, is opened due to the activation of the overload relay `O', the contacts stay open and the motor cannot be started again by pushing the `ON' button S_3. It has to be reset to normally closed position by pushing the reset button. In certain starters, the reset could be done by pushing the `OFF' button which is in line with the overload relay `O'.

Fig 3

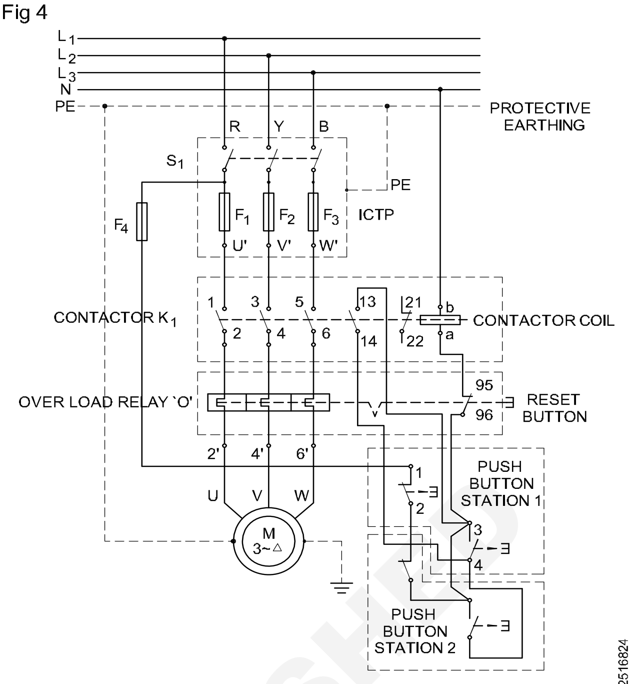


CONTROL CIRCUIT

Push-button actuation from two operating locations: If it is desired to switch a contactor off and on from either of the two locations, the corresponding OFF push-buttons should be connected in series, and the ON push-buttons in parallel, as shown in the complete diagram Fig 4 and the control diagram Fig. 5.

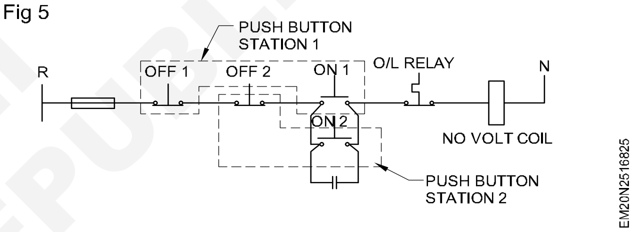
If either of the two ON push-buttons is actuated, K_1 is energised and holds itself closed with the help of normally-open contact 13 & 14 which is closed by contactor K_1. If either of the two OFF push -buttons is actuated, the contactor opens.

Fig 4



COMPLETE CIRCUIT DIAGRAM OF THE CONTACTOR AND THE 3 PHASE SQUIRREL CAGE INDUCTION MOTOR

Fig 5



Purpose of overload relays: The overload relays protect the motor against repeated, excessive momentary surges or normal overloads existing for long periods, or high currents caused in two phases by the single-phasing effect. These relays have characteristics which help the relay to open the contactor in 10 seconds if the motor current is 500 percent of the full load current, or in 4 minutes if the current is 150 percent of the full load current.

Tripping of starters: A starter may trip due to the following reasons.

– Low voltage or failure of power supply

– Persistent overload on the motor

In the first instance, the tripping occurs through the coil which opens the contacts when the voltage falls below a certain level. The starter can be restarted as soon as the supply is back to normal.

The relay trips the starter when there is an overload. It can be restarted only after the relay is reset and the load becomes normal.

No-volt coil: A no-volt coil consists of generally more number of turns of thin gauge of wire.

Coil voltages: Selection of coils depends on the actual supply voltage available. A wide variety of coil voltages like 24V, 40V, 110V, 220 V 230/250 V, 380V 400/440V AC or DC are available as standard for contactors and starters.

Troubleshooting in contactor: Table 1 gives the common symptoms their causes and remedies.

Table 1

Symptoms	Causes	Remedies
Motor does not start when the 'start' button is pressed. However on pressing the armature of the contactor manually, motor starts and runs.	Open in no-volt coil circuit.	Check the main voltage for lower than acceptable value. Rectify the main voltage. Check the control circuit wiring for loose connection. Check the resistance of the no-volt coil winding. If found incorrect replace the coil.
Motor starts when `ON' button is pressed. It however stops immediately when `ON' button is released.	Auxiliary contact in parallel with the start-button is not closing.	Check the parallel connection from `ON' button terminals to the auxiliary contact of the contactor. Rectify the defect. Check the auxiliary contact points of the contactor for erosion and pittings. Replace, if found defective.
Motor does start when the start-button is pressed. However, a humming or chattering noise comes from the starter.	Movable armature and fixed limb of electromagnet are not stably attracted.	Dust or dirt or grit between the mating surfaces of the electromagnetic core. Clean them. Low voltage supply. Find the cause and rectify the defect. Break in the shading ring in the case of AC magnet.
Failure of contactor due to too much heating of the `No' volt coil.	Higher incoming supply rating. No-volt coil rating is not high.	Higher supply voltage than normal. Reduce the incoming voltage. Voltage rating of the no-volt coil is less. Replace with standard rating, according to the main supply.
Motor does not restart immediately after tripping of OL relay even though OL relay was reset.	It takes a little time for the thermal bimetal to cool and reset.	Wait for 2 to 4 minutes before re-starting.
Coil does not get energised even though supply voltage is found across the no-volt coil terminals.	Open-circuited NVC. NVC burnt out.	Check the nylon strip on relay. Check the nylon button below the start button Replace, if necessary.
Relay coil has been changed. However motor does not start when the start-button is pressed.	Control circuit of relay open.	Check the control circuit for open. Clean the control station contacts. Overload relay not reset.
Humming or chattering noise.	Low voltage.	Feed the rated voltage.
	Magnetic face between yoke and armature is not clean.	Clean the surfaces of yoke and armature.
	Shading ring on iron core missing.	Provide shading ring in the iron core

Relays-types-operations-specification-symbols

Objectives: At the end of this lesson you shall be able to
- **define a relay**
- **classify relays according to the operating force and function**
- **state the common codes used for specifying contacts and poles**
- **specify a relay**
- **explain the function of the shading coil in an AC relay**
- **state the causes of the failure of the relay**
- **identify the symbols used in relay as per I.S.2032 (Part XXVII).**

Relay: A relay is a device which opens or closes an auxiliary circuit under predetermined conditions in the main circuit.

Relays are extensively used in electronics, electrical engineering and many other fields.

There are relays that are sensitive to conditions of voltage, current, temperature, frequency or some combination of these conditions.

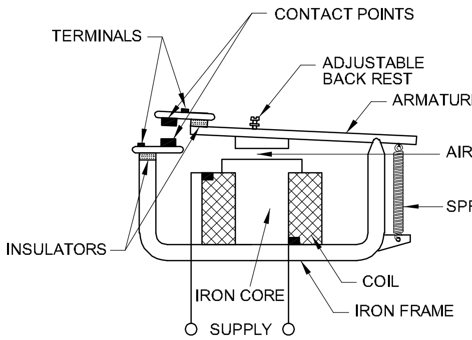
Relays are also classified according to their main operating force as stated under.

– Electromagnetic relays

– Thermal relays

Electromagnetic relay: A relay switch assembly is a combination of movable and fixed low-resistance contacts that open or close a circuit. The fixed contacts are mounted on springs or brackets, which have some flexibility. The movable contacts are mounted on a spring or a hinged arm that is moved by the electromagnet in the relay as shown in Fig. 1.

Fig 1



ELECTRO MAGNETIC RELAY

EM20N2516831

The other types of relays coming under this group are as follows.

Current sensing relay: A current sensing relay functions whenever the current in the coil reaches an upper limit. The difference between the current specified for pick up (must operate) and non-pick up (must not operate) is usually closely controlled. The difference in current may also be closely controlled for drop out (must release) and non-drop out (must not release).

Under-current relay: Under-current relay is an alarm or protective relay. It is specifically designed to operate when the current falls below a predetermined value.

Voltage sensing relay: A voltage sensing relay is used where a condition of under-voltage or over-voltage may cause a damage to the equipment. For example, these types of relays are used in voltage stabilizers. Either a proportional AC voltage derived from a transformer or a proportional DC derived from a transformer and rectifier is used for this purpose.

Latching relays

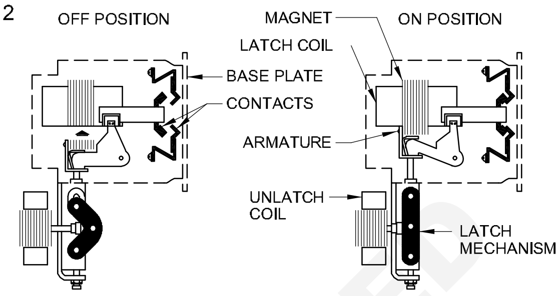
Latching relays are capable of maintaining their contacts in the last assumed position without the maintained current in the coil. These relays hold their contacts in position after power is cut off.

There are two basic kinds of latching relays called mechanical reset and electrical reset.

Mechanical re-set relays: Mechanical re-set relays have a coil, an armature mechanism, and a mechanical latching device that locks the armature in the operated position after the coil has been de-energised. Manual tripping of the locking mechanism, re-sets the relay.

Electrical reset relays: An electrical re-set relay shown in Fig. 2 has the same operating mechanism, but it includes a second coil and armature to trip the latching mechanism. This system allows remote re-setting of the relays to their original position.

Fig 2



LATCH RELAY ELECTRICAL RE-SET TYPE

EM20N2516832

Reed relays

Reed relays physically look different than other kinds of relays. They consist of essentially magnetically actuated reed switches, with actuating solenoids or coils.

In the reed relay, freedom from contamination and the limited number of moving parts, avoid many disadvantages of the conventional electromechanical relays. In addition to the above, the contact resistance is kept to minimum due to the fact the contact points are made either with gold or rhodium. Further, these relays need very low power to operate and can handle a 250 watt solenoid load on their contacts.

There are three types of reed relays namely

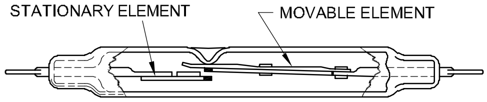
– dry-reed relay

– ferreed relay

– mercury wetted contact relay

Dry reed relay: Fig.3 shows this type of relay. Two opposing reeds are sealed in to a narrow glass tube. The reeds overlap at their free ends. At the contact area, they are usually plated with gold or rhodium to produce a low contact resistance. They may have multipole multicontact designs.

Fig 3



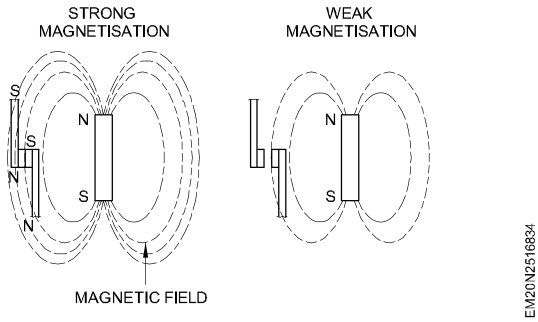
DRY REED RELAY

EM20N2516833

Ferreed relay: The word ferreed denotes a reed relay in which the dry-reed switch is contained with one or more magnetic members. The magnetisation can be changed by current pulses in associated coils.

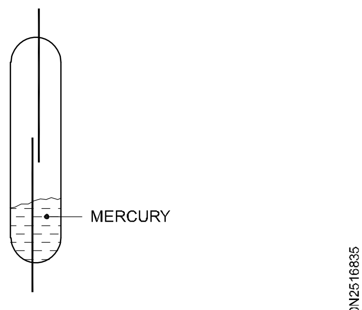
As shown in Fig. 4 in the magnetised state the magnetic members supply a field strong enough to close the contacts. In the other magnetised state, the field is too weak to hold the contacts closed. An operating pulse through the coil produces the first state. A release pulse produces the second state. The contacts can break or make within 5 micro-seconds duration.

Fig 4



Mercury wetted contact relay: As shown in Fig. 5 this relay consists of a glass enclosed reed with its base immersed in a pool of mercury. When the coil surrounding the capsule is activated, mercury makes the contact between fixed and movable contacts.

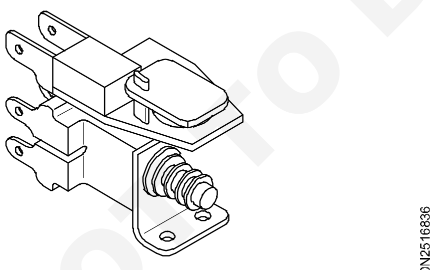
Fig 5



MERCURY-WETTED REED RELAY

Impulse relay: The impulse relay shown in Fig. 6 is a special single-coil relay. It has an armature-driven mechanism that alternatively assumes one of two positions as the coil is pulsed. This mechanism moves the contact from one position to the other and back again as electrical pulses are received. The relay can operate on AC or DC power.

Fig 6



IMPULSE RELAY

Clapper-type armature relay: The simplest contact arrangement used in armature relays is the break-make or transfer-contact combination. A clapper-type armature, shown in Fig. 7 opens or closes the contacts. A movable contact is attached directly to the armature by means of a flexible strip of metal. When the electromagnet operates, the armature moves this contact, opening and closing the two sets of contacts.

Thermal relay: A thermal relay shown in Fig. 8 is one that operates by changes in temperature. Most of the bimetallic relays where the bimetallic element changes its shape, in response to changes in temperature comes under this group. It takes time for the heating element to reach the necessary temperature and more time to raise the temperature of the bimetallic element. Therefore, thermal relays are often used as time-delay relays.

Fig 7

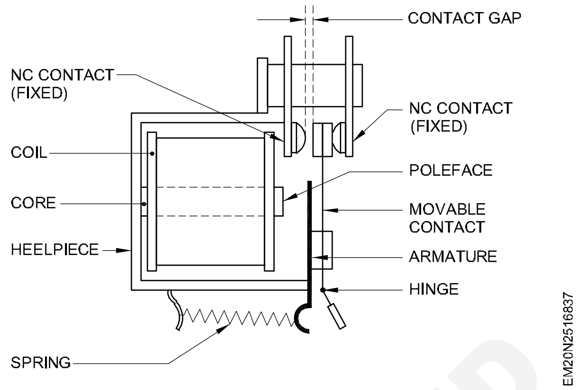
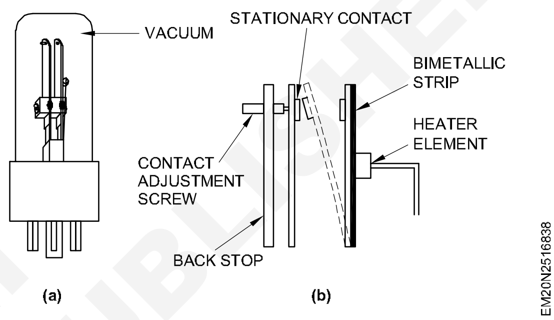


Fig 8



Poles and contacts: Relays may operate single or as multi-poles and may open or close specified contacts. In writing specifications certain abbreviations as stated below are commonly used.

SP - Single pole

SB - Single break

ST - Single throw

DB - Double break

DP - Double pole

DM - Double make

DT - Double throw

NO - Normally open

3P - Three pole

NC - Normally closed

4P - Four pole

For example a 4PDT has a four-pole, double throw contact arrangement.

NO indicates the contacts are open in the unoperated position of the relay and they are called as normally open (NO) contacts.

NC indicates the contacts are closed in the unoperated position of the relay and they are called normally closed (NC) contacts.

Table 1 given below lists some of the relay contact combinations.

Enclosures and mounts: Relays are normally enclosed in plastic or metal caps to protect the operating parts against dust and environment. Relays can be mounted to the circuit direct by plug-in system, PCB mounting or may be wired separately using screws terminals. These types are shown in Fig. 9.

AC relay: In an AC relay magnet, the magnetic field continually changes direction. With a 50 Hz supply the magnetic field passes through zero 100 times per second. At the time of zero field, the armature starts to release. Although the field quickly builds up in the reverse direction, a noisy chatter can result.

Fig 9

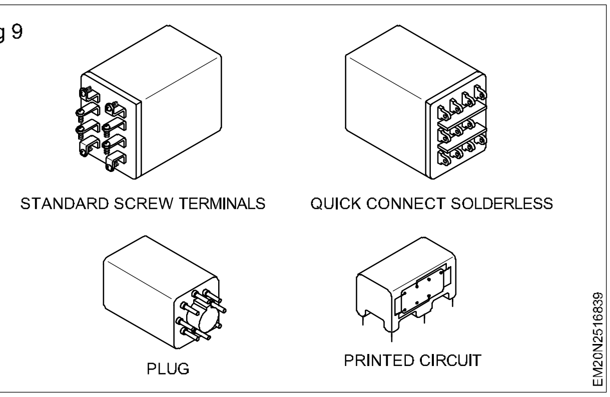
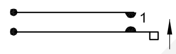
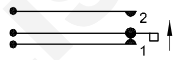
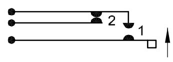
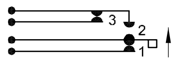
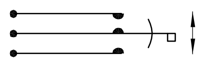
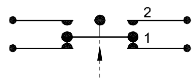
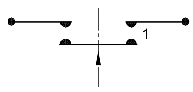
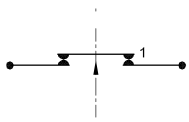
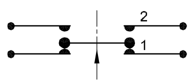
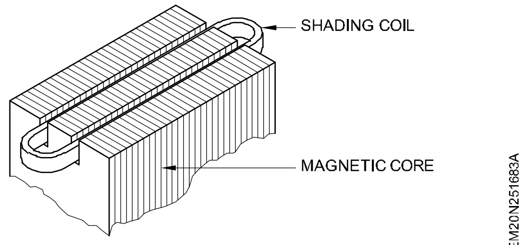


Table 1

Design	Sequence	Symbol
1 SPST-NO	Make 1	
2 SPST-NC SPDT	Break 1 Break1 before make 2	
3 SPDT	Make 1 before break 2	
4 SPDT (B-M-B)	Break 1 before make 2 before break 3	
5 SPDT-NO	Center OFF	
6 SPDT-NC-NO (DB-DM)	Double break 1 double make 2	 
7 SPST-NO (DM)	Double make 1	
8 SPST-NC (DB)	Double break 1	
9 SPDT-NC (DB-DM)	Double break 1 double make 2	

To eliminate chatter, a shading coil as shown in Fig. 10 is placed near the tip of the magnet pole face. This shading coil establishes a magnetic field that lags the main magnetic field slightly and aids in keeping the magnet sealed when the main field passes through zero.

Fig 10



An AC relay should not be used in DC supply.

The AC relay when connected to DC supply, will draw more current in the absence of inductive reactance and result in burning out the coil.

Causes of relay failures: Relay failures are usually caused by the gradual deterioration of the parts. This deterioration can be electrical, mechanical or chemical in nature.

The environmental shirks that contribute to physical breakdown include large temperature changes, shock, vibration and voltage or current changes. Therefore, it is important that these factors are taken into consideration to ensure reliable performance of relays.

In general, when a relay fails, look for the following.

1 Improper control voltage.

2 Dirt, grease or gum on contacts or moving parts.

3 Excessive heating of parts: discolouration or charred insulation on coil or base.

4 Bending of moving parts.

5 Corrosion or deposits on metal parts.

6 Excessive wear on moving parts.

7 Loose connections.

8 Improper spring tension.

9 Improper control pressure.

10 Improper functioning of the time delay device.

While specifying relays the following particulars are necessary.

Type of operating voltage

AC or DC

Sequence of operation ______________________

Operating voltage ______________________ volts

Current rating ______________________ amps

Coil resistance ______________________ ohms

Number of contacts ________ NO ________ NC

Number of poles ______________________

Type of mount ______________________

Type of enclosure ______________________

Symbols used in relay circuit: Following are the I.S. symbols connected with the relays as per I.S.2032(Part XXVII). These may be used along with the contact symbols for illustrating the function of the relay.

Purpose of overload relays: ==The overload relays protect the motor against repeated, excessive momentary surges or normal overloads existing for long periods, or high currents caused in two phases by the single-phasing effect. These relays have characteristics which help the relay to open the contactor in 10 seconds if the motor current is 500 percent of the full load current or in 4 minute

Types of overload relay

There are two types of overload relays. They are :

– magnetic overload relay

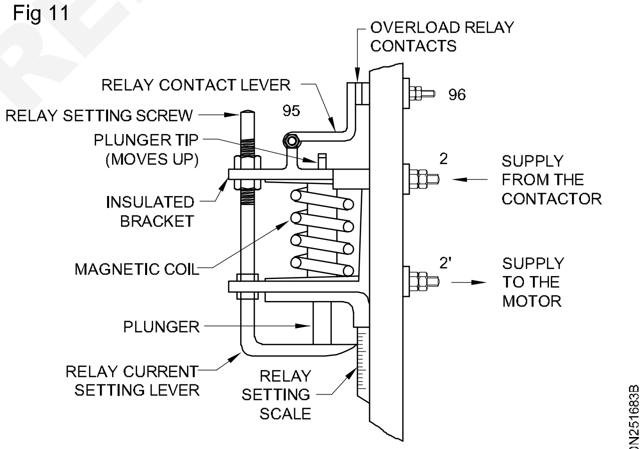
– thermal (bimetallic) overload relay.

Normally there are 3 coils in a magnetic relay and 3 sets of heater coils in a bimetallic relay so that two coils will operate in case of single phasing which help in avoiding the burning out of the motor.

Magnetic overload relay: The magnetic overload relay coil is connected in series with the motor circuits. The coil of the magnetic relay must be wound with a wire, large enough in size to pass the motor current. As these overload relays operate by current intensity and not by heat, they are faster than bimetal relays.

As shown in Fig. 11, the magnetic coil carries the motor current through terminals 2 and 2' which is in series with the power circuit. The relay contacts, 95 and 96, are in series with the control circuit. When a current more than a certain stipulated value, as set by the relay set scale, passes through the power circuit, the magnetic flux produced by the coil will lift the plunger in an upward direction. This upward movement makes the plunger tip to push the relay contact lever, and the contact between terminals 95 and 96 opens. This breaks the no volt coil circuit and the contactor opens the power circuit to the motor. The relay contacts between terminals 95 and 96 stay open till the rest-button (not shown in the figure) is pressed.

Fig 11



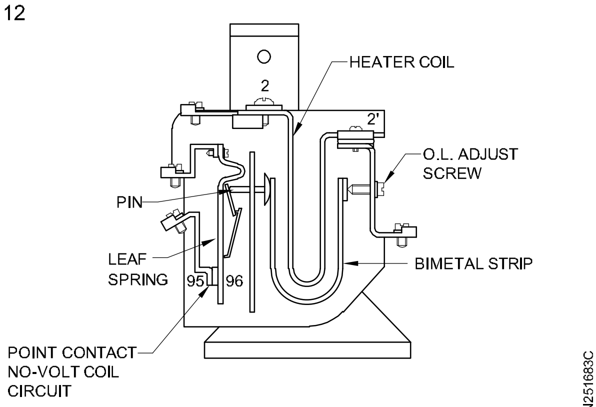
MAGNETIC OVERLOAD RELAY

Bimetallic overload relays: Most bimetallic relays can be adjusted to trip within a range of 85 to 115 per cent of the nominal trip rating of the heater unit. This feature is useful when the recommended heater size may result in unnecessary tripping, while the next larger size will not give adequate protection. Ambient temperatures affect thermally-operated overload relays.

The tripping of the control circuit in the bimetallic relay results from the difference of expansion of two dissimilar metals fused together. Movement occurs if one of the metal expands more than the other when subjected to heat. A U-shaped bimetallic strip is used in the relay as shown in Fig. 12. The U-shaped strip and a heater element inserted in the centre of the U compartments for avoiding possible uneven heating due to variations in the mounting location of the heater element.

As shown in Fig 12, under normal conditions, the bimetallic strip pushes the pin against the leaf-spring tension, and the point contacts 95 and 96 are in a closed position, and hence the no-volt coil circuit is completed while the motor is running. When a higher current passes through the heater coil connected to terminals 2 and 2', the heat generated in the coil heats up the bimetal strip which bends inward. Hence the pin retracts in the right hand direction and the leaf-spring opens the contact between 95 and 96 to open the contactor. The relay cannot be reset immediately as the heat in the bimetallic strips require some time for cooling.

Fig 12



BIMETALLIC OVERLOAD RELAY

DC motor - principle and types

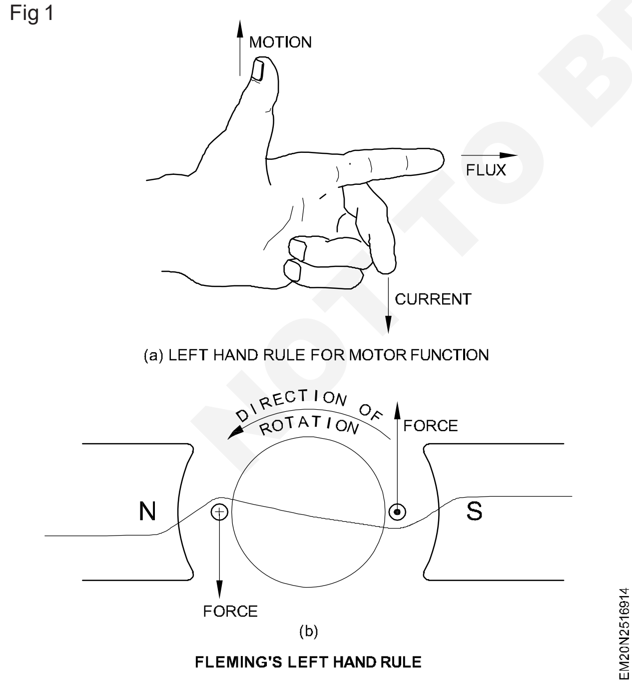
Objectives: At the end of this lesson you shall be able to
- **explain the working principle of a DC motor**
- **state the different types of DC motors.**

Introduction: A DC motor is a machine which converts DC Power energy into mechanical energy. It is similar to a DC generator in construction. Therefore, a DC machine can be used as a generator or as a motor.

Principles of a DC motor: It works on the principle that whenever a current-carrying conductor is kept in a uniform magnetic field, a force will be set up on the conductor so as to move it at right angles to the magnetic field. It can be explained as follows. Fig 1a shows the uniform magnetic field produced by a magnet, whereas Fig 1b shows the magnetic field produced around the current-carrying conductor. Combining the effects of Fig 1a and Fig 1b in one figure, Fig 1c shows the resultant field produced by the flux of the magnet and the flux of the current-carrying conductor. Due to the interactions of these two fields, the flux above the conductor will be increased and the flux below the conductor is decreased as represented in Fig 1c. The increased flux above the conductor takes a curved path thus producing a force on the conductor to move it downwards.

Fleming's Left Hand Rule: The direction of force produced on a current-carrying conductor placed in a magnetic field can be determined by this rule. As shown in Fig 1a, hold the thumb, forefinger and middle finger of the left hand

Fig 1



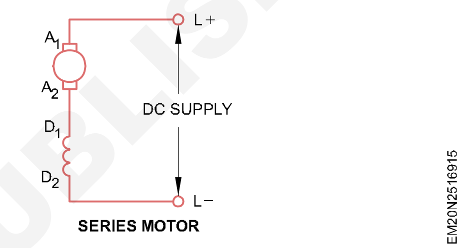
mutually at right angles to each other, such that the forefinger is in the direction of flux, and the middle finger is in the direction of current flow in the conductor; then the thumb indicates the direction of motion of the conductor.

For example, a loop of coil carrying current, when placed under north and south poles as shown in Fig 1b, rotates in an anticlockwise direction.

Types of DC motors: As the DC motors are identical in construction to that of DC generators, they are also classified as series, shunt and compound motors, depending upon their connection of field winding with the armature and supply.

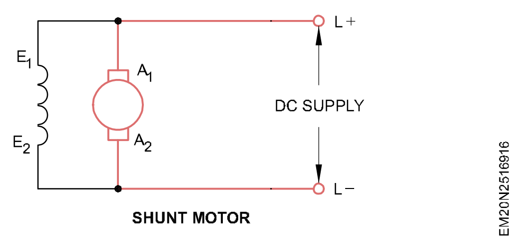
When the armature and field are connected in series, as shown in Fig 2, it is called a series motor.

Fig 2



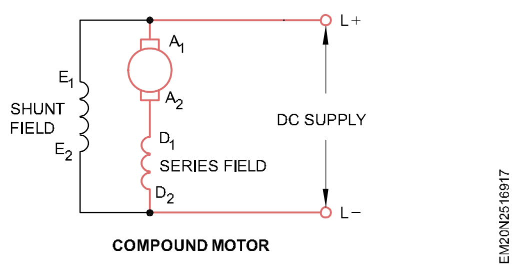
When the armature and field are connected in parallel across supply, as shown in Fig 3, it is called a shunt motor.

Fig 3



When the motor has two field coils, one in series with the armature and the other in parallel with the armature, as shown in Fig 4, it is called a compound motor.

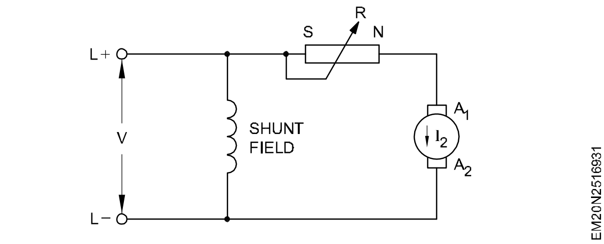
Fig 4



The relation between applied voltage, back emf, armature voltage drop, speed and flux of DC motor, method of changing direction of rotation.

Necessity of starters: Since the armature is stationary before starting, the back emf which is proportional to speed is zero. As the armature resistance is very small, if the rated voltage is applied to the armature, it will draw many times the full load current, and thereby, there is every possibility of damaging the armature due to heavy starting current. Therefore, the starting current should be limited to a safe value. This is done by inserting a resistance in series with the armature at the time of starting for a period of 5 to 10 seconds. As the motor gains in speed, back emf is built up, and then the starting resistance could be gradually cut off. Fig 5 shows such an arrangement. Resistance R is fully included in the armature circuit by keeping the moving arm in position `S' at the time of starting, and then it is moved towards position `N' to exclude the resistance `R' when the motor has picked up its speed. But such an arrangement will be purely manual and needs constant monitoring. For example, if the motor is running, the resistance `R' will be excluded, and the moving arm position will be at position `N'. In case the supply fails, the motor will stop but the moving arm will still be in position `N'. When the supply returns, as there is no resistance included in the armature circuit through `R', the armature may draw heavy current and may get damaged. To prevent such a happening a device called starter is used in motor circuits.

Fig 5



In addition to the automatic inclusion of resistance at the time of starting, the starters may protect the motor from overload and will switch `off' the motor, when supply fails. These starters are named according to the number of connecting terminals as explained subsequently.

Types of starters: Starters used to start the DC motors are generally of three types.

- Two-point starter
- Three-point starter
- Four-point starter

Speed control methods of a DC motor and their applications

Objective: At the end of this lesson you shall be able to
- **explain the principle and the methods of controlling the speed of a DC motor.**

Principle of speed control in DC motors: In certain industrial applications, the variation of speed is a necessity. In DC motors the speed can be changed to any specified value easily. This is the main reason for certain industries to prefer DC motors for drives rather than AC motors. The speed of a DC motor can be varied, based on the following simple relationship.

It is known that the applied voltage = back e m f + armature resistance voltage drop

$V = E_b + I_a R_a$.

Hence $E_b = V - I_a R_a$ and also

the back emf $E_b = \frac{P\varnothing N}{60} \times \frac{Z}{A} = K\varnothing N$

where K is a constant.

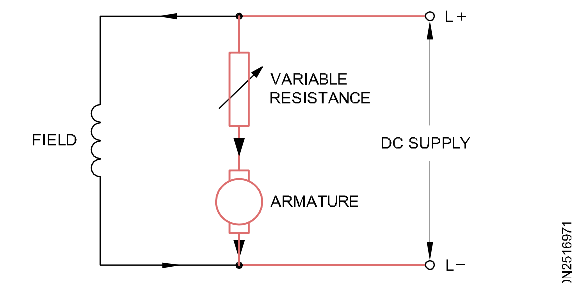
Therefore $N = \frac{E_b}{k\varnothing} = \frac{V - I_a R_a}{k\varnothing}$ Eqn.1

From the above expression, it is clear that the speed of a DC motor is directly proportional to the back emf E_b, and inversely proportional to flux (Ø). Thus the speed of the DC motor can be varied by changing either the back emf E_b or the flux Øor both. In fact, if the back emf is decreased across the armature, the speed decreases, and if the flux is decreased the speed increases. The following are the most common methods of controlling the speed of DC motors based on the above principle.

Methods of speed control in DC shunt motors and compound motors

Armature control method: This method works on the principle that the speed of the DC motor could be varied by varying the back emf. As the back emf = $V - I_a R_a$, by varying the armature resistance we can obtain various speeds. A variable resistance called controller is connected in series with the armature as shown in Fig 1. The controller should be selected to carry the armature current for a longer period.

Fig 1



SPEED CONTROL BY ARMATURE RESISTANCE METHOD

Let the initial and final speeds of the motor be N_1 and N_2, and the back emf be E_{b1} and E_{b2} respectively,

Then $N1 = \frac{E_{b1}}{k}$ .....Eqn.2.

$N2 = \frac{E_{b2}}{k}$ .....Eqn.3.

By dividing Eqn.3 by Eqn.2 we have

$$N_2 = \frac{E_{b2}N_1}{E_{b1}}.$$

By varying the controller resistance value in the armature circuit, the back emf can be varied from E_{b1} to E_{b2}, thereby, the speed can be varied from N_1 to N_2.

Advantages

This method is suitable for constant load drives where speed variations from low speed up to normal speed are only required.

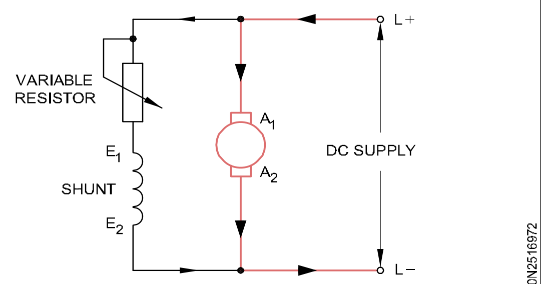
Disadvantages

- Speeds below normal can only be obtained.
- After setting the required speed, it changes with the change in the load because of speed variations not only due to control resistance but also due to load. Hence a stable speed cannot be maintained when the load changes.
- Power loss in the control resistance is high due to the higher current rating, leading to low efficiency of the motor.
- Cost of control resistance is high due to the fact it has to be designed to carry the armature current.
- Requires expensive arrangement to dissipate the heat developed in the control resistance.

Application of the armature control method: Suitable for DC shunt and compound motors used in printing machines, cranes and hoists where the duration of low speed operation is minimum.

The shunt field control method: This method works on the principle that the speed of the DC motor could be varied by varying the field flux. For this, a variable resistance (rheostat) is connected in series with the shunt winding as shown in Fig 2.

Fig 2



SHUNT FIELD CONTROL CIRCUIT

When the resistance is increased in the field circuit, the field current and the flux are reduced. Due to the reduction of flux, the speed is increased.

Advantages

- Higher speeds i.e. above normal speed only can be obtained which will be stable from no load to full load.
- As the magnitude of the field current is low, the power loss in the field rheostat is minimum.
- Control is easy, economical and efficient.

Disadvantages

- Owing to the very weak field, a reduced torque is obtained at top speeds.
- The operation at high speeds with a weak field leads to commutation difficulties unless inter-poles are used.

Application of shunt field control: This method is the most widely used speed control method where speeds above normal are required, and at the same time, the load applied to the motor changes often.

Stepper motor

Objectives: At the end of this exercise you shall be able to
- **state the theory of stepper motor**
- **list and explain the each type of stepper motor**
- **state the advantages, disadvantages and application of stepper motor.**

Basic theory

A stepper motor is basically a synchronous motor. There are no brushes. It is an electromechanical device converts Power pulses into discrete mechanical movements. The shaft or spindle of a stepper motor rotates in discrete step increments when Power command pulses are applied to it in the proper sequence. The motors rotation has several direct relationships to these applied input pulses. The sequence of the applied pulses is directly related to the direction of motor shafts rotation. The speed of the motor shafts rotation is directly related to the frequency of the input pulses and the length of rotation is directly related to the number of pulses applied.

This device does not rotate continuously, but it rotates in the form of pulses. There are different types of motors available based on the stepper rotation, manufactured with steps per revolution of 12,24,72,144,180 and 200 in stepping angles of 300, 150, 50, 2.50, 20 and 1.80 per steps.

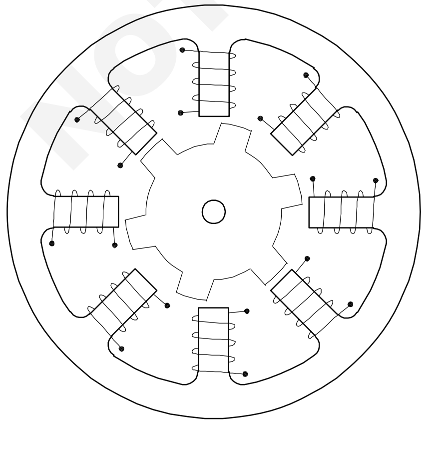
Open loop operation

One of the most significant advantages of a stepper motor is its ability to be accurately controlled in an open loop system. Open loop control means no feedback information about position is needed. This type of control eliminates the need for expensive sensing and feedback devices such as optical encoders. The position is known simply by keeping track of the input step pulses.

Stepper motor types: There are three basic stepper motor types. They are

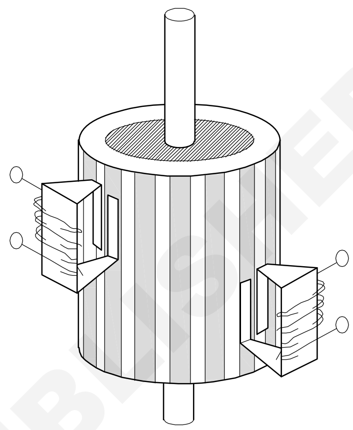
1 Variable-reluctance (Fig 1)

Fig 1



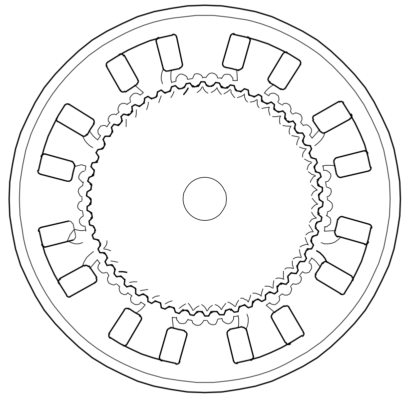
2 Permanent-magnet (Fig 2)

Fig 2



3 Hybrid (Fig 3)

Fig 3



1 **Variable-reluctance (VR):** This type of stepper motor has been around for a long time. It is probably the easiest to understand from a structural point of view (Fig 1) shows a typical VR stepper motor. This type of motor consists of a soft iron multi-toothed rotor and a wound stator. When the stator windings are energized with DC current the poles become magnetized. Rotation occurs when the rotor teeth are attracted to the energized stator poles.

2 **Permanent magnet (PM):** Often referred to as a "tin can" or "can stock" motor the permanent magnet step motor is a low cost and low resolution type motor with typical step angles of 7.50 to 150 (48 - 24 steps/ revolution) PM motors as the name implies have permanent magnets added to the motor structure

(Fig 2). The rotor no longer has teeth as with VR motor. Instead the rotor is magnetized with alternating north and south poles situated in a straight line parallel to the rotor shaft. These magnetized rotor poles provide an increased magnetic flux intensity and because of this the PM motor exhibits improved torque characteristics when compared with the VR type.

3 **Hybrid (HB):** The hybrid stepper motor is more expensive than the PM stepper motor but provides better performance with respect to step resolution, torque and speed. Typical step angles for the HB stepper motor range from 3.60 to 0.90 (100 - 400 steps per revolution) The hybrid stepper motor combines the best features of both the PM and VR type stepper motors. The rotor is multi-toothed like the VR motor and contains an axially magnetized concentric magnet around its shaft (Fig 3). The teeth on the rotor provide an even better path which helps guide the magnetic flux to preferred locations in the airgap. This further increases the detent, holding and dynamic torque characteristics of the motor when compared with both the VR and PM types.

The two most commonly used types of stepper motors are the permanent magnet and the hybrid types.

Advantages and disadvantages

Advantages

1 The rotation angle of the motor is proportional to the input pulse.

2 The motor has full torque at stand still (if the windings are energized)

3 Precise positioning and repeatability of movement since good stepper motors have an accuracy of 3-5% of a step and this error is non cumulative from one step to the next.

4 Excellent response to starting/stopping/reversing.

5 Very reliable since there are no contact brushes in the motor. Therefore the life of the motor is simply dependant on the life of the bearing

6 The motor's response to digital input pulses provides open-loop control, making the motor simpler and less costly to control.

7 It is possible to achieve very low speed synchronous rotation with a load that is directly coupled to the shaft.

8 A wide range of rotational speeds can be realized as the speed is proportional to the frequency of the input pulses.

Disadvantages

1 Resonances can occur if not properly controlled

2 Not easy to operate at extremely high speeds.

Application

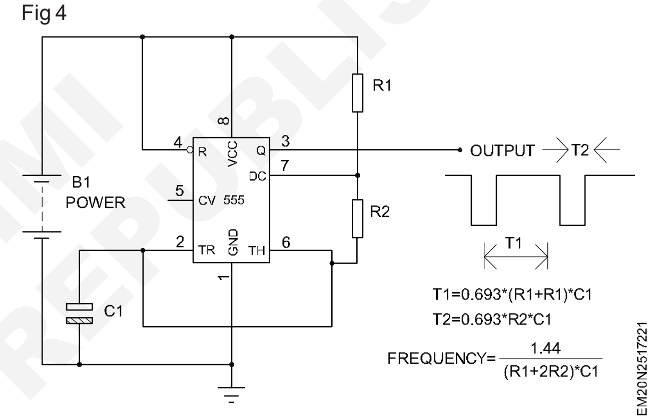
There are different applications. Some of these include printers, plotters, high-end office equipment, hard disk drives, medical equipment, fax machines, automotive and many more.

Stepper motor by varying

Clock pulses

A sample circuit to designed to control the stepper motor using 555 IC shown below

Fig 4



Above circuit produces clock pulsed by varying R_1 R_2 and C_1 out put clock pulsed frequency changes the out put clock pulsed given to stepper motor. Motor runs by varying stepper motor driver circuit clock pulse frequency speed changes.

Stepper motors are controlled by input of electrical pulsed. Such that the speed of motor rotation is proportional to the input pulse rate.

$$\text{pulse rate} = \frac{1.44}{(R_1+2R_2)C_1}$$

Radio wave propagation - principles, fading etc

Objectives : At the end of this lesson you shall be able to
- **explain the fundamentals of radio wave propagation**
- **explain the phenomena of fading & propagation characteristics through different media.**

Radio wave propagation

Radio wave propagation. A radio wave is form of radiant energy (electromagnetic radiation) that propagates at the speed of light (186,000 miles or 300, 000,000 meters per second). Radio propagation is the behavior of radio waves when they are transmitted, or propagated from one point on the earth to another, or into various parts of the atmosphere. As a form of electromagnetic radiation, like light waves, radio waves are affected by the phenomena of reflection, refraction, diffraction, absorption, polarization and scattering.

Radio wave propagation is affected by the daily changes of water vapor in the troposphere and ionization in the upper atmosphere, due to the sun. Understanding the effects of varying conditions on radio propagation has many practical applications, from choosing frequencies for international shortwave broadcasters to design reliable mobile telephone systems, radio navigation and operation of radar systems.

Radio propagation is also affected by several other factors determined by its path from point to point. This path can be a direct line of sight path or an over the horizon path aided by refraction in the ionosphere, which is a region between 60 and 600 km approximately. Factors influencing ionospheric radio signal propagation can include sporadic -E, solar flares, geomagnetic storms, ionospheric layers tilts and solar porton events.

Table 1 : Radio frequencies and their primary mode of propagation

	Band	Frequency	Wave length	Propagation via
ELF	Extremely Frequency	3-30 Hz	100, 000 km 10,000 km	
SLF	Super low Frequency	30-300 Hz	10,000 1,000 km	
ULF	Ultra low Frequency	0.3-3 kHz	1000- 100 km	
VLF	Very low Frequency	3-30 kHz	100 km-10 km	Guided between the earth and the ionosphere
LF	Low frequency	30-300 kHz	10 km-1 km	Guided between the earth and the D layer of the ionosphere and Surface waves
MF	Medium frequency	300-3000 kHz	1000-100m	E, F layer ionospheric refraction at night, when D layer absorption weakens
HF	High frequency (Short wave)	3-30 MHz	100-10m	E Layer ionospheric refraction F1, F2 layer ionospheric refraction
VHF	Very high frequency	30-3000 MHz	10-1 m	Infrequent E ionospheric (E_s) refraction uncommonly F2 layer ionospheric refraction during high sunspot activity up to 50 MHz and rarely to 80 MHz. Generally direct wave. Sometimes tropospheric ducting
UHF	Ultra high frequency	300-300 MHz	100-10 cm	Direct wave. Sometimes tropospheric ducting
SHF	Super high frequency	3-30 GHz	10-1 cm	Direct wave
EHF	Extremely high Frequency	30-300 GHz	10-1 mm	Direct wave limited by absorption
THF	Tremendously high frequency	0.3 - 3 THz	1-0.1 mm	

Surface modes (ground wave)

Surface wave

Lower frequencies (between 30 and 3, 000 KHz) have the property of following the curvature of the earth via ground wave propagation in the majority of occurrences.

Early commercial and professional radio services relied exclusively on long wave, low frequencies and ground - wave propagation. To prevent interference with these services, amateur and experimental transmitters wire restricted to the higher (HF) frequencies, felt to be useless since their ground - wave range was limited. Upon discovery of the other propagation modes possible at medium wave and short wave frequencies, the advantages of HF for commercial and military purposes became apparent. Amateur experimentation was then confined only to authorized frequency segments in that range.

Direct modes (line-of-sight)

Line of sight is the direct propagation of radio waves between antennas that are visible to each other. This is probably the most common of the radio propagation modes at VHF and higher frequencies. Because radio signals can travel through many non - metallic objects, radio can be picked up through walls. This is still line - of sight propagation. Examples would include propagation between a satellite and a ground antenna or reception of television signals from a local TV transmitter.

Ionospheric modes (sky wave)

Sky wave

Sky wave propagation, also referred to as skip, is one of the modes that rely on refraction of radio waves in the ionosphere, which is made up of one or more ionized layers in the upper atmosphere. F2 - layer is the most important ionospheric layer for long - distance, multiple - hop HF propagation, through F1, E and D - layers also play significant roles. The D- layer, when present during sunlight periods, causes significant amount of signal loss, as does the E - layer whose maximum usable frequency can rise to 4 MHz and above, thus block higher frequency signals from reaching the F2 - layer. The layers, or more appropriately "regions", are directly affected by the sun on a daily diurnal cycle, a seasonal cycle and the 11-year sunspot cycle and determine the utility of these modes. During solar maxima, or sunspot highs and peaks, the whole HF range up to 30 MHz can be used usually around the clock and F2 propagation up to 50 MHz is observed frequently depending upon daily solar flux 10.7 cm radiation values. During solar minima, or minimum sunspot counts down to zero, propagation of frequencies above 15 MHz is generally unavailable.

Multipath fading basics

Multipath fading is a feature that needs to be taken into account when designing or developing a radio communications system. In any terrestrial radio communications system, the signal will reach the receiver not only via the direct path, but also as a result of reflections from objects such as buildings, hills, ground, water, etc, that are adjacent to the main path.

The overall signal at the radio receiver is a summation of the variety of signals being received. As they all have different path lengths, the signals will add and subtract from the total dependent upon their relative phases.

At times there will be changes in the relative path lengths. This could result from either the radio transmitter or receiver moving, or any of the objects that provides a reflective surface moving. This will result in the phases of the signals arriving at the receiver changing, and in turn this will result in the signal strength varying as a result of the different way in which the signals will sum together. It is this that causes the fading that is present on many signals.

Need for modulation & types of modulation

Objectives : At the end of this lesson you shall be able to
- **explain the need for modulation**
- **explain various types modulation & demodulation techniques.**

Need for modulation

The velocity of electromagnetic waves is 3×10^8 ms^{-1}. On the other hand, the velocity of sound waves cannot be used to transmit intelligence to far off place. Only electromagnetic waves can be made to do this.

Modulation is extremely necessary in communication systems due to the following reasons.

Sub topics

1 Practical antenna length (L)

2 Wireless communication

3 Operating range

Practical antenna length (L)

When free space is the communication channel, antennas operate effective only when their dimensions are of the order of the magnitude of wave length of the signal being transmitted.

Now, $L = \lambda = \frac{u}{v} = \frac{3 \times 10^8}{v} Hz$

λ = Wave length

u = Velocity of electro magnetic wave

v = Frequency to be radiated in Hz

The audio frequencies range from 20 Hz to 20 kHz. Suppose a frequency of 20 kHz is to be radiated directly into space. For this,

Length of antenna = $\frac{3 \times 10^8}{20 \times 10^3} m = 15000 m = 15$ km

this is too long antenna to be constructed practically. So, it is impracticable to radiate audio signal directly into space.

Let us now calculate the length of the antenna if a carrier wave of say, 1000 kHz is used to carry the signal.

Length of antenna = $\frac{3 \times 10^8}{10^6} m = 300$ m

An antenna of 300 m length can be easily construct.

Wireless communication

One desirable feature of radio transmission is that it should be carried wihtout wires (i.e) radiated into space. At audio frequencies, radiation is not practicable because the efficiency of radiation is poor. However, efficient radiation of electrical energy is possible at high frequencies (>20kHz). For this reason, modulation is always done in communication systems.

Operating range

The energy of a wave depends upon its frequency. The greater the frequency of the wave, the greater is the energy possessed by it. As the audio signal frequencies are small, these cannot be transmitted over large distance if radiated directly into space. The only practical solution is to modulate a high frequency carrier wave with audio signal and permit the transmission to occur at this high frequency (carrier frequency).

What is modulation?

The best way to define modulation is

The process of impressing low -frequency information to be transmitted on to a high -frequency wave, called the carrier wave, by changing the characteristics of either its amplitude, frequency, or phase angle is called modulation.

Another definition for modulation is.

The process of altering the characteristics of the amplitude, frequency, or phase and of the high - frequency signal in accordance with the instantaneous value of the modulating wave is called modulation.

Types of modulation

The sinusoidal carrier wave can be given by the equation.

$V_c = V_c \sin(W_c t+\theta) = V_c \sin 2\pi f_c t+\theta)$

Vc = Maximum value

fc = Frequency

θ = Phase relation

Wc = Angular velocity

t = time

Since the three variables are the amplitude, frequency, and phase angle, the modulation can be done by varying any one of them. Thus there are three modulation types namely.

- Amplitude modulation (AM)
- Frequency modulation (FM)
- Phase modulation (PM)

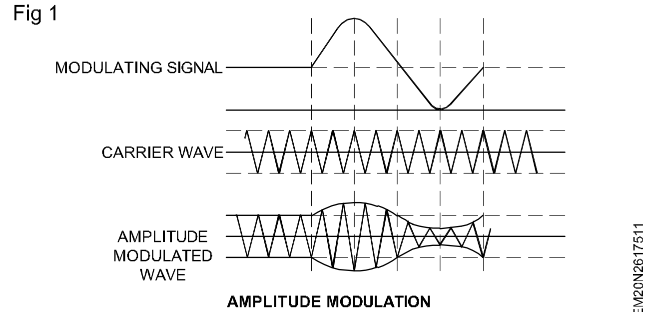
In India, radio broadcasting is done through amplitude modulation. Television broadcasting is done with amplitude modulation for video signals and frequency modulation for audio signals.

Amplitude modulation (AM)

Definition

The method of varying amplitude of a high frequency carrier wave in accordance with the information to be transmitted, keeping the frequency and phase of the carrier wave unchanged is called amplitude modulation. The information considered as the modulating signal and it is superimposed on the carrier wave by applying both of them to the modulator. The detailed diagram showing the amplitude modulation process is given below. (Fig 1)

Fig 1



AMPLITUDE MODULATION

As shown above, the carrier wave has positive and negative half cycles. Both these cycles are varied according to the information to be sent. The carrier then consists of sine waves whose amplitudes follow the amplitude variations of the modulating wave. The carrier is kept in an envelope formed by the modulating wave. From the figure, you can also see that the amplitude variation of the high frequency carrier is at the signal frequency and the frequency of the carrier wave is the same as the frequency of the resulting wave.

Modulation index (m)

The ratio between the amplitude change of modulated carrier wave to the amplitude of the normal carrier wave is called modulation index. It is represented by the letter 'm'.

It can also be defined as the range is which the amplitude of the carrier wave is varied by the modulating signal.

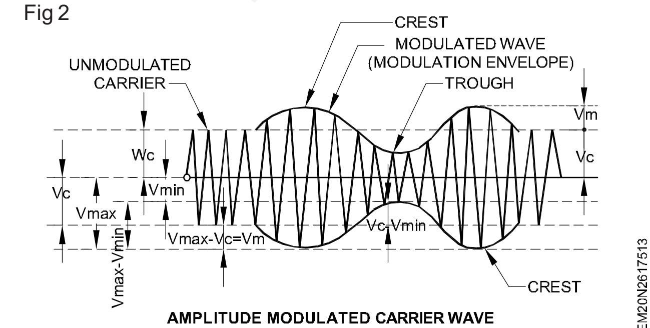
$m=V_m/V_c$

Percentage modulation, $\%m=m*100 = V_m/V_c * 100$

The percentage modulation lies between 0 and 80%

Another way of expressing the modulation index is in terms of the maximum and minimum values of the amplitude of the modulated carrier wave. This is shown in the figure below. (Fig 2)

Fig 2



AMPLITUDE MODULATED CARRIER WAVE

Amplitude modulated carrier wave

Amplitude modulated carrier wave

From the figure we know that

$2V_{in}=V_{max}- V_{min}$

$V_{in} = (V_{max}-V_{min})/2$

$V_c=V_{max} -V_{in}$

$=V_{max} - (V_{max}-V_{min})/2$

$=(V_{max} +V_{min})/2$

Substituting the values of $V_{in}= V_m$ and Vc in the equation m =Vm/Vc, we get

$M= V_{max}-V_{min}/V_{max} + V_{min}$

As told earlier, the value of 'm' lies between 0 and 0.8. The value of m determines the strength and the quality of the transmitted signal. In an AM wave, the signal is contained in the variations of the carrier amplitude. The audio signal transmitted will be weak of the carrier wave is only modulated to a very small degree. But if the value of m exceeds unity, the transmitter output produces erroneous distortion.

Limitations of amplitude modulation

1 Low efficiency- since the useful power that lies in the small bands is quite small, so the efficiency of AM system is low.

2 Limited operating range - The range of operation is small due to low efficiency. Thus, transmission of signals is difficult.

3 Noise in reception- As the radio receiver finds it difficult to distinguish between the amplitude variations that represent noise and those with signals, heavy noise is prone to occur in its reception.

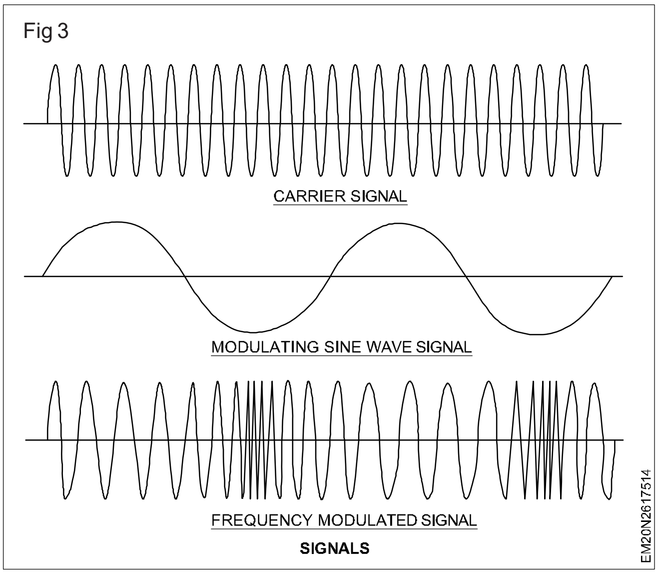
4 Poor audio quality - To obtain high fidelity reception, all audio frequencies till 15 kilo Hertz must be reproduced and this necessitates the band width of 10 Kilo Hertz to minimize the interference from the adjacent broadcasting stations. Therefore, in AM broadcasting stations audio quality is known to be poor.

Frequency modulation

The carrier frequency is varied according to the instantaneous amplitude of message signal or modulating signal by keeping the amplitude of carrier signal constant is called frequency. (Fig 3)

Advantages of frequency modulation

- Frequency modulation has more noise resistivity when compared to other modulation techniques. That is why they are mainly used in broadcasting and radio communications. And we are all well aware that radio communication use mainly frequency modulation for transmission. We know that noise will occur mainly to the amplitude of the signal. In frequency modulation, amplitude is made constant and only frequency is varied, so we can easily find out the noise in the amplitude by using a limiter.



- The frequency modulation is having greater resistance to rapid signal strength variation, which we will use in FM radios even while we are travelling and frequency modulation is also mainly used in mobile communication purposes.
- For transmitting messages in frequency modulation, it does not require special equipments like linear amplifiers or repeaters and transmission levels or higher when compared to other modulation techniques. It does not require any class C or B amplifiers for increasing the efficiency.
- Transmission rate is good of frequency modulation when compared to other modulation that is frequency modulation can transmit around1200 to 2400 bits per second.
- Frequency modulation has a special effect called capture effect in which high frequency signal will capture the channel and discard the low frequency or weak signals from interference.

Disadvantages of frequency modulation

In the transmission section, we do not need any special equipment but in the reception, we need more complicated demodulations for demodulating the carrier signal from message or modulating signal.

Frequency modulation cannot be used to find out the speed and velocity of a moving object. Static interferences are more than compared to phase modulation. Outside interference is one of the biggest disadvantages in the frequency modulation. There may be mixing because of nearby radio stations, pagers, construction walkie-talkies etc.

To limit the band width in the frequency modulation, we use some filter which will again introduce some distortions in the signal.

Transmitters and receiver should be in same channel and one free channel must be there between the systems.

Application of frequency modulation (FM)

- Frequency modulation is used in radio' which is very common in our daily life.
- Frequency modulation is used in audio frequencies to synthesize sound.
- Used in applications of magnetic tape storage.

Phase modulation

PM, is used in many applications to carry both analog and digital signals. Keeping the amplitude of the carrier signal constant, the phase is varied according to the instantaneous amplitude of information signals.

Advantages and disadvantages of phase modulation

- The main advantages of phase modulation is that it has less interference from static, which is why we use this type of modulation in finding, out the speed or velocity of a moving object. In frequency modulation, we cannot find out the velocity of moving object.
- The main disadvantage is phase ambiguity comes if we increase the phase modulation index, and data loss is more and we need special equipment like frequency multiplier for increasing the phase modulation index.

Applications of phase modulation

- Phase modulation application is not different from frequency modulation. Phase modulation is also used in communication systems.
- It may be used in binary phase shift keying

Fundamentals of antenna, various parameters, types & applications

Objectives : At the end of this lesson you shall be able to
- **explain the fundamentals of antenna**
- **explain various types & parameters of antennas**
- **explain the applications of various antennas.**

Antenna fundamentals

An antenna is a device for converting electromagnetic radiation in space into electrical currents in conductors or vice - versa, depending on whether it is being used for receiving or for transmitting, respectively. Passive radio telescopes are receiving antennas. It is usually easier to calculate the properties of transmitting antennas. Fortunately, most characteristics of a transmitting antenna (e.g its radiation pattern) are unchanged when the antenna is used for receiving, so we often use the analysis of a transmitting antenna to understand a receiving antenna used in radio astronomy.

An antenna is an electrical device designated to radiate or capture electromagnetic (EM) waves. In order to properly appreciate this definition, and the physical operation of antennas as a whole, we will have to familiarize the reader with some basic electromagnetic concepts.

The physical laws governing all classical electromagnetic phenomena are maxwell's equations. First introduced by the scottish scientish james clark maxwell, in his famous article. "A dynamical theory of the electromagnetic field', in 1864.

An antenna gives the wireless system three fundamental properties gain, direction and polarization. Gain is a measure of increase in power. Direction is the shape of the transmission pattern. A good analog for an antenna is the reflector in a flashlight. The reflector concentrates and intensifies the light beam in a particular direction similar to what a parabolic dish antenna would do to a RF source in a radio system.

Antenna gain

Antenna gain is measured in decibels, which is a ratio between two values. The gain of a specific antenna is compared to the gain of an isotropic antenna. An isotropic antenna is a theoretical antenna with a uniform three - dimensional radiation pattern (similar to a light bulb with no reflector). dBi is used to compare the power level of a given antenna to the theoretical isotropic antenna. The U.S FCC uses dBi in its calculations. An isotropic antenna is said to have a power rating of 0 dB, meaning that it has zero gain /loss when compared to itself.

Unlike isotropic antennas, dipole antennas are real antennas. Dipole antennas have a different radiation pattern compared to isotropic antennas. The dipole radiation pattern is 360 degrees in the horizontal plane and 75 degrees in the vertical plane (assuming the dipole antenna is standing vertically) and resembles a donut in shape. Because the beam is slightly concentrated, dipole antennas have a gain over isotropic antennas of 2.14 dB in the horizontal plane. Dipole antennas are said to have a gain of 2.14 dBi (in comparison to an isotropic antenna).

Some antennas are rated in comparison to dipole antennas, which is denoted by the suffix dBd. Hence dipole antennas have a gain of 0 dBd (=2.14 dBi)

Note: Majority of documentation refers to dipole antennas as having a gain of 2.2 dBi. The actual figure is 2.14 dBi, but is often rounded up.

You can also use the dB abbreviation to describe the power level rating of antennas.

dBi - For use with isotropic antennas

dBd- With reference to dipole antennas

The power rating difference between dBd and dBi is approximately 2.2 that is, 0 dBd = 2.2 dBi.

Antenna types

Each type of antenna offers different coverage capabilities. As the gain of an antenna increases, there is some tradeoff to its coverage area. Usually high- gain antennas offer longer coverage distances, but only in a certain direction. The radiation patterns below help to show the coverage areas of the styles of antennas that are Omnidirectional, Yagi and Patch antennas.

Omnidirectional antenna

An omnidirectional antenna (Fig 1) is designed to provide a 360 degree radiation pattern. This type of antenna is used when coverage in all directions from the antenna is required. The standard 2.14 dBi "Rubber duck" is one style of omnidirectional antenna.

Fig 1

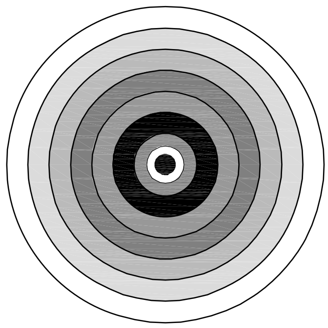


Figure. Omnidirectional antennas

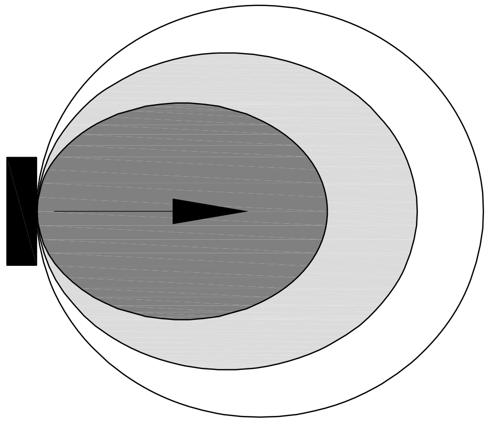
Directional Antennas

Directional antennas come in many different styles and shapes. an antenna does not offer any added power to the signal; it simply redirects the energy it receives from the transmitter. By redirecting this energy, it has the effect of providing more energy in one direction and less energy in all other directions. As the gain of a directional antenna increases, the angle of radiation usually decreases, providing a greater coverage distance, but with a reduced coverage angle. Directional antennas include patch antennas (Fig 2) Yagi antennas (Fig 3) and parabolic, dishes. Parabolic dishes have a very narrow RF energy path and the installer must be accurate in aiming these types of antennas these at each other.

Fig 2 : Directional Antenna

Figure 3 : Yagi antenna

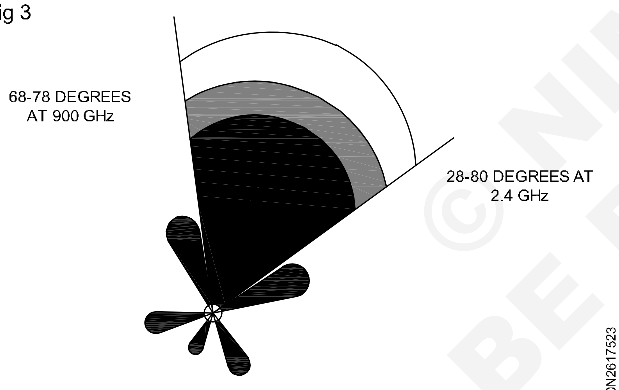
Fig 2



DIRECTIONAL ANTENNA

Yagi antenna / Yagi /Uda antenna

Fig 3



DIRECTIONAL YAGI

The yagi antenna sometimes called the yagi - Uda RF antenna is widely used where gain and directivity are required from an RF antenna design. (Fig 4)

In this section

- Yagi antenna
- Yagi antenna theory
- Yagi antenna gain
- Yagi impedance & matching

The Yagi antenna or Yagi - Uda antenna / aerial is one of the most successful RF antenna designs for directive antenna applications.

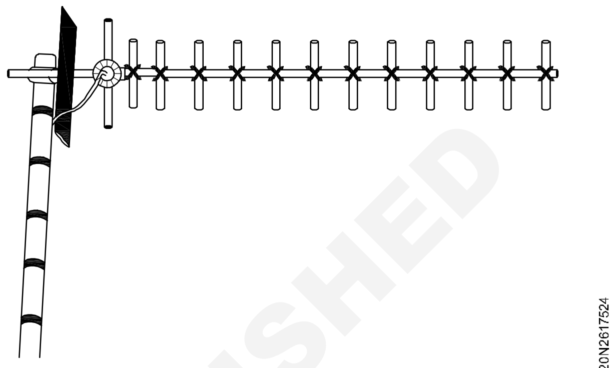
The Yagi or Yagi - Uda antenna is used in a wide variety of applications where an RF antenna design with gain and directivity is required.

The Yagi has become particularly popular for television reception, but it is also used in very many other domestic and commercial applications where an RF antenna is needed that has gain and directivity.

Not only is the gain of the Yagi antenna important as it enables better levels of signals to noise ratio to be achieved, but also the directivity can be used to reduce interference levels by focusing the transmitted power to areas where it is needed, or receiving signals best from where it emanate.

Typical Yagi Uda antenna used for

Fig 4



TYPICAL YAGI UDA ANTENNA USED FOR TELEVISION RECEPTION

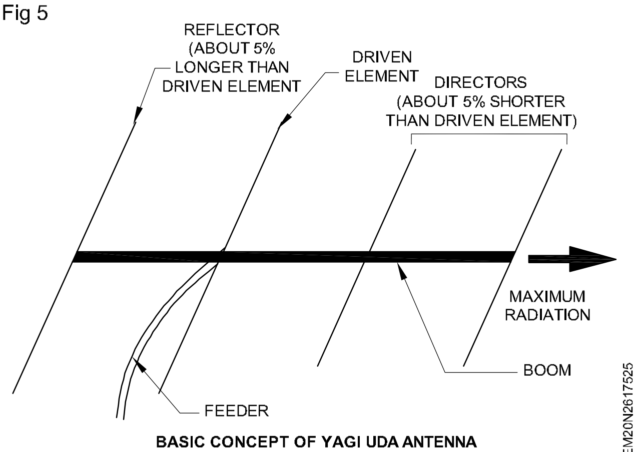
television reception

Yagi antenna history

The full name for the antenna is the Yagi - Uda antenna. The Yagi antenna derives its name from its two Japanese inventors Hidetsugu Yagi and Shintaro Uda. The RF antenna design concept was first outlined in a paper that Yagi presented in 1928.

Yagi antenna - the basics (Fig 5)

Fig 5



BASIC CONCEPT OF YAGI UDA ANTENNA

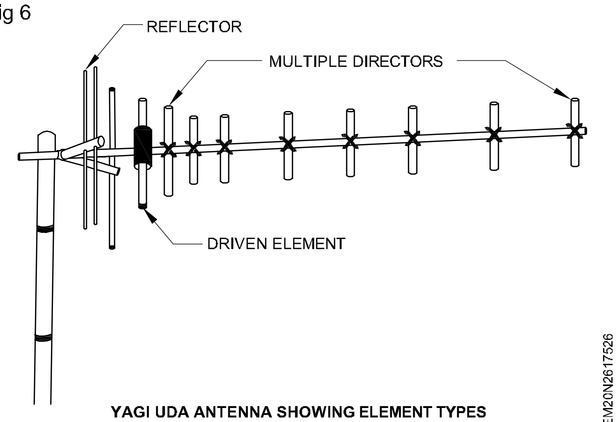
Basic concept of Yagi Uda antenna

The Yagi antenna design has a dipole as the main radiating or driven element. Further 'parasitic' elements are added which are not directly connected to the driven element.

These parasitic elements within the Yagi antenna pick up power from the dipole and re- radiate it. The phase is in such a manner that it affects the properties of the RF antenna as a whole, causing power to be focused one particular direction and removed from others.

The parasitic elements of the Yagi antenna operate by re-radiating their signals in a slightly different phase to that of the driven element. In this way the signal is reinforced in some directions and cancelled out in others. It is found that the amplitude and phase of the current that is induced in the parasitic elements in dependent upon their length and the spacing between them and the dipole or driven element. (Fig 6)

Fig 6



YAGI UDA ANTENNA SHOWING ELEMENT TYPES

Yagi Uda antenna showing element types

There are three types of element within a Yagi antenna.

- Driven element : The driven element is the Yagi antenna element to which power is applied. It is normally a half wave dipole or often a folded dipole.
- Reflector : The Yagi antenna will generally only have one reflector. This is behind the main driven element, i.e the side away from the direction of maximum sensitivity.

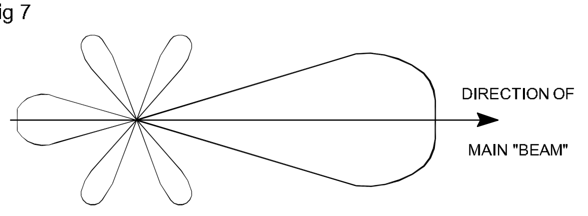
Further reflectors behind the first one add little to the performance. However many designs use reflectors consisting of a reflecting plate, or a series of parallel rods simulating reflecting plate. This gives a slight improvement in performance, reducing the level of radiation or pick - up from behind the antenna, i.e in the backwards direction.

Typically a reflector will add around 4 to 5 dB of gain in the forward direction.

Director : There many be none, one or more reflectors in the Yagi antenna. The director or directors are placed in front of the driven element, i.e in the direction of maximum sensitivity.

The antenna exhibits a directional pattern consisting of a main forward lobe and a number of spurious side lobes. The main one of these is the reverse lobe caused by radiation in the direction of the reflector. The antenna can be optimized to either reduce this or produce the maximum level of forward gain. Unfortunately the two do not coincide exactly and a compromise on the performance has to be made depending upon the application. (Fig 7)

Fig 7

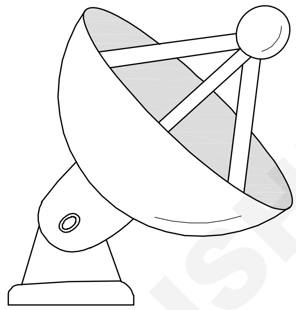


YAGI UDA ANTENNA SHOWING ELEMENT TYPES

Yagi antenna radiation pattern

Parabolic antenna (Fig 8)

Fig 8



PARABOLIC ANTENNA

A parabolic antenna is an antenna that uses a parabolic reflector, a curved surface with the cross - sectional shape of a parabola, to direct the radio waves. The most common form is shaped like a dish and is popularly called a dish antenna or parabolic dish. The main advantage of a parabolic antenna is that it has high directivity. It functions similarly to a search light or flash light reflector to direct the radio waves in a narrow beam, or receive radio waves from one particular direction only. Parabolic antennas have some of the highest gains, that is, they can produce the narrowest beam widths, of any antenna type. In order to achieve narrow beam widths, the parabolic reflector must be much larger than the wave length of the radio waves used, so parabolic antennas are used in the high frequency part of the radio spectrum, at UHF and microwave (SHF) frequencies, at which the wave lengths are small enough that conveniently - size reflectors can be used.

Parabolic antennas are based on the geometrical property of the paraboloid that the paths FP_1Q_1, FP_2Q_2, FP_3Q_3 are all the same length. so a spherical wave front emitted by a feed antenna at the dish's focus F will be reflected into an outgoing plane wave L travelling parallel to the dish's axis VF. (Fig 9)

Basic antenna parameters

An antenna does not radiate uniformly in all directions. For the sake of reference, we consider a hypothetical antenna called an isotropic radiator having equal radiation in all directions. A directional antenna is one which can radiate or receive electromagnetic waves more effectively in some directions than in others. The relative distribution of radiated power as a function of direction in space (i.e., as function of θ and ϕ) is called the radiation pattern of the antenna. Instead of 3D surface, it is common practice to show planar cross action radiation pattern. E- plane and

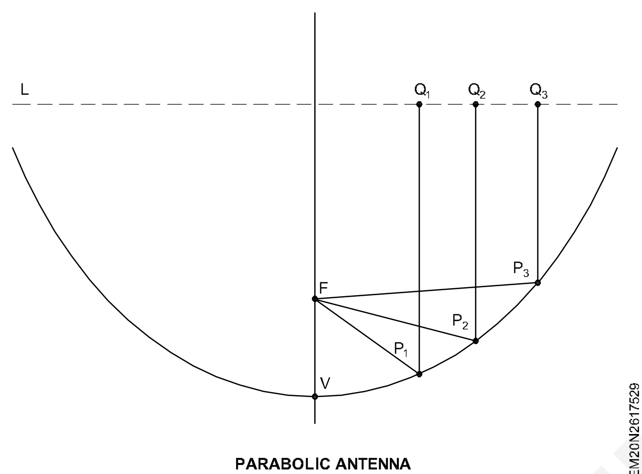
H- plane patterns give two most important views. The E-plane pattern is a view obtained from a section containing maximum value of the radiated field and electric field lies in the plane of the section. Similarly when such a section is taken such that the plane of the section contains H field and the direction of maximum radiation.

A typical radiation pattern plot is shown in Fig 10 below.

Typical radiation pattern in polar coordinates

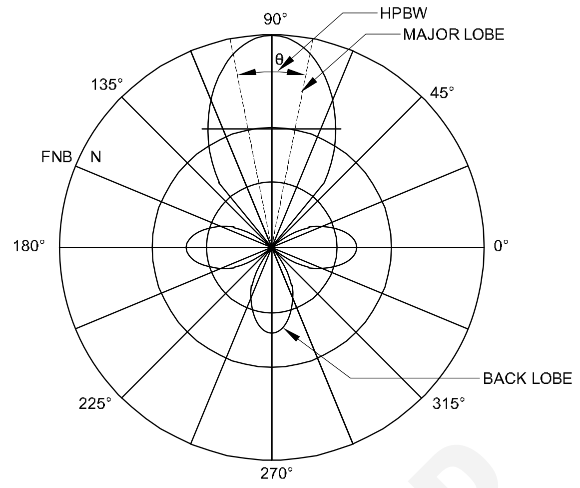
Typical radiation pattern in rectangular coordinates (Fig 11)

Fig 9



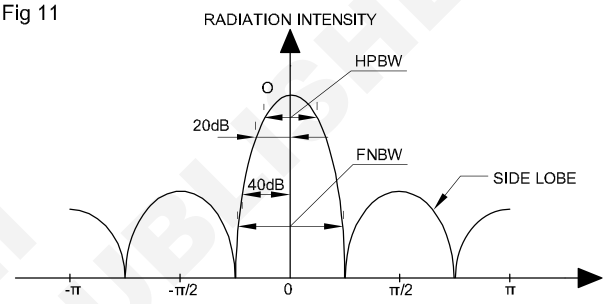
PARABOLIC ANTENNA

Fig 10



TYPICAL RADIATION PATTERN IN POLAR COORDINATES

Fig 11



PARABOLIC ANTENNA

Introduction to AM, FM & PM, SSB-SC, DSB - SC modulation & demodulation techniques

Objectives : At the end of this lesson you shall be able to

- **explain the AM modulation & demodulation techniques**
- **explain the modulation techniques of SSB-SC, DSB - SC in AM**
- **explain the FM modulation & demodulation techniques**
- **explain the PM modulation & demodulation techniques.**

Amplitude modulation index & depth

Amplitude modulation index and modulation depth are key parameters for any AM transmission as it is necessary to keep the index or depth within limits to reduce distortion and interference.

It is often necessary to define the level of modulation that is applied to a signal.

In order to have a standard method of achieving this a factor or index known as the modulation index is widely used for this. A complementary figure known as the amplitude modulation depth is also seen on many occasions.

As an indicator of the level of modulation on an amplitude modulated signal, the modulation index is important - too low level of modulation and the modulation does not utilize the carrier efficiently - too high and the carrier can become over modulated causing sidebands to extend out beyond the allowed bandwidth causing interference to other users.

AM modulation index basics

Modulation indices are described for various forms of modulation. The amplitude modulation, AM, modulation index can be defined as the measure of extent of amplitude variation about an un - modulated carrier.

As with other modulation indices, the modulation index for amplitude modulation (AM) indicates that amount by which the modulated carrier varies around its static un - modulated level.

When expressed as a percentage it is the same as the depth of modulation. In other words it can be expressed as.

Modulation index $m = \frac{M}{A}$

A = carrier amplitude

M = modulation amplitude

Where :

A is the carrier amplitude . M is the modulation amplitude and is the peak change in the RF amplitude from its unmodulated value.

From this it can be seen that for an AM modulation index of 0.5, the modulation causes the signal to increase by a factor of 0.5 and decrease to 0.5 of its original level.

Amplitude modulation depth

A complementary figure to modulation index is also used for amplitude modulation signals. Known as the modulation depth, it is typically the modulation index expressed as a percentage.

Thus a modulation index of 0.5 would be expressed as a modulation depth of 50%.

However often the two terms and figures are used interchangeably and figures for a modulation index of 50% are often seen where the index is 0.5

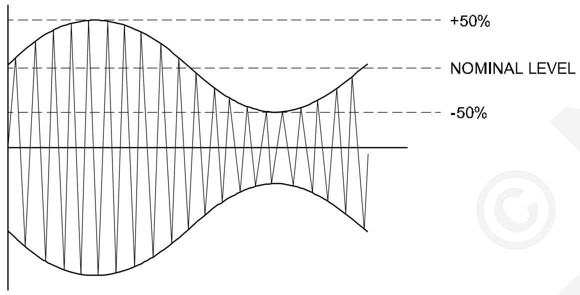
Modulation index / modulation depth examples

Typically the modulation index of a signal will vary as the modulating signal intensity varies. However some static values enable the various levels to visualized more easily.

Amplitude modulated index of 0.5 (Fig 1)

When the modulation index reaches 1.0, i.e a modulation depth of 100% the carrier level falls the zero and rise to twice its non - modulated level.

Fig 1

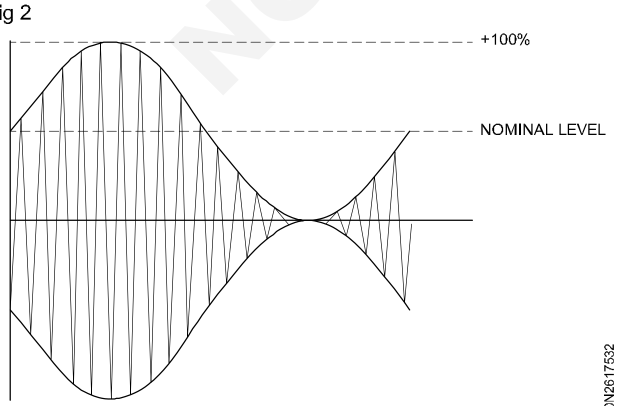


AMPLITUDE MODULATED INDEX OF 0.5

Amplitude modulated index of 1.0 (Fig 2)

Any increase of the modulation index above 1.0, i.e 100% modulation depth causes over modulation. The carrier experiences 180° phase reversals where the carrier level would try to go below the zero point. These phase reversals give rise to additional side bands resulting from the phase reversals (phase modulation) that extend out, in theory to infinity. This can cause serious interference to other users if not filtered.

Fig 2

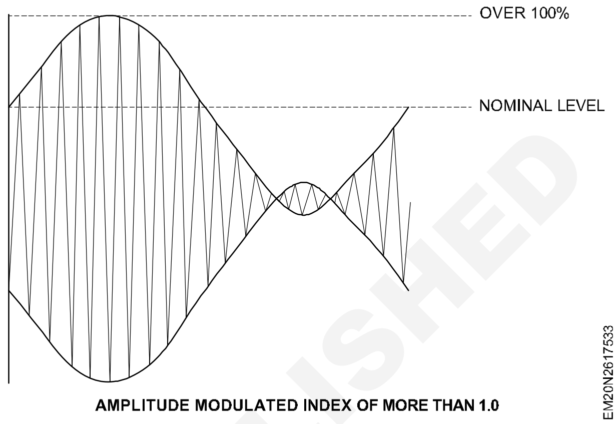


AMPLITUDE MODULATED INDEX OF 1.0

Amplitude modulated index of more than 1.0 i.e over - modulated (Fig 3)

Broadcast stations in particular take measures to ensure that the carrier of their transmissions never become over modulated. The transmitters incorporate limiters to prevent more than 100% modulation. However they also normally incorporate automatic audio gain controls to keep the audio levels such that near 100% modulation levels are achieved for most of the time.

Fig 3



AMPLITUDE MODULATED INDEX OF MORE THAN 1.0

AM - Modulator & demodulator

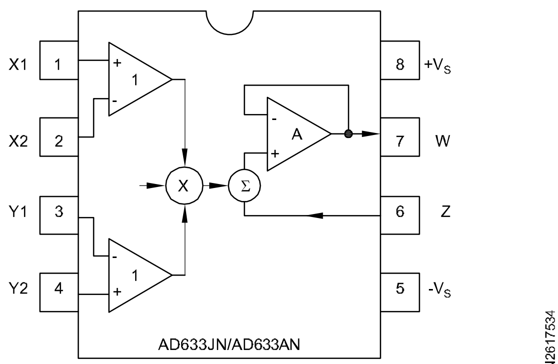
In this section we describe the circuits used for generation and demodulation of amplitude modulated signals. An analog multiplier IC AD633(Analog devices) has been used to generate the AM signal. The AD 633 is a functionally complete, four quadrant, analog multiplier. It includes high impedance, differential X and Y inputs, and a high impedance summing input (Z). The low impedance output voltage is a nominal 10V full scale provided by a buried zener. The functional diagram of the AD633 is shown in figure 4.

Functional block diagram from Fig 4, we find that

$$W = \frac{(X1-X2)\,(Y1-Y2)}{10V} + Z$$

Details of AD633 is available in the data sheet.

Fig 4



FUNCTIONAL BLOCK DIAGRAM

Envelope detection process

For a sinusoid ally modulated signal, if the time constant of the detector is chosen such that

$RC \leq \frac{1}{2\pi f_m}\left(\frac{\sqrt{1-m^2}}{m}\right)$, the detector can always follow the message envelope.

Double - side band suppressed carrier transmission (DSB-SC)

It transmission in which frequencies produced by amplitude modulation (AM) are symmetrically spaced above and below the carrier frequency and the carrier level is reduced to the lowest practical level, ideally being completely suppressed.

In the DSB - SC modulation, unlike in AM, the wave carrier is not transmitted; thus, much of the power is distributed between the side bands, which implies an increase of the cover in DSB-SC, compared to AM, for the same power used.

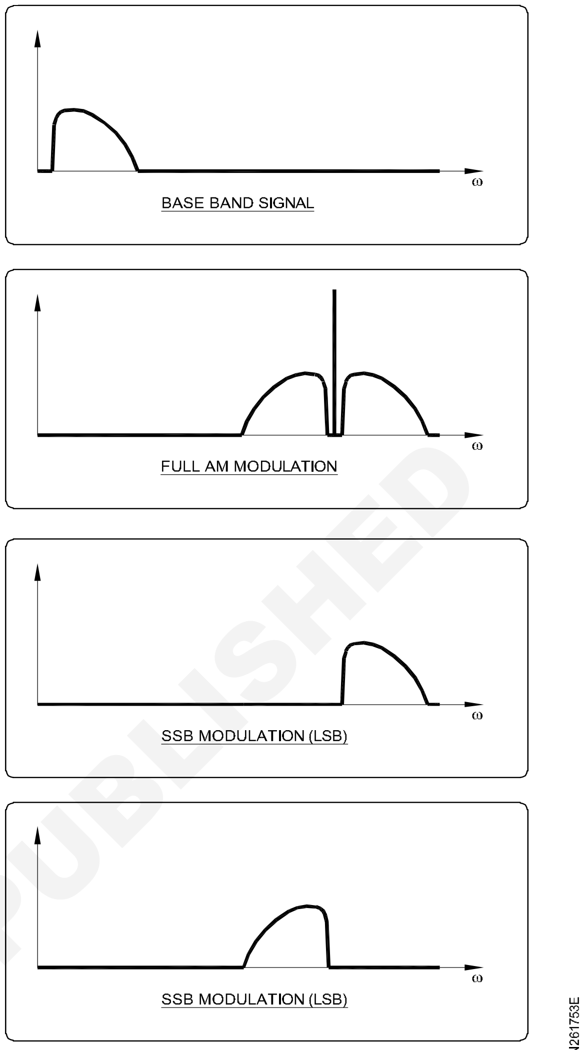
DSB-SC transmission is a special case of double - side band reduced carrier transmission. It is used for radio data systems.

Single - side band modulation

In radio communications, single - side band modulation (SSB) or single - side band suppressed - carrier (SSB-SC) is a refinement of amplitude modulation which uses transmitter power and band width more efficiently. Amplitude modulation produces an output signal that has twice the bandwidth of the original base band signal. Single - side band modulation avoids this band width doubling, and the power wasted on a carrier, at the cost of increased device complexity and more difficult tuning at the receiver.

Illustration of the spectrum of AM and SSB signals is shown in Fig 5. The lower side band (LSB) spectrum is inverted compared to the baseband. As an example, a 2 KHz audio base band signal modulated onto a 5 MHz carrier will produce a frequency of 5.002 MHz if upper side band (USB) is used or 4.998 MHz is LSB is used.

Fig 5



SINGLE-SIDE BAND MODULATION

Frequency modulation

A signal may be carried by an AM or FM radio wave.

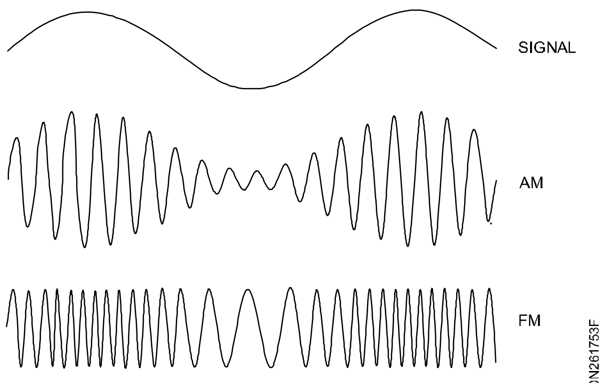
In telecommunications and signal processing, frequency modulation (FM) is the encoding of information in a carrier wave by varying the instantaneous frequency of the wave. (Compare with amplitude modulation, in which the amplitude of the carrier wave varies, while the frequency remains constant) Fig 6.

In analog signal applications, the difference between the instantaneous and the base frequency of the carrier is directly proportional to the instantaneous value of the input - signal amplitude.

Digital data can be encoded and transmitted via a carrier wave by shifting the carrier's frequency among a predefined set of frequencies - a technique known as frequency - shift keying (FSK). FSK is widely used in modems and fax modems, and can also be used to send morse code. Radio teletype also uses FSK.

Frequency modulation is used in radio, telemetry, radar, seismic prospecting, and monitoring newborns for seizures via EEG. FM is widely used for broadcasting music and speech, two - way radio systems, magnetic tape- recording systems and some video- transmission systems. In radio systems frequency modulation with sufficient bandwidth provides an advantage in cancelling naturally - occurring noise.

Fig 6



FREQUENCY MODULATION

Frequency modulation is known as phase modulation when the carrier phase modulation is the time integral of the FM signal.

Modulation index

As in other modulation systems, the value of the modulation index indicates by how much the modulated variable varies around its unmodulated level. It relates to variations in the carrier frequency.

$$h = \frac{\Delta f}{fm} = \frac{f\Delta |x_m(t)|}{f_m}$$

where fm is the highest frequency component present in the modulating signal xm(t), and is the peak frequency - deviation -i.e the maximum deviation of the instantaneous frequency from the carrier frequency. For a sine wave modulation, the modulation index is seen to be the ratio of the amplitude of the modulating sine wave to the amplitude of the carrier wave (here unity)

If h< 1, the modulation is called narrowband FM, and its bandwidth is approximately 2fm. Sometimes modulation index h<0.3 rad is considered as narrowband FM otherwise wideband FM.

Noise reduction

A major advantage of FM in a communications circuit, compared for example with AM, is the possibility of improved signal to noise ratio (SNR). Compared with an optimum AM scheme, FM typically has poorer SNR below a certain signal level called the noise threshold, but above a higher level - the full improvement or full quieting threshold - the SNR is much improved over AM. The improvement depends on modulation level and deviation. For typical voice communications channels, improvements are typically 5-15 dB. FM broadcasting using wider deviation can achieve even greater improvements. Additional techniques, such as pre - emphasis of higher audio frequencies with corresponding de-emphasis in the receiver, are generally used to improve overall SNR in FM circuits. Since FM signals have constant amplitude, FM receivers normally have limiters that remove AM noise, further improving SNR.

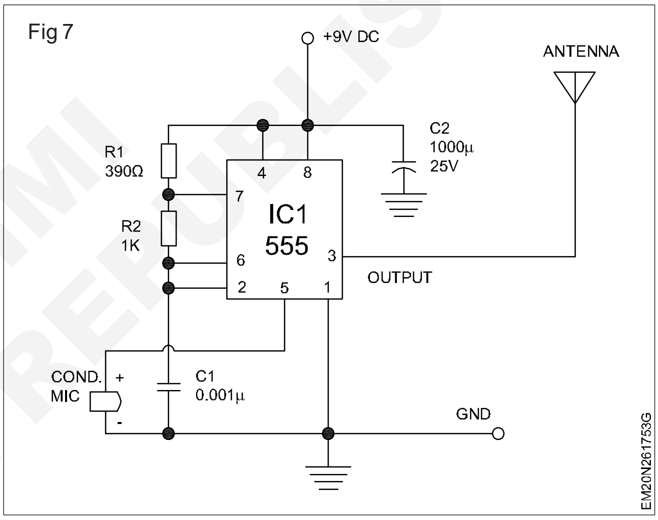
IC based AM transmitter circuit

IC 555 (IC1) is used as a free running multivibrator designed for a frequency of around 600 kHz. The frequency of the multivibrator can be calculated as follows: f =1.443(R1+2R2) C1 where R1 and R2 in ohms, capacitor C1 in microfarads, and frequency f in hertz. This frequency can be changed by simply replacing R2 with a variable resistor or C1 with gang capacitors. A condenser microphone is used for audio signal input.

The IC 555 multivibrator is used as a voltage-to-frequency converter. The output of the condenser microphone is given to pin 5 of ICI, which converts the input voltage or voice signal into appropriate frequency at output pin 3. This frequency produces an electromagnetic wave, which can be detected by a near by AM radio receiver, and you can hear your own voice in that radio. (Note that if there is no noise in receiver, tune it to 600 kHz.)

The circuit operates with a 9V regulated power supply or a 9V battery. For antenna, connect 2-3m long wire at pin 3. (Fig 7)

Fig 7



Block diagram of AM & FM transmitter, FM generation & detection

Objectives : At the end of this lesson you shall be able to
- **explain the working of AM transmitters**
- **explain the working of FM transmitters**
- **list the types of FM detection**
- **sketch the different types of FM detector circuits.**

AM transmitters

Transmitters that transmit AM signals are known as AM transmitters. These transmitters are used in medium wave (MW) and short wave (SW) frequency bands for AM broadcast. The MW band has frequencies between 530 KHz and 1650 KHz, and the SW band has frequencies ranging from 3 MHz to 30 MHz. The two types of AM transmitters that are used based on their transmitting powers are.

High level AM transmitters

Low level AM transmitters

High level transmitters are high level modulation, and low level transmitters use low level modulation.

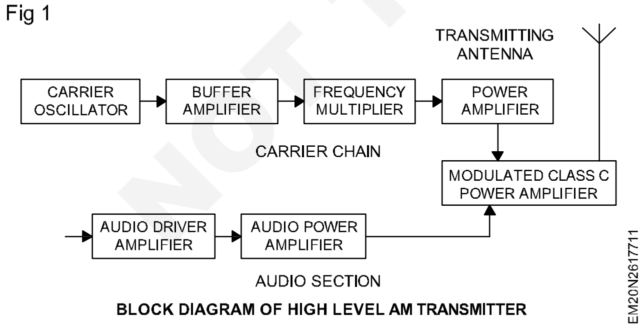
The choice between the two modulation schemes depends on the transmitting power of the AM transmitter. In broadcast transmitters, were the transmitting power may be of the order of kilowatts, high level modulation is employed. In low power transmitters, where only a few watts of transmitting power are required, low level modulation is used.

High level and low level transmitters

Below Fig 1 show the block diagram of high level and low level transmitters. The basic difference between the two transmitters is the power amplification of the carrier and modulating signals.

High level AM transmitter

Fig 1



BLOCK DIAGRAM OF HIGH LEVEL AM TRANSMITTER

Figure (1) is drawn for audio transmission. In high level transmission, the powers of the carrier and modulating signals are amplified before applying them to the modulator stage, as shown in Fig 1. In low level modulation, the powers of the two input signals of the modulator stage are not amplified.

The various sections of the figure(1) are:

- Carrier oscillator
- Buffer amplifier
- Frequency multiplier
- Power amplifier
- Audio section
- Modulated class C power amplifier

Carrier oscillator

The carrier oscillator generates the carrier signals, which lies in the RF range. The frequency of the carrier is always very high. Because it is very difficult to generate high frequencies with good frequency stability, the carrier oscillator generates a sub multiple with the required carrier frequency. This sub multiple frequency is multiplied by the frequency multiplier stage to get the required carrier frequency. Further, a crystal oscillator can be used in this stage to generate a low frequency carrier with the best frequency stability. The frequency multiplier stage then increases the frequency of the carrier to its required value.

Buffer amplifier

The purpose of the buffer amplifier is to first matches the output impedance of the carrier oscillator with the input impedance of the frequency multiplier, the next stage of the carrier oscillator. It then isolates the carrier oscillator and frequency multiplier.

This is required so that the multiplier does not draw a large current from the carrier oscillator. If this occurs, the frequency of the carrier oscillator will not remain stable.

Frequency multiplier

The submultiples frequency of the carrier signal, generated by the carrier oscillator, is now applied to the frequency multiplier through the buffer amplifier. This stage is also known as harmonic generator.

The frequency multiplier generates higher harmonics of carrier oscillator frequency. The frequency multiplier is a tuned circuit that can be tuned to the requisite carrier frequency that is to be transmitted. Power amplifier

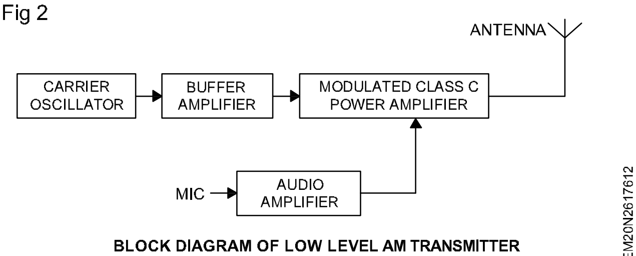
The power of the carrier signals is then amplified in the power amplifier stage. This is the basic requirement of a high level transmitter. A class C power amplifier gives high power current pulses of the carrier signal at its output.

Audio section

The audio signal to be transmitted is obtained from the microphone, as shown in Fig 1. The audio driver amplifiers the voltage of this signal. The amplification is necessary to drive the audio power amplifier. Next, a class A or a class B power amplifier amplifies the power of the audio signal.

Low level AM transmitter

Fig 2



BLOCK DIAGRAM OF LOW LEVEL AM TRANSMITTER

The low level AM transmitter shown in the Fig 2 is similar to a high level transmitter, except that the powers of the carrier and audio signals are not amplified. These two signals are directly applied to the modulated class C power amplifier.

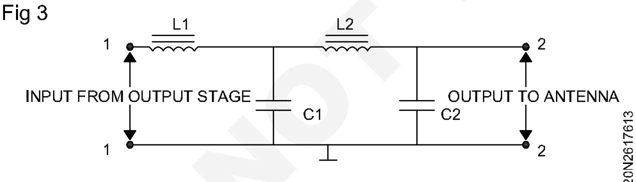
Modulation takes place at the stage, and the power of the modulated signal is amplified to the required transmitting power level. The transmitting antenna then transmits the signal.

Coupling of output stage and antenna

The output stage of the modulated class C power amplifier feeds the signal to the transmitting antenna. To transfer maximum power from the output stage to the antenna it is necessary that the impedance of the two sections match. For this, a matching network is required. The matching between the two should be perfect at all transmitting frequencies. As the matching is required at different frequencies, inductors and capacitors offering different impedance at different frequencies are used in the matching networks.

The matching network must be constructed using these passive components. This is shown in Fig 3

Fig 3



DOUBLE PI MATCHING NETWORK

The matching network used for coupling the output stage of the transmitter and the antenna is called double TT network. This network I consists of two inductors. L1 and L2 and two capacitors, C1 and C2. The values of these components are chosen such that the input impedance of the network between 1 and 1. Shown in figure (3) is matched with the output impedance of the output stage of the transmitter. Further, the output impedance of the network is matched with the impedance of the antenna.

The double TT matching network also filters unwanted frequency components appearing at the output of the last stage of the transmitter. The output of the modulated class C power amplifier may contain higher harmonics, such as second and third harmonics, that are highly undesirable. The frequency response of the matching network is set such that these unwanted higher harmonics are totally suppressed, and only the desired signal is coupled to the antenna.

FM transmitter (Fig 4)

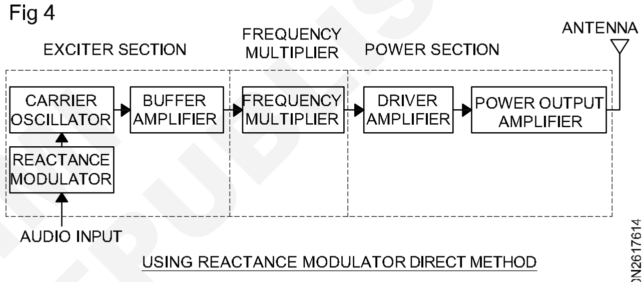
The FM transmitter has three basic sections

1 The exciter section contains the carrier oscillator, reactance modulator and the buffer amplifier

2 The frequency multiplier section, which features several frequency multipliers.

3 The power output section, which includes a low level power amplifier, the final power amplifier, and the impedance matching network to properly load the power section with the antenna impedance.

Fig 4



FM TRANSMITTER

The essential function of each circuit in the FM transmitter may be described as follows.

The exciter

1 The function of the carrier oscillator is to generate a stable sine wave signal at the rest frequency, when no modulation is applied. It must be able to linearly change frequency when fully modulated, with no measurable change in amplitude.

2 The buffer amplifier acts as a constant high impedance load on the oscillator to help stabilize the oscillator frequency. The buffer amplifier may have a small gain.

3 The modulator acts change the carrier oscillator frequency by application of the message signal. The positive peak of the message signal generally lowers the oscillator's frequency to a point below the rest frequency, and the negative message peak raises the oscillator frequency to a value above the rest frequency. The greater the peak to peak message signal, the larger the oscillator deviation.

Frequency multiplier

Frequency multipliers are tuned input, tuned output RF amplifiers in which the output resonant circuit is tuned to a multiple of the input frequency. Common frequency multipliers are 2x, 3x and 4x multiplication. A 5x frequency multiplier is sometimes seen, but its extreme low efficiency forbids widespread usage. Note that multiplication is by whole numbers only.

Power output section

The final power section develops the carrier power, to be transmitted and often has a low power amplifier driven the final power amplifier.

The impedance matching network is the same as for the AM transmitter and matches the antenna impedance to the correct load on the final over amplifier.

Frequency Multiplier

A special form of class C amplifier is the frequency multiplier. Any class C amplifier is capable of performing frequency multiplication.

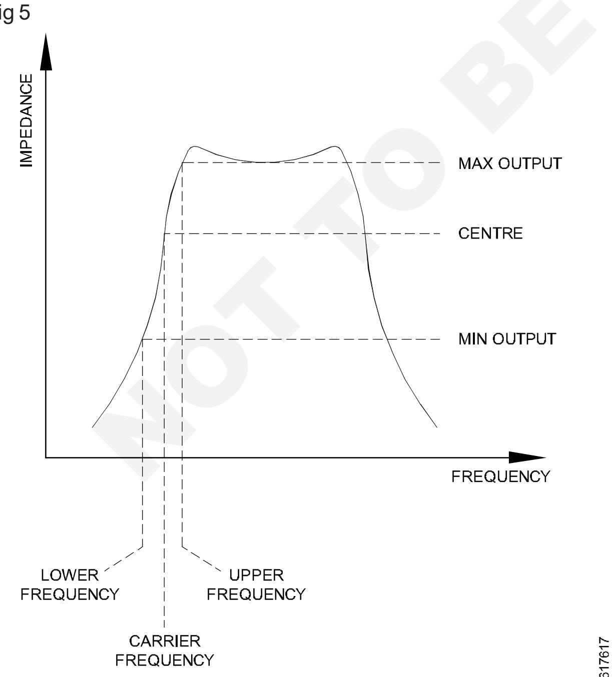
For example a frequency double can be constructed by simply connecting a parallel tuned circuit in the collector of a class C amplifier that resonates at twice the input frequency when the collector current pulse occurs, it excites or rings the tuned circuit at twice the input frequency.

Slope FM detector (Fig 5)

The very simplest from of FM demodulation is known as slope detection or demodulation. It consists of a tuned circuit that is tuned to a frequency slightly offset from the carrier of the signal.

As the frequency of the signals varies up and down in frequency according to its modulation, so the signal moves up and down the slope of the tuned circuit. This causes the amplitude of the signal to vary in t line with the frequency variations. In fact at this point the signal has both frequency and amplitude variations.

Fig 5



FM SLOPE DETECTION CONCEPT

It can be seen from the diagram that changes in the slope of the filter, reflect into the linearity of the demodulation process. The linearity is very dependent not only on the filter slope as it falls away, but also the tuning of the receiver - it is necessary to tune the receiver off frequency and to a point where the filter characteristic is relatively linear.

The final stage in the process is to demodulate the amplitude modulation and this can be achieved using a simple diode circuit. One of the most obvious disadvantages of this simple approach is the fact that both amplitude and frequency variations in the incoming signal appear at the output. However the amplitude variations can be removed by placing a limiter before the detector.

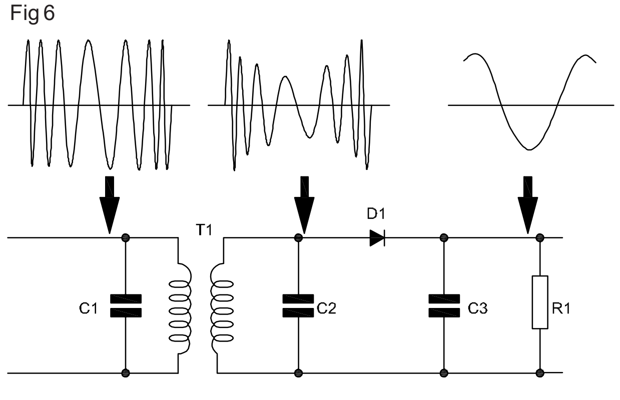
A variety of FM slope detector circuits may be used, but the one below shows one possible circuit with the applicable wave forms. The input signal is a frequency modulated signal. It is applied to the tuned transformer (T1, C1, C2 combination) which is offset from the centre carrier frequency. This converts the incoming signal from just FM to one that has amplitude modulation superimposed upon the signal.

This amplitude signal is applied to a simple diode detector circuit. D1, Here the diode provides the rectification, while C3 removes any unwanted high frequency components, and R1 provides a load

FM slope detection advantages & disadvantages

FM slope detection is not widely used, and yet it has some limited applications. Knowing the advantages and disadvantages enables the technique to be used where applicable. (Fig 6)

Fig 6

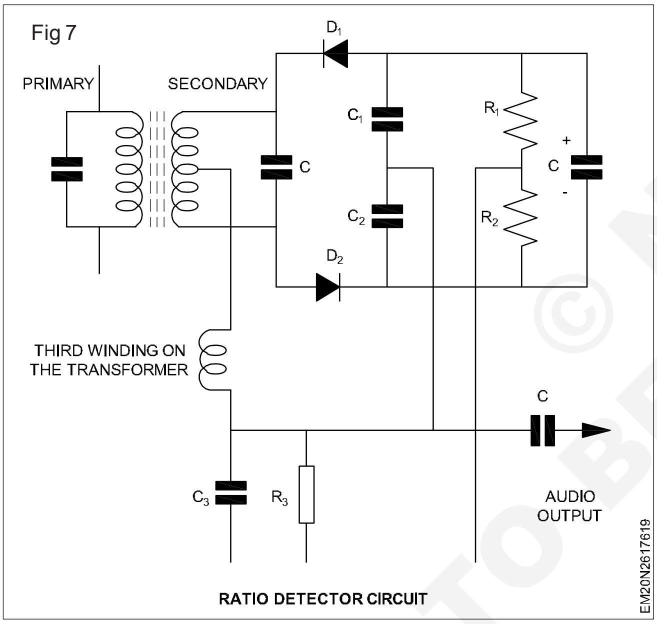


FM SLOPE DETECTOR CIRCUIT SHOWING WAVEFORMS

Advantages	Disadvantages
Simple - can be used to provide of FM demodulation when only an AM detector is present Enable FM to be detected without any additional circuitry	Not linear as the output is dependent upon the curve a filter Not particularly effective as it relies on centering the signal part of the way down the filter curve where signal strengths are less. Both frequency and amplitude variations are accepted and therefore much higher levels of noise and interference are experienced

Ratio detector

When circuits employing discrete components were more widely used, the Ratio and Foster - seeley detectors were widely used. Of these the ratio detector was the most popular as it offers a better level of amplitude modulation rejection of amplitude modulation. This enables it to provide a greater level of noise immunity as most is amplitude noise, and it also enables the circuit to operate satisfactorily with lower levels of limiting in the preceding IF stages of the receiver. (Fig 7)



The operation of the ratio detector centres around a frequency sensitive phase shift network with a transformer and the diodes that are effectively in series with one another. When a steady carrier is applied to the circuit the diodes act to produce a steady voltage across the resistors R1 and R2, and the capacitor C3 charges up as a result.

The transformer enables the circuit to detect changes in the frequency of the incoming signal. It has three windings. The primary and secondary act in the normal way to produce a signal at the output. The third winding is un-tuned and the coupling between the primary and the third winding is very tight, and this means that the phasing between signals in these two windings is the same.

The primary and secondary windings are tuned and lightly coupled. This means that there is a phase difference of 90 degrees between the signals in these windings at the centre frequency. If the signal moves away from the centre frequency the phase difference will change. In turn the phase difference between the secondary and third windings also varies. When this occurs the voltage will subtract from one side of the secondary and add to the other causing an imbalance across the resistors R1 and R2. As a result this causes a current to flow in the third winding and the modulation to appear at the output.

The capacitors C1 and C2 filter any remaining RF signal which may appear across the resistors. The capacitor C4 and R3 also act as filters ensuring no RF reaches the audio section of the receiver.

Ratio detector advantages & disadvantages

As with any circuit there are a number of advantages and disadvantages to be considered when choosing between several options.

Advantages	Disadvantages
Simple to construct using discrete components	High cost of transformer
Offers good level of performance and	Typically lends itself to use in only circuits using discrete components and not integrated within an IC

Type of radio receivers, superheterodyne receiver, block diagram, principles, characteristics, advantages and disadvantages

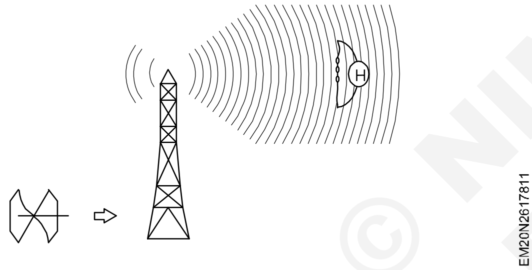
Objectives : At the end of this lesson you shall be able to
- **explain the basic principles and characteristics of radio reception.**
- **list the different types of radio receivers.**
- **explain the advantages and disadvantages of different types of radio receiver.**
- **sketch the blocks of Superheterodyne radio receiver.**

Principle of radio receivers

The modulated wave emitted from a transmitting antenna in the form of electromagnetic waves(energy) travels in free space at the speed of light ($3x10^8$ meters/sec). The distance of electromagnetic waves travel depends upon the chosen type of transmitting antenna and the transmitted power.

As shown in Fig 1, if a wire is suspended above the ground in the region where the electromagnetic waves are traveling. The passing electromagnetic waves induces a small voltage in the wire.

Fig 1



Although the induced voltage in the suspended wire is very small, of the order of microvolts, the wave-form of the induced voltage is an exact replica of the signal transmitted by the transmitting antenna. Thus the suspended wire acts as a receiving antenna.

If the received weak signal, at the receiving antenna is processed, the information (voice and music etc.) which modulates the carrier at the transmitter can be reproduced.

Selecting required electromagnetic waves (signal)

Since several transmitting antennas of several stations transmit information(voice and music etc.) simultaneously into air, the electromagnetic waves of several stations simultaneously exist in free space. All these electromagnetic waves corresponding to several stations intercept(cut) the receiving antenna at the same time. Each of these simultaneously induces voltages in the receiving antenna as shown in Fig 2. Hence, the receiving antenna or the aerial will have signal voltages corresponding to several transmitting stations as shown in Fig 2.

The first job of a radio receiver is to select a particular station signal in which we are interested and reject the rest of signals. This can be done easily using a tuned circuit as shown in Fig 3a.

Fig 2

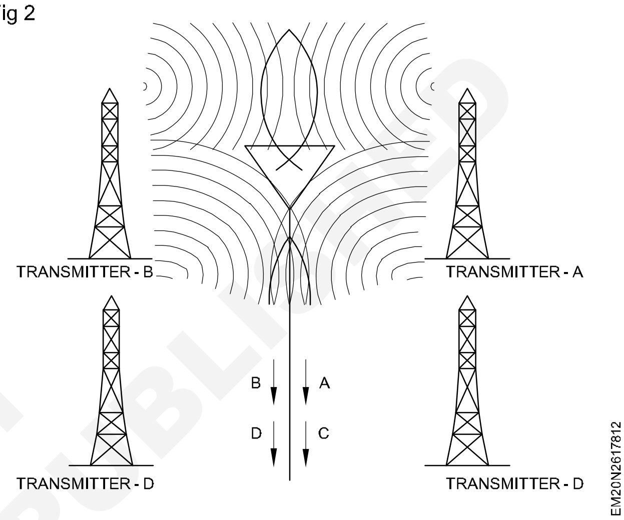
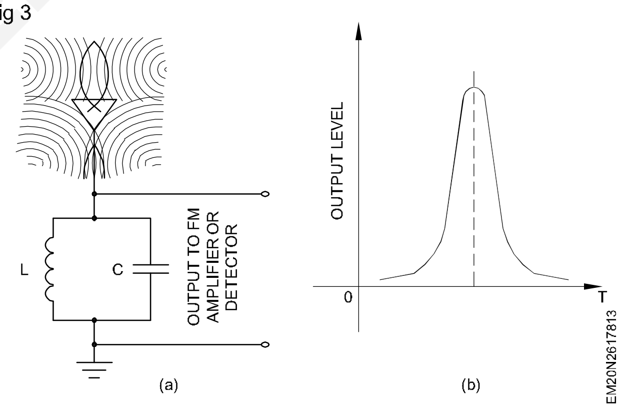


Fig 3



As already discussed in previous units, the frequency response of the parallel tuned circuit in Fig 3a will be as shown in Fig 3b. How good is this parallel tuned circuit, in selecting a particular frequency signal is termed as the selectivity of the circuit. This selectivity of the tuned circuit in a receiver decides whether or not the receiver suffers from interference of unwanted stations.

AM receiver and frequency bands

AM broadcasting is restricted to the following frequency bands;

Medium wave (MW) band 530KHz to 1650KHz

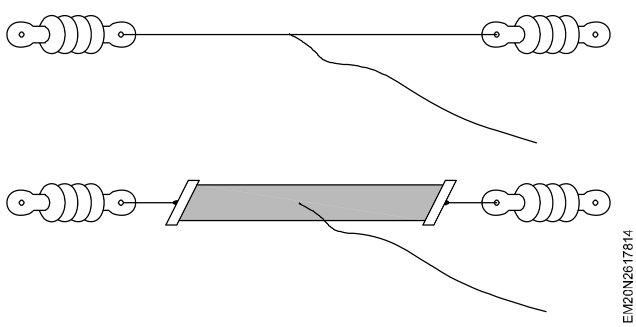
Short wave(SW)band 3MHz to 26 MHz

Broadcasting stations, transmitting amplitude modulated(AM) MW band signals rely on ground waves for propagation. The SW band AM transmitters on the other hand rely both on ground waves and sky waves for propagation. hence, the distance covered by MW stations is much less than that of SW stations.

The receiving antenna of AM receivers

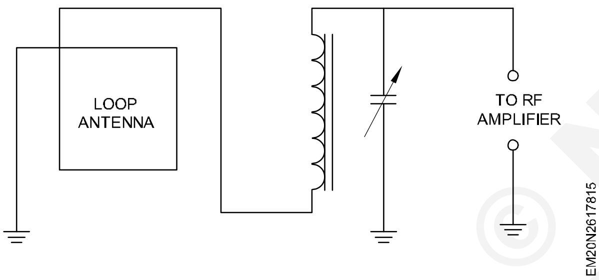
In earlier days a lengthy copper wire or a lengthy copper tape made of a thin copper wire mesh as shown in Fig 4 were used as receiving antennas.

Fig 4



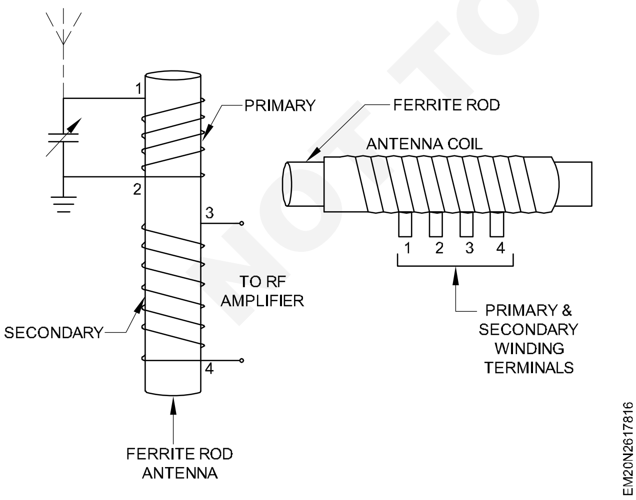
Due to the large space occupied by these antennas, a loop antenna couple to an antenna transformer as shown in Fig 5 is used.

Fig 5



The ferrite rod antenna is shown in fig 6. This antenna with ferrite, having an extremely high permeability has excellent pick-up/receiving characteristics.

Fig 6



The antenna transformer used to couple the selected signal to the next stage is often referred to as antenna coil rather than antenna transformer. The primary winding of the antenna coil (antenna transformer) isolates the antenna side from the tuned circuit and provides proper impedance matching to the antenna.

Generally ferrite core antenna coil is wound on insulating material such as paper or plastic. The gauge of wire used and the number of turns used for the antenna coils designed to receive MW band station and the SW band station differ.

Types of radio receivers

There are mainly 4 types of radio receivers .they are listed as follows

1 Basic crystal Radio Receiver.

2 T.R.F.RadioReceiver.

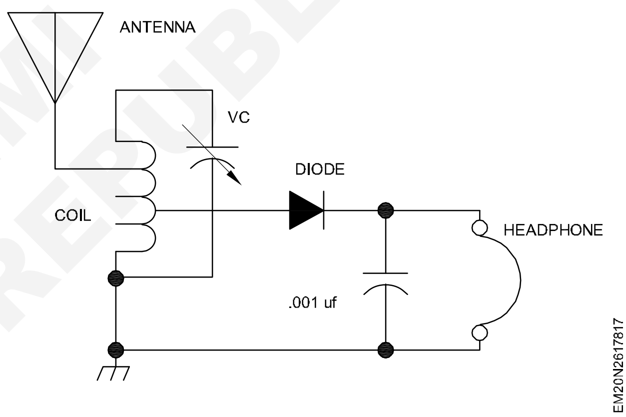
3 Reflex radio Receiver

4 Superheterodyne Radio Receiver.

1 Basic crystal Radio Receiver

Here is the schematic diagram for a very basic crystal radio set Fig 7. This basic radio uses no power other than that provided by the transmitting antenna from the radio station.

Fig 7



This circuit consists of an inductor (also called a coil), a variable capacitor (used to be called a variable condenser), a germanium diode (formerly called a crystal), a filtering capacitor and finally very high impedance headphones.

The inductor has taps on it one to connect the antenna and other to connect the detector diode.

The variable capacitor is usually connected across the whole of the inductor to form a tuned circuit for our crystal radio set.

Earth connection for crystal radio set

For the crystal radio set circuit to perform at all well you need a very good earth connection.

The symbol connected to the top of the inductor or coil and variable capacitor denotes an antenna. The higher and longer (50' or 17 meter s) this antenna is, the better the likely reception.

Radio signals (waves) such as we encounter in the AM radio band have two halves. One half travels across the surface of the earth at the speed of light through people, buildings and other objects. The other half, a mirror image, travels beneath the surface of the earth. This radio wave has a definite length. Its length is the speed of light divided by the frequency. These radio waves we want to detect with our crystal radio set.

Variable Capacitor: .A capacitor which tuned about 15 pF to 365 pF.

Inductor or Coil: Here an air core inductor wound on some suitable non metallic form.

Diode: In lieu of the old crystal detector we use a germanium diode of the 1N34 or OA90 type.

Fixed Capacitor: This is for filtering and may be 0.001 μF, 1 nF or 1000 pF type (all those values are the same - just expressed in different units).

Headphones: This is by far the hardest part to obtain. The type used for hi-fi will network here. Ideally you need high impedance 2,000 ohm types, but these are nearly impossible to find. You can sometimes buy 1,000 ohm crystal earpieces. The headphone is a high impedance load for the crystal set and as we are working on free power from the air we can't load it down. The power is not available. Remember we're using free power from the sky.

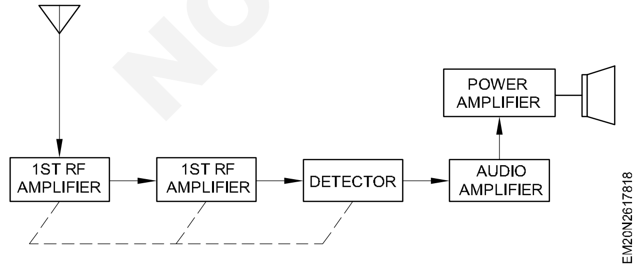
Frequency range: The frequency range of a set like this is mainly determined by the square root of the ratio of Maximum Capacitance to Minimum Capacitance of the variable capacitor.

A.M. Radio band: This would cover about 530 KHz to about 1650 KHz. This is slightly more than a 3:1 ratio.

2. T.R.F. Receiver

A tuned radio frequency receiver (or TRF receiver) is a type of radio receiver that is composed of one or more tuned radio frequency (RF) amplifier stages followed by a detector (demodulator) circuit to extract the audio signal and usually an audio frequency amplifier. This type of receiver was popular in the 1920s. Early examples could be tedious to operate because when tuning in a station each stage had to be individually adjusted to the station's frequency, but later models had ganged tuning, the tuning mechanisms of all stages being linked together, and operated by just one control knob as shown in the block diagram (fig 8).

Fig 8



By the mid 1930s it was replaced by the superheterodyne receiver .

Limitations in the crystal receiver can be largely overcome by what are known as TRF receivers. This type of receiver essentially consists of a chain of radio frequency amplifiers which improves the selectivity and test sensitivity of the radio receiver.

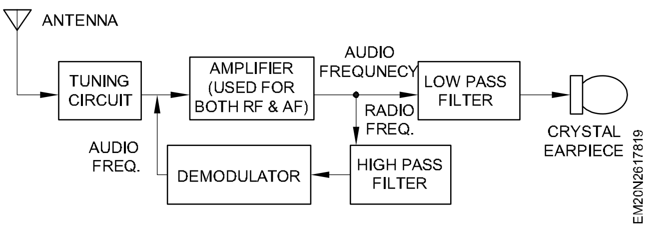
- The selectivity is improved over that of simple crystal receiver .The selectivity is improved because we have introduced a stage of RF amplification before the detector circuit.
- Although theoretically it is possible to further improve the sensitivity of the receiver by adding additional RF amplifier stages. In practice several problems and difficulties arise if the number of RF amplifier stages are more. Some of these difficulties are listed below;
- Because of the instability problem, the number of RF stages that can be used is limited. It is practically impossible to build a very high gain RF amplifier merely by connecting several stages together. Each stage is obviously operating at the same frequency and it is very easy to have positive feedback from the latter stages to the input. Even though the voltage feedback may very small, because of a high gain of the amplifier stages, conditions for self-oscillation are almost always present. Therefore the amplifier may turn around and work as an oscillator.
- The other problem is to do with tracking. Every stage has its own tuned circuit and it is necessary to vary resonant frequency of each tuned circuit in such a way that all tuned circuit have the same resonant frequency. Apart from the practical difficulty of obtaining ganged capacitor with many sections, the inevitable stray capacitance in the various parts of the circuit upset the matching of each stage.
- The next problem has to do with the fidelity of the final audio output. Although additional tune circuits improve the selectivity and results in excellent sensitivity, the overall response becomes very sharp. It is as though a single tuned circuit with an extremely high Q value is being used. In order to receive the transmitted program information, a receiver which can respond not only to the carrier but also to the side bands is required. As the receiver becomes more and more selective, the side bands get eliminated increasingly. Therefore, the audio frequency response becomes restricted.
- Although the above drawbacks severely limit the use of TRF-receivers these receivers are used in some applications in which the radio receiver is expected to receive only a few station and is used sparingly.

3 Reflectional receiver

A reflectional radio receiver (Fig 9) (also called a reflex radio) is a radio receiver in which the same amplifier is used for both the high-frequency radio (RF) and low-frequency sound (AF) signals. The radio signal from the output of the amplifier passes detection and then re-enters the input of the amplifier. During the second pass, the sound frequency is amplified then passed to the earphone. The German company Telefunken applied the German patent 293300 in the year 1913 for the reflex receiver.

Reflectional radio receivers were used because fewer amplifier devices are needed. They also consume less electricity than a receiver designed with two separate amplifiers.

Fig 9



However, this design is less stable, with the possibility of breaking into unwanted oscillation. A greater level of skill and experience is needed to debug the assembled device before it starts working. For a reflex circuit to work properly, bypassing and filtering are major considerations also.

It is important to ensure that the signal is at all time entirely operating within the linear range of the amplifier, or else inter-modulation (IM) will occur. It is difficult to judge when minor amounts of non-linearity occur in an amplifier. A reflex circuit will immediately produce severe distortion and possible oscillation as soon as the signal exceeds the linear range of the active component's curves. As this is the circumstance where the active device begins to work as a detector, which means it is mixing signal with the AF being fed back to amplify. This adds considerable difficulty to the making of a circuit which is dependably free of problems for all signals available.

4. Superheterodyne Receiver (Fig 10)

Edwin Armstrong the US Engineer invented the superhet or superheterodyne receiver as we know it today with a fixed frequency, intermediate frequency, filter and a variable local oscillator. His idea was developed in 1918.

The superheterodyne receiver revolves around the process of mixing. Here RF mixers are used. (This is not the same as mixers used in audio desks where the signals are added together).

When two signals are beating together it is found that the output contains signals at frequencies other than the two input frequencies. New signals are seen at frequencies that are the sum and difference of the two input signals, i.e. if the two input frequencies are f1 and f2, then new signals are seen at frequencies of (f1+f2) and (f1-f2).

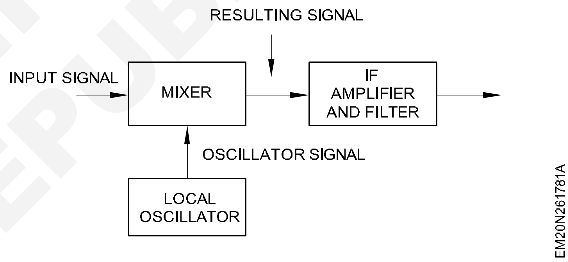
To take an example, if two signals, one at a frequency of 600 KHz and another at a frequency of 1055KHz are mixed together then new signals at frequencies of 455KHzand1655KHz are generated.

Design and principle of operation

In the superhet radio, the received signal enters one inputs of the mixer. A locally generated signal (local oscillator signal) is fed into the other. The result is that new signals are generated. These are applied to a fixed frequency intermediate frequency (IF) amplifier and filter. Any signals that are converted down and then fall within the pass-band of the IF amplifier will be amplified and passed on to the next stages. Those that fall outside the pass-band of the IF are rejected. Tuning is accomplished very simply by varying the frequency of the local oscillator.

The advantage of this process is that very selective fixed frequency filters can be used. They are normally at a lower frequency than the incoming signal. This enables their performance to be better and less costly.

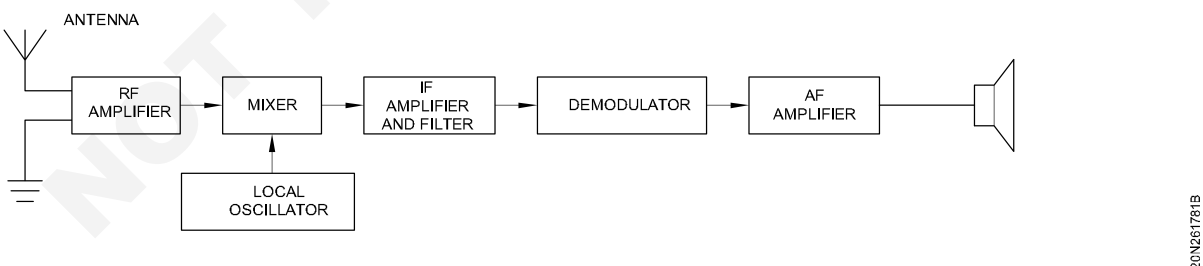
Fig 10



Basic superheterodyne block diagram and functionality

The basic block diagram of a basic superhet receiver is shown below in Fig 11. This details the most basic form of the receiver and serves to illustrate the basic blocks and their function.

Fig 11



BLOCK DIAGRAM OF SUPERHETERODYNE RADIO RECEIVER

- The way in which the receiver works can be seen by following the signal as it passes through the receiver.
- Front end amplifier and tuning block: Signals enter the front end circuitry from the antenna.

This block performs two main functions:

- **Tuning:** The tuning is applied to the RF stage. The purpose of this is to reject the signals on the image frequency and accept those on the wanted frequency. It must also be able to track the local oscillator so that as the receiver is tuned, so the RF tuning remains on the required frequency. Typically the selectivity provided at this stage is not high. Its main purpose is to reject signals on the image frequency which is at a frequency equal to RF + 2IF. As the tuning within this block provides all the rejection for the image response, it must be at a sufficiently sharp to reduce the image to an acceptable level. However the RF tuning may also help in preventing strong off-channel signals from entering the receiver and overloading elements of the receiver.

- **Amplification:** In terms of amplification, the level is carefully chosen so that it does not overload the mixer when strong signals are present, but enables the signals to be amplified sufficiently to ensure a good signal to noise ratio is achieved. The amplifier must also be a low noise design. Any noise introduced in this block will be amplified later in the receiver.
- **Mixer / frequency translator block:** The tuned and amplified signal then enters one port of the mixer. The local oscillator signal enters the other port. The performance of the mixer is crucial to many elements of the overall receiver performance. It should be as linear as possible. If not, then spurious signals will be generated and these may appear as 'phantom' (ghostly appearing) received signals.
- **Local oscillator:** The local oscillator may consist of a variable frequency oscillator that can be tuned by altering the setting on a variable capacitor. Alternatively it may be a frequency synthesizer that will enable greater levels of stability and setting accuracy.
- **Intermediate frequency amplifier, IF block:** Once the signals leave the mixer they enter the IF stages. These stages contain most of the amplification in the receiver as well as the filtering that enables signals on one frequency to be separated from those on the next. Filters may consist simply of LC tuned transformers providing inter-stage coupling, or they may be much higher performance ceramic or even crystal filters, dependent upon what is required. The criterion for choosing a suitable intermediate frequency is, the IF value should not coincide with the frequency of any powerful radio station (or its harmonics). With the above in mind the following IF values have been standardized by the Electronic industries association(EIA) for different types of receivers which are used throughout the world;

Types of receiver Broadcast band IF value

AM receivers 530 KHz to 25 MHz

FM receivers 88 KHz to 108 MHz

- Detector / demodulator stage: Once the signals have passed through the IF stages of the superheterodyne receiver, they need to be demodulated. Different demodulators are required for different types of transmission, and as a result some receivers may have a variety of demodulators that can be switched in to accommodate the different types of transmission that are to be encountered. Different demodulators used may include:
- AM diode detector, Synchronous AM detector (in AM receivers),Basic FM detector,PLL FM detector OR Quadrature FM detector(in FM receiver)
- Audio amplifier: The output from the demodulator is the recovered audio. This is passed into the audio stages where they are amplified and presented to the headphones or loudspeaker.

Image frequency interference

Assume two broadcasting stations are transmitting at two different frequencies say, 800 KHz and 1710 KHz respectively. suppose a receiver is tuned to station broadcasting at 800 KHz, then the local oscillator produces a frequency of 1255 KHz (800 KHz + 455 KHz =1255 KHz) for an IF of 455 KHz . suppose, an undesired station transmitting at 1710 KHz happens to reach the mixer input, then the local oscillator frequency of 1255 KHz, also can mix with this undesired signal of 1710 KHz and produces IF of 455 KHz (1710 KHz -1255KHz = 455 KHz). This results in two signals of 455 KHz reaching the IF stage for amplification.

Since the IF amplifiers amplify all signals in the frequency range of 455 KHz, both the station signals get amplified and are available for detection. When the signal are detected and further amplified by the audio amplifiers, the audio signal so produced will be a mix of the information broadcasted from the two stations. This causes confusion and unintelligible information. This phenomenon is called Image Frequency Interference. The unwanted frequency of 1710 KHz is called the image frequency. The effect of image frequency interference is shown in Fig 12

- Image frequency interference is one major disadvantage of superheterodyne receiver operation.
- The problem of image frequency interference, possibilities of minimizing it and its consequences are listed below;
- Image frequencies can be prevented by using highly selective RF amplifier circuits.
- However, inclusion of RF stage in commercial radio receivers will be quite expensive. Also high selectivity may result in chopping-off of a portion of the received side bands.
- By making the intermediate frequency (IF) value as high as possible such that the image frequencies are outside the RF band of the receiver.
- However, if the value of IF is very high than the selectivity will be such that, unwanted RF signal from an adjacent station will also be picked up resulting in an another type of interference . This is called adjacent channel interference. In addition, a high value of IF result in tracking difficulties. Hence the IF cannot be very high also.

Advantages and drawbacks of the superheterodyne design

An important advantage of superheterodyne receivers is that the intermediate-frequency amplifier does not need to be tuned, Regardless of the frequency of the incoming signal. For this reason, superheterodyne receivers are easy to tune. Only the input circuit, radio-frequency amplifier, and local oscillator needed to be tuned. Such tuning is usually carried out by means of a single control knob. Since the intermediate-frequency amplifier is not tunable, multicircuit electric filters can be readily used in it to provide high selectivity, and the required signal amplification can be easily obtained. Automatic frequency control and automatic gain control can also be incorporated without difficulty.

A disadvantage of superheterodyne receivers is the possibility of spurious responses due to frequency conversion. The image frequency and the frequency of the desired signal exhibit a mirror-like symmetry. Another example of a spurious response is the noise-produced signal distortions that appear as whistles. Methods of minimizing spurious responses include increasing the radio-frequency selectivity of the receiver and choosing an intermediate frequency that is outside the frequency range of the desired incoming signals.

Fig 12

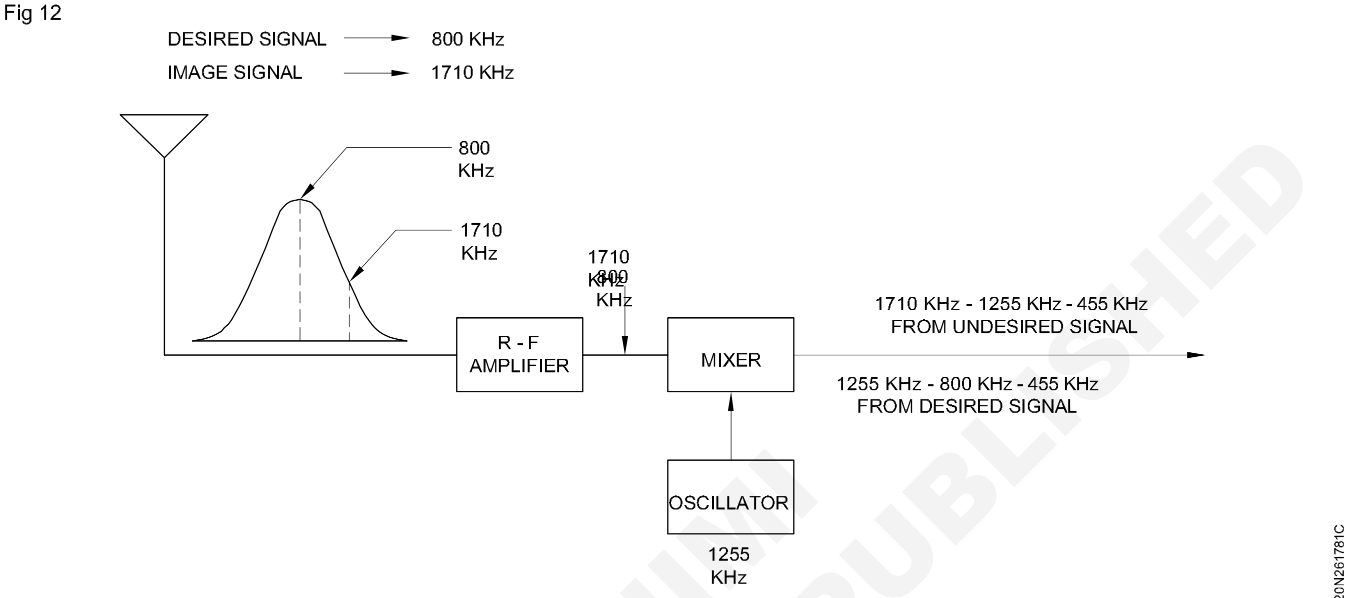


IMAGE FREQUENCY INTERFERENCE

Block diagram of FM Receivers, AM/FM-RF Alignment

Objectives : At the end of this lesson you shall be able to
- **sketch the block of FM receiver**
- **explain the function of limiter circuit in FM receiver**
- **explain the working of discriminator circuit**
- **explain the advantage of radio detector over discriminator**
- **explain the with circuit detector the working of radio detector**
- **explain the IF alignment and RF alignment in receiver.**

FM Receiver

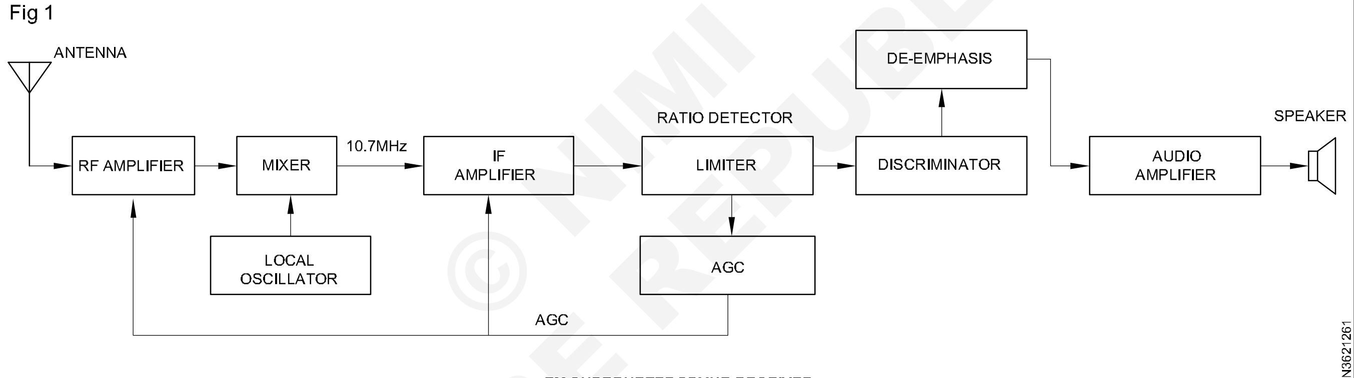
The block diagram of an FM superheterodyne receiver is shown in Fig 1

A typical FM receiver block diagram shown in Fig 1 is quite similar to that of AM receiver. The RF amplifier amplifies the received signal intercepted by the antenna. The amplified signal is then applied to the mixer stage. The second input of the mixer comes from the local oscillator. The two input frequencies of the mixer generate an IF signal of 10.7 MHz. This signal is then amplified by the IF amplifier. The output of the IF amplifier is applied to the limiter circuit. The limiter removes the noise in the received signal and gives a constant amplitude signal.

This circuit is required when a phase discriminator is used to demodulate an FM signal.

The output of the limiter is now applied to the FM discriminator or detector, which recovers the modulating signal.

Fig 1



FM SUPERHETERODYNE RECEIVER

However, this signal is still not the original modulating signal. Before applying it to the audio amplifier stages, it is deemphasized. De-emphasizing attenuates the higher frequencies to bring them back to their original amplitudes as these are boosted or emphasized before transmission.

The output of the deemphasized stage is the audio signal, which is then applied to the audio stages and finally to the speaker.

It should be noted that a limiter circuit is required with the FM discriminators. If the demodulator stage uses a ratio detector instead of the discriminator, then a limiter is not required. This is because the ratio detector limits the amplitude of the received signal.

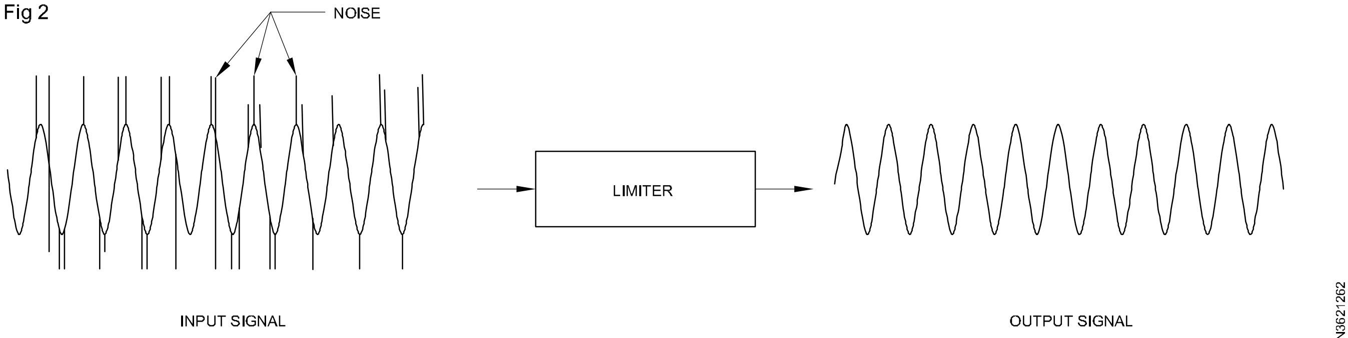
In FM receivers, generally, AGC is not required because the amplitude of the carrier is kept constant by the limiter circuit. Therefore, the input to the audio stages controls amplitudes and there are no erratic changes in the volume level. However, AGC may be provided using an AGC detector. This generates a dc voltage to control the gains of the RF and IF amplifier.

