INFORMATION & COMMUNICATION TECHNOLOGY SYSTEM MAINTENANCE

NSQF LEVEL - 4

1st Year

TRADE THEORY

SECTOR: IT & ITES

(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 : **IT & ITES**

Duration : **2 Years**

Trade : **ICTSM - 1st Year Trade Theory - NSQF Level - 4 (Revised 2022)**

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

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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 Mentor Councils comprising various stakeholder's 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 **ICTSM - 1st Year - Trade Theory - NSQF Level - 4 (Revised 2022) in IT & ITES Sector.** 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 IMPs and that NIMI's effort will go a long way in improving the quality of Vocational training in the country.

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

Jai Hind

Addl. Secretary/Director General (Training)
Ministry of Skill Development & Entrepreneurship,
Government of India.

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 Ministry of Skill Development and Entrepreneurship) Government of India, with technical assistance from the Govt. of the Federal Republic of Germany. The prime objective of this institute is to develop and provide instructional materials for various trades as per the prescribed syllabi (NSQF LEVEL - 4) (Revised 2022) 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.

In order to perform the skills in a productive manner instructional videos are embedded in QR code of the exercise in this instructional material so as to integrate the skill learning with the procedural practical steps given in the exercise. The instructional videos will improve the quality of standard on practical training and will motivate the trainees to focus and perform the skill seamlessly.

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 organisations to bring out this Instructional Material **(Trade Theory)** for the trade of **ICTSM** - NSQF LEVEL - 4 (Revised 2022) under **IT & ITES** Sector for ITIs.

MEDIA DEVELOPMENT COMMITTEE MEMBERS

Smt. M. Subhameena	_	Junior Training Officer, Govt ITI (Women), Cuddalore.
Shri. P. Mohan	_	Junior Training Officer, Govt ITI, Coimbatore.
Shri. P.G. Pramod	_	Junior Instructor, Govt ITI (Women), Kozhikode, Kerala.
Smt. K. Gowrisankari	_	Junior Training Officer, Govt ITI, Madurai.

NIMI CO-ORDINATORS

Shri.Nirmalya Nath	-	Deputy Director, NIMI- Chennai - 32.
Shri.S. Gopalakrishnan	_	Assistant Manager, NMI, Chennai - 32

NIMI records its appreciation for 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 NIMI staff who have contributed towards the development of this Instructional Material.

NIMI is also grateful to everyone who has directly or indirectly helped in developing this Instructional Material.

INTRODUCTION

TRADE PRACTICAL

The trade practical manual is intended to be used in workshop . It consists of a series of practical exercises to be completed by the trainees during the course of the **ICTSM** 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)

Module 1 - Familiarization with the Institute and Safety
Module 2 - Basic Concept of Electricity
Module 3 - Resistors, Soldering and Desoldering
Module 4 - Inductance and Transformers
Module 5 - Capacitance and Resonance Circuits
Module 6 - Electronic Components
Module 7 - Transistor and Amplifiers
Module 8 - Special Semiconductors - FET
Module 9 - Power Supply
Module 10 - Digital Electronics
Module 11 - Battery
Module 12 - Oscilloscope
Module 13 - Other Mechanical, Electrical and Electronics Accessories
Module 14 - Word Processing
Module 15 - Spreadsheet Software
Module 16 - Desktop: PC Repair Safety
Module 17 - Hardware Identification
Module 18 - Hardware: Remove - Test - Replace Installation
Module 19 - Windows Installation
Module 20 - Data Backup
Module 21 - Hardware Troubleshooting
Module 22 - PC Cleaning
Module 23 - Hard Drives
Module 24 - Virus Removal
Module 25 - System Utilities
Module 26 - User Account Customization
Module 27 - Windows Update and Device Driver
Module 28 - Software Installation
Module 29 - Installing Hardware Drivers
Module 30 - Windows Utilities
Module 31 - Junk File Removal
Module 32 - Linux OS
Module 33 - Outlook Configure and Backup
Module 34 - Laptop PCs
Module 35 - SMPS
Module 36 - Motherboard / System Board
Module 37 - Possible Upgrading / Changing Components on the Motherboard
Module 38 - Memory

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 **ICTSM** Trade. The contents are sequenced according to the practical exercise contained in the manual on Trade practical. Attempt has been made to relate the theoreticalaspects with the skill covered in each exercise to the extent possible. This co-relation 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 indicating about the corresponding practical exercise are given in every sheet of this manual.

It will be preferable to teach/learn the trade theory connected to each exercise atleast 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 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	Identify various basic Electrical Components and perform measurement of current, voltage using multimeter following safety precautions. (NOS: Not Available)	1.1.01 - 1.2.10
2	Perform different functions of Resistors including Soldering, De-soldering practice. (NOS: Not Available)	1.3.12 - 1.3.22
3	Recognize different types of Inductors, measure Inductance and uses of Transformer. (NOS: Not Available)	1.4.23 - 1.4.28
4	Measure Capacitance and find resonance value of a circuit. (NOS: Not Available)	1.5.29 - 1.5.33
5	Test and use Diode to construct basic Electronic components. (NOS: Not Available)	1.6.34 - 1.6.38
6	Recognize different types of Transistors and use it as Amplifiers in electronic circuit. (NOS: Not Available)	1.7.39 - 1.7.41
7	Construct and test of an application circuit using different types of Semiconductors. (NOS: Not Available)	1.8.42 - 1.8.47
8	Assemble and test various Power Supply circuit. (NOS: Not Available)	1.9.48 - 1.9.52
9	Construct all digital circuit using logic gates and verify truth table. (NOS: Not Available)	1.10.53 - 1.10-69
10	Familiarize charging of acid battery and verify connections. (NOS: Not Available)	1.11.70
11	Verify internal parts of CRO and use it to measurement voltage, frequency & other signal using CRO (NOS: Not Available)	1.12.71 - 1.12.73
12	Work with some important Mechanical, Electrical & Electronics Accesso -ries used in information communication system. (NOS: Not Available)	1.13.74 - 1.13.78
13	Perform all the functions of Word Processing and Spreadsheet Software. (NOS: Not Available)	1.14.79 - 1.15.96
14	Assemble and replace hardware components of Desktop Computer. (NOS: Not Available)	1.16.97 - 1.18.139
15	Install Operating System and all other application software. (NOS: Not Available)	1.19.140 - 1.19.146
16	Customize Operating System and maintain system application software. (NOS: Not Available)	1.20.147 - 1.26.183
17	Install Operating System and all other application software. (NOS: Not Available)	1.27.184 - 1.33.216
18	Assemble and replace hardware components of Laptop PC. (NOS: Not Available)	1.34.217 - 1.34.227
19	Replace/ install SMPS and troubleshoot its faults. (NOS: Not Available)	1.35.228 - 1.35.232
20	Familiarize and upgrade various components of Motherboard. (NOS: Not Available)	1.36.233 - 1.36.251
21	Recognize different types of memory devices, chips and its structure. (NOS: Not Available)	1.37.252 - 1.38.259

SYLLABUS

Duration	Reference Learning Outcome	Professional Skills (Trade Practical) with Indicative hours	Professional Knowledge (Trade Theory)
Professional Skill 40Hrs; Professional Knowledge 8Hrs	Identify various basic Electrical Components and perform measurement of current, voltage using multimeter following safety precautions. (NOS: Not Available)	**Familiarization with the Institute and Safety** 1. Visits to workshops, labs, office, stores etc., of the institute. (3 hrs) 2. Demonstration of safety precaution. 3 hrs) 3. Demo of first aid practice. (3 hrs) 4. Demo of artificial respiration and practice. (5 hrs) 5. Demo of electrical safety precautions. (5 hrs)	• Punctuality and Discipline expected of trainees. Course duration, methodology and structure of the training program. • About the institute and infrastructure. • Safety in moving and shifting heavy and delicate equipments. • First aid. • Artificial respiration. • Electrical safety.(03 hrs.)
		Basic concepts of Electricity 6. Identify specification of types of fuses. Identification and specification of type of switches. (4 hrs) 7. Identification of meter types and measuring range. (4 hrs) 8. Construct a simple circuit using AC/ DC supply, lamp, fuse and switch. (5 hrs) 9. Measure voltage and current using Multi-meter (analog-digital). (4 hrs) 10. Use Multimeter to check fuses, lamps and switches. (5 hrs) 11.	• Different types of Fuses and their applications. Different types of connectors used in electrical and electronic applications. Different types of switches used in electrical and electronic applications. • Measuring instruments, MC, MI type, Ammeter, Voltmeter, Multimeter for measuring voltage and current. Construction, characteristics/ features and specification. Digital Multimeter. • Meaning of Circuit and basic electrical circuits. • Meaning of resistance, continuity and continuity testers. Multimeter for checking continuity. (05hrs)
Professional Skill 40Hrs; Professional Knowledge 8Hrs	Perform different functions of Resistors including Soldering, De-soldering practice. (NOS: Not Available)	**Resistors. Soldering and De-soldering** 12. Identify different types of resistors from physical appearance. (2 hrs) 13. Identify resistor value and tolerance using colour code. (2 hrs) 14. Measuring resistance using Multimeter. (2 hrs) 15. Soldering and de-soldering techniques, practice using hook-up wires. Soldering resistors on Tag board. (4 hrs) 16. Verification of Ohms Law and Kirchhoff's Laws. (2 hrs) 17. Soldering resistors on PCB. (2 hrs) 18. De-soldering practice. (5 hrs) 19. Experiment using P.T.C and NTC resistors. (5 hrs) 20. Experiment to check VDR's. (5 hrs)	• Classification, characteristics and application of different types of resistors.-carbon film, metal film, wire wound, cermets and surface mounted. • Colour coding of resistors. Calculating Imeasuring resistance value and its tolerance value. Wattage of resistors, specific resistance and their importance. • Soft soldering and precautions to be taken for making a good solder joint. Types of solder and need of soldering paste. • Printed circuit boards and its application. • De-soldering tools. • Temperature dependent resistors and their applications.(PTC and NTC) . • Voltage dependent resistors (VDR).

		21. Experiment to check LDR's. (4 hrs) 22. Test Pots, Presets. (4 hrs)	• Photoelectric effect, Light Dependent resistors. • Variable resistors, pots, presets, types and application. Log and Linear resistors. (8 hrs.)
Professional Skill 40Hrs; Professional Knowledge 10 Hrs	Recognize different types of Inductors, measure Inductance and uses of Transformer. (NOS: Not Available)	**Inductance** 23. Identification of different types of inductors and its specifications. (5 hrs) 24. Measure inductance using LCR meter. Calculate inductive reactance at different input signal frequencies. (8 hrs) 25. Demo on self and mutual induction. (6 hrs) 26. Check step down transformers. (6 hrs) 27. Finding losses and efficiency of given transformers. (8 hrs) 28. Identifying and testing high frequency transformers used in electronic circuits. (7 hrs)	• Definition of inductance. Properties. Types of inductors and their application. • Inductive reactance, measuring inductance and inductive reactance. Meaning of lead, lag. Effect of inductor on power factor. Frequency dependence of inductive reactance. • Self and Mutual inductance. • Transformers. Turns ratio. Transformer winding. Transformer losses and efficiency. • Uses, losses, efficiency type of cores and uses for LF, HF, VHF transformer. • Transformers used in high frequency applications. (10 hrs.)
Professional Skill 32Hrs; Professional Knowledge 6 Hrs	Measure Capacitance and find resonance value of a circuit. (NOS: Not Available)	**Capacitance and Resonance circuits** 29. Identify of different types of capacitors from colour code and typographic code. (4 hrs) 30. Test working condition of capacitor. Measure capacitance using RLC meter. (5 hrs) 31. Measure capacitive reactance at different frequencies. (6 hrs) 32. Measure capacitance and capacitive reactance of, capacitors in series and capacitors in parallel. (6 hrs) 33. Find the resonance frequency of a given Series and parallel resonance circuit. (11 hrs)	• Working principle of capacitors. Electrostatic action, dielectric constant. Unit of capacitance and capacitive reactance. Types of Capacitors-electrolytic, ceramic, polyester, tantalum, mica, surface mounted. Colour coding, and tolerance. • Measuring capacitance and capacitive reactance. • Behaviour of capacitance at different frequencies. • Capacitors in series and parallel. • Meaning of Resonance. Application of resonance. Series and parallel resonance circuits. (06 hrs.)
Professional Skill 40Hrs; Professional Knowledge 8 Hrs	Test and use Diode to construct basic Electronic components. (NOS: Not Available)	**Electronic Components** 34. Identify terminals of different types of diodes. Record its specifications referring to diode data sheet. (5 hrs) 35. Plot forward and reverse characteristics of diode Testing working condition of diodes. (7 hrs) 36. Construct and test a half wave and full wave diode rectifiers. (9 hrs) 37. Construct and test a Bridge rectifier with and without filter. (9 hrs) 38. Draw Zener diode characteristics, Simple voltage regulator using zener diode. (10 hrs)	• Semiconductor, intrinsic and extrinsic semi conductors, P and N type semiconductor. Development of P.N. junction barrier potential. Effect of temperature. Breakdown voltage. • Different types of Diodes. Diode terminals. Diode specifications using data book. • Forward and reverse characteristics of diode. Testing diodes using Multimeter. • Half wave and Full wave rectifiers using diodes. Transformer requirements. Calculating output DC, ripple factor. • Filters for rectifiers. Calculating output DC, ripple factor. • Zener diode-Its characteristics and application for voltage regulation. Calculating the series resistor for required current rating.

			• Specifications of a regulated power supply and testing a power supply for its specifications. (8 hrs.)
Professional Skill 40Hrs; Professional Knowledge 14 Hrs	Recognize different types of Transistors and use it as Amplifiers in electronic circuit. (NOS: Not Available)	**Transistor and Amplifiers** 39. Identify types of transistors based on their physical appearance. Identify the leads of the given assorted types of transistors. (10 hrs) 40. Quick test given transistors using Multimeter. Identify opens, shorted junctions. (10 hrs) 41. Wire and find the gain of amplifiers in - CB, CE, CC configurations. (20 hrs)	• Working principle of PNP, Bipolar transistors. Types of transistors and applications. Leads of transistors and their identification. • Forward and reverse bias of transistor Junction. General values of junction resistances. Quick testing a transistor-using Multimeter. • Transistor configuration - CB, CE, CC, alpha, beta. Types of Biasing of transistor amplifiers, comparison and applications. Thermal runaway. (8 hrs)
Professional Skill 06Hrs; Professional Knowledge 05 Hrs	Construct and test of an application circuit using different types of Semiconductors. (NOS: Not Available)	**Special Semiconductors- FET** 42. Construct and test a JFET amplifier. (01 hrs) 43. Construct and test a MosFET application circuit. (01hrs) 44. Construct and test a relaxation oscillator using UJT. (01hrs) 45. Construct and test an application circuit using SCR. (01hrs) 46. Construct and test an application circuit using DIAC. (01hrs) 47. Construct and test an application circuit using TRIAC. (01hrs)	• Field effect transistors, types, working principle, applications. • Working principle and application of UJT. • Working principle and application of SCR. • Working principle and application of TRIAC. • Working principle and application of DIAC.(05 hrs.)
Professional Skill 32Hrs; Professional Knowledge 08Hrs	Assemble and test various Power Supply circuit. (NOS: Not Available)	**Power supply** 48. Practice on identifying and using the controls on a regulated power supply. (3 hrs) 49. Assemble and test a fixed voltage regulator using 3pin IC. (7 hrs) 50. Assemble and test a variable voltage regulator using IC. (8 hrs) 51. Assemble a simple inverter and converter for use with emergency lamp. (8 hrs) 52. Identify the parts and controls of a UPS. Practice switch-on and switch-off procedures. (6 hrs)	• Unregulated, regulated DC Power supply specifications. Application of different types of power supply for specific application types. • Short circuit protection. Overload protection. • Fixed Voltage regulators using IC's. • Variable voltage regulators using IC's. • Inverters and converters. • Un-interrupted power supply, types and applications. (8 hrs.)
Professional Skill 50Hrs; Professional Knowledge 14 Hrs	Construct all digital circuit using logic gates and verify truth table. (NOS: Not Available)	**Digital Electronics** 53. Identify the specifications of given digital IC's referring to data books. (2 hrs) 54. Verify the truth table of two input OR, NOR, AND, NAND, NOT gates. (3 hrs) 55. Verify of truth table of multiple input logic gates. (3 hrs) 56. Verify the truth table of XOR and XNOR Gates. (3 hrs) 57. Realization of different gate type using NAND gates. (3 hrs)	• Number systems and conversions. Classification of digital IC's. Use of data book for identification of digital IC's. • Basic LOGIC GATES and truth table. Boolean algebra. • Logic families, logic levels, propagation delay. Multiple input gates. • XOR, XNOR gates and application. • Simplification of Boolean equations. • Combinational logic circuits. g) Half adder, full adder, parallel binary adder, half subtractor, fullsubtractor. • Commercially available adders/ subtractors.

		58. Verification of Boolean laws. (3 hrs) 59. Realization of half adder & full adder using NAND gates. Realization half subtractor and full subtractor using NAND gates. (3 hrs) 60. Verification of truth table of 7483- 4bit adder. (3 hrs) 61. Verifying encoder/ decoder/ multiplexer/ demultplexer IC truth tables. (3 hrs) 62. Realization and verification of truth table of RS, JK and MS- JK flip-flop. (3 hrs) 63. Realization and verification of D-flip flop. (3 hrs) 64. Realization and verification of up & down (sync/async) counter. (3 hrs) 65. Verification of A/D & D/A converter. (3 hrs) 66. Realization of shift registers using FF. (3 hrs) 67. Verification of Right-shift, Left- shift registers. (3 hrs) 68. Verification of Serial-in-parallel out and parallel in serial out of data. (3 hrs) 69. Representation of logic function's truth table using K-Map. (3 hrs)	• Comparator, decoders, encoders, multiplexer, demultiplexer. • Parity generators / checkers. RS Flip - Flop, JK flip-flop, Master- Slave flip-flops. • Types of triggering and applications. D flip-flops. • Counters, ripple, synchronous, up-down, scale-n counters. • Principles of A/D & D/A converter. Commercially available A/D & D/A converters. Applications. • Shift registers. Types, applications. • Commercially available shift registers and applications. • Conversion of serial data into parallel and vice-versa. • Concept of Karnaugh Map (K-Map). (14 hrs.)
Professional Skill 16 Hrs; Professional Knowledge 04 Hrs	Familiarize charging of acid battery and verify connections. (NOS: Not Available)	**Battery** 70. Familiarize with the lead acid battery, Charging of batteries, Series parallel connection of batteries. (16 hrs)	• Lead acid cell, its construction and chemical changes during charging and discharging. Battery charging methods. Maintenance free batteries. Lithium cell, Ni-cad cells their construction and applications. (03 hrs.)
Professional Skill 24 Hrs; Professional Knowledge 4 Hrs	Verify internal parts of CRO and use it to measurement voltage, frequency & other signal using CRO (NOS: Not Available)	**Oscilloscope** 71. Identify CRO front panel controls. (7 hrs) 72. Measure of DC/AC voltages and frequency using CRO. (10 hrs) 73. Calibrate a given CRO. (7 hrs)	• Working principle and application. • Precautions to be taken while measuring voltages using CRO. • Simple Calibration procedures care and maintenance. (04 hrs.)
Professional Skill 25Hrs; Professional Knowledge 05 Hrs	Work with some important Mechanical, Electrical & Electronics Accessories used in information communication system. (NOS: Not Available)	**Other Mechanical, Electrical & Electronics Accessories** 74. Working with Stepper Motor, Drive. (5 hrs) 75. Identification and Testing of Sensors. (5 hrs) 76. Working with Relays. (5 hrs) 77. Identification of different advanced Intel microprocessor chips. (5 hrs) 78. Identification of different advanced microprocessor chips other than from Intel. (5 hrs)	• Basics of gears, Belts, Stepper Motor, Drive. • Sensors, its types and working principles. • Relays, types and its working principles. • Introduction to Microprocessor, Pentium processor architecture basics. (05 hrs.)
Professional Skill 50Hrs;	Perform all the functions of Word Processing and	**Word Processing** 79. Creating and saving document files using Word processing software.	• Introduction to Word processing and comparison of features. Creating and

Professional Knowledge 06 Hrs	Spreadsheet Software. (NOS: Not Available)	(3 hrs) 80. Formatting text and editing. (2 hrs) 81. Setting page and margins. Tabs and indents. (3 hrs) 82. Creating multicolumn documents. (3 hrs) 83. Inserting pictures in documents. (2 hrs) 84. Creating tables. (2 hrs) 85. Creating different types of documents. (3 hrs) 86. Saving word documents in other formats. (2 hrs) 87. Mail merge. (3 hrs) 88. Printing documents. (2 hrs)	saving document files using Word processing software. • Formatting test and editing. • Setting page and margins. Tabs and indents. • Creating multicolumn documents. • Inserting pictures in documents. • Creating tables. • Creating different types of documents. • Saving word documents in other formats. • Mail merge. • Printing documents. (03 hrs.)
		Spreadsheet Software 89. Creating Worksheets using Spreadsheet Software. (3 hrs) 90. Formatting cells. (3 hrs) 91. Using formula in cells. (3 hrs) 92. Creating simple spreadsheet for an application. (3 hrs) 93. Creating relation between sheets. (3 hrs) 94. Graphs and tables. (3 hrs) 95. Advanced features. (4 hrs) 96. Printing spread sheets. (3 hrs)	• Introduction to spread sheet. • Creating Worksheets using Spreadsheet Software. • Formatting cells. • Using formula in cells. • Creating simple spreadsheet for an application. • Creating relation between sheets. Graphs and tables. • Advanced features. • Printing spread sheets. (03 hrs.)
Professional Skill 75Hrs; Professional Knowledge 10 Hrs	Assemble and replace hardware components of Desktop Computer. (NOS: Not Available)	**DeskTop :PC Repair Safety** 97. Important Safety Basics. (2 hrs) 98. Identification, specification and application of basic hand tools. (2 hrs) 99. How to handle components to ensure their longevity. (2 hrs) 100. What one shouldn't wear while working inside a computer. (1 hr) 101. The danger of static electricity. (1 hr) 102. How to protect a PC from lightning strikes and power outages. (2 hrs) **Hardware Identification** 103. Identify the front and rear panel controls and ports on a PC. (1 hr) 104. Cases. (1 hr) 105. Cooling. (1 hr) 106. Cables & Connectors. (1 hr) 107. Power Supplies. (1 hr) 108. Power Supply Connections. (1 hr) 109. Motherboard Connections. (1 hr) 110. Motherboard Components. (1 hr) 111. CPU (Processor). (1 hr) 112. RAM (Memory). (1 hr) 113. Hard Drive Connections. (1 hr) 114. Mechanical vs. Solid State Drives. (1 hr)	• Introduction to computers, classification, generations, applications. Basic blocks of a digital computer. • Hand Tools Basics and Specifications. • Types of cabinets, relation with motherboard form factor. Precautions to be taken while opening and closing PC cabinet. • Main devices, components, cards, boards inside a PC (to card or device level only). • Types and specifications of the cables and connectors used for interconnecting the devices, boards, cards, components inside a PC. • Precautions to be taken while removing and/ or re-connecting • cables inside a PC. • Types of I/O devices and ports on a standard PC for connecting I/O devices. • Function of keyboard, brief principle, types, interfaces, connectors, cable. • Function of Mouse, brief principle, types, interfaces, connectors, cable. • Function of monitor, brief principle, resolution, size, types, interfaces, connectors, cable. • Function of Speakers and Mic., brief principle, types, interfaces, connectors, cable.

		115.ROM Drives. (1 hr) 116.Video Cards. (1 hr) 117.Sound Cards. (1 hr)	• Function of serial port, parallel port, brief principle of communication through these ports, types of devices that can be connected, interface standards, connectors, cable. • Precaution to be taken while connecting/ removing connectors from PC ports. Method of ensuring firm connection. (04hrs.)
		Hardware: Remove - Test - Replace/ Install 118.Removing RAM. (02 hrs) 119.Installing RAM. (02 hrs) 120.Removing a ROM Drive. (02 hrs) 121.Installing a ROM Drive. (02 hrs) 122.Removing a Hard Drive. (02 hrs) 123.Installing a Hard Drive. (03 hrs) 124.Removing a Power Supply. (03 hrs) 125.Installing a Power Supply. (02 hrs) 126.Removing a Video Card. (02 hrs) 127.Installing a Video Card. (02 hrs) 128.Install Expansion Cards. (02 hrs) 129.Removing Fans. (02 hrs) 130.Installing Fans. (02 hrs) 131.Removing the Motherboard. (02 hrs) 132.Installing the Motherboard. (5 hrs) 133.Removing the Processor. (02 hrs) 134.Installing the Processor. (03 hrs) 135.Installing a CPU Cooler. (03 hrs) 136.Troubleshooting. (02 hrs) 137.Checking the Power Switch. (01 hrs) 138.Removing the CMOS Battery. (01 hrs) 139.Seating Expansion Cards. (03 hrs)	• Types of Processors and their specifications (Intel: Celeron, P4 family, Xeon, dual core, quad core, core 2 duo, i3,i5,i7 and AMD). • Memory devices, types, principle of storing. Data organization 4 bit, 8 bit, word. • Semi-conductor memories, RAM, ROM, PROM, EMPROM, EEPROM, Static and dynamic. • Example of memory chips, pin diagram, pin function. • "Concept of track, sector, cylinder. FD Drive components-read write head, head actuator, spindle motor, sensors, PCB. • Precaution and care to be taken while dismantling Drives. • Drive bay, sizes, types of drives that can be fitted. Precautions to be taken while removing drive bay from PC. • HDD, advantages, Principle of working of Hard disk drive, cylinder and clusture, types, capacity, popular brands, standards, interface, jumper setting. Drive components- hard disk • platens, and recording media, ,air filter, read write head, head actuator, spindle motor, circuit board, sensor, features like head parking, head positioning, reliability, • performances, shock mounting capacity. HDD interface IDE, SCSI-I/2/3 comparative study. Latest trends in interface technology in PC and server HDD interface. • Precautions to be taken whilefitting • drives into bays and bay inside PC cabinet. • CMOS setting (restrict to drive settings only). • Meaning and need for using Scan disk and defrag. (06 hrs.)
Professional Skill 25Hrs; Professional Knowledge 07 Hrs	Install Operating System and all other application software. (NOS: Not Available)	**Windows Installation** 140.A walkthrough of installing Windows. (4 hrs) 141.Imaging: create a Windows system image. (4 hrs)	• Types of software. System software- OS, Compiler. • Application software like MS office. High Level, low level language, Computer application scientific industrial and business. Functions of an operating system. Disk operating system.

		142.How to Backup/ Restore your Windows partition with the bootable image disk. (3 hrs) 143.Duplicating a partition (creating a multi-boot system). (4 hrs) 144.A multi-boot system: the Windows boot manager vs. an alternative boot manager. (3 hrs) 145.Setting up a multi-boot/ dual-boot system. (4 hrs) 146.Dual Boot Ubuntu and Windows. (3 hrs)	• Concept of GUI, Modes of starting on different occasions. • Desktop, Icon, selecting, choosing, • drag and drop. • My computer, network neighborhood/ network places. • Recycle bin, briefcase, task bar, start menu, tool bar, and menus. • Windows Explorer. • Properties of files and folders. • Executing application programs. • Properties of connected devices. • Applications under windows accessories. • Windows Help. • Finding files, folders, computers. • Control panel. Installed devices and properties. (07 hrs.)
Professional Skill 60Hrs; Professional Knowledge 16 Hrs	Customize Operating System and maintain system application software. (NOS: Not Available)	**Data Backup** 147.3 types of media to use when backing up your data, and when each method is appropriate. (1hrs) 148.How to create automated backups to ensure you always have a recent backup. (2 hrs) 149.Learn how to manually backup data. (1 hrs) 150.How to make an exact copy (clone) of a hard drive. (2 hrs) **Hardware Troubleshooting** 151.The danger in not diagnosing problems first. (3 hrs) 152.Learn how to test your RAM. (3 hrs) 153.Check your hard drive for errors. (3 hrs) **PC Cleaning** 154.The best cleaning supplies to use. (1 hrs) 155.How to increase airflow and increase your computer's lifespan. (1 hrs) 156.How to clean your computer. (2 hrs)	• Utilities for recovering data from defective/ bad hard disks. • Introduction to removable storage devices, Bulk data storage devices- magnetic, optical, magneto optical drives, WORM drives. • CD ROM drives- Technology, Types of CD drives, working principle application. • Drive and back-up procedures. • Technology, working principle, capacity, media of DVD ROM drive. • Technology, working principle, capacity, media of CD WRITER and use different modes of writing on a CD. Using of utility for CD writing. (05 hrs.)
		Hard Drives 157.Partitioning hard disk (primary and extended partitions). (2 hrs) 158.Hard Drive Failures. (2 hrs) 159.How To Troubleshoot a Noisy Hard Drive.(2 hrs) 160.How to Format a Hard Drive. (1 hrs) 161.How to Completely Erase a Hard Disk Drive. (1 hrs) 162.Installation and configuration of storage devices. Integration of PATA and SATA drivers. (3 hrs) 163.Recover emails, files, and data from a crashed hard drive or computer. (2 hrs)	• Inside: Hard Drive Motherboard. • Desktop Hard Drive Buyer's Guide. • What is RAID? Using Multiple Hard Drives for Performance and Reliability. • Partitioning hard disk (primary and extended partitions). • Learn how to prevent your PC from getting malware. • All the different types of malware and how they attack your PC. • The difference between Anti-Virus and Anti-Spyware software. (06 hrs.)

		Virus Removal 164.How to run a full system scan. (1 hr) 165.How to fix your browser from redirecting to other websites (browser hijack). (1 hr) 166.Using a modern anti-virus utility. (1 hrs) 167.When utilities don't fix everything, how to manually remove a virus. (2 hrs) 168.2 specific things to disable when trying to get rid of a nasty virus. (2 hrs) 169.2 special utilities that work wonders. (1 hrs)	
		System Utilities 170.How to check to see if your hard drive has bad sectors. (1 hr) 171.Fix the master boot record. (2 hrs) 172.How to run an in-place installation. (1 hr) 173.Using Task manager and Event Viewer. (1 hrs) 174.Using System Monitor and Performance Logs. (1 hrs) 175.Configure config.sys file. (2 hrs) **User Account Customization** 176.How to create and configure user accounts in Windows Make Changes to an Account. (1 hrs) 177.Changing the storage location of the personal folders. (1 hr) 178.Changing the storage location of installed software. (1 hr) 179.Setting up Parental Controls in Windows. (2 hrs) 180.How to Use Fast User Switching in Windows. (2 hrs) 181.View Hidden Files and Folders. (1 hr) 182.Lock Down Windows 7 / 8 With User Account Control. (1 hrs) 183.How to Delete User Accounts in Windows. (1 hrs)	• Bad Sectors in Hard disk, Master Boot Record, in-place installation, Registry fixing, performance level check, Shortcut fixing, Fixing Startup process, log, etc. • Users and user account. Privileges, scope, permissions etc. • Concept of Virtual Machine. (05 hrs.)
Professional Skill 75Hrs; Professional Knowledge 16 Hrs	Install Operating System and all other application software. (NOS: Not Available)	**Windows Update & Device Driver** 184.How to find your system version in Windows, Linux. (2 hrs) 185.Installing a service pack. (3 hrs) 186.How to perform a Windows Update. (2 hrs) **Software Installation** 187.Installing a software program in windows. (3 hrs) 188.How to run a file from MS-DOS. (3 hrs) 189.Extracting or uncompressing a compressed file. (2 hrs)	• Version of a software, Service pack, Updating of OS, Different configurations of Computer system and its peripherals, Compatible with different hardware/ software. Software Installation - • Pre-installation -Prerequisites, Install procedure, Rollback or Un-install procedure, Tests. • Post-installation - • Backup procedure & specifications, Restore procedure, Periodical view check.

		190.How to compress or make files into one file. (2 hrs) 191.Uninstalling Windows software. (3 hrs) 192.Unable to remove a program from Windows Add/ Remove programs. (3 hrs)	• Awareness of legal aspects of using computers such as copyright, patent etc. (05 hrs.)
		Installing Hardware Drivers 193.How To Update Drivers in Windows.(1 hr) 194.How To Roll Back a Driver in Windows. (2 hrs) 195.Familiarization with Device manager. (2 hrs) 196.Interfacing with cellphone, tablet PC, synchronization of contacts. (2 hrs) **Windows Utilities** 197.How to Repair Corrupted Files Problems. (2 hrs) 198.How to check for corrupted files. (2 hrs) 199.Restore your machine back to normal. (2 hrs) 200.Hard disk is filling up, what should one do? (2 hrs) 201.Where's the disk space? (2 hrs) 202.Top 15 Ways to Speed Up the Computer. (2 hrs) 203.5 Reasons - Computer Is Running Slow. (2 hrs)	• What is a Driver? • What hardware device drivers should be updated? • What is a Device manager? • Computer Maintenance Tips and Tricks to Backup, Scan and Clean. • Power on self test, Peripheral diagnostics, general purpose diagnostics, Operating system diagnostics. • Hardware boot process, Windows boot process. (05 hrs.)
		Junk File Removal 204.How to Remove Junk Files. (1 hr) 205.How to completely remove "deleted" files. (1 hr) 206.How to clear web browser cache Firefox, Internet Explorer, Chrome. (1 hr) 207.5 steps to clean up your computer files. (1 hr) 208.Personalize your Windows XP-based PC. (1 hr) **Linux OS** 209.Using a Linux Live CD. (4 hrs) 210.Why you want a Linux Live CD. (4 hrs) 211.Use Ubuntu Live CD to Backup Files from Your Dead Windows Computer. (4 hrs) 212.Using a live CD as your Linux Desktop. (4 hrs) **Outlook Configure & Backup** 213.Configure outlook. (1 hr) 214.Backup and Restore Outlook. (1 hr) 215.How to restore the Outlook default installation, toolbars and settings. (1 hr)	• Junk files, deleted files, configuration of internet browser. • Introduction to UNIX/LINUX and its structure. • Files and Processes in Linux. • Directory structure of Linux O.S. • Outlook - • Add and use contacts, Calendar basics, Recall and replace sent messages, Send automatic replies when you're out of the office, The ins and outs of BCC, Use Instant Search to find Calendar items, Use Instant Search to find contacts, Use Instant Search to find messages and text, Add holidays to your calendar, Create or delete a search folder, Import and export vCards to Outlook contacts, Make the switch to Outlook 2013, Reach out with contact groups (distribution lists), Send or delete an email stuck in your outbox, Take calendars to the next level, Track email with read receipts, Password protect your mailbox, Use rules to manage your email. (06 hrs.)

		216.Restore Deleted Items from an Outlook PST-file. (1 hr)	
Professional Skill 50Hrs; Professional Knowledge 7 Hrs	Assemble and replace hardware components of Laptop PC. (NOS: Not Available)	**Laptop PCs** 217.Identification of laptop sections and connectors. (03 hrs) 218.Assembling and disassembling a Laptop. (08 hrs) 219.Checking of various parts of a laptop. (03 hrs) 220.Checking of batteries and adaptors. (02 hrs) 221.Replacing different parts of laptops. (8 hrs) 222.Upgrading RAM, HDD and other parts. (05 hrs) 223.Testing, fault finding and troubleshooting techniques. (05 hrs) 224.POST codes and their meaning, fixing of problems based on codes. (05 hrs) 225.Enabling support for SATA technology. Installation of OS using SATA technology drivers. (05 hrs) 226.Laptop troubleshooting. (03 hrs) 227.Latest Tools & Gadgets For Desktop/ Laptop Repairs. (03 hrs)	• Introduction of laptop and comparison of various Laptops. • Block diagram of laptop & description of all its sections. • Study of parts of a laptop. • Input system: Touchpad, Trackball, Track point, Docking station, Upgrade memory, hard disk, replacing battery, Configuring wireless internet in a laptop. • Latest Tools & Gadgets For Desktop/ Laptop Repairs. (07 hrs.)
Professional Skill 25Hrs; Professional Knowledge 03 Hrs	Replace/ install SMPS and troubleshoot its faults. (NOS: Not Available)	**SMPS** 228.Remove the SMPS from PC cabinet. Identify the types of output connectors of SMPS. (05 hrs) 229.Identify output voltages using colour coding. Measure voltage levels. Test power cable and fuse. (05 hrs) 230.Open and cleaning the cooling fan and other parts. (05 hrs) 231.Fix the SMPS inside the PC cabinet and test PC. (05 hrs) 232.Use of Debug Card Post Error & Code, SMPS Tester, PCI slot testing tool. (05 hrs)	• DC power source to PC. Need for SMPS. Specifications. Rating of SMPS based on type of motherboard and devices used. (AT/ ATX, Micro ATX, mini ATX). • Color coding adopted. Types of connectors used. Output voltage levels. Measuring technique. • Precautions to be taken while cleaning the internal area of SMPS. • Precautions to be taken while fixing the SMPS inside the cabinet. (03 hrs.)
Professional Skill 50Hrs; Professional Knowledge 9 Hrs	Familiarize and upgrade various components of Motherboard. (NOS: Not Available)	**Motherboard/ System board** 233.Remove the mother board from PC cabinet. Identify the main components on the motherboard. (3 hrs) 234.Identify the form factor of the mother board. (2 hrs) 235.Identify the chipset used. (2 hrs) 236.Identify the number of slots available for add-in cards (ISA, PCI, AGP). (2 hrs) 237.Identify the type of processor connector (slot/ socket/ dual). (2 hrs) 238.Identify the BIOSROM, make, version. (3 hrs) 239.Identify the jumper settings (if any) on the mother board. (2 hrs)	• Mother board function, types, Main components on the mother board and their interconnection. Functional description of mother board, Specification and variation. Precautions to be taken before removing the mother board from PC cabinet. • Form factor of mother board. • Meaning and function of chips sets. Manufacturers, comparison, importance of quality chip set for performance of PC. • Bus standards-evolution, speed, latest trends (ISA, PCI, AGP, new trends). • Types of processor connectors, examples of latest processor connectors, number of pins. f) Function of BIOS, manufacturers of BIOS.

		240.Identify the types of slots available for memory modules. (3 hrs) 241.Identify the connectors for Hard disk (IDE). (3 hrs) 242.Identify the connector for FDD. (2 hrs) 243.Identify the connector for COM1, Com2. (3 hrs) 244.Identify the connectors for PS/2. (3 hrs) 245.Identify the connectors for USB. (3 hrs) 246.Identify the connectors for Game port. (3 hrs) 247.Identify the connector for parallel port (Centronics). (3 hrs) 248.Identify the connector for Keyboard (in exclusively available). (3 hrs) 249.Identify the specifications of the Lithium battery. (3 hrs) 250.Identify any other special component available on the mother board. (3 hrs) 251.Identify the connectors for front panel switches and display. (2 hrs)	• IDE ports available .Primary, secondary. Number of drives that can be connected. Methods of adding SCSI drives. • Details of FDD connector on mother board. • Facility for serial Communication ports on mother board. • Facility for PS/2 Communication ports on mother board. • Meaning and advantage of USB ports. Facility for USB Communication ports on mother board. • Facility for game ports on mother board. • Facility for parallel Communication port on mother board. • Type of connectors in which keyboards cab be used, old type full size DIN connector. • Need of Lithium battery. Its specifications. Replacement procedure. Effect of removing the battery from mother board. • Other special components available on mother boards such as integrated devices/ drivers.(9 hrs.)
Professional Skill 45Hrs; Professional Knowledge 6 Hrs	Recognize different types of memory devices, chips and its structure. (NOS: Not Available)	**Possible upgrading/ changing components on the mother board** 183.Replace the weak/ dead battery on the mother board. (4 hrs) 184.Replace/ upgrade RAM memory modules. (4 hrs) 185.Replacing/ upgrading Processor. (4 hrs) 186.Carryout Jumper setting on mother board. (4 hrs) 187.Changing CMOS set- up and setting system level password. (4 hrs)	• Effect of weak/ dead battery on PC performance. Identifying weak/ dead battery. Precautions to be taken before replacing the battery. Setting to be done after replacing the battery. • Organization of RAM, types of RAM's, Module types, pins, replacement procedure and precautions. Compatibility of memory modules to the motherboard. • Type of processors, generation, features, speed, popular manufacturers. Advantages and possibility of upgrading Processor of a PC. Motherboard/ Chipset/ speed/ connector/ power/other compatibility criteria for upgrading processor. • Precautions to be taken while removing and placing processor in sockets and slots. • Types of jumper settings on motherboard. Its functions and effects. • CMOS set-up features. Need and procedure for changing the CMOS set-up. Updating Flash BIOS. (06 hrs.)
		Memory 188.Identification of different types of memory devices. (8 hrs) 189. Identification of memory chips. (8 hrs) 190. Identification of SIMM and DIMM memory modules, number of pins, type. (9 hrs)	

Punctuality and Discipline

Objectives: At the end of this lesson you shall be able to
- **importance of punctuality**
- **punctuality at work place**
- **importance of discipline**
- **state the types of injury caused while lifting and carrying loads, and how to prevent them**
- **name the four basic categories of safety signboards.**

Punctuality is the characteristic of being able to complete a required task before or at a previously designated time

Importance of punctuality

Being punctual strengthens and reveals your integrity. If you tell someone that you will meet them at a certain time, you have essentially mad e them a promise. Being on time shows others that you are a man of your word.

Being punctual shows you are dependable. But if a man is not punctual, others cannot depend on him — they do not know where he will be when they need him.

Being punctual builds your self-confidence. Showing up on time not only tells other people you are dependable, it teaches you that you can depend on yourself.

Being punctual assures you're at your best.

Being punctual builds and reveals your discipline. The punctual man shows that he can organize his time, that he pays attention to details, and that he can put aside this to do that – he can set aside a pleasure to take care of business.

Being punctual shows your respect for others. Being late is a selfish act, for it puts your needs above another's.

Being late is a form of stealing. That's a tough truth, but it's a truth nonetheless. When you make others wait for you, you rob minutes from them that they'll never get back. Being punctual shows you value time yourself, and thus wouldn't think of depriving others of this precious, but limited resource.

Being late disturbs the experiences of other people. Your tardiness not only robs others of their time, but of the fullness of their experiences as well.

Being late strains your relationships. When you're late in meeting other people, it makes them feel under-valued, that whatever you couldn't pull yourself away from was more important or that they didn't mean enough to you to warrant allotting sufficient time to arrive on schedule.

Being late hurts your professional career. Whether you're an employee or in business for yourself, being late can hinder your professional success.

Being late takes a toll on your life. Always running behind simply hurts you in all areas of your life.

Punctuality at work place

1 Entering the lab / workshop in time

2 Having everything ready before starting the task/ practicals.

- plan the sequence of work
- layout the tools yours, in the order of sequence

3 Complete the task within the allotted time

Importance of discipline

Discipline is essential for every group, for every society and for every political institution. Without discipline there can be no society or Government. No nation can exist without discipline. It is discipline that units man to man, and one society to another. Hence discipline is one of the basic insignia of social life.

Discipline has to be observed in speech, in sport and in every kind of relationship.

Discipline means the observance of certain well-defined rules. Discipline cannot be acquired from books. Nor can it be learnt from teachers. It has to be as natural component of one's daily life in the discharge of one's duties.

Your discipline will protect you in whatever you do.

Discipline and punctuality are two most essential traits required in a professional to be successful. Discipline ensures individuals behave in an acceptable way at the workplace and also adhere to the rules and regulations of the organization. Misbehaving at the workplace spoils the entire work culture eventually leading to zero or very less productivity. Discipline is crucial at workplace as it ensures employees behave in a decent way and also maintain the decorum of the workplace.

Examples of indiscipline:

1 Excessively late, slow or sluggish

2 Failure to notify of an absence

3 Insubordination willfully disobeying the superior

4 Using rude or abusive language

5 Failure to follow rules procedures or policies

6 Dishonesty

7 Theft of tools, equipments consumables etc

Safety in moving and shifting heavy and delicate equipments

Many of the accidents reported involve injuries caused while lifting and carrying loads. Wrong lifting techniques can result in injury. A load need not necessarily be very heavy to cause injury.

A wrong way of lifting something too heavy causes injury. The muscles and joints are strained. This is especially true in the case of injury to the back. The most common type of injury due to a wrong way of lifting is injury to the back.

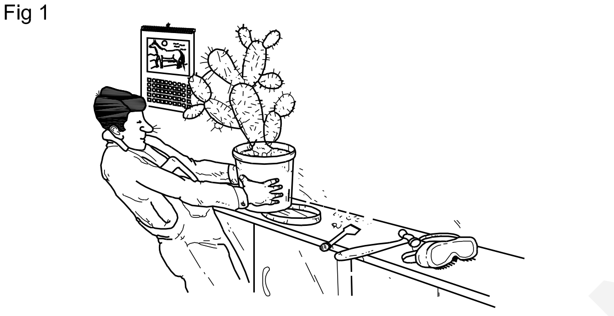
Injuries during lifting and carrying may be caused by tripping over an object and falling, or striking an object with a load.

Types of injury and how to prevent them

Cuts and abrasions: Cuts and abrasions are caused:

- by rough surfaces and jagged edges
- by splinters and sharp or pointed projections. (Fig 1)

Fig 1

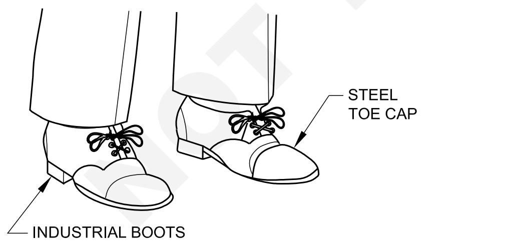


Leather gloves will usually be sufficient for protection, but the load should be checked to make sure of this, since large or heavy loads may involve body contact as well.

Crushing of feet or hands: Feet or hands should be positioned so that they cannot be trapped by the load. Timber wedges can be used when raising and lowering heavy loads to ensure that the fingers and hands are not caught and crushed.

Safety shoes with steel toe caps will protect the feet.(Fig2)

Fig 2

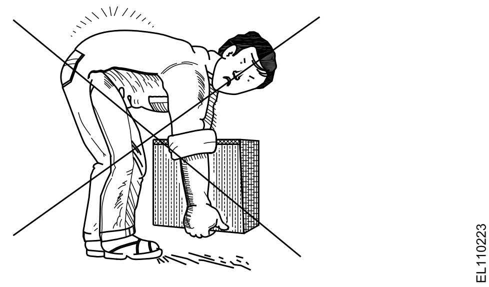


Strains to muscles and joints: Strains to muscles and joints may be the result of:

- lifting a load which is too heavy or
- lifting incorrectly.

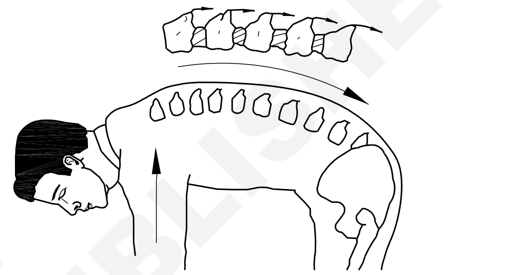
Sudden and awkward movements such as twisting or jerking during a lift can put severe strain on muscles. Injury to the back is most often caused by lifting loads which are too heavy or by employing wrong methods. 'Stoop lifting' - lifting from a standing position with the back rounded (Fig 3) increases the risk of a back injury.

Fig 3



The stress on a rounded back can be up to six times greater than if the spine is kept straight. Fig 4 shows an example of stoop-lifting.

Fig 4



Before lifting or handling any load ask yourself the following questions.

What has to be moved?

Where from and where to?

Will assistance be required?

Before lifting and carrying, make sure the route is clear of obstacles and the place where the load is to be deposited is not obstructed.

The person carrying the load should always be able to see over or around it.

The weight, a person can lift will vary according to:

- age
- physique and
- condition such as other health factors.

It will also depend on whether one is used to lifting and handling heavy loads.

What makes an object difficult to lift and carry?

- Weight is not the only factor which makes it difficult to lift and carry.
- The size and shape can make an object awkward to handle.
- Loads, which require the arms to be extended in front of the body, place more strain on the back and stomach than do compact objects carried close to the body.
- The absence of hand-holds or natural handling points can make it difficult to raise and carry the object.

The kinetic method of lifting: It enables the worker to make full use of the body's own weight to initiate the lift.

The natural shape of the spine is maintained throughout (although the body may be bent forward, the spine should remain straight), and the lift is powered by the strong muscles in the legs and thighs.

It is important to begin with the right posture, that is, the various parts of the body should be correctly positioned before beginning the lift. The following six points should be noted.

– The Feet are placed about 18 inches(45cms) wide apart, with one foot slightly forward, in the direction of movement. This gives a good balance and provides a secure basis for the lift.

– The Knees should be slightly bent (but not fully bent as in a squat).

– The Back must be straight, although the body may be inclined forward as shown in the illustration.

– The Arms should be as close to the body as possible. The farther the arms are extended the greater the strain. Elbows too should be kept in.

– The Grip must be firm and secure.

– The Head should be erect with the chin in.

Correct manual lifting techniques

– Approach the load squarely, facing the direction of travel.

– The lift should start with the lifter in a balanced squatting position, with the legs slightly apart and the load to be lifted held close to the body. Ensure that a safe secure hand grip is obtained. Before the weight is taken, the back should be straightened and held as near the vertical position as possible. (Fig 5)

Fig 5

– To raise the load, first straighten the legs. This ensures that the lifting strain is being correctly transmitted and is being taken by the powerful thigh muscles and bones. Look directly ahead, not down at the load while straightening up, and keep the back straight; this will ensure a smooth, natural movement without jerking or straining. (Fig 6)

– To complete the lift, raise the upper part of the body to the vertical position. When a load is near to an individual's maximum lifting capacity, it will be necessary to lean back on the hips slightly (to counterbalance the load) before straightening up. (Fig 7)

Fig 6

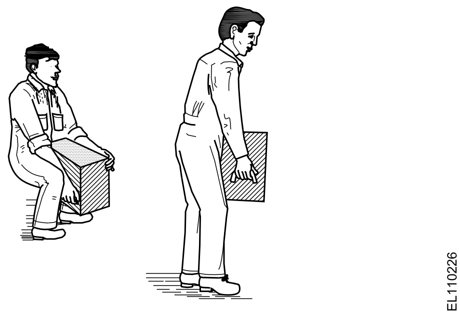
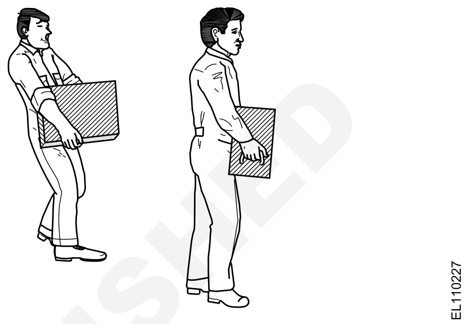


Fig 7

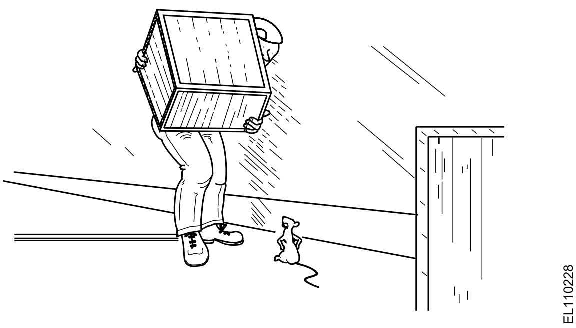


– Keeping the load well into the body, carry it to the place where it is to be set down. When turning, avoid twisting from the waist-turn the whole body in one movement.

Lowering the load: Make sure the area is clear of obstructions. (Fig 8)

Bend at the knees to a semi-squatting position; keep the back and head erect by looking straight ahead, not down at the load. It may be helpful to rest the elbows on the thighs during the final stage of lowering.

Fig 8



Moving heavy equipment

Heavy equipment is moved in industry using any of the following

– Cranes and slings

– Winches

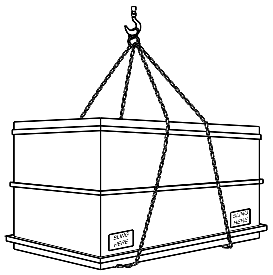
– Machine moving platforms

– Layers and rollers.

Cranes and slings: This method is used whenever loads are to be lifted and moved. (Fig 9) Examine the slings for cuts, abrasion, wear, fraying or corrosion.

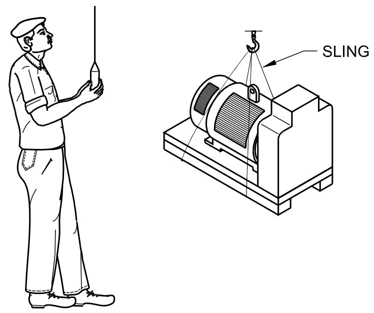
Damaged slings must not be used.

Fig 9



Distribute the weight as evenly as possible between the slings when using more than one sling. (Fig 10)

Fig 10



Keep the slings as near to vertical as possible.

Winches: Winches are used to pull heavy loads along the ground.

Cranes and slings may be power-driven (Fig 3) or hand-operated. (Fig 4)

Ensure that the safe working load (SWL) of the winch is adequate for the task.

Secure the winch to a structure which is strong enough to withstand the pull.

On open ground, drive long stakes into the ground and secure the winch to them.

Choose a suitable sling and pass it around the base of the load. Secure it to the hook of the winch.

Safety signs

Causes for accidents

Accidents happen due to causes which can not be foreseen. Most accidents are a result of human error, ignorance, neglect, forgetfulness or recklessness. Most accidents can be prevented.

Normally accidents do not just happen. They are caused.

Causes for accidents are many, some of the important ones are:

– unawareness of danger
– disregard for safety
– negligence
– lack of understanding of proper safety procedures
– untidy condition of workplace
– inadequate light and ventilation
– improper use of tools

Safe attitudes: People's attitudes govern what **they do** or **fail to do**. In most cases accidents occur when someone is working with unsafe equipment or in an unsafe situation. These situations which cause accidents is because the working person has failed to do certain things.

Safety signboards: Signboards are a common sight in almost all places such as roadways, railways, hospitals, offices, institutions, industrial units and so on.

Signboards are visual indicators. The signs on the signboards may be just a symbol, a small text, a figure or a combination of these.

Signboards carry a single clear message. These messages are to ensure safety.

Signboards can be classified into four basic categories.

Prohibition signs: Indicating a behaviour which is prohibited (not allowed) in that situation or environment. Refer to Chart 1 for examples.

Mandatory signs: Indicating a behaviour which is a must, which when not obeyed may cause accidents. Refer to Chart 1 for examples.

Warning signs: Indicating a warning such that suitable precaution is taken. Refer to Chart 1 for examples.

Information signs: Giving information which is very useful and reduces waste of time. Refer to Chart 1 for examples.

CHART 1

SIGN BOARDS

a) **PROHIBITION SIGNS**

Fig 1

Shape	Circular.
Colour	Red border and cross-bar. Black symbol on white background.
Meaning	Shows what must *not* be done.
Example	No smoking.

b) **MANDATORY SIGNS**

Shape	Circular.
Colour	White symbol on blue background.
Meaning	Shows what *must* be done.
Example	Wear hand protection.

c) **WARNING SIGNS**

Fig 3

WARNING SIGNS

Shape	Triangular.
Colour	Yellow background with black border and symbol.
Meaning	Warns of hazard or danger.
Example	Caution, risk of electric shock.

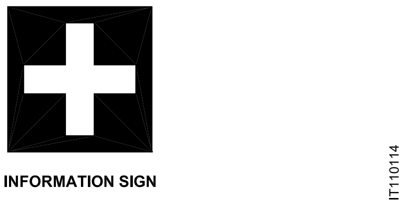
Fig 2

MANDATORY SIGNS

d) **INFORMATION SIGNS**

Shape	Square or oblong
Colour	White symbols on Green background.
Meaning	Indicates or gives information of safety provision/First aid
Example	First aid point.

Fig 4



INFORMATION SIGN

Artificial Respiration & Electrical safety

Objectives: At the end of this lesson you shall be able to
- **state the various methods of artificial respiration**
- **list the procedure to be followed in different methods of artificial respiration**
- **state the action to be taken to treat a victim with cardiac arrest**
- **state the meaning of electric shock.**

RESPIRATION

Respiration is an involuntary function of all living organisms. In human beings respiration involves breathing in and breathing out air. The air taken consists of oxygen which is made use of by the lungs to purify the blood. If a person cannot breathe or stops breathing for any reason he will collapse in no time.

Artificial respiration

When breathing becomes feeble due to sickness, shock or accident. the person becomes unconscious. At this stage it is possible to improve the respiration by artificial means. This is known as artificial respiration.

In artificial respiration, air containing oxygen is forced into the lungs of the unconscious person so as to maintain the supply of oxygen to the body till the time the victim reaches the hospital/clinic for further treatment.

There are several methods by which artificial respiration can be given. Some of the well known methods are,

– HOLGEN-NELSON method

– SCHAFER'S method

– Mouth-to-mouth method.

Basically all these methods serve the same purpose and are equally good. Therefore the person/volunteer can adopt any one of the above methods in which he is trained and is confident. However, Nelson's method and Schafer's method should be avoided while giving artificial respiration to those patients who are suspected to have injuries in the chest wall and abdomen.

Each of the above said methods has a systematic procedure to be followed. These procedures are given below. A person must practice this procedure thoroughly before giving artificial respiration to a sick person. Any short cuts in the procedure is dangerous and may worsen the condition of the sick person instead of improving it.

When breathing becomes feeble due to sickness, shock or accident the person.

NELSON's Method (Arm-lift back-pressure method)

PRECAUTION

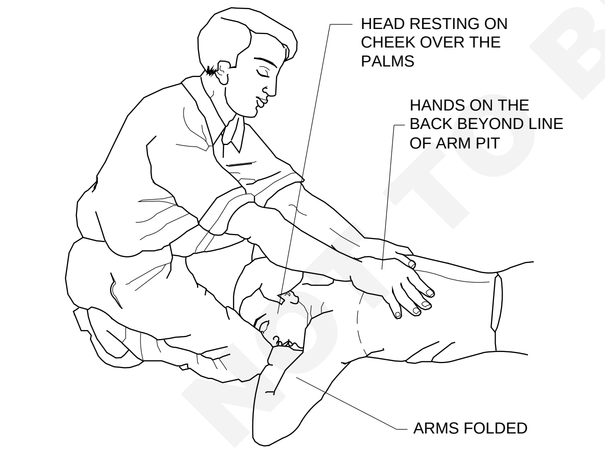
Nelson's arm-lift back pressure method must not be used in case of suspected injuries to the chest wall or abdomen of the victim.

1 Loosen the clothing of the victim as tight clothing interferes with the victim's breathing.

2 Remove any foreign materials or false teeth from the victim's mouth, and keep the mouth open.

3 As shown in Fig 1, place the victim face down with his arms folded, palms one over the other and head resting on his cheek over the palms. Kneel on one or both knees at the victim's hand. Place your hands on the victim's back beyond the line of the armpits. Spread your fingers outwards and downwards with the thumbs just touching each other.

Fig 1



4 As shown in Fig 2, gently rock forward the arms keeping them straight until they are nearly vertical, and thus steadily pressing the victim's back as shown to force the air out of the victim's lungs.

5 As shown in Fig 3, synchronizing the above movement rock backwards sliding your hands downwards along the victim's arms. Grasp his upper arm just above the elbows as shown.

Fig 2

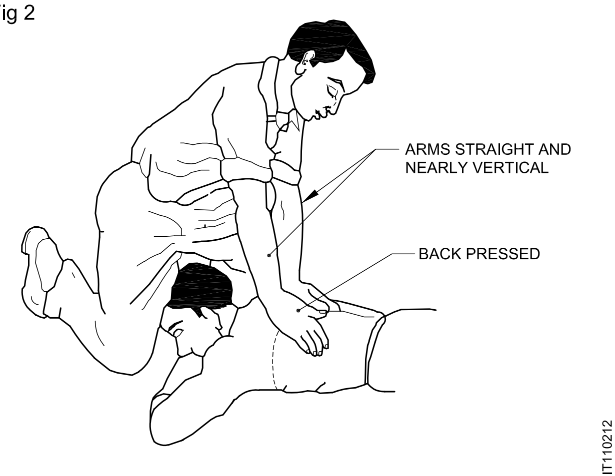
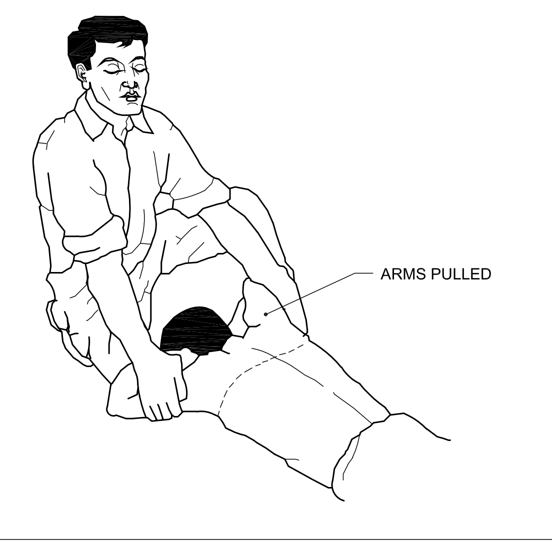


Fig 3

6 Now rock backwards. As you rock backwards, gently raise and pull the victim's arms towards you as shown in Fig 4 until you feel tension in his shoulders. Remain in this position for a few seconds. To complete the cycle, lower the victim's arms and move your hands up to the initial position.

7 Repeat the cycles a few more times by following steps 3 to 6.

Fig 4



SCHAFER'S method

PRECAUTION

> **Do not use this method of artificial respiration in case the victim has injuries on his chest or abdomen.**

> **Be brisk in carrying out above methods but avoid violent operations which may cause injury to the internal parts of the victim.**

1 Loosen the clothing of the victim as tight clothing interferes with the victim's breathing.

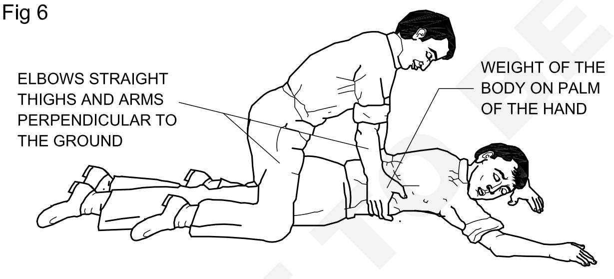
2 Lay the victim on his abdomen. Extend one arm directly forward, and the other arm bent at the elbow as shown in Fig 5. Keep the face turned sidewalk and resting on the hand or forearm as shown in Fig 5.

3 Kneel astride the victim as shown in Fig 5 such that his thighs are between your knees. Position your fingers and thumb as shown in Fig 5.

Fig 5

4 With the arms held straight, swing forward slowly so that the weight of your body is gradually applied on the lower ribs of the victim as shown in Fig 6. This weight force the air out of the victim's lungs.

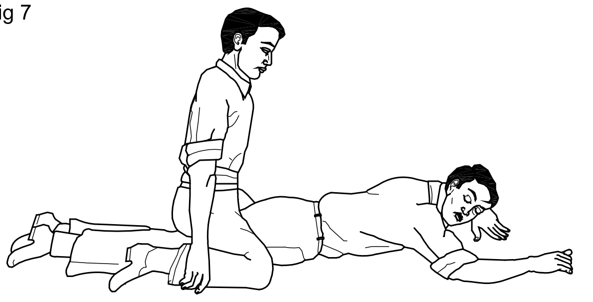
Fig 6



5 Now swing backward immediately removing all pressure on the lower ribs as shown in Fig 7. This allows the lungs to get filled with air.

6 After two to three seconds, swing forward again and repeat the cycle (steps 4 and 5) twelve to fifteen times a minute.

Fig 7



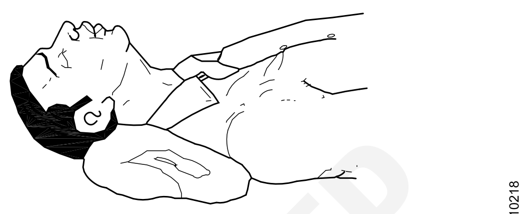
Mouth-to-mouth method of artificial respiration

1 Loosen the clothing of the victim as tight clothing interferes with the victim's breathing.

2 Remove loose dentures or other obstructions from the mouth. Make sure that the victim's nose and mouth are clear.

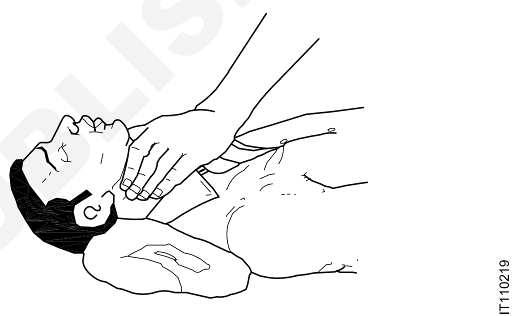
3 Lay the victim flat on his back. Place a roll of clothing under his shoulders such that his head is thrown well back as shown in Fig 8.

Fig 8



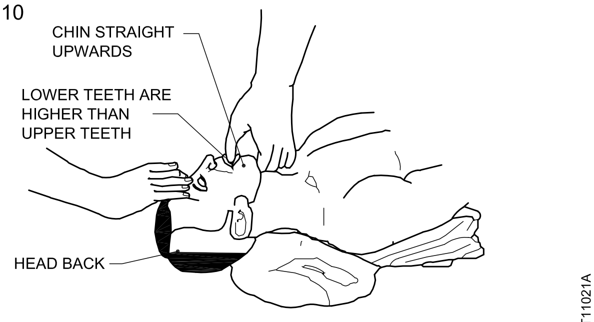
4 Tilt the victim's head back so that the chin points straight upward as shown in Fig 9.

Fig 9



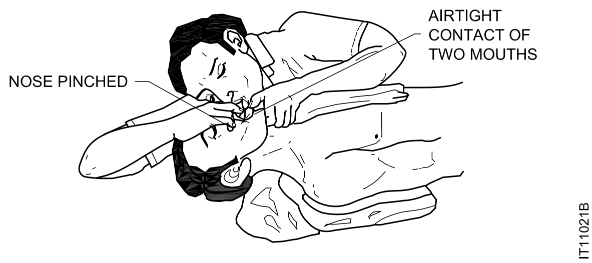
5 Grasp the victim's jaw as shown in Fig 10, and raise it upward until the lower teeth are higher than the upper teeth. Maintain this position throughout the artificial respiration to prevent the tongue from blocking the air passage.

Fig 10



6 Take a deep breath and place your mouth over the victim's mouth as shown in Fig 11 making airtight contact. Hold the victim's nose shut with the thumb and forefinger. Blow into the victim's mouth (gently in the case of infants) until his chest rises. Remove your mouth and release the hold on the victim's nose.

Fig 11



If you dislike direct contact, place a porous cloth between your mouth and the victim's.

If air cannot be blown in, check the position of the victim's head and jaw. Check the mouth for obstructions. Then try again blowing air more forcefully. If the chest still does not rise, turn the victim's face down and strike his back sharply to dislodge obstructions.

7 Let the victim exhale. Hear the out rush of air from the victim's mouth and nose.

Sometimes air enters the victim's stomach as evidenced by a swelling stomach. Expel the air by gently pressing the stomach during the exhalation period.

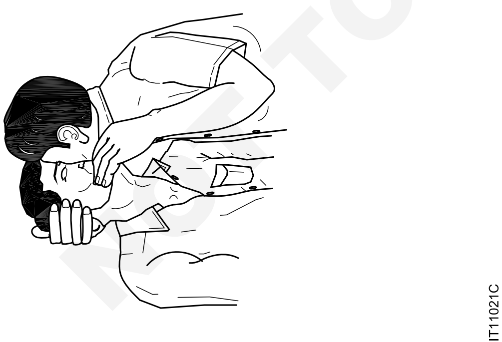
8 Repeat steps 6 and 7, eight to ten times rapidly. Then slow down to 10-12 times a minute. (20 times for infant)

Sometimes it may take hours for the victim to breathe normally. Continue giving artificial respiration till he recovers.

Mouth-to-nose method of artificial respiration

If the victim's mouth will not open, or has a blockage which you cannot clear then the mouth-to-nose method of providing artificial respiration should be followed. In this method use fingers of one hand to keep the victim's lips firmly shut. As shown in Fig 12 seal your lips around the victim's nostrils and blow air gently into his nose and suck back. Check if the victim's chest is rising and falling.

Fig 12

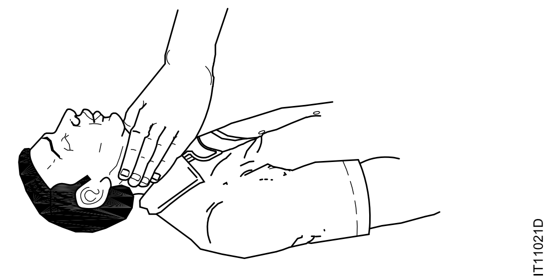


Artificial respiration in case of cardiac arrest

In the case of cardiac arrest where the heart has stopped beating, the following procedure has to be followed. One must act immediately as any delay will reduce the chances of the patient's recovery.

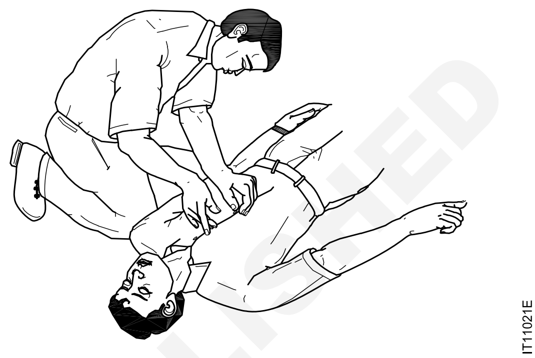
1 As shown in Fig 13, check if the carotid pulse in the neck can be felt. If the pulse is found feeble, go head with the following steps.

Fig 13



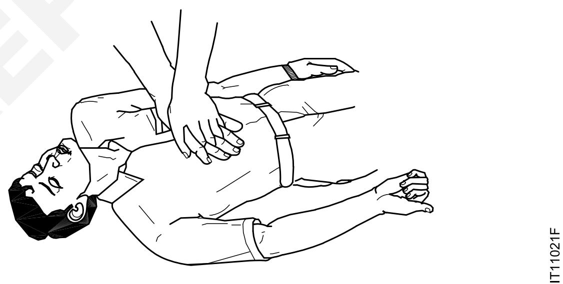
2 Lay the victim on his back on a firm surface. Kneel alongside as shown in Fig 14. Facing the chest, locate the lower part of the breastbone.

Fig 14



3 Place the palm of one hand on the centre of the lower part of the breastbone, keeping your fingers off the ribs. As shown in Fig 15, cover the palm with your other hand and lock your fingers together as shown.

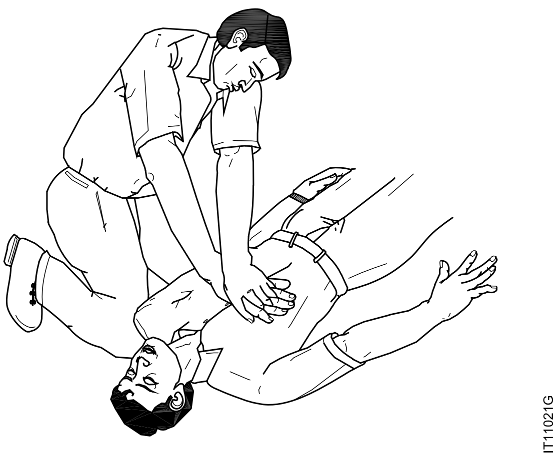
Fig 15



4 Keeping your arms straight as shown in Fig 16, press sharply down on the lower part of the breastbone and release the pressure.

5 Repeat step 4, fifteen times at a rate of approximately one per second.

Fig 16



6 Recheck the carotid pulse as done in step 1, Fig 13.

7 Give two cycles of mouth-to-mouth artificial respiration as shown in Fig 17.

Fig 17

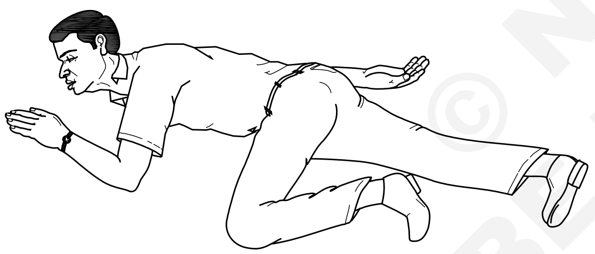
8 Give 10-15 more compressions of heart as done in step 4 and 6 follow it up with a further two cycles of mouth-to-mouth artificial respiration.

9 Checking for the carotid pulse. If the pulse is still feeble, repeat step 10 till the pulse improves.

10 As soon as the heartbeat returns, stop the compressions immediately and continue with mouth-to-mouth artificial respiration until natural breathing is fully restored.

11 Place the victim in the recovery position as shown in Fig.18. Keep him warm and get medical help quickly.

Fig 18



IMPORTANT POINTS TO NOTE AFTER GIVING ARTIFICIAL RESPIRATION TO VICTIMS

1 Even if the victim's breathing and heartbeat have recovered, do not delay in calling a doctor for a check up and treatment.

2 After the victim has recovered, keep the victim warm with a blanket, wrapped up with hot water bags. Stimulate circulation by stroking the insides of the arms and legs towards the heart.

3 When the victim revives, make him lie down. Do not let him exert himself as this may lead to a deterioration in his condition.

4 Do not give the victim any stimulant such as coffee, tea etc. until he is fully conscious.

ELECTRICAL SAFETY

Electric Shock: If a person happens to come in contact with an electrical live wire and if he has not insulated himself, then electric current flows through his body. Since the human body cannot withstand current flow more than a few tens of milliamps, the human body suffers a phenomenon generally known as electric shock. Electric shock may turn out to be hazardous to some of the parts of the human body and sometimes even to the life of the person.

The severity of an electric shock depends on:

– the level of current passing through the body

– how long does the current keep passing through the body.

Therefore, the higher the current or longer the time, the shock may result in a causality.

In addition to the above factors, other factors which influences the severity of shock are:

– age of the person receiving a shock

– surrounding weather condition

– condition of the floor (wet or dry)

– voltage level of electricity

– insulating property of the footwear or wet footwear, and so on.

Effects of electric shock

The effect of electric shock at very low voltage levels may be sufficient to cause someone to lose his balance and fall, resulting in casualty.

At higher voltage levels the muscles may contract and the person will be unable to break off from the contact by himself. He may lose consciousness.

At an excessive level of voltage, the person receiving a shock may be thrown off his feet and will experience severe pain and possibly burns at the point of contact.

Electric shock can also cause burning of the skin at the point of contact.

Action to be taken in case of an electric shock

If the victim of an electric shock is in contact with the supply, break the contact the victim is making with the electricity by any one or more of the following.

– Switch off the electric power, insulate yourself and pull away the person from the electrical contact

OR

Remove the mains electric plug. Avoid direct contact with the victim. Wrap your hands using dry cloth or paper, if rubber gloves are not available.

OR

Remove the electric contact made by wrenching the cable/equipment/point free from contact using whatever is at hand to insulate yourself such as a wooden bar, rope, a scarf, the victim's coat-tails, any dry article of clothing, a belt, rolled up newspaper, non-metallic hose, PVC tubing, baked paper, tube etc. and break the contact by pushing or pulling the person or the cable/equipment/point free.

OR

Stand on some insulating material such as dry wood, rubber or plastic, or whatever is at hand to insulate yourself and break the contact by pushing or pulling the person or the cable/equipment/point free.

> **If you are uninsulated, do not touch the victim with your bare hands. Otherwise you also will get a shock and become a victim.**

If the victim is aloft (working on a pole or at raised place), take suitable measures to prevent him from falling or atleast ensure that his fall is safe.

Treatment to be given for the victim of electric shock

Cover the burnt area with a clean, sterile dressing. Get a doctor's help to treat him as quickly as possible.

If the victim is unconscious after an electric shock, but is breathing, carry out the following first aid:

- loosen the clothing at the neck, chest and waist
- place the victim in the recovery position as shown in Fig 18.
- Keep a constant check on the breathing and pulse rate. If you find them feeble, immediately give artificial respiration and press the lower rib to improve the heartbeat.
- Keep the casualty warm and comfortable.
- Send for a doctor immediately.

> **Do not give an unconscious person anything through the mouth.**
>
> **Do not leave a nunconscious person unattended.**
>
> **A person having received electric shock may also have burn injuries. DO NOT waste time by applying first aid to the burns until breathing has been restored and the patient can breathe normally unaided.**

Treatment to be given in case of burns, severe bleeding

Burns caused due to electrical shock are very painful. If a large area of the body is burnt, clean the wound using clear water, or with clean paper, or a clean shirt. This treatment relieves the victim of pain. Do not give any other treatment on your own. Send for a doctor for further treatment.

A wound which is bleeding profusely, especially in the wrist, hand or fingers must be considered serious and must receive a doctor's attention. As an immediate first aid measure, carry out the following;

- make the patient lie down and rest
- if possible, raise the injured part above the level of the body as shown in Fig 19.

Squeeze together the sides of the wound as shown in Fig 20. Apply pressure as long as it is necessary to stop the bleeding.

Fig 19

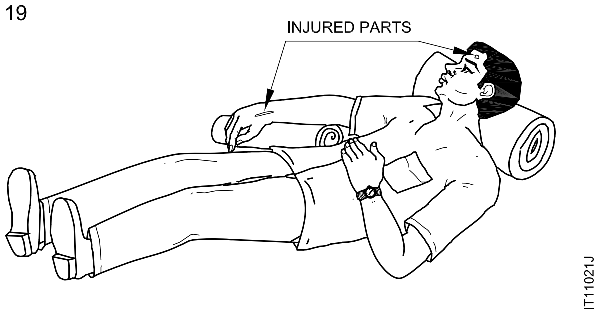
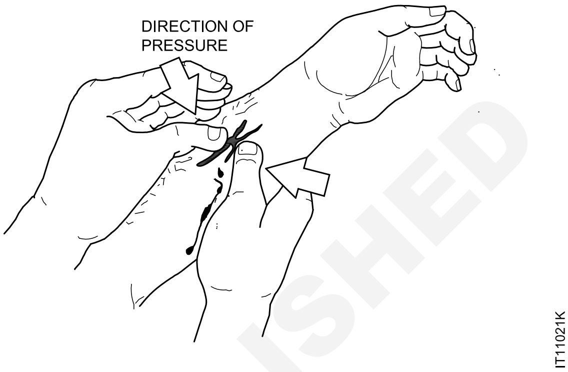
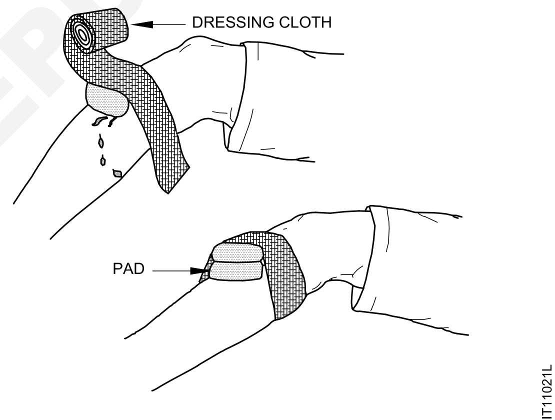


Fig 20



When the bleeding stops temporarily, put a dressing over the wound using sterilized cotton, and cover it with a pad of soft material as shown in Fig 21.

Fig 21



If the wound is in the abdominal area (stab wound), caused by falling on a sharp tool, keep the patient bending over the wound to stop internal bleeding.

General procedural steps to be adopted for treating a person suffering from an electrical shock

1 Observe the situation. Choose the appropriate method (listed in earlier paragraphs) to release the person from electrical contact.

> **Do not run to switch off the supply that is far away or start searching for the mains switch.**

2 Move the victim gently to the nearest ventilated place.

3 Check the victim's breathing and consciousness. Check if there are injuries in the chest or abdomen. Give artificial respiration/applying pressure on the heart if found necessary (refer in this lesson/exercise).

Use the most suitable method of giving artificial respiration depending upon the injuries if any on the chest/abdomen.

4 Send for a doctor.

Till the doctor arrives, you stay with the victim and render help as best as you can.

5 Place the victim in the recovery position.

6 Cover the victim with a coat, socks or any such thing to keep the victim warm.

Actions listed above must be taken sys ematically and briskly. Delay in treating the patient may endanger his life.

First aid

First aid is defined as the immediate care and support given to an acutely injured or ill person, primarily to save life, prevent further deterioration or injury, plan to shift the victims to safer places, provide best possible comfort and finally help them to reach the medical centre/ hospital through all available means. It is an immediate life-saving procedure using all resources available within reach.

First aid procedure often consists of simple and basic life saving techniques that an individual performs with proper training and knowledge.

The key aims of first aid can be summarized in three key points:

- **Preserve life:** If the patient was breathing, a first aider would normally then place them in the recovery position, with the patient leant over on their side, which also has the effect of clearing the tongue from the pharynx. It also avoids a common cause of death in unconscious patients, which is choking on regurgitated stomach contents. The first aider will be taught to deal with this through a combination of 'back slaps' and 'abdominal thrusts'. Once the airway has been opened, the first aider would assess to see if the patient is breathing.
- **Prevent further harm:** Also sometimes called prevent the condition from worsening, or danger of further injury, this covers both external factors.
- **Promote recovery:** First aid also involves trying to start the recovery process from the illness or injury.

Training

To provide effective, life-saving first aid interventions requires instruction and practical training. This is especially true where it relates to potentially fatal illnesses and injuries, such as those that require cardiopulmonary resuscitation (CPR); these procedures may be invasive, and carry a risk of further injury to the patient and the provider. First aid training is often available through community organization such as the Red cross and St. John ambulance.

ABC of firs aid

ABC stands for airway, breathing and circulation.

- **Airway:** Attention must first be brought to the airway to ensure it is clear. Obstruction (choking) is a life-threatening emergency.
- **Breathing:** Breathing if stops, the victim may die soon. Hence means of providing support for breathing is an important next steps. There are several methods practiced in first aid.
- **Circulation:** Blood circulation is vital to keep person alive. The first aiders now trained to go straight to chest compressions through CPR methods.

There are certain basic norms in teaching and training students in the approach and administration of first aid to sick and injured.

Not to get panic

Panic is one emotion that can make the situation more worse. People often make mistake because they get panic. Panic clouds thinking and causes mistakes. First aider need calm and collective approach. Quick and confident approach can lessen the effect of injury.

Call medical emergencies

If the situation demands, quickly call for medical assistance. Prompt approach may save the life.

Surroundings play vital role

Different surroundings require different approach. Hence first aider should study the surrounding carefully.

Do no harm the person while doing first aid procedure unless the situation demands.

Reassurance

Reassure the victim by speaking encouragingly with him.

Stop the bleeding

If the victim is bleeding, try to stop the bleeding by applying pressure over the injured part.

Golden hours: First aid care come handy to save lives with in the golden or critical period. It helps to get to the nearest emergency room as quickly as possible trough safe handling and transportation. The shorter that time, the more likely the best treatment applied.

Maintain the hygiene

Most importantly, first aider need to wash hands and dry before giving and first aid treatment to the patient or wear gloves in order to prevent infection.

Cleaning and dressing

Always clean the wound thoroughly before applying the bandage lightly wash the wound with clean water.

Not to use local medications on cuts or open wounds

CPR (Cardio-Pulmonary Resuscitation) can be life-sustaining

CPR can be life sustaining. If one is trained in PR and the person is suffering from choking or finds difficulty in breathing, immediately begin CPR. However, if one is not trained in CPR, do not attempt as you can cause further injury. CPR, carefully done by highly skilled first aiders is a bridge that keeps vital organs oxygenated until medical team arrives.

How to report an emergency?

Assess the urgency of the situation. Before you report an emergency, make sure the situation is genuinely urgent. Call for emergency services if you believe that a situation is life-threatening or otherwise extremely disruptive.

Call emergency service

The emergency number varies - 100 for Police & Fire, 108 for Ambulance.

Report your location

Give the dispatcher your phone number

Describe the nature of the emergency

Do not hang up the phone until you are instructed to do so. Then follow the instructions you were given.

How to do basic first aid?

Basic first aid allows one to quickly determine a person's physical condition and the correct course of treatment.

Important guideline for first aiders

Evaluate the situation

Remember A-B-Cs

The ABCs of first aid refer to the three critical things the first aiders need to look for.

- Airway - Does the person have an unobstructed airway?
- Breathing - Is the person breathing?
- Circulation - Does the person show a pulse at major pulse points (wrist, carotid artery, groin)

Avoid moving the victim

Avoid moving the victim unless they are immediate danger.

Call emergency services

Call for help or tell someone else to call for help as soon as possible.

Determine responsiveness

If a person is unconscious, try to rouse them by gently shaking and speaking to them.

If the person remains unresponsive, carefully roll them on the side (recovery position) and open his airway.

- Keep head and neck aligned.
- Carefully roll them onto their back while holding his head.
- Open the airway by lifting the chin.

Look, listen and feel for signs of breathing

Look for the victim's chest to raise and fall, listen for sounds of breathing.

Fig 1

If the victim is not breathing, see the section below

- If the victim is breathing, but unconscious, roll them onto their side, keeping the head and neck aligned with the body. This will help drain the mouth and prevent the tongue or vomit from blocking the airway.

Check the victim's circulation

Look at the victim's colour and check their pulse If the victim does not have a pulse, start CPR.

Treat bleeding, shock and other problems as needed

After establishing that the victim is breathing and has a pulse, next priority should be to control any bleeding. Particularly in the case of trauma, preventing shock is the priority.

- **Stop bleeding:** Control of bleeding is one of the most important things to save a trauma victim. Use direct pressure on a wound before trying any other method of managing bleeding.
- **Treat shock:** Shock, a loss of blood flow to the body, frequently follows physical and occasionally psychological trauma. A person in shock will frequently have ice cold skin, be agitated or have an altered mental status, and have pale colour to the skin around the face and lips. Untreated, shock can be fatal. Anyone who has suffered a severe injury or life-threatening situation is at risk for shock.
- **Choking victim:** Choking can cause death or permanent brain damage within minutes.
- **Treat a burn:** Treat first and second degree burns by immersing or flushing with cool water. Don't use creams, butter or other ointments, and do not pop blisters. Third degree burns should be covered with a damp cloth. Remove clothing and jewellery from the burn, but do not try to remove charred clothing that is stuck to burns.
- **Treat a concussion:** If the victim has suffered a blow to the head, look for signs of concussion. Common symptoms are: loss of consciousness following the injury, disorientation or memory impairment, vertigo, nausea, and lethargy.
- **Treat a spinal injury victim:** If a spinal injury is suspected, it is especially critical, not move the victim's head, neck or back unless they are in immediate danger.

Stay with the victim until help arrives: Try to be a calming presence for the victim until assistance can arrive.

Unconsciousness (COMA): Unconscious also referred as Coma, is a serious life threatening condition, when a person lie totally senseless and do not respond to calls, external stimulus. But the basic heart, breathing, blood circulation may be still intact, or they may also be failing. If unattended it may lead to death.

The condition arises due to interruption of normal brain activity.

The following symptoms may occur after a person has been unconscious:

- Confusion
- Drowsiness
- Headache
- Inability to speak or move parts of his or her body (see stroke symptoms)
- Light headedness
- Loss of bowel or bladder control (incontinence)
- Rapid heartbeat (palpitation)
- Stupur

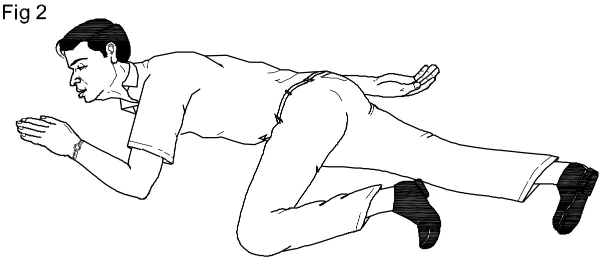
First aid

- Call EMERGENCY number.
- Check the person's airway, breathing, and pulse frequently. If necessary, begin rescue breathing and CPR.
- If the person is breathing and lying on the back and after ruling out spinal injury, carefully roll the person onto the side, preferably left side. Bend the top leg so both hip and knee are at right angles. Gently tilt the head back to keep the airway open. If breathing or pulse stops at any time, roll the person on to his back and begin CPR.
- If there is a spinal injury, the victims position may have to be carefully assessed. If the person vomits, roll the entire body at one time to the side. Support the neck and back to keep the head and body in the same position while you roll.
- Keep the person warm until medical help arrives.
- If you see a person fainting, try to prevent a fall. Lay the person flat on the floor and raise the level of feet above and support.
- If fainting is likely due to low blood sugar, give the person something sweet to eat or drink when they BECOME CONSCIOUS.

DO NOT

- Do not give an unconscious person any food or drink.
- Do not leave the person alone.
- Do not place a pillow under the head of an unconscious person.
- Do not slap an unconscious person's face or splash water on the face to try to revive him.

Fig 2



How to diagnose an unconscious injured person

- Consider alcohol: look for signs of drinking, like empty bottles or the smell of alcohol.
- Consider epilepsy: are there signs of a violent seizure, such as saliva around the mouth or a generally disheveled scene?
- Think insulin: might the person be suffering from insulin shock (see 'How to diagnose and treat insulin shock")?
- Think about drugs: was there an overdose? Or might the person have under dosed - that is not taken enough of a prescribed medication?
- Consider trauma: is the person physically injured?
- Look for signs of infection: redness and/ or red streaks around a wound.
- Look around for signs of Poison: an empty bottle of pills or a snakebite wound.
- Consider the possibility of psychological trauma: might the person have a psychological disorder of some sort?
- Consider stroke, particularly for elderly people.
- Treat according to what you diagnose.

Symptoms of shock

Victims appear pale, ice cold, pulse appear initially faster and gets slower, breathing become shallow. Weakness, dizziness, confusion continue. If unattended the patient may become unconscious and die.

Shock kills, so it is vital that you can recognize these signs and symptoms.

First aid

Keep the patient warm and at mental rest. Assure of good air circulation and comfort. Call for help to shift the patient to safer place/ hospital.

- **Warmth:** Keep the victim warm but do not allow her to get overheated. If you are outside, try to get something underneath her if you can do easily. Wrap blankets and coats around her, paying particular attention to the head, through which much body heat is lost.
- **Air:** Maintain careful eye on the victim's airway and be prepared to turn her into the recovery position if necessary, or even to resuscitate if breathing stops. Try to keep back bystanders and loosen tight clothing to allow maximum air to victim.
- **Rest:** Keep the victim still and preferably sitting or lying down. If the victim is very giddy, lay her down with her legs raised to ensure that maximum blood and therefore maximum oxygen is sent to the brain.

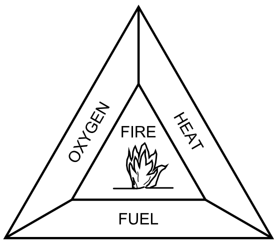
Fire Extinguisher

Objectives: At the end of this lesson you shall be able to
- **state the effects of a fire break out**
- **state the conditions required for combustion relevant to fire prevention**
- **state the general precautionary measures to be taken for fire prevention**
- **determine the correct type of fire extinguisher required for a particular function.**

Fire

Fire is nothing but burning of a combustible material. For combustion the three main requirements are shown in Fig 1.

Fig 1



Fuel

Fuel can be any combustible substance in the form of a solid, liquid or gas. Examples; wood, paper, petrol, kerosene, LPG etc., The fuel will catch fire and burn provided a high enough temperature(heat) is brought about and a continuous supply of oxygen is given. It is important to note that without fuel, combustion cannot take place.

Heat

Fuels will begin to burn at a certain temperature. Different types of fuels need different temperatures to catch fire and burn. For example, wood needs a higher temperature to catch fire and burn than paper. Petrol needs much lesser temperature to catch fire and burn than paper. Generally liquid fuels give off vapour when heated. It is this vapour which ignites. Some liquids such as petrol do not have to be heated as they give off vapour at room temperature (15^oC - 25^oC) itself. It is important to note that without heat, fuel cannot get ignited (catch fire) and hence combustion cannot take place.

Oxygen

Oxygen exists in air. The amount of oxygen in air is sufficient to continue the combustion once it occurs. Hence to keep a fire burning, oxygen is a must. It is important to note that without oxygen, combustion cannot continue to take place.

Controlled and uncontrolled fire

Fire is a boon to mankind. Without fire, there would not be cooked food or hot water for bath as and when we want it. At the same time if the fire does not get constrained to a place of requirement, fire can become a bane(curse) to mankind. An uncontrolled fire can cause such a disaster which not only leads to destruction of material but also endanger the life of persons. Hence, the lesson one must never forget is, *keep the fire under control.* Every effort must be made to prevent uncontrolled fire. When there is a fire outbreak, it must be controlled and extinguished immediately without any delay.

Preventing fire

The majority of fires begin with small outbreaks. If this is not noticed, fire goes out of control and will be on its way of destruction. Hence, most fires could be prevented if suitable care is taken by following some simple common sense rules as given below.

- Do not accumulate combustible refuse such as cotton waste, waste or cloth soaked with oil, scrap wood, paper, etc. in odd corners. These refuse should be in their collection bins or points.
- Do not misuse or neglect electrical equipments or electrical wiring as this may cause electrical fire. Loose connections, low rated fuses, overloaded circuits causes over heating which may in turn lead to fire. Damaged insulation between conductors in cables cause electrical short circuit and cause fire.
- Keep away clothing and other materials which might catch fire from heating appliances. Make sure the soldering iron is disconnected from power supply and is kept safe in its stand at the end of the working day.
- Store highly flammable liquids and petroleum mixtures such as thinner, adhesive solutions, solvents, kerosene, spirit, LPG gas etc. in the storage area exclusively meant for storage of flammable materials.
- Turn off blowlamps and torches when they are not in use.

Controlling and Extinguishing fire

Isolating or removing any of three factors illustrated in Fig 1, will control and extinguish fire. There are three basic ways of achieving this.

1. **Starving the fire of fuel**

   To remove the fuel which is burning or cut further supply of fuel to the fire.

2. **Smothering**

   To stop the supply of oxygen to the fire by blanketing the fire with foam, sand etc.

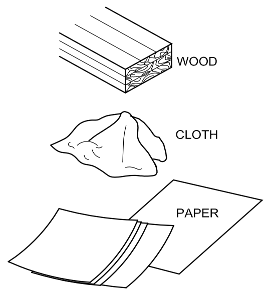
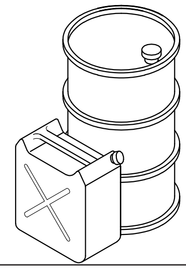
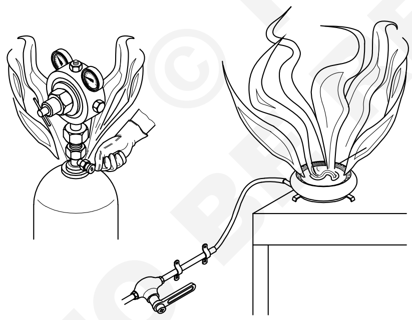
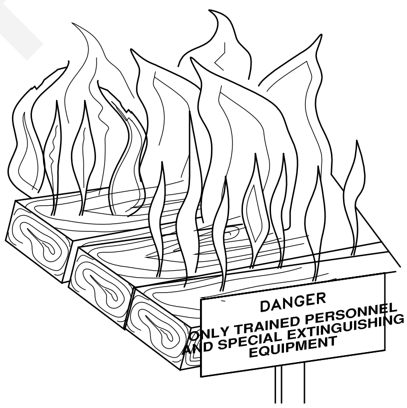
3. **Cooling**

   To reduce the temperature of the fire by spraying water and thus cooling the fire.

By any one of the above three methods, fire can be first controlled and then extinguished.

For the purpose of determining the best method of extinguishing different types of fires, fires are classified under four main classes based on the type of fuel as given in Table 1.

TABLE 1

Classification of Fire	Fuel involved	Precautions and extinguishing
Class A Fire	Wood, paper cloth etc. 	Most effective method is cooling with water.
Class B Fire	Solid materials Flammable liquids & liquefiable solids 	Jets of water should be sprayed on the base Should be smothered. The aim is to cover the entire surface of the burning liquid. This has the effect of cutting off the supply of oxygen to the fire. Water should never be used on burning liquids. Foam, dry powder or CO_2 may be used on this type of fire.
Class C Fire	Gas and liquefied gas 	Extreme caution is necessary in dealing with liquefied gases. There is a risk of explosion and sudden outbreak of fire in the entire vicinity. If an appliance fed from a cylinder catches fire -shut off the supply of gas. The safest course is to raise an alarm and leave the fire to be dealt with by trained personnel. Dry powdered extinguishers are used on this type of fire.
Class D Fire	Involving metals 	The standard range of fire extinguishing agents is inadequate or dangerous when dealing with metal fires. **Fire in electrical equipment**: Carbon dioxide, dry powder, and vapourising liquid(CTC) extinguishers can be used to deal with fires in electrical equipment. Foam or liquid (eg. water) extinguishers must not be used on electrical equipment at all.

Fire extinguishers

Different fire extinguishing agents should be used for different types of fires as listed in Table 1. Using a wrong type of extinguishing agent can make things worse.

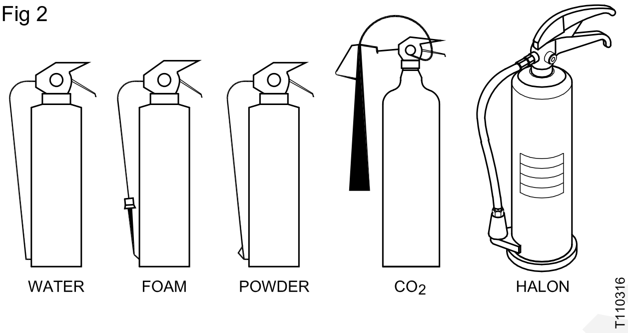
A fire extinguishing agent is the material or substance used to put out the fire. These extinguishing materials are usually (but not always) contained in a container called the 'fire extinguisher' with a mechanism for spraying into the fire when needed.

There is no classification for **electrical fires** as such as these are only fires in materials where electricity is present. To control electrical fire in a building the electrical supply should be cut off first.

Types of fire extinguishers

Many types of fire extinguishers are available with different extinguishing *agents* to deal with different classes of fires as shown in Fig 2.

Fig 2



Water-filled extinguishers

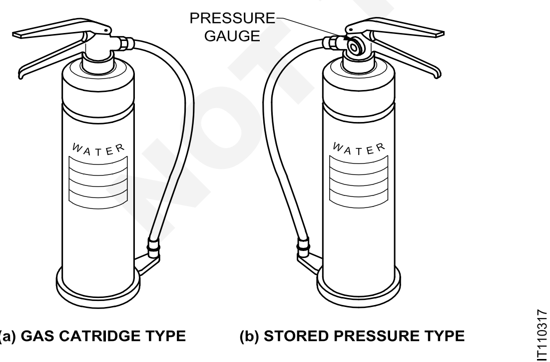
In water-filled extinguishers, as shown in Fig 3, there are two types based on the method of operating the extinguisher.

a Cartridge type

b Stored pressure type

In both the methods of operation, the discharge can be interrupted as required. This is to conserve the contact area and to prevent unnecessary damage to the material due to water.

Fig 3



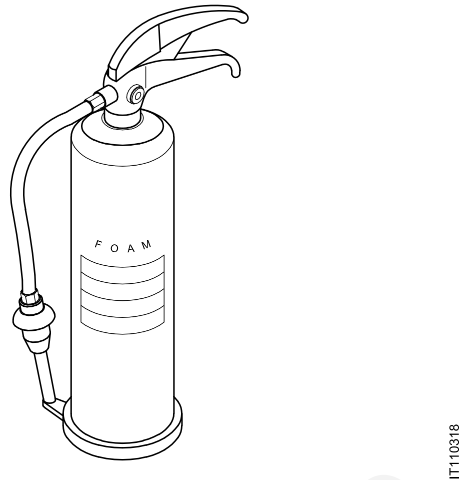
Foam extinguishers: These may be stored pressure or gas cartridge types as shown in Fig 4.

Most suitable for:

– flammable liquid fires

– running liquid fires.

Fig 4

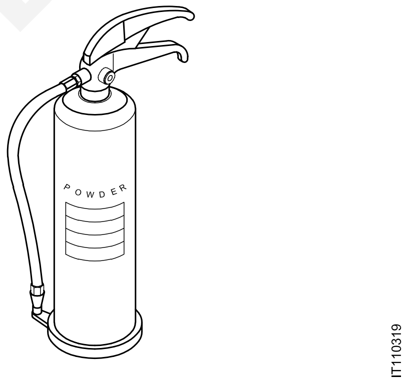


Not to be used in fires where electrical equipment is involved.

Dry powder extinguishers

Extinguishers fitted with dry powder may be of the gas cartridge or stored pressure type as shown in Fig 5. Appearance and the method of operation is the same as that of water-filled one. The main distinguishing feature is the fork-shaped nozzle. Powders have been specially developed to deal with Class D fires.

Fig 5



Carbondioxide (CO_2)

This type is easily distinguished by the distinctively shaped discharge horn as shown in Fig 6. These extinguishers are suitable for fires on flammable liquids and liquefiable solids. Best suited where contamination by deposits must be avoided. Not generally effective in the open air.

Halon Extinguishers (Fig 7)

Carbon tetrachloride(CTC) and Bromo chlorodifluoro methane (BCF). They may be either gas cartridge or non-conductive.

The fumes given off by these extinguishers are dangerous especially in confined space.

General procedure to be adopted in the event of a fire

1 Raise a loud alarm by using any of the following.

Adopt any one method of giving an alarm signal for fire breaking in your institute/ workshop.

– Raising your voice and shouting Fire! Fire!Fire! .... to call the attention of others.

Fig 6

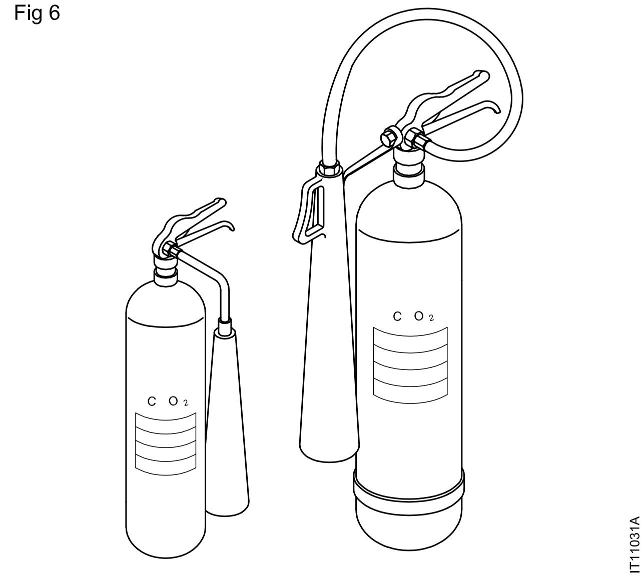


Fig 7

– Running towards the fire shouting Fire! Fire! and actuate fire alarm/bell/siren. This alarm/bell/siren to be actuated only in case of fire.

– Any other means by which the attention of others can be called and are made to understand there is a fire break out.

2 On receipt of the fire alarm signal, do the following:

– stop the normal work you are doing

– turn off the power for all machinery and equipments

– switch off fans/air circulators/exhaust fans

– switch off the mains if accessible.

3 If you are not involved in fire fighting team, then,

– evacuate the working premises

– close the doors and windows, but do not lock or bolt

– assemble at a safe open place along with the others

– if you are in the room/place where the fire has broken out, leave the place calmly through the emergency exit.

4 If you are involved in the fire fighting team,

– take instructions/give instructions for an organized way of fighting the fire.

If you are taking instructions,

– follow the instructions systematically. Do not panic. Do not get trapped in fire or smoke in a hurry.

If you are giving instructions,

– assess the class of fire (class A,B,C or D)

– send for sufficient assistance and fire brigade

– judge the magnitude of the fire. Locate locally available suitable means to put-out the fire.

– ensure emergency exit paths are clear of obstructions. Attempt to evacuate the people and explosive materials, substances that can serve as further fuel for fire within the vicinity of the fire break.

– Allot clear activity to persons involved in firefighting by name to avoid confusion.

– Control and extinguish the fire using the right type of fire extinguisher and making use of the available assistance effectively.

5 After fully extinguishing the fire, make a report of the fire accident and the measures taken to put out the fire, to the authorities concerned.

Reporting all fires however small they are, helps in the investigation of the cause of the fire. It helps in preventing the same kind of accident occurring again.

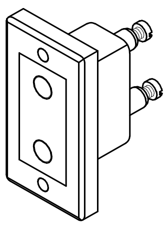
Concept of Fuses & switches

Objectives: At the end of this lesson you shall be able to
- **state the functions, types and specifications of electrical accessories**
- **state the necessity of a fuse.**

Sockets

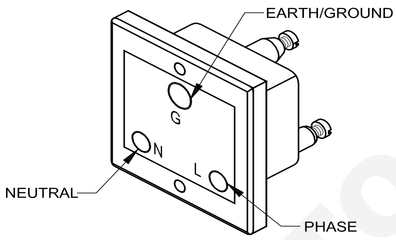
Function of the socket is to keep the AC main supply made available and it can be used whenever required. The types of the sockets are normally 2 pins, 3 pins and 5 pins sockets. In that 2 pin socket will not be having earth point but 3 pin and 5 pin sockets will have earth point. The purpose of providing earth point is to give easiest path for leakage current on the metal body of electrical apparatus/ equipment such as heaters, iron boxes, radios, tape recorders and computers etc. Specifications of the sockets are generally two pin 5A/240V, three pin 5A/240V, 15A/ 240V, two-in-one 5A/240V, 15A/240V. In 3 or 5 pin socket line point always right side, neutral point always left side and top point always earth terminal.

Fig 1



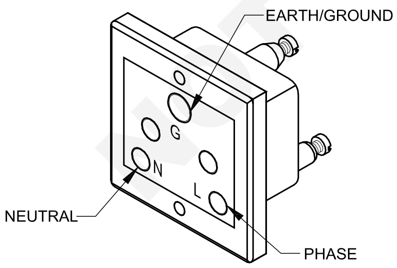
240V,5A,2PIN SOCKET

Fig 2



240V,5A,3PIN SOCKET

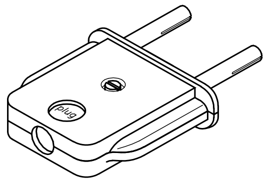
Fig 3



240V,5A,5PIN SOCKET

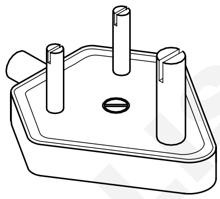
Plugs: The purpose of plug is to take supply from the sockets. In two pin plug there will not be earth point but in 3 pin plug earth point will be available. In 3 pin plug one pin will be bigger in size it is called earth pin. Plugs are made up of Bakelite or PVC materials. The specifications of the plugs are normally two pin 5A/240V, 3 pin 5A/240V, 3 pin 15A/240V.

Fig 4



2PIN PLUG

Fig 5



3PIN PLUG

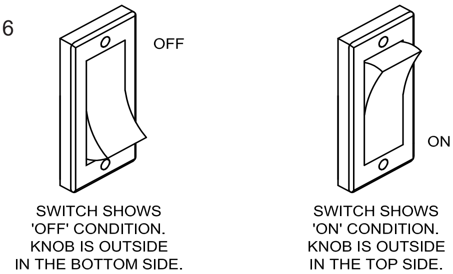
switches

A switch is an electrical component that can break an electrical circuit, interrupting the current or diverting it from one conductor to another.

The most familiar form of switch is a manually operated electromechanical device with one or more sets of electrical contacts, which are connected to external circuits. Each set of contacts can be in one of two states: either "closed" meaning the contacts are touching and electricity can flow between them, or "open", meaning the contacts are separated and the switch is non conducting. The mechanism actuating the transition between these two states (open or closed) can be either a "toggle" (flip switch for continuous "on" or "off") or "momentary" (push-for "on" or push-for "off") type.

An ideal switch would have no voltage drop when closed, and would have no limits on voltage or current rating

Fig 6



FLUSH MOUNTING SWITCHES

Different Types of Switches

Toggle Switch

Toggle switches are triggered by a device in one of two or more positions. Household light switch wiring is an example of a toggle switch. The toggle switch is usually a two position switch. The inside structure has a spring such that it is held tightly in the position to which it has been switched. It is generally used for switching purposes on or off. Many versions are able to tolerate switching 250 VAC at current levels of around 1 amp.

Fig 7

Push Button Switch

Push button switches are mostly used in many electronic circuits and design. These switches required to give a momentary connection. Instead they can be used to deliver a push on - push off action. Pushbutton switches are two-position devices triggered with a button that is pushed and released. Most of it has an internal spring tool that returns the button to its "out" position and "in" position.

Push Button Switch Positions

Fig 8

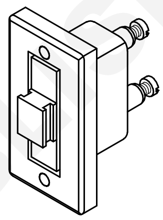
Rotary Switch

As the name denotes, rotary switches are activated by rotating a knob. Choosing the correct position allows the relevant connections to be completed. As rotary switches can have different positions, they permit a particular point to be connected to one of a number of other points in the electronics circuit. Another type of switch is rotary switch consists of three levels attached on a common shaft.

Fuses

Fuse is meant for break the electric supply when short circuit or over current takes place and it will act as a protective device. There are several types of fuses are available in the market, they are flush type, glass fuse, kit-kat fuse, HRC fuse and semiconductor fuse etc. Fuses are slow blow type and fast blow type according to the equipment/device The specifications of the fuses are normally 100mA, 200mA, 500mA (glass type), 5A/240V (flush type) 25A, 50A, 75A, 100A HRC (High ruptchering capacity)/Semiconductor type.

Fig 10

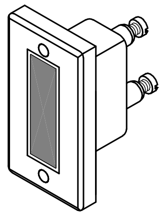


Indicators

The purpose of providing indicator in equipment/device is to identify the electric supply is available or not, after switch on the main supply. Built in type with switch and separate neon indicator lamps are generally used. Indicators are found is all electrical as well as electronics equipements such as nonauto/auto iron box, xerox machine, heaters, power supplies and computers etc

The specification of the indicators are 5A/240V flush type,12V/24V indicators lamps etc.

Fig 11



Meter range & measure types

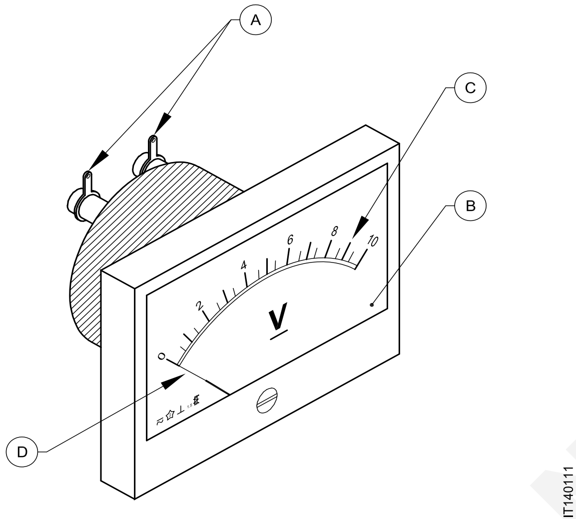
Objectives: At the end of this lesson you shall be
- **state the use of meters**
- **list the basic parts of a simple meter**
- **list the minimum specifications that go with any meter**
- **list the symbols used on meter dial and interpret their meaning.**

Meters are instruments used to measure electrical quantities like voltage, current, resistance etc.,

Measurement of electrical quantities is necessary while installing, operating, testing & repairing electrical & electronic equipments and circuits.

A simple meter is shown in Fig 1.

Fig 1



The electrical quantity to be measured is given to the input terminals (A) of the meter. The internal meter movement or mechanism moves the pointer(D) over the graduated scale(C) marked on a plate called the dial plate(B). The pointer stops at a point on the scale which corresponds to the magnitude of the input given at the input terminals(A).

Any simple meter must have the following minimum specifications.

[1] The electrical parameter it can measure.

Example: DC voltage, AC voltage, DC current, AC current, resistance and so on.

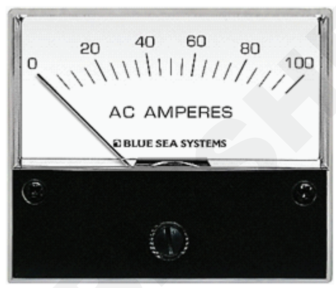
[2] The maximum quantity that it can measure.

Example: 10 volts, 100 volts, 1 ampere and so on.

Ammeter (Fig 2)

- Ammeter is an electronic instruments device used to determine the electric current flowing through a circuit. Ammeters measuring current in milli-ampere range is known as milli-ammeters.
- Ammeters are connected in series to the circuit whose current is to be measured. Hence this electronic instruments are designed to have as Very Low resistance/ loading as possible.
- There are two types of ammeters: DC ammeter, and AC ammeter.
- DC ammeter measures the DC current that flows through any two points of an electric circuit. Whereas, AC ammeter measures the AC current that flows through any two points of an electric circuit.
- An example of practical AC ammeter is shown in figure which is a (0?100A) AC ammeter. Hence, it can be used to measure the AC currents from zero Amperes to 100 Amperes.

Fig 2



Voltmeter (Fig 3)

- Voltmeter is an electronic instruments used in an electric circuit to determine the potential difference or voltage between two different points.
- Voltmeters are usually connected in parallel (shunt) to the circuit. Hence they are designed to have High resistance as possible to reduce the loading effect.
- There are two types of voltmeters: DC voltmeter, and AC voltmeter i.e RMS value of Voltage.
- DC voltmeter measures the DC voltage across any two points of an electric circuit, whereas AC voltmeter measures the AC voltage across any two points of an electric circuit.
- An example of practical DC voltmeter is shown in figure which is a (0?10V)DC voltmeter. Hence, it can be used to measure the DC voltages from zero volts to 10 volts.

Fig 3

Ohmmeter (Fig 4)

- Ohmmeter is used to measure the value of Resistance between any two points of an electric circuit. It can also be used for finding the value of an unknown resistor.

- There are two types of ohmmeters: series ohmmeter, and shunt ohmmeter.
- In series type ohmmeter, the resistor whose value is unknown and to be measured should be connected in series with the ohmmeter. It is useful for measuring high values of resistances.
- In shunt type ohmmeter, the resistor whose value is unknown and to be measured should be connected in parallel (shunt) with the ohmmeter. It is useful for measuring low values of resistances.
- An example of practical shunt ohmmeter is shown in the figure, which is a (0?100?) shunt ohmmeter. Hence, it can be used to measure the resistance values from zero ohms to 100 ohms.

Fig 4

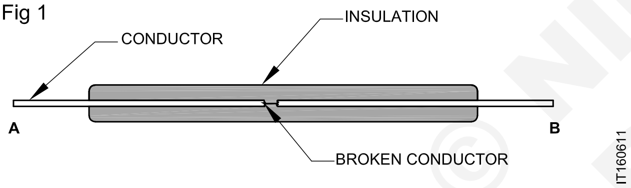
Simple AC, DC Circuits and measure current & voltage

Objectives : At the end of this lesson you shall be able to
- **state the meaning and need of continuity test**
- **define an electric/electronic circuit.**

Continuity Testing

Due to continuous usage and/or rough handling, wires, cables, meter probes etc, becomes defective. One of the most common defect in wires and cables is that, the conductor(s) inside the insulation of the wire gets cut/ broken as shown in Fig 1.

Fig 1



Such defects in wires are not visually detectable because of the insulation over the conductor. The only way to check such a defect is by checking whether continuity exists along the wire or not.

A wire (conductor) without a cut will have *zero ohms of resistance* across its ends. Whereas a conductor *with a cut* will have almost *infinite resistance*. Checking whether the wire has zero resistance or infinite/very high resistance is referred to as *continuity testing*.

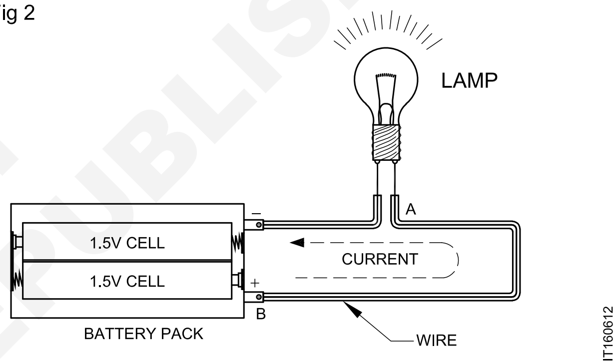
Circuit

A circuit is nothing but, several electrical, electronic components connected in a pre-defined way and energised by a voltage source.

A circuit can be defined as any closed path consisting of two or more electrical/electronic components through which electric current can flow. Fig 2 shows a simple circuit consisting of a battery pack and a lamp interconnected using wires.

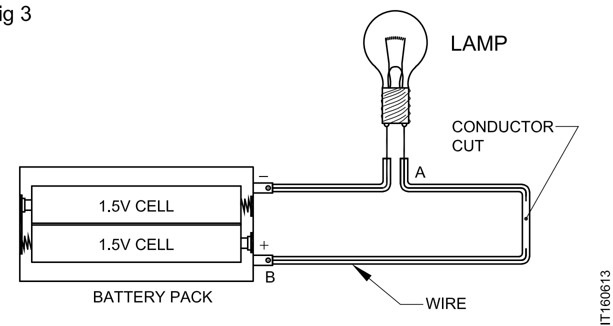
In the circuit in Fig 2 the direction of arrows indicates the direction of current flow.

Fig 2



The voltage source makes the current to flow through the closed circuit. Since, the lamp is a part of this closed circuit, the lamp glows.

Fig 3



From the above it is evident that,

– the lamp *glows* if wire AB has continuity or does not have **breaks or cut**

– the lamp *does not glow* if wire AB has a **discontinuity** or breaks or cuts.

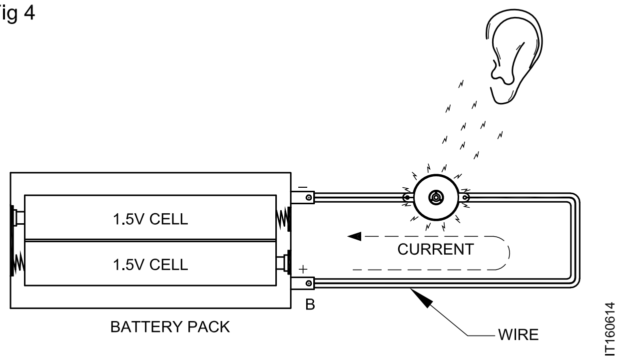
Hence, this circuit shown in Fig 2, can be used as a *continuity tester* by connecting a wire to be tested across A and B of the circuit. This circuit can, therefore, be called a **continuity tester**.

A buzzer is an electromechanical device which produces a buzzing sound when current is made to flow through it.

Continuity tests although can be carried out using an ohmmeter, simple aural or visual continuity testers are easy and is cost-effective. Hence, continuity tester is one of the very important test instruments for electrical and electronic technicians.

In addition to testing the continuity of wires, continuity testers find several applications as given below;

Fig 4



Multimeter

Objectives: At the end of this lesson you shall be
- **state the uses of multimeter and their types**
- **compare analog and digital multimeter.**

Multimeter: A multimeter is an instrument in which the function of an ammeter, voltmeter and ohmmeter are all incorporated for measurement of current, voltage and resistance. Some manufacturers call this as VOM meter as this meter is used as a volt, ohm and milliammeter. The multimeter uses the basic d' Arsonval (P.M.M.C) movement for all these measurements. This meter has facilities through various switches to change the internal circuit to convert the meter into a voltmeter, ammeter or ohmmeter.

Types of multimeters: There are two types of multimeters available in the market. They are:

- ordinary multimeter having passive components in the internal circuitry
- electronic multimeter having active and passive components in the internal circuitry.

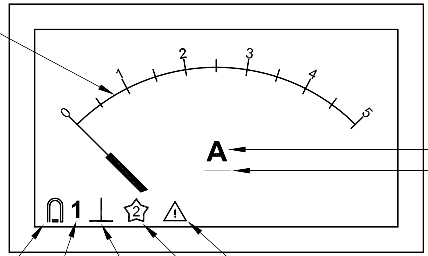
Though the ordinary multimeters are of an analog type, the electronic multimeters can be either analog or digital type. Most of the ordinary multimeters will have a sensitivity of 20 K ohms per volt whereas electronic multimeters have internal resistance to the tune of 5 to 10 megohms, irrespective of the selected ranges.

Comparison of analogue and digital multimeters

Analoque type	Digital type
1 Instrument has moving exercised. Position of use fixed.	There are no moving pointer.Careshould be parts. Used in any position.
2 Reading error due to parallax is possible.	No reading error as they have numerical display.
3 Actual value of indication obtained by computation.	No need to compute. Direct indication of value.
4 Manual zero setting for resistance measurement is required.	Automatic zero setting for resistance measurement.
5 Auto-range setting not possible.	Auto-ranging instruments are available.
6 It can track short term variations and trends in measured quantity.	Not possible - slow response.
7 Indication of measured quantity by the pointer over the graduated scale	Digital numerical read-out.
8 Loads the measuring of circuit.	Practically no loading.

Chart 1

SYMBOLS ON METERS



Scale Marking Linear / Non Linear

Indicates the type of meter

Symbol on meter dial	Meaning of the Symbol
V	VOLTMETER
mV	milli–VOLTMETER
mV	micro–VOLTMETER
A	AMMETER
mA	milli–AMMETER
mA	micro–AMMETER
W	OHMMETER
OHMS	OHMMETER

Indicates the reading of AC/DC

Symbol	Meaning of the Symbol
	DC VOLTAGE OR CURRENT
	DC VOLTAGE OR CURRENT
	AC VOLTAGE OR CURRENT
CURRENT	AC / DC VOLTAGE OR

Indicates the type of mechanism/principle of the meter pointer movement associated with the meter.

Symbol	Meaning of the Symbol
ग द	MOVING COIL
	MOVING COIL WITH PERMANENT MAGNET
	MOVING COIL WITH RECTIFIER
	MOVING COIL WITH THERMAL CONVERTER/ THERMO COUPLE
	MOVING COIL WITH THERMAL CONVERTER ISOLATED
	MOVING COIL QUOTIENT MEASURING
	INDUCTION TYPE
	INDUCTION QUOTIENT MEASURING
	HOT WIRE
	BIMETALL IC
	VIBRATING REED

Symbol	Meaning of the Symbol
ग द	MOVING IRON
	MOVING IRON
	MOVING IRON QUOTIENT MEASURING
	MOVING COIL NEEDLE / MAGNET
	MOVING MAGNET QUOTIENT MEASURING
	ELECTRO DYNAMIC CORELESS
	ELECTRO DYNAMIC QUOTIENT MEASURING CORELESS
	ELECTRO DYNAMIC WITH IRON CORE
	ELECTRO DYNAMIC QUOTIENT MEASURING WITH IRON CORE
	ELECTRO STATIC

Indicates percentage error in the indicated meter reading.

Symbol	Meaning of the Symbol
1	±1% error expressed as a percentage of the end value of measuring range
1.5	± 2.5 % error expressed as a percentage of the end value of measuring range
1.5	± 1.5 % error expressed as a percentage of the total scale length of width.
1.5	± 1.5 % error expressed as a percentage of true value.

Indicates the placement position of the meter

Symbol	Meaning of the Symbol
	VERTICAL POSITION
	VERTICAL POSITION PERMISSIBLE DEPARTURE ± 2^0 FROM VERTICAL POSITION
	HORIZONTAL POSITION
	HORIZONTAL POSITION PERMISSIBLE DEPARTURE ± 10 ^{0} FROM HORIZONTAL POSITION
60°	INCLINED POSITION ANGLE OF INCLINATION 60^0 FROM HORIZONTAL

Indicates special instructions that go with the meter.

Symbol	Meaning of the Symbol
0	**NO TEST VOLTAGE**
	TEST VOLTAGE 500VOLTS
1	**TEST VOLTAGE 1KILOVOLTS**
2	**TEST VOLTAGE 2KILOVOLTS**

Indicates special instructions that go with the meter.

Symbol	Meaning of the Symbol
	MAGNETIC SHIELD
	ELECTROSTATIC SHIELD
!	ATTENTION READ INSTRUCTIONS BEFORE USE..

Resistors and finding its value

Objectives: At the end of this lesson you shall be able to
- **state the function of a resistor in a circuit and unit of resistance**
- **name and list the classifications of resistors**
- **state the meaning of tolerance in resistor and power rating**
- **find the resistance value using colour code.**

Resistors

Resistors are electronic components, used to reduce, or limit, or resist the flow of current in any electrical or electronic circuit. Chart 1 at the end of this lesson shows different types of resistors.

Fig 1 shows a circuit in which the bulb glows brightly. Fig 2 shows the same circuit with a resistor, and the bulb glows dim. This is because, the current in the circuit is reduced by the 1000 ohms resistor. If the value of this resistor is increased, current in the circuit will be further reduced and the light will glow even dimmer.

Fig 1

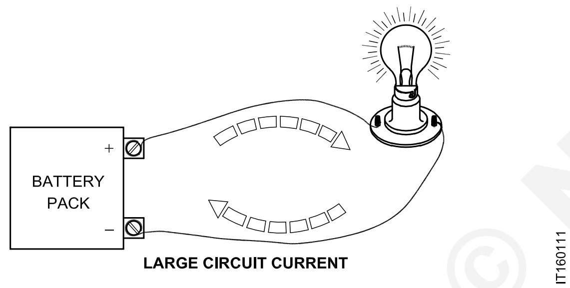
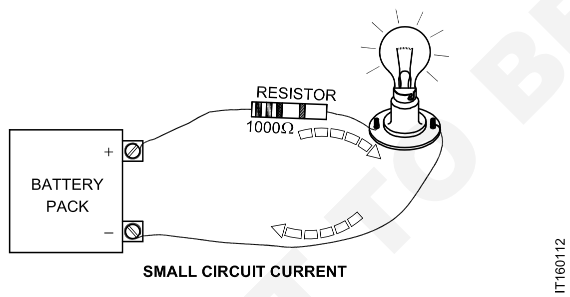


Fig 2



Resistors are made of materials whose conductivity fall in-between that of conductors and insulators. This means, the materials used for making resistors have free electrons, but not as many as in conductors. Carbon is one such material used most commonly for making resistors.

When a large number of electrons are made to flow through a resistor, there is opposition to the free flow of electrons. This opposition results in generation of heat.

Unit of RESISTANCE: The property of the resistor to limit the flow of current is known as *resistance*. The value, or quantity of *resistance* is measured in units called ohms denoted by the symbol Ω .

Resistors are called *passive devices* because, their resistance value does not change even when the level of applied voltage or current to it is changed. Also, the resistance value remains same when the applied voltage is AC or DC.

Resistors can be made to have very small or very large resistance. Very large values of resistances can be represented as given below;

$1000\ \Omega = 1 \times 1000\ \Omega = 1 \times \text{kilo}\Omega = 1\ \text{K}\Omega$

$10{,}000\ \Omega = 10 \times 1000\ \Omega = 10 \times \text{kilo}\Omega = 10\ \text{K}\ \Omega$

$100{,}000\ \Omega = 100 \times 1000\ \Omega = 100 \times \text{kilo}\ \Omega = 100\ \text{K}\Omega$

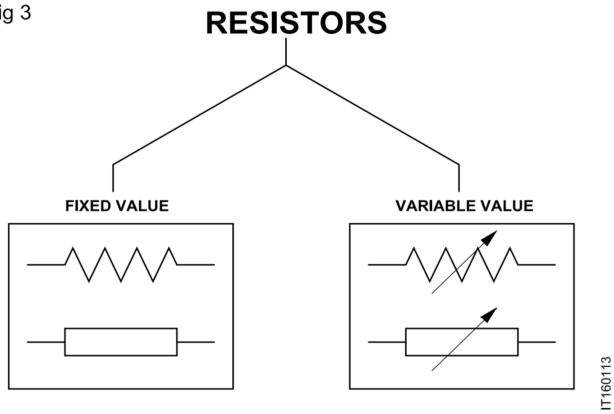
$1000{,}000\ \Omega = 1000 \times 1000\ \Omega = 1000 \times \text{kilo}\ \Omega = 1000\text{K}\Omega$

$1000\text{k}\ \Omega = 1\text{M}\Omega$

Classification of Resistors

Resistors can be classified under two main categories as shown in Fig 3.

Fig 3



Its ohmic value is fixed. This value cannot be changed by the user. Resistors of standard fixed values are manufactured for use in majority of applications.

Fixed resistors are manufactured using different materials and by different methods. Based on the material used and their manufacturing method/process, resistors carry different names.

Fixed value resistors can be classified based on the type of material used and the process of making as follows.

FIXED VALUE RESISTORS

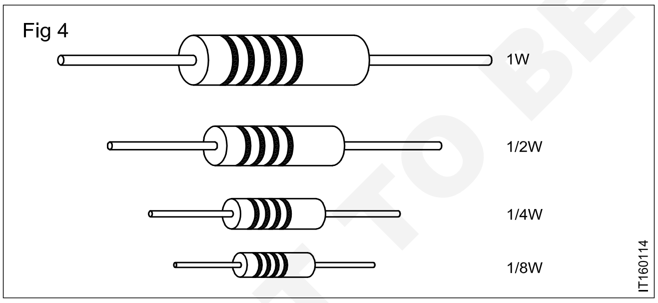
- Carbon composition resistors
- Wire-wound resistors
- Film resistors
  - Carbon - film resistors
  - Metal film resistors
  - Metal oxide film resistors
  - Cermet film resistors
  - Integrated resistors
- Printed resistors

Physical appearance of some types of fixed value resistors is shown in Chart 1 at the end of this lesson.

Power rating: When current flows through a resistor, heat is generated. The heat generated in a resistor will be proportional to the product of applied voltage (V) across the resistor and the resultant current (I) through the resistor. This product VI is known as *power*. The unit of measurement of power is *watts*.

The physical size of a resistor should be sufficiently large to dissipate the heat generated. The higher the physical size, the higher is the heat that a resistor can dissipate. This is referred to as the power rating or wattage of resistors. Resistors are manufacturers to withstand different power ratings. Fig 4 illustrates comparative physical sizes of different wattage resistors. If the product of V and I exceeds the maximum wattage a resistor can dissipate, the resistor gets charred and loses all its property. For instance, if the applied voltage across a 1 watt resistor is 10 volts resulting in 0.5 Amps of current through the resistor, the power dissipated (VI) by the resistor will be 5 watts. But, the maximum power that can be dissipated by the 1W resistor is much less. Therefore, the resistor will get overheated and gets charred due to overheat.

Fig 4



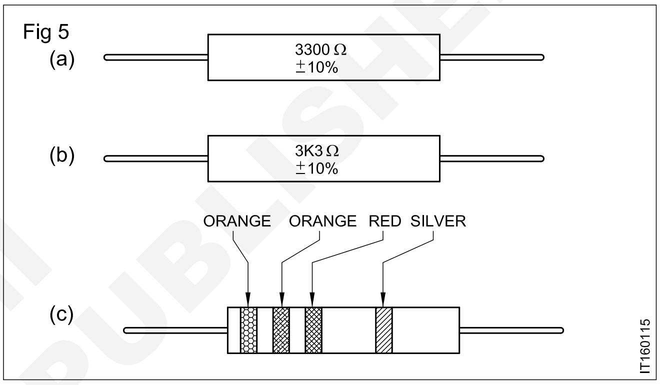
Hence, before using a resistor, in addition to its ohmic value, it is important to choose the correct wattage rating. If in doubt, choose a higher wattage resistor but never on the lower side. The power rating of resistors are generally printed on the body of the resistor.

Resistor values - coding schemes

Before using a resistor in any circuit, it is absolutely necessary to identify the resistor's type, value and power rating.

Selection of a particular type of resistor is possible based on its physical appearance. The resistance value of a resistor will generally be printed on the body of the resistor either directly in ohms as shown in Fig 5A or using a typographic code as shown in Fig 5B or using a colour code as shown in Fig 5C.

Fig 5



Colour band coding of resistors

Colour band coding as shown in Fig 5C is most commonly used for carbon composition resistors. This is because the physical size of carbon composition resistor is generally small, and hence, printing resistance values directly on the resistor body is difficult.

Tolerance

In bulk production/ manufacturing of resistors, it is difficult and expensive to manufacture resistors of particular exact values. Hence the manufacturer indicates a possible variation from the standard value for which it is manufactured.

This variation will be specified in percentage tolerance. Tolerance is the range (max -to- min) within which the resistance value of the resistor will exist.

Appendix D gives a list of commercially available standard resistor values.

Refer to the Appendix D for methods to read the value of resistors and their tolerance for resistors using 3 band, 4 band and 5 band colour coding schemes.

Colour code

Black	- 0	Green	- 5
Brown	- 1	Blue	- 6
Red	- 2	Violet	- 7
Orange	- 3	Grey	- 8
Yellow	- 4	White	- 9

Tolerance

Brown	- ± 1%	Violet	- ± 0.10%
Red	- ± 2%	Gold	- ± 5%
Green	- ± 0.5%	Silver	- ± 10%
Blue	- ± 0.25%		

Wire-wound Resistors

Resistors, in addition to having a required ohmic value, should also be capable of dissipating the heat produced. Carbon by its nature has a limitation in the maximum heat it can dissipate. Carbon resistors become too hot when high current flows through them.

Resistor values

Wire-wound resistors are available from a fraction of an ohm to 100's of Kilo ohms, with a power ratings of 1 watt to several 100s of watts. The higher the power rating, the thicker the resistive wire used, and bigger will be the physical size of the wire-wound resistor.

Applications

Wire-wound resistors are commonly used in electronic circuits where small values, precision values, high wattage ratings are required. A few applications are : regulated power supplies, amplifiers, motor controls, servo control circuits, TV receivers etc.

Comparison of fixed value carbon and wire-wound resistors

Characteristics	Carbon resistors	Wire-wound resistors
Size	Small	Comparatively large
Values available	From 1 ohm to several 10's of megohms	Fraction of an ohm to several 10's kilo ohms
Tolerance	Generally 5% to 20%	As low as 1% available
Wattage	Generally up to 2 watts	As high as 100 watts
Suitability in circuit	Suitable for Highfrequency circuits	Unsuitable for high frequency circuits (Suitable up to 200 KHz)
Noise generated	Less noisy	Very noisy operation
Voltage	Low voltage rating	Wide voltage rating

Typo graphical coding of resistors

In the typographical coding scheme of indicating resistance values, the ohmic value of the resistor is printed on the body of the resistor using a alpha-numeric coding scheme. A few examples of the generally used typographical codes and their meanings with examples are given in Appendix D.

Some resistance manufacturers use a coding scheme of their own. In such cases it will be necessary to refer to the manufacturer's guide.

Applications

Carbon composition, fixed value resistors are the most widely used resistors in general purpose electronic circuits such as radio, tape recorder, television etc. More than 50% of the resistors used in electronic industry are carbon resistors.

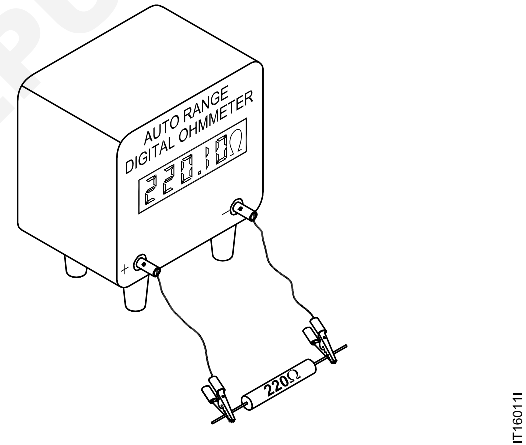
Brief constructional details of a few important types of fixed value resistors is given in Chart-2 at the end of this lesson.

Digital ohmmeters

Digital meters work on the principle of *digital electronics* (discussed in further lessons). These meters will not have any movable parts such as the meter movement, pointer etc., as in analog meters.

A typical digital ohmmeter is shown in Fig 18. Digital meters are more accurate than analog ohmmeters because of the following reasons;

Fig 18



a No mechanical movement is involved.

b No parallax error (meter reading error) occurs as ohmic values are shown directly in numerals.

c Can show values with two or three decimal place accuracy directly.

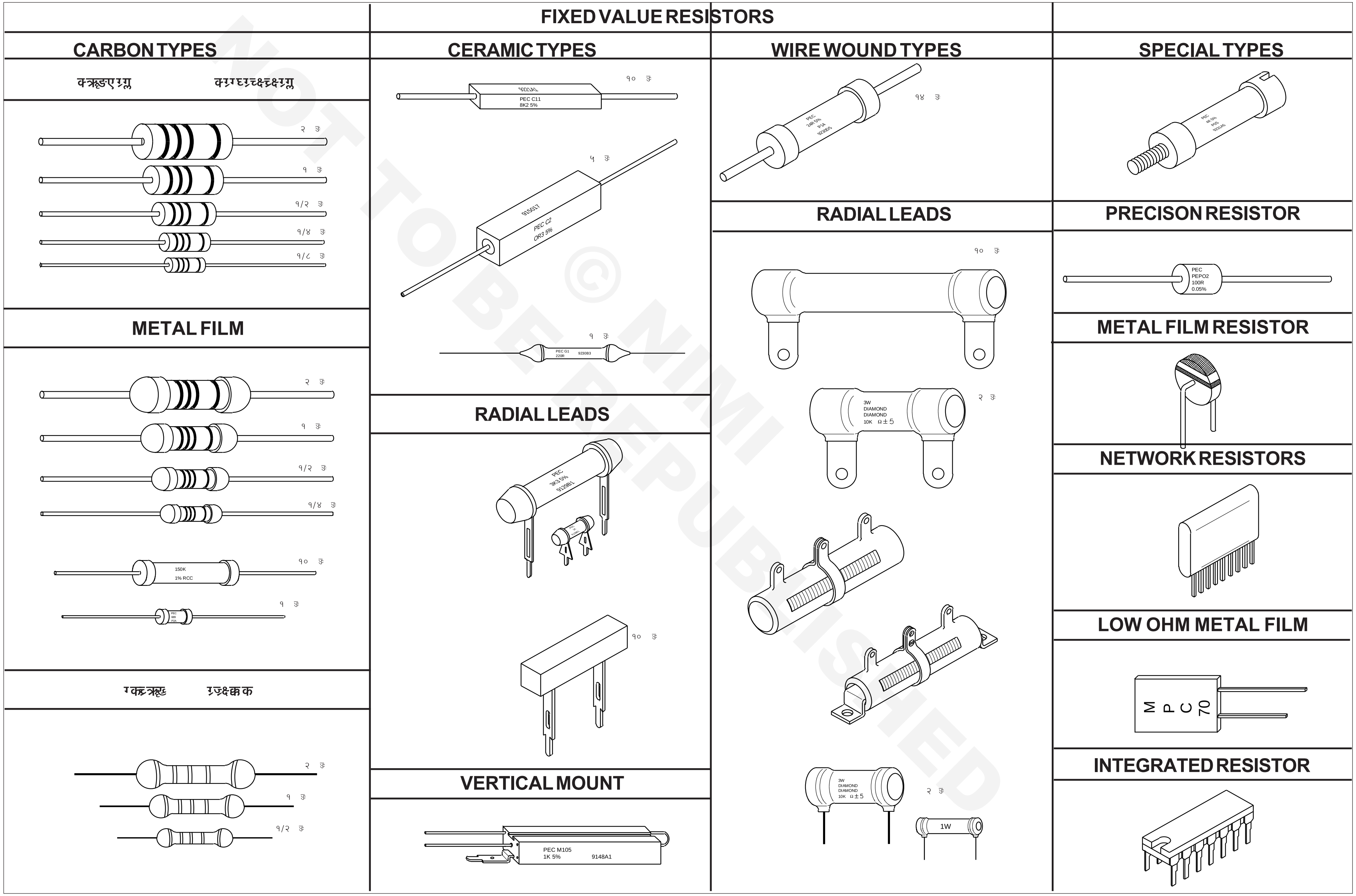
Digital meters are more expensive than analog meters.

Multimeters as ohmmeter

As already discussed in lesson 4.02, multi-meters are used to measure several electrical parameters like voltage, current and resistance. These meters are more popular because of their integrated measurement capabilities.

In these meters, for measuring resistance, the control switch should be put to the suitable resistance range depending upon the value of resistance being measured.

Chart 1 for Lesson 1.2.07



CONSTRUCTIONAL DETAILS OF FIXED VALUE RESISTORS

CARBON COMPOSITION RESISTORS

A mixture of finely powdered carbon or graphite with filler and binder is made into rods or extruded into desired shapes. Leads made of tinned copper is attached to the body by soldering or embedding. A protective layer of phenolic or Bakelite is moulded over the body. Available from few ohms to megaohms in 1/8 to 2 watts. Tolerance generally 5% and above.

WIRE-WOUND RESISTORS

Resistive wires such as Nichrome, Mangamin, Eureka, etc., are wound on porcelain former. Resistance depends on type of wire, dia and number of turns. Wire ends are attached to metallic terminals. Entire construction is coated with shellac, ceramic paste or vitreous enamel. Available from fraction of an ohm to few kilo ohms and upto 100 watts. Superior to carbon composition resistors but are bulky.

INTEGRATED RESISTORS

DIFFUSED RESISTORS

A suitable quantity of impurity material gets diffused into a monolithic IC substrate. The value of resistance depends on the impurity and the cross-section of the doped region. The maximum resistance values attainable are 100 ohms to 10 kilo ohms with tolerance of ±2%.

THIN FILM RESISTORS

These are formed by vacuum deposition or sputtering of Nichrome, tantalum or cermet (Cr-Sio) on points in the circuit on the surface of the substrate of an Integrated circuit. Typical resistor values lie in the range from 100W to 10 kW with ±2% tolerance.

PRINTED RESISTORS

A resistive paint or ink made of finely powdered graphite or other resistive agents suspended in a suitable binder such as shellac is applied on the surface of the Printed circuit board(PCB) at required places. The value of resistance depends upon the length, width and thickness of the paint applied. The resistance value can be adjusted by pruning the edges and the top of the deposit. Drying of paint is done by air and sometimes by baking. After completion, the printed resistors are protected by a coat of lacquer.

FILM RESISTORS

CARBON-FILM RESISTORS

A film of carbon is deposited on a ceramic, glass cylinder/rod. The value of the resistor depends on the thickness and length of the film. Leads are attached and the assembly is moulded in phenolic housing or coated with an insulating varnish and a plastic sleeve slipped over it for protection. Externally the carbon-film resistor resembles the carbon composition resistor, and is marked with the same colour code. This type of resistor has greater stability of resistance with in temperature and humidity. These are often made in small square shape with leads to fit on a PCB.

METAL-FILM RESISTORS

A film of metal or metal alloy deposited on an insulating substrate such as ceramic, glass etc. Construction details similar to carbon-film resistors. These are superior to carbon-film resistors. Availability-same as carbon-film resistors.

METAL-OXIDE FILM RESISTOR

A film of metal oxide, typically tin oxide, deposited over an insulating substrate such as ceramic, glass etc. Construction details similar to carbon-film resistors Metal-oxide resistors of 10,000 megohms with accuracy as fine as 0.5% available. This type of resistor is of great importance in ultra high-resistance applications

CERMET FILM RESISTORS

A mixture of metal and ceramic is deposited/coated as a thin film, generally in the shape of a spiral over an insulating substrate, usually an alumina core. Available in resistance values from 10 ohms to 1 megaohms with 1% tolerance. Highly stable even at very high temperatures.

Ohm’s law

Objectives: At the end of this lesson you shall be able to
- **state Ohm’s law**
- **calculate the total resistance of series resistance circuits**
- **calculate the total resistance of parallel resistance circuits.**

OHM’S LAW

The quantity of current flowing through a resistor depends on two factors:

1 The ohmic value of the resistor.

2 The voltage applied across the resistor.

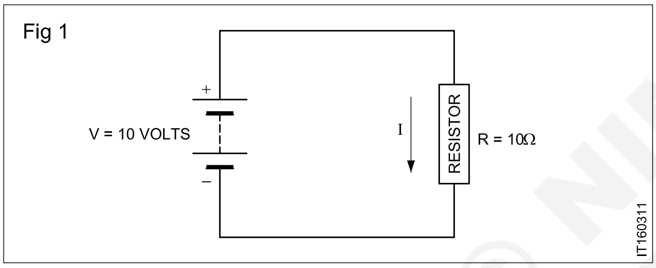
Ohms law status

Under a given constant temperature, the current (I) flowing through a resistor (R) is directly proportional to the voltage (V) across the resistor and inversely proportional to the value of resistance.

$$I = \frac{V}{R}$$

Example 1 : Using ohms law, find the current flowing through the resistor in Fig 1.

Fig 1



Solution :

Applied voltage across the resistor is : 10 volts

Resistance value of the resistor is given as 10 ohms.

Therefore current(I) through the resistor by Ohm’s law is;

$$I = \frac{V}{R}\text{ Amps.} = \frac{10\text{ volts}}{10\text{ ohms}} = 1\text{ amp.}$$

Current through the resistor is 1 ampere.

Total resistance of resistors in series

When resistors are connected in series, the total resistance of the series connection will be equal to, the sum of individual resistance values. In Fig 3, total resistance across points a-d will be equal to $R_1 + R_2$.

Example : In Fig 3, if R_1 is 1 K ohms and R_2 is 2.2K ohms. The total or effective resistance between the terminals a and d will be,

R_1 and R_2 are connected in series.

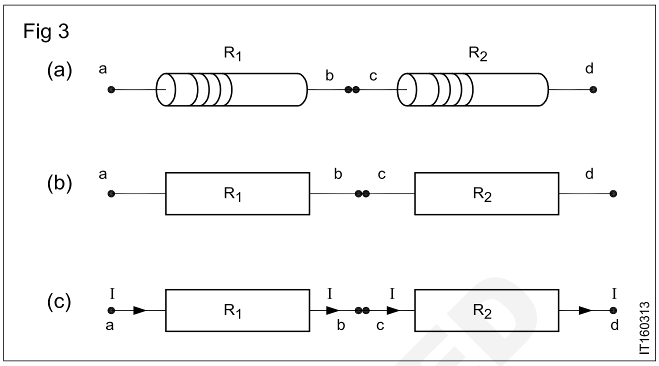
Therefore, the effective circuit resistance is

$= R_1 + R_2$

$= 1.0\text{ K}\Omega + 2.2\text{ K}\Omega = 3.2\text{ K}\Omega.$

Current through a series circuit

Fig 3



When resistors are connected in series as shown in Fig 3, the current that flows through R_1 can only flow through R_2. This is because

– there is no other path for any other extra current to flow through R_2

– there is no other path for the current through R_1 to escape from flowing through R_2.

Therefore in a series circuit, the quantity of current will be the same at all the points (a,b,c,d) of the circuit as shown in Fig 3c.

The quantity of current flowing through the series path is decided by both the resistors put together or the effective resistance of the circuit.

Resistors in Parallel

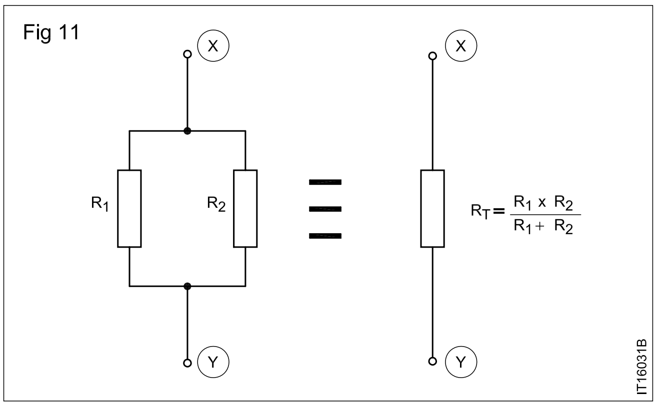
when resistors are connected in parallel as shown in Fig 11, the effective resistance(R_T) across the terminals x & y will be equal to,

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$$

or

$$R_T = \frac{R_1 \times R_2}{R_1 + R_2}$$

Fig 11



Similarly, if 3 resistors are connected in parallel, the effective resistance R_T will be,

$$R_T = \frac{R_1 \times R_2 \times R_3}{R_1 R_2 + R_2 R_3 + R_1 R_3}$$

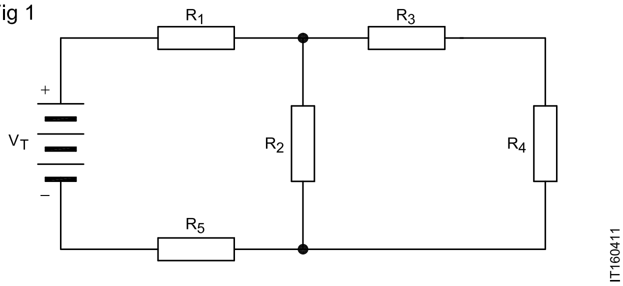
As a thumb rule When resistors are connected in parallel, the effective resistance will always be less than the least resistance value of the resistor in the parallel connection.

Kirchhoff's Laws

Objectives: At the end of this lesson you shall be able to
- **state Kirchhoff's current law**
- **state Kirchhoff's voltage law.**

When a circuit consists of several resistors in a complex series - parallel arrangement as in Fig 1, it is difficult to calculate the currents and voltages in the circuit using Ohm's law.

Fig 1



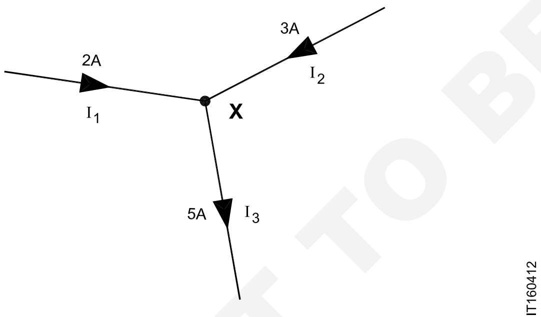
To find current and voltage drops in a complex series - parallel circuit, an easy method was found by a German physicist GUSTAV R. KIRCHHOFF. He formulated two basic laws called,

1. Kirchhoff's Current law
2. Kirchhoff's Voltage law.

1 KIRCHHOFF'S CURRENT LAW:

This law is illustrated in Fig 2.

Fig 2



KIRCHHOFF's Current law states that The sum of currents entering any point in a circuit is equal to the sum of currents leaving that point.

In Fig 2 currents I_1 and I_2 are entering a point X. Current I_3 is leaving the point X.

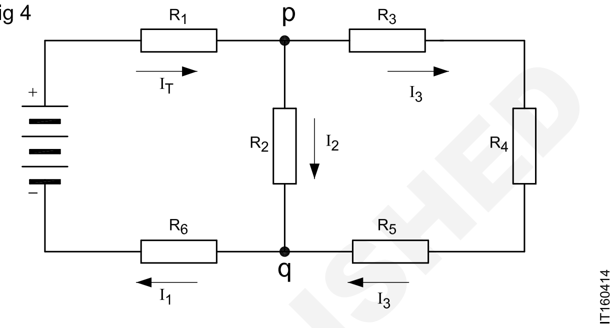
From Kirchhoff's current law, $I_1 + I_2 = I_3$ ....[1]

This equation can also be written as,

$I_1 + I_2 - I_3 = 0$ ....[2]

From equation 2, Kirchhoff's current can also be stated as The algebraic sum of currents entering and leaving any point in a circuit must be equal to zero .

