ELECTRONICS MECHANIC

TRADE PRACTICAL

NSQF LEVEL - 4.5

VOLUME - 1

HANDBOOK FOR CRAFTS INSTRUCTOR TRAINING SCHEME

Directorate General of Training

DIRECTORATE GENERAL OF TRAINING
MINISTRY OF SKILL DEVELOPMENT & ENTREPRENEURSHIP
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A Comprehensive Training Program
under Crafts Instructor Training Scheme (CITS)
for Instructors

HANDBOOK ON TECHNICAL INSTRUCTOR TRAINING MODULES

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कौशल विकास एवं उद्यमिता मंत्रालय
GOVERNMENT OF INDIA
MINISTRY OF SKILL DEVELOPMENT AND ENTREPRENEURSHIP

सत्यमेव जयते

Foreword

In today's rapidly evolving world, the role of skilled craftsmen and women is more crucial than ever. The Craft Instructor Training Scheme (CITS) stands at the forefront of this transformation, shaping the educators who will train the next generation of artisans and technicians. This book aims to provide an in-depth understanding of the subject, exploring its significance, methodologies, and impact on vocational training.

The Craft Instructor Training Scheme was established with the objective of enhancing the quality of instruction in industrial training institutes and other vocational training institutions. By equipping instructors with advanced skills and knowledge, the scheme ensures that they are well-prepared to impart high-quality training to their students. This, in turn, contributes to the creation of a highly skilled workforce capable of meeting the demands of modern industry.

The initial chapters provide the importance of specialized instructor training. Following this, detailed chapters delve into the curriculum covering advanced techniques, safety protocols, and instructional strategies. Each section is designed to offer both theoretical insights and practical applications, ensuring a well-rounded understanding of the subject.

The book offers recommendations for overcoming obstacles and enhancing the effectiveness of the program, with the ultimate goal of producing highly skilled instructors capable of shaping the future workforce.

This book is intended for a diverse audience, including current and aspiring instructors, vocational training administrators, policymakers, and industry stakeholders. It serves as a valuable resource for understanding the intricacies of the subject and its pivotal role in vocational education.

I extend my heartfelt gratitude to all contributors who have shared their experiences and expertise, enriching this book with their valuable insights. Special thanks to the contribution of the development team, reviewers and NIMI that have supported this endeavor, providing essential data and resources.

It is my sincere hope that this book will inspire and guide readers in their efforts to enhance vocational training, ultimately contributing to the development of a skilled and competent workforce.

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GOVERNMENT OF INDIA
MINISTRY OF SKILL DEVELOPMENT & ENTREPRENEURSHIP
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सत्यमेव जयते

FOREWORD

The Craftsmen Training Scheme (CTS) implemented by the Directorate General of Training (DGT) provides skill training to the youth and ensures a steady flow of skilled manpower for the industry. It aims to raise quantitatively and qualitatively the industrial production by systematic training, and to reduce unemployment among the youth by providing them with employable skills.

The Craft Instructor Training Scheme (CITS) is an indispensable part of the Craftsmen Training Scheme (CTS). It offers comprehensive training both in 'skills' and in 'training methodology' to the instructor trainees to make them conversant with techniques of transferring hands-on skills.

I congratulate NIMI for taking the initiative of preparation of the course content for CITS. This will help institutionalize the mechanism for imparting training to the trainers all across the ecosystem. I also extend my gratitude to the Instructors and Officials of National Skill Training Institutes (NSTIs) and the DGT for their invaluable contribution in preparation of the CITS course content.

As we navigate the complexities of a rapidly changing world and the technological disruptions, the significance of CTS and CITS has increased manifold. It not only empowers individuals with practical skills but also lays the foundation for a prosperous future. I am confident that this book will serve as a guiding light to all instructor trainees for skill development and nation-building.

Trishaljit

(Trishaljit Sethi)

PREFACE

The Craft Instructor Training Scheme is an indispensable module of the Craftsmen Training Scheme, which has been an integral part of the Indian skill development industry since its inception. This program aims to equip instructors with the necessary skills and teaching methodology to effectively transfer hands-on skills to trainees and promote a holistic learning experience. The first Craft Instructor Training Institute was established in 1948, followed by six more institutes across India in 1960. Today, these institutes, including the National Skill Training Institute (formerly Central Training Institute for Instructors), offer the CITS course, which is mandated by the Directorate General of Training (DGT).

The Craft Instructor training program is designed to develop skilled manpower for industries. The course aims to offer instructors an opportunity to improve their instructional skills, engage learners effectively, offer impactful mentoring, and make efficient use of resources, leading to a more skilled workforce in various industries. The program emphasizes collaborative and innovative approaches to teaching, resulting in high-quality course delivery. Overall, the Craft Instructor Training Scheme is a pivotal program that helps instructors grow in their careers and make a significant contribution to society. This program is essential for developing skilled manpower and promoting a robust learning environment that benefits both trainees and instructors alike.

ACKNOWLEDGEMENT

National Instructional Media Institute (NIMI) sincerely acknowledges with thanks for the co-operation and contribution extended by the following experts to bring out this Instructional material **(Trade Practical)** for **CITS Electronics Mechanic (Volume - I of II) (NSQF Level - 4.5)** under the **Electronics & Hardware** Sector for **Instructors**.

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

ABOUT THE TEXT BOOK

The Vocational Instructor Training Program is a comprehensive initiative designed to equip aspiring students with the necessary skills and knowledge to effectively teach in vocational education settings. This program encompasses a range of pedagogical strategies, instructional techniques, and subject-specific content tailored to the diverse vocational fields. Participants engage in coursework that covers curriculum development, assessment methods, classroom management, and the integration of industry-relevant technologies. Practical experience and hands-on training are emphasized, allowing participants to apply theoretical concepts in real-world teaching environments. Through collaborative learning experiences and mentorship opportunities, aspiring vocational instructors develop the confidence and competence to facilitate engaging and impactful learning experiences for their students. This training program aims to cultivate a new generation of educators who are not only proficient in their respective vocational fields but also adept at fostering the success and employability of their students in today's competitive workforce.

This text book covers communication, self-management, information and communication technology, entrepreneurial and green skills. It has been developed as per the learning outcome-based curriculum.

G C Rama Murthy,
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MODULE 1: Safety & Maintenance of Tools and Equipments

EXERCISE 01: Practice 5S techniques in the Electronic Mechanic Workshop

Objectives

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

- Understand the procedure to perform 5S techniques in Electronic Mechanic Workshops.

Requirements

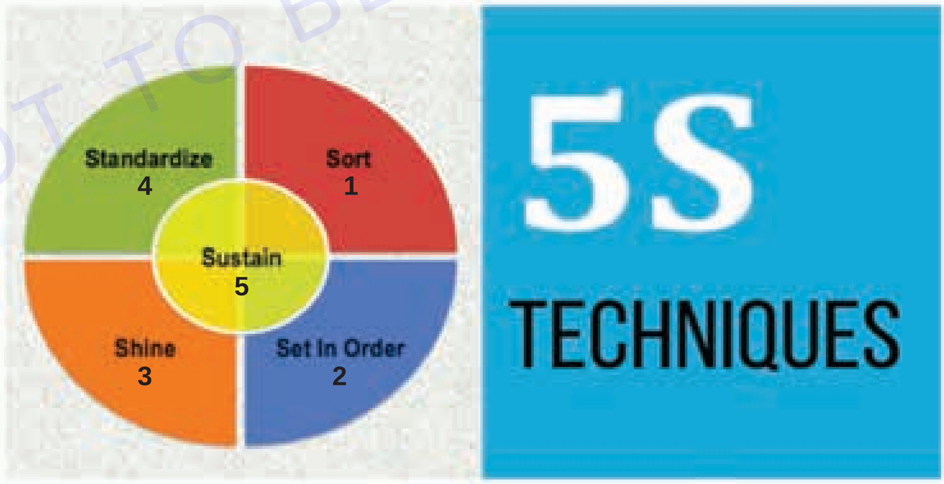
Tools/ Equipments/ Instruments

- Workbenches with electrical fittings, electronic equipments, tools, assembled circuit boards, different connectors, cables etc - 1 set.
- Tools rack/ cabinet/cupboard - 1 No.
- Component Cabinet/ Cupboard with rectangular boxes or bins with label holders - 1 No.
- Portable Vacuum Cleaner - 1 No.
- 5 S Charts - 1 set.

Materials/ Components

- Assorted electronic components - as reqd.
- Equipment Cleaning liquid - 1 bottle.
- Dusting cloth/ cotton waste - as reqd.
- Isopropyl alcohol (IPA) for circuit board cleaning - 1 bottle.

Refer to the 5S Concept before starting the workshop practice.



Please Note:

1 **Upkeep of Laboratory involves tasks like cleaning, repairing, and regular inspections of all electrical and electronic equipments and machinery to maintain the Lab in good working condition.**

2 **Switch OFF all the machinery and equipment before starting the 5S process.**

3 **Wear face mask before cleaning the workspace and while dusting Electrical machinery and while cleaning Electronic Equipments.**

Procedure

TASK 1a: **To Sort, Set in Order, Shine, Standardise & Sustain**

1 Take out the assorted list of electronic components (Transistors, resistors, capacitors, ICs, LEDs, fuses etc.) issued to you from the box.

2 Sort these components based on their ITEM NAME, TYPE/CATEGORY, VALUE/SPECIFICATION and its FUNCTION.

3 Store them item wise into bins or boxes and Stick proper Labels for the component boxes with sample data as shown below.

Item name	Category	Label for boxes/bins – with Specifications
Resistors	1/4 W carbon type resistors	10 ohms, 100 ohms, 120 ohms etc
Resistors	½ W carbon type	220ohms, 1kohms etc
Capacitors	Ceramic disc type	0.01MFD, 0.047MFD,etc
Transistors	NPN type	BC 147, BC148 etc.
Transistors	PNP type	BC 157, BC 158 etc.
Fuses	DC fuse	1A, 2A, 5A etc.
LEDs	Size - 5mm	Red, green, yellow, etc.
ICs	Analog ICs	IC 741, IC 555 etc.
	Digital ICs	IC 7400, 7402, 7404, 7408 etc
	Regulator ICs	IC 7805, 7806, 7812, etc.

4 Arrange all the labelled boxes in a separate cupboard or in a components cabinet category wise as shown in Fig 1.

Fig 1

TASK 1b

1 Identify the different tools available on the table and arrange one set of the Tools issued in right place in the Tool kit as shown in Fig 2.

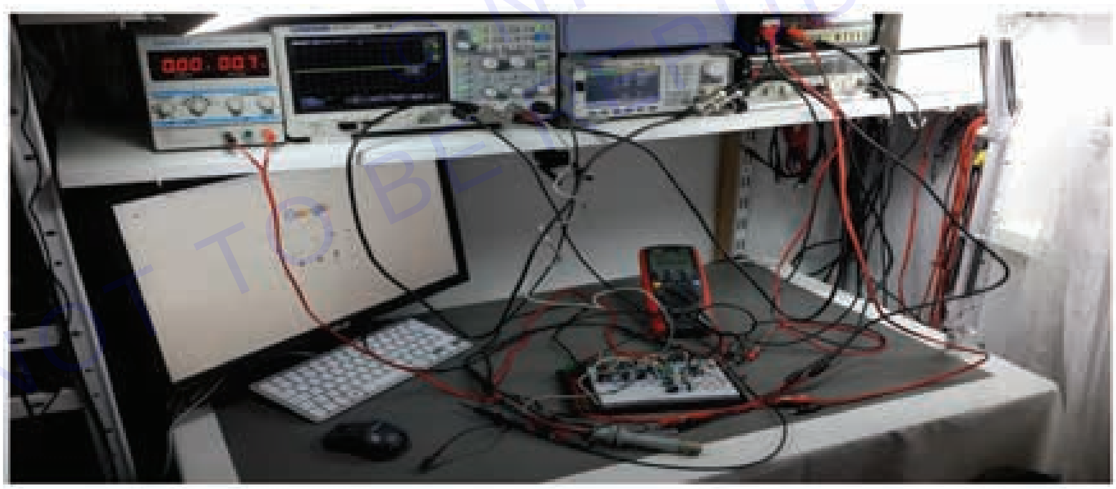
Fig 2

2 Arrange the remaining tools item wise in the allotted cabinets. Stick Labels with clear details about Name of the Tool, Size, Specification etc against each Tool box/ container. Also mention quantity of tools available in each box.

TASK 1c

1 Identify the cables with connectors connected in the equipments as shown in Fig 3.

Fig 3



2 Sort out the cables with CRO / DSO probes, BNC connectors, Cables with crocodile clips, patch cords of different sizes for Trainer kits, etc.

3 Clean the cables and hang them in the given cable hangers provided for various set of cables of different sizes and purpose as shown in Fig 4.

4 The worktable has equipments with connecting wires / cables kept hanging and interconnected between the equipments for the experimental setup.

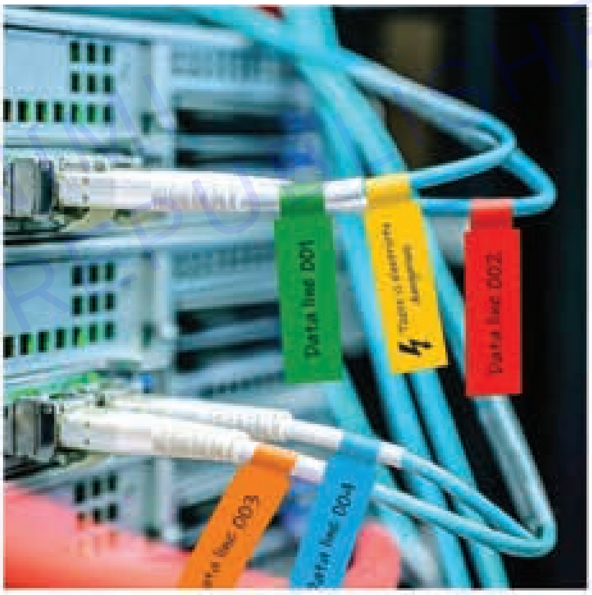
5 Disconnect the wires / cables from the equipments after switching off the power supply and hang them in the hangers in proper order after completion of work as shown in Fig 4.

Fig 4

6 Different coloured tapes as shown in Fig 5 below, can be used on the cables as a Colour tag to quickly identify the type of cable and pick it easily as shown in Fig 6.

Fig 5

Fig 6



TASK 2: **To Sort, Set in order , Shine, Standardise & Sustain**

1 Identify the equipments / machinery and electrical fittings like electrical switches & sockets of workbenches that are under use.

2 Check the electrical fittings for its functionality.

3 Stick label on the Equipment about Working Good / Not working.

4 Use Hand held Vacuum cleaner to clean the dust on the machinery and surrounding area for better upkeep of the Lab infrastructure. Clean the worktables and properly dispose the waste materials.

5 While Cleaning the machinery, Care has to be taken not to disturb / pull out the wiring or damage the cables.

6 Do not Use wet cloth on wired electrical parts or accessories.

7 Finally Power ON all the systems one by one and check that all the equipments / machinery are in working condition after cleaning.

8 Get the work checked by the Instructor.

Note:

1 By performing the above tasks, you can understand the importance of the 5S concepts of Sort, Set in Order, Shine, Standardise and Sustain for quick access of Tools and Electronic Components which will be helpful during circuit Assembly, Testing and troubleshooting of Electronic boards and Equipments.

2 Similarly follow a weekly routine for sorting, arranging and cleaning of equipments, furniture and workspace for upkeep of the Lab and effective training. This also helps to effectively manage the lab inventory and improves the life of infrastructure.

— — — — —

EXERCISE 02: Precautions to be observed while working in the workshop

Objectives

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

- practice the procedure to adopt safety measures in the workshop
- understand the steps to be followed to prevent electrical accidents in the workshop.

Procedure

TASK 1 : **Prevention of electrical accidents**

Note: There is a need to educate one another about the safety precautions and ground rules that are supposed to be taken when working with electricity. Electricity can be very dangerous to deal with and honestly, a minor mistake or irresponsibility can cost you your life.

General Precautions:

1 **Personal Protective Equipment (PPE):**

- Eye Protection: Wear safety glasses to protect against molten solder lead while soldering the PCB.
- ESD Protection: Use anti-static wrist straps and mats to prevent electrostatic discharge (ESD) that can damage electronic components.
- Proper Attire: Avoid loose clothing and jewelry that can get caught in equipment.

2 **Electrical Safety:**

- Power Off: Ensure that all the equipments are powered off and unplugged before you start servicing.
- Insulation: Use tools with insulated handles to prevent electrical shocks.
- Voltage Awareness: Be aware of the voltage levels you are working with and follow appropriate precautions for high-voltage circuits.

3 **Tool and Equipment Safety:**

- Proper Use: Use tools and equipment only for their intended purpose.
- Inspection: Regularly inspect tools for damage or wear and replace them as necessary.
- Soldering Safety: Use soldering irons in well-ventilated areas and handle them carefully to avoid burns.

4 **Fire Safety:**

- Fire Extinguisher: Have a fire extinguisher rated for electrical fires accessible.
- Heat Management: Be cautious with heat sources, such as soldering irons and hot air guns, to prevent fires.

5 **Operation:**

- Attention: Stay focused on your task and avoid distractions, as electronics work requires precision.
- Proper Handling: Handle components and tools with care to avoid damage. Use tweezers for small components.

Soldering: Use a soldering iron at the correct temperature and handle it carefully to avoid burns. Ensure proper ventilation to avoid inhaling fumes.

6 **Emergency Procedures:**

- First Aid: Know the location of the first aid kit and how to use it in case of minor injuries.
- Emergency Exits: Be aware of the nearest exits and have a clear evacuation plan.
- Incident Reporting: Immediately report any accidents or equipment malfunctions to a supervisor.

Personal protective Equipment:

Personal protective equipment is the equipment worn to minimize exposure to hazards that cause serious work place injurious and illnesses. These injurious and illnesses may result from contact with chemical radiological, Physical, Electrical, Mechanical or other workplace Hazards.

Table 1

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

Electrical safety:

1 The first step of electrical safety, is to avoid interaction with water or moist surfaces when working with electricity. Never touch or try repairing any electrical equipment or circuits with wet hands. It increases the conductivity of the electric current.

2 Make sure your body is dry before picking any electrical device or equipment connected to power supply.

Dry Hands

3 You will never know if the cables are covered properly or not (or) if there is a little part broken and you touch it with your wet hands then, an electric shock is expected for sure.

Broken Electrical Power cord

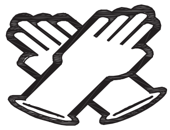
4 Electrical and electronic items and tools that possess ISI (Indian Standards Institute) standards, which is a smart choice for ensuring safety, reliability, and quality.

5 Use properly insulated tester and tools for the job.

6 Never use slightly damaged power Cable, power cords, broken plugs and damaged insulations.

7 **Always Turn Off The Mains First**. Disconnect the equipment to be repaired from the mains line by pulling out the plug-top and not by pulling the power cord.

8 Before testing/repairing electrical power points / equipment; keep yourself isolated from the earth contact by using rubber shoes or by using rubber gloves.



Rubber Gloves

9 Always before checking the electrical equipment with power supply, ensure rubber matting on the floor and place the electrical equipment on dry-wooden table.

10 Before starting the maintenance or repair work on any electric equipment , first disconnect it from the mains supply. Perform physical inspection of the electronic circuit board and power chord for any damaged / charred parts. Always after opening the Electronic equipment and before starting repairs, discharge the " High voltage filter capacitors" of the DC power supply unit, by short circuiting the capacitor terminals with a piece of thick wire or a test lamp.

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 as the component.

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

— — — — —

EXERCISE 03: Handling & maintenance of hand tools, special tools, equipments & machineries

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 toolkit - 1 Set.
- Different types of tools used in Electronics Lab - 1 No each.
- Electronic Equipments / Machinery - 1 Set.

Materials/ Components

- Cotton waste - as reqd.
- Cleaning liquid - 1 bottle.

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 labelled hand tools from the Work bench.

2 Identify and record the name of the hand tool inTable–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 1.

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	LineTester		
4	Instrument Screw Driver		
5	Long Nose Plier		
6	Combination Plier		
7	Side Cutting Plier		
8	Soldering iron with stand		
9	De-soldering Pump		
10	Magnifying Glass		
11	Tweezer		
12	Digital Multimeter		
13	Temperature controlled soldering station		
14	Digital storage Oscilloscope		
15	Cleaning Brush		

- **Proper Storage:** Store tools in a clean, dry place to prevent rust and damage. Use toolboxes, pegboards, or cabinets to organize and protect them.
- **Regular Inspection:** Inspect tools before and after each use for any signs of damage, wear, or defects. Replace or repair damaged tools promptly.
- **Cleaning:** After use, clean tools thoroughly to remove dirt, debris, and any substances that may cause corrosion. Use appropriate cleaning agents and methods for each tool type.
- **Lubrication:** Apply lubricants to moving parts of tools to prevent rust and ensure smooth operation. Follow manufacturer recommendations for the type and frequency of lubrication.
- **Sharpening:** Keep cutting edges sharp by regularly sharpening blades, bits, and cutting surfaces. Dull tools not only perform poorly but also pose safety risks.
- **Proper Handling:** Use tools only for their intended purposes and handle them with care to avoid unnecessary stress or damage. Avoid using excessive force, which can lead to tool breakage or personal injury.
- **Safety Measures:** Always follow safety guidelines and wear appropriate personal protective equipment (PPE) when using tools and equipment. Inspect PPE regularly for any damage and replace as needed.
- **Documentation:** Keep records of tool maintenance, inspections, repairs, and replacements. This helps track tool performance, identify patterns of wear, and plan for future maintenance needs.
- **Special Tools and Equipment:** Some tools and equipment may require specialized maintenance procedures or servicing. Follow manufacturer guidelines and recommendations for these specialized items.
- **Machinery Maintenance:** For machinery, follow manufacturer instructions for maintenance schedules, lubrication points, and troubleshooting procedures. Regularly inspect machinery for wear, leaks, or other signs of malfunction.
- **Emergency Preparedness:** Have procedures in place for handling emergencies such as equipment failure or accidents. Ensure that personnel know how to respond effectively to minimize risks and downtime.

By following these guidelines, you can ensure that hand tools, special tools, equipment, and machinery remain in good condition.

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EXERCISE 04 : Maintenance of Workshop equipments

Objectives

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

- Learn and practice care and maintenance of workshop equipments.

Requirements

Tools/Equipments/Instruments

- Trainees toolkit - 1 Set.
- Different types of tools used in Electronics Lab - 1 No each.
- Electronic Equipments / Machinery - 1 Set.

Materials/Components

- Cotton Waste - 1/2 kg
- Emery sheet - 1 No.
- Lubricating Oil - 1/2 Ltre.
- Equipment cleaning liquid - as reqd.
- Isopropyl alcohol - 1 Ltre.

DO's and DON'Ts :

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 screw drivers 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.

Procedure

TASK 1: **Maintenance of Workshop Equipments**

1 Prepare a list of Equipments available in the section and record the Name and Specification of each equipment in the Table 1.

2 At the end of each working day, clean the tools and equipment used and check them for any damage/ proper working condition. Rectify the fault in the equipment at the earliest with the help of manual to prevent shortage of working equipments.

3 If the equipment could not be repaired, tag the tool or equipment as faulty to get it serviced from other sources.

4 Complete the tasks described on the chart at the required time. This will help to keep the equipment in safe working order.

5 Check the Tool / Equipment data and fill the Table below.

6 Get the work checked by your Instructor.

Table 1

Sl.No	Name of the Tool or Equipment	Specification	Uses / applications	Precautions

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MODULE 2: Digital electronics & simulation software

EXERCISE 05: Identify different logic gates ICs by the number printed on them

Objectives

At the end of this exercise you shall be able to

- identify different logic gates by the IC number printed on them
- use data sheet / semiconductor data manual to obtain their specifications.

Requirements

Tools/ Materials

- Trainees tools kit - 1 Set.
- IC 7408, IC 7432, IC 7404, IC 7400, IC 7402, IC 7486, IC 4077 - 1 No each.
- Data sheet of ICs used - as reqd.

Procedure

Note: The instructor has to provide data sheets and manual. Issue digital ICs with their numbers printed on them clearly visible.

1 Choose one of the ICs and record the IC number in Table 1

2 Refer to the datasheet to determine the logic gate function of the IC pin details. Then draw the symbol and pin out diagram of the IC clearly marking the input, output, and supply pin numbers.

3 Finally get the work checked by the instructor.

4 Repeat the steps for remaining ICs and record the observations in Table-1.

Table 1

SI No	IC number	No.of pins	Logic gate functions	Symbol	Pin out diagram

4 Get the work checked by the Instructor.

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EXERCISE 06: Verify the truth tables of all Logic Gates ICs

Objectives

At the end of this exercise you shall be able to

- construct and test all the Logic Gate ICs
- verify the truth table for all the Logic Gate ICs.

Requirements

Tools/ Equipments/ Instrument

- Trainees tools kit - 1 Set.
- Regulated DC power (RPS) supply 0-30V/ 2A - 1 No.
- Digital multimeter - 1 No.
- Logic probe - 1 No.

Materials/ Components

- IC 7408, IC 7432, IC 7404, IC 7400, IC 7402, IC 7486, IC 4077 with datasheets - 1 No each.
- Bread board - 1 No.
- Resistors 1/4W 330Ω - 1 No.
- Toggle switches miniature type - 2 Nos.
- LED (Red colour) 5mm - 1 No.
- Hookup wire - as reqd.

Procedure

Note : The instructor should provide the Digital ICs datasheet to the trainees and guide them to get information about pin configuration of the logic gates, present inside each digital IC and other necessary details for proper assembly.

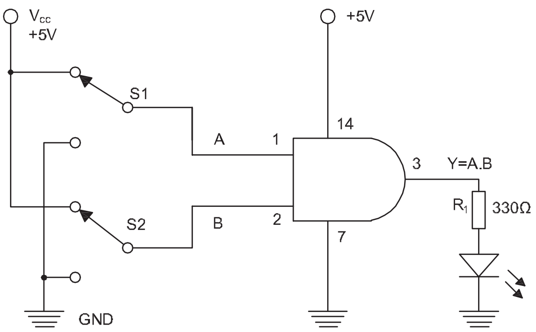
Instructor has to guide the trainees to use the logic probe to check the status of logical inputs/ outputs HIGH(5V) and LOW(0V) of the logic gate and verify the truth table.

Instructor has to guide the trainees for correct use of breadboard before commencing digital practical exercises.

While assembling the circuit, Insert hookup wires properly - straight inside the holes without bend, so as to touch the base plate of the breadboard, to get best interconnections.

TASK 1: **Construct AND gate using IC 7408 and verify its truth table**

Fig 1a



CONSTRUCTION OF AND GATE USING IC 7408

EMC22P0001

AND gate Truth table 1

Sl. No.	Input A	Input B	Output Y = A.B
1	0	0	0
2	0	1	0
3	1	0	0
4	1	1	1

Table 1

Sl. No.	Input A (S1)	Input B (S2)	Output LED status
1			
2			
3			
4			

1 Collect all the required components for assembling the AND gate circuit as shown in Fig 1a.

2 Check each component to ensure that they are in good condition.

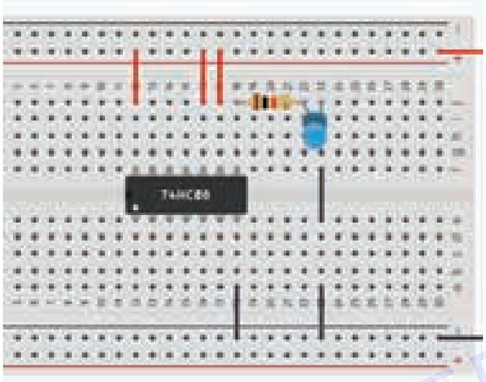
3 Refer to the datasheet of the IC 7408.

4 Assemble AND gate circuit as shown in Fig 1b.

5 Hold the IC from the top while inserting in breadboard, to avoid touching the pins.

6 Place the IC 7408 on the breadboard following its pin layout .

Fig 1b



Note: Pin 1 is always to the left of the dot or notch, when the notch is facing upwards. Ensure correct insertion of IC as shown in Fig 1.b. Apply even pressure on IC to ensure that all pins go into the breadboard without bending.

7 Connect the power supply and adjust it to a voltage of +5V.

8 Connect the 14th pin of the IC to the Vcc (+5V) and 7th pin of the IC to GND.

9 Connect one end of the input switches S1 and S2 to VCC and the other end of switches to GND of power supply.

10 For giving input connections, use centre pin of the toggle switch S1 for input A connected to pin 1 and S2 for input B connected to pin 2.

11 To view the output on LED, connect pin 3 (AND Gate output) to LED through a current limiting resistor as shown in the fig 1.

12 Before applying power, check all the connections on the breadboard.

Make sure there are no loose wires or incorrect connections, and get the assembled circuit checked by the instructor.

13 Switch ON the 5V DC supply and operate switches S1 and S2 for different logic levels, either in the 5V position (logic 1 / high) or 0V (logic 0 / low) position, as shown in the Truth table.

14 Observe the output on the LED for each input combination as per the truth table and record it in the given Table 1.

15 Refer to the datasheet for pin details of other gates in the IC and repeat the same steps for verifying the truth table of remaining AND gates available in the same IC.

Note: Finally, ensure that the instructor reviews and verifies your work

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TASK 2: **Construct the OR gate using IC 7432 and verify its truth table**

1 Collect the components for assembling the OR gate shown in Fig 2.

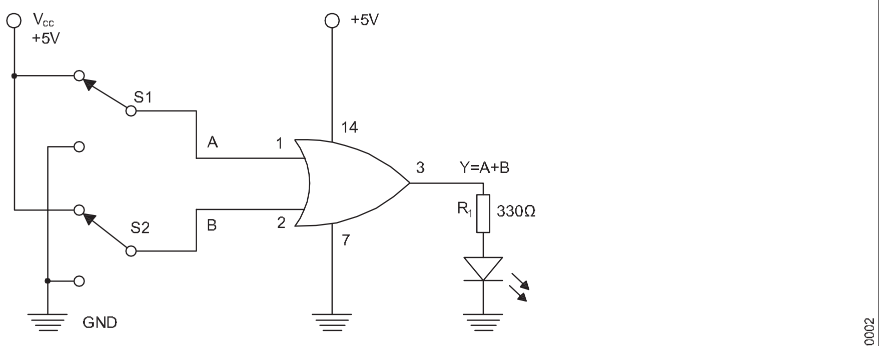
2 Check each component to ensure that they are in good condition.

3 Refer to the datasheet of the IC 7432.

4 Assemble the OR gate circuit as shown in Fig 2 on bread board and repeat the steps 5 to 11 from task 1.

Make sure there are no loose wires or incorrect connections, and get the assembled circuit checked by the instructor.

Fig 2



CONSTRUCTION OF OR GATE USING IC 7432

OR gate Truth table 2

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 status
	A (S1)	B (S2)	
1			
2			
3			
4			

5 Switch ON the 5V DC supply and operate switches S1 and S2 for different logic levels, either in the 5V position (logic 1 / high) or 0V (logic 0 / low) position as shown in the Truth table 2.

6 Observe the output on the LED for each input combination as per the truth table and record it in the given Table 2.

7 Refer to the datasheet for pin details of other gates in the IC and repeat the same steps for verifying the truth table of remaining OR gates available in the same IC.

Note: Finally, ensure that the instructor reviews and verifies your work

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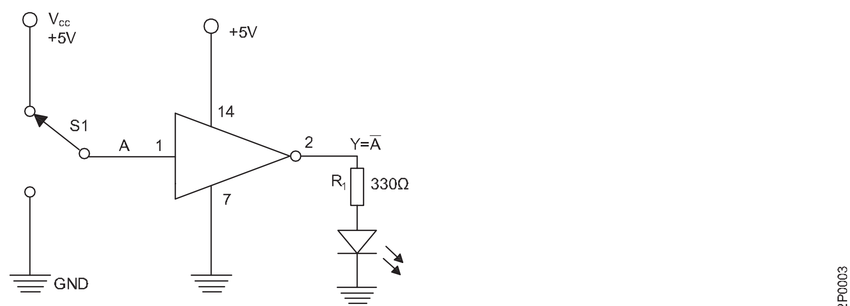
TASK 3: **Construct the NOT gate using IC 7404 and verify its truth table**

Fig 3



CONSTRUCTION OF NOT GATE USING IC 7404

NOT gate Truth table 3

Sl. No.	Input	Output Y = $\overline{A}$
	A	
1	0	1
2	1	0

Table 3

Sl. No.	Input	Output LED status
	A (S1)	
1		
2		

1 Collect the required components for assembling the NOT gate as shown in Fig 3.

2 Check each component to ensure that they are in good condition.

3 Refer to the datasheet of the IC 7404.

4 Assemble the NOT gate circuit as shown in Fig 3 on the breadboard.

5 Place the IC 7404 on the breadboard following its pin layout.

6 Connect the power supply and adjust it to a voltage of +5V DC.

7 Connect 14th pin of the IC to VCC and 7th pin to GND.

8 Connect one end of the toggle switch S1 to Vcc and connect other end to GND.

9 For giving input to NOT gate, connect centre pin of the toggle switch S1 (input A) to pin 1 of NOT gate.

10 To view the output on LED, connect pin 2 (NOT Gate output) to LED through a current limiting resistor as shown in the Fig 3.

11 Before applying power, check all the connections on the breadboard.

Make sure that there are no loose wires or incorrect connections and get the assembled circuit checked by the instructor.

12 Switch ON the 5V DC supply and operate switches S1 for different logic levels, either in the 5V position (logic 1 / high) or 0V (logic 0 / low) position, as shown in the Truth table 3.

13 Observe the output on the LED for each input combination as per the truth table and record it in the given Table 3.

14 Refer to the datasheet for pin details of other gates in the IC and repeat the same steps for verifying the truth table of remaining NOT gates available in the same IC.

Note: Finally, ensure that the instructor reviews and verifies your work

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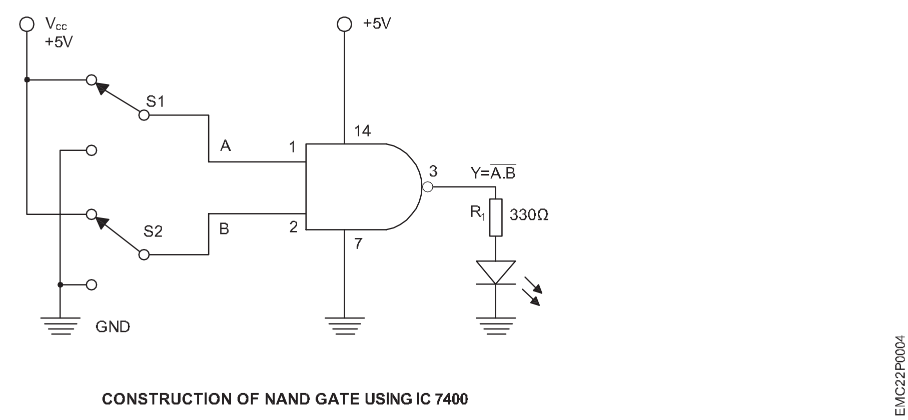
TASK 4: **Construct the NAND gate using IC 7400 and verify its truth table**

Fig 4



CONSTRUCTION OF NAND GATE USING IC 7400

NAND gate Truth table 4

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

Table 4

Sl. No.	Input		Output LED status
	A (S1)	B (S2)	
1			
2			
3			
4			

1 Collect all the required components for assembling the NAND gate circiut as shown in Fig 4.

2 Check each component to ensure that they are in good condition.

3 Refer to the datasheet of the IC 7400

4 Assemble the NAND gate circuit as shown in Fig 4 on bread board and repeat the above steps 5 to 11 from task 1.

5 Before applying power, check all the connections on the breadboard.

Make sure there are no loose wires or incorrect connections, and get the assembled circuit checked by the instructor.

6 Switch ON the 5V DC supply and operate switches S1 and S2 for different logic levels, either in the 5V position (logic 1 / high) or 0V (logic 0 / low) position, as shown in the Truth table.

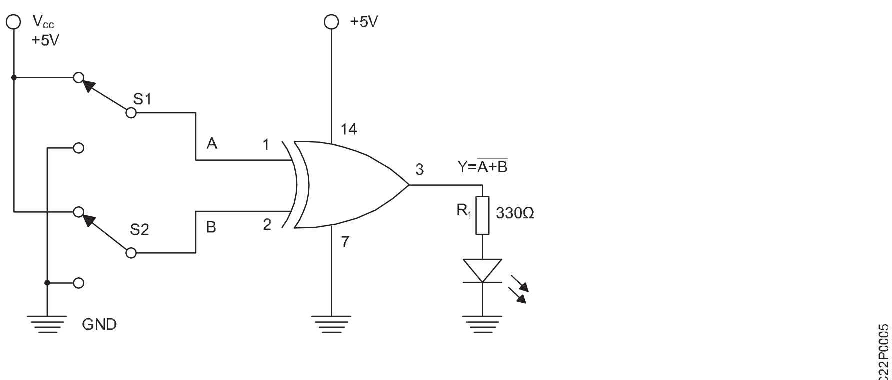
7 Observe the output on the LED for each input combination as per the truth table and record it in the given Table 4.

8 Refer to the datasheet for pin details of other gates in the IC and repeat the same steps for verifying the truth table of remaining NAND gates available in the same IC.

Note: Finally, ensure that the instructor reviews and verifies your work

TASK 5: **Construct the NOR gate using IC 7402 and verify its truth table**

Fig 5



CONSTRUCTION OF EX-OR GATE USING IC 7486

NOR gate Truth table 5

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	0

Table 5

Sl. No.	Input		Output LED status
	A (S1)	B (S2)	
1			
2			
3			
4			

1 Collect all the required components for assembling the NOR gate circuit as shown in Fig 5.

2 Check each component to ensure that they are in good condition. Refer to the datasheet of the IC 7402

3 Assemble the NOR gate circuit as shown in Fig 5 on bread board and repeat the above steps 5 to 9 from task 1.

4 For giving input connections, use centre pin of the toggle switch S1 for input A connected to pin 2 and S2 for input B connected to pin 3.

5 To view the output on LED, connect pin 1 (NOR Gate output) to LED through a current limiting resistor as shown in the fig 5.

6 Before applying power, check all the connections on the breadboard.

Make sure there are no loose wires or incorrect connections, and get the assembled circuit checked by the instructor.

7 Switch ON the 5V DC supply and operate switches S1 and S2 for different logic levels, either in the 5V position (logic 1 / high) or 0V (logic 0 / low) position, as shown in the Truth table 5.

8 Observe the output on the LED for each input combination as per the truth table and record it in the given Table 5.

9 Refer to the datasheet for pin details of other gates in the IC and repeat the same steps for verifying the truth table of remaining NOR gates available in the same IC.

Note: Finally, ensure that the instructor reviews and verifies your work

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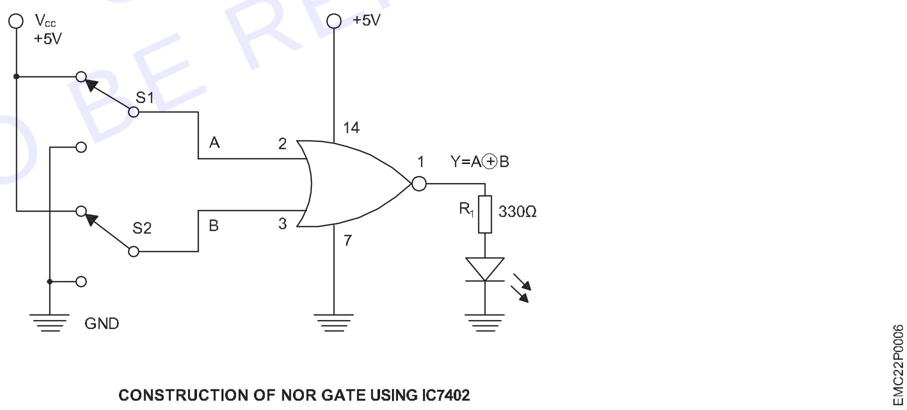
TASK 6: **Construct the EX-OR gate using IC 7486 and verify its truth table**

Fig 6



CONSTRUCTION OF NOR GATE USING IC7402

EX - OR gate Truth table 6

Sl. No.	Input		Output $Y = \overline{A \oplus B}$
	A	B	
1	0	0	0
2	0	1	1
3	1	0	1
4	1	1	0

Table 6

Sl. No.	Input		Output LED status
	A (S1)	B (S2)	
1			
2			
3			
4			

1 Collect all the required components for assembling the EX OR gate circuit as shown in Fig 6.

2 Check each component to ensure that they are in good condition.

3 Refer to the datasheet of the IC 7486.

4 Assemble the EX-OR gate circuit as shown in Fig 6 on bread board and repeat the above steps 5 to 11 from task 1.

5 Before applying power, check all the connections on the breadboard.

Make sure there are no loose wires or incorrect connections, and get the assembled circuit checked by the instructor.

6 Switch ON the 5V DC supply and operate switches S1 and S2 for different volt-age levels, either in the 5V position (logic 1 / high) or 0V (logic 0 / low) position, as shown in the Truth table 6.

7 Observe the output on the LED for each input combination as per the truth table and record it in the given Table 6

8 Refer to the datasheet for pin details of other gates in the IC and repeat the same steps for verifying the truth table of remaining EX-OR gates available in the same IC.

Note: Finally, ensure that the instructor reviews and verifies your work.

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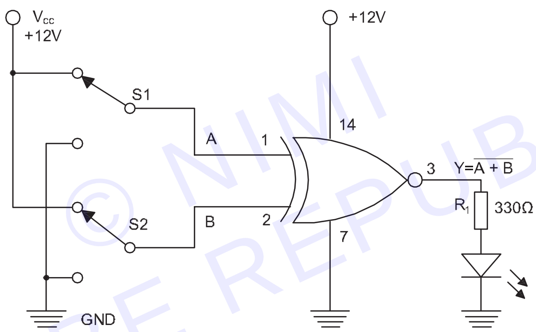
TASK 7: **Construct the EX-NOR gate using IC 4077 and verify its truth table**

Fig 7



CONSTRUCTION OF EX-NOR GATE USING IC 4077

EX - OR gate Truth table 7

Sl. No.	Input A	Input B	Output $Y = \overline{A \oplus B}$
1	0	0	0
2	0	1	1
3	1	0	1
4	1	1	0

Table 7

Sl. No.	Input A (S1)	Input B (S2)	Output LED status
1			
2			
3			
4			

1 Collect all the required components for assembling the EX NOR gate circuit as shown in Fig 7.

2 Check each component to ensure that they are in good condition.

3 Refer to the datasheet of the CMOS IC 4077.

4 Assemble the EX NOR gate according to the diagram in Fig 7 on the breadboard.

5 Place the IC 4077 on the breadboard following its pin layout, ensuring correct insertion with each pin in the right position.