However, notice that a limiter stage appears between the IF stage and the detector stage. This is one way an FM receiver can reject noise. Fig 2 shows what happens in a limiter stage.

In the limiter shown in Fig 2 the input signal is very noisy. The output signal is noise -free. By limiting or by amplitude clipping, all the noise spikes have been eliminated. Some FM receivers uses two stages of limiting to eliminate most noise interference.

Limiting cannot be used in a AM receiver because the amplitude variations carry the information to the detector. In FM reception, the frequency variations contain the information. Amplitude clipping in a FM receiver will remove just the noise but does not remove the information.

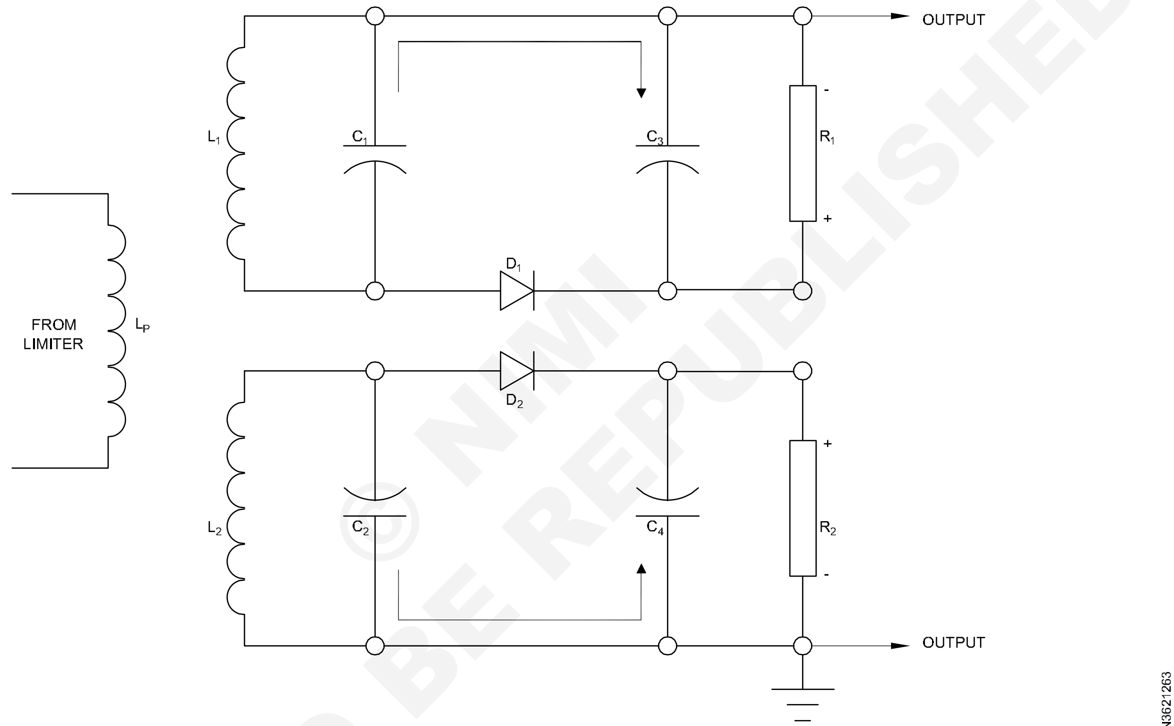
Fig 2



OPERATION OF A LIMITER

Detection in FM is more complicated than in AM. Since FM contains several side bands above and below the carrier, a signal nonlinear detector (such as a diode) will not demodulate the signal. To detect a FM signal needs a double tuned discriminator circuit shown in Fig 3.

Fig 3

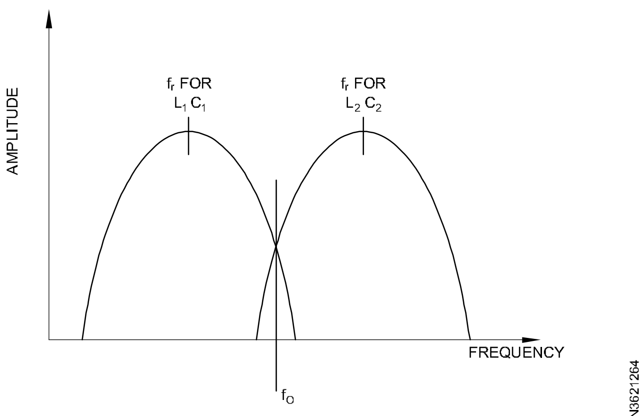


DISCRIMINATOR

The discriminator circuit shown in Fig 3 can serve as an FM detector. The discriminator works by having two resonant points. One is above the carrier frequency, and one is below the carrier frequency.

In the discriminator circuit shown in Fig 3, when the carrier is unmodulated, D1 and D2 will conduct an equal amount. This is because the circuit is operating where the frequency response curves cross . The amplitude is equal for both tuned circuits at this point. The current through R1 will be equal to the current through R2. If R1 are equal in resistance, the voltage drops will also be equal. Since the two voltages are series-opposing, the output voltage will be zero. This means , carrier is at rest(no modulation), the discriminator output is zero. The frequency response curves of this discriminator is shown in Fig 4.

Fig 4



DISCRIMINATOR RESPONSE CURVES

In the frequency response curves for the discriminator circuit, f_o represents the correct point on the curves for the carrier. In a FM receiver, the station's carrier frequency will be heterodyned to f_o. This represents a frequency of 10.7 MHz for broadcast FM receivers. The heterodyning process allows one discriminator circuit to demodulate any signal over the entire commercial FM band.

Suppose the carrier shifts higher in frequency because of modulation, this will increase the amplitude of the signal in L_2C_2 and decrease the amplitude in L_1C_1. Hence there will be more voltage across R_2, and less across R_1. Thus the output of the discriminator goes positive.

On the other hand when the carrier shifts below f_o, the signal is closer to the resonant point of L_1C_1. More voltage will drop across R_1, and less across R_2. Hence, the output goes negative.

The output from the discriminator circuit will be,

- zero when the carrier is at rest,
- positive when the carrier moves higher in frequency, and
- negative when the carrier moves lower in frequency.

Thus the output of the discriminator is a function of the carrier frequency.

Automatic frequency control

The output of the discriminator can also be used to correct any drift in the receiver oscillator frequency. FM detector feeds a signal to the audio amplifier and to a stage marked AFC. AFC stand for automatic frequency control. If the oscillator output frequency happens to change for some reason, then, f_o will not exactly be 10.7 MHz. There will be a steady DC output voltage from the discriminator. This DC voltage can be used as a control voltage to change the oscillator frequency automatically and set it back to 10.7 MHz.

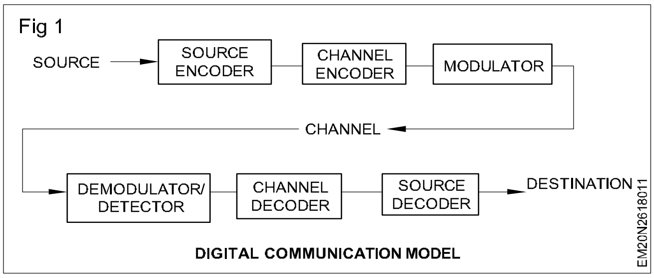
The discriminator circuit discussed above work fairly well; but they are sensitive to amplitude changes. This is why one or two limiters are needed for noise free reception. An improved method of FM detection is by using the ratio detector instead of the discriminator. Ratio detectors are not very sensitive to the amplitude of the signal. This makes it possible to build receivers without limiters and still provide good noise rejection. FM detector circuits used in FM receivers are generally used in conjunction with integrated circuits(IC's).They usually have the advantage of requiring no alignment or only one adjustment whereas alignment for discriminators and ratio detectors is more time-consuming.

Digital modulation and demodulation techniques, sampling, quantization, encoding

Objectives : At the end of this lesson you shall be able to
- **explain the principle of digital communication**
- **list the fundamental techniques of digital modulation and demodulation**
- **explain the term of sampling**
- **explain the meaning of quantization**
- **describe the terms of encoding.**

Digital communication is the physical transfer of data in terms of a digital bit stream or a digitized analog signal over a point-to-point or point-to-multipoint communication channel. (Fig 1)

Fig 1

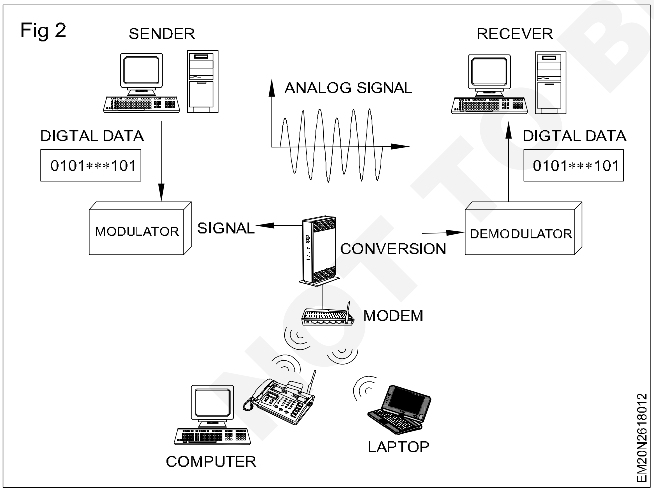


DIGITAL COMMUNICATION MODEL

The messages are either represented by a sequence of pulses by means of a line code (baseband transmission), or by a limited set of continuously varying wave forms (pass-band transmission), using a digital modulation method.

The pass-band modulation and corresponding demodulation (also known as detection) is carried out by modem equipment. (Fig 2)

Fig 2



According to the most common definition of digital signal, both baseband and pass-band signals representing bit-streams are considered as digital transmission, while an alternative definition only considers the baseband signal as digital, and pass-band transmission of digital data as a form of digital-to-analog conversion.

In case of digital transmission, the message signal is transmitted in the form of 0's and 1's. If the signal is digital, it is transmitted directly through the physical wires and if the signal is analog, it is first converted to digital form using PCM and then transmitted through physical wires like coaxial cable or optical fibers.

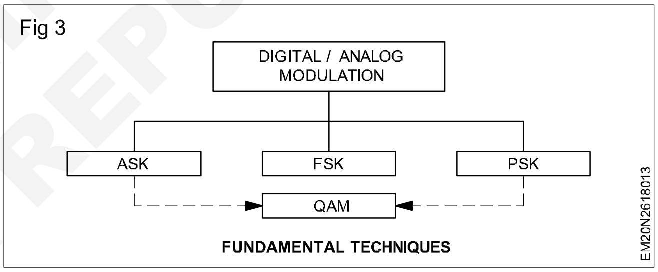
In digital modulation, an analog carrier signal is modulated by a discrete signal.

Digital modulation methods can be considered as digital-to-analog conversion, and the corresponding demodulation as analog-to-digital conversion.

Fundamental Techniques

The most fundamental digital modulation techniques are based on keying: (Fig 3)

Fig 3

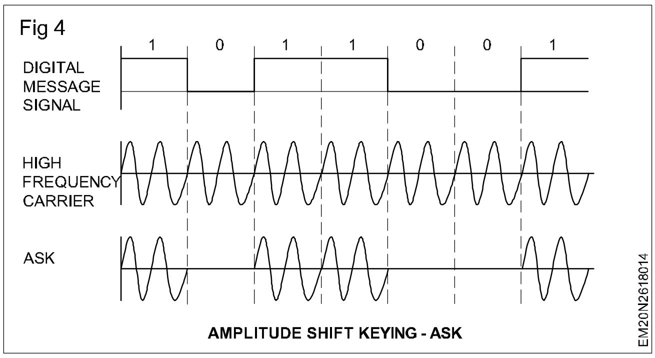


FUNDAMENTAL TECHNIQUES

- ASK (Amplitude-Shift Keying): A finite number of amplitudes are used.
- FSK (Frequency-Shift Keying): A finite number of frequencies are used.
- PSK (Phase-Shift Keying): A finite number of phases are used
- QAM (Quadrature Amplitude Modulation): A finite number of at least two phases and at least two amplitudes are used.

Amplitude Shift Keying - ASK

Amplitude shift keying (ASK) is a digital modulation process, in which digital message signal is modulated with the high frequency carrier. The amplitude of the carrier is changed according to the message signal. It is similar to AM When input = high i.e. at logic 1, output's amplitude is same as high frequency carrier's amplitude. When input = low i.e. at logic 0, output is 0. Hence the information of the message signal is contained in the amplitude of the carrier signal i.e. if input is 1, carrier is on and if input is 0. carrier is off. Therefore, it is also known as On Off keying. (Fig 4)



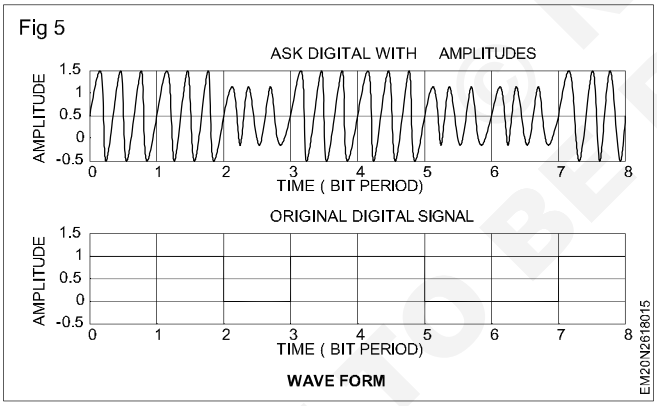
AMPLITUDE SHIFT KEYING - ASK

ASK demodulation

Demodulation is the process of recovering the original message signal from the modulated signal .i.e., the reverse process of modulation. It is also known as Detection. An Ideal demodulator should produce an output as same as the original message signal before modulation.

But practically it is not possible, due the presence of noise (like Gaussian noise, white noise, short noise, etc...), hence, deviations occur after demodulation, this is known as Distortion.

The ASK demodulator, which is designed specifically for the symbol-set used by the modulator, the presence or absence of a sinusoid in a given time interval needs to be determined the amplitude of the received signal and maps it back to the symbol it represents, thus recovering the original data. Frequency and phase of the carrier are kept constant. (Fig 5)



WAVE FORM

Advantages of Amplitude-shift keying (ASK)

The main advantage of ASK modulation is generation of ASK is very much easy. Both ASK modulation and demodulation processes are relatively inexpensive. The ASK technique is also commonly used to transmit digital data over optical fiber. There are many other advantages of ASK, Such as Amplitude-shift keying transmitters are very simple and transmitter current is low.

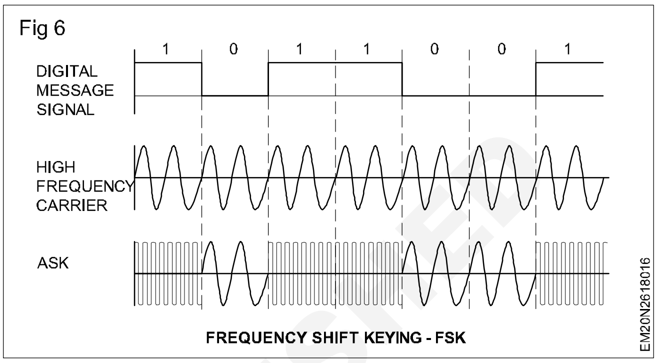
Disadvantages of Amplitude-shift keying (ASK)

ASK is linear and sensitive to atmospheric noise, distortion and propagation condition on different routes in PSTN (Public switched telephone network).It requires excessive bandwidth and is therefore a waste of power.

Frequency Shift Keying - FSK (Fig 6)

Frequency shift keying (FSK) is the most common form of digital modulation in the high-frequency radio spectrum, and has important applications in telephone circuits.

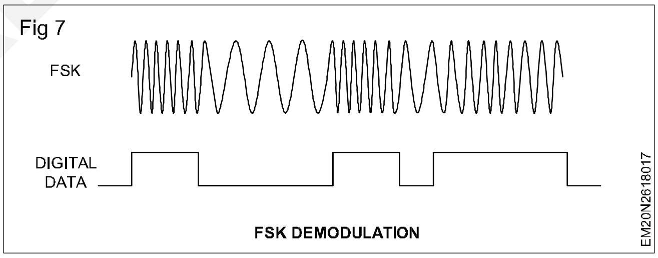
The digital message signal is modulated with the high frequency carrier. The frequency of the carrier is changed according to the message signal. It is similar to FM When input = high i.e. at logic 1, carrier frequency is shifted up i.e. frequency increases. When input = low i.e. at logic 0, carrier frequency is shifted down i.e. frequency decreases. Hence the information of the message signal is contained in the frequency of the carrier signal.



FREQUENCY SHIFT KEYING - FSK

FSK demodulation

The FSK demodulation methods for FSK can be makes all positive voltages into binary 1's and all negative voltages into binary 0's.This type of demodulator was very popular due to its relative simplicity and its noncritical tuning. Phase-locked-loop (PLL) demodulators are a more recent technique, but they have very similar performances to that of FM detector demodulators.(Fig 7)



FSK DEMODULATION

Advantages of FSK

- Low Noise, Since Amplitude Is Constant
- Power Requirement Is Constant
- Operates In Virtually Any Wireless communication Available
- High Data Rate
- Used In Long Distance Communication
- Easy To Decode
- Good Sensitivity

Disadvantages of FSK

- Complex Circuits.
- Coherent FSK is not often used in practice due it the difficulty and cost in generating two reference frequencies close together at the receiver.
- It requires more bandwidth.

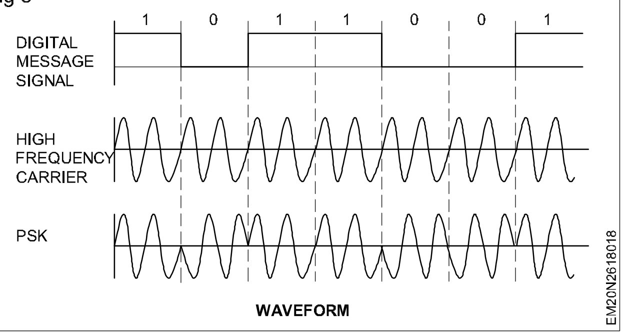
- The FSK is not preferred for the high speed modems because with increase in speed, the bit rate increases.

Phase Shift Keying - PSK:

Phase-shift keying (PSK) is a digital modulation scheme that conveys data by changing, or modulating the phase of a reference signal (the carrier wave).

The digital message signal is modulated with the high frequency carrier. The phase of the carrier is changed according to the message signal. It When input = low i.e. at logic 0, output wave is 180 degrees out of phase with the carrier is similar to PM When input = high i.e. at logic 1, output wave is in phase with the carrier. i.e. 0 degrees phase. (Fig 8)

Fig 8

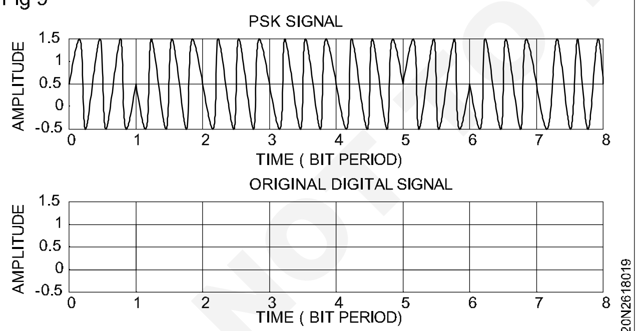


WAVEFORM

Any digital modulation scheme uses a finite number of distinct signals to represent digital data. PSK uses a finite number of phases, each assigned a unique pattern of binary digits.

The demodulator, which is designed specifically for the symbol-set used by the modulator, determines the phase of the received signal and maps it back to the symbol it represents, thus recovering the original data. This requires the receiver to be able to compare the phase of the received signal to a reference signal. (Fig 9)

Fig 9



WAVEFORM

Advantages of PSK

- PSK is less susceptible to errors than ASK, while it requires/occupies the same bandwidth as ASK
- More efficient use of bandwidth (higher data-rate) are possible, compared to FSK.
- High power efficiency
- It is used in low data rate wireless communication.

Disadvantages of PSK

- More complex signal detection / recovery process, than in ASK and FSK.
- Low bandwidth efficiency.

Quadrature Amplitude Modulation - QAM

Quadrature Amplitude Modulation (QAM) is both an analog and a digital modulation scheme. It conveys two analog message signals, or two digital bit streams, by changing (modulating) the amplitudes of two carrier waves, using the amplitude-shift keying (ASK) digital modulation scheme or amplitude modulation (AM) analog modulation scheme.

The two carrier waves, usually sinusoids, are out of phase with each other by 90° and are thus called quadrature carriers or quadrature components - hence the name of the scheme. The modulated waves are summed, and the final waveform is a combination of both phase-shift keying (PSK) and amplitude-shift keying(ASK).

In the digital QAM case, a finite number of at least two phases and at least two amplitudes are used and it also used extensively as a modulation scheme for digital telecommunication systems.

The QAM modulator and QAM demodulator are key elements within any quadrature amplitude modulation system.

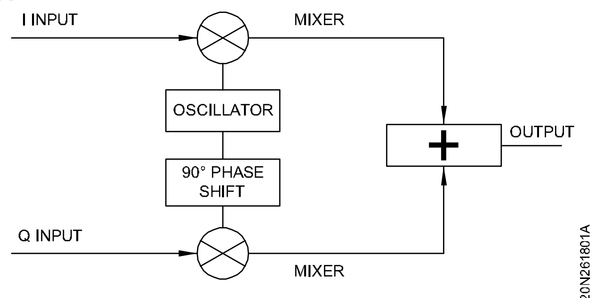
The modulator and demodulator are used to encode the signal, often data into the radio frequency carrier that is to be transmitted. Then the demodulator is used at the remote end to extract the signal from the RF carrier so that it can used at the remote end.

As quadrature amplitude modulation is a complex signal, specialised QAM modulators and demodulators are required.

QAM modulator basics

The QAM modulator essentially follows the idea that can be seen from the basic QAM theory where there are two carrier signals with a phase shift of 90° between them. These are then amplitude modulated with the two data streams known as the I or In-phase and the Q or quadrature data streams. These are generated in the baseband processing area. (Fig 10)

Fig 10

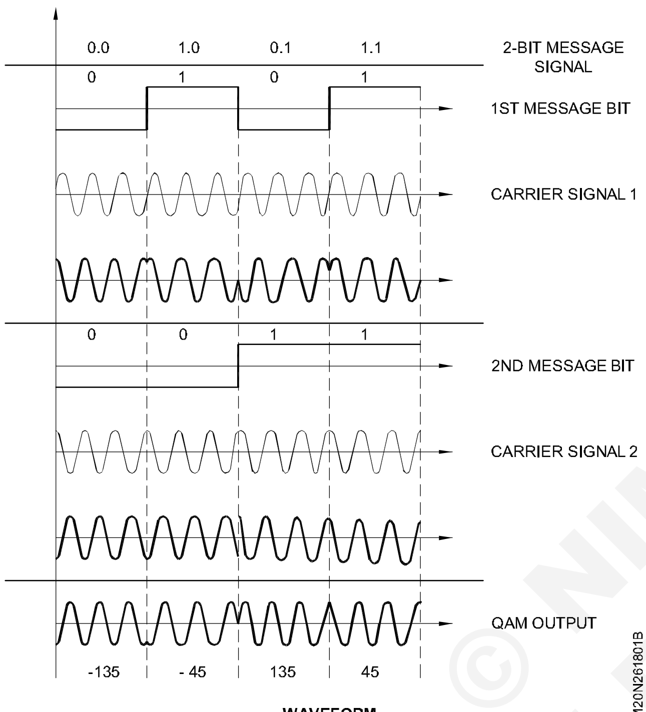


QAM MODULATOR BASICS

The two resultant signals are summed and then processed as required in the RF signal chain, typically converting them in frequency to the required final frequency and amplifying them as required.

It is worth noting that as the amplitude of the signal varies any RF amplifiers must be linear to preserve the integrity of the signal. Any non-line varieties will alter the relative levels of the signals and alter the phase difference, thereby distorting the signal and introducing the possibility of data errors. (Fig 11)

Fig 11

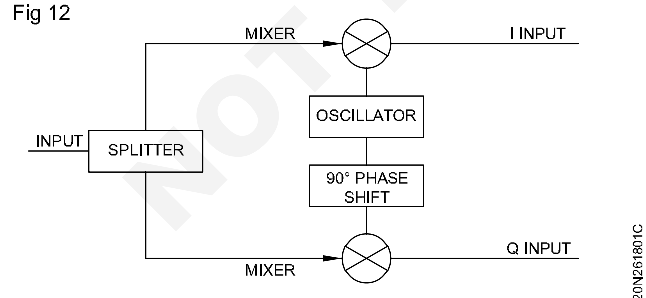


WAVEFORM

The QAM demodulator is very much the reverse of the QAM modulator.

The signals enter the system, they are split and each side is applied to a mixer. One half has the in-phase local oscillator applied and the other half has the quadrature oscillator signal applied. (Fig 12)

Fig 12



BASIC QAM DEMODULATOR DIAGRAM

The basic modulator assumes that the two quadrature signals remain exactly in quadrature.

A further requirement is to derive a local oscillator signal for the demodulation that is exactly on the required frequency for the signal. Any frequency offset will be a change in the phase of the local oscillator signal with respect to the two double sideband suppressed carrier constituents of the overall signal.

Systems include circuitry for carrier recovery that often utilizes a phase locked loop - some even have an inner and outer loop. Recovering the phase of the carrier is important otherwise the bit error rate for the data will be compromised.

Advantages of QAM

- QAM appears to increase the efficiency of transmission for radio communications systems by utilizing both amplitude and phase variations.
- The advantage of using QAM is that it is a higher order form of modulation and as a result it is able to carry more bits of information per symbol.
- By selecting a higher order format of QAM, the data rate of a link can be increased.
- Baud Rate (Baud Rate - No. of symbols per second) is high.

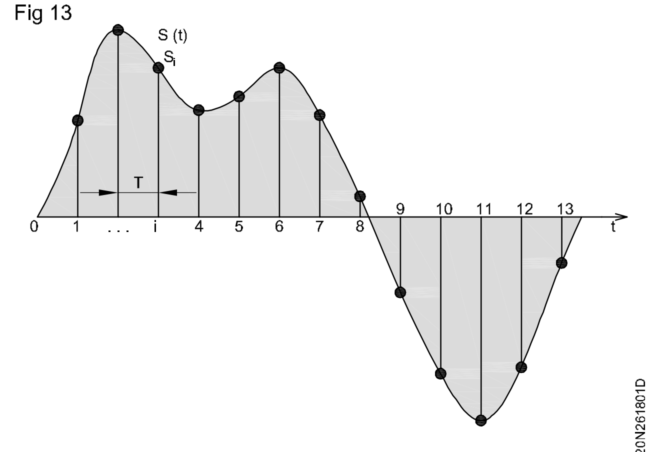
Disadvantages of QAM

- First it is more susceptible to noise. Receivers for use with phase or frequency modulation are both able to use limiting amplifiers that are able to remove any amplitude noise and thereby improve the noise reliance.
- The second limitation is also associated with the amplitude component of the signal. When a phase or frequency modulated signal is amplified in a radio transmitter, there is no need to use linear amplifiers, whereas when using QAM that contains an amplitude component, linearity must be maintained.
- Almost always requires a highly stable local oscillator
- In the optical domain this is very expensive.

Sampling

In signal processing, sampling is the reduction of a continuous signal to a discrete signal. A common example is the conversion of a sound wave (a continuous signal) to a sequence of samples (discrete-time signal). (Fig 13)

Fig 13



SAMPLING OF A RANDOM WAVE

A sample is a value or set of values at a point in time or space. A theoretical ideal sampler produces samples equivalent to the instantaneous value of the continuous signal at the desired points. After sampling, the process of converting a continuous-valued discrete-time signal to a digital (discrete-valued discrete-time) signal is known as analog-to-digital conversion

Sampling is usually done by using PAM (Pulse Amplitude Modulation). In this the analog signal is sampled at a given pulsing frequency.

Criteria for Sampling:

The criteria for sampling is given by Nyquist, known as Nyquist sampling theorem. The Nyquist sampling theorem provides a prescription for the nominal sampling interval required to avoid aliasing. It may be stated simply as follows:

"The sampling frequency should be at least twice the highest frequency contained in the signal."

Types of Sampling

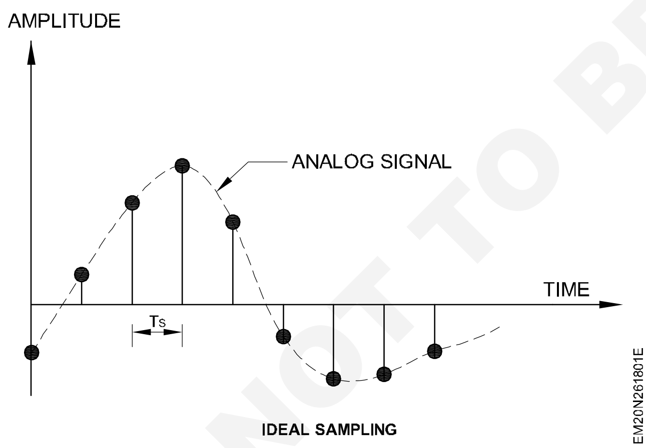
There are three basic types of sampling used in the process of sampling process.

They can be differentiated by their output waveform that they produce and the process involved in producing them.

1 Ideal Sampling (Fig 14)

- In this the samples are the instants of that time
- It is obtained by Pulse Modulation with
- Pulse of low duty cycle ideally, not possible but is used for theoretical purpose.

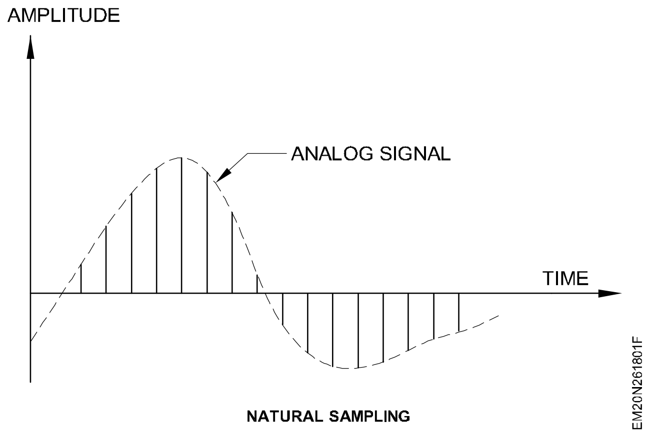
Fig 14



2 Natural Sampling (Fig 15)

- In this the samples are not the instant but of a small period of time
- It is obtained by PAM.
- This is usually used for the comparison of sampled output at various time intervals of various signals
- It has low SNR (Signal to Noise Ratio - The amount of original signal present to that of the noise in given signal).

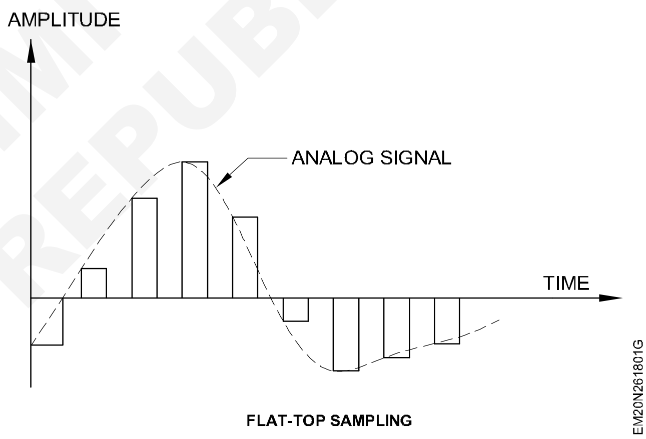
Fig 15



3 Flat- top Sampling (Fig 16)

- This is similar to Natural Sampling
- In this the top is made flat irrespective of the signal form
- This is usually used for Quantization as it gives higher SNR values when compared to natural sampling.

Fig 16



Quantization

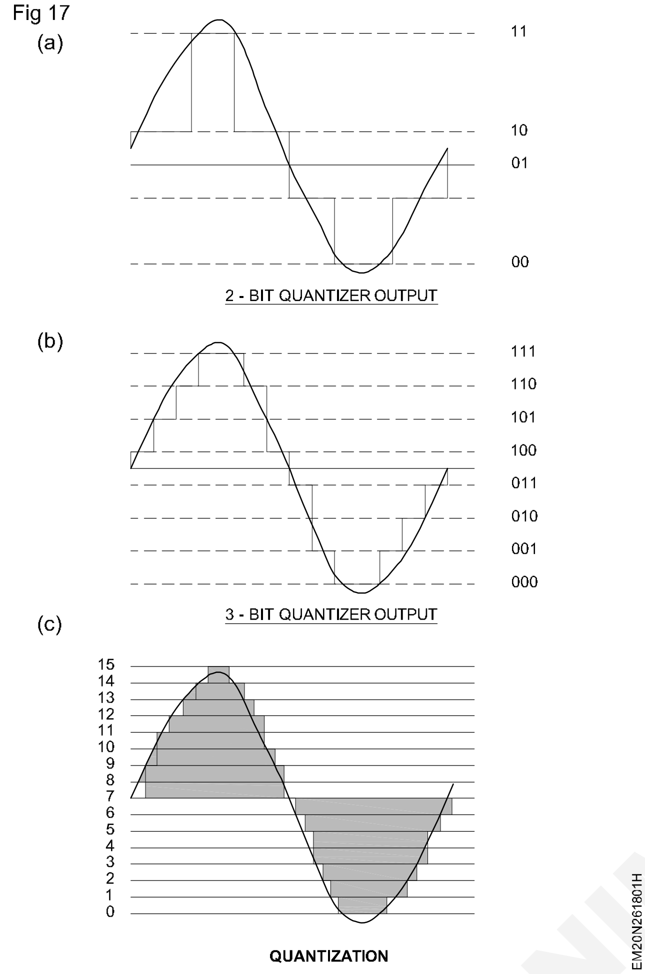
Quantization in digital signal processing, is the process of mapping a large set of input values to a (countable) smaller set - such as rounding values to some unit of precision.

A device or algorithmic function that performs quantization is called a quantizer.

The round-off error introduced by quantization is referred to as quantization error.

In analog-to-digital conversion, the difference between the actual analog value and quantized digital value is called quantization error or quantization distortion. This error is either due to rounding.. The error signal is sometimes modeled as an additional random signal called quantization noise because of its stochastic behavior. Quantization is involved to some degree in nearly all digital signal processing, as the process of representing a signal in digital form ordinarily involves rounding. Fig 17(a b,c)

Fig 17



The output of the quantization depends on the resolution of the quantizer, i.e., if a sinusoidal wave to be quantized is given to a 2-bit quantizer then the output has 4 levels in its output,

If it is a 3-bit quantizer then the output has 8 levels, thus the number of levels can be given based on the resolution of the quantizer, i.e., the number of output bits of the quantizer.

Quantization Error

- When a signal is quantized, we introduce an error - the coded signal is an approximation of the actual amplitude value.
- The difference between actual and coded value (midpoint) is referred to as the quantization error.

Encoding

An encoder is a device, circuit, transducer, software program, algorithm that converts information from one format (code) to another for the purpose of standardization, speed and security.

In telecommunication it is a device used to change a signal such as bit stream into a code.

The encoding is used to follow up standards so that type conversion from one to another doesn't affect the overall process. E.g.: NRZ-S is used in USB communication irrespective of the type of hardware, thus they ensure a standard. The usually used coding technique is line-coding technique. It is the coding technique followed to coding only single bit at a time.

Line coding consists of representing the digital signal to be transported by an amplitude- and time-discrete signal that is optimally tuned for the specific properties of the physical channel (and of the receiving equipment). The waveform pattern of voltage or current used to represent the 1's and 0's of a digital data on a transmission link is called line encoding.

The common types of line encoding are

a Unipolar encoding.

- Return to Zero (RZ).

b Polar encoding.

- Non-Return to Zero Level (NRZ-L).
- Non-Return to Zero Space (NRZ-S).
- Non-Return to Zero Inverted (NRZ-I).
- Non-Return to Zero Mark (NRZ-M).

c Bipolar encoding.

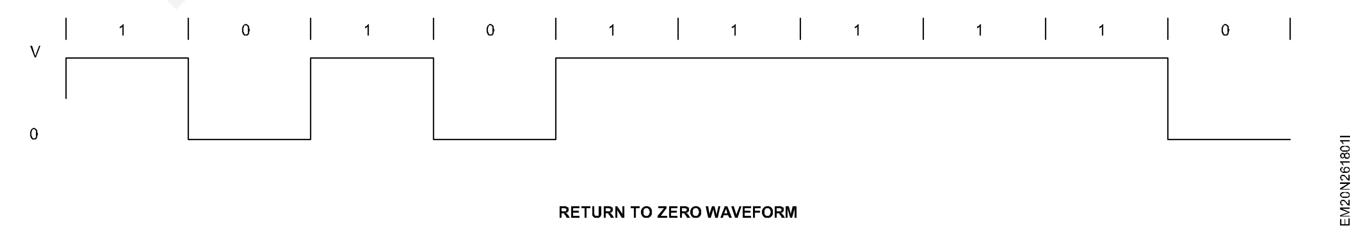
- Alternate Mark Inversion(AMI)

d Manchester encoding.

Unipolar Encoding

Unipolar encoding or Return to Zero is a line code. A positive voltage represents a binary 1, and zero volts indicates a binary 0. It is the simplest line code, directly encoding the bit stream, and is analogous to on-off keying in modulation. (Fig 18)

Fig 18



In unipolar NRZ the duration of the MARK pulse (Γ) is equal to the duration (To) of the symbol slot. (Fig 19)

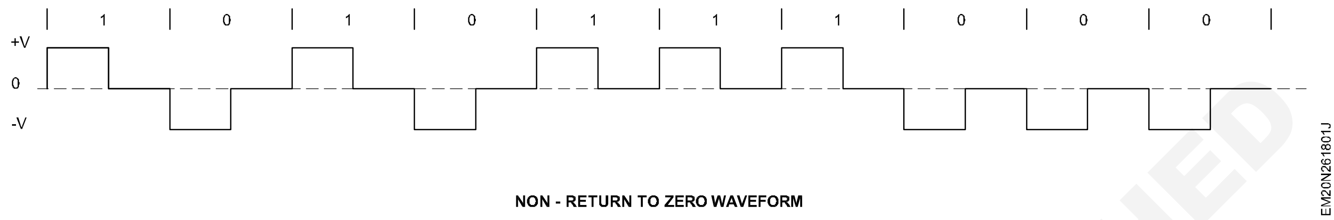
Advantages

- Simplicity in implementation.
- Doesn't require a lot of bandwidth for transmission.

Disadvantages

- Presence of DC level (indicated by spectral line at 0 Hz).
- Contains low frequency components. Causes "Signal Droop" (explained later).
- Does not have any error correction capability.
- Does not possess any clocking component for ease of synchronisation.
- Is not transparent. Long string of zeros causes loss of synchronisation.

Fig 19



NON - RETURN TO ZERO WAVEFORM

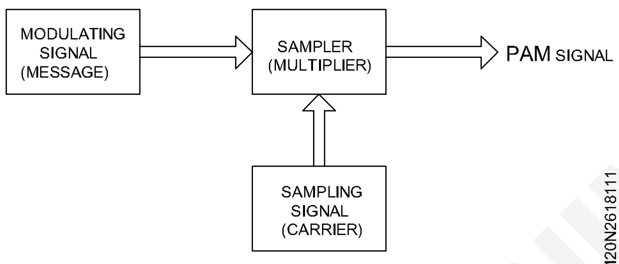
Modulation and Demodulation of analog signal using PAM, PPM,PWM

Objectives : At the end of this lesson you shall be able to
- **processing of PAM, PPM and PWM**
- **Demodulation of PAM, PPM and PWM.**

Pulse amplitude modulation (PAM) is the basic from of pulse modulation in which the signal is sampled at regular intervals and each sample is made proportion to the amplitude of the modulating signal at the sampling instant.

The processing of PAM signal is shown in Fig 1. The two signals i.e, modulating signal and sampling signal or carrier signal are sent to the sampler (Multiplier) stage where the amplitude of the signal proportional to the modulating signal through which information is carried. This is PAM signal

Fig 1



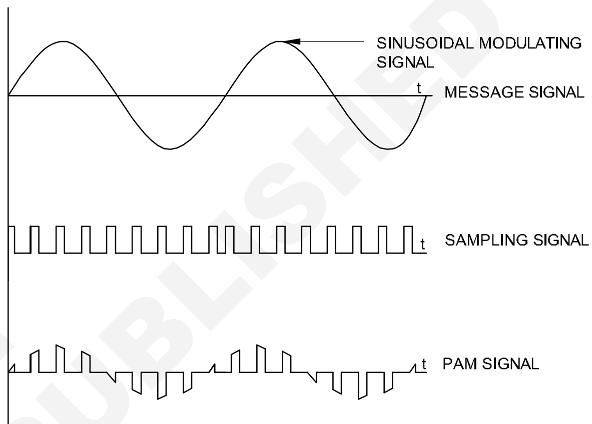
PROCESSING OF PAM SIGNAL

EM20N2618111

The PAM signal along with the message signal and the sampling signal, that is the carrier train of pulses waveform plotted in time domain are shown in Fig 2.

PAM circuit using IC555 and NPN transistor is shown in Fig 3. The timer chip is wired in as table multivibrator configuration with the NPN transistor base at terminal output pin. Its pulse frequency is designed at least twice that of audio signal. The collector of transistor is coupled with low frequency audio signal through positive clamper using capacitor C1 and diode D1.

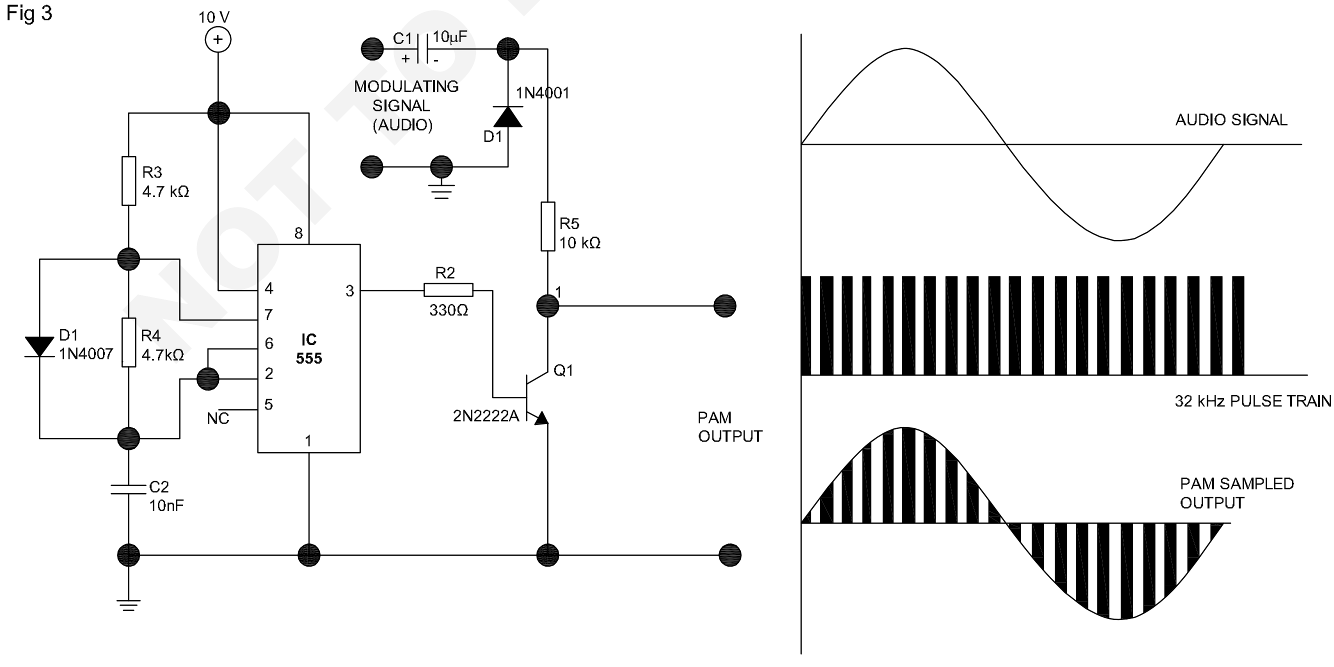
Fig 2



EM20N2618112

The positive clamping will shift the level of audio signal above 'O' volt. The output at the collector of transistor is PAM wave as shown in Fig 3. The amplitude of pulse generated by the IC555 varies in accordance with the instantaneous amplitude of information signal.

Fig 3

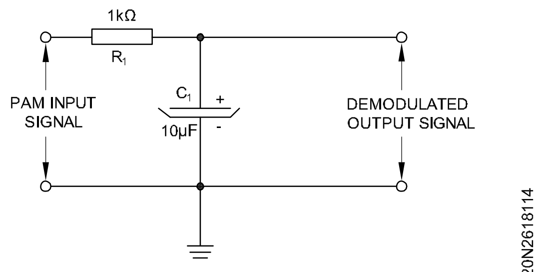


EM20N2618113

Demodulation of PAM

PAM signal is demodulated by the low pass filter circuit shown in Fig 4. The RC network eliminates high frequency ripples and generates the demodulated signal proportional to the PAM input signal.

Fig 4



PAM DEMODULATOR CIRCUIT

Demultiplexing of AM signal

Demultiplexing is the reverse process of the multiplexing action the demultiplexer is also known as 'DEMUX'

A demux circuit separates multiple analog or digital separates form one signal received over a single shared medium such as a single conductor of copper wire or fiber optical cable

Now, each modulated signal is applied at demodulators to detect all the three original message signals at receiving end.

Multiplexing of AM signal

Analog signals are easily multiplexed by using frequency division multiplexing (FDM) technique for multiplexing AM signals for transmission. FDM is a networking technique in which multiple data signals are combined for simultaneous transmission via a shared communication medium. FDM uses a carrier signal at a discrete frequency for each data stream and then combines many modulated signals into one in such a manner that each individual signal can be retrieved at the destination.

The following Fig 5 shows the process of FDM of three voice signals with different carrier frequencies are modulated and sent together over a cable by using FDM technique

In FDM a guard band frequency of 9 khz is provided between different AM channels to keep signals from interfering with each other. This process of multiplexing of AM signal is adopted at Transmitter and then goes to media at different slots of frequency.

Since the PAM, PPM and PNM are analog signals, the multiplexing of these signals are required with FDM technique.

Fig 5

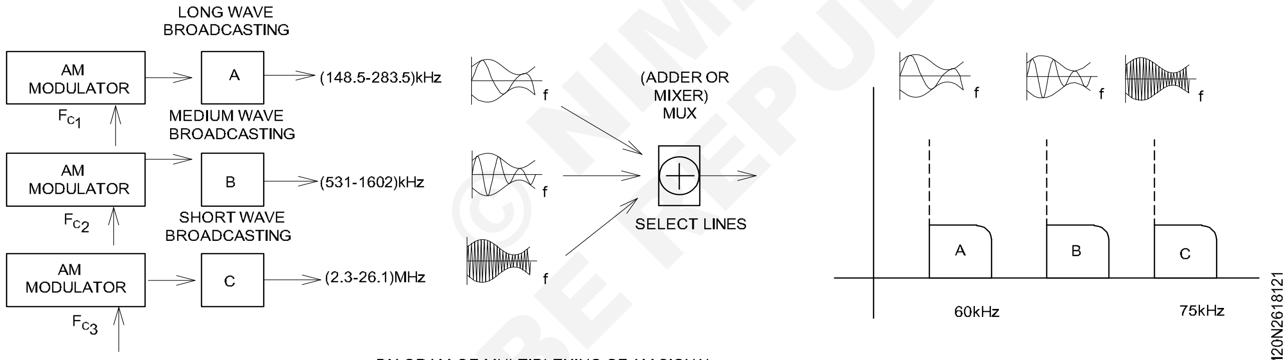
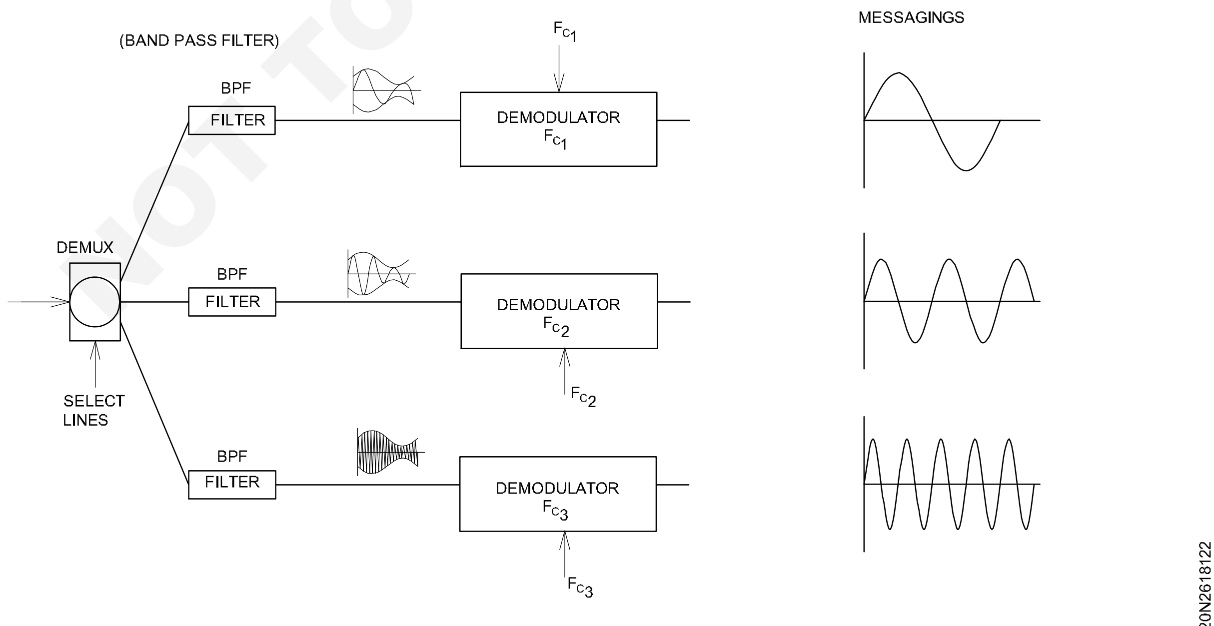


DIAGRAM OF MULTIPLEXING OF AM SIGNAL

Fig 6



DEMULTIPLEXING OF AM SIGNAL

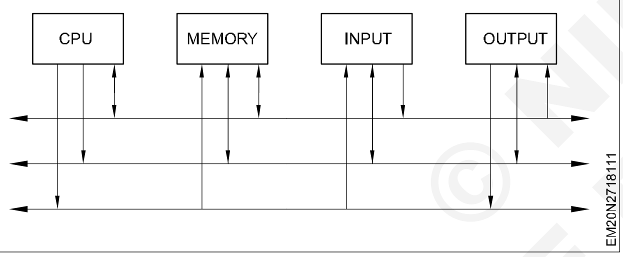
Introduction to Microprocessor and Microcomputer Architecture

Objectives : At the end of this lesson you shall be able to
- **introduction of micro processor and micro controller**
- **architecture of micro processor and micro controller**
- **Difference between micro processor and micro controller.**

Introduction to Microprocessor and Microcomputer Architecture

A microprocessor is a programmable electronics chip that has computing and decision making capabilities similar to central processing unit of a computer. Any microprocessor-based systems having limited number of resources are called microprocessor. Nowadays, microprocessor can be seen in almost all types of electronics devices like mobile phones, printers, washing machines etc. Microprocessors are also used in advanced applications like radars, satellites and flights. Due to the rapid advancements in electronic industry and large scale integration of devices results in a significant cost reduction and increase application of microprocessors and their derivatives.

Fig 1



- **Bit:** A bit is a single binary digit.
- **Word:** A word refers to the basic data size or bit size that can be processed by the arithmetic and logic unit of the processor. A 16-bit binary number is called a word in a 16-bit processor.
- **Bus:** A bus is a group of wires/lines that carry similar information.
- **System Bus:** The system bus is a group of wires/ lines used for communication between the microprocessor and peripherals.
- **Memory Word:** The number of bits that can be stored in a register or memory element is called a memory word.
- **Address Bus:** It carries the address, which is a unique binary pattern used to identify a memory location or an I/O port, For example, an eight bit address bus has eight lines and thus it can address $2^8 = 256$ different locations. The locations in hexadecimal format can be written as 00H - FFH.
- **Data Bus:** The data bus is used to transfer data between memory and processor or between I/O device and processor. For example, an 8-bit processor will generally have an 8-bit data bus and a 16-bit processor will have 16-bit data bus.
- **Control Bus:** The control bus carry control signals, which consists of signals for selection of memory or I/O device from the given address, direction of data transfer and synchronization of data transfer in case of slow devices.

A typical microprocessor consists of arithmetic and logic unit (ALU) in association with control unit to process the instruction execution. Almost all the microprocessors are based on the principle of store-program concept. In store-program concept, programs or instructions are sequentially stored in the memory locations that are to be executed. To do any task using a microprocessor, it is to be programmed by the user. So the programmer must have idea about its internal resources, features and supported instructions. Each microprocessor has a set of instructions, a list which is provided by the microprocessor manufacturer. The instruction set of a microprocessor is provided in two forms. binary machine code and mnemonics.

Microprocessor communicates and operates in binary number 0 and 1. The set of instructions in the form of binary patterns is called a machine language and it is difficult for us to understand. Therefore, the binary patterns are given abbreviated names, called mnemonics, which forms the assembly language. The conversion of assembly-level language into binary machine - level language is done by using an application called assembler.

Classification of Microprocessors:

Based on their specifications, applications and architecture microprocessors are classified.

Based on size of data bus:

- 4-bit microprocessor
- 8-bit microprocessor
- 16-bit microprocessor
- 32-bit microprocessor

Based on application

- General-purpose microprocessor used in general computer system and can be used by programmer for any application. Example, 8085 to Intel Pentium.
- Microcontroller - microprocessor with built - in memory and ports and can be programmed for any generic control application. Example, 8051.

- Special-purpose processors - designed to handle special functions required for an application. Examples, digital signal processors and applications specific integrated circuit (ASIC) chips.

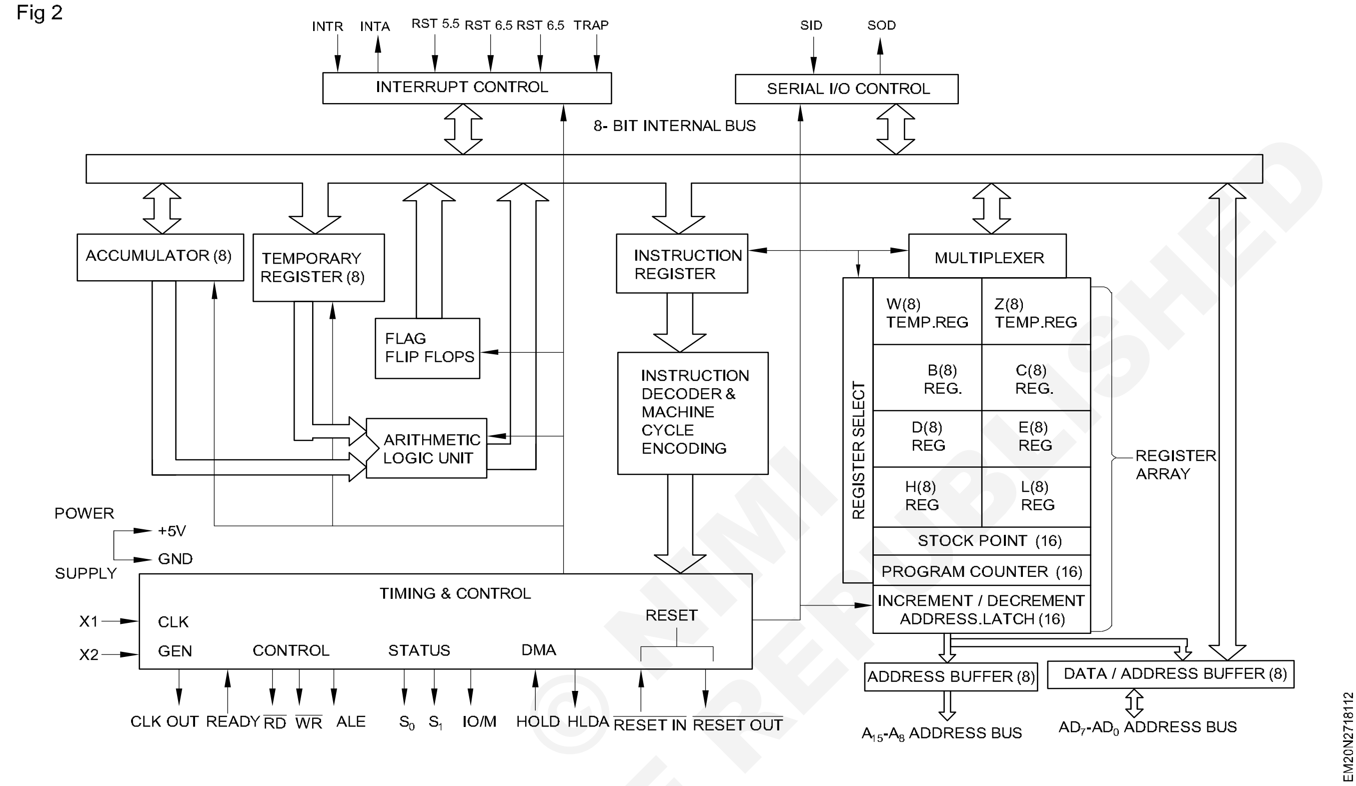
Based on architecture:

- Reduced Instruction Set Computer (RISC) processors
- Complex Instruction Set Computer (CISC) processors

2 8085 Microprocessor Architecture

The 8085 microprocessor is an 8-bit processor available as a 40-pin IC package and uses +5 V for power. It can run at a maximum frequency of 3 MHz. Its data bus width is 8-bit and address bus width is 16-bit, thus it can address 2^{16} - 64 KB of memory. The internal architecture of 8085 is shown is Fig 2.

Fig 2



Arithmetic and Logic Unit

The ALU performs the actual numerical and logical operations such as Addition (ADD), Subtraction (SUB), AND, OR etc.

Register

The 8085 includes six registers, one accumulator and one flag register, as shown in Fig 3. In addition, it has two 10-bit register, stack pointer and program counter.

The 8085 has six general - purpose registers to store 8-bit data, these are identified as B,C,D,E,H and L, they can be combined as register pairs - BC, DE and HL to perform some 16-bit operations. The programmer can use these registers to store or copy data into the register by using data copy instructions.

Accumulator A (8)	FT AG Register
B (8)	C (8)
D (8)	E (8)
H (8)	L (8)
Stack Pointer (SP) (16)	
Program Counter (PC) (16)	

Data Bus — 8 lines Bidirectional

Address Bus — 16 lines unidirectional

Accumulator

The accumulator is an 8-bit register that is a part of ALU. This register is used to store 8-bit data and to perform arithmetic and logical operations.

Flag register

The ALU includes five flip-flop, which are set or reset after an operation according to data condition of the result in the accumulator and other register.

D7	D6	D5	D4	D3	D2	D1	D0
S	Z		AC		P		CY

For examples, after an addition of two numbers, if the result in the accumulator is larger than 8-bit, the flip-flop uses to indicate a carry by setting CY flag to 1. When an arithmetic operation results in zero. Z flag is set to 1. The S flag is just a copy of the bit D7 of the accumulator. A negative number has a 1 in bit D7 and a positive number has a 0 in 2's complement representation. The AC flag is set to 1, when a carry result from bit D3 and passes to bit D4. The P flag is set to 1, when the result in accumulator contains even number of 1s.

Program Counter (PC)

This 16-bit register deals with sequencing the execution of instructions. This register is a memory pointer. The microprocessor uses this register to sequence the execution of the instructions.

Stack pointer (SP)

The stack pointer is also a 16-bit register, used as a memory pointer. It points to a memory location in R/W memory, called stack.

Instruction Register/Decoder

It is an 8-bit register that temporarily stores the current instruction of a program. Latest instruction sent here from memory prior to execution.

Control Unit

Generates signals on data bus, address bus and control bus within microprocessor to carry out the instruction, which has been decoded.

- Data bus: Data bus carries data in binary form between microprocessor and other external units such as memory. It is used to transmit data. i.e information results of arithmetic etc width of 8085 microprocessor. Data bus is in directional in nature. The data bus width of 8085 microprocessor is 8-bit i.e, 2^8 combination of binary digits and are typically identified as D0-D7. Thus size of the data bus determines what arithmetic can be done. If only 8-bit wide their largest number is 11111111 (255 in decimal).Therefore, larger numbers have to be broken down into chunks of 255. This slows microprocessors.
- Address Bus: The address bus carries addresses and is one way bus from microprocessor to the memory or other devices 8085 microprocessor contain 16-bit address bus and are generally identified as A0-A15. The higher order address lines (A8-A15) are unidirectional and the lower order lines (A0-A7) are multiplexed (time-shared) with the eight data bits (D0-D7) and hence, they are bidirectional.
- Control Bus: Control bus are various lines which have specific functions for coordinating and controlling microprocessor operations. The control bus carries control signals partly unidirectional and partly bidirectional. The following control and status signals are used by 8085 processor:

i ALE (output): Address Latch Enable is a pulse that is provided when an address appears on the AD0-AD7 lines, after which it becomes 0.

ii RD (active low output): The read signal indicates that data are being read from the selected I/O or memory device and that they are available on the data bus.

iii WR (active low output): The Write signal indicates that data on the data bus are to be written into a selected memory or I/O location.

iv IO/$\overline{M}$ (output): It is a signal that distinguished between a memory operation and an I/O operation. When I

IO/$\overline{M}$ = 0 it is a memory operation and

IO/$\overline{M}$ = it is an I/O operation.

v S1/S0 (output): These are status signals used to specify the type of operation being performed, they are listed in Table 1.

Table 1 Status signals and associated operations

S1	S0	States
0	0	Halt
0	1	Write
1	0	Read
1	1	Fetch

The schematic representation of the 8085 bus structure is as shown in Fig 3. The microprocessor performs primarily four operations.

i Memory Read: Reads data (or instruction) from memory

ii Memory Write : Writes data (or instruction) into memory

iii I/O Read: Accepts data from input device.

iv I/O Write: Sends data to output device.

The 8085 processor performs these functions using address bus, data bus and control bus.

3 8085 Pin Description

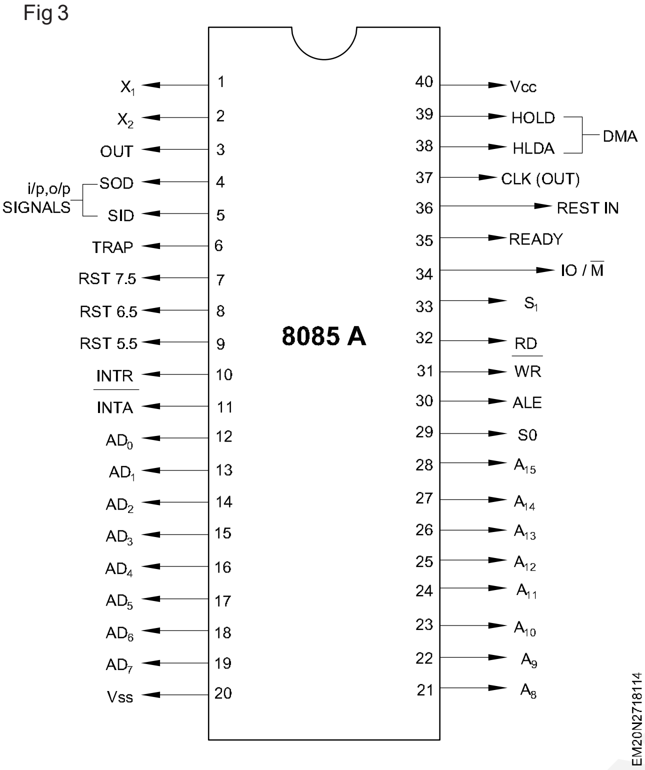
Properties:

- It is a 8-bit microprocessor.
- Manufactured with N-MOS technology.
- 40 Pin IC package.
- It has 16-bit address bus and thus has 2^{16} = 64 KB addressing capability.

- Operate with 3 MHz single phase clock + 5 V single power supply.

The Logic pin layout and signal groups of the 8085 microprocessor are shown in Fig 3. All the signals are classified into six groups:

Fig 3



- Address bus
- Data bus
- Control & status signals
- Power supply and frequency signals
- Externally initiated signals
- Serial I/O signals

Address and Data Buses:

- A8 - A15 (output, 3-state): Most significant eight bits of memory addresses and the eight bits of the I/O addresses. These lines enter into tri-state high impedance state during HOLD and HALT modes.
- AD0 - AD7 (input/output, 3-State): Lower significant bits of memory addresses and the eight bits of the I/O addresses during first clock cycle. Behaves as data bus during third and fourth clock cycle. These lines enter into tri-state high impedance state during HOLD and HALT modes.

Control & Status Signals:

- ALE: Address latch enable
- RD: Read control signal.
- WR: Write control signal
- IO/M: S1 and S0 : Status signals

Power Supply & Clock Frequency:

- Vcc: +5 V power supply
- Vss: Ground reference
- X1, X2: A crystal having frequency of 6 MHz is connected in these two pins.
- CLK: Clock output.

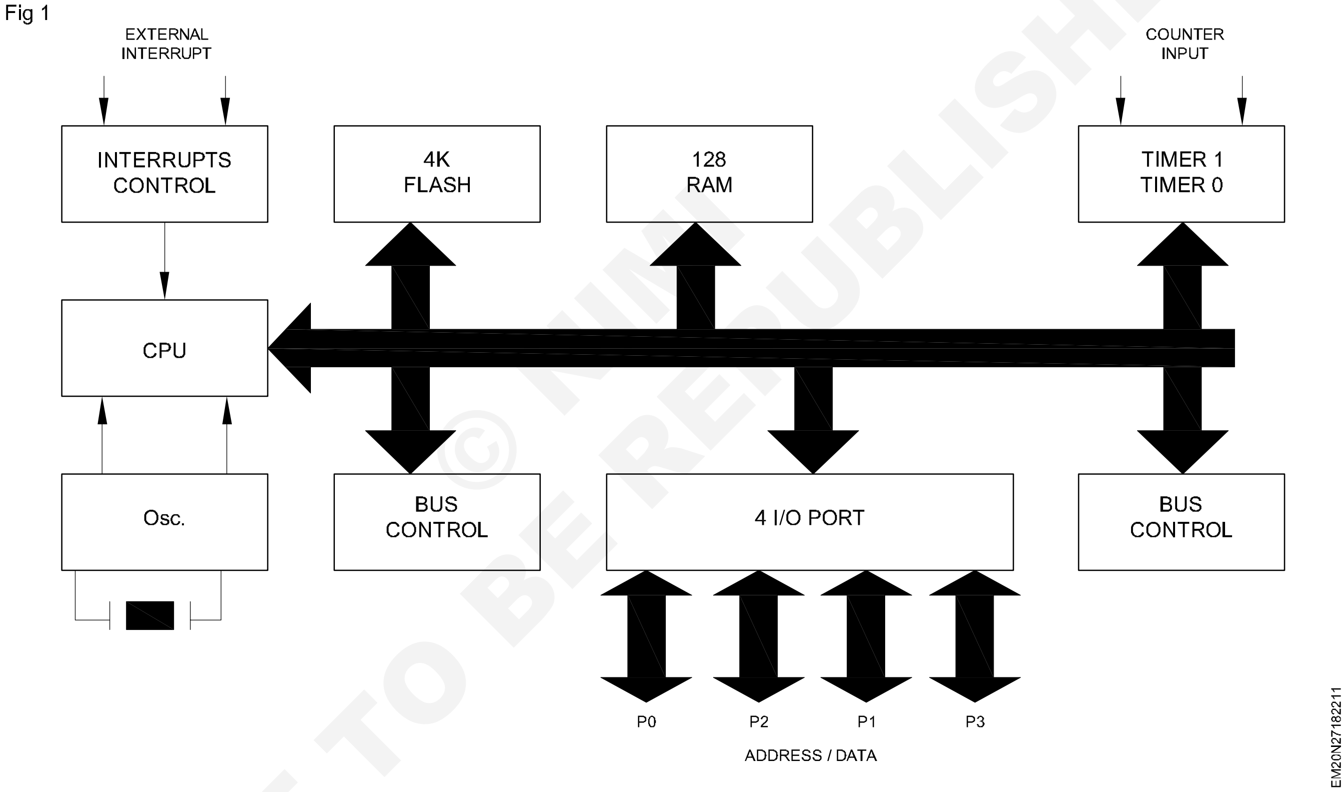
Architecture of 8051

Objectives : At the end of this lesson you shall be able to
- **understand the architecture of 8051 microcontroller**
- **differentiate between microprocessor and microcontroller.**

Microcontroller

The main reason for the development of microcontroller is to overcome the drawback of the microprocessor. Even though microprocessors are powerful devices, they require external chips like RAM, ROM input/output ports and other components in order to design a complete working system. This made it economically difficult to develop computerized consumer appliances on a large scale as the system cost is very high. Microcontrollers are the devices that actually fit the profile "Computer - on - a chip" as it consists of a main processing unit or processor along with some other components that are necessary to make it a complete computer. The components that are present on a typical microcontroller IC are CPU, memory, input / output ports and timers. The block diagram of a microcontroller is shown below in Fig 1.

Fig 1



Microcontrollers are basically used in embedded systems. Microcontrollers can be classified based on bus width, memory structure and instruction set. Bus width indicates a the size of the data bus.

Microcontrollers can be classified as 8-bit, 16- bit or 32-bit based on the bus width. Higher bus widths often result in better performance. Microcontrollers can be divided into two types based on their memory structures ; Embedded memory and external memory. In case of embedded memory microcontrollers, the required data and program memory is embedded into the IC. Whereas external memory microcontrollers do not have program memory embedded on them and require an external chip for the same. Now a day, all microcontrollers are embedded memory microcontrollers. The classification based on instruction set is similar to that of a microprocessor. They can be either CISC (complex instruction set computer) or RISC (Reduced instruction set computer. Majority of microcontrollers follow CISC architecture with over 80 instructions. Microcontrollers can also be divided based on their computer architecture into von neumann and harvard.

Functions of different ICs used in the microcontroller kit

1 EPROM : 27256 (32k x 8 EPROM)

The micro -51 EB LCD has a standard EPROM configuration of 32KB. The address for the monitor EPROM is 0000-3FFF. EPROM expansion is C000-FFFF.

2 RAM : 61256 (256K x 16 BIT SRAM)

The micro - 51 EB LCD has 32 KB of read /write program

/ data memory using one 61256 whose address is from 4000 to BFFFF. The micro - 51 EB LCD has one more 32KB of read/write data memory using one 61256 whose address is 0000-3FFF and C000-FEFF.

3 Parallel I/O interface : 8255 PPI (Programmable peripheral interface)

Intel 8255 programmable peripheral interface 24 programmable I/O lines configured as three 8 bit ports direct bit set / reset capability. Three modes of operation namely basic I/O, strobed I/O and bidirectional bus.

4 RS485 Drivers and RS232 drivers : ICL 232 (RS232) and 74LBC184D (RS485)

8051 is used for serial communication with associated diver for interface immunity and overcoming attenuation.

5 Address Latch : (74LS273)

It is used to latch the address (A0-A7) from AD lines (AD0-AD7). The latch stores the number output by the 8051 from the data bus. So that the LED can be lit with any 8 bit binary number.

6 Data bus buffer : (72LS244)

It connect 8 bit of input data to I/O peripheral devices.

7 LCD interface and LCD module : (IC74174)

The LCD is display is driven by both address latch and data bus buffer.

The following table shows some of the difference between microprocessors and microcontrollers.

Microprocessor	Microcontroller
Microprocessor assimilates the function of a central processing unit (CPU) on to a single integrated circuit (IC)	Microcontroller can be considered as a small computer which has a processor and some other components order to make it a micro computer chip.
Microprocessors are mainly used in designing general purpose systems from small to large and complex systems like super computers	Microcontrollers are used in automatically controlled devices
Microprocessors are basic components of personal computers	Microcontrollers are generally used in embedded system .
A microprocessor based system can perform numerous tasks	A microcontroller based system can perform single of very few tasks .
The main task of microprocessor is to perform the instruction cycle repeatedly. This includes fetch, decode and execute.	In addition to performing the tasks of fetch, decode and execute, a microcontroller also controls its environment based on the output of the instruction cycle.
In order to build or design a system (Computer, a microprocessor has to be connected externally to some other components like memory (RAM and ROM) and input output ports	The IC of a microcontroller has memory (both RAM, ROM) integrated on it along with some other components like I/O devices and timers
The overall cost of a system built using a microprocessor is high. This is because of the requirement of external components.	Cost of a system built using a microcontroller is less, all the components are readily available.
Generally power consumption and dissipation is high because of the external devices. Hence it requires external cooling system.	Power consumption is less
The clock frequency is very high usually in the order of Giga Hertz.	Clock frequency is less usually in the order of Mega Hertz.

Architecture of PIC Microcontroller

Central Processing Unit (CPU)

PIC microcontroller's CPU is not different like other microcontroller CPU, which includes the ALU, controller unit, the memory unit, and accumulator. ALU is mainly used for arithmetic and logical operations. The memory unit is used to store the commands after processing. The control unit is used to control the internal & external peripherals, and the accumulator is used to store the final results and further processes.

Memory Organization

The memory module of the PIC microcontroller architecture consists of Random Access Memory (RAM) Read Only Memory (ROM) and STACK.

Memory Organization

Random Access Memory (RAM)

(RAM) The Random access memory is used to store the information temporarily in its registers. It is categorized into two banks, each bank has so many registers. The RAM registers are categorized into two types, namely Special Function Registers (SFR) General Purpose Registers (GPR).

General Purpose Registers (GPR)

As the name implies, These registers are used for general purpose only. For instance, if we want to multiply any two numbers by using this microcontroller. Usually, registers are used for multiplying and storing in other registers. So, GPR registers don't have any superior function,- CPU can simply access the data in the registers.

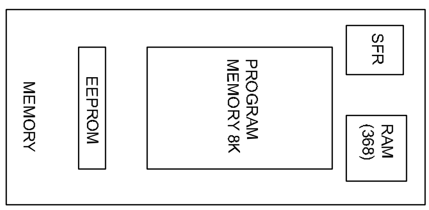
Special Function Registers (SFR)

As the name implies, SFRs are used only for special purposes. These registers work based on the function assigned to them, and these registers cannot work as a normal register. For instance, if you cannot use the STATUS register for storing the information, SFRs are used for viewing the status of the program. So, the user cannot change the SFR's function; the function is given by the manufacturer at the time of built-up.

Memory Organization

The memory organization of Peripheral Interface Controller (PIC) is shown in Fig 2 which includes the following:

Fig 2



- Read Only Memory (ROM)
- Electrically Erasable Programmable Read Only Memory (EEPROM)
- Flash Memory
- Stack

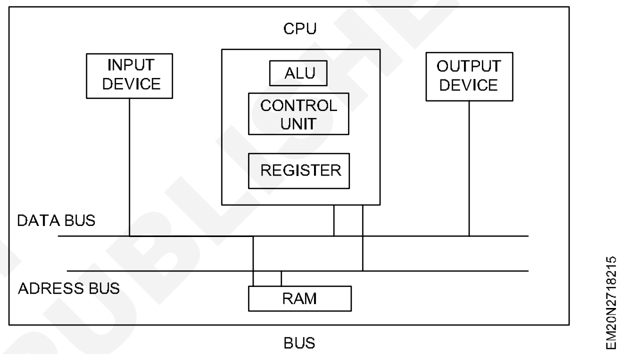
Input Output (I/O) Ports

The PIC microcontroller consists of 5-ports, namely Port-A, Port-B, Port-C, Port-D and Port-E.

BUS

BUS is used to transfer and receive the data from one peripheral to another as shown in Fig 3. It is categorized into two types as data bus and address bus.The Data Bus is used to transfer or receive the data.

Fig 3

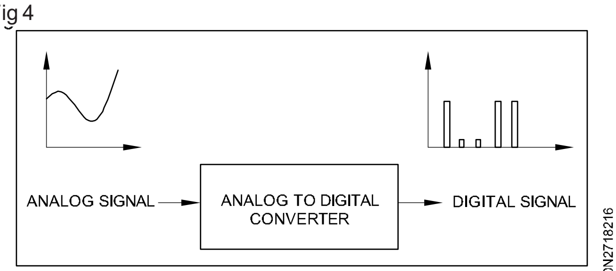


The address bus is used to transfer the memory address from the peripherals to the Central Processing Unit(CPU). Input /Output pins are used to interface the exterior peripherals; both the UART and USART are serial communication protocols, used to interface with serial devices such as GPS, GSM, IR, Bluetooth, etc.

Analog to Digital (A/D) Converter

A/D converter is shown in Fig 4 . It is used to convert analog voltage values to digital voltage values. An A/D module in PIC Microcontroller Controller comprises of 5-inputs for 28-pin devices and 8-inputs for 40-pin devices. The operation of the A/D converter is controlled by special registers like ADCON0 & ADCON1. The upper and lower bits of the converter are stored in registers like ADRESH and ADRESL. In this process, it needs 5V of an analog reference voltage.

Fig 4



ANALOG TO DIGITAL CONVERTER

Timer/Counters

PIC microcontroller has four-timer/counters wherein the one 8-bit timer and the remaining timers have the choice to select 8 or 16-bit mode. Timers are used for generating accuracy actions, for example, creating specific time delays between two operations.

Interrupts

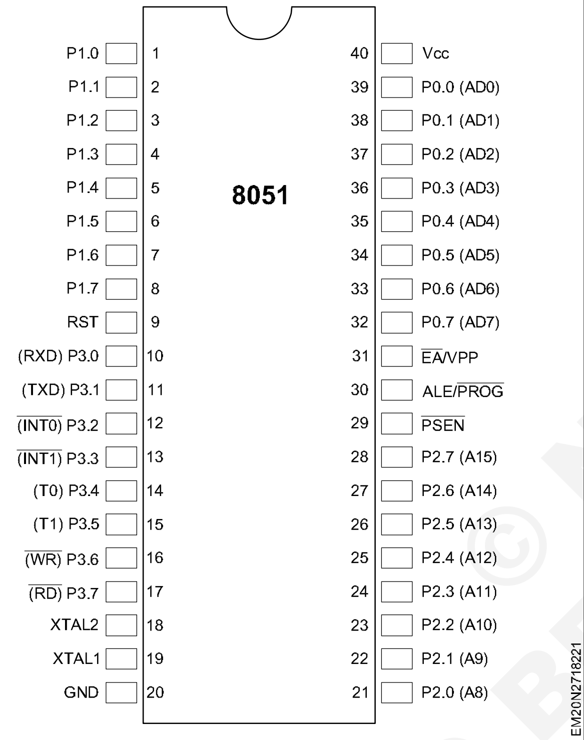
PIC microcontroller consists of 20 internal and 3-external interrupt sources which are allied with different peripherals like USART, ADC, Timers, and so on.

Pin details of 8051, Internal data memory, SFR and on-chip features

Objectives : At the end of this lesson you shall be able to
- **pin diagram of 8051**
- **data memory and special function registers**
- **utilization of on - chip resources such as ADC.**

The pin diagram of 8051: 8051 is a 40 pin microcontroller with I/O ports (Ref.Fig 1)

Fig 1



There are 4 ports in 8051 IC (Port 0, Port 1, Port 2 and Port 3) 32 pins are function as I/O port lines and 24 of these lines are dual purpose (P0, P1, P3). Each can operate as I/O, or as a control line or part of the address or data bus. Eight lines in each port can be used in interfacing to parallel devices like printers, DAC etc., or each line the port can be used in interfacing to single bit devices like LED's, switches, transistors, solenoid, motors and loudspeakers.

PORT 0 (32-39 Pins)

It is a dual purpose port (P0.0-P0.7). For simple design it is used as I/O ports. For larger design with external memory, it is used as multiplexed address and data bus (AD0-AD7)

PORT 1(1-8 Pins)

It is a dedicated I/O port (P1.0-P1.7). It is used only to interface with the external devices.

PORT 2 (21-28 Pins)

It is a dual purpose port (P2.0-P2.7). It is used as I/O port or higher byte of address bus (A8-A15).

PORT 3 (10-17 Pins)

It is a dual purpose port (P3.0- P3.7) It is used as I/O port, or used to special features of 8051 (Table 1)

Table 1

BIT	Name	BIT Address	Alternate function
P 3.0	RXD	B0H	Receive data for serial port
P 3.1	TXD	B1H	Transmit data for serial port
P 3.2	INT0	B2H	External interrupt 0
P 3.3	INT1	B3H	External interrupt 1
P 3.4	T0	B4H	Timer /counter 0 external input
P 3.5	T1	B5H	Timer/counter 1 external input
P 3.6	WR	B6H	External data memory write stroke
P 3.7	RD	B7H	External data memory read stroke
P 1.0	T2	90H	Timer/ Counter 2 external input
P 1.1	T2EX	91 H	Timer /Counter 2 capture / reload

RST (9 Pin No)

It is a master reset input pin. It should be kept high to start - up 8051.

On- chip oscillator (18-19 Pins)

It is a crystal oscillator with stabilizing capacitor connected to pin number 18 and 19. The normal crystal frequency is 12 MHz.

Power connection (20,40 Pins)

The 8051 operates at +5V DC. Pin No. 40 is Vcc. Pin No. 20 is Vss (GND)

PSEN (Program store enable) (29 Pin No)

PSEN is an output and control signal to enable the external memory.

ALE (Address Latch Enable) (30 Pin No)

ALE is an output signal to control demultiplexing the address and data bus. ALE signal oscillates at 2 MHz.

EA (External access) (31 Pin No)

It is an input signal is generally kept high (+5VDC) or low (GND). If EA is high 8051 executes program from internal ROM. If EA is low it executes program from external memory.

Internal data memory

128 Bytes of internal data memory is divided in to two parts, Part I is RAM (00- 7FH) Part II is special function registers (SFR) (80-FFH)

RAM

i Register Bank (00H-1FH) 4 banks (Bank 0,1,2,3) Each bank consisting of 8 register (R0-R7)

ii Bit addressable RAM (20 H-2FH)

iii General purpose RAM (30 H-7FH)

i. Register banks

The bottom 32 locations of internal memory contain the register banks. The 8051 instruction set supports of 8 registers R0 through R7, and by default these registers are addresses 00H-07H.

ii. Bit addressable RAM

There are 128 general - purpose bit addressable locations at byte addresses 20 H through 2FH (8 bits /byte X 16 bytes = 128 bits). These addresses are accessed as bytes or as bits, depending on the instruction.

For example, to set bit 67H, the following instruction could be used.

Set B 67H

Note that “Bit address 67H” is the most significant bit at “byte address 2CH”.

iii. General purpose RAM

General purpose RAM consisting of address location(30H-7FH) which is byte addressable available to programmer to store data /programs.

21 SFRs are available, out of 21, 11 are bit addressable and 10 are byte addressable

P0 (80 H)	: Port 0, bit addressable
SP (81 H)	: Stack pointer
DPL (82 H)	: Data pointer low byte
DPH (83 H)	: Data pointer high byte
PCON (87H)	: Power control register
TCON (88H)	: Timer control register, bit addressable
TMOD (89H)	: Timer mode register
TL0 (8AH)	: Timer 0 low byte
TL1 (8BH)	: Timer 1 low byte
TH0 (8CH)	: Timer 0 high byte
TH1 (8DH)	: Timer 1 high byte
P1 (90H)	: Port 1, bit addressable
SCON (98H)	: Serial port control register, bit addressable
SBUF (99H)	: Serial data buffer, byte addressable
P2 (A0H)	: Port 2, bit addressable
IE (A8H)	: Interrupt enable, bit addressable
P3 (B0H)	:Port 3, bit addressable
IP (B8H)	: Interrupt priority, bit addressable
PSW (D0H)	: Program status word, bit addressable
ACC (E0H)	: Accumulator, bit addressable

On-chip features of 8051 philips microcontroller

The derivative of 8051 philips microcontroller is most powerful 8 bit microcontroller. It has got an 8 bit CPU optimized for control application. 64 K program memory space, 64K data memory space, 4K bytes of on - chip program memory. 128 bytes of on - chip data memory, 32 bi-directional and individually addressable I/O lines, two 16 bit timer / counters, one full duplex serial port and 6 source /5- vector interrupt with two priority level on - chip.

Utilization of on - chip resources such as ADC

The PCF 8591 is a single - chip, single - supply low - power 8 bit CMOS data acquisition, device with four analog inputs, one analog output and a serial I2C - bus interface. The functions of the device include analog input multiplexing, on- chip track and hold function, 8 bit analog-to-digital conversion and an 8- bit digital - to analog conversion. The maximum conversion rate is given by the maximum speed of the I2C- bus.

Features and benefits

- Single power supply
- Operating supply voltage 2.5V to 6.0V
- Low standby current
- Serial input and output via I2C- bus
- I2C address selection by 3 hardware address pins

- Max sampling rate given by I2C- bus speed
- 4 Analog inputs configurable as single ended or differential inputs
- Auto- incremented channel selection
- Analog voltage range from VSS to VDD
- On - chip track and hold circuit
- 8-bit successive approximation A/D conversion
- Multiplying DAC with one analog output.

Applications

Supply monitoring

Reference setting

Instruction set of 8051, arithmetic and logical function

Objectives : At the end of this lesson you shall be able to
- **write program for adding, subtracting, multiplying and dividing two 8 bit numbers**
- **write program for logical and, or function for two 8 bit numbers.**

Assembly software for 8051

Here some simple assembly language programs for 8051 microcontroller are given to understand the operation of different instructions and to understand the logic behind particular program.

MOVC A, @ A+DPTR ; A ← ext_code_mem (A+DPTR)

MOVC A, @ A+PC ; A ← ext_code_mem (A+PC)

8051 Instruction set

The 8051, 8-bit microcontroller family instruction set includes 111 instructions, 49 of which are single - byte, 45 two - byte and 17 three - byte instruction. The instruction opcode format consists of a function mnemonic followed by a destination & source operand field. The instruction set is divided into four functional groups.

- Data transfer
- Arithmetic
- Logic
- Control transfer

i. Data transfer instructions

Data transfer operations are divided into three classes:

- General - purpose
- Accumulator - specific
- Address - object

None of these operations affects the PSW flag settings except a POP or MOV directly to the PSW.

Examples

MOV A, # 45 - Immediate addressing mode

MOV A, R1 - Register addressing mode

MOV 45h, A - Direct addressing mode

MOV @ R1, 32 h - Indirect addressing mode

ii. Arithmetic instructions

The MCS - 51 family microcontrollers have four basic mathematical operations. Only 8- bit operations using unsigned arithmetic are supported directly. The overflow flag, however, permits the addition and subtraction operation to serve for both unsigned and signed binary integers. Arithmetic can also be performed directly on packed BCD representations.

Examples

ADD A, #84 - Immediate addressing mode

SUBB A, R2 - Register addressing mode

ADD 73h, a - Direct addressing mode

ADDC @R1, 25h - Indirect addressing mode

iii. Logic instructions

The MCS - 51 family microcontrollers perform basic logic operations on both bit and byte operands.

Bit level (single operand) operations

In 8051 internal RAM and SFRs can be addressed by the address of each bit within a byte. This bit addressing is very convenient when we wish to alter a single bit of a byte. The ability to operate on individual bits creates the need for the area of RAM that contains data addresses that hold a single bit. The bit addresses are numbered from 00H to 7FH to represent the 128d bit addresses that exist from byte addresses 20H to 2FH.

CLR sets a or any directly addressable bit to zero (0)

SETB sets and directly bit - addressable bit to one (1).

CPL is used to complement the contents of the A register without affecting any flag, or any directly addressable bit location.

RL, RLC, RR, RRC, SWAP are the five operations that can be performed on A. RL, rotate left, RR, rotate right, RLC, rotate left through carry, RRC, rotate right through carry and SWAP, rotate left four. Four RLC and RRC and CY flag become equal to the last bit rotated out. SWAP rotates A left four places to exchange bits 3 through 0 with bits 7 through 4.

Byte level (two operand) operations

ANL performs bits wise logical AND of two operands (for both bit and byte operands) and returns the result to the location of the first operand.

ORL performs bit wise logical OR of two source operands (for both bit and byte operand) and returns the result to the location of the first operand.

XRL performs logical exclusive OR two source operands (byte operands) and returns the result to the location of the first operand.

Example

ANL A, #45h - Immediate addressing mode

ORL A, R2 - Register addressing mode

XRL 52h, A - Direct addressing mode

ANL @R3, 65h - Indirect addressing mode

iv. Control transfer instructions

There are three classes of control transfer operations: unconditional calls, returns, jumps, conditional jumps, and interrupts. All control transfer operations, some upon a specific condition, cause the program execution to continue a non - sequential location in program memory.

Example

CJNE A, #22H, loop - Immediate addressing mode

DJNZ R1, loop - Register addressing mode

DJNZ 30H, loop - direct addressing mode

JMP @A + DPTR - Indirect addressing mode

Notes on data addressing modes

Rn- Working register R0-R7

Direct - 128 Internal RAM locations, any I/O port, control or status register

@Ri - Indirect internal or external RAM location addressed by register R0 or R1

#data - 8-bit constant included in instruction

#data 16- 16- bit constant included as bytes 2 and 3 of instruction.

bit - 128 software flags, any bit - addressable I/O pin, control or status bit

A - accumulator

Notes on program addressing modes

addr16- Destination address for LCALL and LJMP may be anywhere within the 64-kbyte program memory address space.

addr11- Destination address for ACALL and AJMP will be within the same 2- kbyte page of program memory as the first byte of the following instruction.

rel - SJMP and all conditional jumps include an 8-bit offset byte. Range is +127/- 128 byts relative to the first byte of the following instruction.

Instruction set summary

Mnemonic **Arithmetic operations**		**Description**	**Byte**	**Cycle**
ADD	A, Rn	Add register to accumulator	1	1
ADD	A, direct	Add direct byte to accumulator	2	1
ADD	A @Ri	Add indirect RAM to accumulator	1	1
ADD	A, # data	Add immediate data to accumulator	2	1
ADDC	A, Rn	Add register to accumulator with carry flag	1	1
ADDC	A, direct	Add direct byte to A with carry flag	2	1
ADDC	A, @ Ri	Add indirect RAM to A with carry flag	1	1
ADDC	A, # data	Add immediate data to A with carry flag	2	1
SUBB	A, Rn	Subtract register from A with borrow	1	1
SUBB	A, direct	Subtract direct byte from A with borrow	2	1
SUBB	A, @Ri	Subtract indirect RAM from A with borrow	1	1
SUBB	A, #data	Subtract immediate data from A with borrow	2	1
INC	A	Increment accumulator	1	1
INC	Rn	Increment register	1	1
INC	direct	Increment direct byte	2	1
DEC	@Ri	Increment indirect RAM	1	1
DEC	A	Decrement accumulator	1	1
DEC	Rn	Decrement register	1	1
DEC	direct	Decrement direct byte	2	1

DEC	@Ri	Decrement indirect RAM	1	1
INC	DPTR	Increment data pointer	1	2
MUL	AB	Multiply A and B	1	4
DIV	AB	Divide A by B	1	4
DA	A	Decimal adjust accumulator	1	1

Logic Operations		**Description**	**Byte**	**Cycle**
ANL	A, Rn	AND register to accumulator	1	1
ANL	A, direct	AND direct by the to accumulator	2	1
ANL	A, @Ri	AND indirect RAM to accumulator	1	1
ANL	A, @data	AND immediate data to accumulator	2	1
ANL	direct, A	AND accumulator to direct byte	2	1
ANL	direct, #data	AND immediate data to direct byte	3	2
ORL	A, Rn	OR register to accumulator	1	1
ORL	A, direct	OR direct byte to accumulator	2	1
ORL	A, @Ri	OR indirect RAM to accumulator	1	1
ORL	A, #data	OR immediate data to accumulator	2	1
ORL	direct, A	OR accumulator to direct byte	2	1
ORL	direct, #data	OR immediate data to direct byte	3	2
XRL	A, Rn	Exclusive OR register to accumulator	1	1
XRL	A, direct	Exclusive OR direct byte to accumulator	2	1
XRL	A, @Ri	Exclusive OR indirect RAM to accumulator	1	1
XRL	A, #data	Exclusive OR immediate data to accumulator	2	1
XRL	direct, A	Exclusive OR accumulator to direct byte	2	1
XRL	direct, #data	Exclusive OR immediate data to direct byte	3	2
CLR	A	Clear accumulator	1	1
CPL	A	Complement accumulator	1	1
RL	A	Rotate accumulator left	1	1
RLC	A	Rotate accumulator left through carry	1	1
RR	A	Rotate accumulator right	1	1
RRC	A	Rotate accumulator right through carry	1	1
SWAP	A	Swap nibbles within the accumulator	1	1

Data transfer		Description	Byte	Cycle
MOV	A, Rn	Move register to accumulator	1	1
MOV	A, direct	Move direct byte to accumulator	2	1
MOV	A, @Ri	Move indirect RAM to accumulator	1	1
MOV	A, #data	Move immediate data to accumulator	2	1
MOV	Rn, A	Move accumulator to register	1	1
MOV	Rn, direct	Move direct byte to register	2	2
MOV	Rn, #data	Move immediate data to register	2	1
MOV	direct, A	Move accumulator to direct byte	2	1
MOV	direct, Rn	Move register to direct byte	2	2
MOV	direct, direct	Move direct byte to direct byte	3	2
MOV	direct, @Ri	Move indirect RAM to direct byte	2	2
MOV	direct, #data	Move immediate data to direct byte	3	2
MOV	@Ri, A	Move accumulator to indirect RAM	1	1
MOV	@Ri, direct	Move direct byte to indirect RAM	2	2
MOV	@Ri, #data	Move immediate data to indirect RAM	2	1
MOV	DPTR, #data 16	Load data pointer with a 16 - bit constant	3	2
MOV	A, @A+DPTR	Move code byte relative to DPTR to accumulator	1	2
MOVC	A, @A, +PC	Move code byte relative to PC to accumulator	1	2
MOVX	A, @Ri	Move external RAM (8-bit addr.) to A	1	2
MOVX	A, @DPTR, A	Move A to external RAM (16-bit addr.)	1	2
PUSH	direct	Push direct byte onto stack	2	2
XCH	A, Rn	Exchange register with accumulator	1	1
XCH	A, direct	Exchange direct byte with accumulator	2	1
XCH	a, @Ri	Exchange indirect RAM with accumulator	1	1
XCHD	A, @Ri	Exchange low- order nibble indir. RAM with A	1	1

Boolean variable manipulation

Mnemonic		Description	Byte	Cycle
CLR	C	Clear carry flag	1	1
CLR	bit	Clear direct bit	2	1
SETB	C	Set carry flag	1	1
SETB	bit	Set direct bit	2	1
CPL	C	Complement carry flag	1	1
CPL	bit	Complement direct bit	2	1

Mnemonic		Description	Byte	Cycle
ANL	C, bit	AND direct bit to carry flag	2	2
ANL	C, /bit	AND complement of direct bit to carry	2	2
ORL	C, bit	OR direct bit to carry flag	2	2
ORL	C, /bit	OR complement of direct bit to carry	2	2
MOV	c, bit	Move direct bit to carry flag	2	1
MOV	bit, C	Move carry flag to direct bit	2	2

Program and Machine control

Mnemonic		Description	Byte	Cycle
ACALL	addr16	Absolute subroutine call	3	2
LCALL	addr16	Long subroutine call	3	2
RET	-	Return from subroutine	1	2
RETI	-	Return from interrupt	1	2
AJMP	addr16	Absolute jump	3	2
LJMP	addr16	Long jump	3	2
SJMP	rel	Short jump (relative addr.)	3	2
JMP	@A + DPTR	Jump inidrect relative to the DPTR	1	2
JZ	rel	Jump if accumulator is zero	2	2
JNZ	rel	Jump if carry flag is not zero	2	2
JC	rel	Jump if carry flag is set	2	2
JNC	rel	Jump if carry flag is not set	2	2
JB	bit, rel	Jump if direct bit is set	3	2
JNB	bit, rel	Jump if direct bit is set	3	2
JBC	bit, rel	Jump if direct bit is set and clear bit	3	2
CJNE	A, direct, rel	Compare direct byte to A and jump if not equal	3	2
CJNE	A, #data, rel	Compare immediate to A and jump if not equal	3	2
CJNE	Rn, #data, rel	Compare immed. to reg. and jump if not equal	3	2
CJNE	@Ri, #data, rel	Compare immed. to ind. and jump if not equal	3	2
DJNZ	Rn, rel	Decrement register and jump if not zero	2	2
DJNZ	direct, rel	Decrement direct byte and jump if not zero	3	2
NOP		No operation	1	1

Program 1: 16 - bit addition

Objective

To perform 16-bit addition of the two 16-bit data using immediate addressing and store the result in memory.

Theory :

As there is only one 16- bit register in 8051, 16-bit addition is performed by using ADDC instruction twice, i.e adding LSD first and MSD next.

Example

The program is to add the 16-bit data 1234 with the data 5678 and store the result at the locations 4150 and 4151 using immediate addressing.

Result : (4150) = AC (LSB); (4151) = 68 (MSB)

DATAL1 = 34; DATAL2 = 78

DATAM1 = 12; DATAM2 = 56

DATAM1 - MSD OF DATA1,

DATAM2 - MSD OF DATA2,

DATA1 - LSD OF DATA1,

DATA2 - LSD OF DATA 2,

Flowchart:

Program for 16 bit addition (refer manual)

16- Bit Addition

↓

Start

↓

(A) = MSB of I Operand

↓

ADD (A) with MSB of II operand

↓

Store MSB of result in memory

↓

(A) = LSB of II operand

↓

ADD (A) with LSB of II operand

↓

Store LSB of result in memory

↓

Stop

Program :

```
CLR         C
MOV         A, #DATAL1
ADDC        A, #DATAL2
MOV         DPTR, # 4150
MOVX        @DPTR, A
INC         DPTR
MOV         A, #DATAM1
ADDC        A, #DATAM2
MOVX        @DPTR, A
HLT : SJMP  HLT
```

Object codes

Memory addresses	Object codes	Mnemonics
4100	C3	CLR C
4101	74	MOV A,#DATAL1
4102	34	
4103	34	ADDC. A, #DATAL2
4104	78	
4105	90	MOV DPTR, #4150
4106	41	
4107	50	
4108	F0	MOVX @DPTR, A
4109	A3	INC DPTR
410A	74	MOV A, #DATAM1
410B	12	
410C	34	ADDC A, #DATAM1
410D	56	
410E	F0	MOVX @DPTR,A
410F	80	
4110	FE	HERE, SJMP HERE

Program 2 - 8 bit subtraction

Objective

To perform subtraction of two 8-bit data using immediate addressing and store the result in memory.

Theory

Using the accumulator, subtraction is performed and the result is stored. Immediate addressing is employed. The SUBB instruction writes the result in the accumulator.

Example

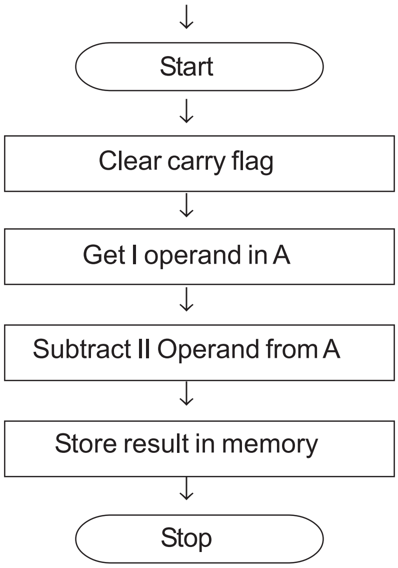
Sample data : DATA1 = 20

DATA 2 = 10

Result : (4500) = 10

Flow chart

8 - bit subtraction



CLR	C
MOV	A, #DATA1
SUBB	A, #DATA2
MOV	DPTR, #4500
MOVX	@DPTR, A
Here : SJMP	Here

Object codes

Memory addresses	Object codes	Mnemonics
4100	C3	CLR C
4101	74	MOV A,#DATAL1
4102	20	
4103	94	SUBB A, #DATAL2
4104	10	
4105	90	MOV DPTR, #4500
4106	45	
4107	00	
4108	F0	MOVX @DPTR, A
4109	80	Here: SJMP here
410A	FE	

Procedure

i Enter the op codes and data in the trainer

ii Execute the program and verify for results

iii Change data and see that correct results are obtained.

Exercises

i. Subtract the contents of location 4500 from the contents of location 4501 and store the result at location 4600.

Sample data : (4500) = 56

(4501) = 6A

Result : (4600) = 14

ii. Perform the same subtraction using two's complement addition.

Program 3 - 8 bit multiplication

Objective

To obtain the product of two 8-bit data using immediate addressing and store the result in memory.

Theory

The 8051 has a "MUL" instruction unlike many other 8-bit processors. MUL instruction multiplies the unsigned eight - bit integers in A and B. The low - order byte of the product is left in A and the high- order byte in B. If the product is > 255, the overflow flag is set. Otherwise it is cleared. The carry flag is always cleared.

Example

Let us multiply the contents of registers A and B and store the 16-bit result at locations 4500 and 4501.

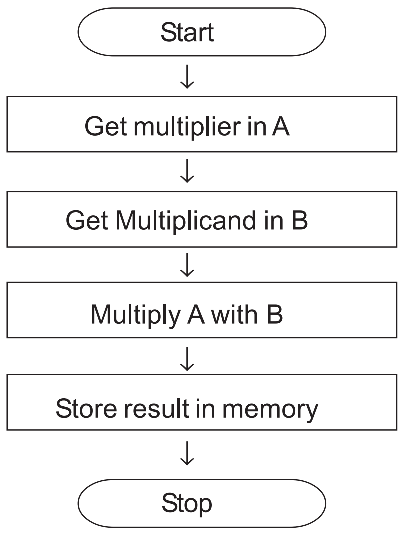
Sample data : DATA 1= 0A

DATA2 = 88

(4500) = 50 (LSB)

(4501) = 05 (MSB)

8-bit Multiplication



Program

MOV	A, #DATA1
MOV	B, #DATA2
MUL	AB
MOV	DPTR, #4500
MOVX	@DPTR, A

INC	DPTR
MOV	A, B
MOVX	@DPTR, A
Here : SJMP	Here

Object codes

Memory address	Object codes	Mnemonics
4100	74	MOV A,#DATAL1
4101	0A	
4102	75	MOV A,#DATAL2
4103	F0	
4104	88	
4105	A4	MUL AB
4106	90	MOV DPTR, # 4500
4107	45	
4108	00	
4109	F0	MOVX @DPTR, A
410A	A3	INC DPTR
410B	E5	MOV A, B
410C	F0	
410D	F0	MOVX, @DPTR, A
410E	80	Here : SJMP here
410F	FE	

Procedure

i. Enter the above opcode from 4100

ii. Execute the program; see that the result is stored correctly.

iii. Change data and check if the results are correct each time.

Exercises

i. Obtain the square of a number stored in memory

Sample : (4500) = 0A

Result : (4600) = 64

ii. Obtain the fourth power of 08 using MUL instruction and store the result in memory.

Result : (4500) = 10 (MSB)

(4501) = 00 (LSB)

iii. Do a decimal multi - byte addition in 32-bit and store the result in memory.

Data : (4500) = 04 - Count

(4551) = 99 - First number

(4552) = 99

(4553) = 99

(4554) = 99

(4561) = 99 - Second number

(4562) = 99

(4563) = 99

(4564) = 99

Result : (4570) = 98

(4571) = 99

(4572) = 99

(4573) = 99

(4574) = 01

Program 4 - 8 bit division

Objective

To divide an 8-bit number by another 8-bit number and store the quotient and remainder in memory.

Theory

The 8051 has a “DIV” instruction unlike many other 8-bit processors. DIV instruction divides the unsigned eight - bit integer in A by unsigned 8-bit integer in register B. The accumulator receives the integer part of the quotient and register B receives the integer remainder. The carry and flags will be cleared.

Example

Let the divisor and dividend be in registers B and A respectively.

Data : DATA 1 = 65 - Dividend

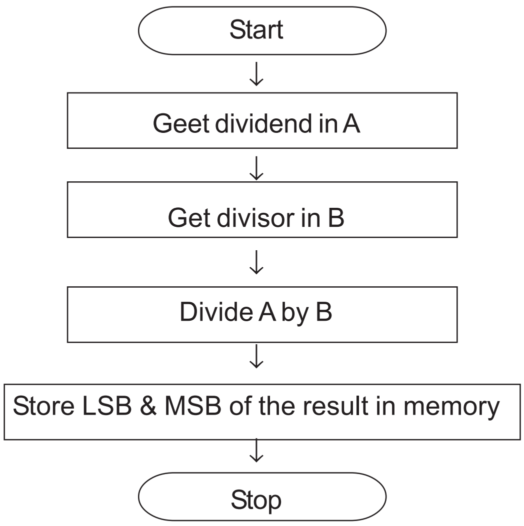
DATA2 = 08 - Divisor

Result : (4500) = 0C - Quotient

(4501) = 05= Remainder

Flow Chart

8 bit by 8- bit division



Program

```
MOV    A, #DATA1 ; Load Acc. with dividend
MOV    B # DATA2 ; Load Reg. B with divisor
DIV    AB
MOV    DPTR, # 4500
MOVX   @DPTR, A ; Store quotient at 4500
INC    DPTR
MOV    A, B ; Store remainder at 4501
MOVX   @DPTR, A
HLT : SJMP HLT
```

Object codes

Memory address	Object codes	Mnemonics
4100	74	MOV A,#DATAL1
4101	65	
4102	75	MOV B,#DATAL2
4103	F0	
4104	08	
4105	84	DIV AB
4106	90	MOV DPTR, # 4500
4107	45	
4108	00	
4109	F0	MOVX @DPTR, A
410A	A3	INC DPTR
410B	E5	MOV A, B
410C	F0	
410D	F0	MOVX, @DPTR, A
410E	80	Here : SJMP here
410F	0E	
4110	41	

Procedure

i. Enter the opcodes and the data in the trainer

ii. Execute the program and check for results

iii. Change data and check for the corresponding results.

Discussion

One's complement is nothing but the logical operation 'NOT' In this example, the CPL instruction has been employed . Since the two's complement of a number is its one's complement +1, by INC instruction has been employed. It can also be performed by adding 1 to one's complement number by using ADD instruction.

Exercise

i) Obtain the one's and two's complement of the data 77 and store it in memory.

Result : One's complement (4500) = 88

Two's complement (4501) = 89

Timer on the microcontroller kit

Objectives : At the end of this lesson you shall be able to
- **Explain the function of timer is 8051**
- **design a delay program using timer in microcontroller kit.**

The 8051 microcontroller has two independent 16 bit up counting timers named timer 0 and timer 1 and this article is about generating time delays using the 8051 timers. Generating delay using pure software loops have been already discussed here but such delays are poor in accuracy and cannot be used in sensitive applications. Delay using timer is the most accurate and surely the best method.

A timer can be generalized as a multi - bit counter which increments / decrements itself on receiving a clock signal and produces an interrupt signal up on roll over. When the counter is running on the processor's clock, it is called a "Timer", which counts a predefined number of processor clock pulses and generates a programmable delay. When the counter is running on an external clock source (may be periodic or aperiodic external signal) it is called a "counter" itself and it can be used for counting external events.

In 8051, the oscillator output is divided by 12 using a divide by 12 network and then fed to the timer as the clock signal. That means for an 8051 running at 12 MHz, the timer clock input will be 1 MHz. That means the timer advances once in every 1µS and the maximum time delay possible using a single 8051 timer is (2^{16}) x (1µS) = 65536µS. Delays longer than this can be implemented by writing up a basic delay program using timer and then looping it for a required number of time. We will see all these in detail in next following sections.

Designing a delay program using 8051 timers

While designing delay programs in 8051, calculating the initial value that has to be loaded in to TH and TL registers forms a very important thing. Let us see how it is done.

Assume the processor is clocked by a 12MHz crystal.

That means, the timer clock input will be 12MHz/12=1MHz

That means, the time taken for the timer to make one increment = 1/1MHz= 1µs.

For a time delay of "X" µS the timer has to make "X" increments.

2^{16}= 65536 is the maximum number of counts possible for a 16 bit timers.

Let TH be the value that has to be loaded to TH registed and TL be the value that has to be loaded to TL register.

Then, THTL = Hexadecimal equivalent of (65536-X) where (65536-X) is considered in decimal.

Example

Let the required delay be 1000 μS =(ie; 1mS)

That means X = 1000

65536- X = 65536 - 1000 = 64536

645536 is considered in decimal and converting it to hexadecimal gives FC18

That means THTL = FC18

Therefore TH=FC and TL = 18

Program for generating 1mS delay using 8051 timer

The program shown below can be used for generating 1mS delay and it is written as a subroutine so that you can call it anywhere in the program. Also you can put this in a loop for creating longer time delays (multiples of 1ms). Here timer 0 of 8051 is used and it is operating in MODE1 (16 bit timer).

Delay : MOV TMOD< #0000001B/ Sets timer 0 to MODE1 (16 bit timer). Timer 1 is not used

MOV TH0, #0FCH // TH0 register with FCH

MOV TL0, #018H // Loads TL0 register with 18H

SETB TR0 // Starts the timer 0

Here : JNB TF0, Here// Loops here until TF is set (ie ; until roll over)

CLR TR0 // Stops timer 0

CLR TF0 // Clear TF0 flag

RET

The above delay routine can be looped twice in order to get a 2mS delay and it is shown in the program below.

Main : MOV R6, #2D

LOOP : ACALL DELAY

DJNZ R6, LOOP

SJMP Main

Delay : MOV TMOD, #00000001B

MOV TH0, #0FCH

MOV TL0, #018H

SETB TR0

Here : JNB TF0, here

CLR TR0

CLR TF0

RET

Few points to remember while using timers

- Once timer flag (TF) is set, the programmer must clear it before it can be set again
- The timer does not stop after the timer flag is set. The programmer must clear the TR bit in order to stop the timer.
- Once the timer overflows, the programmer must reload the initial start values to the TH and TL registers to begin counting up from.
- We can configure the desired timer to create an interrupt when the TF flag is set.
- IF interrupt is not used, then we have to check the timer flag (TF) is set using some conditional branching instruction.
- Maximum delay possible using a single 8051 timer is 65536μS and minimum is 1 μS provided that you are using a 12MHz crystal for clocking the microcontroller.

Application of 8051 (motor, traffic control)

Objectives : At the end of this lesson you shall be able to
- **explain the application of 8051 microcontroller**
- **design the circuit to control of DC motor using 8051.**

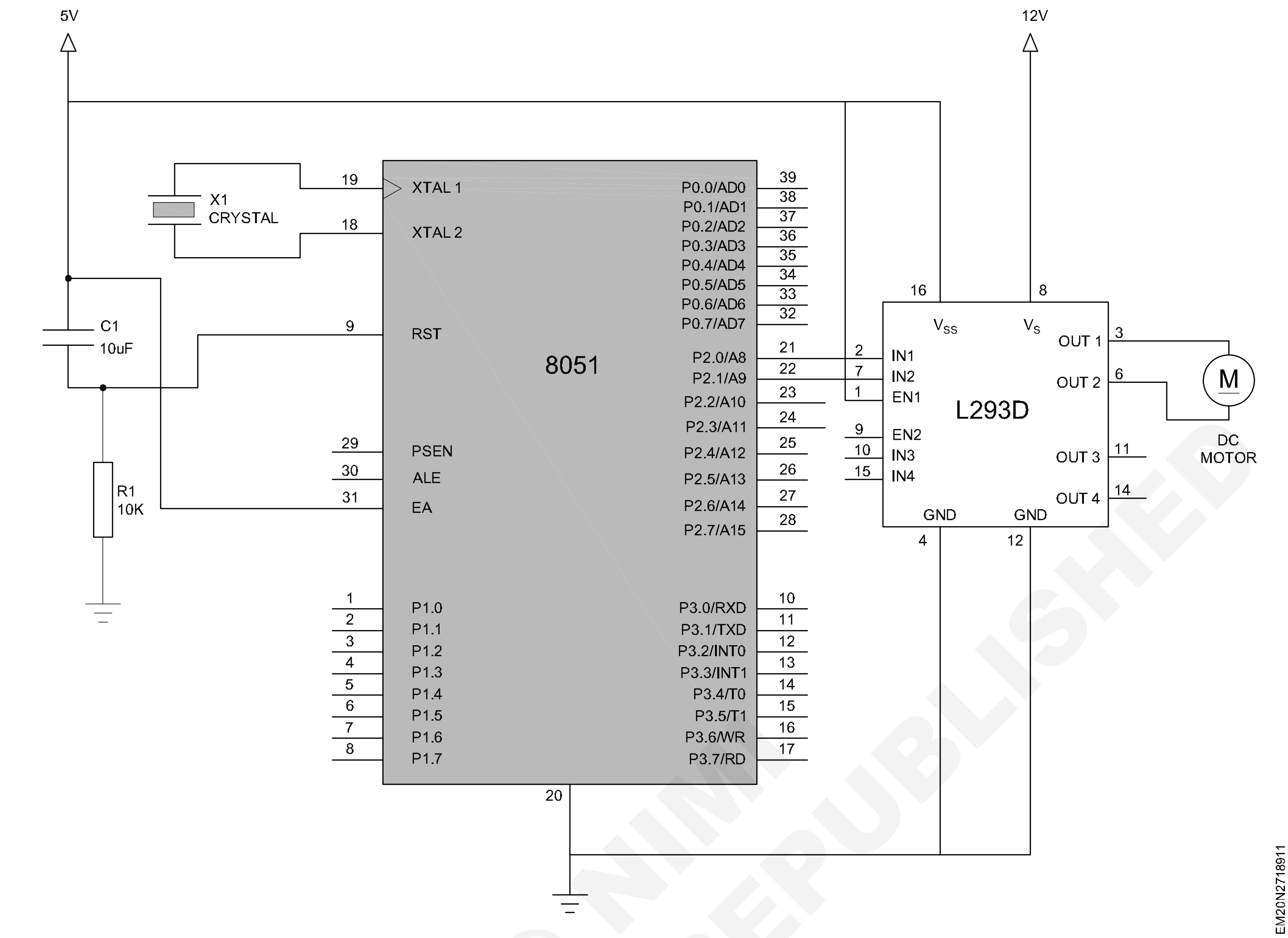
Application of 8051 microcontroller

A microcontroller is a versatile chip which can be used in various fields starting from simple consumer electronics to high end medical, automobile and defense application also. So now a day the microcontrollers are found in every walk of life.

Interfacing DC motor to 8051 using L293D

A DC motor runs in response to the applied DC current. It prodcues torque by using both electric and magnetic field. The DC motor has rotor, stator, field magnet brushes, shaft, commutator etc., The DC motor required large currents of the order of 400 mA for its rotation. But this much amount of current cannot be generated by the ports of the microcontroller. So if it is directly connect the DC motor to the ports of the controller it may draw high current for its operation from the port and hence the microcontroller may be damaged. So we use a driving circuit along with opto isolator provides an additional protection to the microcontroller from large currents. (Fig 1)

Fig 1



Assembly language program to control DC motor using 8051

ORG	0000H		Remarks
Main	Set B	P1.2	
	MOV	P1, # 00000001B	Motor runs in clockwise
	ACALL	Delay	
	MOV	P1, #00000010B	Motor runs in anticlockwise
	ACALL	Delay	
	SJMP	Main	Motor rotates continuously in clockwise for some time and anticlockwise for some time
Delay	MOV	R4, # FFH	Load R4 register with FF
	MOV	R3, #FFH	Load R3 register with FF
LOOP1	DJNZ	R3, LOOP1	Decrement R3 until it is zero
LOOP2	DJNZ	R4, LOOP2	Decrement R4 until it is zero
	RET		Return to the main program

Traffic light control

Traffic lights, which may also be known as stop lights, traffic lamps, traffic signals, signal lights, robots or semaphore, are signaling devices positioned at road intersections, pedestrian crossings and other locations to control competing flows of traffic.

Interfacing traffic light with 8051

The traffic light controller section consists of 12 Nos. point LEDS are arranged by 4 lanes in PS/8051 trainer kit. Each lane has go (green), listen (yellow) and stop (red) LED is being placed (Refer Fig 2).

About the colors of traffic light control

Traffic lights alternate the right of way of road users by displaying lights of a standard color (red, yellow/amber, and green), using a universal color code (and a precise sequence to enable comprehension by those who are color blind). In the typical sequence of colored lights.

Illumination of the green light allows traffic to proceed in the direction denoted.

Illumination of the yellow/ amber light denoting, if safe to do so, prepare to stop short of the intersection, and

Illumination of the red signal prohibits any traffic from proceeding.

Usually, the red light contains some orange in its hue, and the green light contains some blue, for the benefit of people with red - green color blindness, and "green" lights in many areas are in fact blue lenses on a yellow light (which together appear green)

PIN assignment with 8051

LAN direction	8051 lines	Modules
South	P1.0 P1.1 P1.2	Go Listen Stop
East	P1.3 P1.4 P1.5	Go Listen Stop
North	P1.6 P1.7 P3.0	Go Listen Stop
West	P3.1 P3.2 P3.3	Go Listen Stop
PWR	13-16 17,19 18, 20	NC Vcc GND

Assembly program to interface traffic light

Opcode **Mnemonics**

Title :

Program to interface

Traffic light with 8051

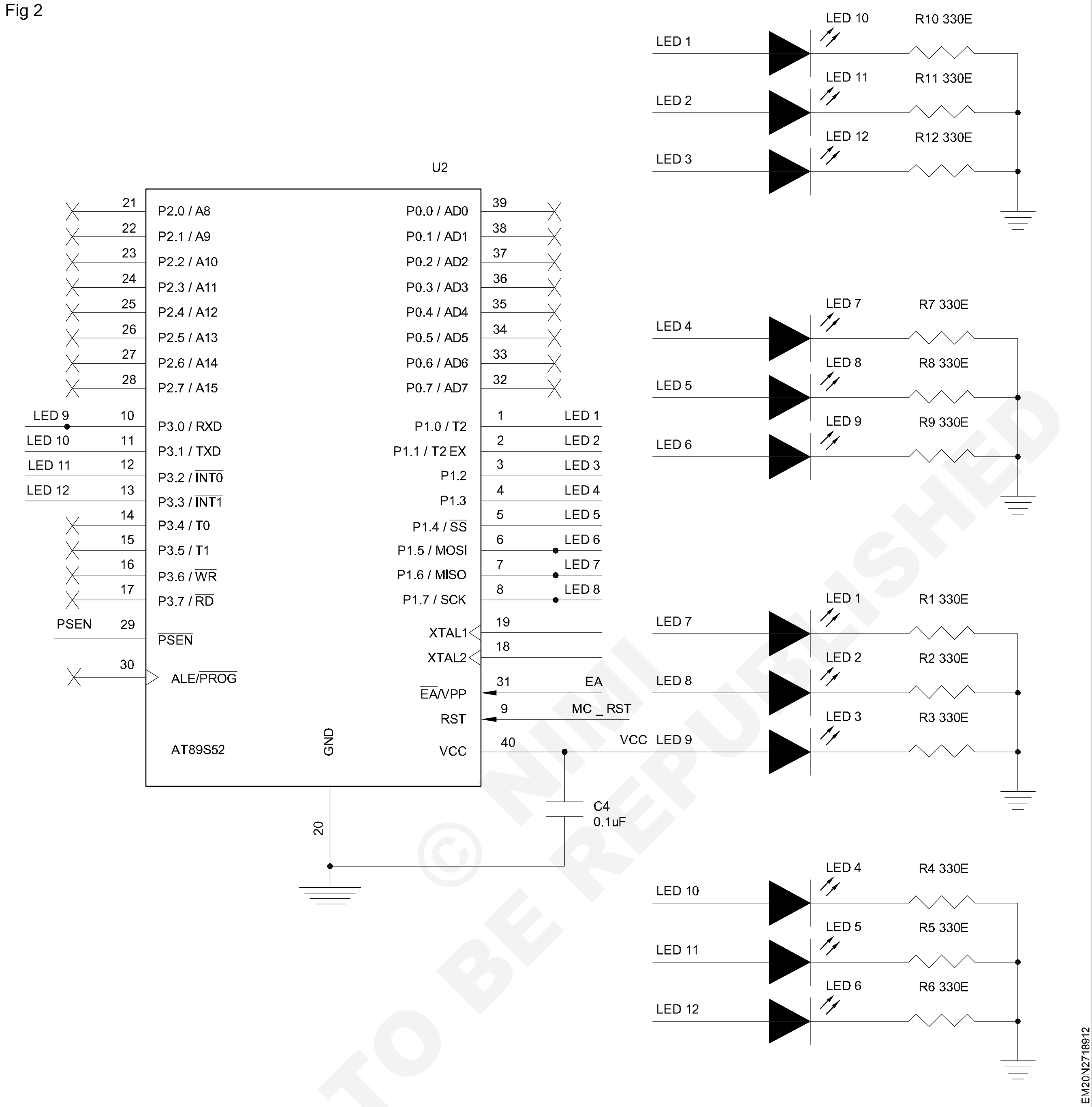
CNTL PORT : 4003

PORT A : 4000

PORT B : 4001

Memory Address	Opcode	Mnemonics
8500	90 85 45	Start : MOV DPTR, # TRE
8503	7A 0C	MOV R2, #0C
8505	E0	MOVX @DPTR, A
8506	C0 83	PUSH DPH
8508	C0 83	PUSH DPL
850A	90 40 03	MOV DPTR, #CNTL PORT
850D	F0	MOVX @DPTR, A
850E	D0 82	POP DPL
8510	D0 82	POP DPL
8512	A3	INC DPTR
8513	E0	LOOP 1: MOVX @DPTR, A
8514	C0 83	PUSH DPH
8516	C0 82	PUSH DPL
8518	90 40 00	MOV DPTR, # PORTA
851B	F0	MOVX @ DPTR, A
851C	D0 82	POP DPL
851E	D0 83	POP DPH
8520	A3	INC DPTR
8521	E0	MOVX @DPTR, A
8522	C0 83	PUSH DPH
8524	C0 82	PUSH DPL
8526	90 40 01	MOV DPTR, #PORT B
8529	F0	MOVX @DPTR, A
852A	12 85 36	LCALL DELAY
852D	D0 82	POP DPL
852F	D083	POP DPH
8531	A3	INC DPTR
8532	DA DF	DJNZ R2, LOOP 1
8534	80 CA	SJMP START
8536	7F 10	DELAY: MOV R7, # 10H
8538	7D FF	LOOP P3, MOV R6, # 0FFH
853C	00	LOOP2 : NOP
853D	00	NOP
853E	DE FC	DJNZ R6, LOOP2
8540	DD F8	DJNZ R5, LOOP3
8542	DF F4	DJNZ R7, LOOP4
8544	22	RET

Fig 2



TRE: 8545

8545	21H, 09H, 10H, 00H (South way)
8549	0CH, 09H, 80J, 00H (East way)
854D	64H, 08H, 00H, 04H (North way)
8551	24H, 03H, 02H, 00H (West way)
8555	End

Note: The schematics sections given is, traffic light connected to port 1 and port 3 the sample program is given based on 8255

Different types of Level Sensors and their workings

Objectives : At the end of this lesson you shall be able to
- **define the transducers, sensors and basics of passive & active transducers**
- **explain thermistor, its types and construction details**
- **describe the working principle, features, applications, advantage & disadvantages.**

Transducers and sensors

Transducer

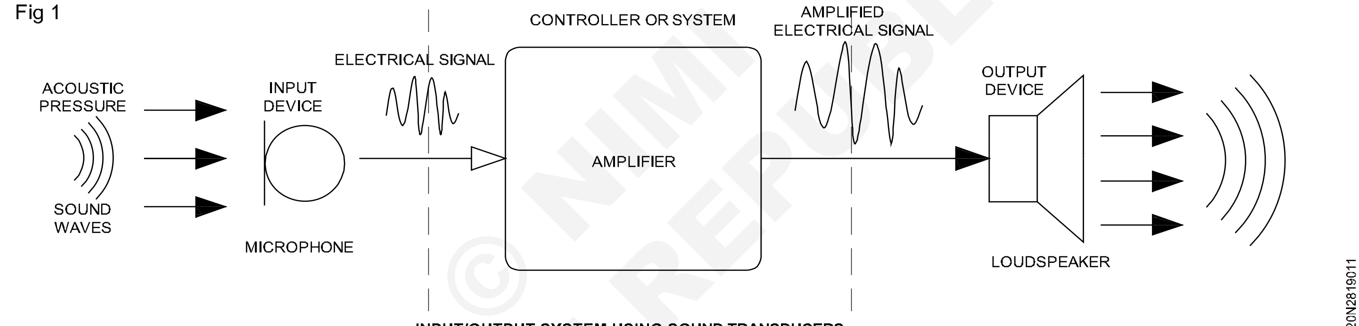
A transducer is a device that is used to convert a physical quantity into its corresponding electrical signal or vice versa. In most of the electrical systems, the input signal will not be an electrical signal, but a non-electrical signal. This will have to be converted into its corresponding electrical signal if its value is to be measured using electrical methods.

Sensor: Devices which perform an "Input" function are commonly called Sensors because they "sense" a physical change in some characteristic that changes in response to some excitation, for example heat or force is converted into an electrical signal.

There are different types of Sensors and Transducers, both analogue & digital and input & output available to choose from. The type of input or output transducer being used, really depends upon the type of signal or process being "Sensed" or "Controlled" but we can define a sensor and transducers as devices that converts one physical quantity into another.

Simple Input/ Output System using Sound Transducers as shown in Fig. 1

Fig 1



INPUT/OUTPUT SYSTEM USING SOUND TRANSDUCERS

There are different types of sensors and transducers available in the market, and the choice of which one to use really depends upon the quantity being measured or controlled. The more common types given in the table 1.

Table 1

Physical quantity being measured by the sensor	Input Device (Sensor)	Output Device (Actuator)
Light Level	Light Dependent Resistor (LDR) Photodiode, Photo-transistor Solar Cell	Lights & Lamps LED's & Displays Fibre Optics
Temperature	Thermocouple, Thermistor, Thermostat, Resistive Temperature Detectors	Heater, Fan
Force/Pressure	Strain Gauge, Pressure Switch Load Cells	Lifts & Jacks Electromagnet, Vibration
Position	Potentiometer, Encoders Reflective/Slotted Opto-switch LVDT	Motor, Solenoid Panel Meters
Speed	Tacho-generator, Reflective/Slotted Opto-coupler, Doppler Effect Sensors	AC and DC Motors Stepper Motor, Brake
Sound	Carbon Microphone, Piezo-electric Crystal	Bell Buzzer, Loudspeaker

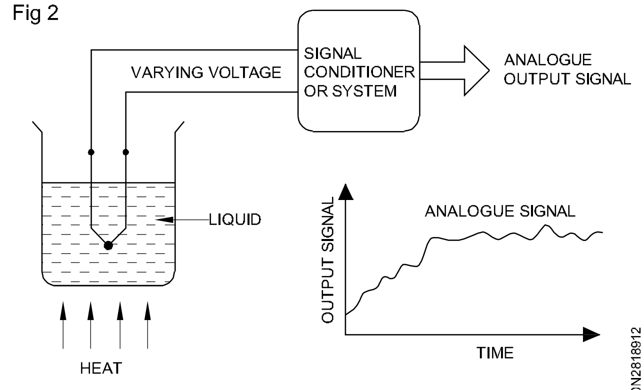
Analogue and Digital Sensors

Analogue Sensors

Analogue Sensors produce a continuous output signal or voltage which is generally proportional to the quantity being measured. Physical quantities such as Temperature, Speed, Pressure, Displacement, Strain etc are all analogue quantities as they tend to be continuous in nature. For example, the temperature of a liquid can be measured using a thermometer or thermocouple which continuously responds to temperature changes as the liquid is heated up or cooled down. as shown in Fig. 2

Thermocouple used to produce an Analogue Signal

Fig 2



THERMOCOUPLE USED TO PRODUCE AN ANALOGUE SIGNAL

Analogue sensors tend to produce output signals that are changing smoothly and continuously over time. These signals tend to be very small in value from a few mico-volts (uV) to several milli-volts (mV), so some form of amplification is required. Then circuits which measure analogue signals usually have a slow response and/or low accuracy. Also analogue signals can be easily converted into digital type signals for use in micro-controller systems by the use of analogue-to-digital converters (ADCs).

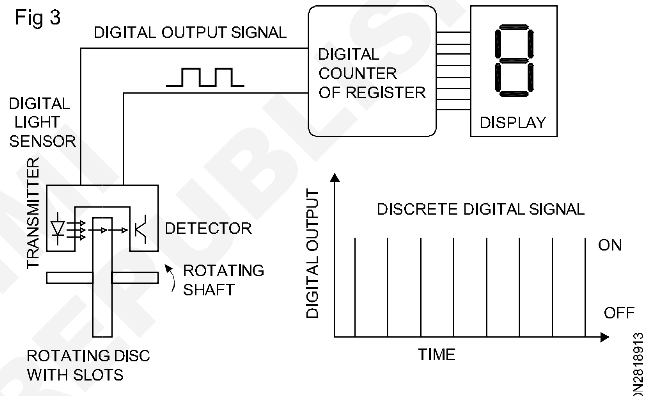
Digital Sensors

As its name implies, **Digital Sensors** produce a discrete digital output signals or voltages that are a digital representation of the quantity being measured. Digital sensors produce a **Binary** output signal in the form of a logic "1" or a logic "0", ("ON" or "OFF"). This means then that a digital signal only produces discrete (non-continuous) values which may be outputted as a single "bit", (serial transmission) or by combining the bits to produce a single "byte" output (parallel transmission).

Light Sensor used to produce an Digital Signal

In our simple example as shown fig.3 the speed of the rotating shaft is measured by using a digital LED/Opto-detector sensor. The disc which is fixed to a rotating shaft (for example, from a motor or robot wheels), has a number of transparent slots within its design, As the disc rotates with the speed of the shaft, each slot passes by the sensor in turn producing an output pulse representing a logic "1" or logic "0" level.

Fig 3



LIGHT SENSOR USED TO PRODUCE AN DIGITAL SIGNAL

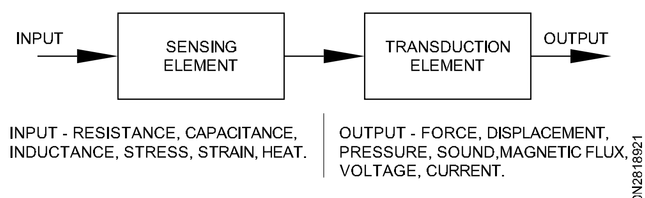
Basics of passive and active transducers

Objectives : At the end of this lesson you shall be able to
- **define the classification of the transducers**
- **explain the various type of passive and active transducers**
- **describe the procedure for selection of transducers.**

A transducer is a device that is used to convert a physical quantity into its corresponding electrical signal. In most of the electrical systems, the input signal will not be an electrical signal, but a non-electrical signal. This will have to be converted into its corresponding electrical signal if its value is to be measured using electrical methods.

A transducer will have basically two main components. They are as shown in Fig. 1

Fig 1



TRANSDUCTION BLOCK DIAGRAM

Sensing Element : The physical quantity or its rate of change is sensed and responded to by this part of the transistor.

Transduction Element : The output of the sensing element is passed on to the transduction element. This element is responsible for converting the non-electrical signal into its proportional electrical signal.

There may be cases when the transduction element performs the action of both transduction and sensing.

Different Types of Level Sensors and their Workings

A level sensor is one kind of device used to determine the liquid level that flows in an open system or closed system The level measurements can be available in two types namely continuous measurements and point level measurements. The continuous level sensor is used to measure the levels to a precise limit whereas point level sensors used to determine the level of liquid whether that is high or low.

Fig 2

LEVEL SENSORS

EMN3822814

Generally these sensors are connected to an output unit for sending out the results to a monitoring system The present technologies use wireless transmission of information to the monitoring system, which is very useful in important and hazardous locations that cannot be simply accessed by common workers.

Classification of Level sensors

Ultrasonic Level sensors

Level sensors are classified according to their working principle and their applications.

Ultrasonic level sensors are used to detect the levels of sticky liquid substances and bulkiness materials as well. They are worked by producing audio waves at the range of frequency from 20 to 200 kHz. These waves are then replicated back to a transducer The ultrasonic level sensors are used to control the liquid level, fine-grained solids within mining and powders, food and beverage industries and chemical processing

Capacitance Level Sensors

These sensors are used to detect the liquid levels like slurries and aqueous liquids They are operated by using a probe for checking level changes. These level changes are transformed into an along signals. The probes are generally made of conducting wire by PTFE insulation But stainless steel probes are extremely response and hence they are appropriate for measuring non-conductive substance granular or materials with low dielectric constant. These types of sensors are very simple to use and clean as they do not have any moving components.

They are commonly used in applications like Tank level monitoring in chemical, water treatment, food, battery industries and involving high pressure and temperature.

Optical Level Sensors

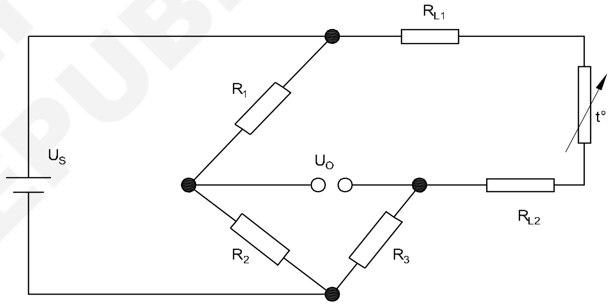
Optical level sensors are used to detect liquid including poised materials, interface between two immiscible liquids and the occurrence of sediments. They are working based on the changes of transmission in infrared light emitted from an IR LED. The interference from the produced light can be reduced by using a high energy IR diode and pulse modulation methods.

Continuous optical level sensors, on the other hand, use the highly internes laser light that can infuse dusty environments and notice liquid substances. They are commonly used in applications like leak detection and tank level measurement

RTD Configuration

An RTD can be connected in a two, three or four-wire configuration. The two-wire configuration is the simplest and also the most error prone. In this setup, the RTD is connected by two wires to a Wheatstone bridge circuit and the two output voltage is measured. The disadvantage of this circuit is that the two connecting lead wire resistances add directly two RTD's resistance and error is incurred.

Fig 3



EM20N2818923

Classification of transducers (Passive & Active)

1. Passive Type Transducers

a) Resistance Variation Type

Resistance Strain Gauge - The change in value of resistance of metal semi-conductor due to elongation or compression is known by the measurement of torque, displacement or force.

Resistance Thermometer / Resistance Temperature Detector (RTD) - The change in resistance of metal wire due to the change in temperature known by the measurement of temperature

Resistance Hygrometer - The change in the resistance of conductive strip due to the change of moisture content is known by the value of its corresponding humidity.

Hot Wire Meter - The change in resistance of a heating element due to convection cooling of a flow of gas is known by its corresponding gas flow or pressure.

Photoconductive Cell - The change in resistance of a cell due to a corresponding change in light flux is known by its corresponding light intensity.

Thermistor - The change in resistance of a semi-conductor that has a negative co-efficient of resistance is known by its corresponding measure of temperature.

Potentiometer Type - The change in resistance of a potentiometer reading due to the movement of the slider as a part of an external force applied is known by its corresponding pressure or displacement.

b) Capacitance Variation Type

Variable Capacitance Pressure Gauge - The change in capacitance due to the change of distance between two parallel plates caused by an external force is known by its corresponding displacement or pressure.

Dielectric Gauge - The change in capacitance due to a change in the dielectric is known by its corresponding liquid level or thickness.

Capacitor Microphone - The change in capacitance due to the variation in sound pressure on a movable diaphragm is known by its corresponding sound.

c) Inductance Variation Type

Eddy Current Transducer - The change in inductance of a coil due to the proximity of an eddy current plate is known by its corresponding displacement or thickness.

Variable Reluctance Type - The variation in reluctance of a magnetic circuit that occurs due to the change in position of the iron core or coil is known by its corresponding displacement or pressure.

Proximity Inductance Type - The inductance change of an alternating current excited coil due to the change in the magnetic circuit is known by its corresponding pressure or displacement.

Differential Transformer - The change in differential voltage of 2 secondary windings of a transformer because of the change in position of the magnetic core is known by its corresponding force, pressure or displacement.

Magnetostrictive Transducer - The change in magnetic properties due to change in pressure and stress is known by its corresponding sound value, pressure or force.

d) Voltage and Current Type

Photo-emissive Cell - Electron emission due to light incidence on photo-emissive surface is known by its corresponding light flux value.

Hall Effect - The voltage generated due to magnetic flux across a semi-conductor plate with a movement of current through it is known by its corresponding value of magnetic flux or current.

Ionisation Chamber - The electron flow variation due to the ionisation of gas caused by radio-active radiation is known by its corresponding radiation value.

2. Active Type

Photo-voltaic Cell - The voltage change that occurs across the p-n junction due to light radiation is known by its corresponding solar cell value or light intensity.

Thermocouple - The voltage change developed across a junction of two dissimilar metals is known by its corresponding value of temperature, heat or flow.

Piezoelectric Type - When an external force is applied on to a quartz crystal, there will be a change in the voltage generated across the surface. This change is measured by its corresponding value of sound or vibration.

Moving Coil Type - The change in voltage generated in a magnetic field can be measured using its corresponding value of vibration or velocity.

Selection of Transducer

Selection of a transducer is one of the most important factors which help in obtaining accurate results. Some of the main parameters are given below.

- Selection depends on the physical quantity to be measured.
- Depends on the best transducer principle for the given physical input
- Depends on the order of accuracy to be obtained
- Based on whether the transducer is active or passive.

Characteristic of transducer

All transducers, irrespective of their measurement requirements, exhibit the same characteristics such as range, span, etc.

Thermistors

Objectives : At the end of this lesson you shall be able to
- **define thermistor and its types**
- **define construction and working principle, salient features of the thermistor**
- **describe the application, advantages & disadvantages.**

Thermistor:

A thermistor is a resistance thermometer, or a resistor whose resistance is dependent on temperature. The term is a combination of "thermal" and "resistor". It is made of metallic oxides, pressed into a bead, disk, or cylindrical shape and then encapsulated with an impermeable material such as epoxy or glass.

A thermistor is a temperature sensor constructed of semiconductor material that exhibits a large modification in resistance in proportion to a tiny low modification in temperature. Thermistor is inexpensive, rugged, and reliable and responds quickly. Because of these qualities thermistors are used to measure simple temperature measurements, but not for high temperatures. Thermistor is easy to use, cheap, and durable and responds predictably to a change in temperature. Thermistors are mostly used in digital thermometers and home appliances such as refrigerator, ovens, and so on. Stability, sensitivity and time constant are the final properties of thermistor that create these thermistors sturdy, portable, cost-efficient, sensitive and best to measure single-point temperature. Thermistors are available in different shapes like rod, disc, bead, washer, etc. This article gives an overview of thermistor working principle and applications.

Types of thermistor:

There are a number of ways in which thermistors can be categorised into the different thermistor types. The first is dependent upon the way they react to heat. Some increase their resistance with increasing temperature, while others exhibit a fall in resistance.

It is possible to use a very simplified equation for the curve of a thermistor to expand this idea:

$$\Delta R = k \times \Delta T$$

Where

ΔR = change in resistance.

ΔT = change in temperature.

k = first-order temperature coefficient of resistance.

In most cases the relationship between temperature and resistance is non-linear, but over small changes a linear relationship can be assumed.

There are two types of thermistor

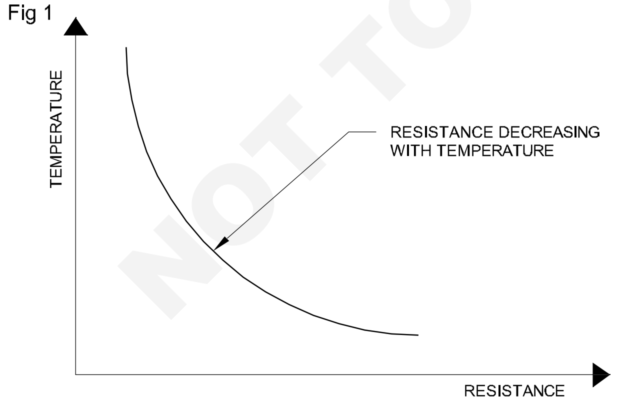
1 Negative Temperature Coefficient (NTC)

2 Positive Temperature Coefficient (PTC)

Negative Temperature Coefficient (NTC):

Negative Temperature Coefficient (NTC) thermistor, when the temperature increases, resistance decreases. Conversely, when temperature decreases, resistance increases as shown in the Fig 1. This type of thermistor is used the most.