Fig 4



KIRCHHOFF's VOLTAGE LAW

In the circuit shown at Fig 5A, consider the two closed paths a-c-d-b-a and a-e-f-b-a as shown in Fig 5b. These closed paths are called as *loops*. Each closed path has several resistors and there will be a voltage drop across each resistor. **KIRCHHOFF's voltage law states that The algebraic sum of voltages around any closed path is zero.**

Electrical power: The rate at which electrical energy is delivered to a load is called ELECTRICAL POWER. The unit of measurement of electric power is the WATT, and the symbol for power is P. In electrical circuits the power is equal to the current, multiplied by the voltage or P= I x E. Therefore, one watt of power is the result of one ampere of current driven by a one volt force through a circuit.

Example :A heater takes 4 amps at 250 volts. How much power does it consume?

P = E x I watts

= 250 x 4 = 1000 watts.

= 1 kilowatt

By simple algebra, we can write the 'Power Law' or 'Watts Law' in three ways as we did for Ohm's law.

$$P = I \times E$$

$$I = \frac{P}{E}$$

$$E = \frac{P}{I}$$

Soldering & De - Soldering Technique

Objectives: At the end of this lesson you shall be able to
- **list the critical factors during soldering**
- **list the five stages and steps involved in selecting and preparation of materials**
- **list the different shapes of tips to be chosen for different types of soldering work**
- **state the functions of soldering iron stand**
- **list the features of a well soldered joint and two stages of inspection of a solder joint.**

Soldering a joint

Selection and preparation of the soldering materials is the most time consuming phase of making a solder joint. Heating the joint and applying solder is the least time consuming but, it is the most important part of the soldering process.

Critical factors during soldering

1 Controlling the temperature of the workpiece

2 Limiting of time that a workpiece is held at soldering temperature.

These factors are specially critical while soldering electronic components like resistors, capacitors, transistors, ICs etc., Failure to correctly time and coordinate the heating of the joint and add solder, will result in a poor quality joint and may even damage the components.

Stages in soldering

The soldering process can be divided into several distinct stages or phases as given below:

1 Selection and preparation of materials.

2 Heating the joint and adding solder.

3 Cooling the joint.

4 Cleaning the joint.

5 Inspecting the joint.

1 SELECTION AND PREPARATION OF MATERIALS

1.1 Selection of soldering iron wattage

Soldering irons are available in different wattage ratings starting from 10 watts to several 100 watts. The wattage of a soldering iron specifies the amount of heat it can produce. As a thumb rule, higher the physical dimension of the workpiece, higher should be the wattage rating of the soldering iron. Some of the suggested wattage choices are given below:

i) For soldering less temperature sensitive components such as, resistors on lug boards, tag boards, use 25 to 60W iron. For soldering on printed circuit boards, use 10 to 25 W iron.

ii) For soldering highly temperature sensitive components such as, diodes, transistors and integrated circuits, use 10 to 25 watts iron.

1.2 Selection of soldering iron tip

To ensure that the joint is heated to the required temperature ideally,

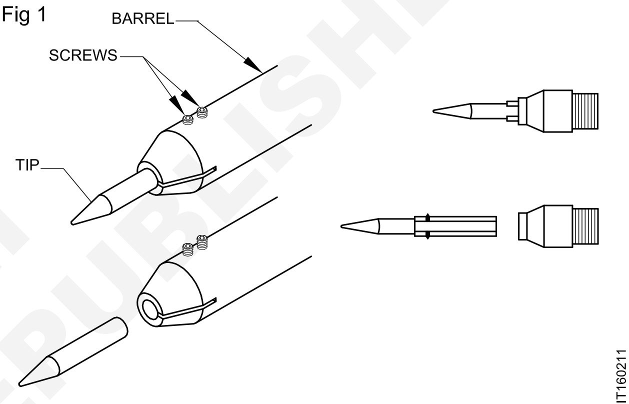
– the area of the tip face should be approximately equal to the area of the joint to be soldered

– the tip should be long enough to allow easy access to the joint.

– the tip should not be too long, as this may result in too low temperature at the tips working face.

In most soldering irons, the tip can be easily removed and replaced as shown in Fig 1a and 1b.

Fig 1

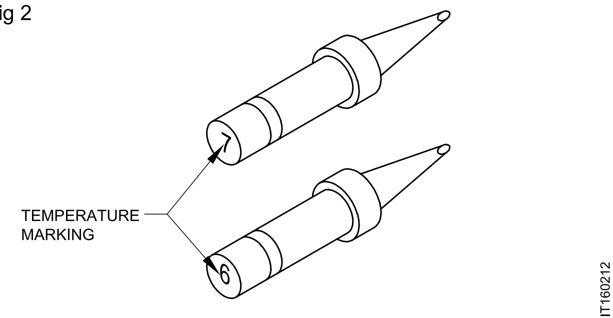


Selection of tip temperature

Good quality soldering iron tips have numbers punched on them as shown in Fig 2. These numbers indicate the temperature to which the tip can be heated, as shown in table in the next page.

Tip No.	Temperature °C	Temperature °F
5	260	500
6	316	600
7	371	700
8	427	800

Fig 2



Selection of tip shape

Suggested soldering tip shapes selection table is given below;

Type of soldering work	Soldering tip shape to choose
Wires, resistors and other passive components on to lug/tag boards	CHISEL TIP
All miniature electronic components except ICs on to lug boards and printed circuit boards (PCB)	BEVEL TIP
Integrated circuits (ICs) on to printed circuit boards (PCBs)	CONICAL TIP

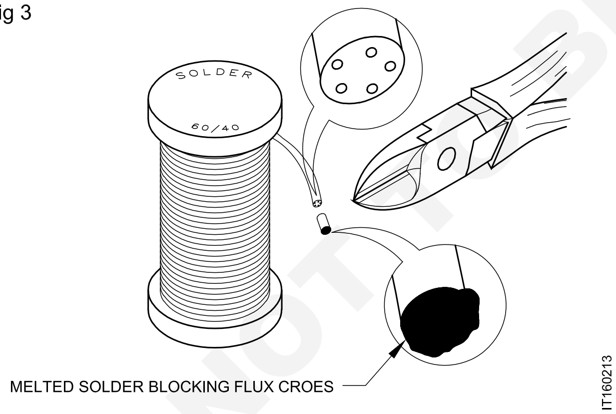
1.3 Selection of solder and flux

There are several sizes of the cored solders whose choice depends on the size of the joints to be soldered. Also the tin and lead percentage of the solder should be checked before using the solder. Different tin and lead combinations of solder need different temperatures for it to melt and reach the liquid state.

For electronic soldering applications, solder of tin and lead of 60/40 proportion is used. This solder proportion has a melting point of 200°C which is the required temperature for general purpose soldering irons.

While soldering to make a strong solder joint the flux should melt first, and then the solder. Therefore, while using rosin cored solder, cut off the first 5 to 10mm of the solder using a side cutter (as shown in Fig 3), so that any earlier melted portion of the solder blocking the rosin core is removed.

Fig 3



Flux is a chemical substance which has acidic properties. Therefore, it is advised not to touch flux by hand. Use a stick or a thin stiff brush to apply flux on workpieces. Hands should be washed after soldering work.

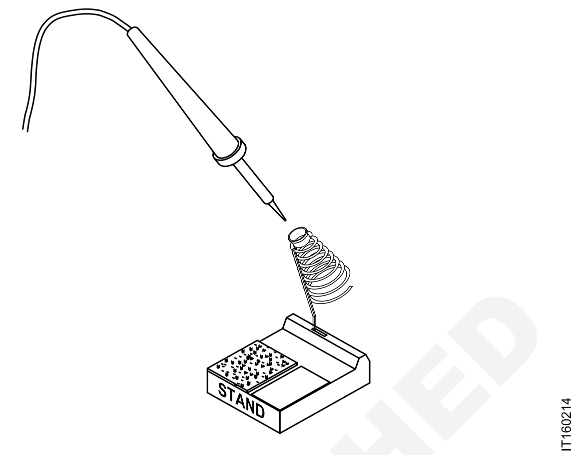
1.4 Soldering stand

Soldering stand plays an important role of retaining the soldering iron tip temperature around the required soldering temperature. The soldering stand should not allow the external temperature to cool the bit. At the same time the stand should not contain all the heat generated.

Soldering stands are specially designed prevents accidental burn injuries to the user of the soldering iron.

Another important requirement of a soldering stand is its mechanical stability. When the iron is taken out or placed in the stand frequently, the stand should not topple.

Fig 4



1.5 Inspection of soldering iron

Most soldering irons are powered by AC mains voltage. This voltage level is high and can give shock if one is careless. Soldering irons will generally have lengthy mains cable. While using the iron, the mains cable gets twisted and will have to bear physical strain. Because of this strain, the insulation of cable may get cut. This may lead to live wires protruding out. The live wires give severe electrical shocks if touched by the user.

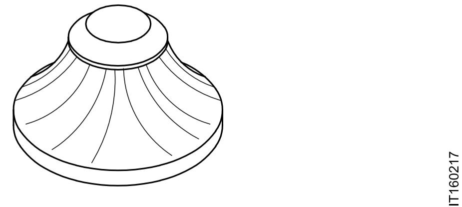
Preparation of soldering iron for soldering

2 HEATING THE JOINT AND ADDING SOLDER

Tips for heating and applying solder to a joint to be soldered are given below:

- Do not apply additional flux required for a joint in one place. Apply a small amount of flux around the joint. Do not allow the flux to flow outside the area to be soldered.
- Place the iron tip at the connection such that the tip gets maximum contact with parts to be joined.
- Slowly feed the solder into the joint starting close to the soldering tip and moving towards the edge of the joint.
- Continue applying the solder to the joint until complete wetting of the joint has been achieved and the joint has a concave fillet as shown in Fig 7.

Fig 7



- After enough solder has been applied and solder removed, keep the soldering iron tip on the joint for a moment to ensure that all the flux on the joint has reached the soldering temperature. This will allow majority of the acids within the joint to break down, which otherwise will corrode the joint after a period of time.

Generally the time taken to make a good soldered joint is between 3 to 7 seconds from applying the soldering iron to removing the soldering iron.

3 COOLING THE JOINT

Tips for cooling a solder joint are given below:

– Allow the joint to cool without assistance. Do not blow air from your mouth or from any other source to cool the joint. Forced cooling, cools the joint much earlier than it has to, resulting in a dry or brittle solder joint which will lead to mechanical and electrical defects of the joint.

– Do not move any part of the joint while it is cooling. This disturbs the chemical bonding taking place. Movement of the joint while it is cooling results in a dry joint.

4 CLEANING THE JOINT

When a solder joint is made, the amount of flux applied should be just sufficient to make a good joint. But, quite often, there will be a brown waxy substance left on the joint. This is nothing but the flux residue. In its original state this residue is corrosive. Hence, the flux residue or excess flux must be removed from the joint before soldering can be considered as complete.

If the flux residue and excess flux are not properly removed, their corrosive nature of the flux will gradually destroy the component leads and the circuit board. The flux residue is also *tacky* and, if not removed, will collect dust and debris often leading to circuit failure.

Removal of flux residue requires the use of solvents. The type of solvent depends on the flux used.

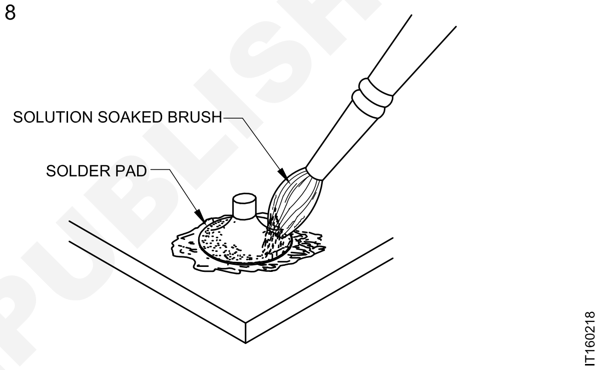
IsoPropyl Alcohol (IPA) is one of the solvents used for removing residual flux. It is available either undiluted or pre-mixed with water and can be obtained in pump sprays, aerosols, cans and drums depending on the quantity and style of use.

Cleaning using water/IPA solution

Determine the right method of application. (spray or liquid). Apply the solvent to the soldered joint. Use a clean acid brush, or some other type of stiff brush, to gently scrub the joint as shown in Fig 8, to help dissolve the residue, taking care to avoid splashing the mixture.

When the residue has been dissolved, dry the joint with a lint-free cloth to remove as much of the dissolved residue as possible.

Fig 8



Don't 's While Soldering

- Do not use a poorly tinned soldering tip.
- Do not cool the tip of the iron by wiping it excessively on a damp sponge.
- Do not allow the solder to be carried to the joint on the tip of the soldering iron.
- Do not attempt to speed up the cooling of the joint by blowing on it.
- Do not move the soldered joint until the solder has cooled to solid state.
- Do not try and improve a bad solder joint by reheating. All the original solder must be removed and the joint preparation and soldering should be redone.

MECHANICAL DEFECTS

Mechanical defects of a solder joint are caused by;

– the movement of parts of a joint while the solder is cooling.

Movement during cooling causes severe dislocation of the crystalline structure of the solder. This results in a weak joint which may fracture later and cause high electrical resistance or an intermittent fault when the circuit is in use. A joint moved before cooling will have a frosted appearance with fractures.

De-soldering and De-soldering tools

Objectives: At the end of this lesson you shall be able to
- **list the two stages in disconnecting a component from a soldered circuit**
- **list different tools used for de-soldering**
- **state the necessity for periodic cleaning of the plunger de-soldering tool.**

Desoldering: Many a time it may be necessary to disconnect/remove components and wires from a soldered or wired circuit due to the following reasons;

- Component failure (open,short etc).
- Incorrect component installation (polarity,position etc).

- Faulty or defective solder connections (dry solder etc).
- Circuit modifications (replacing, removing components etc).

Disconnecting a component or wire from any soldered circuit involves two separate actions. These are:

1 DE-SOLDERING THE CONNECTION - this action involves removal of the solder from a joint

2 REMOVAL OF THE COMPONENT - this action involves removing the component lead from the joint.

De-soldering the connection

De-soldering is a process of heating a soldered joint, to melt the existing solder and removing the molten solder from the joint.

De-soldering makes it easy to separate or pull-out the components, wires from the joint without unnecessary damage to the components and wires.

The heat required to melt the solder is supplied by a soldering iron. But removal of the molten solder from the joint requires the use of one of the following;

– Plunger de-soldering tool or desoldering pump

– Wicking braid

But, in many cases, desoldering is done using a nose player and a soldering iron. First, the joint to be disconnected is heated using the soldering iron. Once the solder at the joint melts, the component lead is pulled away using a nose player. This method of desoldering can be used for heavy components with strong leads. But this method should not be used for desoldering thin lead delicate components such as transistors, integrated circuits etc., This is because, in this method there is likelyhood of component getting overheated or the leads getting cut or leads getting detached from the body of the component.

PLUNGER DE-SOLDERING TOOL

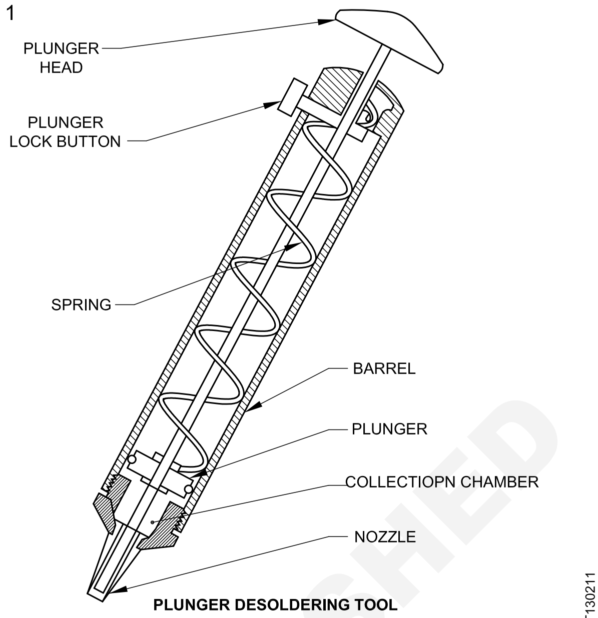
Plunger type desoldering tool as shown in Fig 1 is the most commonly used desoldering tool. This tool works on the principle of air suction. When the plunger head is pushed fully inside it gets locked inside with the help of the plunger button. This is known as cocking tool.

In this condition, the nozzle of the desoldering tool is kept almost touching the joint to be desoldered. If the joint is heated, the solder at the joint melts. If the plunger button of the desoldering pump is pressed, it releases the spring tension and moves the plunger up with a jerk. This causes the air to be sucked-in through the nozzle. Since the nozzle is now in contact with the molten solder, the molten solder is also sucked-in through the nozzle and gets collected in the collection chamber.

When the solder is removed using a plunger de-soldering tool, all the molten solder of a joint may not be sucked by the de-soldering tool at the first attempt, the joint must be reheated and the solder removed in two or three attempts.

After doing one suction of molten solder, while cocking the tool for second suction, face the nozzle into a dirt collector. This is because, the solder collected at the tip of the nozzle gets pushed out every time the tool is cocked.

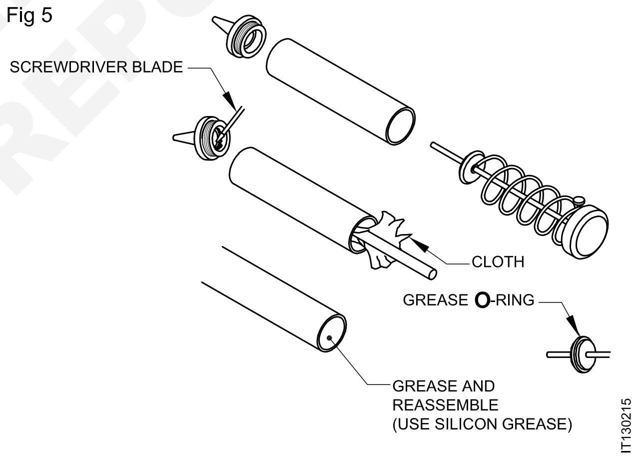
Fig 1



PLUNGER DESOLDERING TOOL

After several operations, the waste solder collected within the tool will begin to interfere with its operation. To prevent clogging of nozzle, this solder must be removed periodically and the tool must be cleaned and lubricated as shown in Fig 5.

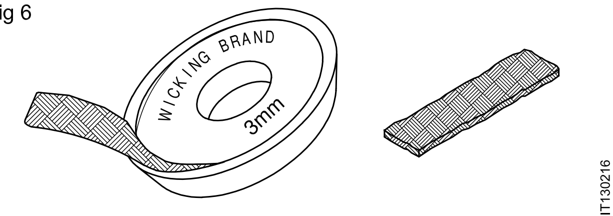
Fig 5



WICKING BRAID

Wicking braid as shown in Fig 6 is another simple de-soldering aid. This is made of copper and is soaked in flux. Wicking braid is nothing but a tape made of thin strands of copper knitted to form a mesh.

Fig 6



A wicking braid relies on the tendency of the hot solder to flow towards the heat source. When a soldered joint is heated via a wicking tape as shown in Fig 7a, the molten solder gets drawn into the wicking braid as shown in Fig 7b.

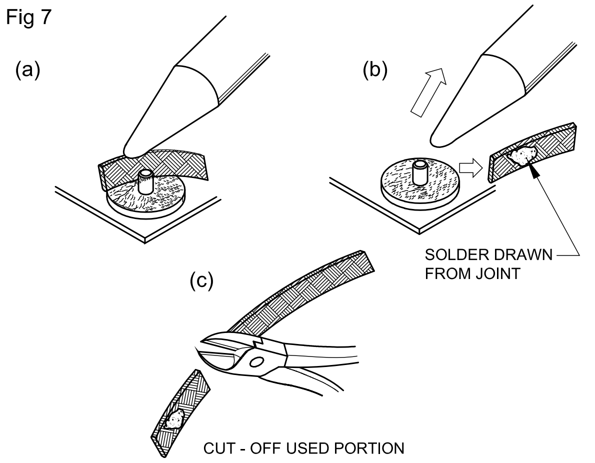
Thus the joint is now free from solder and the component can be removed easily.

The flux content of the wicking braid varies from brand to brand. Generally, the higher the level of flux in the braid, the more efficient it will be at drawing the solder from the joint.

Wicking braids are available in small, hand-held rolls and is supplied in a range of sizes from 0.8 to 6 mm wide so that the correct width of wicking braid can be selected for the joint to be de-soldered.

De-soldering using a wicking braid is commonly used for removing miniature components soldered on printed circuit boards(PCB's) and while removing components which are highly temperature sensitive.

Fig 7



Special types of resistors

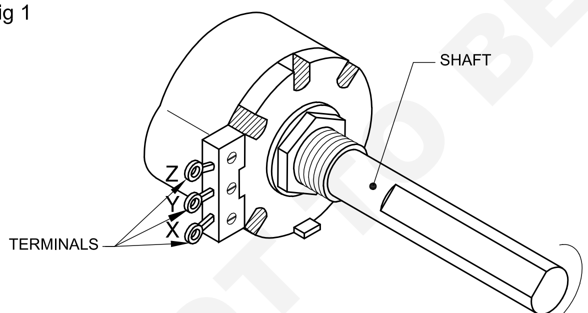
Objectives: At the end of this lesson you shall be able to
- **state the different types of variable resistors**
- **state the important parts of a carbon potentiometer**
- **state advantages of wire wound Potentiometers over Carbon Pots**
- **list a few special purpose Potentiometers.**

VARIABLE RESISTORS

In fixed value resistors the value of resistance is fixed, at the time of manufacture, whereas, variable resistors are manufactured such that its resistance value can be changed by the user. A typical variable resistor, commonly known as potentiometer. (Fig 1)

Any variable resistor will have a minimum of three terminals. Referring to Fig 1, the maximum resistance exists across the end terminals X & Z. The resistance across terminals X & Y or across Z & Y can be varied by rotating the shaft.

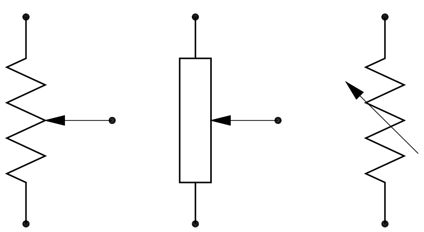
Fig 1



VARIABLE RESISTOR/POTENTIOMETER

Different symbols used to represent variable resistors are shown in Fig 2.

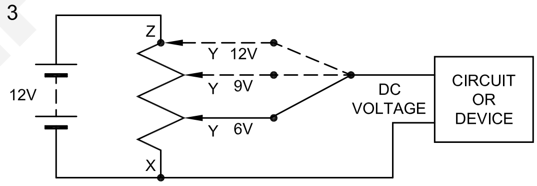
Fig 2



SYMBOLS OF VARIABLE RESISTORS

Variable resistors are also known as Potentiometers *or* Pots. The term potentiometer is used for variable resistors because, a variable resistor can be used to adjust the potential difference (voltage) applied to a device or a circuit as shown in Fig 3.

Fig 3



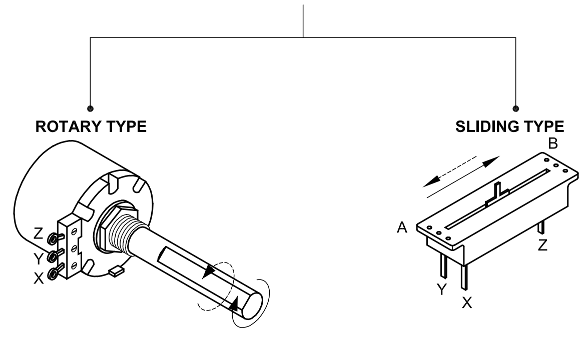
Resistance values of potentiometers are printed on their body either directly in ohms or in a coded form. The value printed always refers to the maximum value that potentiometer can have. Hence the minimum value to which it can be set is always 0 Ω.

Types of variable resistors

Variable resistors of different types are available in the market. These types can be categorized as follows:

1 Based on the type of control as shown in Fig 4.

Fig 4

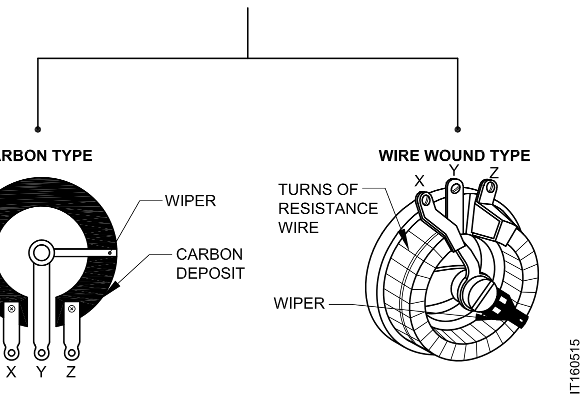


In rotary type of variable resistors, the resistance across the terminals X-Y increases as the shaft is rotated anti-clock-wise whereas in sliding type, resistance across X-Y increases as the slider is moved from A to B.

2 Based on the resistive material used. (Fig 5)

Fig 5 illustrates the brief constructional detail of carbon type and wire wound type variable resistors. In carbon type, the resistive material used is carbon or graphite. Wire wound type variable resistors uses several turns of resistive wire such as tungsten or manganin.

Fig 5

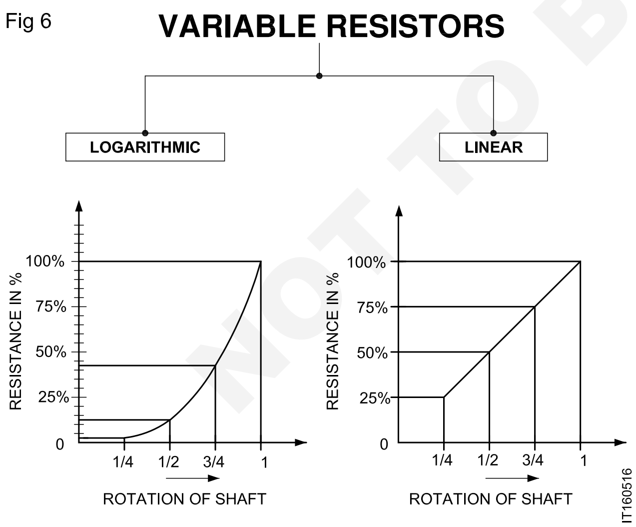


3 Based on variation of resistance with reference to shaft position (no. of turns) as shown in graph at Fig 6.

In linear variable resistors, the resistance across the resistor terminals increases or decreases linearly with respect to the shaft position as shown in the graph at Fig 6.

In logarithmic variable resistors, the resistance across the terminals increases or decreases logarithmically (as shown in graph at Fig 6) with respect to the shaft position.

Fig 6



Presets and Trimpots: These are small to very small sized potentiometers. Chart 1 shows some of the types. These potentiometers are generally used when frequent adjustments are not required. These potentiometers when used in circuits, are used to trim certain value of resistance and are not generally disturbed again. Hence these are called *Presets* or *Trimpots*. These are available in a wide range of values. However, their power handling capacity will be only of the order of a few milli watts.

SPECIAL TYPES OF VARIABLE RESISTORS

1 Potentiometer with built in ON/OFF switch

Carbon potentiometers are also available with the shaft mechanically coupled to a ON/OFF switch. A typical potentiometer with ON/OFF switch is shown in Chart 1. The built-in ON/OFF arrangement will eliminate the need of a separate power switch in equipments/gadgets such as radios, tape recorders etc.,

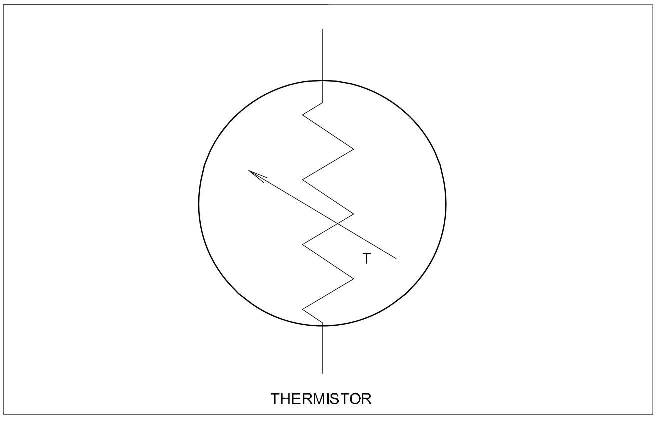
2 Tapped potentiometer

Variable resistors with an additional terminal are available. This terminal is provided to obtain fixed resistance values in addition to variable resistance. Such variable resistors are specified for example, 5K + 17K.

THERMISTOR SYMBOL

A thermistor is a resistor whose resistance changes according to the temperature it is exposed. There are 2 main types of thermistors: negative temperature coefficient (NTC) thermistors and positive temperature coefficient (PTC) thermistors.

NTC thermistors are thermistors whose resistance decreases when the temperature it is exposed to increases. So if heat is applied to a NTC thermistor, its resistance will drop accordingly. PTC thermistors are thermistors whose resistance increases when the temperature it is exposed to increases. So if heat is applied to a PTC thermistor, its resistance increases accordingly. Being that thermistors are components which vary their resistance according to the amount of heat applied, we can exploit this property to test it. All we need to test a thermistor is an ohmmeter or a multimeter that contains an ohmmeter.



Applications

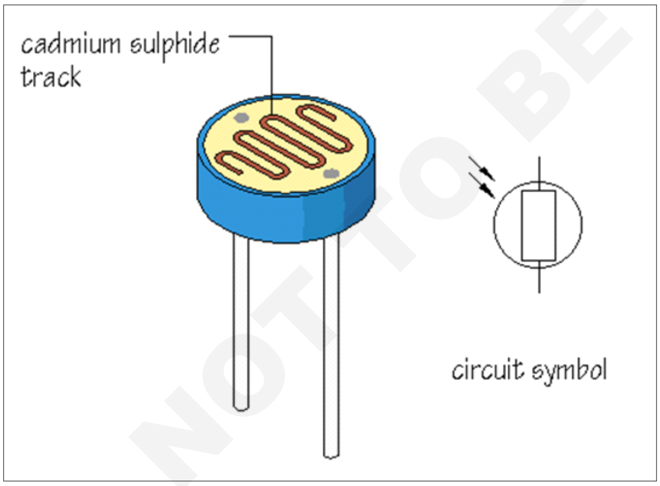
- PTC thermistors can be used as current-limiting devices for circuit protection, as replacements for fuses.
- PTC thermistors were used as timers in the degaussing coil circuit of most CRT displays.
- PTC thermistors were used as heater in automotive industry to provide additional heat inside cabin with diesel engine or to heat diesel in cold climatic conditions before engine injection.

- NTC thermistors are used as resistance thermometers in low-temperature measurements of the order of 10 K.
- NTC thermistors can be used as inrush-current limiting devices in power supply circuits. They present a higher resistance initially which prevents large currents from flowing at turn-on, and then heat up and become much lower resistance to allow higher current flow during normal operation.
- NTC thermistors are regularly used in automotive applications.
- NTC thermistors can be also used to monitor the temperature of an incubator.
- Thermistors are also commonly used in modern digital thermostats and to monitor the temperature of battery packs while charging.
- Thermistors are also used in the hot ends of 3D printers, they produce heat and keep a constant temperature for melting the plastic filament.

LIGHT DEPENDENT RESISTOR(LDR)

A light dependent resistor (LDR) or photoresistor is a resistor whose resistance decreases with increasing incident light intensity; in other words, it exhibits photoconductivity.

A photoresistor is made of a high resistance semiconductor. If light falling on the device is of high enough frequency, photons absorbed by the semiconductor give bound electrons enough energy to jump into the conduction band. The resulting free electron (and its hole partner) conduct electricity, thereby lowering resistance. There are many types of photoresistors, with different specifications and models. Photoresistors can be coated with or packaged in different materials that vary the resistance, depending on the use for each LDR.



Applications

Photoresistors come in many types. Inexpensive cadmium sulphide cells can be found in many consumer items such as camera light meters, street lights, clock radios, alarm devices, outdoor clocks, solar street lamps and solar road studs, etc.

They are also used in some dynamic compressors together with a small incandescent lamp or light emitting diode to control gain reduction and are also used in bed lamps, etc.

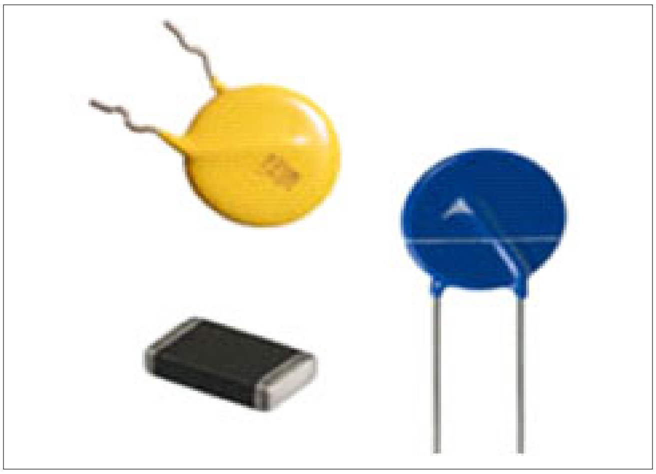
VOLTAGE DEPENDENT RESISTOR / Varistor (VDR)

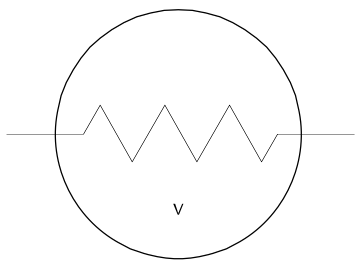
VARISTOR SYMBOL

The resistance of a varistor is variable and depends on the voltage applied. The word is composed of parts of the words "variable resistor". Their resistance decreases when the voltage increases. In case of excessive voltage increases, their resistance drops dramatically. This behavior makes them suitable to protect circuits during voltage surges. Causes of a surge can include lightning strikes and electrostatic discharges. The most common type of VDR is the metal oxide varistor or MOV.

Applications

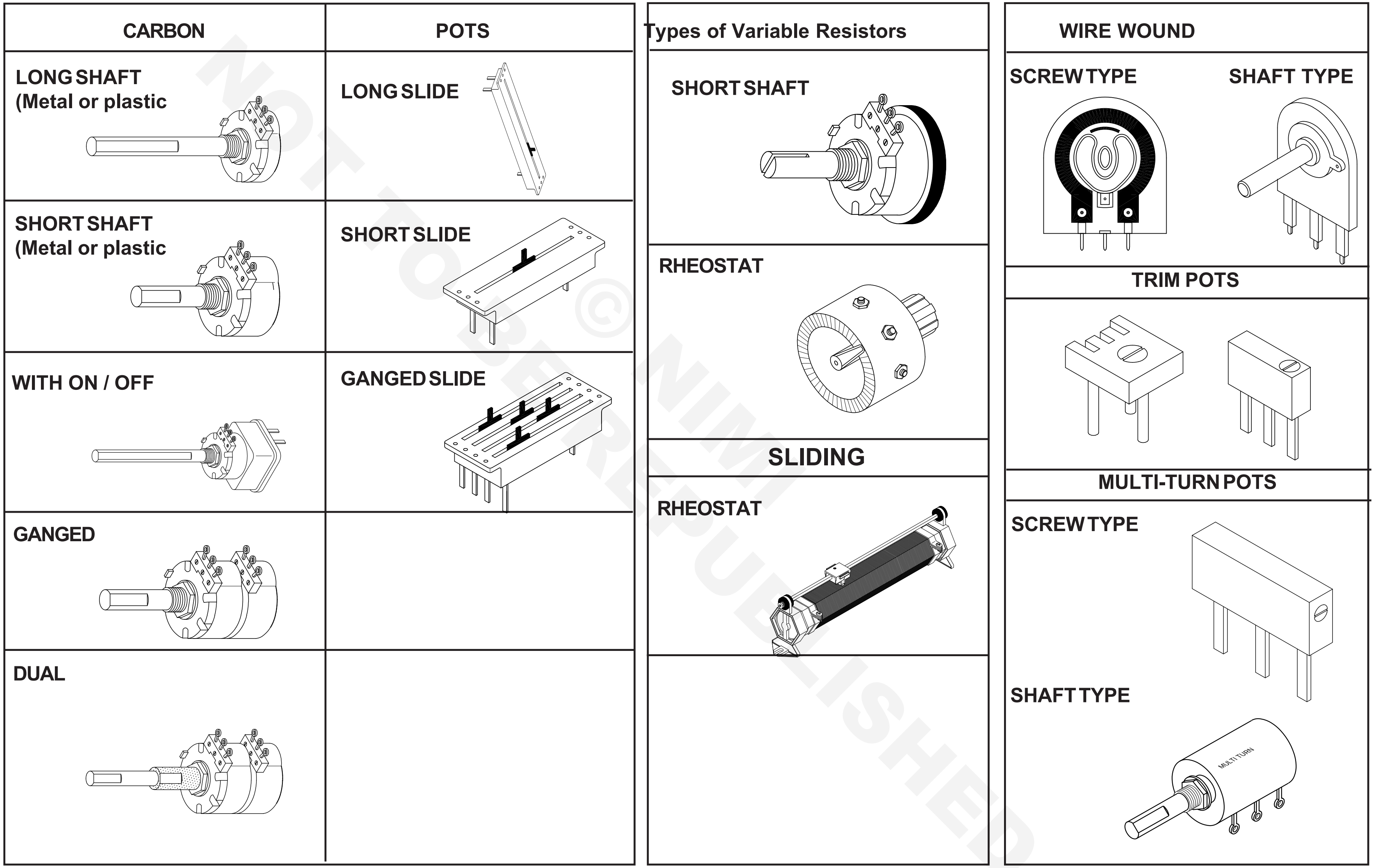
- Telephone and other communication line protection
- Radio communication equipment transient suppression
- Surge protector power strips
- Cable TV system surge protectors
- Power supply protection





VARISTOR SYMBOL

Chart 1

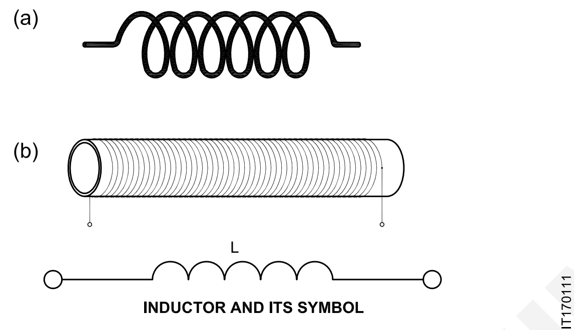

CARBON
LONG SHAFT
(Metal or plastic
SHORT SHAFT
(Metal or plastic
WITH ON / OFF
GANGED
DUAL
POTS
LONG SLIDE
SHORT SLIDE
GANGED SLIDE
Types of Variable Resistors
SHORT SHAFT
RHEOSTAT
SLIDING
RHEOSTAT
WIRE WOUND
SCREW TYPE
SHAFT TYPE
TRIM POTS
MULTI-TURN POTS
SCREW TYPE
SHAFT TYPE
MULTI TURN

Inductors and Inductive Reactance at different frequencies

Objectives: At the end of this lesson you shall be able to
- **state meaning of inductor and inductance**
- **explain through simple example how inductor opposes sudden changes in current through it**
- **state the meaning of self-induction and unit of inductance, its definition**
- **state the meaning of mutual induction**
- **list the different classification of inductors and list few types, applications.**

Inductors are components consisting of coil of wire as shown in Fig 1. The coil of wire may or may not be wound on a former as shown in Fig 1a and 1b. The basic function of an inductor is to **store electric energy in the form of magnetic field**, when current flows through the inductor.

Fig 1



Inductance is the electrical property of inductors. Letter 'L' is used as a symbol to represent Inductance. Inductance, is the ability of a device to oppose any change in the current flowing through it. This opposition to change in current, is achieved by the energy stored by it, in the form of magnetic field.

Inductance, and thus an inductor, chokes off or restricts sudden changes in current through it. The change may be either increasing or decreasing. Hence inductors are also sometimes called as Chokes.

Principle of operation

Recall that, when current begins to flow through a conductor, magnetic flux rings start to expand around the conductor. This expanding flux induces a small voltage in the conductor called back-emf or counter emf. This induced voltage has a polarity that opposes the source voltage which creates the induced voltage.

Thus, the inductance in a coil of wire, carrying current, opposes any rise or fall of current through it and tries to keep the current through it constant.

It should be noted that, the inductance cannot completely stop the increase in current because, the induced voltage is caused by the increasing flux, and the increasing flux depends on the increasing current. Therefore, an inductor can restrict only, the rate at which the current can increase or decrease through it.

This property of a coil to induce an emf within the coil due to a changing current through it is termed as **SELF INDUCTANCE**.

Unit of inductance - The Henry

The basic unit of measure of Inductance is **Henry** abbreviated as **H**. The unit henry is defined in terms of, the amount of cemf produced when the amplitude of current through the inductor is changing. Based on this , One Henry is that amount of Inductance which develops 1 V of cemf in the coil when the current changes at the rate of 1 Amp/sec.

From the above definition, referring Fig 2,

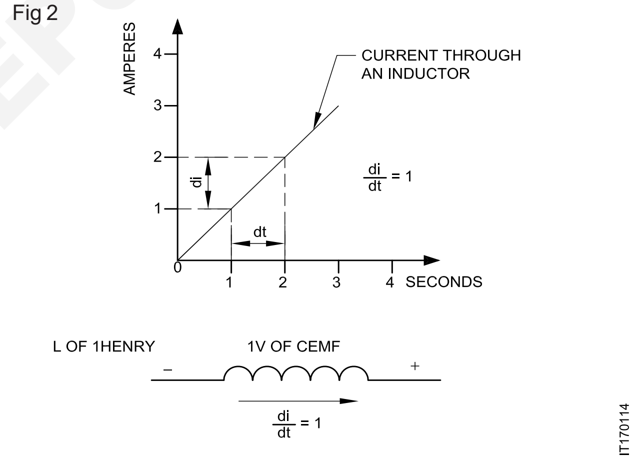
Inductance,

$$L = \frac{V_L}{di/dt}$$

Where, V_L = Induced voltage

and $\frac{di}{dt}$ = rate of change of current. Refer Fig 2.

Fig 2



Factors determining value of Inductance

The inductance of an inductor is primarily determined by the following four factors:

1 The number of turns of wire

2 The material on which the coil is wound or the core material

3 The spacing between turns of wire and

4 The diameter of the coil

Given the parameters listed above, the inductance of a coil can be calculated using the formula,

$$L = \mu \frac{N^2 A}{l} \text{ Henries}$$

where,

μ = Permeability of the magnetic core around which the coil is wound, in Wb/At-m ($\mu = \mu_o \mu_r$)

N = Number of turns of the coil

A = Area of cross-section of the core in square meters, m^2

l = length of the coil in meters.

PRACTICAL INDUCTORS AND TYPES

For practical applications, inductors are manufactured to give a specified amount of inductance. Value of practical inductors range from a few microhenries for application in high frequency communication circuits upto several henries for power supply ripple filter circuits.

Inductors can be classified under various categories as shown in Chart-1 given at the end of this lesson. Illustration of different types of inductors are shown in Chart-2 at the end of this lesson.

Air core coils have practically no losses from eddy currents or hysteresis. However, inductor with air core have their values limited to low values in the range of micro to milli Henries. Air core inductors are used in high frequency applications.

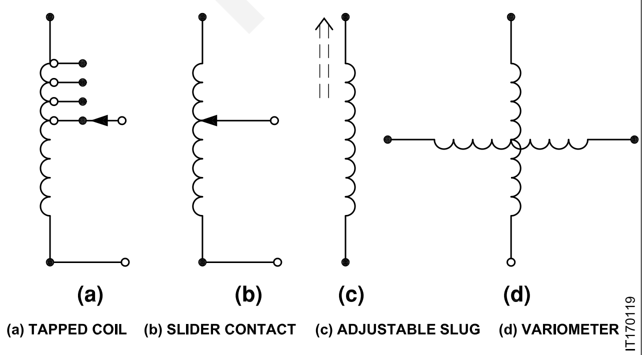
Laminated Iron Core is formed using a group of individual laminations. Each lamination is insulated by a thin coating of iron oxide, silicon steel or varnish. This insulation increases the resistance reducing eddy current losses. These type of inductors are generally used for mains frequency of 50/60 Hz and lower audio frequency range, upto 10 KHz.

Powdered Iron Core is used to reduce the eddy currents in the core when used at radio frequencies. It consists of individual insulated granules pressed into one solid form called slug.

Ferrite Core is made from synthetic ceramic material which are ferromagnetic. They provide high value of flux density like iron, but have the advantage of being insulators, thus reducing the eddy current losses to bare minimum. Because of this advantage, inductors with ferrite core are used for high to very high frequency application.

Variable Inductors unlike fixed Inductors, variable inductors have the facility to vary its inductance value either in steps or continuously. The inductance can be varied by any one of the methods as shown in Fig 3.

Fig 3



(a) TAPPED COIL (b) SLIDER CONTACT (c) ADJUSTABLE SLUG (d) VARIOMETER

Methods (a) & (b) shown in Fig 9 are generally used in low frequency application.

Method (c) is used in coils with ferrite as core. These are used in high frequency applications.

Method (d) is known as Variometer arrangement. In this, the position of one coil is varied within the other. The total inductance will be minimum when the coils are perpendicular to each other.

Shielded/Screened inductors will have a metal cover over the inductor. The shield is usually made of copper or aluminum. The reason for shielding is to isolate the coil from external varying magnetic field and to minimize the effect of the coils RF current on external circuits.

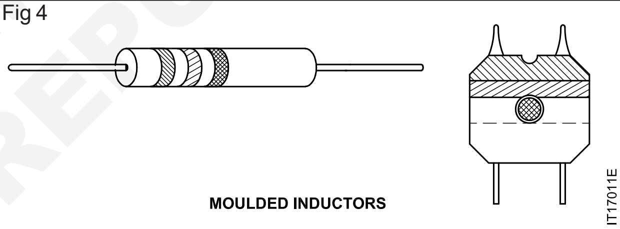
While making a shield/screen for an inductor the following points are to be noted;

i metal used as cover should be a good conductor

ii clearance between the sides of the coil and the metal should be equal to or greater than the coil radius. If the clearance is less, the shield reduces the inductance value drastically.

Moulded inductors, looks like resistors with their values colour coded. The coding scheme is same as in resistor, except that the value of L are given in microhenry (μH). For example, a coil with yellow, red and black stripes or dots as shown in Fig 4, has inductance value of 42 μH.

Fig 4



MOULDED INDUCTORS

Laboratory type variable inductor are available in the form of a **decade box**. In this decade-inductance box precision inductors are switched in-to or out-of circuit by means of rotary switches. Decade variable inductor is used to carryout experiments and in Inductance (L) meters.

Special types of Inductors

Certain electronic circuits use a special type of Inductor called **Thin-film inductors**. These inductors are thin metal films deposited in the form of a spiral on a ceramic or epoxy base. These are tiny sized and have very low value of inductance.

Copper tube Inductors: At high frequencies, current has a tendency to flow in the skin of the conductor, this is known as **skin effect**. Therefore, at high frequency & high power applications hollow copper tube coil is used as inductor instead of solid copper wire.

Variometers: If different radio frequencies are to be received using a single antenna, the electrical length of the antenna will have to be varied, to respond to different wave lengths. Variable inductors used to achieve this are called variometers.

INDUCTANCE MEASURING INSTRUMENTS

Instruments that operate on the principle of wheat stone bridge are used to measure inductance of inductors. These instruments are known as Impedance Bridge, RLC Bridge and so on.

While measuring inductance value using these bridges, an internally generated 1 KHz signal is used for measurement. However an external signal generator may be used to measure the Q of coils at any desired frequency (Q stands for quality-factor: discussed in further lessons).

These instruments can be used to measure inductance values from 1 μH to 1000 H.

Digital Instruments are also available to measure inductance values ranging from 1 μH to 10 H. These Digital meters are simple to operate and are also highly accurate. The meters are commonly known as Digital LC Meters, Digital RLC meters and so on.

Ohmic resistance/DC resistance of INDUCTORS

Inductors are made using generally copper wire. As shown in Fig 11a, any wire will have some amount of ohmic resistance depending upon its length, diameter and resistivity (specific resistance) of the material. This ohmic resistance of an inductor can either be measured using an ohmmeter or calculated using the formula,

$$R = \frac{\rho l}{A}$$

where,

R is the resistance in ohms

ρ is the resistivity of the material in Ohm meters, Ω.m

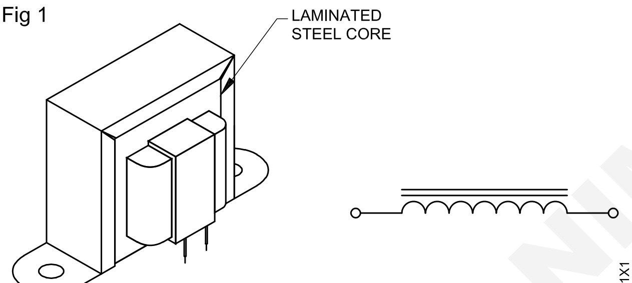
l is the length of wire in metres, m

A is the cross-sectional area of the wire in metre^2, m^2

CHART - 2 - PHYSICAL APPEARANCE OF DIFFERENT TYPES OF INDUCTORS

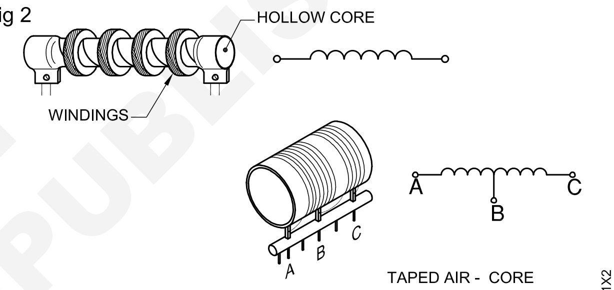
IRON CORE INDUCTOR OR CHOKE

Fig 1



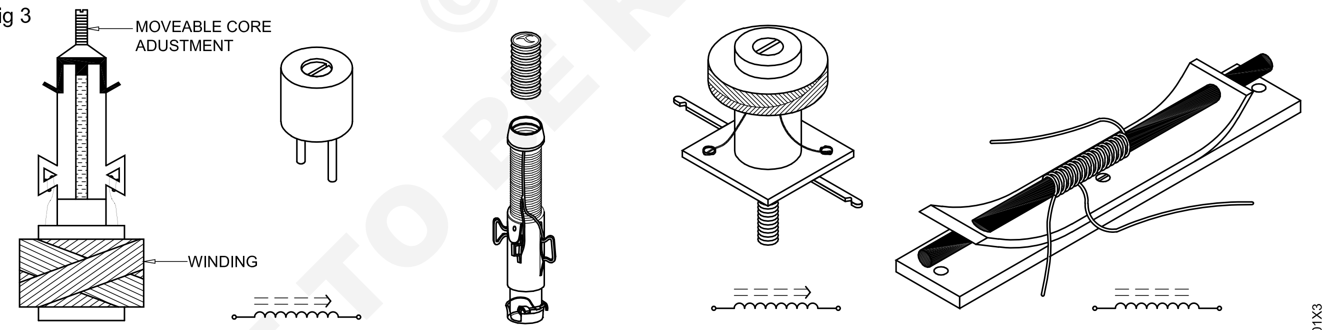
IRON-CORE INDUCTOR OR CHOKE

Fig 2



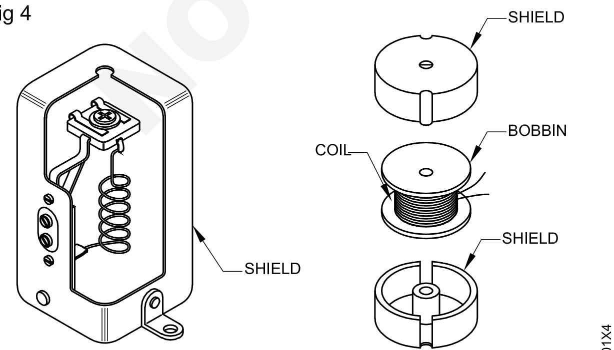
AIR-CORE INDUCTORs

Fig 3



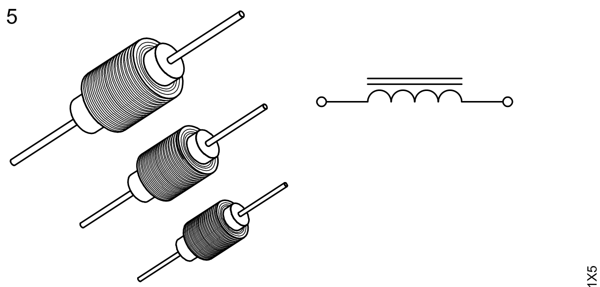
FERRITE-CORE INDUCTORS

Fig 4



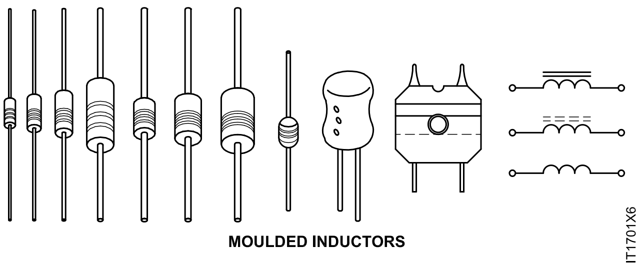
SHIELDED INDUCTORS

Fig 5



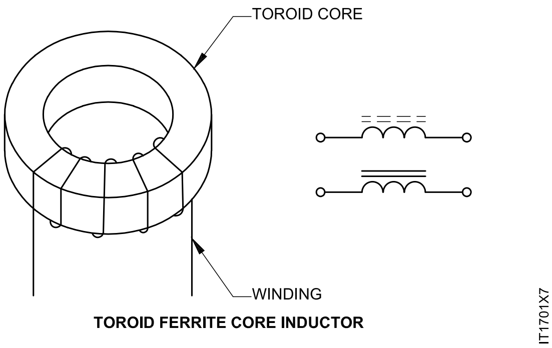
HIGH FREQUENCY INDUCTORS

Fig 6



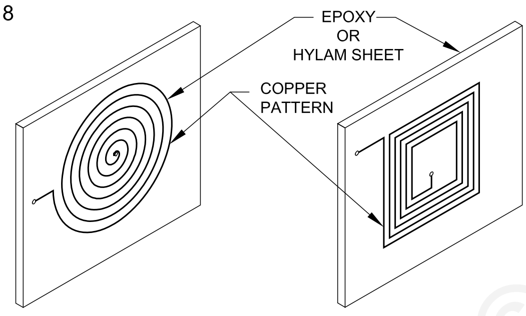
MOULDED INDUCTORS

Fig 7



TOROID FERRITE CORE INDUCTOR

Fig 8

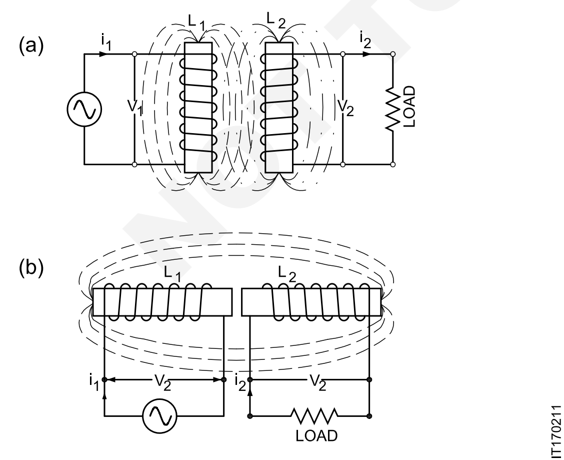


PRINTED CIRCUIT INDUCTOR/THIN FILM INDUCTOR

Mutual Inductance (M)

When two inductors L_1 and L_2 are placed side by side close to each other shown in Fig 9a or Fig 9b, although the two coils are not electrically connected, the two coils are said to be magnetically inter-coupled.

Fig 9



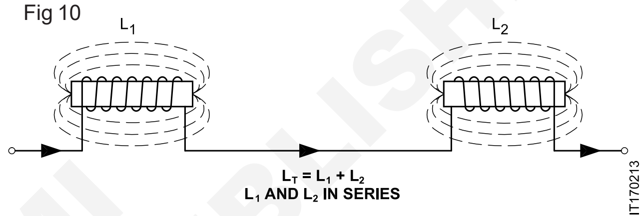
The changing current i_1 in coil L_1 not only self induces an emf (V_1) in L_1, but also causes a voltage (V_2) to be induced in L_2. The voltage V_2 induced in L_2 causes a current i_2 that sets-up its own changing flux around L_2. This in turn, not only self induces a voltage in L_2, but also induces an additional voltage in L_1. That is, a changing current in one coil will induce an emf in other nearby coil. This effect is known as **mutual induction**.

INDUCTORS IN SERIES

In order to obtain a desired value of inductance, inductors can be connected either in series or in parallel.

Fig 10 shows two inductances connected in series. The spacing between the inductors are large enough so that there exists no mutual inductance between the two coils. Hence in Fig 10 k=0. In Fig 10, since the direction of current is same through both coils, the self-induced voltages are additive. Therefore the total inductance of such series connection is given by,

Fig 10



$L_T = L_1 + L_2 + L_3 + ... + L_n$ Henrys (H)

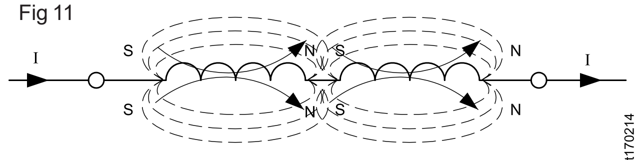
where, L_T is the total inductance across end terminals.

$L_1, L_2 ....L_n$ are individual inductance values.

Series coils with mutual inductance

Unlike in Fig 11, when two inductors L_1 and L_2 are connected in series close to each other as in Fig 4 the total inductance (L_T) will be larger than just the sum of L_1 and L_2. How much larger will this be depends on the mutual inductance M.

Fig 11



In general, the total inductance of two series-connected coils, with mutual inductance M is given by;

$L_T = L_1 + L_2 \pm 2M$

Whether it will be + 2M or - 2M depends on, whether the inductors are connected in series-aiding as shown in Fig 5a or in series-opposing

Transformers and its Types

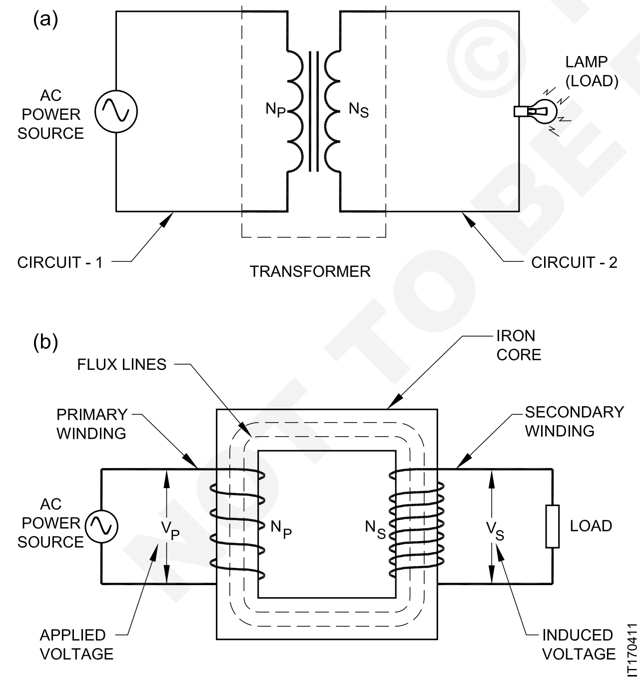
Objectives: At the end of this lesson you shall be able to
- **state the basic function of a transformer**
- **state and explain important terms used with transformers**
- **list the different classifications of transformers**
- **list the common application of different types of transformers**
- **define the term efficiency of a transformer and list out the losses**
- **explain how the losses in a transformer can be minimised**
- **explain how OC and SC tests reveal losses in transformers.**

Transformer is an electrical device used to transfer electric energy from one AC circuit to another circuit by magnetic coupling as shown in Fig 1a.

A transformer essentially consists of two coils of insulated conducting material, generally copper. These coils are wound on a core made of iron or ferrite as shown in Fig 1b. These coils are so arranged that magnetic flux developed in one coil will link with the other coil. Hence, mutual inductance exists between the two coils with tight-coupling (k=1). A change in current through one coil (say N_p) induces a voltage in the other coil (say N_s). The magnitude of induced voltage in the secondary winding depends on the number of turns of the coils and on how tight the magnetic coupling(k) is, between the two coils.

In a transformer, as shown in Fig 1b, the coil or the winding to which electrical energy is given from an ac power source is called the **primary winding**. In Fig 1 this coil is marked N_p.

Fig 1



The second coil to which, energy from the primary winding is coupled magnetically is called the secondary winding (N_s in Fig 1b). If a load, say a lamp or a resistor, is connected across the secondary winding, current flows through the load although there is no direct AC power source connected to it.

Hence, transformers can be defined as devices that make use of the principle of mutual induction, in transferring electrical energy from one ac circuit to another circuit with out direct electrical connection.

It is important to note that transformers cannot transfer DC energy from primary winding to secondary winding, because, a DC current cannot produce changing magnetic field and hence cannot develop induced voltage.

Important terms used with iron-core transformers are explained below;

1 Turns Ratio of a transformer

The ratio of the number of turns of coil in the primary (N_p) to the number of turns of coil in the secondary (N_s) is called the turns ratio of the transformer.

$$\text{Turns ratio} = \frac{N_p}{N_s}$$

For example, 1000 turns in the primary and 100 turns in the secondary gives a turns ratio of 1000/100, or 10:1 which is stated as ten-to-one turns ratio.

2 Voltage Ratio of a transformer

The ratio of voltage across the primary winding(V_p) to the voltage available across the secondary winding(V_s) is called the voltage ratio of the transformer.

$$\text{Voltage ratio} = \frac{V_p}{V_s}$$

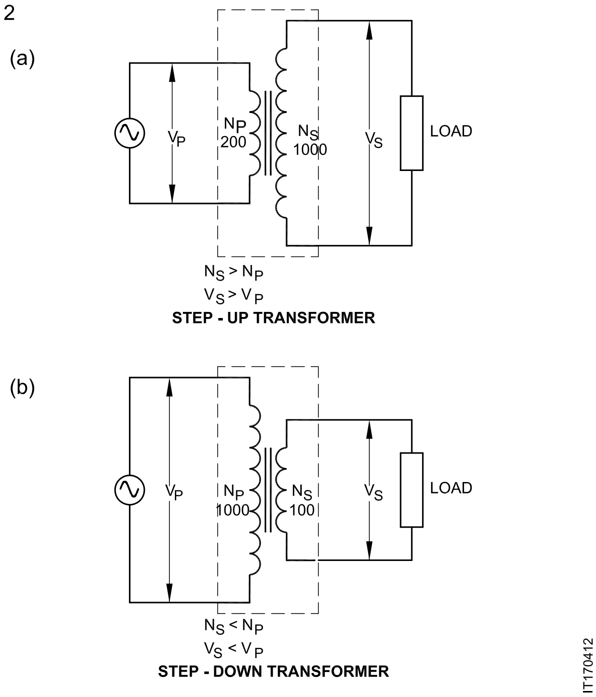
When coefficient of mutual coupling(k) between primary and secondary winding is 1, the voltage induced per turn of the secondary winding is the same as the self-induced voltage per turn in the primary winding. The total voltage appearing across the secondary winding depends on the number of turns of secondary winding.

Therefore, the voltage ratio is in the same proportion as the turn ratio:

$$\frac{V_p}{V_s} = \frac{N_p}{N_s}$$

This means, if the secondary winding has more turns than the primary winding ($N_s > N_p$) then, the secondary voltage will be higher than the primary voltage. In other words, in such a condition the primary voltage is said to be raised or stepped-up. Such transformers are called *STEP-UP TRANSFORMERS* as shown in Fig 2a.

Fig 2



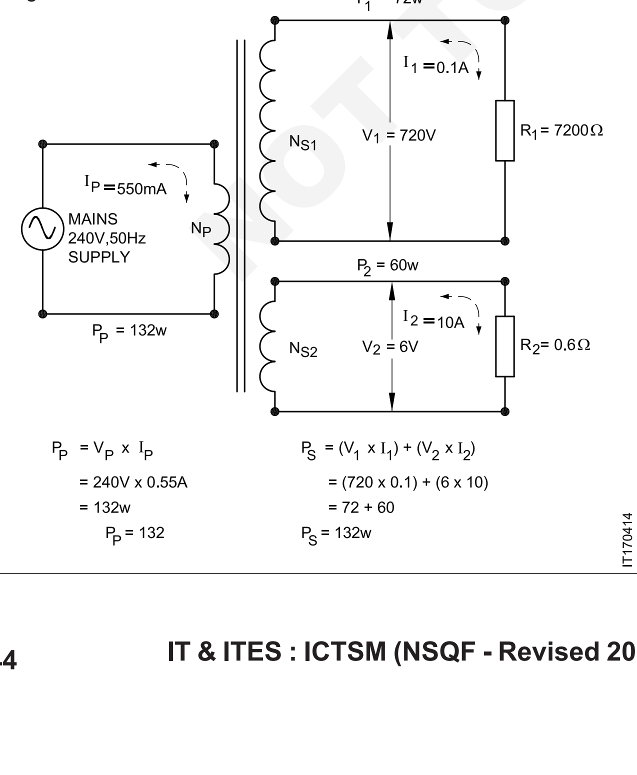
Power in Transformers with more than one secondary winding

A transformer need not have only one secondary winding as shown in Figures 1 to 3. Transformers can have one, two, or more number of secondary windings. Each secondary winding will have induced voltage in proportion to its turns ratio with the common primary winding. Fig 4 shows a transformer with two secondary windings.

Referring to Fig 3, the secondary winding N_{s1} provides voltage step-up and has a step-up of 3:1 providing 720 V. The other winding N_{s2} provides voltage step-down, with a ratio of 40:1 providing 6 V.

If the first secondary circuit consumes 72 watts and the second secondary circuit consumes 60 watts, then the power supplied by the 240 V source in the primary is 72 + 60 = 132 W.

Fig 3



CLASSIFICATION OF TRANSFORMERS

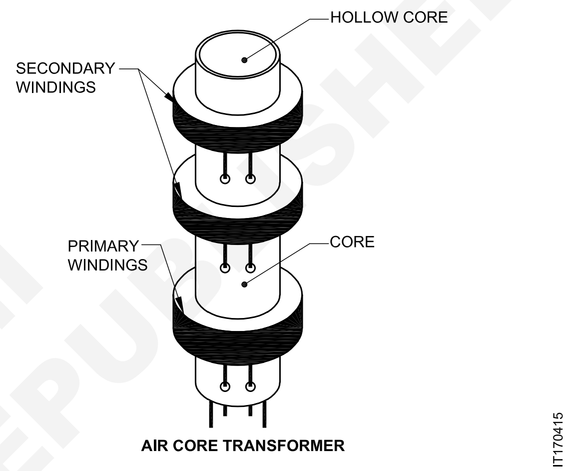
1 Classification based on the type of Core Material used

Transformers can be classified according to the type of material used for the core as;

(a) **Air core transformers:** Fig 4, air core transformers consists of a hollow non magnetic core, made of paper or plastic over which the primary and secondary windings are wound. These transformers will have values of k less than 1. Air core transformers are generally used in high frequency applications because these will have no *iron-loss* as there is no magnetic core material.

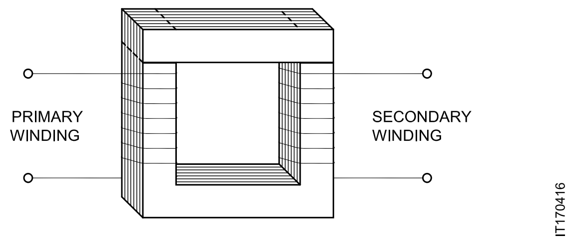
Iron-loss is a type of transformer loss due to core material. Transformer losses are discussed in detail in further lessons.

Fig 4



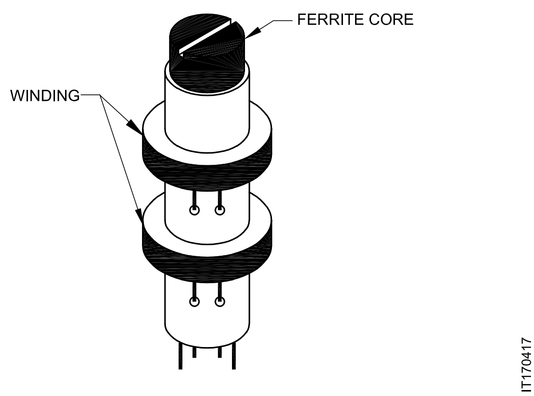
(b) **Iron core transformers**: Fig 5 shows a laminated iron-core transformer. These transformers have stacked laminated sheets of silicon steel over which the windings are wound. This is the most common type of transformer used with mains power supply(240V,50Hz). In these transformers, since the core is a magnetic material and due to the shape of the core, the value of k is almost equal to 1.

Fig 5



(c) **Ferrite core transformers**: Fig 6, these transformers have Ferrite material as its core. In most cases, the primary and secondary windings are wound on a hollow plastic core and the ferrite material is then inserted into the hollow core. These transformers are used in high frequency to very high frequency applications as they have the advantage of introducing minimum losses. In these transformer, the position of core can be changed, thus changing the value of M.

Fig 6



2 Classification based on the shape of core and relative position of primary and secondary windings:

a **Core type transformers**: Refer Fig 1 of Chart 1 given at the end of this lesson. In Core type of transformer, the primary and secondary windings are on two separate sections/limb of core. Core type transformers are less frequently used as their efficiency is low because the magnetic flux spreads out reducing the number of useful flux lines. The shape of core stampings used for these transformers is shown in Fig 1c.

b **Shell type transformers**: Refer Fig 2 of Chart 1. In this type, both the primary and the secondary windings are wound on the same section/limb of the core. As the portion of the core surrounds the two windings, almost all the flux is confined to the core of the transformer. Shell type transformers have a higher efficiency as compared to core type transformers. These are widely used as voltage and power transformers. The shape of core stamping used for these transformers is shown in Fig 2c.

c **Ring type transformers**: Refer Fig 3 of Chart 1. In this, the core is made up of circular or semicircular laminations as shown in Fig 3c. These are stacked and clamped together to form a ring. The primary and secondary windings are then wound on the ring. The disadvantage of this type of construction is the difficulty involved in winding the primary and secondary coils. Ring type transformers are generally used as instrument transformers for measurement of high voltage and current.

3 Classification based on the Transformation ratio:

a **Step-up Transformers**: Transformers in which, the induced secondary voltage is higher than the source voltage given at primary are called *step-up transformers*.

b **Step-down Transformers**: Transformers in which, the induced secondary voltage is lower than the source voltage given at primary are called *step-down transformers*.

c **Isolation transformers**: Transformers in which, the induced secondary voltage is same as that of the source voltage given at primary are called *one-to-one* or *isolation transformers*. In these transformers the number of turns in the secondary will be equal to the number of turns in the primary making the turns ratio equal to 1.

4 Classification based on the operating frequency:

a **Mains transformer**: Refer Fig 4 of Chart 1. These are basically, iron-core shell type transformers. These transformers form the link between AC mains source and other devices requiring AC or DC power. As an example, radio receivers need low voltage DC supply. To use a radio receiver from AC mains, the mains AC is stepped-down, AC is converted to DC (rectification) and fed to the radio receiver. The secondary winding of these transformers may have a centre tap as shown in Fig 7a or may have more than one secondary windings as shown in Fig 7b. These transformers may also have more than two terminals at primary winding as shown in Fig 7c to accommodate for different AC mains levels. Tapped primary also allows changes in the secondary-primary turns ratio. All the power transformers are generally designed to work at mains supply frequency (50 Hz).

Power transformers use colour coding scheme to identify the primary and secondary windings. One such scheme is shown in Fig 8.

b **Audio frequency (AF) transformers**: Refer Fig 5 of Chart 1. These AF transformers look similar to a mains voltage transformer but they are very small in size comparatively. Most AF transformers are of PCB mounting type. These transformers are designed to operate over the audio frequency range of 20 Hz to 20 KHz. Audio transformers are used in,

Fig 7

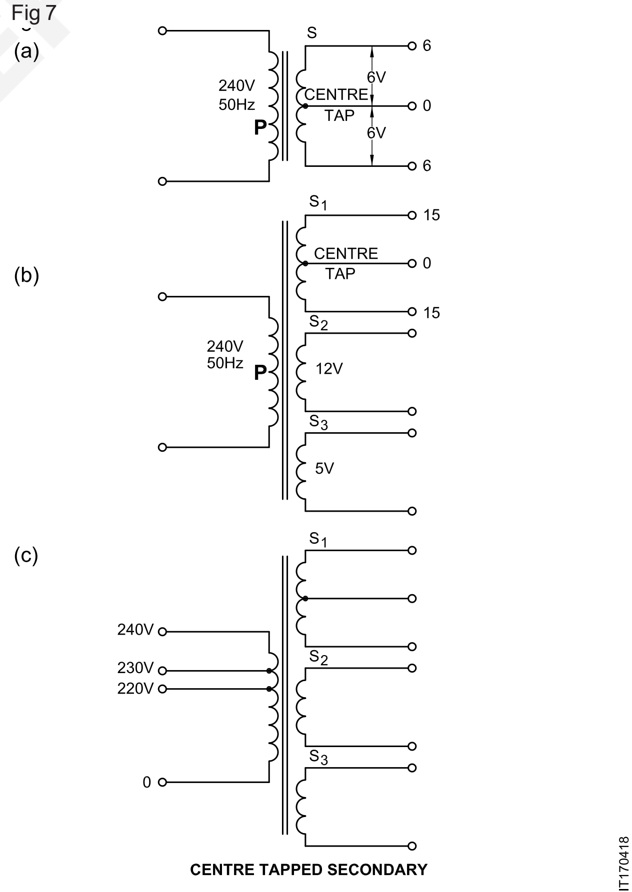
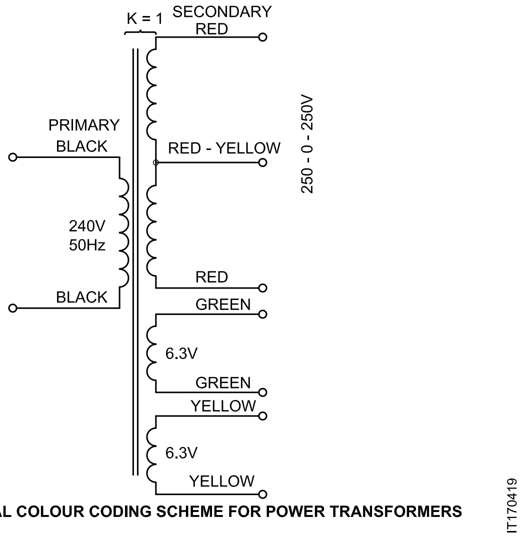


Fig 8



A TYPICAL COLOUR CODING SCHEME FOR POWER TRANSFORMERS

– coupling the output of one stage of audio amplifier to the input of the next stage (interstage coupling)

– the amplified audio signal from an amplifier to the speaker of a sound system.

These transformers are said to have *flat frequency response* over the entire audio range. This means that the transformer behaves equally well over the entire range of audio frequencies.

The transformation ratio of audio transformers will be generally less than unity.

These transformers also use a colour coding scheme to identify those used as driver transformers (for inter-stage coupling) or out-put transformers (for amplifier to speaker).

As the colour coding schemes differ from manufacturer to manufacture, the colour coding is not given in this lesson.

(c) **High frequency transformers**: Refer Fig 6 of Chart 1. The core of high frequency transformers are made of powdered iron or ferrite or brass or air core(hollow core) as shown in Fig 5 and 7 of this lesson. These transformers are called *Radio frequency transformers* (RFTs) and *Intermediate frequency transformers* (IFTs). These transformers are used for coupling any two stages of high frequency circuits such as radio receivers. The upper frequency limit of these transformers is 30 MHz.

Another specialty of these transformers is that the position of the core can be altered, which results in varied coupling and energy transfer. These transformers also have another electronic component called capacitor connected across the windings in parallel. This results in a different behavior of the transformer at different frequencies. Hence these transformer type are also called *Tuned transformers*.

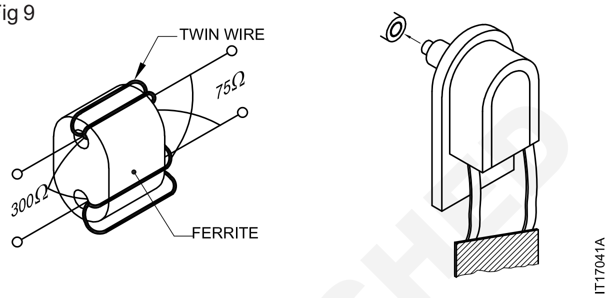
These transformers are smaller than even audio frequency (AF) transformers. These transformers will generally be shielded/screened using a good conductor (recall lesson on inductors for need of screening).

RFTs and IFTs also have a colour coding scheme to identify their different places of application.

Since the coding schemes vary from manufacturer to manufacturer, the colour coding scheme for RFTs and IFTs are not given in this lesson.

(d) **Very high frequency transformers**: These transformers also have air or ferrite or brass as core material. These transformers are constructed specially to minimize energy losses at very high frequencies. Very high frequency transformers are available in several shapes and designs. Some of these find wide application in Television receivers. Fig 9 illustrates a high frequency transformers used in TV reception.

Fig 9



5 Auto-transformers:

Auto-transformer as shown in Fig 10 is a special variety of transformers which have only a single winding. Because of single winding, there is no isolation between primary and secondary side. Auto-transformers are used when isolation between input and output is not important. Auto-transformers can be used for variable voltage operation by using a sliding contact like a potentiometer. But, it is important to note that an auto-transformer does not function as a simple voltage divider.

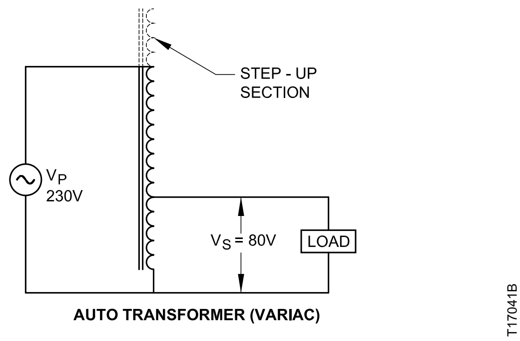
Auto-transformers are smaller in size and uses less iron than a conventional two winding transformer of the same rating.

Auto-transformers used for variable voltage operation are referred to the trade name of VARIAC.

As shown in Fig 10, auto-transformers has a step-up section (shown in dotted lines) which enables the transformer to develop a variable voltage output from 0 to 270V from a 240V input AC supply.

Auto-transformers are mostly used in laboratories for conducting experiments.

Fig 10



AUTO TRANSFORMER (VARIAC)

6 Single phase and three phase transformers:

Transformers Fig 4 of Chart are designed for use with single phase AC mains supply. Hence these transformers will have a single primary winding. Such transformers are known as single phase transformers. Transformers are also available for 3 phase AC mains supply. These are known as poly-phase transformers. Refer Fig 7 of Chart 2. In a 3-phase transformer, there will be three primary windings. Three phase transformers are used in electrical distribution and for industrial applications.

7 Classification based on application:

Transformers can also be classified depending upon their application for a specialized work. Since there are innumerable number of application, the types are also innumerable.

However a few of these are listed below:

Current Transformers - used in clip - on current meters, overload trip circuits etc.,

Constant voltage transformers - used to obtain stabilized voltage supply for sensitive equipments

Ignition transformers - used in automobiles

Welding transformers - used in welding equipments

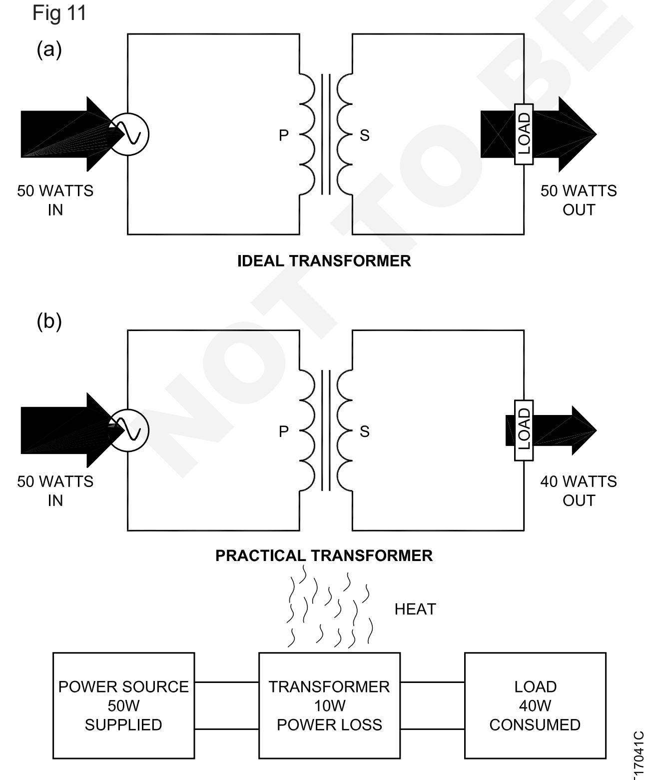
Pulse transformers - used in electronic circuits

Refer reference book for further details on types of transformers and their applications.

EFFICIENCY OF TRANSFORMERS

In an ideal transformer, the power consumed in the secondary is exactly equal to the power consumed in the primary as shown in Fig 11a.

Fig 11



In practice, ideal transformers cannot be made. This is because some amount of power is always wasted in transferring the power from primary to secondary. Hence, the power consumed in primary will always be higher than that available in secondary as shown in Fig 11b. This difference in the power between primary and secondary is lost or wasted as a result of transformer losses.

Transformers can be designed and made so that the transformer losses are minimum. The degree to which any transformer approaches the ideal condition is called the efficiency of the transformer. Efficiency of a transformer is generally expressed in percentage as,

$$\text{Efficiency h (in \%)} = \frac{\text{Output power}}{\text{Input power}} \times 100$$

LOSSES IN TRANSFORMERS

Because of the transformer losses, the transformer heats up when in operation. The losses in the transformer convert some of the electrical energy into heat energy as shown in Fig 11c. As a thumb rule, if a transformer is heating-up while in operation, the losses in the transformer is high.

Most common types of transformer losses which always exist with almost all iron-core transformers are explained below;

1 Copper losses

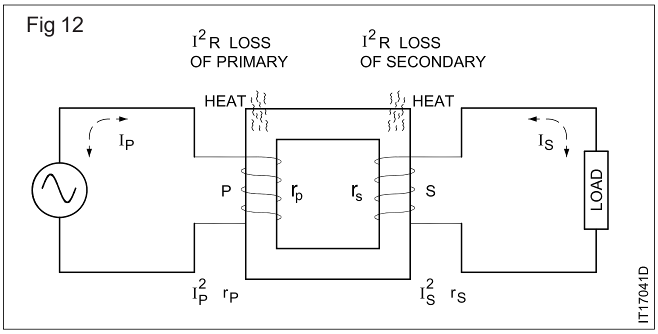
Transformer windings are made of many turns of copper wire. Copper wire although a very good conductor, still has some resistance (refer Appendix D). The value of this resistance depends upon the type of material and the length of wire. As the number of turns in windings increase, the longer is the length of wire, and greater will be the resistance. As shown in Fig 12, when primary and secondary currents flow through the windings, due to the ohmic resistance of the windings, power(I^2R) is dissipated in the form of heat.

These I^2R losses are called *Copper losses*. Copper losses increase if the currents through primary and secondary increases. Total copper loss in a transformer is equal to;

Copper loss = $I_p^2.r_p + I_s^2 r_s$

Copper losses can be minimised by using a thicker gauge copper wire, but this increases the size, weight and cost of the transformer.

Fig 12



2 Core losses or Iron losses

Core/Iron losses in transformer are due to two different types of losses namely;

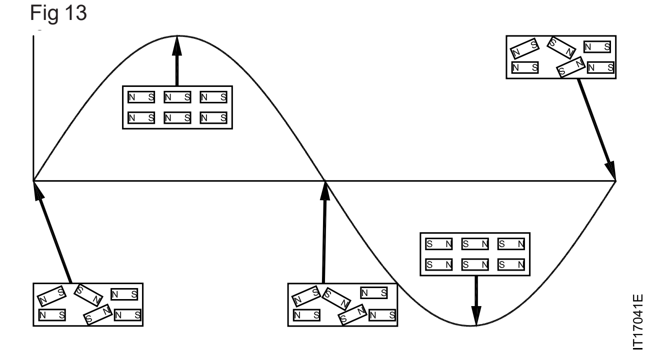
i Hysteresis loss

ii Eddy current loss

i Hysteresis loss

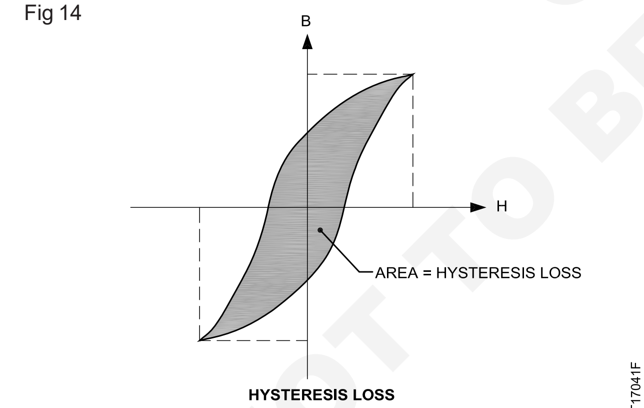
The magnetic field in the iron-core of a transformer undergoes a complete reversal 50 times each second for a mains-supply frequency of 50Hz. As shown in Fig 13, every time the polarity of the supply reverses, the molecules of iron with its N-S poles change its direction, such that the direction of magnetic field reverses.

Fig 13



Energy has to be supplied to the molecules of the iron core to make them catch-up with the new direction of magnetic field. This turning around of molecules, or reversing the magnetism of iron core, consumes energy in the form of heat. This loss of energy, appearing in the form of heat, is proportional to the area of the B-H curve or Hysteresis loop of the core material as shown in Fig 14.

Fig 14



HYSTERESIS LOSS

This loss of energy in the primary of the transformer in reversing the magnetism of the iron core is called *hysteresis loss* of the transformer.

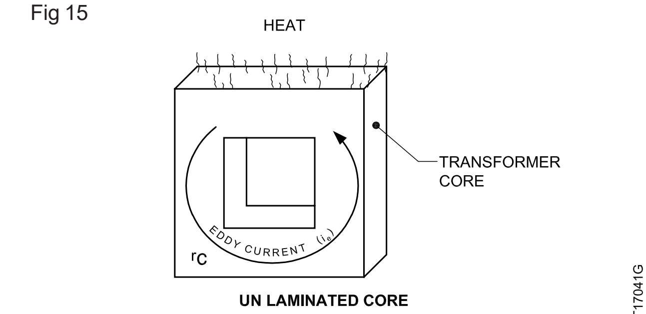
It should be noted that air core transformer will not have hysteresis loss as air core transformers do not use magnetic core material.

ii Eddy current loss

In iron-core transformers, the core material is a conducting material. So, the changing magnetic field of transformer induces a voltage in the core. This induced voltage in the core cause small current to circulate within the core as shown in Fig 16. This current is called eddy current.

The induced eddy current is large if the resistance of the core material is small. Due to this circulating eddy currents and the resistance of the core material, power loss occurs ($P=i_e^2r_c$) in the form of heat as shown in Fig 15.

Fig 15

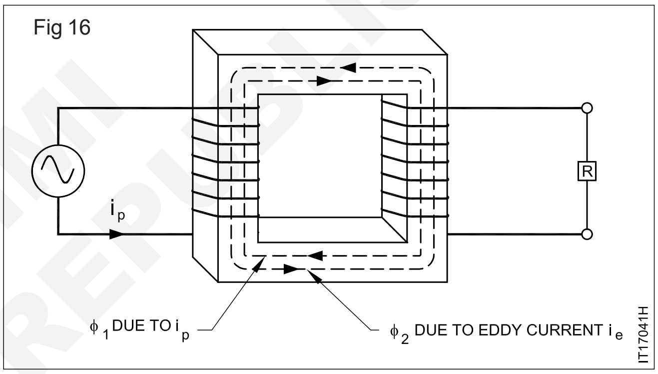


UN LAMINATED CORE

In addition, the induced eddy currents set-up an opposing flux ($ø_2$) in the core as shown in Fig 16. This results in more primary current trying to maintain the magnetic field in the core. This further increases the eddy current and hence the losses due to it.

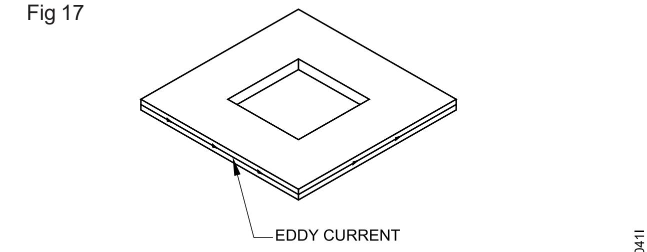
This loss of power in a transformer due to eddy current in the transformer core is referred to as eddy current loss.

Fig 16



Eddy current loss in a transformer core can be reduced by making the core, into thin flat sections as shown in Fig 17 instead of a solid single piece iron as in Fig 17. These thin flat sections are called laminations.

Fig 17

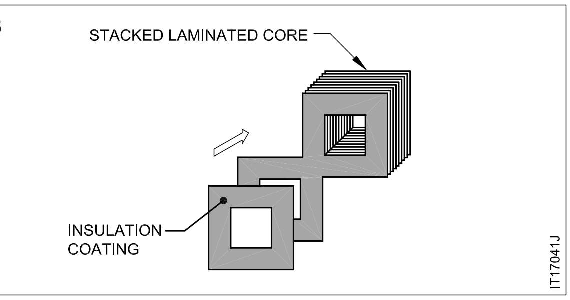


TRANSFORMER CORE LAMINATION

Since these laminations have very small cross-sectional areas, the resistance offered to the setting up eddy current is greatly increased and hence the loss due to it is also reduced.

Such laminations, are stacked together Fig 18. These laminations are insulated from each other by means of an insulation coating, generally shellac. Due to the insulation between laminations, the eddy currents can only flow in individual laminations. Hence the overall eddy current loss of the transformer is greatly reduced.

Fig 18



The power loss due to eddy currents is directly proportional to,

a the frequency of current.

b the magnitude of current.

If iron-core transformers are used at high frequencies, the eddy current losses become high. Hence iron-core transformers are not preferred in high frequency applications.

It should be noted that air core transformer will not have any eddy current loss as they do not have core material in which the eddy current can flow.

Other losses in transformers

In addition to copper losses and iron losses, transformer have two more types of losses. They are:

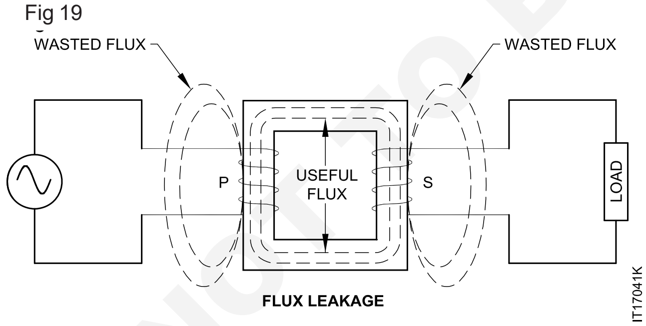
1 Loss due to flux leakage

2 Core saturation loss

Loss due to flux leakage

As can be seen from Fig 19, in transformers all the flux lines produced by the primary and secondary windings does not travel through the iron core. Some of the magnetic lines leak from the windings and go out into space. These leaked magnetic lines cannot do useful work. This leakage of the flux lines represents wasted energy, reducing the efficiency of the transformer.

Fig 19

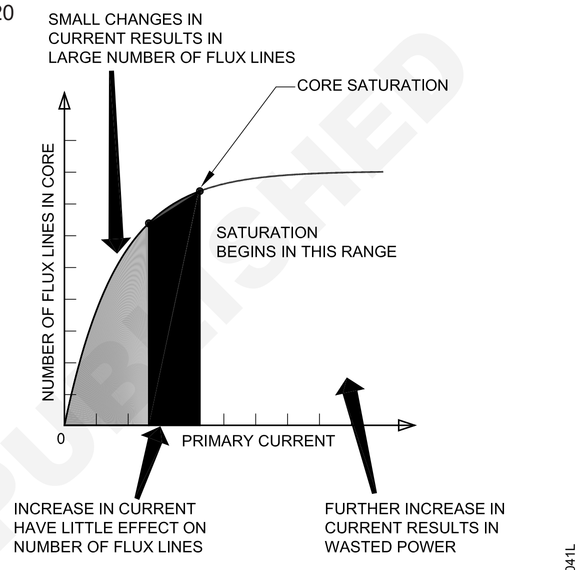


FLUX LEAKAGE

Loss due to core saturation

When the current in the primary winding of an iron-core transformer increases, the flux lines generated follow a path through the core to the secondary winding, and back through the core to the primary winding, As the primary current first begins to increase, the number of flux lines in the core increases rapidly shown in light gray shade in Fig 20. Additional increases in primary current will produce only a few additional flux lines less (shown in dark gray shade in Fig 20) than what it should have produced. The core is then said to be saturated. Any further increase in primary current after core saturation, results in wasted power.

Fig 20



CORE SATURATION

Summing the different types of losses in a transformer, the total loss is given by,

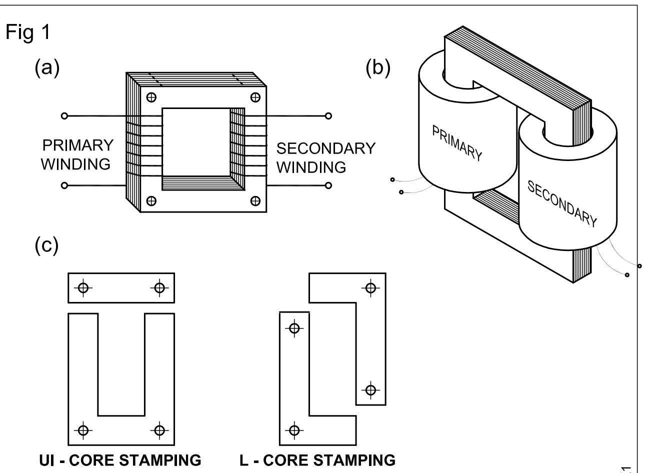
Total transformer loss = Copper losses(primary + secondary) + Iron losses (Hysteresis + eddy current) + Flux leakage loss + Core saturation loss.

Compared with the other two losses, the flux leakage loss and the core saturation loss are negligible. Also these two losses can be greatly reduced by good transformer design and safe current level operation. Hence, the total losses that occur in a transformer can be found knowing its copper losses and iron losses.

CHART- 1

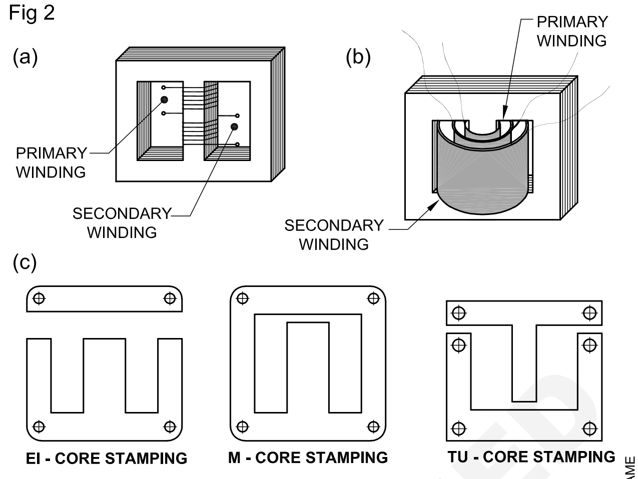
TYPES OF TRANSFORMERS

Fig 1



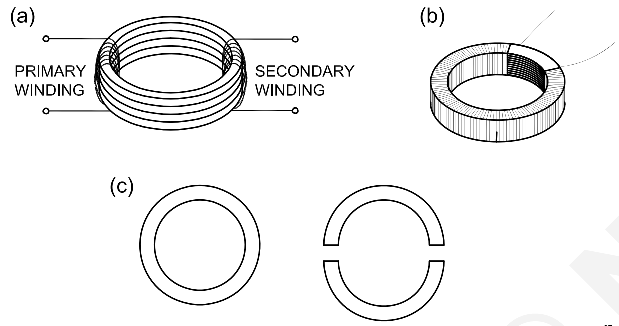
CORE-TYPE TRANSFORMER

Fig 2



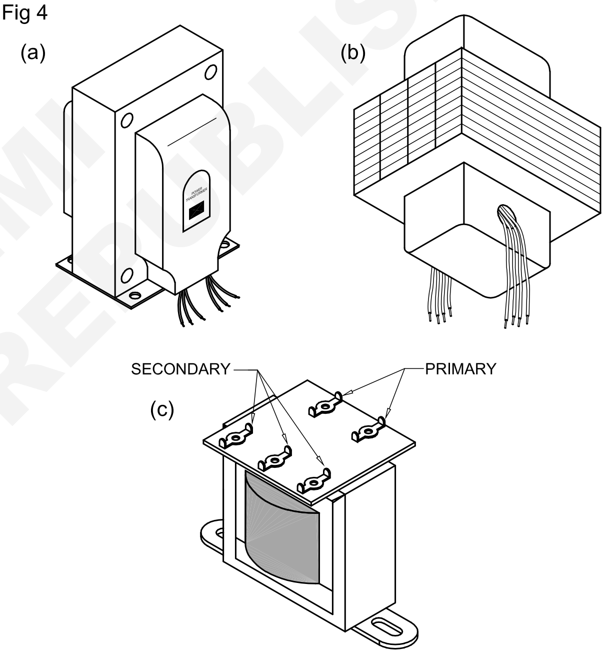
SHELL-TYPE TRANSFORMER

Fig 3



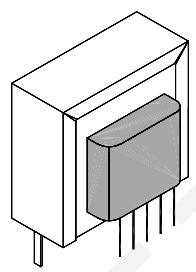
RING - TYPE TRANSFORMER

Fig 4



MAINS FREQUENCY TRANSFORMER

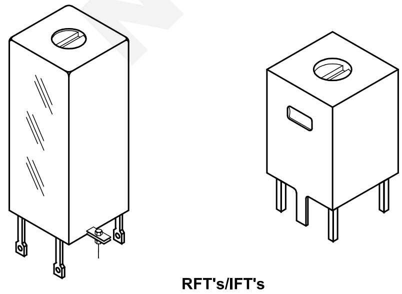
Fig 5



AUDIO FREQUENCY TRANSFORMER

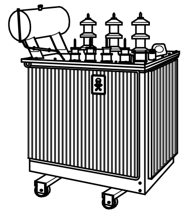
Fig 6

HIGH FREQUENCY TRANSFORMER



RFT's/IFT's

Fig 7



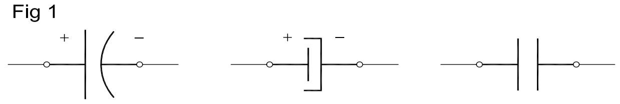
POLY - PHASE TRANSFORMER

Capacitors - construction & testing

Objectives: At the end of this lesson you shall be able to
- **state the basic function of capacitors and meaning of capacitance**
- **describe how capacitor stores energy and define the unit**
- **list functions of dielectric in a capacitor**
- **list main types of fixed value capacitors and minimum specifications.**

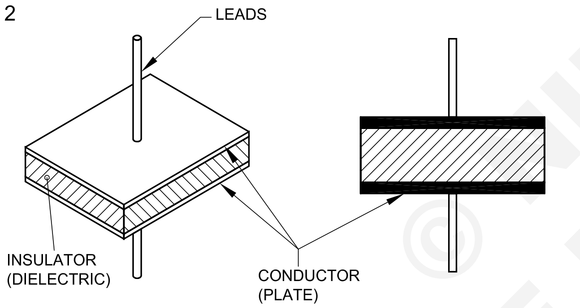
Capacitors are electronic components which can store electric energy in the form of electric charge. The charge storage ability of a capacitor is called the **Capacitance** of a capacitor. Symbols used to represent capacitors are shown in Fig 1. Alphabet 'C' is used to represent the capacitance of a capacitor.

Fig 1



A simple capacitor consists of two pieces of conductors separated by an insulator as shown in Fig 2.

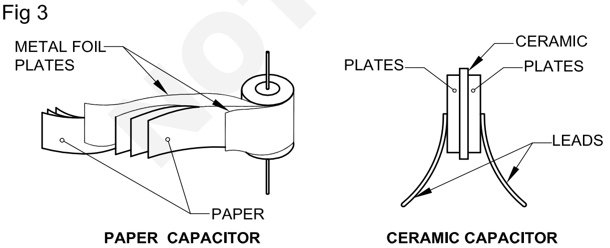
Fig 2



In capacitors the conductors Fig 2 are called **plates** and the insulator is called **dielectric**.

The plates of a capacitor can be of any size and shape and the dielectric may be any one of several insulator materials. Depending on the type of insulator/dielectric used capacitors are called as paper, mica, ceramic, glass, polyester, air electrolyte capacitors etc., (Fig 3)

Fig 3

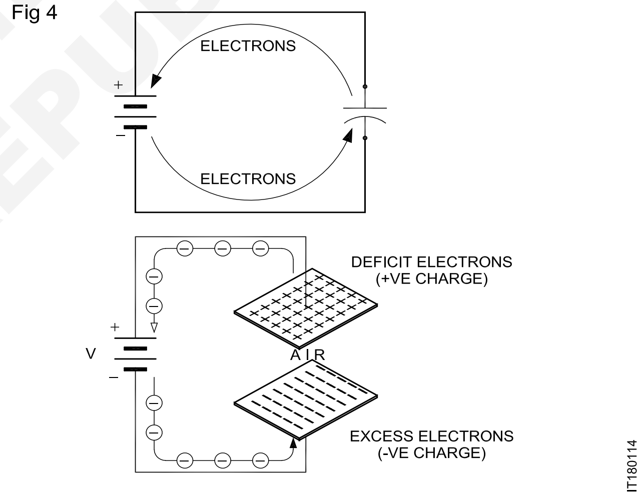


Capacitor action of storing charge

When electric charge is forced on to the plates of a capacitor by some energy source, such as a battery, the capacitor stores these charges.

When a capacitor is connected to a battery as shown in Fig 4, electrons from the negative terminal of battery move through the connecting leads and pile up on one of the plates of the capacitor. At the same time free electrons from the other plate of the capacitor (remember that plates of a capacitor are conductors having free electrons) move through the connecting lead to the positive terminal of the battery. This process is known as 'charging of capacitor'. As the process of charging continues, the net result is that, one plate of the capacitor ends up with excess of electrons (Negative charge) and the other plate with deficiency of electrons (Positive charge). These charges on the plates of the capacitor represent a voltage source similar to that of the charges on the terminals of a battery/cell. The process of charging stops once the energy stored on the capacitor develops a voltage equal to that of the battery.

Fig 4



Unit of capacitance

The ability of capacitor to store electrical energy in the form of electrostatic field is known *capacitance*. The unit used to measure capacitance is **Farad** abbreviated as **F**.

A capacitor is said to have a capacitance(C) of 1 Farad, if it stores a charge(Q) of 1 coulomb when a voltage(V) of 1V is applied across its plates.

Therefore, capacitance can be mathematically expressed as,

$$\text{Capacitance} = \frac{\text{Charge}}{\text{Voltage}}$$

$$C = \frac{Q}{V} \textit{ Farads}$$

Farad(F) is a very large quantity of capacitance. As most circuits use capacitance values much lower than one farad (F), smaller quantities of capacitance given below are generally used:

1 Microfarad or 1μF	= 1/1000000 F	or	10^{-6} farads
1 Nanofarad or 1 nF	= 1/10^{9} F	or	10^{-9} farads
1 Picofarad or 1pF	= 1/10^{12} F	or	10^{-12} farads

Factors that determine the value of capacitance

The capacitance of a capacitor is determined by the following three main factors;

1 Area of the plates

2 Distance between the plates

3 Type of dielectric material.

Function of a dielectric in a capacitor

1 Solves the mechanical problem of keeping two metal plates separated by a very small distance.

2 Increases the maximum voltage that can be applied before causing a breakdown, compared with air as dielectric.

3 Increases the amount of capacitance, compared with air, for a given dimension of plates and the distance between them.

Types of capacitors

Capacitors can be classified under two main categories:

Fixed value capacitors: The capacitance value of these capacitors is fixed at the time of manufacture. This value cannot be varied/altered by the user.

Variable capacitors: The capacitance of such capacitors can be varied between the specified minimum to the specified maximum values by the user.

Amongst fixed value capacitors, many different types of capacitors are manufactured to satisfy the needs of the electronic industry. These different types of capacitors are named according to the

1 Type of dielectric material used in capacitor

Example:

a If paper is used as dielectric, the capacitors are called paper capacitors.

b If ceramic is used as dielectric, the capacitors are called Ceramic capacitors.

2 Type of construction of the capacitor

Example:

a If the foils of the conductor and dielectric are rolled to form a capacitor, such capacitors are called *Rolled foil capacitors*.

b If the plates and dielectric are in the form of Discs, such capacitors are called *Disc capacitors*.

Different types of fixed value capacitors, their sub types, available values, rated voltage and a few applications are given in Chart 2 at the end of this lesson. Also refer to Chart 3 for illustration of some of the popular fixed value capacitors.

Measurement of capacitive reactance at different frequencies

AC bridge method of measuring capacitance

There are several methods of measuring capacitance using AC bridges. The easiest of all these is the *De Santy method*. This method adopts the technique of comparing the value of an unknown capacitor with that of a known capacitor.

Digital meters for capacitance measurement

Digital meters for exclusive measurement of capacitance are available commercially. These meters can measure values from a few hundred pico-farads to a few thousands of micro-farads.

Digital meters are also available which can measure resistance, inductance and capacitance, known as RLC meters. These meters, in addition to measuring the capacitance values, can also measure other properties of capacitors such as leakage current, insulation resistance.

Effect of frequency on capacitor current

The amount of current flowing in any circuit is nothing but the number of electrons that flow past any point in the circuit, in a unit time. In other words, current is equal to the rate of flow of electrons. As an equation, this can be written as,

$$I = \frac{Q}{t} \text{ amperes}$$

where,

Q = number of electrons being transported in time t.

Capacitive reactance

Similar to resistors and inductors, a capacitor also offers opposition to the flow of AC current. This opposition offered to the flow of current by a capacitor is called **capacitive reactance** abbreviated as X_C.

Recall expressions,

$$I = \frac{Q}{t} = \text{ and } Q = CV.$$

Substituting Q = CV in I = Q/t

$$I = \frac{CV}{t}$$

This means,

$I \propto C$, $I \propto V$ and $I \propto f$ (Because, 1/t = f)

From the above equation, the amount of AC current that a capacitor conducts depends on;

– the frequency (f) of the applied voltage

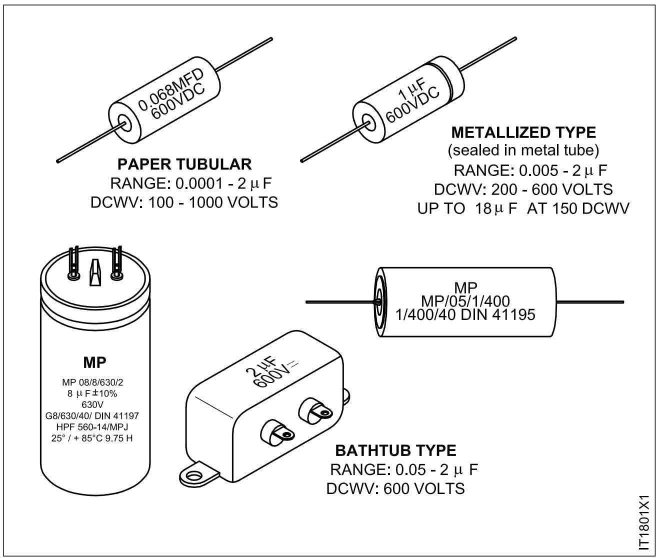
– the capacitance (C) of the capacitor

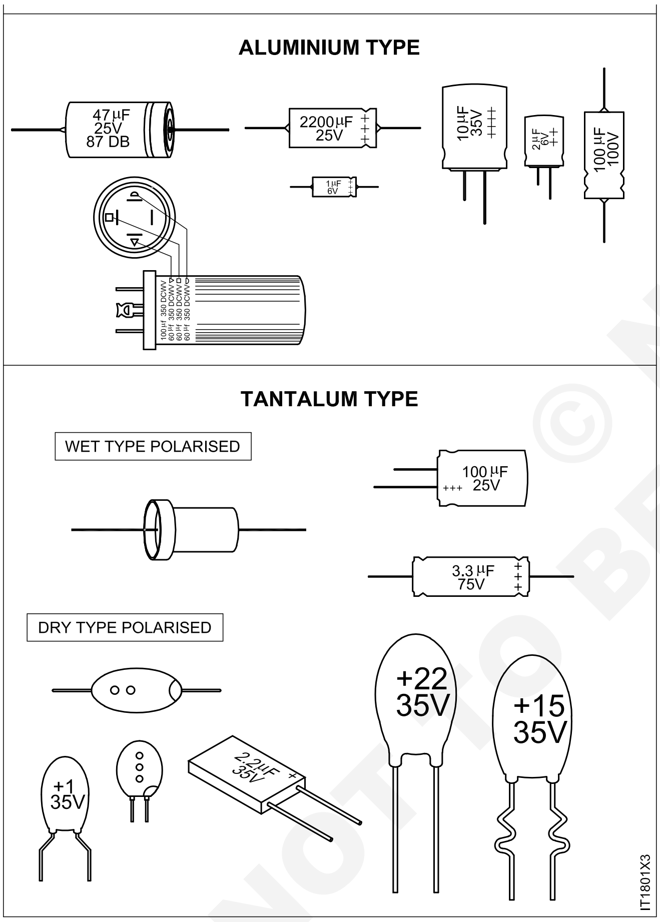
– the amplitude of the applied voltage(V).

Main types of fixed value capacitors

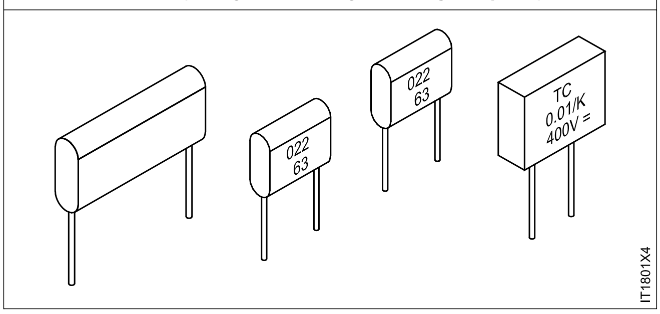
Type	Main sub-types	Dielectric used	Construction	Available capacitances	Rated voltage	Applications
Paper	Foil type & Metallized type	Impregnated special craft paper Special tissue paper	Rolled foils	0.001-1mF	200-1600VDC	Motor - starting, PF correction power supply- filters.
Plastic film	Foil type & Metalised type	i) Polystyrene ii) Polyester (Mylar capacitor)- iii) Poly propylene- iv) Poly carbonate v) Metallized polypropyene- vi) Metallized polyester- vii) Polystyrol (Styroflex)	- Rolled foils	0.001-1mF 0.001-1mF 0.001-0.47mF 0.01-18mF 4-60mF 0.01-10mF	100-200VDC- 100-600VDC- 400-1600VDC- 50-200VDC- 400 VAC, 50 Hz 100-600VDC	General purpose, high stability. General purpose. RF circuits. General purpose. AC motors. Coupling, RF filtering.
Ceramic	Disc type Tube type Monolithic (chip type) Feed-through-stand-off-button type	Class-1 (Non ferro-electric) -Steatite (Talc) -Mix of MgO, TiO_2 -TiO_2, CaO Class-2 (Ferro-electric) -Barium titanate -Ba, Sr, TiO_2+Mg, Zr	Drawn ceramic films Moulded tubes Substrate-Screening-sintering	1PF -1mF 1PF-1000PF 1pF-10mF	50-500VDC 500-5KVDC 50-200VDC	General purpose, RF. General, VHF. VHF, RF coupling. Coupling in VHF range. Decoupling in VHF range. HF circuit feeders.
Electro-lytic	Aluminium (polor, non-polar)(Wet, dry type) Tantalum (polar, non-polar)(Wet, dry type)	Aluminium oxide Tantalum pentoxide	Rolled foil - metallic can Rolled foil - Can/cup/tank	1-500,1000mF 0.1-1000mF	5-500VDC 3-125VDC	Power supplies, filters. Space electronics. Nonpolar Al and Ta capacitors are used in loudspeaker cross-overs.
Mica	Stacked mica- Silvered mica Button type	White mica, Rose mica, Amber mica	Stacked	5 pF-10,000pF 5pF-3300pF	50-100 50-500	High frequency High frequency H.F line feeders
Glass		Thin layer of glass	Stacked	5 pF-5000pF		VHF applications
Vitreous Enamel		Mixture of silica, Potassium, lead oxide and fluorides	Deposited in layers		50-500	

CHART - 3 : Physical appearance of types of fixed value capacitors

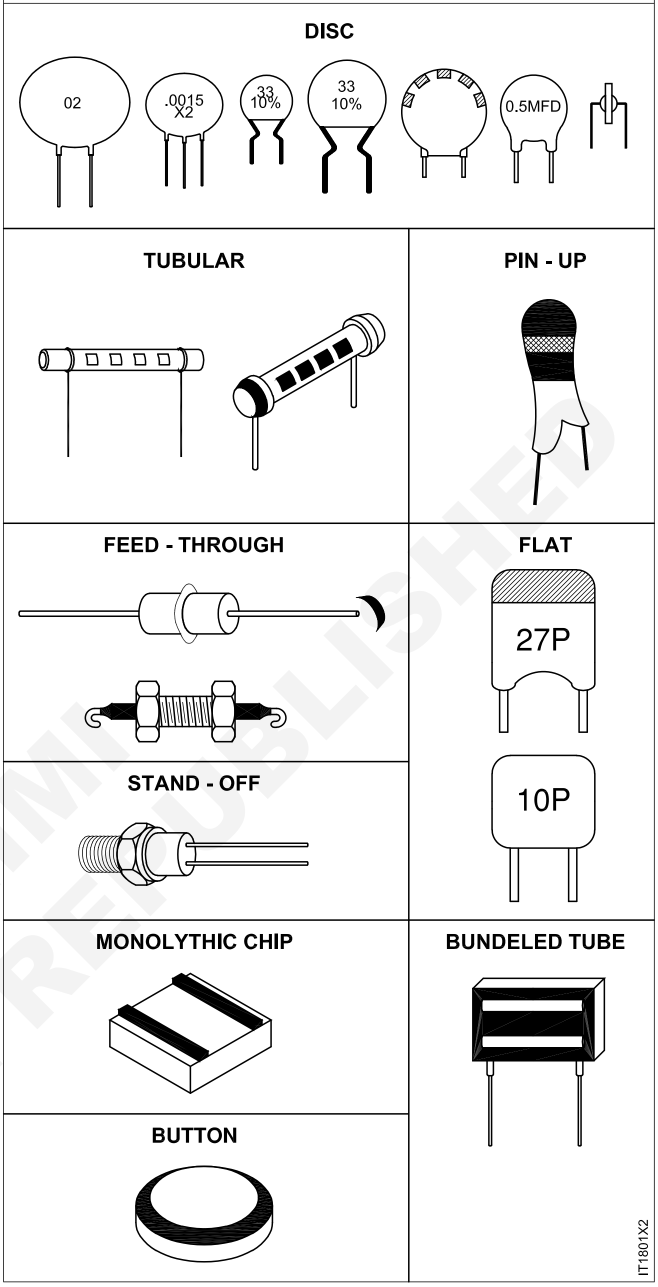


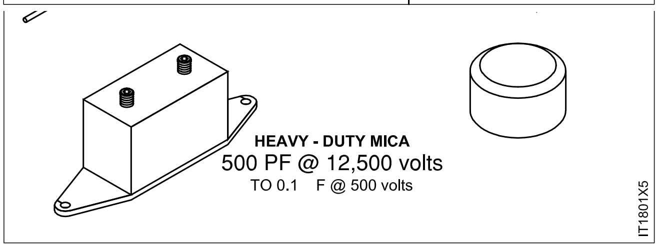


PLASTIC FILM CAPACITORS



CERAMIC CAPACITORS





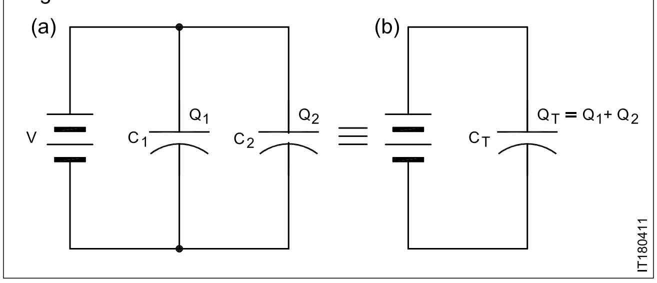
Capacitors in series & parallel

Objectives: At the end of this lesson you shall be able to
- **state the effect of capacitors in parallel and series in respect of total capacitance and reactance**
- **explain why no power is dissipated by a pure capacitor**
- **calculate the energy stored in a capacitor**
- **explain the application of capacitors in power supplies and uses of capacitors.**

Capacitors in parallel

When two capacitors are connected in parallel as shown in Fig 1a, it is possible to represent these two capacitors by a single capacitor of equivalent value.

Fig 1



The charge that accumulates on each capacitor is given by,

$Q_1 = C_1.V$

and $Q_2 = C_2.V$

If C_1 and C_2 are to be represented by one capacitor, say of value C_T, as shown in Fig 1b, then, C_T must store a total charge $Q_T = Q_1 + Q_2$.

Therefore, $Q_T = C_T.V$

$C_T.V = C_1.V + C_2.V$

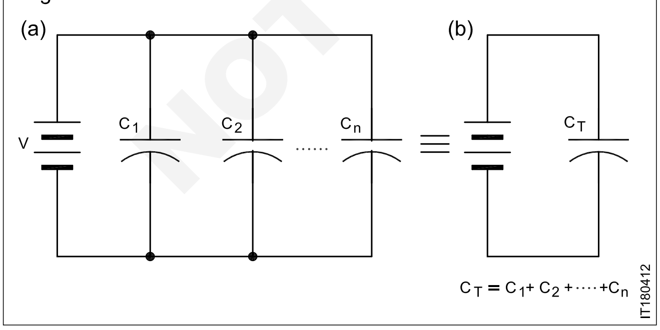
$C_T.V = V(C_1 + C_2)$

or $C_T = C_1 + C_2$.

Generalizing, when several capacitors $C_1, C_2, ... C_n$, are connected in parallel, as shown in Fig 2, then the effective capacitance value C_T of this connection will be,

$$C_T = C_1 + C_2 + C_3 + ... + C_n.$$

Fig 2



Hence, *when capacitors are connected in parallel, the effective capacitance increases.*

It is interesting to note that, the equation for parallel-connected capacitors is similar to the series connection of resistors. The reason why an increase in capacitance results is due to the effective increase in the plate area, A (recall C α A).

When capacitors of different voltage ratings are connected in parallel, the maximum working voltage(DCWV) of the combination will be that of the lowest voltage rating capacitor amongst the group of capacitors.

Example: *Three capacitors of specifications 15 μF - 25V; 100 μF - 20V; and 1 μF - 50V are connected in parallel. Determine,*

a The total capacitance.

b The maximum voltage that can be applied to the circuit.

c The maximum charge that the parallel-connected group can store without damaging any capacitor in the connection.

SOLUTION

a $C_T = C_1 + C_2 + C_3 = 15\ \mu F + 100\ \mu F + 1\ \mu F$

$= 116\ \mu F$

b Maximum working voltage of the combination is the minimum working voltage of the capacitor in the group. In the group, 100 μF has the minimum DCWV of 20V.

Hence, the maximum DCWV of the parallel combination is 20 volts only.

c. $Q_T = C_T.V = 116\ \mu F \times 20$ Volts $= 2320\ \mu C$.

Effective capacitive reactance of capacitors in parallel

When capacitors are connected in parallel, the total capacitance C_T increases. This causes the overall reactance of the circuit to decrease because, $X_C = 1/2\Pi fc$.

Fig 3 shows the capacitive reactance of individual capacitors connected in parallel.

From Fig 3, it can be seen that X_C's in parallel is similar to the resistances in parallel. Therefore, the total capacitive reactance X_{CT} of capacitors in parallel is given by,

$$\frac{1}{X_{CT}} = \frac{1}{X_{C1}} + \frac{1}{X_{C2}} + \frac{1}{X_{C3}} + ... + = \frac{1}{X_{Cn}}$$

Example: *Two capacitors of 8 μF-400V and 4 μF-400V are connected in parallel across a 240 V, 50 Hz supply. Calculate,*

a the total capacitive reactance

b the total current drawn from the supply.

SOLUTION

a. X_{C1} = 1/2x3.141x50x8x10^{-6} = 398 W

X_{C2} = 1/1x3.141x50x4x10^{-6} = 796 W

$$\frac{1}{X_{CT}} = \frac{1}{X_{C1}} + \frac{1}{X_{C2}}$$

$$\text{or } X_{CT} = \frac{X_{C1} \times X_{C2}}{X_{C1} + X_{C2}} = \frac{398\,\Omega \times 796\,\Omega}{398\,\Omega + 796\,\Omega} \approx 256\,\Omega$$

b. $$I_T = \frac{V}{X_{CT}} = \frac{240V}{265\,\Omega} \approx 0.90\text{ A}.$$

CAPACITORS IN SERIES

When two capacitors are connected in series as shown in Fig 4, the charging current is the same throughout the circuit as it is in a series circuit.

Since the current is the same, the same quantity of charge, say Q is deposited on each capacitor. The voltage across any capacitor is given by the formula,

$$Q = CV \text{ or } V = \frac{Q}{C}.$$

Hence, the voltage to which each capacitor charges is given by,

$$V_1 = \frac{Q}{C_1} \text{ and } V_2 = \frac{Q}{C_2}.$$

But, by Kirchhoff's voltage law, $V_S = V_1 + V_2$.

Therefore, $$V_s = \frac{Q}{C_1} + \frac{Q}{C_2}$$

or V_S =

If C_T was the equivalent capacitor of the series connection as shown in Fig 4, for C_T to charge to voltage V is given by,

$$V = \frac{Q}{C_T}.$$

Therefore,

$$\frac{Q}{C_T} = V = \frac{1}{C_1} + \frac{1}{C_2} \text{ or } \frac{1}{C_T} + \frac{1}{C_1} + \frac{1}{C_2}$$

$$\text{or } C_T = \frac{C_1 \times C_2}{C_1 + C_2}.$$

Energy stored in a capacitor

Once a capacitor is charged, the voltage across it remains even when the source is removed. In fact, a capacitor is the only device that can store electrical energy apart from an electric voltaic cell (an inductor also stores energy but only as long as current is flowing through it). In some applications, capacitors can store a charge for even months. This property is used to indicate the measurements of pressure or temperature in remote locations. The energy stored in a capacitor is given by the equation

$$W = \frac{1}{2} CV^2 \text{ joules (J)}$$

where,

W is the energy stored in the capacitor in joules, J

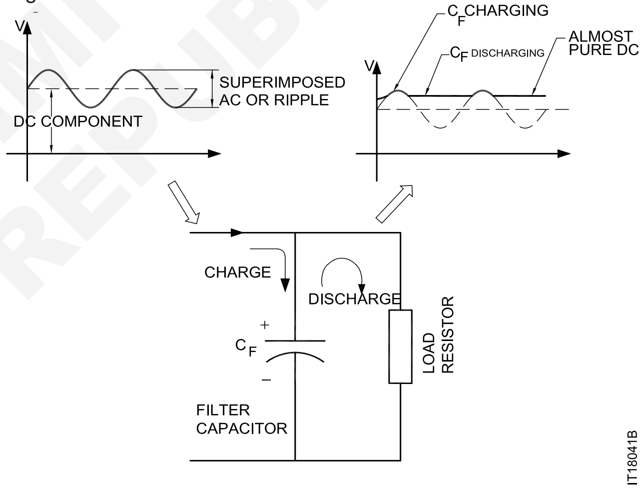
C is the capacitance in farads, F

V is the final voltage across the capacitor in volts, V.

Capacitors as ripple filters

The small unwanted AC voltage superimposed over a pure DC signal as shown in Fig 3 is known as ripple voltage. Such ripple voltage is most common in low quality *battery eliminators* used to obtain DC voltage from AC mains supply.

Fig 3



All electronic circuits invariably need pure DC voltage. If the ripple in the DC is large, the electronic circuits do not behave as expected. For example, a ripple in the DC voltage given to a radio receiver produces an unwanted humming noise in the speaker.

The property of charging and discharging of capacitors is made use of to remove or to filter off the unwanted ripple. (Fig 3)

Capacitors for AF and RF coupling

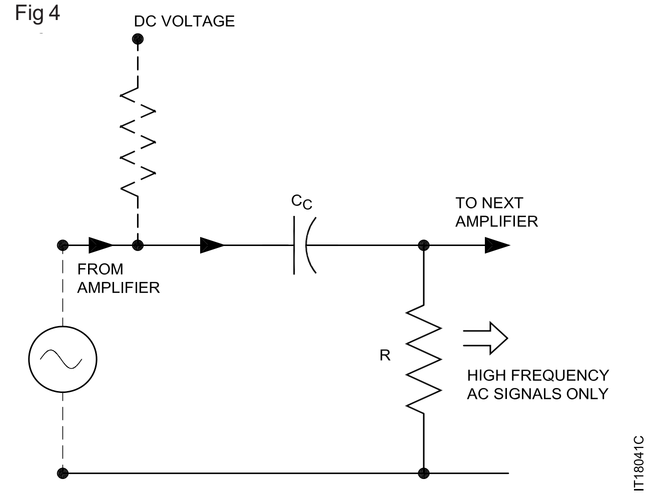
One of the main uses of capacitors is in coupling the signal between the two stages of amplifiers. (Fig 4)

Capacitors are used for coupling because of the following reasons.

1 It provides low reactance at high frequencies, resulting in low AC voltage drop across C.

2 The entire dc voltage is dropped across C with none across R.

Fig 4



As a result, the voltage across R is only of the desired high frequency AC signal and not DC current or very low frequency signal. This application of the capacitor C_C, therefore, is called ac coupling.

The value of C_C to be used depends upon the lower limit of the frequency to be coupled. The table given below gives an idea of the value of capacitor to be used for different frequency ranges.

Frequency range	**Lower frequency limit chosen**	**Value of C_c used**
Low audio frequencies	100 Hz	1 µF
Audio frequencies (mid)	1000 Hz	0.1 µF
Audio frequencies (high)	10 kHz	0.01 µF
Radio frequencies	1000 Hz	100 pF
Very high frequencies	100 MHz	1 pF

Further details on coupling capacitors is dealt in the unit on amplifiers.

Series and parallel resonance

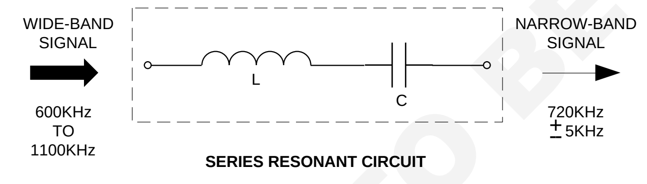
Objectives: At the end of this lesson you shall be able to
- **state the meaning of resonance in LC circuits**
- **state the condition for resonance in a series and parallel LC circuit**
- **list the characteristics of LC circuits at resonance**
- **list a few applications of series and parallel resonance circuits.**

SERIES RESONANCE CIRCUIT

Impedance of series resonance circuit

A simple series LC circuit shown in Fig 1. In this series LC circuit,

Fig 1



– resistance R is the total resistance of the series circuit (internal resistance) in ohms,

– X_L is the inductive reactance in ohms,

and

– X_C is the total capacitive reactance in ohms.

Series resonance

From the above discussions it is found that in a series RLC circuit,

$$\text{Impedance } Z = \sqrt{R^2 + (X_L \sim X_C)^2}$$

$$\text{Current } I = \frac{V}{Z}$$

and,

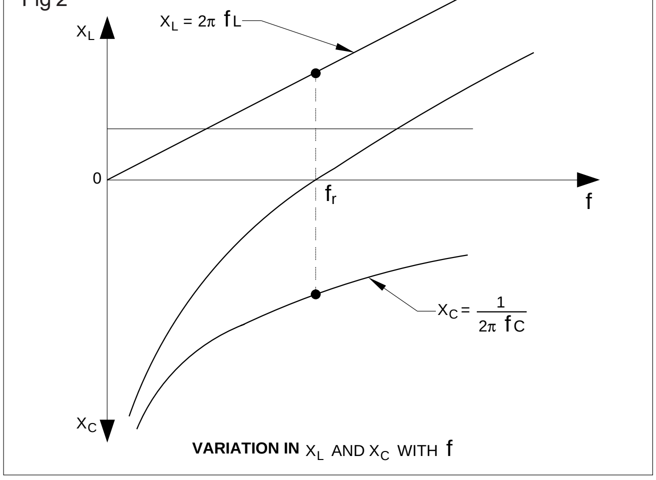
$$\text{Phase angle } \theta = \tan^{-1}\frac{X_L \sim X_C}{R}$$

If the frequency of the signal fed to such a series LC circuit is increased from 0 Hz, as the frequency is increased, the inductive reactance (X_L = 2pfL) increases linearly and the capacitive reactance (X_C = 1/2pfL) decreases exponentially as shown in Fig 2.

As shown in Fig 5, at a particular frequency called the **resonance frequency, f_r**, the sum of X_L and X_C becomes zero ($X_L - X_C = 0$).

From Fig 2 above, at resonant frequency f_r,

Fig 2



- Net reactance, X = 0 (i.e, $X_L = X_C$)
- Impedance of the circuit is minimum, purely resistive and is equal to R
- Current I through the circuit is maximum and equal to V/R
- Circuit current, I is in-phase with the applied voltage V (i.e. Phase angle θ = 0).

At this particular frequency f_r called resonance frequency, the series RLC is said to in a condition of **series resonance**.

Resonance occurs at that frequency when,

$X_L = X_C$ or 2pfL = 1/2pfC

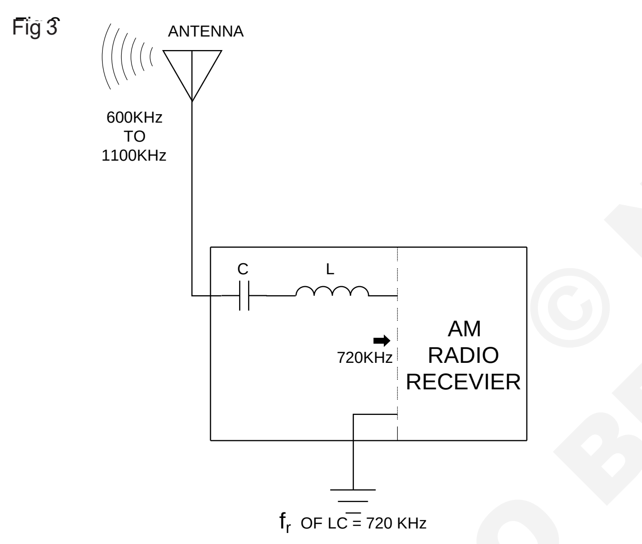
Therefore, **Resonance frequency, f_r** is given by,

$$f_r = \frac{1}{2\pi\sqrt{LC}} \text{ Hz} \qquad ....[1]$$

Application of series resonance circuits

A series resonance circuit can be used in any application where it is required to select a desired frequency. One such application is shown in Fig 3.

Fig 3

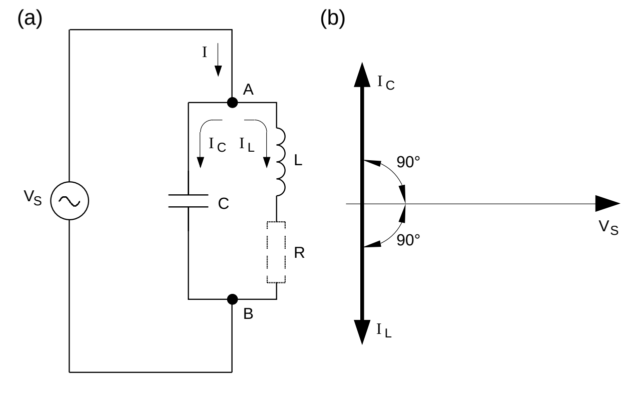


In Fig 3, the radio receiver antenna intercepts all the frequencies available in air. For instance, the antenna intercepts the frequencies transmitted by Chennai-A radio station, Chennai-Vividhabharthi station, and so on. The series LC circuit when tuned to 720KHz(f_r) will allow only the signal corresponding to Chennai-A radio station and rejects all other signal frequencies. This is how a radio can receive any one station although frequencies of many stations are in the air simultaneously.

PARALLEL RESONANCE

The circuit at having an inductor and a capacitor connected in parallel is called parallel LC circuit or parallel resonance circuit. The resistor R, shown in dotted lines indicate the internal dc resistance of the coil L. The value of R will be so small compared to the inductive reactance, that it can be neglected.

Fig 4



From Fig 4, it can be seen that the voltage across L and C is same and is equal to the input voltage V_S.

By Kirchhoff's law, at junction A,

$I = I_L + I_C$.

The current through the inductance I_L (neglecting resistance R), lags V_S by 90°. The current through the capacitor I_C, leads the voltage V_S by 90°. Thus, as can be seen from the phasor diagram at Fig 10b, the two currents are out of phase with each other. Depending on their magnitudes, they cancel each other either completely or partially.

If $X_C < X_L$, then $I_C > I_L$, and the circuit acts capacitively.

If $X_L < X_C$, then $I_L > I_C$, and the circuit acts inductively.

If $X_L = X_C$, then $I_L = I_C$, and hence, the circuit acts as a purely resistive.

Zero current in the circuit means that the impedance of the parallel LC is infinite. This condition at which, for a particular frequency, f_r, the value of $X_C = X_L$, the parallel LC circuit is said to be in parallel resonance.

Summarizing, for a parallel resonant circuit, at resonance,

$X_L = X_C$,

Z_p = ¥

$I_L = I_C$

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

$$I = \frac{V}{Z_p} \text{ ♠ } 0$$

In a parallel resonance circuit, with a pure L(no resistance) and a pure C(loss-less), at resonance the impedance will be infinite. In practical circuits, however small, the inductor will have some resistance. Because of this, at resonance, the phasor sum of the branch currents will not be zero but will have a small value I. This small current I will be in phase with the applied voltage and the impedance of the circuit will be very high although not infinite.

Summarizing, the three main characteristics of parallel resonance circuit at resonance are,

– phase difference between the circuit current and the applied voltage is zero

– maximum impedance

– minimum line current.

Hence, parallel resonant circuits are also called tank circuits.

Application of parallel resonant circuits

Parallel resonance circuits or tank circuits are commonly used in almost all high frequency circuits. Tank circuits are used as collector load in class-C amplifiers instead of a resistor load

Table below gives a comparison between *series resonant* and *parallel resonant* circuit at frequencies above and below their resonant frequency f_r.

Property	Series circuit	Parallel circuit
	At resonant frequency	
Resonant frequency, f_r	$\frac{1}{2\pi\sqrt{LC}}$	$\frac{1}{2\pi\sqrt{LC}}$
Reactance	$X_L = X_C$	$X_L = X_C$
Impedance	Minimum (Z_r = R)	Maximum (Z_r = L/CR)
Current	Maximum	Minimum
Quality factor	$\frac{X_L}{R}$	$\frac{X_L}{R}$
Bandwidth	$\frac{f_r}{Q}$	$\frac{f_r}{Q}$
	Above resonant frequency	
Reactance	$X_L > X_C$	$X_C > X_L$
Impedance	Increases	Decreases
Phase difference	The current lags behind the applied voltage.	The current leads the applied voltage.
Type of reactance	Inductive	Capacitive
	Below resonant frequency	
Reactance	$X_C > X_L$	$X_L > X_C$
Impedance	Increases	Decreases
Phase difference	The current leads the applied voltage.	The current lags behind the applied voltage.
Type of reactance	Capacitive	Inductive

Basic electricity, fuses and switches

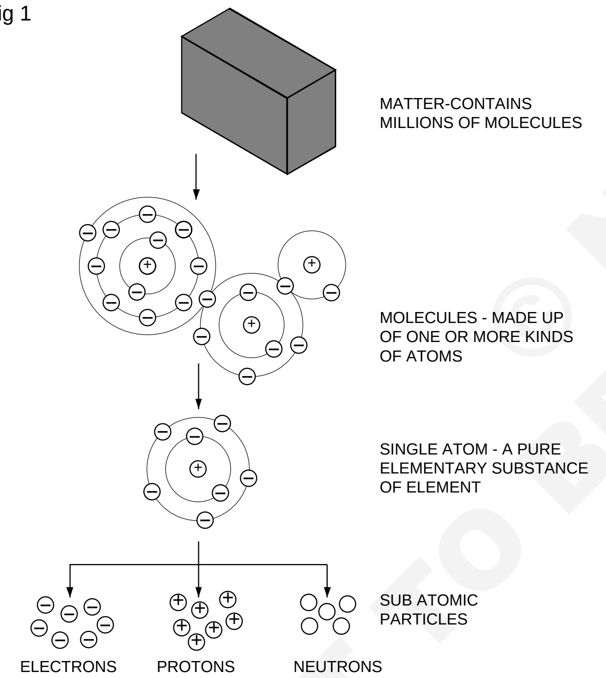
Objectives: At the end of this lesson you shall be
- **draw the structure of an atom and name its sub-atomic particles**
- **identify conductors and insulators from their atomic structure of a given material**
- **list the commonly used conductors, insulators and semiconductors.**

Matter, atomic structure

Anything that one can see, feel, or use is matter. Matter is anything that has weight and occupies space. Matter can be in the form of a solid like stone, wood, metal or liquid like water, alcohol or gas like oxygen, hydrogen, carbon di-oxide etc.

Matter is made up of tiny particles called molecules. Molecules are made up of even smaller particles called atoms. Atoms are made up of further smaller particles called **protons, neutrons** and **electrons** as shown in Fig 1.

Fig 1

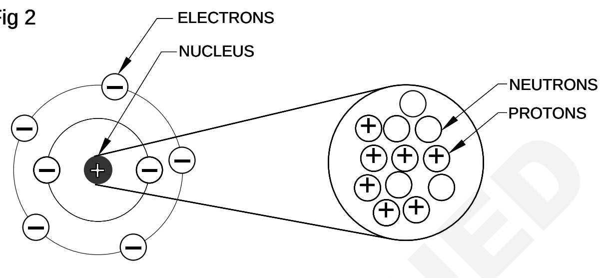


Atomic structure

Although an atom cannot be seen through naked eyes, Neils Bohr has suggested the structure of an atom as shown in Fig 2 which is universally accepted.

As shown in Fig 2, **nucleus** is the central part of the atom. Nucleus is made up of **protons** which are positively charged and **neutrons** which do not have any charge. Electrons revolve around the nucleus and are negatively charged. Generally the number of electrons (-ve charge) in an atom will be equal to the number of protons (+ve charge). The number of protons in the nucleus of an atom of one element differs from that of an atom in another element. Table below gives the number of Protons in atoms of some elements.

Fig 2



Name of the element	No. of protons	Atomic number
Hydrogen	1	1
Oxygen	8	8
Silver	47	47
Gold	79	79

Because the number of electrons in an atom is equal to the number of protons, an atom will be electrically neutral when it is not participating in any chemical, electrical or other activity. In other words, the positive charges of protons will neutralise the negative charges of electrons resulting in zero net charge of an atom.

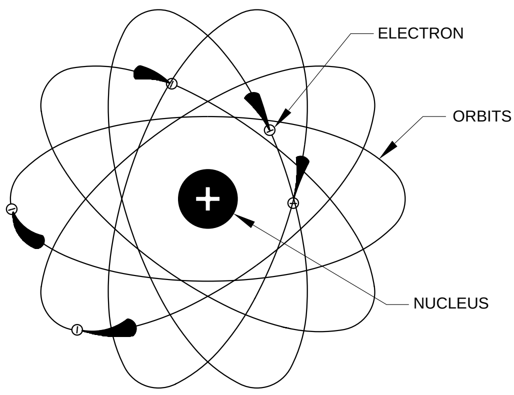
Any atom is recognised by the following specifications;

Atomic number - number of protons or number of electrons.

Atomic weight - total number of protons and neutrons.

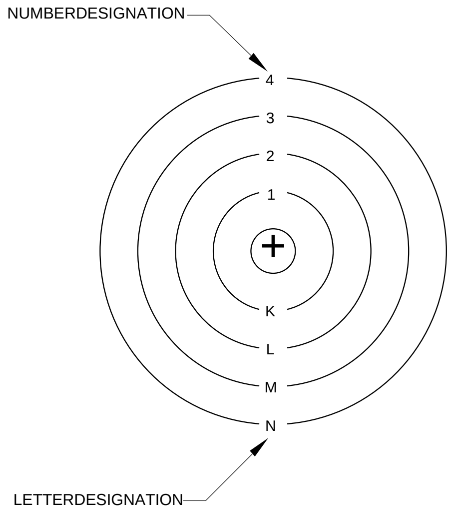
In all atoms, electrons revolve round the nucleus in different orbits as shown in Fig 3.

Fig 3



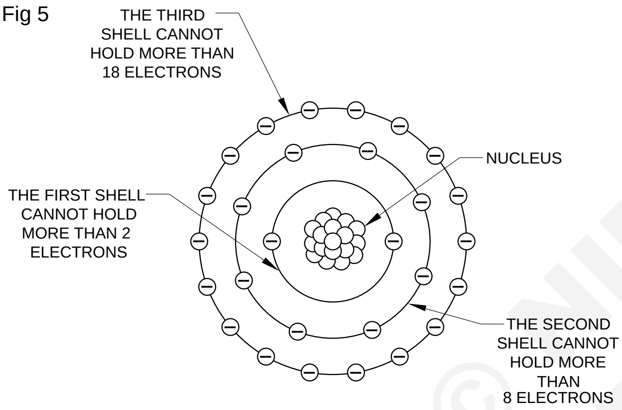
These orbits are also called shells. Shells are identified by numbers or by letters as shown in Fig 4.

Fig 4



The maximum number of electrons in each orbit is given by $2n^2$ where n is the orbit number as shown in Fig 5.

Fig 5



As the protons in the nucleus are positively charged, the electrons revolving round the nucleus will have a force of attraction towards the nucleus (opposite charges attract each other). This force is maximum for the electrons in the innermost shell and minimum for the outermost shell because of its distance from the nucleus. (the magnitude of attraction is inversely proportional to the distance between the charges)

The outermost orbit of an atom is called the **valence orbit**. The electrons in this orbit are called **valence electrons**. These valence electrons are loosely bound to the nucleus as they are far from nucleus.

Depending upon the number of valence electrons in an atom, the materials can be classified as conductors, insulators and semiconductors as shown in Fig 6.

Conductors

In atoms having one or two electrons in its valence orbit, the electrons can be pulled out of their orbit and made available as free electrons. Such materials are called conductors. With the application of external force, these electrons become free to participate in conduction. Electricity is defined as the flow of electrons as shown in Fig 7.

Fig 6

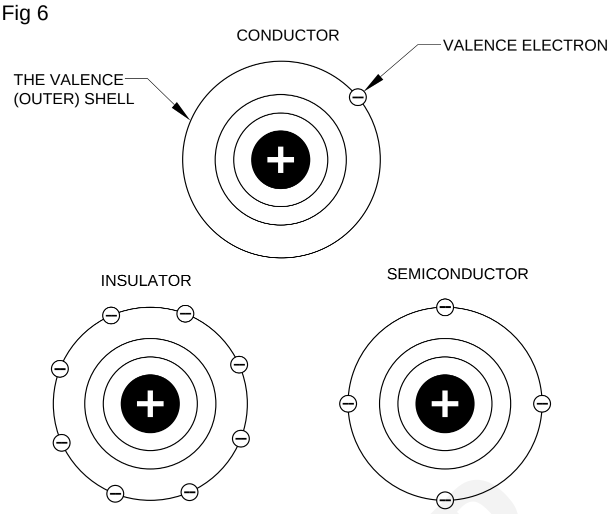
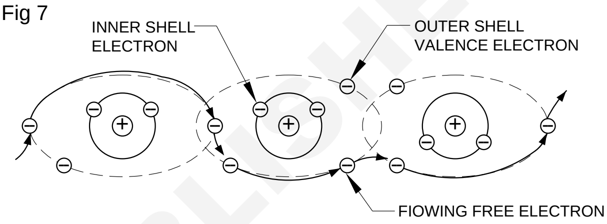


Fig 7



Copper atom has one valence electron. Hence, copper is a very good conductor of electricity. In other words the conductivity of copper is very good. Given below is a list of metal conductors, in the order of their conductivity.

1 Silver
2 Copper
3 Gold
4 Aluminium
5 Iron

From the above list, it is evident that silver is the best conductor followed by copper, gold and aluminium. Copper and aluminum are available in abundance in nature, hence the cost of these metals is cheaper than the other conductors. Therefore, copper and aluminum are the most commonly used for electrical work. Gold is used for special purposes as conductor as this metal has certain special property compared to copper and silver.

INSULATORS

If the number of valence electrons in an atom is 5, 6, 7 or 8 then they tend to bind to the atom. Therefore, even if a large external energy is applied, none of the electrons or very few electrons come out of their orbit and be available as free electrons. Hence such materials which are not good conductors of electricity are called non-conductors or insulators. Some common insulators are listed below, in the descending order of non-conductivity.

1 Porcelain
2 Glass
3 Plastic
4 Rubber
5 Paper
6 Air
7 Wood

SEMICONDUCTORS

If the number of valence electrons in an atom is 4, materials composed of such atoms are called semiconductors. These have the characteristics in-between that of a conductor and an insulator. The conductivity of semiconductors also depends upon the temperature in which they are used. At low temperatures semiconductors behaves as insulators. At high temperatures they behave as fairly good conductors. Examples of most used semiconducting materials are silicon and germanium.

CURRENT

The motion of electrons is called **electric conduction or electric current**. When no external energy is supplied, the free electrons in a conductor move from atom to atom within the conductor. But this motion is at random, without any organised flow through the conductor. Hence when the conductor is considered as a whole, from one end to other end, the current is zero. However when an external force is given to these random moving free electrons, then the motion of electrons will be organised, resulting in the movement of electrons in a particular direction through the wire. This is called flow of electric current.

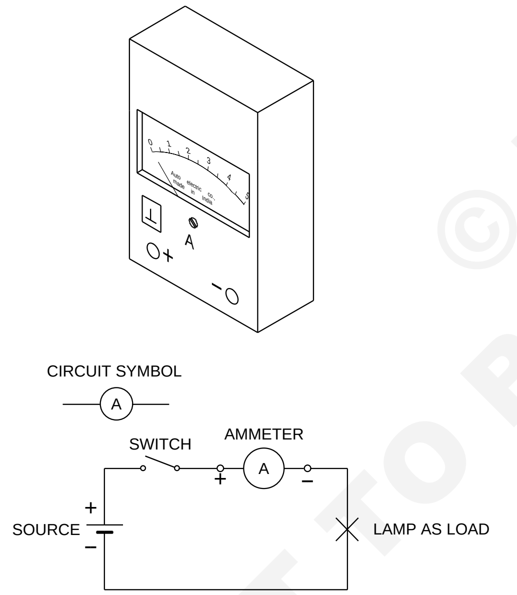
Simple electrical circuit and its elements

Objectives: At the end of this lesson you shall be able to
- **explain the emf, potential difference, their units and method of measurement (Voltmeter)**
- **explain the current, its units and method of measurement (Ammeter)**
- **explain resistance and its unit.**

Ampere

The unit of current (abbreviated as I) is ampere (symbol A). If 6.24×10^{18} electrons pass through a conductor per second, then we can say one ampere current has passed through the conductor.

Fig 1



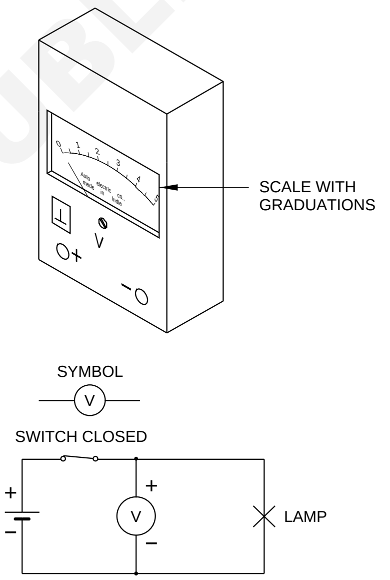
The terminals of the battery are indicated in the circuit symbol by two lines, the longer line for the *positive* and the shorter for the *negative* terminal.

Within the battery the negative terminal contains an excess of electrons whereas the positive terminal has a deficit of electrons. The battery is said to have an electromotive force (emf) which is available to drive the free electrons in the closed path of the electrical circuit. The difference in the distribution of electrons between the two terminals of the battery produces this emf.

Volt

The unit of electromotive force is the volt (symbol V) and the emf is commonly referred as 'voltage'. When the battery is connected to any load, the voltage measured across the terminals is called potential difference (PD) and this will be slightly less than the value of emf.

Fig 2



Resistance

In addition to the current and voltage there is a third quantity which plays a role in a circuit, called the electrical resistance. Resistance is the property of a material by which it opposes the flow of electric current.

Ohm

The unit of electrical resistance (abbreviated as R) is ohm (symbol Ω).

For the decimal multiples or decimal sub-multiples of the ohm we use the following expressions:

1 megohm = 1 M Ω = 1000000? = $1 \times 10^6\Omega$

1 kilo-ohm = 1 k Ω = 1000? = $1 \times 10^3\Omega$

1 milli-ohm = 1 m Ω= 1/1000? = $1 \times 10^{-3}\Omega$

1 micro-ohm = 1 $\mu\Omega$ = 1/1000000? = 1 x $10^{-6}\Omega$

Space for recording additional information

Characteristics & specification of Diodes

Objectives: At the end of this lesson you shall be able to
- **state the meaning of intrinsic and extrinsic semiconductors**
- **define the P and N type semiconductor material**
- **state the meaning of donors and acceptors in doping**
- **state the unique property of a PN junction forward and reverse biasing**
- **list the different classifications of diodes**
- **state how to test a diode using an ohmmeter**
- **list the important specifications of a diode**
- **explain the meaning of forward and reverse biasing of diode.**

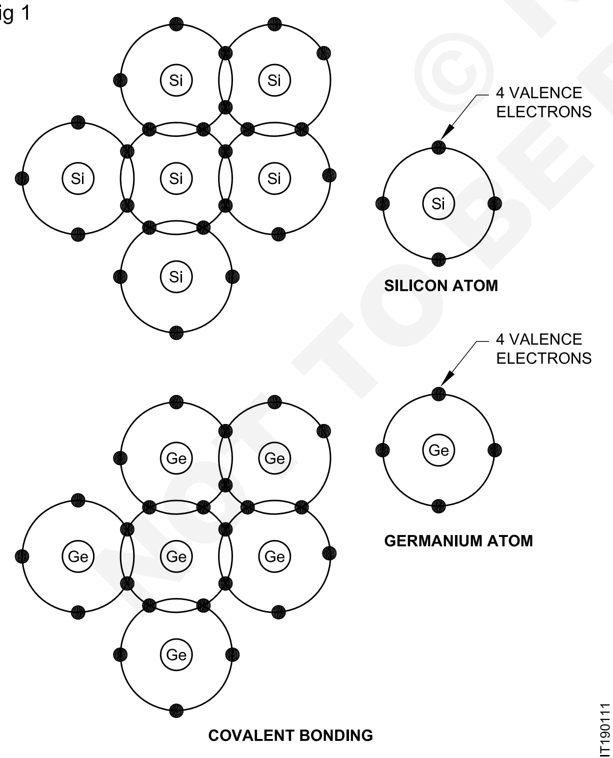
SEMICONDUCTORS

Semiconductors are materials whose electrical property lies between that of Conductors and Insulators. In conductors the valence electrons are always free. In an insulator the valence electrons are always bound. Whereas in a semiconductor the valence electrons are normally bound but can be set free by supplying a small amount of energy.