6 Connect the power supply and adjust it to a voltage of +12V.

7 Connect the 14th pin of the IC to the Vcc (+12V) and 7th pin of the IC to GND.

8 Connect one end of the input switches S1 and S2 to VCC and the other end of switches to GND of power supply.

9 For giving input connections, use centre pin of the toggle switch S1 for input A connected to pin 1 and S2 for input B connected to pin 2.

10 To view the output on LED, connect pin 3 (EX - NOR Gate output) to LED through a current limiting resistor as shown in the Fig 7.

11 Before applying power, check all the connections on the breadboard.

Make sure there are no loose wires or incorrect connections, and get the assembled circuit checked by the instructor.

12 Switch ON the 5V DC supply and operate switches S1 and S2 for different logic levels, either in the 5V position (logic 1 / high) or 0V (logic 0 / low) position, as shown in the Truth table 7.

13 Observe the output on the LED for each input combination as per the truth table and record it in the given Table 7.

14 Refer to the datasheet for pin details of other gates in the IC and repeat the same steps for verifying the truth table of remaining EX-NOR gates available in the same IC..

Note: Finally, ensure that the instructor reviews and verifies your work

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EXERCISE 07: 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.
- verify the truth table for all the logic gates.

Requirements

Tools/ Equipments/ Instrument

- Trainees tools kit - 1 No.
- Regulated DC power (RPS) supply 0-30V/ 2A - 1 No.
- Digital multimeter - 1 No.
- Logic probe - 1 No.

Materials/ Components

- IC 7400, IC 7402, with datasheets - 2 Nos each.
- Bread board - 1 No.
- Resistors 1/4W 330Ω - 1 No.
- Toggle switches miniature type - 2 Nos.
- LED (Red colour) 5mm - 1 No.
- Hookup wire - as reqd.

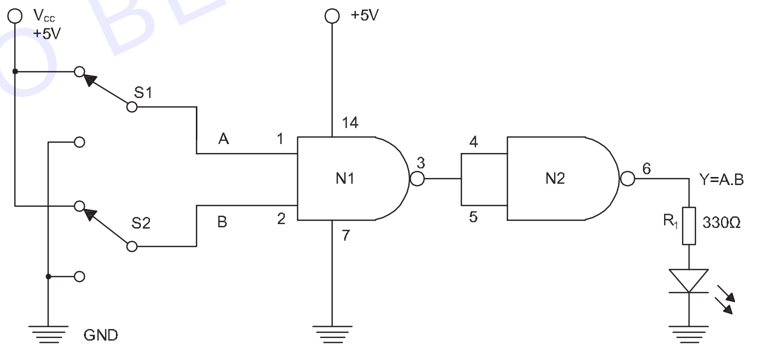
Procedure

Refer to the datasheets of NAND gate IC 7400 and NOR IC 7402. Then, use a logic probe to check the status of each gate output for every combination

TASK 1: **Construct AND gate circuit using NAND gate IC 7400 and verify its truth table**

1 Collect the required components for assembling the AND gate using NAND gate IC as shown in the Fig 1

Fig 1



NAND GATES USED AS AND GATE

AND gate Truth table 1

Sl.No	Input A	Input B	Output Y=A.B
1	0	0	0
2	0	1	0
3	1	0	0
4	1	1	1

Table 1

Sl. No.	A (S1)	B (S2)	N1 $\overline{A}\ \overline{B}$	N2 Y= (AB)	AND gate Output Y=AB
1					
2					
3					
4					

2 Check each component to ensure that they are in good condition.

3 Refer to the datasheet of the IC 7400

4 Assemble the circuit as shown in Fig 1 on the breadboard.

5 Connect the power supply and adjust it to a voltage of +5V.

6 Connect the 14th pin of the IC to the Vcc (+5V) and 7th pin of the IC to GND.

7 Connect one end of the toggle switch S1 and S2 to VCC and the other end of switches to GND of power supply.

8 For giving input connections, use centre pin of the toggle switch S1 for input A connected to pin 1 and S2 for input B connected to pin 2.

9 Connect pin 3 to 4th pin of the same IC, Interconnect 4th and 5th Pin.

10 To view the output on LED, connect pin 6 (NAND Gate 2 output) to LED through a current limiting resistor as shown in the fig 1.

11 Before applying power, check all the connections on the breadboard.

Make sure there are no loose wires or incorrect connections, and get the assembled circuit checked by the instructor.

12 Switch ON the 5V DC supply and operate switches S1 and S2 for different logic levels, either in the 5V position (logic 1 / high) or 0V (logic 0 / low) position, as shown in the Truth table 1.

13 Observe the output of the LED for each input combination and record it in the given Table 1.

Note: Finally, ensure that the instructor reviews and verifies your work.

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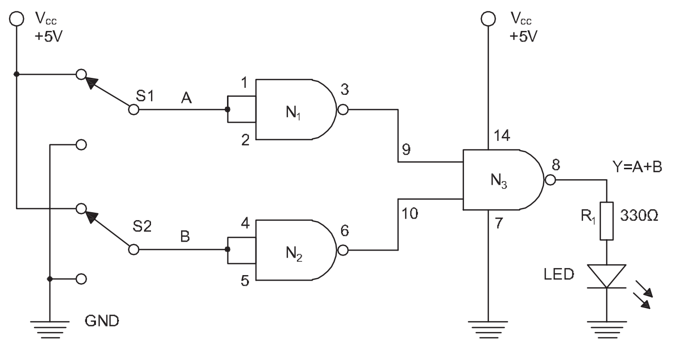
TASK 2: **Construct of OR gate circuit using NAND gate and verify its truth table**

1 Rearrange and repeat the above steps 2 to 7 from task 1 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

EMC22P0009

2 For giving input connections, use centre pin of the toggle switch S1 for input A connected to pin 1 & 2 and S2 for input B connected to pin 4 & 5.

3 Connect pin 3 to pin 9 of the same IC,

4 Connect the pin 6 to pin 10 of the same IC

5 To view the output on LED, connect pin 8 (NAND Gate 3 output) to LED through a current limiting resistor as shown in the Fig 2.

6 Before applying power, check all the connections on the breadboard.

Make sure there are no loose wires or incorrect connections, and get the assembled circuit checked by the instructor.

7 Switch ON the 5V DC supply and operate switches S1 and S2 for different logic levels, either in the 5V position (logic 1 / high) or 0V (logic 0 / low) position, as shown in the Truth table 2.

OR gateTruth table 2

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	A (S1)	B (S2)	N1 $(\overline{A})$	N2 $(\overline{B})$	N3 Y= (A+B)	OR gate Y=A+B
1						
2						
3						
4						

8 Observe the output of the LED for each input combination and record it in the given Table 2.

Note: Finally, ensure that the instructor reviews and verifies your work

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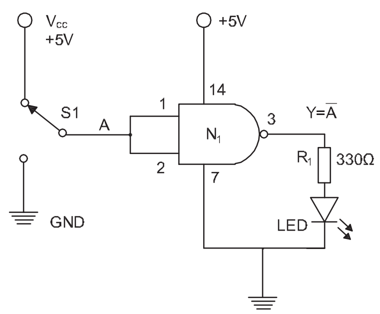
TASK 3: **Construct NOT gate circuit using NAND gate and verify its truth table**

Fig 3



NAND GATE USED AS NOT GATE

EMC22P0010

NOT gateTurth table 3

Sl.No	Input A	Output $Y= \overline{A}$
1	0	1
2	1	0

Table 3

Sl.No	A (S1)	N1 $Y = (\overline{A})$	NOT gate $Y= \overline{A}$
1			
2			

1 Rearrange and repeat the above steps 2 to 6 from task 1 and assemble the NOT gate circuit using NAND gate as shown in Fig 3 on bread board.

2 Connect one end of the toggle switch S1 to VCC and the other end of switch to GND of power supply

3 For giving input connections, use centre pin of the toggle switch S1 for input A connected to pin 1 & 2 of NAND gate.

4 To view the output on LED, connect pin 3 (NAND Gate 1 output) to LED through a current limiting resistor as shown in the Fig 3.

5 Before applying power, check all the connections on the breadboard.

Make sure there are no loose wires or incorrect connections, and get the assembled circuit checked by the instructor.

6 Switch ON the 5V DC supply and operate switches S1 for different logic levels, either in the 5V position (logic 1 / high) or 0V (logic 0 / low) position, as shown in the Truth table 3.

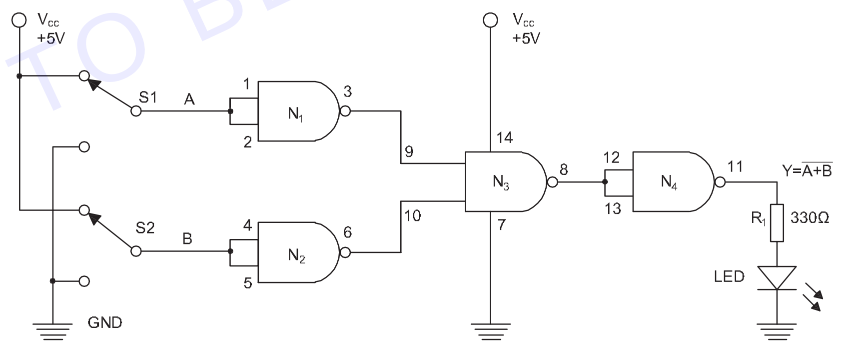
7 Observe the output on the LED for each input combination and record it in the given Table 3.

Note: Finally, ensure that the instructor reviews and verifies your work

TASK 4: **Construct NOR gate circuit using NAND gate and verify its truth table**

1 Rearrange and repeat the above steps 2 to 7 from task 1 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

EMC22P0011

NOR gateTurth table 4

Sl.No	Input A	Input B	Output $Y= \overline{A+B}$
1	0	0	1
2	0	1	0
3	1	0	0
4	1	1	0

Table 4

Sl. No.	A (S1)	B (S2)	N1 $(\bar{A})$	N2 $(\bar{B})$	N3 (A+B)	N4 Y= $\overline{A+B}$	NOR gate output Y = $\overline{A+B}$
1							
2							
3							
4							

2 For giving input connections, use centre pin of the toggle switch S1 for input A connected to pin 1 & 2 and S2 for input B connected to pin 4 & 5.

3 Connect pin 3 to pin 9 of the same IC,

4 Connect the pin 6 to pin 10 of the same IC

5 Connect pin 8 to 12th pin of the same IC, Interconnect 12th and 13th of IC 7400

6 To view the output on LED, connect pin 11 (NAND Gate 4 output) to LED through a current limiting resistor as shown in the Fig 4.

7 Before applying power, check all the connections on the breadboard.

Make sure there are no loose wires or incorrect connections, and get the assembled circuit checked by the instructor.

8 Switch ON the 5V DC supply and operate switches S1 and S2 for different logic levels, either in the 5V position (logic 1 / high) or 0V (logic 0 / low) position, as shown in the Truth table 4.

9 Observe the output on the LED for each input combination and record it in the given Table 4.

Note: Finally, ensure that the instructor reviews and verifies your work

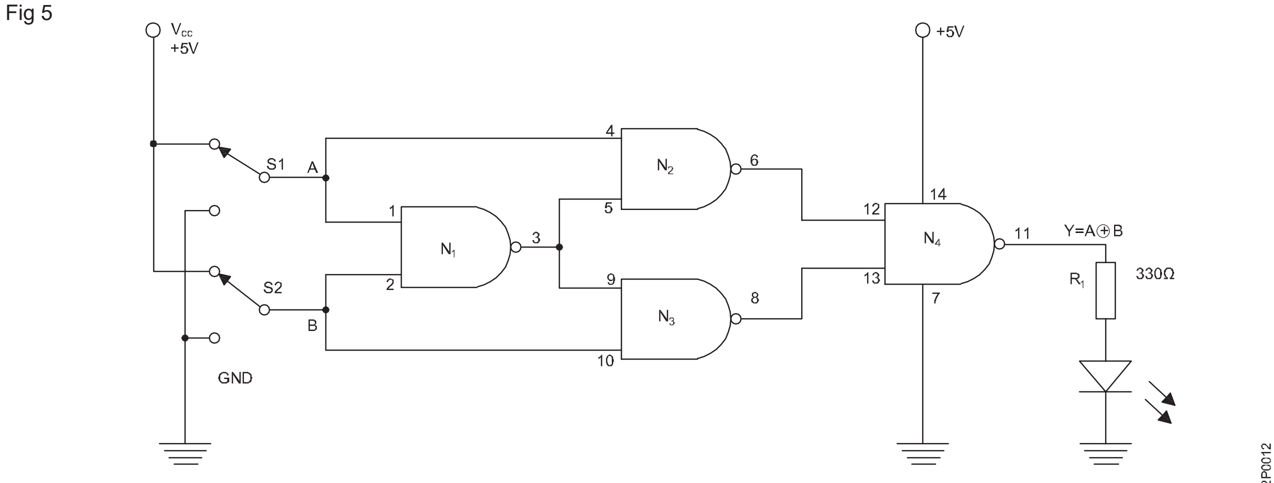
TASK 5: **Construct EX-OR gate circuit using NAND gate and verify its truth table**

1 Rearrange and repeat the above steps 2 to 7 from task 1 and assemble the EX-OR gate circuit using NAND gates as shown in Fig 5 on bread board.

2 For giving input connections, use center pin of the toggle switch S1 for input A connected to pin 1 & 4 and S2 for input B connected to pin 2 &10.

3 Connect pin no 3 to pin no 5 & 9 ,then connect pin no 6 to pin no 12 ,then connect pin no 8 to pin no 13.

Fig 5



NAND GATES USED AS EX-OR GATE

4 To view the output on LED, connect pin 11 (NAND Gate 4 output) to LED through a current limiting resistor as shown in the Fig 5.

5 Before applying power, check all the connections on the breadboard.

Make sure there are no loose wires or incorrect connections, and get the assembled circuit checked by the instructor.

Ex-OR gate Turth table 5

Sl.No	Input		Output
	A	B	$Y = A \oplus B$
1	0	0	0
2	0	1	1
3	1	0	1
4	1	1	0

Table 5

Sl. No.	A (S1)	B (S2)	N1 $\overline{A.B}$	N2 $A\,\overline{(AB)}$	N3 $B\,\overline{(AB)}$	N4 $Y = A \oplus B$	EX - OR gate output $Y = A \oplus B$
1							
2							
3							
4							

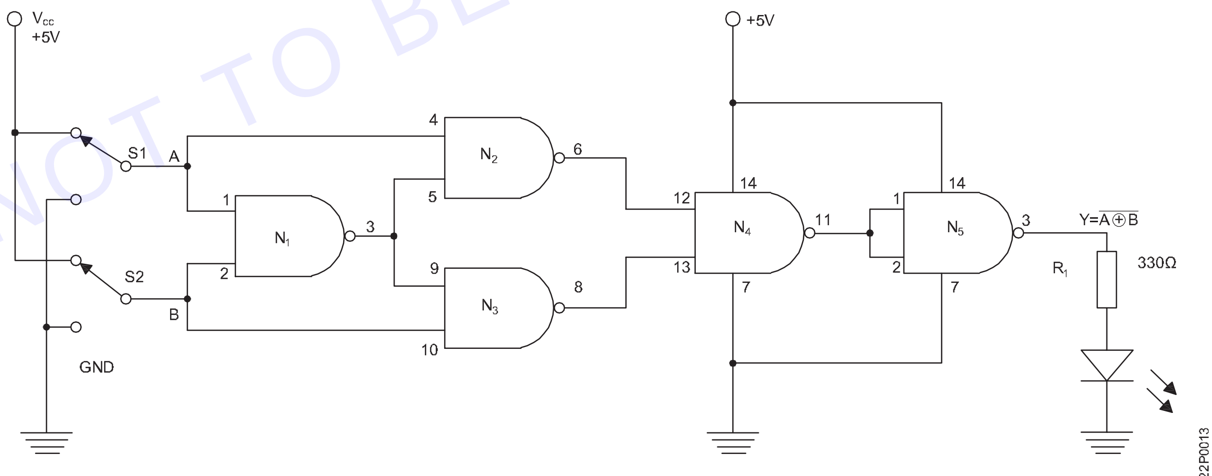
6 Switch ON the 5V DC supply and operate switches S1 and S2 for different logic levels, either in the 5V position (logic 1 / high) or 0V (logic 0 / low) position, as shown in the Truth table 5.

7 Observe the output on the LED for each input combination and record it in the given Table 5.

Note: Finally, ensure that the instructor reviews and verifies your work.

TASK 6: **Construct EX-NOR gate circuit using NAND gate and verifiy its truth table**

Fig 6



NAND GATES USED AS EX-NOR GATE

Ex-NOR gateTurth table 6

Sl.No	Input		Output
	A	B	$Y = \overline{A \oplus B}$
1	0	0	1
2	0	1	0
3	1	0	0
4	1	1	1

Table 6

Sl. No.	A (S1)	B (S2)	N1 $\overline{A.B}$	N2 $A\,\overline{(AB)}$	N3 $B\,\overline{(AB)}$	N4 $A \oplus B$	N5 $Y = \overline{A \oplus B}$	EX - NOR gate output $Y = \overline{A \oplus B}$
1								
2								
3								
4								

1 Rearrange and repeat the above steps 2 to 7 from task 1 and assemble the EX-NOR gate circuit using NAND gates as shown in Fig 5 on the bread board.

2 For giving input connections, use centre pin of the toggle switch S1 for input A connected to pin 1& 4 and S2 for input B connected to pin 2 & 10.

3 Connect pin no 3 to pin no 5 & 9, then connect pin no 6 to pin no 12, then connect pin no 8 to pin no 13.

4 Connect pin 11 to another NAND gate IC of pin no 1 & 2,and join the pin 3 to one end of the resistor; the free end of the resistor should be attached to the anode of the LED, and the cathode of the LED should be connected to the ground as shown in the fig 6.

5 Before applying power, check all the connections on the breadboard.

Make sure there are no loose wires or incorrect connections, and get the assembled circuit checked by the instructor.

6 Switch ON the 5V DC supply and operate switches S1 and S2 for different voltage levels, either in the 5V position (logic 1 / high) or 0V (logic 0 / low) position, as shown in the Truth table 6.

7 Observe the status of the LED for each input combination and record it in the given Table 6.

8 Verify the readings with the Truth Table of EX NOR gate using NAND gate IC.

Note: Finally, ensure that the instructor reviews and verifies your work

TASK 7: **Construct AND gate using NOR gate and verify its truth table**

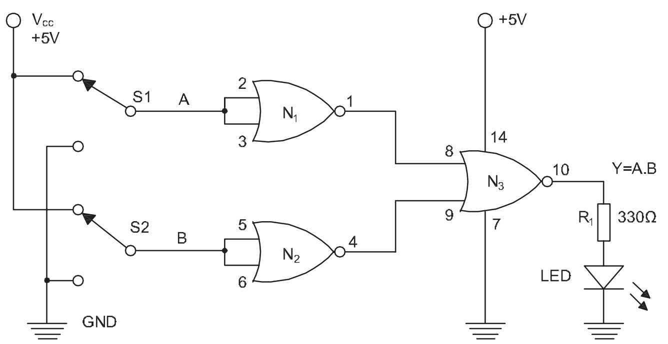
1 Collect the required components for assembling the AND gate using NOR gate IC as shown in the Fig 7.

2 Check each component to ensure that they are in good condition.

3 Refer to the datasheet of the IC 7402.

4 Assemble the circuit as shown in Fig 7 on the breadboard.

Fig 7



NOR GATES USED AS AND GATE

5 Connect the power supply and adjust it to a voltage of +5V

6 Connect the 14th pin of the IC to the Vcc (+5V) and 7th pin of the IC to GND.

7 Connect one end of the toggle switch S1 and S2 to VCC and the other end of switches to GND of power supply.

8 For giving input connections, use center pin of the toggle switch S1 for input A connected to pin 2 & 3 and S2 for input B connected to pin 5 & 6

9 Connect pin no 1 to pin no 8 and pin no 4 to pin no 9 of same IC.

10 To view the output on LED, connect pin 10 (NOR Gate 3 output) to LED through a current limiting resistor as shown in the Fig 7.

AND gate Turth table 7

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

11 Before applying power, check all the connections on the breadboard.

Make sure there are no loose wires or incorrect connections, and get the assembled circuit checked by the instructor.

12 Switch ON the 5V DC supply and operate switches S1 and S2 for different logic levels, either in the 5V position (logic 1 / high) or 0V (logic 0 / low) position, as shown in the Truth table 7.

13 Observe the output on the LED for each input combination and record it in the given Table 7.

Table 7

Sl. No.	A (S1)	B (S2)	N1 ($\overline{A}$)	N2 ($\overline{B}$)	N3 Y = A.B	AND gate Y=AB
1						
2						
3						
4						

Note: Finally, ensure that the instructor reviews and verifies your work

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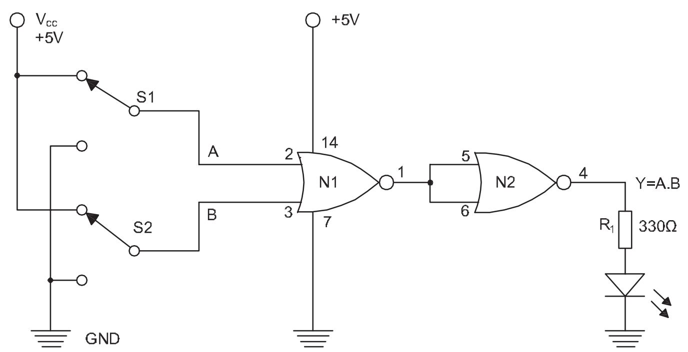
TASK 8: **Construct OR gate using NOR gate IC 7402 and verify its truth table**

1 Rearrange and repeat the above steps 2 to 7 from task 7 and assemble the OR gate circuit using NOR gates as shown in Fig 8 on bread board.

2 For giving input connections, use centre pin of the toggle switch S1 for input A connected to pin 2 and S2 for input B connected to pin 3.

Fig 8



NOR GATES USED AS OR GATE

EMC22P0015

3 Connect pin no 1 to pin no 5 & 6 ,

4 To view the output on LED, connect pin 4 (NOR Gate 2 output) to LED through a current limiting resistor as shown in the fig 8.

5 Before applying power, check all the connections on the breadboard.

Make sure there are no loose wires or incorrect connections, and get the assembled circuit checked by the instructor.

6 Switch ON the 5V DC supply and operate switches S1 and S2 for different logic levels, either in the 5V position (logic 1 / high) or 0V (logic 0 / low) position, as shown in the Truth table 8.

OR gate Turth table 8

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

7 Observe the output on the LED for each input combination and record it in the given Table 8.

Table 8

Sl. No	A (S1)	B (S2)	N1 $\overline{A + B}$	N2 Y=(A+B)	OR gate output Y=A+B
1					
2					
3					
4					

Note: Finally, ensure that the instructor reviews and verifies your work.

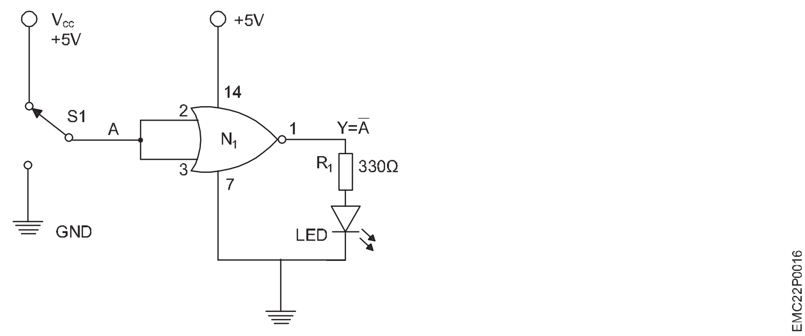
— — — — —

TASK 9: **Construct NOT gate circuit using NOR gate and verify its truth table**

1 Rearrange and repeat the above steps 2 to 5 from task 7 and assemble the NOT gate circuit using NOR gates as shown in Fig 9 on bread board.

2 Connect one end of the toggle switch S1 to VCC and the other end of switch to GND of power supply

Fig 9



NOT gate Turth table 9

Sl.No	Input A	Output Y = $\overline{A}$
1	0	1
2	1	0

Table 9

Sl. No.	A (S1)	N1 Y = $\overline{A}$	NOT gate output Y = $\overline{A}$
1			
2			

3 For giving input connections, use centre pin of the toggle switch S1 for input A connected to pin 2 & 3

4 To view the output on LED, connect pin 1 (NOR Gate 1 output) to LED through a current limiting resistor as shown in the fig 9.

5 Before applying power, check all the connections on the breadboard.

Make sure there are no loose wires or incorrect connections, and get the assembled circuit checked by the instructor.

6 Switch ON the 5V DC supply and operate switches S1 for different logic levels, either in the 5V position (logic 1 / high) or 0V (logic 0 / low) position, as shown in the Truth table 9.

7 Observe the output the LED for input combination and record it in the given Table 9

Note: Finally, ensure that the instructor reviews and verifies your work

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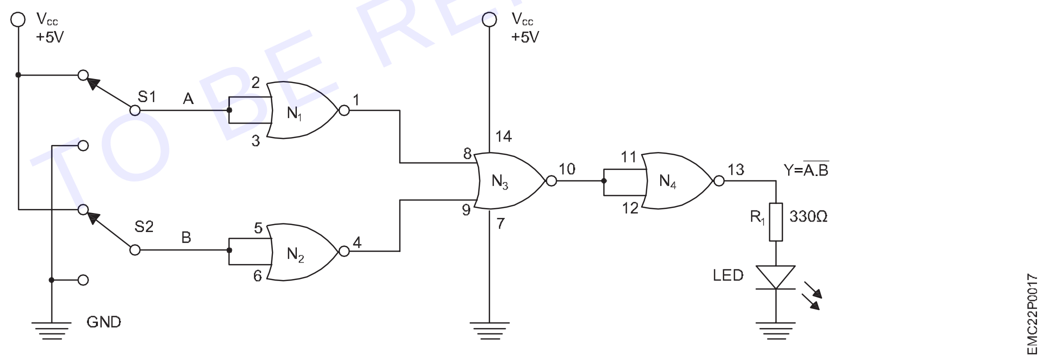
TASK 10: **Construct NAND gate using NOR gate IC 7402 and verify its truth table**

1 Rearrange and repeat the above steps 2 to 7 from task 7 and assemble the EX-OR gate circuit using NOR gates as shown in Fig 10 on bread board.

Fig 10



NAND gate Turth table 10

Sl.No	Input A	Input B	Output Y = $\overline{A.B}$
1	0	0	1
2	0	1	1
3	1	0	1
4	1	1	0

Table 10

Sl. No.	A (S1)	B (S2)	N1 $\overline{A}$	N2 $\overline{B}$	N3 AB	N4 Y = $\overline{AB}$	NAND gate output Y = $\overline{A.B}$
1							
2							
3							
4							

2 For giving input connections, use centre pin of the toggle switch S1 for input A connected to pin 2 & 3 and S2 for input B connected to pin 5 & 6.

3 Connect pin no 1 to pin no 8, and pin no 4 to pin no 9,

4 Connect pin no 10 to pin no 11 & 12 of the same IC.

5 To view the output on LED, connect pin 13 (NOR Gate 4 output) to LED through a current limiting resistor as shown in the Fig 10.

6 Before applying power, check all the connections on the breadboard.

Make sure there are no loose wires or incorrect connections, and get the assembled circuit checked by the instructor.

7 Switch ON the 5V DC supply and operate switches S1 and S2 for different logic levels, either in the 5V position (logic 1 / high) or 0V (logic 0 / low) position, as shown in the Truth table 10.

8 Observe the output on the LED for each input combination and record it in the given Table 10.

Note: Finally, ensure that the instructor reviews and verifies your work

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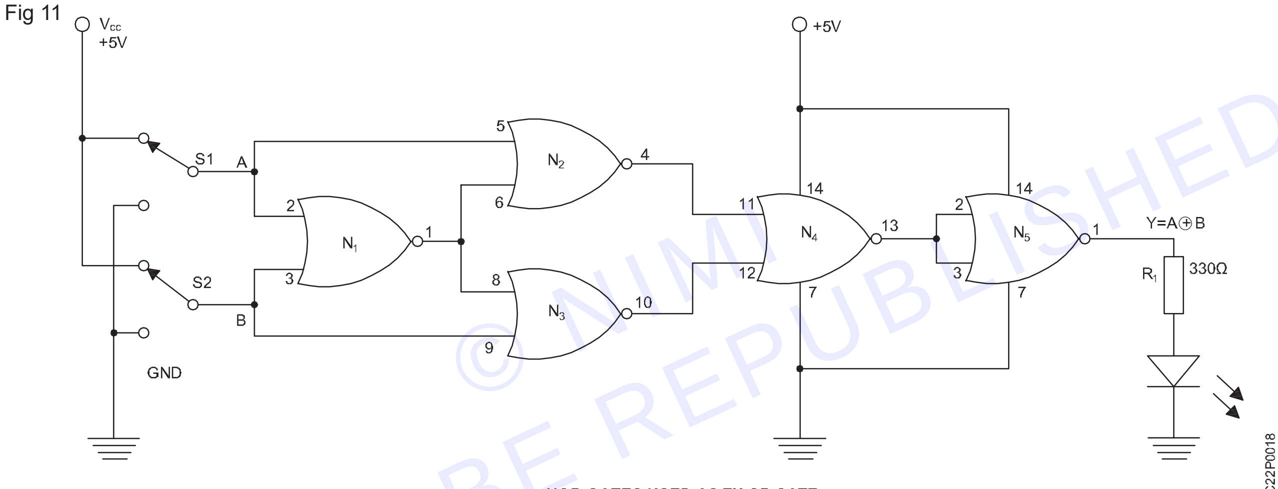
TASK 11: **Construct EX-OR gate using NOR gate IC 7402 and verifiy its truth table**

Fig 11



NOR GATES USED AS EX-OR GATE

Ex-OR gate Turth table 11

Sl. No.	Input A	Input B	Output Y = A ⊕ B
1	0	0	0
2	0	1	1
3	1	0	1
4	1	1	0

Table 11

Sl. No.	A (S1)	B (S2)	N1 $\overline{(A+B)}$	N2 $A + \overline{(A+B)}$	N3 $B + \overline{(A+B)}$	N4 $\overline{A \oplus B}$	N5 Y = A ⊕ B	EX-OR gate output Y = A ⊕ B
1								
2								
3								
4								

1 Rearrange and repeat the above steps 2 to 7 from task 7 and assemble the EX-OR gate circuit using NOR gates as shown in Fig 11 on bread board.

2 For giving input connections, use centre pin of the toggle switch S1 for input A connected to pin 2 & 5 and S2 for input B connected to pin 3 & 9.

3 Connect pin 1 to pin 6 & 8, pin 4 to pin 11, pin 10 to pin 12, pin 13 to connect second IC of pin no 2 & 3

4 To view the output on LED, connect pin 1 of second IC (NOR Gate 5 output) to LED through a current limiting resistor as shown in the Fig 11.

5 Before applying power, check all the connections on the breadboard.

Make sure there are no loose wires or incorrect connections, and get the assembled circuit checked by the instructor.

6 Switch ON the 5V DC supply and operate switches S1 and S2 for different logic levels, either in the 5V position (logic 1 / high) or 0V (logic 0 / low) position, as shown in the Truth table 11.

7 Observe the output on the LED for each input combination and record it in the given Table 11.

Note: Finally, ensure that the instructor reviews and verifies your work.

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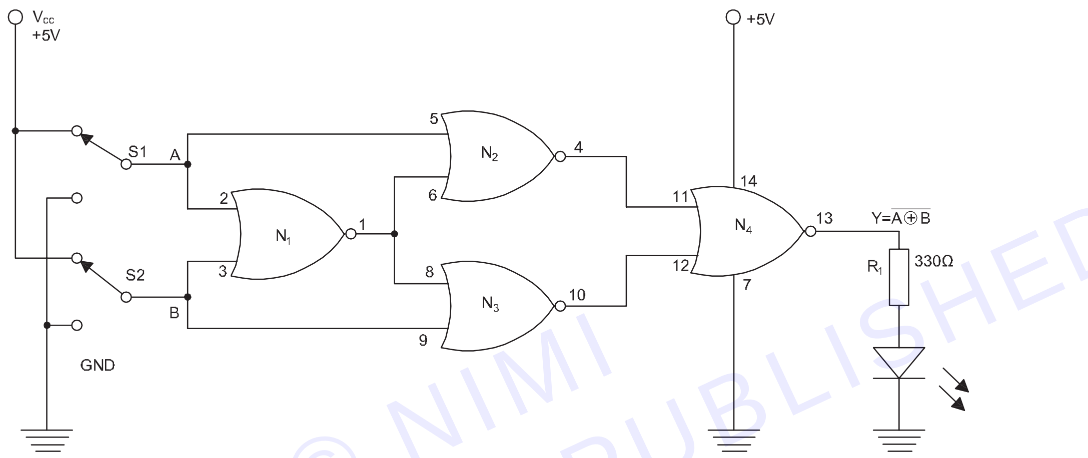
TASK 12: **Construct EX-NOR gate using NOR gate and verify its truth table**

Fig 12



NOR GATES USED AS EX-NOR GATE

Ex-NOR gate Turth table 12

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.	A (S1)	B (S2)	N1 $\overline{A+B}$	N2 $\overline{A+\overline{A+B}}$	N3 $\overline{B+\overline{A+B}}$	N4 $Y = A \oplus B$	EX-NOR gate output $Y = \overline{A \oplus B}$
1							
2							
3							
4							

1 Rearrange and repeat the above steps 2 to 7 from task 7 and assemble the EX-NOR gate circuit using NOR gates as shown in Fig 12 on the bread board.

2 For giving input connections, use centre pin of the toggle switch S1 for input A connected to pin 2 & 5 and S2 for input B connected to pin 3 & 9.

3 Connect pin no 1 to pin no 6 & 8 , pin 4 to pin 11 and pin 10 to pin 12.

4 To view the output on LED, connect pin 13 of the IC (NOR Gate 4 output) to LED through a current limiting resistor as shown in the Fig 12

5 Before applying power, check all the connections on the breadboard.

Make sure there are no loose wires or incorrect connections, and get the assembled circuit checked by the instructor.

6 Switch ON the 5V DC supply and operate switches S1 and S2 for different logic levels, either in the 5V position (logic 1 / high) or 0V (logic 0 / low) position, as shown in the Truth table 12.

7 Observe the output the LED for each input combination and record it in the given Table 12.

Note: Finally, ensure that the instructor reviews and verifies your work

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EXERCISE 08: 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 controls, switches, modes and IC socket of the digital IC tester
- test the given ICs using digital IC tester.

Requirements

Tools/ Equipments/ Instrument

- Trainees tools kit - 1 Set.
- Digital IC tester with manual - 1 No.
- Digital Multi Meter with probes - 1 No.

Materials/ Components

- Assorted Digital ICs (both TTL and CMOS types) - as reqd.
- Digital IC & data sheet - as reqd.

Procedure

1 Refer the Digital IC tester manual and Identify controls, switches, modes and IC socket as shown in Fig 1

Fig 1

2 Ensure the digital IC tester is properly powered on and ready for operation.

3 Pick one of the IC from the assorted lot.

4 Refer the data sheet of the given IC and record the part / code number of the IC in table 1 .

- Count the number of pins on the IC and record it.
- determine the logic family (e.g., TTL, CMOS)., supply voltage requirements, function of the integrated circuit (IC) and package of the IC and record it.

5 Place the IC into the appropriate socket on the tester. Ensure that the orientation of the IC matches the orientation indicated on the tester.

6 Some testing kits feature a keypad or touchscreen interface for entering IC specifications. Additionally, testers may offer both auto mode and manual mode options.

7 In auto mode, upon inserting the IC and pressing the search button, the tester automatically identifies the IC number and proceeds to test its condition by pressing the test button.

8 In manual mode,it requires users to input the IC number manually before initiating the testing process by pressing the test button to determine the IC's condition .

9 Once the testing is complete, the tester will display the results. This typically includes information about condition of the IC - whether the IC is good or bad or NOT Matching/Not found.

10 Record the condition of the IC in the table 1

11 Repeat the same process for remaining ICs.

Table 1

Sl. No.	Part No of IC	No.of pins	Logic family	Function	Package type	Typical VCC voltage for IC	Condition of IC tested

EXERCISE 09: Construct Half Adder circuit using ICs and verify the truth table. 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 the half adder circuit and verify its truth table
- construct the full adder using half adder circuit and verify its truth table.

Requirements

Tools/ Equipments/ Instrument

- Trainees tools kit - 1 Set.
- Digital trainer kit - 1 No.
- Digital IC Tester - 1 No.
- Digital multimeter with probes - 1 No.
- Logic probes - 1 Set.

Materials/ Components

- IC-7486 - 1 No.
- IC-7408 - 1 No.
- IC-7432 - 1 No.
- Data sheet of ICs used - as reqd.
- Hook up wires - as reqd.

Procedure

In a digital trainer kit, users have access to various components such as a power supply, manual clock switch toggle switches, a breadboard, and LEDs with accompanying resistors. These components are included in the kit for testing digital circuits

TASK 1: **construct the half adder circuit and verify the truth table**

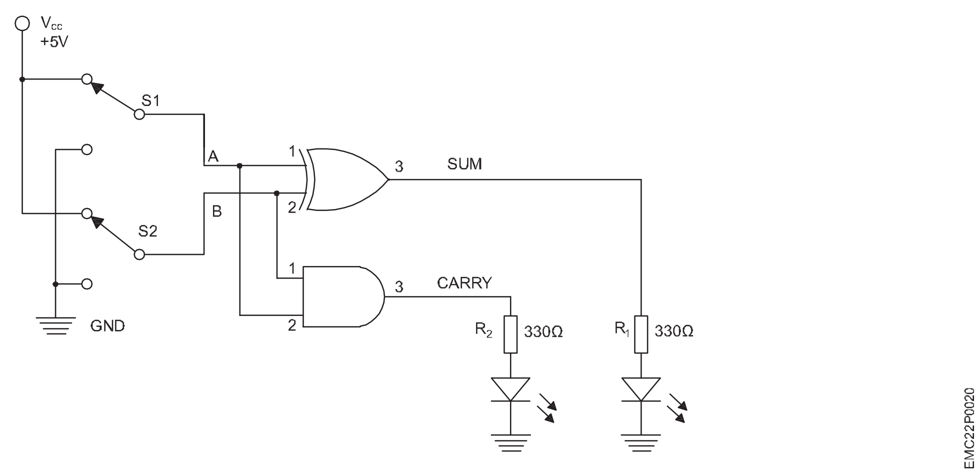
1 Collect all the required components for assembling the half adder circuit using IC 7486 and IC 7408

2 Check each component to ensure that they are in good condition.

3 Refer to the datasheet of the IC 7486 and IC 7408

4 Assemble the Half adder circuit as per the circuit diagram on the breadboard as shown in Fig 1

Fig 1



5 Connect the power supply (+5V) to the 14th pin of the IC 7486 and IC 7408 and connect the ground (0V) to the 7th pin of the IC 7486 and IC 7408.

6 Connect the toggle switch S1 to pin 1 of the EX-OR gate and pin 2 of the AND gate and label this connection as A.

7 Connect the toggle switch S2 to pin 2 of the EX-OR gate and pin 1 AND gate ICs and label this connection as B.

8 Connect output pin 3 of the EX-OR gate to the LED through the resistor.

9 This LED status represents SUM output.

10 Connect output pin 3 of the AND gate to the LED through the resistor.

11 This LED status represents CARRY output.

12 Before switch ON the digital trainer kit, check all the connections on the breadboard.

Make sure there are no loose wires or incorrect connections, and get the assembled circuit checked by the instructor.

13 Switch ON the 5V DC supply. Operate toggle switches S1 and S2 to test various combinations of inputs, with different logic levels, as shown in the Truth table 1.

14 Observe the output of the LED for each input combination and record it in the given Table 1.

Truth Table 1 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	
	A (S1)	B (S2)	Sum	Carry
1				
2				
3				
4				

15 Verify the readings with the Truth Table 1 of Half Adder circuits

Note: Finally, ensure that the instructor reviews and verifies your work

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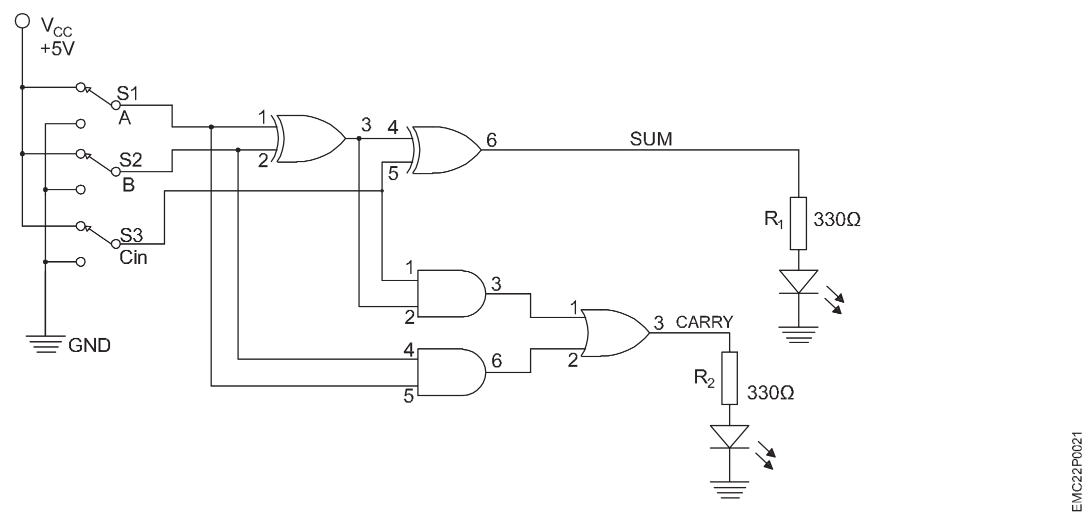
TASK 2: **construct and test full adder using half adder circuits verify the truth table of full adder**

Fig 2



Truth table 2 of Full Adder

Input			Output	
A	B	C	Sum	Carry
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

Table 2

Input			Output	
S1	S2	Cin	(Sum) LED condition	(CARRY) LED condition

1 Collect the required components for assembling the full adder using IC7486,IC 7408 and IC 7432.

2 Check each component to ensure that they are in good condition.

3 Refer to the datasheets of the IC7486, IC 7408 and IC 7432.

4 Assemble the Full Adder circuit as per the circuit diagram shown in Fig 2 on the breadboard.

5 Connect the power supply Vcc(+5V) to the 14th pin of the ICs 7486, IC 7408 and IC 7432 and the ground (0V) to the 7th pin of the ICs 7486, IC 7408 and IC 7432.

