ELECTRONICS MECHANIC

(Common for Technician Power Electronics System)

NSQF LEVEL - 4

1st Year

TRADE PRACTICAL

SECTOR : ELECTRONICS & HARDWARE

(As per revised syllabus July 2022 - 1200 Hrs)

Directorate General of Training

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

NATIONAL INSTRUCTIONAL MEDIA INSTITUTE, CHENNAI

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

Sector : Electronics & Hardware

Duration : 2 - Years

Trade : Electronics Mechanic - 1st Year - Trade Practical - NSQF Level - 4 (Revised 2022)

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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, an autonomous body under the Directorate General of Training (DGT), Ministry of Skill Development & Entrepreneurship is entrusted with developing producing and disseminating Instructional Media Packages (IMPs) required for ITIs and other related institutions.

The institute has now come up with instructional material to suit the revised curriculum for **Electronics Mechanic - Trade Practical - 1st Year in Electronics & Hardware Sector** under **Yearly Pattern.** The NSQF Level - 4 (Revised 2022) Trade Practical will help the trainees to get an international equivalency standard where their skill proficiency and competency will be duly recognized across the globe and this will also increase the scope of recognition of prior learning. NSQF Level - 4 (Revised 2022) trainees will also get the opportunities to promote life long learning and skill development. I have no doubt that with NSQF Level - 4 (Revised 2022) the trainers and trainees of ITIs, and all stakeholders will derive maximum benefits from these 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

SHRI. ATUL KUMAR TIWARI., I.A.S.,
Secretary
Ministry of Skill Development & Entrepreneurship
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New Delhi - 110 001

PREFACE

The National Instructional Media Institute (NIMI) was established in 1986 at Chennai by then Directorate General of Employment and Training (D.G.E & T), Ministry of Labour and Employment, (now under Directorate General of Training, Ministry of Skill Development and Entrepreneurship) Government of India, with technical assistance from the Govt. of 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 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 Practical)** for the trade of **Electronics Mechanic - 1st Year - NSQF Level - 4 (Revised 2022)** under **Electronics and Hardware** sector.

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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 intented to be used in workshop . It consists of a series of practical exercise to be completed by the trainees during the 1st Year course of the **Electronics Mechanic** Trade supplemented and supported by instructions/ informations to assist in performing the exercises. These exercises are designed to ensure that all the skills in the prescribed syllabus are covered.

The manual is divided into Fourteen modules. The distribution of time for the practical in the Fourteen modules are given below.

Module 1	**Basic Workshop Practice**
Module 2	**Basics of AC and Electrical Cables & Single range meters**
Module 3	**Cells & Batteries**
Module 4	**AC & DC Measuring Instruments**
Module 5	**Digital Storage Oscilloscope**
Module 6	**Soldering/Desoldering and various switches**
Module 7	**Active and Passive Components**
Module 8	**Power Supply Circuits & IC Regulators**
Module 9	**Transistor, Amplifier, oscillator and waveshaping circuits**
Module 10	**Power Electronic components**
Module 11	**Opto-Electronics**
Module 12	**Basic Gates, Combinational circuits, Flip flops**
Module 13	**Electronic Circuit Simulator**
Module 14	**Op - Amp & Timer 555 Applications**

The skill training in the computer lab is planned through a series of practical exercises centred around some practical project. However, there are few instance 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 if 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 1st Year course of the Electronics Mechanic Trade. The contents are sequenced according to the practical exercise contained in the manual on Trade practical. Attempt has been made to relate the theoretical aspects 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	Perform basic workshop operations using suitable tools for fitting, riveting, drilling etc. observing suitable care & safety following safety precautions. **(NOS: ELE/N1002)**	1.1.01 - 1.1.12
2	Select and perform electrical/ electronic measurement of single range meters and calibrate the instrument. **(NOS: N/A)**	1.2.13 - 1.1.27
3	Test &service differentbatteries used in electronic applications and record the data to estimate repair cost. **(NOS: ELE/N7001)**	1.3.28 - 1.3.34
4	Measure AC/DC using proper measuring instruments and compare the data using standard parameter. **(NOS:)**	1.4.35 - 1.4.39
5	Measure the various parameters by DSO and execute the result with standard one. **(NOS: N/A)**	1.5.40 - 1.5.43
6	Plan and execute soldering & de-soldering of various electrical components like Switches, PCB & Transformers for electronic circuits. **(NOS:ELE/N7812)**	1.6.44 - 1.5.49
7	Test various electronic components using proper measuring instruments and compare the data using standard parameter. **(NOS:ELE/N5804)**	1.7.50 - 1.7.65
8	Assemble simple electronic power supply circuit and test for functioning. **(NOS:ELE/N5804)**	1.8.66 - 1.8.79
9	Construct, test and verify the input/ output characteristics of various analog circuits. **(NOS: N/A)**	1.9.80 - 1.9.94
10	Plan and construct different power electronic circuits and analyse the circuit functioning. **(NOS: N/A)**	1.10.95-1.10.103
11	Select the appropriate opto electronics components and verify the characteristics in different circuit. **(NOS: N/A)**	1.11.104-1.11.109
12	Assemble, test and troubleshoot various digital circuits. **(NOS:ELE/N1201)**	1.12.110-1.12.123
13	Simulate and analyze the analog and digital circuits using Electronic simulator software. **(NOS:ELE/N6102)**	1.13.124-1.12.127
14	Construct and test different circuits using ICs 741operational amplifiers & ICs 555 linear integrated circuits and execute the result. **(NOS: N/A)**	1.14.128-1.14.136

SYLLABUS

Duration	Reference Learning Outcome	Professional Skills (Trade Practical) With Indicative Hours	Professional Knowledge (Trade Theory)
Professional Skill 65 Hrs; Professional Knowledge 10 Hrs	Perform basic workshop operations using suitable tools for fitting, riveting, drilling etc. observing suitable care & safety following safety precautions. **NOS: ELE/N1002**	Trade and Orientation 1. Visit to various sections of the institute and identify location of various installations. (05 Hrs.) 2. Identify safety signs for danger, warning, caution & personal safety message. (03 Hrs.) 3. Use of personal protective equipment (PPE). (05 Hrs.) 4. Practice elementary first aid. (05 Hrs.) 5. Preventive measures for electrical accidents & steps to be taken in such accidents. (02 Hrs.) 6. Use of Fire extinguishers. (05 Hrs.)	Familiarization with the working of Industrial Training Institute system. Importance of safety and precautions to be taken in the industry/shop floor. Introduction to PPEs. Introduction to First Aid. Response to emergencies e.g. power failure, fire, and system failure. Importance of housekeeping & good shop floor practices. Occupational Safety & Health: Health, Safety and Environment guidelines, legislations & regulations as applicable. (05 Hrs.)
		Hand tools and their uses 7. Identify the different hand tools. (05 Hrs.) 8. Selection of proper tools for operation and precautions in operation. (05 Hrs.) 9. Care & maintenance of trade tools. (05 Hrs.) 10. Practice safety precautions while working in fitting jobs. 1. (10 Hrs.) 11. Workshop practice on filing and hacks awing. (05 Hrs.) 12. Practice simple fitting and drilling. (10 Hrs.)	Identification, specifications, uses and maintenance of commonly used hand tools. State the correct shape of files for filing different profiles. Riveting of tags and lugs, cutting and bending of sheet metals, chassis and cabinets. (05 Hrs.)
Professional Skill 45 Hrs; Professional Knowledge 15 Hrs	Select and perform electrical/ electronic measurement of single range meters and calibratethe instrument. **NOS: N/A**	**Basics of AC and Electrical Cables** 13. Identify the Phase, Neutral and Earth on power socket, use a testers to monitor AC power. (02 Hrs.) 14. Construct a test lamp and use it to check mains healthiness. (02 Hrs.) 15. Measure the voltage between phase and ground and rectify earthing. (03 Hrs.) 16. Identify and test different AC mains cables. (03 Hrs.)	Basic terms such as electric charges, Potential difference, Voltage, Current, Resistance. Basics of AC & DC. Various terms such as +ve cycle, -ve cycle, Frequency, Time period, RMS, Peak, Instantaneous value. Single phase and Three phase supply. Terms like Line and Phase voltage/ currents. Insulators, conductors and semiconductor properties. Different type of electrical cables and their Specifications.

		17. Prepare terminations, skin the electrical wires /cables using wire stripper and cutter. (03 Hrs.) 18. Measure the gauge of the wire using SWG and outside micrometer. (03 Hrs.) 19. Refer table and find current carrying capacity of wires. (01 Hr.) 20. Crimp the lugs to wire end. (03 Hrs.) 21. Measure AC and DC voltages using multi meter. (03 Hrs.)	Types of wires & cables, standard wire gauge (SWG). Classification of cables according to gauge (core size), number of conductors, material, insulation strength, flexibility etc. (08 Hrs.)
		22. Identify the type of meters by dial and scale marking/ symbols. (03 Hrs.) 23. Demonstrate various analog measuring Instruments. (03 Hrs.) 24 Find the minimum and maximum measurable range of the meter. (02 Hrs.) 25. Carryout mechanical zero setting of a meter. (04 Hrs.) 26. Check the continuity of wires, meter probes and fuse etc. (05 Hrs.) 27. Measure voltage and current using clamp meter. (05 Hrs.)	**Single range meters** Introduction to electrical and electronic measuring instruments. Basic principle and parts of simple meters. Specifications, symbols used in dial and their meaning. (07 Hrs.)
Professional Skill 25 Hrs; Professional Knowledge 06 Hrs	Test &service different batteries used in electronic applications and record the data to estimate repair cost. **NOS: ELE/N7001** Measure AC/DC using proper measuring instruments and compare the data using standard parameter.	**Cells & Batteries** 28. Identify the +ve and -ve terminals of the battery. (02 Hrs.) 29. Identify the rated output voltage and Ah capacity of given battery. (01 Hrs.) 30. Measure the voltages of the given cells/battery using analog/ digital multimeter. (03 Hrs.) 31. Charge and discharge the battery through load resistor. (05 Hrs.) 32. Maintain the secondary Battery. (05 Hrs.) 33. Measure the specific gravity of the electrolyte using hydrometer. (03 Hrs.) 34. Test a battery and verify whether the battery is ready for use or needs recharging. (06 Hrs.)	**Cells & Batteries** Construction, types of primary and secondary cells/battery. Materials used, Specification of cells and batteries. Charging process, efficiency, life of cell/battery. Selection of cells / Batteries etc. Use of Hydrometer. Types of electrolytes used in cells and batteries. Series/ parallel connection of batteries and purpose of such connections. (06 Hrs.)
Professional Skill 60 Hrs; Professional Knowledge 20 Hrs	Measure AC/DC using proper measuring instruments and compare the data using standard parameter.	**AC & DC measurements** 35. Use the multi meter to measure the various functions (AC V, DC V, DC I, AC I, R). (10 Hrs.) 36. Identify the different types of meter for measuring AC & 1. DC parameters. (10 Hrs.) 37. Identify the different controls on the CRO/DSO front panel and observe the function of each control. (14 Hrs.)	Introduction to electrical measuring instruments. Importance and classification of meters. MC and MI meters. Characteristics of meters and errors in meters. Multi meter, use of meters in different circuits. Care and maintenance of meters. Use of CRO/DSO, Function generator, LCR meter (20 Hrs.)

		38. Measure DC voltage, AC voltage, time periodusing CRO/DSO sine wave parameters. (12 Hrs.) 39. Identify the different controls on the function generator front panel and observe the function of each control. (14 Hrs.)	
Professional Skill 25 Hrs; Professional Knowledge 09 Hrs	Measure the various parameters by DSO and execute the result with standard one. **NOS: N/A**	**Digital Storage Oscilloscope** 40.Identify the different front panel control of a DSO. (05 Hrs.) 41.Measure the Amplitude, Frequency and time period of typical electronic signals using DSO. (06 Hrs.) 42.Take a print of a signal from DSO by connecting it to a printer and tally with applied signal. (07 Hrs.) 43. Construct and test function generator using IC 8038. (07 Hrs.)	Advantages and features of DSO. Block diagram of Digital storage oscilloscope (DSO)/ CRO and applications. Applications of digital CRO. Block diagram of function generator. Differentiate a CRO with DSO. (09 Hrs.)
Professional Skill 25 Hrs; Professional Knowledge 05 Hrs	Plan and execute soldering & de-soldering of various electrical components like Switches, PCB & Transformers for electronic circuits. **NOS:ELE/N7812**	**Soldering/ De-soldering and Various Switches** 44. Practice soldering on different electronic components, small transformer and lugs. (04 Hrs.) 45. Practice soldering on IC bases and PCBs. (04 Hrs.) 46. Practice de-soldering using pump and wick. (04 Hrs.) 47. Join the broken PCB track and test. (04 Hrs.) 48. Identify and use SPST, SPDT, DPST, DPDT, tumbler, push button, toggle, piano switches used in electronic industries. (04 Hrs.) 49. Make a panel board using different types of switches for a given application. (05 Hrs.)	Different types of soldering guns, related to Temperature and wattages, types of tips. Solder materials and their grading. Use of flux and other materials. Selection of soldering gun for specific requirement. Soldering and De-soldering stations and their specifications. Different switches, their specification and usage. (05 Hrs.)
Professional Skill 85 Hrs; Professional Knowledge 25 Hrs	Test various electronic components using proper measuring instruments and compare the data using standard parameter. **NOS:ELE/N5804**	**Active and Passive Components** 50. Identify the different types of active electronic components. (05 Hrs.) 51. Measure the resistor value by colour code and verify the same by measuring with multimeter. (05 Hrs.) 52.Identify resistors by their appearance and check physical defects. (05 Hrs.) 53. Identify the power rating of carbon resistors by their size. (05 Hrs.) 54. Practice on measurement of parameters in combinational electrical circuit by applying Ohm's Law for different resistor values and voltage sources. (05 Hrs.)	Ohm's law and Kirchhoff's Law. Resistors; types of resistors, their construction & specific use, color-coding, power rating. Equivalent Resistance of series parallel circuits. Distribution of V & I in series parallel circuits. Principles of induction, inductive reactance. Types of inductors, construction, specifications, applications andenergy storage concept. Self and Mutual induction. Behaviour of inductor at low and high frequencies. Series and parallel combination, Q factor.

		55. Measurement of current and voltage in electrical circuits to verify Kirchhoff's Law. (05 Hrs.) 56. Verify laws of series and parallel circuits with voltage source in different combinations. (05 Hrs.) 57. Measure the resistance, Voltage, Current through series and parallel connected networks using multi meter. (05 Hrs.) 58. Identify different inductors and measure the values using LCR meter. (05 Hrs.) 59. Identify the different capacitors and measure capacitance of various capacitors using LCR meter. (05 Hrs.) 60. Identify and test the circuit breaker and other protecting devices. (05 Hrs.) 61.Dismantle and identify the different parts of a relay. (05 Hrs.) 62.Connect a timer relay in a circuit and test for its working. (05 Hrs.) 63.Connect a contactor in a circuit and test for its working. (05 Hrs.) 64.Construct and test RC time constant circuit. (05 Hrs.) 65.Construct a RC differentiator circuit and convert triangular wave into square wave. (05 Hrs.) 66. Construct and test series and parallel resonance circuit. (05 Hrs.)	Capacitance and Capacitive Reactance, Impedance. Types of capacitors, construction, specifications and applications. Dielectric constant. Significance of Series parallel connection of capacitors. Capacitor behaviour with AC and DC. Concept of Time constant of a RC circuit. Concept of Resonance and its application in series and parallel circuit. Properties of magnets and their materials, preparation of artificial magnets, significance of electromagnetism, types of cores. Relays, types, construction and specifications etc (25 Hrs.)
Professional Skill 60 Hrs; Professional Knowledge	Assemble simple ectronic power supply circuit and test for functioning. **NOS:ELE/N5804**	**Power Supply Circuits** 67.Identify different types of diodes, diode modules and their specifications. (04 Hrs.) 68.Test the given diode using multi meter and determine forward to reverse resistance ratio. (04 Hrs.) 69.Measure the voltage and current through a diode in a circuit and verify its forward characteristic. (05 Hrs.) 70.Identify different types of transformers and test. (04 Hrs.) 71.Identify the primary and secondary transformer windings and test the polarity. (04 Hrs.) 72.Construct and test a half wave, full wave and Bridge rectifier circuit. (05 Hrs.) 73.Measure ripple voltage, ripple frequency and ripple factor of rectifiers for different load and filter capacitors. (04 Hrs.) 74.Identify and test Zener diode. (04 Hrs.)	Semiconductor materials, components, number coding for different electronic components such as Diodes Semiconductor materials, components, number coding for different electronic components such as Diodes and Zeners etc.PN Junction, Forward and Reverse biasing of diodes.Interpretation of diode specifications.Forward current and Reverse voltage.Packing styles of diodes. Different diodes, Rectifier configurations, their efficiencies, Filter components and their role in reducing ripple. Working principles of Zener diode, varactor diode, their specifications and applications. Working principle of a Transformer, construction, Specifications and types of cores used. Step-up, Step down and isolation transformers with applications. Losses in Transformers.

		75. Construct and test Zener based voltage regulator circuit. (04 Hrs.) 76. Calculate the percentage regulation of regulated power supply. (04 Hrs.)	Phase angle, phase relations, active and reactive power, power factor and its importance.(10 Hrs.)
		IC Regulators 77. Construct and test a +12V fixed voltage regulator. (05 Hrs.) 78. Identify the different types of fixed +ve and –veregulator ICs and the different current ratings (78/79 series). (04 Hrs.) 79. Observe the output 1. voltage of different IC 723 metal/ plastic type. (04 Hrs.) 80.Construct and test a 1.2V – 30V variable output regulated power supply using IC LM317T. (05 Hrs.)	Regulated Power supply using 78XX series, 79XX series. Op-amp regulator, 723 regulator, (Transistorized & IC based). Voltage regulation, error correction and amplification etc. (05 Hrs.)
Professional Skill 90 Hrs; Professional Knowledge 30 Hrs	Construct, test and verify the input/ output characteristics of various analog circuits. **NOS: N/A**	**Transistor** 81. Identify different transistors with respect to different package type, B-E-C pins, power, switching transistor, heat sinks etc. (06 Hrs.) 82.Test the condition of a given transistor using ohm-meter. (06 Hrs.) 83. Construct and test a transistor based switching circuit to control a relay (use Relays of different coil voltages and Transistors of different β) (06hrs)	Construction, working of a PNP and NPN Transistors, purpose of E, B & C Terminals. Significance of á, â and relationship of a Transistor. Need for Biasing of Transistor. VBE, VCB, VCE, IC, IB, Junction Temperature, junction capacitance, frequency of operation. Transistor applications as switch and amplifier. Transistor input and output characteristics. Transistor power ratings & packaging styles and use of different heat sinks. (09 Hrs.)
		Amplifier 84. Construct and test fixed-bias, emitter-bias and voltage devider-bias transistor amplifier. (06 Hrs.) 85. Construct and Test a common emitter amplifier with and without bypass capacitors. (06 Hrs.) 86. Construct and Test common collector/emitter follower amplifier. (06 Hrs.) 87. Construct and test a two stage RC Coupled amplifier. (06 Hrs.)	Different types of biasing, various configurations of transistor (C-B, C-E & C-C), their characteristics and applications. Transistor biasing circuits and stabilization Techniques. Classification of amplifiers according to frequency, mode of operation and methods of coupling. Voltage amplifiers - voltage gain, loading effect. Single stage CE amplifier and CC amplifier. Emitter follower circuit and its advantages. RC coupled amplifier, Distinguish between voltage and power amplifier, Alpha, beta, voltage gain, Concept of dB dBm. Feedback and its types. (09 Hrs.)

		Oscillators 88.Demonstrate Colpitts oscillator, Hartley oscillator circuits and compare the output frequency of the oscillator by CRO. (06 Hrs.) 89.Construct and test a RC phase shift oscillator circuits. (06 Hrs.) 90.Construct and test a crystal oscillator circuits. (06 Hrs.) 91.Demonstrate Astable, monostable, bistable circuits using transistors. (06 Hrs.)	Introduction to positive feedback and requisites of an oscillator. Study of Colpitts, Hartley, Crystal and RC oscillators. Types of multi vibrators and study of circuit diagrams. (06 Hrs.)
		Wave shaping circuits 92. Construct and test shunt clipper. (06 Hrs.) 93. Construct and test series and dual clipper circuit using diodes. (06 Hrs.) 94. Construct and test clamper circuit using diodes. (06 Hrs.) 95. Construct and test Zener diode as a peak clipper. (06 Hrs.)	Diode shunt clipper circuits, Clamping / limiting circuits and Zener diode as peak clipper, uses their applications. (06 Hrs.)
Professional Skill 75 Hrs; Professional Knowledge	Plan and construct different power electronic circuits and analyse the circuit functioning. **NOS: N/A**	**Power Electronic Components** 96. Identify different power electronic components, their specification and terminals. (05 Hrs) 97.Construct and test a FET Amplifier. (10 Hrs) 98.Construct a test circuit of SCR using UJT triggering. (10 Hrs) 99.Construct a simple dimmer circuit using TRIAC. (10 Hrs) 100.Construct UJT based free running oscillator and change its frequency. (10 Hrs)	Construction of FET & JFET, difference with BJT. Purpose of Gate, Drain and source terminals and voltage / current relations between them and Impedances between various terminals. Heat Sink- Uses & purpose. Suitability of FET amplifiers in measuring device applications. Working of different power electronic components such as SCR, TRIAC, DIAC and UJT. (12 Hrs.)
		MOSFET & IGBT 101.Identify various Power MOSFET by its number and test by using multimeter. (05 Hrs) 102.Construct MOSFET test circuit with a small load. (05 Hrs) 103. Identify IGBTs by their numbers and test by using multimeter. (05 Hrs) 104.Construct IGBT test circuit with a small load. (05 Hrs)	MOSFET, Power MOSFET and IGBT, their types, characteristics, switching speed, power ratings and protection. Differentiate FET with MOSFET. Differentiate Transistor with IGBT. (08 Hrs.)
	Select the appropriate opto electronics components and verify the characteristics in different circuit. **NOS: N/A**	**Opto Electronics** 105.Test LEDs with DC supply and measure voltage drop and current using multimeter. (11 Hrs.) 106.Construct a circuit to test photo voltaic cell. (12 Hrs.) 107.Construct a circuit to switch a lamp load using photo diode. (12 Hrs.) 108.Construct a circuit to switch a lamp load using photo transistor. (12 Hrs.)	Working and application of LED, IR LEDs, Photo diode, photo transistor, their characteristics and applications. Optical sensor, opto-couplers, circuits with opto isolators. Characteristics of LASER diodes. (06 Hrs.)

Professional Skill 75 Hrs; Professional Knowledge 20 Hrs	Assemble, test and troubleshoot various digital circuits. **NOS:ELE/N1201**	**Basic Gates** 109.Verify the truth tables of all Logic Gate ICs by connecting switches and LEDs. (05 Hrs.) 110.Construct and verify the truth table of all the gates using NAND and NOR gates. (05 Hrs.)	Introduction to Digital Electronics. Difference between analog and digital signals. Number systems (Decimal, binary, octal, Hexadecimal). BCD code, ASCII code and code conversions. Various Logic Gates and their truth tables. (05 Hrs.)
		111.Use digital IC tester to test the various digital ICs (TTL and CMOS). (05 Hrs.) **Combinational Circuits** 112.Construct Half Adder circuit using ICs and verify the truth table. (06 Hrs.) 113.Construct Full adder with two Half adder circuit using ICs and verify the truth table. (06 Hrs.) 114.Construct the adder cum subtractor circuit and verify the result. (06 Hrs.) 115.Construct and Test a 2 to 4 Decoder. (06 Hrs.) 116.Construct and Test a 4 to 2 Encoder. (06 Hrs.)	Combinational logic circuits such as Half Adder, Full adder, Parallel Binary adders, 2-bit and four bit full adders. Magnitude comparators. Half adder, full adder ICs and their applications for implementing arithmetic operations. Concept of encoder and decoder. Basic Binary Decoder and four bit binary decoders. Need for multiplexing of data. 1:4 line Multiplexer / De-multiplexer. (10 Hrs.)
		117.Construct and Test a 4 to 1 Multiplexer. (05 Hrs.) 118.Construct and Test a 1 to 4 De Multiplexer. (05 Hrs.) **Flip Flops** 119.Identify different Flip-Flop (ICs) by the number printed on them. (05 Hrs.) 120.Construct and test four bit latch using 7475. (05 Hrs.) 121.Construct and test R-S flip-flop using IC7400 with clock and without clock pulse. (05 Hrs.)	Introduction to Flip-Flop. S-R Latch, Gated S-R Latch, D-Latch. Flip-Flop: Basic RS Flip Flop, edge triggered D Flip Flop, JK Flip Flop, T Flip Flop. Master-Slave flip flops and Timing diagrams. Basic flip flop applications like data storage, data transfer and frequency division. (05 Hrs.)
Professional Skill 48 Hrs; Professional Knowledge 04 Hrs	Simulate and analyze the analog and digital circuits using Electronic simulator software. **NOS:ELE/N6102**	122.Verify the truth tables of Flip-Flop ICs (RS, D, T, JK, MSJK) by connecting switches and LEDs. (05 Hrs.) **Electronic circuit simulator** 123.Prepare simple digital and electronic circuits using the software. (12 Hrs.) 124.Simulate and test the prepared digital and analog circuits. (12 Hrs.) 125.Convert the prepared circuit into a layout diagram. (12 Hrs.) 126.Prepare simple, power electronic and domestic electronic circuit using simulation software. (12 Hrs.)	Study the library components available in the circuit simulation software. Various resources of the software. (04 Hrs.)

Professional Skill 75 Hrs; Professional Knowledge 20 Hrs	Construct and test different circuits using ICs 741operational amplifiers & ICs 555 linear integrated circuits and execute the result. **NOS: N/A**	**Op - Amp & Timer 555 Applications** 127.Use analog IC tester to test the various analog ICs. (07 Hrs.) 128.Construct and test various Op-Amp circuits Inverting, Non-inverting and Summing Amplifiers. (07 Hrs.) 129.Construct and test Differentiator and Integrator. (07 Hrs.) 130.Construct and test a zero crossing detector. (07 Hrs.) 131.Construct and test Instrumentation amplifier. (07 Hrs.) 132.Construct and test a Binary weighted and R-2R Ladder type Digital-to-Analog Converters. (08 Hrs.) 133.Construct and test Astable timer circuit using IC 555. (08 Hrs.) 134.Construct and test mono stable timer circuit using IC 555. (08 Hrs.) 135.Construct and test VCO (V to F Converter) using IC 555. (08 Hrs.) 136.Construct and test 555 timers as pulse width modulator. (08 Hrs.)	Block diagram and Working of Op-Amp, importance, Ideal characteristics, advantages and applications. Schematic diagram of 741, symbol. Non-inverting voltage amplifier, inverting voltage amplifier, summing amplifier, Comparator, zero cross detector, differentiator, integrator and instrumentation amplifier, other popular Op-Amps. Block diagram of 555, functional description w.r.t. different configurations of 555 such as monostable, astable and VCO operations for various application. (20 Hrs.)

Visit various sections of the ITI and identify the location of various installations

Objective: At the end of this exercise you shall be able to
- **list the trades available at the ITI**
- **identify the staff and their designations**
- **draw the layout of the Electronics Mechanic laboratory**
- **identify the location of power room and switch controls.**

Requirements

Tools/Equipments/Instruments

- Trainees Tool kit - 1 Set
- Steel rule, 300 mm - 1 No

Materials/Components

- Pencil HB - 1 No
- Eraser - 1 No
- Drawing sheet - A 4 size - 3 Nos

PROCEDURE:

TASK 1: **Visiting various sections of ITI and identification of trades**

Instructor has to lead the trainees to visit various sections of the ITI.

1 Follow the Instructor, identify each section, name of the staff member, designation and record them in Table - 1

Table - 1

Sl No	Name of the section /Trade	Staff member	Designation	Phone number
1				
2				
3				

2 Collect the telephone numbers of ITI office, nearest hospital, police station, fire station and record them in Table - 2

Table - 2

Sl No.	Place	Phone No	Remarks
1	ITI office		
2	Hospital		
3	Police station		
4	Fire station		

The Instructor may add column for any important aspect if required in Table - 2

3 Get the work checked by the Instructor.

— — — — — — — —

TASK 2: **Drawing the layout of E.M. laboratory / Section and identification of control switches**

1 Draw the plan of EM laboratory / section to a suitable scale in drawing sheet.

2 Identify the location of AC mains power control / back - up power, distribution board, MCB and lighting switch controls.

3 Mark the locations of the above points on the plan drawing / diagram.

Instructor may help them to operate the important switches in case of any emergency situation.

4 Get the work checked by the Instructor.

— — — — — — — —

Identify safety signs for danger, warning, caution & personal safety message

Objectives: At the end of this exercise you shall be able to
- **identify different types of safety signs.**
- **prepare safety sign boards.**

Requirements

Tools/Equipments/Instruments

- Trainees Tool Kit - 1 Set
- Scissors - 1 No

Aids: Wall chart showing all types of safety signs as per the trade syllabus.

Materials/Components

- Pencil - HB - 1 No
- Eraser - 1 No
- Drawing Sheet - A 4 size - 5 Nos
- Colour Sketch Pen - 1 Set
- Cardboard - 1 No
- Gum - 1 No
- Twine Thread - 1 Roll
- Geometry Box - 1 No

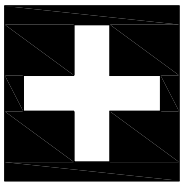
The instructor has to arrange for various types of safety signs with label number for each one.

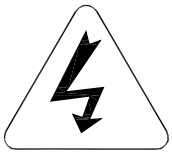
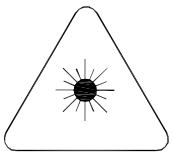
PROCEDURE

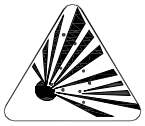
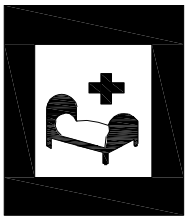
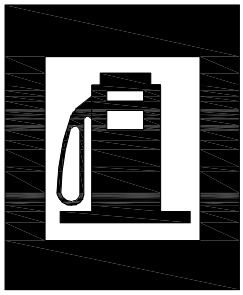
TASK 1: **Identification of different safety signs**

Identify the labelled safety sign, record type of safety sign and the meaning in Table 1.

Table 1

Label No.	Sign	Type	Meaning
1			
2			
3			
4			

Label No.	Sign	Type	Meaning
5			
6			
7			
8			
9			
10			
11			
12			
13			

Label No.	Sign	Type	Meaning
14			
15			
16			
17			
18			

2 Get the work checked by the Instructor.

— — — — — — — —

TASK 2: **Preparation of safety sign boards**

1 Draw the free hand sketch of warning sign on A4 sheet using geometry box.

2 Use sketch pens and apply appropriate colours, finalise the diagram.

3 Cut along the outside line of the prepared diagram using scissors.

4 Keep the safety sign diagram on the card board, mark along the outside line using pencil and cut the excess portion.

5 Paste the prepared safety sign diagram on the card board using gum and allow it to dry up.

6 Make a small hole, insert the thread and tie it to hang the prepared safety sign board as shown in Fig 1.

Fig 1

7 Get the work checked by the Instructor.

— — — — — — — —

Use of Personal Protective Equipment (PPE)

Objective: At the end of this exercise you shall be able to
- **state the use of different PPEs**

Requirements

Tools/Equipments/Instruments		Materials/Components	
• Trainees tool kit	- 1 Set	• Pencil	- 1 No
Aids:		• Eraser	- 1 No
Chart showing all types of PPE items	- 1 No	• Drawing sheet	- 1 No
		• Colour Sketch pen	- 1 Set

The Instructor has to arrange a minimum of five PPE items and label them before issuing to trainees.

PROCEDURE

TASK 1: **Stating the use of different PPEs**

1 Identify the labelled PPE item and record the details of each Personal protective Equipment in column- 3 to 5 about name type of protection and uses in Table - 1.

Table - 1

Label No.	Sign	Name	Type of Protection	Uses
1				
2				
3				
4				
5				
6				

2 Get the work checked by the Instructor.

— — — — — — — —

Practice elementary first aid

Objective: At the end of this exercise you shall be able to
- **study and practice on first aid Artificial respiration.**

Requirements

Tools/Equipments/Instruments

- Rubber mat. - 1 No
- Wall chart on Artificial respiration practice - as reqd
- Audio Visual Aids: video film on Artificial respiration - as reqd

Materials/Components

- Dry wooden stick - 1 No

PROCEDURE

TASK 1: **Providing First-aid to the Victim**

1 Put the main switch to OFF so as to release the victim from live line contact. Increase of difficulty to reach the main switch release the victim by means of a wooden stick / rubber item etc. while keeping yourself isolated from the “Earth” contact.

2 If the victim is unconscious or blisters (Burns) have developed on his/her body then call a doctor through telephone or through some one else but do not leave the victim.

3 Start the following first-aid procedure till the doctor is available:

i Loosen or remove victim’s shoes, cloths etc. But take care that the blisters (Burns) do not break.

ii Cover victim’s body by using a blanket so as to keep him/her warm.

iii If the victim’s breathing appears to be suppressed then remove the crowd from his / her surroundings. If the victim is in a room then open up all doors and windows so as to enable him / her to breath in fresh air.

4 Remove artificial teeth, tobacco etc. from the victim’s mouth and start artificial respiration procedure (suitable) for restoring normal breathing.

— — — — — — — —

TASK 2: **Providing Artificial Respiration**

a HOLGEN-NELSON’S method

- **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.**
- **Be brisk in carrying out this method but avoid violent operations which may cause injury to the internal parts of the victim.**

1 As shown in the 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.

2 As shown in the 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.

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

4 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 arm and move your hands up to the initial position.

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

Fig 1

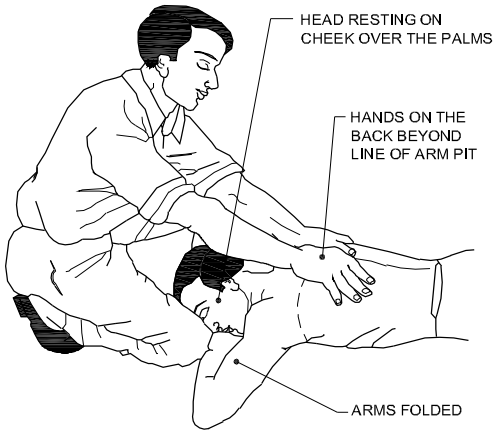


Fig 2

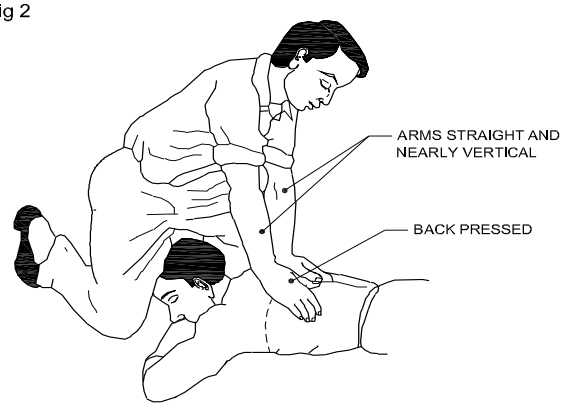


Fig 3

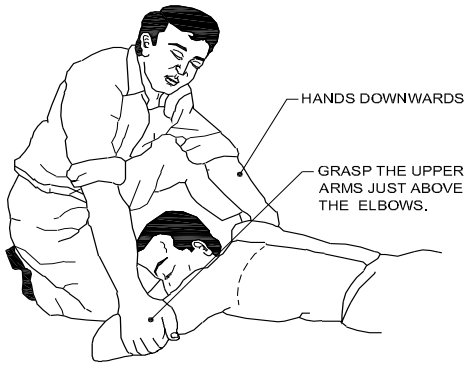
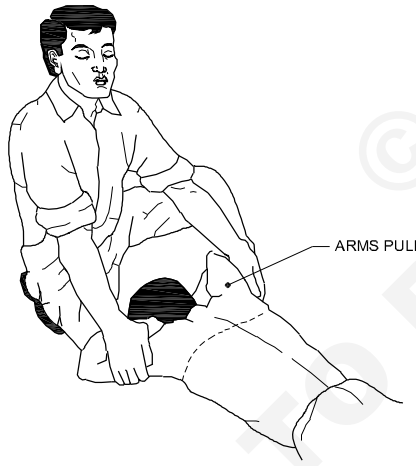


Fig 4



b **SCHAFER'S method**

- **Do not use this method of artificial respiration in case the victim has injuries on his chest or abdomen.**
- **Be brisk in carrying out this method but avoid violent operations which may cause injury to the internal parts of the victim.**

1 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 sidewise and resting on the hand or forearm as shown in Fig 5.

2 Kneel astride the victim as shown in Fig 6 such that his thighs are in between your knees. Position your fingers and thumb as shown in figure.

3 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 figure. This weight forces the air out of the victim's lungs.

4 Now swing backward immediately removing all pressure on the lower ribs. This allows the lungs to get filled with air.

5 After 2 to 3 seconds, swing forward again and repeat the cycle (from step 4 to 5) twelve to thirteen times in a minute.

Fig 5

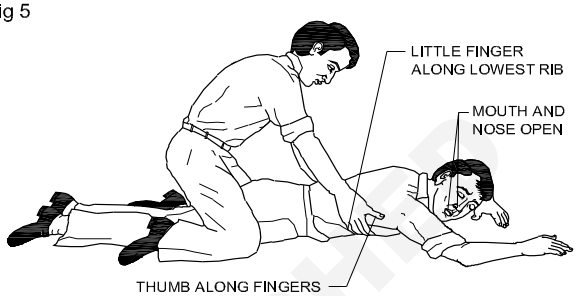
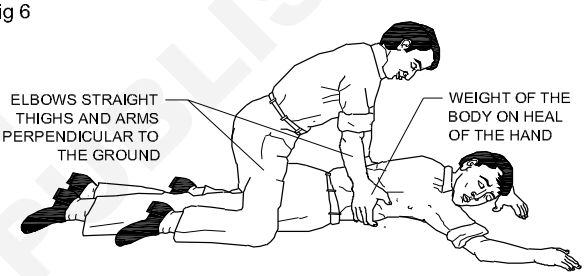


Fig 6



c **Mouth-to-Mouth Process (method)**

- **Be brisk in carrying out this method but avoid violent operations which may cause injury to the internal parts of the victim.**

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

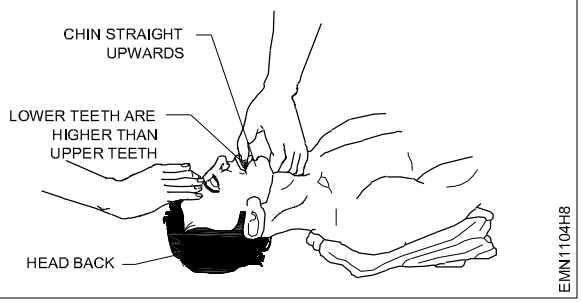
2 Lay the victim flat on his back. Place a roll of clothing under his shoulders such that his head is thrown well back as shown in Fig 7.

Fig 7

3 Tilt the victim's head back so that the chin points straight upward.

4 Grasp the victim's jaw as shown in Fig 8 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 8



5 Take a deep breath and place your mouth over the victim's mouth as shown in Fig 9 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. If you dislike direct contact, place a porous cloth between your mouth and the victim's mouth.

Fig 9

6 If air cannot be blown in, check the position of the victim's head and jaw. Check the mouth for obstructions (block). 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 5 and 7, eight to ten times rapidly. Then slow down to 10-20 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.

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Preventive measures for electrical accidents & steps to be taken in such accidents

Objectives: At the end of this exercise you shall be able to
- **prevent electrical accidents**
- **following the steps to be taken in electrical accidents.**

PROCEDURE

TASK 1: **Prevention of electrical accidents**

1 Keep the work area clean.

2 Use licensed electrical and electronics items only.

3 Ensure that before touching the body of equipment there is no leakage of electric current in it.

4 Before starting the maintenance or repair work on any equipment, either disconnect it from the mains supply or keep yourself isolated from the earth contact by using rubber shoes, rubber matting or dry-wooden board/stool.

6 necessary instruments, circuits, etc. and arrange them on the table as per the sequence of requirement.

7 Select proper insulated tools for the job, clean and restore the same to its place after use.

8 Always disconnect the equipment to be repaired from the mains line by pulling the plug-top and not by pulling the power cord.

9 Always discharge high voltage filter capacitors after opening the equipment and before starting repairs by short circuiting the capacitor terminals with a piece of thick wire.

10 Keep yourself away from the Extra High Tension (EHT) points while the TV receiver is "ON" because 12KV to 25KV EHT remains present on the picture tube and the same can give you a severe electric shock.

11 Always use a 25 Watts or 35 Watts soldering iron while working on a Printed Circuit Board (PCB). The use of more wattage soldering iron can damage the PCB line as well the component.

12 Replace or remove fuses only after switching OFF the circuit / equipment.

— — — — — — — —

TASK 2: **Steps to be taken during the occasion of electrical accidents**

1 Do not touch the victim or the equipment/appliance which is under accident.

2 Unplug the equipment/appliance or turn OFF the mains power.

3 In case you can't turn off the power, use a piece of wood, like a broom handle, dry rope or dry clothing, to separate the victim from the live line.

4 Call the doctor immediately. Even if the victim's breathing and heartbeats have recovered, do not delay in calling a doctor for a check-up and treatment.

5 Keep the victim lying down; Unconscious victim should be placed on their side to allow any fluid coming out from mouth to drain.

6 If the victim is not breathing, apply mouth-to-mouth resuscitation. If the victim has no pulse, begin cardiopulmonary resuscitation (CPR). Then cover the victim with a blanket to maintain body heat, keep the victim's head low and get medical attention.

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

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

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Use of fire extinguishers

Objectives: At the end of this exercise you shall be able to
- **identify the types of fire**
- **select the proper type of fire extinguisher**
- **use of the fire extinguishers.**

Requirements

Tools/Equipments/Instruments		Materials/Components	
• Trainees tool kit	- 1 Set	• Scrap material like Wood / Wire pieces/Oil/Cotton cloth	- 1 kg
• Different type of Fire extinguishers	- 1 No (each)	• Match Box	- 1 No

PROCEDURE

TASK 1: **Identification of types of Fire and Fire Extinguisher to be used**

1 If an electrical system begins sparking or a fire ignites at a wire, appliance, or outlet, then cutting the power to the system is the first as well as best step to take.

2 Identify the type of fire like Class-A (Wood, paper cloth), Class-B (Flammable Liquid & Liquefiable solids), Class-C (Gas and liquefied gas), etc.

3 Based on the type of fire, identify the type of fire extinguisher is to be used like, Dry Powder Fire Extinguisher, Foam type Fire Extinguisher, Carbon-di-oxide Fire Extinguisher, Water Fire Extinguisher, etc.

TASK 2: **Using Procedure of Fire Extinguisher**

1 Stand with your back to an exit as shown in figure.

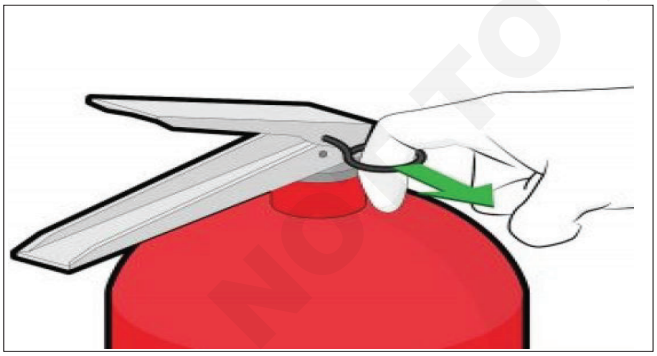
2 To employ the extinguisher with proper technique, just remember the acronym "PASS."

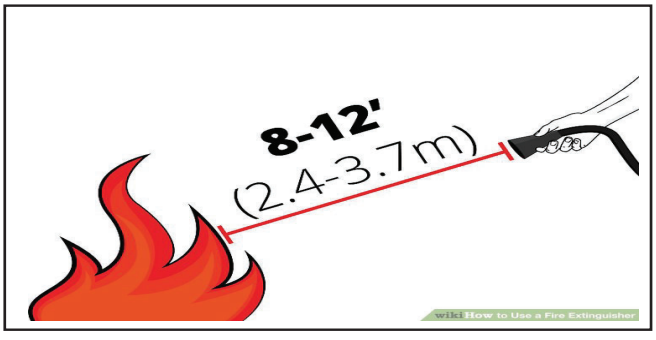
P - Pull

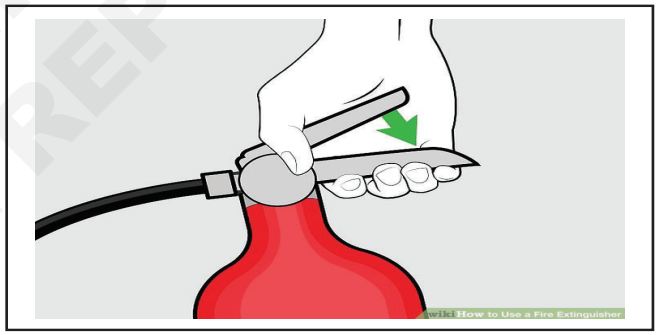
A - Aim

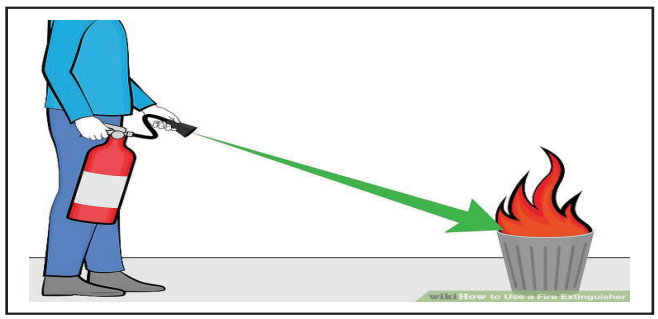
S - Squeeze

S - Sweep









3 **Pull** the safety pin of the Fire extinguisher.

4 **Aim** the nozzle at the base of the fire. Hitting the tops of the flame with the extinguisher won't be effective.

5 **Squeeze** the trigger. In a controlled manner, squeeze the trigger to release the agent.

6 **Sweep** from side to side. Sweep the nozzle from side to side until the fire is put out. Keep aiming at the base while you do so. Most extinguishers will give you about 10-20 seconds of discharge time.

7 Get the work checked by the Instructor.

Identify the different hand tools

Objectives: At the end of this exercise you shall be able to
- **identify the different types of hand tools**
- **record the specification of the hand tools.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set

Materials/Components

- Cotton Waste - ½ kg
- Emery sheet - 1 No

PROCEDURE

- **The Instructor has to label the tools used for this exercise.**
- **And also arrange for tools and the required materials from scrap for practicing the functioning of tools.**

1 Pick one of the labelled hand tools from the Workbench.

2 Identify and record the name of the labelled hand tool in Table - 1.

3 Measure the size and record the specification of the hand tool in the Column-3 of the table.

4 Draw the outline sketch of the hand tool in Column-4 of the table.

5 Repeat step-2 to 4 for the remaining hand tools.

6 Get the work checked by the Instructor.

Table - 1

Label No.	Name of the Tools	Specification	Sketch of Tool
1	Screw Driver		
2	Star Screw Driver		
3	Line Tester		
4	Instrument Screw Driver		
5	Long Nose Plier		
6	Combination Plier		
7	Side Cutting Plier		
8	Wire Stripper		
9	Scriber		
10	Hack Saw Frame		
11	Ball Pein Hammer		
12	Chisel		
13	Soldering iron stand		
14	Soldering Iron		
15	De-soldering Pump		
16	Flat File		
17	Round File		
18	Tweezer		
19	Magnifying Glass		
20	Cleaning Brush		
21	Steel Rule		

Selection of proper tools for operation and precautions in operation

Objectives: At the end of this exercise you shall be able to
- **select proper tools for operation**
- **use the hand tools with precautions.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Different types of tools used in Electronics work - 1 No (each)

Materials/Components

- Cotton Waste - ½ kg
- Emery sheet - 1 No

PROCEDURE

The instructor has to arrange the tools and required materials for practicing the functioning of tools. The Instructor has to label the tools used for this exercise.

1 Pick one of the labeled hand tools from the Workbench.

2 Identify and record the name of the hand tool in Table - 1

3 List the use/application of the tool in Column-3 of the table.

4 Record the precautions involved while operating the tools in Column-4 of the table.

5 Repeat step-2 to 4 for the remaining hand tools.

6 Get the work checked by the Instructor.

Table - 1

Label No.	Name of Tools	Uses/applications	Precautions
1	Screw Driver		
2	Star Screw Driver		
3	Line Tester		
4	Instrument Screw Driver		
5	Long Nose Plier		
6	Combination Plier		
7	Side Cutting Plier		
8	Wire Stripper		
9	Scriber		
10	Hack Saw Frame		
11	Ball Pein Hammer		
12	Chisel		
13	Soldering iron stand		
14	Soldering Iron		
15	De-soldering Pump		
16	Flat File		
17	Round File		
18	Tweezer		
19	Magnifying Glass		
20	Cleaning Brush		
21	Steel Rule		

Care & maintenance of trade tools

Objective: At the end of this exercise you shall be able to
- **learn and practice care and maintenance of hand tools.**

Requirements

Tools/Equipments/Instruments		Materials/Components	
• Trainees tool kit	- 1 Set	• Cotton Waste	- ½ kg
		• Emery sheet	- 1 No
		• Lubricating Oil	- ½ Lt

PROCEDURE:

1 Keep the tools in a Dry Place.

2 Wipe or clean after every use with a clean and soft cloth to remove dirt/ dust.

3 Keep all the tools in a tool room / tool rack.

4 Store power tools in their original cases.

5 Apply the recommended appropriate oil to prevent the tools from rusting.

6 Use silica gel packs

7 Do not use knife, screw driver, hammer etc., without a handle. A tool without a handle should not be used.

8 While giving a tool to another person, always give it through its handle side.

9 During rainy season, fine layer of oil or grease should be applied to the appropriate metallic parts of tools.

10 If a layer of oil or grease is present at the handle of a tool then it should be cleaned off first with a piece of cloth soaked in kerosene oil or petrol, and then the same should be used.

11 A plier should not be used like a hammer and its insulating cover should be preserved.

12 Never use screwdrivers as wood chisel or cold chisel.

13 Steel wires should not be cut with a side cutter.

14 A neon tester should not be used as a screw driver.

15 A knife should not be used for cutting wires. It should be used only for scrapping the insulation of wires.

16 A hacksaw blade should be well tight in its frame and it should cut the metal in its forward stroke.

17 Before using a drilling machine, check that the drill bit is properly tighten.

18 Do not use a soldering iron of more than 15 to 25 watts while working on a circuit containing transistors and ICs.

19 Keep the soldering iron's bit clean and maintain its shape.

20 Use plastic and Bakelite screw drivers for the 'Alignment' job of a radio or TV receiver.

— — — — — — — —

Practice safety precautions while working in fitting jobs

Objective: At the end of this exercise you shall be able to
- **state and practice safety precautions while working in fitting jobs.**

Requirements

Tools/Equipments/Instruments		Materials/Components	
• Trainees tool kit	- 1 Set	• Cotton Waste • Emery sheet	- ½ kg - 1 No

PROCEDURE:

Follow the safety precautions in the fitting workshop

1 Ensure that the handle of file is fitted tightly.

2. Fix the work piece in the vice clamped correctly.

3 Never use hammers with loose heads.

4 Use the proper tool for the job.

5 Do not use a spanner as hammer.

6 Do not use a steel rule as a screw driver.

7 Use coolant at the time of hack - sawing and drilling.

8 Clean the work place after each work and keep neat.

— — — — — — — —

Workshop practice on filing and hacksawing

Objective: At the end of this exercise you shall be able to
- **hold different section of job for hacksawing**
- **cut the job using hacksaw**
- **file the job piece for smoothing the surface.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Engineer's Steel Rule 300 mm - 1 No
- Metallic Scriber 150 mm - 1 No
- Hacksaw frame with Blade 30 mm - 1 No
- Flat file 300 mm - 1 No
- Half Round file 300 mm - 1 No

Materials/Components

- Hylam Board, 2mm Thick - 1 Sq.ft
- Sand paper, No. 60 grade - 1 No
- Cotton waste - ½ kg

PROCEDURE

The Instructor has to give a dimension for the job of hack saw cutting on the Hylam board.

TASK 1: **Marking of Hylam Sheet**

1 Take the Hylam sheet and clean by using dry cloth/ paper.

2 Use the Steel Rule and scriber, mark the given dimensions on the hylam sheet.

3 Get the work checked by the Instructor.

Safety: Hold the hacksaw frame firmly and carefully.

— — — — — — —

TASK 2: **Cutting of Hylam Board using Hacksaw**

1 Fix the job piece in the bench vice tightly.

2 Fix the hacksaw blade into the frame with proper direction.

3 Using hacksaw, cut the hylam board at the markings.

Note: When sawing with the hand hacksaw start the movement from the arms and is assisted by a corresponding movement of the body.

4 Make forward stroke with pressure on the handle by pushing the hack saw for cutting.

5 Make return stroke without pressure by pulling the handle to move backwards.

6 Move the full length of the saw blade for cutting in forward stroke

7 Saw correctly in a straight line along the marked line.

8 Get the work checked by the Instructor.

— — — — — — — —

TASK 3: **Filing the job**

1 Hold the job in the bench vice with a projection of 5 to 10 mm from the top of the vice jaw.

2 Select flat files of various grades and length according to the, size of the job, quantity of metal to be removed/ material of the job.

3 Hold the handle of the file and push the file forward using your hand palm.

4 Hold the tip of the file according to the quantity of the metal to be removed for heavy filing or light filing or for removing local unevenness.

5 Start filing by pushing the file uniformly during the forward stroke and release the pressure during the return stroke.

Note: Continue giving strokes. Balance the pressure of the file in such a way that the file always remains flat and straight over the surface to be filed.

6 Check the surface and continue filing if required.

7 Get the work checked by the Instructor.

— — — — — — — —

Practice simple sheet metal works, fitting and drilling

Objective: At the end of this exercise you shall be able to
- **mark, cut, bend and assemble a sheet metal work.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Engineer's Steel Rule 300 mm - 1 No
- Metallic Scriber 150 mm - 1 No
- Hacksaw frame with Blade 300 mm - 1 Set
- Flat file 300 mm - 1 No
- Half Round file 300 mm - 1 No
- Shearing Machine - 1 No
- Press Break - 1 No
- Centre punch - 1 No
- Ball pein hammer - 1 No
- Electrical hand drilling machine - as reqd

Materials/Components

- Aluminium sheet 2mm Thick - 1 Sq. ft
- Sand paper No 6 grade - 1 No
- Cotton waste - ½ kg
- Rivet (size and number as per the job drawing) - as reqd

PROCEDURE

1 **Marking:** Mark the required dimensions and holes where to be made using steel rule and scriber. Mark the line for rivet/weld on the sheet metal.

2 **Cutting:** Cut a large sheet into smaller rectangles using a shearing machine or snips.

3 **Punching:** Punch the centre points of the holes to be drilled lightly using a centre punch and hammer.

4 **Drilling:** Place the sheet on the workbench and drill the required holes using portable drill machine. If the sheet is thick and hard, then make holes using bench drilling machine.

Safety precaution:

- **Turn OFF the drilling machine when fixing/ changing Drill Bits. Ensure that the Chuck is tight before Using the Drill.**
- **Hold the sheet metal when marking/cutting/ punching or drilling operations bending.**

5 **Bending:** Position the sheet on the Press break so the bend line is above a vee-shaped channel then brings down the bending tool. This pushes the sheet into the vee and the sides of the blank move up as the bend is formed. Hold the Sheet Parallel to the Bender

6 **Assembling:** Each piece of the assembly is held in position with clamps. Then tack weld or rivets or screwing are made to hold everything together.

Wear safety glasses to protect your eyes from flying debris.

7 **Finishing:** After assembly or joining most fabrications get some finishing. This ranges from cleaning up welds to polishing to a mirror finish, range of painting and coating options. These usually have two objectives: protect the fabrication against corrosion, and provide whatever finished appearance is needed.

Identify the phase, neutral and earth on power socket use testers to monitor AC power

Objectives: At the end of this exercise you shall be able to

- **test and identify phase, neutral and earth terminals of a single phase AC mains 3 - pin socket using.**
  1 test lamp
  2 neon tester

Requirements

Tools/Equipments/Instruments

- Trainees Tool Kit - 1 Set
- Neon tester, 500 V - 1 No
- Digital multimeter with probes - 1 No
- Test lamp with holder and grill (240V AC/60 Watt) - 1 No

Materials/Components

- PVC wire (1.5 sq.mm) - 1 m
  Red colour, (5/20 gauge) - 1 m
  Black colour, (5/20 gauge)
- Incandescent bulb 60 watts/250 V - 1 No
  (per batch) - 1 No
- Sketch pen - 1 No

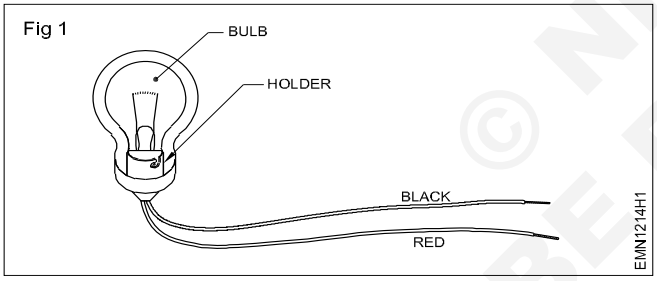
PROCEDURE

Safety precaution: Be cautious and safety from electrical shock.

Fix the grill on the holder to prevent damage to bulb

1 Make a test lamp setup as shown in Fig 1

Fig 1



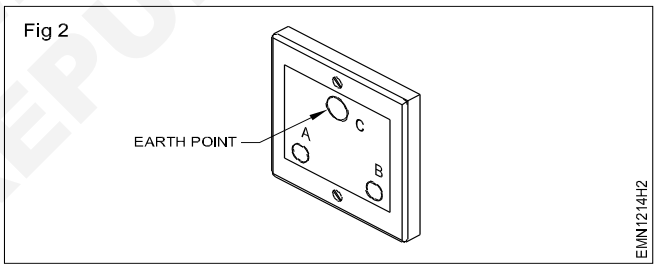
2 Test the continuity at the free ends using an ohmmeter to confirm correct wiring and connections of the test lamp.

3 Mark terminal sockets on the 3 - pin 230V, AC mains socket to identify phase, neutral and earth points as A, B and C using sketch pen as shown in Fig 2.

4 Switch ON the AC supply to the 3 pin socket.

5 Connect the test lamp across the 3 -pin socket outlet points (A&B) and check the presence of mains supply.

Fig 2



6 Record the observation in Table - 1

- If supply does not exist (lamp does not glow), consult your instructor before carrying out further steps.
- If lamp glows, the outlet point B is Phase or Live (L) mark outlet B as 'L' using sketch pen. Repeat steps 5 and 6 with the test lamp across Earth and socket B

7 Repeat steps 5 & 6 with test lamp across A - C and if lamp does not glow, the other point A is neutral (N) mark it as N.

Table - 1

Sl No.	Measurement across			Lamp condition	Remarks
	A- B	B - C	C- A		
1		-	-		
2	-		-		
3	-	-			

8 Get the work checked by the Instructor.

Note: If the mains supply circuit is provided with ELCB, it may break the circuit when the test lamp in connected across the line L and earth E

Construct a test lamp and use it to check mains healthiness

Objectives: At the end of this exercise you shall be able to
- **construct a test lamp**
- **check mains healthiness by using the test lamp.**

Requirements

Tools/Equipments/Instruments

- Trainees Tool Kit - 1 Set
- Digital multimeter with probes - 1 No

Materials/Components

- PVC wire,
  Red colour, (5/20 gauge) - 1 m
  Black colour, (5/20 gauge) - 1 m
- Incandescent bulb 60W/250V - 1 No

PROCEDURE

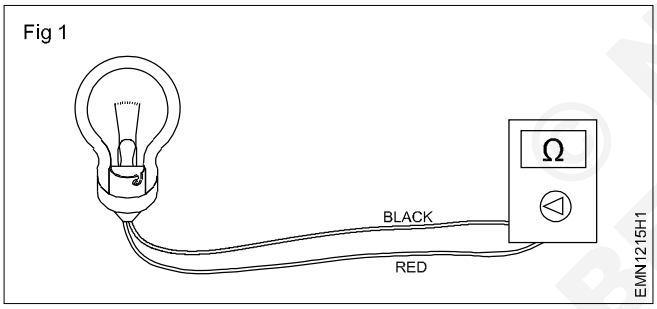
Safety precaution: Be cautious and your safety from electrical shock is your responsibility.

1 Skin the terminals of PVC wire and connect them into pendent lamp holder.

2 Fix the 60 watt bulb into the lamp holder.

3 Use ohm meter test and ensure continuity of the constructed test lamp as shown in Fig 1.

Fig 1



4 Connect the test lamp across live and neutral terminals of AC mains supply point.

5 Switch ON the mains supply and observe the brightness of lamp.

6 Record the observation of mains healthiness as good in Table - 1

Table - 1

Lamp brightness		Mains healthiness
OK	Not OK	

7 Get the work checked by the Instructor.

Measure the voltage between phase and ground and rectify earthing

Objectives: At the end of this exercise you shall be able to
- **measure the voltage between phase to ground and detect the fault**
- **rectify defective earth connection.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Digital multimeter with probes - 1 No
- Test lamp - 1 No

Materials/Components

- Sketch pen - 1 No

PROCEDURE

Safety precaution: Be cautious when working on live Ac mains supply

TASK 1: **Measurement of voltage between phase and ground terminals**

1 Identify the phase and earth terminals of 3 pin AC 230V socket outlet.

2 Mark the three terminals as L.N & E using sketch pen

3 Switch ON the mains supply to the 3 pin socket.

4 Select AC voltage range on the DMM and measure voltage across 'L' and 'E' terminals as shown in Fig 1.

5 Record the observation in Table - 1.

Fig 1

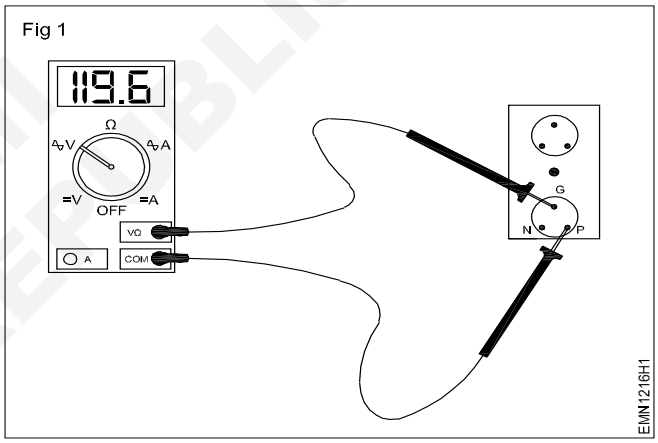


Table - 1

Sl No	AC voltage measured across terminals		Remarks
	L to E	L - N	
1			
2			

6 Get the work checked by the instructor.

— — — — — — — —

TASK 2: **Rectification of the defective earth.**

1 Connect test lamp between the earth and phase terminals socket.

2 Observe the condition of the brightness in the lamp.

3 Connect the test lamp between L and N terminals and confirm the lamp glowing.

4 Switch OFF the mains supply, remove the 3 pin socket and observe the wire connection on the earth terminal.

5 Check and ensure the continuity of the wire to the earth pit on the ground.

6 Check the continuity between the earth electrode and wire conductor.

7 Remove the bolt & nut clean the corrosion on the electrode contact terminal.

8 Refix the earth wire connection to the electrode. (Use new bolt & nut if the old is more corroded).

9 Check the continuity from earth electrode to the 3 pin socket terminal.

10 Switch ON power use test lamp, and measure voltage across 'L' and 'E' terminals record your observations.

11 Get the work checked by the Instructor.

— — — — — — — —

Identify and test different AC mains cables

Objectives: At the end of this exercise you shall be able to
- **identify different types of AC mains cables**
- **test different AC mains cable.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Digital multimeter with probes - 1 No

  Aids: Chart showing different types of cables

Materials/Components

- 5 core cable - 1 m
- 4core cable - 1 m
- 3 core cable - 1 m
- 2 core cable - 1 m
- Cotton waste - as reqd
- Cotton cloth - as reqd

PROCEDURE

Note: The instructor has to select the types of cables for this exercise and label them using numbers

TASK 1: **Identification of types of cables**

1 Pick one of the labelled cable from given lot, identify the number of cores, their colours and number of conductors in each core. (Figs 1 to 4)

2 Record the observations in Table - 1 (Refer to the chart to identify the name of cable)

Fig 1

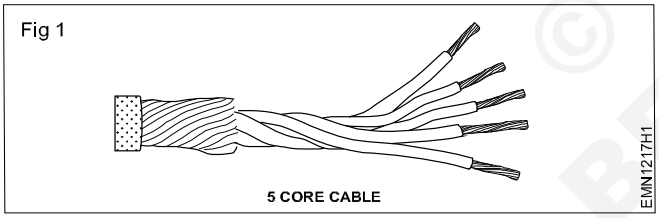


Fig 2

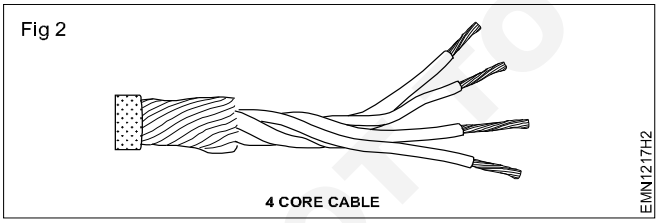


Fig 3

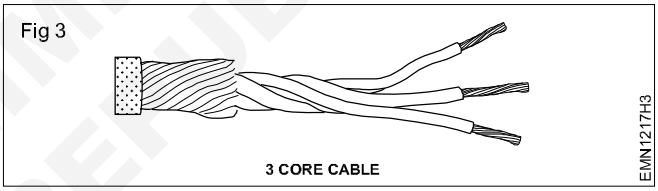
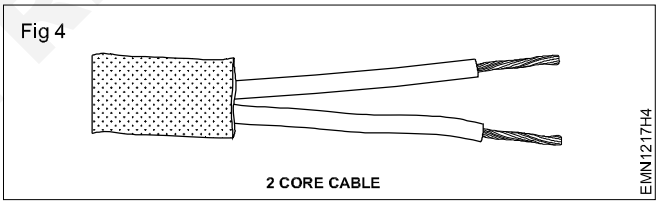


Fig 4



3 Repeat steps 1 & 2 for remaining labelled cables.

4 Check the continuity of each core of above cables and record your observations in Table 1

Table - 1

Sl. No.	Label No.	No of Cores	Colours	No of Strands	Type name	Value in ohms	Remarks
1							
2							
3							
4							
5							

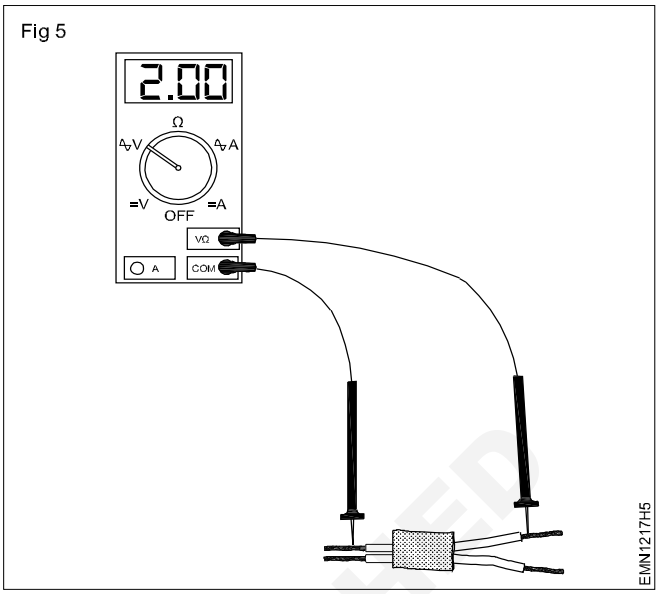
5 Get the work checked by the instructor.

TASK 2: **Testing of different AC mains cables**

1 Connect the each cable ends between the proper terminals of multimeter for continuity test as shown in Fig 5.

2 If the reading shows zero, then there is continuity in the cables. If it shows infinity, there is a break in the cable.

Fig 5



Prepare terminations, skin the electrical wires / cables using wire stripper and cutter

Objectives: At the end of this exercise you shall be able to
- **skin (cut and remove) the insulation of cables using manual stripper**
- **skin the insulation of two core cable using auto ejection type wire stripper**
- **remove the insulation of the PVC sheathed cable using side cutting pliers**
- **terminating wire end with crocodile clip and banana plug**
- **terminating skinned cable to three pin mains plug.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Wire stripper: manual & auto ejection type - 1 each
- Diagonal cutting pliers 150 mm - 1 No

Materials/Components

- Copper and aluminium cables of the following sizes:
- PVC single strand 1.5 sq. mm - 3 m
- PVC single strand 2.5 sq. mm - 3 m
- PVC cable 14/0.2 mm - 3 m
- PVC cable 21/0.2 mm - 3 m
- PVC cable 40/0.2 mm - 3 m
- Crocodile clips (Black x Red) - 2 Sets
- PVC insulated and PVC sheathed cable single core - 3 m
- Two core PVC cable (250V/ 6A) -1 m
- 3 core PVC cable - 1 m
- 3 pin electrical mains plug 250 V/6A - 1 No
- Cut pieces of flat twin core cable - 3 m

PROCEDURE

TASK 1: **Skinning the cable insulation using a manual wire stripper**

1 Pick one of the labelled cable.

2 Straighten the cable ends at which insulation is to be skinned.

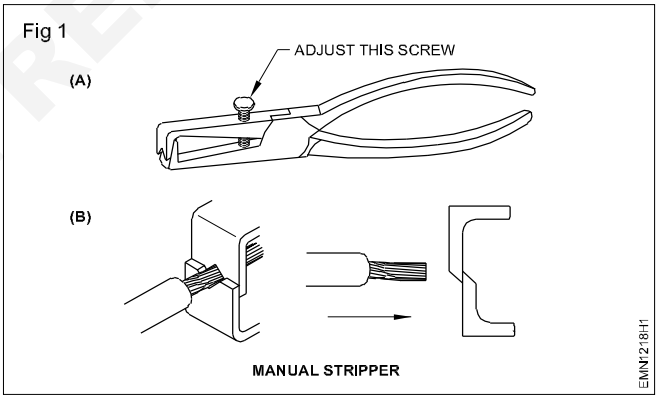
3 Mark the point 10 mm from which the insulation is to be skinned on both the ends of the cable.

4 Adjust the jaws of the manual stripper to suit the gap equivalent to the size of the conductor core. (Fig 1a and 1b) and set the stop position of the screw

5 Hold the cable firmly in one hand, set the jaws at the mark, press the handle of the stripper and make a cut on the insulation.

Safety: Exercise care, not to nick the conductor. For better practice try on small waste pieces of wires.

Fig 1



6 Pull the stripper to remove the insulation.

7 Get the work checked by the Instructor.

— — — — — — — —

TASK 2 : **Skinning the cable insulation using an auto ejection type wire stripper**

1 Repeat steps 1 to 3 of Task - 1

2 Take the auto ejection type wire stripper and jaws, slots for various diameter markings. (Fig 2 and 3)

3 Select a slot in the jaws whose diameter is equal to the conductor core

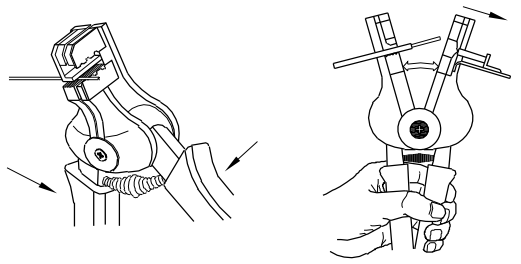
Safety Precaution: While using this stripper the cable insulation should be put in the proper slot to avoid damage to the conductor.

4 Place the marked point of cable at the jaws of the stripper exactly at the slot.

5 Hold the cable firmly in one hand and press stripper handles till the insulation is cut and removed from the cable end.

6 Repeat the above steps to skin the other ends of the cables

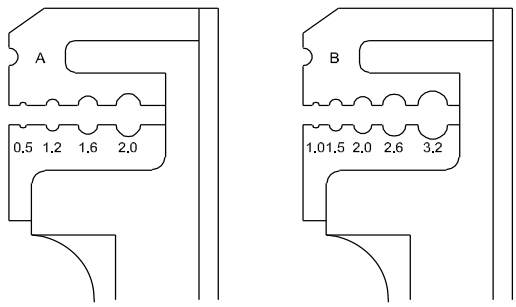
Fig 2



AUTO - STRIPPER

EMN1218H2

Fig 3



JAWS OF AN AUTO STRIPPER

EMN1218H3

7 Get the work checked by the instructor.

— — — — — — — —

TASK 3 : **Skinning the insulation of three core cable**

1 Mark out the length up to which the insulation has to be removed from the cable end.

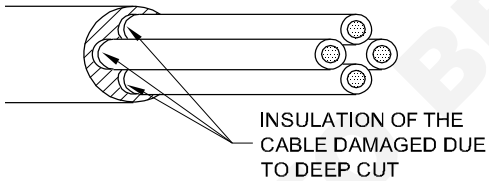
2 Hold the cable firmly, place the electrician knife on the marking of the sheath or insulation of the cable to be removed.

3 cut the insulation to a depth of approximately 1 mm thickness of the sheath or insulation carefully.

Safety precaution: Use the knife carefully. By cutting too deep into the insulation or sheath of a cable will damage the insulation of wires inside the cable. Avoid deep cutting (Fig 4).

This causes short circuit and breakdowns in electrical installations.

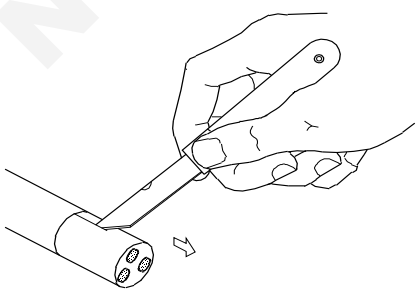
Fig 4



EMN1218H4

4 Place the cable end on table top, use the knife, slit open the sheath or insulation between the circular cut you have made at the end of the cable, as shown in (Fig 5).

Fig 5



CUT ALONG THE CENTRE OF THE CABLE

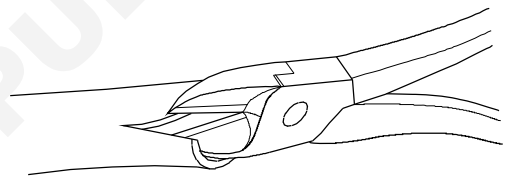
EMN1218H5

Here again be very careful not to cut the insulation of wires inside the cable.

Alternative method - using diagonal cutting pliers.

1 Cut the covering from the marked end up to the length it should be removed by using side cutting pliers as shown in Fig 6.

Fig 6

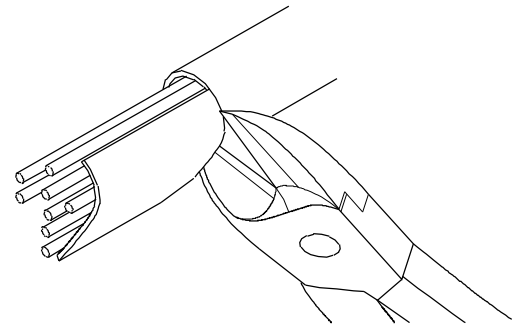


INSULATION REMOVAL BY A SIDE CUTTING PLIER

EMN1218H6

2 Cut the sheathing along the circumference as shown in Fig 7.

Fig 7



EMN1218H7

3 Get the work checked by the Instructor.

— — — — — — — —

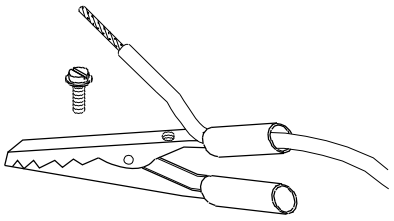
TASK 4 : **Terminating wire end with crocodile clip and banana plug**

1 Take a piece of tinned red wire and a red crocodile clip.

2 Unscrew and take out the screw and washer from the crocodile clip.

3 Insert the tinned end of the wire through the leg of the crocodile clip as shown in Fig 8.

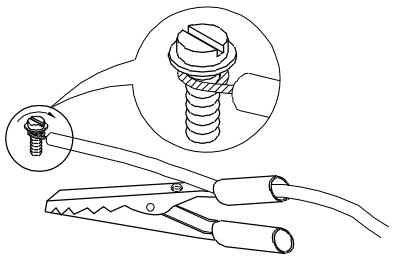
Fig 8



EMN1218H8

4 Bend the tinned exposed conductor to form a loop using a round nose plier. Place the loop in the screw, such that the loop is in the direction of screw as shown in Fig 9

Fig 9



EMN1218H9

5 Put the screw back on the crocodile clip and tighten the screw firmly. While tightening hold the wire such that wire does not protrude below the screw washer.

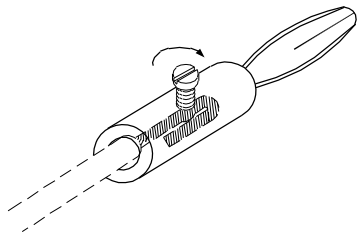
Excessive wire protrusion results in weak termination. Hence, the termination may come out during usage.

6 Take a red colour banana plug, unscrew the loosen screw on it almost fully but do not take out the screw from its place.

As the screw is small it will be time consuming to replace the screw back in its position if taken out from the plug.

7 Bend the other free end of the tinned wire by hand or using a nose pliers such that it takes the shape of a loop and Insert the loop fully into the hole of the banana plug as shown in Fig 10 and tighten the screw firmly. Hold the wire with the body of the banana plug such that the wire does not slip off while tightening.

Fig 10



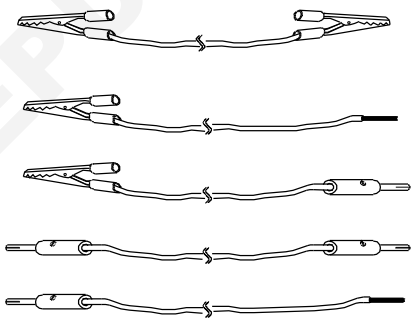
EMN1218HA

8 Holding the banana plug in one hand and the wire in the other pull the wire gently to ensure that the termination is firm. If termination is found loose, unscrew the screw, pull out wire and repeat steps 7.

9 Follow steps 1 to 8 above and prepare a black wire termination with crocodile clip to banana plug.

10 Repeat the steps 1 to 8 and terminate different wires as shown in Fig 11.

Fig 11



EMN1218HB

11 Get the work checked by the Instructor.

— — — — — — — —

TASK 5: **Terminating skinned Cable to three pin mains plug**

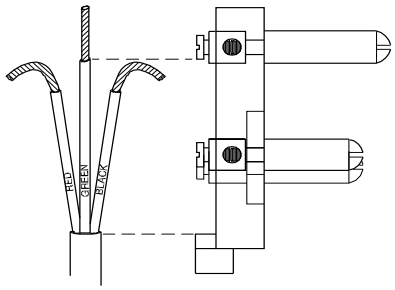
The steps given below are for the most common type of three-pin PLUGS. For other types the steps may vary slightly. Consult the instructor in case of difficulty.

1 Open the outer plastic casing of the 3 pin plug. Remove the cable grip and place them safely in a tray or screw box.

2 Ensure the length of the outer sheath skinned is equal to the distance between the earth terminal and the cable grip as shown in Fig 12.

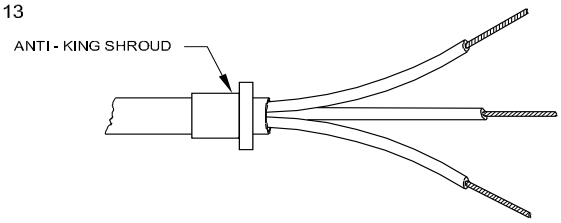
3 Remove the anti-king shroud (anti-king ring) from the plug and take the cable through it as shown in Fig 13.

Fig 12



EMN1218HC

Fig 13

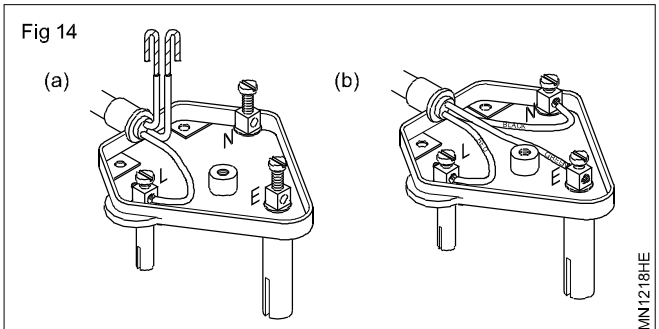


EMN1218HD

4 Make loops of the tinned conductor end of wires Loosen the screw insert the red wire loop into terminal marked L or Live as shown in Fig 14a and tighten the terminal screw.

5 Insert the black/blue wire loop into the terminal marked N or Neutral and the green wire loop to the earth terminal as shown in Fig 14b and tighten screws.

Fig 14



EMN1218HE

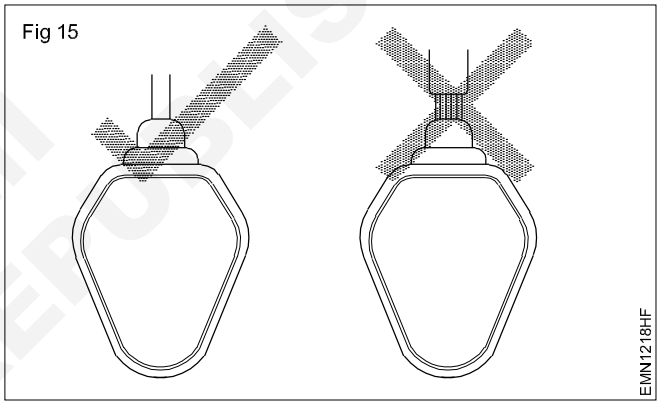
6 Position the anti-king shroud, reassemble the cable grip rubber and its screws.

7 Get the work checked by the instructor.

8 Reassemble the top cover of the plug. The finished work should look as shown in Fig 15.

The cables terminated with 3 pin main plug made in this exercise will be used in further exercises.

Fig 15



EMN1218HF

Measure the gauge of the wire using SWG and outside micrometer

Objectives: At the end of this exercise you shall be able to
- **measure the gauge of the wire using**
  a) standard wire gauge (SWG)
  b) outside micrometer.

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Standard wire gauge (per batch) - 1 No
- Outside micrometer 0-25 mm (per batch) - 1 No
- Pocket table book / wire table - as reqd

Materials/Components

- Single strand wire pieces (assorted sizes) - 2 Nos
- Rigid multistrand wire piece - 1 No
- Flexible multi strand wire pieces
  - Red colour - 1 No
  - Black colour - 1 No
  - Green colour - 1 No
- Dry cloth - as reqd

PROCEDURE

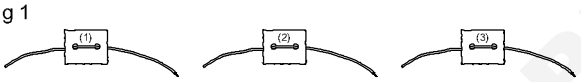
Note: Do not use nose pliers/tweezers to straighten conductors as this may deform conductors diameter.

Dust and other particles on the conductor, bends and kinks in the conductor give wrong measurement of the diameter / gauge number.