Semiconductor theory

Basic semiconductor materials like other materials have crystal structure. The atoms of this structure, are bonded to each other as shown in Fig 1. This bonding is known as covalent bonding.

Fig 1



Intrinsic semiconductors

The most important of the several semiconductor materials are Silicon (Si) and Germanium (Ge). Both these semiconductor materials have four valence electrons per atom as shown in Fig 1. These valence electrons, unlike in conductors, are not normally free to move. Hence, semiconductors in their pure form, known as Intrinsic semiconductors, behave as insulators.

However, the valence electrons of a semiconductor can be set free by applying external energy. This energy will tear-off the bound electrons from their bond and make them available as free electrons. The simplest method of turning bonded valence electrons into free electrons is by heating the semiconductor.

This type of conduction in an intrinsic semiconductor (pure semiconductor) as a result of heating is called intrinsic conduction.

It is important to note that semiconductors are temperature-sensitive materials.

Extrinsic semiconductor

The number of free electrons set free by heating a pure semiconductor is comparatively small to be used for any useful purpose. It is found experimentally that, when a small quantity of some other materials such as Arsenic, Indium, Gallium etc. is added to pure conductor material, more number of electrons become free in the mixed material. This makes the semiconductor have higher conductivity.

These foreign materials added to the pure semiconductor are referred to as impurity materials.

The process of adding impurity to an Intrinsic semiconductor material is known as Doping. Since the doped semiconductor materials are no longer pure, they are called impure or **extrinsic semiconductors.**

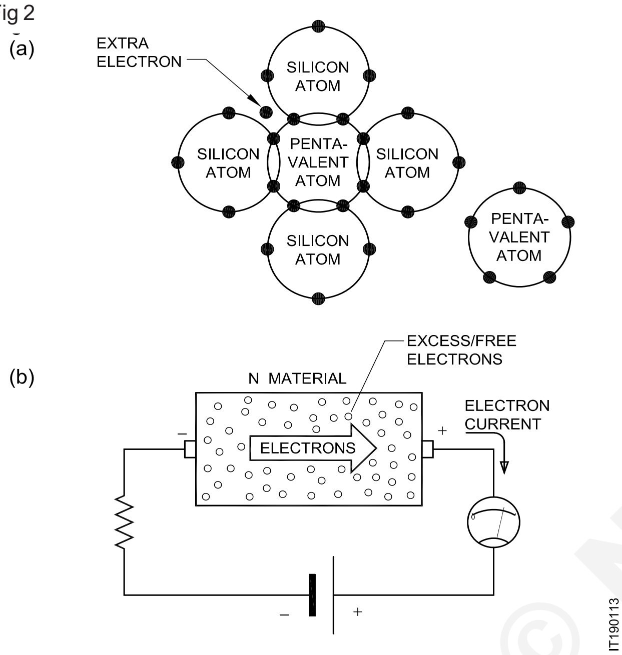
Depending upon the type of impurity used, extrinsic semiconductors can be classified into two types;

1 N-type semiconductors

When a pentavalent material like Arsenic (As) is added to a pure Germanium or pure Silicon crystal, one free electron results per bond as shown in Fig 2a. As every arsenic atom donates one free electron, arsenic is called the donor impurity. Since a free electron is available and since the electron is of a Negative charge, the material so formed by mixing is known as **N type material.**

When a N-type material is connected across a battery, as shown in Fig 2b, current flows due to the availability of free electrons. As this current is due to the flow of free electrons, the current is called electron current.

Fig 2



2 P-type semiconductors

When a trivalent material like Gallium(Ga) is added to a pure Germanium or pure Silicon crystal, one vacancy or deficit of electron results per bond as shown in Fig 3a. As every gallium atom creates one deficit of electron or hole, the material is ready to accept electrons when supplied. Hence gallium is called acceptor impurity. Since vacancy for an electron is available, and as this vacancy is a hole which is of Positive charge, the material so formed is known as **P-type material**.

When a P-type material is connected across a battery as shown in Fig 3b, current flows due to the availability of free holes. As this current is due to flow of holes, the current is called hole current.

P-N junction

When a P-type and a a N-type semiconductors are joined, a contact surface between the two materials called PN-junction is formed. This junction has a unique characteristic. This junction, has the ability to pass current in one direction and stop current flow in the other direction as shown in Fig 4. To make use of this unique property of the PN junction, two terminals one on the P side and the other on the N side are attached. Such a PN junction with terminals attached is called a **Diode.** The typical symbol of a PN-junction diode.

Fig 3

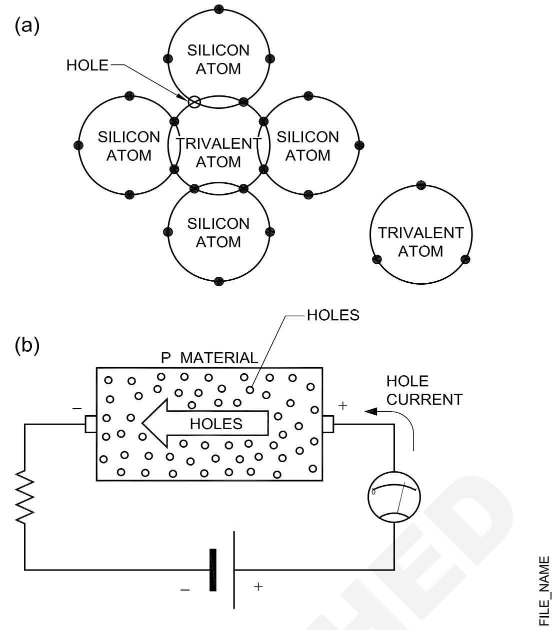
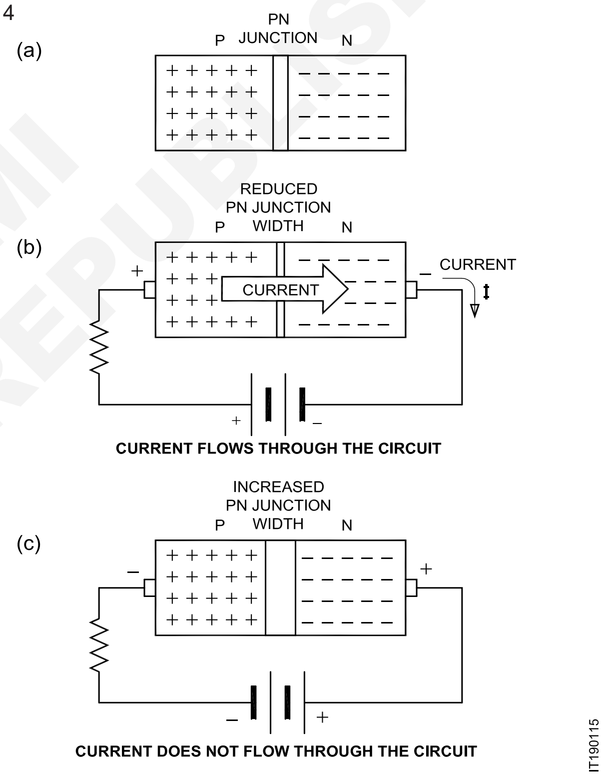
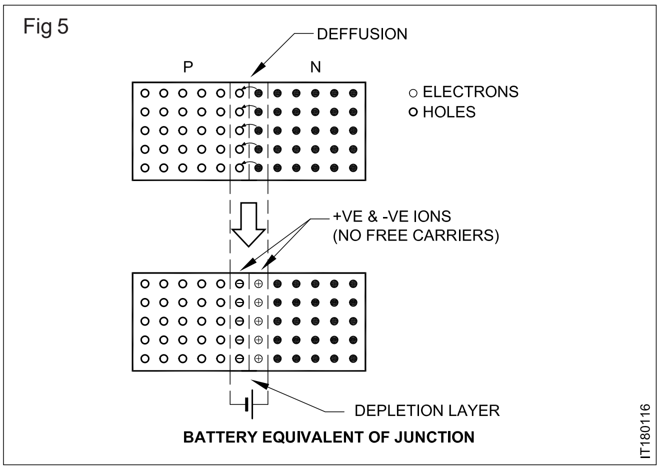


Fig 4



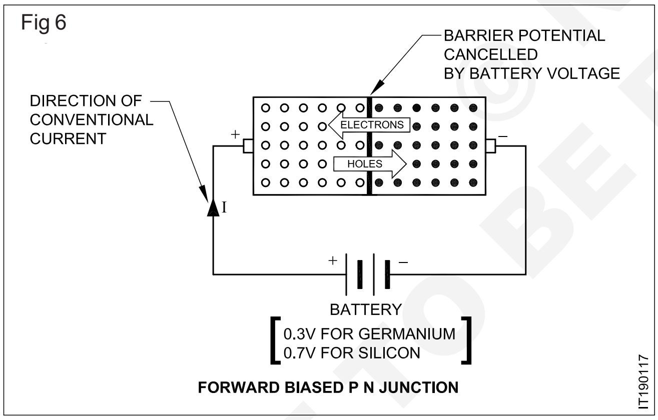
When a P and N material is put together, at the junction of P and N materials, as shown in Fig 5, some electrons from the N-material jump across the boundary and recombine with the hole near the boundary of the P-material. This process is called diffusion. This recombination makes atoms near the junction of the P-material gaining electrons and become negative ions, and the atoms near the junction of the N-material, after losing electrons, become positive ions. The layers of negative and positive ions so formed behave like a small battery. This layer is called the depletion layer because there are neither free electrons nor holes present (depleted of free carriers). This depletion region prevents further the movement of electrons from the N-material to the P material, and thus an equilibrium is reached.



BATTERY EQUIVALENT OF JUNCTION

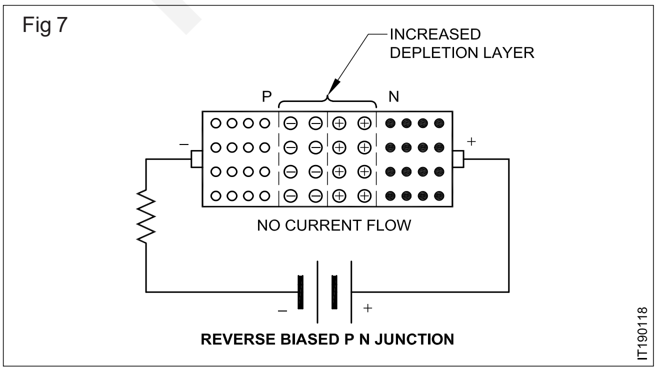
The internal voltage set up due to +ve and -ve ions at the junction is called barrier potential. If any more electrons have to go over from the N side to the P side, they have to overcome this barrier potential. This means, only when the electrons on the N side are supplied with energy to overcome the barrier potential, they can go over to the P side.

In terms of voltage applied across the terminals of the PN junction diode, a potential difference of 0.7V is required across the terminals in the case of silicon diode and 0.3V in the case of Germanium diode for the electrons, in order to cancel off the barrier potential and cross over the barrier as shown in Fig 6. Once the barrier potential gets canceled due to external voltage application, current flows through the junction freely. In this condition the diode is said to be forward biased.



FORWARD BIASED P N JUNCTION

When the applied external battery polarity is as shown in Fig 7, instead of canceling the barrier potential, the external battery voltage adds up to the barrier potential, and, hence, no current flows through the junction. In this condition the diode is said to be reverse biased.



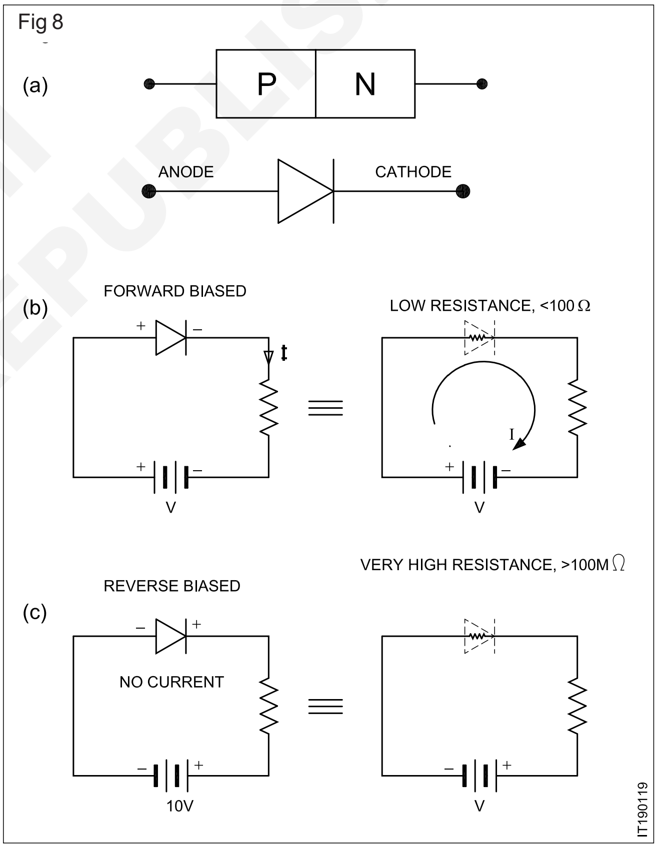
REVERSE BIASED P N JUNCTION

Since current flows through a PN junction diode when it is forward biased and does not when reverse biased, the diode can be thought of to be a unidirectional current switch.

Fig 8a shows the symbolic representation of a Diode. The two leads connected to the P and N terminals are known as Cathode and Anode.

To forward-bias a diode, the Anode should be connected to the +ve terminal of the battery and the Cathode to the -ve terminal of the battery, as shown in Fig 8b. When a diode is in the forward biased condition, the resistance between the terminals will be of the order of a few ohms to a few tens of ohms. Hence, current flows freely when a diode is forward biased.

On the other hand, when a diode is reverse biased as shown in Fig 8c, the resistance between the terminals will be very high, of the order of several tens of megohms. Hence, current does not flow when a diode is reverse biased. As a rule, the ratio of resistance in forward to reverse bias should be of at the minimum order of 1:1000.



Types of diodes

The PN junction diodes discussed so far are commonly referred to as rectifier diodes. This is because these diodes are used mostly in the application of rectifying AC to DC.

Classification of Diodes

1 **Based on their current carrying capacity/power handling capacity, diodes can be classified as**

   – **low power diodes**

   can handle power of the order of several milliwatts only

– **medium power diodes**

can handle power of the order of several watts only

– **high power diodes**

can handle power of the order of several 100's of watts.

2 **Based on their principal application, diodes can be classified as,**

– **Signal diodes**

low power diodes used in communication circuits such as radio receivers etc. for signal detection and mixing

– **Switching diodes**

low power diodes used in switching circuits such as digital electronics etc. for fast switching ON/OFF of circuits

– **Rectifier diodes**

medium to high power used in power supplies for electronic circuits for converting AC voltage to DC.

3 **Based on the manufacturing techniques used, diodes can be classified as,**

– **Point contact diodes**

a metal needle connected with pressure on to a small germanium(Ge) or silicon(Si) tip. See Chart 1 at the end of this lesson.

– **Junction diodes**

made by alloying or growing or diffusing P and N materials on a semiconductor substrate.

Testing rectifier diodes using ohmmeter

A simple ohmmeter can be used to quickly test the condition of diodes. In this testing method, the resistance of the diode in forward and reverse bias conditions is checked to confirm its condition.

Recall that there will be a battery inside an ohmmeter or a multimeter in the resistance range. This battery voltage comes in series with the leads of the meter terminals. In Fig 9, the lead A is positive, lead B negative.

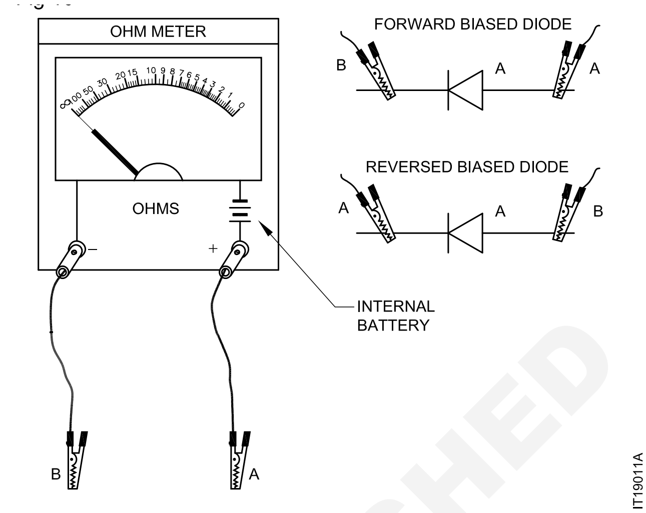
NOTE: If the polarity of the meter leads are not known at first, the polarity of the meter leads can determined using a voltmeter across the ohm meter terminals.

If the positive lead of the ohmmeter, lead A in the Fig 9, is connected to the anode of a diode, and the negative (lead B) to the cathode, the diode will be forward-biased. Current will flow, and the meter will indicate low resistance.

On the other hand, if the meter leads are reversed, the diode will be reverse-biased. Very little current will flow because a good diode will have very high resistance when reverse biased, and the meter will indicate a very high resistance.

While doing the above test, if a diode shows a very low resistance in both the forward and reverse biased conditions, then, the diode under test must have got damaged or more specifically shorted. On the other hand, a diode is said to be open if the meter shows very high resistance both in the forward and reverse biased conditions.

Fig 9



Behaviour of diode when FORWARD BIASED

Fig 10a shows a forward biased silicon PN junction diode using a variable DC supply. When the applied voltage is slowly increased starting from 0 volts as long as the voltage across the diode V_F is less than that of the depletion barrier potential (0.7 volts for Si diodes), no current or a negligible current flows through the diode, and, hence, through the circuit. This is shown in the graph at Fig 10b.

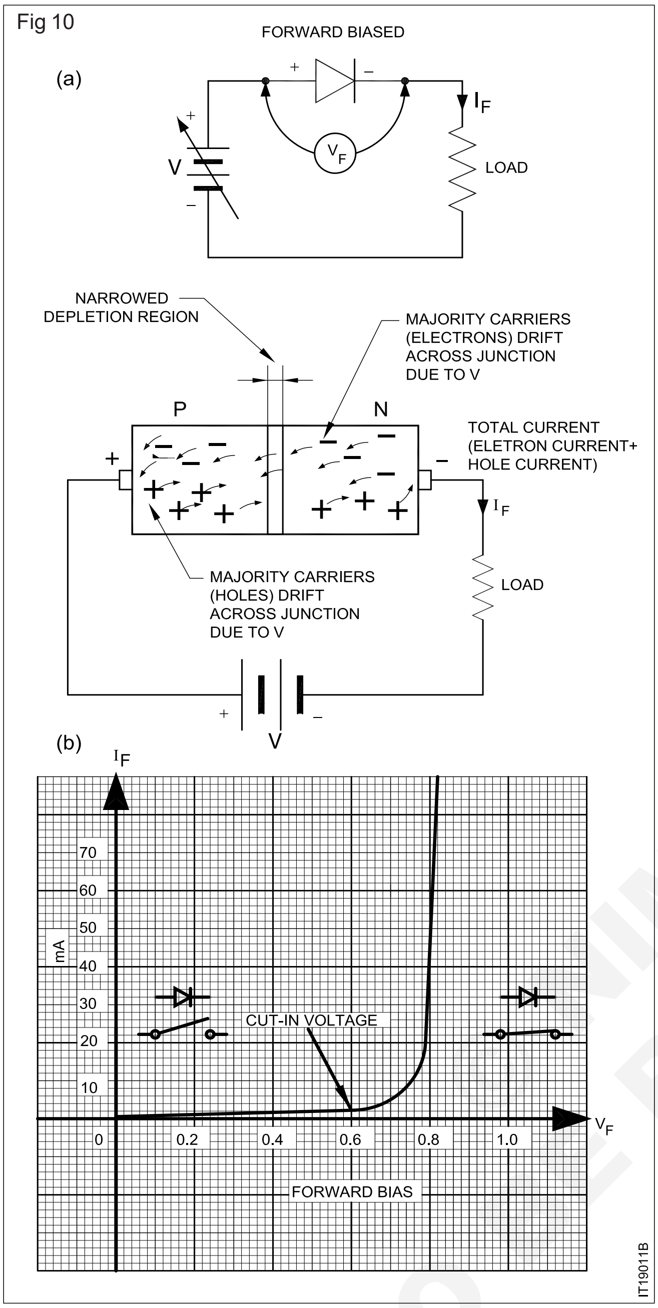
But once the voltage V_F across the diode becomes equal to or greater than the barrier potential 0.6 to 0.7V, there will be a canceling effect of the barrier potential. Hence, the free electrons from the N region get pushed away by the -ve battery terminal (remember like charges repel) and cross over the junction, pass through the P region and get attracted by the + terminal of the battery. This results in the electron current passing through the diode, and, hence, through the Load.

In a similar way, the holes in the P region are pushed away by the +ve battery terminal, resulting in hole current.

Thus current flows through the diode when the forward bias potential is higher than the barrier potential. This current flow through the diode is because of both electrons and holes. The total current in the circuit is the sum of the hole current and the electron current. Hence, diodes are called bipolar devices in which both hole current and electron current flows.

From the graph at Fig 11b, it can be seen that, once the forward voltage goes above 0.6V the diode starts conducting, resulting in considerable current through the circuit. This voltage level across the diode is referred to as cut-in or knee or threshold voltage.

Fig 10



If the applied forward voltage is further increased beyond the cut-in voltage, the depletion layer further narrows down allowing more and more current to flow through the diode. It can be seen from the graph at Fig 1b, that beyond the cut-in voltage, the current increases sharply for very small voltage increase across the diode. In this region, above the cut-in voltage, the forward biased diode behaves almost like a closed switch. The only limiting factor for the current at this stage is the maximum current the diode can handle without getting burnt or the junction getting punctured permanently. This current limit is given in diode data books as maximum forward current, $I_{f\,max.}$

Behaviour of diode when REVERSE BIASED

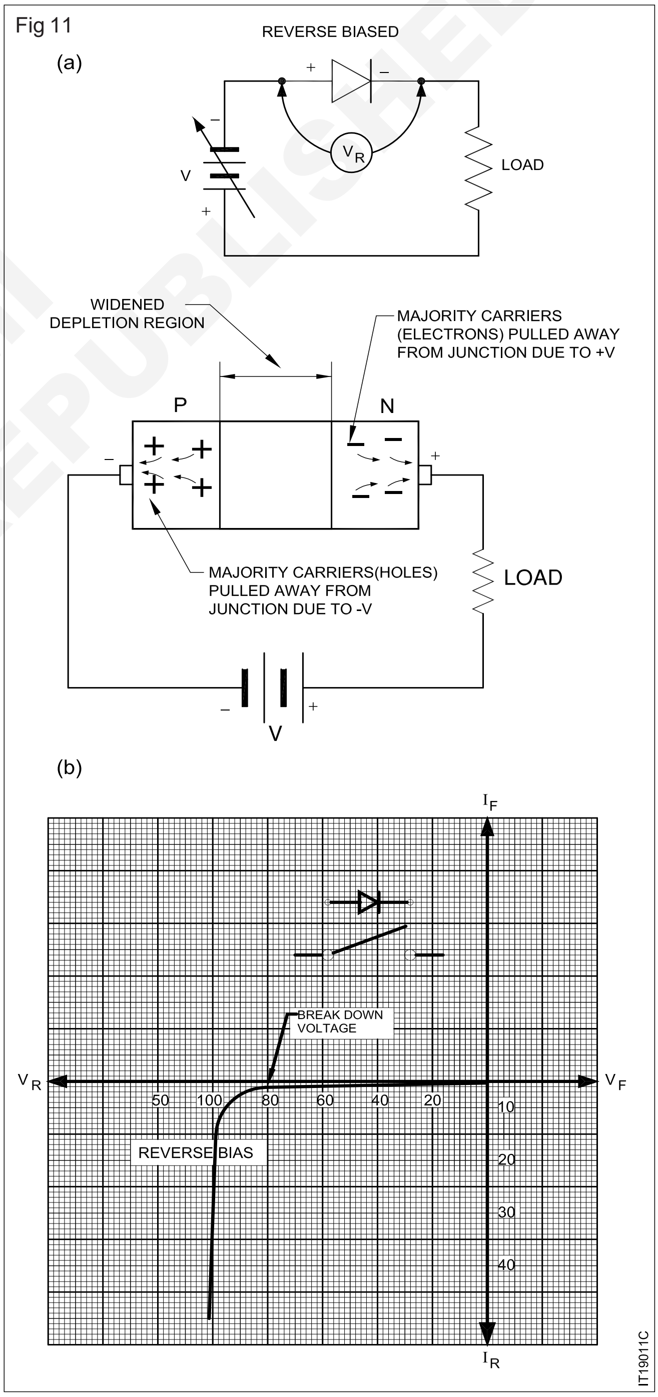
When an external DC voltage is connected across the diode with the polarity as shown in Fig 11, the diode is said to be reverse biased.

In this condition, when the battery voltage is increased from 0 to several tens of volts, the polarity of the applied voltage instead of canceling the barrier potential, aids the barrier potential. This, instead of narrowing the depletion layer, widens the depletion layer. The widening of the depletion layer results in, not allowing the current to flow through the junction, and, hence, the load.

Referring to the graph shown in Fig 11b, it can be seen that there is no current even when the voltage V_R across the diode is several tens of volts.

It the applied reverse voltage is kept on increased, say to hundred volts (this depends from diode to diode), at one stage the applied voltage V_R across the junction is so large that it punctures the junction damaging the diode. This results in shorting of the diode. This short results in uncontrolled heavy current flow through the diode as shown in graph at Fig 12b. This voltage at which the diode breaks down is referred to as reverse break-down or avalanche breakdown.

Fig 11



The maximum reverse voltage that a diode can withstand varies from diode to diode. This reverse voltage withstanding capability of a diode is referred to as the peak-inverse-voltage or PIV of the diode. This value for diodes is given in the diode data manual. The PIV of diodes varies from a minimum of 50 volts in small signal diodes to several thousands of volts in high power diodes.

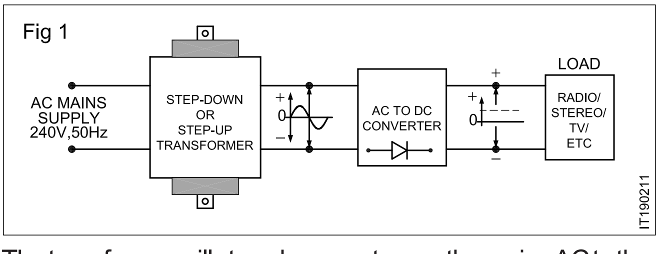
Half wave & Full wave Rectifiers

Objectives: At the end of this lesson you shall be able to
- **state the need for converting AC to DC**
- **state the meaning of the term rectification**
- **describe the working of a half-wave and two diode full-wave rectifier**
- **state the output DC level and the current rating of diode in a two-diode fullwave rectifier**
- **state the ripple frequency in a half-wave rectifier and a full-wave rectifiers.**

RECTIFICATION

This process of converting AC to DC is known as rectification. Fig 1 shows the principle of converting AC to DC of required voltage level.

Fig 1

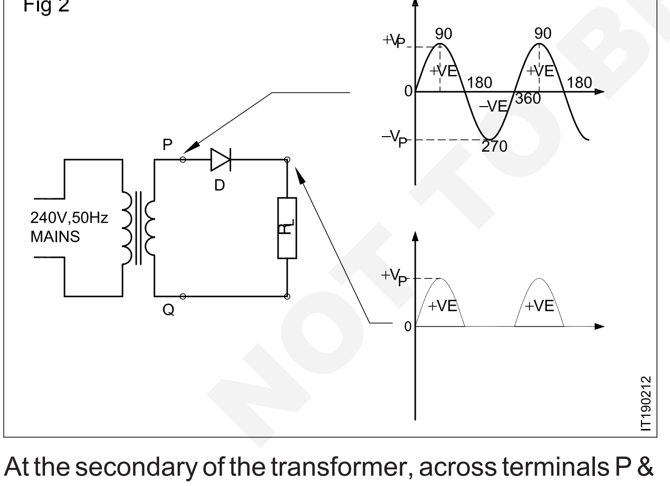


The transformer will step-down or step-up the mains AC to the required level. The stepped-up or stepped-down AC from the output of the transformer is then converted to DC using diodes making use of their unique unidirectional property.

HALFWAVE RECTIFIER

The simplest form of AC to DC converter is by using one diode. such an AC to DC converter is known as half-wave rectifier as shown in Fig 2.

Fig 2



At the secondary of the transformer, across terminals P & Q, when seen on a CRO, the electric signal is a sinusoidal wave with its peak value of V_P and a frequency determined by the rate at which the alternations (+ve to –ve) are taking place. In Fig 2, the frequency is 50Hz as this voltage is taken from 50Hz AC mains supply.

If the voltage across P and Q is measured using an AC voltmeter, the voltmeter shows the rms (root mean square) value, V_{rms} of the sinusoidal wave which will be less than the peak value. The relationship between V_{Peak} and V_{rms} is given by,

$$V_{rms} = 0.707\ V_{peak} \qquad \text{........[1]}$$

conversely,

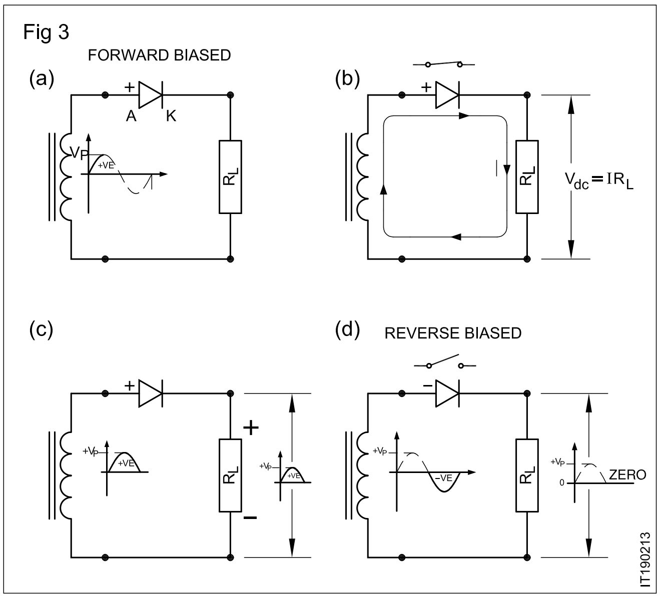
$$V_{peak} = \frac{V_{rms}}{0.707} = \sqrt{2}\ V_{rms}$$

When this sinusoidal signal is applied across the diode D as shown in Fig 2, the diode conducts (behaves as a closed switch) only during the +ve half cycle of the input sinusoidal voltage and does not conduct (behaves as a open switch) during the -ve half of the input sinusoidal voltage. This process repeats again and again thus producing a pulsating +ve wave-form at the output across the load, R_L as shown in Fig 2.

The operation of a half-wave rectifier circuit can be summarised with the help of Fig 3 as follows:

1. During the positive half cycle of AC input, the diode is forward biased as the anode of diode is positive as shown in Fig 3a.
2. Hence current flows from anode to cathode, through load R_L to secondary of transformer as shown in Fig 3b. The IR_L drop across load resistor R_L is the DC voltage V_{dc} with the polarity as shown in Fig 3b.
3. When the +ve half cycle of the input sinusoidal is completed, the voltage across the R_L will be a positive half sinewave as shown in Fig 3c. The peak of rectified voltage is also equal to the peak of the input AC voltage.
4. During the negative half cycle of the input AC, the diode is reverse biased as the anode of diode is negative as shown in Fig 3d.
5. Hence, the diode behaves as an open switch and no current flows through the load and hence there is no voltage output across load R_L as shown in Fig 3d.
6. After completing the –ve half cycle, when the input signal goes positive again, the whole operation repeats starting from step 1.

Fig 3



As can be seen from Fig 2, the output of the half-wave rectifier is always a +ve voltage (DC) although it is pulsating. In other words, the output is either positive (during +ve half cycle of the AC input) or zero (during -ve half cycle of AC input) but never negative. Hence, the output of a rectifier is a pulsating +ve DC voltage.

The circuit at Fig 2 is known as a half-wave rectifier as the rectification is done by the circuit only during one half cycle of the input AC signal.

Calculating output DC level in half-wave rectifiers

Two important points to note for calculating the output DC level of a halfwave rectifier are;

– the output of a halfwave (HW) rectifier across the load resistor is a pulsating DC whose peak voltage is equal to the peak value of the +ve half cycle of the AC input as shown in Fig 4. This can be checked using an oscilloscope.

  The small forward voltage drop of the diode (0.7 for Si) when forward biased is ignored for simplicity in understanding.

– the pulsating signal level is zero when the input AC is in the –ve half cycle as shown in Fig 4.

Hence, When a DC voltmeter is connected across the load resistor R_L, the meter reads the average DC value of the pulsating signal. Ignoring the diode drop, the average DC value of the pulsating output in a half wave rectifier is given by,

$V_{average}$ or $V_{dc} = 0.318\ V_P$ ....[2]

TWO-DIODE FULLWAVE RECTIFIER

In a half-wave rectifier there is no rectification action during the -ve half cycle of the input AC voltage. Because of this the output DC level is low (0.318 $V_{S(peak)}$). This limitation of a half-wave rectifier can be overcome by using two diodes and a centre-tap-transformer.

In Fig 5, each diode and the common load resistor R_L form two independent half-wave rectifiers. Because of the centre-tapped secondary winding, each diode receives only half of the total secondary voltage.

Fig 4

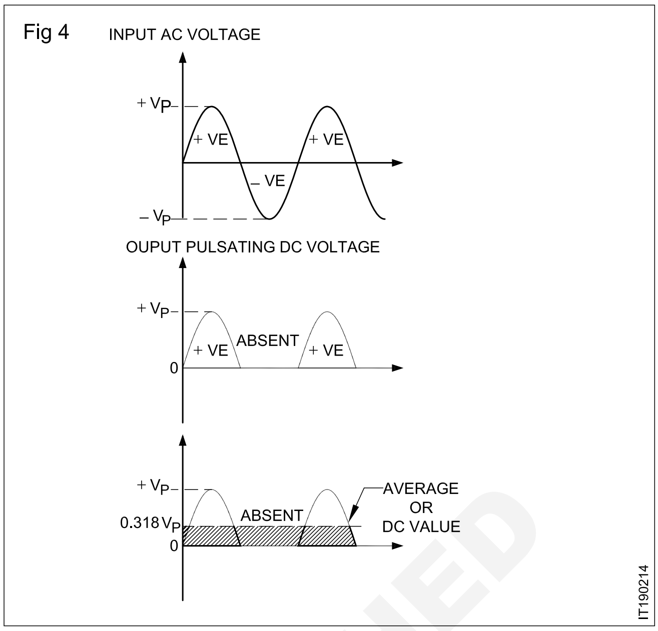
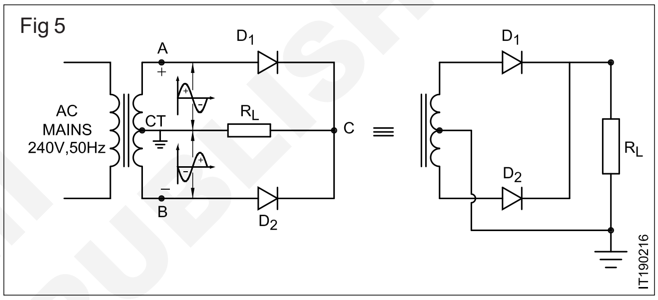


Fig 5



The opposite ends of the transformer secondary windings always have opposite polarities with respect to the centre tap. As shown in Fig 5, when end A of the secondary winding is positive, the bottom end B will be negative.

For the polarity shown in Fig 6a, the anode of D_1 is positive and, hence, forward biased. Whereas, the anode of D_2 is negative, and, hence, does not conduct. Current flows from the transformer(end A) ➔ D_1 ➔ R_L ➔ back to the transformer centre-tap. This direction makes point C across the load R_L as the +ve terminal of the output DC voltage.

During the next half cycle, end B of transformer is +ve and A is –ve as shown in Fig 6b. Hence the anode of D_2 is +ve and this diode conducts whereas D_1 does not. Current flows from the transformer (end B) D_2 ➔ R_L ➔ ➔back to the transformer centre-tap. This direction of current again makes point C across the load R_L as the +ve terminal of the output DC voltage.

It is important to note the following two points;

– At any instant of time either D_1 or D_2 conducts but never both.

– While any of the two diodes is conducting, the rectified current i, flows through R_L in the same direction as shown in Fig 6a and Fig 6b. So the DC output voltage is positive at the common cathodes of the diodes D_1,D_2.

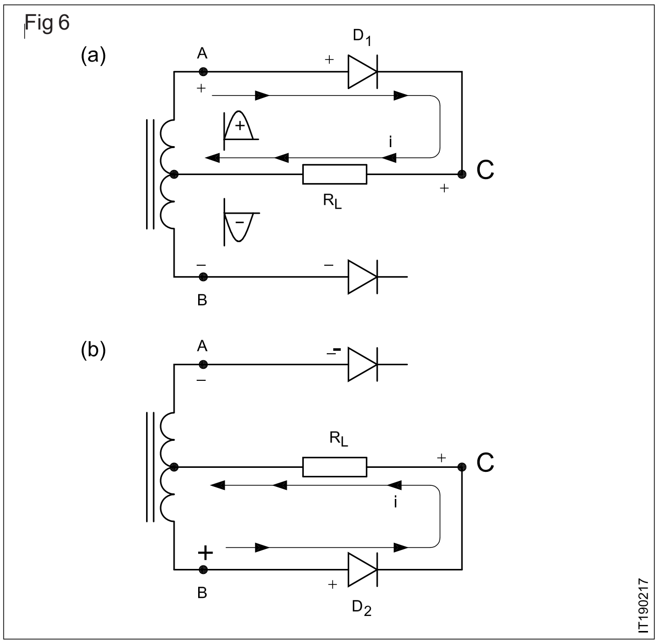


Fig 7 shows the input and output wave-forms of a full wave rectifier. As can be seen from Fig 8, the rectifier works both in the positive and negative half cycles of the AC input to produce a DC output across the load resistor R_L. Although only one diode conducts at a time, the outputs are combined in R_L. Hence, full wave rectifier provides double the DC current to the load compared to that of a half-wave rectifier.

Since both the half cycles of the input AC signal are rectified by the circuit at Fig 6, this circuit is known as a full wave rectifier. Since this full wave rectifier uses two diodes this circuit is also known as two diode full wave rectifier.

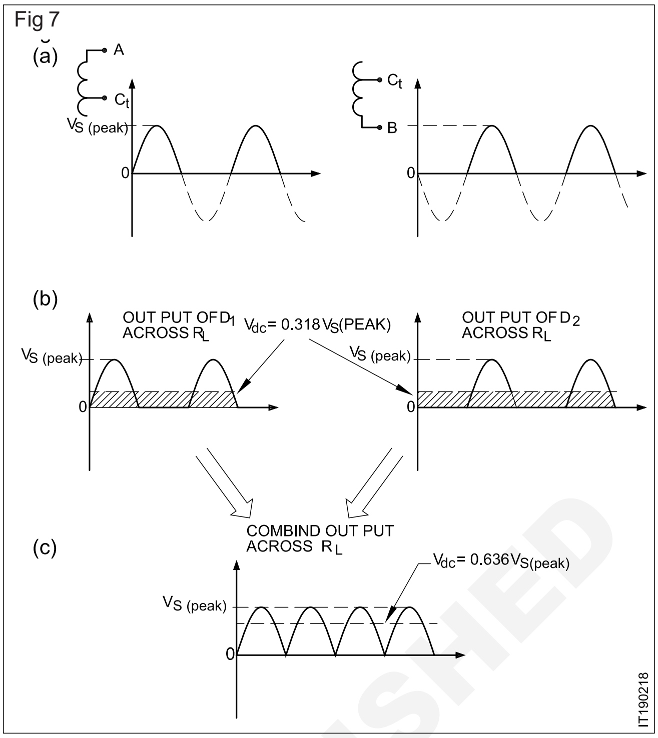
Output DC level in a two-diode full wave rectifier

Since a full wave rectifier is nothing but a combination of two half-wave rectifiers, the average or DC value of a full wave rectifier is naturally twice the output of a half-wave rectifier driven by the same secondary voltage.

From Fig 7 it is evident that the average or DC value of a full wave rectified output is

$$V_{dc} = 0.318\ V_{S(peak)} + 0.318\ V_{S(peak)}$$

$$V_{dc} = 0.636\ V_{S(peak)}$$



where, $V_{S(peak)}$ is the equal peak voltage between the centre-tap and any one end A or B of the transformer secondary.

In terms of $V_{S(rms)}$, V_{dc} of a fullwave rectifier is given by,

$$V_{S(rms)} = 0.707\ V_{S(peak)}$$

Therefore, $$V_{dc} = 0.636 \cdot \frac{V_{s(rms)}}{0.707}$$

$$= 0.9\ V_{S(rms)}$$

Disadvantages of TWO DIODE full wave rectifier

The full wave rectifier using two diodes and centre tap transformer has the following disadvantages;

– A centre-tapped transformer that produces equal voltages on each half of the secondary winding is difficult to manufacture and, hence, expensive.

– Centre-tapped transformers are generally bulkier than ordinary transformers, and, hence, occupy larger space.

– In a two diode full wave rectifier, only half of the secondary voltage is made use of at a time although it works in both +ve and –ve half cycles.

Bridge Rectifiers

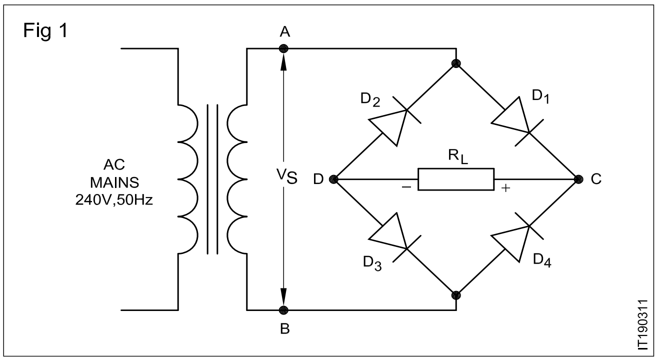
Objectives: At the end of this lesson you shall be able to
- **describe the working of a bridge rectifier**
- **state the output DC level in a bridge rectifier**
- **state the ripple frequency in a bridge rectifier**
- **compare bridge rectifiers with half-wave and full-wave rectifiers.**

THE BRIDGE RECTIFIER

The disadvantages of a full wave rectifier using two diodes and centre-tap transformer can be overcome by a modified full wave rectifier as shown in Fig 1. In Fig 1, since the diodes are connected in the form of a bridge, this rectifier circuit is commonly known as a *Bridge rectifier.*

As can be seen in Fig 1, the bridge rectifier does not need a centre-tapped transformer. Also, all the secondary voltage is used for rectification at any given time.

Fig 1



The operation of a bridge rectifier can be summarized in the following steps;

– When end A of the transformer secondary is +ve, as shown in Fig 2a, diodes D_1 and D_3 are forward biased whereas, D_2 and D_4 are reverse biased, and, hence, D_2 and D_4 do not come in the circuit.

– Current flows from the transformer (end A) ➔ D_1 ➔ R_L ➔ D_3 ➔ back to the transformer(end B). From the direction of the current flow point C is the positive terminal of the DC output across R_L.

– During the other half cycle of the input (–ve half cycle), end B of the transformer becomes +ve as shown in Fig 2b. Diodes D_4 and D_2 are forward biased, whereas D_1 and D_3 are reverse biased.

– Current flows from the transformer (end B) ➔ D_4 ➔ R_L ➔ D_2 ➔ back to the transformer (end A). From the direction of the current flow, point C is again the +ve terminal of the DC output across R_L.

Note that, current I is in the same direction through R_L during both +ve and –ve half cycles of the input AC. The result is, a +ve rectified DC voltage appears at the end of R_L connected to the cathodes of D_1 and D_4.

Output DC level in a bridge rectifier

Fig 3 shows the input AC and the output pulsating DC waveform of a bridge rectifier.

This wave-form is similar to that of the full wave rectifier using a centre-tap transformer. Hence, the average DC value of the output is,

Fig 2

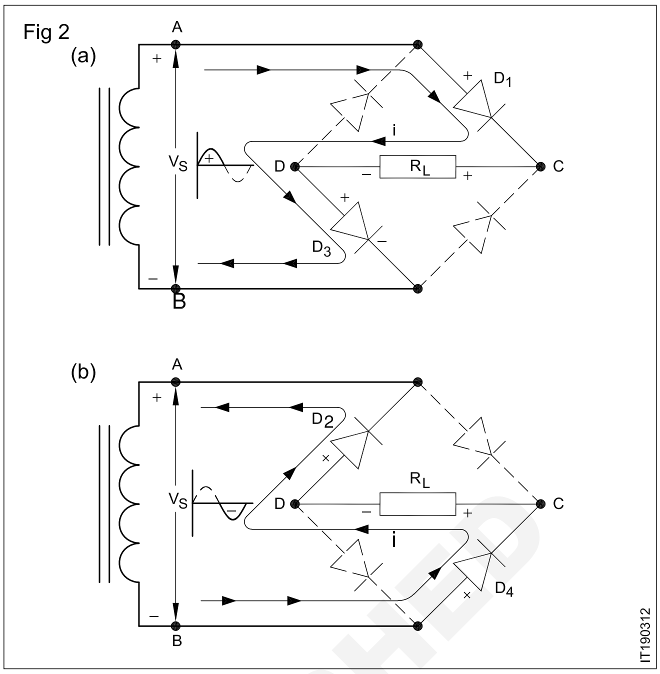
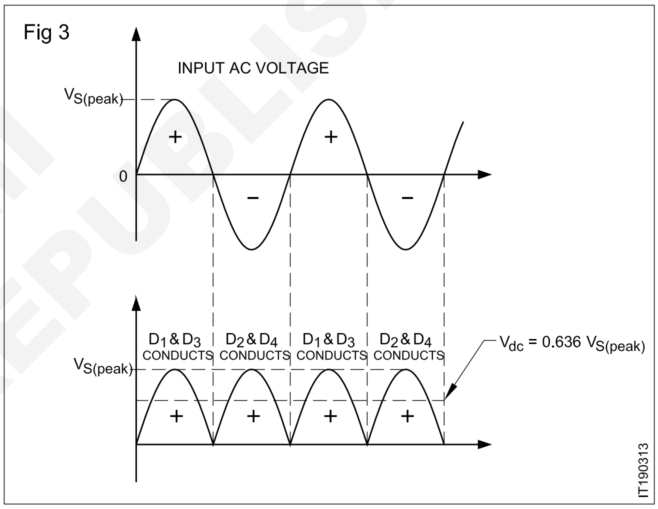


Fig 3



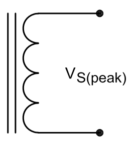
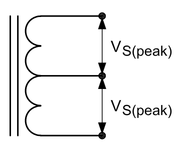
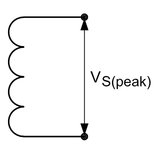
$$V_{dc} = 0.636\ V_{S(peak)}$$

$$\text{or } V_{dc} = 0.9\ V_{S(rms)}$$

where, $V_{S(rms)}$ is the full secondary AC rms voltage.

NOTE: In a two-diode full wave rectifier $V_{S(rms)}$ refers to only half of the total secondary voltage whereas in a bridge rectifier $V_{S(rms)}$ refers to full secondary voltage.

A comparison of **half-wave, full wave** and **bridge rectifier** is given below in a tabular form;

	Half wave	**Full wave**	**Bridge**
Number of diodes required	1	2	4
Transformers Peak output voltage			

DC output voltage in terms of $V_{S(peak)}$	$0.318\,V_{S(Peak)}$	$0.636\,V_{S(Peak)}$	$0.636\,V_{S(Peak)}$
DC output voltage in terms of $V_{S(rms)}$	$0.45\,V_{S(rms)}$	$0.9\,V_{S\,(rms)}$	$0.9\,V_{S(rms)}$
Diode current rating	$I_{L\,(max)}$	$0.5\,I_{L\,(max)}$	$0.5\,I_{L\,(max)}$
Peak inverse voltage	$V_{S(peak)}$	$2V_{S(peak)}$	$V_{S(peak)}$
Ripple frequency	f_{input}	$2f_{input}$	$2f_{input}$

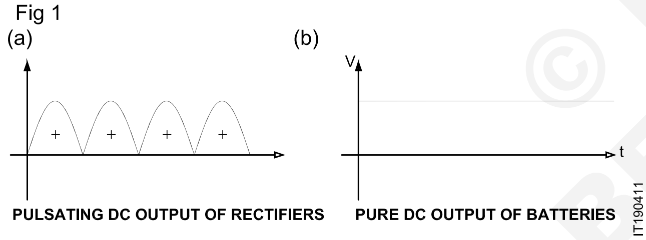
Filters & Rectifiers

Objectives: At the end of this lesson you shall be able to
- **state the need for filtering pulsating DC**
- **describe how a capacitor filters the pulsating DC**
- **state the value of ripple after filtering, using a capacitor input filter in the three types of rectifiers**
- **state the advantages and disadvantages of PI filters**
- **state how inductors can be used to smoothen pulsating DC**
- **list popular types of LEDs**
- **state the advantages of LEDs.**

RIPPLE FILTERS

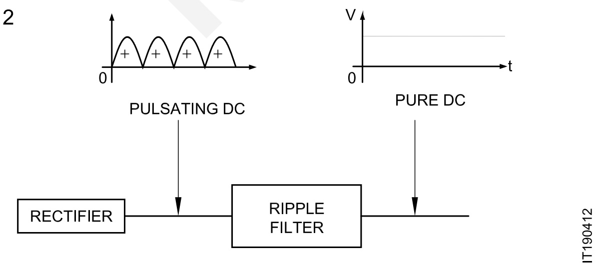
The output of rectifiers is a pulsating DC voltage as in Fig 1a and not a pure DC voltage like the output of cells or a battery as shown in Fig 1b.

Fig 1



Pulsating DC voltages cannot be used in most of the electronic circuits like radios, tape recorders etc. These circuits require pure DC voltage similar to that of the output of a battery as shown in Fig 1b. Hence, it is required to remove or at least reduce the pulsation in the output of the rectifier circuits. The circuits used to filter off or reduce the pulsation in the DC output of rectifiers are known as smoothing circuits or more popularly as *ripple filters* as shown in Fig 2.

Fig 2



CAPACITOR INPUT FILTERS

The most important component used in any ripple filter circuit is the capacitor. Recall capacitors store electrical energy and release it when required. This property of a capacitor is made use of in smoothing the pulsating output of rectifiers.

Filtering output of Half-wave rectifiers

Fig 3a shows a capacitor input filter connected at the output of a half-wave rectifier.

During the first quarter cycle of source voltage V_S, the diode is forward-biased and ideally behaves like a closed switch. Since the output of diode is connected directly across the capacitor, the capacitor charges to the peak voltage $V_{S(peak)}$ as shown in Fig 3b.

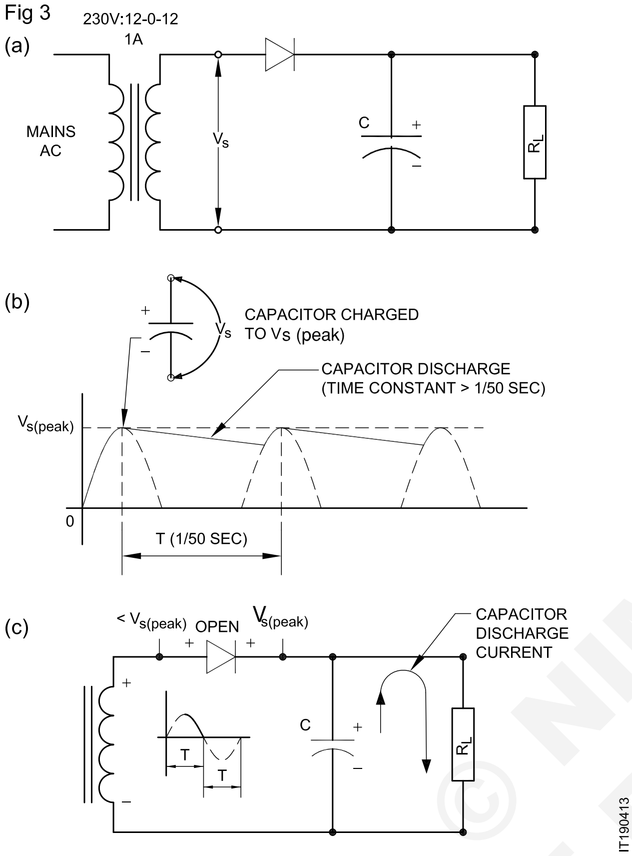
As shown in Fig 3b, when the input V_S just passes the positive peak, the diode stops conducting. This because, the capacitor has $V_{S(peak)}$ volts across it with the polarity shown in Fig 3c. When V_S passes its +ve peak, the voltage at the anode of diode is slightly less than $V_{S(peak)}$. Hence, the diode is reverse biased and behaves like a open switch.

With the diode open, the capacitor discharges through the load resistance R_L. By deliberate design, the discharging time constant (product of R_L and C) is made much greater than the period T of the input signal. Because of this, the capacitor will discharge only a small portion of its stored charge during the OFF time of the diode, as shown in Fig 3b.

By the time the capacitor loses a small portion of its charge, the source voltage again reaches its peak, the diode again conducts and recharges the capacitor to the peak voltage $V_{S(peak)}$. This process of charging during a brief period of positive peak and discharging during the falling period of the positive peak continues as shown in Fig 3b.

From Fig 3b, it can be seen that the voltage across the load resistor is almost a pure DC voltage. The only variation from the pure DC voltage is the small ripple caused by charging and discharging the capacitor.

Fig 3

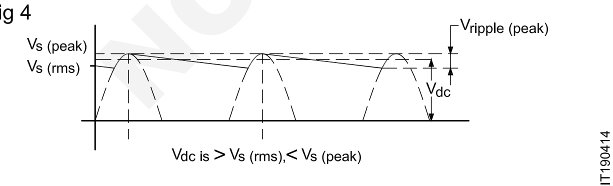


As the capacitor charges to the peak value of the input $V_{S(peak)}$ and discharges only a small portion of it, the DC output of the half-wave rectifier, instead of 0.45 $V_{S(rms)}$ (as discussed in lesson 1.3.02) is only slightly less than $V_{S(peak)}$ as shown in Fig 4.

From Fig 4, the exact value of DC voltage and ripple voltage can be calculated as given below;

$$V_{dc(HW)} = V_{S(peak)} - \frac{V_{rip\,(p-p)}}{2} \qquad .....[1]$$

Fig 4

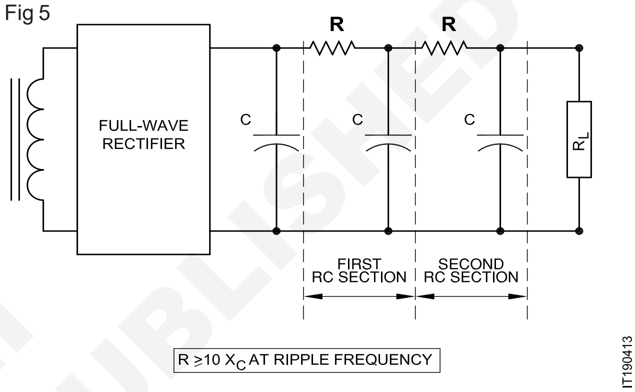


RC filters: Recall that with the 10 % ripple rule we get a peak-to-peak ripple of around 10 percent of the DC load voltage. To further reduce the ripple at the output, filters as shown in Fig 9 may be connected between the filter capacitor and the load. These are known as RC p filters. These filters reduce the ripple in the output to less than 1 percent making the output a pure DC similar to the output of a battery.

In Fig 5, the two RC filter sections are connected between the input capacitor C and the load resistor R_L. While designing these filter sections, the value of R is made much greater than X_C at the ripple frequency. Therefore, a major portion of the ripple voltage gets dropped across R instead of across the load resistor R_L. Typically, the value of R must be at least 10 times greater than X_C at the ripple frequency. This results in each RC section attenuating (reducing) the ripple by a factor of 10. Thus more the number of sections of RC, less is the ripple across R_L and purer is the DC output voltage across R_L.

The main disadvantage of the RC filter sections is the loss of DC voltage across each R. Hence, RC filter circuits are suitable only for small load currents or for large load resistance.

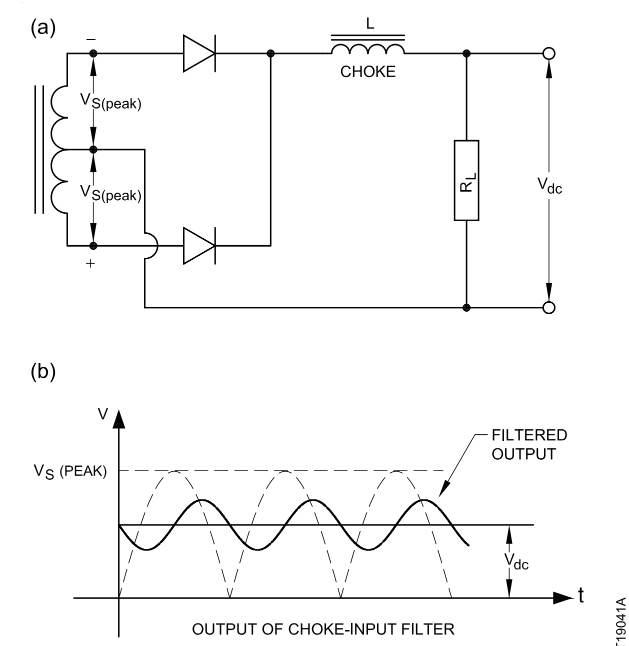
Fig 5



Inductor input filters

An alternative to using a capacitor in parallel with the load resistor, is to use an inductor in series with the load as shown in Fig 6a. Since an inductor opposes any change in current through it, the inductor coil will cause a smoothing effect in the output as shown in Fig 6b. Here the inductors are called *Chokes* as they choke the ripple.

Fig 6



If the coil resistance of the inductor is neglected (being very small), the DC output will be,

$V_{dc} = 0.636\ V_{S(peak)}$ as in the case of capacitance filter.

If the resistance of the coil is considered, the DC output will be slightly less due to the I_R drop across the coil.

The ripple factor r in a full wave rectifier with inductor filter is given by,

$$r = \frac{R_L}{1618L}. \qquad \text{.....झ४ट}$$

LC filters

For large load current requirements, instead of RC filters, LC filters as shown in Fig 7 are preferred. The reason is, a large portion of the ripple voltage is dropped across the inductor with minimum DC voltage drop because inductors have only a small winding resistance.

In Fig 7, X_L is made much greater than X_C at the ripple frequency. Hence, the ripple across the load is reduced to extremely low levels.

Neglecting the choke's resistance, the DC output voltage is given by,

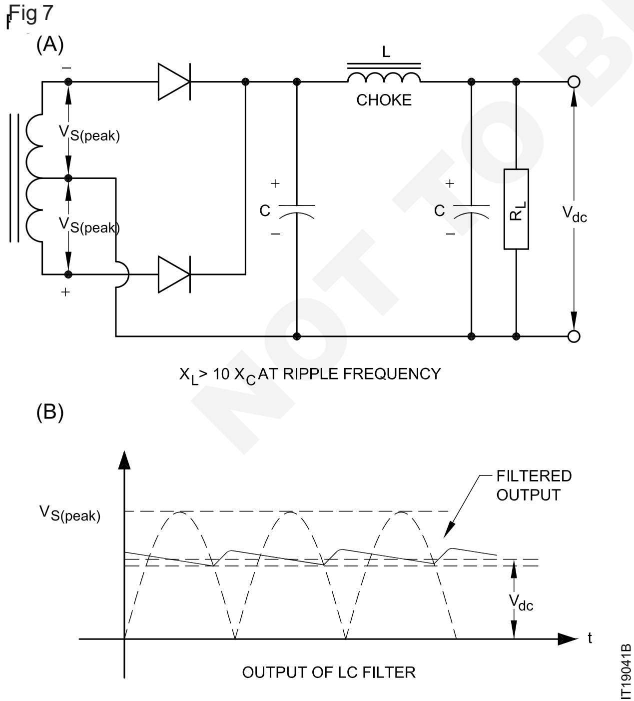
$V_{dc} = 0.636\ V_{S(peak)}$ as in the case of a capacitor input filter.

The ripple factor, r is given by,

$$r = \frac{0.7}{LC} \qquad \text{....[5]}$$

From the above equation for **r**, unlike in case of capacitor input filter, it can be seen that in a LC filter circuit the ripple factor is not determined by the value of the load resistor. Hence, with a capacitor and inductor in the filter circuit, the ripple is independent of the load current.

Fig 7



These days, LC filters are becoming obsolete because of the size and cost of the inductors. LC filters are being replaced by integrated circuit(IC) voltage regulators, active filter circuits which reduce the ripple and keep the DC voltage constant. IC regulators and active filters are discussed in detail in further lessons.

LEDs are typically doped with gallium arsenic, gallium phosphate or gallium arseno-phosphate. Different dopes cause the LED to emit light of different colours(wave-lengths) such as red, yellow, green, amber, or even invisible infrared light.

The schematic symbol of LED is shown in Fig 12b. The arrows are used to indicate that light is radiated from the device.

Types of LEDs

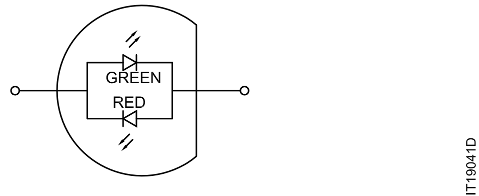
Single colour LEDs: Most of the commercially available and commonly used LEDs are single colour LEDs. These LEDs radiate one of the colours such as red, green, yellow or orange. Different coloured LEDs will have different forward voltages as given in the table below:

Colour of LED	Red	Orange	Yellow	Green
Typical Forward voltage drop	1.8V	2V	2.1V	2.2V

These typical forward voltage drops are at a typical LED forward current I_f = 20 mA

Two colour LEDs: These LEDs can give two colours. Actually, these are two LEDs put in a single package and connected as shown in Fig 8.

Fig 8



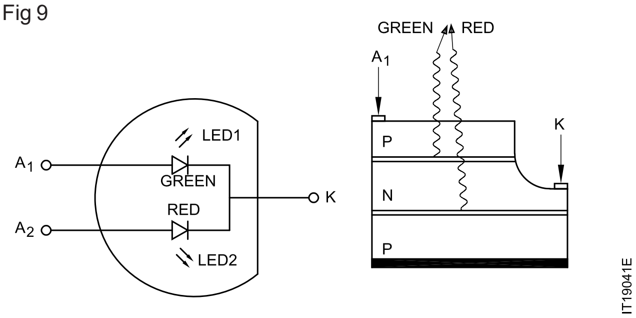
In a two-colour LED, two LEDs are connected in inverse parallel, so that one of the colour is emitted when the LED is biased in one direction and the other colour is emitted when the LED is biased in the other direction. These LEDs are more expensive than the single colour LEDs. These LEDs are useful to indicate +ve, –ve polarities, GO-NOGO indication, null detection etc.

Multicolour LEDs: These are special types of LEDs which can emit more than two colours. These LEDs comprises of a green and a red LED mounted in a three-pin common cathode package as shown in Fig 9.

This LED will emit green or red colour by turning ON only one LED at a time. This LED will emit orange or yellow by turning on the two LEDs with different current ratios as shown in the table given below:

Output colour	Red	Orange	Yellow	Green
LED-1 current	0	5mA	10mA	15mA
LED-2 current	15mA	3mA	2mA	0

Fig 9



Characteristics & specification of zener diodes

Objectives : At the end of this lesson you shall be able to
- **list the main differences between rectifier diodes and zener diodes**
- **list the similarities between rectifier diodes and zener diodes**
- **name the main application of zener diodes**
- **list the important specifications of a zener diode.**

Zener Diode

A Zener diode is a special purpose diode that is designed to operate in the reverse breakdown region of the diode's characteristic curve. Regular diodes will be destroyed if they are used in the reverse breakdown region.

Zener Diode Symbols

The schematic and physical symbols are shown. Note that the symbol is similar but somewhat different than that of a regular diode.

The Zener diode is off when the applied voltage is less than the Zener voltage rating. When the applied voltage is greater than the Zener voltage rating the Zener diode turn on and current flows.

Zener Diode Specifications

Zener (Breakdown Voltage) Voltage - V

Vz is the most common specification. Zener diode voltages range from 3.3 V to 100 V or more. As seen in the graph, the Zener voltage does increase a small amount as the diode current increases. This reflects the fact that the line in the graph is not perfectly vertical.

Power Dissipation – P0

This is the rating for the maximum amount of power the Zener diode can dissipate. Values range from 0.3 W to 50 W.

Power Derating Factor - PDF

The maximum power that the Zener can safely dissipate decreases with temperature. The Power Derating Factor specifies this decrease in maximum power rating.

Voltage regulators

Recall that, the DC output voltage level of power supplies such as, full-wave and bridge rectifiers, tend to decrease or increase,

- when the load current increases or decreases
- when the AC input voltage level decreases or increases.

Such variations in the output DC voltage level of power supply is not acceptable for most of the electronic circuits. Hence, it is required to regulate the DC output of power supplies so as to keep the DC output level constant, inspite of variations in the DC load current or the AC input voltage. Circuits or components used to keep the DC output voltage of a power supply constant are called voltage regulators.

Regulation factor

The ability of a power supply to maintain a constant DC output voltage for variations in the load current is referred to as load regulation. Load regulation of a power supply is generally given as a percentage.

$$\text{Load regulation factor } \% = \frac{V_{NL} - V_{FL}}{V_{NL}} \times 100$$

where,

V_{NL} = DC output at no load or open circuit

and V_{FL} = DC output at rated full load.

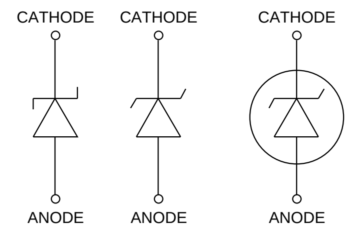
It should be noted that lower the percentage of load regulation factor, better is the voltage regulation.

The zener diode

In a power supply one of the simplest ways of regulating the DC output voltage (keeping the output voltage constant) is by using a zener diode. With zener in reverse breakdown condition, the voltage across the zener diode remains constant for a wide range of input and load variations.

Because of this property, zener diodes are also known as voltage regulators or voltage reference diodes. Fig 1 shows the symbol used for zener diodes.

Fig 1



ZENER DIODE SCHEMATIC SYMBOLS

The difference between a rectifier diode and a zener diode are listed below;

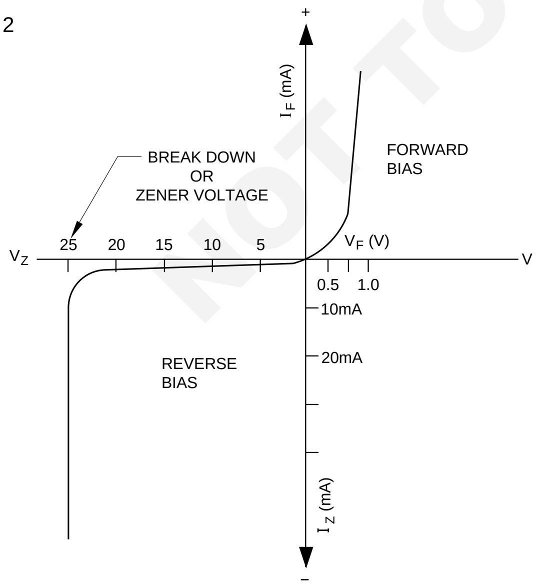
- Compared to normal rectifier diodes, zener diodes are heavily doped.
- Unlike ordinary diodes which do not work in the breakdown region, zener diodes work only in the breakdown region.
- General rectifier diodes are used in forward-biased condition, whereas zeners are always used in reverse-biased condition.
- The reverse breakdown voltage of zener diodes is very much less (3 to 18V) compared to rectifier diodes (minimum 50V).

The similarities of a zener diode with those of general purpose rectifier diodes are listed below;

- Zener diodes are also PN junction diodes, which are also generally made of silicon.
- Zener diodes also have two terminals (anode and cathode).
- In physical appearance, the zener diodes and ordinary diodes look alike.
- Like rectifier diodes, zener diodes are also available with glass, plastic and metal casing.
- The anode and cathode marking technique on the body is same for both zener and rectifier diodes.
- The zener can be tested with an ohmmeter in the same way as in rectifier diodes.
- Zener requires approximately the same voltage for it to be forward-biased into conduction as that of an ordinary diode.

Fig 2 shows the conduction characteristics of a typical zener diode. Because of the nature and heavy doping in a zener, its characteristics are different compared to a rectifier diode.

Fig 2



ZENER DIODE CONDUCTION CHARACTERISTICS

Note that, the zener diode acts as a rectifier diode when forward biased. It also behaves as a rectifier diode when reverse-biased, till the voltage across it reaches the breakdown voltage. As can be seen from Fig 2, even the reverse or leakage current remains almost negligible and constant despite the increase in the reverse-biased voltage till the break down voltage, also called zener voltage is reached. But, Once the zener breakdown voltage is reached, the diode current begins to increase rapidly and the zener suddenly begins to conduct. In the case of a normal rectifier diode, once the break down voltage is reached the diode gets punctured and starts conducting heavily whereas, in a zener diode, the diode does not get punctured even though it conducts current in the reverse biased condition.

The cause for this reverse conduction is referred to as the avalanche effect. The avalanche effect cause, the electrons to be knocked loose from their bonds in the crystal structure. As more electrons are loosened, they in turn knock others and current builds quickly. This action causes the voltage drop across the zener to remain constant regardless of the zener current. As shown in Fig 2, once the zener voltage is reached, very small voltage changes create much greater current changes. It is this characteristic, which makes the zener useful as a constant voltage source or as a voltage regulator.

Unlike in a rectifier diode, the reverse current through the zener is not destructive. If the current is kept within the specified limits depending upon the wattage rating of the zener, using a suitable series resistance, no harm is done to the zener diode.

Because the zener diode is designed to operate as a breakdown device, the zener can be brought out of condition easily. A zener is brought out of its zener conduction by lowering the reverse-biased voltage below the zener voltage or by reversing the polarity of the applied voltage.

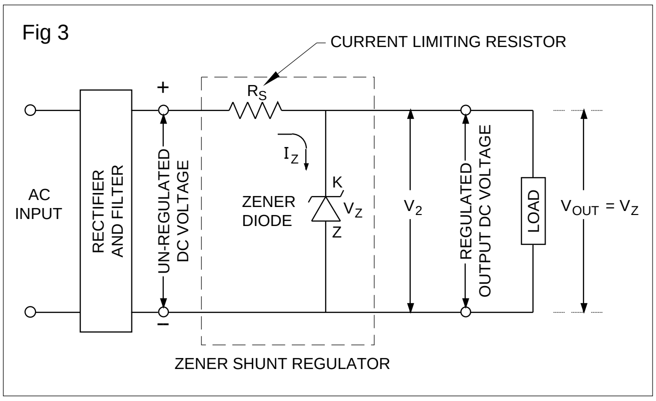
Application of zener diodes

The most popular use of zener diodes is as voltage regulators in DC power supplies. Fig 3 illustrates a simple zener regulated power supply.

In the circuit at Fig 3, the zener diode is in parallel with the output or load of the power supply. It is very important to note that the zener is connected in the reverse-biased condition. Such a parallel circuit connection is often called a shunt. When used in this way, the zener is said to be a shunt regulator.

In Fig 3, the zener begins to conduct in the reverse-biased condition as the voltage across it reaches the zener voltage V_Z. The voltage across the zener remains constant immaterial of the input DC voltage. Since the load is in parallel with the zener, the voltage across the load V_{OUT} will be same as the voltage across the zener V_Z ($V_{OUT} = V_Z$).

If the input DC voltage to the zener increases, as can be seen from its characteristics in Fig 2, the current I_Z through the zener increases but the voltage across the zener remains the same due to avalanche effect. Because the zener voltage, V_Z does not change, the output voltage V_{OUT}, does not change and so the voltage across the load is constant. Thus, the output is said to be regulated.



Referring to Fig 4, the zener can be looked at as an automatically changing resistance. Total current through the resistance R_S is given by,

$$I_T = I_Z + I_L$$

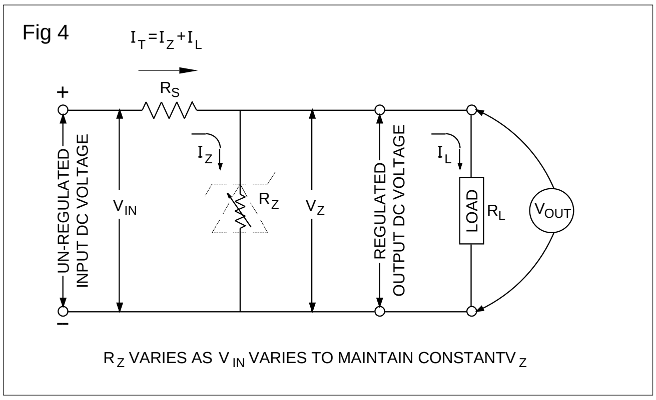
Thus the voltage across R_S is,

$$V_R = (I_Z + I_L) R_S$$

If the input DC voltage V_{IN} increases, output voltage $V_{OUT,}$ tends to increase. In the meantime, the zener conducts more heavily, causing more current (more I_Z) to flow through R_S. Hence, more voltage drop occurs across R_S. This increase in drop across R_S offsets the increase in the output voltage V_{OUT}, thus retaining the voltage across load R_L at its original value. Likewise, if the value of R_L is decreased (increased I_L), current through the zener I_Z decreases, retaining the value of I_T through R_S. This ensures sufficient load current through the load R_L without decrease in the level of V_{OUT}.

Zener specifications

Like in rectifier diodes, the type-code number is marked generally on the body of the zener. From the type-code marked, detailed specifications of the zener can be found referring to any standard diode data manual.



Important zener diode specifications are listed below;

– **Nominal Zener voltage, $V_{Z:}$**: This is the reverse biased voltage at which the diode begins to conduct in reverse bias.

– **Zener voltage tolerance**: Like the tolerance of a resistor, this indicates the percentage above or below V_Z. For example, 6.3 V ± 5 percent.

– **Maximum zener current, I_Z,max**: This is the maximum current that the zener can safely withstand while in its reverse-biased conduction (zener) mode.

– **Maximum power dissipation, P_Z** is the maximum power the zener can dissipate without getting damaged.

– **Impedance (Z_Z)**: The impedance of the zener while conducting in zener mode.

– **Maximum operating temperature** : The highest temperature at which the device will operate reliably.

These specifications of zener diodes are given in diode data books. However a limited list of the most commonly used zener diodes is given in Appendix D

The example given below enables you to interpret the specifications of certain types of zener diodes without the need to refer diode data book:

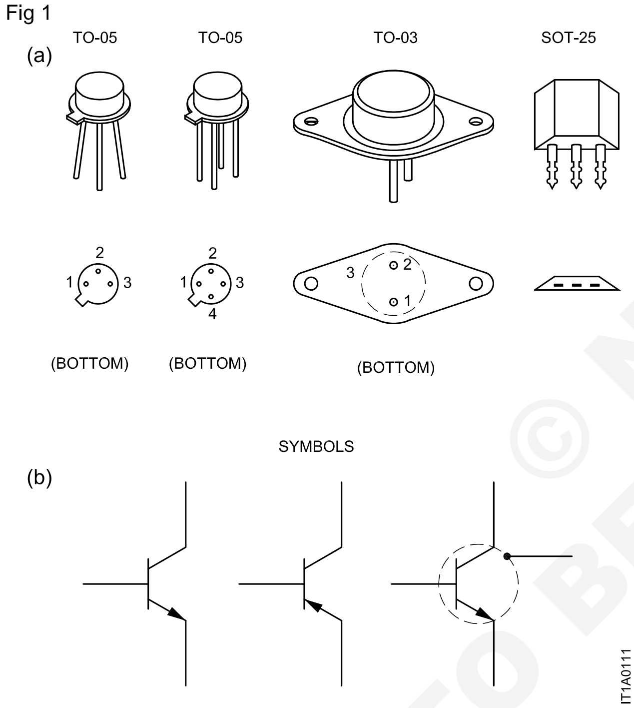
Identify the test different types transistors

Objectives: At the end of this lesson you shall be able to
- **state the two main uses of transistors**
- **list the advantages and classifications of transistors over vacuum tubes**
- **state the names given to the leads of a transistor**
- **state the functions of the three sections of a transistor**
- **describe the two tests to be conducted on a transistor before using it.**

INTRODUCTION TO TRANSISTORS

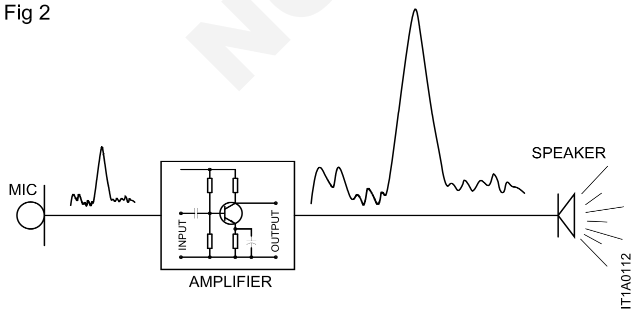
Transistors are the semiconductor devices having three or four leads/terminals. Fig 1a shows some typical transistors. Fig 1b shows the symbols used for different types of transistors.

Fig 1



Transistors are mainly used for enlarging or amplifying small electric/electronic signals as shown in Fig 2. The circuit which uses transistors for amplifying is known as a transistor amplifier.

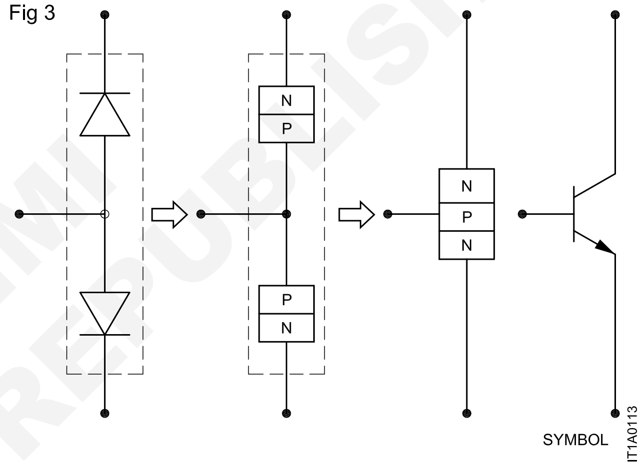
Fig 2



One other important application of transistors is it use as a solid state switch. A solid state switch is nothing but a switch which does not involve any physical ON/OFF contacts for switching.

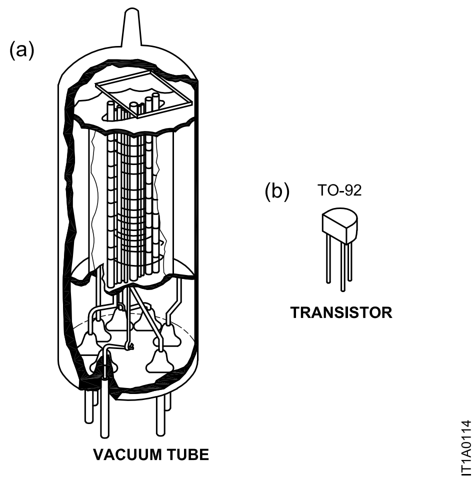
Transistors can be thought of as two PN junction diodes connected back to back as shown in Fig 3.

Fig 3



Before the transistors were invented (1947), there was what were known as vacuum tubes which were used in amplifiers. A typical vacuum tube is shown in Fig 4a.

Fig 4



Compared with the present day transistors the vacuum tubes were big in size, consumed more power, generated lot of unwanted heat and were fragile. Hence vacuum tubes became absolute as soon as transistors came to market.

Transistors were invented by Walter H. Brazil and John Barlow of Bell Telephone Laboratories on 23rd Dec. 1947. Compared to vacuum tubes (also known as valves), transistors have several advantages. Some important advantages are listed below;

- Very small in size
- Light in weight
- Minimum or no power loss in the form of heat
- Low operating voltage
- Rugged in construction.

To satisfy the requirements of different applications, several types of transistors in different types of packaging are available. As in diodes, depending upon the characteristics, transistors are given a type number such as BC 107, 2N 6004 etc., The characteristics data corresponding to these type numbers are given in Transistor data books.

CLASSIFICATION OF TRANSISTORS

1 Based on the semiconductor used.

- Germanium transistors
- Silicon transistors

Like in diodes, transistors can be made, using any one of the above two important semiconductors. However, most of the transistors are made using silicon. This is because, silicon transistors work better over a wide temperature range (higher thermal stability) compared to germanium transistors.

Transistor data books give information about the semiconductor used in any particular transistor.

2 Based on the way the P and N junctions are organized as shown in Fig 5.

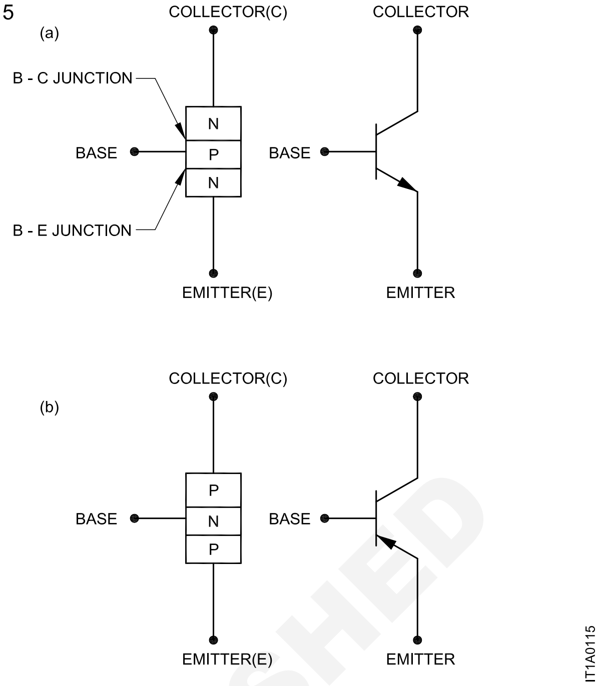
- NPN transistors
- PNP transistors

Both NPN and PNP transistors are equally useful in electronic circuits. However, NPN transistors are preferred for the reason that NPN has higher switching speed compared to PNP.

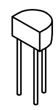
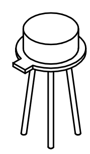
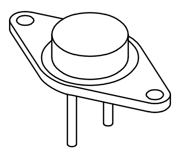
Details of switching speed is discussed in further lessons.

Whether a transistor is PNP or NPN can be found with the help of transistor data book.

Fig 5



3 Based on the power handling capacity of transistors as shown in Table below (Fig 6).

Low power transistors (less than 2 watts)	**Medium power transistors** (2 to 10 watts)	**High power transistors** (more than 10 watts)
Fig 6 TO-92 	TO-05 	TO-03 

Low power transistors, also known as small signal amplifiers, are generally used at the first stage of amplification in which the strength of the signal to be amplified is low. For example, to amplify signals from a microphone, tape head, transducers etc.,

Medium power and high power transistors, also known as *large* signal amplifiers are used for achieving medium to high power amplification. For example, signals to be given to loudspeakers etc. High power transistors are usually mounted on metal chassis or on a physically large piece of metal known as *heat sink*. The function of heat sink is to, take away the heat from the transistor and pass it to air.

Transistor data books give information about the power handling capacity of different transistor.

4 Based on the frequency of application

- Low freq. transistors (Audio frequency or A/F transistors)
- High freq. transistor (Radio frequency or R/F transistors)

Amplification required for signals of low or audio range of frequencies in Tape recorders, PA systems etc., make use of A/F transistors. Amplifications required for signals of high and very high frequencies as, in radio receivers, television receivers etc., use R/F transistors.

The differences between A/F and R/F transistors are discussed in detail in further lessons.

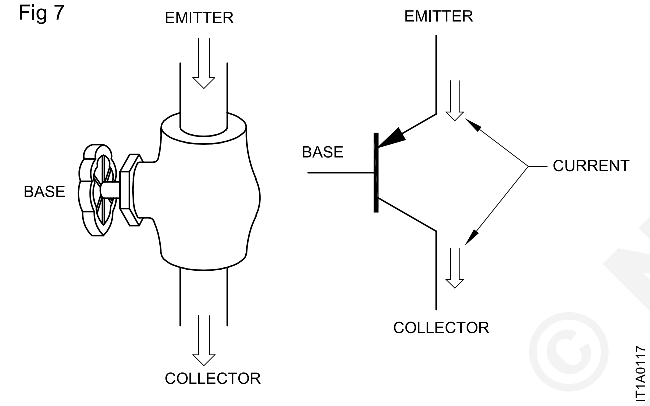
Transistor data books give information for any particular transistor as to whether it is a AF or RF transistor.

INSIDE A TRANSISTOR

Inside a transistor there are two PN junctions connected to each other as shown in Fig 3 and Fig 5. Outside a transistor, one can see only three leads. These leads are known as **base, emitter** and **collector** as shown in Fig 5. As shown in Fig 5, the three leads/pins/pigtails called **base, emitter** and **collector** are taken from each of doped semiconductor material.

In simple terms, as shown in Fig 7, the function of the **base, emitter** and **collector** regions of a transistor are,

Fig 7



Emitter - emits current carriers(electrons/holes)

Collector - collects current carriers

Base - controls flow of current carriers from emitter to collector.

While connecting a transistor to a circuit, it is necessary to identify the base, the emitter and the collector pins. A Transistor data book gives information on pin identification of transistors. However, it is convenient to put sleeve wires over the transistor pins for the following reasons;

- for easy identification while wiring
- sleeves act as spacers while mounting and soldering
- they ensure the required minimum lead distance from the solder joint to the transistor body.

Following colour scheme is suggested for putting sleeves to transistor pins although, any convenient colour scheme may be adopted.

Base pin	-	Blue colour sleeve
Emitter pin	-	Red colour sleeve
Collector pin	-	Yellow colour sleeve
Shield pin	-	Black colour sleeve

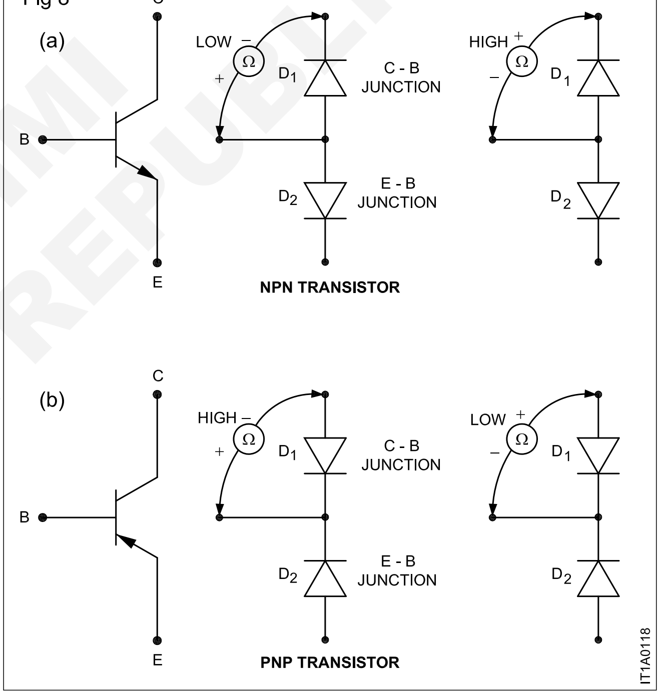
TESTING TRANSISTORS USING OHMMETER

1 Junction test

Since a transistor can be regarded as two diodes connected back-to-back, a transistor's general working condition (quick-test) can be assessed by checking these two diodes as shown in Fig 8a and 8b.

Fig 8a shows a NPN transistor and Fig 8b shows a PNP transistor. The imaginary diodes 1 and 2 can be tested as testing any diode. When a diode is tested, if the ohmmeter shows high resistance in one direction and low resistance in another direction, then the diode corresponding to that diode junction can be regarded as GOOD. One important point to note in a transistor is that, both the diodes of the transistor should be GOOD to declare the transistor as GOOD.

Fig 8



While testing, a transistor using ohmmeter, it is suggested to use the middle ohmmeter range (Rx100) because, ohmmeters in low range can produce excessive current and ohmmeters in high range can produce excessive voltage which may be sufficient to damage small signal transistors.

2 Quick TURN-ON test

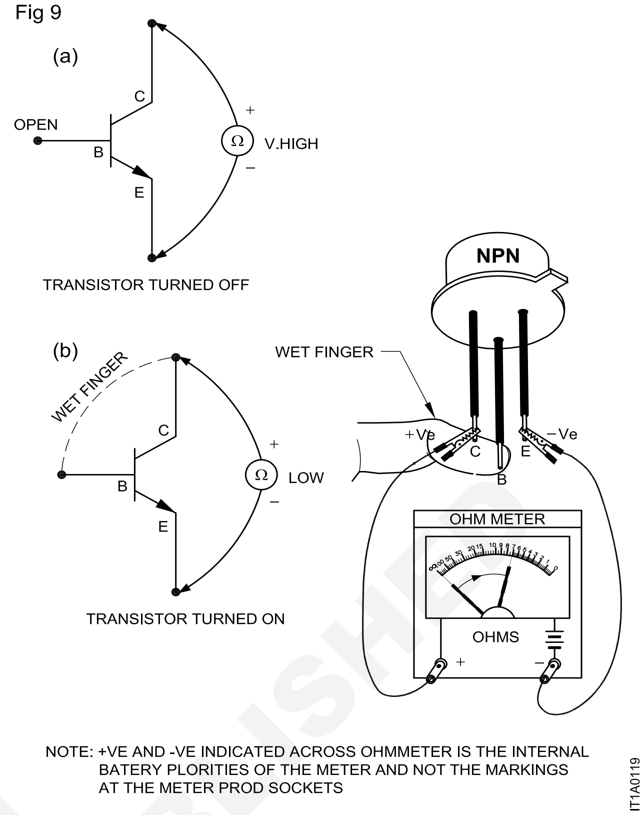
Recall that the base lead of the transistor controls the flow of current carriers from emitter to collector. So, if the base is open, then there can be no current flow through emitter-collector. This means, the resistance between emitter and collector will be high when the base is open as shown in Fig 9a. This can be checked using an ohmmeter with the base lead open.

In Fig 9, the +ve and –ve indicated across ohmmeter is the internal battery polarities of the meter and not the markings at the meter prod sockets.

When the collector and base leads of a transistor is touched with a wet finger as the base of the transistor turns ON the transistor and makes current to flow through emitter-collector. Because of the current flow, the resistance across emitter-collector will be low. From this test it is possible to make a quick test of the transistors basic operation. This test is most suitable for low power and medium power transistors.

The above two tests on a given transistor, using a simple ohmmeter revels the condition of the transistor. These tests are essential before using a transistor in a circuit.

Fig 9



Biasing of Transistors and common Emitter characteristics

Objectives: At the end of this lesson you shall be able to
- **state the biasing of transistors**
- **state the operation of NPN transistor**
- **state the operation of PNP transistor.**

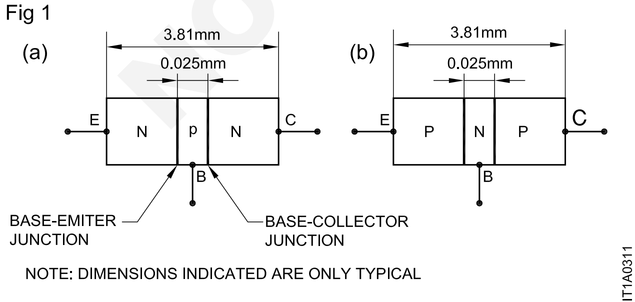
Biasing of transistors

Biasing a transistor means giving correct polarity and current level of voltages at the terminals of a transistor, such that, it functions as intended. (as an amplifier or as a solid state switch etc.)

Recall, transistors are three-layer semiconductor devices consisting of either a P-type layer sandwiched between two N-type layers as shown in Fig 1a or N-type layer between two P-type layers as shown in Fig 1b.

From Fig 1, the following points are important to note;

Fig 1



- The widths of the outer layers, i.e. emitter and collector layers are much greater than that of the base layer.
- The emitter layer is heavily doped compared to both the base and collector layers.
- The base layer is very thin, of the order of 1/10th the width of the outer layers, and is very lightly doped.

Transistor operation

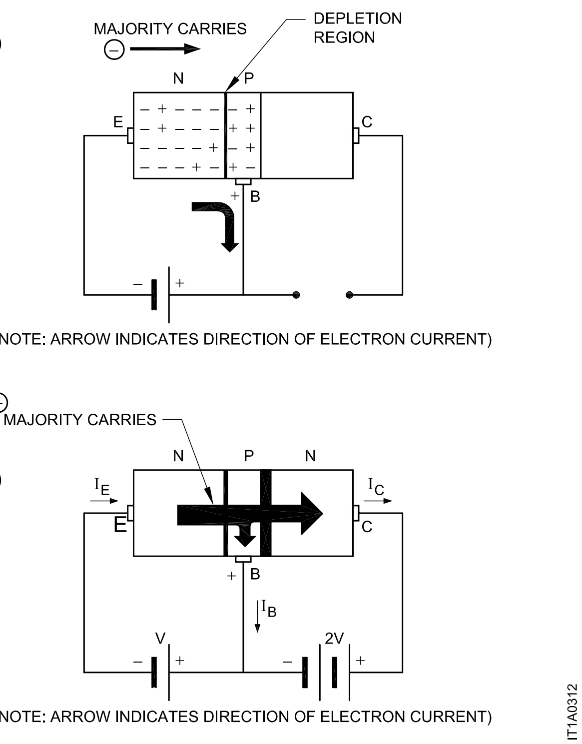
As transistors have three layers, there are two junctions as shown in Fig 1. The **base-emitter** junction behaves as one diode junction. The **base-collector** junction behaves as the other diode junction.

Recall that a diode junction conducts only when +ve supply is connected to the P material and -ve supply to the N material. Fig 2a shows a NPN transistor where the base-emitter junction is forward-biased. Hence, the diode conducts resulting in large flow of majority carriers(electrons) from N-type to P-type material.

Fig 2b shows the base-emitter junction forward biased and the base-collector junction is reverse-biased. Why is the base-collector reverse biased? what effect does this connection have on the transistor operation?

The answer is, in a NPN transistor, majority carriers are electrons, because, the emitter and collector are N-type materials. Free electrons are generated in the N-type emitter because of the forward-biased base-emitter junction. If the collector voltage is not there, then all the generated electrons flow to the base as shown in Fig 2a.

Fig 2



When the base-collector is reverse-biased, then, a positive voltage appears at the collector. This positive voltage at the collector completely changes the path of the electron current flow. Because of the thin base and the low base-to-emitter voltage (0.7V for silicon), about 95 percent of the electrons pass through the thin base and are attracted to the more positive potential collector as shown in Fig 2b. Only a very small percentage of the electrons from the emitter combine with holes in the base.

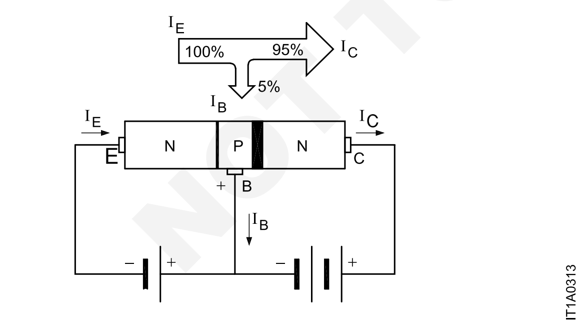
It can be seen from Fig 3, that the,

– current carriers come from the emitter

– base current is small (5% of emitter current)

– and, the collector current is high (95% of emitter current).

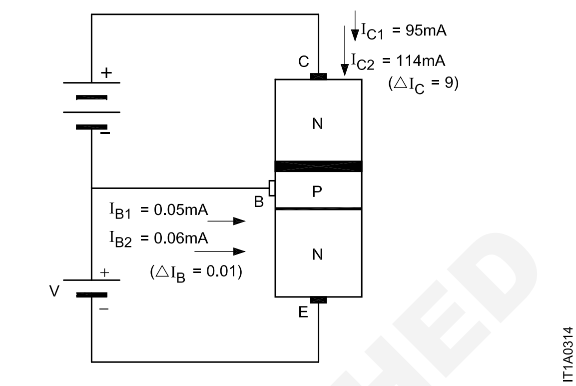
Fig 3



Under such conditions, it can be seen that, small changes in the emitter-base current will result in large change in the collector current. For example, an increase of say one electron in base current will result in an increase of 19 electrons in the collector current. This is because the collector current is 95% of the emitter current whereas the base current is only 5% of emitter current. This means that the value of the collector current can be easily controlled by changes in the bias on the emitter-base junction.

Summarizing, small changes in the base current results in large changes in the collector current as shown in Fig 4. This is nothing but amplification which is the intended function of a transistor. This behaviour of a transistor is known as Transistor action.

Fig 4



The ratio of the change in output current to the change in the input current is called the **amplification** or **gain**. In Fig 4, change in output current is DI_C due to the change in the input current DI_B. Therefore the current gain introduced by the transistor is,

Current gain

$$= \frac{\text{Output current change} \quad \Delta I_C}{\text{Input current change} \quad \Delta I_B} = \frac{9 \text{ mA}}{0.01 \text{ mA}} = 900$$

Gain is a dimension less quantity.

This condition as shown in Fig 4, in which the two junctions of the transistor are connected to such polarities of the voltage source, such that the transistor behaves as an amplifier, the transistor is then said to be properly biased or correctly biased.

Summarising a transistor is said to be properly biased or correctly biased or forward biased if,

– its base-emitter junction is forward biased

– and, its base-collector junction is reverse biased.

On the other hand, if the polarities of voltages connected to transistor junctions is as shown in Fig 5a and 5b, because the base-emitter junction is reverse biased, no electrons are available for conduction, and, hence, the transistor action does not exist. If the base-emitter is forward biased but the base-collector is not reverse biased as shown in Fig 5c, then, there is no amplification as both the junctions simply conduct as diodes.

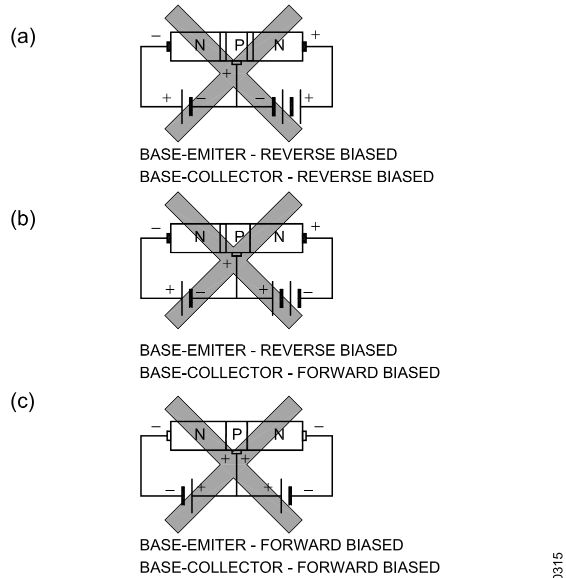
In a properly biased transistor as shown in Fig 3 and Fig 4, the relationship between I_E, I_B and I_C is given by,

$$I_E = I_B + I_C \qquad .....[1]$$

or $I_C = I_E - I_B$

or $I_B = I_E - I_C$.

Fig 5



IMPROPER BIASING OF TRANSISTORS

Operation of PNP transistors

Working of a PNP transistor is exactly the same as that of NPN transistors discussed earlier, if the role played by the electrons in NPN transistors is interchanged with holes as given below;

In a PNP transistor,

– the majority current carriers are holes instead of electrons

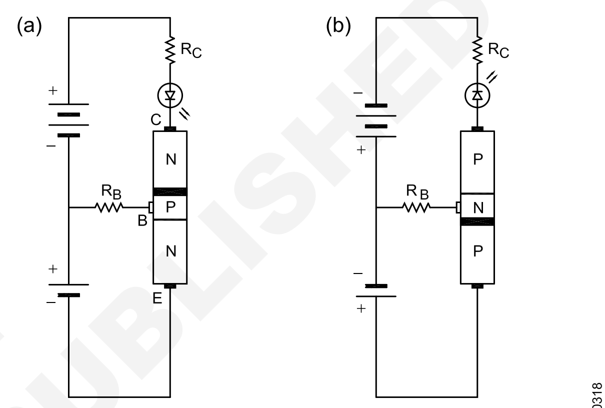
– the minority current I_{CO}, is due to electrons in the N-type base material instead of holes.

Test circuit for testing proper transistor biasing

If a transistor is properly biased (i.e. B-E junction forward biased and C-B junction reverse biased), then, there will be collector current I_C of the order of milliamps. To check this an LED is connected in the collector circuit of the transistors as shown in Figs 6a and 6b. The LED in the collector glows only when the transistor is properly biased otherwise the LED remains OFF.

Resistor R_B and R_C are introduced in the circuit to limit the base and collector currents such that the transistor does not get damaged due to excessive current.

Fig 6



USING NPN TRANSISTOR USING PNP TRANSISTOR

Gain and Impedance of common Emitter amplifier

Objectives: At the end of this lesson you shall be able to
- **state the meaning and method of finding voltage gain**
- **state the meaning and method of finding input impedance**
- **state the meaning and method of finding output impedance**
- **state the meaning and method of finding power gain**
- **state the phase relationship between input and output in a CE amplifier.**

After a transistor is biased with the Q point near the middle of the DC load line, the transistor can be made to amplify ac and dc signals as shown in Fig 1a. When we use a transistor to amplify a small ac signal, the small ac signal to be amplified is coupled to the base of the transistor using a capacitor. A capacitor is used for ac coupling because as discussed in earlier lessons capacitors behave as short for ac signal and open for dc signal. The varying amplitude and frequency of the coupled ac signal produces greater value variations in the collector current of the same shape and frequency as shown in Fig 1b.

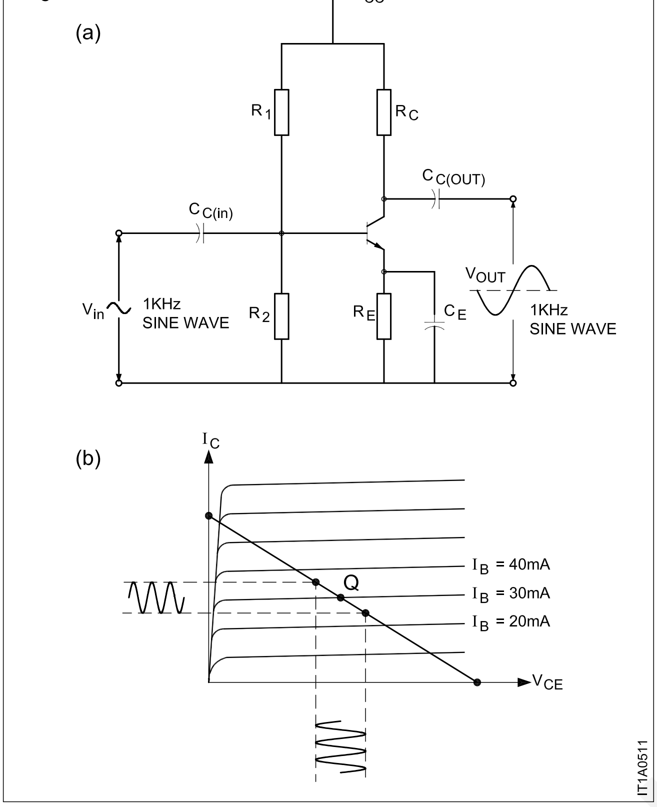
As shown in Fig 1a, if the input is a 1 KHz sine wave, the output will be an enlarged 1 KHz sine wave. The small sine wave given at the base of the transistor produces variations in the base current. Hence, the collector current is an amplified sine wave of the same frequency. The sinusoidal collector current flows through the collector resistor and produces an amplified sine wave output. Such amplifiers which retain the shape of the input signal at the output are called *linear amplifiers*.

Fig 1b, shows the dc load line, the Q point and ac input and output signals. This is generally referred to as the *ac load line*. As can be seen from Fig 1b, the ac input voltage produces variations in the base current. This results in sinusoidal variations about the Q point. Variations in Q point are nothing but the variations in the collector current resulting amplified form of the input signal.

For small input signal levels, generally referred to as small signal operation, the peak to peak swing in the collector current should be less than the ±10% of the collector current at Q point to keep the distortion in the amplified output within acceptable limits.

For large input signal levels, generally referred to as large-signal operation, the peak to peak swing in the collector current will be larger (more than 10%). If the swing is very large, the transistor may go into saturation and cut off. This swing into saturation and cut off will clip the positive and negative peaks of the output signal. This clipping is nothing but distortion, meaning, the output will not be an exact replicate of the input signal.

Fig 1



AC CURRENT GAIN A_i, of a CE amplifier

The ac current gain of a CE amplifier shown in Fig 1 is the ratio of the ac component of the collector current i_c, to the ac base current i_b.

$$A_i = \frac{i_c}{i_b}$$

Small letter i is used to represent ac current whose value keeps changing with time.

It is to be noted that in most linear CE amplifier circuits the current gain A_i is almost equal to b_{dc} of the transistor. Therefore, the following approximation can be used for A_i.

$$A_i \approx \beta$$

In the amplifier at Fig 1, if b_{dc} of the transistor is 100, then the current gain A_i of the amplifier can be taken as 100.

VOLTAGE GAIN, A or A_V of CE amplifier

The voltage gain of an amplifier is the ratio of ac output voltage to the ac input voltage. This is represented as,

$$\text{Voltage gain, } A_V = \frac{V_{out}}{V_{in}}$$

Small letter v is used for voltage because it is ac voltage whose amplitude keeps changing with time.

For example, in Fig 1, if the input voltage v_{in} is 80 m $V_{(p\text{-}p)}$ and the corresponding output voltage v_{out} is 7.2 $V_{(p\text{-}p)}$, then the voltage gain A_V is given by,

$$\text{Voltage gain, } A_V = \frac{7.2\ V_{(p-p)}}{80\,m\ V_{(p-p)}} = 90$$

A voltage gains of 90 means that, in this amplifier, a base voltage of 1 mV produces an output voltage of 90 mV.

The input and output voltage may be rms, peak, peak-to-peak, as long as the input and output are measured the same way consistently.

INPUT IMPEDANCE, Z_{in} of CE amplifier

Recall that the maximum transfer of power takes place when the impedances of the supplying and receiving circuits are matched.

If impedances are to be matched for best circuit operation, both impedances must be known. If a single device such as a microphone, speaker, relay, etc. is to be used, its impedance will be given by the manufacturer. The amplifier to be designed for such a circuit must have an input or output impedance to match the input-output devices.

The ac source driving the amplifier has to supply ac current to the amplifier. The less the current the amplifier draws from the source, the better because the supplying source does not get loaded. The input impedance of the amplifier determines how much of current the amplifier takes from the ac source or the preceding stage of the amplifier.

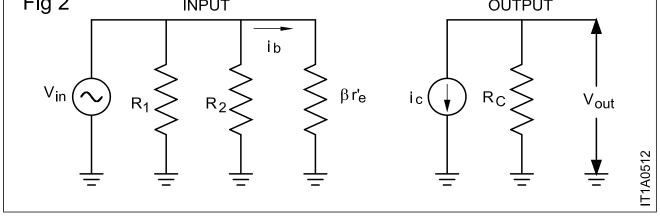
In the normal frequency range of an amplifier, the coupling and by pass capacitors behave as a short for ac. The ac *input impedance* Z_{in} sometimes referred to as input resistance R_{in} is defined as the ratio of input signal voltage to input signal current.

$$Z_{in} = \frac{V_{in}}{i_{in}}$$

where, V_{in} and i_{in} are rms or peak or peak-to-peak values.

Fig 2 shows the ac equivalent circuit of the CE amplifier shown in Fig 1.

Fig 2



From the ac equivalent circuit the input impedance Z_{in} is given by,

$$Z_{in} \approx R_1 \| R_2 \| \beta r'_e \qquad .....[1]$$

where,

R_1 and R_2 are the voltage divider resistors,

b is the dc current gain and r'_e is the ac emitter resistance (V_{BE}/I_E). r'_e is approximately equal to 25W when the Q point is chosen at the mid of the load line.

In the CE amplifier at Fig 1, if R_1 = 18KW, R_2 = 8.2KW and the transistor b is 100, the input impedance Z_{in} will be,

$$br'_e = 100(25\ \Omega) = 2.5\ K\Omega$$

$$Z_{in} = R_1 \parallel R_2 \parallel \text{ɔ} r'_e \parallel$$

$$= 18\ K\Omega\ 8.2\ K\Omega\ 2.5\ K\Omega$$

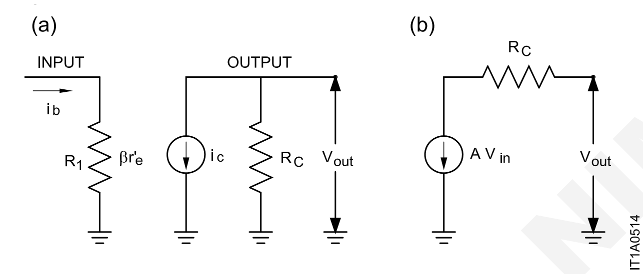
$$= 1.73\ K\Omega.$$

OUTPUT IMPEDANCE, Z_{out}

The output impedance of a CE amplifier is naturally the impedance at the output terminals.

To find the Z_{out} of the CE amplifier, consider the ac equivalent of the output as shown in Fig 3a.

Fig 3



Recall that a transistor operating in the linear portion of its characteristics curve is like a current source. Therefore, we can represent it as a current source i_C.

As can be seen from Fig 3a, this collector current source is in parallel with the collector resistor R_C. Assuming that the collector current source is ideal, it has infinite internal impedance. Then, the only impedance in the output is the collector resistor R_C.

The Thevinin's voltage appearing at the output is the voltage gain(A) times the input v_{in}.

Therefore, $V_{out} = A.v_{in}$

Hence, the output ac equivalent circuit of the amplifier can be simplified as shown in Fig 3b. In Fig 3b, an ideal output voltage source AV_{in} with zero internal impedance is in series with the collector resistor R_C. Therefore, the output impedance of the CE amplifier is approximately equal to the collector resistor R_C,

$$Z_{out} \approx R_C$$

In the CE amplifier circuit at Fig 1, if R_C = 1000W, the output impedance of the amplifier is equal to the value of R_C , that is 1000 W.

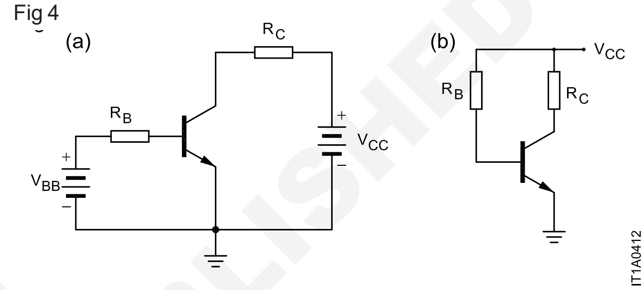
Types of transistor biasing

There are several ways to bias a transistor for linear operation. This means, there are several ways of setting up a Q point near the middle of the dc load line. Important biasing arrangements used with transistors are explained below:

1 **BASE BIAS**: Fig 4 shows one type of biasing of transistor known as base-bias. As shown in Fig 4b, usually, the collector voltage supply itself is used for the base voltage instead of a separate supply.

The value of the base resistor R_B is fixed such that it allows the necessary Q point base current I_B. The value of R_B ensures that the base-emitter diode is always forward biased by allowing 0.7V(for silicon) across V_{EB}.

Fig 4



This type of biasing is the simplest of all. However, this is the worst possible way to bias a transistor because the dc Q point changes when,

– temperature increases and

– b of the transistor is changed.

Hence, in a base-biased transistor, it is impossible to set up a stable Q point. Therefore, base biasing of transistors is not generally done in linear amplifier circuits. However, base biasing is commonly used in digital circuits (discussed in further lessons) where transistors are used as a switch and not as a linear amplifier.

2 **EMITTER BIAS or emitter feedback bias**: Fig 5 shows a emitter-biased transistor. This type of biasing compensates for the variations in b_{dc} and keeps the Q point fairly stable.

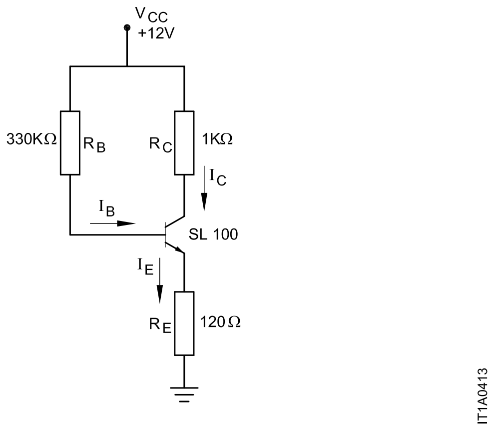
In Fig 5, if b_{dc} increases, the collector current increases. This in turn increases the voltage at the emitter. This increased emitter voltage decreases the voltage across the base-emitter junction and therefore, the base current reduces. This reduced base current results in less collector current, which partially offsets the increase in I_c due to increased b_{dc}.

Emitter bias is also referred to as *emitter feedback bias*. This is because an output quantity, i.e., the collector current, produces a change in an input quantity i.e., the base current. The term feedback means a portion of the output is given back to the input. In emitter bias, the emitter resistor is the feedback element because it is common to both the output and input circuits.

In Fig 3, if we add the voltages around the collector loop, we get,

$$I_C R_C + V_{CE} + I_E R_E - V_{CC} = 0 \qquad .....\{1\}$$

Fig 5



Since I_E approximately equals I_C, (as I_B is comparatively very small), equation..(1) can be arranged as,

$$I_C = \frac{V_{CC} - V_{CE}}{R_C + R_E} \qquad .....\{2\}$$

If we add voltages around the base loop, we get,

$$I_B R_B + V_{BE} + I_E R_E - V_{CC} = 0. \qquad .....\{3\}$$

Since $I_E » I_C$ and $I_B = I_C/b_{dc}$, we can rewrite the equation as,

$$I_C = \frac{V_{CC} - V_{BE}}{R_E + R_B/\beta_{dc}} \qquad .....\{4\}$$

From equation ...(4), the presence of term b indicates that I_C is dependent on b. The intention of emitter-feedback bias to swamp out the effect b_{dc}. This is possible when R_E is made much larger than R_B/b_{dc}. However, in practical circuits R_E cannot be made very large because, large value of R_E takes the transistor out of the linear operating region. Due to this problem, the emitter-feedback bias is almost as sensitive to changes in b_{dc} as is the base-bias. Therefore, emitter-feedback bias is also not a preferred form of transistor bias and should be avoided.

In emitter-bias, the saturation current will be,

$$I_{C(sat)} = \frac{V_{CC} - V_{CE(sat)}}{R_E + R_C} \qquad .....[1]$$

When the transistor is saturated, the value of V_{CE} will be between 0.2 to 0.3V. Hence can be neglected for all practical purposes.

In Fig 3, the saturation current is,

$$I_{C(sat)} = \frac{12\ V}{1000\ \Omega + 120\ \Omega} = 10.71\ mA.$$

NOTE: *$V_{CE(sat)}$ of 0.2 volts is neglected.*

When b_{dc} = 100, equation ...(4) gives,

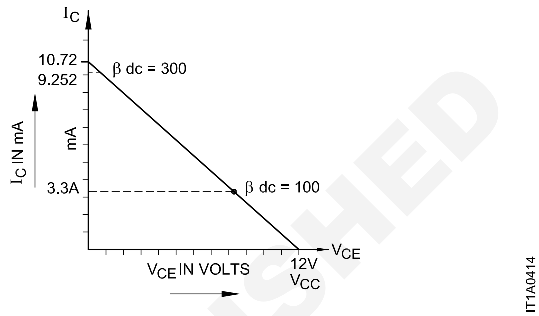
$$I_C = \frac{12\ V - 0.7\ V}{120\Omega + 330K\Omega / 100} = 3.3\ mA.$$

When b_{dc} = 300, the same equation...(4) gives,

$$I_C = \frac{12\ V - 0.7\ V}{120\Omega + 330K\Omega/300} = 9.262\ mA.$$

Fig 6 summarizes the calculations by showing the dc load line and the two Q points. As can be seen, a 3:1 change in b_{dc} produces almost a 3:1 change in the collector current. This change is unacceptable as a stable-biased state.

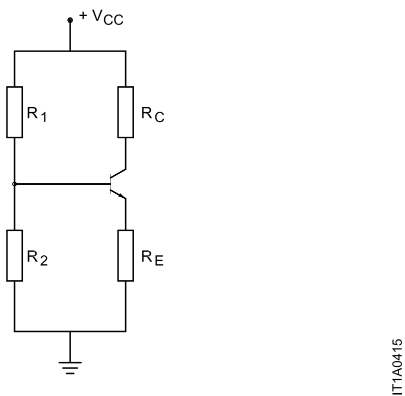
Fig 6



TIP: For linear operation of the transistor, the base resistor R_B should be greater than bR_C. A base resistance of less than $b_{dc}R_C$ produces saturation in an emitter-feedback-biased circuit.

3 VOLTAGE-DIVIDER bias: Fig 7 shows a typical voltage-divider bias. This type of biasing is also called the *universal bias* because, this is the most widely used type of biasing in linear circuits.

Fig 7



This type of biasing is known as *voltage divider bias* because of the voltage divider formed by resistors R_1 and R_2. The voltage drop across R_2 should be such that it forward biases the emitter diode.

Emitter current in voltage divider bias

Assume that the base lead is open as shown in Fig 8b.

Looking back at the unloaded voltage divider,

$$V_{TH} = \frac{R_2}{R_1 + R_2} V_{CC}.$$

V_{TH} is known as the Thevinin's voltage. Refer reference books for Thevinin's theorem.

Now assume that, the base lead is connected back to the voltage divider as in Fig 8a. Then, voltage V_{TH} drives the base of the transistor. In other words, the circuit simplifies to Fig 8a and the transistor acts like the controlled current source.

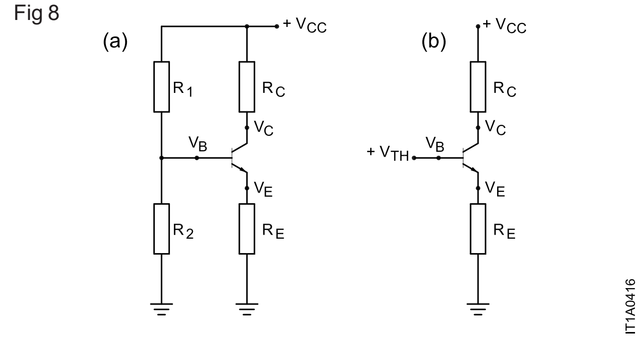


Fig 8

Because the emitter is boot-strapped to the base,

$$I_E = \frac{V_{TH} - V_{BE}}{R_E}$$

The collector current I_C will be approximately equal to I_E.

Notice that b_{dc} does not appear in the formula for emitter current. This means that the circuit is not dependent on variations in b_{dc}. This means that the divider-biased transistor has a stable Q point.

Because of the stable Q point, voltage-divider bias is the most preferred form of bias in linear transistor circuits. Hence, divider bias is used almost universally.

Emitter follower / Common Collector

Objectives: At the end of this lesson you shall be able to
- **state the need for impedance matching**
- **state the popular application of an emitter follower amplifier configuration**
- **calculate the voltage gain, current gain, input impedance and output impedance of a transistor amplifier using circuit component values.**

Fig 1 shows another important transistor amplifier configuration. In this configuration, unlike in a common emitter amplifier where the output is taken from the collector, the output is taken from the emitter terminal of the transistor as shown in Fig 1.

Emitter follower can be used, to match a high impedance source to a low impedance output load. Hence, the emitter follower configuration is frequently used as an impedance matching circuit than as an amplifier.

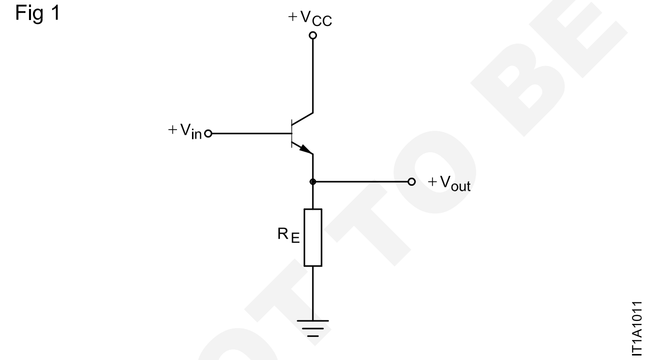


Fig 1

Need for impedance matching

When a high impedance source is connected to a low impedance load, then most of the ac signal of the source gets dropped across the internal impedance of the source itself resulting in a very small portion of the signal appearing across the required load as shown in Fig 2a. One way to overcome this problem, i.e. to have almost all the signal from the source to be developed across the load, is to use an impedance matching device or a circuit between the high impedance source and the low impedance load as shown in Fig 2b.

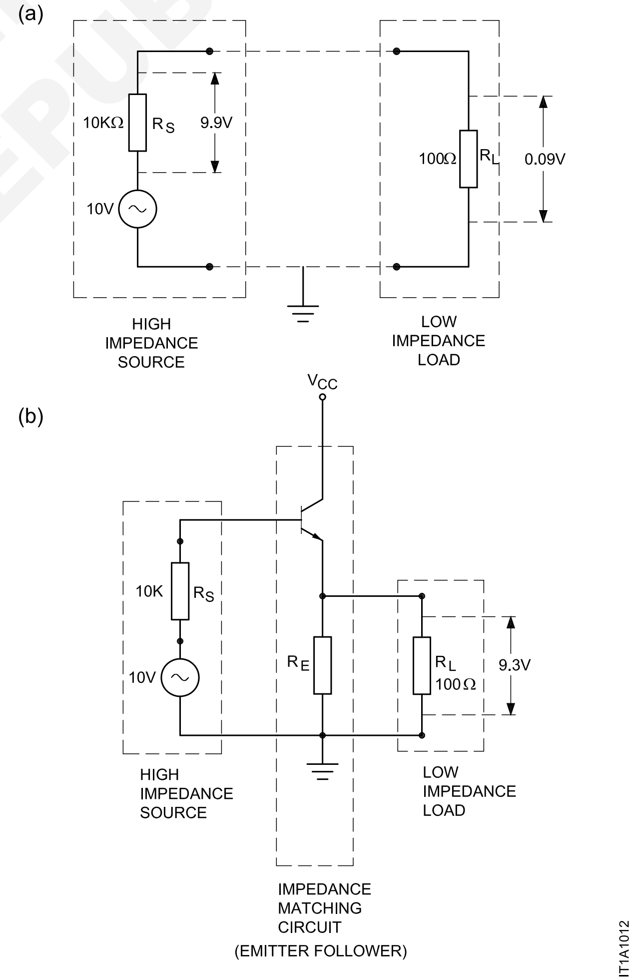


Fig 2

The circuit used for impedance matching in Fig 2b, is an emitter follower transistor amplifier. This is because, the emitter follower has a very high input impedance and a very low output impedance. This can be compared to that of a matching transformer where a load is matched to the source impedance for maximum power transfer.

An emitter follower circuit is also called a *common collector amplifier* because, the collector behaves as the common terminal for AC signal between the input and the output.

Voltage gain of an emitter follower

As can be seen in Fig 3, the DC output voltage of the emitter follower is $V_{out} = V_{in} - V_{BE}$

Since, V_{BE} is almost a constant value (0.7 for silicon, 0.3 for germanium) the emitter voltage follows the base voltage. It is because the emitter voltage follows the base voltage, this circuit is called ***emitter follower.***

In Fig 3, if V_{in} is 3V, then V_{out} = 2.3V. If V_{in} is made 4V then V_{out} increases to 3.3V. This means that changes in V_{out} is in phase with changes in V_{in}. Therefore in an emitter follower the input and output signals are in phase as shown in Fig 3b. (recall, in a CE amplifier the input and output are 180° out of phase.)

Fig 3

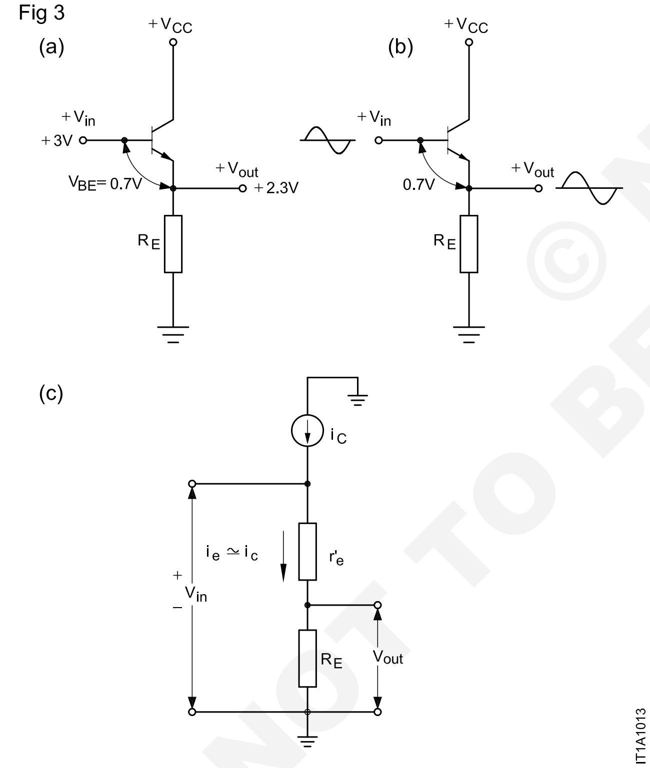


Fig 3c shows the AC equivalent circuit of the emitter-follower shown in Fig 3a. The ac output voltage V_{out} is given by,

$$V_{out} = i_e R_E$$

Since the ac input voltage V_{in} is given by, $V_{in} = i_e\,(R_E + r'_e)$

the voltage gain A_V of the emitter follower is,

$$A_V = \frac{V_{out}}{V_{in}} = \frac{i_e R_E}{i_e (R_E + r'_e)} = \frac{R_E}{R_E + r'_e} \qquad .....\{1\}$$

In equation {1}, since the denominator will always be higher than the numerator, the value of voltage gain A_V will always be less than 1.

But since the value of r'_e is very small compared to R_E, the value of A_V approaches unity. We can therefore say that the voltage gain of the emitter follower is unity.

In Fig 3a, if R_E = 4.7KW and r'_e = 25W then,

$$A_V = \frac{R_E}{R_E + r'_e} = \frac{4700}{4700 + 25} = 0.995 \quad 1$$

Input impedance of emitter follower

The input impedance of the emitter follower shown in Fig 3 is given by,

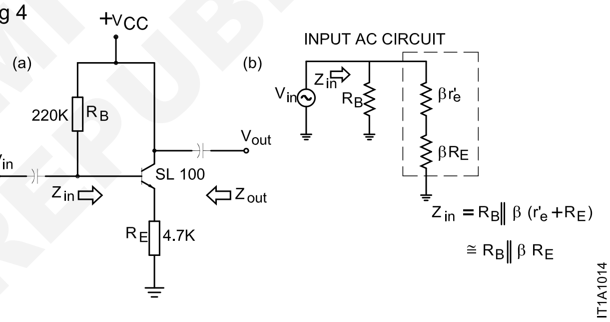
$$Z_{in} = b(R_E + r'_e) \qquad ......\ \{2\}$$

Since r'_e will be generally very small compared to R_E, equation ...{2} can be simplified as,

$$Z_{in} = b\,R_E$$

Fig 4a shows a practical emitter follower circuit using fixed biasing. The total input impedance including the biasing resistor R_B in parallel with the input impedance can be found as follows;

Fig 4



Writing the AC equivalent of the input of the emitter follower shown in Fig 4b, the input impedance Z_{in} is given by,

$$Z_{in} = R_B \,\|\, b(r'_e + R_E) \qquad ....\{3\}$$

If r'_e is neglected, then, $Z_{in} = R_B \,\|\, bR_E$

Equation 3 indicates that the input impedance of a typical emitter follower is decided by the DC biasing resistance R_B. Hence, while designing an emitter follower to match a high source impedance, the values of R_B should be suitably chosen.

Example: In the emitter follower at Fig 4, if b of transistor is 100, R_B = 220 k and R_E = 4.7k the input impedance will be,

$$Z_{in} = R_{in} = R_B \,\|\, bR_E$$

$$= 220\text{ K} \,\|\, b\,R_E$$

$$= 220\text{ K} \,\|\, (100 \times 4.7\text{K})$$

$$= 149.85\text{ K W} \qquad 150\text{ KW}$$

Output impedance of emitter follower

Fig 5 shows an AC equivalent or AC model of the output section of an emitter follower shown in Fig 4a.

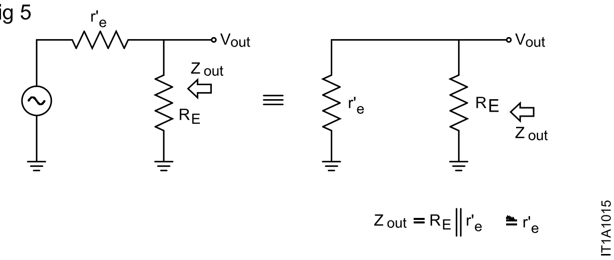
Analysing Fig 5, the output impedance Z_{out} is given by,

$$Z_{out} = R_E \parallel r'_e \qquad \text{......\{4\}}$$

Since R_E is usually a large resistance compared to r'_e, R_E in equation (4) can be neglected. Therefore, the output impedance of an emitter follower is approximately,

$$Z_{out} = r'_e$$

Fig 5



Example 1: Find the output impedance of the emitter follower shown in Fig 4 assuming r'_e = 33W,

$$Z_{out} = r'_e \parallel R_E \quad r'_e = 33W.$$

Current gain in emitter follower

Although the voltage gain A_V of emitter follower is approximately unity, the current gain of emitter follower is high and is given by the equation;

$$A_I = \frac{\beta R_B}{(R_B + \beta R_E)} \qquad \text{.....\{5\}}$$

Example 2: In the emitter follower shown in Fig 4, if b of the transistor is 100, then the current gain of the emitter follower is given by,

$$A_I = \frac{\beta R_B}{(R_B + \beta R_E)}$$

$$= \frac{(100)\,(220K)}{(220K) + (100)\,(4.7K)} = 31.88.$$

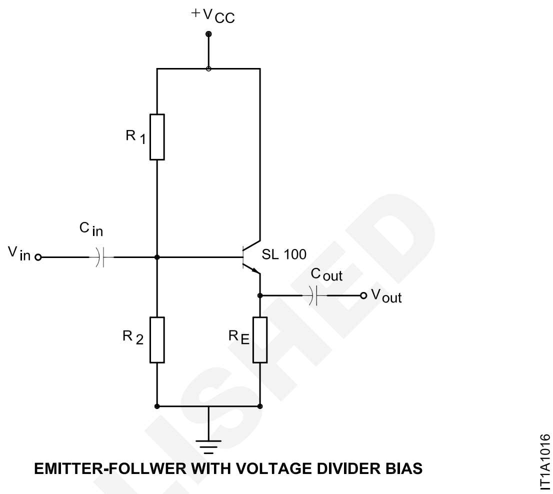
The current gain of the emitter follower can also be found as follows;

$$A_I = A_V \frac{Z_{in}}{R_E} = (0.995)\,\frac{150K}{4.7K} = 31.72.$$

Fixed bias was used in the emitter follower shown in Fig 4. Any other dc biasing could also be employed such as voltage divider bias as shown in Fig 6.

When voltage divider bias is used in an emitter follower, the equations for finding A_V, Z_{in}, Z_{out} and A_i remain the same, except for, that the fixed biased resistor R_B replaced by $R_1 \parallel R_2$.

Fig 6

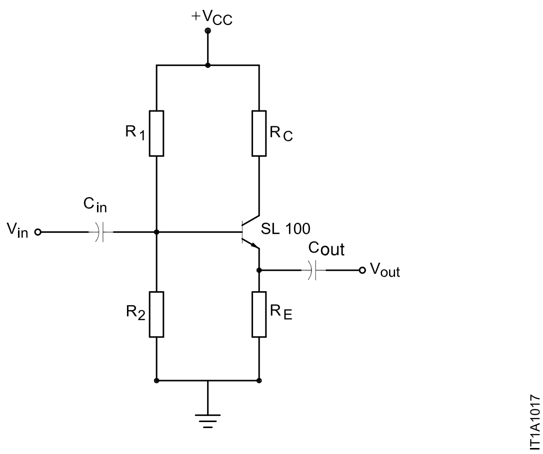


EMITTER-FOLLWER WITH VOLTAGE DIVIDER BIAS

Fig 7 which includes a collector resistor R_C also provides the input-output characteristics of an emitter follower. The input impedance Z_i and the output impedance Z_o are not effected by R_C since it is not reflected into the base or emitter equivalent network of the circuit. The only use of R_C will be to fix the quiescent collector current or Q point of the transistor.

Appendix-D gives a summary of the important parameters of common collector or emitter follower amplifier.

Fig 7

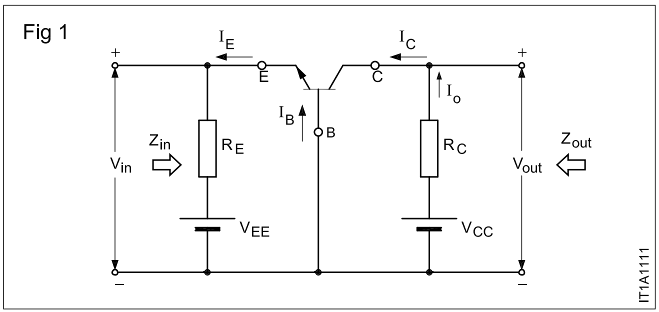


Common base amplifier

Objectives: At the end of this lesson you shall be able to
- **calculate the voltage gain, current gain, input impedance and output impedance of a common base amplifier**
- **list the typical applications of common base amplifiers. using circuit component values.**

Fig 1 shows the typical circuit schematic of a **common base amplifier** (CB-amplifier).

Common base amplifiers have a current gain of less than 1. Recall, the emitter current and the collector current of a transistor are almost equal. In a common base amplifier since the input current is I_E and the output current is I_C, the current gain, symbolically represented as a (alpha), is given by,



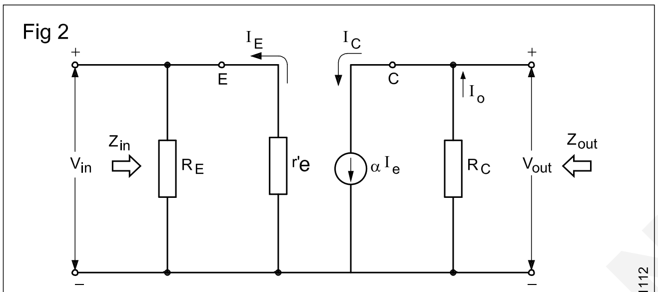
$$\text{Current gain } (\alpha) = \frac{\text{Output current}}{\text{Input current}} = \frac{I_C}{I_E}.$$

Since $I_E > I_C$, a will always be less than 1.

Fig 2 shows the AC equivalent of a common base amplifier, shown in Fig 1.

From Fig 2, the input impedance Z_{in} of CB amplifier is given by,

$$Z_{in} = R_E \parallel r'_e \qquad .....\{1\}.$$



AC EQUIVALENT OF CB AMLIFIER

Since R_E is generally much greater than r'_e, eqn..1 can be simplified as,

$$Z_{in} = r'_e$$

The equation for Z_{in} indicates that, the input impedance of a CB amplifier is very low and almost equal to the AC resistance r'_e of the emitter diode (recall r'_e will be generally 25Ω).

Referring to the AC equivalent network of the CB amplifier, the output impedance Z_{out} of CB amplifier is given by,

$$Z_{out} = R_C \qquad ......\{2\}.$$

Equation 2 indicates that the output impedance of a CB amplifier is relatively high, of the order of kilo ohms (because you can fix the value of R_C as you wish !).

From Fig 2, the output voltage V_{out} is

$$V_{out} = I_o R_C = I_c.R_C$$

Since $\alpha = \dfrac{I_C}{I_E}$, $I_C = \alpha . I_E$

Therefore, $V_{out} = I_C R_C = a.I_E.R_C \qquad ....\{3\}.$

Since, $I_E = \dfrac{V_{in}}{r'e}$ equation 3 can be written as,

$$V_{out} = \alpha \left(\frac{V_{in}}{r'e} \right) R_C$$

The voltage gain A_V of CB amplifier is given by,

$$A_V = \frac{V_{out}}{V_{in}} = \alpha \frac{V_{in}}{r'_e} R_C \frac{1}{V_{in}} = \alpha \frac{R_C}{r'_e} \qquad ......\{4\}$$

Since r'_e is very small compared to R_C, the voltage gain A_V of the CB amplifier is quite high.

The power gain A_p of the CB amplifier is given by,

$$A_P = A_i.A_V$$

Power gain A_P will be medium because although A_i is less than or equal to 1, A_V of the CB amplifier is quite high.

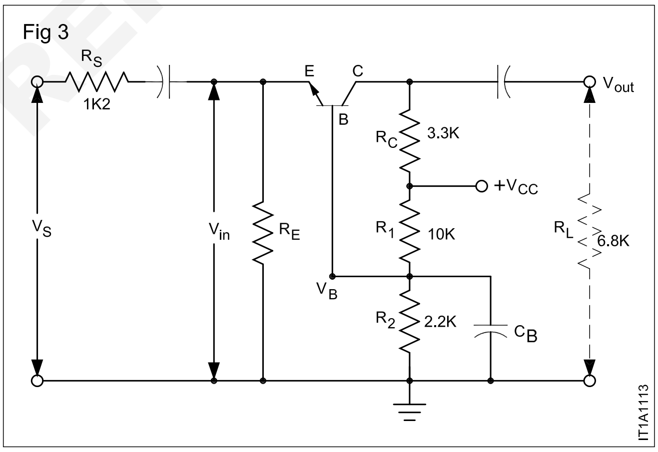
Input/output phase relationship

The input and output of a common base amplifier are in phase with each other. This can be found experimentally.

Fig 3 shows a CB amplifier with voltage divider bias.

In Fig 3, the base of the transistor is at AC ground due to the bypass capacitor C_B. The input signal drives the emitter and the output is taken from the collector. The biasing resistors R_1, R_2 will have negligible effect on the input impedance. Therefore, the input impedance of the CB amplifier is approximately equal to r'_e itself.

The input V_{in} to the amplifier is given by (note that C_B bypass R_2 for AC signal),



$$V_{in} = \frac{r'_e}{R_S + r'_e} V_S$$

$$= \frac{20.5\,\Omega}{1K\Omega + 20.5\,\Omega} 500mV$$

$$= 10 \text{ mV}.$$

Therefore, the unloaded output voltage V_{out} is given by,

$$V_{out\,(No\ load)} = A_V.V_{in}$$

$$= 161 \times 10 \text{ mV}$$

$$= 1610 \text{ mV}$$

$$= 1.61 \text{ volts.}$$

The output voltage of the amplifier with load R_L is given by,

$$V_{out\ (Load)} = \frac{R_L}{R_C + R_L} \times V_{out(No\ load)}$$

$$= \frac{6.8K}{3.3K + 6.8K} \times 1.61V$$

$$= 1.08V$$

The voltage at the base (at T_1) is given by,

$$V_B = \frac{R_2}{R_1 + R_2} . V_{CC}$$

$$= \frac{2.2K}{10K + 2.2K} . 12V$$

$$= 2.16 \text{ volts.}$$

The emitter current I_E is given by,

$$I_E = \frac{V_B - V_{BE}}{R_E}$$

$$= \frac{2.16 - 0.7}{1.2 K\Omega}$$

$$= 1.22 \text{ mA.}$$

Therefore, r'_e is given by,

$$r'_e = \frac{25mV}{I_E}$$

$$= \frac{25mV}{1.22 \text{ mA}}$$

$$= 20.5\Omega$$

Input impedance Z_{in} is given by,

$$Z_{in} \approx r'_e = 20.5\,\Omega$$

The voltage gain A_V is given by,

$$A_V = \frac{R_C}{r'_e}$$

$$= \frac{3.3K}{20.5}$$

$$= 160.97 \approx 161\ \Omega$$

The output impedance Z_{out} is given by,

$$Z_{out} \approx R_C = 3.3K\,\Omega$$

Class Room Assignment: **Calculate the output voltage of the CB amplifier (as done in step above) if load resistor R_L was,**

(i R_L = 3.3K

ii R_L = 10K and,

iii R_L = 100K

Appendix-D gives a summary of the important parameters of common base transistor amplifiers.

Field effect transistor and its types

Objectives: At the end of this lesson you shall be able to
- **explain the difference between bi-polar transistors and Field effect transistors**
- **write the basic construction and symbol used**
- **explain the theory of operation of FETs**
- **explain a typical FET A.C voltage amplifiers.**

FIELD EFFECT TRANSISTORS (FET)

The main difference between a Bi-polar transistor and a FET is that,

Bi-polar transistor is a current controlled device

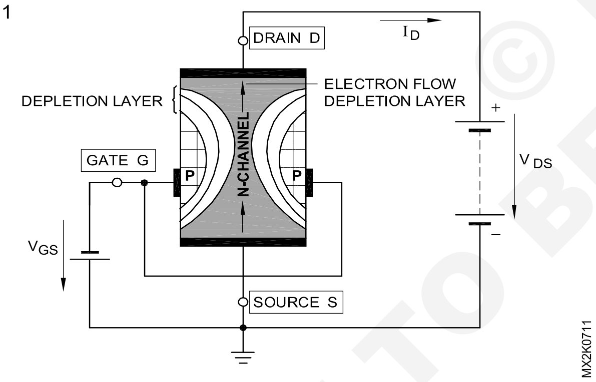
In simple terms, it means that the main current in a bi-polar transistor (collector current) is controlled by the base current.

FET is a voltage controlled device

This means that the voltage at the gate(similar to base of a bi-polar transistor) controlled the main current.

In addition to the above, in a bi-polar transistor (NPN or PNP), the main current always flows through N-doped and P-doped semiconductor materials. Whereas, in a FET the main current flows either only through the N-doped semiconductor or only through the P-doped semiconductor as shown in Fig 1.

Fig 1



If the main current flow is only through the N-doped material, then such a FET is referred as a N-channel or N-type FET. The current through the N-doped material in the N-type FET is only by electrons.

If the main current flow is only through the P-doped material, then such a FET is referred as a P-channel or P-type FET. The current through the P-doped material in the P-type FET is only by Holes.

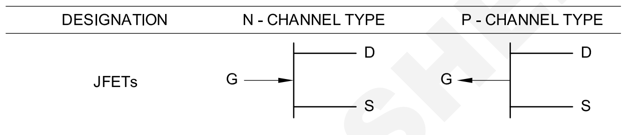
Unlike in bipolar transistors in which the main current is both by electrons and holes, in contrast in FETs depending on the type (P or N type) the main current in either by electrons or by holes and never both. For this reason, FETs are also known as Unipolar transistors or Unipolar device.

There are a wide variety of FETs. In this lesson MOSFET (Metal Oxide Semiconductor FET) and one of the fundamental type called as Junction Field Effect Transistor (JFET) are discussed.

Junction Field effect Transistor(JFET)

It is a three terminal device and looks similar to a bi-polar transistor. The standard circuit symbols of N-channel and P-channel type FETs are shown in Fig 2.

Fig 2



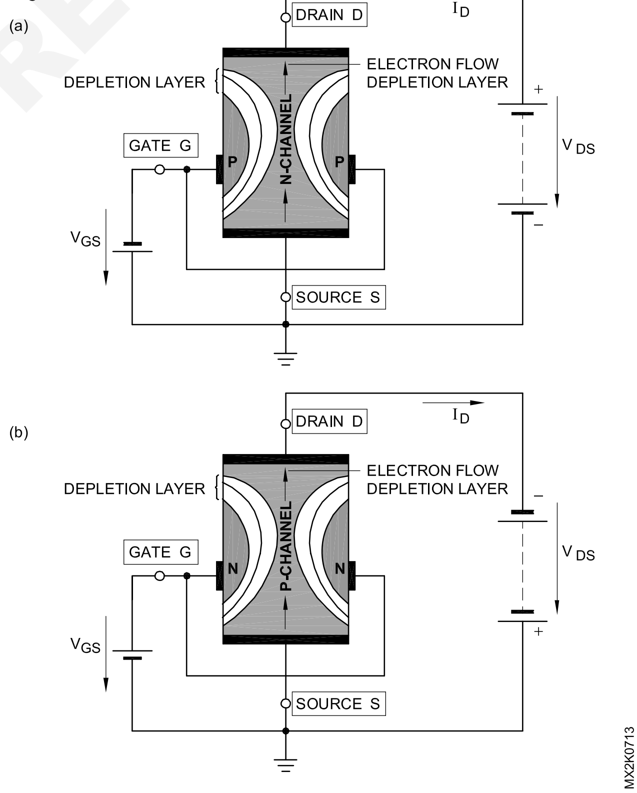
Working of FET

Similar to Biploar transistors, the working point of adjustment and stabilization are also required for FETs.

Biasing a JFET

– Gates are always reverse biased. Therefore the gate current I_G is practically zero.

Fig 3



– The source terminal is always connected to that end of the supply which provides the necessary charge carriers. For instance, in a N-channel JFET source terminal S is connected to the negative of the D.C power supply.

And, the passive of the D.C power supply is connected to the drain terminal of the JFET.

where as in a P channel JFET, Source is connected to the positive end of the power supply and the drain is connected to the negative end of the power supply for the drain to get the holes from the P-channel where the holes are the charge carriers.

Let us now consider an N channel JFET, the drain is made positive with respect to source by voltage V_{DS} as shown in Fig 4a. When gate to source voltage V_{GS} is zero, there is no control voltage and maximum electron current flows from source(S) - through the channel - to the drain(D). This electron current from source to drain is referred to as Drain current, I_D.

When gate is reverse biased with a negative voltage (V_{GS} negative) as shown in Fig 4b, the static field established at the gate causes depletion region to occur in the channel as shown in Fig 4b.

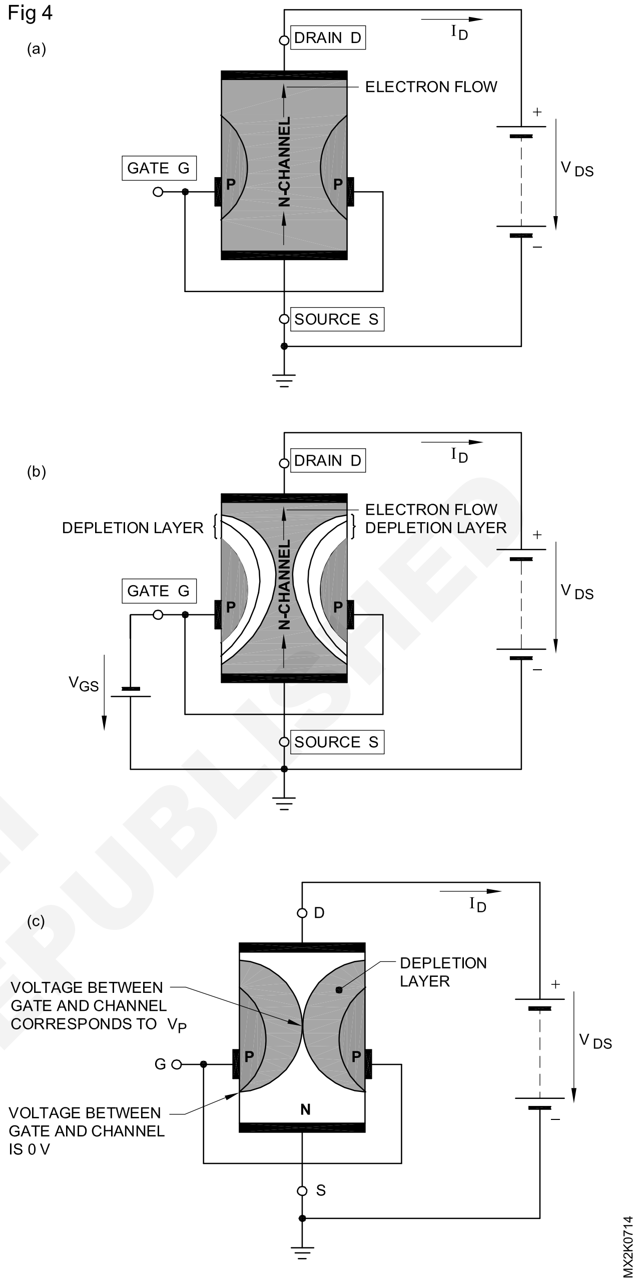
This depletion region decreases the width of the channel causing the drain current to decrease.

If V_{GS} is made more and more negative, the channel width decreases further resulting in further decrease in drain current. When the negative gate voltage is sufficiently high, the two depletion layers meet and block the channel cutting off the flow of drain current as shown in Fig 4c. This voltage at which this effect occurs is referred to as the Pinch off voltage, V_P.

Thus, by varying the reverse bias voltage between gate and source($-V_{GS}$), the drain current can be varied between maximum current (with $-V_{GS}=0$) and zero current (with $-V_{GS}$=pinch off voltage). So, JFET can be referred as a voltage controlled devices.

P channel JFET operates in the same way as explained above except that bias voltages are reversed and the majority carrier of channel are holes.