Fig 1

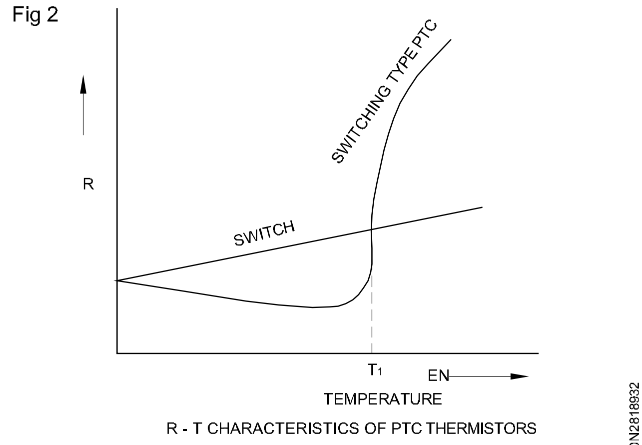


NTC TEMPERATURE VS RESISTANCE CURVE

Positive Temperature coefficient (PTC):

A PTC thermistor works a little differently. When temperature increases, the resistance increases, and when temperature decreases, resistance decreases as shown in the Fig 2.This type of thermistor is generally used as a fuse.

Fig 2

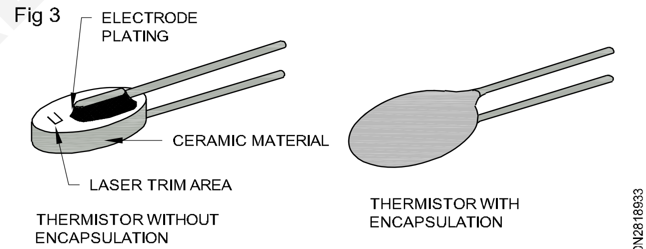


PTC TEMPERATURE VS RESISTANCE

Construction

The device is manufactured from materials like sintered mixtures of oxides of metals such as manganese, nickel, cobalt, and iron. Their resistances range from 0.4 ohms to 75 mega-ohms and they may be fabricated in wide variety of shapes and sizes. Smaller thermistors are in the form of beads of diameter from 0.15 millimeters to 1.5 millimeters. Such a bead may be sealed in the tip of solid glass rod to form probe which is easier to mount than bead. Alternatively thermistor may be in the form of disks and washers made by pressing thermistor material under high pressure into flat cylindrical shapes with diameter from 3 millimeters to 25 millimeters. Washers may be stacked and placed in series or parallel to increase power disciplining capability. As shown in Fig. 3.

Fig 3

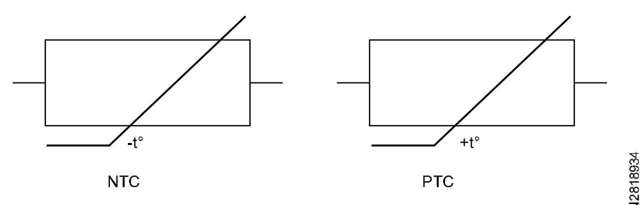


CONSTRUCTION OF THERMISTORS

Working Principle

A thermistor is an inexpensive and easily obtainable temperature sensitive resistor, thermistor working principle is, its resistance is depending upon temperature. When temperature changes, the resistance of the thermistor changes in a predictable way, the benefits of using a thermistor are accuracy and stability, there are two types of thermistors available as NTC and PTC, their symbols are shown in Fig 4.

Fig 4



THERMISTORS SYMBOL

Salient features of thermistor

1 Thermistors are compact, rugged and inexpensive.

2 It exhibit high stability.

3 The response time of thermistor can vary from a fraction of second to minutes, depending on the characteristics and contraction of the thermistor.

4 The response time varies inversely with the dissipation factor.

5 The dissipation factor varies with the degree of thermal isolation of the thermistor.

6 The upper temperature limits is depending on physical changes in the material and the contact materials

7 A low current must be allowed through the thermistor to avoid self heating.

Application

1 Temperature control of air conditioner and refrigerator.

2 Room temperature monitoring

3 Surge Suppression in power lines in SMPS.

4 This device is used to measure the temperature of incubators.

5 NTC thermistors are used to measure and monitor batteries while they are kept for charging.

6 They are used to know the temperature of oil and coolant used inside automotive engines.

Advantages of Thermistor

1 When the resistors are connected in the electrical circuit, heat is dissipated in the circuit due to flow of current. This heat tends to increase the temperature of the resistor due to which their resistance changes. For the thermistor the definite value of the resistance is reached at the given ambient conditions due to which the effect of this heat is reduced.

2 In certain cases even the ambient conditions keep on changing, this is compensated by the negative temperature characteristics of the thermistor. This is quite convenient against the materials that have positive resistance characteristics for the temperature.

3 The thermistors are used not only for the measurement of temperature for the measurement of power etc.

4 They are also used as the controls, overload protectors, giving warnings etc.

5 The size of the thermistors is very small and they are very low in cost. However, since their size is small they have to be operated at lower current levels.

Disadvantages

1 The high resistivity of thermistors is a significant advantage, since it leads to very small errors, which could be even hundred time smaller compared to measurement errors of RTDs.

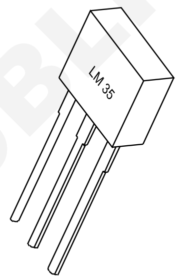
2 In general, thermistors are more fragile than RTDs and thermocouples and therefore require delicate handling and mounting. Another drawback of them is that because they consist of semiconductors, they are more prone to permanent de-calibration (drifting out of their specified tolerance). Contrary to applicability of RTDs and thermocouples, use of thermistors is generally limited to a temperature range of few hundred degrees Celsius.

3 Small mass of thermistors also makes them susceptible to self-heating errors.

Temperature sensor ICs :

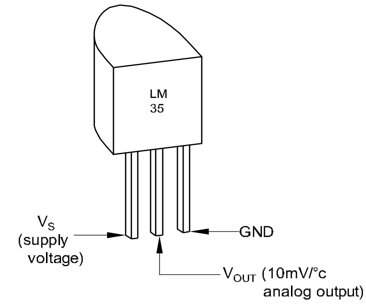
Temperature sensor ICs are classified into different types like voltage output, current output, digital output, resistance output silicon and Diode temperature sensors. Modern semiconductor temperature sensors offer high accuracy and high linearity over an operating range of about 55°C to +150°C. Internal amplifiers can scale the output to convient values, such as 10mV/°C. As an example the LM 35 temperature sensor outline diagram is shown in the Figs 5a and 5b

Fig 5a



EM20N2818937

Fig 5b



EM20N2818938

Feature of LM35 Temperature Sensor:

- Calibrated directly in Celsius.
- Rated for full -55°C to +150°C range
- Suitable for remote applications
- Low cost due to wafer-level trimming
- Operated from 4 to 30 volts
- Low self-heating
- ±1/4°C of typical nonlinearity

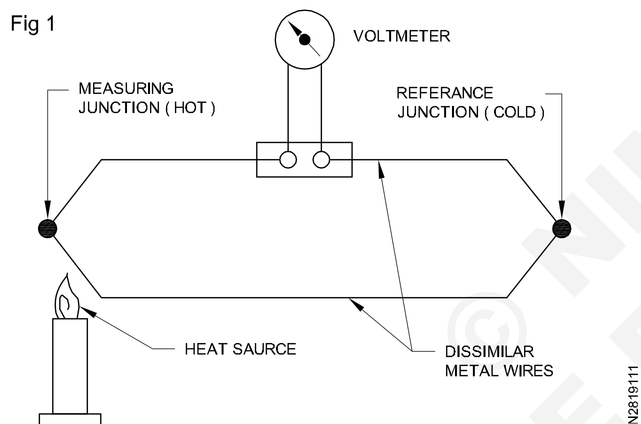
Thermocouple

Objectives : At the end of this lesson you shall be able to
- **define thermocouple and its working principle**
- **explain the various type of thermocouple .**
- **describe the application, advantages & disadvantages**
- **explain the characteristics curve graph of mV Vs temperature measured.**

Thermocouple and its working principle

Thermocouple is a device consisting of two dissimilar conductors or semiconductors that contact each other at one or more points as shown in fig.1. A thermocouple produces a voltage when the temperature of one of the contact points differs from the temperature of another, in a process known as the thermoelectric effect. Thermocouples are a widely used type of temperature sensor for measurement and control and can also convert a temperature gradient into electricity.

Fig 1



THERMOCOUPLE AND ITS WORKING PRINCIPLE

Type of thermocouples

Characteristic functions for thermocouples that reach intermediate temperatures, as covered by nickel alloy thermocouple types E,J,K,M,N,T. Also shown are the noble metal alloy type P, and the pure noble metal combinations gold-platinum and platinum-palladium.

Applications

1 Temperature measurement for kilns, gas turbine exhaust, diesel engines.

2 Temperature measurement of industrial processes and fog machines.

3 For process temperature measurement of Steel, Cement , Petro chemical etc.,

Advantage:

1 Thermocouples are suitable for measuring over a large temperature range, from - 270 up to 3000 °C (for a short time, in inert atmosphere).

2 They are less suitable for applications where smaller temperature differences need to be measured with high accuracy, for example the range 0-100 °C with 0.1 °C accuracy

Disadvantage :

1 Thermocouples measure their own temperature.

2 Thermocouples can error in reading their own temperature, especially after being used for a while, or if the insulation between the wires loses its resistance due to moisture or thermal conditions

3 Beware of electrical hazards using thermocouples, they are electrical conductors. RTD's are less sensitive to electrical noise.

4 Thermocouples DO NOT MEASURE AT THE JUNCTIONS! They can't, it is physically impossible to have a temperature gradient at a point.

5 The distance between thermocouple and heater element will generate a thermal lag which can be compensated by the temperature controller.

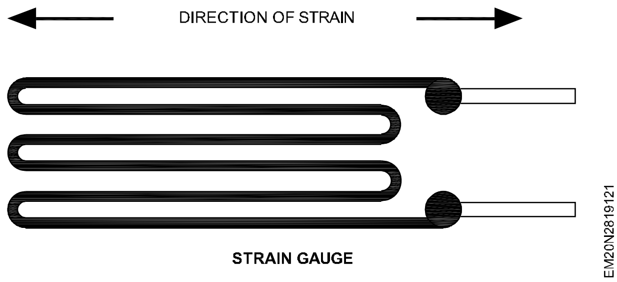
Strain gauges and load cell

Objectives : At the end of this lesson you shall be able to
- **explain the strain gauges and its types**
- **define construction and working principle & gauge factor**
- **explain the load cell and strain gauge load cell**
- **describe the application, advantages and disadvantages.**

Strain Gauges

A strain gauge (or strain gage) is a device used to measure strain on an object. The most common type of strain gauge consists of an insulating flexible backing which supports a metallic foil pattern. The gauge is attached to the object by a suitable adhesive, such as cyanoacrylate. As the object is deformed, the foil is deformed, causing its electrical resistance to change. This resistance change, usually measured using a Wheatstone bridge, is related to the strain by the quantity known as the gauge factor. as shown in Fig 1.

Fig 1



Types of strain gauges

There are four main types of strain gauges: mechanical, hydraulic, electrical resistance, and piezoelectric.

1 Mechanical

2 Hydraulic

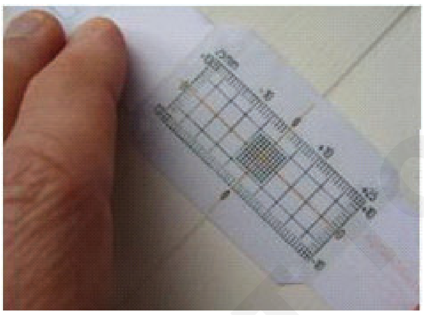
3 Electrical Resistance

4 Piezoelectric

Mechanical strain Gauge

Suppose you have a crack forming in a wall of your home because of subsidence and you want to know if it's getting any worse. Call in the building inspectors and they'll probably glue a piece of tough, plexiglass plastic, ruled with lines and a scale, directly over the crack. Sometimes known as a crack monitor, you'll find it's actually made up of two separate plastic layers. The bottom layer has a ruled scale on it and the top layer has a red arrow or pointer. You glue one layer to one side of the crack and one layer to the other so, as the crack opens, the layers slide very slowly past one another and you can see the pointer moving over the scale. Mechanical strain gauges as shown in Fig 2.

Fig 2

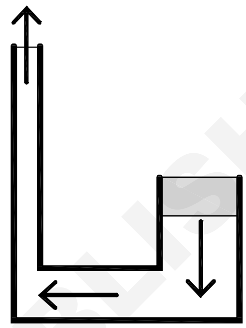


MECHANICAL STRAIN GAUGE

Hydraulic strain Gauge

One of the problems with strain gauges is detecting very small strains. You can imagine, for example, a situation where your house is slowly subsiding but the amount of movement is so small that it won't show up-perhaps until the damage is done. With a simple crack detector such as the ones described above, it takes 1mm of building movement to produce 1mm of movement on the surface of the crack detector. But what if we want to detect movements smaller than this that doesn't show up on a scale? In this case, what we really need is a strain gauge with leverage that amplifies the strain, so even a tiny movement of the detecting element produces a very large and easily measurable movement of a pointer over a scale. Hydraulic detectors offer a solution and work much like simple syringes. Syringes are essentially hydraulic pistons where a small movement of fluid in a large piston (the part you press with your finger) produces a much larger movement of fluid in a small piston attached to it (the needle where the fluid comes out). It's easy to see how this can be used in a strain gauge: you simply connect your large piston to whatever it is that's producing the strain and use a smaller piston in a smaller tube, marked with a scale, to indicate how much movement has occurred. The relative size of the pistons determines how much the movement you're trying to detect is scaled up. Typically, hydraulic strain gauges like this multiply movement by a factor of 10 or so and are commonly used in geology and Earth science. As shown in Fig 3.

Fig 3



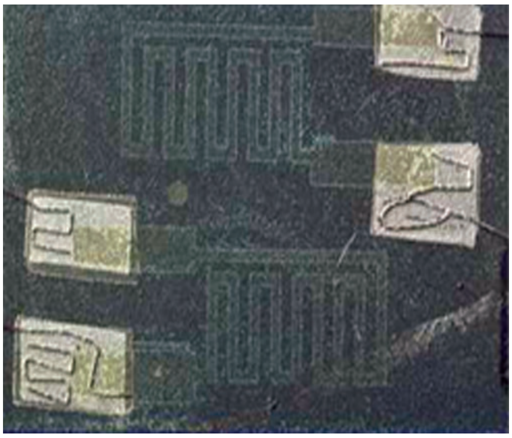
HYDRAULIC STRAIN GAUGE

Electrical Resistance strain gauge

If you're designing something like an airplane wing, typically you need to make far more sophisticated measurements (and many more of them) than a simple mechanical strain gauge will allow. You might want to measure the strain during takeoff, for example, when the engines are producing maximum thrust. You can't go sticking little plastic strain gauges onto the wing and walk out to measure them during a flight! But you can use electrical strain gauges to do much the same thing from a flight recorder in the cockpit.

The most common electrical strain gauges are thin, rectangular-shaped strips of foil with maze-like wiring patterns on them leading to a couple of electrical cables. You stick the foil onto the material you want to measure and wire the cables up to your computer or monitoring circuit. When the material you're studying is strained, the foil strip is very slightly bent out of shape and the maze-like wires are either pulled apart (so their wires are stretched slightly thinner) or pushed together (so the wires are pushed together and become slightly thicker). Changing the width of a metal wire changes its electrical resistance, because it's harder for electrons to carry electric currents down narrower wires. So all you have to do is measure the resistance and, with a bit of calculation, you can calculate the strain. If the forces involved are small, the deformation is elastic and the strain gauge eventually returns to its original shape-so you can keep making measurements over a period of time, such as during the test flight of a prototype plane as shown in Fig 4.

Fig 4



ELECTRICAL RESISTANCE STRAIN GAUGE

Piezoelectric Strain Gauge

Some types of materials, including quartz crystals and various types of ceramics, are effectively "natural" strain gauges. If you push and pull them, they generate tiny electrical voltages between their opposite faces. This phenomenon is called piezoelectricity (pronounced pee-ay-zo electricity) and it's probably best known as a way of generating the timekeeping signal in quartz watches. Measure the voltage from a piezoelectric sensor and you can calculate the strain very simply. Piezoelectric strain gauges are among the most sensitive and reliable and can withstand years of repeated use as shown in Fig 5.

Fig 5

PIEZOELECTRIC STRAIN GAUGE

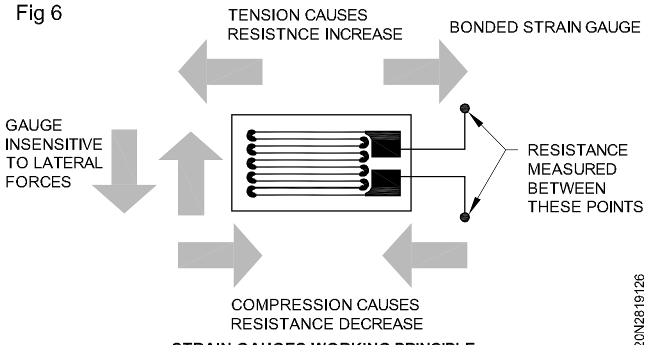
Principle of Working - Strain Gauges

When force is applied to any metallic wire its length increases due to the strain. The more is the applied force, more is the strain and more is the increase in length of the wire. If L1 is the initial length of the wire and L2 is the final length after application of the force, the strain is given as:

$\in = (L_2 - L_1)/L_1$

Further, as the length of the stretched wire increases, its diameter decreases. Now, we know that resistance of the conductor is the inverse function of the length. As the length of the conductor increases its resistance decreases. This change in resistance of the conductor can be measured easily and calibrated against the applied force. Thus strain gauges can be used to measure force and related parameters like displacement and stress. The input and output relationship of the strain gauges can be expressed by the term gauge factor or gauge gradient, which is defined as the change in resistance R for the given value of applied strain $\in$. As shown in fig 6 working principle of strain gauge.

Fig 6



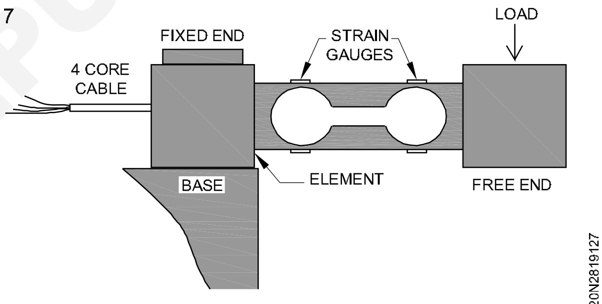
STRAIN GAUGES WORKING PRINCIPLE

Load cell:

A load cell is a device that is used to convert a force into electrical signal. Strain gauge load cells are the most common types of load cells. There are other types of load cells such as hydraulic (or hydrostatic), Pneumatic Load Cells, Piezoelectric load cells, Capacitive load cells, Piezo resistive load cells. etc.

Load cells are used for quick and precise measurements. Compared with other sensors, load cells are relatively more affordable and have a longer life span as shown in Fig 7.

Fig 7



LOAD CELL

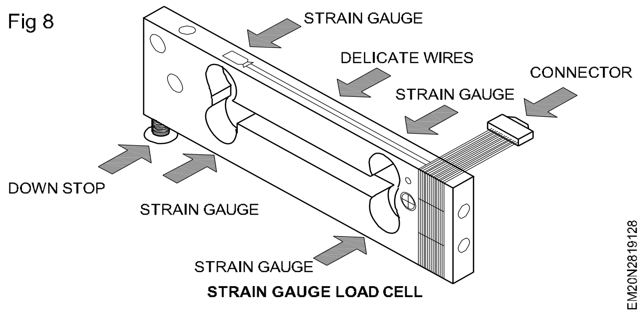
Uses of Load Cells

Load cells are used in several types of measuring instruments such as laboratory balances, industrial scales, platform scales and universal testing machines. Installed load cells in glass fiber nests to weigh albatross chicks. Load Cells are used in a wide variety of items such as the seven-post shaker which is often used to setup race cars.

Strain gauge load cell

Through a mechanical construction, the force being sensed deforms a strain gauge as shown in the Fig 8. The strain gauge measures the deformation (strain) as a change in electrical resistance, which is a measure of the strain and hence the applied forces. A load cell usually consists of four strain gauges in a Wheatstone bridge configuration. Load cells of one strain gauge (Quarter Bridge) or two strain gauges (half bridge) are also available. The electrical signal output is typically in the order of a few millivolts and requires amplification by an instrumentation amplifier before it can be used. The output of the transducer can be scaled to calculate the force applied to the transducer.

Fig 8



STRAIN GAUGE LOAD CELL

Strain gauge load cells are the most common in industry. These load cells are particularly stiff, have very good resonance values, and tend to have long life cycles in application. Strain gauge load cells work on the principle that the strain gauge (a planar resistor) deforms/stretches/ contracts when the material of the load cells deforms appropriately. These values are extremely small and are relational to the stress and/or strain that the material load cell is undergoing at the time. The change in resistance of the strain gauge provides an electrical value change that is calibrated to the load placed on the load cell.

Strain gauge load cells convert the load acting on them into electrical signals. The gauges themselves are bonded onto a beam or structural member that deforms when weight is applied. In most cases, four strain gauges are used to obtain maximum sensitivity and temperature compensation. Two of the gauges are usually in tension, and two in compression, and are wired with compensation adjustments. The strain gauge load cell is fundamentally a spring optimized for strain measurement. Gauges are mounted in areas that exhibit strain in compression or tension. The gauges are mounted in a differential bridge to enhance measurement accuracy. When weight is applied, the strain changes the electrical resistance of the gauges in proportion to the load. Other load cells are fading into obscurity, as strain gauge load cells continue to increase their accuracy and lower their unit costs.

Advantages of strain Gauge

1 There is no moving part.

2 It is small and inexpensive.

Disadvantages of strain Gauge

1 It is non-linear.

2 It needs to be calibrated.

Application of Strain gauge

1 Residual stress

2 Vibration measurement

3 Torque measurement

4 Bending and deflection measurement

5 Compression and tension measurement

6 Strain measurement

Advantages of load cells

1 Rugged and compact construction

2 No moving parts

3 Can be used for static and dynamic loading

4 Highly Accurate

5 Wide range of measurement

6 Can be used for static and dynamic loading

Disadvantages of load cells

1 Calibration is a tedious procedure

Resistance Temperature Detectors (RTD)

Objectives : At the end of this lesson you shall be able to
- **explain about RTD and its types.**
- **define construction and working principle of the RTD (PT100).**
- **describe the application, limitation, advantages & disadvantages.**

Resistance Temperature Detectors

Resistance Temperature Detectors (RTD), as the name implies, are sensors used to measure temperature by correlating the resistance of the RTD element with temperature.

RTDs are relatively immune to electrical noise and therefore well suited for temperature measurement in industrial environments, especially around motors, generators and other high voltage equipment.

A **Resistance Thermometer or Resistance Temperature Detector** is a device which is used to determine the temperature by measuring the **resistance** of pure electrical wire. This wire is referred to as a temperature sensor. If we want to measure temperature with high accuracy, RTD is the only one solution in industries. It has good linear characteristics over a wide range of temperatures. The physical appearances of different RTDs are shown in Fig 1a & 1b.

Fig 1a

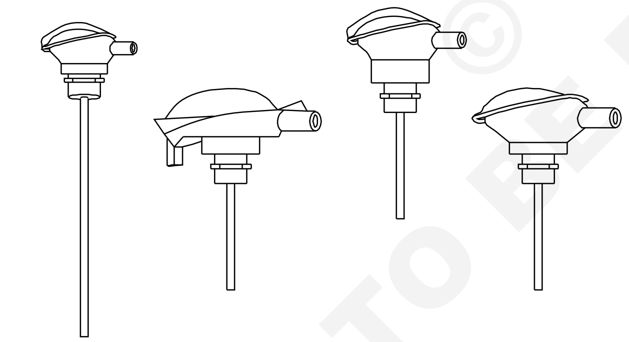
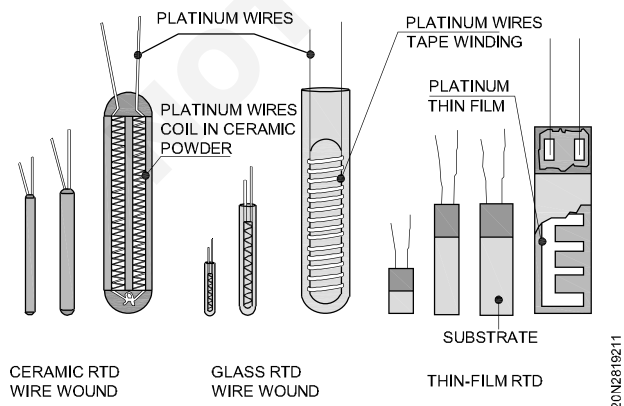


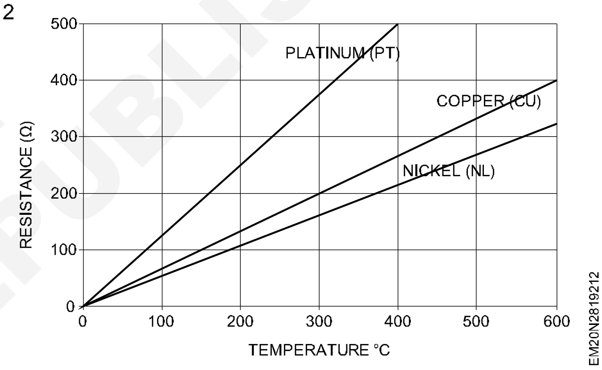
Fig 1b



DEFFERENT TYPES OF RTDs

In **RTD** devices Copper, Nickel and Platinum are widely used metals. These three metals are having different resistance variations with respect to the temperature variations. That is called resistance-temperature characteristics as shown in Fig.2. Platinum has the temperature range of 650°C, and then the Copper and Nickel have 120°C and 300°C respectively. The figure-2 shows the resistance-temperature characteristics curve of the three different metals. For Platinum, its resistance changes by approximately 0.4 ohms per degree Celsius of temperature.

Fig 2



The purity of the platinum is checked by measuring R100 / R0. Because, whatever the materials actually we are using for making the RTD that should be pure. If it is not pure, it will deviate from the conventional resistance-temperature graph. So α and β values will change depending upon the metals.

Types of RTDs based on wires color code : (Fig 3)

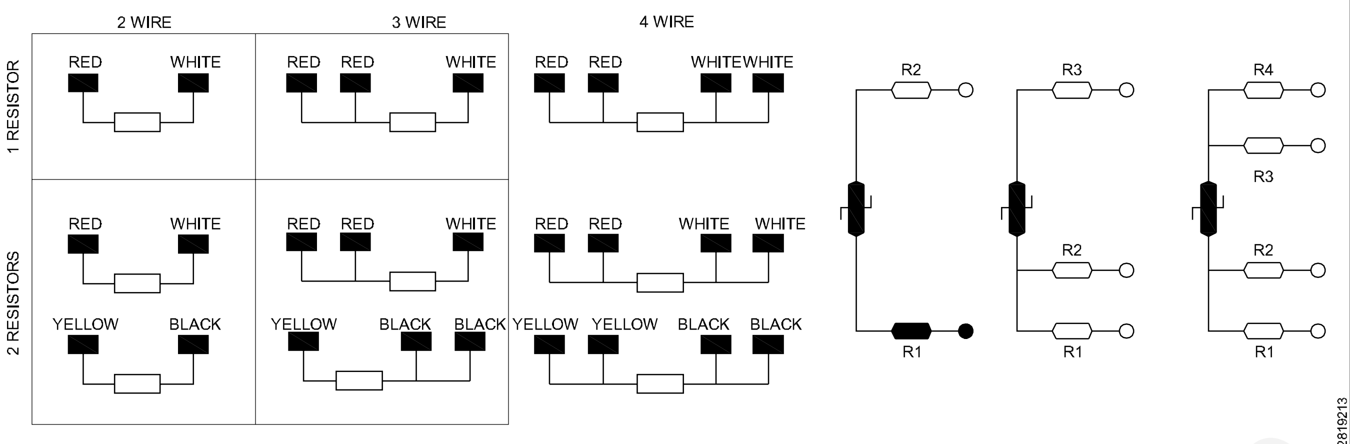
Main trend for industrial resistance temperature detector is platinum RTD due to physical stability and high applicable temperature.

There are the other RTDs such as Nickel, Platinum-cobalt, and so on.

RTD Configuration

An RTD can be connected in a two, three, or four-wire configuration. The two-wire configuration is the simplest and also the most error prone. In this setup, the RTD is connected by two wire to a wheatstone bridge circuit and the output voltage is measured. The disadvantage of this circuit is that the resistance of two connecting lead wires are added directly to the RTDs resistance and an error is incurred.

Fig 3



RTD WIRE TYPES AND ITS COLOR CODE

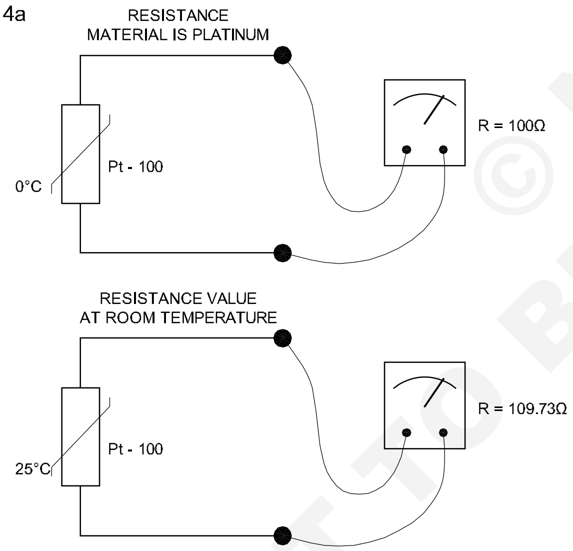
2- Wire Configuration

The four-wire configuration consists of two current leads and two potential leads that measure the voltage drop across the RTD. The two potential leads are high resistance to negate the effect of the voltage drop due to current flowing during the measurement.

This configuration is ideal for cancelling the lead wire resistances in the circuit as well as eliminating the effects of different lead resistances, which was a possible problem with the three-wire configuration is commonly used when a highly accurate measurement is required for the application.

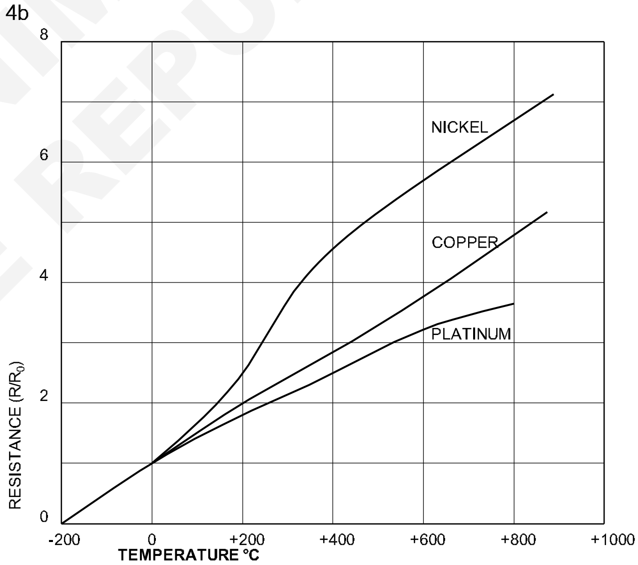
Note: Refer to the RTD user manual/datasheet for type of RTD based on lead colour

Fig 4a



Pt - 100 CONNECTION WIRING DIAGRAM

4b



RESISTANCE VS TEMPERATURE CURVE

Pt-100 working principle

A platinum resistance temperature detector (RTD) Pt100 is a device with a typical resistance of 100 Ω at 0°C (it is called Pt100). It changes resistance value as its temperature changes following a positive slope (resistance increases when temperature is increasing).as show in Fig 4a & 4b.

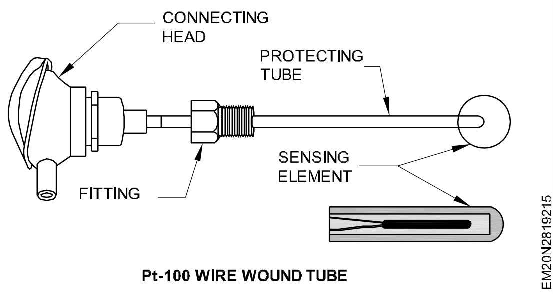
They have been used for many years to measure temperature in laboratory and industrial processes, and have developed a reputation for accuracy, repeatability, and stability. A RTD can typically measure temperatures up to 850 °C.

Pt100 types

There are basically three styles of Pt100 sensing elements. Each style has unique characteristics and advantages.

Wire wound Element: The wire wound sensor is the simplest sensor design. The sensing wire is wrapped around an insulating mandrel or core. The winding core can be round or flat, but must be an electrical insulator. The coil diameter provides a compromise between mechanical stability and allowing expansion of the wire to minimize strain and consequential drift. as shown in Fig. 5

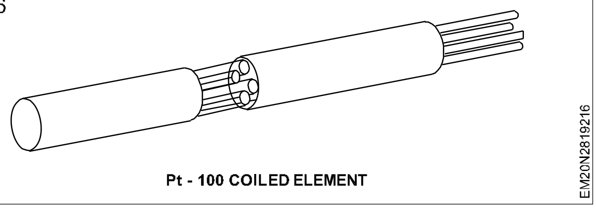
Fig 5



Pt-100 WIRE WOUND TUBE

Coiled Element: The coiled sensor shown in Fig. 6 is a method to produce a "strain free" design. A strain free design allows the sensing wire to expand and contract free of influences from other materials in the assembly. Techniques similar to those used in this design are used in Standard Platinum Resistance Thermometers (SPRT), which are used as laboratory standards.

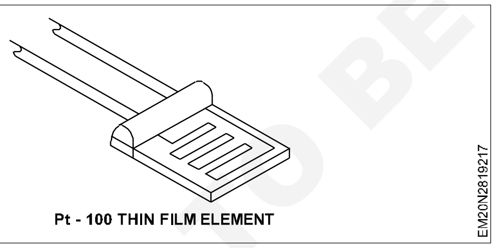
Fig 6



Pt - 100 COILED ELEMENT

Thin Film Element: The thin film sensing element is manufactured by depositing a very thin layer of platinum on a ceramic substrate. This layer is usually just a 10 to 100 angstroms (1e-8 centimeters) thick. The platinum film is coated with epoxy or glass. This coating helps protect deposited platinum film and acts as a strain relief for the external lead wires as shown in Fig 7. The advantage of the thin film Platinum RTD is low cost and low thermal mass. The low thermal mass makes them respond faster and they are easier to assemble into small packages. Disadvantages are that they are not as stable as wire wound RTDs.

Fig 7



Pt - 100 THIN FILM ELEMENT

Limitations of RTD

In the RTD resistance, there will be I2R power dissipation by the device itself that causes a slight heating effect. This is called as self-heating in RTD. This may also cause an erroneous reading. Thus, the electric current through the RTD resistance must be kept sufficiently low and constant to avoid self-heating. Because of this the RTD is used only up to maximum 600°C

Applications of RTDs include

- Air conditioning and refrigeration servicing
- Food Processing
- Stoves and grills
- Textile production
- Plastics processing
- Petrochemical processing
- Micro electronics
- Air, gas and liquid temperature measurement
- Exhaust gas temperature measurement

RTD's should be used

- When accuracy and stability are a requirement of the customer's specification
- When accuracy must extend over a wide temperature range
- When area, rather than point sensing improves control
- When a high degree of standardization is desirable

Advantages of Resistance Temperature Detectors

- The advantages of using RTDs include:
- Linear over wide operating range
- Wide temperature operating range
- High temperature operating range
- Interchangeability over wide range
- Good stability at high temperature

Disadvantages of Resistance Temperature Detectors

The disadvantages of using RTD's include:

- Low sensitivity
- Higher cost than thermocouples
- No point sensing
- Affected by shock and vibration requires three or four-wire operation

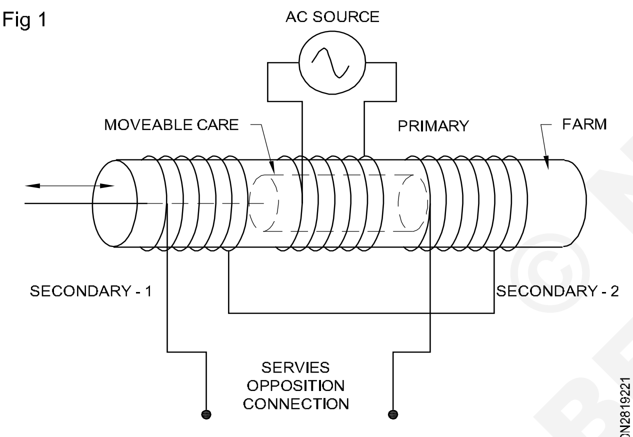
Displacement measurement using LVDT

Objectives : At the end of this lesson you shall be able to
- **define LVDT**
- **explain the working principle and operation of LVDT**
- **state the advantages, disadvantages and application of LVDT.**

Details of LVDT and its construction

Linear variable differential transformers (LVDT) are used to measure displacement. LVDTs operate on the principle of a transformer. As shown in Fig 1, an LVDT consists of a coil assembly and a core. The coil assembly is typically mounted to a stationary form, while the core is secured to the object whose position is being measured. The coil assembly consists of three coils of wire wound on the hollow form. A core of permeable material can slide freely through the center of the form. The inner coil is the primary, which is excited by an AC source as shown. Magnetic flux produced by the primary is coupled to the two secondary coils, inducing an AC voltage in each coil.

Fig 1



GENERAL LVDT ASSEMBLY

LVDTs Working principle

The LVDT or Linear Variable Differential Transformer is a well established transducer design which has been used throughout many decades for the accurate measurement of displacement and within closed loops for the control of positioning. So, how does an LVDT work? In its simplest form, the design consists of a cylindrical array of a primary and secondary windings with a separate cylindrical core which passes through the centre. (Fig 2a).

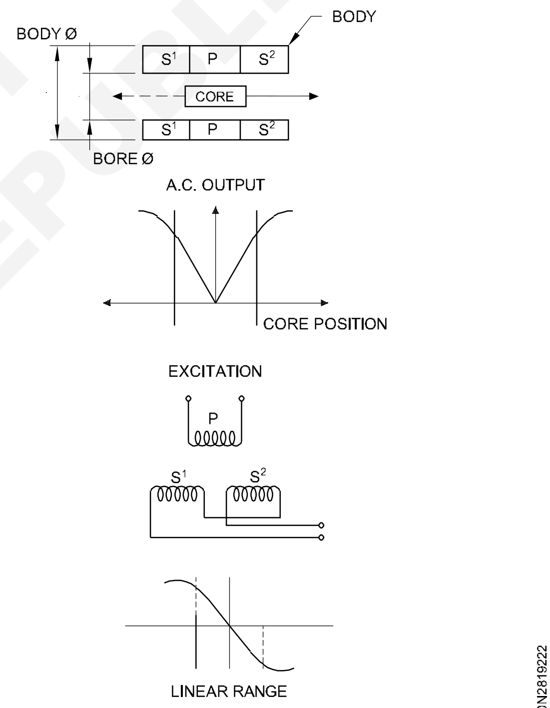
The primary windings (P) are energized with a constant amplitude A.C. supply at a frequency of 1 to 10 kHz. This produces an alternating magnetic field in the centre of the transducer which induces a signal into the secondary windings (S &S) depending on the position of the core.

Movement of the core within this area causes the secondary signal to change (Fig 2b). As the two secondary windings are positioned and connected in a set arrangement (push-pull mode), when the core is positioned at the centre, a zero signal is derived.

Movement of the core from this point in either direction causes the signal to increase (Fig 2c). As the windings are wound in a particular precise manner, the signal output has a linear relationship with the actual mechanical movement of the core.

The secondary output signal is then processed by a phase-sensitive demodulator which is switched at the same frequency as the primary energising supply. This results in a final output which, after rectification and filtering, gives D.C. or 4-20mA output proportional to the core movement and also indicates its direction, positive or negative from the central zero point (Fig 2d).

Fig 2



LVDTs WORKING PRINCIPLE

Advantage:

The distinct advantage of using an LVDT displacement transducer is that the moving core does not make contact with other electrical components of the assembly, as with resistive types, as so offers high reliability and long life. Further, the core can be so aligned that an air gap exists around it, ideal for applications where minimum mechanical friction is required.

The LVDT design lends itself for easy modification to fulfill a whole range of different applications in both research and industry.

Disadvantages of LVDT

- Very high displacement is required for generating high voltages.
- Shielding is required since it is sensitive to magnetic field.
- The performance of the transducer gets affected by vibrations
- Its is greatly affected by temperature changes.
- Internally non contact but externally has to be connected where the measurement has to be made
- Not feasible for very long range measurements

Applications of LVDT

LVDT is used to measure displacement ranging from fraction millimeter to centimeter.

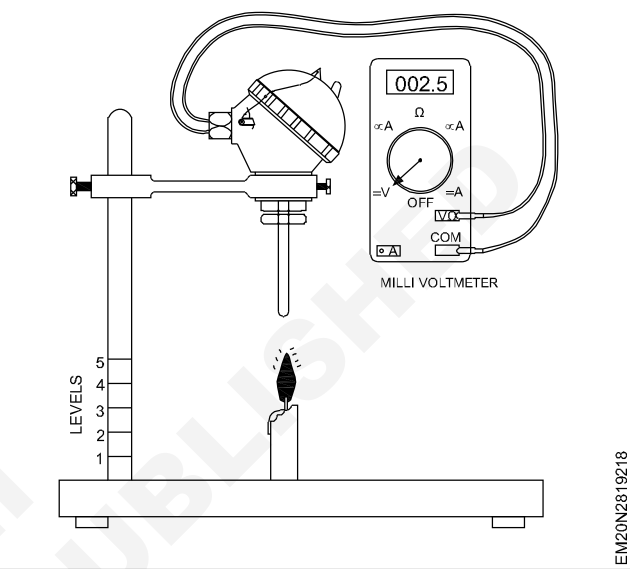
Acting as a secondary transducer, LVDT can be used as a device to measure force, weight and pressure, etc..

Testing of thermocouple sensor under laboratory setup

The thermocouple sensor can be tested in the laboratory by fixing the thermowell bulb on a stand under a lit fire of a candle, as shown in Fig 3. The height of the candle has to be increased form the base as per the graduated scale mashing on the stand. The output voltage produced but the sensor is measured using a DC millivolt meter for each level and reading for corresponding temperatures are recorded and compared to confirm the correct working of thermocouple sensor.

In the same method of experiment, the RTD can also be fixed on the stand under the lit fire flame of the candle . For different height of the flame, corresponding resistance variations of each temperature across the output terminals of the RTD is measured using ohm meter and its working can be ascertained.

Fig 3



Proximity sensors

Objectives : At the end of this lesson you shall be able to
- **define proximity switches**
- **explain the different types of proximity switches**
- **describe the selection, advantages and disadvantages.**

Proximity sensors

Proximity sensors detect the presence of objects without physical contact. It detects the presence or absence of objects using electromagnetic fields, light, and sound. There are many types, each suited to specific applications and environments.

Types of proximity

1 Capacitive

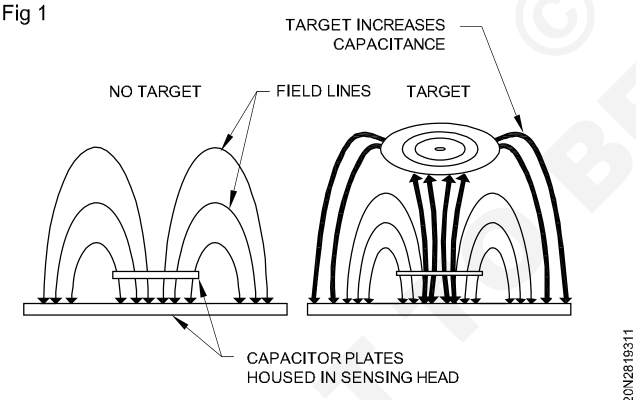
2 Inductive

3 Photo electric

Capacitive Transducers

It is important to know the basics of a parallel plate capacitor. Being the simplest form of a capacitor, it has two parallel conducting plates that are separated to each other by a dielectric or insulator with a permittivity of E (for air). Other than paper, vacuum, and semi-conductor depletion region, the most commonly used dielectric is air. as shown in Fig 1.

Fig 1



CAPACITIVE SENSING

Due to a potential difference across the conductors, an electric field develops across the insulator. This causes the positive charges to accumulate on one plate and the negative charges to accumulate on the other. The capacitor value is usually denoted by its capacitance, which is measured in Farads. It can be defined as the ratio of the electric charge on each conductor to the voltage difference between them.

The capacitance is denoted by C. In a parallel plate capacitor, $C = [A*\in_r*9.85*10^{12} F/M]/d$

A - Area of each plate (m)

d - Distance between both the plates (m)

$\in_r$ - Relative Dielectric Constant

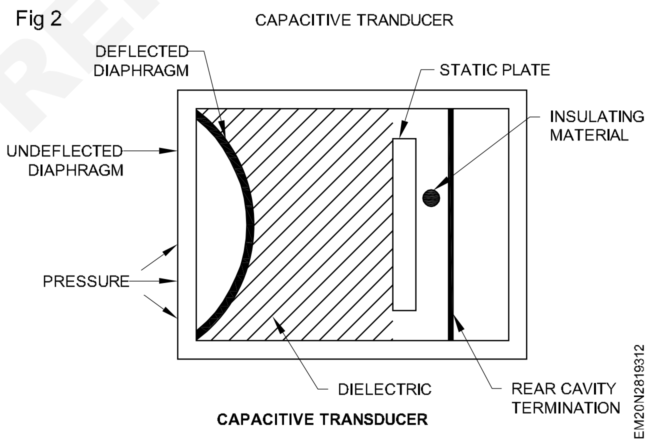
The value $9.85*10^{12}$ F/M is a constant denoted by $\in_0$ and is called the dielectric constant of free space.

From the equation it is clear that the value of capacitance C and the distance between the parallel plates,d are inversely proportional to each other. An increase of distance between the parallel plates will decrease the capacitance value correspondingly. The same theory is used in a capacitive transducer. This transducer is used to convert the value of displacement or change in pressure in terms of frequency.

Parts of Capacitance Transducer (Fig 2)

As shown in the figure 2, a capacitive transducer has a static plate and a deflected flexible diaphragm with a dielectric in between. When a force is exerted to the outer side of the diaphragm the distance between the diaphragm and the static plate changes. This produces a capacitance which is measured using an alternating current bridge or a tank circuit.

Fig 2



CAPACITIVE TRANSDUCER

A tank circuit is more preferred because it produces a change in frequency according to the change in capacitance. This value of frequency will be corresponding to the displacement or force given to the input.

Advantages

- It produces an accurate frequency response to both static and dynamic measurements.

Disadvantages

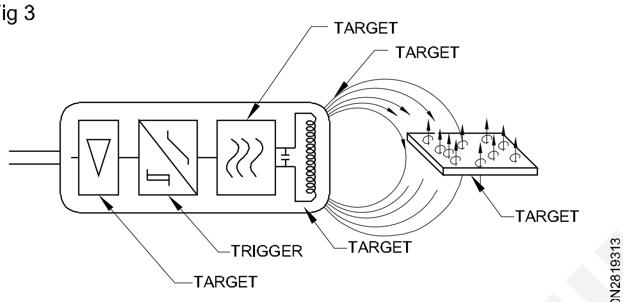
- An increase or decrease in temperature to a high level will change the accuracy of the device.
- As the lead is lengthy it can cause errors or distortion in signals.

Inductance Type Inductive Transducers

The inductance type of the inductive transducers simple single coil is used as the transducer. When the mechanical element whose displacement is to be measured is moved, it changes the permeance of the flux path generated by the circuit, which changes the inductance of the circuit and the corresponding output. The output from the circuit is calibrated directly against the value of the input, thus it directly gives the valve of the parameter to be measured.

The Fig 3 shows the single coil inductive circuit. Here the magnetic material is connected to the electric circuit and it is excited by the alternating current. At the bottom there is another magnetic material that acts as the armature. As the armature is moved, the air gap between the two magnetic material changes and the permeance of the flux generated by the circuit changes that changes the inductance of the circuit and its output. The output meter directly gives the valve of the input mechanical quantity.

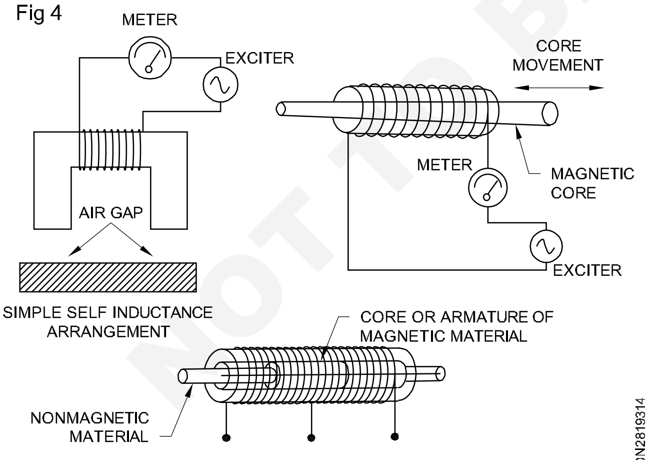
Fig 3



INDUCTANCE TYPE INDUCTIVE TRANSDUCERS

In the Fig 4, coil is wound around the round hollow magnetic material and there is magnetic core that moves inside hollow magnetic material. In the above circuits the change in the air gap or the change in the amount of the magnetic material in the circuit can be used to produce the output proportional to the input.

Fig 4



INDUCTANCE TYPE INDUCTIVE TRANSDUCERS

Another arrangement of the coils is shown in figure 3, where two coils are used. In this circuit the movement of the core changes the relative inductance of the two coils and over all inductance of the circuit. This system is used in the devices along with the inductive bridge circuit. In this circuit the change in the induction ratio of the two coils provides the output proportional to the mechanical input.

In the above arrangements the supply of the current and the output is obtained from the same coil or circuit.

Advantages

1 Non contact type

2 Maintenance free

3 pnp or npn type

4 360°-viewable output indicators for easy operation and maintenance

5 Electrical protections against short circuits, overload, transient noise, false pulses and reverse polarity (DC models) to help reduce downtime and maintenance costs

Disadvantages

Virtually nil but following may be noted

1 Cannot be repaired

2 Must be free from oil and dust

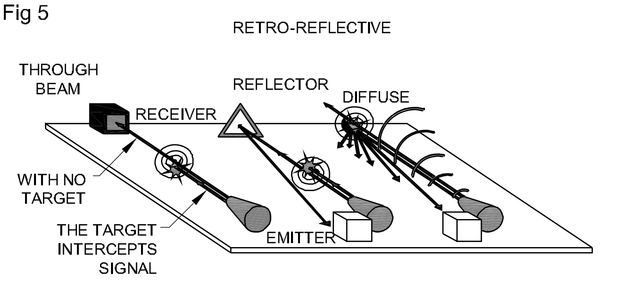
3 Cable connections to be checked regularly

Photoelectric sensors

Photoelectric sensors are so versatile that they solve the bulk of problems put to industrial sensing. Because photoelectric technology has so rapidly advanced, they now commonly detect targets less than 1 mm in diameter, or from 60 m away. Classified by the method in which light is emitted and delivered to the receiver, many photoelectric configurations are available. However, all photoelectric sensors consist of a few of basic components: each has an emitter light source (Light Emitting Diode, laser diode), a photodiode or phototransistor receiver to detect emitted light, and supporting electronics designed to amplify the receiver signal. The emitter, sometimes called the sender, transmits a beam of either visible or infrared light to the detecting receiver.

All photoelectric sensors operate under similar principles as shown in fig. 5 Identifying their output is thus made easy; dark-on and light-on classifications refer to light reception and sensor output activity. If output is produced when no light is received, the sensor is dark-on. Output from light received, and it's light-on. Either way, deciding

Fig 5



LASERS OF SOUND WAVES SERVE AS THE SIGNAL IN THREE SETUPS. IN THROUGH BEAM AND RETRO-REFLECTIVE, THE SIGNAL SHOOTS FROM THE EMITTER TO RECEIVER UNTIL THE TARGET CUTS IT OFF. IN DIFFUSE SENSING, THE SIGNAL DIVERGES UNTIL A TARGET MOVES IN AND REFLECTS SOME BACK TO THE RECEIVER.

PHOTOELECTRIC / ULTRASONIC SENSING SETUPS on light-on or dark-on prior to purchasing is required unless the sensor is user adjustable. (In that case, output style can be specified during installation by flipping a switch or wiring the sensor accordingly.)

Through-beam

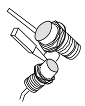
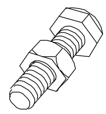
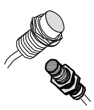
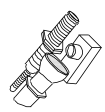
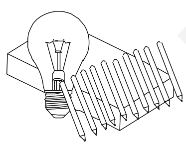
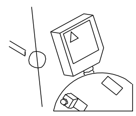
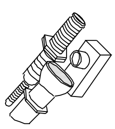
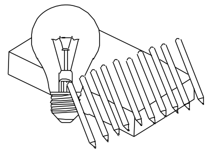
The most reliable photoelectric sensing is with through-beam sensors. Separated from the receiver by a separate housing, the emitter provides a constant beam of light; detection occurs when an object passing between the two breaks the beam. Despite its reliability, through-beam is the least popular photoelectric setup. The purchase, installation, and alignment of the emitter and receiver in two opposing locations, which may be quite a distance apart, are costly and laborious. With newly developed designs, through-beam photoelectric sensors typically offer the longest sensing distance of photoelectric sensors - 25 m and over is now commonplace. New laser diode emitter models can transmit a well-collimated beam 60 m for increased accuracy and detection. At these distances, some through-beam laser sensors are capable of detecting an object the size of a fly; at close range, that becomes 0.01 mm. But while these laser sensors increase precision, response speed is the same as with non-laser sensors - typically around 500 Hz.

One ability unique to through-beam photoelectric sensors is effective sensing in the presence of thick airborne contaminants. If pollutants build up directly on the emitter or receiver, there is a higher probability of false triggering. However, some manufacturers now incorporate alarm outputs into the sensor's circuitry that monitor the amount of light hitting the receiver. If detected light decreases to a specified level without a target in place, the sensor sends a warning by means of a built in LED or output wire.

Through-beam photoelectric sensors have commercial and industrial applications. At home, for example, they detect obstructions in the path of garage doors; the sensors have saved many a bicycle and car from being smashed. Objects on industrial conveyors, on the other hand, can be detected anywhere between the emitter and receiver, as long as there are gaps between the monitored objects, and sensor light does not "burn through" them. (Burn-through might happen with thin or lightly colored objects that allow emitted light to pass through to the receiver.)

Application and selection of proximity sensor:

Proximity Sensor comparison table -1

Technology	Sensing Range	Applications	Target Materials
Inductive 	<4-40 mm	Any close - range detection of ferrous material	Iron Steel Aluminum Copper etc. 
Capacitive 	<3-60 mm	Close - range detection of non - ferrous material	Liquids Wood Granulates Plastic Glass etc. 
Photoelectric 	<1mm - 60 mm	Long - range small or large target detection	Silicon Plastic Paper Metal etc. 
Ultrasonic 	<30 mm - 3 mm	Long - range detection of targets with difficult surface properties. Color/ reflectivity insensitive.	Cellophane Foam Glass liquid Powder etc 

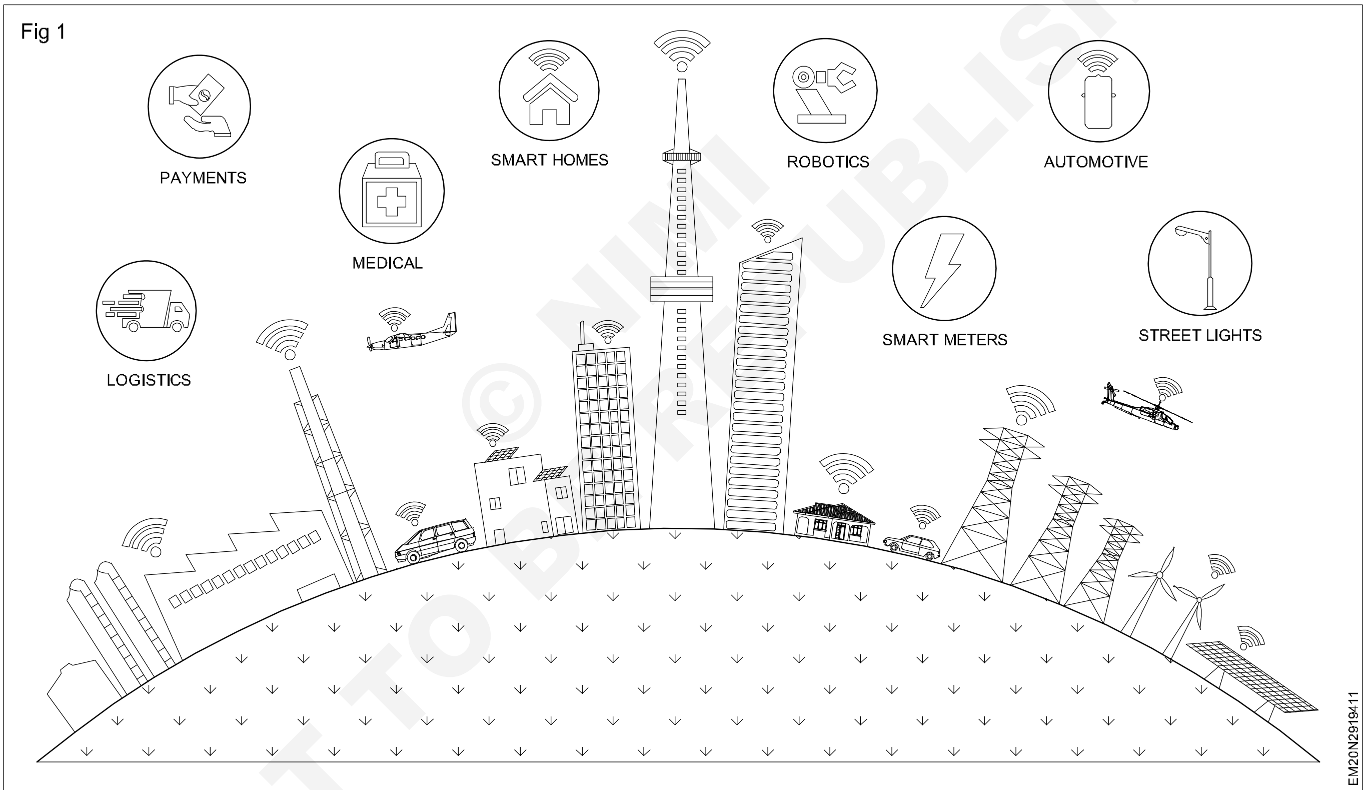
Internet Of Things (IOT)

Objectives : At the end of this lesson you shall be able to
- **identify IOT things**
- **application of IOT**
- **different functional building block of IOT architecture.**

IoT stands for Internet of Things It refers to the interconnectedness of physical devices, such as appliances and vehicles, that are embedded with software, sensors, and connectivity which enables these objects to connect and exchange data. This technology allows for the collection and sharing of data from a vast network of devices, creating opportunities for more efficient and automated systems

Internet of Things (IoT) is the networking of physical objects that contain electronics embedded within their architecture in order to communicate and sense interactions amongst cach other or with respect to the external environment. In the upcoming years, IoT-based technology will offer advanced levels of services and practically change the way people lead their daily lives. Advancements in medicine, power, gene therapies, agriculture, smart cities. and smart homes are just a very few of the categorical examples where IoT is strongly established

Fig 1



Main components used in IoT:

- **Low power embedded systems:** Less battery consumption, high performance are the inverse factors that play a significant role during the design of electronic systems.
- **Sensors:** Sensors are the major part of any IoT applications. it is a physical device that measures and detect certain physical quantity and convert it into signal which can be provide as an input to processing or control unit for analysis purpose.

Different types of Sensors:

1 Temperature Sensors

2 Image Sensors

3 Gyro Sensors

4 Obstacle Sensors

5 RF Sensor

6 IR Sensor

7 MQ-02/05 Gas Sensor

8 LDR Sensor

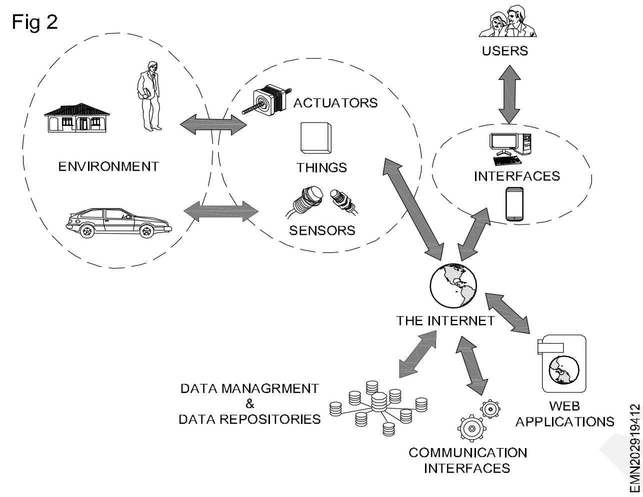
9 Ultrasonic Distance Sensor

Working with IoT Devices:

- **Collect and Transmit Data:** For this purpose sensors are widely used they are used as per requirements in different application areas

- **Actuate device based on triggers produced by sensors or processing devices:** If certain condition is satisfied or according to user's requirements if certain trigger is activated then which action to performed that is shown by Actuator devices.
- **Receive information:** From network devices user or device can take certain information also for their analysis and processing purposes.
- **Communication Assistance:** Communication assistance is the phenomena of communication between 2 network or communication between 2 or more IoT devices of same or different Networks. This can be achieved by different communication protocols like MQTT, Constrained Application Protocol, ZigBee, FTP, HTTP etc.

Fig 2



Application Domains: IoT is currently found in four different popular domains

1 Manufacturing/Industrial business - 40.8

2 Healthcare - 30,38

3 Security-7.78

4 Retail - 8.38

Modern Applications:

1 Environment

2 Smart Grids and energy saving

3 Smart cities/Street light

4 Smart homes/Home automation

5 Earthquake detection

6 Radiation detection/hazardous gas detection

7 Smartphone detection

8 Smart walk a waste management

9 Traffic monitoring

10 Wearables

11 Smart door lock protection system

12 Robots and Drones

13 Healthcare and Hospitals, Telemedicine applications

14 Security

15 Biochip Transponders (For animals in farms)

16 Heart monitoring implants(Example Pacemaker, ECG real time tracking)

Advantages of IoT:

1 Improved efficiency and automation of tasks.

2 Increased convenience and accessibility of information

3 Better monitoring and control of devices and systems

4 Greater ability to gather and analyze data.

5 Improved decision-making

6 Cost savings

Disadvantages of IoT:

1 Security concerns and potential for hacking or data breaches

2 Privacy issues related to the collection and use of personal data

3 Dependence on technology and potential for system failures

4 Limited standardization and interoperability among devices.

5 Complexity and increased maintenance requirements

6 High initial investment costs

7 Limited battery life on some devices.

8 Concerns about job displacement due to automation.

9 Limited regulation and legal framework for IoT, which can lead to confusion and uncertainty.

The Internet of Things (IoT) is a network of devices that allows them to communicate and exchange data with other smart devices over the Internet. The embedded sensors and software make these material things 'smart. In this post, we'll explore the various applications of IoT and what its future looks like.

Applications of IOT:

Agriculture: The ever-increasing world population drives up the demand for agricultural products. However, the migration of young people to big cities destabilizes the human resource required for agricultural development. IoT and related technologies can be pivotal in automating farming processes and fulfilling food demand

Consumer Applications: The Internet of Things makes people's lives easier by monitoring and managing their lifestyles. There is a massive market for intelligent electronics, watches, television systems, health tracking, and virtual reality. In addition, IoT is leading the market with applications such as home security and personal asset tracking

Healthcare: Wearable IoT devices provide a range of benefits to patients and healthcare providers alike. By extension, IoT enables healthcare professionals to monitor patients remotely The devices can automatically collect patients' health vitals like blood pressure heart rate. temperature and more.

Insurance: IoT is altering traditional business models like insurance. It simplifies and accelerates the claim and underwriting process. Besides reducing costs, digital networking via IoT generates additional revenues Cross-selling and more significant customer interaction become a strategic component for insurers

Manufacturing: The Internet of Things creates a more technically driven environment for manufacturing industries. It can automatically track development cycles, facilitate the production flow, and manage inventories.

Retail: toT devices can collect vital data on a products shopping lifecycle Once this data is processed and analyzed, retail managers can make valuable decisions to improve retail operations and the customer experience

Transportation: IoT applications integrate personal and commercial vehicles by improving communication and information distribution Besides connecting consumers and goods, it offers benefits such as route optimization, automobile tracking, weather monitoring, distance coverage, and more

Utilities/Energy: A grid can have IoT capabilities with intelligent meters, receivers, sensors, and energy boxes communicating toT applications in utilities generate revenue, improve efficiency, and conserve resources. Utility providers can keep up with the rising demand by optimizing energy and distribution with the help of IoT

Traffic Monitoring: Intelligent traffic monitoring helps improve decision-making and achieve urban growth. An IoT-based system collects processes, and analyzes real-time traffic data to provide updates on traffic incidents and congestion. In addition, early warming messages save commute time during peak hours.

Hospitality: Many hotels allow quests to control air conditioning heating, or ventilation from a central location. Television control and greeting devices are also common. Moreover, Internet of Things devices alert the staff about various appliances operating status. As a result, technicians can fix critical appliances even before any major functionality loss occurs.

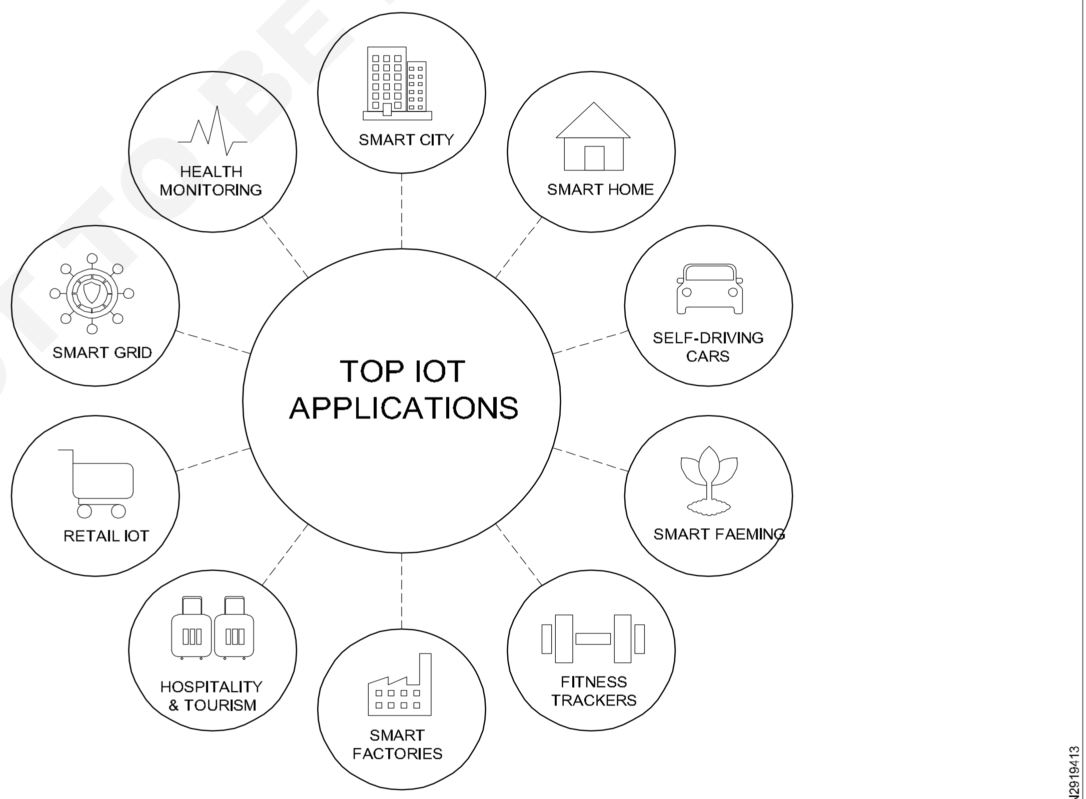
Water Supply: Water scarcity is a reality IoT applications have a potential solution to monitor control, and regulate the quality and usage of water. Besides, it also maintains associated equipment such as pumps, pipes, etc. Smart water technology connects water systems with people.

Fleet Management: IoT enables predictive fleet maintenance by boosting visibility, efficiency and manageability. It helps to monitor cargo better and improves driver operation. In addition to? devices can predict maintenance and help replace parts before the issue gets too expensive.

Smart Pollution Control: IoT devices and attached sensors are stationed at key city locations They monitor pollution levels and periodically upload data to the IoT cloud. The system then processes the information to trigger public actions such as diversions or road closures.

Smart Cities: A smart city has better public utilities, infrastructure, services, and more Smart meters allow utility companies to regulate energy flow efficiently, while connected vehicles make public transit tremendously efficient. In addition, smart grids are coming up to conserve resources and lower peak hour stress.

Fig 3



APPLICATION OF IOT

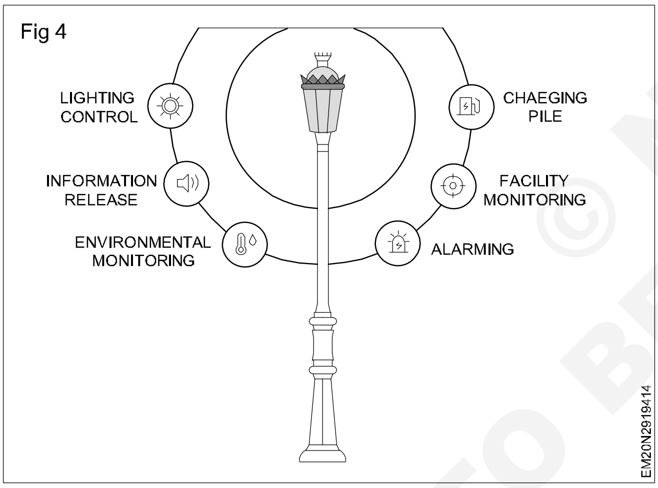
Features of IoT

The following are major IoT features

- **Connectivity:** Establishing a proper connection between all IoT devices and the IoT platform, which could be a server or the cloud.
- **Analyzing:** After connecting all of the relevant things, it is time to analyze the data collected in real-time and use it to build effective business intelligence.
- **Integrating:** IoT integrates various models to improve user experience.
- **Artificial Intelligence:** IoT makes things smart and improves people's lives by utilizing data.
- **Sensing in IoT:** In IoT technologies, sensor devices detect and measure environmental changes and report their status.
- **Active Engagement:** IoT allows connected technology, products, or services to engage in active engagement with one another
- **Endpoint Management:** Endpoint management is critical for all IoT systems. otherwise, the system will fail completely

Smart Street Light using IoT

Fig 4



As an important part of smart city, smart street lighting uses wireless IoT sensors, Zigbee, GPRS, Lora and Bluetooth communication technology to connect the street lamps in the city in series, forming the Internet of things, and realizing the remote centralized control and management of street lamps According to the traffic flow, time, weather conditions and other conditions, the scheme can automatically adjust the brightness, remote control lighting, abnormal will take the initiative to alarm, but also can cooperate with other sensors to play the function of anti-theft and remote meter reading. Smart street lighting using IoT can effectively control the energy consumption, thus enhance the level of public lighting management, decrease the cost of maintenance and management and use the calculation of sensory information processing and analysis to make intelligent response and intelligent decision support, make the city road lighting to achieve a "smart" state.

Smart lighting control

This solution refers to smart city street light using IoT network while performing visual management so that managers can clearly understand the status information of each street lamp in each block. At the same time, each street lamp has built-in sensors or smart plugs to preset lighting equipment, to ensure that the switch state and lighting brightness of each lamp can be accurately controlled, so as to truly realize on-demand lighting and achieve the effect of energy saving.

Information release system

Smart street light using IoT can broadcast advertising messages to nearby passersby while integrating beacons.

Smart city environmental monitoring

Smart street lighting system integrated urban environment sensor to monitor temperature, humidity, noise, air quality (PM25, etc.). The use of street lamp coverage has advantages of wide area more points, to achieve the urban high- density urban micro-environment

Street lamp charging pile

Installing charging piles for new energy vehicles on smart street lamps is the best way to build distributed charging stations for new energy vehicles on roads. At present, charging piles for integrated new energy vehicles are generally AC charging piles with a power of 7KW and a slow charging speed. They are mainly used to supplement the new energy vehicles parked in street lamps. It can be seen that with the further increase of the number of new energy vehicles, the combination of DC charging piles with faster charging speed and street lamps will also appear.

Facility monitoring

Smart street lighting using IoT integrate monitoring modules of urban infrastructure, such as manhole cover monitoring, water level monitoring and other sensor modules, which can effectively sense the status and information of urban infrastructure and provide various services for smart cities. The application provides the data.

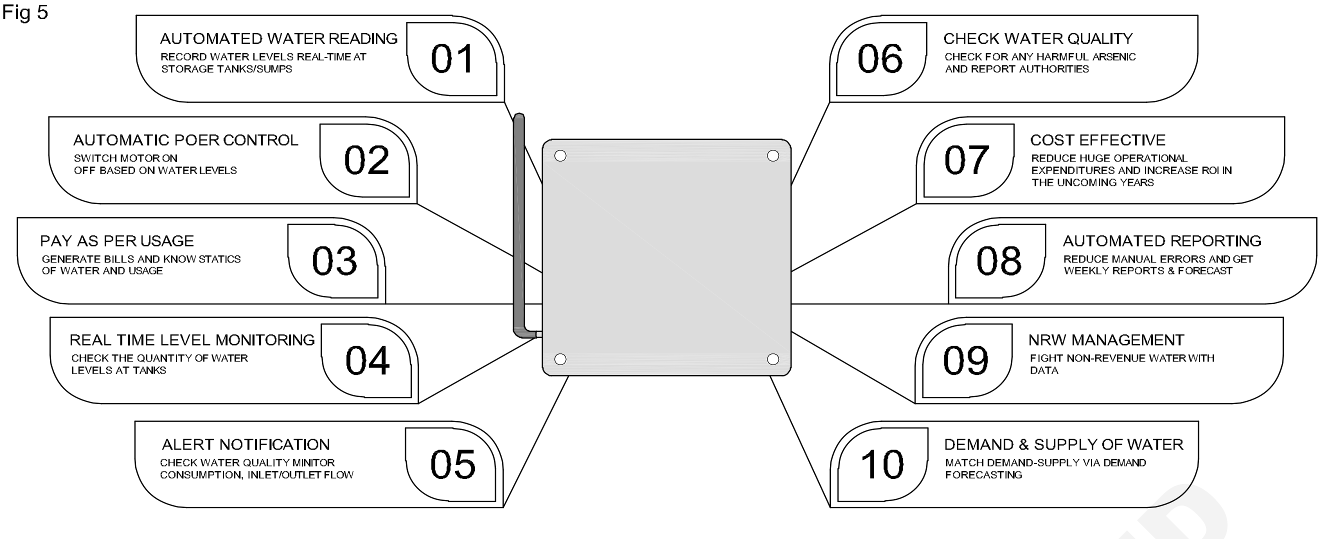
Alarming

The smart street lighting system with panic button integrated can push the alarm information to the information bar of the display screen and the monitoring terminal of the service center, and link with the video monitoring system to deal with emergencies in time. Malignant incidents, to prevent the expansion of danger, and effectively solve the security problems in public places.

Smart water management using IoT

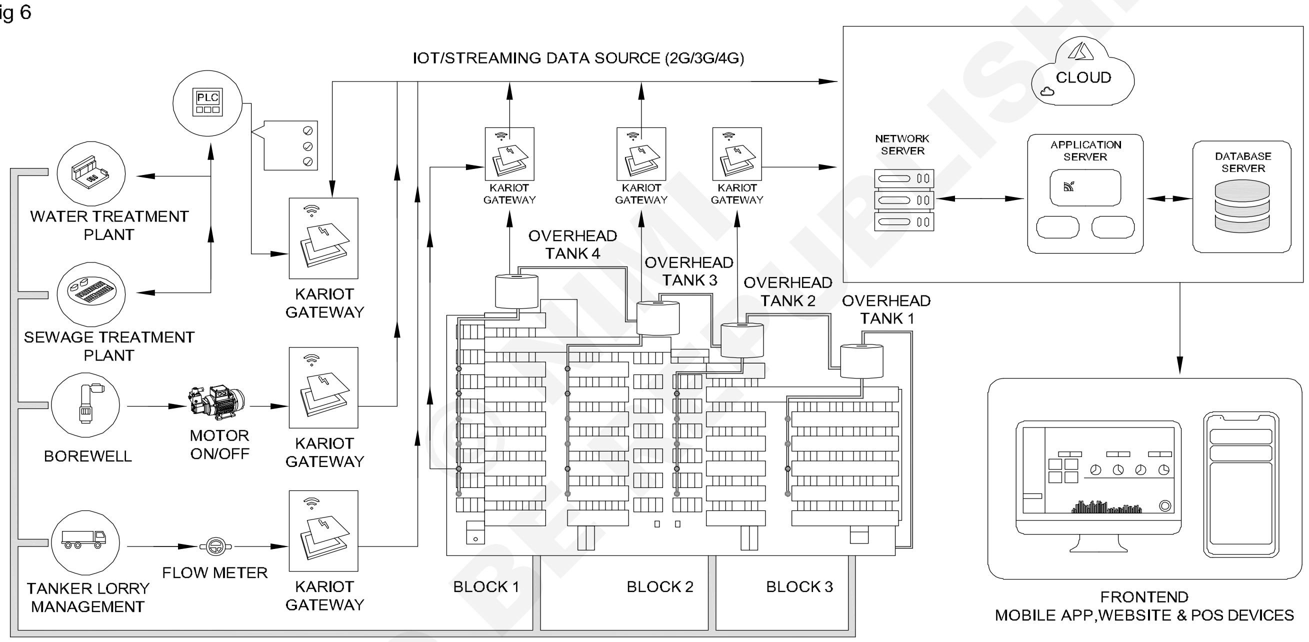
It is better to implement an intelligent water management system. Nowadays, most techies are focusing on the new Smart Water Management using IoT IoT is a gigantic technology that processes a standard process for industrial units. The water sector coerces 100% attention to multiple resources in relevant amounts. The smart water techniques offer enhanced regulation over a water body, or wastewater treatment plant. The on-demand app development companies have started to focus on the IoI sector.

Fig 5



KEY ADVANTAGES OF SMART WATER MANAGEMENT USIONG IOT

Fig 6



SMART WATER MANAGEMENT USING IOT

Internet of Things applies a series of proceedings & methodologies to satisfy the demands & needs with inadequacy in terms of quantity of water. The usage of sensors in industrial water areas advances the different sectors through real-time monitoring systems and instant alert systems. With the aid of IoI-driven scalable solutions, it is feasible to measure the level of misused water and & get immediate alerts when there is water leakage in the tank.

Working Process Of Smart Water Management

Smart water management using IoT provides the solution for the firms to regulate water flow by interconnecting smart sensors and smart meters. The main role of the sensors and meters is to collect water flow data and generate analytical water performance reports. With the aid of web dashboards, industries observe the utilization of water

Eradication of wastage

Smart water management aids to reduce water usage consumed in enormous amounts for different fields like agriculture, production sector, agriculture, etc. It contemplates the multiple practices of farming, agricultural applications faming Mesly everyone has started to enforce agriculture softs are to process the tasks.

Enhanced water quality

The improvement of water quality eradicates contagions due to the wastage of acidification. To enhance water quality, prominent industries are using trendier IoT techniques and sensors to regulate real-time monitoring.

Optimizes efficiency factor

The IoT-enabled smart water management aids in the improvement of the efficiency factor of water distributors and water treatment plants. By developing robust solutions, multiple firms maintain different movements like temperature, the flow of water, pressure, etc. The overall preservation helps to eradicate downtime & detriment of apparatus.

Execution of leakage control

One can achieve water leakage control by executing a smart water management system. The leakage sensors are fixed along with the pipelmes A recent report estimates that nearly three billion dollars are needed to fix the impairment. The conie amount is calculated for about one year.

Striking advantages

There is a list of benefits of executing an lo I enabled Smart water management of system. These benefits directly influence a series of factors like consumption, and conservation We can discuss in detail different advantages one by one. One of the main benefits of smart water management is to increase the transparency factor. The collective data relies on stakeholders activities and supply chain. This one automatically results in the processing of decisions on how to increase operations. The lol-driven scalable solutions enable authorities to automate the process and enhance human power Well-defined water management systems possess the ability to detect bugs & respond instantly to eradicate damages. An automated data-driven approach translates data into typical savings. Next, sustainability is one of the important benefits for water industries: Smart water management plays a vital role in different fields like construction, energy production, etc.

Wastewater Management

The main contradiction in water management is the leakage of water and regulation of water through multiple channels. Initially, the lol sensors are placed at the system point to detect water level, check water quality, leakage of chemicals, etc. It automatically sends notifications to the concened authorities by sending data through the cloud system and solves the issue as soon as possible. An additional advantage of smart water management is to manipulate chemical issues in the water.

Wastewater Treatment

In this present era. lol methodologies are securing the water sector. The inventive solutions help to resolve the complications of the wastewater treatment system. These solutions include level monitoring of water quantity. At the same time, it also aids in the calculation of origin value. Instant alerts will be sent to the user by interconnecting with their smart devices. At the same time, trends & technology provide efficient & quicker wastewater treatment and eradicate wastages due to leakages.

Embedded system used in IOT

Objectives : At the end of this lesson you shall be able to
- **IOT and embedded system**
- **market scope of embedded system and IOT.**

IoT and an Embedded System

Internet of Things is defined as a process in which objects are equipped with sensors, actuators and processors that involve hardware board design and development software systems, web APIs and protocols, which together create a connected environment of embedded systems.

Embedded systems will play an important role in Internet of Things (IoT) due to their unique characteristics and features such as real time computing, low power consumption, low maintenance and high availability are becoming the key enabler of IoT.

This connected environment allows technologies to get connected across multiple devices, platforms, and networks, creating a web of communication to interact digitally with the world. This connected embedded systems are changing interactions and behavior with the environment, communities and homes, and even with our own bodies.

There are embedded systems in our day today life in the form of commercial systems ke vending machines smart kiosks, AC controller, connected cars, hotel bill printers, etc, which are capable of performing a unique variety of operations Hence, when & comes to designing of these embedded IoT systems, they need to be designed for specific functions, possessing qualities of a good product design like low power consumption secured architecture reliable processor.

Market scope for Embedded systems and the Internet of Things

Embedded systems are part and parcel of every modem electronic component. These are low power consumption units that are used to run specific tasks for example remote controls, washing machines, microwave ovens RFID tags, sensors actuators and thermostats used in various applications networking hardware such as switches routers. modems, mobile phones, PDAs.

Usually embedded devices are a part of a larger device where they perform specific task of the device For example embedded systems are used as networked thermostats in Heating Ventilation and Air Conditioning (HVAC) systems, in Home Automation embedded system are used as wired or wireless networking to automate and control lights security, audiovisual systems sense climate change, monitoring, etc.

Embedded systems will also be at the cornerstone for the deployment of many Internet of Things (IoT) solutions especially within certain industry verticals and Industrial Internet of Things (IoT) applications.

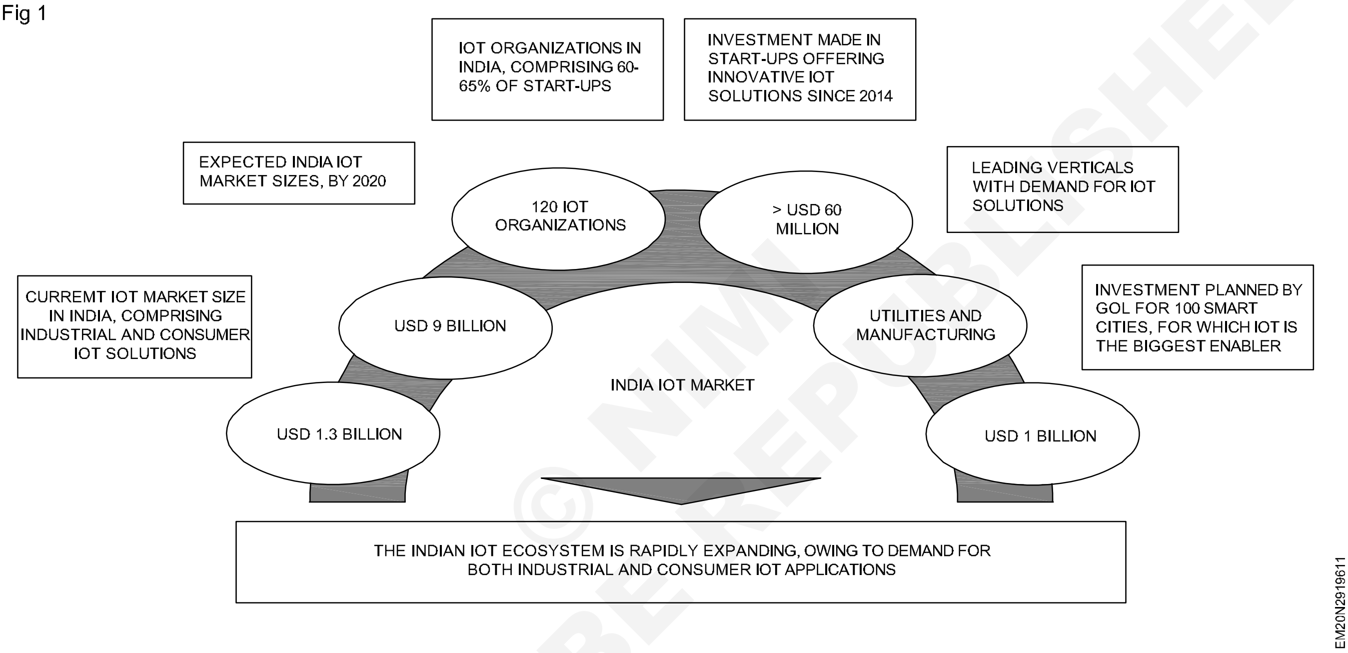
Role and Scope of IoT in present and future market place, Smart objects, wired and wirless technologies

Objectives : At the end of this lesson you shall be able to
- **to understand the current market scenario of IoT**
- **to comprehend the future market trends of IoT in India**
- **to realize the technologies which enable communication among IoT devices.**

Role and Scope of IoT in Present and Future market place

Internet of Things can connect devices embedded in various systems to the internet. When devices/objects can represent themselves digitally, they can be controlled from anywhere. The connectivity then helps us capture more data from more places, ensuring more ways of increasing efficiency and improving safety and IoT security.

Fig 1



1.9 billion devices are expected to be connected in India which leads to grow this market 31 times from the current market share of 5.6 this year.

1.1 IoT Market Trends in India

Indian IoT market has huge potential and expected to grow across industries in manufacturing, automotive, transportation and logistics. IoT is set to become a major differentiation in driving the next generation of services and products.

At present, there are approximately 7.6 billion people on the Earth. Nearly, 3.7 billion of these are connected to the Internet; roughly 50% of such connected population resides in Asia and 24% amongst them belongs to India.

A number of IoT startups In India (roughly 70%) have emerged a few years back only. Healthcare and manufacturing are popular verticals attracting a lot of investor interests. ThingsCloud, Doxper, SeeHow, Uncanny Vision, IOT Pot are some of the popular IoT startups. Market forces like cloud computing and analytics are the key drivers of IoT. There are several factors too that contribute to its growth like increased mobility, the evolution of smarter lifestyle, improved decision making, data analysis etc.

India has already more than 100 smart city initiatives planned. The focus is to enable seamless communication not only amongst humans but between machine to machine and machines to humans.

https://wire19.com/future-of-iot-in-india-current-market-trends-and-use-cases/

1.2 Future of IoT

Everyone wants a world which is connected to the internet and everything in it - from your smartphone to computers to watches and refrigerators can communicate in real- time. Internet of Things certainly makes it possible Future of IoT seems to be very bright as this is feeding and empowering Data Science and Artificial Intelligence in a big way. Data from IoT networks enables us to have better tracking, monitoring, prediction, management and control of various systems in different industries. Manufacturing, transportation, healthcare and utility sectors show more potential for IoT growth in the coming future.

Smart Objects

Objectives : At the end of this lesson you shall be able to
- **introduction of smart objects**
- **application of wired, cables, hubs etc.**

Components & Technologies of IoT

Smart Objects

The concept of smart in IoT is used for physical objects that are active, digital, networked, can operate to some extent autonomously, reconfigurable and has local control of the resources. The smart objects need energy, data storage, etc.

A smart object is an object that enhances the interaction with other smart objects as well as with people also. The world of IoT is the network of interconnected heterogeneous objects (such as smart devices, smart objects, sensors, actuators, RFID, embedded computers, etc.) uniquely addressable and based on standard communication protocols.

In a day to day life, people have a lot of object with internet or wireless or wired connection.

- Smartphone
- Tablets
- TV computer

These objects can be interconnected among them and facilitate our daily life (smart home, smart cities) no matter the situation, localization, accessibility to a sensor, size, scenario or the risk of danger.

Fig 1

Smart objects are utilized widely to transform the physical environment around us to a digital world using the Internet of things (IoT) technologies. A smart object carries blocks of application logic that make sense for their local situation and interact with human users. A smart object sense, log, and interpret the occurrence within themselves and the environment, and intercommunicate with each other and exchange information with people.

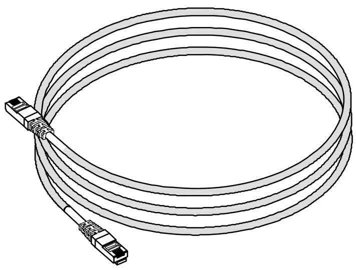
Wired Components

IoT technology is deployed in many ways so no single network solution is right. It depends on the situation and where the devices are located.

Ethernet Cable

A wired network uses Ethernet cable to connect to the network. The Ethernet cable is in turn connected to a DSL or cable to the network gateway. The wired networks are mature technology and it is easy to get plugged into if phone lines, power lines, and coaxial cable lines are available.

Fig 2



Hub

Hub is basically a multiport repeater. A hub connects multiple wires coming from different branches, for example, the connector in star topology which connects different stations. Hubs cannot filter data, so data packets are sent to all connected devices.

Bridge

A bridge is a repeater; with add on the functionality of filtering content by reading the MAC addresses of source and destination. Bridge is a Data link Layer Device. It is also used for interconnecting two LANs working on the same protocol. It has a single input and single output port, thus making it a 2 port device.

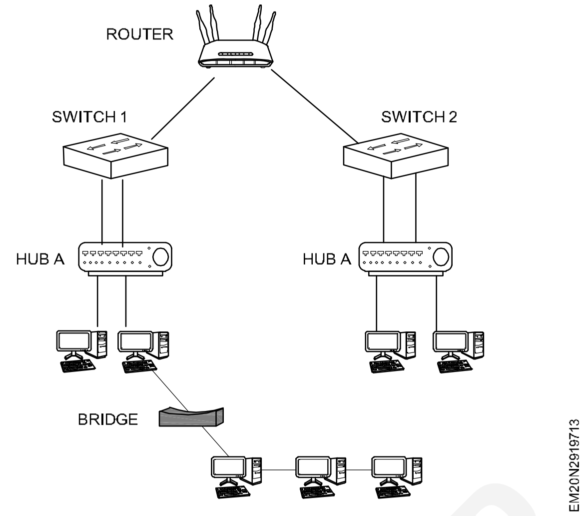
Switch

A switch is a multiport bridge with a buffer and a design that can boost its efficiency and performance. Switch is a Data link Layer Device. The switch can perform error checking before forwarding data that makes it very efficient as it does not forward packets that have errors and forward good packets selectively to correct port only.

Routers

A router is a device like a switch that routes data packets based on their IP addresses. Router is mainly a Network Layer device. Routers normally connect LANs and WANs together and have a dynamically updating routing table based on which they make decisions on routing the data packets.

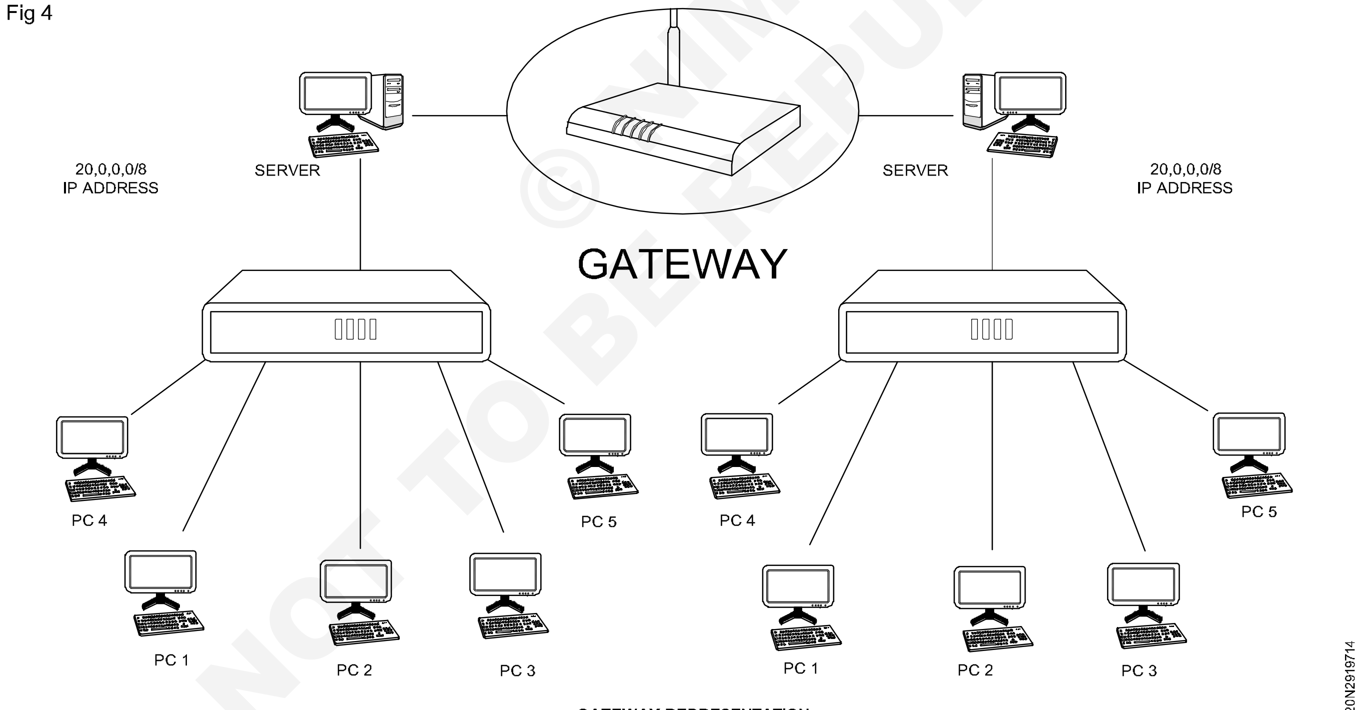
Fig 3



Gateway

A gateway, as the name suggests, is a passage to connect two networks together that may work upon different networking models. They basically work as the messenger agents that take data from one system, interpret it, and transfer it to another system. Gateways are also called protocol converters and can operate at any network layer. Gateways are generally more complex than switch or router.

Fig 4



GATEWAY REPRESENTATION

Wireless Technologies

Setting up a wireless network is a simple process that involves configuring it to get it up and running in no time.

With the evolution of network technologies, a wide range of solutions like RFID, Bluetooth, WiFi as well as the less familiar ones like - ZigBee, Z-Wave or UWB (Wltra Wide- Band).

Bluetooth Low Energy, Bluetooth Smart

Bluetooth is a short-range communications technology, which has become important in computing and consumer products. It will be the key for wearable products connecting to Internet of Things via smartphones in most cases. For IoT applications it is Bluetooth Low-Energy or Bluetooth Smart, which is more important since its power consumption is lower than Bluetooth.

Unlike Bluetooth, Bluetooth Smart cannot be used for file transfers and its data packet size is smaller.

- Frequency: 2.4GHz
- Range: less than 150m
- Data Rates: 1Mbps

Zigbee

ZigBee and its various industrial profiles are based on IEEE802.15.4 protocol, which is an industry-standard wireless networking technology. It is meant for applications requiring limited data transfers at low transfer rates within 100m range, typically in a home or building. It has advantages in complex systems requiring low-power operation, high levels of security, high scalability, high node counts and can support wireless control and sensor networks in IoT applications.

- Frequency: 2.4GHz
- Range: less than 100m
- Data Rates: 250kbps

WiFi

WiFi connectivity is an obvious choice for developers, especially within home environments and LANs. It provides fast data transfer and can handle high quantities of data. But its power consumption is likely to be too high for many IoT applications.

- Frequencies: 2.4GHz and 5GHz bands
- Range: Approximately 50m
- Data Rates: 150-200Mbps is typical, 600 Mbps maximum, latest 802.11-ac offers 500Mbps to 1Gbps

Cellular

Any IoT application that requires operations over long distances can take advantage of Cellular GSM, 3G, 4G. Cellular is suitable for high volumes of data, but the cost and power consumption for managing high volumes of data transfer are likely to be too high for most IoT applications. Cellular is suitable for sensor driven, low data projects, transferred over the Internet.

- Frequencies: 900, 1800, 1900, 2100MHz
- Range: 35km max for GSM, 200km max for HSPA
- Data Rates: less than 170kps GPRS, less than 384kbps EDGE, less than 2Mbps UMTS, less than 10Mbps HSP, 3-10Mbps LTE

Different functional building blocks of IoT architecture

Objectives : At the end of this lesson you shall be able to
- **to understand basic IoT architecture representation**
- **to realize the working process of connected components**
- **ability to develop an architecture functional blocks for the given application.**

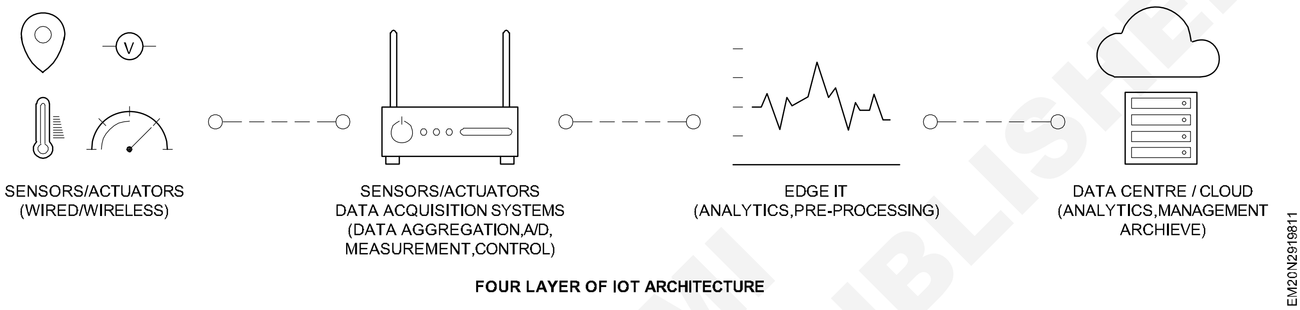
IoT Architecture

IoT architecture comprises a collection of physical objects, sensors, cloud services, developers, actuators, communication layers, users, business layers, and IoT protocols.

1.1 Basic Architecture

While every IoT system is different, the foundation of each Internet of Things architecture as well as its general data process flow is same. The below diagram shows the four layers

Fig 1



FOUR LAYER OF IOT ARCHITECTURE

1.1.1 Layer 1

First layer consists of the Things, which are objects connected to the Internet which by means of their embedded sensors and actuators are able to sense the environment around them and gather information that is then passed on to IoT gateways. To pick up physical parameters in the outside world or within the object itself, they need sensors. These can be either embedded in the devices themselves or implemented as standalone objects to measure and collect telemetry data. For an example, think of agricultural sensors whose task is to measure parameters such as air and soil temperature and humidity, soil pH levels or crop exposure to sunlight.

Another indispensable element of this layer are the actuators. Being in close collaboration with the sensors, they can transform the data generated by smart objects into physical action.

Example

Let's assume a smart watering system with all the necessary sensors in place. Based on the input provided by the sensors, the system analyses the situation in real time and commands the actuators to open selected water valves located in places where soil humidity is below the set value. The valves are kept open until the sensors report that the values are restored to default. Obviously, all of this happens without a single human intervention.

1.1.2 Layer 2

The Second stage consists of IoT data acquisition systems and gateways that collect the great mass of unprocessed data, convert it into digital streams, filter and pre-process it so that it is ready for analysis. Gateway act as an intermediaries between the connected things and the cloud and analytics,.

Gateways provide a place for the local preprocessing of sensor data which is squeezed into useful bundles ready for further processing.

Another aspect that the gateways support is security. Because the gateways are responsible for managing the information flow in both directions, with the help of proper encryption and security tools they can prevent IoT cloud data leaks as well as reduce the risk of malicious outside attacks on IoT devices.

1.1.3 Layer 3

The third layer is represented by edge devices responsible for further processing and enhanced analysis of data. This layer is also where visualization and machine learning technologies are applied. Data is transferred to data centers which can be either cloud-based or installed locally, where the data is stored, managed and analyzed in depth for actionable insights.

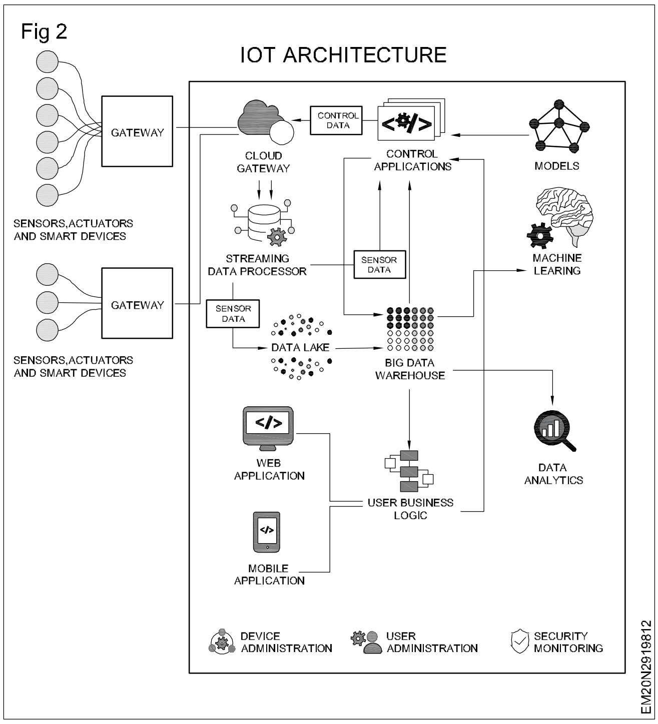
1.2 IoT Architecture

Because of the wide domain of internet objects, there is no single consensus on IoT architecture, which is universally agreed

1.2.1 Architecture Components

Things. A "thing" is an object equipped with sensors that gather data which will be transferred over a network and actuators that allow things to act .

Gateways. Data goes from things to the cloud and vice versa through the gateways. A gateway provides



connectivity between things and the cloud part of the IoT solution, enables data preprocessing and filtering before moving it to the cloud and transmits control commands going from the cloud to things.

Cloud gateway facilitates data compression and secure data transmission between field gateways and cloud IoT servers. It also ensures compatibility with various protocols and communicates with field gateways using different protocols depending on what protocol is supported by gateways.

Streaming data processor ensures effective transition of input data to a data lake and control applications. No data can be occasionally lost or corrupted.

1.2.2 Device management

To ensure sufficient functioning of IoT devices, there are some procedures required to manage the performance of connected devices (facilitate the interaction between devices, ensure secure data transmission and more):

- Device identification to establish the identity of the device to be sure that it's a genuine device with trusted software transmitting reliable data.
- Configuration and control to tune devices according to the purposes of an IoT system. Some parameters need to be written once a device is installed (for example, unique device ID). Other settings might need updates (for example, the time between sending messages with data).
- Monitoring and diagnostics to ensure smooth and secure performance of every device in a network and reduce the risk of breakdowns.
- Software updates and maintenance to add functionality, fix bugs, address security vulnerabilities.

1.2.3 User management

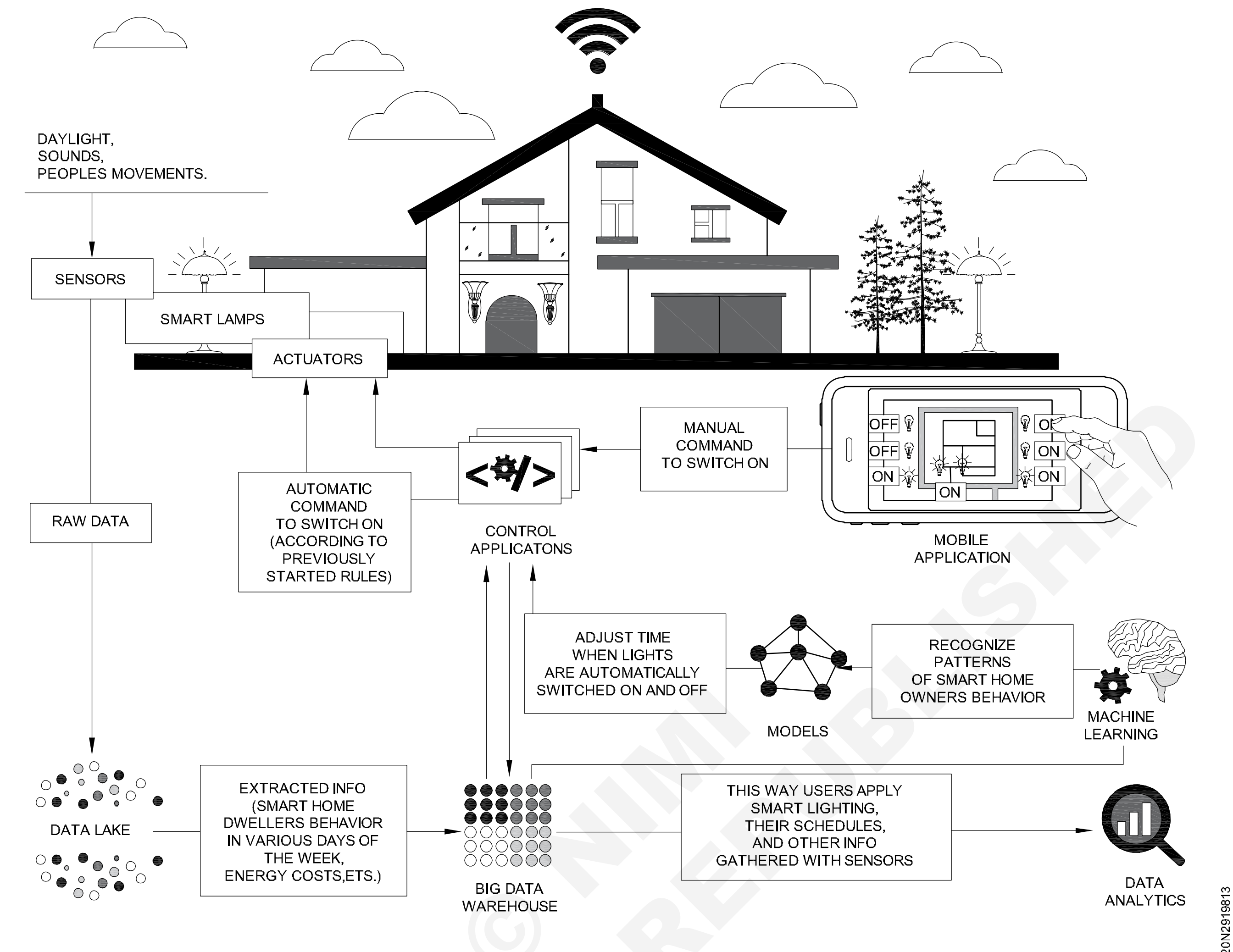
Along with device management, it's important to provide control over the users having access to an IoT system.

User management involves identifying users, their roles, access levels and ownership in a system. It includes such options as adding and removing users, managing user settings, controlling access of various users to certain information, as well as the permission to perform certain operations within a system, controlling and recording user activities and more.

1.2.4 Security monitoring

Security is one of the top concerns in the internet of things. Connected things produce huge volumes of data, which need to be securely transmitted and protected from cyber-criminals.

Fig 3



INTERLLIGENT LIGHTING

Fiber optic communication

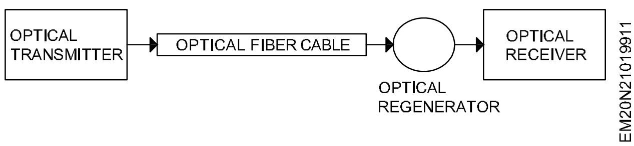
Objectives : At the end of this lesson you shall be able to
- **define the fiber optic communication**
- **explain the block diagram and function of the fiber optic communication**
- **state the advantages and disadvantages of the optical fiber communication**
- **state the applications of the fiber optic communication.**

Fiber optics is a branch of optics that deals with the study of propagation of light through transparent dielectric wave guides.

Fiber-optic communication is a method of transmitting information from one place to another by sending pulses of light through an optical fiber.

A simple typical optical fiber telecommunication system is as shown in Fig 1.

Fig 1



Fiber-optics have revolutionized the telecommunication industry and have played a major role in this. Because of its advantages over electrical signal transmission, optical fibers have largely replaced copper wire communications in core networks in the developed world. Optical fiber is used by many telecommunication companies to transmit telephone signals, Internet communication, and cable television signals.

A detailed block diagram of optical fiber communication system is shown in Fig 2.

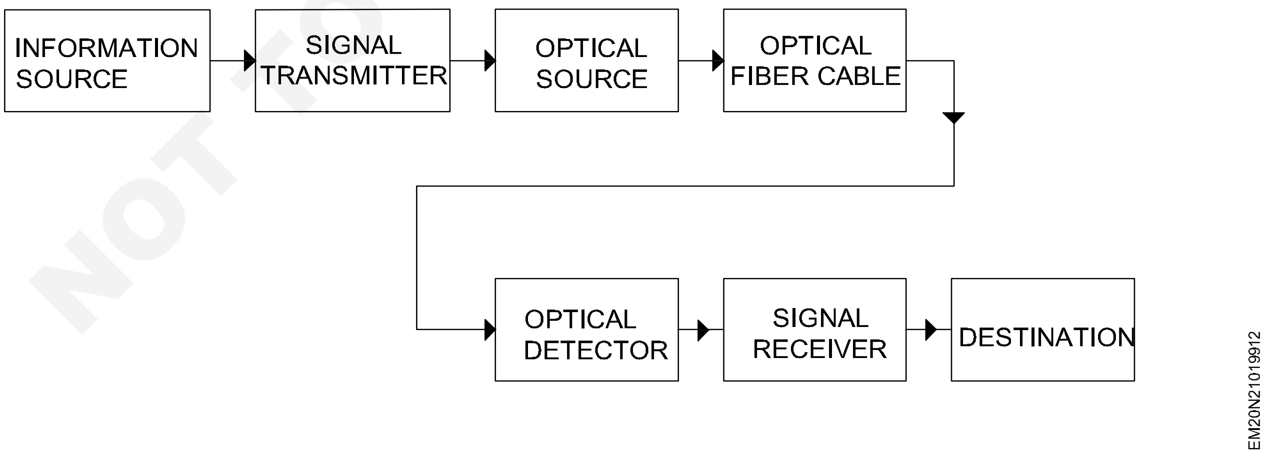
When the input data in the form of electrical signals, is given to the transmitter circuitry; it converts them into light signal with the help of a light source. This source is of LED whose amplitude, frequency and phases must remain stable and free from fluctuations in order to have efficient transmission. The light beam from the source is carried by a fiber optic cable to the destination circuitry wherein the information is transformed or converted back to the electrical signal by a receiver circuit.

The Receiver circuit consists of a photo detector along with an appropriate electronic circuit, which is capable of measuring magnitude, frequency and phase of the optic field. This type of communication uses the wave lengths near to the infrared band that are just above the visible range. Both LED and Laser can be used as light sources based on the application.

Visible light range

Light is an electromagnetic signal like radio wave. It can be modulated by the information signal and sent over the fiber- optic cable. The frequency of light is extremely high; it can be used to accommodate very wide bandwidth of the information and extremely high data rates can be achieved with excellent reliability. Fig 3 shows the frequency spectrum and wavelengths of visible light spectrum.

Fig 2



Basic elements of a fiber optic communication system

There are three main basic elements of fiber optic communication system. They are

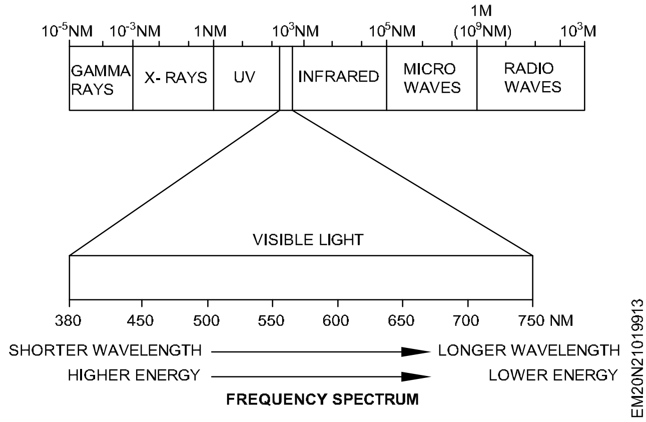
1 Compact light source

2 Low loss optical fiber

3 Photo detector

Accessories like connectors, switches, OFC couplers, multiplexing devices, amplifiers and splicer are also essential elements in this optical fiber communication system.

Fig 3



1 **Compact light source:** Depending on the applications, the light source requirements may vary. The requirements of the sources including power, speed, spectral line width, noise, ruggedness, cost, temperature, and so on. Two components are used as light sources: light emitting diodes (LEDs) and laser diodes.

The light emitting diodes are used for short distances and low data rate applications due to their low bandwidth and power capabilities. Two such LEDs structures include Surface and Edge Emitting Systems. The surface emitting diodes are simple in design and are reliable, but due to its broader line width and modulation frequency limitation, edge emitting diodes are mostly used. Edge emitting diodes have high power and narrower line width capabilities.

For longer distances and high data rate transmission, Laser Diodes are preferred due to its high power, high speed and narrower spectral line width characteristics. But these are inherently non-linear and more sensitive to temperature variations.

2 **Low loss optical fiber:** The purpose of optical fiber is to transmit light signal from transmitter to receiver. Optical fiber is a cable, which is also known as cylindrical dielectric waveguide made of low loss material. An optical fiber considers the parameters like the environment in which it is operating, the tensile strength, durability and rigidity. The fiber optic cable is made of high quality extruded glass (si) or plastic, and it is flexible. The diameter of the fiber optic cable is in between 0.25 to 0.5mm (slightly thicker than a human hair).

3 **Photo detectors:** The purpose of photo detectors is to convert the light signal back to an electrical signal. Two types of photo detectors are mainly used for optical receiver in optical communication system: PN photo diode and avalanche photo diode. Depending on the applications wavelengths, the material composition of these devices may vary. These materials include silicon, germanium, InGaAs, etc.

Advantages

The primary advantages of the Fiber-optic cables over conventional cables and radio waves are:

1 **Wider band width:** Optical fiber have greater information capacity than metallic cable because of the inherently wider bandwidth upto several thousand GHz available with optical frequencies. It has higher information carrying capacity.

2 **Lower loss:** With fiber-optic cables, there is less signal attenuation over long distances.

3 **Small size and Light weight:** Optical fibers are very small diameter in the range from 10 micrometers to 50 micrometers. The space occupied by the fiber cable is negligibly small as compared to the conventional electrical copper cables.

4 **Security:** Fiber-optic cables cannot be "tapped" as easily as electrical cables.

5 **Environmental immunity:** OFC cables are more resistant to environment extremes including weather variations than metallic cables. Optic cables also operate over a wide temperature range and are less affected by corrosive liquids and gases.

6 **Electrical Isolation:** Optical -fibers are fabricated from glass or plastic polymers, they are electrical insulators therefore they do not exhibit earth loop, interference problems, electromagnetic waves or any high current lightning.

7 **Potential low cost and maintenance:** In comparison with the copper conductors optic-fiber offers low cost line communication. This is because many miles of optical cables are easier and less expensive to install than the same amount of copper wire or cable.

Disadvantages

The cost of interfacing equipments necessary to convert electrical signals to optical signals is more. (Optical transmitters, receivers). Splicing fiber optic cable is also more difficult.

1 Expensive over short distance.

2 Requires highly skilled installers.

3 Adding additional nodes is difficult.

Ruggedness: The main disadvantage of the fiber-optic cable is its small size and brittleness makes more difficult to work with it.

Fiber-Optic Applications: Telecommunication applications are widespread, ranging from global networks to desktop computers. This involves the transmission of voice, data, or video over distances of less than a meter to hundreds of kilometers using fiber designs.

Optical fiber is used extensively for transmission of data. Multinational firms need secure, reliable systems to transfer data and financial information between buildings to the desktop terminals or computers and to transfer data around the world. Cable television companies also use optical fiber communication system for the delivery of digital video and data services. The high bandwidth provided by fiber makes it perfect choice for transmitting broadband signals, such as high-definition television (HDTV) telecasts.

Intelligent transportation systems, such as smart highways with intelligent traffic lights, automated tollbooths, and changeable message signs, also use fiber-optic-based telemetry systems.

Another important application for optical fiber is the biomedical industry. Fiber-optic systems are used in most modern telemedicine devices for transmission of digital diagnostic images. Other applications for optical fiber include space, military, automotive, and the industrial sector.

Optical fiber

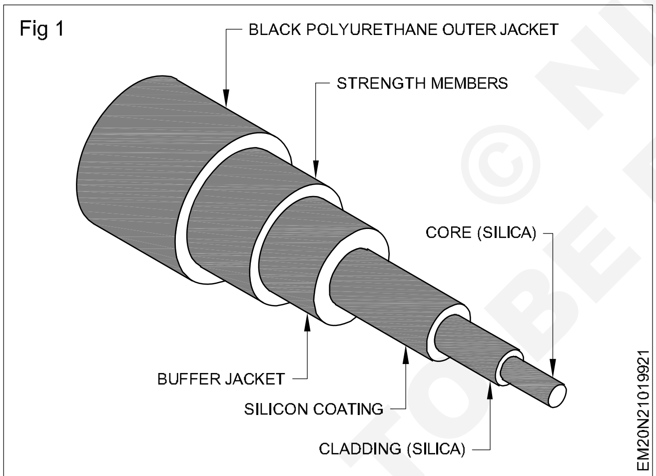
Objectives : At the end of this lesson you shall be able to
- **define optical cable**
- **explain the construction details of an optical cable**
- **define refractive index and total internal deflection**
- **explain the working principle of an optical cable**
- **state the types of fiber**
- **differentiate the single mode and multi mode optical cable.**

What is an optical fiber?

Typically, fiber optics are long, thin strands of glass (SiO_2) about the diameter of human hair; some can be made out of plastic. Long distance telecommunication systems always use glass because of its lower optical absorption during transmission to maintain the signal strength. When arranged in bundles, they are called optical cables which are used to transmit light signals containing information over long distances.

Construction of optical fiber: The structure of optical fiber is shown in Fig 1.

Fig 1



1 Core

2 Cladding

3 Buffer

4 Jacket

Core

The core of a fiber cable is a cylinder of plastic or silica or glass that runs all along the fiber cable's length, and offers protection by cladding. The diameter of the core depends on the application used. Due to internal reflection, the light travelling within the core reflects from the core and the cladding boundary. The core cross section needs to be a circular one for most of the applications.

Cladding: Cladding is an outer optical material that protects the core. The main function of the cladding is that it reflects the light back into the core. When light enters through the core (dense material) into the cladding (less dense material), it changes its angle, and then reflects back to the core.

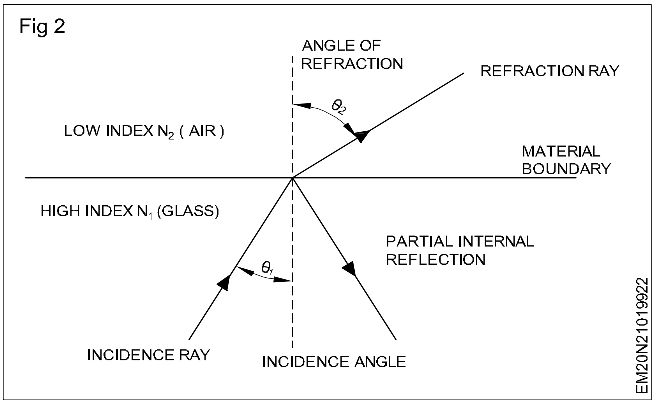
Buffer jacket: The main function of the buffer is to protect the fiber from damage while arranged in optical cables. These bundles are protected by the cable's strength members covering.

Outer jacket: Fiber optic cable's jackets are available in different colours that can easily make us recognize the exact colour of the cable we are dealing with. The colour yellow clearly signifies a single mode cable, and orange colour indicates multimode. It is also given mechanical strength to the optical cables.

Characteristics of light: Reflection: The bouncing back of rays of light from a polished and shiny surface is called reflection of light.

Refraction: It is the bending of light ray that occurs when the light ray passes from one medium to the other.

Fig 2



Angle of incidence: The angle at which light strikes a surface with respect to the normal.

Angle of reflection: The angle at which light is reflected from a surface.

Index of refraction: The index of refraction (or refractive index) is a way of measuring the speed of light in a material. Light travels fastest in vacuum, such as in outer space. The speed of light in a vacuum is about 300,000 kilometers (186,000 miles) per second. The refractive index is the ratio of the speed of light in vacuum to the speed of light in that medium. The refractive index of a vacuum is therefore 1, by definition.

Total internal reflection: The heart of an optical communication system is the optical fiber that acts as the transmission channel carrying the light beam loaded with information.

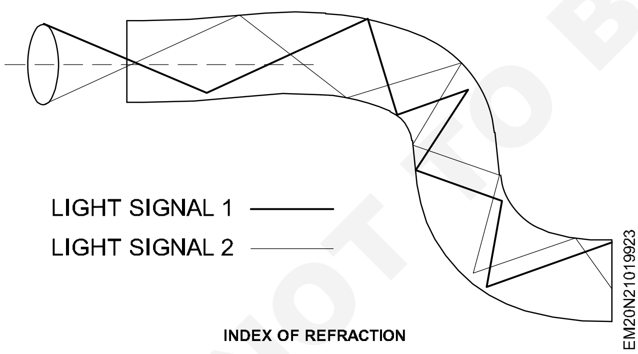
When the light ray strikes the interface at an angle greater than the critical angle, the light ray does not pass through the interface into the glass. The effect is as if a mirror existed at the interface.

When this occurs the angle of reflection is equal to the angle of incident as if a real mirror were used. This action is known as total internal reflection.

Critical angle is the angle of incidents that causes the refracted light to travel along the interface between two different media. If the angle of incidents is made greater than the critical angle, the reflection occurs instead of refraction.

Working principle of fiber optic cable: The principle of operation of an optical fiber lies in the behavior of light as shown in Fig 3 that the light always travels in straight line and at constant speed. In this, the light propagates in straight lines, but it is reflected inside the optical Fiber. Million and trillion times of reflected by the clad, it acquires the shape of the optical fiber. So effectively, it is said to have been travelling along the Fiber as shown in the Fig 3. It changes its direction only if there is a change in the dielectric medium . The propagation of light within an optical fiber is necessary to take in to account the refractive index of the dielectric medium.

Fig 3



INDEX OF REFRACTION

Refractive index of a medium is defined as the ratio of velocity of light in vacuum to velocity of light in medium.

$$\text{Refractive index} = \frac{\text{Velocity of light in vacuum}}{\text{Velocity of light in medium}}$$

Since, the velocity of light in any solid, transparent material is less than in vacuum, the refractive index of such material is always greater than 1. A ray of light travels slowly in an optical medium than one that is less dense. Now, the direction that the light approaches the boundary between the two materials is very important. When a ray is incident on the interface between two dielectrics of differing refractive indices, refraction occurs. The light is refracted and also partly reflected internally in the same medium; which is referred as Partial Internal Reflection.

Classification of optical fiber: There are two basic ways of classifying fiber

1 Based on the modes

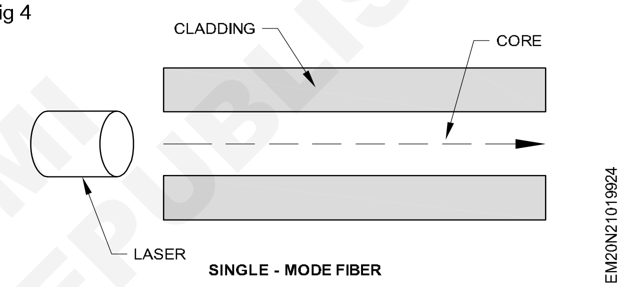
   i Single mode fiber ii Multi mode fiber

2 Based on index of refraction varies across the cross section of the cable.

   i Step index fiber ii Graded index fiber

Single mode fibers: The single mode optical fiber SMF (mono mode optical fiber, single mode optical wave guide, or uni mode fiber) type has the smaller core diameter in the order of 3.5 x 10^{-4} inches or 9 microns and a cladding diameter of 125 mm. These fibers are used in telephone and television due to small cores.

Fig 4

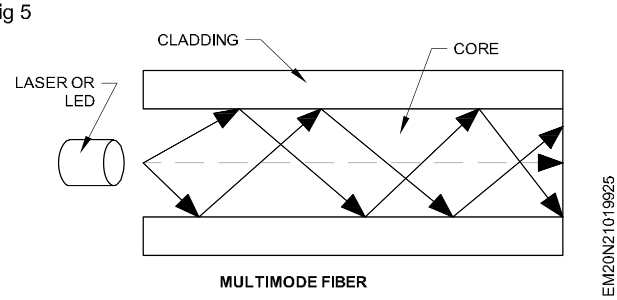


SINGLE - MODE FIBER

This SMF is designed to carry only a single ray of light (mode). Although the ray travels parallel to the length of the fiber, it is often called transverse mode since its electromagnetic vibrations occur perpendicular (transverse) to the length of the fiber.

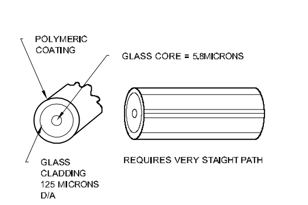
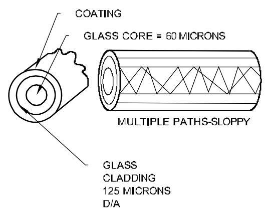
Multi mode fibers: The MMF type has larger core diameters on the order of 2.5 x 10^{-3} inches or 62.5 microns as to transmit many signals per fiber. While the number of light reflections increased as the light passes through the core increases. It creates the ability for more data to pass through at a given time. Because of the high dispersion and attenuation rate with this type of fiber, the quality of the signal is reduced over long distances. This application is typically used for short distance, data and audio/video applications in LANs. RF broadband signals commonly used by the cable companies, cannot be transmitted over multimode fiber.

Fig 5



MULTIMODE FIBER

Difference between Single Mode & Multi Mode

SINGLE MODE 	MULTIMODE 
Small core(9 microns)	Larger core than single-mode cable (50 microns or greater)
Less dispersion	Allows greater dispersion and therefore, loss of signal.
Suited for long-distance applications (upto-3 km)	Used for long-distance application, but shorter than single-mode(upto 2 km)
Used lasers as the light source for distances of several thousand meters	Uses LEDs as the light source often within LANs or distances of a couple of hundred meters.

The following IST specifications for the selection and installation of fiber-optic cable and associated hardware are intended to ensure a reliable and consistent fiber optic media infrastructure

1 Single mode fibers

i Thickness of fiber: 8.3 to 125micro meter

ii Wave length (to be used): 1310 nano meter,1550 nano meter

iii Maximum attenuation: 1.0dB/ kilometer

iv Capable to support tensile load of 180 Kg

v Capable of minimum crush resistance of 152 Kg/cm

vi Cable should be tight buffered, ie., the fiber should not be placed loosely in cladding layer.

2 Multi mode fiber

i Thickness of fiber: 8.3 to 125 micrometer.

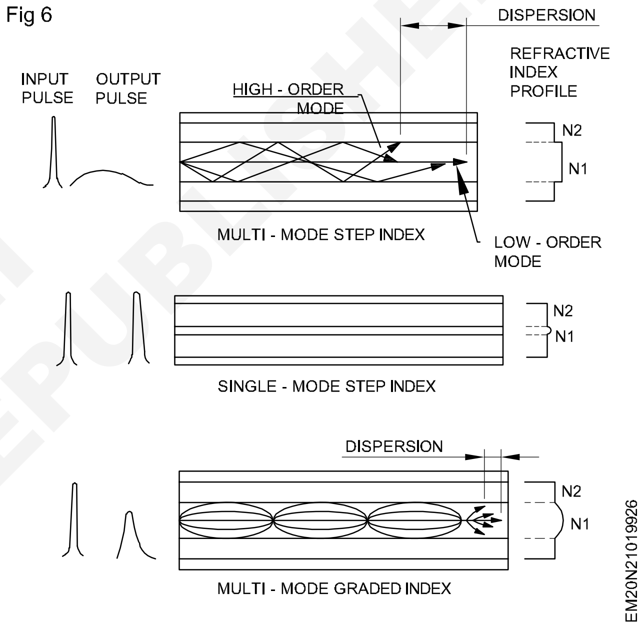
ii Wave length (to be used): 850 nano meter,1550 nano meter.

iii Capable to support tensile load of 180 Kg.

iv Capable of minimum crush resistance of 152 Kg/cm.

v Folded core ie., fibers with cladding layer should have been closely bunched together.

Fig 6



Losses in optical fibers

Objectives : At the end of this lesson you shall be able to
- **state the types of losses in the fiber optics**
- **explain the attenuation losses in an optical cable**
- **define dispersion**
- **state the types of dispersion and explain about each type.**

Losses: The Signal transmitting through the fiber is degraded by two mechanisms. (Fig 1)

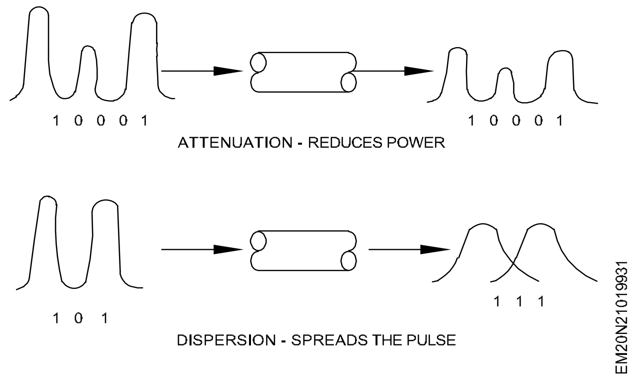
1 Attenuation   2 Dispersion

Both are important to determine the transmission characteristics of the fiber at operating wavelength.

Attenuation: Power loss in a fiber cable is probably the most important characteristics of the cable. Power loss is often called as attenuation.

Attenuation is a measure of decay of signal strength or loss of light power that occurs as light pulses propagate through the length of the fiber.

Fig 1



Attenuation has several adverse effects on performance, including reducing the system bandwidth, information transmission rate, efficiency, and overall system capacity.

Total power loss in an optical fiber cable is

$$\boxed{A(dB) = 10 \log (Pout/Pin)}$$

Where

A(dB) - Total reduction in power level, attenuation.

Pout - Cable output power (watts) and

Pin - Cable input power (watts)

The basic attenuation mechanisms in a fiber are

1 Absorption

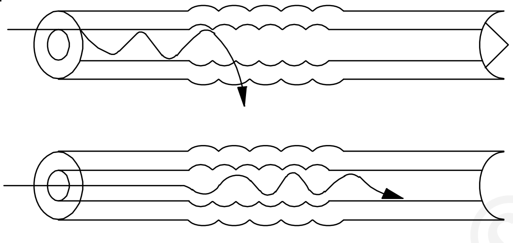
2 Scattering and

3 Radiative losses of the optical energy

Absorption is related to the fiber material and scattering also due to the fiber material and with structural imperfections in the optical waveguide.

Radiative losses occur whenever an optical fiber under goes a bend (both microscopic and macroscopic) of finite radius of curvature as shown in Fig 2.

Fig 2

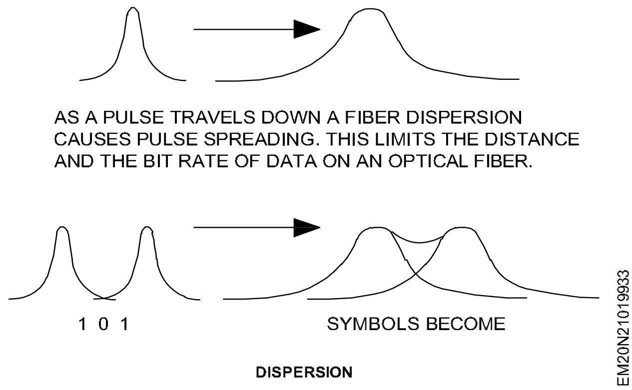


Dispersion: Dispersion means the spreading of light pulse as it propagates through the fiber as shown in Fig 3.

It introduces Inter Symbol interference (ISI). It limits the information carrying capacity of fiber.

The dispersion effect can be explained on the basis of behaviour of group velocities of the guided modes in the

Fig 3



DISPERSION

optical fiber. Group velocity means the velocity at which energy in a pulse travel along the fiber.

Types of dispersion

Disperson is mainly 2 types

1 Intramodal dispersion

2 Intermodal dispersion

Intermodal dispersion is divided into

i Material or chromatic dispersion

ii Waveguide dispersion

iii Group velocity dispersion (GVD) or Modal dispersion

Intramodal dispersion

Intramodal dispersion is pulse spreading that occurs within a single mode.

It arises due to group velocity being a function of wavelength. The increasing spectral width of the optical source will increase the intramodal dispersion.

Intermodal distortion (or) Multimode dispersion

1 The intermodal distortion arises due to the variation in the group delay for each individual mode at single frequency.

2 This distortion is available in multimode fibers.

Encoding and decoding of light

Objectives : At the end of this lesson you shall be able to
- **define encoding and decoding of light**
- **explain the different types of optical sources**
- **diode and different types of optical decoders**
- **state the requirement of photo detectors used in the optical communication system.**

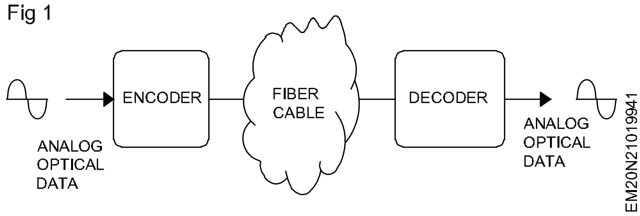
Encoding in optical fiber transmission means the transmission of analog optical information through fiber optics digitally as shown in Fig 1.

This improves the acceptable signal-to-noise ratio (SNR) by 20 to 30 dB over analog transmission.

Transmitter

Fiber optic transmitters are typically composed of a buffer, driver and optical source. The buffer provide both an electrical connection and isolation between the

Fig 1



transmitter and the electrical system supplying the data. The driver provides electrical cover to the optical source. Finally the optical source converts the electrical current to the light energy with the same pattern.

Optical source

Optical Sources are active components whose fundamental function is to convert the electrical energy into optical energy(light) in an effective manner. Hence the optical sources are transducers.

Optical source is major component in an optical transmitter.

Popularly used optical sources are Light emitting diode (LED) and semiconductor laser diodes (also referred to as injection laser diodes or ILDs).

Requirements of light sources for communication

i Light output should be highly directional.

ii It must require very small power for its operation.

iii Optical output should be stable irrespective of changes in temperature.

iv The light source should have compact size and high efficiency.

v High optical output power and coupling efficiency.

vi It is essential that the source is comparatively cheap and highly reliable in order to compete with conventional transmission techniques.

Almost all these requirements are satisfied by LASER and LED. Both operate in forward-biased mode.

1 LED-Monochromatic incoherent source.

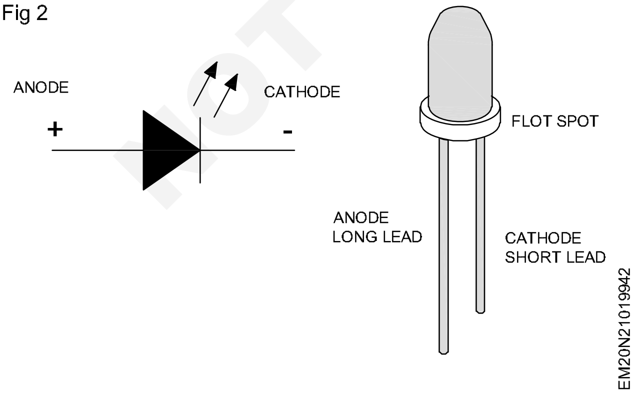
2 LASER-Monochromatic coherent source.

Light Emitting Diode (LED)

LEDs are used in optical communication systems that require bit rate less than approximately 100-200 mbps. It is mostly coupled with multimode fiber.

It covers broad spectrum of wavelengths and the emitted power is proportional to the diode current. (Fig 2)

Fig 2



Emission of light from LED

Conduction band of the semiconductor is populated by electrons injected into it. By the forward current through the junction and light is generated when these electrons recombine with holes in valence band to emit a photon.

LED can be used in fiber transmission applications must have

i High Radiance output or brightness.

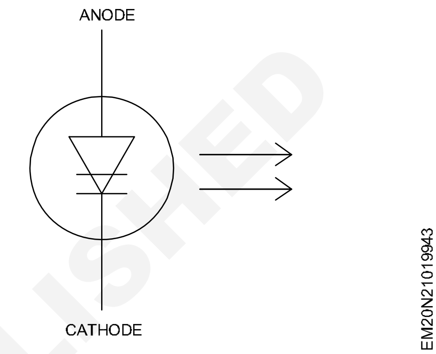
ii Fast transmission response time.

iii High quantum efficiency.

LASER diode

LASER is acronym for Light Amplification by Stimulated Emission of Radiation. (Fig 3)

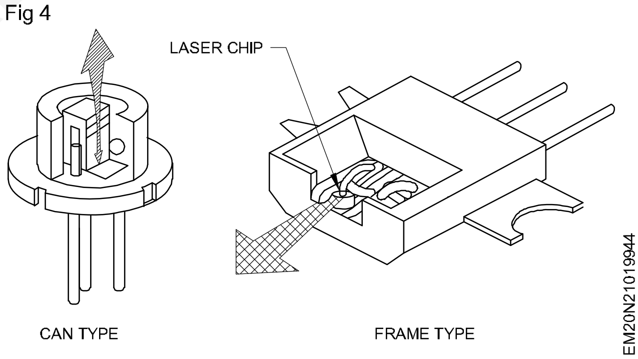
Fig 3



Ideal LASER light is single-wavelength only. This is related to the molecular characteristics of the material being used in the LASER. It is formed in parallel beams and in single phase. That is, it is coherent.

Laser diode is available in two different packages as shown in Fig 4.

Fig 4



1 Can type package

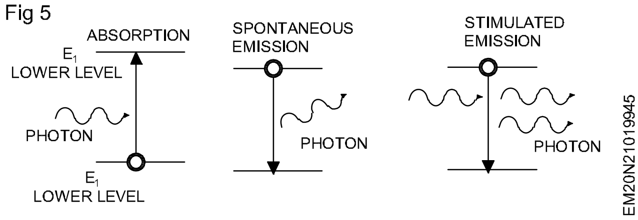
2 Frame type package

The lasing medium can be a gas, a liquid, an insulating crystal, or a semiconductor.

Principle of operation

The three different mechanisms are shown in Fig 5 below.

Fig 5



1 **Absorption:** An atom in a lower level absorbs a photon and moves to an upper level.

2 **Spontaneous emission:** An atom in an upper level can decay spontaneously to the lower level and emit a photon if the transition between upper and lower energy level. This photon has a random direction and phase.