TASK 1: **Measurement of gauge number of wire using standard wire gauge**

1 The Instructor has to attach labels to identify each piece of wire correctly as shown in Fig 1.

Fig 1



EMN1219H1

2 Clean the skinned end of single strand wires using dry cloth and straighten the conductors by hand.

3 Pick a labelled single strand wire for measurement of gauge number.

4 Hold the SWG in one hand and insert the exposed conductor of the wire into one of the large holes of the stranded wire gauge (SWG) and take out the wire through the upper slot above that hole as shown in Fig 2.

5 Repeat step 3 till the conductor exactly fits into the slot as shown in Fig 3. Remove the conductor by pushing it down into the hole and pulling it out.

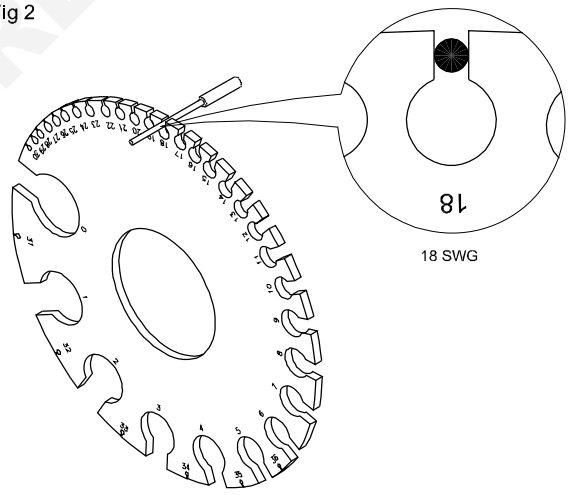
6 Note down the number printed / marked at the hole and record the observation in Table 1.

7 Repeat steps 3 and 4 for the other end of the wire.

8 Repeat steps 3 to 6 for the other single strand wires.

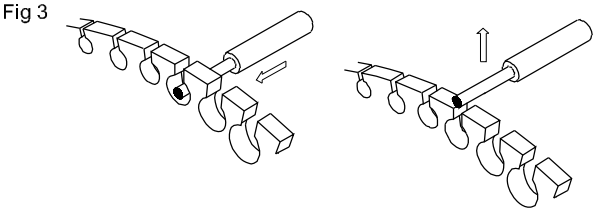
9 Get the work checked by the Instructor.

Fig 2



EMN1219H2

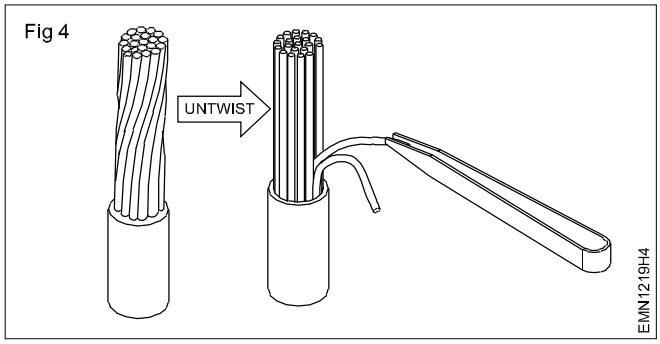
Fig 3



EMN1219H3

10 Take the rigid multistrand wire. Clean the conductors and untwist the twisted strands and separate one of the strands as shown in Fig 4.

Fig 4



11 Carry out steps 3 & 4 measure and record the SWG of one strand of the wire.

12 Count the total number of strands available in that wire and record it in Table 1

12 Repeat steps 9 to 11 for the flexible multistrand wires.

13 Refer pocket table book/wire table and convert the measured SWG value of wires into diameter of the wires in inches and millimeters. Record the readings in Table 1.

Table 1

	WireTag No.		Conductor Size of SWG	Conductor dia. in mm	Conductor dia.in inches	No. of Conductors
Single Strand Wire	Sample Entry	END 1	20	0.91	0.036	1
		END-2	20	0.91	0.036	
	1	END-1				
		END-2				
	2	END-1				
		END-2				
Multi-strand Wire	3					
	4					
	5					
	6					
	7					
	8					

14 Get the work checked by the Instructor.

— — — — — — — —

TASK 2 : **Measurement of diameter of the wire using Outside Micrometer**

Note: The Instructor has to guide the trainees in handling the micrometer and taking precise measurements.

1 Find the least count and zero error of the given micrometer as shown in Fig 5. Note down the values in Table 2.

2 Take the wire with label No. 1 for measurement. Clean and straighten the exposed conductor.

3 Carefully hold the micrometer in hand and place the conductor in the gap between the anvil and spindle. Turn the thimble till the conductor is just held between the anvil and the spindle as shown in Fig 5. Turn the ratchet till a click sound is heard.

Safety precaution:

Do not over tighten as this may deform the conductor and hence give wrong measurement.

4 Record the reading on the barrel and thimble in table 2. Loosen the grip on the conductor and take out the conductor from the micrometer.

5 Repeat steps 2,3 & 4 for the remaining single strand and multi-strand wires

Measure the diameter of only one strand in the case of multi-strand wires.

6 Calculate and record the diameter of the wires in mm for the micrometer readings recorded.

7 Compare the dia. of the wires noted in Table 1 using stranded wire gauge and the dia. measured using micrometer. If readings are found not matching consult the instructor.

8 Get the work checked by the Instructor.

Note: Keep the wires to be utilized for the next exercise.

Fig 5

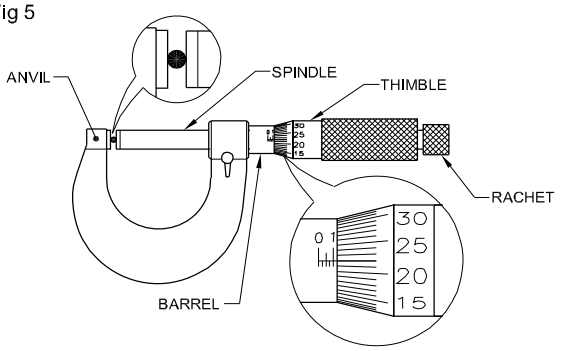


Table 2

Least count (LC)			
Zero error correction (ZC)			
Wire tag No.	**Barrel reading**	**Thimble reading (Thimble div x LC)**	**Wire dia. in mm (2) + (3) ± ZC**
1			
2			
3			
4			
5			
6			
7			
8			
9			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			

Refer table and find current carrying capacity of wires

Objectives: At the end of this exercise you shall be able to
- **determine the current carrying capacity of copper conductor by referring to the wire table**
- **determine the current carrying capacity of aluminium conductor by referring table.**

Requirements

Materials / Components

- Cotton cloth - as reqd
- Different size of copper conductor cable - as reqd
- Different size of aluminium conductor cable - as reqd
- wire table - as reqd

SWG size in inches/mm
Wire table of carrying capacity of insulated copper wire table 4 & 5

PROCEDURE

TASK 1 : **Determination of current carrying capacity of copper conductor**

Assumption: A bunch of different diameters of copper conductors are to be displayed on the work bench. Trainees are required to find out the current carrying capacity of wires given below by referring the Table 1.

1 Determine the current carrying capacity of the given copper conductor and note down in Table 2.

Table 1

COPPER AND EQUIVALENT ALUMINIUM CONDUCTOR CABLES CURRENT RATINGS

Copper Conductor				Aluminium Conductor			
Size of cable		Current Rating in amperes		Size of cable		Current Rating in Amperes	
No & dia of wire(mm)	Nominal area in mm^2	2-core Cable	3 or 4 core cable	No & dia in mm	Nominal area in mm^2	2-core Cable	3 or 4 Core cable

Table 2

Size of cable of Copper Conductor		Current Rating in amperes
No and dia of wire in mm	Normal area in mm^2	

2 Determine the copper conductor size for the given current rating and note down in Table 3.

Table 3

Current rating in Amperes	Copper Conductor size

3 Get the work checked by the Instructor.

— — — — — — — —

TASK 2 : **Determination of the current carrying capacity of Aluminium conductor**

1 Determine the current carrying capacity of the given aluminium conductor and note down in Table 4.

Table 4

Size of cable of Aluminium Conductor		Current Rating in amperes
No and dia of wire in mm	Normal area in mm^2	

2 Determine the aluminium conductor size for the given current and note down in Table 5.

Table 5

Current rating in Amperes	Aluminium Conductor size

3 Get the work checked by the Instructor.

— — — — — — — —

Crimp the lugs to wire end

Objectives : At the end of this exercise you shall be able to
- **choose the wire**
- **collect the suitable size of lug**
- **crimping the lug.**

Requirements

Tools/Instruments/Equipments

• Crimping pliers (1mm to 16mm)	- 1 No
• Steel rule 300mm	- 1 No
• Insulated side cutting pliers	- 1 No
• Electrician Knife	- 1 No
• Wire stripper auto-eject 200mm	- 1 No
• Wire stripper (manual) 200 mm	- 1 No

Materials/Components

• Lugs 1.5 mm	- 6 Nos
• Lugs 2.5 mm	- 6 Nos
• Lugs 4 mm	- 6 Nos
• Lugs 6 mm	- 6 Nos
• Cable 1.5 sq mm,2,4,5,6 length 300mm	- 1 No each
• Cotton waste	- as reqd
• Conducting paste	- 1 tube

PROCEDURE

TASK 1 : **Choosing the wire**

1 Select the wire depending on the application of work.

2 Cut the wire 300 mm length from the wire coil as shown in Fig 1.

3 Get the work checked by the Instructor.

Fig 1

TASK 2 : **Collecting the suitable size of Lug**

1 After finding the cable size, select the correct lug from the table as shown in Fig 2.

2 Show it to the instructor for its correctness.

3 Get the work checked by the Instructor.

Fig 2

TASK 3: **Crimping the lug**

1 After selecting wire and lug select the correct crimping tool

2 Measure the length of Lug using steel rule.

3 Measure appropriate strip length. Line up the connector barrel to the wire and mark the cable as shown in Fig 3.

4 Once determined the length of the wire strip the end using wire stripper, being careful not to damage the conductors as shown in Fig 4.

5 Check the striped insulation to the proper length, so that the conductor can be fully inserted into the connector barrel as shown in Fig 5.

Fig 3

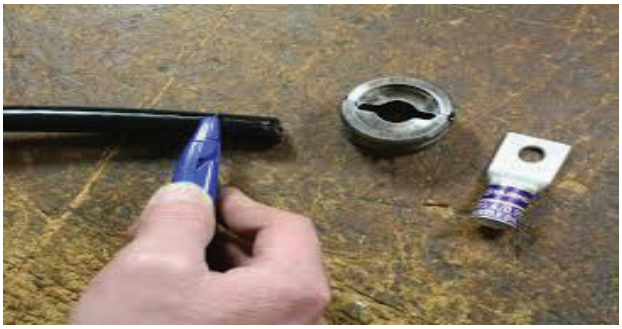


Fig 4

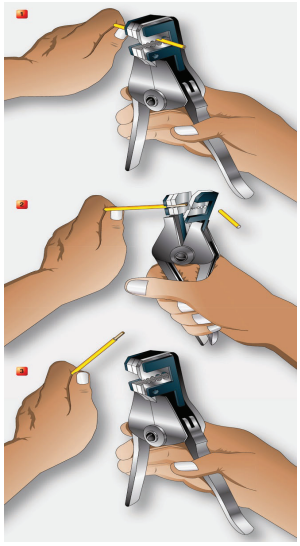


Fig 5

6 Insert the wire in to the lug as shown in the Fig 6.

Fig 6

7 Ensure that all wires of the conductor are within the crimp barrel as shown in Fig 7.

Fig 7

8 Select the appropriate die style to match the installation tool. The die index number and colour code indicated on the connector should match when the correct die is chosen as shown in Fig 8.

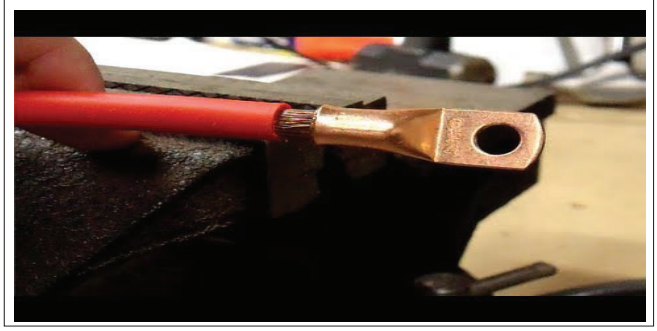
Fig 8

9 Start the crimping tool cycle and hold steady until the entire cycle is complete. Release ram. Repeat the same process until all crimp locations on the barrel have been completed as shown in Fig 9.

Fig 9

10 After crimping remove the crimped cable as shown in Fig 10.

Fig 10



11 Get the work checked by the Instructor.

Measure AC and DC voltages using multimeter

Objectives: At the end of this exercise you shall be able to
- **measure the AC voltage using multimeter**
- **measure the DC voltage using multimeter.**

Requirements

Tools/Instruments/Equipments

- Digital Multimeter with probes - 1 No
- Auto transformer (VARIAC) single phase having input 0-220V AC output 0-270VAC /15A - 1 No

Materials/Components

- Dry cell 1.5 V / AA size - 1 No
- 3V CR 2032 Lithium - 1 No
- 9V battery (Alkaline type) - 1 No
- 12 V battery (SMF type) AH rating available in the section) - 1 No

Note:

1 **The instructor has to explain the differences between the analog multimeter and DMM.**

2 **Provide an analog multimeter to trainees and instruct them to study the panel/ranges/ scales/selector switch/socket etc., in it.**

PROCEDURE

TASK 1: **Measurement of AC voltage using multimeter.**

1 Observe and check the number of available ranges in the given multimeter.

2 Plug the black colour probe into the COM socket and plug the red colour probe into the V, Ω, mA, socket of multimeter as shown in Fig 1.

Fig 1

3 Select the multimeter knob (switch) to the AC Voltage range.

Note : Most multimeters power up in Auto range mode. This automatically selects a measurement range based on voltage present.

4 Connect the meter across the autotransformer output socket.

Safety precaution:

Note: Before power ON auto transformer keep the voltage selector knob in 0V, position.

5 Power ON the Auto Transformer observing the multimeter increase the voltage to 10 volt.

6 Record the observation in Table - 1

7 Repeat the above step in steps of 10V up to 50V note down the corresponding readings in Table 1.

8 Get the work checked by the instructor

9 Bring down the voltage selector to OV position and switch OFF the variac.

Table - 1

S.No	Variac dial position	Meter reading	Remarks
1			
2			
3			
4			
5			

TASK 2 : **Measurement of DC voltage using multimeter**

1 Select the multimeter knob (switch) to the DCV or V Voltage section as shown in Fig 2.

Fig 2

2 Take the 9V battery identify supply terminals place the red probe on the positive terminal, and the black probe on the negative terminal.

Note: If the range was set too high, may not get a very accurate reading. Turn the dial to a lower range to get a better reading as shown in Fig 3.

3 With the range set correctly, as shown in Fig 3, measure the voltage of the battery and record the readings in Table - 2.

4 Repeat the above steps for other battery and record the reading in Table - 2.

Fig 3

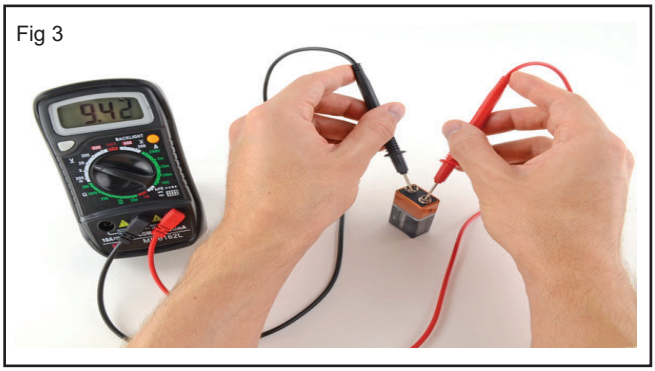


Table 2

S No.	Battery type	Mark readings	Remarks
1	1.5 V		
2	3 V		
3	9 V		
4	12 V		

5 Get the work checked by the Instructor.

— — — — — — — —

Identify the type of meters by dial and scale marking / symbols

Objectives: At the end of this exercise you shall be able to
- **identify the type of meter (AC/DC) and function from the dial markings**
- **identify the type of meter (AC/DC) from the symbols on the dial.**

Requirements

Tools/Instruments/Equipments

- Voltmeter 0 - 250 V, DC, MC panel type - 1 No
- Voltmeter 0 - 500V, MI panel type - 1 No
- Ammeter 0 - 5A, DC, MC panel type - 1 No
- Ohmmeter 0 - 2 MΩ - 1 No
- Multimeter - analog type with probes - 1 No
- Multi-range voltmeter MC/MI - 1 No

Aids: Chart showing different dial scale markings (Linear and non linear) and symbols used on AC/DC and DC meters.

Materials / Components

- Connecting leads flexible - assorted sizes

Note: The Instructor has to label the meters used for this exercise before issuing to trainees.

PROCEDURE

Identification of meter type (AC/DC) and its function from the dial markings.

1 Pick one of the labelled meter from the lot, observe the markings on the dial scale calibration. Refer to the chart and record the observation in Table 1.

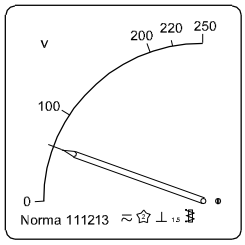
2 Observe the symbols printed at the bottom line on the dial plate and record the observations in Table 2. with reference to the chart.

Table 1

Label No of Meter	Dial scale divisions markings: Linearly Yes/ No	Dial scale divisions markings: Non - Linearly Yes/ No	Function letter V/mA / Ω	Type of meter AC/ DC or DC only
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				

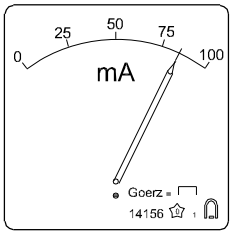
3 Identify the instruments shown in Figs 1 & 2 for their types - DC, AC or both, with reference to Fig 3 Record the response in the Table 2.

Fig 1



EMN1323H1

Fig 2



EMN1323H2

TABLE 2

Instrument	Symbol	Function
Figure 1		
Figure 2		

Fig 3

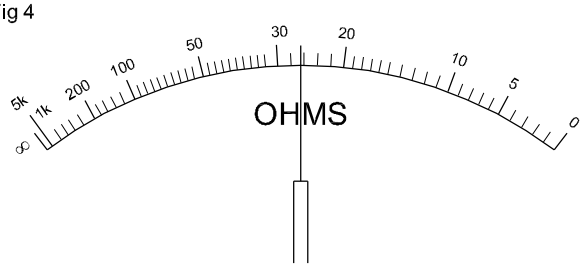
	MOVING COIL MEASURING ELEMENT
	MOVING COIL MEASURING ELEMENT WITH RECTIFIER
	MOVING IRON MEASURING ELEMENT
—	TYPE OF CURRENT: ONLY DIRECT CURRENT
~	TYPE OF CURRENT: ONLY ALTERNATING CURRENT
≂	DIRECT AND ALTERNATING CURRENT
⊥	POSITION FOR USE: VERTICAL
⌐	POSITION FOR USE: HORIZONTAL
1	INDICATION ERROR ±1%
2.5	INDICATION ERROR ±2.5%
3.5	INDICATION ERROR ±3.5%
2	TEST VOLTAGE: 2KV=2000V
!	OBSERVE INSTRUCTIONS FOR USE

SYMBOL FOR CHARACTERISING ELECTRICAL MEASURING INSTRUMENTS

EMN1323H3

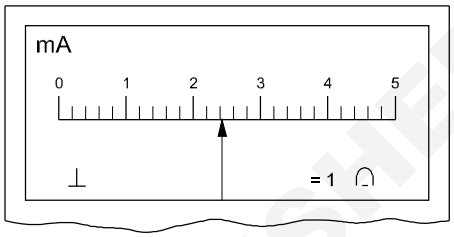
4 Identify the instruments single or multi-scale / multi-range instruments and their functions. Record the response in Table 3.

Fig 4



EMN1323H4

Fig 5



EMN1323H5

TABLE 3

Instrument	Range	Scale	Function
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

5 Get the work checked by the Instructor.

Demonstrate various analog measuring instruments

Objectives: At the end of this exercise you shall be able to
- **select various analog measuring instruments**
- **demonstrate various analog measuring instruments.**

Requirements

Tools/Equipments

- MC Ammeter 0-5A - 1 No
- MI Ammeter 0-10A - 1 No
- MC Milli ammeter 0-1mA - 1 No
- MC Milli volt meter 0 - 100mV - 1 No
- MC voltmeter 0-50V - 1 No
- MI Voltmeter 0-500 V - 1 No
- Mega ohmmeter 0-10 Mega ohm - 1 No

Materials/Components

- Cotton Waste -as reqd

PROCEDURE

Demonstration of various analog measuring instruments.

1 The Instructor has to arrange a set of moving coil / moving iron type analog measuring instruments such as Ammeters, voltmeters, milliammeters, milli voltmeters, etc and demonstrate them to trainees.

2 Label each meter type separately and group them under MC / MI

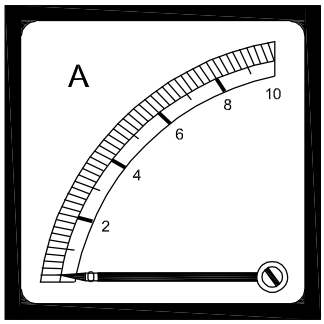
1 Pick one of the labelled meter, observe the panel and record the observations in Table - 1

2 Repeat the above step for all the labelled meters.

Table 1

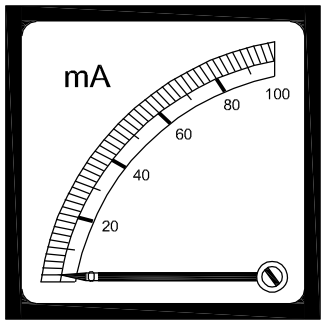
Label No. (1)	Name of the Meter (2)	Measuring Range (3)	Diagram of dial scale marking (4)
1	MI Ammeter (Fig 1)		
2	MI Milli ammeter (Fig 2)		
3	Mega Ohmmeter (Fig 3)		
4	MC Milli Voltmeter (Fig 4)		
5	MC Milli ammeter (Fig 5)		
6	MC ammeter (Fig 6)		
7	MI Voltmeter (Fig 7)		

Fig 1



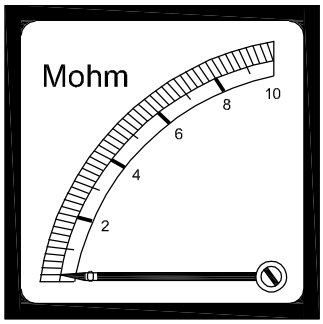
EMN1324H1

Fig 2



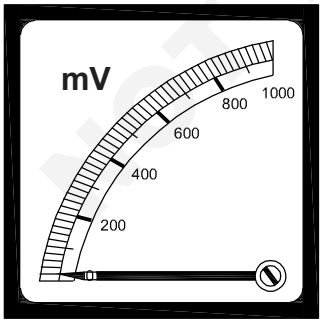
EMN1324H2

Fig 3



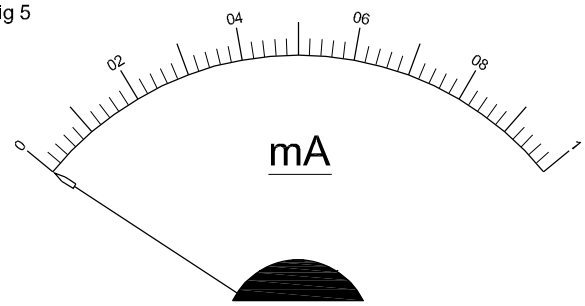
EMN1324H3

Fig 4



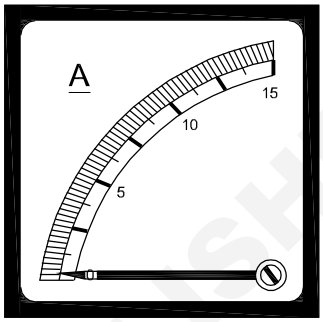
EMN1324H4

Fig 5



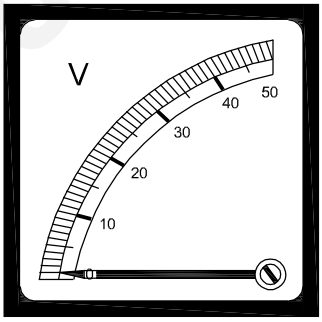
EMN1324H5

Fig 6



EMN1324H6

Fig 7



EMN1324H7

3 Get the work checked by the Instructor.

Find the minimum and maximum measurable range of the meter

Objective: At the end of this exercise you shall be able to
- **determine the minimum and maximum measurable range of the meter.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- MC ammeter 0-500 mA - 1 No
- MC voltmeter 0-10V - 1 No

Materials/Components

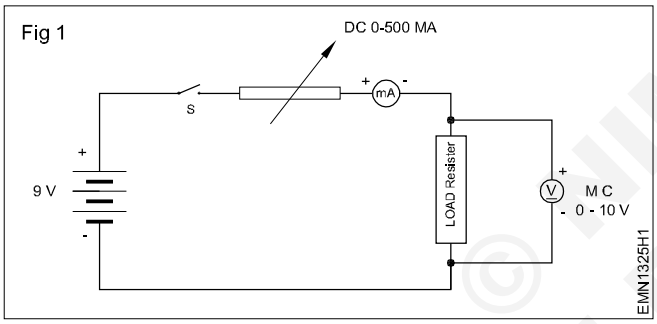
- Connecting cable copper 1.5sq.mm - as reqd
- Cotton cloth - as reqd
- Variable resistor/Rheostat 0-1kΩ - 2 Nos
- SP Switch 6A, 240V - 1 No
- 9V Battery - 1 No

PROCEDURE

1 Collect ammeter, voltmeter, variable resistance battery and SP switch.

2 Assemble the circuit as shown in Fig 1.

Fig 1



3 Set the variable resistance to have zero out.

4 Close the switch 'S'.

5 Note down the minimum measurable range of milliammeter and voltmeter and record in the Table 1.

6 Gradually increase load to 500 mA by varying variable resistance.

7 Also adjust the voltage across load resistor to 10 volts.

8 Note down the maximum measurable range of milliammeter and voltmeter and record it in Table 1.

Table -1

1	**Minimum range of milli ammeter** _____
2	**Minimum range of volt meter** _____
3	**Maximum range of milliammeter**_____
4	**Maximum range of voltmeter** _____

9 Get the work checked by the Instructor.

— — — — — — — —

Carryout mechanical zero setting of a meter

Objectives: At the end of this exercise you shall be able to
- **carry out mechanical zero setting of an analog meter**
- **measure the voltage of a dry cell using a single range voltmeter.**

Requirements

Tools/Equipments/Instruments

- MC Voltmeter 0-5V or 0-50V - 1 No
- MC Voltmeter 0-15V - 1 No
- Screw driver 150mm with 3mm blade - 1 No

Materials / Components

- Dry cells of different voltage range - as reqd
- Lead acid battery 12V/60 AH - 1 No

Note: The instructor has to label the meter before issuing them to trainees.

PROCEDURE

TASK 1 : **Carry out Mechanical zero setting of a meter**

1 Take one of the labelled MC Voltmeter and check whether the meter needle moves freely on the graduated scale.

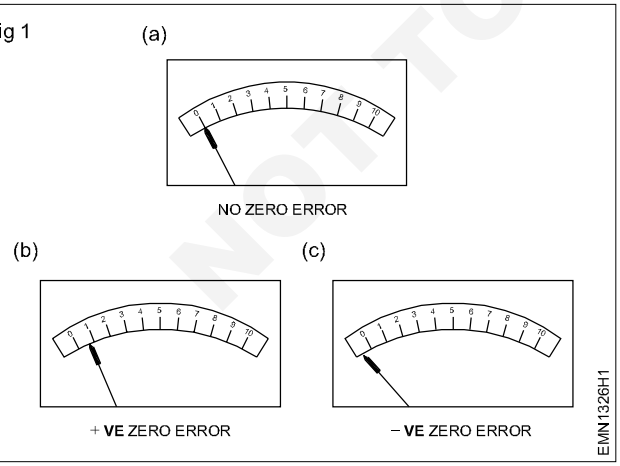
If the needle is not moving freely consult your instructor.

2 Place the meter on the table horizontally and check whether the needle is pointing exactly on the zero position on the meter scale as shown in Fig 1a.

If the pointer is exactly on the zero marking of he scale, the mechanical zero setting of the meter is proper.

3 If the pointer is not pointing exactly on the zero marking as in Fig 1(b) & (C) the meter has the Mechanical Zero error.

Fig 1



4 Record your observation in Table 1.

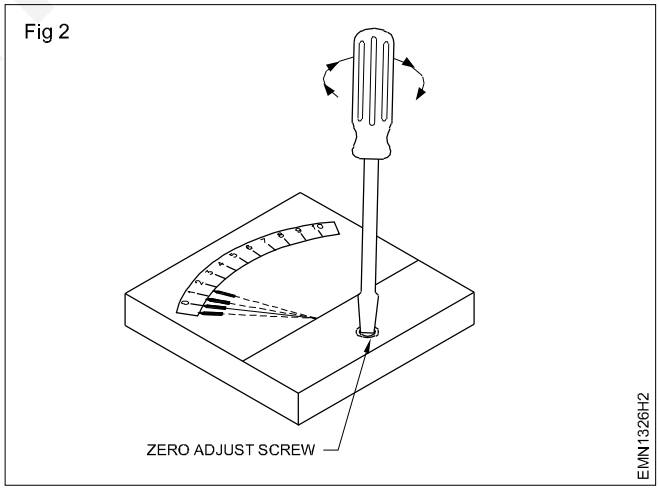
5 Repeat the steps 1 to 4 for the other meter also.

6 Permission to correct the error on the meter.

7 Put the screw driver on the mechanical zero adjust the screw as shown in Fig 2.

8 Observing the pointer, turn the screw very slowly as required till the pointer reaches exactly on the 'O' marking on the scale.

Fig 2



9 Get the work checked by the Instructor.

Table 1

Label No.	Meter range	Pointer Position on the dial scale	Positive/ Negative error	Direction of screw driver rotation needed clock-wise/counter clock wise	Avoid parallax error
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					

— — — — — — —

TASK 2 : **Measurement of the voltage of dry cell & lead acid battery using single range voltmeter.**

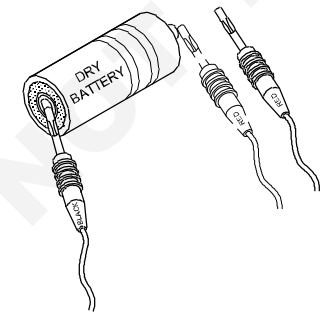
1 Take any one of dry cell from the given lot Clean its terminals using cloth.

2 Identify the +ve and -ve terminals of the cell.

3 Touch the -ve meter probe (Black) to the -ve terminal of the cell as shown in Fig 3.

4 Also touch the +ve probe (Red) to the +ve terminal of the cell as shown in Fig 3.

Fig 3



EMN1326H3

If the pointer deflects reverse direction on the scale the identified cell polarity is wrong. Recheck and interchange connection.

5 Note down the voltmeter reading.

6 Repeat the steps for the remaining cells and lead acid battery and note down the voltmeter reading.

7 Get the work checked by the Instructor.

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Check the continuity of wires, meter probes and fuse etc

Objectives: At the end of this exercise you shall be able to
- **check the continuity of a 1.5 sqmm PVC wire**
- **check the continuity of multimeter probes**
- **check the continuity of a glass cartridge fuse.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Digital Multimeter with probes - 1 No
- Continuity tester - 1 No
- Wire stripper - 1 No
- Battery pack/Lead acid Battery 6V/5AH - 1 No

Materials/Components

- Miniature lamp holder with 12V - 1 No
- PVC wire 2.5 sq.mm - 1 m
- PVC wire 1.5 sq.mm - 1 m
- Multimeter Probes - 1 Pair
- Glass cartridge fuse assorted ratings/sizes - 3 Nos

The instructor has to provide assorted wires of any length for continuity checking. Different size and rated glass cartridge fuses both serviceable and unserviceable ones for this task.

PROCEDURE

TASK 1 : **Checking the Continuity of meter probes**

1 Set the range selector switch to continuity/buzzer position on the DMM.

2 Insert both the test probes into the COM and VΩmA sockets following colour codes.

3 Touch both the open ends of test probes and observe for the zero Ohm on the display and listen to the buzzer sound.

4 Record your observations in Table - 1 to ensure the continuity of the meter probes.

5 Get the work checked by the Instructor.

Table 1

Sl.No.	Name of the Item	Display on meter	Buzzer sound	
			Yes	No
1	Meter test probes			
2	Wire - 1			
3	Wire - 2			
4	Fuse - 1, Fuse-2			

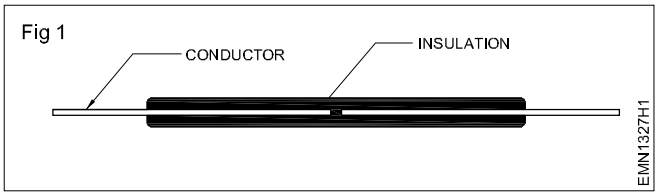
— — — — — — — —

TASK 2 : **Checking the Continuity of wires**

1 Select two assorted wires of any length.

2 Mark 10mm and skin the insulation at both ends of the wires using wire stripper as shown in Fig 1.

Fig 1



3 Ensure that the DMM is set to continuity/buzzer position.

4 Connect both skinned ends of the wire across the open ends of test probes and observe for buzzer sound and zero display on the meter.

5 Record the observations in Table - 1.

6 Repeat steps 2 to 5 for the other wire also.

7 Get the work checked by the Instructor.

— — — — — — — —

TASK 3 : **Checking the Continuity of fuse**

1 Ensure that the DMM is set to continuity/buzzer position.

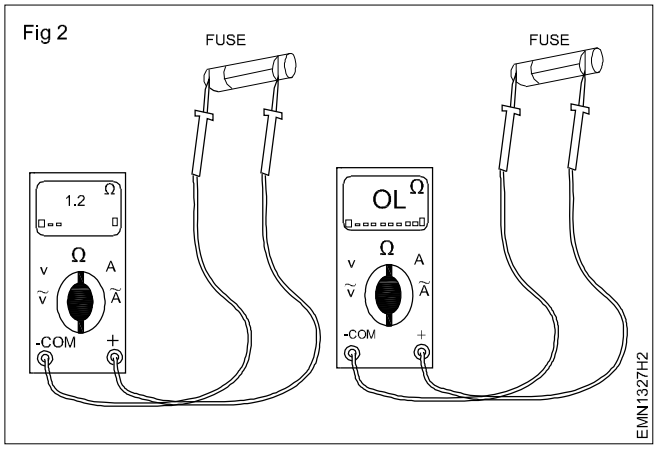
2 Pick and connect the glass cartridge fuse across the open ends of test probes as shown in Fig 2.

3 Observe the display; listen to the buzzer sound and record the observations in Table 2

If the reading is between 0 and 5 ohms the fuse is good. A higher reading indicates a bad or degraded fuse. A reading of OL (over limit or infinity) definitely means a blown fuse wire.

4 Repeat above steps for all the fuses and record observations in Table.

Fig 2



5 Get the work checked by the Instructor.

Table 2

Sl.No.	Fuse reading in ohm	Fuse name/type	Remarks
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
12			
13			
14			
15			
16			
17			
18			
19			
20			

Measure voltage and current using clamp meter

Objectives: At the end of this exercise you shall be able to
- **measure AC voltage using clamp meter**
- **measure DC voltage using clamp meter**
- **measure AC current using clamp meter**
- **measure DC current using clamp meter.**

Requirements

Tools/Equipments/Instruments

- Clamp meter with built in multimeter - 1 No
- Clamp meter (Digital) voltage, current measurement - 1 No
- Variac 0-270VAC - 1 No
- Regulated power supply 0-30V/2A - 1 No

Materials/Components

- 12V/10W bulb with holder and wire - 1 Set
- 100W/240V Test lamp with wire - 1 No
- Lead acid battery 12V / 7AH - 1 No
- SPST switch - 1 No

PROCEDURE

TASK 1 : **Identification of ranges and display on Digital Clamp meter**

1 Refer to the user manual of the Digital clamp meter.

2 Switch ON the clamp meter and observe the display, identify each icon representing various parameters measured by the clamp meter.

3 Note down each one of them, with reference to user manual record details in the Table 1.

Table 1

Sl. No	Description of the display/icon	Meaning/ function	Remarks
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			

TASK 2 : **Measurement of AC voltage with Clamp meter**

1 Connect the black test of probe into the COM terminal/ socket.

2 Plug the red probe into the VΩmA socket.

3 Turn the rotary function switch to ACV/ voltage section as shown in Fig 1.

Note: For auto ranging model it automatically display the measured value for other models.

4 Turn on the Clamp meter.

5 Measure the voltage by touching the probes to the AC wall socket of the circuit as shown in Fig 2.

Fig 1

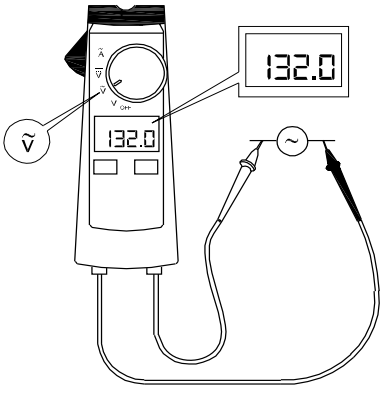
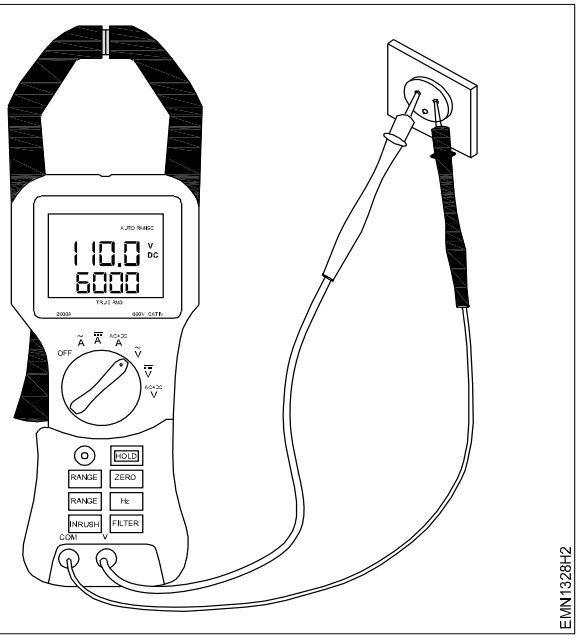


Fig 2



6 View the reading on the display and note down voltage in Table 2.

7 Repeat step 5 for other test point across variac and note down the voltage in Table 2.

8 Get the work checked by the Instructor.

Table 2

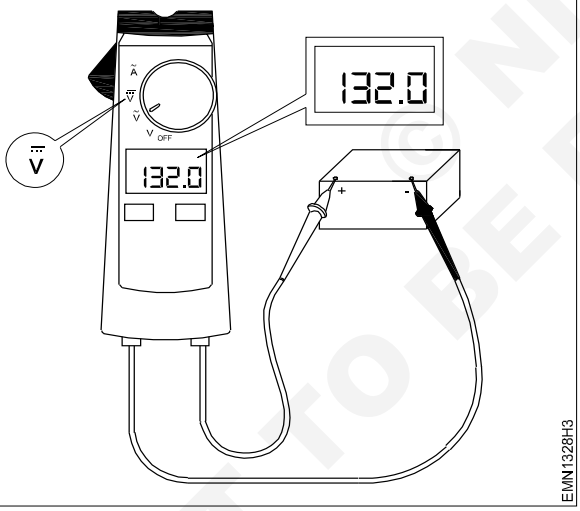
Sl. No	Quantity Measured	Volt AC/DC	Remarks
1	Wall socket		
2	Variac		
3	Lead Acid Battery		
4	Regulated DC power supply		

TASK 3 : **Measurement of DC voltage using Clamp meter**

1 Follow the Steps 1 and 2 of task 2.

2 Turn the rotary function switch of the clamp meter to DCV voltage section as shown in Fig 3.

Fig 3

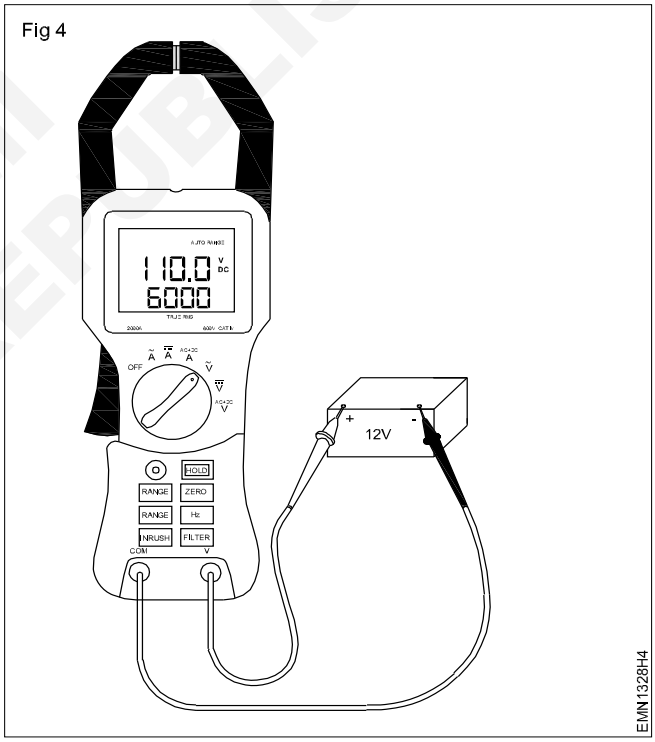


3 Turn on the Clamp meter.

4 Measure the DC voltage by touching the probes across the terminals of battery as shown in Fig 4.

5 Observe the reading on the display and note down in Table 2.

Fig 4



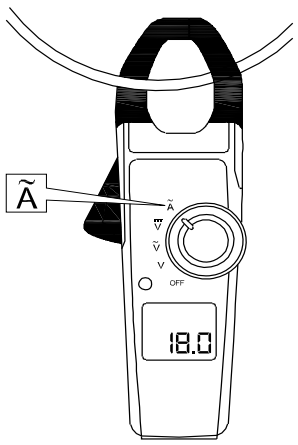
6 Repeat the DC voltage across the regulated power supply and record the observation in Table 2.

7 Get the work checked by the Instructor.

TASK 4 : **Measurement of AC current using Clamp meter**

1 Turn the rotary function switch to of the clamp meter ACA current section as shown in Fig 5.

Fig 5



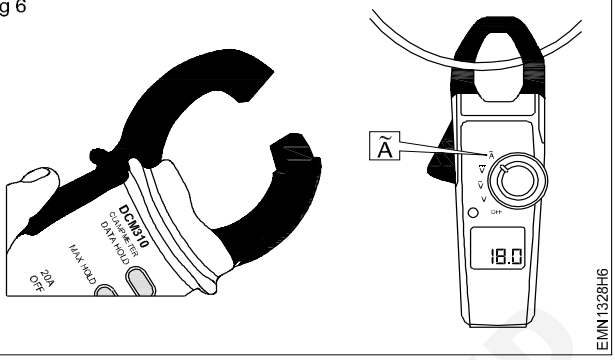
2 Select the circuit current to be measured in AC load and determine the approximately nearest current range on the meter.

The clamp meter will automatically measure the current by the auto ranging model.

3 Identify the Phase conductor cable and separate it from the Neutral and Earth cables.

4 Open the jaws of clamp meter by pressing the jaw keep the phase conductor inside and release as shown in Fig 6.

Fig 6



5 Observe the current reading displayed on the meter and record the readings in Table 3.

6 Connect the 100W test lamp to AC mains, and switch ON the circuit.

7 Repeat steps 4 and 5, record readings.

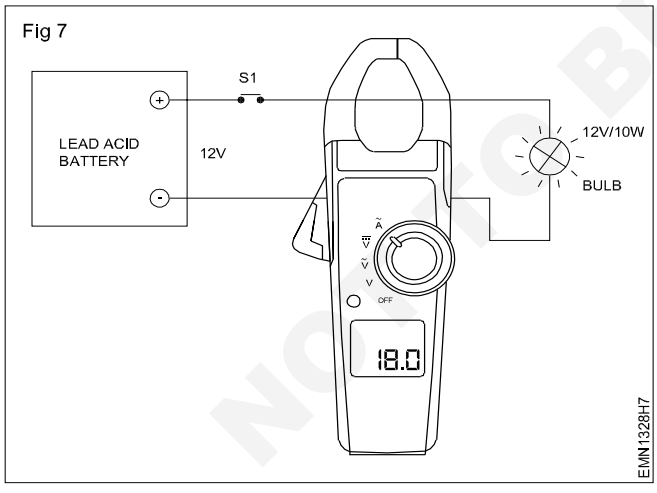
8 Get the work checked by the Instructor.

TASK 5: **Measurement of DC current using Clamp meter**

1 Connect the 12V/10W lamp across the 12V lead acid battery as shown in Fig 7.

2 Turn the rotary function switch to DC A Current section as shown in Fig 7.

Fig 7



3 Switch ON the 12V DC power supply and ensure the lamp is glowing.

4 Repeat steps 4 and 5 of task 4 above and record the readings in Table 3.

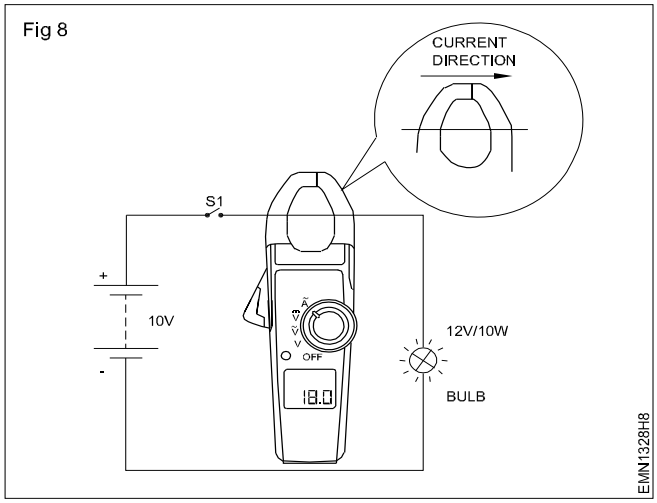
5 Repeat the steps with the lamp connected across the DC power supply with 10V.

6 Switch ON the 10V DC supply measure the DC current and record the readings in Table 3.

Table 3

Sl. No	Current measured circuit/point	Current AC/DC	Remarks
1	AC load circuit	A.AC	
2	Test lamp 100W	A.AC	
3	Battery circuit	A.DC	
4	DC power supply circuit	A.DC	

Fig 8



7 Get the work checked by the Instructor.

Identify the +ve and -ve terminals of the battery

Objectives: At the end of this exercise you shall be able to
- **determine the polarity of a battery using a digital voltmeter and analog voltmeter.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Voltmeter 0-15V MC - 1 No
- Voltmeter 0-300 MC - 1 No
- Digital multimeter with probes - 1 No
- Lead acid Battery 12V/7AH - 1 No

Materials/Components

- Connecting leads flexible - as reqd
- Test probes - 2 Nos

Note: The instructor has to provide a fully charged lead acid battery with specification details clearly in the name plate.

PROCEDURE

1 Collect the lead-acid battery, observe the construction, supply terminals and specifications/details printed.

2 Draw the free hand sketch and mark the supply polarities in it.

3 Record the technical details like nominal voltage, current capacity, charging current, discharging rate etch in Table 1.

4 Select DC volt measuring range (preferably higher range) in DMM, insert the black colour test probe into the COM socket and red colour test probe into the V, Ω, mA marked socket.

5 Touch both the test probes across the lead-acid battery terminals and observe the meter display Mark the polarity of the battery as that of the voltmeter; the +ve terminal of voltmeter as +ve terminal and the -ve terminal of voltmeter that touches the battery terminal as -ve terminal of the battery.

Note: If the deflection is reverse and the pointer kicks backward, do not try again.

6 Observe the polarity displayed and bring the voltage measuring range down/nearer to the battery voltage printed/marked.

7 Record the readings in Table and confirm the correct polarities of battery.

8 Interchange the test probes, repeat the steps 5 to 7 and verify the + or - sign displayed with the digits.

-ve sign indicates that test probes/battery polarities are reversed; on the battery terminal red colour is marked to indicate positive polarity along with a + sign and black colour is marked to indicate negative polarity colour is marked to indicate negative polarity along with a - sign by the side of terminal posts/connecting points.

Note: Analog type volt meter reads the DC voltage of battery with current polarity. The pointer will reverse its deflection for opposite polarities. Do not keep the meter in the reversed polarity longer.

Table 1

1	Model/Make		Free hand sketch of battery
2	Nominal volt		
3	Nominal current capacity		
4	Charging current		
5	Discharge rate		
6	DC output measured using DMM		
7	DC output measured using analog voltmeter		
	Effect an analog meter test probes interchanged.		

9 Get the work checked by the Instructor.

— — — — — — — —

Identify the rated output voltage and AH capacity of given battery

Objectives: At the end of this exercise you shall be able to
- **identify the rated output voltage and Ampere hour capacity of given battery.**

Requirements

Tools/Equipments/Instruments

- MC Voltmeter 0-5A - 1 No
- Digital multimeter with probes - 1 No

Materials/Components

- Lead acid battery 6V/4.5 AH - 1 No
- Lead acid battery 12V/7AH - 1 No
- 12V/10W bulb with holder - 1 No
- Connecting cables - as reqd
- SPST switch - 1 No

Note: The instructor has to provide fully charged batteries with specification/details clearly visible and label them for this exercise/task.

PROCEDURE

1 Collect the battery, read and record the name plate details in Table 1.

2 Identify the rated output voltage and record it in the Table -1.

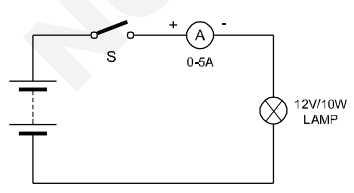
3 Identify the Ampere hour capacity and record it in the Table -1.

Table 1

Name plate details	Label No.1	Label No.2
Manufacturer Name:		
Type:		
Model :		
No. of Cells:		
Rated output voltage:		
AH Capacity:		

4 Connect the lamp in series circuit with ammeter as shown in Fig 1.

Fig 1



5 Switch ON the circuit, observe the lamp is glowing and the ammeter current reading.

6 Record the reading in Table 2

7 Keep the lamp in ON condition for 15 min and record the current flow in Table 2.

Table 2

Sl. No	Terminal voltage	Load Current	After 15 min current

8 Switch OFF the circuit remove the battery and replace the other battery.

9 Repeat steps 5 to 7, record readings.

10 Get the work checked by the Instructor.

Measure the voltages of the given cells/battery using analog/digital multimeter

Objectives: At the end of this exercise you shall be able to
- **measure the voltage of given cell/battery using analog multimeter**
- **measure the voltage of given cell/battery using digital multimeter.**

Requirements

Tools/Equipments/Instruments

- Digital multimeter with probes - 1 No
- Analog multimeter with probes - 1 No

Materials/Components

- Lead acid battery 6V/12V any AH rating - 1 No
- 1.5V/3V/9V battery -1 No each

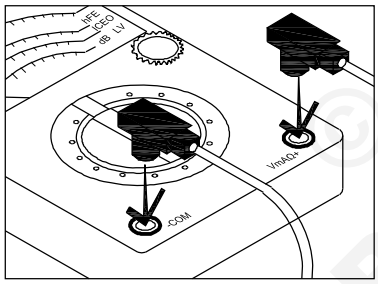
Note: The instructor has to label the cells and batteries used for this exercise /Task

PROCEDURE

TASK 1 : **Measurement of cell/battery voltage using analog multimeter**

1 Observe the front panel and insert the black colour probe "COM" socket of analog multimeter and insert the red colour probe into the V mA Ω socket as shown in Fig 1.

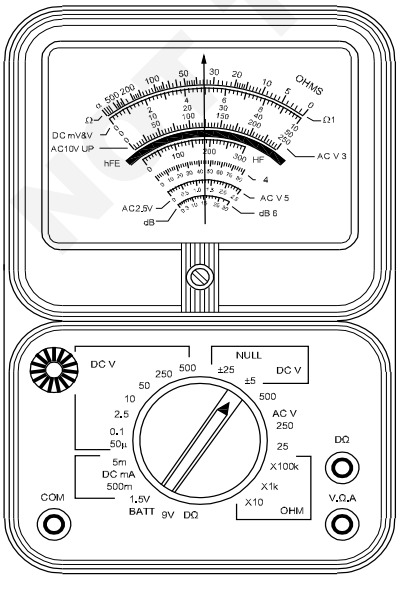
Fig 1



EMN1431H1

2 Set the range selector knob of multimeter to DCV, as shown in Fig 2.

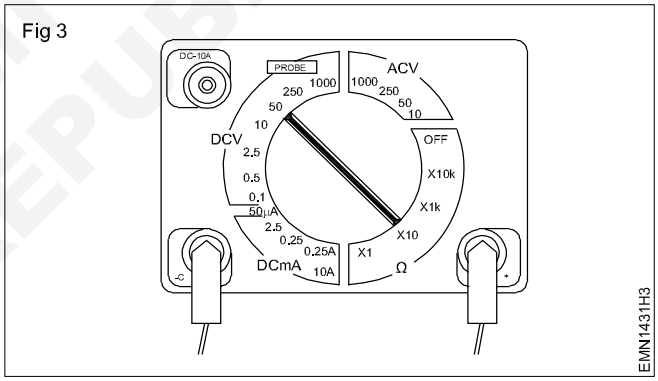
Fig 2



EMN1431H2

3 Set the voltage range nearest to the cell / battery voltage as shown in Fig 3.

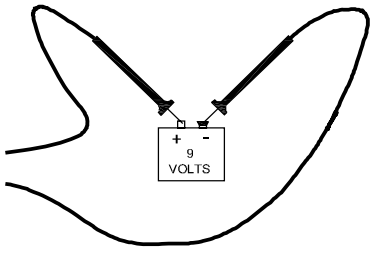
Fig 3



EMN1431H3

4 Pick the 9V battery, place the black probe on the negative (-) terminal and red probe on the positive (+) terminal of the battery as shown in Fig 4.

Fig 4



EMN1431H4

5 Check the Analog voltmeter reading as shown in Fig 5 and record the reading in Table 1.

6 Repeat step 4 and 5 for the remaining labelled cells/ battery.

7 Get the work checked by the Instructor

Fig 5

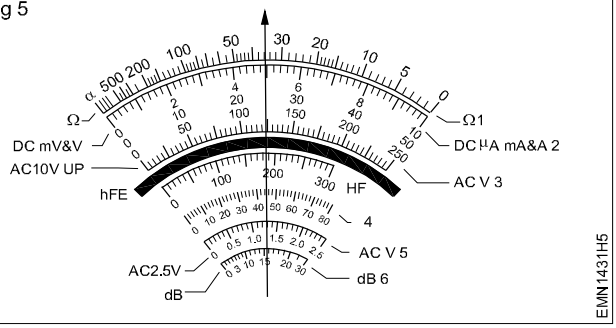


Table 1

Label No	Voltage marked on the cell/ battery	Meter range selected	Measured reading

Note: Readjust the voltage selector knob of the analog meter suitably measure the cell/battery voltage with accuracy of deflection of the pointer on the calibrated scale.

TASK 2 : **Measurement of cell/battery voltage using Digital Multimeter**

1 Plug the black colour probe into the COM socket on the digital multimeter and red colour probe into the V Ω mA socket.

2 Turn the multi meter knob to the DC Voltage selection as shown in Fig 6a and b.

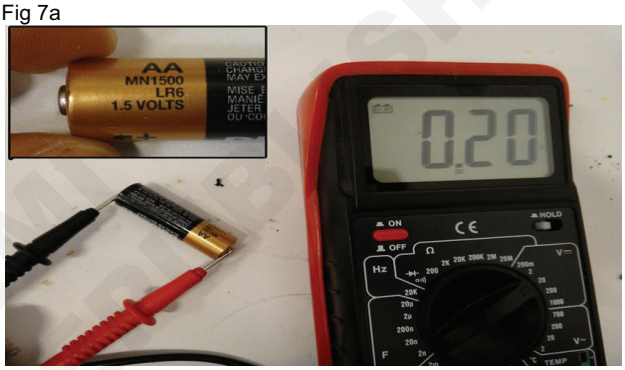
Fig 6a

Fig 6b

Note: Most digital multimeter power up in Auto range mode. This automatically selects a measurement range based on voltage present.

3 Pick one of the labelled battery and measure the terminal voltage as shown in Fig 7a and b.

Fig 7a



4 Observe the reading displayed on the digital meter and record it in Table 2.

Table 2

Label No	Voltage marked on the cell/ battery	Meter range selected	Measured reading

5 Repeat step 3 and 4 for other labelled batteries also.

Note: For accurate measurement, the voltage range selector of digital meter may be readjusted suitably.

6 Get the work checked by the Instructor.

Charge and discharge the battery through load resistor

Objectives : At the end of this exercise you shall be able to
- **check the voltage of each cell with a voltmeter in a lead acid battery**
- **check the level and top up electrolyte in lead acid battery**
- **determine the battery condition with a high rate discharge (H R D) tester after one hour charging**
- **check and clean the battery terminals**
- **connect and charge the battery by the constant current method**
- **connect and charge the battery by the constant potential method**
- **discharge the battery through load resistor.**

Note: The instructor has to mark the cells with serial numbers suitably.

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Voltmeter 0-15V MC - 1 No
- Ammeter 0-10A MC - 3 Nos
- Hydrometer - 1 No
- High rate discharge tester - 1 No
- 12V Battery charger - 1 No
- Low voltage DC power supply (0-3V) 10A - 1 No
- Variable resistor 10 ohms, 5A capacity - 2 Nos
- Safety goggles - 1 No
- Lead acid battery 12 volts - 1 No
- Lamp Bank (240V, 1KVA) - 1 No
- DPIC 16A - 1 No

Materials/Components

- Distilled water (450ml) - 1 Bottle
- Petroleum jelly - as reqd
- Sandpaper ('Zero' grade) - as req
- Test leads with crocodile clips - 1 pair
- Hydrogen peroxide - as reqd
- Clips - 1 pair

Safety precaution: Wear the goggles to protect eyes from acid or any dust particles.

PROCEDURE

TASK 1 : **Inspection of the battery electrolyte level**

1 Visually inspect the outside body for any physical damage or bulging; Clean the terminals, if corroded, with sandpaper: if sulphated, clean with wet cotton waste or with soda bicarbonate.

2 Measure voltage across each cell using DC voltmeter and record in Table 1.

Do not scrape the battery terminal by any metal strip; it may damage the terminal.

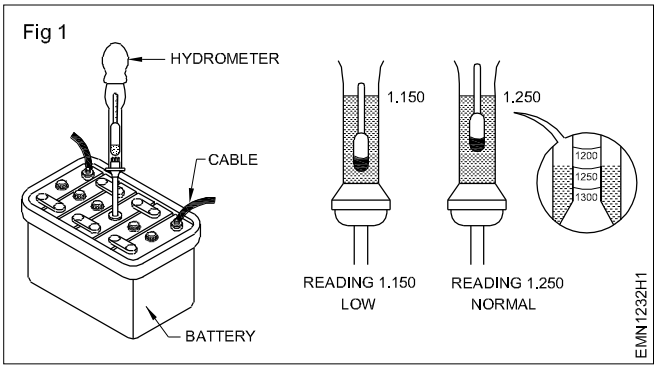
3 Unscrew and remove all the vent plugs; keep them separately and check the level of electrolyte in all cells.

Do not clean the battery top surface keeping the vent plugs open. The accumulated dirt may fall inside the cells and form sediments.

4 Top up the electrolyte to the marked level in all the cells with distilled water.

5 Insert the Hydrometer rubber nozzle inside the cell, press the bulb, suck electrolyte and release to allow the float to measure specific gravity as shown in Fig 1.

Fig 1

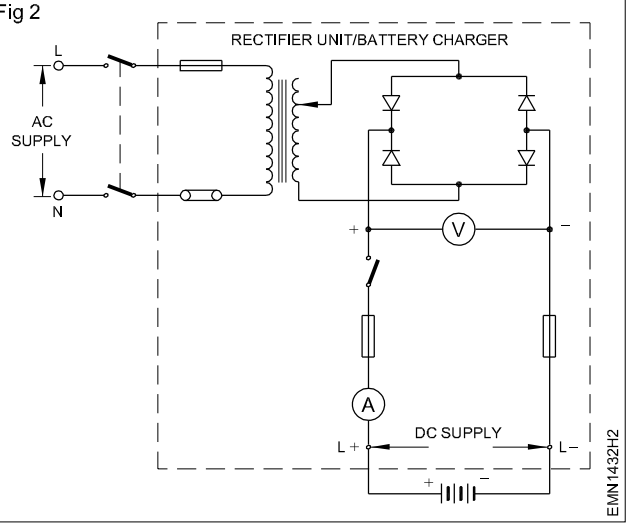


6 Observe and check the initial specific gravity of the electrolyte of each cell using the above step as shown in Fig 1 and record in Table1.

Do not use a high rate discharge tester for measuring initial voltage.

7 Connect the battery charger's +ve lead to the +ve terminal of the battery and the -ve lead of the charger to the -ve terminal of the battery as shown in Fig 2.

Fig 2



8 Adjust the battery charger output voltage equal to or a little higher than the voltage of the battery to be charged.

9 Set the charger voltage to produce the determined value of initial charging current and record it in Table 1.

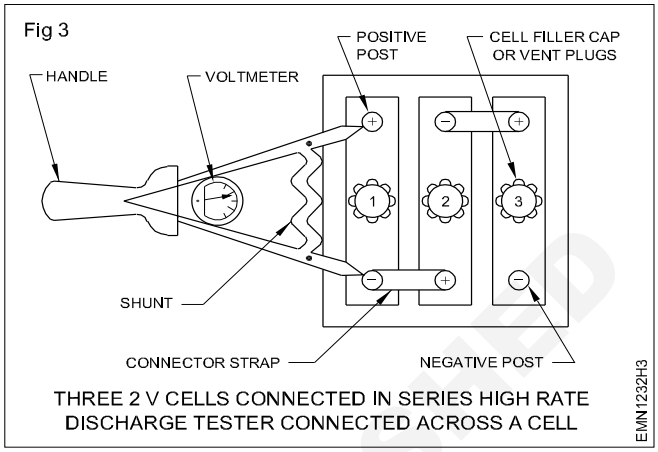
Follow the manufacturer's recommendation for current setting for charging as well as discharging.

10 Observe the voltage of each cell of the battery and specific gravity of the electrolyte at regular intervals (say ONE hour); record the observations in Table 1.

11 Switch OFF the battery charger and disconnect the battery when fully charged; Fit the vent plugs, clean the outer surface with wet cloth and apply petroleum jelly to the terminals.

12 Check the battery for its working voltage under load using a high rate discharge tester for a short period. as shown in Fig 3.

Fig 3



THREE 2 V CELLS CONNECTED IN SERIES HIGH RATE DISCHARGE TESTER CONNECTED ACROSS A CELL

Do not keep a high rate discharge tester for a long period, say more than five seconds.

13 Record the voltage reading shown by the high rate discharge tester= ----------V.

14 Get the work checked by the Instructor.

Table 1

Cell No.	Initial condition			Charged condition after									
	Voltage	Charging current	Specific Gravity	1 Hr		2 Hr		3 Hrs		4 Hrs		5 Hrs	
				V	SP	V	SP	V	SP	V	SP	V	SP
1													
2													
3													
4													
5													
6													

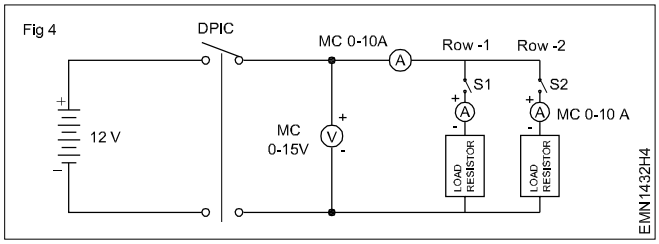
— — — — — — — —

TASK 2 : **Discharging the battery through load resistor**

1 Check the specific gravity and voltage before discharging.

2 Connect the load resistors to the battery and meter as shown in Fig 4.

Fig 4



3 Switch ON the circuit for a short time (15 to 30 sec) and observe the ammeter readings.

4 Record the observations in Table - 2.

5 Read and record, the current voltage and specific gravity at regular interval say one hour in Table 2.

Do not discharge the battery beyond the minimum value of voltage say 1.75V.

6 Check the specific gravity and voltage after discharge.

7 Check and compare the differences of specific gravity and voltage before and after discharging the battery.

8 Stop the discharge when the battery reaches below 1.75 volts.

9 After discharge, recharge the battery immediately.

10 Get the work checked by the Instructor.

Table 2

Time after	Load Current I in amps	Changed Condition after Discharge	
		Specific Gravity	Voltage
30 Sec			
60 Sec			
90 Sec			

— — — — — — — —

Maintain the secondary cells

Objectives : At the end of this exercise you shall be able to
- **check and inspect the battery type, voltage and rating details**
- **clean the battery, test battery condition, electrolyte level and charge the battery.**

Requirements

Tools/Equipments/Instruments

- Trainees tool Kit - 1 Set
- Hydrometer - 1 No
- Voltmeter 0-15V DC MC type - 1 No
- Digital multimeter with probes - 1 No

Materials/Components

- Lead acid battery 6V/12V 100 AH - 1 No
- Distilled water 500 ml - as reqd
- Petroleum jelly - as reqd
- Cleaning cloth - as reqd
- Cleaning brush 2 inch - 1 No
- Goggles - 1 No
- Hand gloves - 1 No
- Baking soda - as reqd

Safety precaution: Always wear the necessary protective clothing when working with a battery, especially gloves and safety goggles.

- Do not keep the screw driver, spanners or any tools on the battery, as it may short circuit the terminals.
- Do not wear metallic watch strap or bangles while working with batteries.
- Carry out the exercise in a well ventilated, dry and level place.

PROCEDURE

TASK 1 : **Inspection of the battery type, terminal voltage and Ampere hour rating**

1 Examine the outside appearance of the battery.

2 Observe the details marked in the label on battery.

3 Check the battery type, voltage and ampere hour rating and note down the details in Table - I.

4 Inspect for any fluid in and around the battery for elctrolyte is spilling or leaking out.

5 Check cables, clamps, and housing for obvious damage or loose connections.

6 Look closely for loose or damaged terminal clamps; ensure that the battery cables are intact. (Broken or frayed cables are extremely hazardous-Replace if found damaged).

7 Tight all wiring/connections from the battery.

8 Get the work checked by the Instructor.

Table - 1

Sl No.	Battery Type	Voltage	Ampere hour Rating	Remarks

— — — — — — — —

TASK 2 : **Testing the battery condition**

1 Discount the loads from the batteries and clean the terminals using the cleaning brush dipped in the mixture of baking soda and water.

2 Use the cleaning cloth and wipe the battery clean.

3 Measure the Voltage across battery terminals using Digital multimeter.

4 Compare the measured voltage with the readings mentioned in the Chart-1.

5 Get the work checked by the Instructor.

Chat showing the relation with open circuit voltage, specific gravity and percentage of charge

Open - Circuit Voltage						Specific gravity corrected to	Percentage of Charge
6V	8V	12V	24V	36V	48V		
6.37	8.49	12.73	25.46	38.20	50.93	1.277	100
6.31	8.41	12.62	25.24	37.85	50.47	1.258	90
6.25	8.33	12.50	25.00	37.49	49.99	1.238	80
6.19	8.25	12.37	24.74	37.12	49.49	1.217	70
6.12	8.16	12.27	24.48	36.72	48.96	1.195	60
6.02	8.07	12.10	24.20	36.31	48.41	1.172	50
5.98	7.97	11.89	23.92	35.87	47.83	1.148	40
5.91	7.88	11.81	23.63	35.44	47.26	1.124	30
5.83	7.77	11.66	23.32	34.97	46.63	1.098	20
5.75	7.67	11.51	23.02	34.52	46.03	1.076	10

TASK 3 : **Testing electrolyte level and charging the battery**

1 Open the vent caps from the battery.

2 Check the electrolyte level inside the battery visually for the top of plates are exposed or immersed in electrolyte in all the cells.

Note: If the plates are exposed, top up of distilled water is required.

3 Add distilled water till the plates are covered approx 3 mm.

4 Repeat the above steps for all the cells and ensure the same level in all the cells of the battery; tightly close all the vent caps.

5 Connect the battery charger and set the battery under charge with recommended voltage/current settings.

6 Get the work checked by the Instructor.

TASK 4 : **Maintaining the battery**

1 Check that all vent caps of the battery are tightly in their place.

2 Remove the connectors from the battery terminal by moving them from side to side and gently pulling them up.

3 Dip the wire brush into the solution of baking soda mixed with distilled water and clean the terminals of the battery as shown in Fig 1.

Fig 1

4 Clean the battery top with brush using the solution of baking soda and water.

5 Clean with water and dry using a clean cloth.

Note: When cleaning do not allow any cleaning solution or other foreign matter to get inside the battery.

6 Apply grease to both the battery terminals and reconnect the clamps to the terminals correctly.

7 Get the work checked by the Instructor.

Measure the specific gravity of electrolyte using hydrometer

Objectives: At the end of this exercise you shall be able to
- **Measure the specific gravity of electrolyte in lead acid battery.**

Requirements

Tools/Equipments/Instruments

- Lead acid battery 12V/60 AH - 1 No
- Battery charger 12V - 1 No
- Hydrometer - 1 No
- Safety googles - 1 No

Materials/Components

- Distilled Water 500 ml - 1 Bottle
- Concentrated sulphuric acid - 200 ml
- Clean Jar for mixing 1 Ltr.capacity - 1 No

Safety precaution: Near the safety goggles to protect eyes from acid or any dust particles.

PROCEDURE

1 Visually inspect the top surface of the battery; clean the terminals.

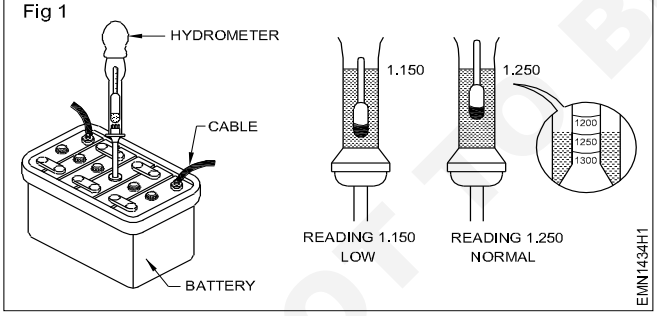
Note: If sulphated clean with wet cotton waste or with soda bicarbonate.

2 Unscrew all the vent plugs and check the level of the electrolyte.

Don't clean the battery top surface keeping the vent plugs open . The accumulated dirt may fall inside the cells and form sediments.

3 Insert the hydrometer rubber nozzle inside the battery vertically as shown in Fig 1.

Fig 1



4 Pump the electrolyte upto reference mark by pressing the bulb.

5 Check the initial specific gravity of the electrolyte of each cell using hydrometer and record it in Table 1.

Note:
1. **In a fully charged lead acid cell the specific gravity of the electrolyte should be 1.28 at room temperature.**
2. **When the specific gravity of electrolyte falls down to about 1.150 the cell can be taken as fully discharged.**

6 Record the status of charge condition each cell in Table 1.

7 Get the work checked by the instructor.

Table 1

Cell No.	Specific gravity	Charge condition	Remarks
1			
2			
3			
4			
5			
6			

Test a battery and verify whether the battery is ready for use or needs recharging

Objectives : At the end of this exercise you shall be able to
- **test a battery and verify whether the battery is ready for use**
- **verify whether battery needs recharge.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- High rate discharge tester - 1 No
- Hydrometer - 1 No
- MC voltmeter 0-15V - 1 No
- Lead acid type 12V - 1 No

Materials/Components

- Cotton waste - as reqd
- Test probes with crocodile clip - 1 Pair

PROCEDURE

TASK 1 : **Testing the a battery and verifying whether battery is ready for use**

1 Clean the terminals; measure the cell voltage and battery voltage using voltmeter; record the observations in Table 1.

2 Check the level of the electrolyte in the battery

3 Measure the specific gravity of electrolyte of each 3 cell with hydrometer and record the observations in Table 1.

4 Observe whether the specific gravity is 1.28.

5 See whether the level of electrolyte is above the level of electro plate.

6 If all the above test results are satisified, then the battery is ready for use.

Fig 1

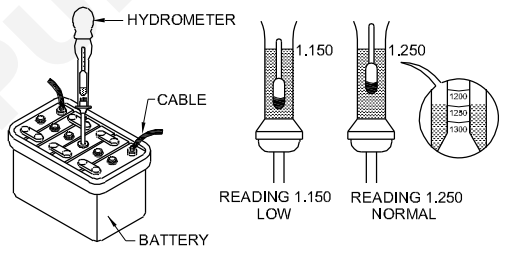


Table 1

Cell No.	Measured voltage	Specific gravity	Condition	Remarks
1				
2				
3				
4				
5				
6				

TASK 2 : **Verifying whether battery needs recharge or not**

1 Check the battery for its working voltage under load using a high rate discharge tester for a short period say within 5 seconds.

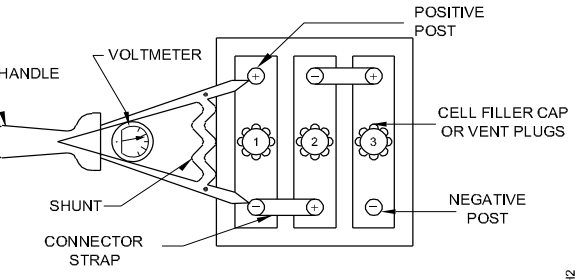
2 Observe whether each cell voltage is below 1.8V.

3 Measure the specific gravity of electrolyte of each cell with a hydro meter.

4 observe whether the specific gravity is below 1.24.

5 If all the test results are in the above condition then the battery needs recharge.

Fig 2



THREE 2 V CELLS CONNECTED IN SERIES HIGH RATE DISCHARGE TESTER CONNECTED ACROSS A CELL

Use the multimeter to measure various functions (AC V, DC V, AC I, DC I, R)

Objectives : At the end of this exercise you shall be able to
- **identify available ranges in the given multimeter**
- **measure voltage and current of DC supply**
- **measure voltage and current of AC supply**
- **measure resistance (continuity) of a switch.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- DC RPSU unit, 0-30V/5A - 1 No
- Auto transformer, 0-270V/1A - 1 No
- Digital multimeter with probes - 1 Set

Materials/Components

- Battery 1.5V AA Size - 1 No
- Lead-acid battery, 12 volts - 1 No
- Assorted value of resistor - 5 Nos

PROCEDURE

TASK 1: **Study on Multi-meter**

1 In the given multi-meter, check the available ranges scales and other information and record these details in Table -1.

2 Check the symbol on meter indicating its placement position. In the case of analog multimeter, carryout mechanical zero setting of the meter.

3 Connect the meter prods ensuring proper colour of probes at meter terminals.

Table 1

a Name of the given multimeter & model number.

b Manufacturer name.

c List of input socket available on the meter.

d List the available measuring ranges and scale marking on the meter.

Table 1

DC Voltage		AC Voltage	
Range No.	**Voltage Range**	**Range No.**	**Voltage Range**

DC Current		AC Current	
Range No.	**Current Range**	**Range No.**	**Current Range**

Resistance Ranges:

Range No.	Ohms Range

TASK 2: **Measurement of DC voltage**

1 Set the meter range switch to measure cell voltages and choose the scale for taking readings. Record the chosen range position and scale in Table 2.

2 Measure and record the voltage of cell & battery in Table 2.

3 Set the meter range to measure the unknown DC voltage from the regulated DC power supply unit (RPSU).

4 Measure the output voltage of RPSU. Change the set range if necessary to measure the set RPSU voltage more accurately. Record the measured voltage in Table 2.

Table 2: DC Voltage measurement

Sl.No.	Source of DC Voltage	Label Marked set voltage	Measured voltage
1	AA size battery		
2	Battery, 12V/9V		
3	RPSU output		

— — — — — — — —

TASK 3: **Measurement DC current**

1 Set the multimeter to measure an unknown DC current.

2 Connect the meter terminals as shown in Fig 1.

3 Measure and record the readings shown by the meter in Table 3.

4 Change the set range if necessary to measure the current more accurately.

5 Change the resistor value and measure different current values in Table 3.

Fig 1

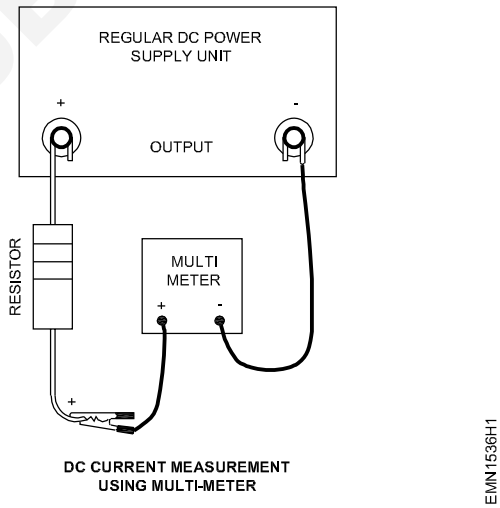


Table 3: DC Current Measurement

Sl.No	Set current range	Measured current
1		
2		
3		

— — — — — — — —

TASK 4: **Measurement of AC voltage**

1 Set the multi-meter to measure higher AC voltage.

2 Connect the meter terminal to a variable AC source (Auto-transformer).

3 Measure and record the readings shown by the meter in Table-4. Change the set range if necessary to measure the voltage more accurately.

4 Change the set value of AC voltage and repeat step-1 to step-3.

Table 4: AC voltage measurement

Sl. No	Set voltage range	Measured voltage
1		
2		
3		

— — — — — — — —

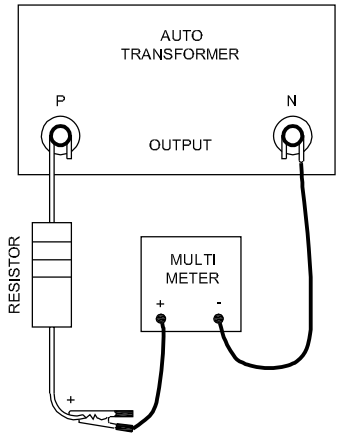
TASK 5: **Measurement of AC current**

1 Set the multi-meter to measure an unknown AC current.

2 Connect an Auto-transformer to the supply source and set the output voltage to 50V, AC.

3 Connect the meter terminals as shown in Fig 2.

Fig 2



AC CURRENT MEASUREMENT USING MULTI-METER

4 Measure and record the readings shown by the meter in Table 5. Change the set range if necessary to measure the current more accurately.

5 Change the resistor value and measure different current values in Table 5.

Table 5: AC current measurement

Sl. No	Set current range	Measured current
1		
2		
3		
4		
5		
6		
7		
8		

TASK 6: **Measurement of resistance of a switch**

1 Set the multi-meter to continuity range.

2 Check the switch under both two condition.

3 In one position, the meter shows zero reading and gives sound that means the switch is in ON position.

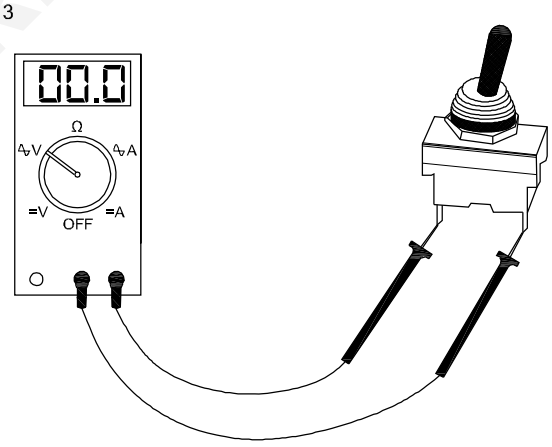
4 In another position, the meter shows 1 at the left side of the display that is high resistance and the switch is in OFF position. (Fig 3)

5 Record the observations in the Table 6.

Table 6: Measurement of resistance of a switch

Sl. No	Condition of switch	Resistance
1	ON	
2	OFF	

Fig 3



Identify the different types of meter for measuring AC & DC parameters

Objective : At the end of this exercise you shall be able to
- **identify the type of instruments (AC/DC) and their function from the dial markings.**

Requirements

Tools/Equipments/Instruments

- Voltmeter 0 - 300 V MC - 1 No
- Ammeter 0-15 A MI panel board type - 1 No
- Ammeter 0 - 5A MC - 1 No
- Ohmmeter-shunt and series type - 1 each
- Watt meter 0-400 kW - 1 No
- Frequency meter 45-55Hz - 1 No
- Multi-range voltmeter MC 0-75, 150, 300 & 600 V - 1 No
- Multi-range voltmeter MI 0-150, 300 and 600 V - 1 No
- Power factor meter 0.5 lead 0-0.5V lag - 1 No

PROCEDURE

The instructor has to label the meters serially before issued to trainees. Provide the chart showing symbols and their respective meaning for identification and reference.

1 Pick one of the labelled meter; observe the alphabet/ function marked on the centre of the dial/panel to identify the parameter/function.

2 Draw the sketch of the meter and record the observation in Table 1.

3 Observe the small symbols printed at the bottom line on the dial/panel.

4 Refer to the chart - 1, identify and compare the symbol and its meaning; record it in Table 2.

5 Repeat the above steps for all the remaining meters and record the observations in Table 2.

6 Get the work checked by the Instructor.

CHART 1
SYMBOLS FOR CHARACTERISING ELECTRICAL MEASURING INSTRUMENTS.

	MOVING COIL MEASURING ELEMENT
	MOVING COIL MEASURING ELEMENT WITH RECTIFIER
	MOVING IRON MEASURING ELEMENT
—	TYPE OF CURRENT: ONLY DIRECT CURRENT
~	TYPE OF CURRENT: ONLY ALTERNATING CURRENT
≂	DIRECT AND ALTERNATING CURRENT
⊥	POSITION FOR USE: VERTICAL
⌐	POSITION FOR USE: HORIZONTAL
1	INDICATION ERROR ±1%
2.5	INDICATION ERROR ±2.5%
3.5	INDICATION ERROR ±3.5%
☆2	TEST VOLTAGE: 2 kV=2000 V
⚠	OBSERVE INSTRUCTIONS FOR USE

EMN1537H1

Table 1

Label No.	Sketch of the meter	Type AC/DC	Function	Single/ multi range	Single/ multi scale	Remarks

Table 2

Sl.No.	Symbol on the meter	Description	Sl.No.	Symbol on the meter	Description
1			6		
2			7		
3			8		
4			9		
5			10		

Identify the different controls on the CRO/DSO front panel and observe the function of each control

Objectives: At the end of this exercise you shall be able to
- **identify operating controls on the CRO/DSO front panel**
- **observe the function of each front panel control.**

Requirements

Tools/Equipments/Instruments

- 0-20 MHz Dual channel CRO/DSO-with probe kit and operating manual - 1 Set

Materials/Components

- - Nil -

Note: The instructor has to take the xerox copy of front panel of CRO/DSO available in the lab; mark serial numbers for each control and issue to trainees.

Provide the operating manual of the CRO/DSO to refer the function of each control.

PROCEDURE

TASK 1 : **Identification of operator controls on the CRO/DSO front panel**

1 Keep on the work bench; observe the name of controls printed on each of them on the panel.

2 Refer to the serial numbers marked on the xerox copy for each control from power ON/OFF, note down the name in the Table 1.