6 Connect the toggle switch S1 to pin 1 of the EX-OR gate and pin 5 of the AND gate and label this connection as A.

7 Connect the toggle switch S2 to pin 2 of the EX-OR gate and pin 4 of the AND gate IC and label this connection as B.

8 Connect the output pin 3 of the EX-OR gate to pin 4^{th} of the same IC.

9 Connect the toggle switch S3 to pin 5 of the EX-OR gate and label this connection as Cin.

10 Join the 4th and 5th pins of the EX-OR gate to the corresponding 1 and 2 pins of the AND gate IC.

11 Connect the output of this EX-OR gate IC, (which is the 6th pin), to the LED through the resistor.

12 This LED status represents the SUM output.

13 Connect the output 3rd and 6th pins of these two AND gates IC to the pins 1 and 2 of the OR gate IC.

14 Connect the output of OR gate IC, (which is the 3rd pin), to the LED through the resistor.

15 This LED status represents the CARRY output.

16 Before switch ON the digital triner kit, check all the connections on the breadboard.

Make sure there are no loose wires or incorrect connections, and get the assembled circuit checked by the instructor.

17 Switch ON the 5V DC supply and operate toggle switches connected (S1 to S3) to test various combinations of input, for different logic levels as shown in the Truth table 2.

18 Observe the status of the LED for each input combination and record it in the given Table 2.

19 Verify the readings with the Truth Table 2 of Full Adder full adder using two half adder circuits

Note: Finally, ensure that the instructor reviews and verifies your work

EXERCISE 10: Construct the adder cum subtractor 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/ Instrument

- Trainees tools kit - 1 Set.
- Digital trainer kit - 1 No.
- Digital multimeter with probes - 1 No.
- Digital IC Tester - 1 No.
- Logic probe - 1 No.

Materials/ Components

- IC-7486 - 1 No.
- IC-7483 - 1 No.
- Data sheet of ICs used - as reqd.
- Hook up wires - as reqd.

Procedure

Note: In a digital trainer kit, users can access the to various components such as a power supply, manual clock switch, toggle switches, a breadboard, and LEDs with accompanying resistors. These components are included in the kit for testing digital circuits

TASK 1: **construct a 4 bit binary adder circuit using IC 7483, IC7486 and verify the result**

1 Collect the required components for assembling the adder cum subtractor circuit using IC7486 and IC 7483.

2 Test each component to ensure that they are in good condition.Use Digital IC tester for testing above ICs.

3 Refer to the datasheets of the IC7486 and IC 7483.

4 Assemble the adder cum subtractor circuit as per the circuit diagram shown in Fig 1 on the breadboard.

5 Connect the power supply Vcc(+5V) to the 5th pin of the IC 7483 and 14th pin of the ICs 7486 and the ground (0V) to the 12th pin of the IC 7483 and 7th pin of the ICs 7486.

6 Connect the toggle switches as S1, S2, S3 and S4 to pins 10, 8, 3 and 1 of the IC 7483 as 1st set of inputs - A1, A2, A3 and A4 for the Adder/ Subtractor.

7 Connect the toggle switches S5, S6, S7 and S8 to pins 1, 4, 10 and 13 of the EX-OR gate IC 7486.

8 Now interconnect the pins 2, 5, 9 and 12 of IC 7486 and connect it with the Mode selector switch (Adder / Subtractor function select switch) S9 and connect the same with pin 13 of IC 7483.

9 Switch - S9 is the Mode selector switch(C-in). If S9 is Off/ logic 0, it works as Adder. If S9 is ON-Logic 1, then it works as Subtractor.

10 Connect the EX-OR gate (IC 7486) output pins 3, 6, 8, and 11 to pins 11, 7, 4, and 16 of the IC 7483 respectively, as the second set of inputs B1, B2, B3 and B4.

11 Connect the outputs of the Adder/Subtractor IC - ie. Q1, Q2, Q3, and Q4 Cout (available at pins 9, 6, 2 and 15 pins of IC 7483) to the LEDs through the resistor.

12 Now toggle the mode select switch S9 to 0(V) position (Logic '0') for Adder function Select.

13 Before switch ON the trainer kit, check all the connections on the breadboard.

Make sure there are no loose wires or incorrect connections, and get the assembled circuit checked by the instructor.

14 Switch ON the 5V DC supply and operate toggle switches connected (S1 to S8) to test various combinations of Operand A and Operand B inputs, as given in the example.

Examples:

1 For Adddition: Add the decimal numbers 9 + 7 = 16. Perform this addition using Adder/ Subtractor circuit.

Operand A input is 1001 and Operand B input is 0111. Choose Cin as 0 for addition. A + (B⊕Cin) + Cin ⇨ A + (B ⊕ 0) + 0 ⇨ A + B There is no change in

EX-OR gate outputs, then the result A + B = Sum with Carry(1001 + 0111 + 0=10000), where SUM=0000 and Cout =1.

2 For Subtraction (ex-1): Subtract the decimal numbers 9 - 7 = 2. Perform the subtraction using Adder/ Subtractor circuit by setting Cin as 1. Operand A input is 1001 and Operand B input is 0111. When Cin is 1 and connected as input to Ex-OR gate, then EX-OR gate gives 1'compliment inverted outputs.

To describe this: 9 - 7= 1001 - 0111 becomes 1001 + 1000 + 1 for performing Subtraction function using Adder circuit.

Hence A + (B⊕Cin) + Cin ⇨ A + (B ⊕ 1) + 1 = Sum with carry (1001 + 1000 + 1=10010), where SUM=0010 and Cout =1.

(Assume If Cout is 1 : result is positive, if Cout is 0: result is negative).

Hence result is SUM = 9 – 7=+2

3 For Subtraction (ex-2): Subtract the decimal numbers 7 - 9 = -2. Perform the subtraction using Adder/ Subtractor circuit by setting Cin as 1. Operand A (input) is 0111 and Operand B(input) is 1001.

Cin is set to '1' and connected as input to Ex-OR gate. Now EX-OR gate gives 1's compliment inverted outputs.

(Now Operand B becomes "-9 ")

To describe this: 7 - 9=0111-1001 becomes 0111 + 0110+1 for performing Subtraction function using Adder circuit. Hence A + (B⊕Cin) + Cin = Sum with carry (0111 +0110+1 =01110). Here result 01110 is in 2's complement form, where SUM=1110 and Cout =0.

(since Cout is 0: result is negative).

(To cross check the result, use 2's complement method and get the result as 0010)

Hence result is SUM = 7 – 9= - 2

Observe the outputs on the LED for each A and B input combinations as given above and record it in the given Table 1.

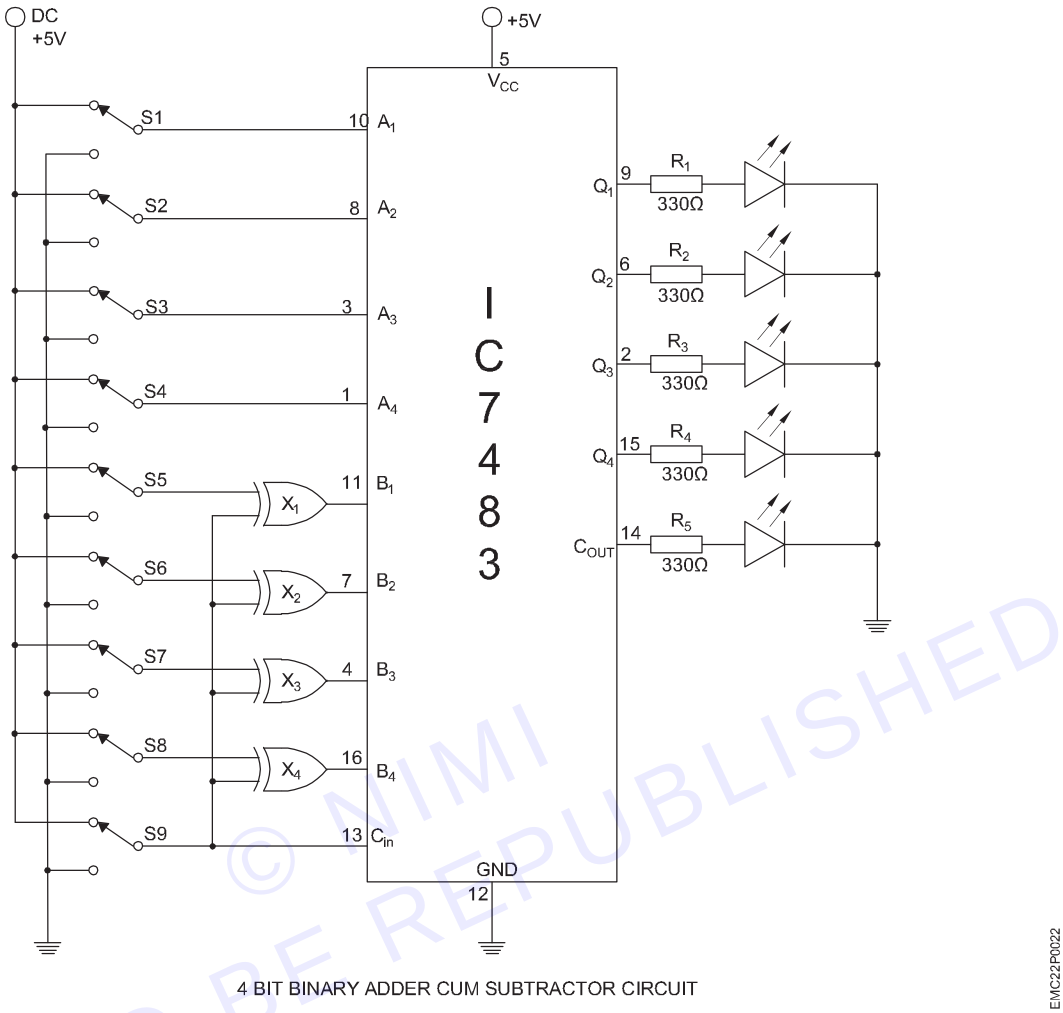
15 Toggle the mode select switch S9 to 5(V) position (Logic '1')

16 Observe the outputs on the LED for each A and B input combinations and record it in the given Table 1.

17 Repeat the above steps for different input combinations and record it in the given Table 1.

Note: Finally, ensure that the instructor reviews and verifies your work

Fig 1



4 BIT BINARY ADDER CUM SUBTRACTOR CIRCUIT

Table 1

Sl. No.	Inputs				Inputs					Mode switch =OV Status of LEDs					Mode switch =5V Status of LEDs				
	A_4	A_3	A_2	A_1	B_4	B_3	B_2	B_1	$carry_{out}$	Q_4	Q_3	Q_2	Q_1	$Carry_{out}$	Q_4	Q_3	Q_2	Q_1	$carry_{out}$
1																			
2																			
3																			
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11																			
12																			

EXERCISE 11 : 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/ Instrument

- Trainees tools kit - 1 Set.
- Digital trainer kit - 1 No.
- Digital IC Tester - 1 No.
- Digital multimeter with probes - 1 No.
- Logic probe - 1 No.

Materials/ Components

- IC 7404 - 1 No.
- IC 7408 - as reqd.
- Data sheet of ICs used - as reqd.
- Hookup wires - as reqd.

Procedure

In a digital trainer kit, users have access to various components such as a power supply, toggle switches, a breadboard, and LEDs with accompanying resistors. These components are included in the kit for testing digital circuits

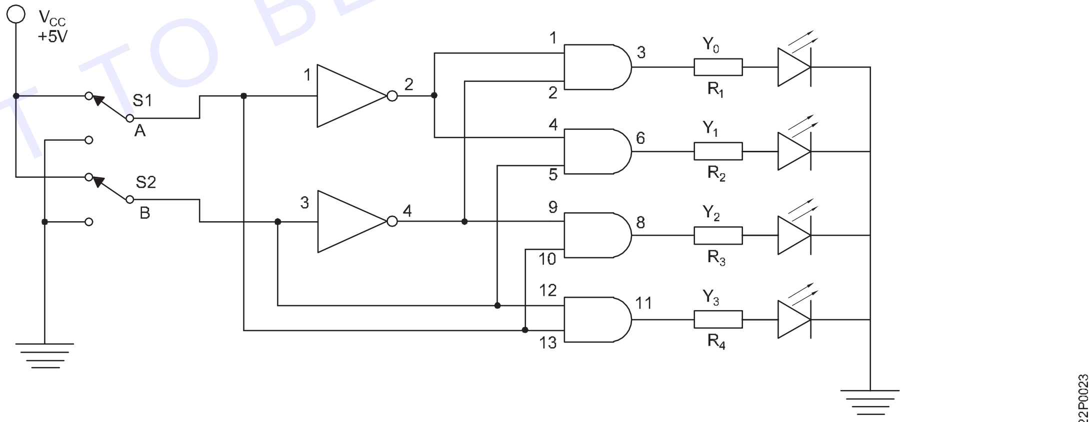
1 Collect the required components for assembling the 2 to 4 decoder using IC7404 and IC7408.

2 Check each component to ensure that they are in good condition.

3 Refer to the datasheet of the IC7404 and IC7408.

4 Assemble the 2 to 4 decoder circuit as per the circuit diagram shown in Fig 1 on the breadboard.

Fig 1



CONSTRUCTION OF 2 TO 4 DECODER

5 Connect the power supply (+5V) to the 14th pin of the IC 7404 and IC 7408 and connect the ground (0V) to the 7th pin of the IC 7404 and IC 7408.

6 Connect the toggle switch S1 to input pin 1 of the NOT gate it is represents as A, connect the same to pin 13 & 10 of the AND gate.

7 Connect the toggle switch S2 to input pin 3 of the NOT gate it is represents as B, connect the same to pin 12 & pin 5 of the AND gate IC

8 The output pin 2 of the NOT gate is connect to the pin 1 & pin 4 of the same AND gate.

9 The output pin 4 of the NOT gate is connect to the pin 2 & pin 9 of the same AND gate.

10 The pins 3, 6, 8, and 11 are the output pins (Y0, Y1, Y2, Y3) of a decoder are connect to the LEDs through the resistor.

11 Before switch ON trainer kit, check all the connections on the breadboard.

Make sure there are no loose wires or incorrect connections, and get the assembled circuit checked by the instructor.

12 Switch ON the 5V DC supply and operate toggle switches connected (S1 to S2) to test various combinations as shown in the Truth table.

2 to 4 Decoder TRUTH TABLE

SI.NO	INPUT		OUTPUTLED 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

13 Observe the output on the LED for each input combination and record it in the given Table 1

Table 1

SI.NO	INPUT		OUTPUTLED Status			
	A	B	Y0	Y1	Y2	Y3
1	0	0				
2	0	1				
3	1	0				
4	1	1				

14 Verify the readings with the Truth Table of 2 to 4 decoder.

Note: Finally, ensure that the instructor reviews and verifies your work.

EXERCISE 12: 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 and verify the truth table.

Requirements

Tools/ Equipments/ Instrument

- Trainees tools kit - 1 Set.
- Digital trainer kit - 1 No.
- Digital multimeter with probes - 1 No.
- Digital IC Tester - 1 No.
- Logic probe - 1 No.

Materials/ Components

- Data sheet of IC 7432 - 1 Set.
- IC 7432 - 1 No.
- Hook up wires - as reqd.

Procedure

In a digital trainer kit, users have access to various components such as a power supply, toggle switches, a breadboard, and LEDs with accompanying resistors. These components are included in the kit for testing digital circuits

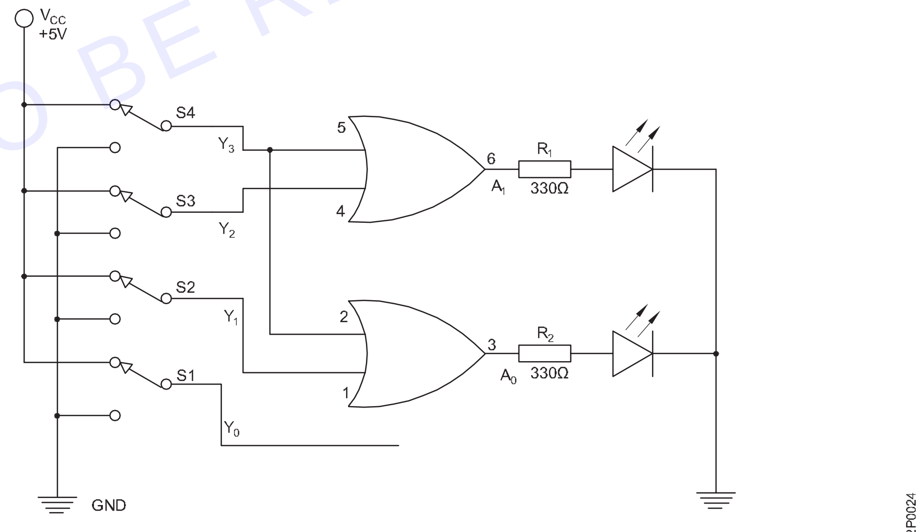
1 Collect the required components for assembling the 4 to 2 Encoder using IC 7432.

2 Check each component to ensure that they are in good condition.

3 Check whether IC is in good condition using digital IC tester.

4 Refer to the datasheet of the IC 7432.

Fig 1



CONSTRUCTION OF 4 TO 2 ENCODER

5 Assemble the 4 to 2 Encoder as per the circuit diagram shown in Fig 1 on the breadboard.

6 Connect the power supply (+5V) to the 14th pin and the ground (0V) to the 7th pin of the IC 7432.

7 Select toggle switches S1, S2, S3 and S4 labelled as Y0, Y1, Y2 and Y3

8 Make S1 to free without connecting anything.

9 Connect S2 to pin 1, S3 to pin 4 and S4 to pin 5 & 2 as Input of the AND gate IC 7408.

10 Connect the output pin 6 & 3 as A1 and A0 to the LEDs through the resistor as shown in the Fig 1.

11 Before switch the trainer kit, check all the connections on the breadboard.

Make sure there are no loose wires or incorrect connections, and get the assembled circuit checked by the instructor.

12 Switch ON the 5V DC supply and operate toggle switches connected to the input pins (S4 to S1) for the 4 to 2 Encoder and to test various combinations for different voltage levels, either in the 5V position (logic 1 / high) or 0V (logic 0 / low) position, as shown in the Truth table.

13 Observe the output on the LED for each input combination and record it in the given Table 1

14 Verify the readings with the Truth Table of 4 to2 Encoder.

Note: Finally, ensure that the instructor reviews and verifies your work

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		

4 to 2 Encoder Truth table 1

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

EXERCISE 13: Construct and Test the 4 to 1 Multiplexer

Objectives

At the end of this exercise you shall be able to

- construct and test the 4 to 1 multiplexer circuit using IC 74153.

Requirements

Tools/ Equipments/ Instrument

- Trainees tools kit - 1 Set.
- Digital trainer kit - 1 No.
- Digital IC Tester - 1 No.
- Digital multimeter with probes - 1 No.
- Logic probe - 1 No.

Materials/ Components

- IC-74153 - 1 No.
- Data sheet of IC 74153 - 1 No.
- Hook up wires - as reqd.

Procedure

In a digital trainer kit, users have access to various components such as a power supply, toggle switches, a breadboard, and LEDs with accompanying resistors. These components are included in the kit for testing digital circuits

1 Collect the required components for assembling the 4 to 1 multiplexer using IC 74153.

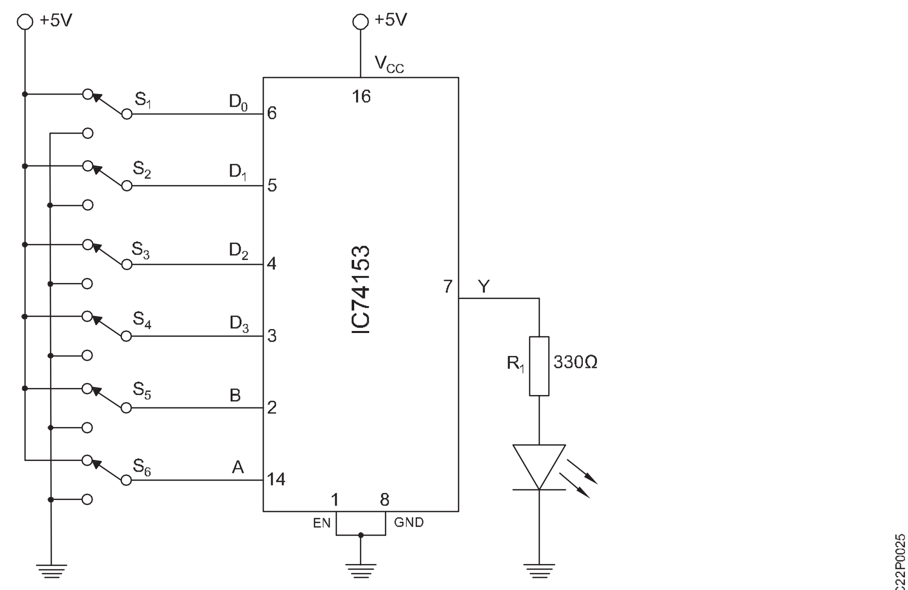
2 Check each component to ensure that they are in good condition.

3 Check whether IC is in good condition using digital IC tester.

4 Refer to the datasheet of the IC 74153.

The 74153 comes in a 16-pin package and consists of two individual 4-to-1 multiplexers within a single IC. However, the selector input switches are common for both multiplexers within the single IC

Fig 1



4 TO 1 MULTIPLEXER

Truth Table of Select Inputs

B	A	Y
0	0	I0
0	1	I1
1	0	I2
1	1	I3

Table 1

Sl. No.	SELECT SEQUENCE		DATA INPUTS (LOGIC LEVELS)				LED OUTPUT (Y)
	B	A	I_3	I_2	I_1	I_0	
	S6	S5	S4	S3	S2	S1	
1	0	0	X	X	X	0	
2	0	0	X	X	X	1	
3	0	1	X	X	0	X	
4	0	1	X	X	1	X	
5	1	0	X	0	X	X	
6	1	0	X	1	X	X	
7	1	1	0	X	X	X	
8	1	1	1	X	X	X	

5 Assemble the 4 to 1 Multiplexer as per the circuit diagram shown in Fig 1 on the breadboard.

6 Connect the power supply and adjust it to a voltage of +5V.

7 Connect the power supply (+5V) to the 16th pin and the ground (0V) to the 8th pin of the IC 74153

8 Connect the toggle switches S1 to pin 6, S2 to pin 5, S3 to pin 4, and S4 to pin 3, These switches S1, S2, S3 and S4 are consider as Input Data of the first multiplexer.

9 Join the Selector input A with pin 14 and B with pin 2 through switches S5 and S6.

10 Make sure the enable pin of the multiplexers i.e. pin 1 to ground, because these pins 1 and 15 are normally Active Low input pins.

11 To view the output connect pin 7 to the the LED through the resistor as shown in the Fig 1.

12 Before switch ON the trainer kit, check all the connections on the breadboard.

Make sure there are no loose wires or incorrect connections, and get the assembled circuit checked by the instructor.

13 Switch ON the 5V DC supply and operate toggle switches connected to the data input pins (S1 to S4) and the selector input pins (S5, S6) for the first multiplexer, and to test various combinations for different logic levels, either in the 5V position (logic 1 / high) or 0V (logic 0 / low) position, as shown in the Truth table.

14 Observe the output on the LED for each input combination and record it in the given Table 1.

15 Verify the readings with the Truth Table of 4 to1 Multiplexer.

16 Repeat the same steps for the second multiplexer, using the same switches. Observe the results.

Note: Finally, ensure that the instructor reviews and verifies your work

EXERCISE 14 : 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 74LS139.

Requirements

Tools/ Equipments/ Instrument

- Trainees tools kit - 1 Set.
- Digital trainer kit - 1 No.
- Digital IC Tester - 1 No.
- Digital multimeter with probes - 1 No.
- Logic probe - 1 No.

Materials/ Components

- IC-74139 - 1 No.
- Data sheet of IC 74139 - 1 No.
- Hook up wires - as reqd.

Procedure

In a digital trainer kit, users have access to various components such as a power supply, toggle switches, a breadboard, and LEDs with accompanying resistors. These components are included in the kit for testing digital circuits

1 Collect the required components for assembling the 1 to 4 demultiplexer using IC 74139.

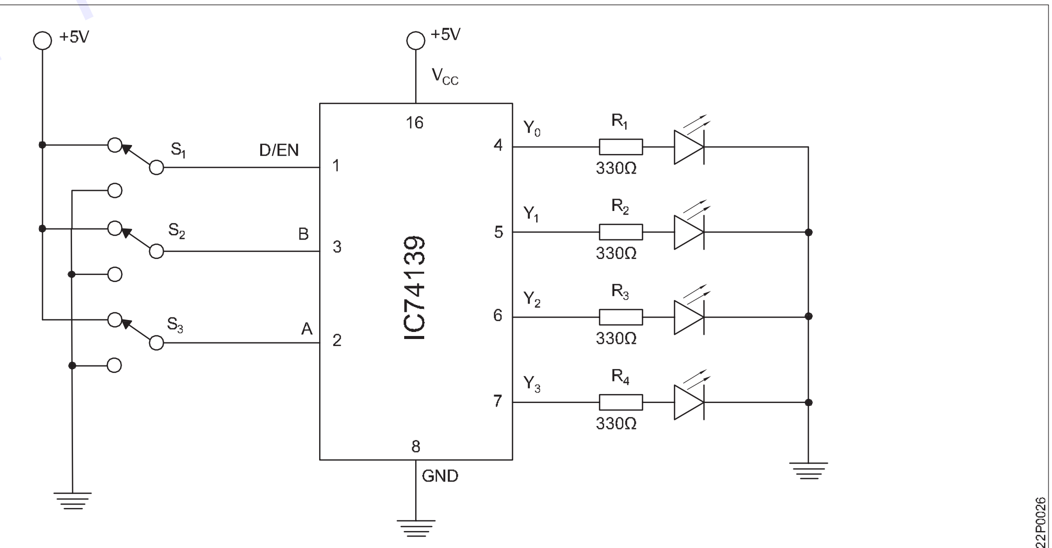
2 Check each component to ensure that they are in good condition.

3 Check whether IC is in good condition using digital IC tester.

4 Refer to the datasheet of the IC 74139

The 74139 comes in a 16-pin package and it has two separate demultiplexer sections, each with two selection inputs (A and B) and four outputs (Y0, Y1, Y2, Y3) within a single IC.

Fig 1



1 TO 4 DEMULTIPLEXER

Table 1

Input	Selector switch		Output			
DIn	B	A	Y_3	Y_2	Y_1	Y_0
D	0	0	1	1	1	D
D	0	1	1	1	D	1
D	1	0	1	D	1	1
D	1	1	D	1	1	1

Truth Table

Sl No	Data Input	Selection Sequence		LED Output			
	E (S1)	B (S2)	A (S3)	Y3	Y2	Y1	Y0
1	0	0	0				
2	1	0	0				
3	1	0	1				
4	1	1	0				
5	1	1	1				

5 Assemble the 1 to 4 demultiplexer as per the circuit diagram shown in Fig 1 on the breadboard.

6 Connect the power supply (+5V) to the 16th pin and the ground (0V) to the 8th pin of the IC 74139

7 Connect the S1 to pin 1 is consider as Input Data/ Enable pin of the first demultiplexer.

8 Join the Selector input A with pin 2 and B with pin 3 through switches S3 and S2

9 Connect the output pins 4, 5, 6, and 7 are represents as (Y0, Y1, Y2, Y3) of a demultiplexer to LEDs through the resistor as shown in the fig 1.

10 Before switch ON the the digital trainer kit, check all the connections on the breadboard.

Make sure there are no loose wires or incorrect connections, and get the assembled circuit checked by the instructor.

11 Switch ON the 5V DC supply and operate toggle switches connected to the data input pin (S1) and the selector input pins (S2, S3) for the first demultiplexer, and to test various combinations for different logic levels, either in the 5V position (logic 1 / high) or 0V (logic 0 / low) position, as shown in the Truth table.

12 Observe the output on the LED for each input combination and record it in the given Table 1.

13 Verify the readings with the Truth Table of 1 to 4 demultiplexer.

14 Repeat the same steps for the second demultiplexer, using the same switches. Observe the results.

Note: Finally, ensure that the instructor reviews and verifies your work

EXERCISE 15: Demonstrate 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/ Instrument

- Trainees tool kit - 1 Set.
- Digital IC tester - 1 No.

Materials/ Components

- Assorted flip flop ICs with data sheet - as reqd.
- Magnifying Lens - as reqd.

Procedure

Note: The instructor should provide the document (datasheet) and demonstrate to the trainees to check the important information about pin configurations, electrical characteristics, and recommended usage.

1 Collect the different flip-flops used in upcoming exercises from the instructor

2 Pick one of the IC from the lot

Hold the IC by the edges to avoid touching the pins.

3 Identify the IC and locate a part number that is printed on it

4 The IC number serves as a unique identifier, part number, or alphanumeric code that distinguishes the IC from others.

5 Check whether IC is in good condition using digital IC tester.

6 Record or note this information in Table -1

7 Refer to the data sheet of the IC, draw the symbol, pinout diagram, type of clock input and mark the details in Table 1

Table 1

Sl.No	IC Number	Condition of the IC	Logic gates function	Symbol	Clock input	Pinout diagram

8 Repeat the above steps for remaining Flip flop ICs.

Note: Finally, ensure that the instructor reviews and verifies your work

EXERCISE 16 : 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/ Instrument

- Trainees tool kit - 1 Set.
- Digital trainer kit - 1 No.
- Digital multimeter with probes - 1 No.
- Digital IC Tester - 1 No.
- Logic probe - 1 No.

Materials/ Components

- IC-7475 with data sheet - 1 No.
- Hook up wires - as reqd.

Procedure

In a digital trainer kit, users have access to various components such as a power supply, toggle switches, a breadboard, and LEDs with accompanying resistors. These components are included in the kit for testing digital circuits

1 Collect the required components for assembling the four bit latch using 7475

2 Check each component to ensure that they are in good condition.

3 Identify the four-bit latch IC using a magnifying lens with their part number 7475 on top of the IC.

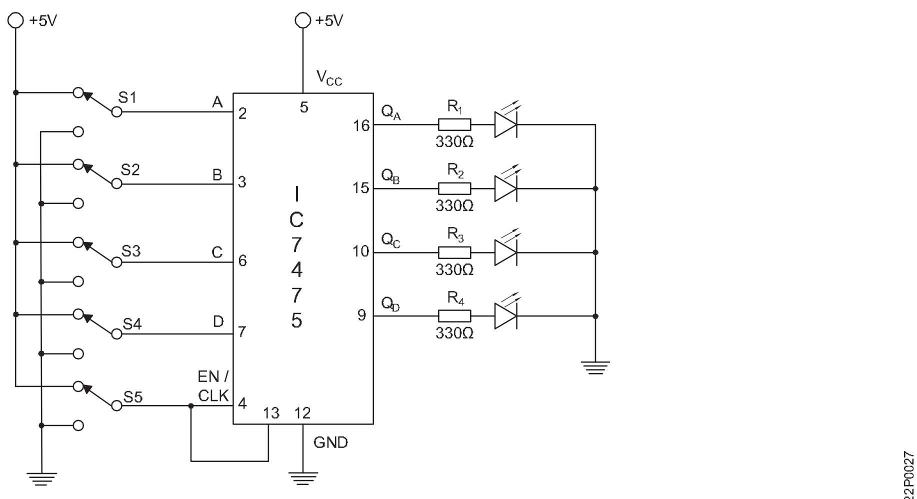
4 Check whether IC is in good condition using digital IC tester.

5 Refer to the datasheet of the IC 7475.

The 7475 is a quad bistable D-type latch integrated circuit (IC) which means it can store and hold 4 bits of data. It contains 4 transparent D latches with a common enable (gate) on latches 0 and 1 and another common enable on latches 2 and 3. When Q follows D (latch enabled) the latch is said to be transparent.

6 Assemble the four bit latch using IC 7475 as per the circuit diagram shown in Fig 1 on the breadboard.

Fig 1



FOUR BIT LATCH

7 Connect the power supply (+5V) to the 5th pin and the ground (0V) to the 12th pin of the IC 7475

8 Connect the toggle switch of the S1 to pin 2, S2 to pin 3, S3 to pin 6, and S4 to pin 7

9 Make a short between the pins between 4 and 13 using jumper wire and connect either the 4 or 13 pins to switch S5 as per the circuit diagram.

10 Use toggle switch S1 as data input A, switch S2 as data input B, switch S3 as data input C, switch S4 as data input D and switch S5 as Enable/clock input.

11 The pins 16, 15, 10 and 9 are the output pins (QA, QB, QC, QD) of of the Four bit Latches are connect to the LEDs through resistor as shown in the Fig 1.

12 Before switch ON the trainer kit, check all the connections on the breadboard.

Make sure there are no loose wires or incorrect connections, and get the assembled circuit checked by the instructor.

15 Switch ON the 5V DC supply and operate toggle switches connected to the data input pins (S1 to S4), and to test various combinations for different logic levels, either in the 5V position (logic 1 / high) or 0V (logic 0 / low) position.

16 Set the toggle switch S5 Enable / Clock to the ON position for the four bit latches

17 Observe the output status of the LED and record it in the given Table 1.

18 Set the toggle switch S5 Enable/ Clock to the OFF position for the four bit latches,

19 Observe the output status of the LED and record it in the given Table 1

20 Repeat the above steps for each combinations

Note: Finally, ensure that the instructor reviews and verifies your work

Table 1

Sl.No.	Inputs				Enable/clock =1				Enable/clock =0			
					Output LEDs				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								

EXERCISE 17: 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 RS flip-flop with clock pulse.

Requirements

Tools/ Equipments/ Instrument

- Trainees tools kit - 1 Set.
- Digital multimeter with probes - 1 No.
- Digital trainer kit - 1 No.
- Logic probe - 1 No.
- Digital IC tester - 1 No.

Materials/ Components

- IC-7400 NAND gate with data sheet - 1 No.
- Hook up wires - as reqd.

Procedure

In a digital trainer kit, users have access to various components such as a power supply, toggle switches, a breadboard, and LEDs with accompanying resistors. These components are included in the kit for testing digital circuits

TASK 1: **Construction and testing of R-S Flip-Flop without clock pulse using IC 7400**

1 Collect the required components for assembling the R-S Flip-Flop without clock pulse using IC 7400

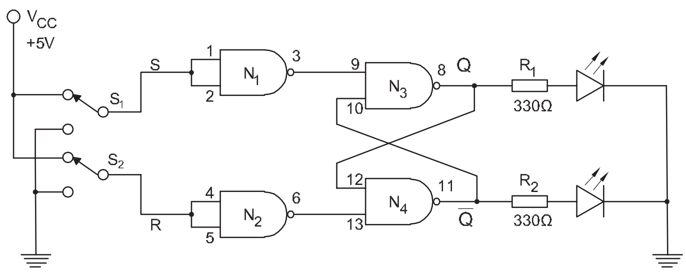
2 Check each component to ensure that they are in good condition.

3 Check whether IC is in good condition using digital IC tester.

4 Refer to the datasheet of the IC 7400.

5 Assemble the R-S Flip-Flop without clock pulse using IC 7400 as per the circuit diagram shown in Fig 1 on the breadboard.

Fig 1



R-S FLIP-FLOP CIRCUIT USINGNAND GATE

EMC22P0028

6 Connect the power supply (+5V) to the 14th pin and the ground (0V) to the 7th pin of the IC 7400.

7 Make a short between the pins between pin 1 and 2 of the NAND gate1 using jumper wire.

8 Make a short between the pins between pin 4 and 5 of the NAND gate 2 using jumper wire.

9 Connect the S1 to pin 1 or 2, S2 to pin 4 or 5, These switches S1 and S2 are consider as Inputs SET and RESET.

10 Join the output pin 3 of the NAND gate 1 to 9th pin of the NAND gate 3

11 Join the the output pin 6 of the NAND gate 2 to 13th pin of the NAND gate 4

12 Connect the output pin 8 of the NAND gate 3 cross coupled to the input of the 12 pin of the NAND gate 4

13 Connect the output pin 11 of the AND gate 4 cross coupled to the input of the 10 pin of the NAND gate 3

14 To view the output pins (Q and $\overline{Q}$) of the R-S Flip-Flop connect the pins 8 and 11 to LEDs through the resistor as shown in the Fig 1.

15 Before switch ON the trainer kit, check all the connections on the breadboard.

Make sure there are no loose wires or incorrect connections, and get the assembled circuit checked by the instructor.

16 Switch ON the 5V DC supply and operate toggle switches connected to the data input pins (S1 to S2), and to test various combinations for different voltage levels, either in the 5V position (logic 1 / high) or 0V (logic 0 / low) position and

17 Observe the output status of the LED for each input combination and record it in the given Table 1.

Table 1

RS flip-flop using NAND gate

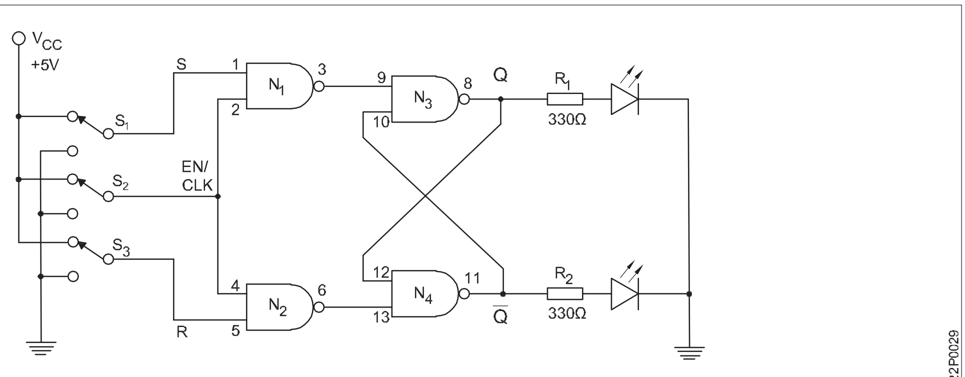
Input		Output				Operating Mode
S	R	Q	Q - LED Status (ON/OFF)	$\overline{Q}$	$\overline{Q}$-LED Status (ON/OFF)	

Note: Finally, ensure that the instructor reviews and verifies your work

— — — — —

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



RS FLIP-FLOP CIRCUIT USING NAND GATE

1 Repeat the same steps follows in Task 1 but few changes you have to do, connect S1 to pin 1 S2 to pin 224, S3 to pin 5 of the IC 7400.

2 S2 will be consider as enable pin / clock pulse

3 Before switch ON the trainer kit, check all the connections on the breadboard.

Make sure there are no loose wires or incorrect connections, and get the assembled circuit checked by the instructor.

4 Switch ON the 5V DC supply and operate toggle switches connected to the data input pins (S1 to S2), and to test various combinations for different voltage levels, either in the 5V position (logic 1 / high) or 0V (logic 0 / low) position and

5 Observe the output status of the LEDs for each input combination and record it in the given Table 2

Table 2

Clock Input	Input		Output				Operating Mode
	S	R	Q	Q - LED Status (ON/OFF)	$\overline{Q}$	$\overline{Q}$-LED Status (ON/OFF)	

Note: Finally, ensure that the instructor reviews and verifies your work

EXERCISE 18: Verify the truth tables of Flip-Flop 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
- construct and verify the truth table of D flip flop
- construct and verify the truth table of T flip flop
- construct and verify the truth table of JK flop
- construct and verify the truth table of MSJK flip flop.

Requirements

Tools/ Equipments/ Instruments

- Trainees tools kit - 1 Set.
- Digital trainer kit - 1 No.
- Digital ic tester - 1 No.
- Digital Multimeter - 1 No.
- Logic probe - 1 No.

Materials/ Components

- IC 7400 with Data manual - 1 No.
- IC 7410 with Data manual - 1 No.
- IC 7474 with Data manual - 1 No.
- IC 7476 with Data manual - 1 No.
- Hook up wires - as reqd

Procedure

In a digital trainer kit, users have access to various components such as a power supply, toggle switches, a breadboard, and LEDs with accompanying resistors. These components are included in the kit for testing digital circuits

TASK 1 : **Construct RS flipflop circuit and verify of the truth table**

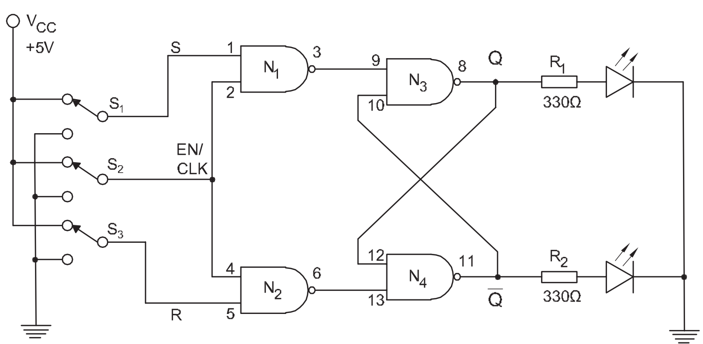
1 Collect all the required components specified for the experiment.

2 Check to ensure the components are in working condition.

3 Test the IC 7400 using a digital IC tester to determine whether it is in good or bad condition.

4 Refer to the datasheet for the IC 7400, and then assemble the circuit on a breadboard as per the circuit diagram as shown in Fig 1.

Fig 1



CLOCKED RS FLIP-FLOP CIRCUIT

EMC22P0242

5 Connect the Pin 14 to + 5 V (Vcc) and Pin 7 to ground (GND).

6 Use the toggle switches S1 ,S2 and S3 to represent Set(S) and Reset(R) and Clock inputs to the IC 7400

7 Connect the toggle switches S1 to pin 1, S2 to pin 5, S3 to pin 2 and 4 of the IC 7400.

8 Connect the pins 3 to 9, 6 to 13, 10 to 11, 12 to 8 as per the circuit diagram using jumper wires.

9 Connect the pins 8 and 11 to the output LEDs inbuilt in the trainer kit as Q and $\overline{Q}$ as shown in Fig 1

10 Switch ON the 5V DC supply and operate toggle switches for different voltage levels, either in the 5V position (logic 1 / high) or 0V (logic 0 / low) position as per the truth table1.

Truth table 1

Clk/ E	S	R	Q	Q’	Condition
0	0	0	x	x	Previous condition
1	0	0	x	x	No change
1	0	1	0	1	Reset
1	1	0	1	0	Set
1	1	1	1	1	Forbidden state

11 Apply different Inputs to S and R as given in truth table 1 and record the corresponding output levels and the status of the LEDs in the given Table 1.