3 **Stimulated emission:** An incident photon causes an upper level atom to decay and emitting a "stimulated" photon whose properties are identical to those of the incident photon. The term "stimulated" underlines the fact that this kind of radiation only occurs if an incident photon is present. The amplification arises due to the similarities between the incident and emitted photons.

Comparison of LASER & LED

The differences between LASER and LED for various parameters are listed in the TABLE below.

Sl. No.	Parameter	LASER	LED
1.	Output beam	Coherent	Incoherent
2.	Coupling co efficiency	High	Low
3.	Output power	High	Low
4.	Cost	Expensive	Less
5.	Application	Moderate distance with low data rate	Long distance with high data rate
6.	Circuit complexity	Complex	Simple
7.	Temperature dependent	More	Less

Optical receiver: Optical receiver (photo detector) converts the variation in optical power into a corresponding variation in the electric current. The design of an optical receiver is much more complicated than that of an optical transmitter because the receiver must first detect weak, distorted signals and then make decisions on what type of data was sent based on an amplified version of this distorted signal.

The optical receiver can be broken down into three parts. These consist of:

1 Channel coupler (Output)

2 Detector

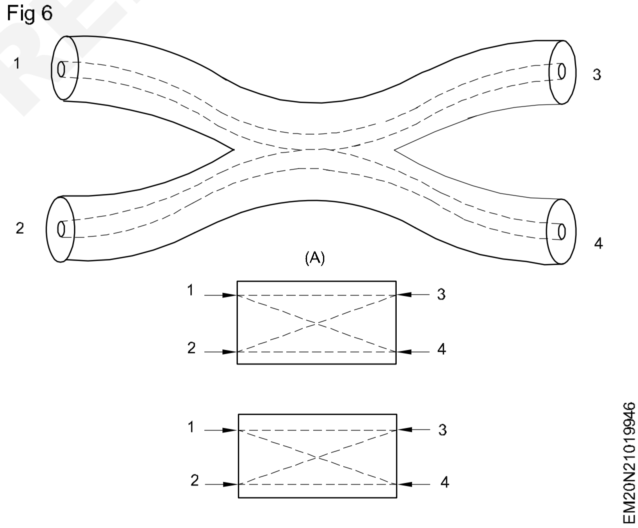
3 Signal processor

Channel coupler (Output): In a fiber system, the output coupler merely directs the light emerging from the fiber into the light detector. This light is radiated in a pattern identical to the fiber's acceptance cone as shown in Fig 6.

Detector: The detector is an essential component of an optical fiber communication system and is one of the crucial elements which decides the overall system performance.

The information being transmitted must now be taken off the carrier wave. In the fiber system, the optic wave is converted into an electric current by a photo detector.

Fig 6

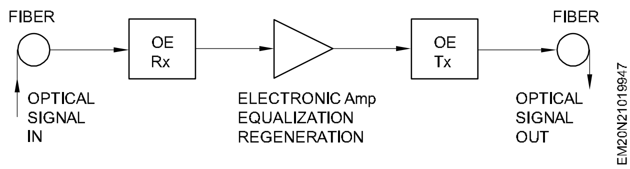


Optical amplifiers: In order to transmit signals over long distances (100 km) it is necessary to compensate for attenuation losses within the fiber““Initially this was accomplished with an optoelectronic module consisting of an optical receiver, a regeneration and equalization system, and an optical transmitter to send the data““Although functional this arrangement is limited by the optical to electrical and““electrical to optical conversions.

- Several types of optical amplifiers have since been demonstrated to replace the OE-electronic regeneration systems.

- These systems eliminate the need for E-O and O-E conversions.
- This is one of the main reasons for the success of today's optical““communications systems.

Fig 7



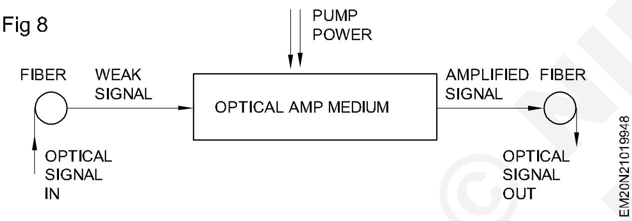
Optical amplifiers: The general form of an optical amplifier

Some types of OAs that have been demonstrated include:

- Semiconductor optical amplifiers (SOAs)
- Fiber Raman and Brillouin amplifiers
- Rare earth doped fiber amplifiers (erbium-EDFA 1500 nm. praseodymium-PDFA 1300 nm)

The most practical optical amplifiers to date include the SOA and EDFA types New pumping methods and materials are also improving the performance of Ram in amplifiers.

Fig 8



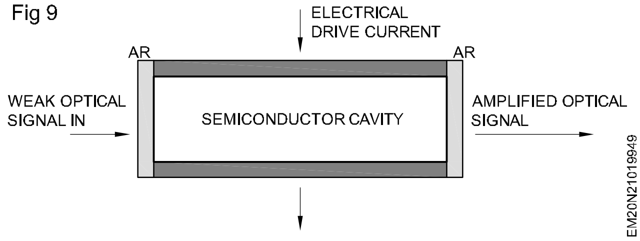
Characteristics of SOA types:

- Polarization dependent-require polarization maintaining fiber
- Relatively high gain-20 dB
- Output saturation power 5-10 dBm
- Large BW
- Can operate at 800, 1300, and 1500 nm wavelength regions.
- Compact and easily integrated with other devices
- Can be integrated into arrays
- High noise figure and cross-talk levels due to nonlinear phenomenon such as 4-““wave mixing

This last feature restricts the use of SOAS

- Semiconductor Optical Amplifier (SOA)- similar to a laser cavity. Used as a discrete amplifiers. They can be integrated into arrays of amplifying switching and gating devices. Finding application in all optical 3R regeneration systems
- Limited in operation below 10 Gb/s (Higher rates are possible with lower gain)

Fig 9



Rare Earth Doped Fiber Amplifier characteristics: Rare earth doped fiber amplifiers are finding increasing importance in optical communications systems. Perhaps the most important version is erbium doped fiber amplifiers (EDFAs) due to their ability to amplify signals at the low loss 1.55 um wavelength range.

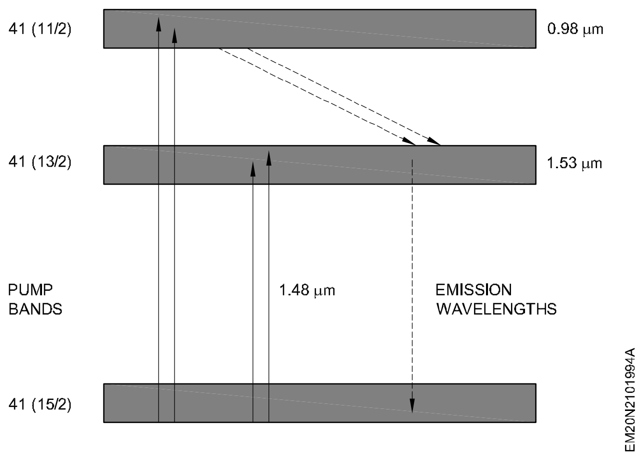
Characteristics of EDFAS (advantages):

- High power transfer efficiency from pump to signal power (50%)
- Wide spectral band amplification with relative flat gain (>20 dB)- useful for““WDM applications
- Saturation output 1 mW (10 to 25 dBm)
- Gain-time constant long (>100 msec) to overcome patteming effects and inter-““modulation distortions (low noise).
- Large dynamic range.
- Low noise figure
- Polarization independent
- Suitable for long-haul applications.

Disadvantages of EDFAS:

- Relatively large devices (km lengths of fiber)- not easily integrated with other devices
- ASE-amplified spontaneous emission. There is always some output even with““no signal input due to some excitation of ions in the fiber-spontaneous noise.
- Cross-talk effects
- Gain saturation effects
- An energy level diagram for Er doped silica is shown below.
- Pumping is primarily done optically with the primary pump wavelengths at 148 jump and 0.98 m. As indicated atoms pumped to the 41 (11/2) 0.98 um band decays to the primary commission transition band. Pumping with 1.48 um light is directly to the upper transition levels of the emission band.
- Semiconductor lasers have been developed for both pump wavelengths.
- 10-20 mW of absorbed pump power at these wavelengths can produce 30-40 dB of amplifier gain.
- Pump Efficiencies of 11 dB/mW achieved at 980 nm.
- Pumping can also be performed at 820 and 670 nm with GaAIAs laser diodes. Pump efficiencies are lower but these lasers can be made with high output power.

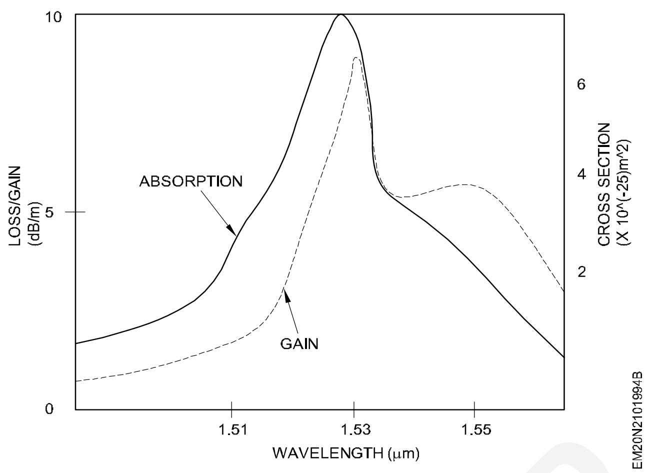
Fig 10



Typical Absorption Gain Spectrum for Erbium Doped Fiber:

- Since the gain spectrum of erbium resembles a 3-level atom it is possible to model the gain properties using this approach.
- Several different wavelength bands have been designated for wavelength division multiplexing and EDFAs have been designed to operate in these bands.

Fig 11



- The divisions have been designated as""

S-Band 1480-1520 nm

C-Band 1521-1560 nm

L-Band 1561-1620 nm

(Note some variability in these values is common)

Pulse modulation technique

Objectives : At the end of this lesson you shall be able to

- **define pulse**
- **state the types of pulse modulation**
- **explain PCM,PAM,PWM and PPM**
- **state the advantages, disadvantage and applications of each type of modulation**
- **compare the different types of pulse modulation techniques.**

Pulse

A pulse is an abruptly changing voltage or current wave which may or may not repeat itself as shown in Fig 2. The Fig 2(b) Shows a repetitive pulse train and Fig 2(c) shows a pulse with its trailing and leading edges.

Types of modulation

AM, FM modulation & demodulation already we discussed in Semester 3 Communication Electronics topic. Here we can discussed with PWM, PPM.

Fig 1

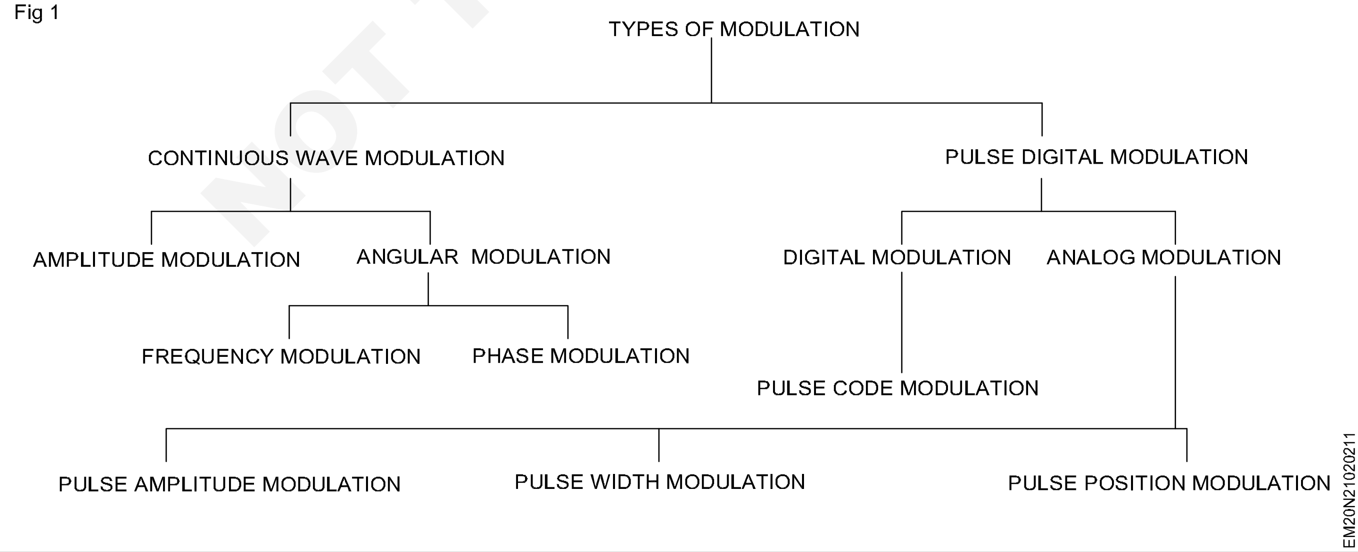
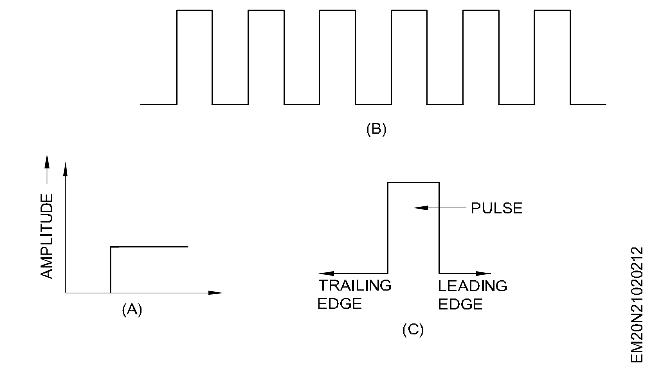


Fig 2



Pulse modulation

It may be defined as a modulation system in which some parameter of a train of pulse is varied in accordance with the instantaneous value of the modulating signal. In this system, waveforms are sampled at regular intervals and the information is transmitted through the sampling rate. The parameters of the pulses which may be varied are : amplitude, width (or duration), position and time etc

In pulse modulation, there are different types of modulation techniques for analog and digital as given below:

PCM : Pulse Code Modulation for Digital Modulation.

PPM : Pulse Position Modulation for Analog Modulation

PWM : Pulse Width Modulation for Analog Modulation.

PAM : Pulse Amplitude Modulation for Analog Modulation.

1 Pulse Code Modulation (PCM)

PCM will transmit the analog in a digital form, whose signal is sampled at regular intervals of time and quantized at same quantum levels to digital code as shown in Fig 3. We know that digital code is nothing but binary code which consists of 1's and 0's that is logic1 and logic0. So we will transmit the digital data in the form of 1's and 0's. When the signal is received by the receiver, demodulator in the receiver will demodulate the binary signal back into pulses with same quantum levels like in modulator and these pulses are again used for regenerating the required analog signal.

Advantages of Pulse Code Modulation

1 Pulse code modulation will have low noise addition and data loss is also very low.

2 The received signal is exact replica of the transmitting signal without any distortion loss.

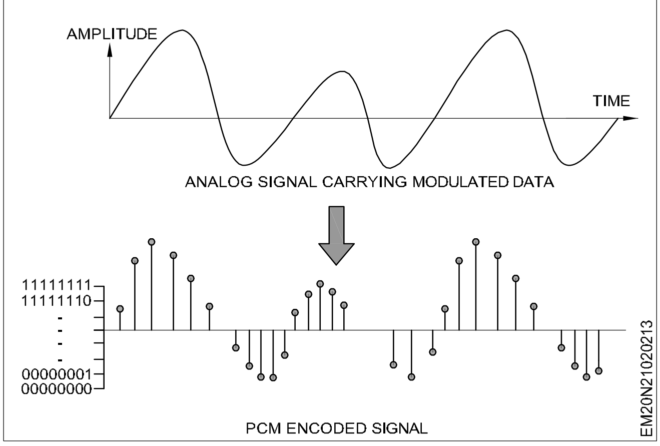
3 PCM can encode the data.

4 Multiplexing of signals can also be done using pulse code modulation. Multiplexing is nothing for adding the different signals and transmitting the signal at same time.

5 Pulse code modulation permits the use of pulse regeneration.

6 PCM can be used in storing data.

Fig 3



Disadvantages of Pulse Code Modulation

1 Specialized complicated complex circuitry is required for transmitting and encoding.

2 Pulse code modulation receivers are costlier than other modulation receivers.

3 Developing pulse code modulation is bit complicated and checking the transmission quality is also difficult and takes more time.

4 It requires larger bandwidth than normal analog signals to transmit message.

5 Channel bandwidth should be more for digital encoding.

6 Decoding also needs special equipments and they are also too complex.

Applications of Pulse Code Modulation (PCM)

1 Pulse code modulation is used in telecommunication systems, air traffic control systems etc.

2 Pulse code modulation is used in compressing the data that is why it is used in storing data in optical disks like DVD, CDs etc. PCM is even used in the database management systems.

3i Pulse code modulation is used in mobile phones, normal telephones etc.

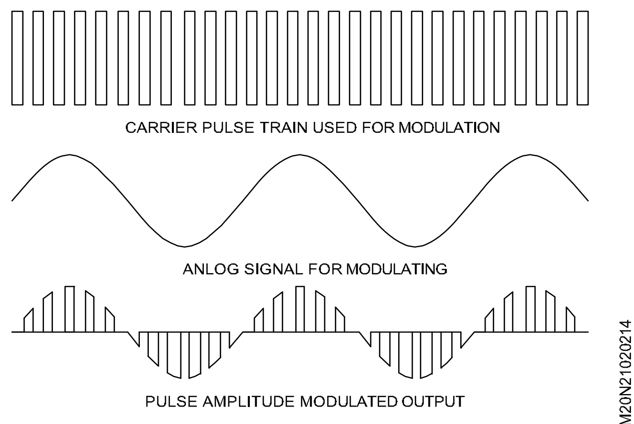
4 Remote controlled cars, planes, trains use pulse code modulations technique.

2 Pulse Amplitude Modulation (PAM)

In pulse amplitude modulation, the amplitude of regular interval of periodic pulses or electromagnetic pulses are varied in proportion to the sample of modulating signal or message signal as shown in Fig 4. This is an analog type of modulation. These sample pulses can be transmitted directly using wired media or we can use a carrier signal for transmitting through wireless. It is almost equal to amplitude modulation.

Advantages of Pulse Amplitude Modulation (PAM)

1 It is the base for all digital modulation techniques and it is simple process for both modulation and demodulation technique.



2 No complex circuitry is required for both transmission and reception. Transmitter and receiver circuitry is simple and easy to construct.

3 PAM can generate other pulse modulation signals and can carry the message or information at the same time.

Disadvantages of Pulse Amplitude Modulation (PAM)

1 Bandwidth should be large for transmitting the pulse amplitude modulation signal.

2 The frequency varies according to the modulating signal or message signal. Due to these variations in the signal frequency, interferences will be there. So noise will be great. Pulse amplitude signal varies, so power required for transmission will be more, peak power is also, even at receiving more power is required to receive the pulse amplitude signal.

Applications of Pulse Amplitude Modulation (PAM)

1 It is mainly used in Ethernet which is type of computer network communication.

2 It is also used for photo biology which is a study of photosynthesis.

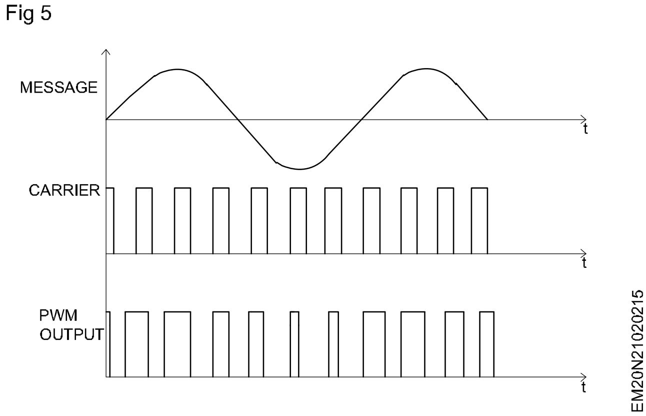
3 Used as electronic driver for LED lighting.

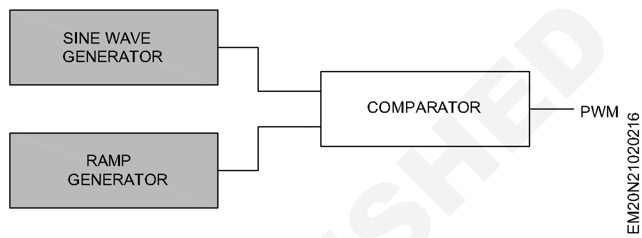
4 Used in many micro controllers for generating the control signals etc.

3 Pulse Width Modulation (PWM) or Pulse Duration Modulation (PDM):

It is a type of analog modulation. In pulse width modulation or pulse duration modulation, the width of the pulse carrier is varied in accordance with the sample values of modulating signal as shown in Fig 5. In this the amplitude is made constant and width of pulse and position of pulse is made proportional to the amplitude of the signal.

The conventional method of generating a PWM modulated wave is to compare the message signal with a ramp waveform using a comparator. The block diagram required for the generation of a simple PWM is shown in the Fig 6.





Advantages of Pulse Width Modulation (PWM)

1 Noise interference is less due to amplitude has been made constant.

2 Signal can be separated very easily at demodulation and noise can also be separated easily.

3 Synchronization between transmitter and receiver is not required.

Disadvantages of Pulse Width Modulation (PWM)

1 Power will be variable because of varying in width of pulse. Transmitter can handle the power even for maximum width of the pulse.

2 Bandwidth should be large to use in communication, should be huge even when compared to the pulse amplitude modulation.

Applications of Pulse Width Modulation (PWM)

1 PWM is used in telecommunication systems.

2 PWM can be used to control the amount of power delivered to a load without incurring the losses. So, this can be used in power delivering systems.

3 Audio effects and amplifications purposes also used.

4 PWM signals are used to control the speed of the robot by controlling the motors.

5 PWM is also used in robotics.

6 Embedded applications.

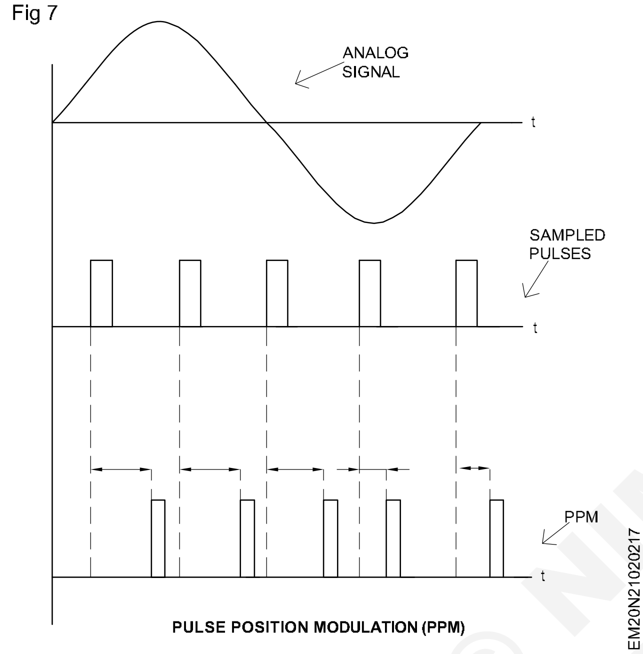
7 Analog and digital applications etc.

4 Pulse Position Modulation (PPM)

In the pulse position modulation, the position of each pulse in a signal by taking the reference signal is varied according to the sample value of message or modulating signal instantaneously. In the pulse position modulation, width and amplitude is kept constant. It is a technique that uses pulses of the same breadth and height but is displaced in time from some base position according to the amplitude of the signal at the time of sampling. The position of the pulse is 1:1 which is proportional to the width of the pulse and also proportional to the instantaneous amplitude of sampled modulating signal. The position of pulse position modulation is easy when compared to other modulation.

The waveform of the Pulse position modulation is as follows. (Fig 7)

Fig 7



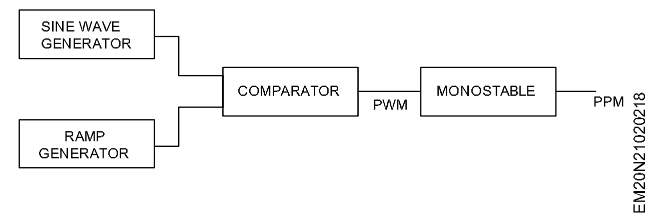
The Pulse Position Modulation (PPM) is a modulation technique designed to achieve the goals like simple transmitter and receiver circuitry, noise performance, constant bandwidth and the power efficiency and constant transmitter power.

In Pulse Position Modulation the amplitude of the pulse is kept constant as in the case of the FM and PWM to avoid noise interference. Unlike the PWM the pulse width is kept constant to achieve constant transmitter power.

Fig 8 shows the block diagram of PPM.

It requires pulse width generator and monostable multivibrator.

Fig 8



Pulse width generator is used for generating pulse width modulation signal which will help to trigger the monostable multivibrator, here trailing edge of the PWM signal is used for triggering the monostable multivibrator. After triggering the monostable multivibrator, PWM signal is converted into pulse position modulation signal.

Advantages of Pulse Position Modulation (PPM):

1 Pulse position modulation has low noise interference when compared to PAM because amplitude and width of the pulses are made constant during modulation.

2 Noise removal and separation is very easy in pulse position modulation.

3 Power usage is also very low when compared to other modulations due to constant pulse amplitude and width.

Disadvantages of Pulse Position Modulation (PPM):

1 The synchronization between transmitter and receiver is required, which is not possible for every time and we need dedicated channel for it.

2 Large bandwidth is required for transmission same as pulse amplitude modulation.

3 Special equipments are required in this type of modulations.

Applications of Pulse Position Modulation (PPM):

1 Used in non coherent detection where a receiver does not need any Phase Locked Loop(PLL) for tracking the phase of the carrier.

2 Used in radio frequency (RF) communication.

3 Also used in contactless smart card, high frequency, RFID (radio frequency ID) tags, etc.

Comparison between PAM,PWM,PPM

The differences between PAM,PWM and PPM are given in the table below:

Sl. No.	PAM	PWM(or PDM, PLM)	PPM
1.	Amplitude of the carrier pulse is proportional to the amplitude of the modulating signal.	The width (or duration or length) of the carrier pulse is proportional to the amplitude of the modulating signal.	The relative position of the carrier pulse is proportional to the amplitude of the modulating signal.
2.	The B.W. of the transmitting channel depends upon the width of the pulse.	The B.W. of the channel depends upon rise time of the pulse B.W. = ½ t Where t is the rise time	The B.W.of the channel depends upon the rise time of the pulse. B.W. = ½ t
3.	The instantaneous power of the transmitter varies.	The instantaneous power of the transmitter varies.	The instantaneous power of the transmitter remains constant.
4.	Noise interference is high.	Noise interference is low.	Noise interference is low.
5.	Similar to amplitude modulation(AM)	Similar to frequency modulation (AM)	Similar to phase modulation(PM)

1 Fiber optic cable connector

- A fiber - optic cable connector is a mechanical device which is used to terminate the end of a fiber-optic cable and it enables a quicker connection and disconnection with respect to joining which is a permanent, method of joining. The use of fiber-optic cable connectors net result is attenuation in signal strength.
- It consists of an adapter and two connector plugs. Most of the connectors are spring loaded so that the two fiber faces remains pressed together, leaving no air-gap between them, when the connectors are mated.
- Separate connectors are made for glass to glass fibers and teflon to teflon fibers. Different types of fiber optic cable connectors are shown in fig.1 is described as follows:

a **Standard connector (SC)** - SC connectors use a ceramic ferrule to deliver accurate alignment of the Single Mode Fiber (SMF).

b **Ferrule core connector (FC)** - FC connectors are widely used in fiber optic networks. This connector used a threaded container and a position locatable notch to achieve exact locating of the Single Mode Fiber (SMF) in relation to the receiver and the optical source.

C **Straight Tip (ST) connector** - The ST connector's keyboard bayonet design is similar to that of a BNC (Bayonet Nut Connector or bayonet Neill-Concelman) connector.

d **SMA (Subminiature version-A) connector** - The obsolete SMA connector was the forerunner to the ST connector.

e **Lucent connector (LC)** - The LC, sometimes referred to as the little connector, is a small form factor FOC that uses a 1.25mm ferrule.

f **Plastic fiber optic cable connector** - There are relatively fewer plastic connectors available when compared to glass fiber.

g **Enterprise systems connection connector (ESCON)** - ESCON connectors were developed by IBM for interfacing peripheral storage devices,

h **Fiber distributed data interface connector (FDDI)** - FDDI provides data transmission at 100 Mbps in a dual ring token local area network within a 200-kilometer rang. The FDDI connector connects network equipment to a wall plug.

i **Opti-jack Connector** - The opti-jack duplex connector resembles the universal RJ-45 connector.

j **LX-5 Connector** - The LX-5 provides high density, high performance and reliable connections.

k **MT-RJ Connector** - The single polymer ferrule duplex MT-RJ connector includes alignment.

l **MU Connector** - MU connectors have a reduced footprint and are new generation connectors used mainly in dense applications.

m **MT Connector** - The MT connector is a ribbon cable that has 12 fiber connectors.

n **E2000 Connector** - Modern day telecommunication networks increasingly make use of E2000 connectors.

o **Local connector (LC)** - which is in the shape of round.

- The most widely used connector for fiber optic cable is SMA (Subminiature version-A).

2 Precautions and safety aspects while handling optical cables

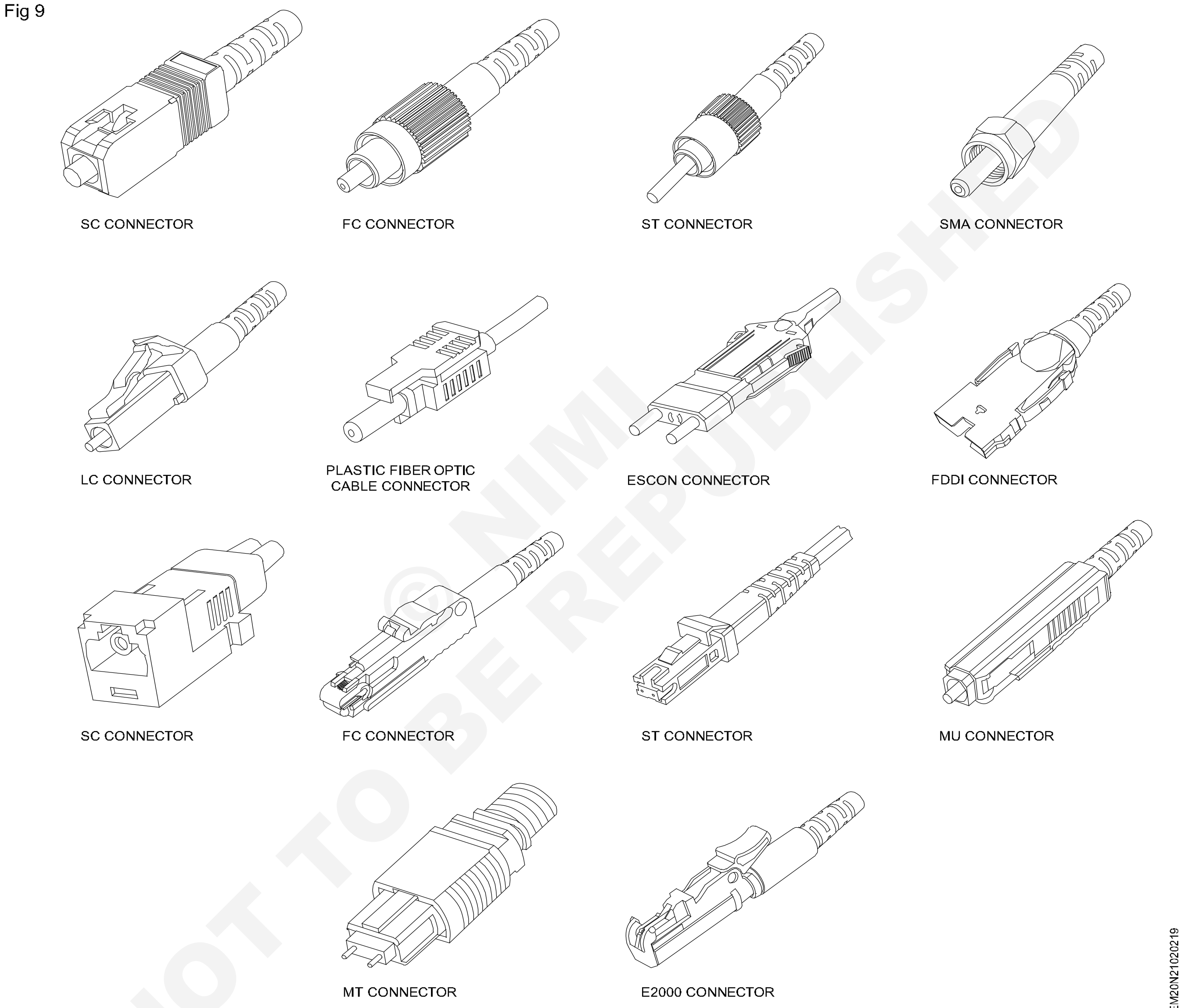
- Optical fibers are made of glass or plastic fibers therefore, following safety precaution should be taken into consideration while using them.

Micro bending: A problem that often occurs in cabling of the optical fiber is the twisting of the fiber core axis an a microscopic scale within the cable form. This phenomenon known as micro bending result from small lateral forces exerted on the fiber during the cabling process and it causes losses due to radiation in both multimode and single mode fiber. Do bend the fiber more than 200% of its core diameter.

Example:

- Diameter of bend for optical fiber 125mm will be 25 mm
- Diameter of bend for optical fiber of 400mm will be 80mm.
- Do not keep any heavy load or hand machine on the fiber.
- Protect the fiber from sharp edges otherwise that can damage its protection jacket and harm the cladding and core.
- Fiber should not come in contact of any abrasive or acetone etc.
- Do not throw the pieces of fibers in dustbin etc. and do keep pieces of glass with optical fibers.
- Do not keep eatables or beverages near the ends of optical fibers as they have a high radiation.

Fig 9



Fiber optical splicing

Objectives : At the end of this lesson you shall be able to
- **define splicing**
- **state the related tools used along with splicer**
- **explain cleaving**
- **explain various steps involved in the splicing.**

Introduction

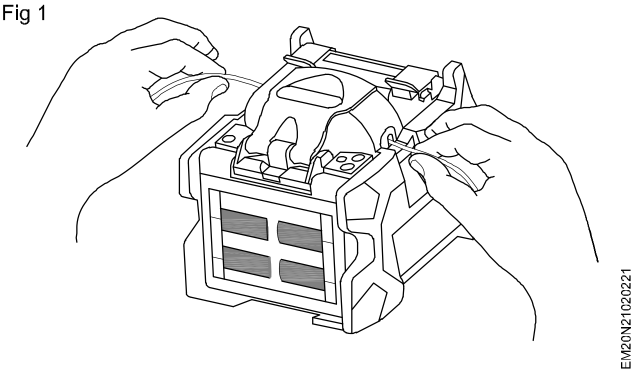
Splicing is the process of joining two ends of optical fiber using electric arc or mechanical means.

In practice, to cover larger distance and as well as to repair the OFC cuts, joints have to be made i.e. OFC has to be joined. This joining is called as splicing.

Fiber splicing is a complicated procedure and requires skilled manpower to achieve. We should completely clean off the gel component when the cable end is stripped for termination.

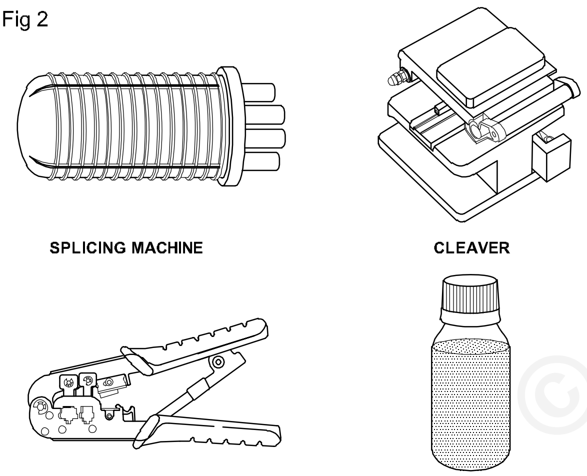
The necessary tools and accessories for splicing are splicing machine, cleaver, cable cutter, iso-propyl alcohol and tissue paper as shown in Fig 1 and 2.

Fig 1



EM20N21020221

Fig 2



EM20N21020222

Splicing machine

A special machine which is used to join the fiber using fusion technique.

Clever (diamond cutter)

It is used to cut optical fiber perpendicular to cable axis exactly by 90 degrees.

Multi purpose cutter (stripper)

It is used to remove primary coating of fiber.

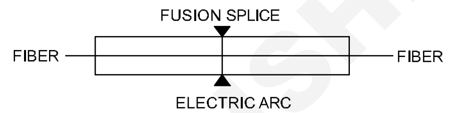
Iso-propyl alcohol, acetone and tissue paper

It is used to clean the dust of fiber before splicing.

Fusion splicing

Splicing is the practice of joining two fibers together without using fiber connectors as shown in Fig 3. Two types of fiber splices exist: fusion splicing and mechanical splicing. Splicing may be made during installation or repair.

Fig 3



EM20N21020224

Splices generally have lower loss and better mechanical integrity than connectors, while connectors make system configuration much more flexible. So typically, splices are used to connect fiber cables in outdoor applications and connectors terminate fiber cables inside buildings.

Fusion splicing process has to use high temperature heat generated by electric arc and fuse two glass fibers together (end to end with fiber core aligned precisely). The tips of two fibers are butted together and heated so they melt together. This is normally done with a fusion splicer, which mechanically aligns the two fiber ends, then applies a spark across the fiber tips to fuse them together.

Testing of optical fiber

Objectives : At the end of this lesson you shall be able to
- **define testing**
- **state the different procedures followed for testing**
- **explain different types of testing of fiber optic component.**

Fiber testing

After the installation of cable, next step is testing. Testing is the process to evaluate the performance of fiber optic components (like fiber, connectors, splices, LED or laser sources, detectors and receivers), cable plants and systems. Testing confirms their performance, specifications and helps understand how they will work together.

Procedures are required under the testing some are listed below

1 Selection of tools

i Source and power meter, optical loss test set or test kit with proper equipment adapters for the cable network are required for testing.

ii Reference test cables that match the cables to be tested and mating adapters, including hybrids if needed.

iii Fiber tracer or Visual fault locator.

iv Cleaning materials - lint free cleaning wipes and pure alcohol.

v OTDR and launch cable for outside plant jobs.

2 Documentation: This is an important part of the testing of fiber. Make sure all cable layouts are available before testing the network. Prepare a spread sheet of all the cables and print a copy for recording each test data.

3 **Safety notes:** Fiber optic sources, including test equipment, are generally too low in power to cause any eye damage, but it's still a good idea to check connectors with a power meter before looking into it. Some systems like CATV have very high power and they could be harmful.

Types of testing

There are three basic tests

1 Visual inspection for continuity or connector checking

2 Loss testing

3 Network Testing.

Visual inspection

Visual tracing: Continuity checking makes sure that the fibers are not broken and to trace a path of a fiber from one end to another through many connections by using a visible light "fiber optic tracer" or "pocket visual fault locator". It looks like a flashlight or a pen-like instrument with a light bulb or LED source that mates to a fiber optic connector. Attach a cable to test to the visual tracer and look at the other end to see the light transmitted through the core of the fiber. If there is no light at the end, go back to intermediate connections to find the faulty section of the cable.

Visual fault location: A higher power version of the tracer uses a laser that can also find faults. The red laser light is powerful enough to show breaks in fibers or high loss connectors. It also use this gadget to optimize mechanical splices or pre polished-splice type fiber optic connectors.

Visual connector inspection: Fiber optic microscopes are used to inspect connectors to check the quality of the termination procedure and diagnose problems. A well made connector will have a smooth, polished, scratch free finish and the fiber will not show any signs of cracks, chips or areas where the fiber is either extended from the end of the ferrule(connector) or pulling back into it.

The magnification for viewing connectors can be 30 to 400 times but it is best to use a medium magnification. The best microscopes allow you to inspect the connector from several angles, either by tilting the connector or having angle illumination to get the best picture of what's going on. Check to make sure the microscope has an easy-to-use adapter to attach the different types of connectors to the microscope.

Optical power ("Absolute" vs. "Relative"): Practically every measurement in fiber optics refers to optical power. The power output of a transmitter or the input to receiver are "absolute" optical power measurements, that is, it can measure the actual value of the power. Loss is a "relative" power measurement. A simple method for the power measurement is shown in Fig 1.

Measuring power: Power in a fiber optic system is like voltage in an electrical circuit - it's what makes things happen! It's important to have enough power, but not too much. Too little power and the receiver may not be able

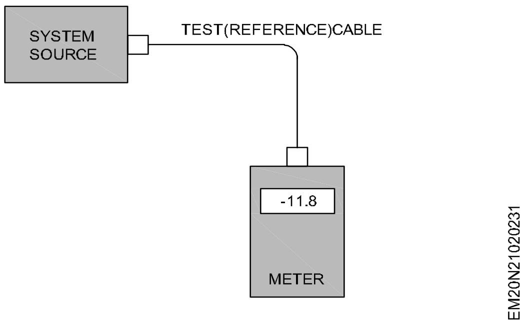
Fig 1

to distinguish the signal from noise; too much power overloads the receiver and causes errors too.

Measuring the power requires a power meter. For that, the meter must be set to the proper range (usually dBm, sometimes microwatts, but never "dB" that's a relative power range used only for testing loss!) and the proper wavelengths matching the source being used.

To measure the receiver power, a reference test cable (tested and known to be good) is attached with the meter to the output side of the cable ., or to a reference test cable (tested and known to be good) that is attached to the transmitter, acting as the "source", to measure transmitter power as shown in Fig 2.

Fig 2



Turn on the transmitter/source and note the power the meter measures. Compare it to the specified power for the system and make sure it's enough power but not too much.

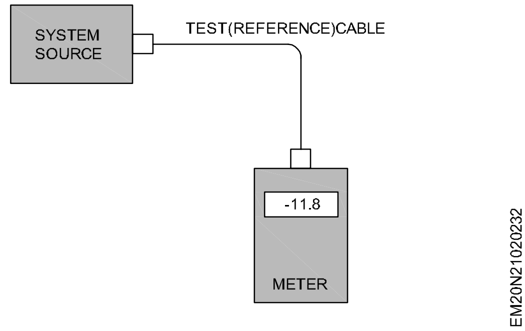
Loss Testing

Testing loss is the difference between the power coupled into the cable at the transmitter end and what comes out at the receiver end. Testing for loss requires measuring the optical power lost in a cable (including connectors , splicers, etc.) with a fiber optic source and power meter by using good reference cables.

The accuracy of the measurement is depends on the quality of reference cables used.

Turn on the source and select the wavelength required for the loss test. Turn on the meter, select the "dBm" or "dB" range and select the wavelength value for the loss test. Measure the power at the meter. This is the reference power level for all loss measurements as shown in the Fig 3.

Fig 3



There are two methods that are used to measure loss, "single-ended loss" and "double-ended loss". Single-ended loss uses only the launch cable, while double-ended loss uses a receive cable attached to the meter also. Single-ended loss is measured by connecting together with the cable has to be tested, to the reference launch cable and measuring the power out the far end with the meter.

In a double-ended loss test, can attach the cable to test between two reference cables, one attached to the source and the other to the meter.

Introduction of panel meter

Objectives : At the end of this lesson you shall be able to
- **explain analog panel meter**
- **explain digital panel meter**
- **describe the working of a seven segment display**
- **state the types of seven segment display.**

Introduction

Panel meters are instruments that display an input signal in analog or digital form. These are available in two types as

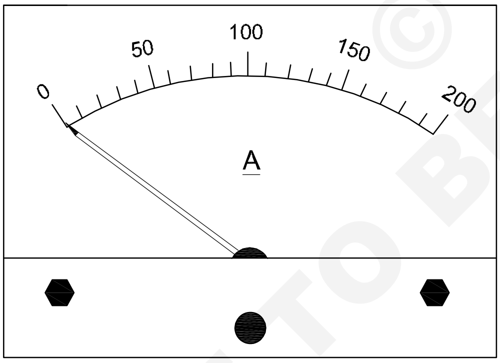
1 Analog panel meter (APM)

2 Digital panel meter (DPM)

Analog Panel Meter (APM)

An analog panel meter uses a moving pointer and a dial to display information, and works on either the band or the jewel and pivot method. A taut band device uses a pointer suspended between two ribbons of metal. Able to withstand high-shock. It generally measures direct current (DC). The less accurate pivot and jewel unit has a coil and pointer supported by polished steel, which fits into two jewel bearings. Better at withstanding vibration, it typically measures alternating current (AC) as shown in Fig 1.

Fig 1

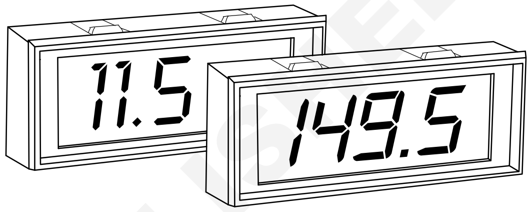


An analog panel meter is more economical than its digital counterpart, but it is less accurate. Non-linear movement can produce errors, and the small meter screen can be difficult to interpret. It typically displays one value, however, so it's considered quicker to read. Analog meters are useful when relative change is more important than absolute accuracy.

Digital Panel Meter (DPM)

A digital panel meter is used to measure and display all types of processes and electrical variables, voltage current, flow, speed, etc. It has a bright LED display that presents information in an alphanumerical format with little or no ambiguity. Many digital panel meters can accept multiple inputs and have adjustable or bar graph displays that allow users to easily switch between these inputs. Displays may also have totalizing, recording, conditioning, or other functional capabilities.

Fig 2



Digital panel meter have two types of displays

1 LED Display

2 LCD display

Digital panel meters are available in LED or LCD display. LED (Light Emitting Diode) display is the easiest to see even in small character heights and is available in colour. LCD (liquid Crystal Display) can be either unlighted "transflective" that depends on ambient lighting or back lighted and can be hard to read at certain angles and lighting. Since Digital Panel Meters actually measure voltages in discrete steps, all inputs must be scaled to match the full count range of the meter. A 3 digit digital panel meter has a count range of 0-999 where a 3½ digit doubles the count to 1999 for very little extra electronics circuits. Scaling for the Digital Panel Meters is accomplished by using a voltage divider usually dividing down the input by a factor of 10, 100, 1000 although there are other factors used.

Types of DPM and its use

1 **4 digit voltmeter and Ammeter -** it is capable to measure upto 9999 volts or amperes

2 **Three phase voltmeter and Ammeter -** it is capable to measure to 3 phase volts or amperes

3 **3½ digit voltmeter and Ammeter -** it is capable to measure up to 1999 volts or amperes in 3 phase star circuit

4 **4½ digit voltmeter and Ammeter -** it is capable to measure up to 19999 volts or amperes

5 4 and 5 digits frequency meter

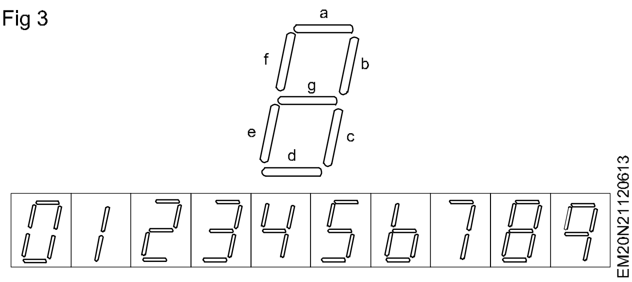
6 Digital power factor meter

7 Digital wattmeter.

Seven-segment display

A seven segment display (SSD), or Seven-Segment Indicator (SSI) is the most basic electronic display device that can display digits from 0-9 is shown in Fig 3.

Fig 3

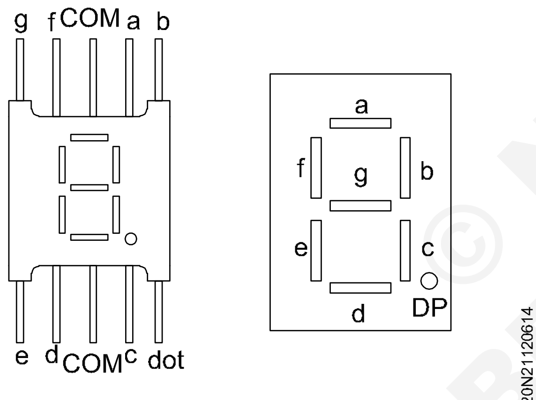


Seven-segment displays are widely used in digital clocks, electronic meters, Radio, Microwave ovens, Basic calculators, and other electronic devices etc.

Concept and visual structure

A seven-segment display consists of seven elements that are made of either LCDs (Liquid Crystal Display) or LEDs (Light-Emitting Diodes). The elements are labelled from a to g as shown in Fig 4.

Fig 4



SEVEN SEGMENT DISPLAY

Depending on which elements are turned ON, the display decimal numerals 0 to 9. In a common cathode display, the cathodes of all the LEDs are joined together and the individual segments are illuminated by HIGH voltages. In a common anode display, the anodes of all the LEDs are joined together and the individual segments are illuminated by connecting to a LOW voltage.

Pin diagram of seven-segment display

Working of seven segment display

Seven segment display works by glowing the respective LEDS in the number. The display is controlled using pins that are left freely. Forward biasing of these pins in a sequence will display the particular number or alphabet. Depending on the type of seven segments the segment pins are applied with logic high or logic zero.

For example to display Number '1' segments b and c are to be switched on and the remaining segments are required to be switched off. In order to display two digits two seven segments are used.

Types of seven-segment display

There are two important types of 7-segment LED display.

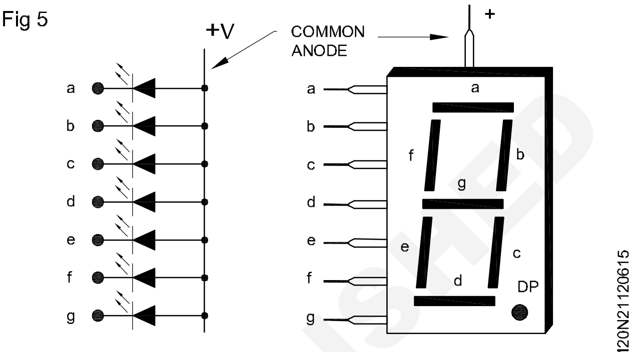
1 Common Anode (CA) Seven-segment

2 Common Cathode (CC) Seven-segment

1 Common Anode (CA) Seven-segment display

In common anode type, all the anodes of 8 LED's are connected to the common terminal and cathodes are left free. Thus, in order to glow the LED, these cathodes have to be connected to the logic '0' and anode to the logic '1'. as shown in Fig 5.

Fig 5



COMMON ANODE DISPLAY

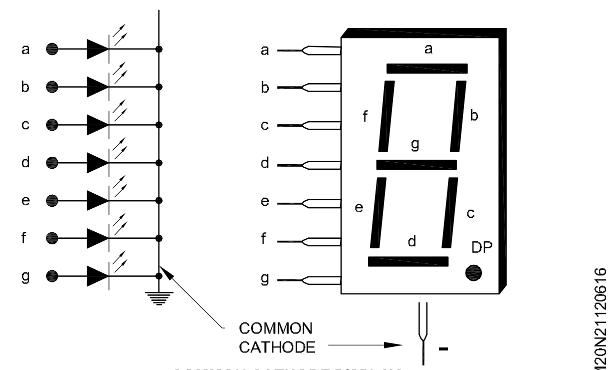
2 Common Cathode (CC) Seven-segment display

As the name indicates cathode is the common pin for this type of seven segments and remaining 8 pins are left free. Here, logic low is applied to the common pin and logic high to the remaining pins as shown in Fig 6.

7-segment display truth table

Truth table shows the data to be applied to the seven segments to display the digits. In order to display digit'0' on seven segment , segments a , b , c , d , e and f are applied with logic high and segment g is applied with logic low.

Fig 6



COMMON CATHODE DISPLAY

Fig 7

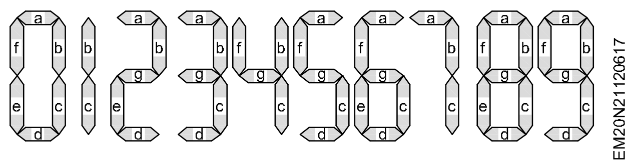


TABLE 1

The TABLE 1 shows the decimal number and respective segments to glow its value on the display.

Decimal number	Individual segments illuminated						
	a	b	c	d	e	f	g
0	On	On	On	On	On	On	Off
1	Off	On	On	Off	Off	Off	Off
2	On	On	Off	On	On	Off	On
3	On	On	On	On	Off	Off	On
4	Off	On	On	Off	Off	On	On
5	On	Off	On	On	Off	On	On
6	On	Off	On	On	On	On	On
7	On	On	On	Off	Off	Off	Off
8	On	On	On	On	On	On	On

Display decoder/driver

Objectives : At the end of this lesson you shall be able to
- **explain the display decoder/driver**
- **explain the binary to decimal decoder**
- **describe different methods of driving the seven segment display.**

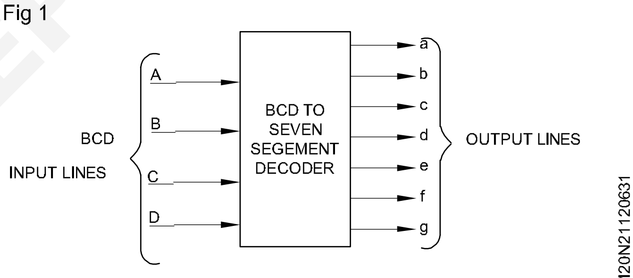
Display decoder

Display decoder is a device which converts one digital format into another digital format. One of the most commonly used devices for doing this is called Binary Coded Decimal (BCD) to Seven- Segment Display (SSD) decoder.

It can be seen that to display any single digit number from 0 to 9 in binary or letters from A to F in hexadecimal, we would require 7 separate segment connections plus one additional connection for the LED's "common" connection. Also as the segments are basically a standard light emitting diode, the driving circuit would need to produce up to 20mA of current to illuminate each individual segment. To display the number 8, all 7 segments would need to be lit resulting a total current of nearly 140mA.

Obviously, the use of so many connections and power consumption is impractical for some electronic or microprocessor based circuits and so in order to reduce the number of signal lines required to drive just one single display, display decoders such as the BCD to 7-segment display decoder and driver IC's are used as shown in Fig 1.

Fig 1



BCD TO SEGMENT DISPLAY

BCD numbers only range from 0 to 9, with the binary number patterns of 1010 through to 1111 (A to F) being invalid inputs for this type of display and so are not used as shown in TABLE 1.

TABLE 1

Decimal	Binary pattern				BCD
	8	4	2	1	
0	0	0	0	0	0
1	0	0	0	1	1
2	0	0	1	0	2
3	0	0	1	1	3
4	0	1	0	0	4
5	0	1	0	1	5
6	0	1	1	0	6
7	0	1	1	1	7

Binary Coded Decimal (BCD)

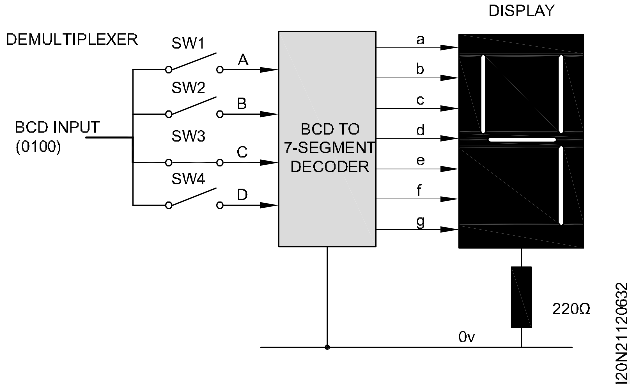
Binary-coded decimal (BCD) or packet decimal is a class of binary encodings of decimal numbers where each decimal digit is represented by a fixed number of bits, usually four or eight. Special bit patterns are sometimes used as a sign for other indications.

8	1	0	0	0	8
9	1	0	0	1	9
10	1	0	1	0	Invalid
11	1	0	1	1	Invalid
12	1	1	0	0	Invalid
13	1	1	0	1	Invalid
14	1	1	1	0	Invalid
15	1	1	1	1	Invalid

BCD to Seven-segment display decoder

An example of the 4-bit BCD input (0100) representing the number 4 is as shown in Fig 2.

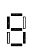
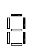
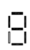
Fig 2



BCD TO SEVEN SEGMENT (DISPLAY)

BCD to seven segment display decoder is a circuit used to convert the input BCD into a form suitable for the display. It has four input lines A, B, C and D and 7 output lines a, b, c, d, e, f and g as shown in Fig 1. Considering common cathode type of arrangement, the truth table for the decoder can be given as in TABLE 2.

TABLE 2

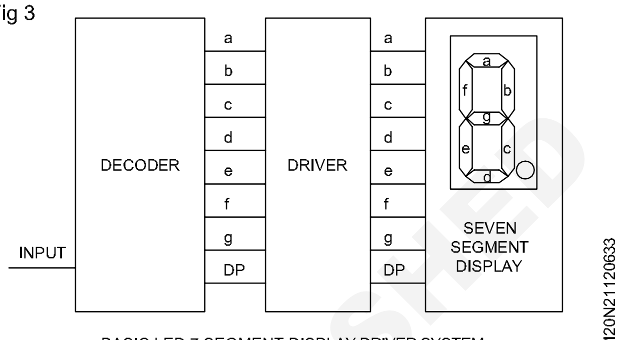
Decimal digit	Input lines A	B	C	D	Output lines a	b	c	d	e	f	g	Display pattern
0	0	0	0	0	1	1	1	1	1	1	0	
1	0	0	0	1	0	1	1	0	0	0	0	
2	0	0	1	0	1	1	0	1	1	0	1	
3	0	0	1	1	1	1	1	1	0	0	1	
4	0	1	0	0	0	1	1	0	0	1	1	
5	0	1	0	1	1	0	1	1	0	1	1	
6	0	1	1	0	1	0	1	1	1	1	1	
7	0	1	1	1	1	1	1	0	0	0	0	
8	1	0	0	0	1	1	1	1	1	1	1	
9	1	0	0	1	1	1	1	1	0	1	1	

Driving a 7-segment display

7-segment display can be thought of as a single display, it is still seven individual LEDs within a single package and as such these LEDs need protection from over current. LEDs produce light only when it is forward biased with the amount of light emitted being proportional to the forward current.

The block diagram of a basic LED seven segment display system that can display a given input in numerical form is shown Fig 3.

Fig 3



BASIC LED 7 SEGMENT DISPLAY DRIVER SYSTEM

Concept of multiplexing: The decoder block converts the given input signal into an 8 line code corresponding to the 'a' to 'g' segments and the decimal point which controls the segments to display the desired number. For example if the line corresponding to 'f' and 'e' are activated then segments f and e of the display glows indicating a "1". If the input quantity is an analogue signal then it must be converted into digital format using an ADC before applying to the decoder. If the input signal is digital then there is no need for the ADC and the decoder alone will convert the particular input code into the 8 line code compatible to the seven segment LED display. The purpose of the driver stage is to provide the necessary current drive in order to drive the LED seven segment displays. If the decoder stage is powerful enough to drive the display, then the driver stage is not required. A typical 7 segment display driver stage consists of an array (8 nos) transistor or FET based switches. For example consider the line 'a'. The "a" output of the decoder is connected to the input terminal (base/gate) of the corresponding switching element inside the driver stage. The same line is buffered by the switching element and is available as output line 'a' of the driver. This output is connected to the corresponding 'a' element of the display. The driver can be arranged in sinking or sourcing mode.

The following methods are practiced to drive the seven segments.

1 Driving a seven segment display with resistor

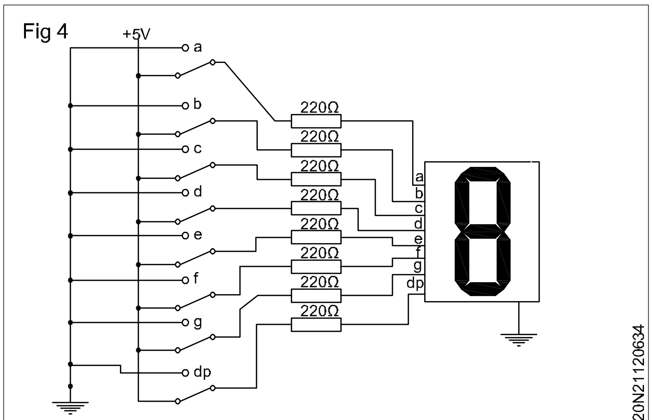
2 Driving a seven segment display with transistor

3 Driving a seven segment display with integrated circuit (IC)

Driving a seven segment display with resistor

Driving a seven segment using resistor is the most common method. In this, generally we use the resistor as the driving element. Generally, LED requires 20 milli

Amps of current. Current more than this value may damage the LED. To limit this current a resistor is used .This is called current limiting resistor. Circuit is as shown Fig 4.



DRIVING SEVEN SEGMENT DISPLAY WITH RASISTOR

Segment pins of the seven segments are connected using a resistor and a switch. The 8 switches are connected to the 8 current limiting resistors and they are connected to a to g segments of display. Let us see how this circuit drives the digital display.

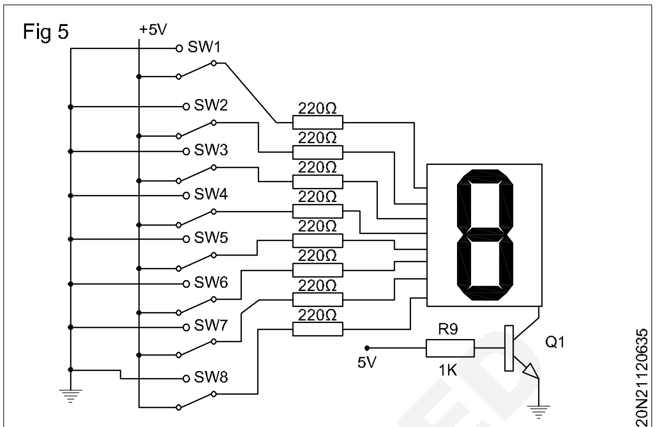
To glow the segment 'a', close the switch 'a'. The current passes through resistor and some drop occurs at current limiting resistor. Thus, the sufficient current passes to the LED. Suppose to display digit 7 switches a, b, c are closed. But the disadvantage here is, illuminating all the LEDs at a time reduces the current.

Driving a seven segment display with transistor

Another way of driving the seven segments is through transistor. In this, transistor is used for amplifying the input current. The collector of the transistor is connected to the common pin of the seven segment, emitter is connected to the ground and base is connected Vcc. The transistor connected to the common pin amplifies the current in the seven segments as shown in Fig 5.

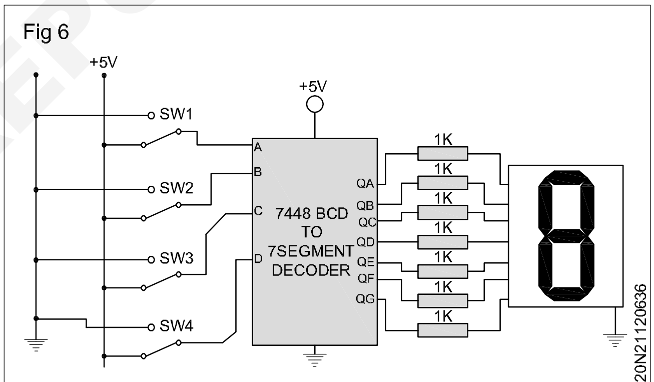
Driving a seven segment display with integrated circuit

Another way of driving the seven segments is through integrated circuits. This is generally called as seven segment driver or decoder. The most frequently used decoder is 7448. This chip converts 4 bit binary coded decimal to 8 bit seven segment data. This seven segment decoder connected to the seven segments is shown Fig 6.



DRIVING SEVEN SEGMENT DISPLAY WITH TRANSISTOR

The below figure shows driving of a seven segment display using BCD to seven segment decoder. Here we have to give BCD data as input to display digits 0 to 9. For example, to display the digit 7 the input to be applied is 0111. The decoder decodes the applied BCD input and sends the appropriate output to the segments. The decoder outputs are connected to the seven segment inputs through the resistors. These resistors are used to limit the current.



DRIVING SEVEN SEGMENT DISPLAY WITH INTEGERATED CIRCUIT

Multiplexing IC 7106/IC 7107

Objectives : At the end of this lesson you shall be able to
- **describe the concept of multiplexing**
- **state the advantages of multiplexing**
- **list out the IC7106/IC7107 pin diagram.**

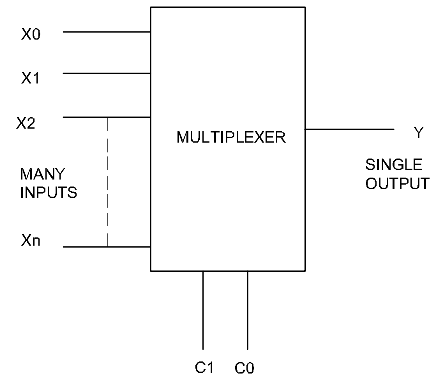
Multiplexing

A Multiplexer is a device that allows one of several analog or digital input signals which are to be selected and transmits the input that is selected into a single medium. Multiplexer is also known as data selector. Multiplexer is abbreviated as MUX as show in Fig 1. MUX sends digital or analog signals at higher speed on a single line in one shared device. It recovers the separate signals at the receiving end. The multiplexer boosts or amplifies the information that later transferred over network within a particular bandwidth and time.

Concept of multiplexing

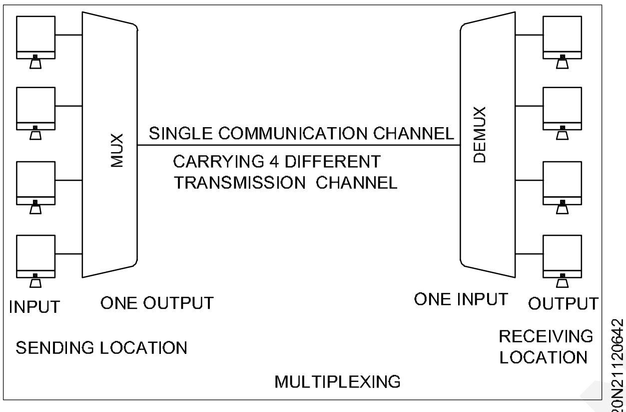
As shown in Fig 2 multiplexer takes 4 input lines and diverts them to single output line. The signal from 4 different devices is combined and carried by this single line. At the receiving side, a demultiplexer takes this signal from a single line and breaks it into the original signals and passes them to the 4 different receivers.

Fig 1



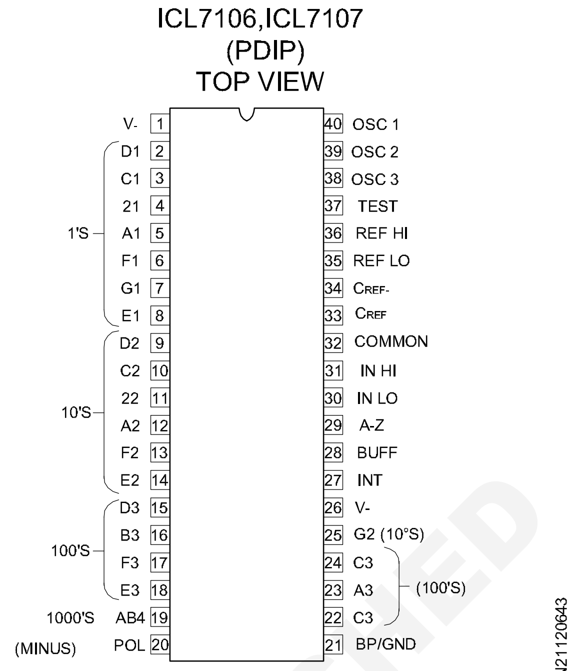
MULTIPLEXER

Fig 2



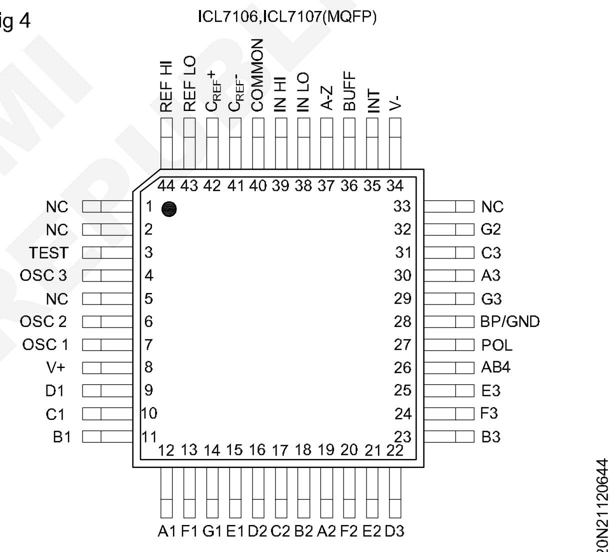
CONCEPT OF MULPLEXING

Fig 3



PIN DIAGRAM OF ICL 7106/ICL 7107

Fig 4



TOP VIEW

Advantages of multiplexing

1 It reduces number of wires

2 It reduces circuit complexity and cost

3 It simplifies logic design

4 We can implement many combinational circuits using MUX

5 It does not need K-maps and simplification.

ICL7106/ICL7107

The ICL7106 /ICL7107 are monolithic analog - to digital converters (ADCs). They have very high input impedances and required no external display drive circuitry. On-board active components include polarity and digits drivers, segment decoders, voltage reference and a clock circuit. The ICL7106 will directly drive a no multiplexed liquid crystal display (LCD), whereas the ICL7107 will directly drive a common Anode Light Emitting Diode (LED) display

PIN diagram of ICL 7106 / ICL 7107

Application

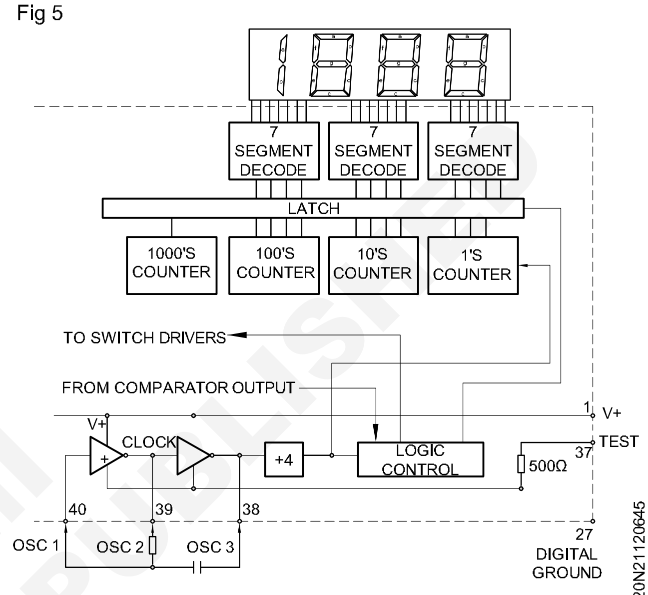
This device can be used in wide range of digital panel meter application such as the measurement of pressure, voltage, resistance, temperature, current, speed, material thickness and conductance.

Pin Number

Sl. No.	Description
1	V+ - Positive Supply
2	D1 - 1's Digit - D Segment
3	C1 - 1's Digit - C Segment
4	B1 - 1's Digit - B Segment
5	A1 - 1's Digit - A Segment
6	F1 - 1's Digit - F Segment
7	G1 - 1's Digit - G Segment
8	E1 - 1's Digit - E Segment
9	D2 - 10's Digit - D Segment
10	C2 - 10's Digit - C Segment
11	B2 - 10's Digit - B Segment

12	A2 - 10's Digit - A Segment
13	F2 - 10's Digit - F Segment
14	E2 - 10's Digit - E Segment
15	D3 - 100's Digit - D Segment
16	B3 - 100's Digit - B Segment
17	F3 - 100's Digit - F Segment
18	E3 - 100's Digit - E Segment
19	AB4 - 1000's Digit
20	POL - Polarity Sign
21	BP/GND - Backplane Conn. for LCD/Ground
22	G3 - 100's Digit - G Segment
23	A3 - 100's Digit - A Segment
24	C3 - 100's Digit - C Segment
25	G2 - 10's Digit - G Segment
26	Vneg - Negative Supply
27	INT - Integrator
28	BUFF - Buffer
29	A-Z - Auto Zero
30	IN LO - Input Low
31	IN HI - Input High
32	COMMON - Input Common
33	Cref- - Reference Capacitor
34	Cref+ - Reference Capacitor
35	REF LO - Reference Low
36	REF HI - Reference High
37	TEST - Test
38	OSC3 - Oscillator
39	OSC2 - Oscillator
40	OSC1 - Oscillator

Fig 5



BLOCK DIAGRAM OF ICL7106/7107

configurations

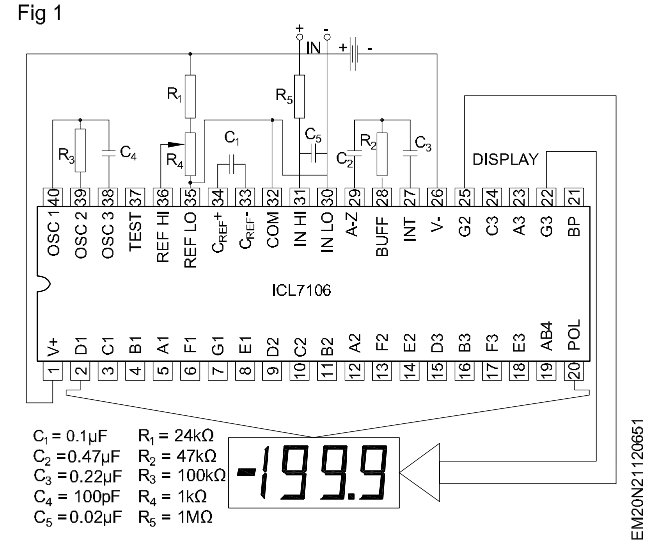
Objectives : At the end of this lesson you shall be able to
- **explain working of IC 7107/ IC 7106 based voltmeter**
- **list out common parameters.**

Application circuits

IC 7106 and IC 7107 are 3½ digit low power consuming A/D converters. Can possible to design panel meter by using about 10 external components and display the result.

Typical test circuit of IC 7106 and IC 7107 are shown in Fig 1 and 2.

Fig 1

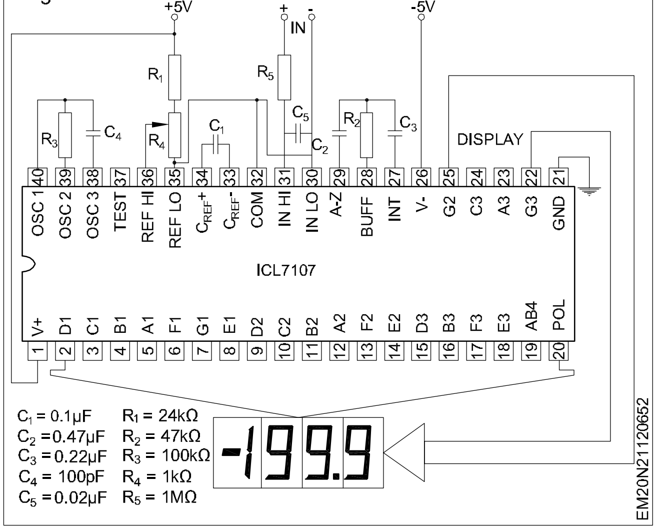


Working of circuit

The measuring voltage is applied at pin 31 and 32 through capacitor C_5 and resistor R_5. The resistor R_5 and capacitor C_5 are used to set the internal oscillator (clock) frequency at 48Hz, clock rate at which there will be three readings per second.

The errors due to internal reference voltage can be by using capacitor C_1 connected at pin 33 and 34. It can help to keep display in steady state. The resistor R_2 and capacitor C_2 are used for integration of input measuring voltage for sampling and prevent division of input voltage and it helps to work circuit faster. It reduces the errors so circuit works more reliable.

Fig 2



If there is no voltage at the input of the circuit, then the capacitor forces the device to display zero using R_1 and R_4. The current through the displays can be controlled to provide sufficient current for brightness without any over current using the resistor R_6. IC 7107 is capable of driving four LED displays in which first three are used to display numbers from 0 to 9 and the most significant LED segment is used only to display number 1 or "-" sign if the voltage is negative. The entire supply to the circuit is given through dual DC supply of +5V at pin 1, 0V at pin 21, and -5V at pin 26 of IC 7107.

Oscillator frequency

The IC-7106 and IC-7107 require an oscillator clock pulse to operate. So in pin configuration pin 38, pin 39, and pin 40 are used for connecting reference clock signal.

We can provide clock reference by

1 can connect external clock frequency at pin 40.

2 can connect the crystal between 39 and 40.

3 can connect RC oscillator using R and C.

RC oscillator is cost effective. This is shown in Fig 1 resistor R_3 and C_4 connected for generating clock signal. The frequency can be calculated by using formula

$$F_{osc} = 0.45 / (R_3 + C_4)$$

Reference capacitor selection

Reference capacitor connected between 34 and 33. Generally this capacitor is 0.1 micro farad is suitable in most of the conditions. But, in some cases like when pin no 32 (COMMON) and pin 35 (REF LOW) are not using in some design cases. In that condition capacitor with higher value like 1 micro farad works better for good performance.

Auto zero settings

Pin 29 (A-Z) is refers the auto zero setting. Auto zero setting is indicates the recovery overload speed and level of noise reduction. The value of the auto-zero capacitor has some influence on the noise of the system. For 200mV full scale where noise is very important, a 0.47mF capacitor is recommended. On the 2V scale, a 0.047mF capacitor increases the speed of recovery from overload.

Reference voltage

The analog input required to generate full scale output (2000 counts) is: $V_{IN} = 2V_{REF}$. Thus, for the 200mV and 2V scale, V_{REF} should equal 100mV and 1V, respectively. So, we connect a suitable value of resistor R_4 between pin number 36 and 35 and R_1 with V_{cc} (Fig 1 and 2). For better adjust selecting a R4 as a preset potentiometer to get adjustment.

Removing common mode voltages

This IC has an N-Channel FET and generating 2.8 V. which is below supply of IC voltage that is 2.8 V. This voltage can find at the COMMON pin 32 and can sink up to 25 mA. It is for battery operation and in cases where the input signal floats with respect to the power supply. The voltage at pin 32 can also be utilised as a reference. But it can generate internal heat in IC.

So for removing this voltage can short between pin 32 and 30 and possible to remove common mode voltages for IC. By shorting pin 32 and 35 can possible to remove common mode voltages form reference system also. Refer Fig 1 and Fig 2 at pin 32, 30 and 35 for connections.

Liquid Crystal Display

Objectives : At the end of this lesson you shall be able to
- **explain the working principle of LCD**
- **compare different LCD panel size**
- **list the LCD decoder/driver IC.**

Liquid Crystal Display (LCD)

LCD stands for Liquid Crystal Display, which is used to show status of an application, display values, debugging a program- etc.,

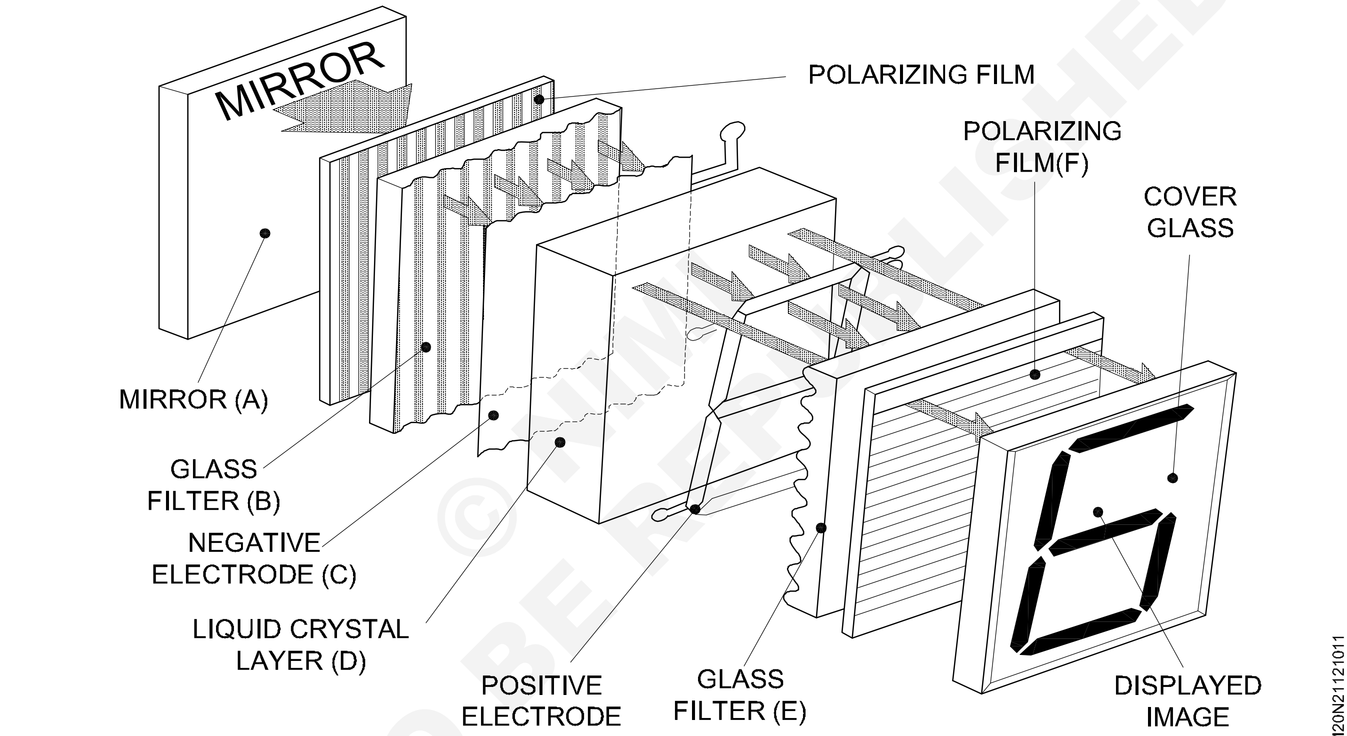
Basics of LCD Displays

The liquid-crystal display has the distinct advantage of having low power consumption than the LED. It is typically of the order of microwatts for the display in comparison to some order of mill watts for LEDs. Low power consumption requirement has made it compatible with MOS integrated logic circuit. Its other advantages are its low cost, and good contrast. The main drawbacks of LCDs are additional requirement of light source, a limited temperature range of operation (between 0 and 60°C), low reliability, short operating life, poor visibility in low ambient lighting, slow speed and the need for an AC drive.

Principles of working of LCD

The main principle behind liquid crystal molecules is that when an electric current is applied to them, they tend to untwist. This causes a change in the light angle passing through them. This causes a change in the angle of the top polarizing filter with respect to it. So little light is allowed to pass through that particular area of LCD, thus that area becomes darker comparing to others For making an LCD screen, a reflective mirror has to be setup in the back. An electrode plane made of indium-tin oxide is kept on top and a glass with a polarizing film is also added on the bottom side. The entire area of the LCD has to be covered by a common electrode and above it should be the liquid crystal substance. Next comes another piece of glass with an electrode in the shape of the rectangle on the bottom and, on top, another polarizing film. It must be noted that both of them are kept at right angles. When there is no current, the light passes through the front of the LCD will be reflected by the mirror and bounced back. As the electrode is connected to a temporary battery the current from it will cause the liquid crystals between the common-plane electrode and the electrode shaped like a rectangle to untwist. Thus the light is blocked from passing through that particular rectangular area appears blank.

Fig 1



Different LCD panel sizes

Alphanumeric LCD Display Sizes

TextLCD::LCD16x2 16x2 LCD panel (default)

TextLCD::LCD16x2B 16x2 LCD panel alternate addressing

TextLCD::LCD20x2 20x2 LCD panel

TextLCD::LCD20x4 20x4 LCD panel

Note: There is now also support for

TextLCD::LCD8x1 8x1 LCD panel

TextLCD::LCD8x2 8x2 LCD panel

TextLCD::LCD16x1 16x1 LCD panel

TextLCD::LCD16x4 16x4 LCD panel

TextLCD::LCD24x2 24x2 LCD panel

TextLCD::LCD24x4 24x4 LCD panel (for KS0078 controller)

TextLCD::LCD40x2 40x2 LCD panel

TextLCD::LCD40x4 40x4 LCD panel (two controllers)

Graphic LCD Display

Graphic LCD Display -122 x 32 Display

Graphic LCD Display -122x64 to 320x240

Decoder / Driver IC used in LCD

A decoder / driver IC is necessary for the conversion of BCD digits into a signal which is capable to energize segments of LCD display unit. The BCD digits are in nipple form, where as LCD display panel required a seven bit signal for seven segment display. A number of decoder /Driver ICs have been developed for this purpose such as M7211AM, MM5483, MM145453 etc.

LCD digital panel display device

Objectives : At the end of this lesson you shall be able to
- **state the pin configurations of the 16 x 2 LCD display**
- **list the commonly used command words in 16 x 2 LCD displays.**

LCD display are used to display the messages for more interactive way to operate the system or displaying error messages etc. Interfacing LCD to microcontroller is very easy if you understand the working of LCD. In order to understand the interfacing, first you have to know about the 16×2 LCD module.

16×2 Liquid Crystal Display which will display the 32 characters at a time in two rows (16 characters in one row). Each character in the display of size 5×7 pixel matrix. Although this matrix differs for different 16×2 LCD modules this matrix will not be same for all the 16×2 LCD modules. There are 16 pins in the LCD module, the pin configuration is given below.

V_{EE} pin is meant for adjusting the contrast of the LCD display and the contrast can be adjusted by varying the voltage at this pin. This is done by connecting one end of a POT to the V_{DD} (5V), other end to the Ground and connecting the center terminal (wiper) of of the POT to the V_{EE} pin.

Sl. No.	Name	Function
1	V_{SS}	This pin must be connected to the ground
2	V_{DD}	Positive supply voltage pin (5V DC)
3	V_{EE}	Contrast adjustment
4	RS	Register selection
5	R/W	Read or write
6	E	Enable
7	DB0	Data
8	DB1	Data
9	DB2	Data
10	DB3	Data
11	DB4	Data
12	DB5	Data
13	DB6	Data
14	DB7	Data
15	LEDA	Back light LED+
16	LEDK	Back light LED-

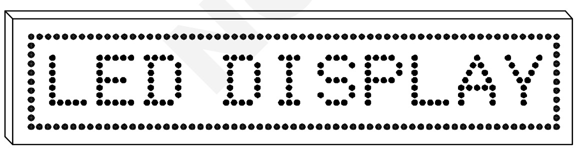
Scrolling display

Objectives : At the end of this lesson you shall be able to
- **explain the functions of dot matrix LED display**
- **describe the operation and application of scrolling display.**

Introduction

- We normally use a simple static LED display screen to convey a message. Earlier, when we want to display large and lengthier data, we used to change message for every few instances. Now scrolling displays are more preferred to static as shown in Fig 1.

Fig 1



- Scrolling means a sliding text or image or video across a monitor or display. It may be horizontally or vertically.

DOT matrix display

- It is a display device used to display information on machines, clocks, railway departure indicators and many other devices requiring a simple display device of limited resolution.
- The dot matrix display consists LED lights arranged in rows and columns of a matrix.
- A dot matrix controller converts instructions from a processor into signals which turns ON or OFF in the matrix so that the required display is produced by the LED display.
- Common sizes of dot matrix displays are as follows

  128 x 16 (Two lined)

  128 x 32 (Four lined)

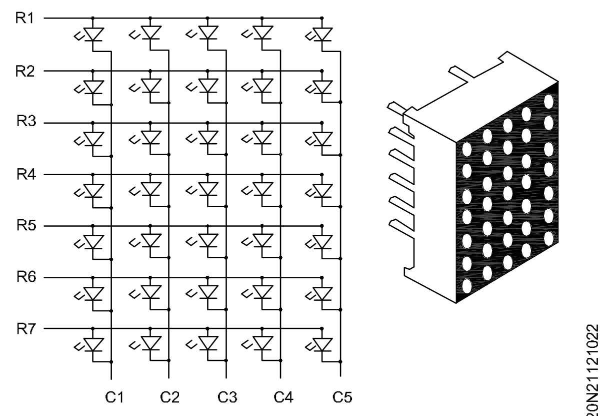
  192 x 64 (Eight lined)

The 5x7 dot matrix LED display is shown in Fig 2. By switching the selected lights ON or OFF any text or graphics can be displayed.

Scrolling display

By using a pre-programmed microcontroller, we can make dot matrix LED display in scrolling. We can also make LED display in scrolling. We can also make dot matrix LED to adoptable by using PC controller based system.

Fig 2



5 X 7 DOT MATRIX LED DISPLAY

- A scrolling message can be used to attract the attention of viewers. For example, TV station has used it to announce the breaking news and companies often use scrolling message on their web site to highlight breaking news, key products, or special promotions.
- Scrolling LED display can be implemented in various methods. Two methods are widely in use,
  - Using decade counters and
  - Using shift registers.

Voltage and current measurement in DPM

Objectives : At the end of this lesson you shall be able to
- **describe the measurement of AC voltage using DPM**
- **explain the measurement of current using DPM.**

Use a Digital Panel Meter (DPM) to measure AC voltage

Digital Panel Meters (DPMs) are strictly DC meters due to the digital circuitry used. Often it is desired to utilize a DPM to measure AC voltages to take advantage of the improved accuracy and readability of a DPM. This application note will describe the method to accurately display AC voltage values on a DPM. The full scale range of this DPM is 200 mV. To use the DPM to measure AC voltages, the AC voltage must be converted to DC by a rectifier diode. The output from the rectifier diode will be a "pulsed" DC voltage and may produce undesired fluctuations in the reading on the DPM, so we will add a small filter capacitor across the rectified output voltage. The voltage rating of this capacitor and the rectifier diode must be high enough to handle the voltage levels present in the circuit. To be safe, we will use a rectifier diode and capacitor rated at 400V or higher. Since we are using a single rectifier diode to convert the AC into DC, we will have to choose our divider resistors appropriately to compensate for the effects of the half wave rectifier operation. Since the AC power line voltage is rectified by the series diode, the voltage applied to our DPM is the peak value of the 230V line voltage which is 230V multiplied by 1.414

$$V_{out} = V_{in} \times (1.414) = 115 \times (1.414) = 169 \text{ V (DC)}$$

This is the actual DC voltage applied to our voltage divider resistors, so we will use the voltage divider formula to determine the required resistors to produce the correct reading on the DPM.

To keep the calculated values within a range that is readily obtainable, we will use 10 Meg ohms as the maximum series resistor value. We can then calculate the shunt resistor for our voltage divider network using the voltage divider equation

$$\frac{V_{out}}{V_{in}} = \frac{R_{shunt}}{R_{series} + R_{shunt}}$$ rearranging we can solve for the required.

Use Rseries = 10 Meg Ohms

For 0-120 Volts, Rshunt = 7.2 K ohms (use 7.5 K ohm)

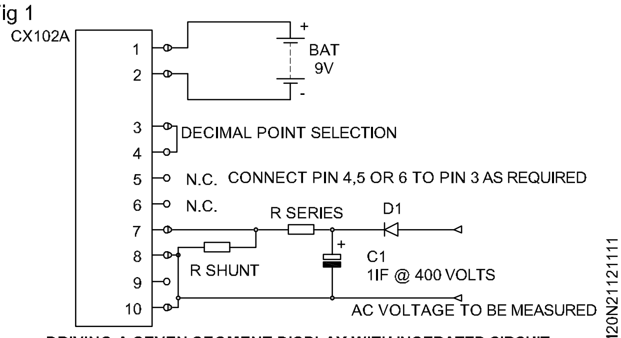
We will also need to connect pin 3 to pin 4 (for proper decimal point display).

Note that the voltage value displayed on the meter can be fine-tuned by adjusting the trimmer potentiometer on the back of the DPM.

This application note has shown how a Digital Panel Meter may be used to measure and display AC voltage values. The connection diagram is shown below.

Note that pins 8 & 10 are shorted together and connected to the Neutral connection of the AC voltage that is being measured. Rshunt will be connected across pins 7 & 8 and Rseries will have one end connected to pin 7 and the other end to the voltage that is being measured.

Fig 1



DRIVING A SEVEN SEGMENT DISPLAY WITH INGERATED CIRCUIT

Measuring Current with a Digital Panel Meter (DPM)

When current measurement is required, the current must be converted to a voltage if a digital value is to be displayed. This application note will describe the method will accurately display DC current values on a DPM.

There are several methods that can be used to convert current to voltage such as Hall Effect devices and shunt resistors. Since shunt resistors are the easiest to use and provide the greatest amount of accuracy. The shunt resistor is placed in series with the applied current which causes a voltage drop to occur across the shunt. To minimize the voltage drop in the circuit, the smallest resistance value possible should be chosen. This value depends on the maximum current value that will be encountered. For relatively small current values (below 1 Amp) a 0.1 ohm shunt resistor should perform adequately. This value will minimize any loading on the circuit but will still produce a reasonable reading on the DPM. If higher current levels will be encountered, a 0.01 ohm or lower value should be used.

The CX102A Digital Panel Meter from Circuit Specialists is ideal for this application, as it is designed to use in a system that has the measured signal isolated from the power supply voltage. The application is for a 0-1 Amp DC meter powered by an external 9 volt battery. This application could also be powered by a "wall-wart" type of AC adapter if desired.

Like all Digital Panel Meters, the full scale range of these DPMs is 200 mv. To use the DPM to measure current, we will choose a shunt resistor to assure that not more than 200 mV is developed across it. We will also set the Decimal point jumpers accordingly to indicate the correct Amp reading. For instance, if 1 Amp is the full scale reading desired, we will use the 0.1 ohm resistor and set the decimal point jumper to show three digits to the right of the decimal point. We must also determine the correct power rating of the shunt resistor by using the ohms law power formula P (Power)=E (Voltage) x I (Current).

$$P = V_{max} \times I_{max} = (0.200) \times (1.0) = 0.2 \text{ Watt}$$

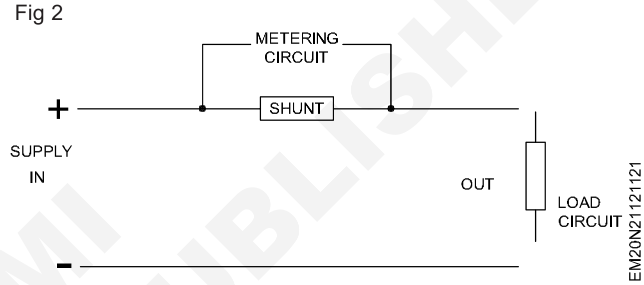
So we should use a ¼ watt 1% resistor to be safe.

We will also need to connect pin 3 to pin 6 (for proper decimal point display).

Note that the current value displayed on the meter can be fine-tuned by adjusting the trimmer potentiometer on the back of the DPM.

This application note has shown how a Digital Panel Meter may be used to measure and display DC current values. The connection diagram is shown Fig 2.

Fig 2



Note that pins 8 & 10 are shorted together and connected to the Negative end of the shunt resistor. Rshunt will be connected across pins 7 & 8 and will be connected in series with the load.

Measurement of current using DPM

Objectives : At the end of this lesson you shall be able to
- **convert the digital voltmeter to measure the current**
- **calculate the shunt resistance required to measure the current.**

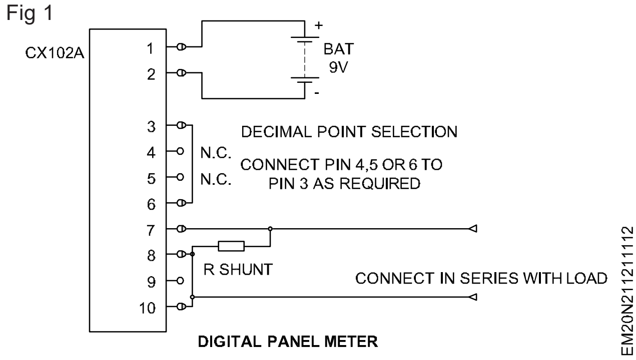
Digital voltmeter using IC7107 has been discussed in this module. It is a high performance, low power, 31/2 digit A/D converters. Included are seven segment decoders, display drivers, a reference, and a clock. The ICL7106 is designed to interface with a liquid crystal display (LCD) and includes a multiplexed backplane drive; the ICL7107 will directly drive an instrument size light emitting diode (LED) display.

The same PCB of digital voltmeter can be used to display the current too. Please note that the only difference in the PCB would be to replace the 1Mohm used in the DVM by a 10K and the 1.2 K resistance is removed. Designing of Digital Ammeter is basically a process of converting a voltmeter into a Ammeter.

We know that V=I x R. From this we can say that Voltage is directly proportional to the current (V = I) flowing through resistance. In ammeter this resistance is call Shunt. Shunt resistance have very small value and it will not affect the load voltage. Use low value for shunt resistance.

The formula for measuring the current is quite simple. Refer to the diagram below Fig 1.

Fig 1



To measure the voltage, the voltmeter is connected in parallel and to measure current in a circuit it is connected in series.

By applying Ohms law

$$V = I \times R$$

Select the Shunt value or the R value to be 1ohm , then the formula above reduces to:

V = I

So, keeping the points above in mind, say that if R = 1 ohm or in orders of 1 milliohm, then measure the voltage it is as good as getting the current reading as V = I.

Hence the selection of the shunt value is quite crucial .

0.01 Ohm resistor should be made out of 1.5 mm thick / 5 cm long copper wire. 0.1 Ohm and 1 Ohm resistors should have 5W ratings.

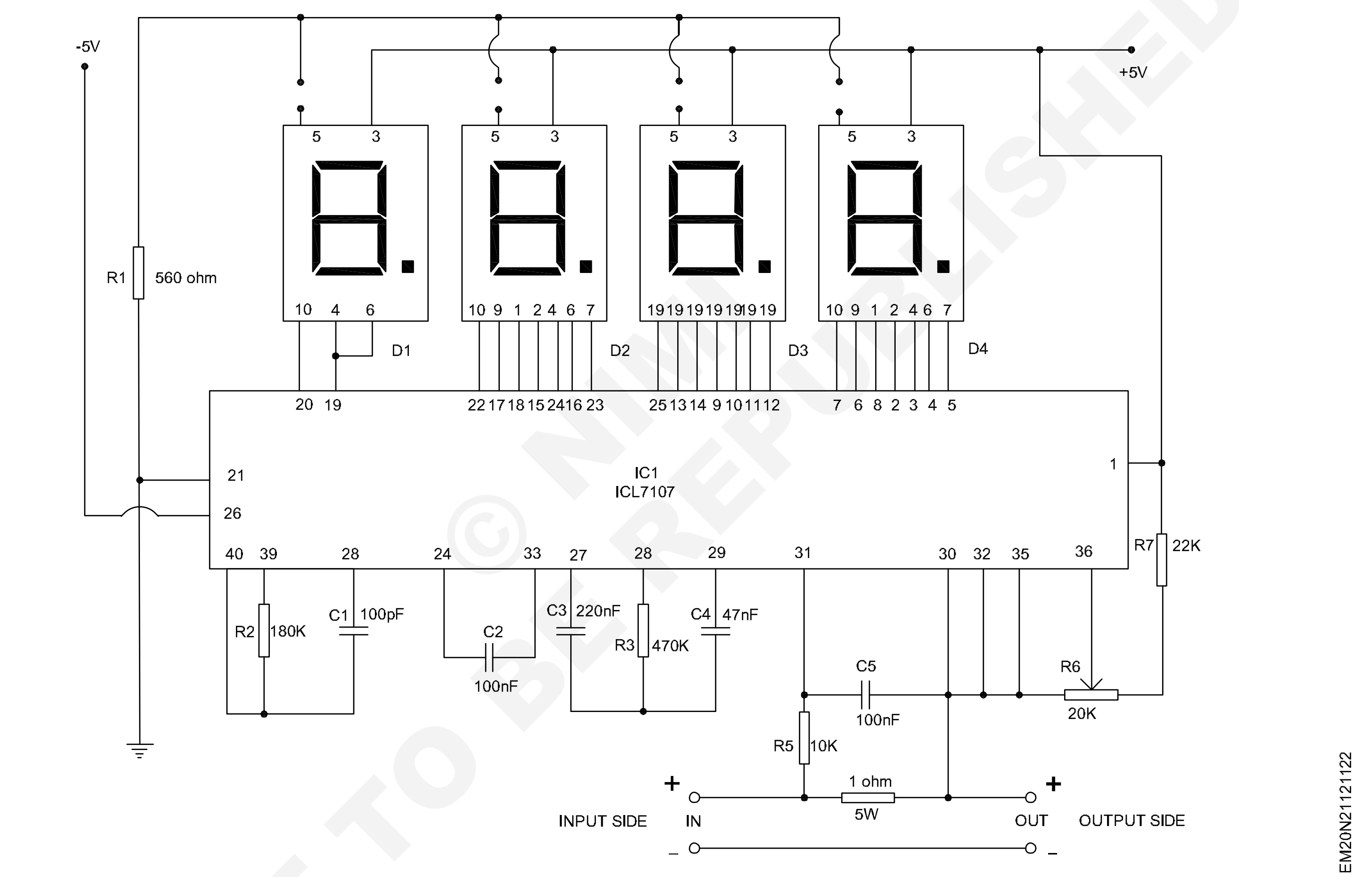
For highest accuracy it is recommended that the ICL7107 Ammeter module should be supplied with its own voltage supply. If measurement of the current of the same supply is needed, ICL7107 Ammeter would have to sample negative not positive voltage supply.

Brightness of the LED displays can be varied by adding or removing 1N4148 small signal diodes that are connected in series. Use two 1N4148 diodes for higher brightness.

Also, the use of 7805 5V voltage regulator is highly recommended to prevent the damage of ICL7107 and 7660 ICs.

Use 10K potentiometer to set the reference voltage between PIN 35 and PIN 36 of the ICL7107 IC to 1V.

Fig 2



Stabilizers

Objectives : At the end of this lesson you shall be able to
- **discuss about the power conditioning required in electrical appliances**
- **describe about the voltage stabilizer and its types**
- **explain the working principle of voltage stabilizer**
- **explain about constant voltage transformer**
- **describe the working of servo voltage stabilizer.**

Introduction: Electrical appliances and equipment require definite input voltage for their smooth operation. For single phase equipment the magnitude of input voltage is 220 volt and frequency is 50Hz. Six percent variation in voltage and three percent variation in frequency is tolerable. Input voltage should be between 216 and 244 volt and frequency should be between 48.5 Hz and 51.5 Hz. Variation beyond these limits are harmful for equipment. In reality voltage as low as 170 volt or even lower and as high as 280 or even more are observed. Too high or too low input voltage or sudden and abrupt variation in input voltage or sudden switching off can damage equipment. Unwanted and harmful electrical noise, harmonics and surges are also sometimes may be present in the normal electrical power. These are to be filtered out for the safety of equipment and appliances.

Voltage stabilizer: A voltage stabilizer stabilises voltage. Mains AC voltage is the input to the voltage stabilizer and nearly constant voltage of 220 volt is the output from the voltage stabilizer. A voltage stabilizer senses the input voltage and compares whether the input voltage is equal to the desired voltage of 220 volt. If the input is different from 220 volt, some action is initiated to adjust the voltage to 220 volt. Loads are connected to the output of the voltage stabilizer. Voltage stabilizer supplies nearly constant voltage even when the input voltage and load varies. The capacity of a voltage stabilizer is expressed in Volt Ampere (VA).

Voltage stabilizers can be classified as

1 Manual voltage stabilizer

2 Automatic voltage stabilizer

3 Constant voltage transformer (CVT)

4 Servo voltage stabilizer

Fig 1

EM430411

Manual voltage stabilizer

The essential parts of a basic manual voltage stabilizer are

1 Autotransformer

2 Rotary switch

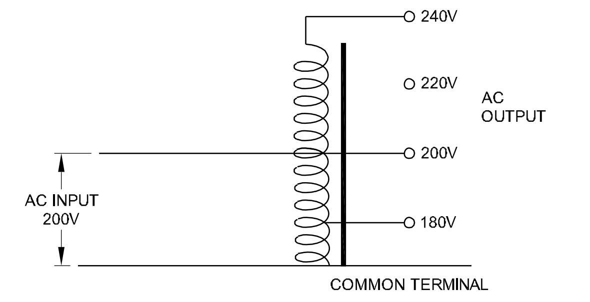
Auto-transformer is the main component of a voltage stabilizer. An auto-transformer is a winding of copper wire wound over magnetic core. There are several tapings. It is basically a transformer with single winding. The same winding acts as primary and also as secondary. A terminal is common to both primary and secondary. AC voltage is applied between the common terminal and a tapping. Then different voltages are available at the autotransformer tapings. These voltages change whenever there is a change in input voltage or input is applied between different tapings. The output voltage is taken between the common terminal and appropriate tapping.

Output voltage is to be monitored manually. When output voltage is not equal to the desired voltage of 220 volt, then by rotating the switch, output voltage is adjusted to the desired value. There are two basic configurations: Without up-down switch and with up-down switch.

Neutral of mains AC is connected to the common terminal of autotransformer. Other terminals of the autotransformer are connected to the rotary switch points. Phase of mains AC is connected to the pole of rotary switch. Output is taken from some point of the rotary switch. Configuration with up-down switch has an additional one pole two way switch and the output is taken from the pole of the up down switch. Step up and step down voltages can be selected by the up down switch and the value of voltage can be adjusted by rotating the rotary switch.

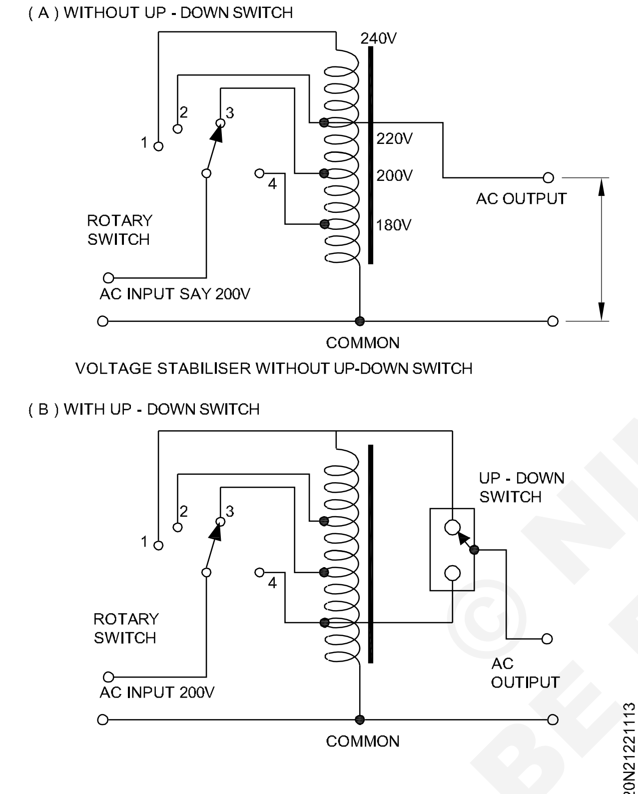
A voltmeter with a switch is connected to show the input and output voltages. The output voltage can be changed in discrete steps. Continuous adjustment of output voltage is not possible and some delay is involved between the instants the voltage changes till the instant of adjusting the output voltage. This is why manual voltage stabilizers are not capable of providing adequate protection against abrupt variation in voltage and automatic voltage stabilizers are replacing manual voltage stabilizers.

Fig 2



AUTO - TRANSFORMER

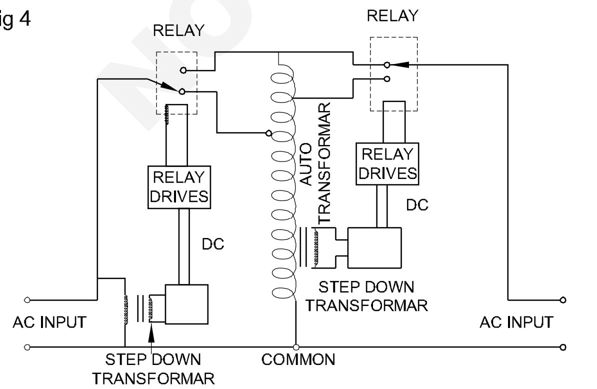
Fig 3



VOLTAGE STABILISER WITH UP - DOWN SWITCH

Automatic voltage stabilizer: Automatic voltage stabilizer does not require manual intervention. Relay switches are used which change autotransformer connections. Output voltage adjustment is automatic. (Fig 4)

Fig 4



BASIC AUTOMATIC VOLTAGE STABILISER

The essential parts of a basic automatic voltage stabilizer are

1 Autotransformer

2 Relay switches

3 Relay driver circuit

4 Control circuit

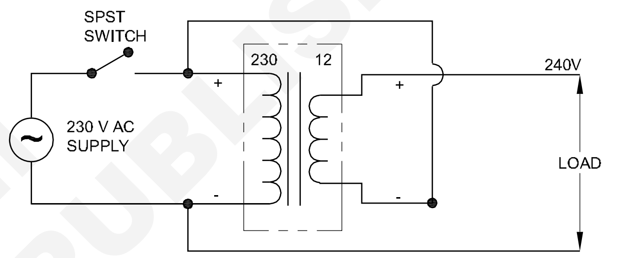
5 Low voltage power supply

6 Accessories

Basic principle of operation of voltage stabilizer: The voltage regulation is required for two distinct purposes; over voltage and under voltage conditions. The process of increasing voltage from under voltage condition is called as boost operation, whereas reducing the voltage from overvoltage condition is called as buck operations.

Boost operation: The principle of boost operation of a voltage stabilizer is shown in Fig 5.

Fig 5



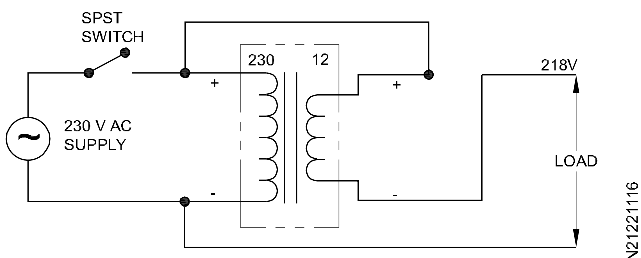
BOOST OPERATION

Here, the supply voltage is given to a transformer, which is normally a step-down transformer. This transformer is connected in such a way that the secondary output is added to the primary supply voltage.

In case of low voltage condition, the electronic circuit in the stabilizer switches corresponding relay such that this added supply (incoming supply + transformer secondary output) is applied to the load.

Buck operation: The principle of buck operation of a voltage stabilizer is illustrated in Fig 6.

Fig 6



BUCK OPERATION

In buck operation, the secondary of step-down transformer is connected in such a way that secondary output voltage is deducted from incoming voltage.

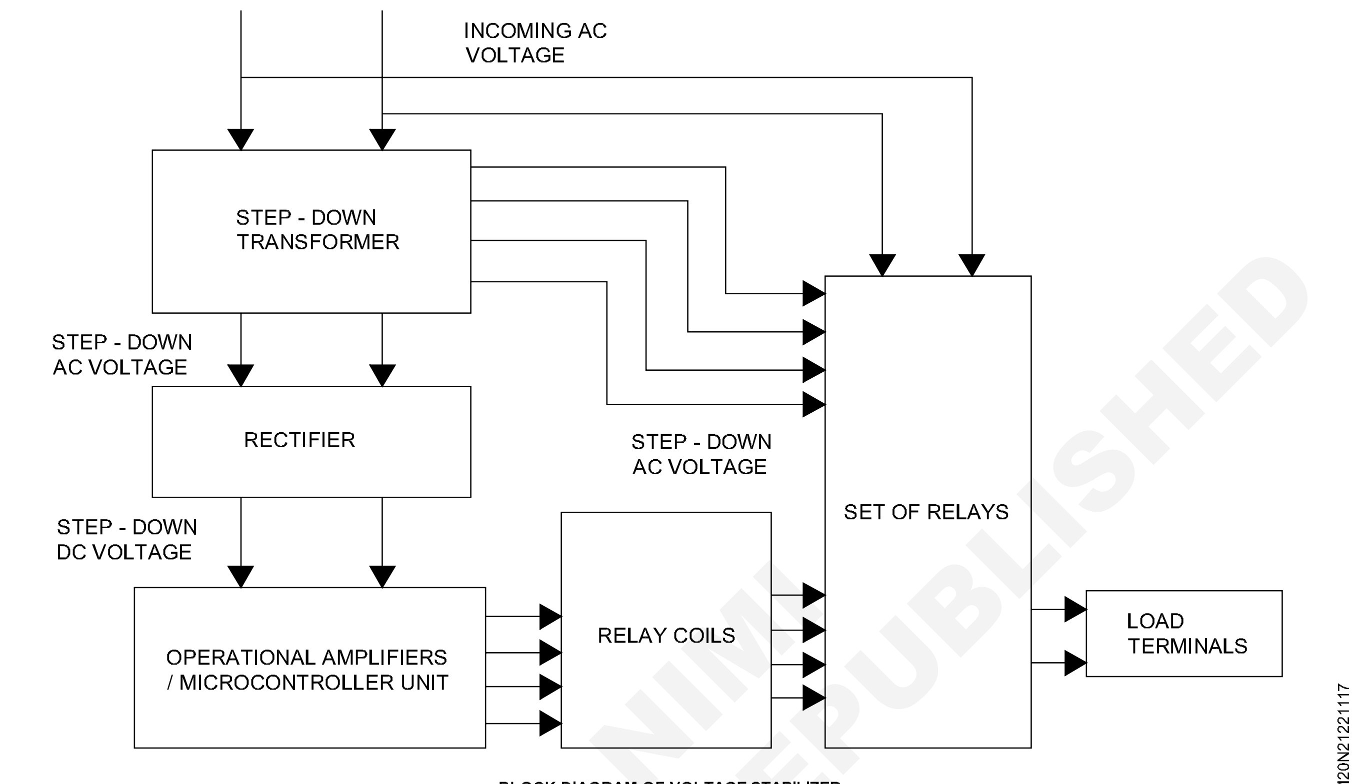
Therefore, in case of incoming voltage rise, the electronic circuit switches the relay that switches deducted supply voltage (i.e., incoming voltage–transformer secondary voltage) to the load circuit.

In case of normal voltage operating condition, electronic circuit switches the load entirely to incoming supply without any transformer voltage.

Working of voltage stabilizer

The Fig 7 below shows the working model of a voltage stabilizer that contains a step-down transformer (usually provided with taps on secondary), rectifier, operational amplifier/microcontroller unit and set of relays.

Fig 7



BLOCK DIAGRAM OF VOLTAGE STABILIZER

In this, op-amps are tuned in such way that they could sense various set voltages such as lower cut off voltage, boost condition voltage, normal operating voltage, higher cut off voltage and buck operating voltages.

A set of relays are connected in a manner that they trips the load circuit during higher and lower cut off voltages and also they switch buck and boost voltages to the load circuit.

A step-down tap changing transformer has different secondary voltage tapping which are helpful for operating operational amplifier for different voltages and also to add-up and deduct voltages for boost and buck operations respectively.

A rectifier circuit converts AC supply into DC to power-up entire electronic control circuit as well as relay coils.

Let us assume that this is 1 KVA single phase stabilizer that provides stabilization for voltage range of 200 to 245 with a boost-buck voltage of 20-35 V for input voltage of 180 to 270 V.

If the input supply is, say 195 V, then operational amplifier energizes boost relay coil such that 195 + 25 = 220V is supplied to the load. If the input supply is 260 V, corresponding op-amp energizes buck relay coil so that 260-30 = 225 V is supplied to the load.

If the input voltage is below 180 V, corresponding op-amp switches lower cut off relay coil such that load is disconnected from the supply.

And if the supply is beyond 270 V, corresponding op-amp energizes higher cut off relay coil and hence load is terminated from the supply.

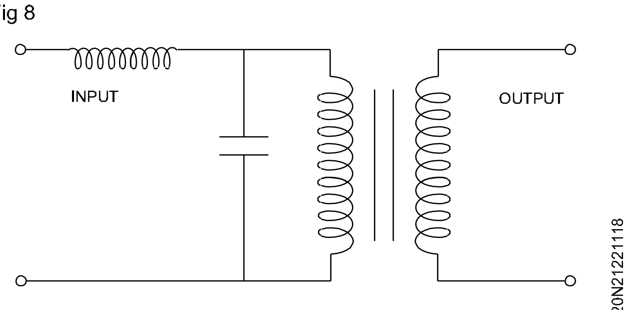
All these values are approximate values; it may vary depending on the application. By this way, a stabilizer operates under different voltage conditions.

Constant Voltage Transformer (CVT)

The parts of a constant voltage transformer are

1 Transformer
2 Capacitor
3 Inductor

Fig 8

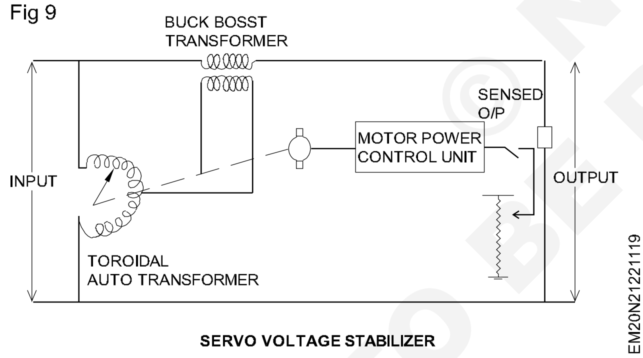


CONSTANT VOLTAGE TRANSFORMER (CVT)

The capacitor is connected in parallel with the primary winding and the inductor is connected in series with the primary winding of the transformer. Output is taken from the secondary. The working of a CVT is based on ferro resonance. Ferro resonance is an interaction between capacitor and iron core inductor and occurs when the capacitive reactance is equal to the inductive reactance. The voltage across capacitor becomes high and high amount of current flows through the primary winding. The transformer core gets saturated. Further change in current in primary does not result in change of magnetic flux in transformer core and hence secondary voltage remains relatively constant. Thus, in spite of variation in the input voltage, the output of a constant voltage transformer remains constant. CVT gives instantaneous adjustment of output voltage, provides isolation between input and output, suppresses spikes and noises and provides instantaneous short circuit and overload protection. CVT requires minimum maintenance as number of components is minimum. Occasionally the capacitor becomes defective and needs replacement.

Servo voltage stabilizer: A servo voltage stabilizer continuously senses and monitors the voltage. Whenever the output voltage differs from the desired voltage of 220 volt, it generates control signal to automatically adjust the output to the desired value of 220 volt. A servo voltage stabilizer uses a servo motor mechanism and continuously adjusts the output voltage. Servo voltage stabilizers are normally available with power rating more than 1KVA.

Fig 9



SERVO VOLTAGE STABILIZER

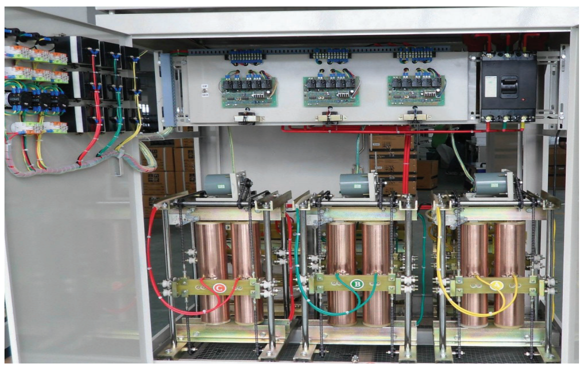
The essential parts of a servo voltage transformer are -

1 Auto transformer
2 Buck boost transformer
3 Motor
4 Motor driver
5 Control circuit
6 Power supply for control circuit.
7 Set point
8 Accessories

The auto transformer is toroidal in shape and is connected between the phase and neutral of input voltage. The buck boost transformer is connected between input and output of the stabilizer. One end of the primary of buck boost transformer is permanently connected to a suitable tapping of autotransformer. The other end is connected to an arm and brush mechanism attached to the shaft of the motor. The motor is a DC servo motor or an AC synchronous motor and is fitted on top of the autotransformer centre. The motor can rotate in both directions. As the motor rotates the other end of primary of buck boost transformer continuously slides over autotransformer wires and makes contact with different points on the autotransformer winding. The motor driver and the control circuit are solid state circuit with transistors and operational amplifier IC 741. A step down transformer and rectifier unit produces low voltage DC supply for motor driver and control circuit. A stable low DC voltage reference source is obtained and is used for set point. By adjusting the set point, the desired value of output is set usually between 220 to 240 volt. The actual output voltage is continuously sensed and is compared with the desired voltage. The comparator is generally based on operational amplifier 741 IC. When the actual output changes, the motor driver makes the motor in proper direction. The contact of sliding end of primary of buck boost transformer with autotransformer changes and a voltage gets applied to the primary. Voltage in the secondary is induced and because of this voltage the actual output gets adjusted to the desired value.

Servo voltage stabilizer provides continuous adjustment of output as input voltage varies and correction speed is usually between 20 to 40 volt per second. It suppresses voltage surge, spikes and noises that may be present in the input voltage. Features include over voltage and under voltage protection, overload and short circuit protection, auto and manual mode for adjusting output etc. Common problem include oscillatory movement of motor, defects in motor driver and control circuit, jamming or loose contact of arm and brush mechanism attached to the shaft of motor etc.

Fig 10



Switch Mode Power Supply

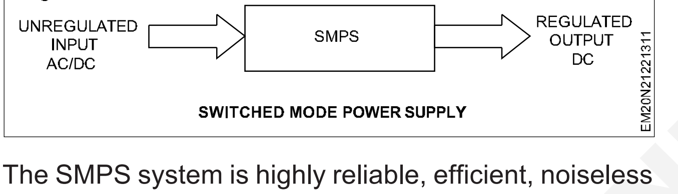
Objectives : At the end of this lesson you shall be able to
- **state the need for SMPS**
- **describe the basic concept of SMPS**
- **compare between linear power supply and SMPS**
- **explain the working principles of different types of SMPS**
- **list out the advantages and disadvantages of SMPS**
- **state the applications and topologies of SMPS.**

Switched-Mode Power Supply(SMPS)

The electronic power supply integrated with the switching regulator for converting the electrical power efficiently from one form to another form with desired characteristics is called as switched mode power supply. This is working on the principle of switching regulation.

It is used to obtain regulated DC output voltage from unregulated AC or DC input voltage.

Fig 1



The SMPS system is highly reliable, efficient, noiseless and compact because the switching is done at very high rate in the order of several KHz to MHz.

Need for switch-mode power supplies

Many household electrical devices require a supply of voltage which is both constant and well regulated, but the voltage which comes from power outlets are noisy AC voltages. The power from such outlet needs to be managed by electronic circuits which are generally referred to as power supplies, even though the power comes from the outlets.

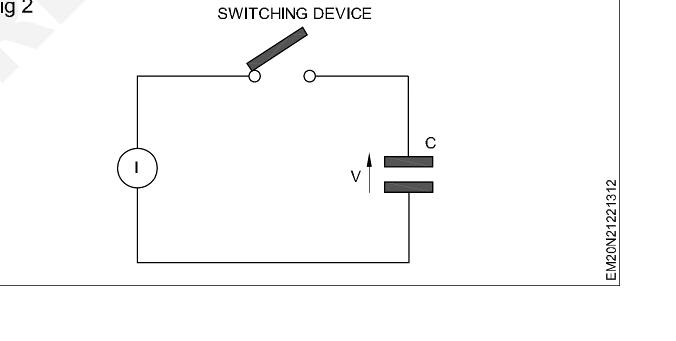
Basically, the AC supply from the outlet has a sinusoidal wave shape, and it is rectified in order to produce a DC voltage. The noisy high voltage need to be converted to a regulated low voltage so that it can be used by low voltage electronic devices such as TV, DVD, Mobile, etc.

Basic concept of SMPS

The basic concept of SMPS is the regulation by using a switching regulator. SMPS uses a series switching element that turns the current supply to a smoothing capacitor on and off.

The switching element is turned on is controlled by the voltage on the capacitor. If it is higher than required, the series switching element is turned off, if it is lower than required, it is turned on. In this way the voltage on the smoothing or reservoir capacitor is maintained at the required level.

Fig 2



Comparison between linear power supply and SMPS

	Linear power supply	SMPS
1) Transformer size and weight	Heatsinks for high power linear regulators add size and weight.	Smaller transformer
2) Operating frequency	50 Hz or 60 Hz	15 KHz to1 MHz
3) Output voltage	Limited voltage available. Voltage varies significantly with load.	Any voltages available. Voltage varies little with load.
4) Efficiency, heat, and power dissipation	If regulated: efficiency largely depends on voltage difference between input and output; output voltage is regulated by dissipating excess power as heat resulting in a typical efficiency of 30–40%. If unregulated,	Output is regulated using duty cycle control; the transistors are switched fully on or fully off, so very little resistive losses between input and the load.

	transformer iron and copper losses may be the only significant sources of inefficiency.	The only heat generated is in the non-ideal aspects of the components and quiescent current in the control circuitry.
5) Circuit complexity	Usually a simpler circuit; unregulated may be simply a diode and capacitor. Regulated has a voltage-regulating circuit and a noise-filtering capacitor.	Consists of a controller IC, one or several power transistors and diodes as well as a pulse transformer, inductors, and filter capacitors. Some design complexities present which are not found in linear regulator circuits.
6) Radio frequency interference	Mild high-frequency interference may be generated by AC rectifier diodes under heavy current loading.	EMI/RFI produced due to the current being switched on and off sharply. Therefore, EMI filters and RF shielding are needed to reduce the disruptive interference.
7) Electronic noise at the output terminals	It can cause audible mains hum in audio equipment, brightness ripples in analog security cameras.	Noisier due to the switching frequency of the SMPS.
8) Electronic noise at the SMPSs	Causes harmonic distortion to the input AC. input terminals	Non power-factor-corrected cause harmonic distortion.
9) Power factor	Low for a regulated supply because current is drawn from the mains at the peaks of the sinusoidal voltage.	Ranging from very low to medium since a simple SMPS without PFC draws current spikes at the peaks of the AC.

Working principles of SMPS

Fig 3 shows the block diagram of SMPS with an AC input and a regulated DC output.

AC input section

Input filter

The AC input from the main supply goes to the input filter to reduce EMI.

Input filter is a protective circuit, which is used to suppress short pulses around the AC voltages. The circuit consists of inductor and high voltage capacitors. A MOV(Metal Oxide Vaistor) is connected across the AC supply to prevent any surge or spikes in the voltages and also PFC circuit is used to correct the power factor.

Rectifier

AC input is converted to DC voltage using a rectifier diodes. The rectifier consisting of a full wave bridge diode or module and large filter capacitors to obtain a smoothed high DC voltage around 300 V DC. The current is drawn from the mains supply.

Power section

The power section consists of high frequency ferrite core transformer and switching power transistors (MOSFETs) to switch D.C Voltage across the transformer winding. This section coverts the rectified high voltage DC into AC at a frequency of 20 KHz - 100 KHz. A current sense circuit is provided to sense overload current and to protect SMPS from overloading. Since the input voltage is chopped into an AC waveform and placed into a magnetic element additional winding can be added to provide for more than one output voltage.

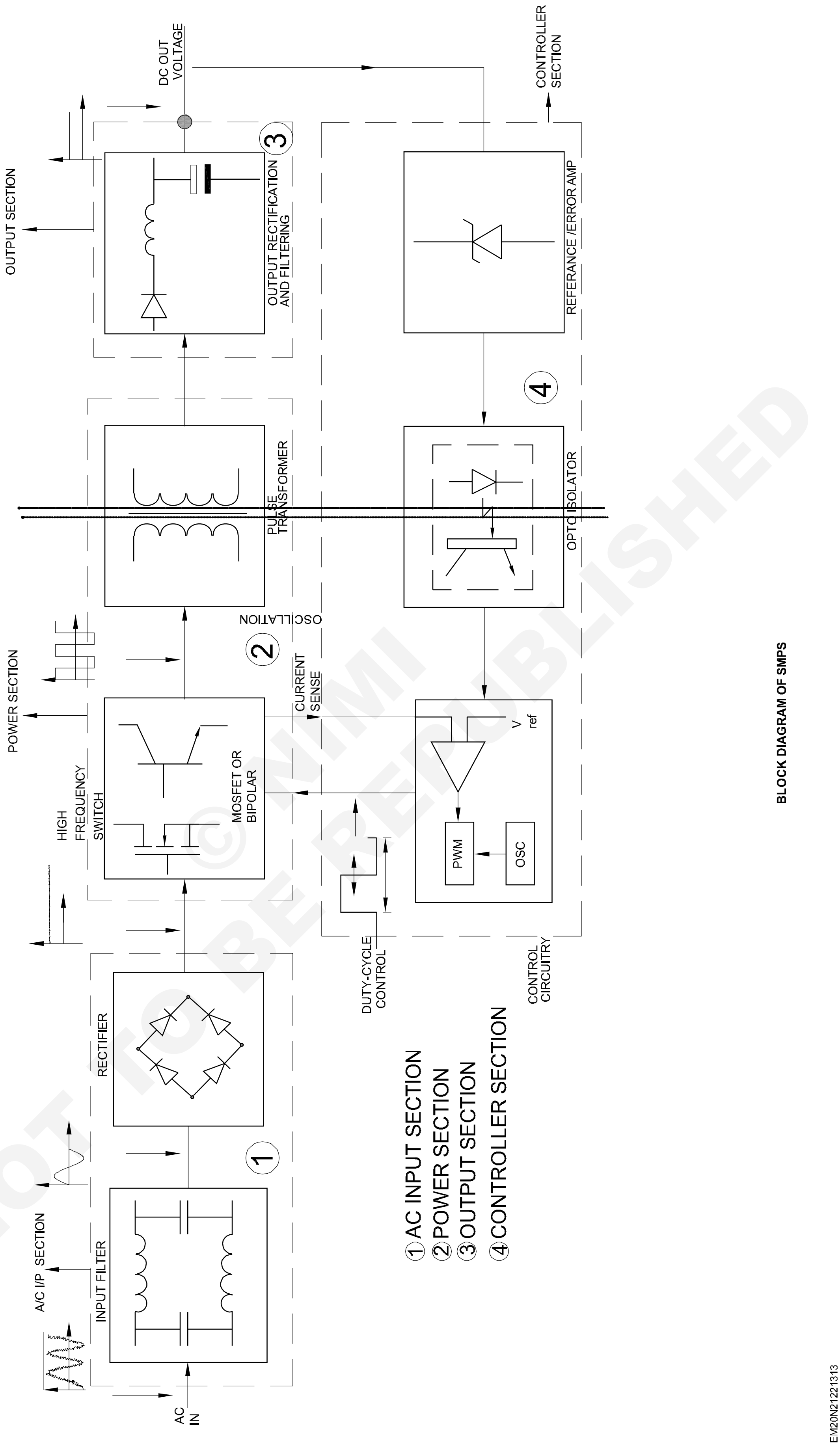
Output section

The output section consists of rectifier and filter circuits for output above the volts ordinary silicon diodes are used. Since the A/C output of the transformer at 20 KHz schottky diodes are used, because of its fast recovery than silicon diodes to get lower voltages. For even lower output voltages MOSFETs may be used as synchronous rectifiers. The filter circuit consists of an inductor and capacitor.

Control section

The controller consists of a feedback circuit PWM circuit and isolation mechanism (opto - coupler). A feedback circuit monitors the output ref voltage of 2.5V and compares it with a reference voltage. Any change in 5V with respect to the load creates an error voltage. This error voltage modifies the pulse width of the output pulses. The output pulses in turn drives the power switching transistor. The output pulses are not directly connected to the power switching transistor. For safety

Fig 3

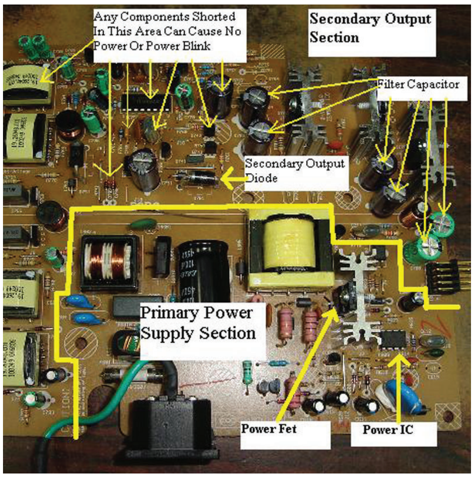


reasons, the output section is isolated by an opto-coupler and transformer. Over current is sensed through a current transformer. The output of current transformer is rectified and used to shut down the power controller when an excess current is drawn.

Different types of SMPS

Model 1 : SMPS

Fig 4



Model 2 : SMPS used in PC

Fig 5

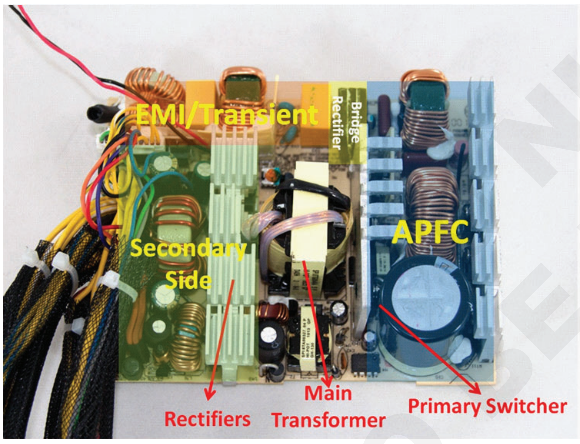
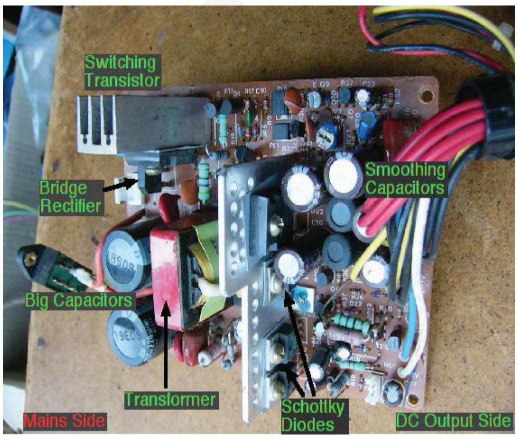
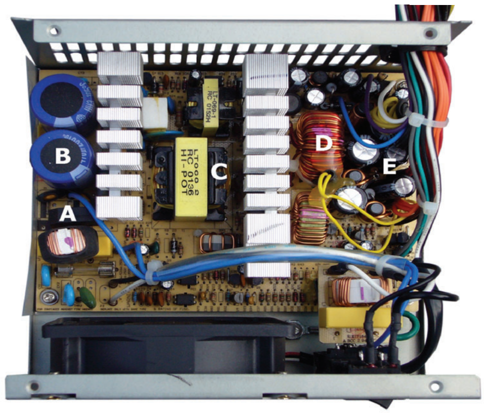


Fig 6



SMPS IN PC

Fig 7



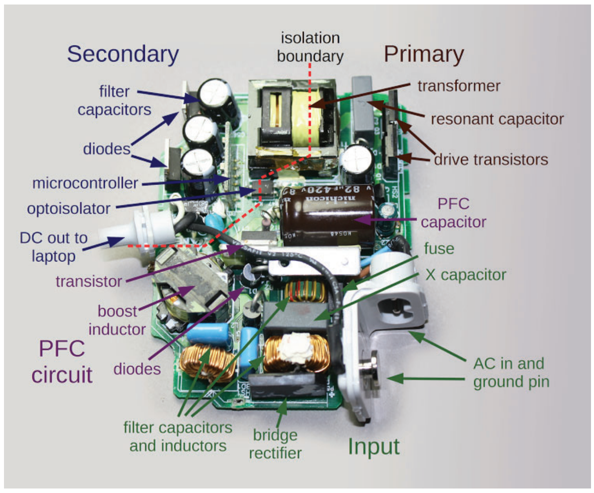
SMPS used in PC(ATX)

ATX SMPS (Fig 7)

below A	: input EMI filter and bridge rectifier;
B	: input filter capacitors
Between B and C	: Primary side heat sink;
C	: Pulse transformer
Between C and D	: Secondary side heat sink;
D	: Output filter coil;
E	: Output filter capacitors.

The coil and large yellow capacitor below E are additional input filtering components that are mounted directly on the power input connector and are not part of the main circuit board.

Fig 8



SMPS used in Laptop

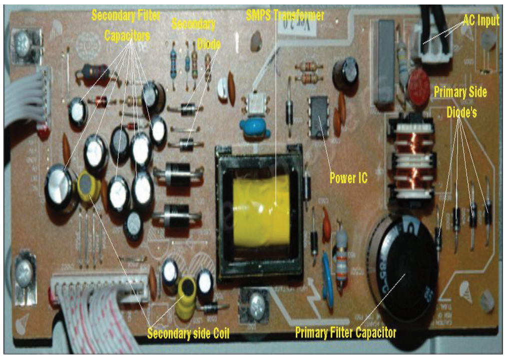
Basic parts and their function

1 **EMI/Transient filter :** Suppress incoming and out coming EMI/RFI and protects from voltage spikes.

2 **Bridge rectifier :** Rectifies the AC power stream to DC.

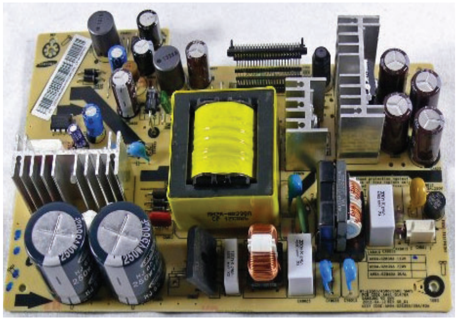
3 **APFC :** Controls the current supplied to the PSU so that the current waveform is proportional to the mains voltage waveform.

Fig 9



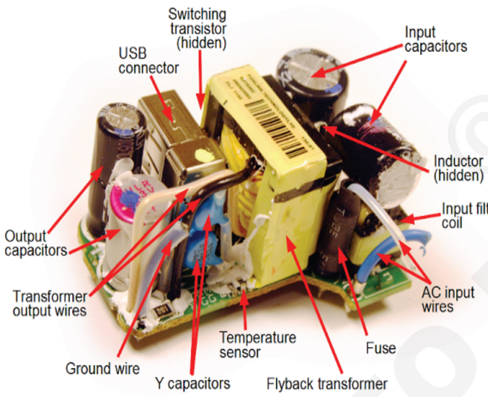
SMPS in DVD player

Fig 10



SMPS in Home theature main board

Fig 11



SMPS in Cell phone charger

4 **Main switches:** Chop the DC signal to very small energy packets, with high frequency.

5 **Transformer :** Isolates primary from secondary side and converts (steps down) the voltage.

6 **Output rectifiers & filters :** Generate the DC outputs and filter them.

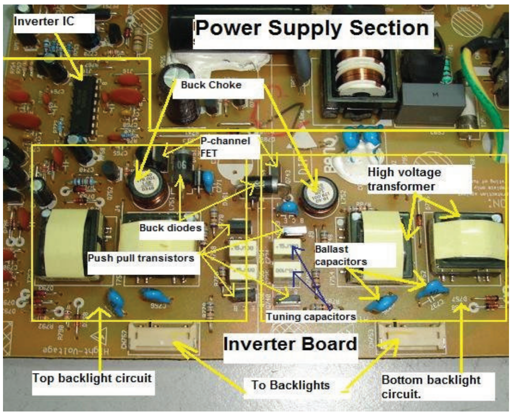
7 **Protection circuits :** Shut down the PSU when something goes wrong.

8 **PWM controller :** Adjusts the duty cycle of the main switches, in order to keep steady output voltage under all loads.

9 **Isolator :** Isolates the voltage feedback that comes from the DC outputs and heads to the PWM controller.

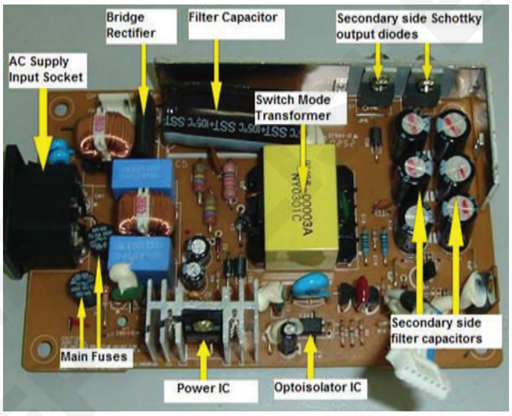
10 The part of the SMPS before the pulse transformer is called "primary" side and the part after it "secondary" side.