Fig 4



Types of FET(s)

Objectives: At the end of this lesson you shall be able to
- **discuss different types field effect transistors**
- **discuss special type of MOSFETs.**

INTRODUCTION TO DIFFERENT TYPES OF FETS

There is a wide variety and types of FET. Basically, There are two groups:

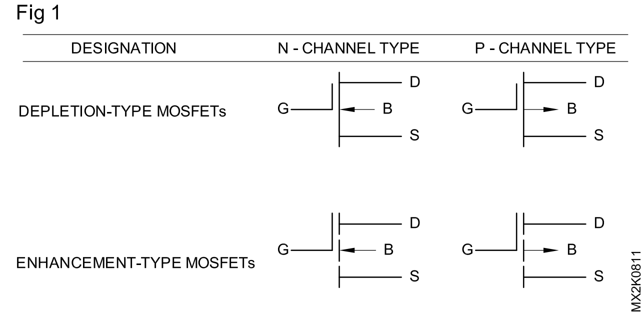
1 Junction FETs (discussed in previous lesson)

2 MOSFETs (MOS = Metal-Oxide-Semiconductor FET).

JFETs as already discussed are further subdivided into n-channel types and p-channel types. In the case of MOSFETs, on the other hand, we must differentiate between enhancement-type and depletion-type MOSFETs, for which again n-channel types and p-channel types occur. There are also a few special types.

The circuit symbols of MOSFET's are shown in Fig 1.

Fig 1



One characteristic property of all FETs is their high input resistance. In the case of JFETs it is around $10^9\,\Omega$, and in the case of MOSFETs roughly $10^{15}\Omega$.

In addition to the standard types of JFET and MOSFET, there are a few special types of further developments of MOSFETs. These are the dual-gate MOSFET, the VMOSFET and SIPMOSFET.

Dual-gate MOSFETs are used to construct amplifiers, whose amplification factors can be controlled within wide limits. VMOSFETs and SIPMOSFETs, on the other hand, were developed specially for amplifying and switching high powers of the order of 5KW. Their great advantage is the very low control power required.

Metal-Oxide-Semiconductor Field Effect Transistors (MOSFETs)

In MOSFETs, control is via an insulating layer instead of a junction (as in JFETS). This insulating layer is generally made of silicon dioxide, from which the very name MOSFET is derived (Metal Oxide Semiconductor). Sometimes the MOSFETs are also referred to as Insulated-gate FET, for which the abbreviation used are IFET or IGFET.

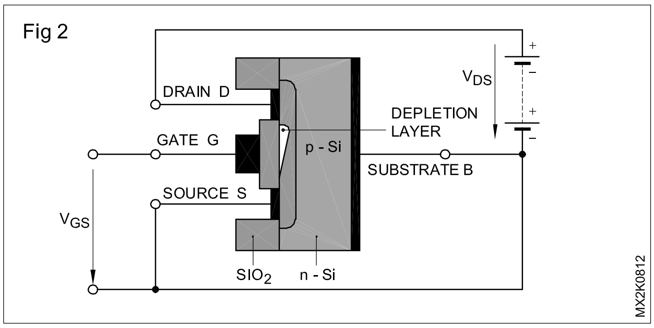
Depletion-type MOSFETs

Construction and mode of operation

Fig 2 shows the construction of a depletion MOSFET of the n-channel type.

Here, two highly doped n-zones are diffused into a p-doped silicon plate, which is referred to as the substrate, and are provided with junction-free drain and source connections. Between the two zones there is a thin n-doped channel, which produces an electrical connection between the

Fig 2



source and drain without an external field-action. This channel is covered by an insulting layer of silicon dioxide (SiO_2), to which a metal electrode is applied as the gate connection.

If a voltage U_{DS} is applied between source and drain, at U_{GS} = 0V an electron current flows from the source electrode via the n-channel to the drain electrode. If, however, a negative voltage is applied to control electrode G, the electrons present in the n-channel are forced out of the vicinity of the gate electrode, so that a zone depleted of charge carriers is produced there. This causes a constriction of the n-channel and consequently also a reduction of its conductivity. If the gate voltage becomes more negative, the conductivity of the channel is reduced, as is consequently also the drain current I_D. Another peculiarity of depletion-type MOSFETs is that they can also be controlled with a positive gate-voltage. Charge carriers are then drawn out of the p-doped substrate into the n-channel and its conductivity is increased even further, compared with the conductivity at U_{GS} = 0V.

Unijunction Transistor (UJT) its applications

Objectives: At the end of this lesson you shall be able to
- **aware of the construction and working principle of UJT**
- **able to make a quick test of UJT**
- **able to list the important specification of UJT**
- **list and explain the application of UJTs.**

Unijunction transistor(UJT) is a three terminal semiconductor device as shown in fig 1a. In its appearance it looks like a transistor as shown in Fig 1b. As shown in Fig 1a, it consists of two layers (a P-layer and a N-layer) and therefore it has only one junction(hence its name, (unijunction).

The symbol of UJT and its electrical equivalent circuit is shown in Fig 1c and 1d.

UJT is a special semiconductor device because it exhibits negative resistance characteristics as shown in Fig 2. The details of the characteristics is discussed in subsequent paragraphs.

Fig 1

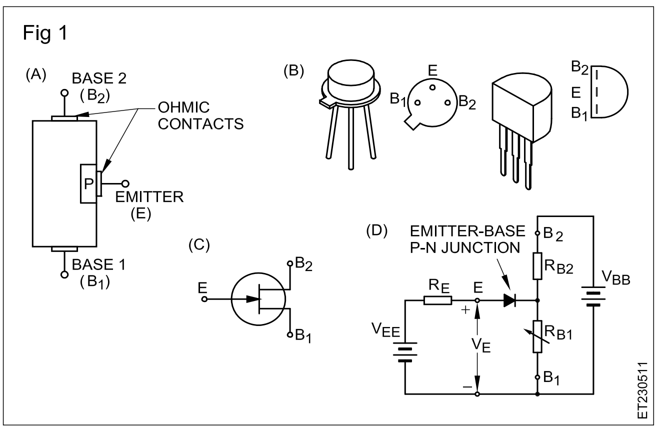
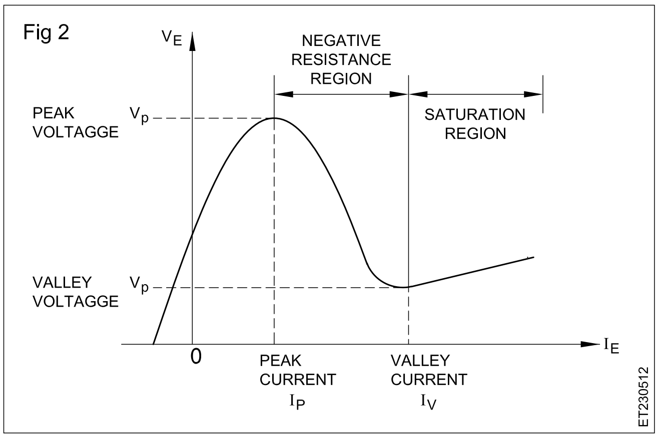


Fig 2



Quick test of UJT using OHM meter

From the construction of a UJT it can be seen that, Emitter and Base-1 with Base-2 open, behaves as a PN diode. Therefore, when tested using a ohm meter this should show low resistance when forward biased and high resistance when reverse biased.

Similarly, Emitter and Base-2 with Base-1 open behaves as a PN diode and hence the same forward and reverse bias test using a ohm meter can be carried out to confirm its good condition.

To carry out a quick test of a given UJT, check forward and reverse bias conditions of the two diodes of UJT as given in above two paragraphs.

Typical UJT Specifications

UJT specification as can be seen in any data manual is given below. 2N 2646 UJT is taken only as a sample for understanding the specifications. Specifications for other UJT will almost be in the same format. However, the manufacturers data sheets give more details than what is listed below;

Type	Device	I_P	I_V	R_{BBO}	Eta(h)	Package
2N 2646	UJT-P	5μA	4mA	15Kohms	0.60	see page X

Application of UJTs

UJTs are employed in a wide variety of circuits involving electronic switching and voltage or current sensing applications. These include,

– Triggers for thyristers

– As oscillators

– As pulse and Saw tooth generators

– Timing circuits

– Regulated Power supplies

– Bistable circuits and so..on.

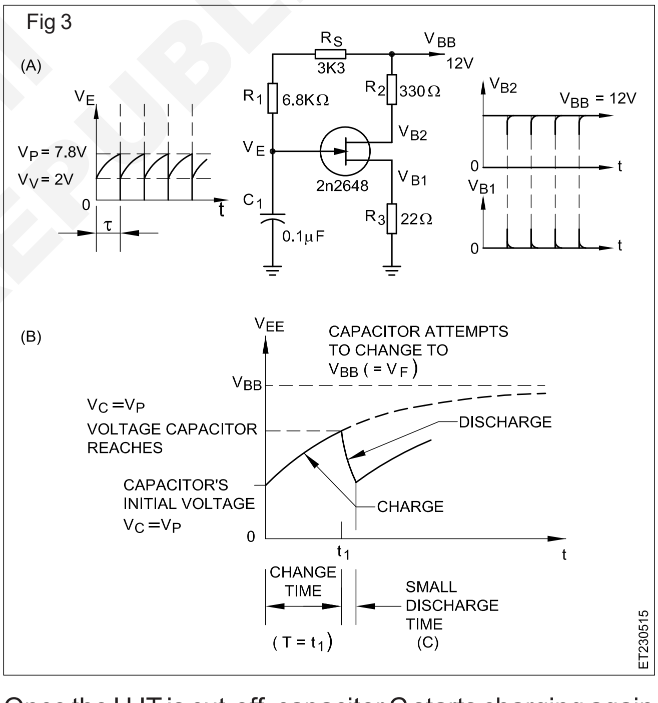
The most common and popular application of UJT is the Relaxation oscillator. Fig 5a shows a practical relaxation oscillator using 2N 2646 UJT.

As the voltage V_{BB} is supplied, capacitor C is charged via Resistors R_s and R_1. If the voltage V_C across the capacitor cross the peak point voltage(V_P) of UJT, the UJT goes into conduction.

The sooner UJT goes into conduction, the charged capacitor C discharges rapidly as shown in Fig 5b via the low inner base resistance RB1 and R_3. This conduction of UJT and the discharge of C through the emitter-Base1 of UJT results in a sudden rush of current through R_3 and hence the voltage across R_3 increases sharply as shown in Fig 3.

By discharging the voltage across it, the voltage across the capacitor becomes smaller than the valley point voltage V_V. Because of this, UJT cuts-off once again. Because the UJT is cut-off, there is no current through R_3 and hence the voltage across it (output voltage) becomes zero as shown in Fig 4.

Fig 3



Once the UJT is cut-off, capacitor C starts charging again through R_S and R_1. When the charged voltage again crosses the value of V_P, UJT turns-on again and the cycle repeats resulting in continuous pulse wave form at the output (across R_3).

The frequency of oscillation of the UJT oscillator depends on,

[1] Time constant tow(t) given by tow(t) = R_E x C

and [2] Value of intrinsic standoff ration eta(h) of the UJT.

The frequency of oscillation(f_o) of the UJT relaxation oscillator is given by the formula,

$$f_o = \frac{1}{T} \approx \frac{1}{R_E C_1 l_n \left[\frac{1}{(1-\eta)} \right]}$$

For a UJT to function properly in an oscillator, its DC load line must cross the negative resistance region of its emitter characteristics as shown in Fig 4.

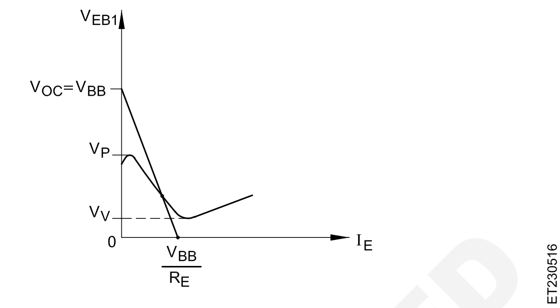
An important thumb rule while designing an relaxation oscillator using UJT is given below;

Minimum and Maximum values of R_E to ensure oscillations,

$$R_{E(max)} = \frac{V_{BB} - V_P}{I_P}$$

$$R_{E(min)} = \frac{V_{BB} - V_V}{I_V}$$

Fig 4



Working of SCR, TRIAC and DIAC

Objectives: At the end of this lesson you shall be able to
- **aware of construction and principle of working of SCR**
- **able to list the specifications and make a quick test of a given SCR**
- **different ways of triggering triac and quick testing of a TRIAC**
- **use of triac for full wave control of ac**
- **know the working and use of a DIAC**
- **know the method of quick testing a DIAC.**

INTRODUCTION TO INDUSTRIAL ELECTRONICS

Industrial electronics is concerned primarily with electronics as applied to industries such as industrial equipments, controls and processes. An important application of electronics in industries is in controlling of machinery.

In communication electronics, domestic & entertainment electronics, generally, the electronic devices operate with currents in the order of microamperes to milliamperes. For industrial applications, most frequently, devices are required to handle currents in the range of few ampers to several hundreds of ampers. This, therefore calls for high power electronic devices. One such high power electronic device frequently used in industrial electronic application is the SCR. SCRs can be used to run, dc motors from an ac power source, control power tool speed,also to control motor speeds of small appliances like, mixers and food blenders, illumination control, temperature control and so on.

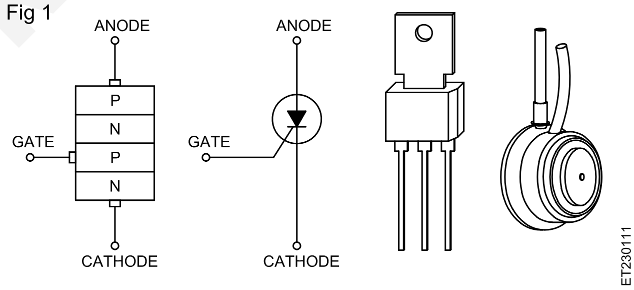
Silicon Controlled Rectifier(SCR)

Before Silicon controlled rectifiers were invented(1956), a glass tube device called Thyratron was used for high power applications. Silicon controlled rectifier (SCR) is the first device of the thyristor family. The term thyristor is coined from the expression Tyratron-transistor. SCR is a semiconductor device. SCR does the function of controlled rectification. Unlike a rectifier diode, SCR has an additional terminal called the gate which controls the rectification(gated silicon rectifier).

The basic principle application of SCRs is to control the amount of power delivered to a load(motor, lamp, etc.,).

A rectifier diode will have one PN junction. SCRs on the other hand will have two PN junctions (P-N-P-N layers) . Fig 1 shows the electrical symbol, basic construction and a typical SCR packages.

Fig 1



Basic operation of SCR

When a gate current is applied to the gate terminal, forward current conduction commences in the SCR(latched into conduction). When the gate current is removed, the forward current through the SCR **does not cut-off**. This means, once the SCR is latched into conduction, the gate loses control over the conduction. The current through the SCR can be turned off only by reducing the current through it(load current) below a critical value called the **Holding current**.

Fig 2 shows how an SCR can be gated into conduction or turned off.

In Fig 2a, with switched S1 open the SCR is in OFF state and no current is flowing through the load.

In Fig 2b, when S1 is closed, a small gate current(around 1/1000 or less compared to load current) turns-ON (fires) the SCR. A heavy load current starts flowing through the SCR and load R_L.

In Fig 2c, when S1 is opened, gate current becomes zero. This will have no effect on the current through the SCR and the heavy load current continues to flow through the SCR.

In Fig 2d, if a shorting wire is placed across the anode and the cathode terminals, the current though the SCR gets by-passed and all the current starts flowing through the shorted wire instead through the SCR. This means the current through the SCR is reduced below the rated holding current(minimum current required through SCR to keep it latched). This turns-OFF the SCR. Even when the shorting wire is removed the SCR remains to be in OFF state.

Fig 2e shows an alternative method of turning-OFF the SCR. In this instead of shorting the anode and cathode terminals of the SCR, the load current is cut-off by opening the Switch S2. This reduced the current through the SCR below the holding current and thus turns- OFF the SCR. Once the SCR is turned_OFF, the SCR does not turn-ON even if the switch S2 is closed. To make the SCR fire again, with the switch S2 closed, the gate current should be made to flow by closing the switch S1.

Since the SCR does not conduct in the reverse direction, the anode of the SCR should always be positive with respect to cathode for conduction.

Important features of SCR,

– A very small gate current will control the switching of a large load current.

QUICK Check of SCRs

Quick check on SCRs can be carried out using a ohmmeter/ multimeter. Since SCRs are made of PNPN junction, resistance between junctions can be measured to conclude good working condition of the SCR. A good SCR shows following resistances between its terminal leads;

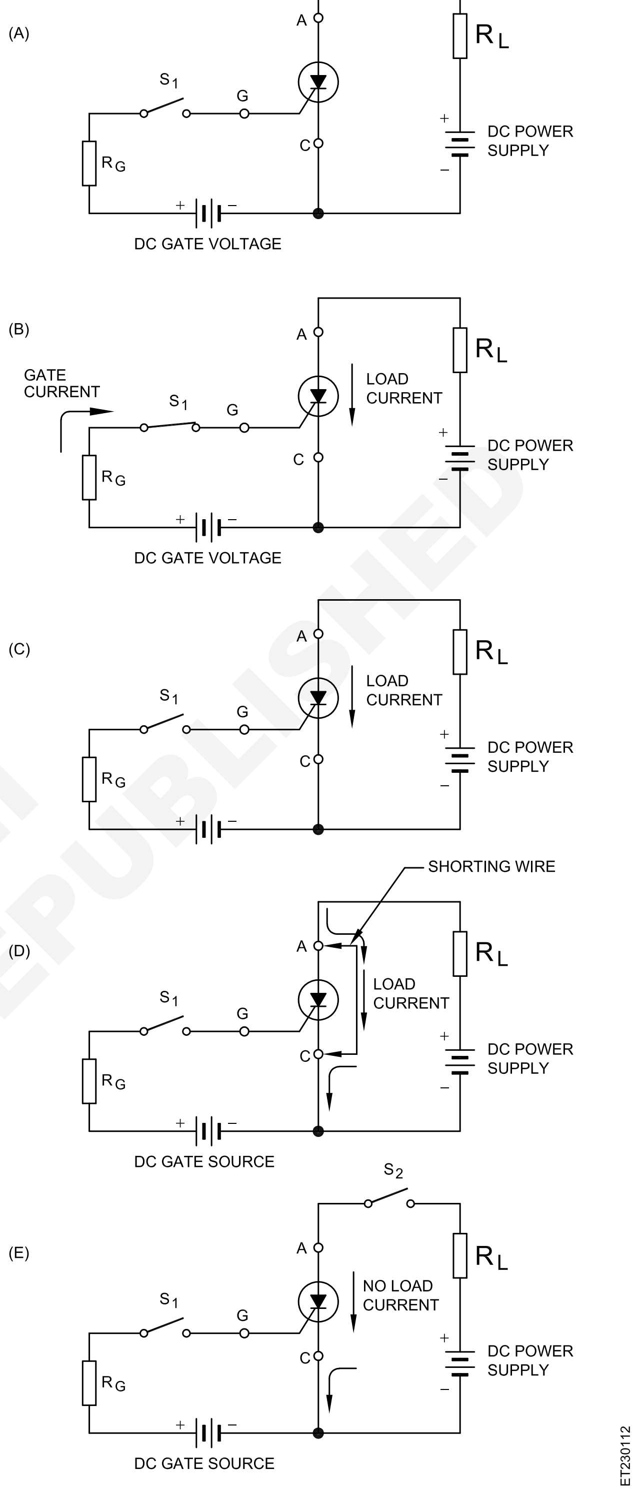
CHECK - 1

Between Anode - Cathode	- Infinite resistance
[Irrespective of polarity]	
Between Gate - Cathode	
(i) Forward biased	- Very low resistance (30 to 500 ohms)
(ii) Reverse biased	- High resistance
Between Gate - Anode	- Infinite resistance
[Irrespective of polarity]	

TRIAC

TRIAC is a three terminal gated semiconductor device for controlling a.c in either direction. The term TRIAC stands for TRIode AC semiconductor. TRIAC is very similar to that of two SCR connected in reverse parallel. A triac is able to conduct a large current in both directions, being trigged ON in one direction or the other by a gate pulse of the appropriate polarity.

Fig 2



Basic construction of a triac, its symbol and a typical Triac is shown in Fig 3a,3b and 3c.

As can be noticed in Fig 8, the electrodes of a triac are labeled as,

Main terminal-1(MT1)

Main terminal-2(MT2)

and Gate(G).

The terminals are so labeled because, this device operated in both directions and hence the terms anode and cathode does not apply.

Fig 3

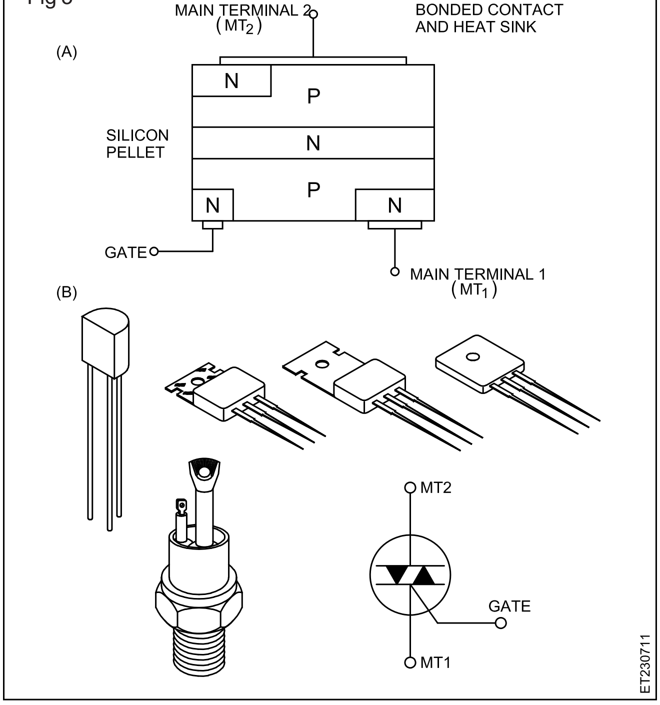
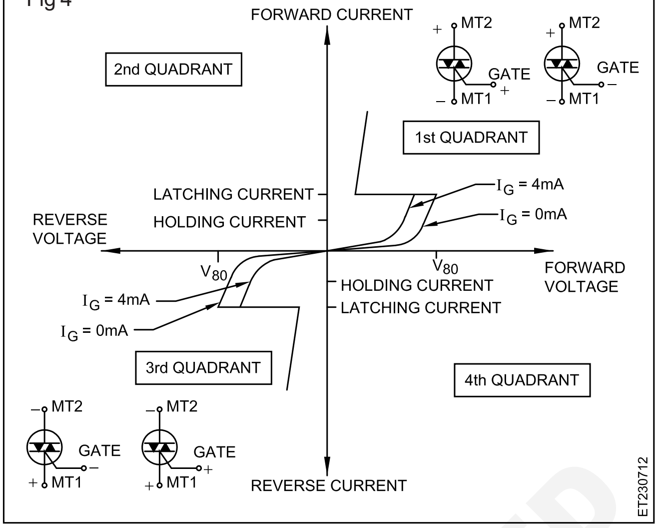


Fig 4



TRIAC triggering

Triac can be triggered/turned-ON by,

1 applying a gate current,

2 exceeding the avalanche breakdown voltage V_{BO}.

3 allowing the MT1 - MT2 applied voltage to increase at a rate in excess of the maximum dv/dt figure.

Methods 2 and 3 above are not employed in normal traic operation but they may be considered as limiting factors in circuit design. Hence all further discussion is restricted to triggering the triac via the gate. Since triac is a bi-directional device, it can be triggered into conduction by a negative or a positive gate signal. Triacs potentials are all considered with respect to main terminal-1(MT1). This gives the following possible *operating* situations or *modes*;

– MT2 +ve with respect to MT1 —Gate signal +ve (1st quadrant+)

– MT2 +ve with respect to MT1 —Gate signal -ve (1st quadrant-)

– MT2 -ve with respect to MT1 —Gate signal +ve (3rd quadrant+)

– MT2 -ve with respect to MT1 —Gate signal -ve (3rd quadrant-)

Unfortunately, triac is not equally sensitive in all the above said modes. It is least sensitive in 3rd quadrant mode(MT2 negative with respect ot MT1 and trigger by a +ve gate signal) so this mode is very rarely used in practice.

When a triac is ON the current flowing between MT1 and MT2 is known as **Principal current**.

The triac will remain ON as long as the current flowing through it is larger than the holding current as shown in the static characteristics of a triac in Fig 4.

From the triac static characteristics. When MT2 is positive with respect to MT1, the triac operates in the first quadrant of its static characteristics, if it is not triggered, the small forward current increases slowly with increase in voltage until the breakdown voltage V_{BO} is reached and then the current increases rapidly. The device can be, and usually is, turned 'ON' at a smaller forward current by injecting a suitable gate current and the characteristics shows the effect of increasing the gate current from zero to 4 mA. The gate current must be maintained until the main current is at least equal to the latching current.

When terminal MT1 is positive with respect to MT2 the triac operates in the third quadrant and the current flows in the opposite direction.

FULL WAVE control using a TRIAC

Fig 5a shows a triac used for controlling the current flowing in an a.c circuit. Fig 5b shows the wave forms with different settings of POT V_{R1}.

On observing the waveforms at Fig 5b, it can be seen that control is achieved by firing the triac at the same point in both the positive and negative half cycle.Once triggered the device remains ON until the supply is switched OFF.

Choosing a TRIAC

Like all other components, Triacs have maximum specified values of current and voltage that must not be exceeded. Important specifications of a traic with an example is given below;

TRIAC Type code	:	BT 136	TIC 201D
I_T (rms)	:	4 Amps.	2 Amps.

The maximum rms current that can continuously pass without damage occurring.

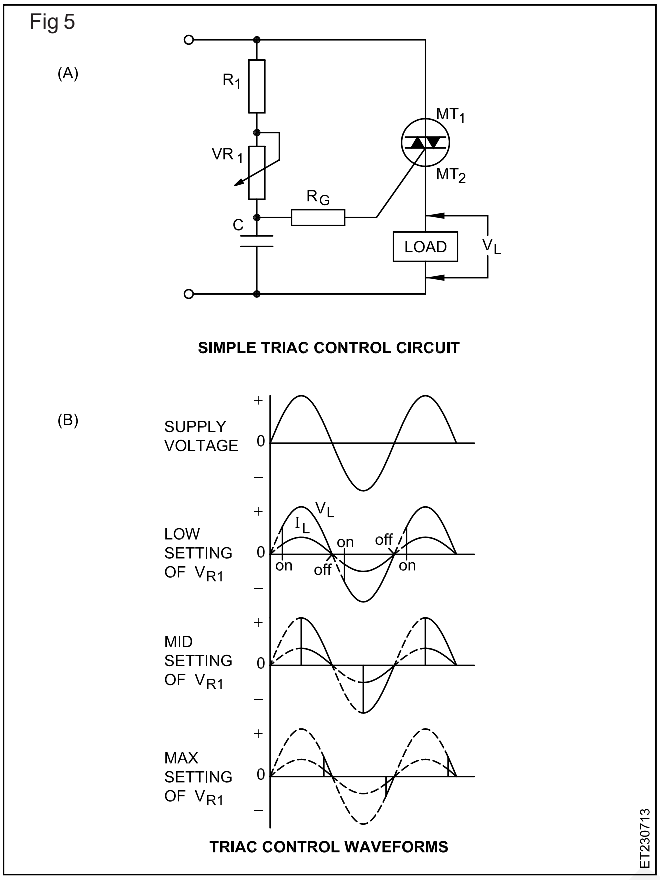
V_{GT}	:	1.5 Volts.	2.5 Volts.

The value of gate current required to achieve switch on.

V_{DRM}	:	400 Volts.	400 Volts.

The maximum permitted peak

voltage.



NOTE: In triacs the terms forward and reverse do not arise since it is bidirectional.

QUICK TESTING TRAICs

A quick test can be carried out on Traic using an ohmmeter. If the readings taken are comparable to the one shown in table below, the Triac can be considered as satisfactory and can be used in circuit;

Meter polarities +	-	Resistance
MT2	MT1	>1M
MT1	MT2	>1M
MT2	G	>1M
G	MT2	>1M
MT1	G	~300W
G	MT1	~300W

Testing Triac DC Characteristics

A simple test setup for basic triac characteristics is shown in Fig 1 of exercise 1.3.14. The purpose of this experiment is to investigate the switching characteristics and operation of a typical Triac with DC supply in different triggering modes.

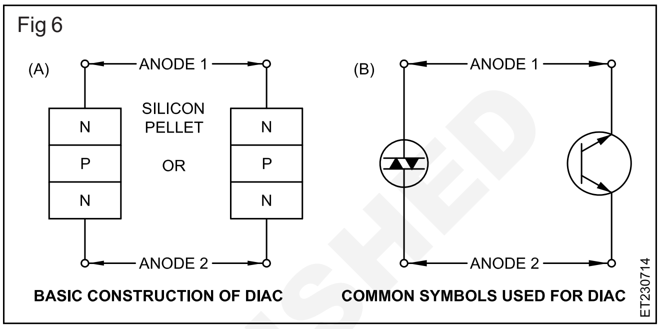
Refer Fig 2 of exercise 1.3.14 while discussing the test circuit in class room.

The LED's used in the test circuit are to indicate the direction of current flow. With the gate voltage polarity in one direction, upon increasing the gate trigger voltage, traic fires and conducts in one direction and one of the LED glow. With the gate voltage polarity reversed, upon increasing the gate trigger voltage, triac fires and conducts in other direction and the other LED glows. In the experiment at 1.3.14 the values of V_{GT} and I_{GT} for a given Triac can be found in different modes of operation.

THE DIAC

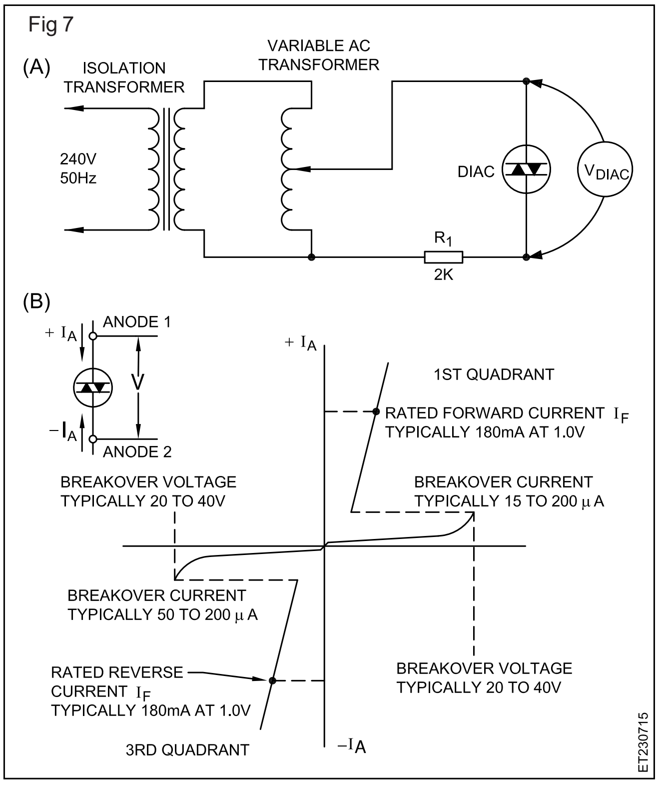
Like UJTs, DIAC is a semiconductor device used extensively as a trigger device for thyristors gate circuit. In its most elementary form, DIAC is a three layer device as shown in Fig 6.

As can be seen from Fig 6, DIAC is a three layer, two terminal semiconductor device capable of conducting current in both directions.



DIACs resembles an NPN or PNP bipolar transistor with no base connection. Unlike bipolar transistor, the diac possesses uniform construction. This means, N-type and P-type doping is essentially the same at both junctions. As shown in Fig 7, diac may be constructed as either an NPN or PNP structure.

Fig 7a shows the experimental set up for testing the diac. The isolation transformer is used to isolate the circuit from the supply mains. The variable transformer or variation is used to apply the variable voltage to diac under test. The characteristic curve a typical diac is shown in Fig 7b.



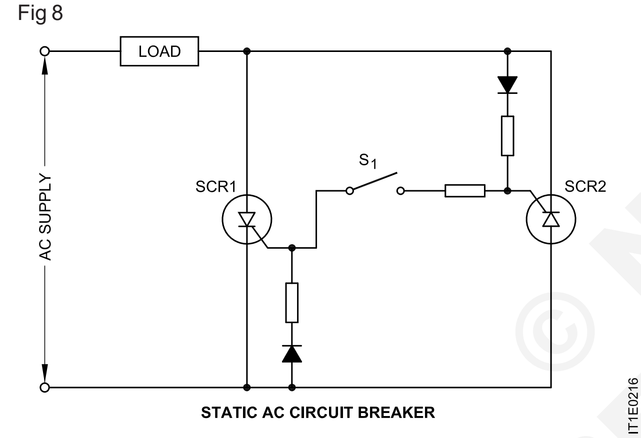
As shown in the experimental set-up at Fig 7a, when a small voltage of either polarity is applied across a DIAC, the current flows is very small as can be seen from its characteristics in the first and the third quadrants. If the applied voltage is steadily increased, the current will remain at a low value until the applied voltage reaches a value known as the Break over voltage of the DIAC as shown in Fig 12b. Once this point is reached the diac current increases rapidly and the diac voltage falls to a low value. At this point, the diac exhibits negative resistance characteristics (current conduction increases while the voltage across the device decreases). The diac will continue to conduct current as long as the current is greater than the Holding current of the device.

A diac acts in a similar manner to two diodes that are connected in reverse parallel and it therefore is able to rectify a.c voltage during both half cycles. The symbol used for DIAC is shown in Fig 7b.

Static circuit breaker using SCRs

Fig 8 shows a simple AC circuit breaker circuit. In this circuit SCRs are used for making and breaking the circuit.

Fig 8



STATIC AC CIRCUIT BREAKER

When the switch S1 is closed, SCR1 will fire at the beginning of the +ve half cycle. SCR1 will turn-off when the positive half cycle goes through value. As soon as SCR1 is turned off, SCR2 will fire since the input ac voltage polarity reversed.

To break the circuit, switch S1 is opened. Although the current through the load circuit may be heavy, the current through the gate circuit and switch is very small, therefore opening the gate circuit poses no problem. With the switch S open, no further gate signal will be applied to the SCRs and thus the SCRs will not be triggered and hence the load current will be zero.

The maximum time delay for breaking the circuit is one-half cycle.

The circuit shown in Fig 6 is one type of circuit breaker. There are several possible variations to it. Refer reference books listed at the end of this book for further reading.

Power control circuits

The bistable property(ON/OFF) of SCRs and the efficient gate control to trigger the SCR makes it ideally suited for many industrial applications. One such application is in the control of AC and DC power delivered to the load. Such power control is used in voltage control of DC power supplies, temperature regulators, light dimmers etc., Details of power control application circuits are discussed in further lessons as majority of these circuits use a few more components not so far discussed in previous lessons.

TIME DELAY CIRCUITS

Whenever power is to be applied or removed from a circuit at a pre determined time after initial signal applied in industrial circuits, time delay circuits are frequently used. SCRs in conjunction with a few other components can be used to provide the necessary time delays. Time delay circuits are discussed in detail in further lessons after introducing a few other components that go along with the circuit.

SOFT TURN-ON CIRCUITS

In many power control circuits, it is desirable to apply power gradually rather than suddenly. For example, in the lamps used with overhead projectors, the cold resistance of the lamp filament is low and there will be a very high current surge if full voltage is applied at once. This heavy surge current may damage the costly lamps used in overhead projectors. By using a soft start circuit, using SCR and using phase control, voltage is applied is applied gradually to the lamp protecting the lamp from getting damaged.

Choosing DIACs

Quick Testing DIACs

Since Diacs are similar to two diodes connected back to back and break down in either direction once the applied voltage reaches the breakdown voltage of the diode, while testing a diac using a ohmmeter, it should show high resistance (infinite resistance) when checked in either direction. This quick test only confirms that the DIAC is not shorted; however this quick test is worth carrying out before using the Diac in a circuit.

Series voltage regulators

Objectives: At the end of this lesson you shall be able to
- **design a simple series regulator for a required dc output voltage**
- **write the blocks of a series regulator with voltage feedback and explain their functions**
- **state the modification necessary to make the output of a voltage regulator variable**
- **state the method of increasing the load current capacity of series regulator.**

Power supply characteristics

A power supply is said to be good, if its output voltage changes by as small a value as possible when the load current changes or when the input voltage changes. These are specified in terms referred as,

- Load regulation
- Source regulation [also called line regulation.]

Load regulation

Load regulation is defined as the change in the regulated output voltage when the load current changes from the minimum to the maximum.

Load regulation = $V_{NL} - V_{FL}$

where, V_{NL} = output voltage at no-load

V_{FL} = output voltage at full-load.

For instance, in the regulated power supply designed above, it has 12V across its output when the load is not connected, and, 11.8 V when the rated full load is connected. The load regulation of this power supply is given by,

Load regulation $= V_{NL} - V_{FL}$

$= 12V - 11.8V = 0.2V$

Load regulation is generally expressed as a percentage. Percentage regulation is calculated as follows;

$$\% \text{ Load regulation} = \frac{V_{NL} - V_{FL}}{V_{NL}} \times 100\%$$

Percentage load regulation in the example connsidered above will be,

$$\% \text{ Load regulation} = \frac{12 - 11.8}{12} \times 100\% = 1.67\%$$

TIP: The lower the % load regulation value, the better is the quality of the power supply.

Line regulation

Line regulation is the change in the regulated load voltage for the specified range of input voltage or line voltage. Line voltage generally means the mains AC supply voltage.

For example, if the output voltage (also referred to as load voltage) changes from 12 V to 11.6 V when the line voltage changes from 240 to 200 V, then the line regulation of the power supply is,

Line regulation = 12 – 11.6V = 0.4V.

Line regulation is also generally in percentage as,

$$\% \text{ Line regulation} = \frac{\text{Line regulation}}{\text{Nominal load voltage}} \times 100$$

For the above example,

$$\% \text{ Line regulation} = \frac{0.4}{12} \times 100 = 3.33\%.$$

TIP: The lower the % line regulation the better is the quality of the regulated power supply.

Ripple rejection

Voltage regulators not only regulate or stabilize the output voltage against changes in the load current and input voltage but also reduce or attenuate the ripple that comes with the input voltage.

This is because of the fact that the ripple in the input is equivalent to a change in the input voltage, the voltage regulator reduces the effect of these changes at the output.

Ripple rejection (RR) is expressed as a ratio of the amount of ripple at the output and that at the input. RR is expressed usually in decibels. For example, if RR is specified as 80db, it means that the ripple at the output is 80 db or 10,000 times less than the ripple at the input.

With an intension to further reduce the ripple in the regulated output some series regulator circuits use a small value electrolytic capacitor at the output.

Summarising, the advantages of simple series regulators over zener regulators are,

1 reduced wattage requirement of zener diode

2 reduced output impedance

3 increased load and line regulation

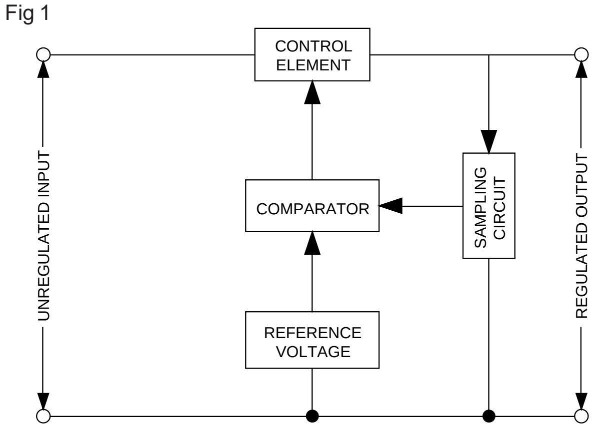
4 reduced ripple at the output.

SERIES REGULATOR

A simple series regulator, consisting of a zener diode and an emitter follower was discussed. That was an improvement over the zener regulator. It is possible to further improve the voltage regulation of the simple series regulator by providing a voltage feedback as shown in Fig 3. To understand this circuit better, consider the block diagram of series voltage regulator with feedback as shown in Fig.2.

In Fig 1, the control element generally a pass transistor, controls the amount of input voltage that gets to the output. The output voltage is sampled by the sampling circuit. The sampled voltage provides a feed-back voltage to the comparator. The other input to the comparator is the reference voltage, generally using a zener diode.

Fig 1



If the output voltage increases (or tends to increase), the sampling circuit provides a sample of the increase to the comparator. The comparator circuit provides a control voltage (based on the amount of increased output) to the series element to decrease the output voltage, thereby maintaining the output voltage constant.

On the other hand, if the output voltage decreases (or tends to decrease) due to higher load current, the comparator provides a control signal to the series element to increase the output voltage, thereby maintaining the output voltage constant.

From Fig 2, it can be seen that the negative feedback provided will hold the output voltage almost constant despite the relative large changes in the input voltage and load current.

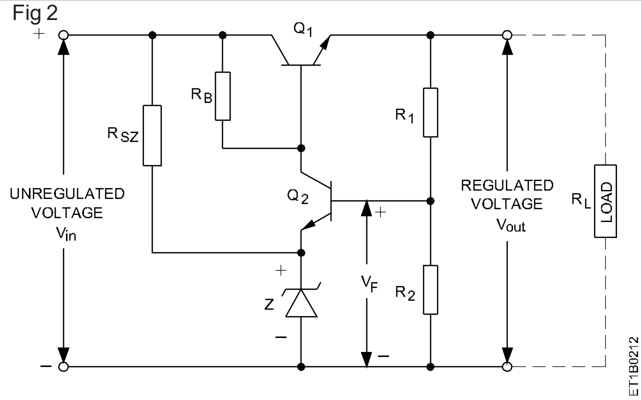
Practical transistor series regulator with feedback

Fig 2 shows a practical circuit schematic of a series regulator.

Transistor Q_1 is the pass transistor or the control element. As in a simple series regulator, the pass transistor Q_1 is connected as a emitter follower. Therefore, its base voltage is one V_{BE} (0.7V) higher than the output voltage V_{out} across the load.

Transistor Q_2 does the job of a comparator. This transistor Q_2, operates in the active region as a linear amplifier.

Fig 2



The zener diode Z, provides the necessary reference voltage. In critical applications, zeners having a temperature coefficient approaching zero are used.

TIP: Zener voltages near 6 V have temperature a coefficient approaching zero.

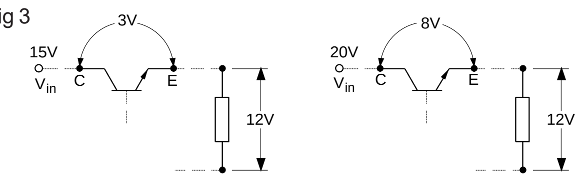
The voltage divider network, R_1 and R_2 form the *sampling circuit*. The voltage divider samples the output voltage V_{out} and provides a feedback voltage V_F to the base of Q_2.

The feedback voltage V_F varies the collector current of Q_2. For instance, if V_{out} tries to increase, more V_F is fed to the base of Q_2. This produces larger Q_2 collector current through R_B. Larger collector current of Q_2 results in increased voltage drop across R_B and reduced voltage at the collector of Q_2. Reduced collector voltage at Q_2 means, less base voltage at Q_1. The reduction in the base voltage of Q_1 results in reduced output voltage (recall Q_1 is an emitter follower).

Similarly, if the output voltage tries to decrease, there will be less feedback voltage V_F. Therefore, less base voltage at Q_2 resulting in less collector current of Q_2. This results in more base voltage at Q_1, and therefore, more output voltage across the load.

It is important to remember that the V_{CE} drop across the pass transistor Q_1 will be the difference between the input voltage V_{in} and the output voltage V_{out} as shown in Fig 3.

Fig 3



Simple design guidelines

Assuming an unregulated input of 34V to the regulator to the designed. Referring to Fig 3, the output voltage V_{out} is applied to the voltage divider formed by R_1 and R_2. The feedback fraction k is given by,

$$k = \frac{R_2}{R_1 + R_2} \quad ....[1]$$

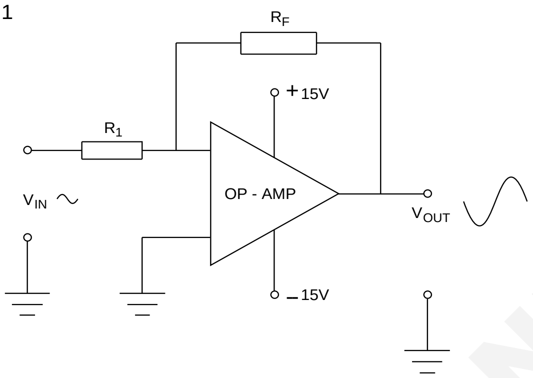
Fixed & variable regulators using 3 pin ICs

Objectives: At the end of this lesson you shall be able to
- **draw the circuit diagram of a dual power supply**
- **list a few variable regulator 3-pin ICs**
- **draw the circuit diagram of a variable output regulator using a LM317 IC**
- **draw the circuit diagram of a variable output regulator using a 723 IC**
- **state the functions of the external components in regulator circuits.**

Most electronic circuits generally need either a +ve DC supply or a -ve DC supply for its working. However, there are circuits which are designed to work using both + and - supplies. An example of circuits which require both +ve and -ve supply are the OP-AMPs. OP-AMPs are integrated circuit amplifiers which need, +ve supply, -ve supply and ground. A typical OP-AMP circuit is shown in Fig 1.

> **Details of OP-AMPs and its application is discussed in further lessons.**

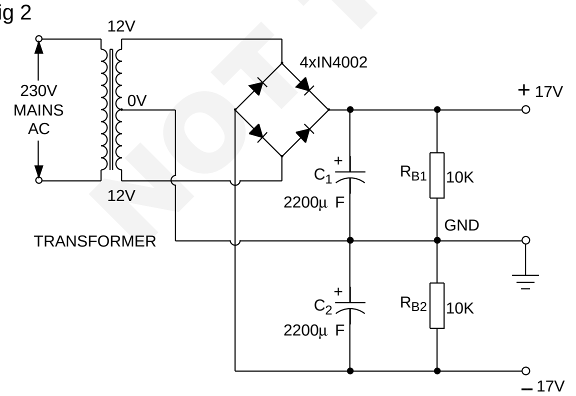
Fig 1



Therefore, for circuits which require both + and - DC supplies, a single power supply which can deliver both ± DC is required to be designed. Power supplies which can deliver both ± DC are generally referred to as *Dual Power Supply*.

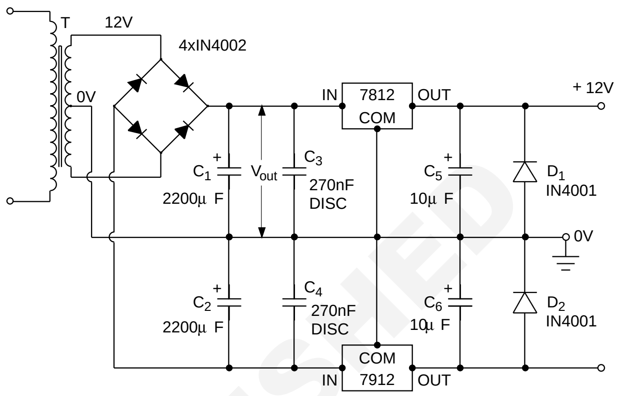
To design a ± or dual regulated power supply, as a first step it is required to design a ± unregulated DC supply. Fig 2 shows a simple method of obtaining ± unregulated DC supply.

Fig 2



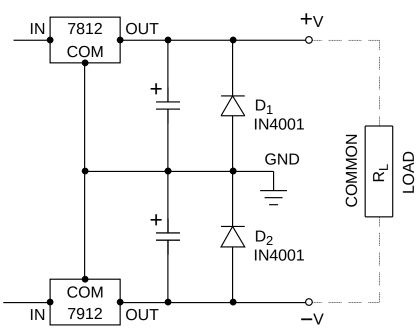
Once, a ± unregulated DC supply is available, one each of +ve regulator 3-terminal IC and a -ve regulator 3-terminal IC can be attached, to obtain a ± regulated DC supply. One such ± regulated DC supply using 7812 (+ve regulator) and 7912 (-ve regulator) is shown in Fig 3.

Fig 3



For +ve and -ve regulator circuits shown in Fig 3 used the diodes D_1 and D_2. The function of these diodes is very important. If these diodes are not used, the regulator ICs may get damaged due to *common load* problems. The term common load means, a load connected across the +ve and -ve outputs of the regulator as shown in Fig 4. Because of the fact that these common leads does not make use of the ground (GND) several problems occur when the supply is switch ON, in case of over loads and so on (For further details on common-load problems in dual supplies refer reference books listed at the end of this book). Hence to avoid the common load problem in dual power supplies diodes D_1 and D_2 are very essential.

Fig 4



Variable/adjustable output voltage regulators

A number of IC voltage regulators are available using which an adjustable output voltage of 1.2V to 32 volts can be obtained. Amongst these adjustable output voltage regulators, there are two types:

3-Terminal variable output voltage regulators ICs

Multi-terminal variable output voltage regulator ICs

3-Terminal variable output regulators ICs

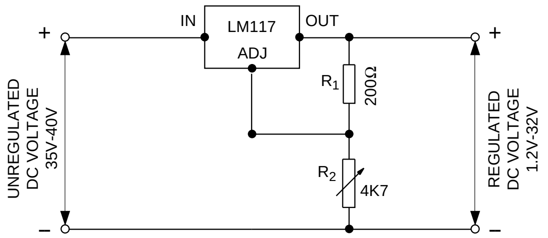
These ICs look like 3-terminal fixed output voltage regulators as shown in Fig 3. A few examples of 3-terminal adjusted output voltage regulator ICs are,

- LM117   Output adjustable from 1.2 V to 37 V
- LM317   Output adjustable from 1.2 V to 32 V
- LM338   Output adjustable from 1.2 V to 32 V
- LM350   Output adjustable from 1.2 V to 33 V

These variable output voltage regulator ICs are designed for adjustable output voltage, unlike the fixed output 3-pin regulators such as 7812, LM 340-5 etc which can be modified to get variable output voltage.

Fig 5 shows a basic variable output voltage regulator.

Fig 5

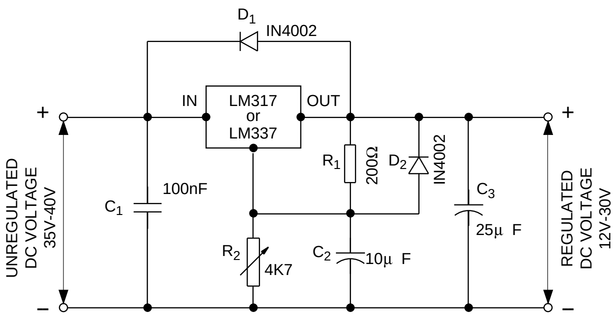


In the circuit at Fig 3, if the adjustment terminal (ADJ) is grounded, the output of the regulator will be 1.2 volts. To obtain a higher output voltage a small reference voltage is given at ADJ using a voltage divider circuit consisting of R_1 and R_2 as shown in Fig 5. With this the regulated output voltage is approximately given by

$$V_{out} = 1.2V \times \left(1 + \frac{R_2}{R_1}\right) \quad ....\{1\}$$

A practical version of the circuit at Fig 3 is shown in Fig 6. This circuit uses a few bypass capacitors and protection diodes.

Fig 6



In Fig 6, capacitor C_1 is used to prevent setting up of the oscillations and should be connected as close to IC as possible. Capacitor C_2 is used to improve the ripple in the output voltage. Note that the value of C_3 should not be very high (recall, surge current). Capacitor C_2 is used to avoid excess ringing.

When external capacitors are used with any IC regulator, it is necessary to add protection diodes to prevent the capacitors from discharging through low current points into the regulator. Hence, diodes D_1 and D_2 are used. D_1 protects the IC against shorts due to C_3 and D_2 protects against shorts due to C_2.

The ICs LM317 and 338 have built in fold back current limiting and thermal protection. These IC are available in both plastic and metal packages with current ratings from 0.1A (LM317L) to 5A(LM338K). For other details refer Appendix.

LM117, LM317 and LM338 are of the same family ICs, and hence, are interchangeable. For details refer the National Semiconductor application notes.

Working of inverters

Objectives : At the end of this lesson you shall be able to
- **define the detail study of inverter**
- **design inverter**
- **define application of inverter.**

An **inverter** is an electronic circuit that converts direct current (DC) to alternating current (AC). Inverters are used in a wide range of applications, from small switching power supplies in computers, to large electric utility applications that transport bulk power. The inverter is so named because it performs the opposite function of a rectifier.

Fig. 1

Inverter applications

The following are examples of inverter applications.

DC power source utilization

Inverter designed to provide 115 VAC from the 12 VDC source provided in an automobile

An inverter allows the 12 or 24 volt (battery) DC power available in an automobile or from solar panels to supply AC power to operate equipment that is normally supplied from a main power source.

Inverters are also used to provide a source of AC power from photovoltaic solar cells and fuel cell power supplies.

Uninterruptible power supplies

One type of uninterruptible power supply uses batteries to store power and an inverter to supply AC power from the batteries when main power is not available. When main power is restored, a rectifier is used to supply DC power to recharge the batteries.

Induction heating

Inverters convert low frequency main AC power to a higher frequency for use in induction heating. To do this, AC power is first rectified to provide DC power. The inverter then changes the DC power to high frequency AC power.

High-voltage direct current (HVDC) power transmission

With HVDC power transmission, AC power is rectified and high voltage DC power is transmitted to another location. At the receiving location, an inverter in a static inverter plant converts the power back to AC.

Variable-frequency drives

A variable-frequency drive controls the operating speed of an AC motor by controlling the frequency and voltage of the power supplied to the motor. An inverter provides the controlled power. In most cases, the variable-frequency drive includes a rectifier so that DC power for the inverter can be provided from main AC power. Since an inverter is the key component, variable-frequency drives are sometimes called inverter drives or just inverters.

Electric vehicle drives

Adjustable speed motor control inverters are currently used in some electric locomotives and diesel-electric locomotives as well as some battery electric vehicles and hybrid electric highway vehicles such as the Toyota Prius. Various improvements in inverter technology are being developed specifically for electric vehicle applications.

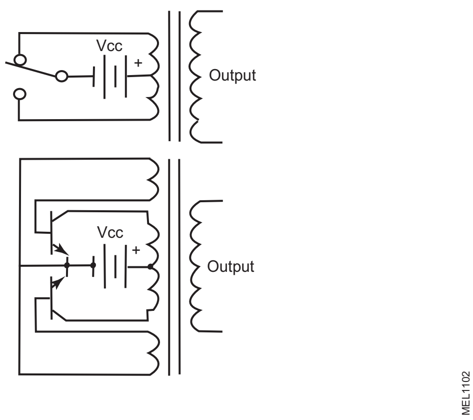
Inverter circuit description

Simple inverter circuit shown with an electromechanical switch and with a transistor switch is shown in Fig 2.

Basic inverter designs

In one simple inverter circuit, DC power is connected to a transformer through the centre tap of the primary winding. A switch is rapidly switched back and forth to allow current to flow back to the DC source following two alternate paths through one end of the primary winding and then the other. The alternation of the direction of current in the primary winding of the transformer produces alternating current (AC) in the secondary circuit.

Fig 2



The electromechanical version of the switching device includes two stationary contacts and a spring supported moving contact. The spring holds the movable contact against one of the stationary contacts and an electromagnet pulls the movable contact to the opposite stationary contact. The current in the electromagnet is interrupted by the action of the switch so that the switch continually switches rapidly back and forth. This type of electromechanical inverter switch, called a vibrator or buzzer, was once used in vacuum tube automobile radios. A similar mechanism has been used in door bells, buzzers and tattoo guns.

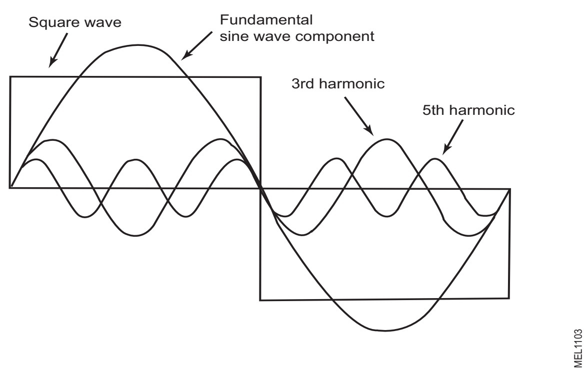
As they have become available, transistors and various other types of semiconductor switches have been incorporated into inverter circuit designs.

Square waveform with fundamental sine wave component, 3rd harmonic and 5th harmonic

Inverter output waveforms

The switch in the simple inverter described above produces a square voltage waveform as opposed to the sinusoidal waveform that is the usual waveform of an AC power supply. Using Fourier analysis, periodic waveforms are represented as the sum of an infinite series of sine waves. The sine wave that has the same frequency as the original waveform is called the fundamental component. The other sine waves, called harmonics, that are included in the series have frequencies that are integral multiples of the fundamental frequency.

Fig 3



The quality of the inverter output waveform can be expressed by using the Fourier analysis data to calculate the total harmonic distortion (THD). The total harmonic distortion is the square root of the sum of the squares of the harmonic voltages divided by the fundamental voltage:

$$\mathrm{THD} - \frac{\sqrt{V_2^2 + V_3^2 + V_4^2 + \ldots + V_n^2}}{V_1}$$

The quality of output waveform that is needed from an inverter depends on the characteristics of the connected load. Some loads need a nearly perfect sine wave voltage supply in order to work properly. Other loads may work quite well with a square wave voltage.

Introduction to UPS

Objectives : At the end of this lesson you shall be able to

- **state the purpose of an UPS**
- **state the types of UPS system**
- **list the advantages and disadvantages of an off-line UPS**
- **describe different front panel indications, rear panel sockets and switches**
- **state the type of protections used in UPS**
- **list the tips for testing the UPS**
- **define the types of change over in off-line system.**

UPS (Uninterrupted Power Supply) is the only solution available to an individual customer faced with the problem of ensuring high quality of power for critical loads. All UPS designs contain a battery charger to keep the battery fully charged by the power from mains. Small UPS normally comes with a sealed maintenance free (SMF) batteries which can provide 10 to 15 minutes of power backup, the backup time increases with the capacity of the battery. Tubular batteries or automotive batteries are used in medium and large capacity UPs.

UPS classification

There are two broad categories of UPS topologies - OFF line, and ON line. These topologies differ in the way they serve the load when the mains is present and is healthy. They vary in features & pricing.

Offline and online

Offline UPS filters the aims and feeds it directly to the load for most of the time. When the mains is unhealthy, perhaps due to a slight dip in voltage, the load is switched by a fast rely, in typically less than half a cycle, to an inverter deriving its power from a battery. The inverter generates a square or stepped waveform to emulate the mains-satisfactorily for most computers. This particular technique represents the lowest cost solution.

Online UPS converts AC mains into DC before inverting again to AC to power the load with a synthetic sine wave. A battery connected across the DC link acts as the backup power source.

This gives a supply for the computer that totally isolates the input mains from the load, removing all mains noise and with no break when the mains fail.

Standby/OFF line block diagram

In the off line UPS, the load is connected directly to the mains when the mains supply is available. when outage/ over voltage/under voltage conditions are detected on the mains, the off line UPS transfers the load to the inverter. When the line is present, the batter charger charges the battery and the inverter may either be shut down or will be idling. Thus an off line UPS transfers the load to the inverter. When the line is present, the battery charger charges the battery and the inverter may either be shut down or will be idling. Thus in an off line UPS, there is a load transfer involved every time, the mains are interrupted and restored. This transfer is effected by changeover relays or static transfer switches. in any case there will be a brief period during which the load is not provided with voltage. if the load is a computer and the transfer time is more than 5ms, then there is a chance that the computer will reboot. So modified designs incorporate a limited range of voltage regulation by transformer tapping and a certain degree of transient protection by using RF filters and MOV's(Metal Oxide Varistor). Offline UPS is an economical and simple design and hence it is preferred for small rating, low cost units aimed at individual PC user's market. When the load is really a critical one an off line UPS is not acceptable. Usually square wave output off line UPS are available in market with lower loading capacities.

Advantage of OFF ine UPS : high effficncy, small size, low cost.

Disadvantages: There can be change over complaint in offline UPS. Offline very much depends on battery. If battery fails entire system fails. Sometimes during changeover computer re-boots which causes loss of files. Another disadvantage is that output voltage will be a varying one. usually in the range of 200V-240V and hence not suitable to all gadgets.

Different front panel indications and rear panel sockets/ switches that are used in UPS

All UPS systems have

- Fuse/Fuse holder
- Switches
- Sockets
- Panel indicator (LED and Neon lamp)
- Meters (Volt/ampere)

Fig 1

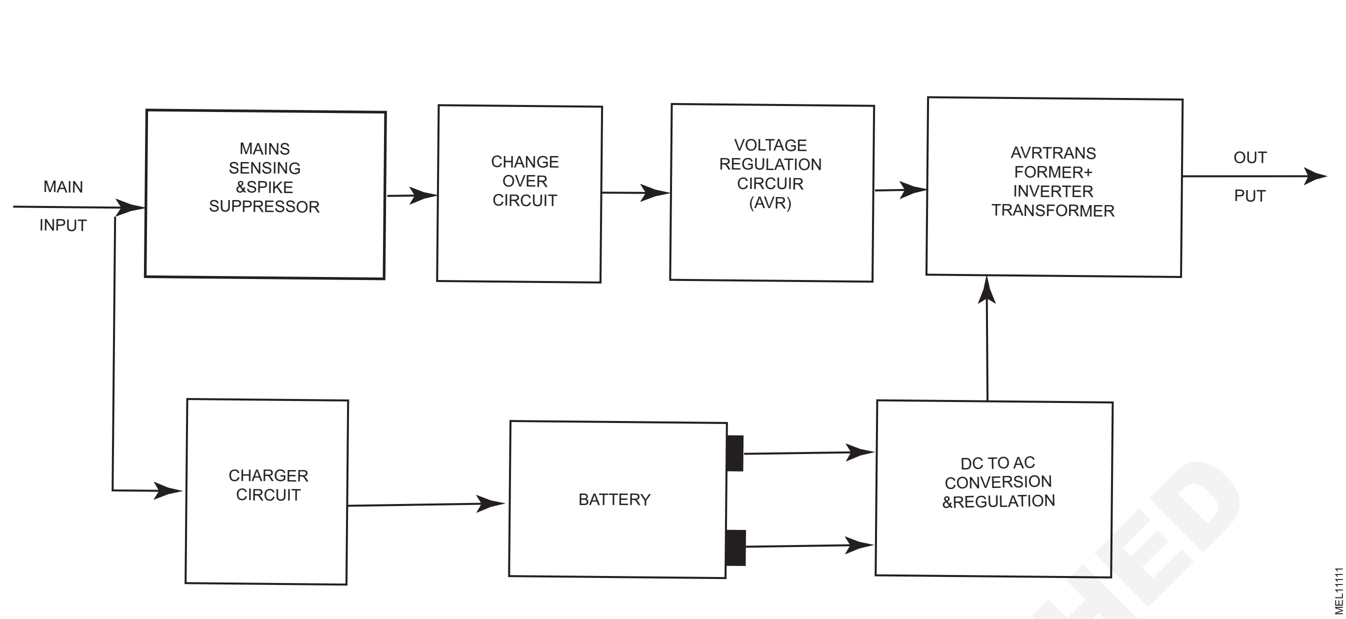
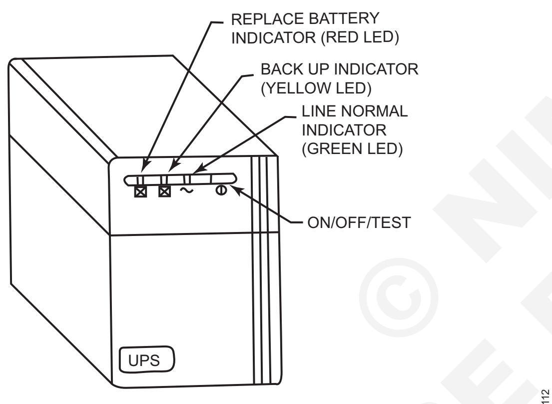


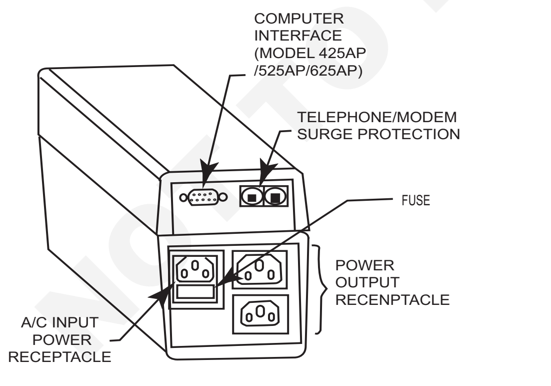
Fig 2&3 shows the front and rear panel controls/sockets

Fig 2



UPS FRONT PANEL

Fig 3



UPS REAR PANEL

Switches: On/Off switch and reset switch are commonly used in UPS. Reset switch is used to cut off an overload circuit and restart the supply. This is a push to off switch. in normal position this switch keeps the circuit on and when pushed, it cuts off the circuit.

Socket : A common 5 Amp. or 15 Amps . three pin power output socket is used in UPS to provide UPS output to the various devices. One can connect an ordinary 5/15 amp. plug to the UPS output.

Different LED indications/buzzers that are used in UPS

Main ON indication: It indicates mains input is present and UPS is working on mains.

Mains Low indication: It indicates mains input is low and is below a rated value.

Mains high indication: It indicates mains input is high.

Inverter ON indication: It indicates that UPS is working in the battery mode and mains is absent.

To get the output from UPS switch ON the 'Inverter ON' switch

UPS Trip indication: It indicates that UPS output is Off or tripped

Overload indication: Which indicates that the load current is above a pre-determined value.

Overload buzzer: It keeps whenever overload occurs.

Low battery warning: It indicates battery voltage is below a pre-determined value along the buzzer.

Battery charging indication : It indicates that battery is charging properly.

Output voltage low indication : It indicates that output voltage is below a pre-determined value.

General specifications & UPS protections

UPS are available from 500VA to 20 KVA or above. VA is volt ampere.

Power factor specification will be different for different manufactures. Suppose for 1 KVA UPS with a power factor 0.6 the load will be 1000 * 0.6 = 600 watts.

Normally a single PC takes around 180 watts. There are sine wave, square wave and quasi square wave output UPS. Usually sinewave output UPS is better than square wave output UPS.

General specifications

Output capacity = Output capacity will be in volt amperes (VA)

Input voltage = 230V AC + or - 20% , 50 Hz single phase sine wave

Output voltage = 230 V AC + or - 10% , 50 Hz quare wave or sine wave

Battery = 7 AH, 12V Sealed Maintenance free(SMF) for OFF- Line (depends on the capacity of the UPS)

Tubular batteries from 40 AH to 160 AH(12V to 120V) for On-Line (depends on the capacity of the UPS)

Availability of Automatic Voltage Regulation (AVR) feature.

Typical recharge time to charge 90% of the full capacity of the battery is 5 hours.

Different types of protection in UPS

IInput fuse on mains: It protects the system from high voltage inputs, line disturbances and short circuiting etc.

MOV (Metal Oxide varistor) protection: MOV conducts when high input voltage appears thereby blowing the fuse.

Polyester capacitor for lightening protection: This is connected across the transformer winding. It burns when lightening occurs and protects the transformer.

Fuses to protect the MOSFETS: MOSFETS are highly sensitive to rapid changing currents. these fuses are used to protect the MOSFET.

Charger fuse to protect the charger circuit: If any fault in charger circuit occurs, use blows to protect SCRs.

Output high voltage protection MOV: This MOV is connected across output sockets phase and neutral. If feedback circuit fails, the output voltage will jump to more than 300 volts. In such situation the MOV coducts to protect the load.

Overload protection: It protects the UPS especially MOSFET /IGBT when output current exceeds a preset value (overloading the UPS) . when this occurs, UPS output becomes OFF along with an indication.

Battery over charge/Discharge protection: It protects the battery from charging to a high value (SMF batteries will charge upto 15.8V) and tubular batteries upto 14.1V. It also protects the battery from getting discharged below a level(low battery protection). If the battery voltage is discharged below 10.5 V, then the UPS gets automatically switched OFF.

General tips for testing a UPS

Connect the battery to the terminals using a fuse wire. If any fault occurs in testing the fuse will blow to protect the UPS

Do the testings on no load condition.

Check the gate voltages of the two MOSFET banks it should be the same. If PWM gate pulses are not present gate voltage will be around 5.6V . If the PWM gate pulses are present then the gate voltage will be around 2 - 2.5 volts

Some frequency meters are designed to measure pure AC frequency only. If the UPS output is square wave, then the reading will not be correct. To measure the correct frequency, connect a 60/100W load at the output of the UPS. Then the frequency meter shows a near correct frequency

For overload setting in On-line UPs, the load current is calculated by dividing the maximum load with the output voltage. This can also be measured using a clam pp meter on the output terminal. Overload is set at this value of load current

While using extension boxes either in the input or on the output of an UPS, ensure proper earth connection. Improper earthling may lead to poor line filtering and shock hazards.

If number of MOSFETs are connected in parallel, care should be taken to see that all the MOSFETs are of the same Rds. for MOSFET Rds value (dran to source resistance) and current rating are important.

Changeover in OFF-Line UPS system

The circuit diagram shows the output of OPTO coupler is given to a NAND gate IC, it controls the transistor BC548. This transistor controls the over transistor which controls the relay coil supply. Usually mains input is connected to the relay's common point. Output connection is taken from the normally open contact. When really gets supply voltage across its coil, common comes in contact with NO contact. Normally closed contact is always left alone (There is no connection on this point). From normally open point the input to the ACR card is made.

In this type of relay control the battery voltage is used for relay coils. If the battery voltage is too low, then relay coil will not get sufficient supply to trigger the switch. This may lead to the absence of mains voltage, even if mains is present and his healthy. This type of OFF-Line systems is battery dependent.

Some OFF-Line systems are battery independent. The coil supply is provided by the mains itself. Mains supply is reduced and rectified. This rectified supply is given to the changeover relay coil. Battery low voltage does not affect the really coil supply. This type of OFF-line UPS provides mains output irrespective of the battery condition.

Number systems and conversions

Objectives: At the end of this lesson you shall be able to
- **differentiate between different number systems like decimal, octal, binary and hexadecimal and conversion between them and different types of codes**
- **explain NOT gate using transistor.**

INTRODUCTION

When we hear the word 'number' immediately we recall the decimal digits 0,1,2....9 and their combinations. Modern computers do not process decimal numbers. Instead, they work with binary numbers which use the digits '0' and '1' only. The binary number system and digital codes are fundamental to digital electronics. But people do not like working with binary numbers because they are very long when representing larger decimal quantities. Therefore, digital codes like octal, hexadecimal and binary coded decimal are widely used to compress long strings of binary numbers.

Binary number systems consist of 1s and 0s. Hence this number system is well suited for adopting it to the digital electronics.

The decimal number system is the most commonly used number system in the world. It uses 10 different characters to show the values of numbers. Because this number system uses 10 different characters it is called base-10 system. The base of a number system tells you how many different characters are used. The mathematical term for the base of a number system is radix.

The 10 characters used in the decimal number systems are 0,1,2,3,4,5,6,7,8,9.

Positional notation and weightage

A decimal integer value can be expressed in units, tens, hundreds, thousands and so on. For example, decimal number 1967 can be written as 1967 = 1000 + 900 + 60 + 7. In powers of 10, this becomes

10^3	10^2	10^1	10^0
1	9	6	7

$1 \times 10^3 = 1000$
$9 \times 10^2 = 900$
$6 \times 10^1 = 60$
$7 \times 10^0 = 7$
1967

i.e. $[1967]_{10} = 1(10^3) + 9(10^2) + 6(10^1) + 7(10^0)$

This decimal number system is an example of positional notation. Each digit position has a weightage. The positional weightage for each digit varies in the sequence 10^0, 10^1, 10^2, 10^3 etc starting from the least significant digit.

The sum of the digits multiplied by their weightage gives the total amount being represented as shown above.

In a similar way, binary number can be written in terms of weightage.

To get the decimal equivalent, then the positional weightage should be written as follows.

$[1010]_2 = 1(2^3) + 0(2^2) + 1(2^1) + 0(2^0)$

$= 8 + 0 + 2 + 0$

$[1010]_2 = [10]_{10}$

Any binary number can be converted into decimal number by the above said positional weightage method.

Decimal to Binary conversion

Divide the given decimal number by 2 as shown below and note down the remainder till you get the quotient - zero.

Example

	OT
2	34
2	17 - 0 → LSB
2	8 - 1
2	4 - 0
2	2 - 0
	1 - 0
	↑ MSB

The remainder generated by each division form the binary number. The first remainder becomes the LSB and the last remainder becomes the MSB of binary number.

Therefore, $[34]_{10} = [100010]_2$

Table below shows all the binary numbers from 0000 to 1111 equivalent to decimal 0 to 15.

Decimal	Binary
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
10	1010
11	1011
12	1100
13	1101
14	1110
15	1111

Addition of binary numbers

	Sum	Carry
	0 + 0 = 0	0
	1 + 0 = 1	0
	0 + 1 = 1	0
	1 + 1 = 0	1 (one plus one is equal to zero with carry one)

Ex: 1

```
  1 0
+ 1 1
------
 1 0 1
------
```

Ex: 2

```
1 +1+1 =   1
         + 1
          10
           1
          11
```

(one plus one plus one is equal to one with carry one)

Hexadecimal number system: In hexadecimal system there are 16 characters. They are 0,1,2,3,4,5,6,7,8,9, A,B,C,D,E,F where A=10, B=11, C=12, D=13, E=14, F=15 in decimal. In this system, the base is 16. This system is mainly used to develop programmes for computers.

For Example

$[23]_{16} = [35]_{10}$; $16^1 \text{ X } 2 + 16^0 \text{ X } 3 = 32 + 3 = 35$;

$[2C]_{16} = [44]_{10}$; $16^1 \times 2 + 16^0 \times 12 = 32 + 12 = 44$;

Decimal to hexadecimal conversions

The conversion of decimal to hexadecimal is similar to binary conversion. Only difference is that divide the decimal number successively by 16, and note down the remainder.

```
        0
16 |    1     1   ⟶ MSB
16 |   27    11 or B
16 |  432     0   ⟶ LSB
```

$[432]_{10} = [1B0]_{16}$

Hexadecimal to Decimal

This conversion can be done by putting it into the positional notation.

Ex: $223A_{16} = 2 \times 16^3 + 2 \times 16^2 + 3 \times 16^1 + A \times 16^0$

$= 2 \times 4096 + 2 \times 256 + 3 \times 16 + 10 \times 1$

$= 8192 + 512 + 48 + 10$

$= 8762_{10}$

OCTAL NUMBER

The octal number system provides a convenient way to express binary numbers. It is used less frequently compared to hexadecimal in conjunction with computers and microprocessors to express binary quantities for input and output purposes.

The octal number system is compared of digit symbols such as right symbols such as 0,1,2,3,4,5,6,7.

Since there are 8-symbols, radix or base is 8. Positional weightage is ....8^3, 8^2, 8^1, 8^0.

To distinguish octal numbers from other number systems subscript 8 is used as follows:

Ex: $(15)_8$ ˜ $(13)_{10}$

Octal Decimal

Octal to Decimal conversion

```
       0
8 |    1     1   ⟶ ग्चए
8 |   13     5   ⟶ ख्चए
```

∴ $(13)_{10} = (15)_8$

As in other number systems, each digit should be multiplied by its positional weightage and added to get decimal equivalent.

Convert $(2374)_8$ into decimal number

Positional weightage : 8^3, 8^2, 8^1, 8^0

Octal number 2 3 7 4

$(2374)_8 = (2 \times 8^3)+(3 \times 8^2)+(7 \times 8^1)+(4 \times 8^0)$

$= (2 \times 512)+(3 \times 64)+(7 \times 8)+(4 \times 1)$

$= 1024 + 192 + 56 + 4$

$(2374)_8 = (1276)_{10}$

Decimal to octal conversion

A method of converting a decimal number to an octal number is the repeated division by 8, each successive division by 8 yields a remainder that becomes a digit in the equivalent octal number. The first remainder generated is the least significant digit (LSD).

$(359)_{10} = (547)_8$

	0		
8	5	5	⟶ MSB
8	44	4	
8	359	7	⟶ LSB

Octal to binary

Each octal digit can be represented by a 3-bit binary number, because of this it is very easy to convert from octal to binary. Each octal digit is represented by three bits as shown in the table.

Octal digit	0	1	2	3	4	5	6	7
Binary	000	001	010	011	100	101	110	111

To convert each octal number to a binary, simply replace each octal digits with the corresponding binary bits.

Example

1 $(25)_8 = (\quad)_2$

2 5

010 101

$(25)_8 = (010101)_2$

2 $(7526)_8 = (\quad)_2$

7 5 2 6

111 101 010 110

$(7526)_8 = (111101010110)_2$

Binary to octal

Conversion of a binary number to an octal number is the reverse of the octal-to-binary conversion. The procedure is as follows.

1 Start with the right most group of three bits and moving from right to left, convert each 3-bit group to the equivalent octal digit.

2 If there are not three bits available for the left most group, add either one or two zero's to make complete group. These leading zero's will not affect the value of the binary number.

Example

$(110101)_2 = (\quad)_8$

110 101

6 5 $= (65)_8$

$(11010000100)_2 = (\quad)$

011 010 000 100 $= (3204)_8$

3 2 0 4

BCD (Binary Coded Decimal)

Binary Coded Decimal (BCD) is a way to express each of the decimal digits with a binary code, since there are only ten code groups in the BCD system, it is very easy to convert between decimal and BCD. Because decimal system is used for read and write, BCD code provides an excellent interface to binary systems. Examples of such interfaces are keypad inputs and digital readouts.

8421 code

The 8421 code is a type of binary coded decimal (BCD), binary coded decimal means that each decimal digit, 0 through 9 is represented by a binary code of four bits. The designation 8421 indicates the binary weights of the four bits (2^3, 2^2, 2^1, 2^0). The ease of conversion between 8421 code numbers and the familiar decimal numbers in the main advantage of this code. All you have to remember are the ten binary combinations that represents the ten decimal digits as shown in Table.

Decimal digit	0	1	2	3	4	5	6	7	8	9
BCD	0000	0001	0010	0011	0100	0101	0110	0111	1000	1001

The 8421 code is the pre-dominant BCD code, and when we refer to BCD, we always mean the 8421 code unless otherwise stated.

Inverters (NOT Gate)

An inverter is a gate with only one input signal and one output signal. The output state is always the opposite of the input state. Logic symbol is shown in Fig 1.

Transistor inverter

The above circuit shows the transistor inverter circuit. The circuit is a common emitter amplifier which works in saturation or in cut off region depending upon the input voltage. When V_{in} is in low level, say less than the transistor cut in voltage 0.6V in silicon type, the transistor goes to cut off condition and the collector current is zero. Therefore, V_{out} = +5V which is taken as high logic level. On the other hand, when V_{in} is in high level, the transistor saturates and $V_{out} = V_{sat}$ = 0.3V i.e low level.

Fig 1

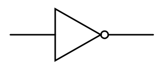
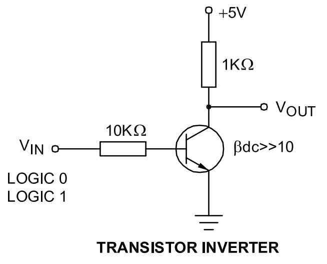


Fig 2



TRANSISTOR INVERTER

The table summarizes the operation

Vin	Vout
Low(0)	High(1)
High(1)	Low(0)

The logic expression for the inverter is as follows: If the input variable is 'A' and the output variable is called Y, then the output Y = A.

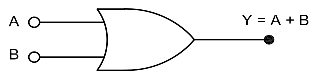
OR, NOR gate circuits and RS flip flop

Objectives: At the end of this lesson you shall be able to
- **explain OR gate using diode and its truth table**
- **explain T.T.L OR gate IC 7432**
- **explain NOR gate and its truth table.**

OR GATE

The output of an OR will be in 1 state if one or more of the inputs is in 1 state. Only when all the inputs are in 0-state, the output will go to 0-state. Fig 1 shows the schematic Symbol of an OR Gate :

Fig 1



The Boolean expression for OR gate is Y=A+B.

The equation is to be read as Y equals A OR B. Two-input truth table given below is equivalent to the definition of the OR operation.

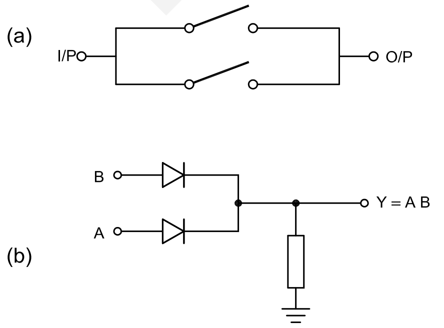
Truth table for OR gate

A	B	Y=A + B
0	0	0
1	0	1
0	1	1
1	1	1

Electrical equivalent circuit

The Fig 2a shows the electrical equivalent circuit of an OR gate. It is evident that if any one of the switch is closed, there will be output.

Fig 2



2 in-put OR gate using diode

The Fig 2b shows one way to build a 2-input OR gate, using diodes. The inputs are labeled as A and B, while the output is Y.

Assume logic 0 = 0V (low)

logic 1 = +5V (high)

Since this is a 2 input OR gate, there are only four possible cases,

Case 1: A is low and B is low. With both the input voltage low, both the diodes are not conducting. Therefore, the output Y is in low level.

Case 2: A is low and B is high, the high B input voltage (+5V) forward biases the lower diode, producing an output voltage that is ideally +5V (actually +4.3V taking the diode voltage drop 0.7V into consideration). That is, the output is in high level. During this condition, the diode connected to input A is under reverse bias or OFF condition.

Case 3: A is high and B is low, the condition is similar to case 2. Input A diode is ON and Input B diode is OFF and Y is in high level.

Case 4: A is high, B is high. With both the inputs at +5V, both diodes are forward biased, since the input voltages are in parallel, the output voltage is +5V ideally [+4.3V to a second approximation]. That is, the output Y-is in high level.

OR gates are available in the IC form. IC7432 is a T.T.L OR gate IC having 4 OR gates inside it. For pin diagram refer Appendix 'D'.

Simple application of OR gate

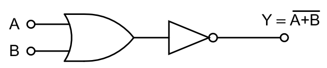
Intrusion detection

Simplified portion of an intrusion detection and alarm system is two windows and a door. The sensors are magnetic switches that produce a high (1) output when windows and doors are opened and a low (0) output when closed. As long as the windows and the door are secured, the switches are closed and all three of the OR gate inputs are in low (0). When one of the windows or the door is opened, a high (1) output is produced on that input of the OR gate and the gate output goes high. It then activities an alarm circuit to warn of the intrusion.

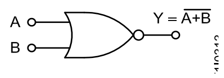
NOR Gate

In the Fig 3 the output y of the circuit equals the complement of A OR B, because the circuit is an OR gate followed by a NOT gate. To obtain high output [Logic-1], both the inputs should be tied to low input [Logic-0]. For the rest of the other three possibilities, output will be zero, the combination of this OR and NOT gate is called as NOR gate.

Fig 3



Symbol:



We can define a NOR gate as follows:

The output of a NOR gate is 0, even if one of the inputs is in logic-1. Only when both the inputs are in logic-0, the output is in logic-1.

Truth table

A	B	A+B
0	0	1
0	1	0
1	0	0
1	1	0

IC7402 is a T.T.L NOR gate IC. It contains 4 NOR gates. For pin details, refer data book.

AND, NAND and XOR gate circuits

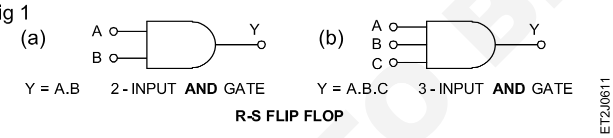
Objectives: At the end of this lesson you shall be able to
- **explain AND gate using diodes and its truth table**
- **explain NAND gate and its truth table**
- **explain AND gate application**
- **explain logic pulser using NAND gates.**

AND gates

The AND gate has two or more inputs but only one output. All input signals must be held high to get a high output. Even if one of the inputs is low, the output becomes low.

AND gate symbols for 2 input and 3 input gates are shown in Fig 1a and 1b.

Fig 1



Truth table

Two input AND gate

A	B	Y=AB
0	0	0
0	1	0
1	0	0
1	1	1

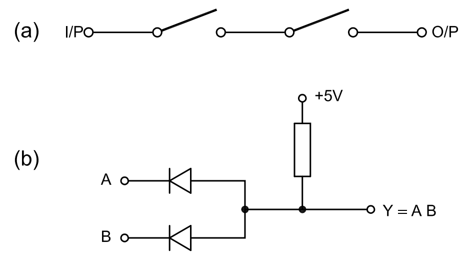
Three input AND GATE

A	B	C	Y=ABC
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	1

Electrical equivalent circuit of an AND gate

The output is available only when both the switches are closed. IC7408 is a T.T.L quad AND gate IC. (Refer data book for pin diagram). The electrical equivalent of AND gate and AND gate using diodes are shown in Fig 2a and 2b.

Fig 2

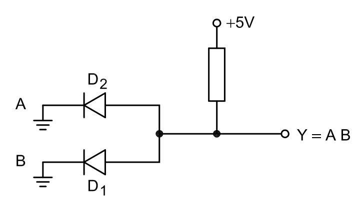


Two input AND gate using diode

I condition

A=0, B=0, Y=0 as shown in Fig 3.

Fig 3

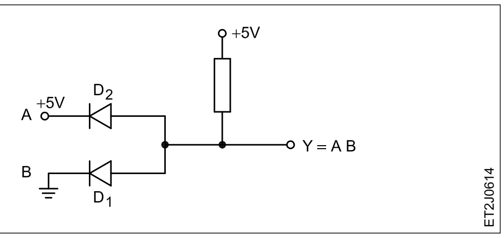


During the above condition I/P A and B are connected to ground to make logic low inputs. During this condition, both the diodes conduct, and pulls the O/P Y to logic-0.

II condition

A=0, B=1, Y=0 as shown in Fig 4.

Fig 4

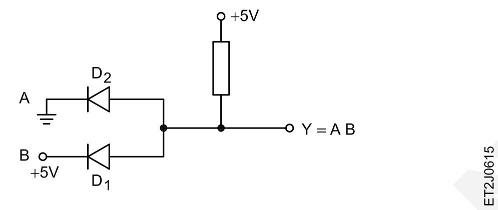


In the II condition shown in the figure above, diode D_1 is connected logic-0 input and diode D_2 is connected to +5V [Logic high]. Diode D_1 is in forward bias and conducts. Diode D_2 is having equal potential (+5V) at anode and cathode. So potential difference between anode and cathode is 0. Hence diode D2 does not conduct. The output Y is pulled down to logic zero, since D_1 is conducting.

III condition

A=1, B=0, Y=0 as shown in Fig 5.

Fig 5

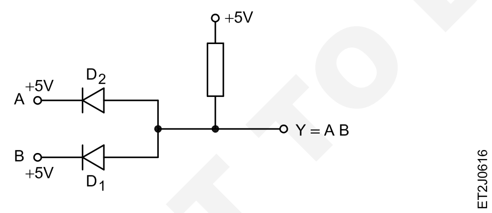


The III condition is similar to the II condition. D_2 is forward biased. D_1 is reverse biased. Hence output Y is pulled to logic-0.

IV condition

A=1, B=1, Y=1 as shown in Fig 6.

Fig 6



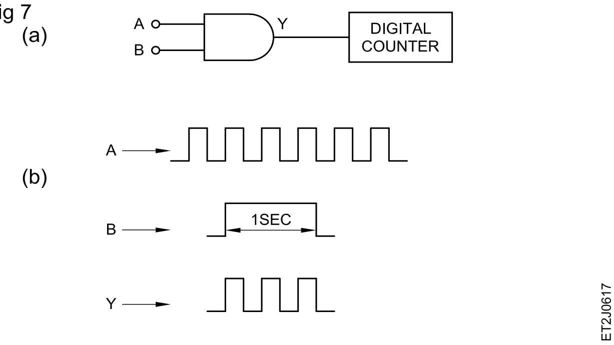
In this condition both the diodes are reverse biased. So both the diodes act as open circuit. Therefore, output y is +5V i.e y is in logic-1 condition.

AND gate as an Enable/Inhibit device

A common application of the AND gate is to enable (i.e to allow) the passage of a signal (pulse waveform) from one point to another at certain times and to inhibit (prevent) the passage at other times.

In Fig 7a AND gate controls the passage of a signal (waveform A) to a digital counter. The purpose of this circuit is to measure the frequency of waveform 'A'. The enable pulse has a width of precisely 1 second. When the enable pulse applied at B is high, waveform A passes through the gate to the counter, and when the enabled pulse is low, the signal is prevented (inhibited) from passing through. Refer Fig 7b for the waveforms of the above process.

Fig 7



During the 1 second interval of the enabled pulse, a certain number of pulses in waveform A pass through the AND gate to the counter. The number of pulses counted by the counter is equal to the frequency of the waveform A. For example, if 1000 pulses pass through the gate in the 1 second interval of the enabled pulse, there are 1000 pulses/sec. That is, frequency is 1000Hz.

NAND gate

An AND gate followed by a NOT gate forms the NAND gate as shown in Fig 8a. In this gate to get a low output (logic=0), all the inputs must be in high state and to get high output state, any one of the inputs or both inputs must be in low state.

Fig 8

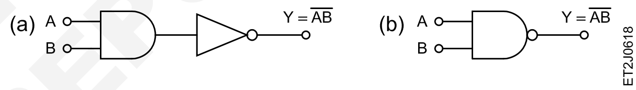


Fig 8b is the standard symbol for a NAND gate. The inverter triangle has been deleted and the bubble is moved to the AND-gate output.

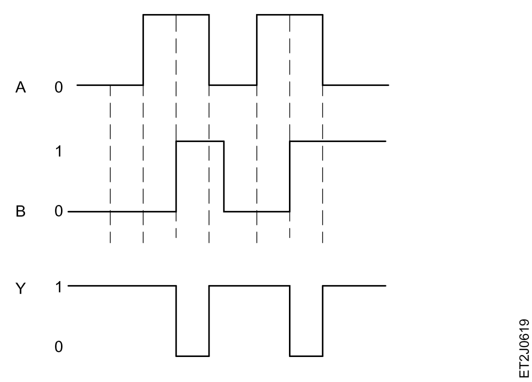
Truth table for NAND gate

A	B	$Y=\overline{AB}$
0	0	1
0	1	1
1	0	1
1	1	0

Pulsed operation

Output waveform Y is low only for the time intervals when both inputs A and B are high as shown in the timing diagram Fig 9.

Fig 9



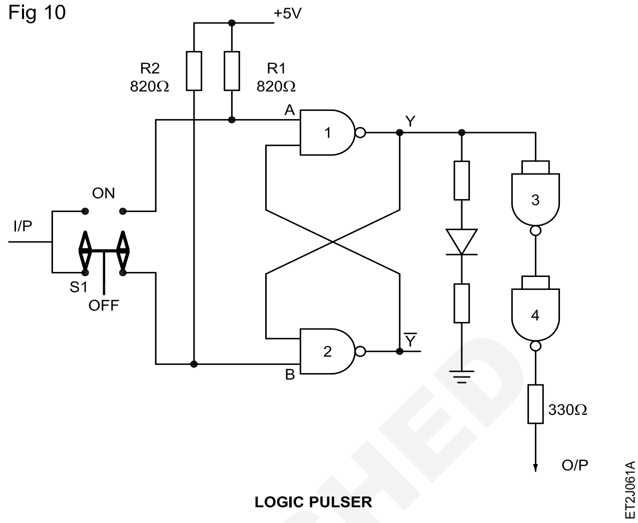
Logic pulser

The Fig 10 shows the circuit diagram of logic pulser, the circuit essentially consists of NAND gates connected dibouncer circuit and its output is Double inverted. The LED indicates, pulses ON or OFF status.

When switch S1 is not pressed, (OFF position) B input of NAND gate No.2 is grounded, hence its output $\overline{Y}$ is forced to go logic HIGH. This HIGH output is feedback to NAND gate 1, A input of NAND gate 1 is also held HIGH through R_1 resistor (820W) and thus the output of NAND gate-1 'Y' is at low. This logic low output keeps LED in OFF condition and this logic low is again double inverted at the logic pulser tip through NAND gate 3 and 4 to get logic low level at pulser tip.

When S1 is pressed to ON, A input of NAND gate is forced to go logic-low. Hence the output of this NAND gate is forced to go logic-HIGH. Therefore the 'Y' output is at logic-1, so LED glows and a logic-HIGH appears at probe tip. Also note that with HIGH at Y output, the inputs of NAND gate 2 are also at logic-HIGH and the output of NAND gate-2 is forced to go low. As long as switch S1 is at ON position the probe tip is HIGH. When it is released it springs back to OFF position, and the output returns to a logic-LOW condition.

Fig 10



LOGIC PULSER

R.S Flip-flops and D Flip-flop using NAND gate

Objectives: At the end of this lesson you shall be able to
- **logic diagram for the given Boolean equations**
- **simplify the logic diagram using Boolean algebra**
- **explain D flip-flop and its truth table**
- **clocked D flip-flop and its truth table**
- **explain the difference between edge triggering and level triggering and types of edge trigger**
- **explain wave shaping circuits used for clocking**
- **why do you need to know about karnaugh maps**
- **how karnaugh map is used for boolean equation.**

A flip-flop is a digital circuit that has two stable states. It remain in one of these states until triggered into the other.

Flip-flops are used to store binary information. Digital memory circuits that can store bits of data are an essential part of any computer system.

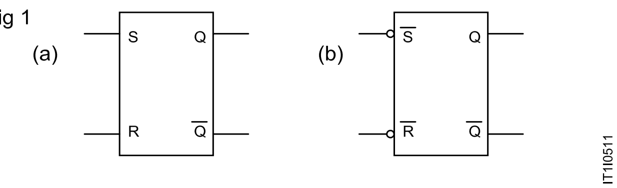
RS flip flops

The most basic type of flip flop is the reset/set type, hence it is known as RS flip flop.

The basic RS flip-flop can be constructed from either two NOR gates or two NAND gates. The circuit symbols is shown in Fig 1. Fig 1a shows RSF/F with active HIGH inputs.

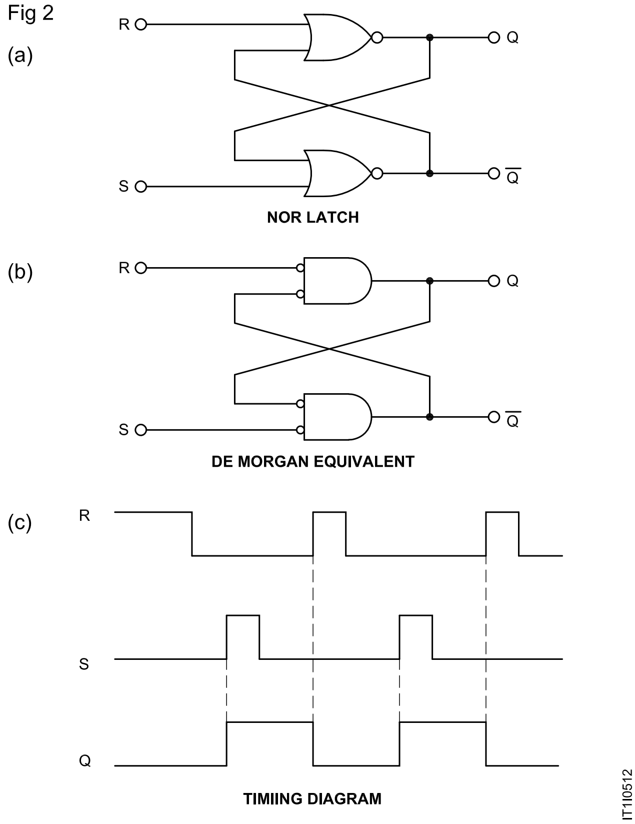
Fig 1b shows RSF/F with active LOW inputs. The NOR gate latch and NAND gate latch both are shown in Fig 2 and Fig 3 respectively.

Fig 1



NOR latch: From Fig 2, the two NOR gates are cross-coupled so that out of one NOR gate is connected to other NOR gate input and vice versa.

Fig 2



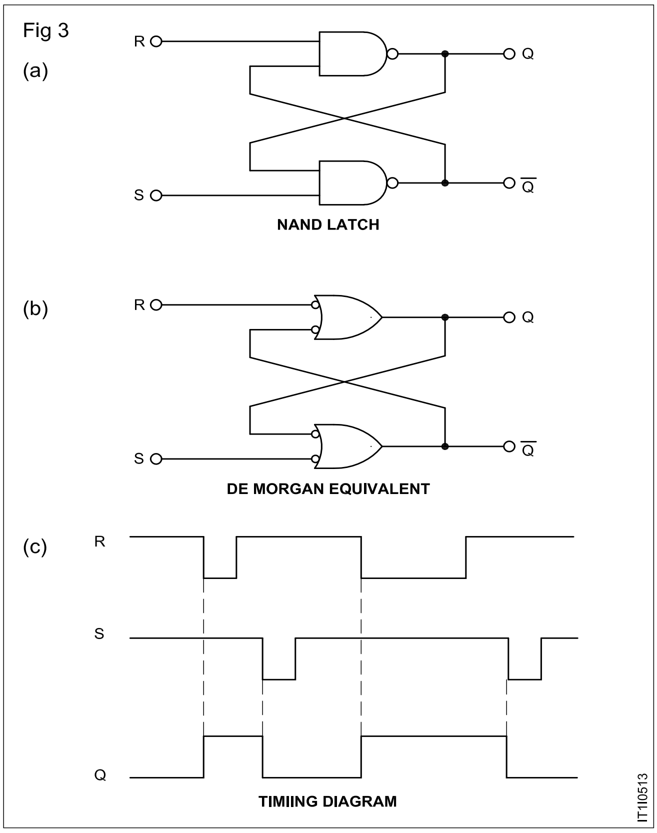


Fig 3

Truth table for NOR latch

R	S	Q	Comment
0	0	NC	No change
0	1	1	Set
1	0	0	Reset
1	1	*	Race

Truth table for NAND latch

R	S	Q	Comment
0	0	*	Race
0	1	1	Set
1	0	0	Reset
1	1	NC	No change

The NOR latch output are labelled as Q and $\overline{Q}$. The outputs will always be the inverse of each other. From the truth table of NOR latch, it can be summarised as follows.

Condition 1

R=0 S=0, this condition produce the inactive state. Output `Q' will remain with no change.

Condition 2

R=0 S=1, this condition cause to go to the Q=1 state where it always remain after R returns high. This is known as setting the latch.

Condition 3

R=1 S=0, this condition cause to go to the Q=0 state where the output remain even after S returns HIGH. This is called resetting the latch.

Condition 4

R=1 S=1, this condition produce a race condition. Therefor avoid R=1 and S=1 condition while using a NOR latch.

NAND latch

From the NAND gate latch as shown in Fig 2, The two NAND gates are cross-coupled so that output of one NAND is connected to other NAND gate input and vice versa. The NAND latch outputs are labelled as Q and $\overline{Q}$. These outputs will always be the inverse of each other.

From the truth table, it can be summarized as follows.

Condition 1

R=0, S=0. This condition produce ambiguous results. It should not be used.

Condition 2

R=0, S=1. This condition cause the output to go the Q=1 state where it will remain after R returns high. This is known as setting the latch.

Condition 3

R=1, S=0. This condition cause the output to go the Q=0 state, where the output will remain even after S returns HIGH. This is called clearing or resetting the latch.

Condition 4

R=1, S=1. This condition is the normal resting state and it has no effect on the output state. The Q and $\overline{Q}$ outputs will remain in whatever state they were prior to this input condition.

Clocked RS flip-flop

It is possible to strobe or clock the flip-flop in order to store information (set it or reset it) at any time, and then hold the stored information for any desired period of time. This flip-flop is called a clocked RS flip-flop and is shown in Fig 4a and 4b.

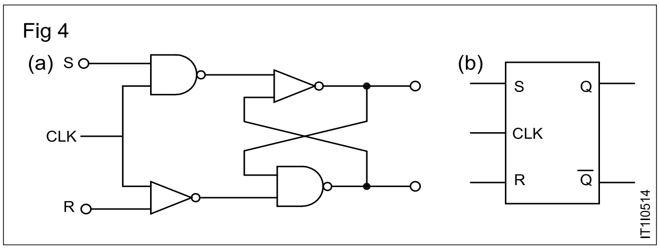


Fig 4

Truth Table

Clock	R	S	Q
0	0	0	NC
0	0	1	NC
0	1	0	NC
0	1	1	NC
1	0	0	NC
1	0	1	1
1	1	0	0
1	1	1	Illegal

For the flip-flop to operate properly there must be a transition form low to high on the clock input, while clock is high, the information on R and S causes the latch to set or reset. Then when clock transitions back to low, this information is retained in the latch. When this high to low transition occurred both R and S inputs were low (0) and thus there was no change of state.

D-flip-flop

The RS flip-flop has two data inputs, R and S. To store a high bit, you need a high S and to store a low bit, you need a high R. Generation of two signals to drive a flip-flop is a disadvantage in many applications. Furthermore the RS flip-flop is susceptible to a race condition. We will modify the design to eliminate the possibility of a race condition, to overcome the above disadvantage, R.S flip is slightly modified as shown in Fig 5 to have a single input called D-flip-flop.

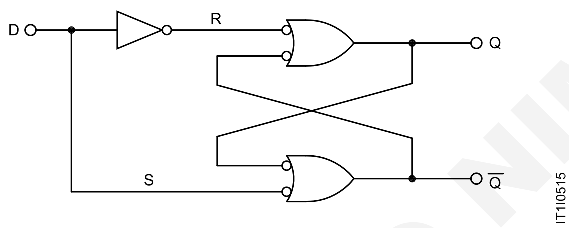
Unclocked D latch

D	Q
0	0
1	1

Clock D latch

CLK	D	Q
0	X	NC
1	0	0
1	1	1

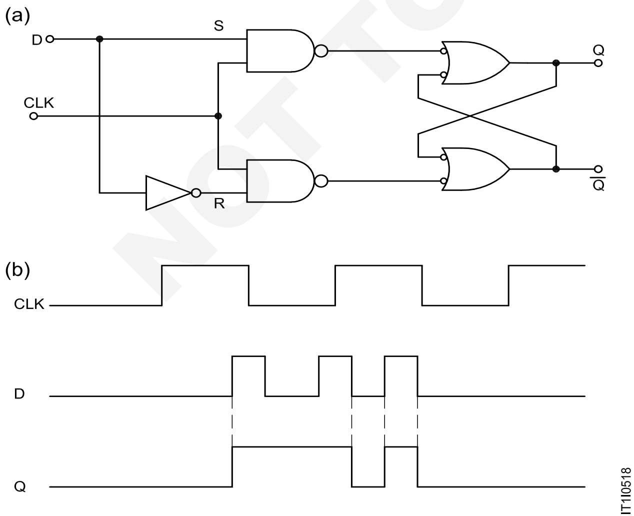
Fig 5



Clocked D-flip-flop

The Fig 8a shows the level clocked D type flip-flop. A low clock disables the input gates and prevents the latch from changing states, in other words, while clock is low, the latch is in the inactive state D controls the output, A high D sets the latch, while a low D resets it.

Fig 8



Truth table for level clocked D flip flop

Clk	D	Q
0	X	NC
1	0	0
1	1	1

The truth table summarizes the operation 'X' represents a don't care condition, it stands for either 0 or 1, while clock is low the output can't change, no matter what 'D' is, when clock is high, the output equals the input. Q = D.

Boolean algebra

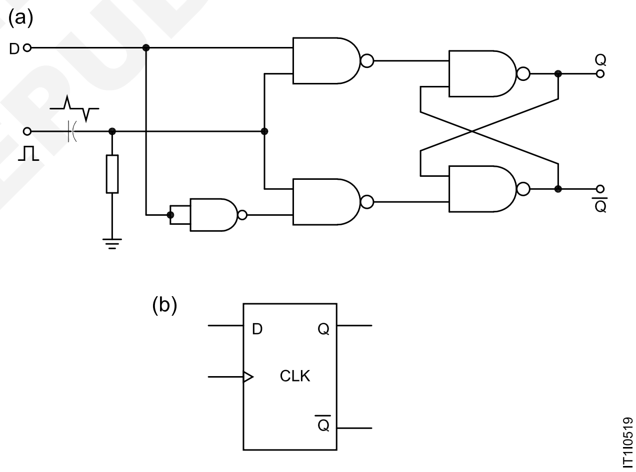
Boolean algebra is a convenient and systematic way of expressing and analysing the operation of logic circuits.

Truth table

Edge triggered D-Flip-flop

CLK	D	Q
0	X	NC
1	X	NC
—	X	NC
-	0	0
-	1	1

Fig 9



Variable

A variable is a symbol (usually an italic uppercase letter) used to represent a logical quantity. Any single variable can have a 1 or 0 value.

Ex: A,B,C,D or X,Y,Z etc

Complements

The complement is the inverse of a variable and is indicated by a bar over the variable.

Ex: The complement of A is $\overline{A}$, the complement of A is read as "A bar".

Literal

A literal is a variable or the complement of a variable.

Boolean addition

0 + 0 = 0

0 + 1 = 1

1 + 0 = 1

1 + 1 = 1

In Boolean algebra, a sum term is a sum of literals. In logic circuits, a sum term is produced by an OR operation with NO AND operation involved.

Ex: $A+B$, $A+\overline{B}$, $\overline{A} + B$

A sum term is equal to 1 when one or more of the literals in the term are 1. A sum term is equal to 0 if and only if each of the literal is 0.

Boolean multiplication

Boolean multiplication is equivalent to the AND operation and the basic rules are as follows.

0.0 = 0

1.0 = 0

0.1 = 0

1.1 = 1

In Boolean algebra a product term is the product of literals. In logic circuits a product term is produced by an AND operation with NO OR operations involved.

Ex: AB, $\overline{A}B$, $A\overline{B}$, $\overline{A}\,\overline{B}$

A product term is equal to 1 if and only if each of the literals in the term is one(1). A product term is equal to 0 when one or more of the literal are 0.

Laws of Boolean algebra

Commutative law

The commutative law for addition for two variables is written algebraically A + B = B + A as shown in Fig 10a.

Fig 10a

The commutative law for two variable multiplication is

AB = BA as shown in Fig 10b.

This law states that the order in which the variables are ORed/ANDed make no difference.

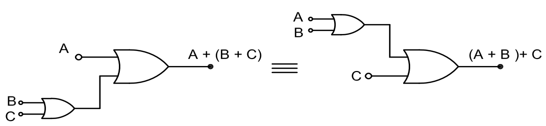
Fig 10b

Associative law

The associative law of addition is written algebraically as follows for three variables as shown in Fig 10c.

A+(B+C) = (A+B)+C

Fig 10c

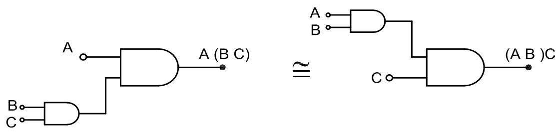


The associative law of multiplication is written as follows for three variables.

A(BC) = (AB)C

This law states that it makes no difference in what order the variables are grouped when ORing/ANDing more than two variables.

Fig 10d



Distributive law

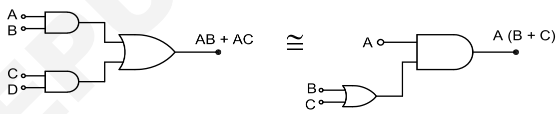
The distributive law is written for three variable as follows.

A(B+C) = AB + AC

This law states that ORing two or more variables and ANDing the result with a single variable is equivalent to ANDing the single variable with each of the two or more variables and then ORing the products as shown in Fig 10e. The distributive law also express the process of factoring in which the common variable 'A' is factored out of the product terms.

Ex: AB + AC = A(B+C)

Fig 10e



Boolean Algebra Rules

1 $A + 0 = A$

2 $A + 1 = 1$

3 $A + A = A$

4 $A + \overline{A} = 1$

5 $A + AB = A$

6 $A + \overline{A}B = A + B$

7 $A \cdot 0 = 0$

8 $A \cdot 1 = A$

9 $\overline{\overline{A}} = A$

10 $A \cdot A = A$

11 $A \cdot \overline{A} = 0$

12 $(A + B)(A + C) = A + BC$

De-Morgans theorem

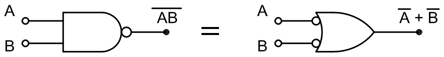
I theorem

The complement of a product of variables is equal to the sum of the complements of the variables.

$\overline{AB} = \overline{A} + \overline{B}$

The complement of two or more variables ANDed is equivalent to the OR of the complements of the individual variables. The related figure is shown in Fig 11a.

Fig 11a



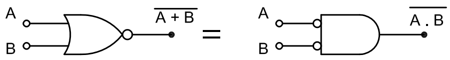
II theorem

The complement of a sum of variables is equal to the product of the complements of the variables.

$$\overline{A}+\overline{B}=\overline{A}\cdot\overline{B}$$

The complement of two ore more variables ORed is equivalent to the AND of the complements of the individual variables as shown in Fig 11b.

Fig 11b



Simplify the equation using De-Morgan's theorem

1 $\overline{(\overline{A+B+C})D}=\overline{\overline{A+B+C}}\ \overline{D}$ ($\overline{AB}=\overline{A}+\overline{B}$)

$$=\overline{A}\cdot\overline{B}\cdot\overline{C}+\overline{D} \quad (\quad \overline{A+B}=\overline{A}.\ \overline{B}$$

2 $\overline{ABC+DEF}=\overline{ABC}\ .\ \overline{DEF}$ ($\overline{A+B}=\overline{A}.\ \overline{B}$)

$$=(\overline{A}+\overline{B}+\overline{C})\cdot(\overline{D}+\overline{E}+\overline{F})$$

$\overline{A}$

Simplification of Boolean equations

Prove that $A+\overline{A}B=A+B$

LHS

$= A+\overline{A}B$

$= (A+AB)+\overline{A}B$

$= AA+AB+\overline{A}\cdot B$

$= AA+AB+\overline{A}B+0$

$= AA+AB+\overline{A}B+A\overline{A}$

$= A(A+B)+\overline{A}(B+A)$ Since A=A.A;

$= (A+\overline{A})(A+B)$

$= 1.(A+B)$ A =0;

$= A+B$

Prove that (A+B) (A+C) = A + BC

LHS = (A+B) (A+C)

= AA + AB + AC + BC

= A + AC + AB + BC

= A(1+C) + AB + BC

= A + AB + BC

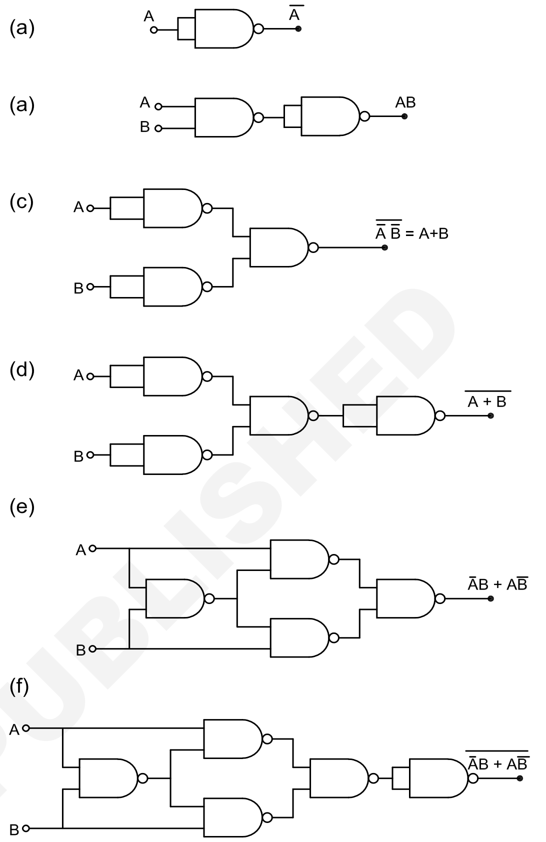
= A(1+B) + BC

= A + BC

Universal property of NOR gate and NAND gate

The universality of the NAND or NOR gate means that it can be used as an inverter and that combination of NAND/NOR gate alone can be used to implement the all other remaining gates. (such as AND, OR, EXOR, EX-NOR)

Fig 14



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NAND gate as a universal logic element is shown in Fig 14a to Fig 14f.

Similarly NOR gate as universal logic gate as shown in Fig 15a to 15f.

Karnaugh Map

The Karnaugh map (K Map) is a graphical tool used to simplify a logic equation or to convert a truth table to its corresponding logic circuit in a simple orderly process. It is easier to simplify an expression using K-Maps when the number of variables is higher.

Truth table gives the value of output for each combination of input values, whereas the K Map gives the same information in a map.

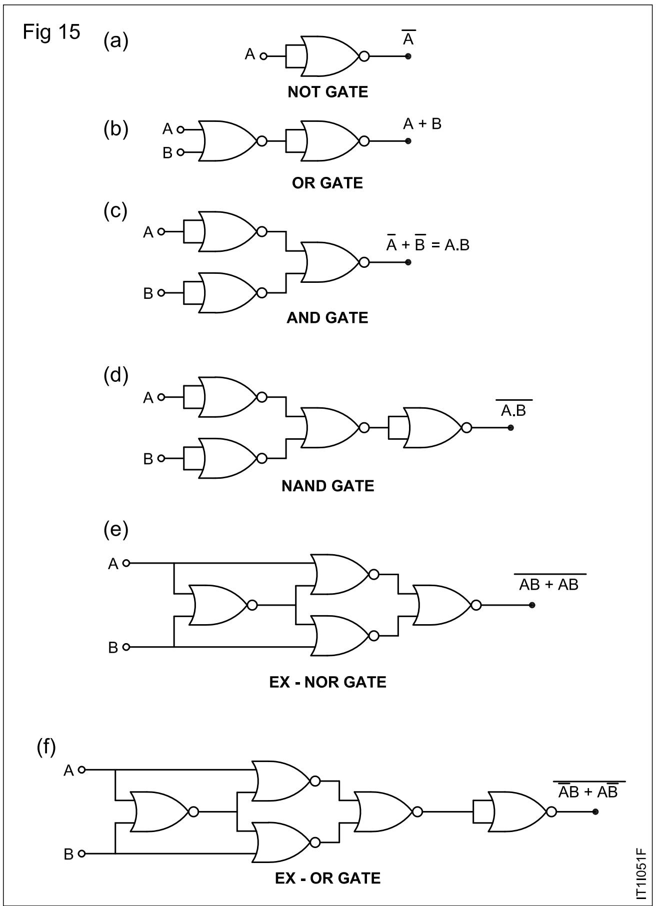
Two types of methods are used for writing logic circuit expressions

Sum of products and Products of sums

Sum of products (SOP) expression consists of two or more AND terms that are ORed together.

Example of sum of products

$$ABC+\overline{A}'\overline{B}'C$$



Product of sum expression consists of two or more OR terms that are AND ed together.

Example of product of sum

$(A+\overline{B}+C)\,(A+C)$

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

The K-map drawn for the above truth table is given below in Fig.

		B 1
$\overline{A}$'0	0	0
A1	1	1

Steps for drawing the above K-map

Each case in the truth table corresponds to a square in the K-map.

1 A=0, B=0 condition in truth table corresponds to $\overline{A}'\overline{B}$ square in the K-Map. The truth table shows Y=0 for A=0, B=0 so a '0' is placed in the A'B' square in the K-Map.

2 A=0, B=1 condition in truth table corresponds to $\overline{A}'B$ square in the K-map. Because Y=1 for this case a '1' is place in the A'B square.

3 A=1, B=1 condition in truth table corresponds to AB square in the K-Map. Because Y=1 for this case a '1' is place in the A'B square.

4 Similarly A=1, B=0 condition in truth table corresponds to $A\overline{B}'$ square in the K-Map. Because Y=1 for this case a '1' is place in the $\overline{A}'B$ square.

5 The logic expression can be simplified by properly combining the squares in the K-Map that contain 1.

6 In Fig. This map contains a pair of 1' that are vertically and horizontally adjacent to each other. The first represents the AB'+AB = A and the second represents A'B+AB = B. Combining together we get

Y = A + B

	B' 0	B 1
A'0	0	0
A1	1	1

So far we have focused on K-maps for three variables. Karnaugh Maps are useful for more than

three variables, and we'll look at how to extend ideas to four variables here. Shown below is a K-map for four variables.

Note the following about the four variable Karnaugh Map.

WX \ YZ	00	01	11	10
00	1	0	0	1
01	1	1	0	0
11	1	0	0	0
10	1	0	0	1

- There are 16 cells in the map. Anytime you have N variables, you will have 2N possible combinations, and 2N places in a truth table or Karnaugh Map.
- Imagine moving around in the Karnaugh Map. Every time you cross a horizontal or vertical boundary one - and only one - variable changes value.
- The two pairs of variables - WX and YZ - both change in the same pattern.

Otherwise, if you can understand a Karnaugh Map for a three-variable function, you should be able to understand one for a four-variable function. Remember these basic rules that apply to Karnaugh maps of any size.

- In a Karnaugh Map of any size, crossing a vertical or horizontal cell boundary is a change of only one variable - no matter how many variables there are.
- Each single cell that contains a 1 represents a minterm in the function, and each minterm can be thought of as a "product" term with N variables.
- To combine variables, use groups of 2, 4, 8, etc. A group of 2 in an N-variable Karnaugh map will give you a "product" term with N-1 variables. A group of 4 will have N-2 variables, etc.
- You will never have a group of 3, a group of 5, etc. Don't even think about it. See the points above.

Let's look at some examples of groups in a 4-variable Karnaugh Map. Example 1 - A Group of 2

Here is a group of 2 in a 4-variable map.

WX \ YZ	00	01	11	10
00	0	0	0	0
01	1	1	0	0
11	0	0	0	0
10	0	0	0	0

Note that Y and Z are 00 and 01 at the top of the two columns in which you find the two 1s. The variable, Z, changes from a 0 to a 1 as you move from the left cell to the right cell. Consequently, these two 1s are not dependent upon the value of Z, and Z will not appear in the product term that results when we combine the 1s in this group of 2. Conversely, W, X and Y will be in the product term. Notice that in the row in which the 1s appear, W = 0 and X = 1. Also, in the two columns in which the 1s appear we have Y = 0. That means that the term represented by these two cells is:

- $\overline{W} \cdot X \cdot \overline{Y}$

WX \ YZ	00	01	11	10
00	1	0	0	1
01	0	0	0	0
11	0	0	0	0
10	1	0	0	1

Larger groups in Karnaugh Maps of any size can lead to greater simplification. Let's consider the group shown shaded below. There are four terms covered by the shaded area.

In the upper left:-

- $\overline{W} \cdot \overline{X} \cdot \overline{Y} \cdot \overline{Z}$

In the upper right;

- $\overline{W} \cdot \overline{X} \cdot Y \cdot \overline{Z}$

In the lower left;

- $W \cdot \overline{X} \cdot \overline{Y} \cdot \overline{Z}$

In the lower right;

- $W \cdot \overline{X} \cdot Y \cdot \overline{Z}$

These terms can be combined (assuming they are all ones in the Karnaugh Map!). The result is

By combining the first two terms above (the two terms at the top of the Karnaugh Map):-

- $\overline{W} \cdot \overline{X} \cdot \overline{Z}$

By combining the last two terms above (the two terms at the bottom of the Karnaugh Map):-

- $W \cdot \overline{X} \cdot \overline{Z}$

Then, these two germs can be combined to give:

- $\overline{X} \cdot \overline{Z}$

Notice how making the grouping larger reduces the number of variables in the resulting terms. That simplification helps when you start to connect gates to implement the function represented by a Karnaugh map.

By now you should have inferred the rules for getting the sum-of-products form from the Karnaugh map.

The number of ones in a group is a power of 2. That's 2, 4, 8 etc.

If a variable takes on both values (0 and 1) for different entries (1s) in the Karnaugh Map, that variable will not be in the sum-of-products form. Note that the variable should be one in half of the K-Map ones and it should be zero (inverted) in the other half.

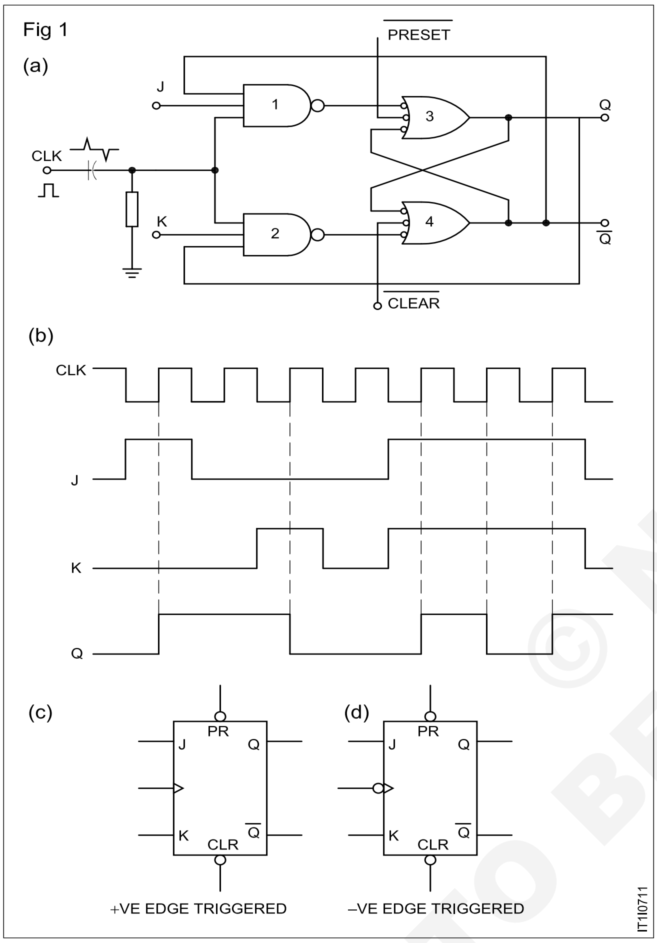
If a variable is always 1 or always zero (it appears either inverted all the time in all entries that are one, or it is always not inverted) then that variable appears in that form in the sum-of-products form.

J.K Flip-flop

Objectives: At the end of this lesson you shall be able to
- **explain construction of J.K flip-flop using NAND gates**
- **explain the function of Preset and clear inputs**
- **explain what is meant by active low and active high**
- **explain the working function of J.K master slave flip-flop**
- **explain flip-flop applications**
- **explain binary counter and their types**
- **explain asynchronous ÷ 16 counter using flip-flops**
- **explain modulus of a counter.**

Operation of J-K flip flop

Fig 1



Truth table

CLK	J	K	Q	
0	x	x	NC	
_	x	x	NC	
	x	x	NC	
x	0	0	NC	
-	0	1	0	Reset
-	1	0	1	Set
-	1	1	Toggle	Toggle

The figure shows one way to build a J.K flip-flop. The variables J and K are called control inputs. An R.C circuit with a short time constant, converts the rectangular clock pulse to narrow spikes. Because of the double inversion through the NAND gates, the circuit is +ve edge triggered. In other words, the input gates are enabled only on the rising edge of the clock as shown in truth table.

Reset

When J is low and K is high the upper output gate is disabled. So there is no way to set the flip flop. The only possibility is reset. When Q is high, the lower gate passes a reset trigger as soon as the +ve clock edge arrives. This forces Q to become low. Therefore, J=0 and k=1 means that a rising clock edge resets the flip-flop.

Set

When J is high and K is low, the lower output gate is disabled. So it is impossible to reset the flip-flop. But flip-flop can be set, when Q is low, Q is high, the gate 1 passes a set trigger on the positive clock edge. This drives Q into the high state. That is J=1 and K=0 means that the next positive clock edge sets the flip flop.

Toggle

When J and K are both high, it is possible to set or reset the flip flop depending on the current state of the output if Q is high, the lower gate passes a reset trigger on the next positive clock edge on the other hand. When Q is low the upper gate passes a set trigger on the next positive clock edge. Either way Q changes to the complement of the last state. Therefore J=1 and K=1 means that the flip-flop will toggle on the next positive clock edge.

To summarize the operation of the J.K.flip-flop, the circuit is inactive when the clock is low, high or on its -ve edge. Likewise the circuit is inactive when J and K are both low. Output changes occur only on the rising edge of the clock as indicated by the last three entries of the table. The o/p either resets, sets or toggles.

Racing

Toggling more than once during a clock cycle is called Racing. Assume that the circuit is level clocked. In other words, assume that RC circuit has been removed and run the clock straight, into the gates, with a high J, high K and high clock, the output toggles. New outputs are then fed back to the input gates. After two propagation times (input and output gates), the output toggles again. And once more new outputs return to the input gates. In this way the output can toggle repeatedly as long as the clock is high.

To overcome this racing problem, J.K master slave flip-flop has been developed.

Clear

When power is first applied, flip-flops come up in random states. To get some computers started, an operator has to push a master reset button, this sends a clear (reset) signal to all flip-flops, normally clear signal will be active low, (i.e logic zero should be applied for clear the output. When clear is applied to gate-4 as shown in Fig 1a then the Q will be forced to Logic-0, then automatically Q will go to logic-1 condition. This signal, J and K signals have no control over output Q, when clear is set.

Pre-set

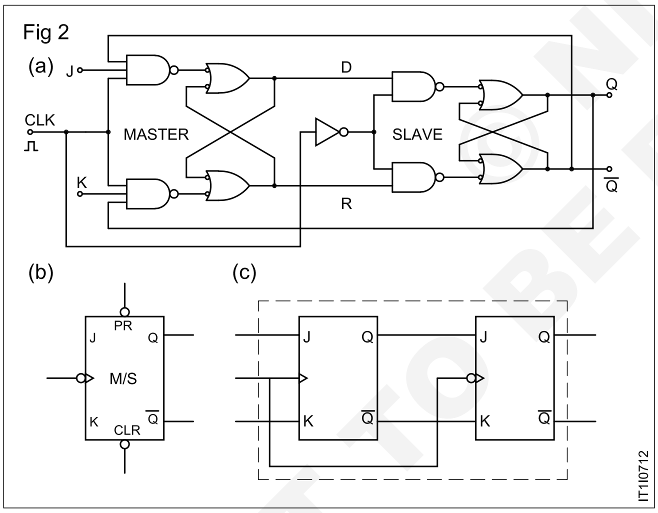
Like clear preset is an active low input. This input also independent of CLK, J & K inputs. When preset is made logic-0, the output Q is set to logic one. It is necessary in some digital system to preset the output before the system actually runs.

Master Slave Flip-flop

The figure shows the J.K.Master Slave Flip-flop. It provides another way to avoid racing. A master slave flip-flop is a combination of two clocked flip-flops connected in cascade. Master flip-flop is positive edge triggered, slave flip-flop is negative edge-triggered flip-flop.

– While the clock is high, the master is active and the slave is inactive.

– While the clock is low, the master is inactive and the slave is active.



The J.K master slave flip-flop is used as the main counting device. The popular IC 54LS/74LS76 is a dual JK master slave flip-flop.

Truth table for positive edge triggered JK flip flop

PR	CLR	CLK	J	K	Q
0	0	X	X	X	Race
0	1	X	X	X	1
1	0	X	X	X	0
1	1	X	0	0	NC
1	1	-	0	1	0
1	1	-	1	0	1
1	1	-	1	1	Toggle

Look at the Summarized truth table of J.K master slave flip-flop. A low PR and LOWCLR produces a race condition therefore, PR and CLR are normally kept at a high voltage when inactive. To clear, the flip flop make clear low, to preset the F/F make preset low.

Low J & Low K produces an inactive state regardless of the what the clock is doing. If K goes high by itself, the next clock pulse resets the flip-flop. If J goes high by itself, the next clock pulse sets the flip-flop when J & K are both high, each clock pulse toggle the state of flip flop.

Frequency division using flip flops

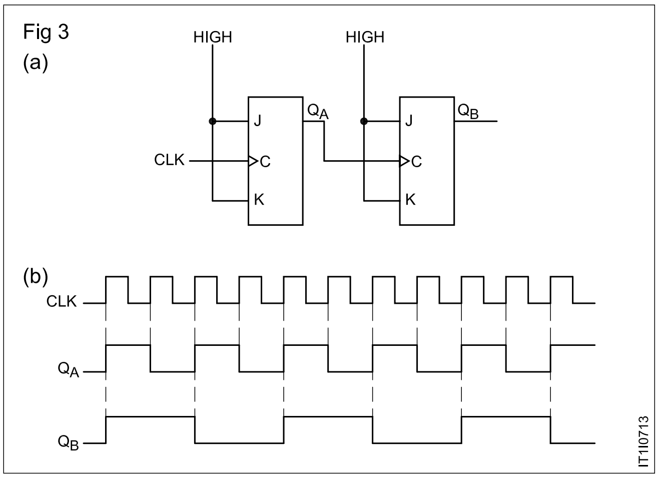
Flip-flops are used as frequency dividers of a periodic waveform. When a pulse waveform is applied to the clock input of a J.K flip-flop which is wired for toggle operation, provides square wave output with one half the frequency of the clock input. Thus a single flip-flop can be used for divide by -2 operation as illustrated in Fig 3. The flip-flop changes state on each triggering clock edge. This results in an output which is at half the frequency of the clock waveform.

Further division of clock frequency can be achieved by using the output of one flip-flop as the clock input to a second flip-flop as shown in Fig 3. The frequency of the QA output is divided by 2 by flip-flop B. The QB output is therefore, one fourth the frequency of the original clock input.

By connecting flip-flops in this way, a frequency division of 2^n is achieved, where n is the number of flip-flops. For example, three flip-flops divide the clock frequency by $2^3 = 8$. Four flip-flops divide the clock frequency by $2^4 = 16$; and so on.

Counter

A counter is one of the most useful and versatile subsystems in a digital system. A counter driven by a clock can be used to count the number of clock cycles. Since the clock pulses occur at known intervals, the counter can be used as an instrument for measuring time and therefore period or frequency.



Basically there are two types of counters

1 Synchronous counter

2 Asynchronous counter

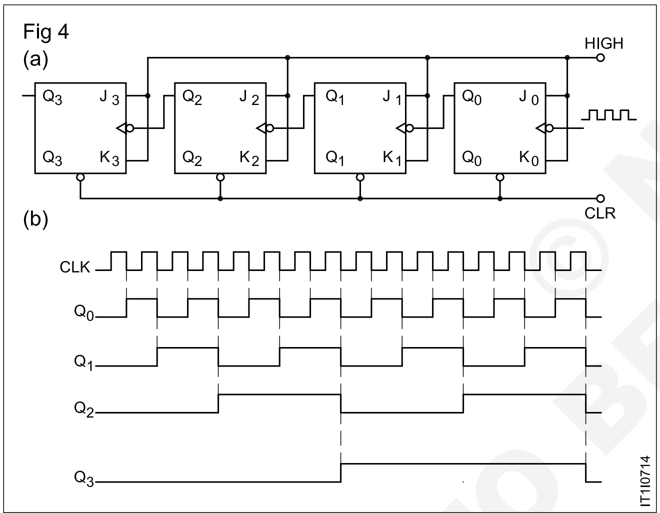
Synchronous counter

In this counter every flip-flop is triggered by the clock parallel (synchronously) and thus settling time is simply equal to the delay time of a single flip-flop. The increase in speed is usually obtained at the price of increased hardware.

Asynchronous counter

Asynchronous counters are simple and straight forward in operation and construction and usually requires a minimum of hardware, however have a speed limitation. Each flip-flop is triggered by the previous flip-flop, [i.e., clock is applied serially] and thus the counter has a cumulative settling time. Counters such as these are also called as serial counters or ripple counters.

Serial and parallel counters are used in combination to compromise between speed of operation and hardware count. Serial, parallel or combination counters can be designed such that each clock pulse advances the contents of the counter by one, it is then operating in a count-up mode. The opposite is also possible; the counter then operates in the count-down mode. Furthermore, many counters can be either 'cleared' so that every flip-flop contains a zero, or preset such that the contents of the flip-flops represent any desired binary number.



Ripple counter

The Fig shows a counter built with J.K flip-flops since the J&K inputs are tied to a high voltage, each flip-flop will toggle, when its clock input receives a negative edge.

Visualize the Q outputs as a binary word.

$Q = Q_3Q_2Q_1Q_0$

Q_3 is the most significant bit (MSB) and Q_0 is the least significant bit (LSB). When CLR goes low, all flip-flops reset, this results in a digital word of Q = 0000.

When clear returns to high, the counter is ready to go, since the LSB flip-flop receives each clock pulse, Q_0 toggles once per negative clock edge, as shown in Fig 4b. The remaining flip-flops toggle less often because they receive their negative edges from the preceding flip-flop outputs(Q). The triggers move through the flip-flops like a ripple in water, that is why this type of counter is called ripple counter.

The sixth clock pulse gives Q = 0110.

and the seventh pulse gives Q = 0111.

ON the eighth clock pulse Q_0 resets and carrier, Q_1 resets and carrier, Q_2 resets and carry, and Q_3 advances to 1. So the output word becomes Q = 1000.

The ninth clock pulses gives Q = 1001.

The tenth gives Q = 1010 and so on

at the 15th clock pulse Q = 1111

The 16th clock pulse resets all flip-flops. Therefore the counter resets to Q = 0000 and the cycle repeats.

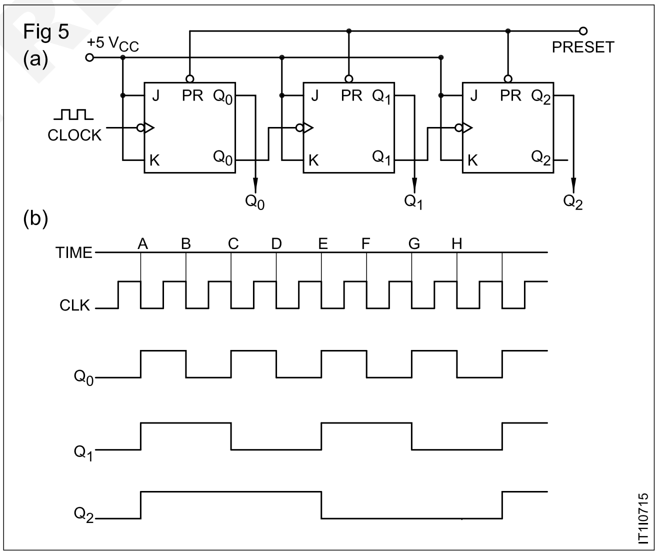
By adding more flip-flops to the left end of the counter circuit, the counter length can be extended. Eight flip-flops gives an 8 bit ripple counter, twelve flip-flops result in a 12 bit ripple counter and so on.

Down counter

The counter discussed above is an up counter, counts from 0 to 15 [0000 to 1111]. If a counter counts from 1111 to 0000 then it is called DOWN counter. In a down counter Q output as shown in Fig 5 is connected to the clock input of the next flip-flop. Each flip-flop toggles when its clock input goes from 1 to 0. Flip flop Q_0 toggles with each negative clock transition as before. But flip flop Q_1 will toggle each time Q_0 goes high. Notice that each time Q_0 goes high, Q_0 goes low, and it is this negative transition on Q_0 that triggers Q_1.

A low preset signal sets all output, producing an output word of Q = 1111.

When pre goes high, the action starts.



The first clock pulse produces a negative toggle in Q_0, nothing else happens. Q = 1110

The second clock pulse produces a positive toggle in Q_0, which produces a negative toggle in Q_1. Q = 1101

On the third clock pulse Q_0 toggles negatively and Q = 1100

On the fourth clock pulse, Q_0 toggles positively Q_1 toggles positively and Q_2 toggles negatively. Q = 1011.

Likewise counting down from 15-0 takes place, when count reaches 0, i.e.Q=0000, on the next clock pulse, all flip-flops toggles positively to get Q=1111 and the cycle repeats.

Modulo -10 Counter

Asynchronous Decade counters

Regular binary counters have a maximum modulus, which means they progress through all of their possible states. The maximum possible number of states (maximum modulus) of a counter is 2", where n is the number of flip-flops in the counter.

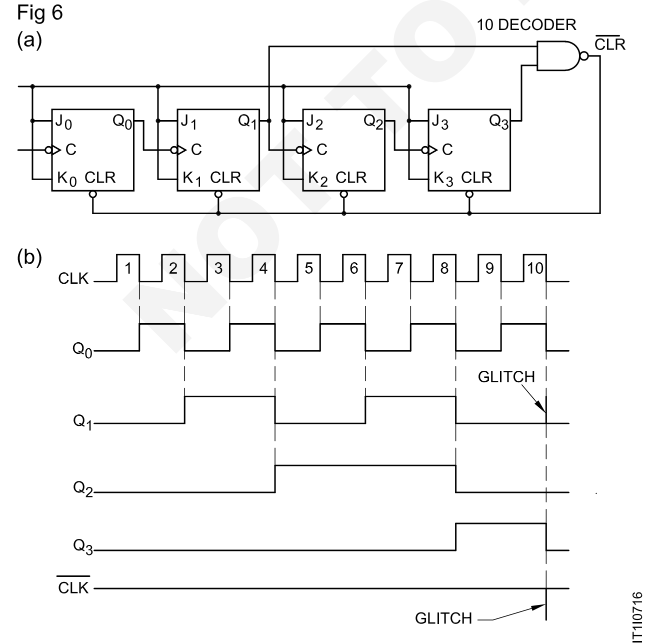
Counters can also be designed to have a number of states in their sequence that is less than the maximum of 2". The resulting sequence is called a truncated sequence.

One common modulus for counters with truncated sequence is ten. Counters with ten states in their sequence (modulus-10) are called decade counters. A decade counter with a count sequence of zero (0000) through nine (1001) is a BCD decade counter because its ten-state sequence is the BCD code. This type of counter is useful in display applications in which BCD is required for conversion to a decimal readout.

To obtain a truncated sequence, it is necessary to force the counter to recycle before going through all of its normal states. For example, the BCD decade counter must recycle back to the 0000 state after the 1001 state. A decade counter requires four flip-flops (three flip-flops are insufficient because $2^3 = 8$).

We will use a 4-bit asynchronous counter such as the one in Fig 6a and modify its sequence to illustrate the principle of truncated counters. One way to make the counter recycle after the count of nine (1001) is to decode count ten (1010) with a NAND gate and connect the output of the NAND gate to the clear ($\overline{CLR}$) inputs of the flip-flops, as shown in Fig 6.

Fig 6



Notice in Fig 6a that only Q_1 and Q_3 are connected to the NAND gate inputs. This arrangement is an example of particle decoding, in which the two unique states (Q_1=1 and Q_3=1) are sufficient to decode the count of ten, because none of the other states (zero through nine) have both Q_1 and Q_3 HIGH at the same time. When the counter goes into count ten (1010), the decoding gate output goes LOW and asynchronously resets all the flip-flops.

The resulting timing diagram is shown in Fig 6b. Notice that there is a glitch on the Q_1 waveform. The reason for this glitch is that Q_1 must first go HIGH before the count of ten can be decoded. Not until several nanoseconds after the counter goes to the count of ten does the output of the decoding gate go LOW (both inputs are HIGH) . Thus, the counter is in the 1010 state for a short time before it is reset to 0000, thus producing the glitch on Q_1 and the resulting glitch on the CLR line which resets the counter.

Other truncated sequences can be implemented in a similar way.

Modulo-12 counter

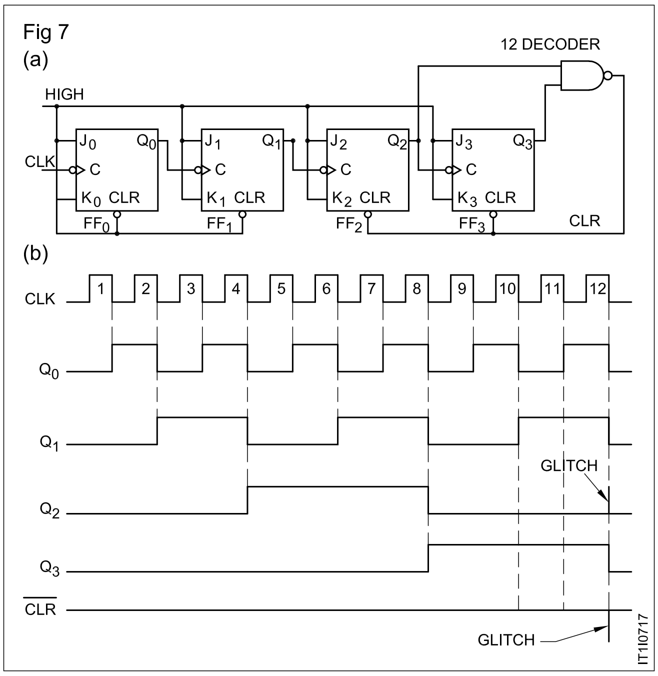
An asynchronous counter can be implemented having a modulus of twelve with a straight binary sequence from 0000 through 1011.

Since three flip-flops can produce a maximum of eight states, four flip-flops are required to produce any modulus greater then eight but less than or equal to sixteen.

When the counter gets to its last state, 1011, it must recycle back to 0000 rather than going to its normal next state of 1100, as illustrated in the following sequence chart:

Q_3	Q_2	Q_1	Q_0	
0	0	0	0	←
.	.	.	.	
.	.	.	.	Recycles
.	.	.	.	
1	0	1	1	
1	1	0	0	← Normal next state

Observe that Q_0 and Q_1 both go to 0 anyway, but Q_2 and Q_3 must be forced to 0 on the twelve clock pulse. Fig 7a shows the modulus-12 counter. The NAND gate partially decodes count twelve (1100) and resets flip-flop 2 and flip-flop 3. Thus, on the twelve clock pulse, the counter is forced to recycle from count eleven to count zero, as shown in the timing diagram of Fig 7b. (It is in count twelve for only a few nanoseconds before it is reset by the glitch on CLR.)



Up/down counters

Objectives: At the end of this lesson you shall be able to
- **explain the basic operation of an up/down counter**
- **discuss the 74LS190 up/down decade counter.**

UP/DOWN SYNCHRONOUS COUNTERS

An up/down counter is one that is capable of progressing in either direction through a certain sequence. An up/down counter, sometimes called a bidirectional counter, can have any specified sequence of states. A 3-bit binary counter that advances upward through its sequence (0,1,2,3,4,5,6,7) and then can be reversed so that it goes through the sequence in the opposite direction (7,6,5,4,3,2,1,0) is an illustration of up/down sequential operation.

In general, most up/down counters can be reversed at any point in their sequence. For instance, the 3-bit binary counter can be made to go through the following sequence:

UP UP

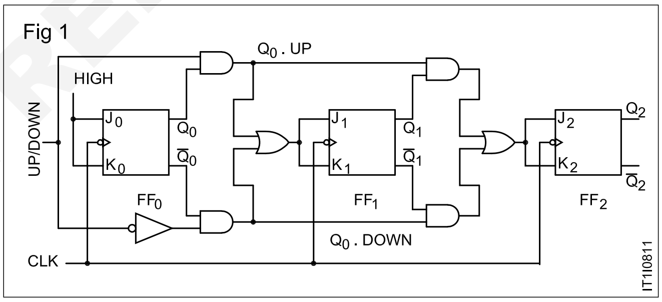
0, 1, 2, 3, 4, 5, 4, 3, 2, 3, 4, 5, 6, 7, 6, 5,etc.

DOWN DOWN

Table 1 shows the complete up/down sequence for a 3-bit binary counter. The arrows indicate the state-to-state movement of the counter for both its UP and its DOWN modes of operation. An examination of Q_0 of Fig 1 for both the up and down sequences shows that FFO toggles on each clock pulse. So the J_0 and K_0 inputs of FFO are

$$J_0 = K_0 = 1$$

For the up sequence, Q_1 changes state on the next clock pulse when Q_0 =1. For the down sequence, Q_1 changes on the next clock pulse when Q_0=0. Thus, the J_1 and K_1 inputs of FFI must equal 1 under the conditions expressed by the following equation:



$$J_1 = K_1 = (Q_0.UP) + (\overline{Q}_0.DOWN)$$

For the up sequence, Q_2 changes state on the next clock pulse when Q_0 = Q_1 = 1.For the down sequence, Q_2 changes on the next clock pulse when Q_0 =Q_1 =0. Thus, the J_2 and K_2 inputs of FF2 must equal 1 under the conditions expressed by the following equation:

$$J_2 = K_2 = (Q_0 . Q_1 . UP) + (\overline{Q}_0 . \overline{Q}_1 . DOWN)$$

Each of the conditions for the J and K inputs of each flip-flop produces a toggle at the appropriate point in the counter sequence.

A synchronous 4-bit binary up/down counter

A timing diagram and the sequence of a synchronous 4-bit binary up/down counter if the clock and UP/DOWN control inputs have waveforms as shown in Fig 2. The coutner starts in the all 0s state and is positive edge-triggered.

Table 1

Up/Down sequence for a 3-bit binary counter

Clock pulse	UP	Q_2	Q_1	Q_0	Down
0		0	0	0	
1		0	0	1	
2		0	1	0	
3		0	1	1	
4		1	0	0	
5		1	0	1	
6		1	1	0	
7		1	1	1	

The timing diagram showing the Q outputs is shown in Fig 2b. From these waveforms, the counter sequence is as shown in Table 2.

Fig 2

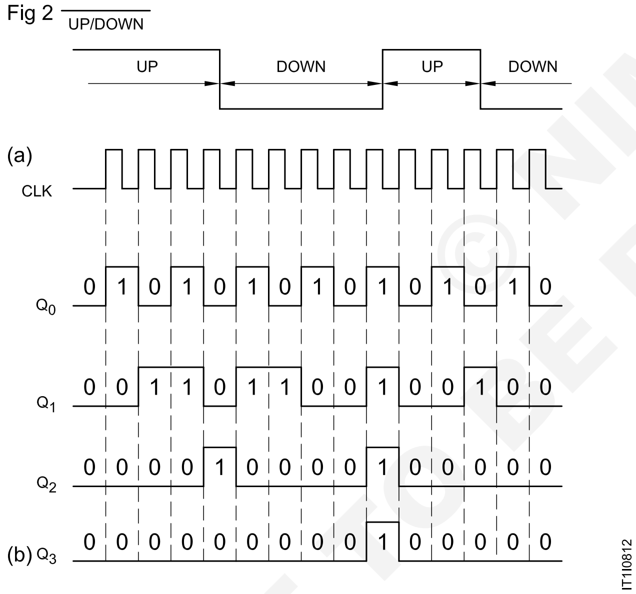


Table 2

Q_3	Q_2	Q_1	Q_0	
0	0	0	0	UP
0	0	0	1	
0	0	1	0	
0	0	1	1	
0	1	0	0	
0	0	1	1	DOWN
0	0	1	0	
0	0	0	1	
0	0	0	0	
1	1	1	1	
0	0	0	0	UP
0	0	0	1	
0	0	1	0	
0	0	0	1	DOWN
0	0	0	0	

The 74LS190 Up/down decade counter

Fig 3 shows a logic diagram for the 74LS190, a good example of an integrated circuit up/down counter. The direction of the count is determined by the level of the up/down input ($\overline{D}/U$). When this input is HIGH, the counter counts down; when it is LOW, the counter counts up. Also, this device can be preset to any desired BCD digit as determined by the states of the data inputs when the LOAD input is LOW.

The MAX/MIN output produces a HIGH pulse when the terminal count nine (1001) is reached in the UP mode or when the terminal count zero (0000) is reached in the DOWN mode. This MAX/MIN output, along with the ripple clock output ($\overline{RCO}$) and the count enable input ($\overline{CTEN}$) is used when cascading counters.

Fig 4 is an example timing diagram showing the 74LS190 counter preset to seven (0111) and then going through a count-up sequence followed by a count-down sequence. The MAX/MIN output is HIGH when the counter is in either the all-0s state (MIN) or the 1001 state (MAX).

Fig 3

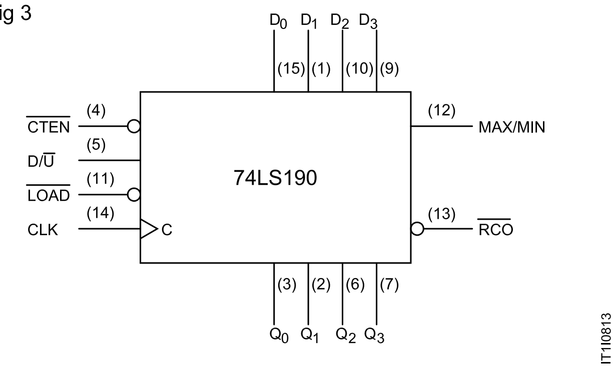
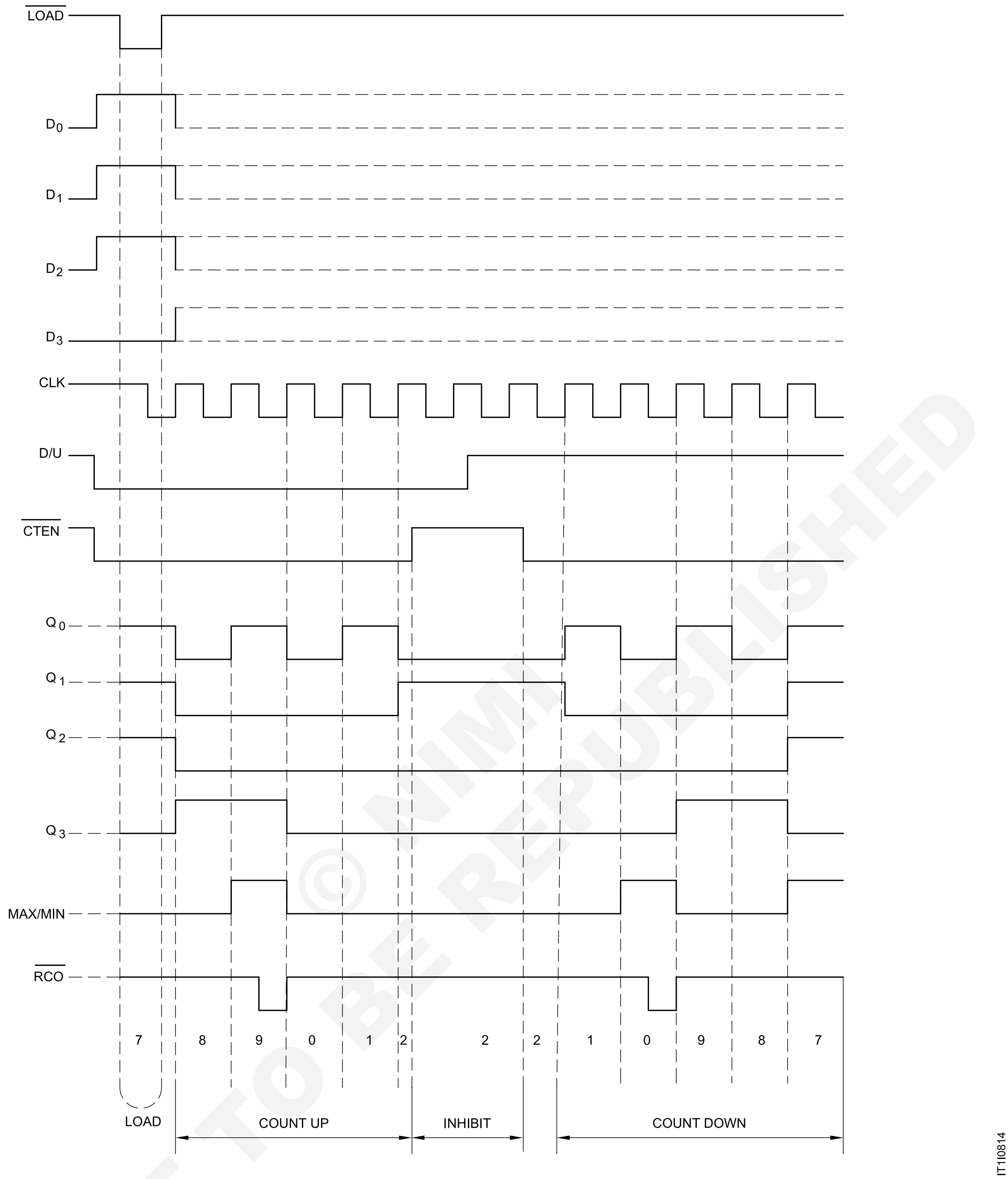


Fig 4


LOAD
D0
D1
D2
D3
CLK
D/U
CTEN
Q0
Q1
Q2
Q3
MAX/MIN
RCO
7 8 9 0 1 2 2 2 1 0 9 8 7
LOAD
COUNT UP
INHIBIT
COUNT DOWN
IT110814

Binary arithmetic

Objectives: At the end of this lesson you shall be able to
- **explain half adder circuit, full adder circuit**
- **explain the IC 74LS83, 4 bit parallel adder**
- **explain IC 74LS83 4 bit parallel adder can be used for subtraction.**

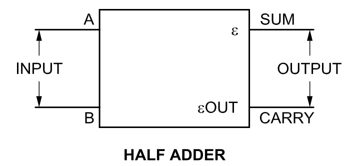
Basic Adder

Adders are used in many types of digital systems in which numerical data are processed. Computers and calculators perform binary operations on two binary numbers at a time, where each number can have several binary digits. The logic symbol for a half adder is shown in Fig 1. There are two basic categories of adders.