Table 1

Clk/ E	S	R	Q output status	$\overline{Q}$ output status	Condition
0	0	0			
1	0	0			
1	0	1			
1	0	0			
1	1	0			
1	0	0			
1	1	1			

12 Get the circuit checked by the Instructor.

— — — — —

TASK 2a: **Construct D flip flop circuit using Gates and verify of the truth table**

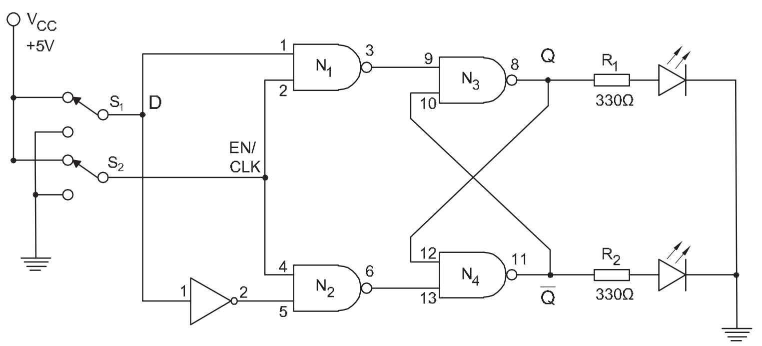
1 Repeat the same steps follows in Task 1 but few changes you have to do.

2 Use the toggle switches S1 and S2 to represent Data input and Clock input to the IC 7400

3 Connect S1 to pin 1 of the NAND gate IC and to the pin 1 of the NOT gate IC

4 Connect the Pin 2 of the NOT gate IC to pin 5 of the IC 7400, S2 to pin 2 and 4 of the IC 7400.

Fig 2



D FLIP-FLOP CIRCUIT

EMC22P0243

5 Switch ON the 5V DC supply and operate toggle switches for different voltage levels, either in the 5V position (logic 1 / high) or 0V (logic 0 / low) position as per the truth table 2 and

Truth table 2

Clk/ E	Data	Q	$\overline{Q}$	Condition
0	0	x	x	Previous condition
1	0	0	1	Reset
1	1	1	0	Set

Table 2

Clk/ E	Data	Q output status	$\overline{Q}$ output status	Condition
0	0			
1	0			
1	1			

6 Apply different Inputs to D as given in truth table 2 and record the corresponding output levels and the status of the LEDs in the given Table 2.

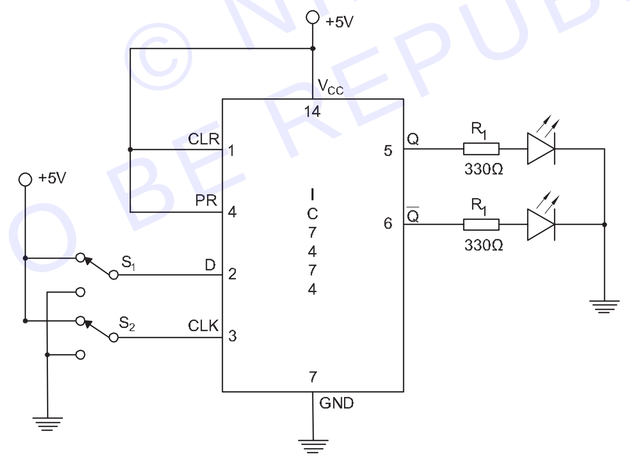
7 Get the circuit checked by the Instructor.

— — — — —

TASK 2b: **Construct D flips flop circuit using IC 7474 and verify the truth table**

1 Collect the IC 7474 and required components specified for the experiment as shown in the Fig 3.

Fig 3



D FLIP-FLOP CIRCUIT USING IC7474

2 Test the IC 7474 using a digital IC tester to determine whether it is in good or bad condition.

3 Refer to the datasheet for the IC 7474, and then assemble the circuit on a breadboard as per the circuit diagram as shown in Fig 4.

4 Use the toggle switches S1 to represent Data(D) and Clock /Enable input to the IC 7474

5 Connect S1 to pin 2 of the IC 7474 and the pin 3 to clock / enable input.

6 Connect the Pin 1, 4 and 14 to + 5 V (Vcc) and Pin 7 to ground (GND).

7 Connect the pins 5 and 6 to the output LEDs inbuilt in the trainer kit as Q and $\overline{Q}$ as shown in Fig 3.

8 Repeat the steps 5 to 7 in task 2a

9 Verify the truth table 2 and record the corresponding output levels and the status of the LEDs in the given Table 3.

Table 3

Input				Output	
PR	CLR	CLK	D	Q	$\overline{Q}$
L	H	X	X		
H	L	X	X		
L	L	X	X		
H	H	↑	H		
H	H	↑	L		
H	H	L	X		

— — — — —

TASK 3a: **Construct T flip flop circuit and verify of the truth table**

1 Collect the required components specified for the experiment.

2 Check to ensure the components are in working condition.

3 Test the IC 7400 and IC 7410 using a digital IC tester to determine whether it is in good or bad condition.

4 Refer to the datasheet for the IC 7400 and IC 7410, and then assemble the circuit on a breadboard as per the circuit diagram as shown in Fig 4 .

5 Connect the Pin 14 to + 5 V (Vcc) and Pin 7 to ground (GND) of both the ICs.

6 Connect the pins 1 and 3 of IC 7410 (three input NAND gates) using jumper wire and connect them to the clock input.

7 Connect the 5 and 13 using a jumper wire and connect them to the T input toggle switch.

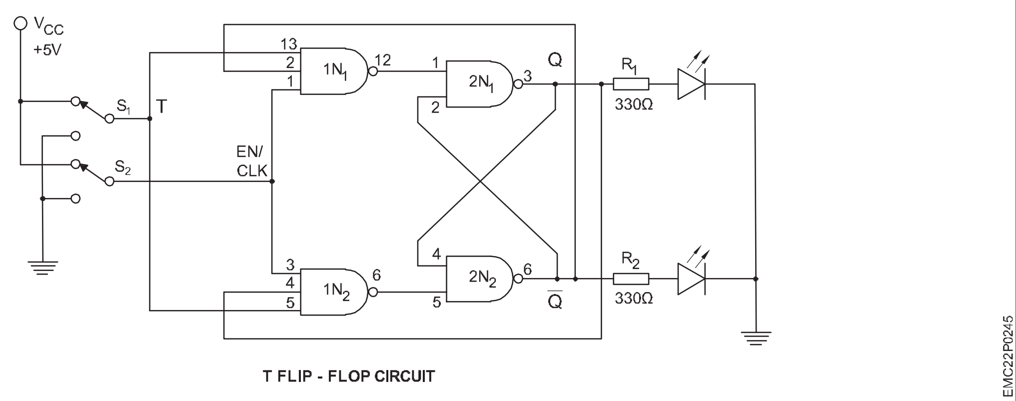
8 Connect the pin No. 6 of the IC 7410 to the pin 5 of the IC 7400 (two input NAND gates), and Pin 12 of IC 7410 to Pin 1 of IC 7400.

9 Connect the pins 2 to 6 and 3 to 4 of the IC 7400.

10 Connect the pins 4 of the IC 7410 to the pin 3 of the IC 7400 and connect the pins 2 of the IC 7410 to the pin 6 of the IC 7400.

11 Connect the pins 3 and 6 to the output LEDs inbuilt in the trainer kit as Q and $\overline{Q}$ as shown in Fig 4 .

Fig 4



T FLIP - FLOP CIRCUIT

12 Use the toggle switches S1 and S2 to represent Toggle input and Clock inputs to the IC 7410

13 Switch ON the 5V DC supply and operate toggle switches for different voltage levels, either in the 5V position (logic 1 / high) or 0V (logic 0 / low) position as per the truth table 4

Truth table 4

Clk/ E	Toggle input	Q	$\overline{Q}$	Condition
0	0	x	x	Previous condition
1	0	1	0	Set
1	1	0	1	Reset

Table 4

Clk/ E	Toggle input	Q output status	$\overline{Q}$ output status	Condition
0	0			
1	0			
1	1			

14 Apply different Inputs to Toggle Flip Flop as given in the truth table 4 and record the corresponding output levels and the status of the LEDs in the given Table 4.

15 Get the circuit checked by the Instructor.

— — — — —

TASK 3b: **Construct T flip flop circuit using IC 7476 and verify of the truth table**

1 Collect the IC 7476 and required components specified for the experiment as shown in the Fig 5.

2 Test the IC 7476 using a digital IC tester to determine whether it is in good or bad condition.

3 Refer to the datasheet for the IC 7476, and then assemble the circuit on a breadboard as per the circuit diagram as shown in Fig 5.

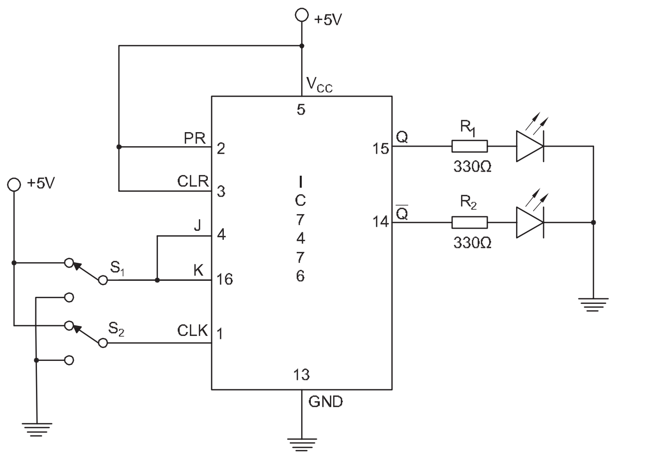
4 Use the toggle switches S1 to represent Toggle (T) and Clock/ Enable input to the IC 7476

5 Connect S1 to pin 4 and 16 of the IC 7476 and the pin 4 to clock / enable input.

6 Connect the Pin 2, 3 and 15 to + 5 V (Vcc) and Pin 13 to ground (GND).

7 Connect the pins 15 and 14 to the output LEDs inbuilt in the trainer kit as Q and $\overline{Q}$ as shown in Fig 5.

Fig 5



T FLIP-FLOP CIRCUIT USING IC7476

EMC22P0246

8 Use the toggle switches S1 and S2 to represent Toggle input and Clock inputs to the IC.

9 Repeat the steps 13 to 15 in Task 3a

10 Verify the truth table 4 and record the corresponding output levels and the status of the LEDs in the given Table 5.

Table 5

Clk	Toggle input	Q output status	Q' output status	Condition
1	0			
0	0			
0	1			

— — — — —

TASK 4: **Construction of JK flip flop circuit using IC 7476 and verification of the truth table**

1 Collect the IC 7476 and required components specified for the experiment as shown in the Fig 6.

2 Test the IC 7476 using a digital IC tester to determine whether it is in good or bad condition.

3 Refer to the datasheet for the IC 7476, and then assemble the circuit on a breadboard as per the circuit diagram as shown in Fig 6.

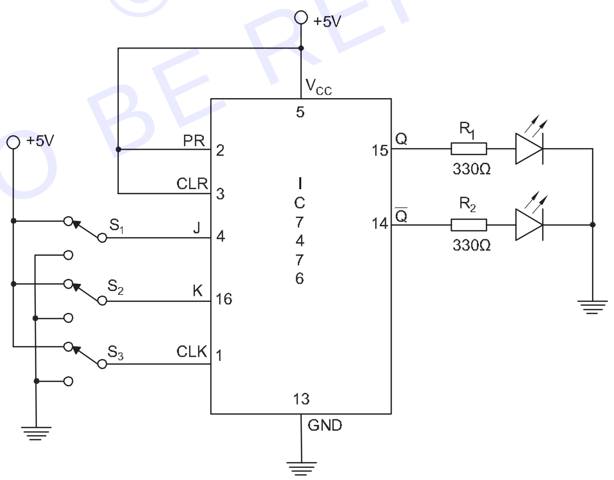
4 Use the toggle switches S1 ,S2 and S3 to represent J and K and Clock inputs to the IC 7476

5 Connect the toggle switches S1 to pin 4, S2 to pin 16, S3 to pin 1 of the IC 7476.

6 Connect the Pin 2, 3 and 5 to + 5 V (Vcc) and Pin 13 to ground (GND).

7 Connect the pins 15 and 14 to the output LEDs inbuilt in the trainer kit as Q and $\overline{Q}$ as shown in Fig 6

Fig 6



JK FLIP-FLOP CIRCUIT USING IC7476

EMC22P0247

8 Repeat the steps 13 to 15 in Task 3a

9 Verify the truth table 6 and record the corresponding output levels and the status of the LEDs in the given Table 6.

Truth table 6

Input					Output	
Preset	Clear	Clock	J	K	Q	$\overline{Q}$
1	1	↑	X	X	Q	$\overline{Q}$
1	1	↓	0	0	0	$\overline{Q}$
1	1	↓	1	0	1	0
1	1	↓	0	1	0	1
1	1	↓	1	1	TOGGLE	

Table 6

Input			Condition
Preset	Clear	Clock	
1	1	↑	
1	1	↓	
1	1	↓	
1	1	↓	
1	1	↓	

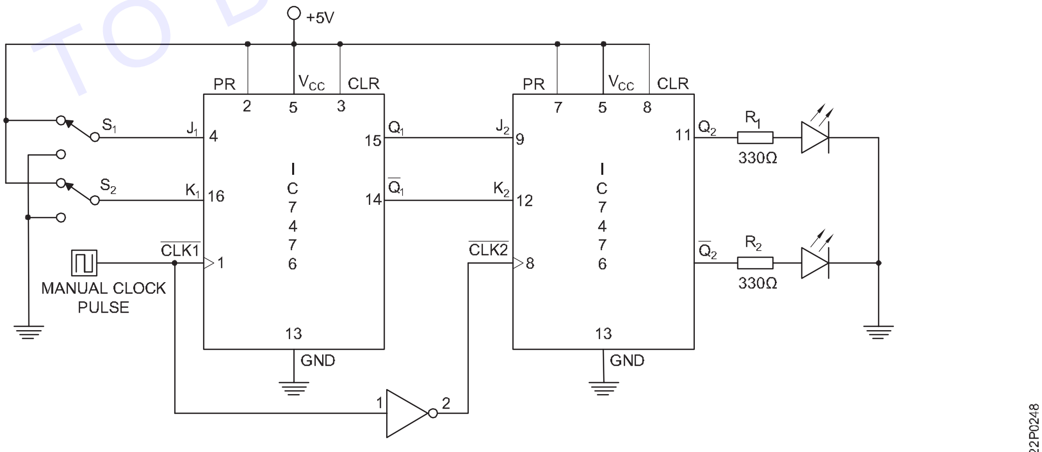
— — — — —

TASK 5: **Construction of a master -slave JK flip-flop circuit using IC 7476 and verification of the truth table**

1 Repeat the steps 1 to 6 followed in task 4

2 Assemble a MS-JK flip-flop circuit by referring to Fig 7 on a breadboard.

Fig 7



MASTER SLAVE JK FLIP-FLOP

3 Connect the Pin 7 and 8 to + 5 V (Vcc)

4 Connect the manual clock switch/ clock pin 1 of the IC 7476 and one end of the NOT gate IC 7404 pin 1, connect other end of the NOT gate pin 2 to 6th pin of the IC 7476.

5 Connect the 15th pin to 9th pin and 14th pin to 12th of the IC 7476.

6 Check the connections and Switch ON the 5V DC supply and operate toggle switches for different voltage levels of MSJK flip-flop as given in the truth table 7.

7 Verify the corresponding output levels and status of LEDs Q and $\overline{Q}$ and record it in the table

Truth table 7 of master slave JK flip flop

Trigger	**Inputs**		**Output**						**Inference**
			Present state		**Intermediate**		**Next state**		
CLK	**J**	**K**	**Q**	**$\overline{Q}$**	**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		0	1	
↑	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	

Table 7

PRE	CLR	Master					Slave					Condition
		CLK	J	K	Q	$\overline{Q}$	CLK	J	k	Q	$\overline{Q}$	
1	1											
1	1											
1	1											
1	1											
1	1											
1	1											

— — — — —

EXERCISE 19: Construct and test a four bit asynchronous binary counter using IC 7493

Objectives

At the end of this exercise you shall be able to

- construct and test trace bit asynchronous binary counter using IC 7493. (4 bit ripple counter).

Requirements

Tools/ Equipments/ Instruments

- Trainees tools kit - 1 Set.
- Digital trainer kit - 1 No.
- Digital IC tester - 1 No.
- Digital Multimeter with probes - 1 No.
- Logic probe - 1 No.

Materials/ Components

- IC 7493 - 1 No.
- Data sheet of IC 7493 - 1 No.
- Hook up wires - as reqd.

Procedure

In a digital trainer kit, users have access to various components such as a power supply, toggle switches, a breadboard, and LEDs with accompanying resistors. These components are included in the kit for testing digital circuits

TASK 1: **Construct and test the asynchronous binary counter using IC7493 (4 bit ripple counter)**

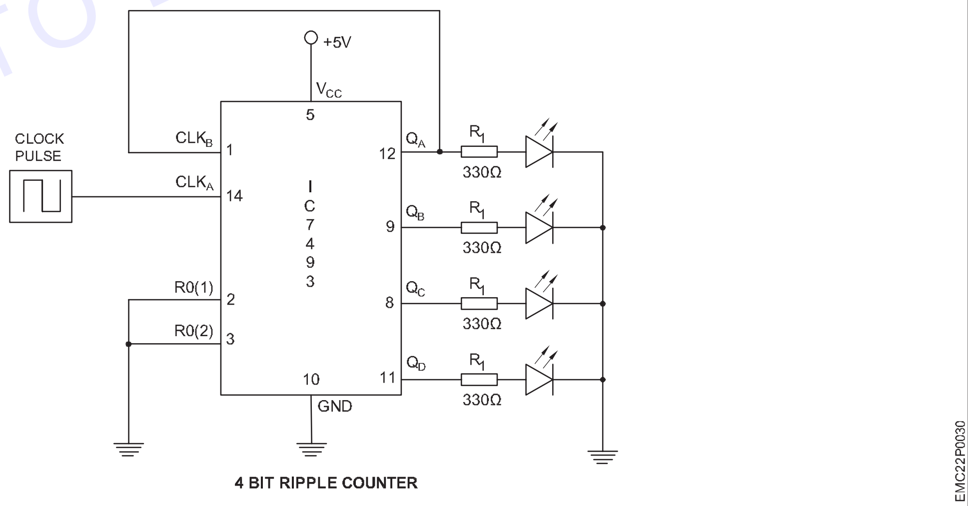
1 Collect the required components for assembling the asynchronous binary counter using IC7493 (4 bit ripple counter)

2 Check each component to ensure that they are in good condition.

3 Check the IC using digital IC tester whether it is in good or bad condition

4 Refer to the datasheet of the IC 7493

Fig 1



4 BIT RIPPLE COUNTER

5 Assemble the 4 bit asynchronous binary ripple counter as per the circuit diagram shown in Fig 1 on the breadboard.

6 Connect the power supply (+5V) to the 5th pin and the ground (0V) to the 10th pin of the IC 7493.

7 Join the 2 and 3 pin using jumper wire and connect to ground.

8 Connect the pin 1 to 12th of the IC 7493 and connect 14th pin to the manual clock pulse/ push button switch to ground.

9 The pins 12,9,8 and 11 are the output pins (QA, QB, QC and QD) of the asynchronous binary counter are connect to the LEDs through the resistors .as shown in the Fig 1.

10 Before switch ON trainer kit, check all the connections on the breadboard.

Make sure there are no loose wires or incorrect connections, and get the assembled circuit checked by the instructor.

11 Switch ON the 5V DC supply and press the manual clock pulse / push button switch

12 Observe the output status of the LEDs and record it in the table 1

13 Repeat pressing of the push button and observe the output.

14 Verify that the count goes from zero (0000) to fifteen (1111).

Note: Finally, ensure that the instructor reviews and verifies your work

Table 1

Clock	QD	QC	QB	QA

EXERCISE 20: Construct and test 7493 as a modulus-12 counter

Objectives

At the end of this exercise you shall be able to

- construct and test modulus 12 counter using IC-7493.

Requirements

Tools/ Equipments/ Instruments

- Trainees tools kit - 1 Set.
- Digital trainer kit - 1 No.
- Digital multimeter with Probes - 1 No.
- Digital IC tester - 1 No.
- Logic probe - 1 No.

Materials/ Components

- IC 7493 - 1 No.
- IC 7408 - 1 No.
- Hookup wire - as reqd.
- Data sheet of the IC's - as reqd.

Procedure

In a digital trainer kit, users have access to various components such as a power supply, toggle switches, a breadboard, and LEDs with accompanying resistors. These components are included in the kit for testing digital circuits

Modulus 12 Counter: A modulus 12 counter is a type of counter circuit that counts in modulo 12, meaning it will cycle through 12 different states before returning to zero. It's commonly used in applications where a 12-step sequence is needed.

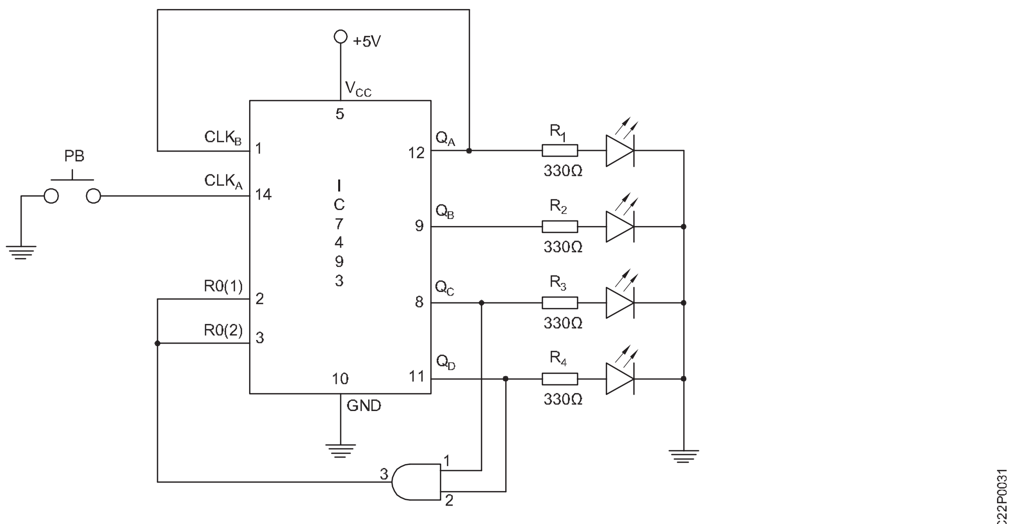
1 Collect the required components for assembling the modulus 12 counter /counter using IC 7493

2 Check each component to ensure that they are in good condition.

3 Check the IC using digital IC tester whether it is in good or bad condition

4 Refer to the datasheet of the IC 7493 and IC 7408

Fig 1



MOD-12 COUNTER

5 Assemble the modulus 12 counter as per the circuit diagram shown in Fig 1 on the breadboard.

6 Connect the power supply (+5V) to the 5th pin of the IC(1) 7493 and 14th pin of the IC(2) 7408

7 Attach the ground (0V) to the 10th pin of the IC (7493) and 7th pin of the IC (2) 7408

8 Connect pin 1 to pin 12 of the IC7493

9 Connect pin 8 of IC(1) to pin 1 of IC(2), the 11th pin of IC(1) to pin 2 of IC(2), and connect the 3rd pin of IC(2) to either the 2nd or 3rd pin of IC(1). Join pins 2 and 3 using a jumper wire

10 Connect the 14th pin of IC(1) to the manual clock pulse/ push button switch and attach to ground.

11 The pins 12, 9, 8, and 11 are the output pins (QA, QB, QC, and QD) of the modulus 12 counter are connect LEDs through the resistors as shown in the fig 1

12 Before switch ON the digital trainer kit, check all the connections on the breadboard.

Make sure there are no loose wires or incorrect connections, and get the assembled circuit checked by the instructor.

12 Switch ON the 5V DC supply and press manual clock pulse/ push button switch as shown in the Fig 1

13 Observe the output status of the LEDs, confirm that the count progresses each pressing of push button from zero (0000) to leven (1011), and record the observations in Table 1.

Note: Finally, ensure that the instructor reviews and verifies your work

Table 1

Clock input	Four bit mod-12 counter			
Count	**QD**	**QC**	**QB**	**QA**
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				

EXERCISE 21: Construct and test a four bit synchronous binary counter using IC 74163

Objectives

At the end of this exercise you shall be able to

- construct and test synchronous binary counter using IC 74163.

Requirements

Tools/ Equipments/ Instruments

- Trainees tools kit - 1 Set.
- Digital trainer kit - 1 No.
- Digital multimeter with Probes - 1 No.
- Digital IC tester - 1 No.
- Logic probe - 1 No.

Materials/ Components

- IC 74163 (synchronous binary counter) - 1 No.
- Hook - up wire - as reqd.
- Data sheet of the IC 74163 - 1 No.

Procedure

In a digital trainer kit, users have access to various components such as a power supply, toggle switches, a breadboard, and LEDs with accompanying resistors. These components are included in the kit for testing digital circuits

TASK 1: **Construction and testing of synchronous binary counter**

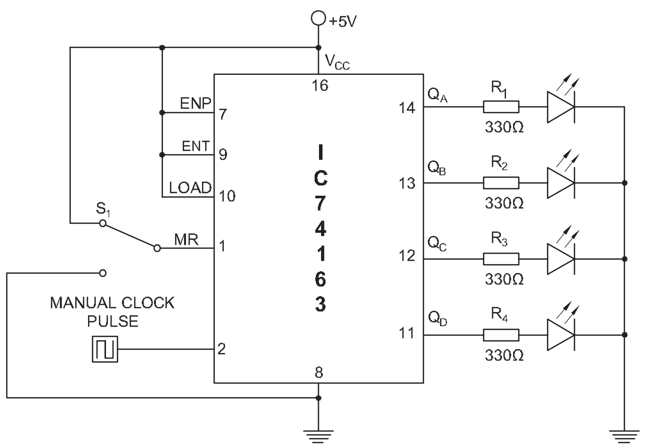
1 Collect all the required components specified for the experiment.

2 Check to ensure the components are in working condition.

3 Test the IC 74163 using a digital IC tester to determine whether it is in good or bad condition.

4 Refer to the datasheet for the IC 74163, and then assemble the circuit on a breadboard as per the circuit diagram as shown in Fig 1.

Fig 1



4-BIT SYNCHRONOUS BINARY COUNTER

EMC22P0032

5 Connect the power supply (+5V) to the 16th pin of the IC 74163.

6 Attach the ground (0V) to the 8th pin of the IC 74163.

7 Connect the 1st pin of the IC 74163 to the toggle switch.

With this setup, when the power is applied, the switch will be initially in the high position (connected to +5V), and the counting process will begin. If you later toggle the switch to the low position (connected to 0V), it will reset the counting process

8 Connect pins 9, 7, and 10 together and then join them to the 16th pin

9 Connect the 2nd pin of IC to the manual clock pulse/ push button switch and attach to ground.

10 The pins 14,13, 12 and 11 are the output pins (QA, QB, QC, and QD) of the synchronous binary counter are connect to the LEDs through resistors as shown in the Fig 1.

11 Before switch ON the digital trainer kit, check all the connections on the breadboard.

Make sure there are no loose wires or incorrect connections, and get the assembled circuit checked by the instructor.

12 Switch ON the 5V DC supply and press the to the manual clock pulse/ push button switch as shown in the Fig 1

13 Observe the output status of the LEDs, confirm that the count progresses pressing of push button from zero (0000) to fifteen (1111), and record the observations in Table 1.

Note: Finally, ensure that the instructor reviews and verifies your work

Table 1

Pulse clock	QD	QC	QB	QA

EXERCISE 22 : Construct and test synchronous Decade counter

Objectives

At the end of this exercise you shall be able to

- construct and test synchronous decade counter.

Requirements

Tools/ Equipments/ Instruments

- Trainees tools kit - 1 Set.
- Digital trainer kit - 1 No.
- Digital multimeter with Probes - 1 No.
- Digital IC tester - 1 No.
- Logic probe - 1 No.

Materials/ Components

- IC 74LS90 (Decade counter) with data manual - 1 No.
- IC 7447 (7-seg driver) with data manual - 1 No.
- 7 segment common anode - 1 No.
- Hook up wires - as reqd.

Procedure

In a digital trainer kit, users have access to various components such as a power supply, toggle switches, a breadboard, and LEDs with accompanying resistors. These components are included in the kit for testing digital circuits

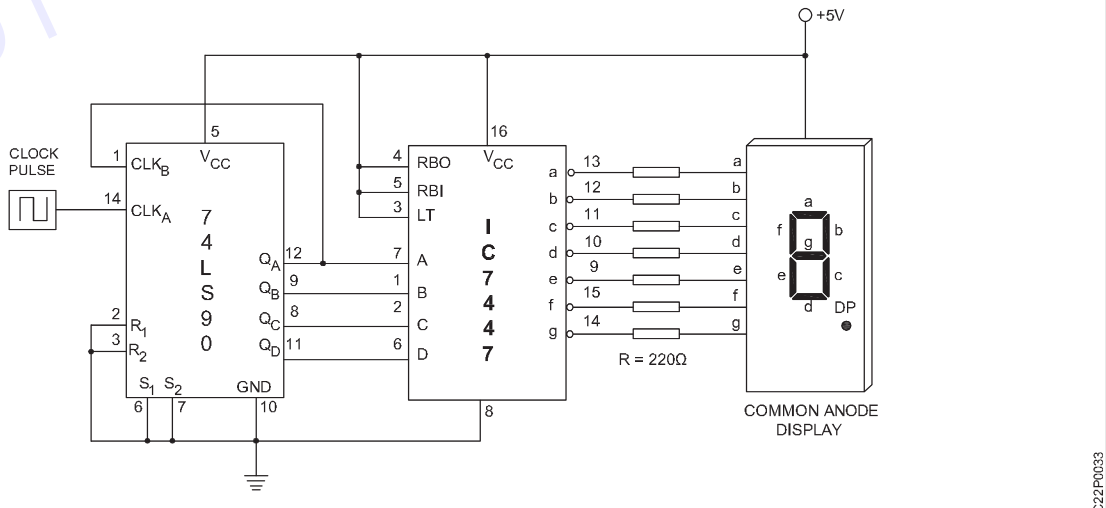
1 Collect the required components specified for the experiment.

2 Check to ensure the components are in working condition.

3 Test the IC 7490 (Decade counter) and IC 7447 using a digital IC tester to determine whether it is in good or bad condition.

4 Refer to the datasheet for the IC 7490 (Decade counter) and IC 7447 and then assemble the circuit on a breadboard as per the circuit diagram as shown in Fig 1.

Fig 1



SYNCHRONOUS DECADE COUNTER

5 Connect the power supply (+5V) to the 5th pin of the IC 7490, the 16th pin of the IC 7447, and the common pin of the common anode, which is either the 3rd or 8th pin

6 Attach the ground (0V) to the 10th pin of the IC 7490 and the 8th pin of the IC 7447.

7 Connect the pins 2, 3, 6, and 7 together and then connect them to the 10th pin of the IC 7490.

8 Connect the 1st pin to the 12th pin of the IC 7490.

9 Connect the 14th pin of IC to the manual clock pulse/ push button switch attached to ground

10 Connect the output pins (QA, QB, QC, and QD) of the IC 7490, which are pins 12, 9, 8, and 11, respectively, to the 7th, 1st, 2nd, and 6th pin of the IC 7447.

11 Connect pins 4th, 5th, and 3rd together, and then join them to the 16th pin of the IC 7447.

12 Connect the output pins (a, b, c, d, e, f, and g) of the IC 7447, which are pins 13, 12, 11, 10, 9, 15, and 14 respectively, to one end of seven resistors.

13 The other end of these resistors is connected to the seven-segment display with common anode, specifically to pins 7, 6, 4, 2, 1, 9, and 10.

14 Before switch ON the digital trainer kit, check all the connections on the breadboard.

Make sure there are no loose wires or incorrect connections, and get the assembled circuit checked by the instructor.

15 Switch ON the 5V DC supply and press the manual clock pulse/ push button switch as shown in the Fig 1

16 Observe the output status of the LEDs on the IC 7490, confirming the count progression of pressing the push button from (0000) to (1001) and record it in the table 1.

17 Additionally, observe the seven-segment display, verifying that the count progresses from 0 to 9, and record the observations in Table 1.

Note: Finally, ensure that the instructor reviews and verifies your work

Table 1

Pulse clock	QD	QC	QB	QA	Display value

— — — — —

EXERCISE 23: Construct and test an UP/ DOWN synchronous decade counter using 74190 and monitor the output on LEDs

Objectives

At the end of this exercise you shall be able to

- construct and test an UP counter using IC 74190
- construct and test the DOWN counter using IC 74190.

Requirements

Tools/ Equipments/ Instruments

- Trainees tools kit - 1 Set.
- Digital trainer kit - 1 No.
- Digital multimeter with Probes - 1 No.
- Digital IC tester - 1 No.
- Logic probe - 1 No.

Materials/ Components

- IC 74190 (Up/ Down decade counter) - 1 No.
- Hook up wires - as reqd.
- Data sheet of the IC 74190 - 1 No.

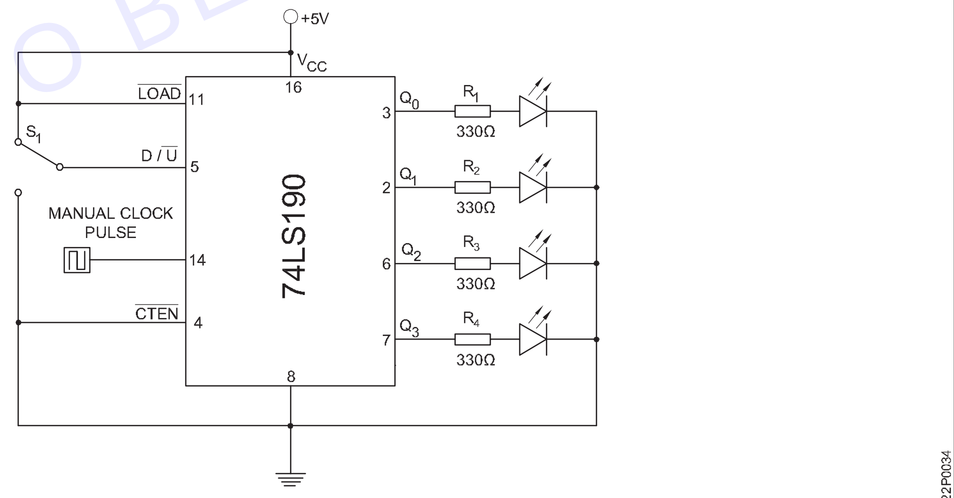
Procedure

In a digital trainer kit, users have access to various components such as a power supply, toggle switches, a breadboard, and LEDs with accompanying resistors. These components are included in the kit for testing digital circuits

TASK 1: **Construction of synchronous UP/ DOWN decade counter using 74190**

1 Collect the required components for assemble the circuit of an up/ down decade counter on a breadboard using IC74190 as shown in Fig 1.

Fig 1



UP/DOWN DECADE COUNTER

2 Check each component to ensure that they are in good condition.

3 Check the IC using digital IC tester whether it is in good or bad condition

4 Refer to the datasheet of the IC 74190

5 Assemble the up/ down decade counter on a breadboard using IC 74190 as per the circuit diagram as shown in Fig 1.

6 Connect the power supply (+5V) to the pin 16 & 11 and the ground (0V) to the pin 8 & 4 of the IC 74190.

7 Connect the pin 14 to the manual clock pulse/ push button switch to ground.

8 Connect the toggle switch S1 to pin 5 (if S1 is ON / HIGH it works as a DOWN counter else if S1 is OFF / LOW it works as an UP counter).

9 The pins 3,2,6 and 11 are the output pins (Q_0, Q_1, Q_2 and Q_3) of the up/ down decade counter are connect to the LEDs inbuilt in the trainer kit.

10 Before switch ON the trainer kit, check all the connections on the breadboard.

Make sure there are no loose wires or incorrect connections, and get the assembled circuit checked by the instructor.

11 Switch ON the 5V DC supply and press the manual clock pulse/ push button switch as shown in the Fig 1.

12 Observe the output status of the LEDs on the IC 74190, confirming the count progression of pressing the push button from (0000) to (1001) and from (1001) to (0000) record it in the table 1.

Note: Finally, ensure that the instructor reviews and verifies your work

Table 1

$D/\overline{U}$	Pulse Count	Q_3	Q_2	Q_1	Q_0

EXERCISE 24: Identify and test common anode and common cathode seven segment LED display using multimeter

Objectives

At the end of this exercise you shall be able to

- test the common anode and common cathode by using multimeter.

Requirements

Tools/ Equipments/ Instruments

- Trainees tools kit - 1 Set.
- Digital multimeter with probes - 1 Set.

Materials/ Components

- Seven segment LED (common anode) - as reqd.
- Seven segment LED (common cathode) - as reqd.

Procedure

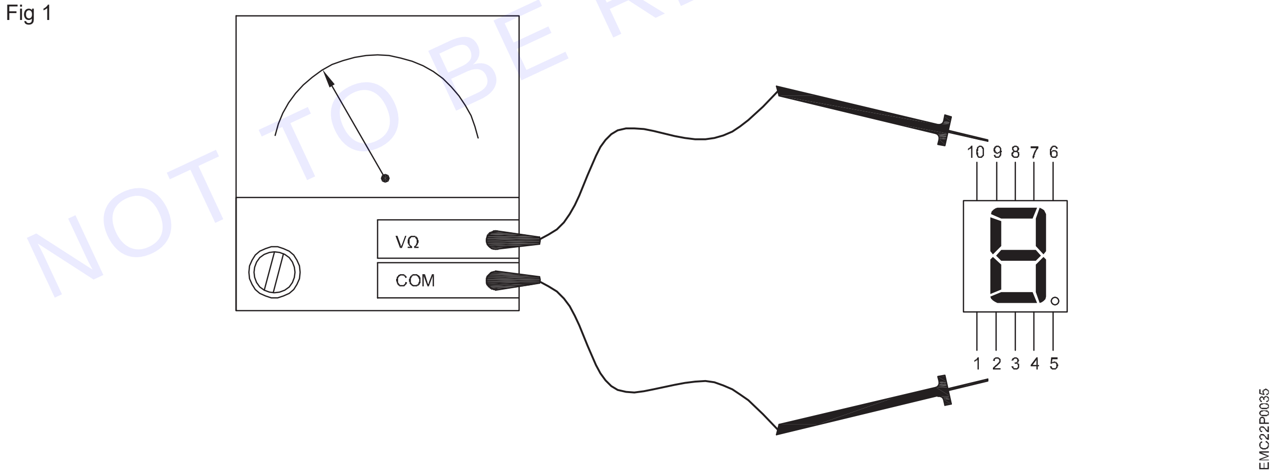
TASK 1: **Testing the seven segment - LED display and identify the type**

1 Collect the components from Instructor. Check the 7-seg display units by using multimeter.

2 Identify the given display whether it is common anode (or) common cathode using data book.

3 Check each segment using multimeter in diode mode as shown in Fig 1. (Each segment is an LED inside when forward biased LED glows when reverse biased LED does no glow). Refer to Fig 2 & 3 to know the common terminal.

Fig 1



4 Connect multimeter +ve probe to common pin and -ve probe to other pins one by one as shown in the Fig 2 and observe it.

5 Connect multimeter -ve probe to common pin and +ve probe to other pins one by one as shown in the Fig 3 and observe it.

Fig 2

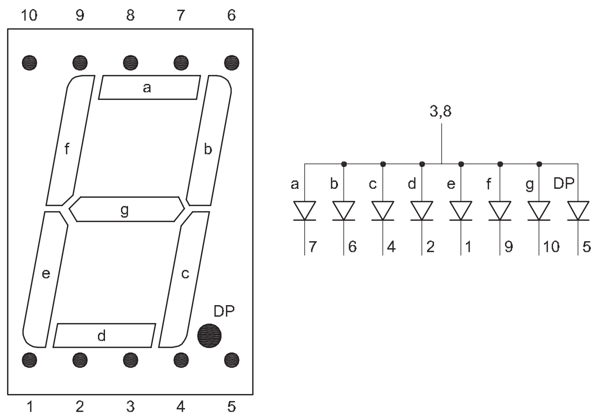
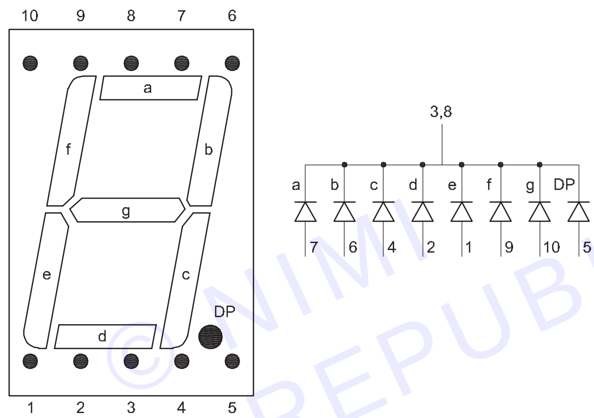


Fig 3



6 Get the work checked by the Instructor.

EXERCISE 25: Display the two digit count value on seven segment display using decoder/ driver ICs

Objectives

At the end of this exercise you shall be able to

- construct and test a decade counter using IC 7490 with a BCD to seven segment decoder/ driver and 7-segment display
- construct a 2 digit counter & display count value.

Requirements

Tools/ Equipments/ Instruments

- Trainees tools kit - 1 Set.
- Logic probe - 1 No.
- Digital trainer kit - 1 No.
- Digital multimeter - 1 No.
- Digital IC tester - 1 No.

Materials/ Components

- IC 7490 - 1 No.
- IC 7447 - 1 No.
- Resistor 330 Ω /1/4 W/CR25 - 7 Nos.
- Hookup wires - as reqd.
- 7 segment LED display FND507 - 1 No.

Procedure

In a digital trainer kit, users have access to various components such as a power supply, toggle switches, a breadboard, and LEDs with accompanying resistors. These components are included in the kit for testing digital circuits

1 Collect the required components specified for the experiment.

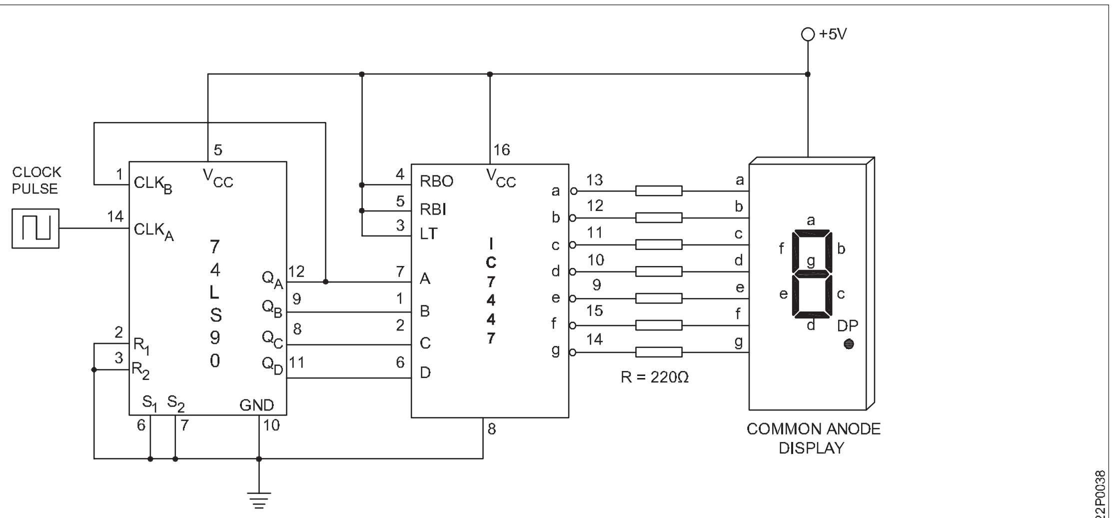
2 Check to ensure the components are in working condition.