Fig 12



SMPS in LED TV

Fig 13



SMPS in LCD monitor

Advantages & Disadvantages of SMPS

Advantages

1 Higher efficiency, smaller size, lighter weight.

2 Heat dissipation is very low.

3 Wide AC input voltage range. (Ex. 90V-270V)

4 High precision voltage regulation.

5 Low output noise ripple.

6 Strong protection function. (Ex. Short circuit in output)

Disadvantages

1 Complexity of the circuit.

2 Line filter is necessary to avoid EMI.

3 Non-PFC SMPS cause harmonic distortion.

4 Serving of SMPS is very difficult.

Applications of SMPS

1 Personal computers

2 Battery chargers

3 Central power distribution

4 Vehicles (Electric bike vehicle & space vehicles)

5 Consumer electronics

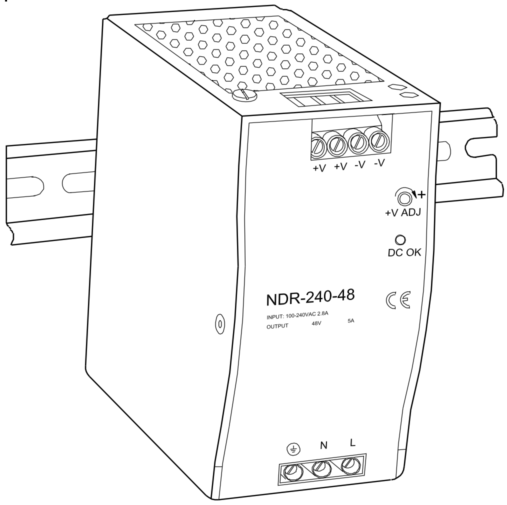
6 Lighting

7 Space station

Personal computers

Personal computers have parts like Hard disk, Mother

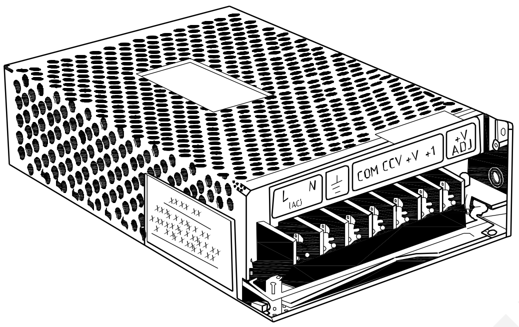
Fig 14



DIN RAIL SMPD IN CONTROL PANEL

EM20N2122131E

Fig 15



SMPS IN CONTROL PANEL

EM20N2122131F

board, CPU, CD Rom, etc. In order to run these devices switch mode power supply is used efficiently.

Battery chargers (Mobile phone, Digital camera, Laptop computer)

Due to their high volumes, mobile phone chargers uses effective ringing choke converter (RCC) SMPS topology.

Central power distribution

Where integration of capacitors for stabilization and batteries as an energy storage or AC hum and other interference needs to be avoided in the power distribution, SMPS may be essential for efficient conversion of electric DC energy. For AC applications where frequency and voltage can't be produced by the primary source an SMPS may be essential.

Vehicles

In automobile industry where ordinary trucks use nominal 24V DC but they need 12 V DC & SMPS. Cars use nominal 12V DC and may need to convert this to drive equipment using SMPS. Space vehicles use a lightweight switched-mode power supplies to convert voltages produced by solar panels and fuel cells to the voltages required by equipment.

Consumer electronics

Television receivers, DVD players, Home theatres, Cordless phone, uses a switch-mode power supply. When the A/C voltage reduced to as low as 90 V and as high as 260V, but the image has no alterations.

Lighting

Powering of LED circuits is accomplished with switched-mode power supply setup as a constant current source where efficiency is important.

Space station

The electrical power system on the International Space Station (ISS) uses multiple switch-mode power supplies to convert between the voltage produced by the solar array and battery system, and the voltages required by the different modules. The eight solar panels generate 262 kW at 160 V DC, used to charge nickel-hydrogen batteries that provide power when the solar array is in shadow during earth eclipse. A system voltage of 160 V DC is used for the main power distribution throughout the station.

The space shuttle uses three fuel cells generating 30–36V DC. Some is converted into 400 Hz AC power and 28V DC power using SMPS.

Topologies of Switch Mode Power Supply

There are different types of topologies for SMPS, among those, a few are as follows

1 DC to DC converter

2 AC to DC converter

3 Fly back converter

4 Forward converter

Common problems appearing from a faulty SPMS 1)

The power is not reaching the computer system

Check the power from the source

Check the setting of the coltage in CPU

Check the front panel of motherboard.

Check the power supply connections to the motherboard.

Check the SMPS without connecting to the motherboard

2) Computer getting started after second or third try- Check the power supply switch on the cabinet

Consider replacing SM

3) Display comes to monitor and becomes black?

Replace SMPS and try again

The problem may arise from Motherboard

4) The PC pen without display

Check the VGA cable and monitor connections

Discard the SMPs, it has been damaged hardly by voltage fluctuation

Check the display card modern

5) There is a whistling squealing motor like noise from SMPS when PC starts

Chat SMPS fan

Gemine SSIPS problem on replacing

The PC freezes or reboots suddenly

Overheating problem of SMPS

All these solution need to be applied through protesters to prevent to further problems was the post useful to you? If yes then stay connected to our blog space for further informative updates.

Trouble shooting of SMPs

Problem	Symptoms	Diagnosis
Faulty primary side components rectifier diodes, filter capacitor(s), MOVs and other parts located before the switch mode (chopper) transistor(a) may short due to a surge, lightning, or for no apparent reason,	Totally dead supply fuse blows instantly (vaporizes or explodes) even if switch mode transistor is removed unless a fusible resistor has blown to protect the fuse.	Test all components on line side of high frequency transformers the short-circuit failures with a multi meter.
Shorted switch mode transistor may take out additional parts such as fusable, flameproof resistors in collector or emitter circuits (or source or drain circuits for MOSFETs)	Totally dead supply fuse blows instantly (vaporizes or explodes) unless fusible resistor has opened.	Measuring across CE or DS of switch mode transistor yields near zero ohms even when it is removed from circuits.
Shorted rectifier diodes in secondary circuits - these are high frequency, high efficiency diodes under a fair amount of stress.	In a very basic supply without over current protection, the failure of one or more of these diodes may then overload the supply and cause a catastrophic failure of the switch mode power transistor (see above) and related components. Thus, these should be checked before reapplying power in a supply that had a shorted switch mode transistor. On short circuits protected supplies, the symptom may be a periodic, "tweet-tweet-tweet" or "flub-flub-flub" as the supply attempts to restart and then shuts down. Any power or indicator lights may be blinking in this rate as well.	Test with an ohmmeter a low reading in both directions indicates a bad diodes. Sometimes these will test fine but fail under load or at operating voltage (easiest to replace with known good diodes to verify diagnosis) Rectifiers either look like IN400X type on steroids cylinder about 1/4 inch x 1/2 inch (Example, HFR854) or TO220 package (example C92M) with dual diodes connected at the cathode for positive supplies or the anode for negative supplies (the package may include a little diagram as well). These may either be used with a center-tapped transformer or simply parallel for high current capacity. If in doubt, remove from the circuit and rest with the ohmmeter again. If its not the output used for regulations feedback, try the supply with the rectifier removed. Leakage may reduce the output of the main output (and, as a consequences, all the others as well) Where a controller like a UC1842 is used, a failure of the capacitor on its V_{cc} pin may result in a aborted startup or cycling behavior as it is starved for juice each time if pulses the switch mode power transistor. In almost all cases, when in doubt, parallel a known good capacitor of similar capacitance and at least equal voltage rating (except for these slew rate limiting capacitors where substitution is the only sure test)
Bad connection/cold solder joints as with all other mass produced power systems (Including TVs and monitors), cracked or	Almost any kind of behavior is possible. The unit may be erratic, intermittent or totally dead.	Visually inspect the solder side of the circuit board using a height light and magnifying glass, if necessary. Gently prod or twist the circuit board with an

defective solder connections are very common especially around the pins of high power components like transformers, power resistors and transistors and connectors.		insulating stick to see if the problem can be made to change. Note chat a one time intermittent can blow many component, so inspecting for intermittents is a really good idea even if you believe that all had components have been replaced.
Regulation problems outputs high or low	Voltage has changed and adjustment pot, if one exists, has no effect or its unable ot set voltage to proper value.	Most common parts are readily available from parts distributors like MCM Electronics, as well as general electronics distributors like Digi Key and Mouser, Rebuild kits are available for many common supplies used in VCRs monitors, and terminals. Also while it is tempting to suspect any ICs or hybrid controllers and especially the high frequency transformer since it is thought that replacements are difficult and expensive to obtain, these parts are pretty robust and don't make the top 10 list.
Bad start up circuit initial base (gate) drive is often provided by a high value, high power resistor or resistors from the rectified AC voltage. These can simply open for no good reason.	The main filter capacitor may dry up or open and cause the output to be pulsing at 60 (10) or 120 (100) Hz causing all kinds of regulation problems. Excess depts under moderate load is an indication of a dried up or open capacitor. In extreme castes, a main filter capacitor with greatly reduced capacity or one that is totally open may result in failure of the switch mode transistor and a dead supply that blows fuses or fusible resistors.	Measure voltage across main filter capacitor(s). If the reading is low and drops in a much lower value to 0 instantly upon pulling the plug, then one of these capacitors may be open or dried up, if you have an oscilloscope, monitor for ripple (use an isolation transformer) It is always a good idea to test the electrolytic capacitors whenever repairing a SMPS that has blown its switch mode transistor. Capacitors in the low voltage section may fail causing regulation problems. Sometimes there are slew rate limiting capacitors that feed from the primary output to the regulator controller to limits initial in rush and overshoot. A failure of one of these may mess up regulation at the very least. For example, excess.

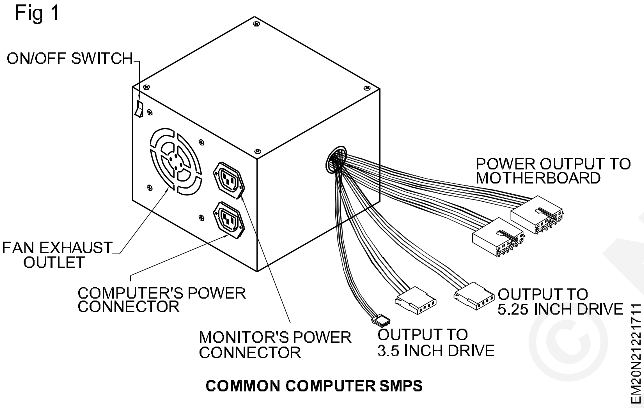
SMPS used in personal computers

Objectives : At the end of this lesson you shall be able to
- **explain SMPS and different types of SMPS used in PC**
- **explain different types of connectors used in personal computer SMPS**
- **discuss the need of ATX SMPS in PC**
- **explain the functions of SMPS used in PC**
- **explain the working of PWM IC**
- **differentiate between AT and ATX type SMPS.**

SMPS used in PC

Switch Mode Power Supply of a PC is housed in a metal box. It consists of an electronic circuit board, a fan, AC power sockets, power supply interface connectors for motherboard, hard disk drive and floppy disk drive. AC power switch is connected as an optional item to the power cable from the SMPS.

Fig 1



COMMON COMPUTER SMPS

Basic connectors in PC SMPS

20 + 4 Pin ATX / Motherboard connector

CPU 4 + 4 Pin connector

SATA power connector

Floppy 4 pin connector

Peripheral 4 pin molex connector

PCI-e 6 pin/PCI-e 8 pin connector.

Types of SMPS used in PC

There are 3 types of SMPS

1 AT SMPS

2 ATX SMPS

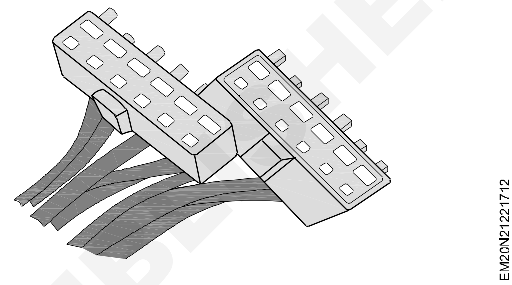
3 BTX SMPS

These three types of SMPS have different connectors and each wire has different voltages.

AT SMPS

AT stands for Advanced Technology. These are all old SMPSs. They had 12pin power connector, this is called as AT power connector. They were used in Pentium-I, Pentium-MMX, Pentium-II and Pentium-III CPUs as shown in Fig 2.

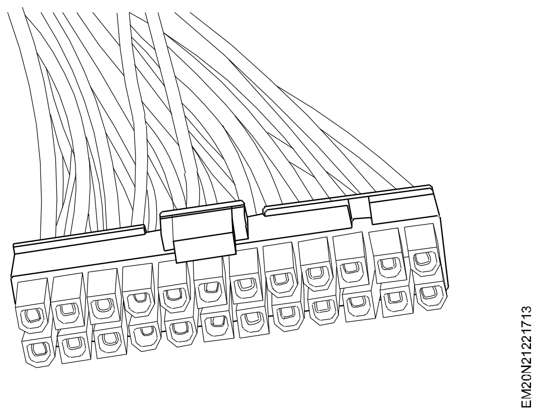
Fig 2



ATX SMPS

ATX stands for Advanced Technology extended. They had 20pin Power connector, this is called as ATX power connector. They were used in Pentium-III, Pentium-IV and AMD CPUs as shown in Fig 3.

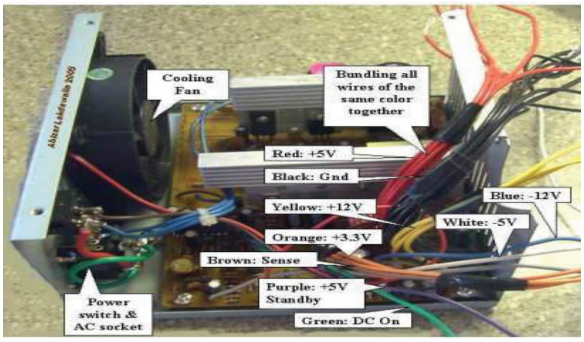
Fig 3



BTX SMPS

BTX stands for Balanced Technology extended. They have 24pin Power connector, this is also called as ATX power connector. It has 15pin SATA power connectors. They are used in Dual core, core2duo, Quad core, i3, i5, i7 and latest AMD CPUs.

Fig 4



Voltages of power connector

SMPS	AT	ATX	BTX
Red	+5V	+5V	+5V
Yellow	+12V	+12V	+12V
Blue	-12V	-12V	-12V
White	-5V	-5V	-5V
Black	0V	0V	0V
Orange	+5V	+3.3V	+3.3V
Green	---	+5V	+5V
Gray or Brown	---	+5V	+5V
Purple	---	+5V	+5V

Red : It is used to provide stated voltage.

Yellow : It is used for motor running

White &Blue : It is used for backward compatibility

Black : It is used for grounding purpose

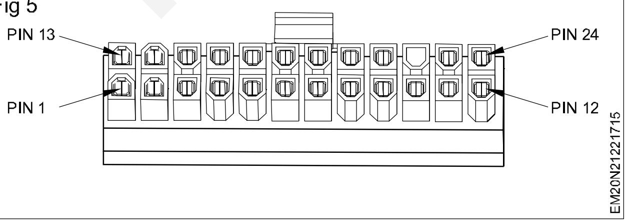
Orange : It is used to provide stated voltage

Green : It is used for power supply ON in ATX

Gray or Brown : It is used for power Good(Self-test OK) signal in ATX

Purple : It is used to provide +5V whenever the PSU is powered. Even when the green wire is not connected to ground. (Stand by)

Fig 5



Connectors

20/24 Pin ATX / Mother board connector

This is the connector that goes to the motherboard to provide it with power. The connector has 20 or 24 pins. One of the pins belongs to the PS-ON wire (it is usually green). This connector is the largest of all the connectors. In older AT power supplies, this connector was split in two: P8 and P9. A power supply with a 24-pin connector can be used on a motherboard with a 20-pin connector. In cases where the motherboard has a 24-pin connector, some power supplies come with two connectors (one with 20-pin and other with 4-pin) which can be used together to form the 24-pin connector as shown in Fig 6 and 7.

Fig 6

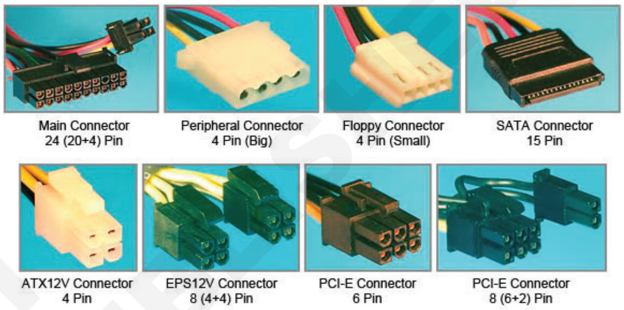


Fig 7

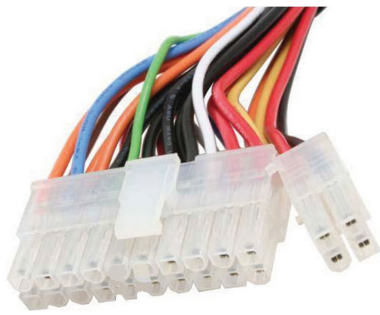
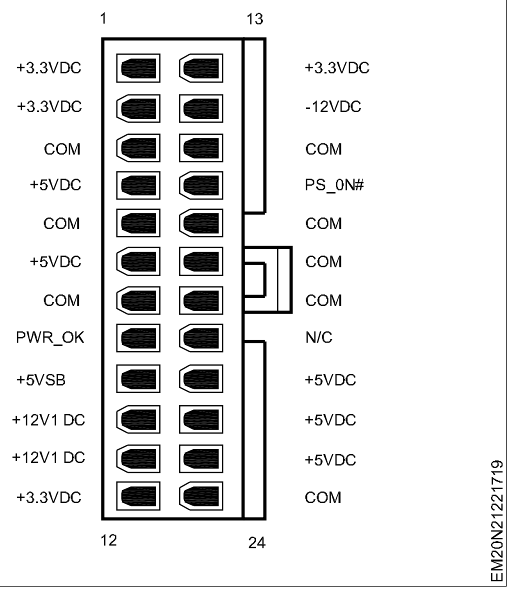


Fig 8

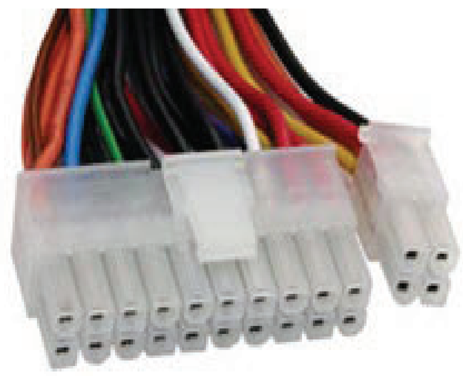
Connected attached (24 pins)

Fig 9



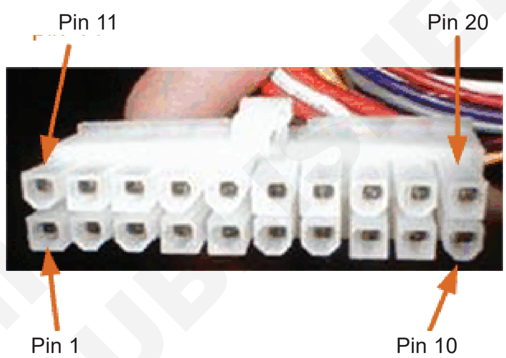
Pin	Name	Color	Description
1	+3.3V	Orange	+3.3 VDC
2	+3.3V	Orange	+3.3 VDC
3	COM	Black	Ground
4	+5V	Red	+5 VDC
5	COM	Black	Ground
6	+5V	Red	+5 VDC
7	COM	Black	Ground
8	PWR_ON	Gray	Power Good
9	+5VSB	Purple	+5 VDC Standby
10	+12V1	Yellow	+12 VDC
11	+12V1	Yellow	+12 VDC
12	+3.3V	Orange	+3.3 VDC
13	+3.3V	Orange	+3.3 VDC
14	-12V	Blue	-12 VDC
15	COM	Black	Ground
16	PS_ON#	Green	Power Supply On
17	COM	Black	Ground
18	COM	Black	Ground
19	COM	Black	Ground
20	NC	White	-5 VDC (Optional - Removed in ATX12V v2.01)
21	+5V	Red	+5 VDC
22	+5V	Red	+5 VDC
23	+5V	Red	+5 VDC
24	COM	Black	Ground

Fig 10



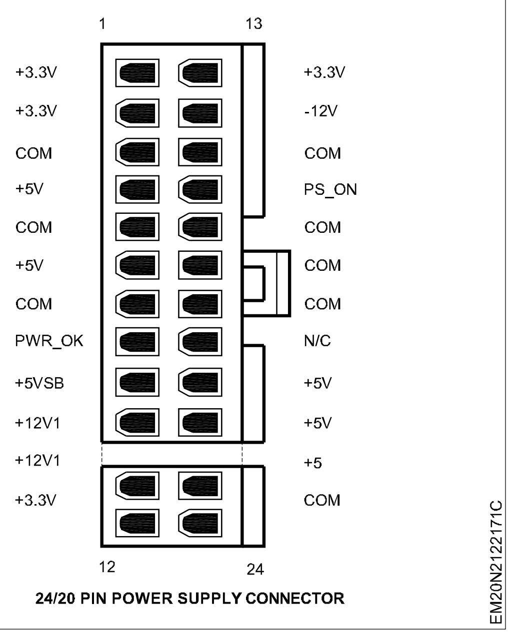
24 Pin detachable connector (20+4)

Fig 11



20 Pin molex connector

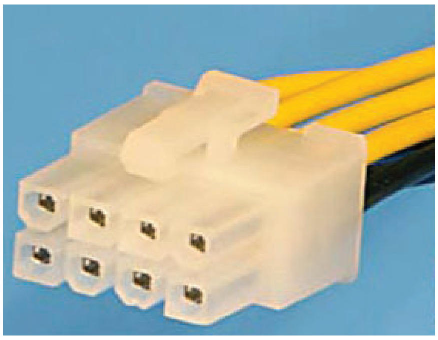
Fig 12



24/20 PIN POWER SUPPLY CONNECTOR

ATX P4 12V 4-pin power connector (also called the P4 power connector). A second connector that goes to the motherboard (in addition to the main 24-pin connector) to supply dedicated power for the processor. For high-end motherboards and processors, more power is required, therefore EPS12V has an 8-pin connector.

Fig 13



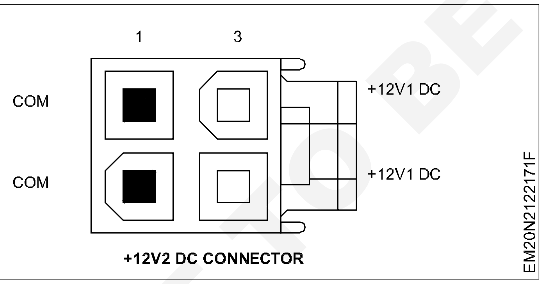
Connector attached (8 Pin)

Some motherboards have 4 pin 12V CPU socket and some have 8 pin 12V socket. Therefore most of the power supply comes with 8 pin (4+4) detachable connector which can be split into two 4 pin connectors.

Fig 14

8 Pin connector detachable

Fig 15



Pin	Name	Color	Description
1	COM	Black	Ground
2	COM	Black	Ground
3	+12VDC	Yellow	+12 VDC
4	+12VDC	Yellow	+12 VDC

4-pin peripheral power connector (usually called molex)

These are the other smaller connectors that go to the various disk drives cooling fans and other smaller devices of the computer. Most of them have four wires: two black, one red, and one yellow. Unlike the standard mains electrical wire color-coding, each black wire is a ground, the red wire is +5V, and the yellow is +12V. In some cases these are also used to provide additional power to PCI cards such as fire wire 800 cards.

Fig 16

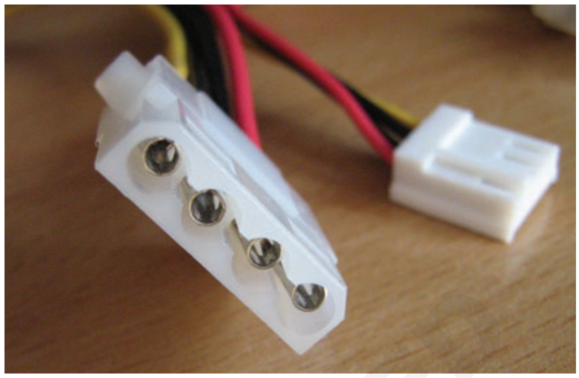
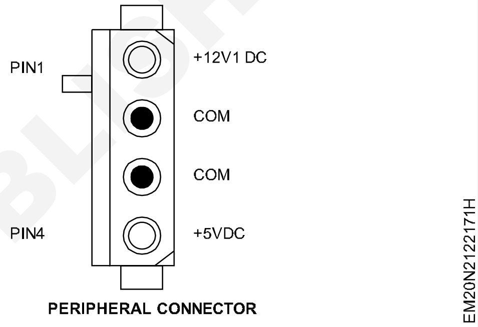


Fig 17



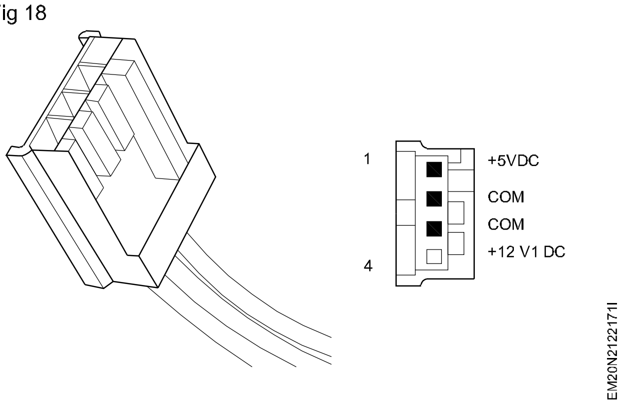
Pin	Name	Color	Description
1	+12VDC	Yellow	+12 VDC
2	COM	Black	Ground
3	COM	Black	Ground
4	+5VDC	Red	+5 VDC

Berg floppy drive 4 pin power connector (Fig 18)

The floppy drive 4 pin power supply connector is the standard floppy drive power connector in computers today.

The power connector itself is a Berg connector, sometimes referred to as a Mini-Molex connector.

Fig 18



Pin	Name	Color	Description
1	+5VDC	Red	+5 VDC
2	COM	Black	Ground
3	COM	Black	Ground
4	+12VDC	Yellow	+12 VDC

15 pin serial ATA power connector

A 15 pin power supply connector which uses SATA power plug is one of the standard peripheral power connectors in computers. This power connector for all SATA based hard drives and optical drives. This connector supplies power at three different voltages such as +3.3V, +5V and +12V. Modern power supply must have at least 4 of these, to power up drives at the SATA standard.

4 pin molex connector to SATA power converter cables are also available.

Fig 19

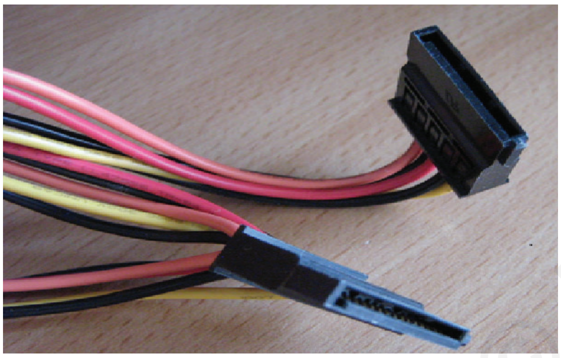
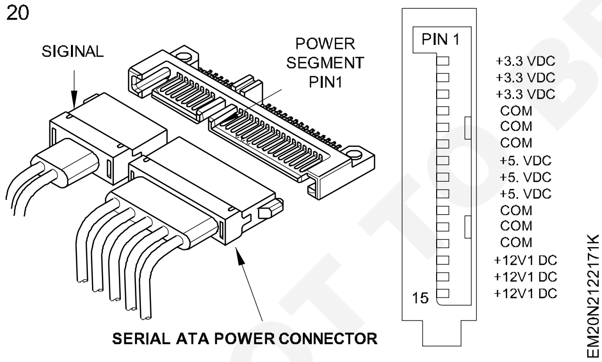


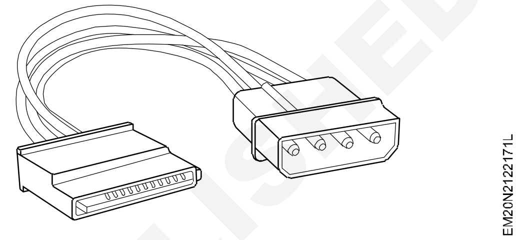
Fig 20



Pin	Name	Color	Description
1	+3.3VDC	Orange	+3.3 VDC
2	+3.3VDC	Orange	+3.3 VDC
3	+3.3VDC	Orange	+3.3 VDC
4	COM	Black	Ground
5	COM	Black	Ground
6	COM	Black	Ground
7	+5VDC	Red	+5 VDC
8	+5VDC	Red	+5 VDC
9	+5VDC	Red	+5 VDC
10	COM	Black	Ground
11	COM	Black	Ground (Optional or other use)
12	COM	Black	Ground
13	+12VDC	Yellow	+12 VDC
14	+12VDC	Yellow	+12 VDC
15	+12VDC	Yellow	+12 VDC

The wire numbers in serial power ATA(SATA) connector are not 1:1. There are three pins for each voltage.

Fig 21



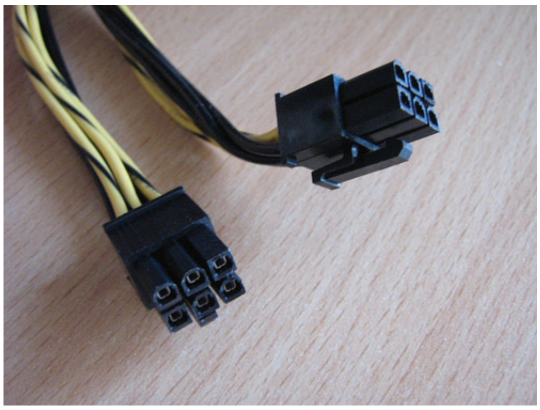
Molex 4 pin connector to SATA power converter cable

The PCI Express connector (PCI - e 6 pin/ PCI - e 8pin)

Most modern computer power supplies include 6-pin connectors which are generally used for PCI express graphics cards, but a newly introduced 8-pin connector should be seen on the latest model power supplies. Each PCI express 6-pin connector can output a maximum of 75W.

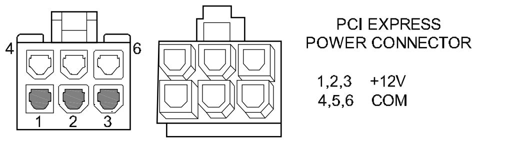
6+2 pin for the purpose of backwards compatibility, some connectors designed for this kind of pin configuration to use with PCI express graphics card feature. It allows either a 6-pin card or an 8-pin card to be connected by using two separate connection modules wired into the same sheath: one with 6 pins and another with 2 pins as shown in Fig 24.

Fig 22



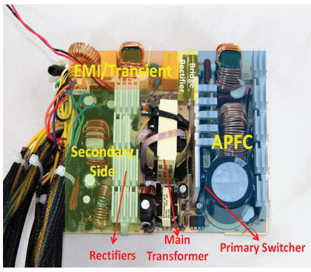
If your power supply doesn't have an 8-pin connector, there are 6-8 adapters.

Fig 23



Pin	Name	Color	Description
1	COM	Black	Ground
2	COM	Black	Ground
3	COM	Black	Ground
4	+12VDC	Yellow	+12 VDC
5	+12VDC	Yellow	+12 VDC
6	+12VDC	Yellow	+12 VDC

Fig 24



Need of SMPS in PC

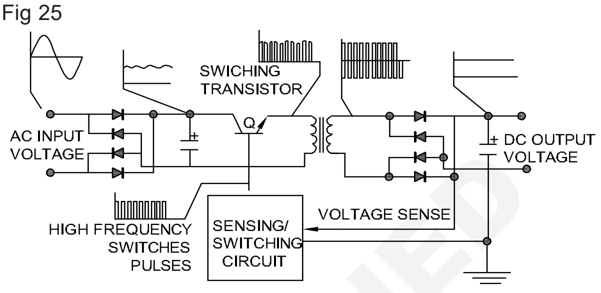
On ATX and most of the other later form factors, the motherboard can turn the power supply on or off. This is done through the PS-ON (power supply on) signal that passes between the motherboard and the power supply. If your PC powers off when windows is finished shutting down, you have this feature.

Another indicator that your power supply supports PS-ON is the use of Momentary On or Always On power switches that are connected to the motherboard in place of an exterior switch connected to the power supply. When this signal line is pulled to a low voltage signal, the +12V DC, +5V DC, +3.3V DC, -5V DC and -12V DC power lines are turned on. When it is pulled to a high-voltage signal, or open-circuited, the DC output lines should no longer have current. The +5V DC output is always on as long as the power supply is receiving AC power. Because the ATL, NLX, LTX and other form factor motherboards have some power running to them at all times, you will always want to unplug the PC before working on it.

Function of SMPS in PC

AC line input is rectified and converted to DC voltage. The DC voltage is switched at high frequency nearly 20 KHz. The switched voltage is fed to the high frequency step down transformer. The output of the transformer is rectified and energy is stored in an inductor and smoothened by a capacitor. The switching period (pulse width) is controlled by the feed back given to the controller section. Power switching transistors ON time is varied according to the load. When the load increases the output voltage tends to drop. This drop in voltage is fed as the error signal to power controller which increases the ON period of switching pulses. When the load decreases the output goes high. The error voltage is fed to the controller which reduces the ON period of switching pulses. Since there are many outputs in a PC SMPS i.e. 12V, -12V, -5 only the main 5 volts which supplies maximum current is sensed and regulated. The transformer winding is designed taking care of this aspect. A simplified diagram of a switching power supply is shown in Fig 25.

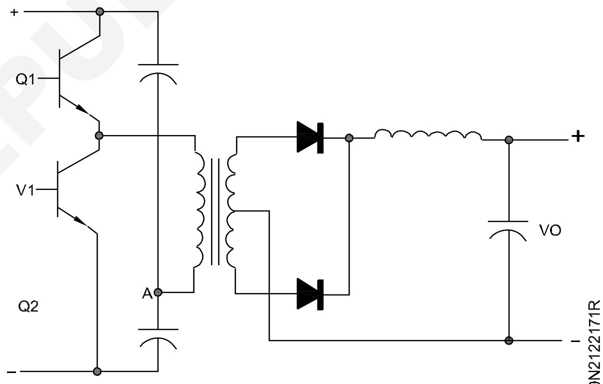
Fig 25



SIMPLIFIED DIAGRAM OF A SWITCHING POWER SUPPLY

Most widely used configuration in PC SMPS is half bridge converter circuit as shown in Fig 26. Power transistors Q1 and Q2 switch the DC voltage through the windings in a push pull manner.

Fig 26



HALF-BRIDGE CONVERTOR CIRCUIT

Use of the fan in PC SMPS

A 12V DC fan is used for removing the heat generated inside the power supply. The fan blows out air from the SMPS. The fan also helps in air circulation inside the cabinet. Proper working of fan is ensured by periodic cleaning. Whenever the fan is working intermittently the fan should be cleaned for dust near the motor. A failed fan can result in the failure of the SMPS because of excess heat.

Difference between AT & ATX power supply

AT power supply does not have soft start option.

AT power supply does not generate 3.3V DC.

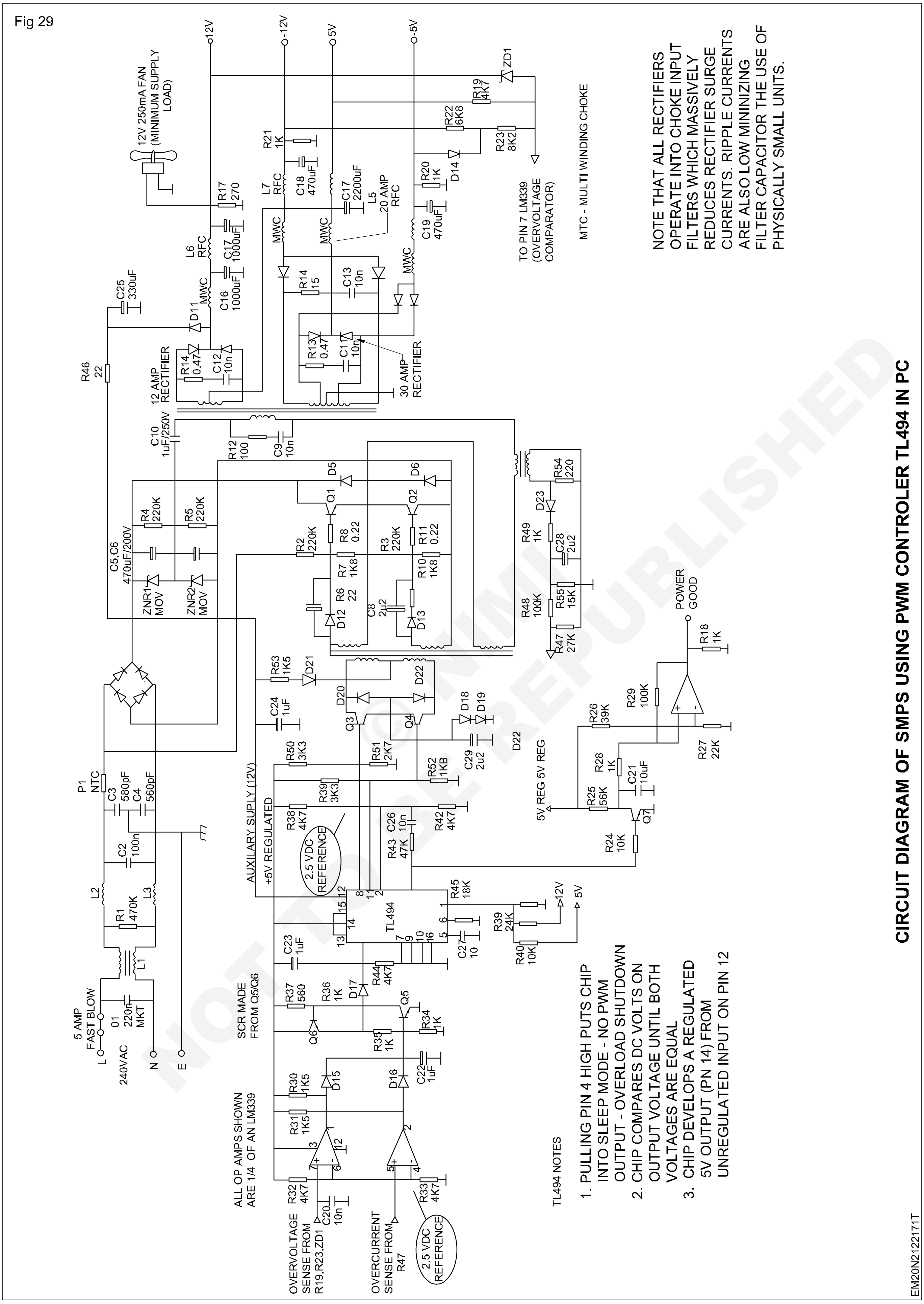
AT motherboard supply connectors come with 2x6 pin connection.

ATX power supply has a soft start.

ATX power supply does not shut down completely. Always the ATX power supply gives 5 volt to the mother board.

ATX power supply generates a 3.3V DC for the processor core voltage.

Fig 29



CIRCUIT DIAGRAM OF SMPS USING PWM CONTROLER TL494 IN PC

Inverter

Objectives : At the end of this lesson you shall be able to
- **describe the basic concept of inverter**
- **explain principle of operation of inverter**
- **explain the functional blocks of inverter**
- **state the installation procedure of inverter**
- **classify the types of inverter**
- **state the applications of inverter.**

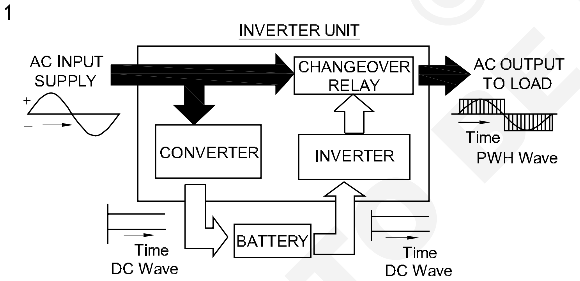
Definition: Converts DC to AC power by switching the DC input voltage (or current) in a pre-determined sequence so as to generate AC voltage (or current) output.

Circuitry that performs the opposite function of rectifier, converting DC to AC, is called an inverter.

The input voltage, output voltage, output frequency, and overall power handling depends on the design of the specific device or circuitry of inverter. The inverter does not produce any power; it only converts the DC battery power into AC power to load.

Principle of operation: Inverter unit converts AC mains supply into DC and stores DC power in the battery. when AC mains present (Mains mode) the input AC power is directly passes to output load through changeover relay. When the absence of AC mains (inverter mode), DC power stored in the battery is converted into AC by the use of electronic circuits, inverter transformer, etc. and is supplied to the load as shown in fig.1.

Fig 1



PRINCIPLE OF OPERATION OF INVERTER

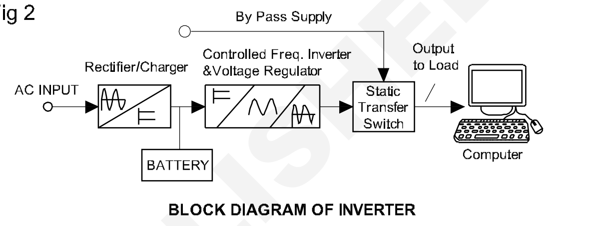
Block diagram representation: The simplified block diagram of the inverter is shown in fig.2. AC mains supply is connected to the sensing section, which senses the presence of AC input voltage and activates the battery charging section through the solid-state relay. During the presence of AC mains, AC supply directly goes to the output socket and to the connected load.

In the absence of AC mains supply, the AC mains sensing section activates the changeover type solid-state relay in milli-seconds time and connects the battery supply to the oscillator, driver and output chopper/ switching sections to produce the 50Hz sine wave.

The oscillator generates trigger pulses and amplified by the driver section, which controls the duty cycle of the semiconductor switches.

Thus, the inverter circuit produces AC supply and the battery supplies the required DC for the standby operation to run the AC load.

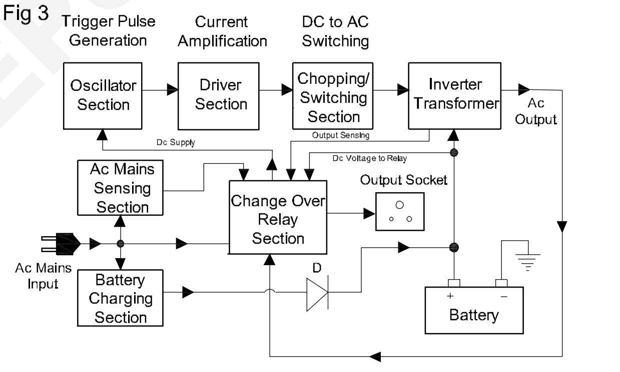
Fig 2



BLOCK DIAGRAM OF INVERTER

Function of an inverter: The Function block diagram of the inverter is shown in fig.3. The functioning of an inverter may be understood in the following two situations.

Fig 3



BLOCK DIAGRAM OF INVERTER

a When the AC mains power supply is available.

b When the AC mains power supply is not available.

When the AC mains power supply is available - Main mode

- When the AC mains supply is available, the AC mains sensing circuit senses it and the supply goes to the changeover relay, which provides,

i Mains supply to the battery charging section and

ii AC mains supply directly to the output socket/load.

- Battery charging section converts AC mains into 12/ 24V DC voltage, then regulated and battery is charged using it.
- There are special circuits for sensing the battery voltage and when the battery is fully charged the charging is stopped.

- In some inverters there will be a trickel charging circuit which keeps the battery constantly at full charge.

When the AC mains power supply is not available - inverter mode: Under the absence of the AC mains power supply, an oscillator circuit inside the inverter produces a 50Hz trigger signal.

This trigger signal is amplified by the driver section and applied to the chopper/switching section.

The semiconductor switching devices like SCR, TRIAC, MOSFET, IGBT, etc. are connected to the primary winding of the inverter transformer and starts switching/chopping the battery DC supply at a rate of 50 Hz. This switching action of the MOSFETs or transistors produces 50Hz alternating signal at the primary of the inverter transformer.

- Thus a 220V AC supply is available at the secondary of the inverter transformer.
- This secondary voltage is made available at the output socket of the inverter by a changeover solid state realy.

Changeover period: The time required for an inverter to switch from AC mains power to battery power is known as changeover period. This is in the range of 3-8 milli-seconds.

Annunciation and protection section: Inverter contains various circuits to automatically sense and tackle various situations that may occur when the inverter is running or in standby.

This annunciation section monitor the abnormal situations such as overload, over heat, low battery, over charge etc. and indicates by means of LED display/indicators and buzzer alarm.

The overload protection circuit is used for the protection of inverter and trips the unit and low battery cut-off circuit is used to cut-off the load from the inverter.

Installation of an inverter: Power rating and calculation: Inverter power is rated in VA or KVA. Before purchasing the inverter, power consumption of load/appliances that is to be connected with inverter is to be calculated as follows;

Power in VA (Volt ampere) = AC volts x Total load current.

Power in KVA (Volt ampere) = (AC volts x Total load current)/1000.

Power in watts = AC voltage x Total load current x P.F. where P.F = power factor (If not given assume approximate value of 0.8. which is standard for homes)

Also power in watts = power in VA x P.F.

Example: Connected loads:

3 Nos. of ceiling fans	= 2 x 75 watts	= 150 watts
3 Nos. of cfl light	= 3 x 23 watts	= 69 watts
1 No. of television	= 1 x150 watts	= 150 watts
	Total	= 369 watts

Therefore the connected load in wattage is 369 W.

Considering approximate power factor of 0.8, the connected load in VA is 369/0.8 = 461.25VA as the connected load capacity comes to 462 VA, the required inverter capacity to be purchased is 500 VA.

Selection of location: The first thing is selection of suitable location for placing the inverter. While choosing the location the following points are to be considered for better operation;

- Make sure the inverter is not placed near any hazardous or flammable materials.
- It must also not be exposed to moisture or water.
- The selected location must be away from direct sunlight and is a dry area.
- It must be placed in an area near the main board of house.

Mounting the inverter: An inverter can be mounted horizontally either on a vertical surface or on or under a horizontal surface as well. Inverter is always placed on the insulation material like wood, foam or hard broad.

Battery installation: There are two main families of batteries used in inverters

- Nickel - cadmium batteries
- Lead - acid batteries

Most commonly liquid or pasted (SMF - Sealed Maintenance Free) Lead-acid batteries are using.

Before connecting the new battery to inverter, battery is to be charged fully, otherwise its life and backup time will be reduced.

While connecting the batteries the polarity of the battery and the inverter terminals should exactly match i.e. positive and negative to negative.

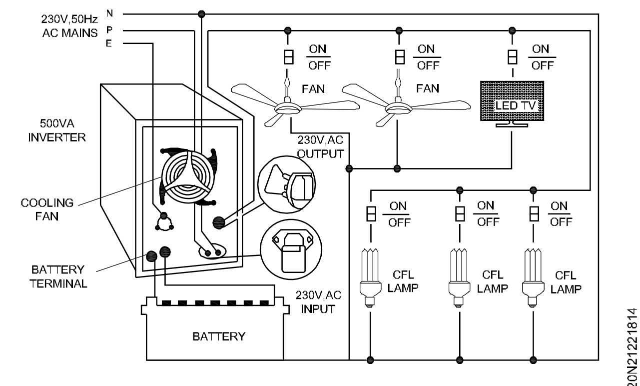
During charging/discharging of batteries, oxygen and hydrogen gas produced due to chemical reactions in the batteries and hence a vent hole will be there in the top up cap.

For liquid type batteries, distilled or demineralised water is to be added periodically with the electrolyte for maintaining the specific gravity of electrolyte between 1.260-1.280 (Fully charged battery).

Inverter wiring: The input connector of the inverter is connected with the AC mains supply and the AC output of the inverter is connected to the electrical/electronics appliances which is called inverter load. Always the connected load should be less than the VA capacity of the inverter.

It is important to note that the neutral connection of the inverter output is directed connected with the neutral wire of AC mains supply as shown in fig.4.

Fig 4



INVERTER CONNECTION DIAGRAM

Earthling: In an inverter installation proper earthling is essential because,

It protects the user against electric shock

It protects the inverter incase of an electric short - circuit

It completes the battery's circuit in the cases of vehicles like car, bike, etc.

Classification

a Based on application:

The inverters are classified in two types according to the applications, as

i **Domestic inverters -** The domestic inverter is mainly used for household electrical/electronics appliance.

ii **Industrial inverters** - The industrial inverter system is mainly used with existing plant battery and no need of having separate battery bank. It is used in industries for applications like AC/DC drives for controlling motors, turbine & boiler control, DCS (Distributed control system), and PLC (Programmable logic control), etc.

b Based on connected load:

The inverters are classified in two types according to the connected load, as

Single phase inverters - A single-phase inverter converts a DC input into a single - phase AC output. These type of inverters mainly used in domestic purpose to run the loads like ceiling fans, CFL lights, television, etc.

Three phase inverters - A three-phase inverter converts a DC input into a three-phase AC output. The phase angle difference between the three phases are 120° so as to generate a three-phase AC supply. Three phase inverters are used where the connected loads are high and three phase system loads.

Based on the circuit arrangements: According to the circuit arrangement, inverter is classified as

i Voltage source inverters and

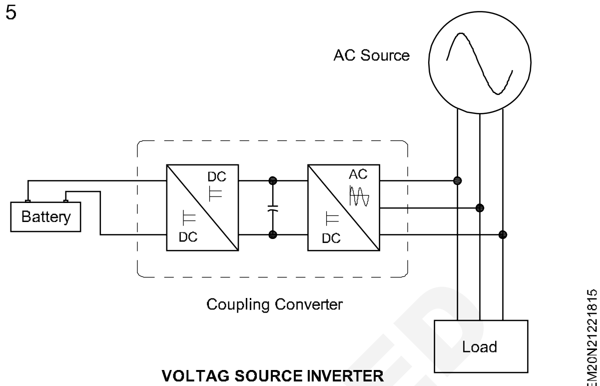
ii Current source inverters

Voltage source inverter: A voltage source inverter (VSI or voltage stiff inverter) forms the voltage with required properties: magnitude, frequency, and phase.

It is the most commonly used type of inverter. This inverter has the low internal impedance.

Generally, it has a capacitor of high capacity connected across the supply source that keeps constant input voltage as shown in Fig.5.

Fig 5



VOLTAG SOURCE INVERTER

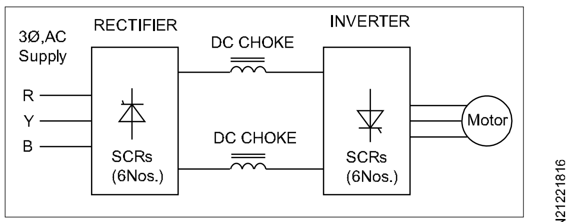
The switches of VSI are constructed using full controlled devices like, transistors, thyristors, MOSFET, etc.

If bidirectional current (AC) is required, the freewheeling diodes also called feedback diodes which are connected across the switches.

Current sources inverter: A current source inverter (CSI) is the source of the current with the required properties: magnitude, frequency, and phase.

As a rule, it has an inductor connected in series with the supply source that keeps the current constant as shown in fig.6.

Fig 6



CURRENT SOURCE INVERTER

d **Based on the input power**

According to the input power used for changing batteries, inverter is classified as:

i AC power inverter - In this case, AC mains supply is converted into DC supply by using rectifier circuit and changes the battery through a battery charger circuit.

ii Solar inverter - In this case, photovoltaic cell (PV cell) converts the solar energy into direct DC supply and charges the battery through a battery charger circuit.

Applications:

Domestic use:

- To provide back-up power to the domestic appliances when power fails.

An inverter is used to control the speed of the compressor motor, so as to continuously regulate the temperature in refrigerator and air-conditioner.

Industrial use:

- AC/DC drives for controlling motors
- Turbine & boiler control
- Industrial motor driven equipment
- DCS (Distributed Control System)
- PLC (Programmable Logic Control), etc.
- Electric trains

Automotive electronics uses: Application of power electronics in automotive applications plays a major role in controlling automotive electronics. Automotive electronics include,

- Modern electric power steering
- HEV main inverter
- Central body control
- Braking system
- Seat control, and so on.

A power inverter, or inverter, is an electronic device or circuitry that changes direct current (DC) to alternating current (AC) and is also called static inverter.

In rotary type of inverter, the DC motor drives the AC generator (alternator) and supplies AC power to the dynamic loads in industries.

Inverter and principle of operation

Objectives : At the end of this lesson you shall be able to
- **explain the working of the Inverter circuit**
- **explain the working principle of Microcontroller based Inverter**
- **state common inverter problems and solutions.**

Working of Inverter circuit

The simple circuit diagram of DC or AC Inverter is shown in Fig.1.

It comprises of the following sections;

- Battery charger section
- Battery
- PWM section
- Inverter switching/chopper
- Section
- Sensing/Feedback section

Battery charger section: The 230V, 50Hz, AC mains supply is applied to the step-down transformer where the step-down transformer where the input AC high voltage is reduced to 15V AC low voltage. The reduced AC voltage is rectified and applied to the battery through SCR TYN616 which controls and regulates the battery charging voltage to 12V DC. The trigger pulse to the SCR comes from the variable voltage regulator IC LM317 which is working here as comparator and the firing angle can be varied by the 4.7K reference pre-set.

Battery: A 12V liquid type or SMF lead-acid battery is connected to the output of charger section and battery gets charged steadily.

PWM section: CA3524 is a 16 pin Pulse Width Modulator (PWM) IC. It generates trigger pulses at pin 11 & 14 which is applied to the gate terminals of semiconductor switch MOSFET 1 & 2 respectively through a bias resistors. The trigger pulse generated by the PWM IC is based on the feedback voltage obtained from the sensing/feedback section at Pin 1.

Inverter switching/Chopping section: The bias DC voltage for MOSFETs are obtained from the battery through the centre tapped primary of the output transformer. The MOSFETs Q1 & Q2 are switched alternatively by the trigger pulses obtained from the PWM IC. The duty cycle of the MOSFET switching controls the AC output voltage. If the connected load of the inverter draws less current, PWM IC generates trigger pulses with reduced duty cycle and thus output decreased. In this manner, the output voltage of the inverter is sensed and duty cycle of the switch PWMs are modified to produce the steady and regulated output voltage. Then a capacitor helps filters the waveform to make a clean 50Hz AC sine wave.

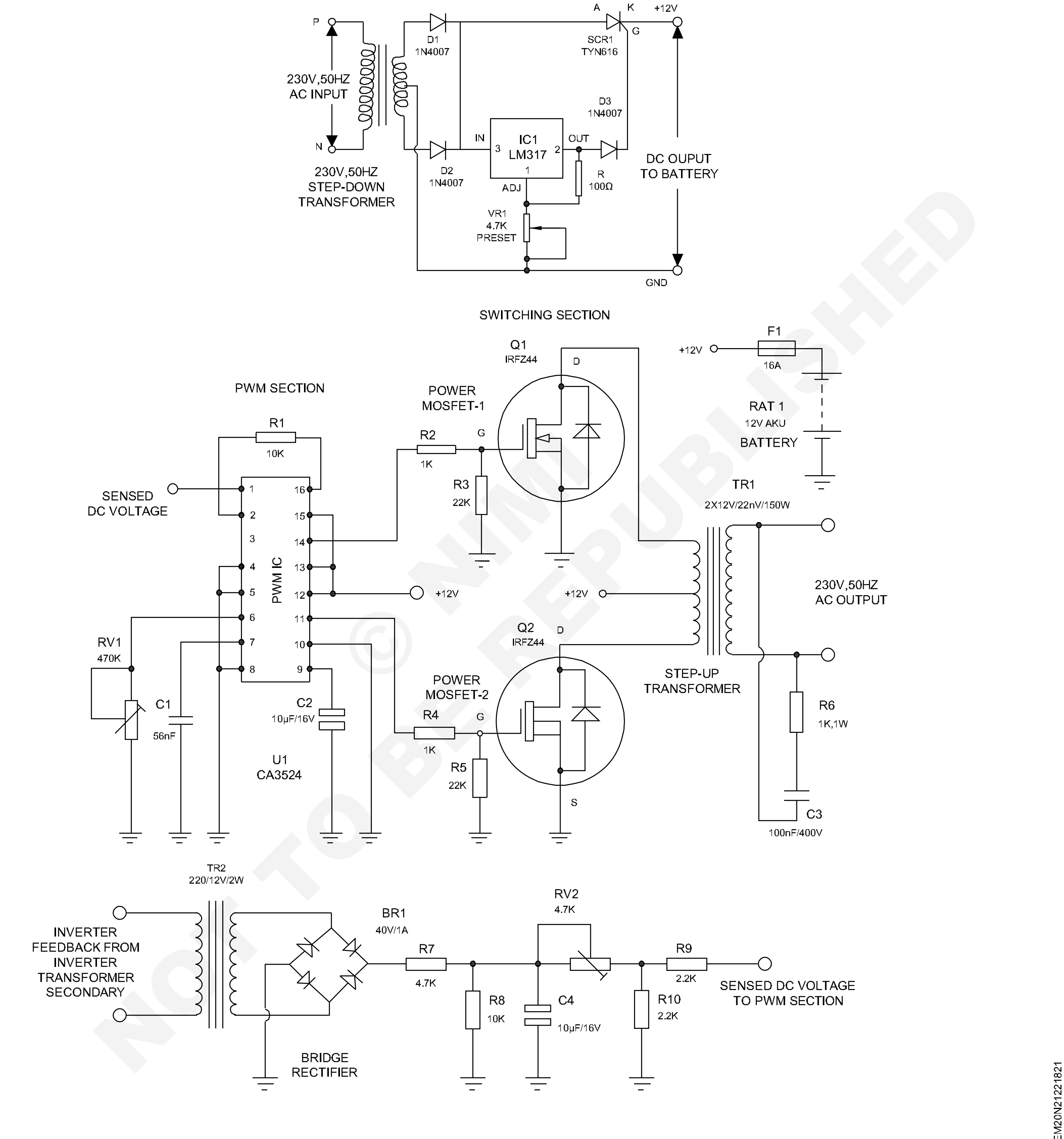
Sensing/feedback section: Portion of AC voltage is fed to the sensing section, where it is rectified into DC. This feedback voltage is sent to PWM IC as sensing volage and compared with the reference voltage in order to control the duty cycle.

Microcontroller based inverter: The major sections of a modern inverter producing pure sine wave, designed using the simple electronic devices to the complex embedded microcontrollers is shown in Fig.2. It uses pulse width modulation technique, different sensors, actuators, LCD display for status, audible alarm, feather touch switches, etc. for the reliable and user-friendly failsafe operation.

- Under mains mode, the solid-state changeover relay passes the AC input voltage directly to the output and allows charging of the battery.
- Under inverter mode, the absence of AC mains voltage is sensed by the solid-sate relay and microcontroller inverter section is actuated. The microcontroller, which is a part of the inverter section, generates the trigger pulse to the gate driver input to the MOSFET switching devices.

- The battery voltage is first chopped using high frequency PWM and switching device, (generally 3KHz to 20KHz) to produce an AC waveform. The iron cored step-up transformer boosts the 12V chopped waveform to 220V, 50Hz AC output waveform.
- Then the AC output from the transformer shaped to 50Hz AC sine wave with the helps of capacitor and filter circuits.

Fig 1



Common inverter problems and solutions

The common faults which occur in the inverter, probable causes and their remedies are listed below

Sl. No.	Common problems	Probable cause	Solutions/remedy
1	Inverter not turning ON	Battery disconnected, terminals loose or rusty & corroded.	If the terminals of the battery are loose, check them for corrosion. Clean the terminals and terminate properly.
		Weak battery	If the battery has gone weak, keep the battery under boost charging for 8 hours and connect with the inverter.
		Discharged battery	In case of fully discharged battery or faulty battery replace the battery with the same rating.
		Defective power switch	Check and replace the power switch.
2	Battery is not getting charged	Dead battery Battery charger section problem	The battery must be replaced. Check the rectifier diodes, input fuses and loose battery connection and set right.
3	Backup time is less	Too much of power Consumption Battery not properly charged	Remove the extra load connected. Charge the battery and top up the electrolyte with distilled water. Remember that the water level must be maintained between the maximum and minimum water limit.
4	Inverter working always in inverter mode	Either input is not connected or fuse may be blown off.	Check the power cable and change the fuse respectively.
		Low or high input voltage	The AC mains supply voltage may be always low or high, hence connect a stabilizer in the input to give input voltage at the prescribed limit.
		Changeover relay problem	Check and replace the relay.
5	Alarm beeping Continuously	Inverter overload	The possible cause could be either overload on the inverter or a stuck cooling fan. Check and set right the cooling fan and disconnect all the extra load in case of overload.
6	Inverter cannot boot	Low battery	Charge the battery.
		Too low battery voltage or damaged	Recharge or replace the battery

7	No output	The battery is not connected	Connect the battery
		Too low battery voltage or damaged	Recharge or replace the battery. Check whether the wire connection is good.
8	Inverter works on mains mode but does not operate on inverter mode	Too high input voltage	Adjust/reduce the input voltage and switch ON the inverter or use stabilizer at the AC input
		Battery fuse is blown	Check the fuse and polarity of battery. Replace the fuse
9	Battery voltage is good but no output voltage	Battery is discharged	Recharge or replace the battery with same rating.
		Problem with PWM IC	Check the input/output voltage PWM IC and if it faulty replace it.
		Fault in switching device	Check the switching device and replacing it if faulty.
10	Inverter output is high	Fault in feed back loop	Check the sensing circuit and feedback transformer wiring and adjust the feedback voltage pre-set.

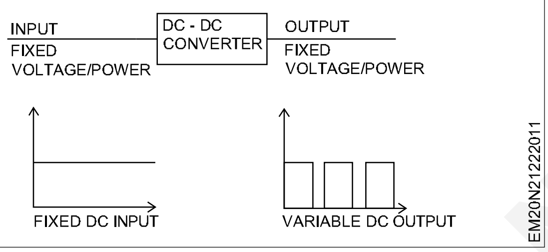
DC-DC converter

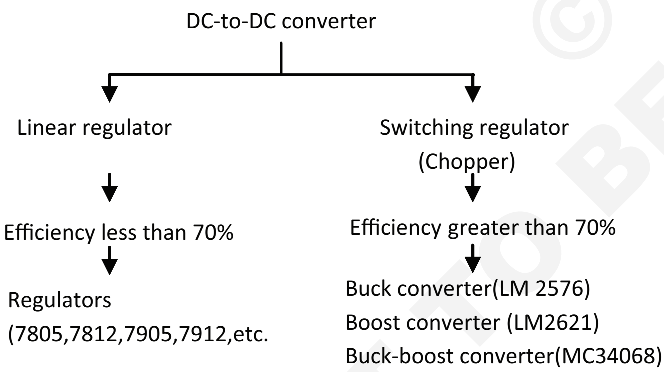
Objectives : At the end of this lesson you shall be able to
- **state chopper and types of chopper**
- **explain the principle of chopper operation and classifications**
- **compare step-down and step-up chopper**
- **list the application of chopper**
- **explain the working of buck converter, boost converter and buck-boost converter**
- **classify chopper circuit and its quadrant of operation**
- **list out the IC's used in buck converter, buck-boost converter, inverting converter.**

Introduction to DC-to-DC converter

A DC-to-DC converter (chopper) is an electronic circuit that converts one DC voltage level to another, which may be higher or lower by storing the input energy temporarily and then releasing that energy to the output at a different voltage. The storage may be either magnetic field storage (Inductors) or electric field storage. (Capacitors)

Fig 1





A linear regulator uses a resistive voltage drop to regulate the voltage, which losses power in the form of heat.

Switching regulator uses an inductive voltage drop, where the energy is stored and can be recovered. This results a much higher efficiency and much less heat.

Choppers

A chopper is basically a dc to dc converter whose main function is to create adjustable dc voltage from fixed dc voltage sources through the use of semiconductors.

Types of choppers

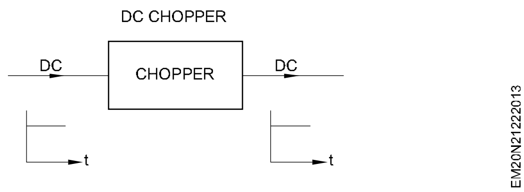
There are two types of choppers - AC and DC.

AC Link Chopper (Fig 2)

In an AC link chopper, DC is converted to AC with the help of an inverter. After that, AC is stepped-up or stepped-down by a transformer, which is then converted back to DC by a diode rectifier. AC link chopper is costly, bulky and less efficient as the conversion is done in two stages.

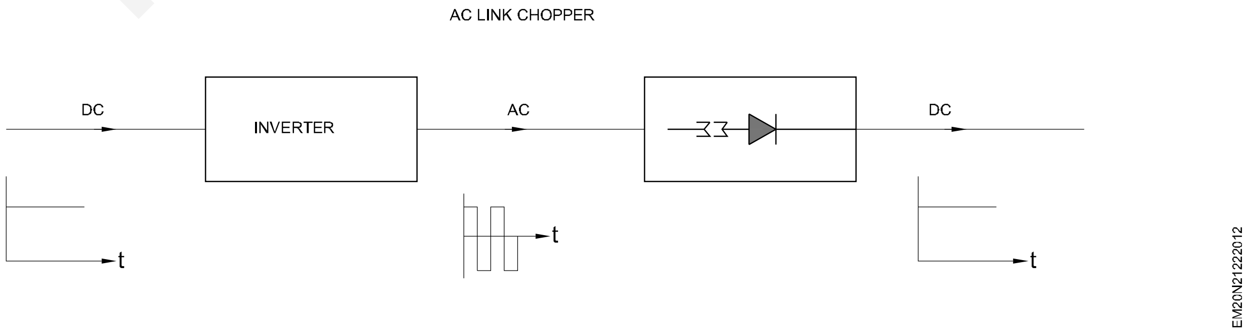
DC Chopper (Fig 3)

Fig 3



A DC chopper is a static device that converts fixed dc input voltage to a variable dc output voltage directly. A chopper can be used to step up or step down the fixed dc output voltage. Choppers are used in many applications in various electronic equipments. A chopper system has a high efficiency, fast response and a smooth control.

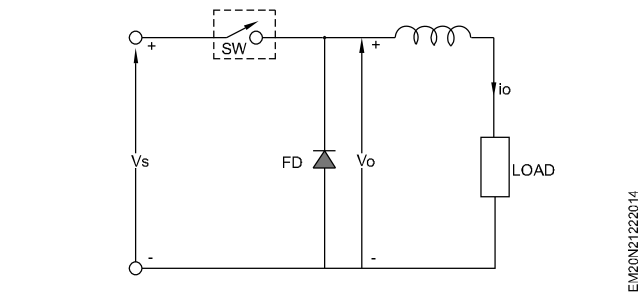
Fig 2



Principle of chopper operation

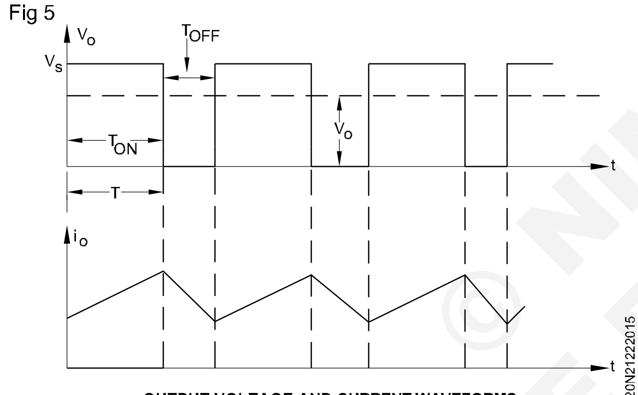
A chopper is a high speed on/off semiconductor switch. Source to load connection and disconnection from load to source happens in a rapid manner. In figure, a chopped load voltage can be obtained from a constant dc supply of voltage, which has a magnitude V_s. Chopper is represented by 'SW' inside a dotted square which can be turned ON or OFF as desired. (Fig 4)

Fig 4



Output voltage and current waveforms (Fig 5)

Fig 5



OUTPUT VOLTAGE AND CURRENT WAVEFORMS

Devices used in chopper

Low power application : GTO, IGBT, Power BJT, Power MOSFET etc.

High power application : Thyristor like SCR.

Classifications

Chopper may be classified depending upon the direction of O/P current and voltage. ie., step down (Buck converter) Step-up (Boost converter).

1 On the basis of input and output voltage levels

Step-down chopper

Class A

Class B

Class C (Combination of A & B)

Class D

Class E

Step-up chopper

Class B

2 **On the basis of circuit operation**

First quadrant

Two quadrant

Four quadrant

3 On the basis of commutation method

Voltage commutated

Current commutated

Load commutated

Impulse commutated

Comparison between step-up and step-down chopper

Sl.no	Parameters	Step down chopper	Step up chopper
1	Range of output voltage	0 to V volts	V to +0 volts
2	Position of chopper switch	In series with load	In parallel with load
3	Expression for output voltage	V_L dc = D x V volts	V_o = V/(1 - D) volts
4	External inductance	Not required	Required for boosting the output voltage
5	Use	For motoring operation, motor for motor load	For regenerative braking for load.
6	Type of chopper	Single quadrant	Single quadrant
7	Quadrant of operation	1^{st} quadrant	1^{st} quadrant

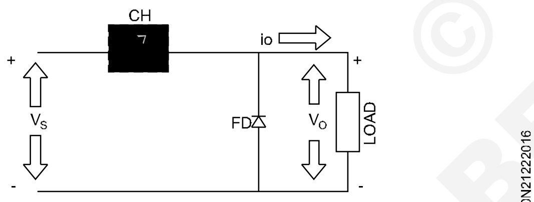
Applications

1. Switched mode power supplies, including DC to DC converters in computers
2. Speed controllers for DC motors
3. Class D Electronic amplifiers
4. Switched capacitor filters
5. Variable-frequency drives
6. D.C. voltage boosting
7. Battery-operated electric cars
8. Battery-operated appliances
9. Battery chargers
10. Subway cars
11. Trolley buses
12. Battery-operated vehicles
13. Solar energy conversion & wind energy conversion
14. Air planes and spaceships
15. On-board regulated DC power supplies
16. Commercial electronics & Electronic instruments.

Step down chopper

Step down chopper as Buck converter is used to reduce the i/p voltage level at the output side. In buck converter, the o/p voltage is lower than the i/p voltage. (Fig 6)

Fig 6

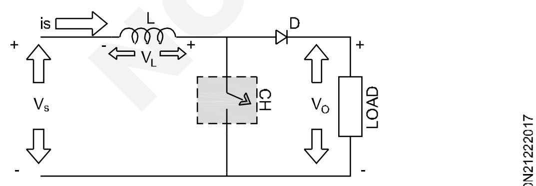


STEP DOWN CHOPPER

Step up chopper or Boost converter

Step up chopper or boost converter is used to increase the input voltage level of its output side. In boost converter the o/p voltage is higher than the i/p voltage. (Fig 7)

Fig 7

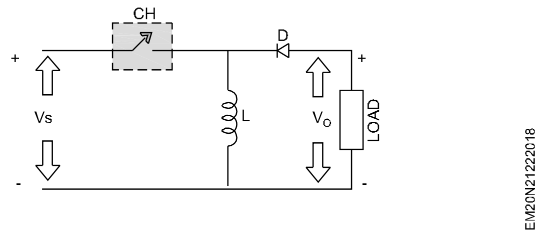


STEP UP CHOPPER OR BOOST CONVERTER

Buck-Boost converter or step up step down converter

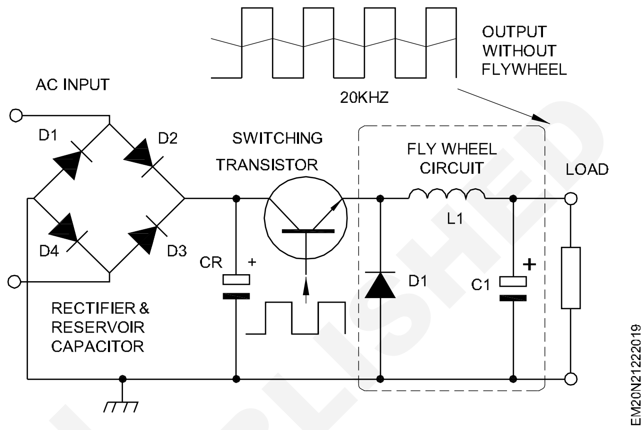
With the help of Buck-Boost converter we can increase or decrease the input voltage level at its output side as per our requirement. This type of converter produces an o/p voltage that is either lower or higher than the i/p voltage. (Fig 8)

Fig 8



Buck converters (Fig 9)

Fig 9



The buck converter

The buck converter is used in SMPS circuits where the DC output voltage needs to be lower than the DC input voltage.

The switching transistor between the input and output of the buck converter continually switches ON and OFF at high frequency. To maintain a continuous output, the circuit uses the energy stored in the inductor L, during the ON periods of the switching transistor, to continue supplying the load during the OFF periods. The circuit operation also called a flywheel circuit.

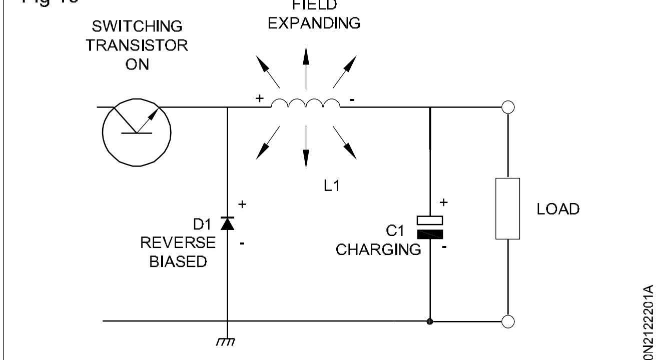
The buck converter is a form of DC to DC converter that can take an input directly from a DC source, such as a battery. The input could also be DC derived from the AC mains (line) as shown in Fig 10 via a rectifier/reservoir capacitor circuit. The AC input to the rectifier circuit could be AC at high voltage directly from the AC mains supply, or alternatively at a lower voltage via a step down transformer. However the DC applied to the buck converter is obtained; it is then converted to a high frequency AC, using a switching or 'chopper' transistor, driven by a (usually pulse width modulated) square wave.

Buck converter operation

As shown in Fig 10 the buck converter circuit consists of the switching transistor, together with the flywheel circuit (DI, L1 and C1). While the transistor is on, current is flowing through the load via the inductor L1. The action of any inductor opposes changes in current flow and also acts as a store of energy. In this case the switching transistor output is prevented from increasing immediately to its peak value as the inductor stores energy taken from the increasing output; this stored energy is later released back into the circuit as a back e.m.f. as current from the switching transistor is rapidly switched OFF.

Transistor switch ON period

Fig 10



TRANSISTOR SWITCH ON PERIOD

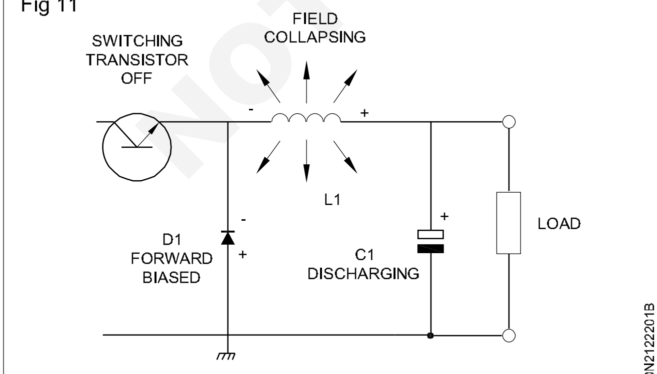
In Fig 10 when the switching transistor is switched ON, it is supplying the load with current. Initially current flow to the load is restricted as energy is also being stored in L1, therefore the current in the load and the charge on C1 builds up gradually during the ON period. Notice that throughout the ON period, there will be a large positive voltage on D1 cathode and so the diode will be reverse biased.

Transistor switch OFF period

When the transistor switches OFF as shown in Fig 11 the energy stored in the magnetic field around L1 is released back into the circuit. The voltage across the inductor (the back e.m.f.) is now in reverse polarity to the voltage across L1 during the ON period, and sufficient stored energy is available in the collapsing magnetic field to keep current flowing for at least part of the time the transistor switch is open.

The back e.m.f. from L1 now causes current to flow around the circuit via the load and D1, which is now forward biased. Once the inductor has returned a large part of its stored energy to the circuit and the load voltage begins to fall, the charge stored in C1 becomes the main source of current, keeping current flowing through the load until the next ON period begins.

Fig 11

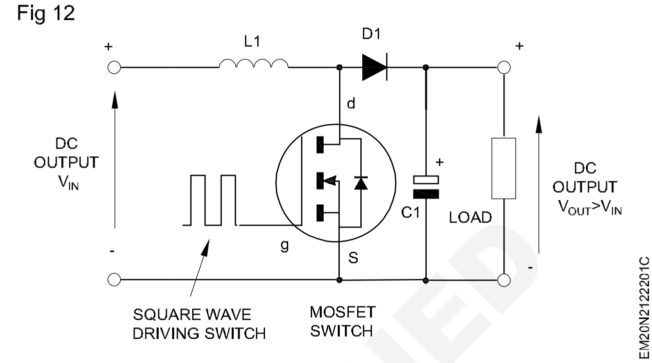


TRANSISTOR SWITCH OFF PERIOD

Boost converter

Fig 12 illustrates the basic circuit of a Boost converter. The switching transistor is a power MOSFET, both Bipolar power transistors and MOSFETs are used in power switching. The rest of the components are the same as those used in the buck converter except that their positions have been re-arranged.

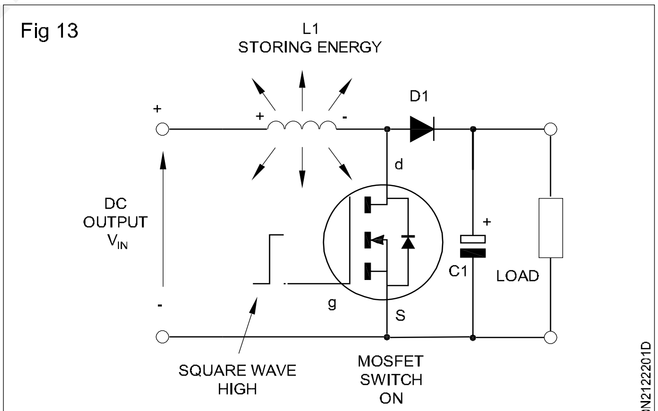
Fig 12



Boost converter operation

Fig 13 illustrates the circuit action during the initial high period of the high frequency square wave applied to the MOSFET gate at start up. During this time MOSFET conducts, placing a short circuit from the right hand side of L1 to the negative input supply terminal. Therefore, a current flows between the positive and negative supply terminals through L1, which stores energy in its magnetic field. There is virtually no current flowing in the remainder of the circuit as the combination of D1, C1 and the load represent a much higher impedance than the path directly through the heavily conducting MOSFET.

Fig 13



BOOST CONVERTER OPERATION AT SWITCH ON

Fig 14 shows the current path during the low period of the switching square wave cycle. As the MOSFET is rapidly turned OFF the sudden drop in current causes L1 to produce a back e.m.f. in the opposite polarity to the voltage across L1 during the on period, to keep current flowing. This results in two voltages, the supply voltage V_{IN} and the back e.m.f.(V_L) across L1 in series with each other.

This higher voltage (V_{IN} +V_L), now that there is no current path through the MOSFET, forward biases D1. The resulting current through D1 charges up C1 to V_{IN} +V_L minus the small forward voltage drop across D1, and also supplies the load.

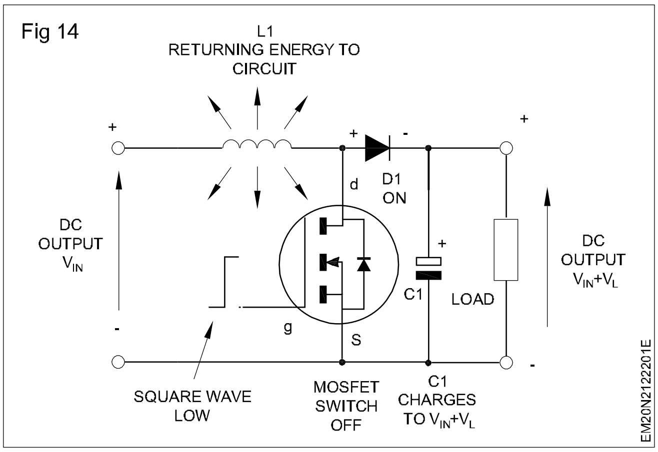


Fig 14

Fig 15 shows the circuit action during MOSFET on periods after the initial start up. Each time the MOSFET conducts, the cathode of D1 is more positive than its anode, due to the charge ON C1. D1 is therefore turned OFF so the output of the circuit is isolated from the input, however the load continues to be supplied with V_{IN} +V_L from the charge ON C1. Although the charge C1 drains away through the load during this period, C1 is recharged each time the MOSFET switches OFF, so maintaining an almost steady output voltage across the load.

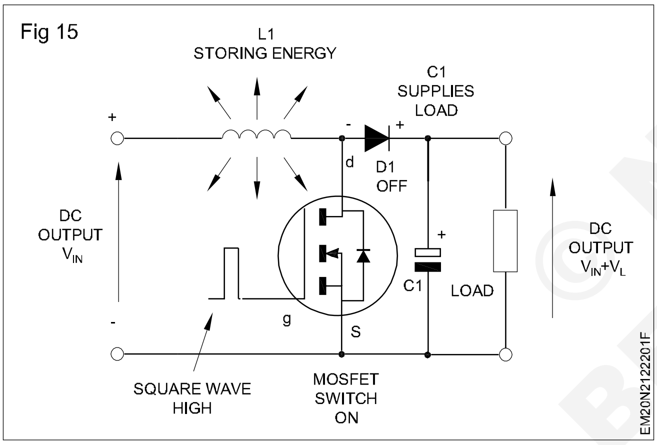


Fig 15

Buck-boost converters

A Buck-Boost converter is a type of switched mode power supply that combines the principles of the Buck Converter and the Boost converter in a single circuit.

The Buck converter produces a DC output in a range from 0V to just less than the input voltage. The boost converter will produce an output voltage ranging from the same voltage as the input, to a level much higher than the input.

Buck-boost converters are used in Battery-powered systems, where the input voltage can vary widely, starting at full charge and gradually decreasing as the battery charge is used up. At full charge, where the battery voltage may be higher than actually needed by the circuit being powered, a buck regulator would be ideal to keep the supply voltage steady. However as the charge diminishes the input voltage falls below the level required by the circuit, and either the battery must be discarded or re-charged; at this point the ideal alternative would be the boost regulator.

By combining these two regulator designs it is possible to have a regulator circuit that can cope with a wide range of input voltages both higher or lower than that needed by the circuit. Both buck and boost converters use very similar components.

In Fig 16 the common components of the buck and boost circuits are combined. A control unit is added, which senses the level of input voltage, then selects the appropriate circuit action. (Note that in the examples in this section the transistors are shown as MOSFETs, commonly used in high frequency power converters, and the diodes shown as Schottky types. These diodes have a low forward junction voltage when conducting, and are able to switch at high speeds).

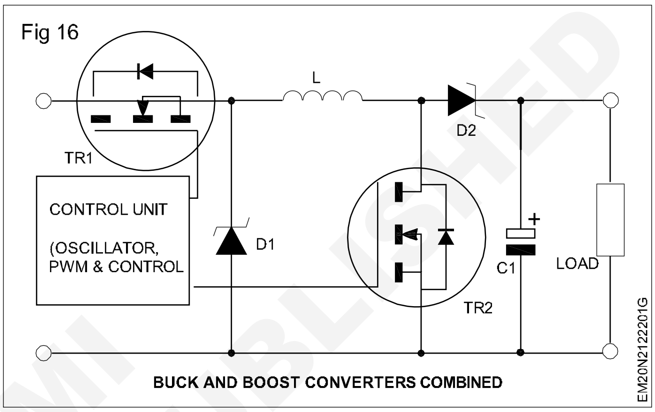


Fig 16

Operation as a buck converter

The basic operation of the buck boost converter is illustrated in Fig 16 and 17.

Fig 17 shows the circuit operating as a buck converter. In this mode Tr2 is turned off, and Tr1 is switched on and off by a high frequency square wave from the control unit. When the gate of Tr1 is high, current flows though L, charging its magnetic field, charging C and supplying the load. The schottky diode D1 is turned off due to the positive voltage on its cathode.

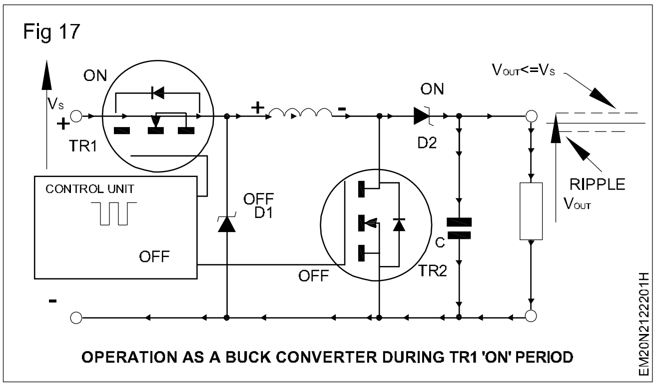
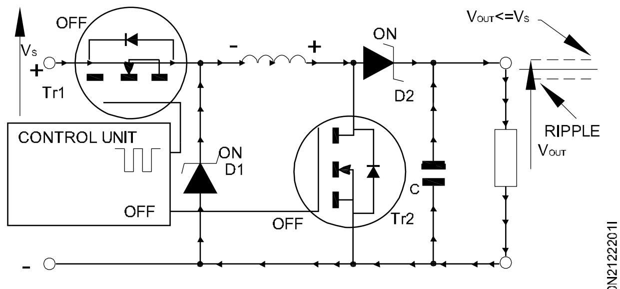


Fig 17

Fig 18 shows the current flow during the buck operation of the circuit when the control unit switches Tr1 off. The initial source of current is now the inductor L. Its magnetic field is collapsing, the back e.m.f. generated by the collapsing field reverses the polarity of the voltage across L, which turns on D1 and current flows through D2 and the load.

As the current due to the discharge of L decreases, the charge accumulated in C during the on period of Tr1 now also adds to the current flowing through the load, keeping V_{OUT} reasonably constant during the OFF period. This helps keep the ripple amplitude to a minimum and V_{OUT} close to the value of V_S.

Fig 18

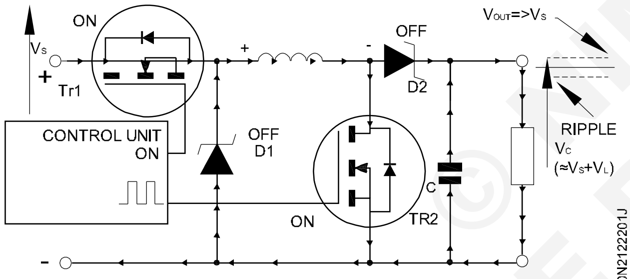


OPERATION AS A BUCK CONVERTER DURING Tr1 'OFF' PERIOD

Operation as a boost converter

In boost converter mode, Tr1 is turned on continually and the high frequency square wave applied to Tr2 gate. During the ON periods when Tr2 is conducting, the input current flows through the inductor L and via Tr2, directly back to the supply negative terminal charging up the

Fig 19



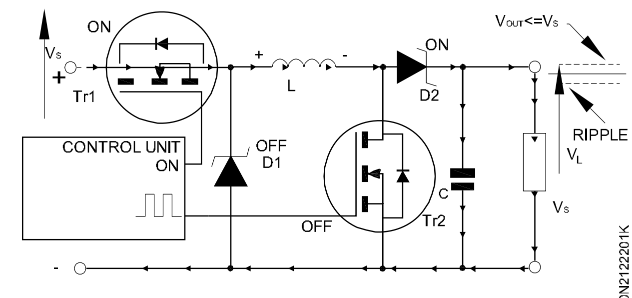
OPERATION AS A BOOST CONVERTER DURING Tr2 'ON' PERIOD

magnetic field around L. Whilst this is happening D2 cannot conduct as its anode is being held at ground potential by the heavily conducting Tr2. For the duration of the ON period, the load is being supplied entirely by the charge on the capacitor C, built up on previous oscillator cycles. The gradual discharge of C during the ON period (and its subsequent recharging) accounts for the amount of high frequency ripple on the output voltage, which is at a potential of approximately $V_S + V_L$.

Transistor OFF period

At the start of the OFF period of Tr2, L is charged and C is partially discharged. The inductor L now generates a back e.m.f. and its value that depends on the rate of change of current as Tr2 switches OFF and ON the amount of inductance the coil possesses; therefore the back e.m.f can be any voltage over a wide range, depending on the design of the circuit. Notice particularly that the polarity of the voltage across L has now reversed, and so adds to the input voltage V_S giving an output voltage that is atleast equal to or greater than the input voltage. D2 is now forward biased and so the circuit current supplies the load current, and at the same time recharges the capacitor to $V_S + V_L$ ready for the next ON period of Tr2.

Fig 20



OPERATION AS A BOOST CONVERTER DURING Tr2 'OFF' PERIOD

Buck converter (IC LM2576)

1 Features

i 3.3-V, 5-V, 12-V, 15-V, and adjustable output versions

ii Adjustable version output voltage range,1.23 V to 37 V (57 V for HV version) ±4% maximum over line and load conditions

iii Specified 3-A output current

iv Wide input voltage range: 40V upto 60 V for HV version

v Requires only 4 external components

vi 52-kHz fixed-Frequency internal oscillator

vii TTL-shutdown capability, Low-power standby mode

viii High efficiency

ix Uses readily available standard inductors

x Thermal shutdown and current limit protection

2 Applications

i Simple high-efficiency step-down (Buck) regulator

ii Efficient pre-regulator for linear regulators

iii On-card switching regulators

iv Positive-to-Negative converter (Buck-Boost)

3 Description

The LM2576 series of regulators are monolithic integrated circuits that provide all the active functions for a step-down (buck) switching regulator, capable of driving 3-A load with excellent line and load regulation. These devices are available in fixed output voltages of 3.3 V, 5 V, 12 V, 15 V, and an adjustable output version.

Requiring a minimum number of external components, these regulators are simple to use include fault protection and a fixed-frequency oscillator.

The LM2576 series offers a high-efficiency replacement for popular three-terminal linear regulators. It substantially reduces the size of the heat sink, and in some cases no heat sink is required.

A standard series of inductors optimized for use with the LM2576 are available from several different manufacturers. This feature greatly simplifies the design of switch-mode power supplies.

Other features include a ±4% tolerance on output voltage within specified input voltages and output load conditions, and ±10% on the oscillator frequency. External shutdown is included, featuring 50-μA (typical) standby current. The output switch includes cycle-by-cycle current limiting, as well as thermal shutdown for full protection under fault conditions.

Pin configuration and functions

Fig 21

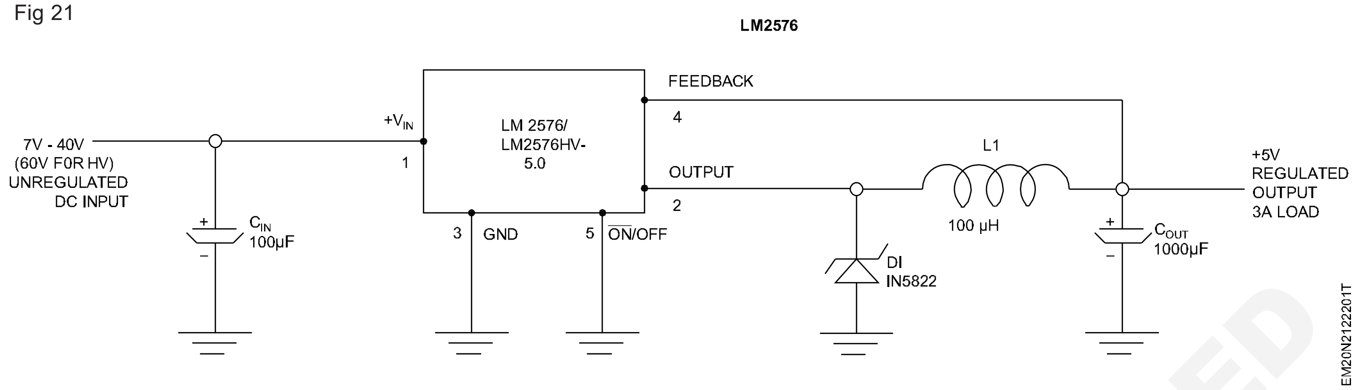
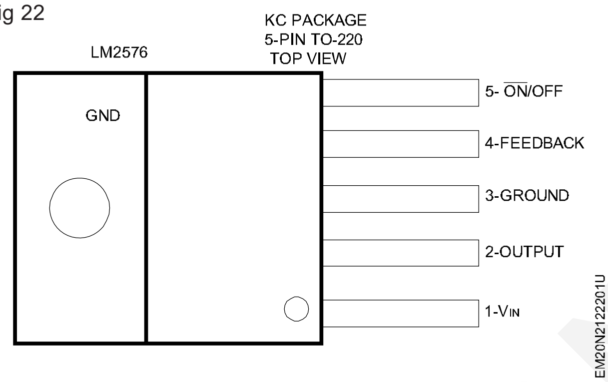


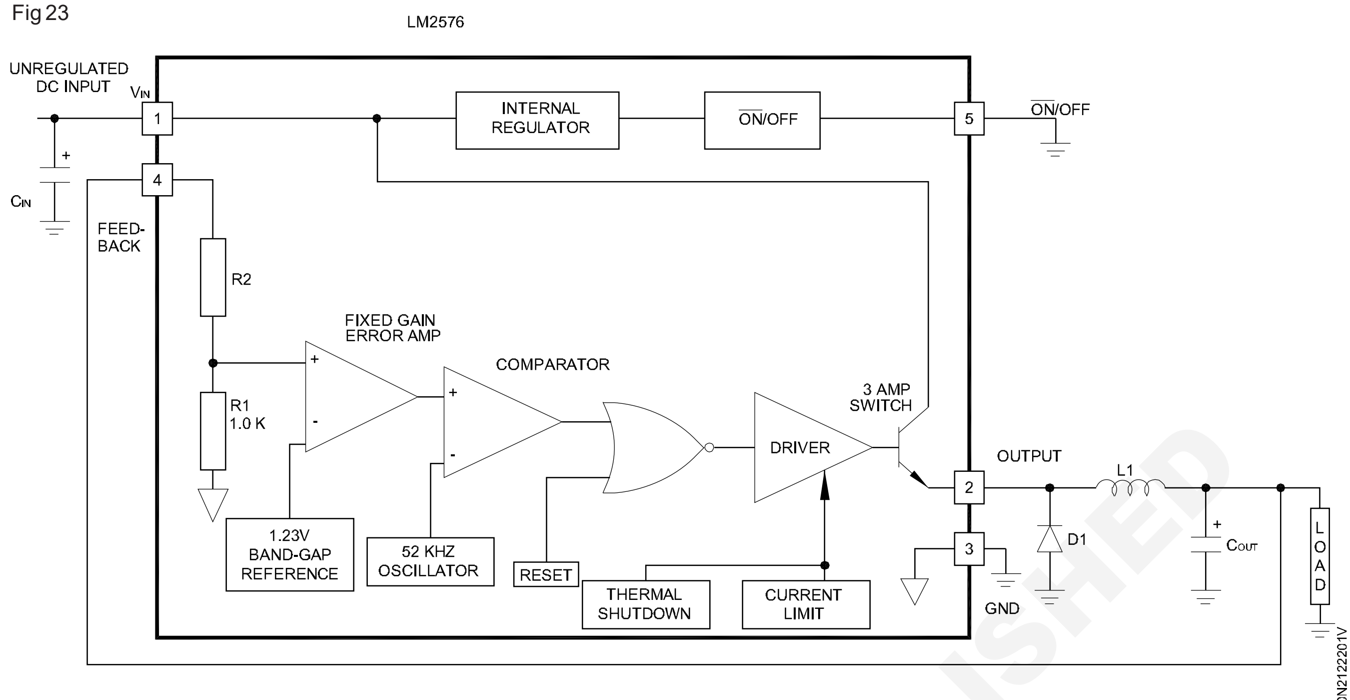
Fig 22



PIN		I/O	DESCRIPTION
NO.	NAME		
1	V_{in}	I	Supply input pin to collector pin of high-side transistor. Connect to power supply and input bypass capacitors C_{in}. Path from V_{in} pin to high frequency bypass C_{in} and GND must be as short as possible.
2	OUTPUT	O	Emitter pin of the power transistor. This is a switching node. Attached this pin to an inductor and the cathode of the external diode.
3	GROUND	—	Ground pin. Path to C_{in} must be as short as possible.
4	FEEDBACK	I	Feedback sense input pin. Connect to the midpoint of feedback divider to set V_{OUT} for ADJ version or connect this pin directly to the output capacitor for a fixed output version.
5	ON/OFF	I	Enable input to the voltage regulator. High = OFF and low = ON. Connect to GND to enable the voltage regulator. Do not leave this pin float.
—	TAB	—	Connected to GND. Attached to heatsink for thermal relief for TO-220 package or put a copper plane connected to this pin as a thermal relief for DDPAK package.

Functional block diagram

Fig 23



FUNCTIONAL BLOCK DIAGRAM

3.3 V R2 = 1.7 k 5 V, R2 = 3.1 k 12 V, R2 = 8.84 k	15 V, R2 = 11.3 k For ADJ. Version R1 = Open, R2 = 0Ω

Uninterruptible Power Supply

Objectives : At the end of this lesson you shall be able to
- **state the need of UPS**
- **differentiate inverter and UPS**
- **explain the block diagram of UPS.**

Uninterruptible Power Supply (UPS)

An uninterruptible power supply (UPS) is a device that allows a computer to keep running for at least a short time when the primary power source is lost. It also provides protection from power surges.

Need of UPS

An Uninterruptible Power Supply (UPS) is used to protect critical loads from mains supply problems, including spikes, voltage drops, fluctuations and complete power failures using a dedicated battery.

A surge protector (or surge suppressor or surge diverter) is an appliance or device designed to protect electrical devices from voltage spikes. A surge protector attempts to limit the voltage supplied to an electric device by either blocking or shorting to ground any unwanted voltages above a safe threshold.

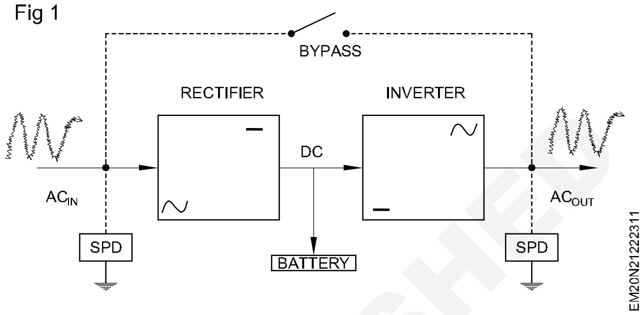
Difference between Inverter and UPS (TABLE 1)

The differences between inverter and UPS under certain important parameters are given in TABLE 1 below.

Block diagram of UPS

The simplified block diagram of UPS is shown in Fig 1.

Fig 1



In UPS, the AC from the mains power is tranformed to DC. This DC is continuously charging the battery. The DC output from the battery is fed to inverter that converts it into AC output and supplies to the equipment.

Rectifier

A rectifier is an electrical device that converts alternating current (AC), which periodically reverses direction, to direct current (DC), which flows in only one direction. The process is known as rectification.

Battery

Battery is a device consisting of one or more electrochemical cells with external connections provided, to power electrical devices.

TABLE 1

Difference between Inverter and UPS

Sl. No.	Parameters	Inverter	UPS
1.	Back-up time	In inverter, the back up time is not rapid. So the computers may break down or data loss.	In UPS, the back up time of power supply is rapid. It will not make any computer crash or loss of data.
2.	Technical variation	The power is consistently drawn from battery.	The AC is changed into DC. This DC helps to charge the battery.
3.	Time delay	500 ms	3 to 8 ms
4.	Connection	The inverter connected to main power supply for providing electricity to different applications such as fan, lights, etc.	UPS directly connected to different application such as computer, printers, etc.
5.	Price	Low	High

Inverter

Inverter is an electronic circuit that converts low voltage DC into high voltage AC power. In solar-electric systems, an inverter may take the 12, 24, or 48 volts DC and convert to 230 volts AC, conventional household power.

The main power AC is supplied to the inverter, and it is transformed into DC simultaneously, which keeps charging the battery continuously. There is a sensor and relay structure that always monitors the ON or OFF status of the main supply.

As soon as there is a power failure, the relay actuator activates the inverter switch. Every other action is similar to the UPS, but because of the sensor and relay process, there is a delay while activating the switch.

Static transfer switch

Static transfer switches (STS) are such electrical devices which are used for very fast switching between electrical power sources. It is used in UPS immediately switch main power supply, to its stored backup power.

They perform instantaneous switching operations and thus supply immediate power to the load.

Types of UPS

Objectives : At the end of this lesson you shall be able to
- **list different types of UPS**
- **compare ON-line, OFF-line and line interactive types of UPS**
- **state specification of UPS, power factor, calculating battery back-up**
- **explain types of indications and protection.**

Different types of UPS

1 ON line UPS

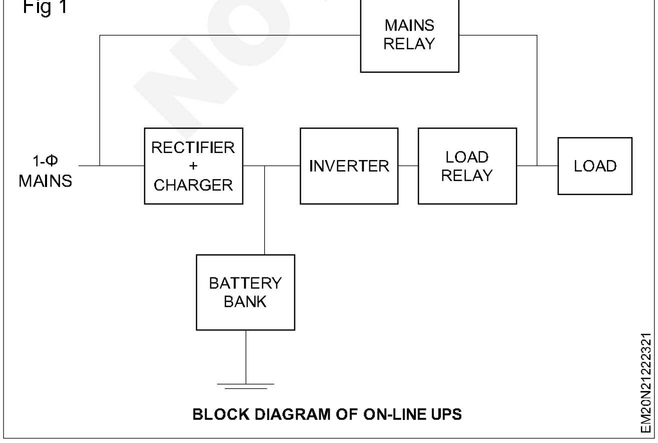
2 OFF line UPS

3 Line interactive UPS

ON line UPS

ON line UPS are also known as double conversion UPS or True ON Line UPS. There are two stages in its operation. In the first stage the mains AC is rectified to DC. There is a DC bus. DC bus can get power from both the DC battery and DC obtained by rectifying the mains AC. In the second stage DC power available from DC bus is converted to AC by the inverter and this AC is connected to the output. In normal operation output comes from mains AC via rectifier and inverter. When mains AC fail, output comes from DC battery via inverter. The changeover is instantaneous. There is no power transfer switch and hence no time delay. When mains AC is available normal operation continues and the rectifier recharges the battery. A bypass switch connects mains AC directly to the output in case there is some problem with the UPS. (Fig 1)

Fig 1



BLOCK DIAGRAM OF ON-LINE UPS

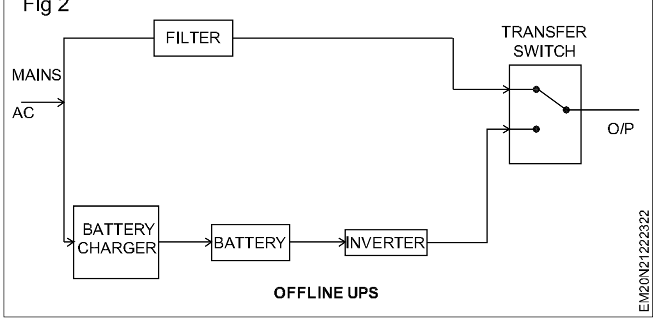
Metal Oxide Semiconductor Field Effect Transistor (MOSFET) power transistors, Insulated Gate Bipolar Transistor (IGBT) devices, microprocessor ICs, Operational amplifier ICs, adjustable voltage regulator ICs, Oscillator and pulse width modulator ICs, GATE ICs, timer etc. are some the important components found in on line UPS.

On line UPS offer the best power protection against all types of disturbances. The output voltage of an On Line UPS is highly stabilized with typical value of tolerance of 1 percent i.e. the output voltage is between 227 and 233 volt and frequency is between 49.95 Hz and 50.05 Hz. The output waveform is purely sinusoidal. A typical modern on line UPS is equipped with protections against short circuit, over-voltage and under-voltage etc, MCB for input, output and battery, and has digital LCD display with facility for displaying input and output voltage and frequency, battery status, output power delivered and error codes and messages.

On line UPS models generally have capacity more than 5kVA. High capacity On Line UPS can be built for all possible requirements and battery backup time can be increased to suit particular need by adding batteries. Sophisticated on Line UPS are available with many advanced features and are highly reliable but are costlier.

OFF line UPS

Fig 2



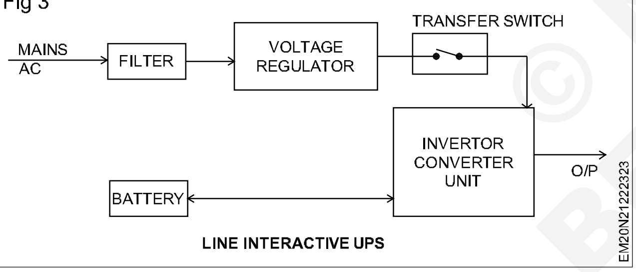
OFFLINE UPS

An OFF line UPS is shown in Fig 2. It is also known as stand by UPS or Backup UPS and supplies emergency power when mains AC fail. The capacity of an off line UPS is generally below 1kVA. A very common application is with PC. In the event of sudden load shedding the off line UPS supplies emergency power to the PC so that work can be continued till normal power is restored or the PC can be safely switched off.

In normal mode mains AC is directly connected to the output through a filter unit. The filter unit filters noise present in the mains AC. When mains AC fails the inverter converts DC power of battery to AC and transfer switch connects this AC to the output. This changeover happens very quickly but is not instantaneous and a time delay of few milliseconds is involved. This time delay normally does not affect ordinary load. Again when mains AC comes, the transfer switch connects mains AC to output. Thus the transfer switch keeps on changing connection of output to between mains AC and AC output of inverter. When mains AC is available, the charger unit recharges the battery. An offline UPS does not have provision for stabilizing the mains AC. Under voltage and over voltage of mains AC activates the power transfer switch and connects AC obtained from inverter to the output. Thus in case of off line UPS under voltage and over voltage of mains AC has similar impact as absence of mains AC.

Line interactive UPS

Fig 3



LINE INTERACTIVE UPS

In a line interactive UPS mains AC is connected to the output through a filter and voltage regulating unit. The voltage regulator usually is an auto transformer with number of tapping and stabilizes the mains input by bucking or boosting as per requirement. A single unit called Inverter converter unit performs the functions of battery charger and inverter. When mains AC is available inverter converter unit charges the battery. When mains AC fails it inverts DC to AC and supplies power to load. The transition is not instantaneous and time delay of few milliseconds is involved. Compared to Off line UPS, line interactive UPS performs better as the mains AC is regulated. Line interactive UPS are generally available with capacity between 750VA and 5KVA and are commonly used for computer network with small group of computers.

Comparison between OFF- line, ON- line and LINE-interactive UPS

OFF- Line UPS

OFF-line UPS passes the input AC to the output sockets if the AC power is available. It always monitor the voltage level in the mains, and if there is a voltage drop or mains failure, it switches ON the inverter to give AC power to the device until the mains supply returns to normal. The switch over time from AC to inverter AC is less than five milli seconds so that the functioning of the equipment is not affected.

ON- Line UPS

ON- Line UPS uses an inverter which always ON to give sine wave AC to the output socket. The incoming AC is first converted into DC to charge the battery as wll as to give power to the inverter. The inverter converts the DC to AC continuously to power the load. If power fails, the battery backup circuit switches ON and takes the load. Online UPS is more efficient than the Offline UPS and uses a "constant duty inverter". It also has a "static bypass" system that transfers the load to the AC power if the inverter system fails. The advantage of the online

Specification of UPS

Sl. No.	Parameter	Details
1.	Type of UPS	TRUE ONLINE
2.	CAPACITY	2 KVA/5 kVA
3.	Technology	The UPS shall be based on IGBT, and microprocessor controlled for providing better sine wave output.
4.	AC input voltage range	175V to 275 V AC, single phase
5.	Input frequency	47-53 Hz, (Suitable for working with generator supply)
6.	UPS power factor	0.9 or better
7.	AC output voltage	230V AC, Single phase
8.	Output frequency	50 Hz
9.	Waveform	Sinusoidal

10.	Efficiency	90% (at rated output voltage and frequency)
11.	Total harmonics distortion	2% maximum
12.	Indications	Standard visual indications for proper function of UPS.
13.	Protections	Over & Under voltage cut-off, overload, and short
14.	Back up time	2kVA = 8 hour at 400 watt load, 5kVA = 8 hr at 1000W load
15.	Type of batteries	Sealed maintenance free (SMF) Lead Acid Battery
16.	Remote monitoring	SNMP based monitoring

UPS is that, it clean up the AC waveform by converting it into DC then reconverting this DC to fresh AC. ON- Line UPS regulate voltage within ± 2-3%.

Line-interactive UPS

Line-interactive UPS system use automatic voltage regulation (AVR) to correct abnormal voltages without switching to battery. The UPS detects when voltage crosses a preset low or high threshold value and uses transformers to boost or lower the voltage by a set amount to return it to the acceptable range. Line-interactive UPS system typically regulate output within ± 8-15% of the nominal voltage.

Power factor

Power factor is a quantity which has important implications when sizing a UPS system and power distribution equipment. Power is a measure of the delivery rate of energy and in DC (direct current). Electrical circuits is expressed as the mathematical product of Volts and Amps (Power = Volts x Amps). However, in AC (alternating current) power system, a complication is introduced; namely that some AC current (Amps) may flow into and back out of the load without delivering energy. This current, called reactive or harmonic current, gives rise to an "apparent" power (Volt x Amps) which is larger than the actual power consumed. This difference between the apparent power and the actual power gives rise to the power factor. The power factor is equal to the ratio of the actual power to the apparent power. The apparent power is expressed as the Volt-Amp or VA rating. Therefore, the actual power in any AC system is the VA rating multiplied by the power factor.

"Watts = volts x amps x power factor". Unfortunately, the PF is rarely stated for most equipment, but it is always a number of 1.0 or less.

A double-conversion UPS gives voltage distortion problem created by the UPS. The input of a double-conversion UPS is essentially a big rectifier. The current drawn by the UPS is non-sinusoidal. This can cause the voltage from the AC mains also to become non-sinusoidal. The voltage distortion can cause problems in all electrical equipment connected to that power source, including the UPS itself. It will also cause more power to be lost in the wiring supplying power to the UPS due to the spikes in current flow. This level of "noise" is measured as a percentage of "total harmonic distortion of the current" (THDI). Classic UPS rectifiers have a THDI level of around 25%-30%.

There are several solutions to reduce the THDI in a double-conversion UPS:

Passive power-factor correction

Classic solutions such as passive filters reduce THDI to 5%-10% at full load. They are reliable, but big and only work at full load.

Active power-factor correction

An alternative solution is an active filter. Through the use of such a device, THDI can drop to 5% over the full power range. The newest technology in double-conversion UPS units is a rectifier that does not use classic rectifier components (thyristors and diodes) but uses high-frequency components instead. A double-conversion UPS with an insulated-gate bipolar transistor rectifier and inductor can have a THDI as small as 2%.

Uninteruptible power supply (UPS) systems are rated in kilowatts (kW) and others in kilo-volt-amperes (kVA).

1 kW and kVA simply mean 1,000 watts or 1,000 volt-amperes - the "kilo" prefix being used for larger numbers.

For large UPS systems have been designed based on a PF of 0.8, which means that a 100 kVA UPS will only support 80 kW of "real" power load. Most UPS systems has power factors of 0.95 - 0.98.

Neither the kW nor the kVA capacity of the UPS can be exceeded, but because of the higher PF numbers, it is usually the kW rating. There are some UPS systems on the market that are PF-corrected so that the kW and kVA ratings are the same.

Calculating UPS/Inverter battery backup

Before calculating the Battery Backup, let us know a few factors that vary battery backup.

For UPS with 875VA we can use a maximum load of 640 watts.

677VA we can use a maximum load of 540 watts.

The main thing is that what ever may be the UPS wattage the battery backup will not vary. The battery backup will only vary depending on the battery Ah and the Usage Load.

To calculate UPS backup, We have a simple formula.

UPS Backup = Battery AH x (Volts/Load) x (1/Powerfactor)

Example : Let us calculate the backup for a system UPS

Load is the usage power, suppose we are running a PC then the load is around 300 watts.

Power factor varies for device to device, the average power factor is 1.4

Voltage is the voltage of the battery.

For a single battery the voltate is 12v.

If the batteries are connected in a series Voltage = 12 x no. of batteries.

Battery AH is the battery ampere used for the ups, system UPS battery AH is 7.

Then battery backup = 7 x (12/300) x (1/1.4)

= 7 x (0.04) x (0.7)

= 0.19 hours

= 19 Minutes

Battery rating calculation

The formula for battery rating calculation is as below :

Formula employed

$$\text{Capacity of Battery(AH)} = \frac{\text{DC current x Duration in Hrs.}}{\text{\%age capacity utilization}}$$

Where, DC Current =

$$\frac{\text{UPS(KVA) x 1000 x Load power factor(PF=1)}}{\text{Inverter efficiency x End voltage}}$$

Hence , VAH = AH x Nominal Voltage

For example : for 3 KVA UPS , 1 hour Backup :

$$\text{DC current} = \frac{3 \times 1000 \times 1}{0.93 \times 10.5 \times 18} = 17.0\text{A}$$

$$\text{Battery "AH"} = \frac{17.0 \times 1.0}{0.62} = 27.4\text{AH}$$

Hence, 18 nos of 12V/28AH batteries are required.

Total VAH = 18 x 12 x 28 = 6048 VAH

The following assumptions have been made in the above calculations:-

1 DC voltage – 216 for 3 KVA

2 End cell voltage / battery of 10.5 V

3 Load Power Factor = 1.0

4 Inverter efficiency = 93%

% Capacity utilization is :

Duration	% Capacity utilization
½ hr (30 mins)	52%
1 hrs	62%
2 hrs	74%
3 hrs	83%
4 hr	85%

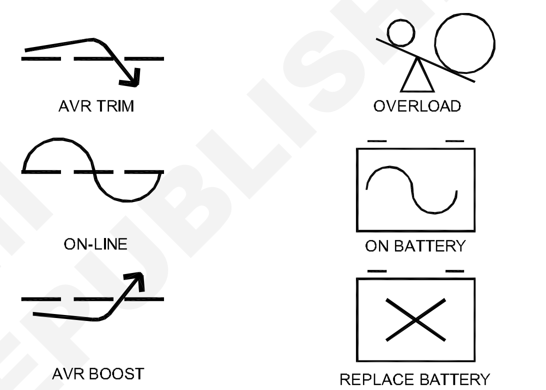
Types of indications and protections

Front panel Indicators (Fig 4)

On-Line

The online LED illuminates when the UPS is supplying utility power to the connected equipment. If the LED is not lit, the UPS is either not turned ON, or is supplying battery power.

Fig 4



AVR Trim

This LED illuminates to indicate the UPS is compensating for a high utility voltage. While the UPS can run in this mode indefinitely without any negative impact on the UPS, the circuit should be checked by a qualified electrician if the utility voltage is consistently high.

AVR boost

This LED illuminates to indicate the UPS is compensating for a low utility voltage. While the UPS can run in this mode indefinitely without any negative impact on the UPS, the circuit should be checked by a qualified electrician if the utility voltage is consistently low.

ON battery

This LED illuminates to indicate the UPS is supplying battery power to the connected equipment.

Overload

This LED illuminates to indicate the equipment plugged into the UPS exceeds the total capacity of the UPS. Some of the equipment (the load) on the UPS should be removed or turned off.

Replace battery

This LED will illuminate when the battery in the UPS has failed.

Some standard UPS incorporates both audio and visual warnings for the user to understand that the power is being consumed from the battery and not from the AC mains.

Visual warning

There are UPS that have ONE LED, TWO LED's and THREE LED's.

1 For UPS with a single LED

The LED glows a green color, indicating the system is working on the main power line. When the power fails, the LED turns either amber or a red with blinking at an interval of thirty seconds indicating that the UPS is working with back up power; power being supplied from the battery that is in the UPS. After for a particular duration of time and if by then the power is not restored by switching on a generator / alternator, the light turns a bright red along with continuous blinking indicating that it has critical two minutes left for the power of the battery to drain out and crash abruptly.

2 For UPS with Two LEDs

If the UPS is having two lights then the green is a solo type indicating mains and the other only one green light is visible. If the green LED is "ON" and the other LED is off indicating main power line consumption. When the main power fails, the other LED either a red or amber turns ON indicating the power is OFF after last two minutes. This is accompanied by continuous blinking of the LED indicator.

3 For UPS that have Three LEDs

The green indicates UPS working from main lines, the amber indicates the UPS working from battery back up and the red LED indicates UPS working from critical backup. As mentioned in the UPS with two LED's the blinking of the UPS is the same here too. For back up it is blinking at the rate of thirty seconds per blink and for critical power it is blinking at the rate of almost one second per blink.

Audio warning

Almost all UPS have an audio warning incorporated into the circuit. The audio warning is a beep sound produced by a piezo buzzer circuit. During critical back up power being consumed the beep is continuous with a frequency that is equal to the blink rate. The audio warning gives an indication to shut down UPS after saving data.

Conditioning and Protection

Sag

A reduction of the AC voltage, at the power frequency, that lasts from a half cycle to a few seconds.

Spike

This is a transient electrical impulse with a duration much less than 1/2 cycle.

Surge / Overvoltage

A voltage that exceeds specified limits either for a short time (seconds) or longer periods.

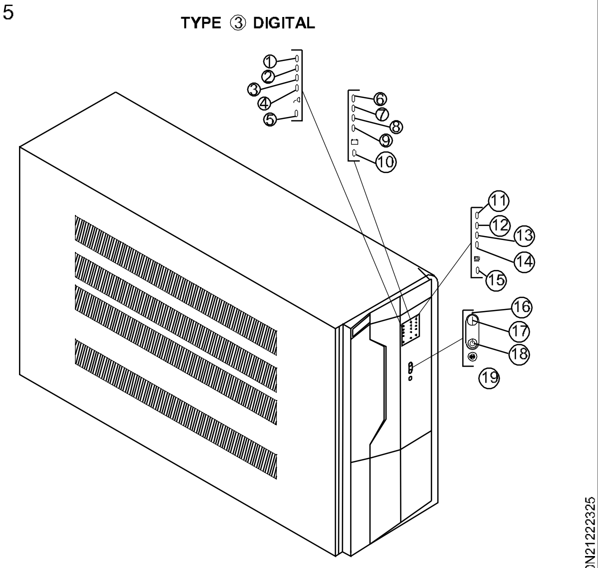
These types of disturbances can occur several times per day throughout most of the country. When a UPS is in a normal mode (not on battery power) these disruptions will not generally cause the UPS to switch to battery mode. Some UPS manufacturers have adjustable threshold settings that can activate the back up at various levels of interference. To avoid excessive switchovers, a conditioning and protection sub-system should be used in the normal mode.

		Symbol
①–④	AC input level	Power cord
⑤	Site wiring fault indicator	
⑥–⑨	Battery charge level	Battery
⑩	Battery service indicator	
⑪–⑭	Load level	Load devices
⑮	Communications	
⑯	ON LED	
⑰	ON button	⏽
⑱	STANDBY button	⏻
⑲	TEST/ALARM RESET button	◉

Indicators on UPS

Type 1 : The front panel LED Display (Digital)

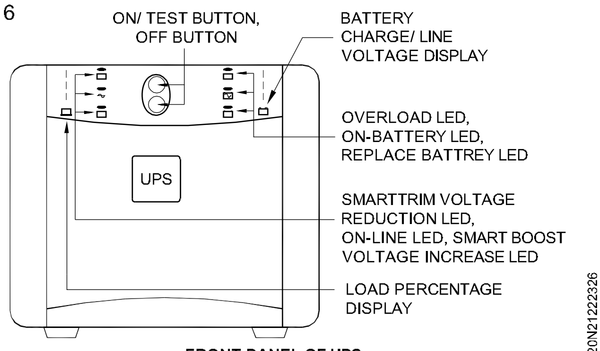
Fig 5



THE FRONT PANEL LED DISPLAY (TOWER MODEL)

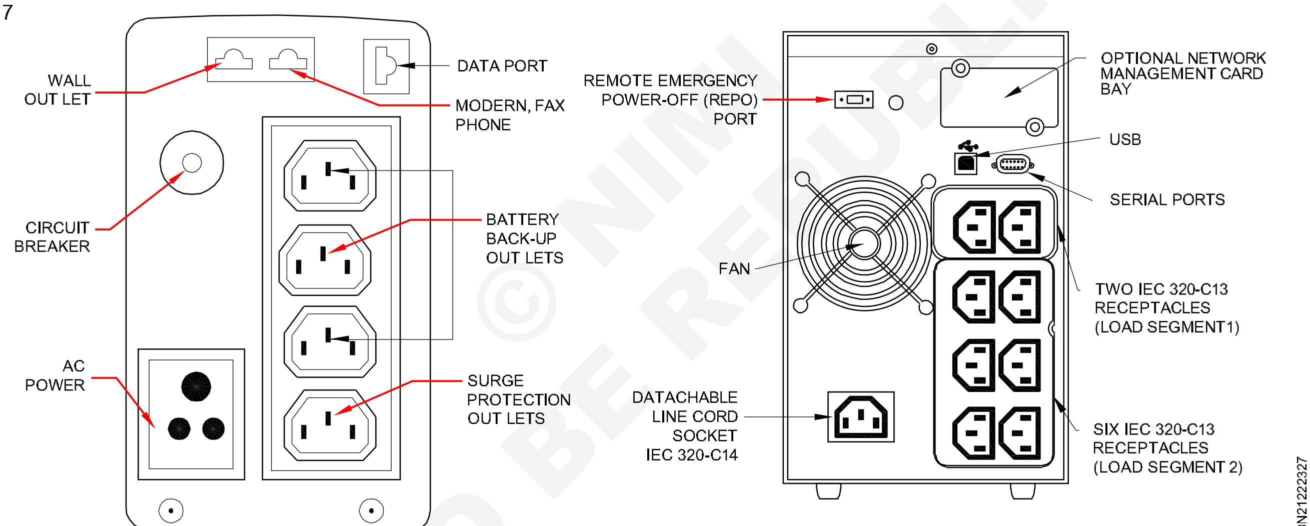
Type 2 :

Fig 6



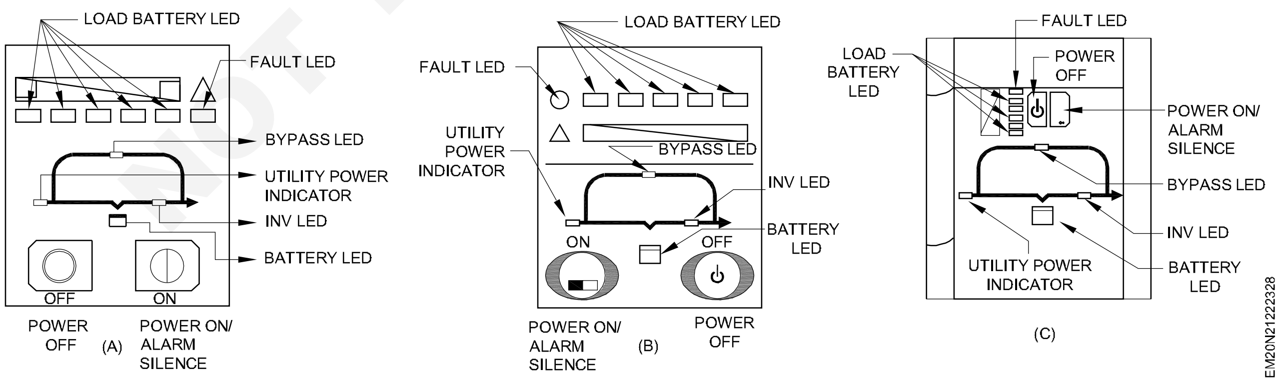
FRONT PANEL OF UPS

Fig 7



REAR PANEL OF UPS

Fig 8



UPS circuit description and working

Objectives : At the end of this lesson you shall be able to
- **describe working of UPS circuit**
- **explain controller circuit**
- **explain the working of ON- Line UPS using PIC micro controller, charging circuit, alarm circuit and indicator circuit**
- **explain 3∅ UPS, types and specification of 3∅ UPS**
- **compare single phase and three phase UPS**
- **explain different methods of battery installation**
- **explain earthing and types of earthing**
- **describe three point/four point method of measurement of earth resistance**
- **discuss about the maintenance of batteries used in inverter**
- **list out the probable faults and rectification of UPS.**

Uniterruptible power supply (UPS) : Circuit description and working (Fig 1)

The circuit drawn pertains to a regular industrial UPS (Uninterruptible Power Supply), which shows how the batteries take control during an in electrical supply variation beyond the normal limits of the voltage line, without disruption on the operation providing a steady regulated output (5V by LM7805) and an unregulated supply. (12V).

The input to the primary winding of the transformer (TR1) is 240V. The secondary winding can be 15 volts if the value is atleast 12 volts running 2 amp. The fuse(FS1) acts as a mini circuit for protection against short circuits, or a defective battery cell. The presence of electricity will cause the LED 1 to light. The circuit is designed to offer more flexible pattern wherein it can be customized by using different regulators and batteries to produce regulated and unregulated voltages. Utilizing two 12 volt batteries in series and a positive input 7815 regulator, can control a 15V supply.

UPS are generally categorized as:

Standby - battery backup and surge protection

Line interactive - variable - voltage transformer and regulates the output AC voltage.

Online - Supplies all or at least a part of the output power.

Digital control of an UPS

Uninterruptible power supply systems (UPS) are necessary for all applications where electronic systems have to work also in case of power failure (i.e. computer centers, hospital equipment, communication equipment etc.). Many mainframe computers are fed by UPS systems.

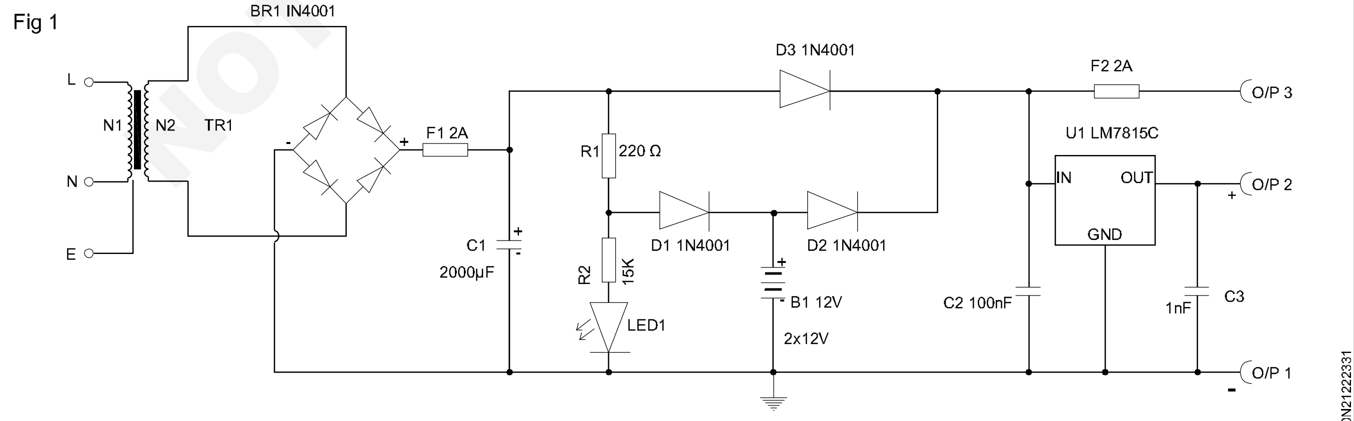
UPS systems conventionally consist of a synchronous generator, a fly-wheel for short-time energy storage and a battery powered motor or diesel engine.

By progress in power electronics static power converters can be realized, especially for mid-range output power (i.e. 5 - 50 kVA). In recent times there is increasing demand for UPS systems with low-distortion output voltages and sinusoidal input currents. Even at non-linear loads producing output currents with high harmonic content, sinusoidal output voltage is required. Due to this, even at unsymmetrical loads a static inverters can be better than rotary converters.

Static UPS system hardware

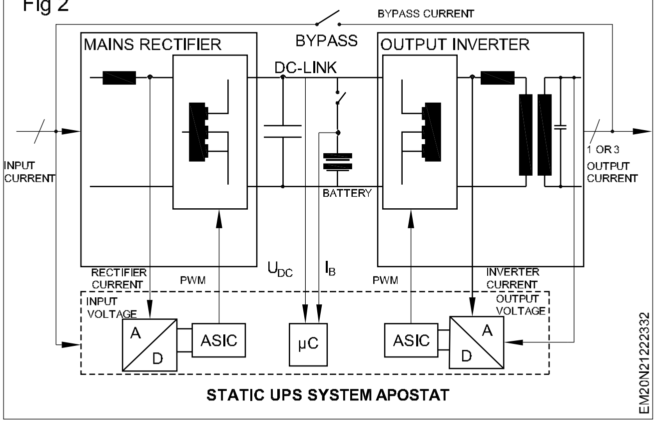
Static UPS systems consist of a rectifier with a single or three-phase mains connection, a DC-link with a battery for power storage and a single- or three-phase output converter. The bypass serves as an energy link in times of system failure or overload situations. (Fig 2)

Fig 1



UNINTERRUPTIBLE POWER SUPPLY (UPS): BASIC CIRCUIT DIAGRAM

Fig 2



STATIC UPS SYSTEM APOSTAT

Static UPS system hardware

Static UPS systems consist of a rectifier with a single or three-phase mains connection, a DC-link with a battery for power storage and a single- or three-phase Output converter. The bypass serves as an energy link in times of system failure or overload situations. (Fig 3)

Output Inverter

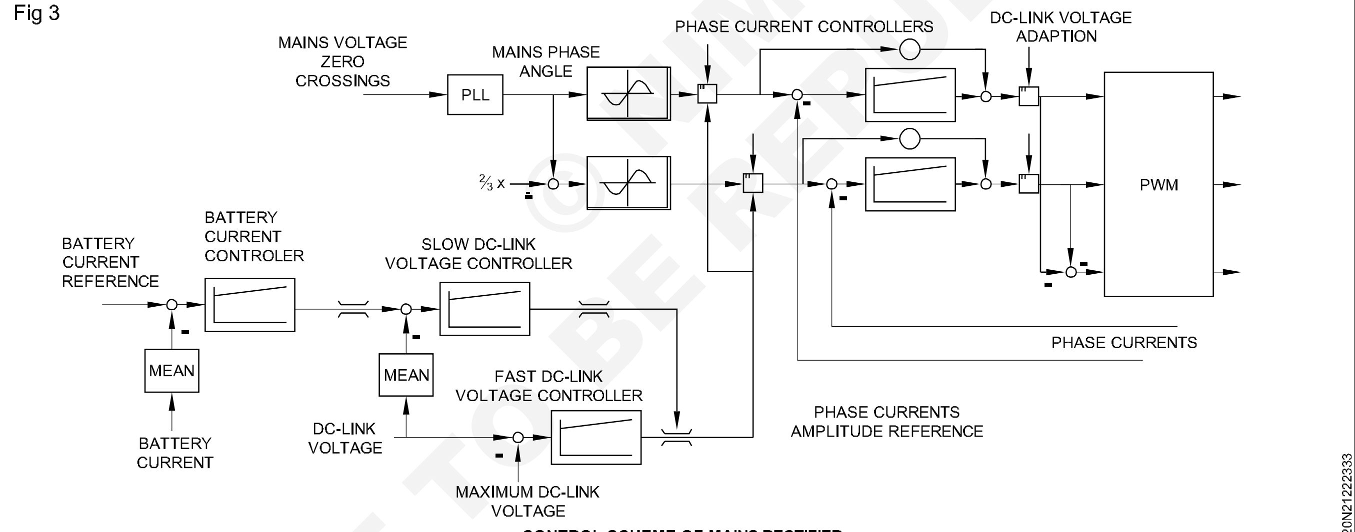
Since output loads are not symmetrical, every output inverter is made up of four power switches building a four-quadrant converter feeding the output transformer. The stray filters the output voltage Inductance of the specially-designed transformer and the output capacitance.

The control scheme of the output inverter is shown in Fig 4. The Controlled quantity is the output voltage. An underlying current control loop is implemented for protection of the power devices. The output value is transformed to switching signals by pulse width modulation (PWM).

PI-controllers for AC quantities normally have phase and amplitude errors, which are not tolerable. On the other hand, PI-controllers provide predictable behavior at all operating modes. To reduce undesired effects feed-forward signals from the reference and output voltage are used. To eliminate the influence of the changing DC link voltage on the gain of the current controller the current control output is multiplied with the reciprocal value of the DC voltage.

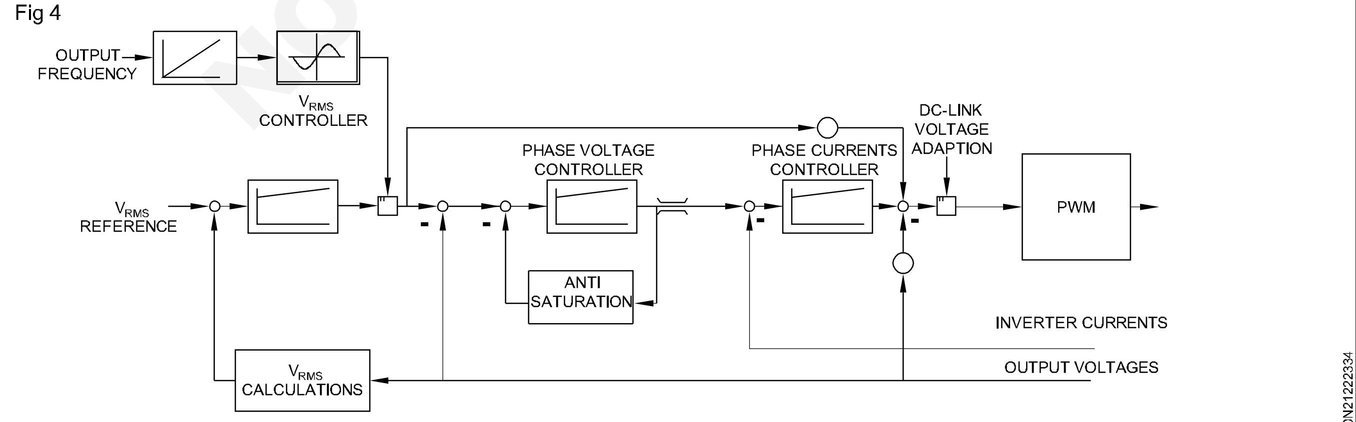
The reference for the current controller is taken from the voltage controller. A modified PI-controller was chosen; special algorithms are implemented to cope with the saturation problem of the output transformer. The output of the voltage controller is limited to the current capability of the devices.

Fig 3



CONTROL SCHEME OF MAINS RECTIFIER

Fig 4



CONTROL SCHEME OF UPS OUTPUT INVERTER

A sine generator running at a programmable frequency and amplitude produces the reference for the output voltage. An additional voltage controller monitoring the RMS-value of the output voltage during an output cycle calculates the amplitude.

Universal control structure

It was decided to use only digital controllers in order to achieve stability, easy parameter adjustment and additional monitoring features. Some of the controllers have to be very fast to gain best response (current control, output voltage control). For implementing these algorithms fast signal processors and application specific integrated circuits (ASICs) are available. Signal processors do not contain inverter specific peripheral circuitry like pulse width modulation, phase measurement etc. For these functions, an ASIC was the solution with the best price performance ratio. Signal processors are optimized for digital filtering and not for control algorithms. Integrating the control algorithms into the ASIC the calculation times could be minimized by developing a processor structure perfectly adapted to the application.

This ASIC containing both peripheral and signal processing hardware is a very cost-effective solution for this UPS system. The disadvantage of having hardware algorithms was acceptable due to the fixed specification of the UPS system and counterbalanced by an universal control structure performed by the ASIC with many switches and load able parameters.

All inner current and voltage control loops are performed with a sampling rate equivalent to the switching frequency of the power devices (10 or 20 kHz).

Output inverter and controlled rectifier both contain equivalent circuitry and signal processing pulse width modulator, current control, sine wave generation, DC-link measurement and adaptation. The whole UPS family consists of both one- and three-phase systems. Integrating the total functions for a three-phase rectifier and inverter into one ASIC would be overloaded for single-phase applications.

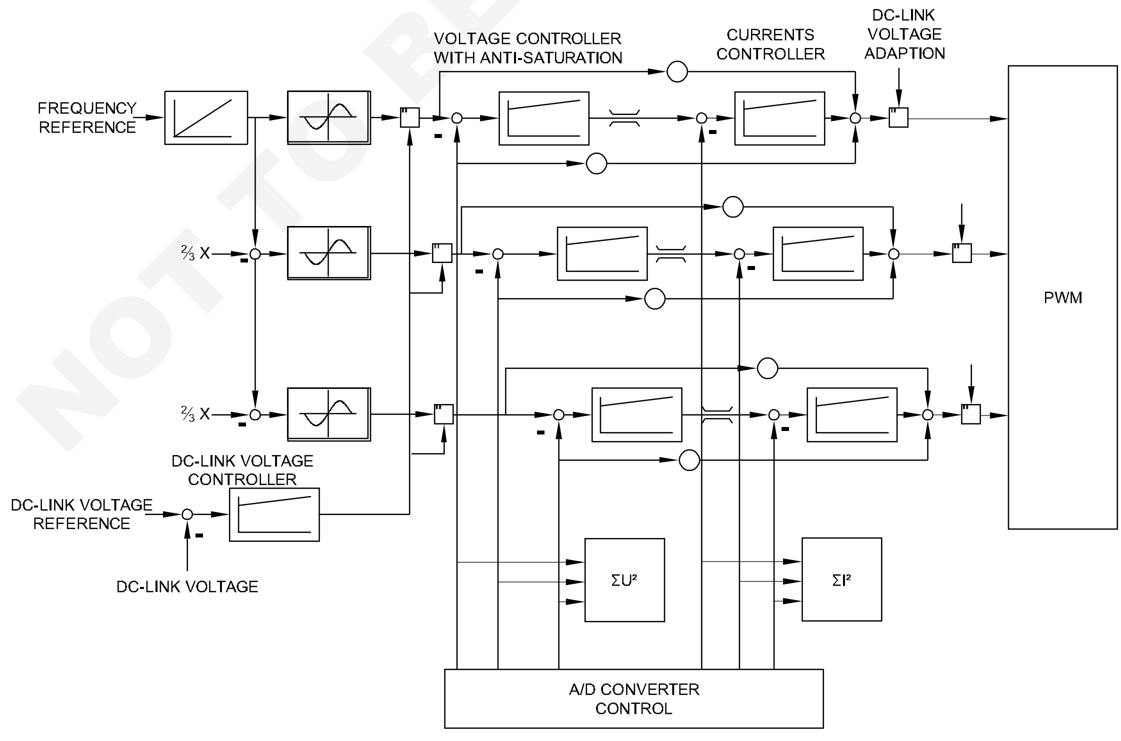
Therefore, it was decided to put the control of three-phase inverter into one circuit. This can be used for the three-phase output inverter, the three-phase rectifier and also for both a one-phase rectifier and inverter.

Fig. 5 shows the universal control block diagram of the ASIC. It contains seven PI-controllers in total. The pulse width modulation generates the signals for six inverter legs. This allows for three independent four-quadrant DC-inverters being used for a three-phase output inverter. The current controllers operate in two modes: for the output inverter three current controllers are used to control the three phases independently. For the rectifier only two controllers are used; the third phase is calculated at the output voltage level. The voltage controllers are only used for output inverter operation. They can be bypassed at the rectifier mode.

Some additional circuitry was included. The measurement of the phase difference for the PLL-control of the line frequency is supported by the ASIC using phase angle captures functions. To support the microcontroller to determine the effective output voltage and current load the integrated squares of the measured values are calculated during a period of the sine wave frequency.