3 Refer to the operating manual and note down the functions in Table 1.

4 Repeat steps 2 and 3 for all controls on the CRO/DSO front panel. (Fig 1)

Fig 1

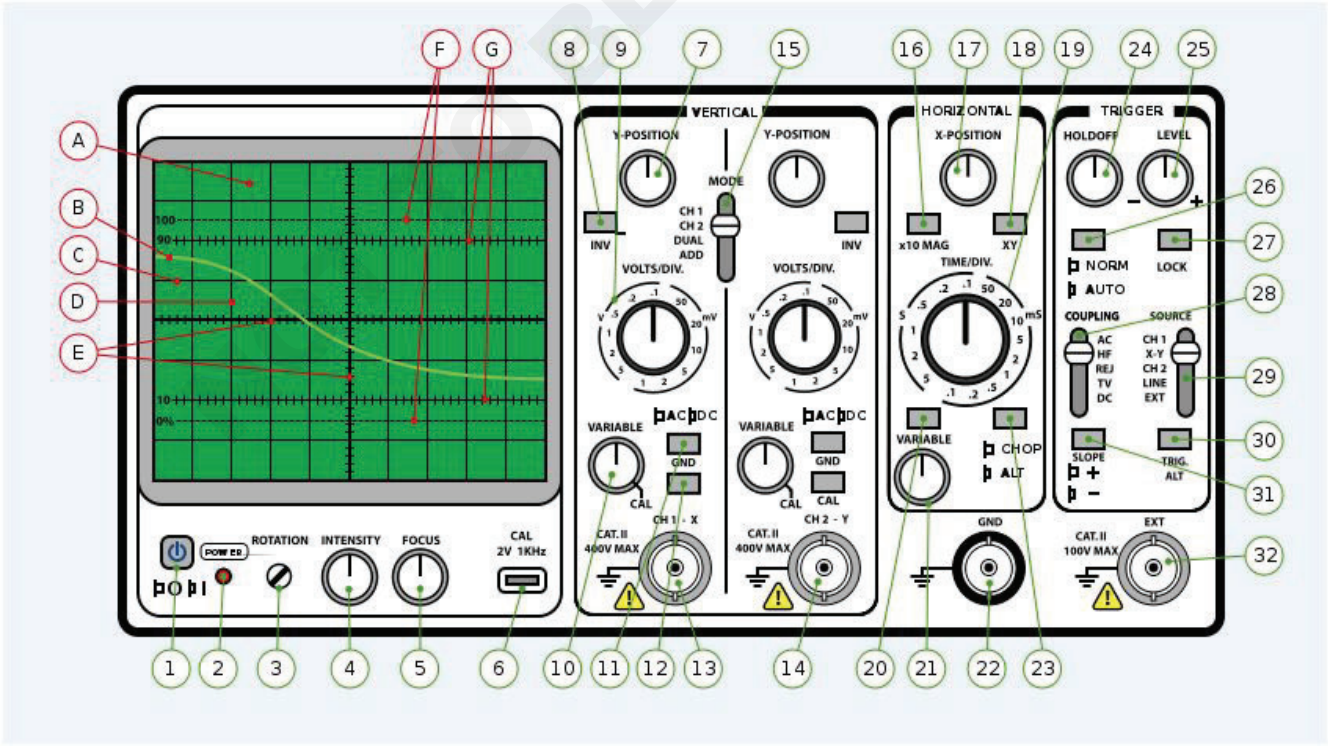


Table I

Label No.	Name of the Front Panel Controls	Remarks
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
12		
13		
14		
15		

5 Get the work checked by the instructor

— — — — — — — —

TASK 2 : **Observation of function of each front panel control in CRO/DSO**

1 Connect the power cord to the CRO/DSO and plug it to AC mains supply.

2 Switch 'ON' and allow warm up time till the trace appears on the screen.

3 Adjust intensity and focus controls for a observing effect of size and brightness of trace on the screen, record observation in Table 2.

4 Re adjust the above controls for a sharp trace on the screen.

5 Adjust time/Div control, observe the effect of trace movement and bring back to the previous setting; record observations in Table 2.

6 Adjust horizontal position control, observe the shifting of the trace, bring back to the previous setting; record observations in Table 2.

7 Repeat the step 6 for vertical position control and record observations in Table 2.

8 Connect the output of built in calibration signal to the channel 1 input using suitable cable/CRO probe.

9 Observe the waveform, vary the settings of above controls one at a time and observe the effect on the display.

10 Record the observations in Table 2.

Table 2

Sl. No.	Name of the control	Effect of display on screen
1	POWER - ON/OFF	
2	Intensity	
3	Focus	
4	Time/Div	
5	Horizontal position	
6	Vertical position Ch-1	
7	Vertical position Ch-2	
8	Trigger Int./Ext.	

11 Repeat the steps for remaining controls and record observations.

12 Get the work checked by the Instructor.

— — — — — — — —

Measure V_{DC}, V_{AC}, time period using CRO/DSO sine wave Parameters

Objectives : At the end of this exercise you shall be able to
- **measure D.C. voltage (V_{DC})**
- **measure the values of AC voltage (V_{P-P})**
- **measure the time period of a sine wave parameters.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Oscilloscope, 20MHz - 1 No
- RPS, 0-30V, 1A - 1 No
- Voltmeter/Multimeter - 1 No

Materials/Components

- Step-down transformer, 230V/12V, 200 mA - 1 No
- Probes for Oscilloscope - 1 No
- Dry cell, 1.5 V - 1 No
- Hook-up wire - 1 m

PROCEDURE

TASK 1 : **Measurement of DC voltage**

1 To measure the voltage of the dry cell, set the volt per division to 0.5 V/Div.

2 Connect the black (ground) probes to the negative end and the red probe to the positive end of the dry cell.

3 Observe the trace on the screen. It will be observed that the trace will move up by 3 divisions from the centre line indicating the voltage in positive.

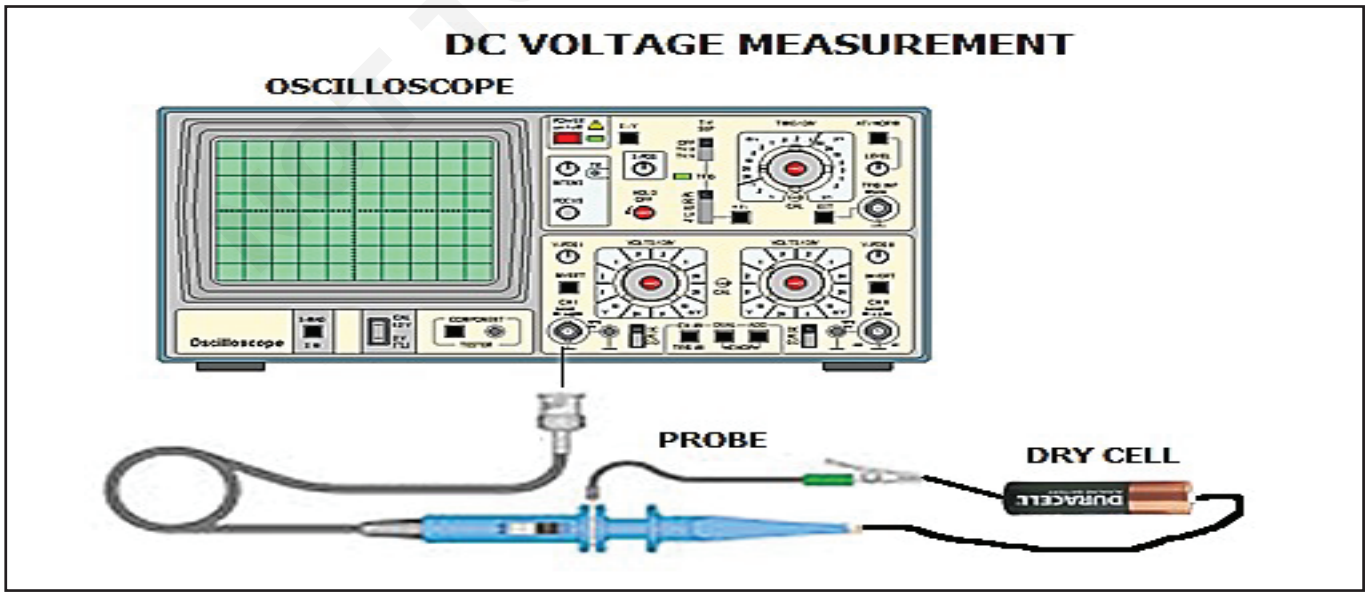
4 The magnitude of the EMF of the cell is given by,

5 Now, reverse the leads, the trace will move down by 3 divisions indicating the voltage is negative and again the EMF of the cell = 3 x 0.5 = -1.5V.

6 Instead of a dry cell use the regulated DC power supply (0-30V) and repeat steps-2 to step-4 and record the observations in Table 1.

Table 1

Sl No.	Power supply voltage in volt	Attenuator position	No.of divisions moved up	No.of divisions moved down	Voltage measured in CRO
1					
2					



TASK 2 : **Measurement of AC voltage**

1 To measure AC voltages, set the AC-DC switch in (out) AC position.

2 Set the volt per division to 50V, if the input voltage is unknown and adjust the time base switch to 10 milliseconds.

3 Connect a step-down transformer secondary leads one to the common input terminal to the ground side for signal source and another lead to the input terminal.

4 Switch ON the oscilloscope, adjust the trace to centre and focus intensity controls for a sharp bright trace.

5 Switch ON and energize the primary of the transformer.

6 Observe the wave form that appears on the screen.

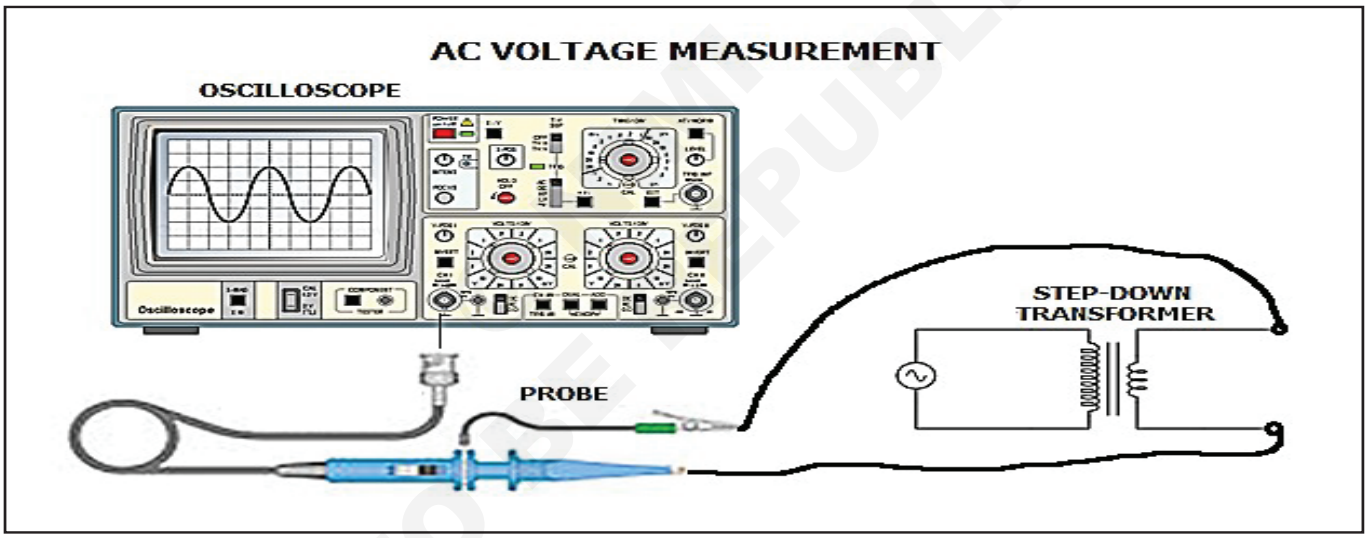
7 Increase the vertical sensitivity by the Volts/Div switch such that the wave form display is clearly seen.

8 Measure the peak to peak voltage of the displayed waveform, by counting the number of divisions between positive and negative peaks. Record the observations in Table 2.

9 Determine the RMS value of the voltage by measuring the voltage across the secondary of the transformer using multimeter.

Table 2

Sl. No.	Attenuator switch range Volts/Div	No.of divisions counted peak voltage	No.of divisions counted peak to peak voltage	Peak voltage	Peak to peak voltage	RMS voltage (measured by voltmeter)
1						



TASK 3 : **Measurement of time period and frequency of sine wave**

1 After measurement of peak to peak voltage in Task 2, turn the time base vernier (1) to CAL position.

2 Set the Time/Div switch to a range where the signal can be clearly seen.

3 Count the number of divisions horizontally for one complete cycle and record the same in Table 3.

4 Calculate the frequency of the displayed wave form the using formula,

Where, T is the time period in seconds. Enter the values in Table 3.

5 Formula to be used:

Time period (T) = Time base range x No. of divisions/ Cycles.

Frequency (f) = 1/T Hertz.

Table 3

Sl No.	Attenuator switch range Time/Div	No.of divisions per cycle	Time period (T)	Frequency f=1/T Hertz
1				

Identify the different controls on the function generator front panel and observe the function of each controls

Objectives: At the end of this exercise you shall be able to
- **identify the different front panel control in function generator**
- **observe the function of each front panel control in function generator.**

Requirements

Tools/Equipments/Instruments

- 0-20MHz CRO-dual channel with probe kit and operating manual - 1 Set
- Function generator with operating instruction manual - 1 No

Materials/Components

The instructor has to use the xerox copy of the front panel of function generator available in the lab. Mark each control with serial numbers for identification/function of them and provide to trainees.

PROCEDURE

TASK 1 : **Identification of different controls on the Function generator front Panel**

1 Keep the function generator on the work bench; observe the name of controls printed on each of them.

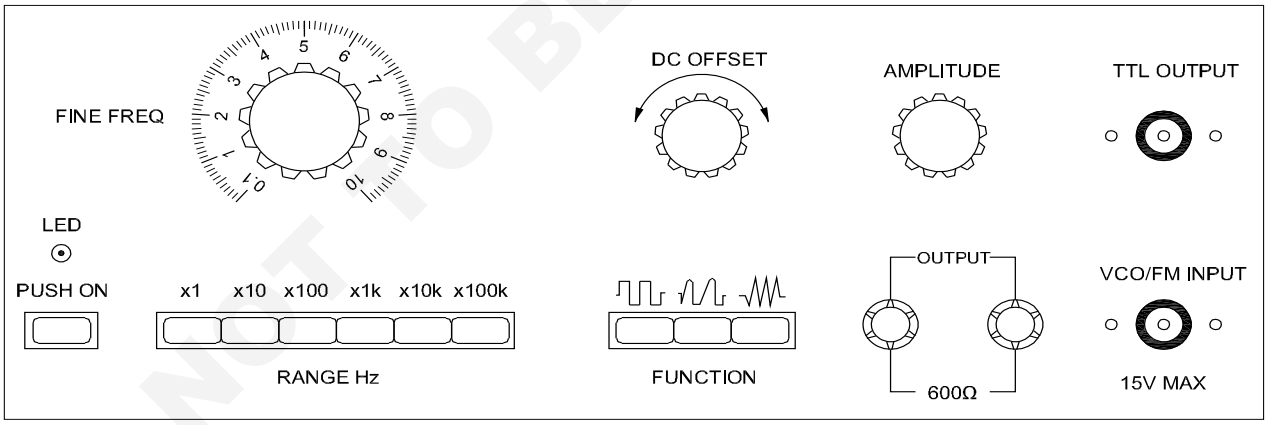
2 Start from label No.1, refer to the identify and note down name of the control in Table 1.

3 Repeat to the operating/Instruction manual of the function generator and note down the function control in Table 1.

4 Repeat the above step for all the labelled controls and record their name in Table 1.

5 Get the work checked by the Instructor.

Fig 1



FRONT PANEL OF FUNCTION GENERATOR

Table - 1

Label No.	Name of the Front Panel Controls	Function
1		
2		
3		
4		
5		

Table - 2

Label No.	Name of the Front panel control	Function of control waveform/frequency amplitude	Remarks
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			

Note:

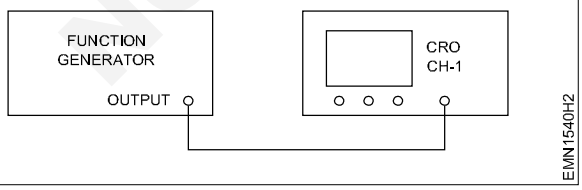
- **The instructor has to guide the trainees for identification of controls/sockets or switches on the rear panel of the function generator and record them in Table 3.**
- **If more controls are available, make the trainees to observe under separate task following above procedure.**

— — — — — — — —

TASK 2 : **Observe the functioning of each control on the front panel of function generator**

1 Connect the output of function generator to the channel-1 input of CRO as shown in Fig 2 using BNC cable/ connector.

Fig 2



2 Switch ON the CRO; allow warm-up time, adjust controls and prepare CRO for measurements.

3 Switch ON the function generator; operate the frequency select control, amplitude etc. One at a time and observe the waveform on CRO screen by varying their position.

4 Record the observation in table 2; operate other controls, observe corresponding change in waveform/ frequency/amplitude and record them in Table 2.

5 Repeat the steps for all the controls on the front panel and record observations.

6 Get the work checked by the Instructor.

— — — — — — — —

Identify the different controls on the front panel of a Digital Storage Oscilloscope

Objectives: At the end of this exercise you shall be able to
- **Identify different controls on the front panel of a DSO**
- **to operate the front panel controls on the DSO.**

Requirements

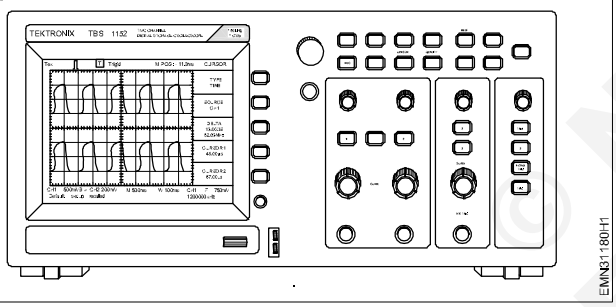
Tools/Equipments/Instruments

• DSO	- 1 No.
• Manual	- 1 No.

PROCEDURE

The Fig 1 shows the front panel of a digital storage oscilloscope for 2-channel models. Here TDS 2002 tektronix oscilloscope as taken as reference. Other DSO will also have the same features. If it differs from this, you may refer manual to understand the functions.

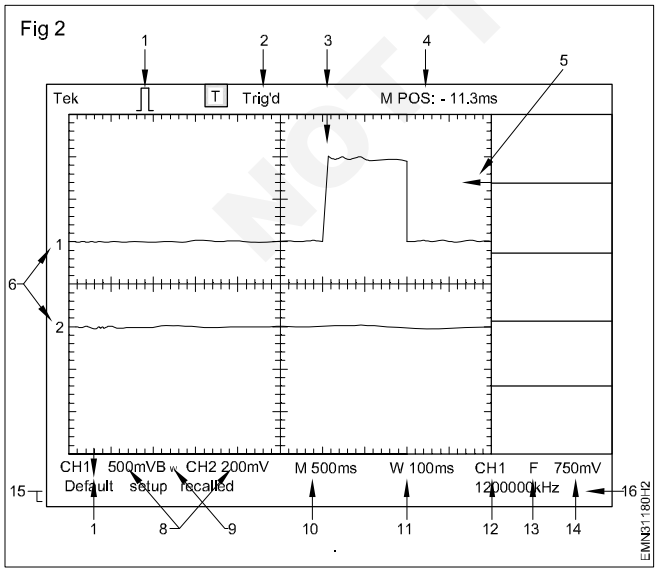
Fig 1



Display Area

In addition to displaying waveforms, the display is filled with many details about the waveform and the oscilloscope control settings. (refer Fig 2)

Fig 2



1 Icon display shows acquisition mode.

Sample mode

Peak detect mode

Average mode

2 Trigger status indicates the following:

Armed : The oscilloscope is acquiring pretrigger data. All triggers are ignored in this state.

Ready: All pretrigger data has been acquired and the oscilloscope is ready to accept a trigger.

Trig'd: The oscilloscope has seen a trigger and is acquiring the post trigger data.

Stop: The oscilloscope has stopped acquiring waveform data.

Acq. Complete : The oscilloscope has completed a single sequence acquisition.

Auto: The oscilloscope is in auto mode and is acquiring waveforms in the absence of triggers.

Scan: The oscilloscope is acquiring and displaying waveform data continuously in scan mode.

3 Marker shows horizontal trigger position. Turn the HORIZONTAL POSITION knob to adjust the position of the marker.

4 Readout shows the time at the center graticule. The trigger time is zero.

5 Marker shows Edge or Pulse Width trigger level.

6 On-screen markers show the ground reference points of the displayed waveforms. If there is no marker, the channel is not displayed

7 An arrow icon indicates that the waveform is inverted.

8 Readouts shows the vertical scale factors of the channels.

9 A BW icon indicates that the channel is bandwidth limited.

10 Readout shows main time base setting

11 Readout shows window time base setting if it is in use.

12 Readout shows trigger source used for triggering.

13 Icon shows selected trigger type as follows


Edge trigger for the rising edge


Edge trigger for the falling edge


Video trigger for line sync.


Video trigger for field sync.


Pulse width trigger, positive polarity.


Pulse width trigger, negative polarity.

14 Readout shows Edge or Pulse Width trigger level.

15 Display area shows helpful messages; some messages display for only three seconds.

16 Readout shows trigger frequency

Message Area

The oscilloscope displays a message area (item number 15 in the previous figure) at the bottom of the screen that conveys the following types of helpful information:

- Directions to access another menu, such as when you push the TRIG MENU button:

For TRIGGER HOLDOFF, go to HORIZONTAL Menu

- Suggestion of what you might want to do next, such as when you push the MEASURE button:

Push an option button to change its measurement

- Information about the action the oscilloscope performed, such as when you push the DEFAULT SETUP button:

Default setup recalled

- Information about the waveform, such as when you push the AUTOSET button:

Square wave or pulse detected on CH1

Using the Menu System

The oscilloscope uses four methods to display menu options:

- **Page (Submenu) Selection:** For some menus, you can use the top option button to choose two or three submenus. Each time you push the top button, the options change. For example, when you push the top button in the SAVE/REC Menu, the oscilloscope cycles through the Setups and Waveforms submenus.
- **Circular List:** The oscilloscope sets the parameter to a different value each time you push the option button. For example, you can push the CH 1 MENU button and then push the top option button to cycle through the Vertical (channel) Coupling options.
- **Action:** The oscilloscope displays the type of action that will immediately occur when you push an Action option button. For example, when you push the DISPLAY Menu button and then push the Contrast Increase option button, the oscilloscope changes the contrast immediately.
- **Radio:** The oscilloscope uses a different button for each option. The currently-selected option is highlighted. For example, the oscilloscope displays various acquisition mode options when you push the ACQUIRE Menu button. To select an option, push the corresponding button.

Vertical Controls

CH 1, CH 2, Cursor 1 and Cursor 2 position: Positions the waveform vertically. When you display and use cursors, an LED lights to indicate the alternative function of the knobs to move the cursors.

CH 1 & CH 2 Menu: Displays the vertical menu selections and toggles the display of the channel waveform on and off.

VOLTS/DIV (CH 1 & CH 2): Selects calibrated scale factors.

Horizontal Controls

HORI MENU: Displays the Horizontal Menu.

SET TO ZERO: Sets the horizontal position to zero.

SEC/DIV: Selects the horizontal time/div (scale factor) for the main or the window time base. When Window Zone is enabled, it changes the width of the window zone by changing the window time base.

Trigger Controls

LEVEL and USER SELECT: When you use an Edge trigger, the primary function of the LEVEL knob is to set the amplitude level the signal must cross to cause an acquisition. You can also use the knob to perform USER SELECT alternative functions. The LED lights below the knob to indicate an alternative function

TRIG MENU: Displays the Trigger Menu.

SET TO 50%: The trigger level is set to the vertical midpoint between the peaks of the trigger signal.

FORCE TRIG: Completes an acquisition regardless of an adequate trigger signal. This button has no effect if the acquisition is already stopped.

TRIG VIEW: Displays the trigger waveform in place of the channel waveform while the TRIG VIEW button is held down. You can use this to see how the trigger settings affect the trigger signal, such as trigger coupling.

Menu and Control Buttons

SAVE/RECALL: Displays the Save/Recall Menu for setups and waveforms.

MEASURE: Displays the automated measurements menu.

ACQUIRE: Displays the Acquire Menu.

DISPLAY: Displays the Display Menu.

CURSOR: Displays the Cursor Menu. Vertical Position controls adjust cursor position while displaying the Cursor Menu and the cursors are activated. Cursors remain displayed (unless the Type option is set to off) after leaving the Cursor Menu but are not adjustable.

UTILITY: Displays the Utility Menu.

HELP: Displays the Help Menu.

DEFAULT SETUP: Recalls the factory setup.

AUTOSET: Automatically sets the oscilloscope controls to produce a usable display of the input signals.

SINGLE SEQ: Acquires a single waveform and then stops.

RUN/STOP: Continuously acquires waveforms or stops the acquisition.

PRINT: Starts print operations..

Connectors

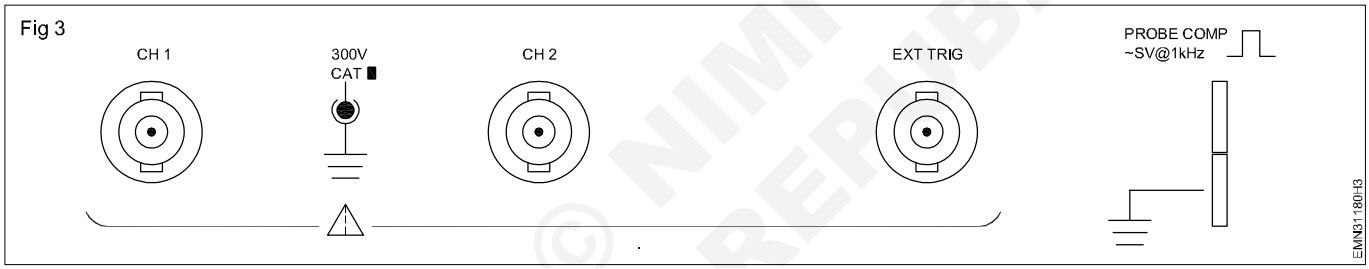
PROBE COMP: Voltage probe compensation output and ground. Use to electrically match the probe to the oscilloscope input circuit. Refer to ex no 1. The probe compensation ground and BNC shields connect to earth ground and are considered to be ground terminals

CAUTION : If you connect a voltage source to a ground terminal, you may damage the oscilloscope or the circuit under test. To avoid this, do not connect a voltage source to any ground terminals

CH 1, CH 2: Input connectors for waveform display. (Fig 3)

EXT TRIG: Input connector for an external trigger source. Use the Trigger Menu to select the Ext or INT trigger source

Fig 3



Measure the Amplitude, frequency and time period of typical electronic signal using DSO

Objectives: At the end of this exercise you shall be able to
- **measure the time, frequency and amplitude of a square/ rectangular waveform**
- **measure the time, frequency and amplitude of a sine waveform.**
- **measure the time, frequency and amplitude of a two signals to compare the phase shift.**

Requirements

Tools/Equipments/Instruments

- DSO with instruction manual and probe kit - 1 No
- Analog trainer kit with manual - 1 No
- Signal generator with manual - 1 No

PROCEDURE

TASK 1: **Taking Automatic Measurements of square wave forms**

The oscilloscope can take automatic measurements of most displayed signals, to measure signal frequency, period, and peak-to-peak amplitude. The following steps may be followed.

1 Connect a signal generator to a DSO and switch on the DSO and signal generator. Set signal generator frequency at 1kHz and amplitude at 5V as in Fig 1.

2 Push the **MEASURE** button to see the Measure Menu.

3 Push the top option button; the **Measure 1** Menu appears. Push the Type option button and select Freq. The Value readout displays the measurement and updates.

NOTE: If a question mark (?) displays in the Value readout, turn the VOLTS/DIV knob for the appropriate channel to increase the sensitivity or change the SEC/DIV setting.

4 Push the **Back** option button.

5 Push the second option button from the top; the **Measure 2** Menu appears.

6 Push the Type option button and select **Period**. The Value readout displays the measurement and updates.

7 Push the **Back** option button.

8 Push the middle option button; the **Measure 3** Menu appears.

9 Push the Type option button and select Pk-Pk. The Value readout displays the measurement and updates.(*Pk-Pk= Peak - Peak)

10 Push the **Back** option button.

11 Push the second option button from the bottom; the **Measure 4** Menu appears.

12 Push the Type option button and select **Rise Time**. The Value readout displays the measurement and updates.

13 Push the **Back** option button.

14 Push the bottom option button; the **Measure 5** Menu appears.

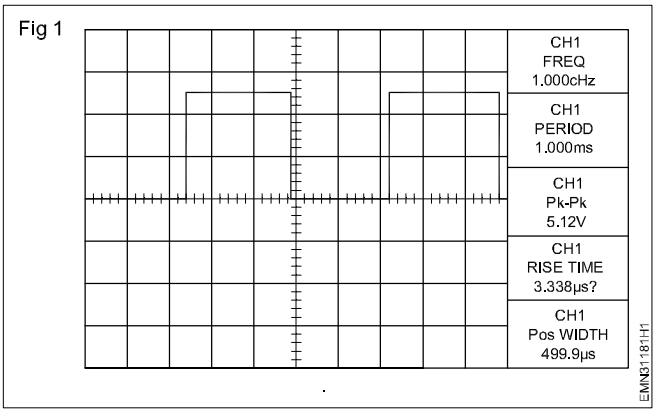
15 Push the Type option button and select PosWidth. The Value readout displays the measurement and updates.

16 Push the **Back** option button.

17 Repeat steps 2 to 15 by varying amplitude and frequency.

18 The steps 2 to 11 may be followed by connecting other type of waveforms (sine wave and triangular wave).

Fig 1



TASK 2: **Measure the time, frequency and amplitude of a two signals to compare the phase shift**

To activate and display the signals connected to channel 1 and to channel 2,

1 Construct the amplifier as shown in Fig 2 using the trainer kit. If trainer kit is not available in the lab, construct the circuit using discrete components on breadboard/PCB.

2 Connect two oscilloscope channels to the amplifier input and output as shown.

3 If the channels are not displayed, push the **CH 1 MENU** and **CH 2 MENU** buttons.

4 Push the **AUTOSET** button.

5 Push the Measure button to see the **Measure Menu**

Note: Any amplifier circuit may be used to perform this experiment.

6 Push the top option button; the **Measure 1** Menu appears.

7 Push the Source option button and select **CH1.**

8 Push the Type option button and select **Pk-Pk**.

9 Push the **Back** option button.

10 Push the second option button from the top; the **Measure 2** Menu appears

11 Push the Source option button and select **CH2.**

12 Push the Type option button and select **Pk-Pk**.

13 Push the **Back** option button

14 Read the displayed peak-to-peak amplitudes for both channels and observe the phase differences between the wave forms. It may appear as shown in Fig 2.

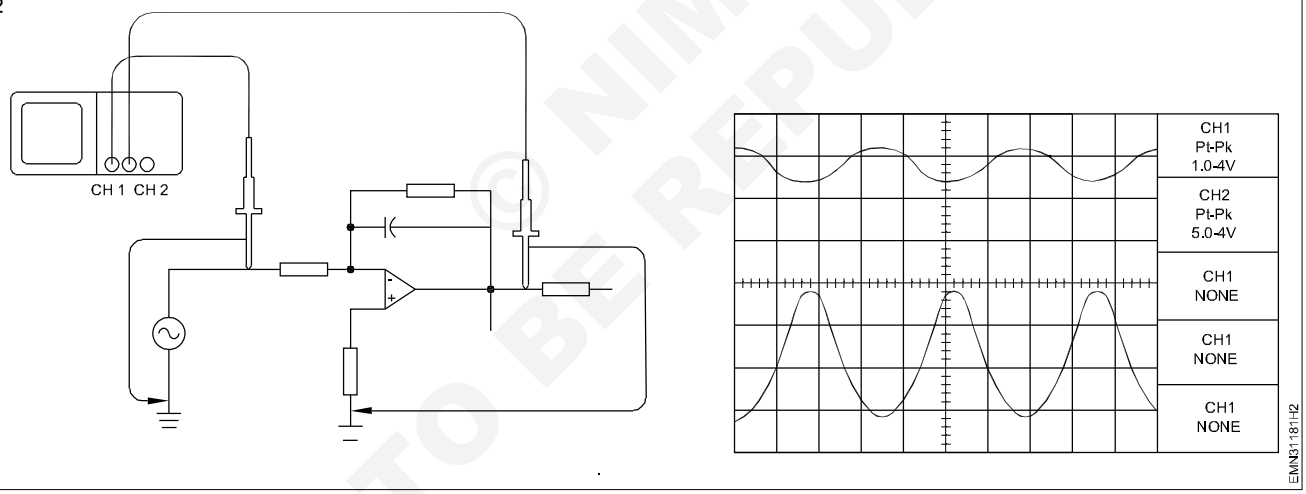
15 Vary the frequency and amplitude one by one and repeat the step 14 record your reading in the table 1.

16 Performs step 15 till you can read the values thoroughly.

17 Get the work checked by the instructor.

Sl No	Frequency	V_{in}	V_{out}	Gain=V_{out}/V_{in}

Fig 2



TASK 3: **Measure the Ring Frequency**

1 To measure the ring frequency at the rising edge of a signal, push the CURSOR button to see the Cursor Menu as in Fig 3.

2 Push the Type option button and select Time.

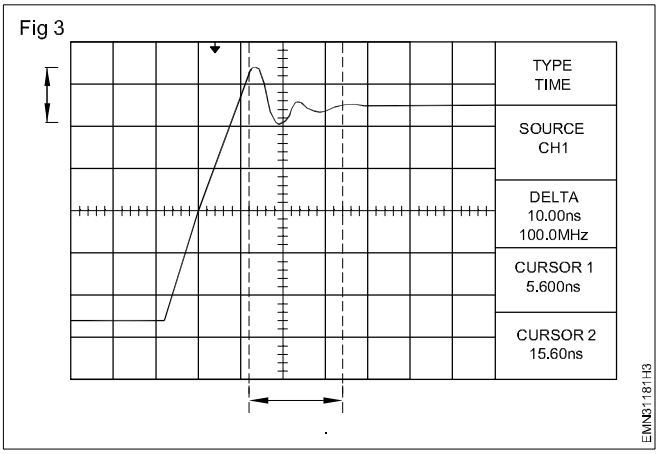
3 Push the Source option button and select CH1.

4 Turn the CURSOR 1 knob to place a cursor on the first peak of the ring.

5 Turn the CURSOR 2 knob to place a cursor on the second peak of the ring.

6 Observe that the delta time and frequency (the measured ring frequency) in the Cursor Menu.

Fig 3



TASK 4: **Measure the ring amplitude**

1 To measure the amplitude of the ringing. To measure the amplitude, push the CURSOR button to see the Cursor Menu as in Fig 4.

2 Push the Type option button and select Voltage.

3 Push the Source option button and select CH1.3.

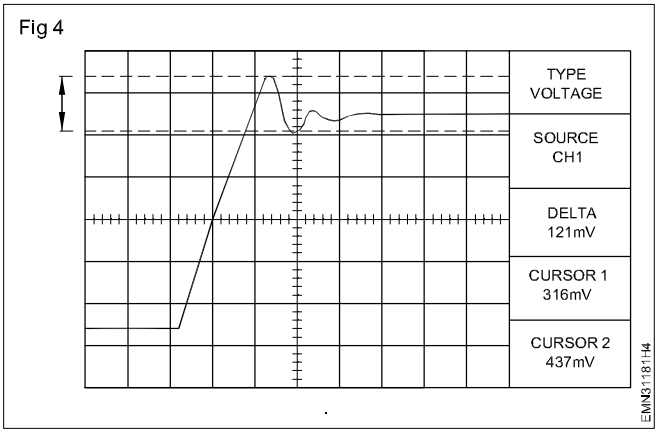
4 Turn the CURSOR 1 knob to place a cursor on the highest peak of the ring.

5 Turn the CURSOR 2 knob to place a cursor on the lowest point of the ring.

6 You can see the following measurements in the Cursor Menu:

- The delta voltage (peak-to-peak voltage of the ringing)
- The voltage at Cursor 1.
- The voltage at Cursor 2

Fig 4



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TASK 5 : **Measure the pulse width**

1 To measure the width of a pulse using the time cursors, push the CURSOR button to see the Cursor Menu as in Fig 5

2 LEDs light under the VERTICAL POSITION knobs to indicate the alternative CURSOR 1 and CURSOR 2 functions

3 Push the Source option button and select CH1.

4 Push the Type option button and select Time.

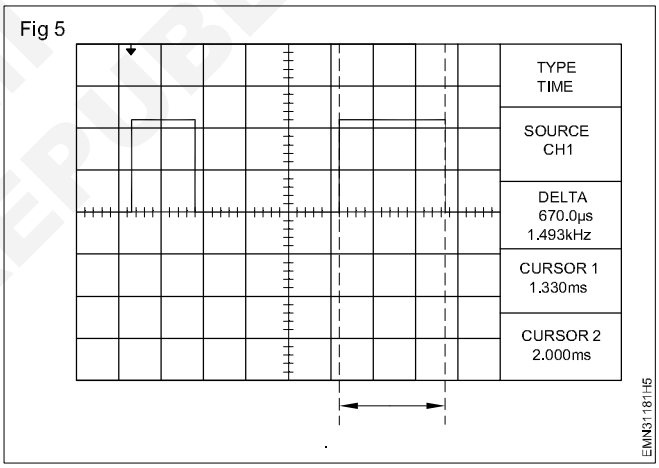
5 Turn the CURSOR 1 knob to place a cursor on the rising edge of the pulse.

6 Turn the CURSOR 2 knob to place the remaining cursor on the falling edge of the pulse.

7 Observe the following measurements in the Cursor Menu:

- The time at Cursor 1, relative to the trigger.
- The time at Cursor 2, relative to the trigger.
- The delta time, which is the pulse width measurement

Fig 5



Note:

The Positive Width measurement is available as an automatic measurement in the Measure Menu.

The Positive Width measurement also displays when you select the Single-Cycle Square option in the AUTOSET

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TASK 6: **Measuring rise time**

1 Turn the SEC/DIV knob to display the rising edge of the waveform.

2 Turn the VOLTS/DIV and VERTICAL POSITION knobs to set the waveform amplitude to about five divisions.

3 Push the CH 1 MENU button to see the CH1 Menu if it is not displayed.

4 Push the Volts/Div option button and select Fine.

5 Turn the VOLTS/DIV knob to set the waveform amplitude to exactly five divisions..

6 Turn the VERTICAL POSITION knob to center the waveform position the baseline of the waveform 2.5 divisions below the center graticule.

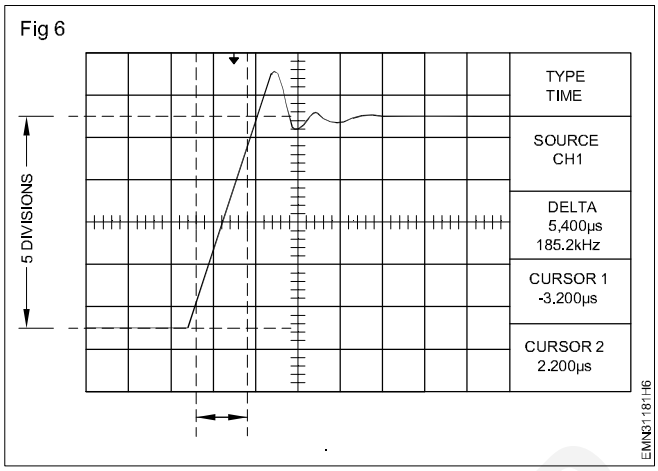
7 Push the CURSOR button to see the Cursor Menu.

8 Push the Type option button and select Time.

9 Turn the CURSOR 1 knob to place the cursor at the point where the waveform crosses the second graticule line below center screen. This is the 10% level of the waveform as in Fig. 6.

10 Turn the CURSOR 2 knob to place the second cursor at the point where the waveform crosses the second graticule line above center screen. This is the 90% level of the waveform.

Fig 6



11 The Delta readout in the Cursor Menu is the rise time of the waveform.

Note :

The Rise Time measurement is available as an automatic measurement in the Measure Menu.

The Rise Time measurement also displays when you select the Rising Edge option in the AUTOSET Menu.

Take a print of a signal from DSO by connecting a printer and tally with applied signal

Objectives: At the end of this exercise you shall be able to
- **connect a printer to a DSO and print the screen data**
- **connect a computer to a DSO and save the screen data**
- **connect a USB flash device and save the screen data**
- **recall the saved data from the USB flash drive.**

Requirements

Tools/Equipments/Instruments

- DSO - 1 No.
- Manual - 1 No.
- Analog trainer kit - 1 Set
- Signal generator - 1 No.
- Power supply 0-30 V/2A - 1 No.

Materials/Components

- IC-555 - 1 No.
- Resistor ¼ W/CR25 - 1 No.
  - 47 kΩ - 1 No.
  - 68 kΩ - 1 No.
  - 330Ω - 1 No.
- Diode 1N4007 - 1 No.
- Capacitor
  - 0.01µF - 2 Nos.
  - 10µF - 1 No.
- LED - 1 No.

PROCEDURE

TASK 1: **Connect a printer to a DSO and print the screen data**

1 Assemble an analog circuit using the analog trainer kit. E.g assemble a as table multivibrator circuit as shown in Fig 1.

2 Connect a power supply to the circuit and switch on the power supply and connect the output to the DSO.

3 Switch on the Digital storage oscilloscope

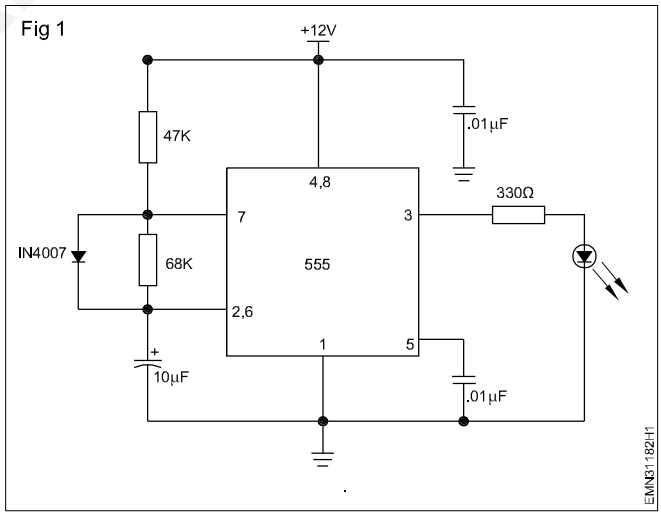
4 Press **AUTOSET**

5 Connect the printer using a USB cable to the rear panel of the DSO

6 Select the **UTILITY → OPTIONS → Rear USB Port → Printer→ Printer setup**

7 Push the option button labeled **PRINT Button** to select prints. The oscilloscope takes a snapshot of the screen and begins to send the image to the printer.

Fig 1



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TASK 2: **Connect a computer to a DSO and save the screen data**

1 Repeat the steps from 1 to 4 of task 1

2 Connect the computer using a USB cable to the rear panel of the DSO

3 Select the **UTILITY → OPTIONS → Rear USB Port → computer → Printer setup**

4 Push the option button labeled **PRINT Button** to save the image. The oscilloscope takes a snapshot of the screen and begins to send the image to the computer.

— — — — — — — —

TASK 3: **Save a screen data in a USB flash drive**

1 Repeat steps 1 to 3 of task 1

2 Connect a USB flash drive to the DSO on the front panel

You can use the **PRINT button** or the **SAVE/RECALL** menu **Save Image Action** option to save the current screen image to a file on a USB flash drive, the **PRINT** button is more versatile than the option button , because it can be used with any menu

3 Press **SAVE/RECALL** menu button.

4 Push the action button to select **Save all.**

5 Push the option button labeled Print button to select saves all to files.

6 Push <select Folder> to set a different folder as the current folder, if you desire to store at different folder. The oscilloscope will create a new folder within the current folder with and automatically generated name. every time you much push the print button

7 Access the screen you want to save

8 Push the Print button, the oscilloscope creates screen image in the new folder, with automatically generates file names

9 To see al list of the files created by Save All To Files, use < File Utilities>.

The save LED near the print button lights, to indicate that pushing the button will save the data to USB flash drive.

— — — — — — — —

TASK 4: **To recall a setup from a USB flash drive**

- Check that a USB flash drive is inserted in the oscilloscope
- Push the SAVE/RECALL menu button
- Push the Action option button to select Recall setup
- Push the Recall From option button to display the Recall setup menu
- Use the multipurpose knob to select a file or folder
- If desired, use the Change folder option button to navigate to a different folder
- Push the Recall option button, This causes the oscilloscope to recall the selected setup from the USB flash drive and change to the recalled settings.

Note: If the analog trainer kit is not available. The above circuit or any amplifier or oscillator circuit may be constructed using discrete components and the waveforms may be printed or saved.

Help System

The oscilloscope has a Help system with topics that cover all the features of the oscilloscope. You can use the Help system to display several kinds of information:

General information about understanding and using the oscilloscope, such as Using the Menu System.

Information about specific menus and controls, such as the Vertical Position Control.

Advice about problems you may face while using an oscilloscope, such as Reducing Noise.

Push the Exit option button or any menu button to remove the Help text from the screen and return to displaying waveforms.

— — — — — — — —

Construct and test function generator using IC 8038

Objectives: At the end of this exercise you shall be able to
- **construct a Function generator using IC 8038**
- **connect a DSO to various output points and trace the waveforms**
- **measure the amplitude and frequency.**

Requirements

Tools/Equipments/Instruments

- Regulated Power supply 0-30 VDC/2A - 1 No.
- DSO with probe kit - 1 No.
- Trainees tool kit - 1 Set.

Materials/Components

- IC 8038 - 1 No.
- Resistor 2.2k, 10k ¼ W - 1 No. each
- Potentiometer 10k - 1 No.
- Capacitors 1 µF, 0.1 µF, 0.01µF, 0.001 µF - 1 No. each
- IC Socket - 1 No.
- GPPCB Board/bread board - 1 No.

PROCEDURE

1 Construct the Function generator circuit by referring to the circuit as shown in Fig 1

2 Connect a power supply to the circuit, set the voltage at 15V and switch on the power supply

3 Switch on the DSO and perform quick check

4 Connect the DSO probes at any one of the output terminal and ground, trace the waveform

5 Measure the frequency and record the reading in Table 1.

6 Repeat the step 4 and 5 for other output terminals.

7 Calculate the frequency using the formula (f)= 0.15/ $(VR_1+R_1)C_1$

8 Vary the C_1 as shown in the table 2 and repeat steps 5 to 8

9 Compare the measured frequency and calculated frequency.

10 Get the work checked by the instructor.

Note : to get different frequencies the capacitor c_1 may be varied, the Table 1 shown below gives the different frequency range for the different capacitor values

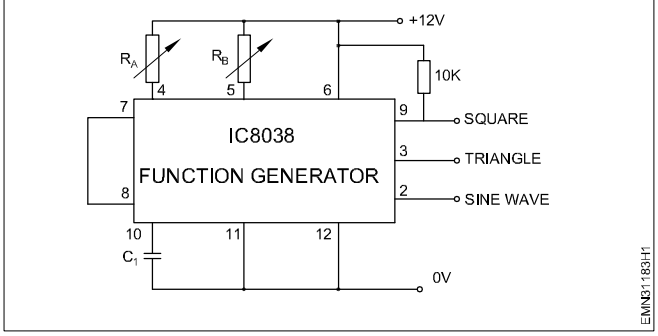
Table 1

Type of wave form	Calculated frequency	Measured frequency	Amplitude (P-P)
Sine wave			
Square wave			
Triangular wave			

Table 2

Frequency range	C_1 value
1Hz - 100Hz	1µF
100Hz-1kHz	0.1µF
1kHz-10kHz	0.01µF
10kHz-100kHz	0.001µF

Fig 1



Practice soldering on different electronic components, small transformer and lugs

Objectives : At the end of this exercise you shall be able to
- **tin the ends of hookup/flexible wires/lug terminals**
- **solder different electronic components on lug terminals**
- **solder a small transformer on a general purpose PCB.**

Requirements

Tools/Equipments/Instruments

- Soldering iron 25W/240V - 1 No
- Trainees tool kit - 1 Set
- Cleaning brush, 1/2inch - 1 No
- Step down transformer 240V/6V 300mA With flexible wire termination - 1 No

Materials/Components

- Lug board (Code No.103-06-LB) - 1 No
- Single strand wire(hook-up-wire) - 1 m
- Solder wire 60/40 18 SWG - 25 gms
- Soldering flux - as reqd
- Gen purpose PCB (Type 107) - 1 No
- Soldering iron stand - 1 No
- Electronic components assorted items - as reqd

Note: The instructor has to ensure that the trainees keep the soldering iron on its stand and no electrical leakage on its metal body;

Guide the trainees to keep the tip of the soldering iron bit tinned.

PROCEDURE

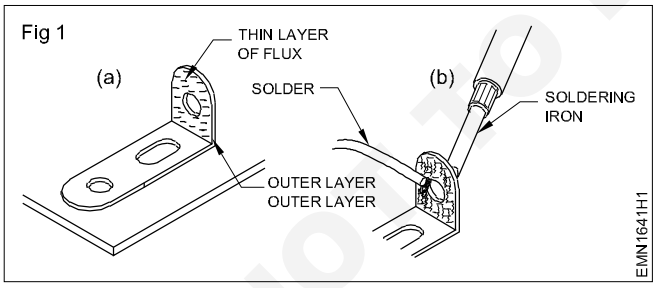
TASK 1 : **Tinning the lug terminals**

1 Visually check the lug terminals on the lug board are clean and bright.

2 Scrape the dirt/oxide layer on both sides of the lug terminal using a knife and clean all the lug terminals on the lug board.

3 Apply a thin layer of flux on the face of lug terminal as shown in Fig 1a.

Fig 1



Note: Properly tinned tip of the soldering iron bit is in bright shining, silvery colour; The molten solder on the tip of soldering iron is essential for efficient transfer of heat for soldering or desoldering process.

4 Touch the lug by molten solder on the bit of soldering iron at the lug no.1 as shown in Fig 1(b).

5 Hold the tip of solder wire at the outer face of the lug as shown in Fig 1b.

6 Take out the solder wire within 2 to 3 seconds time as the solder melts on the lug and take out the soldering iron tip from the lug.

7 Allow the molten solder to solidify over the lug.

Do not blow air to cool the solder on the lug.

9 Get the work checked by the Instructor.

— — — — — — — —

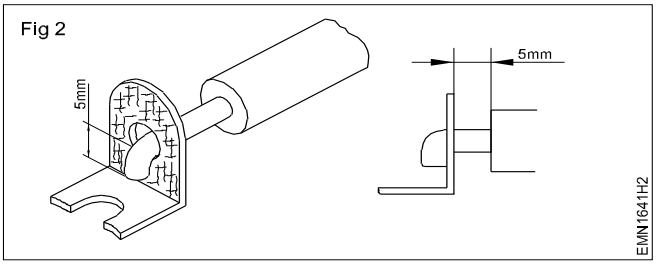
TASK 2: **Soldering of wire/electronic components on lug terminals**

1 Mark 10 mm and skin the insulation at both ends of hook up wire piece.

2 Scrape the conductor using knife, apply flux and tin the conductor ends.

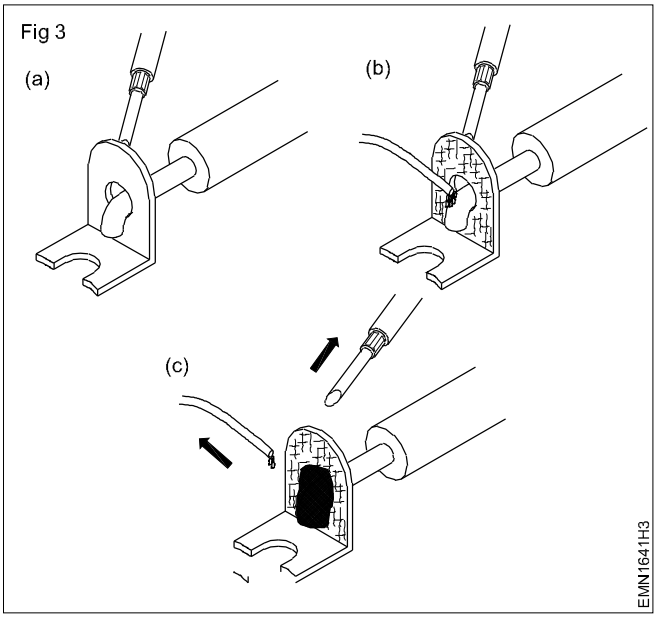
3 Insert and bend the tinned wire in lug 1 hole as shown in Fig 2. (side entry method).

Fig 2



4 Touch the lug by the molten solder on the bit of soldering iron a shown in Fig 3a and hold it for 2 seconds.

Fig 3



5 Apply the tip of solder wire on the lug; as the solder starts melting, take out the solder and within 2 to 3 seconds remove the soldering iron tip from the joint.

Precaution: Due care to be exercised with the hot soldering iron, molten/melting solder.

Keeping the soldering iron tip for more than 2-3 seconds will damage the insulation of the wire.

6 Allow the molten solder to solidify with the wire joined on the lug terminal.

7 Do not shake the wire till the soldered joint on the lug terminal becomes smooth and shiny.

8 Repeat the above steps for tinning all the lugs on the lug board.

9 Select the electronic component to be soldered on the lug terminal (Resistor/Diode).

10 Scrape/clean both ends of the component and tin them.

11 Insert the timed lead into lug terminal 2, as shown in Fig 2.

12 Repeat steps 4 to 7 for a smooth and shiny soldered joint.

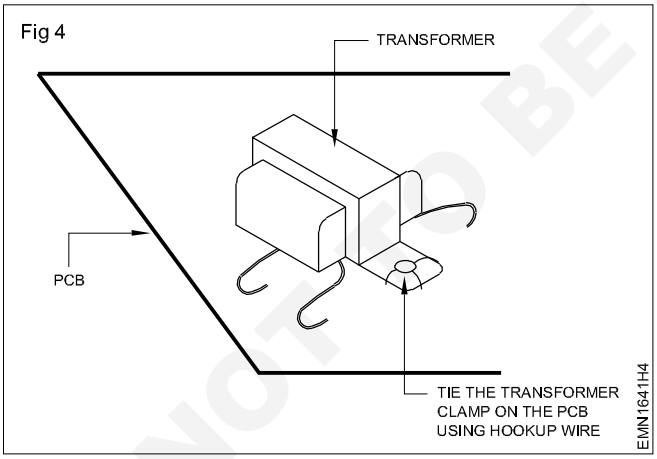
13 Get the work checked by the Instructor.

— — — — — — — —

TASK 3: **Soldering the transformer on PCB/Lug board**

1 Position the transformer on the component side of the general purpose PCB as shown in Fig 4 and tie it on PCB using hookup wire.

Fig 4



2 Mark 10 mm and skin the insulation at the end of wire; twist the bunch of multi stranded conductors into a single core and tin it.

3 Repeat the above step for all the wires on primary and secondary sides of the transformer.

4 Identify suitable points on the PCB for soldering the primary and secondary wires.

5 Insert the timed terminals at the identified points and solder them correctly.

6 Arrange the lead dress of wires neatly on the PCB after soldering work.

7 Get the work checked by the Instructor.

Follow steps in Task-2 to solder the transformer terminals to the lug board.

— — — — — — — —

Practice soldering IC bases on PCBs

Objectives: At the end of this exercise you shall be able to
- **soldering IC bases on PCB**
- **inspect the soldered joints of IC bases on the PCB.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Soldering Iron, 25W - 1 No
- Magnifier with lamp and crocodile clip fixture attachment - 1 No

Materials/Components

- General Purpose PCBs (IC base fixing type) - 1 No
- IC base (8 pin or 14 pin) - 1 No
- Solder Wire 60/40 18 SWG - as reqd
- Flux - as reqd
- Soldering iron stand - 1 No
- Desoldering Wick - as reqd
- Soldering tip cleaning sponge - as reqd
- Cleaning brush - 1 No
- IPA solution - as reqd

PROCEDURE

TASK 1: **Soldering the IC base on PCB**

1 Inspect the copper clad/solder side and component side of the selected PCB is suitable for soldering work.

2 Check all the pins of the IC base in correct shape as shown in Fig 1a & b.

Fig 1a

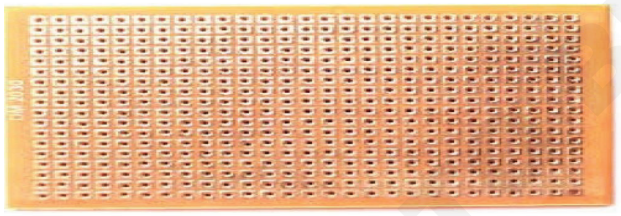
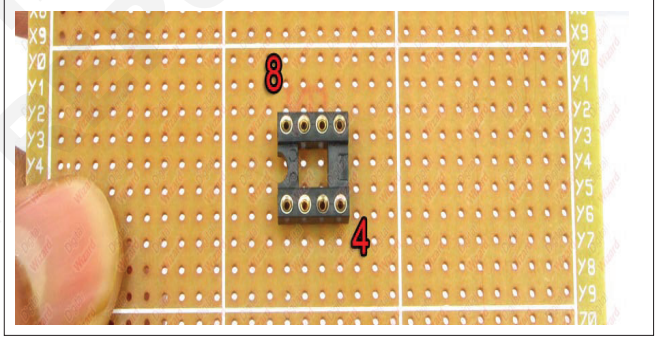


Fig 1b

3 Plan and decide the location on the PCB for the IC base soldering work.

4 Insert the IC base pins through the component side as shown in Fig 2 and press till it sits correctly on the PCB.

Fig 2



5 Prepare the soldering iron for soldering work; apply a small quantity of flux on each pin of the IC base.

6 Solder the pin no. 1 onto the pad quickly within 1 to 2 seconds time.

Safety precaution: Avoid over heating the PCB track/pad.

If the time taken to solder the pin is more, the heat produced by the soldering iron tip will make the pad/track to peel off the PCB damaged permanently.

7 Solder the remaining pins of the IC base quickly.

Caution: Do not apply more solder on the pin. Excessive solder may bridge the pads and short circuit them.

8 Clean the flux and other residue on the soldered pins using the IPA solution with cleaning brush.

9 Get the work checked by the Instructor.

TASK 2: **Inspection of soldered IC base pins**

1 Keep the soldered PCB under the magnifying lens using the crocodile clip fixture attachment as shown in Fig 3.

Fig 3

2 Switch ON the lamp, adjust the height of lens and observe the soldered pins with clarity.

3 Inspect the pins are soldered correctly and no excessive solder is bridging the pin connections/pads or tracks causing short circuit.

4 Desolder the excess solder if found bridging between pins/pads/tracks using soldering iron.

5 Clean the desoldered spot and inspect under the magnifier.

6 Ensure that all the pins of IC base is correctly soldered and no defect found.

7 Get the work checked by the Instructor.

Practice desoldering using pump and wick

Objectives : At the end of this exercise you shall be able to
- **desoldering components from PCB using desoldering pump**
- **desoldering component using desoldering wick.**

Requirements

Tools/Equipments/Instruments

• Trainees tool kit	- 1 Set
• Soldering iron, 25W	- 1 No
• Desoldering pump (plunger type)	- 1 No
• Heat sink plier	- 1 No

Materials/Components

• Desoldering wick	- as reqd
• Cleaning solution (IPA)	- as reqd
• Flux	- as reqd
• Cleaning Brush	- 1 No
• Safety goggles	- 1 No
• Crocodile clip	- 1 No
• Assembled PCB board for Desoldering work	- as reqd

Note: Check the correct functioning of desoldering pump by closing the nozzle and press the plunger; feel the air pressure. Keep the nozzle closed by a finger and release the button and feel the suction to conform correct working.

PROCEDURE

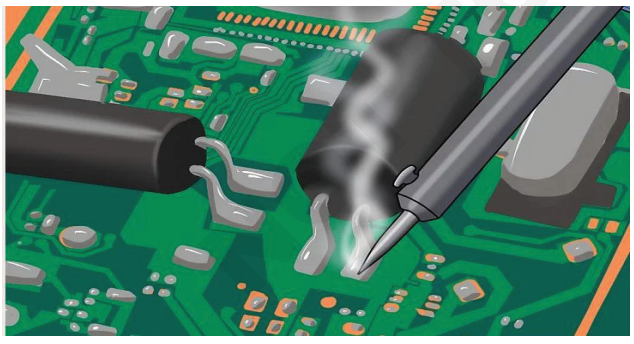
TASK 1: **Desoldering components from PCB using desoldering pump**

1 Clean the PCB using brush; locate the component to be desoldered fro the PCB as shown in Fig 1.

2 Mark the component lead soldered pad/track on the solder of PCB.

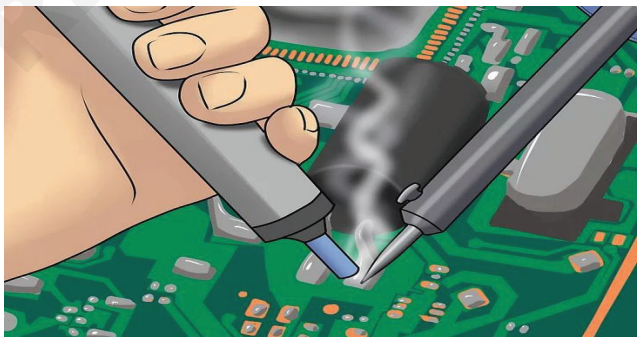
3 Prepare the soldering iron for desoldering work; touch the hot soldering iron top on the marked solder joint as shown in Fig 1.

Fig 1



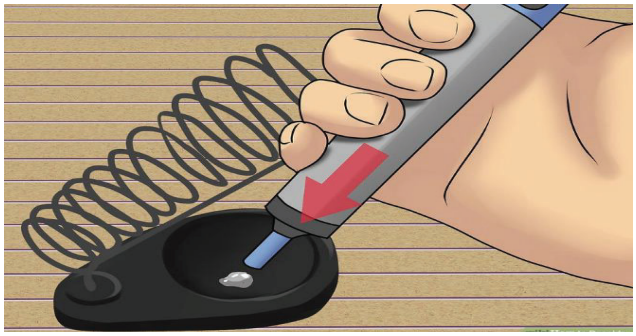
4 Press the plunger, lock and hold the desoldering pump in left hand; keep the nozzle on the desoldering point, hold the desoldering pump firmly and release the button to suck the molten solder as shown in Fig 2.

Fig 2



5 Empty the desoldering pump into the trash so that pump is ready for next desoldering ping. (Refer Fig 3)

Fig 3



6 Repeat steps 3 to 5 on the other marked point also to desolder the molten solder on the joint.

7 Visually inspect for leads of the component are free from the pad and pull the component from top side of PCB using crocodile clip.

8 Get the work checked by the Instructor.

— — — — — — — —

TASK 2: **Desoldering components using desoldering wick**

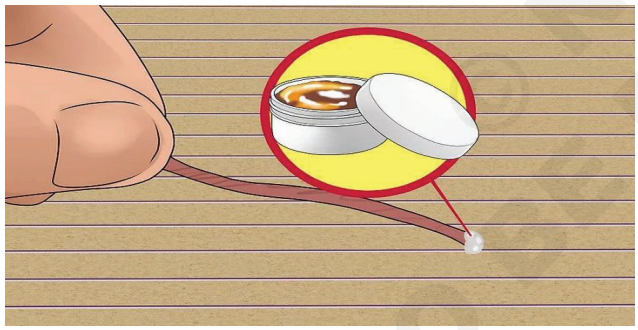
1 Follow the steps 1 to step 3 of task 1.

2 Unwind few inches of solder wick from the coil as shown in Fig 4.

Fig 4

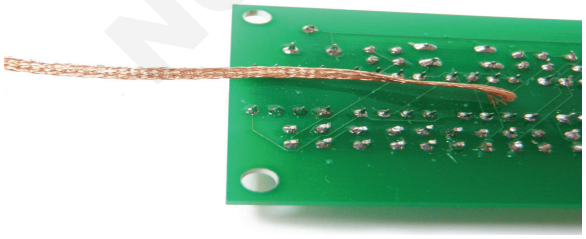
3 Dip the end of wick into the flux and make for a clean removal as shown in Fig 5.

Fig 5



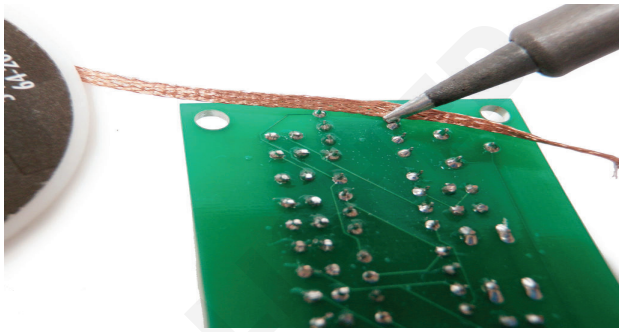
4 Place the braid over the marked soldered joint as shown in Fig 6 for desoldering the component.

Fig 6



5 Place a hot soldering iron tip over the braid at the desired pin as shown in Fig 7 and allow the molten solder is absorbed by the desolder wick.

Fig 7



Safety precaution: Do not touch the hot solder wick; keep it away from the PCB.

6 Remove the soldering iron and the braid quickly from the PCB; discard the used portion of the wick.

7 Observe the pad/track on the PCB and ensure the component lead is desoldered from that point.

8 Repeat the above steps for other terminals of component to be desoldered/removed.

9 Clean the PCB using IPA solution with brush.

10 Get the work checked by the Instructor.

— — — — — — — —

Join the broken PCB track and test

Objectives : At the end of this exercise you shall be able to
- **repair the broken PCB track and test the continuity.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Soldering iron 25 watts/240 VAC - 1 No
- Digital multimeter with probes - 1 No

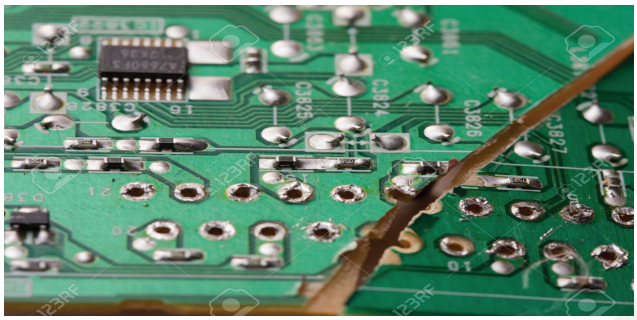
Materials/Components

- Tracks cut broken PCB - 1 No
- Hook up wire - as reqd
- Epoxy tube - 1 No
- Emery cloth /paper - as reqd
- Magnifying glass - 1 No
- Solder flux - as reqd
- Rosin cored solder 60/40 - as reqd
- Cleaning brush - 1 No
- IPA solution - as reqd

PROCEDURE

1 Identify and inspect the edges of the broken track on PCB using magnifying glass as shown in Fig 1.

Fig 1



2 Mix the Epoxy according to the manufacturer's instructions and apply a little quantity to one side of the PCB.

3 Position them correctly and Press the two halves of the broken PCB together and hold them until the epoxy sets hard.

Hold both ends together without shaking; the epoxy will set in a few seconds, but should wait for thirty minutes for hardening before proceeding to next step.

4 Scrape/clean the solder mask coating on the broken edges of PCB tracks to be joined.

Sand the ends of these traces until bright copper shows clearly.

5 Plug the soldering iron into mains socket and wait for a while to get ready for soldering work.

6 Cut a piece of hookup wire, take out the bare conductor; scrape it and tin the conductor.

7 Use tweezers and keep the tinned wire over the joined PCB track bridging both sides, solder it along the track.

8 Check the continuity of the repaired track on the PCB.

Precaution: Avoid bridging/shorting with the adjacent tracks/pads on the repaired PCB.

Fig 2

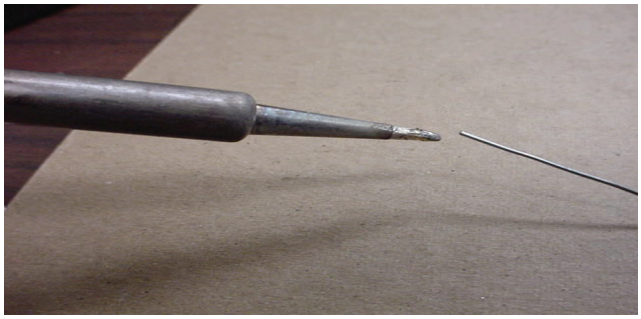
9 Inspect the repaired track using magnifying lens and also the continuity of track using DMM.

Apply appropriate heat to melt the solder. Too much heat will cause the copper pads/tracks to peel off the PCB.

10 Join the other tracks following above steps; finally clean the tracks on the PCB using IPA solution with brush.

11 Get the work checked by the Instructor.

Fig 3



Identify and use SPST, SPDT, DPST DPDT, tumbler. push button, toggle , piano switches used in electronic industries

Objectives : At the end of this exercise you shall be able to
- **identify SPST, SPDT, DPST, DPDT tumbler, push button, toggle and piano switches**
- **test all the switches.**

Requirements

Tools/Equipments/Instruments

- Trainees Tool Kit - 1 Set
- Digital multimeter with probes - 1 No

Materials/Components

- SPST switch 240V/6A - 1 No
- SPDT Switch 240V/15A - 1 No
- DPST Switch 240V/15A - 1 No
- DPDT Switch 240V/15A - 1 No
- Tumbler switch, 1 pole, 240V/16A - 1 No
- Push button switch 240V/6A - 1 No
- Toggle Switch 240V/6A - 1 No
- Piano Switch 240V/6A - 1 No

PROCEDURE

The instructor has to label the different types of switches used for this exercise.

1 Pick one of the labelled switch from the lot, identify the name, type and record it in the table 1.

2 Refer to the chart (Fig 1 to 8) compare verify the details and record it in the Table.

3 Repeat the steps 1 and 2 for the remaining labelled switches and record it in Table 1.

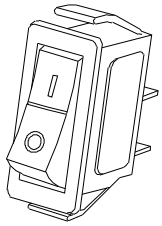
4 Note down the uses of each switch and also draw the free hand sketches of the switches.

5 Get the work checked by the Instructor.

Table 1

Sl. No	Name of Switch	Free hand sketch	Uses	Remarks
(1)	SPST			
(2)	SPDT			
(3)	DPST			
(4)	DPDT			
(5)	Tumbler			
(6)	Push button			
(7)	Toggle			
(8)	Piano			

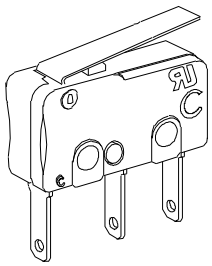
Fig 1



SPST SWITCH

EMN1645H1

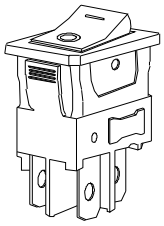
Fig 2



SPDT SWITCH

EMN1645H2

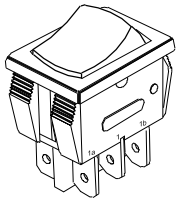
Fig 3



DPST SWITCH

EMN1645H3

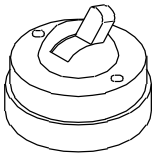
Fig 4



DPDT SWITCH

EMN1645H4

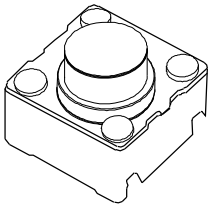
Fig 5



TUMBLER SWITCH

EMN1645H5

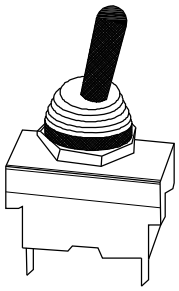
Fig 6



PUSH BUTTON SWITCH

EMN1645H6

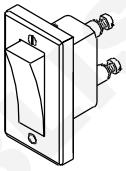
Fig 7



TOGGLE SWITCH

EMN1645H7

Fig 8



PIANO SWITCH

EMN1645H8

Make a panel board using different types of switches for a given application

Objectives : At the end of this exercise you shall be able to
- **draw a schematic diagram to show one electric bell controlled by one push button switch on the panel board.**
- **fix different types of switches on the panel board**
- **wire the cable on the panel board according to the wiring diagram**
- **connect the cables in the accessories**
- **test the circuit.**

Requirements

Tools / Instruments

• Screw driver 150mm	- 1 Set
• Cutting pliers 200 mm	- 1 No
• Hand drilling machine with 3mm/ 4 mm drill bit each one	- 1 No
• Electrician Knife	- 1 No
• Side cutting plier	- 1 No
• Trainees tool kit	- 1 Set
• Try square 150mm	- 1 No
• Poker 200 mm	- 1 No

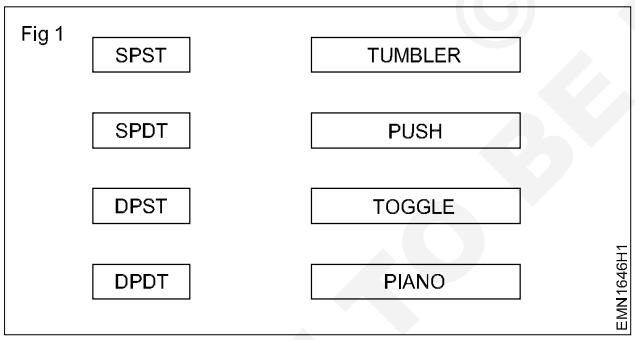
Materials

• Wooden Panel Board available in the section	- 1 No
• Bell push switch 6A,240V (Surface Mounting)	- 1 No
• Electric bell 240V	- 1 No
• Wood Screws	- as reqd
• SPST	- 1 No
• SPDT	- 1 No
• DPST	- 1 No
• Tumbler switch	- 1 No
• Toggle switch	- 1 No
• Piano switch	- 1 No

PROCEDURE

1 Draw the layout diagram as shown in Fig 1.

Fig 1



2 Collect the calling bell, SPST, SPDT, DPST, DPDT, tumbler switch, bell push switch, toggle switch and piano switch.

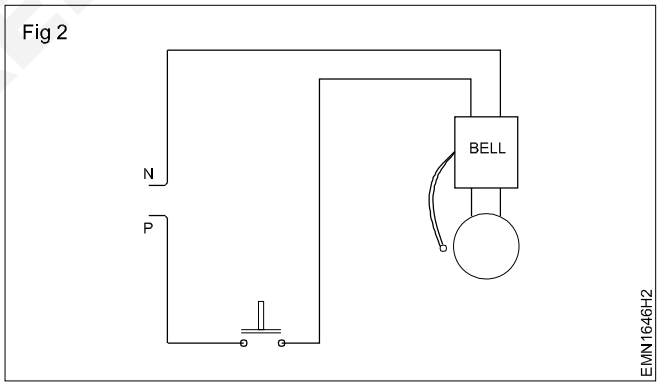
3 Place the switches and calling bell on the panel board to suit the technical aspects.

4 Mark the position of switches on the panel board as per the given layout.

5 Fix the switches and calling bell on the panel board.

6 Prepare the end termination of the cables. Insert them into respective switches.

Fig 2



7 Give connections to Bell Push switch and Electric bell as per connection diagram mentioned in Fig 2 and test it.

If it is incorrect make necessary changes.

8 After getting the approval of the instructor connect the main supply and test the circuit.

9 Connect other switches for different applications and get the formed circuit checked by instructor.

— — — — — — — —

Identify the different types of active electronics components

Objective : At the end of this exercise you shall be able to
- **identify the different types of active electronics components by referring to the Pictorial representation.**

Requirements

Tools/Equipments/Instruments

- Trainees Tool Kit - 1 Set
- Magnifying Glass - 1 Set
- Components Data Sheet with Lead Identification - 1 No

Materials/Components

- Diodes - 1 No
- Zener Diode - 1 No
- Transistor - 1 No
- Unijunction Transistor(UJT) - 1 No
- Field Effect Transistor (FET) - 1 No
- DIAC - 1 No
- TRIAC - 1 No
- Silicon Controlled Rectifier (SCR) - 1 No
- Integrated Circuit (IC) - 1 No

PROCEDURE

Note: Instructor shall label the active components used for this exercise.

1 Pick one of the labelled active components from the given lot.

2 Identify the components name from the Pictorial representation (Shape, Leads, Colours).

3 Record the names, code No. and number of Pins of the components in Table-1.

4 Repeat the step-2 & 3 for the remaining components.

5 Get the work checked by the Instructor.

Table 1

Sl. No.	Component	Free hand sketch	Device symbol	Remarks
1	LDR			
2	DIODE			
3	LED			
4	Zener Diode			
5	Transistor			
6	SCR			
7	TRIAC			
8	DIAC			
9	UJT			
10	JFET			
11	IC			

— — — — — — — —

Measure the resistor value by colour code and verify the same by measuring with multimeter

Objectives : At the end of this exercise you shall be able to
- **determine resistance value by colour code**
- **determine resistance value by typographic/numeric code**
- **measure resistance value using ohmmeter/multimeter.**

Requirements

Tools/Equipments/Instruments

- Trainees Tool Kit - 1 Set
- Multimeter with probes - 1 No
- Electrician Knife - 1 No

Materials/Components

- Different types of fixed value resistors - 10 Nos
- Cotton cloth - 1 No

The Instructor has to label the different values of fixed resistors.

PROCEDURE

TASK 1: **Calculation of Resistor value from Colour bands**

1 Pick one of the labelled resistor from the given lot and identify the colours of bands starting from one end of the resistor. Observe and record colours of the bands in Table-1. (Refer chart 1)

2 Calculate the resistor value using color code and record values in Table 1.

3 Also find the tolerance of the resistors and record.

4 Scrape the resistor leads using knife to remove oxide/ varnish layers on the leads.

5 Using a cloth wipe the leads to make them free from moisture, oil, etc.

6 Short meter probes and adjust the zero set knob of the meter and carry out the resistance zero setting of the meter.

Do not touch the leads of the resistor while measuring. This will make the meter show the body resistance and not the resistor under measurement.

7 Set the meter to the suitable resistance range.

8 Check and record the values shown by the meter in the Table-1.

9 Compare the measured value and the calculated value of the resistor.

10 Repeat steps-1 to 9 for the remaining colour coded resistors.

11 Get the work checked by the Instructor.

Chart 1

Color	1st Band (1st figure)	2nd Band (2nd figure)	3rd Band (multiplier)	4th Band (tolerance)
Black	0	0	10°	±1%
Brown	1	1	10^{1}	±2%
Red	2	2	10^{2}	
Orange	3	3	10^{3}	
Yellow	4	4	10^{4}	
Green	5	5	10^{5}	
Blue	6	6	10^{6}	
Violet	7	7	10^{7}	
Gray	8	8	10^{8}	
White	9	9	10^{9}	
Gold			10^{-1}	±5%
Silver			10^{-2}	±10%

Table 1

Label No.	First Band		Second Band		Third Band		Resistance value using colour code			Tolerance		Meter Measured Value
	Colour	Code	Colour	Code	Colour	Code	decoded value	Maximum value	Minimum value	Colour	Percentage	

— — — — — — — —

TASK 2: **Calculation of resistor value from Typographic Code**

1 Pick a typographically coded resistor from the given lot. Record the printed codes value of resistance and tolerance in Table-2. (Refer chart 2)

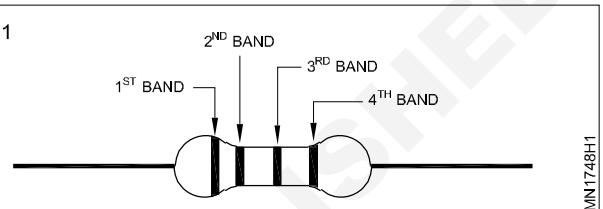
2 Check the nominal value of the resistor and record in Table-2.

3 From the tolerance value noted, calculate and record the minimum and maximum value of the resistor.

4 Repeat steps-1 to 3 for the remaining typographically coded resistors. (Fig 1)

5 Get the work checked by the Instructor.

Fig 1



Standard Value = 5600 ohms

Minimum Value

= 5600 - (5600 x 5%)

= 5600 - 280

= 5320 ohms

Maximum Value

= 5600 + (5600 x 5%)

= 5600 + 280

= 5880 ohms (Fig 2)

Chart 2

Printed Code Format	Meaning	Example of printed Code	Corresponding Resistance Value
xE	X Ohms	1E	1 Ohms
X	X Ohms	100	100 Ohms
xW	X Ohms	56 W	56 Ohms
xKy	X.y K Ohms	4K7	4.7 K Ohms
x.K	X K Ohms	56K	56 K Ohms
xMy	X.y M Ohms	6M8	6.8 M Ohms
xM	X M Ohms	10 M	10 M Ohms

Fig 2

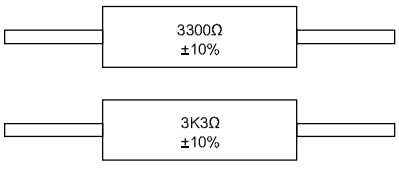


Table 2

Label No.	Printed code on the Resistor	% Tolerance	Resistance value using code			Meter measured value
			Standard Value	Maximum Value	Minimum Value	

— — — — — — — —

Identify resistors by their appearance and check physical defects

Objectives : At the end of this exercise you shall be able to
- **identify different types of fixed resistor by their appearance**
- **check the physical condition of fixed resistors.**

Requirements

Tools/Equipments/Instruments

- Trainees Tool Kit - 1 Set

Materials/Components

- Assorted types & Values of Fixed value resistors - 10 Nos

The Instructor has to label the different types of resistors used for this exercise.

PROCEDURE

1 Pick one of the labelled resistor from the given lot.

2 Identify the resistor and observe the following:
- Type of Resistor
- Lead Type
- Physical Defect Refer (Lead Defect Chart)
- Overall usability of Resistor

3 Record the observations in Table-1.

4 Repeat step-2 & 3 for the remaining resistors.

5 Get the work checked by the Instructor.

Chart 1

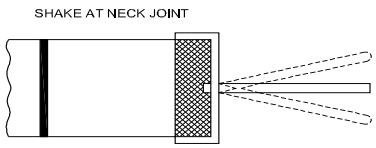
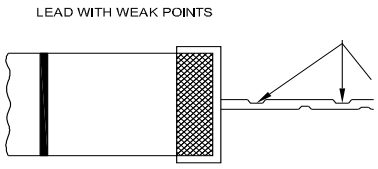
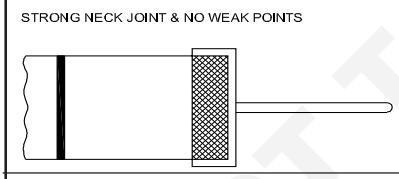
Leads Defects	Defect code	Remarks	Serviceable/unserviceable
	Lead Shaky (LS)	May become electrically open, while handling, bending	Unserviceable
	Lead Weak (LW)	Lead may get cut while handling, Bending	Unserviceable
	Strong Leads (SL)	----	Unserviceable
Skin Coating Pealed off	SPE	Value might have deviated	Unserviceable
Body Cracked	BCR	May be open or value deviated	Unserviceable
CAP Shacking/Cracked	CSH	May be open or loose contact	Unserviceable
Body Charred or become	BCH	May be open, short, value deviated	Unserviceable

Table 1

Label No.	Type Name	Lead Type	Physical Defect code	Remarks	Usability of Resistor Serviceable/unserviceable
1					
2					
3					
4					
5					

Identify the power rating of carbon resistors by their size

Objectives : At the end of this exercise you shall be able to
- **identify the power rating of carbon resistors.**

Requirements

Tools/Equipments/Instruments

- Trainees Tool Kit - 1 Set

Materials/Components

- Resistors different type and wattages - 10 Nos

The instructor has to label the different types, sizes and ratings of carbon resistors used for this exercise.