3 Test the IC 7490 (Decade counter) and IC 7447using a digital IC tester to determine whether it is in good or bad condition.

4 Refer to the datasheet for the IC 7490 (Decade counter) and IC 7447 and then assemble the circuit on a breadboard as per the circuit diagram as shown in Fig 2.

5 Refer the previous exercise of decade counter and repeat the same steps to assemble counter for one digit count value as shown in the Fig 1.

Fig 1

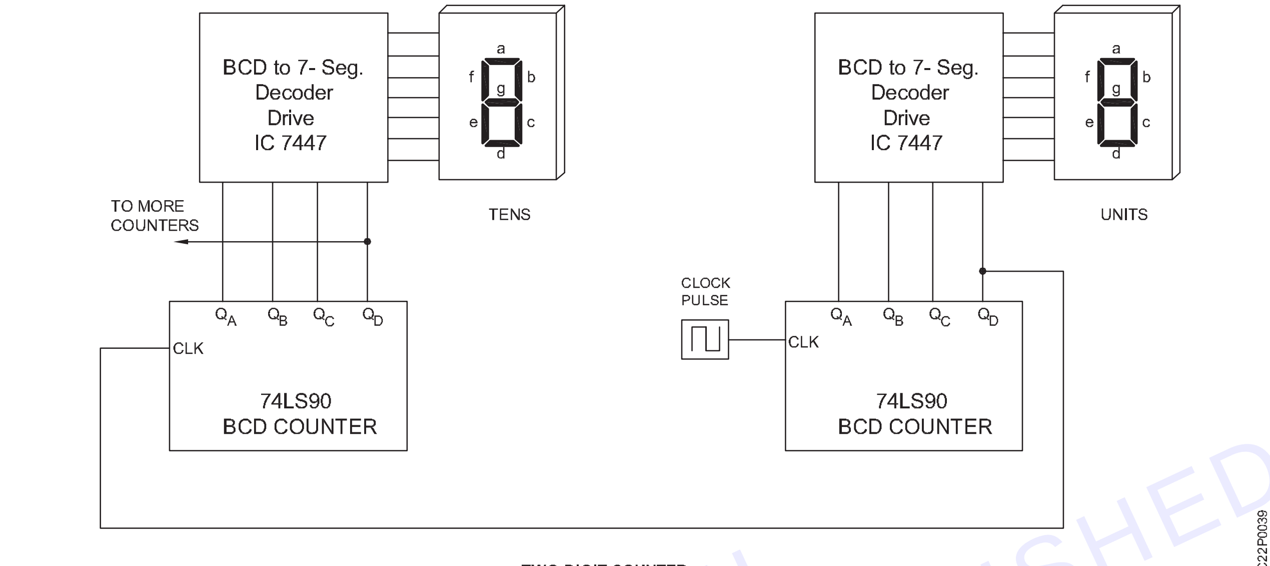


SYNCHRONOUS DECADE COUNTER

6 Similarly assemble one more decade counter to count two digits as shown in Fig 1 & 2 on the same bread board.

7 To obtain two digit counting, connect the Qd output of 1's counter to the CLK input of the 10's counter as shown in Fig 2

Fig 2



TWO DIGIT COUNTER

8 Before switch ON the digital trainer kit, check all the connections on the breadboard.

9 Get the assembled circuit checked by the instructor.

Make sure that there are no loose wires or incorrect connections, and get the assembled circuit checked by the instructor.

10 Switch ON the 5V DC supply and press the manual clock pulse / push button switch as shown in the Fig 2.

11 Observe the output status of the LEDs on the IC 7490, confirm the count progression by pressing the push button and record it in Table 1.

12 Also observe and record the output of IC 7447 (7 segment driver) and the number/ digit displayed on seven segment display in Table 1.

13 Get the work checked by the instructor.

Table 1

Clock input	Output of 7490				7-segment display reading	Output of 7447						
Reset	Q_D	Q_C	Q_B	Q_A		a	b	c	d	e	f	g
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												

EXERCISE 26: Construct a shift register using Flip- Flop IC and verify the result

Objectives

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

- construct a shift register using flip-flop IC.

Requirements

Tools/ Equipments/ Instruments

- Trainees tools kit - 1 Set.
- Digital trainer kit - 1 No.
- Digital multimeter with probes - 1 No.
- Digital IC tester - 1 No.
- Logic probe - 1 No.

Materials/ Components

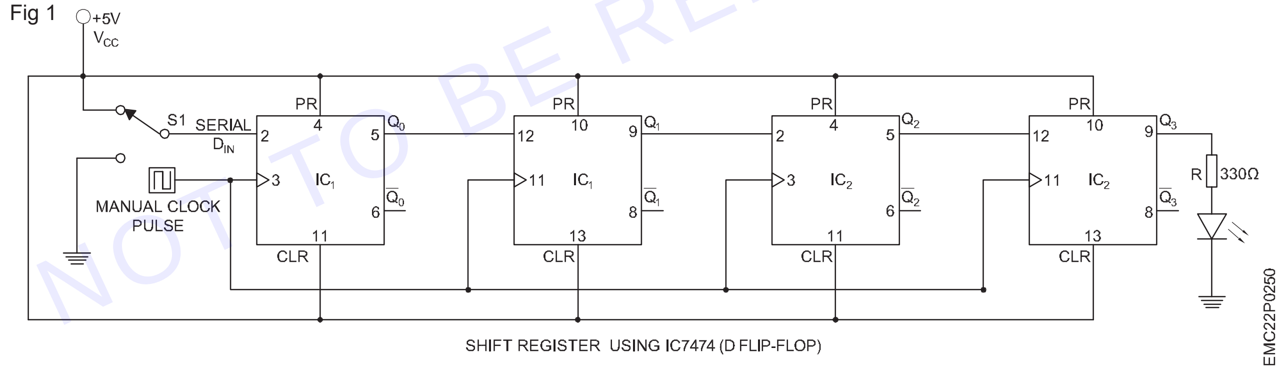
- IC 7474 with data sheet - 2 Nos.
- Hook up wire/ connecting wires - as reqd.

Procedure

In a digital trainer kit, users have access to various components such as a power supply, toggle switches, a breadboard, and LEDs with accompanying resistors. These components are included in the kit for testing digital circuits

1 Collect the required components to assemble the circuit for a serial in, serial out (SISO) shift register using D Flip-Flop IC 7474 as shown in Fig 1.

Fig 1



SHIFT REGISTER USING IC7474 (D FLIP-FLOP)

2 Check each component to ensure they are in good condition.

3 Use a digital IC tester to check if the IC is in good condition.

4 Refer to the datasheet of the IC 7474.

5 Assemble the four-bit serial in, serial out (SISO) shift register using D Flip-Flop as shown in Fig 1 on the breadboard.

6 Refer to the circuit diagram and connect the clock pulse generator or manual clock pulse setup to the clock input pin of IC1 and IC2.

7 Have the assembled circuit checked by the instructor to ensure all connections are correct and components are properly placed.

8 Switch ON the kit. Before applying the clock pulse, observe the serial output and Q0, Q1, Q2, and Q3 logic levels, and record them in Table 1.

9 Set the input data high.

10 Apply each clock input and record the output logic level in Table 1, and observe the data shifting in serial in and serial out.

Table 1

Clock	Serial in	Q0	Q1	Q2	Q3	Serial Out
0	1					
1	1					
2	1					
3	1					
4	1					

— — — — —

EXERCISE 27: Construct a test four bit SIPO register

Objectives

At the end of this exercise you shall be able to

- construct and test 4 bit SIPO register using IC 7495.

Requirements

Tools/ Equipments/ Instruments

- Trainees tools kit - 1 Set
- Digital multimeter with probes - 1 No.
- Digital trainer kit - 1 No.
- Digital IC tester - 1 No.
- Logic probe - 1 No.

Materials/Components

- IC 7495 with data sheet - 1 No.
- Hookup wires - as reqd.

Procedure

In a digital trainer kit, users have access to various components such as a power supply, toggle switches, a breadboard, and LEDs with accompanying resistors. These components are included in the kit for testing digital circuits

1 Collect the required components for assemble the serial in, parallel out (SIPO) shift register as circuit shown in Fig 1.

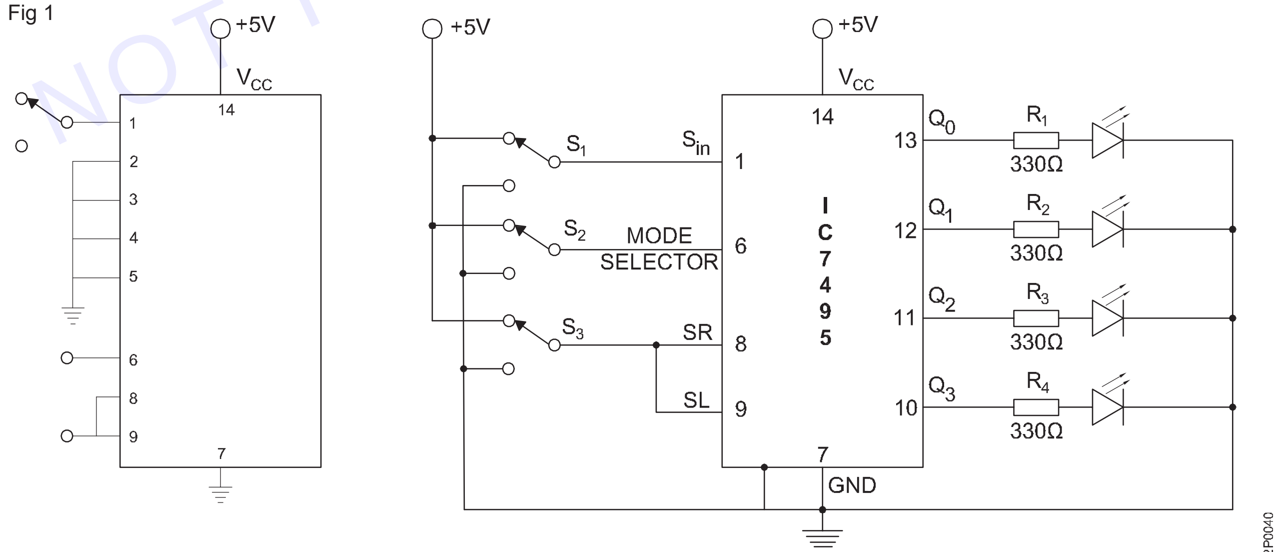
2 Check each component to ensure that they are in good condition.

3 Check whether IC is in good condition using digital IC tester.

4 Refer to the datasheet of the IC 7495.

5 Assemble the serial in, parallel out (SIPO) shift register circuit using IC 7495 as shown in Fig 1 on the breadboard.

Fig 1



SERIAL IN PARALLEL OUT (SHIFT RIGHT) CIRCUIT

6 Connect the power supply (+5V) to the 14th pin and the ground (0V) to the 7th pin of the IC 7495.

7 Connect the pins 2, 3, 4 and 5 of the IC 7495 to ground.

8 Connect the S1 to pin 1 as serial input and S2 to pin 6 as mode selector.

9 Connect manual clock pulse/ push button through ground to pin 8 & 9 as clock input

10 To view the output pins (Q_0, Q_1, Q_2 and Q_3) of the (SIPO) shift register connect the pins 13, 12, 11 and 10 to LEDs through the resistor as shown in the Fig 1.

11 Before switch ON the trainer kit, check all the connections on the breadboard.

Note: Make sure there are no loose wires or incorrect connections, and get the assembled circuit checked by the instructor.

12 Switch ON the 5V DC supply and operate toggle switches S1 and S2 for different voltage levels, either in the 5V position (logic 1 / high) or 0V (logic 0 / low) position.

13 Apply S2 logic-1 as mode control input and press manual clock pulse/ push button and observe the parallel output logic levels Q_0, Q_1, Q_2 and Q_3 (should be 0000) and record it in the given Table 1.

Serial in, parallel out (Shift right)

Mode control	Clock Input	Serial Input	Paralel Output			
			Q_0	Q_1	Q_2	Q_3
1		1	0	0	0	0
0		1				
0		0				
0		1				
0		0				

14 Apply S2 logic-0 as mode control input and also press manual clock pulse/ push button and observe the parallel output logic levels Q_0, Q_1, Q_2 and Q_3 as per S1 (position) data given by you and record it in the given Table 1.

Assume: If data is 1010 at S1 (applying data one by one bit at a time), by pressing the push button (clk i/p) once, you will get 0 at Q_0,

By pressing the push button (CLK I/ P) once again, you will get 1 at Q_0 and 0 at Q_1

Similarly repeat the above steps for getting Q_0 = 1 ,Q_1 = 0, Q_2 = 1 and Q_3 = 0.

15 For a SIPO shift register, apply data serially (one be one) and observe the parallel output at Q_0,Q_1,Q_2 and Q_3 of IC 7495 using logic probe.

Note: Finally, ensure that the instructor reviews and verifies your work.

EXERCISE 28: Construct and test four bit PIPO register

Objectives

At the end of this exercise you shall be able to

- construct and test a 4 bit PIPO shift register using IC 7495.

Requirements

Tools/ Equipments/ Instruments

- Trainees tools kit - 1 Set
- Digital multimeter with probes - 1 No.
- Digital trainer kit - 1 No.
- Digital IC tester - 1 No.
- Logic probe - 1 No.

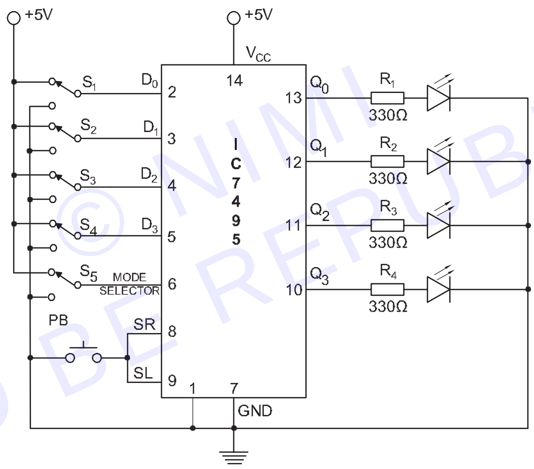
Materials/Components

- IC 7495 with data sheet - 1 No.
- Hookup wires - as reqd.

Procedure

1 Collect the required components for assemble the parallel out (PIPO) shift register circuit as shown in Fig 1.

Fig 1



P I P O SHIFT REGISTER

EMC22P0041

2 Check each component to ensure that they are in good condition.

3 Check whether IC is in good condition using digital IC tester.

4 Refer to the datasheet of the IC 7495.

5 Assemble the parallel in, parallel out (PIPO) shift register using IC 7495 as shown in Fig 1 on the breadboard.

6 Connect the power supply (+5V) to the 14th pin and the ground (0V) to the 7th pin of the IC 7495.

7 Connect the pins 2, 3, 4 and 5 of the IC 7495 to S1, S2, S3 and S4 as parallel input and S5 to pin 6 as mode selector.

8 Connect the pin 1 of the IC 7495 to ground.

9 Connect manual clock pulse/ push button through ground to pin 8 & 9 as clock input.

10 To view the output pins (Q_0, Q_1, Q_2 and Q_3) of the (PIPO) shift register connect the pins 13, 12, 11 and 10 to LEDs through the resistor as shown in the Fig 1.

11 Before switch ON the trainer kit, check all the connections on the breadboard.

Note: Make sure there are no loose wires or incorrect connections, and get the assembled circuit checked by the instructor.

12 Switch ON the 5V DC supply and operate toggle switches S1,S2, S3, S4, and S5 for different voltage levels, either in the 5V position (logic 1 / high) or 0V (logic 0 / low) position.

13 Apply S5 logic-0 as mode control input and also press manual clock pulse/ push button and observe the parallel output logic levels Q_0, Q_1, Q_2 and Q_3 (should be 0000) and record it in the given Table 1.

Table 1

Mode Control	Clock Input	Parallel Input				Parallel Output			
		A	B	C	D	Q_0	Q_1	Q_2	Q_3
0	↑	1	0	0	1				
1	↓	1	0	0	1				

14 Apply S2 logic-1 as mode control input and also press manual clock pulse/ push button and observe the parallel output logic levels Q_0, Q_1, Q_2 and Q_3 as per S1,S2, S3, S4 (position) data given by you and record it in the given Table 1.

Assume: If data is 1001 at S1,S2, S3, S4 (applying data at one time), by pressing the push button (clk i/p) once, you can get Q_0 = 1, Q_1 = 0, Q_2 = 0 and Q_3 = 1.

15 For a PIPO shift register, apply parallel input and observe the parallel output at Q_0, Q_1, Q_2 and Q_3 of IC 7495.

Note: Finally, ensure that the instructor reviews and verifies your work.

EXERCISE 29: Construct and test bidirectional shift register

Objectives

At the end of this exercise you shall be able to

- construct and test bidirectional shift register using IC 74194.

Requirements

Tools/ Equipments/ Instruments

- Trainees tools kit - 1 Set
- Digital multimeter with probes - 1 No.
- Digital trainer kit - 1 No.
- Digital IC tester - 1 No.
- Logic probe - 1 No.

Materials/ Components

- 1C 74194 (bidirectional shift register) - 1 No.
- Data sheet of the IC - as reqd.
- Hook up wires - as reqd.

Procedure

In a digital trainer kit, users have access to various components such as a power supply, toggle switches, a breadboard, and LEDs with accompanying resistors. These components are included in the kit for testing digital circuits

1 Collect the required components for assemble the bidirectional shift register circuit using IC 74194 as shown in Fig 1.

2 Check each component to ensure that they are in good condition.

3 Check whether IC is in good condition using digital IC tester.

4 Refer to the datasheet of the IC 74194.

5 Assemble the bidirectional shift register circuit using IC 74194 as shown in Fig 1 on the breadboard.

6 Connect the power supply (+5V) to the 16th pin and the ground (0V) to the 8th pin of the IC 74194.

7 Connect the pins 3, 4, 5, 6, 2, 7 and 10 of the IC 74194 to the toggle switches S1, S2, S3, S4, S5, S6, S7 and S8 named as D0, D1, D2, D3 (Data inputs), DSR (Data Shift Right), DSL (Data Shift Left), S0 and S1.

8 Connect the Master Reset/ Clear pin to toggle switch S9 as shown in the fig 1.

9 Connect manual clock pulse/ push button through ground to pin 11 as clock input.

10 To view the output pins (Q_0, Q_1, Q_2 and Q_3) of the Bidirectional shift register IC 74194 connect the pins 15, 14, 13 and 12 to LEDs through the resistor as shown in the Fig 1

11 Before switch ON the trainer kit, check all the connections on the breadboard.

Make sure there are no loose wires or incorrect connections, and get the assembled circuit checked by the instructor.

12 Switch ON the 5V DC supply and operate toggle switches S1to S9 for different voltage levels, either in the 5V position (logic 1 / high) or 0V (logic 0/ low) position.

13 Apply S9 logic-0 as mode/ control input and also press manual clock pulse/ push button and observe the output logic levels Q_0, Q_1, Q_2 and Q_3 (should be 0000) and record it in the given Table 1.

14 Apply S9 logic-1 as mode control input and also press manual clock pulse/ push button and observe the output logic levels Q_0, Q_1, Q_2 and Q_3 as per S8 (S1) and S7 (S0) (position) as given in the truth table 1.

If S1= 0, S0= 0, output gives previous state

S1= 0, S0= 1, this response to send data to shift right side in the output.

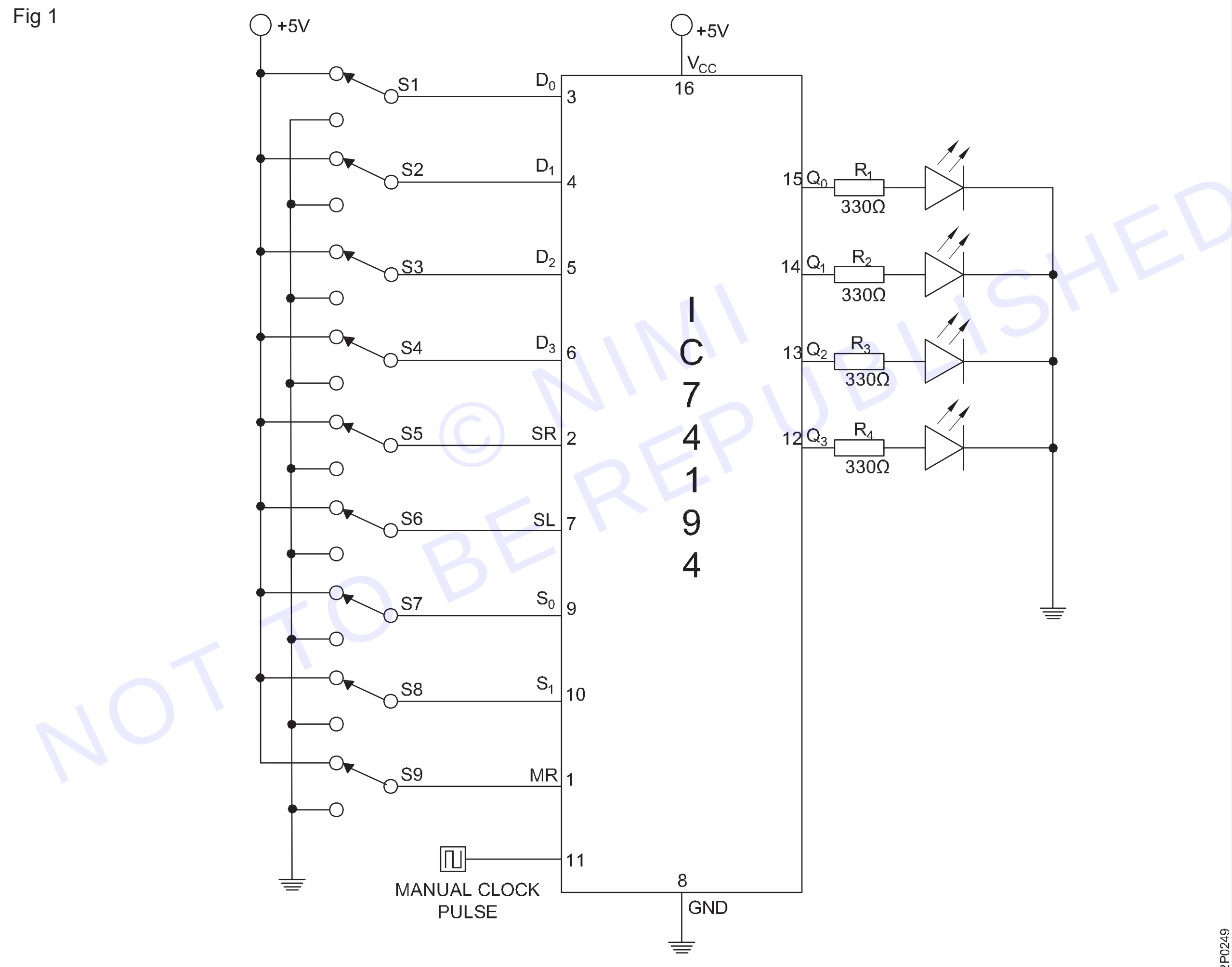
S1= 1, S0= 0, this response to send data to shift left side in the output.

sS1= 1, S0= 1, this response to send parallel data input to output.

Truth Table 1

S1	S0	O/P
0	0	NC
0	1	DSR
1	0	DSL
1	1	Parallel load

Fig 1



BIDIRECTIONAL SHIFT REDISTER

15 Use toggle switches and operate all the switches, Observe the status of all the LEDs for each step of combinations, record them in the respective tables given

Table 1

Sl. No.	CLK	MR	S1	S0	DSL	DSR	D_0	D_1	D_2	D_3	Q_0	Q_1	Q_2	Q_3

Note: Finally, ensure that the instructor reviews and verifies your work.

EXERCISE 30-32: Prepare and simulate simple analog and digital electronic circuits using the simulation software and convert them into PCB layout

Objectives

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

- identify the simulation software tools.
- prepare and simulate the analog and digital circuits and run it
- convert it into PCB layout

Requirements

Tools/ Equipments/ Instruments

- Personal computer installed with simulation software - 1 No.

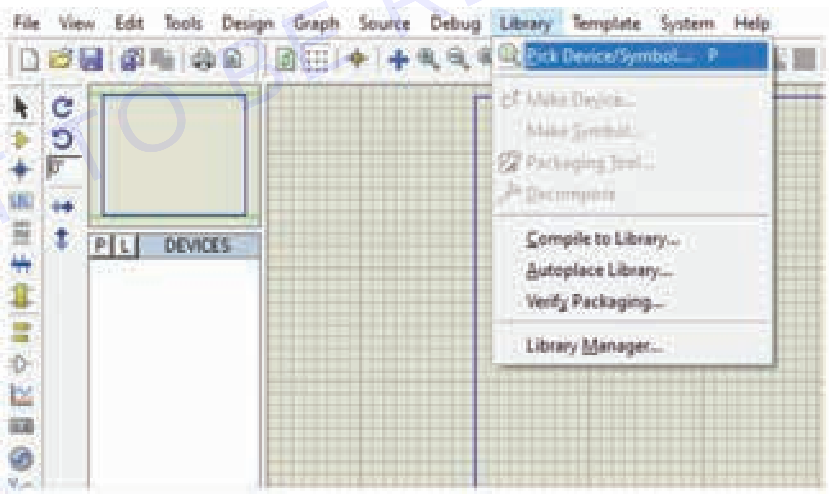
Procedure

TASK 1 : **Construction of EX-OR gate using simulation software**

1 Open the Simulation software on your computer.

2 Access the menu options available in Simulation software and labelled as “Component Library” or something similar. Click on it to open the library as shown in Fig 1.

Fig 1



3 In the component library, you will find a wide range of electronic components categorized into groups like passive components (resistors, capacitors, inductors), active components (transistors, diodes), ICs (integrated circuits), sensors, etc as shown in Fig 2.

4 You can either browse through these categories or use the search bar to find specific components / part name as shown in Fig 3.

5 Once you’ve selected the components, simply click and drag them into the workspace area where you have to design the circuit as shown in Fig 4a&b.

Fig 2

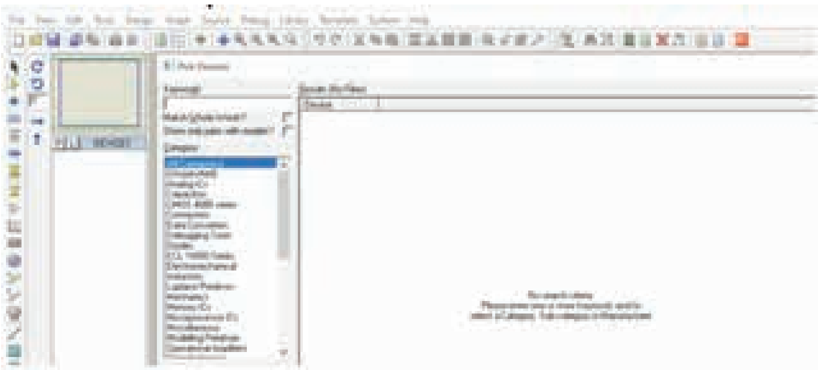


Fig 3

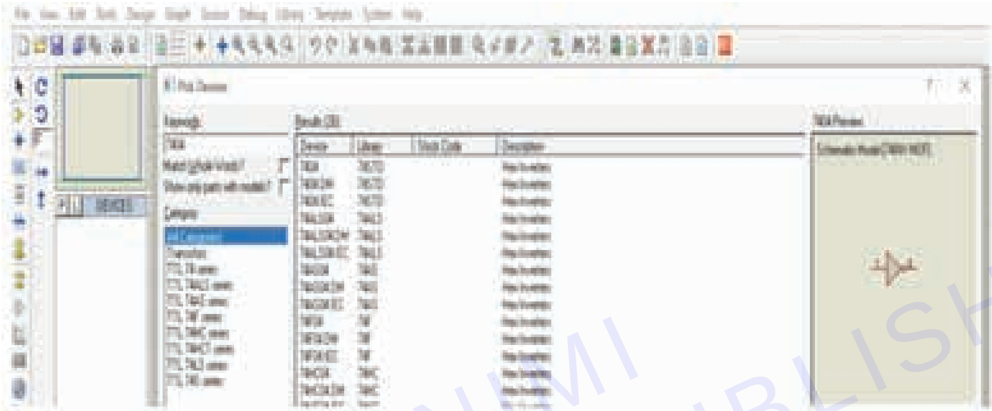


Fig 4 a

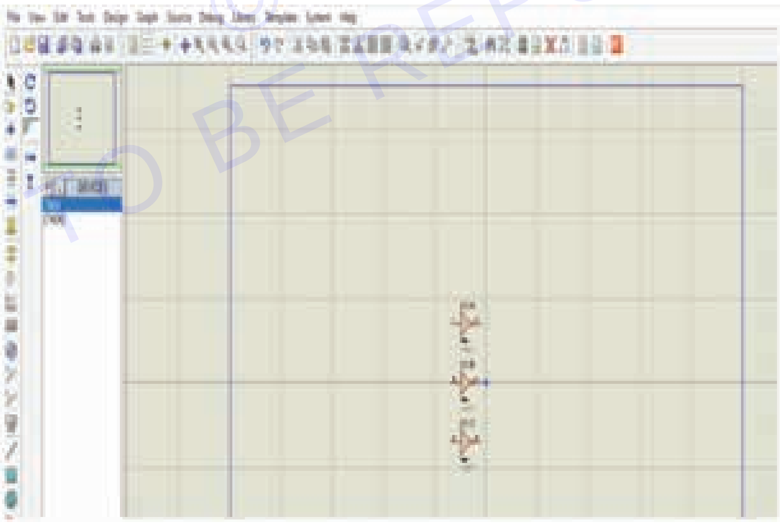
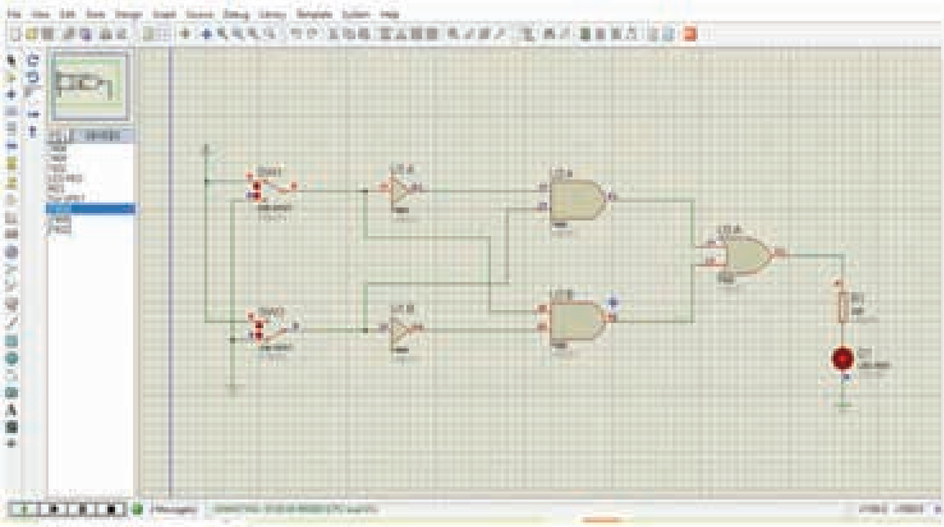


Fig 4b



EX-OR gate using basic gates

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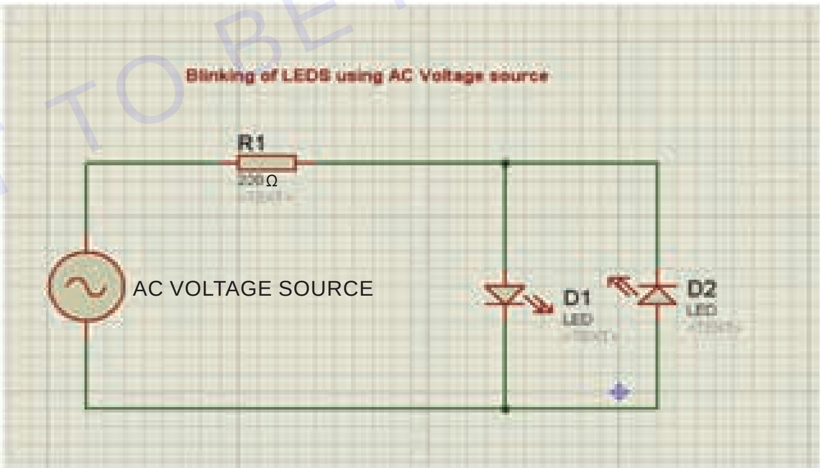
TASK 2:

Note : Different simulation software tools for analog and digital circuits often have their own unique sets of features, capabilities, user interfaces, and procedures for developing and executing circuits.

1 Choose a simple circuit for testing a analog circuit using Simulation software.

2 Pick the components from the library, construct the circuit for **Blinking of LEDs using AC Voltage source** as shown in Fig 5

Fig 5



3 Go to debug option available in menu bar and execute it (run it) as shown in Fig 6 and observe the output

4 Similarly construct & test another circuit for analog (CE Amplifier) as shown in the Fig 7 and observe the O/ P waveform using CRO function in Simulator as shown in Fig 8.

Fig 6

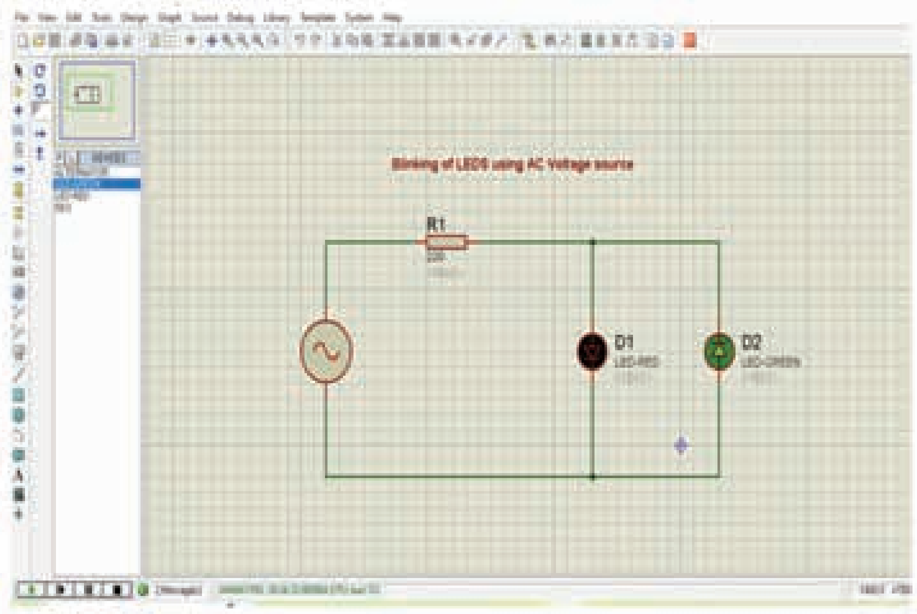
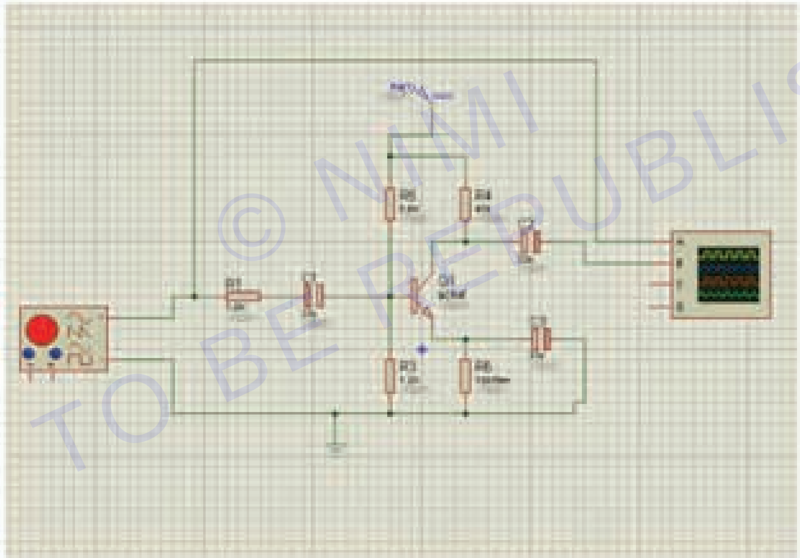
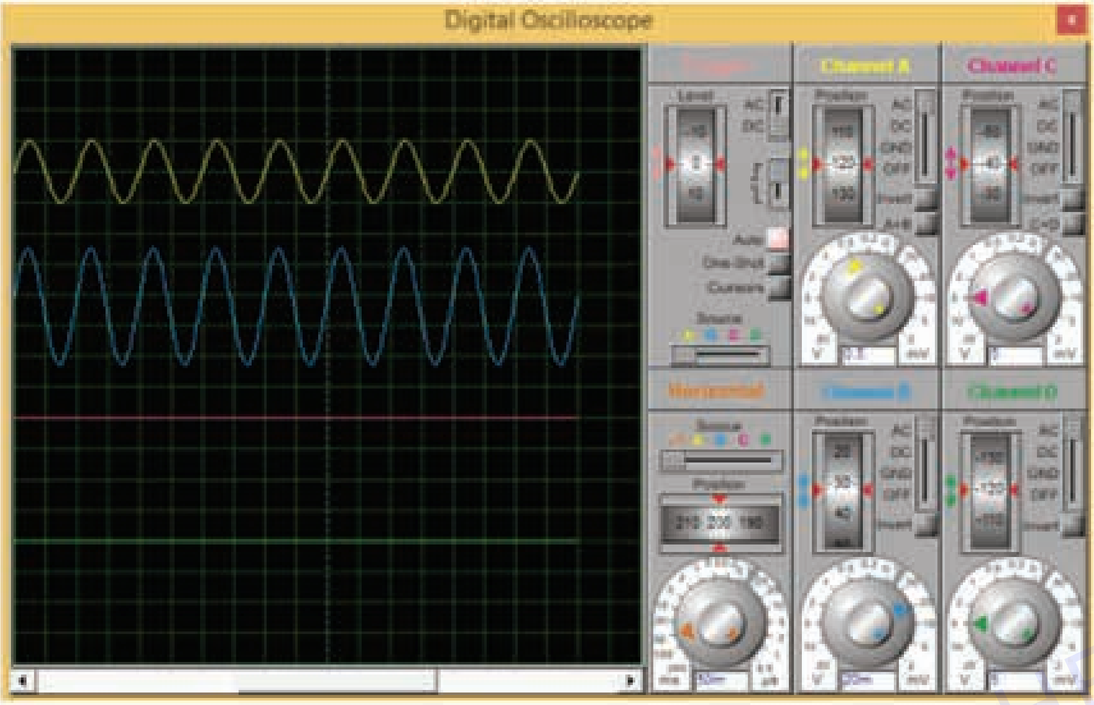


Fig 7



CE Amplifier

Fig 8



CRO I/P and O/P wave form

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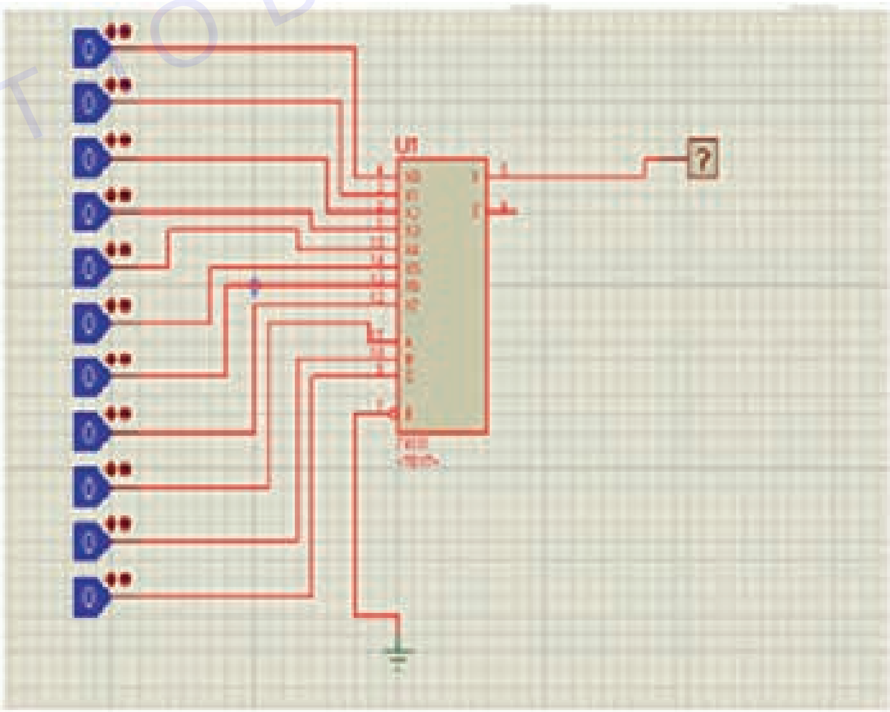
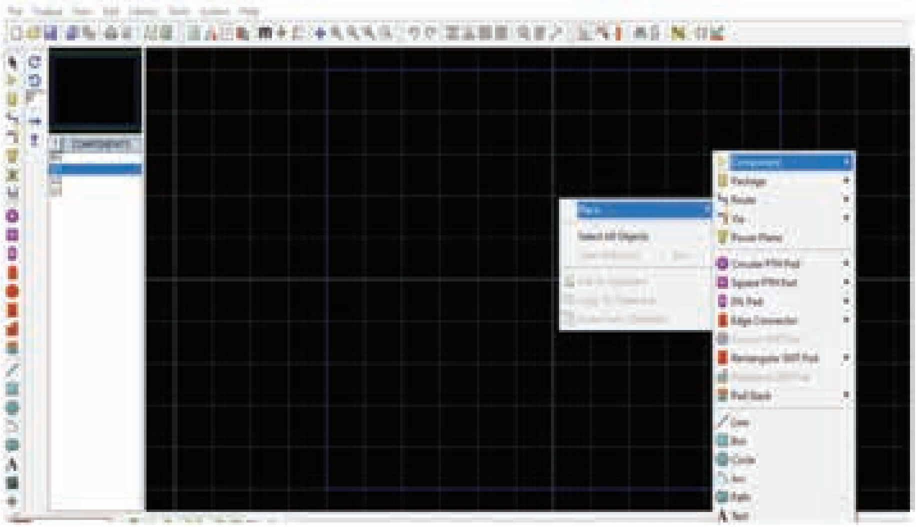
TASK 3: **Convert the given into PCB layout using simulation software**

1 Construct a 8:1 multiplexer circuit using simulation S/W with reference to the procedure followed in the previous tasks.