The repetition cycle of all calculations performed by the
The repetition cycle of all calculations performed by the

Fig 5



UNIVERSAL CONTROL SCHEME OF ASIC

EM20N21222335

ASIC is the switching frequency of the inverter legs. This frequency normally amounts to 20 kHz. At the beginning of the cycle the A/D-conversion is started. The ASIC calculates the references and the A/D voltage controller. After at most 15 ìs the A/D-conversion is ready and the calculation of the controllers starts being performed in 10 ìs for all six PI-algorithms. New PWM-values are given to the modulator at the middle of the switching cycle. In the remaining second half of the cycle the ASIC performs the calculation of sum of squares of the measured values.

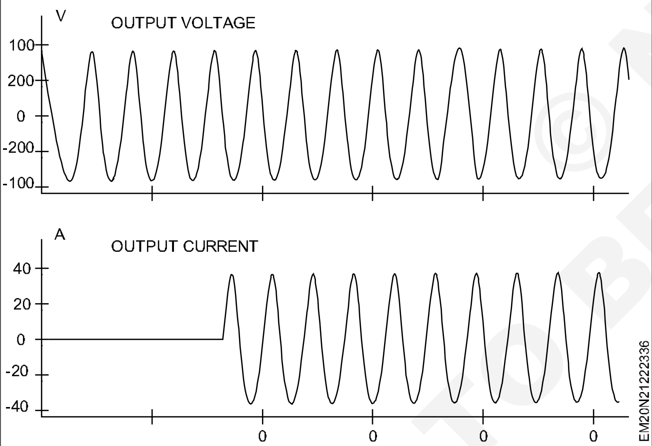
Measured performance results of the UPS system

The inverter controller ASIC is used at the control board of a series of static UPS systems (APOSTAT). This series consists of one phase units with sinusoidal input currents (6.6 kVA and 10 kVA) and three-phase units (10 kVA and 20 kVA).

Due to the high sampling rate of the digital control algorithms an excellent dynamic behavior of the UPS-system is achieved. This is important in case of load-steps (Fig. 6) and non-linear loads (Fig. 6). The output inverter and the output filter circuit provide high peak currents (crest factor 3). Harmonic distortions of the output voltages range from 1% to 2% at linear loads and to 5% at non-linear loads.

Using a controlled step-up chopper the input currents of the single-phase controlled rectifiers are pure sinusoidal. This transforms nonlinear loads at the output side into linear resistive loads at the line-side. (Fig 7)

Fig 6



The output transformer of the three phase units consists of three individually controlled single-phase transformers. Therefore, voltage distortions of one phase resulting from the load (for example short circuit) do not affect the other phases. Fig. 8 demonstrates the inverter being capable of clearing the short circuit by blowing the fuse without transferring to bypass operation. The maximum peak current available of the inverter during this operation is 300% of RMS-rating. If the output voltage exceeds the allowed voltage range for more than 4 ms the system automatically switches from inverter to bypass operation.

Fig 7

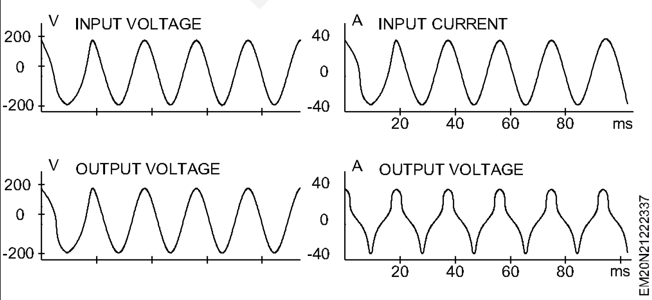
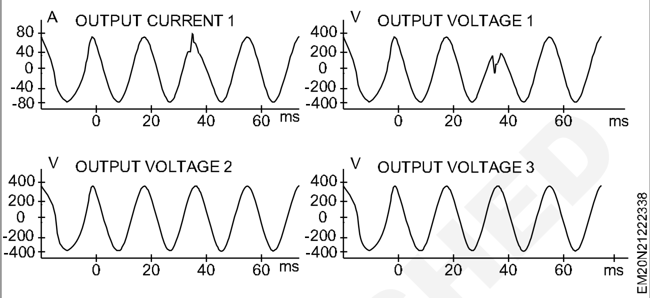
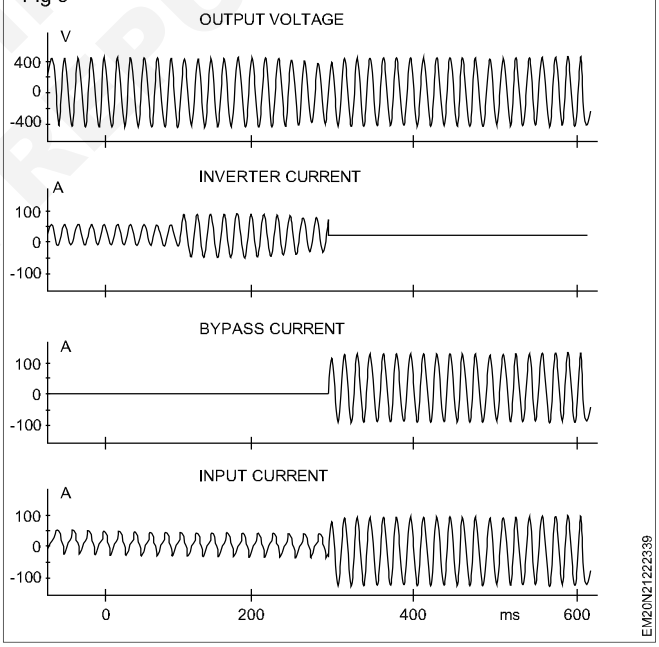


Fig 8



The inverter is able to provide short time overloads (20%/100 ms, 1500%/5 sec, 120%/1min). If the load exceeds the current or time limit a current controller reduces output currents and voltages. Fig. 9 shows that the bypass will be activated to supply the output power.

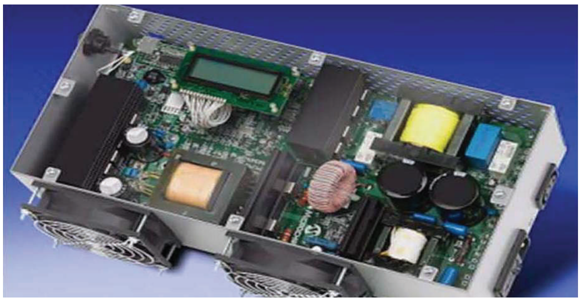
Fig 9



Block diagram of ON- Line UPS using PIC micro controller (Fig 11)

ON- Line uninterruptible power supply (UPS) offers AC voltage regulation with the controllable battery charger. The battery is Lead Acid Type battery. The charge control technique used for battery is constant current charging technique. The constant current is achieved by limiting the duty cycle of charger (or step-down chopper). In protection of battery over charge and battery under discharge is available with relay trip through PIC 16F877A microcontroller by monitoring voltages on continuous

Fig 10



Pictorial diagram of microcontroller UPS

basis. The backup of battery takes place the load without spikes or delay when the mains power gets fails or interrupted. Based upon the constant current charging technique, a digital charger is designed and is control through PIC 16F877A microcontroller software. The inverter is simple square wave inverter.

Circuit description of PIC micro controller (Fig 11)

The AC voltages are applied to Rectifier through the step down transformer and power supply. An uncontrolled rectifier converts AC voltages into DC voltages. The fixed DC is fed to the step-down chopper. The PWM control technique keeps switching frequency constant and also regulates duty cycle to ensure the MOSFET to turn on. In constant current charging method current is set at a fixed rate. Constant current is achieved by switching of the chopper. The step-down chopper produces a lower average output voltage than the input voltage. The battery is connected to the variable DC through the relay. Relay gives the trip on the conditions of overcharging and under discharging. The relays will work as static switches. The switching of inverter is controlled through PIC microcontroller. The battery feeds the inverter. The AC output from inverter will fed to load.

230 AC voltages are applied to the step down transformer of 0-18 V/ 8 A. The output of 18 V ac is converted into 12 V dc through rectifier. Rectifier with filter capacitor converts AC into 12 V DC. The capacitors of 2200 mF/ 50 V are used to control the heavy current which may damage the MOSFET switch. The switching frequency of MOSFET switch is 8 kHz. The turn on time and turn off time of MOSFET controlled through the isolated driver which may also regulates the voltage. The turn on time of MOSFET will be different as for constant current charging. Hence, duty ratio will also be different. The inductor used is toroidal type. The variable DC is fed to the battery through the resistors of 12 kW and 3 kW. The voltage sample Vx is taken between 12 kW and 3 kW resistor. Also, other voltage sample Vy is taken across the battery. The voltage samples Vx and Vy are given to the PIC microcontroller for comparing purpose for constant current charging of battery. When the voltage sample Vy is less than 14 V, the load relay will be turns off, and when the voltage sample Vy is more than 12 V, the load relay will be turns on. Also, when voltage sample Vy is more than 14 V it will increases the duty cycle of step down chopper and when voltage sample Vy is less than 14 V it will decreases the duty cycle of step down chopper. The output from pin 17 of port C is given to pin 3 of the level shifter CD4504. At pin 1 of CD4504 the supply of +5 V is fed. Also, the capacitors of 100 uf / 16 V and 0.1 uf are connected for high and low frequency input noise suppression. The level shifter shifts voltages from +5 V to +12 V (low to high). The output from level shifter CD4504 is fed to pin 10 of MOSFET driver IR2110. The output from pin 7 through the current limiting resistor of 100W is given to the gate terminal of MOSFET.

There are four different conditions:

1 Mains available and Battery fully charged at that time

i Charger to battery relay will be OFF and battery to load relay will be ON.

ii Also, Vl to be regulated equal to Vb so that battery will not discharge.

2 Mains available and battery not fully charged

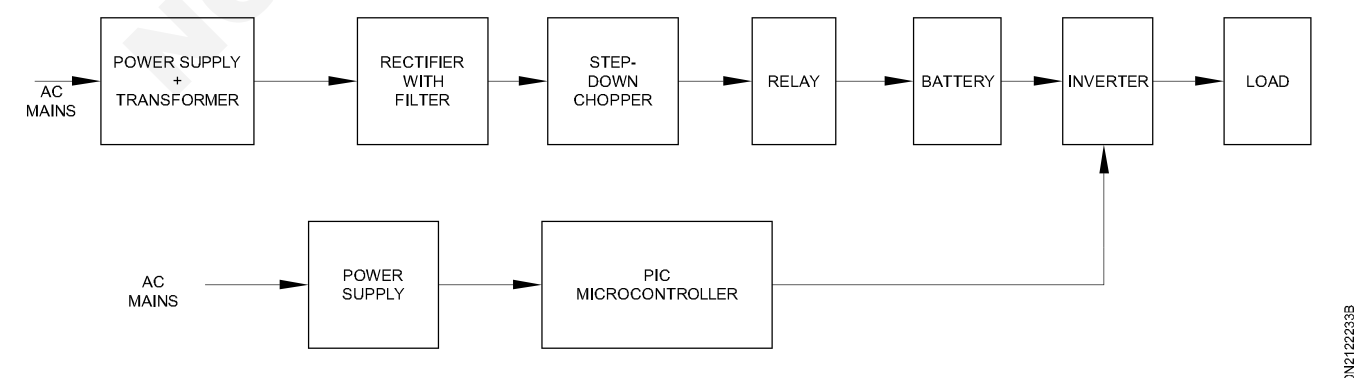
i Charger to battery relay will be ON and battery to load relay will be ON.

ii Charging to be regulated so as to keep Ib < 1 A

3 Mains fail and battery not fully charged but not discharged

i Charger to battery relay will be OFF and battery to load relay will be ON.

Fig 11



BLOCK DIAGRAM OF ON-LINE UPS USING PIC MICRO CONTROLLER

4 Mains fail and battery discharged

i Charger to battery relay will be OFF and battery to load relay will be OFF.

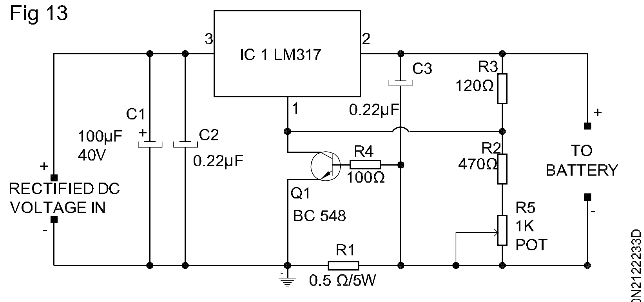
Circuit description for inverter (Fig 12)

The push-pull configuration of inverter is used for designing of inverter for ON-Line UPS. For switching operation MOSFET Switches IRFP150 are used. For that MOSFET switches MOSFET driver IR2110 is used. The output from pin 33 and 34 as PWM waveforms are fed to pin 5 and pin 7 of the level shifter CD4504. The level shifter shifts voltages from +5 V to +12 V (low to high). The 12 V output from level shifter CD4504 is fed to pin 10 and pin 12 of MOSFET driver IR2110. The power supply for MOSFET driver IR2110 is connected at pin 6 which is as shown in Fig 12. When one switch is ON at that time other switch is OFF, therefore dead band circuit is not required for push-pull arrangement of inverter. For MOSFET diver IR2110, isolated power supply is not required because sources of both the MOSFET switches are grounded. The resistor connected at gate of MOSFET is used for current limiting. The capacitors connected across the MOSFET switches are used for snubbing.

Battery charger circuit (Fig 13)

Battery charger circuit using IC LM 317 provides the correct charging voltage for the battery. A battery must be charged with 1/10 its AH value. This charging circuit is designed based on this fact. The charging current for the battery is controlled by Q1, R1, R4 and R5. Potentiometer R5 can be used to set the charging current. As the battery gets charged the current through R1 increases .This changes the conduction of Q1.Since collector of Q1 is

Fig 13

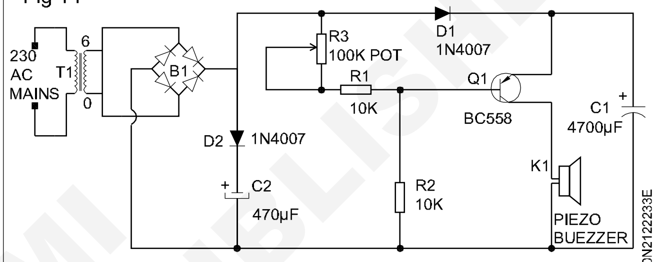


BATTERY CHARGER

connected to adjust pin of IC LM 317 the voltage at the output of LM 317 increases. When battery is fully charged charger circuit reduces the charging current and this mode is called trickle charging mode.

Alarm circuit (Fig 14)

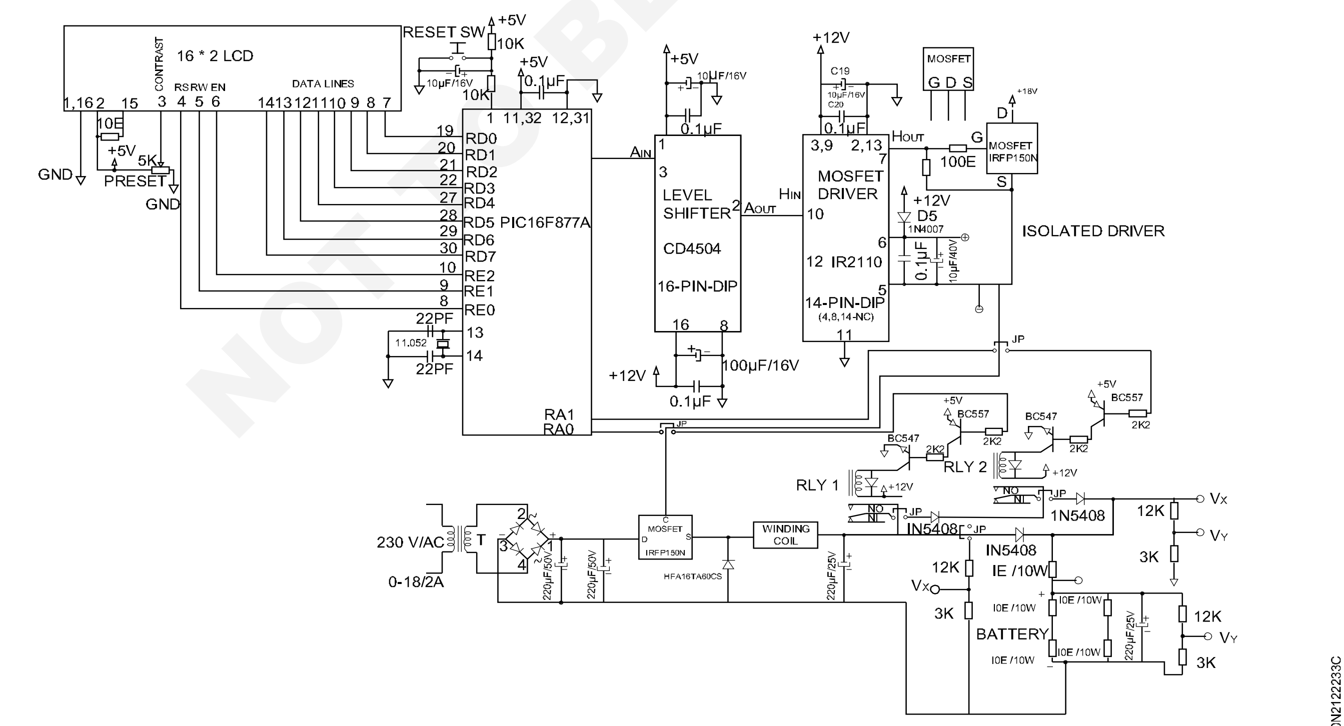
Fig 14



ALARM CIRCUIT

A simple mains power failure alarm/detector circuit that produces an alarm whenever the mains supply fails. Lot of such circuits are available, but the peculiarity of this circuit is that it requires no back up power source like a battery to power the alarm when the mains is absent.

Fig 12



CIRCUIT DIAGRAM OF ON-LINE UPS USING PIC MICRO CONTROLLER

When there is mains supply the transistor Q1(BC558) will be OFF and the capacitor C1 will be charged. When the mains supply fails the transistor Q1 becomes ON and the capacitor C1 discharges through the Q1 to drive the buzzer to produce an alarm. The capacitor C2 is the filter capacitor for the bridge. Diode D2 prevents the discharge of the C2 when mains fails. If D2 is not there, the alarms will remain silent for a time capacitor C2 to fully discharge after the power failure.

Indicator circuit (Battery level indicator) (Fig 15)

This battery level indicator offers five LEDs that light up progressively as the voltage increases: These five LEDs show the approximate charge of the battery in percentage; each LED represents approximately a 25% charge on the battery.

i Red : Power connected (0%)

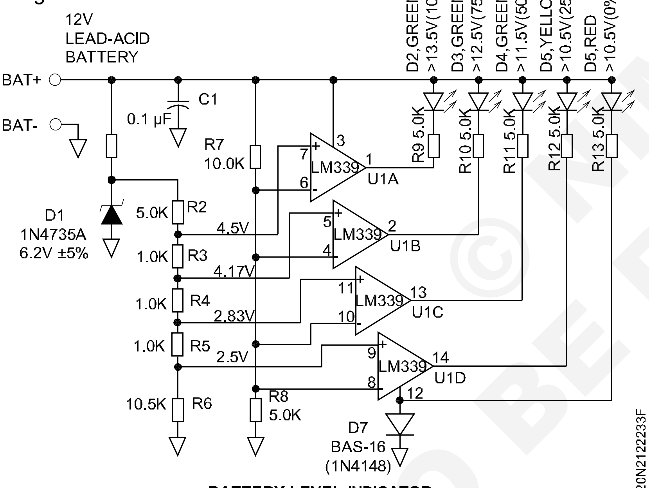
ii Yellow : Greater than 10.5V (25%)

iii Green 1: Greater than 11.5V (50%)

iv Green 2: Greater than 12.5V (75%)

v Green 3: Greater than 13.5V (100%)

Fig 15

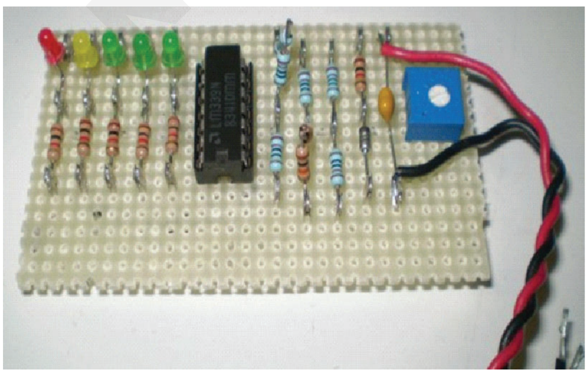


BATTERY LEVEL INDICATOR

Operation of the battery level indicator

D1 is the voltage reference zener. A string of divider resistors (R2-R6) set the various fixed voltage levels. R7 and R8 form a voltage divider to that reduces the battery voltage by a factor of 3. U1 is an LM339 quad comparator that compares the various voltages from the two dividers. The comparator sections have open collector outputs which function as switches to operate the LEDs. D7 protects against reverse battery connection.

Fig 16



The LEDs are biased to operate at about 4mA which is quite bright. This current can be adjusted by varying the series resistors (R9 through R13).. For energy conservation, connect the battery via a pushbutton switch.

Single phase UPS

A single phase installation consists of a single sine wave input and is typically a single phase of a larger 3 phase supply. A typical example of this would be a local 3 pin socket which uses 230/240 VAC (Single phase) to supply power. Most small power hardware including rack mounted servers, telecoms, network switches, computer systems or any device running from a standard 3 pin plug, operate from a single phase supply.

All single phase UPS up to 3kVA will typically be installed to a standard plug. Sizes above 3kVA would be installed to a single phase distribution board.

Three Phase Uninterruptible Power Supplies (UPS) Introduction

3 phase UPS

A 3 phase installation uses the full 3 phases which is generated from the grid. A 3 phase electrical supply comprises of three individual sine waves, and can be installed as either a 3 wires or 3 wire & neutral configuration. A three phase source would typically come from a local transformer, with the standard three phase voltage being 400/415 VAC.

Three phase uninterruptible power supplies (UPS) operate in conjunction with existing electrical systems to provide power conditioning, back-up protection, and distribution for electronic equipment loads that use three-phase power. A three phase UPS also prevents power disturbances such as outages, sags, surges, spikes, and noise from affecting the performance and life of the electronic device and data. Selecting three phase uninterruptible power supplies (UPS) requires an analysis of technology types, product specifications, and features.

3 phase UPS systems are usually used on larger installations such as data centers, medical equipment / theatres and large industrial applications. All 3 phase UPS need installation to a 3 phase distribution board, which is usually achieved via a bypass switch facility.

Types of three phase uninterruptible power supplies (UPS)

There are three basic types of three phase uninterruptible power supplies (UPS):

1 On-line or double-conversion

2 Line-interactive

3 Off-line or standby

1 On-line or double-conversion

With on-line units, the load is supplied from a continuously-operating power converter that receives its input from a DC supply. This DC supply consists of a battery and a large battery charger, which are connected in parallel.

2 Line- interactive

With line-interactive devices, the inverter works in parallel with conditioned-input AC power to supply power to the load (boosting or bucking), and only handles the full load power when the AC input power fails.

3 OFF- line or standby

With an off-line unit, the power is usually derived directly from the power line, until power fails. After power failure, a battery-powered inverter turns on to continue supplying power.

Capacity specifications

Capacity specifications of three phase uninterruptible power supplies (UPS) are the volt-amp rating, watt rating, and input voltage range. Three phase uninterruptible power supplies (UPS) are rated in volt-amperes (VA) or kilo-VA (kVA).

Note that the VA rating is not the same as the power drain (in watts) of the equipment.

The watt rating is specified only if VA rating is unknown; the watt Rating is less than or equal to VA rating. The input voltage range is the precise identification of the electrical system is critical in the proper selection and application of a three phase UPS.

Performance specifications

Performance specifications for three phase uninterruptible power supplies (UPS) include runtime half load, runtime at full load, and switchover time. Runtimes refer to the length of time the three phase UPS will run at half load, full load, and the amount of time for switchover.

Note that ON-line or double-conversion devices do not have a switchover time.

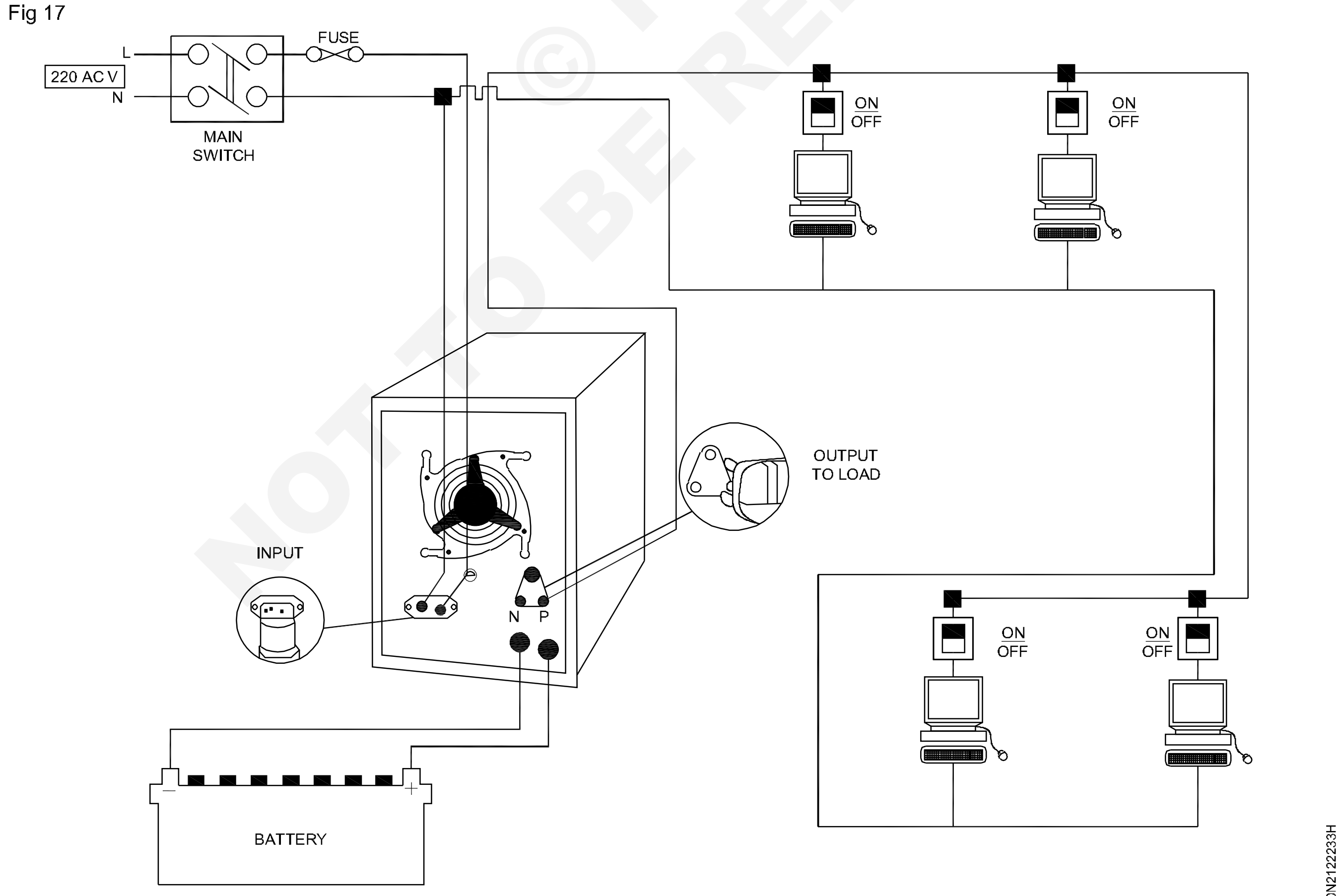
Output specifications

Output specifications for three phase uninterruptible power supplies (UPS) include output voltage in battery mode, number of backed-up outlets, and outlet options. Outlet options include additional electrical outlets, RJ type connectors, and coaxial cable connectors. Mounting options for uninterruptible power supply (UPS), three-phase include tower type, rack or tray, strip type or plug strip, and mounts on or in device protected. In addition to battery backup systems, rotary or battery-free three phase uninterruptible power supplies (UPS) are available that use the energy stored in a rotating member as backup energy.

Electrical wiring of UPS

Single phase UPS system wiring diagram

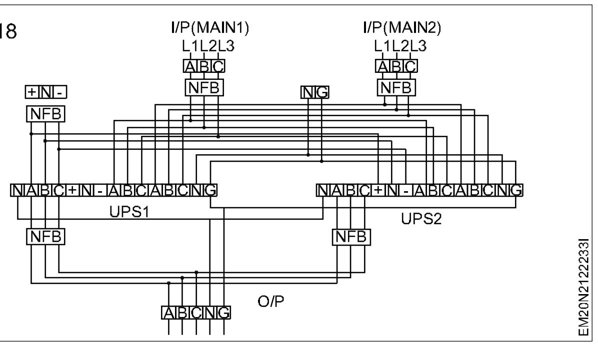
Fig 17



AUTOMATIC UPS SYSTEM WIRING DIAGRAM FOR HOME OR OFFICE (NEW DESIGN WITH ONE LIVE WIRE)

Three phase UPS

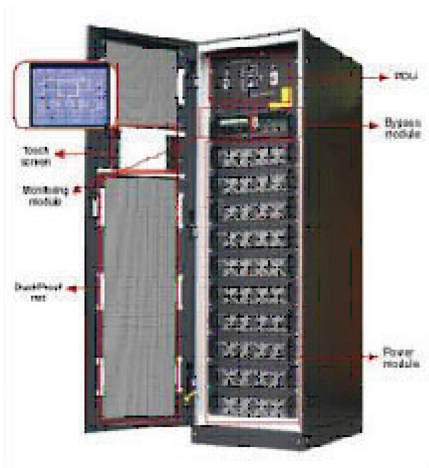
Fig 18



Pictorial diagram of Three phase UPS

1

Fig 19



2

Installation of batteries

Fig 20

A battery is made up of interconnected cells which may be vented or of the recombination type.

There are two main types of batteries:

1 Nickel-cadmium batteries

2 Lead-acid batteries

3 Vented cells (lead-antimony): They are equipped with ports to

   i Release to the atmosphere the oxygen and hydrogen produced during the different chemical reactions

   ii Top up the electrolyte by adding distilled or demineralized water

4 Recombination cells (lead, pure lead, lead-tin batteries): The gas recombination rate is at least 95% and they therefore do not require water to be added during service life

Recombination batteries are also often called "sealed" batteries.

Types of batteries used in UPS

1 Sealed lead-acid batteries, used 95% of the time because they are easy to maintain and do not require a special room

2 Vented lead-acid batteries

3 Vented nickel-cadmium batteries

The above three types of batteries may be proposed, depending on economic factors and the operating requirements of the installation, with all the available service-life durations.

Capacity levels and backup times may be adapted to suit the user's needs.

Installation methods

Depending on the UPS range, the battery capacity and backup time, the battery is:

1 Sealed type and housed in the UPS cabinet

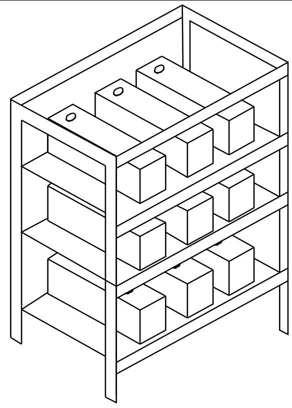
2 Sealed type and housed in one to three cabinets

3 Vented or sealed type and rack-mounted. In this case the installation method may be

On shelves (Fig 21)

1 This installation method is possible for sealed batteries or maintenance-free vented batteries which do not require topping up of their electrolyte.

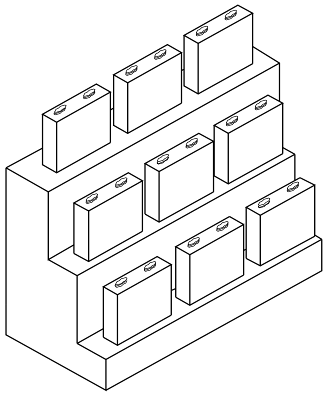
Fig 21



Tier mounting (Fig 22)

1 This installation method is suitable for all types of batteries and for vented batteries in particular, as level checking and filling are made easy.

Fig 22



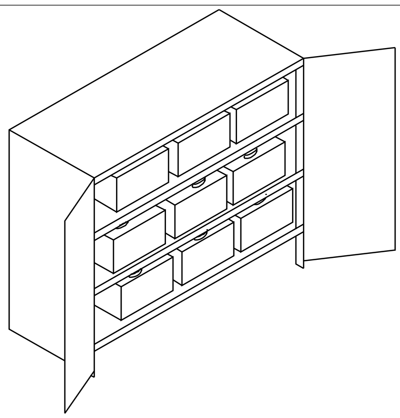
TIER MOUNTING

EM20N2122233M

In cabinets (Fig 23)

This installation method is suitable for sealed batteries. It is easy to implement and offers maximum safety.

Fig 23



CABINET MOUNTING

EM20N2122233N

Installation of UPS

The equipment must be installed in upright position. The equipment requires space to front and back to enable cooling airflow, service and maintenance. All cooling air enters at front and exits at unit rear. The required min. clearance from unit rear to an obstruction is 150 mm.

Ventilation space around the equipment

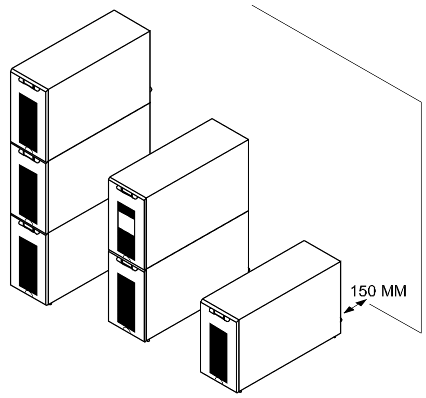
It is required to arrange ventilation of the UPS room. Sufficient amount of air cooling is needed to keep the max. room temperature rise at desired level:

1 Temperature rise of max. +5°C requires the airflow of 600 cubic meter per 1 kW of losses.

2 Temperature rise of max. +10°C requires the airflow of 300 cubic meter per 1 kW of losses.

An ambient temperature of 15 to 25 Celsius degrees is recommended to achieve a long life of the UPS and batteries. The cooling air entering the UPS must not exceed +40°C. Avoid high ambient temperature, moisture and humidity.

Fig 24



VENTILATION SPACE AROUND THE EQUIPMENT

EM20N2122233O

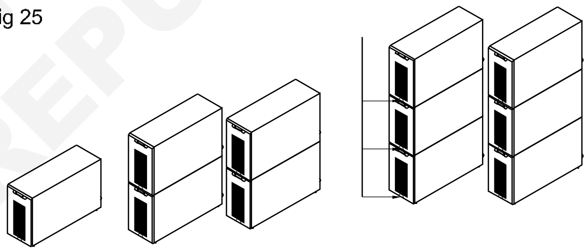
The floor material should be non-flammable and strong enough to support the heavy load. The UPS has (4) leveling feet that should be used when finalising the installation. The diameter of a single leveling foot is 1 inch (25.4 mm).

Cabinet installation

The required distance for UPS units next to each other is ten millimeters. The same applies to the optional battery cabinets that should be installed next to the UPS cabinet.

The UPS family has several alternative battery cabinets and configurations depending on the selected back-up time and quality of batteries.

Fig 25



UPS AND EXTERNAL BATTERY CABINETS

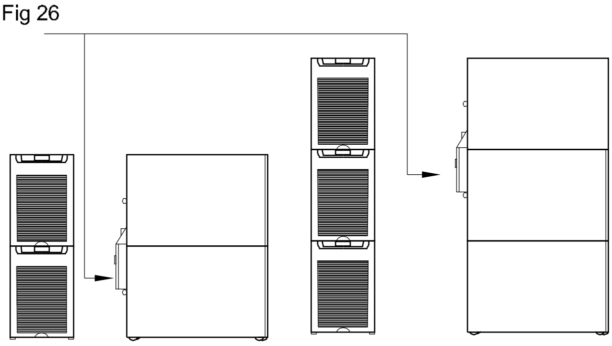
EM20N2122233P

Maintenance bypass switch (Fig 26)

The maintenance bypass switch (MBS) shall be mounted in back of the UPS battery compartment.

Fix the switch MBS to the wall (din rail) or to the back of the UPS as shown below.

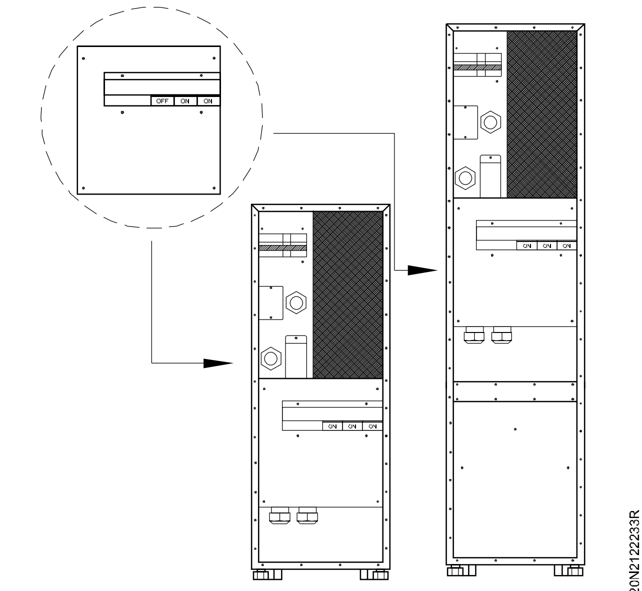
Fig 26



INSTRUCTIONS FOR LOCATING THE MAINTENANCE BYPASS SWITCH

EM20N2122233Q

Fig 27



THE MAINTENANCE BYPASS SWITCH (MBS) WHEN INSTALLED IN THE BACKSIDE EM20N2122233R

Relay outputs

Relay outputs can be used for remote alarm indications.

Each relay has four standard pre-programmed settings for alarms:

One of the standard relay settings is "custom" that can be customised by the user. The procedure to select customised alarms:

1 Push any key of the control panel to enable the functions on the LCD screen.

2 First select "SETTINGS", then "USER SETTINGS" and finally "RELAY CONFIG" from the LCD menu.

3 Select the relay what is needed to be configured (ALARM-1 is fixed relay output X57).

4 Select "empty" to clear old settings.

5 Select "custom" and activate needed alarms with the button on the right.

6 After the selection press "OK" button

7 Finally test that UPS alarms correctly

Checking of UPS

Check the mechanical and electrical installation of the UPS before start-up.

1 Read the attached safety manual before work on the unit.

2 The unit is fixed according to mechanical installation

3 The ambient conditions are within specification.

4 The cooling air will flow freely.

5 The UPS is grounded properly.

6 The input and bypass voltages match the UPS nominal voltage.

7 The input, bypass, battery and output terminal connections are OK.

8 Appropriate input and bypass fuses and disconnectors are installed.

9 Appropriate backfeed warning sign for disconnectors are installed.

10 Appropriate cables sizes are used.

11 The external control connections inside the UPS are OK.

12 There are no tools, foreign objects or dust inside the UPS from the installation.

13 Covers are in place.

14 Optional MBS is placed to UPS position as default.

Starting up the UPS

1 Turn the battery and input circuit breakers to ON position.

2 UPS will enter a stand-by mode and starts to charge batteries with a cooling fan operational. Output is without the voltage in the stand-by mode.

3 Push any key of the control panel to enable the functions of the LCD screen

4 Select 'TURN UPS ON' from the LCD menu (see: Display functions)

5 Press and hold button for 2 sec. There shall be no sound during the hold.

The UPS shall check its internal functions, synchronise to bypass and start to supply the load. The green LED is blinking if there occurs an active notice. In normal operation the green LED is constantly lit if no new active notice such as 'unsyncronised' or similar notices present.

The output voltage shall be verified from the output measurements screen of the LCD. If there is voltage in the output then UPS is supplying the load.

Battery start-up

UPS will start on battery if mains is not available.

Shutdown

The procedure to shutdown from LCD is following:

1 Push any key of the control panel to enable the functions of the LCD screen.

2 Select 'TURN UPS OFF' from the LCD menu (see: Display Functions).

3 Press and hold button for 5 sec. There shall be an indication sound during the hold.

4 UPS shall do a shutdown routine.

5 Turn the battery and input circuit breakers to OFF position to finalise the shutdown procedure.

Earthing in electrical network

The main reason for doing earthing in electrical network is for the safety. When all metallic parts in electrical equipments are grounded then if the insulation inside the equipments fails there are no dangerous voltages present in the equipment case.

If the live wire touches the grounded case then the circuit is effectively shorted and fuse will immediately blow. When the fuse is blown then the dangerous voltages are away.

Purpose of earthing

1 Safety for human life/Building/Equipment

To save human life from danger of electrical shock or death by blowing a fuse. It provides an alternative path for the fault current to flow so that it will not give danger to the user.

To protect buildings, machinery and appliances under fault conditions.

To ensure that all exposed conductive parts do not reach a dangerous potential.

To provide safe path to dissipate lightning and short circuit currents.

To provide stable platform for operation of sensitive electronic equipments i.e. to maintain the voltage at any part of an electrical system at a known value so as to prevent over current or excessive voltage on the appliances or equipment.

2 Over voltage protection

Lightning, line surges or unintentional contact with higher voltage lines can cause dangerously high voltages to the electrical distribution system. Earthing provides an alternative path around the electrical system to minimize damages in the System.

3 Voltage stabilization

There are many sources of electricity. Every transformer can be considered as a separate source. If there were not a common reference point for all these voltage sources it would be extremely difficult to calculate their relationships to each other.

The earth is the most important conductive surface, and so it was adopted in the very beginnings of electrical distribution systems as a nearly universal standard for all electric systems.

Conventional methods of earthing

1 Plate type earthing

Generally for plate type earthing normal Practice is to use

Cast iron plate of size 600 mm x 600 mm x12 mm. (or)

Galvanized iron plate of size 600 mm x600 mm x6 mm. (or)

Copper plate of size 600 mm x 600 mm x 3.15 mm

Plate burred at the depth of 8 feet in the vertical position and GI strip of size 50 mmx6 mm bolted with the plate is brought up to the ground level.

These types of earth pit are generally filled with alternate layer of charcoal and salt upto 4 feet from the bottom of the pit.

2 Pipe type earthing

For pipe type earthing normal practice is to use GI pipe of 75 mm diameter, 10 feet long welded with 75 mm diameter GI flange having 6 numbers of holes for the connection of earth wires and inserted in ground by auger method.

These types of earth pit are generally filled with alternate layer of charcoal and salt or earth reactivation compound.

Method for construction of Earthing pit

Excavation on earth for a normal earth pit size is 1.5M x 1.5M x 3.0 M.

Use 500 mm x 500 mm x 10 mm GI plate or bigger size for more contact of earth and reduce earth resistance.

Make a mixture of wood coal powder salt and sand all in equal part.

Wood coal powder use as good conductor of electricity, anti corrosive, rust proves for GI Plate for long life.

The purpose of coal and salt is to keep wet the soil permanently.

The salt percolates and coal absorbs water keeping the soil wet.

Care should always be taken by watering the earth pits in summer so that the pit soil will be wet.

Coal is made of carbon which is good conductor minimizing the earth resistant.

Salt used as electrolyte to form conductivity between GI plate coal and earth with humidity.

Sand has used to form porosity to cycle water and humidity around the mixture.

Put GI Plate (EARTH PLATE) of size 500 mm x 500 mm x 10 mm in the middle of mixture.

Use double GI strip size 30 mm x 10 mm to connect GI plate to system earthing.

It will be better to use GI pipe of size 2.5 diameter with a flange on the top of GI pipe to cover GI strip from EARTH PLATE to top flange.

Cover top of GI pipe with a T joint to avoid jamming of pipe with dust and mud and also use water time to time through this pipe to bottom of earth plate.

Maintain less than one Ohm resistance from EARTH PIT conductor to a distance of 15 Meters around the EARTH PIT with another conductor dip on the Earth at least 500 mm deep.

Check voltage between earth pit conductors to neutral of mains supply 220V AC 50 Hz it should be less than 2.0 volts.

Battery level

Maintenance of battery in inverters

Batteries are expensive items to replace. They should be serviced regularly as recommended by the manufacturer.

If maintained properly, they can be used for longer periods. The following aspects are to be checked to maintain the battery in good condition.

Check and top up electrolyte level every week. Electrolyte should be 10 mm to 15 mm above the plates.

If the voltage of each cell is less than specified, then the battery should be recharged.

While charging do not overcharge the battery.

Keep the battery terminals always tight and clean.

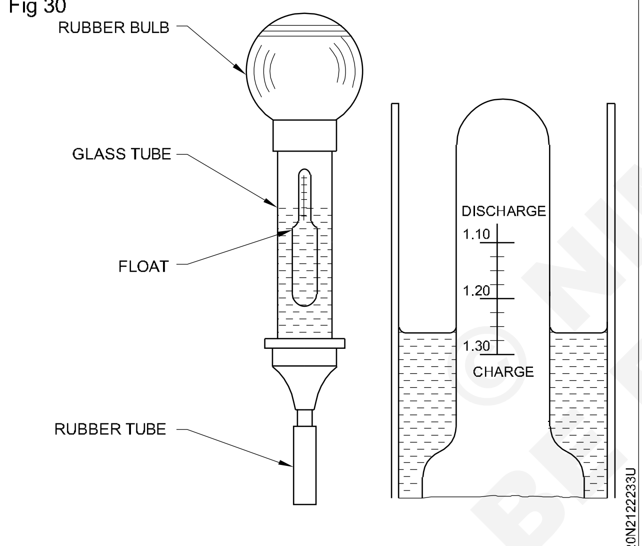
To prevent formation of corrosion on the terminals smear petroleum jelly on it.

Hydrometer

Hydrometer is a device used to check the specific gravity of the battery as shown in fig 30.

Check the specific gravity of the battery with a hydrometer. If the specific gravity falls below 1.180 then add a few drops of Sulphuric acid.

Fig 30



HYDROMETER

Specific gravity readings and the state of charge of the battery are as follows.

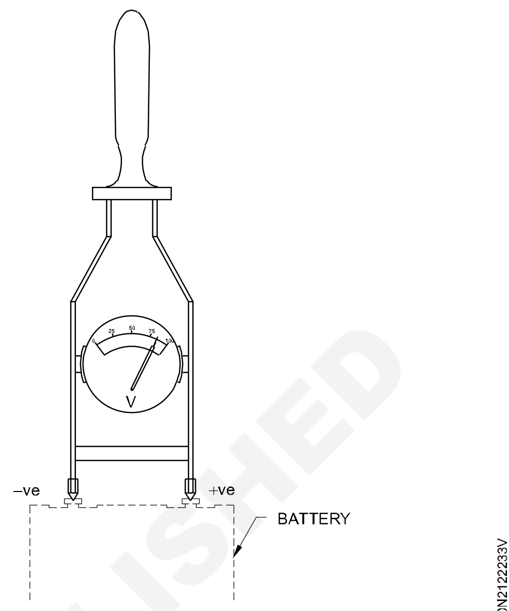
Sl. No.	Specific gravity	State of charge of the battery
1.	1.260 - 1.280	Fully charged
2.	1.230 - 1.260	3/4 charged
3.	1.200 - 1.230	1/2 charged
4.	1.170 - 1.200	1/4 charged
5.	1.140 - 1.170	About run down
6.	1.110 - 1.140	Discharged

High rate discharge tester

The two legs of the cell tester are alternatively pressed against each of the battery terminals for a period of 5 to 10 seconds as shown in Fig 31 below.

The needle must be in the green area (voltage reading between 1.75 to 1.80 volts). There should not be any sudden drop of the needle within 5 to 10 seconds. If the needle drops suddenly battery should be recharged.

Fig 31

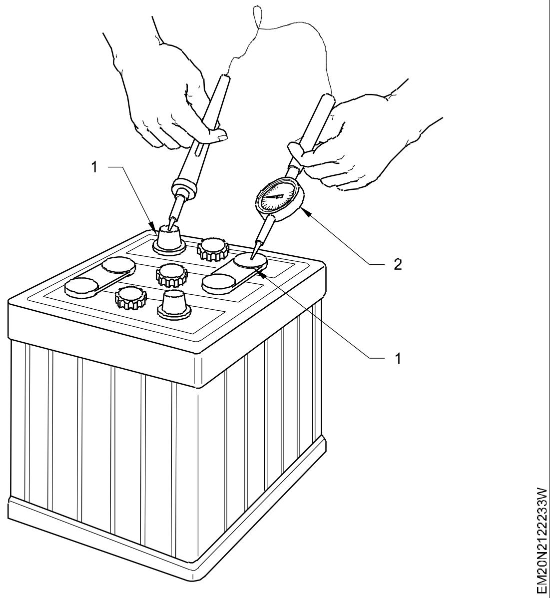


CHECKING OF VOLTAGE

Voltage check of battery

With the help of a voltmeter the voltage of each cell is tested as shown in Fig 32. This will commonly vary from 2.0V to 2.15V and 2.3 volts per cell for fully charged condition. The difference of voltage between the cells in one battery should not exceed 0.1 volt. If the difference is more than 0.1 volt then the battery should be recharged.

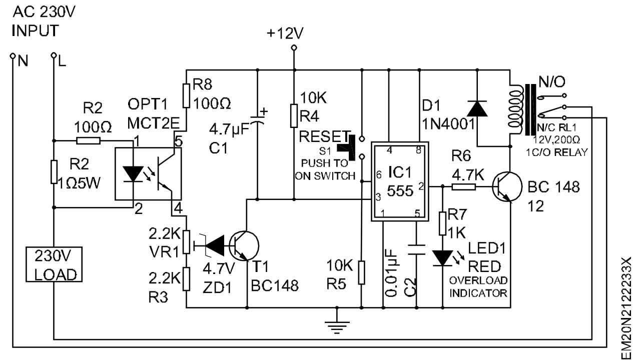
Fig 32



Overload protection circuit using 555 timer

Overload protection circuits are required in inverters to make sure that the loads connected to them do not exceed the maximum power ratings. This project describes a simple overload protection circuit based on a 555 timer IC is given in Fig 33. The current drawn by a load is sensed through a 5W 1 Ohm resistor. The voltage drop across this resistor is proportional to the current drawn and hence can be used to sense any short circuit or excess load current. An optocoupler is used to isolate the mains AC part from the rest of the circuit.

Fig 33



Overload current threshold can be varied through the potentiometer VR1. The mains AC supply to the load is connected through the N/C (normally closed) connection of relay RL1. When an overload is detected, the relay is energized to disconnect the load from the mains supply. The bypass capacitor C1 avoids any false trigger of the circuit because of fluctuations in the mains supply.

Trouble shooting / Fault finding methods

Problem	Probable cause	Solution/Remedy
No LED display on the front panel	Low battery	Charge the UPS at least 8 hours
	Battery fault	Replace the battery with the same type of battery.
	The UPS is not turned on	Press the power switch again to turn on the UPS
Alarm continuously sounds when the mains is normal.	The UPS is overloaded.	Remove some loads first. Before reconnecting equipment, please verify that the load matches the UPS capability specified in the specs.
	UPS fault	Send/Return the unit to service center
Alarm sounds every 2 seconds when the mains is normal.	Battery defective	Replace the battery with the same type of battery.
	Charging circuit is damaged.	Send/Return the unit to service center.
When power fails, backup time is shortened.	The UPS is overload Battery voltage is too low.	Remove some critical load Charge the UPS at least 8 hours
	Battery defective.	Replace the battery with the same type of battery.
The mains is normal but green LED is flashing	Power cord is loose	Reconnect the power cord properly.

Trouble shooting chart

Sl.No	Fault	Possible reason	Trouble shooting
1.	UPS works on 220 VAC mains, but does not operate on battery.	1. Battery fuse is blown 2. Battery is discharged	1. Check the fuse and polarity of battery. If the fuse is blown, replace it, if it is loose, tighten. 2. Recharge the battery
2.	When UPS is switched on, charger does not turn on.	1. Mains input fuse may be blown 2. Charger input fuse may blown	1. Change mains fuse 2. Check the battery polarity and conditions, correct it if wrong replace the fuse. 3. Check the supply from mains. If OK then check relay wiring, check relay coil.
3.	220VAC mains supply NOT available.	1. Input AC mains is very high 2. Capacity of i/p cable is low 3. Loose connection of i/p wiring	1. Check the supply of mains 2. Change cable 3. Tight the connection of wiring coming from distribution board.
4.	DC voltage is OK, but UPS shows DC under voltage and trips.	Inverter fuse is blown	Replace fuse
5.	When the UPS is switched ON with out load, DC under voltage indicator turns ON and inverter turns/trips OFF.	1. Capacity of mains input cable is low 2. Loose connection of input side	1. Use cable with proper rating 2. Tight the connections of input cable
6.	When the UPS is switched on with load, overload indicator turn ON.	Surge in the load	When the output voltage is 230V, add loads one by one.
7.	Where there is no AC mains supply, and the UPS is operating on battery, DC under voltage indicator turns ON.	Battery is discharged state	Recharge the battery use cable with proper current capacity with the battery.
8.	DC fuse blows OFF	1. Skin effect due to long use 2. Overload or short circuit	1. Change DC fuse 2. Reduce the overload. If power transistors are short of leaky replace them.
9.	UPS does not switch ON	1. Supply is stopped due to blown fuse or some break in cable. 2. No DC supply in the control card due to dry soldering loose connection or de soldering	1. Check correct dry soldering loose connection and replace the fuse. 2. Check control card wiring
10.	UPS trips when full load is connected.	Overload cut setting is wrong	Adjust the overload cut setting check the power consumption of the load. When 220v o/p is available, slowly increase the load.

11.	UPS output is high	1. Some connection is broken in the feed back loop 2. Control card is not functioning properly. 3. Over voltage sensing is faulty	1. Check feedback transformer wiring and adjust feed back voltage preset. 2. Check /Replace control card 3. Check overload sensing circuit
12.	When the mains or inverter section turn on, UPS does NOT work.	Output fuse is blown.	Check/Replace output fuse/fuse holder.
13.	Mains switch trips frequently	This could happen when the UPS is operating on generator	Check/set output frequency.
14.	Low battery indication glows	This could be due to the DC capacitor is not getting properly charged	Check/Replace capacitors.
15.	UPS does not switch on in battery mode	Mains earthing is not proper	Check battery, MOSFET, oscillator section, driver section, output section. Check and correct the earthing properly
16.	Battery wire getting burned	This happens if the relay points are joined together.	Check/Replace relays.
17.	Change over time high, computer connected to the UPS reboots during change over.	Check oscillator circuit	Check/Replace ICS and other components of oscillator section
18.	Low backup time	Main filter capacitor	Check battery
19.	MOSFETs getting burned	Battery short	High current from battery

Semiconductor properties and types

Objectives : At the end of this lesson you shall be able to
- **explain the semiconductor properties**
- **define a photo voltaic (PV) cell and state it's application**
- **explain the IV curve of Solar PV cell and factors affecting its performance**
- **state various types of Solar cells and their properties.**

(P-type and N-type semiconductors, PN junction)

Classification of metals based on electrical conductivity:

- Conductors – copper, aluminum etc
- Insulators – wood, paper etc
- Semiconductors – silicon (Si) & Germanium (Ge)

Intrinsic semiconductors:

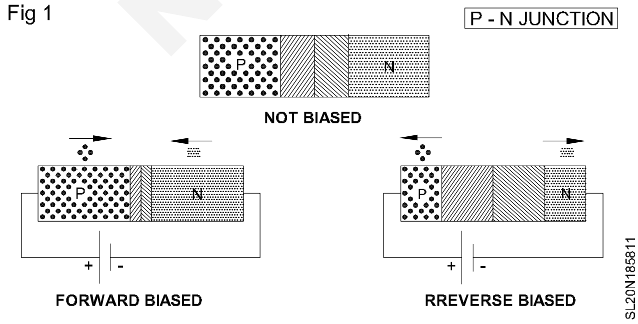
- Pure form of semiconductors
- Tetravalent atoms – each surrounded by four other atoms establishing covalent bonds
- Have two types of current carriers namely electrons and holes
- Electron – hole pairs are thermally liberated carriers

Extrinsic semiconductor:

- Results while impurity (trivalent or pentavalent) atoms are added to the pure tetravalent atoms
- The method of adding impurity to the semiconductor is called DOPING.
- P type semiconductor results by adding trivalent impurity (Al, In, B etc) to the pure silicon.
- P type has holes the majority carriers and electrons the minority carriers.
- N type semiconductor results by adding pentavalent impurity (As, P etc) to the pure silicon.
- N type has electrons the majority carriers and holes the minority carriers.

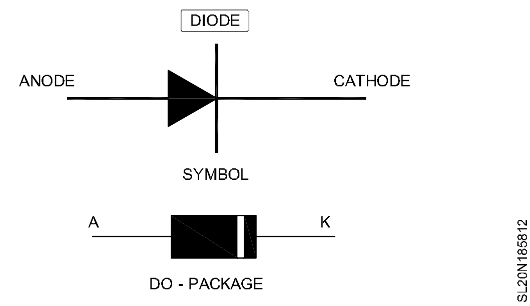
P N junction (Fig 1)

Fig 1



- Formed by fusing/growing together one P-type and one N-type semiconductor.
- All semiconductor devices has one or more P-N junctions
- The combined behaviour of junction(s) will decide the characteristics of the device.
- Hence understanding its characteristics is very important.
- P-N junction has two bias conditions
- Forward bias – when P end is connected to positive terminal of power supply & N end negative
- Reverse bias – when P end is negative & N positive
- Forward bias will reduce the depletion layer and allow the current flow through the junction
- Reverse bias will enhance the depletion layer and block the current flow

Fig 2



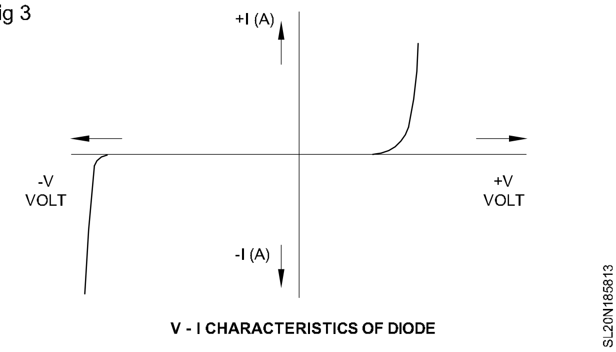
Diode

- A semiconductor diode has one PN junction
- It has two electrodes namely anode and cathode
- A diode behaves similar to the behaviours of a PN Junction in forward & reverse bias conditions

V-I Characteristics:

- Forward bias
- the anode is positive with respect to the cathode
- Reduces the potential barrier
- The junction offers negligible forward resistance to the flow of current (Rf = Zero)
- Diode works like a closed switch
- Reverse bias
- the cathode is positive with respect to the anode
- Enhances the depletion layer

Fig 3



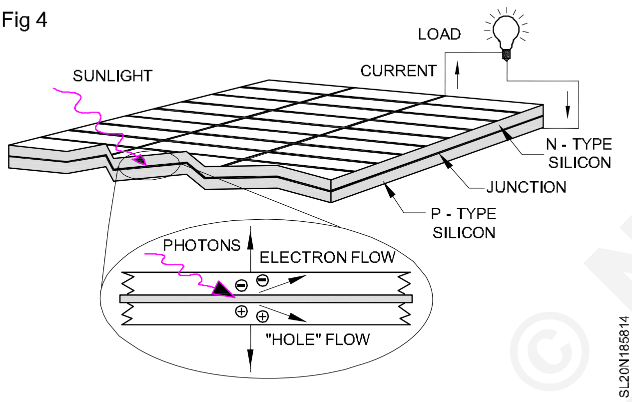
V - I CHARACTERISTICS OF DIODE

- The junction offers very high reverse resistance, (Rr = “) blocking the flow of current
- The diode works like an opened switch.
- **Types :** signal diode, Rectifier diode, Regulator diode, Light Emitting Diode and photo sensitive diode

Conversion of solar radiation to electricity.

Photovoltaic Cell / Solar Cell (Fig 4)

Fig 4



A solar cell or photovoltaic cell is an electrical device that converts the energy of light directly into electricity by the photovoltaic effect. It is a form of photoelectric cell (in that its electrical characteristics e.g. current, voltage, or resistance vary when light is incident upon it) which, when exposed to light, can generate and support an electric current without being attached to any external voltage source. This method converts the sun’s energy into electricity.

A single solar PV cell will have an output of approximately 0.5 V and current of few mA which depends on various factors such as type & quality of the cell, Solar irradiation, incident angle of solar irradiation, shadow, Spectrum of incident radiation etc. They are grouped to get higher outputs.

Applications of solar cells:

The electricity generated by the photoelectric effect can be either used directly or can be stored in batteries or can directly fed into an electric utility’s grid system. The energy stored in the battery (in the form of chemical energy) can be used to operate any electrical device. If the device operates on DC, then it can be directly connected to the output load. If the device operates on AC, then an inverter is required to convert DC into AC.

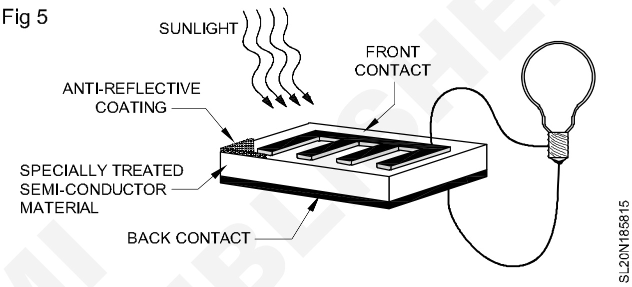
Main materials used to develop solar cells (Silicon, Cadmium tellurides, etc.)

A photovoltaic (PV) cell is an energy harvesting technology that converts solar energy into useful electricity through a process called the photovoltaic effect. There are several different types of PV cells which all use semiconductors to interact with incoming photons from the Sun in order to generate an electric current.

A photovoltaic cell is comprised of many layers of materials, each with a specific purpose. The most important layer of a photovoltaic cell is the specially treated semiconductor layer. It is comprised of two distinct layers (p-type and n-type), and is what actually converts the Sun’s energy into useful electricity through a process called the photovoltaic effect.

Working

Fig 5



On either side of the semiconductor is a layer of conducting material which “collects” the electricity produced. Note that the backside or shaded side of the cell can afford to be completely covered in the conductor, whereas the front or illuminated side must use the conductors sparingly to avoid blocking too much of the Sun’s radiation from reaching the semiconductor. The final layer which is applied only to the illuminated side of the cell is the anti-reflection coating. Since all semiconductors are naturally reflective, reflection loss can be significant. The solution is to use one or several layers of an anti-reflection coating (similar to those used for eyeglasses and cameras) to reduce the amount of solar radiation that is reflected off the surface of the cell.

Photovoltaic cell can be manufactured in a variety of ways and from many different materials. The most common material for commercial solar cell construction is Silicon (Si), but others include Gallium Arsenide (GaAs), Cadmium Telluride (CdTe) and Copper Indium Gallium Selenide (CIGS). Solar cells can be constructed from brittle crystalline structures (Si, GaAs) or as flexible thin-film cells (Si, CdTe, CIGS). Crystalline solar cells can be further classified into two categories—monocrystalline and polycrystalline.

As the names suggest, monocrystalline PV cells are comprised of a uniform or single crystal lattice, whereas polycrystalline cells contain different or varied crystal structures. Solar cells can also be classified by their number of layers or “p-n junctions”. Most commercial PV cells are only single-junction, but multi-junction PV cells have also been developed which provide higher efficiencies at a greater cost.

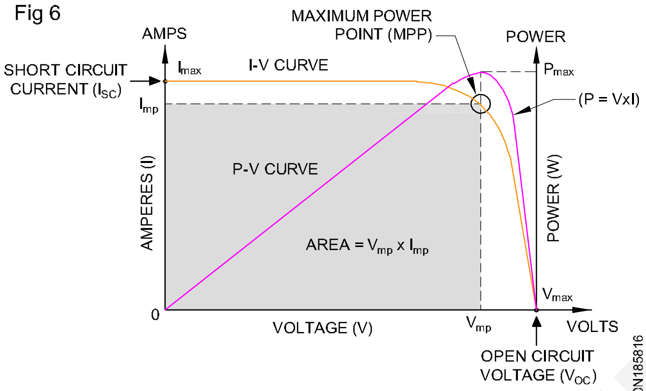
Accordingly, Crystalline Silicon (Si), Amorphous Silicon, Cadmium Telluride (CdTe), Copper Indium Selenide (CIS), Copper Indium Gallium Selenide(CIGS) are the main materials used to develop Solar Cells.

Light sensitive properties of PN junction.

P-N junction diode in the reverse-biased configuration is sensitive to light from a range between 400nm to 1000nm, which includes VISIBLE light. Therefore, it can be used as a photodiode. It can also be used as a solar cell. P-N junction forward bias condition is used in all LED lighting applications. The voltage across the P-N junction biased is used to create Temperature Sensors, and Reference voltages.

I-V curve

Fig 6



SOLAR CELL I-V CHARACTERISTIC CURVE

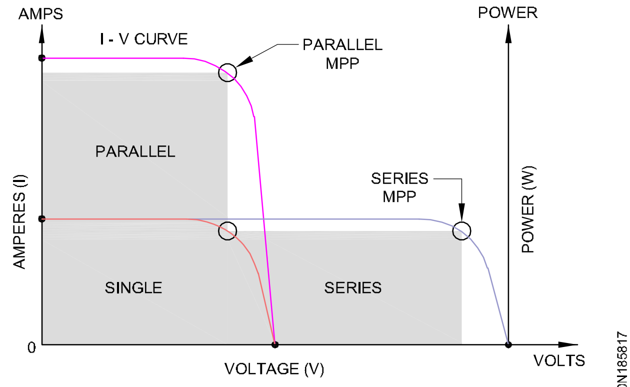
The solar cell I-V characteristics curves shows the current & voltage (I-V) characteristic of a particular photovoltaic (PV) cell, module or array. If gives a detailed description of its solar energy conversion ability and efficiency. Knowing the electrical I-V characteristics (more importantly Pmax) of a solar cell, or panel is critical in determining the device's output performance and solar efficiency.

Photovoltaic solar cells convert the suns radiant tight directly into electricity. With increasing demand for a clean energy source and the sun's potential as a free energy source, has made solar energy conversion as part of a mixture of renewable energy source increasingly important.

The above graph shows the current voltage (IV) characteristics of a typical silicon PV cell operating under normal conditions. The power delivered by a single solar cell or panel is the product of its output current and voltage (IV) If the multiplication is done, point to point for all voltage from short- circuit to open circuit conditions, the power curve above is obtained for a given radiation level.

With the solar cell open circuited, that is not connected to any load, the current will be at its minimum (o) and the voltage across the cell and its maximum, known as the solar cell open circuit voltage or VOC. At the other extreme when the solar cell is short circuited that is the positive and negative leads connected together, the voltage across the cell is at its minimum (Zero) but the current flowing out of the cell reaches its maximum, known as the solar cell short circuit current or Isc.

Fig 7



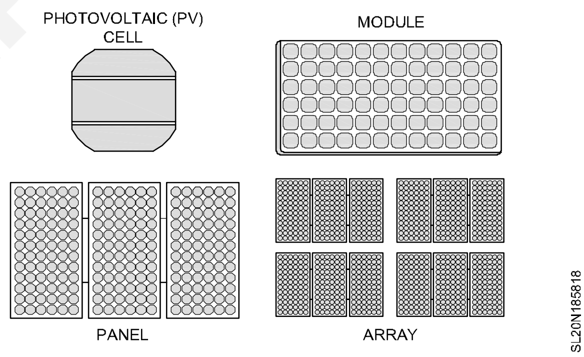
SOLAR PANEL I-V CHARACTERISTIC CURVES

PV panels can be wired or connected together in either series or parallel combination, or both to increase the voltage or current capacity of the solar array. If the array panels are connected together in a series combination. Then the voltage increase and if connected together in parallel then the current increases.

The electrical power in walts, generated by these different photovoltaic. Combinations will still be the product of the voltage times the current, (P= V x I). However the solar panels are connected together, the upper right hand. Corner will always be the Maximum Power Point (MPP) of the array.

Comparison of a cell, panel and array (Fig 8)

Fig 8

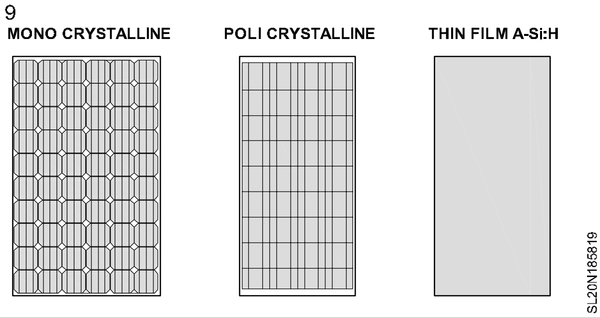


Selection of Solar PV panel

We should understand various features about a solar PV panel to be considered while buying it. Here we have a short look into it.

Types of Solar panel (Fig 9)

Fig 9



Points to remember for selection of a solar PV panel

1 Type

2 Size

3 Specification

4 Test certificate

5 Quality standard

Type

- Monocrystalline
- Poly/Multi crystalline
- Thin film

Size

- Peak power output (WP)
- Specification
- For selected WPlook for
- VM: Maximum voltage at WP
- IM: Maximum current at WP
- Maximum system voltage
- Standard Testing Condition (STC)

Typical Specifications of a solar panel (Label on backside of a panel) (Fig 10)

Fig 10

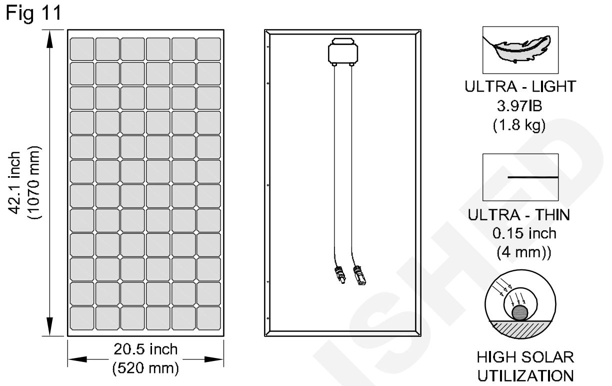
SL20N18581A

- Test Certificate
- Manufacturer's test certificate
- Quality Standard

Backside of the Solar Panel (Fig 11)

In a designer approved Single Line Diagram (SLD) the above points are already considered and made available in SLD and part list. The technician can verify as far as possible the panels issued for installation or drawn from store shall have these information correct.

Fig 11



SL20N18581B

Standard test conditions (STC) of a PV module.

Every manufacturer tests their modules under something called Standard Test Conditions (STC).

STC is a set of rules to follow at manufacturing industry. These rules allow consumers and solar designers to compare panels.

Energy sources

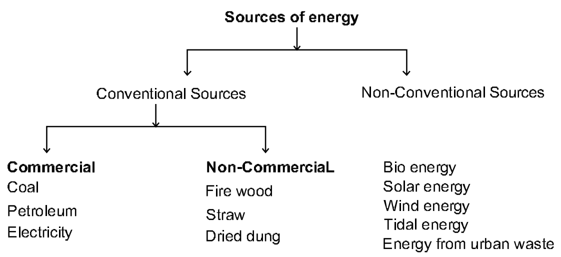
Objectives : At the end of this lesson you shall be able to
- **define energy**
- **list out the types of energy**
- **discuss about conventional energy and its types**
- **state renewable energy and its types**
- **differentiate conventional and non conventional sources of energy.**

Energy

Energy is one of the most important components of economic infrastructure.

Main sources of energy

The source of energy is following two types.



Conventional sources of energy

The conventional sources of energy is also called Non renewable energy source. These sources of energy are in limited quantity.

The conventional energy sources are classified in two types like Commercial and non-commercial.

Commercial conventional energy

Coal, petroleum and electricity, these are called commercial energy because they have a price and consumer has to pay the price to purchase them.

Coal

Coal is a major conventional energy sources. It was formed from the remains of the trees and ferns grew in swamps around 500 millions year ago. The bacterial and chemical decomposition of such plant debris (which remained buried under water or clay) produced an intermediate product known as peat which is mainly cellulose $(C_6H_{10}O_5)n$.

$$\text{Plants} \xrightarrow[\text{and Chemical action}]{\text{Bacterial}} \text{Peat} \xrightarrow[\text{Pressure}]{\Delta} \text{Lignite} \xrightarrow[\text{Pressure}]{\Delta\Delta} \text{Bituminous coal} \xrightarrow[\text{Pressure}]{\Delta\Delta} \text{Anthracite coal}$$

Coal deposits in India are 148790 million tonnes. Total lignite reserves found at Neyveli are 3300 million tonnes. In 1950-51, annual production of coal was 32 million tonnes. In 2005-06, annual production of coal was 343 million tonnes.

Coal deposits are mainly found in Orissa, Bihar, Bengal and Madhya Pradesh.

Petroleum or oil and natural gases

Oil is considered as the most important source of energy in India and the world. It is widely used in automobiles, trains, planes and ships etc.

Petroleum is a complex mixture of hydrocarbons, mostly alkanes and cycloalkanes. It occurs below the earth crust entrapped under rocky strata. In its crude form, the viscous black liquid is known as petroleum and a gas in contact with petroleum layer which flows naturally from oil wells is termed as natural gases. The composition of natural gas is a mixture of mainly methane, (95.0%), small amounts of ethane, propane and butane (3.6%) and traces of CO_2 (0.48%) and N_2 (1.92%).

A liquid mixture of propane and butane can be obtained from natural gas or refinery gases at room temperature under a pressure of 3-5 atmospheres. This is stored and distributed in 40-100 liter capacity steel cylinders.

Natural gas has been the most important source of energy since last two decades. It can be produced in two ways:

(i) With petroleum products as associated gas.

(ii) Free gas obtained from gas fields in Assam, Gujarat and Andhra Pradesh.

Electricity

Electricity is the common and popular source of energy. It is used in commercial and domestic purposes. It is used for lighting, cooking, air conditioning and working of electrical appliances like T.V., fridge and washing machine.

Fuel woods

The rural peoples require fuel wood or fire Wood for their day to day cooking which are obtained from natural forests and plantations. Due to rapid deforestation, the availability of fire wood or fuel wood becomes difficult. This problem can be avoided by massive afforestation (plantation) on degraded forest land, culturable waste land, barren land grazing land etc.

Hydropower

Energy obtainable from water flow or water falling from a higher potential to lower potential, is known is hydropower. It is a conventional and renewable form of energy which can be transmitted to long distance through cables and wires.

Nuclear energy

A small amount of radioactive substance (U^{235}) can produce a lot of energy through the process of nuclear fission. For example, one ton of uranium can provide energy which is much higher than three million tons of coal or 12 million barrels of oil. In order to obtain nuclear energy, nuclear reactors are required. There are around 300 nuclear reactors all over the world. India has only four nuclear power stations (reactors).

Non- conventional Energy or Renewable Energy

Renewable energy is energy that is generated from natural processes that are continuously replenished. This includes sunlight, geothermal heat, wind, tides, water, and various forms of biomass. This energy cannot be exhausted and is constantly renewed.

Renewable energy source types

1 Solar power

Fig 3

Solar Power

2 Wind power

Fig 4

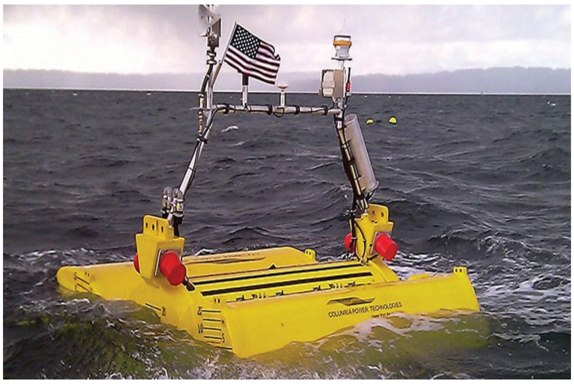
Wind Power

3 Tidal Energy

4 Geothermal

5 Hydroelectricity/micro hydro

Fig 5



Tidal Energy

Fig 6

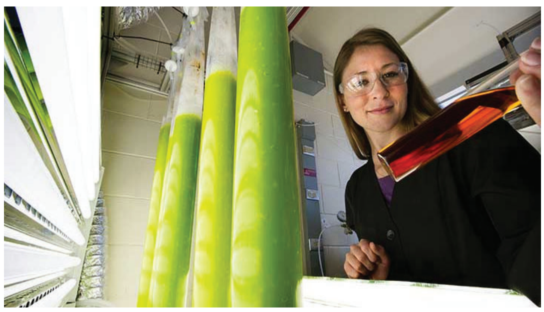
Geothermal

Fig 7

Hydroelectricity/micro hydro

6 Biomass and bio-fuels

Fig 8



BIOMASS

Difference between conventional energy and non conventional energy

S.No	Conventional energy	Non conventional energy
1.	Conventional energy, such as thermal powers (from coal, petroleum, and natural gas), hydel power (from high velocity of running water) are tapped and used abundantly at present.	Non-conventional sources of energy (solar energy, tidal energy, geo-thermal energy, wind energy etc) are not used frequently and in large scale (commercially).
2.	Their uses are practiced for a long time.	Their uses are comparatively more recent.
3.	Except hydel power, the sources of thermal power i.e. other conventional energies are non renewable in nature.	But the sources of non-conventional energy are flow-resources. There is no anxiety for their exhaustion.
4.	Except hydel power, the generation of other conventional energy produces air pollution.	But the generation of non-conventional energy does not produce air pollution.
5.	Except hydel power, the other conventional energy is costly.	But comparatively, the non-conventional energy is much cheaper.

Solar cells (photovoltaic cell)

Objectives : At the end of this lesson you shall be able to
- **define solar cells**
- **describe working of photovoltaic's cell**
- **explain photovoltaic cell basics**
- **list the types of solar cells**
- **differentiate monocrystalline and polycrystalline solar panels.**

Solar cells or photovoltaic cell

Photovoltaic: Photovoltaic (PV) materials and devices convert sunlight into electrical energy, and PV cells are commonly known as solar cells.

Photovoltaic cells

Photovoltaic (PV) cells, or solar cells, take advantage of the photoelectric effect to produce electricity. PV cells are the building blocks of all PV systems because they are the devices that convert sunlight to electricity.

PV cells come in many sizes and shapes, from smaller than a postage stamp to several inches across.

Crystalline silicon cells

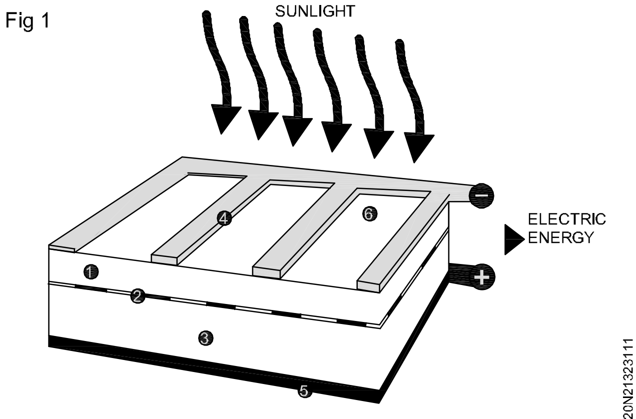
Crystalline silicon PV cells are the most common photovoltaic cells in use today. They are also the earliest successful PV devices. Therefore, crystalline silicon solar cells provide a good example of typical PV cell functionality.

Working principle of photovoltaic cell or solar cell

Photovoltaic cell consists of high-purity silicon. On the silicon, a PN (positive-negative) junction was formed as a potential barrier. Photons falling on the PN junction cause the rise of pairs of opposite electrical charge carriers (electron - hole), which as a result of the presence of PN junction are separated into two different directions. Electrons go to the semiconductor N and holes go to the semiconductor P. The voltage will arise on the junction.

Because the separated electrical charges are redundant carriers, having so called, infinite life and a PN junction voltage is constant, the junction, on which the light falls acts as a stable electric cell.

Fig 1



CONSTRUCTION OF PHOTOVOLTAIC CELL

1 Semiconductor n

2 p-n junction

3 Semiconductor p

4 Metallic connection

5 Anti-glare material

Cell coating

Silicon is a shiny grey material that can act as a mirror by reflecting more than 30% of the light that impinges on it. To improve the conversion efficiency of a solar cell, the amount of light reflected must be minimized. Two techniques are commonly used to reduce reflection.

The first technique is to coat the top surface with a thin layer of: silicon monoxide (SiO). A single layer reduces surface reflection to about 10%, and a second layer can lower the reflection to less than 4%.

The second technique is to texture the top surface. Chemical etching creates a pattern of cones and pyramids, which captures light rays that might otherwise be deflected away from the cell. Reflected light is redirected into the cell, where it has another chance to be absorbed.

Solar cell materials

Silicon (Si) - including single - crystalline Si, multicrystalline Si, and amorphous Si

Polycrystalline thin films - including copper indium diselenide (CIS), cadmium telluride (CdTe), and thin-film silicon

Single-Crystalline thin films - including high-efficiency material such as gallium arsenide (GaAs).

Photovoltaic cell basics

Crystalline silicon cells are the most common type, photovoltaic (PV), or solar cells, can be made of many semiconductor materials. Each material has unique strengths and characteristics that influence its suitability for specific applications. For example, PV cell materials may differ based on the crystallinity, bandgap, absorption, and manufacturing complexity.

Crystallinity

The crystallinity of a material indicates how perfectly ordered the atoms are in the crystal structure. Silicon, as well as other solar cell semiconductor materials, comes in various forms, including:

1 Single-crystalline,
2 Multicrystalline,
3 Polycrystalline, and
4 Amorphous

In a single-crystal material, the atoms that make up the framework of the crystal are repeated in a very regular, orderly manner from layer to layer. In contrast, in a material composed of numerous smaller crystals, the orderly arrangement is disrupted moving from one crystal to another.

Bandgap

The bandgap of a semiconductor material is the minimum energy needed to move an electron from its bound state within an atom to a free state.

This free state is where the electron can be involved in conduction.

The lower energy level of a semiconductor is called the valence band. The higher energy level where an electron is free to roam is called the conduction band.

The bandgap (often symbolized by Eg) is the energy difference between the conduction and valence bands.

Absorption

The absorption coefficient of a material indicates how far light with a specific wavelength (or energy) can penetrate the material before being absorbed. A small absorption coefficient means that light is not readily absorbed by the material.

The absorption coefficient of a solar cell depends on two factors:

1 The material of the cell and the
2 Wavelength or energy of the light being absorbed

Solar cell material has an abrupt edge in its absorption coefficient because light with energy below the material's bandgap cannot free an electron.

Manufacturing complexity

The most important parts of a solar cell are the semiconductor layers because this is where electrons are freed and electric current is created.

Several semiconductor materials can be used to make the layers in solar cells, and each material has its benefits and drawbacks. The cost and complexity of manufacturing varies across materials and device structures based on many factors, including deposition in a vacuum environment, amount and type of material used, number of steps.

1 Semiconductor n
2 p-n junction
3 Semiconductor p
4 Metallic connection
5 Anti-glare material

Cell coating

Silicon is a shiny grey material that can act as a mirror by reflecting more than 30% of the light that impinges on it. To improve the conversion efficiency of a solar cell, the amount of light reflected must be minimized. Two techniques are commonly used to reduce reflection.

The first technique is to coat the top surface with a thin layer of: silicon monoxide (SiO). A single layer reduces surface reflection to about 10%, and a second layer can lower the reflection to less than 4%.

The second technique is to texture the top surface. Chemical etching creates a pattern of cones and pyramids, which captures light rays that might otherwise be deflected away from the cell. Reflected light is redirected into the cell, where it has another chance to be absorbed.

Solar cell materials

Silicon (Si) - including single - crystalline Si, multicrystalline Si, and amorphous Si

Polycrystalline thin films - including copper indium diselenide (CIS), cadmium telluride (CdTe), and thin-film silicon

Single-Crystalline thin films - including high-efficiency material such as gallium arsenide (GaAs).

Photovoltaic cell basics

Crystalline silicon cells are the most common type, photovoltaic (PV), or solar cells, can be made of many semiconductor materials. Each material has unique strengths and characteristics that influence its suitability for specific applications. For example, PV cell materials may differ based on the crystallinity, bandgap, absorption, and manufacturing complexity.

Crystallinity

The crystallinity of a material indicates how perfectly ordered the atoms are in the crystal structure. Silicon, as well as other solar cell semiconductor materials, comes in various forms, including:

1 Single-crystalline,

2 Multicrystalline,

3 Polycrystalline, and

4 Amorphous

In a single-crystal material, the atoms that make up the framework of the crystal are repeated in a very regular, orderly manner from layer to layer. In contrast, in a material composed of numerous smaller crystals, the orderly arrangement is disrupted moving from one crystal to another.

Bandgap

The bandgap of a semiconductor material is the minimum energy needed to move an electron from its bound state within an atom to a free state.

This free state is where the electron can be involved in conduction.

The lower energy level of a semiconductor is called the valence band. The higher energy level where an electron is free to roam is called the conduction band.

The bandgap (often symbolized by Eg) is the energy difference between the conduction and valence bands.

Absorption

The absorption coefficient of a material indicates how far light with a specific wavelength (or energy) can penetrate the material before being absorbed. A small absorption coefficient means that light is not readily absorbed by the material.

The absorption coefficient of a solar cell depends on two factors:

1 The material of the cell and the

2 Wavelength or energy of the light being absorbed

Solar cell material has an abrupt edge in its absorption coefficient because light with energy below the material's bandgap cannot free an electron.

Manufacturing complexity

The most important parts of a solar cell are the semiconductor layers because this is where electrons are freed and electric current is created.

Several semiconductor materials can be used to make the layers in solar cells, and each material has its benefits and drawbacks. The cost and complexity of manufacturing varies across materials and device structures based on many factors, including deposition in a vacuum environment, amount and type of material used, number of steps involved, and the need to move cells into different deposition chambers

Types of solar cells

There are four types solar cells

1. Monocrystalline silicon solar cell
2. Polycrystalline (or multi-crystalline) solar cell
3. Amorphous/thin film solar cell
4. Hybrid silicon solar cell

Monocrystalline silicon solar cell

Monocrystalline solar cells are made out of silicon ingots, which are cylindrical in shape. To optimize performance and lower costs of a single monocrystalline solar cell, four sides are cut out of the cylindrical ingots to make silicon wafers, which give monocrystalline solar panels their characteristic look.

Polycrystalline silicon solar cells

Solar panels based on polycrystalline silicon, which also is known as polysilicon (p-Si) and multi-crystalline silicon (mc-Si), unlike monocrystalline-based solar panels, polycrystalline solar panels do not require the Czochralski process. Raw silicon is melted and poured into a square mold, which is cooled and cut into perfectly square wafers.

Thin-Film solar cells (TFSC)

Depositing one or several thin layers of photovoltaic material onto a substrate is the basic gist of how thin-film solar cells are manufactured. They are also known as thin-film photovoltaic cells (TFPV). The different types of thin-film solar cells can be categorized by which photovoltaic material is deposited onto the substrate:

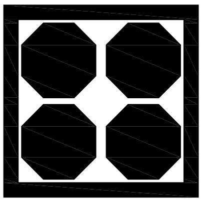
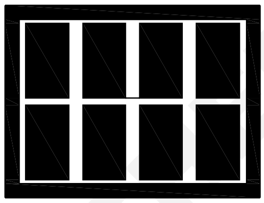
1. Amorphous silicon (a-Si)
2. Cadmium telluride (CdTe)
3. Copper indium gallium selenide (CIS/CIGS)
4. Organic photovoltaic cells (OPC)

Depending on the technology, thin-film module prototypes have reached efficiencies between 7-13% and production modules operate at about 9%. Future module efficiencies are expected to climb close to the about 10-16%.

Hybrid silicon solar cell

Hybrid solar panels are made from a mix of amorphous and monocrystalline cells to generate maximum efficiency. There are a variety of types of hybrid cells and they are still very much at the research and development stage.

Difference between monocrystalline and polycrystalline solar panels

Sl.No.		Monocrystalline solar panels	Polycrystalline solar panels
1.	Shape	Square with missing corners	square shaped
2.	Colour	Black	Blue / metal shard
3.	Efficiency	high	low
4.	Sensitive	high	low
5.	Cost	high	Low
6.	Panel type		
7.	Cell arrangement	One direction	Made up of several bits
8.	Angle	Correct angle	All angle

Photovoltaic systems materials

Objectives : At the end of this lesson you shall be able to
- **discuss about the photovoltaic system**
- **explain the photovoltaic module or panel**
- **describe the working of solar panel and photovoltaic array**
- **differentiate solar cell and module array.**

Photovoltaic system

Photovoltaic (PV), or solar electric system, is made up of several photovoltaic solar cells.

An individual PV cell is usually small, typically producing about 1 or 2 watts of power. To boost the power output number of PV cells are connected together to form larger units called modules. Modules, in turn, can be connected to form even larger units called arrays, which can be interconnected to produce more power, and so on. In this way, PV systems can be built to meet almost any electric power need, small or large

Photovoltaic cells or solar cell

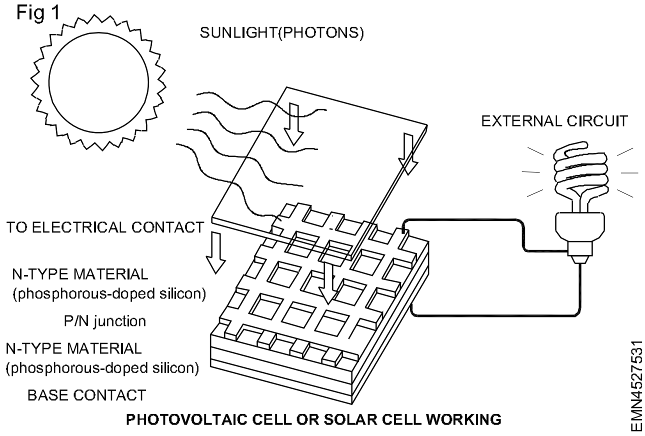
Photovoltaic (PV) cells, or solar cells, take advantage of the photoelectric effect to produce electricity. PV cells are the building blocks of all PV systems because they are the devices that convert sunlight to electricity.

PV cells come in many sizes and shapes, from smaller than a postage stamp to several inches across.

Photovoltaic cell or solar cell working

A PV / Solar cell is a semiconductor device that can convert solar energy into DC electricity through the "Photovoltaic Effect" (conversion of solar light energy into electrical rays energy) as shown in Fig 1. When light rays impinges on a PV/solar cell, it may be reflected, absorbed, or passes right through. But only the absorbed light generates electricity.

Fig 1



PHOTOVOLTAIC CELL OR SOLAR CELL WORKING

Photovoltaic Module or solar panel

A solar module is an individual solar panel - consisting of multiple solar cells, wiring, a frame, and glass. PV or solar modules are manufactured in standard sizes such as 36-cell, 60-cell and 72-cell modules. The term solar panel is sometimes used interchangeably with solar module

Photovoltaic or solar panel working

Solar panels work through photovoltaic process - where radiation energy (photo) is absorbed and generates electricity (voltaic).

Radiation energy is absorbed by semi conductor cells - normally silicon - and transformed from photo energy (light) into voltaic (electrical current).

The sun's radiation hits a silicon atom; a photon of light energy is absorbed and released electrons to create an electric current.

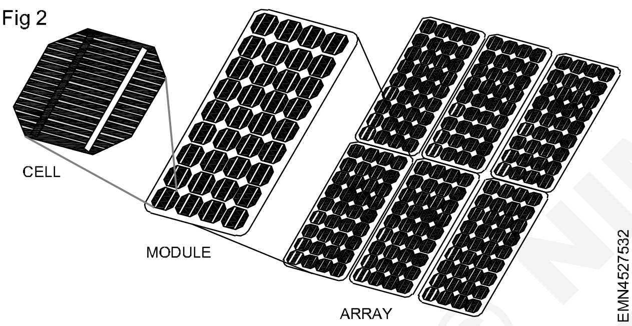
The electric current then goes to an inverter unit, which converts the current from DC (direct current) to AC (alternating current).

The system is then connected to the mains power or electricity grid.

Photovoltaic array

Photovoltaic array is the complete power-generating unit, consisting of any number of PV modules and panels, as shown in Fig 2.

Fig 2



Photovoltaic array working

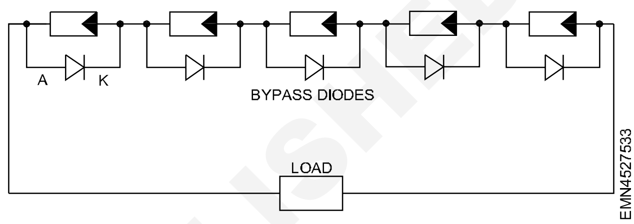
The Sun generates photons that stream down to earth as visible light. Solar cells convert the energy of light directly into electricity. Assemblies of solar cells are used to make solar modules (or panels). One or more solar panels are typically put together on a rack that faces the sun called an array. Some racks have motors that keep them pointed directly at the sun as it moves across the sky. The DPU-NEDO racks are fixed and do not move to track the sun.

Many racks of solar panels are typically lined up into long columns and those columns form a large scale Photovoltaic Array, "Solar Array," or Grid. The array generates direct current (DC) electrical power. The DC power (480 volts) must be converted to Alternating Current (AC) by inverters in order for the power to be fed into transformers that setup the power to Electrical Grid after passing through a Vista power switch.

By pass diode

PV / Solar cells are wired in series and in parallel to form a PV / Solar Panel (Module). The number of series cells indicates the voltage of the Panel (Module), whereas the number of parallel cells indicates the current. If many cells are connected in series, shading of individual cells can lead to the destruction of the shaded cell or of the lamination material, so the Panel (Module) may blister and burst. To avoid such an operational condition, Bypass Diodes are connected anti-parallel to the solar cells as in Fig.3 As a consequence, larger voltage differences cannot arise in the reverse-current direction of the solar cells. In practice, it is sufficient to connect one bypass diode for every 15-20 cells. Bypass diodes also allow current to flow through the PV module when it is partially shaded, even if at a reduced voltage and power. Bypass diodes do not cause any losses, because under normal operation, current does not flow through them.

Fig 3



Battery

Battery can be defined as direct current (DC) electrical energy storage. Even PV system that is connected to a grid can often benefit from a battery backup system where outages are a concern.

Inverter

The DC-AC inverter converts direct current (DC) power into alternating current (AC) for use in appliances, electronics and other devices.

Charge controller

A charge controller regulates, charges, and maintains battery voltage.

Electrical load

Electrical load includes the appliances and other device that use of energy generated by the PV system. Electrical load can be either DC or AC; it is possible to have both kinds of electrical load on the same PV system.

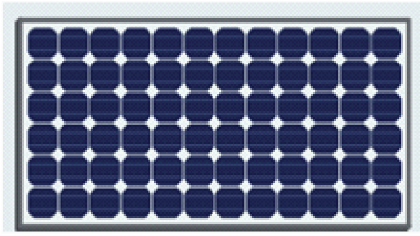
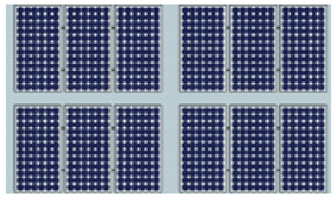
Wiring

The wiring includes the wires also known as conductors that connect the system components to complete circuit.

Surge protector

A surge protector is device that safeguards against electrical shock from short circuit and damaging power fluctuations.

Difference between solar cell, module & array

Sl.No	Solar cell	Solar module	Solar array
1			
2	The basic element of a PV system is photovoltaic (PV) cell, also called solar cell.	A number of individual PV series cells are interconnected together in a sealed, weatherproof package called a Panel (Module)	Modules are wired in parallel is called a PV Array

Solar electric system

Objectives : At the end of this lesson you shall be able to
- **define solar power**
- **describe the block diagram of solar electric system**
- **explain briefly about the components of solar electric system**
- **discuss about types of solar electric system**
- **discuss about sizing of solar electric system**
- **list out the advantages and disadvantages of solar electric system.**

Solar power

Solar power is the conversion of sunlight into electricity, either directly using photovoltaic's (PV), or indirectly using concentrated solar power.

Solar power working principles

Solar heating principles

Solar heating systems perform the following three basic functions.

Collection: Radiant energy from the Sun is captured and converted to solar thermal energy using solar collectors.

Storage: The solar thermal energy is stored using thermal mass, water tanks, or rock bins.

Distribution: Distribution of the heat can be done with both active solar energy and passive solar energy methods. Example: Solar space heating, solar water heating, and solar pool heating systems.

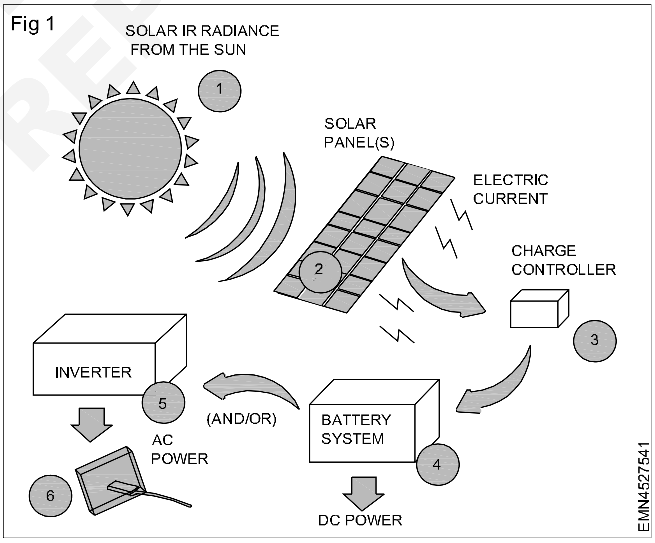
Solar electricity principles

Solar electric systems use solar cells to convert the Sun's radiant energy into electricity. This is done using a principle known as the photovoltaic effect.

Solar energy block diagram

Solar panels convert sunlight into DC electricity, which is stored via a charge controller into batteries; DC loads can be run directly off these batteries. Cables from the batteries go to an inverter, which changes the DC to AC to run the conventional household loads.

Fig 1



Components of Solar Electric System

Photovoltaic module

Photovoltaic module consists of solar cells which convert light into electricity. When light photons are absorbed by the atomic electrons in the semiconductor material from which the solar cells are made. Each photon absorbed causes an electron to be freed from its atom and drift through the semiconductor material in an electric field created by p-n junction formed just below the surface of the solar cell. The free electrons and the resultant positive changes are collected by metallic contacts applied to the front and back surfaces of the solar cells thereby setting up an electron current which is made to flow through an electrical circuit to deliver power just like a storage battery. The current produced by a solar cell is proportional to its surface area and the light intensity, whereas the voltage is limited by the forward potential drop across the p-n junction.

In order to get higher voltages and currents, the cells are arranged in series and parallel strings and packed into modules for mechanical protection. The support structure for PV modules should be corrosion resistant (galvanized or stainless steel or aluminum) and electrolytically compatible with materials used in the module frame, fasteners, nuts, and bolts. The design of the support structure should allow for proper orientation of the module and tilt.

Charge controller

As PV cell costs continue to fall, the battery in a stand-alone PV system becomes an increasingly large part of the system cost. Battery's life now has the greatest impact on the economic viability of solar electric system. The controller must manage a rapid, yet safe, recharge under a very diverse range of system conditions. The charge controller in small stand-alone systems is the primary driver of system reliability and battery life. An advanced controller will affect the system performance more than any other component, and an improved controller will on the long run reduce the system's cost as the battery won't need to be replaced often.

Battery

The most commonly used battery in solar electric systems is a lead-acid battery of the type used in automobiles, sized to operate for desired hours or days. Automotive batteries are often used because they are relatively inexpensive and readily available. Ideally, solar electric systems should use deep cycle lead-acid batteries that have thicker plates and more electrolyte reserves than automotive batteries and allow for deep discharge without seriously reducing the life of the battery or causing damage. In a well designed solar electric system, such batteries can last for more than ten years.

Inverter

An inverter is a basic component of any independent power system that produces AC power. Inverters convert DC power from PV module or stored in batteries into AC power to run conventional appliances. Another application of inverter is in the case of uninterruptible power supply where the inverter with the aid of 12V DC battery is able to generate up to 220V AC that can be used to power most house and office appliances depending of their power rating. While one needs to buy PV module and battery, a hobbyist who likes putting things together may personally love to build an inverter for his solar electric project by himself. Of course I do for personal uses. Why the waste of time and resources when there are cheap and neatly packaged inverters in the market.

Types of solar electric system:

Solar electric system can be classified into two major types.

1 Off-grid systems

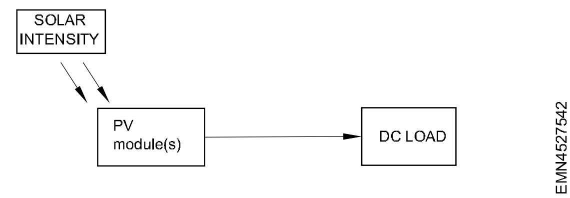
2 Grid-tied systems

Off - grid systems

Off- grid system also called stand-alone systems. Although they are most common in remote locations without utility grid service, off-grid solar-electric systems can work anywhere. These systems operate independently from the grid to provide household's electricity. That means no electric bills and no blackouts-at least none caused by grid failures. They are generally designed and sized to supply DC and/or AC electrical load. People choose to live off-grid for different reasons, including the prohibitive cost of bringing utility lines to remote home sites, the appeal of an independent lifestyle, or the general reliability a solar-electric system provide. Those who choose to live off-grid often need to make adjustments to when and how they use electricity, so they can live within the limitations of the systems design.

The simplest type is the direct-coupled system, where the DC output of a PV module is directly connected to a DC load. The critical part of designing a well performing direct-coupled system is the matching of impedance of the electrical load to the maximum power output of the PV module. It can be used to operate pumping machine where water is pumped in the day to reservoir for used in the night. The drawbacks in this type of off-grid are:

Fig 2



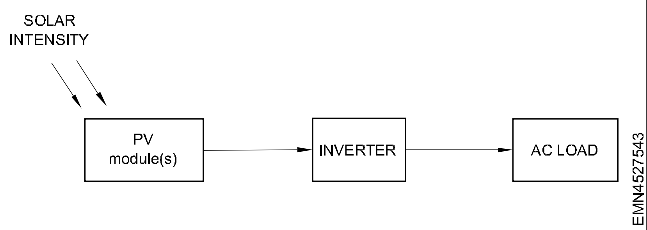
1 It can only be used in the day to supply load as there is no battery for storing energy.

2 It cannot be used with AC load.

Direct-coupled system

Another type of off-grid system is the type that incorporate inverter unit for conversion of DC voltage to AC at appropriate voltage level. The only drawback of this system is the lack of storage unit, so it will not supply load at night. The block diagram is shown in Fig 3.

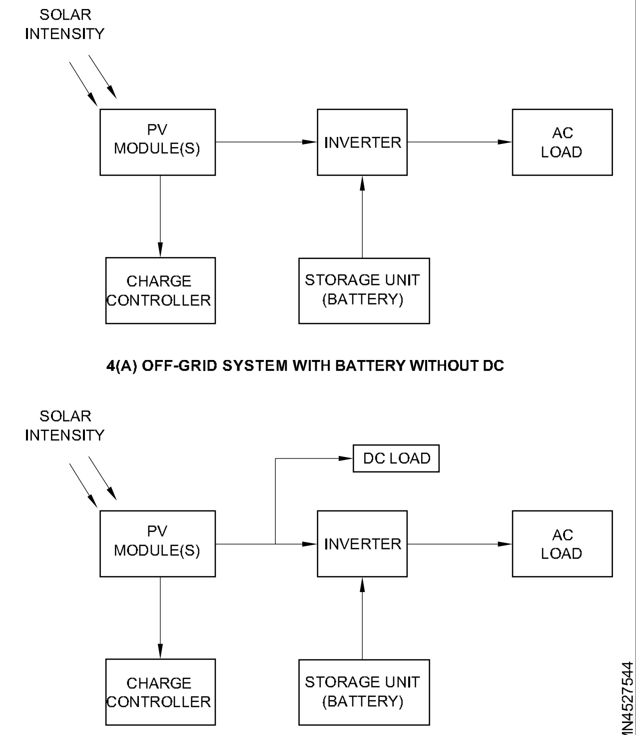
Fig 3



System with inverter

The problem of no electricity generation in the night is eliminated with the inclusion of storage unit (batteries) as backup energy in the night. The block diagrams of this type is shown in Fig 4.

Fig 4

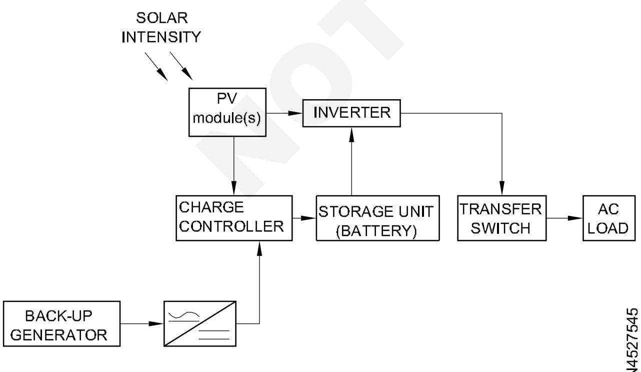


4(A) OFF-GRID SYSTEM WITH BATTERY WITHOUT DC

4(B) OFF-GRID SYSTEM WITH BATTERY WITH DC

Off grid systems can also be sized to provide electricity during cloudy periods when the sun doesn't shine. Sizing a system to cover a worst-case, like several clouds days can result in a very large expensive system that rarely get used to its capacity. To reduce cost, it is sized moderately, but includes a back-up engine generator to get through occasional sunless stretches. The generator produces AC electricity that a battery charger (either stand-alone or incorporated into the system) converts to DC energy, which is stored in batteries. Below is the block diagram of this type of stand-alone system with generator back-up.

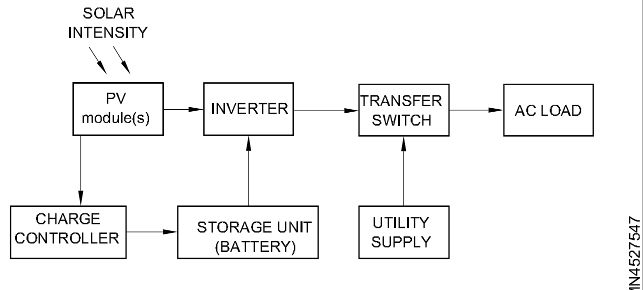
Fig 5



OFF-GRID SYSTEM WITH ENGINE GENERATOR AS BACK-UP

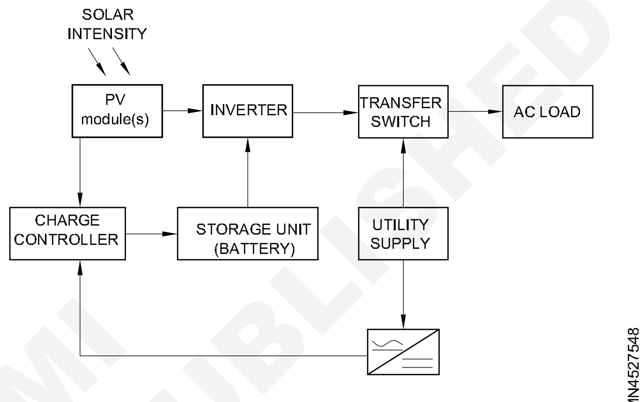
Grid-tied system can also be connected in a way that utility supply will be charging battery in the period of low light intensity. It has the same features as off-grid system with engine generator back-up. In the case of long cloudy days and utility outage, there is likely to be blackout.

Fig 6



GRID-TIED SYSTEM WITH BATTERIES FOR STORING CHARGES

Fig 7



GRID-TIED SYSTEM WITH UTILITY CONNECTED TO CHARGE BATTERY

Sizing solar electric system

Before sizing various components of solar electric system, need to find out what average energy usage is.. Dividing this by the number of days of the month gives you an average daily energy usage.

It is also important to estimate various losses associated with installation. Some of these include losses due to orientation of PV module, shade, dust, temperature effect, name plate mismatch, cable loss, semiconductor loss (in inverter), running power of charge controller etc.

Sizing of PV module

The capacity of modules is given in watt-peak. This allows for calculation of electricity generated under different levels of sunshine. To standardize the capacity of solar PV modules, the capacities are given at an illumination at exactly 1000 watts per square meter. One watt-peak generate one watt of electricity under the standard test conditions of 1000 watts per square meter and temperature of 25ºC.

Again, one needs to know the amount of sun that is available. Meteorological tables show the solar insulation (usually in KWh/m^2/day). This is different from day to day and shows a seasonal variation over the year. It is safe to design the system based on the average daily insulation in the month with lowest insulation. The easiest way to know the average daily insulation of area is to search the internet: someone must have published something on that.

Having done that, you can now slot in all the information into the formula below to get the required PV module size in watt-peak (W_p)

$$\frac{\text{Daily energy consumption}}{\text{Insolation x efficiency}}$$

Sizing of battery bank

Batteries are rated in ampere-hour (AH) and the sizing depends on the household energy consumption.

Due to low voltage disconnect, one does not use the complete battery capacity. Only certain percentage (discharge capacity) of the battery would be used. A deep-cycle battery can be discharged up to 80% (actual value depends critically on the low voltage setting) of its capacity. Now battery is sized with the formula below.

$$\text{Battery size(AH)} = \frac{\text{Daily energy consumption}}{\text{battery voltage x discharge capacity}}$$

If the system is being designed to power ac load and inverter is needed, one has to put into consideration the inverter efficiency. The formula above can be modified to

$$\text{Battery size (AH)} = \frac{\text{Daily energy consumption}}{\text{battery voltage x discharge capacity x inverter efficiency}}$$

Advantages of solar electric system

1 Renewable energy source

2 Reduces electricity bills

3 Diverse application

4 Low maintenance cost

5 Technology development

Disadvantages of solar electric system

1 Initial installation cost is very high.

2 Affected due to weather condition.

3 Battery storage is expensive.

4 Uses a lot of space.

SPV system and solar charge controller

Objectives : At the end of this lesson you shall be able to
- **describe SPV system**
- **list the types of SPV system**
- **differentiate SPV system and conventional power**
- **define charger control**
- **list types of solar charger control**
- **explain working of solar charger control**
- **state the application of solar charger control.**

SPV system

Solar photo Voltaic means generation of voltage from sunlight. Photovoltaic cells are also called solar cells and these cells converts light energy in to electric energy.

Though the Photovoltaic cells can produce electric energy in the presence of light but cannot store it. As soon as the source of light is removed, they stop generating electric energy. It is a known fact that full sunlight is not available throughout the day. It is therefore essential that there should be some device which can store the energy produced by SPV cells so that it may be utilised whenever required. The storage batteries are mainly used for this purpose. These batteries convert the electric energy generated by the SPV cells into chemical energy and deliver back for the use of converting the chemical energy back to electric energy. Thus the SPV Power Source is a non-conventional energy source, comprised of a SPV Modules, which convert Solar Energy (Sun light) directly into DC electricity to charge the battery, through a charge controller. The Charge Controller is used to control the charging process

There are three types of SPV system

1 Stand alone system

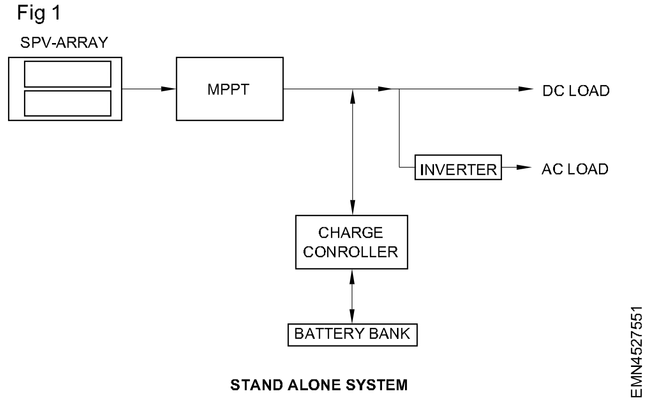
2 Hybrid system

3 Grid-connected system

Stand alone system

The entire power is generated by an SPV array and stored in a battery to be provided in response to demand.

Fig 1

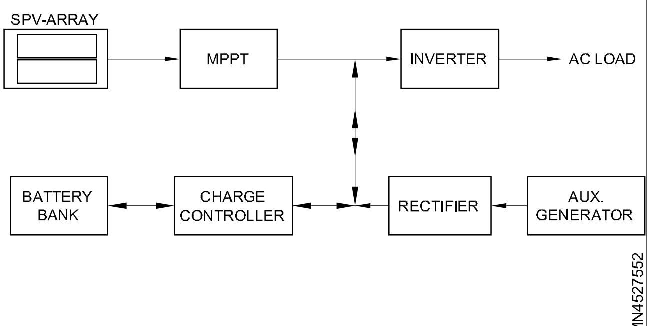


STAND ALONE SYSTEM

Hybrid system

In addition to an SPV array, other means such as AC mains, wind and diesel generators are also used to supply power.

Fig 2

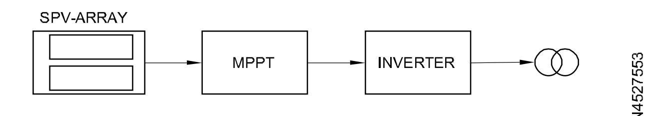


HYBRID SYSTEM

Grid-Connected system

In such system the output of SPV planes is connected to the grid and there is no storage battery; metering is used to keep account of imported and exported power by the user.

Fig 3



GRID-CONNECTED SYSTEM

Solar charge controller

A solar charge controller is fundamentally a voltage or current controller to charge the battery and electric cells from overcharging. It limits the rate at which the voltage/ current is charged or discharged from batteries. It is also charge regulator or battery regulator.

Types of solar charger controller

There are three different types of solar charge controllers,

1 Simple 1 or 2 stage controls

2 PWM (pulse width modulated)

3 Maximum power point tracking (MPPT)

Simple 1 or 2 stage controls: It has shunt transistors to control the voltage in one or two steps. This controller basically just shorts the solar panel when a certain voltage is arrived at.

PWM (Pulse Width Modulated): This is the traditional type charge controller, for instance anthrax, Blue Sky and so on. These are essentially the industry standard now.

Maximum power point tracking (MPPT): The MPPT solar charge controller is the sparkling star of today's solar systems. These controllers truly identify the best working voltage and amperage of the solar panel exhibit and match that with the electric cell bank. The outcome is extra 10-30% more power out of your sun oriented cluster versus a PWM controller. It is usually worth the speculation for any solar electric systems over 200 watts.

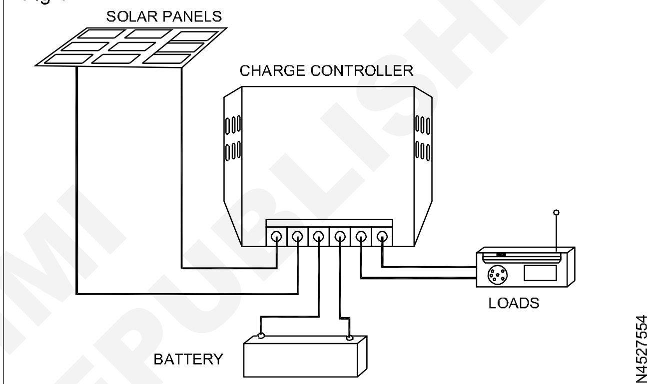
Working of solar charge controller

The most essential charge controller basically controls the device voltage and opens the circuit, halting the charging, when the battery voltage ascents to a certain level. More charge controllers utilized a mechanical relay to open or shut the circuit, halting or beginning power heading off to the electric storage devices.

Generally solar power systems utilize 12V of batteries. Solar panels can convey much more voltage than is obliged to charge the battery. The charge voltage could be kept at a best level while the time needed to completely charge the electric storage devices is lessened. This permits the solar systems to work optimally constant. By running higher voltage in the wires from the solar panels to the charge controller, power dissipation in the wires is diminished fundamentally.

The solar charge controllers can also control the reverse power flow. The charge controllers can distinguish when no power is originating from the solar panels and open the circuit separating the solar panels from the battery devices and halting the reverse current flow.

Fig 4



WORKING OF CHARGE CONTROLLER

This unit performs 4 major functions

1 Charges the battery.

2 Gives an indication when battery is fully charged.

3 Monitors the battery voltage and when it is minimum, cuts off the supply to the load switch to remove the load connection.

4 In case of overload, the load switch is in OFF condition ensuring the load is cut off from the battery supply.

A solar panel is a collection of solar cells. The solar panel converts the solar energy into electrical energy. The solar panel uses Ohmic material for interconnections as well as the external terminals. So the electrons created in the N-type material passes through the electrode to the wire connected to the battery. Through the battery, the electrons reach the P-type material. Here the electrons combine with the holes. When the solar panel is connected to the battery, it behaves like other battery, and both the systems are in series just like two batteries connected serially. The solar panel has totally consisted of four process steps overload, under charge, low battery and deep discharge condition. The output from the solar panel is connected to the switch and from there the output is fed to the battery and setting from there it goes to the load switch and finally at the output load. This system consists of 4 different parts-over voltage indication and

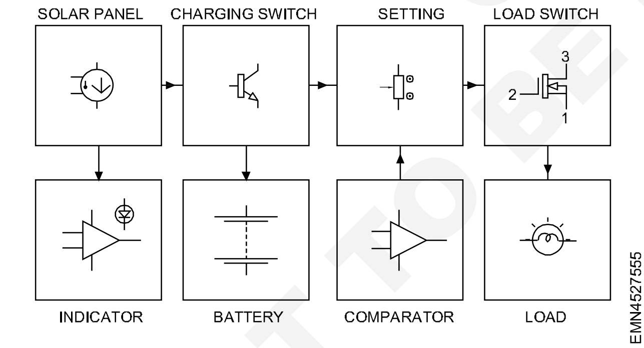
TABLE 1

Difference between SPV and conventional power

Sl.No.	Item	Power plant configuration	
		Solar PV	Conventional power
1	Operation	Decentralised	Centralised
2	Dependency on external fuel source	Very low	Completely
3	Design	Load specific	Capacity -specific
4	Suitability	Lower capacity	Higher capacity
5	Gestation period	Short	Long
6	Transmission losses	Low	High
7	O&M costs	Low	High
8	Capital cost	High	Low
9	Running cost	Low	High
10	Environmental pollution	None	Add gaseous and particulate toxins which causes pollution and ecological imbalance

detection, over charge detection, over charge indication, low battery indication and detection. In case of the over charge, the power from the solar panel is bypassed through a diode to the MOSFET switch. In case of low charge, the supply to MOSFET switch is cut OFF to make it in OFF condition and thus switch OFF the power supply to the load.

Fig 5



Solar energy is the cleanest and most available renewable energy source. The Modern technology can harness this energy for a variety of uses, including producing electricity, providing light and heating water for domestic, commercial or industrial application.

MPPT Solar charger controller parts and working

1 Charging LED indicator.

2 Battery status LED indicator.

3 Local temperature sensor-acquires ambient temperature to perform temperature compensation for charging and discharging.

4 Setting LED Indicators-work mode, timers, and battery selection.

5 LCD display-load and work mode status is displayed.

6 Set button-Adjust parameters, cycle through settings, or turn load ON/OFF.

7 RJ45 port for MT-5 Tracer (optional accessory)-connects remotely to temperature sensor in order to acquire ambient temperature.

LED indicators in MPPT solar charger controller

Applications

The process of generating electricity from sunlight is having more popularity than other alternative sources and the photovoltaic panels are absolutely pollution free and they don't require high maintenance. The following are some examples where solar energy is being utilized.

1 Street lights use photovoltaic cells to convert sunlight into DC electric charge. This system uses solar charge controller to store DC in the batteries and uses in many areas.

2 Home systems use PV module for house-hold applications/appliances.

3 Hybrid solar system uses for multiple energy sources for providing full time backup supply to other sources.

Fig 6

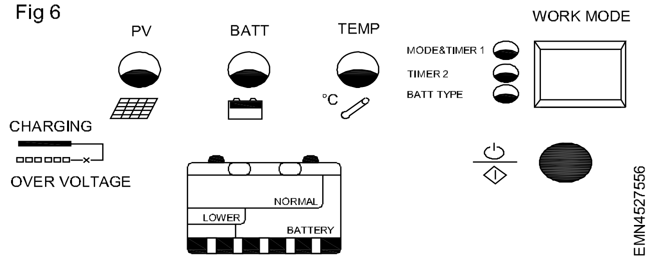
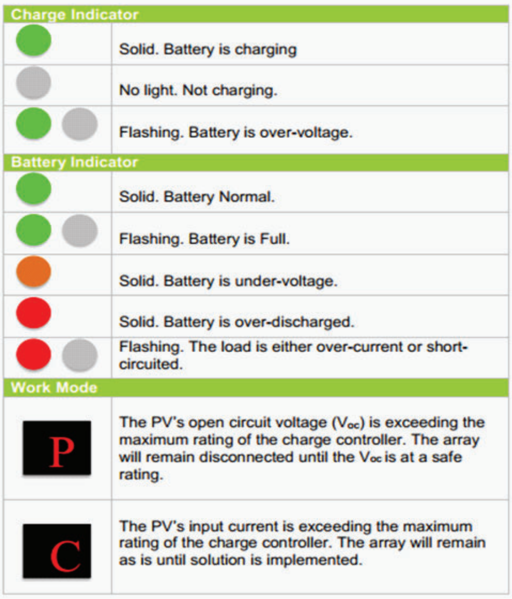


Fig 7



Charge Indicator	
	Solid. Battery is charging
	No light. Not charging.
	Flashing. Battery is over-voltage.
Battery Indicator	
	Solid. Battery Normal.
	Flashing. Battery is Full.
	Solid. Battery is under-voltage.
	Solid. Battery is over-discharged.
	Flashing. The load is either over-current or short-circuited.
Work Mode	
P	The PV's open circuit voltage (V_{oc}) is exceeding the maximum rating of the charge controller. The array will remain disconnected until the V_{oc} is at a safe rating.
C	The PV's input current is exceeding the maximum rating of the charge controller. The array will remain as is until solution is implemented.

Safety precaution in solar electric system

Objectives : At the end of this lesson you shall be able to

- **state general safety precautions in solar electric system**
- **safety while working on solar panel**
- **safety on solar installation.**

General safety precautions

The safety basics

Solar system is fully automatic and comes with built-in safety features. Do not attempt to work on, alter, or repair the system; doing so could expose you to dangerous electrical currents and void manufacturer warranties.

Do not attempt to service any portion of the system. Only a trained and certified professional should service the system.

It's not necessary to go on the roof for panel cleaning or inspection. If choose to go on roof, take all safety precautions and do not touch or disturb the panels or wiring. It is important to remember that only an authorized person should repair or touch system components.

Always, remind anyone going on roof that they should not disturb the panels or wiring.

Do not step on the panels or allow objects to fall on the panels.

Do not disassemble or remove any part of the system. This will void manufacturer warranties.

Small children and pets should be kept away from the inverter.

Safety precautions for installing a solar photovoltaic system

1 Solar modules produce electrical energy when exposed to sunlight. DC voltages may exceed 30V on a single exposed module.

2 Connect modules with the same rated output current only in series. If modules are connected in series, the total voltage is equal to the sum of the individual module voltages.

3 Connect modules or series combinations of modules with the same voltage in parallel. If modules are connected in parallel, the total current is equal to the sum of individual module or series combination currents.

4 Bypass diodes are pre-assembled in each module. Do not remove these diodes.

5 Keep children well away from the system while transporting and installing mechanical and electrical components.

6 Completely cover all modules with an opaque material during installation to prevent electricity from being generated.

7 Do not wear metallic rings, watchbands, ear, nose, or lip rings or other metallic devices while installing or troubleshooting photovoltaic systems.

8 Use appropriate safety equipment (insulated tools, insulating gloves, etc) approved for use on electrical installations.

9 Observe the instructions and safety precautions for all other components used in the system, including wiring and cables, connectors, DC-breakers, mounting hardware, inverters, etc.

10 Use only equipment, connectors, wiring and mounting hardware suitable for use in a photovoltaic system.

11 Always use the same type of module within a particular photovoltaic system.

12 Under normal operating conditions, PV modules will produce currents and voltages that are different than those listed in the data sheet. Data sheet values are applicable at standard test data.

13 Short-circuit current and open-circuit voltages should be multiplied by a factor of 1.25 when determining component voltage ratings, conductor ampacity, fuse sizes and size of controls connected to the module or system output. An additional multiplying factor of 125 percent (80 percent de-rating) may be applicable.

Safety while working on solar panel

1 Never work on a PV system alone.

2 Know the system before start to work on it.

3 Study electrical diagrams of the system.

4 Discuss the test objectives and techniques with partner.

5 Keep test equipment in top operating condition.

6 Check test equipment before go to the system site.

7 Wear appropriate clothing.

8 Wear only approved electrical safety hat.

9 Wear eye protection, particularly if working on batteries. Remove any jewellery.

10 Wear dry leather gloves to reduce the probability of getting shocked.

11 Measure the conductivity from exposed metal frames and junction boxes to ground.

12 Measure voltage from all conductors (on the PV output circuit) to ground.

13 Measure the operating voltage and current. Work with one hand whenever possible.

Solar safety

Follow these solar power safety rules to minimize the risk

The first safety rule to keep in mind when working with photovoltaic panels or other PV components is, always stop working in bad weather. PV panels can be blown around by the wind or a storm which can result in falling or damage to the PV system.

Do not apply pressure on PV photovoltaic panels by sitting or stepping on them or they might break and cause bodily injury, electrical shock or damage to the solar panels. Also never drop anything on the PV panels.

Through the entire process of photovoltaic solar installation, make sure don't get the home's sheathing wet or roof may leak thereafter. This is usually an issue with roofs that are just being built, but it can happen to older roofs too.

Do not install a PV system in any location within 0.3 miles of an ocean or salty water. Vapours and mist could interfere with photovoltaic equipment and cause damage or electrical shock.

Also do not install photovoltaic equipment in locations that are corrosive area.

Make sure that the roof where mounting solar panels is strong enough to support the weight.

This next PV safety rule could save life. Make sure entire PV system is properly and safely earth grounded to prevent electrical shock and injury.

Never work when it's raining, immediately after rain or in wet or slippery conditions or with wet tools.

Never install a PV system near flammable gases or could cause a fire or explosion.

Cover photovoltaic solar panels with an opaque material during wiring to stop or prevent electricity production.

Make sure the area underneath your solar panels is clean, clear and free of foreign objects.

Another solar safety rule is do not wear metallic jewellery when working on PV system, or it could cause electric shock. Also never touch any electrical contacts or wiring without proper protection and safety gear.

When working on roof tops. Always insure that extreme safety precaution (including harnesses, lifelines and safety nets) are taken to prevent slipping, falling and causing injury or death.

Inspect all power tools to ensure that they are working safely prior to starting the installation of PV system. Also, use insulated tools when working on a photovoltaic system.

Another solar safety rule you should always follow is never work in conditions of snow or high wind or when these conditions are expected due to increased chance of slipping or losing your balance.

Always get a second person to securely hold ladders as climb and use rubber latex mats to prevent the ladder from slipping.

Wear all necessary protective safety clothing including work clothes that fit well and allow to move easily and freely, non-slip shoes, insulating gloves and a helmet. When installing a PV system, use scaffolds (not ladders) at height 6 foot and higher. Be very careful of falling objects and do not ever throw objects up or down when installing a PV system.

Always protect wires or cables with flexible metal conduit when wiring through walls, for wires exposed to sunlight, rain or anywhere outdoors. Failure to follow this photovoltaic solar safety rule can result in electrical shock or short circuit

Use waterproof fitting or duct seal to prevent water from entering the conduit and damaging photovoltaic system.

Always connect a grounding wire from the mounting hardware to the earth to prevent shock.

Maintenance and troubleshooting of solar electric system

Objectives : At the end of this lesson you shall be able to
- **explain the maintenance of solar electric system**
- **maintenance of solar charge control**
- **troubleshooting of solar electric system**
- **troubleshooting of solar charge control.**

Maintenance of solar panel

Solar panel maintenance is important because insufficient care for solar panels can reduce the amount of energy. Since a solar panel system needs to absorb energy from the sun the most vital component of solar panel care is to keep the panels clean. Usually maintain a solar panel using the same equipment that uses to wash residential and automobile windows, as long as provide regular care and don't allow dirt and other environmental elements from settling on the panels for too long.

Solar panel cleaning

1 Solar panels cleaning kit should contain a liquid soap, a wiper, a small brush and in some cases another brush with a longer handle. In many ways, these items are similar to clean the car, so if you cannot purchase a cleaning kit that is specifically designed for cleaning solar panels then you can substitute it with your car cleaning equipment instead.

2 Mix the soap with water in a bucket. The amount that needs to be mixed should be mentioned on the bottle of liquid soap as shown in Fig 1.

Fig 1

3 Dip the brush into the soap and water mixture and gently rub it over the solar panels; solar panels divided into smaller arrangements with a small handheld brush. However, for larger arrangements it can be difficult to reach the panels in the middle so need to use the brush with the longer handle as shown in Fig 2.

4 Wipe the solar panels with the wiper while the panels are still wet. At times, the wiper is attached at the back of the brush. It is important that you don't allow the soap to dry on the solar panels since this will block the amount of sunlight that they can absorb and make them inefficient as shown in Fig 3.

Fig 2

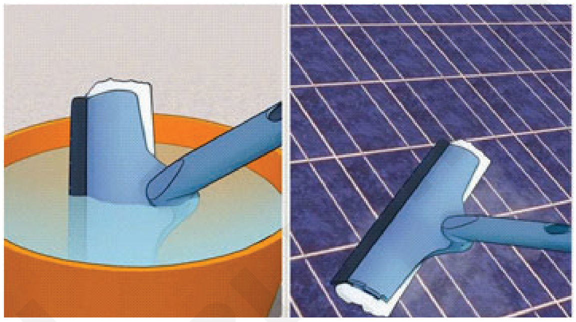
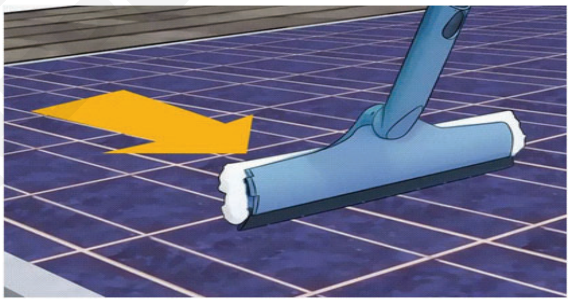


Fig 3



Maintenance of solar charge controller

1 Check that controller is mounted in a clean, dry, and ventilated area.

2 Check wiring going into the charge controller and make sure there is no wire damage or wear.

3 Tighten all terminals and inspect any loose, broken, or burnt up connections.

4 Make sure readings in the LCD and LED are consistent. Take necessary corrective action.

5 Check to make sure none of the terminals has any corrosion, insulation damage, high temperature, or any burnt/discoloration marks.

Troubleshooting of solar electric system

Problem	Possible causes	Solution/Remedy
The light does not turn on at all.	The batteries are discharged	Charge the batteries
	The batteries are bad.	Replace the batteries
	The LED fixture is bad	Replace the LED fixture
	A fuse is blown	Replace the fuse
	Controller is bad.	Check the controller
The light does not stay on for the	The run time is incorrectly set. expected period of time.	Contact authorised service personnel for assistance
The light turns on at dusk but does not turn on again at dawn (split run time)	The run time exceeds the maximum run time for your model and location.	Contact authorised service personnel for assistance
	Low battery voltage caused by inclement weather.	Allow for two to three days of consecutive sunny weather to charge the battery pack.
	Low battery voltage caused by shading of the PV panel.	Clear tree branches and other obstructions from the vicinity of the PV panel.
	The batteries are bad.	Replace the batteries
The red LED on the controller remains illuminated The light does not operate every day.	Low battery voltage caused by inclement weather	Allow for two to three days of consecutive sunny weather to charge the battery pack.
	Low battery voltage caused by shading of the PV panel.	Clear tree branches and other obstructions from the vicinity of the PV panel.
	The batteries are bad.	Replace the batteries
The fuse blows repeatedly.	There is a short circuit in the wiring	Check all system wiring for a short circuit.
The battery voltage is less than 9.0 volts	One (or both, if there are two) controller is bad.	Check the controller(s)
	The batteries are bad.	Replace the batteries

Troubleshooting of solar charge control:

Sl.No	Trouble symptom/Fault	Remedy
1.	OFF during day light	**Charge indicator**
		Ensure that the PV wires are correctly and tightly secured inside the charge controller PV terminals. Use a multi-meter to make sure the poles are correctly connected to the charge controller.
2.	Flashing green light	Use a multi-meter to check the battery voltage and make sure it is within specification for the charge controller. NEVER disconnect battery without disconnecting the solar panels first.
3.	Solid orange light	**Battery Indicator** Disconnect loads, if any, and let the PV modules charge the battery bank. Use a multi-meter to frequently check on any change in battery voltage to see if condition improves. This should ensure a fast charge. Otherwise, monitor the system and check to see if system improves.
4.	Solid Red	The controller will have cutoff the output of the battery to ensure that it charges. Make sure there are no excessive loads and give the system appropriate time and sunlight to charge. Monitor readings with a multi-meter to see if they system improves
5.	Flashing Red light	**Overload:** Use a multi-meter to check load drawn and limit loads if possible. If no progress, disconnect all loads and gradually reconnect loads to see if the condition improves.
		Short-circuit: Upon experiencing its first short circuit, the controller will cut off for 10 seconds, and then resume normal operation. Upon the second short-circuit, the controller will not automatically reboot and the user must press the orange button to resume controller working.

Mobile communication

Objectives : At the end of this lesson you shall be able to
- **state mobile communication**
- **state mobile phone function**
- **explain the generation of cellphones**
- **explain the concept of cell site, hand off and frequency reuse.**

Mobile communication

Mobile communication is wireless form of communication in which voice and data information is emitted, transmitted and received via microwaves. This type of communication allows individuals to converse with one another and /or transmit and receive data while moving from place to place. Example - cellular and digital cordless telephones, pagers, telephone answering devices, air-to-ground telecommunications and satellite-based communications.

A cellular phone is a portable telephone that does not use a wired connection. It connects to a wireless carrier network using radio waves.

Mobile phone

The mobile phone or cell phone is a portable electronic device used for mobile communication through wireless network using radio waves. In addition to the standard voice function of a telephone, current mobile phones can support many additional services such as SMS for text messaging, email, packet switching for access to the Internet, and MMS for sending and receiving photos and video. Most current mobile phones connect to a cellular network of base stations (cell sites), which is in turn interconnected to the public switched telephone network (PSTN) Mobile Communications.

Generation of cellphones

When wireless generation started, it was analog communication. That generation is 1G. They used various analog modulation for data transfer. Now when the communication migrated from analog to digital, the foundation of latest communication were lead. Hence came 2G.

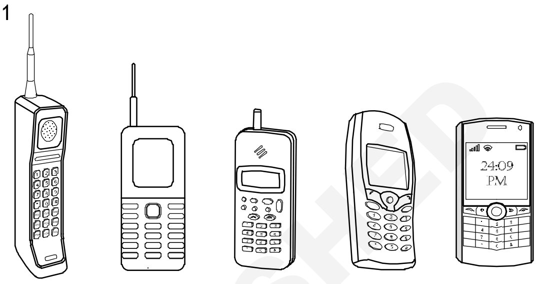
1G technology mobile phones

1 1G refers to the first generation of wireless telephone technology in mobile telecommunications which was introduced in 1980s and completed in early 1990s.

2 It's speed was upto 2.4kbps, allowed the voice calls within the country.

3 It used analog signal and Advance Mobile Phone System (AMPS) was first launched in USA in 1G mobile systems shown in Fig 1.

Fig 1



EM20N21423511

Drawbacks

1 Poor voice quality

2 Poor battery life

3 Large phone size

4 No security

5 Limited capacity

6 Poor handoff reliability

2G technology mobile phones

1 2G technology refers to the 2^{nd} generation which is based on GSM as shown in Fig 2.

2 It was launched in Finland in the year 1991 and used digital signals.

3 It's data speed was upto 64 kbps.

Features

1 It enables services such as text messages, picture messages and MMS (multi media message service).

2 It provides better quality and capacity.

Drawbacks

1 2G requires strong digital signals for mobile phones work. If there is no network coverage in any specific area, signals will weak.

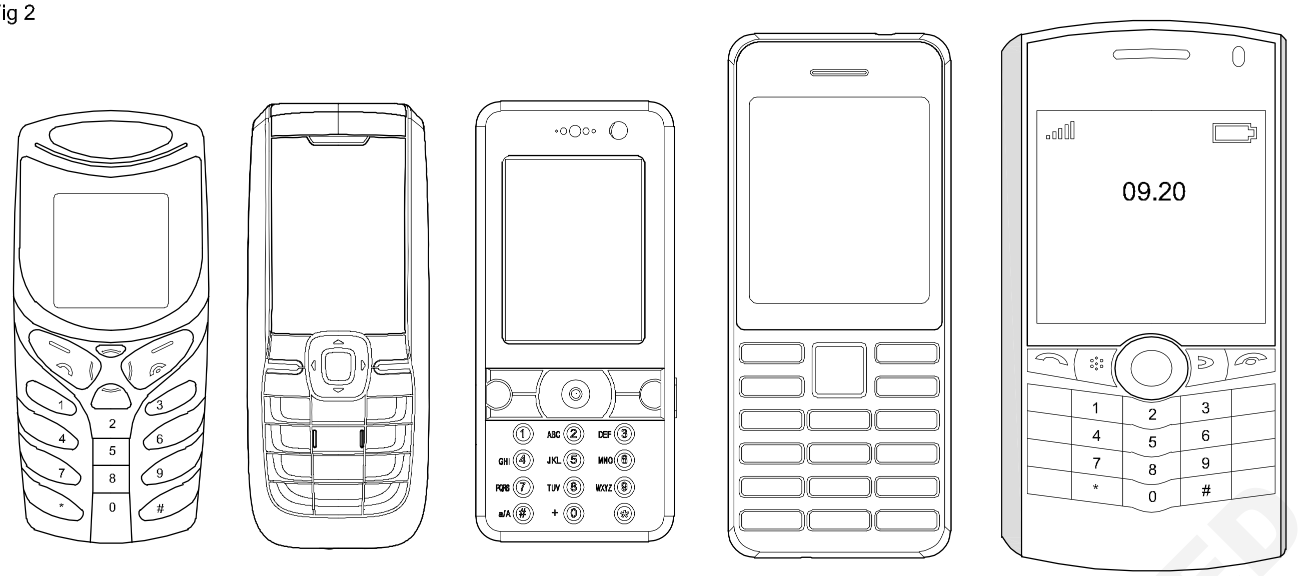
2 These systems are unable to handle complex data such as videos.

2.5G technology

1 2.5G is a technology between the second (2G) and third (3G) generation of mobile telephony shown in Fig 3.

2 It is sometimes described as 2G Cellular Technology combined with GPRS.

Fig 2



2G TECHNOLOGY PHONES

EM20N21423512

Features includes

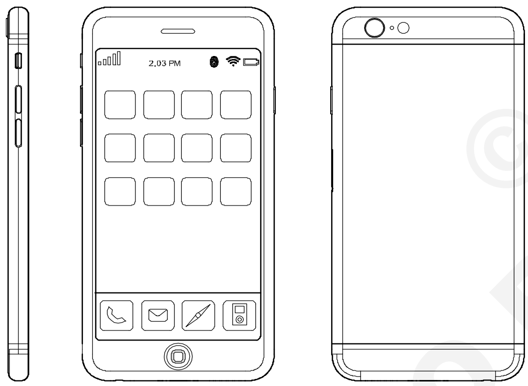
1 Phone calls

2 Send/Receive E-mail messages

3 Web browsing

4 Speed : 64-144 kbps

Fig 3



EM20N21423513

5 Camera phones

3G Technology

1 3G technology refer to third generation which was introduced in the year of 2000s.

2 Data transmission speed is 144kbps- 2Mbps.

3 Typically called smart phones as shown in Fig 4 and features increased its bandwidth and data transfer rates to accommodate web-based applications and audio and video files.

Features include

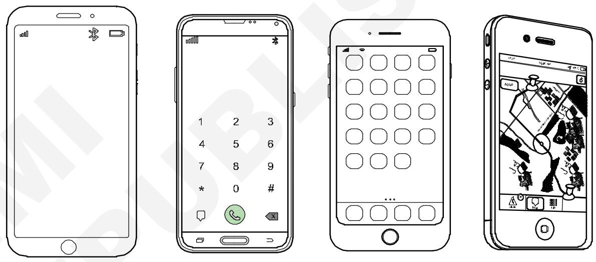
1 Providing faster communication

2 Send/Receive large email messages

3 High speed web / more security

4 Video conferencing / 3D gaming

Fig 4



EM20N21423514

5 TV streaming / mobile TV/ Phone calls

6 Large capacities and broadband capabilities

7 11 sec - 1.5 min. time to download a 3 min Mp3 song.