PROCEDURE

1 Pick one of the labelled resistor from the given lot.

2 Identify the type of carbon resistors. Refer the chart 1 and observe the details of resistors.

3 Measure the sizes of Carbon resistor.

4 Record the power rating of Carbon Resistor in Table-1.

5 Repeat step-2 & 4 for the remaining resistors.

6 Get the work checked by the Instructor.

Chart 1

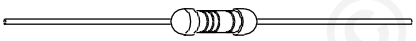
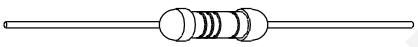
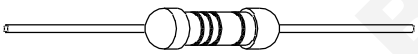
Power Ratings	Appearance	Diameter (mm)	Length (mm)	Lead Length (mm)	Lead Diameter (mm)
0.125w (1/8w)		1.8	3	28	0.45
0.250w (1/4w)		2.5	6.5	28	0.6
0.5w (1/2w)		3.2	8.5	28	0.6
1w		5	11	28	0.8

Fig 2

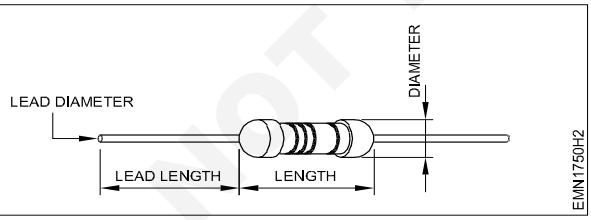


Table 1

Label No.	Type Name	Size	Power Rating in Watt	Remarks
1				
2				
3				
4				
5				

Practice on measurement of parameters in combinational electrical circuit by applying Ohm's Law for different resistor values and voltage sources

Objectives : At the end of this exercise you shall be able to
- **verify Ohm's law and plot the graph.**

Requirements

Tools/Equipments/Instruments

- Trainees Tool Kit - 1 Set
- Soldering Iron, 230V/25 watts - 1 No
- Ammeter, 0-30m.A, DC - 1 No
- Ammeter, 0-10m.A, DC - 1 No
- Multimeter with probes - 1 No
- Regulated DC power supply 0-30V/2A - 1 No

Materials/Components

- SPST Toggle Switch/1A - 1 No
- Resistor, 1kΩ/1W - 3 Nos
- Rosin cored solder - 1 m
- Soldering flux - 1 Box
- Hook-up wires - 2 m
- Patch Cords - 10 Nos
- Lug Board - 1 No

PROCEDURE

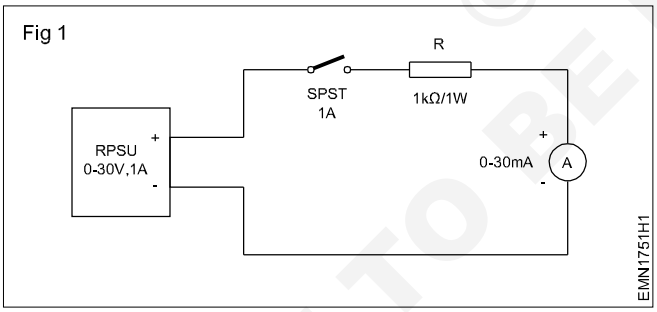
TASK 1: **Measuring current in the circuit with one resistor**

1 Check physical and electrical condition of the given ammeter, meter probes, patch cords, toggle switch soldered on the lug board.

2 Measure and record the resistance value in the Table1.

3 Refer the circuit diagram-1 and assemble the circuit using patch cords. (Fig 1)

Fig 1



4 Calculate the theoretical current that is expected to flow in the circuit for a DC supply of 6 Volts. Record the calculated value in Table-1.

Table 1

Sl. No.	Resistance Value (R)	Supply Voltage (V)	Circuit current (I)	
			Calculated	Measured
1		6 Volts		
2		9 Volts		
3		12 Volts		

5 Switch ON RPS and set the output voltage to 6 Volts.

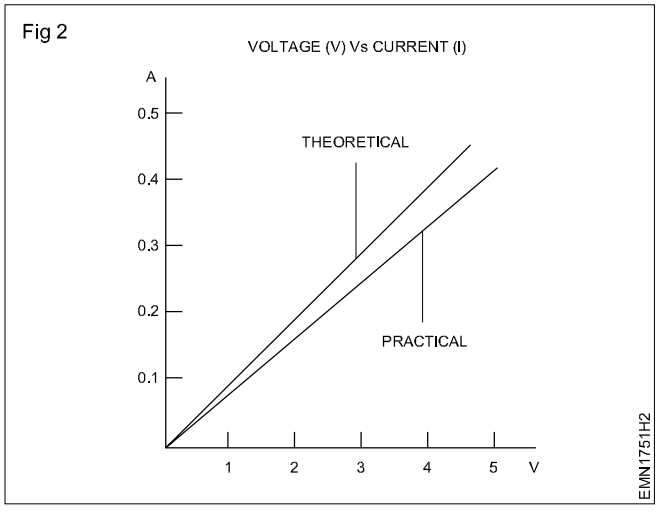
6 Switch ON SPST, measure and record the circuit current in the Table-1.

7 Keep the SPST to OFF. Increase the output of RPS to 9 Volts and 12 Volts and record the circuit current.

8 Switch OFF SPST and RPS.

9 From the recorded readings in Table-1, plot a graph of circuit voltage (V) versus circuit current (I) in a graph sheet. (Fig 2)

Fig 2

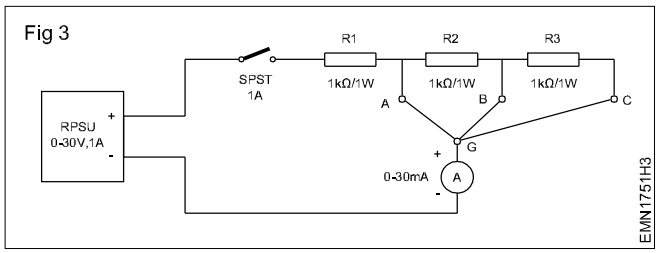


10 Get the work checked by the Instructor.

TASK 2: **Measuring circuit current with varying circuit Resistances**

1 Refer the circuit diagram-3 and assemble the circuit using suitable patch cords. (Fig 3)

Fig 3



2 Measure the circuit resistance and calculate the theoretical current that is expected to flow in the circuit for a DC supply of 12 volts. Record the calculated value in Table-2.

Table 2

Sl. No.	Set Voltage (V)	Measured Resistance Value (R)	Circuit current (I)	
			Calculated	Measured
1	12 Volts			
2	12 Volts			
3	12 Volts			

3 Switch ON RPS and set the DC voltage to 12 Volts.

4 Connect the terminal "G" with terminal "A". Switch ON SPST. Measure and record the circuit current in Table 2.

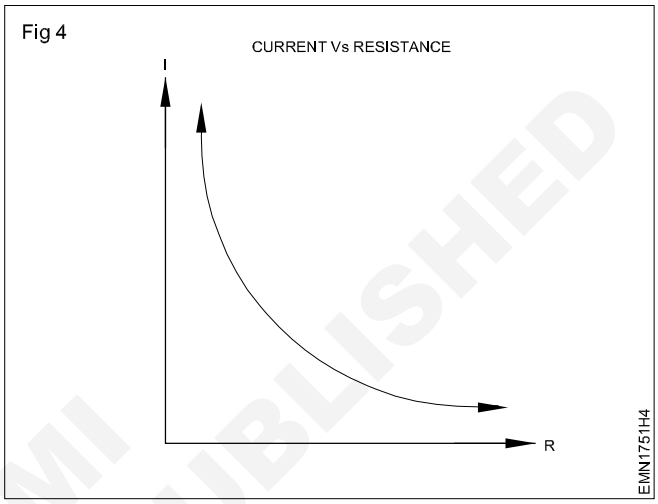
5 Switch OFF SPST and connect the terminal "G" with terminal "B". Switch ON SPST. Measure and record the circuit current in Table-2

6 Similarly measure the circuit current under the connection of terminal "G" with "C".

7 Switch OFF SPST and RPSU.

8 From the recorded readings in Table-2 plot a graph of circuit current (I) versus Circuit resistance (R) in graph. (Fig 4)

Fig 4



9 Get the work checked by the Instructor.

Measurement of current and voltage in electrical circuits to verify Kirchhoff's Law

Objectives : At the end of this exercise you shall be able to
- **verify the Kirchhoff's Current Law with three branch circuit**
- **verify the Kirchhoff's Voltage Law with one voltage source.**

Requirements

Tools/Equipments/Instruments

- Trainees Tool Kit - 1 Set
- Soldering Iron, 230V/25 watts - 1 No
- Milli-Ammeter, 0-10m.A, DC - 3 Nos
- Milli-Ammeter, 0-25m.A, DC - 1 No
- Multimeter with probes - 1 No
- Regulated DC power supply 0-30V/1A - 1 No

Materials/Components

- SPST Toggle Switch/1A - 1 No
- Resistor, 1kΩ/1W - 3 Nos
- Resistor, 2.2kΩ/1W - 1 No
- Resistor, 3.3kΩ/1W - 1 No
- Rosin cored solder - 1 m
- Soldering flux - 1 Box
- Hook-up wires - 2 m
- Patch Cords - 10 Nos
- Lug Board - 1 No

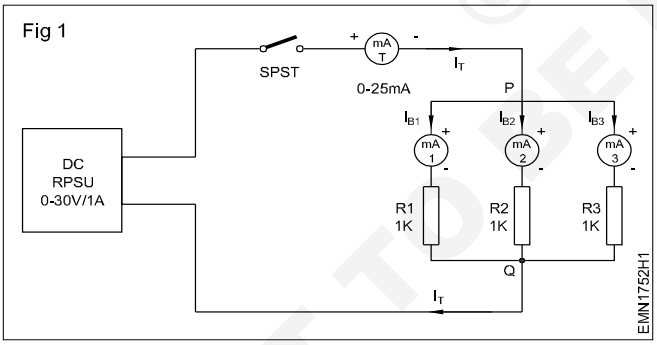
PROCEDURE

TASK 1: **Verification of Kirchhoff's Current Law**

1 Check physical and electrical condition of the given ammeter, meter prods, patch cords, toggle switch soldered on the lug board.

2 Make the connections on the Lug board as per the circuit diagram. (Fig 1)

Fig 1



3 With the SPST in OFF position, set the output of Power Supply to 12 volts.

4 Switch ON the SPST switch. Measure and record currents, IT, IB1, IB2, and IB3 in Table-1.

5 Switch OFF SPST and PSU.

6 Write Kirchhoff's current equations at Nodes P and Q. Verify the equation using measured current values.

7 Get the work checked by the Instructor.

Table 1

RPS Voltage	Total circuit Current I_T	Branch Current I_{B1}	Branch Current I_{B2}	Branch Current I_{B3}	Addition of Branch Current $I_T = I_{B1}+I_{B2}+I_{B3}$
12V					

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TASK 2: **Verification of Kirchhoff's voltage law**

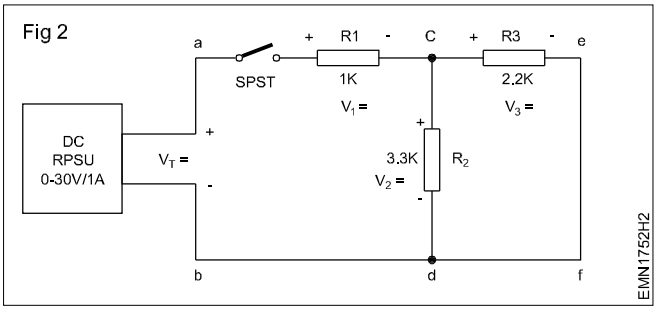
1 Check physical and electrical condition of the given meter probes, patch cords, toggle switch soldered on the lug board.

2 Measure and record the values of Resistor R1, R2 and R3 in the Table.

3 Make the connection on the Lug board as per the circuit diagram. (Fig 2)

4 With the SPST in OFF position, set the output of Power Supply to 12 volts.

Fig 2



5 Mark the polarity of the voltage drops across resistors R1, R2 and R3.

6 Switch ON the SPST switch.

7 Following the voltage polarities marked across the resistors, measure and record the voltage drop across R1, R2 and R3 in Table.

8 Switch OFF SPST and Regulated power supply.

9 Write Kirchhoff's loop equations for the closed paths a-c-d-b-a, a-e-f-b-a and c-e-f-d-a. Substitute the voltage readings recorded in Table in the equations for verification.

10 Verify the equation using measured voltage values.

Table 2

RPS Voltage	Value of Resistor			Voltage Across Resistor		
	R_1	R_2	R_3	R_1	R_2	R_3
12V						

11 Get the work checked by the Instructor.

Loop:- a-c-d-b-a:

$+V_1 + V_2 - VT = 0$

$+V_1 + V_2 = VT$

Loop:- a-c-e-f-d-b-a:

$+V_1 + V_3 - VT = 0$

$+V_1 + V_3 = VT$

Loop:- c-e-f-d-e:

$+V_3 - V_2 = 0$

$V_3 = V_2$

— — — — — — — —

Verify laws of series and parallel circuits with voltage source in different combinations

Objective : At the end of this exercise you shall be able to
- **verify the Laws of Series and Parallel circuits with voltage source.**

Requirements

Tools/Equipments/Instruments

- Trainees Tool Kit - 1 Set
- Soldering Iron, 230V/25 watts - 1 No
- Milliammeter, 0-10m.A, DC - 3 Nos
- Multimeter with probes - 1 No
- DC Regulated Power supply 0-30V/2A - 1 No

Materials/Components

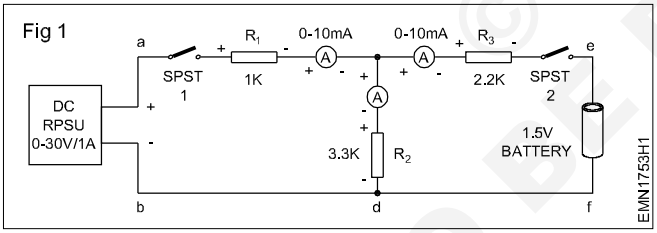
- SPST Toggle Switch/1A - 1 No
- Resistor, 1kΩ/1W - 1 No
- Resistor, 2.2kΩ/1W - 1 No
- Resistor, 3.3kΩ/1W - 1 No
- 1.5V Pen torch Cell - 1 No
- Rosin cored solder - 10 gm
- Soldering flux - 1 Box
- Hook-up wires - 2 m
- Patch Cords - 10 Nos
- Lug Board - 1 No

PROCEDURE

1 Check physical and electrical condition of the given ammeter, meter probes, patch cords, toggle switch soldered on the lug board.

2 Make circuit connection on the Lug board as per the circuit diagram. (Fig 1)

Fig 1



3 With the SPST-1 & 2 in OFF position, set the output of Power Supply to 5 volts.

4 Switch ON the SPST-1 & 2 switch. Measure and record the following currents in Table-1.
- Current through a to c
- Current through c to e
- Current through c to d

5 Measure and record the following voltages in Table-1.
- Voltage across a to b
- Voltage across a to c
- Voltage across c to d
- Voltage across c to e
- Voltage across e to f

6 Switch OFF SPST and PSU.

7 From the recorded readings verify the laws of series parallel circuit.

Keep RPS and the two SPST Switches in OFF position while making circuit connection.

Table 1

Current through a to c	Current through c to e	Current through c to d	Voltage across a to b	Voltage across a to c	Voltage across c to d	Voltage across c to e	Voltage across e to f

Measure the resistance, voltage, current through series and parallel connected network using multimeter

Objectives : At the end of this exercise you shall be able to
- **connect the circuit elements in series and test.**
- **measure and verify Voltage, Current, Resistance in series circuit**
- **connect the circuit elements in parallel and test.**
- **Measure and verify voltage, Current, Resistance in parallel circuit.**

Requirements

Tools/Equipments/Instruments

• Trainees Tool Kit	- 1 Set
• Soldering Iron, 230V/25 watts	- 1 No
• Ammeter, 0-25mA, DC	- 1 No
• Ammeter, 0-100mA, DC	- 2 Nos
• Ammeter, 0-200mA, DC	- 1 No
• Ammeter, 0-500mA, DC	- 1 No
• Voltmeter, 0-15 V, DC	- 1 No
• Multimeter with probes	- 1 No
• DC Regulated power supply, 0-30V/2A	- 1 No

Materials/Components

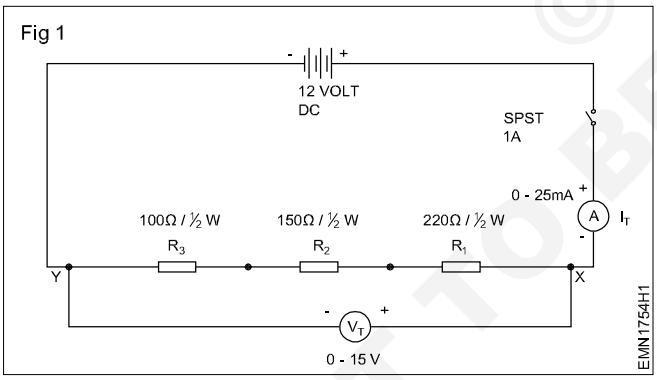
• SPST Toggle Switch/1A	-1 No
• Resistor 100Ω/½ watts	-1 No
• Resistor 150Ω/½ watts	-1 No
• Resistor 220Ω/½ watts	-1 No
• Hook-up wires	- 2 m
• Patch Cords	- 10 Nos
• Lug Board	- 1 No
• Rosin cored Solder	- 1 m
• Soldering flux	-1 Box

PROCEDURE

Measurements on Series Circuit

1 Connect the resistors in series and also wire up the voltmeters and ammeters as shown in Fig 1.

Fig 1



2 Measure resistance across each resistor using multi-meter and record in Table-1.

3 Measure the total resistance using multi-meter between the terminals X & Y.

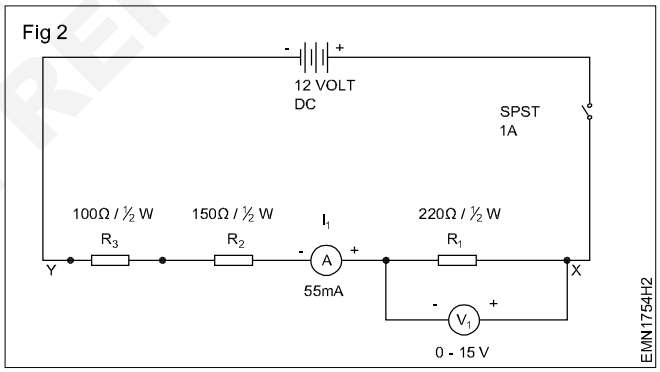
4 Switch ON the RPSU and set the output voltage to 12 Volts.

5 Close the switch and measure the Current (I_T) and Voltage (V_T).

6 Enter the measured value in Table-1.

7 Switch OFF the supply. Reconnect the ammeter and voltmeter as shown in Fig 2.

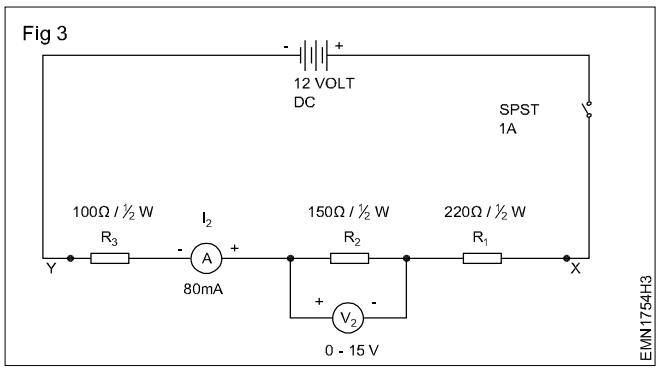
Fig 2



8 Measure and record the Voltage (V_1) and Current (I_1) through Resistor R_1.

9 Switch OFF the supply. Reconnect the ammeter and voltmeter as shown in Fig 3.

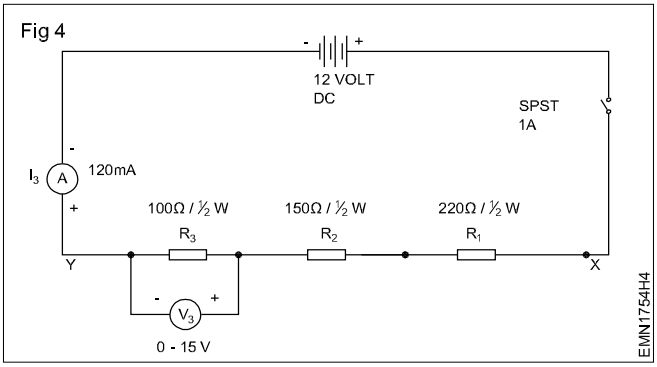
Fig 3



10 Measure and record the Voltage (V_2) and Current (I_2) through Resistor R_2.

11 Switch OFF the supply. Reconnect the ammeter and voltmeter as shown in Fig 4.

Fig 4



12 Measure and record the Voltage (V_3) and Current (I_3) through Resistor R_3.

13 Calculate total resistance, total current, total voltage using measured values.

14 Verify the laws of series circuit and Compare the values with the calculated values.

15 Get the work checked by the Instructor.

Table 1

R_1	R_2	R_3	R_T	V_T	I_T	V_1	I_1	V_2	I_2	V_3	I_3

Identify different Inductors and measure the values using LCR meter

Objectives : At the end of this exercise you shall be able to
- **identify different types of inductors by their appearance.**
- **measure the value of inductance using Digital LCR meter.**

Requirements

Tools/Equipments/Instruments

- Trainees Tool Kit - 1 set
- Digital LCR Meter with manual - 1 No
- Electrician Knife - 1 No

Materials/Components

- Assorted types and values of inductors - 10 Nos
- Hook up wires - 1 m
- Cotton cloth/cleaning brush - 1/4 kg

PROCEDURE

Instructor has to label the different value of inductors used for this exercise.

1 Pick one of the labelled inductor from the given lot.

2 Identify the type name, symbol and record it in Table 1. Refer the chart (Fig 1) compare identify and record in Table 1.

3 Measure and record the resistance across the inductor terminals.

4 Switch ON the Digital LCR meter and make the setting for inductance measurement.

5 Connect the inductor across the digital LCR meter and record the inductance value shown by the Digital meter.

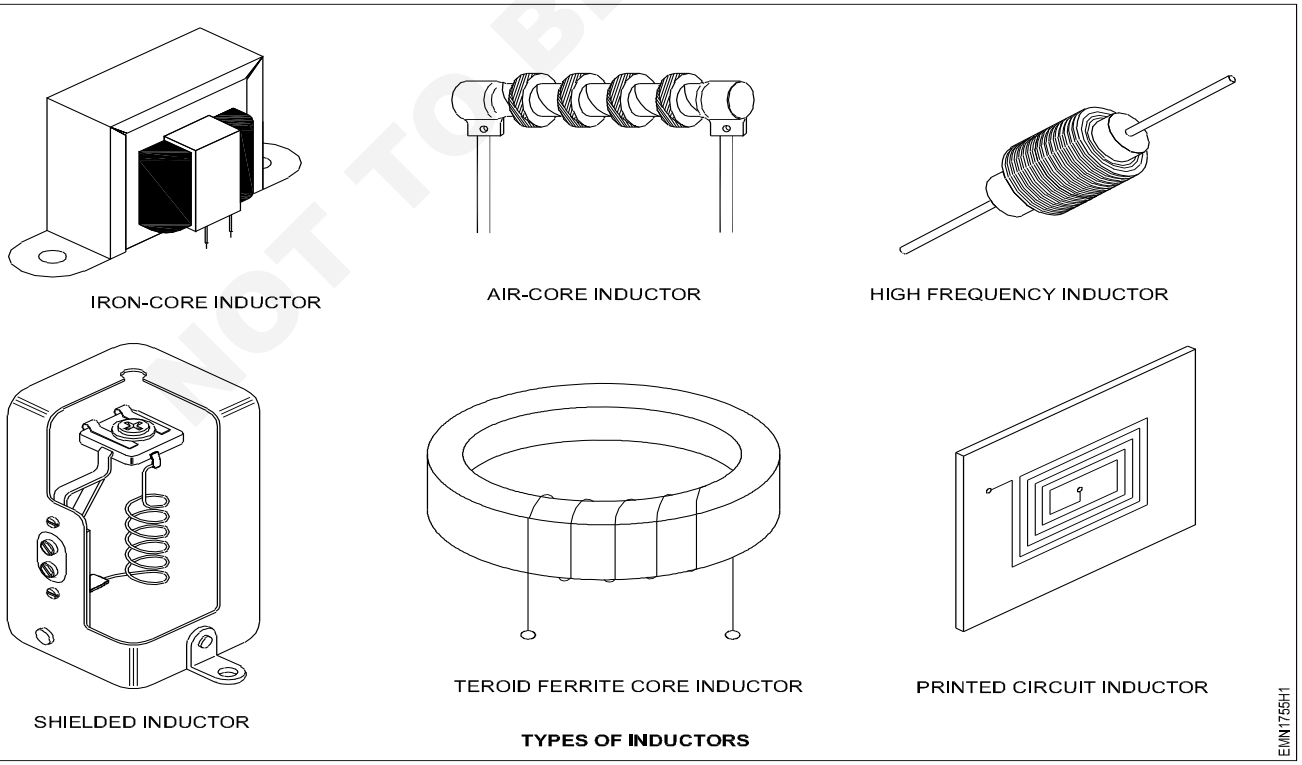
6 Repeat the steps-2 to 5 and measure inductance of the remaining inductors, and record in Table 1.

7 Get the work checked by the Instructor.

Table 1

Label No.	Type/Name of Inductor	Symbol	Resistance across coil terminals	Inductance value
1				
2				
3				
4				

Fig 1



TYPES OF INDUCTORS

Identify the different capacitors and measure capacitance of various capacitors using LCR meters

Objectives : At the end of this exercise you shall be able to
- **identify different types of capacitors by their physical appearance**
- **determine the capacitance value by typographic codes.**

Requirements

Tools/Equipments/Instruments

- Trainees Tool Kit - 1 Set
- DC Regulated Power Supply, 0-30V/2A - 1 No
- Digital LCR Meter with manual - 1 No
- Ohm meter - 1 No
- Electrician Knife - 1 No

Materials/Components

- Assorted types and values of different types of capacitors - 10 Nos
- Cotton cloth/cleaning brush - 1/4 kg

PROCEDURE

The instructor has to label the different types of capacitors used for this exercise.

1 Pick one of the labelled capacitor from the given lot.

2 Identify the type name and record it in Table 1.

3 Refer the typographic code chart (Fig 1) for capacitors. Observe and record the Capacitance value of the capacitor.

4 Prepare LCR meter and connect a capacitor, observe and measure the capacitor value and record in Table 1.

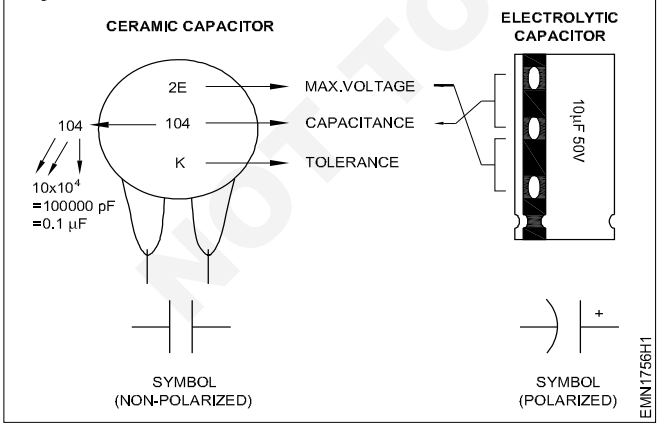
5 Repeat steps-2 to 4 for remaining capacitors and record in Table 1.

6 Get the work checked by the Instructor.

Table 1

Label No.	Type of Capacitor	Capacitor value code	Capacitor value	Capacitor value by measuring LCR meter
1				
2				
3				
4				

Fig 1 CAPACITOR CODING SCHEME



Capacitor Conversion Values

Microfarads (µF)		Nanofarads (nF)		Picofarads (pF)
0.000001 µF	↔	0.001 nF	↔	1 pF
0.00001 µF	↔	0.01 nF	↔	10 pF
0.0001 µF	↔	0.1 nF	↔	100 pF
0.001 µF	↔	1 nF	↔	1,000 pF
0.01 µF	↔	10 nF	↔	10,000 pF
0.1 µF	↔	100 nF	↔	100,000 pF
1 µF	↔	1,000 nF	↔	1,000,000 pF
10 µF	↔	10,000 nF	↔	10,000,000 pF
100 µF	↔	100,000 nF	↔	100,000,000 pF

Tolerance

Code	Percentage
B	±0.1 pF
C	±0.25 pF
D	±0.5 pF
F	±1%

Code	Percentage
G	±2%
H	±3%
J	±5%
K	±10%
M	±20%
Z	±80%, - 20%

Max.Operating voltage

Code	Max.Voltage
1H	50V
2A	100V
2T	150V
2D	200V
2E	250V
2G	400V
2J	630V

Identify and test the circuit breaker and other protecting devices

Objectives : At the end of this exercise you shall be able to
- **identify the terminals of Miniature Circuit Breaker (MCB).**
- **connect the MCB in an electrical circuit and check the operation of MCB and ensure its function.**

Requirements

Tools/Equipments/Instruments

- Trainees Tool Kit - 1 Set
- Digital multimeter with probes - 1 No
- Electrical Loads - 5 Nos
- Single Phase Motor/1HP/240V/50Hz - 1 No
- M.I. Ammeter 0-10A - 1 No

Materials/Components

- MCB, Single pole, 240V/6A - 10 Nos
- Connecting wires - 5 m
- SPST Switch, 240V/15A - 1 No
- Rheostat, 2500 ohm/10A - 1 No

PROCEDURE

TASK 1: **Identification of terminals of the MCB**

1 Identify the supply and load terminals of a single pole MCB.

2 Check the continuity between source and load terminals by keeping MCB in OFF position (Should be infinity).

3 Check the continuity between source and load terminals by keeping MCB in ON position (Should be zero).

4 Record the observations in Table-1.

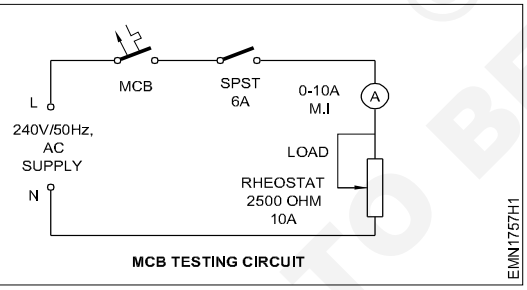
5 Get the work checked by the Instructor.

TASK 2: **Testing of MCB**

1 Collect the miniature circuit breaker and read the specifications of it.

2 Connect the circuit elements as per the circuit diagram shown in figure 1.

Fig 1



MCB TESTING CIRCUIT

3 Keep Rheostat in maximum position before switching ON supply.

4 Keep the MCB in ON condition and switch ON the mains power supply.

5 Close the SPST switch.

6 Increase the rheostat gradually and note down the readings of the ammeter.

7 Wait for 5 to 10 minutes and note down the status of the MCB in Table-2.

8 Continue the process by increasing the load till the MCB trips.

9 Note down the value of current at which the circuit breaker trips in the circuit.

10 Check whether the MCB trips at 1.3 X In, Where In is the normal rated current of the MCB.

11 Get the work checked by the Instructor.

Note: Instead of Rheostat load, Motor load can also be used for testing the MCB operation.

Specification :
Make :
Type :
Current :
Voltage :
Short Circuit Current :

Table 1

MCB Position	Continuity Between Source and Load Terminal
OFF	
ON	

MCB trips Current = 1.3 X In = 1.3 X 6 = 7.8 A

**** MCB Trips at ___ Amps after ____ Seconds**

Table 2

Sl.No	Load current	MCB status
1	0.5 A	
2	1.0 A	
3	2.0 A	
4	5.0 A	
5	6.0 A	
6	8.0A	

Dismantle and identify the different parts of a relay

Objectives : At the end of this exercise you shall be able to
- **identify the parts of relay and trace the wiring diagram of the relay**
- **test and verify the operation of the Relay.**

Requirements

Tools/Equipments/Instruments

- Trainees Tool Kit - 1 Set
- Regulated DC Power Supply, 0-30V/2A - 1 No
- Multimeter/Ohmmeter - 1 No
- DC Ammeter, 0-1A - 1 No
- DC Voltmeter, 0-30V - 1 No

Materials/Components

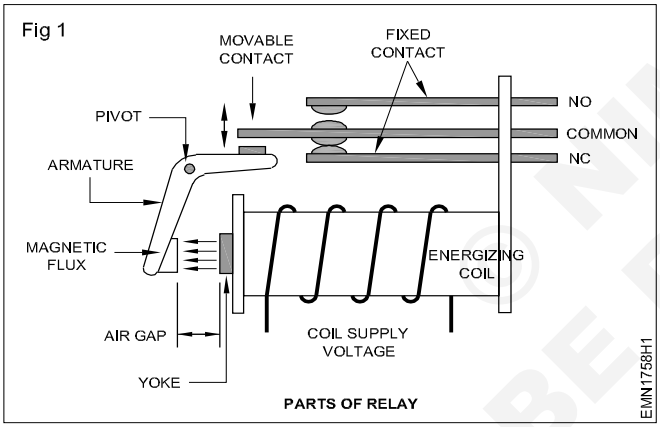
- Hook-up wire - 5 m
- 12V Relay - 1 No

PROCEDURE

TASK 1: **Identification of Relay Parts**

1 Collect the relays along with the instruction booklet. (Refer Fig 1)

Fig 1



PARTS OF RELAY

2 Inspect and determine the terminal connection of the coil and the number of contacts.

3 Identify the normally open and closed contacts by using Ohmmeter/multimeter.

4 Record the relay and contact terminal number.

5 Draw the connection diagram of the relay in the record.

6 Measure the coil resistance and record.

7 Record all the details in Table 1.

Table 1

1	Type of Relay	:	
2	Coil Voltage	:	
3	Number of terminals	:	
4	Number of NO contact	:	
5	Number of NC contact	:	
6	Coil Resistance	:	Ohm
7	Pickup Current	:	mA
8	Reset Current	:	mA

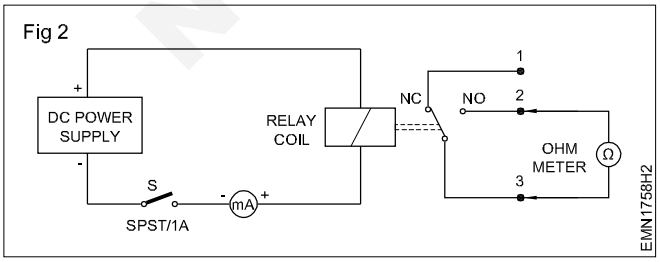
8 Get the work checked by the Instructor.

— — — — — — — —

TASK 2: **Testing of a Relay**

1 Connect the supply as per the diagram.(Fig 2)

Fig 2



2 Adjust the power supply voltage to minimum.

3 Switch ON the Switch 'S'.

4 Slowly increase the DC Voltage till the ohmmeter/ multimeter connected across the normally open contact shows deflection or makes sound.

5 Observe the minimum current (Pick up Current) required to activate the relay and enter the value.

6 Slowly reduce the voltage of the power supply till the ohmmeter/multimeter connected across the normally open contact shows infinity deflection or sound gets OFF.

7 Observe the minimum current (Reset current) required to deactivate the relay and enter the value.

8 Get the work checked by the Instructor.

— — — — — — — —

Connect a timer relay in a circuit and test for its working

Objectives : At the end of this exercise you shall be able to
- **identify the terminals of the timer relay**
- **test and verify the operation of the timer Relay.**

Requirements

Tools/Equipments/Instruments

- Trainees Tool Kit - 1 Set
- Regulated DC Power Supply, 0-30V/2A - 1 No
- Multimeter with probes - 1 No
- Timer Relay 12V DC - 1 No

Materials/Components

- Hook-up wire - 5 m
- Bulb, 230V/40W - 1 No
- Power Cord - 1 No
- SPST Switch/1A - 2 Nos

PROCEDURE

TASK 1: **Identification of terminals of the Timer Relay**

1 Collect the timer relays along with the instruction booklet.

2 Inspect and determine the terminal connection of the coil and the number of contacts.

3 Identify the normally open and closed contacts by using Ohmmeter/Multimeter.

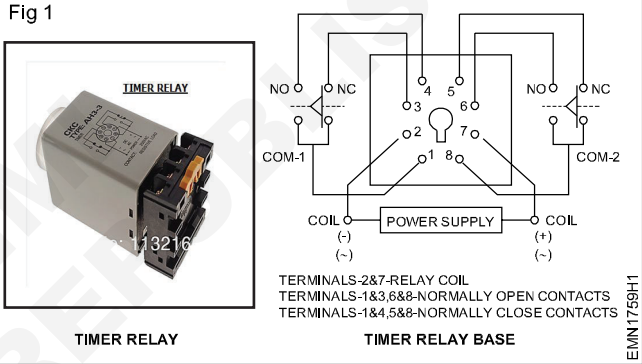
4 Record the relay and contact terminal number.

5 Draw the connection diagram of the relay in the record.

6 Measure the coil resistance and record.

7 Get the work checked by the Instructor.

Fig 1

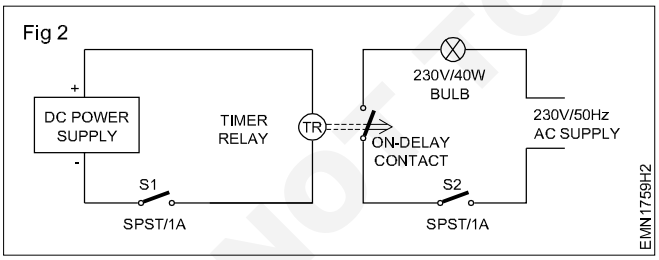


— — — — — — — —

TASK 2 **Testing of a Relay**

1 Connect the timer relay control and power circuit connection as per the circuit diagram shown in Fig 2.

Fig 2



2 Note down the coil supply of the timer relay in the Table-1 and set the DC power supply voltage accordingly.

3 Set the time of the timer relay to 1 minute.

4 Switch ON the SPST Switch 'S1' and check the control circuit operation of the relay.

5 Give 230V/50Hz/AC power supply to the power circuit and Switch ON the SPST switch S2.

6 Note down the delay time in the Table-1 and observe the bulb condition.

7 Get the work checked by the Instructor.

Table 1

Coil Supply	Timer setting	Delay Time Measured

— — — — — — — —

Connect a contactor in a circuit and test for its working

Objectives : At the end of this exercise you shall be able to
- **identify the terminals and auxiliary contacts of the contactor**
- **test and verify the operation of the contactor.**

Requirements

Tools/Equipments/Instruments

- Trainees Tool Kit - 1 Set
- Multimeter with probes - 1 No
- Contactor with 2NO/2NC/230V/1A - 1 No

Materials/Components

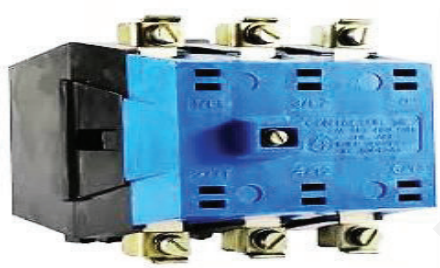
- 1Sq.mm Multi-strand wire - 5 m

PROCEDURE

TASK 1: **Identification of terminals auxiliary contacts of the Contactor**

1 Collect the contactor along with the instruction booklet. (Fig 1)

Fig 1



2 Find the main and auxiliary contacts and note down the details in Table-1.

3 Identify the normally open and closed contacts by using Ohmmeter/Multimeter.

4 Record the coil details and its resistance in the Table 1.

5 Get the work checked by the Instructor.

Table 1

Coil supply	Coil Resistance	No.of Main contact	No. of Auxiliary NO contact	No. of Auxiliary NC contact

— — — — — — — —

TASK 2: **Testing of Relay**

1 Make connection to the coil terminal of the contactor.

2 Before energizing the coil, check the continuity of the NO/NC auxiliary contacts and record the observations in the Table-2.

3 Give 230V/50Hz/AC supply to the coil of the contactor and switch ON the supply.

4 Observe the operation of the Contactor.

5 After energizing the coil, check the condition of the NO/NC auxiliary contacts and record the observations in the Table-2.

6 Get the work checked by the Instructor.

Table 2

Before Energizing		After Energizing	
Normally Open (NO)	Normally Close (NC)	Normally Open (NO)	Normally Close (NC)

— — — — — — — —

Construct and test RC-time constant circuit

Objectives : At the end of this exercise you shall be able to
- **construct a RC time constant circuit**
- **measure the charging time delay in RC circuits.**

Requirements

Tools/Equipments/Instruments

- Trainees Tool Kit - 1 Set
- Digital LCR Meter with manual - 1 No
- Multimeter with probes - 1 No
- Dual Trace Oscilloscope, 0-20MHz with manual - 1 No
- Function Generator with manual - 1 No

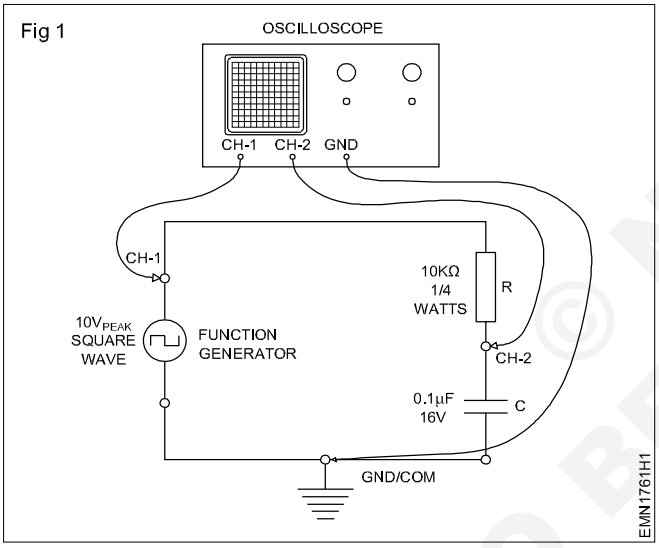
Materials/Components

- Lug Board - 1 No
- Capacitor, 0.1µF/16V - 1 No
- Resistor, 10kΩ/¼ CR 25 - 1 No
- Patch Cords - 10 Nos

PROCEDURE

1 Connect the test set-up as shown in Fig 1.

Fig 1



2 Measure and record the values of Resistor and Capacitor in Table-1.

3 Calculate the RC Time constant, (τ=RC seconds) of the circuit and record in Table-1.

4 Set the output of function generator to square wave with a pulse time t_p equal to 6m second (6τ). Set the function generator level to $10V_{P-P}$. Record the set voltage in Table-1.

5 Switch ON CRO. Set CH-1 and CH-2 Time/Div of CRO to 1mS and position the two wave-forms as shown in figure. Adjust the Volts/Div of CRO such that both the waveforms are clearly seen on the screen.

6 Find out the Time constant τ in the charging curve at 63.2% of the input voltage.

7 Compare the practical value with calculated value of τ.

8 Get the work checked by the Instructor.

- Maximum Capacitor Charging Voltage = ……Volt
- 63.2% of Capacitor Voltage = ……Volt.

Table 1

Value of Resistor in Ohm	Value of Capacitor in µF	Time Constant τ = RC	Practical Time Constant τ	Difference

Construct a RC differentiator circuit and convert triangular wave into square wave

Objectives : At the end of this exercise you shall be able to
- **identify the components to the given circuit**
- **test the RC differentiator circuit**
- **record the out put wave form and plot a graph.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- CRO dual trace 0-20 MHz - 1 No
- Signal generator - 1 No

Materials/Components

- Breadboard - 1 No
- Resistor 1.5 kΩ, ¼ W/CR 25 - 2 Nos
- Capacitor 10 nF - 2 Nos

PROCEDURE

TASK 1 : **Testing of RC differentiator circuit**

1 Check the given breadboard.

2 Check the components by using multimeter.

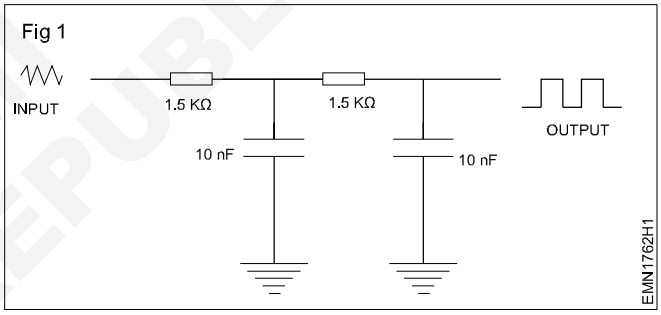
3 Assemble the components as per circuit diagram. (Fig 1)

4 Prepare the CRO and connect the CRO in the circuit.

5 Give the input signal as triangular wave from signal generator and observe the output as square wave.

6 Record the output wave form and plot a graph of input voltage VS time. (Fig 2)

Fig 1

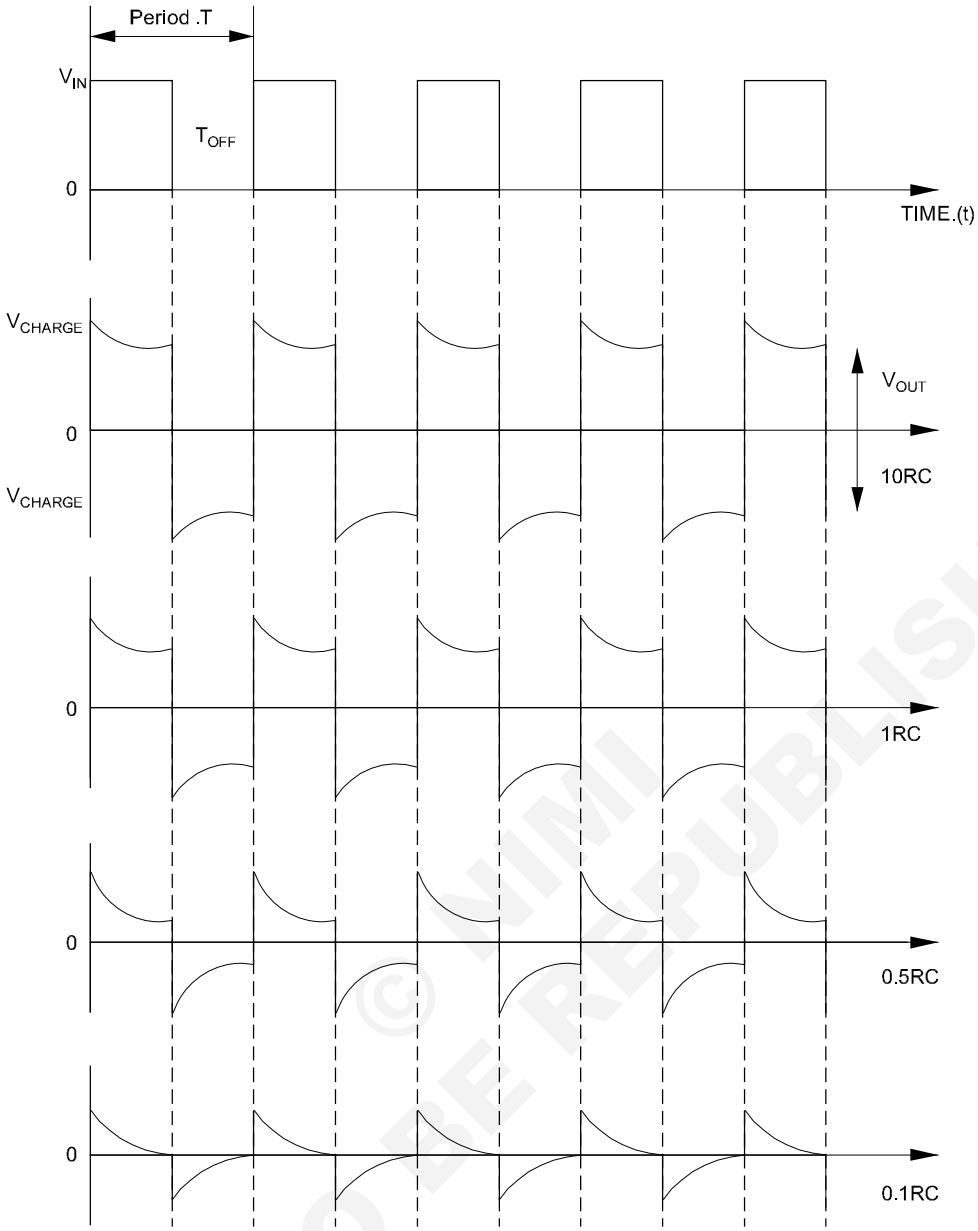


Note : The out wave form depends on the ratio of the pulse width to the RC time constant. when RC is much larger (greater than 10 RC) than the pulse width the output waveform resembles the square wave of the input signal. When RC is much smaller (less than 0.1 RC) than the pulse width, the output waveform takes the form of very sharp and narrow spikes as shown above.

So by varying the time constant of the circuit from 10 RC to 0.1 RC produce a range of different wave shapes.

Generally a smaller time constant.

Fig 2



INPUT AND OUTPUT WAVE FORM OF RC DIFFERENTIATOR

EMN1762H3

Construct and test series and parallel resonance circuit

Objectives : At the end of this exercise you shall be able to
- **determine the resonance frequency of a given LC series circuit**
- **determine the circuit current at different frequencies**
- **plot a graph of frequency versus circuit current.**
- **determine the resonance frequency of a given LC parallel circuit.**

Requirements

Tools/ Equipment/ Instruments

- Trainees tool kit - 1 Set
- Dual trace CRO, 0-20 MHz with manual - 1 No
- Function generator with manual - 1 No
- Milli Ammeter 0-30mA - 1 No

Materials/ Components

- General purpose Lug board - 1 No
- Capacitor 0.1 µF - 1 No
- Inductor coil, around 40mH (Use the solenoid coil made in unit 5) - 1 No
- Unknown value Inductor - 1 No
- LED with holder - 1 No
- Hook-up wires - as reqd

PROCEDURE

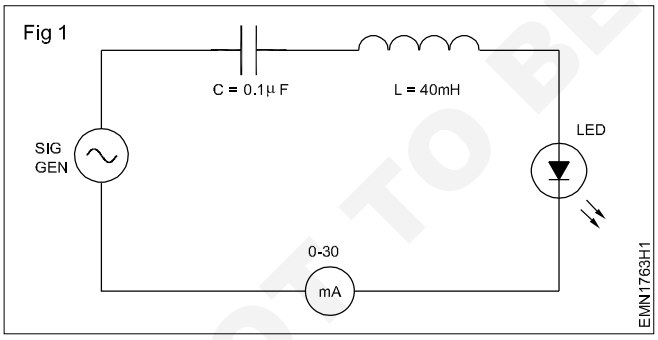
TASK 1 : **Determine the resonance frequency of a given LC series circuit**

1 Measure and record the inductance of the coil.

2 Solder the components as shown Fig 1 to obtain a simple series resonance circuit. Connect instruments as shown in Fig 1

The LED in the circuit is to get a visual indication of the current through the circuit at different frequencies.

Fig 1



3 Knowing the values of L and C, calculate and record the resonance frequency of the series resonance circuit.

4 Set the output of the signal generator to $10V_{rms}$ and frequency to 1 kHz. Record the current, I through the circuit.

LED may not be glow or may be very dim, because the set frequency of 1 kHz may not be the resonance frequency of the circuit.

5 Increase the frequency gradually and record the resonance frequency for at which the circuit current becomes maximum (LED glows brightly)

This is the resonance frequency of the series resonance circuit because at series resonance current I through the LC circuit will be maximum.

6 Compare and record the difference in the resonance frequency calculated at step 3 and that measured in step 5.

7 Vary the input frequency in steps of 500 Hz around the resonance frequency and in each step record the value of circuit current.

8 From the recorded readings of current in step 6, plot a graph of frequency versus current and mark the resonance frequency of the LC series circuit.

9 Get the working of the circuit, recorded readings and the graph checked by the instructor.

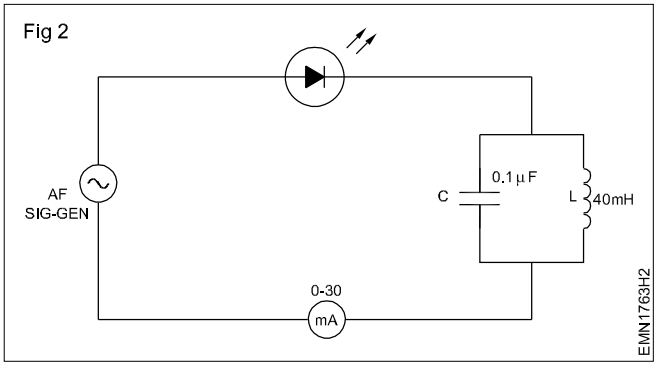
TASK 2 : **Determine the resonance frequency of a given LC parallel circuit**

1 Measure and record the inductance of the coil.

2 Solder the component as shown Fig 2 to obtain a simple parallel resonance circuit. Connect components as shown in Fig 2.

The LED in the circuit is to get a visual indication of the current through the circuit at different frequencies.

Fig 2



3 Knowing the values of L and C, calculate and record the resonance frequency of the parallel resonance circuit.

4 Set the output of the signal generator to $4V_{rms}$ and frequency to 1 kHz. Record the current I through the circuit.

Ensure that the current through the circuit is around 10 to 12 mA and not more. If more current is flowing, reduce the output level of the signal generator. LED will glow at all frequencies other than at the resonant frequency.

5 Increase the frequency gradually and record the resonance frequency f at which the circuit current becomes minimum (LED does not glows or glows very dim).

This is the resonance frequency of the parallel resonance circuit because at parallel resonance, current (I) through the parallel LC circuit will be minimum.

6 Compare and record the difference in the resonance frequency calculated at step 3 and that measured in step 5.

7 Vary the input frequency in steps of 500 Hz around the resonance frequency and in each step record the value of circuit current.

8 From the recorded readings of current in step 6, plot a graph of frequency verses current and mark the resonance frequency of the LC parallel circuit.

9 Get the working of the circuit, recorded readings and the graph checked by the instructor.

— — — — — — — —

Identify different types of diodes, diode modules and their specifications

Objectives : At the end of this exercise you shall be able to
- **identify the diode type, module and specification.**

Requirements

Tools/Equipments/Instruments

- Trainees Tool Kit - 1 Set
- Semi conductor diode data book/ manual - 1 No

Materials/Components

- Assorted type of Diodes - 10 Nos

PROCEDURE

The instructor has to label the different types of Diodes used for this exercise.

1 Pick one of the labelled diode from the given assorted lot.

2 Observe the code number printed on the diode and record in the Table-1.

3 For chosen diode, refer semiconductor data book/ manual and identify the type of diode, semiconductor material type of package.

4 Also record the maximum Forward Current, I_f, peak Inverse Voltage, PIV, forward Voltage Drop, V_f.

5 Repeat step-2 to 4 for all the remaining diodes, and record it in Table 1.

6 Get the work checked by the Instructor.

Fig 1

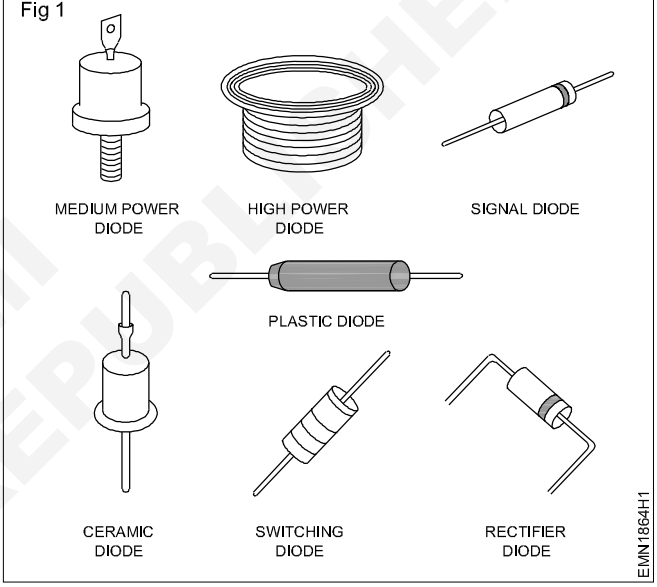


Table 1

Label No.	Code No.of Diode	Type of Diode	Semiconductor Material	Type of Package	Maximum Forward Current I_f	Peak Inverse Voltage PIV	Forward Voltage Drop V_f
1							
2							
3							
4							

Test the given diode using multimeter and determine forward to reverse resistance ratio

Objectives : At the end of this exercise you shall be able to
- **test the diode using multimeter**
- **determine the forward to reverse resistance ratio.**

Requirements

Tools/Equipments/Instruments

- Trainees Tool Kit - 1 Set
- Multimeter with probes - 1 No
- Semi conductor data manual - 1 No

Materials/Components

- Assorted type of Diodes - 10 Nos
- Red colour Sleeve Wire - 1 No
- Patch Cords - 10 Nos

PROCEDURE

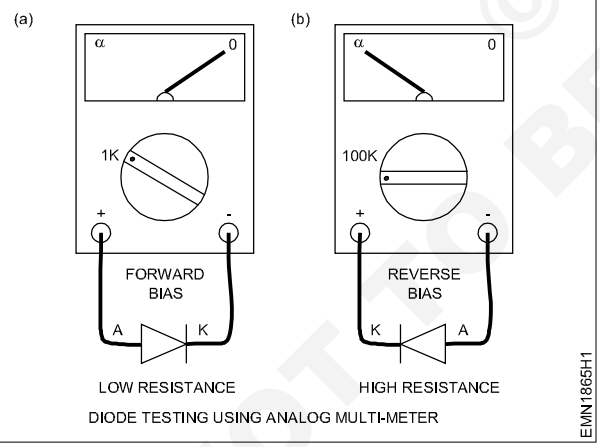
The instructor has to label the different types of diodes used for this exercise.

1 Pick one of the labelled diode from the given assorted lot.

2 Set the multimeter to x100Ω range. Carry out resistance zero setting of the meter.

3 Connect the multimeter probes across the diode terminals as shown in the Fig 1a. Record the resistance reading shown by the meter in Table-1.

Fig 1



4 Reverse the meter probe connected to the diode as shown in the Fig 1b and record the reading shown by the meter in Table-1.

5 From the readings noted in step-3 and step-4 calculate and record the ratio between Forward resistance (R_F) to Reverse resistance (R_R).

6 From the recorded information given conclusion of diode.

- In good diodes, resistance will be less than 100Ω in one direction and very high or almost infinity/open in the other direction.
- In most cases the ratio between low to high resistance would be at 1:1000.
- If get zero both ways, the diode is shorted.
- If get INFINITY both ways, the diode is open.

7 Repeat step-3 to step-6 for all the remaining diodes, and record in Table 1.

8 Get the work checked by the Instructor.

Table 1

Label No.	Code No.of Diode	Forward Resistance (F_R)	Reverse Resistance (R_R)	Ratio of F_R/R_R	Serviceable/ Unserviceable
1					
2					
3					
4					

Measure the voltage and current through a diode in a circuit and verify its forward characteristics

Objectives : At the end of this exercise you shall be able to
- **find and plot the forward characteristics of a diode.**

Requirements

Tools/Equipments/Instruments

- Trainees Tool Kit - 1 Set
- Regulated DC power supply, 0-30V/2A - 1 No
- DC milli-ammeter, 0-500mA - 1 No
- DC milli-Voltmeter, 0-1000mV - 1 No
- DMM with probes - 1 No

Materials/Components

- Lugboard - 1 No
- Semiconductor diode, 1N4007 or BY127 - 1 No
- Resistor, 470Ω/½ watt CR25 - 1 No
- Hook up Wire - 2 m
- Patch Cords - 10 Nos

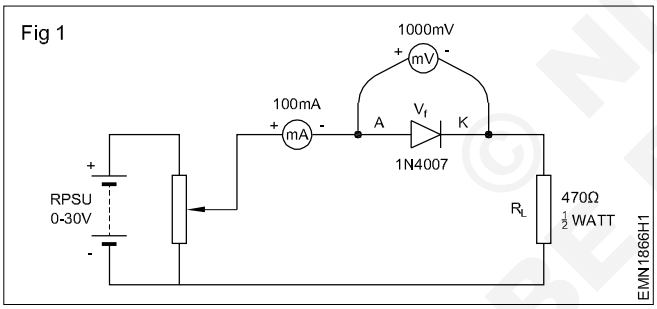
PROCEDURE

1 Check to confirm the good physical and electrical working condition of the given diode.

2 Identify the Anode and Cathode terminals of the diode.

3 Construct the circuit as shown in Fig 1.

Fig 1



4 Switch ON the Regulated Power Supply and increase the output voltage of the RPSU such that the diode drop V_f varies from 0 to 1V in steps as given in Table-1.

5 At each step record the values of I_f.

6 Switch OFF the RPSU. From the recorded values of V_f and I_f, calculate and the forward resistance R_f of the diode.

7 From the recorded readings in Table-1, plot a graph of V_f and I_f.

8 Get the work checked by the Instructor.

Table 1

- Diode Type Number :
- Forward Resistance of Diode :
- Reverse Resistance of Diode :
- Lamp Resistance :

Forward voltage drop across Diode V_f in mV	Forward current I_f in mA	Forward Diode Resistance Ω
100mV		
200mV		
300mV		
400mV		
500mV		
600mV		
700mV		
800mV		
900mV		
1 Volt (1000mV)		

Identify different types of transformers and test

Objectives : At the end of this exercise you shall be able to
- **identify different types of transformer by appearance.**
- **identify different types of transformer by using multimeter.**

Requirements

Tools/Equipments/Instruments

- Trainees Tool Kit - 1 Set
- Multimeter with probes - 1 No
- Types of Transformer Chart - 1 No

Materials/Components

- Assorted type of Transformers - 10 Nos
- Cotton Waste - ½ kg

PROCEDURE

The instructor has to label the different types of transformers like, Low voltage step-down transformer, EHT transformer of T V, IFT, Auto transformer.

1 Take one of the labelled transformer from the given lot. Enter its label number in Table-1.

2 For the given transformer, from its appearance, shape of core, etc., identify the type of the transformer, rated voltage and record details in the Table-1.

3 Find the HT and LT winding by measuring resistance with the ohm meter/multimeter/DMM.

4 Draw the symbol of the each transformer in Table-1. Observe the resistance value of windings using multimeter record it in Table 1.

5 Repeat steps-2 to steps-4 for the remaining transformers.

6 Get the work checked by the Instructor.

Table 1

Label No.	Name of the Transformer	Voltage rating		Measured Resistance value		Type/shape of core	Symbol
		H.T	L.T	H.T	L.T		

— — — — — — — —

Identify the primary and secondary windings of transformer and test the polarity

Objectives : At the end of this exercise you shall be able to
- **read and interpret the name plate details of single phase transformer**
- **find out the polarity of the transformer.**

Requirements

Tools/Instruments

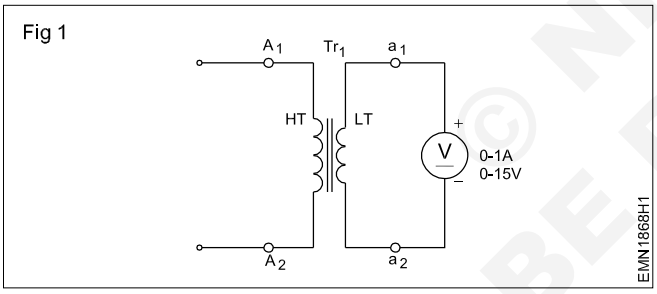
• MI Voltmeter 0-300V	- 2 Nos
• Ohmmeter 0-500Ω	- 1 No
• MI Ammeter 0-10A	- 1 No
• MI Ammeter 0-100mA	- 1 No
• Push button switch	- 1 No
• 12 V battery	- 1 No

PROCEDURE

TASK 1 : **Identify the primary and secondary winding of a transformer.**

1 Find out the corresponding terminals and two windings (HT & LT) with ohm meter as shown in Fig 1 by checking the continuity.

Fig 1



2 Determine HT & LT winding by measuring resistances with the ohmmeter.

LT windings will have low resistance; mark accordingly.

3 Record resistance of both parts

1st pair -------- ohms. This is HT/LT winding

2nd pair-------ohms. This is HT /LT winding

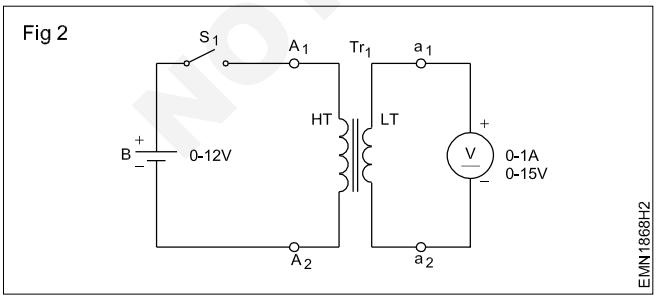
— — — — — — — —

TASK 2 : **Test the polarity of a transformer**

1 Connect DC supply to HT through push button switch.

2 Connect voltmeter to LT as shown in Fig 2.

Fig 2



3 Mark HT terminals as A_1 and A_2.

4 Mark LT terminals as a_1 and a_2.

5 Press the push button switch.

6 Observe the deflection of the pointer of the voltmeter. If the pointer deflects in the right direction, retain the markings made on terminals.

7 Change the voltmeter connections made to LT terminals and change the marking made on LT terminals if the deflection is in the reverse direction.

8 Now press the push button switch once again and observe that the voltmeter deflecting in right direction.

— — — — — — — —

Construct and test a Half-wave, Full wave and Bridge rectifier circuit

Objectives: At the end of this exercise you shall be able to
- **construct and test a half-wave rectifier**
- **construct and test a two diode full-wave rectifier**
- **construct and test a full-wave bridge rectifier.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Oscilloscope 0-30MHz, Dual Trace with probe kit - 1 No
- Multimeter with probes - 1 No

Materials/Components

- Lug Board/PCB - 1 No
- Semiconductor diode, 1N4007 or By127 - 4 Nos
- Step-down Transformer, 230V/12V/500mA - 1 No
- Centre tapped Step-down Transformer, 230V/12-0-12V/ 500mA - 1 No
- Main cord with Three Pin Plug - 1 No
- Resistor, 470Ω/1W CR25 - 1 No
- Hook up Wire - 5 m

PROCEDURE

TASK 1 : **Construction and Testing of a Half-Wave rectifier**

1 Check to confirm the good condition of the given components.

2 Using Lug board/PCB, construct the Half-wave rectifier as shown in Fig 1.

3 Connect AC mains to the Transformer and switch ON mains.

4 Measure and record the mains voltage and transformer secondary AC voltage $V_{S(rms)}$ to the rectifier in the Table-1.

5 Calculate the expected DC voltage V_{dc} across the load resistor R_L using the formula,

$V_{dc} = 0.45V_{S(rms)}$

Where, $VS_{(rms)}$ is the AC input to the rectifier.

6 Measure and record the rectifier output DC voltage V_{dc} across R_L using multimeter/Voltmeter.

7 Record the difference in the calculated and measured values.

8 Connect the two channel input probes of the CRO. Set the Volt/div and Time/div of CH-1 and CH-2 such that the two waveforms are seen clearly.

9 From the displayed waveforms on the screen, measure and record the following parameters;

a Peak value of Source Voltage V_S (Input Volt to Rectifier).

b Frequency of Source Voltage V_S.

c Peak value of pulsating DC - V_{dc}.

10 Frequency of Pulsating DC - V_{dc}.

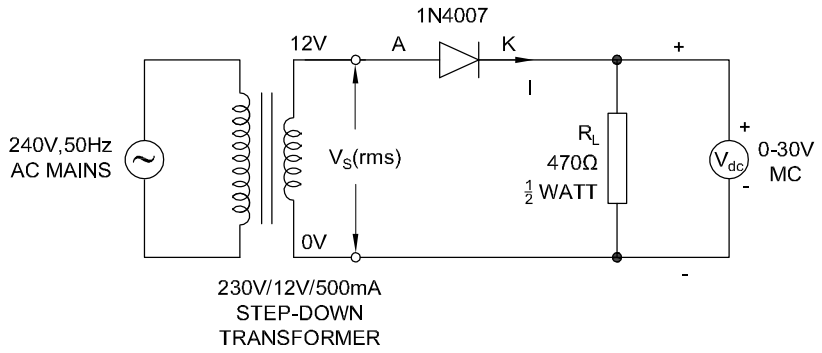
11 Get the work checked by the Instructor.

Table 1

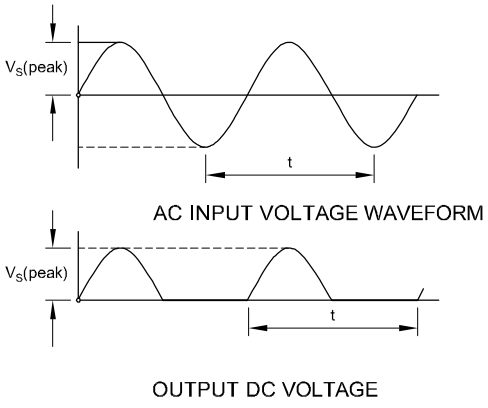
- Type of Transformer :
- Rated Primary Voltage :
- Rated Secondary Voltage :

Mains supply voltage	Secondary voltage $V_{S(rms)}$	Calculated V_{dc}	Measured V_{dc}	Difference between (3) and (4)	Peak value V_S	Frequency of V_S	Peak Value of pulsating V_{dc}	Frequency of pulsating V_{dc}

Fig 1



HALF-WAVE RECTIFIER



HALF-WAVE RECTIFIER WAVEFORMS

EM20N1869H1

— — — — — — — —

TASK 2: **Construction and Testing of a two diode Full-Wave rectifier**

1 Construct the two diode Full-wave rectifier as shown in Fig 2.

2 Connect AC mains to the centre tapped Transformer and switch ON mains.

3 Measure and record the mains voltage and transformer secondary AC voltage $V_{S(rms)}$ to the rectifier in the Table-2.

4 Calculate the expected DC voltage V_{dc} across the load resistor R_L using the formula,

$V_{dc}=0.9V_{S(rms)}$

Where, $V_{S(rms)}$ is the AC input to the rectifier.

5 Measure and record the rectifier output DC voltage V_{dc} across R_L using multimeter/Voltmeter.

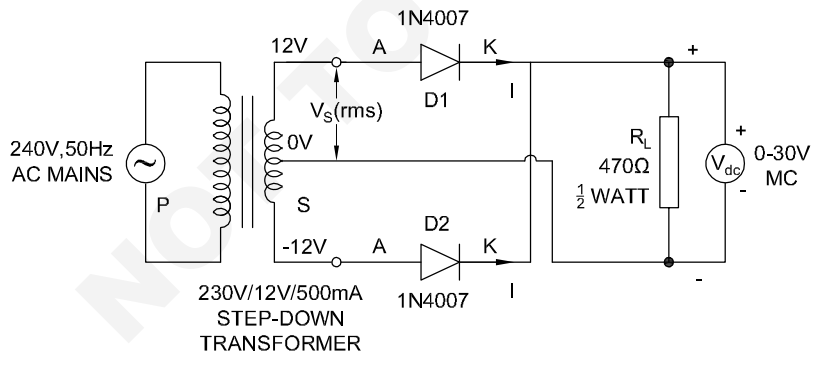
6 Record the difference in the calculated and measured values.

7 Connect the two channel input probes of the CRO. Set the Volt/div and Time/div of CH-1 and CH-2 such that the two waveforms are seen clearly.

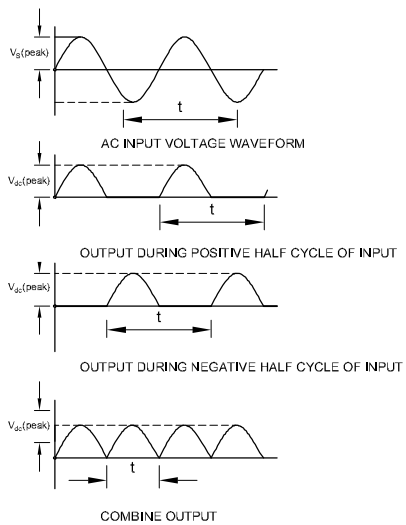
8 From the displayed waveforms on the screen, measure and record peak value of Source Voltage V_S (Input Volt to Rectifier), frequency of Source, Voltage V_S, peak value of pulsating DC - V_{dc}, frequency of Pulsating DC - V_{dc}.

9 Get the work checked by the Instructor.

Fig 2



CENTRE TAPPED FULL-WAVE RECTIFIER



FULL-WAVE RECTIFIER WAVEFORMS

EM20N1869H2

Table 2

- Type of Transformer :
- Rated Primary Voltage :
- Rated Secondary Voltage :

Mains supply voltage	Secondary voltage $V_{S(rms)}$	Calculated V_{dc}	Measured V_{dc}	Difference between (3) and (4)	Peak value V_S	Frequency of V_S	Peak Value of pulsating V_{dc}	Frequency of pulsating V_{dc}

— — — — — — — —

TASK 3: **Construction and Testing of four diode full wave bridge rectifier**

1 Construct the Full-wave Bridge rectifier as shown in Fig 3.

2 Connect AC mains to the Transformer and switch ON mains.

3 Measure and record the mains voltage and transformer secondary AC voltage $V_{S(rms)}$ to the rectifier in the Table-3.

4 Calculate the expected DC voltage Vdc across the load resistor RL using the formula,

$V_{dc}=0.9V_{S(rms)}$

Where, $V_{S(rms)}$ is the AC input to the rectifier.

5 Measure and record the rectifier output DC voltage V_{dc} across R_L using multi-meter/Voltmeter.

6 Record the difference in the calculated and measured values.

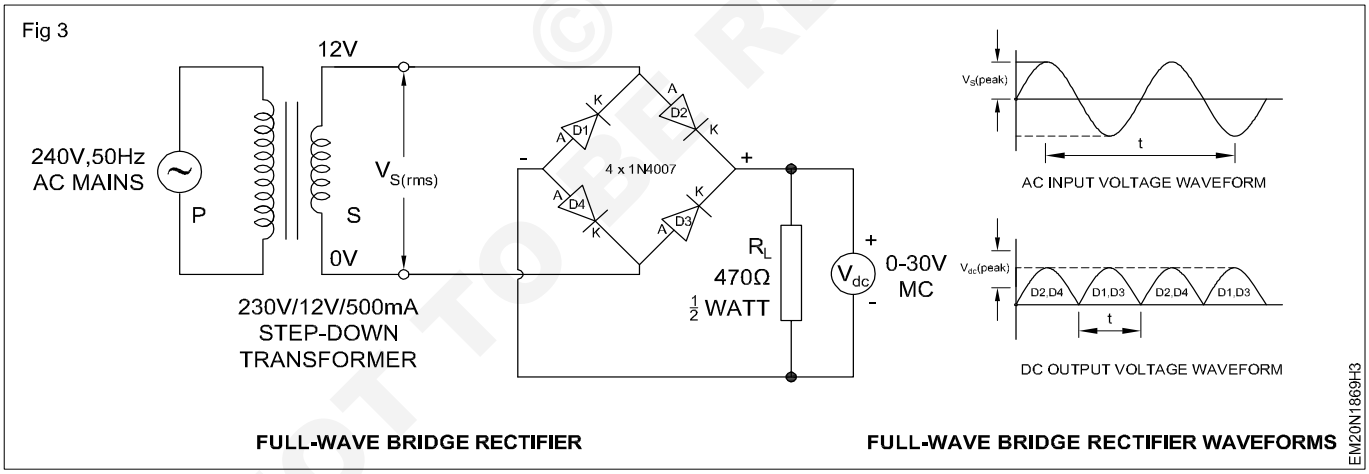
7 Connect the two channel input probes of the CRO. Set the Volt/div and Time/div of CH-1 and CH-2 such that the two waveforms are seen clearly.

8 From the displayed waveforms on the screen, measure and record the following parameters;

- Peak value of Source Voltage V_S (Input Volt to Rectifier).
- Frequency of Source Voltage V_S.
- Peak value of pulsating DC - V_{dc}.
- Frequency of Pulsating DC - V_{dc}.

9 Get the work checked by the Instructor

Fig 3



FULL-WAVE BRIDGE RECTIFIER **FULL-WAVE BRIDGE RECTIFIER WAVEFORMS**

Table 3

- Type of Transformer :
- Rated Primary Voltage :
- Rated Secondary Voltage :

Mains supply voltage	Secondary voltage $V_{S(rms)}$	Calculated V_{dc}	Measured V_{dc}	Difference between (3) and (4)	Peak value V_S	Frequency of V_S	Peak Value of pulsating V_{dc}	Frequency of pulsating V_{dc}

Measure ripple voltage, ripple frequency and ripple factor of rectifiers for different load and filter capacitors

Objectives: At the end of this exercise you shall be able to
- **construct and test the effect of capacitor filter with different load condition**
- **determine the ripple voltage, ripple frequency and ripple factor.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Oscilloscope Dual Trace 0-20 MHz - 1 No
- Multimeter with probes - 1 No
- Voltmeter, 0-30V, MC - 1 No

Materials/Components

- Lugboard/PCB - 1 No
- Semiconductor diode, 1N4007 or By127 - 4 Nos
- Step-down Transformer, 12V/500mA - 1 No
- Mains cord with Three Pin Plug - 1 No
- Resistor, 5Ω /½W - 1 No
- Resistor, 470Ω/1W - 1 No
- Electrolytic Capacitor, 1000µF/25V - 2 Nos
- SPST switch/1A - 5 Nos
- Hook up wire - 5 m
- Patch cords - 10 Nos

PROCEDURE

1 Collect and check the required components.

2 Connect the components as shown in Fig 1.

3 Energize the input to the transformer with 230V AC.

4 Observe the output waveform on CRO and measure the output with switch S_1, S_3 open and S_2, S_4 closed under full-wave rectifier.

5 With switch S_1, S_2, S_4 "ON" and S3 "OFF" the circuit acts as capacitor input filter. Observe the output waveform on the CRO and plot it.

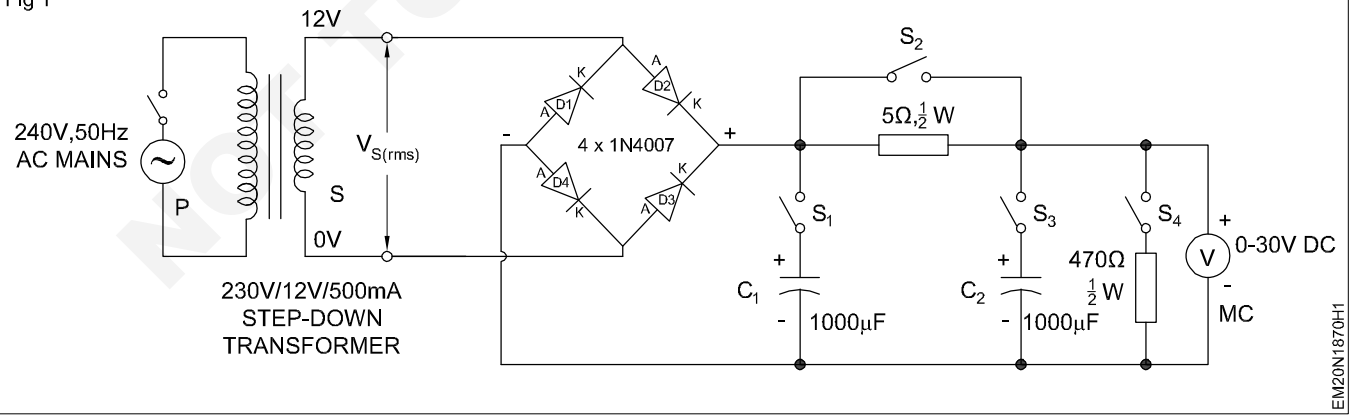
6 Switch "OFF" S_2 and switch "ON" S_1, S_3, S_4, the circuit becomes full-wave rectifier with filter. Observe the output voltage wave shape on CRO and plot it.

7 Measure the output voltage ($V_{r(p-p)}$) as well as DC.

8 Calculate the Ripple factor for all the three conditions.

9 Get the work checked by the Instructor.

Fig 1



Identify and test zener diode

Objectives : At the end of this exercise you shall be able to
- **identify and test the Zener Diodes.**

Requirements

Tools/Equipments/Instruments

- Trainees Tool Kit - 1 Set
- Multimeter with probes - 1 No
- Semi conductor data manual - 1 No

Materials/Components

- Assorted type of zener diodes - 1 No each

PROCEDURE

The instructor has to label the different types of zener diodes used for this exercise.

1 Pick one of the labelled Zener diode from the given lot.

2 Record the code number printed on the Zener diode in the Table-1.

3 For chosen Zener diode, refer semiconductor data book and identify the following.
- Zener Voltage, V_Z
- Maximum Zener Current, I_Z
- Maximum Power dissipation, P_Z and record in the table.

4 Connect the multimeter probes across the Zener diode terminals as shown in the figure -1a. Measure and record the resistance value shown by the meter in Table-1.

5 Reverse the meter probe connected to the Zener diode as shown in the figure- 1b measure and resistance record the value shown by the meter in Table-1.

6 From the recorded information given conclusion of Zener diode.
- In good Zener diodes, resistance will be less than 100Ω in one direction and very high or almost infinity/open in the other direction.
- If you get zero both ways, the diode is shorted.
- If you get INFINITY both ways, the diode is open.

7 Repeat step-2 to step-6 for all the remaining Zener diodes.

8 Get the work checked by the Instructor.

Fig 1

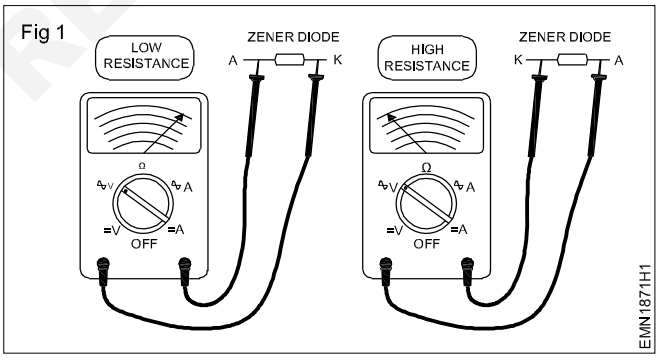


Table 1

Label No	Code No. of Diode	Zender Voltage V_Z	Maximum Zener Current, I_Z	Maximum Power Dissipation, P_Z	Forward Resistance F_R	Reverse Resistance R_R	Remarks
1							
2							
3							

Construct and test zener diode based voltage regulator circuit

Objectives: At the end of this exercise you shall be able to
- **construct and test the Zener based voltage regulator circuit**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Regulated DC power Supply 0-30V/2A - 1 No
- Multimeter with probes - 1 No
- Ammeter, 0-300mA MC - 1 No
- Voltmeter, 0-30V, MC - 2 Nos
- Voltmeter, 0-10V, MC - 1 No

Materials/Components

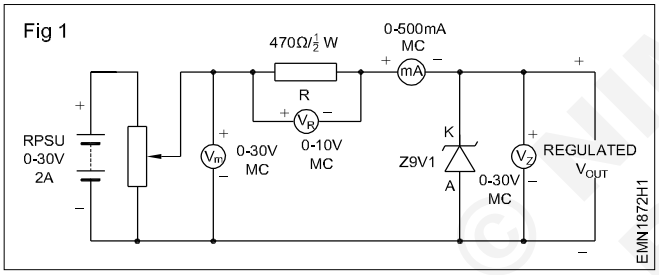
- Lug Board/PCB - 1 No
- Zener Diode, 5.6V - 1 No
- Resistor, 470Ω/½W - 1 No
- Hook up wire - 3 m
- Patch cords - 10 Nos

PROCEDURE

1 Collect the equipments and components and check the items for its good working condition.

2 Connect them as in the circuit diagram-1.

Fig 1



3 Switch ON the input supply.

4 Measure and record the values of V_R, V_Z and I_Z in the Table-1.

5 After observing readings, switch "OFF" PSU and from the recorded readings, calculate the Zener resistance R_Z and power dissipated P_Z for each set of readings.