2 Excute the circuit and verify the multiplexer function



8:1 Multiplexer



3 After designing and simulating your circuit in Simulation software, you'll have a completed circuit diagram ready for PCB layout.

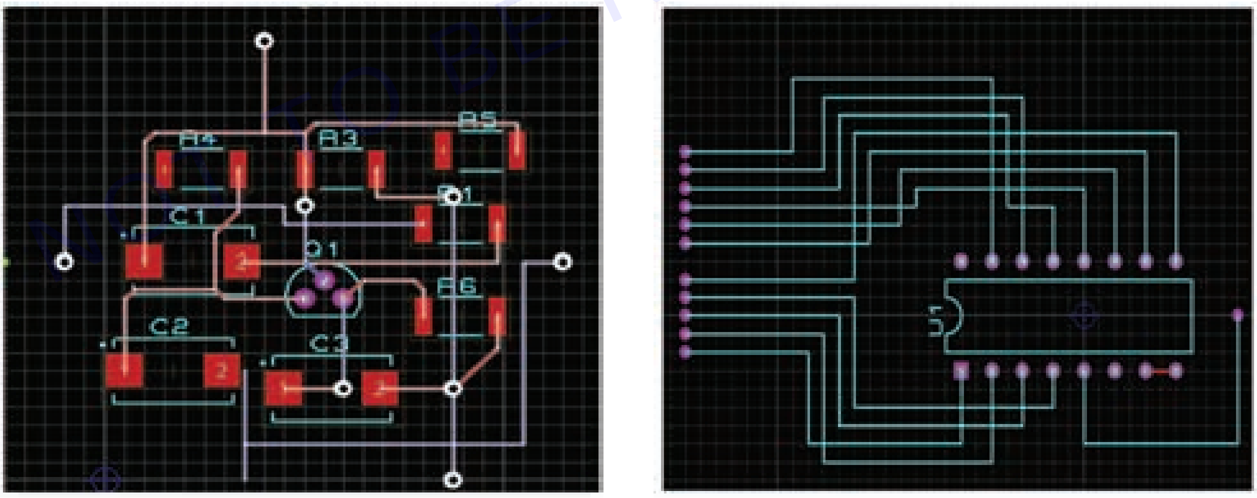
4 Select the PCB layout (ARES) from the menu or toolbar.

5 **Select or drag components for routing the wires in** PCB layout environment (ARES)

Routing is the process of creating connections (traces) between the pads of components on the PCB layout.

6 If you want to manually adjust the routing, it is also possible or you can use Auto router tool as shown in fig

7 An auto-router tool can automatically route the connections for you based on predefined rules and algorithms.



8 Similarly design and simulate other such circuits following the above procedure.

— — — — —

EXERCISE 33: 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

- Desktop computer installed with simulation software

Procedure

Engaging trainees in practical exercises using simulation software first allows them to experiment and understand the behavior of analog and digital circuits in a controlled environment.

Once they have grasped the concepts and gained confidence, implementing the circuits in hardware provides a hands-on experience that further solidifies their understanding.

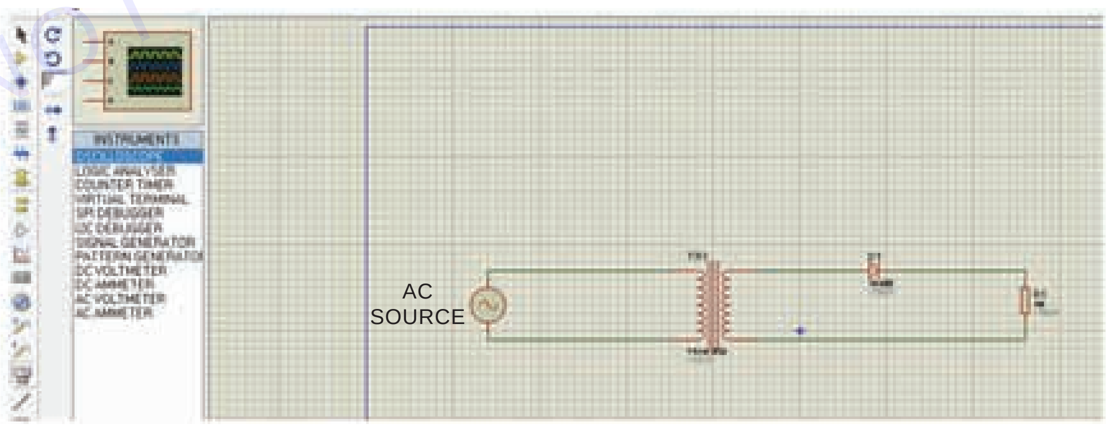
This approach helps trainees develop a comprehensive understanding of both analog and digital electronics circuits.

TASK 1 : **Construction of simple power electronic circuit (half wave rectifier) using simulation software**

1 Switch ON the computer and double click on the simulator icon available in the desk top.

2 Refer to the previous exercise follow the steps and select the components from the library for constructing the half wave rectifier using simulation software as shown in the Fig 1.

Fig 1

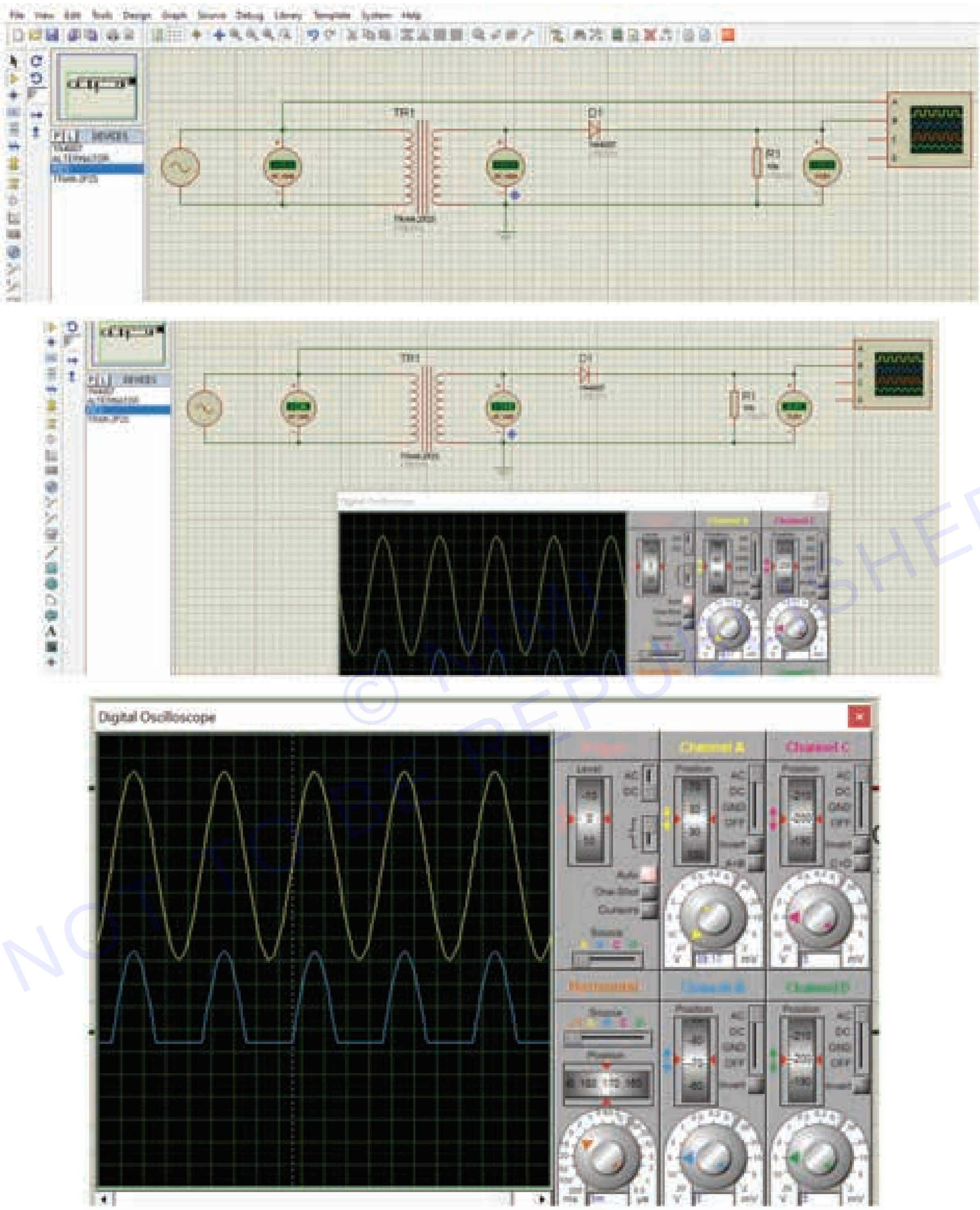


3 Double click the AC source and choose the voltage and frequency to be given as input to HWR.

4 To measure the AC and DC voltage & waveform, select the AC Voltmeter and DC voltmeter and CRO functions available in the instruments list of Simulator S/W.

5 Execute the circuit and check the AC voltage, DC voltage and observe the input and output waveforms as shown in Fig 2.

Fig 2



6 Stop the simulation.

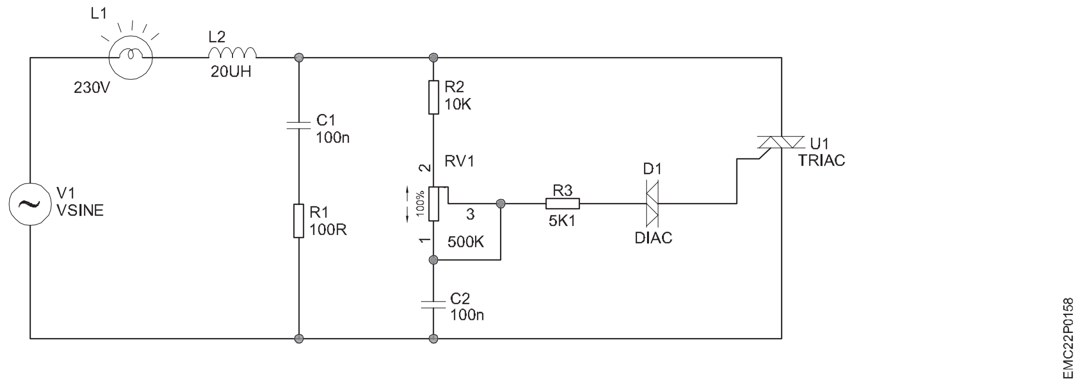
— — — — —

TASK 2 : **Construction of simple domestic electronic circuit (lamp dimmer) using simulation software**

1 Switch ON the computer and double click on the simulator icon available in the desk top.

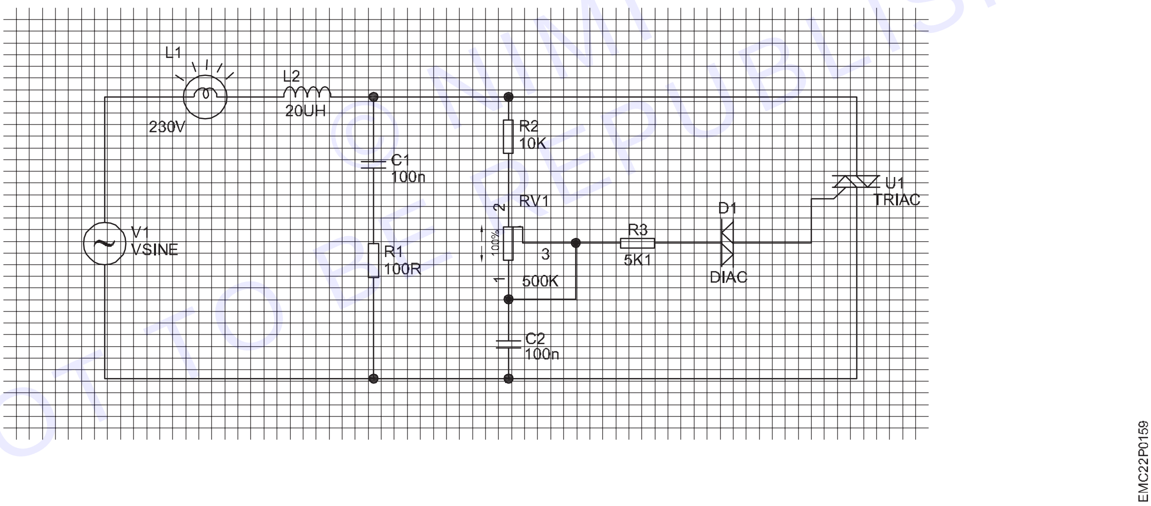
2 Refer to the previous exercise follow the steps and select the components from the library for constructing the lamp dimmer using simulation software as shown in the Fig 3

Fig 3



3 Execute the circuit and observe that the bulb is ON. Adjust the rheostat R_{V1} (Potentiometer/preset) and control the brightness of the lamp as shown in Fig 4.

Fig 4



4 Get the work checked by the Instructor.

— — — — —

MODULE 3: Microcontroller (8051)

EXERCISE 34: Identify various ICs and their function on the given microcontroller kit

Objectives

At the end of this exercise you shall be able to

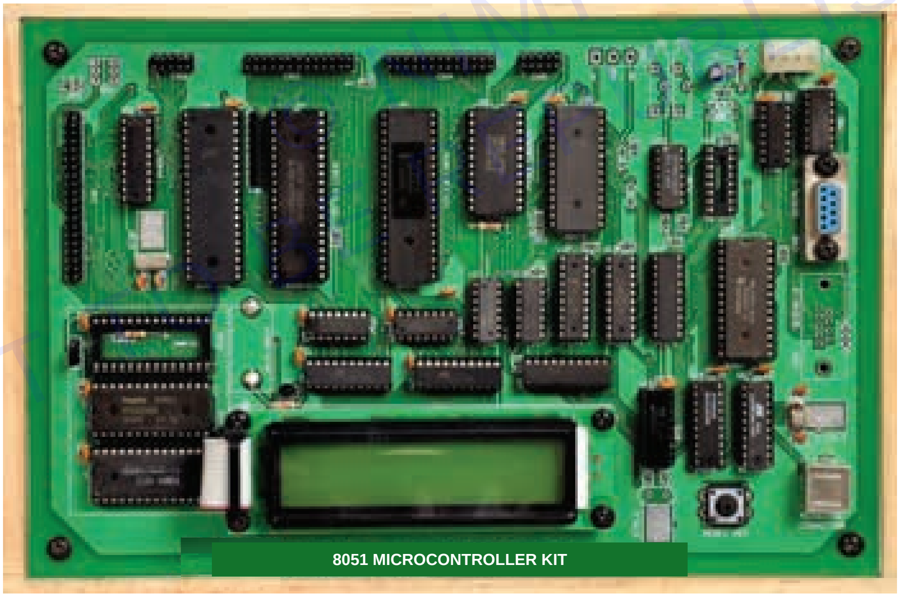
- identify the various ICs on the microcontroller trainer kit
- note down the function of ICs on the microcontroller trainer kit.

Requirements

Tools / Equipments / Instruments

- 8051 Microcontroller Trainer kit with manual - 1 Set
- Trainee's tool kit - 1 Set
- Digital Multimeter with probes - 1 No.

Procedure



Note: The instructor should guide the trainees in identifying and locating various Integrated Circuits (ICs) within the microcontroller kit. It is also important to provide detailed instructions and information regarding the types, functions, and placements of the ICs present in the kit.

1 Collect the microcontroller trainer kit with its operating instructions manual.

2 Open the top cover of the microcontroller trainer kit, and observe the ICs on the board

3 Note down the code number / marking on each IC, number of pins, functions of IC and record the observations in Table 1.

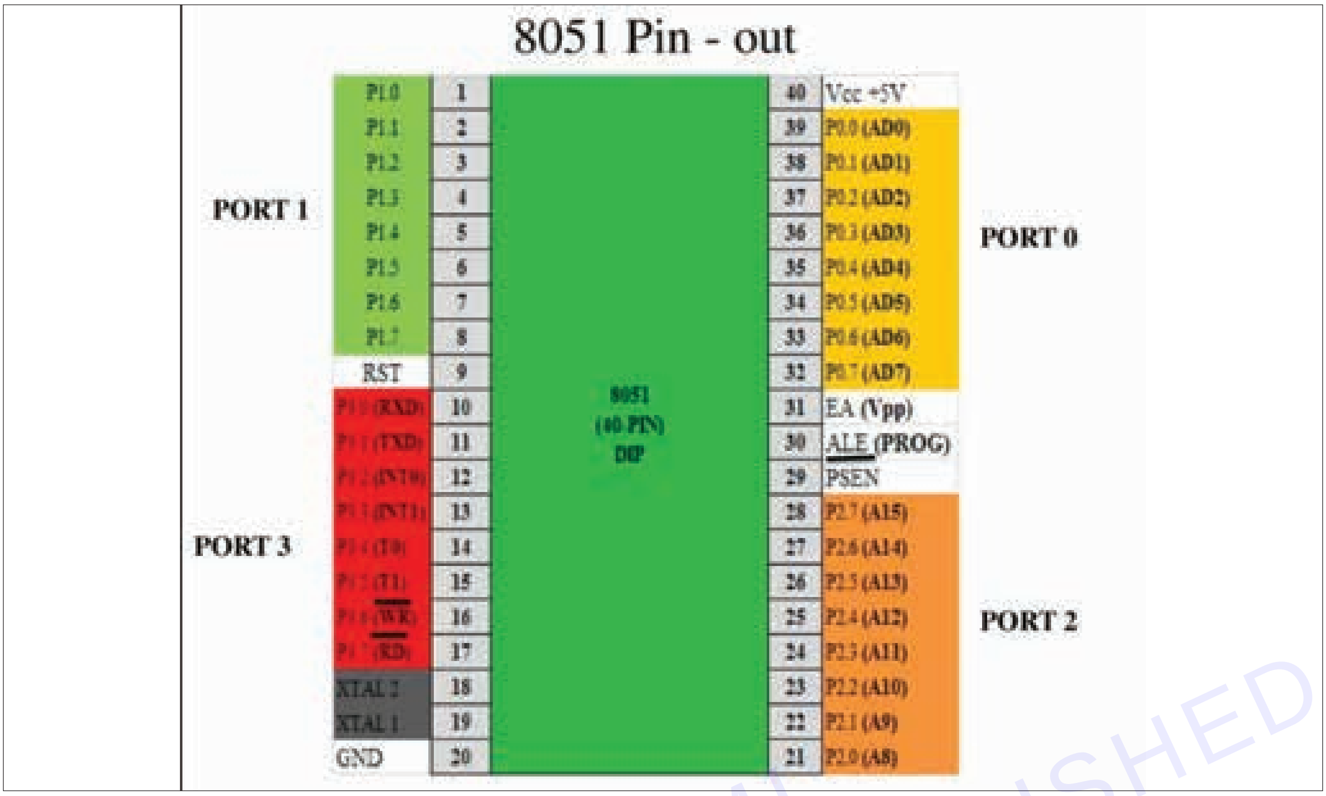


Table 1

Sl. No.	IC No	No.of Pins	Function / Purpose of IC	Remarks

4 Get the work checked from the instructor.

EXERCISE 35: Identify the address range of RAM & ROM of 8051 microcontroller

Objectives

At the end of this exercise you shall be able to

- identify address range of RAM of the 8051 microcontroller trainer kit
- identify address range of ROM of the 8051 microcontroller trainer kit.

Requirements

Tools / Equipments / Instruments

- 8051 Microcontroller Trainer kit with manual - 1 Set

Procedure

Note: The instructor should refer to the 8051 microcontroller trainer kit manual to locate the designated memory locations in both RAM and ROM for user programs on the lab's trainer kit. On board memory varies with Microcontroller Trainer kit.

1 Collect the microcontroller trainer kit with its operating instructions manual.

2 Refer to the instruction manual of the microcontroller trainer kit, read the RAM address range which is allocated to load user program.

3 Refer to the instruction manual of the microcontroller trainer kit, read the ROM address range which is allocated to load user program. Record the address of RAM and ROM used in the microcontroller trainer kit in the given Table 1.

4 Calculate the memory capacity by subtracting the starting address from the end address (using hexadecimal number) and record in Table 1.

Memory Organisation (MC 8051-On Chip Memory)

Memory	Address	Description
ROM / Program Memory	0x0000 - 0xFFFF	Program code (Instructions)
RAM / Data Memory	0x00 - 0x7F	General-purpose RAM (Data variables, stack, etc)
Special Function Registers (SFRs)	0x80 - 0xFF	

Memory Organisation (External Memory) on board memory

Table 1

Memory Type	Starting Address	End Address	Memory Capacity
RAM			
ROM			

5 Get the work checked by the instructor.

EXERCISE 36: Measure the crystal frequency, connect it to the Controller

Objectives

At the end of this exercise you shall be able to

- identify the crystal oscillator
- measure the clock frequency of the given microcontroller kit.

Requirements

Tools / Equipments / Instruments

- 8051 Microcontroller Trainer kit with manual - 1 No.
- Digital frequency meter - 1 No.
- Oscilloscope (0-20 MHz) with manual and probes - 1 Set

Procedure

Note: The instructor should demonstrate this practical. Care should be taken to avoid any short circuiting of Microcontroller pins while checking the crystal Oscillator output using CRO probes.

1 Refer to the operating manual, Identify the crystal oscillator component on the microcontroller kit.

2 Switch ON both the microcontroller kit and the CRO.

3 Locate the crystal oscillator terminals connected to 8051 controller.

4 Select CH-1 input of the CRO and connect the positive probe to the 18th pin of IC 8051 with the negative (ground) probe connected to the 20th pin (GND).

Table 1

Clock Frequency as per manual	CRO waveform / frequency		Remarks
	Pin No. 18	Pin to. 19	

5 Observe the waveform and note down the readings. Measure the frequency.

6 Record readings in the Table 1.

7 Repeat the above steps at pin No.19.

— — — — —

EXERCISE 37: Demonstrate the Input / Output port pins of the 8051 Microcontroller & Configure the ports for Input & Output operation

Objectives

At the end of this exercise you shall be able to

- identify the I / O port pins of the Controller & Configure the ports for Input & Output operations .

Requirements

Tools / Equipments / Instruments

- 8051 Microcontroller Trainer kit with manual - 1 Set

Procedure

Note: Instructor should refer the instruction manual of the microcontroller kit

- **Port 1 can be used for Input (switches) or Output devices (LEDs).**
- **Port 2 and Port 0 can be used to access external memory.**
- **External memory pointing to the address FF22H can be used to connect the input devices (like switches or sensors) and FF23H can be used to connect the output devices.(like LED or buzzer or relay).**
- **This address varies depends on kit provided by the manufacturer.**

1 Identify the Port 1 and Port 2 lines of 8051 Micro Controller connected to the input (switches) and output (LEDs) in the kit.

2 Switch ON the Microcontroller kit.

3 Enter the program codes for the simple I / O operation. Execute the program by switching on the Execute button.

4 Operate the switches and observe the flashing of the LEDs on the kit.

Program 1

```
(LOOP)    MOV A,P1
          MOV DPTR,#FF23
          MOVX @DPTR,A
          SJMP  (LOOP)
```

Port 1 should be connected to Switch

Program 2

```
(LOOP)    MOV DPTR,#FF22
          MOVX A,@DPTR
          MOV P1,A
          SJMP (LOOP)
```

Port 1 should be connected to LED

EXERCISE 38: Use 8051 Microcontroller to blink 8 LEDs with a Single switch

Objectives

At the end of this exercise you shall be able to

- enter the program to blink 8 LEDs using a single switch and run it on the microcontroller trainer kit
- use KEIL micro vision software (KEIL compiler) to write an assembly program for operating 8 LEDs using switch.

Requirements

Tools / Equipments / Instruments

- 8051 Microcontroller trainer kit with instructional manual - 1 Set

Materials / Components

- 8 LEDs interface module (available on board) - 1 No.

Procedure

TASK 1: **Enter the program to blink 8 LEDs using a single switch and run it on the microcontroller trainer kit**

Note: The instructor must make necessary modifications in program address based on the microcontroller trainer kit available in the lab. Additionally, the instructor should explain the program and its functioning step by step.

1 Refer to the instruction manual and identify all operating controls / switches.

2 Port - 1 of the 8051 microcontroller kit can be configured as an input port using jumper wires.

3 Switch ON the Microcontroller kit.

4 Enter the program to make the 8 LEDs blink with a switch on the microcontroller trainer kit.

5 Execute the program by switching on the Execute button.

Main Program

```
Loop 1 MOV DPTR,#FF22
MOVX  A , @DPTR
ANL A,#01
JZ loop 1
MOV DPTR,#FF23
MOV A,#data1
MOVX @DPTR,A
ACALL delay
MOV A,#data2
MOVX @DPTR,A
ACALL delay
SJMP loop 1
```

Delay program

```
MOV R0,#FF
address 1 MOV R1,#FF
address 2 DJNZ  R1, address2
DJNZ  R0,address 1
RET
```

— — — — —

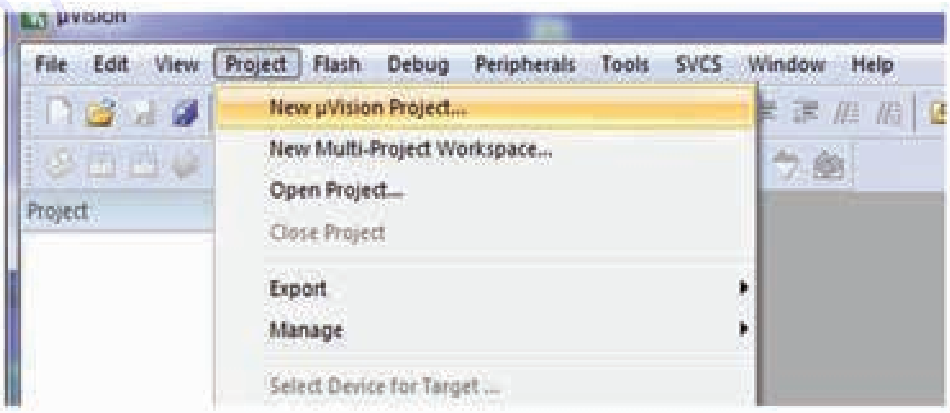
TASK 2: **Use KEIL micro vision software (KEIL compiler) to write an assembly program for operating 8 LEDs using switch**

Note:

- **Compilers are programs used to convert a High Level Language to object code.**
- **Desktop compilers produce an output object code for the microprocessor and microcontrollers.**
- **By using this compilers, development of complex embedded systems can be completed in a fraction of the time, reliability is improved, and maintenance is easy.**
- **Cross compilers are very popular for embedded development.**
- **Knowledge of the particular processor architecture and instruction set is not required.**
- **Program development and debugging times are also reduced when compared to assembly language programming.**

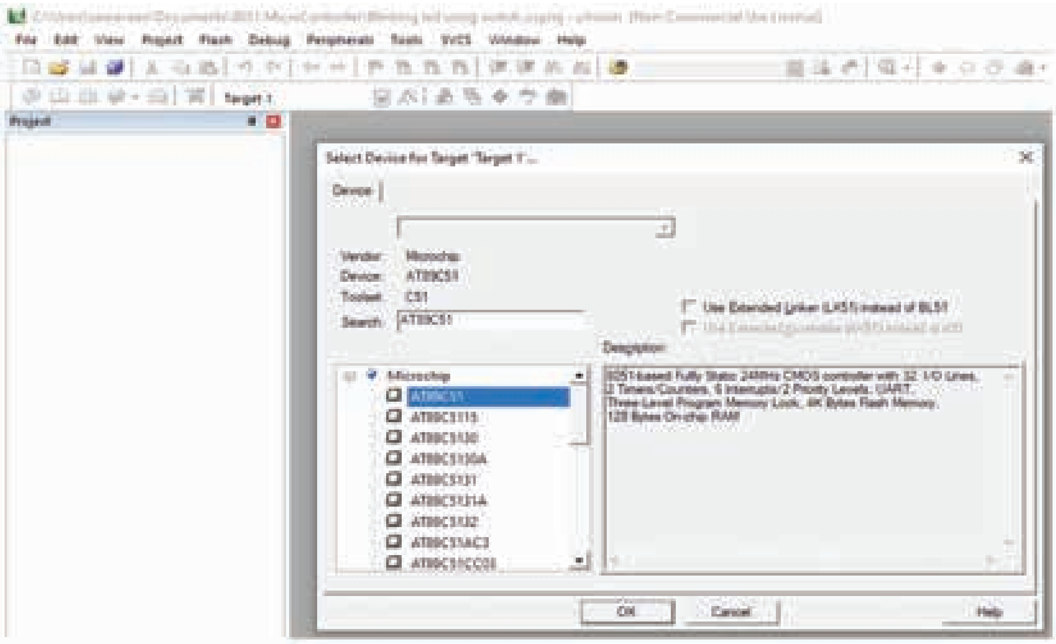
1 Select the KEIL Micro vision Software and install it in the computer system, whose icon is as shown in **KEIL µVISION5 ICON**.

2 After installation, double click on the Keil icon on your Windows Desktop to launch the IDE to create a new 8051 project using Keil IDE, Click on the 'Project' item on the IDE Menu bar and select ' New µVision Project... 'as shown in the Fig below.

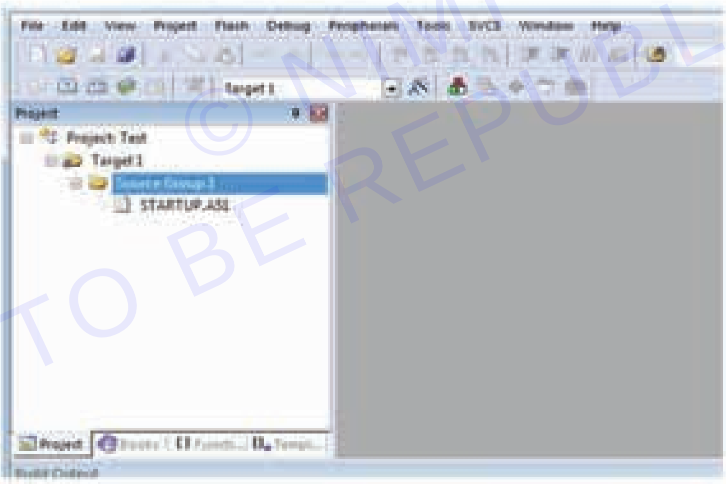


3 Now open a new Folder to create your project and give a name to your Project files (*.uvproj), for eg Test (Test.uvproj).

4 Now choose the microcontroller you want to work with. Select the 8051 device in Keil device selection dialog box as shown in the figure "select device for Target-1", where you can select the desired microcontroller. The Keil IDE also displays the features of the selected microcontroller on its left pane .You can Click OK to confirm your choice.



5 After selecting your 8051 derivative, you will get another dialog box as shown in Fig below. Asking to copy "STARTUP.A51", then you have click "NO"



6 On the left side of the screen a tab called project appears

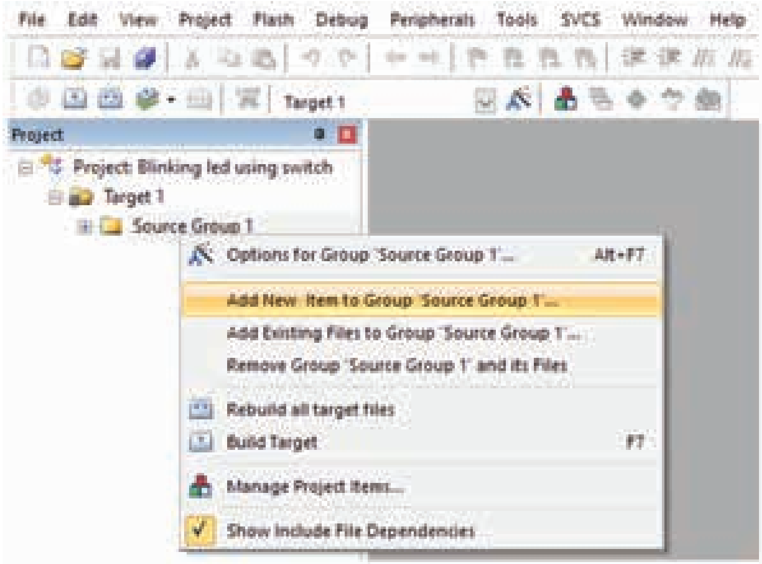
7 Click on the Target 1 -> Source group opens

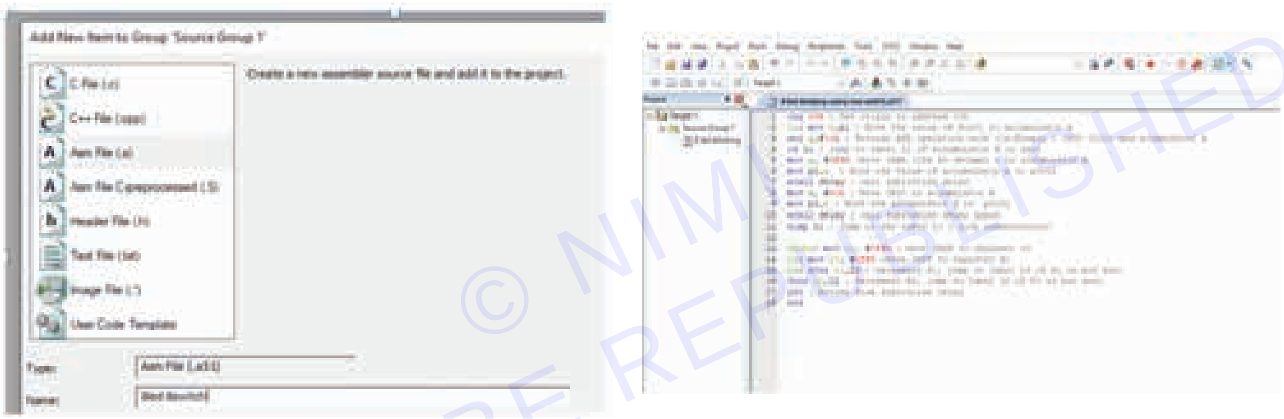
8 Right click on the source group 1 and select the "Add New item to group 'source Group 1'

9 Select the .asm file since we are writing the program in assembly language.

10 Name the assembly program file as "8led 8switch'. Then, Click Save to Proceed.

11 Click on the add, to add it on to the source group.



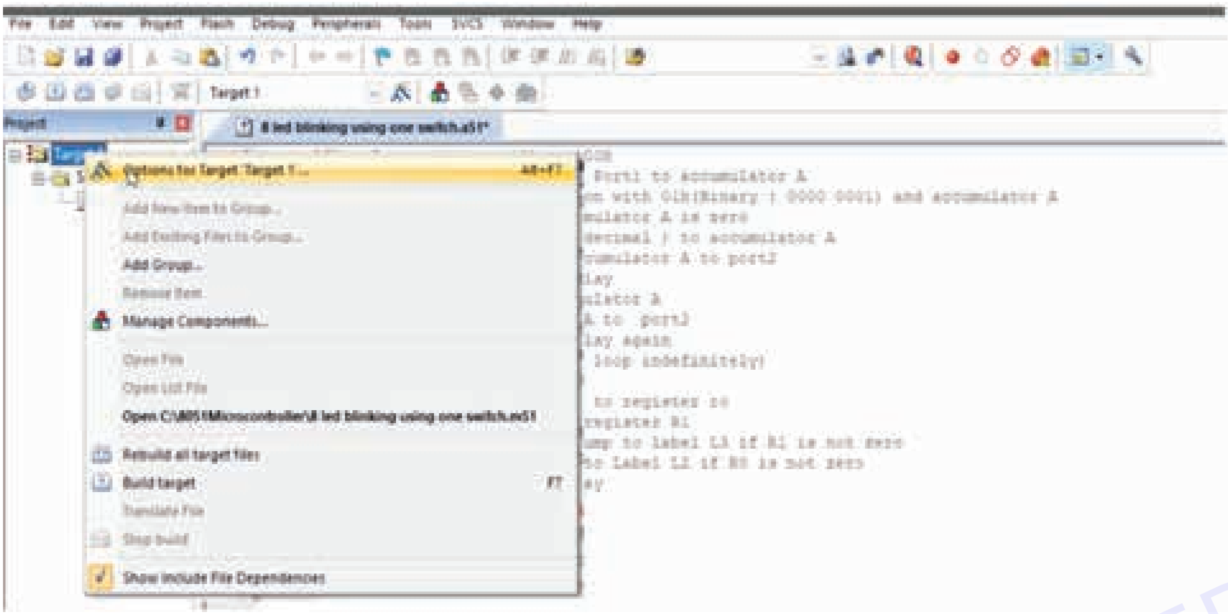


12 Write the program in the file you created as given below.

```
org 00h;                    //Set origin to address 00h
L1: mov a,p1;               //Moves the value of Port 1 to accumulator A
anl a,#01h;                 //Bitwise AND operation with 01h (Binary: 0000 0001) and accumulator A
j: L1;                      //Jump to Label LI if accumulator A is zero
mov a, #0ffh;               //Moves OKAA (255 in decimal) to accumulator A
mov p2a;                    //Moves the Value of accumulator A to porta
&call delay call subroutine delay
mov a, #00h;                //Moves 0X00 to accumulator A
mov p2, a;                  //Moves the accumulator A to port2
&call delay;                //call subroutine delay again
sjmp L1;                    //Jump to the Label Li (loop indefinitely)

delay: mov R0, #0ffh;       //Move Oxff to register zo
L2: mov R1, #offh;          //Move Oxff to register R1
L3: djnz R1,L3 Decrement R1, jump to label L3 if R1 is not zero
    djnz R0, L2 Decrement R0, Jump to Label L2 if R0 is not zero
ret: Return from subroutine delay
end
```

13 Now navigate to the target and right click, then follow the steps as shown in fig below.



14 Check the crystal oscillator whether it is 11.05MHz and tick the small box :Use On Chip ROM as per below fig.

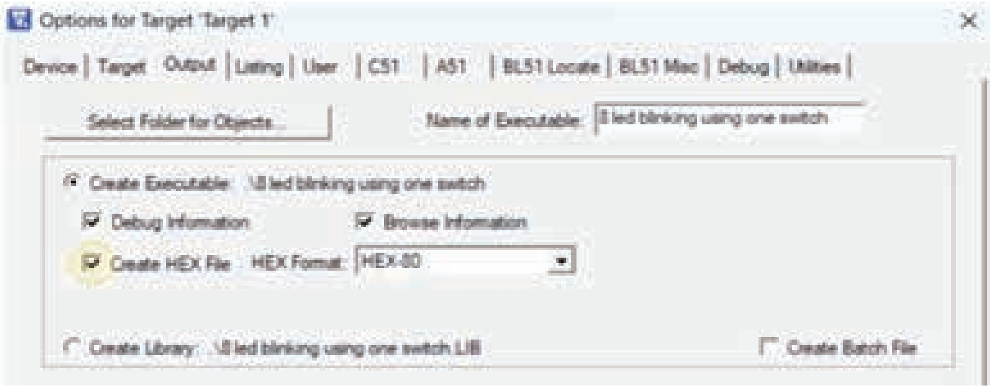
15 Now, Select the output option, tick the small box of create Hex file as per figure “options for target-1”.

Note: The hex file stores a hex program and consequently data but is not executable. It is part of the modules of an object program/application/customized program compiled into hex. The hex file is now a source program/code in hexadecimal form.

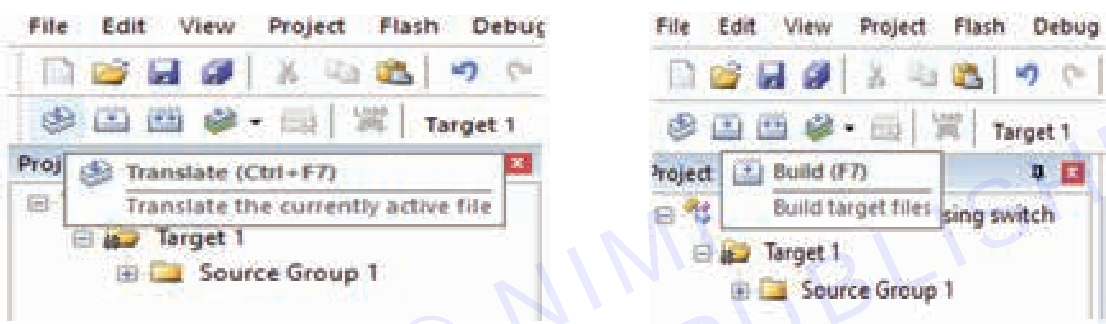
16 After that, translate the current file to check if there are any errors or warnings.

17 To run the program, you need to correct the program till it becomes/ shows zero Errors and warnings.

18 Click on the Build Target



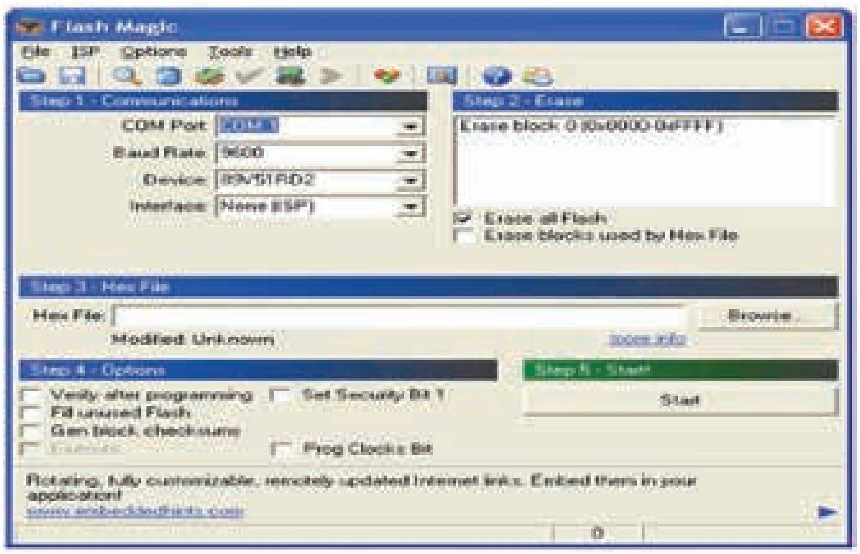
19 If you have written the correct program it will show in build output that 0 error and 0 warning or if there is any error this will alert you automatically, sometimes with suggestions also.