Drawbacks

1 Expensive fees for 3G licenses services

2 It was challenge to build the infrastructure for 3G

3 High bandwidth requirement

4 Expensive 3G phones.

5 Large cell phones

4G technology

1 4G technology refer to fourth generation which was started from late 2000s.

2 Capable of providing 100Mbps - 1Gbps speed.

3 One of the basic term used to describe 4G is MAGIC. 4G mobile phones are shown in Fig 5.

Magic

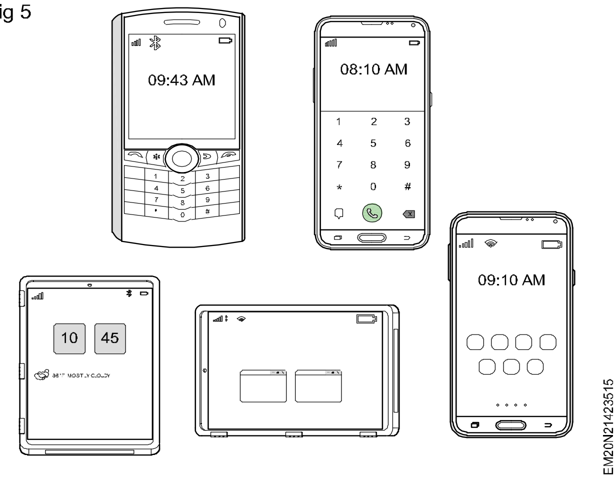
1 Mobile multimedia

2 Anytime anywhere (Universal)

3 Global mobility support

4 Integrated wireless solution

Fig 5



5 Customized personal services.

6 Also known as mobile broadband everywhere.

7 The next generations of wireless technology that promises higher data rates and expanded multimedia services.

8 Capable to provide speed of 100Mbps-1Gbps.

9 High quality of services(QOS) and High security.

10 Provide any kind of service at any time at anywhere as per user requirements.

Features include

1 More security

2 High speed

3 High capacity

4 Low cost per-bit

Drawbacks

1 Battery usage is more.

2 Need complicated hardware.

3 Expensive equipment required to implement next generation network.

Concept of cell

1 Cell refers to the geographical area under one base station with a single transmitter and receiver.

- The size of a cell depends upon the density (number) of users in a given area.
- For a heavily populated city area, many small cells are

Comparison of 1G, 2G, 3G, 4G, 5G

Comparison of all generation of mobile technologies (1G-5G)

Generation	1G	2G	2.5G	3G	3.5G	4G	5G
Start	1970 -1980	1990 -2000	2001 - 2004	2004 - 2005	2006 - 2010	2011- Now	2024 Now
Data Bandwidth	2 kbps	64 kbps	144 kbps	2 Mbps	More than 2 Mbps	1 Gbps	More than 1 Gbps
Technology	Analog cellular	Digital cellular	GPRS, CDMA	CDMA 2000 (1×RT, EVDO) UMTS, EDGE	EDGE, Wi-Fi	WiMAX LTE Wi-Fi	WWWW
Service	Voice	Digital voice, SMS, Higher capacity packet size Data	SMS, MMS	Integrated high Quality Audio, Video & Data	Integrated High Quality Audio, Video & Data	Dynamic information access, wearable Devices	Dynamic information access, wearable devices with all capabilities
Multiplexing	FDMA	TDMA, CDMA	TDMA, CDMA	TDMA, CDMA	TDMA, CDMA	TDMA, CDMA	TDMA, CDMA
Switching	Circuit	Circuit, packet	Packet	Packet	All Packet	All packet	All Packet
Core Network	PSTN	PSTN	PSTN	Packet N/W	Internet	Internet	Internet
Handoff	Horizontal	Horizontal	Horizontal	Horizontal	Horizontal	Horizontal & Vertical	Horizontal & Vertical

used to ensure service.

- In less populated rural areas, fewer cells are used.
- A group of cells are called a cluster. Each cell in a cluster will be having different frequencies to avoid interference.
- The cell will be in hexagonal shape in a honeycomb pattern.

The geographical area or cellular service is divided into small hexagonal region called cells. It is the basic unit of a cellular system. These cells collectively provide coverage over larger geographical areas.

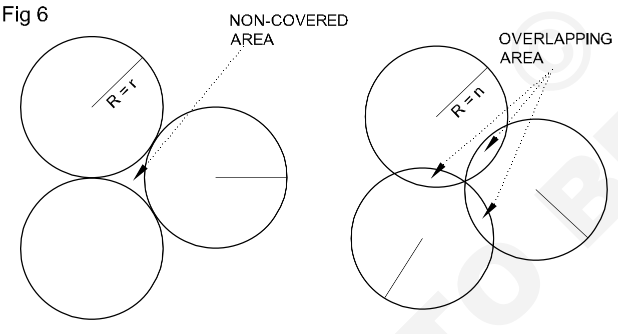
Hexagonal cell shape as shown in Fig 8 is perfect over square or triangular cell shapes in cellular architecture because it cover an entire area without overlapping i.e. they can cover the entire geographical region without any gaps. If cell is in circular shape, there may be overlapping of areas or some geographical area may not be covered as shown in Fig 6.

Frequency reuse and cell splitting is the process of dividing a larger congested cell into smaller cells. Each cell has its own base station.

When the traffic in an area increases, larger cells are split into smaller cells so that frequency can be reused. By splitting the cell, the capacity of the system will be increased because availability of additional number of channels per unit service area is also increased.

Cell site

Fig 6

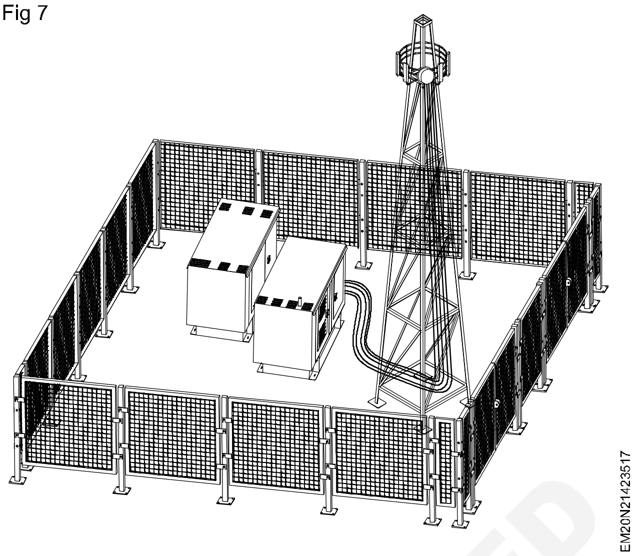


The cell site is used to refer to the physical location of the radio equipment that provides coverage within the cell. A list of hardware located at a cell site include power source interface equipment, radio frequency transmitter, receiver and antenna system as shown in Fig 7.

Frequency reuse concept

- Since the frequencies available for mobile communication are limited compared to the user demand of these systems, the concept of frequency reuse is employed.
- Frequency reuse is the process in which the same set of frequencies (channel) can be allocated to more than one cell, provided the cells are separated by sufficient distance (to avoid mutual interference).

Fig 7



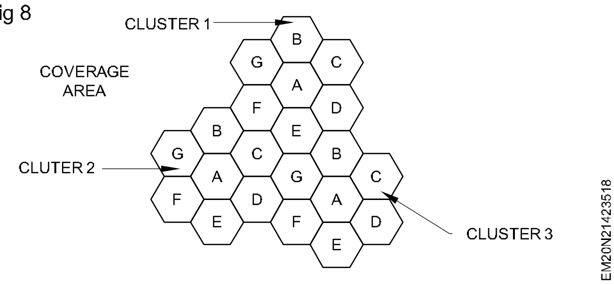
- The figure 8 shows a geographic cellular coverage area with 3 clusters. There are seven cells in each cluster, each cells having a different frequencies (denoted by the letters A, B C, D, E, F, and G)
- Cells with the same letter uses the same set of channel frequencies.
- Here the same set of frequencies are used 3 times, which increases the number of usable channels by threefold.

Structure of cells for frequency reuse

Concept of handoff

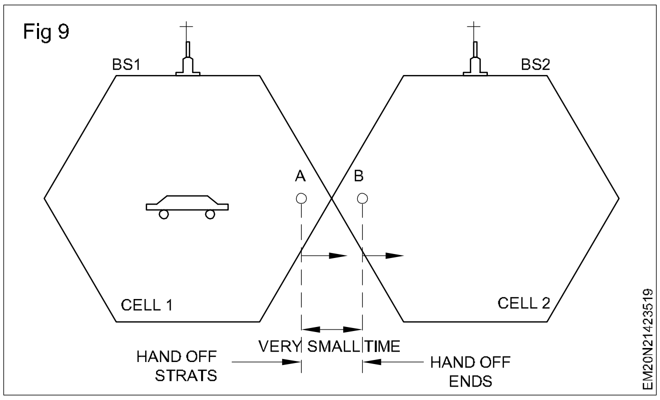
- A handoff refers to the process of transferring an active call or data session from one cell in a cellular network to another.
- Handoff is often initiated either by crossing a cell boundary or by deterioration in quality of signal in current channel.
- For instance, if a subscriber moves out of the coverage area from a particular cell while entering to another, a handoff takes place between the two cells as shown in Fig 9. The cell that served the call prior to the handoff is relieved of its duties, which are then transferred to the second cell.

Fig 8



- A handoff may also be triggered when the number of subscribers using a particular cell has already reached the cells maximum limit (capacity). Such a handoff is possible because the reach of the cell sites serving these cells can sometimes overlap.

Fig 9



Cellular network

Objectives : At the end of this lesson you shall be able to
- **explain the cellular system infrastructure**
- **state GSM network**
- **describe CDMA network**
- **compare GSM & CDMA**
- **explain GPRS network.**

Cellular system infrastructure

1 Cellular system infrastructure was developed to increase the capacity for mobile radio telephone service.

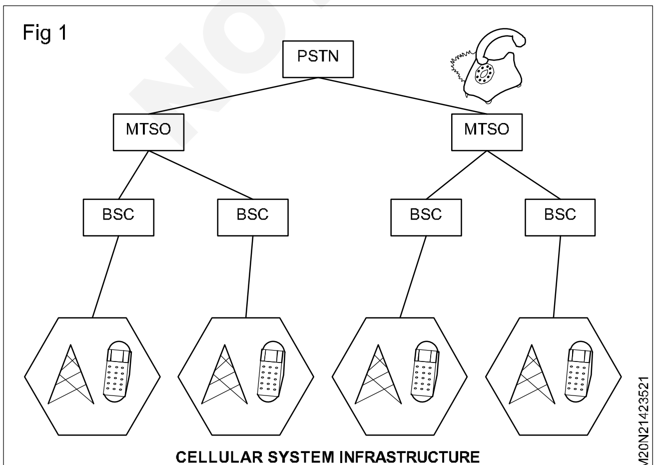
2 A basic cellular system consists of 3 layers as shown in Fig 1.

   i **Mobile unit -** It is the mobile which is in the hands of users.

   ii **Base Station Controller (BSC) -** The mobile unit is normally connected to the base station. The base stations are considered as cells. The base station includes an antenna, a controller and a number of transceivers for communicating on channel assigned to that cell.

   iii **Mobile Telephone Switching Office (MTSO)** - Each BSC is connected to an MTSO, with one MTSO serving with multiple base stations. MTSO is also connected to PSTN (Public Switched Telephone Network) or the conventional landline. The MTSO assigns voice channels to each call, performs hand off, and monitors the call for billing information.

Fig 1



CELLULAR SYSTEM INFRASTRUCTURE

Global System for Mobile Communication (GSM)

1 Earlier cellular telephone systems in European countries were working at different frequencies, they were incompatible with other systems.

2 To improve the inter operatability among various cellular communication systems the European telecommunication Standardization Institute (ETSI) has formulated a global standard called GSM.

3 It is world's first cellular system to specify digital modulation and level architecture and service, and it is the most popular 2G technology.

GSM Services

1 GSM services are classified into three groups

   i **Teleservices -** Tele services includes the voice communication via mobile phones.

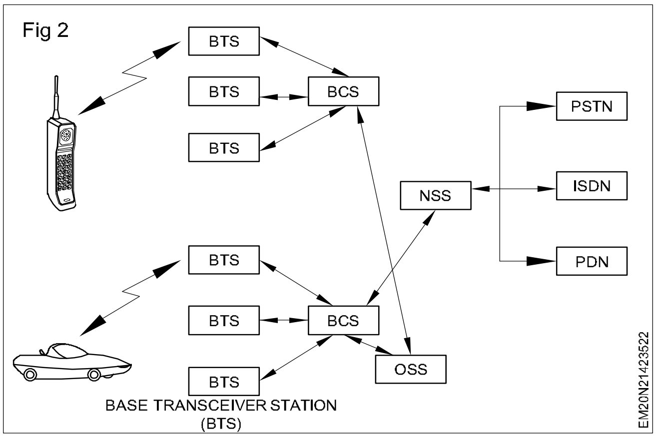
   ii **Data services -** Data services include various data services for information transfer between GSM and other networks like PSTN, ISDN etc. Data services also include short message service (SMS).

   iii **Supplementary services -** Supplementary services such as call forwarding, call barring etc are also offered with GSM.

GSM architecture

GSM architecture components

1 GSM architecture has three major interconnected subsystems that interact among one another and with subscribers through specified network interfaces as shown in Fig 2.



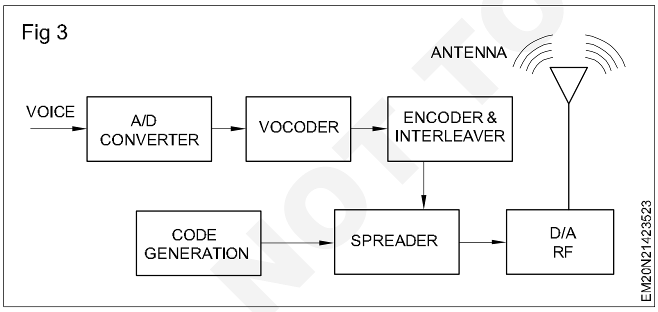
i **Base Station Subsystem (BSS) -** BSS is also known as radio subsystem as it provides and manages radio-frequency transmission paths between mobile unit and the mobile switching center (MSC). Mobile Unit is also considered as a part of BSS.

ii **Network Switching Subsystem (NSS) -** NSS manages the switching function of the system and allows MSC to communicate with other telephone network like PSTN (Public Switched Telephone Network), ISDN (Integrated Services Digital Network) and PDN (Public Data Network).

iii **Operational Support Subsystem (OSS) -** The OSS supports operation and maintenance, of the system and allows engineers to monitor, diagnose, and troubleshoot every aspect of the GSM network.

Advantages of GSM over earlier Analog systems

1 Capacity increases.
2 Reduced RF transmission power, thus longer battery life.
3 International roaming capability.
4 Better security
5 Encryption capability for information security and privacy.



6 Compatibility with ISDN, leading to wider range of services.

Code Division Multiple Access (CDMA)

1 CDMA is a digital cellular technology based on spread spectrum technique, where the entire bandwidth of frequencies is available to each user at the same time.

2 CDMA operates by coding to discriminate between users.

There are two types of CDMA

1 **Direct Sequence Spread Spectrum (DSSS) CDMA** Here a narrowband input from a user is coded (spread) by a unique broadband code (Pseudorandom Noise) and then transmitted. All the receivers get this coded broadband signal. But only the receiver who knows this unique broadband code can recover the user data.

2 **Frequency Hopping Spread Spectrum (FHSS) CDMA -** Here each user narrowband signal varies among discrete frequencies based on a code. Only the receiver who knows this code for frequency variation can recover the data. Frequency hopping technique is used by the military since it gives very high data security.

Block diagram of CDMA system

Fig 3 shows the block diagram of a CDMA system. It consists of

1 **A/D converter -** It converts analog voice signal to digital signal.

2 **Vocoder-** Digitalized voice is vocoded. Here the digital voice is variably compressed to make more efficient use of the air link and system resources.

3 **Encoder and Interleaver -** The purpose of encoder is to build redundancy into the signal. Interleaving is a method of reducing the effects of burst errors and recovering bits when burst errors occur.

4 **Spreader -** the encoded signals are spread (channelized) using spreader. The spreader converts the narrowband signal into a wideband signal using spreading code such as walsh code or pseudo- noise codes.

5 **Code generator -** The code generator generates the spreading code. Orthogonal (Walsh) codes are used on the forward link (base station to mobile station) to channelize the users. A Pseudorandom Noise (PN) code is used on the reverse link (mobile station to base station).

6 **D/A converter -** It converts digitally coded signal to analog RF signal for transmission.

7 **Antenna -** It transmits the RF signal which can be received by uses with mobile handsets.

8 Only the users who knows the pseudorandom noise code (or the frequency variation code in FHSS CDMA) can recover the original data.

Advantages of CDMA

1 Capacity increases 4 to 5 times that of GSM systems.

2 Improved call quality.

3 Simplified system planning through the use of same frequency in every sector of every cell.

4 Enhanced privacy.

5 Improved coverage characteristics, allowing the possibility of fewer cell sites.

6 Extra bandwidth can be made available on demand.

General Packet Radio Services (GPRS)

1 GPRS is a non voice value added service that allows data information to be sent and received across a mobile telephone network.

2 It uses existing GSM networks to transmit and receive TCP/IP (Transmission Control Protocol/ Internet Protocol) based data to and from mobile devices.

3 GPRS involves overlaying a packet based air interface on the existing GSM network. Thus network architecture of GPRS is similar to that of GSM.

4 GPRS facilitates instant connection whereby information can be sent or received immediately as the need arises, subject to radio coverage. No dial-up modem connection is necessary.

Advantages of GPRS

Speed - GPRS can achieve speed up to 171.2 kilobits per second (KBPS) using all eight timeslots at the same time. This is thrice as fast as older data transmission systems.

Immediacy - GPRS facilitates instant connections whereby information can be sent or received immediately as the need arises, subject to radio coverage. No dial up modem connection is necessary.

New and better applications - GPRS facilitates several new applications that have not previously been available on GSM network due to the limitations in speeds and lengths. GPRS fully enable the internet applications normally used on desktop computers (from web browsing to chat) over the mobile networks.

Difference between CDMA & GSM

	CDMA	GSM
Stands for	Code Division Multiple Access.	Global system for mobile communication.
Storage Type	Internal memory.	SIM (subscriber identity module) card.
Network	There is one physical channel and a special code for every device in the coverage network. Using this code, the signal of the device is multiplexed, and the same physical channel is used to send the signal.	Every cell has a corresponding network tower, which serves the mobile phones in that cellular area.
International roaming	Less Accessible.	Most Accessible.
Frequency band	Single (850 MHZ).	Multiple (850/900/1800/1900 MHZ).
Network service	Handset specific.	SIM specific. User has option to select handset of this choice.
Dominance	Dominant standard in the U.S.	Dominant standard worldwide except the U.S.
Secrecy	More	Less

Block diagram and features of cell phones

Objectives : At the end of this lesson you shall be able to
- **explain the block diagram of cell phone**
- **state the feature and application of cell phone**
- **list the features of smartphone**
- **state the uses of cell phone.**

Block diagram of the cell phone

Now-a-days cell phone become more popular for SMS/ MMS and internet applications due to GPRS feature. After the introduction of Smartphone many applications such as face book, Orkut, Twitter, Various games comes built-in the phone. Now mobile phone has slowly taken the place of laptop for many of the applications.

Fig 1 shows the block diagram of a cell phone with respect to GSM standard.

RF Part

As shown in the figure 1, every mobile phone will have RF part which consists of RF frequency up converter and RF frequency down converter. There are two approaches employed in GSM Mobile phone receiver, i.e. heterodyne or homodyne. The basic component used for frequency conversion is RF mixer.

Antenna

Antenna is the metallic object which converts electro-magnetic signal to electric signal and vice versa. Commonly used antennas in the mobile phone are helix type, planar inverted F type, and whip or patch type. Micro strip based patch type of antennas are popular among mobile phones due to its size, easy integration on the PCB and multi frequency band of operation and supports various GSM bands and also various technologies such as CDMA, LTE, WiMAX (Worldwide Interoperability for Microwave Access) and also WLAN, Bluetooth and so on.

Tx/Rx Switch

As there is only one antenna used for both transmit and receive at different times, Tx/Rx Switch is used to connect both Tx path and Rx path with antenna. Tx/Rx Switch is controlled automatically by DSP (digital signal processor) based on GSM. For FDD (Frequency Division Duplexing) systems diplexer is used in place of switch which acts as filter to separate various frequency bands.

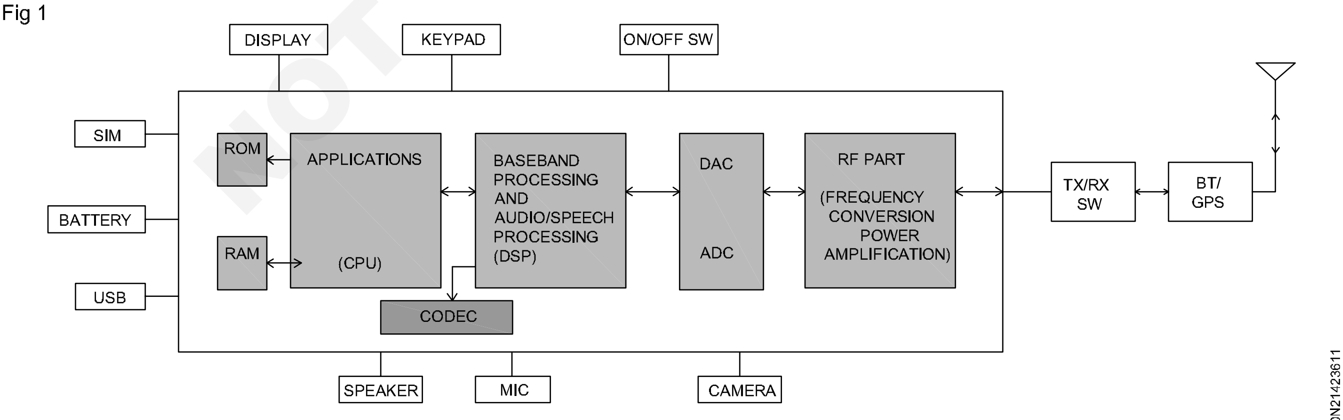
Baseband Part

This part is used to convert voice/data to be carried over GSM air interface to baseband signal. This is the core part which changes for various air interface standards viz. CDMA, Wimax, LT E, and more. For speech/audio, codec is used to compress and decompress the signal to match the rate to the frame it has to fit in. CODEC converts speech at 8 KHz sampling rate to kbps rate for full rate speech traffic channel.

ADC and DAC

ADC (Analog to Digital Converter) and DAC (digital to analog converter) is used to convert analog speech signal to digital signal and vice versa in the mobile handset. At transmit path, ADC converted digital signal is given to speech coder. AGC (Automatic Gain Control) and AFC (Automatic Frequency Control) is used in the receiver path to control gain and frequency. AGC helps maintain working of DAC satisfactorily, as it keeps signal within the dynamic range of DAC. AFC keeps frequency error within limit to achieve better receiver performance.

Fig 1



GSM CELL PHONE BLOCK DIAGRAM

Application layer

It also runs on CPU. Various applications run in GSM mobile phone. It includes audio, video and image/graphics applications. It supports various audio formats such as MP3, MP4, WAV, RM, JPEG image formats are usually available. It supports video formats e.g. MPEG-1 to MPEG-5.

Operating system

Various operating systems are supported in mobile phone such as Symbian, java, android, RT-Linux, Palm. It runs on CPU of different manufacturers. For time critical application RTOS (real -time operating system) is used.

Battery

It is the major source of power to make/to keep mobile phone functional. There are various types of batteries made of Nickel Cadmium (NiCd), Nickel Metal Hydride (NiMH), based on lithium, Li-ion and so on. Battery comes usually with 3.6 or 3.7 voltage and 600 mAH or 960 mAH ratings. Li-ion is long lasting and lighter, but more expensive.

Connectivity (WLAN, Bluetooth, USB, GPS)

To make data transfer fast enough between mobile phone and other computing devices (laptop, desktop, tablet) or between mobile and mobile various technologies are evolved which include WLAN, Bluetooth, USB, GPS (global positioning system) is used for location assistance and will enable google map to work efficiently.

Bluetooth and wi-fi uses 2.4 GHz frequency band. This band is the most favourite and it is license free band.

Microphone

Microphone or mic converts sound signal variations to electrical signal to couple on the PCB for further processing. Usually in mobile phone mics having different types such as condenser, dynamic, carbon or ribbon.

Speaker

It converts electrical signal to sound signal (pressure vibrations) for human being to hear. This is often coupled with audio amplifier to get required amplification of audio signal. It also tied with volume control circuit to change the amplitude of the audio signal.

Camera

The mobile phone camera feature is available for one to click pictures at various occasions. It is the major specifications in increasing cost of mobile phone. There are various mega pixel cameras for mobile phones are available such as 12 mega pixel, 14 mega pixel and even 41 mega pixel available in smart phones. This has become evident because of advancement in sensor technology.

Display

Displays are used to viewing the various information. There are various display devices used in mobile phone such as LCD (liquid crystal display), TFT (Thin-film transistor) screen, OLED (organic light emitting diode), TFD (thin film diode), touch screen of capacitive and resistive type.

Keypad

Earlier days keypad was simple matrix type keypad which contains numeric digits (0 to 9), alphabets (a to z), special characters and specific function keys. These has been designed for various applications such as accepting call, rejecting call, cursor movement (left, right, up, down) dialing number, typing name/sms/mms and so on. Now-a days keypad has been removed from the phone design and it has become part of mobile phone software. It loops on the display screen itself which can be operated by user using touch of a finger tip.

Features

1 **Accessories -** Manufacturers offer a number of accessories that can make phones even more convenient to use, such as hands-free options (headsets, ear buds, bluetooth hands free devices), extra batteries, and portable charging adapters.

2 **Bluetooth -** This wireless communications technology links compatible for mobile phone datas to transfer.

3 **Caller ID -** A feature that displays the name or number of the calling party on the phone's display when an incoming call is received.

4 **Digital Camera -** Allows to take digital photos and transmit the images wirelessly.

5 **Display -** Prices increase along with display sizes. However, a larger display is a virtual requirement for wireless internet users. Wireless web use should consider a smartphone of larger and color screen for viewing images or web-surfing then.

6 **GPS -** Some selected phones offer GPS, or global positioning and navigation functions. This feature can be especially useful to those who often travel.

7 **International Support -** Travelers may want to investigate a world phone, compatible with the respective frequencies (GSM or CDMA) most commonly used in Europe, Asia, and North America. Users want international access to make sure to research which networks are used in areas they will be travelling, as GSM and CDMA are not compatible.

8 **Multimedia -** To download digital ringtones to download and play MP3s, and stream video.

9 **Organizer Applications -** Even basic cell phones often have organizer applications, such as calendaring.

10 **SIM Card -** Number of SIM slots are available with new generation cell phone.

11 **Smartphone (Palm or Pocket PC) -** Devices, with computing, Internet, and networking features, are often referred to as smart phones.

12 **Speakerphone -** Persons such as drivers who want to keep their hands free can buy phones with built-in speakerphone capability.

13 **Text Messaging -** Text messaging allows short text messages to be received and displayed on the phone.

14 **Video Recording**

15 **Voice Dialing -** This feature lets users speak a name to dial a number.

16 **Voice Mail -** A feature that supports audio messages from callers. Users can leave spoken messages for one another and listen to the messages by executing the appropriate command. This is often a standard feature that comes with a mobile phone service.

17 **Weight -** Mobile phone manufactures consistently streamline their products; however, some phones are heavier and more awkward than others.

18 **Wi-Fi -** Wireless fidelity is technology for providing a local area network that allows compatible devices to access data on the network or other networks such as the internet.

19 **Infrared (IR) PORT -** A wireless data communications connection between 2 devices that uses an Infrared signal. The 2 devices must have line- of - sight position.

Smart phone

A cell phone having advanced computing ability through the use of an application software is called a smart phone. It contains the following additional stages.

1 Digital camera module

2 Internal and external memory cards

3 Radio tuner

4 CPU and Computer OS software

5 Appointment calendar (Outlook synchronization for faculty and staff through ActiveSync)

6 Address book

7 MP3 player

8 Web browser

9 E-mail access, in addition to text messaging

10 Mini-keyboards or onscreen keyboards

11 Voice dialing

12 Bluetooth

13 Character recognition (allowing for handwritten input)

14 Synchronization of information with desktop or laptop computers

15 Voice recording

16 Digital camera

17 Video recording

18 GPS

19 Microsoft Office (MS) compatible applications (Native with Pocket PC operating systems; Palm operating systems may require third-party software)

Main uses of cell phones

The most popular uses and applications of mobile phones are:

1 Voice calling - Talking on the telephone.

2 Voice mail - Callers can leave a message if your phone is busy or turned off.

3 E-mail - Send and receive e-mails with other e-mail addresses.

4 Messaging - Send and receive text, picture and instant (chat) messages with other mobile phone users and e-mail addresses.

5 Mobile content - Get news, weather, sports, financial and other information.

6 Gaming - Play games that are downloaded to your handset or played online on the Internet.

7 Personalize your phone - to your own style by adding custom ringtones, ring back tones, face-plates, themes, background images, icons, voice greetings and screen-savers.

8 Play music - using an audio (MP3) player to play downloaded tracks or listen to radio.

9 Take photos or videos - with a built-in camera. Then send the image files to others.

10 Download and view images - with a photo (JPEG) viewer or video (MPEG) player.

11 Organize personal information - using a calendar, clock, alarm, address book, task manager or memo pad.

12 Shop - Make retail purchases from Web-based stores (e-commerce).

13 Bank - Manage your money using an e-wallet.

14 Location-based services - Maps & directions. Retail store directory. Track persons, cars, pets, etc.

15 Business Uses for Mobile Phones

16 For the Mobile Professional

17 Mobile Business Applications

18 Small Business

Data transfer among phone, internal and external

Objectives : At the end of this lesson you shall be able to
- **differentiate between internal and phone memory**
- **describe SD card memory**
- **explain the data transfer between phone memory and S.D card memory**
- **explain how to interface the cell phone/smart to the PC and transfer data.**

Internal Storage

There are three types of memory capacities in our smart phones these days: Internal, Phone and External. The first two are often confused for each other while the third is still understood as SD card storage.

Internal memory used for installing the applications (the operating system) and data. Applications are installed in this storage and the personal data such as text messages, contact lists, email settings and the likes are stored on this. This is considered to be quite sensitive information and this is not accessible to user. Whenever the phone is reset to factory settings, all this storage gets erased. This memory is reserved for the operating system and personal data. It will never show up whenever phone is connected to computer.

Phone Storage

This is the storage that is available to user. This is the storage that user get from the phone itself. Games and applications are installed in this one and it is the default memory for storing pictures, movies, songs and so on. User can access it when the phone is connected to computer.

When use most of internal storage, user will get a notification for low storage, asking to delete some files, even when user have most of phone storage empty. This message will be triggered by a system file which stores its data on Internal Storage. If user attempt to download more apps, they will be housed on phone storage. So user can store apps on phone storage as well. It can also disable apps which prompt low storage message due to lack of storage space to refresh their app data.

External Storage

It is the external storage capacity of phone. It depends on the compatibility of the memory card slot and to what extent is it supported. In simpler terms, it is the storage which can be removed easily by user (memory card) and can be used for storing pictures, music, videos and many more. It may or may not be able to install applications on it. This is because some manufacturers allow for it while some don't. To an extent, even user's cloud storage can be categorized as external storage.

Data transferring

The data in the cell phone is possible to transfer from phone to SD memory or PC and vice versa. Even we can transfers the same application (Apps) stored in phone to SD card for improving performance. Data transferring to/ from cell phone.

1 Phone to SD card

2 Phone to PC

   i Using data cable

   ii Using card reader

   iii Using wi-fi syncing

   iv Using bluetooth

   v Using e-mail

   vi Using cloud storage

Application (App) transfer

Apps are transferable from phone memory to SD and vice versa for improving performance and using memory efficiently. This is possible in Android base phones mostly. This option is available at settings and application manager. In application manager, consisting a tab for moving data. We can also delete the application by uninstalling the app.

Data transfer between phone and SD memory

The data or file in phone or SD card can inter-transferable in the cell phone. This can be achieved by simply selecting and copying the data and pasting folder view options are need to get by installing apps. The new folder can create by simply selecting options.

Data transfer between phone and PC (Using data cable)

There are so many methods and techniques for transferring data. In those, using data cable is the easiest method.

In this, data cable is connected between PC and phone. Most of the cases PC will detect the phone as a memory devices. In some cases need to download the supporting file from internet. It need to permit the PC to access phone for accessing data. This can be automatically asks when the phone is connected to PC.

The data can copy or clang from phone to PC and vice versa, as like memory card (Pen drive).

Data transfer using card reader

The phone data can also be transferred by using card reader. For this we need to ensure the data of phone is available in SD card memory. For this transfer data from phone to SD card by copy and paste. Need to switch OFF the phone before removing SD card. SD card can also be removed by unmounting the external memory in phone setting at memory section. The data in the memory is transferable by using card reader as pen drive in PC.

Data transfer using wi-fi

If the PC can support wi-fi (in built), phone can transfer data simply by enabling wi-fi network. For this, some software for PC and apps like "SHARE IT" for phone must be available in internet. For connecting wi-fi to the PC, external wi-fi cards are available in the market. This is faster than bluetooth method.

In this method, there is no need of any physical connection between PC and phone. It is suitable for large files like video, audio, etc.

Data transfer using bluetooth

It is also similar to the wi-fi method. But for this method there is no special software or apps are needed to install. Most of the phones and PCs are supporting bluetooth. In some cases PC needs bluetooth connecting device for enabling. It is slower than wi-fi method. But it is cost effective. It is suitable for small size of files like photos, text, etc.

Data transferring using e-mail

This is a technique used for transferring data. This method mostly used for long distance data transfer. In this simply mailing the required data file to self address or some one address and this can be downloaded by opening email from PC or phone. But this method requires internet connection. It is having limitations of file size due to email support. This can overcome by cloud storage method.

Data transferring using cloud storage

This method is similar to e-mail method. But, here instead of email account, using cloud storage account. For this, so many third party cloud store operators are available in internet. They are offering large amount of data space for file storage. For data transfer, need to install cloud storage software in PC and App in phone. We can simply transfer data by upload method and downloading. This method also required internet connection.

Setting-up flashing files

Objectives : At the end of this lesson you shall be able to
- **define flashing of a cell phone and effects of cellphone after flashing**
- **define flashing files**
- **explain the availability of flashing files.**

Flashing

Inside the cell phone handset, software is used to run and control its different functions. Software makes the mobile handset to function in a good and proper manner.

During the normal day to day operation, this software could become corrupt and the phone will start to function in some unpredictable manner.

Phone could completely stop working or will start to show some errors.

In this type of situation Universal Flash Storage (UFS) device can be used to reload the mobile phone with the correct software, so that the phone will once again start working properly.

This process of loading the mobile phone with correct software using the UFS device is called “Flashing”.

This process is also known as “Software Repairing” of the mobile phones.

During the flashing process the UFS device sends some files to the cell phone. These files replace the corrupted/ damaged file on the mobile phone and the phone will return to its proper state. This process is similar to the way operating system is reinstalled on a computer system when it becomes corrupt.

Flashing files

Files sent by the UFS device to the mobile phone are called flashing files. These files contain the software required for proper operation of the mobile phone. Different functions provided by the mobile phone depend on these software. These files could also contain ringtones, wallpapers and various operating commands.

When the flashing is done, the UFS device first removes existing data and files from the mobile phone and then the new data and files are written.

Flashing files supported by some mobile are:

1 Nokia - MCU, PM, PMM, WUG, SLD, FBI, EEP, PP, MLF, RPL.

2 Samsung - MCU, AXF, OGM, MEL, S3, TFS, CLA, SRE.

3 Ericsson - MCU, MOD, GDF, PDA, LANG.

4 Sony Ericsson - MCU, CUST/FS, GDF.

5 Motorola-Acer - FLX, MCU, LP.

Availability of flashing files

When one buys UFS package, with the UFS box set of flashing cables and flashing software CDs are also provided. The number of flashing cables and software received with the UFS package depends on the make/ brand of the UFS package and also on how latest is the package being purchased.

For example, sometimes back one used to get 38 to 55 flashing cables with the UFS package, but currently around 60 flashing cables are provided with the latest UFS-3 package.

One also gets around 25 CD with the latest UFS-3 package. These CDs contain driver for UFS package, flashing software and flashing files for different make/ model of mobile handsets.

Current UFS-3 device can be used to flash/repair more than 400 models of Nokia, Samsung, Sony Ericsson, LG, Sharp, Motorola etc., make of handsets.

Flashing files required to flash/repair these mobile handsets are provided on the CDs provided with the UFS package. Many of these flashing files are provided in compressed ZIP format on the CD.

Compressed files are files with file names ending with ZIP, LZH, ARJ, or ARC, depending on how they were created. One need to decompress/extract these files before using them, this decompression process is commonly known as “Unzipping the file”.

Before using the ZIP files on the CD, you need to extract them to some folder on the hard disk drive. For this you need WinZip or WinRar program installed on your computer.

Extracting these files on the hard disk drive will consume a lot of hard disk space, so you will require a computer with large hard disk drive for mobile flashing purpose. If you have limited hard disk space then you can extract files of only those mobile handsets which you require frequently. Other files can be extracted as and when the need arises.

Flashing files of some of the mobile sets needs to be installed before using them. When looking at the folder on flashing CD, if you see application files, instead of ZIP files then that file needs to be installed.

Process to extract or install these files are explained later in this book.

One can also copy all the CDs received with the UFS device to some folder on the hard disk drive, and install/ unzip them as and when required. This will be helpful if you misplace the CDs or CDs become corrupt due to any reason (scratch etc.).

Various locks of cell phone

Objectives : At the end of this lesson you shall be able to
- **state the need of cell phone locks**
- **explain different types of lock and unlock functions**
- **describe lock and unlock functions in your cell phone.**

Cell phone locks

Following are some of the locks which can be used in cell phone. The various lock of the mobile handset is used for safety purpose.

1 Keypad Lock

2 Phone Lock

3 Security Lock

4 SIM Lock

Keypad Lock

As the name suggests, this lock will locks the handset's keypad, one will not be able to use the keypad for any type of number or text entry.

Even when the keypad lock is active one can answer incoming call by pressing the keypad keys.

Different handsets use different method to enter into keypad lock mode and to remove the lock. When the phone is in keypad lock mode, pressing of any key on the keypad will display a message on the screen, explaining the process to unlock the keypad.

Phone Lock

In this mode the handset cannot be used to make/receive any call, even though the keypad stays active during this lock.

In this mode, when the handset is switched on, it asks for an unlocking code known as PIN or Personal Identity Number". If this PIN is entered only it will work.

Security lock

Security lock is used to lock all the functions of the mobile handset. When the security lock is on, the phone asks for the PIN code when it is switched on.

Some handset may ask for the PIN number even when the SIM card of the phone is changed.

This facility is not provided on all handsets.

SIM Lock

When one buys a mobile handset from mobile service provider under some scheme, the provider may lock the handset with the SIM card in the phone.

This prevents the user from using the handset with SIM card from some other service provider.

Currently, phones can be locked to accept only SIM cards from one or more of the following:

1 Countries (your phone will work in one country, but not another)

2 Network/ Service providers (e.g. T-Mobile, Movistar, Vodafone etc)

3 SIM types (i.e. only specific SIM cards can be used with the phone).

Unlocking technology

A handset can be unlocked by entering a special code, or in some cases, over-the-air by the carrier.

Typically, a locked phone will display a message if a restricted SIM is used, requesting the unlock code.

For example, in some mobile phone, "Insert correct SIM card" will appear on the phone's display if the wrong SIM is used. Once a valid unlocking code is entered, the phone will display "Network unlocked". In some cases, the phone will simply display a message explaining that it is locked.

The code required to remove all SIM locks from a phone is called the master code or network code key.

The unlock code is verified by the phone itself, and is either stored in a database or calculated using an obscure mathematical formula by the provider.

In some other mobiles embed a random number in the handset's firmware that is only retained by the network on whose behalf the lock was applied. Such phones can often still be unlocked, but need to be connected to special test equipment that will rewrite that part of its firmware where the lock status is kept.

Most phones have security measures built in its software that prevent users from entering the unlock code too many times, usually four. After that the phone becomes "hard-locked" and special unlocking equipment has to be used in order to unlock it.

The main reason to unlock a phone is to be able to use it with a different SIM card. For example, when travelling abroad it is usually cheaper to temporarily use a foreign network, for example with a prepaid subscription. Contrary to some beliefs, an unlocked phone can't access extra cell phone towers or give free phone service. All it can do is accept other SIMs.

Unlocking via computer

One of the most popular way of phones are unlocked is using the USB, RS-232 or LPT port of a computer using software usually written specifically for the model of phone being unlocked. In some cases, special "unlocking clips" or "unlocking boxes" are used which re-program the software that controls the phone, removing the SIM lock. However, such clips are usually very expensive.

Unlocking via Mail

Some companies have begun to offer a "mail-in" service, such as travelinsider.com. These services allow the user to send their phone in and have it sent back in an unlocked condition.

Regulations on unlocking

Unlocking a phone without the permission or unlocking code from the provider is usually in breach of the agreement with the provider, though most countries do not make specific laws prohibiting the removal of SIM locks.

Security lock

A security code is for the safety and security of your mobile phone. If you activate it in the security settings, the phone will ask it while booting it every time or when you lock the keypad and want to unlock the keypad.

The default security codes of major brands of cell phones are as follows:

Samsung : 0000 / 00 00 00 / 00 00 00 00

Nokia : 12345

All other brands of cell phones : 0000 / 1234

Chinese brands : 1122 / 0000 / 1234 / 4321

So it is advisable to change the security code for safety. So if you change the security code, you should never forget it. If you forget and put the wrong security code, the handset will not accept it. So if you forget it and are unable to put the right code, your phone will be considered as locked. You will have to get it unlocked by special software.

Internet on cell phone and IMEI number

Objectives : At the end of this lesson you shall be able to
- **define internet and working of internet**
- **define to access the internet**
- **explain some applications of internet from cell phone**
- **define the IMEI NO and its importance**
- **list the precaution to maintain the cell phone.**

Internet

The Internet is a decentralised, international network of networks.

Devices such as computers, mobile phones can connect each other and form a network. The networks are connected to each other through electronic, wireless and optical networking technologies.

Multiple interconnected networks form the Internet.

Working of Internet

The Internet works based on protocols which handle chunks of data, known as "packets".

Various types of hardware, such as an ethernet network card or a modem, convert our device's binary packet data into network signals and then back into packet data.

Internet Protocols(IP) are used to direct packets to a specific computer or server.

Transmission Control Protocols (TCP) are used to direct packets to specific applications on a computer using a port number.

Accessing the Internet

We access the Internet because our router connects our device to an Internet Service Provider (ISP).

Internet Service Providers (ISPs), such as Verizon, AT&T and Comcast, give us access to the Internet through a range of technologies.

A single device is assigned an address when it connects to the Internet: an Internet Protocol (IP) address. This address distinguishes our device in the network from all other devices.

However, our national ISP can only connect us directly to servers located in our country. If we want to connect to servers located in a different country, then we need that country's ISP to connect us to those servers.

Protocols translate the text of our message into electronic signals, transmit it through the network and translate it back into text once it reaches another device.

Data plan

Phones today have lots of features through the accessing of internet. You can check email, get directions, and even chat over video. Ultimately, you can stay connected at all times. But in order to do so, your device needs to be able to connect to the Internet to send and receive data.

If you're somewhere that offers Wi-Fi (like your house), staying connected is as simple as logging on to the server. However, if you want to stay connected on the go, you're going to need a data plan to give you access to your provider's data network.

Navigation

GPS is a wonderful way to get around town. However, those map apps definitely use data. In order to find your destination, note your current location, and give you turn-by-turn directions, your GPS app needs to be connected to the Internet.

Uploads

In order to upload and post a picture or video to social media, you need to first be able to access it, which requires an Internet connection. While you can draft posts offline on some channels (like Facebook), your device needs to be connected to the Internet through Wi-Fi or your cellular data network in order to actually publish.

Downloads

This is the process of receiving data over the internet. It is the opposite of uploaders.

IMEI number

IMEI is short for International Mobile Equipment Identity and is a unique number given to every single mobile phone, typically found behind the battery. The IMEI is only used for identifying the device and has no permanent or semi-permanent relation to the subscriber. Instead, the subscriber is identified by transmission of an IMEI number, which is stored on a SIM card that can be transferred to any handset. However, many network and security features are enabled by knowing the current device being used by a subscriber

IMEI numbers of cellular phones connected to a GSM network are stored in a database (EIR - Equipment Identity Register) containing all valid mobile phone equipment.

When a phone is reported stolen or is not type approved, the number is marked invalid.

The number consists of four groups that look similar to this:

AA-BBBBBB-CCCCCC-D

AA - BBBBBB - CCCCCC - D

TAC Serial # Checksum

The Type Allocation Code (TAC) is the initial eight-digit portion of the 15-digit IMEI code used to uniquely identify wireless devices. The first two digits represent the country code. The second group of numbers identifies the manufacturer. The third set is the serial number and the last single digit is an additional number (usually 0).

For example 99-000033-792410-8:

- 99 is country
- 000033 is manufacturer
- 792410 is the serial number
- 8 is the checksum value

How to check IMEI Number for your mobile: *06#

Mobile phone maintenance

Mobile phone is delicate device and needs care for its proper functioning. Here are the common measures to keep the mobile phone in good condition.

- Do not keep mobile phone in wet area or use it with wet hands. Moisture can cause non-repairable internal corrosion of parts.
- Do not drop the phone or damage the connection points.
- Do not over stress the phone. It may damage the display.
- Do not keep the phone near heat generating devices. High temperature in a car can damage its electronics.
- Do not over charge the battery. Charge the battery only its charge status goes below 50 percent.
- Prevent cloning.

Current technology of cell phones

Cell phone has the following special features;

a The fingerprint or iris scanners.

b New facial recognition technology which scans the contours the person face and head.

c Unbreakable and foldable phones - The display screens are flexible and hence it is foldable.

d Improved power backup - using nano batteries, hydrogen fuel cells and solar power the power backup time to the cell phones can be improved. The future phones battery can also be charged improved. The future phones battery can also be charged faster by wi-fi with the help of wireless signals and no need of conventional power source/power bank.

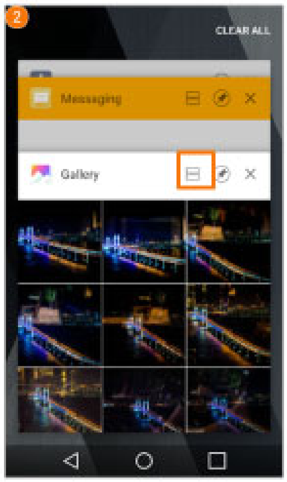
e Contextual intelligence(also known as practical intelligence) - The phones will use sensors to get data about your physical surroundings and conditions, use saved information about you along with the contextual intelligence technology to make decisions for you even before you thought of the question.

f Depth-sensing cameras-It provides 3D printing and 3D scanning facility as shown in Fig.1.

Fig 1

g Multi-screen capabilities or screen casting - To connect and share the screen of the smartphone with the tablet, television or projector with no limitations imposed by different platforms or OS, and irrespective of make or form as shown in Fig.2.

Fig 2

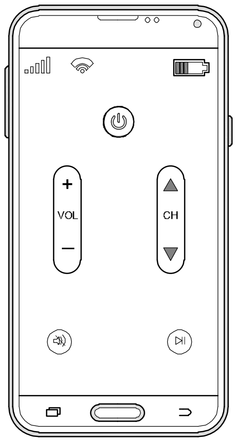


h Infrared support - Turn the smartphone into universal to operate the electronic and electrical gadget using remote control as shown in fig.3. When this remote control goes missing, we can give phone call and find out the remote/Cell phone.

i Dual recording - Existing smartphones come with front and rear cameras but only one of them works at a time. Future smartphones may have better camera support to allow simultaneous recording using both cameras.

j Besides the above features, there are numerous user friendly apps with encrypted security & hardware are developed to use the smartphone to function like & special device for a dedicated purpose also.

Fig 3



EM20N21423913

Advanced features in cell phones

Current technology cell phones has the following special features:

a The fingerprint or iris scanning.

b New facial recognition technology which scans the contours the persons face and head.

c Unbreakable and foldable phones - The display screens are flexible and hence it is foldable.

d Improved power backup - using nano batteries, hydrogen fuel cell phones can be improved. The up time to the cell phones can be improved. The future phones battery can also be charged faster by wi-fi with the help of wireless signals and no need of conventional power source/power bank.

e Contextual intelligence (also known as practical intelligence) - The phones will use sensors to get data saved information about you along with the contextual intelligence technology to make decisions for you even before you thought of the question.

f IoT Technology - The smart phone can be used as control device for IoT (internet of things) platforms like, to enable remote health monitoring and emergency notification systems, industrial controls, house hold appliances/gadgets/security monitoring and controlling, etc.

g Depth - sensing cameras - It provides 3D printing and 3D scanning facility as shown in fig.4.

h Multi-screen capabilities or screen casting - To connect and share the screen of the smartphone with the tablet, television or projector with no limitations imposed by different platforms or OS, and irrespective of make or form as shown in fig.5.

Fig 4

Fig 5

i Infrared support - Turn the smartphone into universal remote contralto operate all the electronic and electrical gadgets using remote control as shown in fig.6. When this remote control goes missing, we can give a phone call and find out the remote/cell phone.

j Dual recording - Existing smartphones come with front and rear cameras support to allow simultaneous recording using both cameras.

Besides the above technical features, there are numerous user friendly apps with encrypted security and hardware are developed to use the smart phone accordingly to function like a special device for a dedicated purpose also.

Fig 6

ANNEXTURE

Mobile Phone Related Abbreviations

In this article we expand common, and not so common, Mobile and Mobile Telephony abbreviations.

AC = Authentication Center;

ACRE = Authorisation and Call Routing Equipment;

A - GPS (also: AGPS) = Assisted - Global Positioning System;

AMOLED = Active Matrix Organic Light Emitting Diode;

AMPS = Analogue (Also: Advanced) Mobile Phone System;

ANS = Advanced Network Services;

App(s) = Application(s);

BS = Base Station;

BSC = Base Station Controller;

BSS = Base Station System;

CAMEL = Customised Applications (for) Mobile-network Enhanced Logic (GSM / ETSI);

CDMA = Code Division Multiple Access;

(C)EIR = (Central) Equipment Identity Register; Blocked and Blocking and IMEI And Phone Identity.

CMAS - Commercial Mobile Alert Service;

CSIM = CDMA Subscriber Identity Module;

D-AMPS = Digital Advanced Mobile Phone Service;

EDGE = Enhanced Data (for) GSM Evolution;

EE = Everything Everywhere (Merger between T-Mobile and Orange);

EGSM = Extended Global System (for) Mobile;

EIR = Equipment Identity Register;

EMS = Enhanced Message Service;

ESN = Electronic Serial Number;

ETSI = European Telecommunications Standards Institute;

EUIMID = Expanded User Identity Module Identifier;

FAC = Final Assembly Code; IMEI And Phone Identity

GMSC = Gateway Mobile Switching Center;

GPS = Global Positioning System;

GPRS = General Packet Radio Services;

GPU = Graphics Processing Unit;

GSM = Global System (for) Mobile Communication;

GSMA = Global System (for) Mobile Association;

GSMS = GPRS Short Message Service;

GTP = GPRS Tunneling Protocol;

ICCID = Integrated Circuit Card Identifier;

IMEI = International Mobile Equipment Identity;

IMEISV = International Mobile Equipment Identity Software Version;

IMSI = International Mobile Subscriber Identity;

IMT2000 = International Mobile Telecommunications 2000;

LAI = Local Area Identity;

LTE = Long Term Evolution;

MAG = Mobile Access Gateway;

MAP = Mobile Application Part;

ME = Mobile Equipment;

MEID = Mobile Equipment Identifier;

MCC = Mobile Country Code;

MIM = Mobile Instant Messaging;

MIN = Mobile Identification Number;

MMS = Multimedia Message Service;

MNC = Mobile Network Code;

MNO = Mobile Network Operator;

MNP = Mobile Number Portability;

MP3 = MPEG-1 Audio Layer-3 (Moving / Motion Picture Expert Group 3);

MP4 = MPEG-4 Part - 4 (Moving / Motion Picture Expert Group 4);

MPEG = Moving (Also: Motion) Picture Experts Group;

MS = Mobile Station;

MSC = Mobile Switching Centre(s);

MSE = Mobile Station Equipment;

MSIN = Mobile Station Identification Number;

MT = Mobile Terminated;

MTSO = Mobile Telephone Switching Office;

MVNA = Mobile Virtual Network Aggregators;

MVNE = Mobile Virtual Network Enabler;

MVNO = Mobile Virtual Network Operator;

N-AMPS = Narrowband - Advanced Mobile Phone Service;

NUC = Network Unlocking Code;

OMA = Open Mobile Alliance;

PAC = Port Authorisation Code;

PAYG = Pay As You Go;

PAYM =Pay Monthly;

PDA = Personal Digital Assistant; Also: Portable Digital Assistant;

PIM = Personal Information Manager;

PIN = Personal Identification Number;

PLMN = Public Land Mobile Network;

PSTN = Public Switched Telephone Network;

GSM = Global System for Mobile Communication;

PUK = Pin Unlock Key;

RAM = Random Access Memory;

RIM = Research In Motion (The company behind Blackberry);

ROM = Read Only Memory;

R-UIM = Removable - User Identity Module;

SAP = SIM Access Profile;

S - GPS (Also: SGPS) = Simultaneous - Global Positioning System;

SIC = System Identification Code;

SIM = Subscriber Identity Module; SIM Card Facts

SMS = Small Message Service; Also: Short Message Service;

SMSC = Small Message Service Center; Also: Short Message Service Center;

SMC-CS = Small (Also: Short) Message Control - Circuit Switched;

SMC-GP = Small (Also: Short) Message Control - GPRS Protocol;

SMSMM = Small (Also: Short) Message Service Mobility Management;

SMS - MO = Small (Also: Short) Message Service - Mobile Originated;

SMS - MT = Small (Also: Short) Message Service - Mobile Terminated;

SM-RL = Small (Also: short) Message - Relay Layer;

SM-TL = Small (Also: Short) Message - Transfer Layer;

SNS = Social Network Service (Also: Social Network Server)

TAC = Type Approval Code; or Type Allocation Code; IMEI And Phone Identity

TMSI = Temporary Mobile Subscriber Identity;

UI = User Interface;

UIMID = User Identity Module Identifier;

UMA = Unlicensed Mobile Access;

UMTS = Universal Mobile Telecommunications System (ETSI);

USIM = Universal Subscriber Identity Module;

USB = Universal Serial Bus;

VLR = Visitor Location Register;

VoIP = Voice over Internet Protocol;

WAP = Wireless Application Protocol;

Wi-Fi = Wireless Fidelity;

2G = 2^{nd} Generation;

3G = 3^{rd} Generation;

3G-MSC / VLR = 3^{rd} Generation Mobile Switching Centre Visitor Location Register;

3GPP = 3^{rd} Generation Partnership Project;

3G-SGSN = 3^{rd} Generation Serving GPRS Support Node;

4G = Fourth (4^{th}) Generation;

Formatting and the need for formatting of cell phones

Objectives : At the end of this lesson you shall be able to

- **explain meaning of formatting of cell phone and the need for formatting**
- **define virus**
- **explain the signs of a phone infected by virus**
- **protect the cell phone from virus**
- **list the various steps to be followed to keep the handset secure from different malwares.**

Formatting of mobile phone

Formatting a cell phone means erasing or deleting all the stored data and information like contacts, images, multimedia files, etc from the phone memory. Data stored in the memory card is not deleted, it will remain safe during formatting.

In formatting the cell phone the operating system like iOS, Symbian, Windows or Android are not at all to be reinstalled unlike in computers. The OS is not affected and it remains intact.

The procedure where we have to reinstall the OS is called flashing in cell phone repair jargon. Which is very much different from formatting. So let us go ahead with formatting a phone and not get confused with flashing.

In general the process of formatting is usually done when there is any problem due to infection by a virus.

Virus

A mobile virus is nothing but a small software code written by some one to corrupt or damage the information stored in the mobile system.

The signs that the phone is infected by virus are:

1 **Slow Functioning :** The entire handset will become very slow. If you open the menu, it will load after 2-5 seconds. Also all the software's and apps will take double the time to open. In short, the handset will stuck!

2 **Frequent Freezing :** The device will freeze very frequently. It will get stuck all of a sudden and hang. Sometimes the handset will not even switch OFF. It has to restarted or remove the battery and insert again.

3 **Switching Off Automatically :** Many times, the device will switch off automatically without informing. This will happen for more than 3-5 times a day!

4 **Restarting:** Sometimes instead of switching off automatically, it will restart frequently.

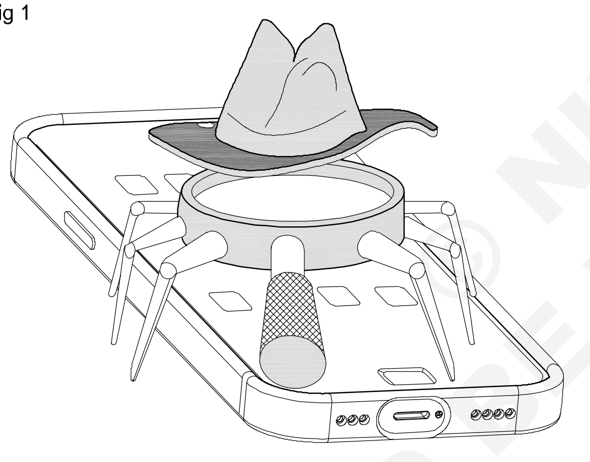
5 **Not Booting Properly :** Sometimes, the virus can corrupt the OS very badly, so that the cell phone will not boot properly i.e. it will display a blank screen or it will get stuck at the logo when switched on. It will not proceed further.

6 **Failure of some apps :** Some of the applications will not function properly.

Protect a mobile phone from virus

A virus can infect your mobile phone the same way that it infects computer. It will do the same damage like what a computer virus can do! It becomes very difficult to operate when it gets infected with any malware, spyware, trojan or any other virus whether it is an android, Apple iphone, Blackberry or any other smartphone or a tablet. It is important to clean the infected phone from all badware before it spreads. Protecting cell phone from virus is shown in Fig 1.

Fig 1



EM20N21423921

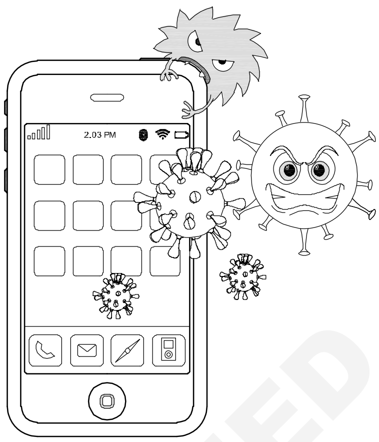
Before knowing how to protect one should know the sources from which viruses can come and also take precautions so that it does not infect the gadget again. The best precaution against viruses is to install a reputed and updated antivirus program. If not, then one may end up getting the phone infected very soon.

The sources from which viruses can come in to the device are: (Fig 2)

1 **Internet surfing:** This is the most common source, especially if the user is visiting unknown and untrusted sites. The phone may most likely to get infected, if the user visit untrusted websites.

2 **MMC card:** If you insert your memory card into a virus infected gadget and then insert it back into your phone, your handset will most likely get infected. Also do not put any other MMC card into your device, because if the other MMC has virus, it will spread into your device as well.

Fig 2



EM20N21423922

3 **Bluetooth / Wi-Fi / Hotspot:** While transferring files to and from one phone to the other via bluetooth, WI-Fi or hotspot, when accept files from other phones, ensure that the user antivirus scans the incoming files before opening them.

It is easy to keep your handset safe and secure from different malwares, if you follow these simple steps:

1 **Install antivirus program and keep it updated:** Always keep the bluetooth switched-off unless required. Or it is preferable to keep the handset to hidden mode unless it needs to be visible.

2 **Keep your bluetooth switched-off:** Always keep the bluetooth switched-off. If by fluke, the phone has kept on, do not accept any files from unknown sources. Still if the user have got any file by mistake NEVER OPEN SUCH FILE AS IT IS MOST LIKELY A VIRUS. Just delete the file.

3 **Don't visit untrusted websites:** While surfing the internet, only visit the most trusted and reputed websites. Also if you have visited any unknown website, it's ok until you find it to be a suspicious one.

4 **Don't download from untrusted sources:** Surfing unknown websites is not as risky as downloading content from them. Be careful of downloading any file especially if you find the website to be a suspicious one. If you have downloaded anything, please do not open that file and just delete it.

5 **Be careful of the memory card:** The MMC have to be used carefully. So do not put your MMC in another handset or anybody's MMC into your handset. It might get infected easily and spread very fast.

Cell Phones - Interfacing

Objectives : At the end of this lesson you shall be able to
- **interfacing smartphone to computer**
- **dismantle and assembling of cellphone**
- **healthiness of power.**

Performing interfacing a cell phone/smartphone to a computer

Interfacing a cell phone or smartphone to a computer allows for various functionalities such transferring files, syncing data, and even controlling the device remotely To perform this interfacing, we need to consider the following steps:

Connection Methods: There are multiple methods available to establish a connection between a cell phone and a computer.

a USB Cable The most common method is using a USB cable that connects the phone's USB port to the computer's USB port. This creates a direct physical connection between the two devices.

b Bluetooth Some phones support Bluetooth connectivity, allowing wireless communication with a computer that also has bluetooth capabilities.

c Wi-Fi or LAN Certain smartphones enable connection via Wi-Fi or local area network (LAN) This involves connecting both devices to the same network and using appropriate software to establish communication.

2 Software Requirements: Depending on the phone's operating system, specific software or drivers may be necessary to facilitate the connection These software components ensure compatibility and enable communication between the phone and the computer.

3 Phone Settings Before interfacing, certain settings on the phone need to be configured. This typically involves enabling USB debugging or granting permission for the computer to access the device's data The exact steps vary depending on the phone's operating system (eg Android, iOS)

4 Interfacing Functions Once the connection is established, venous functions can be performed

a File Transfer. The most basic functionality is transferring files between the phone and the computer This allows for sharing documents, photos, videos and other types of data.

b Data Synchronization software enables the transfer of contacts, calendars, emails, and other data between the phone and the computer. This ensures that both devices have the most up- to-date information

c Remote Control. Certain applications or software allow for remote control of the phone from the computer. This can be useful for accessing the phone's screen, making calls, or sending messages remotely.

Dismantling a Cell Phone and Identifying the Power Section:

Dismantling a cell phone requires caution and expertise to avoid damaging the components: Here are the general steps to dismantle a cell phone and identify the power section.

1 **Gather Tools:** Prepare the necessary tools such as precision screwdrivers, prying tools, and an antistatic mat or wristband to protect against static electricity.

2 **Power Off:** Make sure the phone is turned off and remove any external power sources, such as the battery or charger.

3 **Remove Back Cover:** If applicable, remove the back cover of the phone by following the manufacturer's instructions or using prying tools to gently release any clips or screws.

4 **Disassemble the Phone:** Carefully remove the screws to ensure proper holding the phone's casing together Take note of the location and size of the screws to ensure proper reassembly.

5 **Separate Components:** Once the casing is opened, you will have access to the internal components. Identify and separate the different modules such as the motherboard, display camera, and battery.

6 **Locate Power Section:** The power section of a cell phone typically consists of the battery power management (PC) components may be the motherboard is usually a distinct component, while the other components may be integrated into the motherboard.

7 **Visual Inspection:** Examine the power section for any signs of damage, such as burnt components. corrosion or loose connections Pay attention to the PMIC and charging circuit, as these are critical for power management and charging functionality.

Testing the Healthiness of the Power Section:

To test the healthiness of the power section, you can perform the following steps:

1 Visual Inspection Inspect the power section for any visible signs of damage, such as burnt or swollen components, loose connections, or corrosion. These issues can indicate potential problems with the power section.

2 Battery Test if the battery is removable, test its voltage using a multimeter, Compare the measured voltage with the manufacturer's specifications to determine if the battery is functioning within the expected range. Additionally, check if the battery holds a charge and provides sufficient power to the phone.

3 Power Management IC (PMIC) Test The PMIC is responsible for regulating the power flow within the phone. To test its functionality, you would typically require specialized equipment and technical expertise. it is recommended to consult a professional or contact the manufacturer for further assistance in testing the PMIC

4 Charging Circuit Test Check the charging circuit for any faults or malfunctions. This involves measuring the voltage output from the charging port using a multimeter while the phone is connected to a power source. Ensure that the charging voltage matches the expected values for the specific phone model

5 Voltage Regulator Test: Voltage regulators are responsible for providing stable and regulated voltages to various components within the phone. If you suspect an issue with a particular voltage rail, you can test the corresponding voltage regulator using a multimeter or specialized testing equipment to verify its output voltage.

6 Functional Testing After examining the power section, reassemble the phone and power it on Monitor its behavior during the boot-up process and observe if it powers up normally, charges properly, and maintains stable operation. Test different functions that rely on the power section, such as making calls using data connectivity, and running power-intensive applications, to assess overall healthiness,

It's important to note that dismantling a cell phone and performing tests on its power section requires technical expertise and proper equipment. If you're not experienced or comfortable with these procedures, it's recommended to seek assistance from a qualified technician or contact the manufacturer for professional support.

Finding and rectifying faults in a basic cell phone system-ringer section and check the performance. Replace carious faulty parts like mic, speaker, data etc.,

A basic cell phone system consists of carious components and circuits that work together to provide functionality, including the ringer section responsible for producing sound alerts and ringing tones. To find and rectify in the ringer section, you can follow these steps:

1 Identify the Fault

a No Sound If the phone is not producing any sound or there is no audible ringer tone, the fault may lie in the ringer section.

2 Gather tools and equipment

To diagnose and rectify faults in the ringer section, you may need the following tools:

a Precision screwdrivers: To open the phones casing and access the internal components.

b Multimeter: To measure voltage, continuity, and check for short circuits.

c Soldering iron and solder: For making repairs or reflowing solder joints if necessary.

d Replacement components: In case any components in the ringer section need to be replaced.

3 Disassemble the Phone

Follow the manufacturer's instructions or guidelines to disassemble the phone carefully. This usually Involves removing the back cover, battery, and any screws holding the casing together.

4 Locate the ringer section

The ringer section is generally located near the top or bottom of the phone's circuit board. It consists of components such as the ringer speaker ringer IC (integrated circuit), capacitors, resistors, and associated wiring.

5 Visual Inspection

Perform a thorough visual inspection of the ringer section Look for any signs of physical damage, loose connections, or burnt components Pay attention to the ringer speaker, as it is prone to damage or malfunction.

6 Check Connections

Ensure that all connections between the ringer speaker, ringer IC, and associated components are core and properly soldered Use a multimeter to check for continuity between the connections and confirm that there are no open or short circuits.

7 Test the Ringer Speaker

Use a multimeter set to the resistance (ohms) mode to measure the resistance across the terminals of the ringer speaker Compare the measured value with the manufacturer's specifications. A significantly higher or lower resistance reading may indicate a faulty ringer speaker that needs replacement.

8 Check Ringer

IC If the ringer IC is a separate component, inspect it visually for any physical damage or signs of overheating If there are multiple pins, check for continuity between the pins using a multimeter to ensure proper functioning.

9 Repair or Replace Faulty Components

If any faulty components are identified during the inspection and testing, repair or replace them as necessary This may involve soldering or desoldering components and using suitable replacements Ensure that all connections are secure and soldered property.

10 Reassemble the Phone

Once the necessary repairs or replacements have been made, reassemble the phone by following the reverse steps of disassembly. Ensure that all screws are tightened correctly and all connectors are securely attached.

11 Performance Testing

Power on the phone and test the ringer section by making a call or setting an alert. Verify if the sound produced by the ringer is clear, loud, and of the expected quality. Adjust the volume settings if necessary.

Note It's important to exercise caution and, if unsure, seek assistance from a qualified technician or the manufacturer's support team when dealing with complex repairs or if you're not experienced with handling electronic components

Potential Hazards Associated with Mobile Phone Repair

Your physical well being is important not only to yourself, but also to others. Therefore, as you embark on mobile phone repair, you should be aware of all the potential hazards and how to prevent them.

What is a hazard?

A hazard is anything that has the potential to cause harm to yourself or those around you. Before you learn the different types of hazards, let's start by defining some of the terms associated with hazards. Write down the meaning of the terms in the following activity.

Let us now look at the various types of hazards that you could encounter when repairing or maintaining a mobile phone?

There are quite a number of potential hazards that one can encounter when servicing or repairing a mobile phone. These are listed in Table 1 together with the preventive actions that you could take to avoid them.

Table 1 Perential mods during mobile phone repair and their prevention

Hazard	Preventive actions
Burns	Use of well insulated tools Use of gloves Keeping the soldering iron in the night place Unplugging equipment when not in use
Pricks by sharp objects	Appropriate storage of equipment Proper disposal of sharp objects Use of appropriate tools and equipment
Environmental pollution	Proper disposal of electronic waste
Trailing electrical cables	Make sure electrical equipment is unplugged while not in use Safe storage of cables
Falls	Keep all tools, bis etc. in the right place

Having looked at potential hazards and how to protect ourselves during mobile phone repair, let us now consider the parts of a mobile phone.

A mobile phone has several parts or components. It is important for you to know the parts and understand their functions so that you can easily diagnose and solve problems. How many parts of a mobile phone do you know?

Take a minute to think about it and then complete the following activity.

A conventional mobile phone is made up of many parts. Table 2 below explains the functions of the main parts.

Table 2: Parts of a mobile phone and their functions

Parts of a mobile cell phone	Functions
Keypad	Used for inputting or entering data into the phone. Its connected directly to the CPU
Ear piece	Converts the electric signal to a sound signal
Mouth piece	Transmits sound from one phone to another
Battery	Source of power supply to a mobile phone
Power switch	Switches the phone on and off

Power IC	It takes power from the battery and supplies to all other parts of a mobile phone
Oscillator	It creates frequency during outgoing calls
Screen or display	Displays data It is connected to the CPU to receive following signals LCD Data Signal, LCD Reset Signal LCD WR Signal LCD RD Signal, LCD FLM Signal LCD HSYN Signal
Flash IC	Stores the software and other programs installed in the mobile phone
Charging IC	Takes the current hon the charger and charges the battery
CPU	Controls all sections of a mobile phone
Antenna	Receives and transmit radio frequencies and helps the phone to connect to the cellular network

Fig 5 below shows a printed circuit board (PCB) of a mobile phone showing the different internal parts. As you can see from this diagram the PCB is divided into two parts, the network section and the power section. The network section controls the incoming and outgoing phone calls, while the power section controls the memory and power related functions of the phone.

We hope you now know the different parts of a mobile phone and their functions. Make sure that you learn them well and are be able to locate them easily before you move on to the next section. Let us now look at the tools that you need to repair mobile phones.

Disassembling and assembling a mobile cell phone:

What is to disassemble?

To disassemble is to take something apart or to break it down into pieces

What is to assemble?

To assemble is to fit together all the separate pieces in order to form one whole.

Disassembling a Mobile Phone The following are the steps that you should take when disassembling a mobile phone:

1 Switch off the phone
2 Remove the battery cover
3 Remove the battery. SIM card memory card (if any)
4 Remove all the screws from the phone
5 Lift back the cover with the help of a flat screwdriver
6 Remove the strips (buzzer strip, display, camera, volume and speaker button strips)
7 Remove the antennae wire from the outside
8 Remove the motherboard and vibrator.

To successfully disassemble a phone, you need to understand the various internal sections of a mobile phone and how they are connected to the CPU. Let us look at that next.

Internal Parts of a Mobile Phone

Table 3 below outlines the main sections and how they are connected.

Table 3 Internal parts of a mobile phone

Internal Section	Connections
SIM card section	SIM Card Interface section is directly connected with the CPU in most mobile cell phones. If there is no power supply in a mobile phone then the SIM section is connected with the CPU through the Power IC.
Memory card section	In most phones the micro SD card holder is connected through a 8-pin socket. The memory card section is found inside the CPU
Ear Speaker Section	In modern mobile cell phones which have a separate ear speaker, the speaker is directly connected to the CPU. It receives sound via signals directly from the CPU of from the audio section inbuilt within the CPU. In some mobile phones, these sound signals are received via coil / resistance. Some mobile phones have audio IC in the audio section, while others have audio amplifier.
Speaker/Ringer Section	The ringer, buzzer or speaker in most mobile phones are connected to the audio amplifier IC to obtain loud sound. The amplifier IC amplifies the sound or audio signal received from the CPU of the audio section.
Key Backlight Section	LED Lights are connected according to the parallel circuit in the key backlight section Anode ends of all the LEDS are connected to each other and all the cathode ends to each other 3 to 3.3V supplied for the functioning of these key LED Lights

LCD Backlight Section	LCD Backlight in mobile cell phones is made according to the series circuit. A Boost Voltage Generator section is built for the supply of high voltage (10 to 18V) for the functioning of the LCD LED Boost coil, Boost Von Driver IC Rectifier Diode are present in this section
Vibrator Motor Section	Positive power supply is given to this section directly from the positive end of the battery Negative power supply a given through a NPN transistor or from the ground of any circuit
Network section	Antenna, External Antenna Socket, RX Band Pass Filter, RF Crystal, FEM, PFO, TX Band Pass Filter, RF IC CPU are connected in the Network Section
Battery Charging Section	Charger and system interface connector is made together in most modem mobile cell phones Regulator section is made separately for the battery charging section in some mobile phones the battery charging section is made inside the Power IC
FM Radio Section	FM Radio Driver C FM Antenna, Signal and Supply Components are made in the FM Radio Section
Bluetooth section	Bluetooth Antenna, Bluetooth RF Signal Titer. Bluetooth Driver IC Supply and Signal Components are found in this section. The Bluetooth section functions like the Network Section The RF CLK signal is given to the Bluetooth driver IC during signal processing
Hands free (Earphone) Section	The hands free sack, hands free MIC speaker signal component and hands free audio amplifier are present in this section Hands free symbol is displayed after connecting the Hands free jack

Assembling a Mobile Phone

The following are the steps that you should take when assembling a mobile phone:

1 Fix the vibrator strips of speaker and volume button

2 Fix the motherboard

3 Connect the antenna with wire

4 Place the camera and connect it

5 Place the buzzer

6 Put the camera cover

7 Make sure that the LCD is working before you place the screen

8 Put battery and battery cover So far you have learnt about the hazards of mobile phone repair, the parts of a mobile phone, the tools to use and how to assemble and disassemble a mobile phone. Now let us look at how to diagnose and repair a mobile phone.

Diagnosing and Repairing Mobile Phone Faults

The correct diagnosis of mobile cell phone faults is the key to successful and cost effective repair of the phone. Let us start by looking at the skills that you need to have to be able to diagnose and repair a mobile phone.

Skills Needed to Diagnose and Repair a Mobile Phone Before you can diagnose and repair a phone, there are some skills that you need to learn.

These skills are:

- Soldering
- Desoldering
- Testing using a multimeter .
- Jumper setting

Testing a phone using a multimeter

We hope you still remember that a multimeter is a device that is used to measure the voltage, current and resistance of various components of a mobile phone. Figure 29 below shows the various parts of a multimeter.

a Measuring resistance

To measure resistance follow these steps

1 Plug your red and black probes into the appropriate sockets on your multimeter.

2 Choose the appropriate resistance measurement setting on your millimeter’s

3 Hold the probes against the resistor.

4 Check the resistor value on the display.

b Measuring voltage

Testing for proper supply voltage is usually the first step when troubleshooting a circuit.

To measure voltage you should follow these steps

1 Select V (ac) or V (dc), as desired.

2 Plug the black test probe into the COM input jack Plug the red test probe into the V input jack.

3 If the DMM has a manual range only, select the highest range so as not to overload the input.

4 Touch the circuit with the tips of the probes.

5 Read the number in the display window and take note of the unit of measurement.

c Measuring Current

1 Turn off power to the circuit.

2 Cut or unsolder the circuit, creating a place where the meter probes can be inserted.

3 Select A (ac) or A (dc) as desired.

4 Plug the black test probe into the COM input jack. Plug the red test probe into the amp or milliamp input jack, depending on the expected value of the reading

5 Connect the probe tips to the circuit across the break so that all current will flow through the DMM (a series connection)

6 Turn the circuit power back on.

Jumper setting

Jumpering means to temporarily complete a circuit or to bypass a break in a circuit by making a connection from one point to another. A good conductor wire is used to make a jumper which by-passes the components and passes on a signal or supply line for further uses. When wire is used as a jumper, it must have some special specifications as required. These jumper wires can mainly be of two types ie insulated and non-insulated. In the mobile phone insulated wires are used for jumpers The length of a jumper depends on the two points connected in between.

Why do Jumpering:

While repairing mobile phones, we find that certain faulty components are very difficult to get from the market. To repair such mobile phones the only immediate option is the use of jumpers. By use of jumpers we will bypass the faulty components specifically

How to Jumper:

1 Disassemble mobile phone and place it on a PCB holder

2 Using a multimeter, check track and find the fault or the missing track that need jumper

3 Apply liquid soldering flux to the points where you need to solder jumper wire.

4 Cut jumper wire to desired length and remove its lamination using blade cutter 5. Hold one end of the jumper wire and solder it to one point of the faulty circuit track. Use a good quality tweezers to hold the wire and good quality of soldering iron and solder wire to solder

6 Now hold the other end of the jumper wire and solder to the other point of the track

7 Using a multimeter check the jumper

The Fig 31. Below shows jumper settings in of the jumpers may look like on your motherboard. In this example, the jumper is the white block covering two of the three gold pins. Also, next to the pins is a silkscreen description of what the pins do, in this case when pins 1-2 are jumped the computer is operating normal, when 2-3 are jumped it is set into configuration mode, and when open the computer will be in recovery mode.

What is a fault?

A fault is a defect (a failure in a circuit) or an electronic device

What causes faults or failures in mobile phones?

Failures can be caused by any of the following:

- excess temperature,
- excess current or voltage,
- Ionizing radiation, mechanical shock,
- stress or impact.
- contamination,
- mechanical stress,
- short circuits,
- imperfect connections
- poor insulation or wiring caused by grounding

There are three types of mobile phone faults

i Hardware faults occur due to hardware malfunctioning

ii Software faults occur due to problems with software

iii Settings faults occur due to wrong/invalid settings

Let us discuss each type of faults and how they can be repaired.

Hardware Faults

There are many hardware faults that can occur in a mobile phone, but in this section we shall discuss the following

a Battery charging faults/problems

b Mobile phone battery problem (faults)

c Network not working problem

d Overheating problem

e Sound faults

d Ear piece, ringer and microphone problem

e Display problems

f Lighting or LED problems

g Touchscreen problems

h Keypad problems

i SIM faults

j WiFi problem and internet connectivity problems

a Battery Charging Faults/Problems

Battery charging faults manifest in a number of ways

- The battery is not charge at all,
- There is a sign of battery charging but the battery does not get charged.
- When the charger is inserted, it shows Not Charging
- When the charger is connected it shows 'Bad Connecting Charging
- When the charger is inserted the mobile phone gets hot

Solutions to Battery charging faults

1 Change the charger and check. The voltage must be between 5 and 7 Volts

2 Clean, resold or change the charger Connector

3 If the phone shows "FALSE CHARGING" then use a 3.6 Volt Zenor Diode and do direct charging as shown in Figure 32

4 If the problem is not solved then change the battery and check again

5 Check the voltage of the battery connector using a Multimeter. The voltage should be between 15 and 37 Volts

6 If there is no voltage in the connector check the track of the charging section Refer to the diagram of the particular model of the mobile phone

7 if the problem still persists, check the fuse, call and regulator one by one and change the faulty part.

8 if the problem is still not solved then heat or change the charging IC

9 Finally heat, re ball or change the Power IC

b Mobile Phone Battery problem

A mobile cell phone can have any of the following battery problems:

Low Battery

Battery Drains Fast

Battery Backup Low

Battery Not charging

Solutions to Battery faults

1 Check the battery connector and charger plug to see if there is any problem

2 Check if there is any dust or corrosion in the connector or any broken pin Clean the points using IPA or cleaning swabs.

3 Check the Interface Connector to see if there is any dust. If there is dust clean or replace the interface connector.

4 If the battery problem is not solved then upgrade the software or operating system to latest version

5 If the problem is still not solved then check the Mobile Phone PBA current consumption.

6 Check for any short circuit.

7 If there is serious problem at the board level then it is better to replace the whole Logic Board of the Mobile Cell Phone.

c Network Not Working Problem

The common issues related to this problem include the following

- There is no network in the mobile phone .
- There is less or weak network signal
- Sometimes there is a signal and sometimes there is no network signal.

Solutions to Network fault

1 Manually search for the network. if the 'no network problem persists, then there is a problem with the Antenna Switch. Repair or replace it.

2 If the network resumes after manual search but the home network cannot be selected, then there is a problem with the PFO Repair or change the PFO

3 If the Network gets disconnected during phone calls then you should repair or change the Network IC

4 Clean the antenna tips and point,

5 If the network problem persists, heat or change the 26MHz Crystal Oscillator 6. If the problem is still not solved then heat or change the Antenna Switch. You can also jumper if the Antenna Switch is not available.

7 Heat, Change or Jumper the PFO if the problem still persists. 8 Heat, re ball or change the Network IC.

9 Heat, re ball or change the Power IC

10 Heat, re ball or change the CPU

d Network Signal and Call Drop Problem

If a mobile phone is having network problems and dropping calls, then you should use the following steps to solve it:

1 Check the SIM Card Insert the SIM card in other mobile phone and see if the network problem or the 'call drop' problem is still there.

2 Alternatively, try to insert another SIM card inside the mobile phone that has the network problem.

3 If the problem is caused by the SIM card, then you should change or replace

4 If the problem is still not resolved then upgrade the operating system to the latest version. You can also rewrite the IMEI Number of the mobile cell phone

5 If the problem is not solved then you may have to change the mobile phone.

e Mobile Phone Overheating

A mobile phone may overheat either inside or on the body. To solve this problem you should proceed as follows

1 Check if the mobile phone overheats when a particular application is running or if the overheating happens all the time.

2 Upgrade the mobile phone software operating system to the latest version. This may solve the overheating problem.

3 Smartphone's overheat if too many applications are running at the same time. Close all the applications and try to run 1 application at a time

4 If overheating persists, then there is some internal hardware problem Change the PCB or Logic Board to solve the heating problem.

f Sound Faults

We shall consider the following types of sound faults

- Earpiece or ear speaker problem
- Mobile phone speaker problem
- Ringer problem
- Vibration problem
- Microphone problem

i Earpiece or Ear Speaker Problem

The Earpiece or speaker is the electronic component or part that helps us to listen to sound during a phone call. It is controlled by Audio IC or Power IC (UEM). See Figure 27 for a picture of an ear speaker.

The common problems associated with the ear speaker are

- No sound during phone call
- Low sound during phone call
- Sound has interruptions.

How to Solve Earpiece or Speaker Fault

1 Check the speaker volume during a phone call

2 if speaker volume is fine, then check the earpiece by keeping the multimeter in buzzer mode. The value must be between 25-35 Ohm if the value is not between 25-35 Ohm then change the earpiece

3 If the problem is not solved then check the Circuit Track of the earpiece section. Do jumper wherever required

4 if the problem persists heat, reball of change the UEM/Audio IC

5 If the problem is still not solved then heat, reball or change the CPU

Ringer Problem

A Ringer is any type of electronic component that rings or plays a loud sound it is also called the IHF Speaker, buzzer, melody, etc. Figure 28 shows a picture of a ringer.

The following are the types of problems associated with the ringer

- Ringer not working
- Low sound from the Ringer
- Sound coming from Ringer but with interruption
- Sound not clear

How to Solve Ringer Foults

1 Check the ringer settings in the mobile phone Check Ringer volume and lent mode. Adjust or change the volume and /or mode if required.

2 if the problem is not solved then open the mobile phone and clean the ringer point and ringer connector

3 if the problem is not solved then check the ringer by keeping the multimeter in buzzer mode The value must be between 8-10 Ohm if the value is not between 8-10 Ohm then change the Ringer

4 If the problem is not solved then check the track of ringer section. Do jumper wherever required) 5. If the problem is not solved then check the Ringer IC Heat or change the IC

6 If the problem is not solved then heat, reball or change the UEM/Logic IC

7 If the problem is still not solved then heat, reball or change the CPU

Vibration Problem

The vibrator is an electronic device that generates vibrations, it is contioled by the Logic C or Power IC

The common types of faults associated with the vibrator are

- Vibrator not working
- Vibration has an interruption
- Vibration Hangs

How to solve Mobile Vibrator faults

1 Check the vibrator settings in the mobile phone. Check if the Vibrator ON of OFF

2 If the problem is not solved then open the mobile cell phone and clean the vibrator tips and connector

3 If the problem is not solved the check the vibrator with the multimeter in Buzzer Mode The value must be between 8-16 ohm. If the value is not between 8-16 ohm then change the Vibrator or Motor

4 If the problem is not solved then check the track of the vibrator section Do jumper wherever required.

5 If the problem is not solved then heat, reball or change the UEM/Logic IC /Power IC

6 If the problem is still not solved then heat, reball or change the CPU.

J Microphone Problem

The Microphone is an electronic component that helps to transmit sound during

phone call. A microphone is controlled by Audio IC or Power IC (UEM)

The common types of problems associated with the microphone are:

- Low sound during phone call
- Sound has interruption
- Change in sound

How to Solve Microphone Fault

1 Check the Microphone settings

2 If all the settings are normal, then check and clean the Microphone tips and connector

3 If the problem is not solved then check the Microphone with the multimeter in Buzzer Mode. The value must be between 600-1800 Ohm. If the value is not in between that range, then change the Microphone Note that only one side will give a value.

4 If the problem is not solved then check the track of the Microphone section. Do Jumper wherever required.

5 If the problem is not solved then heat or change the Microphone IC

6 If the problem is not solved then heat, reball, or change the UEM/Audio IC /Power IC

7 if the problem is still not solved then heat, reball or change the CPU.

Display Not Working

This is the part that displays information in a mobile phone. It is controlled by the CPU in some cell phones there is an interface IC called the display IC situated between the display and the CPU

The following are the common types of problems associated with the display

- Display is blank.
- Display not working properly.
- Only half the display works
- White display.

Display is upside down

Display is broken.

When the mobile phone is switched ON, the Logo appears and then the display disappears

How to Solve Display Faults in a Mobile Cell Phone

1 Clean the display tips and display connector.

2 Resold the display connector-

3 Change the display

4 Check the display Track

5 Resold or change the display IC

6 Heat, reball or change the CPU

h Mobile Light or LED Problem and Solution

The LED is the electronic component that generates light in the mobile phone. There are 2 types of connections in the light section of a mobile phone

- Series Connection.
- Parallel Connection.

The common symptoms of LED problems are

- No Light
- Light only in the Keypad or display
- Some lights not working

How to Solve a LED problem.

1 Check the light settings

2 If the settings are normal then resold all the LED

3 If the problem is not solved then change the display or the screen Next check all the LEDS with the multimeter on Buzzer mode if the

4 Next check all the LEDs with the multimeter on buzzer mode. If the LED is good then it will glow if the LED is faulty then it will not glow

5 Change the LED or jumper if required

6 If the problem is not solved then check the Track of the light section of the PCB and jumper if required.

7 Next check the Boosting Coil and change if required

8 If the problem is not solved then heat or change the Light IC

9 If the problem is still not solved then heat, reball or change the Power IC

Phone Touch Screen (PDA) fault

A Touch Screen (PDA) is an electronic component that allows you to input data or control your mobile phone by touching the screen It normally has 4 Points namely

(+)

(-)

(RX)

(TX)

The touch screen is normally controlled by the CPU in some mobile phones there is an Interface IC called PDA IC or Screen Touch IC

The following are the faults associated with the Touch Screen

- Touch Screen not working
- Only half the Touch Screen works
- When one key is pressed another key works.

1 Check the settings if the mobile phone has both a keypad and a touch screen

2 Clean and resold the PDA Tips and PDA connector

3 Change the PDA.

4 Check the Track of the PDA section and Jumper if required

5 Heat or change the PDA IC

6 Heat, reball or change the CPU

Keypad Problems

The keypad enables you to enter data, such as, phone numbers and names in your mobile phone

The main types of problems associated with the keypad are

- Some keys not working
- Keys need more pressure to work
- When a key is pressed it works continuously
- When one key is pressed, some other key works
- When one key is pressed, some other key works simultaneously

How to Solve a Keypad Faults

1 Check the facial of the keypad. Figure 38 below

2 Clean the keypad and keypad points shown fig below

3 Using the multimeter in buzzer mode and check the row and column of the keypad if there is a beeping sound then the keypad is working

4 If there is no improvement, heat or change the Keypad C or the interface IC

5 If still no change, heat, reball or change the CPU.

Mobile Phone SIM faults

A Subscriber Identify Module (SIM) card is an integrated circuit that securely. stores information about the number of the cell phone line, password, and information related to your local network service. It has a unique serial number.

The following are the common problems associated with the SIM card:

- SIM is inserted but still there is a message saying "Insert SIM"
- The mobile phone goes OFFUNE when the SIM card is inserted
- The SIM works for sometime and then stops working
- There is a message that says "Invalid SIM"

How to Solve SIM Card Fault

1 Check settings and see if the mobile phone is in Fight Mode, if it is in "Flight Mode" then change it to Normal mode.

2 Clean the SIM Card Tips and SIM Connector

3 If the problem is not solved then change the SIM card and check

4 If the problem still persists then change the SIM connector

5 If you still do not find a solution to the problem, check the Track of the SIM section

6 If the problem is still not solved then heat or change the SIM IC

7 Finally, if there is no change, heat, reball or change the Power IC.

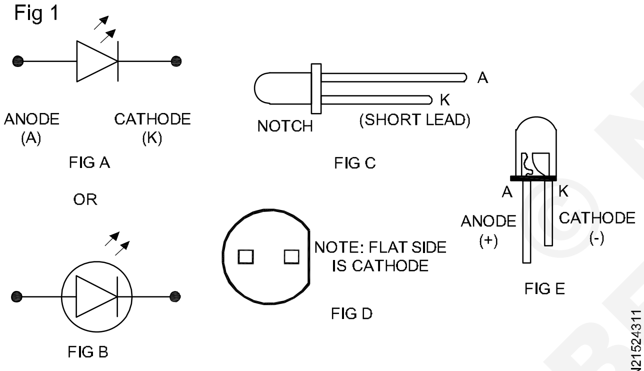
Introduction of LED lights

Objectives : At the end of this lesson you shall be able to
- **define LED and the advantages of LED lights over other lighting systems**
- **state the difference between LED lights and traditional lights**
- **explain the parts and working of LED lights**
- **describe the different colour generation in LED lights.**

Introduction

The LED is used as a light source in our day to day applications. LED is the short form of "Light Emitting Diode". LEDs are basically electronic devices, made with semiconducting material, which that emits light when it is connected in forward bias mode. LED's properties are similar to general purpose diodes consisting of two leads called as anode and cathode. LED lights are energy efficient and having long life making them ideal replacements for traditional power halogen and standard incandescent lights. LED lights can save up to 90% of household lighting costs. Fig 1 shows LED symbol and lead identification.

Fig 1



FIG(A,B) SYMBOL OF LED FIG(C,D,E) LEAD IDENTIFICATION

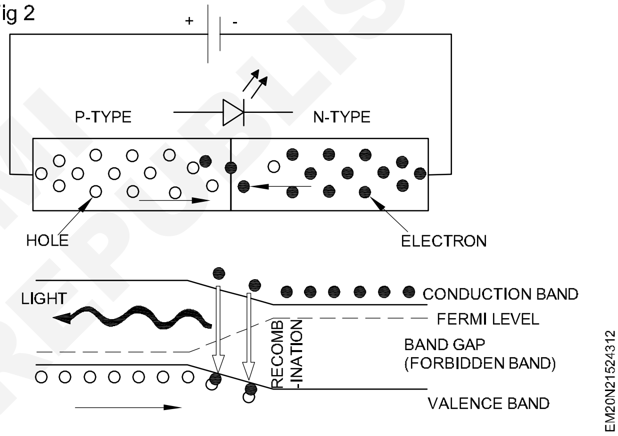
Difference between traditional lights and LED lights

LED lighting differs from incandescent lamp and compact fluorescent lamp in several ways. When designed well, LED lighting can be more efficient, durable, versatile and long lasting. Incandescent lamp produces light by use of a filament. When current passing through a bulb, bulb will dissipate the power in the form of heat, thus producing light. CFLs (compact fluorescent Lamps) are producing light by exciting the mercury vapour held inside the lamp with electricity. LEDs produce light through a "cold process" when current flowing through the semiconducting material (usually gallium, arsenic and phosphorus), electrons are able to recombine with holes within the device, releasing energy in the form of photons (i.e. light). This effect is called "electroluminescence".

LED working

Basically LED is a semiconductor device which is made with P N junction. LED is used to convert current into light when it is in forward biased condition. When LED is forward biased, the electrons in N region are crossing the junction and recombine with the holes in P region. In energy band diagram electrons are in conduction band whereas holes are in valance band as shown in Fig 2. At the time of electron hole recombination electrons are moving from higher energy band (conduction band) to lower energy band (valance band). So dissipate some amount of energy. This emitted energy will be in the form of light.

Fig 2



Parts of LED

The Fig 3(A) shows basic parts of LED and Fig 3(B) shows a power LED with heat sink.

When a LED connected to supply, current flows to semiconductor chip through anode lead(1) and a whisker (4). The other side of the semiconductor is attached to the top of the anvil (7) and cathode (2). The colour of LED light depends on the material used for making LED chip (5). There are no loose or moving parts within the solid epoxy enclosure.

Fig 3

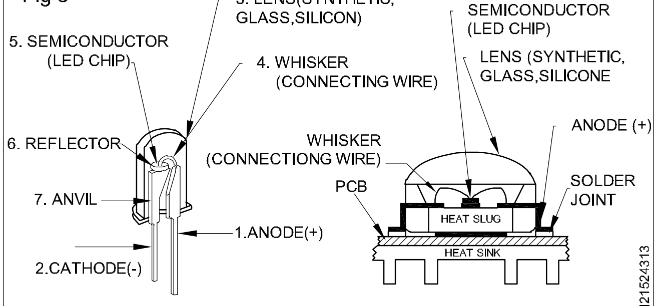


FIG (A) BASIC LED PARTS FIG (B) LED PACKAGE WITH PCB AND HEAT SINK

The LED package will protect the LED chip from the outside environment. The dissipated heat can be transferred by using a heat sink. The epoxy resin enclosure lens (3) has the following three functions.

1 It is designed to allow more light from the semiconductor.

2 It focuses the light (viewing angle).

3 It protects the semiconducting material from the other elements.

Colours of LEDs

LEDs are used to generate a monochromatic colour of particular wave length. The generated colour of LED is depends upon the material used to make the LED chip. Unlike normal signal diodes, Light Emitting Diodes are made from exotic semiconductor compounds such as Gallium Arsenide (GaAs), Gallium Phosphide (GaP), Gallium Arsenide Phosphide (GaAsP), Silicon Carbide (SiC) or Gallium Indium Nitride (GaInN) all mixed together at different ratios to produce a distinct wavelength of colour.

The semiconductor material used will determine the wavelength of the photon light emission and the resulting colour of the emitted light as shown in TABLE 1.

1 Gallium Arsenide (GaAs) - infra-red

2 Gallium Arsenide Phosphide (GaAsP) - red to infra-red, orange

3 Aluminium Gallium Arsenide Phosphide (AlGaAsP) - high-brightness red, orange-red, orange, and yellow

4 Gallium Phosphide (GaP) - red, yellow and green

5 Aluminium Gallium Phosphide (AlGaP) - green

6 Gallium Nitride (GaN) - green, emerald green

7 Gallium Indium Nitride (GaInN) - near ultraviolet, bluish-green and blue.

8 Silicon Carbide (SiC) - blue as a substrate

9 Zinc Selenide (ZnSe) - blue

10 Aluminium Gallium Nitride (AlGaN) - ultraviolet.

White light from LED

Unlike incandescent lamps, LEDs are not inherently white light sources. LEDs emit highly efficient coloured light for the applications such as traffic lights and exit signs. General light source needs white light. In LED white light can be achieved in three ways:

1 **Phosphor conversion :** In which a phosphor is used on or near the LED is used to convert the coloured light to white light as shown in Fig 4.

2 **RGB systems:** In which light from multiple monochromatic LEDs (e.g., red, green, and blue) are mixed, resulting in white light as shown in Fig 4.

3 **A hybrid method :** In which uses both phosphor-converted (PC) and monochromatic LEDs.

Phosphor white light is more efficient than RGB white.

In the phosphor conversion method white light can be produced by a single LED combining with a short wavelength LED such as blue or UV, and a yellow phosphor coating. The blue or UV photons generated in the LED either travels through the phosphor layer without alteration, or they are converted into yellow photons in the phosphor layer. The combinations of the blue and yellow photons combine to generate white light.

Fig 4

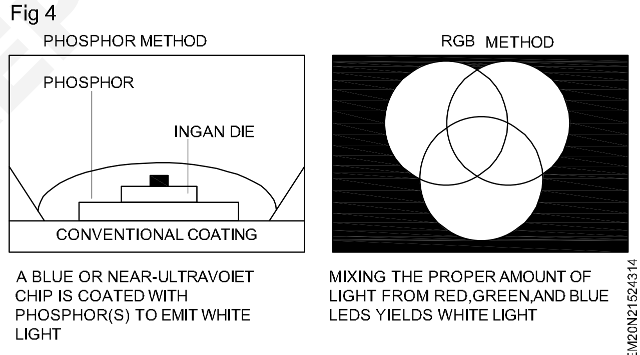
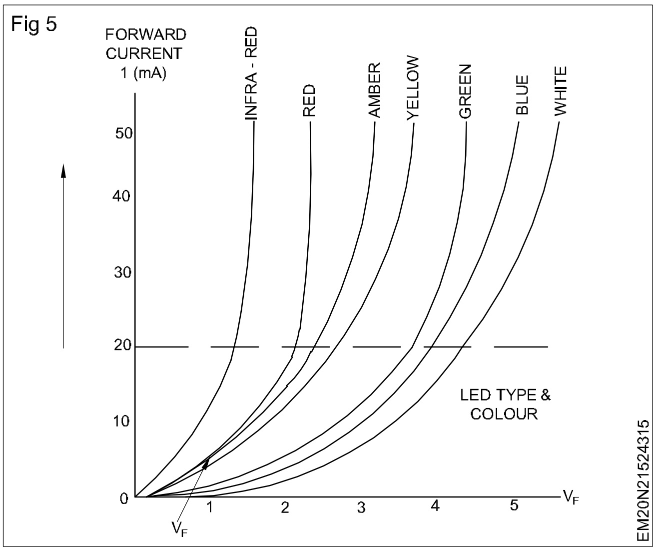


TABLE 1

Typical LED characteristics

Sl.No.	Semiconductor material	Wavelength	Colour	VF @ 20mA
1.	GaAs	850-940nm	Infra-Red	1.2v
2.	GaAsP	630-660nm	Red	1.8v
3.	GaAsP	605-620nm	Amber	2.0v
4.	GaAsPN	585-595nm	Yellow	2.2v
5.	AlGaP	550-570nm	Green	3.5v
6.	SiC	430-505nm	Blue	3.6v
7.	GaInN	450nm	White	4.0v



VI characteristics of LED

VI characteristics curve of a LED is shown in Fig 5.

To emit light in a LED needs a current flow through it, as it is a current dependent device with their light output intensity being directly proportional to the forward current flowing through the LED.

As the LED is to be connected in a forward bias condition across a power supply it should be a current limiter (using a series resistor) to protect it from excessive current flow, it will destroy instantly because of too much current will pass through and burn it out. Generally 5mA is the maximum forward current for a simple LED and 30 mA for a high bright light output LED.

From the TABLE 1 the characteristics of each LED has its own forward voltage drop across the PN junction and this parameter which is determined by the semiconductor material used for a forward current of 20mA.

LED efficiency, comparision with CFL and incandescent lamps

Objectives : At the end of this lesson you shall be able to
- **compare LED lights and traditional lighting system**
- **state the characteristics for the LED lighting system**
- **list the advantages of LED lighting system**
- **state the limitations of LED lighting system.**

LED efficiency, comparison with CFL and Incandescent lamps

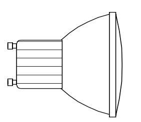
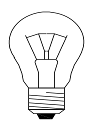
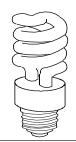
Many types of lighting systems are available such as incandescent lamps, fluorescent lamps and LED lamps. Incandescent lamps are traditional and available from long back. These are bulky in size, more power consuming than others and having less life span. The compact florescent lamps are popular due to more efficient , high illumination, more life span, less power consumption than incandescent lamps.

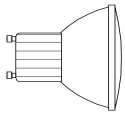
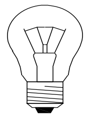
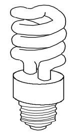
Now a day's LED lights are more popular and emerging technology in lighting systems. TABLE 1 gives the comparison between these three lighting systems by various aspects.

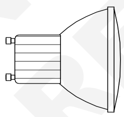
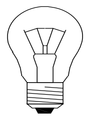
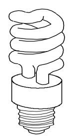
TABLE 1

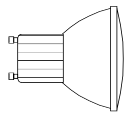
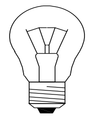
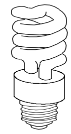
Comparison chart

LED lights vs Incandescent light bulbs vs. CFLs

Sl. No.	Particulars	LED light	Incandescent lamp	Compact Fluorescent Lamp(CFL)
	I. Energy efficiency & Energy costs			
1.	Life span (Average)	50,000 hours	1,200 hours	8,000 hours
2.	Watts of electricity used (equivalent to 60 watt bulb)	6 - 8 watts LEDs use less power (watts) per per unit of light generated(lumens). LEDs help to reduce green house gas emissions from power plants and lower electric bills.	60 watts	13 - 15 watts
3.	Kilo-watts of electricity used (Equivalent to 30 Incandescent bulbs per year)	329 KWh/yr.	3285 KWh/yr.	767 KWh/yr.

Sl. No.	Particulars	LED light	Incandescent lamp	Compact Fluorescent Lamp(CFL)
	II. Environmental impact			
1.	Contains the TOXIC Mercury (equivalent to 60 watt bulb)	No	No	Yes - Mercury is very toxic to health and the environment.
2.	RoHS complaint	Yes	Yes	No - Contains 1 mg - 5 mg of mercury and is major risk to the environment.
3.	Carbon-di-oxide emissions (30 bulbs per year) Lower energy consumption decreases: CO_2 emissions, Sulphur oxide and high-level nuclear waste.	451 pounds/year	4500 pounds/year	1051 pounds/year

Sl. No.	Particulars	LED light	Incandescent lamp	Compact Fluorescent Lamp(CFL)
	III. Important facts			
1.	Sensitivity to low temperatures	None	Some	Yes - may not work under negative 10 degrees fahrenheit or over 120 degrees fahrenheit.
2.	Sensitive to humidity	No	Some	Yes
3.	Turns on instantly	Yes	Yes	No - takes time to warm up
4.	Durability	Very durable	Not very durable glass or filament can break easily.	Not very durable - glass can break easily.
5.	Heat emitted	3.4 btu's / hour	85 btu's / hour	30 btu's / hour
6.	Failure modes	Not typical	Some	Yes - may catch on fire, smoke, or emit an odor.

Sl. No.	Particulars	LED light	Incandescent lamp	Compact Fluorescent Lamp(CFL)
	IV. Light output			
1.	Lumens	Watts	Watts	Watts
2.	450	4 - 5	40	9 - 13
3.	800	6 - 8	60	13 - 15
4.	1100	9 - 13	75	18 - 25
5.	1600	16 - 20	100	23 - 30
6.	2600	25 - 28	150	30 - 55

Characteristics of LED lights

1 Colour quality
2 Light output
3 Less power consumption
4 High efficiency
5 Long lifetime
6 Smallest in size
7 High resistance to switching cycles
8 Immediate light at switching on
9 Wide operating temperature range
10 High impact and vibration resistance
11 No UV or IR radiation
12 High colour saturation level without filtering
13 Mercury-free

Lifespan of LED Lighting

All the lighting sources having different expected lifespan under various laboratory test conditions. Manufacturers will provide these information on their product packages on hours basis. In TABLE 2 shows the expected lifespan of various lights.

The life of LED is about 10 to 25 times higher than incandescent lamp and 2 to 5 times than CFL's. So, LED bulbs are good for long time considerations. TABLE 3 shows some calculation regarding operational cost of various lighting systems.

TABLE 2

Types of bulbs	Expected lifetime
Incandescent Bulbs	Between 750 and 2,000 hrs.
Compact Fluorescent Lamp (CFL)	Between 6,000 and 10,000hrs.
LED Lights	Between 20,000 and 50,000 hrs.

TABLE 3

Aspect	Incandes-cent	CFL	LED
Approximate cost per bulb	Rs. 20/-	Rs.100/-	Rs 250/-
Average lifespan	1,200 hrs	8,000 hrs	25,000 hrs
Watts used	60 W	15 W	10 W
No. of bulbs needed for 25,000 hrs of use	20	3	1
Total purchase price of bulbs (25,000 Hrs.)	Rs.1200/-	Rs.300/-	Rs. 250/-
Total cost of electricity used (25,000 hours at Rs.3 per kWh)	Rs.4500/-	Rs.1125/-	Rs. 750/-
Total operational cost over (25,000 Hrs.)	Rs. 5700/-	Rs.1425/-	Rs. 1000/-

Advantages of LED Lighting:

LEDs are having a number of advantages when compared to traditional lighting systems.

Durability of LED lights

Incandescent bulbs and fluorescent lamps will break easily when shaken or dropped. The incandescent bulb has a filament that is likely to break in such a situation. The LED lights are made in robust design. They are suffering considerably less degradation over time. A typical LED light would be expected to lose only 2 per cent of its total efficiency after a period of 10,000 hours.

The useful lifespan of LED lighting products is defined differently than that of other light sources, such as incandescent or CFL. This is because LEDs typically do not "burn out" or fail. Instead, they experience lumen depreciation, where the amount of light produced decreases and light colour appearance can shift over time.

LED lighting efficiency

Incandescent bulb and fluorescent lamp dissipate more amount of energy, so that heat produced, because they distribute light in many directions. By comparison, LED lights operate at low temperature and produce more focused form of light. A typical incandescent lamp operates at an efficiency level of around 9 percent. LED light can achieve efficiency levels which is closer to 40 per cent. The LED lights can be manufactured in smaller sizes and can be placed in spaces that would not be suitable for other forms of lighting.

Light output

Modern LED lights have the appropriate light output and colour characteristics to exceed the performance levels of incandescent bulbs. LED lighting can also be used in connection with standard household dimmer switches, or with more flexible control systems, allowing colour settings to be manipulated quickly.

Disposing of LED Lights

Unlike fluorescent bulbs, LED lights does not release mercury into the air. Some studies have shown that, they include a number of other toxic materials. When dealing with a broken LED light, it is advisable to make use of gloves and to be aware of the toxic nature of the materials that have been used in the manufacture of the lights. However, LED lights can be disposed at landfill sites.

Range of uses

LED Lights do not release out an Ultra Violet (UV) rays, which means that they can safely be used in situations where precious items need to be exhibited. An example of this might be in the case of lighting the paintings or other artifacts. The lack of UV rays means that insects are not attracted to these light sources. This is particularly useful for the food industry and also for external installations. It is also possible to create lighting in a wide range of colours, without the need of different coloured bulbs or filters. As a result, interesting effects can be created using LED lighting, allowing for an element of creativity within domestic and commercial purposes.

Instant lighting

One of the drawback of traditional lighting is they does not light up immediately. With LED lighting, there is no such delay. When switched on, they reach full brightness up to 100 times faster than other alternatives. This feature ensures that they are well suited to use in vehicles.

Less wiring required

LED lights operate with low voltage and current. So the size (Gauge) of wire used for house wiring will be less. So the cost of wire bundle will be lesser in all aspects.

Health benefits

Fluorescent lamp can be replaced by the LED lights due to flickering effect. Such an effect can be annoying, it can also have more serious health implications. Migraine sufferers and epileptics may find that the use of LED tubes more comfortable.

Lower maintenance costs

LED lights never needed to be replaced and maintenance costs tend to be extremely low. It is rare for an individual LED to fail, if such a situation occurs, it does not mean that the entire lamp will fail.

Directional light source

LEDs are "directional" light sources, which means they emit light in a specific direction, unlike incandescent and compact fluorescent bulbs, (which emit light and heat in all directions). For this reason, LED lighting is able to use light and energy more efficiently in many applications. However, sophisticated engineering is needed to produce an LED light bulb that emit light in all directions like an incandescent lamp.

A general purpose LED may not distribute light in all directions if used in a table lamp.

Heat dissipation by LED

The LED lighting systems are not radiate heat as much as an incandescent lamp or halogen bulb. This is usually done with the help of a heat sink, which is a passive device that absorbs the heat produced and dissipates it into the surrounding environment. This keeps LEDs from over heating and burning out. Thermal management is one of the most important factor for the successful performance of an LED product. Because the higher the operating temperature of a LED more quickly the light will degrade, and the shorter the useful lifespan will be.

Limitations of LED bulbs

1 The initial cost of LED bulbs are more. The price per lumen is very high than other types.

2 LED bulbs need a definite voltage and constant current for good results.

3 LED drivers are more costlier.

4 LED bulb colours are changing due to age and ambient temperature.

5 Two different white LEDs are not having same colour characteristics.

6 LED performance mostly depends on the correct engineering to manage the heat generated by the LED. Which causes deterioration of the LED chip itself. Otherwise overheating the LED package, eventually leading to device failure. Adequate heat-sink is required to maintain long life.

Types of LED lights

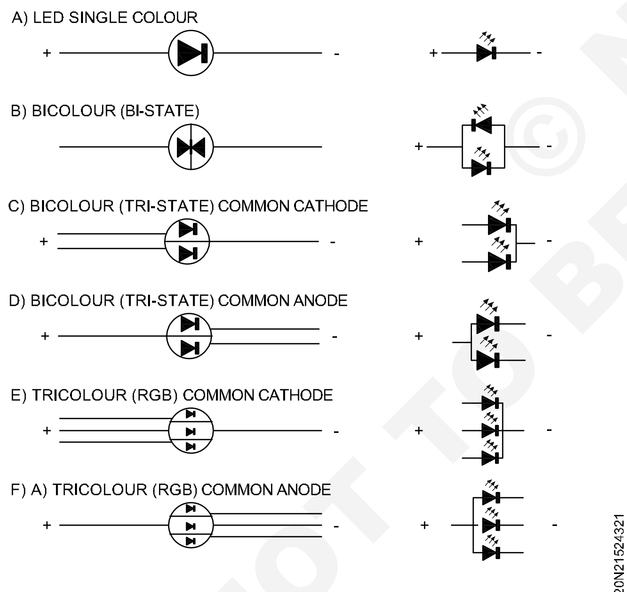
Objectives : At the end of this lesson you shall be able to
- **list out the type of LED lights**
- **explain the classification of low power LEDs**
- **explain the classification of high power LEDs**
- **list out the specification of LED lights.**

Introduction

LED lights are mostly used for white colours in domestic and industrial applications. But in some other applications we need different colour LED lights in - red, orange, green, blue, etc.

Some LED lights are available in single colour, dual colurs and multi-colour types. These multicolour lights consist of 2 or more colour LEDs in a board. By operating external switches or by remote we can select the colour of LED lights . By selecting 2 or more colours we can generate various combinations of colours. Fig 1 shows the symbols of different type of LEDs

Fig 1



DIFFERENT TYPES OF LEDS

2-Pin LED

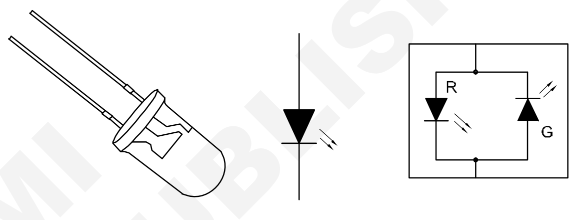
The most common type of LED is the 2-pin, 5 mm, round lens type. Generally these are a single LED. Polarity is indicated by the long lead (+/anode) or the flat on one side of the base (-/cathode).

The two-pin package can contain a single or two back-back LEDs.

Be aware that bi-colour LEDs are also sold in this package. Some are dual-colour so that reversing the current through them changes the colour. Others may have both LEDs the same colour and this can be useful in AC applications as it can conduct on both cycles of the mains and eliminates the need for a rectifier.

The data sheet of the bi-colour LED provides the terminal connection for the colours

Fig 2



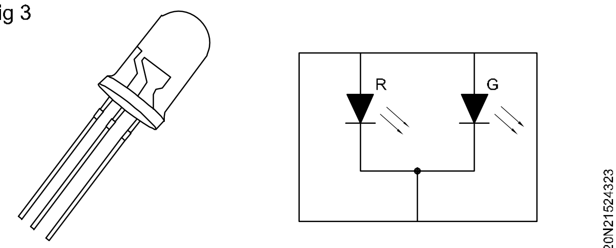
A TYPICAL 2 PIN LED

3-Pin LED

The three-pin LED is usually a pair of LEDs of different colours sharing a common anode or common cathode. Either LED can be turned on independently or blended to create a combination.

A bi-colour, 3-pin, common-cathode LED is shown in Fig 3

Fig 3



3 PIN LED

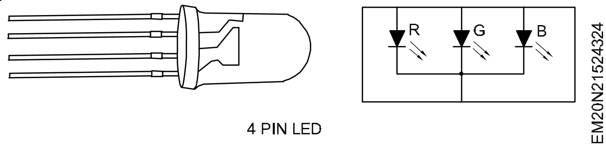
4-Pin LED

The 4-pin LED package is most commonly seen on RGB (Red-green-blue) LEDs. Common cathode and common anode versions are available. It produces the red, green and blue colours across the visible spectrum, common cathode type. The RED LED in a 4 pin package is shown in Fig.4

6-Pin

RGB with individual pinouts allows common anode, common cathode configuration as well as series connection of the LEDs is shown in Fig 5

Fig 4



When the number of Pins reaches six all sorts of strange variations are possible to bring out each LED anode and cathode on individual pins. This allows a single part to be used to common anode, common cathode and series LED configurations.

A slightly modified 6-pin, RB-GB, LED, has two separate 3-pin LEDs in one package as shown in Fig.6

LF5WAEMBGMDW, 6-pin, RB-GB LED has two 3-pin LEDs in one package. Both have a blue LED. Note the pin length orientation clue.

Fig 5

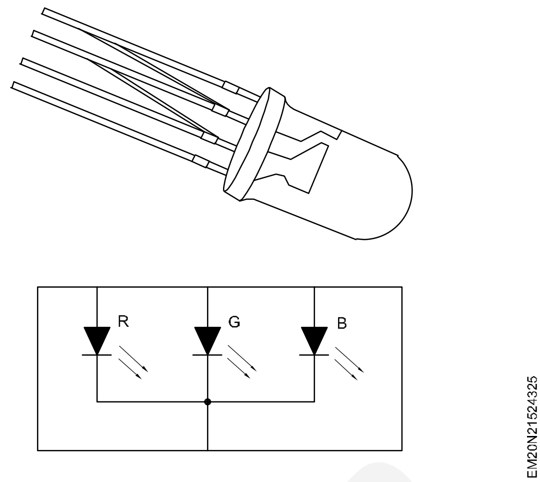
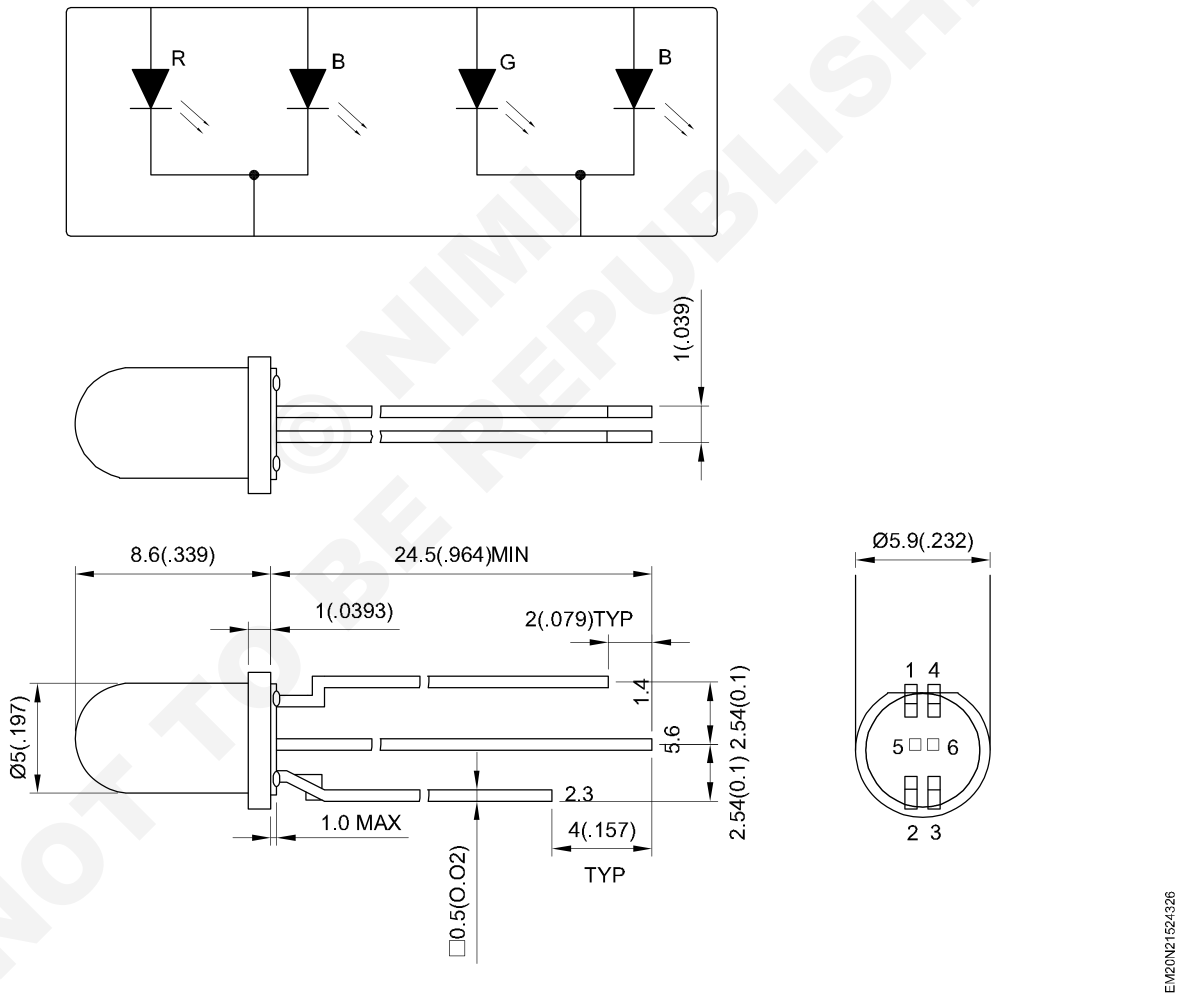


Fig 6



Classification of LED lights

A. According to the power level

LED lights are classified in to two categories. Those are

I. Low power LEDs or miniature LEDs

II. High power LEDs

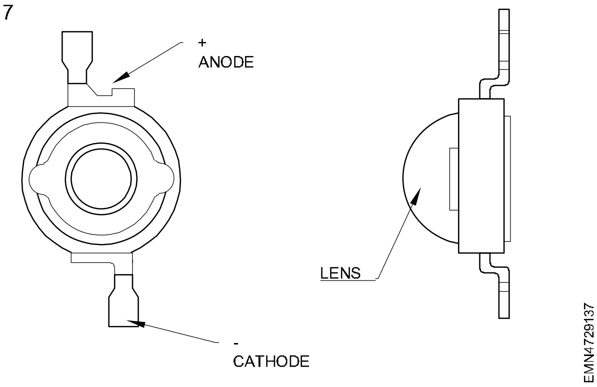
I. Low power LEDs or miniature LEDs

These LEDs are more familiar as indicators in mobile phones, in television sets and in different types of digital devices. They are usually available in standard size & shape from 2 mm to 10 mm in hole and surface mount packages. There is no need of separate heat sink. So it is compatible to different circuit boards.

Different companies are manufacturing these LEDs in 5V and 12V ranges. Generally current rating about 1 mA to 20 mA. They are available in a "ready to fit" mode.

Common package shapes include round, with a domed or flat top, rectangular with a flat top, and triangular or square with a flat top as shown in Fig 2.

Fig 7



There are three main categories

1 Low-current

Typically rated for 2 mA at around 2 V (approximately 4 mW consumption)

2 Standard

20 mA LEDs (ranging from approximately 40 mW to 90 mW) at around:

i 1.9 to 2.1 V for red, orange, yellow, and traditional green

ii 3.0 to 3.4 V for pure green and blue

iii 2.9 to 4.2 V for violet, pink, purple and white

3 Ultra-high-output

II. High power LEDs

These LEDs are the result of advanced semiconductor technology. As the name indicates, these LEDs are known by its high output. High-power LEDs (HP-LEDs) or high-output LEDs (HO-LEDs) can be driven at currents from hundreds of mA to more than an ampere, compared with the other LEDs. LED power density up to 300 W/cm^2 has been achieved. They are capable of producing light output with higher luminous intensity. The HP-LEDs must be mounted on a heat sink for heat dissipation. If the heat from a HP-LED is not removed, the device will fail in seconds.

High power LED's come in different shapes & sizes. A common example of high power LED in daily use is "LED strips" that are used for walls & room interiors.

Different types of LED lights are shown in Fig 3.

LED lights are made of arrays of SMD modules. Such lights are made with standard shapes and fittings like Edison screw base, MR16 shape with a bi-pin base, or a GU5.3 (bi-pin cap) or GU10 (bayonet fitting) etc. are as shown in Fig 4.(Refer page 167) They are compatible with the supply sockets. They included driver circuitry.

B. According to the shape LED lights are divided in to 3 categories.

1 Spherical lights,

2 Tapered lights

3 Cup-shaped lights

C. LED tube lights

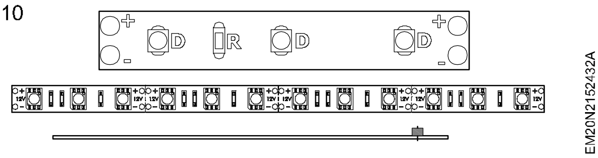
LED tube lights are designed to physically fit in fixtures instead of fluorescent tubes. Some LED tube are suitable for existing fixtures if appropriate ballast is used. An LED tube light generally uses many individual Surface-Mounted LEDs which are directional and require proper orientation to emit light in all directions around the tube. Most LED tube lights can be used in place of T8, T10, or T12 tube designations, T8 is D26mm, T10 is D30mm, in lengths of 590 mm (23 inch), 1,200 mm (47 inch) and 1,500 mm (59 inch).

D. LED strip lights

An LED Strip Light also known as an LED tape or ribbon light. LED strip light is a flexible circuit made by surface mounted light-emitting diodes (SMD LEDs) on a flexible type PCB layers. These strips are usually comes with an adhesive agent in back. Previously, strip lights had been used solely in accent lighting, backlighting, task lighting, and decorative lighting applications. Now a days due to the increased luminous efficacy and longer life-spans LED strip lights are used in applications such as high brightness task lighting, fluorescent and halogen lighting replacements, indirect lighting applications, Ultra Violet inspection during manufacturing processes, costume design, etc.

E. SMD LEDs

Fig 10



SMD is short form of "Surface Mount Device", describes LED packages that can be mounted on a surface or a PCB by soldering method as shown in Fig 5. SMDs come in all shapes and sizes, and are typically described with a four digit number. 3528 SMDs and 5050 SMDs are presently some of the most commonly used SMDs. The four digit numbers refer to the length and width dimensions of the SMD, in this case, 3.5 x 2.8 mm and 5.0 x 5.0 mm, respectively.

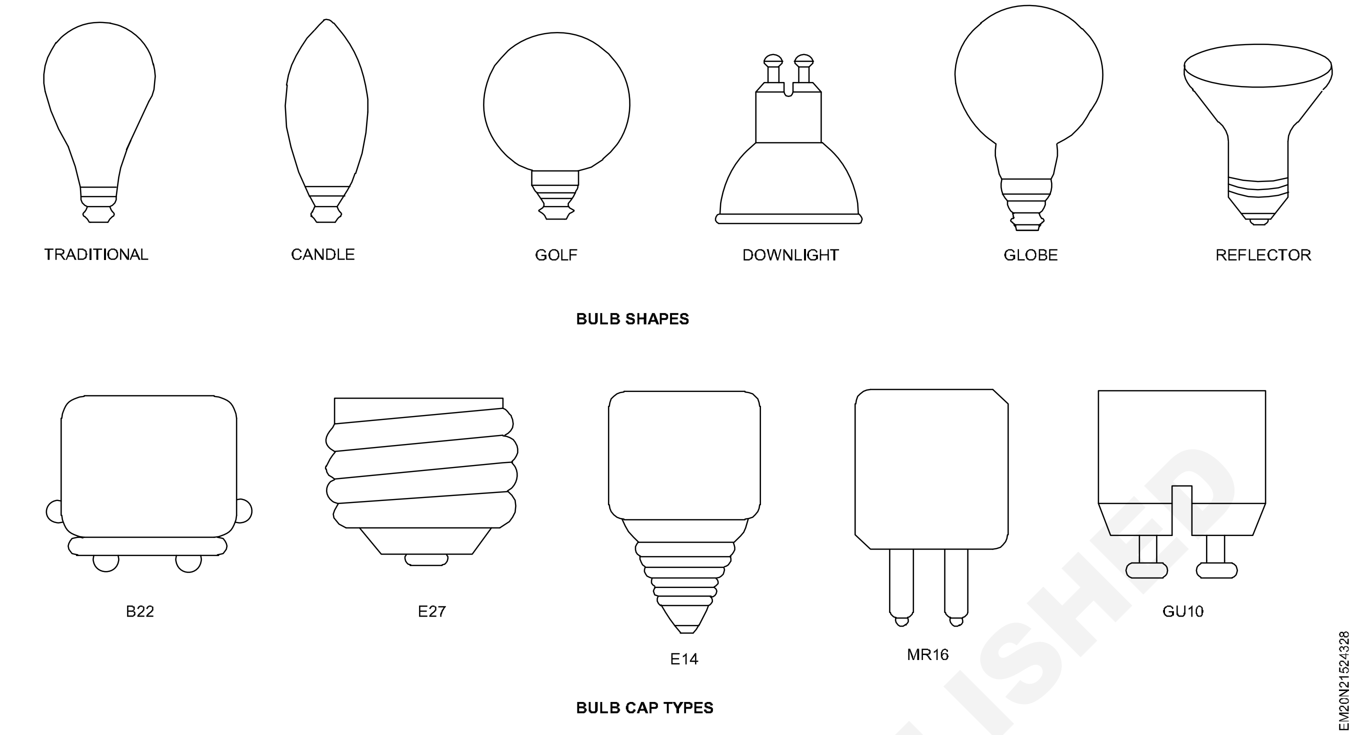
F. COB (chip on board) LED modules

These are LED lighting system have multiple LED chips mounted on a single PCB, encapsulated in a phosphor epoxy mix. These modules can reach many hundreds watts, delivering over 10000 lumens. They can often be used in high-bay or exterior lighting.

LED light can be described in a number of ways

1 LED bulb shape

Fig 8



2 LED bulb diameter

3 LED bulb length

4 LED bulb base type

LED light bulb shape

It's shapes describe the general physical characteristics of the LED light. LED light bulbs vary in shape from tube shaped bulbs to funnel or pear shaped light bulbs. These LED light bulb shapes each have a code. For example: T designates a 'tube', PAR signifies a 'parabolic aluminium reflector' and MR is used for 'multifaceted reflector'.

LED bulb diameter

The diameter of a light bulb is measured in two ways, in millimetres and in $1/8^{th}$ of an inch. The diameter for light bulb shape is measured at the point of maximum size. Examples are: T12 is 12 eights of an inch or 12/8 = 1.5 inches in diameter, PAR20 is 20 eighths of an inch in diameter or 2.5 inches, MR16 is 16 eighths = 16/8 = two inches in diameter.

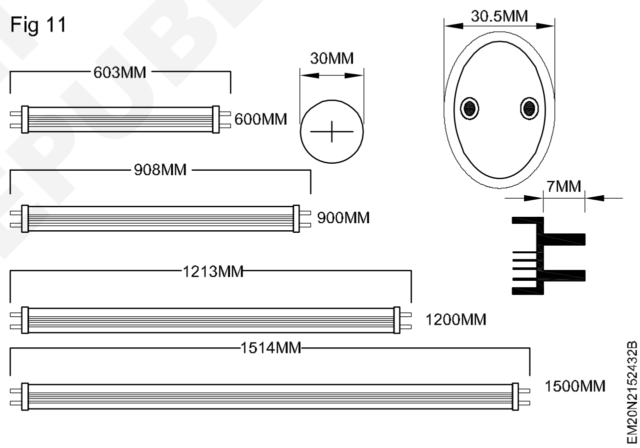
LED light bulb length

LED light bulb length is the overall length measured, typically in electrical connection, from base to the tip of the bulb. Or in the case of Tube from end to end. This can be in metric or in inches or feet as shown in Fig 5.

Bulb base types

LED light bulb base types are typically measured by type and diameter in millimetres. For example a typical Edison medium screw-in base like E27 is 27 millimetres in diameter. LED bi-pin bases, like a fluorescent tube replacement or a bi-pin MR16, are measured between the centres of each pin.

Fig 11



Size of LED on strip

The light output (lumen output) and light patterns are depending on the size of LEDs on strips. Integral LED strips are available with two sizes

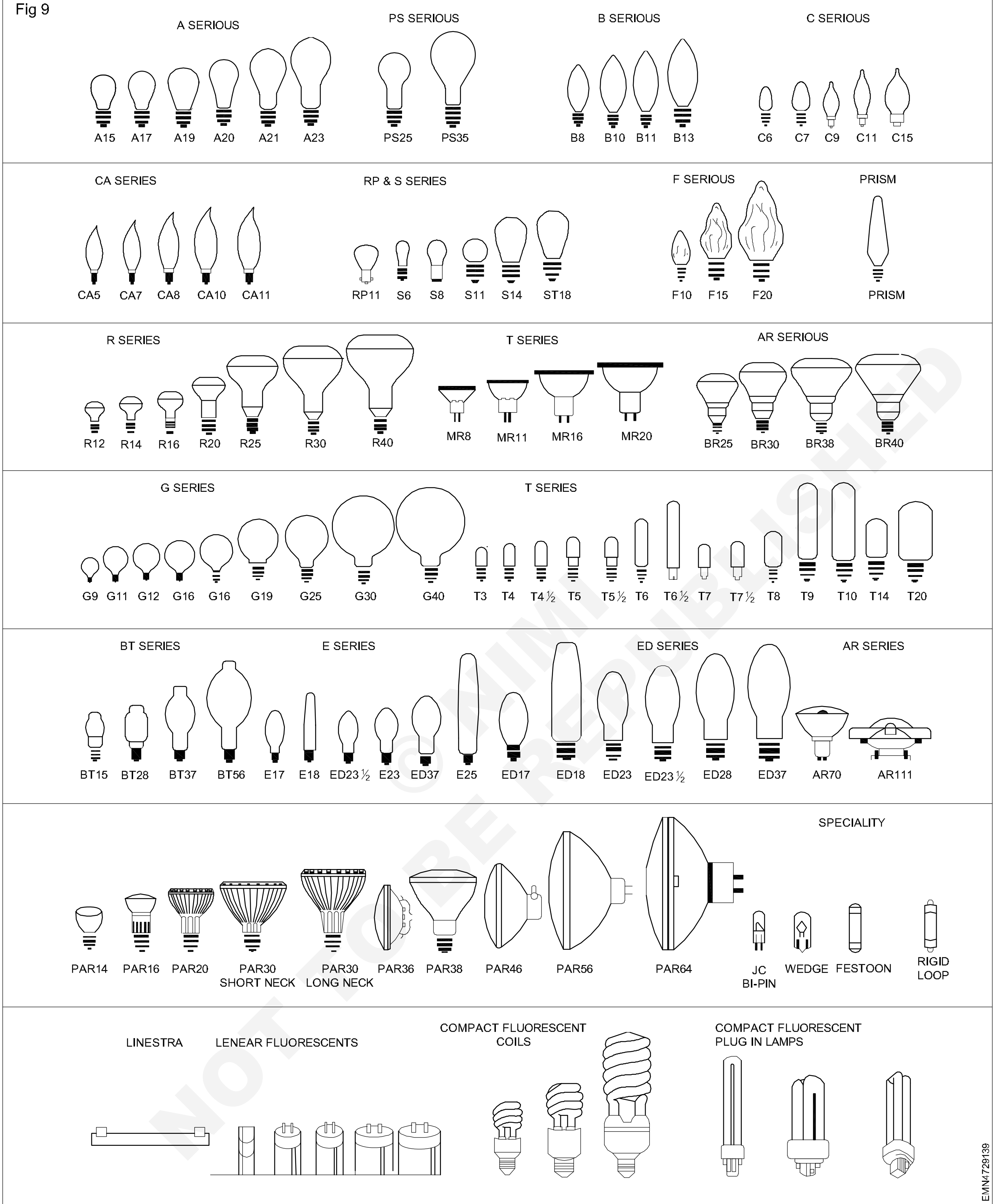
1 35:28 - this indicating LED size as 3.5mm x 2.8mm LED. These are suitable for domestic applications like cabinet decoration, stairs , windows , photos, celing coves etc.

2 50:50 - this is indicating LED size as 5.0mm x 5.0mm LED. These are bright LED strips and the size will be about 40% bigger than 35:28 LEDs. These producing high light output. These can use for both commercial and domestic applications such as outdoor lighting, ambient lighting for commercial areas, wall washers etc.

Number of LEDs per meter

The number of LEDs per metre affects the brightness (lumens) and light pattern of a strip. Integral LED strips are available in three variations:

Fig 9



1 30 LEDs/m - generally using domestic decorations like kitchen kick plates, etc.

2 60 LEDs/m - task lighting, under kitchen cabinets, bar tops, steps/staircase edging, doorway frames.

3 120 LEDs/m - high ceiling coves, exterior edge lighting, path ways, signage.

LED cut marks are normally 3 LEDs apart. The distance between cut marks will depend on the number of LEDs per metre.

Thermal management of high-power LEDs

High power light-emitting diodes (LEDs) can use 350 milliwatts or more in a single LED. Most of the electricity in an LED becomes heat rather than light (about 70%

heat and 30% light). If the dissipated heat is not removed, the LEDs operates at high temperatures will causes to lowers their efficiency, and reliability. So it is necessary to keep the temperature with in safe limit and remove excess heat form the light for improving its lifespan and accuracy.

The excess temperature of LED light can be eliminated by

1 Using heat adhesive with boards and heat sinks.

2 **Heat sinks :** The thermal conductive type materials (eg. aluminium) are using with LEDs which are dissipating heat by conduction methods. The shape and size of heat sink also effects the speed of heat dissipation.

i Surface finishing of a heat sinks effecting the heat dissipation. A painted surface having more heat emission than unpainted and unfinished one.

ii Mounting methods also effect the cooling system. Heat-sink mountings with screws or springs are often better than regular clips, thermal conductive glue or sticky tape.

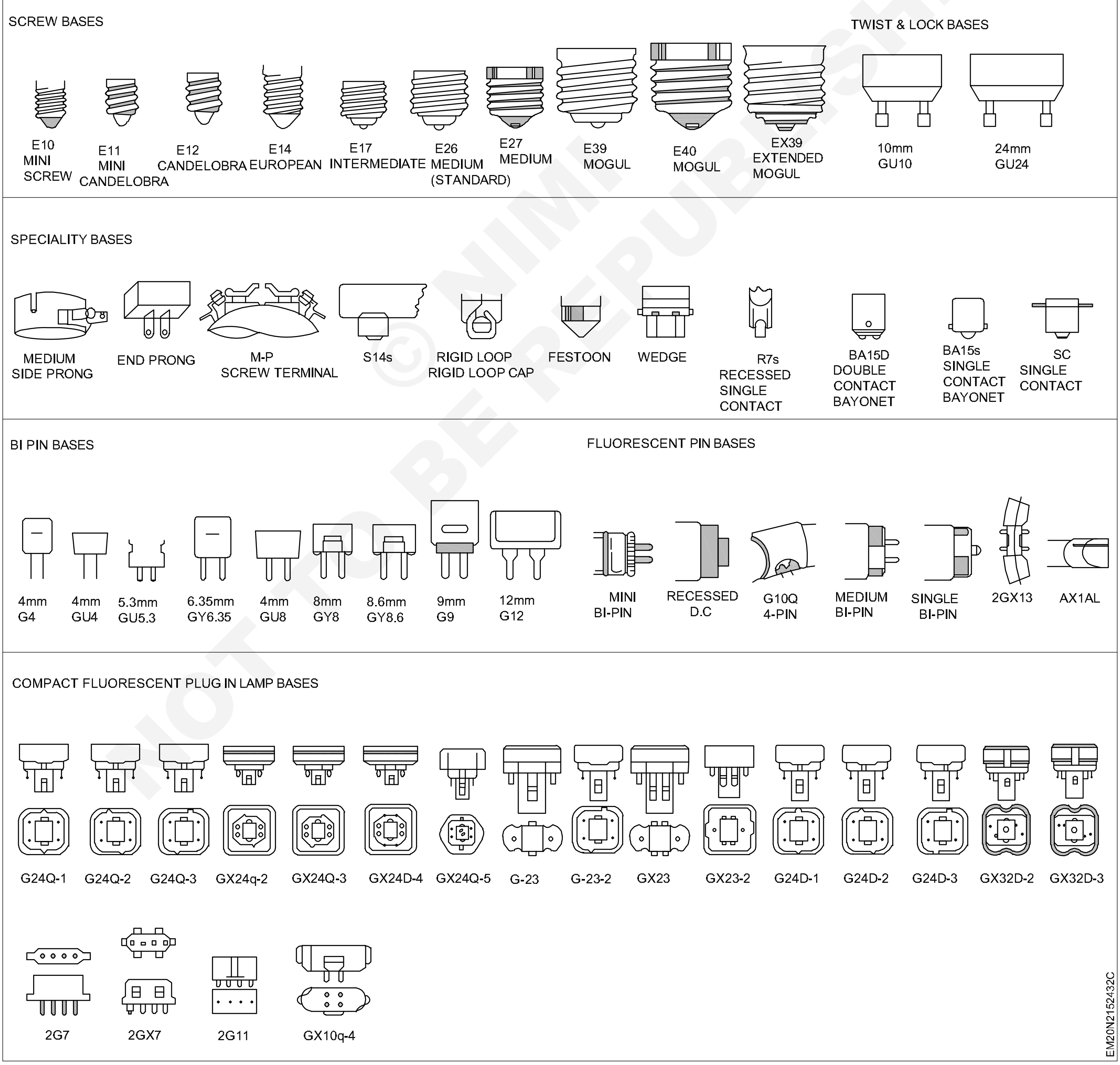
LED lamp specifications

It is important to know the specifications of LED lights for its selection . LED lights having so many specifications in those more important specifications are as given below.

1 Power rating

2 Equivalent incandescent lamp rating

Fig 12



3 Operating voltage and frequency

4 The light colour emitted

5 Its colour rendering index (CRI)

6 Luminous flux

7 Operating life time

8 Fitting type and whether the lamp is dimmable

9 In the case of directional lamps, the luminous intensity and beam angle may also need to known.

LED stacks - Connections, Driver circuits

Objectives : At the end of this lesson you shall be able to
- **describe the LED panel materials**
- **explain the stacking of LED**
- **explain the working of LED driver circuits.**

The main materials of LED panel light structure are as follows

1 Aluminum frame

AL6063, aluminum extrusion mold is used due to low initial investment cost, good surface appearance, good heat dissipation.