6 Get the work checked by the Instructor.

Do not dismantle the circuit board as this is to be utilized for exercise No.1.8.73

Table 1

Sl. No.	Unregulated Input voltage, V_{in}	Voltage Drop across series Resistor V_R	Zener voltage V_Z	Zener current, I_Z	Calculated	
					Zener Resistance, R_Z	Zener Power, P_Z

Formula:

- Zener Resistance = $R_z = \frac{V_z}{I_z}$
- Zener Power = $P_Z = V_Z.I_Z$

— — — — — — — —

Calculate the percentage regulation of regulated power supply

Objectives: At the end of this exercise you shall be able to
- **construct test and calculate the percentage regulation of regulated power supply.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Power Supply Unit, 0-30V/1A - 1 No
- Multimeter with probes - 1 No
- Ammeter, 0-300mA MC - 1 No
- Voltmeter, 0-30V, MC - 2 Nos
- Voltmeter, 0-10V, MC - 1 No

Materials/Components

- Lug Board/PCB - 1 No
- Zener Diode, 5.6V - 1 No
- Resistor, 4.7kΩ/1/2W - 1 No
- Resistor, 3.3kΩ/1/2W - 1 No
- Resistor, 2.2kΩ/1/2W - 1 No
- Resistor, 1kΩ/1/2W - 1 No
- Resistor, 470Ω/1/2W - 1 No
- Hook up wire - 3 m
- Patch cords - 10 Nos

PROCEDURE

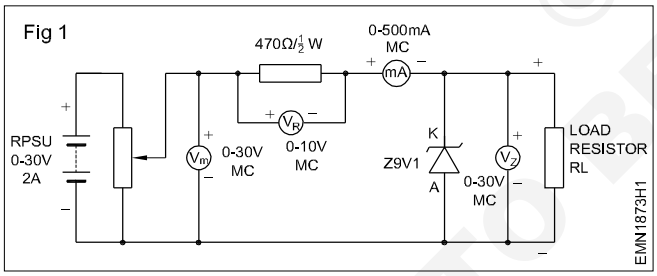
1 Use the assembled circuit diagram of exercise-1.8.72, for this task.

2 Switch "ON" PSU, set input voltage (V_{in}) to 15V.

3 Measure and record the no load voltage V_{out}.

4 Connect load resistor of values given in the Table-2 across the output terminals and in each case measure and record load current I_L and output voltage V_{out}.

Fig 1



5 Calculate and record the output percentage of load regulation at different loads using the formula,

$$\% \text{ of Load Regulation} = \frac{V_{NL} - V_L}{V_{NL}} \times 100$$

Where, V_{NL} - V_{out} at no-load

V_L - V_{out} at load

6 Get the work checked by the Instructor.

Table 1

V_{IN} at 10 Volts Constant			
Load Resistor, R_L	**Output Voltage, V_{OUT}**	**Load Current, I_L**	**% of Load Regulation**
0 Ohms			
2.2kΩ			
3.3kΩ			
4.7kΩ			

Formula:

- Percentage Load Regulation = $\frac{V_{NL} - V_L}{V_{NL}} \times 100$

Construct and test a +12V fixed voltage regulator using 3 terminal regulator IC

Objective : At the end of this exercise you shall be able to
- **construct and test a +12V regulator using IC 7812.**

Requirements

Tools/Equipments/Instruments

- DC Regulated power supply 0-30 V/2A - 1 No
- Trainees tool kit - 1 Set
- DC ammeter, 0-1A - 1 No
- Digital multimeter with probes - 1 No
- Rheostat 100Ω/1A - 1 No

Materials/Components

- Breadboard - 1 No
- Three-pin voltage regulator IC 7812 or equivalent - 1 No
- Suitable heat sink for IC 7812 - 1 No
- Capacitor 270 nF, disc/25V - 1 No
- 10 µF/25 V, electrolytic - 1 No
- Red LED/5mm - 1 No
- Resistor 820Ω, ¼W CR25 - 1 No
- Hook up wires (red and black colour) - 1 m each
- Wire sleeves (R,Y,G) - 2 cm each
- Rosin cored solder - 10 gm

PROCEDURE

1 From the type code marked on the given 3 pin regulator IC. Identify the terminals of IC 7812.

2 Insert sleeves to the terminals using colour coding scheme given below;

Input - Yellow/Orange sleeve.

Common - Green/Black sleeve.

Output - Red sleeve.

3 Get the work done in steps 1 and 2 checked by the instructor.

4 Fix the suitable aluminium heat sink for IC 7812 on the bread board Refer Fig 2 for the position of heat sink on the breadboard.

5 Construct the voltage regulator circuit referring to the schematic and layout diagram shown in Fig 1 & Fig 2.

Fig 1

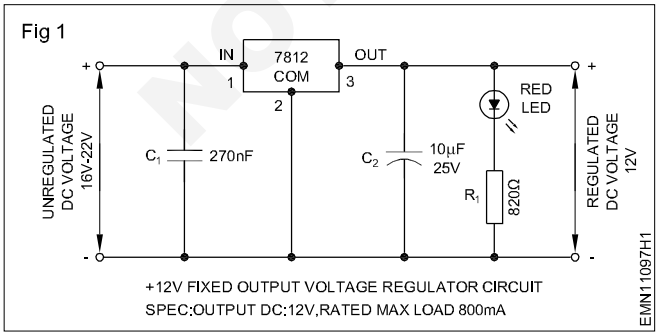
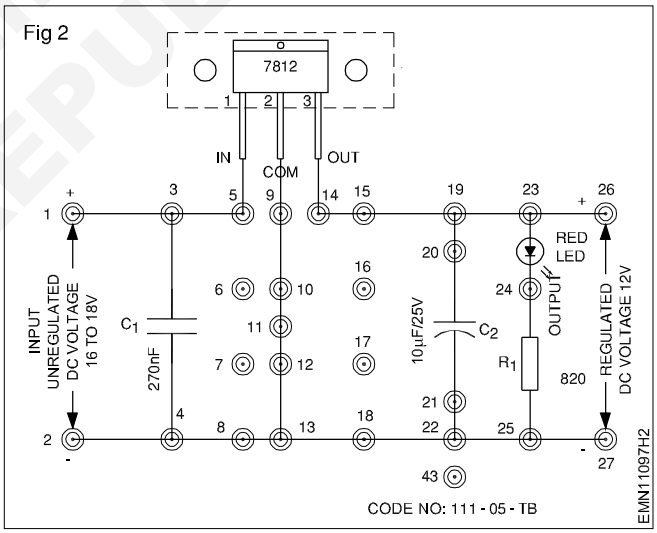


Fig 2



6 Get the neatness and correctness of your wiring checked by your instructor.

7 Apply 16 to 20 volts unregulated dc voltage to the input of the wired 12V regulator. Record the unregulated input voltage and no-load output voltage of the regulator in O & T sheet.

The unregulated dc voltage to the regulator should not be more than 24 volts; otherwise the IC may get damaged.

8 Using loading rheostat, load the regulator in steps of 200 mA upto 800mA and at each step measure and record,

- Regulated dc output voltage
- Input and output ripple.

Loading is limited to 80% of its rated maximum of 1A. This is because the heat sink used with IC 7812 may not be very effective in transferring away the heat.

9 From the recorded readings, calculate the

– output voltage regulation at each step of loading.

– ripple rejection at each step of loading.

10 Get the work checked by the Instructor.

O & T Sheet

1 Neatness and correctness of wiring: Very good ☐ Good ☐ Satisfactory ☐ Poor ☐ Continue Exercise ☐

2 Level of unregulated input voltage to the regulator : _____

		Load - Current			
	No-load	**200 mA**	**400 mA**	**600 mA**	**800 mA**
Output voltage					
Input ripple (P-P)					
Output ripple					
Ripple rejection					
Output regulation					

Identify the different types of fixed +ve and -ve regulator ICs and the different current ratings

Objective : At the end of this exercise you shall be able to
- **construct and test a +12 volts regulator to get a variable output regulation.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Semi conductor data book - 1 No
- Multimeter/DMM with probes - 1 No

Materials/Components

- Different types of -ve and +ve regulator ICs (78/79 series) - 10 Nos

Note: The instructor has to label the different types of fixed positive and negative regulator ICs.

PROCEDURE

TASK 1 : **Identification of different types of fixed positive and negative voltage regulator ICs**

1 Pick one of the labelled IC regulator from the lot, identify the code number and other details and record the observations in Table 1.

2 Refer the semiconductor data manual and verify the details of the IC regulators, compare and record in Table 1.

3 Repeat the steps 1 and 2 for the remaining labelled IC regulators and record the observation and note down in Table 1.

4 Get the work checked by the Instructor.

Table 1

Sl.No.	Label No.	Type of regulators (+ve/-ve)	Voltage rating	Current rating	Remarks
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					

Observe the output voltage of different IC 723 metal / plastic type and IC 78S40 regulators by varying the input voltage with fixed load

Objectives : At the end of this exercise you shall be able to
- **observe the output voltage of IC 723 and IC 78S40 regulators.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Soldering Iron 25W/240VAC - 1 No
- Digital multimeter with probes - 1 No
- Ammeter - 1 No

Materials/Components

- Breadboard - 1 No
- IC 723 - 1 No
- Capacitor 100PF - 1 No
- Resistor 1kΩ/½W - 1 No
- Resistor 2.7kΩ/½W - 1 No
- Resistor 6.8kΩ/½W - 1 No
- Resistor 4.7kΩ/½W - 1 No
- 10Ω Potentiometer/1A carbon type - 1 No

PROCEDURE

1 From the type code marked on the given 14 pin positive regulator IC.

2 Identify the pins of IC 723 and insert sleeves to the terminals using colour coding scheme given below

Input Yellow / Orange Sleeve

Output Red sleeve

Earth - Green / Black sleeve.

3 Construct the voltage regulator circuit referring to the schematic circuit diagram shown in Fig 1.

4 Get the neatness and correctness of the wiring checked by the instructor.

5 Apply regulated dc voltage to the input of the wired regulator. Record the output voltage of the regulator in Table 1.

6 From the recorded readings. Calculate the output voltage regulation at each step and plot the graph.

7 Get the work checked by the Instructor.

Table 1

S No.	Input voltage (V_i) in Volts	Output voltage in volts (V_o) in Volts
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Fig 1

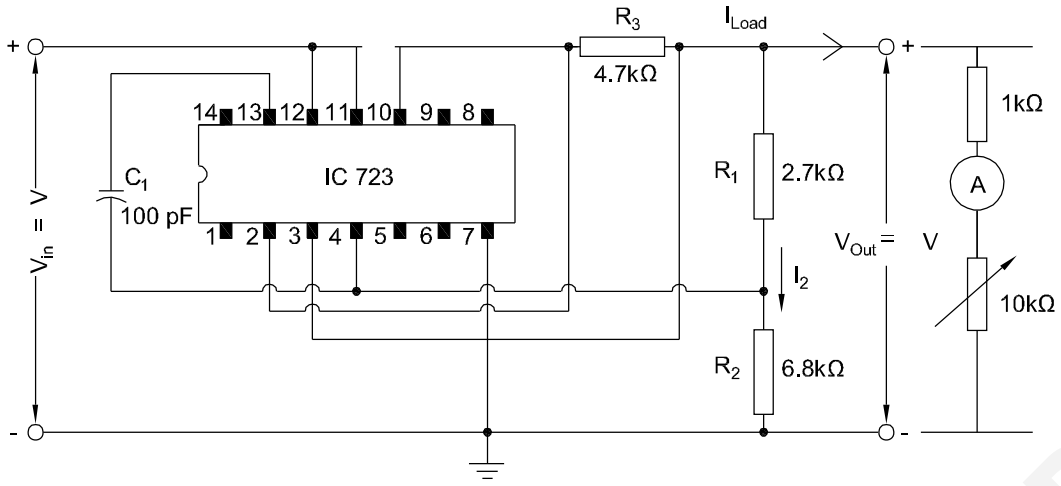
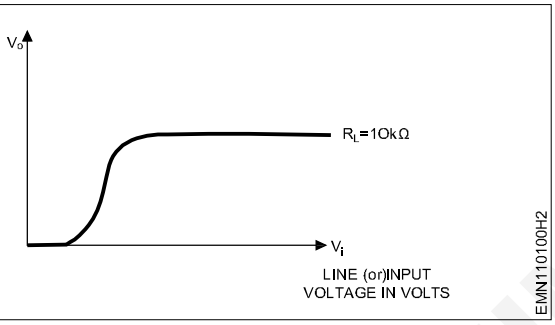


Fig 2



Construct and test a 1.2V to 30V variable output regulated power supply using IC LM317T

Objective : At the end of this exercise you shall be able to
- **construct and test a 1.2 V to 30 V variable output regulated power supply.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Soldering Iron 25W/230V - 1 No
- Digital multimeter with probes - 1 No
- Rheostat 100Ω/1A - 1 No

Materials/Components

- Breadboard/PCB - 1 No
- Step down transformer, 240V/24V or 12-0-12/24V - 1 No
- Diodes, 1N4002 or BY127 or Eqv - 6 Nos
- Capacitors 2200 µF/50V electrolytic - 1 No
  25 µF/50V, electrolytic - 1 No
  10 µF/50V, electrolytic - 1 No
  100 nF, ceramic disc - 1 No
- LED, Red, 5mm - 1 No
- Resistors
  4K7, potentiometer, carbon, rotary - 1 No
  2K2, carbon, ½W - 1 No
  220Ω, carbon, ¼W - 1 No
- 3-terminal voltage regulator, LM317T, TO-220 - 1 No each
- 1A, slow blow fuse with fuse holder - 1 No.
- Hook up wires - as reqd
- Rosin cored solder - 20 gm
- Heat sink for TO-220 package - 1 No

PROCEDURE

1 Test all the components to confirm their good working condition. Record the specifications of IC LM317T in O&T sheet, refer with semi conductor data manual.

2 Check the given bread board.

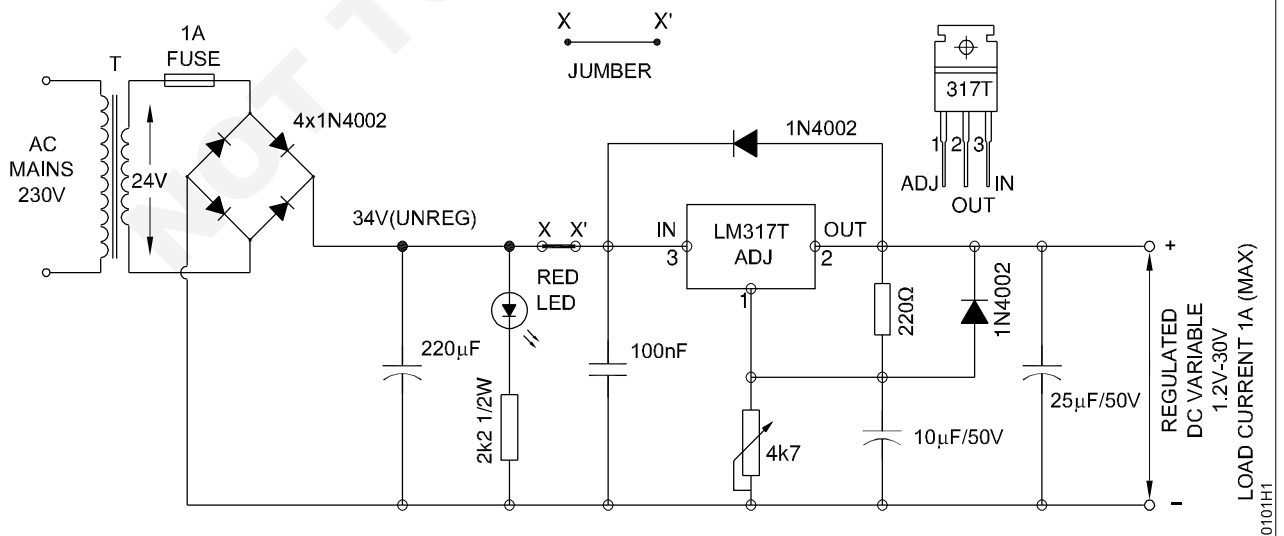
3 Construct a variable regulated output power supply on the given bread board referring to the schematic shown in Fig 1.

All components except the transformer to be mounted on bread board. Use suitable heatsink with IC 317 T.

5 Get the correctness and neatness of wiring checked by the instructor.

6 Diagram connect the secondary of (230/24V) transformer to the assembled circuit. Switch ON mains supply.

Fig 1



NOTE: INSERT ALL COMPONENTS EXCEPT THE FUSE & TRANSFORMER ON THE BREAD BOARD

Switch OFF main supply immediately if burning, smoking overheating, sparks are observed in any of the components, and report to the instructor. Check the IC and ensure that it is not heated-up

7 Measure and record the unregulated dc input and the minimum, maximum variable voltage of the regulator under no-load condition.

8 Set the output to +15 volts and load the output using a loading rheostat in steps of 200 mA up to 600 mA. In each step measure and record the output voltage and the ripple voltages.

Load current is restricted to 600mA as heat-sink is provided to the IC may not be the ideal one.

9 Calculate and record the output regulation and ripple rejection of the regulator.

10 Using a dc current meter (0-1A range) short the load terminals momentarily and record the *short circuit fold back protection* current level.

11 Get the readings checked by the instructor.

Lab Assignment: Mount the regulator IC on a good aluminium heat-sink (available in market). If a good heat-sink is used with the IC, you can draw upto 1Amps easily. Mount the transformer and the wired PCB in a metallic box of suitable size. Mount the POT on the front panel of the box made. Mount output terminal sockets (Red and black) on the front panel of the box from which DC voltage can be taken. This will serve you as a 1.2V to 30V, 1A rating variable power supply for servicing circuits in forthcoming exercises as well for the hobby gadgets and general servicing.

Table 1

Type number	Package type	Output voltage		Max. output current
		Min.	Max.	

1 Specification of the given 3-terminal regulator IC.

2 **Neatness and correctness of wiring:** Very good ☐ Good ☐ Satisfactory ☐ Poor ☐ Continue Exercise ☐

3

Unregulated dc input to regulator : _____

Minimum adjustable output voltage (No-load) : _____

Maximum adjustable output voltage (No-load) : _____

4

Set output voltage : 15 volts

Load current	200mA	300mA	400mA	500mA	600mA
Output voltage					
Output ripple (p-p)					
Input ripple					
Output regulation					

— — — — — — — —

Identify different transistors with respect to different package type, B-E-C pins, power, switching transistor, heatsink etc

Objectives : At the end of this exercise you shall be able to
- **identify transistor by different package type, pin configuration**
- **identify power, switching transistor, heat sinks etc from the data manuals/books.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Transistor data book - as reqd
- Multimeter/DMM with probes - 1 No

Materials/Components

- Different types of transistor packages from T0-1, T0-5, T0-18, T0-39, T0-72, T0-92, T0-3, T0-66, T0-126, T0-202, T0-220, T0-3P, T0-247 - 15 Nos
- Different Heat sinks suitable for above transistors - 10 Nos

Note:

1 The Instructor has to select and label the transistors used for this exercise.

2 A minimum of one number in each type of package has to be arranged.

3 Label the heat sinks also in the similar way

PROCEDURE

TASK 1 : **Identification of transistor by different package type, pin configuration, power rating, type of transistor & heat sink**

1 Pick one of the Labelled transistors from given assorted lot, identify the code number, and record them in Table 1.

2 Refer to the Chart 1 semiconductor data book, identify the type of package, all other details as required in Table 1 and record them.

3 Refer to the Chart 2, different types of heat sinks used for transistors, compare, verify the details of a transistor in the above Table 1 and select the heat sink suitable for the transistor in hand.

4 Record the heat sink type in Table 1 and repeat the above step for remaining labelled transistors.

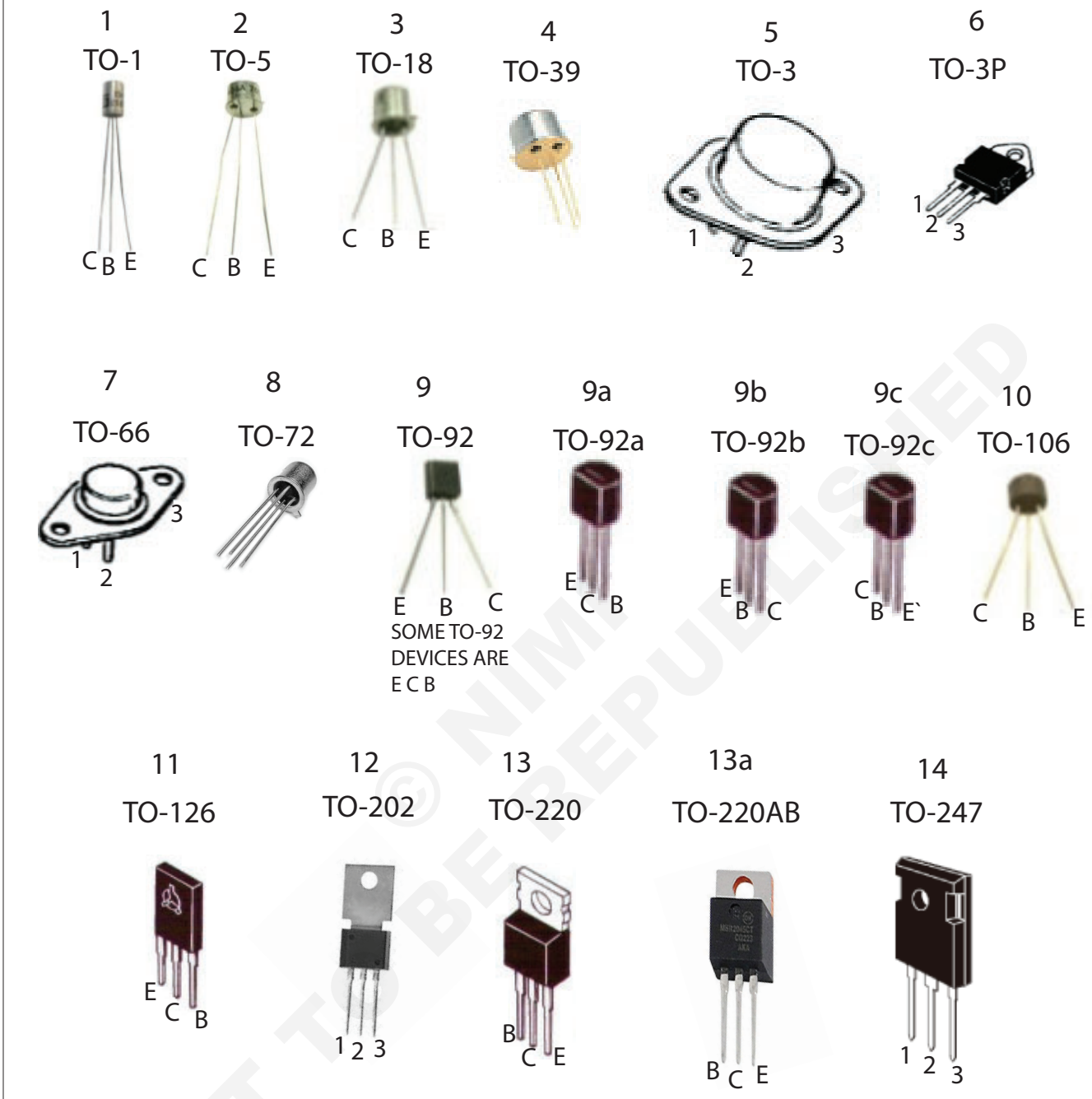
5 Some metallic transistor have notch on its surface. Identify the mark or notch available in transistor. (Terminal adjacent to the notch or mark will be emitter.)

Table 1

Sl.No.	Label No	Transistor code number	Transistor package type	Package diagram with pin description	Current & Voltage		Power rating	Suitable Heatsink type
					Current rating	Voltage rating		

6 Get the work checked by the Instructor.

CHART 1

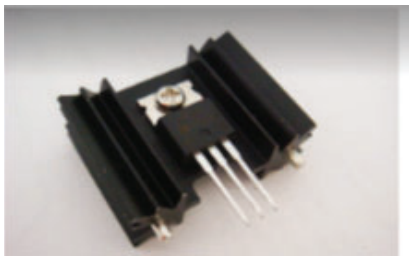


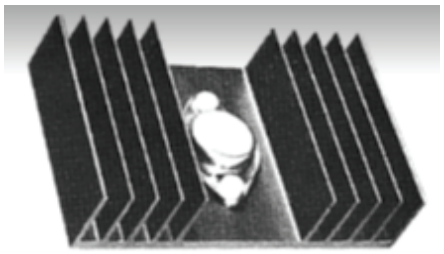
DIFFERENT TRANSISTOR PACKAGES

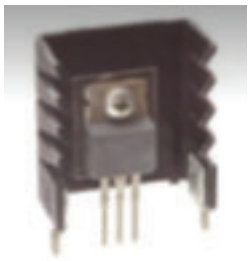
_ _ _ _ _ _ _

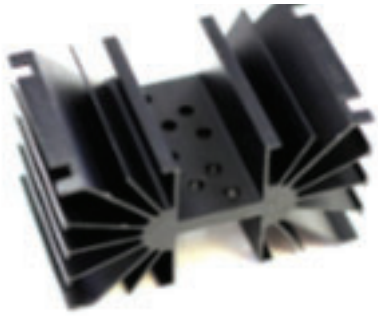
CHART 2

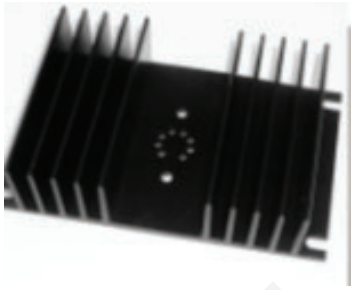
Chart showing different types of heatsinks used for transistor packages

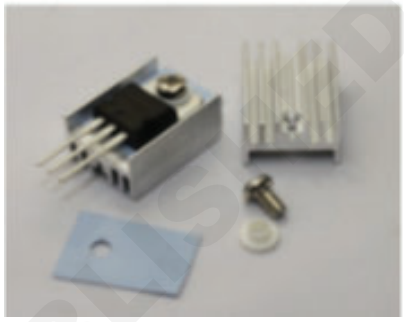


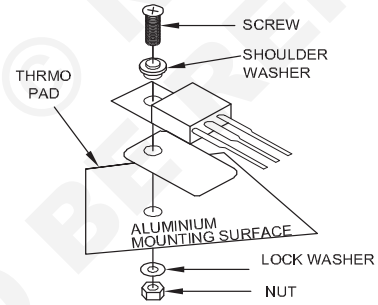


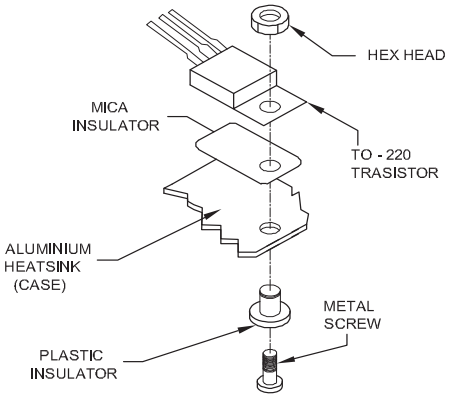












Test the condition of a given transistor using Ohm-meter

Objectives: At the end of this exercise you shall be able to
- **test the condition of transistor using ohm meter/multimeter.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Digital multimeter/Analog multimeter with crocodile clip probes - 1 Set

Materials/Components

- Transistor assorted types (T0-3, T0-5, T0-66, T0-18, T0-72, T0-92A, 92B, T0-202, T0-220, T0-247) - 10 Nos
- Transistor data book - as reqd

Note :

1 **The instructor has to arrange a minimum of one number in each type and label the transistors used for this exercise**

2 **Incase, the Analog type multimeter is not available, skip the Task 1 and proceed with Task 2 of this exercise using Digital multimeter.**

PROCEDURE

TASK 1 : **Testing transistor using analog multimeter**

1 Pick one of the labelled transistor from given assorted lot and enter its number in the Table -1.

2 Verify the label number, and other details recorded in the Table 1 of Exercise No.1.9.81. Refer the databook, identify the transistor type, pin diagram and record details in Table 1.

In some power transistor, the metal body itself is connected to the collector terminal. All transistors will not have shield pin.

Fig 1

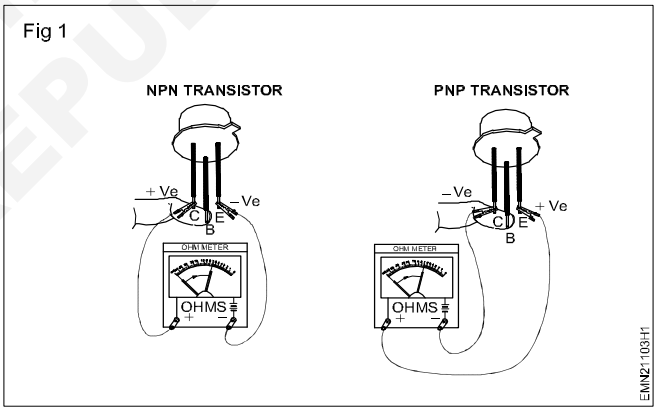


Table 1

Sl.No.	Label No	Code no.of transistor	Package type	Forward/Reverse	Measured resistance between			Remarks
					B-E	B-C	E-C	
1				Forward				
2				Reverse				
3				Forward				
4				Reverse				
5				Forward				
6				Reverse				
7								
8								
9								
10								

3 Connect crocodile clip probes to the analog multimeter & select ohms range for testing.

In using analog multimeter, select resistance range RX100 Ohm, low range may damage low power transistors.

4 Identify the transistor terminals as Base, Emitter and Collector.

Testing the transistor using the analog type Ohm meter is shown in Fig 1 for guidance.

5 Test resistance value between Base & Emitter terminals in forward and reverse direction by connecting probes as shown in Fig 1 and record readings in Table 1.

6 Repeat the above step between Base & collector terminals and record readings.

7 Repeat the step between Emitter & collector and record readings.

8 Repeat steps 4 to 7 for all the remaining labelled transistors.

9 Get the work checked by the Instructor.

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Task 2: **Testing the condition of transistor using Digital multimeter (DMM)**

1 Pick one of the labelled transistor from the given lot, enter its number in Table 2.

2 Verify the details like transistor type, pin configuration etc recorded in the Table 1 of Ex.No.1.9.81/Refer to the data book, identify all the details required.

3 Connect the crocodile clip probe to the DMM and set the selector, switch to the Diode testing position/range.

4 Connect the positive test probe of the DMM to the Base (B) terminal and the negative probe to the Emitter (E) of the transistor as shown in Fig 2.

For a good NPN transistor, the meter should show between 0.45V to 0.9V and for a PNP transistor, the meter should show "OL" (Over Limit) means infinity.

5 Observe the reading displayed on the DMM, record the value in Table 2.

6 Keep the positive probe at Base and connect the negative probe to the collector (C) terminal, observe the reading on the DMM, record it in Table 2.

For a good NPN transistor the meter should show between 0.45 to 0.9V and for a PNP type transistor, the meter should show "OL" (Over Limit) means infinity.

7 Repeat setps 4,5 and 6 with reversed polarities of DMM and record those readings in Table 2.

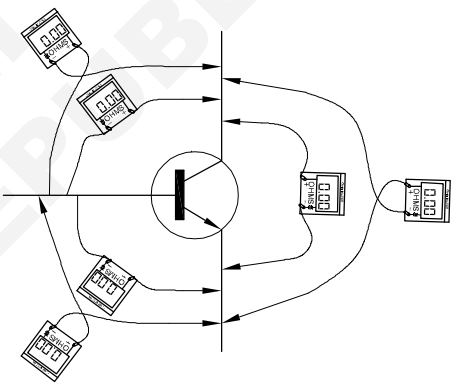
8 Connect the positive probe to the Emitter terminal and negative probe to the Collector (C) of transistor as shown in Fig 2; Record the observations in Table 2.

9 Repeat step 8 with reversed polarities of DMM.

10 Carry out steps 4 to 9 for all the remaining labelled transistors and record readings in Table 2.

11 Get the work checked by the Instructor.

Fig 2



TESTING TRANSISTOR USING DMM

EMN21103H2

Note:

Compare the resistance values recorded in forward and reverse directions between B-E, B-C and E-C terminals.

Conclude the condition of tested transistor is defective/unserviceable if the resistance value is same on both directions for B-E or B-C junctions, shorted / open junctions show same resistance value in both directions otherwise, the transistor is good/serviceable.

Table 2

Sl.No.	Lable No NPN/PNP	Transistor Code No and type	Meter reading between the terminals				Remarks
			Direction	Base to emitter	Base to collector	Emitter to collector	
1			Forward				
2			Reverse				
3			Forward				
4			Reverse				
5			Forward				
6			Reverse				
7			Forward				
8			Reverse				
9			Forward				
10			Reverse				

– – – – – – –

Construct and test a transistor based switching circuit to control a relay (use relays of different coil voltages and transistors of different β)

Objectives : At the end of this exercise you shall be able to
- **construct and test transistor based switching circuit to control a relay**
- **construct and test transistor based relay control circuit using different Beta.**

Requirements

Tools/Equipments/Instruments

- Digital multimeter with probes - 1 Set
- Trainees tool kit - 1 Set
- Regulated DC Power supply 0-30V/2A - 1 No
- Soldering Iron 25W/230V - 1 No

Materials/Components

- Transistor -BC 147, SL100 - 1 No each
- Semiconductor data manual - as reqd
- General purpose PCB - 1 No
- Resistor
- 10 kΩ , ¼ W/CR25 - 1 No
- Solder wire - 1 No
- Solder flux - as reqd
- SPDT switch - 1 No
- Connecting wires - as reqd
- Diode -1N4001 - 1 No
- 12V/30mA/10A/1CO - 1 No each
- Relay 5V/50 mA/10A 1CO - 1 No each
- Bulb (100W/230V A/C) with holder - 1 No
- Twisted pair flexible wire - 2 m

PROCEDURE

TASK 1 : **Construction and testing of transistor based switching circuit to control a relay**

1 Collect all the components required, test them and plan the layout of components on the general purpose PCB.

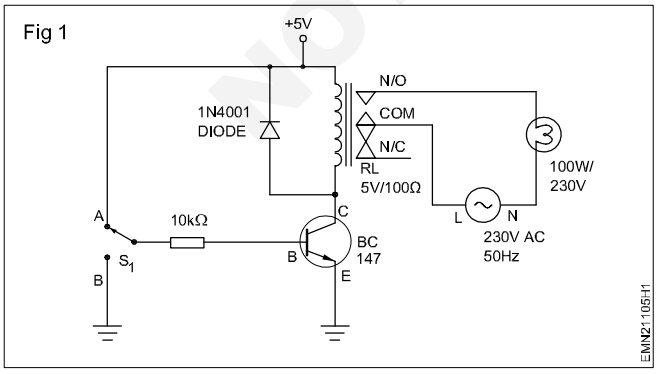
2 Identify the transistor number their leads and record the h_{FE} of given transistor and other parameters with reference to the data sheet in Table 1.

Table 1

Code No.of transistor	Type	I_C	V_{CEO}	V_{CBO}	V_{EBO}	h_{FE}

3 Assemble the circuit as shown in Fig 1.

Fig 1



4 Get the circuit checked by the Instructor.

5 Keep the switch S_1 in position B.

6 Switch ON the 5V, DC supply and AC mains to the circuit.

Take care of 230V AC manins supply link.

7 Measure voltage at Base and collector terminals with respect to Emitter terminal; Record the readings in

Table 2

Sl. No.	Switch position	Voltage a		Relay condition	Status of bulb
		Base (V_{BE})	Collector (V_{CE})		
1	A				
2	B				

Table 2.

8 Change the switch to point A, observe the condition of relay and record the observations in Table 2.

9 Switch OFF the DC and AC manis supply.

10 Get the work checked by the Instructor.

TASK 2 : **Construction and testing of switching circuit to control a relay of higher coil voltage with transistor of different $h_{FE.}$**

1 Modify the circuit of Task 1 with 12 V relay and transistor SL 100 for switching circuit.

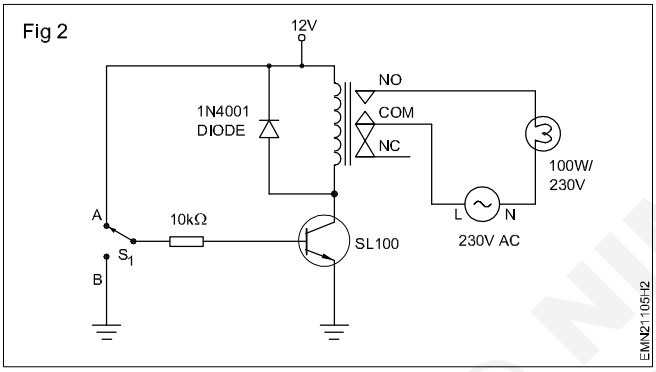
2 Identify the transistor leads, find Beta ($h_{FE.}$) and other parameters in the data sheet, record them in Table 3.

Table 3

Code No.of transistor	Type	I_C	V_{CEO}	V_{CBO}	V_{EBO}	h_{FE}

3 Assemble the circuit as shown in Fig 2 and get it checked by the Instructor.

Fig 2



4 Keep the switch S_1 in position 'B', switch ON the 12 VDC supply and AC mains supply to the circuit.

Safety: Take care of 230 VAC mains supply lines

5 Measure voltage at Base, collector terminals with respect to Emitter terminals and record the readings in Task 4.

6 Change the switch S_1 to point 'A', measure voltages status of relay, lamp and record the observations in Task 4.

Table 4

Sl. No.	Switch position	Voltage a		Relay condition	Status of bulb
		Base (V_{BE})	Collector (V_{CE})		
1		A			
2		B			

7 Switch OFF the DC and AC supply to the circuit.

8 Get the work checked by the Instructor.

– – – – – – –

Construct and test fixed bias, emitter bias, and voltage divider bias transistor amplifier

Objectives : At the end of this exercise you shall be able to
- **construct and test fixed bias arrangement to transistor amplifier circuit**
- **construct and test emitter bias arrangement to transistor amplifier circuit**
- **construct and test voltage divider bias arrangement to transistor amplifier circuit.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Digital multimeter with probes - 1 No
- CRO, 20 MHz, Dual Trace - 1 No
- Regulated DC Power Supply, 0- 30V/2A - 1 No
- AF signal generator - 1 No
- DC micro ammeter 0-500 µA - 1 No
- DC miliammeter 0-30 mA - 1 No

Materials/Components

- Breadboard - 1 No
- Transistor BC 107, SL100 - 1 No each
- Capacitor
  - 1 µF/25V - 1 No
  - 10kpf - 2 Nos
  - 25µF/25V - 2 Nos
- Resistor/¼ W/CR25
  - 220kΩ - 1 No
  - 5.1kΩ - 1 No
  - 1.5kΩ - 2 Nos
  - 5.6kΩ - 1 No
  - 12kΩ - 1 No
  - 120Ω -1 No
  - 470Ω - 1 No
  - 1kΩ - 3 Nos
- Hook up wires - as reqd

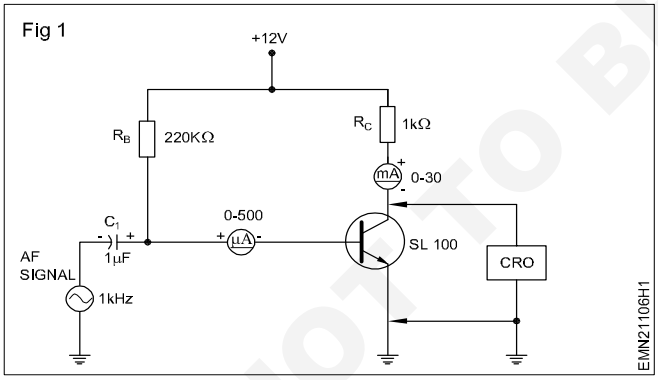
PROCEDURE

TASK 1 : **Construction and testing of fixed bias arrangement for transistor amplifier circuit using BJT**

1 Collect all the components required and check them for good working condition using multimeter.

2 Assemble the circuit as shown in Fig 1.

Fig 1



3 Calculate base current 'I_B' using the formula.

$$I_B = \frac{V_{CC} - V_{BE}}{R_B}$$

4 Now switch - ON the DC supply to the circuit and record readings in Table 1 without signal.

5 Prepare CRO for measurement and apply AF signal kHz/20mV sine wave from AF signal generator as input.

6 Observe and record the values of I_B, I_C and V_{CE} for the fixed bias amplifier circuit in Table-1.

7 Compare the calculated values with the observed values.

8 Get the values checked by the Instructor.

Note:

1 We assume that the Amplifier operation is in the active region, and hence V_{BE}= 0.7 V.

2 β is the amplification factor of the transistor by which the base current gets amplified.

3 β dc refers to current gain, when DC bias voltage is applied.

4 Output collector current 'I_C' = β dc x I_B.

5 When transistor is in active region, I_C gradually increases towards higher values. At the same time, V_{CE} decreases from peak towards lower values.

6 When saturation is attained by amplifier, I_C goes to peak but V_{CE} drops to less than 0.7V.

7 For calculating I_C and V_{CE} , following formulae should be used.

$V_{CE} = V_{CC} - I_C.R_C$ Say β = 100 & $I_C = \frac{V_{CC} - V_{CE}}{R_C}$

Table 1

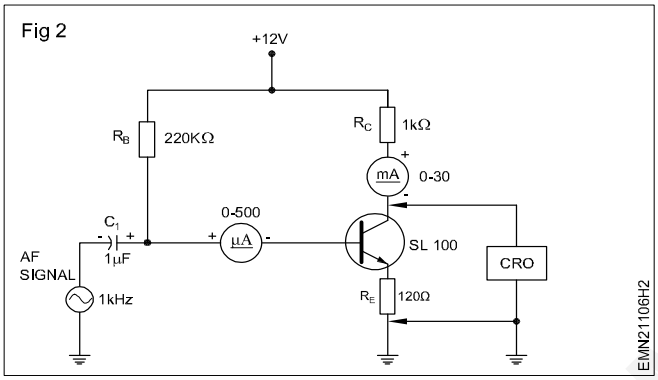
Input condition	Base Current I_B	Collector current I_C	V_{CE}	Voltage across load V_{RL}	Current gain $A_i = I_C / I_B$	$A_V = \frac{V_C}{V_{in}}$
Without signal						
With input Signal						

– – – – – – –

TASK 2 : **Construction and testing of emitter feedback bias amplifier circuit using BJT**

1 Modify the circuit as shown in Fig 2.

Fig 2



2 Calculate the values of I_B, I_C β_{dc} and V_{CE} by using the formulae given in the note and record the values in Table 2.

3 Switch ON the 12V DC supply and AF signal generator input to the circuit assembled and measure base current I_B, collector current I_C,V_{BE} (forwad bias of transistor) and the voltage drops across base resistor R_B the emitter resistor R_E, collector resistor R_C and V_{CE} record the observed values in Table 3.

Table 2

Calculated Observed values	Collector Current I_C	Base current I_B	V_{CE}	Current gain Ai (β_{dc})	Voltage gain A_V
Calculated values					
Observed values					

4 Prepeare CRO for measurements, connect and observe the peak-to-peak AC signal input from AF signal generators at CH1 and amplified AC signal output of the emitter feedback bias amplifier circuit at CH-2 and record the readings.

5 Increase the input A/C signal voltage applied to emitter feedback amplifier gradually and repeat the observations of the parameters given in step 3.

6 Note that the collector current 'I_C' remains stable to maintain constant 'Q' - operating point of the amplifier.

7 Get the values checked by the Instructor.

8 Calculate and record the I_C (sat) of the emitter-bias circuit

9 Get the values checked by the Instructor

Note:

1 Emitter bias is also refered to as emitter feedback back bias (i.e) a portion of the output is given back to the input as feedback.

2 In this circuit, the voltage across resistor 'R_E' is used to offset changes is β_{dc}.

3 This type of biasing compensates for the variation in β_{dc} and keeps the 'Q' point fairly stable.

4 If β_{dc} increases, the collector current increases, which in turn increases the voltage at the emitter.

5 This increased emitter voltage (plus the VBE drop of transistor) decreases the voltage across the base-resistor.

6 **There fore base current reduces, and hence collector current reduces. This prevents I_C from action varying continuously.**

$$I_B = \frac{V_{CC} - (V_{BE} + V_E)}{R_B}$$

7 **It partially offsets the original increase in I_C due to increased β_{dc}. Due to feedback only the output 'I_C' could change the input I_B this maintain stable Q print.**

8 **In emitter-bias, the current 'I_C' will be**

I_C - β_{IB} (i.e) $I_C = \beta$

$$\frac{V_{CC} - V_{BE}}{R_B + (\beta + 1)R_E} \text{ \& } I_B = \frac{V_{CC} - V_{BE} - I_E R_E}{R_B}$$

Assuming I_E I_C ; V_{CE} - (R_C + R_E) I_C

Table 3

AF Signal Generator - AC input = Sinewave 1kHz/20mV

Value/ signal condition	Base Current I_B	Collector current I_C	Current gain $\beta = \frac{I_C}{I_B}$	V_{BE}	V_{CE}	DRB	Drop across R_E	Drop across R_C
Calculated Value								
Measured Values								
Without Signal								
With signal								

– – – – – – –

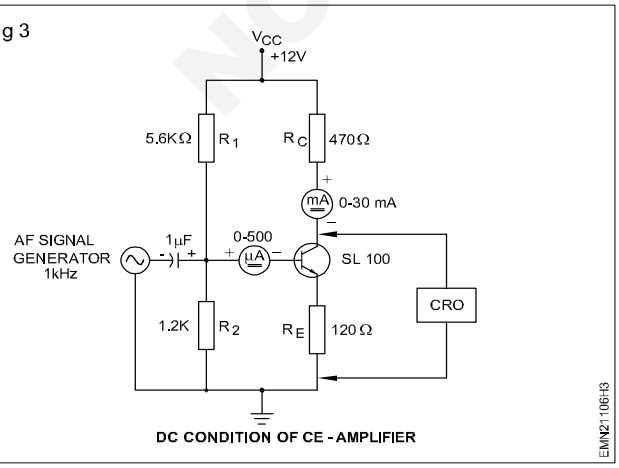
TASK 3 : **Construction and testing of voltage divider biased transistor CE amplifier**

1 Check all the components and assemble the circuit as shown in Fig 3.

2 Get the assembled circuit checked by the Instructor.

3 Measure and record I_B and I_C in Table 4, calculate current gain β_{dc} and record it.

Fig 3



DC CONDITION OF CE - AMPLIFIER

Table 4

Collector current I_C	Base current I_B	Current gain A_i β_{dc}

4 Apply AC input signal of 1 kHz, 20 mV from AF signal generator to the voltage divider biased CE amplifier.

5 Prepare the CRO for measurements connect CRO to observe/measure AC signal input to amplifier from AF signal generator to CH-1 and amplified AC signal output of voltage divider bias to CH-2.

6 Measure and record the observed values as required in Table 5. Calculate & record Ai and Av of the amplifier observe and record the Input/Output waveforms available on the CRO.

Note:

- **In this circuit note that the base of the transistor is biased by voltage divider network made up of R_1 & R_2.**
- **Q point of this circuit lies half way along the transistor's load line.**
- **$V_{CE} = V_{CC} - I_C (R_C+R_E)$ and $I_C = \beta x I_B$**
- **RB << $(\beta+1) R_E$ and $R_B = R_1 // R_2$.**

Table 5

Signal Condition	Base current I_B	Collector current I_C	β_{dc}	Voltage drop Across				V_{BE}	V_{CE}	Voltage gain $AV = \frac{V_{Load}}{V_{in}}$
				R_1	R_2	R_C	R_E			
Without signal										
With signal										

7 Get the work checked by the Instructor.

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Construct and test a CE amplifier with and without emitter bypass capacitors

Objectives: At the end of this exercise you shall be able to
- **construction and find the effect of emitter bypass capacitor on amplifier gain and input impedance**
- **plot the frequency response of CE amplifier with by pass capacitor.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- CRO, 20 MHz Dual trace - 1 No
- AF Signal generator - 1 No
- Regulated DC power supply, 30V/2A - 1 No
- Digital multimeter with probes - 1 No

Materials/Components

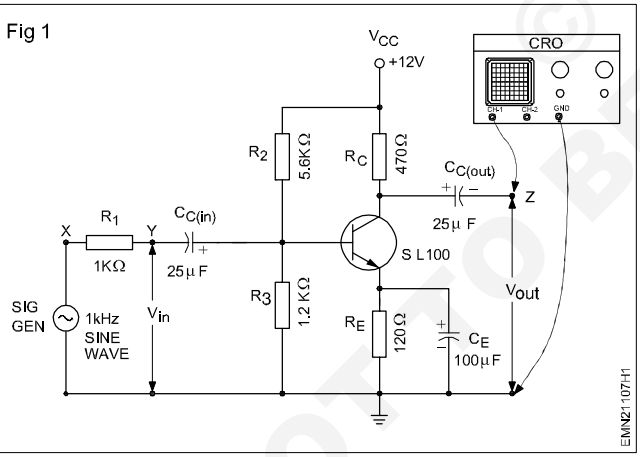
- Hook-up wires - as reqd
- Breadboard - as reqd
- Resistor/¼W/CR25
  1kΩ,1.2 kΩ, 5.6 kΩ
  120Ω, 470Ω - 1 No each
- Capacitors
  25 μF/25V - 2 Nos
  4.7 μF/25V - 1 No
  100 μF/25V - 1 No
  470 μF/25V - 1 No

PROCEDURE

TASK 1 : **Construction and testing of the effect of bypass capacitor in CE amplifier**

1 Collect all the components, test them assemble the circuit as shown in Fig 1 on breadboard. Capacitor C_E is the emitter by pass capacitor.

Fig 1



2 Get the circuit connections checked by the Instructor.

3 Prepare the CRO for measurements and switch 'ON' 12V DC supply to the circuit, adjust the output of the signal generator at 1kHz such that V_{out} is large enough and undistorted.

4 Record the peak to peak values of input V_{in} and output V_{out} in Table 1; Calculate and record the voltage gain A_v of the amplifier.

5 Find the input impedance Z_{in} and output impedance Z_{out} of the amplifier using the same procedure as followed for Task 2 of Ex. 1.9.84; Record values in Table 1.

6 Measure and record the AC and DC voltages at various points of the amplifier in Fig 2 and Fig 3.

7 Switch off DC supply to the circuit. Disconnect 100 μF capacitor connected across the 120Ω emitter resistor.

Now the input V_{in} may show higher value due to increased Z_{in} without the bypass capacitor. Do not alter the output level / frequency of the signal generator.

8 Switch 'ON' DC supply to the circuit, repeat steps 4 and record readings in Table 1.

9 Measure and record the AC and DC levels at various points of the amplifier without the bypass capacitor in Fig 3.

10 Switch-OFF DC supply to the circuit and from the recorded readings, complete the sentences given in record sheet.

11 Get the work checked by the Instructor.

Table - 1

Condition	$V_{in(peak-to-peak)}$	$V_{out(peak-to-peak)}$	A_v	Z_{in}	Z_{out}
With bypass capacitor C_E connected across R_E					
Without bypass capacitor C_E					

Fig 2

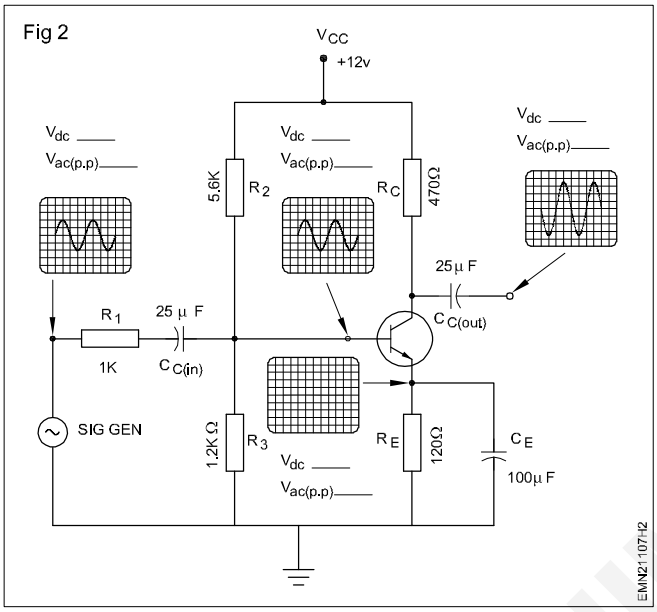
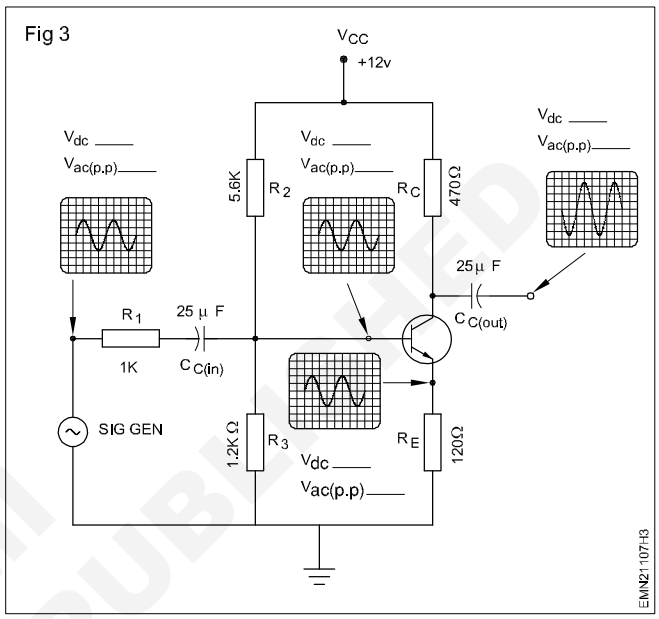


Fig 3



12 Complete the sentences given below with the readings recorded in Table 1.

When the emitter bypass capacitor was removed

a)the voltage gain of the amplifier decreased by _____%.

b)the input impedance of the amplifier _____ by _____%.

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TASK 2 : **Plotting the frequency response of CE amplifier**

1 Modify the circuit to confirm to the schematic diagram as given in Fig 4.

2 Set the output of the signal generator to sine wave, 1 KHz. Adjust the input voltage to the transistor V_{in} = 200mV.

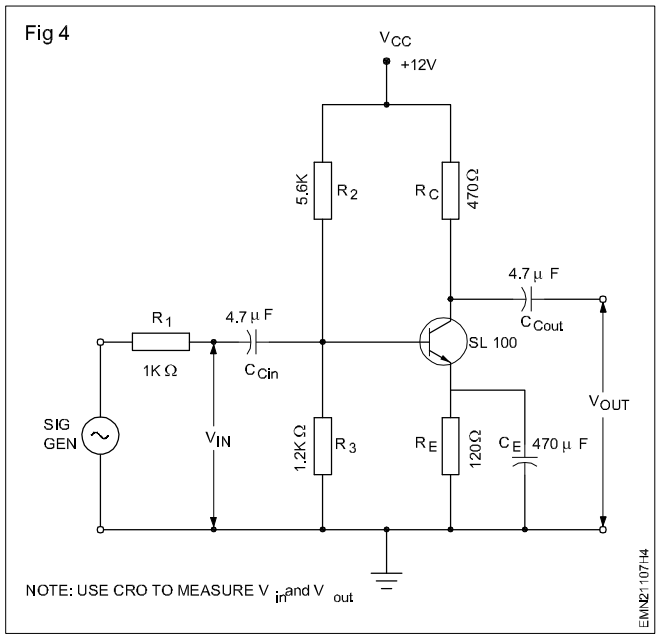
3 Record the set input level V_{in} and corresponding value of output V_{out} of the amplifier in the appropriate row of the Table 2.

4 Vary the output frequency of the signal generator above and below the set frequency of 1 kHz in steps as given in Table 2. At each step record the output of amplifier, V_{out}.

5 Calculate and record the voltage gain A_V of the amplifier at different frequencies.

6 Change the value of $C_{C(in)}$ to 4.7µF and repeat steps 2 to 5.

Fig 4



7 Plot the graph of frequency (f_{in}) versus voltage gain A_V for the readings taken with the capacitor values of 0.047 and 4.7 µF in Table 2. Find and mark the low frequency cut off/half power point on the graph.

The cut off/half power point is 0.707 A_V at the mid-band gain.

8 Switch OFF DC supply to the circuit; change the value of the input coupling capacitor $C_{C(in)}$ to 100 µF.

$C_{C(in)}$ is made 100µF to eliminate the effect of the coupling capacitor while finding the effect of C_E on the frequency response.

9 Change value of the bypass capacitor C_E to 0.47µF and repeat steps 2 to 5, record readings in Table 3.

10 Change the value of the bypass capacitor C_E back to 470µF and repeat steps 2 to 5.

11 Find the dominant lower cut off frequency of the amplifier with $C_{C(in)}$ = 4.7µF and C_E = 470µF.

The effect of $C_{C(out)}$ on the amplifier frequency response is not given in the procedure as the effect of $C_{C(out)}$ is almost same as that of $C_{C(in)}$.

Table - 2

Frequency response for different C_{cin}

Set value of V_{in} = _____ at f_{in} = 1 kHz C_E = 470 µF C_{Cout} = 4.7 µF				
frequency f_{in} H_Z	C_{Cin} = 0.047 µF		C_{Cin} = 4.7 µF	
	V_{out}	A_V	V_{out}	A_V
10				
20				
30				
100				
200				
400				
800				
1000				
1200				
1400				
1600				
2000				
3000				

Table - 3

Frequency response for different C_E

Set value of V_{in} = _____ at f_{in} = 1 kHz C_{Cin} = 100 µF C_{Cout} = 4.7 µF				
frequency f_{in} H_Z	C_E = 0.47 µF		C_E = 470 µF	
	V_{out}	A_V	V_{out}	A_V
10				
20				
30				
100				
200				
400				
800				
1000				
1200				
1400				
1600				
2000				
3000				

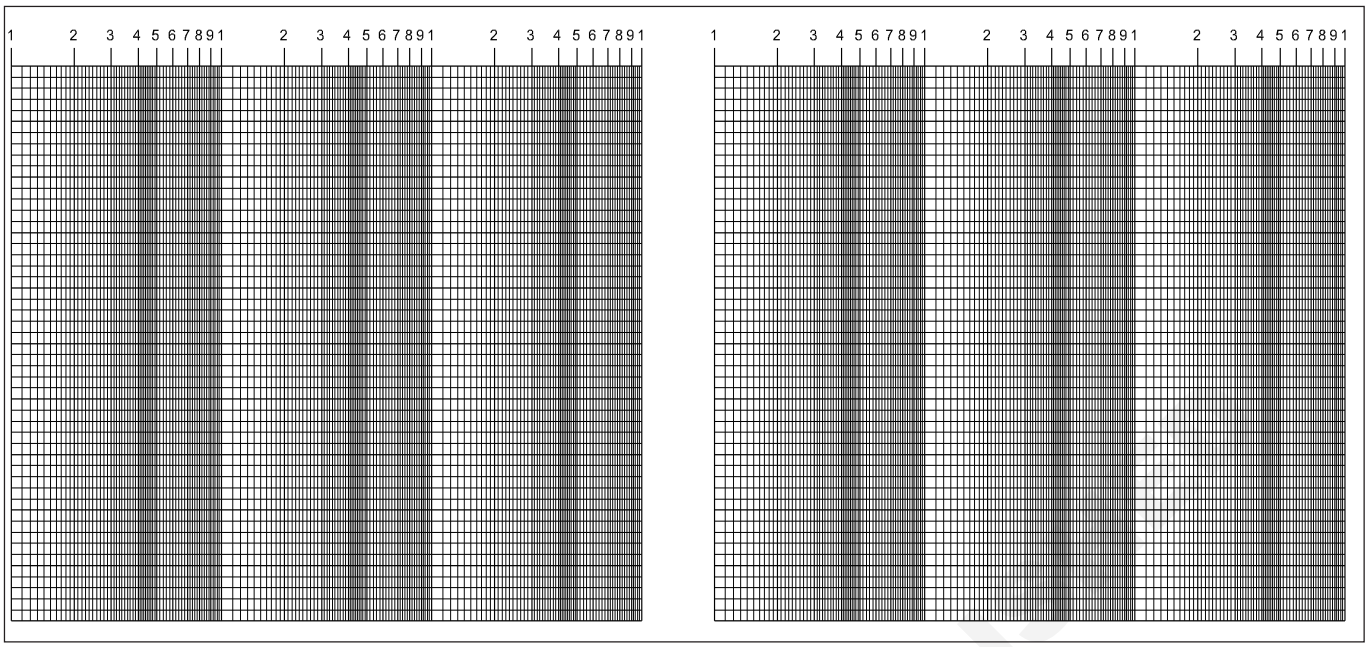
12 Get the work checked by the Instructor.

Graph 1

Frequency response with C_{cin} = 0.047capacitor

Graph 2

Frequency response with C_{cin} = 4.7µ F



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Construct and test a Common Collector/Emitter Follower amplifier

Objectives: At the end of this exercise you shall be able to

- **construct a common collector/Emitter Follower amplifier and measure current gain, voltage gain of Emitter Follower amplifier**
- **compare input - output phase relationship of Emitter Follower amplifier**
- **measure input impedance Z_{in} ,output impedance Z_{out} and power gain of Emitter Follower amplifier.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- DC microammeter 0-500 µA - 1 No
- DC milliammeter 0-1 mA - 1 No
- Regulated DC power supply 0-30V/2A - 1 No
- A.F Signal generator - 1 No
- CRO, 20MHz-Dual trace - 1 No
- Multimeter / DMM with probes - 1 No

Materials/Components

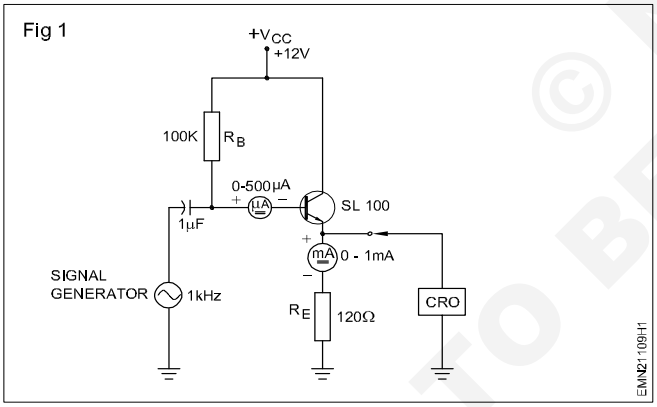
- Breadboard
- Transistor, SL100 or equivalent - 1 No
- Resistors/¼ W/CR25
  - 120Ω - 1 No
  - 100kΩ - 1 No
  - 1kΩ - 1 No
- Preset, 470Ω - 1 No
- Capacitors, 0.47 µF/25V - 2 Nos

PROCEDURE

TASK 1: **Construction and measurement of current gain and voltage gain of emitter follower**

1 Collect all the components, test and assemble the emitter follower circuit as shown in Fig 1, on breadboard.

Fig 1



2 Get the assembled circuit checked by the Instructor.

3 Measure and record the values of I_B and I_E, in Table 1. Assuming $I_C \approx I_E$, calculate and record the β of the transistor using the formula in Table 1.

$$\beta \approx \frac{I_E}{I_B} \approx \frac{I_C}{I_B}$$

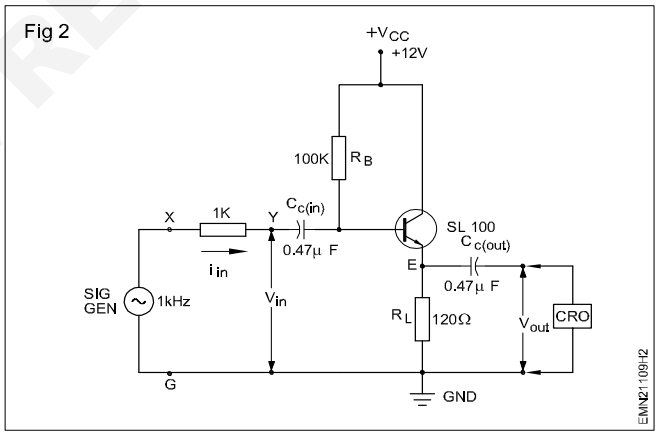
4 Calculate and record the theoretical values of voltage gain A_v, input impedance Z_{in}, output impedance Z_{out} and current gain A_i of the amplifier in Table 2.

[To calculate the value of r'_e use the formula,

$$r_e' = \frac{25mV}{I_E} \ ]$$

5 Modify the assembled circuit as shown in Fig 2. Get the correctness of the assembled circuit checked by the Instructor.

Fig 2



6 Connect the signal generator to the input of the emitter follower amplifier. Set the signal generator output to sine wave, 1 kHz.

7 Adjust the signal generator output level such that the AC input $V_{in(p-p)}$ = 500 mV. Measure and record the corresponding output $V_{out(p-p)}$ of amplifier in record sheet Table 3.

8 From the measured values of V_{in} and V_{out}, calculate and record the voltage gain A_V of the circuit.

9 Compare the values of calculated voltage gain A_v of the amplifier in step 4 and that found in step 8. Record the difference in Table 3.

Table - 1

I_B	I_E	Current gain $A_i = I_E/I_B \approx \beta$

Table - 2

Values calculated using circuit component values

A_v	Z_{in}	Z_{out}	A_i	r'_e

Table 3

(a) Measured value of A_v

Frequency set to 1 KHz

$V_{in(p-p)}$	$V_{out(p-p)}$	A_V
500 mv		

10 Get the work checked by the Instructor.

(b) Difference between calculated (at step-4) and measured value of A_v (at step-8):-

– – – – – – –

TASK 2: **Measure input and output impedance of emitter follower**

1 Set the output of the signal generator to sine wave, 1 kHz, 500 m $V_{(p-p)}$ in Fig. 2 and record V_{in} and V_{out} levels in Table 4.

2 Measure voltages V_{XG} and V_{YG} on either side of the 1KΩ resistor. Record readings in the record sheet at Table 4.

3 From the recorded values of V_{XG} and V_{YG}, calculate the input signal current I_{in} to the amplifier using Ohms law as given below,

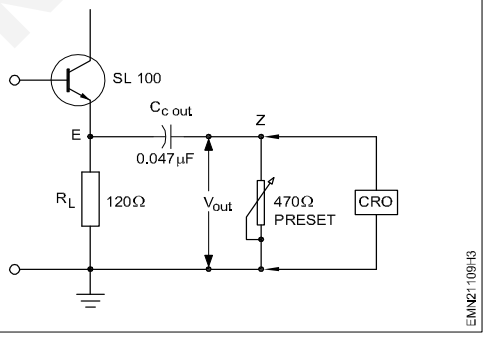
$$I_{in} = \frac{V_{XG} - V_{YG}}{1k\Omega}$$

4 From the values V_{in} and I_{in}, calculate and record the input impedance Z_{in} using the formula

$$Z_{in} = \frac{V_{in}}{I_{in}}$$

5 Connect a 470Ω preset across the output of the amplifier as shown in Fig 3. Keep the preset in the maximum resistance position before switching ON DC supply to the circuit.

Fig 3



Precaution: Since there is no limiting resistor in the collector, if the preset is set at zero or low resistance heavy current may damage the transistor.

6 Adjust the preset until V_{out} is half the value measured at Step 1 and record the input & output waveforms in graph sheet

Do not adjust the output level of signal generator set at step 1 of this task.

7 Switch OFF DC supply to the circuit. Take out the preset from the circuit without disturbing its adjusted position.

8 Measure the adjusted resistance value of the preset and record it as the amplifier's output impedance Z_{out} in Table 4.

9 From the values recorded, calculate and record, current gain A_i, and power gain A_P of the amplifier, using the formulae

$$A_i = A_V \frac{Z_{in}}{R_E}$$

$$P_{in} = \frac{V_{in}^2}{Z_{in}}$$

$$P_{out} = \frac{V_{out}^2}{R_{out}}.$$

$$\text{Power gain of amplifier } A_P = \frac{P_{out}}{P_{in}}$$

$$\text{Power gain } A_P \text{ in decibel} = 10 \log \frac{P_{out}}{P_{in}}$$

Table - 4

Frequency set to 1kHz

$V_{in(p-p)}$	$V_{out(p-p)}$	V_{XG}	V_{YG}	I_{in}	Input impedance Z_{in} of amplifier	Output impedance Z_{out} of amplifier
500 mV						

2 Current gain A_i using the formula $A_i = A_v(Z_{in}/R_E)$: _____

3 Power gain A_e of emitter follower/CC amplifier : _____

4 Power gain A_p of emitter follower/CC amplifier in dB : _____

10 Get the work checked by the Instructor.

_ _ _ _ _ _ _

TASK 3: **Comparison of phase relationship between the input and output of emitter follower amplifier.**

1 Find the phase relationship between the input and output of the emitter follower in the same way as done for common emitter amplifier in Exercise 2.1.107 or Ex. No. 1.9.85

Graph of Input and output phase relationship.

2 Get the work done by the Instructor.

Amplifiers input wave-form	Amplifiers output wave-form	Remarks on input-output phase relationship

_ _ _ _ _ _ _

Construct and test a two stage RC-coupled Amplifier

Objectives: At the end of this exercise you shall be able to
- **construct and test two stage amplifier using RC coupling**
- **observe the frequency response of RC coupled amplifier.**

Requirements

Tools/Equipments/Instruments

• Trainees tool kit	- 1 Set
• CRO, 20 MHz Dual trace	- 1 No
• AF Signal generator	- 1 No
• Regulated DC power supply 0-30V/2A	- 1 No
• Semiconductor data manual	- as reqd

Materials/Components

• Breadboard	- 1 No
• Transistor SL 100	- 2 Nos
• Resistor ¼ W/CR25	
5.6 kΩ	- 2 Nos
1kΩ	- 2 Nos
3.3 kΩ, 22 kΩ	- 1 No each
15 kΩ, 2.5 kΩ	- 1 No each
• Capacitor	
1 μF/25V	- 3 Nos
100 μF/25V	- 2 Nos
• Hook up wire	- as reqd
• Patch cords	- as reqd

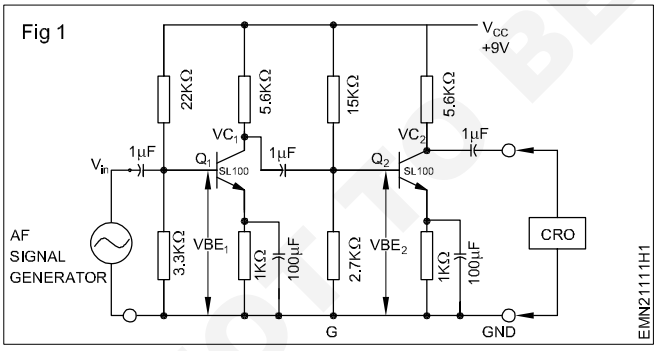
PROCEDURE

TASK 1: **Construction and testing of 2 stage RC coupled amplifier**

1 Collect all the components, identify the base, emitter and collector pins of given transistors and test for their good working condition.

2 Assemble the RC coupled amplifier on breadboard as shown in Fig 1.

Fig 1



3 Get the assembled circuit checked by the Instructor.

4 Switch ON 9 VDC supply to the assembled circuit, measure the DC levels at different test points V_{BE}, V_{CE}, V_{BE2}, V_{CE2} (of both transistors) shown in Fig 1; record the measured voltages in Table 1.

5 Connect the A.F. signal generator at the input of the assembled amplifier; set the output of the signal generator at 20 mV, 1 kHz, sinewave.

6 Prepare the CRO for measurements, measure and record the output of each stage in Table 2.

7 From the recorded readings find and record the gain of each stage and the overall voltage gain of the cascaded amplifier.

8 Vary the output frequency of the signal generator between 20 Hz to 20 kHz in steps as given in Table 3 and record overall gain of the amplifier at different frequency settings in Table 3.

9 Plot the graph of frequency versus voltage gain and mark the low frequency cut-off (f_{LC}) and high frequency cut-off (f_{HC}) points on the graph.

10 Get the working of the circuit and the recorded readings checked by the Instructor.

Table 1

Vin = 9V DC

Transistor Q_1 (DC levels)		Transistor Q_2 (DC levels)		Transistor Condition
V_{BE1}	V_{CE1}	V_{BE2}	V_{CE2}	ON/OFF

Table 2

V_{in} = 20 mV, F = 1kHz, sinewave

Amplifier-1 stage output Voltage	Amplifier-2 stage output Voltage	Amplifier output waveform on CRO
V_{C1} - Gnd	V_{C2} - Gnd	

Table 3

V_{in} = 20mV Observation of frequency response of RC coupled amplifier

Sl No.	Input frequency	V_o	Voltage Gain $= \frac{V_o}{V_{in}} = A_V$
1	10Hz		
2	50Hz		
3	100Hz		
4	200kHz		
5	500kHz		
6	1kHz		
7	2kHz		
8	5kHz		
9	10kHz		
10	15kHz		
11	20MHz		

Demonstrate Colpitt's oscillator, Hartley oscillator circuits and compare the output frequency of the oscillator by CRO

Objectives : At the end of this exercise you shall be able to
- **construct and test a Colpitts oscillator**
- **construct and test a Hartley oscillator**
- **compare the measured output frequency with calculated frequency.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- CRO 20 MHz -Dual trace - 1 No
- Regulated DC power supply 0-30V/2A - 1 No
- Digital multimeter with probes - 1 No
- Soldering iron 25W/230V - 1 No
- Soldering iron stand - 1 No

Materials/Components

- Transistor BF 195 - 1 No
- MW oscillator coil - 1 No
- Breadboard - 1 No
- Resistor ¼ W/CR25
  18kΩ, 390Ω, 82kΩ, 3K9 - 2 Nos each
- Capacitor
  0.1 μF - 1 No
  0.01 μF - 2 Nos
- 2J gang capacitor - 1 No
- Hook up wires - as reqd
- Rosin cored solder - as reqd

PROCEDURE

TASK 1 : **Construction and testing of a Colpitts oscillator**

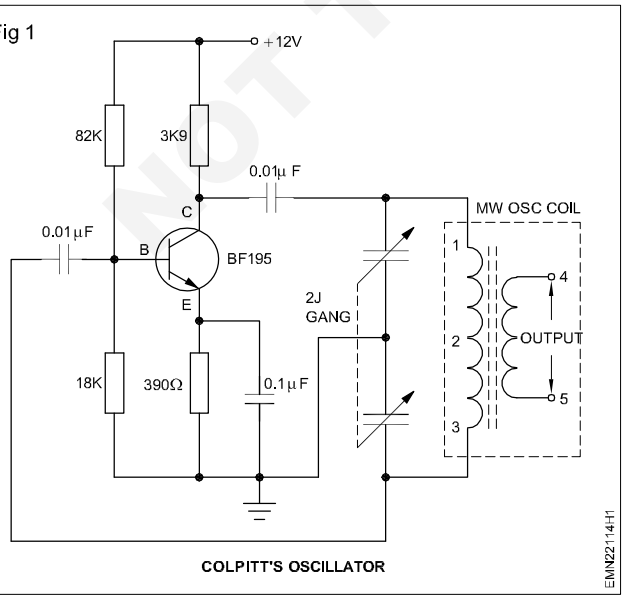
1 Collect all the required components for assembling/ collect trainer kit & test the component for working condition.

2 Plan the layout and assemble the circuit on the bread-board as shown in Fig 1.

Note: If the trainer kit on oscillator is not available, the instructor can use assembled oscillator for demonstration.

3 Get the assembled circuit checked by the Instructor.

Fig 1



COLPITT'S OSCILLATOR

4 Prepare the CRO for measuring the output of oscillator.

5 Switch ON the 12VDC supply to the circuit connect the CRO at the output terminal of the oscillator circuit and measure the waveform.

6 Adjust the gang capacitor to get the desired frequencyo on CRO.

Note: The operating range of Colpitts oscilator using medium wave oscillator coil is from 1000 kHz to 2055 kHz Frequency of Colpitts oscillator can be determined therotically by using Formula:

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

Where 'C' is the capacitance of 2J gang and L is the inductance of the oscillator coil in the tank circuit.

7 Repeat the above step, by changing the position of the gang capacitor and record the readings in Table 1.

8 Draw waveform observed at 3 positions of gang capacitor and note down the frequencies.

9 Compare the calculated value with observed value of frequencies.

Table 1

Colpitts oscillator Observation

	Conventional circuit		
Position of gang capacitor	Amplitude in volts	Frequency in Hz	
		Calculated	Observed
Gang capacitor at one extreme end			
Gang capacitor at other extreme end			
Gang capacitor at approximately mid-position			

10 Get the work checked by the Instructor.

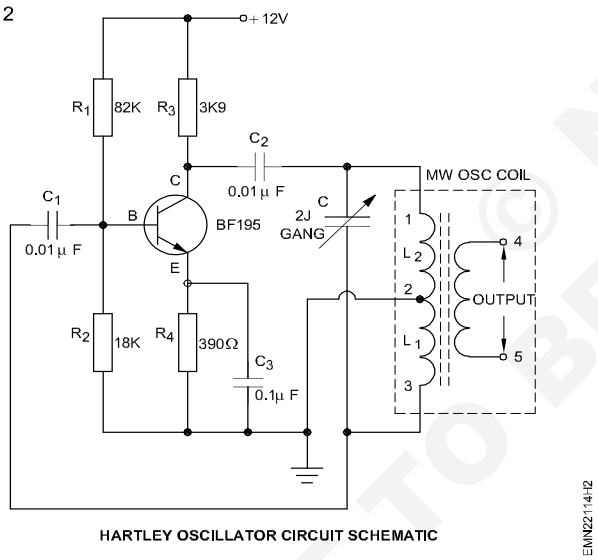
– – – – – – –

TASK 2 : **Construction and testing of a Hartley oscillator**

1 Use trainer kit (or) assemble the components as shown in Fig 2 on breadboard.

2 Connect the DC supply and set for 12V

Fig 2



HARTLEY OSCILLATOR CIRCUIT SCHEMATIC

3 Switch on the supply

4 Switch on the CRO and adjust to get horizontal trace.

5 Connect the CRO in the O/P terminal of the circuit.

6 Observe the output of the circuit in the CRO, adjust the time/div, V/div knobs to get stable wave form.

7 Measure the time period & calculate the frequency of oscillator using the formula $F = \frac{1}{T}$ practically.

Note: Frequency of Hartley oscillator can be determined theoritically by using formula

$$F = \frac{1}{2\pi\sqrt{LC}}$$, **Where 'C' is the capacitance of the capacitor C1 in tank circuit and L = L1 + L2 the effective series inductances of tank circuit.**

8 Repeat the above steps by changing the position of the gang capacitor and record the readings in Table 2.

9 Draw waveform observed at different settings of gauged capacitor and note down the frequencies as given in Table 2.

Table 2

	Conventional circuit	
Position of gang capacitor	Amplitude in volts	Frequency in Hz
Gang capacitor at one extreme end		
Gang capacitor at other extreme end		
Gang capacitor at approximately mid-position		

10 Get the work checked by the Instructor.

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Construct and test RC phase-shift oscillator circuits

Objectives: At the end of this exercise you shall be able to

- **construct and test RC phase shift oscillator circuit using transistor and vary the output frequency of the oscillator.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Regulated DC power supply, 0-30V/2A - 1 No
- CRO, 20 MHz - Dual channel - 1 No
- Digital frequency counter - 1 No
- Soldering Iron 25W/230V with stand - 1 No
- Digital multimeter with probes - 1 No

Materials/Components

- Breadboard - 1 No
- Resistor ¼ W/CR25
  10kΩ, 2k2, 680Ω, 47kΩ - 1 No each
- Resistor 4.7kΩ/¼ W/CR25 - 2 Nos
- Capacitor 25VDC working
  0.01 µF - 3 Nos
  1µF, 22µF - 1 No each
- Transistor BC 107 - 1 No
- POT 4.7kΩ - 1 No
- Hookup wire - as reqd

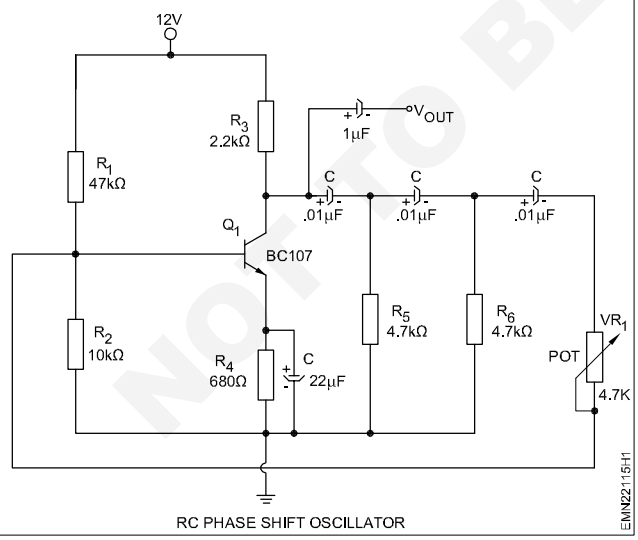
PROCEDURE

TASK 1 : **Construction and testing of RC phase shift oscillator circuit using transistor**

1 Collect all the components from instructor and test them.

2 Assemble the RC phase-shift oscillator as shown in Fig 1 on the breadboard.

Fig 1



RC PHASE SHIFT OSCILLATOR

3 Get the assembled circuit checked by the Instructor.

4 Prepre the CRO for measurements and connect it across the output terminals.

5 Switch ON the 12VDC supply to the RC phase shift oscillator circuit and measure the output waveform using CRO.

If there is no output, adjust the value of POT to get the output; even after adjusting the POT no output is available consult the instructor.

6 Keep the preset VR_1 at maximum resistance position adjust the preset pot and observe the change in frequency/waveform on CRO.

7 Measure and record the oscillator output frequency in Table1.

8 Measure the output using frequency counter also and record the readings in Table 1.

9 Adjust POT suitably and find the minimum and maximum frequency of oscillations of the circuit. Record the observations in Table.