1 Half adder

2 Full adder

Fig 1



Half adder

The half-adder accept two binary digits on its inputs and produces two binary digits on its outputs, a sum bit and a carry bit.

Table 1 (Truth table)

A	B	Sum $S=A\oplus B$	Carry C_{out} = AB
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

From the logic operation of the half-adder as stated in the Table 1, expression can be derived for the sum and the output carry as functions of the inputs, notice that the output carry is a 1 only when both A and B are 1s. Therefore carry (C_{out}) can be expressed as the AND of the input variables.

C_{out} = A.B ——> 1

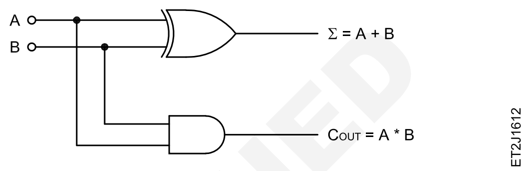
The sum output(S) is a 1 only if the input variables, A and B are not equal.

The sum can therefore be expressed as the exclusive -OR of the input variables.

Sum(S) = $A\oplus B$ ——> 2

From equation 1 and 2 the logic implementation required for the half-adder function can be developed. The output carry is produced with an AND gate with 'A' and 'B' on the inputs and the sum outputs is generated with an Ex-OR gate, as shown in Fig 2.

Fig 2



Full adder

The full adder accepts three inputs including an input carry and generates a sum output and an output carry.

The basic difference between a full-adder and a half-adder is that the full-adder accepts an input carry. A logic symbol for a full-adder is shown in Fig 3 and the truth table in the Table 2 shows the operation of a full-adder.

Fig 3

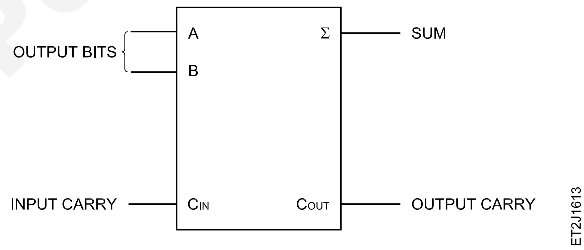


Table 2

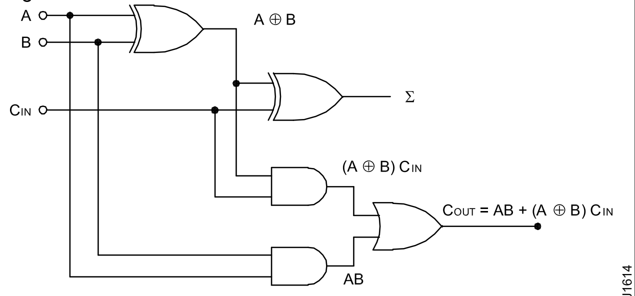
A	B	C_{in}	Cout	S
0	0	0	0	0
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	1	0
1	1	1	1	1

The full-adder must add the two input bits along with the input carry. From the truth-table of the half-adder we know that the sum of the input bits A and B is $A\oplus B$. To get the sum output of the full edder the input carry (C_{in}) must be exclusive-ORed with $A\oplus B$. Then the sum

$S = (A \oplus B) \oplus C_{in}$

This means that to implement the full-adder sum function, two exclusive-OR gates can be used. The first must generate the term A + B, and the second has the inputs from the output of the XOR gate and the input carry, as shown in Fig 4.

Fig 4



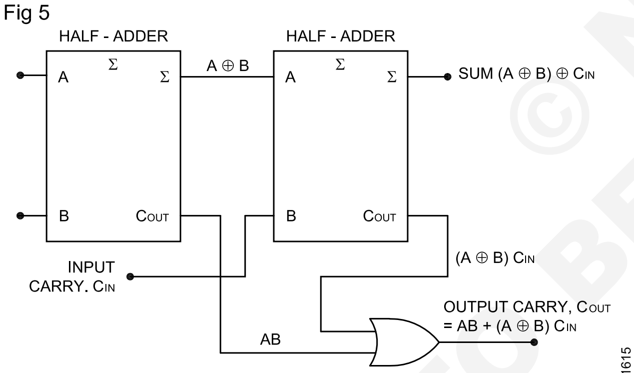
LOGIC DIAGRAM OF FULL ADDER

The output carry of the full-adder is therefore produced by the inputs A, ANDed with B and $A \oplus B$ ANDed with C_{in}. These two terms are ORed, and expressed in equation shown below and this function is implemented and combined with the sum logic to form a complete full-adder circuits, as shown in Fig 4.

$C_{out} = AB + (A \oplus B)\ C_{in}$

The Fig 5, shows there are two half-adders, connected as shown in block diagram to form full-adder.

Fig 5

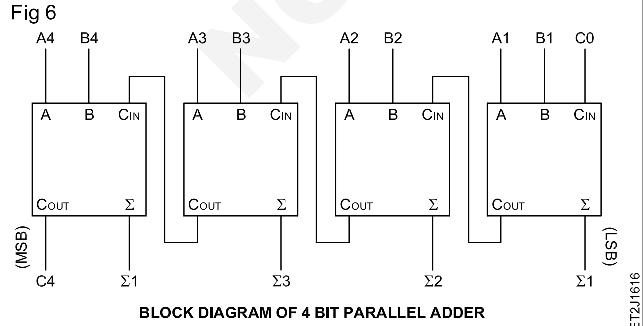


FULL - ADDER IMPLEMENTED WITH HALF - ADDERS

Four bit parallel adder

A basic 4-bit parallel adder is implemented with four full-adders as shown in the Fig 6.

Fig 6



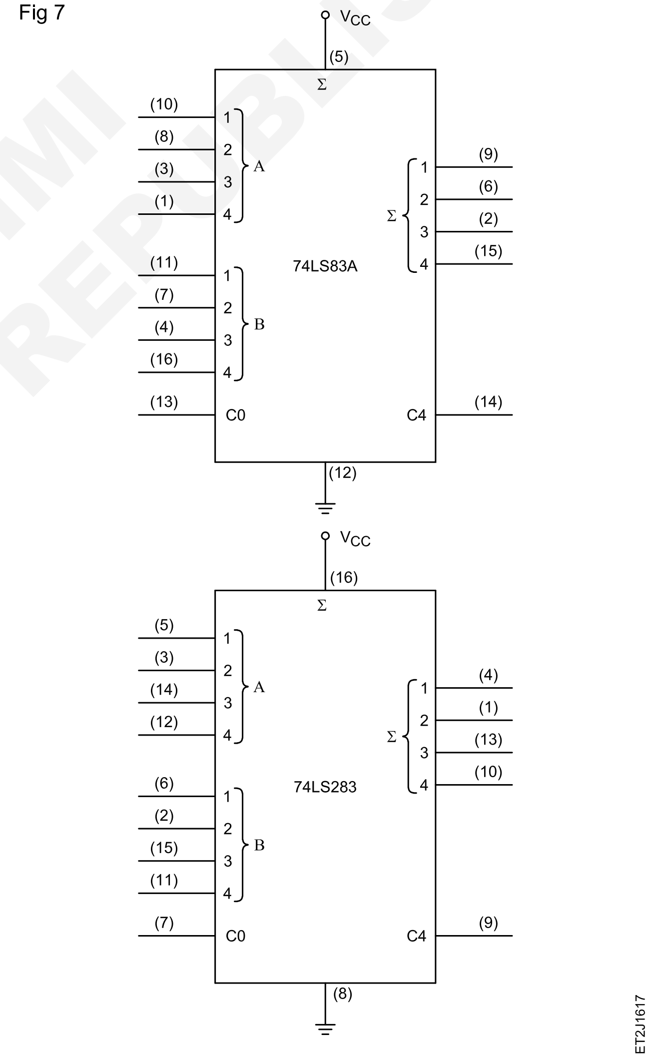
BLOCK DIAGRAM OF 4 BIT PARALLEL ADDER

Block diagram of 4 bit parallel adder: The LSB, (A1 and B1) in each number being added into the right most full-adder; the higher order bits are applied as shown to the successively higher order adders, with MSBs (A4 and B4) in each number being applied to the left most full adder. The carry output of each adder is connected to the carry input of the next higher order adder as indicated.

In the manufacturer's data sheets the input labeled C_0 is the input carry to the least significant bit adder, C_4 is the output carry of the most significant bit adder, and S_1(LSB) through S_4(MSB) are the sum outputs.

74LS83 4 bit parallel adder: 4-bit parallel adders that are available as Medium-Scale Integrated(MSI) circuits are the 74LS83A and the 74LS283 low-power Scotty TTL devices. These devices are also available in other logic families such as standard TTL (7483A and 74283) and CMOS (74HC283). The 74LS83A and the 74LS283 are functionally identical to each other but not pin compatible, that is the pin numbers for the inputs and outputs are different due to different power and ground pin connections. For the 74LS83A, V_{CC} is pin 5 and ground is pin 12 on the 16-pin package. For the 74LS283, V_{CC} is pin 16 and ground is pin-8, which is a more standard configuration. Logic symbols for both of these devices are shown in Fig 7 with pin numbers in parenthesis.

Fig 7



The 4 bit parallel adder can be expanded to handle the addition of higher bit numbers by a process called cascading. In this process, the carry output of the lower-order adder is connected to carry input of the higher-order adder being cascaded.

Multiplexers & Demultiplexers

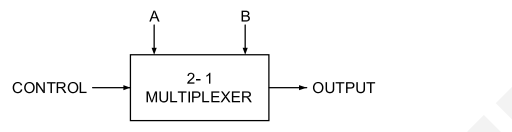
Objectives: At the end of this lesson you shall be able to
- **explain the need of multiplexers and demultiplexers in digital circuits**
- **explain the function of a multiplexer with an example**
- **explain the relationship between number of input lines and required number of control lines**
- **list a few commercially available multiplexer and demultiplexer ICs**
- **explain the application of a multiplexer & demultiplexer in data transmission.**

Many applications in digital logic requires circuit with multiple input and single output, single input and multiple outputs. The output of such circuits should however be uniquely determined by a set of control signals. Such circuits find immense application in computer and data transmission. Such circuits that have one or more input lines and give one or more output which are uniquely determined by the inputs are called *Combinational circuits.* Two of the most important combinational circuits are the *Multiplexers* and *Decoders*.

Multiplexers

A multiplexer having 2^n data inputs, one data output and an *n*-bit control input which selects one of the input and routes it to the output is shown in Fig 1.

Fig 1



In Fig 1, the multiplexer has two inputs ($2^n = 2^1 = 2$, hence n=1). It has 1-bit control signal (because, n=1) which selects A or B as the output as given in the Truth Table 1.

Truth Table

INPUTs		Control	Output
A	B		
1	0	0	1 (A -->output)
1	0	1	0 (B -->output)

The inverse of a Multiplexer is a Demultiplexer as shown in Fig-2. This has n input (in this case, n=1), 2n output (in this case, $2^n = 2^1 = 2$ outputs) and n number of control signals (in this case n=1, hence control line=1). The single input is routed to one of the 2^n outputs, depending on the value of the n control lines. The truth table for the demultilexer at Fig 2 is given in Table 2.

Fig 2

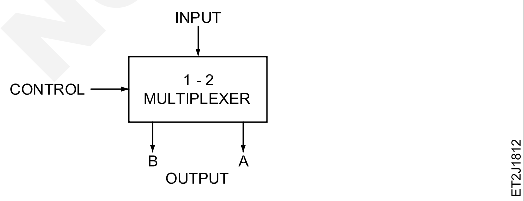


Table 2

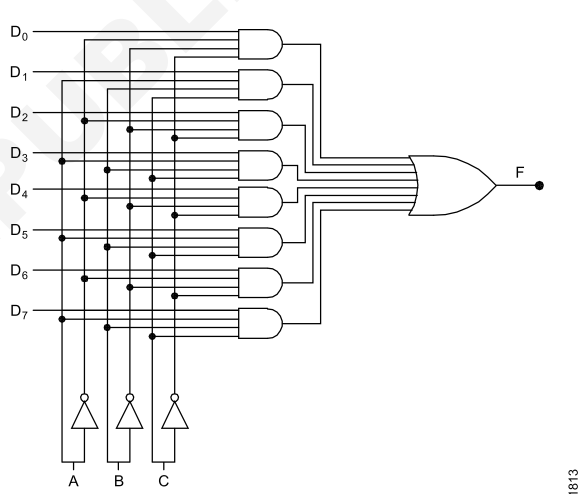
INPUT	Control	Output
1	0	Input --> A (Therefore, A=1)
1	1	Input --> B (Therefore, B=1)

8-line Multiplexer

As discussed in earlier paragraphs, a multiplexer is a circuit with 2^n data inputs, one data output and *n* control inputs. The selected data is gated or routed to the output. Fig 3 shows the schematic of an eight-input or eight-line multiplexer.

As can be seen in Fig 3, the three control lines A,B and C encode a 3-bit number that specifies which of the eight input lines is gated to the OR gate and then to the output. Immaterial of what value is on the control lines, seven of the AND gate will always output 0, the other one may output 0 or 1 depending on the value of the selected input line. Each gate is enables by a different combination of the control inputs.

Fig 3



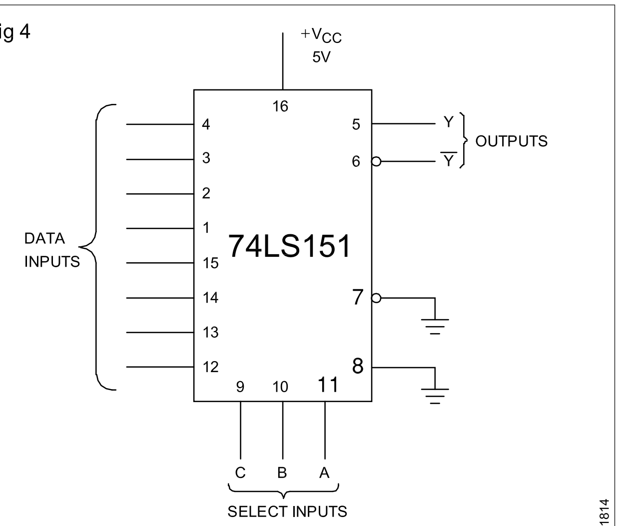
AN EIGHT DIGIT MULTIPLEXER CIRCUIT

Such a eight-line multiplexer is available as a MSI chip. With 8 input lines, 3 control lines, one output, may be an additional compliment output line and power supply and ground lines is implemented as a 16 pin package. One such package is the 74LS151 , 8-line multiplexer IC shown in Fig 4.

Demultiplexer

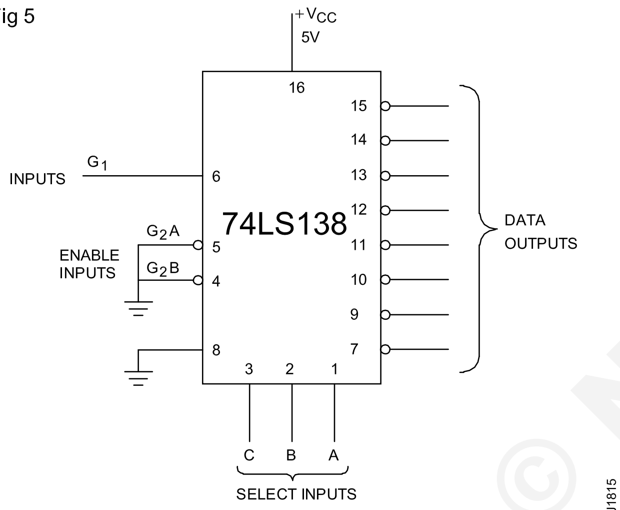
The inverse of a multiplexer is a demultiplexer. A demultiplexer routes its single input signal to one of 2n outputs, depending on the values of the n control lines. For instance, if the binary value on the control signal is all zeros, the 0th output line is selected and if the binary value on the control lines is *k,* then, the k^{th} output line is selected for routing the input signal. Such demultiplexers are also available in IC package. One such IC is the 1line to 8 line demultiplexer 74LS138 as shown in Fig 5.

Fig 4



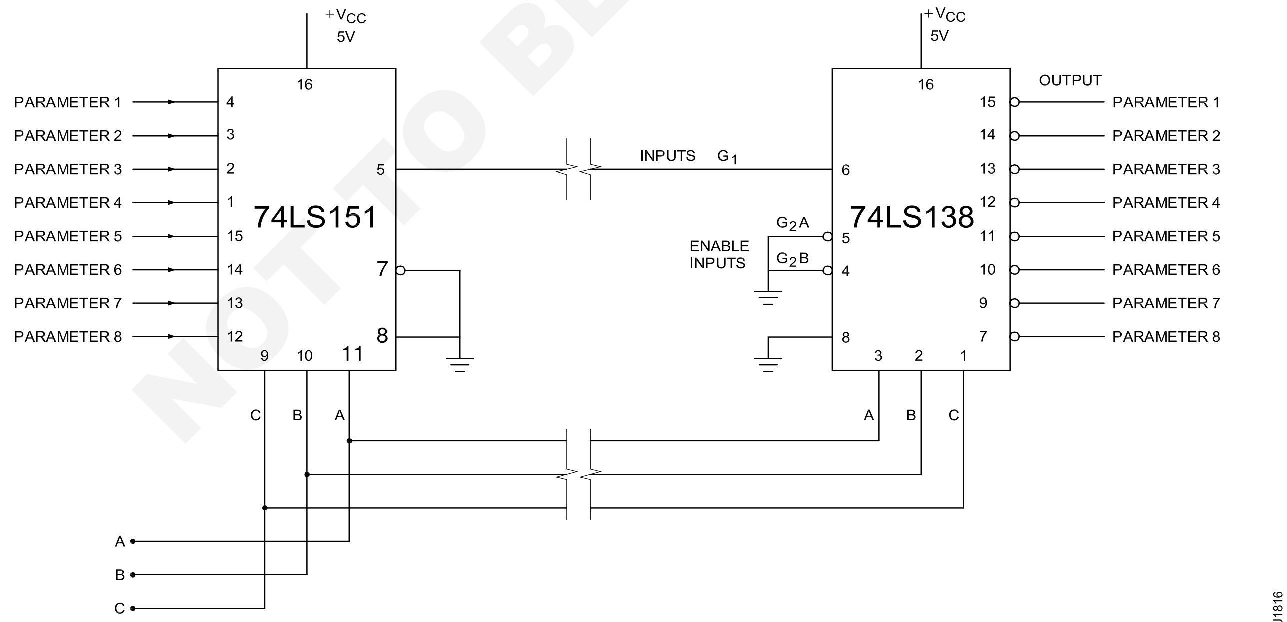
8 LINE MULTIPLEXER

Fig 5



8 LINE DEMULTIPLEXER

Fig 6



APPLICATION OF MULTIPLEXER AND DEMULTIPLEXER

Application of Multiplexers and Demultiplexers

There are almost innumerable applications of multiplexers and demultiplexers. Just to list a few are in implementing a multiplexed display, parallel to serial data converter etc.,

The application of multiplexer and demultiplexer can be appreciated in data transmission as shown in Fig 6.

In Fig 6, the eight inputs could be eight signals coming from different transducers measuring eight different type of data (say, temperature, pressure,...) in a industrial environment. At the other end the output of the demultiplexer may be fed to eight different measuring instruments meant for measuring the individual parameters.

If the control lines of the multiplexer and demultiplexer are simultaneously fed with binary signals sequentially from 000 to 111, then each of the parameter of the input at any given time is communicated over the line to the demultiplxer which in-turn routes it to meter which is meant for displaying the value of the value of the parameter.

Observe from Fig 6, that only one transmission line is used for communicating all the eight parameters at different intervals of time. This is known as *Time division multiplexing.* Hence, multiplexers and demultiplexers are invariably used in such communication. The three control lines shown in Fig 6 could even be generated at sending and receiving station independently using one of the input line as the synchronizing input.

Discuss in detail the working of the schematic diagram shown in Fig 1 of exercise 19.19 taking different control signal situations.

Analog-to-digital converter

Objectives: At the end of this lesson you shall be able to
- **explain the necessity of A to D converter**
- **explain successive-approximation method of A/D converter**
- **explain the characteristic of ADC0809 IC.**

Analog to digital conversion is the process by which an analog signal is converted to an equivalent digital signal. This conversion is necessary when measured quantities must be in digital form for processing in a computer for display or storage. For example, an A/D converter is used to change the analog output signals from transducers measuring parameter like temperature, pressure, vibration etc into equivalent digital signals. The major factors that determine the quality performance of A/D converter are resolution, sampling rate, speed and linearity. The resolution is the smallest change in voltage that can be detected by the system and that can produce a change in the digital code. The speed of a A/D converter is determined by the time it takes to perform the conversion process. The sampling rate is the no. of times per second that the analog signal can be sampled and converted into a digital code. For proper A/D conversion, the minimum sampling rate must be atleast two times the highest frequency of the analog signal being sampled to satisfy the sampling theorem. The A/D requires a voltage reference in order to achieve absolute conversion accuracy. Same A/D converter ICs have internal voltage reference whereas others accept external voltage references. Analog signal can be converted to digital codes by many methods of which successive approximation and flash A/D conversion methods are most common S/A - A/D conversion techniques is used commonly in medium to high speed data acquisition applies. It is one of the fastest A/D conversion techniques that requires a minimum amount of circuitry.

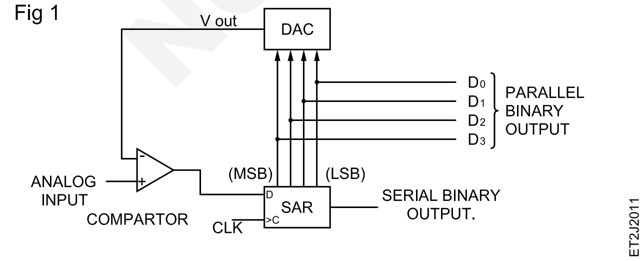
Successive-approximation A/D converter

Successive approximation is perhaps the most widely used method of A/D conversion. It has a much shorter conversion time, it also has fixed conversion time that is the same for any value of the analog input.

The Fig 1 shows basic block diagram of a 4 bit successive approximation ADC. It consists of a DAC, a successive-approximation register (SAR), and a comparator.

The basic operation is as follows:

Fig 1



The input bits of the DAC are enabled (made equal to logic-1) one at a time, starting with MSB, as each bit is enabled, the comparator produces an output that indicates whether the analog input voltage is greater or less than the output of the DAC for the corresponding I/p. If the DAC output is greater than the analog input, the comparator's output is low, causing the bit in the register to RESET. If the DAC output is less than the analog input the '1' bit is retained in the SAR register. The system does this with the MSB first, then the next most significant bit, then the next and so on. After all the bits of the DAC have been tried, the conversion cycle is complete.

Fig 2 illustrates the step-by-step conversion of a constant analog input voltage (5V in this case). Let us assume that the DAC has the following output characteristic: V_{out} = 8V for the 2^3 bit (MSB), V_{out} = 4V for the 2^2 bit, V_{out} = 2V for the 2^1 bit and V_{out} = 1V for the 2^0 bit (LSB).

Fig 2

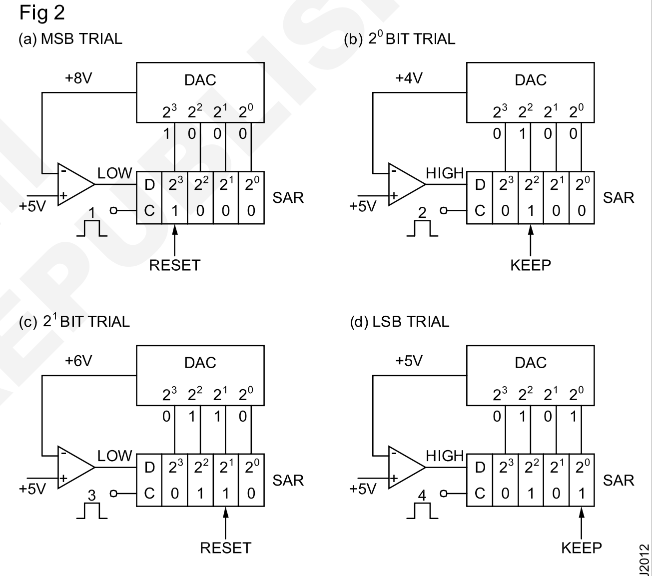


ILLUSTRATION OF SUCCESSIVE-APPROXIMATION CONVERSION PROCESS

Fig 2a shows the first step in the conversion cycle with the MSB=1, the output of the DAC=8V. Since this is greater than the analog input of 5V, the output of the DAC is 8V. Since this is greater than the analog input of 5V, the output of the comparator is low, causing the MSB in the SAR to be reset to a logic-0.

Fig 2b shows the second step in the conversion cycle with the 2^2 bit equal to a logic-1. The output of the DAC is 4V, since this is less than the analog input of 5V, the output of the comparator switches to a HIGH, causing this bit to be retained in the SAR.

Fig 2c shows the third step in the conversion cycle with the 2^1 bit equal to a logic-1. The output of the DAC is 6 volts because there is a logic-1 on the 2^2 bit input and on the 2^1 bit input 4V+2V=6V, since this is greater than the analog input of 5V, the output of the comparator. Switches to a LOW, causing this bit to be RESET to a logic-0.

Fig 2d shows the fourth and final step in the conversion cycle with the 2^0 bit equal to a logic-1. The output of the DAC is 5V because there is a logic-1 on the 2^2 bit input and on the 2^0 bit input 4V+1V=5V.

The four bits have all been tried, thus completing the conversion cycle. At this point the binary code in the register is 0101, which is the binary value of the analog input of 5V. Another conversion cycle now begins and the basic process is repeated. The SAR is cleared at the beginning of each cycle.

Analogue to digital converter ADC0808/0809 8 bit microprocessor compatible A/D converter

The ADC0808/0809 data acquisition device implement on a single chip most the elements of the standard data acquisition system. They contain an 8-bit A/D converter, 8 channel multiplexer with an address input latch and associated control logic. These device provide most of the logic to interface to a variety of microprocessors with the addition of a minimum number of parts.

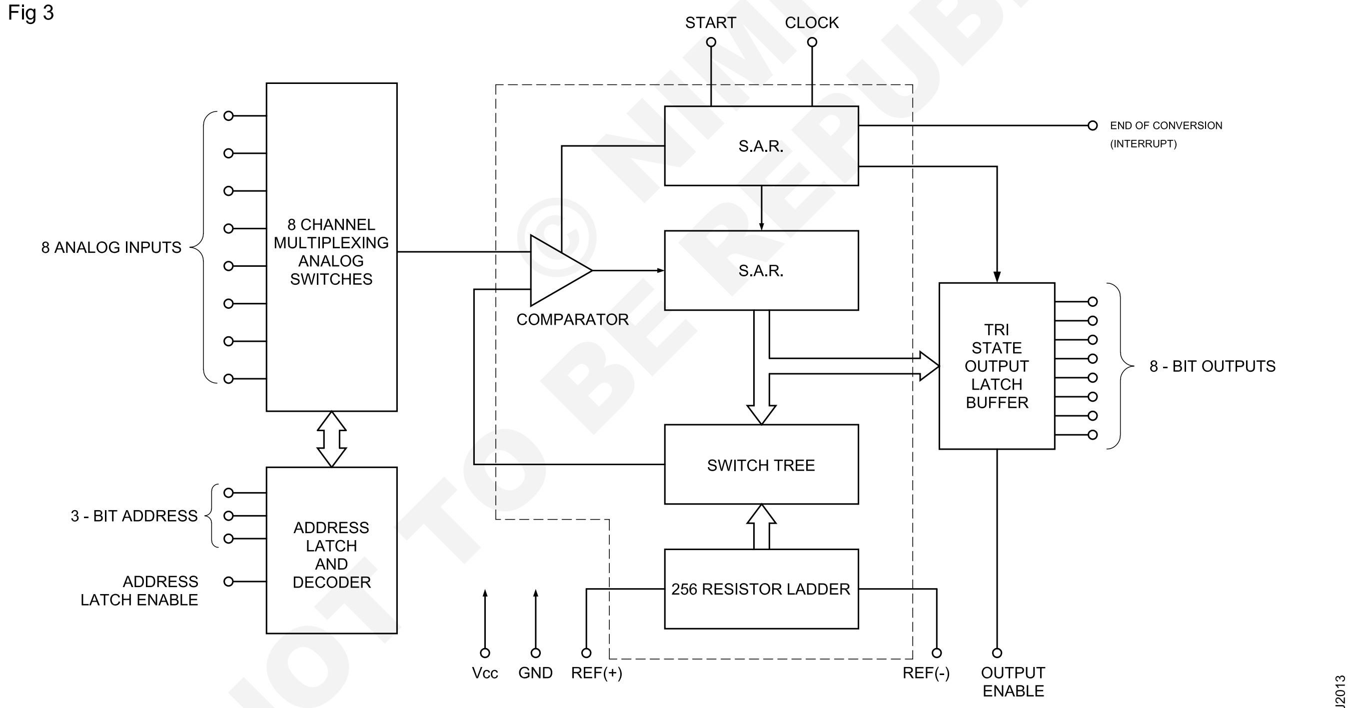
Functional description

The ADC0808/0809 shown in the above Fig 3 can be functionally divided into 2 basic sub circuits. These two sub circuits are an analog multiplexer and an A/D converter. The multiplexer uses 8-standard CMOS analog switches to provide for upto 8 analog inputs, the switches are selectively turned on, depending on the data latched into 3-bit multiplexer address register.

The second function block, the successive approximation A/D converter transforms the analog output of the multiplexer to an 8 bit digital word, the output of the multiplexer goes to one of two comparator inputs. The other input is derived from a 256R resistor ladder, which is tapped by a MOSFET transistor switch tree. The converter control logic controls the switch tree, funneling a particular tap voltage to the comparator, based on the result of this comparison, the control logic and the successive approximation register (SAR) will decide whether the next tap to be selected should be higher or lower than the present tap on the resistor ladder, this algorithm is executed 8 times per conversion, once every 8 clock periods, yielding a total conversion time 64 clock period.

When the conversion cycle is complete the resulting data is loaded into the tri-state output latch can then be read by the host system any time before the end of the next conversion. The try state capability of the latch allows easy interface to bus oriented systems.

Fig 3



BLOCK DIAGRAM OF 8 - BIT MICROPROCESSOR COMPATIBLE ANALOG TO DIGITAL CONVERTERS

Interfacing the digital and analog signals

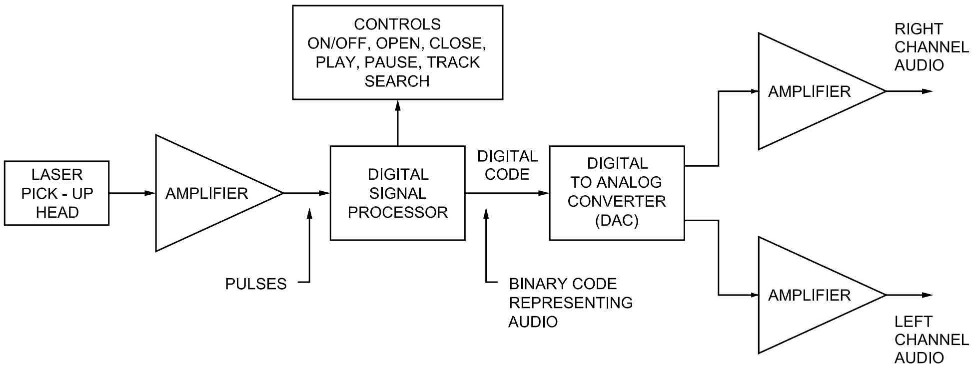
Digital-to-analog converter

Digital to analog converter is an important section in any digital system as indicated in the above two examples. OP-AMP is the most common element used in the D to A converter.

The basic problem in converting a digital signal into an equivalent analog signal is to change the 'n' digital voltage levels into one equivalent analog voltage. This can be most easily accomplished by designing a resistive network as shown in Fig 5, that will change each digital level into an equivalent binary weighted voltage or current.

The values of the input resistors network is chosen to be inversely proportional to the binary weights of the corresponding input bits, the lowest-value resistor(R) corresponds to the highest binary weighted input (2^n). The other resistors are multiples of R(2R, 4R and 8R) and correspond to the binary weights, 2^{n-1}, 2^{n-2}, 2^{n-3} ....2^{n-n} respectively.

Fig 4

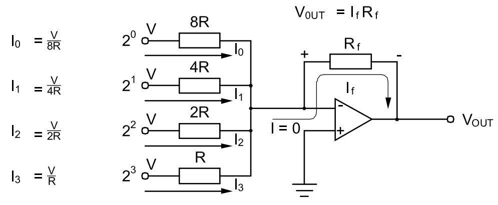


BASIC BLOCK DIAGRAM OF A CD PLAYER

ET2J2114

The I/P currents are also proportional to the binary weights, thus the o/p voltage is proportional to the sum of the binary weights because the sum of the input current is through R_f.

Fig 5



FOUR BIT DIGITAL-TO-ANALOG CONVERTOR

ET2J2115

The Fig 5 shows a 4 bit DAC, each of the input resistors will either have current or have no current, depending on the input voltage level. If the input voltage is zero (binary 0), the current is also zero. If the input voltage is HIGH (binary 1), the amount of current depends on the input resistor value and is different for each input resistor.

Since there is practically no current into the op-amp inverting input, all of the input currents SUM together and go through R_f, since the inverting input is at 0V (Virtual ground), the drop across R_f is equal to the o/p voltage, so $V_{out}=I_f R_f$.

The main disadvantage of this type of DAC is the number of different resistor values. For example, An 8 bit converter requires eight resistors, ranging from some value of R to 128R in binary-weighted steps. This range of resistors requires tolerances of one part in 255 (less than 0.5%) to accurately convert the input, making this type of DAC very difficult to mass-produce.

Shift registers, Types, applications

Objectives: At the end of this lesson you shall be able to
- **explain the basic functions of a shift register**
- **explain different configurations of shift register**
- **explain the function of IC7495 in different configurations.**

INTRODUCTION TO SHIFT REGISTERS

A shift register is a very important digital building block. Registers are often used to momentarily store binary information appearing at the output of an encoding matrix. A register might be used to accept input data from an alphanumeric keyboard and then present this data at the input of a microprocessor chip. Similarly, shift registers are often used to momentarily store binary data at the output of a decoder. For instance, a register could be used to accept output data from a microprocessor chip and then present this data to the circuitry used to drive the display on a CRT screen. Thus registers form a very important link between the main digital system and the input-output channels.

A binary register also forms the basis for some very important arithmetic operations. For example, the operations of complementation, multiplication, and division are frequently implemented by means of a register. A shift register can also be connected to form a number of different types of counters. These counters offer some very distinct advantages.

Types of registers

A register is simply a group of flip-flops that can be used to store a binary number. There must be one flip-flop for each bit in the binary number. For instance, a register used to store an 8-bit binary number must have eight flip-flops. Naturally the flip-flops must be connected such that the binary number can be entered (shifted) into the register and possibly shifted out. A group of flip-flops connected to provide either or both of these functions is called a shift register.

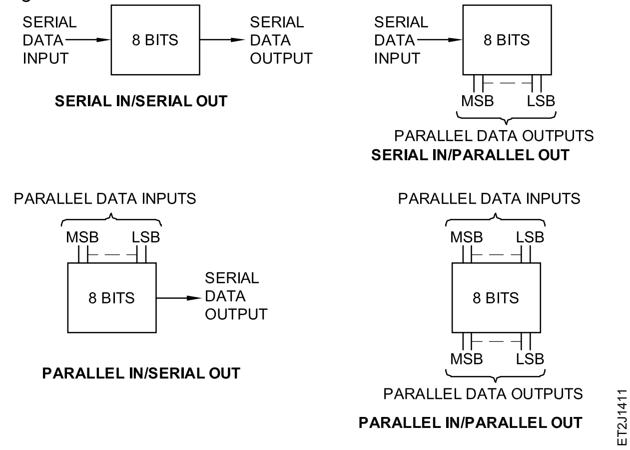
The bits in a binary number (let's call them the data) can be moved from one place to another in either of two ways. The first method involves shifting the data 1 bit at a time in a serial fashion, beginning with either the MSB or the LSB. This technique is referred to as serial shifting. The second method involves shifting all the data bits simultaneously and is referred to as parallel shifting.

There are two ways to shift data into a register (serial or parallel) and similarly two ways to shift the data out of the register. This leads to the construction of four basic register types as shown in Fig 1 -serial in - serial out, serial in -

parallel out, parallel in - serial out, and parallel in - parallel out. All of these configurations are commercially available as TTL MSI/LSI circuits. For instance:

Serial in - serial out - 54/74L91, 8 bits
Serial in - parallel out - 54/74164, 8 bits
Parallel in - serial out - 54/75165, 8 bits
Parallel in - parallel out - 54/74194, 4 bits
Parallel in - parallel out - 54/74198, 8 bits

Fig 1



The shifting capability of a register permits the movement of data from stage to stage within the register or into or out of the register upon application of clock pulses. Fig 2a to 2g illustrate the types of data movement in shift registers. The block represents any arbitrary 4-bit register and the arrow indicate the direction of data movement.

Serial in - serial out operation

The flip-flops used to construct registers are usually either JK or D types. So let's begin by summarizing the operation of JK flip-flop.

For a JK flip-flop, the data bit to be shifted into the flip-flop must be present at the J and K inputs when the clock transitions (low or high). Since the data bit is either a 1 or a 0, there are two cases:

– To shift a 0 into the flip-flop, J=0 and K=1.

– To shift a 1 into the flip-flop, J=1 and K=0.

The important point to note is that the J and K inputs must be controlled to provide the correct input data. The J and K logic levels may be changing while the clock is high (or low), but they must be steady from just before until just after the clock transition (remember, setup time and hold time). For our discussion we shall use JK master-slave flip-flops having clock inputs that are sensitive to negative clock transitions. Incidentally, this negative transition of the clock is frequently referred to as a shift pulse.

The waveforms in Fig 3 illustrate these ideas. At time A, Q is reset low (a 0 is shifted into the flip-flop). At time B, Q does not change since the flip-flop had a 0 in it and another 0 is shifted in. At time C, the flip-flop is set (a 1 is shifted into it). At time D, another 0 is shifted into the flip-flop. In essence, we have shifted 4 data bits into this flip-flop in a time sequence: a 0 at time A, another 0 at time B, a 1 at time C, and a 0 at time D.

Fig 2

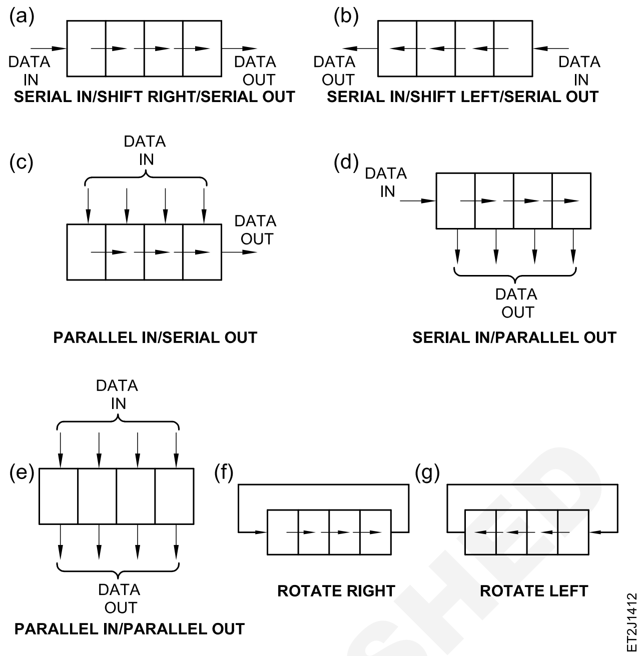
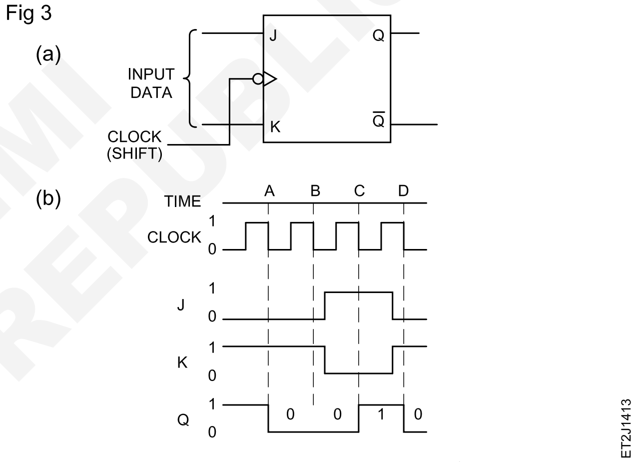


Fig 3



Now, consider adding three more flip-flops connected as shown in Fig 4. Let's begin with all the flip-flops reset and then apply the exact same input signals to flip-flop Q as we did in Fig 3. Here's what happens:

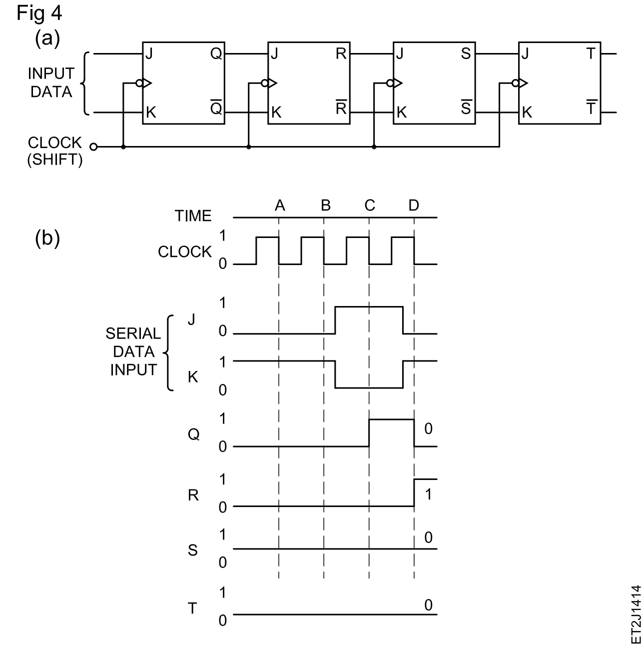
At time A: All the flip-flops are reset, so all J inputs are low and all K inputs are high. Then T is reset (the 0 in S is shifted into T). Similarly, the 0 in R is shifted S, the 0 in Q is shifted into R, and the 0 at the data input is shifted into Q. The flip-flop outputs just after time A are QRST = 0000.

At time B: The flip-flops all contain 0s. Thus the 0 in S is shifted into T, the 0 in R shifts into S, the 0 in Q shifts into R, and the 0 at the data input shifted into Q. The flip-flop outputs are QRST = 0000.

At time C: The flip-flops still all contain 0s. The 0 in S shifts into T, the 0 in R shifts into S, and the 0 in Q shifts into R, but a 1 at the data input now shifts into Q. The flip-flop outputs are QRST = 1000.

At time D: The 0 in S shifts into T, the 0 in R shifts into S, the 1 in Q shifts into R (the J input to R is high and the K input is low), and the 0 at the data input shifts into Q. The flip-flop outputs are QRST = 0100.

Fig 4

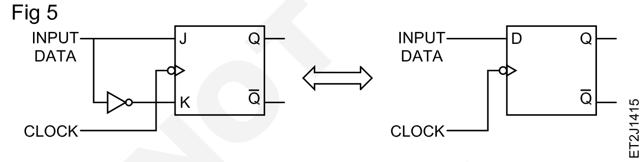


To summarize, we have shifted 4 data bits in a serial fashion into four flip-flops. These 4 data bits could represent a 4-bit binary number 0100, assuming that we began shifting with the LSB first. Notice that the LSB is in T and the MSB is in Q. These four flip-flops could be defined as a 4-bit shift register; thus this is the technique used to construct a serial-input shift register.

The serial data input for the register shown in Fig 4 requires two input signals J and K. But look carefully at the waveforms. Clearly, K = J, or J=K. In other words, one signal is always the complement of the other. If we were to connect an inverter between J and K on flip-flop Q with the input at J, therefore, we would need to have only one data input signal - the one required for J. But this is precisely a D-type flip-flop as shown in Fig 5. Remember the rules for a type D flip-flop; on the negative clock transition, the data present at the D input (either a 1 or a 0) will shift into the flip-flop.

Thus the 4-bit serial input shift register shown in Fig 5 can be constructed by replacing the JK flip-flops with type D flip-flops.

Fig 5

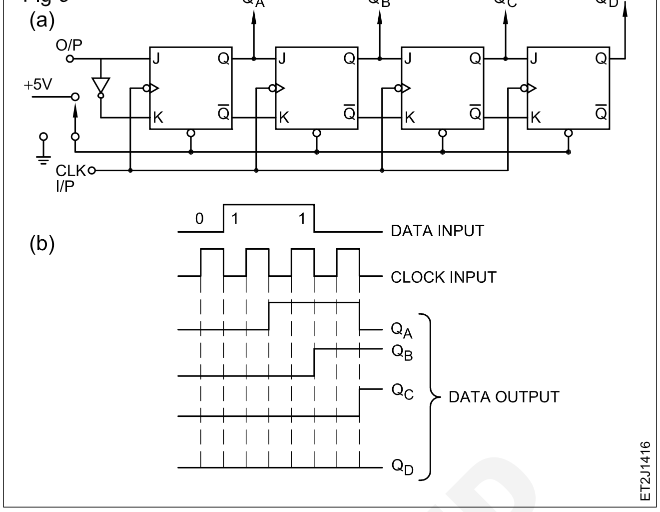


Serial in parallel out (SIPO): Data is entered serially into this type of register, and data bits are taken out of the register parallel from the output of each stage. Once the data bits are stored, each bit appears on its respective output line, and all bits are available simultaneously, rather than on a bit-by-bit basis as with the serial output.

The Fig 6a shows the SIPO shift register using J.K.flip-flops. All the inputs are tied to the compliment of J-inputs. The clock, preset and clear inputs are -ve edge triggered.

Initially all the flip-flops are cleared to logic-0 state by applying logic-0 pulse to the clear inputs.

Fig 6



The sequence of shifting logic information is shown in Fig 6b which gives waveform diagrams of data input, data output and clock input.

4-bit right-shift left-shift register IC7495: The Fig 7 shows the internal logic diagram of 4 bit shift register with parallel load capability, and with all flip-flop outputs available. This makes it possible to perform the right shift or left shift operation under control of the mode control input. For greater flexibility, the mode control selects clock-1 for the right shift mode and clock 2 for the parallel load (left shift) mode. The clock 1 and clock 2 inputs are tied together if only one clock source is required. Data transfer occurs once the -ve going edge of the clock pulse occurs.

Parallel in parallel out (PIPO): The Fig 8 shows the pins to be used for parallel in parallel out operation in IC7495. For this operation mode control should be kept at logic high. Clock 2 should selected for applying clock pulse, data inputs are to be connected to the A,B,C & D parallel inputs, data output can be taken simultaneously from Q_A, Q_B, Q_C and Q_D.

When mode control is at logic high, inverter 1 output will be at logic-0. Hence AND gates 1,3,5,7 and 9 are disabled because one of the inputs of those gates will be at logic-0. Therefore clock 1 and serial inputs will be disconnected from the flip-flops. At the same time AND gates 2,4,6,8 and 10 are enabled because, both the AND gate inputs of enabled gates will have high inputs simultaneously, when clock is high. Hence only clock 2 and parallel inputs are routed to the flip-flop inputs. Falling edge of the clock pulse, transmits the data information from parallel inputs to parallel outputs, simultaneously.

This type of register requires very less time (i.e one clock pulse) for transfer 1 set of parallel data information.

Serial in serial out (SISO): The Fig 9 shows the pins to be used for SISO operation in IC 7495. When the mode control input is at logic-0 condition inverter 1 (refer functional diagram of 7495 for inter blocks) output will be at logic-1 and that enables AND gates 3,5,7,9 and 1. AND gate-1 selects clock-1 status for triggering flip-flops through OR gate. AND gates 3,5,7,9 selects serial input data. At the same time inverter-2 output will be at logic-0 that disables AND gates 4,6,8,10 thus disconnecting all parallel inputs A,B,C

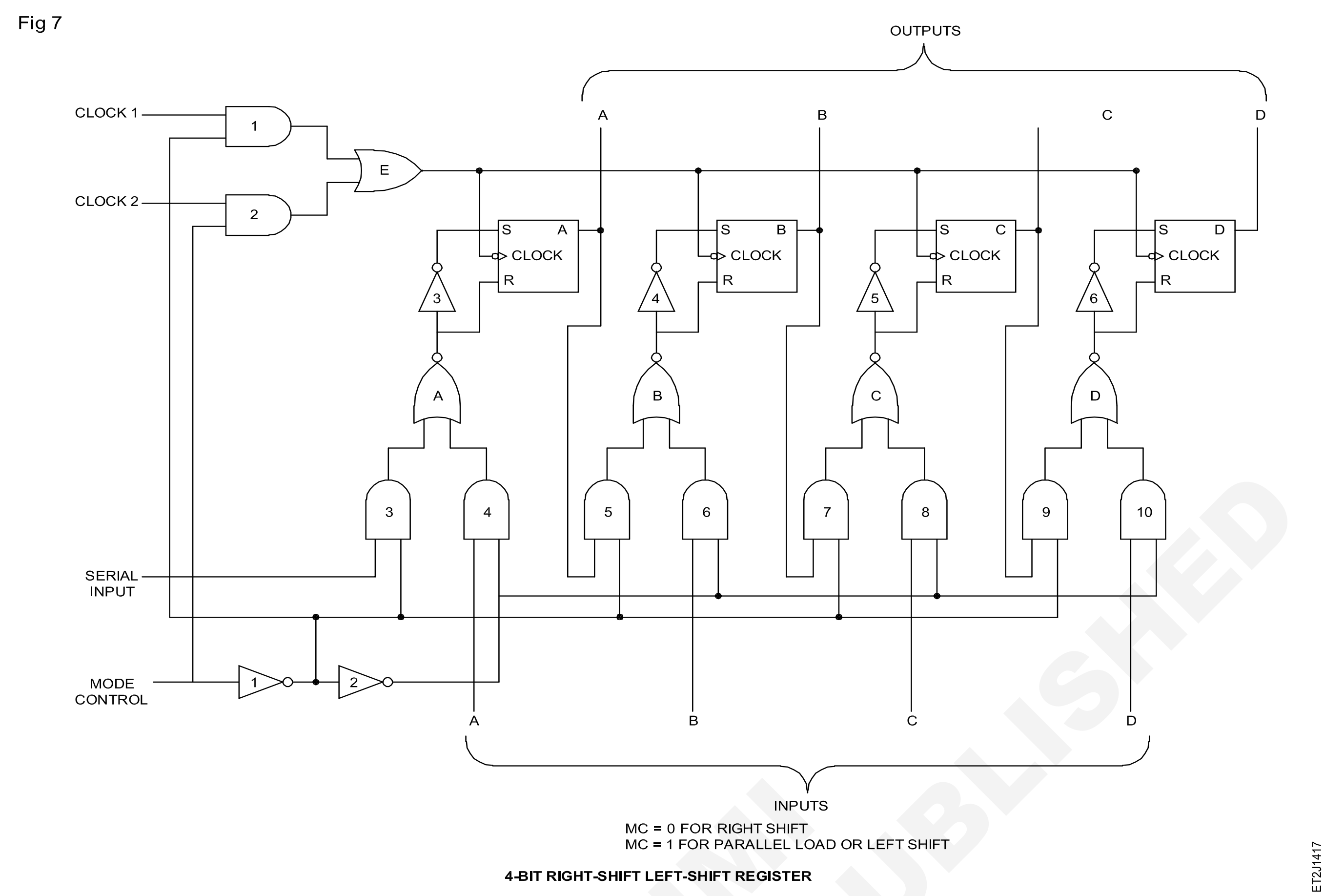


Fig 7

4-BIT RIGHT-SHIFT LEFT-SHIFT REGISTER

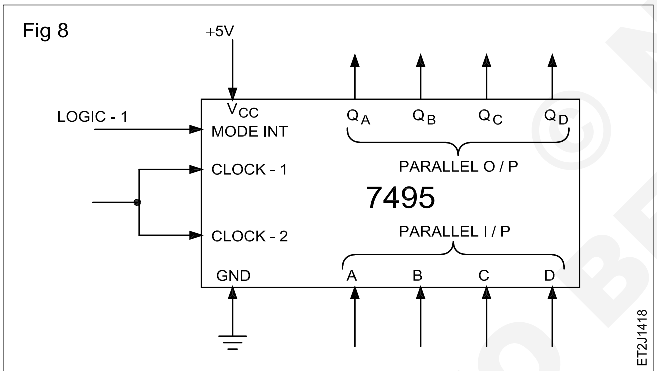


Fig 8

and D reaching flip-flop 4 clock pulses are required to transfer data from input to output of the shift register.

If the outputs are taken from all the outputs Q_A, Q_B, Q_C and Q_D, then this register works like serial in parallel out (shift right) register.

Serial in parallel out (shift left)

The Fig 10 shows external wiring diagram for serial in parallel out shift left register. For shift left operation mode control signal level should be logic-1.

Data input is applied to the parallel input-D remaining parallel inputs A, B and C receives signals from the outputs Q_B, Q_C and Q_D respectively as shown in Fig 10.

When mode control signal is at logic-1 AND gate 2 is enabled and AND gate 1 is disabled. Hence all the flip-flops get triggering pulse from clock 2. At the same time AND gates 3,5,7 and 9 are disabled and AND gates 4,6,8 and 10 are enabled, therefore parallel inputs A,B,C and D routed

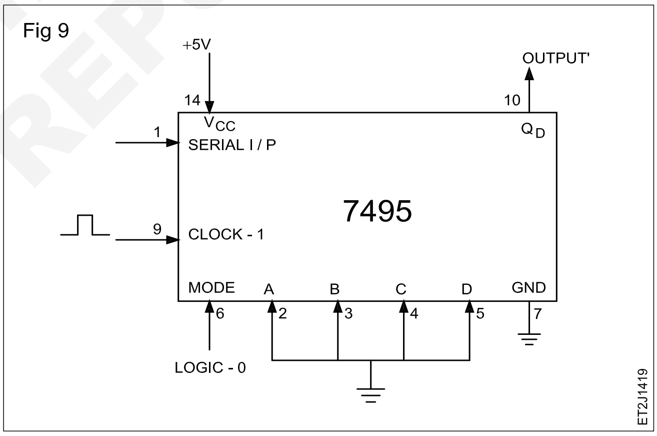


Fig 9

to the flip-flops inputs, and serial input is disabled from the flip-flops. The data input given at the D input is shifted left as the clock pulse progress. To move data from Q_D to Q_A, 4 clock pulses are required.

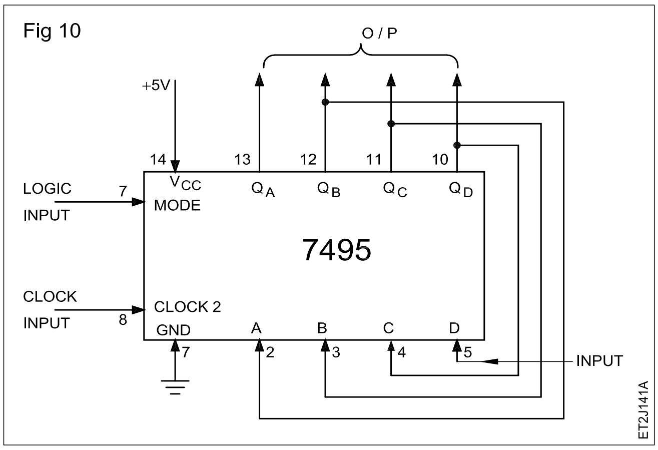


Fig 10

Series & parallel connection of batteries

Objectives: At the end of this lesson you shall be able to
- **state and describe the principle and construction of a primary cell**
- **list the common primary cells in use**
- **explain the effect of the internal resistance of a cell**
- **state the working principle of lead acid battery.**

Cell: A cell is an electrochemical device consisting of two electrodes made of different materials and an electrolyte. The chemical reaction between the electrodes and the electrolyte produces a voltage.

Cells are classified as

– dry cells

– wet cells.

Cells and batteries are classified as either dry or wet. Historically, a dry cell is one that has a paste or gel electrolyte. It is semi-sealed and could be used in any position. With newer designs and manufacturing techniques, it is possible to completely (hermetically) seal a cell. With complete seals and chemical control of gas build-up, it is possible to use liquid electrolytes in dry cells. Today the term `dry cell' refers to a cell that can be operated in any position without electrolyte leakage.

Wet cells are cells that must be operated in an upright position. These cells have vents to allow the gases generated during charge or discharge to escape. The most common wet cell is the lead-acid cell.

Primary cells: Primary cells are those cells that are not rechargeable. That is, the chemical reaction that occurs during discharge is not easily reversed. When the chemicals used in the reactions are all converted, the cell is fully discharged. It must then be replaced by a new cell. Included in the primary cell category are the following types.

– Voltaic cell

– Carbon-zinc (Leclanche cell) (Dry cell)

– Alkaline

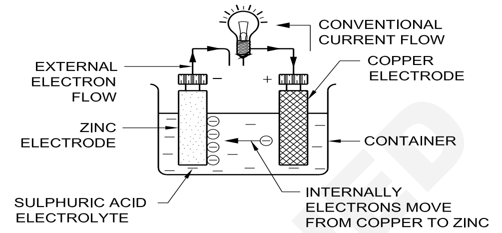
– Mercury

– Silver oxide

– Lithium

Simple voltaic cell: A voltaic cell uses copper and zinc as the two electrodes and sulphuric acid as the electrolyte. When placed together a chemical reaction occurs between the electrodes and the sulphuric acid. This reaction produces a negative charge on the zinc (surplus of electrons) and a positive charge on the copper (deficiency of electrons). If an external circuit is connected across the two electrodes, electrons will flow from the negative zinc electrode to the positive copper electrode. (Fig 1) The electric current will flow as long as the chemical action continues. In this type of cell the zinc electrode is eventually consumed as part of the chemical reaction.

Fig 1

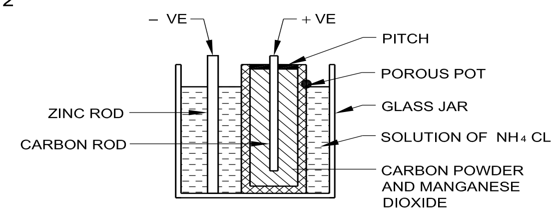


VOLTAIC CELL

The voltaic cell is also known as a wet cell because it uses a liquid solution for the electrolyte.

Leclanche cell (Carbon-zinc cells) : The container of this cell is a glass jar. The jar contains a strong solution of ammonium chloride (NH_4Cl). This solution is an alkali and acts as the electrolyte. A porous pot is placed at the centre of the glass jar. This porous pot has in it a carbon rod surrounded by a mixture of manganese dioxide (MnO_2) and powdered carbon. The carbon rod forms the positive electrode of the cell and MnO_2 acts as the de-polarizer. A zinc rod is dipped in the solution in the jar and acts as the negative electrode. (Fig 2)

Fig 2

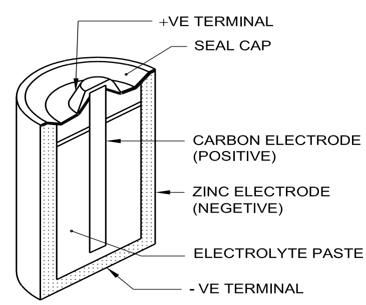


LECLANCHE CELL

Dry cell (Carbon-Zinc cell): The danger of spilling the liquid electrolyte from a Leclanche type of cell led to the invention of another class of cells called dry cells.

The most common and least expensive type of a dry cell battery is the carbon-zinc type. (Fig 3) This cell consists of a zinc container which acts as the negative electrode. In the centre is a carbon rod which is the positive electrode.

Fig 3



CARBON-ZINC DRY CELL

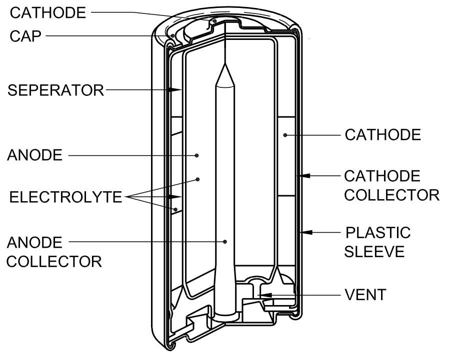
The electrolyte takes the form of a moist paste made up of a solution containing ammonium chloride. As with all primary cells, one of the electrodes becomes decomposed as part of the chemical reaction. In this cell the negative zinc container electrode is the one that is used up. As a result, cells left in equipment for long periods of time can rupture, spilling the electrolyte and causing damage to the neighbouring parts.

Carbon-zinc cells are produced in a range of common standard sizes. These include 1.5 V AA,C,D cells.

(AA Pen type cell, `C' medium size, 'D' large/economy size.)

Alkaline cells: Alkaline cells use a zinc container for the negative electrode and a cylinder of manganese di-oxide for the positive electrode. (Fig 4) The electrolyte is made up of a solution of potassium hydroxide or an alkaline solution.

Fig 4

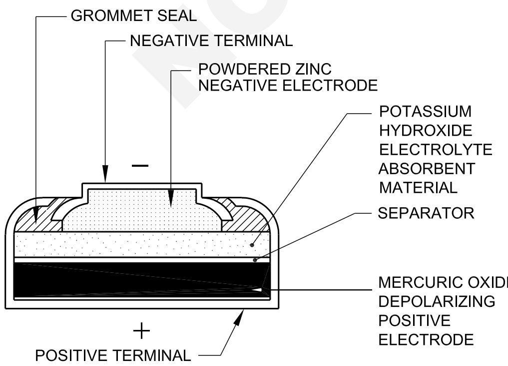


ALKALINE CELL

Alkaline cells are produced in the same standard sizes as carbon-zinc cells but are more expensive. They have the advantage of being able to supply large currents for a longer period of time. For example, a standard `D' type 1.5 V alkaline cell has a capacity of about 3.5 A.h compared with about 2 A.h for the carbon-zinc type. A second advantage is that the alkaline cell has a shelf life of about two and a half years as compared to about 6 to 12 months for the carbon-zinc type.

Mercury cells: Mercury cells are most often used in digital watches, calculators, hearing aids and other miniature electronic equipment. They are usually smaller and are shaped differently from the carbon-zinc type. (Fig 5)

Fig 5

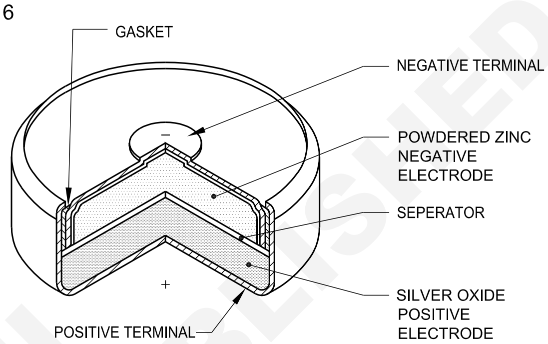


MERCURY CELL

The electrolyte used in this cell is alkaline and the electrodes are of mercuric oxide (cathode) and zinc (anode).

Silver oxide cells: Silver oxide cells are much like mercury cells. However, they provide a higher voltage (1.5 V) and they are made for light loads. The loads can be continuous, such as those encountered in hearing aids and electronic watches. Like the mercury cell, the silver oxide cell has good energy-to-weight and energy-to-volume ratios, poor low-temperature response, and flat output voltage characteristics. The structures of the mercuric and silver oxide cells are very similar. The main difference is that the positive electrode of the silver cell is silver oxide instead of mercuric oxide. Fig 6 shows the cross-section of a silver oxide cell.

Fig 6



SILVER OXIDE CELL

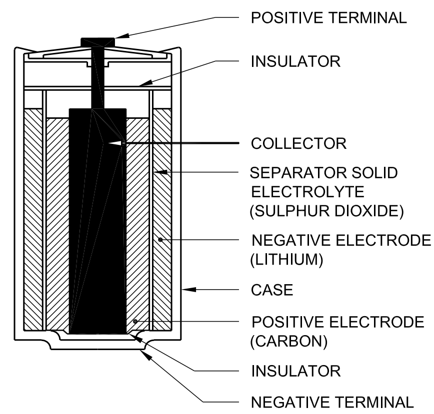
Lithium cells: The lithium cell is another type of primary cell. (Fig 7) It is available in a variety of sizes and configurations. Depending on the chemicals used with lithium, the cell voltage is between 2.5 and 3.6 V. Note that this voltage is considerably higher than in other primary cells. Two of (Fig 7) the advantages of lithium cells over other primary cells are:

– longer shelf life - up to 10 years

– higher energy-to-weight ratios up to 350 Wh/Kg.

Lithium cells operate at temperatures ranging from −50 to +75°C. They have a very constant output voltage during discharge.

Fig 7



CYLINDRICAL CELL

Uses: Primary cells are used in electronic products ranging from watches, smoke alarms, cardiac pacemakers, torches, hearing aids, transistor radios etc.

Internal resistance: The output voltage from a cell varies as the load on the cell changes. Load on a cell refers to the amount of current drawn from the cell. As the load increases, the voltage output drops, and vice versa. The change in output voltage is caused by the internal resistance of the cell.

Since materials from which the cell is made are not perfect conductors, they have resistance. Current flowing through the external circuit also flows through the internal resistance of the cell.

According to Ohm's law, a current flowing through a resistance (either external or internal) results in a voltage drop ($V = IR$). Any voltage developed across the internal resistance is not available at the terminals of the cell.

The voltage at the terminals is the voltage due to the chemical reactions minus the voltage dropped across the internal resistance. The terminal voltage of a cell, therefore, depends on both the internal resistance of the cell and the amount of load current.

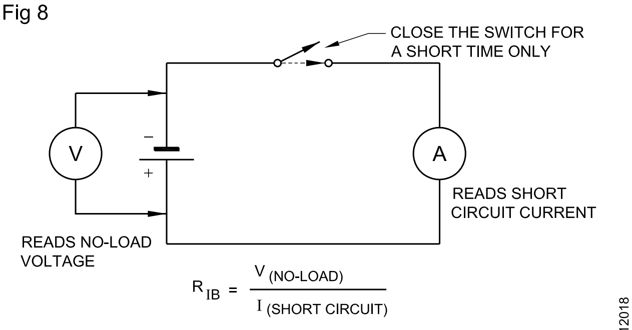
In some applications, the changes in cell terminal voltage are so small that they make no practical difference. In other applications, the changes are very noticeable. For example, when an automobile engine is started, the battery output voltage changes from about 12.6 to 8V.

The method of calculating the internal resistance of a cell is shown in Fig 8.

As a cell discharges, its internal resistance increases. Therefore, its output voltage decreases for a given value of load current.

Defects of a simple cell: With a simple voltaic cell, the strength of current gradually diminishes after some time. This defect is mainly due to two causes.

Fig 8



CALCULATING CELL INTERNAL RESISTANCE

– Local action

– Polarisation

Local action: In a simple voltaic cell, bubbles of hydrogen are seen to evolve from the zinc plate even on open circuit. This effect is termed local action. This is due to the presence of impurities like carbon, iron, lead, etc. in the commercial zinc. This forms small local cells on the zinc plate and reduces the strength of current of the cell.

The local action is prevented by amalgamating the zinc plate with mercury. To do so, the zinc plate is immersed in dilute sulphuric acid for a short time, and afterwards, mercury is rubbed over its surface.

Polarisation: As current flows, bubbles of H_2 evolve at the copper plate on which they gradually form a thin layer. Due to this the current strength falls and finally stops altogether. This effect is called the polarization of the cell.

Polarisation can be prevented by using some chemicals which will oxidize the hydrogen to water before it can accumulate on the plate. The chemicals used to remove polarisation are called de-polarisers.

COMPARISON OF COMMON PRIMARY CELLS

	Carbon -Zinc	**Alkaline-Manganese**	**Mercury**	**Silver oxide**
Negative, anode	Zinc	Zinc	Zinc	Zinc
Positive, cathode	Carbon	Manganese dioxide	Mercuric oxide	Silver oxide
Electrolyte	Ammonium Chloride	Potassium hydroxide	Potassium hydroxide	Potassium hydroxide
Nominal voltage, volts	1.5	1.5	1.35 or 1.4	1.5
Max. rated current amperes	2-30	0.05-20	0.003-3	0.1
Energy output				
Watt-hrs	22	35	46	50
Ampere-hours	2.0	3.5	6.0	8.0
Temperature range				
Storage ^{0}F	–40 to 120	–40 to 120	–40 to 140	–40 to 140
Operating ^{0}F	20 to 130	–5 to 160	–5 to 160	–5 to 160
Shelf life in months at 68°F to 80% initial capacity	6 to 12	30 to 36	30 to 36	30 to 36
Shape of discharge curve	Sloping	Sloping	Flat	Flat

Charging techniques of secondary batteries

Secondary batteries

Secondary batteries are made of small units known as cells. The main difference between a primary and a secondary cell is that a secondary cell can be recharged. This is because the type of chemicals used in a secondary cell is such, the chemical reaction is reversible.

When a secondary cell is supplying current to a load, the cell is said to be *discharging*. This discharging current gradually neutralizes the separated positive and negative charges at the electrodes (Anode and Cathode).

On the other hand, when current is supplied to a cell, the charges get re-formed on the electrodes due to reverse chemical reaction. This action is known as *charging* the cell. For charging a cell, the charging current is supplied by an external dc voltage source, with the cell behaving as a load.

The process of discharging and recharging is called *cycling* of the cell. As long as the cell is in good condition the discharge and charge cycles can be repeated several hundred times.

Since a secondary cell can be recharged, in other words the charges restored, these cells are called *storage cells*.

The most common type of secondary cell is the *Lead-acid cell*. A battery consisting of a combination of such cells is called *Lead-acid battery*. Lead-acid batteries are commonly used in automobiles such as cars, buses and lorries etc.,

Lead-acid, wet type cells

Lead-acid secondary batteries made of lead-acid are used in almost every automobile, for starting the engine. These batteries supply load current of 100 to 400A to the starter motor of automobiles.

The nominal voltage of a lead-acid cell is 2.2 V. By connecting three or six cells in series, batteries of 6V or 12V is obtained.

Principle of chemical action

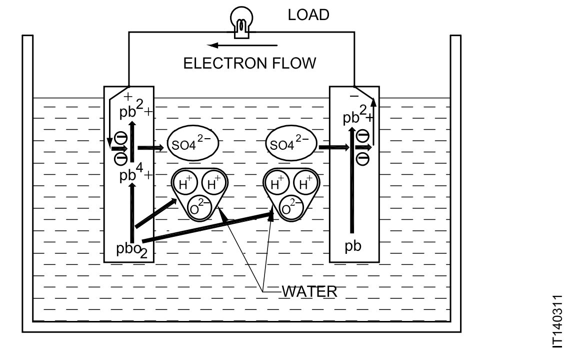
A fully charged lead-acid cell has a lead peroxide (PbO_2) positive electrode, which will be reddish brown in colour and a gray spongy lead (Pb) as the negative electrode. These two electrodes are immersed in an electrolyte which is a diluted solution of sulphuric acid (27% sulphuric acid) having a specific gravity of 1.3. Such a cell produces an output of 2.2 V.

Discharging of lead-acid cells

The chemical action that take place during the discharging of a lead-acid cell is shown in Fig 9.

During discharge, the lead (Pb) in both the electrodes react with sulphuric acid (H_2So_4) to displace hydrogen and form lead sulphate ($PbSo_4$). This lead sulphate, a whitish material, is somewhat insoluble and hence gets partially coated on both positive and negative plates. Since both plates approach the same material ($PbSo_4$) chemically, the potential difference between these plates begins to

Fig 9



decrease. At the same time, the combining of oxygen in the lead peroxide (PbO_2) with the hydrogen atoms of the electrolyte forms water (H_2O) as shown in the equation given below,

$$Pb + PbO_2 + 2H_2So_4 \xrightarrow{\text{Discharge}} 2PbSo_4 + 2H_2O$$

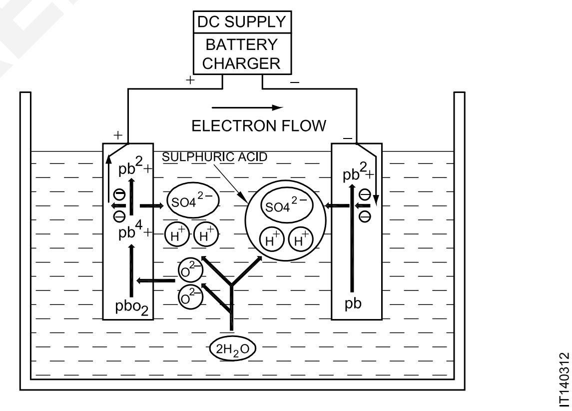
It can be seen from the discharging equation that as the battery discharges (delivers energy to a load), the sulphuric acid solution becomes weaker (more and more diluted) with its specific gravity approaching 1.0.

The coating of whitish lead sulphate on the electrodes and the decrease in specific gravity of the electrolyte makes the voltage of the cell to drop off. Also, the internal resistance of the cell rises due to the sulphate coating on the plates.

Charging of lead-acid cells

The chemical reaction that take place during charging of a lead-acid cell is shown in Fig 10.

Fig 10



When a battery charger, having an output voltage (2.5V) which is slightly higher than the nominal voltage of the cell (2.2V), is connected as shown in Fig 2, the direction of ionic flow gets reversed (refer to Fig 1 for the discharging direction).

The electrical energy supplied by the charger causes the recombination of lead sulphate ($PbSo_4$) with hydrogen ions in the electrolyte. Therefore, the excess water is removed from the electrolyte solution. As the electrolyte returns to its normal strength of sulphuric acid (27%) and the plates return to their original form of lead peroxide and spongy lead, the voltage across the electrodes returns to its nominal value of 2.2 V. The chemical action involved during charging can be represented by the following equation;

At the negative pole:

$PbSO_4$ + 2 electrons $\longrightarrow$ $Pb + SO_4$

At the positive pole:

$PbSO_4$ - 2 electrons + $2H_2O$ $\longrightarrow$ $PbO_2 + So_4^{2-} - 4H$

As the above reactions take place simultaneously, the equation can be written as,

$2PbSO_4 + 2H_2O$ + Electrical energy $\longrightarrow$ $2H_2So_4 + Pb + PbO_2$.

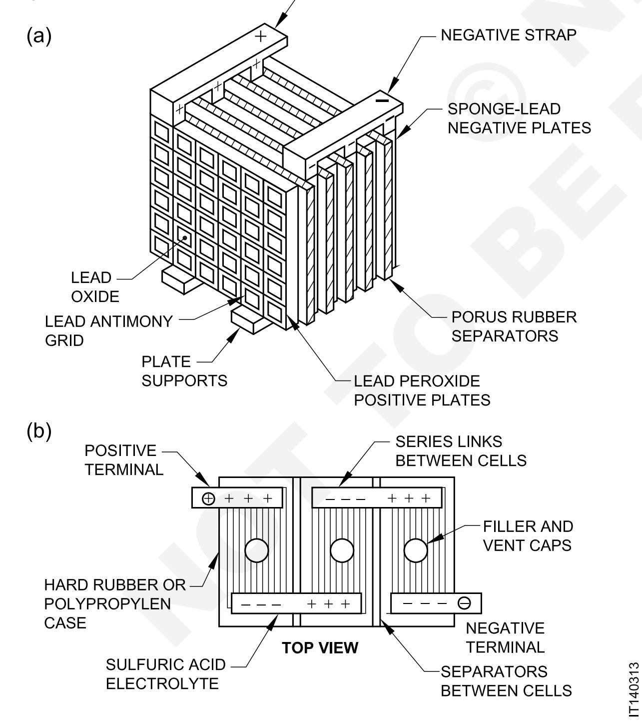
IMPORTANT TIPS: *It should be noted that, to charge a* lead-acid battery of 12 V (2.2 V x 6 cells), the output voltage of the battery charger used for charging should be between 14.1 V to 15 V, and, its current rating not larger than 30 A. Charging batteries at excessively higher currents can cause **boiling** of the electrolyte. This reduces the liquid level in the battery and causes **backing** and **crumbling** of the electrodes, thus reducing the life of the cells and hence the battery.

The lead sulphate ($PbSO_4$) which gets coated on the +ve and -ve plates tends to harden into an insoluble salt over a period of time. Hence, it is recommended to fully recharge a battery even if it is not used for quite some time.

Construction of lead-acid batteries

Fig 11 shows the principle behind the construction of commercial lead acid batteries.

Fig 11



Although in Figs 1 and 2, the lead-acid cell electrodes were shown as single plates, in a practical cell, it will not be the case. To increase the surface area and current capacity, a number of positive and negative plates are interleaved and separated by porous rubber sheets as shown in Fig 3a. All the positive plates are electrically connected, and all the negative plates are electrically connected. These parallel connections yield a higher current capacity of the cell with an overall cell output voltage of 2.2V. Several such cells can be connected in series to obtain the required battery voltage. For example, Fig 3b shows three such cells connected in series to produce a 6 volts Lead acid battery.

In lead-acid batteries, since hydrogen gas is produced during recharging, vents (holes) are provided on the battery compartment to let hydrogen and water vapour escape into free air. The vents also help in adding distilled water to the cells to compensate the water evaporated from the electrolyte.

For further details on the construction and manufacturing techniques of lead acid batteries refer reference books listed at the end of this unit.

Current rating of Lead acid batteries

The current rating of a lead acid battery is usually given in ampere-hour (Ah) units, based on an 8 hour discharge period. In other words, batteries are rated in terms of how much discharge current they can supply for a specified period of time (often 8 hours). During this time, the cell's output voltage must not drop below 1.7 volts. Typical Ah values of automobile batteries range from 60 Ah to 300 Ah.

For example, A 60-Ah battery, used in smaller automobiles, can supply a load current of 60/8 or 7.5 amperes for 8 hours without the cell voltages dropping below 1.7 volts. However, this battery can supply less current for longer time (5 amps for 12 hours) or more current for a shorter time (60 amps for 1 hour).

Effect of temperature on Ah capacity of Lead-acid batteries

As in the case of primary cells, the capacity of a lead-acid cells also decreases significantly with temperature. These cells lose approximately 0.75% of its rated ampere-hour (Ah) capacity for every 1°F decrease is temperature. At 0°F (–18°C), its capacity is only 60% of the value at 60°F (15.6°C). In cold weather, therefore, it is very important to have an automobile battery always fully charged. In addition, at very cold temperature, the electrolyte freezes more easily as it is diluted by water in the discharged condition.

TIP: *Keep the batteries always fully charged especially in cold weather conditions.*

Specific gravity of electrolyte

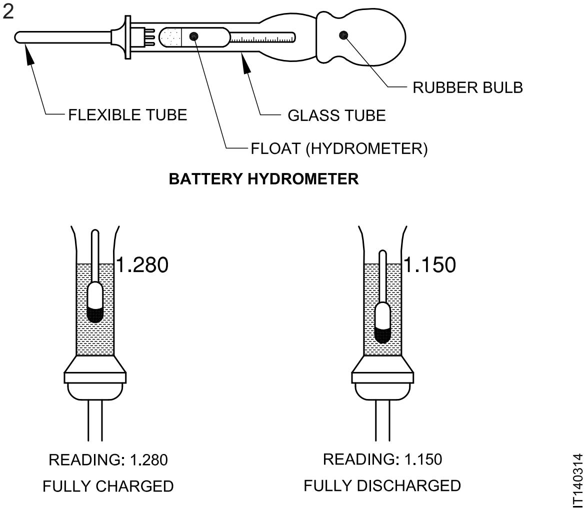
Specific gravity is a ratio comparing the weight of a substance with the weight of water. The specific gravity of water is taken as 1 as a reference. For instance, specific gravity of concentrated sulphuric acid is 1.835.

This means, sulphuric acid is 1.835 times heavier than water for the same volume.

In a fully charged lead-acid cell, the specific gravity of the electrolyte, which is a mixture of sulphuric acid and water should be 1.28 at room temperature of 70 to 80°F. As the cell discharges, more and more water gets released into the electrolyte, lowering the specific gravity. When the specific gravity of the electrolyte falls down to about 1.150, the cell can be taken as fully discharged. Hence, the state of discharge of a lead-acid cell can be found out by measuring the specific gravity of its electrolyte.

The specific gravity of electrolyte is measured using a instrument known as *Battery hydrometer* as shown in Fig 12 below.

Fig 12



The importance of specific gravity can be seen from the fact that the open circuit voltage(V) of lead-acid battery is approximately given by,

V = Specific gravity + 0.84.

For instance, if the specific gravity is 1.280 then,

V=1.280 + 0.84 = 2.12V

Recharging lead-acid batteries

Recall that lead-acid batteries are rechargeable. Once the cell voltages of a lead-acid battery falls below 1.8 V, the battery needs recharging. This discharged state of battery can be found by measuring the specific gravity of the electrolyte (1.150) or by measuring the voltage across the cells of the battery.

To charge a lead-acid battery, an equipment known as *Battery charger* is used. A battery charger is nothing but a dc voltage source which can supply the necessary voltage and charging current to the battery.

There are two main methods of charging batteries. They are;

1 Constant current battery charging

2 Constant voltage battery charging.

FLOAT Charging

In this method, the charger and the battery are always connected in parallel for supplying current to the load. The charger provides current for the load and the current necessary to keep the battery fully charged. The battery here is an auxiliary source of dc power.

Note that an automobile battery is in a floating-charge circuit. The battery charger is an ac generator or alternator with rectifier diodes driven by a belt from the engine. When the car is started, the battery supplies the cranking power. Once the engine is running, the alternator charges the battery.

Precautions for charging battery

- Batteries should never be charged or discharged at a higher rate than that specified by the manufacturer. This will weaken the plate structure and reduce battery life.
- Batteries should be recharged as early as possible after a discharge.
- The *high rate discharge tester* should be used only on fully charged batteries and that too for less than ten seconds.
- The specific gravity of the electrolyte should be checked before and after a battery is charged.
- The battery charging room should always be well ventilated for the gases to escape freely.
- If a battery is not being used for a long period, then the battery should be put on trickle charge.
- The vent plugs should be kept open while charging, for free liberation of gases.
- Avoid overcharging and discharging at a high rate. This causes the plates to bend from their position and buckle.
- Make sure that, while charging, the positive terminal of the charger is connected to the positive terminal of the battery, and the negative terminal of the charger to the negative terminal of the battery. Wrong connection causes very high current which can seriously damage both the battery and the charging unit.
- Make sure the cell temperature during charge does not exceed the limit specified (43°C) as per the manufacturer's instruction.
- The rate of charging at the end of the period called finish rate is most important. It must not exceed the value recommended by the manufacturer.
- During recharging, lead acid batteries produce flammable gases. An accidental spark can ignite these gases, causing an explosion inside the battery. Such an explosion can break the battery case and throw acid on the people and equipment in the area.
- Always wear safety glasses when working with lead acid cells and batteries. If acid does come in contact with clothing or with the skin, immediately flush with clean water. Wash your hands in soap and water after handling batteries.

Working principle of CRO

Objectives: At the end of this lesson you shall be able to
- **state the meaning of AC current and AC voltage**
- **state the method of graphically representing an electrical quantity**
- **describe the important terms used in quantifying AC**
- **state the names and functions of front panel control switches and inputs/outputs of a typical CRO**
- **state the method of measuring waveform using a CRO.**

Alternating current

Alternating current is a current that changes the direction of flow periodically, changing its instantaneous magnitude.

If an alternating current is connected to a load, then an alternating voltage is developed across the load. We often refer to this developed alternating voltage as *AC voltage*. The other way round, an AC voltage produces an alternating current through a load. Likewise, AC power refers to the power that is produced or consumed by alternating current and alternating voltage.

Waveforms

An electrical waveform could be represented by a line or a curve on a graph, as shown in Fig 1a. The line or curve is produced by plotting points on a graph and then connecting the points. The points represent the value of some electrical quantity at different times. The magnitude and direction of the electrical quantity (voltage or current) are generally indicated on the vertical axis of the graph. Time is indicated on the horizontal axis.

The waveform shown in Fig 1a represents the voltage across the resistor in Fig 1b. In this case, the units on the vertical axis is volts. The waveform shows that when the circuit is energised, the voltage rapidly increases to its maximum value (4V). The voltage remains at its maximum value until the circuit is opened. When the circuit is opened at the 14th unit of time, the voltage across the resistor suddenly drops to zero.

The waveform of Fig 1a could just as well represent the current in Fig 1b. For the current waveform the unit for vertical axis will be amperes.

Waveform polarity

In Fig 1a as can be seen, the waveform is always above the zero reference line. This means that the polarity of the plotted voltage in Fig 1b is always positive. If the waveform is in case a current waveform, then the waveform means, that the direction of the current is unidirectional or it never reverses. In other words, Fig 1a is a waveform of a steady DC voltage or DC current.

Waveforms other than pure DC waveforms are shown in Fig 2a, 2b and 2c. The most common type of AC waveform is shown in Fig 2c. This waveform is referred to as sinusoidal or sine wave.

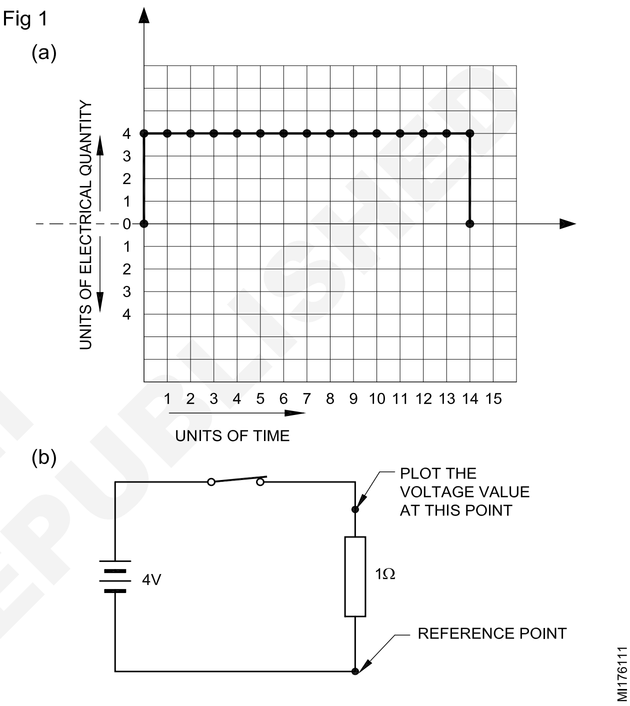
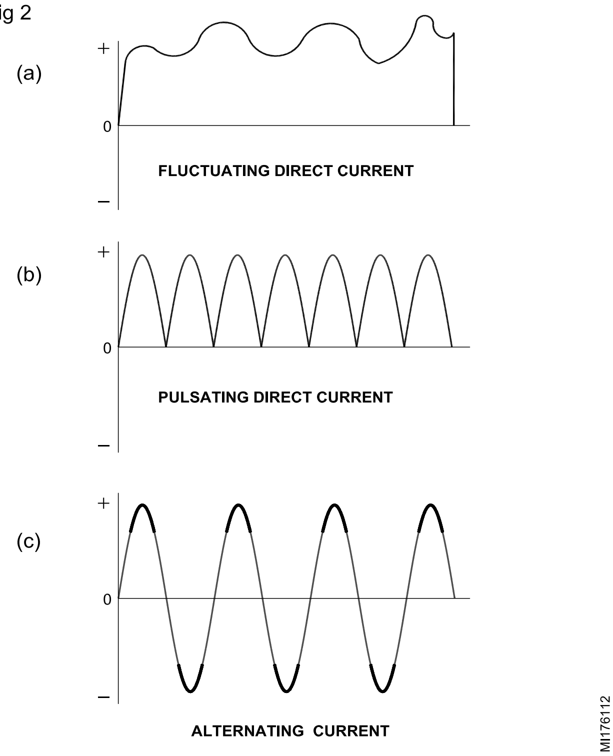
Fig 1


Fig 2


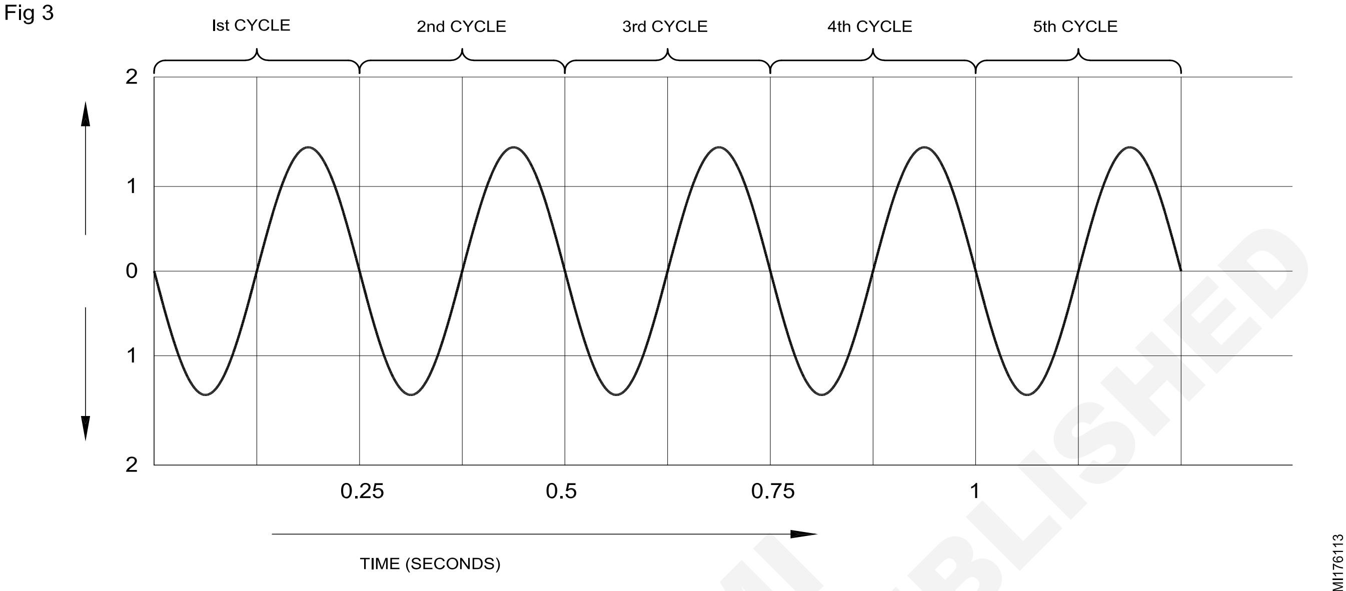
Quantifying AC

Full description of an alternating sinusoidal voltage or current requires the use of a number of terms. Some of these terms have general meanings, but, when used in electricity they have very specific meanings. The most important terms used with AC voltage and AC current are given below;

CYCLE

The waveform in Fig 3 shows five cycles of AC. Each cycle in Fig 3 is a duplicate of every other cycle in the figure.

Fig 3



The part of the cycle above the horizontal line or the zero reference line in Fig 3 is called **positive half cycle**. A half cycle is also called an **alternation**. Therefore, the positive half cycle could be called the positive alternation. The **negative half cycle**, is that part below the horizontal reference line.

PERIOD

In any AC waveform, the time required to complete one cycle is called the **period (T)** of a waveform. In Fig 3 the period (T) of that waveform is 0.25seconds.

FREQUENCY

The number of complete cycles produced in one second is called the **frequency (f)** of an AC current or AC voltage. Therefore, frequency refers to how rapidly the current or voltage changes its polarity. In Fig 3, the frequency (f) of that waveform is 4 cycles or 4 Hz.

Specifying amplitude of AC waveforms

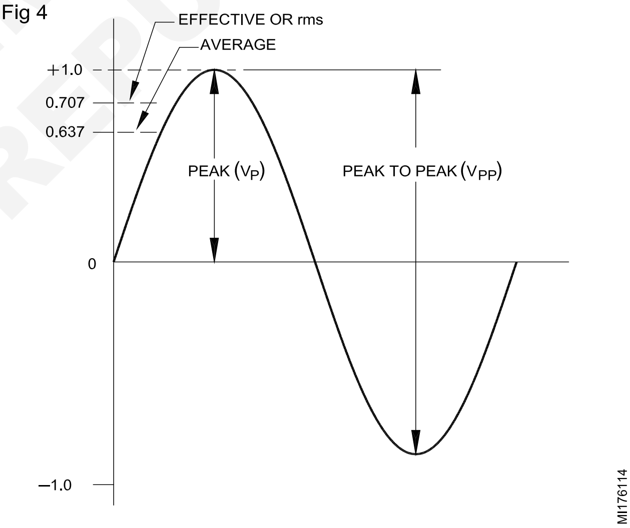
The amplitude of an AC waveform can be specified in several different ways, as shown in Fig 4. These ways of specifying amplitude are common for both voltage and current.

PEAK and PEAK-TO-PEAK VALUE

For symmetrical waveforms like sinusoidal waveform, *the peak value* (V_p), also called the maximum value, of both the positive and negative half cycle will be equal. Therefore, the *peak-to-peak value* (V_{p-p}) is twice as great as the peak value. For a sinusoidal AC voltage we can write,

$$V_{p-p} = 2\ V_p \qquad .....[1]$$

Fig 4

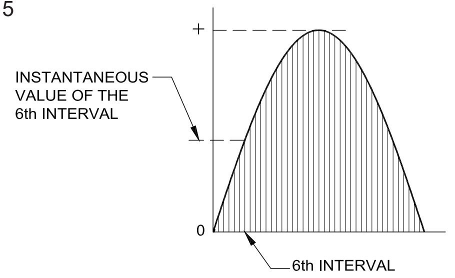


Average value

The average value (V_{av}) of a waveform is the arithmetical mean value. Finding the arithmetical mean of a +ve half cycle of a sine waveform is illustrated in Fig 5.

In Fig 5, the instantaneous values of the +ve half cycle of a sinewave waveform is determined at a number of equally spaced intervals along the horizontal axis. Then, all the instantaneous values are added together and divided by the total number of intervals. The closer the intervals, the more accurate the estimate of the average value of the waveform. In a pure sinusoidal waveform, since the +ve and -ve half cycles are the same the average value of the

Fig 5



METHOD OF DETERMINING THE AVERAGE VALUE

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The relationship between peak value and average value is indicated in Fig 4. This relationship can be written as,

$V_{av} = 0.637\ V_p$ ..... [2]

or, $V_p = 1.57\ V_{av}$ ..... [3]

The relationship between average and peak is used when analyzing circuits which convert AC voltage to pulsating DC voltage.

Example: **What is the average voltage of the +ve half cycle of a sinusoidal waveform if its peak-to-peak voltage is 300V?**

Given: $V_{p-p} = 300V$

To find: V_{av}

known: $V_{av} = 0.637\ V_p$

Solution: $V_p = \frac{V_{p-p}}{2}$

$V_p = \frac{300\ V}{2} = 150\ V$

$V_{av} = 0.637 \times 150\ V = 95.6\ V$

Answer: The average voltage of the +ve half cycle is +95.6V.

The average value of the negative half cycle of the same waveform will be – 95.6V. Hence the average value of one complete cycle of this sinewave is equal to 0.

Root-mean-square (rms) or effective value

Another most common way of quantifying AC is by stating its effective, or rms (root mean square) value. The rms value of an alternating current, is given by that steady DC current, which when flowing through a given circuit for a given time produces the same heat as produced by the alternating current by flowing through the same circuit for the same time.

For sinusoidal AC, the rms value and peak value are related by the following formulae;

$V_{rms} = 0.707\ V_p$ ..... [4]

and $V_p = 1.414\ V_{rms}$ ..... [5]

Example: **What is the peak voltage of 230 V rms main AC voltage?**

Given: $V_{rms} = 230$ V

To find: V_p

Known: $V_p = 1.414\ V_{rms}$

Solution: $V_p = 1.414 \times 230\ V = 325.22$ volts

Answer: The peak voltage of main AC is 325.22 V.

AC currents and AC voltages are usually specified in rms values. It is a common practice to assume that AC is in rms units unless a subscript "p-p" or "p" is included. For example, the voltage at the outlets in our home is specified as 230 V. This means, it is 230V rms voltage.

Waveform measuring instrument - THE CATHODE RAY OSCILLOSCOPE (CRO)

The cathode ray oscilloscope abbreviated as CRO is the most common instrument for the study of waveforms. It can be used for observing the type of waveform and for measuring voltage, frequency, time interval, and phase etc.

Chart 1 at the end of this lesson shows the front panel and controls of a simple, low cost oscilloscope.

Make a chart of the front panel and controls of the oscilloscope available in your institute for ease of understanding and use during exercises.

These oscilloscopes are generally powered by 230 Volts,50 Hz, AC mains supply. Important parts of a CRO and their functions are given below;

SCREEN

The waveforms under study are displayed on the screen. This screen on its inside surface is coated with fluorescent chemicals that glow when struck by a beam of electrons. The screen is protected by a flat piece of transparent hard plastic, called **graticule** which has vertical and horizontal calibrated lines like a graph sheet.

ON/OFF and INTENSITY CONTROL

The power ON/OFF switch for low cost CRO's are generally incorporated along with the INTENSITY control. The INTENSITY control allow the brightness of display to be adjusted.

FOCUS CONTROL

The FOCUS controls permit the beam to be focused to a fine point or to a fine line when a waveform is being displayed.

VERTICAL(Y) BEAM POSITION CONTROL

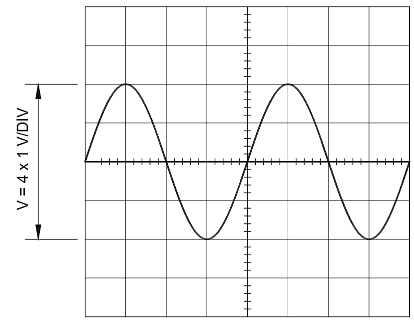
The **Y-POSITION** controls are used to move the displayed waveform or beam vertically up or down the screen, just to set it in a convenient position for viewing.

AMPLITUDE/DIVISION OR SENSITIVITY SELECTOR

The AMPL/DIV selector switches determine the sensitivity of the display to input voltages. When this control is set to 1V, that is, 1V per vertical division on the graticule, an input voltage with a peak-to-peak amplitude of 4 V, for example, would occupy four vertical divisions on the oscilloscope screen as shown in Fig 6.

In some oscilloscopes a small control knob at the centre of the AMPL/DIV control knob will be provided. This knob will permit continuous sensitivity adjustment, so that the display amplitude may be increased as desired. When the AMPL/DIV selection is to be used for measuring the amplitude of a displayed waveform, the small centre knob must be turned to its extreme clockwise or anticlockwise (calibrated) position depending on the oscilloscope.

Fig 6



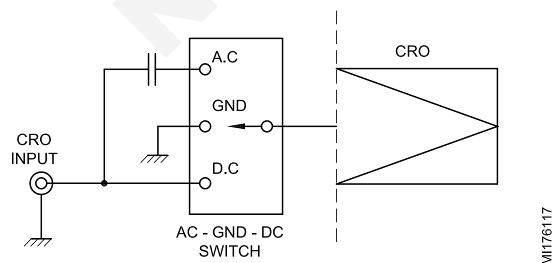
This knob is used to calibrate the AMPL/DIV when the calibration gets offset.

The typical sensitivity range available (as illustrated in chart 1) is from 2mV/division to 10V/division. In some oscilloscopes a "1 x 10" switch alongside the AMPL/DIV selector knob will be provided which allows the sensitivity to be multiplied 10 times. This selector knob is used when a higher amplitude waveform is to be displayed. Thus, the amplitude of the displayed waveform can be increased 10 times, and this tenfold increase applies to all sensitivity selections.

AC, DC, O(GND) switches

As shown in Fig 7, the AC, DC and O(ground) switches permit the input signal to be connected to the CRO input **directly (DC position)**, **CRO input grounded (O position)**, or connected **via a capacitor (AC position)**.

Fig 7



Capacitors are electronic components which allows AC to pass through it and blocks DC.

Direct connection would be required, for example, to study DC voltage levels, or to investigate AC-DC voltage combinations. Sometimes it is necessary to display an AC voltage but not the DC level it may be superimposed upon. This is achieved by setting the switch to AC, where the coupling capacitor passes the AC quantity and blocks DC.

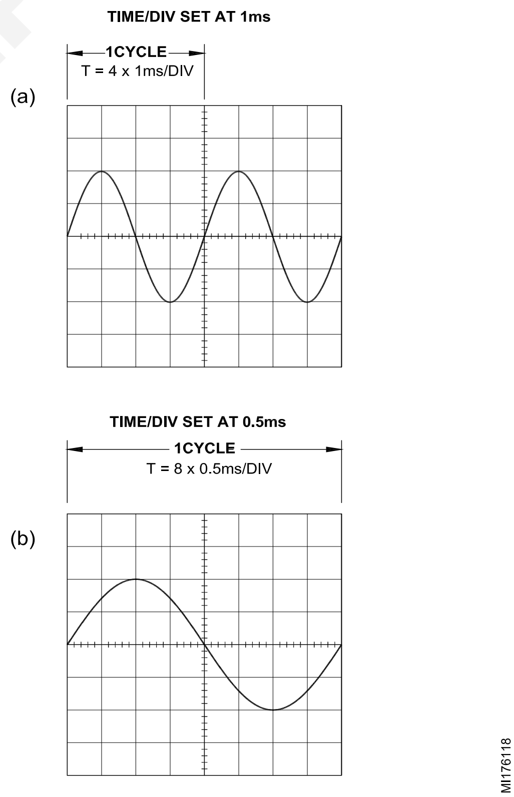
SIGNAL INPUT PORTS

The coaxial-type input connections (BNC-sockets) for each channel is given on the front panel as A and B. Two separate signals can be given simultaneously to these two inputs. This is specially useful while comparing two waveforms and while measuring phase shift.

TIME/DIVISION or TIME BASE

As already explained, the AMPL/DIV switch adjusts the vertical amplitude of the display, by selecting the voltage sensitivity. In a similar way, the TIME/DIV switch or *time base* determines the horizontal amplitude of each cycle of input waveform displayed. This control applies to both channels (A & B). Refer to the waveform displayed on the screen in Fig 8a and assume that the TIME/DIV switch is set to 1 ms (i.e., 1 ms/horizontal division on the graticule). One cycle of the waveform occupies four horizontal divisions; therefore, its *time period is 4 x 1 ms*, or 4 ms. If the TIME/DIV switch is set to 0.5 ms (i.e., 0.5 ms/horizontal division on the graticule) as shown in Fig 8b, one cycle of the wave form occupies eight horizontal divisions.

Fig 8



A typical time-base range available as shown in chart 1, is from 0.5 μs/division to 200 ms/division. At one extreme position of the TIME/DIV knob, TRIG or X EXT marking will be made. When put to this position, the internal circuits which produce horizontal motion of the electron beam will get disconnected. This allows horizontal deflection to be controlled by an external voltage connected to the CRO at the terminal marked as TRIG or X-EXT.

In some oscilloscopes a small control knob at the centre of the TIME/DIV knob will be provided for continuous time-base adjustment, so that the displayed waveform may be increased horizontally (widened) as desired. When the TIME/DIV selection is to be used for measuring the time period of a displayed waveform, the small centre knob must be turned to its extreme clockwise or anticlockwise (calibrated) position depending upon the oscilloscope.

This knob is used to calibrate the TIME/DIV when calibration gets off-set.

TRIGGERING MODE - LINE(A/B), EXT, ±, NORMAL/TV

In order to provide a useful display of waveforms, it is necessary to ensure that the display commences at the left hand side of the screen, exactly when one of the input waveforms is at its zero position. Thus, the time-base circuits are said to be triggered at this instant.

A - LINE - B positions

The triggering waveform is selected by the A - LINE - B switch. Thus, at A, the waveform on beam A (or channel A) is used to trigger the time base. Where as at B position, the waveform on beam B triggers the time base.

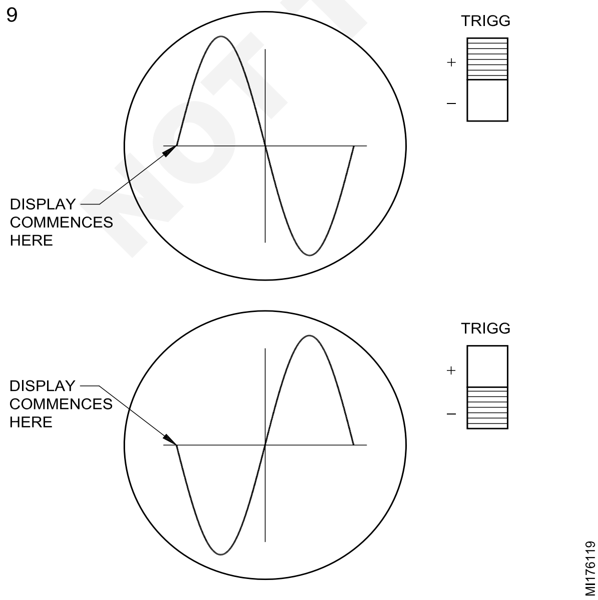
EXT position

When put to EXT, triggering is provided by an external source connected at the TRIG input terminal.

± position

Triggering may be + or - , selected by the ± switch. This simply means that the displayed waveform may be made to commence either when it is *going positive* or when it is going negative as shown in Fig 9.

Fig 9



NORMAL/TV position

The NORMAL/TV switch applies only for certain tests on television sets and for most purposes is left at the NORMAL position.

TRIG LEVEL CONTROL

The LEVEL knob is a triggering level control knob for the time-base circuits. This determines the voltage level of the trigger waveform at which the display commences. By adjusting the knob, an observable stationary waveform can be obtained on the screen.

HORIZONTAL(X) POSITION CONTROL

The X position control has a similar function to the Y position knobs. It shifts the displayed waveforms horizontally about the screen, as desired for the best viewing.

Some oscilloscopes have the **X MAGN** (X-magnification) knob which varies the sensitivity of the TIME/DIV selection. When the X MAGN is at extremely counterclockwise position (at x 1), all the TIME/DIV selections are exactly as identified. When the X MAGN control is at its extreme clockwise position (x 5), the TIME/DIV selections all have their sensitivities increased five times. X MAGN control is usually kept at its x 1 position while making measurement.

When making measurement on electronic circuits, it is often a great advantage to be able to display two different waveforms simultaneously on the CRO screen to find the relationship between these waveforms.

To enable viewing two waveforms simultaneously a control switch generally called ALT/CHOP (Alternate/chopped) is available on the front panel of CRO's.

In alternate(ALT) mode the two waveforms are displayed alternately on the CRO screen. However, due to persistence of vision, both the waveforms are seen simultaneously on the screen.

In chopped (CHOP) instead of alternative display of the full waveform only small portions of both the waveforms are displayed consecutively and alternatively. In CHOP mode the waveforms will look much brighter than in ALT mode.

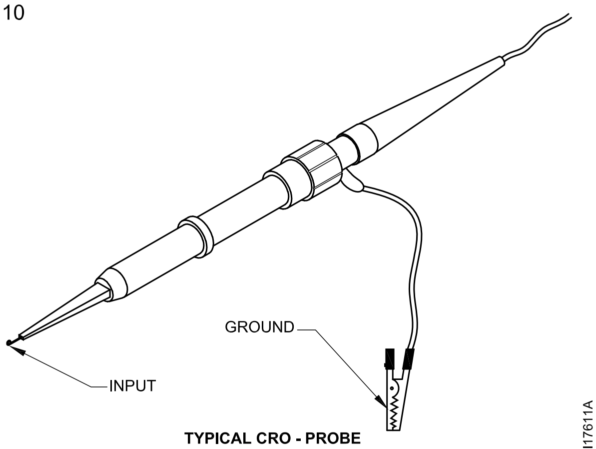
GRATICULE ILLUMINATION CONTROL

Some oscilloscopes have ILLUM switch which illuminates the graticule to enable easy reading of the waveform levels. By this the level of illumination of the graticule can also be varied depending on requirement.

OSCILLOSCOPE PROBES

The signals to be displayed on CRO are normally connected to the oscilloscope via coaxial cables called CRO probes. One end of a CRO probe will have a BNC female connector and the other end will have an insulated connecting clip as shown in Fig 10.

Fig 10

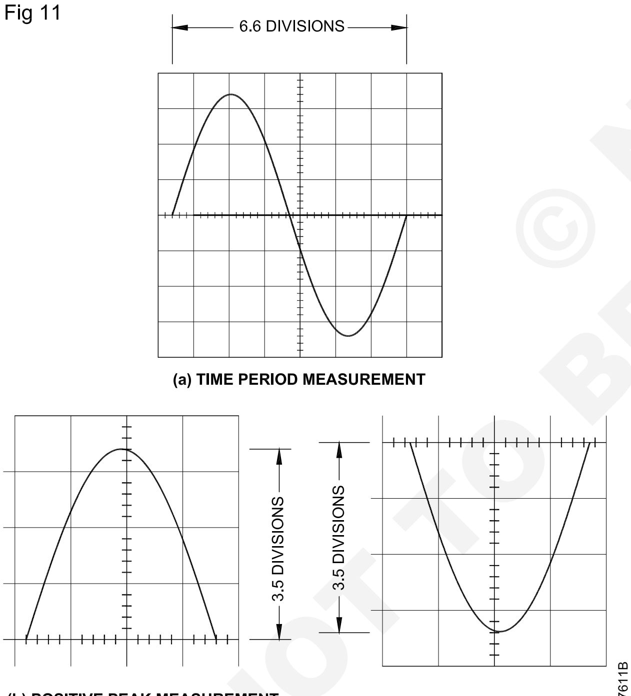


TYPICAL CRO - PROBE

Some probes termed as attenuator probes, have resistors inside them to increase the input impedance from the normal 1-MW input impedance of the oscilloscope to 10 MW. These probes also have the effect of reducing the voltage applied to the oscilloscope by a factor of 10. Thus, they are usually referred to as 10:1 probes, and the ordinary non-attenuator probes are termed 1:1 probes.

Fig 11a illustrates the method that should be used to make accurate measurement of displayed signal parameters.

Fig 11



(a) TIME PERIOD MEASUREMENT

(b) POSITIVE PEAK MEASUREMENT

(c) NEGATIVE PEAK MEASUREMENT

Steps to follow;

- By means of the appropriate Y SHIFT control, the unused beam should be shifted off the screen.
- The AMPL/Div and TIME/Div controls are then to be adjusted to give the largest possible display of one cycle of input waveform as shown in Fig 11a. Note that the small central knobs on the AMPL/div and TIME/div controls if available must be turned to calibrated position.

From Fig 11a, the time period of the waveform is 6.6 divisions x time/division setting.

Fig 11b and 11c shows how the displayed waveform should be moved horizontally by the X position control, in order to accurately measure the peak or peak-to-peak amplitude of the waveform.

From the Fig 11b and 11c, the peak-to-peak is

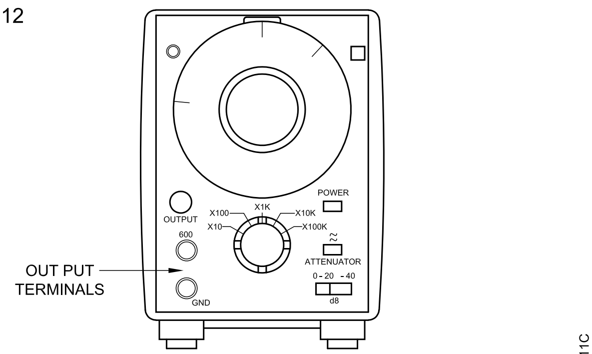
3.5 + 3.5 divisions x volts/division setting.

For specific details about the front-panel controls and inputs/outputs of the CRO used in your institute, read the CRO user manual by obtaining the same from your instructor.

AUDIO SIGNAL GENERATOR

Audio signal generators provide sinusoidal output voltage. The frequency of the output signal is usually variable from 1Hz to several tens of kilo Hz. The amplitude of output is also variable with a maximum value ranging from 10 to 20 volts peak-to-peak. Signal generators are used to inject signals into circuits such as amplifiers, allowing oscilloscope to make measurements of the gain and frequency characteristics of the circuit. Audio signal generators are generally referred to as AF generators. A typical audio signal generator is shown in Fig 12.

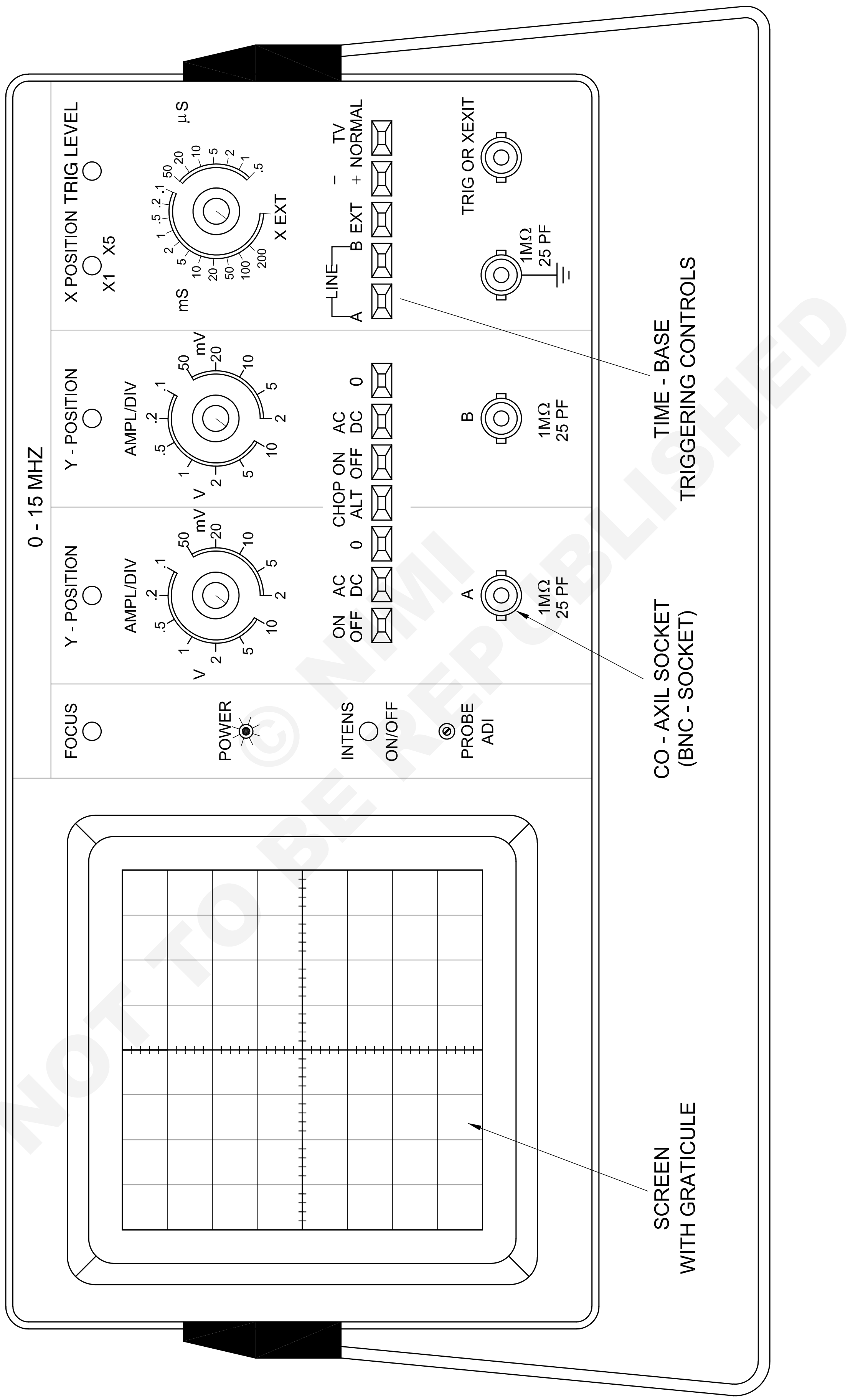
Fig 12



AUDIO SIGNAL GENERATOR

CHART - 1

Typical Oscilloscope (CRO) and Controls, Inputs and Outputs

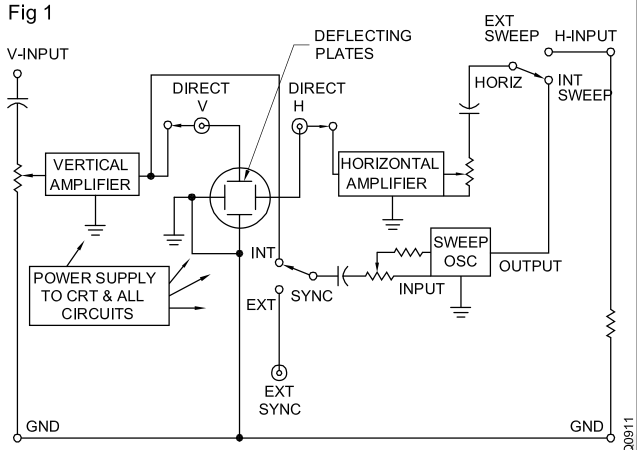


Working principle

After using the Oscilloscopes in many of the previous exercises, you must be now familiar with the use of Oscilloscope. Hence, this lesson will focus on the working principle and internal details of a typical oscilloscopes used in laboratory tests.

Oscilloscope is an electrostatic measurement device. The movable pointer is composed of electrons being subjected to applied electrostatic field to be measured. As electrons are the lightest charged particles, they can directly respond to very fast changes of the electrical field strength. The heart of a Oscilloscope is the Cathode Ray Tube (CRT) which makes the signal visible by the actio of an electronic beam.

Fig 1



BLOCK DIAGRAM OF TYPICAL CATHODE-RAY OSCILLOSCOPE

Fig 1 illustrates the simplified functional block diagram of the internal parts of an oscilloscope.

Referring to the block diagram of a general oscilloscope shown in Fig 1, observe that there are Five main functional units. These enable to display the input signal waveform.

1 Cathode Ray Tube (CRT).

2 The Vertical amplifier : This provide ample deflection of the input signal.

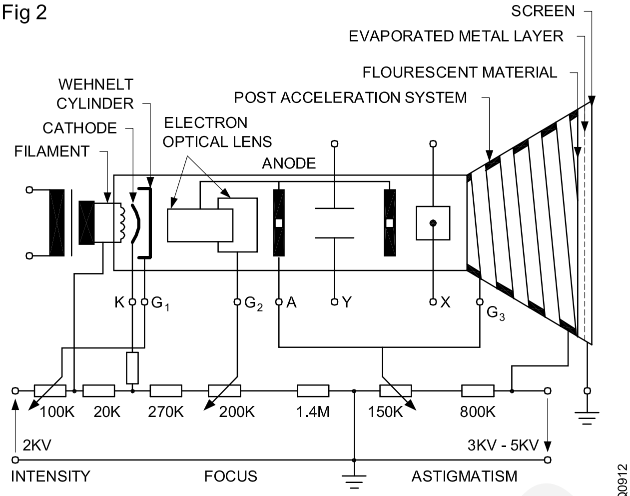
3 The Horizontal amplifier combined with the Sweep oscillator/time-base: This provide suitable time base deflection in synchronism with the input signal.

4 The Power supply: This is made-up of a low voltage section and a high voltage section. This supplies the required power to all the internal parts of the oscilloscope.

The Cathode Ray Tube (CRT)

All the parts of the cathode ray tube is housed inside an evacuated glass enclosure as shown in Fig 2. CRT produces a narrow beam of electrons from an electron gun assembly,. This beam is than accelerated and impinges at high speed on the phosphorescent coating (screen) of the tube face. The impact of the narrow beam of electrons on the phosphor produces a single small spot of light on the screen. It is this small round spot of light that traces out the pattern of the wave form as it is moved by the vertical and horizontal deflecting plates of the CRT.

Fig 2



CATHODE RAY TUBE

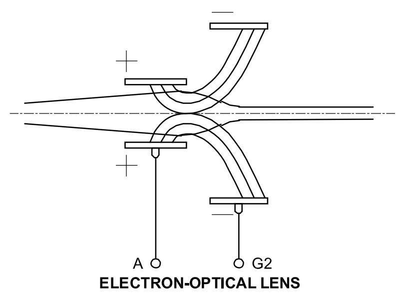
Cathode: The cathode is indirectly heated. Due to a barium oxide layer on the cathode surface, a temperature of around 800°C is needed to emit sufficient number of electrons per unit of time.

Wehnelt Cylinder: This is designed as an orifice plate. It is connected to a negative voltage towards the cathode which controls the beam and intensity with the help of P1. This way the brightness of the screen trace can be adjusted.

Electron Optical lens: This does the compression of the electron beam onto a thin line as shown in Fig 3.

The effect of the electron optical system quite similar to the effect of a convex lens on visible light. By changing the potential of G2 towards A with the help of P2, the focal length of the lens can be set to produce a depiction which is well in focus on the screen. After having passed the electron optical lens, a parallel beam is obtained having a circular cross-section of a very small diameter.

Fig 3

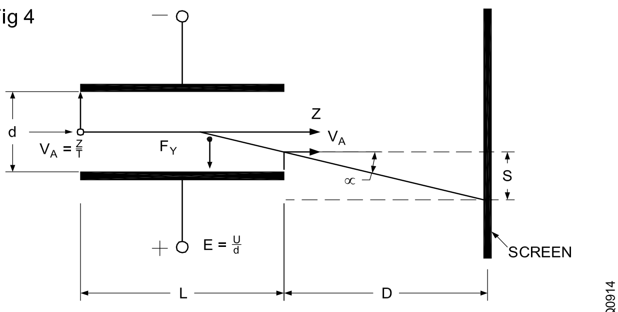


ELECTRON-OPTICAL LENS

Anode: It is the last electrode of the beam generating system. It is supplied by a voltage which may range between 1 and 5KV with respect to cathode. This high potential accelerates the electrons to a considerable high speed. This high speed (kinetic energy) is converted into a visual trace on the screen. The center of the anode is designed as a hole, hence the electrons are channeled through it and continue to travel with a constant velocity before hitting the phosphor material behind the face of the screen of CRT.

Deflection Plates: After having passed the anode opening, the electrons approach the uniform fields of the deflection plates. First they reach the Y-plates which deflect the beam in vertical direction. After that they pass the X-plates designed quite the same way as the Y-plates but turned 90 degrees towards the Y-plate. This way they deflect the beam in horizontal direction. The voltage to be measured is applied to the Y-plates, which deflects the beam by an amount (say) S as shown in Fig 4. Further details of the CRT is discussed later.

Fig 4



BEAM DEFLECTION BETWEEN THE Y-PLATES

Vertical Amplifier

The frequency response characteristics and sensitivity of the oscilloscope are determined chiefly by the vertical amplifier. Greater the sensitivity means narrower bandwidth. This is because, the product of gain times bandwidth is constant for a given amplifier.

Therefore the sensitivity of the oscilloscope is specified as so many volts/cm of vertical deflection at mid-band frequency. The 3db down response will also be specified at some specific band edge frequencies.

Sweep Oscillator

The sweep oscillator for generating the time base in a typical general purpose oscilloscope has a frequency range from say from 10Hz to 30 KHz. It is controlled by a coarse-frequency switch and a fine-frequency variable control. The scope can thus display as many as 5 cycles of a 50Hz input and 10 cycles of 300 KHz input.

Almost in all oscilloscopes the time base is synchronized, allowing a choice between "internal" and "external" synchronization. In the internal sync position, the fine-frequency control is adjusted to set the sweep frequency as close as possible to the desired sub multiple of the input signal, then a small amount of the synchronizing voltage from the input signal locks the pattern into a stationary display. Further details about triggering is discussed in subsequent paragraphs.

Horizontal Amplifier

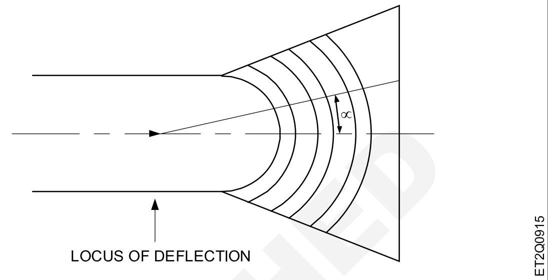
The horizontal amplifier serves two purposes. In ordinary waveform presentation, it amplifies the time-base voltage from the sweep oscillator. A control makes it possible to adjust the width of the resulting pattern. When switched out of the internal sync position, it accepts an external signal applied to the horizontal terminals and amplifies the horizontal signal to the amount required for horizontal deflection. More details about the x-deflection is discussed in further paragraphs.

Post acceleration system

A high velocity of the electrons would certainly a cause bright appearance of the depicted spot on the screen. A high speed is obtained from a high anode voltage, which unfortunately would spoil a good deflection S. But both good deflection and a bright depiction need be coped up with.

To achieve this a post acceleration system is introduced. This system does not effect the deflection angle a, but only provides additional acceleration to the electrons. For this purpose concentric rings made from graphite or a spiral are introduced into the conical part of the glass bulb as shown in Fig 5.

Fig 5

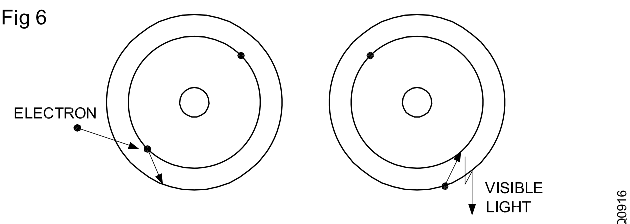


Their potential rises up to 5 kV. The rings provide areas of equal potential which are ball sections, having their centre at the locus of deflection. This design allows a post acceleration independently of the deflection angle. For any a, the electrons have to pass the same difference of potential resulting in the same final velocity for each of them. Eventually they hit the fluorescent screen with a very high speed thus producing a bright trace.

Fluorescent screen

The screen of an oscilloscope is covered from inside with a fluorescent substance which consists of zinc compounds. They differ from each other by different persistence and different colours. Once the electrons hit the fluorescent material they excite it for visible light radiation as shown in Fig 6.

Fig 6



EXCITATION MECHANISM OF THE FLOURESCENT MATERIAL

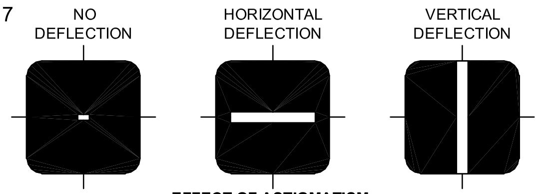
The high velocity electrons hit the atoms of the light emitting substance and they lift their electrons to orbits (around the atom core) which are of a higher energy level. They stay there for a certain short time which is typical for each substance. After that they fall back to their original orbit of lower energy level. The energy difference is emitted as a light quantum h.v ('h' being PLANCK's natural constant and v, the frequency of the radiated light).

In order to avoid a negative charging of the screen trace (due to the charges of the arriving electrons) a thin metal layer of the thickness of only a few molecules is deposited on the screen from inside. It is transparent and grounded in order to draw out the incoming charge.

Astigmatism

The cross section area of the beam should be a narrow circle, and so should the light spot on the screen. For this purpose, the electric fields of the beam generating components need be extremely symmetrical and the deflection fields should be homogenous. Because of this condition the potentials right in the middle between the y- and the x- plates need to be the one of the anode as well as the one of the orifice plate between them which serves shielding purposes. The symmetry is set to its necessary amount with the help of potentiometer P_3. In case P_3 is not properly adjusted the horizontally deflected beam may be depicted well in focus but the vertically deflected one may produce a wide screen appearance as shown in Fig 7. Modern scopes provide low tolerances for all components. So there is no need for any astigmatism potentiometer. But older types may still have it.

Fig 7



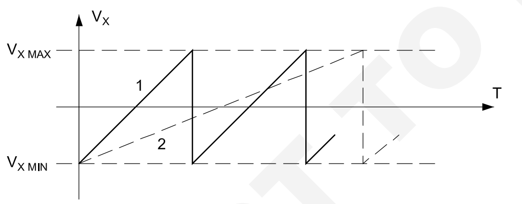
EFFECT OF ASTIGMATISM

ET2Q0917

Time base

In order to deflect the beam horizontally proportional to time a voltage V_x is needed which rises linearly with time. It is used to control the position of the light spot on the screen in x-direction. Its lowest value Vx min should set the beam to the left edge of the screen and its highest one Vx max to the right edge. The whole run should be provided repeatedly. The switching back from the right to the left edge should be effected as fast as possible. So, a saw tooth X-deflection voltage as shown in Fig 8 serves this purpose. For trace 2 the deflection is slower than for trace 1.

Fig 8



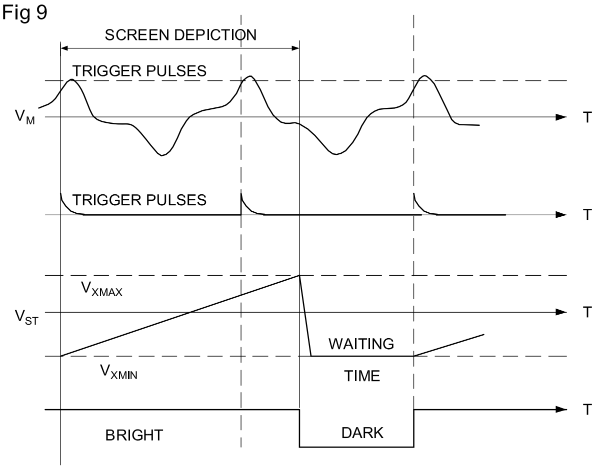
VOLTAGE ACROSS THE X-PLATES FOR FAST(1) & SLOW (2) DEFLECTION

ET2Q0918

Trigger method: The trigger instant of the saw tooth is linked to a certain instantaneous value of the **measurand**, the trigger level, and its slope. Once the trigger level is reached by V_m at a positive slope as shown in Fig 9, the beam starts at the left edge, for at that instant V_{ST} = Vx min. The light spot travels with a certain speed in x-direction across the screen according to the slope of V_{ST} and finally reaches the right edge.

V_{ST} is equal to $V_{x\,max\,then}$. Immediately after V_{xmax} was reached the beam is switched back to the left edge where the trace of the measurand during the positive slope of V_{ST}. No depiction appears during the fly back time and the waiting time of the spot.

Fig 9



VOLTAGE & SCREEN DEPICTION OF A TRIGGER SCOPE

ET2Q0919

The trigger "level" may be shifted throughout the whole voltage range between peak to peak value of the measured. Doing this the depiction appears to be shifted in x-direction.

The slope of the saw tooth voltage V_{ST} can be changed in wide range from very slow to very fast allowing to depict many periods of the measurandon the screen but also only part of it.

Power supply

Different voltages required for the oscilloscope is obtained from this unit. The exact value of voltages required for each model of the oscilloscope depends on the type of CRT used, the type of circuit components used and so..on. However essentially any CRO need a high voltage supply for the CRT and low voltage supply for the electronic circuits.

Lissajous figures

Lissajous figures are depictions of two voltages applied to the Y- and X- plates which are periodical time functions. But the depiction on the screen is independent of the time. Whether the frequencies of V_x and V_y change fast or slow is not decisive. The trace will be the same in any case.

Frequency measurements

Lissajous figures can be obtained from independent voltages V_x and V_y.In this case they are usually used for frequency measurements. The unknown frequency can be determined if the other one is known. Consider Fig 10a, the first graph depicts a voltage V_x of frequency f_x and a voltage V_y of the frequency $f_y = 2f_x$. The Lissajous figure can be sketched with the help of the voltage pairs Vx, Vy for the 9 sample points.

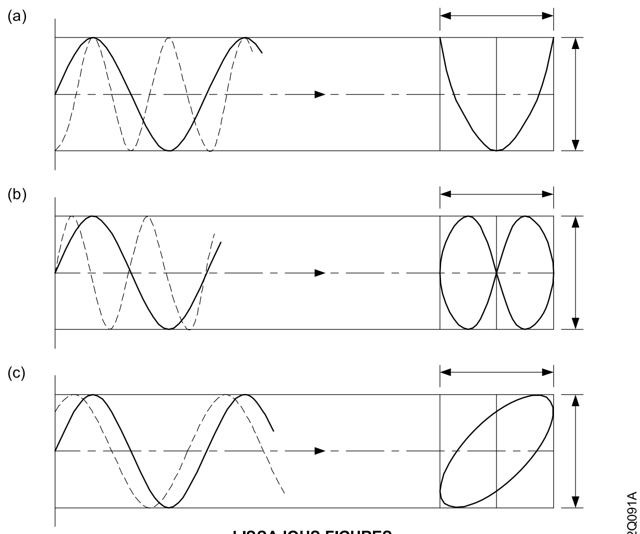
The same result for the frequency f_y is obtained from the second and third illustrations at Fig 10b and Fig 10c. But here the Lissajous figure appears quite different due to the phase shifted U_y. By these figures, if one frequency is known the other can be determined. But the ratio of f_y/f_x needs to be a proper fraction in order to obtain a standing screen depiction. This condition can be met with the help of a tunable frequency generator for f_x. As long as the frequency condition is not fulfilled the depiction changes its shape continuously.

Frequency measurements employing the Lissajous method have lost importance because electronic frequency counters provide easy handling possibilities and high accuracy.

Phase measurements

If the Lissajous figure is one continuous loop as in the third depiction of Fig 10c. The frequencies f_x and f_y are equal. In this case the figure can also be used to determine the phase angle j between V_x and V_y.

Fig 10



LISSAJOUS FIGURES

ADVANCED OSCILLOSCOPES

Dual Beam Oscilloscope

In circumstance while measuring high frequency signal a dual trace may not be fast enough to display in either its “alternate mode” or “chopping mode”. For such application the oscilloscope need to have two separate electron guns in one tube assembly. Such oscilloscopes are more expensive than general single beams oscilloscopes.

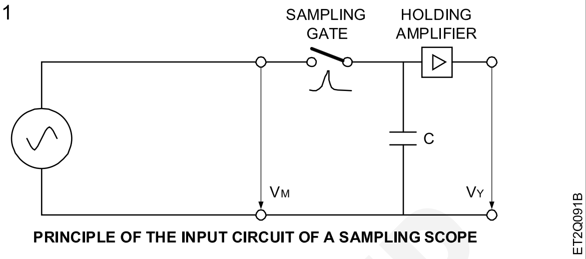
Sampling oscilloscopes

To extend the range of oscilloscopes to hundreds of megahertz, a highly effective method is used called the sampling method. This method looks at the successive points with each sweep. In this way the sweep need recur only in kilohertz range to investigate and display signals in mega and gigahertz range. By this method even though the display produced may be dotted in form, it is possible to visualize waveform patterns reasonably well.

Measurands of very high frequencies (> 100 MHz) cannot be directly depicted using the trigger method. But the sampling method can cope up with such signals in case they are periodical. The measured voltage V_m is continuously scanned by taking a sample, during each cycle. But the time instant of measurement is slightly shifted consecutively for each new sample. The principle of the input circuit of a sampling scope is shown in Fig 11.

The sampling gate is periodically activated for a very short sample time, scanning the voltage V_m which is provided by its source generator. During the sample time the capacitor C is charged. It takes over a voltage equal to the instantaneous value of V_m during the sample time. After the sampling gate has opened, the charge of the capacitor remains unchanged and so does its voltage. It is held constant until the gate is switched-on again and another V_m may change the capacitor voltage. This means: during the pause between two sample pulses, the capacitor voltage stays constant and an amplifier provides it at a higher (energy) level as V_y.

Fig 11



PRINCIPLE OF THE INPUT CIRCUIT OF A SAMPLING SCOPE

The rising signal V_m to be measured causes a trigger pulse periodically as shown in Fig 11. This in turn generate sampling pulses with a delay as shown in Fig 12. Each sample pulse connects the capacitor C for a very short time to the measurand and takes over its instantaneous voltage. Hence V_y changes in steps following V_m. If there are 10 sample pulses during 10 period durations of V_m, the voltage V_y has followed in steps only once. The x-plates are supplied by a step voltage arising in equal steps from Vx min to V_{xmax}. In this way the beam is deflected in steps from the left edge to the right edge. The step width is 1/10 of V_{xmax} - Vx min. In this way the light emitting spot on the screen leaps from one depicted dot to the other. A dotted trace occurs. It gives quite a good imagination of the actual signal.

The number of sampling pulses needed for a full depiction of one cycle, times the period duration of the measurand, equals the time for depicting the trace once. The screen shows a time expanded appearance of V_m. It is a stroboscopic presentation of the measurand.

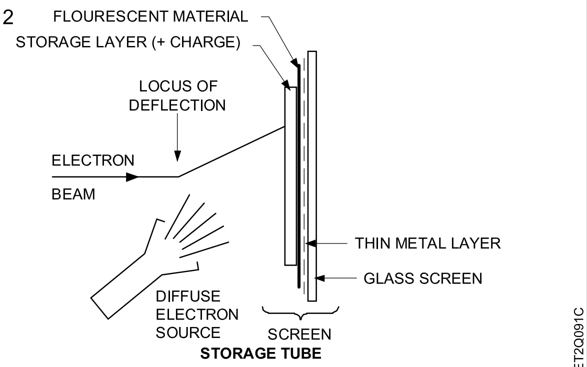
Storage Oscilloscope

The ability to store a display on the oscilloscope screen has great utility for observing the transients and other phenomenon in cased where it is not practicable to relay on photographic the trace at critical moments or in a rapidly changing circumstances. The storage oscilloscopes makes it possible to store repetitive signals from very low rates up to several hundred kilohertz and also single transients. Images of high contrast can be stored for several months . Storage oscilloscopes can provide readout for computers, printers and plotters such that leisurely examination of any waveform is possible.

CRT of Storage Oscilloscopes

Storage tube: Light emitting fluorescent substances are available with wide ranges of their persistence. But fluorescent materials with a very long persistence cannot cope with non-repetitive measurement voltages, which are available only once. The screen depiction may emerge too fast for proper assessment. In such cases storage tubes are of good advantage. The principle of action is shown in Fig 12.

Fig 12



STORAGE TUBE

Behind the screen there is additionally a storage layer, which is positively charged. Once the incoming electrons reach this layer, they neutralize it at the location of the trace to be depicted (due to their own negative charge). According to the function y(t) which the electron ray marks, a neutral trace is left behind amidst the positively charged area of the storage layer. This happens within the 'writing' mode of the scope which stores the information this way. For watching the trace, a second source needs to be employed which emits electrons in a diffused way with comparatively low kinetic energy. These electrons (uniformly distributed) are sprayed at the storage layer. At the location of the neutral trace they may pass and can excite the fluorescent layer for light emission. The trace becomes visible. At the other positively charged area the electrons cannot pass. Their negative charge recombines with the positive charges and this part of the field remains in dark. At first a bright trace (or spot) appears within a dark surrounding producing a beautiful contrast. But gradually, more incoming electrons discharge the positive area of the surrounding field and finally they all manage to pass over to the screen thus exciting light emission everywhere. The contrast emerges and the stored information disappears gradually, because the whole area gets neutralized eventually. This happens within the scope mode of 'view'. Usually a short time of viewing may be sufficient to assess the measurand. So one should switch over to the mode 'store' in order to sustain the information. The storage time ranges up to 60 hours for storage scopes these days, even for the switched off device. Advances in the technology of insulation materials provide this feature. In case a new trace should be stored, the whole layer needs be 'erased' first. This is effected by recharging its entire area positively.

Storage tubes are expensive. The most recent oscilloscopes store the information in digital memories. The most recent of storage oscilloscopes are the *digital storage oscilloscopes*. Refer books listed at the end for information on digital storage oscilloscopes.

General Accessories of Oscilloscopes

Marker Generator

The marker generator provides visual time-interval or frequency reference marks on the scope trace. Such markers can select time intervals from 1 microsecond all the way upto 5 seconds. These are particularly useful in rise-time and pulse-duration measurements.

Electronic switch

The electronic switch displays two signals simultaneously on single-trace scopes. It is essentially a square-wave generator. The two signals which are viewed are each connected to a separate grid of a dual-section amplifier tube, operating with cutoff bias. The square wave is applied in such a fashion that is alternately unblanks each tube section, thus presenting each signal alternately to the vertical amplifier of the scope, with appropriate vertical spacing between the signals. When the switching rate is high enough, each signal appears continuous, even though it is actually being periodically interrupted. Switching rates as high as 100 kilohertz are available.

Oscilloscope probes

The probe connects the test circuit to the testing instrument, without appreciably altering, loading, or otherwise disturbing the test circuit. Although probes may be given many different names, they fall into three principle types:

1 Direct probe (or test cable)

2 Circuit-isolation (or voltage-divider) probes

3 Detector (or demodulator) probe.

Direct probe

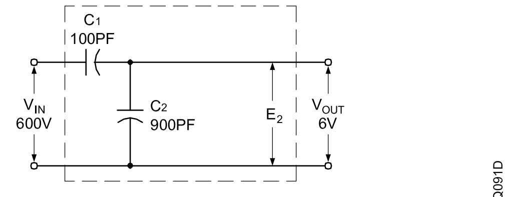
This simplest probe is a shielded coaxial cable. It avoids the stray pickup that can be troublesome when low-level signals are being examined with correspondingly high-gain settings on the scope. It is most effective in relatively low-frequency circuits, where cable capacitance is not too important, and in such cases allows the maximum sensitivity of the scope to be used. However, the shunt capacitance of the probe and cable is added to the input impedance and capacitance of the scope, and lowers the scope's response to high impedance and high-frequency circuits being tested. Where this effect becomes important, the isolation probe is used.

Isolation probe

To avoid the undesired circuit loading, the isolation probe is used to decrease the input capacitance and increase the input resistance of the oscilloscope. The low-capacitance probe attenuates the scope's input capacitance usually by a 10:1 ratio, necessarily attenuating the input signal by the same ratio. To equalize the time constant, resistors are commonly placed across the voltage-dividing capacitors.

Where it is desired to measure signals of high enough voltage to damage the scope's input circuity, signal attenuation is desired, and a high-voltage probe is used. Such a probe consists of a resistive or capacitive voltage-divider circuit as shown in Fig 13. These probes allows only a small portion of the input signal to reach the scope, but preserves the waveform accurately. When isolation probes are used to measure the magnitude of test voltages, the attenuation factor by which the probe divides the input signal voltage must obviously be known, and measurements calculated accordingly.

Fig 13



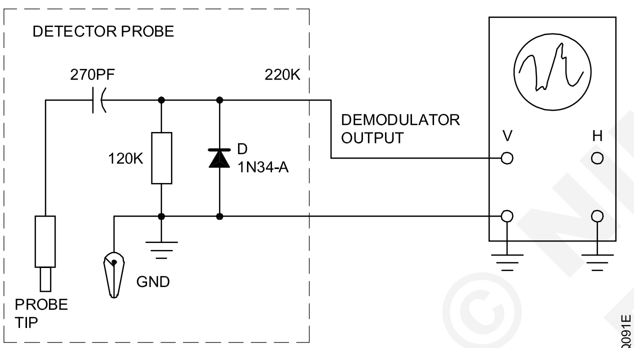
CAPACITOR VOLTAGE DIVIDER

Detector or Demodulator probe

The detector or demodulator probe is used in analyzing response to high-frequency modulated signals used in communication, as in the R-F section of AM, FM and TV receivers. By rectifying and by-passing the radio frequency, the modulation envelope is displayed on the scope. This allows a scope capable of only audio-frequency response to trace communication signals in the range of hundreds of megahertz a range which would otherwise be far beyond the capabilities of all but highly specialised scopes. The detector probe separates the audio-frequency modulation component from the radio-frequency carrier.

The detector circuit of the probe is shown in Fig 14.

Fig 14



DETECTOR (DEMODULATOR PROBE)

After being rectified by diode D, the audio signal corresponding to the original modulation is passed on to the output terminals. The resulting display of the audio signal can then be used to indicate the proper alignment and response of each tuned R-F circuit.

Summary of major applications of oscilloscopes

It would be in practical even to attempt a complete listing of all the applications of the oscilloscope. However a few major fields of application are listed below:

1 Measurements of instantaneous voltage and of current (indirectly)

2 Amplifier gain, frequency response and phase relations

3 Rise time and duration of pulses

4 Modulation percentage

5 Distortion

6 Timing comparisons of pulse trains as in ignition systems, vibration studies, telemetry and digital techniques.

7 Response of tuned circuits

8 Industrial display of non-electrical quantities, using transducers for mechanical, thermal, optical, acoustic, chemical, biological and nuclear properties.

Calibration

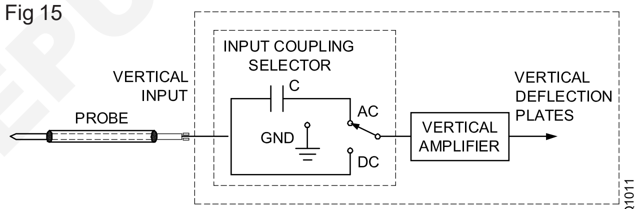
All oscilloscopes have a CAL output. The amplitude and the frequency of the calibration signals are indicated on the front panel by the side of the output. The calibration signal can be used to check the amplitude and the time base calibration of the oscilloscope.

Some oscilloscopes provide two calibration signals, both having the same frequency but different amplitudes. Oscilloscope may have two calibration signal outputs i.e. 2Vp-p at 1 kHz and 200m Vp-p should be checked with both the signals. Scope's calibration should be adjusted at regular internals.

In some oscilloscopes, the output of calibration is indicated by a glowing LED. You will find an LED near the time base setting and LEDs near the vertical deflection factor selector switches of the vertical input channels. Calibration signal is also employed to adjust the probe. The conditions of an under compensated or an overcompensated probe can be easily seen with the calibration signal used as a reference.

Vertical input coupling modes: All oscilloscopes have two vertical input coupling modes, namely AC coupling and DC coupling as shown in Fig 15. In DC coupling selection, the signal to vertical input BNC receptacle is directly routed to the input of the relevant vertical amplifier as shown in Fig 1 inside the scope. As a result, what you see on the oscilloscope is what you feed into it.

Fig 15



VERTICAL INPUT COUPLING MODES

The DC coupling mode is used in majority of oscilloscope measurements whether it is measuring DC amplitudes or seeing logic low and high levels over analysing transient and repetitive AC waveforms over the specified bandwidth of the oscilloscope. However, when it comes to measuring only the amplitude of a certain DC voltage with no intention of analysing the quality of DC or looking for presence of any noise spikes, the oscilloscope in the DC coupling mode does the job.

In the AC coupling mode, the applied signal is routed to the vertical amplifier input through capacitor (Fig 1) with the result that DC, if any, in the signal gets blocked and only the AC or the time varying part is able to get through and reach the vertical amplifier input. So the displayed waveform is not what you actually feed. For instance, if you want to analyse noise spikes or ripple content riding on a DC you would have no option other than going in for the AC coupling mode.

In the DC coupling mode, the beam would go off the screen as you increase the vertical sensitivity to get an expanded display of comparatively much smaller ripple amplitude. In the AC coupling mode, you could expand the display and make the ripple portion fill the entire screen for detailed analysis.

Gears, Belts, Stepper Motor

Objectives: At the end of this lesson you shall be able to
- **define types of Gears**
- **define types of Belts**
- **define types of Stepper Motor.**

Gears

Gears are used in most of the mechanical devices. They do several important jobs, importantly, they provide speed increase or speed reduction in motorized equipment. This is important because, often, a small motor spinning very fast can provide enough power for a device, but not enough torque. For instance, in a Laser Printer has gear reduction because it needs lots of torque to turn the Drum in the Toner cartridge, but the motor only produces a small amount of torque at a high speed. With a gear reduction, the output speed can be reduced while the torque is increased.

Belts

It is the main driving mechanism of all rotating parts. Equipments may have one or more belts to drive varies rotating parts. Belt drives are widely used in for power transmission. They are subject to rotary and push-pull motions with varying dynamic characteristics. Belts are friction drives, which mean they depend on friction between the belt and pulley/sheave to transmit power. Since it the belt which transfers the rotation to all other rotating parts, the quality of belt used should be very good. Rubber is the main material used for making the belt. A belt made of low quality rubber may become loose very soon resulting in slipping. The sides of the belt may get worn out due to it constant rubbing with other parts. Due to this, the belt tension becomes weak with use. This will make the belt slip away from the pulley or it will create irregular speed in the mechanism. Also, a low quality belt may become sticky with time and temperature.

Selection of belts

Different types of belts are available in the market in various sizes as shown in Fig 1. Belts are generally available in four types, there are four types of belts are available, they are:

1 Square type

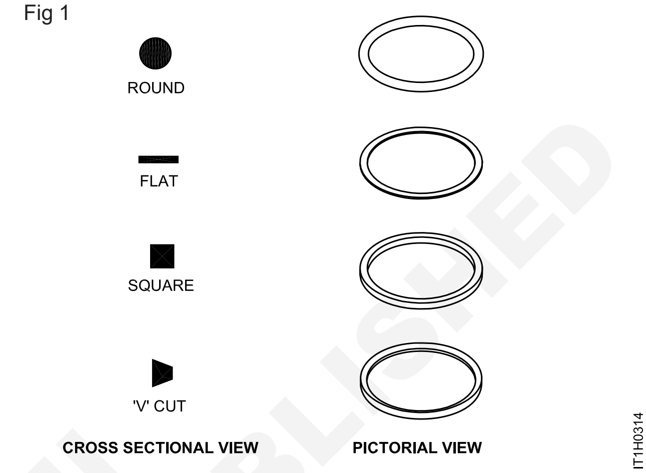
2 Round type

3 V out type

4 Flat type

5 Toothed belt/timing belt

Fig 1



While replacing belt in any mechanism the following points should be considered;

1 Always use original size of belt.

2 DO NOT compromise on the quality of the belt.

3 DO NOT use a different type of belt. (Do not use a V - type or Square type in place of a flat belt)

4 While changing the belt be sure about the pulleys through which it should be routed.

5 Do not elongate and use a belt.

A General information on stepper motors

Stepper motor: Stepper motors are special versions of the synchronous machine, in which the rotor is a permanent magnet, while the stator consists of a coil package. In contrast to synchronous motors, stepper motors have a large number of pole pairs. Motor operation requires a control unit, which energies the individual motor windings based on a certain pulse sequence. A stepper motor has a tendency to mechanical oscillation. Above its load limit it loses dynamic characteristics and may lose individual steps. Under high load the shaft may even stop. Safe positioning is therefore only guaranteed within the performance limits. If the motor is operated within its had limits, positioning without feedback of the rotor position can be achieved by linking individual steps. The operating mode (open loop control) and the durability of the stepper motor enable it to be used as a positioning drive in price - sensitive applications.