2 Diffuser plate

Installation of diffusion plate is used to invisible the screen dot. Diffuser plate generally uses acrylic diffuser plate or PC 2.0 materials. Acrylic diffuser plate is low cost, higher light transmission than PC 2.0 and is poor in anti-aging. The price of PC 2.0 is slightly higher, but it is good at anti-aging. Acrylic diffuser plate light transmission rate is 92% and that of PC 2.0 is 88%. We can choose the materials of diffuser plate according to different requirement and usually use the acrylic materials.

3 Light guide plate

To emit the uniform light, light guide plate plays an important roll in blocking the screen dot. The side LED light changes the angle of light ray by light refraction of screen dot. Light guide plate is the heart of the LED panel light and its screen dot design is very important. If the screen dot design is not good, the overall lighting effect will be bad like 1. Bright in the middle and dark in both sides. 2. Bright in the bright side and dark in the middle.

4 Rear cover

Sealing lamp body usually uses aluminum. It plays a role of dissipating heat and protecting the light.

5 LED lighting source

3528 is the usual light source. Besides, there are 5630 and 5050. The luminous efficiency of 5630 and 5050 is not high and the design of their screen dot is difficult but their cost is lower. The lighting effect of 3528 is high and the screen dot is in acceptable range.

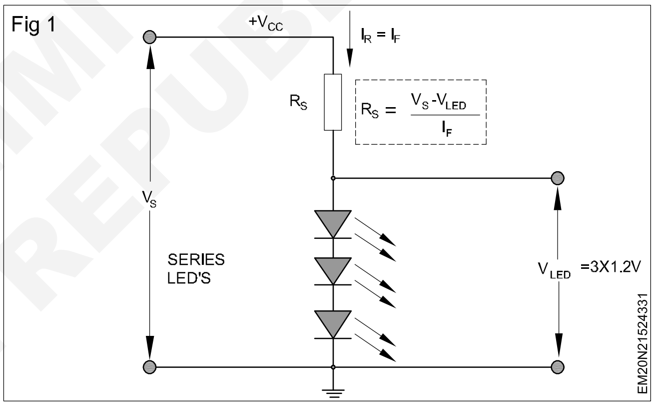
6 Drive power

There are two kinds of power modes: first, directly using cross-flow power (this mode has high efficiency and PF value is up to 0.95, so it is cost-effective);second, constant pressure with cross-flow mode (this mode is stable, but with low efficiency and high cost).

LEDs in series

We can connect LED's together in series to increase the light level. If LED's are connected in series all have the same forward current flow as shown in Fig 1.

Fig 1



Although, the series voltage drop across them needs to be considered when calculating the required value of the current limiting resistor, Rs. If we assume that each LED has a voltage drop of 1.2V across its when it is illuminated then the voltage drop across three will be 3x1.2v =3.6 volts. Consider that the supply voltage is 5 volt with a forward current of about 10mA. The value of series resistance Rs. will be calculated as:

$$V_{LED} = 3 \times 1.2 \text{ volts} = 3 \times 1.2 \text{ V} = 3.6 \text{ V}$$

$$R_S = V_S - V_{LED} = 5 - 3.6 = 1.4 \text{ volts}$$

$$R_S = \frac{1.4v}{10mA} = 140 \text{ W}$$

Stacking of LEDs

Stacking means grouping of LEDs. LEDs may be connected in series, parallel or series - parallel combinations. It is necessary in each stacking that a LED is operated at its rated DC voltage and the current passed through a LED does not exceed to its rated value. The voltage rating of LEDs ranges from 1.6V to 4.2V and the current rating ranges from 2mA to 20mA.

1 Parallel stacking

In this stack, all the LED are connected in parallel to a single source of supply with a current limiting resistor for each LED. Decorative lighting strip may contain any number of LEDs that are connected in parallel with a current limiting resistor for each LED.

2 Series-parallel stacking

LED light panels generally contain a parallel group of some series groups. Each series group usually contains 3 to 4 LEDs. These panels may be of built-in type or mounted type.

3 Series stacking

In this stack, LEDs are connected in series, but usually more than 3-4 LEDs are not connected in series. Of course, some series groups of 3-4 LEDs may be connected in parallel. The reason behind it is different voltage distribution and current limiting of LEDs.

Driving of LED stacks

Here, driving means to apply DC supply to a stack (group) of LEDs. In general, a current limiting resistor is used with each LED.

1 Driving a single LED

For driving (operating) a single 3 resistors. In the given Fig 3, only two groups of 3 LEDs each are shown, but there are 24 such groups. IC 555 is used to limit the, circuit current at 10mA.

2 Driving a stack of 72 LEDs

For driving a stack of 72 LEDs, IC 555 may be used. 72 LEDs are divided into 24 groups of 3 LEDs connected in series and all the 24 groups are connected in parallel across an IC 555 and 12 volts DC source. A current limiting and voltage dropping resistor of 82 ohms is used in each group of 3 resistors. In the given figure, only two groups of 3 LEDs each are shown, but there are 24 such groups. IC 555 is used to limit the, circuit current at 10mA.

3 Other driving circuits

A number of LEDs stack driving circuits have been developed which employ different ICs. A current limiting resistor is necessarily connected in series of a single LED or a series group of 3-4 LEDs.

Driver circuit

Fig 2

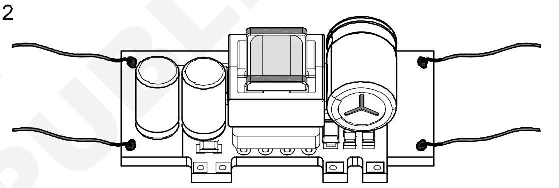
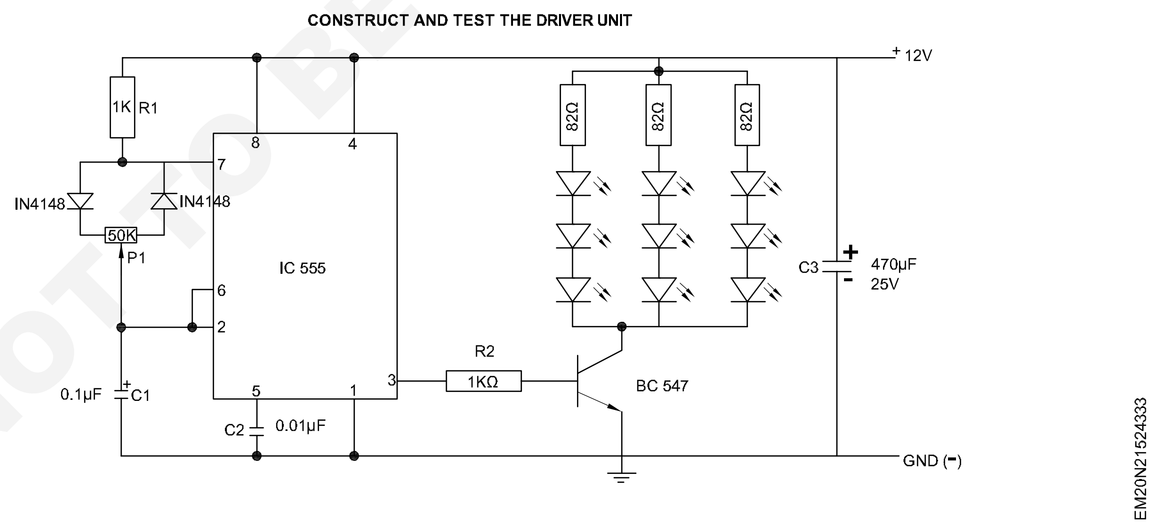


Fig 3



LED drivers and its types

Objectives : At the end of this lesson you shall be able to
- **explain the need for a LED driver**
- **list out the types of LED drivers**
- **explain the factors to be considered to choose a LED driver**
- **describe the working of LED driver circuit.**

Need for a LED Driver

LED light sources require specialized devices called LED drivers to operate. LED drivers (also known as LED power supplies) are similar to ballasts for fluorescent lamps or transformers for low voltage bulbs: they provide LEDs with the electricity they require to function and perform at their best.

LEDs require drivers for two purposes:

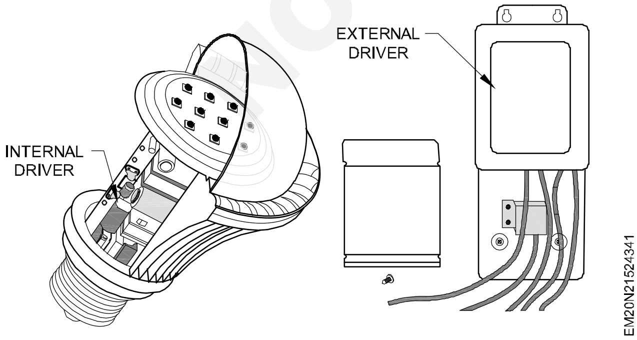
1. LEDs are designed to run on low voltage (12-24V), direct current electricity. However, most places supply higher voltage (120-270V), alternating current electricity. An LED driver rectifies higher voltage, alternating current to low voltage, direct current.
2. LED drivers also protect LEDs from voltage or current fluctuations. A change in voltage could cause a change in the current being supplied to the LEDs. LED light output is proportional to its current supply, and LEDs are rated to operate within a certain current range (measured in amps). Therefore, too much or too little current can cause light output to vary or degrade faster due to higher temperatures within the LED.

In brief, LED drivers convert higher voltage, alternating current to low voltage, direct current. They also keep the voltage and current flowing through an LED circuit at its rated level.

Internal vs. External drivers (Fig 1)

For the aforementioned reasons, every LED light source requires a driver. However, some LEDs, particularly those designed for household use, contain internal drivers rather than separate, external drivers. Household bulbs usually include an internal driver because it makes replacing old incandescent or CFL bulbs easier. The figure 1 shows the external and internal drivers.

Fig 1



Choosing an LED Driver

There are two main types of external LED drivers, constant-current and constant-voltage, as well as a third type of driver called an AC LED driver. Each type of driver is designed to operate LEDs with a different set of electrical requirements. When replacing a driver, the old driver's input/output requirements must be matched as closely as possible.

Constant-Current drivers

Constant-current drivers power LEDs that require a fixed output current and a range of output voltages. There will be only one output current specified, labeled in amps or milliamps (350mA, 700mA or 1A), along with a range of voltages that will vary depending on the load (wattage) of the LED.

Constant-Voltage Drivers

Constant-voltage drivers power LEDs that require a fixed output voltage with a maximum output current. In these LEDs, the current is already regulated, either by simple resistors or an internal constant-current driver, within the LED module. These LEDs require one stable voltage, usually 10 V, 12V DC or 24V DC.

AC LED Drivers

LEDs have such a small electrical load that regular transformers do not register that they're wired to a bulb at all. AC LED drivers are typically used with bulbs that already contain an internal driver that converts the current from AC to DC, so an AC LED driver's job is to register the low wattage of LEDs and step down the voltage to meet the bulb's voltage requirements, usually 12 or 24 volts. AC LED drivers are typically used to power 12-24V AC input LED MR16 bulbs.

Factors to be considered to choose a LED driver

Max Wattage

According to the NEC (National Electrical Code), LED drivers should be paired with LEDs that use 20% less than their maximum rated wattage (with the exception of AC LED drivers). Drivers should not be paired with an LED that is at or exceeds the driver's maximum wattage to avoid overstressing the driver components. For example, if you have a driver that can operate a maximum of 96 watts, it should only operate LEDs that use 77 watts at most (96 x 0.8 = 76.8).

Dimming

Dimming functions are desirable to optimize illumination as ambient light levels may change due to artificial or natural variations in the lighting variations both indoors and outdoors.

Both constant-current and constant-voltage LEDs and drivers can be made with a dimming capability. Dimmable external drivers often require an external dimmer, or other dimming control devices to work. Since technologies are improving rapidly, it's best to test specific LED/ dimmable driver combinations for acceptable dimming performance.

Power Factor

Power factor describes how efficiently an LED driver uses electricity. The closer to 1 the power factor is, the more efficient the driver is. A good power factor is 0.9 or above.

Ingress Protection (IP) Rating

IP ratings tell users the environmental protection that a driver's outer casing provides. The first number specifies protection against solid objects, and the second number specifies protection against water elements. For example, according to the chart below, a driver with an IP67 rating is protected against dust and temporary immersion in water.

Physical size and shape

Consider the physical dimensions of the driver. Make sure it will fit in the area you will place it.

Design a emergency light using LEDs

Objectives : At the end of this lesson you shall be able to
- **state the brief idea about the emergency light**
- **explain the working of the emergency light with charging circuit.**

A simple LED emergency light circuit that can be implemented for home lighting during power failures is given in the figure below. This LED lighting circuit design is intended to light automatically during main power failures. This circuit is a simple and low cost emergency light. The main part of this LED light schematic is a relay, which automatically connects DC voltage to the battery when main power is present and connect LEDs to the battery in the absence of mains AC power supply.

Working of Emergency light charger circuit

The step down transformer and the diode bridge rectifier steps down and convert the high AC(in the range 230V) voltage to low (12V) DC voltage. The diode D5 prevents the battery charge from flowing back, it acts as a free wheeling diode too.

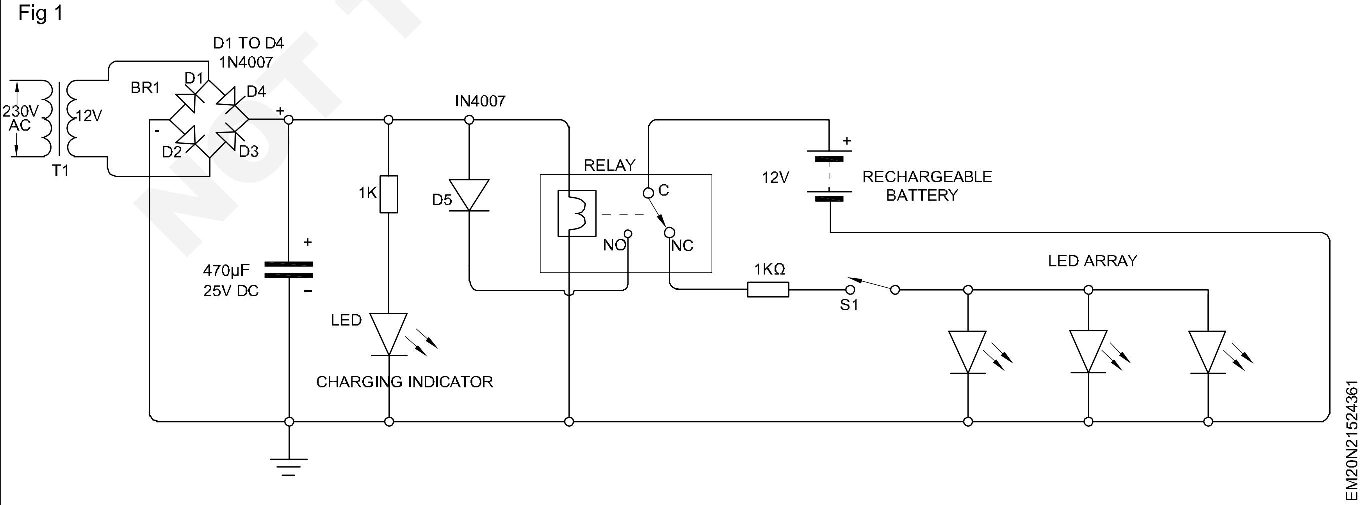
In the presence of electricity, the relay contact connects the NO (Normally Open) terminal to battery. Thus battery charges during this time. A red LED is used in the circuit as the charging indicator which glows when the emergency light battery is charging.

When AC mains supply failure occurs, relay connects the NC (Normally Closed) terminal to the battery. If the switch S1 is closed, the LED arrays are connected to NC terminal, thus they glow by using the charge stored in the battery.

Whenever the emergency light is not used or not required to light, the switch S1 may be released, so that the LEDs will not glow.

To increase the brightness or light few more LEDs may be connected in series and parallel.(series and parallel combination)

Fig 1



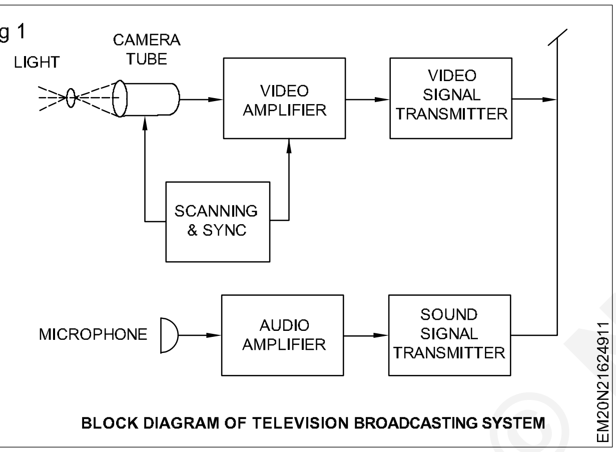
Television transmitter and receiver

Objectives : At the end of this lesson you shall be able to
- **explain the television broadcasting system**
- **explain the television broadcast channel**
- **state the three television systems used across/around the world.**

Television broadcasting

The meaning of the word television "Tele" means at a distance, "vision" means to see the scene or a picture is focused through a TV camera which converts the scene or picture into images to electrical signal. The camera's output signal is modulated and transmitted as electromagnetic waves along with respective sound as in Fig 1.

Fig 1

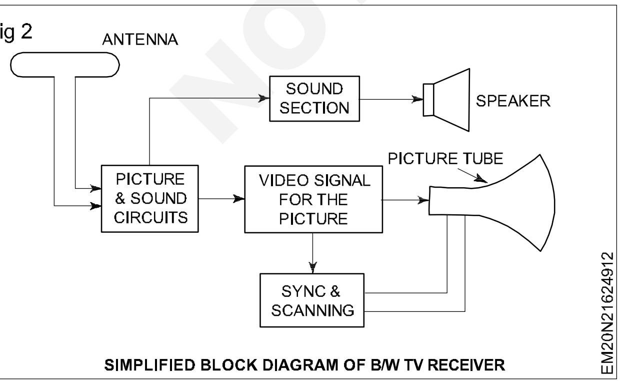


BLOCK DIAGRAM OF TELEVISION BROADCASTING SYSTEM

The term broadcast means to send out in all directions. The transmitting antenna radiates electromagnetic waves which can be picked up by the receiving antenna. The TV transmitter has two functions visual and sound transmission. Both picture signal and the sound signal are emitted from the common radiating antenna.

The receiving antenna intercepts both the picture and the sound carrier signals. The signals are amplified and then detected to recover the original modulation. Then the detected video signal is amplified enough to drive the picture tube.

Fig 2



SIMPLIFIED BLOCK DIAGRAM OF B/W TV RECEIVER

There are three major television systems which are followed in different parts of the world. India and many of the "European" countries follows a system of "PAL" (Phase Alternate Line) which is based on 625 lines 7 MHz channel width with a line frequency of 50Hz. In "America" a system known as "NTSC" (National Television Systems Committee) is followed which is based on 525 lines, 6MHz channel width operating on line frequency of 60 Hz. "France" and some "European" countries follows a system called "SECAM" (Sequential a memory) based on 625 lines with 9 MHz band width.

A television based on one particular system cannot be used in other countries following a different system. For example a television used in America cannot be used in India. The present day Televisions have provision to select one of the three systems so that the same TV could be used with different system in different countries.

Television broadcast channels

The band of frequencies used for video and audio signal transmission is called a television channel.

TV signals are radiated at frequencies above 40 MHz. The VHF and UHF frequency bands that have been assigned for the use of the TV stations are as follows.

Television channel

TABLE 1

Band I	41 MHz to 68 MHz channel 1 to 4
Band II	88 MHz to 108 MHz used for FM Radio broadcast
S-Band	104 MHz to 174 MHz
Band III	174 MHz to 230 MHz Channel 5 - 12 known as VHF band
Hyper Band	230 MHz to 470 MHz and 2 to 20 known as UHF
Band IV	470 to 582 MHz channel 21 to 36
Band V	606 to 870 MHz channel 37 to 69

Only band I and III are used for TV transmission in India. Each band is divided in to a number of channels. According to the standards adopted in India each channel width is 7 MHz.

TV transmitters are provided in different places to cater the needs of the local population. Depending upon the area to be covered either a low-power transmitter (LPT) or high power transmitter (HPT) is installed. A high power transmitter can service an area of around 120Km and a low power transmitter around 20Km radius only.

Scanning bandwidth composite video signal

Objectives : At the end of this lesson you shall be able to
- **define scanning**
- **explain different types of scanning**
- **explain USB transmission and band width of TV signal.**

Scanning

Scanning is the process of reading the scene rapidly both in the horizontal and vertical directions simultaneously to provide sufficient number of complete pictures or frames per second to give the illusion of continuous uniform motion. Instead of 24 frames as is the practice in commercial motion pictures, the frame repetition rate is 25 per second in most television systems.

Horizontal scanning

Fig 1 shows the trace and retrace of several horizontal lines. The linear rise of current in the horizontal line deflection coils as shown in Fig 2 deflects the beam across the screen with a continuous, uniform motion for the trace from left to right.

Fig 1

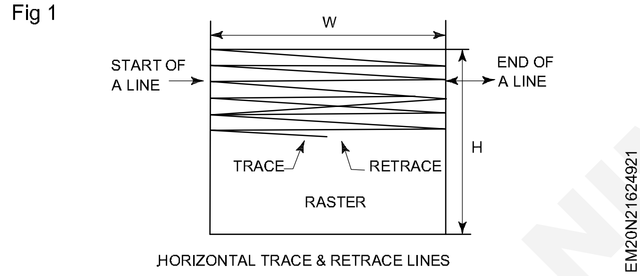
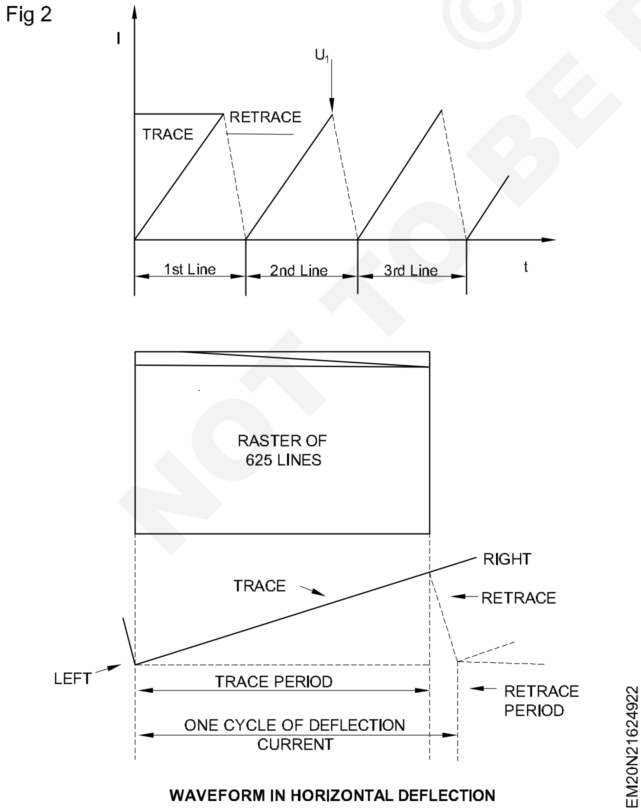


Fig 2

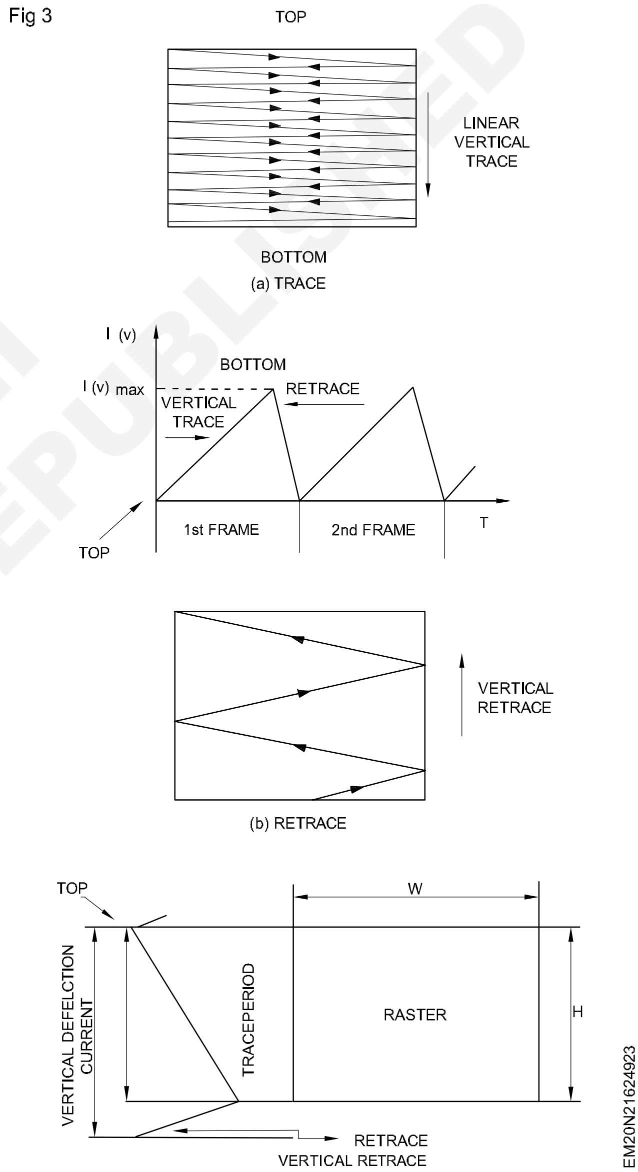


At the peak of its rise the saw tooth wave-reverses direction and decreases rapidly to its initial value. This fast reversal produces the retrace or fiy back. The start of horizontal trace is at the left edge of raster. The finish is at the right edge and then the fly back produces retrace back to the left edge.

The heavy lines indicate useful scanning time and dashed lines correspond to the retrace time.

Vertical scanning

Fig 3



The saw tooth current in the vertical deflection coils as shown in Fig 3 moves the electron beam from top to bottom.

As shown in Fig 3 the trace part of the saw tooth wave for vertical scanning deflects the beam to the bottom of raster. Then the rapid vertical retrace returns the beam to the top.

During vertical retrace, horizontal scanning continues and several lines get scanned during this period. Because of motion in the scene being televised, the information at the top of the picture tube screen normally changes by the time the beam returns to the top to recommence the whole process. This information is picked up during the next scanning cycle and the whole process is repeated 25 times per second to cause an illusion of continuity".

It must be noted that both during horizontal and vertical retrace intervals the scanning beams at the camera tube and picture tube are blanked and no picture information is either picked up or reproduced. These short retrace intervals are utilized for transmitting distinct narrow pulses to keep sweep oscillators of the picture tube deflection circuits of the receiver in synchronization with those of the camera at the transmitter. This ensures exact correspondence in scanning at the two ends and results in distortion less reproduction of picture details.

Interlaced scanning

Although the rate of 24 pictures per second in motion pictures and that of scanning 25 frames per second in television pictures is enough to cause an illusion of continuity, they are not rapid enough to allow the brightness of one picture or frame to blend smoothly into the next through the time when the screen is blanked between successive frames. This results in definite flicker of light that is very annoying to the observer when the screen becomes alternately bright and dark.

This problem is solved in motion picture by showing each picture twice so that 48 views of the scene are shown per second although there are still the same 24 picture frames per second. As a result of the increased blanking rate flicker is eliminated.

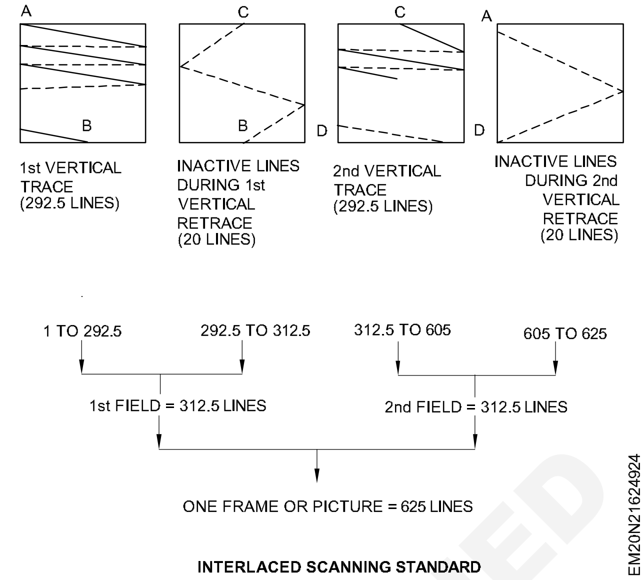
In television pictures an effective rate of 50 vertical scans per second is utilized to reduce flicker, by making every alternate line to get scanned instead of every successive line. Then when the beam reaches the bottom of picture frame at the end of the first scan, it quickly returns to the top to scan those lines that were missed in the first scanning. Thus the total number of lines are divided into two groups called as "Odd" field and "Even" field. Each field is scanned alternately. This method of scanning is known as ‘Interlaced scanning.

In the 625 line TV system each frame or picture is divided into sets of 312.5 lines and each set is scanned alternately to cover the entire picture area. To achieve this the horizontal sweep oscillator is made to work at a frequency of 15625 Hz (312.5 x 50 = 15625), to scan the same number of lines per frame (15625/25 = 625 lines), but the vertical sweep circuit is run at a frequency of 50 Hz.

Note that since the beam is now deflected from top to bottom in half the time and the horizontal oscillator is still operating at 15625 Hz. The first field ends in a half line and the second field commences at middle of the line on top of the screen. The complete geometry of the standard interlaced scanning pattern is shown in Fig 4.

The function of video amplifier is to provide sufficient gain to the video signal such that it can drive the picture tube from cut-off for blanking, to zero grid cathode voltage for peak white. The peak to peak value of the video signal required to drive the picture tube vary depending on its size. The video signal with range of video frequencies from 25Hz to over 4 MHz has to be uniformly amplified by the video amplifier. So a wide band amplifier is used with a high amplification factor.

Fig 4



INTERLACED SCANNING STANDARD

The three basic requirements of a video amplifier are

1 The entire band of video frequencies should be uniformly amplified.

2 As the amplitude of the video signal determines the contrast of the picture, the peak-to-peak value of the video signal is to be sufficient enough to produce a range from bright to dark picture elements on the screen. If the peak-to-peak value is low then the picture on the screen will be very dim.

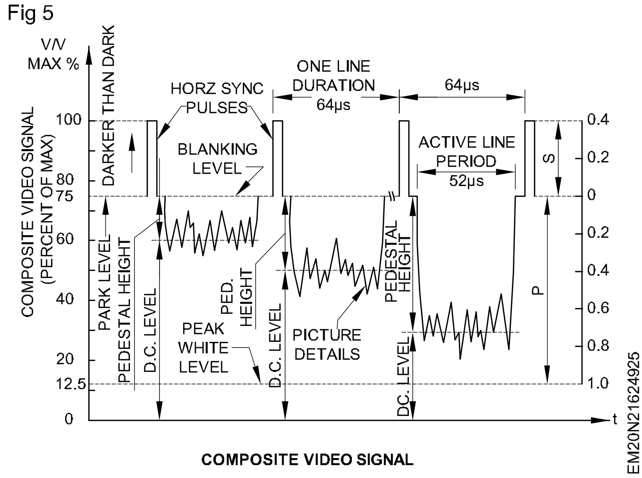
3 Composite video signal with negative polarity is to be applied at the cathode of the picture tube. Hence the video amplifier should produce such signal from the output of video detector. The Fig 5 shows such type of composite video signal.

VSB or Vestigial side-band transmission

Vestigial sideband transmission system is employed in telecasting. Since, the bandwidth of a Television channel width is 7 MHz and if double sideband transmission is employed then the total telecasting bandwidth will be equal to 14 MHz. Hence, it will be necessary to keep a minimum difference of 14 MHz between two telecasting stations and thus the number of total telecasting stations in the V.H.F and U.H.F. Bands will be reduced. Therefore, V.S.B. transmission system is suitable for telecasting. The width of a T.V. channel is kept 7 MHz for the reason that sound signal is also transmitted along with the video signal. Secondly, a small portion of lower and full upper sidebands is also included in the telecast, see Fig 6.

The system of transmitting video and audio carriers together by employing a single unit is known as inter carrier system. Here, the video carrier frequency is kept

Fig 5



COMPOSITE VIDEO SIGNAL

1.25 MHz higher than the channel's lower frequency. Similarly, the sound carrier frequency is kept 0.25 MHz lower than the channel's higher frequency. In this way, the sound carrier frequency rests 5.5 MHz higher than the video carrier frequency. The sound signal is modulated in F.M. mode, therefore, the sound carrier frequency has a sideband of ±100 KHz only.

For example the video carrier frequency and sound carrier frequency of TV channel - 4 under VHF band-I is given below:

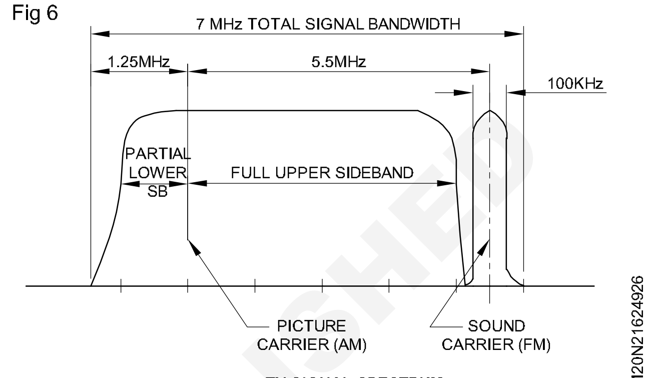
Frequency band allocated - 61 MHz to 68 MHz.

Video carrier frequency is 62.25 MHz (61 + 1.25 MHz = 62.25 MHz)

Sound carrier frequency is 67.75 MHz (68 - 0.25 MHz = 67.75 MHz)

Inter carrier frequency is 67.75 - 62.25 MHz = 5.5 MHz

Fig 6



TV SIGNAL SPECTRUM

Principles of colour TV system

Objectives : At the end of this lesson you shall be able to
- **list the primary colours used in colour TV system**
- **define additive and subtractive mixing**
- **describe the production of luminance and chrominance signals**
- **explain QAM signals.**

Primary colours and their mixing

There are three primary colours RED, BLUE and GREEN (RGB) which are used in colour Television system. These three primary colours are capable to produce all the seven rainbow colours - VIOLET, INDIGO, BLUE, GREEN, YELLOW, ORANGE and RED (VIBGYOR).

a) Additive Mixing

Red + Green = Yellow

Red + Blue = Magenta

Blue +Green = Cyan

b) Subtractive Mixing

Yellow = White - Blue

Magenta = White - Green

Cyan = White - Red

So, by additive and subtractive mixing of colours, many other colours are produced.

c) Colour specification

A colour can be specified by three characteristics known as HUE (TINT), SATURATION and LUMINANCE.

i Hue represents the actual colour as seen by the eye. The seven colours of rainbow have different wavelengths and they produce different hue.

ii Saturation represents the purity of a colour. A fully 'saturated' colour will have no white colour mixed in it.

iii Luminance or brightness is the amount of light intensity.

d) Chrominance

The term used to describe the information about hue and saturation of a colour. Different colours represent waves of different frequencies in the visible spectrum. These are electromagnetic waves of frequencies ranging from 4×10^{14} Hz to 8×10^{14} Hz (red to violet) corresponding to 780×10^{-9}m to 380×10^{-9} m wavelengths. Each colour will have a frequency (i.e., hue) and amplitude (i.e., luminance).

Colour TV Camera

For televising a scene in colour, the light originating from a scene is first separated into three primary colours with the help of special filters. Each filter allows only one colour to pass through. Then, the three primary colours (RGB) are converted into three video signals by three camera tubes, see Fig 1. The three video signals called R, G and B signals are then 'encoded' (combined in specific proportions) to produce following two main signals.

i Luminance signal (Y-signal)

It is also known as y signal. It is obtained by mixing red, green and blue colours in the following ratio:

Y=30% Red + 59% Green + 11% Blue

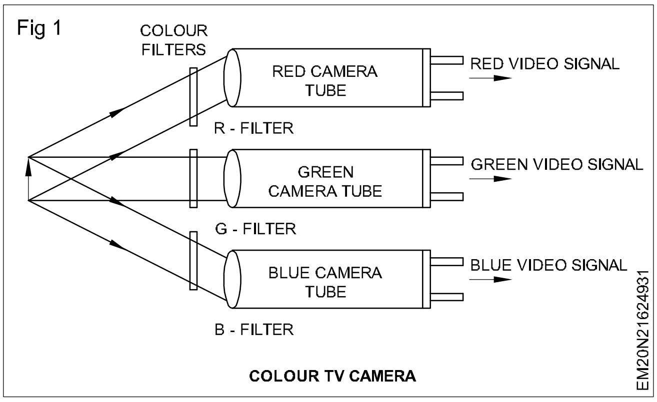


Fig 1 COLOUR TV CAMERA

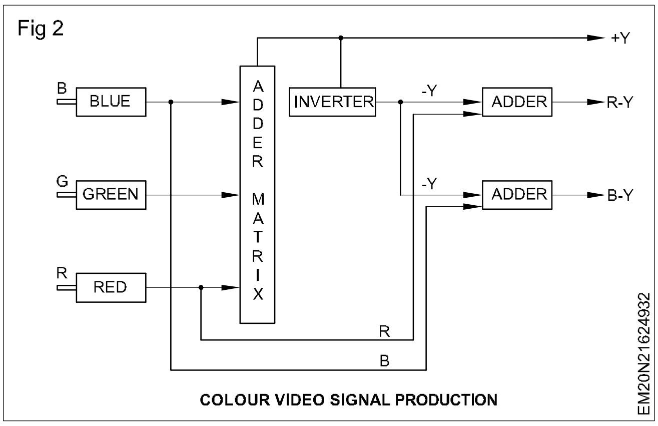


Fig 2 COLOUR VIDEO SIGNAL PRODUCTION

The above percentage is chosen with a view to the colour sensitivity of human eye. Luminance signal is modulated to the video carrier frequency to provide compatibility by reproducing a black and white picture on a monochrome TV receiver. In colour TV this signal helps in decoding the three primary colours at the colour picture tube.

ii Chrominance signal (C-signal)

It contains all the colour information regarding 'hue' and 'saturation' of a colour. This information is then produced in the form of V(R-y) and U(B-y) signals, for LCD and LED TV Receivers.

For this purpose. The Y signal is inverted into (-Y) by an inverter stage and then added to R and B signals in the following manner:

R + (-Y) = R - Y (V-signal)

B + (-Y) = B - Y (U-signal)

G-Y signal is not required because the G-information is already contained in the Y-signal. The two colour-difference signals (R-Y and B-Y) are modulated with a subcarrier frequency of 4.43 MHz (Fig 2)

Matrix

The circuit in which, the video signals are mixed in a given proportion and modulated with a sub-carrier frequency for telecasting, is called matrix unit.

A special type of amplifier stage is used which produces Quadrature Amplitude Modulated (QAM) signal. The chrominance signal is obtained by employing amplitude modulation. The two colour difference signals (R-Y and B-Y) are modulated with a sub carrier frequency (4.43 MHz) in amplitude modulation mode so that they have a phase difference of 90°, i.e., they are in 'quadrature'.

At any instance, the amplitude and phase of the chrominance signal depends on the relative amplitudes and phases of the colour-difference-signals. The amplitude of chrominance signal represents the 'saturation; and its phase represents the 'hue' in the modulated signal. Since, R-Y and B-Y signals are mutually at right angles, therefore, the modulated signal is called 'quadrature amplitude modulated' signal.

Difference between CTV with LCD/LED TV and CRT screen

	LCD & LED	CRT
Slim Factor	Slim	Bulky
Viewable screen	Full or very close to its size	Usually 0.9 inches or less than actual size
Screen Flatness	True Flat	Fake Flat (unless aperture grille)
Radiation	Little or none	More Radiation
Weight	Light	Heavy
Power Requirements	Low Power requirement	250% or more power compared to LCD/LED TV
Glare	No Glare	Reduced Glare
Image Sharpness	Sharp	Slightly less sharp images
Automatic Resize	Perfect	Imperfect
Burn-In	None	Suffers from burn-in problem
Refresh Rate	No refresh rate (60hz fixed)	Needs refresh rate (minimum 72hz)
Warmness	Little	CRT cathode gets warm after sometime

Dead / Stuck Pixel	No such problem	May have dead / stuck pixel
Response Rate	No issue with response rate	Slow
Price	Cheap	Expensive
Native Resolution	None	Has a native resolution
Max Colours	32 bit	8-Bit max, 16.7 million colours.
Viewing Angle	Wide viewing angle	Narrow viewing angle
Video	Ideal for any video viewing including HD	Not ideal for videos, unless HD
Blackness	True Black	Between Dark Grey to Grey

Block diagram of colour Television

Objectives : At the end of this lesson you shall be able to
- **state various stages of a colour TV receiver**
- **describe the broad functions of the individual stages**
- **state the names of important components in the stages.**

The block diagram of a CTV receiver is shown at the end of this lesson. As a reference will help in understanding the concepts of CTV. It stages and flow of signals easy for the beginners. It uses PAL standard.

The basic functions of each stage/blocks are as follows.

Antenna

Antenna receives the electromagnetic waves and converts them into corresponding RF signals which is fed to the television set.

Yagi antenna is commonly used in VHF/UHF range for its simple construction and low air resistance. (Now-a-days cable TV and DTH set-top box is used)

Tuner

The main functions of the tuner are

1 to select the desired channel signal and rejects others.

2 to convert the RF signal into intermediate frequency (IF) by mixing it with local oscillator frequency.

3 to provide gain to the weak input signal picked up by the antenna.

4 to isolate the local oscillator from the feeder circuit to prevent undesired radiation through the antenna.

5 to match the antenna with input circuits of the receiver, and to prevent the appearance of ghost image.

6 to reject the image frequency which also causes the ghost image along with the picture.

The main blocks of the tuner are RF amplifier, oscillator and mixer stage.

Television receiver controls

Most televisions especially B/W TV have the basic controls like brightness, contrast, channel selector and fine tuning, volume control and ON OFF switch. In colour televisions in addition to the above there will be a control for colour.

There are two types of tuning mechanisms available in television which are as follows.

1 Mechanical tuner (Turret type or wafer type)

2 Electronic tuner.

Turret type tuners are used mainly in B/W TVs where a channel is selected by rotating the selector switch and then adjusting the clarity by rotating the fine tuning ring . In electronic tuners there are 8 to 12 switches called as program selectors. Each selector switch has a separate band selector and tuning facility, individual selectors can be tuned to different channels, and subsequently any pre tuned program can be seen in the TV just by pressing the required selector switch.

The brightness control varies the brightness level of the picture and contrast control helps to get the desired gray tone and variations on the picture.

VIF stage

Pre-Amplifier

It amplifies the IF signal obtained from the tuner. IC 203 (SL 1430) is used in this stage.

This stage of amplification is necessary because the gain of receiver is reduced by the use of SAW filter.

VIF Amplifier

This stage has the blocks of video IF amplifier, video detector, Automatic gain control (AGC) and Automatic frequency tuning (AFT) circuit. This stage has been constructed around IC201 (TDA4420).

Sound section

IC 202(TDA1701) performs the function of complete sound section accommodating sound IF amplifier (SIF), FM detector, Audio driver and audio output.

Luminance and delay line (Y delay)

From buffer amplifier, Y-signal passes through a delay line to Y-amplifier stage. The delay line delays the Y-signal by approximately 60 micro seconds time.

The delay line is a very thin metallic coil with very high value of inductance and distributed capacitance, so that the speed of the signal through the delay line is greatly reduced.

If this delay is not introduced, luminance signal will reach to the picture tube earlier than chrominance signal.

The two main reasons required for delay in Y-signal are as follows

1 Chrominance signal has to pass through relatively complex circuit of the decoder and for this reason it is functionally delayed as compared to Y-signal.

2 The bandwidth of Y-signal is more than that of Chrominance signal. The narrower bandwidth signals take longer time to travel a particular distance.

The main luminance (Y) amplifier

After the delay line the Y-signal is fed to the main Y-amplifier. The circuit used is also called emitter follower which acts as buffer amplifier to prevent any mutual interference between contrast control and black level clamp circuits.

The output signal voltage from Y amplifier is fed to the matrix where it is added with colour difference signals to produce original red, green and blue colour signals.

The horizontal and vertical blanking pulses derived from horizontal and vertical output stages are also fed to Y-amplifier stage.

These pulses ensure that the Y-signal fed to the matrix is held at black level during retrace periods. The average value of luminance signal fed to the matrix unit determines the mean brightness of the picture appearing on the screen.

The contrast control is used for adjusting the amplitude of the luminance signal obtained from the amplifier.

Chrominance signal

IC8707TDA3561 is used in this section (PAL decoder)

Composite colour video signal obtained from video IF section is given to this amplifier. It isolates the video IF section from the other sections, composite video signal output is taken from the emitter circuit which contains.

1 The luminance or Y-signal

2 The colour sub-carrier carrying red and blue chroma signals.

3 The horizontal and vertical sync pulses and

4 The colour burst signal.

Here the division of the luminance and chroma separation takes place. From here composite colour video signal is coupled to chroma band-pass amplifiers through chroma filter, sync separator and the luminance delay line.

U and V signal demodulators

The function of U and V demodulators is to detect U (B-Y) and V (R-Y) modulating signals from the U and V chroma signals.

Each demodulator has two input signals

1 Chroma signal, which is to be demodulated and

2 A constant amplitude output from the sub-carrier oscillator.

After modulation U (B-Y) and V (R-Y) modulating colour difference signals are fed to the matrix from where separated R, G and B colour video signals are available. Y-signal (luminance) is also fed to the matrix.

Video output

The colour video signals R, G and B are fed to respective cathodes of the picture tube after one stage of amplification. Video output circuits for each colour signal are identical. Transistors 92 PU393 is used for all the three video output circuits.

Horizontal section

This section includes sync separator, AFC .horizontal oscillator driver and output stage. This stage has been constructed around IC 601 (TDA1940F)

Horizontal driver stage

The signal obtained from horizontal oscillator is very weak; in this stage voltage amplification is provided and sent to the horizontal output stage through the horizontal driver transformer. Transistor T714 (BF393) is used in this circuit as horizontal driver.

Horizontal output stage

This stage consists of a transistor T716 (BU 508) and Extra high tension transformer (E HT) / line output transformer (LOT).

Power amplification is provided to the horizontal scanning signal by this stage. The 15625Hz signal is sent to the horizontal deflection yoke (HDC) and EHT/ horizontal output transformer.

Other functions of horizontal output stage

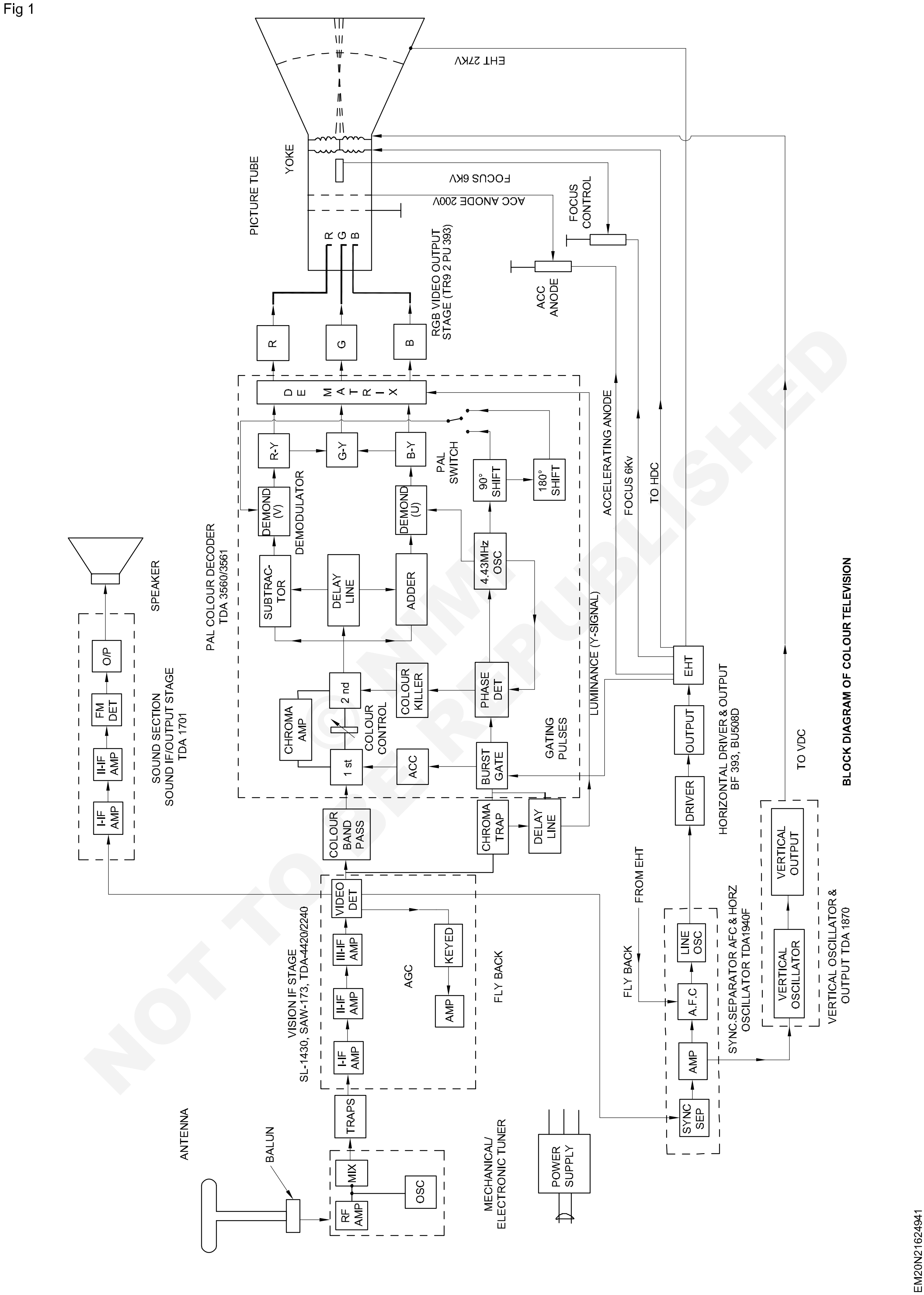
Vertical section

IC401 (TDA1870) is used in vertical section. This section consists of vertical trigger cum vertical oscillator or saw tooth generator, vertical driver and output.

Vertical output

It provides the sufficient power amplification to the vertical deflection signal and then it is sent to the vertical deflection yoke (VDC). Vertical blanking signal is also achieved from this stage and is fed to the video output section.

Fig 1



BLOCK DIAGRAM OF COLOUR TELEVISION

Principles and working of LCD

Objectives : At the end of this lesson you shall be able to
- **explain the construction of LCD display**
- **describe the working principle of LCD display**
- **list the advantages and disadvantages of LCD displays.**

Introduction

LCD stands for Liquid Crystal Display used to show status of an application, display values, debugging a program, etc.

LCD TV is a television display technology based on LCD. By the development of LCD, conventional TVs are changed by the LCD TV. LCD TV consumes much less power and utilize less space. They work on the principle of blocking light rather than emitting, etc.

Construction and working of LCD

Construction of LCD is rather simple, there are certain facts that should be noted while making it.

1 The basic structure of an LCD should be controlled by changing the applied electric current.

2 The light that is used on the LCD can be polarized.

3 Liquid crystals should be able to control both transmit and change the polarized light.

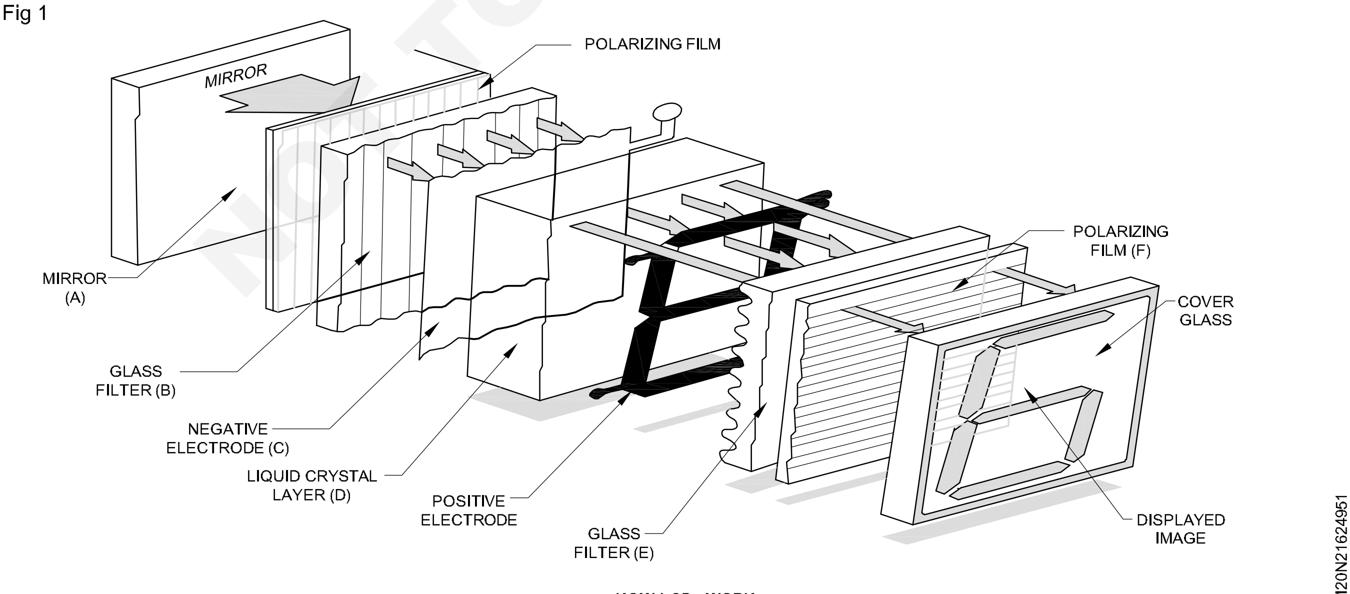
4 There are transparent substances that can conduct electricity.

The constructional details of LCD is shown in Fig 1. Two polarized glass filter pieces are required to construct the LCD. The glass which does not have a polarized film on the surface. It must be rubbed with a special polymer which creates microscopic grooves in the surface of the polarized glass filter and the grooves must be in the same direction of the polarized film. Then added a coating of nematic liquid crystals to one of the polarized filters of the polarized glass. The microscopic channel will cause the first layer of molecules to align with the filter's orientation. When the right angle appears at the first layer piece places a second piece of glass with the polarized film. The first filter will be naturally polarized as the lights strikes it at the starting sleek. Thus the light passes through each layer and is guided on to the next with the help of molecules. The molecules tend to change the plane of vibration of the light in order to match their angle. When the light reaches the far end of the liquid crystal substance, it vibrates at the same angle as the final layer of molecules vibrates. The light is only allowed to enter into the device only if the second layer of the polarized glass matches with the final layer of the molecule.

Working principle

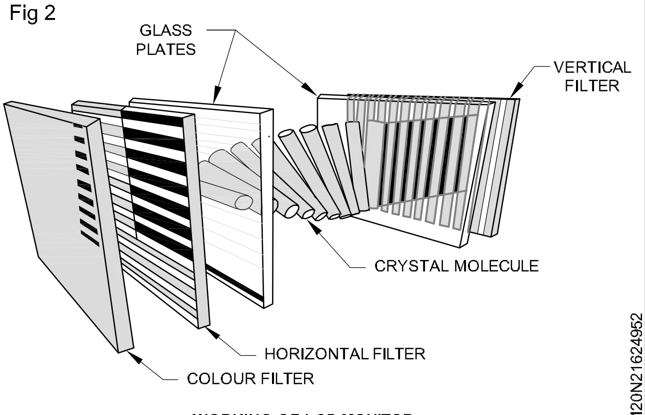
LCD displays consists of two sheets of polarized glass plates separated by a thin layer of liquid crystal molecule as shown in Fig 2. The type of liquid crystal used in LCD panels have very specific properties. That serves as effective 'shutters' to open and close to block or permit light through in response to an electric current. The current through the liquid crystal is controlled by a voltage applied between the glass plates via transparent electrodes that form a grid with rows on one side of the panel and columns on the other. As the electric current passes through these liquid crystals, they untwist to change the angle of the molecules depending on the applied voltage. This untwisting effect will change the polarization of the light passing through the LCD panel. As the polarization changes with respect to the applied voltage across the glass plates, more or less light is able to pass through the particular area of the polarized filter on the face of the LCD.

Fig 1



HOW LCDs WORK

Fig 2

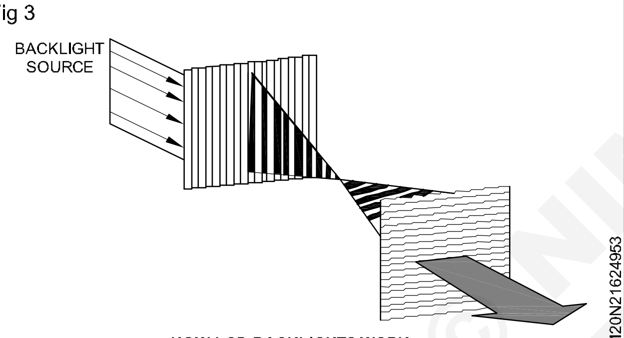


WORKING OF LCD MONITOR

How LCD TV backlights work (Fig 3)

There are too many different types of LCD TV backlight. This hasn't always been the case, though. Initially, the only option was a cold-cathode-fluorescent-lamp system, which essentially comprises of fluorescent tubes behind an LCD panel, providing the light that makes the picture visible.

Fig 3



HOW LCD BACKLIGHTS WORK

Advantages of an LCD's

1 LCD's consumes less amount of power compared to CRT due to the emission of less amount of heat.

2 LCDs are of low cost.

3 Provides excellent contrast.

4 LCD screen is very compact and light weight.

5 Very little emission of electromagnetic radiation.

Disadvantages of an LCD's

1 Limited viewing angle

2 Require additional light sources

3 Range of temperature is limited for operation

4 Low reliability

5 Speed is very low

6 LCD's need an AC drive

7 Some times black level will be unacceptable bright.

Applications of Liquid Crystal Display

Liquid crystal technology has major applications in the field of science and engineering as well on electronic devices.

1 Liquid crystal thermometer

2 Sometimes black level will be unacceptable bright with direct sunlight LCD shows a poor display.

3 Optical imaging

4 The liquid crystal display technique is also applicable in visualization of the radio frequency waves in the waveguide

5 Used in the medical applications

6 Used as TV monitor.

Types of LCD panels

Objectives : At the end of this lesson you shall be able to
- **explain the types of LCD panels**
- **explain twisted nematic display**
- **explain IPS display technology**
- **compare the advantages and disadvantages of IPS screen over the TN display.**

LCD display

LCD displays are mainly two types

1 Twisted Nematic display (TN display)

2 In-plane switching or IPS screen technology

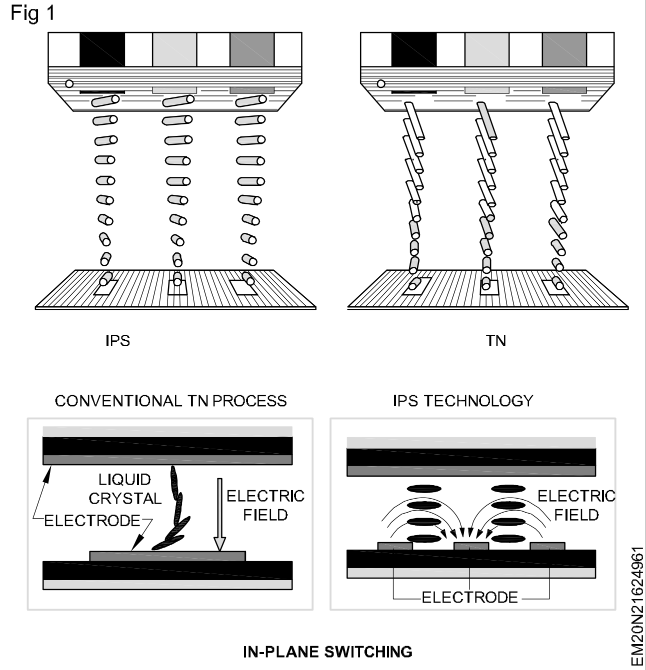
Twisted Nematic display (TN display)

A twisted nematic (TN) display is a common type of liquid-crystal display (LCD) that consists of a substance called a nematic liquid crystal that is confined between two plates of polarized glass as shown in Fig 1.

The TN display takes advantage of the ability of the nematic substance to rotate the polarization of light beams passing through it. Two polarizing filters, parallel planes of glass with their polarizing lines oriented at right angles with respect to each other, are positioned on either side of the liquid crystal. When light enters the display, it is polarized by the input filter. In the absence of an electric field, all the incoming light is transmitted. This is because the light polarization is rotated 90 degrees by the nematic liquid crystal, and the light therefore passes easily through the output filter, which is oriented to match the 90-degree shift.

With the application of a voltage, an electric field is produced in the nematic liquid crystal . Under these conditions the polarization effect is reduced. If the voltage is large enough, the polarization effect disappears altogether, and the light is blocked by the output polarizing filter.

Fig 1



Most TN displays have a characteristic black-on-gray or black-on-silver appearance, and are suitable for use in alphanumeric readouts such as those found in wristwatches, cell phone displays, and some calculator displays.

Disadvantages

1 In this particularly poor viewing angle and

2 Low-quality colour reproduction, as well as

3 Poor off-axis image quality and moving picture quality.

4 The application of LCD would be limited to small-display devices, suitable for use in alphanumeric readouts such as calculator displays, digital wristwatches, and earlier models of mobile phones.

In-plane switching or IPS screen technology

IPS, also known as In-Plane Switching, is a type of monitor display and screen technology. More specifically, an IPS panel is a type of TFT LCD (or "active matrix" LCD). The light modulating properties from unlit liquid crystals are used for providing a flat panel or electronic visual display. TFT, which stands for Thin Film Transistor, is an LCD display used for enhanced colour, as well as contrast and black levels.

The active matrix IPS TFT LCD was developed by Hitachi in 1996 as a solution to the display limitations of TN TFT LCDs (Twisted Nematic). The TN display is known for its flawed viewing angles, such as inverting colours at extreme angles, and poor colour quality. By contrast, IPS displays provide wider viewing angles and higher quality colour reproduction by altering pixels to be parallel, rather than perpendicular as shown in Fig 1,2. In an IPS screen, the liquid crystals run parallel with the panels when energized. In a TN display, the crystals turn perpendicular to the top of the panel. High-performance tablets and smart phones deploy IPS display technology used to watch movies, video chat and store photos. The improved angle and colour technology features provide an overall better experience.

Other IPS versions include the following technologies:

1 Super TFT (IPS) for a wide viewing angle.

2 Super-IPS (S-IPS) for colour shift free and an improvement on pixel refresh timing.

3 Advanced Super-IPS (AS-IPS) for high transmittance.

4 Enhanced IPS (E-IPS) for an enhanced diagonal viewing angle and reductions in response time.

5 Horizontal IPS (H-IPS) for an improved contrast ratio and an Advanced True White polarizing film that creates a more natural colour of white.

6 Professional IPS (P-IPS) for truer colour depth.

Advantages of IPS screen technology over TN

1 IPS screen technology is the wide viewing angle.

2 This also results in better colour reproduction.

3 It becomes very popular in displays for television, computers, and laptops, in consumer electronic devices, particularly smartphones and tablets.

4 Under bright outdoor lights or direct sunlight, an IPS screen is more viewable or readable.

Disadvantages of IPS as compared to TN

1 More power consumption. A typical IPS screen requires 15 percent more power than TN.

2 Faster battery drainage.

3 Producing IPS screen displays is more expensive than producing a TN LCD because of the involved engineering complexity. Thus, this screen technology is commonly featured in high-end devices.

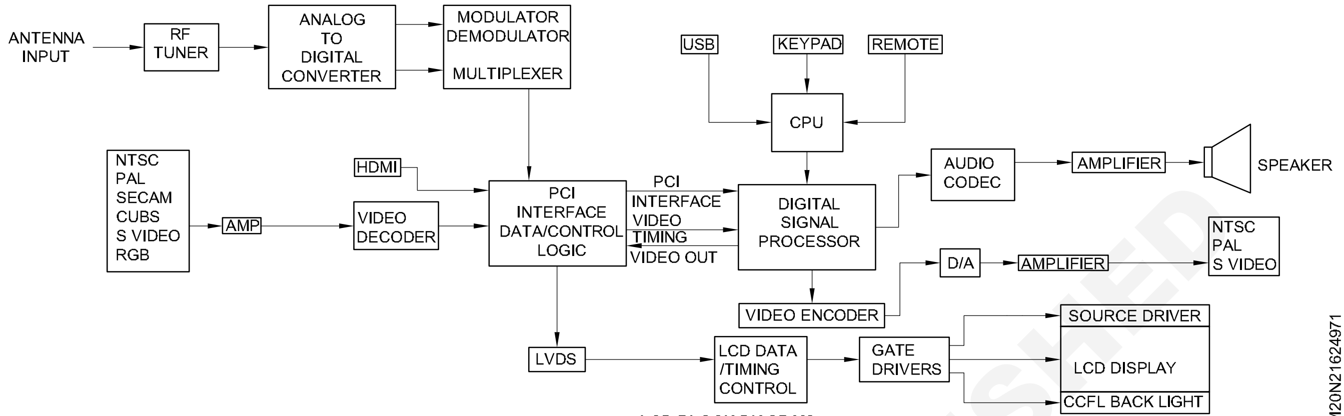
4 The refresh rate of IPS is also slower than TN. This disadvantage makes a conventional IPS screen unsuitable for watching high definition movies or playing fast-paced video games due to ghosting effects.

Block diagram of LCD TV

Objectives : At the end of this lesson you shall be able to
- **explain the block diagram of LCD TV**
- **illustrate block diagram of LCD television**
- **state the features of LCD television.**

Block diagram of LCD TV (Fig 1)

Fig 1



LCD BLOCK DIAGRAM

LCD TV block diagram explanation

1 RF Tuner

RF tuner receives the analog signal and converting into VIF & SIF. This signal is demodulated to get video signal. This CVBS(Composite Video Baseband Signal) is processed, and decoded video signal is given to a LCD display panel. The sound signal is demodulated, amplified, and sent to drive the speaker.

2 Digital broadcast

Digital tuner receives the digital signal and demodulate it. The MPEG decoder and composite video encoder-decodes the MPEG compressed data and also encodes video into NTSC/PAL/SECAM signal as an output.

3 HDMI (High Definition Multimedia Interface)

HDMI video signal is processed by video decoder video processor and LVDs (Low Voltage Differential Signal). This signal goto drive the display panel. HDMI audio signal is sent to processor, audio decoder, preamplifier and finally goes to the loud speaker.

All input signals whether it is coming from antenna, audio video, video graphics, HDMI and USB are fed to corresponding processing circuit. Processed converts all the signals into digital signal and fed to PCI (Pheripheral Component Interconnect) interface.

4 PCI interface (Data and control logic)

With the help of CPU all the signals from previous section (audio/video signals) are processed, and sent to output section which is controlled by a front panel control and also by a remote control.

5 Front panel controls

The controls in the TV front panel are used to adjust/ control the overall performance of the TV.

6 Digital signal processor

The signal that comes from the PCI section is processed by the DSP section. The sound signal converted into analog signal (DAC) and fed to audio amplifier stage and digital video signal processed and feeding to video encoder section.

7 Image signal processing

The signal that comes from the PCI interface section is processed (Amplification error correction, colour signal separation) and sent to LCD screen and colour processor.

8 Colour processor

The signal from the image signal processor is processed (Horizontal timing colour correction) and fed to LCD screen.

9 LCD screen

LCD display receive both the signals from LCD data/ timing control and colour processor. According to both the signals the LCD screen produce the picture or image.

10 Colour balance in LCD screen

In a TV displays, colour is achieved by a continuous flow of light waves at pixel, and also by an amount of light passed by a mosaic filter (Red, Green, Blue). Colour balance is extremely difficult in LCD monitor, because colour trial must remain constant for any change in light. This is difficult for black, because all colour wavelength is different, so some light passes and produce other colour rather than black. One way to block light of all wavelength by maintaining a liquid crystal cell gap at a particular distance to the wavelength of light going from same location. The practical way is only by a multiple gap technology. The thickness of the red, green and blue mosaic filters are arranged in the cell gap is 6.4 μm, 5.8 μm and 4.8 μm respectively.

11 Power section

Power section including the AC to DC conversion to create the main power for the entire unit. Most of the functional block in the LCD TV requires a particular voltage and current especially for the main processor, DDR memory, the tuner and video/audio signal chains.

12 LCD

The LCD screen brightness is not enough to view with bare eyes. So some backlight is needed to light the image, which is done by Cold Cathode Fluorescent Lamp (CCFL) in LCD TV.

Working principle of LED TV

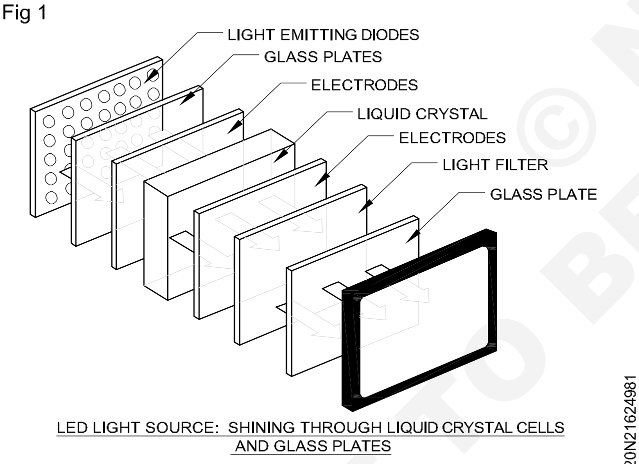
Objectives : At the end of this lesson you shall be able to
- **describe LED TV technology**
- **explain the type of LED lighting technology**
- **explain the difference between LED and LCD TV.**

The LED has become a pivotal illumination technology with a wide variety of applications. The rapid advancement of semiconductor technology together with new concepts in packaging design has led to a significant increase in LED brightness, so that the use of light emitting diodes in backlighting applications has gained increasing importance. Due to their increased efficiency, LEDs are being used in many new application areas ranging from larger display panels to television screens.

LED TV technology

LED, which stands for "Light Emitting Diodes", differs from general LCD TVs in that LCDs use fluorescent lights as backlight while LED TVs use those light emitting diodes.

Fig 1



LED TV TECHNOLOGY PROCESS

An LED TV illuminates its LCD panel with light-emitting diodes as shown in Fig 1. LEDs consist of small semiconductors, which glow during exposure to electric current. Specifically, this current flow between LED anodes and LED cathodes as shown in Fig 2.

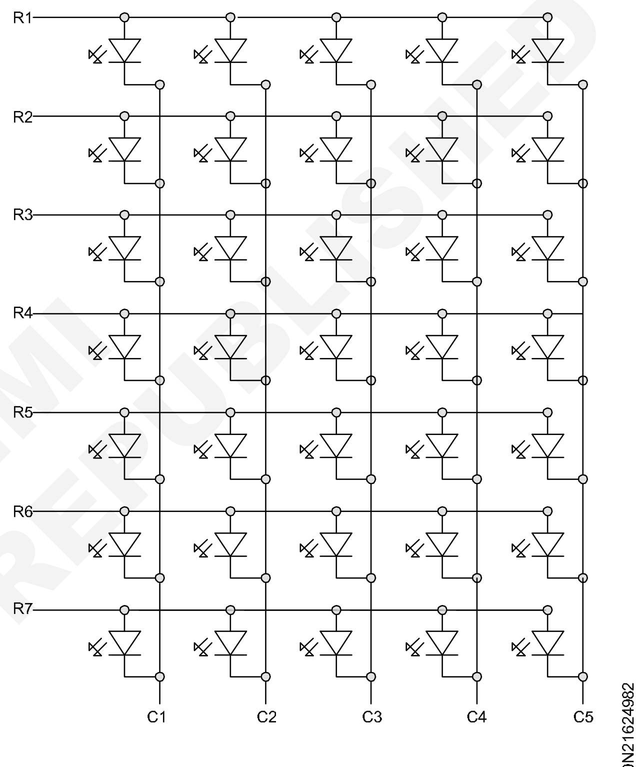
The fluorescent lamps function in LED TV by using mercury vapour to create ultraviolet rays, which in turn cause the phosphor coating of the lamps to glow.

LEDs have several advantages over fluorescent lamps, including requiring less energy and being able to produce brighter on-screen colours.

Types of LED lighting technology

There are two primary forms of LED lighting technology that LED TVs can utilize full-array LED backlighting and

Fig 2



CONSTRUCTION OF LED BACKLIGHTING

edge-lit LED backlighting. Also known as local-dimming technology, full-array technology employs arrays or banks of LEDs that cover the entire back surfaces of LED TV screens.

In contrast, edge-lit technology employs LEDs only around the edges of LED TV screens. Unlike an edge-lit LED TV, an LED TV with full-array technology can selectively dim specific groups of LEDs, allowing for superior contrast ratio and superior overall picture quality.

Energy consumption

As with any TV, an LED TV needs energy in order for its components to function. Specifically, an LED TV needs electric current for stimulating the liquid crystals in its LCD panel and for activating its LED backlighting.

In comparison to standard LCD TVs, LED TVs consume less energy. An LED TV will typically consume between 20 and 30 percent less energy than an LCD TV with the same screen size.

Difference between LCD and LED

1 LCD stands for "Liquid Crystal Display" and technically, both LED and LCD TVs are liquid crystal displays. The basic technology is the same in that both television types have two layers of polarized glass through which the liquid crystals both block and pass light. So really, LED TVs are a subset of LCD TVs.

2 LED, which stands for "Light Emitting Diodes", differs from general LCD TVs in that LCDs use fluorescent lights as backlight while LEDs use those light emitting diodes.

3 The fluorescent lights in an LCD TV are always behind the screen. On an LED TV, the light emitting diodes can be placed either behind the screen or around its edges.

4 The difference in lights and in lighting placement has generally meant that LED TVs can be thinner than LCDs. It has also meant that LED TVs run with greater energy efficiency and can provide a clearer, better picture than the general LCD TVs.

5 LED TVs provide a better picture for two basic reasons, first, LED TVs work with a colour wheel or distinct RGB-coloured lights (red, green, blue) to produce more realistic and sharper colours, second, light emitting diodes can be dimmed. The dimming capability on the back lighting in an LED TV allows the picture to display with a truer black by darkening the lights and blocking more light from passing through the panel. This capability is not present on edge-lit LED TVs. However, edge-lit LED TVs can display a truer white than the fluorescent LED TVs.

6 All the LCD TVs are thin-screen, each has particular viewing angle and anti-glare issues. The backlit TVs provide better, cleaner viewing angle than the edge-lit LED TV. However, the backlit LED TV will usually have better viewing angle than the standard LCD TV.

Block diagram of LED TV

Objectives : At the end of this lesson you shall be able to
- **explain the block diagram of LED TV**
- **describe the back light in an LED TV**
- **explain the driver circuit used in an LED TV.**

Introduction

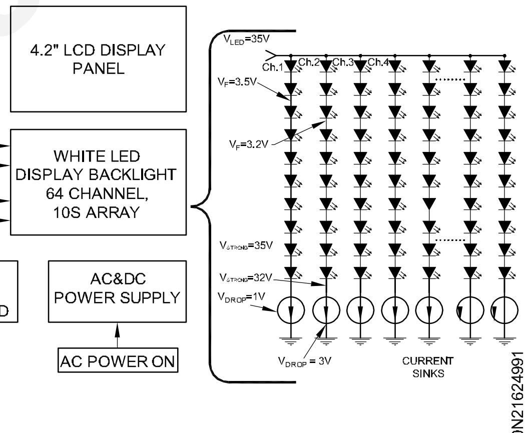
The functional block diagram of LED TV is similar to that of a LCD TV. The only difference is in its display screen technology.

LED Driver and back light in LED TV

There are large arrays of LEDs located behind the LCD panel in a typical LCD TV LED backlighting system as shown in Fig 1. In this array are a large number of parallel channels of LEDs connected in series depending on the size of the TV and the type of backlighting, for example edge backlighting (less LEDs but more in series) or direct backlighting (more LEDs in parallel).The LED voltage (VLED) is provided by the White LED Backlight Driver Board to each LED channel and is regulated to a level needed by the highest voltage required to maximize the light output of each LED string.

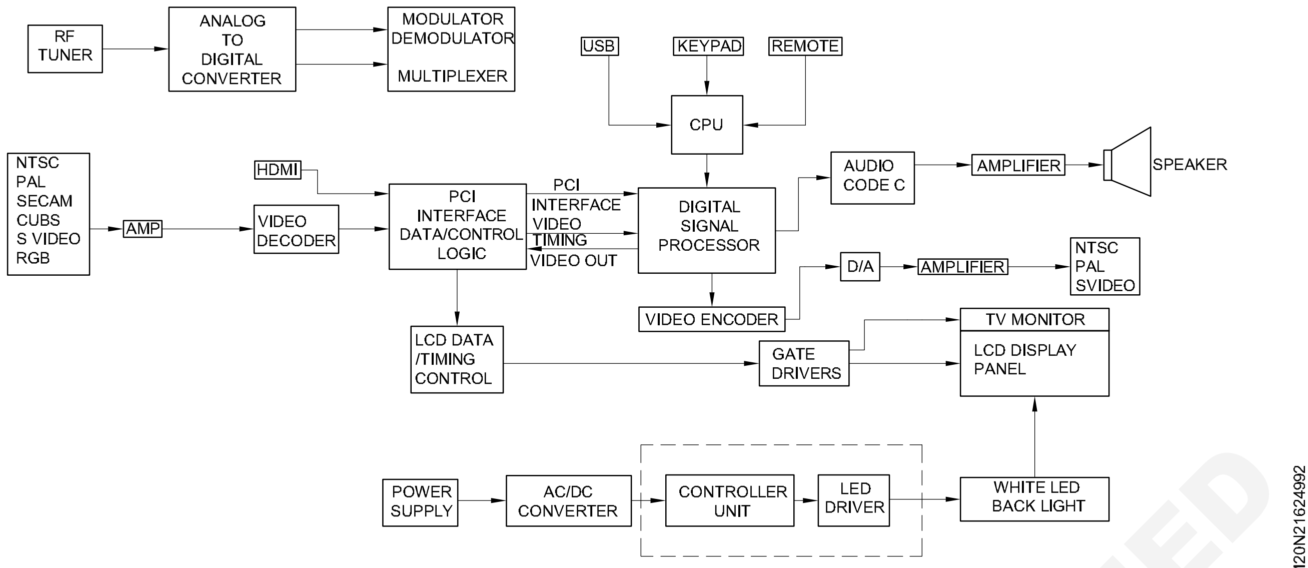
Depending upon the power supply requirements determined by the number of LEDs in the string or grouping of parallel LED strings, the up-stream power source for the LED backlight driver board may be a DC/DC step-up boost converter, a DC/DC step-down converter or more commonly an AC/DC converter. In the case where supply voltage is lower than the required VLED, a step-up boost converter will be used.

Fig 1



BLOCK DIAGRAM OF LED BACK LIGHT AND DRIVER

Fig 2



LED TV BLOCK DIAGRAM

Introduction of OLED TV

Objectives : At the end of this lesson you shall be able to
- **define OLED TV**
- **working of OLED TV**
- **types of OLED TV**
- **OLED advantages and disadvantages**
- **application, of OLEDs**

OLED TV

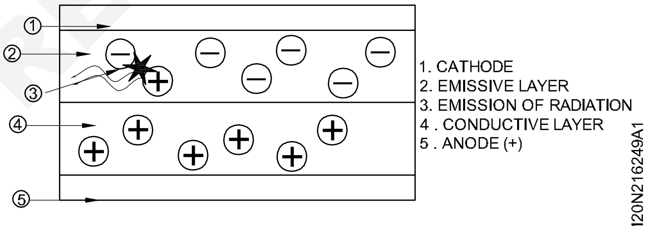
An OLED TV is a television display technology based on the characteristics of organic light-emitting diodes (OLED). An organic light-emitting diode (OLED) is a light-emitting diode (LED) in which an emissive electroluminescent layer as a film of organic compound is sandwiched between two conductors, which emits light in response to an electric current. A typical OLED is composed of an emissive layer, a conductive layer, a substrate, and anode and cathode terminals. The layers have conductivity levels ranging from insulators to conductors, so OLEDs are considered as organic semiconductors. OLED TV is a different technology than LED TV.

The OLED displays do not require backlighting. They can be thinner and weigh less than other display technologies like LCD. OLED displays also have a wide viewing angle - up to 160 degrees even in bright light and use only two to ten volts to operate. An OLED display works without a backlight; thus, it can display deep black levels.

Working of OLED TV

The first most basic OLEDs consisted of a single organic layer, light-emitting polymer device synthesised by Burroughs et al from USA , involved a single layer of poly(p-phenylene vinylene). Multilayer OLEDs can have more than two layers to improve device efficiency. As well as conductive properties, layers may be chosen to aid charge injection at electrodes by providing a more gradual electronic profile, or block a charge from reaching the opposite electrode and being wasted.

Fig 1



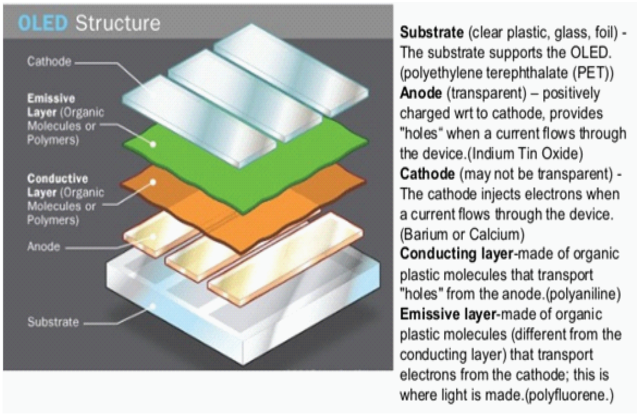
SCHEMATIC OF A 2-LAYER OLED

A voltage is applied across the OLED such that the anode is positive with respect to the cathode. This causes a current of electrons to flow through the device from cathode to anode. Thus, the cathode gives electrons to the emissive layer and the anode with draws electrons from the conductive layer; in other words, the anode gives electron holes to the conductive layer.

Soon, the emissive layer becomes negatively charged, while the conductive layer becomes rich in positively charged holes. Electrostatic forces bring the electrons and the holes towards each other and they recombine. This happens closer to the emissive layer, because in organic semiconductors holes are more mobile than electrons. The recombination causes a drop in the energy levels of electrons, accompanied by an emission of radiation whose frequency is in the visible region. That is why this layer is called emissive.

Indium tin oxide is commonly used as the anode material. It is transparent to visible light and has a high work function which promotes injection of holes into the polymer

Fig 2



layer. Metals such as aluminum and calcium are often used for the cathode as they have low work functions which promote injection of electrons into the polymer layer.

OLED types

OLEDs can be categorized into passive-matrix and active-matrix displays.

AMOLED

Active-matrix OLEDs (AMOLED) require a thin-film transistor backplane to switch each individual pixel ON or OFF, but allow for higher resolution and larger display sizes.

PMOLED

PMOLED stands for Passive-Matrix OLED, which relates to the way to control (or drive) the display. A PMOLED display uses a simple control scheme in which to control each row (or line) in the display sequentially (one at a time). PMOLED do not contain a storage capacitor and so the pixels in each line are actually off most of the time. To compensate for this you need to use more voltage to make them brighter.

OLED advantages

1 Flexible
2 Very thin
3 Colour capability
4 Power consumption
5 Bright images
6 Wide viewing angle
7 Fast response time

OLED disadvantages

1 Moisture sensitive

2 Limited life

3 **Lifespan:** The lifespan of the OLED displays is a major problem. Currently they are around half that of an LCD, being around 15 000 hours.

4 **UV sensitivity:** OLED displays can be damaged by prolonged exposure to UV light. To avoid this UV blocking filter is often installed over the main display, but this increases the cost.

Applications

OLEDs are being used in many applications from television set screens, and computer monitors, along with other small, portable system screens such as mobile smart phones to watches, advertising, information, and indication. OLEDs are also used in large-area light-emitting elements for general illumination.

Currently OLEDs emit less light than their in-organic counterparts, but their flexibility means that they can be used in a much greater number of applications.

Concept of 3D TV

Objectives : At the end of this lesson you shall be able to
- **define 3D TV technology**
- **concept of 3D TV**
- **different 3D TV standards.**

Definition of 3D TV technology

3D TV is a television display technology that enables a "three dimensional effect", so that viewers perceive that an image has depth as well as height and width, similar to objects in the real world.

The principles of 3D TV and how it works

The viewer perceives depth because the right eye and the left eye are in different locations and each eye captures even so slightly different image. The brain processes the two different images into a single image enabling us to focus and perceive the world around us with a sense of depth.

The central principle behind 3D TV is exactly the same - two different images are displayed and then shown to the left eye and right eye. The footage shown to the eyes is recorded from two slightly different perspectives, either from two different cameras, or a camera with two lenses.

This footage is then interlaced into one image and broadcast to 3D-ready TVs which are then able to polarise (separate) the original 3D broadcast back into separate images. They appear on the screen as not clear images - but when viewed through 3D glasses, the separate images are directed to either the right eye or left eye, creating the impression of depth.

Different 3D TV standards

Anaglyphic 3D

Many people associate 3D with a pair of cardboard red/ cyan (a kind of greenish colour) tinted glasses and legendary

movies like "jaws 3D". This format is called anaglyphic 3D and till quite recently this was the most popular way to create 3D content.

Anaglyphic 3D is created by filming in two different coloured layers. Usually red and cyan, these images are filmed slightly offset from the actual image focused on. The viewer when wearing the filtered glasses sees a differently coloured image in each eye. However, the viewers brain is tricked into thinking the coloured layers are as one, thus creating an added sense of depth and creating the 3D image.

This form of 3D viewing is now largely obsolete. Common problems with the format included poor image quality, blurring and even motion sickness in extreme cases.

Polarisation 3D

The polarisation format will be instantly familiar to anyone who has been to see a 3D movie at the cinema of lately. These grey tinted, plastic glasses are much more substantial.

The general principles are the same as for the anaglyphic 3D format as two slightly different images are seen by each eye, assembled by the brain into one image creating a sense of depth. The way of achieving this though is very different. These glasses work by allowing each eye to see differently polarised light. For example, light polarised in one direction will be seen by the left eye and light polarised in the other by the right.

Alternate frame sequencing

The frame sequential format is already the accepted standard for 3D blu-ray. This format requires a pair of active shutter glasses to deliver its 3D content.

In this format the footage is recorded by two cameras (or a single dual lensed camera) and is then placed next to each other on a strip of film, following this it is displayed frame-by-frame in an alternating order. The active shutter glasses are synchronised with the television through an infra-red signal and rapidly blink on and off to play to back images alternatively to the viewers eyes at a rate of 50 frames per second.

The majority of new 3D TVs come with one or two pairs of active shutter glasses. These glasses are typically designed to be brand specific although Panasonic and Samsung are interchangeable. These glasses are primarily designed for watching 3D blu-ray content. These glasses are also quite a lot more expensive and require a power source to drive the LCD shutters, usually via a USB port on the television. Some viewers have complained of warm eyes after prolonged use from these early models.

Comparison of CRT and LCD/LED TV

Objective : At the end of this lesson you shall be able to
- **list out the differences between CRT, LED and LCD TV.**

Comparison between CRT with LCD and LED TV

	LCD & LED	CRT
Slim Factor	Slim	Bulky
Viewable screen	Full or very close to its size	Usually 0.9 inches or less than actual size
Screen Flatness	True Flat	Fake Flat (unless aperture grille)
Radiation	Little or none	More Radiation
Weight	Light	Heavy
Power Requirements	Low Power requirement	250% or more power
Glare	No Glare	Reduced Glare
Image Sharpness	Sharp	Slightly less sharp images
Automatic Resize	Perfect	Imperfect
Burn-In	None	Suffers from burn-in problem
Refresh Rate	No refresh rate (60Hz fixed)	Needs refresh rate (minimum 72 Hz)
Warmness	Little	Cathode gun gets warm after some time
Dead / Stuck Pixel	No such problem	May have dead / stuck pixel
Response Rate	No issue with response rate	Slow
Price	Cheap	Expensive

Native Resolution	None	Has a native resolution
Max Colours	32 bit	8-Bit max, 16.7 million colours.
Viewing Angle	Wide viewing angle	Narrow viewing angle
Video	Ideal for any video viewing including HD	Not ideal for videos, unless HD
Blackness	True Black	Between Dark Grey to Grey

Types of cables used in LCD/LED TV

Objectives : At the end of this lesson you shall be able to
- **differentiate types of input/output sockets provided on the LCD/LED TV**
- **explain the different types of cables used in LED and LCD TV.**

Types of cables used in LCD/LED TV

The modern television technology has paved the way for using the TV as a versatile display device for various audio visual equipments as well as computer.

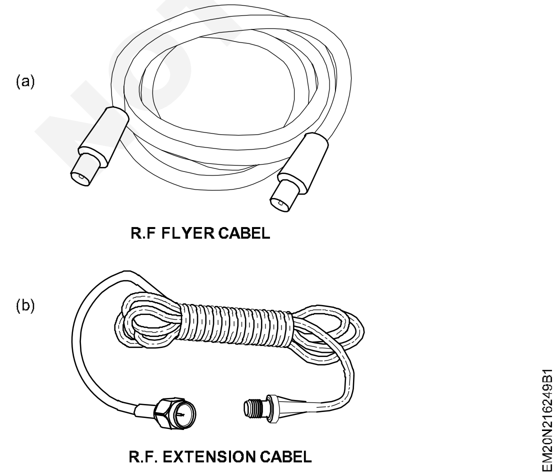
The following types of connectors are provided on the side/rear or on the front panel of the latest television sets.

1 R.F. socket
2 A.V. input/output
3 HDMI socket
4 USB socket
5 DVI cable
6 Optical input/output
7 VGA input
8 3.5 mm stereo jack

1 R.F. socket

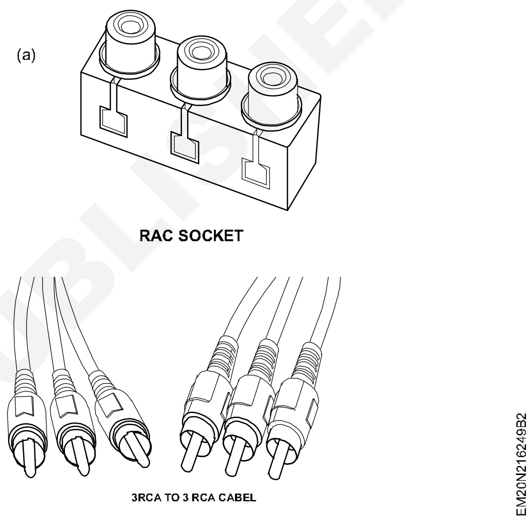
It is used to connect the antenna signal to the TV. An aerial fly lead as shown in Fig 1a is used to connect from a TV aerial socket on the wall to an aerial input socket on a TV or set-top box. It will have a male aerial plug at both ends. Co-axial aerial extension lead has both male and female plug at each end. (Fig 1b). They are also used to connect set-top box and recorders to TV sets.

Fig 1



2 A.V. input/output (RCA cables)

Fig 2



For audio and video signals RCA cables are used to connect the VCR, CD/DVD players, set-top box, video camera, etc to TV sets. These RCA cables are available as 2RCA to 2RCA as well as 3RCA to 3RCA cable pairs to connect stereo audio red for right channel, white for left channel and yellow for video signal. Separate set of AV input and output sockets are provided to play or record signals.

3 HDMI socket (High Definition Multimedia Interface)

This socket is a common digital interface for audio and video signals from DVD /Blue ray/ Home theatre system, set-top box, etc. HDMI is a digital interface for audio and video that provides a single cable solution for consumer electronics equipments like TVs, home theatre, blue-ray/ DVD, set-top box, etc. This replace long running analog interfaces like VGA, S-Video and RGB.

4 USB socket (Universal Serial Bus)

USB 2.0 terminal for connecting USB flash drive/mass storage devices MP3 music/songs and movies playing directly on LCD/LED TV set. Stored programs can be selected by the remote control of the TV set.

Fig 3

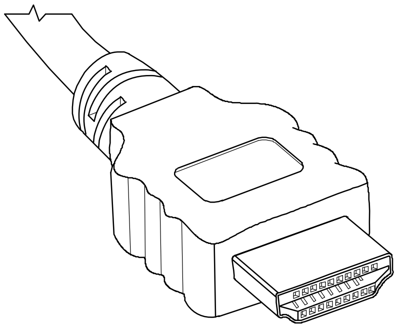
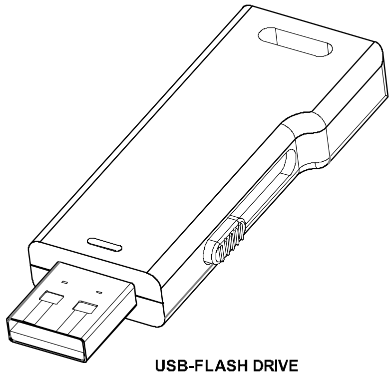


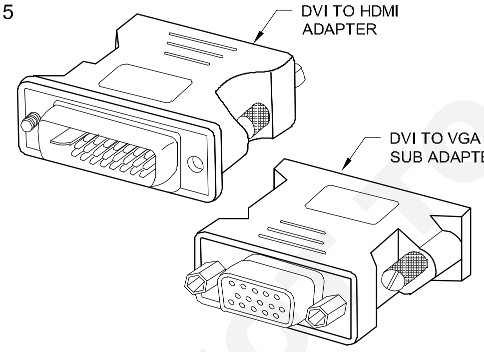
Fig 4



5 DVI cable (Digital Visual Interface cable)

This is also known as Digital Versatile Interface cable. It is used to connect video signals to the display devices of desktop computers and LCD/LED monitors. It is similar to VGA connectors with upto 24 pins and supports for analog as well as digital video. DVI can stream upto 1320 x 1200 HD video or with dual link DVI connectors can support upto 2500 x 1600 pixels.

Fig 5



6 Optical input/output

This cable is also known as SPDIF connector. This is used to connect the home theatre/DVD player/Blue ray disc player into LCD/LED TV for playback. It is also used to play the audio/music from LCD/LED TV through the home theatre system.

7 VGA input(15 pin D-type)

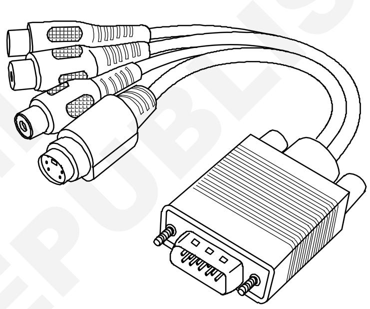
This terminal is used to connect computer output using VGA cable for functioning the LCD/LED TV as video monitor. Even the laptop output can be displayed on the wide LCD/LED screen of the TV set.

Fig 6a

AV input/output

Fig 6b

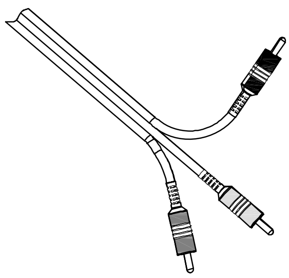
Fig 7



8 3.5 mm stereo jack

This socket is provided to connect stereo head phone for TV program sound/audio. It can be used for recording the audio signal thro external equipment or play the sound/audio using public address amplifier system.

Fig 8



Remote control

Objectives : At the end of this lesson you shall be able to
- **define remote control**
- **describe different types of remote controls**
- **list out parts of a remote control**
- **explain the block diagram of IR transmitter and IR receiver**
- **explain the working principle of a IR remote control.**

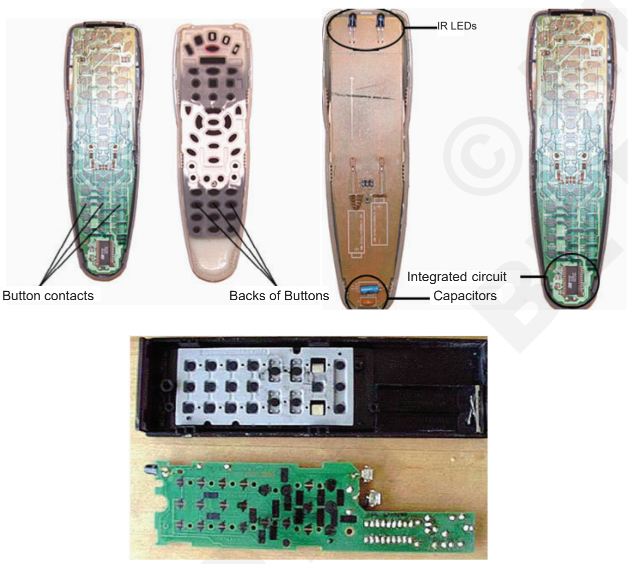
Introduction

Remote control is an electronic device, used to control the functions of another device wirelessly from a short distance.

A remote control (RC) is a small, usually hand-held, electronic device for controlling another device, such as a television, radio or audio/video recording device, gaming console, set-top box etc. Remote controls commonly operate via infrared(IR) signals but sometimes by radio frequency signals also. The remote control may control a variety of functions such as volume, channel, track number and other functions. Modern remote control devices often have more controlling functions, which may have only a few primary essential controls.

A remote control may also be called a clicker, flipper, tuner, changer or converter.

Fig 1



Types of Remotes

There are three basic types of remote controls in common usage:

1 Infrared (IR) Remote

2 RF Remote

3 Bluetooth Remote

Infrared Remote (IR)

IR remote control works on a pretty simple principle of "Photo electric effect".

Infra Red remote control is wireless device used to operate audio, video and other electronic equipment within a room using light signals in the infrared (IR) range. Infrared light requires line of sight to its destination. Low-end remotes use only one transmitter at the end of the unit and have to be aimed directly pointing to the receiving sensor on the other equipment. High-quality remotes have three or four powerful IR transmitters set at different angles to shower the room with signals.

Radio Frequency Remote control (RF)

Radio frequency remote control also is a wireless device used to operate audio, video and other electronic equipment using Radio Frequency (RF) transmission. Unlike the common infrared (IR) remotes, RF remotes do not have to be aimed at the equipment.

Bluetooth remote control

A subset of RF remotes, these rely on the Bluetooth protocol to communicate. Most commonly used for video game controllers and some newer set-top boxes

Parts of a IR remote control

The internal parts of IR type remote control is shown in Fig 1. The basic parts involved in sending IR signal include

1 Buttons/Keypads

2 Integrated circuit

3 Button contacts

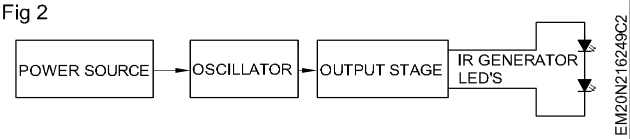
4 IRLED

5 Battery

IR code Transmitter

The block diagram of the remote control transmitter is shown in Fig 2.

Fig 2

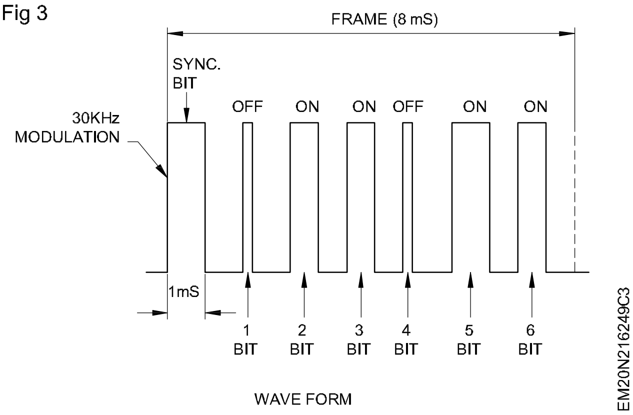


The transmitter section consist of power supply, an oscillator and an output stage including IR LEDS in the transmitter section. Oscillator IC 555 is wired as an astable multivibrator with a centre frequency of about 36 KHZ. The transmitter is powered from 2 nos of 'AA' or 'AAA' size battery.

Signaling from remote

The modern infra-red remote control system works on multi channel system. Each channel gives a digital control signal for each independent work like ON, OFF, volume, channel selection etc. A sample output wave form is shown in Fig 3.

Fig 3



WAVE FORM

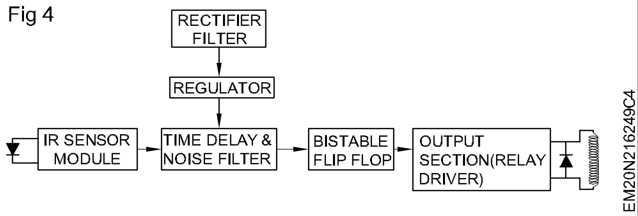
Channel number	Six-bit code	Decoded function
1	000 000	Switch A on
2	000 001	Switch A off
3	000 010	Switch B on
4	000 011	Switch B off
-	---------------	---------------
-	---------------	---------------
61	111 100	Volume increase
62	111 101	Volume decrease
63	111 110	Brilliance increase
64	111 111	Brilliance decrease

It is basic 6 bit multi channel output, the first bit is of 1 mS duration provides frame synchronization signal to the decoder the subsequent 6 bits provides logic code depending on the duration of pulse. If the pulse duration is less than 0.25 mS then it is taken as logic 0 and if it is more than 0.25 mS it is taken as logic 1. With this type of six bit coding it is possible to generate 64 independent functions as shown below.

IR code Receiver

The block diagram of the IR receiver is shown in Fig 4.

Fig 4



The receiver section comprises of power supply, an infrared detector module, time delay circuit with noise filter, bi-stable flip flop.

This signal is received via our receiver circuit's phototransistor. The high pass amplifier allows us to preserve only the high frequency components of our received signal. The band pass filter is tuned to our modulation frequency, thus removing more noise at higher and lower frequencies. The signal at this point is a high frequency AC signal. The rectifier and low pass filter convert the signal from AC to DC, and the comparator allows us to adjust the sensitivity threshold so that we do not detect spurious noise signals. Finally, the flip-flop toggles the output on and off with each subsequent press of the transmission button.

Infrared is a part of electromagnetic spectrum and these IR waves moves in the form of pulse train. When any one of the button/key on the remote is pressed, this circuit translate the action into a beam of IR waves which moves to the receiver circuit. It sends out different codes for different way commands. The sensor in the TV receives this signal and the microchip reads, amplifies and controls the functions like volume up/down or changing channels, etc. If any obstruction/blocking between the remote control and TV receiver, the command is not working because the IR waves always travels in a straight line only.

General faults in remote controls

Since the remote control is a small hand held device, sometimes it slips from our hand and falls down resulting in malfunctioning. The most probable troubles with the remote control operation is that the batteries are dead or it has not been programmed properly. It is often easy to fix the problems with the remote control.

i) Problems with remote control

1 Dead batteries or batteries inserted wrongly.

2 Corroded battery contacts.

3 Broken or intermittent contacts on the circuit board.

4 Dry soldered/broken ceramic resonator/transistor.

5 Dirt, spills, oily build-up inside the contacts.

6 Worn or corroded pods on circuit board.

7 Worn conductive material on rubber button.

8 Cracked circuit board.

9 Bad IR LED.

10 Bad IC.

11 Dead memory capacitor.

ii) Problems with the other device/equipment

1 Increased range of remote path.

2 Wrong positioning of device.

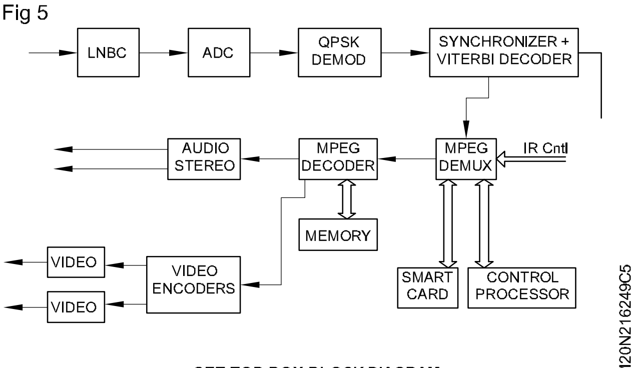
3 Dust covered on the receiver sensor.

4 Program mode done wrongly.

Set-top box

A set- top Box is a consumer electronics device connected between a television and a content provider such as Direct Broadcast Satellite operator, Cable operator or Terrestrial operator. This device converts and provides digital audio and video sources after decoding the incoming digital signals. It then separates audio and video data streams for presenting them to respective displays. The function of set-top box is to provide more TV channels on the same limited number of frequencies. The block diagram of set-top box is shown in Fig 5.

Fig 5



SET TOP BOX BLOCK DIAGRAM

The basic features of set-top box are to receive, demodulate, demultiplex, and decode the incoming digital signal and convert it into analog format. Input digital stream to STB may be from satellite, cable or terrestrial medium. It can also descramble the received signal and thus provide the conditional access to the STB. Conditional Access is key feature for pay TV system. Input digital signal contains audio, video and high speed and low speed data contents, which is reproduced by the set-top box. In future the STB will have features like Internet on cable, interactive TV, VOD (Video On Demand), music on demand etc.

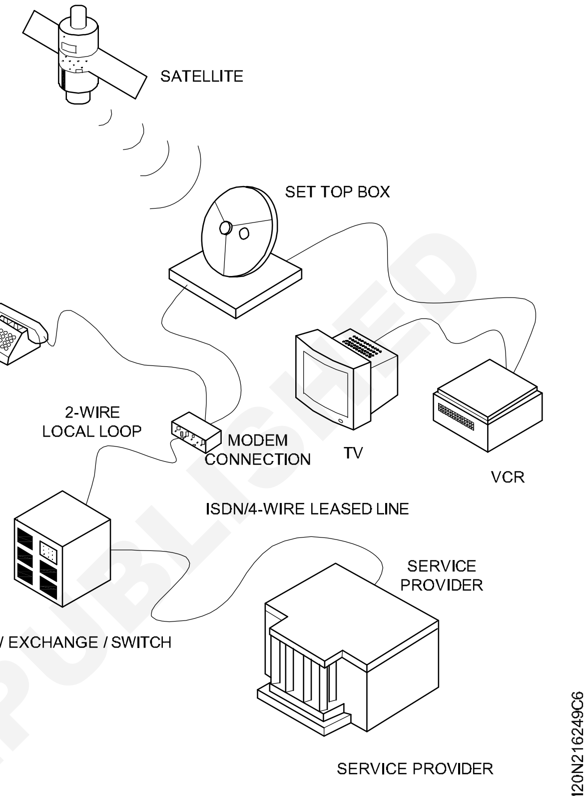
Working of set-top box

The set-top box accepts the entire down converted band and separates out the individual transponder frequency. Then signals are first converted to fixed IF and then QPSK demodulated. After the QPSK (Quadrature Phase-Shift Keying) demodulation, the digital bit stream obtained contains several multiplexed channels as well as error control bits. The bit stream is processed to correct and detect errors, de-interleaved, and decrypted. A digital de-multiplexer then extracts the bits for wanted channel, and sends them to MPEG decoder, and finally generates stereo audio and video signals with DIA converters to drive TV set. Connection of set-top box to TV is shown in Fig 5.

Basic operation of STB

Set-top box can be operated using either by front panel switches or using Remote control as shown in Fig 5 and Fig 6. The various functions which can be operated, using front panel control or remote control are tuning of particular channel, feeding frequency, symbol rate and other useful data, generating test patterns. All the functions available in the set-top box are displayed on the TV screen using On Screen Display (OSD). It is Graphical User Interface (GUI) for ease of operation. Remote control and front panel switches are the main input console for set-top box.

Fig 6

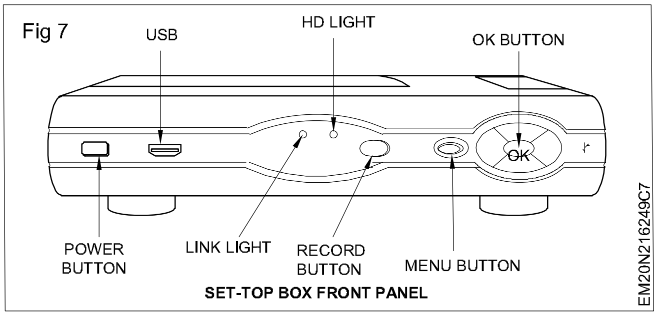


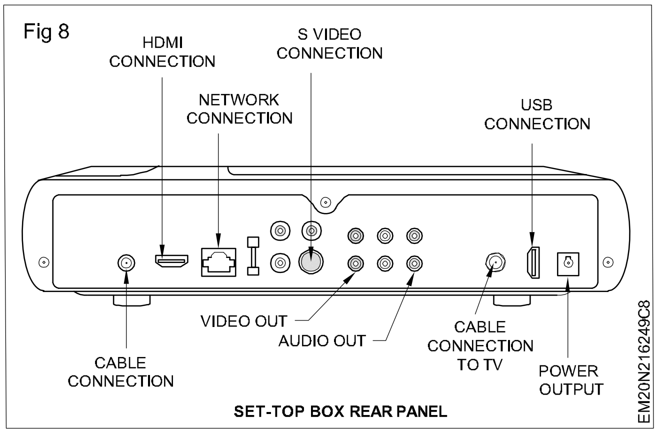
CONNECTION OF SET TOP BOX TO TV

Input to the set-top box is RF signal and its range and type of Modulation depends upon its application. If set-top box is used for satellite application then Input frequency range is 950 to 2150 MHz and modulation technique used is QPSK. For Set Top Box for cable application the input frequency range is 110 to 862 MHz and type of modulation is QAM. While frequency range for set-top box for terrestrial is 47 to 860 MHz and type of modulation use for it is COFDM.

The basic technology used in Set Top Box is DVB (Digital Video Broadcasting) and MPEG (Moving Picture Expert Group). Modern compression technique allows a TV signal to be compressed and transmitted at rate 1.5 to 15 Mbps. The standardization process initiated in 1988 and almost completed in 1994 - which develop MPEG 1, MPEG 2 up to MPEG 7. DVB is recently created DTV transmission standard, which allows Inter- operability between different systems and manufactures. DVB group establishes a set of transmission parameters for compression, error correction and channel coding. DVB technology leads to transformation of basic analog transmission system into digital, which is used for all transmission and communication applications.

Figs 6 & 7 shows front and rear view of a set-top box.





LCD and LED TV:

Detecting and Rectifying Defects in an LED/LCD TV Receiver and Rectify the fault.

when an LED/LCD TV receiver experiences defects or malfunctions, it's important to systematically troubleshoot and rectify the issues. Here are the steps to detect and rectify faults:

1 No Power/Power issues:

a Check the Power Source: Ensure that the TV is properly plugged into a functional power outlet. Test the outlet using another device to verify its functionality.

b Power cord and connections: inspect the power cord for any signs of damage or loose connections. Ensure that the power cord is securely connected to both the TV and the power outlet.

c Power Indicator LED: Check if the power indicator LED on the TV lights up when the power is turned on. If it doesn't, the issue may lie in the power supply board or the main board.

d Power Supply Board: Inspect the power supply board for any visible sign of damage, such as bulging capacitors or burnt components. Replace any faulty components or consider replacing the entire power supply board if necessary.

2 Pictures Issues:

a No Display/Blank Screen: verify that the TV is turned on and the correct input source (e.g., HDMI, VGA). Test the input source

b Flickering/intermittent picture: Ensure that all cables are securely connected. try using different input sources and cables to determine if the issue is specific to one source or input. Check for loose or damaged connectors.

c Distorted/Unusual Colors adjust the picture settings on the TV, including brightness, contrast and color settings. If the issue persists, it could indicate a problem with the display panel or the mainboard“

d Backlight Issues If the TV has a backlight but no picture, the backlight may be faulty Shine a flashlight on the screen and check if you can see a faint image If so, the backlight or its associated circuitry may require replacement.

3 Audio Issues

a No Sound: Verify that the TV volume is not muted and is turned up Check the audio settings and ensure the correct audio output source is selected Test the TV with different audio sources (eg, external speakers) to determine if the issue lies with the TV's speakers or audio circuitry.

b Distorted Sound: Adjust the audio settings, such as bass treble, and equalizer settings. Check for “loose connections between the TV and extemal audio devices If the issue persists, there may be a““problem with the audio amplifier or speakers““

4 Remote Control Issues:

a Replace Batteries: Check if the batteries in the remote control are depleted and replace them if necessary.

b Line of Sight Interference: Ensure there are no obstructions between the remote control and the TV. Remove any objects blocking the infrared (IR) sensor on the TV

c Paining Reset: Consult the TV's manual to determine if the remote control needs to be paired or if there's a procedure to reset the remote control

5 Software/Firmware Update: Check if there are any available software or firmware updates for the TV Updating the TV's software can sometimes resolve performance or compatibility issues. Follow the manufacturer's instructions to perform the update correctly.

6 Professional Assistance: If the troubleshooting steps do not resolve the issues, or if you are uncomfortable performing repairs on your own, it's recommended to seek professional assistance. Contact the manufacturer's support team or a qualified technician to diagnose and rectify the faults.

Note: When troubleshooting and performing repairs, ensure the TV is unplugged and avoid touching sensitive components without proper precautions. If you're unsure or inexperienced, it's best to consult a professional to avoid causing further damage to the TV

1 **Power Buttons:** It is used to turn on /off the unit

2 **Navigation Buttons:** These buttons typically arranged in a circular or cred con““allow you to navigate through menus and options on the TV

3 **Number Buttons:** These buttons are bond with numbers and are used to directly input channel numbers of numerical values

4 **Volume and Me Buttons:** These button control the TV’s audio. The volume increase or decrease the sound level, while the mute button temporary disables audio

5 **Input/Source Button:** This button allows you to with between different input sources, such a HDMI, AV or VGA

6 **Menu button:** Pressing the button on the TV's on-screen menu, which provides to various settings and options

7 **Function Buttons:** Some remote controls have additional function buttons that provide quick access to specific features, such as picture mode, sound mode, subtitle control, or aspect ratio adjustment.

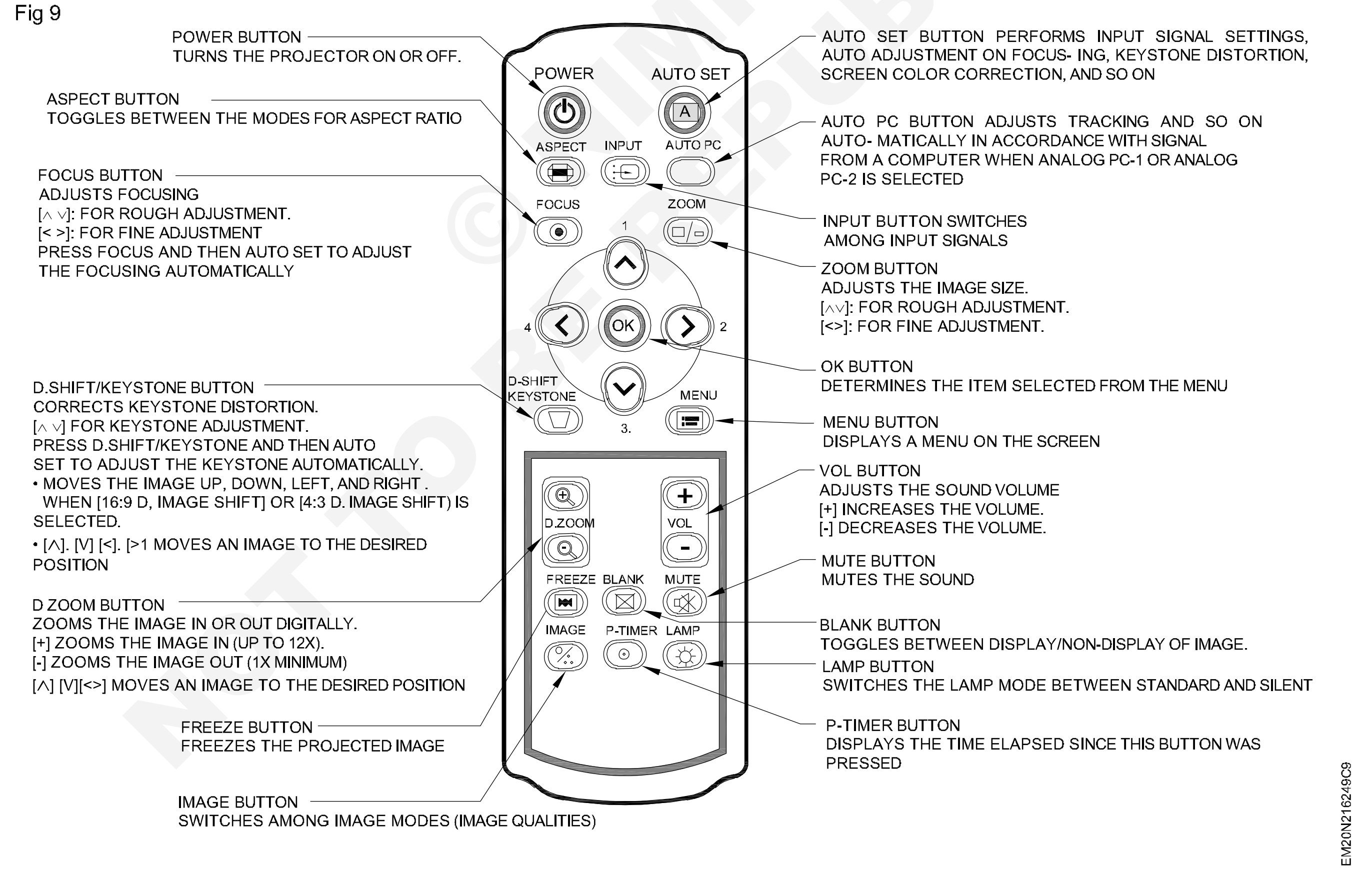
8 **Transport Buttons:** These buttons include play, pause, stop, rewind, and fast-forward functions for controlling playback of media content.

9 **Remote control indicator:** This small LED or infrared transmitter on the front of the remote control emits a signal when a button is pressed. It communicates with the TV receiver to execute the corresponding command.

10 **Battery compartment:** Typically located on the back of the remote control, the battery compartment houses the batteries that power the remote.

These parts may vary slightly depending on the specific make and model of the remote control. Additionally, advanced remote controls may include additional features such as voice control, dedicated app buttons, or smart home integration.

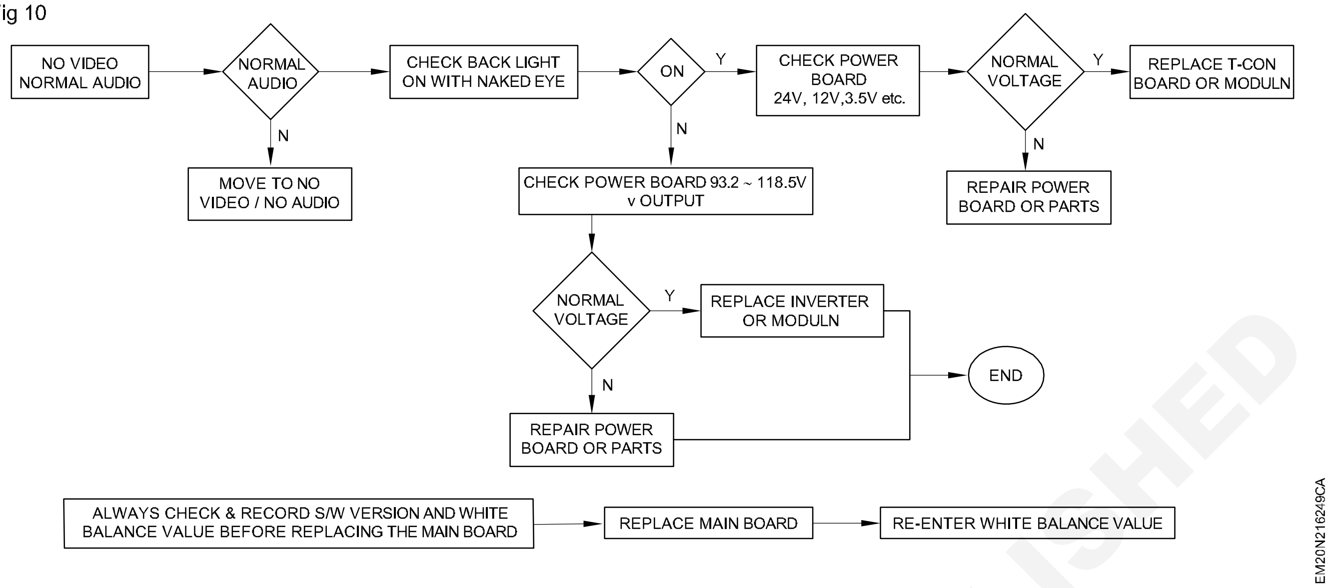
Fig 9



Troubleshooting chart-LED LCD TV's

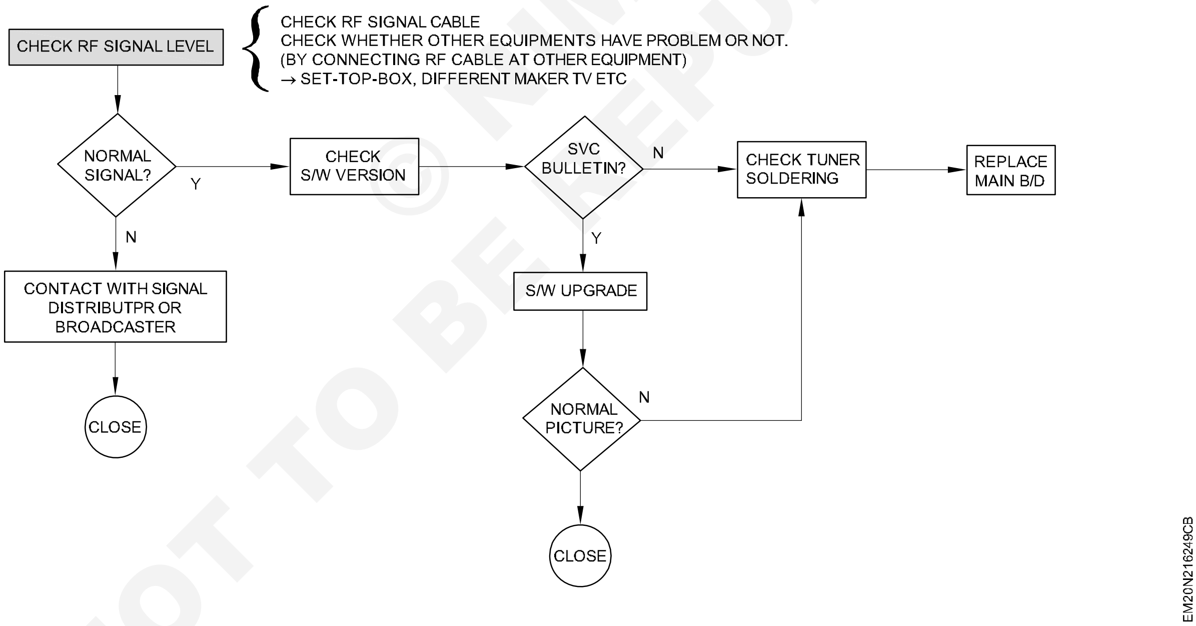
Trouble shooting: First of all check whether all of cable between board is inserted properly or not. (Main B/D- power B/D, LVDs cable, speaker cable)

Fig 10



Picture broken/freeaing

Fig 11



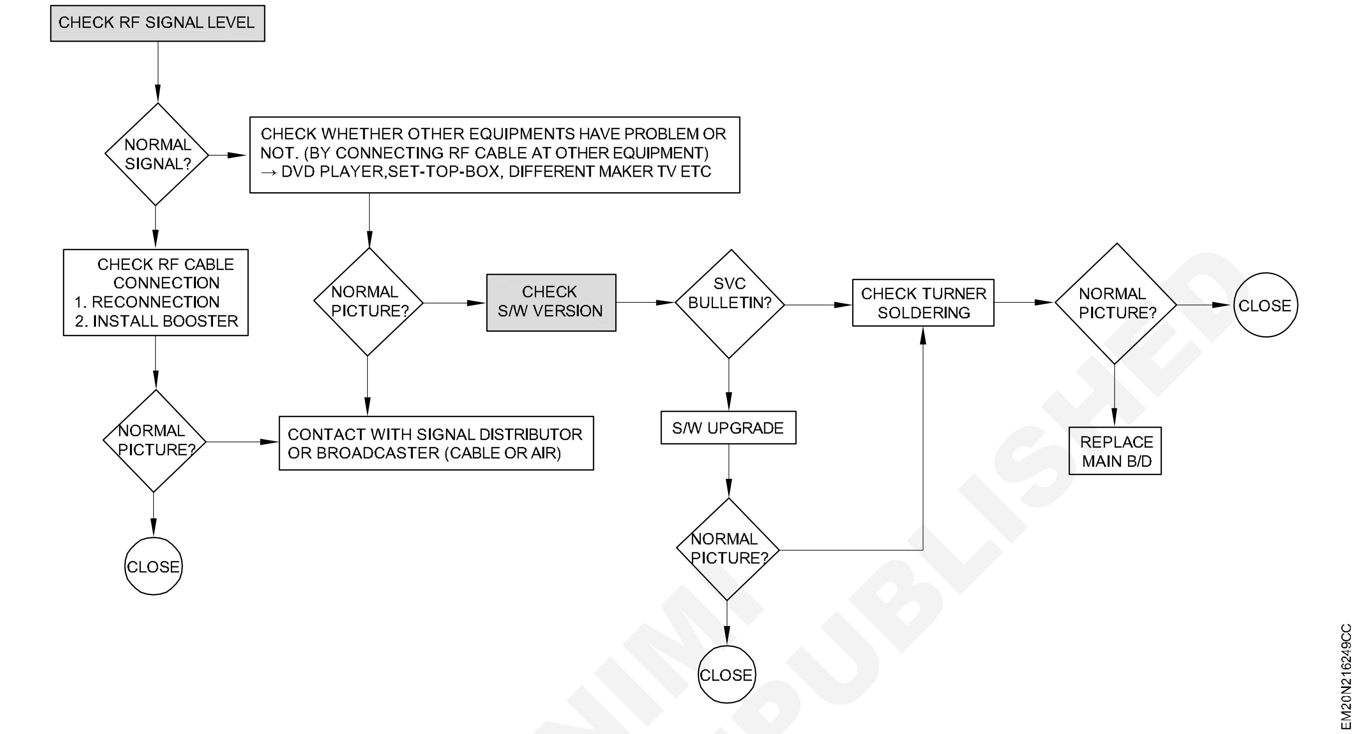
Check RF signal cable

Check whether other equipment have problem or not.

(By connecting RF cable at other equipment)

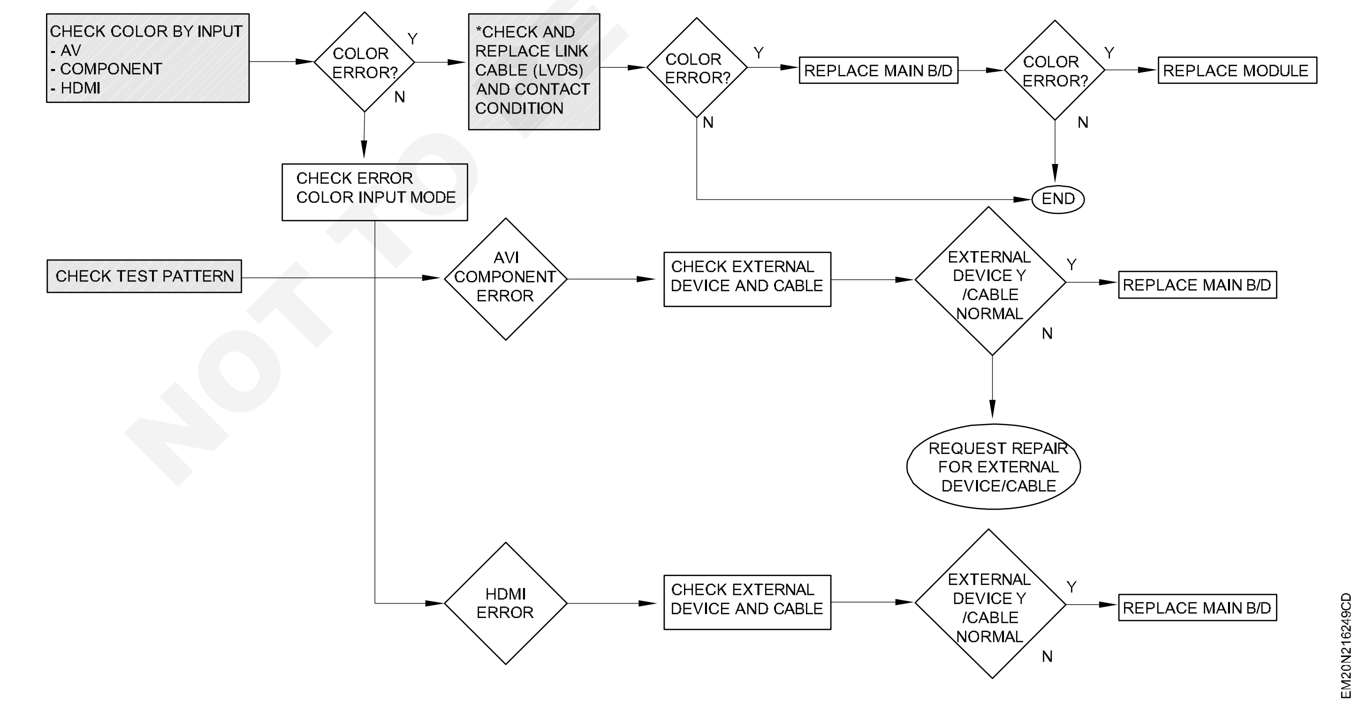
Set-Top-Box, Different maker TV etc.

Fig 12



Colour error

Fig 13



Vertical/Horizontal bar, residual image, light spot, external device colour error

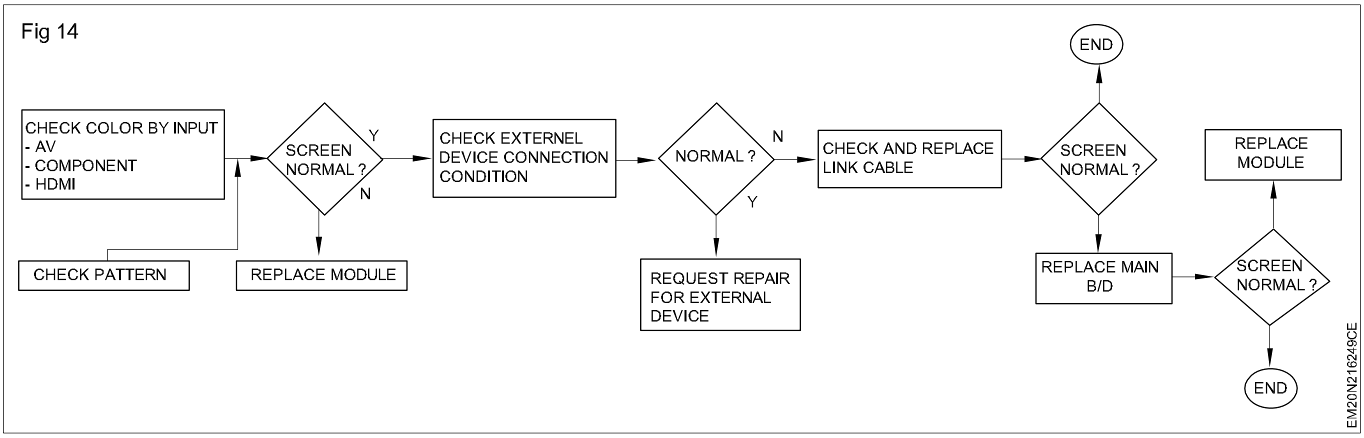


Fig 14

External device screen error-colour error

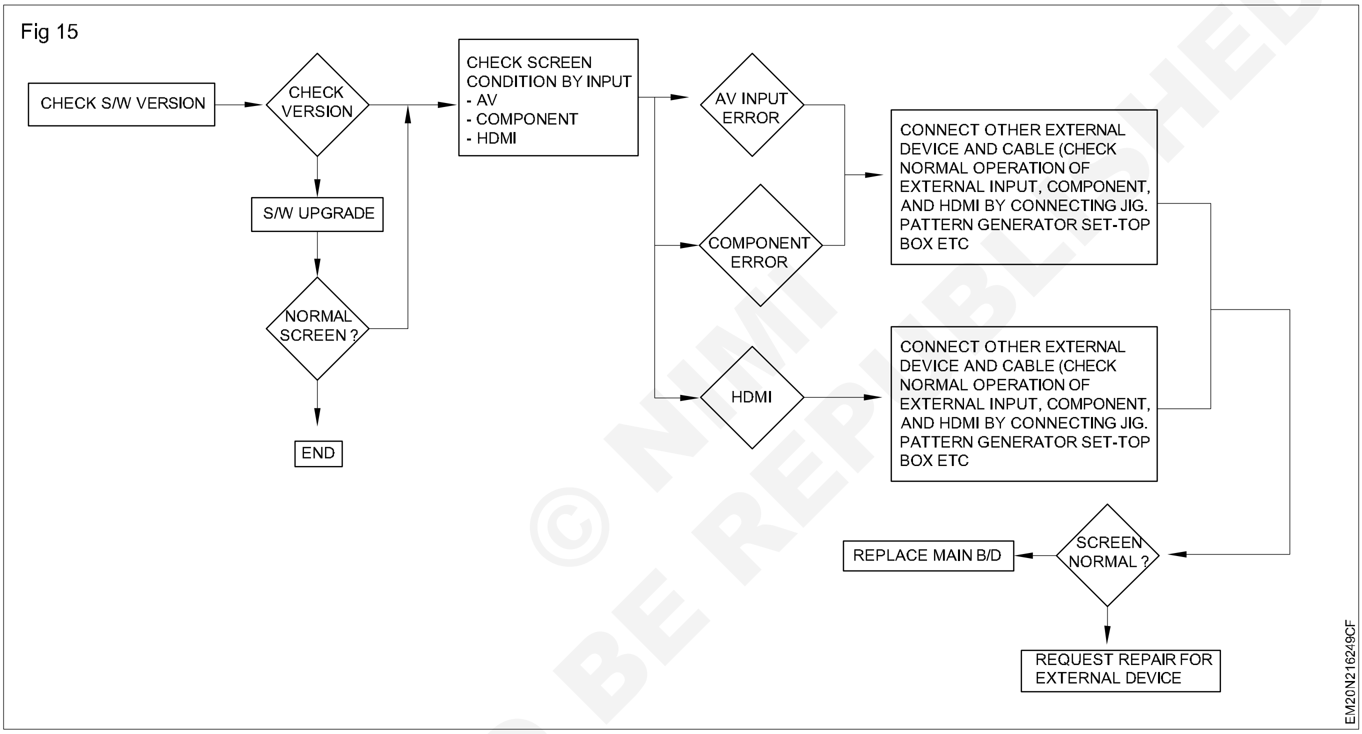


Fig 15

No power

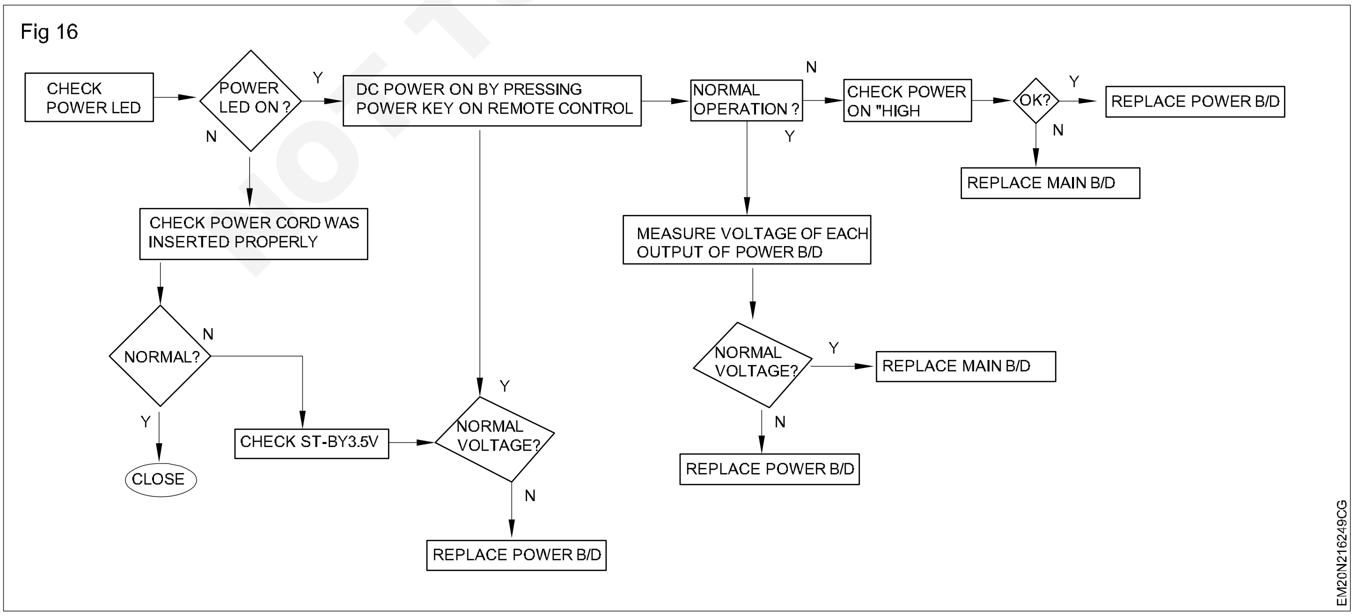
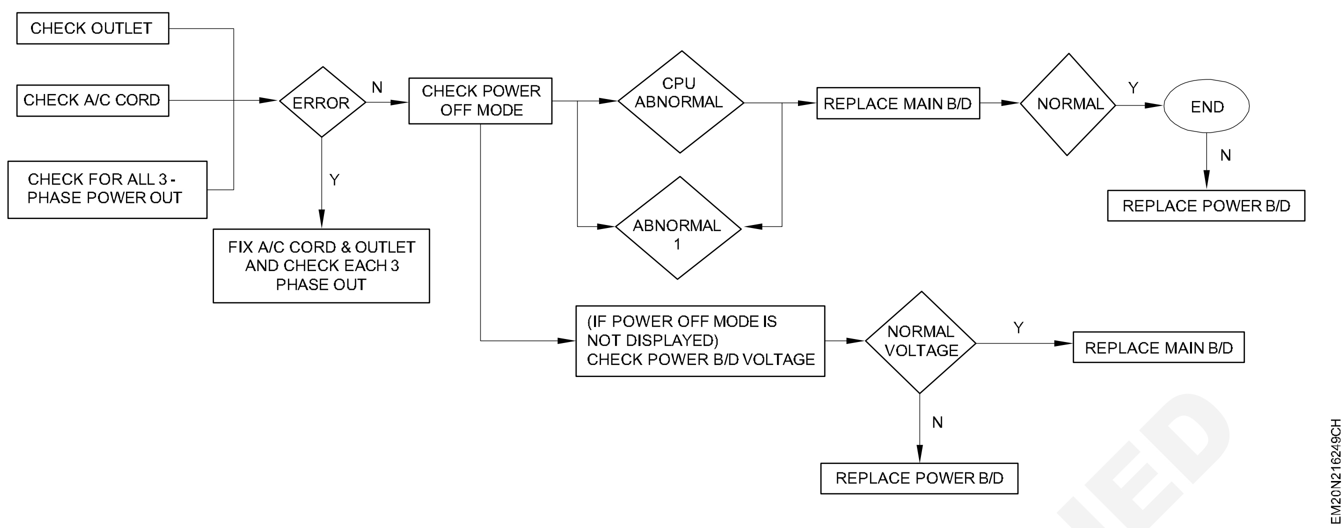


Fig 16

Switches ON/OFF while viewing

Fig 17



Status	Power off list	Explanation
	“POWEROFF REMOTEKEY”	Power off by REMOT CONTROL
	“POWEROFF OFFTIMER”	Power off by OFF TIMER
	“POWEROFF SLEEPTIMER”	Power off by SLEEP TIMER
Normal	“POWEROFF_INSTOP”	Power off by INSTOP KEY
	“POWEROFF AUTOOFF”	Power off by AUTO OFF
	“POWEROFF_ONTIMER”	Power off by ON TIMER
Abnormal	“POWEROFF RS232C°	Power off by RS232C
	“POWEROFF SWDOWN”	Power off by S/W download
	“POWEROFF UNKNOWN”	Power off by unknown status except listed case
	“POWEROFF_ABNORMAL 1”	Power off by abnormal status except CPU trouble
	“POWEROFF_CPUABNORMAL”	Power off by CPU abnormal