10 Compare the calculated and measured frequency of the oscillator.

11 Get the work checked by the Instructor.

Table 1

Output frequency at different positions of R_3 preset Calculated frequency _____ Hz

Sl. No.	Position of preset VR_1	Frequency measured using CRO	Frequency measured using freq counter	$\left.\begin{matrix}Calculated\\Frequency\end{matrix}\right\} F = \frac{1}{2\pi RC\sqrt{6}}$
1	Minimum			
2	Middle			
3	Maximum			

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Construct and test a crystal oscillator circuit

Objectives : At the end of this exercise you shall be able to
- **construct and test a Crystal oscillator using transistor.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Oscilloscope, 20 MHz Dual trace - 1 No
- Regulated DC power supply 0-30V/2A - 1 No
- Digital multimeter with probes - 1 No

Materials/Components

- Breadboard - 1 No
- Hook up wires - as reqd
- 8.44 MHz Crystal with holder - 1 No
- Capacitors - 25V DC wkg
  - 680pF - 1 No
  - 330pF - 1 No
- Capacitor 0.1μF - 2 Nos
- Transistor BF195 - 1 No
- Resistors ¼ W/CR25 82kΩ,18kΩ, 3.9kΩ, 390Ω - 1 No each

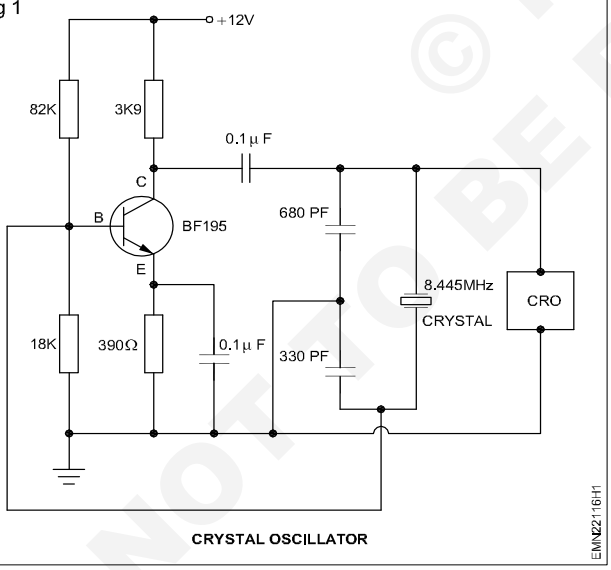
PROCEDURE

TASK 1 : **Construction and testing of crystal controlled Pierce oscillator**

1 Record the frequency marked on the crystal.

2 Collect all the required components, test and assemble pierce crystal controlled oscillator circuit on breadboard as shown in Fig 1.

Fig 1



CRYSTAL OSCILLATOR

3 Connect 12V DC supply to the oscillator circuit.

4 Prepare the CRO for measurement and connect it cross the output of the oscillator.

5 Adjust the CRO time-base to get a clear sinusoidal waveform on the screen. Measure and record the amplitude and frequency of oscillations.

If oscillations are not seen, the crystal may be bad. Consult your instructor.

6 Decrease the supply voltage to find and record the minimum V_{CC} voltage at which the crystal oscillator oscillates satisfactorily.

7 Get the working of the circuit and the recorded readings checked by the instructor.

– – – – – – –

TASK 2 : **Construct and test a Pierce Crystal oscillator**

1 Frequency marked on crystal :_____

2 (a) Amplitude of oscillations :_____

(b) Frequency of oscillations :_____

3 (a) Minimum V_{CC} at which crystal oscillator work satisfactorily :_____

(b) Output frequency :_____

(c) Output amplitude :_____

– – – – – – –

Demonstrate Astable, Monostable and Bistable multivibrator using circuits transistors

Objectives : At the end of this exercise you shall be able to
- **construct and test an astable multivibrator using transistors**
- **construct and test a monostable multivibrator using transistors**
- **construct and test a bistable multivibrator using transistors.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Oscilloscope 20 MHz Dual trace - 1 No
- Digital multimeter with probes - 1 No
- Regulated DC power supply 0-30V/2A - 1 No

Materials/Components

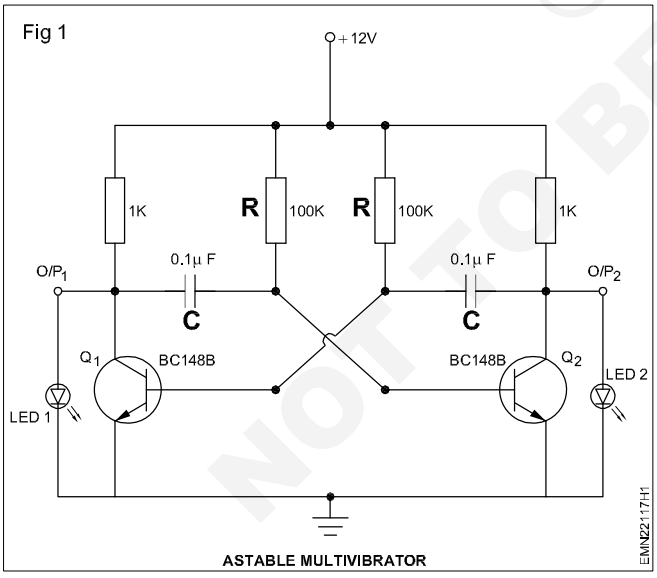
- Breadboard - 1 No
- Transistor BC 148 B - 2 Nos
- LED 5mm, Red and Green - 1 No each
- Resistors/¼ W/CR25
  - 100 kΩ - 2 Nos
  - 1kΩ - 4 Nos
  - 10 kΩ - 2 Nos
  - 33 kΩ - 1 Nos
  - 150 kΩ - 1 No
- Capacitors 25 V DC wkg
  - 0.1 µF - 2 Nos
- Diode- 1N4001 - 2 Nos
- Push button Switch (push-to-ON) - 2 Nos
- Hook up wires - as reqd

PROCEDURE

TASK 1 : **Construction and testing of astable multivibrator using transistors**

1 Collect the required components, test and assemble the astable multivibrator on breadboard as shown in Fig 1.

Fig 1



ASTABLE MULTIVIBRATOR

2 Connect 12 V DC supply and switch ON the circuit.

1 (a) Calculated ON-time (t_{ON}) : (0.69 RC): _____

(b) Calculated OFF-time (t_{OFF}) : (0.69 RC) : _____

2 (a) Measured ON-time (t_{ON}) : _____

(b) Measured OFF-time (t_{OFF}) : _____

3 Prepare the CRO for measurements and connect it across any one of the collector of the transistor and ground.

4 Observe the waveform, measure the frequency of oscillation and record it in Table 1.

5 Calculate the ON time OFF time, PRF and record the values.

6 Observe the of LEDs and record in Table 1.

Table 1

Value of		Wave form at		Calculated frequency (PRF)	Measured frequency (PRF)	Status of LEDs	Remarks
R	C	Base	Collector				

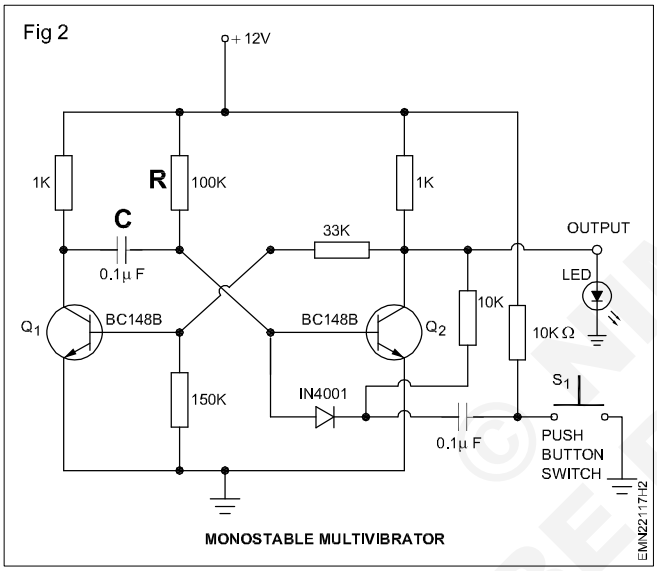
7 Get the work checked by the Instructor.

– – – – – – –

TASK 2 : **Construction and testing of monostable / One shot multivibrator using transistors**

1 Assemble the monostable multivibrator as shown in Fig 2.

Fig 2



MONOSTABLE MULTIVIBRATOR

2 Calculate and record the ON time of the monostable multivibrator.

3 Get the circuit and calculated values checked by the Instructor.

4 Switch ON 12 VDC supply to the circuit, connect the CRO probe at the collector of Q_1 with reference to ground.

1 Calculated ON time : _____

2 Measured ON time of the output pulse (t_{ON}) with C = 100µF : _____

3 Calculated ON time : _____

Measured ON time : _____

5 Press switch S_1 and observe the LED and one single pulse output on CRO. Repeat this step for adjusting the CRO controls such that the pulse can be clearly seen on CRO.

6 Press S_1 repeatedly such that the pulse keep appearing on the screen repeatedly. Measure and record the ON time of the pulse.

If the CRO used has storage option, use this option to measure the ON time more conveniently. Take the help of the instructor to use the storage option on the DSO.

7 Change the value of the capacitor C from 0.1µF to 100µF. Calculate and record the new ON-time of the pulse.

8 Switch ON DC supply to the circuit. Press switch S_1 and observe the LED glowing. Try to find the approximate glow time using a stop watch record the glowing time of the LED.

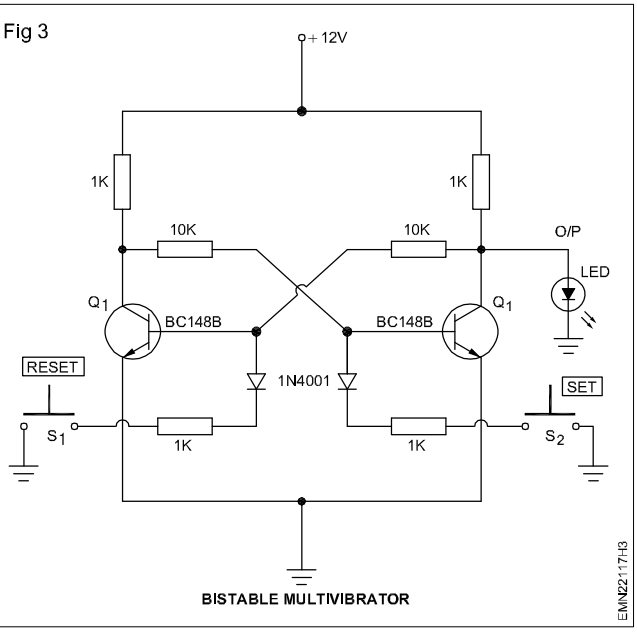
9 Get the working of the circuit checked by the Instructor.

– – – – – – –

TASK 3 : **Construction and testing of Bistable multivibrator using transistors**

1 Assemble the bistable multivibrator as shown in Fig 3.

Fig 3



BISTABLE MULTIVIBRATOR

2 Connect the 12VDC supply to the circuit and switch ON.

3 Press switch S_1, observe the condition of LED.

4 Press switch S_2, observe the condition of LED.

5 Record the observations in Table 1.

Table 1

Sl. No.	Switch to press	Output condition	
		(HIGH/LOW)	(Glow / No Glow)
	Set		
	Reset		

6 Get the work checked by the Instructor.

– – – – – – –

Construct and test shunt clipper

Objectives : At the end of this exercise you shall be able to
- **construct and test the positive shunt clipper circuit using descrete components**
- **construct and test the shunt negative clipper circuit.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Function Generator - 1 No
- Oscilloscope 20 MHz - Dual trace - 1 No
- Regulated DC power supply 0-30V/2A - 1 No
- Digital multimeter with probe - 1 No

Materials/Components

- Diode 1N 4007 - 1 No
- Resistor 10 kΩ/¼ W/CR25 - 1 No
- Breadboard - 1 No
- Hook up wires - as reqd

PROCEDURE

TASK 1 : **Construction and testing of positive shunt clipper circuit using discrete components**

1 Collect the components identify the diode number and cathode terminal.

2 Carry out quick test to confirm good working condition of the given diode using multimeter

3 Construct the positive shunt clipper circuit as shown in Fig 1 and verify the circuit connection by the Instructor.

4 Switch on the 5 VDC power supply to the shunt clipper circuit.

5 Set the function generator to sinewave output with 1kHz 10 V_{P-P}.

6 Prepare the CRO for meaurements.

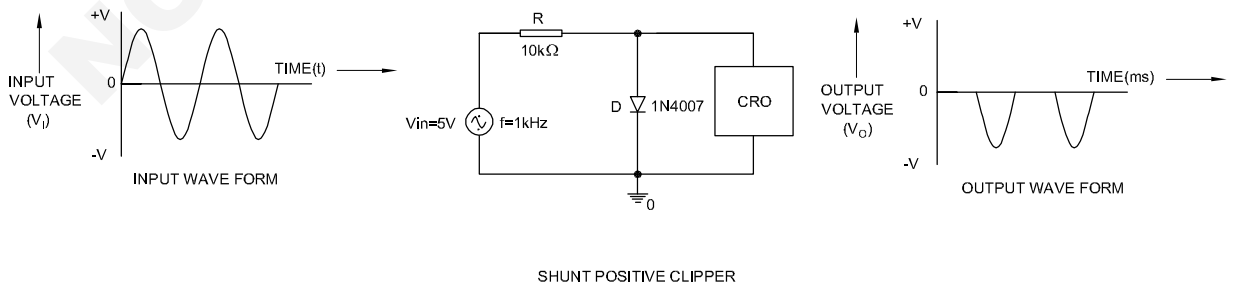
7 Observe the input waveform, output clipped waveform and record them in Table 1.

8 Use DMM measure the input, output voltages and record the radings in Table 1.

Table - 1

Sl. No.	Voltage	Waveform	Voltage as per CRO	Voltage as per DMM	Remarks
1	Input voltage				
2	Output voltage				

Fig 1



9 Get the work checked by the Instructor.

– – – – – – –

TASK 2 : **Construction and testing of negative shunt clipper**

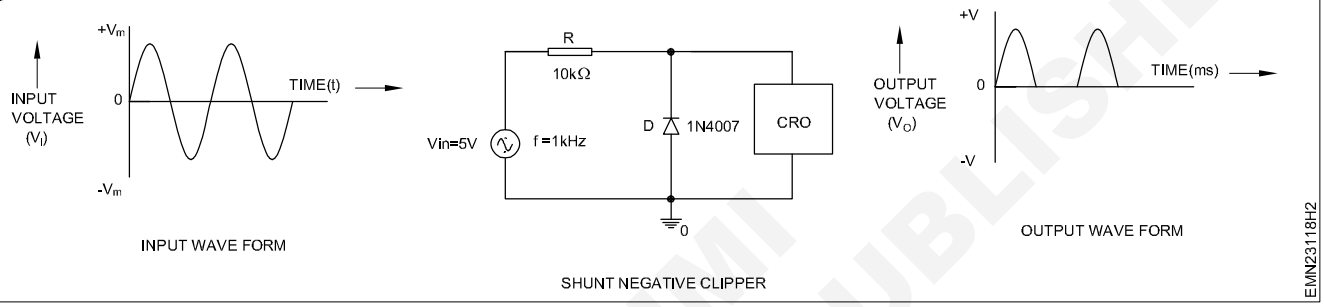
1 Modify the polarities of the diode as shown in Fig 2 for negative shunt clipper circuit.

2 Repeat steps 4 to 8 of Task 1 and record the readings in Table 2

Table - 2

Sl. No.	Voltage	Waveform	Voltage as per CRO	Voltage as per DMM	Remarks
1	Input				
2	Output				

Fig 2



3 Ge the work checked by the Instructor.

– – – – – – –

Construct and test series and dual clipper circuit using diodes

Objectives : At the end of this exercise you shall be able to
- **construct and test series negative clipper circuit using diode**
- **construct and test series positive clipper circuit using diode**
- **construct and test dual clipper circuit using diode.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Function Generator - 1 No
- CRO 20 MHz - Dual trace - 1 No
- Regulated DC power supply 0-30V/2A - 1 No
- Digital multimeter with probes - 1 No

Materials/Components

- Diode 1N 4007 - 1 No
- Resistor 10 kΩ /¼ W/CR25 - 1 No
- Breadboard - 1 No
- Hook up wires - as reqd

PROCEDURE

TASK 1 : **Construction and testing of series negative clipper circuit using discrete components**

1 Collect the components, identify the diode number and cathode terminal.

2 Carry out quick test to confirm good working condition of the given diode using multimeter.

3 Construct the series negative clipper circuit as shown in Fig 1 on breadboard and verify the circuit connection by the Instructor.

4 Switch ON the 5 VDC power supply to the series negative clipper circuit.

5 Set the function generator to sinewave output with 1kHz 10 V_{P-P}.

6 Prepare the CRO for meaurements.

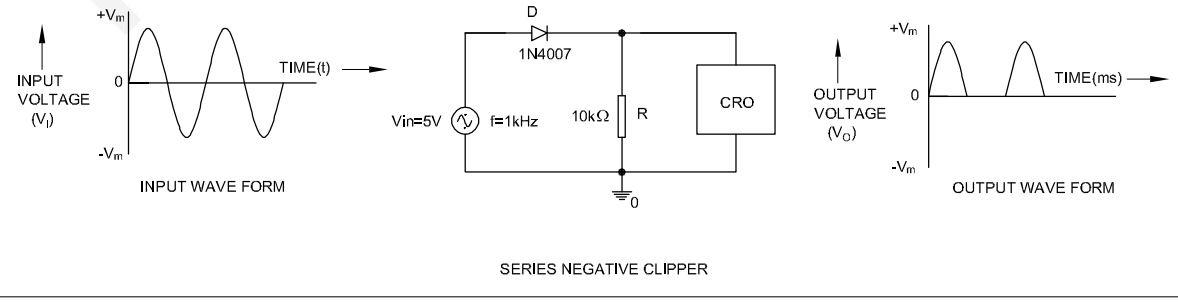
7 Observe the input waveform, output clipped waveform and record them in Table 1.

8 Use DMM measure the input, output voltages and record the readings in Table 1.

Table - 1

Sl. No.	Voltage	Waveform	Voltage as per CRO	Voltage as per DMM	Remarks
1	Input				
2	Output				

Fig 1



9 Get the work checked by the Instructor.

– – – – – – –

TASK 2 : **Construction and testing of series positive clipper**

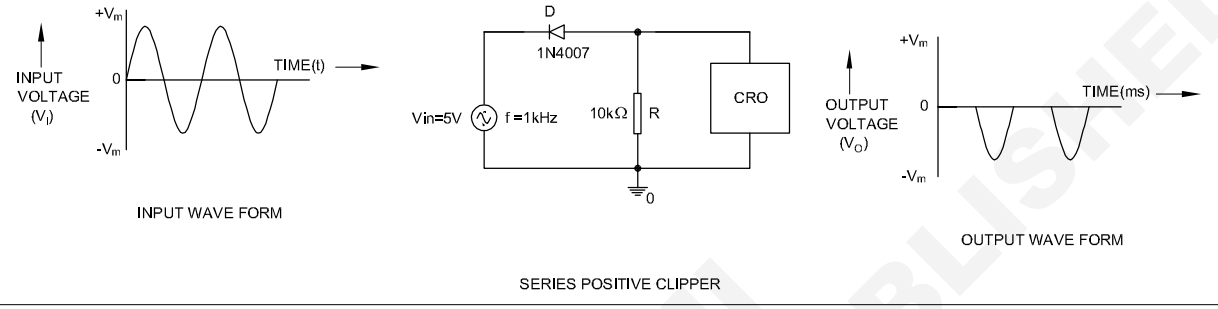
1 Modify the polarities of the diode as shown in Fig 2 for series positive clipper circuit.

2 Repeat steps 4 to 8 of Table 1 and record the readings in Table 2.

Table - 2

Sl. No.	Voltage	Waveform	Voltage as per CRO	Voltage as per DMM	Remarks
1	Input				
2	Output				

Fig 2



3 Get the work checked by the Instructor.

– – – – – – –

TASK 3 : **Construction and testing of dual Clipper Circuit using discrete components**

1 Collect the components, check them and assemble the dual clipper circuit on breadboard as shown in Fig 1.

2 Set 2V DC on both the sections of dual DC power supply and connect as V1 AND V2 as shown in the circuit.

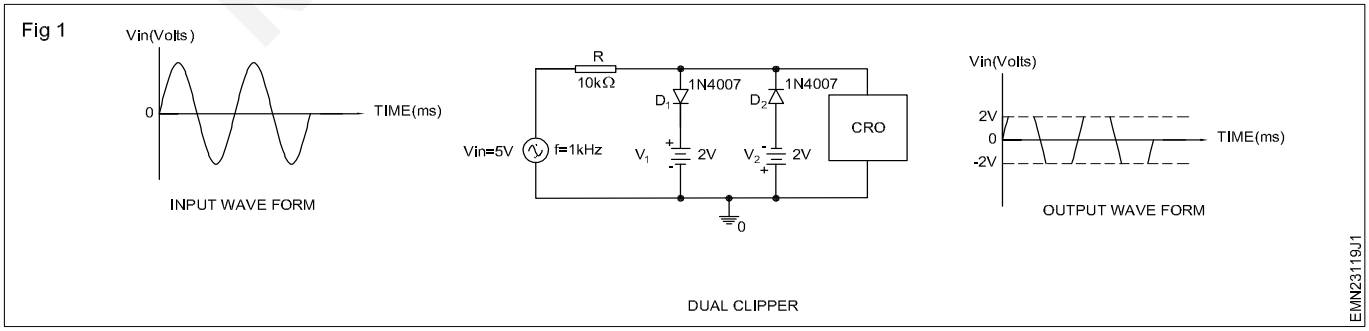
3 Check and verify the circuit connection by the instructor.

4 Repeat steps 4 to 8 of Task 1 and record the readings in Table 3.

Table - 3

Sl. No.	Voltage	Waveform	Voltage as per CRO	Voltage as per DMM	Remarks
1	Input				
2	Output				

Fig 1



5 Ge the work checked by the Instructor.

– – – – – – –

Construct and test clamper circuit using diodes

Objectives : At the end of this exercise you shall be able to
- **construct and test a positive clamper circuit using diode**
- **construct and test a negative clamper circuit using diode.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Function Generator 0-1 MHz - 1 No
- Oscilloscope 20 MHz - Dual trace - 1 No
- Regulated DC power supply 0-30V/2A - 1 No
- Digital multimeter with probes - 1 No

Materials/Components

- Diode 1N 4007 - 1 No
- Resistor 10 kΩ /¼ W/CR25 - 1 No
- Capacitor 0.1 μF/25VDC - 1 Nos
- Breadboard - 1 No
- Connecting wires/Hook up wires - as reqd

PROCEDURE

TASK 1 : **Construction and testing of positive clamper circuit using discrete components**

1 Collect all the components required identify the diode number and cathode terminal.

2 Carryout quick test to confirm good working condition of the given diode using multimeter.

3 Construct the positive clamper circuit as shown in Fig 1 on breadboard.

4 Check and verify the circuit connection by the Instructor.

5 Switch ON the 5 VDC power supply to clamper circuit.

Safety precautions: Ensure the variable DC power supply control zero volt position.

6 Set the Sinewave generator frequency to 1kHz and its output amplitude to 10 V_{p-p}.

7 Prepare the CRO for measurements.

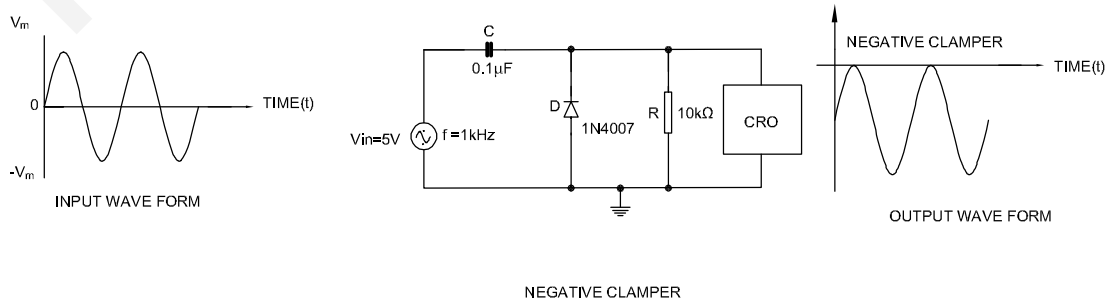
8 Observe the output waveform on the CRO, and record the amplitude and time period from the waveforms in Table 1.

9 Measure the clamped voltage verify with the input voltage using DMM and record the observations in Table 1.

Table - 1

Sl. No.	Voltage	Waveform	Voltage as per CRO	Voltage as per DMM	Remarks
1	Input				
2	Output				

Fig 2



10 Get the work checked by the Instructor.

– – – – – – –

TASK 2 : **Construction and testing of negative clamper circuit using discrete components**

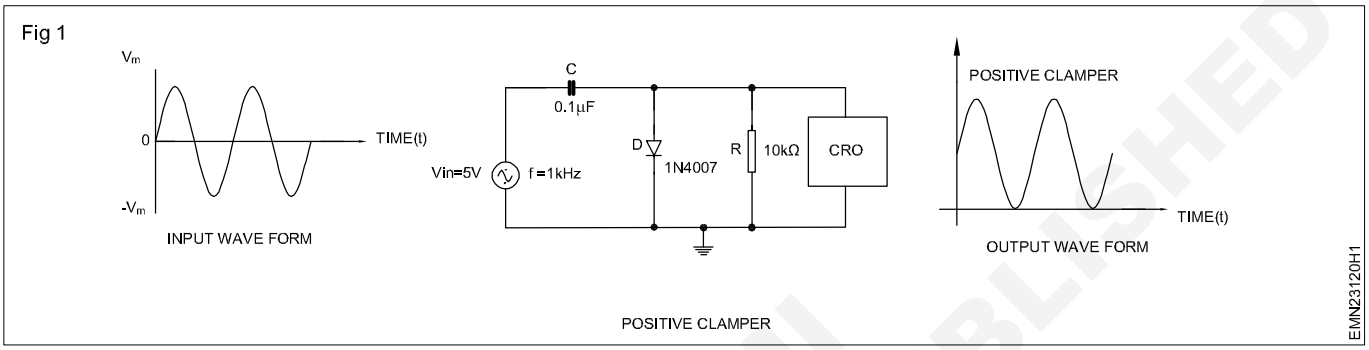
1 Modify the polarities of the diode as shown in Fig 2 for negative clamper circuit.

2 Repeat steps 4 to 9 of Task 1 and record the observations in Table 2.

Table - 2

Sl. No.	Voltage	Waveform	Voltage as per CRO	Voltage as per DMM	Remarks
1	Input				
2	Output				

Fig 1



3 Get the work checked by the Instructor.

– – – – – – –

Construct and test zener diode as a peak clipper

Objectives : At the end of this exercise you shall be able to
- **construct zener diode circuit as peak clipper**
- **test zener diode circuit.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Function Generator 0-1MHz - 1 No
- Oscilloscope 20 MHz - Dual trace - 1 No
- Regulated DC power supply 0-30V/2A - 1 No
- Digital multimeter with probes - 1 No

Materials/Components

- Zener Diode BZX55 or equivalent - 1 No
- Resistor 1kΩ /¼ W/CR25 - 1 No
- Breadboard - 1 No
- Connecting wires/Hook up wires - as reqd

Aids: Semiconductor data manual - as reqd

PROCEDURE

TASK 1 : **Construction of peak clipper Circuit using Zener Diode**

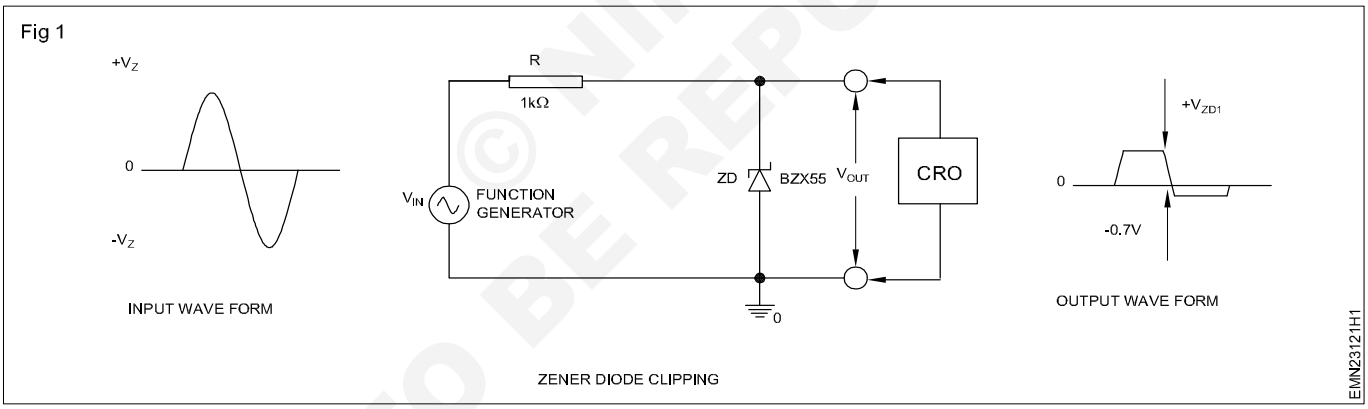
1 Collect the components and identify the Zener diode number and cathode terminal.

2 Carry out quick test to confirm good working condition of the given diode using multimeter.

3 Construct the peak clipper circuit as shown in Figure 1.

4 Check and verify the circuit connection by the Instructor.

Fig 1



– – – – – – –

TASK 2 : **Test the clipper circuit**

1 Switch ON the 5 VDC power supply to the peak clipper circuit.

2 Switch ON the signal generator, apply Sinewave input amplitude greater than the clipping level of the zener diode.

3 Prepare the CRO for measurements.

4 Observe the output waveform on the CRO, record the amplitude and time period from the waveform in Table 1.

5 Measure the clipped voltage, verify with the input voltage using DMM and record the observations in Table 1.

Table - 1

Sl. No.	Voltage	Waveform	Voltage as per CRO	Voltage as per DMM	Remarks
1	Input				
2	Output				

6 Get the work checked by the Instructor.

– – – – – – –

Identify different power electronic components, their specification and terminals

Objectives : At the end of this exercise you shall be able to
- **identity the terminals of FET, UJT and its specification using data manual**
- **identify the terminals of SCR, TRIAC, DIAC and its specification using data manual.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Semiconductor data manual for the active devices used for this exercise - as reqd
- Digital multimeter with probes - 1 No

  Aids: Chart showing the pin out diagram of active devices used for this exercise - as reqd

Material/Components

- Assorted types of N-Channel FET - 3 Nos
- Assorted types of SCR - 3 Nos
- Assorted types of UJT - 2 Nos
- Assorted types of TRIAC - 2 Nos
- Assorted types of DIAC - 2 Nos
- Plastic sleeves (2mm dia)-Red, Green, Yellow, Black - 1 M each

Note: The instructor has to label the active devices used for this exercise

PROCEDURE

TASK 1 : **Identification of leads of given FETs and its specifications using Data manual**

1 Collect the components and pick a labelled FET from the assorted lot record the code number of the FET and enter against its label number in Table 1.

2 Draw the pinout package diagram, refer to the chart/ data manual/identify and record the following important specification of the FET based on its type Number, package type,
- Polarity of the device (N-type/P-type)
- Maximum drain-source Voltage, V_{DS}
- Maximum gate-source Voltage, V_{GS}
- Maximum drain current, I_D.
- Maximum forward gate current, I_G.
- Pinch-off Voltage (at I_D =0), V_P.
- Maximum power dissipation, P_{max}

3 Put sleeves of suitable length to the leads following the colour scheme given below.

Drain - Red

Source - Green

Gate - Yellow

Shield - Black

4 Repeat steps 1 to 3 for the remaining labelled FETs.

Table 1

Sl. No.	Label	FET No.	Type	V_{DS}	V_{GS}	I_D	I_G	V_P	P_{max}	Package/ diagram pinout
1										
2										
3										

5 Get the work checked by the Instructor.

– – – – – – –

TASK 2 : **Identifications of UJT by its code number**

1 Pick a labelled UJT, record the code number, refer to the data manual find and record the specification of the given UJTs in Table 2.

2 Draw the pinout/package diagram and mark the terminal.

Table 2

Sl.No	Type Label No.	Device code number	I_P	I_V	R_{BB}	h	Package pinout diagram
1							
2							

3 Get the work checked by the Instructor.

– – – – – – –

TASK 3 : **Identification and specifications of SCR by its code number**

1 Collect the components from the instructor and pick one of the labelled SCR from the assorted lot, note down the SCR label number and its Code number printed on the SCRI in Table 3.

2 Draw the package/pinout diagram of SCR identify the terminals of SCR referring to the data manual, and record the specifications in Table 3.

In some power SCRs, the metal case itself will act as anode. Mark "A' on the case using a pencil or put a RED colour dot using colour marker pen.

3 Repeat above steps for remaining labelled SCRs from the assorted lot.

Table 3

Sl. No.	Label No	Code number of SCR	V_{RRM-}	$I_{T(RMS)-}$	I_{TSM}	I_{GT}	V_{GT}	I_H	Package/ pinout diagram
1 2 3									

4 Get the work checked by the Instructor.

– – – – – – –

TASK 4 : **Identification of leads of given TRIAC and its specifications using data manual**

1 Pick a labelled TRIAC from the given lot, record the code number of the TRIAC against its label number in Table 4.

2 Draw the pinout/package diagram, refer to the chart/ data manual, identify and record the important specifications used on the code number in Table 4.

3 Repeat above steps for the remaining labelled TRIAC and record the observations in Table 4.

Table 4

Sl. No.	Label No.	Code number	Voltage off state	Current on-state (I_t)	Voltage gate trigger (V_{gt})	Current gate trigger (I_{gt})	Package pinout diagram
1							
2							

4 Get the work checked by the Instructor.

– – – – – – –

TASK 5 : **Identification of leads of given DIAC and its specifications using data manual**

1 Pick a labelled DIAC from the given lot, record the code number against its label number in Table 5.

2 Draw the package/terminal diagram, refer to the datasheet, identify and record the important specifications of the DIAC in Table 5.

3 Repeat above steps for the remaining labelled DIACs and record the observations in Table 5.

Table 5

Sl.No	Label No.	Code number	V_{BO}	I_{TRM}	T_j	Package pinout diagram
1						
2						

4 Get the work checked by the Instructor.

– – – – – – –

Construct and test a FET Amplifier

Objectives : At the end of this exercise you shall be able to
- **construct a voltage amplifier using a JFET**
- **measure the gain of JFET amplifier with different input voltages**
- **calculate the gain of the amplifier at different frequencies.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Regulated DC power supply 0-30V/2A - 1 No
- Function generator - 1 No
- Soldering iron 25W/240VAC - 1 No
- Oscilloscope 0-20 MHz Dual trace - 1 No
- Digital multimeter with probes - 1 No

Materials/Components

- Assorted types of N-channel JFET - 4 Nos
- Plastic sleeves Red, Green, Yellow, Black (each of 10mm length) - 4 Nos

Aids: Semiconductor data manual/ data sheet of the FET - as reqd

- Capacitors
  - 5.6 nF/25V DC - 1 No
  - 270 nF/25V DC - 1 No
  - 6.8 µF/25V - 1 No
- Resistors, ¼ W/CR25
  - 10 kΩ - 1 No
  - 12 kΩ - 1 No
  - 47 kΩ - 1 No
  - 1 MΩ - 1 No
- Solder, flux - as reqd
- Hook up wires - as reqd

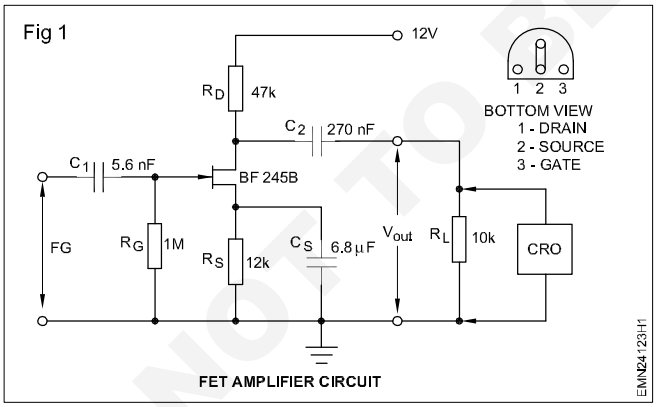
One of the given JFET should be a BF 245B or BFW 10 or equivalent.

TASK 1 : **Construction and testing of FET amplifier**

1 Collect the required components, test and assemble the FET amplifier as shown in Fig 1.

Construct the circuit on a bread board or on a GPCB.

Fig 1



FET AMPLIFIER CIRCUIT

2 Get the assembled circuit checked by the instructor.

3 Switch ON the 12 VDC to the circuit.

4 Set the function generator output with sinewave at 10 kHz, 100 mV_{p-p} as the input to the FET amplifier.

5 Prepare the CRO for measurements and observe the output across the R_L.

6 Record the output reading in Table 1.

Table 1

Input frequency : 10 kHz			
Sl. No.	Input voltage (mV)	O/P voltage	Gain= Output voltage / Input voltage
1	100		
2	200		
3	300		
4	400		
5	500		
6	600		
7	700		
8	800		
9	900		
10	1000		

7 Increase the input voltage in steps of 100 mV upto 1V, record the observation in Table 1.

8 Calculate gain for each setting of input and record them.

9 Get the work checked by the Instructor.

– – – – – – –

TASK 2 : **Measurement of gain of FET amplifier at different frequencies**

1 Set the function generator output with sinewave at 20 kHz- 400 mV, switch ON the FET amplifier

2 Measure the output across R_L using CRO and record the readings in Table 2.

Table 2

Input volt 400mV		
Frequency kHz	O/P Voltage	Gain = $\frac{\text{Output voltage}}{\text{Input voltage}}$
40 80 100 120 150		

3 Increase the signal frequency from 20 kHz in steps of 20 kHz, measure the output voltage and record the readings in Table 2.

4 Calculate the gain for each setting of input and record them.

5 Get the work checked by the Instructor.

– – – – – – –

Construct and test a circuit of SCR using UJT triggering

Objectives : At the end of this exercise you shall be able to
- **construct and test of SCR using UJT triggering.**

Requirements

Tools/Equipments/Instruments

- Digital multimeter with probes - 1 No
- Trainees tool kit - 1 Set
- AC Power supply (0-250V) - 1 No
- CRO, 0-20MHz-Dual channel - 1 No

Materials/ Components

- Stepdown transformer 230V/0-12V/500mA - 1 No
- Diode 1N4007 - 2 Nos
- Zener diode 12V/1W - 1 No
- LED-5mm/Red - 1 No
- UJT 2N2646 - 1 No

  Aids: Semiconductor data manual data sheet of the LOT and SCR - as reqd
- Miniature toggle switch SPST - 2 Nos
- SCR. Ty 6004 - 1 No
- Variable Resistor pot 100 K - 1 No
- Lamp 12V/5W with holder - 1 Set
- Capacitor 100 μF/25V, 10 μF/25V - 1 No each
- Resistor
  - 100 Ω - 2 Nos
  - 12 Ω - 1 No
  - 4.7 kΩ - 1 No
  - 3.3 kΩ - 1 No
  - 560 Ω - 1 No
  - 1 kΩ - 1 No
- Gen purpose PCB - 1 No
- Rosin cored solder - as reqd
- Hook up wire - as reqd

PROCEDURE

1 Collect all the components required, test them and confirm their working condition.

2 Plan the layout of components on the General purpose PCB, assemble the circuit as shown in Fig 1.

3 Verify the connections and get the assembled circuit checked by the Instructor.

4 Keep switch S2 open, switch ON mains supply to transformer, observe the LED is ON.

5 Measure the DC voltage at cathode of zener diode, B1 & B2 terminals of UJT and record the readings in Table 1.

Table 1

Voltage across			Waveform across	
Zener diode	UJT B1	B2	B2	Lamp

6 Prepare CRO for measurements and observe the Pulse waveform at B2 terminal of UJT.

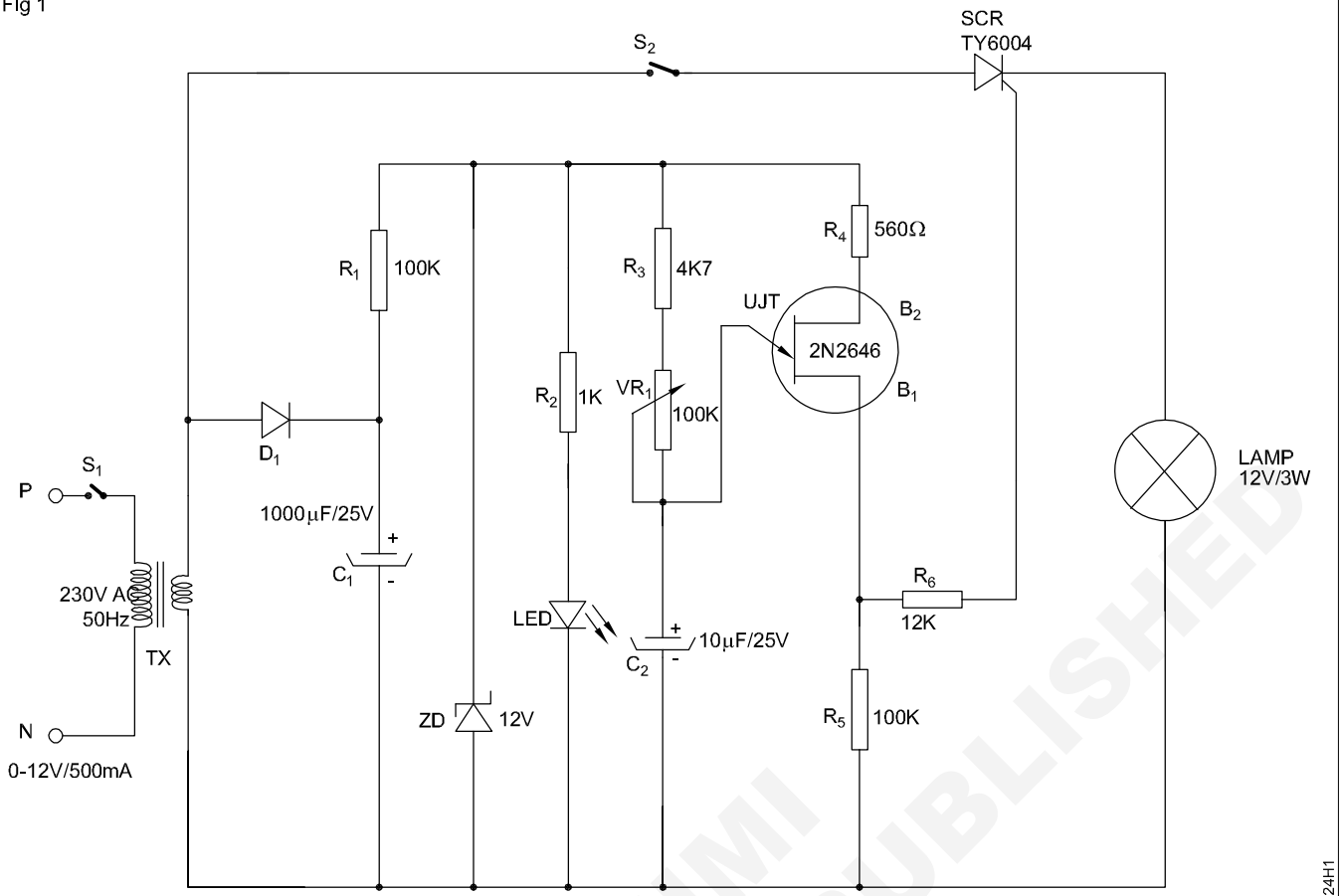
7 Close the switch S2 to allow AC supply to SCR, observe the Lamp is ON.

8 Measure the waveform across the Lamp and record the observations in Table 1.

9 Get the work checked by the Instructor.

Note: The Instructor has to adjust the preset slightly and observe the pulse frequency waveform, explain the reasons to trainees.

Fig 1



UJT TRIGGERED SCR CIRCUIT

Construct a simple dimmer circuit using TRIAC

Objectives: At the end of this exercise you shall be able to
- **assemble and test a lamp dimmer circuit using TRIAC and DIAC**
- **test the lamp dimmer circuit using domestic fan.**

Requirements

Tools/Equipments/Instruments

- Soldering iron 25W/230V - 1 No
- Trainees tool kit - 1 Set
- Lamp load (60 watts 230V) with holder - 1 No
- Digital multimeter with probes - 1 No

Materials/Components

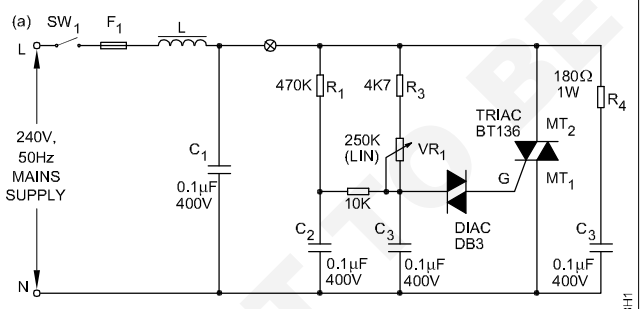
- Printed circuit Board, (as Fig 2) - 1 No
- Resistors 180 ohms 1W, carbon film - 1 No
  4.7 kΩ, ½ W - 1 No
  470 kΩ, ½ W - 1 No
- Potentiometer 250kΩ, 16 mm plastic shaft - 1 No
- Capacitor 0.1 μF 400 volts - 3 Nos
- TRAIC BT136 or equivalent - 1 No
- DIAC D3202 or equivalent - 1 No
- Inductor / Choke (25 SWG,40 turns on 10mm ferrite rod with former made of leatheroid paper) - 1 No
- SPST switch flush type, 5 amps, 240V - 1 No
- Knob (for potentiometer) - 1 No
- 2 core mains cord, 240V/5 amps - 1 No
- Solder and Flux - as reqd
- Fuse 500 mA - 1 No
- Connecting wires - as reqd
- 2 core twisted pair flexible wire - 1 No

PROCEDURE

TASK 1: **Construction and testing of lamp dimmer using TRIAC and DIAC**

1 Collect all the required components to assemble the circuit as shown in Fig 1

Fig 1

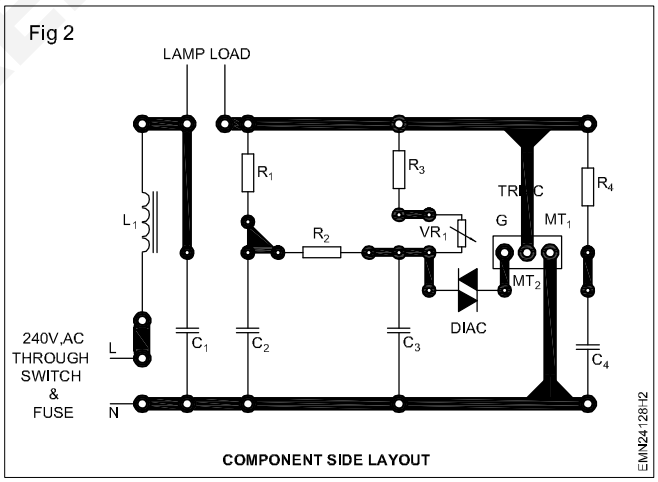


2 Plan the layout of components on the Gen.purpose PCB.

Use the dimmer circuit PCB if available as shown

3 Assemble the lamp dimmer circuit reference to the schematic diagram shown in Fig 1 & PCB layout diagram shown in Fig 2.

Fig 2



4 Get the wired circuit checked by the Instructor.

5 Connect the load and keep the lamp on a safe place to avoid heatung nearby items.

6 Switch ON AC mains supply to the circuit, observe the lamp and increase the potentiometer position to the maximum brightness

7 Gradually decrease lamp brightness, and record the observations in Table - 2 (as dim, bright, very bright).

8 Get the work checked by the Instructor.

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TASK 2 : **Testing the lamp dimmer circuit to control the speed of domestic Fan**

1 Remove the lamp load and connect the domestic fan across the terminals.

2 Keep the potentiometer at minimum position, switch ON AC mains supply to the circuit, gradually increase to maximum observing the rotation of fan speed.

3 Gradually decrease the speed and record the observations in Table 2 (as slow, medium, or fast).

4 Get the work checked by the instructor.

Table 1

Sl. No.	Potentiometer position	Fan speed	Remarks
1	Minimum		
2	Middle		
3	Maximum		

– – – – – – –

Construct UJT based free running oscillator and change its frequency

Objectives: At the end of this exercise you shall be able to
- **construct and test free running oscillator**
- **measure time period and frequency.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- CRO dual trace 20MHz - 1 No
- Regulated DC power supply 0-30V/2A - 1 No
- Digital multimeter with probes - 1 No

Materials/Components

- UJT 2646 - 1 No
- Resistor 47 ohm 1/4W - 1 No
- 10Ω/¼ W - 1 No
- Resistor 330 Ohm/¼ W - 1 No
- Preset 47kΩ - 1 No
- Capacitor 0.1μF - 2 Nos
- Hookup wires - 1 No
- Breadboard - 1 No
- Miniature toggle switch SPST - 1 No

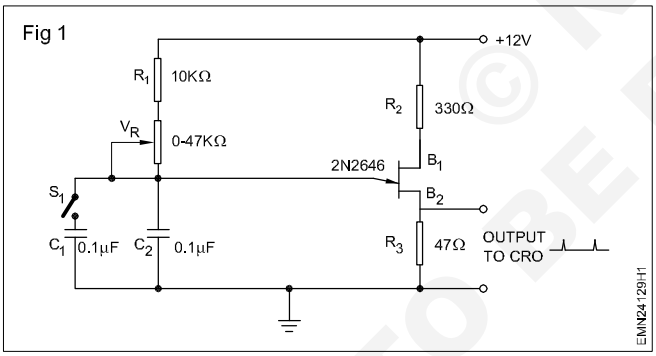
PROCEDURE

1 Collect all the components, test them to confirm their working condition.

2 Assemble the circuit on the breadboard as shown in Fig 1

3 Get the assembled circuit checked by the instructor.

Fig 1



4 Switch ON 12VDC power supply to the circuit

5 Prepare CRO for measurements, observe keeping preset value maximum

6 Observe the waveform across resistor R3 and record them in Table - 1

7 Measure time period & frequency of waveform compare with calculated values and record it.

8 Adjust the preset, change the value of VR measure the resistance value and record in Table - 1.

9 Repeat steps 6&7

10 Close switch S_1 to increase the value of 'c' and repeat steps 6&7

Table 1

Sl. No	Value of R	Value of C	Calculated frequency	Mesured frequency

Wave form

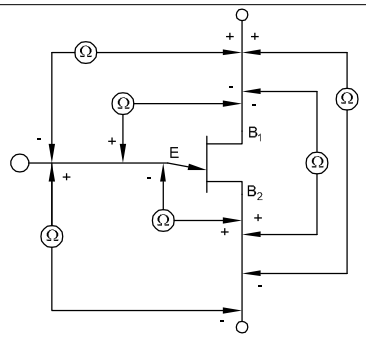
Across R_1

Across C

Table 2

UJT No.	Resistance						Conclusion
	B_1 & B_2		B_1 & G		B_2&G		
	Forward	Reverse	Forward	Reverse	Forward	Reverse	

Fig 2



11 Get the work checked by the Instructor.

– – – – – – –

Identify various power MOSFETs by its number and test by using multimeter

Objectives: At the end of this exercise you shall be able to
- **identify given MOSFET type by its number and test MOSFET using multimeter.**

Requirements

Tools/Equipments/Instruments		Materials/Components	
• Trainees tool kit	- 1 Set	• MOSFET IRF 540	- 1 No
• Digital multimeter with probes	- 1 No	IRF Z44	- 1 No
• MOSFET Data book	- 1 No	IRF 840	- 1 No

PROCEDURE

Identification of the given MOSFET by its number and testing with a multimeter

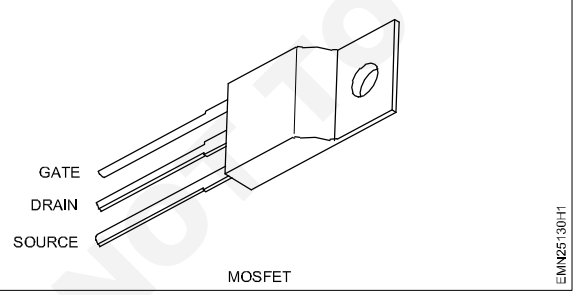
MOSFET is easily destroyed with static electricity, always ground yourself before working with one.

1 Note down the number, specification & type of given MOSFET by using MOSFET data book.

2 Identify which pins of the MOSFET are its source, gate and drain leads. Look up the device's part number in the MOSFET data book to verify its leads layout.

3 For testing the MOSFET using multimeter, hold the MOSFET by the case or the tab but don't touch the metal parts of the test probes with any of the other MOSFET'S terminals until needed. Do not allow a MOSFET to come in contact with your clothes, plastic or plastic products, etc. because of the high static voltages it can generate.

Fig 1



4 First, touch the multimeter positive lead onto the MOSFET'S 'Gate' and negative lead onto the source.

This testing procedure is for use with a digital multimeter in the diode test-range with a minimum of 3.3 volt over diode-under-test. If your multi-meter battery is less than that it will not do the test. Check your meter for the specification.

Table 1

Sl. No.	MOSFET No.	V_{GD}	V_{DS}	V_{GS}	Condition of MOSFET

5 Now move the positve probe to the 'Drain'. You should get a 'low' reading. The MOSFET'S internal capacitance on the gate has now been charged up by the meter and the device is 'turned-ON'.

6 With the meter positive still connected to the drain, touch a finger between source and gate (and drain if you like, it does not matter at this stage). The gate will be discharged through your finger and the meter reading should go high, indicating a non-conductive device/high resistance condition.

The above test means that, actually testing the cut-off voltage, which is basically the highest voltage put on the gate without making it conduct.

7 If the meter reading is low on both sides of VGS (or) VDS, then MOSFET is short circuted/defective.

8 Get the work checked by the Instructor.

Construct MOSFET test circuit with a small load

Objectives: At the end of this exercise you shall be able to
- **to construct MOSFET test circuit with a small load.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Regulated DC power supply 0-30V/2A - 1 No
- Multimeter with probes - 1 No

Materials/Components

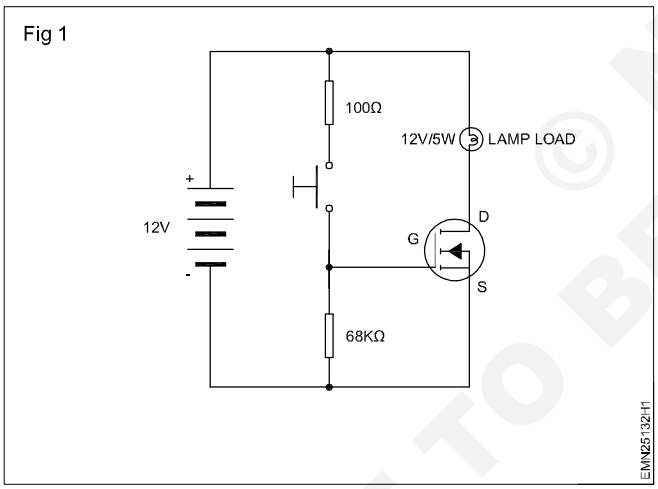
- MOSFET (assorted number) - 5 Nos
- Resistor 1kΩ, ¼ W/CR25 - 1 No
- Resistor 100 Ohm/ ¼ W/CR25 - 1 No
- Resistor 68kΩ/¼ W/CR25 - 1 No
- ON/OFF Switch - 2 Nos
- Socket for MOSFET - 1 No
- 12V lamp - 1 No
- Hook up wires - as reqd
- Solder flux - as reqd
- Connecting wires - as reqd
- PCB/Bread board - 1 No

PROCEDURE

1 Check the working condition of all given components with multimeter.

2 Assemble the circuit on bread board as shown in the circuit Fig 1.

Fig 1



3 Insert MOSFET (to be checked) in socket.

4 Power on the supply, Press switch S and observe that lamp glows. This means MOSFET is turned ON. Note down the status of lamp in Table 1.

5 Thus MOSFET act as open switch if gate voltage is zero. If gate voltage is applied then the MOSFET will act as closed switch then the working condition of MOSFET is good/ON.

6 If the MOSFET is P-channel then reverse the polarity of power supply and lamp load then check the condition of lamp load.

Table 1

Sl. No.	MOSFET No.	Type	Status of lamp ON/OFF	MOSFET Condition

7 Get the work checked by the Instructor.

– – – – – – –

Identify IGBTs by their numbers and test by using multimeter

Objectives: At the end of this exercise you shall be able to
- **identify IGBT by its number, specification, pin configuration type and application**
- **test IGBT by using multimeter.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Multimeter with probes - 1 No

Materials/Components

- IGBT with assorted rating - 5 Nos
- IGBT data book - 1 No

PROCEDURE

TASK 1 : **Identification of IGBTs by their number, pin configuration of type**

1 Note down the number printed on given device.

2 Identify the number in data book and note IGBT type.

3 Record the specification like voltage & current rating of given IGBT in Table 1.

4 Identify the terminals gate, emitter & collector with the help of the data book.

Table

Sl.No.	IGBT No.	Specifications							
		VR (Voltage Rating)	CR (Current Rating)	ID (Gate Input Drive)	II (Input Impedence)	OI (Output Impedence)	SS (Switching Speed)	Pin configuration	Application

– – – – – – –

TASK 2 : **Testing of IGBT using multimeter**

1 To test IGBT with multimeter use meter in diode checking mode with battery voltage of less than 20 V.

2 To test collector emitter junction remove the conductive foam and short the gate to the emitter

3 As the multimeter is in diode check mode, the collector to emitter should give a normal diode reading with positive on the collector and negative on the emitter.

4 The multimeter should read open or infinite with collector negative and emitter positive.

5 If IGBT is damaged it may test as shorted in both positive and negative directions, open in both directions, or low resistive in both directions.

6 For gate oxide test keep the meter in resistance mode, where the resistance from gate to collector and gate to emitter should be infinite on a good device

7 If it is a damaged device it appears shorted or have leakage resistance from gate to collector and/ or emitter.

Note: The input section of IGBT junctions like a MOSFET and the output section of IGBT functions like a bipolar juntion transistor.

8 Get the work checked by the Instructor.

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Construct IGBT test circuit with a small load

Objectives: At the end of this exercise you shall be able to
- **to determine the working condition of IGBT by using test circuit.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Regulated DC power supply 0-30V/2A - 1 No
- Multimeter with probes - 1 No

Materials/Components

- IGBT (5SMV 86M1731) - 5 Nos
- Resistor 1kΩ/¼ W - 1 No
- Resistor 2.2kΩ/¼ W - 2 Nos
- ON/OFF Switch - 2 Nos
- Socket for IGBT - 1 No
- Breadboard - 1 No
- 12V lamp - 1 No

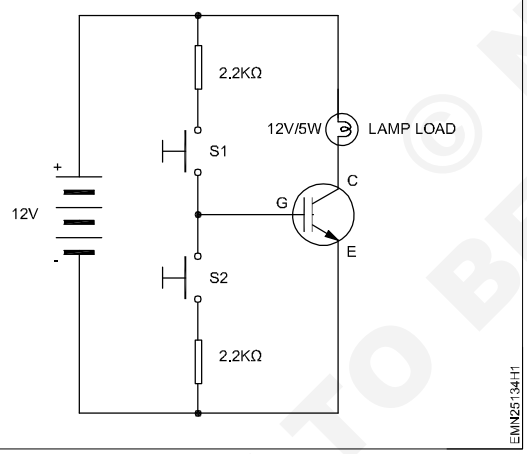
PROCEDURE

TASK 1 : **Construction and testing of IGBT test circuit**

1 Collect and check the working condition of all the given components by multimeter.

2 Assemble the circuit on breadboard as shown in Fig 1.

Fig 1



3 Insert IGBT (to be checked) in socket.

4 Power ON the supply & Press switch S_1 and observe that lamp load will glow this means IGBT is turned ON.

5 Switch OFF S_1 and press switch S_2 observe that lamp will turn OFF this means IGBT is turned OFF.

Thus IGBT act as open switch if gate voltage is not provided. If positive gate voltage is applied then the IGBT will act as closed switch then the working condition of IGBT is good.

7 Test all given IGBT by using above procedure.

8 Note down the readings on Table 1.

Table 1

Sl. No.	IGBT No.	S_1 Position	S_2 Position	Lamp ON/OFF	IGBT Condition
1		Closed	Open		
		Open	Closed		
2		Closed	Open		
		Open	Closed		
3		Closed	Open		
		Open	Closed		

9 Get the work checked by the Instructor.

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Test LEDs with DC supply and measure voltage drop and current using multimeter

Objectives: At the end of this exercise you shall be able to
- **measure voltage drop and current using multimeter by testing LED.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Digital multimeter with probes - 1 No
- Ammeter (0-50) mA - 1 No

Materials/Components

- LED (assorted colour, Type & size) - 10 Nos

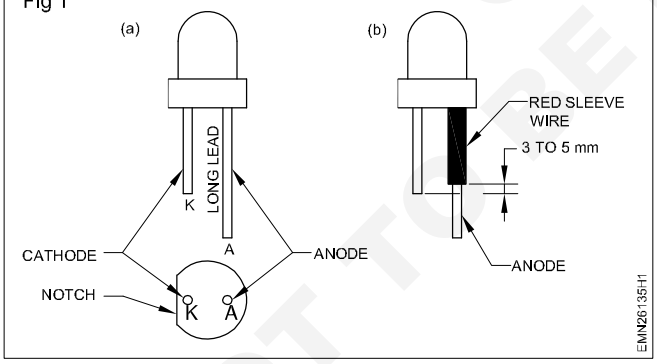
PROCEDURE

1 Note down the type of LED by physical identification. (ie. Single colour 5mm LED, Miniature, flashing LED, Bi-colour or tri-colour) and for details look-into the data sheet.

2 Determine the Anode and Cathode terminaols of the LED.

If it is a new LED, the long leg should be the anode(+) and the short leg is the cathode(-). You can also look inside the LED and the larger electrode is cathode and the smaller electrode is the anode (+).

Fig 1



3 Turn digital multimeter ON and set it to diode mode testing position will be marked by a diode symbol.

Note: In diode mode and resistance mode of testing using multimeter, the battery of the multimeter is engaged for providing DC bias (or) DC supply voltage required for testing.

4 Clip the positive(+) of meter to the predetermined anode(+) of the LED and the negative(-) to the cathode (-). The LED should glow and shows bias in display.

5 If the connection is correct and the LED does not light up then LED is bad.

6 Connect ammeter in series with the LED and measure current.

Note: Man forward voltage that can be applied to a smm LED can draw is only20 ma.SO always use a current limiting resistor in series with an LED (for using in the circuits)

7 Record it in Table 1.

8 Repeat the procedure for testing other LEDs.

Table 1

Sl. No.	Type of LED	LED ON/OFF	Voltage drop	I when LED is ON

9 Get the work checked by the Instructor.

Construct a circuit to test photo voltaic cell

Objectives: At the end of this exercise you shall be able to
- **construct a simple photovoltaic (PV) system, using a PV cell(s) and a DC ammeter**
- **learn how the amount and wavelength of light affect the generation of electricity.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- DC ammeter 0-500 mA - 1 No
- DC volt meter 0-24V - 1 No
- Multimeter/DMM with probes - 1 No

Materials/Components

- Small PV cells
- Sheets of colored transparency film in different colors - as reqd
- Two electrical leads with crocodile clips
- Source of bright light or access to direct sunlight (desk lamp or flashlight could be substituted)
- Goggles/gloves - 1 Set

PROCEDURE

TASK 1: **Constructing the Photovoltaic Energy System for Light Source Changes**

1 If your PV cell mini panel does not have wires already attached to it, you should attach 15 cm of wire to each node of the PV cell. The cell should have either clips or hooks around which you can manually twist the wire.

2 Follow the Instructor safety instructions and attach the red wire from the PV cell to the red lead of the volt meter and ammeter (either clip or connect the wires together).

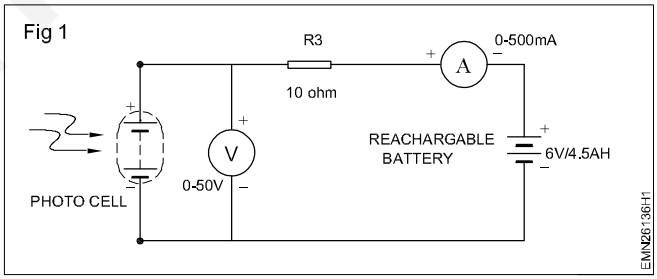
3 Similarly, connect the black wires from the PV cell to the negative terminal black lead of the voltmeter.

4 Connect the 6V/4.5Ah battery between negative terminal of Ammeter and negative terminal of solar panel.

4 Use the direct light/other source on the PV cell to see if you are getting a current reading. If the ammeter shows no current, check the wire connections.

5 Check DC voltage across battery.

Fig 1



TASK 2: **Performing the Activity for Light**

1 Keeping the sunlight constant (or the light source at constant distance), cover the PV cell(s) with a piece of coloured transparency film. Repeat with the other colours of transparency film and then use just direct sunlight alone (or light substitute). Record the current generated for all colours tested and for direct light in Data Table 1.

Note that different colours (wave lengths) of light on the solar panel produces different voltage. It is concluded that the wave length of light affects the electricity.

Table 1 Effect of Colour (Wavelength) on Cell Current

Color of Filter	Current	Remarks
Red		
Green		
Blue		
Yellow		
No filter		

2 With just 1 PV cell in the circuit, shade 1/4 of the PV cell with a piece of cardboard or paper and take a reading. Shade 1/2, 3/4 and then all of the photovoltaic cell. Record the readings in Data Table 2.

Table 2 Effect of Shading on Cell Current

Amount of Shade Current	Current
No shade	
1/4 covered	
1/2 covered	
3/4 covered	
All covered	

Note:-

Safety Precautions to be followed while handling photo-voltaic cells.

1 Do not press (or) apply pressure on PV cell (a) panel, they may break (or) cause injury or damage to the solar panel.

2 Make sure you entire PV system is properly and safely earth grounded to prevent electrical shock and injury.

3 When the solar panel is exposed to sunlight, do not touch any electrical lubricant (or) wiring with bare hands. Wear goggles to protect eyes form bright-light.

3 Get the work checked by the Instructor.

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Construct a circuit to switch a lamp load using photo diode

Objectives: At the end of this exercise you shall be able to
- **construct a circuit to switch a lamp using photo diode and test the working of photo diode.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- DC Power Supply 0-30V/2A - 1 No
- Multimeter with probes - 1 No

Materials/Components

- Photo diode BPW 34 - 1 No
- POT 4.7kΩ/1W, linear - 1 No
- Relay (SPST) 12V - 1 No
- Transistor BC548 - 1 No
- Lamp 12V - 1 No
- Diode 1N4007 - 1 No
- Bread board - 1 No

PROCEDURE

1 Check all given component using multimeter for good working condition.

2 Assemble the circuit on bread board as shown in diagram, connect a lamp to relay contact.

3 Switch on DC power supply, cover photo diode with card board. & observe the position of relay & load lamp. At this position relay will be activated and the lamp will produce light as shown in Fig 1.

4 Expose the photo diode with a light (gran IR LED or with trorch light) & note down the position of relay and lamp condition. Lamp will not produce output.

5 Record the observation in the Table 1.

Fig 1

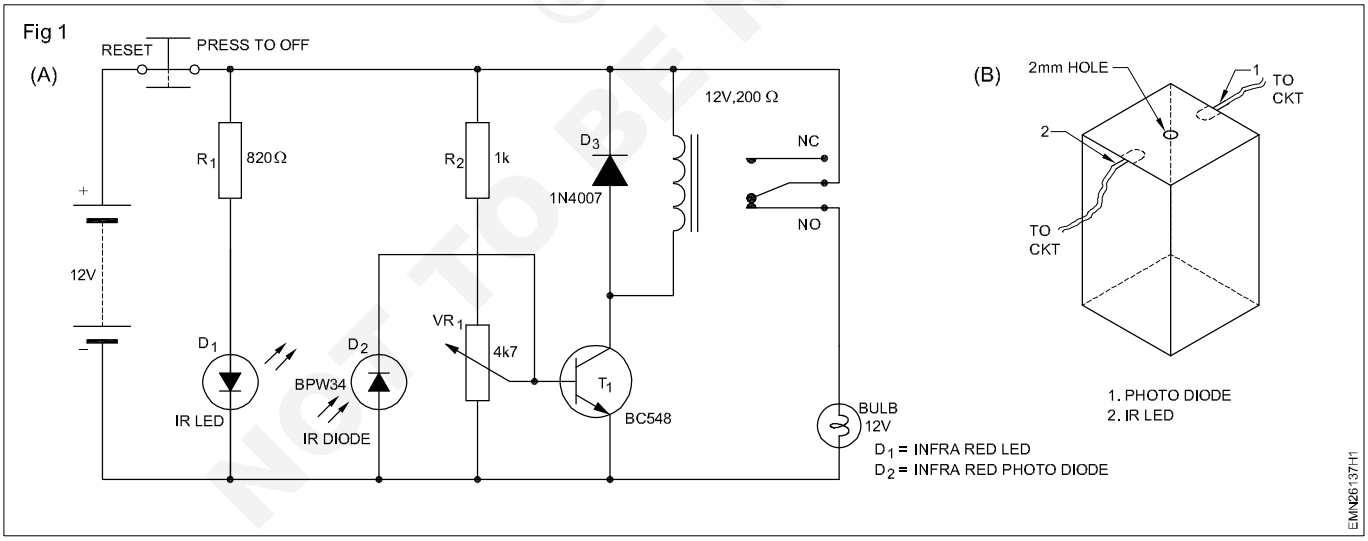


Table 1

Sl. No	Light falling on photo diode	Relay position	Lamp condition
1	Darkness		
2	Exposed to Lamp light		

6 Get the work checked by the Instructor.

– – – – – – –

Construct a circuit to switch a lamp load using photo transistor

Objectives: At the end of this exercise you shall be able to
- **construct a circuit to switch a lamp using photo transistor and test the working of photo transistor.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- DC Power Supply, 0-30V/2A - 1 No
- Multimeter DMM with probes - 1 No

Materials/Components

- Photo transistor PT 1504-6B - 1 No
- POT 100kΩ/1W, linear - 1 No
- Transistor 2N2222 - 1 No
- Relay 6 V - 1 No
- Lamp - Green, Red 12V/5W - 1 No each
- Breadboard - 1 No

PROCEDURE

TASK 1: **Construction and testing of photo transistor using a switch and lamp load**

1 Test all given component on multimeter for good working condition.

2 Assemble the circuit on bread board as shown in fig 1.

3 Cover photo transistor with card board & switch on the DC & AC power supply.

4 Relay will be OFF hence lamp L_2 will turn ON & L_1 will remain OFF.

5 Now remove card board & expose phototransistor to light Lamp of 10W & again observe position of relay. Now relay will be activated & Lamp L_1 will turn ON & Lamp L_2 will turn OFF.

6 Note down position of phototransistor, Relay & Lamp in observation Table 1.

Fig 1

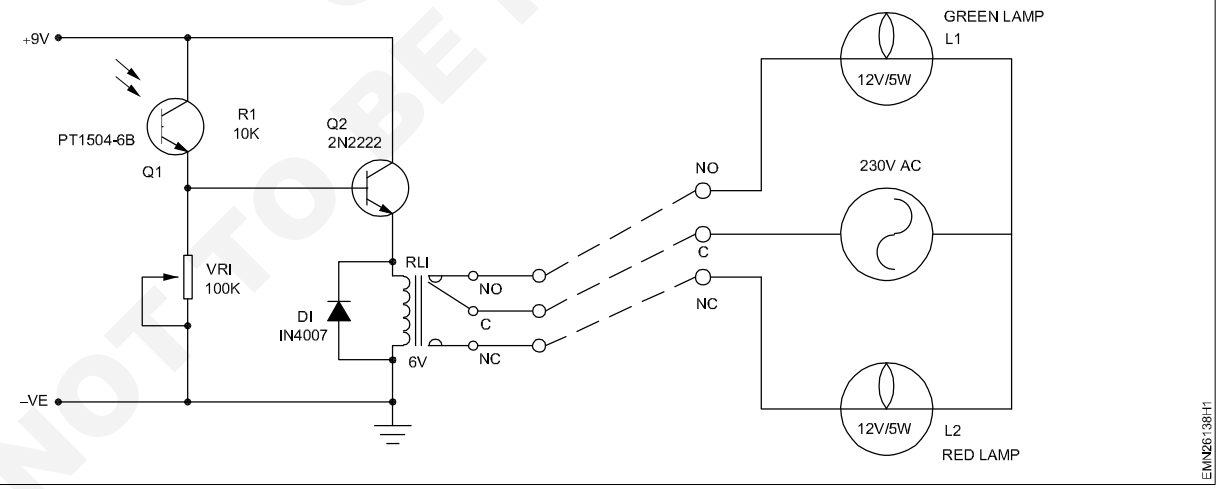


Table 1

Sl . No	Light falling on photo transistor	Relay position	Lamp L_1	Lamp L_2
1	Darkness			
2	Exposed to Lamp light			

7 Get the work checked by the Instructor.

– – – – – – –

Verify the truth tables of all logic gate ICs by connecting switches and LEDs

Objectives: At the end of this exercise you shall be able to
- **construct AND, OR, NOT, NAND, NOR and EX-OR gates using ICs**
- **verify truth tables of AND, OR, NOT, NAND, NOR and EX-OR gates using switches and LEDs.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Regulated DC power supply 0-30V/2A - 1 No
- Digital multimeter with probes - 1 No

Materials/Components

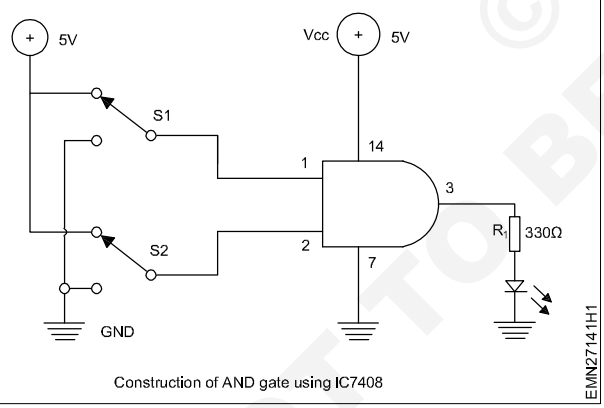
- Breadboard - 1 No
- IC 7408 - 1 No
- IC - 7432 - 1 No
- IC-7486 - 1 No
- IC-7400 - 1 No
- SPDT Switches (Miniature Toggle) - 2 Nos
- IC 7404 - 1 No
- Hook up wire, red and black - as reqd
- Flexible wires - as reqd
- Resistor/¼ W/CR25 - 1 No
- 330Ω - 1 No
- LED 5mm, Red - 1 No
- Data sheets of ICs used - as reqd

PROCEDURE

TASK 1 : **Construction and AND gate using IC 7408 and verification of its truth table**

1 Collect all the components, check them, refer to the data sheet of the IC 7408, assemble the AND gate as shown in Fig 1 on the bread board.

Fig 1



Construction of AND gate using IC7408

2 Use toggle switches S_1 as input A and switch S_2 as input B.

3 Get the assemble circuit checked by the Instructor.

4 Switch ON 5VDC supply and operate switches S_1 & S_2 for different levels either in 5V position or zero volt (GND) position as shown in Table 1.

5 Observe the status of LED for each step of combinations, record the observations in Table 1.

Table 1

Sl.No.	Input		Output LED status
	A	B	
1			
2			
3			
4			

AND gate Truth table

Sl.No.	Input		Output Y=A.B
	A	B	
1	0	0	0
2	0	1	0
3	1	0	0
4	1	1	1

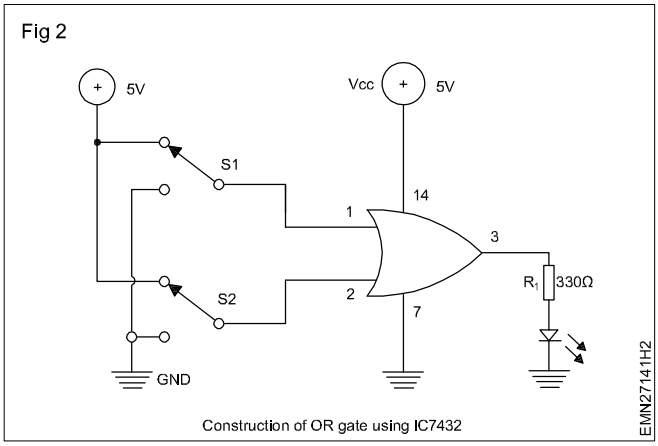
6 Verify the readings with the truth table of AND gate.

7 Get the work checked by the Instructor.

TASK 2 : **Construction of OR gate using IC 7432 and verification of its Truth table**

1 Collect all the components, check them, refer to the data sheet of the IC 7432, assemble the OR gate as shown in Fig 2 on the bread board.

Fig 2



Construction of OR gate using IC7432

2 Repeat steps 2 to 5 of Task 1 and record the observations in Table 2.

3 Verify the readings with the truth table of OR gate.

4 Get the work checked by the Instructor.

Table 2

Sl.No.	Input		Output LED status
	A	B	
1			
2			
3			
4			

OR gate Truth table

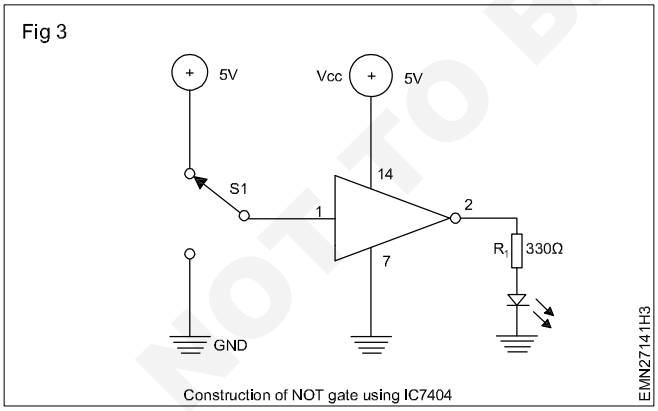
Sl.No.	Input		Output Y=A+B
	A	B	
1	0	0	0
2	0	1	1
3	1	0	1
4	1	1	1

– – – – – – –

TASK 3 : **Construction of NOT gate using IC 7404 and verification of its Truth table**

1 Collect all the components, check them, refer to the data sheet of the IC 7404, assemble the NOT gate as shown in Fig 3 on the bread board.

Fig 3



Construction of NOT gate using IC7404

2 Use toggle switches S_1 as input A.

3 Repeat steps 3 to 5 of Task 1 and record the observations in Table 3.

4 Verify the readings with the truth table of NOT gate.

5 Get the work checked by the Instructor.

Table 3

Sl.No.	Input	Output LED status
	A	
1		
2		

NOT gate Truth table

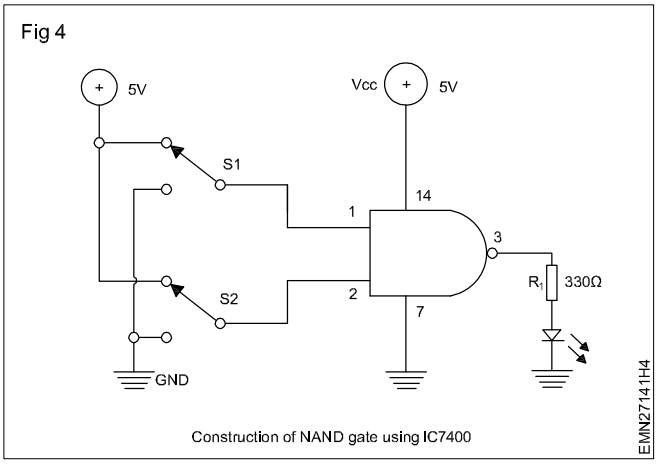
Sl.No.	Input	Output $\bar{Y}=A$
	A	
1	0	1
2	1	0

– – – – – – –

TASK 4 : **Construction of NAND gate using IC 7400 and verification of its Truth table**

1 Collect all the components, check them, refer to the data sheet of the IC 7400, assemble the AND gate as shown in Fig 4 on the bread board.

Fig 4



Construction of NAND gate using IC7400

2 Repeat steps 2 to 5 of Task 1 and record the observations in Table 4.

3 Verify the readings with the truth table of NAND gate.

4 Get the work checked by the Instructor.

Table 4

Sl.No.	Input		Output LED status
	A	B	
1			
2			
3			
4			

NAND gate Truth table

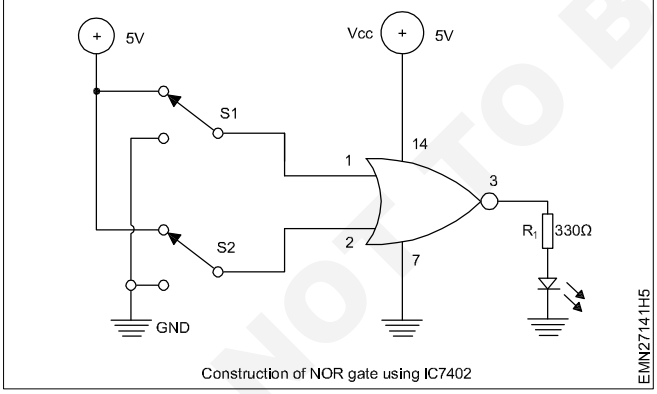
Sl.No.	Input		Output $Y=\overline{A.B}$
	A	B	
1	0	0	1
2	0	1	1
3	1	0	1
4	1	1	0

– – – – – – –

TASK 5 : **Construction of NOR gate using IC 7402 and verification of its Truth table**

1 Collect all the components, check them, refer to the data sheet of the IC 7402, assemble the NOR gate as shown in Fig 5 on the bread board.

Fig 5



Construction of NOR gate using IC7402

2 Repeat steps 2 to 5 of Task 1 and record the observations in Table 5.

3 Verify the readings with the truth table of NOR gate.

4 Get the work checked by the Instructor.

Table 5

Sl.No.	Input		Output LED status
	A	B	
1			
2			
3			
4			

NOR gate Truth table

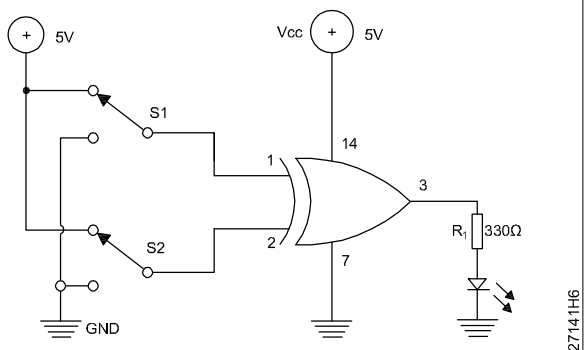
Sl.No.	Input		Output $Y=\overline{A+B}$
	A	B	
1	0	0	1
2	0	1	0
3	1	0	0
4	1	1	1

– – – – – – –

TASK 5 : **Construction of EX-OR gate using IC 7486 and verification of its Truth table**

1 Collect all the components, check them, refer to the data sheet of the IC 7486, assemble the EX-OR gate as shown in Fig 6 on the bread board.