Electrical / Electronic & Mechanical Sensors

Objectives : At the end of this lesson you shall be able to
- **types of electrical / electronic sensors**
- **types of mechanical sensors**
- **explain types of sensors.**

Sensors

A sensor is a device that measures a particular characteristic of an object or system. Some sensors are purely mechanical, but most sensors are electronic, returning a voltage signal that can be converted into a useful engineering unit. Sensors take advantage of the mechanical or electrical response of its components to relate the response to a relevant quantity. Engineers use sensors in test and monitoring applications, but homeowners interact with sensors every day. Automobiles are filled with sensors, from the engine to the airbag.

Electrical / Electronic Sensors

convert desired parameter into electrically measurable signal

General Electronic Sensor

Mechanical Sensors

Mechanical sensors measure the change in a mechanical property of an object or system. The primary mechanical sensor is the strain gauge, which forms the basis of several different types of mechanical sensors. A strain gauge is a variable resistor that measures the amount of deformation that a part endures when it is affected by a force. Strain gauges form the basis of load cells, humidity sensors and pressure transducers. Another common mechanical sensor is the potentiometer, which measures angular or linear displacement.

Mechanical sensors are used for positioning and limit switch tasks on machine tools and presses, flexible production centres, robots, assembly and conveying equipment, and in machine and plant construction. For decades, they have proven their worth as the traditional strongmen of automation.

- Reliable and robust: even in harsh environments
- Flawless function in the face of vibrations, shocks, rapid temperature fluctuations, aggressive cooling lubricants, and heavy chip accumulation

Sensors

- To detect sound, e.g. piezoelectric microphones (sound waves bend the piezoelectric material, creating a changing voltage) and piezoelectric pickups for electrically amplified guitars.

Working with Relays

Objectives: At the end of this lesson you shall be able to
- **parts of a typical relay**
- **describe terms Pull-in and Drop-out**
- **explain the functions of relay parts**
- **list the classification of relays**
- **list the specifications of a relay coil**
- **list the different types of contacts in relays**
- **list a few common relay contact and spring defects.**

Introduction

In addition to solenoids, one other most popular application of electromagnets is in what are called electromagnetic relays.

Important similarities and differences between a solenoid and a relay is illustrated in Fig 1.

Electromagnetic relays

The term relay was used for the first time, to describe an invention made by Samuel Morse in 1836. The device invented by Morse was a Telegraph Amplifying Electromagnetic Device. 'This device enabled a small current flowing in a coil to switch-ON a large current in another circuit, and thus helped in relaying of telegraph signals.

In any application, the object of a relay is generally to act as a remote switch or as a electrical multiplier switch. This means, a relay enables a comparatively weak current to bring into operation a much stronger current or currents as shown in Fig 2a and Fig 2b.

In Fig 2a, a 150mA relay current can switch-ON or switch-OFF a high power motor which draws 15 Amperes. In Fig 2b, by operating the relay, multiple circuits can be switched-ON or switched-OFF.

Construction and operation of a simple relay

Electromagnetic relay is basically a switch or a combination of switches operated by magnetic force generated by a current flowing through a coil.

Fig 1

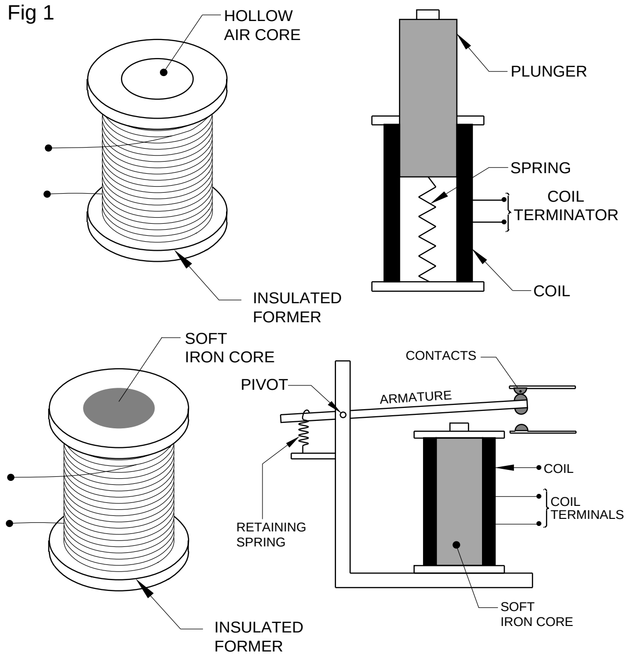
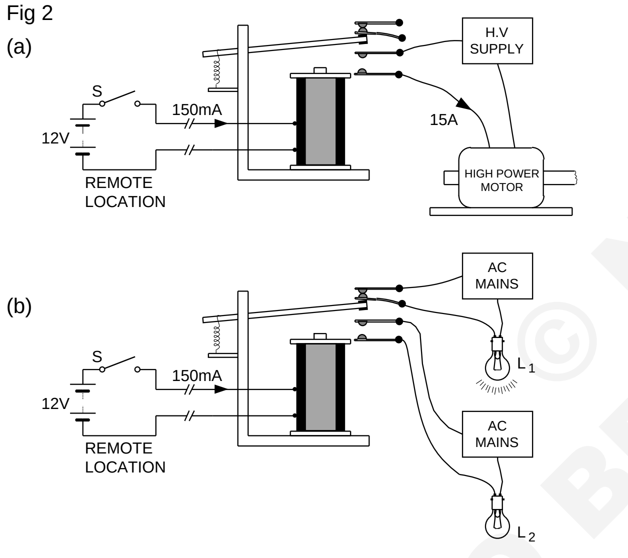


Fig 2



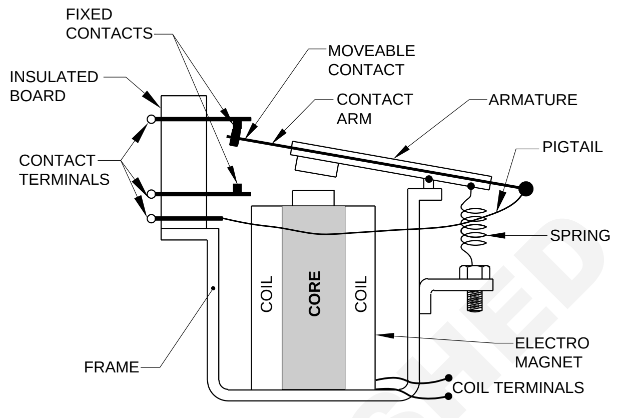
Essentially, a typical relay shown in Fig 3 consists of the following parts;

- an electromagnet comprising of a core and coil
- a movable armature, pivoted and held in tension by a spring
- a set of contacts
- a frame to mount all these components.

As shown in Fig 3, a typical relay consists of a core surrounded by a coil of wire. This is mounted on a metal frame. The movable part of the relay is the armature. One end of the armature is hinged and connected to a spring. On the armature is mounted a contact arm carrying movable contacts. The fixed relay contacts and its terminals are mounted on an insulated terminal board.

When the relay is OFF or not energized, the contact arm touches the top contact. When the relay is energized by applying voltage to the coil terminals, the metallic armature is attracted. The armature and contact arm assembly move downward so that the contact arm mounted on the armature touches the bottom contact. Thus, the relay is doing the function of a single pole, double throw (SPDT) switch.

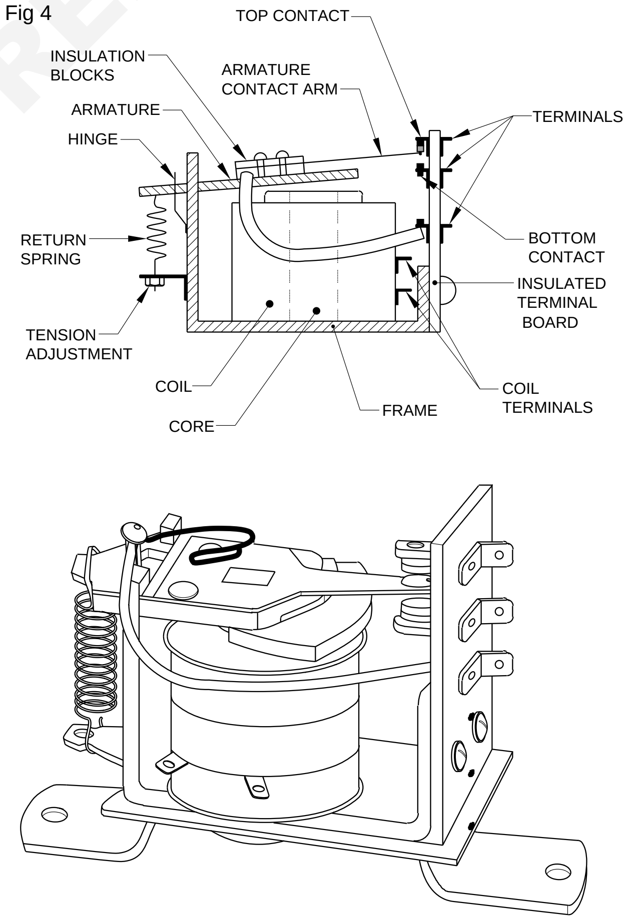
Fig 3



On removing the voltage applied to the coil, the spring attached to one end of the armature returns the armature to its original position and the contact arm touches the top contact.

The constructional details of a commercially available, most common type of relay known as a clapper type relay is shown in Fig 4. The working principle of this relay is same as explained for the relay as shown in Fig 3.

Fig 4



PARTS OF A RELAY

Each part of a relay is as important as the other in the overall performance of the relay. Details of the parts of a relay and their purpose are given below;

Frame and core : One of the main function of the relay frame is to provide a base for mounting other relay parts. But, the most important function is, the frame forms a part of the complete magnetic path between the armature and core. The core, frame and armature are made of an easily magnetizable material such as iron.

Hinges : The hinges connect the armature to the frame. A good hinge must be as free from friction as possible. They must also be strong enough to support the weight of the armature and contacts. The hinges must provide low reluctance to the magnetic flux in its path from the core through the frame and the armature.

Return springs : The springs are usually very thin and cannot concentrate any large amount of flux. Spring steel, which has a lower reluctance than other materials acts to retain its magnetism and remain attracted to the core after the relay is de-energised. Springs also have a disadvantage of being stiff and are likely to break after a few operations.

Relay coil : The coil is usually wound on a former and slipped over the magnetic core in the relay frame. This permits easy replacement of damaged coils by new ones.

Advanced intel microprocessor chips

Objectives: At the end of this lesson you shall be able to
- **identify different advanced Intel microprocessor chips.**

Processors

The processor also called as microprocessor or CPU is the brain of the PC. It performs all computing tasks and coordinates tasks done by memory, video, disk storage and other system components. CPU is the most complex chip that resides on the motherboard. Almost all modern CPUs come with an execution unit, branch predictor, floating point unit, primary cache etc.

Most processors have an internal cache which stores frequently used data and instructions. Cache is broken up into two classifications, L1 which is the internal cache and L2 which is the external cache.

Each processor have buses that go along with them. The external bus (system bus) allows the processor to connect with other devices, such as expansion cards and slots.

The data bus is used to send and receive data.

The address bus is used to describe memory address locations. Each CPU handles a different width of each of the different types of buses.

Processors speed

The clock that resides in the CPU coordinates all the activities by periodically generating a time reference signal called a clock cycle. It is specified in MHz or GHz. Some instructions require one and others require multiple clock cycles and some CPUs execute multiple instructions in one cycle. This timing depends on the architecture of the CPU, its instruction set and the specific instruction itself. Different processors have their own strengths and weaknesses. Even within a family of processors, the performance differ from one to the other. The first IBM PC CPU, the 8088 ran at 4.77 MHz, today's PC can exceed 1 GHz.

Processor architecture

Over the time, the clock speed of the processors increased. If designers have concentrated only on clock speeds the performance factor would have been only to the extent of speed factor. Recent processors work at 150 times the clock speed of PC/XTs 8088, but provide 1500 times the performance which means major architectural improvements are made in CPUs to get faster. The major architectural features of today's processor are wider data buses and registers, floating point units, pipelining and superscalar architecture.

A list of processors of different generations from a few manufacturers are given in charts 2 & 3.

LGA115x-based Processors Microprocessor 8088

It comes in 40 pin DIP socket from INTEL

Operating Frequency : 5 MHz or 8MHz

This microprocessor was used for many applications which do not require the use of complex calculations. Typical applications include word processing, data processing, games, spreadsheets and some programs which do not require the Windows environment.

Microprocessor 80286

It comes in 68 pin package.

Operating Frequency 12 MHz, 16 MHz, 20 MHz or 25 MHz.

This microprocessor was used for many applications which do not require the use of high efficiency calculations. Typical application includes word processing, data processing, games, spreadsheets and some programs which do not require the Windows environment. Feature with managing functions involving multi tasking and multiuser functions.

Microprocessor 80386SX

It comes in 100 pin mounted from INTEL

Operating Frequency: 25 MHZ, 33MHz or 40 MHz

This is a low power version of microprocessor 80386DX. This inexpensive microprocessor ideal for word processing, simple games and Network Node (where the data processing is to quite simple nature) and you can run Windows 3.1

Microprocessor 80386DX:

It comes in 132 pin PGA socket from INTEL

Operating Frequency : 25 MHz, 33MHz or 40 MHz

Useful for most Windows based applications and 2-D imaging. Although, working Windows 3.11 applications is quite convenient with this microprocessor. But if the numeric coprocessor not installed then this inexpensive microprocessor is ideal for Network Server which does not require use of high efficiency numeric calculations. Such applications are rather simple in nature and require the microprocessor basically for managing purposes.

Microprocessor 80486SX

Type of connector: Socket 3 ZIF (Zero Insertion Force) from INTEL

Operating Frequency: 25MHz, 33MHz, 40MHz

Useful for most Windows based applications and 2-d Imaging. But if you are using Windows 95, you will feel that your application is running rather slow. Although working with Windows 3.1 applications is quite convenient with this microprocessor. If the numeric coprocessor is not installed then this inexpensive microprocessor is ideal for Network Server which does not require the use of high efficiency numeric calculations. Such applications are rather simple in nature and require the use of microprocessor basically for managing purposes.

Microprocessor 80486DX/DX-2/DX-4

Type of connector: socket 3 ZIF (Zero Insertion force) from INTEL

Operating Frequency: 25MHz, 33MHz, 40MHz, 50MHz, 66MHz, 80MHz, 100MHz or 120MHz

Comments: A version of 80486 use ful for most Windows based applications and 2D imaging. But if you are using Windows 95 you will feel that your application is running rather slow. Although working with Windows 3.1 applications is quite convenient with this microprocessor.

Microprocessor Pentium

Type of connector : Socket 7 ZIF (Zero Insertion Force) from INTEL

Operating Frequency: 75MHz to 233MHz

Comments : Useful for most Windows based applications. Versions with lower clock speeds might make you feel uncomfortable when you work on 3D imaging. But if you are using Windows 98, you will fee that your application is running rather slow. Although working with Windows 95 applications is quite convenient with this microprocessor. Better still, select a Pentium processor supporting MMX technology.

Microprocessor Pentium Pro

This Microprocessor is manufactured by INTEL

Type of connector : Socket 8 ZIF (Zero Insertion Force) from INTEL

Operating Frequency : 233 MHz to 300 MHz

Comments : Useful for most Windows based applications, Web surfing, and 2 D imaging. Versions with lower clock speeds might make you feel uncomfortable when you work on 3 D imaging. Working with Windows 98 applications is quite convenient with this microprocessor.

Microprocessor Celeron

This microprocessor is manufactured by INTEL

Type of connector : Slot 1 or Socket 370 ZIF

Operating Frequency : 266MHz to 450MHz

Useful for most windows based applications, multimedia and web surfing, 2D imaging. Versions with lower clock speeds might make you feel uncomfortable when you work on 3D imaging.

Microprocessor Pentium II

This microprocessor is manufactured by INTEL

Type of connector : Slot 1

Operating frequency : 300 MHz to 550 MHz

Useful for Multimedia 3D virtual worlds, Video conferencing, Internet, PC imaging and some other new Windows based applications.

Microprocessor MXI (cayenne)

This microprocessor is manufactured by Cyrix

Type of connector : Socket 7

Operating Frequency : 400 MHz upwards

A completely new design. Suitable for Multimedia, 3D virtual worlds, video conferencing, internet, PC imaging and some other new Windows based applications.

Microprocessor K6-3 (sharptooth)

This microprocessor is manufactured by AMD (Advance Micro Devices)

Type of connector: Socket 7

Operating Frequency: 350 - 450 MHz

This is an advanced version of the K6-2 microprocessor of the same company. Suitable for Multimedia, 3D virtual Worlds, Video Conferencing, Internet, PC imaging and some other new Windows based applications. This microprocessor is expected to be faster than the Pentium II at the same clock speeds.

Microprocessor Pentium III

This microprocessor is manufactured by INTEL

Type of connector : Slot 1

Operating Frequency : 450 MHz upwards

This microprocessor is an improved version of pentium II and it is very suitable for Multimedia, 3D Virtual worlds, Video conferencing, internet, PC imaging and some other new windows based application.

Microprocessor K7

This microprocessor is manufactured by AMD

Type of connector: Slot A(Alpha EV-6)

Operating Frequency : 500MHz upwards

This is an advanced version of the K6 microprocessor from the same company. Suitable for Multimedia, 3D virtual worlds, Video conferencing, Internet, PC imaging and some other new windows based applications.

Microprocessor M III (JALAOENO)

This microprocessor is manufactured by cyrix.

Type of connector: Super 7

Operating Frequency: 600 MHz upwards

A completely new CPU design. Suitable for Multimedia, 3D virtual worlds, Video conferencing, Internet, PC imaging and some other new windows based applications.

Microprocessor IA-64 (MERCD):

This microprocessor is manufactured by INTEL

Type of connector: Slot M

Operating Frequency: 800 MHz upwards

This microprocessor has a totally new internal architecture. This microprocessor is useful for multimedia, 3D virtual worlds, Video conferencing, Internet, PC imaging and some other new windows based applications.

Nowadays processors of speeds above 3 GHz are available from manufacturers like Intel AMD etc.

The following tables summarize the processor chips and their characteristics:

CPU	Data bus (bits)	Address Bus (bits)	Speed (MHz)	Transistors
8088	8	20	4.77	29,000
80286	16	24	8-12	134,000
80386SX	32	24	16-20	275,000
80386DX	32	32	16-33	275,000
80486SX	32	32	16-33	1.185 Million
80486DX	32	32	25-50	1.2 Million
486DX2	32	32	33-66	2 Million
486DX4	32	32	75-100	2.5 Million
Pentium	32	32	60-166	3.3 Million
Pentium Pro	64	32	150-200	5.5 Million
Pentium Pro II	64	64	233-400	7.5 Million

CPUs are mounted in different sockets depending on the size of the chip. Also, 486 chips and newer usually contain heat sinks, with fans, which fit on top of the processor chip. The CPU socket information is summarized in this table:

Socket	Voltage	Pins	Processors	Upgrade
0	3.3	168	486DX	486DX2/486DX4
1	3.3	169	486DX, 486SX	486DX2.486DX4
2	3.3	238	486DX, 486SX, 486DX2	486DX2/4, Pentium
3	3.3 or 5	237	486DX, 486SX, 486DX2, 486DX4	486DX2/486DX4
4	5	273	60/66 MHz Pentium	Pentium
5	3.3	320	Other Pentium	Pentium
6	3.3	235	486DX4	Pentium
7	3.3	321	Other Pentium	Pentium
8	3.3	387	Pentium Pro	Pentium Pro

There are two types of upgrade methods, ZIF (Zero Insertion Force) and LIF (Low Insertion Force) sockets. ZIF sockets have a mounting bar attached.

Introduction to MS Word

Objectives: At the end of this lesson you shall be able to
- **state what is MS Office**
- **brief MS Word and starting steps**
- **explain office button, quick access toolbar, tabs, ribbon and common tools in MS word**
- **brief the step by step procedure to edit, format text and documents in word.**

Microsoft Office

Microsoft Office is a bundled application software package introduced by Microsoft Corporation. Microsoft Office consists of the following popular application packages are:

- Microsoft Office Word
- Microsoft Office Excel
- Microsoft Office Access
- Microsoft Office PowerPoint
- Microsoft Office Publisher
- Microsoft Office Outlook

Microsoft Office Word

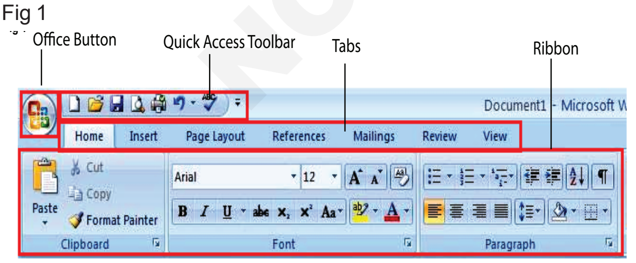
Microsoft Office Word is a word processor. A word processor is a software package that helps to create and edit a document. Word perfect, Word star, Write, Microsoft word are the popular word processors. Now, Microsoft word is the most popular word processor today. It helps to produce professional-looking documents by providing a comprehensive set of tools for creating and formatting a document, memos, letters, reports, brouchers, business documents and even internet web pages.

Starting word

Click the Mouse on **Start → All Programs → Microsoft Office → Microsoft Office Word**. Microsoft Office Word opens along with a default blank document named with Document 1 it has tabs and buttons. Office button, Quick Access Toolbar, Tabs, and Ribbon as Fig 1.

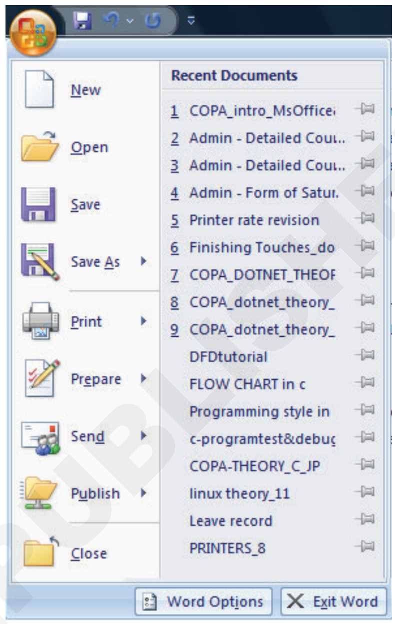
Office button: which is similar to the File menu in MS Word 2003. It provides a way to customize the quick access toolbar as in Fig 2.

Fig 1



- Start new project; Open a Project, Save, Print, etc.
- This shows recent documents and it is a quick way to open a recent project.

Fig 2



- This opens the Word Options window, it can be used to change settings and customize the Quick Access Toolbar.

Quick Access Toolbar: With this tool bar one can set it up to the needs. To do so just click the arrow at the end of this bar and select items which best suit is the needs.

They will be placed in the order they are selected. Again to customize this Quick Access Toolbar go to the office button and select Word Options. Clicks customize on the left and search for any buttons that suit the needs. A Shortcut to customize this bar is to right click in the Tabs bar and select Customize Quick Access Toolbar.

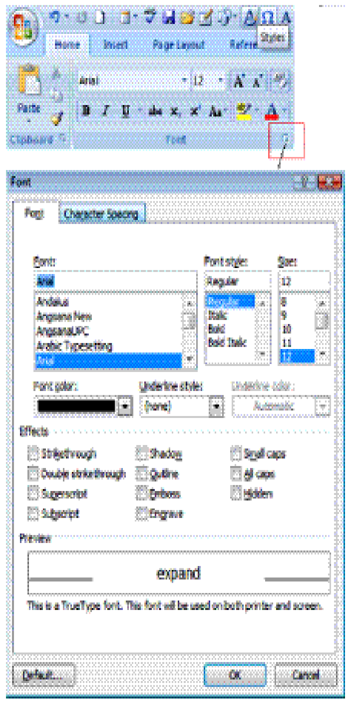
Tabs: Tabs are similar to the menu system of MS Word 2003 instead of having dropdown menus MS Word 2010 created with Tab and Ribbon system. When selected a tab it will display the Ribbon associated with that tab. Here everything has been changed into button form.

Ribbon: In this Ribbon there are many buttons that are grouped into categories such as Clipboard, Font, and Paragraph as in Fig 3.

In Fig 4 following buttons and bars are available.

1 **Title bar** will appear at the top of the application window. It displays the name of the currently active word document1.

Fig 3



2 **Office button** contains the file attribute options and recently opened document list to quick access. It has the word options to set the properties of few actions.

3 **Menu bar** Shows the Home, Insert, Page Layout, references, Mailings, Review, View menus and Help button.

4 **Vertical Ruler** used to align text or objects in the document. The measuring units can be changed according to our requirements.

5 **Status bar** shows the current position of the cursor to indicates page number and words

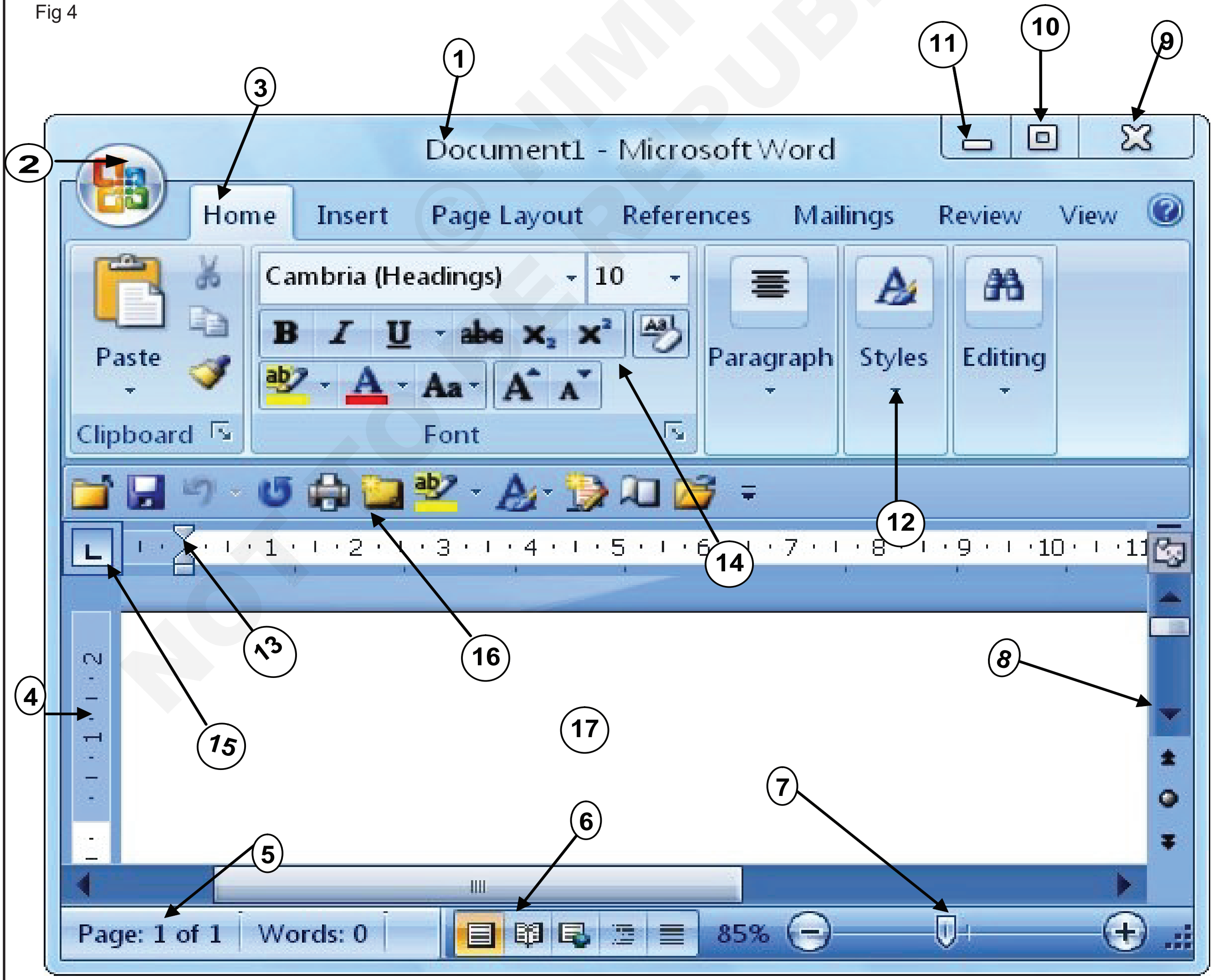
6 **Layout View** can be used to switch the view mode of the active document. This contains Print Layout, Full Screen Reading, Web Layout, Outline and Draft.

7 **Zoom option** can be used to zoom the document to fine tune the objects and reading text clearly. The Zoom options has 10% to 500% enlargement.

8 **Vertical Scroll bar** are used to move the document up/ down to view the entire document

9 **Close button** is located at the top right corner of the window. It is used to close the document as well as the application window.

Fig 4



1 Title bar	5 Status bar	9 Close button	13 Horizontal Ruler
2 Office button	6 Layout view	10 Maximize button	14 Formatting tools
3 Menus	7 Zoom	11 Minimize button	15 Tab setting button
4 Vertical Ruler	8 Vertical Scroll bar	12 Styles	16 Customize Quick Access Toolbar
			17 Work area

10 **Maximize button** are used to maximize the document when it was minimized.

11 **Minimise button,** when this button be clicked the active document will be minimized on to the taskbar of the windows.

12 **Styles** are the some pre-defined format for the quick format for the text.

13 **Horizontal ruler** is useful to align text and objects and the tab settings can be done on the horizontal ruler.

14 **Formatting tool bar** is the important to give print effects to the text document such as fonts, point size, toggle bold, italic & underline, bulleting and numbering

15 **Tab button** is the place where the type of tab can be selected such as left tab, right tab, centre tab, decimal tab etc.,

16 **Customize Quick Access toolbar** is a shortcut bar where the familiar and repeated functions tools can be kept there.

17 **Work space** is the area in which text can be entered in to a document.

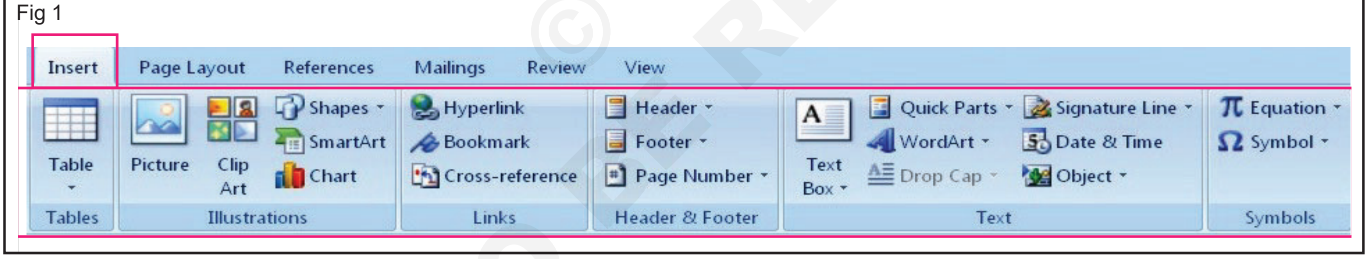
Insert tab

Objectives: At the end of this lesson you shall be able to
- **state the location and uses of inset tab in word**
- **explain how to add table and formatting table using design and layout**
- **state graphic tools in word.**

Insert Tab

The **Insert Tab** is right next to the Home Tab in Microsoft Word . This tab has a lot of useful features such as insert a pictures, clipart, shapes, smart art images, charts etc. Insert tab shown in Fig 1.

Fig 1



Columns

The **Columns** button is great for news papers and newsletters. This feature will break the document up into as many columns as shown in Fig. 18. It can make selection either before or after typing the articles.

Dividing a page into columns

- Select the **Page Layout** tab.
- In the **Page Setup** section, click **Columns**.
- Select the appropriate column option.
- More column, option shows the "columns" dialog box to customize column widths.

To remove Columns

- Select the **Page Layout** tab.
- In the **Page Setup** section, click **Columns**.
- Select **One**.

Page layout and mail merge

Objectives: At the end of this lesson you shall be able to
- **explain the concept of mail merge**
- **state how to create mail merge**
- **explain the most commonly used menus in MS Word 2007.**

Mail Merge

The mail merge tool merge a file of information to a variety of forms such as letters, mailing labels, lists or envelopes. The mail merge process is made up of four steps:

- Create the data source file
- Create or open the main document, (your letter, etc.)
- Complete the main document.
- Merge the data to the main document.

Mail merge terminology

Data source: This is the table or list that holds the data to merge, such as a list of names and addresses. The data source can come from a Microsoft Word table, from an Excel spreadsheet or from an Access database.

Merge document: This is the main letter or label template. This document has the fields in it, but not the data. It can be saved to use again. It can be saved for a record of the mailing, so that do not have to save all of the copies of the Merged Document. The merge document, together with the data source, is save as a permanent record.

Merge field: This is the title of the field (such as name, address, etc.) that you are merging from the data source.

Merged document: This is what you will be printing. This document does not have the field names; it has the data merged from the data source.

The data source

The data source contains the information that varies with each form document, Such as name, address, and phone number. The data source file is merged with the Main Document to produce letters, labels, etc. The data source can be a Word table, an Excel spreadsheet, an Access database, or a plain text file.

Give each column a title to make it easier to view your merge.

Save this file in the appropriate file location and close the file. You have to close this file before you start the merge, and you have to close the Merge Document if you need to open the data file again. When the Merge Document Is open and you try to open the excel file you get a message saying that it might Be corrupted. Do not panic, it is not corrupted, it is just in use.

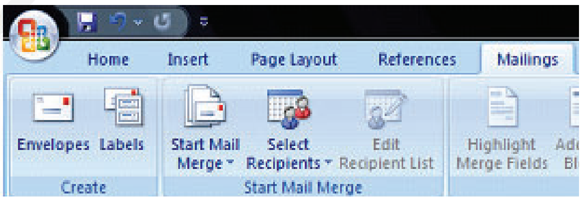
Creating your merge main document

With your Data Source completed and selected, you can now create your Main Document. If you are creating a form letter, then you will need to type the letter. Use generic placeholders to help you space your document (Dear Name:)

You can also open a document that has already been created, or one that you have used this for same purpose already. Many people use a form letter over and over again.

Go to the Mailings Tab and select Start Mail Merge or Envelopes or Labels if that is what you are creating as in Fig 1.

Fig 1



Shortcut keys in Word 2010

Learn the shortcut keys in MS Word.

CTRL+SHIFT+A	converts the selected text to capital letters or vice versa
CTRL+SHIFT+F	Displays the Font dialog box.
CTRL+SHIFT+G	Displays the Word Count dialog box.
CTRL+SHIFT+S	Displays the Apply Styles task pane.
ALT+R	Displays the Review tab
ALT+CTRL+1	Apply Heading 1, Similarly ALT + CTRL + 2 will apply heading 2
CTRL+SHIFT+L	Applies Bullets
CTRL+SHIFT+F5	Bookmark
CTRL + B	Bold Text
CTRL + I	Italic Text
CTRL + U	Underline Text
CTRL+PAGE DOWN	Browse Next
CTRL+E	Navigate to the center Paragraph
CTRL+SHIFT+ENTER	Column Break
CTRL+SHIFT+C	Copy Format
ALT+SHIFT+F7	Dictionary
ALT+CTRL+S	Splits the Document
CTRL+SHIFT+D	Double Underline
CTRL+END	End of Document
END	End of line
CTRL+SHIFT+P	Font size select
SHIFT+F5 or ALT+CTRL+Z	Go Back to previous state
CTRL+SHIFT+.	Grow Font
CTRL+]	Grow Font one point
ALT+SHIFT+R	Header Footer Link
CTRL+K	Hyperlink
CTRL+M	Indentation
CTRL+J	Justifies Paragraph
ALT+F8	Inserts Macros
ALT+SHIFT+K	Mail Merge Check
F10	Menu Mode
ALT+F7	Moves to the Next Misspelling
CTRL+H	Replace
CTRL+P	Print
CTRL+SHIFT+F12	Also launches Print
ALT+SHIFT+BACKSPACE	Redo
F12	Save As
CTRL+SHIFT+K	Small Caps
CTRL+SHIFT+S	Style
SHIFT+F7	Thesaurus
ALT+SHIFT+T	Time Field
CTRL+SHIFT+M	Unindent

Introduction to MS-Excel 2010

Objectives: At the end of this lesson you shall be able to
- **features & Functions of Microsoft Excel**
- **formulas and Functions**
- **move Around in Excel 2010**
- **conditional Formatting**
- **link Excel Spreadsheet Data**

Features & Functions of Microsoft Excel

Whether for work or home use, an Excel spreadsheet is the best tool in Microsoft Office for organizing data and making lists. Although Word documents can include tables and columns, Excel makes laying out information for easier. Excel also has a range of functions for designing formulas that automate calculations. Although Excel looks intimidating at first, the program's layout is similar to other Office applications.

Cells and Worksheets

The main portion of Excel's window consists of a spreadsheet -- or worksheet of cells. Just as with a paper spreadsheet, each cell can contain any numbers or any text -- unlike working with an Access database, Excel allows to simply click on any cell and fill it however best fits the project.

In some cases, such as to track spending, if want to use an organized series of rows and columns. Other times, such as building a list of team members, cell order and positioning won't play a major role. One advantage to Excel is how simple it makes reorganizing data: select a cell and drag its border to move it to a new spot on the sheet.

Excel Workbooks

Every Excel file, called a workbook, contains one or more worksheets. To switch between sheets in a workbook, use the tabs in the lower left corner of the window. Since Excel 2010, most workbooks use the file extension XLSX, whereas older versions used XLS files. New copies of Excel can read these old files, but to open a new workbook in an old edition, the old PC needs the Office compatibility pack.

Formulas and Functions

In addition to containing plain text and numbers, cells can contain formulas, which always start with an equals sign. With a formula, Excel displays the result of an equation in a cell, but automatically keeps that result up-to-date as you change its components. A basic formula can take the place of a calculator: write "=2+4" and Excel displays "6." Formulas also work with data in other cells: "=A1+B1" adds the values of cells A1 and B1.

For procedures other than direct arithmetic, use functions to perform various operations on data. Functions' abilities range from simple math, such as "AVERAGE" to average a range of cells, to modifying text, such as "LOWER" to convert a line to lower case.

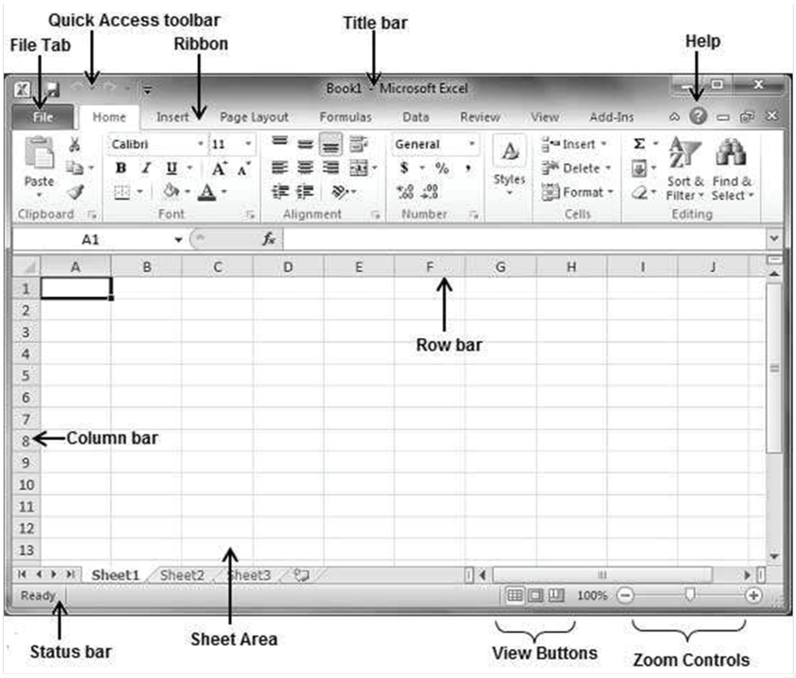
The two terms are often confused, but remember that each cell can contain only one formula, but each formula can use multiple functions, such as "=AVERAGE(A1, B1)+SUM(A2, B2)" to add the sum of two cells to the average of two other cells.

The following basic window appears when you start the excel application. Let us

now understand the various important parts of this window as shown in fig-1.

Ribbon Tabs

Fig 1

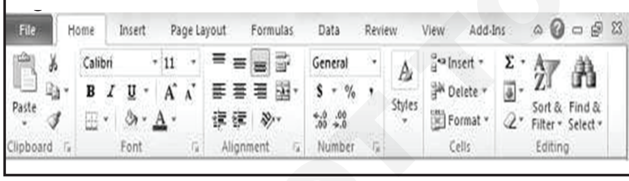


Copa 1203901

As with the rest of Office since 2007, Microsoft has replaced Excel's menus with ribbon tabs as shown in fig-2. The tab as visual menus that remain open each tab contains a set of related features with explanatory icons. For example, the Home tab contains the most common options, such as font and text color, while the Insert tab offers ways to insert tables, text boxes and charts. One tab, File, behaves differently. File still contains basic tasks including "New," "Open" and "Save," but displays these tasks in a full-screen area with extra options, called the backstage view. For example, the "New" button in the backstage view offers a searchable selection of templates for new workbooks.

Ribbon contains commands organized in three components:

Fig 2



Copa 12039C

Tabs: They appear across the top of the Ribbon and contain groups of related commands. Home, Insert, Page Layout is the examples of ribbon tabs.

Groups: They organize related commands; each group name appears below the group on the Ribbon. For example, group of commands related to fonts or group of commands related to alignment etc.

Home: Use this tab when creating, formatting, and editing a spreadsheet.

This tab is arranged into the Clipboard, Font, Alignment, Number, Styles, Cells, and Editing groups.

Insert: Use this when adding particular elements (including graphics, PivotTables, charts, hyperlinks, and headers and footers) to a spreadsheet. This tab is arranged into the Tables, Illustrations, Sparkline, Filter, Charts, Links, and Text groups.

Page Layout: Use this tab when preparing a spreadsheet for printing or reordering graphics on the sheet. This tab is arranged into the Themes, Page Setup, Scale to Fit, Sheet Options, and Arrange groups.

Formulas: Use this tab when adding formulas and functions to a spreadsheet or checking a worksheet for formula errors. This tab is arranged into the Function Library, Defined Names, Formula Auditing, and Calculation groups. Note that this tab also contains a Solutions group when activate certain add-in programs,

Data: Use this tab when importing, querying, outlining, and subtotaling the data placed into a worksheet's data list. This tab is arranged into the Get External Data, Connections, Sort & Filter, Data Tools, and Outline groups.

Review: Use this tab when proofing, protecting, and marking up a spreadsheet for review by others. This tab is arranged into the Proofing, Language, Comments, and Changes groups. Note that this tab also contains an Ink group with a sole Start Inking button if you're running Office 2010 on a Tablet PC or on a computer equipped with some sort of electronic input tablet.

View: Use this tab when changing the display of the Worksheet area and the data it contains. This tab is arranged into the Workbook Views, Show, Zoom, Window, and Macros groups.

Title Bar

This lies in the middle and at the top of the window. Title bar shows the program and the sheet titles.

Help

The Help Icon can be used to get excel related help anytime you like. This provides nice tutorial on various subjects related to excel.

Zoom Control

Zoom control lets to zoom in for a closer look at your text. The zoom control consists of a slider that user can slide left or right to zoom in or out. The + buttons can be clicked to increase or decrease the zoom factor.

View Buttons

The group of three buttons located to the left of the Zoom control, near the

bottom of the screen, lets to switch among excel's various sheet views.

Normal Layout view: This displays the page in normal view.

Page Layout view: This displays pages exactly as they will appear when printed. This gives a full screen look of the document.

Page Break view: This shows a preview of where pages will break when printed.

Sheet Area

The area where to enter data. The flashing vertical bar is called the insertion point and it represents the location where text will appear when type.

Row Bar

Rows are numbered from 1 onwards and keeps on increasing as to keep entering data. Maximum limit is 1,048,576 rows.

Column Bar

Columns are numbered from A onwards and keeps on increasing as to keep

entering data. After Z, it will start the series of AA, AB and so on. Maximum limit is 16,384 columns.

Status Bar

This displays the sheet information as well as the insertion point location. From left to right, this bar can contain the total number of pages and words in the document, language etc.

user can configure the status bar by right-clicking anywhere on it and by selecting or deselecting options from the provided list

File Tab

The File tab replaces the Office button from Excel 2010. user can click it to check the Backstage view, where user come to open or save files, create new sheets, print a sheet, and do other file-related operations.

Quick Access Toolbar

The File tab and its purpose is to provide a convenient resting place for the Excel's most frequently used commands. And customize this toolbar based on the comfort.

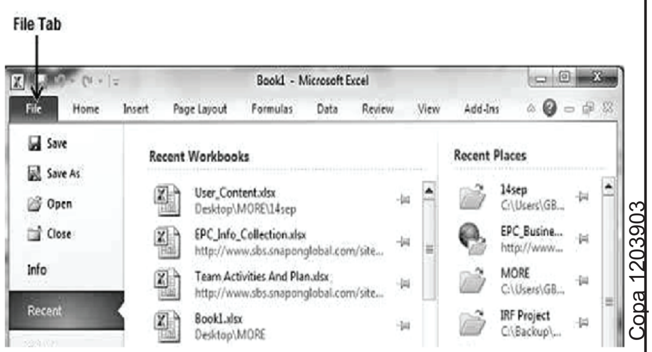
Dialog Box Launcher (Fig 3)

This appears as a very small arrow in the lower-right corner of many groups on the Ribbon. Clicking this button opens a dialog box or task pane that provides more options about the group.

If already have an opened sheet then it will display a window showing the

details about the opened sheet. Backstage view shows three columns when select most of the available options in the first column.

Fig 3



First column of the backstage view will have the following options as shown in

Table-1

Option	Description
Save	If an existing sheet is opened, it would be saved as is, otherwise it will display a dialogue box asking for thesheet name.
Save As	A dialogue box will be displayed asking for sheet name and sheet type. By default, it will save in sheet 2010 format with extension .xlsx.
Open	This option is used to open an existing excel sheet.
Close	This option is used to close an opened sheet.
Info	This option displays the information about the opened sheet.

Option	Description
Recent	This option lists down all the recently opened sheets.
New	This option is used to open a new sheet.
Print	This option is used to print an opened sheet.
Save & Send	This option saves an opened sheet and displays options to send the sheet using email etc.
Help	You can use this option to get the required help about excel 2010.
Options	Use this option to set various option related to excel 2010.
Exit	Use this option to close the sheet and exit.

Sheet Information

When click Info option available in the first column, it displays the following information in the second column of the backstage view:

Compatibility Mode: If the sheet is not a native excel 2007/2010 sheet, a Convert button appears here, enabling to easily update its format. Otherwise, this category does not appear.

Permissions: This option used to protect the excel sheet. And can set a password so that nobody can open the sheet, or lock the sheet so that nobody can edit the sheet.

Prepare for Sharing: This section highlights important information should know about the sheet before send it to others, such as a record of the edits the made as developed the sheet.

Versions: If the sheet has been saved several times, and may be able to access previous versions of it from this section.

Sheet Properties

When click Info option available in the first column, it displays various properties in the third column of the backstage view. These properties include sheet size, title, tags, categories etc.

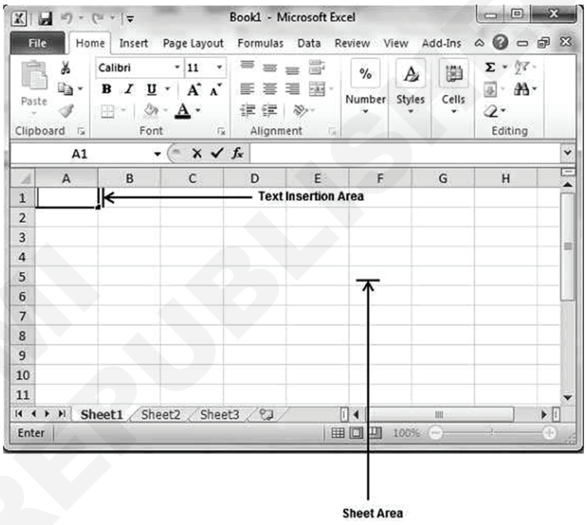
user can also edit various properties. Just try to click on the property value and if property is editable, then it will display a text box where can add the text like title, tags, comments, Author.

Entering values

A new sheet is displayed by default when open an excel sheet as shown in the Fig 4 screen shot.

Sheet area is the place of type the text. The flashing vertical bar is called the insertion point and it represents the location where text will appear when type. When click on a box then the box is highlighted. When double click the box, the flashing vertical bar appears and can start entering the data.

Fig 4



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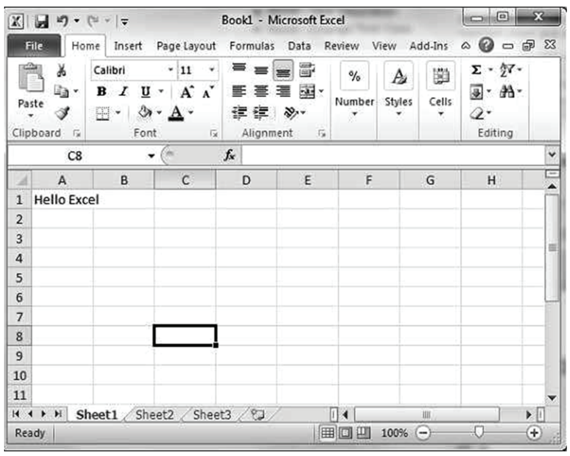
So, just keep the mouse cursor at the text insertion point and start typing whatever text would like to type. We have typed only two words "HelloExcel" as shown Fig 5. The text appears to the left of the insertion point.

Fig 5



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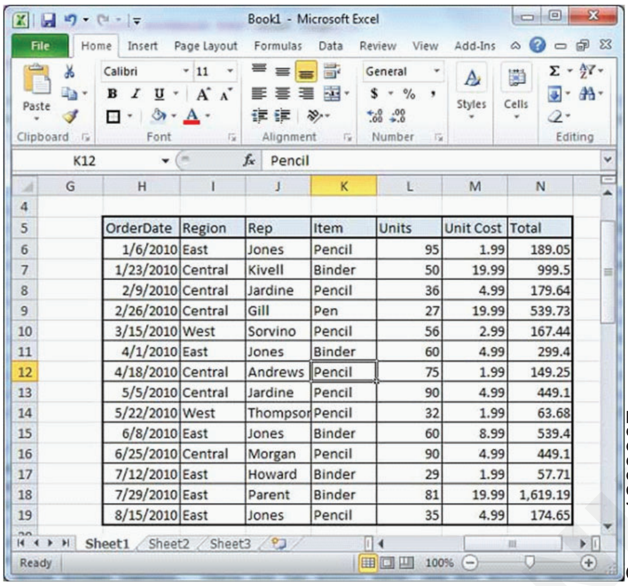
There are following three important points, which would help while typing:

- Press Tab to go to next column.
- Press Enter to go to next row.
- Press Alt + Enter to enter a new line in the same column.

Move Around in Excel 2010

Excel provides a number of ways to move around a sheet using the mouse and the keyboard.

Fig 6 Table-2



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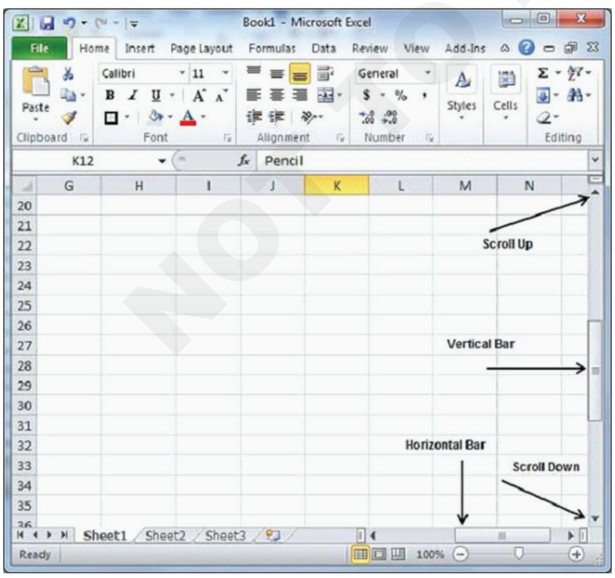
Moving with Mouse

Mouse can easily move the insertion point by clicking in the text anywhere on the screen. Sometime if the sheet is big then user cannot see a place need to move. In such situations, to use the scroll bars, as shown Fig 7 screen shot.

Fig 7



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User can scroll the sheet by rolling mouse wheel, which is equivalent to clicking the up-arrow or down-arrow buttons in the scroll bar.

Moving with Scroll Bars

As shown in the above screen capture, there are two scroll bars: one for moving vertically within the sheet, and one for moving horizontally. Using the vertical scroll bar, user may?

- Move upward by one line by clicking the upward-pointing scroll arrow.
- Move downward by one line by clicking the downward-pointing scroll arrow.
- Move one next page, using next page button (footnote).
- Move one previous page, using previous page button (footnote).
- Use Browse Object button to move through the sheet, going from one chosen object to the next.

Moving with Keyboard

The following keyboard commands, used for moving around your sheet, also move the insertion point -

Keystroke	Where the Insertion Point Moves
→	Forward one box
←	Back one box
↑	Up one box
↓	Down one box
PageUp	To the previous screen
PageDown	To the next screen
Home	To the beginning of the current screen
End	To the end of the current screen

User can move box by box or sheet by sheet. Now click in any box containing data in the sheet. It would have to hold down the Ctrl key while pressing an arrow key, which moves the insertion point as described here -

Key Combination	Where the Insertion Point Moves
Ctrl + →	To the last box containing data of the current row.
Ctrl + ←	To the first box containing data of the current row.
Ctrl + ↑	To the first box containing data of the current column.
Ctrl + ↓	To the last box containing data of the current column.
Ctrl + Page Up	To the sheet in the left of the current sheet.
Ctrl + Page Down	To the sheet in the right of the current sheet.

Ctrl + Home	To the beginning of the sheet.
Ctrl + End	To the end of the sheet.

Conditional Formatting

MS Excel 2010 Conditional Formatting feature enables to format a range of values so that the values outside certain limits, are automatically formatted.

Choose Home Tab " Style group " Conditional Formatting dropdown.

Functions and formulas in MS-Excel 2010

Objectives: At the end of this lesson you shall be able to
- **formulas and functions**
- **data validation**
- **data table with example**
- **page setup and printing worksheet**
- **excel shortcut keys.**

Formulas in MS Excel

Formula, worksheet will be just simple tabular representation of data. A formula consists of special code, which is entered into a cell. It performs some calculations and returns a result, which is displayed in the cell.

Formulas use a variety of operators and worksheet functions to work with values and text. The values and text used in formulas can be located in other cells, which makes changing data easy and gives worksheets their dynamic nature. For example, it can quickly change the data in a worksheet and formulas works.

Elements of Formulas

A formula can consist of any of these elements?

- **Mathematical operators, such as +(for addition) and *(for multiplication)**

Example -

=A1+A2 Adds the values in cells A1 and A2.

- **Values or text**

Example -

=200*0.5 Multiplies 200 times 0.5. This formula uses only values, and it always returns the same result as 100.

- **Cell references (including named cells and ranges)**

Example -

=A1=C12 Compares cell A1 with cell C12. If the cells are identical, the formula returns TRUE; otherwise, it returns FALSE.

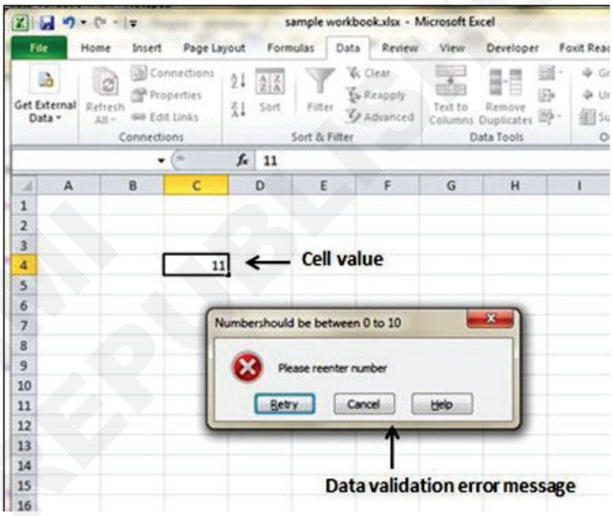
- **Worksheet functions (such as SUMor AVERAGE)**

Example -

=SUM(A1:A12) Adds the values in the range A1:A12.

Data Validation: MS Excel data validation feature allows to set up certain rules that dictate what can be entered into a cell. For example, user want to limit data entry in a particular cell to whole numbers between 0 and 10. If the user makes an invalid entry, and display a custom message as shown Fig 1

Fig 1



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Validation Criteria

To specify the type of data allowable in a cell or range, follow the steps below, which shows all the three tabs of the Data Validation dialog box.

- **Select the cell or range.**
- Choose Data " Data Tools " Data Validation. Excel displays its Data Validation dialog box having 3 tabs settings, Input Message and Error alert.

Settings Tab

Here user can set the type of validation. Choose an option from the Allow drop-down list. The contents of the Data Validation dialog box will change, displaying controls based on your choice.

- **Any Value -** Selecting this option removes any existing data validation.
- **Whole Number -** The user must enter a whole number. For example, you can specify that the entry must be a whole number greater than or equal to 50.
- **Decimal -** The user must enter a number. For example, you can specify that the entry must be greater than or equal to 10 and less than or equal to 20.

- **List -** The user must choose from a list of entries you provide. You will create drop-down list with this validation. You have to give input ranges then those values will appear in the drop-down.
- **Date -** The user must enter a date. You specify a valid date range from choices in the Data drop-down list. For example, you can specify that the entered data must be greater than or equal to January 1, 2013, and less than or equal to December 31, 2013.
- **Time -** The user must enter a time. Specify a valid time range from choices in the Data drop-down list. For example, user can specify that the entered data must be later than 12:00 p.m.
- **Text Length -** The length of the data (number of characters) is limited. specify a valid length by using the Data drop-down list. For example, that the length of the entered data be 1 (a single alphanumeric character).
- **Custom -** To use this option, must supply a logical formula that determines the validity of the user's entry (a logical formula returns either TRUE or FALSE).

Charts

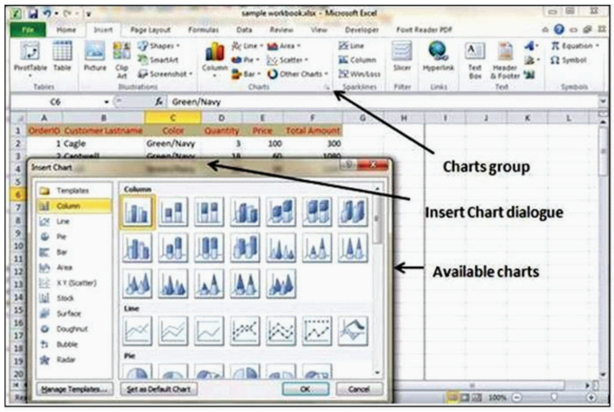
A chart is a visual representation of numeric values. Charts (also known as graphs) have been an integral part of spreadsheets. Charts generated by early spreadsheet products were quite crude, but thy have improved significantly over the years. Excel provides you with the tools to create a wide variety of highly customizable charts. Displaying data in a well-conceived chart can make your numbers more understandable. Because a chart presents a picture, charts are particularly useful for summarizing a series of numbers and their interrelationships.

Types of Charts

There are various chart types available in MS Excel as shown in Fig 2.

- **Column:** Column chart shows data changes over a period of time or illustrates comparisons among items.
- **Bar:** A bar chart illustrates comparisons among individual items.
- **Pie:** A pie chart shows the size of items that make up a data series, proportional to the sum of the items. It always shows only one data series and is useful to emphasize a significant element in the data.
- **Line:** A line chart shows trends in data at equal intervals.
- **Area:** An area chart emphasizes the magnitude of change over time.
- **X Y Scatter:** An xy (scatter) chart shows the relationships among the numeric values in several data series, or plots two groups of numbers as one series of xy coordinates.

Fig 2



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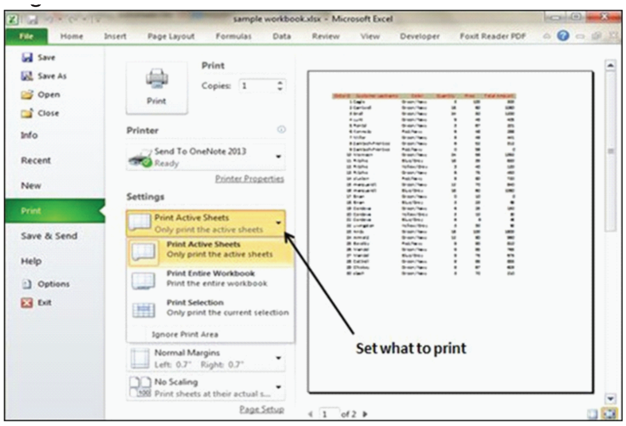
- **Stock:** This chart type is most often used for stock price data, but can also be used for scientific data (for example, to indicate temperature changes).
- **Surface:** A surface chart is useful to find the optimum combinations between two sets of data. As in a topographic map, colors and patterns indicate areas that are in the same range of values.
- **Doughnut:** Like a pie chart, a doughnut chart shows the relationship of parts to a whole; however, it can contain more than one data series.
- **Bubble:** Data that is arranged in columns on a worksheet, so that x values are listed in the first column and corresponding y values and bubble size values are listed in adjacent columns, can be plotted in a bubble chart.
- **Radar:** A radar chart compares the aggregate values of a number of data series.

MS Excel Keyboard Short-cuts

MS Excel offers many keyboard short-cuts. Below is the list of all the major shortcut keys in Microsoft Excel. (Fig 3)

Fig 3



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- **Ctrl + A** - Selects all contents of the worksheet.
- **Ctrl + B** - Bold highlighted selection.
- **Ctrl + I** - Italicizes the highlighted selection.
- **Ctrl + K** - Inserts link.
- **Ctrl + U** - Underlines the highlighted selection.
- **Ctrl + 1** - Changes the format of selected cells.
- **Ctrl + 5** - Strikethrough the highlighted selection.
- Ctrl + P - Brings up the print dialog box to begin printing.
- **Ctrl + Z** - Undo last action.
- **Ctrl + F3** - Opens Excel Name Manager.
- **Ctrl + F9** - Minimizes the current window.
- **Ctrl + F10** - Maximize currently selected window.
- **Ctrl + F6** - Switches between open workbooks or windows.
- **Ctrl + Page up** - Moves between Excel work sheets in the same Excel document.
- **Ctrl + Page down** - Moves between Excel work sheets in the same Excel document.
- **Ctrl + Tab** - Moves between Two or more open Excel files.
- **Alt + =** - Creates a formula to sum all of the above cells
- **Ctrl + '** - Inserts the value of the above cell into cell currently selected.
- **Ctrl + Shift + !** - Formats the number in comma format.
- **Ctrl + Shift + $** - Formats the number in currency format.
- **Ctrl + Shift + #** - Formats the number in date format.
- **Ctrl + Shift + %** - Formats the number in percentage format.
- **Ctrl + Shift + ^** - Formats the number in scientific format.
- **Ctrl + Shift + @** - Formats the number in time format.
- **Ctrl + Arrow key** - Moves to the next section of text.
- **Ctrl + Space** - Selects the entire column.
- **Shift + Space** - Selects the entire row.
- **Ctrl + -** - Deletes the selected column or row.
- **Ctrl + Shift + =** - Inserts a new column or row.
- **Ctrl + Home** - Moves to cell A1.
- **Ctrl + ~** - Switches between showing Excel formulas or their values in cells.
- **F2** - Edits the selected cell.
- **F3** - After a name has been created F3 will paste names.
- **F4** - Repeat last action. For example, if you changed the color of text in another cell pressing F4 will change the text in cell to the same color.
- **F5** - Goes to a specific cell. For example, C6.
- **F7** - Spell checks the selected text or document.
- **F11** - Creates chart from the selected data.
- **Ctrl + Shift + ;** - Enters the current time.
- **Ctrl + ;** - Enters the current date.
- **Alt + Shift + F1** - Inserts New Worksheet.
- **Alt + Enter** - While typing text in a cell pressing Alt + Enter will move to the next line allowing for multiple lines of text in one cell.
- **Shift + F3** - Opens the Excel formula window.
- **Shift + F5** - Brings up the search box.

Introduction to computers

Objectives: At the end of this lesson you shall be able to
- **define the computer**
- **explain the classification of computer**
- **explain the generation of computer**
- **explain the application of computer**
- **explain the basic blocks of digital computer**
- **explain the tools used to service a computer.**

Computer - Definitions

A computer is an electronic machine, operating under the control of instructions stored in its own memory that can accept data (input), manipulate the data according to specified rules (process), produce results (output), and store the results for future use.

Technically, a computer is a programmable machine. This means it can execute a list of programmed instructions and respond to new instructions that it is given.

History of Computer

Charles babbbage's machine

The working principles of today's computers were provided by an English mathematician Charles Babbage around 1833's invented a machine called the "Analytical Engine". A machine which could calculate and print tables of functions using limited techniques.

Hence, Charles Babbage is considered as the "Father of the Computer".

The generations of computers are characterized by a major technological development that fundamentally changed the way computers operate, resulting in increasingly smaller, cheaper, more powerful and more efficient and reliable devices. The various generations of computers are listed below:

First Generation (1946-1954): In **1946** the digital computer using **electronic valves** (Vacuum tubes) are known as first generation computers. The first **'computer'** to use electronic valves i.e. vacuum tubes. The high cost of vacuum tubes prevented their use for main memory. They stored information in the form of propagating sound waves.

The vacuum tube consumes a lot of power. These computers were large in size and writing programs on them was difficult. Some of the computers of this generation were:

Mark I : The **IBM Automatic Sequence Controlled Calculator (ASCC),** called the Mark I by **Harvard University**, was an **electro-mechanical computer**. Mark I is the first machine to successfully perform a long services of **arithmetic and logical operation.** Mark I is the **First Generation Computer.**

Limitations of First Generation Computer

Followings are the major drawbacks of First generation computers.

- They used valves or vacuum tubes as their main electronic component.
- They were large in size, slow in processing and had less storage capacity.
- They consumed lots of electricity and produced lots of heat.
- Their computing capabilities were limited.
- They were not so accurate and reliable.
- They used machine level language for programming.
- They were very expensive.

Second Generation (1955-1964): The second-generation computer used **transistors** for CPU components and **ferrite cores for main memory & magnetic disks** for secondary memory. They used high-level languages such as **FORTRAN (1956), ALGOL (1960) & COBOL (1960 - 1961).** Input Output (I/O)processor was included to control I/O operations.

Manufacturing cost was also very low. Thus the size of the computer got reduced considerably.

It is in the second generation that the concept of Central Processing Unit (CPU), memory, programming language and input and output units were developed. Some of the second generation computers are IBM 1620, IBM 1401,CDC 3600.

Features

- Transistors were used instead of Vacuum Tube.
- Processing speed is faster than First Generation Computers (Micro Second)
- Smaller in Size (51 square feet)
- The input and output devices were faster.

Third Generation (1964-1977): By the development of a small chip consisting of the capacity of the **300 transistors.** These Integrated Circuits (IC)s are popularly known as **Chips.**

A single IC has many transistors, registers and capacitors built on a single thin slice of silicon. So it is quite obvious that the size of the computer got further reduced. Some of the computers developed during this period were **IBM-360, ICL-1900, IBM-370, and VAX-750.** Higher level language such as **BASIC (Beginners All purpose Symbolic Instruction Code)** was developed during this period.

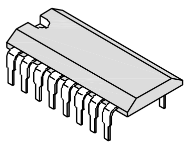
Computers of this generation were small in size, low cost, large memory and processing speed is very high. Very soon ICs were replaced by **LSI (Large Scale Integration),** which consisted about 100 components.

An IC containing about 100 components is called LSI as in (Fig 1).

Features

- They used Integrated Circuit (IC) chips in place of the transistors.
- Semi conductor memory devices were used.
- The size was greatly reduced, the speed of processing was high, and they were more accurate and reliable.
- Large Scale Integration (LSI) and Very Large Scale Integration (VLSI) were also developed.
- The mini computers were introduced in this generation.
- They used high level language for programming.

Fig 1



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Fourth Generation (1978 - present): An IC containing about 100 components is called LSI (Large Scale Integration) and the one, which has more than 1000 such components, is called as VLSI (Very Large Scale Integration).

It uses large scale Integrated Circuits(LSIC) built on a single silicon chip called microprocessors. Due to the development of microprocessor it is possible to place computer's central processing unit(CPU) on single chip. These computers are called microcomputers.

Later very large scale Integrated Circuits(VLSIC) replaced LSICs. Thus the computer which was occupying a very large room in earlier days can now be placed on a table. The personal computer (PC) that you see in your school is a Fourth Generation Computer Main memory used fast semiconductors chips up to 4 M bits size. Some of the Fourth generation computers are IBM PC, Apple-Macintosh, etc.

Hard disks were used as secondary memory. Keyboards, dot matrix printers etc. were developed. Operating System (OS)-such as MS-DOS, UNIX, Apple's Macintosh were available. Object oriented language, C++ etc were developed.

Features

- They used Microprocessor (VLSI) as their main switching element.
- They are also called as micro computers or personal computers.
- Their size varies from desktop to laptop or palmtop.
- They have very high speed of processing; they are 100% accurate, reliable, diligent and versatile.
- They have very large storage capacity.

Fifth Generation (PRESENT AND FUTURE): 5th generation computers use ULSI (Ultra-Large Scale Integration) chips. Millions of transistors are placed in a single IC in ULSI chips.

64 bit microprocessors have been developed during this period. Memory chips and flash memory up to 1 GB, hard disks up to 600 GB & optical disks up to 50 GB have been developed (Fig 2).

Fifth generation computing devices, based on Artificial Intelligence, are still in development, though there are some applications, such as voice recognition, that are being used today.

Artificial Intelligence is the branch of computer science concerned with making computers behave like humans. The term was coined in 1956 by John McCarthy at the Massachusetts Institute of Technology. Artificial intelligence includes:

- **Games Playing:** Programming computers to play games such as chess and checkers.
- **Expert Systems:** Programming computers to make decisions in real-life situations (for example, some expert systems help doctors diagnose diseases based on symptoms).
- **Natural Language:** Programming computers to understand natural human languages.
- **Neural Networks:** Systems that simulate intelligence by attempting to reproduce the types of physical connections that occur in animal brains.
- **Robotics:** programming computers to see and hear.

Fig 2

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Table 1

Generation	Electronic component	Advantages	Disadvantages
First	Vacuum tube	Helped in calculation and computational work	1.Big size 2.Very costly 3.Slow speed 4.Low accuracy 5.Low storage 6.High power requirements 7.High heat generation 8.High failure rate 9.Used machine language 10.No operating system
Second	Transistor	1.Smaller size 2.Less cost 3.Better speed 4.Low power consumption and less heat generation 5.Better storage capacity 6.Better accuracy and more reliability	1.Need air conditioning 2.Constant maintenance 3.No operating systems 4.Later stage computers used assembly languages
Third	Integrated Circuits(IC) small & medium scale	1.Better in all aspects compared to I & II 2.Used operating systems and high level language	1.Initial problem with manufac-turers 2.No insight obtained into internal working
Fourth	VLSI or Microprocessor	1.Low cost 2.Excellent speed and reliability 3.Computers close to man	1.Less powerful than main frame computers
Fifth (Knowledge Information Processing Systems)	ULSI or Bio-Chips	1.Very cheap 2.super speeds 3.Very high storage capacity 4.Highly sophisticated OS 5.Posses intelligence and decision making ability	1.New low level language needed

Classification of computers

Computers are classified according to the following criteria:

- Principle of Operation
- Computing Power, Memory Capacity and cost
- Technological Development
- Principle of operation
  - Analog computer
  - Digital Computer
  - Hybrid Computer

Analog Computer

It is a computer that measures continuously changing physical quantities such as current, temperature, pressure etc. and converts them into quantities which can be used as data for computation. As these computers deal with continuously varying quantities, they will give only approximate results. Its output is usually displayed on a meter or scale. Analog computer has low memory and fewer functions. These are used for engineering and scientific applications.

- Thermometer
- Speedometer
- Analog clock

Digital Computer

A digital computer works with digital data. Digital computer uses binary number system. Binary number system consists of only two digits '0' and '1'. A digital computer represents data in digital signals. A '0' represents OFF and a '1' represents ON. Digital computer performs arithmetic and logical operations on data. It gives output in digital form.

Table 2

	Analog Computers	Digital Computers
1	Analog Computers Work on continuous values.	Digital computers Work on discrete values.
2	Analog Computers have low memory.	Digital computers have a very large memory
3	Analog computers have Slow speed.	Digital computers have fast speed.
4	Analog computers are less reliable.	Digital computers are more reliable.
5	Analog computers used in engineering and science and medical fields.	Digital computers are used in all fields of life.
6	Analog computers are used to calculate / measure analog quantities like speed and temperature.	Digital computers are used to calculate mathematical and logical operations. It can solve addition, subtraction, division, multiplication and other mathematical and statistical operations.
7	Analog computers provide less accurate results.	Digital computers provide 100% accurate results.
8	Normally Analog Computers are specific purpose	Digital Computers are general purpose
9	Analog computers are difficult to use	Digital computers are easy to use
10	Examples of Analog computers are: thermometer, analog clock, speedometer etc.	Examples of digital computers are: Personal Computer, laptops, smart phones etc.

Digital computers are very fast. These computers can store results. They have large Memory (that is data storing capacity). Today most of the computers used in offices and homes are Digital computers.

The digital computers are further divided into the following two groups:

- Special purpose computers
- General purpose computers

Special Purpose Computers

It is a computer designed to solve specific type of problem. The computers used in ships and aircrafts, etc.

General Purpose computers

It is a computer designed to solve a wide variety of problems, A General purpose, Computer can store different programs and process them.

The differences between analog and digital computers are listed in table 2

Hybrid Computer (Fig 3)

A hybrid computer is a combination of both analog and digital computer. Hybrid computer can handle both analog and digital data. A hybrid computer combines the best characteristics of both the analog and digital computer. It can accept data in both analog and digital form.

Applications: Hybrid computer devices are used in hospitals that may calculate patient's heart function, temperature and blood pressure etc. This calculation may be converted into numbers and shown in digital form. For example, The Vital Signs Monitoring unit also called (VSM) in short. It has Blood Pressure monitor, ECG monitor, respiratory monitor, and is also used for monitoring anesthesia.

Fig 3

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- Hybrid computers are also used in spaceships and missile system.
- Hybrid Computer Machines are generally used in scientific applications
- Hybrid computers are used for controlling industrial processes.

Computers are classified on the basis of computing power, memory capacity and cost.

- Microcomputer or Personal Computer.
- Mini Computer.
- Mainframe Computer.
- Super Computer.

Micro Computers

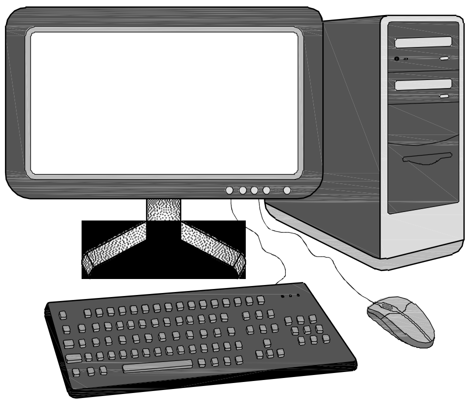
Micro computer is also called personal computer. It was introduced in 1970. Examples of personal computers are

PC and Apple Macintosh. The major types of personal computers are desktop computer and portable computer.

Desktop Computer

These computers can easily fit on a table or desktop, hence the name. These computers come in two models or casings. In Desktop model, the system unit is placed on the desktop or table. Monitor is placed on the system unit. In Tower model, both monitor and system unit are placed on the table as in (Fig 4).

Fig 4



TOWER MODEL COMPUTER

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Portable computer

Portable is a personal computer that can be carried from one place to other easily. Notebook computer and handheld computer (smart phone) are examples of portable computers. Notebook computer is also called laptop computer. Laptop computers are very small in size and can be placed easily on lap.

Lap top computer or notebook computer

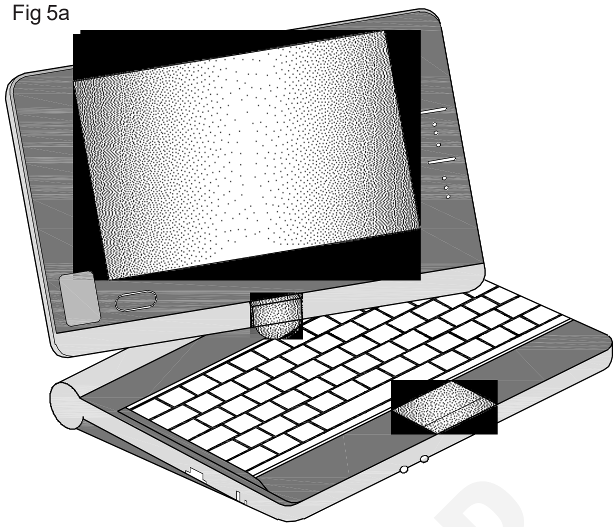
The laptop computer or notebook computer will be as shown in Fig 5a and Fig 5b.It is also called as tower model computer.

Fig 5

Palmtop Computer/Digital Diary /Notebook /PDAs:

A handheld computer (like smart phone) is also portable. Hand held computer is known as palmtop computer. Palmtops have no keyboard but the screen serves both as an input and output device. It easily fits in the hand of the user.

Fig 5a



LAP TOP COMPUTER OR NOTE BOOK COMPUTER

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Uses of Micro Computer

The PC is the most common type of computer used in the office. It is now widely used in many homes. These are also used for business and engineering application.

Mini Computer

Mini computers were introduced in the 1960s. Minicomputer is larger and more powerful computer than personal computer. It can execute five million instructions per second. It generally consists of two or more processors.

Minicomputer can serve up to 4000 connected users simultaneously. It is normally accessed by users via personal computer or terminal. A device with a monitor and keyboard is called terminal. It is also known as dumb terminal. It has no processing power and cannot work as stand-alone computer. Some of the minicomputers models are VAX-8800, AS400

Uses of Mini Computer

Mini computers are often used by small and medium-sized companies to provide centralized store of information.

Mainframe Computer

Mainframe computers were introduced in 1975. A mainframe computer is a very large computer in size. It is

processors. It is designed to perform multiple tasks for multiple users at the same time. Mainframe computers can serve up to 50,000 users at the same time.

The users access a mainframe computer through terminal or personal computer. A typical mainframe computer can execute 16 million instructions per second. Some of the main computers models are

- NEC 610
- DEC 10

Uses of Mainframe Computer

Mainframe computers are used primarily by corporate and governmental organizations for critical applications, bulk data processing such as senses, industry and consumer statistics, and transaction processing.

Super computer

Super computers were introduced in 1980s. Super computer is the fastest computer. Super computer is the biggest in size and the most expensive in price than any other computers.

It is the most sophisticated, complex and advanced computer. It has a very large storage capacity. It can process trillions of instructions in one second. Super Computer is the fastest and most powerful computer of a time. Supercomputers are very expensive. Supercomputers are used for highly calculation-intensive tasks. Super computers are also used for specialized applications that require immense amounts of mathematical calculations.

Applications of Super Computer

- Weather forecasting,
- Animated graphics like in Hollywood movies,
- Fluid dynamic calculations
- Nuclear energy research
- Space science
- Weapon and missile design
- Petroleum exploration, and etc.

Today, supercomputers are produced by traditional companies such as Cray, IBM and Hewlett- Packard. Since October 2010, the Tianhe-1A supercomputer has been the fastest in the world; it is located inChina.

The main difference between a supercomputer and a mainframe is that a supercomputer channels all its power into executing a single program as fast as possible, whereas a mainframe uses its power to execute many programs concurrently. The modern super computer consists of thousands of microprocessors. Super computer uses high-speed facilities such as satellite for online processing.

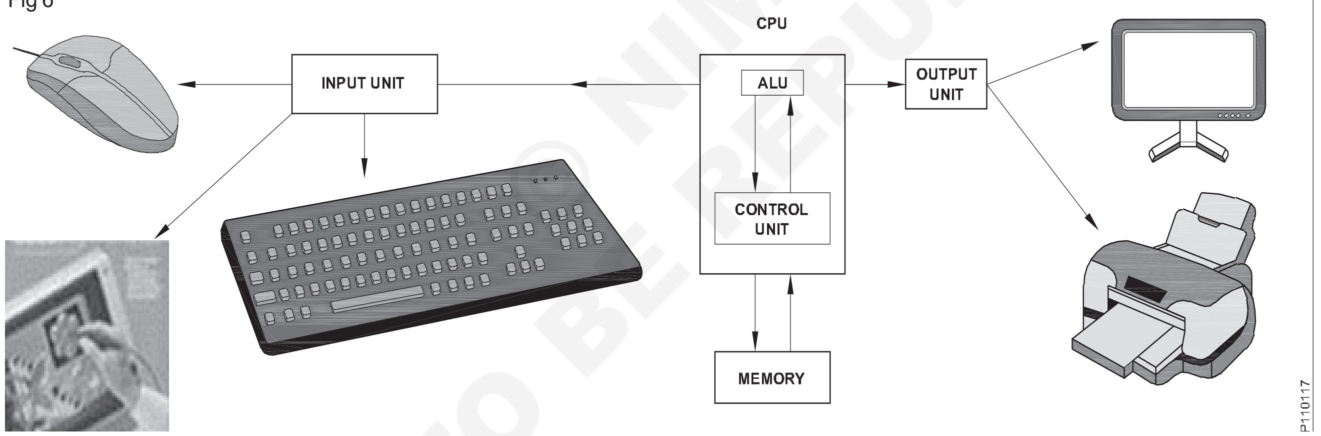
Sum of the super computers models are CRAY-XP, ETA-10, Param and Deep Blue .

Basic blocks of digital computer

All computers are made up of following basic units as shown in Fig 6. They are as follows:-

1 Input Unit
2 Central processing Unit (CPU)
   a) Arithmetic Logic Unit(ALU)
   b) Control Unit (CU)
3 Memory
4 Output Unit

Fig 6



Input Unit

Computers need to receive data and instruction in order to solve any problem. Therefore, we need to input the data and instructions into the computers. The input unit consists of one or more input devices. Keyboard is the one of the most commonly used input device. Some of the input devices are listed in table 1.

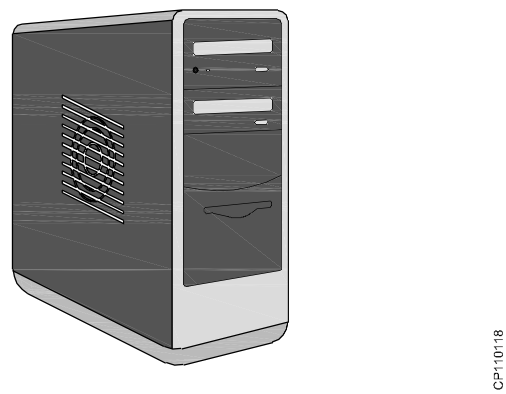
Input devices perform the following functions.

- Accept the data and instructions from the outside world.
- Convert it to a form that the computer can understand.
- Supply the converted data to the computer system for further processing.

Central Processing Unit (CPU) (Fig 7)

The central processing unit (CPU) is the electronic brain of the computer. The CPU in a personal computer is usually a single chip. It organizes and carries out instructions that come from either the user or from the software. The processor is made up of many components. CPU performs the following functions:

Fig 7



- It performs all calculations.
- It takes all decisions.
- It controls all units of the computer.

Two typical components of a **CPU** are the following:

The arithmetic logic unit (ALU), which performs arithmetic and logical operations.

The control unit (CU), which extracts instructions from memory and decodes and executes them, calling on the ALU when necessary.

Memory

Memory refers to the physical device used to store the program or data on the temporary or permanent basis for use in a computer or other digital electronic device.
There are two types of memory in computer.

- Primary Memory
- Secondary Memory

Output Unit

Output unit receive the informations from the processing unit and provide the results in human readable form.

Output Devices

The some of the output devices are

- Monitor
- Printer
- Plotter
- Speaker

Applications of computers

Science: Scientists have been using computers to develop theories and to analyse and test the data. The high speed and accuracy of the computer allow different scientific analyses to be carried out. They can be used to generate detailed studies of how earthquakes affect buildings or pollution affects weather pattern. Satellite-based applications have not been possible without the use of computers. Moreover, it would not be possible to get the information of the solar system and the cosmos without computers.

Education: Computers have also revolutionized the whole process of education. Currently, the classrooms, libraries and museums are efficiently utilizing computers to make the education much more interesting. Unlike recorded television shows, computer-aided education (CAE) and computer-based training (CBT) packages are making learning much more interactive.

Medicine and Health Care: There has been an increasing use of computers in the field of medicine. Now, doctors are using computers right from diagnosing the illness to monitoring a patient's status during complex surgery. By using automated imaging techniques, doctors are able to look inside a person's body and can study each organ in detail (e.g. CT scans or MRI scans), which was not possible few years ago. There are several examples of special-purpose computers that can operate within the human body such as cochlear implant, a special kind of hearing aid that makes it possible for deaf people to hear.

Engineering/Architecture/Manufacturing: The architects and engineers are extensively using computers in designing and drawings. Computers can create objects that can be viewed from all the three dimensions. By using techniques like virtual reality, architects can explore houses that have been designed but not built. The manufacturing factories are using computerized robotic arms to perform hazardous jobs. Besides, computer-aided manufacturing (CAM) can be used in designing the product, ordering the parts and planning production. Thus, computers help in coordinating the entire manufacturing process.

Entertainment: Computers are finding greater use in entertainment industry. They are used to control the images and sounds. The special effects, which mesmerize the audience, would not have been possible without the computers. In addition, computerized animation and colourful graphics have modernized the film industry.

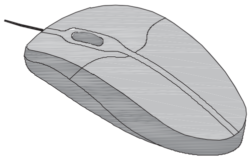
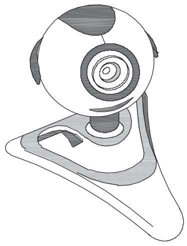
Communication: E-mail or electronic mail is one of the communication media in which computer is used. Through e-mail, messages and reports are passed from one person to one or more persons with the aid of computer and telephone line. The advantage of this service is that while transferring the messages it saves time, avoids wastage of paper and so on. Moreover, the person who is receiving the messages can read the messages whenever he is free and can save it, reply it, forward it or delete it from the computer.

Business Application: This is one of the important uses of the computer. Initially, computers were used for batch-processing jobs, where one does not require the immediate response from the computer. Currently, computers are mainly used for real-time applications (like at the sales counter) that require immediate response from the computer. There are various concerns where computers are used such as in business forecasting, to prepare pay bills and personal records, in banking operations and data storage, in various types of life insurance business and as an aid to management. Businesses are also using the networking of computers, where a number of computers are connected together to share the data and the information. Use of e-mail and the Internet has changed the ways of doing business.

Publishing: Computers have created a field known as desktop publishing (DTP). In DTP, with the help of computer and a laser printer one can perform the publishing job all by oneself. Many of the tasks requiring long manual hours such as making table of contents and index can be automatically performed using the computers and DTP software.

Banking: Computers are extensively used in the field of banking and finance. People can use the ATM (automated teller machine) services 24 hours a day to deposit and withdraw cash. When different branches of the bank are connected through computer networks, the inter branch transactions such as cheque and draft can be performed without any delay.

Table 1

 MOUSE	 KEYBOARD
 SCANNER	 DIGITAL CAMERA
 WEB CAMERA	 JOYSTICKS
 TRACK BALL	 TOUCH PAD
 LIGHT PEN	 BAR CODE READER
 MICRO PHONE	 GRAJOC TABLET
 MAGNETIC INK CHARACTER READER (USED IN BANK)	 OPTICAL MARK READER (USED FOR ANSWER SHEET MARKED PURPOSE)
 MAGNETIC CARD READER	 BLUE TOOTH

Railway Reservation System

Using this system, the user can perform following operations through online. (web site: www.irctc.co.in)

- search the train and its timings
- check seats and birth availability
- booking and cancelling tickets
- status of PNR (Passenger Name Record)

Telephone / Electricity Board Billing:

The users can do the following operations through online by using this system. (Web site: portal.bsnl.in - BSNL)

- Register the telephone / electricity board number
- Check and pay the bill amount
- Register the complaints

E-Governance

E-Governance implies technology driven governance. E-Governance is the application of Information and Communication Technology (ICT) for delivering government services, exchange of information communication transactions, integration of various stand-alone systems and services between Government-to-Citizens (G2C), Government-to-Business(G2B),Government-to-Government(G2G) as well as back office processes and interactions within the entire government frame work.

E-Governance covers all the sectors with a view to providing hassle free, transparent and efficient service to the common man (both in urban and rural areas).

Tools used in Computer servicing

For every job there is the right tool. Skilled use of tools and software makes the job less difficult and ensures that tasks are performed properly and safely. A toolkit should contain all the tools necessary to complete hardware repairs. Hardware tools are grouped into four categories:

- ESD tools
- Hand tools
- Cleaning tools
- Diagnostic tools

ESD Tools

There are two ESD tools, the antistatic wrist strap and the antistatic mat. The antistatic wrist strap protects computer equipment when grounded to a computer chassis. The antistatic mat protects computer equipment by preventing static electricity from accumulating on the hardware or on the technician.

Antistatic Wrist Strap

The purpose of self-grounding or wearing an antistatic wrist strap is to equalize the electrical charge between you and the equipment. Self-grounding is done by touching a bare metal part of a computer case. The antistatic wrist strap is a conductor that connects your body to the equipment that you are working on. When static electricity builds up in your body, the connection made by the wrist strap to the equipment, or ground, channels the electricity through the wire that connects the strap.

Take care to

Attach the wire on the same side of the equipment as the arm wearing the antistatic wrist strap. This helps keep the wire out of the way while you are working.

Roll up your sleeves, remove scarves or ties, and tuck in your shirts to prevent interference from clothing. Ensure that earrings, necklaces, and other loose jewellery are properly secured.

Antistatic Mat

Carpets can cause the build-up of electrostatic charges. If you cannot avoid the carpeting, ground yourself to the unpainted portion of the case of the computer on which you are working before touching any components.

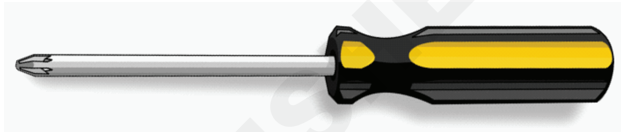
Hand Tools

- **Flat-head screwdriver:** Used to tighten or loosen slotted screws. (Fig 8)

Fig 8

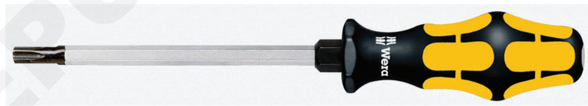
- **Phillips-head screwdriver:** Used to tighten or loosen cross-headed screws. (Fig 9)

Fig 9



- **Torx screwdriver:** Used to tighten or loosen screws that have a star-like depression on the top, a feature that is mainly found on laptops. (Fig 10)

Fig 10

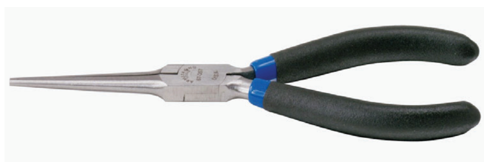


- **Hex driver:** Used to tighten or loosen nuts in the same way that a screwdriver tightens or loosens screws (sometimes called a nut driver). (Fig 11)

Fig 11

- **Needle-nose pliers:** Used to hold small parts. (Fig 12)

Fig 12



- **Wire cutters:** Used to strip and cut wires. (Fig 13)

Fig 13

- **Tweezers:** Used to manipulate small parts. (Fig 14)

Fig 14

- **Part retriever:** Used to retrieve parts from locations that are too small for your hand to fit. (Fig 15)

Fig 15

- **Flashlight:** Used to light up areas that you cannot see well. (Fig 16)

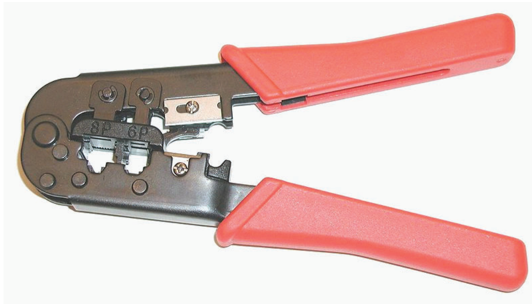
Fig 16

- **Wire stripper:** A wire stripper is used to remove the insulation from wire so that it can be twisted to other wires or crimped to connectors to make a cable. (Fig 17)

Fig 17

- **Crimper:** Used to attach connectors to wires. (Fig 18)

Fig 18



Use a flat-head screwdriver when you are working with a slotted screw. Do not use a flat-head screwdriver to remove a Phillips-head screw. Never use a screwdriver as a pry bar. Use a Phillips-head screwdriver with crosshead screws. Do not use this type of screwdriver to puncture anything. This will damage the head of the screwdriver. Use a hex driver, shown in, to loosen and tighten bolts that have a hexagonal (six-sided) head. Hex bolts should not be over-tightened because the threads of the bolts can be stripped. Do not use a hex driver that is too large for the bolt that you are using.

Cleaning Tools

- **Soft cloth:** Used to clean different computer components without scratching or leaving debris.
- **Compressed air:** Used to blow away dust and debris from different computer parts without touching the components. (Fig 19)

Fig 19

Diagnostic Tools (Fig 20)

A digital multimeter, as shown in Fig, is a device that can take many types of measurements. It tests the integrity of circuits and the quality of electricity in computer components. A digital multimeter displays the information on an LCD or LED.

Miscellaneous Tools

- Wrap plugs
- Small mirror
- Small dust brush
- Scissors
- Electrical tape

Fig 20

- Pencil or pen
- Masking tape for labelling parts
- Magnifying glass
- **Cable ties:** Used to bundle cables neatly inside and outside of a computer. (Fig 21)
- **Parts organizer:** Used to hold screws, jumpers, fasteners, and other small parts and prevents them from getting mixed together. (Fig 22)

Fig 21

Fig 22

Hardware Maintenance

Objectives: At the end of this lesson you shall be able to
- **explain types of I/O devices on a standard PC**
- **explain the types of ports on a standard PC**
- **explain the different types of computer cases**
- **explain front and rear panel controls and ports on a PC**
- **explain a CPU cooling fan.**

Types of I/O Devices and Ports on a Standard PC for connecting I/O devices

Input Device

An input device is any hardware device that sends data to a computer, allowing users to interact with and control it.

Following are few of the important input devices which are used in a computer:

- Keyboard
- Mouse
- Joy Stick
- Light pen
- Track Ball
- Scanner
- Graphic Tablet
- Microphone
- Magnetic Ink Card Reader(MICR)
- Optical Character Reader(OCR)
- Bar Code Reader
- Optical Mark Reader(OMR)

Keyboard

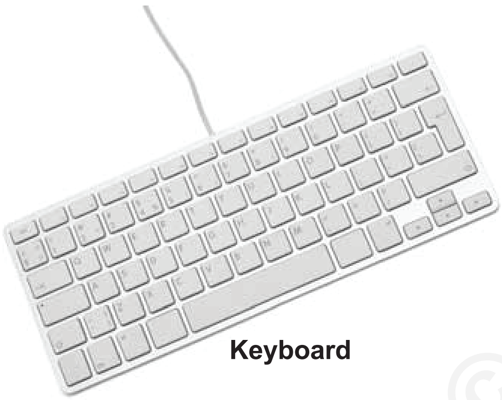
Keyboard is the most common and very popular input device which helps in inputting data to the computer. The layout of the keyboard is like that of traditional typewriter, although there are some additional keys provided for performing additional functions.

Keyboards are of two sizes 84 keys or 101/102 keys, but now keyboards with 104 keys or 108 keys are also available for Windows and Internet. (Fig 1)

The keys on the keyboard are as follows:

Sl.No.	Keys	Description
1	Typing Keys	These keys include the letter keys (A-Z) and digit keys (0-9) which generally give same layout as that of typewriters.
2	Numeric Keypad	It is used to enter numeric data or cursor movement. Generally, it consists of a set of 17 keys that are laid out in the same configuration used by most adding machines and calculators.
3	Function Keys	The twelve function keys are present on the keyboard which are arranged in a row at the top of the keyboard. Each function key has unique meaning and is used for some specific purpose.
4	Control keys	These keys provide cursor and screen control. It includes four directional arrow keys. Control keys also include Home, End, Insert, Delete, Page Up, Page Down, Control(Ctrl), Alternate(Alt), Escape(Esc).
5	Special Purpose Keys	Keyboard also contains some special purpose keys such as Enter, Shift, Caps Lock, Num Lock, Space bar, Tab, and Print Screen.

Fig 1



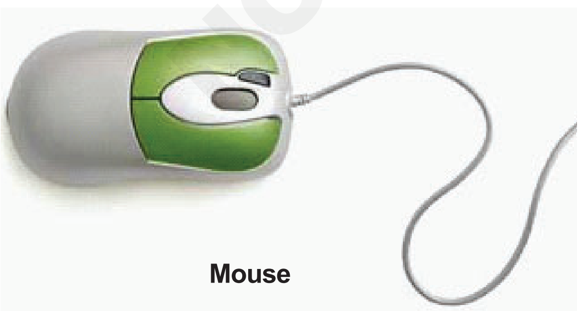
Keyboard

Mouse

Mouse is most popular pointing device. It is a very famous cursor-control device having a small palm size box with a round, ball at its base which senses the movement of mouse and sends corresponding signals to CPU when the mouse buttons are pressed.

Generally, it has two buttons called left and right button and a wheel is present between the buttons. Mouse can be used to control the position of cursor on screen, but it cannot be used to enter text into the computer. (Fig 2)

Fig 2



Mouse

Advantages

- Easy to use
- Not very expensive
- Moves the cursor faster than the arrow keys of keyboard.

Joystick

Joystick is also a pointing device which is used to move cursor position on a monitor screen. It is a stick having a spherical ball at its both lower and upper ends. The lower spherical ball moves in a socket. The joystick can be moved in all four directions.

The function of joystick is similar to that of a mouse. It is mainly used in Computer Aided Designing (CAD) and playing computer games. (Fig 3)

Fig 3

Joystick

Light Pen

Light pen is a pointing device which is similar to a pen. It is used to select a displayed menu item or draw pictures on the monitor screen. It consists of a photocell and an optical system placed in a small tube. When the tip of a light pen is moved over the monitor screen and pen button is pressed, its photocell sensing element detects the screen location and sends the corresponding signal to the CPU. (Fig 4)

Fig 4

Light Pen

Track Ball

Track ball is an input device that is mostly used in notebook or laptop computer, instead of a mouse. This is a ball which is half inserted and by moving fingers on ball, pointer can be moved. Since the whole device is not moved, a track ball requires less space than a mouse. A track ball comes in various shapes like a ball, a button and a square. (Fig 5)

Fig 5

Track ball

Scanner

Scanner is an input device which works more like a photocopy machine. It is used when some information is available on a paper and it is to be transferred to the hard disc of the computer for further manipulation. Scanner captures images from the source which are then converted into the digital form that can be stored on the disc. These images can be edited before they are printed. (Fig 6)

Fig 6

Scanner

Digitizer

Digitizer is an input device which converts analog information into digital form. Digitizer can convert a signal from the television or camera into a series of numbers that could be stored in a computer. They can be used by the computer to create a picture of whatever the camera had been pointed at. Digitizer is also known as Tablet or Graphics Tablet because it converts graphics and pictorial data into binary inputs. A graphic tablet as digitizer is used for doing fine works of drawing and image manipulation applications. (Fig 7)

Fig 7

Digitizer

Microphone

Microphone is an input device to input sound that is then stored in digital form. The microphone is used for various applications like adding sound to a multimedia presentation or for mixing music. (Fig 8)

Fig 8

Microphone

Magnetic Ink Card Reader (MICR)

MICR input device is generally used in banks because of a large number of cheques to be processed every day. The bank's code number and cheque number are printed on the cheques with a special type of ink that contains particles of magnetic material that are machine readable. This reading process is called Magnetic Ink Character Recognition (MICR). The main advantages of MICR is that it is fast and less error prone. (Fig 9)

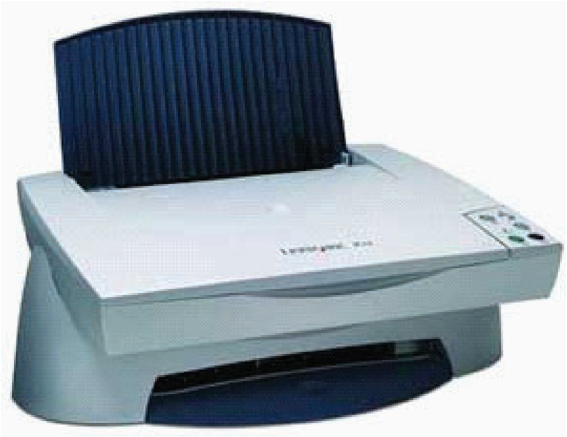
Fig 9

MCR

Optical Character Reader(OCR)

OCR is an input device used to read a printed text. OCR scans text optically character by character, converts them into a machine readable code and stores the text on the system memory. (Fig 10)

Fig 10



OCR

Bar Code Readers

Bar Code Reader is a device used for reading bar coded data (data in form of light and dark lines). Bar coded data is generally used in labelling goods, numbering the books etc. It may be a hand held scanner or may be embedded in a stationary scanner. Bar Code Reader scans a bar code image, converts it into an alphanumeric value which is then fed to the computer to which bar code reader is connected. (Fig 11)

Fig 11

Barcode Reader

Optical Mark Reader (OMR)

OMR is a special type of optical scanner used to recognize the type of mark made by pen or pencil. It is used where one out of a few alternatives is to be selected and marked. It is specially used for checking the answer sheets of examinations having multiple choice questions. (Fig 12)

Output Devices

Following are few of the important output devices which are used in a computer.

- Monitors
- Graphic Plotter
- Printer

Fig 12

Optical Mark Reader

Monitors

Monitors, commonly called as Visual Display Unit (VDU), are the main output device of a computer. It forms images from tiny dots, called pixels that are arranged in a rectangular form. The sharpness of the image depends upon the number of pixels.

There are two kinds of viewing screen used for monitors.

- Cathode-Ray Tube (CRT)
- Flat- Panel Display

Cathode-Ray Tube (CRT) Monitor

The CRT display is made up of small picture elements called pixels. The smaller the pixels, the better the image clarity, or resolution. It takes more than one illuminated pixel to form whole character, such as the letter 'e' in the word help.

A finite number of characters can be displayed on a screen at once. The screen can be divided into a series of character boxes - fixed location on the screen where a standard character can be placed. Most screens are capable of displaying 80 characters of data horizontally and 25 lines vertically. There are some disadvantages of CRT: (Fig 13)

- Large in Size
- High power consumption

Fig 13

Flat-Panel Display Monitor

The flat-panel display refers to a class of video devices that have reduced volume, weight and power requirement in comparison to the CRT. You can hang them on walls or wear them on your wrists. Current uses of flat-panel displays include calculators, video games, monitors, laptop computer, graphics display.

The flat-panel display is divided into two categories:

- **Emissive Displays :** The emissive displays are devices that convert electrical energy into light. Example are plasma panel and LED(Light-Emitting Diodes).
- **Non-Emissive Displays :** The Non-emissive displays use optical effects to convert sunlight or light from some other source into graphics patterns. Example is LCD(Liquid-Crystal Device) (Fig 14)

Fig 14

Printers

Printer is an output device, which is used to print information on paper.

There are two types of printers:

- Impact Printers
- Non-Impact Printers

Impact Printers

The impact printers print the characters by striking them on the ribbon which is then pressed on the paper.

Characteristics of Impact Printers are the following:

- Very low consumable costs
- Very noisy
- Useful for bulk printing due to low cost
- There is physical contact with the paper to produce an image

These are further divided into two types:

- Dot Matrix Printer(DMP)
- Daisy Wheel

Dot matrix printer

In the market one of the most popular printers is Dot Matrix Printer. These printers are popular because of their ease of printing and economical price. Each character printed is in form of pattern of dots and head consists of a Matrix of Pins of size (5*7, 7*9, 9*7 or 9*9) which come out to form a character that is why it is called Dot Matrix Printer. (Fig 15)

Fig 15

Advantages

- Inexpensive
- Widely Used
- Other language characters can be printed

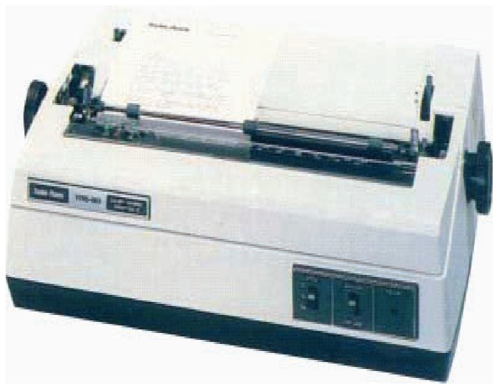
Disadvantages

- Slow Speed
- Poor Quality

Daisy wheel printer

Head is lying on a wheel and pins corresponding to characters are like petals of Daisy (flower name) that is why it is called Daisy Wheel Printer. These printers are generally used for word-processing in offices which require a few letters to be sent here and there with very nice quality. (Fig 16)

Fig 16



Advantages

- More reliable than DMP
- Better quality
- The fonts of character can be easily changed

Disadvantages

- Slower than DMP

- Noisy
- More expensive than DMP

Line Printers

Line printers are the printers which print one line at a time. (Fig 17)

Fig 17

These are of further two types

- Drum Printer
- Chain Printer

Drum printer

This printer is like a drum in shape so it is called drum printer. The surface of drum is divided into number of tracks. Total tracks are equal to size of paper i.e. for a paper width of 132 characters, drum will have 132 tracks. A character set is embossed on track. The different character sets available in the market are 48 character set, 64 and 96 characters set. One rotation of drum prints one line. Drum printers are fast in speed and can print 300 to 2000 lines per minute.

Advantages

- Very high speed

Disadvantages

- Very expensive
- Characters fonts cannot be changed

Chain printer

In this printer, chain of character sets are used so it is called Chain Printer. A standard character set may have 48, 64, or 96 characters.

Advantages

- Character fonts can easily be changed.
- Different languages can be used with the same printer.

Disadvantages

- Noisy

Non-impact Printers

Non-impact printers print the characters without using ribbon. These printers print a complete page at a time so they are also called as Page Printers.

These printers are of two types

- Laser Printers
- Inkjet Printers

Characteristics of Non-impact Printers

- Faster than impact printers.
- They are not noisy.
- High quality.
- Support many fonts and different character size.

Laser Printers

These are non-impact page printers. They use laser lights to produce the dots needed to form the characters to be printed on a page. (Fig 18)

Fig 18

Advantages

- Very high speed
- Very high quality output
- Give good graphics quality
- Support many fonts and different character size

Disadvantages

- Expensive.
- Cannot be used to produce multiple copies of a document in a single printing.

Inkjet Printers

Inkjet printers are non-impact character printers based on a relatively new technology. They print characters by spraying small drops of ink onto paper. Inkjet printers produce high quality output with presentable features.

They make less noise because no hammering is done and these have many styles of printing modes available. Colour printing is also possible. Some models of Inkjet printers can produce multiple copies of printing also. (Fig 19)

Advantages

- High quality printing
- More reliable

Fig 19

Disadvantages

- Expensive as cost per page is high
- Slow as compared to laser printer

Computer Cases: The most common system case type is the tower. Depending on the specific number of internal drive bays and the height of the tower, these cases can be further classified into mini-size, mid-size and full-size tower cases. One of the biggest considerations when choosing between case sizes is the number of slots and the number of devices we would like to add to those cases.

Front panel buttons/Switches

In the following picture, you can see the front of a basic computer. Starting at the bottom and going up, you can see that there is a large round button. That's the power switch. Its used to turn the computer on and off.

Above the power button, you can see a row of ports. The four rectangular ports are USB ports.

They are typically used with USB flash drives or external hard drives to transfer information onto or from the computer.

Between the USB ports are the headphone and microphone jacks. These can be used for gaming headsets. The smaller button to the right of the right-most USB port is the reset button. The reset button should only to be used in the case of a serious crash where the computer freezes.

On some machines (machine is slang for computer), the reset button is omitted. If that's the case with your machine, you can reset it by holding down the power button for ~5 seconds.

In the front of this computer, there is only one drive. It's an optical drive (term used for CD, DVD and Blu-ray drives - drives that read and write with a laser). Some computers have multiple optical drives but you only need one to burn optical disks.

Most computers have both 'power lights' and 'hard drive lights'. The power light (power LED) lets you know when the computer is on. If it's on constantly, the computer is operating normally. If it's blinking, it's likely that the computer has gone into either hibernation or suspend mode.

The image below is the rear of the computer that we'll cover on this page. The individual groups of rear panel components will be covered in detail later on this page. This computer doesn't have some of the connectors found on the older computers. If you have an older computer and want to se e what the connectors.

Rear Panel Controls and ports

At the top of this computer, you can see where the power source (from the AC mains - the household wall outlet) plugs in. It is plugged into the 'power supply'. The power supply converts the mains voltage 115VAC/230VAC to the various voltages needed by the computer (we'll cover those various DC supply voltages later). On this particular power supply, you can see 2 switches.

One is the main power switch. The other is the voltage selector switch. The main power switch completely cuts power to the power supply. Switching this off is essentially the same as unplugging the cord from the power supply. When the end of the switch with the '1' is depressed (as it is below), the power supply is able to power up when asked to by the motherboard.

The voltage selector switch allows the power supply to operate with different mains voltages. In Europe and other areas of the world, they use 230VAC (Volts Alternating Current) instead of the 115VAC we have here in the US.

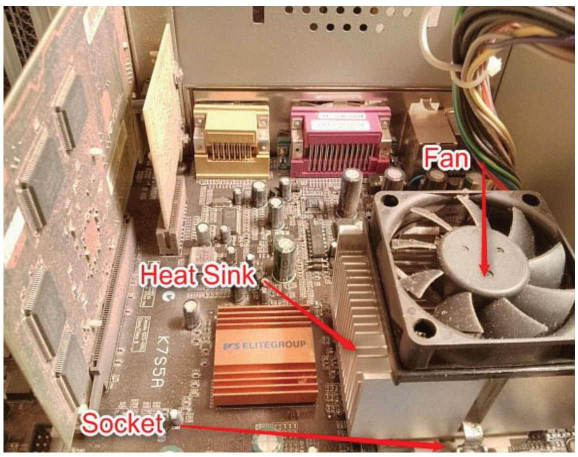
CPU Cooling fan

About CPU Cooling Fans

With the increase in magnitude of the usage of computers to more than 18 hours a day, there are additional demands placed on the processor. The processor then starts generating a lot of heat which is caused by the internal electrical energy of the components, and gets warmer the harder the components have to work.

Improper maintenance of heat and overheating of the processor can reduce the lifespan or cause irreparable damage to the components in the processor, including components like circuits, microchips, RAM, or hard drives, and makes the computer inoperable. In order to avoid damaging the components and prevent loss of data, it becomes essential to have good cooling equipment like a CPU fan. (Fig 20)

Fig 20



How a CPU Cooling Fan Works

One of the main components in the CPU is the CPU fan. It is the most economical and effective way to cool down the processor and protect it from overheating. The CPU fan is critically necessary to ventilate the heat generated from the components, and actively cools the processor by bringing in cooler air before the heat damages the computer components.

Cooling fans for the CPU are available in different sizes and is usually sold with an aluminum or copper heat sink fan. The CPU cooling fans are attached directly on top of the CPU, and works along with an aluminum heat sink fan to cool down the CPU and dispels any hot air from circulating around any circuitry boards, video cards, the motherboard, and other components that work with your computer, thereby ensuring that they are cool and operable.

Heat Sink Fan

The aluminum heat sink fan is a cooling device that works on its own to efficiently draw heat away from the components into its large surface area to transfer cooler air into its fin-like aluminum structure. This cooling device works in unison with all the major components of the computer.

The fan is attached to this fin-like structure and improves the transfer of hot air by pulling the hot air from the electrical heat generated by the components and pushing in cooler air between the aluminum fins, thus keeping the processor cool.

The Placement of the Fan in the Processor

The internal set up of the processor also directs the placement of the cooling device. If your processor has only one fan then it will mostly be located in the back of the processor, and this will be blowing out the hot air. If you have two CPU fans, then one fan will be located at the back, and the other will be located at the front of the processor. While the main function of the back fan is to blow out the hot air, the front fan moves in cooler air as the front of the CPU has more open area to allow the free inflow of cooler air. Ideally, all processors should have at least two fans: one fan to intakes cool air, while the other fan expels heat by blowing the hot air out.

Specifications of the Fan

The specification of the heat sinks and cooling fans depends on its compatibility with the processor, and on how much they are expected to perform. For instance, if insufficient cooling fans are installed when the processor calls for a super efficient cooling device, then the processor will have a shortened life span. The cooling fans should work on par with the demands placed on the processor.

Cables and Connectors in a PC system

Identification of Computer Hardware

Objectives: At the end of this lesson you shall be able to
- **explain types of cabinets, relation with motherboard form factor**
- **know what precautions to be taken while opening and closing a cabinet**
- **explain devices, components, cards & boards inside a PC**
- **explain interconnection of devices, boards, cards & components inside a PC**
- **know what precautions to be taken while removing and connecting cables inside a PC.**

Motherboard Form Factor

The size and shape of a computer case is usually determined by the form factor of the mother board. They need to match. The size of the motherboard is often called the Form Factor and there are several standards. The form factor identifies the size of the circuit board, the location of the slots as well as the location of the faceplate that comes out the back of the computer. The form factor also identifies the location of the holes that are used to mount the motherboard into the system case. For example, the full tower has more than enough room to fit an ATX motherboard. Mid-tower case can also accommodate an ATX motherboard in most cases.

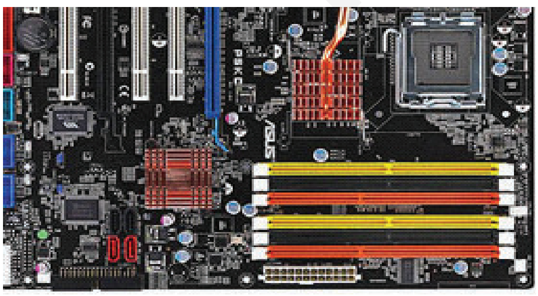
ATX Form Factor (Full ATX)

Probably the most common form factor for a motherboard is the ATX form factor. The board is approximately 12" x 9.6" (30cm x 24cm). (Fig 1)

Mini ATX

A mini-ATX motherboard is a slightly smaller variation of the full ATX size that measures 11.2" x 8.2" (28cm x 21cm). The main difference between ATX and mini-ATX is the number of buses and possibly memory slots on the motherboard. Mounting holes for both are located in the same place, making them interchangeable in most cases. A case that supports an ATX motherboard can also support mini-ATX motherboard.

Fig 1

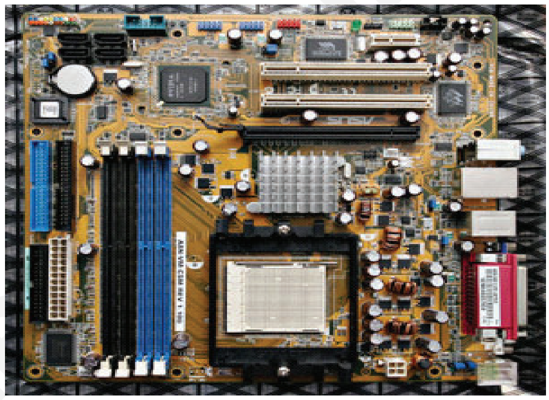


ATX Form Factor

Micro ATX

The micro-ATX form factor is an even smaller version of the ATX standard, with a maximum size of 9.6" x 9.6" (24cm x 24cm). The faceplate line up to the exact same position as in all other versions of ATX. System case that can hold an ATX motherboard can also hold micro ATX motherboard. The smaller mid or mini tower cases would likely be too small for a full ATX motherboard but should accommodate micro ATX motherboard. The terms mini-ATX and micro-ATX are often used interchangeably. (Fig 2)

Fig 2

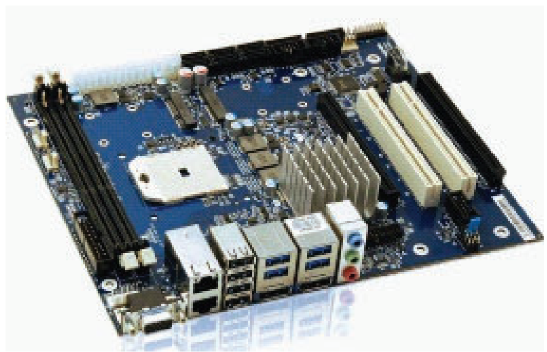


Micro ATX Form Factor

Flex ATX

The size of Flex ATX is 9" x 7.5" (22,9 cm x 19,1 cm). It is derived from Micro ATX and is used in small computer cases. (Fig 3)

Fig 3



Flex ATX Form Factor

Mini ITX

Going down in size we have a mini ITX motherboard with a maximum size of 6.7" x 6.7" (17cm x 17cm). Notice that there is a single expansion slot and the motherboard itself is considerably smaller than the ATX and even the micro ATX. Also notice that the faceplate still line up and the hole positions still match the ATX hole positions.

Theoretically we could take this micro ITX motherboard and place it inside a full tower case. However, we usually use a small form factor case for this motherboard. (Fig 4)

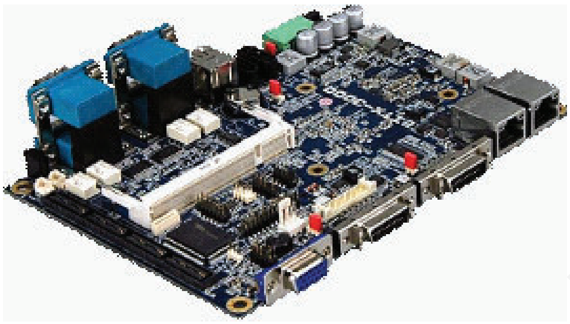
Fig 4

Mini ITX Form Factor

Em ITX

Em ITX dimensions are 17 cm x 12 cm. (Fig 5)

Fig 5

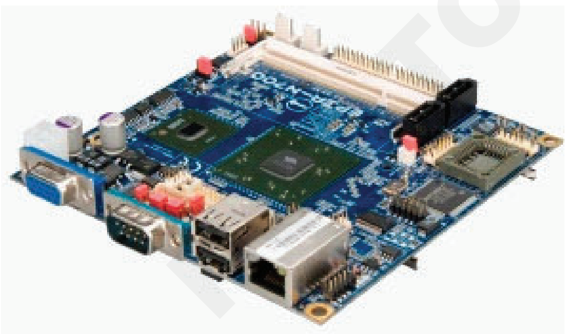


EM ITX Form Factor

Nano ITX

Measures of Nano ITX are 4.7" x 4.7" (12 cm x 12 cm). It is used with smaller devices like set-top boxes, car PCs, media centers, and other embedded devices. (Fig 6)

Fig 6



EM ITX Form Factor

Precautions to be taken while opening and closing PC cabinet

Before opening the case, disconnect all the cables from the back of the computer and place it on a table. Next, identify the chassis you're working with. Below is a short list of different ways a computer case cover is held on.

1 **Screw :** Case held on with screws.

2 **Thumbscrew:** Case with screws that require no special tools and can be tightened and loosened with your fingers. Often, these screws also have indents that allow them to also work with tools if needed.

3 **Screw less:** Case that has no screws, only held on with metal or plastic clamps that can release from the case by pressing buttons or switches.

Screw and thumbscrew computer cases

Often, the power supply screws are also visible from the back of the computer; however, these are often in the middle of the back of the computer case. The screws you want to remove to open the case are always on the outer-edges of the back of the computer.

The screws, buttons, or other mechanisms to open a computer case are almost always located on the back edges of a computer. If the case has screws, these need to be removed before the case cover can be removed. Once screws have been removed from the back of the case, push the side cover of case will slide off, or the complete cover will be removed. the computer case towards the back of the computer. Either the side of the computer Some computer cases use a combination of thumbscrews and screwless mechanisms to hold on the side of a computer case.

If you've removed a side of the computer but cannot see the inside of the computer, it's likely the wrong side of the computer case was removed; remove the other side to expose the inside of the computer.

Screwless computer cases

There are several techniques on how computer and case manufacturers develop a screwless entry chassis. Therefore, keep in mind that the steps below may not apply to your computer case.

As mentioned earlier, screwless computer cases work by using buttons, levers, or push arms. For example, NEC, Dell, and other major computer manufacturers used a popular screwless entry case where a single thumbscrew is removed from the back right side of the computer case, and while the computer is on its side, press and hold in two small levers on the top and bottom and push the side towards the back of the case.

In addition to the above example, a screwless computer case may have similar levers that may be located in other locations such as the bottom of the computer case or the front of the computer.

Finally, there are also other screwless computer cases that utilize buttons often located on the front bottom portion of the computer case. pressing this button will release the side of the case, allowing it to be removed.

Many power cables and data cables exist inside your computer, providing power to various components and allowing communication between devices.

The motherboard has one or more power connectors, as do devices like hard drives, optical drives , and even some video cards. All of these devices connect to the motherboard via the use of data interface cables

Tip: You can see how all of these devices connect to one another by taking a Tour Inside Your PC

Before you can reseat any cables inside your computer, you should unplug any external power cables, just to be safe. You should also remove any other external cables and attachments that might get in your way

Once you've opened your computer's case, locate, unplug, and then firmly reattach every power cable inside your computer.

There may be many different styles of power connectors inside your computer but all of them, aside from the large one connecting to the motherboard, will be small and relatively flat. If you have any doubt as to what is a power connector, follow the cable. If you can trace it back to the power supply, then it's a power connector.

All peripheral devices inside your computer will have a power connector including hard drives, optical drives (like CD/DVD/Blu-ray drives), and floppy drives. The motherboard itself will also have a large power connector and very often also a small 4, 6, or 8-prong power connector near the CPU.

Choose a device to work with (for example, one of your hard drives) and carefully unplug the data cable from both the device end and the motherboard end.

After you've unplugged both ends of the data cable, plug each end back in, just as you found them.

Important: Don't try to reseat every data cable at the same time or you're likely to get confused about which cable went where. If you were to accidentally connect a device to a different port on the motherboard, there's a good chance you could change the way it's configured which may cause your computer to stop booting properly.

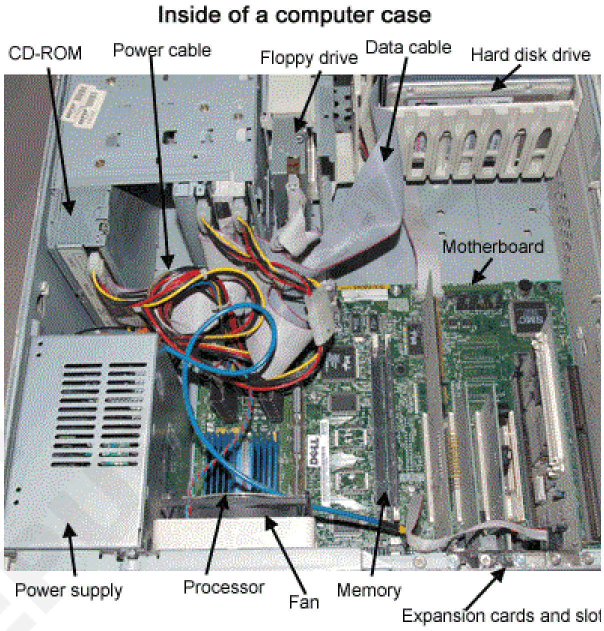
Take a close look at each device and area of the motherboard that you worked with and make sure that the correct power and data cables are attached.

Now that you've reseated all of the power and data cables inside your PC, you'll need to close your case and hook your computer back up.

Main Devices, components, cards, boards inside a pc

The inside of a desktop computer is not as complicated as you may think. Below is an example of what the inside of a computer looks like and each of the parts of the computer with pointers to each of the major components that make a computer (Fig 7)

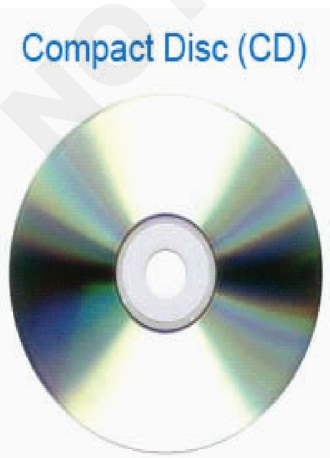
Fig 7

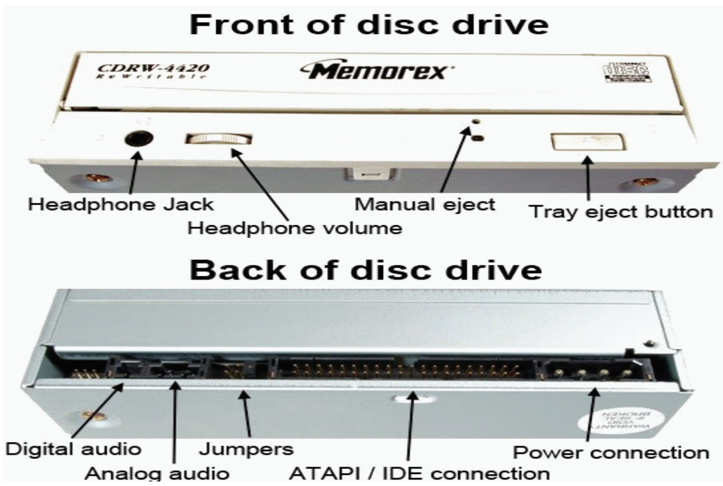


CD-ROM

Compact Disc-Read Only Memory, a CD-ROM is an optical disc which contains audio or software data whose memory is read only. A CD-ROM Drive or optical drive is the device used to read them. CD-ROM drives have speeds ranging from 1x all the way up to 72x, meaning it reads the CD roughly 72 times faster than the 1x version. As you would imagine, these drives are capable playing audio CDs and reading data CDs. Below is a picture of the front and back of a standard CD-ROM drive. (Fig 8)

Fig 8





Expansion Card

Alternatively referred to as an add-on card, expansion board, internal card, interface adapter, or just card. An expansion card is an electronic board or card added into the expansion slot of a desktop computer or other non-portable computer to give that computer a new ability, such as the ability to connect to another computer using a network cable.

Types of expansion cards in a computer

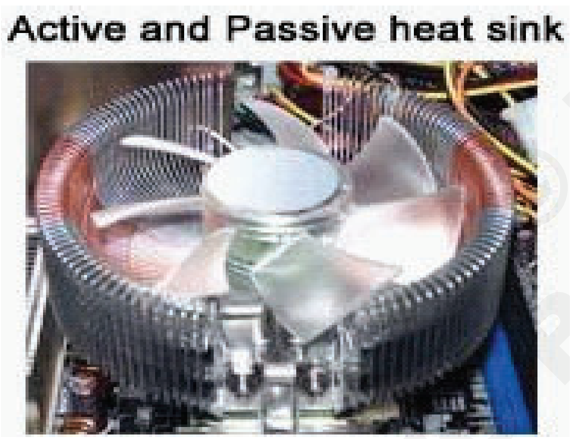
- Interface card (Bluetooth, IDE, Parallel, RAID, SCSI, Serial, and USB)
- Modem
- Network Card
- Sound Card
- Video Card

In computer it may have

Fan

A hardware device that keeps the overall computer or a computer device cool by circulating air to or from the computer or component. The picture is an example of a fan on a heatsink. (Fig 9)

Fig 9



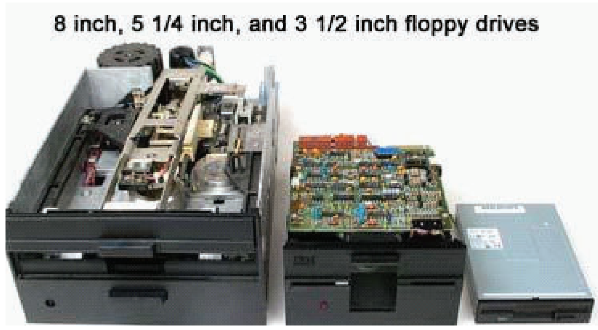
FDD

A Floppy Disk Drive, or FDD or FD for short, is a computer disk drive that enables a user to save data to removable diskettes. Although 8" disk drives were first made available in 1971, the first real disk drives used were the 5 1/4" floppy disk drives, which were later replaced with 3 1/2" floppy disk drives. Today, because of the limited capacity and reliability of floppy diskettes many computers no longer come equipped with floppy disk drives and are being replaced with CD-R, other writable discs, and flash drives. (Fig 10)

Hard disk drive

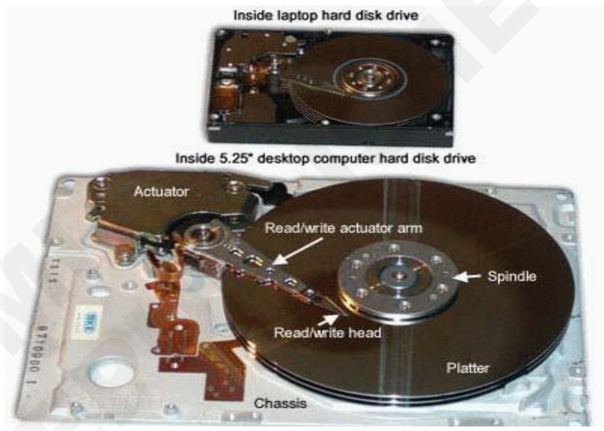
Alternatively referred to as a hard disk drive and abbreviated as HD or HDD, the hard drive is the computer's main storage media device that permanently stores all data on the computer.

Fig 10



Most computer hard drives are in an internal drive bay at the front of the computer and connect to the motherboard using either an ATA, SCSI, or SATA cable and power cable. (Fig 11)

Fig 11



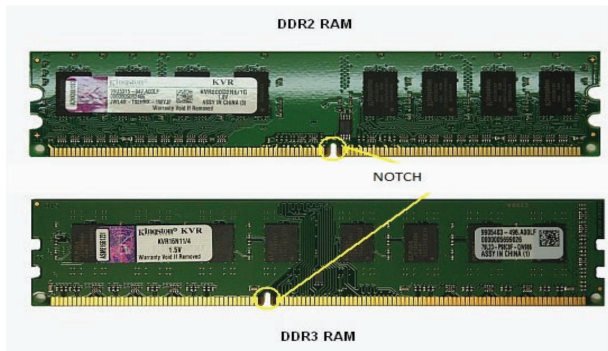
RAM

Alternatively referred to as main memory, primary memory, or system memory, Random Access Memory (RAM) is a computer storage location that allows information to be stored and accessed quickly from random locations within DRAM on a memory module.

Because information is accessed randomly instead of sequentially like a CD or hard drive the computer can access the data much faster than it would if it was only reading the hard drive.

However, unlike ROM and the hard drive RAM is a volatile memory and requires power in order to keep the data accessible, if power is lost all data contained in memory lost. (Fig 12)

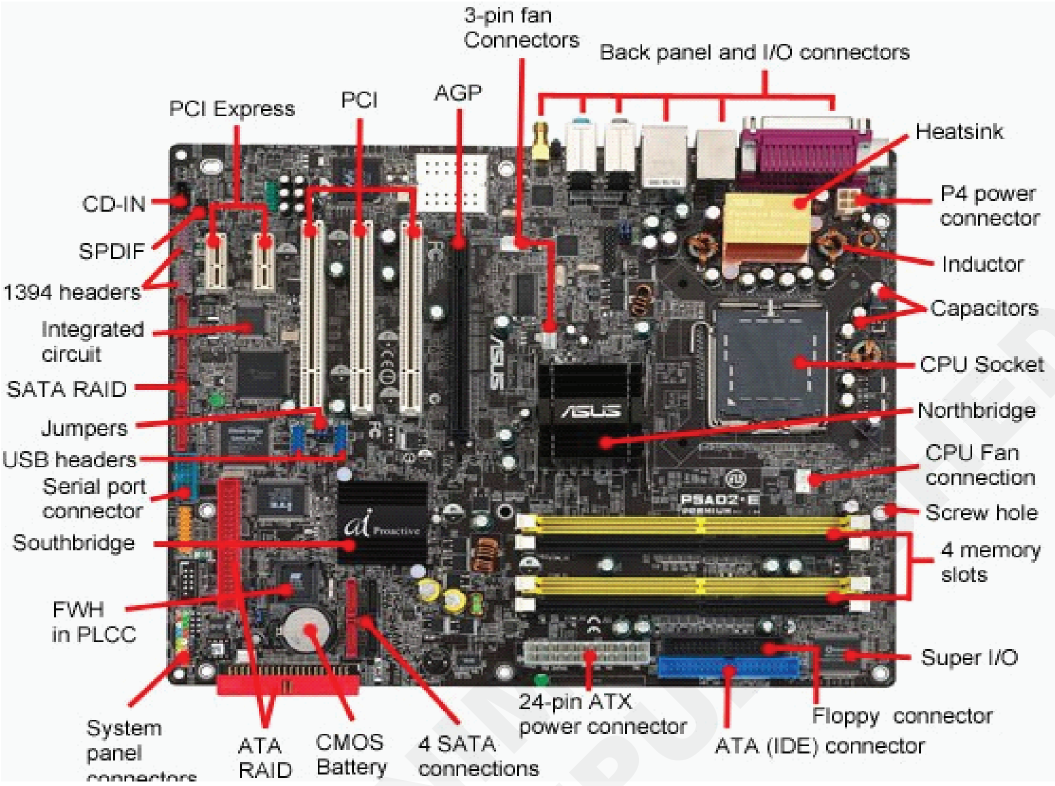
Fig 12



Motherboard

Alternatively referred to as the MB main board main circuit board, system board. The motherboard is a printed circuit board that is the foundation of a computer, located at the bottom of the computer case. It allocates power to the CPU, RAM, and all other computer hardware components and allows them to communicate with one another. (Fig 13)

Fig 13



Power supply

Short for Power Supply and sometimes abbreviated as PSU, which is short for Power Supply Unit. The PS is an internal hardware component used to supply the components in a computer with power by converting potentially lethal 220-230 volt alternating current (AC) into a steady low-voltage direct current (DC) usable by the computer. A power supply is rated by the number of watts it generates. (Fig 14)

Fig 14

CPU: Alternatively referred to as the brain of the computer, processor, central processor, or microprocessor, the CPU (pronounced as C-P-U) was first developed at Intel with the help of Ted Hoff in the early 1970's and is short for Central Processing Unit. The computer CPU is responsible for handling all instructions it receives from hardware and software running on the computer.

In the picture below, is an example of what the top and bottom of an Intel Pentium processor looks like. The processor is placed and secured into a compatible CPU socket found on the motherboard, and because of the heat it produces it is covered with a heat sink to help keep it cool and running smoothly. (Fig 15)

Fig 15

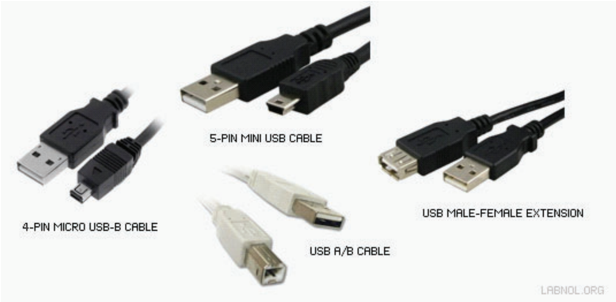
Types and specification of cables and connectors used for interconnecting the devices.

USB Cable

USB cables are used to connect most new devices to the computer including flash memory sticks, portable media players, internet modems and digital cameras. (Fig 16)

Audio Cables and Connectors

Fig 16



3.5mm headphone jack

The most common audio cable is the standard headphone jack, otherwise known as a TSR connector. It is available in several sizes, but the most common ones used with computers are the 3.5 mm or 1/8? mini audio jack.

Most speakers and microphones can connect to the computer with these audio cables. The microphone port on your computer is usually pink while the speaker port, where you insert the stereo audio cable, is colored green. Some computers have additional TSR audio ports colored black, grey, and gold; these are for rear, front, and center/subwoofer output, respectively. (Fig 17)

Fig 17

Digital Optical Audio

For high-end audio, like when you want to connect the output of a DVD player or a set-top box to a Dolby home theater, you need the TOSLINK (or S/PDIF) connector. (Fig 18)

Fig 18

These are fiber optic cables and can therefore transmit pure digital audio through light. Some laptops and audio equipment have a mini-TOSLINK jack.

Video Cables

VGA

One of the most common video connectors for computer monitors and high-definition TVs is the VGA cable. A standard VGA connector has 15-pins and other than connecting a computer to a monitor, you may also use a VGA cable to connect your laptop to a TV screen or a projector. (Fig 19)

Fig 19

DVI Monitor Port

If you have purchased a computer in the recent past, chances are that it uses DVI instead of VGA. The new breed of "thin" laptops use the smaller variants of DVI like the Mini-DVI and Micro-DVI (first seen in MacBook Air).

A DVI cable has 29 pins, though some connectors may have less pins depending on their configuration. DVI's video signal is compatible with HDMI, so a simple converter can allow a DVI monitor to receive input from an HDMI cable.

Additionally, DVI to VGA converters are also available for connect your new graphics card to old monitor that supports only VGA mode. (Fig 20)

Fig 20

S-Video

S-Video cables, otherwise known as Separate Video or Super Video cables, carry analog video signals and are commonly used for connecting DVD players, camcorders, older video consoles to the television. (Fig 21)

Standard S-Video connectors are round in shape and may have anywhere between 4-9 pins.

Fig 21

HDMI Cables

HDMI is the new standard that provide both audio and video transmission through a single cable. HDMI support a very high resolution with up to 8 channels of digital audio and are used for connecting Blu-Ray players to an HDTV. (Fig 22)

Fig 22

Standard HDMI cables can be up to 5 meters long, but higher quality ones can be up to 15 meters long, and the length can be further increased with amplifiers. HDMI is backwards compatible with DVI so you can use a converter to watch video on a DVI device through the HDMI cable though you will have to use another cable for the audio.

DisplayPort

A combined digital video and audio cable that is more commonly used in computers is DisplayPort and the smaller derivative Mini DisplayPort. Both support up to 8 channels of digital audio.

Mini DisplayPort connector is currently used in MacBooks expecting them in other computers as well in the near future.

Standard DisplayPort cables can be up to 3 meters long, but at a lower resolution cables can be up to 15 meters long. DisplayPort connectors are available to connect VGA, DVI video, or HDMI video and audio with a DisplayPort cable or connection. Additionally, converters are available to convert Mini DisplayPort into standard DisplayPort. (Fig 23)

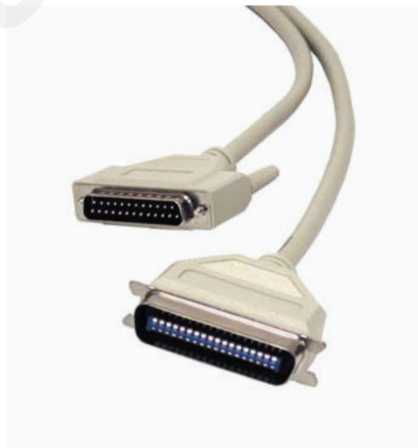
Fig 23

Data Cables

Parallel port printer cable (Fig 24)

The parallel port socket on your computer uses 25 pins. On most peripherals like printers, the 36 pins Centronics version is used. Printers are connected to a computer using a cable with a 25 pins DB male connector at one side and a 36 pins centronics connector on the other.

Fig 24



Firewire IEEE 1394

Firewire, otherwise known as IEEE 1394, i.LINK, or Lynx, is a faster alternate to USB and is commonly used for connecting digital camcorders and external hard drives to a computer. It is also possible to ad-hoc network computers without a router over FireWire. (Fig 25)

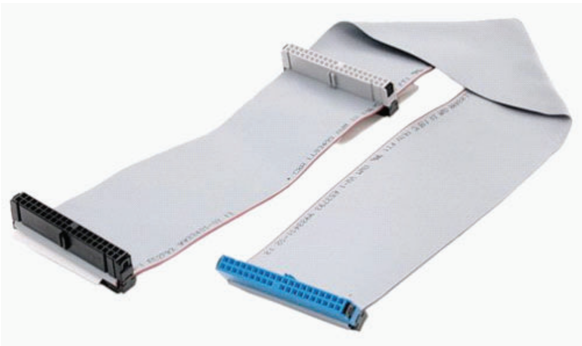
Firewire typically has 6 pins in its connector, though a 4 pin variety is common as well.

Fig 25

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 26)

Fig 26



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 27)

Fig 27

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 28)

Fig 28

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 29)

Fig 29

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.

Networking Related Cables

Phone RJ11 Cable

The telephone cable, otherwise known as RJ11, is still used around the world for connecting to the Internet through DSL/ADSL modems. A standard phone cable has 4 wires and the connector has four pins. (Fig 30)

The connector has a clip at the top to help maintain a tight connection.

Ethernet Cable (Fig 31)

Power Connector Cables

Molex 4 pin Peripheral Power Connector: The Molex 4 pin power supply connector is one of the standard peripheral power connectors in computers today. This power connector is the standard connector for all PATA based hard drives, many high end video cards, and some older optical drives and other internal devices. (Fig 32)

Fig 30

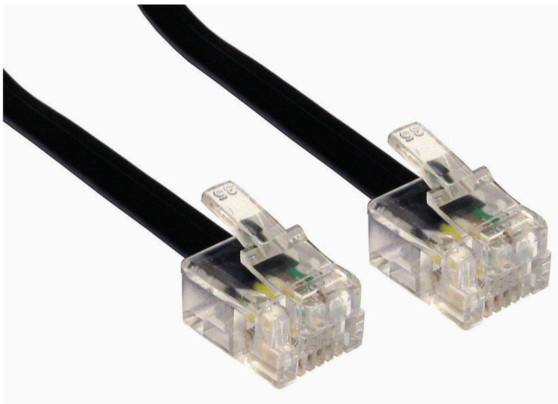


Fig 31

Fig 32

ATX 24 pin 12V Power Supply connector

The ATX 24 pin power supply connector is the standard motherboard power connector in computers. (Fig 33)

Floppy Drive 4 pin Power Connector

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 34)

Fig 33

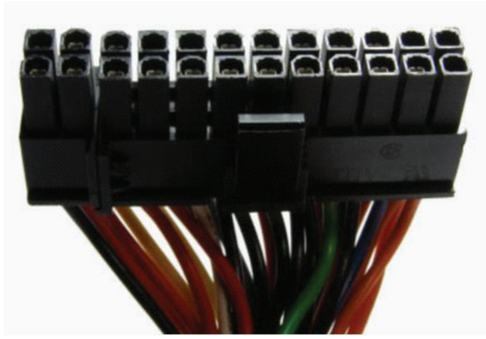
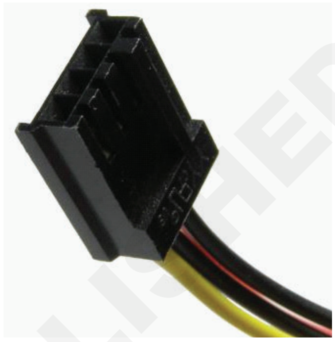


Fig 34



15 pin SATA Power Connector (Fig 35)

The SATA 15 pin power supply connector is one of the standard peripheral power connectors in computers today.

Fig 35

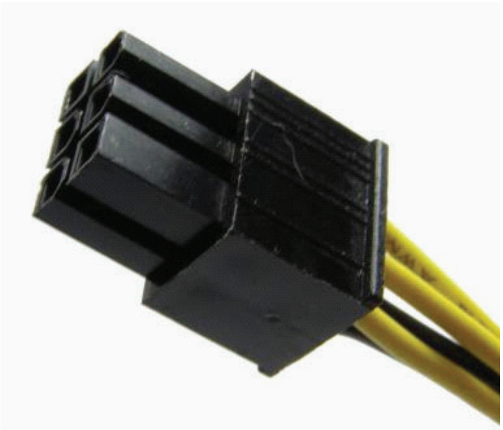
6 pin Motherboard Power Connector (Fig 36)

The ATX 6 pin power supply connector is a seldom used motherboard power connector used to provide +12 VDC to the processor voltage regulator.

Twisted-pair Ethernet cable is the most common type of cable used for interconnection of two or more computers. Twisted-pair Ethernet cables are used to connect:

- Routers or modems to computers
- Computers to hubs or switches
- Computers to other computers
- Other devices (such as network printers) to computers, hubs, or switches

Fig 36



The difference between a wire and a cable is

A wire is a single conductor (typically copper) that may be solid or stranded.

Two or more insulated wires grouped together in a sleeve or jacket (typically plastic) form a cable.

When purchasing network cables, you will most likely need Cat5e or Cat6, UTP (Unshielded Twisted Pin) straight-through Ethernet cables with RJ-45 connectors. (RJ stands for registered jack.)

Twisted pairs and RJ-45 connectors

Twisted-pair Ethernet cables consist of eight copper insulated wires in a plastic sleeve. Two wires are twisted together in a pair for a total of four pairs, and then the four pairs are twisted together to form the cable. The twists and pairs affect certain performance characteristics of the cable, such as crosstalk, attenuation, and electromagnetic interference (EMI).

Crosstalk occurs when an electrical signal transmitted over one wire negatively affects the electrical signal transmitted over another wire. Attenuation is the gradual loss of intensity of an electrical signal as it travels over the wire. EMI is noise (unwanted electrical signals) that is generated between the wires by the various electrical signals that are transmitted.

A clear plastic jack, known as an RJ-45 connector, is attached to both ends of the twisted-pair Ethernet cable. An RJ-45 connector looks very similar to a telephone jack (which is known as an RJ-11 connector). (Fig 37)

Twisted-pair Ethernet cable with RJ-45 connectors

Twisted-pair Ethernet cabling is commonly referred to as simply Ethernet, Cat5, or UTP cable. Technically, Ethernet is a wiring and signaling standard that covers many types of cabling technologies; Cat5 is one category of several available categories; and UTP is one of two possible types. However, these terms are commonly understood to refer to twisted-pair Ethernet cabling.

Fig 37

Hardware identification - II

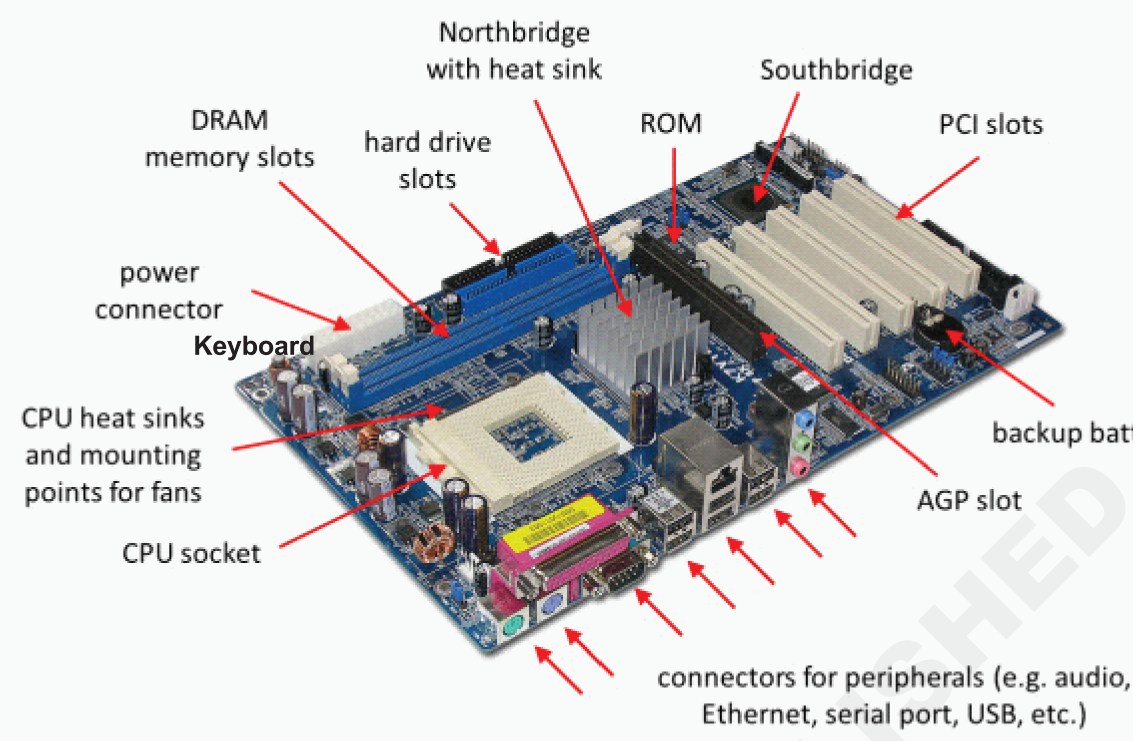
Objectives: At the end of this lesson you shall be able to
- **explain motherboard components and connections**
- **explain CPU (Processor)**
- **explain RAM (Memory)**
- **explain hard disk drive connections**
- **explain sound card**
- **explain ports on a PC**
- **explain connecting or removing connectors from PC port.**

Motherboard Components and Connectors (Fig 1)

Every motherboard has connectors and slots to connect all the remaining parts of CPU. here the list of all the slot and connector of motherboard.