20 Turn ON the microcontroller kit after entering the program in the software

21 Connect the PC / Laptop to the microcontroller kit using USB cable.

22 Click the Flash Magic software to burn the program from the computer into the microcontroller.

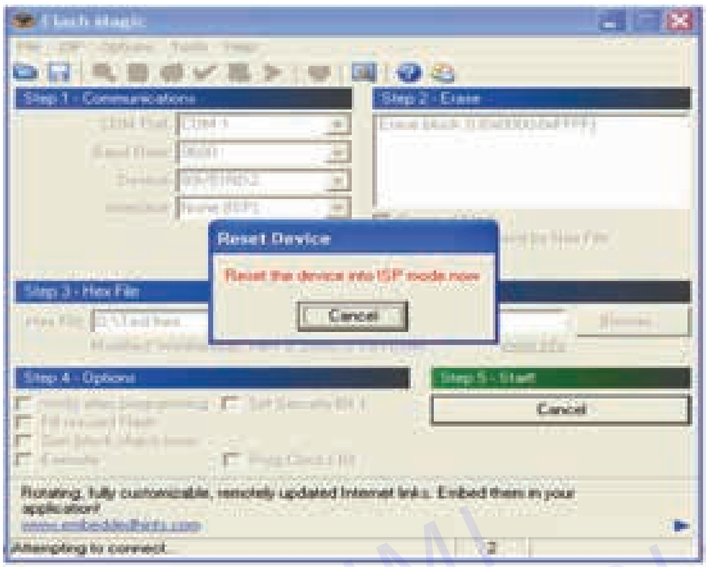


23 Here you have to select the COM number as per Step 1 i.e. shown in above fig, for that you have to select the device manager – Ports (COM & LPT) - USB Serial port (COM 1), it varies kit to kit.

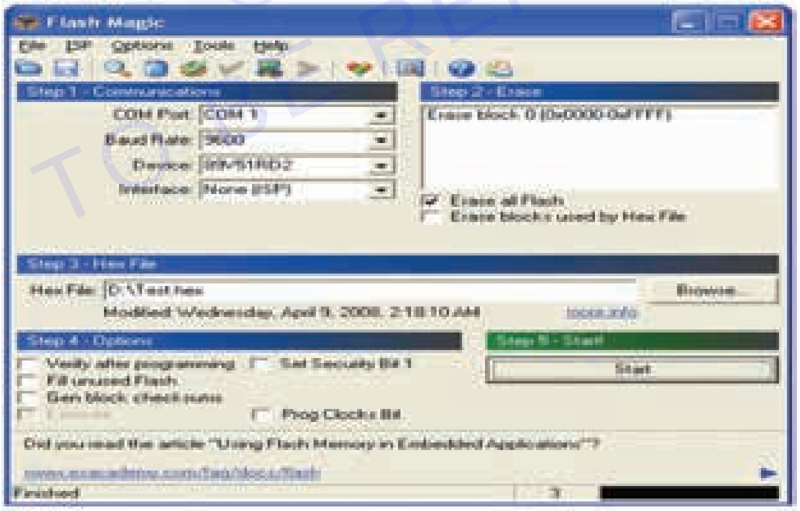
24 Then select the Baud rate to 9600 and select microcontroller IC (ex: 89V51RD2)

25 Tick the check box appeared in right side to Erase all flashes as per in Step 2

26 Now as per Step 3, locate hex file using browsing button as shown in the fig and Select Hex file that you saved.



27 Start the program by pressing start button of step 5 as shown in the above Fig



28 Then Reset the reset button in the microcontroller kit and burn the program in the microcontroller IC.

29 Observe the " blinking of LEDs" in the microcontroller kit as a result.

EXERCISE 39: Perform the Initialization, load program & turn-on LEDs with delay using Timer

Objectives

At the end of this exercise you shall be able to

- enter the program to turn ON LEDs with delay using timer in 8051 microcontroller trainer kit
- execute the program on the 8051 microcontroller trainer kit.

Requirements

Tools / Equipments / Instruments

- 8051 Microcontroller trainer kit with instructional manual - 1 Set

Materials / Components

- 8 LEDs interface module (available on board) - 1 No.

Procedure

1 Collect the 8051 microcontroller kit from the instructor.

2 After receiving the kit, refer to the instructional manual that follows it. Identify and take note of all the operating controls and switches specified in the manual.

3 Once you have identified the controls and switches, proceed to configure Port 1 of the microcontroller as an output port using jumper settings mentioned in the manual.

4 Enter the given program to turn ON the LEDs with a delay using the timer.

5 Execute the program and observe the result or LEDs blinking with delay using a timer into the microcontroller kit:

Main Program

```
MOV TMOD, #10
HERE    MOV TH1, #0F
MOV TL1, #F0
MOV A, #55
MOV 90, A
ACALL DELAY
ACALL DELAY
MOV A, #00
MOV P1, A
ACALL DELAY
ACALL DELAY
SJMP HERE
```

Delay Program

```
SET B TR1 (8E)
AGAIN JNB TF1 (8F), AGAIN
CLR TR1
CLR TF1
RET
```

EXERCISE 40: Use Timer as an Event Counter to count External events

Objectives

At the end of this exercise you shall be able to

- demonstrate the program to count external events using the 8051 microcontroller kit and verify the output.

Requirements

Tools / Equipments / Instruments

- Trainees tool kit - 1 Set
- 8051 microcontroller trainer kit with instructional manual - 1 Set

Materials / Components

- Push-to-on switch - 1 No.
- Bread board - 1 No
- Hook up wire - as reqd.

Procedure

- **For giving input toTimer 1, Connect the push button switch at pin No.15 and ground using bread board, (if the push button is not provided in your kit).**
- **For giving input to Timer 0, Connect the push button switch at pin No.14 and ground using bread board.**
- **Make necessary modifications in steps / program according to the microcontroller trainer kit available in the section.**

1 Switch ON the 8051 microcontroller trainer kit.

2 Refer to the Instructional manual and identify all the operating controls / switches.

Note: The Instructor has to explain about the program and its working step by step

3 Enter the given program into the microcontroller kit.

4 Execute the program, press the push button connected to the Timer pin and observe the output port 1 connected to LEDs.

5 It will count from OOH to FFH for each press of the push button.

Program

```
START   MOV TMOD, #60
        MOV TH0, #00
BACK    SET B TR0
        MOV P1,TL0
        MOV A,P1
        CJNE A,#10 BACK
        CLR  TR0
        SJMP START
```

EXERCISE 41: Demonstrate a simple Arithmetic program, Execute and monitor the result on LCD display

Objectives

At the end of this exercise you shall be able to

- enter and execute the program to add two 8 bit numbers using 8051 microcontroller kit
- enter and execute the program to subtract two 8 bit numbers using 8051 microcontroller kit.

Requirements

Tools / Equipments / Instruments

- 8051 microcontroller trainer kit with instruction manual - 1 Set

Procedure

Note: The instructor must make necessary modifications, based on the microcontroller trainer kit available in the lab. Additionally, the instructor should explain the program and its functioning step by step.

TASK 1: **Enter the program to perform addition of two 8-bit numbers (data)**

1 Collect the 8051-microcontroller kit from the instructor.

2 Refer to the instruction manual and identify all the operating controls and switches.

3 Switch ON the 8051 microcontroller trainer kit.

4 Enter the simple assembly language program for two 8-bit addition into the microcontroller.

5 Execute the given program and verify the result.

6 Record the data and result obtained in Table 1.

7 Repeat the steps 3 and 4 for different values and record it in Table 1.

8 Get the work checked by the instructor.

Program

```
CLR B
MOV DPTR,#address
MOV A,#data 1
ADD A,#data2
JNC Label
INC B
Label  MOVX  @DPTR,A
MOV A,B
INC DPTR
MOVX @DPTR,A
Here   SJMP here
```

TASK 2: **Enter the program to perform subtraction of two 8-bit numbers(data)**

1 Repeat the same steps from task 1 to enter and execute the program for subtraction of two 8-bit numbers using the microcontroller.

2 Record the data and result in Table 1.

3 Repeat the process for different values and record it in Table 1.

4 Get the work checked by the instructor.

Program

MOV Ro,#00

MOV A, #data1

SUBB A, # data2

MOV DPTR, #address

JNC label

CPL A

ADD A, #01

INC B

Label MOVX @DPTR,A

INC DPTR

MOV A, B

MOVX @DPTR,A

Here SJMP here

Note: Instructors should assign tasks to trainees to develop programs for 8-bit multiplication, division, and other related operations.

	Data 1	Data 2	Execution Result 1	Execution Result 2
Addition				
Subtraction				
Multiplication				
Division				

— — — — —

EXERCISE 42: Perform assembly language programming to read the status of Input port – switches and display the status as 8 bit Hex code on LCD display

Objectives

At the end of this exercise you shall be able to

- enter the program in the 8051 microcontroller kit using switches and observe the output using LCD display.

Requirements

Tools / Equipments / Instruments

- 8051 Microcontroller with instruction manual - 1 Set

Procedure

Note: The instructor must make necessary modifications to the steps based on the microcontroller trainer kit available in the lab. Additionally, the instructor should explain the program and its functioning step by step

1 Refer to the instruction manual and identify all operating controls, switches and LCD display.

2 Switch ON the 8051 microcontroller trainer kit.

3 Write a program and Configure the port - 1 as an Input port using jumper settings.

4 Set the switch positions at the input port to desired position, before executing the program.

5 Enter the provided program using switches and LCD display through Input / output ports.

6 Execute the program and verify the result.

Program

```
MOV A,P1
MOV DPTR,#16 bit data
MOVX  @DPTR,A
Here SJMP  here
```

MODULE 4: Sensors, Transducers and Applications

EXERCISE 43: Demonstrate different sensors used in process industries

Objectives

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

- identify sensors used in process industries such as RTDs, Temperature ICs, Thermocouples, PT 100 (platinum resistance sensor), proximity switches (inductive, capacitive and photo electric), LVDT, load cells, strain gauge
- identify water level sensor, thermostat float switch by their appearance and record their specifications.

Requirements

Tools / Equipments / Instruments

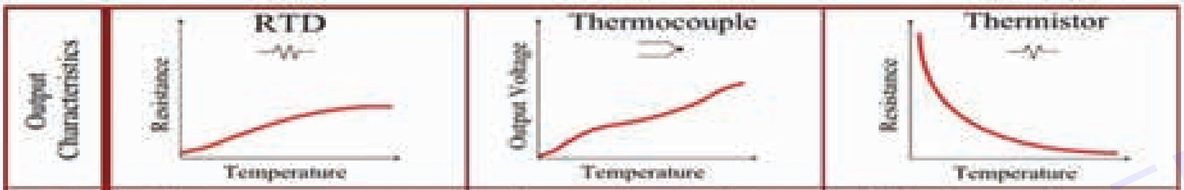
- Sensors –
  RTD – PT 100 (platinum resistance sensor) of length 6 inches - 1 No.
  Temperature sensor IC – LM 35 - 1 No.
  K –type thermocouple - 1 No.
  Proximity switches (inductive, capacitive and photo electric) - 1 No each.
  Load cell - 1 No.
  Strain gauge - 1 No.
  LVDT water level sensor - 1 No.
  Thermostat float switch - 1 No.
  Float valve - 1 No.
- Digital Multimeter - 1No.
- Regulated power supply unit (RPS) - 1 No.
- Sensing materials & load for testing - e.g standard weights for load cells, strain gauge, etc - as reqd.
- Data sheets & Charts – for the sensors & applications.

Note: Trainer should prepare necessary Charts for the topic and use Data sheets of various sensors / transducers available in technical manual of the Sensor Trainer kit.

The instructor should provide the data sheet / manual to the trainees and guide them to use the manual, identify sensors and note down the necessary specifications – name of sensor, type, important features, Connecting details, sensing range, voltage / Current / resistance range for measurement, limitations & Uses. Demonstrate to the trainees - how different sensors work.

Procedure

Note: The temperature sensor refers to a sensor that can sense the temperature and convert it into a usable output signal, which is the core part of the temperature measuring instrument. The temperature sensor is one of the most frequently used sensors, which is widely used in Computers, Automobiles, Kitchen appliances, Air Conditioners, and Household Thermostats. The common types of temperature sensors include thermocouples, Thermistors, RTDs (Resistance Temperature Detectors), Analog and digital thermometer IC. etc.



	RTD	Thermocouple	Thermistor
Advantages	• Most accurate • Best stability • Higher linearity • Best interchangeabilty • Wide temperature range	• Largest variety of styles • Self-powered • Rugged • Largest temperature range • Small size / fast response	• High resistance values • Large resistance change • Two wire ohms measurement • Low sensor cost • Small size / fast response
Disadvantages	• Current source required • Smaller resistance change • Low absolute resistance • Self heating • Higher sensor cost	• Lowest stability • Low voltage output • Nonlinear • Cold junction reference needed • Lowest sensitivity	• Limited temperature range • Current source required • Nonlinear • Self heating • Fragile
Temperature Range	-260 to 850° C	-200 to 1800° C	-80 to 300° C

— — — — —

TASK 1: **Identify the type of RTD (Resistance temperature detector) sensor and record the details / specifications**

1 Collect the sensors and arrange them on the table.

Note : RTD (Resistance Temperature Detector) is a temperature sensor that operates based on the principle of resistance change with temperature. PT100 is a specific type of RTD that uses platinum as the sensing element with a nominal resistance of 100 ohms at 0°C.

Labeling : The labels on the RTD often indicate the type of RTD and may include details such as the material used (typically platinum) and the temperature range it's designed for.

Documentation: The user & technical manual supplied with the sensor has information about the specifications like type of RTD, material composition, useful temperature range etc.

2 Refer to the manual, above instructions, data sheet and fig-1 to identify the RTD sensor, type of RTD, temperature range, material used etc and record the observed information in the Table -1.

3 Disassemble and Identify the parts of the RTD sensor and record it in the Table.

4 Repeat the above procedure to identify other type of RTDs issued to you and record it in Table 1.

Fig 1

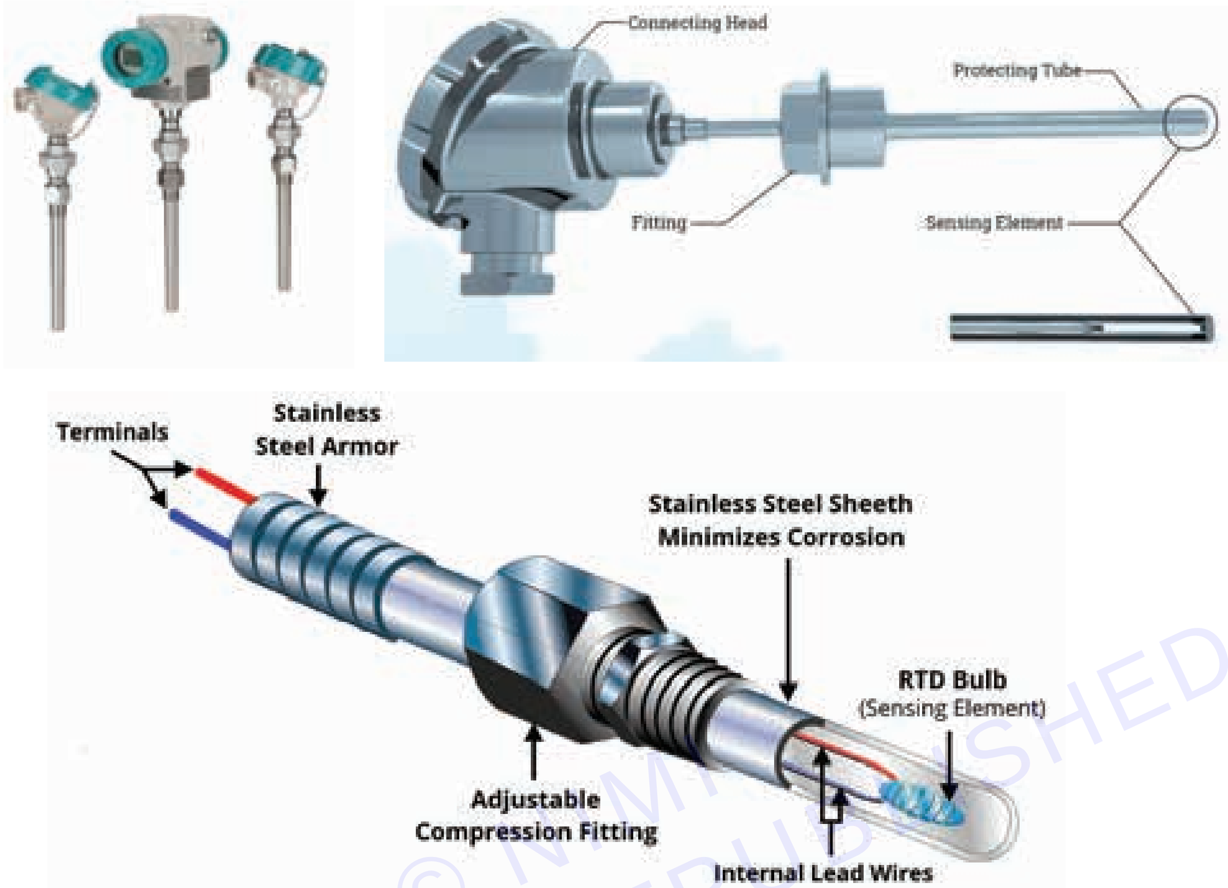


Table 1

Sl. No.	Name of the Temperature sensor	Type of sensor	Operating temperature range	Materials used in that type of sensor	Parts of the RTD sensor	Purpose / Usage / Applications
	RTD					

5 Get the work checked by the Instructor.

— — — — —

TASK 2: **Identify the type of thermocouple sensor and record the details / specifications**

1 Collect the temperature sensors from the Instructor for demonstration purpose.

Note:

THERMOCOUPLES are the easiest temperature sensor to identify. A thermocouple probe has two wires identified by a colour code. Thermocouples usually come in a 2-wire construction. Sometimes they employ a 3-wire construction if a ground or shielding wire is present. They have very low resistance (compared to RTDs and thermistors).

Identifying a thermocouple involves several methods

Color Coding: Thermocouple wires are often color-coded for easy identification. K type thermocouples typically have yellow and red wires. However, the color-coding may vary depending on the manufacturer, so it's essential to confirm the type using other methods as well.

Labeling: Look for labels or markings on the thermocouple itself or its packaging. These labels often indicate the type of thermocouple, such as "K" for K type thermocouples.

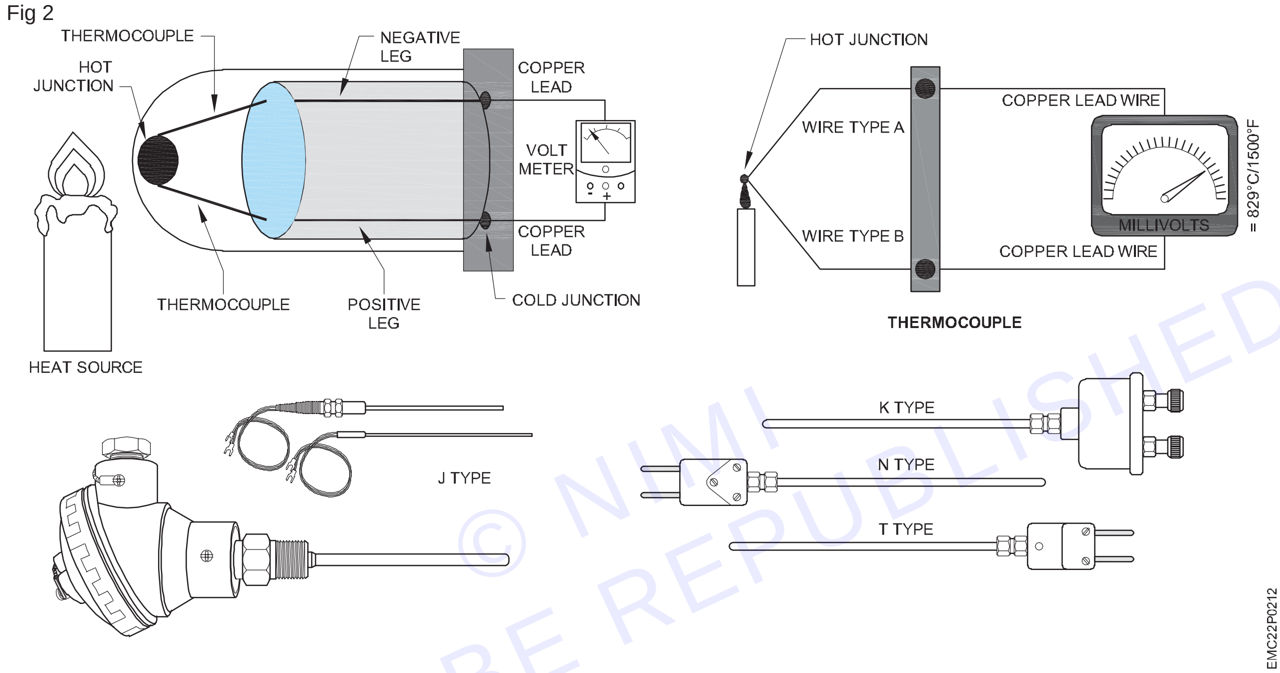
Documentation: Use data sheets and user manual for the codes / specifications mentioned on the thermocouple to identify the type of thermocouple and other details such as its material composition, temperature range etc.

K Type thermocouples have a wide temperature range of approximately -200°C to 1,372°C (-328°F to 2,502°F) and are commonly used in applications such as furnace and oven temperature control, gas turbine exhaust monitoring, and in the automotive industry.

2 Refer to the manual, above instructions, data sheet and fig 2 to identify the thermocouple sensor, its parts, type, temperature range, material used, applications etc and record the observed information in the Table 2.

3 Disassemble and Identify parts of the thermocouple and record it in the Table.

Fig 2



4 Repeat the above procedure to identify other type of thermocouple issued to you and record it in Table 2.

Table 2

Sl. No.	Name of the Temperature sensor	Type of sensor	Operating temperature range	Materials used in that type of sensor	Parts of the RTD sensor	Purpose / Usage / Applications
	Thermocouple					

5 Get the work checked by the Instructor.

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TASK 3: **Identify the type of thermistor and record the details / specifications.**

Note:

Thermistors are resistive temperature devices. You can measure the resistance across the two leads using a multimeter. They can vary in size and color depending on the manufacturer and type. It is largely used as a protective device in electronic gadgets. It provides better protection against overloading. Refer to the thermistor datasheet to find the temperature range over which the thermistor operates effectively. This range may vary depending on the type and application of the thermistor. There are two common types of thermistors : NTC (Negative Temperature Coefficient) and PTC (Positive Temperature Coefficient). NTC thermistors decrease in resistance as temperature increases, while PTC thermistors increase in resistance with temperature.

Fig 3

1 Select the thermistors for demonstration purpose.

2 Refer to the manual, data sheet along with the above instructions and Fig 3 to identify the thermistor sensors, its temperature range, structure, NTC / PTC type, applications etc and record the observed informations in the Table 3.

3 Repeat the above procedure to identify other type of thermistors issued to you and record it in the Table 3.

Table 3

Sl. No.	Name of the Temperature sensor	N Type / P type of sensor.	Operating temperature range	Types of thermistor based on its shape	Purpose / Usage / Applications
	Thermistors				

4 Get the work checked by the Instructor.

— — — — —

TASK 4: **Identify the type of Load cell pressure sensor and record the details / specifications**

Units for measuring pressure:

Pressure sensors can be measured using various units depending on the application and the system of measurement being used. Some common units for pressure measurement include: **Pascals (Pa):** The SI unit of pressure. **1 Pascal** is equal to **1 Newton** per square meter. **Bar (bar):** Commonly used in industries like engineering, meteorology, and automotive. **1 bar** is approx equal to atmospheric pressure at sea level.

Pounds per square inch (psi): Commonly used in engineering and for measuring pressure in pneumatic systems.

1 Select the load cell pressure sensor for demonstration purpose.

Guidelines to identify Load Cell pressure sensor:

Load cells are of different types - Strain Gauge Load Cells, Bending Beam Load Cells, S-Beam Load Cells, Compression Load Cells, Pneumatic Load Cells:, Hydraulic Load Cells, Capacitive load cells, Magnetostrictive load cells, etc. They are often used in high-pressure and high-capacity applications, such as in heavy industrial equipment and construction machinery, industrial weighing applications, etc.

- **To identify a load cell, look for any labels, markings, or documentation / manual / datasheet that provide information about the sensor's specifications, such as its model number, manufacturer, operating temperature range, accuracy, and calibration details.**
- **Load cell pressure sensors usually have a compact and robust design. They might appear as small metal structures, often with a cylindrical or rectangular shape. They usually have input and output wires for connecting to a measurement device.**
- **Load cells are often rated in kilograms (kg) for weight measurement, or in pounds per square inch (psi) or bars for pressure measurement.**
- **Output Type: Load cells typically produce an electrical signal proportional to the applied force or pressure. Common output types include analog voltage (mV / V), analog current (4-20mA), or digital (such as digital serial communication protocols like RS-485 or Modbus).**

Fig 4

LOAD CELL WEIGHING MACHINE

2 Refer to the manual, data sheet along with above instructions and fig 4 to identify the load cell pressure sensor, its operating range, structure, type, applications etc and record the observed information in the Table 4.

3 Disassemble and Identify the parts of the load cell and record it in the Table 4.

4 Repeat the above procedure to identify other type of load cells issued to you and record it in the Table 4.

Table 4

Sl. No.	Name of the pressure sensor	Types of load cells.	Operating pressure range	Parts of a load cell	Purpose / Usage / Applications
	Load cell				

5 Get the work checked by the Instructor.

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TASK 5: **Identify the type of Strain gauge pressure sensor and record the details / specifications**

1 Collect the strain gauge pressure sensor for demonstration purpose.

Fig 5a

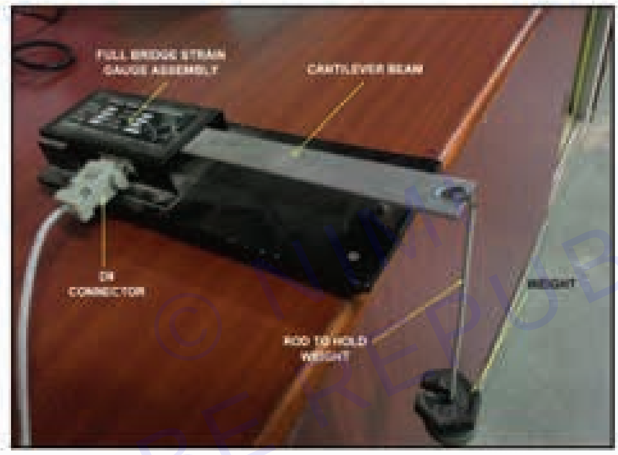
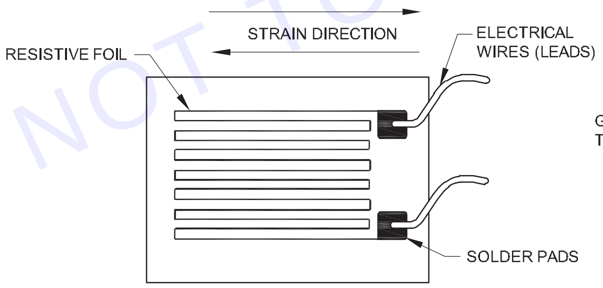
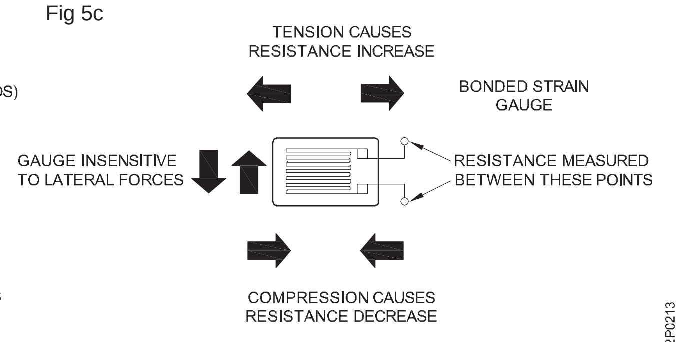


Fig 5b



STRAIN GAUGE CONSTRUCTION

Fig 5c



STRAIN GAUGE

EMC22P0213

2 Refer to the manual / data sheet along with the above guidelines and fig 5a,5b,5c to identify the strain gauge pressure sensor, its operating range, structure, type, applications etc and record the observed information in the Table 5.

3 Disassemble and Identify the parts of the strain gauge and record it in the Table 5.

4 Repeat the above procedure to identify other types of strain gauges issued to you and record it in the Table 5.

Table 5

Sl. No.	Name of the pressure sensor	Type of strain gauges.	Operating pressure range	Parts of the Strain gauge	Purpose / Usage / Applications
	Strain gauge				

5 Get the work checked by the Instructor.

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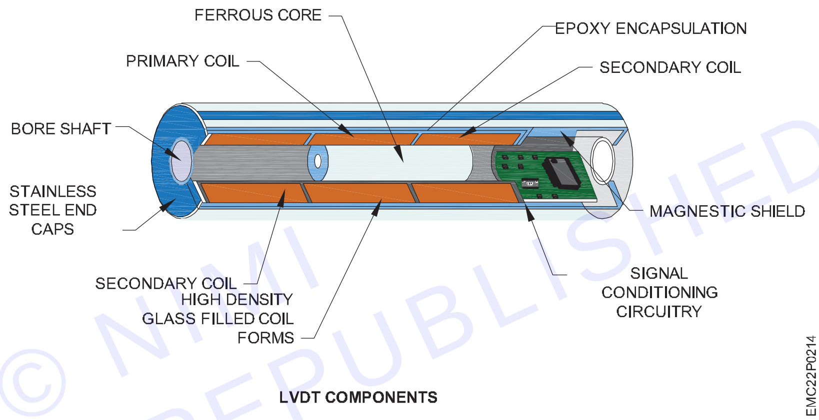
TASK 6: **Identify the type of LVDT pressure sensor and record the details / Specifications**

1 Collect the pressure sensors and arrange them on the worktable.

Fig 6a

LVDT POSITION SENSORS
LINEAR VARIABLE DIFFERENTIAL TRANSFORMER



LVDT COMPONENTS

GUIDELINES TO IDENTIFY LVDT PRESSURE / POSITION SENSOR: A Linear Variable Differential Transformer (LVDT) is an electrical transducer or sensor used for the measurement of physical quantities like displacement, force, pressure, acceleration, etc. Linear Variable Differential Transformer is a non-contact transducer that converts linear displacement into an analog electrical output signal proportional to the physical quantity applied which is to be measured.

LVDTs are used in computerized manufacturing, robotics, avionics, and machine tools, etc.

- Shape and Size: LVDT sensors typically have a cylindrical or tubular shape. They can vary in size depending on their application, but they are generally elongated with a shaft-like appearance.
- Coil Arrangement: LVDT sensors consist of primary and secondary coils wound around a hollow cylindrical core. The primary coil is typically located in the center, while the secondary coils are symmetrically positioned on either side.
- Core: The LVDT core is a movable, ferromagnetic material (often made of nickel-iron alloy) that slides inside the primary coil. It is attached to the object whose displacement or position is being measured.
- Connector: LVDT sensors usually have electrical connectors for wiring purposes. These connectors may vary depending on the specific model but often include pins or terminals for connection to measurement devices or instrumentation.
- Label or Markings: Many LVDT sensors have labels or markings that provide information such as the manufacturer's name, model number, and specifications. These labels are often located on the body of the sensor or near the electrical connectors.
- Datasheet: The datasheet or technical manual for the LVDT sensor will provide detailed information about its specifications, including its measurement range, accuracy, frequency response, and electrical characteristics.

2 Refer to the manual, data sheet along with above guidelines and Fig 6a,6b to identify the LVDT pressure based position sensor, its operating range, structure, type, applications etc and record the observed information in Table 6.

3 Disassemble and Identify the parts of the LVDT pressure / position sensor and record it in the Table 6.

4 Repeat the above procedure to identify other type of LVDTs issued to you and record it in the Table 6.

Fig 6b

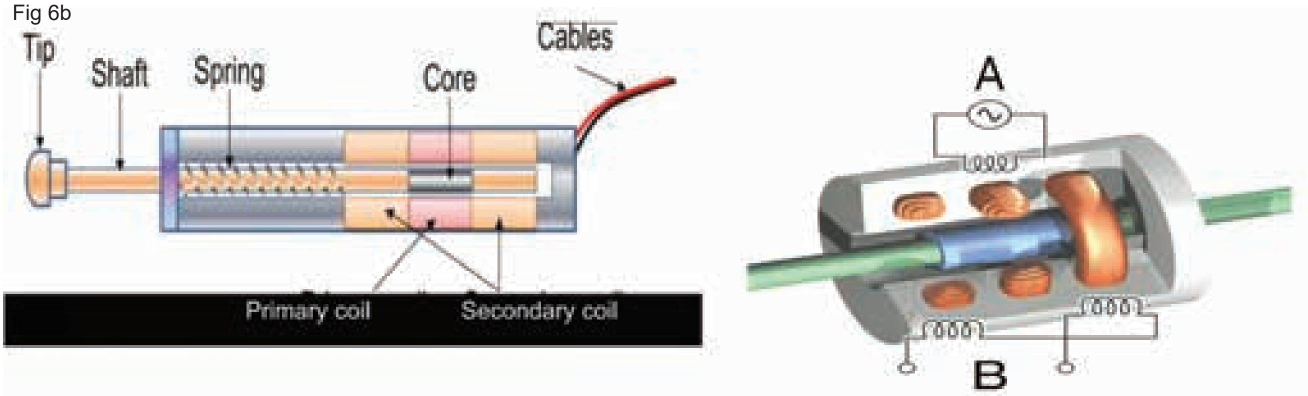


Table 6

Sl. No.	Name of the pressure sensor	Types of LVDT.	Operating pressure range	Parts of an LVDT	Purpose / Usage / Applications
	LVDT				

5 Get the work checked by the Instructor.

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TASK 7: **Identify the type of proximity sensor and record the details / specifications**

Proximity sensors

Note: Proximity sensors are devices that detect the presence or absence of objects within a certain range without physical contact. They work by emitting electromagnetic fields, light beams, or sound waves and then detecting changes in these fields caused by the presence or absence of an object. Proximity sensors are widely used in industrial automation, robotics, automotive applications, and consumer electronics for various purposes such as object detection, position sensing, and safety monitoring.

Guidelines to Identify Proximity sensors:

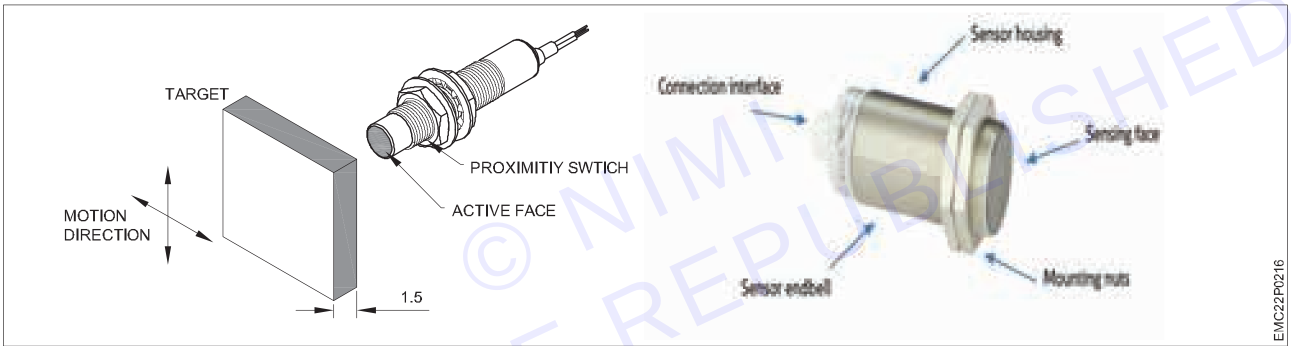
1 Inductive Proximity Sensors: These sensors use electromagnetic fields to detect metallic objects. They are typically used in applications where non-contact detection of metallic objects is required. Inductive sensors are often cylindrical in shape and have a sensing face at one end.

2 Capacitive Proximity Sensors: Capacitive sensors detect the presence of both metallic and non-metallic objects by measuring changes in capacitance. They are suitable for detecting materials with different dielectric constants such as plastics, liquids, and powders. Capacitive sensors often have a flat sensing face and can be used in various industries, including food and beverage, pharmaceuticals, and automotive.

3 Photoelectric Sensors: Photoelectric sensors use light beams to detect the presence or absence of objects.

4 Ultrasonic Sensors: Ultrasonic sensors emit high-frequency sound waves and measure the time it takes for the sound waves to bounce back after hitting an object. They are suitable for detecting objects regardless of their material composition and surface properties. Ultrasonic sensors are commonly used in applications such as level measurement, object detection, and distance sensing.

1 Collect the proximity sensors from the Instructor.



2 With reference to the above note and figures, identify the type of proximity sensor .

3 Disassemble and identify the parts of the sensor namely – sensing element, lead wires, enclosure, connection terminals, adjustment controls, etc. Identify the terminals and record it in the Table.

4 Observe the specifications for each sensor as given in manual / data sheet – type of sensor, sensing range, supply voltage for its operation etc.

Note:- Instructor should explain how proximity switches detect metallic and non metallic objects through electromagnetic fields. Capacitive switches sense changes in capacitance and photoelectric switches detect objects when light beam is interrupted by an object.

5 Record the observations in the Table -7.

Table - 7 for recording the details / specifications of proximity sensors

Sl. No.	Name of the Proximity Switches / sensors	Parts of the Sensor	Materials that can be sensed	Specifications / Operating voltage range	Uses / Applications
1	Inductive sensor 				

2	Capacitive sensor 				
3	Photoelectric sensor 				
4	Ultrasonic sensor 				

WATER LEVEL SENSORS AND FLOAT SWITCHES:

Note: A water level sensor is a device used to detect the level of water or other liquids in a reservoir, tank, or container. It measures the depth or height of the liquid and provides an output signal indicating the current level. There are several types of water level sensors, each utilizing different principles of operation: As the liquid level rises or falls, the float moves correspondingly, activating or deactivating the switch.

- Capacitive Sensors: Capacitive water level sensors use the principle of capacitance to measure the level of liquid. Ultrasonic water level sensors emit ultrasonic waves towards the surface of the liquid and measure the time it takes for the waves to reflect back. The time delay is proportional to the distance to the liquid surface, which allows the sensor to determine the level. Pressure-based water level sensors measure the pressure exerted by the liquid column above the sensor.
- Float Switches: Float switches consist of a buoyant float connected to a mechanical or electrical switch.

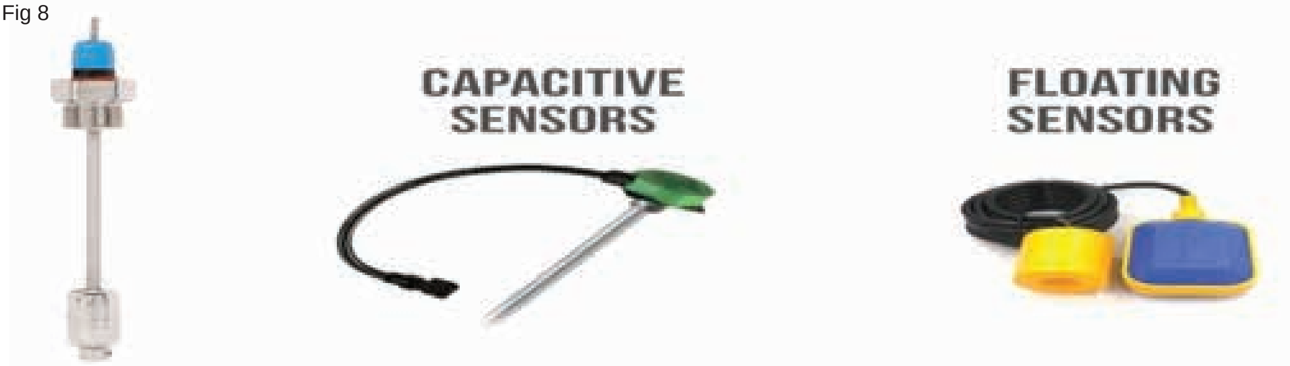
Guidelines to identify the level sensors / switches:

- Manufacturer Label or Markings: Many sensors have manufacturer labels, part numbers, or other markings that can help identify them. Look for any identifying information printed or engraved on the sensor housing or attached documentation. A thermostat float switch is a type of switch used in heating, ventilation, and air conditioning (HVAC) systems and other applications to control the operation of equipment based on the fluid level in a reservoir or tank.
- Control Function: The thermostat float switch is used to control the operation of equipment such as pumps, heaters, or alarms based on predefined temperature and fluid level thresholds. For example, in an HVAC system, the switch may activate a pump to circulate water when the fluid level in a reservoir drops below a certain level and deactivate it when the level rises again.

TASK 8: **Identify the type of Thermostat Float Switches, Float Valves, water sensor and level sensors and record the details / specifications**

Trainer has to display samples of water level sensors, such as float sensor and capacitive sensors, used for monitoring liquid levels in tanks or reservoirs.

Fig 8



1 Identify the type of the sensor, parts namely – sensing portion, sensing input, input and output terminals, (2 or 3 wires), etc. with reference to the above figures and manual.

2 Observe the specifications for each sensor as given in manual / data sheet – like type of sensor, Operating range, supply voltage for its operation etc.

3 Similarly observe the specifications of float valves and parts and record the details in Table -8a and 8b.

Table -8a

Sl. No.	Name of the sensor	Type of water sensor.	Operating temperature range	Materials used in that type of sensor	Parts of the sensor	Purpose / Usage / Applications
1						
2						
3						
4						
5						

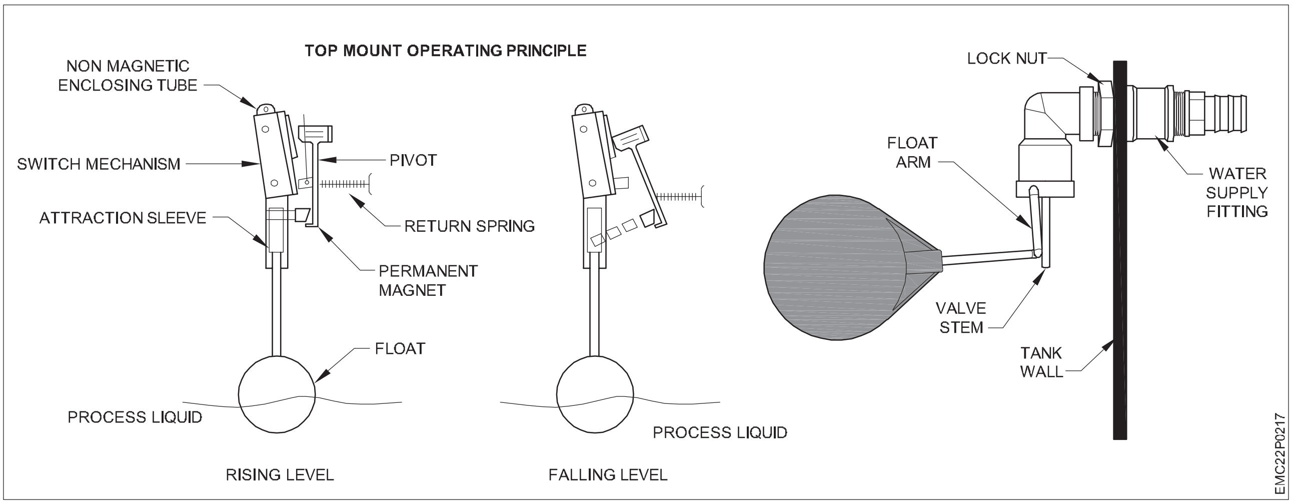
4 Record the observations in the Table -8a and 8b.