Fig 6



Construction of EX-OR gate using IC7486

2 Repeat steps 2 to 5 of Task 1 and record the observations in Table 6.

3 Verify the readings with the truth table of EX-OR gate.

4 Get the work checked by the Instructor.

Table 6

Sl.No.	Input		Output LED status
	A	B	
1			
2			
3			
4			

EX-OR gate Truth table

Sl.No.	Input		Output Y=A⊕B
	A	B	
1	0	0	0
2	0	1	1
3	1	0	1
4	1	1	0

– – – – – – –

Construct and verify the truth table of all the gates using NAND and NOR gates

Objectives : At the end of this exercise you shall be able to
- **construct AND, OR, NOT, NOR, EX-OR and EX-NOR gates using NAND gate**
- **construct AND, OR, NOT, NAND, EX-OR and EX-NOR gates using NOR gates.**

Requirements

Tools/Equipments/Instruments/Data Manuals

- Logic probe - 1 No
- Trainees tool kit - 1 Set
- Regulated DC power supply 0-30V/2A - 1 No
- Digital multimeter with probes - 1 No

Materials/Components

- Digital IC data manual - 1 No
- IC 7400 - 2 Nos
- IC 7402 - 2 Nos
- Hook up wires - as reqd
- 14 pin IC base - 4 Nos
- Toggle switches miniature type SPDT - 2 Nos
- Bread board - 1 No
- LED 5mm, Red - 1 No
- Resistor - 330Ω/1/4W - 1 No

Note:

1 **The Instructor has to guide the trainees to record 5VDC given to gate input as logic high (1) and GND (zero volt) as logic low (0)**

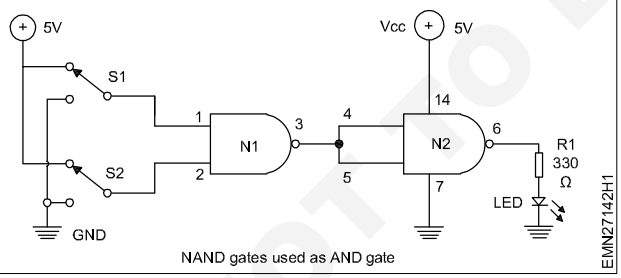
2 **The condition of LED ON as Logic '1' and OFF as logic '0'.**

PROCEDURE

TASK 1 : **Construction of AND gate circuit using NAND gate IC 7400 and verification of its truth table**

1 Collect all the components, check them, refer to the data sheet of the IC 7400, assemble the AND gate as shown in Fig 1 on the bread board.

Fig 1



NAND gates used as AND gate

2 Use toggle switches S_1 as input A and switch S_2 as input B.

3 Get the assembled circuit checked by the Instructor.

4 Switch ON 5VDC supply and operate switches S_1 & S_2 for different logic levels either in 5V position or zero volt position as shown in Table 1.

5 Observe the LED for each step of combinations, record the observations in Table 1.

AND gate Truth table

Sl.No.	Input		Output Y=A.B
	A S_1	B S_2	
1	0	0	0
2	0	1	0
3	1	0	0
4	1	1	1

Table 1

Sl.No.	Input		Output LED Condition
	A S_1	B S_2	
1			
2			
3			
4			

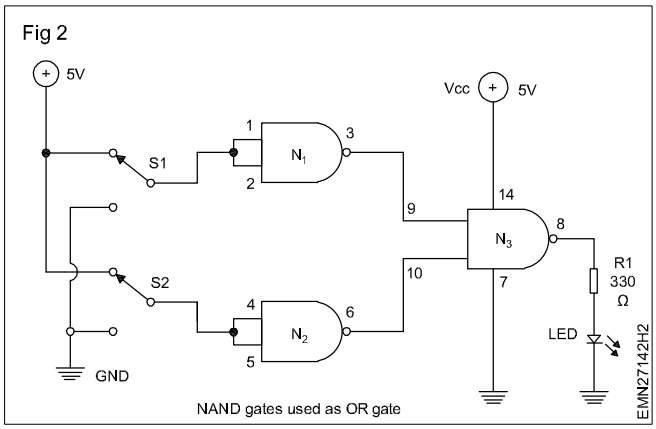
6 Get the work checked by the Instructor.

– – – – – – –

TASK 2 : **Construction of OR gate circuit using NAND gate and verification of its truth table**

1 Rearrange the connections and assemble the OR gate circuit using NAND gates as shown in Fig 2 on bread board.

Fig 2



NAND gates used as OR gate

2 Repeat steps 2 to 5 of Task 1 and record the observations in Table 2.

3 Verify the readings with the truth table of OR gate.

4 Get the work checked by the Instructor.

Note: Use logic probe to check the status of each pin to confirm the functioning of each gate.

OR gate Truth table

Sl.No.	Input		Output Y=A+B
	A	B	
1	0	0	0
2	0	1	1
3	1	0	1
4	1	1	1

Table 2

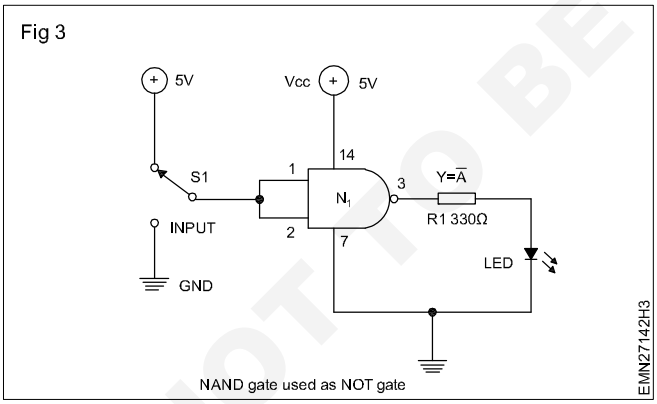
Sl.No.	Input		Output LED
	A	B	
1			
2			
3			
4			

– – – – – – –

TASK 3: **Construction of NOT gate circuit using NAND gate and verification of its truth table**

1 Rearrange the connections and assemble the NOT gate circuit using NAND gates as shown in Fig 3 on bread board.

Fig 3



NAND gate used as NOT gate

2 Use toggle switch S_1 as input A.

3 Repeat steps 3 to 5 of Task 1 and record the observations in Table 3.

4 Get the work checked by the Instructor.

NOT gate Truth table

Sl.No.	Input	Output
	A	Y=$\overline{A}$
1	0	1
2	1	0

Table 3

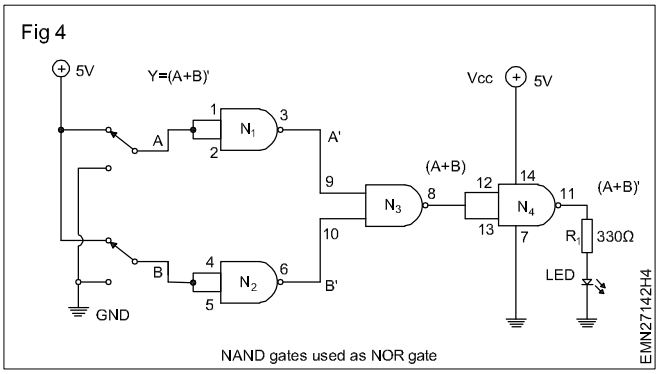
Sl.No.	Input	Output LED
	A	
1	0	
2	1	

– – – – – – –

TASK 4 : **Construction of NOR gate circuit using NAND gate and verification of its truth table**

1 Rearrange the connections and assemble the NOR gate circuit using NAND gates as shown in Fig 4 on bread board.

Fig 4



NAND gates used as NOR gate

2 Repeat steps 2 to 5 of Task 1, and record the observations in Table 4.

3 Verify the readings with the truth table of NOR gate.

4 Get the work checked by the Instructor.

Note: Use logic probe to check the status of each pin to confirm the functioning of each gate.

NOR gate Truth table

Sl.No.	Input		Output
	A	B	$Y=\overline{A+B}$
1	0	0	1
2	0	1	0
3	1	0	0
4	1	1	0

Table 4

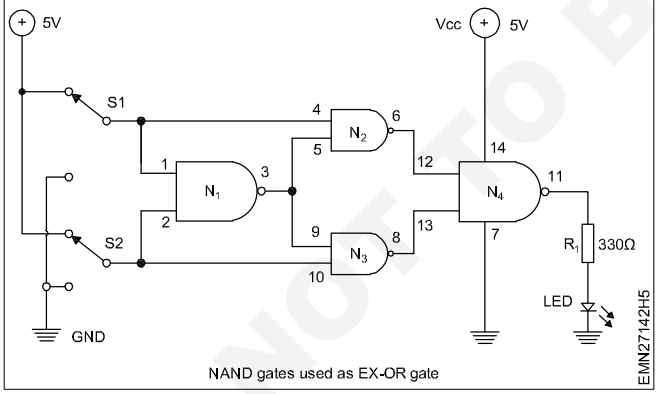
Sl.No.	Input		Output LED
	A	B	
1			
2			
3			
4			

– – – – – – –

TASK 5 : **Construction of EX-OR gate circuit using NAND gate and verification of its truth table**

1 Rearrange the connections and assemble the EX-OR gate circuit using NAND gates as shown in Fig 5 on bread board.

Fig 5



NAND gates used as EX-OR gate

2 Repeat steps 2 to 5 of Task 1, and record the observations in Table 5.

3 Verify the readings with the truth table of EX-OR gate.

4 Get the work checked by the Instructor.

Note: Use logic probe to check the status of each pin to confirm the functioning of each gate.

EX-OR gate Truth table

Sl.No.	Input		Output $Y=A \oplus B$
	A	B	
1	0	0	0
2	0	1	1
3	1	0	1
4	1	1	0

Table 5

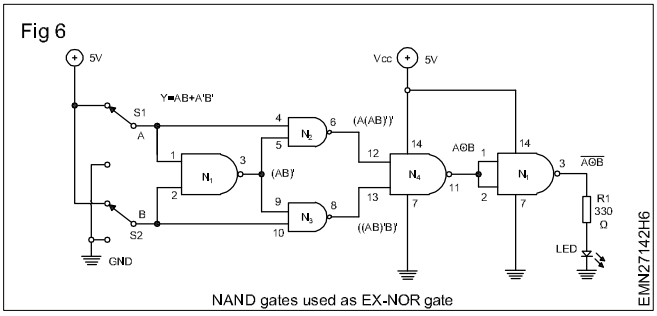
Sl.No.	Input		Output LED
	A	B	
1			
2			
3			
4			

– – – – – – –

TASK 6 : **Construction of EX-NOR gate circuit using NAND gate and verification of its truth table**

1 Rearrange the connections and assemble the EX-NOR gate circuit using NAND gates as shown in Fig 6 on bread board.

Fig 6



NAND gates used as EX-NOR gate

2 Repeat steps 2 to 5 of Task 1, and record the observations in Table 6.

3 Verify the readings with the truth table of EX-NOR gate.

4 Get the work checked by the Instructor.

Note: Use logic probe to check the status of each pin to confirm the functioning of each gate.

EX-NOR gate Truth table

Sl.No.	Input		Output $Y=\overline{A \oplus B}$
	A	B	
1	0	0	
2	0	1	
3	1	0	
4	1	1	

Table 6

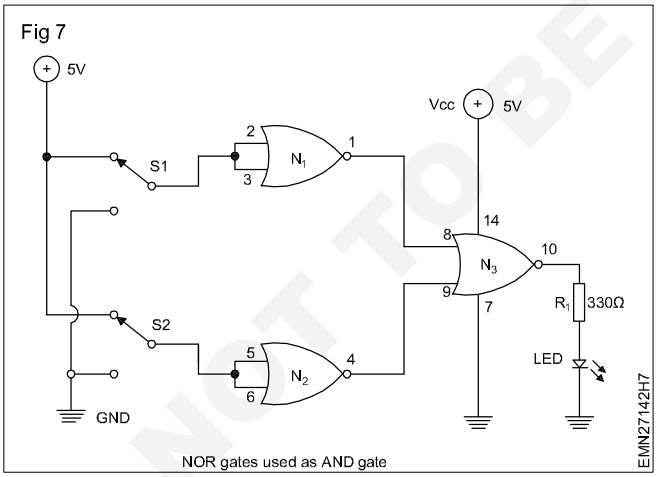
Sl.No.	Input		Output LED
	A	B	
1			
2			
3			
4			

– – – – – – –

TASK 7 : **Construction of AND gate using NOR gate IC 7402 and verification of its truth table**

1 Collect all the components, check them, refer to the data sheet of the IC 7402, assemble the AND gate as shown in Fig 7 on the bread board.

Fig 7



NOR gates used as AND gate

2 Repeat steps 2 to 5 of Task 1, and record the observations in Table 7.

3 Verify the readings with the truth table of AND gate.

4 Get the work checked by the Instructor.

Note: Use logic probe to check the status of each pin to confirm the functioning of each gate.

AND gate Truth table

Sl.No.	Input		Output Y=A.B
	A	B	
1	0	0	0
2	0	1	0
3	1	0	0
4	1	1	1

Table 7

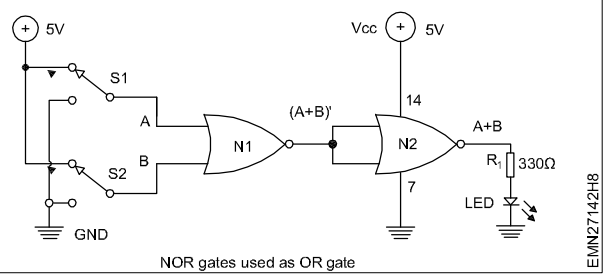
Sl.No.	Input		Output LED
	A	B	
1			
2			
3			
4			

– – – – – – –

TASK 8 : **Construction of OR gate using NOR gate IC 7402 and verification of its truth table**

1 Collect all the components, check them, refer to the data sheet of the IC 7402, assemble the OR gate as shown in Fig 8 on the bread board.

Fig 8



NOR gates used as OR gate

2 Repeat steps 2 to 5 of Task 1, and record the observations in Table 8.

3 Verify the readings with the truth table of OR gate.

4 Get the work checked by the Instructor.

Note: Use logic probe to check the status of each pin to confirm the functioning of each gate.

OR gate Truth table

Sl.No.	Input		Output Y=A+B
	A	B	
1	0	0	0
2	0	1	1
3	1	0	1
4	1	1	1

Table 8

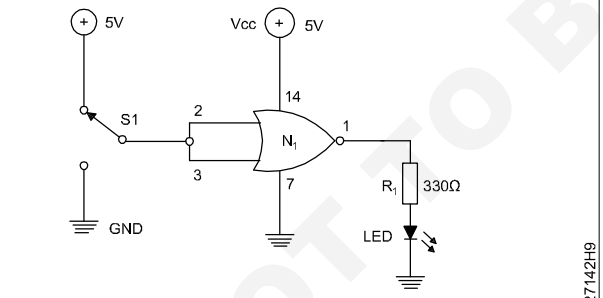
Sl.No.	Input		Output LED
	A	B	
1			
2			
3			
4			

– – – – – – –

TASK 9 : **Construction of NOT gate using NOR gate IC 7402 and verification of its truth table**

1 Collect all the components, check them, refer to the data sheet of the IC 7402, assemble the NOT gate as shown in Fig 9 on the bread board.

Fig 9



2 Repeat steps 2 to 5 of Task 9, and record the observations in Table 9.

3 Verify the readings with the truth table of NOT gate.

4 Get the work checked by the Instructor.

NOT gate Truth table

Sl.No.	Input	Output $Y=\overline{A}$
	A	
1	0	1
2	1	0

Table 9

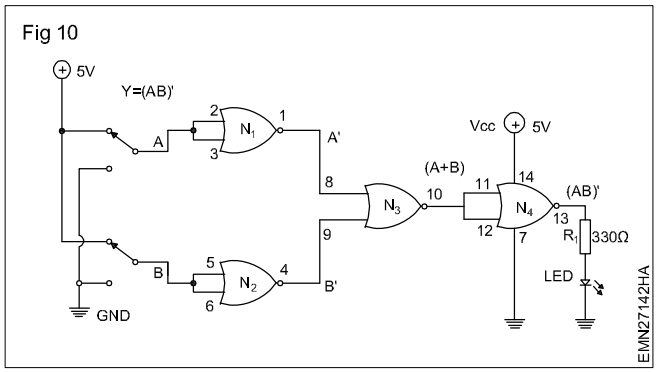
Sl.No.	Input	Output LED
	A	
1		
2		

– – – – – – –

TASK 10 : **Construction of NAND gate using NOR gate IC 7402 and verification of its truth table**

1 Collect all the components, check them, refer to the data sheet of the IC 7402, assemble the NAND gate as shown in Fig 10 on the bread board.

Fig 10



2 Repeat steps 2 to 5 of Task 9, and record the observations in Table 10.

3 Verify the readings with the truth table of NAND gate.

4 Get the work checked by the Instructor.

Note: Use logic probe to check the status of each pin to confirm the functioning of each gate.

NAND gate Truth table

Sl.No.	Input		Output $\overline{Y=A.B}$
	A	B	
1	0	0	1
2	0	1	1
3	1	0	1
4	1	1	0

Table 10

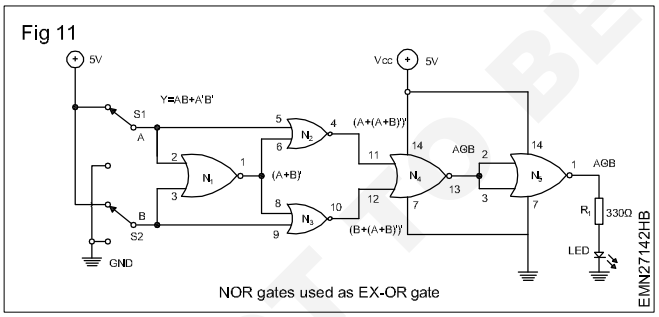
Sl.No.	Input		Output LED
	A	B	
1			
2			
3			
4			

– – – – – – –

TASK 11 : **Construction of EX-OR gate using NOR gate IC 7402 and verification of its truth table**

1 Collect all the components, check them, refer to the data sheet of the IC 7402, assemble the EX-OR gate as shown in Fig 11 on the bread board.

Fig 11



2 Repeat steps 2 to 5 of Task 9, and record the observations in Table 11.

3 Verify the readings with the truth table of EX-OR gate.

4 Get the work checked by the Instructor.

Note: Use logic probe to check the status of each pin to confirm the functioning of each gate.

EX-OR gate Truth table

Sl.No.	Input		Output Y=A⊕B
	A	B	
1	0	0	0
2	0	1	1
3	1	0	1
4	1	1	0

Table 11

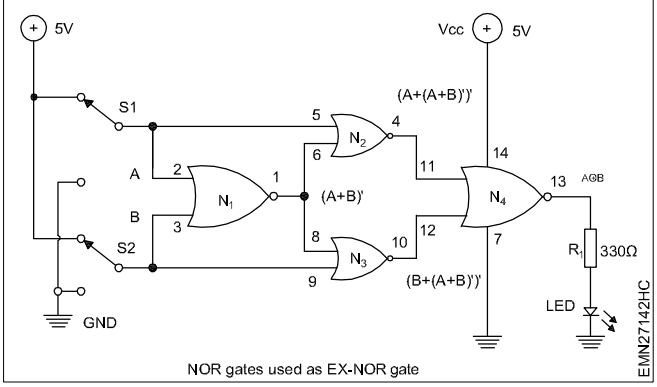
Sl.No.	Input		Output LED
	A	B	
1			
2			
3			
4			

– – – – – – –

TASK 12 : **Construction of EX-NOR gate using NOR gate IC 7402 and verification of its truth table**

1 Collect all the components, check them, refer to the data sheet of the IC 7402, assemble the EX-NOR gate as shown in Fig 12 on the bread board.

Fig 12



NOR gates used as EX-NOR gate

2 Repeat steps 2 to 5 of Task 9, and record the observations in Table 12.

3 Verify the readings with the truth table of EX-NOR gate.

4 Get the work checked by the Instructor.

Note: Use logic probe to check the status of each pin to confirm the functioning of each gate.

EX-NOR gate Truth table

Sl.No.	Input		Output $Y=\overline{A \oplus B}$
	A	B	
1	0	0	1
2	0	1	0
3	1	0	0
4	1	1	1

Table 12

Sl.No.	Input		Output LED
	A	B	
1			
2			
3			
4			

– – – – – – –

Use digital IC tester to test various digital ICs (TTL and CMOS)

Objectives: At the end of this exercise you shall be able to

- **identify the IC manufacturers' names from the logo given on the IC and manufacturers data**
- **identify IC code number printed on the given digital IC**
- **identify the type of package of the given digital IC (TTL and CMOS)**
- **identify the logic family of the given digital IC referring databook**
- **identify the pin numbers of the given Digital IC referring data book**
- **test the given IC using digital IC tester.**

Requirements

Tools/Equipments/Instruments/Data manual

- Digital IC databook - 1 No
- Digital IC tester with manual - 1 No
- DMM with probes - 1 No

Materials/Components

- Assorted Digital ICs (both TTL and CMOS types) - 10 Nos
- Breadboard - 1 No
- Hook up wires - as reqd

Note: The Instructor has to label all the ICs serially

Keep a minimum of 20 numbers of assorted labeled TTL and CMOS ICs for these exercise. Instruct the trainees to pick one IC at a time and carryout the exercise.

Demonstrate setting the controls and testing ICs using digital IC tester. No detailed procedure for using IC tester is given as different IC testers used in different institutes may have different operating procedures and specification.

PROCEDURE

1 Identify operator controls, switches and IC socket on the digital IC tester as shown in Fig 1 with reference to the manual.

2 Pick one of the labeled IC from the assorted lot and record its label number.

3 Refer to the data manual interpret the manufacturer's logo given on the IC or alphabets used for the IC type identify and record the details in Table 1.

4 Identify and record the logic family supply voltage and function of the IC referring the data manual.

5 Count and record the number of pins on the IC.

6 As demonstrated by the instructor, test and record the condition of the IC using digital IC tester for atleast 10 different ICs both in TTL and CMOS types.

Note: Follow the procedure demonstrated by the instructor for setting the controls on digital IC tester while testing the IC.

7 Get the recorded information checked by the instructor for 10 different ICs.

– – – – – – –

TABLE 1

Sl. No.	Label No. IC	Code No. of IC	No.of pins	Logic family	Function	Package type	Maximum V_{cc} voltage	Condion of IC tested
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								

Construct Half Adder circuit using ICs and verify the truth table

Objectives: At the end of this exercise you shall be able to
- **construct the half adder circuit and verify the truth table.**

Requirements

Tools/Equipments/Instruments

- Soldering iron 25W/230V - 1 No
- Logic probe - 1 No
- Trainees tool kit - 1 Set
- Regulated DC power supply 0-30V/2A - 1 No
- Digital multimeter with probes - 1 No

Materials/Components

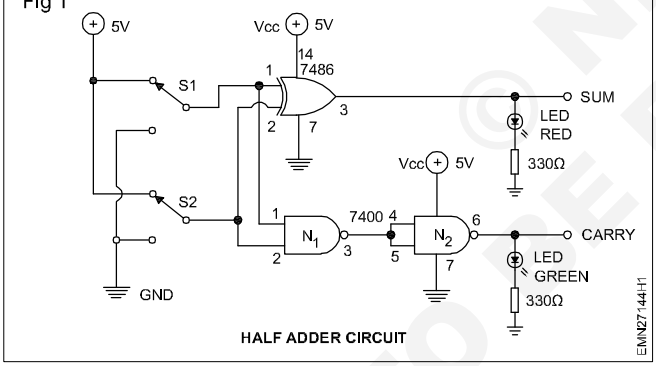
- IC-7486 with base - 1 No
- IC-7400 with base - 1 No
- Data sheet of ICs used - 1 No each
- LED 5mm Red, Green - 2 Nos
- Resistor 330Ω/¼ W/CR25 - 2 Nos
- Miniature toggle switch SPDT - 3 Nos
- Breadboard - 1 No
- Solder, flux - as reqd
- Hook up wires - as reqd

PROCEDURE

Construction of Half Adder circuit and verification of truth table

1 Collect all the components, check them and assemble the Half adder circuit as shown in Fig 1on breadboard.

Fig 1



Use 14 pin IC base on the bread board for this task.

2 Use toggle switch S_1 as input A and switch S_2 as input B.

3 Get the assembled circuit checked by the Instructor.

4 Switch ON 5VDC supply and operate switches S1 & S2 for different logic levels either in 5V position for zero volt (GND) position as shown in Table 1.

5 Observe the LEDs for each step of combinations, record your observations in Table 1.

6 Verify readings with truth table of Half Adder.

Use logic probe to check the status of each pin to confirm the functioning of the gate.

Truth Table of Half Adder

Sl. No.	Input		Output	
	A	B	Sum	Carry
1	0	0	0	0
2	0	1	1	0
3	1	0	1	0
4	1	1	0	1

Table 1

Sl. No.	Input		Output LED	
	A	B	Red (Sum)	Green (carry)
1				
2				
3				
4				

7 Get the work checked by the instructor.

– – – – – – –

Construct Full adder with two Half adder circuit using ICs and verify the truth table

Objectives: At the end of this exercise you shall be able to
- **construct and test full adder using half adder circuits.**

Requirements

Tools/Equipments/Instruments

• Soldering iron 25W/230V	- 1 No
• Logic probe	- 1 No
• Trainees tool kit	- 1 Set
• Regulated DC power supply 0-30V/2A	- 1 No
• Digital multimeter with probes	- 1 No

Materials/Components

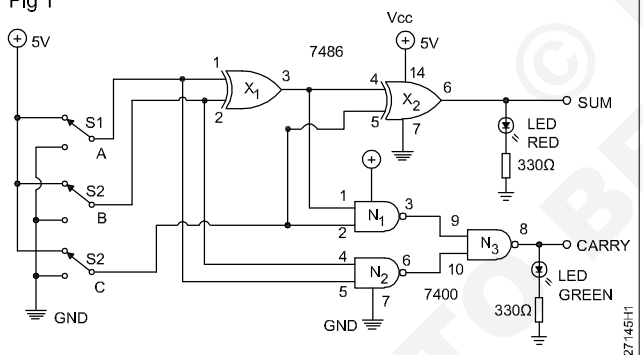
• IC-7486 with base	- 1 No
• IC-7400 with base	- 1 No
• Data sheet of ICs used	- as reqd
• LED 5mm Red, Green	- 1 No each
• Resistor 330Ω/¼ W/CR25	- 2 Nos
• Miniature toggle switch SPDT	- 3 Nos
• Breadboard	- 1 No
• Solder, flux	- as reqd
• Hook up wires	- as reqd

PROCEDURE

Construction of Full Adder using two Half Adder circuits and verification of truth table

1 Collect all the components, check them and assemble the Full adder circuit as shown in Fig 1on breadboard.

Fig 1



FULL ADDER CIRCUIT

2 Use toggle switch S_1 as input A and switch S_2 as input B and switch S_3 as input C.

3 Get the assembled circuit checked by the Instructor.

4 Switch ON 5VDC supply and operate all the switches for different logic levels either in 5V position for zero volt (GND) position as shown in Table 1.

5 Observe the LEDs for each step of combinations, record the observations in Table 1.

6 Verify readings with truth table of Half Adder.

Note: Use logic probe to check the status of each pin to confirm the functioning of the gate.

Truth table of Full Adder

Sl. No.	Input			Output	
	A	B	C	Sum	Carry
1	0	0	0		
2	0	0	1		
3	0	1	0		
4	0	1	1		
5	1	0	0		
6	1	0	1		
7	1	1	0		
8	1	1	1		

Table 1

Sl. No.	Input			Output	
	A	B	C	Sum	Carry
1					
2					
3					
4					
5					
6					
7					
8					

7 Get the work checked by the instructor.

Construct the adder cum subtract or circuit and verify the result

Objectives: At the end of this exercise you shall be able to
- **construct a 4 bit binary adder circuit using IC 7483, IC7486 and verify the result**
- **construct a 4 bit binary subtractor circuit using IC7483, IC7486 and verify the result.**

Requirements

Tools/Equipments/Instruments

- Soldering iron 25W/230V - 1 No
- Trainees tool kit - 1 Set
- Regulated DC power supply 0-30V/2A - 1 No
- Digital multimeter with probes - 1 No
- Logic probe - 1 No
- Data sheet of ICs used - as reqd

Materials/Components

- Miniature toggle switch SPDT - 3 Nos
- IC-7486 with base (14 pin) - 1 No
- IC-7483 with base (16 pin) - 1 No
- Breadboard - 1 No
- Solder, flux - as reqd
- Connecting wires - as reqd
- Resistor 330Ω ¼ W/CR25 - 2 Nos
- Hook up wires - as reqd
- LED 5mm, Red - 4 Nos
- LED 5mm, Green - 1 No
- Resistor 330Ω/¼ W/CR25 - 5 Nos

PROCEDURE

TASK 1: **Construction and testing of 4 bit binary adder circuit**

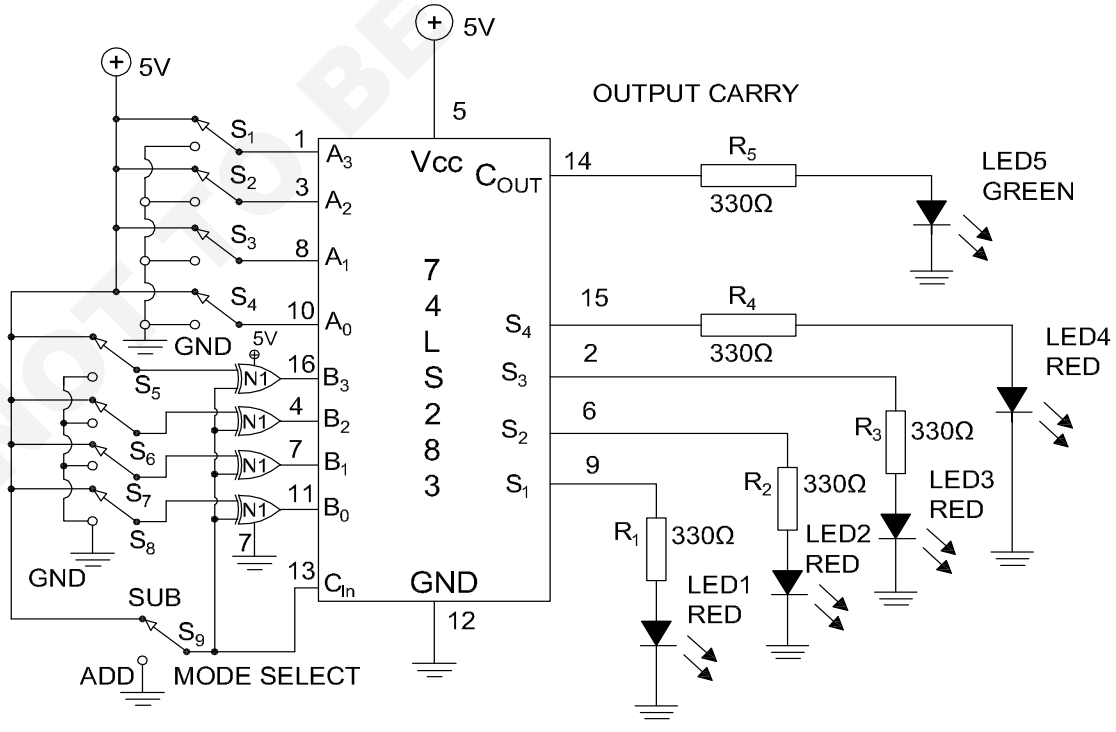
1 Collect all the components required, test them refer to the data sheet of ICs, assemble the 4 bit binary adder circuit as shown in Fig 1 on bread board.

2 Use toggle switch S_1 as data input A_0, switch S_2 as data input A_1, and switch S_3 as data input A_2, and switch S_4 as data input A_3 as shown in Fig 1.

3 Use toogle switch S_5 as data input B_0, switch S_6 as data input B_1, and switch S_7 as data input B_2, and switch S_8 as data input B_3 and switch S_9 as mode select switch as shown in Fig 1.

4 Get the assembled circuit checked by the Instructor.

Fig 1



4 BIT BINARY ADDER CUM SUBTRACTOR CIRCUIT

EMN27146H1

5 Switch ON 5VDC supply and operate switches S_1 to S_8 for different logic levels either in 5V position or zero volt (GND) position keeping the switch S_9 at END positon to operate the circuit as 4 bit binary adder as shown in Table 1.

6 Observe the status of all the five LEDs for each step of combinations record them in Table 1.

Table 1

Sl.No	Inputs				Inputs					Mode switch=OV					Mode switch=5V				
										Status of LEDs					Status of LED				
	A_3	A_2	A_1	A_0	B_3	B_2	B_1	B_0	$Carry_{out}$	Q_3	Q_2	Q_1	Q_0	C_{out}	Q_3	Q_2	Q_1	Q_0	$Carry_{out}$
1																			
2																			
3																			
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11																			
12																			
13																			
14																			
15																			
16																			

7 Get the work checked by the Instructor.

– – – – – – –

TASK 2: **Construction and testing of 4 bit binary subtract or circuit**

Use the assembled circuit for 4 bit binary subtract or function/operation with following steps.

1 Set/toggle the mode select switch S_9 to 5VDC position (Logic '1')

2 Switch ON 5VDC supply and operate switches S1 to S8 for different logic levels either in 5V position or zero volt (GND) position as shown in Table 1.

3 Observe the status of all the five LEDs for each step of combinations and record them in Table 1.

4 Get the work checked by the Instructor.

– – – – – – –

Construct and test a 2 to 4 Decoder

Objectives : At the end of this exercise you shall be able to
- **construct a 2 to 4 decoder using AND, NOT gates and verify the truth table.**

Requirements

Tools/Equipments/Instruments

- Logic probe - 1 No
- Trainees tool kit - 1 Set
- Regulated DC power supply 0-30V/2A - 1 No
- Soldering iron 25W/230V - 1 No
- Digital multimeter with probes - 1 No
- Data sheet of ICs used - as reqd

Materials/Components

- Rosin cored solder - as reqd
- Miniature toggles - 2 Nos
- 14 pin IC Base Switch SPDT - 2 Nos
- Breadboard - 1 No
- IC-7404 - 1 No
- IC-7408 - 1 No
- LED 5mm, Red - 4 Nos
- Resistor 330Ω/¼ W/CR25 - 4 Nos

Note:

1 The Instructor has to guide the trainees to record 5VDC given to gate input as Logic High (1) and GND as Logic Low (0).

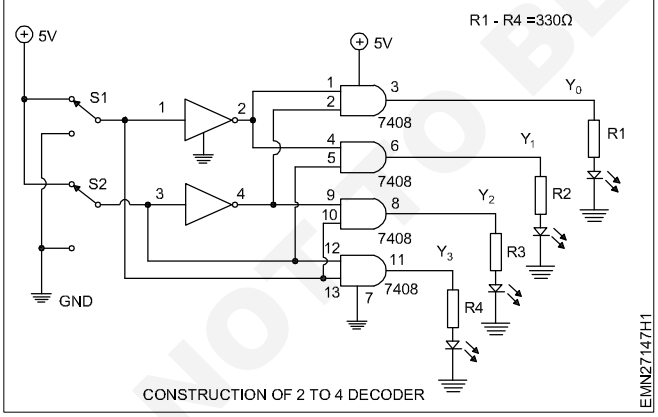
2 The status of LED ON as Logic '1' and 'OFF' as Logic '0'.

PROCEDURE

TASK 1 : **Construction of 2 to 4 decoder circuit and verification of truth table**

1 Collect all the components, check them, refer to the data sheet of the ICs assemble the 2 to 4 decoder circuit as shown in Fig 1 on breadboard.

Fig 1



CONSTRUCTION OF 2 TO 4 DECODER

2 Use toggle switch S_1 as input A and switch S_2 as input B.

3 Get the assembled circuit checked by the Instructor.

4 Switch ON 5VDC supply and operate switches S_1 & S_2 for different logic levels either in 5V position or zero volt (GND) position as shown in Table - 1.

5 Observe the status of LEDs for each step of combinations and record the observations in Table - 1.

Table 1

Sl. No	INPUT		OUTPUT LED Status			
	A	B	Y0	Y1	Y2	Y3
1	0	0				
2	0	1				
3	1	0				
4	1	1				

2 to 4 Decoder TRUTH TABLE:

Sl. No	INPUT		OUTPUT LED Status			
	A	B	Y0	Y1	Y2	Y3
1	0	0	1	0	0	0
2	0	1	0	1	0	1
3	1	0	0	0	1	0
4	1	1	0	0	0	1

6 Verify the readings on the Table with the Truth table of 2 to 4 Decoder Truth table given.

7 Get the work checked by the Instructor.

Construct and test a 4 to 2 Encoder

Objectives : At the end of this exercise you shall be able to
- **construct and test 4 to 2 Encoder.**

Requirements

Tools/Equipments/Instruments

- Soldering iron 25W/230V - 1 No
- Trainees tool kit - 1 Set
- DC power supply 0-30V/2A - 1 No
- Digital multimeter with probes - 1 No
- Data sheet of ICs used - as reqd

Materials/Components

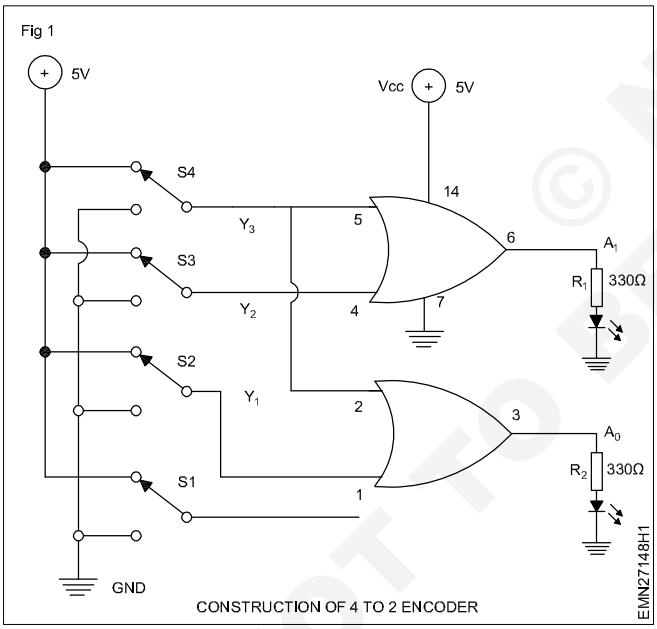
- Miniature toggles Switch SPDT - 4 Nos
- Breadboard - 1 No
- IC-7432 - 1 No
- LED 5mm, Red, Green - 1 No each
- Hook up wires - as reqd
- Rosin cored solder - as reqd
- Resistor 330Ω/¼ W/CR25 - 2 Nos

PROCEDURE

TASK 1: **Construction of 4 to 2 Encoder circuit and verification of its truth table**

1 Collect all the components, check them and assemble the 4 to 2 Encoder circuit as shown in Fig 1 on bread board.

Fig 1



CONSTRUCTION OF 4 TO 2 ENCODER

2 Use toggle switch S_1 as input Y_0, switch S_2 as input Y_1, switch S_3 as input Y_2 and switch S_4 as input Y_3.

In the 4 to 2 Encoder using OR gates note that the switch S_1 is kept unconnected to the input, as neither of the outputs depend on it.

3 Get the assembled circuit checked by the Instructor.

4 Switch ON 5VDC supply, and operate switches S_2, S_3 and S_4 only for different logic levels either in 5V position or zero volt (GND) position as shown in Table - 1.

Table 1

Sl. No	INPUT				OUTPUT	
	Y3	Y2	Y1	Y0	A1	A0
1	0	0	0	1		
2	0	0	1	0		
3	0	1	0	0		
4	1	0	0	0		

2 to 4 Decoder TRUTH TABLE:

Sl. No	INPUT				OUTPUT	
	Y3	Y2	Y1	Y0	A1	A0
1	0	0	0	1	0	0
2	0	0	1	0	0	1
3	0	1	0	0	1	0
4	1	0	0	0	1	1

5 Observe the status of LEDs for each step of combinations and record your observations in Table - 1.

6 Verify the readings on the Table with the Truth table of 4 to 2 Encoder given.

7 Get the work checked by the Instructor.

Construct and test a 4 to 1 Multiplexer

Objectives : At the end of this exercise= you shall be able to
- **construct and test 4 to 1 multiplexer circuit using IC74LS151.**

Requirements

Tools/Equipments/Instruments

- Soldering iron 25W/230V - 1 No
- Trainees tool kit - 1 Set
- Regulated DC power supply 0-30V/2A - 1 No
- Digital multimeter with probes - 1 No

Materials/Components

- Rosin cored solder - as reqd
- IC-74LS151 - 1 No
- IC 7432 IC base - 1 No
- Digital IC trainer kit with instruction manual - 1 No
- Resistor 330Ω/¼ W/CR25 - 2 Nos
- Bread board - 1 No
- LED 5mm, Red - 1 No
- Hook up wires - as reqd
- Miniature SPDT toggle switch - 6 Nos
- Data sheet of IC 74LS151 - 1 No

Safety Precaution: Ensure that the IC pins are not bent while inserting into the bread board IC Base.

PROCEDURE

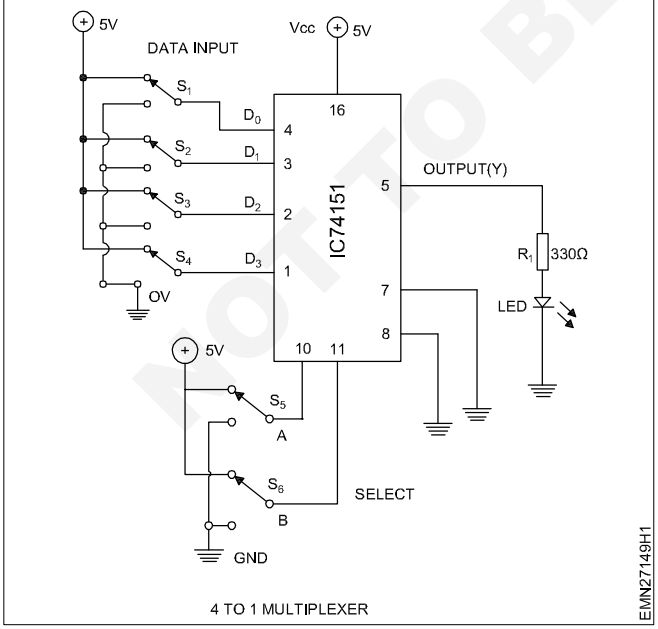
Note: If the digital IC trainer kit is not available in the lab, follow the steps given for this exercise .

TASK 1 : **Construction and testing of 4 to 1 multiplexer circuit using IC 74LS151**

1 Collect the components required, check them and assemble the multimeter circuit as shown in Fig 1 on breadborad.

Use the 16 pin IC base for IC74LS151.

Fig 1



4 TO 1 MULTIPLEXER

2 Use toggle switches either in 5V position or in Zero Volt position for different logic levels as shown in Table-1.

3 Get the assembled multiplexer circuit checked by the Instructor.

4 Switch ON the 5VDC supply to the circuit and operate switches S1 to S4 for Data inputs and S5 & S6 for selection Sequence.

5 Observe the LED for each setting and record it in Table 1.

Note: When data input is not available, multiplexer does not produce output for the select condition.

6 Verify the output by keeping data input switches S1 to S4 in 5VDC position and select S5 & S6 randomly.

7 Observe the LED and change Data input switches one at a time for the LED to go OFF.

It confirms that input is selected and goes to the output.

8 Repeat steps 6 & 7 with different combinations of S5 & S6 and confirm the Data selected.

Table 1

Sl. No.	DATA INPUTS (LOGIC LEVELS)				SELECT SEQUENCE		LED OUTPUT (Y)
	D3	D2	D1	D0	B	A	
1	0	0	0	1	0	0	D0-LED ON
2	0	0	1	0	0	1	D1-LED ON
3	0	1	0	0	1	0	D2-LED ON
4	1	0	0	0	1	1	D3-LED ON
5	1	1	1	1			

9 Get the work checked by the Instructor.

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Construct and test a 1 to 4 Demultiplexer

Objectives : At the end of this exercise you shall be able to
- **construct and test a 1 to 4 demultiplexer circuit using IC 74LS138.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Regulated DC power supply 0-30V/2A - 1 No
- Digital multimeter with probes - 1 No
- Soldering iron 25W/230V - 1 No
- Digital IC trainer kit with instruction manual - 1 Set

Materials/Components

- IC-74LS138 with data sheet - 1 No
- 16 pin IC Base - 1 No
- LED 5mm, Red, Green - 4 Nos
- Resistors 330Ω/¼W/CR25 - 4 Nos
- Hook up wires - as reqd
- Breadboard - 1 No
- Rosin cored solder - as reqd

Note: If the digital IC trainer hit is not available in the lab, follow the steps given for this exercise.

PROCEDURE

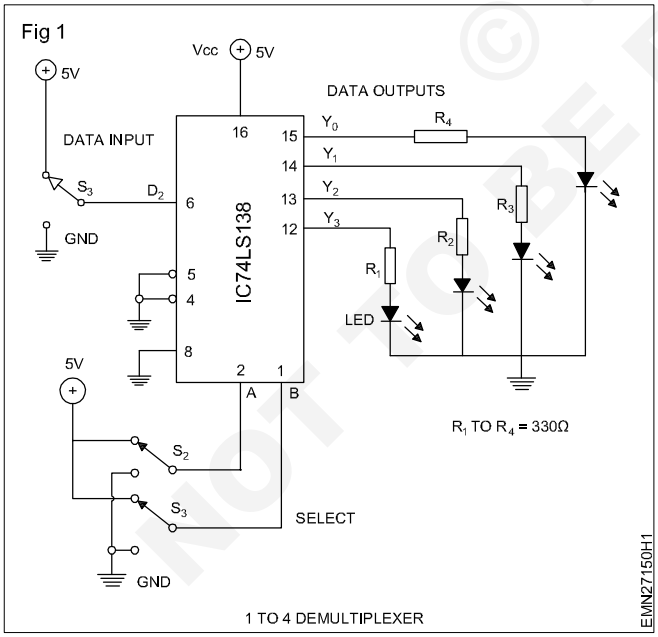
TASK 1 : **Construction and testing of 1 to 4 Demultiplexer circuit using IC74LS138**

1 Collect all the components check them and assemble the demultiplexer as shown in Fig 1 on breadboard.

Use the 16 pin base for IC74LS138.

2 Connect the toggle switch at input as shown in the circuit

Fig 1



3 Get the assembled circuit checked by the Instructor.

4 Switch ON the 5VDC supply to the circuit, Keep S1 at + 5VDC for the data input high. Change the settings of switches S2 and S3 for different combination of Data select sequence as shown in Table -1.

5 Observe the LEDs for each setting and record the status in Table -1

Note: When data input is not available, Demultiplexer does not produce output for that condition in any of the Data output pins.

6 Verify the output by keeping the Data input switch S1 to ground, Select Switch S2 & S3 randomly.

7 Observe the LED, Change switches S2 & S3 to other three combinations, for whether any of the LEDs to glow.

8 Repeat steps 6 and 7 by keeping the switch S1 at +5VDC and confirm the LEDs are glowing independently as per the selection sequence in Table -1

Table 1

Sl. No.	Selection Sequence		Output channels(Pin Nos.) LED ON =1 LED OFF = 0								Remarks
	A	B	Y0 pin 15	Y1 pin 14	Y2 pin 13	Y3 pin 12	Y0 LED	Y1 LED	Y2 LED	Y3 LED	
1											
2											
3											
4											
5											

9 Get the work checked by the Instructor.

– – – – – – –

Identify different Flip-Flop ICs by the number printed on them

Objectives : At the end of this exercise you shall be able to
- **identify different Flip Flop by the number printed on the ICs.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set

Aids: Data sheet of ICs used for this exercise

Materials/Components

- 74 LS 73
  74 LS 74
  74 LS 76
  74 LS 107
  74 LS 109
  - 1 No each

Note: Instructor has to label the different types of logic gates ICs.

PROCEDURE

1 Collect the labelled flipflop ICs from the Instructor

2 Pick one of the IC from the lot, and identify the code number printed on the IC and noted in Table -1

3 Refer to the data sheet of the IC, draw the pinout diagram and mark the details in Table 1.

4 Repeat the steps 2 and 3 for remaining labelled logic gates.

Note:

1 The Instructor has to provide/ensure the Flipflop ICs with their number printed on them is clearly visible.

2 Insert all the ICs on the breadboard.

Safety Precaution: Do not touch the pins of ICs with fingers.

Table 1

Sl.No.	IC Number	Logic gates function	Symbol	Pinout diagram
1		74LS73		
2		74LS74		
3		74LS76		
4		74LS107		
5		74LS109		

5 Get the work checked by the Instructor.

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Construct and test four bit latch using 7475

Objectives : At the end of this exercise you shall be able to
- **Construct and test four bit latch using IC 7475**

Requirements

Tools/Equipments/Instruments

• Trainees tool kit	- 1 Set
• Regulated DC power supply 0-30V/2A	- 1 No
• Digital multimeter with probes	- 1 No
• Data sheet of IC7475	- 1 No

Materials/Components

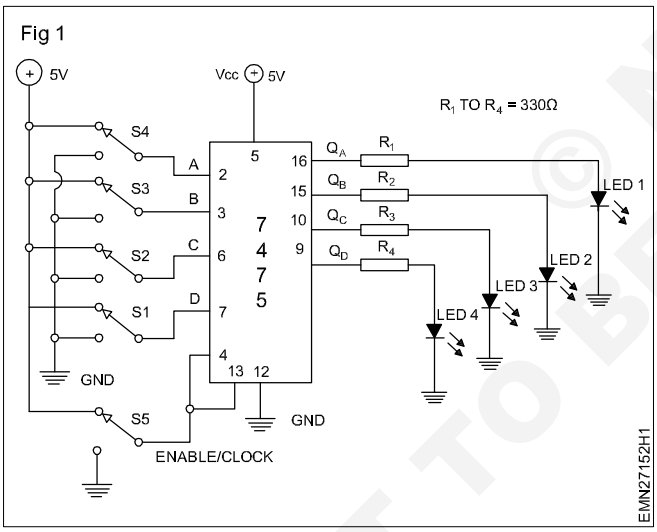
• Breadboard	- 1 No
• IC-7475 (D-Latch) with base	- 1 No
• LED 5mm, Red	- 4 Nos
• Resistors 330Ω/¼ W/CR25	- 4 Nos
• Miniature toggle Switch SPDT	- 5 Nos
• Hook up wires	-as reqd

PROCEDURE

TASK 1 : **Construction and testing of four bit batch circuit using IC7475**

1 Collect all the components, check them refer to the data sheet of the IC, assemble the 4 bit latch circuit as shown in Fig 1 on breadboard.

Fig 1



Use the 16 pin IC base on the breadboard for this exercise.

2 Use toggle switch S_1 as data input A, switch S_2 as data input B, switch S_3 as data input C, switch S_4 as data input D and switch S_5 as Enable/clock input.

3 Get the assembled circuit checked by the Instructor.

4 Switch ON 5VDC supply and operate switches S_1 to S_5 for different logic levels either in 5V position or zero volt (GND) position as shown in Table - 1.

5 Observe the LEDs for each step of combinations, record them in Table 1.

Table 1

Sl.No	Inputs				Enable/clock =1 Output LEDs				Enable/clock =0 Output LEDs			
	A	B	C	D	Q_A	Q_B	Q_C	Q_D	Q_A	Q_B	Q_C	Q_D
1	0	0	0	0								
2	0	0	0	1								
3	0	0	1	0								
4	0	0	1	1								
5	0	1	0	0								
6	0	1	0	1								
7	0	1	1	0								
8	0	1	1	1								
9	1	0	0	0								
10	1	0	0	1								
11	1	0	1	0								
12	1	0	1	1								
13	1	1	0	0								
14	1	1	0	1								
15	1	1	1	0								
16	1	1	1	1								

6 Get the work checked by the Instructor.

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Construct and test R-S Flip-flop using IC 7400 with clock and without clock pulse

Objectives: At the end of this exercise you shall be able to
- **construct and test R-S flip-flop using IC 7400 without clock pulse**
- **construct and test RD flip-flop with clock pulse.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- DC power supply 0-30VDC/2A - 1 No
- Digital multimeter with probes - 1 No

Materials/Components

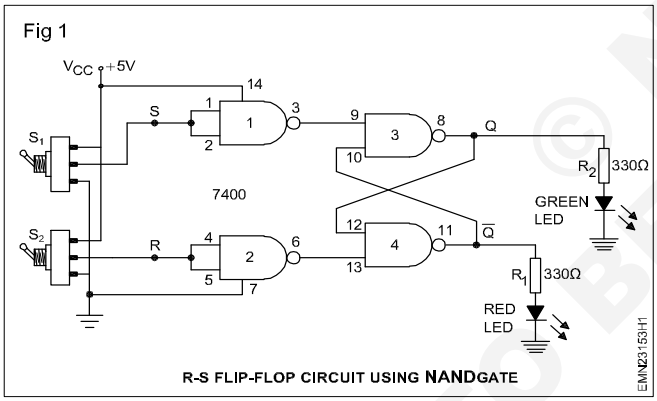
- Breadboard - 1 No
- IC-7400 NAND gate with data sheet - 1 No
- Miniature toggles switch - 2 Nos
- Hook up wires - as reqd
- LED 5mm, Red, Green - 1 No each
- Resistor 330Ω/¼ W/CR25 - 2 Nos

PROCEDURE

TASK 1: **Construction and testing of R-S Flip-Flop without clock pulse using IC 7400**

1 Collect all the components required, check them and assemble the RS flipflop circuit on the breadboard as shown in Fig 1

Fig 1



2 Get the assembled RS flipflop circuit checked by the Instructor.

3 Switch ON 5DVC supply to the circuit, use switches S_1 and S_2 for setting input logic levels as shown in Fig 1.

4 Operate the switches to apply different logic levels and observe corresponding output.

5 Record the status of LEDs for each step of logic levels.

Table 1

RS flip-flop using NAND gate

Input		Output				
S	**R**	**Q**	**Q - LED Status (ON/OFF)**	**Q**	**Q - LED Status (ON/OFF)**	**Operating Mode**
0	**1**					**Set**
1	**1**					**No Change**
1	**0**					**Reset**
1	**1**					**No Change**
0	**0**					**Forbidden**

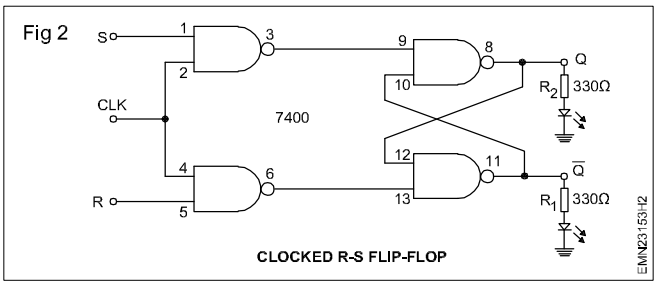
6 Get the work checked by the Instructor.

– – – – – – –

TASK 2 : **Construction and testing of RS flipflop with clock pulse using IC 7400**

1 Modify the RS flipflop circuit into clocked RS flipflop circuit as shown in Fig 2.

Fig 2



2 Connect switches S1 and S2 at R and S inputs 3 respectively.

3 Switch ON 5VDC supply to the circuit, operate switches S1,S2 apply different logic levels to the input keeping clock input at ground/negative.

4 Observe the status of LEDs for the above four steps and record in Table 2.

5 Connect the clock input to +5VDC and repeat steps 3 and 4 and record the observation for next four steps.

Table 2

Clock Input	Input		Output			
	S	R	Q	Q-LED Status (ON/OFF)	Q	Q-LED Status (ON/OFF)
0	0	1				
0	1	0				
0	1	1				
0	0	0				
1	0	1				
1	0	0				
1	1	0				
1	0	0				
1	1	1				

6 Get the work checked by the Instructor.

– – – – – – –

Verify the truth tables of Flipflop ICs (RS, D, T, JK, MSJK) by connecting switches and LEDs

Objectives: At the end of this exercise you shall be able to
- **construct and verify the truth table of RS flip flop by connecting switches and LEDs**
- **construct and verify the truth table of D flip flop by connecting switches and LEDs**
- **construct and verify the truth table of T.flip flop by connecting switches and LEDs**
- **construct and verify the truth table of JK flop by connecting switches and LEDs**
- **construct and verify the truth table of JK flip flop by connecting switches and LEDs.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1Set
- DC power supply - 0-30V/2A - 2 Nos
- DMM with probes - 1 No

Materials/Components

- Breadboard - 1 No
- IC 74 HC00 (Quad Nand Gate) - 2 Nos
- IC 74LS10 (3 Input NAND) - 1 No
- IC MC74HC 73 (Dual/JKFlip-Flop) - 1 No
- IC 74LS76 (JK-FF) - 1 No
- Resistors 330Ω/¼ W/CR25 - 4 Nos each
- LED (Red, Green) - 1 No each
- Toggle switch - 4 Nos
- Connecting wire - as reqd
- Battery (9V) - as reqd

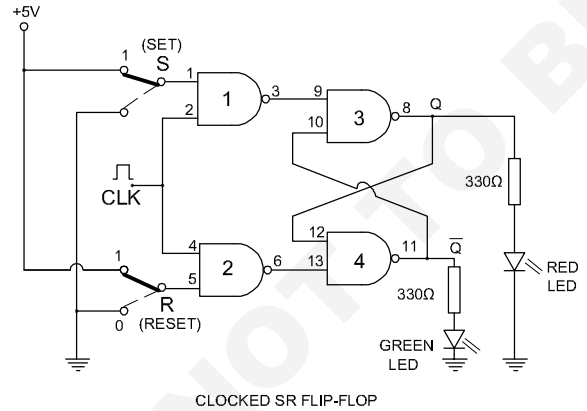
Aids: • Semiconductor digital IC-Data manual
• charts

PROCEDURE

TASK 1: **Construction of RS flipflop circuit and verification of the truth table.**

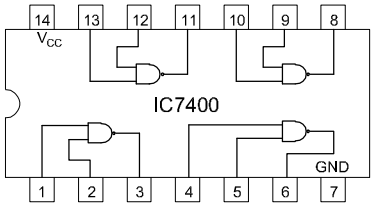
- Collect the materials, check them and assemble RS flipflop circuit on a breadboard as shown in Fig 1a.

Fig 1a



CLOCKED SR FLIP-FLOP

Fig 1b



PINOUT DIAGRAM OF IC7400

EMN23154H1

- Get the circuit checked by the Instructor.
- Apply different Inputs to S and R as given in truth table 1 and record the corresponding output levels and the status of the LED.
- Thus for different inputs at S and R the corresponding output can be seen through LED Q and $\overline{Q}$.

Table 1

Truth table of clocked SR Flip-flop

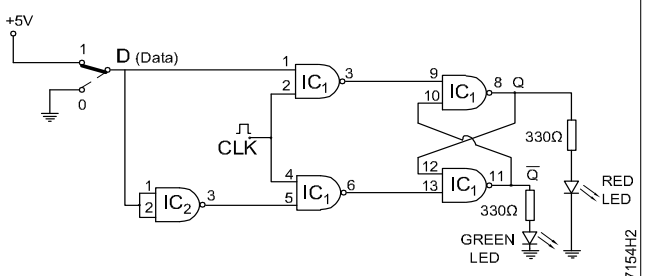
CLK	INPUT		OUTPUT		State of Flip flop
Clock	S	R	Q	$\overline{Q}$	
LOW	x	x	0	1	Previous state
HIGH	0	0	0	1	No state
HIGH	0	1	0	1	Reset
HIGH	1	0	1	0	High
HIGH	1	1	x	x	In terminate

- Get the work checked by the Instructor.

TASK 2 : **Construction of D flipflop circuit and verfication of the truth table**

- Assemble a D flipflop circuit by referring to Fig 2 on a bread board
- Get the circuit checked by the instructor.
- Apply different input to D Flip Flop as given in the truth table and verify the corresponding output level and the status of LEDs at Q and $\overline{Q}$ of the FF.

Fig 2



D FLIP-FLOP

Table 2

Truth table of D Flip-Flop - clocked

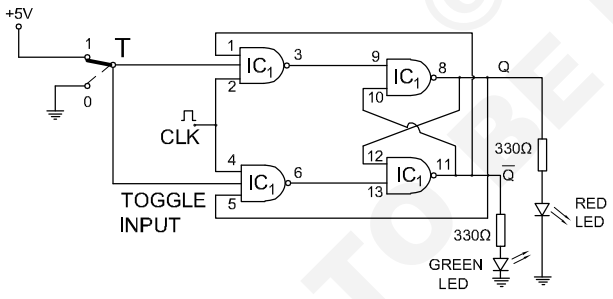
Clock	INPUT		OUTPUT
	D	Q	$\overline{Q}$
LOW	x	0	1
HIGH	0	0	1
HIGH	1	1	0

- Get the work checked by the Instructor.

TASK 3: **Construction of T.flip flop circuit and verification of the truth table**

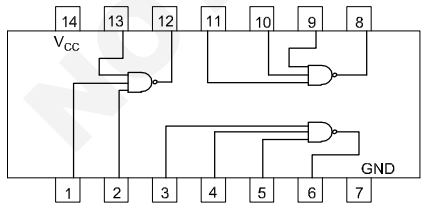
- Assemble a T.flipflop on a breadboard as shown in Fig 3a.

Fig 3a



T FLIP-FLOP

Fig 3b



PIN DIAGRAM OF IC74LS10

- Get the circuit checked by the Instructor
- Apply different inputs to toggle FF as given in the truth table at table and verify the corresponding output level and the status of LED
- Thus for different inputs at T.flip flop corresponding outputs can be seen through LEDs Q and Q'.

Table 3

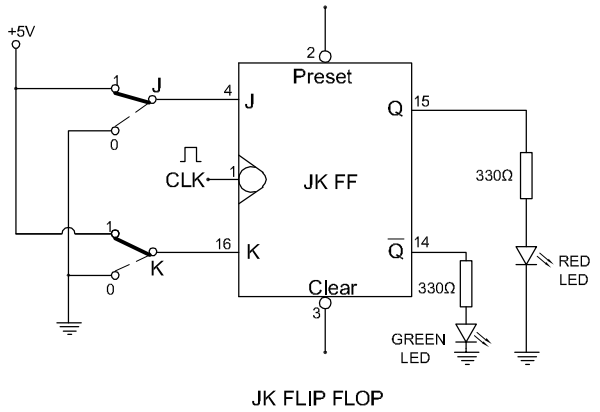
Clock	INPUT	OUTPUT		Status of output
High/Low	T	Q	$\overline{Q}$	
Low	x	0	1	Previous
High	0	0	1	No change
High	1	1	0	Output-toggles

- Get the work checked by the Instructor.

TASK 4 : **Construction of JK flip-flop circuit and verification of the truth table**

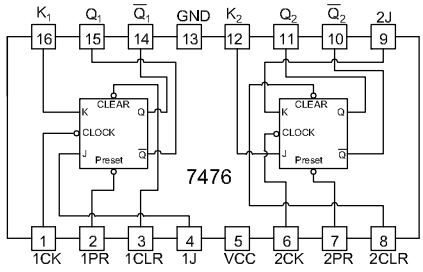
- Assemble a Jk flip-flop circuit by referring to Fig 4 on a bread board

Fig 4a



JK FLIP FLOP

Fig 4b



PINOUT DIAGRAM OF IC7476

EMN23154H4

- Get the circuit checked by the Instructor.
- Apply different inputs J and K, as given in the truth table 4 and verify the corresponding output levels and the status of LEDs.
- Thus for different inputs of JK flip-flop corresponding outputs can be seen through LEDs Q and $\overline{Q}$.

Table 4

Truth table of JK Flip Flop

Clock Input H/L	INPUTS				OUTPUTS	
	Preset	Clear	J	K	Q	$\overline{Q}$
X	0	0	X	X	1	1
X	0	1	X	X	1	0
X	1	0	X	X	0	1
L	1	1	0	0	0	Q
L	1	1	1	0	1	0
L	1	1	0	1	0	1
L	1	1	1	1	Toggles	Toggles
L	1	1	X	X	Q	$\overline{Q}$

- Get the work checked by the Instructor.

TASK 5 : **Construction of a master -slave JK flip-flop circuit and verification of the truth table**

- Assemble a MSJK flip-flop circuit by referring to Fig 5 on a breadboard
- Get the circuit checked by the Instructor
- Apply different Inputs J and K, MSJK as given in the truth table 5 and verify the corresponding output levels and status of LEDs.
- Thus for different Inputs of MSJK flip-flop corresponding outputs can be seen through LEDs Q and Q'

Note: MS JK FF.

It may be noted that in the Fig 5. the output of the master J-K FF is led to the input of slave FF. the outputs of slave - FF is used as leed back inputs to master J-k FF. The clk pulse is inverted and applied to slave FF. So the inputs are received by the slave FF only during trailing edge of clock pulse [logic-level-0]. Hence the Master - slave Jk Flip-Flop is a "Synchronons' device as it a passes data with the timing of the clock signal.

When Master receives Input during positive clock signal, slave FF outputs are said to be in latched condition (means no change).

In the truth table, M_1 and M_2 are outputs of Master FF and Q & Q are the outputs of slave FF.

Fig 5a

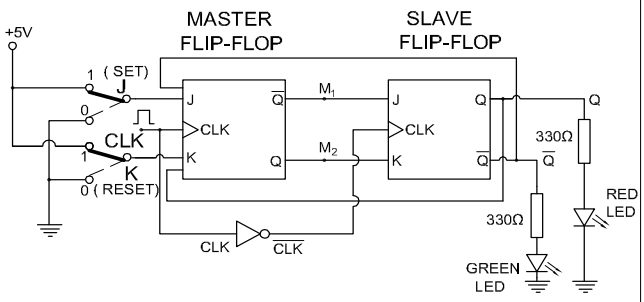
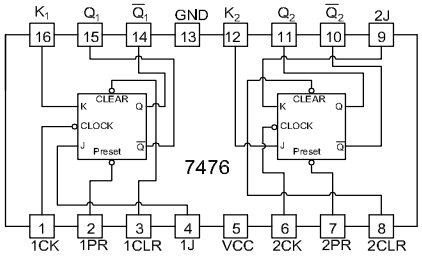


Fig 5b



PINOUT DIAGRAM OF IC7476

EMN23154H5

Table 5
Truth table of master slave JK Flip Flop

Trigger	Inputs		Output						Inference
			Present state		Intermediate		Next state		
CLK	J	K	Q	Q	M1	M2	Q	$\overline{Q}$	
↑	0	0	0	1	0	1	Latched		No Change
↓			0	1	Latched		0	1	
↑			1	0	1	0	Latched		
↓			1	0	Latched		1	0	
↑	0	1	0	1	0	1	Latched		Reset
↓			0	1	Latched		0	1	
↑			1	0	0	1	Latched		
↓			1	0	Latched		0	1	
↑	1	0	0	1	1	0	Latched		Set
↓			0	1	Latched		1	0	
↑			1	0	1	0	Latched		
↓			1	0	Latched		1	0	
↑	1	1	0	1	1	0	Latched		Toggles
↓			0	1	Latched		1	0	
↑			1	0	0	1	Latched		
↓			1	0	Latched		0	1	

- Get the work checked by the Instructor.

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Prepare simple digital and electronic circuits using the software

Objectives: At the end of this exercise you shall be able to

- **construct EX-OR gate using IC7404, 7408 and 7432 by the simulation software**
- **construct a positive shunt clipper circuit using discrete components by simulation software.**

Requirements

Tools/Equipments/Instruments

- Personal computer installed with simulation software like TINA/Multisim or similar software - 1 No
- Printer - 1 No

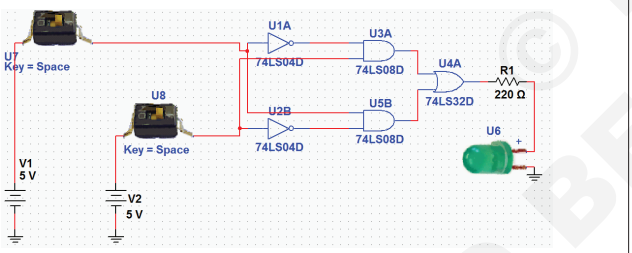
Note: This exercise has been developed using the multisim simulation software. The instructor has to follow/guide the trainees as per the steps/sequence with reference to the software available in the Lab/ computer.

PROCEDURE

TASK 1 : **Construction of EX-OR gate using simulation software**

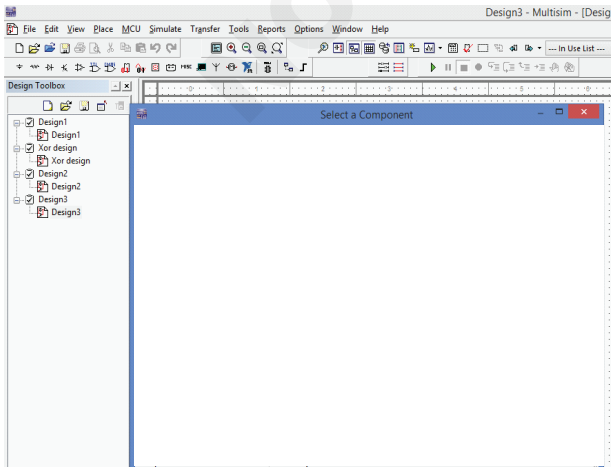
1 Select the circuit diagram to construct using simulation software. (For example the XOR gate is selected for this exercise) as shown in Fig 1.

Fig 1



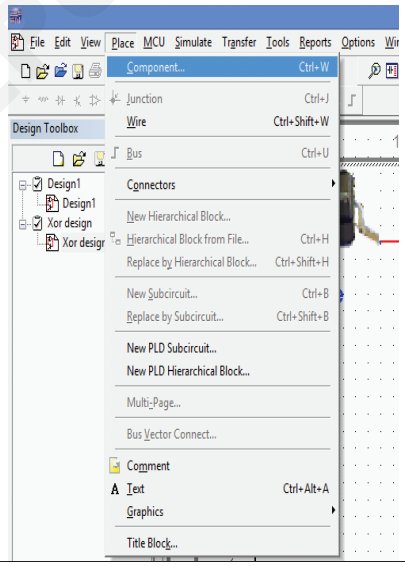
2 Switch ON computer, open the simulation software through the windows start menu or click on the simulator icon on your desktop and get the first screen as shown in Fig 2.

Fig 2



3 Click on **Place** menu and pull down the options as shown in Fig 3.

Fig 3



4 Click on component group, select **TTL** and scroll to **74LS** and select the required IC (**74LS04D**) and click **OK** as shown in the Fig 4.

Fig 4

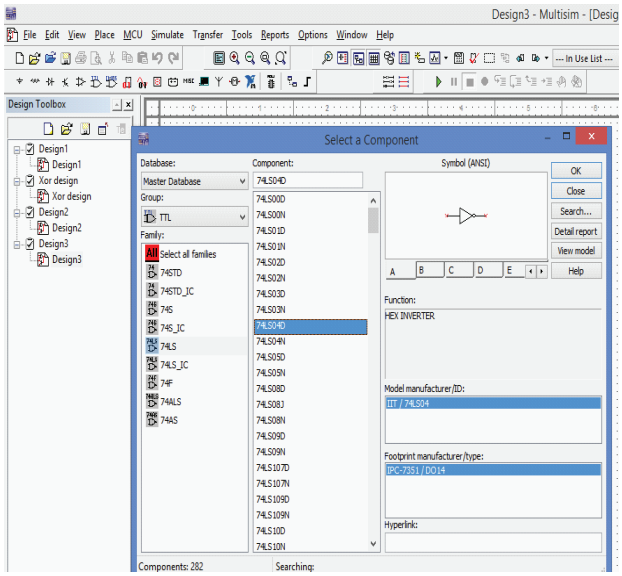
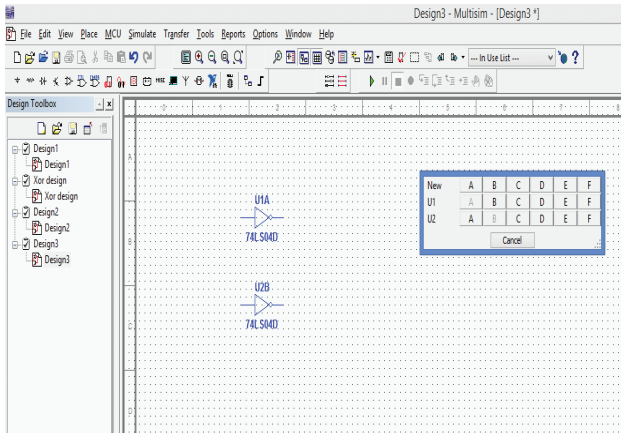


Fig 5



5 Click on A and OK, if more than one gate is required click on A and B, etc. as shown in the Fig 5.

6 Follow the step 4&5 to select the other logic gates 7408 and 7432 as shown in Fig 6.

7 Select the required resistor by referring the figure given in Fig 7 and click **OK.**

Fig 6

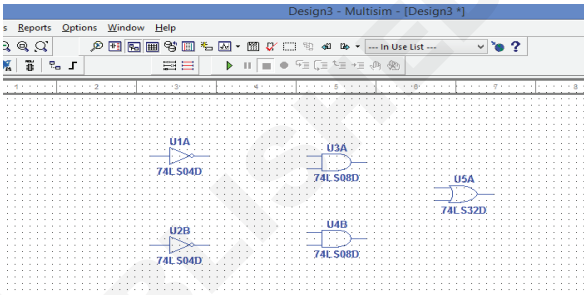
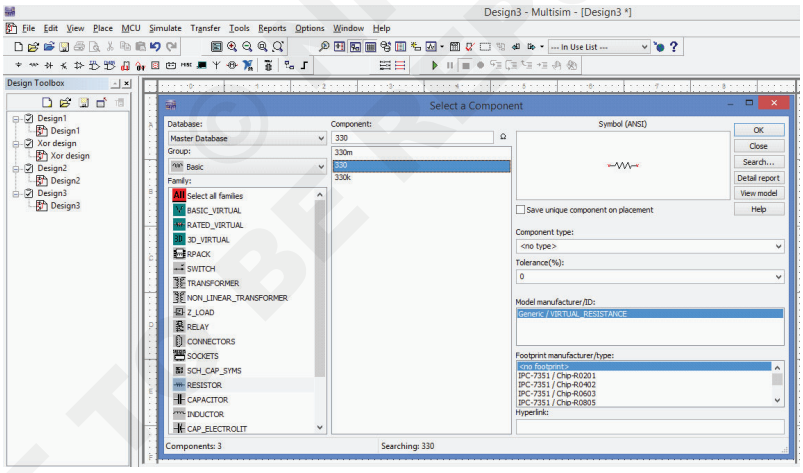


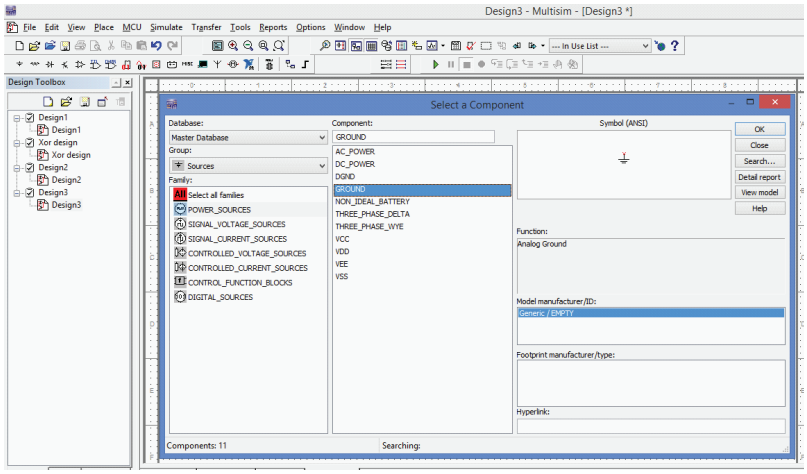
Fig 7



8 Select the required LED and click OK.

9 Add the power supply and ground to the circuit as shown in Fig 8.

Fig 8

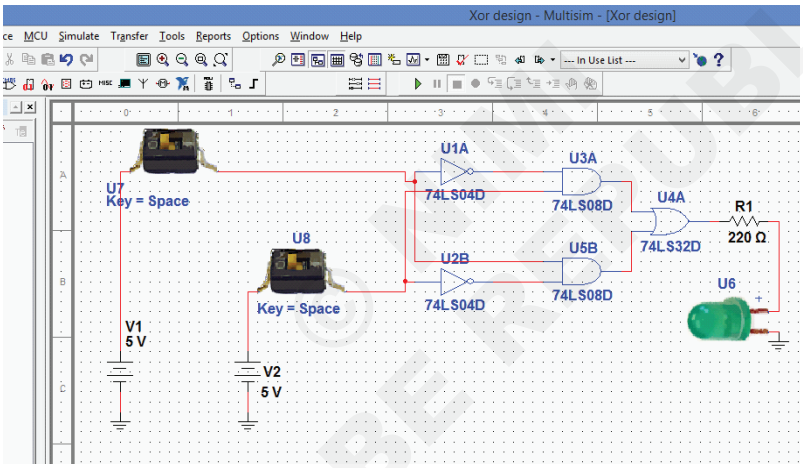


10 Make the wiring of the circuit by following Fig 1. Keep the cursor at one node of the component a dot will appear, move the cursor to the place of wiring the dot will appear at that node, now click the mouse to finish the wiring.

11 Double click on the power supply and change the label as A and B and set the voltages to 0.

12 Double click on the LED and change the label as C as shown in Fig 9 and save it.

Fig 9



13 Get the work checked by the Instructor.

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TASK 2 : **Construction of positive shunt clipper circuit using simulation software**

1 Select the positive shunt clipper circuit by referring to the circuit as shown in in Fig 10.

2 Switch ON the computer, double click on the simulator icon on the desktop.

3 Click on semiconductor and then click on diode, drag the diode into the user area as shown in Fig 11

4 Double click on the diode in the user area and click on the TYPE.

Fig 10

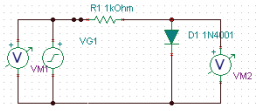
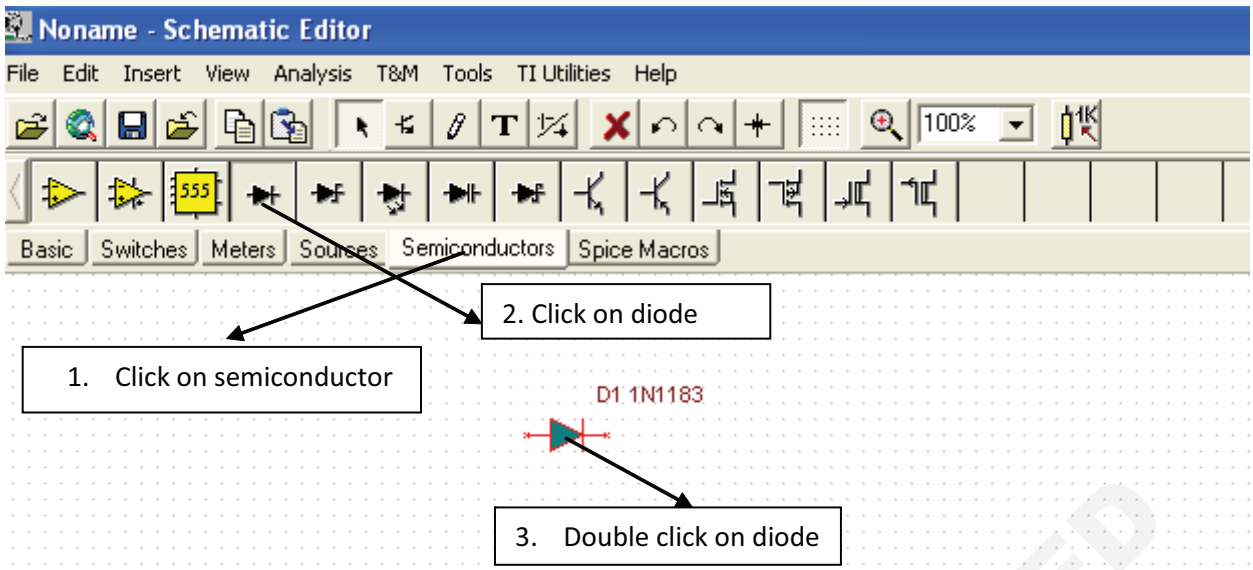


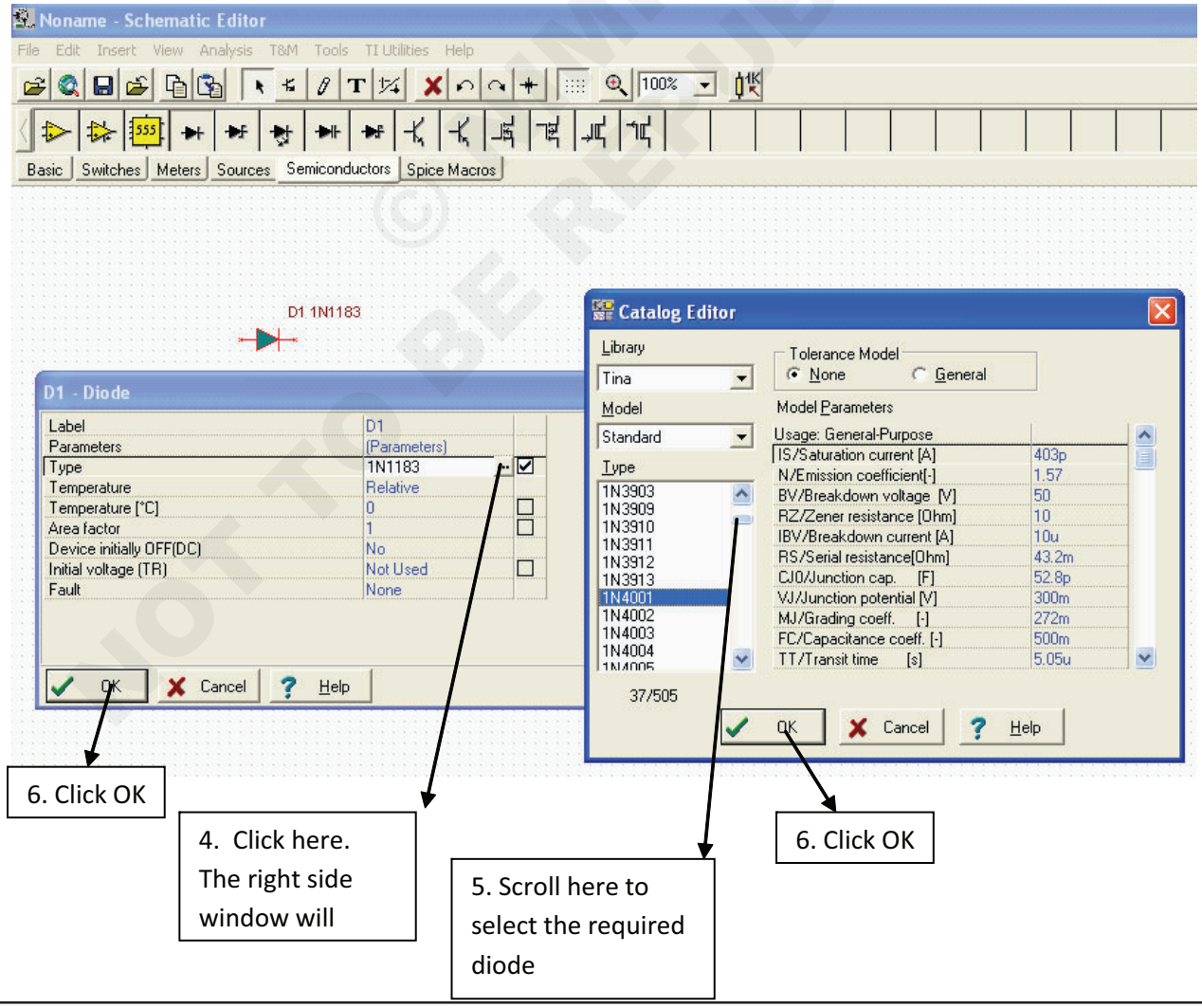
Fig 11



5 Select the suitable diode as shown in Fig 12 and Click **on OK** tab.

6 Ensure that the selected diode type number is displayed near the diode symbol.

Fig 12



7 Right click on the diode select **Rotate Right** if you want to place the diode in the vertical position as shown in Figs 13 & 14.