- CPU Socket
- North Bridge
- South Bridge
- RAM Slots
- AGP Slot
- PCI Slots
- CNR Slot
- Floppy Connector
- Primary and Secondary IDE Connectors
- SATA connectors
- Power Connector
- BIOS
- CMOS battery
- Ports

Fig 1

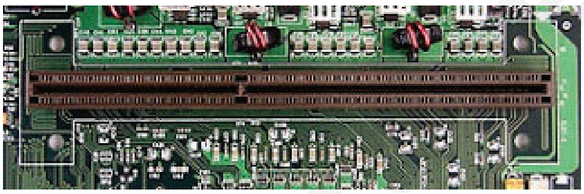


Block Diagram of a Mother Board

CPU Socket

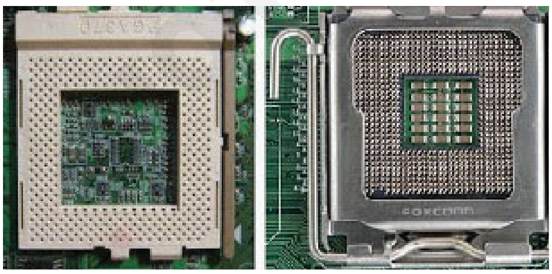
CPU Socket or Processor Socket. Which is used to install or insert the processor. we have two types of sockets. LIF sockets and ZIF socket. LIF stands for Low Insertion Force, this is the old model sockets and ZIF stands for Zero Insertion Force, this is the present model sockets. (Fig 2 & Fig 3)

Fig 2



LIF socket or slot type processor socket

Fig 3

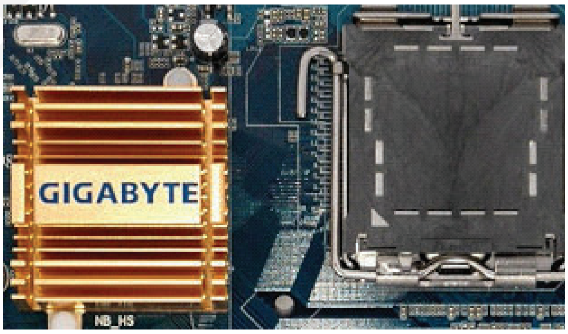


ZIF socket or PGA sockets

North Bridge

North Bridge is always near the processor socket. which is one of the important component of a motherboard. It is a focal Point of Motherboard and It is also called as Memory Controller Hub. North Bridge interconnects Processor socket, RAM slots and AGP slot. here Gigabyte chip is north bridge it is near Processor socket. (Fig 4)

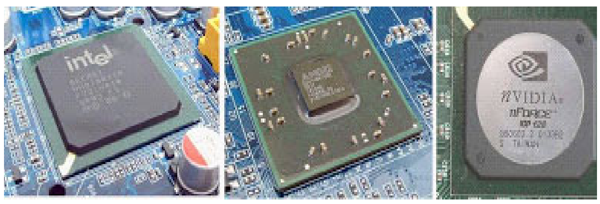
Fig 4



South Bridge

North bridge and south bridge are the two main poles of a motherboard. South Bridge interconnects Primary and Secondary IDE interfaces, SATA connectors, Floppy Drive Connector, PCI slots and BIOS. (Fig 5)

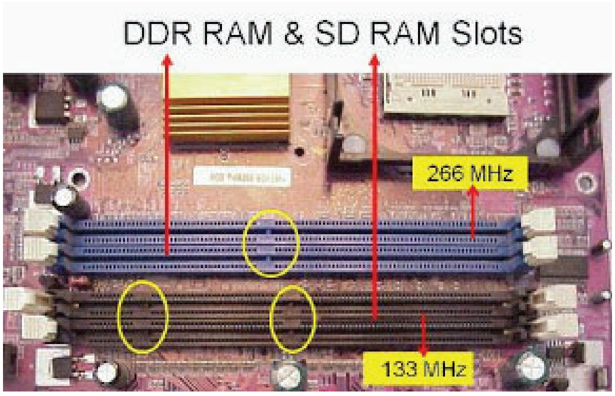
Fig 5



RAM Slots

RAM slots are used to insert RAMs. there are so many types of ram slots. they are SD ram slots, DDR ram slots, DDR2 and DDR3 ram slots. SD stands for synchronize Dynamic and DDR Stands for Double Data Rate. (Fig 6)

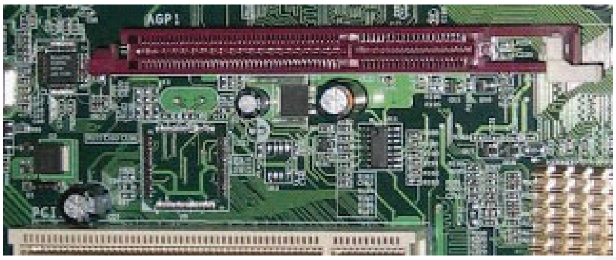
Fig 6



AGP slot

AGP slots are used to insert or install AGP Cards. AGP full form is Accelerated Graphics Port. This slot is for graphics and 3d gaming purpose. it is always beside the PCI slots. (Fig 7)

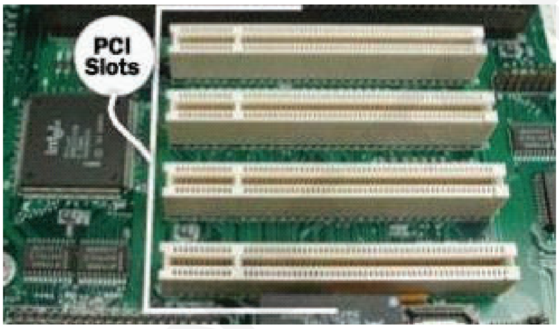
Fig 7



PCI slots

PCI slots are used to Insert or install Add-on cards, such as LAN cards, Sound cards, Capture cards and TV tuner cards. PCI full form is Peripheral Component Interconnect. (Fig 8)

Fig 8



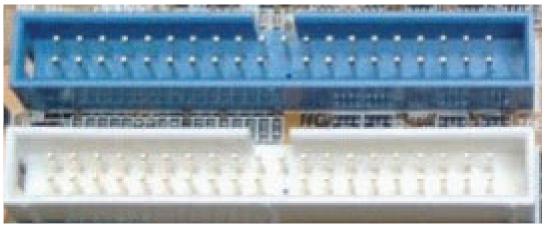
Floppy Drive Connector

Floppy Drive Connector is used to connect floppy drives. It supports two floppy drives. so that A and B drives are reserved for two floppy drives in My computer. it has 32 pins.

Primary and Secondary IDE Interfaces

Primary and Secondary IDE interfaces are also called as IDE connectors or PATA connectors. IDE full form is Integrated Device Electronics. it supports IDE devices, such as Hard disks and CD and DVD drives. (Fig 9)

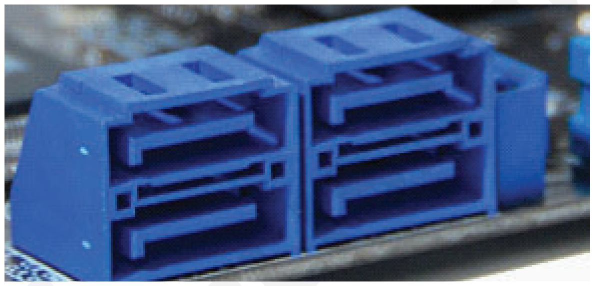
Fig 9



SATA Connectors

SATA connectors are also called as Serial ATA connectors. SATA full form is Serial Advanced Technology Attachment. These are connect, with serial ATA devices, such as Hard disk drives and CD or DVD drives. (Fig 10)

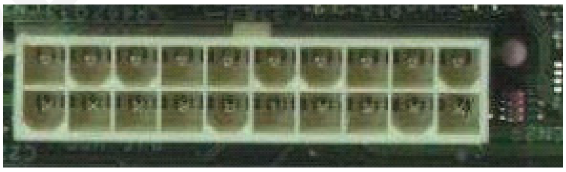
Fig 10



Power Connector

This power connector is ATX power connector. it has 20 or 24 pin connector. mother takes the power from this connector to work. (Fig 11)

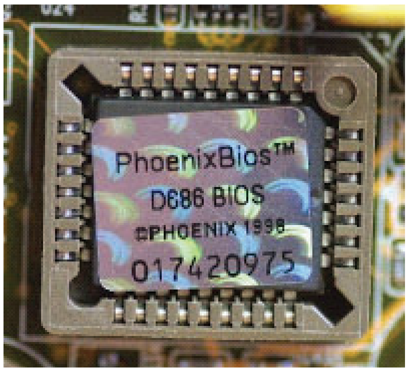
Fig 11



BIOS

BIOS stands for Basic input and Output system. This is also one of the important chips. it conducts the POST (Power On Self Test). (Fig 12)

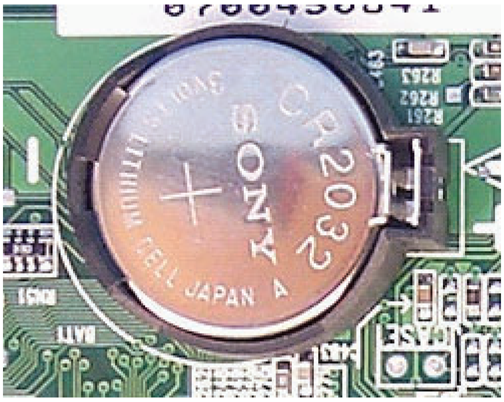
Fig 12



CMOS battery

There is a battery in the motherboard, which is used to power the south bridge and the BIOS to save the setting, data and time. (Fig 13)

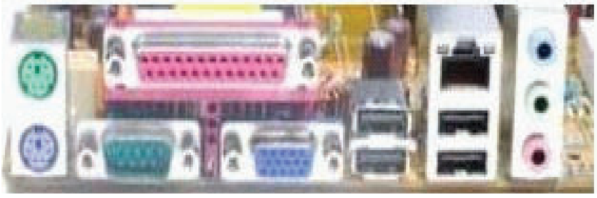
Fig 13



Ports

Ports are used to connect input and output devices. they are attached and come with motherboard and they are in backside of CPU. (Fig 14)

Fig 14



CPU(Processor)

Processor Sockets

CPU is connected to the mother board through a socket . The pins of the processor are connected to main system, memory, bios and motherboard chipset.

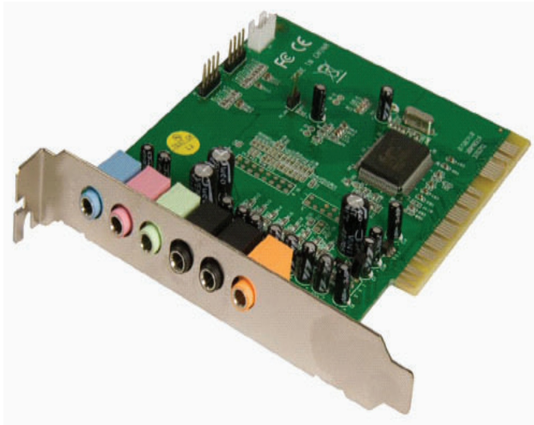
Various types of sockets are provided for Processor and memory modules. Processor Sockets generally seen on many types of mother boards have numbers such as socket 1, socket 2, socket 3, socket 4, socket 5, socket 6, socket 7, socket 370. They are also called ZIF sockets (zero insertion force). Inserting ICs into sockets without this facility needs careful handling of pins. With ZIF socket, insertion is made easy by widening the pin holes and tightening it after insertion. CPU sockets have pin orientation. Processor Pin 1 and socket pin 1 markings should match while insertion or always ensure processor IC pin arrangements match with that of socket. Different types of sockets.

Sound Card

Sound card with 16 bit ISA or 32 bit PCI interface. Sound card is an essential component of multimedia. The sound card comes with features for using microphone, speakers, audio input and joy stick input for playing video games. Musical instrument digital interface (MIDI) port for playing keyboard instrument.

The sound card also has a provision to connect CD ROM drives audio output, to play audio CD's directly. With this facility songs from CD's can be played through CD drive in background while working on a program. Fig gives the sound card layout. Now a days sound card comes as built in resource of the motherboard. (Fig 15)

Fig 15



The sound card converts digitized audio signal, stored in CDROM or hard disk as wav files, to an analog signal, which is fed to the amplifier/speaker. Similarly external audio through a microphone can be digitized and stored as wav files in hard disk.

RCA jacks and DB 15 game port connector are fixed on the bracket. All sound cards comes with drivers for different operating systems. Without proper installation of drivers the sound card may not function properly.

Microsoft Windows users can determine the sound card currently installed in their computer by following the steps below.

1 Click the Start Button and then click the "Programs" folder.

2 Next, click the "Accessories" and then the "System Information" folder.

3 Within the System Information window, click the + symbol next to Components.

4 Click "Sound Device" (or "Multimedia" and then "Sound Device") and in the right-side of the window you should be able to locate complete information about the sound card.

Another method of determining the sound card manufacturer or model is by opening the computer and physically looking at the sound card. Commonly the sound card manufacturer and model will be listed on the card.

Ports on a PC

- Is a physical docking point using which an external device can be connected to the computer.
- can also be programmatic docking point through which information flows from a program to computer or over the internet.

Characteristics

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 device is plugged in.

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

Following are few 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
- Also known as IEEE 1284-compliant 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 mouse and keyboard
- Also known as IEEE 1284-compliant Centronics port

Universal Serial Bus (or USB) Port

- It can connect all kinds of external USB devices such as external hard disk, printer, scanner, mouse, keyboard etc.
- It was introduced in 1997.
- Most of the computers provide two USB ports as minimum.
- Data travels at 12 megabits per seconds
- USB compliant devices can get power from a USB port

VGA Port

- Connects monitor to a computer's video card.
- Has 15 holes.
- Similar to serial port connector but serial port connector has pins, it has holes.

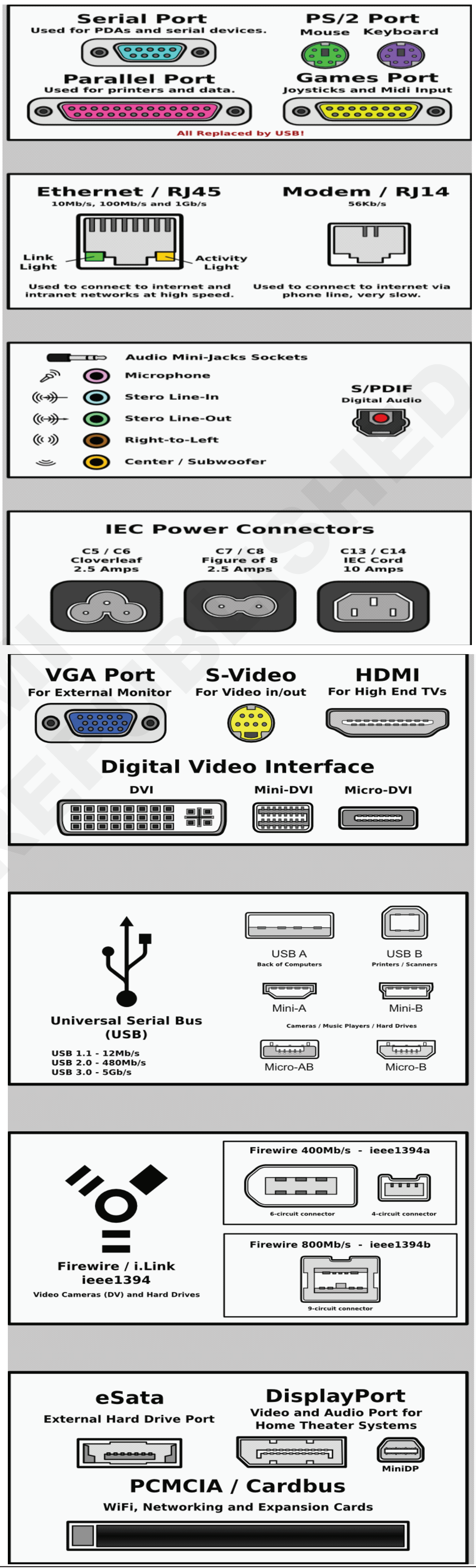
Power Connector

- Three-pronged plug
- Connects to the computer's power cable that plugs into a power bar or wall socket

Firewire Port

- Transfers large amount of data at very fast speed.
- Connects camcorders and video equipments to the computer
- Data travels at 400 to 800 megabits per seconds
- Invented by Apple

Fig 16



- Three variants : 4-Pin FireWire 400 connector, 6-Pin FireWire 400 connector and 9-Pin FireWire 800 connector

Modem Port

- Connects a PC's modem to the telephone network

Ethernet Port

- Connects to a network and high speed Internet.
- Connect network cable to a computer.
- This port resides on an Ethernet Card.
- Data travels at 10 megabits to 1000 megabits per seconds depending upon the network bandwidth.

Game Port

- Connect a joystick to a PC
- Now replaced by USB.

Digital Video Interface, DVI port

- Connects Flat panel LCD monitor to the computer's high end video graphic cards.
- Very popular among video card manufacturers.

Sockets

- Connect microphone, speakers to sound card of the computer.

Hardware installation/Uninstallation - I

Objectives: At the end of this lesson you shall be able to
- **explain memory devices**
- **explain random access memory (RAM)**
- **explain read only memory (ROM)**
- **explain construction and operation of hard disk drives**
- **explain floppy disk drive components and their functions.**

Memory Devices

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 is to be processed and instructions required for processing are stored.

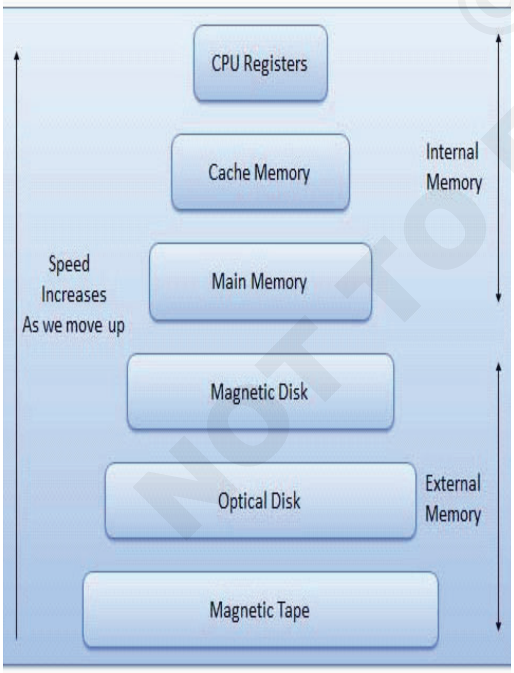
The memory is divided into large number of small parts. Each part is called cell. Each location or cell has a unique address which varies from zero to memory size minus one.

For example, if computer has 64k words, then this memory unit has 64 * 1024=65536 memory location. The address of these locations varies from 0 to 65535.

Memory is primarily of two types

- **Internal Memory:** Cache memory and primary/main memory
- **External Memory:** Magnetic disk / optical disk etc. (Fig 1)

Fig 1



Characteristics of Memory Hierarchy are following when we go from top to bottom.

- Capacity in terms of storage increases.
- Cost per bit of storage decreases.
- Frequency of access of the memory by the CPU decreases.
- Access time by the CPU increases

RAM (Random Access Memory)

RAM is considered "random access" because you can access any memory cell directly if you know the row and column that intersect at that cell. RAM is made in electronic chips made of so called semiconductor material, just like processors and many other types of chips. In RAM, transistors make up the individual storage cells which can each "remember" an amount of data, for example, 1 or 4 bits - as long as the PC is switched on. Physically, RAM consists of small electronic chips which are mounted in modules (small printed circuit boards). The modules are installed in the PC's motherboard using sockets - there are typically 2, 3 or 4 of these.

There are two basic types of RAM :

i Dynamic Ram

ii Static RAM

Dynamic RAM : loses its stored information in a very short time (for milli sec.) even when power supply is on. D-RAM's are cheaper & lower.

Similar to a microprocessor chip is an Integrated Circuit (IC) made of millions of transistors and capacitors.

Some other RAMS are :

a **EDO (Extended Data Output) RAM :** In an EDO RAMs, any memory location can be accessed. Stores 256 bytes of data information into latches. The latches hold next 256 bytes of information so that in most programs, which are sequentially executed, the data are available without wait states.

b **SDRAM (Synchronous DRAMS) :** SGRAMs (Synchronous Graphic RAMs) These RAM chips use the same clock rate as CPU uses. They transfer data when the CPU expects them to be ready.

c **DDR-SDRAM (Double Data Rate - SDRAM) :** This RAM transfers data on both edges of the clock. Therefore the transfer rate of the data becomes doubles.

RAM is of two types

- Static RAM (SRAM)
- Dynamic RAM (DRAM)

Static RAM (SRAM)

The word static indicates that the memory retains its contents as long as power remains applied. However, data is lost when the power gets down due to volatile nature. SRAM chips use a matrix of 6-transistors and no capacitors. Transistors do not require power to prevent leakage, so SRAM need not have to be refreshed on a regular basis.

Because of the extra space in the matrix, SRAM uses more chips than DRAM for the same amount of storage space, thus making the manufacturing costs higher.

Static RAM is used as cache memory needs to be very fast and small.

Dynamic RAM (DRAM)

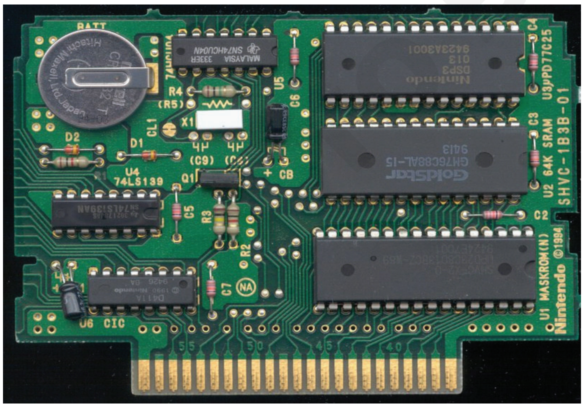
DRAM, unlike SRAM, must be continually refreshed in order for it to maintain the data. This is done by placing the memory on a refresh circuit that rewrites the data several hundred times per second. DRAM is used for most system memory because it is cheap and small. All DRAMs are made up of memory cells. These cells are composed of one capacitor and one transistor.

ROM (Read Only Memory)

1 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.

2 A ROM, stores such instruction 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 2)

Fig 2



Following are the various types of ROM

1 MROM (Masked ROM)

The very first ROMs were hard-wired devices that contained a pre-programmed set of data or instructions. These kinds of ROMs are known as masked ROMs. It is inexpensive ROM.

2 PROM (Programmable Read only Memory)

PROM is read-only memory that can be modified only once by a user. The user buys a blank PROM and enters the desired contents using a PROM programmer. Inside the PROM chip there are small fuses which are burnt open during programming. It can be programmed only once and is not erasable.

3 EPROM (Erasable and Programmable Read Only Memory)

The EPROM can be erased by exposing it to ultra-violet light for duration of up to 40 minutes. Usually, an EPROM eraser achieves this function. During programming an electrical charge is trapped in an insulated gate region. The charge is retained for more than ten years because the charge has no leakage path. For erasing this charge, ultra-violet light is passed through a quartz crystal window (lid). This exposure to ultra-violet light dissipates the charge. During normal use the quartz lid is sealed with a sticker.

4 EEPROM (Electrically Erasable and Programmable Read Only Memory)

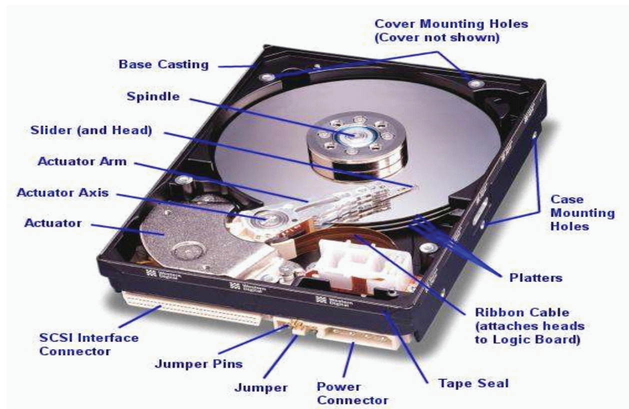
The EEPROM is programmed and erased electrically. It can be erased and reprogrammed about ten thousand times. Both erasing and programming take about 4 to 10 ms (milli second). In EEPROM, any location can be selectively erased and programmed. EEPROMs can be erased one byte at a time, rather than erasing the entire chip. Hence, the process of re-programming is flexible but slow.

Hard disk drive

Construction and Operation of the Hard Disk

It is hard to really understand the factors that affect performance, reliability and interfacing without knowing how the drive works internally. Fortunately, most hard disks are basically the same on the inside. While the technology evolves, many of the basics are unchanged from the first PC hard disks in the early 1980s. (Fig 3)

Fig 3



Hard disk operational overview: A hard disk uses round, flat disks called platters, coated on both sides with a special media material designed to store information in the form of magnetic patterns. The platters are mounted by cutting a hole in the center and stacking them onto a spindle.

The platters rotate at high speed, driven by a special spindle motor connected to the spindle. Special electromagnetic read/write devices called heads are mounted on to sliders and used to either record information onto the disk or read information from it. The sliders are mounted onto arms, all of which are mechanically connected into a single assembly and positioned over the surface of the disk by a device called an actuator. A logic board controls the activity of the other components and communicates with the rest of the PC.

Each surface of each platter on the disk can hold tens of billions of individual bits of data. These are organized into larger "chunks" for convenience, and to allow for easier and faster access to information. Each platter has two heads, one on the top of the platter and one on the bottom, so a hard disk with three platters (normally) has six surfaces and six total heads. Each platter has its information recorded in concentric circles called tracks. Each track is further broken down into smaller pieces called sectors, each of which holds 512 bytes of information.

1 The first step in accessing the disk is to figure out where on the disk to look for the needed information. Between them, the application, operating system, system BIOS and possibly any special driver software for the disk, do the job of determining what part of the disk to read.

2 The location on the disk undergoes one or more translation steps until a final request can be made to the drive with an address expressed in terms of its geometry. The geometry of the drive is normally expressed in terms of the cylinder, head and sector that the system wants the drive to read. (A cylinder is equivalent to a track for addressing purposes). A request is sent to the drive over the disk drive interface giving it this address and asking for the sector to be read.

3 The hard disk's control program first checks to see if the information requested is already in the hard disk's own internal buffer (or cache). It if is then the controller supplies the information immediately, without needing to look on the surface of the disk itself.

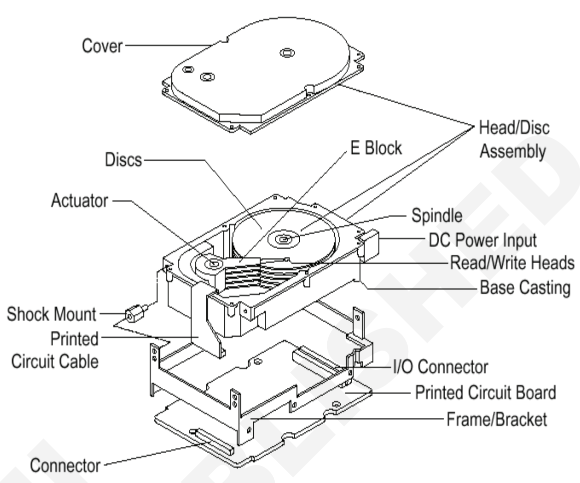
4 In most cases the disk drive is already spinning. If it isn't (because power management has instructed the disk to "spin down" to save energy) then the drive's controller board will activate the spindle motor to "spin up" the drive to operating speed.

5 The controller board interprets the address it received for the read, and performs any necessary additional translation steps that take into account the particular characteristics of the drive. The hard disk's logic program then looks at the final number of the cylinder requested. The cylinder number tells the disk which track to look at on the surface of the disk. The board instructs the actuator to move the read/write heads to the appropriate track.

6 When the heads are in the correct position, the controller activates the head specified in the correct read location. The head begins reading the track looking for the sector that was asked for. It waits for the disk to rotate the correct sector number under itself, and then reads the contents of the sector.

7 The controller board coordinates the flow of information from the hard disk into a temporary storage area (buffer). It then sends the information over the hard disk interface, usually to the system memory, satisfying the system's request for data. (Fig 4)

Fig 4



Tracks and Sectors

Platters are organized into specific structures to enable the organized storage and retrieval of data. Each platter is broken into tracks--tens of thousands of them--which are tightly-packed concentric circles. These are similar in structure to the annual rings of a tree (but not similar to the grooves in a vinyl record album, which form a connected spiral and not concentric rings).

A track holds too much information to be suitable as the smallest unit of storage on a disk, so each one is further broken down into sectors. A sector is normally the smallest individually-addressable unit of information stored on a hard disk, and normally holds 512 bytes of information.

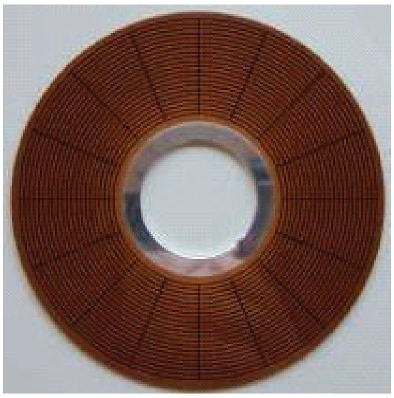
The first PC hard disks typically held 17 sectors per track. Today's hard disks can have thousands of sectors in a single track, and make use of zoned recording to allow more sectors on the larger outer tracks of the disk. (Fig 5)

Head Actuator

The actuator is the device used to position the head arms to different tracks on the surface of the platter (actually, to different cylinders, since all head arms are moved as a synchronous unit, so each arm moves to the same track number of its respective surface).

The actuator is a very important part of the hard disk, because changing from track to track is the only operation on the hard disk that requires active movement: changing heads is an electronic function, and changing sectors involves waiting for the right sector number to spin around and come under the head (passive movement).

Fig 5



Warranty

A desktop hard drive may have a 1 year warranty while a server hard drive will have a 3 to 5 year warranty.

Interface

Desktop/Laptop hard drives have SATA interfaces which work great for single users. SATA is quite fast and reliable. Enterprise hard drives use SAS or Fibre Channel. These interfaces are designed for faster and more reliable access. SATA is typically half the speed of SAS. The SATA interface is catching up in some of the latest desktop drives.

Storage: It may seem surprising but laptop and PC drives usually have more storage capacity per drive. This is not necessarily a bad thing for servers. Servers tend to have lots of smaller drives in order to provide higher performance rather than a few big drives.

Precautions to be taken while installing and uninstalling Hard Disk Drive

1 Turn the system's power off

2 Mount the drive in the system

Scan Disk and Defrag: One of the best ways to ensure optimum performance of your computer is to perform regular maintenance on the hard drive. Scan Disk and Disk Defragmenter (Defrag) are two programs that when run in conjunction with each other have the ability to detect and resolve many of the problems which can cause poor performance and in more serious cases the loss of files.

Both Scan Disk and Defrag can be found under System Tools located within the Accessories group, which can be found by clicking "Start" on your task bar and highlighting "Programs". Before running either of these utilities, be sure to disable any screensavers and or virus protection programs that you may have set on your PC. To run a thorough ScanDisk followed by Defrag, it can take up to 30 minutes. Should a screen saver be enabled, it will continuously interrupt these programs causing them to have to restart after each interruption.

Floppy disk drive Components and functions

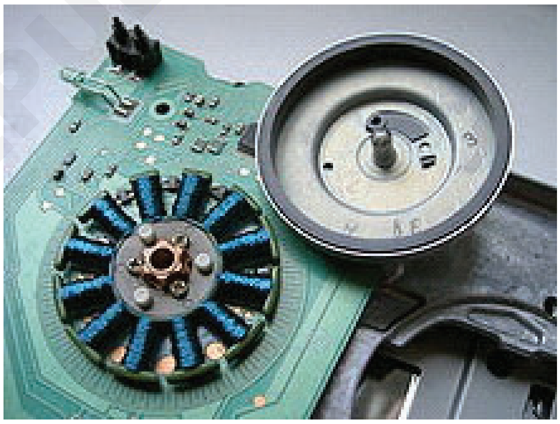
1 A floppy disk drive (FDD), or floppy drive, is a hardware device that reads data storage information. It was invented in 1967 by a team at IBM and was one of the first types of hardware storage that could read/write a portable device. FDDs are used for reading and writing on removable floppy discs. Floppy disks are now outdated, and have been replaced by other storage devices such as USB and network file transfer. (Fig 6)

Fig 6

Floppy Disk

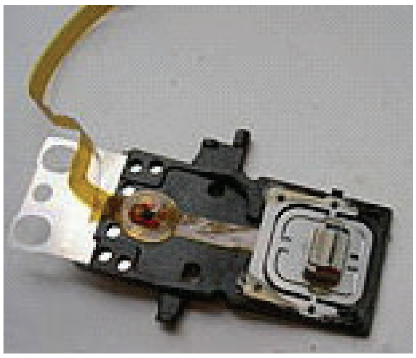
2 A spindle motor in the drive rotates the magnetic medium at a certain speed, while a stepper motor-operated mechanism moves the magnetic read/write head(s) along the surface of the disk. Both read and write operations require the media to be rotating and the head to contact the disk media, an action accomplished by a "disk load". (Fig 7 & Fig 8)

Fig 7



Spindle Motor

Fig 8



Read-Write Head

3 To write data, current is sent through a coil in the head as the media rotates. The head's magnetic field aligns the magnetic particles directly below the head on the media. When the current is reversed the particles align in the opposite direction encoding the data digitally.

To read data, the magnetic particles in the media induce a tiny voltage in the head coil as they pass under it. This small signal is amplified and sent to the floppy disk controller, which converts the streams of pulses from the media into data, checks it for errors, and sends it to the host computer system.

4 A blank "unformatted" diskette has a coating of magnetic oxide with no magnetic order to the particles. During formatting, the particles are aligned forming a pattern of magnetized tracks, each broken up into sectors, enabling the controller to properly read and write data.

5 The tracks are concentric rings around the center, with spaces between tracks where no data is written; gaps with padding bytes are provided between the sectors and at the end of the track to allow for slight speed variations in the disk drive, and to permit better interoperability with disk drives connected to other similar systems. Each sector of data has a header that identifies the sector location on the disk. A cyclic redundancy check (CRC) is written into the sector headers and at the end of the user data so that the disk controller can detect potential errors. Some errors are soft and can be resolved by automatically re-trying the read operation; other errors are permanent and the disk controller will signal a failure to the operating system if multiple attempts to read the data still fail.

Some precautions to be taken while installing and dismantling floppy drives

- Floppy disks contain important data and care must be taken in handling them.
- Do not place floppy disks anywhere near objects that emit a magnetic field.
- Do not open and close the shutter or touch the magnetic disk surface.
- Floppy disks are equipped with a write protection tab to prevent data being lost through misuse.
- It is recommended that the data stored on floppy disks is backed up onto other disks.
- It is necessary to format new floppy disks. Note that formatting a floppy disk will erase all previously stored data. Refer to "15-6. Erasing Setup Conditions" for details on formatting.

Overview of computer

Objectives: At the end of this lesson you shall be able to
- **explain different types of computer software's**
- **define functions of operating system**
- **list out the application areas of computer**
- **explain overview of windows desktop and its properties**
- **define control panel and its options.**

Software - Definitions

Software is a generic term for an organized collection of computer data and instructions. It is responsible for controlling, integrating and managing the hardware components of a computer system and for accomplishing specific tasks.

In other words, software instructs the computer what to do and how to do it. For example, software instructs the hardware what to be displayed on the user's screen, what kind of input to be taken from the user and what kind of output to be generated. Thus, software communicates with the hardware by organizing the control sequences, and the hardware carries out the instructions defined by the software.

As discussed earlier, a computer needs to be instructed to perform any task. These instructions are given in the form of computer programs, which are written in computer programming languages. A program controls the activity of the processor and the processor performs exactly what a program instructs. The moment the hardware (e.g. processor and memory) acts as per the instructions of a program, the program is said to be in the running or in the execution.

Relationship Between Software and Hardware

Software is a set of instructions that tells the hardware what to do and how to perform the requested actions. Thus, hardware and software share a special relationship. If hardware is the 'heart' of a computer system, software is its 'soul'. Both are complimentary to each other.

Software Categories

Software can be divided into two major categories:

1 **System software:** It provides the basic non-task specific functions of the computer. System software is essential for a computer to function.

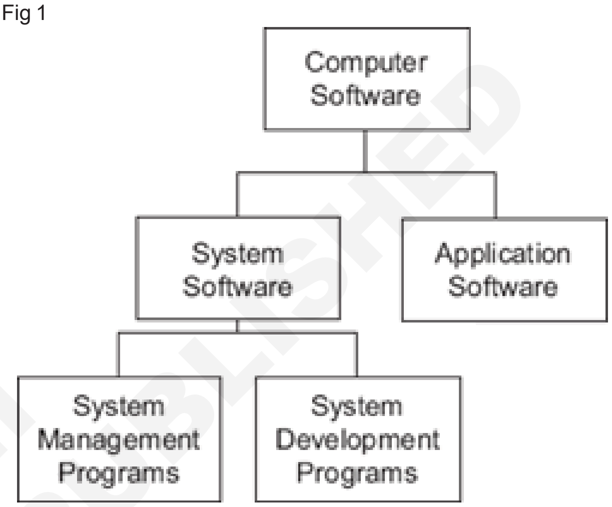
2 **Application software:** It is utilized by the users to accomplish specific tasks. It is the additional software that the users choose according to their needs (Fig 1).

1 System software

a) Operating System Software

An operating system is a collection of system programs **Fig 16** that together controls the operation of a computer system.

Fig 1



Operating system along with hardware, application and other system software, and users constitute a computer system. It is the most important part of any computer system. It acts as an intermediary between a user and the computer hardware.

Examples: DOS, Windows XP, Windows Vista, Windows 7, Windows 8, Unix/Linux, MAC/OS X etc.

b) Utility Software:

Utility software is system software designed to help analyze, configure, optimize or maintain a computer. A single piece of utility software is usually called a utility or tool.

Utility software usually focuses on how the computer infrastructure (including the computer hardware, operating system, application software and data storage) operates

Examples: Windows Explorer (File/Folder Management), Windows Media Player, Anti-Virus Utilities, Disk Defragmentation, Disk Clean, Backup, WinZip, WinRAR etc…

2 Application software:

The Application software includes enterprise, accounting software, office suites, graphics and media softwares. Apps may be bundled with the computer and its system software, or may be published separately. Some users are satisfied with the bundled apps and need never install one.

Some of the Package Softwares are MS Office 2003,MS Office 2007, Macromedia (Dreamweaver, Flash, and Freehand), Adobe (PageMaker, Photoshop), Corel draw, Autocad, etc…

Programming Languages

A language is a means of communication, a computer language are used for communication between the user and the computer. With the help of computer language, a programmer tells the computer what he wants the computer to do.

However, all computer language can be classified in the following categories.

1 Machine Level Language

2 Assembly Level Language

3 High Level Language (procedure oriented language)

Machine Level Language

Language which can be understood by the computer without using any translation program is called as Machine level Language. In machine language all the data and instructions should be given to the computer using the binary code of 1s and 0s. The binary code is called the machine code or machine language.

Assembly Language

It is a machine oriented language. Here no numeric codes are used. This language uses symbolic codes for operations.

Examples:

ADD (or) A is used to represent Addition and SUB or S is used for subtraction.

ADD A, B

STORE X, A

Assembly language Assembler

Machine language

Computer understand only machine -code instruction. Therefore, a program written in assembly language must be translated into machine language is called Assembler.

High Level Language

A computer programming language that allows instructions to be written in a way familiar to the User is called high level language. These are called compiler language or procedure-oriented languages.

The structure is closer to that of human languages. The instructions are given using simple English and mathematical symbols. It is a machine independent language.

A computer cannot understand a high level language directly. Hence a high level language program should be converted into machine language. A program used for this translation is called a compiler.

Some of the most common high - level languages are:

FORTRAN, BASIC, COBOL, FORTRAN, PASCAL, C,

C++, JAVA, DOTNET, etc.…

DATABASE

A database can be defined as a collection of related data in an organized way. A database can be anything from a simple collection of roll numbers, names, addresses and phone numbers of the students to a complex collection of sound, images and even video or film clippings.

Examples of non computerized databases are a dictionary, a phone book, a collection of recipes and a TV guide

The examples of computerized databases include customer files, employee rosters, books catalog, equipment inventories and sales transactions.

Database Management System

DBMS can be defined as a collection of interrelated data and a set of programs to access that data.

Examples

Dbase, Sybase, Foxbase, Paradox, Foxpro, Ms-Access, Sql-server, My-sql, Oracle, etc…

Operating system (OS)

An operating system is a collection of system programs that together controls the operation of a computer system. Operating system along with hardware, application and other system software, and users constitute a computer system. It is the most important part of any computer system. It acts as an intermediary between a user and the computer hardware.

The operating system has two objectives

- Managing the Computer's hardware
- Providing an Interface

Functions of Operating System

The main functions of a modern operating system are as follows:

- **Process Management :** As a process manager, the operating system handles the creation and deletion of processes, suspension and resumption of processes and scheduling and synchronization of processes.
- **Memory Management :** As a memory manager, the operating system handles the allocation and deallocation of memory space as required by various programs.
- **File Management :** The operating system is responsible for creation and deletion of files and directories. It also takes care of other file-related activities such as organizing, storing, retrieving, naming, and protecting the files.
- **Device Management :** Operating system provides input/output subsystem between process and device driver. It handles the device caches, buffers and interrupts. It also detects the device failures and notifies the same to the user.

- **Security Management :** The operating system protects system resources and information against destruction and unauthorized use.
- **User Interface :** Operating system provides the interface between the user and the hardware. The user interface is the layer that actually interacts with the computer operator. The interface consists of a set of commands or menus through which a user communicates with a program.

Modern Operating Systems

Microsoft Windows is the most popular series of operating system in the past decade. Windows 95 revolutionized the personal computer operating system market. Then came Windows NT, Windows 98, Windows ME, Windows 2000, Windows , and Windows Vista and so on. Windows 7 & Windows 8 is one of the latest offering made by Microsoft and has already gained reputation among the business market.

Application software

It is utilized by the users to accomplish specific tasks. It is additional software that the users choose according to their needs.

Example:

Ms office, Macromedia (Dreamweaver,Flash), Anti virus, Games

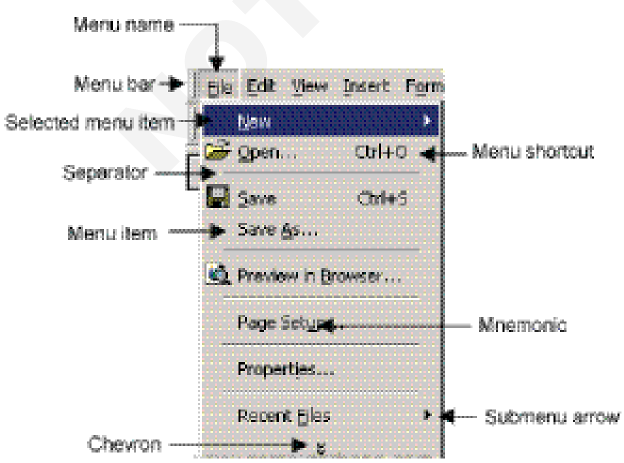
Concepts of GUI

A GUI is a user interface that provides graphical two-way communication between the user and the application. It consists of menus, windows, widgets, input devices (keyboard, mouse - point-and-click), output devices (audio - the "beeps" and other sounds the computer makes,

Menu

A menu is a list of commands or choices offered to the user. Menus are commonly used in GUI operating systems and allow a user to access various options the software program is capable of performing. File menus are commonly accessed using the computer mouse; however, may also sometimes be accessed using shortcuts or the keyboard. Below is a visual example of what a menu may look like in a GUI environment. (Fig 2)

Fig 2

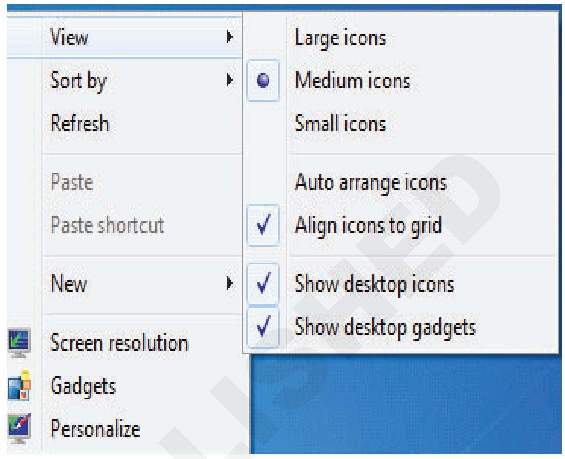


Context menu

A context menu (also called contextual, shortcut, and popup or pop-up menu) is a menu in a graphical user interface (GUI) that appears upon user interaction, such as a right- click mouse operation as on Fig 3.

A context menu offers a limited set of choices that are available in the current state, or context, of the operating system or application

Fig 3



The Taskbar (Fig 4)

The Taskbar lies across the bottom edge of your screen. The Start button on the left provides access to all the programs, data files, and other features available on the computer.

Fig 4

The Start menu

When click on the Start button, a set of menu options is displayed. The contents will vary depending on the computer setup and most frequently accessed programs.

If click on the All Programs option, you'll see a list of all the programs installed on the computer - even those that don't have icons on the desktop as on Fig 5.

Press the [ESC] (escape) key to close the menu.

Windows Briefcase

Windows Briefcase automatically synchronizes multiple copies of files. If you use a desktop computer at the office but work from home on a laptop, you can synchronize the files between your laptop and desktop using Windows Briefcase. Briefcase updates the files on your desktop to match the modified versions from your laptop when you reconnect the two computers.

Using mouse

The mouse is most useful tool when working with Windows! It allows you to quickly select and run programs by simply clicking a button.

It all clicks into place

You can use mouse in a number of different ways in Windows:

Fig 5

1 Pointing

Move the mouse so that the cursor points to an item on the screen.

2 Clicking

Hold the mouse still, and click the left mouse button once. Clicking usually selects an object (highlighting it) or opens a menu or window.

3 Double-clicking

Hold the mouse still and click the left mouse button twice in quickly. Double-clicking is usually used to open a program or file, or to expand a folder so that you can see its contents.

4 Right-clicking

Hold the mouse still, and click the right mouse button once. Right clicking usually opens a context-sensitive menu that provides you with a set of relevant options.

5 Dragging

Position your mouse on an object; hold down the left mouse button, and drag the object before releasing the button.

My Network Places

Microsoft Windows My Network Places is a network browser that displays network connections a computer has to other computers and servers and is what replaces Network Neighborhood found in Windows 95, 98, and NT. In a home network setting, My Network Places can display the other computers, network printers, and other network resources. In an office setting, it can display computers, servers, and network printers in the user's local workgroup. With the release of Microsoft Windows Vista and Windows 7, My Network Places has been renamed to Network.

An icon for Network Neighborhood, My Network Places, or Network may be on the Windows Desktop and is also accessible through the Windows Explorer.

Windows Explorer

Windows Explorer uses include browsing or searching the contents of disks, folders and libraries, opening files, deleting files and folders, renaming them, copying and moving them around, and creating new folders. One way of opening Windows Explorer is to press Windows Key + E.

File Properties

Properties are descriptive pieces of information that help you to find and organize files. Properties are not included within the actual contents of a file. Rather, they provide information about files. In addition to tags, which are custom properties that can contain any text you choose, your files include many other properties, including Date Modified, Author, and Rating.

To view the most common properties

You can see the most common properties that are associated with a file in the Details pane.

1 Open the folder that contains the file whose properties you want to see.

2 Click the file to see its properties in the Details pane at the bottom of the folder window.

To view all the properties

The Details pane is convenient, but it doesn't show all of the properties that are associated with a file. If you need to see all the properties that are associated with a file, follow these steps:

1 Open the folder that contains the file whose properties you want to see.

2 Right-click the file whose properties you want to see, and then click Properties.

3 Click the Details tab to see all the properties associated with this file.

Executing Application software

Start all programmes then navigate to the particular programme you need and select, then opens the particular programme.

Start a program by using the Run command in Windows 7

Using the Run command is a quick way to open programs, files, folders, and-when connected to the Internet-websites. If user not using the Start menu in Classic view, the Search box on the Start menu can also be used in place of the Run command.

1 Click the Start button  click All Programs, click Accessories, and then click Run or Press windows key + R.

2 In the Open box, type the name of a program, folder, file, or website.

Recycle Bin

Recycle bin is temporary storage for files that have been deleted in a file manager by the user, but not yet permanently erased from the file system. Typically, a recycle bin is presented as a special file directory to the user allowing the user to browse deleted files, undelete those that were deleted by mistake, or delete them permanently (either one by one, or by the "Empty Recycle bin" function).

Within a Recycle bin folder, a record is kept of each file and/or directory's original location. On certain operating systems, files must be moved out of the Recycle bin before they can be accessed again.

Toolbar

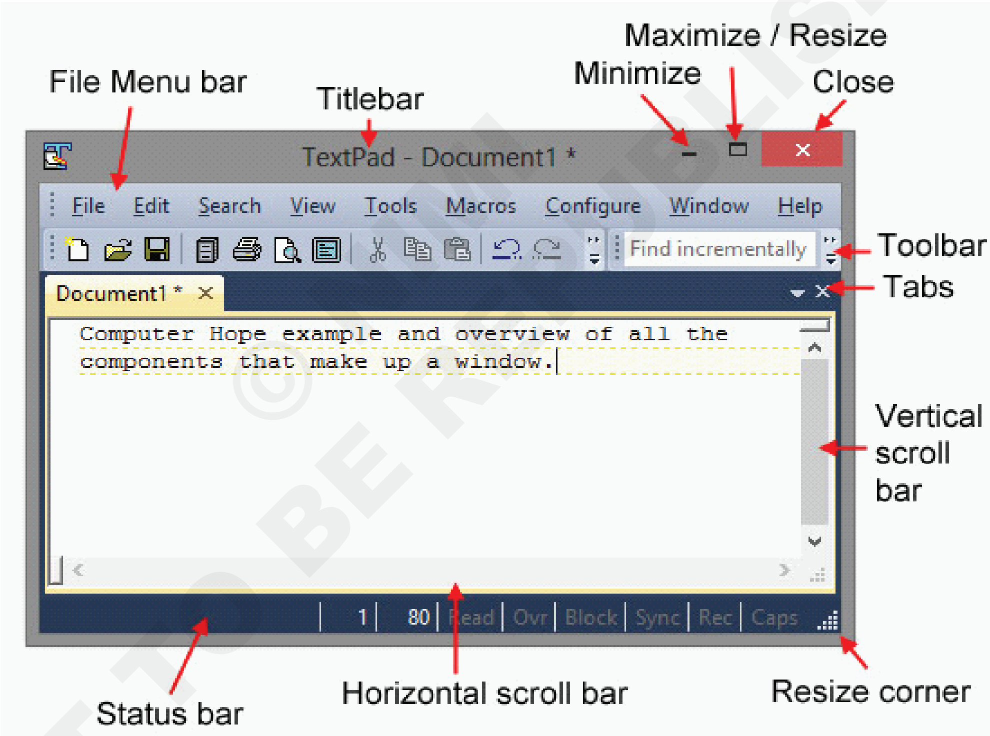
Sometimes referred to as a bar, the toolbar is a row of boxes, often at the top of an application window that control various functions of the software. The boxes often contain images that correspond with the function they control as seen in the picture below. (Fig 6)

A toolbar often provides quick access to functions that are commonly performed within the program. For example, a formatting toolbar in a program such as Microsoft Excel or Word gives access to functions such as making text bold, or aligning the text, or other commonly used formatting buttons. In a browser toolbars often add additional functionality to the browser that may not come pre-installed. For example, with the Google Toolbar installed, it gives access to handy Google features.

If missing a window toolbar try pressing Alt on the keyboard. Some programs hide the toolbar until Alt is pressed.

In most Microsoft Windows programs, the toolbars can be adjusted, hidden, or displayed by clicking on View at the top of the window and clicking Toolbars. In programs that do not have "View" look in the "Settings" or "Properties" section.

Fig 6



Windows Help and Support

Windows Help and Support is the built-in help system for Windows. It's a place to get quick answers to common questions, suggestions for troubleshooting, and instructions for how to do things. If need help with a program that's not part of Windows, consult that program's Help.

To open Windows Help and Support

1 Click the Start button  , and then click Help and Support.

2 On the toolbar in Windows Help and Support, click Options, and then click Settings.

3 Under Search results, select the Improve my search results by using online Help (recommended) check box, and then click OK. The words Online Help will be displayed in the lower-right corner of the Help and Support window when you are connected.

System Tools

Disk Defragmenter:

(Start button >> Programs >> Accessories >> System Tools >> Disk Defragmenter)

With continuous use of computer, the files used again and again become fragmented as these are written and rewritten on a very fast revolving hard disk. Due to fragmentation of files, the seek time of the hard disk increases and its efficiency comes down. Defragmentation of files results in reducing the seek time and restoring the efficiency of the hard disk. Defragmentation of a drive may take hours depending upon the volume of data stored on the disk. However, to maintain efficiency of the hard disk and computer it is recommended to defragment the hard disk once every 2-3 months.

System Information

(Start button >> Programs >> Accessories >> System Tools >> System Information)

This tool provides information about all hardware and other available resources in the computer viz.

System Restore

(Start button >> Programs >> Accessories >> System Tools >> System Restore)

Enables setting up of a restore point. In case of a problem with the system, you can restore the system to the position obtaining at the time of setting the restore point.

Disk Cleanup

(Start button >> Programs >> Accessories >> System Tools >> Disk Cleanup)

Over a period of time due to internet surfing and use of other applications and programs a large number of files are created in the system, which have not been used by the system for long. This tool deletes such unnecessary files from the hard disk and creates space for other useful data/information.

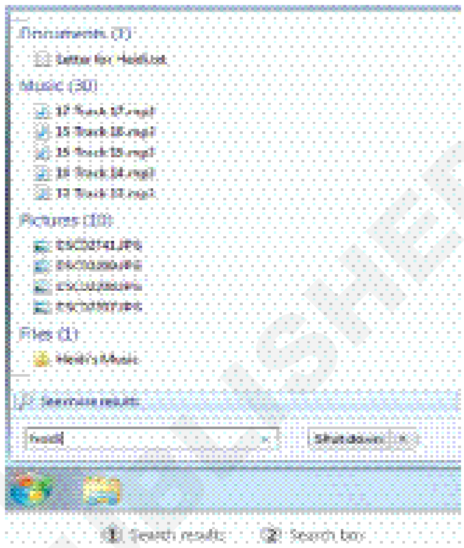
Find a file or folder in Windows 7

To find an item using the Start menu:

- Click the Start button, and then type a word or part of a word in the search box.

Search results appear as soon as start typing in the search box. The items that match with text will appear on the Start menu. The search results are based on text in the file name, text in the file, tags, and other file properties. (Fig 7)

Fig 7



Overview of computer storage devices

Objectives: At the end of this lesson you shall be able to
- **define hard disk data recovery**
- **list out the various storage devices of computer**
- **explain working principle of storage devices.**

Hard disk data recovery

Hard disk data recovery is possible because of data remembrance, which means that some data continues to exist on the hard disk drive even after it has been deleted. Data remembrance is beneficial to hard disk data recovery.

The process of hard disk data recovery finds the data that the operating system is unaware of, but still exists in individual clusters on the hard disk drive. However, clusters that have become corrupted or physically damaged cannot be recovered. In these cases, hard disk recovery has a greater likelihood of success if it is attempted immediately after the failure so as not to give the sectors with missing data an opportunity to be overwritten.

This takes the form of a stand-alone device that is separate from the computer. External drives are connected to the computer with a cable plugged into a suitable interface such as an USB port. Data then passes back and forth across the interface.

Removable Storage Devices

Once an external drive is attached to the system, it appears as an extra drive letter in the folder tree, for example, E drive or K drive. The user can transfer files in the usual way by using the drag and drop method.

The main advantage of external drives is that they are portable and so data is easily moved from one location to another. External drives also allow safe backup of internally stored data.

The main disadvantage compared to an internal drive is data transfer is slower and they also take up space around the computer. Constant plugging in and out can also physically wear out the port over time.

External storage takes many forms, for example:

- Portable Hard disk
- Magnetic tape
- Memory stick/Flash drive
- DVD/CD

Each type of external storage has to have the correct interface on the computer in order to connect.

Optical storage

Optical storage is the storage of data on an optically readable medium. Data is recorded by making marks in a pattern that can be read back with the aid of light, usually a beam of laser light precisely focused on a spinning disc. There are other means of optically storing data and new methods are in development. Optical storage differs from other data storage techniques that make use of other technologies such as magnetism or semiconductors.

Magneto-optical drive

A magneto-optical drive is a kind of optical disc drive capable of writing and rewriting data upon a magneto-optical disc. Both 130 mm (5.25 in) and 90 mm (3.5 in) form factors exist. The technology was introduced commercially in 1985. Although optical, they appear as hard disk drives to the operating system and can be formatted with any file system.

WORM

WORM can also mean "Write Once, Read Many." It is an optical storage technology that allows a disc to be written only once but read an unlimited number of times. WORM devices were introduced in the 1970's and gained popularity as a way of archiving data. The storage capacity of WORM discs began around 140MB, but increased to more than 3.0GB over the past few decades. Yet the WORM technology has no standard format, so WORM discs are only compatible with the drives that wrote them. This limitation has kept WORM equipment relatively expensive and has kept the technology from gaining widespread acceptance.

CD-ROM: An introduction

CD-ROM and DVD are optic readable media, contrary to hard disks, floppy disks and tapes, which are magnetic.

The optic storage media are read with a very thin and very precisely aimed laser beam. They supplement the magnetic media. They have clear advantages in the areas of data density and stability: Data can be packed much more densely in optic media than in magnetic media. And they have much longer life span. It is presumed that magnetic media, such as a hard disk or DAT (digital audio tape) can maintain their data for a maximum of five years. The magnetism simply fades away in time. Conversely, the life span of optic media are counted in tens of years.

The Compact Disk

The compact disk (CD) was introduced by Philips and Sony in 1980 to replace LP records. It is a small plastic disk with a reflecting metal coating, usually aluminum. Myriads of tiny indentations are burned into this coating.

These indentations contain the music in millions of bits. The CD is organized in tracks. Each track is assigned a number.

The big advantage of the CD is its high quality music reproduction and total absence of back ground noise as well as a great dynamic. During operation, the software in the drive can correct errors caused by such things as finger marks on the disk. All in all, CDs are excellent music storage media.

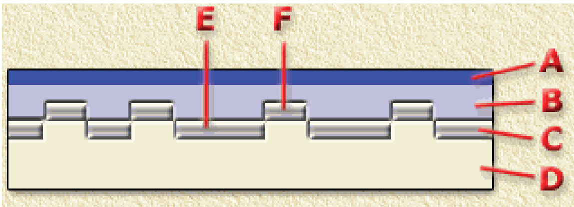
In the optic readable CD-ROM, the data storage consists of millions of indentations burnt into the lacquer coated, light reflecting silver surface. The burnt dents reflect less light than the shiny surface. A weak laser beam is sent to the disk through a two-way mirror and the sensor registers the difference in light reflection from the burnt and shiny areas as zeros and ones.

CD Surface

Basically a Compact Disc is nothing more than a plastic (polycarbonate) disc with several layers. The diameter of a CD is about 12 centimeters and is about 1,2 millimeter thin.

If we look at a CD from the side, for example using a microscope, we will see something similar to this picture information must be digital in order to store it on a CD, a lot of 1's and 0's. Now we can imagine what the pits (F) and bumps (E) are used for in the previous drawing. (Fig 1)

Fig 1



A	label layer
B	protection layer
C	Data layer (reflection layer)
D	protection layer (transparent)
E	Logical 0 (bump)
F	Logical 1 (pit)

Track

A different feature of a CD is the so called Track (helix) on the disc. Basically this is the track followed by the laser and it's sensor. This works similar as the good old record-player, the needle moves through a groove (the track) until the end of the groove has been reached.

This track or helix, can be up to 5 kilometers in length. In the above picture simplified this, in reality the density is much higher. (Fig 2)

Fig 2

An introduction to the DVD

The DVD is a high-capacity optic media.

The DVD standard was developed in the mid-1990s by leading companies like Philips and Sony. DVD stands for Digital Versatile Disk.

DVD disks are read by a laser beam of shorter wave-length than used by the CD-ROM drives. This allows for smaller indentations and increased storage capacity.

The data layer is only half as thick as in the CD-ROM. This opens the possibility to write data in two layers. The outer gold layer is semitransparent, to allow reading of the underlying silver layer. The laser beam is set to two different intensities, strongest for reading the underlying silver layer.

The DVD drives will not replace the magnetic hard disks. The hard disks are being improved as rapidly as DVD, and they definitely offer the fastest seek time and transmission rate (currently 20-30 MB/second). No optic media can keep up with this nor with the speedy seeks we get from the hard disks.

But the DVD will undoubtedly gain a place as the successor to the CD-ROM. New drives will read both CD-ROMs and DVDs.

DAT Drive

Digital Audio Tape (DAT or R-DAT) is a signal recording and playback medium developed by Sony and introduced in 1987. In appearance it is similar to a Compact Cassette, using 4 mm magnetic tape enclosed in a protective shell, but is roughly half the size at 73 mm × 54 mm × 10.5 mm. As the name suggests, the recording is digital rather than analog. DAT has the ability to record at higher, equal or lower sampling rates than a CD (48, 44.1 or 32 kHz sampling rate respectively) at 16 bits quantization. If a digital source is copied then the DAT will produce an exact clone, unlike other digital media such as Digital Compact Cassette or non-Hi-MD Mini Disc.

DAT drive for Computer data storage (Fig 3)

The format was designed for audio use, but through the ISO Digital Data Storage standard was adopted for general data storage, storing from 1.3 to 80 GB on a 60 to 180 meter tape depending on the standard and compression. It is a sequential-access medium and is commonly used for backups. Due to the higher requirements for capacity and integrity in data backups, a computer-grade DAT was introduced, called DDS (Digital Data Storage). Although functionally similar to audio DATs, only a few DDS and DAT drives are capable of reading the audio data from a DAT cassette.

Fig 3

Computer Hardware Servicing

Objectives: At the end of this lesson you shall be able to
- **state the basic steps involved in troubleshooting a PC**
- **explain the basic approach to solve a problem**
- **explain the need to optimize the PC**
- **state the steps involved in optimizing different sections of PC**
- **list the probable defect and symptoms in the faulty Computer**
- **analyse the causes for the complaint "Dead" with the help of a Problem Tree and TSC**
- **state the shortest path for servicing the defect using SFS.**
- **list the probable defect and symptoms in the faulty Computer**
- **analyse the causes for the complaint "System not booting" with the help of a Problem Tree and TSC**
- **state the shortest path for servicing the defect using SFS.**
- **list the probable defect and symptoms in the faulty Computer**
- **analyse the causes for the complaint "System gets frequently hanging" with the help of a Problem Tree and TSC**
- **state the shortest path for servicing the defect using SFS.**

Basic Troubleshooting

One of the difficulties while troubleshooting problems on a PC is that in most cases they are not what they seem. The cause behind a frequent hanging of a PC may be due to one of six or more well defined areas or a dozen of unidentified problems. The problem could be due to software or hardware. Even with years of experience and training, PC technicians come out with troubleshooting procedures that do not solve the real problem. For example a personal computer running windows operating system with several i/o cards connected may freeze the screen, mouse, and keyboard and take as long as 3 minutes before responding. After trying out with all the options like replacing a memory module, installing new parallel port and NIC drivers, the technician finally checks the system logs to find that a vital operating system library was corrupted and needed to be reinstalled. The issue to be mentioned here is that if the technician used a systematic approach to troubleshooting, the problem would likely have been solved much sooner. Maintaining a good troubleshooting plan certainly gives us the scope to approach the problem in a more systematic and scientific manner. A troubleshooting plan is nothing but a written check list that we use for any problem. The elements that should be included in any troubleshooting plan are as follows

- Maintenance record
- Identification of possible causes
- Identification of possible solutions
- Application and testing of solutions
- Follow-up

In the maintenance record, record the hardware installed in the PC when it is installed, all preventive maintenance activities, all software updates or additions, and all hardware installations and upgrades. Further any problems that occur and the actions you take to resolve them should be recorded. When it comes to troubleshooting a PC, with the maintenance record one can pin down a problem and devise solution for it. The first entry in such record should be a profile of the PC, which includes its configuration, operating system, and the date each component was installed. A sample of the maintenance record is given in the Table 1.

Table 1
Sample maintenance journal

Component	Configuration	Date in service	Notes
CPU	PIII667MHz	15/5/01	Fan and heatsink factory installed
System RAM	256MB (2-128MB DIMM)	15/5/01 16/5/01	Second DIMM added 16/5/01
Hard disk	20GB IDE	15/5/01	Interface on motherboard
Chipset	810EX	15/5/01	
Op Sys	Windows 2000 Pro	15/501	Windows 98 replaced on 15/5/01

– Make, model, type and speed of the modem

– The version number of the operating system

– A list of software applications installed on the PC

– A list of peripheral equipment attached to the PC, indicating the port to which they are attached

The maintenance record should be updated each time any maintenance work is carried over on the PC. Any time new or replacement hardware is installed, record the activity and update the system configuration. The activity entries should include

– Date of the activity or changes made to the system

– The make, model and serial number of any hardware removed or added to the PC

– The name, version and publisher of any software added to the PC

– Detailed information on any configuration changes made to the basic input/output system(BIOS) or other configuration for the new device or software.

Troubleshooting approach

For solving any problems associated with PC, first go through the maintenance record of that PC and follow a systematic procedure for isolating the problem. The standard problem solving process includes the following steps

Identify the problem: This is the most difficult part of the process. To perform this step successfully collect all the data about the problem

Identify possible causes: analyse all the symptoms of the problem and try to list all the causes in order from the most likely to the least likely.

Identify possible solutions: identify solutions for each of the causes that are identified. A possible cause could have more than one possible solution.

Analyze the possible solutions: if two solutions produce the same result, consider the one which is more economic and apply the same.

After following the above steps and on solving the problem update the maintenance record and make necessary entries into it. In some cases, the problems may be very clear and the solution is very transparent and even in such cases try to follow the above mentioned steps to make it a practice to follow the systematic approach. Whenever a problem occurs with a PC, while following the steps, try to collect the information about the system by answering questions such as

– Under what circumstances this problem cropped up?

– Were there any indications in the form of beep codes/ error messages or any clear symptoms?

– What softwares were active when the problem happened?

– Has it happened for the first time or occurred in the past also?

– Were there any configuration changes made during the session that required a restart that was not performed?

Optimizing the PC:

A PC which was functioning absolutely well and developed a symptom of slowing down or if it is unable to keep pace with the demands of newer software, one of the possible solutions is to consider updating or optimizing the PC to enhance its performance. Optimization steps may cost money, but many involve software you already own or software readily available on the web.

Optimizing the BIOS and Boot process:

BIOS setup configuration includes many settings in the CMOS. How quickly the system boots and performs depends on these settings. Enabling of valuable features such as system caching or using the quick POST process are very vital for optimum performance.

Optimizing the hard disk: Windows ScanDisk and Disk Defragmenter utilities are the best tools available for optimizing the hard disk in terms of usage and access speeds. ScanDisk is used to check a disk for errors and repair them or remove unrecoverable areas of the disk from the usage tables to prevent future errors. Similarly, Disk Defragmenter organizes data file fragments into a more optimized and logical format that provides for faster access times and less head movement.

Optimizing the Expansion cards: The best way to optimize I/O controllers and other expansion cards is to install them in the correct order. No harm is done even if they are installed out of order, but there is some benefit to be gained from putting them in the proper sequence. On a Pentium system, use PCI cards and avoid ISA cards, if possible. All I/O adapters including video cards, sound cards, NICs, modems and SCSI adapters are available for the PCI expansion bus. Consult the motherboard documentation and install video card in the first PCI slot, followed by the NIC, modem, and sound card, in that order.

Optimizing the processor: One can speed up the processor in the following ways

– Replace it with a faster speed or higher level processor

– Use a utility from the processor manufacturer to apply patches or fixes to the processor's logic

– Overclock the processor

The requirement for replacing the processor with a higher level or faster processor is that your motherboard and chipset will support the new processor both logically and physically. Logically the chipset and motherboard must support the bus speed of the processor and have the supporting circuits it requires. It is often much better to replace the complete motherboard. Sometimes the manufacturer of the processor may release some utilities that will improve some aspect of processor's capabilities such as video processing, buffer handling, caching and other processor based functions. Overclocking a processor means running a processor at speeds faster than it was released to support. Most processors are capable of running at speeds higher than their nominal speeds. The nominal speed of a processor is the speed at which it has been tuned to run with a certain chipset, motherboard, cooling system, and other components of the PC. Raising the speed of the processor can create heating problems on the processor and lead to frequent system lockups, memory problems and other issues.

Troubleshooting sources of Non-software problems:

Any time pc fails for no apparent software reason, check the following areas

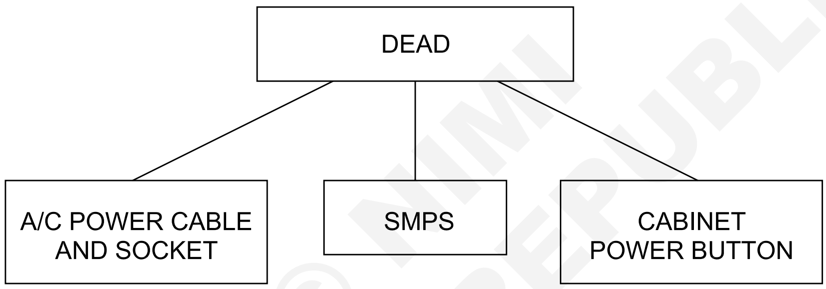
- Ensure proper AC power.
- Scan the PC for a computer virus.
- Ensure that CPU fan is spinning .
- Ensure proper connections of external I/O connectors.
- Reseat the expansion cards and check the power and data cables of internal devices.
- Most of the boot problems are the result of a recent change, check out the BIOS setup configuration data.
- To install any new hardware or software, visit manufacturer's web site for any known conflict or incompatibility.
- Check for any resource conflict if any new hardware or software is installed.

The forth coming lessons on Troubleshooting PC are provided with Problem Trees for different type of problems which a user face normally. Each Tree with a specific problem gives scope to analyse the areas to be suspected or looked into for fixing the problem. This lesson includes a Problem Tree for a PC which is Dead with no display on monitor.

PROBLEM TREE : **PT- 01**

Observed symptom : Dead

Additional symptom : No display



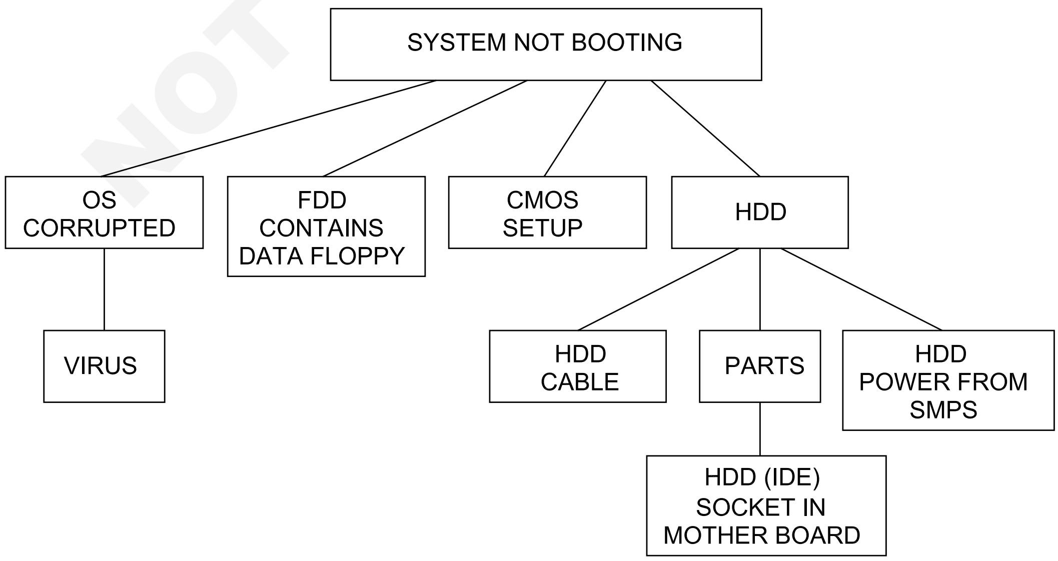
Discuss the Troubleshooting chart (TSC-01) and Service flow sequence (SFS-01) for the complaint "Dead" referring to exercise 2.32.

Various faults discussed for the above complaint shall be applied to actual Computer given to you for practical exercises.

PROBLEM TREE : PT- 02

Observed symptom : System not booting

Additional symptom : POST operations are being initiated



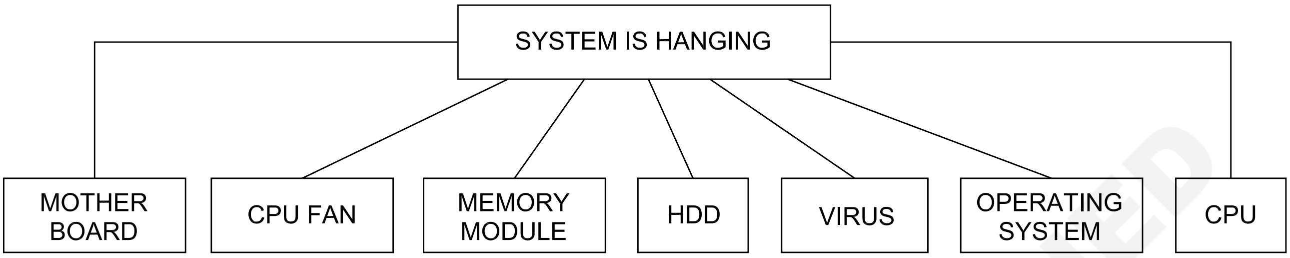
Discuss the Troubleshooting chart (TSC-02) and Service flow sequence (SFS-02) for the complaint "System not booting" referring to exercise 2.32

Various faults discussed for the above complaint shall be applied to actual Computer given to you for practical exercises.

PROBLEM TREE : PT- 03

Observed symptom : System is frequently hanging

Additional symptom :



Discuss the Troubleshooting chart (TSC-03) and Service flow sequence (SFS-03) for the complaint "System gets frequently hanging" referring to exercise 2.32

Various faults discussed for the above complaint shall be applied to actual Computer given to you for practical exercises.

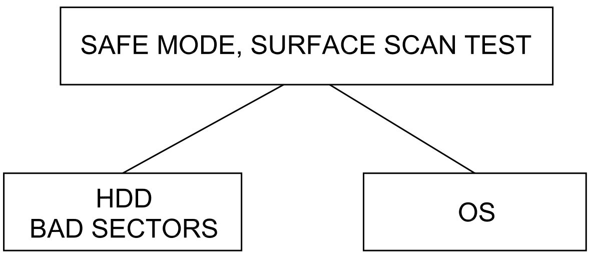
Troubleshooting Computer Part - I

Objectives: At the end of this lesson you shall be able to
- **list the probable defect and symptoms in the faulty Computer**
- **analyse the causes for the complaint "When windows is started, system runs surface test and goes to safe mode" with the help of a Problem Tree and TSC**
- **state the shortest path for servicing the defect using SFS.**
- **list the probable defect and symptoms in the faulty Computer**
- **analyse the causes for the complaint "While working, windows shows error - illegal operation" with the help of a Problem Tree and TSC**
- **state the shortest path for servicing the defect using SFS.**
- **list the probable defect and symptoms in the faulty Computer**
- **analyse the causes for the complaint "Floppy drive not working" with the help of a Problem Tree and TSC**
- **state the shortest path for servicing the defect using SFS.**

PROBLEM TREE : **PT- 01**

Observed symptom : When windows is restarted it goes to safe mode

Additional symptom : It performs surface test



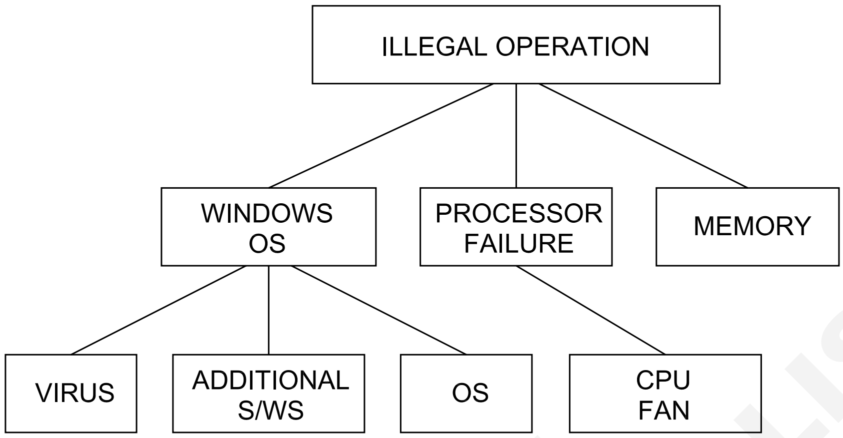
Discuss the Troubleshooting chart (TSC-01) and Service flow sequence (SFS-01) for the complaint "When windows is started system runs surface test and goes to safemode" referring to exercise 2.33

Various faults discussed for the above complaint shall be applied to actual Computer given to you for practical exercises.

PROBLEM TREE : **PT- 02**

Observed symptom : Windows shows "illegal operation"

Additional symptom : Windows not working



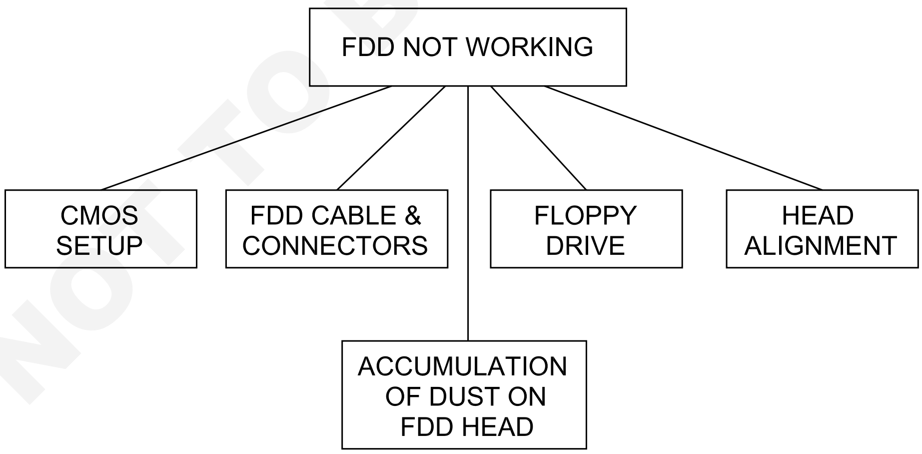
Discuss the Troubleshooting chart (TSC-02) and Service flow sequence (SFS-02) for the complaint "While working, windows shows error - illegal operation" referring to exercise 2.33

Various faults discussed for the above complaint shall be applied to actual Computer given to you for practical exercises.

PROBLEM TREE : **PT- 03**

Observed symptom : Floppy drive can't read

Additional symptom :



Discuss the Troubleshooting chart (TSC-03) and Service flow sequence (SFS-03) for the complaint "Floppy drive not working" referring to exercise 2.33

Various faults discussed for the above complaint shall be applied to actual Computer given to you for practical exercises.

Troubleshooting Computer Part - II

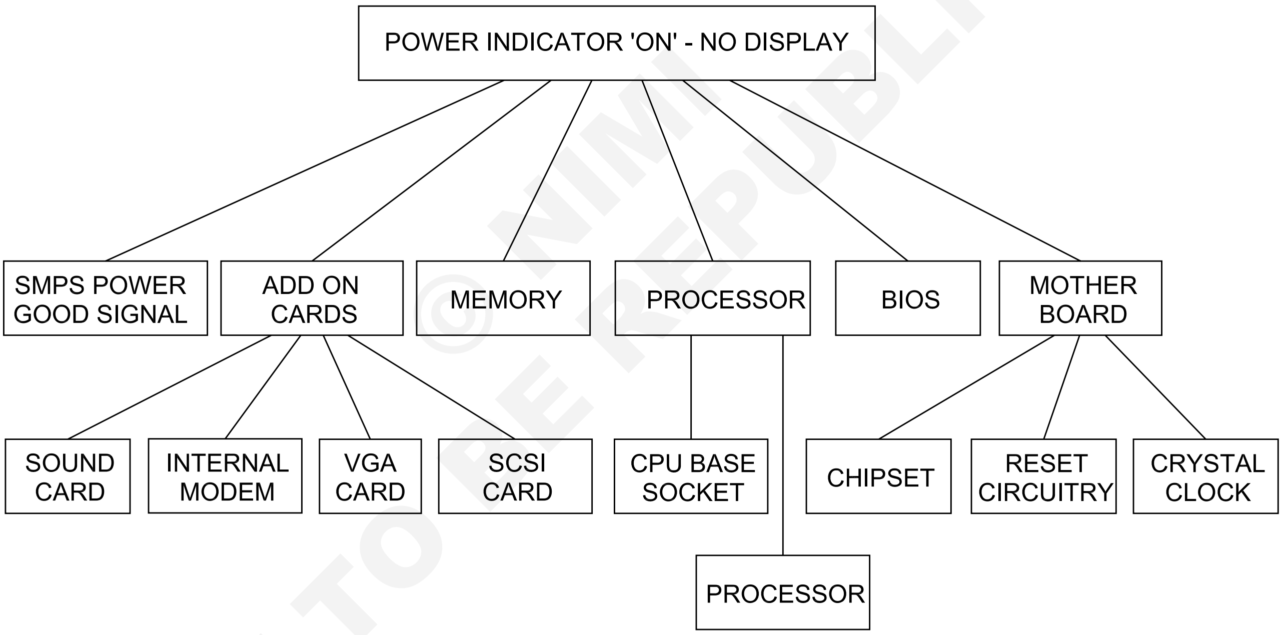
Objectives: At the end of this lesson you shall be able to

- **list the probable defect and symptoms in the faulty Computer**
- **analyse the causes for the complaint "Power indicator ON, No display" with the help of a Problem Tree and TSC**
- **state the shortest path for servicing the defect using SFS.**
- **list the probable defect and symptoms in the faulty Computer**
- **analyse the causes for the complaint "System is frequently restarting" with the help of a Problem Tree and TSC**
- **state the shortest path for servicing the defect using SFS.**
- **list the probable defect and symptoms in the faulty Computer**
- **analyse the causes for the complaint "System gives continuous beeps" with the help of a Problem Tree and TSC**
- **state the shortest path for servicing the defect using SFS.**
- **list the probable defect and symptoms in the faulty Computer**
- **analyse the causes for the complaint "CMOS error" with the help of a Problem Tree and TSC**
- **state the shortest path for servicing the defect using SFS.**

PROBLEM TREE : **PT- 01**

Observed symptom : Power indicator ON, No display

Additional symptom : No beeps



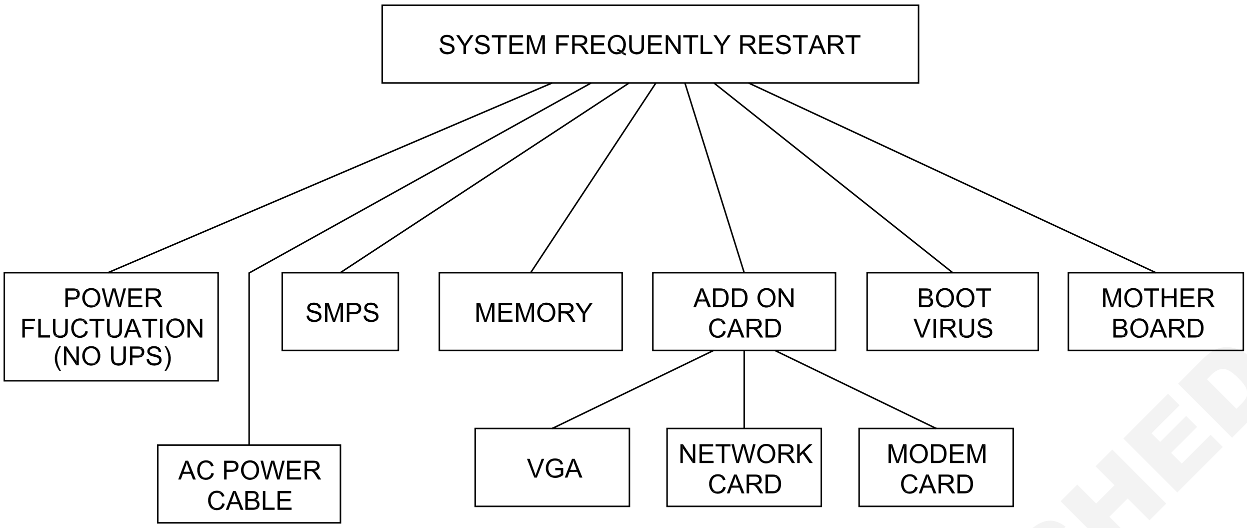
Discuss the Troubleshooting chart (TSC-01) and Service flow sequence (SFS-01) for the complaint "Power indicator ON, No display" referring to exercise 2.34

Various faults discussed for the above complaint shall be applied to actual Computer given to you for practical exercises.

PROBLEM TREE : **PT- 02**

Observed symptom : System is frequently restarting

Additional symptom :



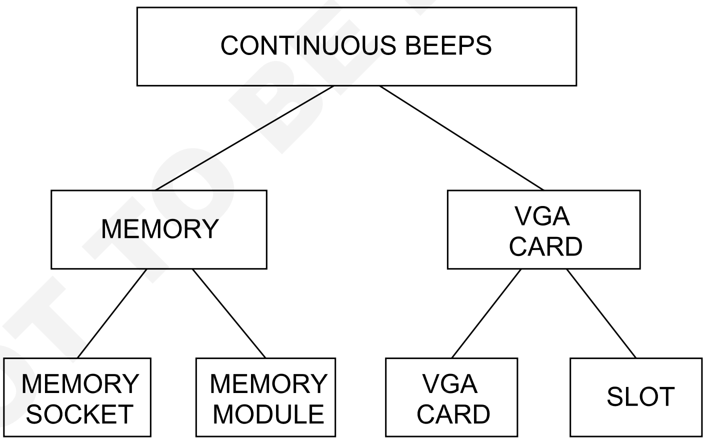
Discuss the Troubleshooting chart (TSC-02) and Service flow sequence (SFS-02) for the complaint "System is frequently restarting" referring to exercise 2.34.

Various faults discussed for the above complaint shall be applied to actual Computer given to you for practical exercises.

PROBLEM TREE : **PT- 03**

Observed symptom : Continuous beeps

Additional symptom : No display



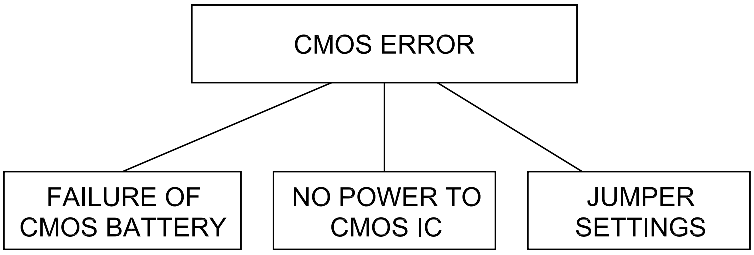
Discuss the Troubleshooting chart (TSC-03) and Service flow sequence (SFS-03) for the complaint "System gives continuous beeps" referring to exercise 2.34

Various faults discussed for the above complaint shall be applied to actual Computer given to you for practical exercises.

PROBLEM TREE : **PT- 04**

Observed symptom : CMOS error

Additional symptom : Press F1 to continue with load default



Discuss the Troubleshooting chart (TSC-04) and Service flow sequence (SFS-04) for the complaint "CMOS error" referring to exercise 2.34.

Various faults discussed for the above complaint shall be applied to actual Computer given to you for practical exercises.

Troubleshooting Computer Part - III

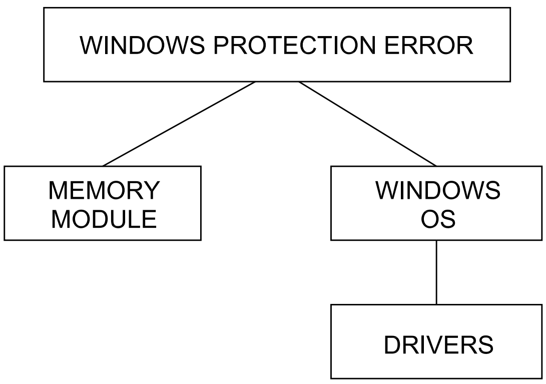
Objectives: At the end of this lesson you shall be able to

- **list the probable defect and symptoms in the faulty Computer**
- **analyse the causes for the complaint "Windows not starting, Windows protection error" with the help of a Problem Tree and TSC**
- **state the shortest path for servicing the defect using SFS.**
- **list the probable defect and symptoms in the faulty Computer**
- **analyse the causes for the complaint "Fatal error displayed with some memory address" with the help of a Problem Tree and TSC**
- **state the shortest path for servicing the defect using SFS.**
- **list the probable defect and symptoms in the faulty Computer**
- **analyse the causes for the complaint "Vxd corrupted reinstall windows (Windows not working)" with the help of a Problem Tree and TSC**
- **state the shortest path for servicing the defect using SFS.**
- **list the probable defect and symptoms in the faulty Computer**
- **analyse the causes for the complaint "Error, Keyboard not present" with the help of a Problem Tree and TSC**
- **state the shortest path for servicing the defect using SFS.**
- **list the probable defect and symptoms in the faulty Computer**
- **analyse the causes for the complaint "Windows didn't detect mouse" with the help of a Problem Tree and TSC**
- **state the shortest path for servicing the defect using SFS.**

PROBLEM TREE : **PT- 01**

Observed symptom : Windows protection error

Additional symptom : Windows not loading



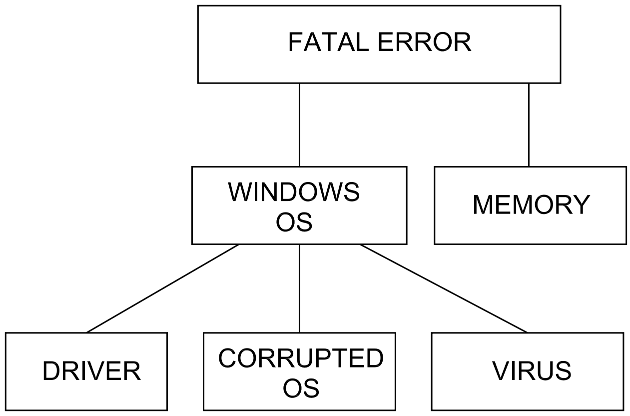
Discuss the Troubleshooting chart (TSC-01) and Service flow sequence (SFS-01) for the complaint **"Windows not starting, Windows protection error" referring to exercise 2.35.**

Various faults discussed for the above complaint shall be applied to actual Computer given to you for practical exercises.

PROBLEM TREE : **PT- 02**

Observed symptom : Fatal error

Additional symptom : Windows not working - memory address displayed



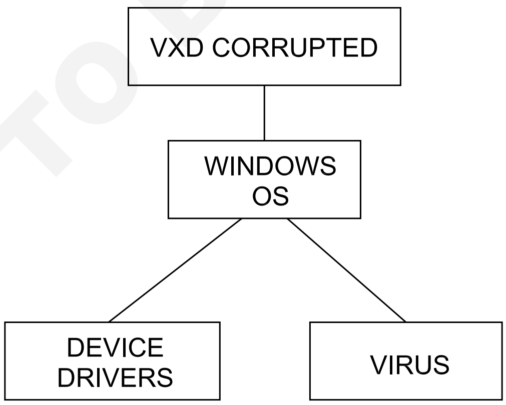
Discuss the Troubleshooting chart (TSC-02) and Service flow sequence (SFS-02) for the complaint "Fatal error dispalyed with some memory address" referring to exercise 2.35.

Various faults discussed for the above complaint shall be applied to actual Computer given to you for practical exercises.

PROBLEM TREE : **PT- 03**

Observed symptom : Vxd corrupted

Additional symptom : Windows not working



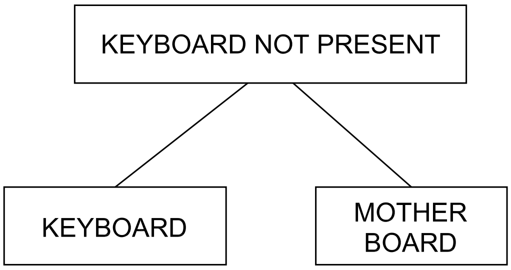
Discuss the Troubleshooting chart (TSC-03) and Service flow sequence (SFS-03) for the complaint "Vxd corrupted reinstall windows (Windows not working)" referring to exercise 2.35.

Various faults discussed for the above complaint shall be applied to actual Computer given to you for practical exercises.

PROBLEM TREE : **PT- 04**

Observed symptom : "Keyboard not present" Error

Additional symptom :



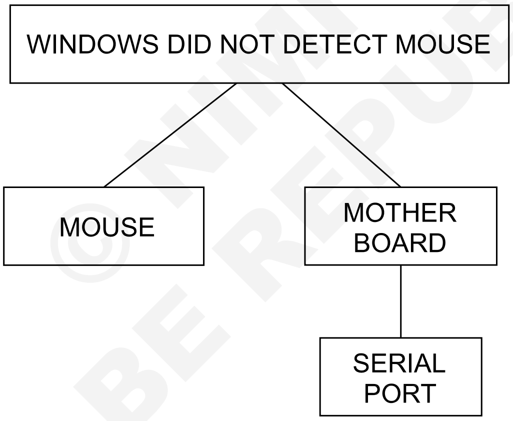
Discuss the Troubleshooting chart (TSC-04) and Service flow sequence (SFS-04) for the complaint "Error, Keyboard not present" referring to exercise 2.35

Various faults discussed for the above complaint shall be applied to actual Computer given to you for practical exercises.

PROBLEM TREE : **PT- 05**

Observed symptom : Windows didn't detect mouse

Additional symptom : Windows is working



Discuss the Troubleshooting chart (TSC-05) and Service flow sequence (SFS-05) for the complaint "Windows didn't detect mouse" referring to exercise 2.35.

Various faults discussed for the above complaint shall be applied to actual Computer given to you for practical exercises.

Computer hardware cleaning procedures

Objectives: At the end of this lesson you shall be able to
- **state the PC cleaning tools**
- **explain cleaning of interior of PC.**

Cleaning tools

Although computer cleaning products are available. Below is a listing of items you may need or want to use while cleaning your computer.

- **Cloth :** A cotton cloth is the best tool used when rubbing down computer components. Paper towels can be used with most hardware, but we always recommend using a cloth whenever possible. However, only use a cloth when cleaning components such as the case, a drive, mouse, and keyboard. should not use a cloth to clean any circuitry such as the RAM or motherboard.
- **Water or isopropyl alcohol :** When moistening a cloth, it is best to use water or isopropyl alcohol. Other solvents may be bad for the plastics used with the computer.
- **Portable Vacuum Cleaner :** Sucking the dust, dirt, hair, cigarette particles, and other particles out of a computer can be one of the best methods of cleaning a computer. However, do not use a vacuum that plugs into the wall since it creates lots of static electricity that can damage the computer.
- **Cotton swabs :** Cotton swaps moistened with isopropyl alcohol or water are excellent tools for wiping hard to reach areas in your keyboard, mouse, and other locations.
- **Foam swabs :** Whenever possible, it is better to use lint-free swabs such as foam swabs.

CD and DVD disc cleaning

Dirty CDs can cause read errors or cause CDs to not work at all.

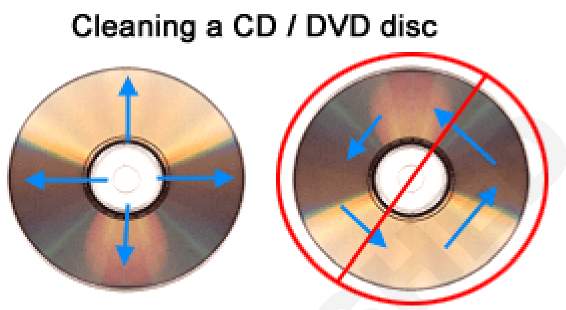
Procedure : Use a cleaning kit or damp clean cotton cloth to clean CDs, DVDs, and other discs. When cleaning a disc wipe against the tracks, starting from the middle of the CD or DVD and wiping towards the outer side as shown in the picture below. Never wipe with the tracks; doing so may put more scratches on the disc. (Fig 1)

Tip: If the substance on a CD cannot be removed using water, pure alcohol can also be used.

Hard drive cleaning

Hard drives cannot be physically cleaned, however, they can be cleaned with software utilities to help it run fast and efficiently. Utilizing these utilities prevent the hard drive from slowing down.

Fig 1



Headphones cleaning

Headphones used by many different people may need to be frequently cleaned to help prevent the spreading of germs and head lice.

Procedure: If the headphones being used are plastic or vinyl, moisten a cloth with warm water and rub the head and earpieces of the headphones. If the headphones are being used for a library or school do not use any disinfectant or cleaning solvent since some people can have allergic reactions to the chemicals they contain.

Headphones that have cushions also have the availability of having the cushions replaced. Replacing these cushions can also help keep the headphones clean.

Finally, in regards to headphones spreading head lice. If many different students use the same headphones, consider having the students using their own headphones, placing bags over the headphones, or using headphones that can be wiped with warm water after each use.

Keyboard cleaning(From Dust, dirt, and bacteria)

The computer keyboard is usually the most germ infected items in your home or office, it may even contain more bacteria than your toilet seat. Cleaning it helps remove any dangerous bacteria and keeps the keyboard working properly. (Fig 2)

Procedure: Before cleaning the keyboard first turn off the computer or if using a USB keyboard unplug it. Not unplugging the keyboard can cause other computer problems as you may press keys that cause the computer to perform a task you do not want it to do.

Many people clean the keyboard by turning it upside down and shaking. A more efficient method is to use compressed air. Compressed air is pressurised air contained in a can with a very long nozzle. aim the air between the keys and blow away all of the dust and debris that has gathered there. A vacuum cleaner can also be used, but make sure the keyboard does not have loose "pop off" keys can be sucked up by the vacuum. If you want to clean the keyboard more extensively remove the keys from the keyboard. After the dust, dirt, and hair has been removed. Spray a disinfectant onto a cloth or use disinfectant cloths and rub each of the keys on the keyboard. As mentioned in our general cleaning tips, never spray any liquid onto the keyboard.

Fig 2

Substance spilt into the keyboard

If the keyboard has anything spilt into it (e.g. pop, cola, Pepsi, Coke, beer, wine, coffee, and milk), not taking the proper steps can destroy the keyboard.

Procedure: If anything is spilt onto the keyboard turn the computer off immediately or at the very least disconnect the keyboard from the computer. Once done flip the keyboard over to prevent the substance from penetrating circuits. While the keyboard is upside down, shake the keyboard over a surface that can be cleaned later. While still upside down, use a cloth to start cleaning the keys. After cleaned leave the keyboard upside down for at least one night allowing it to dry. Once dry, continue cleaning the keyboard with any remaining substance.

If after cleaning the keyboard noticed any keys stick remove the keys and clean below the keys and the bottom portion of the key.

LCD cleaning

Dirt, dust, and fingerprints can cause the computer screen to be difficult to read.

Procedure: Unlike a computer monitor, the LCD or flat-panel display is not glass and requires special cleaning procedures.

When cleaning the LCD screen it is important to remember to not spray any liquids onto the LCD directly, press gently while cleaning, and do not use a paper towel since it scratches the LCD.

To clean the LCD screen use a non-rugged microfiber cloth, soft cotton cloth, or duster. If a dry cloth does not completely clean the screen, use LCD cleaning liquid and wipe the screen with a wet cloth.

CRT Monitor cleaning

Dirt, dust, and fingerprints can cause the computer screen to be difficult to read.

Procedure: A glass monitor screen can be cleaned with ordinary household glass cleaner. Be sure to remove power from the monitor and spray the cleaner onto a tint free-cloth so the fluid does not leak into the electrical components inside the monitor. Vacuum off any dust that has settled on top of the monitor, and make sure no books or papers are covering the air vents. Obstructed monitor vents can cause the monitor to overheat or even catch on fire.

Caution: Use a cloth dampened with water when cleaning non-glass monitors or any anti-glare screens. Using ordinary household glass cleaner on special screens, especially cleaners with ammonia can remove anti-glare protection or other special surfaces.

Cleaning of computer interior

Dust Precautions

Computers make pretty good dust collectors and if it is normally placed on or near the floor (especially carpeted floor) or if you have pets, are a smoker, or the computer is situated in a high pollution area there could be a lot of dirt trapped in the system. When blow this out with the compressed air it will be spread through the room. You should work with good ventilation and if you suffer from allergies you should consider wearing a dust mask.

Setting Up

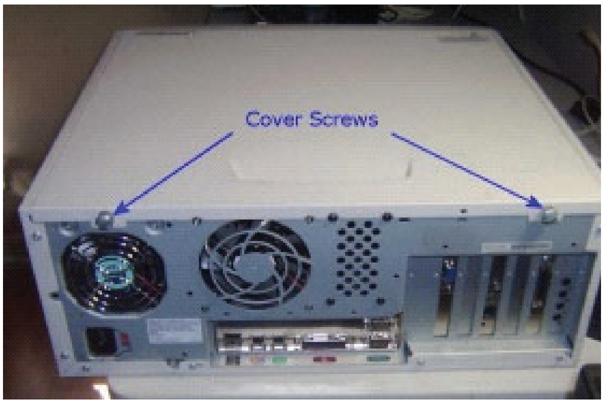
Shutdown the computer and disconnect all the cables plugged into it. You may need the flat-bladed screwdriver to undo some of the connector screws. Put newspaper down on your work surface so it doesn't get scratched. Locate the work surface near a power outlet and plug in the computer power cord. Put the computer on work surface and connect the power cord to the computer but do not turn it on. Set out the tools and materials so do not need to move around much to reach them during cleaning. Starting about two inches (50mm) from the blunt end of the pencil fasten insulating tape down the length of the pencil to the blunt end and cut the tape 2"(50mm) beyond the end of the pencil. Smooth the tape around the pencil then fold the excess length over the blunt end and up the other side. Press the tape down so it is firmly stuck to the length of the pencil.

Opening the Case

The standard tower case usually has either a single metal cover covering the top and both sides, held in place by three or four screws or has removable side panels each held in place by two screws as on Fig 3.

Use the screwdriver to remove the three or four screws holding on the cover(s) and put them aside where they will not be lost. Remove the cover(s) and put them to one side but within reach. If you are using a static strap put it on your wrist and attach it to a metal part of the chassis, if you do not have a static strap touch the metal of the chassis with both hands. Then remove the power cord from the back of the computer.

Fig 3

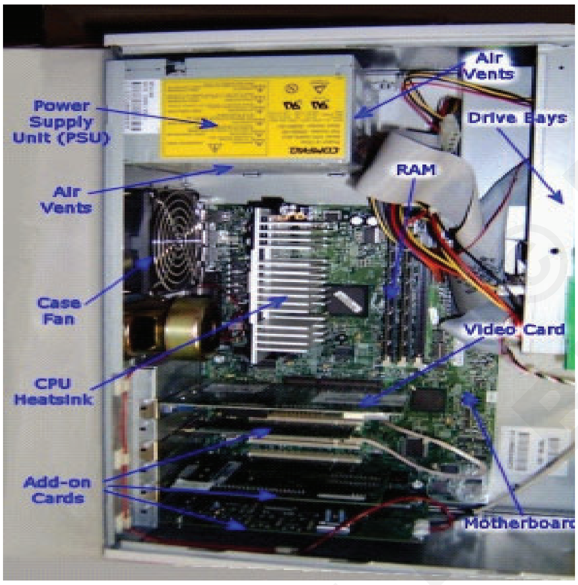


Cleaning the Interior

A Case vents and PSU vents

Run the vacuum cleaner nozzle over any air vents at the front, side and rear of the case and over any vents in the PSU especially the air vents in the sides of the PSU inside the computer as on Fig-14. If the covers have vents then clean those as well. (Fig 4)

Fig 4



B PSU fans (Fig 5)

Use the blunt, insulated end of the pencil to hold the fan blades steady and blow compressed air into the PSU fan(s) and through the PSU. Significant dust may be ejected from the power supply.

C CPU fan and heatsink (Fig 6)

This is the most important part of the cooling system - dirt collects on the fan blades and clogs the heatsink vanes. Use the paintbrush to brush the dirt off each blade and off the heatsink vanes if accessible. Using the pencil to hold the fan blades still, blow out the fan and the heatsink with the compressed air. It is important not to let the CPU fan (or other fans) spin up under the air blast as damaging voltages can be generated through a dynamo effect. Expect significant dirt to be ejected from the CPU heatsink. If you want to be particularly thorough moisten a Cotton-tip with glass cleaning fluid and wipe down the upper and lower surface of each fan blade.

Fig 5

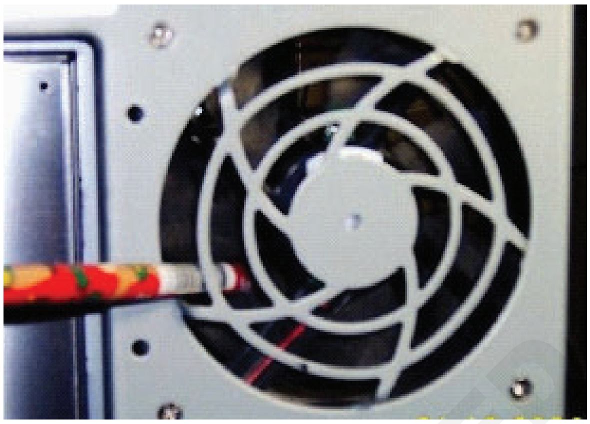
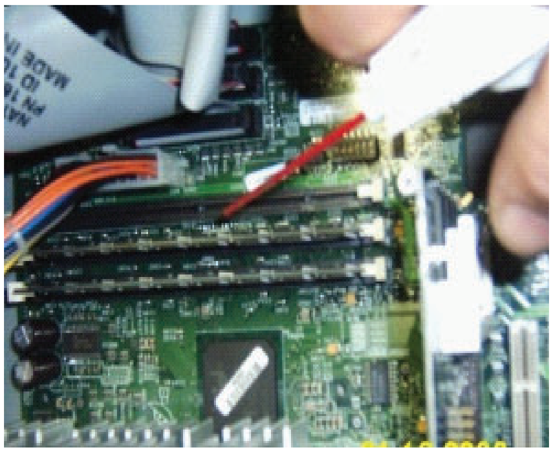


Fig 6

D RAM Sticks and Expansion Slots (Fig 7)

Dirt can sometimes build up in 'drifts' around the memory sticks and the video, sound or modem card slots. Use the compressed air to blow it out. Do not use the brush here.

Fig 7



E Case fans (Fig 8)

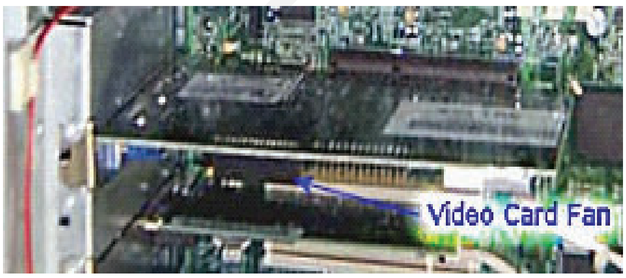
Cases often have one or more fans attached to the front or rear panels. Using the pencil to stop fan rotation blow the dirt from the case fans with the brush and compressed air.

Fig 8

F Video card fan and heatsink (Fig 9)

This can be hard to see as it is usually on the lower side of the video card. Depending on the design either use the paintbrush to remove dirt from the heatsink and/or use compressed air while holding the fan still with the pencil. To do a thorough job will probably require removing the Video Card which is normally held in place with one screw where it meets the case. Remove the screw and unplug the card by pulling firmly outwards. There may be a plastic latch at the back of the card, press down on this to help eject it. If you do remove the video card keep good contact with the PC chassis as often as possible to minimise static buildup and rest the video card on part of the case while it is being cleaned. When the fan is clean use compressed air to blow out the video card slot, on older cards if the edge connectors of the card look tarnished clean them lightly with a pencil eraser. Reinsert the video card making sure the plastic latch clips into place indicating the card is properly seated in the slot (not all systems have a latch). Then do up the screw.

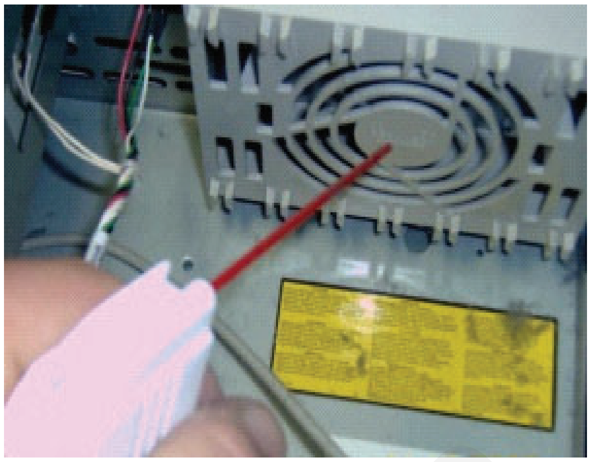
Fig 9



G The case (Fig 10)

Vacuum the dust from the bottom of the case being careful to keep the nozzle away from the motherboard. Spray some paper towels with glass cleaner and wipe down the flat metal surfaces of the case and the inside of the cover(s).

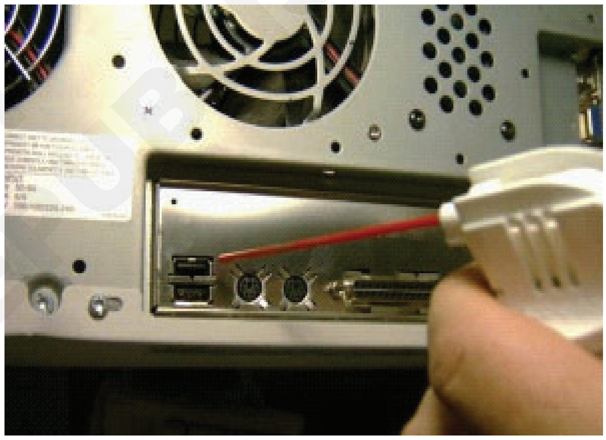
Fig 10



H The Ports (Fig 11)

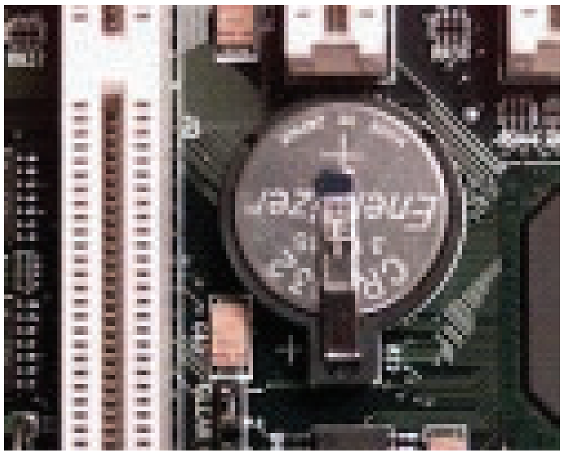
Dust often accumulates in the I/O Ports where you plug in peripherals on the back of the computer. Use the brush and compressed air to clean them out.

Fig 11



I CMOS battery (Fig 12)

Fig 12



Although this is not a cleaning process, if your PC is more than a couple of years old this might be a good time to change the CMOS battery - usually a round, silver-colored button battery e.g. Energizer CR2032 Lithium 3v. The battery 'pops' out of its holder with a little pressure on the side near the clip and the replacement slips in. Note: Changing the battery may reset some BIOS options to factory defaults so If you have complex BIOS settings because of SATA drives, USB keyboards, RAID controllers or network parameters for example it would be best to note down all the settings before changing the battery and check for changes afterward.

Floppy Drive, Optical Drives and Hard Drives (Fig 13)

Fig 13

Floppy drives can collect a lot of dust which could prevent them from working properly. Push the nozzle of the compressed-air can a little way into the drive opening so that the flap is held open, or use Cotton-tips to hold the flap open wide, then use the compressed air to blow out the dust. There are special floppy cleaning disks available which are used to clean the floppy drive read/write heads but these are often more expensive than replacing the drive and are only needed if the drive is old or gets very heavy usage.

The CDROM drives or DVD drives are unlikely to be clogged by dust but they may collect dirt on the optical lens which can cause errors. Use the CD lens cleaning disk following the manufacturer's instructions to clean the lenses on these drives - this has to be done when the PC is operating.

Hard Drives are sealed units and require no cleaning, but to maximise the air-flow around them use the compressed air to blow away any dust from the drive's upper surfaces.

Check the Fan Rotation (Fig 14)

Connect the PC power cable again and switch on the PC, while it is open, for just long enough to see that all the fans identified above are spinning. Fans which do not spin turn into miniature heaters which makes the situation worse than without a fan. If you find a fan which is not working then, after turning off the PC, note what kind of fan it is, where it is and, if possible, unplug it. You can probably order a replacement online or they may have stock in your local computer store. If the CPU fan is not working, then you should not run the computer for more than a few minutes until it is replaced. If the PC has started to boot while you were inspecting the fans and is reluctant to turn off, just hold the power button in for about 5 seconds and the PC will switch off.

Fig 14

Reassembly

Make sure nothing has been left inside the case and nothing is likely to get caught in the fans. Any cables that were moved to get access to other items should be put back in place. Inspect the cables going to the optical drives, floppy drive and hard drive(s) to check none have been dislodged. Put the cover(s) back on the system and do up the screws to hold them in place. Unplug the power cable and return your PC to its normal location. Connect up all the cables that were originally present and reconnect the power cable. Plug into the power outlet and switch on. Make sure the monitor is switched on and check the computer boots up normally. Now you can use the CD lens cleaner if required

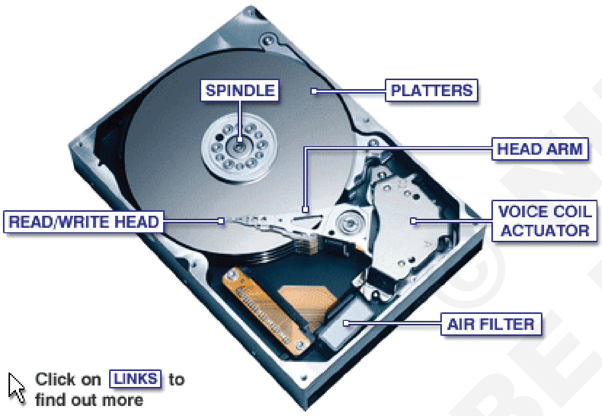
Working principle of harddisk drive

Objectives: At the end of this lesson you shall be able to
- **know about harddisk and how it works**
- **know the types of harddisk**
- **know how to buy a harddisk.**

Introduction

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 1.

Fig 1



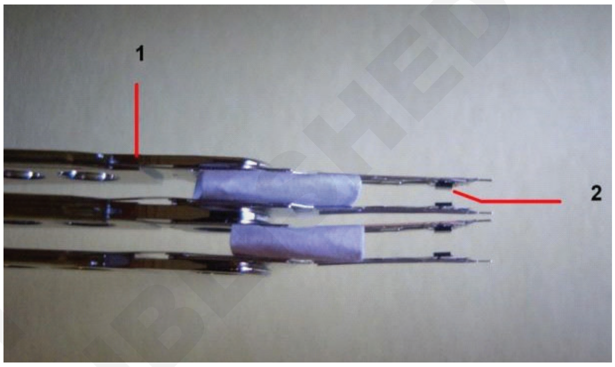
The primary characteristics of an HDD are its capacity and performance. Capacity is specified in powers of 1000: a 1-terabyte (TB) drive has a capacity of 1,000 gigabytes (GB; where 1 gigabyte = 1 billion bytes). Performance is specified by the time required to move the heads to a track or cylinder (average 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.

Illustration of Read/Write Heads:

The data is of course written and read by the heads as shown in Fig 2.

Fig 2



1 Arm Assembly.

2 Read /Write element or "head" (Fig 3)

Fig 3

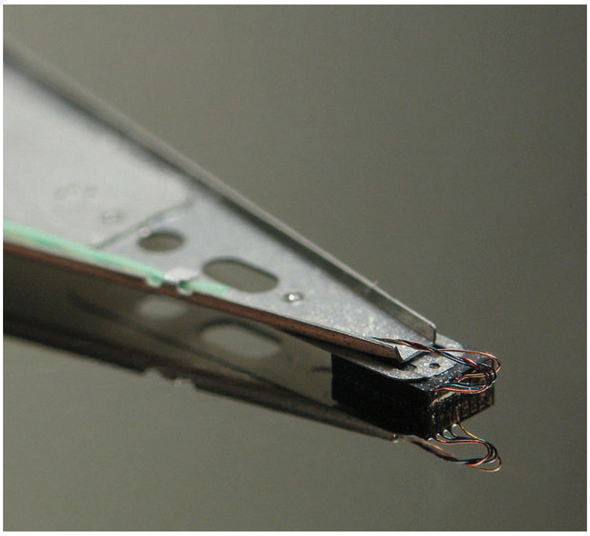
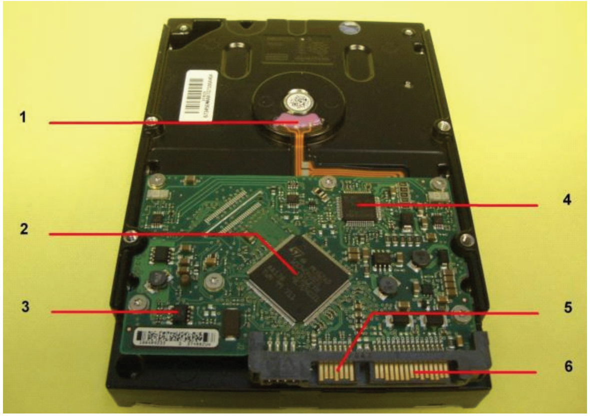


Fig 4 Shows the different connections in a typical Hard drive PCB

1 Electrical connections to platter motor.

2 Microprocessor chip.

Fig 4



3 Programmable flash memory chip (stores the PCB portion of the drive's firmware-see below).

4 Platter motor controller chip.

5 S-ATA data connector (the connection between the hard drive and the motherboard).

6 S-ATA power connector (provides the drive with DC power).

A hard disk drive contains rigid, disk-shaped platters, unlike floppy disks, the platters can't bend or flex hence the term hard disk. In most hard disk drives, you can't remove the platters, which is why they are sometimes called fixed disk drives. Removable hard disk drives are also available. Usually, this term refers to a device in which the entire drive unit is removable.

The Hard Drive Buying Guide - Hard Drive Types

Before buying a new hard drive consider the following questions.

- Will you install it in your existing computer to replace an outdated hard drive?
- Will it serve as a second drive just for media storage?
- Will it need to be easily unplugged so you can take it with you between work and home?

Internal - Replacing the hard drive is one of the easiest upgrades inside the computer.

An internal hard drive is your cheapest and most popular option, when replacing the existing harddrive in the computer

External - With an external hard drive, you can leave your computer's case intact and just plug your new drive into an available USB, Fire wire, or Thunderbolt port on the front or back of the computer.

Portable - A portable drive gives you the advantages of an external drive with added shock protection for constant handling and transportation.

Network - External or internal, network drives save data through multiple computers on the same network. These drives should be large and as fast as possible, since they may be accessed by multiple users simultaneously.

Hard drive installation and configuration - I

Disk Formatting

Disk formatting is the process of preparing a data storage device such as a hard disk drive, solid-state drive, floppy disk or USB flash drive for initial use. In some cases, the formatting operation may also create one or more new file systems.

Two formatting procedures are required before you can write user data to a disk:

- Physical, or low-level formatting
- Logical, or high-level formatting

A hard disk, however, requires two separate formatting operations. Moreover, a hard disk requires a third step, between the two formatting procedures, to write the partitioning information to the disk. Partitioning is required because a hard disk is designed to be used with more than one operating system. Using multiple operating systems on one hard drive is possible by separating the physical formatting in a procedure that is always the same, regardless of the operating system used and the high-level format (which is different for each operating system). Partitioning enables a single hard disk drive to run more than one type of operating system, or it can enable a single operating system to use the disk as several volumes or logical drives. A volume or logical drive is any section of the disk to which the operating system assigns a drive letter or name.

Consequently, preparing a hard disk drive for data storage involves three steps:

1 Low-Level Formatting

2 Partitioning

3 High-Level Formatting

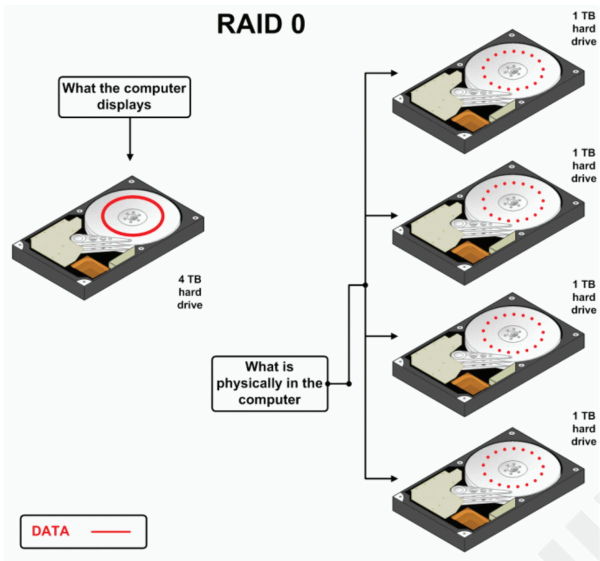
Hard Disk and Partitions

Partitioning is a process of dividing the Hard disk into several chunks, and uses any one of the partition to install OS or use two or more partitions to install multiple OSes. But it can always have one partition, and use up the entire Hard disk space to install a single OS, but this will become data management nightmare for users of large Hard disks. Now, because of the structure of the Master Boot Record (MBR), you can have only four partitions, and these four partitions are called Primary Partitions. Again, if we have a large hard disk, we cannot have only four primary partitions, hence Extended Partition is introduced. This Extended Partition is not a usable partition by itself, but it's like a "container" and it is used to hold Logical Drives That is this Extended Partition can be subdivided into multiple logical partitions. In order to boot into a Partition, it must be designated as bootable partition or Active Partition. Active Partition is that partition which is flagged as bootable or which contains OS, this is generally a Primary Partition.

RAID or Disk Array

RAID stands for Redundant Array of Inexpensive Disks. It improves the transfer speed of individual disks by configuring multiple disk drives in a disk array. In a Redundant Array of Independent Disks (RAID), multiple SCSI, ATA, or FireWire disk drives are grouped together via hardware or software and treated as a single data storage unit. This allows you to record data to multiple drives in parallel, increasing access time significantly. You can also partition the array into multiple volumes. (Fig 5)

Fig 5



Creating a disk array is necessary only if high performance is required to capture and play back your video at the required data rate without dropping frames.

There are three commonly used types of RAID: RAID 0, RAID 1, and RAID 5. You can also combine different types of RAID arrays, such as RAID 0+1 and RAID 1+0, which is called nesting.

If rock-solid data integrity, is required consider purchasing a RAID. Many RAIDs record the same data on more than one disk, so that if a drive fails, the same data can still be retrieved from another disk. There are many RAID variations available, but one that offers high performance for both digital video capture and data redundancy is RAID level 3. Because they use specialized hardware, RAID level 3 systems can be more expensive, but they should be considered whenever the safety of your media is more important than the cost of your disks.

RAID 0 treats several drives as a single drive in order to speed up reading from and writing to the drive. Basically, it breaks up a file into several parts and writes those parts to multiple drives simultaneously. While it increases speed, it also increases risk. A failure of one drive destroys all the data. RAID 0 is also used to create a single large volume.

RAID 1 writes the same data to multiple drives to help ensure seamless operation in the event of drive mechanism failure. Mirrored RAID is appropriate for operations that truly need 24/7 functionality, or for files that are works in progress and might represent a whole day's work. Even with mirrored RAID, there is still need to have a set of offline backups because mirroring does not protect against some of the most common causes of data loss (theft, virus, and power surge). It also provides no protection against human error, such as accidentally erasing or downsizing a file.

RAID 5 provides a combination of striping and mirroring, resulting in a large single volume with redundant protection. A Level 5 system should be able to survive the loss of any single drive since a parity file (a copy of the data) is written to each of the other drives. Level 5 is probably the most popular current RAID choice for large data storage. The parity file is a compressed copy of the data; it can store the information in a small space, but requires computation to write and read.

RAID 6 is an increasingly popular choice for enterprise-level systems since it builds upon the capability of Level 5 by adding the capacity to survive the loss of any two drives in the system. This configuration is typically found in corporate environments.

Virus protection

Objectives: At the end of this lesson you shall be able to
- **know the different types of malware and how they attack your PC**
- **learn how to prevent your PC from getting affected by malware**
- **understand the difference between anti-virus and anti-spyware software.**

Introduction to Malware

Malware is an abbreviated term meaning "malicious software." This is software that is specifically designed to gain access or damage a computer without the knowledge of the owner. There are various types of malware including spyware, key loggers, true viruses, worms, or any type of malicious code that infiltrates a computer. Generally, software is considered malware based on the intent of the creator rather than its actual features. Malware was originally created as experiments and pranks, but eventually led to vandalism and destruction of targeted machines. Today, much of malware is created for profit through forced advertising (adware), stealing sensitive information (spyware), spreading email spam or child pornography (zombie computers), or to extort money (ransom ware). Various factors can make computers more vulnerable to malware attacks, including defects in the operating system design, having all of the computers on a network run the same OS, giving users to much permissions or just using the Windows OS (due to its popularity, it gets the most malware written for it). The best protection from malware continues to be the usual advice: be careful about what email attachments open, be cautious when surfing and stay away from suspicious websites, and install and maintain an updated, quality antivirus program.

Symptoms of Malware Infection

Some of the symptoms of a Malware infected system are:

- Change in browsers home page or default search
- Web browser hangs or becomes sluggish
- Computer starts behaving sluggishly or hangs often
- Unable to open security-related sites or Microsoft.com domains.
- Web pages get re-directed to unintended pages.
- Unexpected toolbars displayed in the browser
- Security software or Firewall gets disabled
- Security software shows up warnings or its icon turns red.
- Unknown or excessive Pop-ups while browsing.

Malware Cleaning steps

- Disconnect from network
- Identify malicious processes and drivers
- Terminate identified processes
- Identify and delete malicious autostarts
- Delete malware files
- Reboot and repeat the steps.

Virus

A virus is just a computer program. Like any other program, it contains instructions that tell your computer what to do. But unlike anapplication, a virus usually tells your computer to do something you don't want it to do, and it can usually spread itself to other files on yourcomputer-and other people's computers.

The most common entry-points used by viruses are the following:

- Removable disk drives
- Computer networks
- Internet
  - E-mail
  - Web pages
  - File Transfers (FTP)
  - Downloads
  - Newsgroups

Types of Viruses

Worms: Worms are different to other viruses since they do not infect other files. Their sole objective is to propagate or spread to other systems as quickly as possible. They do however make use of replication (propagation) techniques. In fact their objective is to copy themselves and then infect other systems. Their infections or replications usually take place through e-mails, computer networks and Internet IRC Channels. They could also replicate inside the memory of a PC.

Trojan Horses (or Trojans): Trojans cannot be considered viruses as such. They seem to be harmless programs which get into a computer through any channel. When that program is executed (they have names or characteristics which trick the user into doing so), they install other programs on the computer which could be harmful.

Logic Bombs: These activate and damage an infected system only when one or more condition/s are met. They are not considered viruses as such, since they do not replicate, but rather depend on the actions taken by the user (the user usually copies and/ or executes them unintentionally).

Encrypted: Rather than a virus category, this is a technique that viruses could use. A virus could belong to another category and be also encrypted (if it uses this technique). The virus encodes or encrypts itself so that antivirus programs cannot easily detect it. In order to perform these activities, the virus de-encrypts itself and, when it is finished, encrypts itself again.

Polymorphic: These are virus that use a new technique to avoid detection by antivirus programs (they are usually the hardest viruses to find). They change with every infection they carry out. In this way, they create a large number of copies of themselves.

Symptoms of Virus: It may appear that you have a virus in your computer, but you cannot be sure that this is the case until it is detected using an antivirus tool (programs that detect and eliminate viruses). Some actions that can be carried out by a virus are obvious enough to be recognized and could include: messages displayed onscreen, operations slowing down, the properties of some files change, files and folders disappear, the computer will not start, the content of the infected disk is lost, etc.

What do virus infect: The main targets of viruses are files located in storage devices such as hard and floppy disks. They target program files, although other types of files and documents can also be infected. A program is simply a file with an EXE or COM extension, which can be run to perform specific operations.

As we have already mentioned, there are viruses designed to infect files that are not programs. However, these documents contain elements known as macros.

Macros are small programs that the user can include in certain types of files.

Other elements prone to virus attack are the storage devices themselves, especially boot sector. By attacking the places in which files are stored, the damage produced by the virus will affect all of the information they contain.

Virus Detection and Prevention Tips

1 Do not open any files attached to an email from an unknown, suspicious or untrustworthy source.

2 Do not open any files attached to an email unless you know what it is, evenif it appears to come from a dear friend or someone you know. Some viruses can replicate themselves and spread through email.

3 Do not open any files attached to an email if the subject line is questionable or unexpected. If the need to do so is there always save the file to your hard drive before doing so.

4 Delete chain emails and junk email. Do not forward or reply to any to them. These types of email are considered spam, which is unsolicited, intrusive mail that clogs up the network.

5 Do not download any files from unknown sources.

6 Exercise caution when downloading files from the Internet. Ensure that the source is a legitimate and reputable one. Verify that an anti-virus program checks the files on the download site. If you're uncertain, don't download the file at all or download the file and test it with anti-virus software.

7 Update your anti-virus software regularly. These updates should be at least the product’s, virus signature files. Also update the product's scanning engine.

8 Back up files on a regular basis. Store the backup copy in a separate location from the work files, one that is preferably not on computer.

9 When in doubt, do not open, download, or execute any files or email attachments. Check with the product vendors for updates which include those for the operating system web browser, and e-mail

What is a Rootkit?

The term rootkit is used to describe the mechanisms and techniques whereby malware, including viruses, spyware, and Trojans, attempt to hide their presence from spyware blockers, antivirus, and system management utilities. There are several rootkit classifications depending on whether the malware survives reboot and whether it executes in user mode or kernel mode.

Antivirus Software: According to Microsoft, an antivirus program is one that detects, prevents, and takes action to disarm or remove malicious software programs, such as viruses and worms. These programs must be updated regularly due to the constant influx of new viruses on the Internet.

Antispyware Software: Spyware is software that aids in gathering information about a person or organization without their knowledge and that may send such information to another entity without the consumer's consent, or that asserts control over a computer without the consumer's knowledge.

"Spyware" is mostly classified into four types: system monitors, Trojans, adware, and tracking cookies.

Spyware is mostly used for the purposes of tracking and storing Internet users' movements on the Web and serving up pop-up ads to Internet users.

Whenever spyware is used for malicious purposes, its presence is typically hidden from the user and can be difficult to detect.

Some spyware, such as key loggers, may be installed by the owner of a shared, corporate, or public computer intentionally in order to monitor users.

Antispyware software removes spyware, programs that engage pop-up advertisements, slow down computer speed and can obtain personal information or reconfigure the computer. Antispyware programs should also be updated regularly and used to scan for spyware frequently.

Viruses and spyware can both slow down and harm the personal computer. Both should be removed as soon as possible, but there exists, differences between the two, thus the software to remove them are different as well.

Windows registry

Objectives: At the end of this lesson you shall be able to
- **how to edit the registry?**
- **check the performance level of a system**
- **how to fix shortcuts, startup and error logs?**
- **fix startup problems using system configuration.**

Registry

The registry is a database in Windows that contains important information about system hardware, installed programs and settings, and profiles of each of the user accounts on the computer.

Windows refers to this information and updates it when changes are made to the computer, such as installing a new program, creating a user profile, or adding new hardware. Registry Editor helps to view registry folders, files, and the settings for each registry file.

An incorrect change to the computer's registry could render the computer inoperable. However, if a corrupt file appears in the registry, it is required to make changes. It is strongly recommend to back up the registry before making any changes. Some registry editor programs available for free on the Internet might contain spyware, adware, or viruses.

Registry Editor can be accessed by executing regedit from the Command Prompt or from the search or run box from the Start menu.

The registry contains registry values, located within registry keys, all within one of several registry hives. Making changes to these values and keys using Registry Editor will change the configuration that a particular value controls.

The Structure of the Registry

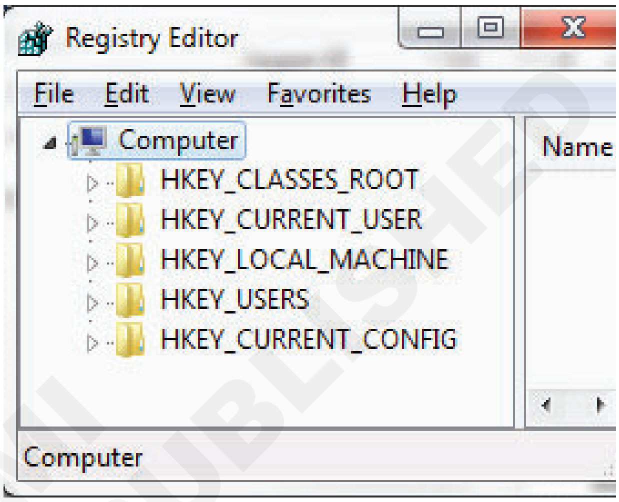
The Registry has a hierarchal structure, although it looks complicated the structure is similar to the directory structure on your hard disk, with Regedit being similar to Windows Explorer.

Each main branch (denoted by a folder icon in the Registry Editor, see left) is called a Hive, and Hives contains Keys. Each key can contain other keys (sometimes referred to as sub-keys), as well as Values. The values contain the actual information stored in the Registry. There are three types of values; String, Binary, and DWORD- the use of these depends upon the context

In windows 7 There are Five main branches, each containing a specific portion of the information stored in the Registry. They are as follows:

- **HKEY_CLASSES_ROOT :** This branch contains all of your file association mappings to support the drag-and-drop feature, OLE information, Windows shortcuts, and core aspects of the Windows user interface.

Fig 1



- **HKEY_CURRENT_USER :** This branch links to the section of HKEY_USERS appropriate for the user currently logged onto the PC and contains information such as logon names, desktop settings, and Start menu settings.
- **HKEY_LOCAL_MACHINE :** This branch contains computer specific information about the type of hardware, software, and other preferences on a given PC, this information is used for all users who log onto this computer.
- **HKEY_USERS :** This branch contains individual preferences for each user of the computer, each user is represented by a SID sub-key located under the main branch.
- **HKEY_CURRENT_CONFIG :** This branch links to the section of HKEY_LOCAL_MACHINE appropriate for the current hardware configuration.

  Each registry value is stored as one of five main data types:

- **REG_BINARY :** This type stores the value as raw binary data. Most hardware component information is stored as binary data, and can be displayed in an editor in hexadecimal format.
- **REG_DWORD :** This type represents the data by a four byte number and is commonly used for Boolean values, such as "0" is disabled and "1" is enabled. Additionally many parameters for device driver and

services are this type, and can be displayed in REGEDT32 in binary, hexadecimal and decimal format, or in REGEDIT in hexadecimal and decimal format.

- **REG_EXPAND_SZ :** This type is an expandable data string that is string containing a variable to be replaced when called by an application. For example, for the following value, the string "%SystemRoot%" will replaced by the actual location of the directory containing the Windows NT system files. (This type is only available using an advanced registry editor such as REGEDT32)
- **REG_MULTI_SZ :** This type is a multiple string used to represent values that contain lists or multiple values, each entry is separated by a NULL character. (This type is only available using an advanced registry editor such as REGEDT32)
- **REG_SZ :** This type is a standard string, used to represent human readable text values.

Other data types not available through the standard registry editors include:

- **REG_DWORD_LITTLE_ENDIAN :** A 32-bit number in little-endian format.
- **REG_DWORD_BIG_ENDIAN :** A 32-bit number in big-endian format.
- **REG_LINK :** A Unicode symbolic link. Used internally; applications should not use this type.
- **REG_NONE :** No defined value type.
- **REG_QWORD :** A 64-bit number.
- **REG_QWORD_LITTLE_ENDIAN :** A 64-bit number in little-endian format.
- **REG_RESOURCE_LIST :** A device-driver resource list.

Editing the Registry

The Registry Editor (REGEDIT.EXE) is included with most version of Windows it enables you to view, search and edit the data within the Registry. There are several methods for starting the Registry Editor, the simplest is to click on the Start button, then select Run, and in the Open box type "regedit" and click on OK.

Using Regedit to modify your Registry

In Regedit, on the left side there is a tree with folders, and on the right the contents (values) of the currently selected folder.

Like Windows explorer, to expand a certain branch click on the plus sign [+] to the left of any folder, or just double-click on the folder. To display the contents of a key (folder), just click the desired key, and look at the values listed on the right side. You can add a new key or value by selecting New from the Edit menu, or by right-clicking your mouse. And you can rename any value and almost any key with the same method used to rename files; right-click on an object and click rename, or click on it twice (slowly), or just press F2 on the keyboard. Lastly, you can delete a key or value by clicking on it, and pressing Delete on the keyboard, or by right-clicking on it, and choosing Delete.

It is always a good idea to backup your registry before making any changes to it. It can be intimidating to a new user, and there is always the possibility of changing or deleting a critical setting causing you to have to reinstall the whole operating system. It's much better to be safe than sorry!

Importing and Exporting Registry Settings

A great feature of the Registry Editor is it's ability to import and export registry settings to a text file, this text file, identified by the .REG extension, can then be saved or shared with other people to easily modify local registry settings. You can see the layout of these text files by simply exporting a key to a file and opening it in Notepad, to do this using the Registry Editor select a key, then from the "Registry" menu choose "Export Registry File...", choose a filename and save. If you open this file in notepad you will see a file similar to the example below:

REGEDIT4

[HKEY_LOCAL_MACHINE\SYSTEM\Setup]

"SetupType"=dword:00000000

"CmdLine"="setup -newsetup"

"SystemPrefix"=hex:c5,0b,00,00,00,40,36,02

The layout is quite simple, REGEDIT4 indicated the file type and version,[HKEY_LOCAL_MACHINE\SYSTEM \Setup] indicated the key the values are from, "SetupType"=dword:00000000 are the values themselves the portion after the "=" will vary depending on the type of value they are;DWORD, String or Binary.

So by simply editing this file to make the changes you want, it can then be easily distributed and all that need to be done is to double-click, or choose "Import" from the Registry menu, for the settings to be added to the system Registry.

Deleting keys or values using a REG file

It is also possible to delete keys and values using REG files. To delete a key start by using the same format as the REG file above, but place a "-" symbol in front of the key name you want to delete. For example to delete the [HKEY_LOCAL_MACHINE\SYSTEM\Setup] key the reg file would look like this:

REGEDIT4

[-HKEY_LOCAL_MACHINE\SYSTEM\Setup]

The format used to delete individual values is similar, but instead of a minus sign in front of the whole key, place it after the equal sign of the value. For example, to delete the value "SetupType" the file would look like:

REGEDIT4

[HKEY_LOCAL_MACHINE\SYSTEM\Setup]

"SetupType"=-

Use this feature with care, as deleting the wrong key or value could cause major problems within the registry, so remember to always make a backup first.

Regedit Command Line Options

Regedit has a number of command line options to help automate its use in either batch files or from the command prompt. Listed below are some of the options, please note the some of the functions are operating system specific.

regedit.exe [options] [filename] [regpath]

[filename]	Import .reg file into the registry
/s [filename]	Silent import, i.e. hide confirmation box when importing files
/e [filename] [regpath]	Export the registry to [filename] starting at [regpath] e.g. regedit /e file.reg HKEY_USERS\.DEFAULT
/L:system	Specify the location of the system.dat to use
/R:user	Specify the location of the user.dat to use
C [filename]	Compress (Windows 98)
/D [regpath]	Delete the specified key (Windows 98)

Clean out old data from the Registry

Although it's possible to manually go through the Registry and delete unwanted entries, Microsoft provides a tool to automate the process, the program is called RegClean. RegClean analyzes Windows Registry keys stored in a common location in the Windows Registry. It finds keys that contain erroneous values, it removes them from the Windows Registry after having recording those entries in the Undo.Reg file.

A registry cleaner is a class of third party software utility designed for the Microsoft Windows operating system, whose purpose is to remove redundant items from the Windows registry.

Registry cleaners are not supported by Microsoft, but vendors of registry cleaners claim that they are useful to repair inconsistencies arising from manual changes to applications, especially COM-based programs.

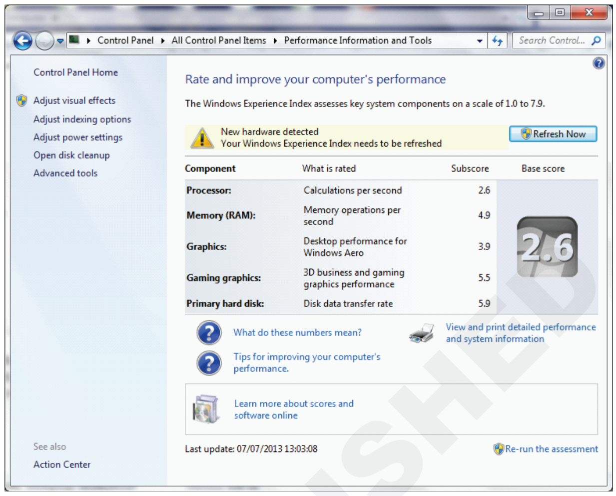
Checking the Performance Level of a system

The Windows Experience Index measures the capability of your computer's hardware and software configuration and expresses this measurement as a number called a base score. A higher base score generally means that your computer will perform better and faster than a computer with a lower base score, especially when performing more advanced and resource-intensive tasks.

Each hardware component receives an individual sub score. Your computer's base score is determined by the lowest sub score. For example, if the lowest sub score of an individual hardware component is 2.6, then the base score is 2.6. The base score is notan average of the combined sub scores. However, the sub scores can give you a view of how the components that are most important to you will perform, and can help you decide which components to upgrade.

You can use the base score to buy programs and other software that are matched to your computer's base score. For example, if your computer has a base score of 3.3, then you can buy any software designed for this version of Windows that requires a computer with a base score of 3 or lower.

Fig 2



The scores currently range from 1.0 to 7.9. The Windows Experience Index is designed to accommodate advances in computer technology. As hardware speed and performance improve, higher score ranges will be enabled. The standards for each level of the index generally stay the same. However, in some cases, new tests might be developed that can result in lower scores.

Tasks that can help improve performance

The following tasks helps in improve performance

Fix broken desktop shortcuts and common system maintenance tasks

Microsoft fixit utility automatically diagnoses and repair problems with broken or not working desktop shortcuts and synchronize the system clock when a wrong time is displayed.

The utility can be downloaded freely from Microsoft website

https://support.microsoft.com/en-us/mats/system_maintenance_for_windows

It fixes the following problems

- Problems with desktop shortcuts and icons.
  - Shortcuts on the desktop don't work or are broken.
  - Desktop icons are broken or have not been used in 3 months.
  - Startup items don't work or are broken.
- System maintenance tasks.
  - Free up disk space by repairing disk volume errors such as bad sectors, lost clusters, cross-linked files and directory errors.
  - Free up disk space by removing error reports and troubleshooting history older than 1 month.

Task	Description
Adjust visual effects	Optimize performance by changing how menus and windows appear.
Adjust indexing options	Indexing options can help find necessary files quickly and easily on the computer.Searching can be done more efficiently by narrowing the search to focus on those files and folders that are commonly used.
Adjust power settings	Change power-related settings so that the computer resumes from power-saving settings more efficiently, and adjust battery usage for portable computers.
Open Disk Cleanup	This tool deletes unnecessary or temporary files on your hard disk thereby increasing the amount of storage space.
Advanced tools	Advanced system tools, such as Event Viewer, Disk Defragmenter, and System Information, can be used to solve problems. View notifications about performance-related issues and what to do about them. For example, if Windows detects that a driver is reducing performance, click the notification to learn which driver is causing the problem and update the driver. Issues listed at the beginning of the list are impacting the system more than issues listed further down the list.

- Set the correct system time and synchronize system clock with the time server.

Performance Monitor

Windows Performance Monitor is a Microsoft Management Console (MMC) snap-in that provides tools for analyzing system performance. From a single console, Application and hardware performance can be monitored in real time, customize what data you want to collect in logs, define thresholds for alerts and automatic actions, generate reports, and view past performance data in a variety of ways.

Windows Performance Monitor combines the functionality of previous stand-alone tools including Performance Logs and Alerts (PLA), Server Performance Advisor (SPA), and System Monitor. It provides a graphical interface for the customization of Data Collector Sets and Event Trace Sessions.

To launch Windows Performance Monitor

Click **Start ,** click in the Start **Search box,** type **perfmon** and press **ENTER.**

Performance Monitor provides a visual display of built-in Windows performance counters, either in real time or as a way to review historical data. You can add performance counters to Performance Monitor by dragging and dropping, or by creating custom Data Collector Sets. It features multiple graph views that enable you to visually review performance log data. You can create custom views in Performance Monitor that can be exported as Data Collector Sets for use with performance and logging features.

Windows Performance Monitor uses performance counters, event trace data, and configuration information, which can be combined into Data Collector Sets.

Performance counters are measurements of system state or activity. They can be included in the operating system or can be part of individual applications. Windows Performance Monitor requests the current value of performance counters at specified time intervals.

Event trace data is collected from trace providers, which are components of the operating system or of individual applications that report actions or events. Output from multiple trace providers can be combined into a trace session.

Configuration information is collected from key values in the Windows registry. Windows Performance Monitor can record the value of a registry key at a specified time or interval as part of a log file.

Resource Monitor

Resource Monitor is a tool that can be used to monitor the usage of CPU, hard disk, network, and memory in real time.

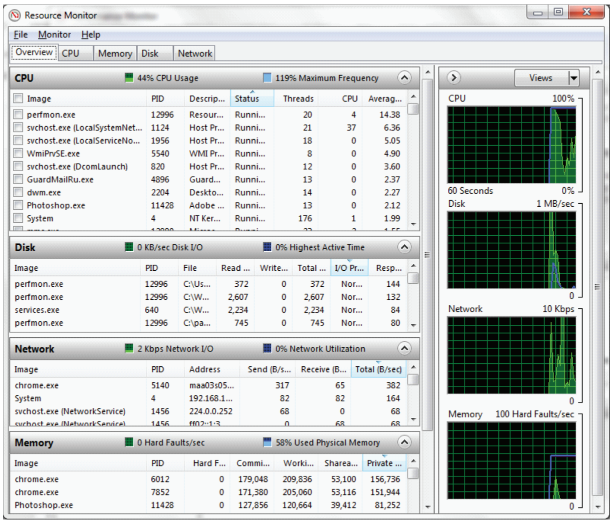
To open Resource Monitor click the **Start** button. In the **search box,** type **Resource Monitor,** and then, in the list of results, click Resource Monitor. Administrator permission is required, if prompted for an administrator password or confirmation, type the password or provide confirmation.

System Configuration

System Configuration is a tool that can help identify problems that might prevent Windows from starting correctly. Windows can be started with common services and startup programs turned off and then turn them back on, one at a time. If a problem doesn't occur when a service is turned off, but does occur when that service is turned on, then the service could be the cause of the problem.

System Configuration is intended to find and isolate problems, but it's not meant as a startup management program. To permanently remove or turn off programs or services that run at startup, see Uninstall or change a program.

Fig 3



General tab

Lists choices for startup configuration modes:

Normal startup. Starts Windows in the usual manner. Use this mode to start Windows after you're done using the other two modes to troubleshoot the problem.

Diagnostic startup. Starts Windows with basic services and drivers only. This mode can help rule out basic Windows files as the problem.

Selective startup. Starts Windows with basic services and drivers and the other services and startup programs that you select.

Boot Tab

Shows configuration options for the operating system and advanced debugging settings, including:

- **Safe boot: Minimal.** On startup, opens the Windows graphical user interface (Windows Explorer) in safe mode running only critical system services. Networking is disabled.
- **Safe boot :** Alternate shell. On startup, opens the Windows command prompt in safe mode running only critical system services. Networking and the graphical user interface are disabled.
- **Safe boot :** Active Directory repair. On startup, opens the Windows graphical user interface in safe mode running critical system services and Active Directory.
- **Safe boot :** Network. On startup, opens the Windows graphical user interface in safe mode running only critical system services. Networking is enabled.
- **No GUI boot.** Does not display the Windows Welcome screen when starting.
- **Boot log.** Stores all information from the startup process in the file %SystemRoot%Ntbtlog.txt.
- **Base video.** On startup, opens the Windows graphical user interface in minimal VGA mode. This loads standard VGA drivers instead of display drivers specific to the video hardware on the computer.
- **OS boot information.** Shows driver names as drivers are being loaded during the startup process.
- **Make all boot settings permanent.** Doesn't track changes made in System Configuration. Options can be changed later using System Configuration, but must be changed manually. When this option is selected, you can't roll back your changes by selecting Normal startup on the General tab.

Advanced boot options

- **Number of processors.** Limits the number of processors used on a multiprocessor system. If the check box is selected, the system boots using only the number of processors in the drop-down list.
- **Maximum memory.** Specifies the maximum amount of physical memory used by the operating system to simulate a low memory configuration. The value in the text box is megabytes (MB).
- **PCI Lock.** Prevents Windows from reallocating I/O and IRQ resources on the PCI bus. The I/O and memory resources set by the BIOS are preserved.
- **Debug.** Enables kernel-mode debugging for device driver development. Go to the Windows Driver Kit website for more information.
- **Global debug settings.** Specifies the debugger connection settings on this computer for a kernel debugger to communicate with a debugger host. The debugger connection between the host and target computers can be Serial, IEEE 1394, or USB 2.0.
- **Debug port.** Specifies using Serial as the connection type and the serial port. The default port is COM 1.
- **Baud rate.** Specifies the baud rate to use when Debug port is selected and the debug connection type is Serial. This setting is optional. Valid values for baud are 9600, 19,200, 38,400, 57,600, and 115,200. The default baud rate is 115,200 bps.
- **Channel.** Specifies using 1394 as the debug connection type and specifies the channel number to use. The value for channel must be a decimal integer between 0 and 62, inclusive, and must match the channel number used by the host computer. The channel specified does not depend on the physical 1394 port chosen on the adapter. The default value for channel is 0.
- **USB target name.** Specifies a string value to use when the debug type is USB. This string can be any value.

Services Tab

Lists all of the services that start when the computer starts, along with their current status (Running or Stopped). Use the Services tab to enable or disable individual services at startup to troubleshoot which services might be contributing to startup problems.

Select Hide all Microsoft services to show only third-party applications in the services list. Clear the check box for a service to disable it the next time you start the computer. If you've chosen Selective startup on the General tab, you must either choose Normal startup on the General tab or select the service's check box to start it again at startup.

Warning Disabling services that normally run at startup might cause some programs to malfunction or result in system instability. Don't disable services in this list unless you know they're not essential to your computer's operation. Selecting Disable all won't disable some secure Microsoft services required for the operating system to start.

Startup Tab

Lists applications that run when the computer starts up, along with the name of their publisher, the path to the executable file, and the location of the registry key or shortcut that causes the application to run.

Clear the check box for a startup item to disable it on your next startup. If you've chosen Selective startup on the General tab, you must either choose Normal startup on the General tab or select the startup item's check box to start it again at startup.

If you suspect an application has been compromised, examine the Command column to review the path to the executable file.

Note Disabling applications that normally run at startup might result in related applications starting more slowly or not running as expected.

Tools Tab

Provides a convenient list of diagnostic tools and other advanced tools that you can run.

User accounts & Task manager

Objectives: At the end of this lesson you shall be able to
- **understand users and user account**
- **know about task manager**
- **to monitor computer performance**
- **understand privileges, scope, permissions etc**
- **know the concept of virtual machine.**

User Accounts

A user account is a collection of information that tells Windows which files and folders can be accessed by the user, what changes can be made to the computer by the user, and personal preferences, such as the user's desktop background or screen saver. User accounts let the user share a computer with several people, while having the user's own files and settings. Each person accesses his or her user account with a user name and password.