Fig 13

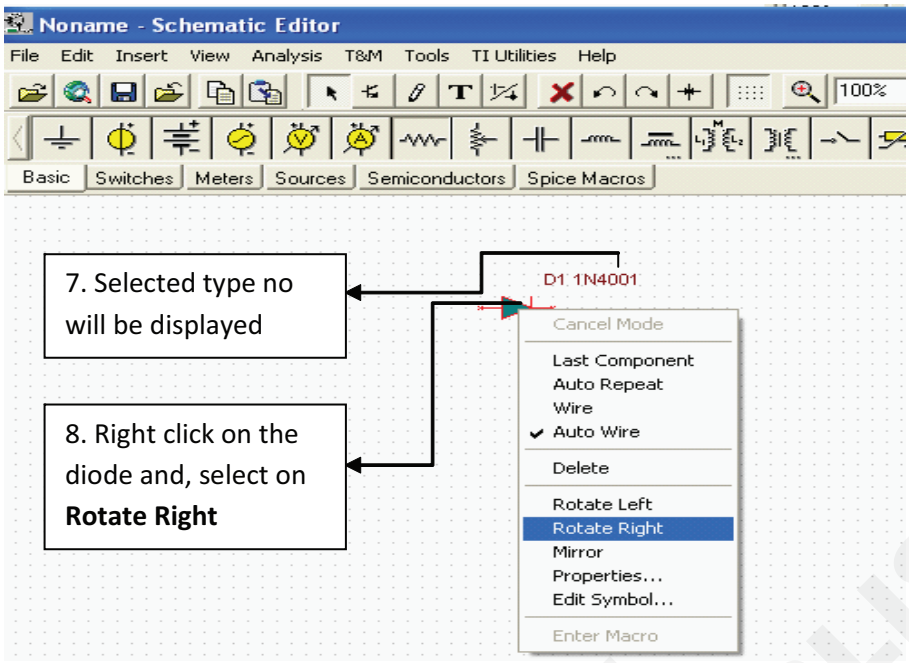
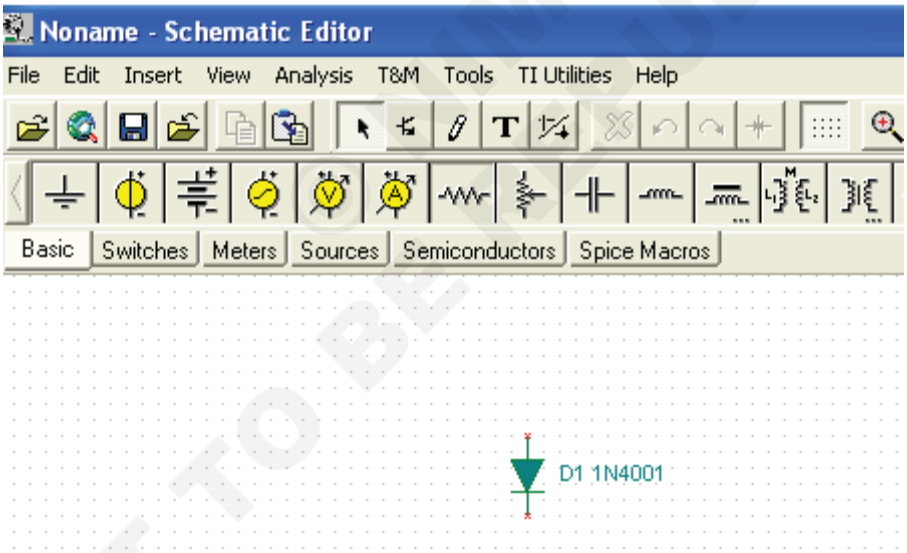


Fig 14

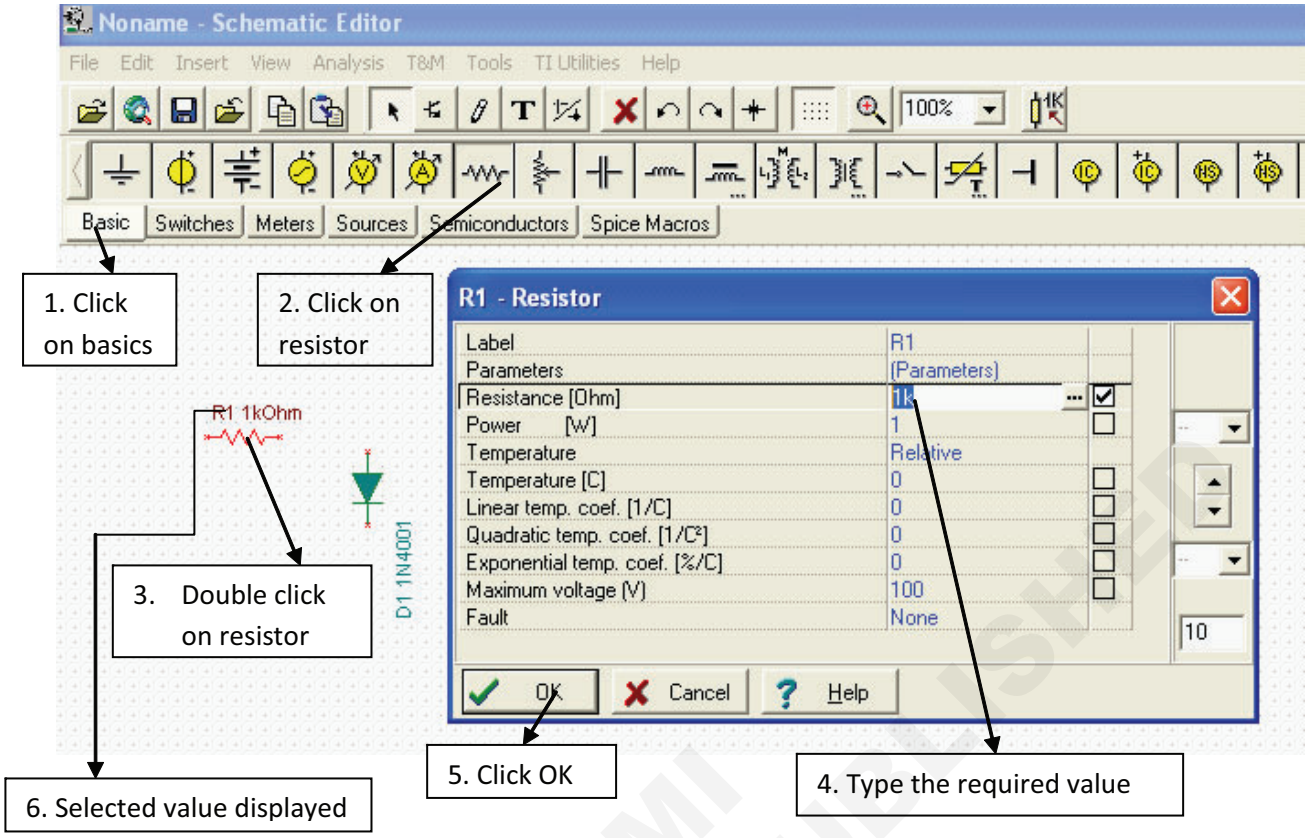


8 Click on **Basic menu to select a resistor and** click on resistor, drag the resistor into the user area.

9 Double click on selected resistor, type the value of resistor and click OK as shown in Fig 15.

Ensure that the selected resistor value is displayed near the resistor symbol.

Fig 15



10 Keep the cursor at one of the resistor terminal and drag the mouse towards the terminals of the diode make the wiring.

Refer the circuit in figure 10 for making other connections.

1 **Keep the cursor at the red dot of one of the terminal and then drag the mouse, till the red dot of the other device where you want to make the wiring.**

2 **If any component/device is edited by double clicking on it, the symbol will appear red, otherwise it appear in green colour.**

3 **Press ESC on the keyboard if you have clicked on any symbol which you donot want to use in the circuit**.

11 Click on the **Sources** menu to connect a voltage generator and voltmeters.

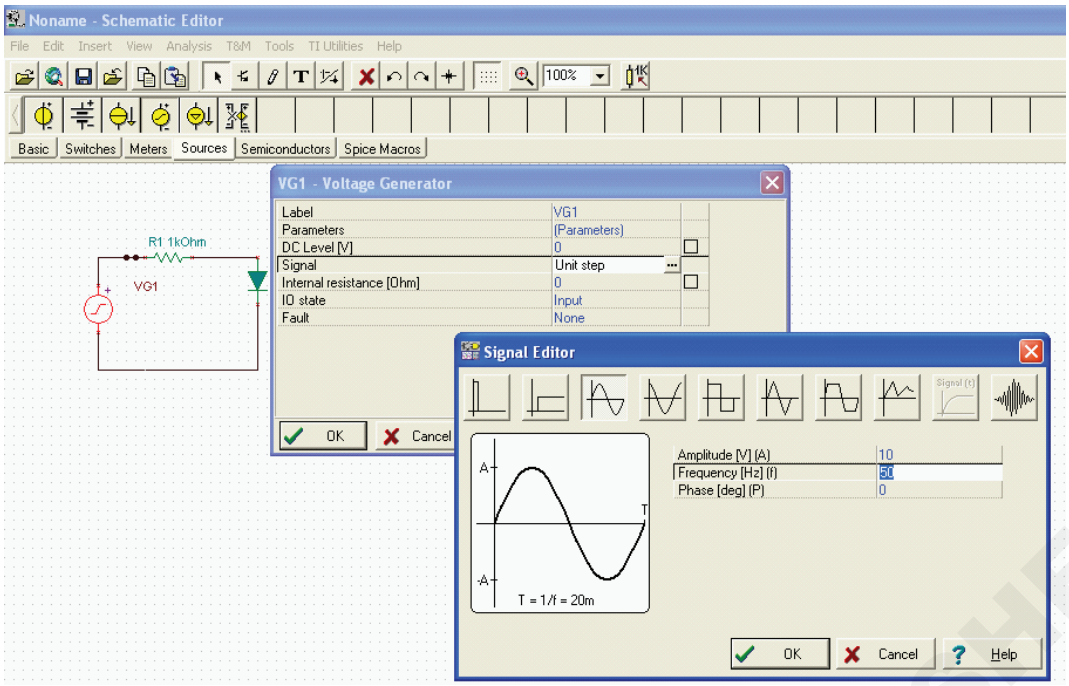
12 Click on the **voltage generator** dialog box and double click on the generator symbol.

13 Click on **Signal** and then **Unit step** dialog box.

14 Click on the required waveform appearing in the pop up window as shown in Fig 16.

15 Click on amplitude, frequency and phase to select the required value respectively and click OK and save the circuit.

Fig 16



16 Get the work checked by the Instructor.

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Simulate and test the prepared digital and analog circuits

Objectives: At the end of this exercise you shall be able to
- **test the prepared digital circuits using simulation software**
- **test the prepared analog circuits using simulation software.**

Requirements

Tools/Equipments/Instruments

- Desk top computer with simulation software installed - No

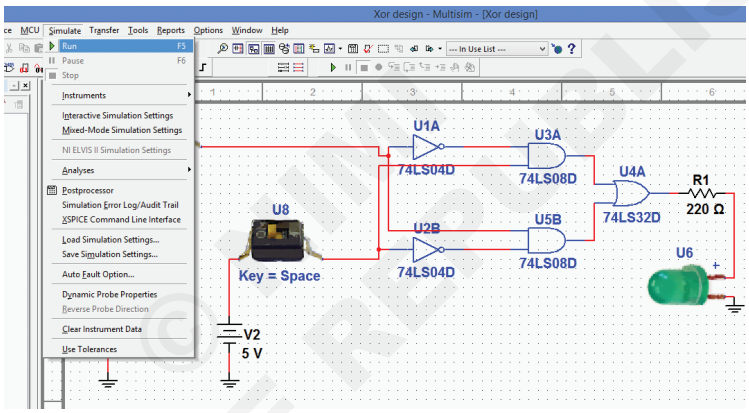
PROCEDURE

TASK 1 : Testing the constructed digital circuit (OR gate) using simulation software

1 Switch ON the computer, open the simulation software and open the saved OR gate circuit.

2 Click on simulate menu to run the circuit as shown in Fig 1.

Fig 1

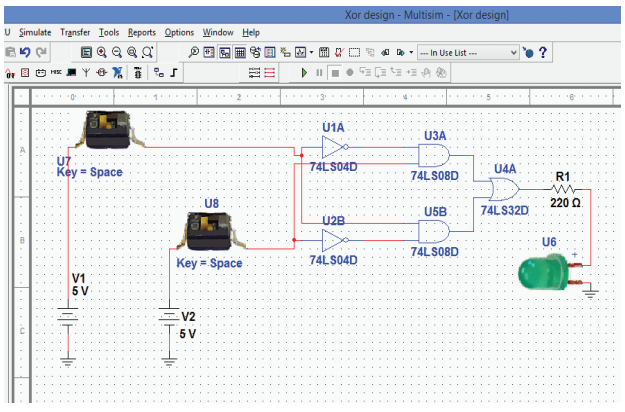


3 Modify the supply voltages as shown in the truth table and verify the truth table (If the output is one, the arrow in the LED will become RED (if red LED is selected; otherwise respective colour as shown in Fig 2, if the output is zero the arrow will be no glow).

Truth table of OR gate

S_1	S_2	LED condition
Open	Open	
Open	Close	
Close	Open	
Close	Close	

Fig 2



4 Get the work checked by the Instructor.

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TASK 2 : **Testing the prepared analog circuit positive shunt clipper using simulation software**

1 Open the saved positive shunt clipper circuit.

2 Click on **meters** on the menu bar.

3 Click and drag **volt meter** and connect across the voltage generator.

4 Once again Click and drag **volt meter** and connect across the diode (output terminal) as shown in Fig 3.

5 Click on **T&M** on the menu bar, Select **oscilloscope** and click on it.

6 On pop up window Click on **Run** and observe the wave form displayed in the CRO.

7 Adjust **Time/div** and **Volt/div positions** to the suitable value as shown in Fig 4.

8 So that the waveform clearly seen select second channel by the probe in the CRO and click on the output terminal get both the waveforms visible on the CRO.

Fig 3

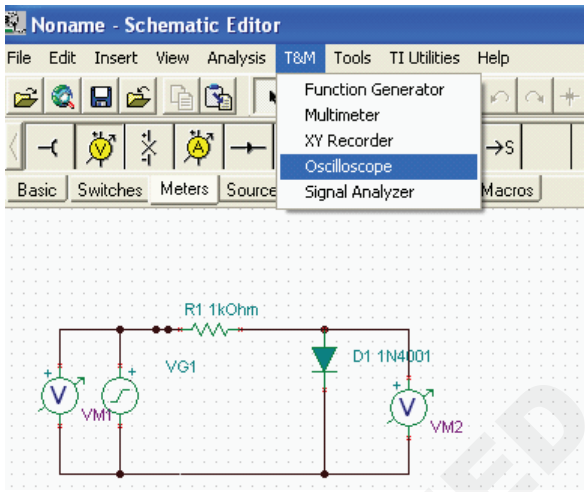
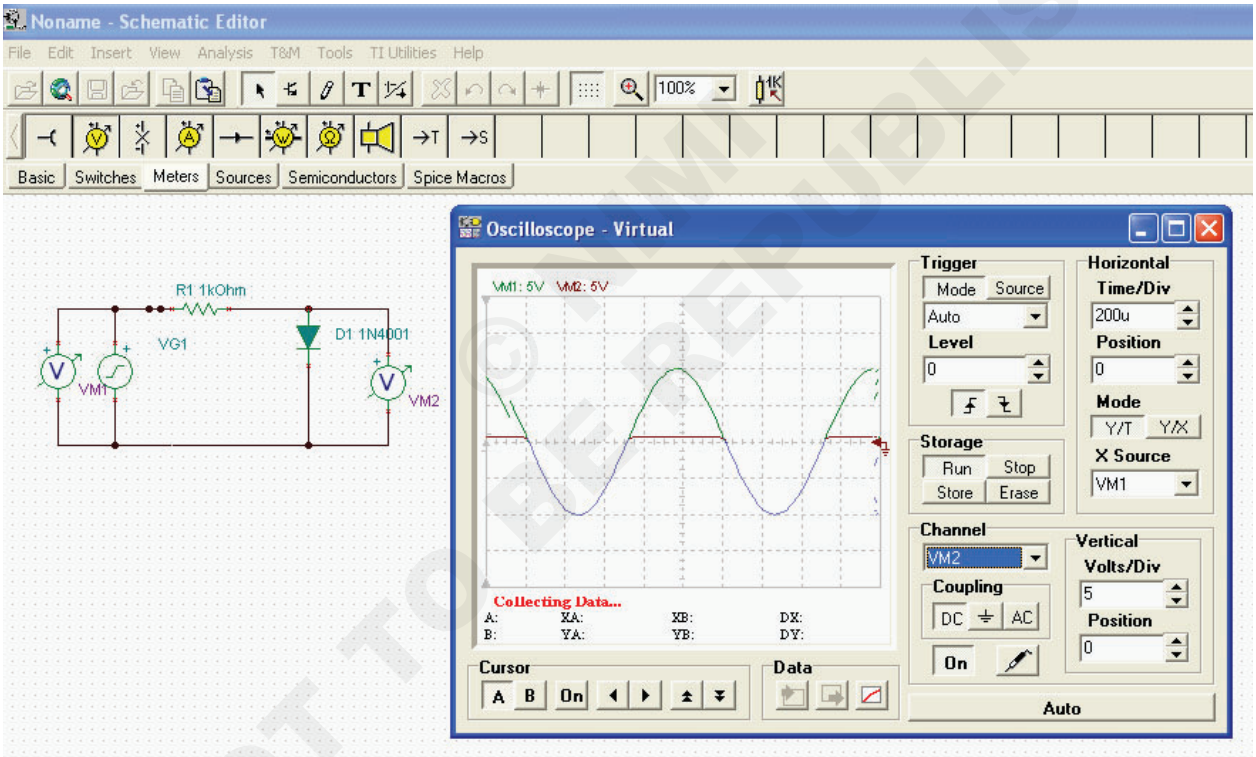


Fig 4



9 Click on stop , trace the waveforms and save it.

Save the circuit, so same circuit may be used later for revision.

10 Get the result checked by the Instructor.

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Convert the prepared circuit into a layout diagram

Objectives: At the end of this exercise you shall be able to
- **construct a single stage transistor amplifier using simulation software**
- **construct the prepared circuit into a layout diagram using simulation software.**

Requirements

Tools/Equipments/Instruments

- Personal computer installed with simulation software - 1 No

PROCEDURE

TASK 1 : **Construction of a single stage transistor amplifier circuit using simulation software**

1 Switch ON the computer, double click the icon on the desktop, open the software and pick the required components from the transistor amplifier circuit.

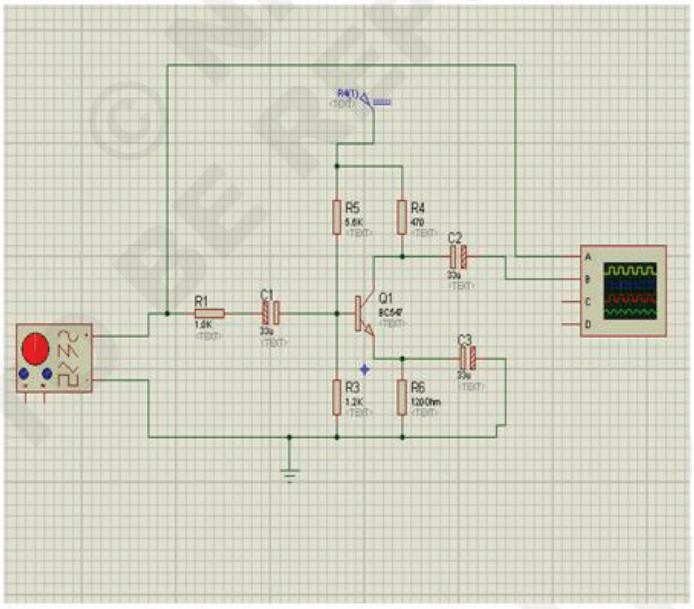
2 Place the required components, assemble the circuit in the work sheet area as shown in Fig 1.

3 Select required junction dot, terminal lead place in circuit for coupling required to construct wiring.

4 Connect the necessary equipments and instruments to the circuit as shown and save it.

5 Get the work checked by the Instructor.

Fig 1



TASK 2 : **Conversion of the prepared circuit into a layout diagram.**

1 Open the circuit for conversion in the user area.

2 Click file menu, select convert PCB option and open PCB layout.

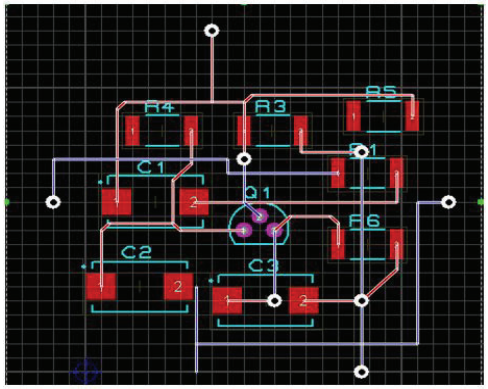
3 Click view menu, select grid size, and board outline.

4 Click and drag the components into the created layout.

5 Click for auto routing and save the lay out diagram as shown in Fig 2.

6 Get the work checked by the Instructor.

Fig 2



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Prepare simple, power electronic and domestic electronic circuit using simulation software

Objectives : At the end of this exercise you shall be able to
- **prepare a simple power electronic circuit (half wave rectifier) using simulation software.**
- **construct a domestic electronic circuit using simulation software.**

Requirements

Tools/Equipments/Instruments

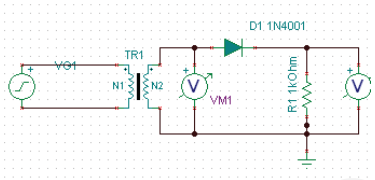
- Desk top computer installed with simulation software

PROCEDURE

TASK 1 : **Construction of simple power electronic circuit (half wave rectifier) using simulation software**

1 Select the components required for constructing the half wave rectifier as shown in Fig 1.

Fig 1



2. Switch ON the computer and double click on the simulator icon available in the desk top.

3 Refer to the Ex No. 2.8.155, Task 2, follow steps and select the required resistor, diode and voltmeter by clicking on them.

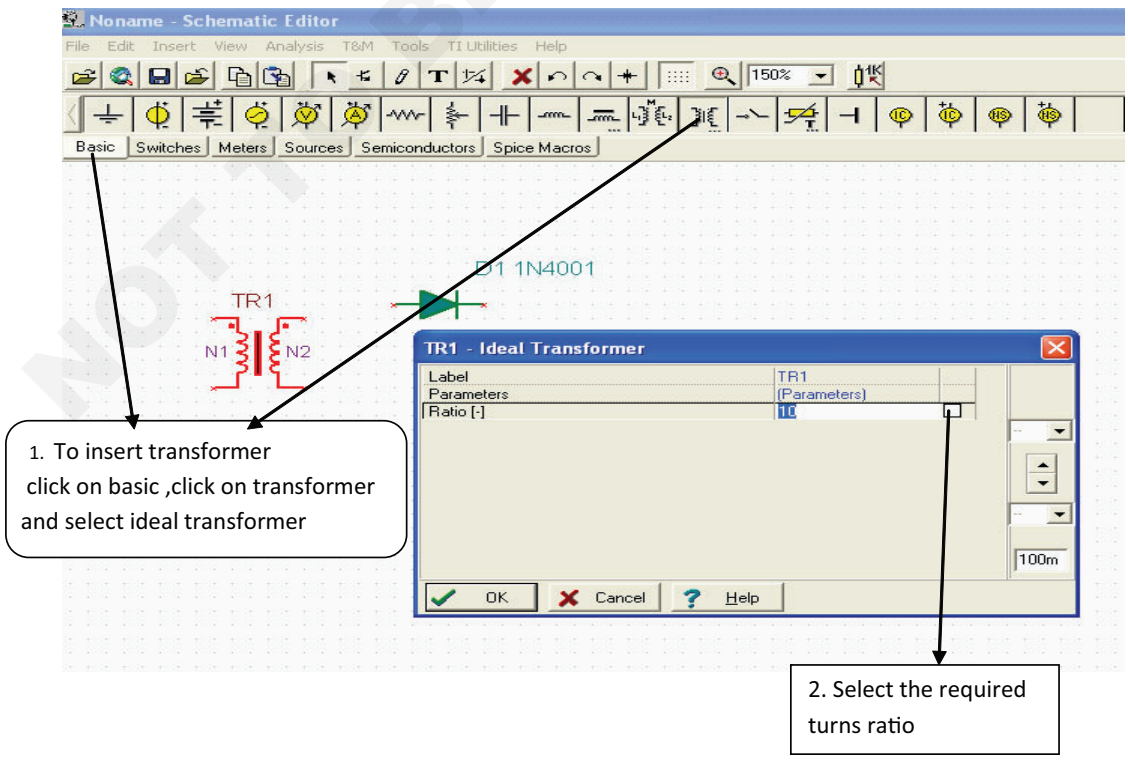
1 If you need to change the type of diode double click on diode & change its type.

2 To rotate the diode right click on it & select rotate option.

4 Click on Basics menu and on transformer, select ideal transformer.

5 Double click on the transformer, select the required turns ratio as shown in Fig 2.

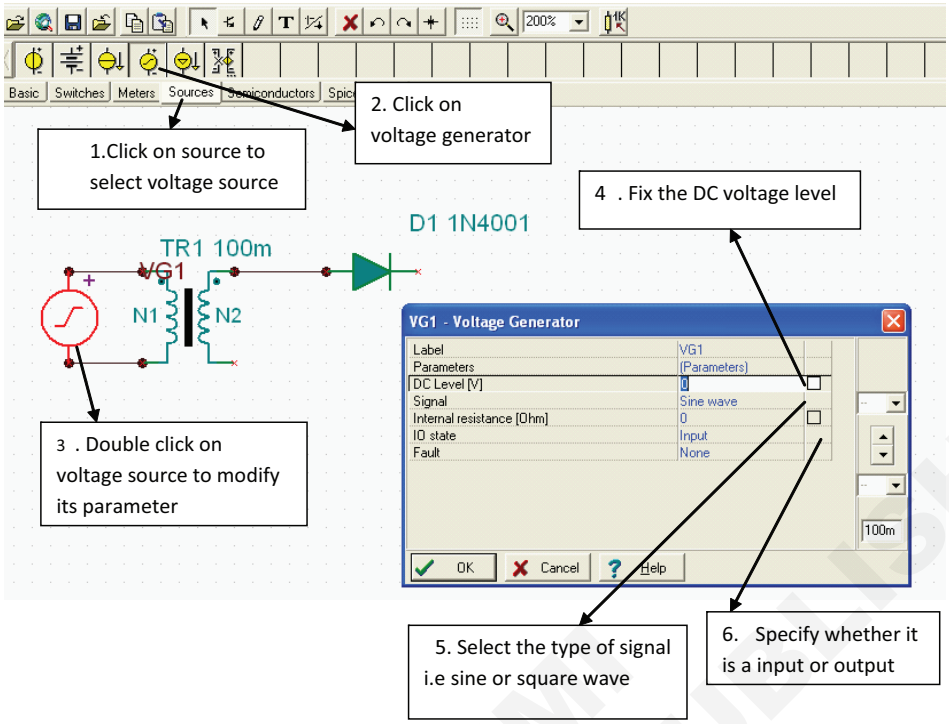
Fig 2



6 Click on **source** menu and insert the voltage source.

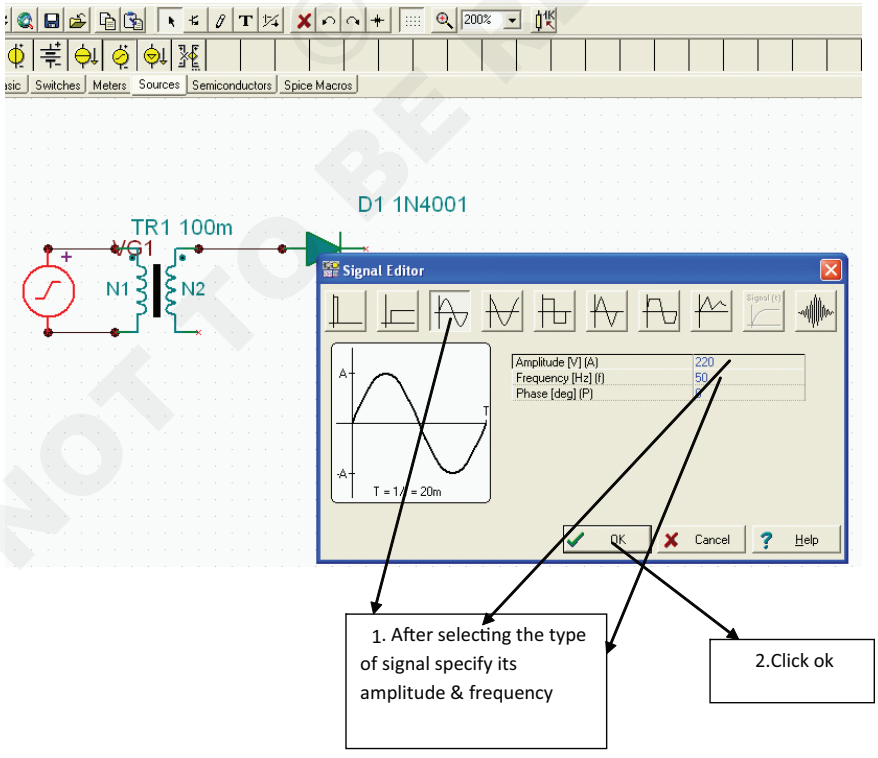
7 Click on **voltage generator** and double click on voltage generator to fix the parameters as shown in Fig 3.

Fig 3



8 Click on signal dialogue box, set the type of waveform, amplitude, frequency & phase as shown in Fig 4.

Fig 4

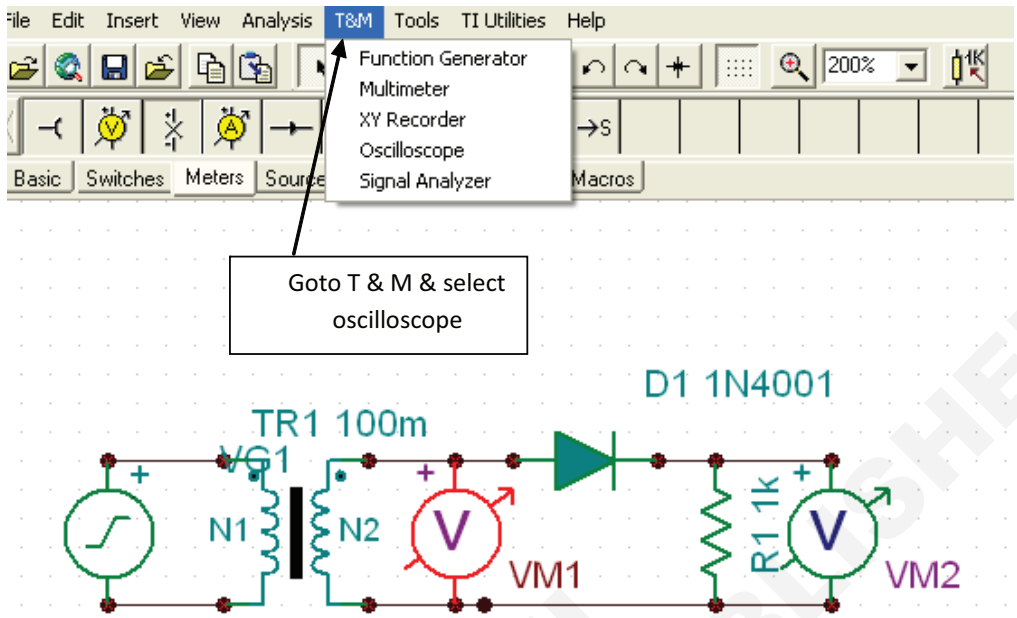


9 Make the connections by referring to the circuit diagram in Fig 1; Keep the cursor on the x mark on the component and drag the mouse wherever it need to be connected.

10 Go to menu bar & click T&M, select CRO as shown in Fig 5, click on it to use CRO.

11 Get the work checked by the Instructor.

Fig 5



TASK 2 : **Construction of electronic lamp dimmer circuit using simulation software**

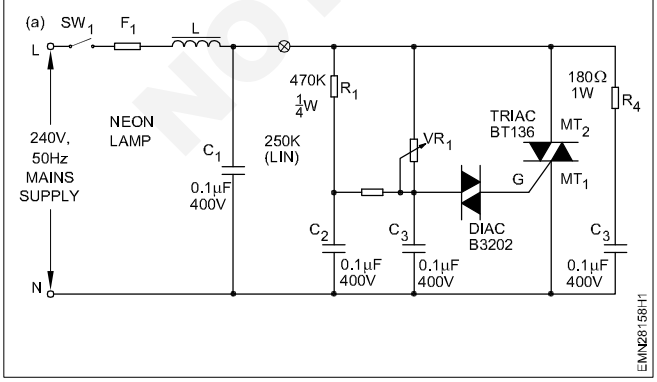
Note:

This exercise /Task has been developed using proteus - ISIS free simulation software.

The Instructor has to guide the trainees to follow each and every critical steps to select the components their values and placement / position, printing their numbers etc to complete the task as per the simulation software available in the lab.

1 Select the circuit for construction of electronic dimmer circuit as shown in Fig 1.

Fig 1



2 Switch ON the computer, double click the simulator icon on the desktop.

3 Open a new project the schematic and go to the schematic capture option.

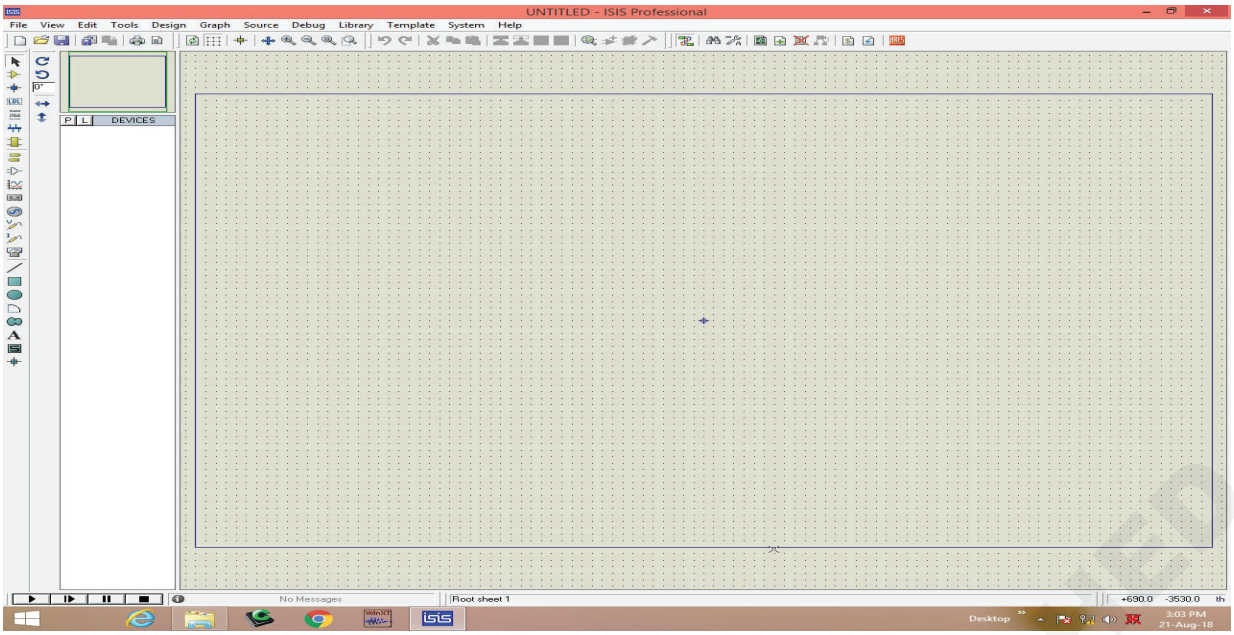
4 Click and select all the parts required from resistors, capacitor to disc and triac into the library as shown in Fig 2.

5 Move the cursor, select the triac, left click drag and place it on the user area place and position it on the user area.

6 Similarly select and place all the components, voltage source etc as per the diagram of the dimmer circuit.

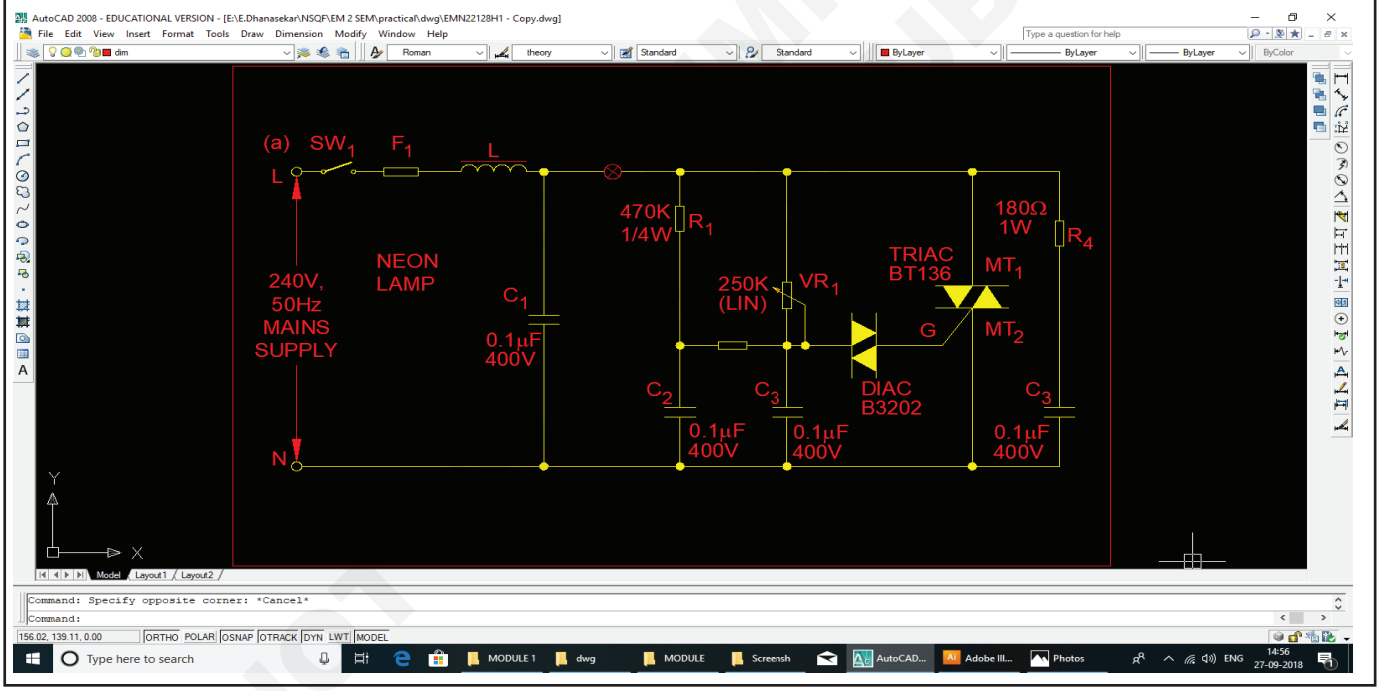
7 Click the cursor to wire the connection on the component tip a red square dot appears move the cursor click again complete the wiring.

Fig 2



8 Close the switch S1 and observe the bulb is ON and adjust the a rheostat VR1 the brightness is reduced as shown in Fig 3.

Fig 3



9 Get the work checked by the Instructor.

Use analog IC tester to test various analog ICs

Objectives: At the end of this exercise you shall be able to
- **identify various analog ICs with their specifications**
- **test the analog ICs using analog IC tester.**

Requirements

Tools/Equipments/Instruments

- Analog/IC Tester with operating manual - 1 No
- Semiconductor Data book/manual - as reqd

Materials/Components

- Assorted analog ICs such as Op-Amp and timer ICs (IC 74, LM 324 IC 555) - Minimum 3 Nos each

Keep a minimum of 10 nos of assorted labeled ICs on a table at two places and instruct the trainees to pick one IC at a time to carry out the testing work.
Instructor should demonstrate the operation of IC tester available in the laboratory. A typical IC tester is shown in Fig 1.

PROCEDURE

TASK 1 : **Identification of various Analog ICs with their specifications and pin diagram**

1 Pick one of the labeled IC from the assorted lot and record its product code /label number printed on the body.

2 Refer to the data sheet semiconductor international data book for Op-Amp / Timer (which ever applicable) and record the following specifications of the given IC;
   – Type of package
   – Manufacturers name
   – Number of OP-Amps/timers in the IC
   – Rated maximum DC supply voltage
   – Open-loop gain A_{VOL}
   – Minimum output current $I_{out(min)}$
   – Slew rate of the IC
   – Any other parameter applicable to this IC
   – Typical applications.

3 Count the number of pins in the given IC. Make a rough sketch of the IC. Identify and record the pin numbers.

4 Repeat the steps for atleast four different ICs having different product code.

Table 1

Sl.No.	Label No.	IC Number	Manufacturer name	V_{cc} max	A_{VOL}	I_{OUT} (min)	Application	Pin diagram

5 Get the work checked by the Instructor.

– – – – – – –

TASK 2 : **Testing of the given Op- Amp and Timer IC with Analog IC Tester**

IC Tester has self test button. On pressing it, The IC tester performs self Diagnostic test its own hardware. It has two modes of operations

1 Quick test - To test and give result immediately.

2 Stepwise test - To know which portion of hardware in IC has failed. In this method, even if one AMP in a dual Op-Amp IC is GOOD that IC can be used.

1 Refer to the instruction operation manual of IC tester, familiar with operation of analog/universal IC tester available in laboratory.

Use operator manual note down the library of analog ICs of the tester to know which ICs may be tested with the tester as shown in Fig 1.

Fig 1

Analog IC Tester

2 Pick one of the labelled IC, identify the pin no. 1, orient it/as per the ZIF socket position.

3 Open the level of the ZIF socket and insert the IC into position carefully.

Note: ZIF socket refers to Zero Insertion Force. It is a type of socket for mounting electronic devices that is designed not to stress or damage them during Insertion.

4 Switch on the power switch of IC tester enter the IC number on the keypad of the IC tester and press TEST key and see the result.

Note: The IC tester comprises of programs /set of testing procedure to test every analog IC available in its library. it checks the procedures of various steps and produces the result as GOOD or BAD on the display provided in it.

5 Find out whether the given IC is GOOD (or) BAD by observing the display of the IC tester and record the result in Table 2.

6 Repeat the exercise for at least 3 Op-Amps and 3 Timer IC to show the difference between good and defective and record in Table 2.

Table 2

Sl.No.	IC No. test	Mode	Condition of IC

7 Get the work checked by the Instructor.

– – – – – – –

Construct and test various Op-Amp circuits Inverting, Non-inverting, Summing Amplifiers

Objectives : At the end of this exercise you shall be able to
- **construct and test Inverting amplifier using LM 324**
- **construct and test Non-Inverting amplifier using LM 324**
- **construct and test summing amplifier and differential amplifier using LM 324.**

Requirements

Tools/Equipments/Instruments

- Analog/Universal IC Tester with instruction manual - 1 No
- CRO, 20 MHz Dual trace - 2 Nos
- Semiconductor Data book - 1 No
- Analog/Digital multimeter with probes - 1 No
- Dual regulated DC power supply 0-30V/2A - 1 No
- Function generator - 1 No
- Trainees tool kit - 1 Set

Materials/Components

- Op-Amp ICs LM324, UA741 - 2 Nos each
- Breadboard - 2 Nos each
- Resistors 10 kΩ,¼ W/CR25 - 7 Nos
  100 kΩ,¼ W/CR25 - 1 No
- Hook up wires/connecting wires - as reqd
- IC base (8 pin), DIP - 2 Nos
- Diodes 1N4001 - 4 Nos

PROCEDURE

TASK 1 : **Construction and testing of an inverting amplifier**

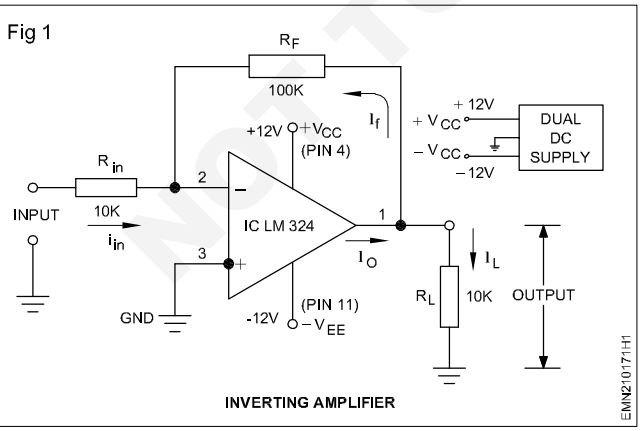
1 Collect all the required components from the instructor and check them with multimeter; use IC tester for checking ICs.

2 Identify the type of package and pins of the given Op-Amp using Data book.

3 Refer to circuit diagram shown in Fig 1 and assemble the inverting amplifier circuit on bread board.

4 Get the assembled circuit checked by the Instructor.

Fig 1



INVERTING AMPLIFIER

Always keep an IC base fixed on the breadboard for inserting the Op-Amp IC.

5 Connect +12V, -12V and GND of dual DC power supply to pin 4, pin 11 and GND respectively.

6 Prepare the CRO for measurements and apply $0.2V_{p-p}$ at the input.

7 Measure the output using DMM and CRO.

8 Vary the input voltage and observe the output variations using multimeter and oscilloscope; record the observation in Table 1.

9 Change the value of feedback resistor R_F and R_{in} observe the variation in gain and record them in Table.

8 Get the completed work checked by the Instructor.

TASK 2 : **Construction and testing of a non-inverting amplifier using IC LM324**

1 Refer to the circuit diagram shown in Fig 2 and modify the assemblled circuit on Bread board.

2 Get the assembled circuit checked by the Instructor.

3 Repeat steps 5 to 8 of Task 1 and record the observations.

4 Repeat the steps 9, record the observations and calculate the gain and record them.

Fig 2

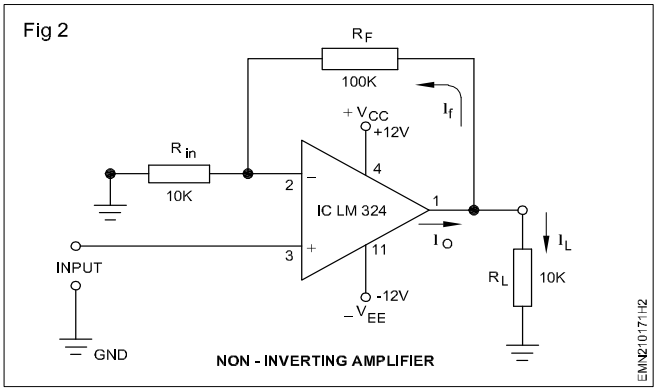


Table 1

Sl.No.	Input voltage applied (V_i)	Output voltage		Gain normal observed values V_{out} / V_{in}		Gain x Vin= Volt Calculate values	
		Inverting amplifier	Non inverting amplifier	Inverting amplifier	Non inverting amplifier	Inverting amplifier (R_f/R_{in}) x Vin	Non inverting $(1+(R_f/R_1)$xVin
1	0.2V						
2	0.4V						
3	0.6V						

5 Get the work checked by the Instructor.

– – – – – – –

TASK 3 : **Construction and testing of a summing amplifier using IC LM324**

Carry out the experiment on a Bread board. The suitable values for input voltage are kept such that.

$$\frac{R_F}{R_1} = \frac{R_F}{R_2} = \frac{R_F}{R_3} = \frac{R_f}{R_{in}}$$

1 Collect all the required items, check the components and assemble the circuit according to the amplifier circuit shown in Fig 3.

Note the inputs have been applied to inverting terminal.

2 Get the assembled circuit checked by the instructor.

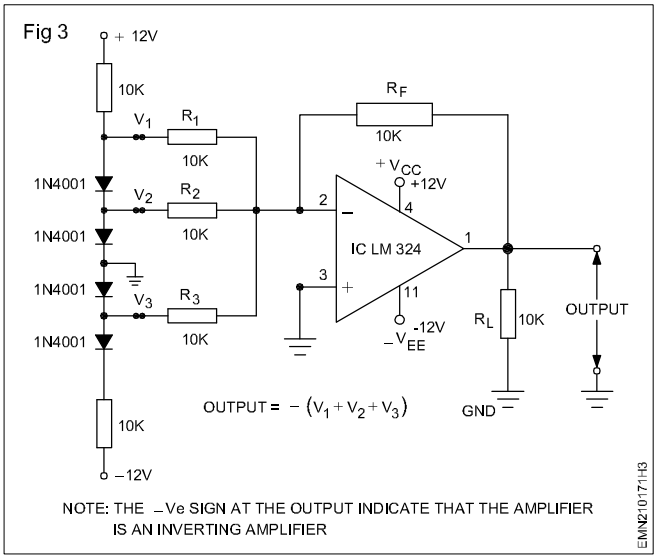
3 Switch ON the dual DC power supply measure the output using multimeter and CRO.

Use the given formula to calculate the output voltage for summing amplifier.

4 Verify the results obtained & compare with the calculated values.

To apply inputs to noninverting terminal exchange the inputs applied on inverting and non inverting terminals.

Fig 3



Observation table

Table 2

S.No.	Configuration	Output voltage	Result
1	When inputs V_1, V_2 & V_3 have been applied on -Ve terminal	Vo=	Is O/P proportional to sum of inputs? (Yes / No)
2	When input V_1, V_2 & V_3 have been applied on +Ve terminal	Vo=	Is output proportional to sum of inputs? (Yes / No)

Formula to calculate output voltage of summing amplifier

i For Inverting Amplifier

$$V_o = -\left(\left(\frac{R_f}{R_{in}} \times V_1\right) + \left(\frac{R_f}{R_{in}} \times V_2\right) + \left(\frac{R_f}{R_{in}} \times V_3\right)\right) = \frac{R_f}{R_{in}}\left(V_1 + V_2 + V_3\right)$$

ii For Non-Inserting Amplifier

$$V_o = \left(\left(1 + \frac{R_f}{R_{in}}\right)V_1 + \left(1 + \frac{R_f}{R_{in}}\right)V_2 + \left(1 + \frac{R_f}{R_{in}}\right)V_3\right) = \left(1 + \frac{R_f}{R_{in}}\right)\left(V_1 + V_2 + V_3\right)$$

If $R_f = R_1$

$V_o = 2\ (V_1 + V_2 + V_3)$

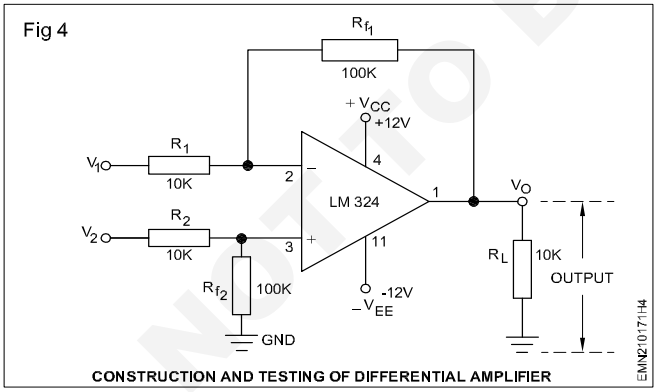
– – – – – – –

TASK 4 : **Construction and testing of Differential Amplifier using LM324**

1 Modify the components values and assemble the circuit shown in Fig 4.

2 Get the assembled circuit checked by the instructor.

Fig 4



3 Repeat step 5 of Task 1.

4 Apply the DC inputs to the differential amplifier circuit at pin 2 and pin 3 through 10k resistors as per the Table 3.

4 Measure the output using Multimeter and record in given table.

5 Change the input values at V1 and V2 and record the output readings in Table 3.

6 Compare the calculated value with observed.

7 Get the work checked by the Instructor.

Note: A $R_{f1} = R_{f2} = R_f$ and $R_1 = R_2 - R_{in}$

V_o Output = $(V_2 - V_1)\ \frac{R_f}{R_{in}}$

Observation table

Table 3

Input to Differential Amplifier		Output to (V_O) calculated	Output Observed (V_O)
V_1	V_2		
0.5V	1V		
+1V	-2V		
-2V	+2.5V		

– – – – – – –

Construct and test Differentiator and integrator

Objectives : At the end of this exercise you shall be able to

- **construct and test differentiator circuit using Op-Amp IC 741**
- **construct and test integrator circuit using Op-Amp IC 741.**

Requirement

Tools/Equipments/Instruments / Data Book

- Trainees tool kit - 1 Set
- CRO 20MHz dual trace - 1 No
- Digital multimeter with probes - 1 No
- Voltmeter 0-10V - 1 No
- Regulated dual DC power supply 0-30V/2A - 1 No
- Function generator - 1 No

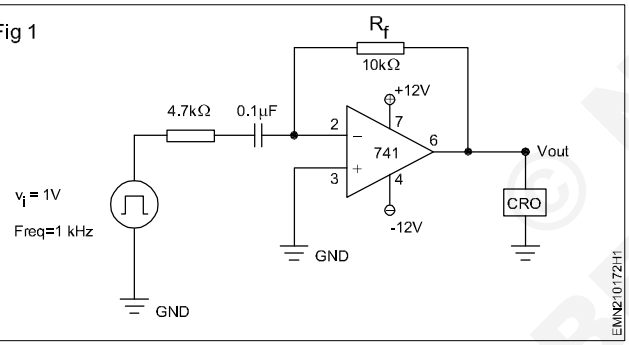
Materials/Components

- Resistors 1kΩ, 10kΩ, 4.7kΩ ¼ W/CR25 - each 1 No
- IC 741 Op-Amp - 1 No
- Capacitor 0.1 μF/25V - 1 No
- Hook up wire - as reqd
- Breadboard - 1 No
- Graph sheet (Linear) - 1 No

TASK 1 : **Construction and testing of a differentiator circuit**

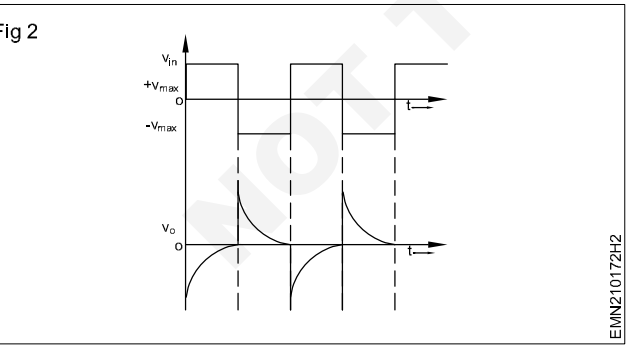
1 Collect and check the components for the good working condition and assemble the circuit on the bread board as shown in Fig 1.

Fig 1



2 Get the assembled circuit checked by the Instructor Calculate RC time constant($T=R_fC$).

Fig 2



3 Give a square wave input of 1 V_{p-p} to the inverting terminal and set the frequency to 1/T in the function generator.

4 Switch ON the dual power supply and set it to +12V and -12V and GND as shown in Fig 1.

Note: For a differentiator,

$$VO = R_fC \frac{d(V_{in}(t))}{dt}$$

5 Prepare the CRO for measurement and observe the output waveform on the CRO.

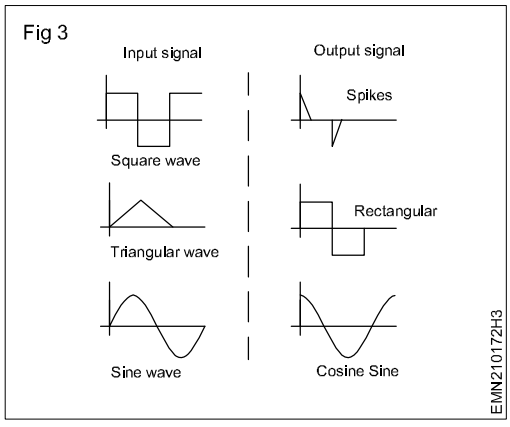
6 Vary the frequency to 1/10T and observe the waveform.

7 Vary the frequency to 1/0.1T and observe the waveform.

8 Draw output and input waveform of the circuit as shown in 2 on a graph sheet for all the 3 steps.

9 Repeat the above procedure for different input signals viz. triangular waveform and sinewave waveform as shown in Fig 3.

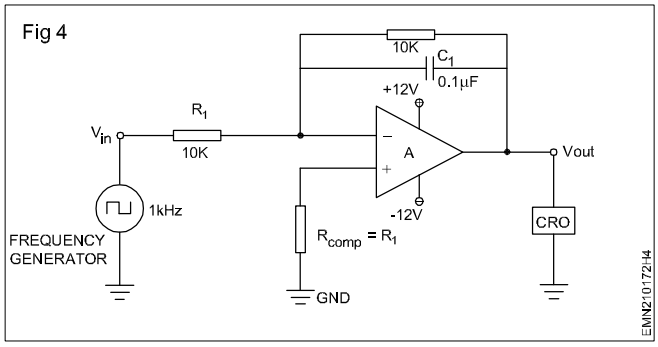
Fig 3



TASK 2 : **Construction and testing of a integrator circuit**

1 Check the components for their good working condition and connect the circuit on the bread board as shown in the Fig 4.

Fig 4



2 Calculate RC time constant($T=R_1C$).

3 Apply a non sinusoidal input of 1 V_{p-p} to the inverting terminal and set the frequency to 1/T in the function generator.

Note: For a Integrator:

$$VO = -\frac{1}{R_1C_1} \int V_{in}\, dt$$

4 Switch ON the dual power supply and set it to +12V, -12V and GND connections.

5 Observe the output waveform on the CRO.

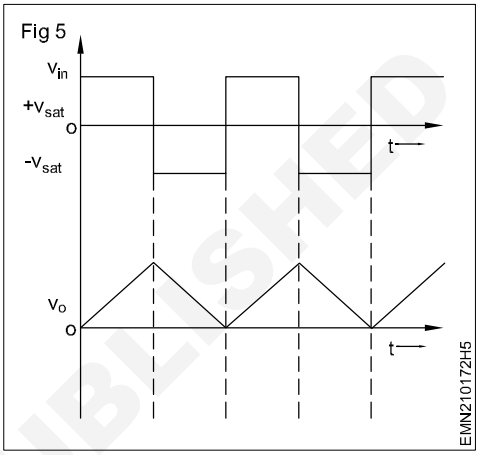
6 Vary the frequency to 1/10T and observe the waveform.

7 Vary the frequency to 1/0.1T and observe the waveform.

8 Draw output and input waveform of the circuit as shown in Fig 5, on a graph sheet for all the 3 steps.

9 Repeat the same procedure for different input signals viz. square wave, triangular waveform.

Fig 5



10 Get the result checked by the Instructor.

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Construct and test a zero crossing detector

Objectives : At the end of this exercise you shall be able to
- **verify the operation of a zero crossing detector circuit using Op-Amp IC741.**

Requirement

Tools/Equipments/Instruments / Data Book

- CRO Dual trace 0-20 MHz - 1 No
- Signal Generator - 1 No
- Regulated dual DC power supply 0-30V/2A - 1 No
- Trainees tool kit - 1 Set

Materials/Components

- Breadboard - 1 No
- IC 741 - 1 No
- Diode 1N4007 - 2 Nos
- Resistor 1kΩ, ¼ W/CR25 - 3 Nos

PROCEDURE

Construction and testing of Zero crossing detectors using Op-Amp IC741

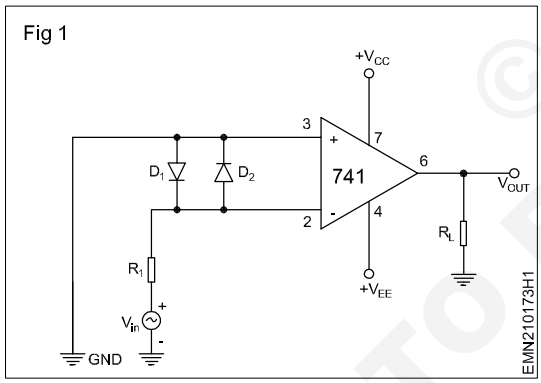
1 Collect all the materials check the working condition using the multimeter and assemble the circuit as shown in Fig 1 on bread board.

Check the IC using the IC tester.

2 Connect the reference Input to zero crossing detector, pin no 3 to GND.

3 Get the assembled circuit checked by the Instructor.

Fig 1



4 Connect the input sinewave signal, obtained from a Function generator, at 1 kHz/1 $V_{p-p.}$

5 Prepare the CRO for measurements and connect the input and output to dual channel CRO, and compare the input and output wave forms with Fig 2 and record the observations in Table 1.

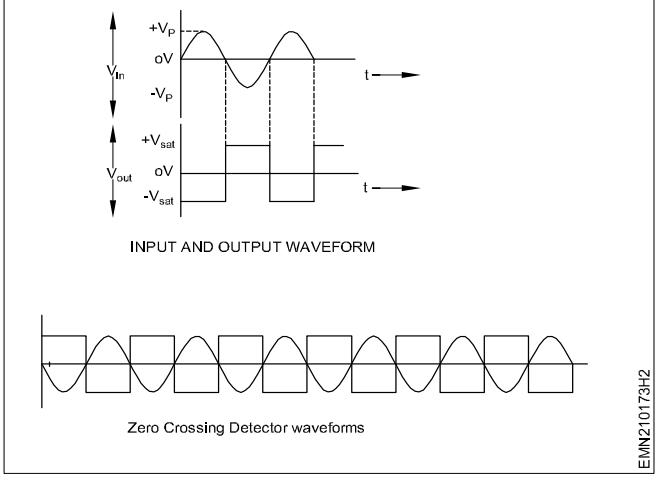
6 Get the work checked by the Instructor.

Observation Table

Table 1

Parameter	Waveform	Time
Input - Voltage (V_{in}) = _____		
Output - Voltage (V^{out}) = _____		

Fig 2



Note: Instructor may guide the trainees to note that output waveform changes state, whenever the input sinewave signal crosses the zero level. The circuit works as an Inverting Comparator.

Construct and test instrumentation amplifier

Objectives : At the end of this exercise you shall be able to
- **construct and test Instrumentation amplifier circuit using IC LM324.**

Requirement

Tools/Equipments/Instruments/Data Book

- Function generator - 1 No
- CRO dual trace 20MHz - 1 No
- Dual regulated DC power supply 0-30V/2A - 1 No
- Trainees tool kit - 1Set
- Digital multimeter with probes - 1 No
- Data sheet of the IC LM324 - as reqd

Materials/Components

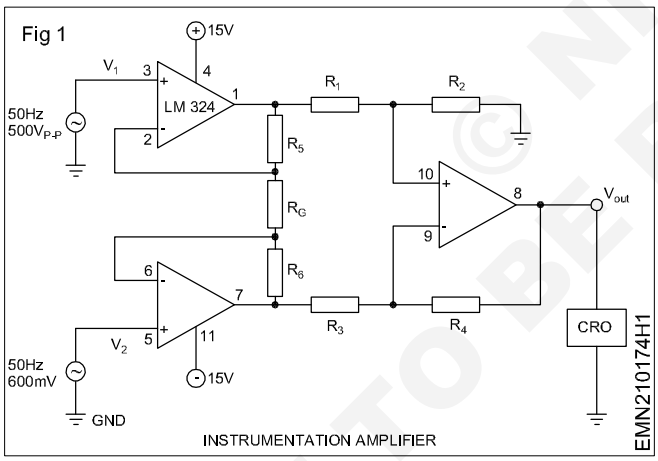
- Resistors ¼ W/CR25
  - 1kΩ - 4 Nos
  - 100kΩ - 4 Nos
  - 1kΩ POT - 1 No
- IC LM324 - 1 No
- Breadboard - 1 set

PROCEUDRE

Construction and testing of an Instrumentation amplifier circuit

1 Collect all the components, test them and refer to the pin out diagram of the IC and assemble the circuit as per the circuit diagram shown in Fig 1.

Fig 1



2 Get the assembled circuit checked by the Instructor.

3 Set the inputs V_1 and V_2 at different values but at the same frequency.

4 Switch ON the dual power supply and set the voltage + 15V, -15V and GND.

5 Prepare the CRO for measurements and measure the output at the output pin.

6 Calculate the theoretical gain from the given formula and verify the practical values.

Formula

$$Voltage gain A_V = \frac{V_0}{V_2 - V_1} = \left(1 + \frac{2R_1}{R_{gain}}\right) \times \left(\frac{R_3}{R_2}\right)$$

Table

Sl.No.	Applied input voltage	Voltage gain AV	Output voltage calculated (V_o)	Result Observed Output 'V_o'
1	V_1= V_2=	V_o=		

7 Get the work checked by the Instructor.

– – – – – – –

Construct and test a Binary weighted and R-2R Ladder type Digital- to- Analog converters

Objectives: At the end of this exercise you shall be able to
- **assemble and test a digital to analog converter using R-2R ladder network using Op-Amp.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Regulated dual DC power supply 0-30V/2A - 1 No
- DC power supply 15V/500 mA - 1 No
- Digital multimeter with probe - 1 No

Materials/Components

- IC LM741 - 1 No
- Data sheet of the ICs used - as reqd
- Resistor, carbon film 10 kΩ/¼ W/CR25 - 16 Nos
- Breadboard - 1 No
- IC Base 8 pin - 1 No
- Hook up wire - as reqd
- Miniature toggle switch SPDT - 4 Nos

PROCEDURE

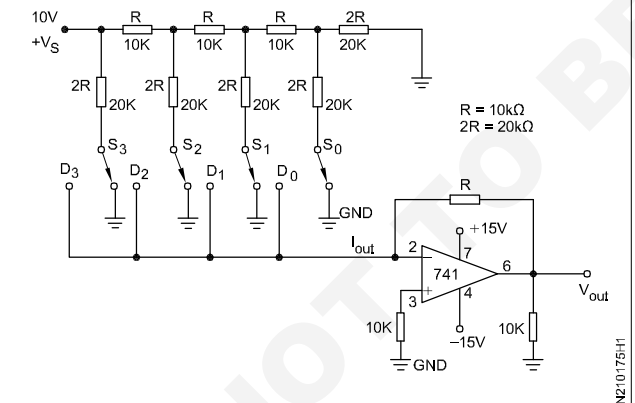
Construct and test D to A converter using R-2R ladder network

1 Collect all the components, check them; Refer Fig 1 and assemble the op-amp circuit using IC741 with 8 pin IC base on bread board.

2 Get the assembled circuit checked by the Instructor.

3 Connect the dual DC power supply +15, -15V and GND terminals to the IC741 referring to Fig 1.

Fig 1



D TO A CONVERTER USING R-2R LADDER NETWORK

4 Assemble the remaining part of R-2R ladder network on bread board ensuring four terminal connections D_0 to D_3 which are digital inputs.

5 Use the toggle switches S_0 to S_3 and operate them to provide logic levels low (GND) and thigh (1) as per the Table 1.

6 Get the work checked by the Instructor.

7 Apply binary logic inputs at D_0 to D_3 as per Table 1, measure voltage at the output of the Op-Amp and record them in Table.

8 Repeat step 7 for different binary input combinations.

9 Calculate the theoretical V_o by using the formula for different binary input combinations and record the same in Table 1.

Formula for theoretical output V_0

$$V_0 = \frac{D_0.2^o+D_1.2^1+D_2.2^2+D_3.2^3}{2^3}$$

Digital Input = logic 0/logic 1

Note: For (e.g) If the 4 bit binary inputs are [D0 D1 D2 D3 - Decimal values = 7.

The equivalent analog value of the D to A converter can be calculated as follows:

As logic - 2 refer to 5V, V_{ref} = 5V in the circuit.

For the binary inputs 1110, the input voltage x at pin 2 of Op - Amps, is

$$V_x = [(2^0 \times 1)+(2^1 \times 1) + (2^2 \times 1) + (2^3 \times 0)]$$

$$\text{Analog} = \frac{1}{16}(7) = \left(\frac{7}{16}\right)$$

$$\text{O/P } V_o = \frac{7}{16} \times 5V$$

For binary Input $(-1111)_2$

Analog output will = -5V

(-1 is the inverting amplifier gain).

Table 1

Decimal Value of Input	4-bit Digital Input				V_o Calculated	V_o Measured
	D_3	D_2	D_1	D_0		
0	0	0	0	0		
1	0	0	0	1		
2	0	0	1	0		
3	0	0	1	1		
4	0	1	0	0		
5	0	1	0	1		
6	0	1	1	0		
7	0	1	1	1		
8	1	0	0	0		

10 Get the work checked by the Instructor.

– – – – – – –

Construct and test Astable multivibrator circuit using IC 555

Objectives: At the end of this exercise you shall be able to
- **assemble and test an astable multivibrator circuit using IC 555**
- **measure pulse repetition frequency (PRF), rise time and fall time of the pulses.**

Requirements

Tools/Equipments/Instruments

- Regulated DC power supply 0-30/2A - 1 No
- Trainees tool kit - 1 Set
- CRO 20MHz, Dual trace - 1 No
- Digital multimeter with probes - 1 No

Materials/Components

- Bread board - 1 No
- IC base, 8 pin DIL - 1 No
- IC 555 - 1 No
- Carbon resistors, ¼ W/CR25
  1kΩ - 1 No
  10k preset - 1 No
- Preset, 10kΩ - 1 No
- Capacitors
  0.01 µF/25V - 1 No
  0.1 µF/25V - 1 No
  4.7 µF/25V - 1 No
- Speaker, 8Ω, 2" or any small speaker (used in pocket radios) - 1 No
- LED 5mm, Red - 1 No
- Hook up wires -as reqd

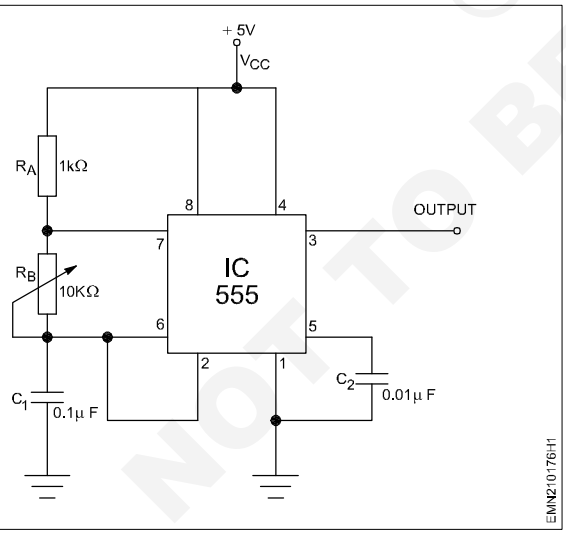
PROCEDURE

Construction and testing of an astable Multivibrator using IC 555

1 Collect all the required components, check them and assemble the astable multivibrator circuit on breadboard as shown in Fig 1.

2 Get the assembled circuit checked by the Instructor.

Fig 1



Place and fix the IC in the IC socket ensuring that the IC pins do not get bent or come out of the IC base.

3 From the values of the circuit components, calculate and record the ON-time(t_{ON}), OFF-time(t_{OFF}) and the pulse repetition frequency(PRF) of output.

4 Get the calculated values checked by the instructor.

5 Prepare the CRO for measurements.

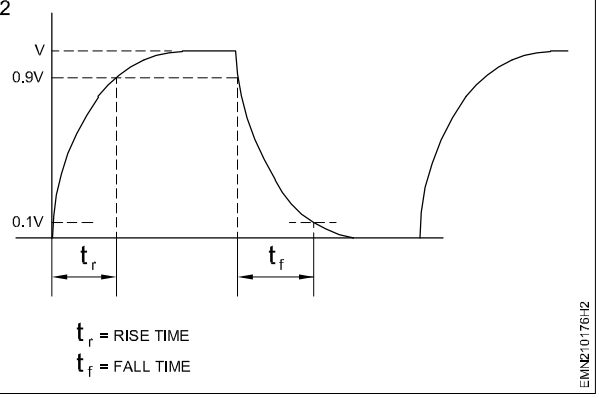
6 Switch ON DC voltage to the circuit and check for continuous rectangular pulses at the output of the circuit using the CRO.

If there is no output, switch off the voltage to the circuit and check the circuit connections. Take the help of the Instructor, if necessary.

7 Measure and record the ON-time, OFF-time and PRF (pulse repetition frequency) of the output pulses.

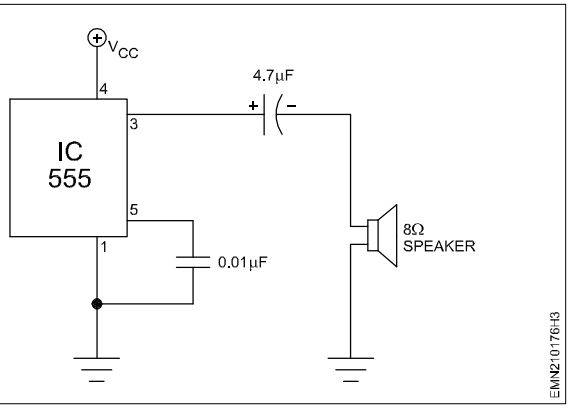
8 Measure and record the rise-time and fall-time of the pulses as shown in Fig 2.

Fig 2



9 Connect a capacitor 4.7μF and a 8Ω, 2 inch speaker at the output in series with a capacitor as shown in Fig 3.

Fig 3



10 Switch ON the DC supply and listen to the audible sound from the speaker. Change the position of the preset 'RB' and check for changed frequency output from the speaker.

11 Measure and record output frequencies and duty cycle at four different positions of preset.

12 Get the working of astable multivibrator circuit and the recorded readings checked by the Instructor.

Note:

The frequency (or) PRF of Astable multivibrator is:

- **f = =** $\frac{1.44}{(R + 2RB)C}$
- **t OFF = 0.693 x RB x C**
- **t ON = 0.693 (RA + RB) C**
- **D = Duty Cycle =** $\frac{(RA + RB)}{(RA + 2RB)}$

1 (a) Measured ON-time (t_{ON}) : _____

(b) Measured OFF-time (t_{OFF}) : _____

(c) Measured pulse repetition frequency (PRF) : _____

(d) Duty cycle : _____

2 Rise time of pulse (Observed) : _____

3 Fall time of pulse (Observed) : _____

4 (a) Audible output heard from speaker : YES/NO

(b) Frequency/pitch of audible output from speaker varies with position of preset : YES/NO

Table 1

Resistance of preset RB	Output Frequency	Waveform on CRO

– – – – – – –

Construct and test Monostable multivibrator circuit using IC 555

Objective : At the end of this exercise you shall be able to
- **assemble and test a monostable multivibrator using IC 555.**
- **use the monostable multivibrator as a touch switch.**

Requirements

Tools/Equipments/Instruments

- Digital multimeter with probes - 1 No
- Trainees tool kit - 1 Set
- Storage oscilloscope/CRO-0-20 MHz dual trace - 1 No
- Regulated DC power supply 0-30V/2A - 1 No

Materials/Components

- Breadboard - 1 No
- 8-pin IC base - 1 No
- IC 555 - 1 No
- Carbon resistors, 1/4 watt
  10 MΩ - 1 No
  33 kΩ 330Ω, 1MΩ - 1 No
- Capacitors 25VDC - 1 No each
  0.01µF - 2 Nos
  4.7µF - 1 No
- LED 5mm, Red - 1 No
- Push-button switch (Push-to-ON) - 1 No
- Hook up wires - as reqd

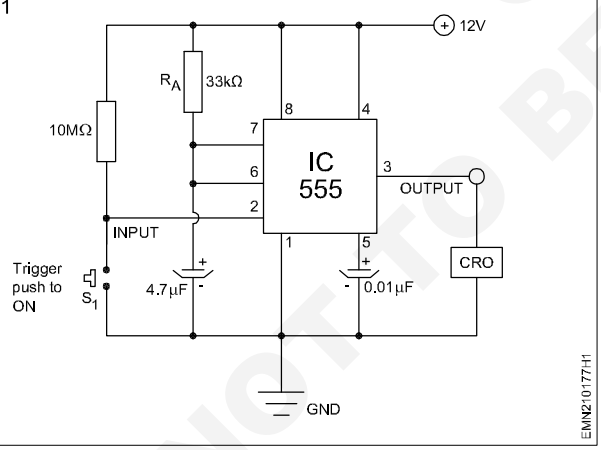
PROCEDURE

TASK 1 : **Construction and testing of Monostable multivibrator circuit using IC 555**

1 Collect all the materials required and check them.

2 Assemble the monostable multivibrator on breadboard referring to the circuit diagram shown in Fig 1.

Fig 1



3 Get the assembled circuit checked by the instructor.

4 Switch ON the 12VDC supply to the circuit.

5 Prepare the CRO for measurements and connect the CRO at the output of the monostable multivibrator.

6 Press the push-button(trigger signal) and observe the output pulse on the CRO.

7 Keep pressing and releasing the trigger button and measure the ON-time(t_{ON}) of the output pulse. Record the reading in Table 1&2.

If the CRO has a storage option, use it to measure the pulse width conveniently. Take the help of the instructor to use the storage option.

8 Connect the CRO probe at pin No. 2 of the IC; keep pressing and releasing the trigger button and observe the trigger input waveform on the CRO. Sketch the observed waveform in the space provided in the Table 2.

9 Change the value R_A from 33 KΩ to 1 MΩ. Connect the LED with a 330 Ω resistor in series at the output pin 3 to GND.

10 Switch ON DC supply to the circuit; press the push-button (trigger) and observe the LED glow for a few seconds and turn OFF again. Record your observation.

Table 1

S.No.	R_A	C	Time	
			Calculated $T=1.11 \times R_A C$	Measured
1	33kΩ	4.7µF		
2	1MΩ	4.7µF		

Table 2

Wave form at Trigger Input Pin -2	Wave form at Output Pin-3

11 Get the work checked by the Instructor.

– – – – – – –

TASK 2 : **Construction and testing of Monostable multivibrator as a touch switch**

1 Remove the push-button switch connected at pin No.2 of the IC. Connect a wire of about 0.5 metres skinned at both ends at pin No. 2 of IC.

2 Switch ON DC supply to the circuit. Touch once, the free end of the wire by your fingers and observe the LED glow. Repeat this step a few more times and record your observation.

The circuit is now working as a touch-switch.

3 Get the working of the touch-switch checked by the Instructor.

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Construct and test VCO (V to F converter) using IC 555

Objectives : At the end of this exercise you shall be able to
• construct and test VCO circuit using IC 555.

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Digital multimeter with probes - 1 No
- Regulated DC power supply 0-30V/2A - 1 No

Materials/Components

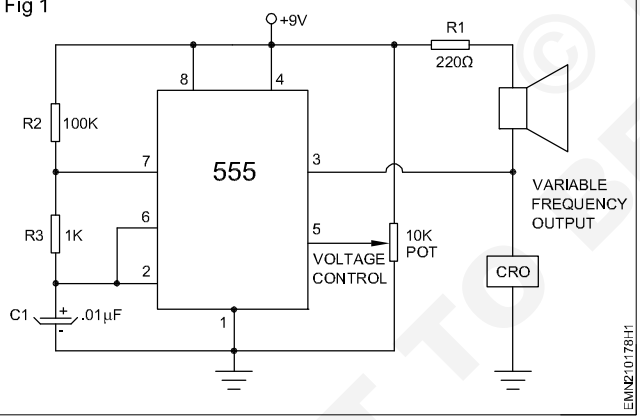
- Bread board - 1 No
- Resistor 100kΩ, 1kΩ, 220Ω ¼ W/CR25 - 1 No each
- IC 555 - 1 No
- Capacitor 0.01µF/25V - 1 No
- Loud speaker 8Ω/1W - 1 No
- Hookup wire - as reqd
- 10k Linear potentiometer - 1 No

PROCEDURE

Construction and testing of VCO circuit using IC 555

1 Collect all the materials required for the circuit diagram shown in the Fig 1 and check them for their working condition using multimeter.

Fig 1



2 Assemble the components on breadboard according to the circuit shown in Fig 1.

3 Get the assembled circuit checked by the Instructor.

4 Switch ON 9V DC supply to the circuit from the Regulated DC power supply.

5 Prepare the CRO for measurement, and observe the waveform at pin no.3.

6 Adjust the DC control voltage at pin no. 5 and observe the sound and measure the effect on the output of the circuit.

This observation, conclude that the output of the circuit (i.e the frequency of astable multivibrator) varies on varying the control voltage at pin no. 5 then the circuit behaves as voltage controlled oscillator.

7 Change the DC control voltage settings as per the table and record the readings in Table 1.

Table 1

Sl.No.	Input Voltage	CRO readings
1	1.5V	
2	3V	
3	4.5V	
4	7.5V	

8 Get the work checked by the Instructor.

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Construct and test 555 timers as pulse width modulator

Objective: At the end of this exercise you shall be able to
• construct and test a PWM circuit using IC555 to generate pulse width modulated output.

Requirements

Tools/Equipments/Instruments/Data Book

- Trainees tool kit - 1 Set
- Digital multimeter with probes - 1 No
- Regulated DC power supply 0-30V/2A - 1 No
- Function generator - 1 No
- AF signal generator - 1 No

Materials/Components

- Breadboard - 1 No
- IC 555 - 1 No
- IC Base-8 pin - 1 No
- Diode 1N4001 - 1 No
- Resistor
  15kΩ, carbon, ¼ W - 1 No
  10kΩ, carbon, ¼ W - 1 No
  5.6kΩ, carbon, ¼ W - 1 No
- Capacitors 25V DC
  0.1µF, ceramic disc - 2 Nos
  10 µF - 1 No
- LED 5mm, Red - 1 No
- Push-button switch (Push-to-ON) - 1 No
- Hook up wires - as reqd

PROCEDURE

Construction and testing of PWM circuit using IC 555

1 Collect all the materials required identify the components as per the circuit diagram. Ensure working condition of the components by using multimeter and IC tester.

2 Assemble the PWM control circuit using IC 555 as shown in Fig 1.

3 Switch ON 12V DC power supply.

4 Connect the square wave input as carrier, from function generator. Set the waveform to the required duty cycle and AF signal as message.

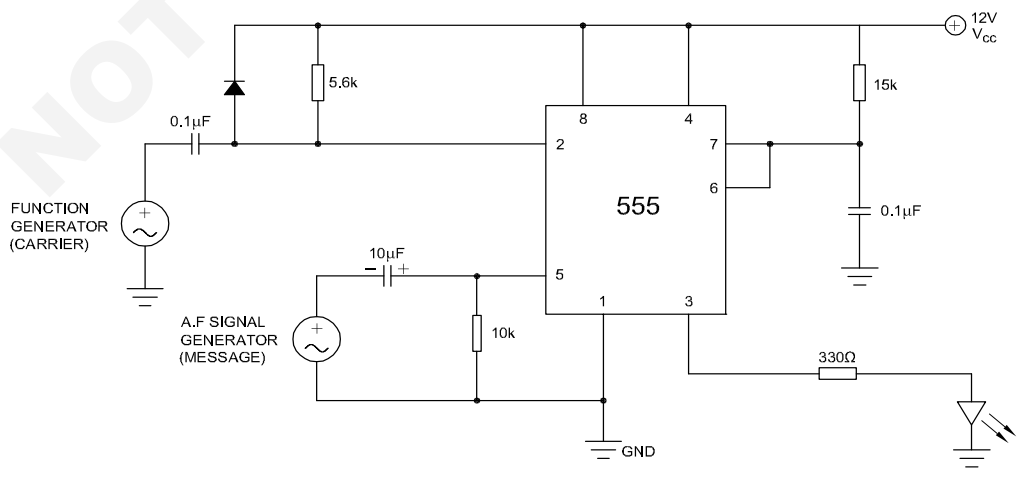
5 Observe the output LED at pin 3 and the brightness of the LED.

6 Prepare the CRO for measurement and observe the out waveform verify PWM frequency and duty cycle; record the waveform in Table 1.

Table 1

Function Generator frequency	A.F. Generator frequency	Output waveform	Remarks

Fig 1



7 Get the result checked by the Instructor.