There are three types of accounts. Each type gives users a different level of control over the computer:

- Standard accounts are for everyday computing.
- Administrator accounts provide the most control over a computer, and should only be used when necessary.
- Guest accounts are intended primarily for people who need temporary use of a computer.

Permissions

Permissions are rules related with objects on a computer or network, such as files and folders. Permissions determine whether the user can access an object and what he can do with it. For example, the user might have access to a document on a shared folder on a network. And even though the user can read the document, he might not have permissions to make changes to it. System administrators and people with administrator accounts on computers can assign permissions to individual users or groups.

Table 1.Lists the permission levels that are typically available for files and folders.

Permission Level	Description
Full control	Users can see the contents of a file or folder, change existing files and folders, create new files and folders, and run programs in a folder.
Modify	Users can change existing files and folders, but cannot create new ones.
Read and execute	Users can see the contents of existing files and folders and can run programs in a folder.
Read	Users can see the contents of a folder and open files and folders.
Write	Users can create new files and folders and make changes to existing files and folders.

Table 1

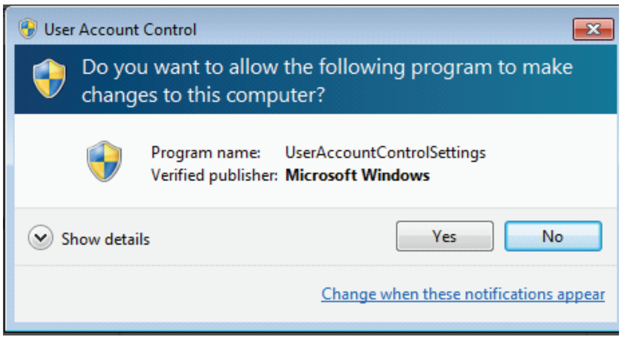
User Account Control (UAC)

UAC is a security feature of Windows which helps prevent unauthorized changes to the computer. These changes can be initiated by applications, viruses or other users. User Account Control makes sure these changes are made only with approval from the administrator. If the changes are not approved by the administrator, they are not executed and Windows remains unchanged. When an application wants to make a system change like: modifications which affect other users, modifications of system files and folders, installation of new software, an UAC prompt appears as shown in Fig 1, asking for permission.

If the user clicks or taps No, the change won't be performed. If the user clicks or taps Yes, the application receives administrative permissions and it is able to make the system changes it requires. These permissions are given only until the application stops running or it is closed by the user. There are many changes which require administrative privileges and, depending on how UAC is configured, they can cause an UAC prompt to show up and ask for permission. These are the following:

- Running an application as administrator
- Changes to system-wide settings or to files in the Windows or Program Files folders
- Installing and uninstalling drivers & applications
- Installing ActiveX controls
- Changing settings to the Windows Firewall
- Changing UAC settings
- Configuring Windows Update

Fig 1



- Adding or removing user accounts
- Changing a user's account type
- Configuring Parental Controls or Family Safety
- Running Task Scheduler
- Restoring backed-up system files
- Viewing or changing another user's folders and files
- Changing the system date and time

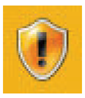
in Windows 7 and Windows 8 there are four levels to choose from.

UAC is a feature in Windows that helps the user stay in control of the computer by informing the user when a program makes a change that requires administrator-level permission. UAC works by adjusting the permission level of the user account.

When changes are going to be made to the computer that require administrator-level permission, UAC notifies the user. If the user is an administrator, he can click Yes to continue. If the user is not an administrator, then a person with an administrator account on the computer will have to enter their password to continue. Even if the user uses an administrator account, changes cannot be made to your computer without the user knowing about it, which can help prevent malicious software (malware) and spyware from being installed on or making changes to the computer.

When a permission or password is needed to complete a task, UAC will notify the user with one of four different types of dialog boxes. Table 2. Describes the different types of dialog boxes used to notify the user and the guide on how to respond to them.

It is better to log on to the computer with a standard user account most of the time. Browsing the Internet, sending e mail, and using a word processor, can all be done without an administrator account. When an administrative task, such as installing a new program or changing a setting that will affect other users, it is not necessary to switch to an administrator account; Windows will prompt for permission or an administrator password before performing the task. It is better to create standard user accounts for all the people who use the computer.

Icon	Type	Description
	A setting or feature that is part of Windows needs the user's permission to start.	This item has a valid digital signature that verifies that Microsoft is the publisher of this item. If the user gets this type of dialog box, it is usually safe to continue. If unsure, check the name of the program or function before running.
	A program that is not part of Windows needs the user's permission to start	This program has a valid digital signature, which helps to ensure that the program verifies the identity of the publisher of the program. If the user gets this type of dialog box, he has to make sure that the program is the one that he wants to run and that he trusts the publisher.
	A program with an unknown publisher needs the user's permission to start.	This program doesn't have a valid digital signature from its publisher. This doesn't necessarily indicate danger, as many older, legitimate programs lack signatures. However, the user should use extra caution and only allow a program to run if he had obtained it from a trusted source, such as the original CD or a publisher's website.
	The User has been blocked by the system administrator from running this program.	This program has been blocked because it is known to be untrusted. To run this program, the user needs to contact the system administrator.

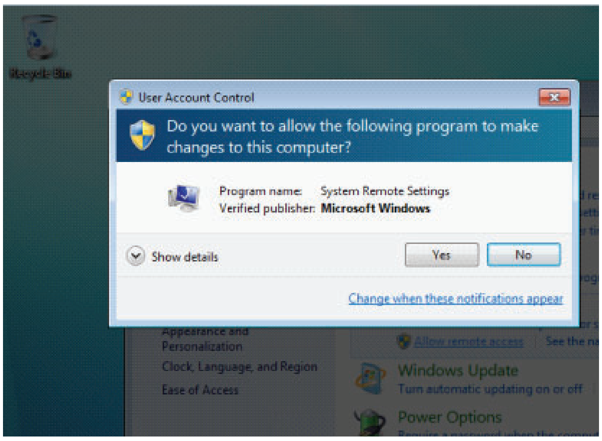
There are four levels to choose from when UAC is turned On or Off, in Windows 7 and Windows 8. The differences between them are the following:

1 Always notify - at this level you are notified before applications and users make changes that required administrative permissions. When an UAC prompt shows up, the desktop is dimmed as shown in the screenshot below. You must choose Yes or No before you can do anything else on the computer. This is the most secure setting and the most annoying.

2 Notify me only when programs/apps try to make changes to my computer - this is the default level and UAC notifies only before programs make changes that require administrative permissions. If changes to

Windows are done manually, then a UAC prompt is not shown. This is less secure than the first setting because malicious programs can be created to simulate the keystrokes or mouse movements made by a user and change Windows settings.

Fig 2



3 Notify me only when programs/apps try to make changes to my computer (do not dim my desktop) - this level is identical to the one above except the fact that, when a UAC prompt is shown, the desktop is not dimmed and other programs are able to interfere with it. This level is even less secure as it makes it easy for malicious programs to simulate keystrokes or mouse moves that interfere with the UAC prompt.

4 Never notify - at this level, UAC is turned off and it doesn't offer any protection against unauthorized system changes. With UAC turned off it is much easier for malicious programs to infect your computer and take control.

Virtual machine

Objectives: At the end of this lesson you shall be able to
- **know the concept of virtual machine**
- **understand the need for a virtual machine.**

Virtual Machine

A virtual machine program is a computer program that creates a virtual computer system, complete with virtual hardware devices. This virtual computer "machine" runs as a process in a window on your current operating system. An Operating system can be booted using a system installer disc (or live CD) inside the virtual machine, and the operating system will be "tricked" into thinking it is running on a real computer. It will install and run just as it would on a real, physical machine. Whenever you want to use the operating system, you can open the virtual machine program and use it in a window on your current desktop.

A virtual machine's operating system is stored on a virtual hard drive - a big, multi-gigabyte file stored on your hard drive. The file is presented to the operating system as a real hard drive. This means there is no need to create a new partition.

Virtual machines uses some resources, so they will not be as fast as the operating system installed on real hardware.

Uses of Virtual Machine

They allow the user to experiment with another operating system without leaving your current operating system. They're a good way to play with Linux, or at least a new Linux distribution, without actually installing that Linux distribution on your current hardware or even just booting to a live CD or USB drive. After experimenting with the operating system, the virtual machine can be deleted. A virtual machine is also a great way to test out a new version of Windows.

A virtual machine gives a way to run another operating system's software. A Linux user, you can install Windows in a virtual machine and run Windows desktop programs in that virtual machine. Mac users can also use virtual machines to run Windows software. Even Windows users could benefit from a virtual machine allowing them to run Linux software in a virtual machine environment using a dual-boot configuration.

Virtual machines are also isolated from the rest of the system, which means that software inside a virtual machine can't escape the virtual machine and tamper with the rest of the system. A virtual machine can be a good place to test out programs which the user does not trust. It also allows the user to run insecure operating systems more safely.

Virtual Machine Programs

Some of the different virtual machine programs are given below

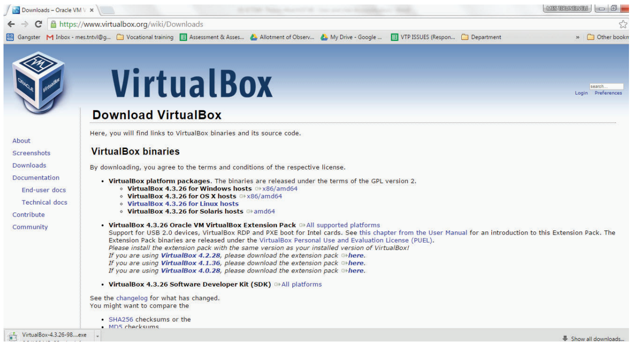
- VirtualBox (Windows, Linux, Mac OS X): VirtualBox is open-source and completely free
- VMware Player (Windows, Linux):
- VMware Fusion (Mac OS X):
- Parallels Desktop (Mac OS X):

Setting up a virtual machine is easy.

Virtualbox can be downloaded freely from www.virtualbox.org/wiki/Downloads see Fig 1.

Open it and click the button to create a new virtual machine. A wizard opens up as shown in Fig 2.

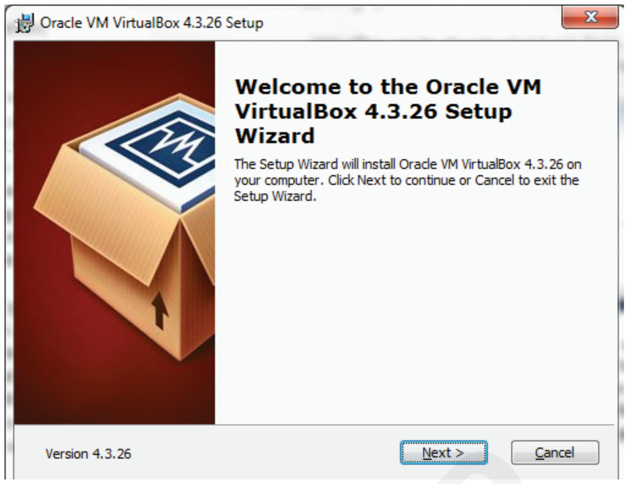
Fig 1



A wizard asks for the operating system that is to be installed. The wizard will choose the appropriate defaults for the operating system of choice, Follow through the wizard just accepting the default settings.

At the end, the wizard prompts to insert installation media - for example, an ISO file with a Windows or Linux installer on it or a physical CD or DVD. The virtual machine will then boot and load the operating system from that installation media normally. The operating system installation process is normal, but it happens in a window on your desktop.

Fig 2



After completing the virtual machine, it can be shut down or the window can be just closed. The virtual machine program can be opened again by double-clicking the virtual machine.

Each virtual machine's files are also stored in a folder on your hard drive, which can be copied to back them up or move them between computers.

Windows update and service pack

Objectives: At the end of this lesson you shall be able to
- **know software version**
- **know about service pack**
- **difference between update and upgrade.**

Software Versioning

Software versioning is the process of assigning either unique version names or unique version numbers to unique states of computer software. Within a given version number category (major, minor), these numbers are generally assigned in increasing order and correspond to new developments in the software.

Service Pack

A service pack (SP) or a feature pack (FP) comprises a collection of updates, fixes, or enhancements to a software program delivered in the form of a single installable package. Companies often release a service pack when the number of individual patches to a given program reaches a certain (arbitrary) limit, or the software release has shown to be stabilized with a limited number of remaining issues based on users feedback and bug tracking. In large software applications such as office suites, operating systems, database software, or network management, it is common to have a service pack issued within the first year or two of a product's release. Installing a service pack is easier and less error-prone than installing many individual patches, even more so when updating multiple computers over a network, where service packs are common.

Service packs are usually numbered, and thus shortly referred to as SP1, SP2, SP3 etc. They may also bring, besides bug fixes, entirely new features.

Incremental and Cumulative SP

Service Packs for Microsoft Windows were cumulative through Windows XP. This means that the problems that are fixed in a service pack are also fixed in later service packs. For example, Windows XP SP3 contains all the fixes that are included in Windows XP Service Pack 2 (SP2). Windows Vista SP2 was not cumulative, however, but incremental, requiring that SP1 be installed first.

Office XP, 2003, and 2007 service packs have been cumulative.

Operating system updates

Operating system updates are corrections for program incompatibilities, discovered errors, and security vulnerabilities. There are errors and security problems discovered in every operating system and updates are created and distributed on a regular basis.

Operating system updates often address security vulnerabilities that have been discovered or not previously disclosed. If operating system updates are not installed in a timely manner it can lead to unauthorized access, theft of personal, confidential, or Protected Health Information, or the destruction of data. The UCSF community is encouraged to use automatic operating system updates, where available, to help prevent these types of problems and to meet the minimum security requirements. For those systems where automatic operating system updates are not available a plan should be put in place which 1) identifies which systems are not automatically updated, 2) states which resource(s) will be used to determine if an operating system update is available, and 3) directs how and by whom the update will be installed.

Difference between an update and an upgrade

A software update provides bug fixes for features that aren't working quite right, minor software enhancements and sometimes include new drivers to support printers, DVD drives or other hardware. Software updates are free, and are sometimes called a patch because the update is installed over software. It is not a full software installation.

A software upgrade requires a purchase of a new version of software, usually at a lower price than you would pay if you bought the software for the first time. Most software companies will offer a free update to the latest version if you just recently bought software, so be sure to register the software when install it so we know if we qualify for deals like this.

Software installation and uninstallation

Objectives: At the end of this lesson you shall be able to
- **prerequisites of software installation.**

Software Installation

To be used efficiently, all computer software needs certain hardware components or other software resources to be present on a computer. These prerequisites are known as (computer) system requirements and are often used as a guideline as opposed to an absolute rule. Most software defines two sets of system requirements: minimum and recommended.

Recommended system requirements

Often manufacturers of games will provide the consumer with a set of requirements that are different from those that are needed to run a software. These requirements are usually called the Recommended Requirements. These requirements are almost always of a significantly higher level than the minimum requirements, and represent the ideal situation in which to run the software. Generally speaking, this is a better guideline than minimum system requirements in order to have a fully usable and enjoyable experience with a software.

Hardware requirements

The most common set of requirements defined by any operating system or software application is the physical computer resources, also known as hardware, A hardware requirements list is often accompanied by a hardware compatibility list (HCL), especially in case of operating systems. An HCL lists tested, compatible, and sometimes incompatible hardware devices for a particular operating system or application. The following sub-sections discuss the various aspects of hardware requirements.

Architecture

All computer operating systems are designed for a particular computer architecture. Most software applications are limited to particular operating systems running on particular architectures. Although architecture-independent operating systems and applications exist, most need to be recompiled to run on a new architecture. See also a list of common operating systems and their supporting architectures.

Processing power

The power of the central processing unit (CPU) is a fundamental system requirement for any software. Most software running on x86 architecture define processing power as the model and the clock speed of the CPU. Many other features of a CPU that influence its speed and power, like bus speed, cache, and MIPS are often ignored. This definition of power is often erroneous, as AMD Athlon and Intel Pentium CPUs at similar clock speed often have different throughput speeds. Intel Pentium CPUs have enjoyed a considerable degree of popularity, and are often mentioned in this category [citation needed].

Memory

All software, when run, resides in the random access memory (RAM) of a computer. Memory requirements are defined after considering demands of the application, operating system, supporting software and files, and other running processes. Optimal performance of other unrelated software running on a multi-tasking computer system is also considered when defining this requirement.

Secondary storage

Hard-disk requirements vary, depending on the size of software installation, temporary files created and maintained while installing or running the software, and possible use of swap space (if RAM is insufficient).

Display adapter

Software requiring a better than average computer graphics display, like graphics editors and high-end games, often define high-end display adapters in the system requirements.

Peripherals

Some software applications need to make extensive and/or special use of some peripherals, demanding the higher performance or functionality of such peripherals. Such peripherals include CD-ROM drives, keyboards, pointing devices, network devices, etc.

Software requirements

Software requirements deal with defining software resource requirements and prerequisites that need to be installed on a computer to provide optimal functioning of an application. These requirements or prerequisites are generally not included in the software installation package and need to be installed separately before the software is installed.

Platform

A computing platform describes some sort of framework, either in hardware or software, which allows software to run. Typical platforms include a computer's architecture, operating system, or programming languages and their runtime libraries.

Operating system is one of the requirements mentioned when defining system requirements (software). Software may not be compatible with different versions of same line of operating systems, although some measure of backward compatibility is often maintained. For example, most software designed for Microsoft Windows XP does not run on Microsoft Windows 98, although the converse is not always true. Similarly, software designed using newer features of Linux Kernel v2.6 generally does not run or compile properly (or at all) on Linux distributions using Kernel v2.2 or v2.4.

APIs and drivers

Software making extensive use of special hardware devices, like high-end display adapters, needs special API or newer device drivers. A good example is DirectX, which is a collection of APIs for handling tasks related to multimedia, especially game programming, on Microsoft platforms.

Web browser

Most web applications and software depending heavily on Internet technologies make use of the default browser installed on system. Microsoft Internet Explorer is a frequent choice of software running on Microsoft Windows, which makes use of ActiveX controls, despite their vulnerabilities.

Other requirements

Some software also has other requirements for proper performance. Internet connection (type and speed) and resolution of the display screen are notable examples.

Example: Prerequisite requirements for installing Autodesk Maya 2015

Software	
Operating System	• Microsoft® Windows® 7 (SP1), Windows® 8 and Windows® 8.1 Professional operating system • Apple® Mac OS® X 10.8.5 and 10.9.x operating system • Red Hat® Enterprise Linux® 6.2 WS operating system • Fedora™ 14 Linux operating system • CentOS 6.2 Linux operating system
Browser	Autodesk recommends the latest version of the following web browsers for access to online supplemental content: • Apple® Safari® web browser • Google Chrome™ web browser • Microsoft® Internet Explorer® web browser • Mozilla® Firefox® web browser

Hardware	
CPU	64-bit Intel® or AMD® multi-core processor
Graphics Hardware	Refer to the Recommended Hardware wizard for a detailed list of recommended systems and graphics cards
RAM	4 GB of RAM (8GB recommended)
Disk Space	4GB of free disk space for install
Pointing Device	Three-button mouse

Information Technology Act, 2000

An Act to provide legal recognition for transactions carried out by means of electronic data interchange and other means of electronic communication, commonly referred to as "electronic commerce", which involve the use of alternatives to paper-based methods of communication and storage of information, to facilitate electronic filing of documents with the government agencies and further to amend the Indian Penal Code, the Indian Evidence Act, 1872, the Banker's Books Evidence Act, 1891 and the Reserve Bank of India Act, 1934 and for matters connected therewith or incidental thereto.

The Information Technology Act 2000 has been substantially amended through the Information Technology (Amendment) Act 2008 which was passed by the two houses of the Indian Parliament on December 23, and 24, 2008. It got the presidential assent on February 5, 2009 and came into force on October 27, 2009. The amended Act has provided additional focus on information security. It has added several new section on offences including cyber terrorism and data protection. A set of Rules related to sensitive personal information and reasonable security practices (Mentioned in section 43A of the ITAA, 2008) was notified in April 2011.

Provisions

Information technology Act 2000 consisted of 94 sections segregated into 13 chapters. Four schedules from part of the Act. In the 2008 version of the Act, there are 124 sections (Excluding 5 sections that have been omitted from the earlier version) and 14 chapters. Schedule I and II have been replaced. Schedules III and IV are deleted.

Information Technology ACT 2000 addressed the following issues:

1 Legal recognition of electronic documents

2 Legal recognition of digital signatures.

3 Offenses and contraventions

4 Justice dispensation systems for cybercrimes.

According to Section 10A of information technology Act, 2000 (amended in 2008) it also validates E-contracts.

Section	Offence	Punishment
65	Tampering with computer source documents - Intentional concealment, destruction or alteration of source code when the computer source code is required to be kept or maintained by law for the time being in force.	Imprisonment up to three years, or/ and with fine up to 2 lakh rupees.
66	Hacking	Imprisonment up to three years, or/ and with fine up to 5 lakh rupees.
66-A	Sending offensive message through electronic means - Sending any information through an electronic message that is grossly offensive or has menacing character and might cause insult, injury, criminal intimidation, enmity, hatred or ill will, etc. or sending such mail intended to deceive or to mislead the addressee or recipient about the origin of such messages	Imprisonment up to three years, and with fine

Offence

Section 66A is widely criticized. It has led to numerous abuses reported by the press. Section 66A has also been criticised and challenged in Lucknow and Madras High Court for its constitutional validity. Based on Section 66A, Bombay High Court has held that creating a website and storing false information on it can entail cybercrime. On 24 march 2015, Supreme Court of India strike down section 66A of the IT Act as unconstitutional on the grounds of violating Article 19(1)(a) of the Constitution of India which grants freedom of speech and expression.

Cybercrime

Cybercrime or **Computer crime,** refers to any crime that involves a computer and a network. The computer may have been used in the commission of a crime, or it may be the target. Net crime is criminal exploitation of the Internet. Cybercrimes is defined as; "offences that are committed against individuals or groups of individuals with a criminal motive to intentionally harm the reputation of the victim or cause physical or mental harm to the victim directly or indirectly, using modern telecommunication networks such as Internet (Chat rooms, emails, notice boards and groups) and mobile phones (SMS/MMS)". Such crimes may threaten a nation's security and financial health. Issues surrounding these types of crimes have become high-profile, particularly those surrounding cracking, copyright infringement, child pornography, and child grooming. There are also problems of privacy when confidential information is lost or intercepted, lawfully or otherwise.

Computer crime encompasses a broad range of activities. Generally, however, it may be divided into two categories:

1 Crimes that target computers directly

2 Crimes facilitated by computer networks or devices, the primary target of which is independent of the computer network or device.

Crimes that primarily target computer networks or devices include:

- Computer viruses
- Denial-of-service attacks
- Malware (malicious code)

Crimes that use computer networks or devices to advance other ends include:

- Cyber stalking
- Fraud and identity theft
- Information warfare
- Phishing scams

Cyber law

Cyber law or **Internet law** is a term that encapsulates the legal issues related to use of the Internet. It is less a distinct field of law than intellectual property or contract law, as it is a domain covering many areas of law and regulation. Some leading topics include internet access and usage, privacy, freedom of expression, and jurisdiction.

"Computer law" is a third term which tends to relate to issues including both internet law and the patent and copyright aspects of computer technology and software.

An example of information technology law is India's Information Technology Act, 2000. This Act applies to whole of India, and its provisions also apply to any offense or contravention, committed even outside the territorial jurisdiction of Republic of India, by any person irrespective of his nationality. In order to attract provisions of this Act, such an offence or contravention should involve a computer, computer system, or computer network located in India.

Copyright

Copyright is a legal right created by the law of country, that grants the creator of an original work exclusive rights to its use and distribution, usually for a limited time, with the intention of enabling the creator (e.g. the photographer of a photograph or the author of a book) to receive compensation for their intellectual effort.

Copyright infringement is the use of works protected by copyright law without permission, infringing certain exclusive rights granted to the copyright holder, such as the right to reproduce, distribute, display or perform the protected work, or to make derivative works. The copyright holder is typically the work's creator, or a publisher or other business to whom copyright has been assigned.

Software copyright is used by proprietary software companies to prevent the unauthorized copying of their software. Free and open source licenses also rely on copyright law to enforce their terms. For instance, copy left licenses impose a duty on licenses to share their modifications to the copy lefted work with the user or copy owner under some circumstances. No such duty would apply had the software in question been in the public domain. A copy left is a type of copyright license that allows redistributing the work (with or without changes) on condition that recipients are also granted these rights.

Software patent

A patent is a set of exclusionary right granted by a state to a patent holder for a limited period of time, usually 20 years. These rights are granted to patent applicants in exchange for their disclosure of the inventions. Once a patent is granted in a given country, no person may make, use, sell or import/export the claimed invention in that country without the permission of the patent holder. Permission, where granted, is typically in the form of a license which conditions are set by the patent owner: it may be gratis or in return for a royalty payment or lump sum fee. A software patent has been defined by the Foundation for a Free Information Infrastructure (FFII) as being a "patent on any performance of a computer realised by means of a computer program".

Most countries place some limits on the patenting of invention involving software, but there is no legal definition of a software patent. For example, U.S. patent law excludes "abstract ideas", and this has been used to refuse some patents involving software. In Europe, "Computer programs as such" are excluded from patentability and European Patent Office Policy is consequently that a program for a computer is not patentable if it does not have the potential to cause a "further technical effect" beyond the inherent technical interactions between hardware and software.

Types of Cyber Crimes

Section	Offence	Description	Penalty
65	Tampering with computer source documents	If a person knowingly or intentionally conceals, destroys or alters or intentionally or knowingly causes another to conceal, destroy or alter any computer source code used for a computer, computer programme, computer system or computer network, when the computer source code is required to be kept or maintained by law for the time being in force.	Imprisonment up to three years, or/and with fine up to INR2,00,000
66	Hacking with computer system	If a person with the intent to cause or knowing that he is likely to cause wrongful loss or damage to the public or any person destroys or deletes or alters any information residing in a computer resource or diminishes its value or utility or affects it injuriously by any means, commits hack.	Imprisonment up to three years, or/and with fine up to INR500,000
66B	Receiving stolen computer or communication device.	A person receives or retains a computer resource or communication device which is known to be stolen or the person has reason to believe is stolen.	Imprisonment up to three years, or/and with fine up to INR100,000
66C	Using password of another person	A person fraudulently uses the password, digital signature or other unique identification of another person.	Imprisonment up to three years, or/and with fine up to INR100,000
66D	Cheating using computer resource	If a person cheats someone using a computer resource or communication.	Imprisonment up to three years, or/and with fine up to INR100,000
66E	Publishing private images of others	If a person capture, transmits or publishes images of a person's private parts without his/her consent or knowledge.	Imprisonment up to three years, or/and with fine up to INR200,000
66F	Acts of cyber terrorism	If a person denies access to authorised personnel to a computer resource, accesses a protected system or introduces contaminant into a system, which the intention of threatening the unity, integrity, sovereignty or security of India, then he commits cyberterrorism.	Imprisonment up to life.

Section	Offence	Description	Penalty
67	Publishing information which is obscene in electronic form.	If a person publishes or transmits or causes to be published in the electronic form, any material which is lascivious or appeals to the prurient interest or if its effect is such as to tend to deprave and corrupt persons who are likely, having regard to all relevant circumstances, to read, see or hear the matter contained or embodied in it.	Imprisonment up to five years, or/and with fine up to INR1,000,000
67A	Publishing images containing sexual acts	If a person publishes or transmits images containing a sexual explicit act or conduct.	Imprisonment up to seven years, or/and with fine up to INR1,000,000
67B	Publishing child porn or predating children online	If a person captures, publishes or transmits images of a child in a sexually explicit act or conduct. If a person induces a child into a sexual act. A child is defined as anyone under 18.	Imprisonment up to five years, or/and with fine up to INR1,000,000 on first conviction. Imprisonment up to seven years, or/and with fine up to INR1,000,000on second conviction.
67C	Failure to maintain records	Persons deemed as intermediator (such as an ISP) must maintain required records for stipulated time. Failure is an offence.	Imprisonment up to three years, or/and with fine.
68	Failure/refusal to comply with orders	The Controller may, by order, direct a Certifying Authority or any employee of such Authority to take such measures or cease carrying on such activities as specified in the order if those are necessary to ensure compliance with the provisions of this Act, rules or any regulations made thereunder. Any person who fails to comply with any such order shall be guilty of an offence.	Imprisonment up to three years, or/and with fine up to INR200,000
69	Failure/refusal todecrypt data	If the Controller is satisfied that it is necessary or expedient so to do in the interest of the sovereignty or integrity of India, the security of the State, friendly relations with foreign Stales or public order or for preventing incitement to the commission of any cognizable offence, for reasons to be recorded in writing, by order, direct any agency of the Government to intercept any information transmitted through any computer resource. The subscriber or any person in charge of the computer resource shall, when called upon by any agency which has been directed, must extend all facilities and technical assistance to decrypt the information. The subscriber or any person who fails to assist the agency referred is deemed to have committed a crime.	Imprisonment up to seven years and possible fine.
70	Securing access or attempting to secure access to a protected system	The appropriate Government may, by notification in the Official Gazette, declare that any computer, computer system or computer network to be a protected system. The appropriate Government may, by order in writing, authorise the persons who are authorised to access protected systems. If a person who secures access or attempts to secure access to a protected system, then he is committing an offence.	Imprisonment up to ten years, or/and with fine.
71	Misrepresentation	If anyone makes any misrepresentation to, or suppresses any material fact from, the Controller or the Certifying Authority for obtaining any licence or Digital Signature Certificate.	Imprisonment up to three years, or/and with fine up to INR100,000

Drivers

Objectives: At the end of this lesson you shall be able to
- **about device drivers**
- **the application of device drivers.**

Drivers

A driver is software that allows the computer to communicate with hardware or devices. Without drivers, the hardware with the computer will not work properly.

Device Driver

A device is a computer program that operates or controls a particular type of device that is attached to a computer. A driver provides a software interface to hardware devices, enabling operating systems and other computer programs to access hardware functions without needing to know exact details of the hardware being used.

A driver communicates with the device through the computer bus or communications subsystem to which the hardware connects. When a calling program raises a routine in the driver, the driver issues commands to the device. Once the device sends data back to the driver, the driver may raise routines in the original calling program. Drivers are hardware-dependent and operating-system-specific.

Device drivers simplify programming by acting as translator between a hardware device and the application or operating systems that use it. Programmers can write the higher-level application code independently of whatever specific hardware the end-user is using. The task of writing drivers thus usually falls to software engineers or computer engineers who work for hardware-development companies.

Applications

Because of the diversity of modern hardware and operating systems, drivers operate in many different environments. Drivers may interface with:

- Printers
- Video adapters
- Network cards
- Sound cards
- Local buses of various sorts-in particular, for bus mastering on modern systems
- Low-bandwidth I/O buses of various sorts (for pointing devices such as mice, keyboards, USB, etc.)
- Computer storage devices such as hard disk, CD-ROM, and floppy disk buses (ATA, SATA, SCSI)
- Implementing support for different file systems
- Image scanners
- Digital cameras

Common levels of abstraction for device drivers include:

1 For hardware:

- Interfacing directly
- Writing to or reading from a device control register
- Using some higher-level interface (e.g. Video BIOS)
- Using another lower-level device driver (e.g. file system drivers using disk drivers)
- Simulating work with hardware, while doing something entirely different.

2 For software:

- Allowing the operating system direct access to hardware resources
- Implementing only.
- Implementing an interface for non-driver software (e.g., TWAIN)
- Implementing a language, sometimes quite high-level (e.g., PostScript)

So choosing and installing the correct device drivers for given hardware is often a key component of computer system configuration.

Like computer programs drivers also have updates and service packs to fix bugs and add features. It is important to know the driver version, particularly when there is a problem with a device, it can be very helpful to know what version of the driver being used. To check the driver version, open device manager using the start menu search box, find the driver in the list, right-click and choose properties. The version information and date on the driver tab can be viewed. Drivers can also be updated, roll backed, or uninstalled from this view.

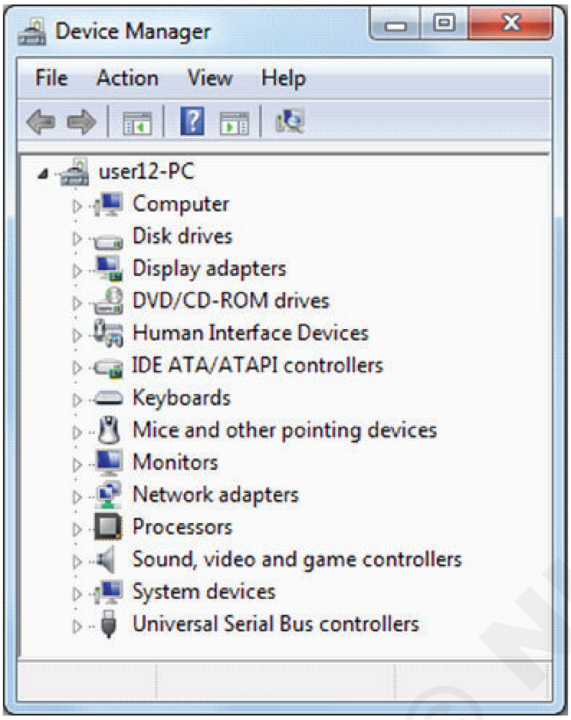
If there is a problem with a particular device, it can be quickly upgraded to a newer version by opening device manager, right-clicking on the device, and choosing update driver software. This will pop up a wizard that will either search windows update or your PC for the latest drivers - or manually install the drivers by using the browse option. If windows is allowed to automatically update, it will install right away and ask for reboot. If the problem is not fixed then the driver can be rolled back.

Device Manager

Screenshot of the Device Manager tool under Windows 8

The Device Manager is a Control Panel applet in Microsoft Windows operating systems. It allows users to view and control the hardware attached to the computer. When a piece of hardware is not working, the offending hardware is highlighted for the user to deal with. The list of hardware can be sorted by various criteria.

Fig 1



For each device, users can:

- Supply device drivers
- Enable or disable devices
- Tell Windows to ignore malfunctioning devices
- View other technical properties

Device Manager was introduced with Windows 95 and later added to Windows 2000. In NT-based versions, it is included as a Microsoft Management Console snap-in.

Types of icons for device

Disabled device

A disabled device has either been manually disabled by a user or by some way of error. In Windows 95 through XP, this is denoted by a red X. In Windows Vista and Windows 7, this was replaced by a grey downward pointing arrow in the lower right-hand corner of the device's icon.

Hardware not working properly

There are many reasons why hardware may not work properly. If Windows recognizes a problem with a device, it is denoted by a black exclamation point (!) on a yellow triangle in the lower right-hand corner of the device's icon.

Hardware not recognized

Hardware may not be recognized if it is not installed properly or not compatible with your system. This is denoted by a yellow question mark in place of the device's icon.

Device manually selected

A blue "i" on a white field in the lower right-hand corner of a Device's icon indicates that the Use automatic settings feature is not selected for the device and that the resource was manually selected. Note that this does not indicate a problem or disabled state.

Code	Meaning
1	This device has not been configured correctly.
3	The driver for this device may be corrupted, or your system may be running low on memory.
10	This device cannot start.
12	Not enough resources for the device.
14	You must restart your computer for the device to work properly.
16	Windows can't identify all the resources this device requires.
18	Drivers for this device must be reinstalled.
19	Configuration information in Windows registry is damaged or corrupted for this device.
21	Windows is removing this device.
22	This device is disabled.
24	This device is not present, does not have all its drivers installed, or is not working properly.
28	The drivers for this device are not installed.
29	The firmware of the device did not give it the required resources.
31	Windows cannot load the drivers required for this device.
32	A driver for this device has been disabled.

33	Windows cannot determine which resources are required for this device.
34	Windows cannot determine the settings for this device.
35	Your computer's firmware does not include enough information to properly configure and use this device.
36	This device is requesting a PCI interrupt but is configured for an ISA interrupt (or vice versa).
37	Windows failed to initialize the device driver for this hardware.
38	Windows cannot run the driver for this device because a previous instance of the driver exists.
39	Windows cannot load the driver for this device. The driver may be corrupted or missing.
40	Windows cannot access this hardware because its service key information in the registry is missing or corrupted.
41	Windows successfully loaded the device driver for this hardware but cannot find the hardware device.
42	Windows cannot run the driver for this device because there is a duplicate device already running in the system.
43	Windows has stopped this device because it has reported problems.
44	An application or service has shut down this hardware device.
45	This hardware device is not connected to the computer.
46	Windows cannot gain access to this hardware device because the operating system is in the process of shutting down.
47	Windows cannot use this device because it has been prepared for safe removal, but it has not been removed from the computer.
48	The driver for this device has been blocked from starting because it is known to have problems with Windows.
49	Windows cannot start new hardware devices because the system hive is too large and exceeds the Registry Size Limit.
52	Windows cannot verify the digital signature for the drivers required for this device. A recent hard ware or software change might have installed a file that is signed incorrectly or damaged.

Speed up your computer

Objectives: At the end of this lesson you shall be able to
- **know how to speed up windows 7 PC.**

Limit how many programs run at startup

There are a lot of programs that load automatically when the system boot up - which can really hamper performance. To manage these programs like a pro, learn how to get a comprehensive of what's running :

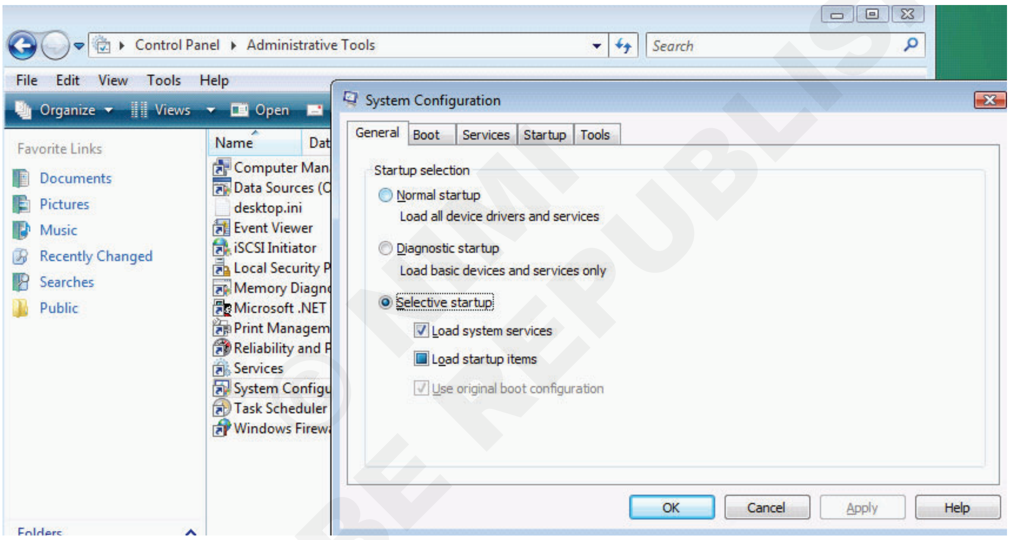
Click the **Start** button, type **System Configuration** in the search box, and then click **System Configuration** in the list of results. (Fig 1)

Click the Startup tab. The program set to run at startup are indicated with a check mark. Clear the check boxes for any non-essential programs to disable them, but make sure you only disable programs are familiar with. When in doubt, don't clear the check box.

Delete the programs

A clean machine is a fast machine. That means best option is to uninstall all the programs that don't use. Delete things like trial software, limited-edition versions, and anything else that never going to use. To uninstall software.

Fig 1



Click the **Start** button, and then click **Control Panel** under **Programs,** click **Uninstall a program.** (If it is don't see this page, change the **View by** option int he upper-right corner to **Category**) (Fig 2)

Click the program you want to delete, and then click uninstall.

Run fewer programs at the same time

Click to see how many programs have running. All programs take up system memory, which can have a huge impact on performance. In some cases, having multiple instances of a program (Such as several open email messages) or multiple versions of a program type (more than one antivirus program) can use up memory. Respond to and close message right away and keep open only the programs that are necessary for the work that currently doing - and we will see a boost in speed.

Trouble shoot

- Click the **Start** button, and then click **Control Panel.**
- In the search box, type troublehooting and then click **Troubleshooting** in the list of results.
- Under **Systems and Security,** click **Check for performance issues. (Fig 3)**
- Run the performance troubleshooter by clicking **Next** in the lower-right corner.

Clean your hard drive

The more we use your PC, the more programs, we use and the more services we are running. Closing a program doesn't always close the service. That's why restarting fixes so many problems; it clears out the memory. You should also make a habit of cleaning your hard disk to remove temporary files, emptying the recycle bin, and getting rid of system files you don't need any more.

Fig 2

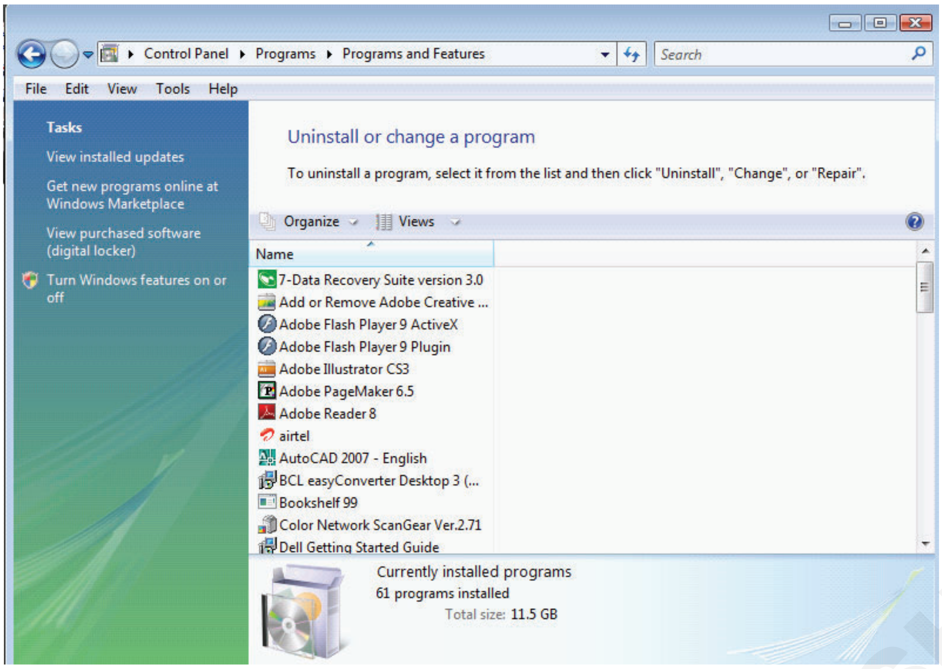
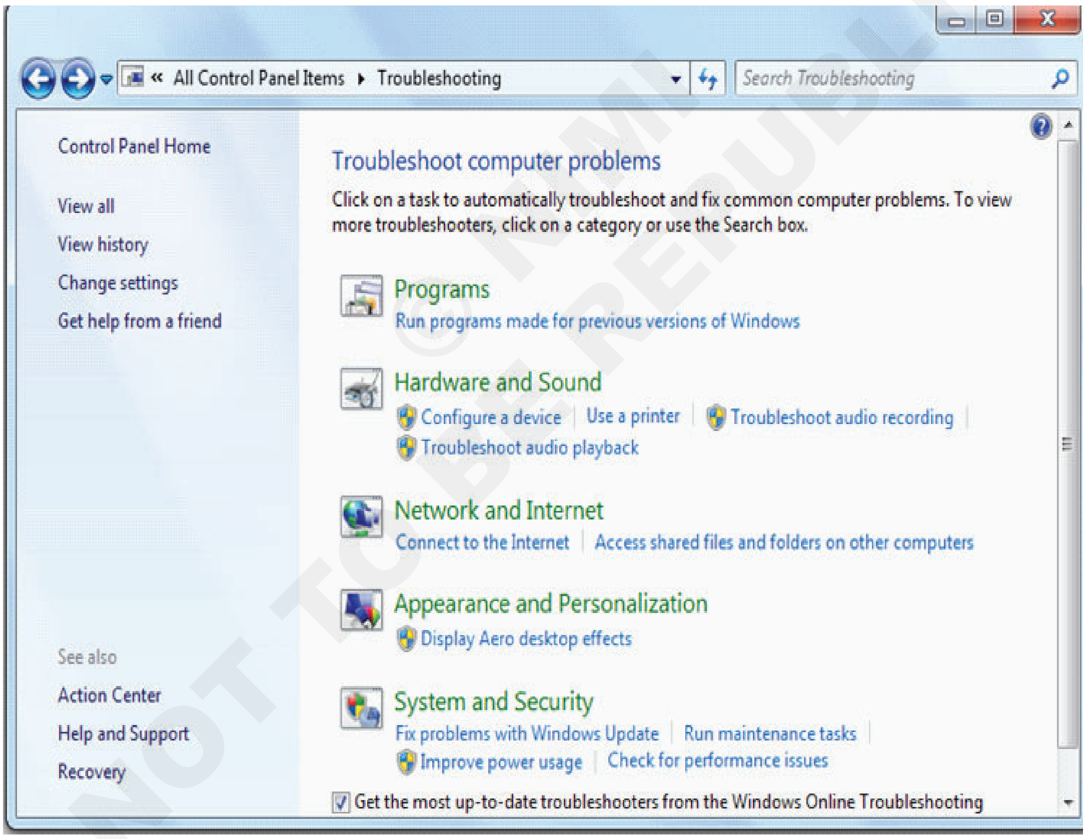


Fig 3

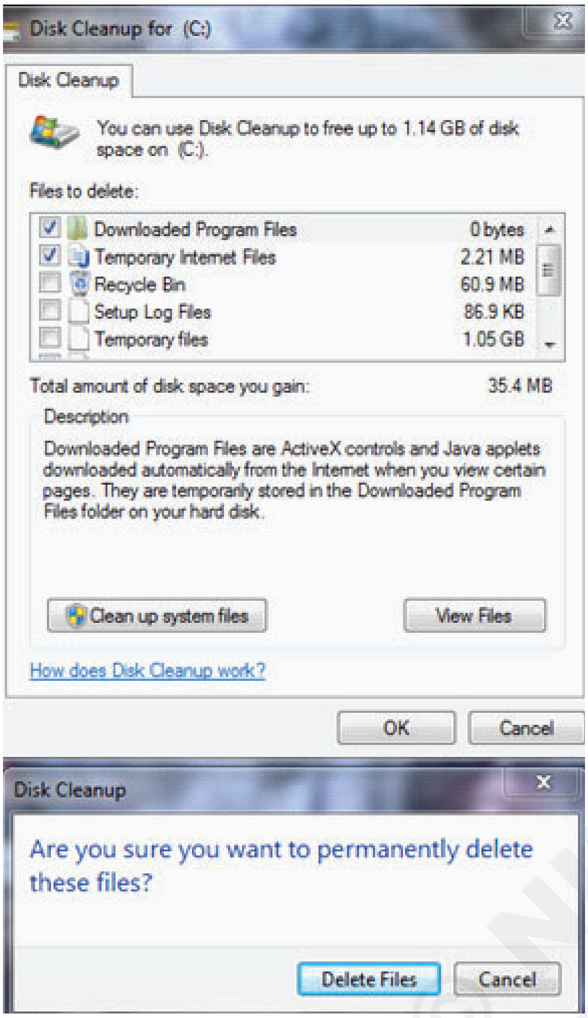


- Click the **Start** button, type **Disk Cleanup** in the search box and then click **Disk Cleanup** in the list of results.
- After the utility runs, you'll see how much disk space you can free up.
- Click **OK** and then click **Delete files. (Fig 4)**

Check your hardware

Take a look at the Windows Experience Index, a method of rating the PC on five key components. Depending on a particular hardware, it might need a new PC or some hardware upgrades. To see the Windows Experience Index.

Fig 4



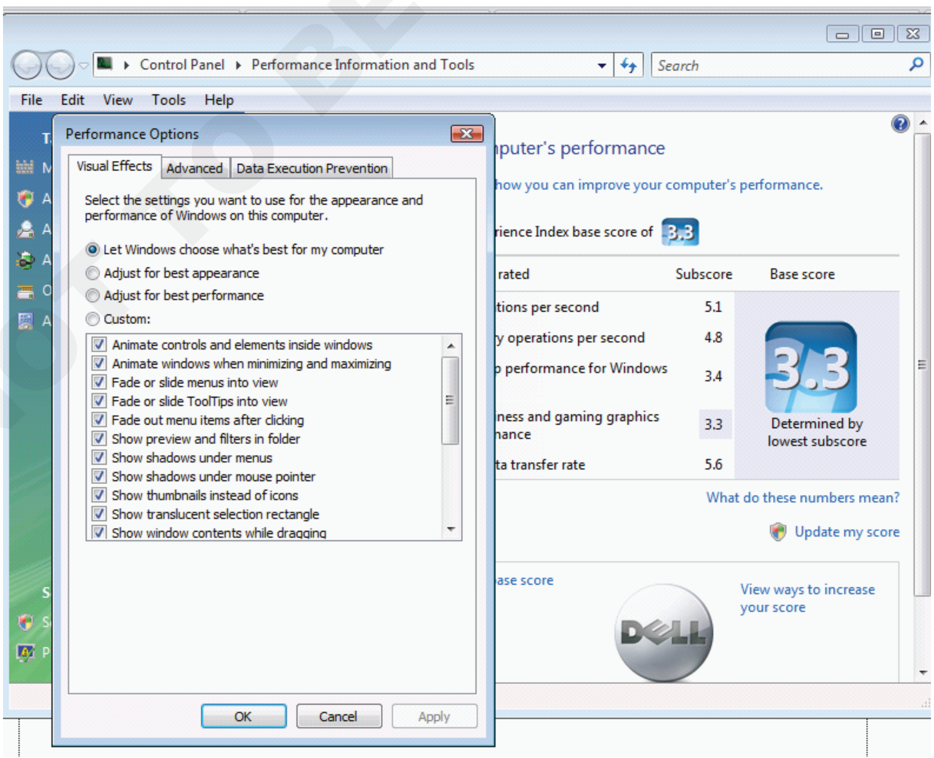
- Click the **Start** button, type **Performance Information and Tools** in the search box, and then click **Performance Information and Tools** in the list of results.
- Click **Re-run the assessment** in the lower-right corner of the window.
- Check on your base score. If your score is lower than 3, it might be time to consider a new PC.

Adjust visual effects

Windows includes some stunning effects, but if we need more speed we can customize the settings for the appearance of the windows.

- Click the Start button, type Performance Information and Tools in the search box, and then click Performance Information and Tools in the list of results.
- Click Adjust Visual Effects.
- Here we can decide and adjust the best apperance for best performance. (Fig 5)

Fig 5



Backup & Restore

Objectives: At the end of this lesson you shall be able to
- **know about windows backup**
- **know about windows restore.**

Backup and Restore

Backup and Restore (formerly Windows Backup and Restore Center) is a component of Microsoft Windows introduced in Windows Vista and included in later versions that allows users to create backups and restore from backups. It is a replacement of NTBackup, which was included in previous Windows versions. It became a deprecated feature in Windows 8 and was completely removed in Windows 8.1 in favour of File History.

Features

There are two different types of backup supported: File backup and system image. File backups are saved to ZIP files. Two methods of file backup are supported: The first, normal backup, stores everything selected for backup. The second, incremental backup stores only files that are changed after a previous backup. The other method of backup, system image, is a disk image of the backed up system saved block by block in a VHD file (versus file by file in the file backup and NTBackup). Block-based backup is more efficient at performing subsequent differential backups, as only the blocks that have changed need to be backed up.

During a backup, Windows uses Volume Shadow Copy Service to ensure that files are not changed while they are being backed up. VSS ensures both file system level consistency as well as application-level consistency for applications registered as VSS writers. Newer backup media such as CD, DVD and Blu-ray discs are supported in Backup and Restore.

Windows Backup service is the Windows service responsible for backup and restore operation. The Backup and Restore application, however, is not the only way of interfacing with this service: The Wbadmin command-line utility may also be used.

The entire disk or individual files can be restored through the utility. In addition, the VHD file can be attached (mounted) as a separate disk. Regardless of latest backup being incremental or full, the attached disk will reflect the state of the disk at the latest backup, with the previous versions feature exposing older backup sets.

System image

The image-based full system backup option, called Complete PC Backup in Windows Vista or system image in Windows 7, allows for the imaging of the entire system including operating system and data volumes. The backed up image can later be restored through the Windows Recovery Environment either to the same computer or to a new computer of different brand and type. The file format used when doing an image-based backup is VHD. A VHD image can also be mounted for extracting individual files, or booted from (using Windows 7 Enterprise and Ultimate only) after the full system image backup has been done.

Beginning with Windows Vista SP1, system images can be restored to a machine with a different motherboard which may have a different disk controller; but the machine must have the same number of disks.

Related features

The Volume Shadow Copy Service also creates and maintains periodic copies of system and user data on the same local volume as a part of System Restore operation. This stores previous versions of those files with incremental block-level changes automatically but on the same volume. They can be restored using System Restore or the Previous Versions shell extension.

Limitations

Windows Backup does not support tape drives. It also does not support backing up to or restoring from a subfolder of a disk; instead, it creates subfolders of its own. Backup and Restore can only make a system image of disks with NTFS file system. If the system image is to be saved on a USB flash drive, it must be formatted with NTFS file system.

The version of Windows Backup supplied with Windows Server 2008 does not support hard disk drives with large sector sizes (4096 bytes) unless they support 512 byte emulation.

Differences among editions (Windows Vista and Windows 7)

The features included in Backup and Restore may differ depending on the edition of Windows. Only Windows Vista Home Premium, Business, Enterprise or Ultimate editions can schedule automatic backups or back up files and folders to a network location. Only Windows Vista Business, Enterprise and Ultimate editions support Complete PC Backup.

The Windows Vista Business edition does not support writing PC backup images to dynamic drives; e.g. flash drives.

Another notable limitation of the Backup and Restore Center in Windows Vista is that it does not allow users to specify individual files or folders to be backed up or skipped, it only allows users to choose file type categories (based on MIME type, application association, and file extension) such as documents, music, videos etc. This limitation has been removed in Windows 7.

In Windows Vista, a Complete PC Backup could not be performed to a network location. Windows 7 allows performing a full system image backup to a network location However, subsequent incremental system image backups cannot be performed to a network; all image based backups to the network must be full backups. Full system image backups to local or removable storage can be incremental.

For Windows 7, file backup to a network share is available only with Windows 7 Professional, Enterprise and Ultimate editions whereas it was included in Windows Vista Home Premium. Manual image-based full system backup (including incremental backup) can be done on local or removable media in Windows 7 Home Premium. Full system backup to a network also requires Windows 7 Professional or above editions.

Removal

Backup and Restore was removed in Windows 8 and Windows Server 2012. Microsoft says this program is underused and is touting File History as the feature to replace file-based backup. All access points were removed except a Control Panel applet called Windows 7 File Recovery.

In Windows 8.1, the Control Panel applet was removed but this functionality is still available as System Image Backup from File History. The Windows 8.1 System Image Backup function does not allow backing up individual files, folders, or libraries. Also, users can no longer scheduled backups in the GUI, although the wbadmin tool is still available, which can be used to execute scheduled backups using Task Scheduler.

Junk files and deleted files

Objectives: At the end of this lesson you shall be able to
- **understand the junk files**
- **understand the deleted files**
- **know the using of Delete and cipher.**

Junk files

Every time you use your computer, different files are created. When you open a document, Microsoft Word creates temporary files that help things run smoothly and automatically back up your work. When you browse the Internet, your browser downloads temporary Internet files that get pre-loaded whenever you visit the same websites again to make pages load faster. Even when you simply power on or shut down your computer, Windows creates temporary system files. All these files are very useful there and then, but the problem is that they don't get deleted automatically when they are no longer needed by your system or your software. That's how temporary files become junk files.

Because we often add, delete software and online internet and other behaviors when we using our computers, the hard disk will have a variety of junk files, and these junk files not only take up hard disk much room, but will also reduce the speed of the computer, affect the efficiency of our work. What are the type of junk files

1 The temporary files generated in the process of installed software

Many software extract their own installation files to a temporary directory (usually under the Temp directory of Windows system directory) and then install it. When the installation is complete, these temporary files will become a pile of garbage inside the hard disk.

2 The temporary files generated in the process of running software

The same as the installation of the software, it will usually produce some temporary swap file in the process of running the software, and after run some software, it will left as many as hundreds of megabytes garbage such as *.old*,.bak., the backup files generated by antivirus software or system software when checking the hard disk.

3 Files Left after uninstalling the software

After the software is uninstalled, it often left some directory, *.dll files in the hard drive, become veritable garbage. There are many beginners often mistakenly deleted the directory using the direct method "uninstall" software, which will leave more invalid documents such as *.ini*,.dll. At the same time remaining a large number of obsolete data in the registry, and have a greater impact on the stability of the system.

4 Temporary files generated when we surfing the Internet

The browser is always download files to your local machine when you surfing the Internet, these cache files will occupy much disk room.

5 Files that not frequently used

Why junk files should be deleted

Junk files sound pretty harmless, but unfortunately that's not the case. If you have too many junk files stored on your computer, they will start causing all sorts of problems. The main problem is that they take up a lot of disk space. If you've never done junk files cleanup, then we are talking about gigabytes of wasted space. And even if you run disk cleanup occasionally or have a relatively new computer, you may still have one or two gigabytes of junk. So, if you start running out of space and especially if you have an SSD, you should run disk cleanup regularly.

Another reason why you should delete junk files is that they make your computer slow. The more outdated temporary files you have, the more time your system needs to find your documents, open programs, launch web pages and so on. And if there are too many junk files on your disk, your computer can get really slow on startup. Deleting junk files will not only free up valuable disk space, but it will also make your computer faster.

How to delete junk files

The best way to delete junk files is to use a disk cleanup utility that will find them all and let you delete them in just one mouse click. Windows has a built-in disk cleaner that you can use for basic file cleanup. But if you are looking for something more advanced or something that will delete junk files automatically in the background. e.g FileCleaner.

Introduction to UNIX/LINUX and its structure

Objectives: At the end of this lesson you shall be able to
- **understand directory structure of unix/linux**
- **understand the files and processes of unix/linux.**

Unix

Unix (all-caps UNIX for the trademark) is a multitasking, multiuser computer operating system that exists in many variants. The original Unix was developed at AT&T's Bell Labs research center by Ken Thompson, Dennis Ritchie, and others. From the power user's or programmer's perspective, Unix systems are characterized by a modular design that is sometimes called the "Unix philosophy," meaning the OS provides a set of simple tools that each perform a limited, well-defined function, with a unified filesystem as the main means of communication and a shell scripting and command language to combine the tools to perform complex workflows.

Linux

Linux was originally developed as a free operating system for Intel x86-based personal computers. It has since been ported to more computer hardware platforms than any other operating system. It is a leading operating system on servers and other big iron systems such as mainframe computers and supercomputers. As of June 2013, more than 95% of the world's 500 fastest supercomputers run some variant of Linux, including all the 44 fastest. Linux also runs on embedded systems, which are devices whose operating system is typically built into the firmware and is highly tailored to the system; this includes mobile phones, tablet computers, network routers, facility automation controls, televisions and video game consoles. Android, a widely-used operating system for mobile devices, is built on top of the Linux kernel.

A list of common GNU software:

Bash: The GNU shell

GCC: The GNU C Compiler

GDB: The GNU Debugger

Coreutils: a set of basic UNIX-style utilities, such as ls, cat and chmod

Directory name	Typical contents
/bin	Commands and programs used by all the users of the system
/boot	Files required by the boot loader
/dev	CD/DVD-ROM, floppy drives, USB devices, etc.
/etc	System configuration files
/home	User data files

Files and Processes

Everything in Unix is a file or a process. In Unix a file is just a destination for or a source of a stream of data. Thus a printer, for example, is a file and so is the screen. A process is a program that is currently running. So a process may be associated with a file. The file stores the instructions that are executed for that process to run. Another way to look at it is that file is a collection of data that can be referred to by name. Files are created by users either directly (using text editors, running compilers etc.) or indirectly (by running some program - like processing a text input file to produce a formatted file for printing).

Examples of files include:

a text document;

a program written in a programming language such as C++ or Java;

a jpeg;

a directory: directories can be thought of as the analogue of Windows' folders. Directories are files that contain files.

Microsoft outlook

Objectives: At the end of this lesson you shall be able to
- **know the features of MS outlook contacts**
- **know the features of MS outlook calendar**
- **know the features of MS outlook search folders**
- **understand new features of MS outlook 2013**
- **know managing email messages by using rules.**

Microsoft Outlook: Microsoft Outlook is a personal information manager from Microsoft, available as a part of the Microsoft Office suite. Although often used mainly as an email application, it also includes a calendar, task manager, contact manager, note taking, journal, and web browsing. It can be used as a stand-alone application, or can work with Microsoft Exchange Server and Microsoft SharePoint Server for multiple users in an organization, such as shared mailboxes and calendars, Exchange public folders, SharePoint lists, and meeting schedules. There are third-party add-on applications that integrate Outlook with devices such as BlackBerry mobile phones and with other software such as Office and Skype internet communication. Developers can also create their own custom software that works with Outlook and Office components using Microsoft Visual Studio. In addition, Windows Mobile devices can synchronize almost all Outlook data to Outlook Mobile.

Add a contact in Microsoft Outlook: You can add new contacts to your Microsoft Office Outlook 2007 Contacts by typing all the information directly in a new contact form, or by taking advantage of contact information sent to you to automatically fill in some or all of the information. In Office Outlook 2007, each of your contacts is also displayed as an Electronic Business Card. Any information that you add to a contact is automatically made to the corresponding Electronic Business Card, and vice versa.

To create a contact in Microsoft Outlook, follow the steps below.

1 Open Microsoft Outlook

2 Click the **Tools** menu and then **Address Book** or press **CTRL + Shift + B.**

3 In the Address Book window, click the **New** button and then **New contact**, click **File** and then **New contact**, or press **CTRL + N.**

4 In the Properties window, type the name and e-mail of the contact as well as any other contact information need to remember such as phone number and address.

1 A contact form that contains Jon Morris's information.

2 A view of the Edit Business Card dialog box, with the corresponding fields filled in for Jon Morris's Electronic Business Card.

Below are some examples of what can be done with contacts.

- No longer need to remember someone's e-mail address, just their name; typing in the name in the e-mail will pull up the contact for the user and send the e-mail to the user's primary e-mail address. Also press CTRL + K while typing in the name to have the name autocomplete. For example, if the name was "Computer Hope", type "com" press CTRL + K, and as long as no other name starts with "com", Microsoft Outlook will auto complete the remainder of the name.
- Create Groups of contacts, this allows to e-mail multiple people at once. For example, create a group of family contacts and just type "Family" in the e-mail to e-mail all family members. Groups are created in the Address Book next to the contact.
- Setup Microsoft Rules through the Microsoft Rules Wizard to perform certain tasks when receiving an e-mail from a particular user. For example, for an important contact, create a rule to alert any time an e-mail comes from that contact.

Calendar basics

You can schedule activities in your Outlook calendar as appointments, meetings, events, or tasks. Your choice of entry type will depend on who else is involved and how you want the entry to appear. By selecting entries in your calendar correctly, you'll know at a glance what's going on, when, and with whom.

Here are two quick ways to see the calendar:

1 Click **Calendar** in the **Navigation Pane**.

2 Click a date on the Date Navigator (which you'll find at the top of the **To-Do Bar**).

Once you're looking at your calendar, you can use the buttons at the top of the window to navigate and to show or hide detail.

1 Click **Day, Week,** or **Month** to quickly switch views.

2 **Forward** and **Back** buttons allow you to easily move through your calendar.

3 More buttons let you show or hide days or detail, depending on your view.

Now that you see your calendar, you can start scheduling. You'll choose from four types of entry. By knowing the different types, you can be more effective when you schedule your activities.

1 **Appointment :** An appointment is an activity that involves only you, at a scheduled time.

2 **Meeting :** A meeting occurs at a scheduled time, like an appointment. The difference is that you invite other people by using a meeting request that's sent via e-mail.

3 **Event:** An event is an activity that lasts all day long. Unlike an appointment or meeting, an event doesn't block out time in your calendar. With an event, you can still have other entries appear in your schedule for that day.

4 **Task :** A task is an activity that involves only you, and that doesn't need a scheduled time. New to Outlook 2007 is an area in your calendar's Day and Week views that shows tasks.

Use an appointment when you know you'll be busy but no one else is involved. You might enter an appointment to block out time in your calendar for research on a project, for writing a report, or for running an errand on the way home from work.

One quick way to start an appointment (or any calendar entry, for that matter) is to rest the pointer over the desired time in Day view, click, and type the details. It is shown the steps to do this in the picture.

1 Rest the pointer over the desired time in your calendar and click.

2 Type the details.

3 Need more time for your appointment? Simply drag the handle to make the appointment longer.

A meeting occurs at a scheduled time, and it includes other people and a meeting location. A meeting in your calendar could be one you set up, or it could be one you've been invited to by someone else. Meetings appear both in your calendar and in the calendars of the other people who are involved.

In your calendar, you can tell the difference between a meeting and an appointment by the information in the meeting entry. In a meeting you'll see these:

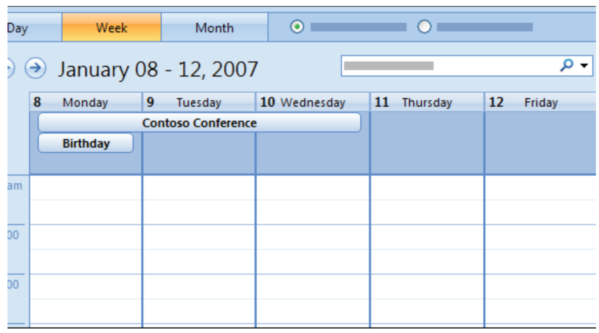
1 The location of the meeting.

2 The meeting organizer's name.

A meeting in Outlook is set up with the help of a **meeting request**, which is delivered to the meeting participants via e-mail.

An event lets you note activities that last all day. Events do not occupy scheduled time in your calendar; instead, they appear in banners at the top of the date you specify. For example, in the picture (see Fig 1) the **Contoso Conference** is an event lasting three days and the **Birthday** is an event lasting one day.

Fig 1



Use an event when you want to enter an activity on a specific day without letting it clutter up all of that day's time slots in your calendar. Here are some activities for which you might use an event:

- Conferences, business travel, or vacations, for one day or longer
- Birthdays and anniversaries
- Holidays

A task is an entry for any activity that you want to see in your calendar, but that doesn't need to be scheduled for a specific time or involve the whole day. You'll see the Tasks area when you look at the calendar in Day or Week view.

For example, if you have a number of errands that you need to do, enter each errand as a task. When you complete a task, check it off. A completed task will stick to the day on which it's completed, keeping a tidy list of that day's accomplishments at your fingertips. It is shown in the picture: the completed task has a check mark and a line through it.

You can enter a task with a scheduled start date and due date. If you don't complete a task on its due date, it will automatically move forward and appear on the current day until you reschedule it or check it off. To quickly reschedule a task, use the Week view and drag a task from one day to another.

To tell Outlook that an appointment, meeting, or event occurs over, and over, and over, you use the **Recurrence** feature. The frequency of the activity is called its recurrence pattern.

To set up a recurrence pattern, open the appointment and click the **Recurrence** button in the **Options** group of the **Appointment** tab. A recurring appointment appears repeatedly and displays a recurrence icon .

To open a recurring calendar entry to see its details or to change it, you'll double-click it. When you do this, you'll see a message like the one in the picture which gives you two options:

Open this occurrence : Choose this option when you want to see or change one instance, not the entire series. On one particular day, for example, you might want to exercise a half-hour later than usual, without changing the usual time.

Open the series : Choose this option when you want to see or change the entire series - if, for example, you decided to shift all instances of your "Exercise" appointment by half an hour.

After the series is open, to change its recurrence pattern, click the Recurrence button on the **Appointment** tab.

When you create any type of calendar entry, a reminder is set automatically. Outlook will notify you of appointments and meetings 15 minutes before they start. In the picture, it is showing the steps to change the reminder time for any calendar entry by opening the entry and adjusting the settings in the **Reminder** box on the **Appointment** tab.

1 Double-click the appointment to open it.

2 Choose the reminder time.

3 A reminder appears at the specified time.

Want birthdays to catch your eye and personal appointments to stand out from business ones? Colored categories let you name your colors (and change the names when you want to). Use colors to make certain entries stand out at a glance,

When you schedule a meeting, you want to choose a time when people can attend. Outlook lets you and your colleagues tell each other who's busy, who's out of the office, who's free - and when.

The border color of a calendar entry indicates whether that time is scheduled as free, tentative, or out of office. You'll see the border color in your own calendar and you can change it.

Newly created appointments and meetings are automatically entered as busy, and events are automatically entered as free. By keeping this information current and accurate, you'll benefit from features that let you share your schedule with others.

Recall and replace a message

You send an e-mail message, asking your co-workers to review the sales figures for this year, but you forget to attach the sales figures. After you send the message, your Inbox is flooded with messages that ask "What attachment?", "I didn't get the attachment!", or "Can you resend the attachment?"

How can you undo your error? You can recall the original message and then resend it with the missing attachment. For all of your co-workers who haven't opened the message yet, you can perform an e-mail sleight of hand and replace the original message with another one that contains the attachment.

In another scenario, you accidentally send a message announcing a party for your staff that afternoon. However, the party is actually scheduled for the next week. In this case, you want to recall the message but not replace the message at this time.

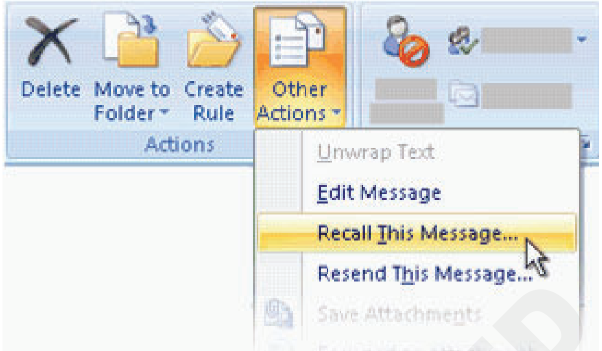
Recall a message do the following:

1 In **Mail,** in the **Navigation Pane**, click **Sent Items**.

2 Open the message that you want to recall.

3 On the **Message tab**, in the **Actions** group, click **Other Actions,** and then click **Recall This Message** (see Fig 2).

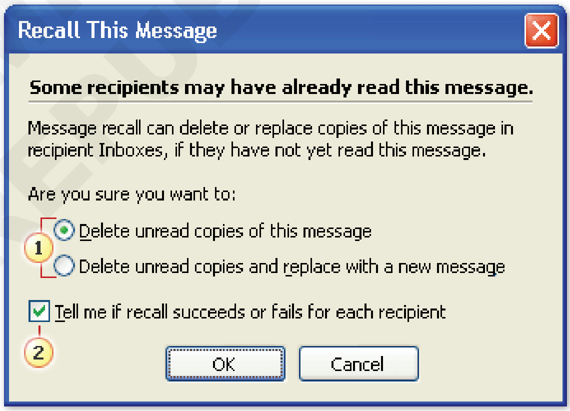
Fig 2



4 Click **Delete unread copies and replace with a new message**

If you are sending the message to a large number of people, you may want to clear the 'Tell me if recall succeeds or fails for each recipient' check box (see Fig 3).

Fig 3



- Select whether you want to only delete the message or delete and replace the message.
- Select the check box to receive a confirmation that the recall was successful.

5 Click **OK,** and then type a new message and include the attachment.

6 Click **Send.**

Creating Out of Office Replies

Consider the creation of **Out of Office** messages a part of your preparations for your absence. Outlook allows you to create two different **Out of Office** messages: one which will reply to messages sent from from your organization, and one which will reply to messages sent from anyone not from your organization, or if specified, your **Contacts** list. Do the following:

1 On the **Tools** menu, click **Out of Office Assistant.**

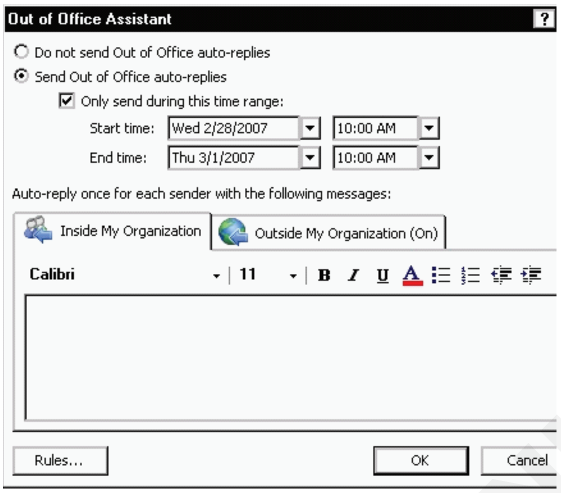
2 In the **Out of Office Assistant** dialog box, select the **Send Out of Office auto-replies** check box.

3 If you want to specify a set time and date range, select the **Only send during this time range** check box. Then set the **Start time,** and then set the **End time** (see Fig 4).

4 In the **Inside my organization** tab, type the message that you want to send within your organization, and in the **Outside my organization** tab, type the message that you want to send outside your organization (see Fig 4).

5 Click **OK.**

Fig 4



6 If you selected the "Only send during this time range" option in step 4, the **Out of Office Assistant** feature will continue to run until the date and time set for the End Time in step 5 is reached. Otherwise, the Out of Office Assistant will continue to run until you repeat step 1 and select the **"Do not send Out of Office auto-replies"** option.

The ins and outs of Bcc

Send email

When you send a message, recipients can not only see who sent it, but also who else received it. But not if you use Bcc (blind carbon copy). First add the **Bcc** field by going to the **Options** tab in the new message, and clicking **Bcc**. Then, add a name to the field, and **Send** the message.

Recipients can still see the addresses in the **To** and **Cc** fields, but not the **Bcc** field. Even if they click **Reply All,** they won't see nor be able to send their response to the addresses on the Bcc field. The only person who can see the names of Bcc recipients of a message is the sender.

If you are the message sender, to View all Bcc recipient of a message that sent. Open the message that was sent. By default, sent messages are saved in the Sent Items folder. All recipients appear in the header section of the message.

People who use rules to sort their e-mail into folders will be inconvenienced if you list the name of the distribution list in the **Bcc** box. Because their rules depend on the name of the distribution list being in the **To** box or **Cc** box, your message will not be sorted according to their rules.

Many e-mail service providers set limits for the number of names that can be included in the **To, Cc,** and **Bcc** boxes in a message. For example, your e-mail service provider may limit each message to a maximum of 100 e-mail addresses. If these addresses are distributed among the **To, Cc,** and **Bcc** boxes, remember that the names in the Bcc box will count toward your total limit.

Set up meetings

If you want to invite someone to a meeting, but you don't want any of the other attendees to know about it, you can use Bcc when you set up a meeting. The **Resources** field is typically used to book a conference room. But you can also use it as a **Bcc** field. When you add an address to Resources, only the person who organized the meeting can see it.

The BCC process silent and invisible

E-mail senders will never know that a BCC copy was sent from their machines. They will not find Silent BCC in their Outlook, nor will they ever see a BCC address in Sent Items. The Silent BCC for Outlook leaves absolutely no traces of its work. It is perfectly invisible in Outlook and everywhere else in the system, there is no user interface for the user to turn the plug-in off or alter your monitoring settings.

Instant Search to find messages and text

Instant Search helps to quickly find items in Microsoft Office Outlook . The Instant Search pane is always available in all of your Outlook views, such as Mail, Calendar, and Contacts.

1 **In Mail,** click the folder that want to search.

2 In the Instant Search box, type your search text.

3 Messages that contain the text that you typed are displayed in the **Instant Search Results** pane with the search text highlighted.

By default, it is not necessary to click the 'Search button' to start the search. The Search button is enabled only if you have cleared the 'Display search results as I type when possible' check box in the 'Search Options' dialog box.

4 Click to clear the **Instant Search box**, and then start a new search.

5 To widen your search to include all folders in **Mail**, at the end of the search results, click **Try searching again in All Mail Items.**

Alternatively, in the Navigation Pane under **Mail Folders,** click **All Mail Items** or press CTRL+ALT+A.

Include subfolders in Instant Search

Instant Search can search every folder, including subfolders, in the Outlook Folder List, but the option to search all folders is not selected by default. You must turn on this search option.

1 On the **Tools** menu, point to **Instant Search,** and then click **Search Options.**

2 Under **Instant Search Pane,** select **All folders.**

Include the Deleted Items folder in Instant Search

By default, the Deleted Items folder is not included when searching All Mail Items. To include the Deleted Items folder, do the following:

1 On the **Tools** menu, point to **Instant Search,** and then click **Search Options.**

2 Under **Deleted Items,** select the **Include messages from the Deleted Items folder in each data file when searching in All Items** check box.

Include data files in searches

By default, Outlook includes the following data files in a search of **All Mail Items**

- All indexed data files. These include Personal Folders files (.pst) and Offline Folder files (.ost). Indexing ensures that Instant Search is fast.
- Outlook data file for your default e-mail account, regardless of whether it is indexed or not.

However, you can select any data file to be included in searches.

1 In **Mail,** in the **Navigation Pane,** click the arrow in **All Mail Items.**

2 Select the name of the data file that you want to include or exclude in your searches.

Instant Search to find Calendar items

- Open your Calendar, and type a word to search for in the Search box. Then, the Calendar switches to list view and immediately starts searching, even before you finish typing.
- If you want to search for items in which the words appear together, add quotation marks around the words.
- Also use combining words like AND, OR and NOT. For example, type capital OR between the words, and Outlook searches for any Calendar item that contains any of the words you typed.

Do the following:

1 Click **'Calendar'**.

2 Click the **'Search Calendar'** box on the top right of the Calendar.

3 Click the **'Search Tools Search'** tab. **'Current Folder'** is selected by default. But you can click **'Subfolders'** to expand the search to your subfolders, or **'All Calendar Items'** to search everything in your Calendar. Or click **'All Outlook Items'** to expand the search to your mail, contacts and tasks.

Advanced finding

1 Click **Calendar.**

2 Click the **Search Calendar** box on the top right of the Calendar.

3 Click the **Search Tools Search** tab.

4 Click **Search Tools** > **Advanced Find.** With this tool, you have a different way to enter search criteria. For example, you can search by organizer by typing the names in the **Organized By** box. Or click **Organized By** to browse for names. Click **Find Now** to start the search and the results appear at the bottom. Click the **Advanced** tab, if you want to confine your search to specific fields in items.

Instant Search to find contacts

Find people and contacts

1 Click **People** at the bottom of the screen.

2 Above the contacts list, click the **Search Contacts** box.

By using the 'Search People' box, which is in the top right corner on the 'Home' tab works only if you type the person's name (or part of their name).can't use this box to search on things like phone numbers or addresses.

3 Start typing the person's name, or other information you want to search.

4 Click the person you want from the search results.

Getting too many results when you search on complete or partial information Consider further refining in the search. When clicking the **Search People** box on the **People** tab, the **Search Tools** tab appears.

There are a lot of options here to help narrow the search, including the following groups of options on the **Search Tools** tab:

Scope : Change the folders that want to search in.

Refine : Search for people who have phone numbers in their contact information, or other specific types of information.

Options : Use previous searches or change advanced search

You also can search for contacts from any folder in your mailbox. If you are sending an email and you want to look someone up, in the **Find** group, in the **Search People** box, type the name of the person you want to find. You can enter a partial name, a first or last name, an e-mail address, a display name, or a company name.

Holidays and Events

Holidays are all-day events. You can also create custom holiday files for other types of non holiday events, such as quarterly deadlines or your organization's paydays.

Add holidays and events

1 On the **Tools** menu, click **Options,** and then click **Calendar Options.**

2 Under **Calendar** options, click **Add Holidays.**

3 Select the check box next to each country/region whose holidays you want to add to your calendar, and then click **OK**.

Your own country/region is automatically selected.

If you already added a country's or region's holidays to your calendar, the check box for that country/region is selected in the **Add Holidays to Calendar** dialog box. If you try to add the same items again, you receive the following message:

Holidays for **country/region** are already installed. Do you want to install them again?

If you click **Yes,** the holidays and events are installed a second time, and you see duplicate holiday and event entries.

Delete holidays and events

You can use the following steps to delete any duplicate holidays that were added while you were adding holidays to your calendar.

1 In **Calendar,** on the **View** menu, point to **Current View,** and then click **Events.**

2 Select the holidays that you want to delete. To select multiple rows, press the CTRL key, and then click other rows.

Click the Calendar icon to select a row. Do not click in the data cells of the row.

3 Click Delete Button image on the **Standard** toolbar.

To quickly delete all of the holidays for a country/region, click the 'Location' column heading to sort the list of events so that it displays all of the holidays for a country/region together.

Search Folders

A Search Folder is a virtual folder that provides a view of all e-mail items that match specific search criteria. For example, the Unread Mail Search Folder allows you to view all unread messages from one location even though the messages may be located in different Mail folders.

Default Search Folders

There are three default Search Folders in the Navigation Pane.

- **Categorized Mail** includes items that have been assigned a color category.
- **Large Mail** includes items that are larger than 100 kilobytes (KB).
- **Unread Mail** includes items that are marked as unread.

Search Folders can be created in other locations for data files such as a Personal Folders file (.pst) or Archived Folders file (Archive.pst). Search Folders cannot contain search results from across multiple data files. In addition to the default Search Folders, Outlook includes a list of predefined Search Folders. You can customize a predefined Search Folder with your own search criteria.

You can also create your own custom Search Folder by defining specific search criteria that e-mail messages must meet to be displayed in the Search Folder (see Fig 22).

Search Folders in Microsoft Office Outlook 2007 support prefix matching in the text strings that you specify. For example, if you want to include all messages with the word "rain" in the Search Folder, the Search Folder will also include messages with words like "raining" or "rainy" but won't include words like "brain."

Add a predefined Search Folder

1 In **Mail,** on the **File** menu, point to **New,** and then click **Search Folder.**

To open the New Search Folder dialog box, press CTRL+SHIFT+P.

2 Click a predefined Search Folder.

3 If prompted, under **Customize Search Folder,** specify the search criteria to use.

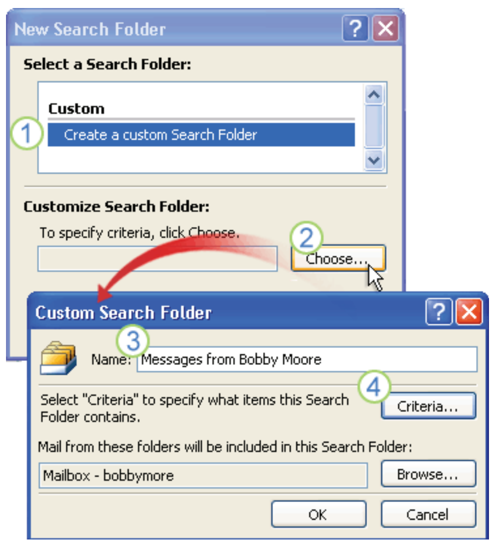
4 To select a different mailbox to search, under **Customize Search Folder,** click the arrow, and then select the mailbox from the list.

To change the criteria for a Search Folder, right-click the folder, click **Customize this Search Folder,** click **Criteria,** and then change the criteria. The criteria of Search Folders in the **Reading Mail group** cannot be changed.

Create a custom Search Folder

1 In **Mail,** on the **File** menu, point to **New,** and then click **Search Folder** (see Fig 5).

Fig 5



2 Click **Create a custom Search Folder.**

3 Under **Customize Search Folder,** click **Choose.**

4 Type a name for your custom Search Folder.

5 Click **Criteria,** select the options that you want, and then click **OK.**

6 Click **Browse,** select the folders that you want to be searched, and then click **OK** three times.

Delete a Search Folder

1 In **Mail,** in the **Navigation Pane,** right-click the Search Folder.

2 On the shortcut menu, click **Delete Search Folder name.**

When you delete a Search Folder, the e-mail messages shown in the Search Folder are not deleted from their original locations, because those items are only viewed in a Search Folder. However, if you open or select one or more e-mail messages shown in a Search Folder and then delete them, the messages will be deleted from the Outlook folders where they were stored.

Import a single vCard (Virtual business cards) into Outlook

1 Open Outlook and select **File** > **Import and Export,** the Import and Export, Wizard dialog appears.

2 Selected Import a VCARD File (.vcf), click Next.

3 Locate and select the location of the VCARD, click **Open.**

4 Click on the contacts in the left navigation panel.

5 The new VCARD should be available and visible.

Export Contacts From Outlook using a CSV File Format

1 Open **Outlook** select **File > Import and Export.**

2 Select "Export to a File", Click "Next".

3 Select "Comma Separated Values" ,Click "Next".

4 Select the Contacts folder to be exported. Click "Next".

5 Select the file name and location where to save the exported file. Click **Next.**

6 Click on **Map Custom Fields.**

It is recommended to Clear the Map on the right window and follow the order of the columns as listed below.

Import vCards to Outlook contacts

When someone sends vCards (virtual business cards that most email programs recognize), here showing how to save them to Outlook contacts list.

Import a vCard from an Outlook email message

To save vCards you receive as attachments as new contacts, add each vCard one-by-one to the list of Outlook contacts.

1 In the body of the email message, click a vCard, right-click it, and then click Add to Outlook Contacts.A new window appears, displaying the contact information.

2 In the contact window, click **Save & Close.**

3 Repeat steps 1 and 2 for each vCard in the message.

Import a vCard from another mail program

1 Open the email message, and click the attached vCard.

2 Open or save the vCard option is coming, choose to open it.

3 The vCard opens in an Outlook window since the .vcf file name extension is associated with Outlook.

4 Click **Save & Close.**

Make the switch to Outlook 2013

Signatures

You can create personalized signatures for your email messages that include text, images, your electronic business card, a logo, or even an image of your handwritten signature. Your signature can automatically be added to outgoing messages, or you can manually add the signature to only the messages that you choose.

Start a new email message, click **Message > Signature > Signatures.**

Out of Office messages

From the Inbox, click **File > Automatic** replies. If the user has no Exchange account, won't see that button. Click **Send Automatic Replies,** select an optional start and stop time, enter a message, click **OK.**

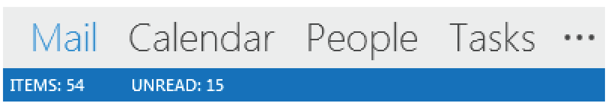
The Outlook window

Continue to enjoy the way the navigation bar speeds up communication. Use it to open your email, calendar, contacts, and tasks fast. Everything you need is there.The new Navigation Bar in Outlook 2013 displays four views Mail, Calendar, People, and Tasks. To see other views-Notes, Folders, and Shortcuts, click ... (see Fig 6).

The ribbon

The icon for Outlook 2013 has changed and is now blue instead of orange. Beginning with Outlook 2010, a ribbon with the commands has taken the place of the tool bar. Outlook has several ribbons, all different. The Inbox ribbon is different than the ribbon for an email message, and so on.

Fig 6



Contacts are now People

Click **People** to work with the contacts.

Import from your old mailbox

On the computer with the previous version of Outlook.

1 Click File > Import and Export > Export to a file > Personal Folder File.

2 Choose the items to export, such as the Inbox, contacts, or calendar.

3 Choose a location for the exported data (a .pst file).

What's new in Outlook 2013

Communicate

Preview messages in the message list

Know at a glance which messages to read and tackle first.

Respond faster with inline replies

Reply with one click by typing the response right in the Reading Pane. Or, start a Lync IM conversation for a real-time chat.

Use commands in the message lists for quick action

Flag, delete, or mark your messages read or unread with handy commands in the message list.

Also, with the **All** and **Unread** buttons in the inbox, you can focus on the messages you want.

View only unread messages

To see only the messages haven't read yet, do the following:

In any folder in your email box, at the top of the list of messages, click **Unread**.

Flag incoming messages for follow-up

Some messages might require more time before you respond. A flag gives you a visual cue that you want to return to that message later.

In the message list, do one of the following:

- Click to flag the message for follow-up today.
- Right-click to select other date options.

If the message has opened and are reading it in its own window, click the **Message** tab, click **Follow Up,** and then click when it want to follow-up (see Fig 30).

The **Tasks** peek on the Navigation Bar shows all flagged items and any tasks user created. If user pin the Tasks peek to the right side of the Outlook window, the flagged message appears there as well.

Set a reminder for more important items

If a lot of messages flagged, it might be easy to miss one that is more important. This is where reminders can help. Flags are subtle visual reminders, but a reminder pops up and demands attention-just like the alerts for imminent meetings or appointments.

Right-click the flag, and then click **Add Reminder**.

In the **Custom** dialog box, it is recommend changing the default **Flag to** text to a description or action. For example, type Send Anne an answer to the permit question.

The **Reminder** box is already checked, so enter the date and time when the reminder pop up to appear.

To change the flag's or reminder's follow-up date or time, in the message list, right-click the flag, and then click **Tomorrow, This Week, Next Week, No Date,** or **Custom.**

If the message is open in its own window, click the **Message** tab, click **Follow Up,** and then click one of the choices. If it is frequently change from **Today** to another choice, then set that as the Quick Flag-the flag type that is set when you first click the flag.

In the message list, right-click any flag, click **Set Quick Click** and choose **Today, Tomorrow, This Week, Next Week,** or **No Date.**

Delete a message

Delete messages you no longer need or want to see in your Inbox or mail folders.

In the message list, when point to or select a message, the icon appears. To delete the message, press

If a message is open in its own window, click Message > Delete.

When a message is deleted in Outlook 2013, it's moved to the **Deleted Items** folder.

To bypass the **Deleted Items** folder and permanently delete a message, press Shift + Delete or Shift+ .

Keep calendar, appointments and meetings always in view

Grab a quick glance of schedule and appointment, no need to switch to Calendar. Pin the Calendar peek to any view in Outlook.

The Calendar peek appears on the Navigation Bar, point and pause over **Calendar.**

To keep the Calendar peek always in view, click to dock it to the right edge of the Outlook window.

To remove a Calendar peek from the Outlook window, click .

While dock or close the docked Calendar peek in one view, such as Mail, Calendar, People, or Tasks, it doesn't add or remove it from the others. The calendar is more than a display of the current calendar month. It also allows jumping to a different date and seeing any appointments and meetings for that date.

Keep upcoming tasks always in view

When pointing to Tasks on the Navigation Bar, the Tasks peek shows the upcoming tasks and flagged to-do items. To keep both in view, pin the Tasks peek to the Outlook window by clicking (see Fig 38). To close the peek, at the top of the pinned Tasks peek, click .

When a peek is pinned or unpinned it only affects that view. For example, if currently in Mail and pin the Tasks peek, when switch to Calendar, the Tasks peek doesn't appear. Pin or unpin the Tasks peek in each view by clicking or

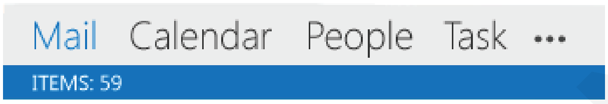
All contact details in one place

The People Card collects all the key details about a contact in one place: phone, email, address, company info, social media updates, even whether they're available. From the card, it is possible to schedule a meeting, send an instant message, or give them a call, making it a one-stop-shop for all communication.

Quickly switch between the main Outlook elements

Just above the status bar at the bottom of the screen, there is a clearer view of Mail, Calendar, People, and Tasks, for easy navigation (see Fig 7).

Fig 7



Customized Inbox

Rename the folders in the Inbox and move them around to support the way of work.

One place for all project docs and email in Site Mailboxes

Give everyone of the team to access the team folder, calendar, and task list to manage on the go, using the combined power of Outlook, Exchange, and SharePoint.

Reach out with contact groups (distribution lists)

Use a contact group (formerly called a "distribution list") to send an email to multiple people-a project team, a committee, or even just a group of friends-without having to add each name each time you want to write them.

Create a contact group

1 On the Navigation bar, click **People**.

2 Under **My Contacts,** pick where to add the contact group. For this example, click Contacts.

3 Click **Home > New Contact Group.**

4 On the **Contact Group** tab, in the **Name** box, type a name for the group.

5 Click **Add Members,** and then add people from address book or contacts list. To add someone who is not in the address book or contacts, create or add a person as a contact.

6 Click **Save** and **Close.**

Send an email message to a contact group

1 Click **Home > New Email.**

2 In the new email message, click **To.**

> **The 'Global Address Book' is set as the default address book in Outlook. To change the 'address book', under Address Book, click the down arrow and choose a different address book.**

3 In the **Search** box, type the name of the contact group.

4 Double-click the name to add it to the **To** box, and then click **OK.**

Remove names from a contact group

1 On the Navigation bar, click **People** to view your **contacts.**

2 Double-click the contact group to open it.

3 Select the names to remove from the group, and then on the **Contact Group** tab, click **Remove Member.**

4 Click **Save & Close.**

Sending or deleting an email stuck in the outbox

Fix messages that are stuck in the Outbox

When a message gets stuck in the Outbox, the most likely cause is a large attachment.

1 Click **Send/Receive > Work Offline.**

2 In the Navigation Pane, click **Outbox.**

3 From here:

- Delete the message. Just select it and press **Delete.**
- Drag the message to the drafts folder, double-click to open the message, delete the attachment (click it and press Delete).

4 If an error tells that Outlook is trying to transmit the message, close Outlook. It may take a few moments to exit. If Outlook doesn't close, press Ctrl+Alt+Delete and click **Start Task Manager.** In **Task Manager,** click the **Processes** tab, scroll down to **outlook.exe,** and click **End Process.**

5 After Outlook closes, start it again and repeat 2 to 3.

6 After the removement of the attachment, click **Send/ Receive > Work Offline** to deselect the button and resume working online. Messages also get stuck in the Outbox when clicked the **Send** but not connected. Click **Send/Receive** and look at the **Work Offline** button. If it's blue, you're disconnected. Click it to connect (the button turns white) and click **Send All.**

Taking calendars to the next level

Change a single appointment or meeting

1 Open the appointment or meeting. If it is opening an item that is part of a recurring series, in the **Open Recurring Item** dialog box, click **Just this one,** and then click **OK.**

2 On the **Item Occurrence** tab, change the options want, and then click **Save & Close,** or for a meeting, click **Send Update.**

Drag the appointment or meeting to a different date on the calendar. Also change the subject by clicking the text, and then typing the changes.

Change a recurring appointment or meeting

1 Open the appointment or meeting. If it is opening an item that is part of a recurring series, in the **Open Recurring Item** dialog box, click **The entire series,** and then click **OK.**

2 On the **Appointment Series** or **Meeting Series** tab, change the options that want.

3 To change recurrence options, on the **Appointment Series** or **Meeting Series** tab, in the **Options** group, click **Recurrence**. Change the options that want, such as time, recurrence pattern, or range of recurrence, and click **OK.**

4 Click **Save & Close,** or for a meeting, click **Send Update.**

Change an event

Events differ from appointments or meetings as they are all-day items that appear as free time on the calendar. A conference or a vacation is an example of an event. To change an event into an appointment, by opening the event, and then unchecking the **All day event** box. Now, as an appointment, the time is marked as busy on the calendar. If you add attendees, your appointment becomes a meeting. After you finish making changes, click **Save & Close.**

Track email with read receipts

Read and delivery receipts

Before send a message, click the Options tab. Then, click Request a Delivery Receipt or Request a Read Receipt. When the message was send, it's routed to the recipient's email server, which delivers it to his inbox. And the server sends the delivery receipt to sender as requested. Note that the server, not the recipient, is shown as the sender of the delivery receipt.

When the recipient double-clicks the email to open it, he can choose to send a read receipt or choose not to.

When the recipient receives a message with a read receipt request, which means the sender wants to get confirmation that recipient received the message. Read receipts can be automatically returned or not, or the recipient can choose what to do for each read receipt request.

1 Click the **File** tab.

2 Click **Options.**

3 Click **Mail.**

4 Under **Tracking,** under **For any message received that includes a read receipt request,** click one of the following options:

- Always send a read receipt
- Never send a read receipt
- Ask each time whether to send a read receipt

When the recipient opens the email, he or she will be asked to send a read receipt or not.

If the recipient chooses yes, then gets a receipt showing the email was opened.

Notice that the email came from the recipient and not from the server. This is the big difference between read and delivery receipts. To make sure technical issues like server downtime, incorrect email addresses, or connection issues on sender end are keeping the email from sending, then enable delivery receipts. If it is want to make sure the recipient opened the email, enable read receipts.

Password protected mailbox

With Outlook and Windows, multiple people can protect their email on one shared computer. First, there's sharing at work and home. In this scenario, people can protect their email with their own password-protected Windows user accounts. The second scenario is sharing a public computer, where the best way to protect your email is by using the Outlook Web App or some other browser-based email app.

Sharing a public computer

The easiest and most secure way to access email on a public computer is through a web browser. To do that, you need three pieces of information: your user name, password, and the login URL for your email. You can get this address from your email provider. For example, the login address for a Microsoft email account is live.com or outlook.com. Type your email address and password. Then, click **Sign In.**

When you're finished, go to **Internet options** in the browser and delete history, temporary Internet files, and passwords.

Require a logon to Exchange

if you want additional protection, you can require a logon to access your Exchange email. Why would you want to make it more difficult for yourself by having to enter a password? Perhaps you're located in an area where lots of people can easily access your computer.

1 In Outlook, click **File > Info.** Then, in **Account Settings,** click **Account Settings.**

2 On the **E-mail tab,** select your email account. This method will only work if the account **Type** is Microsoft Exchange.

3 Click **Change.** Click **More Settings.** Then, on the **Security** tab, check **Always prompt for logon credentials.**

4 Click **OK.** Click **Next** and **Finish.**

Manage email messages by using rules

Rules help reduce manually filing or taking the same action when a similar message arrives. Unlike Quick Steps, rules typically are always on and run automatically. For example, when a message is received from a specified person, it's automatically moved to the folder that you designate. The Rules Wizard helps you design rules to manage messages. Rules fall into one of two categories - organization and notification. The Rules Wizard includes templates for the most frequently used rules, which include the following.

1 **Stay Organized :** These rules help you file and follow up on messages. For example, you can create a rule for messages from a specific sender, such as Anne Weiler, with the word "sales" in the Subject line, to be flagged for follow-up, categorized as Sales, and moved to a folder named Anne's Sales.

2 **Stay Up to Date :** These rules notify you in some way when you receive a particular message. For example, you can create a rule that automatically sends a message to a mobile device when you receive a message from a family member.

3 **Start from a blank rule :** These are rules that you create without the aid of a rule template and that you can completely customize.

Create a rule

Outlook includes rule templates for common scenarios. Use these **rule templates,** or create design your own **custom rules.**

Create a rule based on senders or recipients of a message

A rule can be quickly created from any message. The advantage of this method is that rules are suggested based on the message sender or recipients. For example, when you start with a message, one rule that is suggested moves all messages from that sender to a folder that you choose.

Import or export a set of rules

When you import rules, they are added to the end of the existing list of rules. You can import only one set of rules at a time. When you export rules, they are saved in a file with an .rwz extension.

Server-based rules versus client-only rules

There are two types of rules in Outlook - server-based and client-only.

- Server-based rules While using a Microsoft Exchange Server account, some rules are server-based rules. These rules run on mailbox on the Exchange mail server, even when Outlook isn't running. Server-based rules must apply to messages when they are first delivered to your Inbox, and the rules must be able to run until they are completed on the server. For example, a rule that specifies that a message be printed can't run until it is completed on the server. If a rule can't be applied on the server, it is applied when starts the Outlook and then becomes a client-only rule.

- Client-only rules These are rules that run in Outlook instead of on the Exchange server. Client-only rules can only run when Outlook is running. If the lists of rules contains both kinds of rules, the server-based rules are applied first, followed by the client-only rules.

Applying rules Outlook items Delivery receipts, voting responses, and Automatic Replies

When rules are applied, delivery receipts, read receipts, voting responses, and Automatic Replies (Out of Office notifications) are processed as if they are messages. For example, a rule that moves items with the word "meeting" in the subject to a specific folder, also moves all delivery receipts, voting responses, or an Automatic Reply that contains the word "meeting" in the subject.

When a rule moves voting responses from the Inbox to another folder, vote tracking is affected. When a sent message that included a voting button is opened, the tracking information won't include a tally for responses that a rule moved. Manually moving or deleting a response doesn't affect the tracking.

Meeting requests, task requests, and documents

When applying rules, meeting requests, task requests, and documents are considered messages. For example, a rule that moves items with the word "meeting" in the Subject box to a specific folder also moves any task request or meeting request that meets that condition. However, be aware the following limitations when you create rules that affect these kinds of items:

- An item moved to a folder other than a mail folder might not work as expected after it is moved. For example, if a message is moved to the **Calendar** folder, a new appointment isn't created.

- If a meeting or task response is moved to the **Deleted Items** folder by using a rule, the response isn't tracked by the original item.

- If a meeting request is automatically moved to the **Deleted Items** folder, the meeting isn't added to the **Calendar.**

- Rules that affect messages that you send aren't applied to task requests and meeting requests.

Identify the Laptop parts

Objectives: At the end of this lesson you shall be able to
- **explain laptop and notebook**
- **classification of laptop and notebook**
- **components of laptop**
- **major laptop brands.**

Laptop

A laptop or a notebook is a portable personal computer with a clamshell form factor, suitable for mobile use. There was a difference between laptops and notebooks in the past, but nowadays it has gradually died away. Laptops are commonly used in a variety of settings, including at work, in education, and for personal multimedia.

A laptop combines the components and inputs of a desktop computer, including display, speakers, keyboard and pointing device (such as a touchpad or a trackpad) into a single device. Most modern-day laptops also have an integrated webcam and a microphone. A laptop can be powered either from a rechargeable battery, or by mains electricity via an AC adapter. Laptop is a diverse category of devices and other more specific terms, such as rugged notebook or convertible, refer to specialist types of laptops, which have been optimized for specific uses. Hardware specifications change significantly between different types, makes and models of laptops.

Portable computers, which later developed into modern laptops, were originally considered to be a small niche market, mostly for specialized field applications, such as the military, accountancy, for sales representatives etc. As portable computers developed and became more like modern laptops, becoming smaller, lighter, cheaper, and more powerful, they became very widely used for a variety of purposes.

Classification

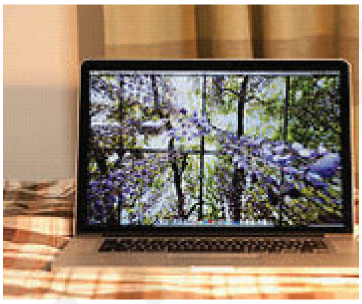
Since the introduction of portable computers in late 70s, their form has seriously changed over decades, spawning a variety of visually and technologically differing subclasses.

Traditional laptop (Fig 1)

Apple MacBook Pro, a laptop with a traditional design

The form of a traditional laptop computer is a clamshell, with a screen on one of its inner sides and a keyboard on the opposite. It can be easily folded to conserve space while traveling. The screen and keyboard are inaccessible while closed. Devices of this form are commonly called a 'traditional laptop' or notebook, particularly if they have a screen size of 13 to 17 inches measured diagonally and run a full-featured operating system like Windows 8.1, OS X or Linux. Traditional laptops are the most common form of laptop, although Chromebooks, Ultrabooks, convertibles and laplets (described below) are becoming more common, with similar performance being achieved in their more portable or affordable forms.

Fig 1



Subnotebook (Fig 2)

A subnotebook or an ultraportable is a laptop designed and marketed with an emphasis on portability (small size, low weight and often longer battery life). Subnotebooks are usually smaller and lighter than standard laptops, weighing between 0.8 and 2 kg (2 to 5 pounds), with a battery life, exceeding 10 hours. Since the introduction of netbooks and ultrabooks, the line between subnotebooks and either category has been blurry. Netbooks are in essence a more basic-featured and a cheap subcategory of subnotebooks, and while some ultrabooks have a screen size too large to qualify as subnotebooks, certain ultrabooks fit in a subnotebook category. One notable example of a subnotebook is Apple Macbook Air.

Fig 2

Netbook (Fig 3)

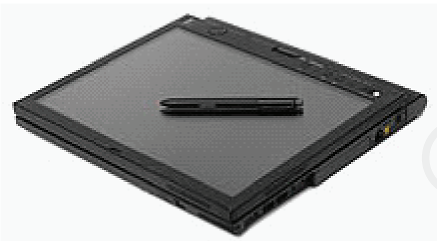
Netbook was a form of a laptop as inexpensive, light-weight, energy-efficient device, especially suited for wireless communication and Internet access. Netbooks first became commercially available in around 2008 on the market, featuring a weight, a display size and a price combination of < 1 kg, < 9. The name netbook (with net short for Internet) is used as "the device excels in web-based computing performance". To begin with, netbooks were mostly sold with light-weight variants of the Linux operating system, although later versions often have Windows XP or Windows 7 operating systems. All major netbook producing companies stopped producing them by the end of 2012.

Fig 3

Convertible (Fig 4)

Typical modern convertibles have a complex joint between the keyboard housing and the display permitting the display panel to swivel and then lie flat on the keyboard housing. Most convertibles feature a touchscreen display alongside the traditional touchpad, to work in a tablet mode. The convertibles fit both in laptop and tablet device categories, but usually considered laptops, due to increased size and weight over the mainstream tablets.

Fig 4



The single joint used to enable the rotate and swivel motion of the screen creates a physical point of weakness on the laptop. Some manufacturers have attempted to overcome these weak points by adopting innovative methods such as a sliding design in which the screen slides up from the slate-like position and locks into place to provide the laptop mode. Due to the design of convertibles, they have few other weaknesses over traditional laptops, although a smaller form is often desired to increase portability.

Main laptop and notebook parts

System Board or Mother board

The system board is the main logic board in any laptop. All internal components are connected to the system board. This is one of the most expensive parts in a laptop. (Fig 5)

Memory (Ram) (Fig 6)

Hard drive

The laptop can use different kinds of hard drives. The current 3 most common found are SATA, PATA IDE and SSD. SSD refers to Solid State Drives, which are similar looking

Fig 5

Fig 6

to a laptops Wi-Fi card. The SSD is the newest of these three drives. The PATA IDE is the oldest of the three. The SATA and PATA drives are identical except for the connection plug ends, as they both use Platters and magnets to store data. SSD cards are made with no moving parts. This is what makes them different than the typical drive. They will not produce heat like the SATA/ PATA drives, most commonly used in Fanless Netbooks. (Fig 7)

Fig 7

Processor (CPU)

The processor is the brain of your laptop. Faster CPU means faster data processing. (Fig 8)

Keyboard (Fig 9)

CD/DVD OPTICAL DRIVE

Fig 8

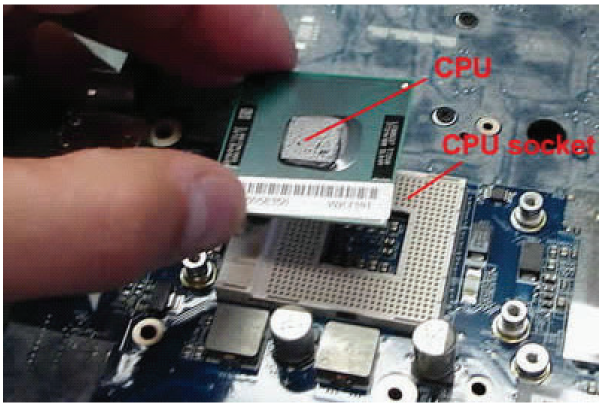


Fig 9

The CD/DVD drive allows you to read/write data from/to a CD or DVD disc (Fig 10)

Fig 10

Cooling fan

The cooling fan is a part of the cooling module in a laptop. The fan helps to cool down the processor when the laptop is turned on. (Fig 11)

Video card graphics card

In most modern laptops the video card is integrated into the system board. If the video card fails you have to replace the whole motherboard. In some laptops the video card is a discrete module and can be removed or replaced separately from the motherboard. (Fig 12)

Audio board (Sound Board)

In most laptops the audio board is a part of the motherboard. If that's the case, all audio board input/output

Fig 11

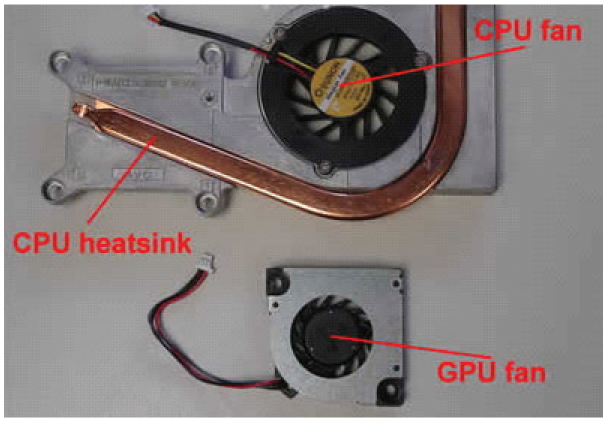
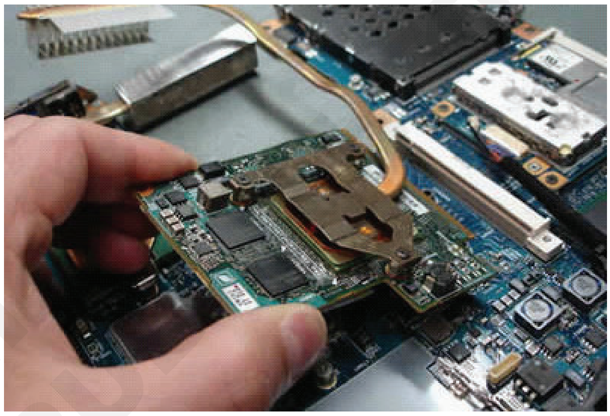
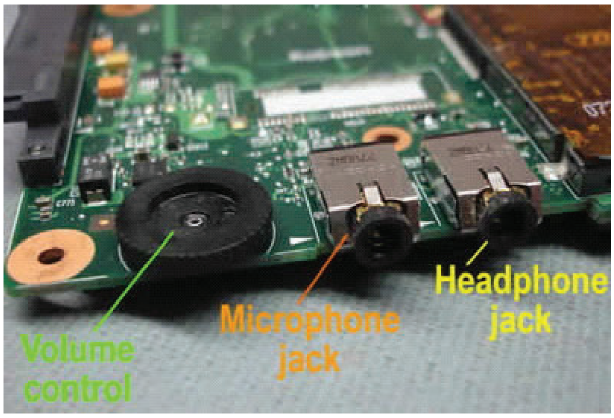


Fig 12



components such as volume control, microphone jack and headphone jack are soldered directory to the motherboard. (Fig 13)

Fig 13



Wireless network card

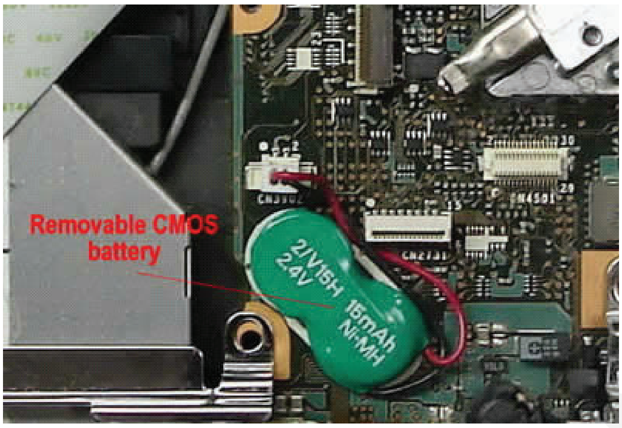
The internal wireless card helps you to connect to the Internet without running a cable. (Fig 14)

CMOS Battery (RTC Battery)

The CMOS battery provides power to the CMOS chip when the laptop is turned off or disconnected from the wall outlet. (Fig 15)

Fig 14

Fig 15



LCD Screen

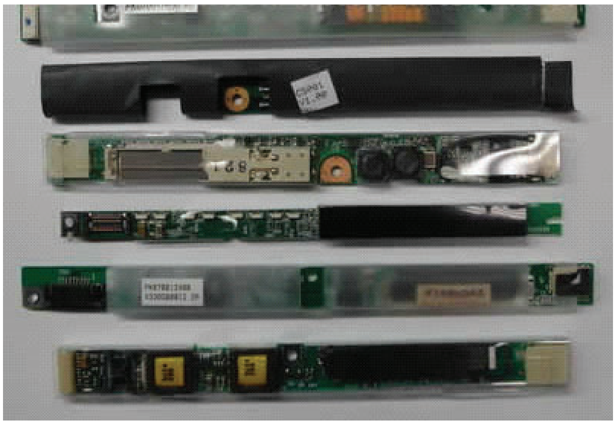
The LCD screen is one of the most expensive parts in a laptop computer. (Fig 16)

Fig 16

Screen inverter board (FL inverter) (Fig 17)

The inverter board is a power supply for the backlight lamp inside the LCD screen. When inverter fails, the LCD screen goes very dark and barely see any image on the screen. In most laptops the inverter board is mounted inside the display panel below the LCD screen.

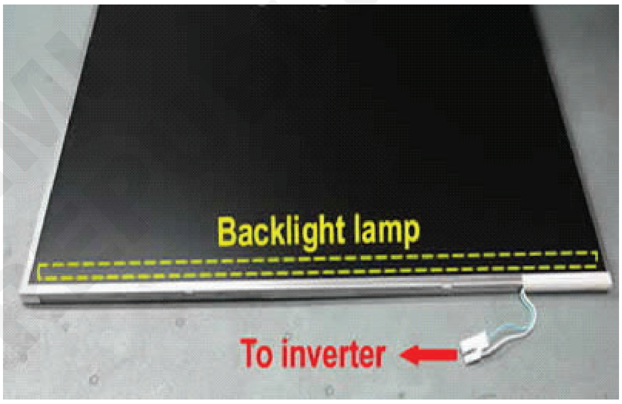
Fig 17



Screen backlight lamp or CCFL tube

The backlight lamp is the main source of light in the LCD screen. The backlight lamp is mounted inside the screen. When the backlight lamp fails, no need to replace the whole LCD screen. It's possible to replace just the lamp inside the screen also. (Fig 18)

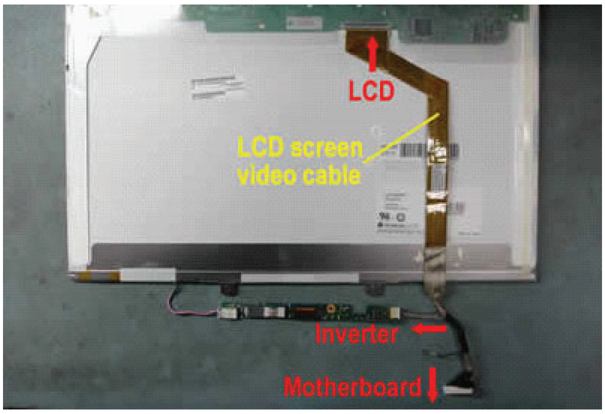
Fig 18



Screen cable or video cable

The video cable connects the Laptop screen to motherboard. The video cable carries data signal for the LCD screen and power for the inverter board. (Fig 19)

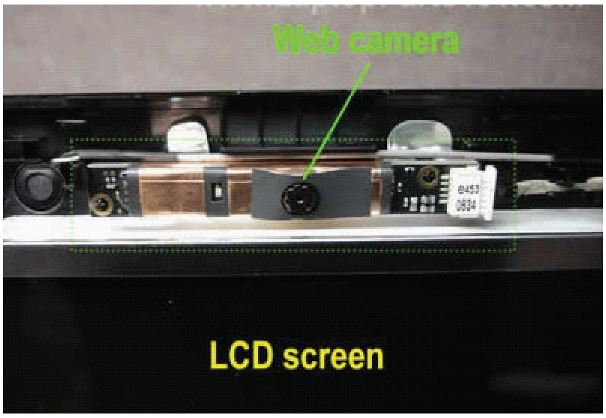
Fig 19



Web camera

Many modern laptops come with a web camera built into the display panel. The web camera is not a part of the LCD screen. The web camera is located on a separate board and can be replaced separately from the LCD. (Fig 20)

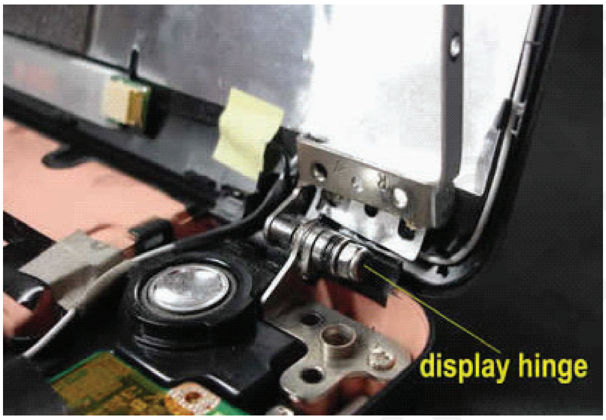
Fig 20



Display hinges or screen hinges

The dispaly hinges connect two main parts of any laptop - the display panel and base assembly. (Fig 21)

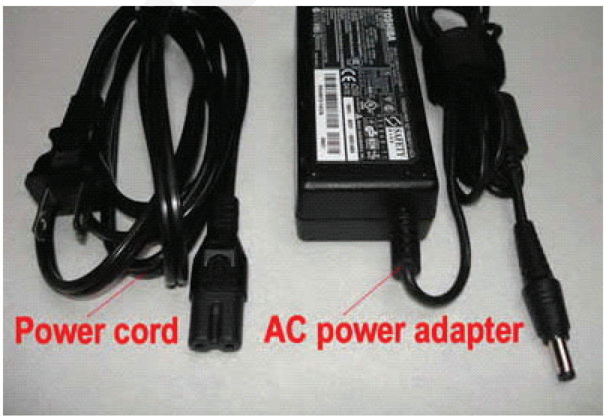
Fig 21



AC/DC Power adapter

The AC/DC power adapter converts high voltage AC power from the mains to low voltage DC power required by the laptop. (Fig 22)

Fig 22



Main battery

The battery is a secondary source of power for a laptop. The battery gets charged while the laptop is plugged into the mains and keeps the laptop running when it's unplugged from the mains. (Fig 23)

Fig 23

Basic tools used by a Laptop Technician

Phillips Head Screwdriver (Fig 24)

This is not the average sized screwdriver, as that would be too large for the tiny screws used on laptops today. This is the micro-sized screwdriver,

Fig 24

Star Tipped Screwdriver

This is also a commonly used tool, mainly used on the Macintosh brand, though also common on many laptops and we need the multiple tip pack to allow different sizes for different laptop models.

Mini Pliers

mini needle nosed pliers because they are easier to use on the micro sized components that make up the laptop. Better to use 3 inches long, the normal sized pliers are too big and do not reach into certain areas that the mini can. (Fig 25)

Cleaning brush (Fig 26)

This is the second most used tool in Laptop Repair. Brush is used to clean any and all parts and components in and on the laptop. Cleaning the laptop parts as you repair is necessary to the longevity of the laptops life. It is used to clean the keyboard, the motherboard and any case part.

Fig 25

Fig 26

Liquid (no residue) Flux

For this tool, I recommend that you get both a paste form and the liquid PEN form. Both are readily available on Ebay for a small price, yet are hard to find locally at a store, you can try shopping at Radio Shack for Flux Paste, but doubtful they have the flux pens.

Thin Tipped Black Permanent Marker

This is used often to mark screw holes, or to mark the areas of damage on the laptops parts.

Plastic Prying Tools

These will be needed for almost every laptop repair procedure. When able, you will ALWAYS use plastic over metal to disassemble or work on the laptop or any electronic component. There are various kinds that are used and needed. A guitar pick is the most used tool, not a flimsy pick rather a slightly thicker guitar pick that can withhold bending back and forth numerous times. Another great plastic tool is one you will need to purchase off of Ebay and is part of the IPOD repair kit (do a search for these on Ebay.com).

Part Plastic/Metal Epoxy Glue

You will find many varieties of this product and will have to choose the best one for yourself, I typically use the Black/ Clear mix… As it has a longer drying time, it will allow more strength over time and hold up to heat exposure. This will be used in many areas of the laptop, and being that a laptop motherboard is Self Grounded… it can be used directly on the PCB to cover components or traces. A common use for this Epoxy is for DC Jack Repair, as it will be used in the last step and applied to the jacks rear end and sides to help secure it to the motherboard. Also this will be used to brace the Jack when the laptops lower cases DC Jack holding cage breaks (common issue for Toshiba - newer model laptops).

Toothpicks

These have many uses and are a handy tool to have nearby. Used to apply fluxes, used to apply epoxies, also can be used to help plug or unplug certain ribbon cables or thin wire(s).

Thermal Paste

You will only be using Silver thermal paste in a Laptop, Never Ceramic Paste. Laptops will use 2 cooling sources…. Either Silver paste or a thermal pad. Pads will be hard to repurchase, and silver thermal paste will be readily available for sale everywhere. If a part or component originally used a thermal pad, it is highly recommended that you keep using a pad and not switch it out to using paste… These pads also are used to cover a gap which is left for that specific part for thermal expansion and contraction.

30 to 50 Watt Soldering Iron

You can use any brand of these and they are typically disposable. I recommend that you do dispose of the cheaper soldering irons after 10 or so uses, or get yourself some Tinner to refresh the tip. I do recommend a 50 watt iron for laptop component repair as it will allow for better ?flow? of the solder due to the higher temperature output.

Solder

The average Rosin Core Solder will do, get your self 1.0mm solder, any thicker and it will apply to heavily.

Circuit Board Cleaning Solution/WD40

This solvent is used to clean the motherboard, and I will clarify its uses throughout this book. WD40 is more readily available to purchase and can suffice. Again, I will also explain how to properly use WD40 to clean components/ remove flux and so forth.

Multi-meter

This can be bought at your local Home

Improvement store, and you will find a wide variety of quality choices. For a beginner, it is ok to purchase the cheapest Multi-meter to learn its uses and familiarize yourself with it.

Heat Gun

The better the quality the better the final results of your repairs will be. On average, you want to use at least a heat gun with switchable settings… One that will produce temperature of 700 to 800 degrees. I use a RYOBI heat gun, 120v, 11a, Temp: 200-1100 degrees Farenheit.

Heat Gun Add On Tips -

You will find for sale on Ebay or the Web, tips for the heat gun… these are the same or similar to the tips used in professional Rework stations (I'll explain what a Rework Station is later in the book). There are a lot of different tips you can buy and a lot of different sizes to choose from. You will buy these according to your specific needs. I personally use the Cone telescoping tips, and the Square GPU Covering

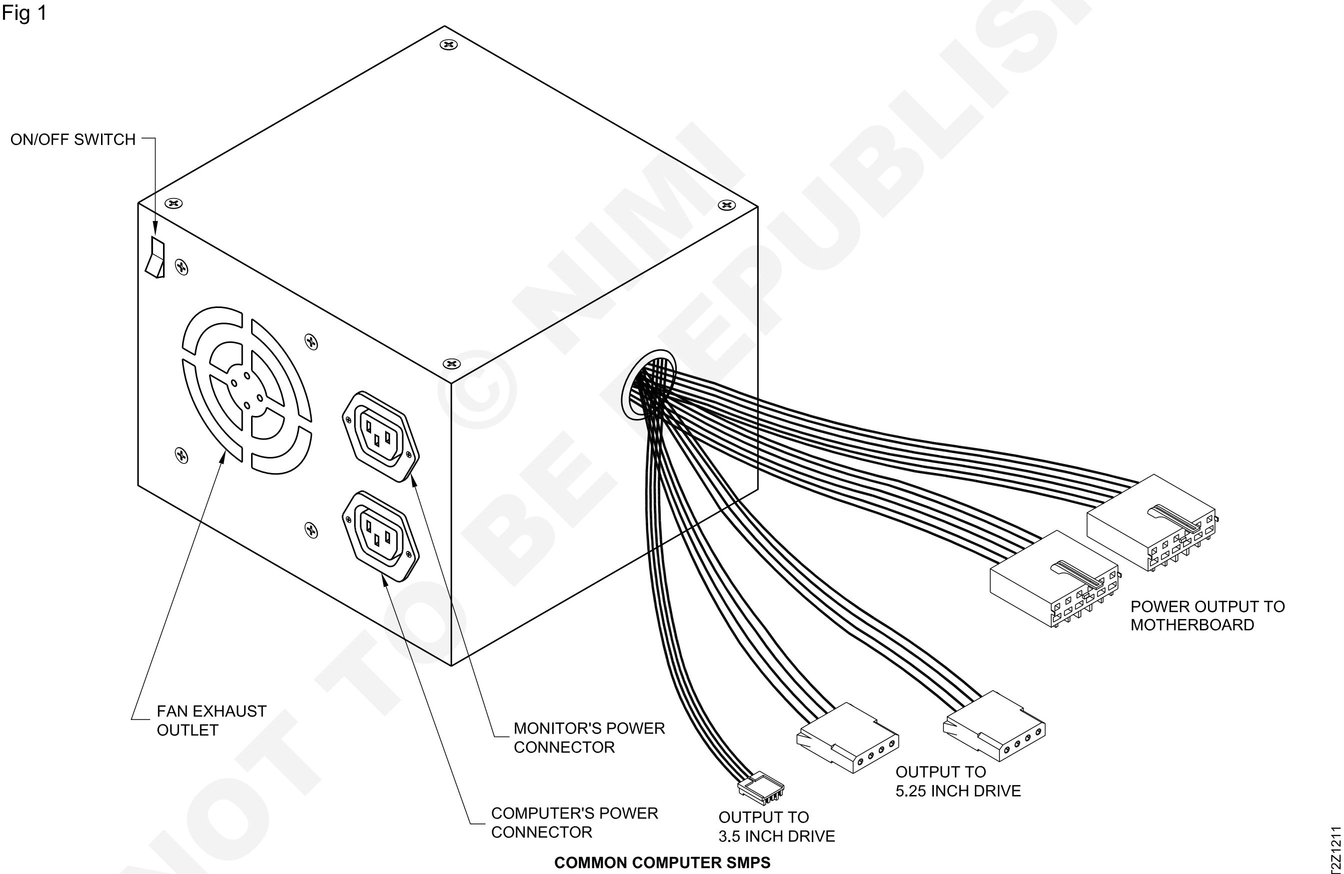
Switch Mode Power Supply for PC

Objectives: At the end of this lesson you shall be able to
- **list the parts of SMPS**
- **list the various power capacities of SMPS**
- **explain the use of fan**
- **explain with block diagram the working principle of an SMPS**
- **state the advantages and disadvantages SMPS over conventional power supply**
- **state the difference between AT and ATX power supplies.**

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. A typical SMPS is shown in Fig 1.

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.

Fig 1



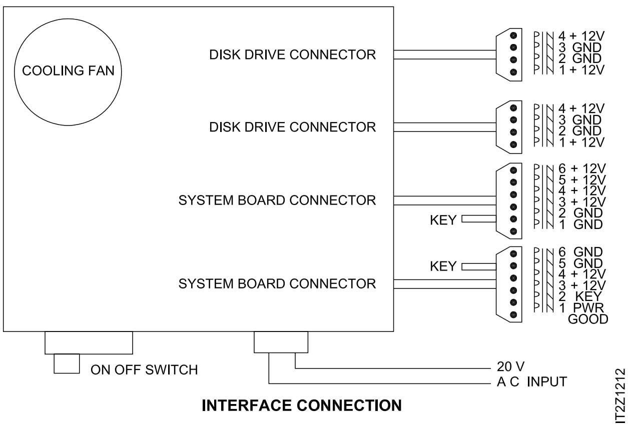
COMMON COMPUTER SMPS

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



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 interdependence 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.

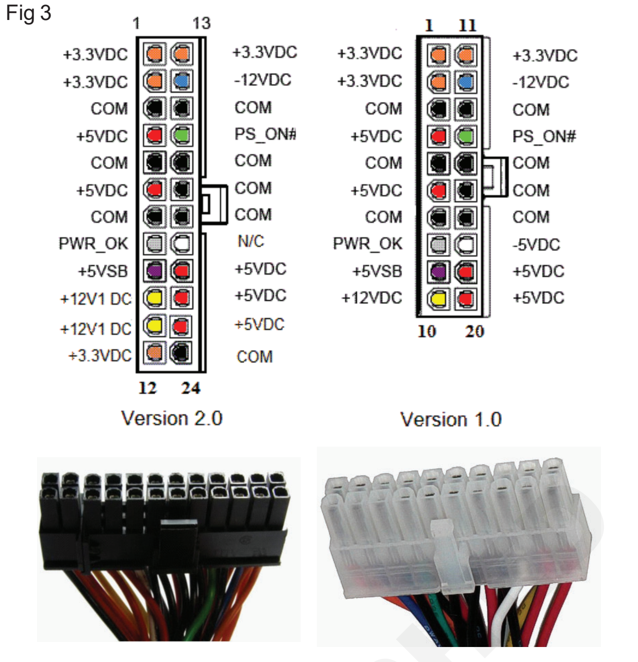
ATX power supply generates a 3.3V DC for the processor core voltage.

Precaution to be taken while testing and servicing an SMPS

ATX 24 pin and 20 pin motherboard connector (Fig 3)

The original ATX systems had 20-pin main connector P1. When PCI Express bus was introduced, PCIe cards needed up to 75W extra. To provide the additional wattage, the old part has been replaced by a new 24-pin connector. Accordingly, different ATX-style PSU may use different number of power wires: see the pinout diagram.

Fig 3

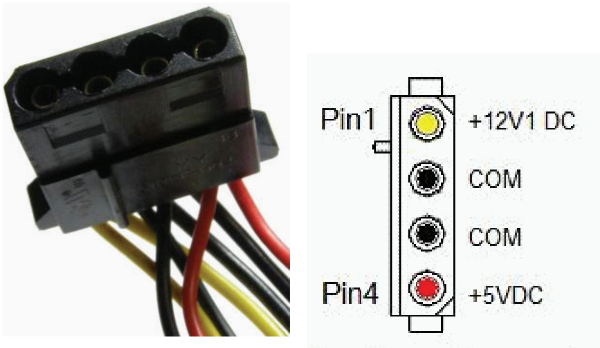


Pin	Name	Color	Description
1	+3.3V	Orange	+3.3 VDC
2	+3.3V	Orange	+3.3 VDC
3	COM	Black	Ground
4	+5V	Red	+5 VDC
5	COM	Black	Ground
6	+5V	Red	+5 VDC
7	COM	Black	Ground
8	PWR_ON	Gray	Power Good
9	+5VSB	Purple	+5 VDC Standby
10	+12V1	Yellow	+12 VDC
11	+12V1	Yellow	+12 VDC
12	+3.3V	Orange	+3.3 VDC
13	+3.3V	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

Molex 4 pin Peripheral Power Connector (Fig 4)

The rated current of the main Molex connector is 6A per contact. The voltages for the various pin are given below

Fig 4



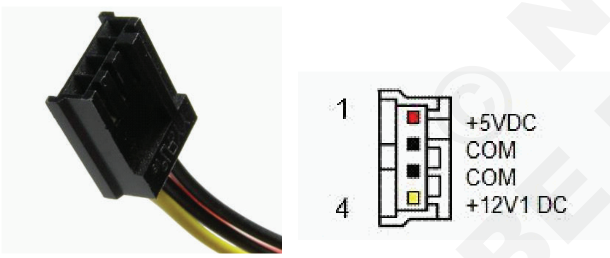
Pin	Name	Color	Description
1	+12VDC	Yellow	+12 VDC
2	COM	Black	Ground
3	COM	Black	Ground
4	+5VDC	Red	+5 VDC

Berg Floppy Drive 4 pin Power Connector (Fig 5)

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 5



Pin	Name	Color	Description
1	+5VDC	Red	+5 VDC
2	COM	Black	Ground
3	COM	Black	Ground
4	+12VDC	Yellow	+12 VDC

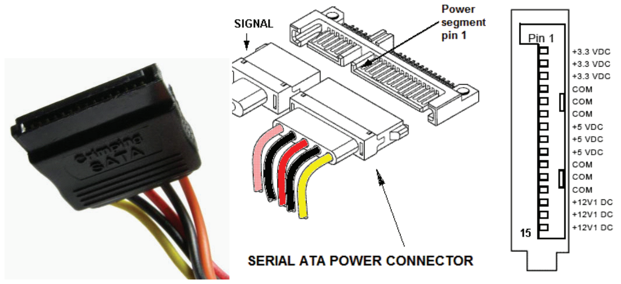
15 pin SATA Power Connector (Fig 6)

The SATA 15 pin power supply connector is one of the standard peripheral power connectors in computers today. This power connector is the standard connector for all SATA based hard drives and optical drives.

6 pin Motherboard Power Connector (Fig 7)

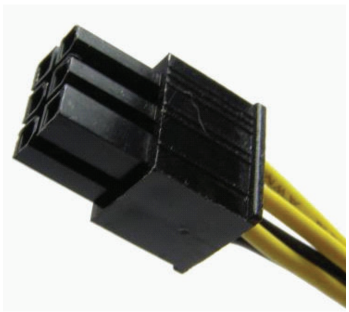
The ATX 6 pin power supply connector is a seldom used motherboard power connector used to provide +12 VDC to the processor voltage regulator.

Fig 6



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

Fig 7

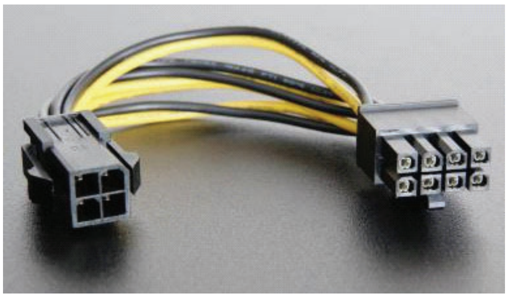


Pin	Name	Color	Description
1	COM	Black	Ground
2	COM	Black	Ground
3	COM	Black	Ground
4	+12VDC	Yellow	+12 VDC
5	+12VDC	Yellow	+12 VDC
6	+12VDC	Yellow	+12 VDC

ATX 4 pin 12V Power Connector (Fig 8)

The ATX 4 pin power supply connector is a standard motherboard power connector used to provide +12 VDC to the processor voltage regulator.

Fig 8



Pin	Name	Color	Description
1	COM	Black	Ground
2	COM	Black	Ground
3	+12VDC	Yellow	+12 VDC
4	+12VDC	Yellow	+12 VDC

Motherboard identification

Objectives: At the end of this lesson you shall be able to
- **know the add on cards/expansion cards fitted in motherboard**
- **know motherboard form factors.**

Motherboard Form factors

A motherboard form factor describes the dimensions of the motherboard and the layout of the motherboard components.

It is important to understand different motherboard form factors to place it in a computer case. For example, A full AT motherboard can be fixed only in a full AT case, a Baby AT board in a Baby AT case, and an ATX board in an ATX case.

Common Motherboard form factors are

Full AT

Baby AT

LPX/NLX

ATX

microATX

FlexATX

ITX

BTX

Pico BTX

WTX

SSICEB

DTXXT

IBM 1983

Form factor	Originated	Max. size	Description
XT	IBM 1983	8.5 × 11 in 216 × 279 mm	Obsolete
AT (Advanced Technology)	IBM 1984	12 × 11-13 in 305 × 279-330 mm	Obsolete, Created by IBM for the IBM Personal Computer/AT, an Intel 80286machine. Also known as Full AT, it was popular during the era of the Intel 80386 micro processor. Superseded by ATX.
Baby-AT	IBM 1985	8.5 × 10-13 in 16 × 254-330 mm	BM's 1985 successor to the AT motherboard Functionally equivalent to the AT, it became popular due to its significantly smaller size.
ATX	Intel 1996	12 × 9.6 in 305 × 244 mm	Created by Intel in 1995. As of 2007, it is the most popular form factor for commodity motherboards.
SSI CEB	SSI	12 × 10.5 in 305 × 267 mm	Created by the Server System Infrastructure (SSI) forum. Derived from the EEB and ATX specifications. It has the same mounting holes and the same IO connector area as ATX motherboards.
SSI EEB	SSI	12 × 13 in 305 × 330 mm	Created by the SSI Forum Derived from the EEB and ATX specifications. It has the same mounting holes and the same IO connector area as ATX motherboards.
SSI MEB	SSI	16.2 × 13 in 411 × 330 mm	Created by the SSI Forum Derived from the EEB and ATX specifications. It has the same mounting holes and the same IO connector area as ATX motherboards.
microATX	1996	9.6 × 9.6 in 244 × 244 mm	A smaller variant of the ATX form factor (about 25% shorter). Compatible with most ATX cases, but has fewer slots than ATX, for a smaller power supply unit. Very popu lar for desktop and small form factor computers as of 2007.
Mini-ATX	AOpen 2005	5.9 × 5.9 in 150 × 150 mm	Mini-ATX is slightly smaller than Micro-ATX. Mini-ATX motherboards were designed with MoDT (Mobile on Desk top Technology) which adapt mobile CPUs for lower power requirement, less heat generation and better application capability.

FlexATX	Intel 1999	9.0 × 7.5 in 228.6 × 190.5 . mm max	A subset of microATX developed by Intel in 1999. Allows more flexible motherboard design, component position ing and shape. Can be smaller than regular microATX.
Mini-ITX	VIA 2001	6.7 × 6.7 in 170 × 170 mm max.	A small, highly integrated form factor, designed for small devices such as thin clients and set-top boxes.
Nano-ITX	VIA 2003	4.7 × 4.7 in 120 × 120 mm	Targeted at smart digital entertainment devices such as PVRs, set-top boxes, media centers and Car PCs, and thin devices.
Pico-ITX	VIA 2007	3.9 × 2.8 in 100 × 72 mm max.	
Mobile-ITX	VIA 2007	2.953 × 1.772 in 75 × 45 mm	
Neo-ITX	VIA 2012	170 × 85 × 35 mm	Used in the VIA Android PC
BTX (Balanced Technology Extended)	Intel 2004	12.8 × 10.5 in 325 × 267 mm max.	A standard proposed by Intel as a successor to ATX in the early 2000s, according to Intel the layout has better cooling. BTX Boards are flipped in comparison to ATX Boards, so a BTX or MicroBTX Board needs a BTX case, while an ATX style board fits in an ATX case. The RAM slots and the PCI slots are parallel to each other. Processor is placed closest to the fan. May contain a CNR board.
MicroBTX (oruBTX)	Intel 2004	10.4 × 10.5 in 264 × 267 mm max.	
PicoBTX	Intel 2004	8.0 × 10.5 in 203 × 267 mm max.	
DTX	AMD 2007	200 × 244 mm max.	
Mini-DTX	AMD 2007	200 × 170 mm max.	
ETX	Kontron	95 × 114 mm	Used in embedded systems and single board computers. Requires a baseboard.
COM Express Basic	PICMG	95 × 125 mm	Used in embedded systems and single board computers. Requires a carrier board. Formerly referred to as ETXexpress by Kontron.
COM Express Compact	PICMG	95 × 95 mm	Used in embedded systems and single board computers. Requires a carrier board. Formerly referred to as microETXexpress by Kontron.
COM Express Mini	PICMG	55 × 84 mm	Used in embedded systems and single board computers. Requires a carrier board. Formerly referred to as nanoETXexpress by Kontron. Also known as COM Express Ultra and adheres to pin-outs Type 1 or Type 10
CoreExpress	SFF-SIG	58 × 65 mm	Used in embedded systems and single board computers. Requires a carrier board.
Extended ATX (EATX)	Unknown	12 × 13 in 305 × 330 mm	Used in rackmount server systems. Typically used for server-class type motherboards with dual processors and too much circuitry for a standard ATX motherboard. The mounting hole pattern for the upper portion of the board matches ATX.

Enhanced Extended ATX(EEATX)	Supermicro	13.68 × 13 in 347 × 330 mm	Used in rackmount server systems. Typically used for server-class type motherboards with dual processors and too much circuitry for a standard E.ATX motherboard.
LPX	Unknown	9 × 11-13 in 229 × 279-330 mm	Based on a design by Western Digital, it allowed smaller cases than the AT standard, by putting the expansion card slots on a Riser card.[2] Used in slimline retail PCs. LPX was never standardized and generally only used by large OEMs.
Mini-LPX	Unknown	8-9 × 10-11 in 203-229 × 254-279 mm	Used in slimline retail PCs.
WTX	Intel 1998	14 × 16.75 in 355.6 × 425.4 mm	A large design for servers and high-end workstations fea turing multiple CPUs and hard drives.
SWTX	Unknown	16.48 × 13 in 418 × 330 mm	A proprietary design for servers and high-end worksta tions featuring multiple CPUs.
HPTX	EVGA 2008	13.6 × 15 in 345.44 × 381 mm	A large design by EVGA currently featured on two motherboards; the eVGA SR2 and SRX. Intended for use with multipleCPUs. Cases require 9 expansion slots to contain this form-factor.

Replacing the battery of motherboard (CMOS battery)

Objectives: At the end of this lesson you shall be able to
- **replace the battery of motherboard (CMOS battery)**
- **explain about CPU and its usage.**

Replacing the battery of your motherboard (CMOS battery)

A computer may sometimes show error messages related to time and date options or other errors like 'no operating system or new CPU is installed'. All these are indications that it is time to change the battery of the motherboard i.e. the CMOS battery of the system. The weakening of this battery happens and hence it must be replaced ideally every five years. The replacement process has to be carefully followed to avoid any accidental problems. Saving the BIOS data prior to the battery change and configuration of the same, after the installation of the new CMOS battery, must also be done properly.

Symptoms

If the computer is experiencing problems with the date and time or you see the following error messages:

- BIOS CMOS checksum error defaults loaded
- BIOS CMOS battery low cmos wrong memory size
- No operating system
- CPU overclocking failed
- New CPU has been installed

These problems may be due to the fact that your CMOS battery is depleted and it's time to replace it.

Replacement sequence

It is recommended that you change the CMOS battery every 5 years.

Saving the BIOS data

Open the BIOS screen and note all the information on a piece of paper. It's important that you don't make any modifications. Once completed this document will be useful to check out if all the parameters are correctly inserted after replacing the battery.

Identify the CMOS battery

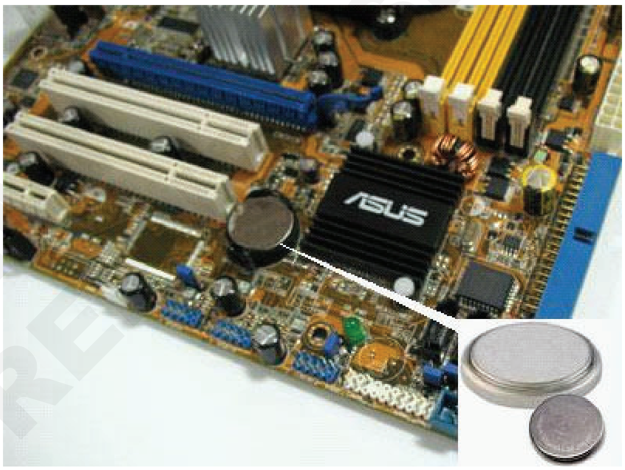
The CMOS battery is thin round button-like object. It can sometimes be hidden by extension cards or connectors. On older PCs it may have a cylindrical shape. The most widely used battery model is the CR2032:

- Where :
- CR- lithium battery
- 20 - 20mm diameter
- 32- Thickness 32* 0.1 mm
- This type of battery is easily found and fairly cheap to purchase

How to locate it:

- Turn off your PC
- Remove the power cable attached to your system unit and remove the casing.
- Discharge your system unit from static electricity by touching it with a metallic object.

Fig 1



Removing the discharged battery

First of all, be sure that the System unit is laid down horizontally. The positive pole of the battery should be visible. Remove the battery, but avoid forcing it and any contact with other parts of your motherboard (refer to the manual provide with your motherboard). Go to your local retailer any buy a battery of the same model or something equivalent.

Installing the new battery

Be sure that the battery is placed correctly (firmly) in the slot allocated

Verify the BIOS data and resetting the clock

Once the operation complete, it is important to configure the BIOS settings:

- Start your PC.
- Enter the BIOS.
- Modify the date.
- Perform any modifications required if not
- Save and quit BIOS.

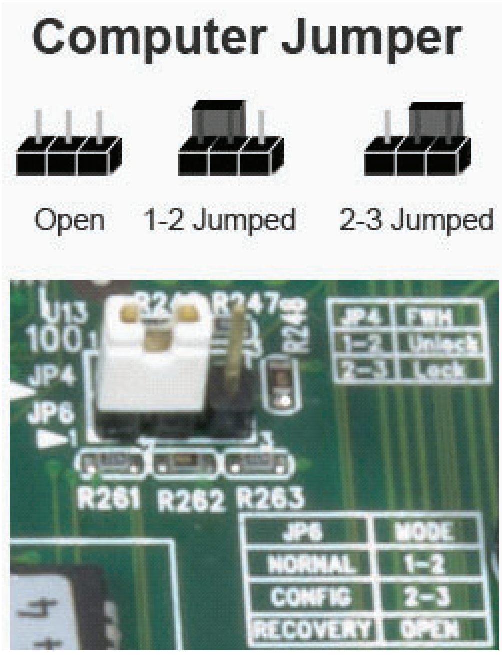
Companies Utilizing ARM Architecture

ARM	System-on-a-chip (SoC)	Notable Product(s) Containing	Type of ARM Processor	Number of Cores
Apple	A4	iPhone 4, iPod Touch (4th Gen), iPad (1st Gen), AppleTV (2nd Gen)	Cortex-A8	1
	A5	iPhone 4S, iPad 2, AppleTV (3rd Gen)	Cortex-A9	2
	A5X	iPad (3rd Gen, Retina Display)	Cortex-A9	2
Samsung	Exynos 3 Single	Samsung Galaxy S, Samsung Galaxy Nexus S,	Cortex-A8	1
	Exynos 4 Dual	Samsung Galaxy SII, Samsung Galaxy Note (International)	Cortex-A9	2
	Exynos 4 Quad	Samsung Galaxy SIII	Cortex-A9	4
	Exynos 5 Dual	N/A	Cortex-A15	2
Nvidia	Tegra	Microsoft Zune HD	ARM11	1
	Tegra 2	ASUS Eee Pad Transformer, Samsung Galaxy Tab 10.1, Motorola Xoom, Dell Streak 7 & Pro, Sony Tablet S	Cortex-A9	2
	Tegra 3	ASUS Transformer Pad 300, ASUS Nexus 7, Acer Iconia Tab A510 & A700, HTC One X	Cortex-A9	4
Qualcomm	Snapdragon S2	Nokia Lumia 900	N/A	1
	Snapdragon S3	Galaxy Note LTE (AT&T), HP TouchPad	N/A	2
	Snapdragon S4	Samsung Galaxy SIII LTE, HTC EVO 4G LTE	N/A	2, 4
Texas Instruments	OMAP 3	Barnes and Noble Nook Color	Cortex-A8	1
	OMAP 4	Amazon Kindle Fire, Samsung Galaxy Tab 2, Blackberry Playbook, Samsung Galaxy Nexus, Barnes and Noble Nook Tablet	Cortex-A9	2
	OMAP 5	N/A	Cortex-A15	2

Feature	Explanation	Processors using feature
	Intel Features	
Hyper-Threading (HT)	Improves the performance by allowing the operating system to improve its ability to 'multitask' processes more intelligently. One physically present core is treated as two logical cores which share workloads between each other. Hence, a dual-core with HT has 4 logical cores and a quad-core has 8 logical cores.	Core i7, Core i5, Core i3, Atom
Turbo Boost	Allows the processor to intelligently and dynamically over clock a core(s) such that thermal/power constraints are not violated. For example, a dual core processor with Turbo Boost can overclock one core to much higher frequencies while decreasing speed of the other core; in some situations this can improve performance.	Core i7, Core i5 (Mobile Dual-Cores only)
QuickPath Interconnect (QPI)	An Intel technology which replaced Front Side Bus (FSB) -- similar in purpose to AMD's competing HyperTransport technology.	Implemented in some fashion across all Intel core iX series
Tri-Gate (3D) Transistor	A new fabrication technology implemented for mass production for the first time in 2012 with Ivy Bridge. Essentially, increases the surface area of each transistor on the chip while also reducing power leakage which on the whole significantly decreases power consumption and improves performance.	Ivy Bridge (2012) iX series
vPro	Synchronizes remote desktop, security, and other multi-station support features. Decreases desk-side maintenance visits.	Current Intel processors
Execute Disable Bit	Prevents certain viruses from infecting the system by labeling some data "executable."	Current Intel processors
	AMD Features	
HyperTransport	A feature that helps minimize the number of buses in a system. This can reduce system 'bottlenecks' and allow microprocessors to use system memory more efficiently.	All current AMD processors
Cool'n'Quiet	Reduces heat and noise of processors allowing for increased energy efficiency.	Phenom I & II, Athlon, Sempron (with exceptions)
Turbo Core	Turbo Core allows for contextual overclocking of the processor to optimize performance subject to electrical and thermal requirements/specifications.	Phenom II X6, Trinity APUs
CoolCore	Limits unused elements of the processor such that power is conserved -- allows for increased notebook battery life on a single charge.	Phenom I & II, Turion

Jumper (Fig 1)

Fig 1



Jumpers allow the computer to close an electrical circuit, allowing the electricity to flow certain sections of the circuit board. Jumpers consist of a set of small pins that can be covered with a small plastic box (jumper block) as shown in the illustration above. Below the illustration, is a picture of what the jumpers may look like on your motherboard. In this example, the jumper is the white block covering two of the three 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.

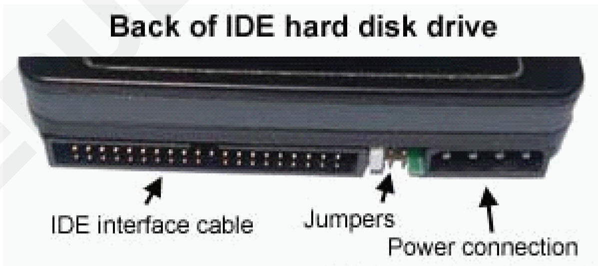
Jumpers are used to configure the settings for computer peripherals such as the motherboard, hard drives, modems, sound cards, and other components. For example, if your motherboard supported intrusion detection, a jumper can be set to enable or disable this feature.

In the past, before Plug and Play, jumpers were used to adjust device resources, such as changing what IRQ the device is using. Today, most users will not need to adjust any jumpers on their motherboard or expansion cards. Usually, you are most likely to encounter jumpers when installing a new drive, such as a hard drive. As can be seen in the picture below, ATA (IDE) hard drives have jumpers with three sets of two pins. Moving a jumper between each two pins will change the drive from master drive, slave drive, or cable select. (Fig 2)

Some documentation may refer to setting the jumpers to on, off, closed, or open. When a jumper is on or covering at least two pins it is a closed jumper, when a jumper is off, is covering only one pin, or the pins have no jumper it is an open jumper.

Caution: When changing the jumpers on any device, the device and your computer needs to be turned off. In addition, whenever working in a computer or with any electronic device be aware of ESD.

Fig 2



SIMM and DIMM Memory Modules

Objectives: At the end of this lesson you shall be able to
- **identify the SIMM and DIMM memory modules.**

DIMM stands for Dual in line memory module and is a type of computer memory. A DIMM is a small circuit board that holds memory chips. It uses a 64 bit bus to the memory. Whereas a Single in-line memory module (SIMM) only has a 32 bit path.

The main difference between DIMM and SIMM are: A DIMM is a double sided SIMM.

SIMM can be installed in in-line pairs while DIMM is independent of the side. Because a DIMM has separate contacts on each side of the board, it provides twice as much data as a single SIMM.

The classic or most common pin configuration of the SIMM module is 72 pins. The foremost common pin configuration of the DIMM module is 168 pins.