Note: Float valves are typically used to control liquid flow in a tank or container by using a valve controlled by a float at the end of a lever.

For example, a float ball valve can fill a tank with water until it reaches a certain level. Once the liquid reaches the predetermined level, the float activates the valve and stops the liquid flow.

On the other hand, float switches are commonly used to control other devices, such as alarms and pumps. For example, if a tank starts to overflow, a float switch sensor can be used to activate an alarm or shut off the pump.

Similarly, if a tank starts to run low on liquid, a float switch can be used to turn on a pump to refill the tank.



Note: Trainer has to display thermostat float switches and float valves that are used for controlling liquid levels and preventing overflow in tanks or vessels.

Table 8 b

Sl. No.	Name of the Switch or valve	Parts	Specifications	Where it is used / purpose
1	Thermostat Float switches			
2	Float Valves			

Safety Precautions:

- **Trainer should ensure that all demonstrations are conducted safely, especially when dealing with electrical equipment or hazardous materials.**
- **Handle sensors and related equipment with care to prevent damage or injury.**

— — — — —

EXERCISE 44: Measuring the temperature of a lit fire using a thermocouple and recording the readings

Objectives

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

- measure the temperature of a lit fire using a thermocouple and record the readings.

Requirements

Tools / Equipments / Instruments

- Thermocouple probe with display unit
- Digital multimeter capable of measuring temperature
- Fire proof gloves (optional but recommended for safety).
- Data chart for the type of thermocouple being used (to convert voltage readings to temperature)

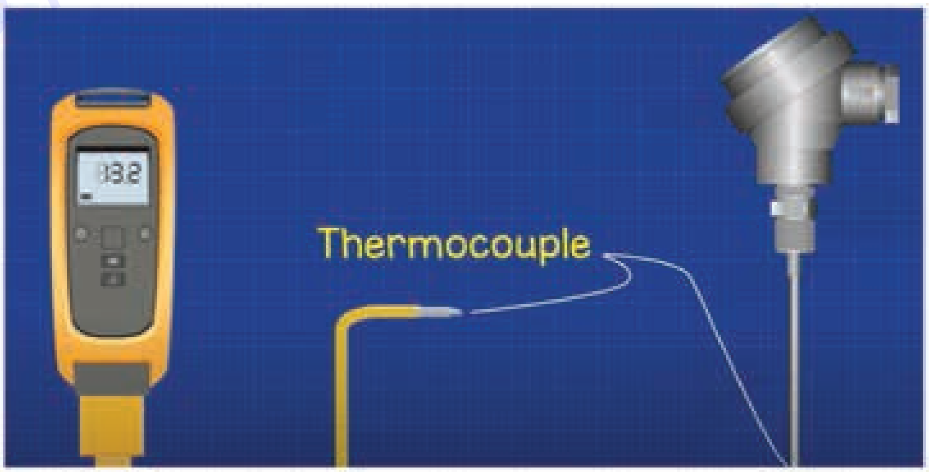
Note: The functionality of a thermocouple relies on the Seebeck effect. When two different or dissimilar metals or alloys are joined together at one end, and there is a temperature difference between the joined end and the other ends, a voltage is generated that can be correlated directly to the temperature. ,A thermocouple consists of two wire legs made from different metals. The wire legs are welded together at one end, creating a junction. This junction is where the temperature is measured. When the junction experiences a change in temperature, a voltage (known as thermoelectric voltage) is created. The other end of these wire legs is connected to a measurement system or multimeter. The difference in voltage between the two ends of the wires can then be interpreted as a temperature measurement.

Thermocouple is largely used in Industries, Consumer Electronics, Automotive and Aerospace sectors.

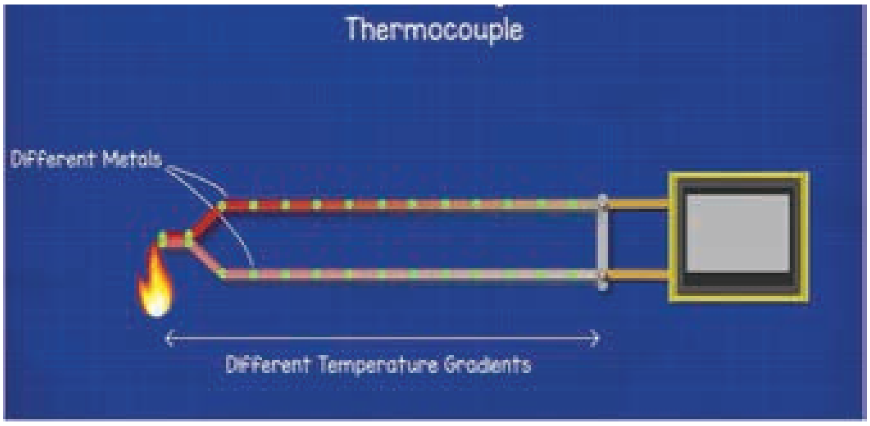
Procedure

1 Prepare the Thermocouple:

2 Connect the thermocouple probe terminals to the multimeter.



- Before switching ON the power, ensure that the thermocouple probe is clean and free from any dust or foreign particle that could affect the accuracy of the temperature readings.
- Check the connections between the thermocouple probe and the display unit or multimeter to ensure that they are secure to use and then switch ON the power to the heating unit or candle.

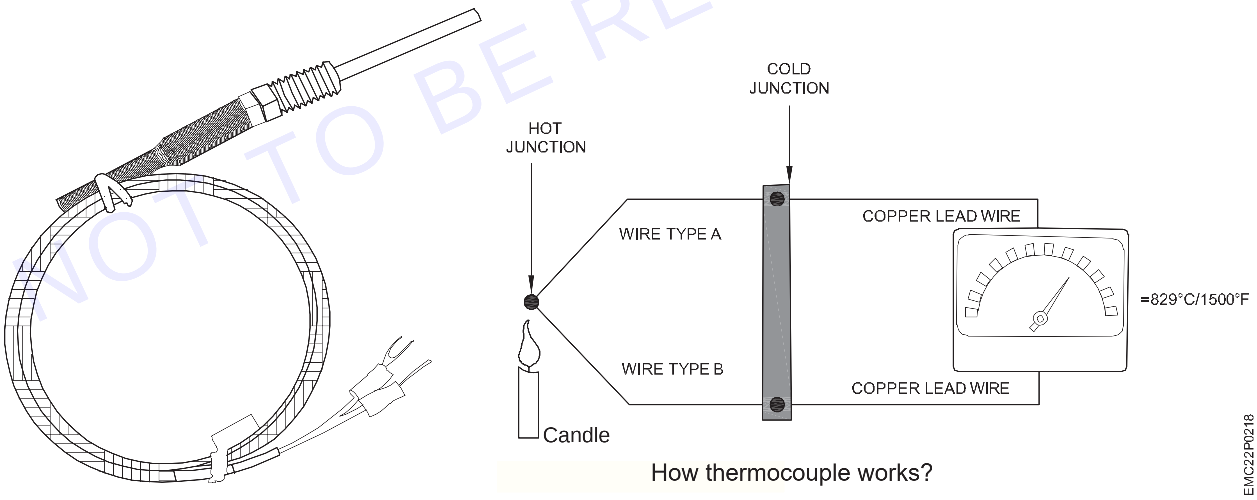


Safety Precautions:

- **Put on fireproof gloves to protect yourself from burns, especially when working near the fire.**
- **Make sure the area around the fire is clear of any flammable materials that could ignite.**
- **Remember to prioritize safety at all times when working with open flames and hot surfaces**

3 Positioning the Thermocouple:

- Ensure that the thermocouple probe is sensing the temperature near the fire, also check that it is not directly into the flames but close enough to measure the heat accurately.
- Avoid touching the probe with bare hand, to prevent burns due to radiating heat.



How thermocouple works?

4 Record Initial Reading:

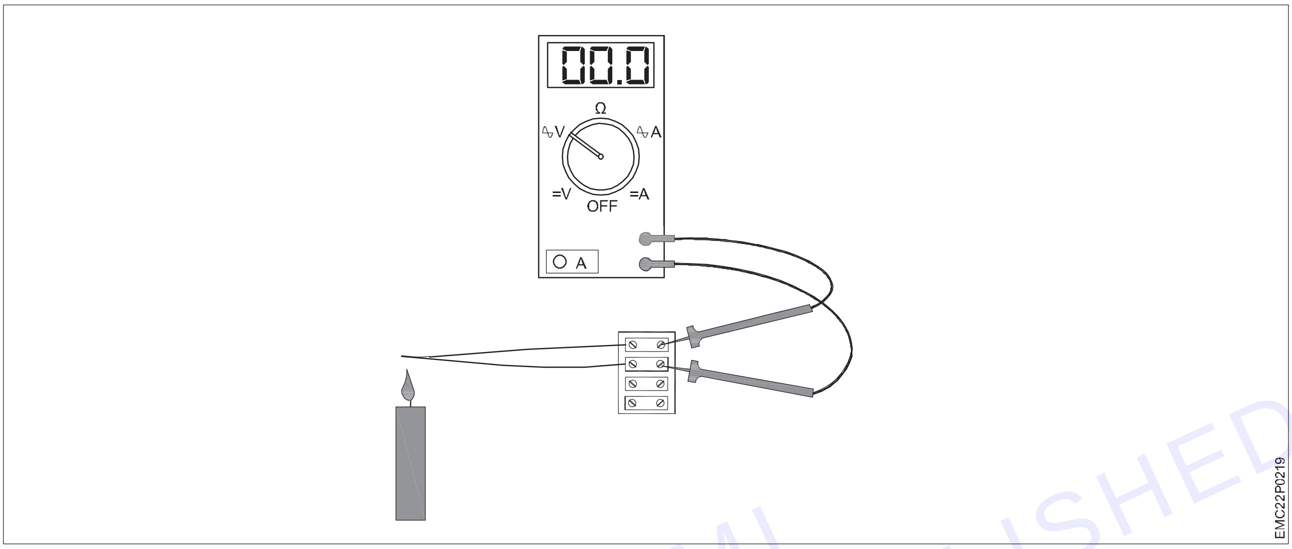
- Trainee has to note down the initial temperature reading displayed on the thermocouple unit.

5 Monitoring and Recording:

- Keep an eye on the temperature reading as the heater or candle heats. Record the temperature at regular intervals (e.g., every minute) or as necessary for your specific experiment or observation.
- Be aware of the fluctuations in temperature and record the changes in the temperature and corresponding voltage (proportional to fire's intensity).

6 Refer to Data Chart:

- If using a thermocouple without a built-in display, record the voltage readings from the multimeter.
- Refer to the data chart specific to the type of thermocouple being used to convert the voltage readings to temperature measurements.
- Note down the corresponding temperatures in the Table -1.



7 End of Measurement:

- Once you have collected sufficient temperature data or achieved your experimental objectives, carefully remove the thermocouple probe from the close area of the fire.
- Turn off any equipment used for temperature measurement and ensure all safety precautions are followed.

Table -1

Sl. No	Type of thermocouple	Temperature	Voltage	Time
1				
2				
3				
4				

8 Get the work checked by the instructor.

EXERCISE 45: Measuring the temperature of a lit fire using a Resistance Temperature Detector (RTD) and record the readings referring to data chart

Objectives

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

- measure temperature of a lit fire using RTD
- record the readings referring to data chart.

Requirements

Tools / Equipments / Instruments

- RTD probe or sensor - 1No.
- RTD measurement device /RTD trainer kit - 1No.
- Fireproof gloves (recommended for safety)
- Data chart for the specific RTD being used (to convert resistance readings to temperature)

Procedure

1 Prepare the RTD:

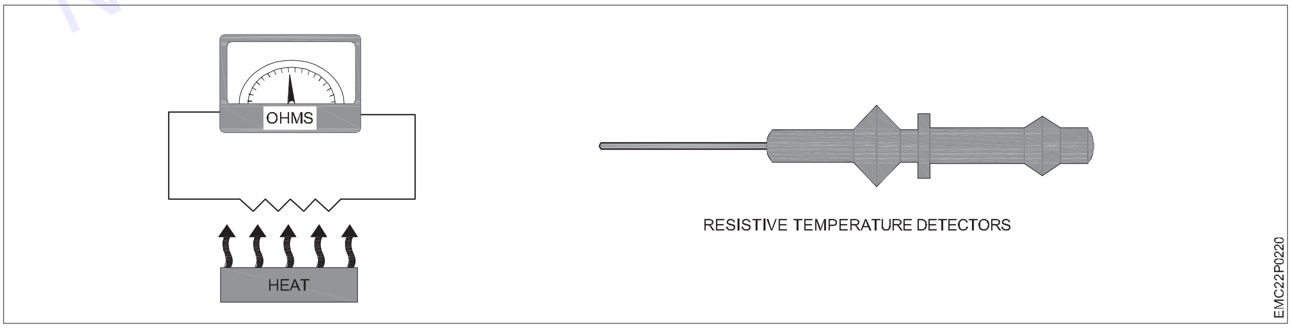
- Ensure that the RTD probe or sensor is clean.
- Check the connections between the RTD probe and the measurement device to ensure they are secure.

Safety Precautions:

- **Put on fireproof gloves to protect yourself from burns, especially when working near the fire.**

2 Positioning the RTD:

- Carefully place the RTD probe in the vicinity of the fire, ensuring that it is not directly in the flames but close enough to measure the heat accurately.
- Avoid touching the probe directly to any burning materials to prevent damage.



3 Record Initial Reading:

- Note down the initial resistance reading displayed on the RTD measurement device.

4 Monitoring and Recording:

- Trainee has to keep an eye on the resistance reading as the fire burns. Record the resistance at regular intervals (e.g., every minute).
- Be cautious of any fluctuations in resistance and observe any changes in the fire's intensity or behavior.

5 Refer to Data Chart:

- If trainee is using an RTD without a built-in temperature display, measure and record the resistance readings using multimeter.
- Refer to the data chart specific to the type of RTD being used to convert the resistance readings to temperature measurements.
- Trainee should note down the corresponding temperatures in Table -1.

6 End of Measurement:

- Once sufficient temperature data has been obtained, carefully remove the RTD probe from the nearness of the fire.
- Turn off the source of fire and the measuring device used for temperature measurement and ensure that all safety precautions are followed.

Table -1

Sl. No	RTD's temperature reading - in (°C)	Multimeter reading - resistance (Ω)	Voltage (mV)
1			
2			

8 Get the observation records checked by the Instructor.

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EXERCISE 46 : Measure the DC voltage output of a LVDT

Objectives

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

- LVDT sensor
- Multimeter capable of measuring DC voltage
- LVDT excitation source (if not already provided)
- LVDT signal conditioner (if required).

Requirements

Tools / Equipments / Instruments

- LVDT displacement sensor/ LVDT trainer kit - 1 No.
- Trainee's tools kit - 1 No.
- Power supply unit / VARIAC - 1 No.
- Digital mutimeter - 1 No.

Note:

- **LVDT stands for Linear Variable Differential Transformer. It is an electromechanical device used to convert linear displacement into an electrical signal.**
- **An LVDT consists of a primary winding and two secondary windings symmetrically placed around a movable core, usually made of a ferromagnetic material.**

Brief on LVDT operation:

Primary Winding: An AC voltage is applied to the primary winding, creating a magnetic field.

Secondary Windings: The magnetic field induces voltages in the secondary windings.

Core Movement: When the core is in the center position, the induced voltages in the secondary windings are equal but opposite in phase, canceling each other out, resulting in a null output.

Displacement: As the core moves from the center position, the voltages in the secondary windings become unbalanced. The difference in these voltages is proportional to the displacement of the core, providing a corresponding electrical output.

Procedure

1 Prepare the LVDT:

- Collect the LVDT. Check whether LVDT sensor is properly connected to its excitation source and signal conditioner (if necessary). The LVDT should be securely mounted in the position where you want to measure displacement.

2 Set Up the Multimeter:

- Now, turn on the multimeter and set it to measure DC voltage.
- Select an appropriate voltage range on the multimeter. Choose a range higher than the expected output voltage of the LVDT to ensure accurate measurement.

3 Connect the Multimeter:

- Connect the positive (red) probe of the multimeter to the positive output terminal of the LVDT.
- Connect the negative (black) probe of the multimeter to the negative output terminal of the LVDT.

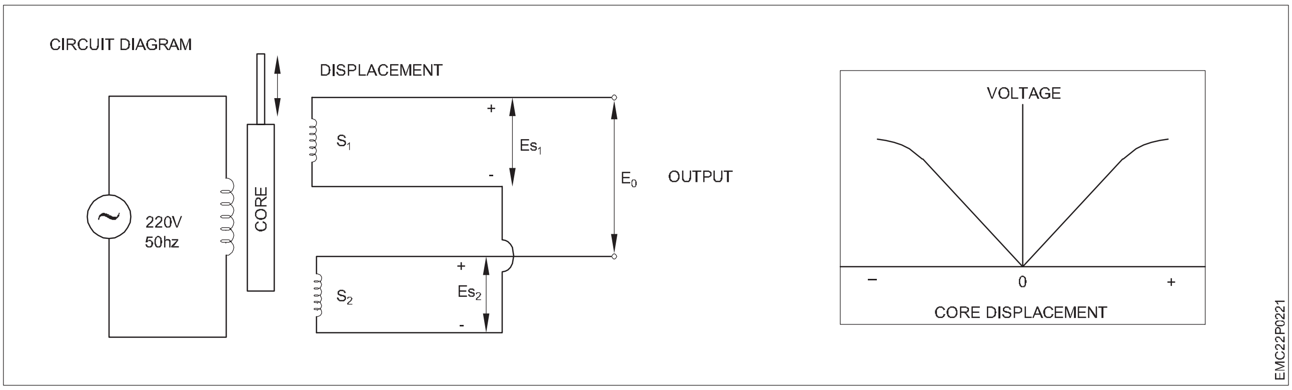
4 Apply Excitation to LVDT:

- Check that LVDT is properly powered with appropriate excitation voltage. This voltage typically ranges from a few volts to several volts, depending on specific LVDT model.

- Make sure the LVDT is properly configured and calibrated according to the manufacturer's instructions.

5 Read Voltage Output:

- Observe the voltage reading displayed on the multimeter and record it in the Table -1. This reading corresponds to the DC voltage output of the LVDT.
- This value represents the position or displacement of the LVDT's core relative to its windings.



6 Repeat Measurements (Optional):

- If necessary, perform multiple measurements at different positions or under different conditions to study the behavior of the LVDT.
- Remember that the LVDT should be properly powered and connected throughout the measurement process.

Table -1

Sl. No	AC Input voltage	Displacement of the core	Output Voltage
1			
2			
3			

Safety Precautions:

- **Handle the LVDT and multimeter with care to avoid damage.**
- **Ensure that all electrical connections are secure and properly insulated to prevent short circuits or electrical hazards.**

7 Get the work checked by the Instructor.

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EXERCISE 47: Detect different objects using capacitive, inductive and photo electric proximity sensors

Objectives

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

- demonstrate detection of different objects using photo electric
- proximity sensors and capacitive, inductive proximity sensors.

Requirements

Tools / Equipments / Instruments

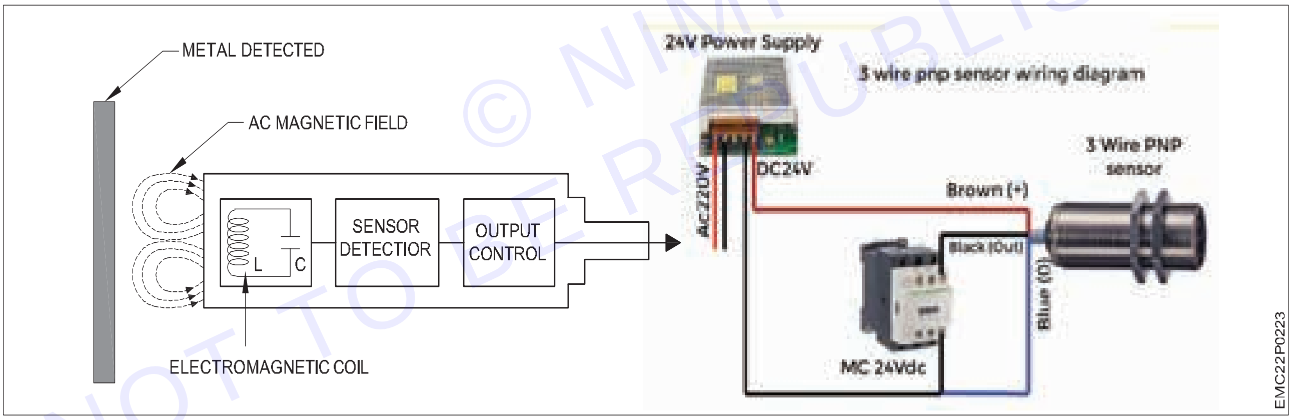
- DC Power supply unit (0 to 30V) - 1 No.
- Digital Multimeter - 1 No.
- Trainees tool kit - 1 No.

Materials

- Capacitive, Inductive and Photo electric proximity sensors - 1 No each.

Teaching Aid

- Charts indicating different sensors with necessary operating voltages and output signals. (voltage or current output produced as a result of sensing objects).



Note: **A proximity sensor** is one of the types of sensor. It is a non-contact sensor which is able to detect nearby objects without any physical contact. It is possible because they sense objects with the help of electromagnetic radiation beams or electromagnetic fields . These sensors are commonly used in Smartphones and Tablets. Other applications of Proximity sensor are as follows

Automated Water Taps:

These are touch-free or hands-free faucet (tap) that opens the valve to allow water flow in the presence of the user's hands in close proximity. This faucet is equipped with a proximity sensor and mechanism that open or close the valve based on the presence of the user's hands in close proximity.

Usage in Automation Industry: These sensors are widely used in automated production lines for detection, positioning, inspecting and counting purposes. This system is used in manufacturing plants. It is also used in filling processes.

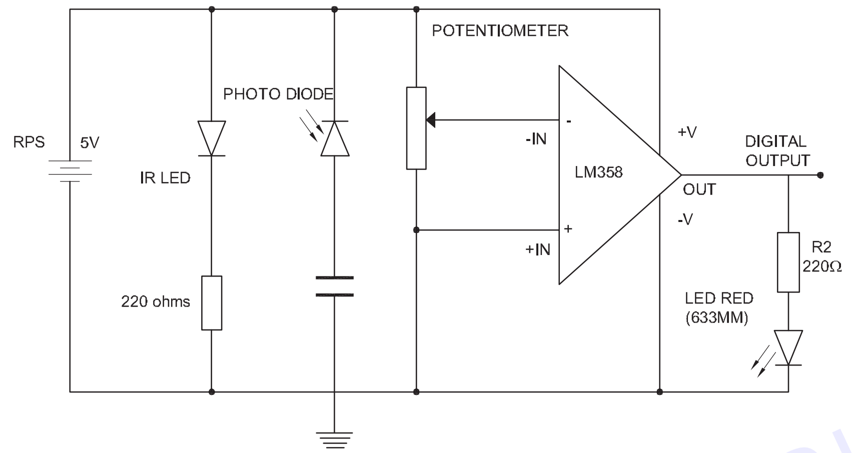
Usage in Collision detection in robots:

It is an interesting application of proximity sensor. It is used in robots to sense nearby obstacle and avoid hurting itself. These robots are now used for many purposes such as cleaning house, serving customers in restaurants, military work, toys, etc.

Procedure

TASK 1: **Demonstrate detection of objects using photo electric proximity sensor circuit**

Proximity sensor operation: An infrared proximity sensor is one kind of electronic device used to detect the existence of a target through reflected IR rays, once the object comes within the fixed range of the sensor. This sensor uses an operational amplifier, LM358. The internal circuit of the sensor is shown below.



PHOTOELECTRIC - PROXIMITY SENSOR CIRCUIT DIAGRAM

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1 Assemble the circuit as shown in the above circuit diagram and power ON.

2 The photo diode acts as the sensing device / part of the proximity sensor.

3 Take any object near the photo diode and block the light waves falling on photo diode.

4 Once the light falling on the light sensor (photo diode) is stopped, a low output signal is produced.

5 Observe the output when photo diode is sensing light waves from IR LED.

6 Measure the voltages at the input and output terminals of the Operational Amplifier LM358 and record the observations in the Table-1 given below.

Table 1

Condition	Voltage at inverting Input of Op Amp	Voltage at Non-inverting input of Op Amp	Op Amp – digital Output	LED status
When Proximity sensor senses light				
When Proximity sensor does not sense light				

— — — — —

TASK 2: **Demonstrate detection of objects using inductive / capacitive proximity sensor unit**

1 Connect 24V DC power supply to the sensor input terminals.

2 Connect a contactor or relay to the output terminals.

3 Place a metal object within 8mm distance of the inductive sensor front.

4 Observe the LED blinking in the sensor unit and the contactor goes ON.

5 Any load connected in series to the contactor also gets ON.

6 Repeat the experiment with capacitive sensor and a contactor.

7 Place a metal object for sensing followed by a non metal object and record the observations.

8 Get the work checked by your Instructor.

— — — — —

MODULE 5: SMPS, Inverter and Uninterrupted power supply (UPS)

EXERCISE 48: Demonstrate the components/ devices of SMPS and draw their corresponding symbols

Objectives

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

- Draw the layout diagram of the SMPS unit and identify various electronic devices / components of SMPS unit and draw the symbols.

Requirements

Tools/ Equipments/ Instruments

• ESD wrist band	- 1 No.
• Trainees tool kit	- 1 Set.
• Digital multimeter with probes	- 1 No.
• SMPS unit	- 1 No.
• Aids: Charts showing block diagram of various types of SMPS used in market.	
• Chart showing Major sections of SMPS and circuit diagrams	- as reqd.

Procedure

1 The Instructor should prepare Charts on SMPS Block diagrams for different types of SMPS categories available in market and corresponding circuit diagrams with test points marked in each section, before commencing demonstration on SMPS.

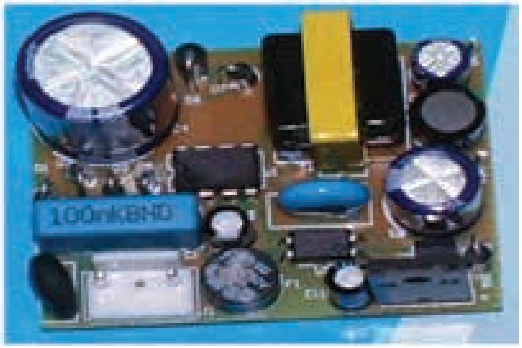
2 Major components / devices should be labelled in each section of the SMPS units, issued to the trainees.

3 Charts to be displayed by the Instructor to describe the Symbols of all Electronic components used in various SMPS units.

TASK 1: **Draw the layout diagram of the SMPS unit and identify various electronic devices / components of SMPS unit and draw the symbols.**

- Collect the SMPS unit from the Instructor.
- Remove the SMPS cover.
- Identify the type of SMPS unit issued.
- Observe the major components of various sections of the SMPS unit.
- With the guidance of Instructor, mark the boundaries (input and output devices) of each section.
- Identify the major components/ devices of each section, name the devices and draw their symbols in the Table-1.
- Draw the layout diagram of the SMPS unit indicating major sections & components starting from AC mains input to the output terminals.
- Some of the SMPS circuit boards and component symbols are shown below for reference purpose.

Note: SMPS is available in varied circuit designs, according to the voltage and power requirements of the load, SMPS type required (Isolated/ Non-isolated SMPS), size, application etc.



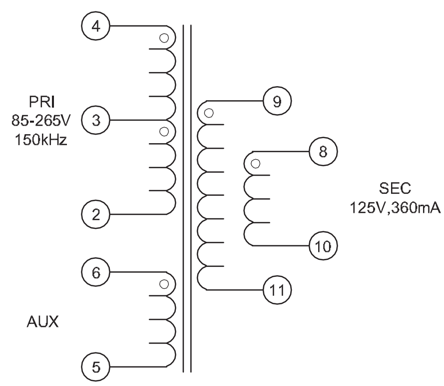
Note: Instructor may guide the students to identify the major sections and components of SMPS unit – namely EMI filter, Input fuse, Electrolytic Capacitors, Polyester Capacitors, Thermistor, MOV, Rectifier, Switching MOSFET, SCR, driver IC, PWM IC, driver transistor, Switching Transformer and its pin configuration, Inductor filter, EMI filter, Optocoupler etc.

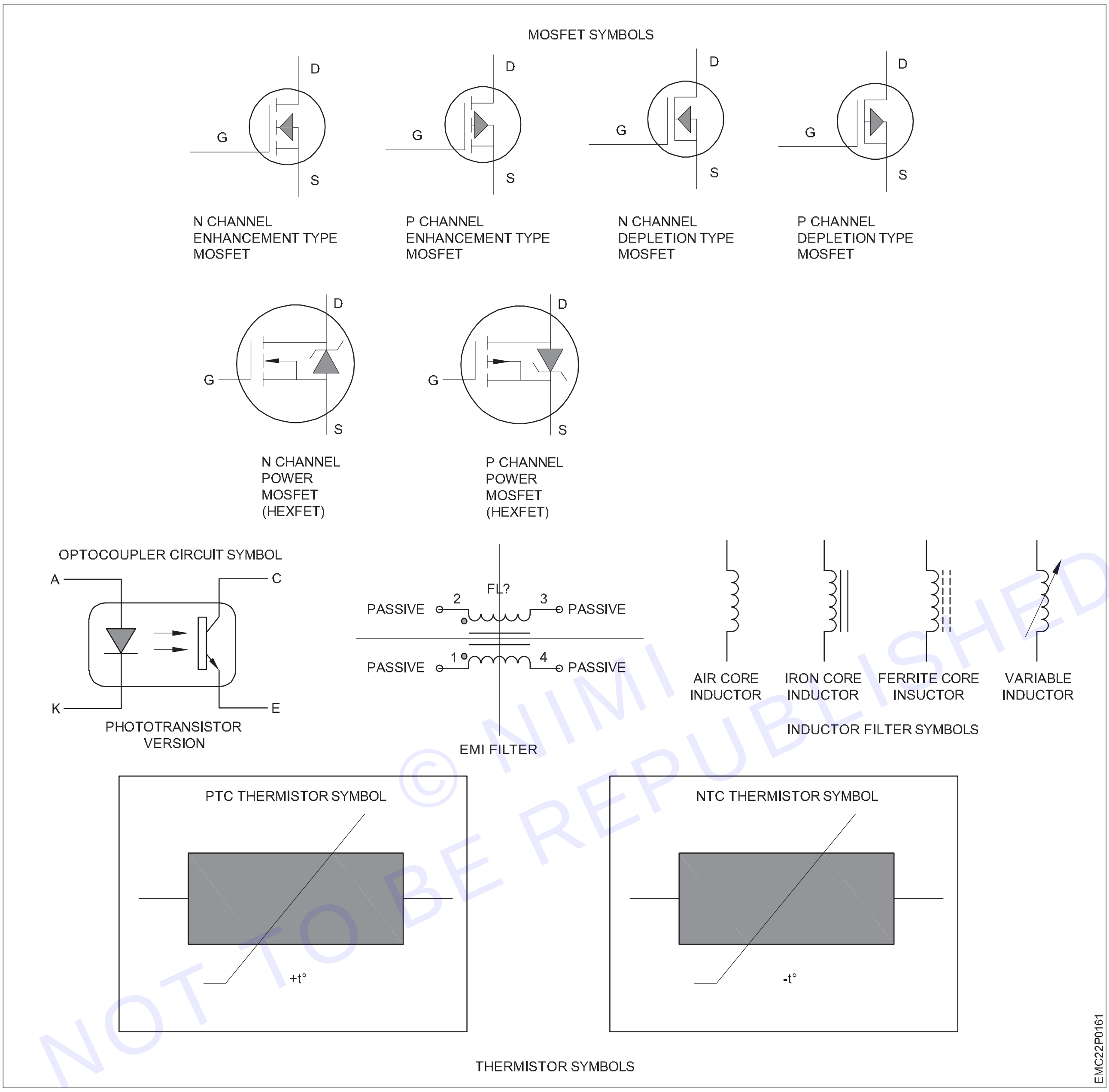
SWITCHING TRANSFORMER FRONT VIEW

SWITCHING TRANSFORMER OF DIFFERENT SIZES

BOTTOM VIEW

SWITCHING TRANSFORMER – CENTRE TAPPED PRIMARY WINDING 2-3-4, AUX WINDING 5-6 , SECONDARY WINDINGS 8-10 AND 9-11.





- Draw the symbol of major components present in your SMPS unit in the Table-1.

Table 1

Sl. No.	Name of the section	Name of the major components in the section	Component Symbol

— — — — —

EXERCISE 49: Dismantle the given Stabilizer and find major sections/ ICs & Components and demonstrate the Operation of different types of Automatic Voltage Stabiliser

Objectives

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

- dismantle the given voltage stabilizer & Identify major sections, ICs &Components of voltage stabilizer.
- measure the voltage at various test points of the stabiliser.

Requirements

Tools/ Equipments/ Instruments

- Trainees tool kit - 1 Set.
- Digital multimeter with probes - 1 No.
- Voltage stabilizer (automatic type with instruction manual) 500VA - 1 No.
- VARIAC/ Auto Transformer to apply variable AC input to stabilizer - 1 No.
- Chart showing various sections of a Voltage Stabiliser with Test points highlighted.

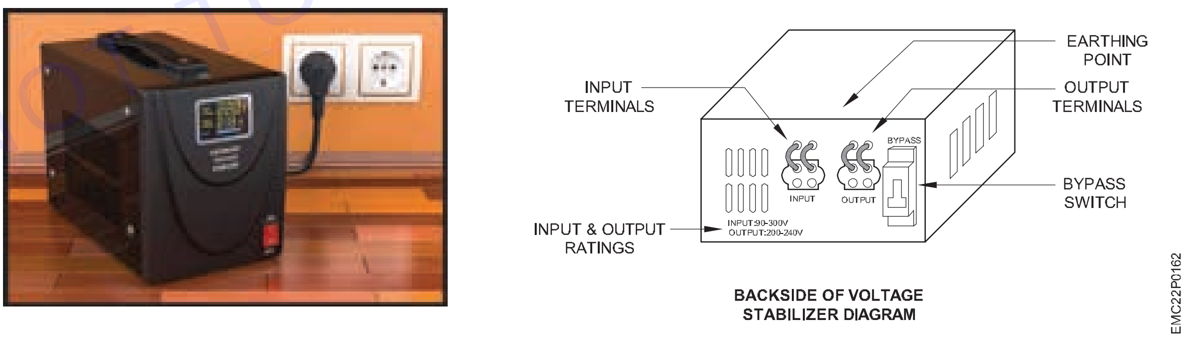
Procedure

Note:-

The instructor may guide the trainees to handle the weight of the voltage stabilizer. Remove the power cord from the A/ C mains supply .

The Instructor may brief the purpose of using a Voltage Stabiliser and demonstrate various sections available in Voltage Stabiliser and briefly explain their function using Chart as listed in Table 1.

Fig 1



TASK 1: **Dismantle the given stabilizer and find major sections/ ICs & Components**

- Collect the Voltage Stabiliser and remove the Stabiliser cover fittings, screws/ nut bolt etc and keep them safely in a box separately.
- Note down the name plate details of the Voltage stabilizer and record them in Table-1.
- Observe various sections of the stabilizer unit.
- Identify major components with Instructor's guidance.
- Mark the location and note down the function of major components/ parts in each section.
- Record the observations in the Table-1.

Table 1

Note down the Name plate details:-

SI.No.	Name of the section	Major/ important components/ parts	Function of major components
		Input 3 pin plug	
		Line Filters	
		Surge protector	
		Buck boost transformer	
		Op-Amp Comparator ICs	
		Driver transistors	
		Relays	
		Integrated Circuit (IC)	
		Trim PoT or Preset for voltage setting (ADJ)	
		Power On indicators	
		Input/ Output Voltmeter	
		Output terminal sockets	
		Input/ Output Fuses	
		Protection circuits	

- Get the work checked by the Instructor.

— — — — —

TASK 2: **Demonstrate the operation of an Automatic Voltage Stabiliser (motorized Auto Transformer type) and measure the voltage at various test points**

- For the same Voltage Stabiliser, identify the Voltage Input, Output sections, mains sensing and output feedback sensing devices, Control section, Buck boost transformer terminals and expected voltages. Refer to Fig 3, 4 and 5.

Fig 2

VARIAC/ Auto Transformer
(Used to provide variable AC supply to test a voltage stabiliser)

Fig 3

Buck/ Boost Transformer
(A part of Automatic voltage stabiliser)

Fig 4

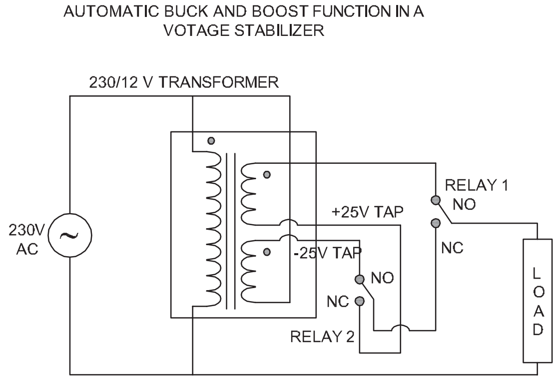
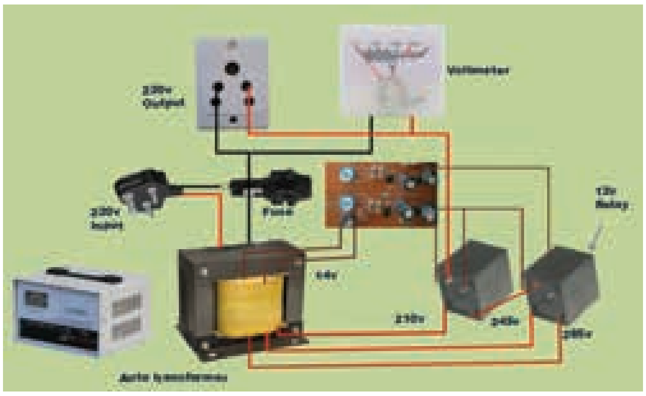


Fig 5



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- From the Instructor, get the list of expected working voltage at various test points of the Stabiliser.
- Connect a Variac/ Auto Transformer for providing variable AC input voltage to the Stabiliser, in order to test the buck boost operations of the Stabiliser.
- Switch ON the Stabiliser. Use multimeter to measure the voltage at various test points starting from the supply input to the Buck-boost Transformer and Input sensing section. Then from Control section through relays and Buck boost transformer to the output section.
- Record the observed voltages at each test point with necessary details in Table-2.
- Demonstrate the function of the Stabiliser in BUCK and BOOST MODES.
- To demonstrate the Buck function (high voltage to Low voltage) of the Stabiliser, increase the input AC voltage of the Stabiliser (more than 230V) upto 270V AC, using a VARIAC/ Auto Transformer to apply variable AC input.
- You will hear the relay switching sound (relay-1 acts as buck relay) and Buck boost transformer producing an ouput voltage equal to the PRESET VALUE, ie. 230V AC. [Buck means – high voltage to low voltage].
- To demonstrate the Boost function of the Stabiliser, decrease the Input voltage (less than 230V) to the stabilizer to 170V AC using a Variac. [Boost means – low voltage to high voltage conversion].
- Spontaneously you will hear the relay switching sound in the Stabiliser (relay-2 acts as boost relay) and the Buck boost transformer ouput voltage increasing to 230V.

Table 2

SI.No.	Name of the section	Test points	Observed Voltage
		Input 3 pin plug Line Filters Auto transformer Input terminals Input Sensing devices Op-Amp Comparator ICs Driver transistors Relay Output – both relays Integrated Circuit (IC) pins Trim PoT or Preset for voltage setting (ADJ) Input/ Output Voltmeter Input/ Output Fuses Protection circuits Auto Transformer output terminals	

- Record the observed input and output voltages (seen on panel meter of Stabiliser) in Table-3.

Table 3

Sl.No.	AC Input Voltage to the Stabiliser (from Variac)	Output Voltage observed on Panel meter of STABILISER	What is the Mode of Operation of Stabiliser - Buck / Boost
1	230 V	230V	Normal
2	250 V	230V	BUCK
3	270 V	230V	BUCK
4	170 V	230V	BOOST
5	210 V	230V	BOOST

- Repeat the exercise with various input voltages and update the result in Table-3.
- Get the work checked by the Instructor.

— — — — —

TASK 3: **Demonstrate the operation of an Automatic Digital / Solid State Voltage Stabiliser and measure the voltage at various test points**

1 Collect the Microprocessor controlled Stabiliser from the Instructor.

2 Open the system and identify the digital component (Microprocessor) present in this system.

3 Refer to Fig 6&7 to identify the scontrol circuit and the major components present and fill in the Table -4.

4 Measure the voltage at various test points of the Solidstate - Automatic Voltage Stabiliser.

5 Repeat the procedures mentioned in Task-1 and 2 to demonstrate the operation of a Microprocessor Controlled Stabiliser with Solid State IGBT Switches.

Fig 6

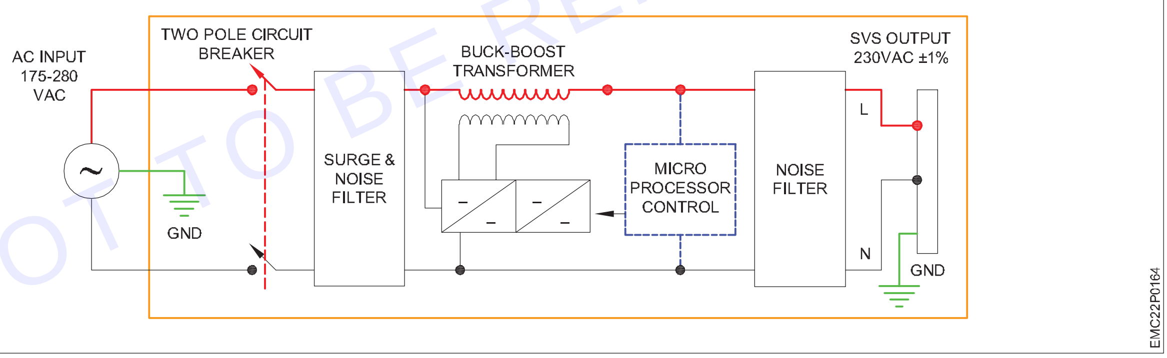


Fig 7

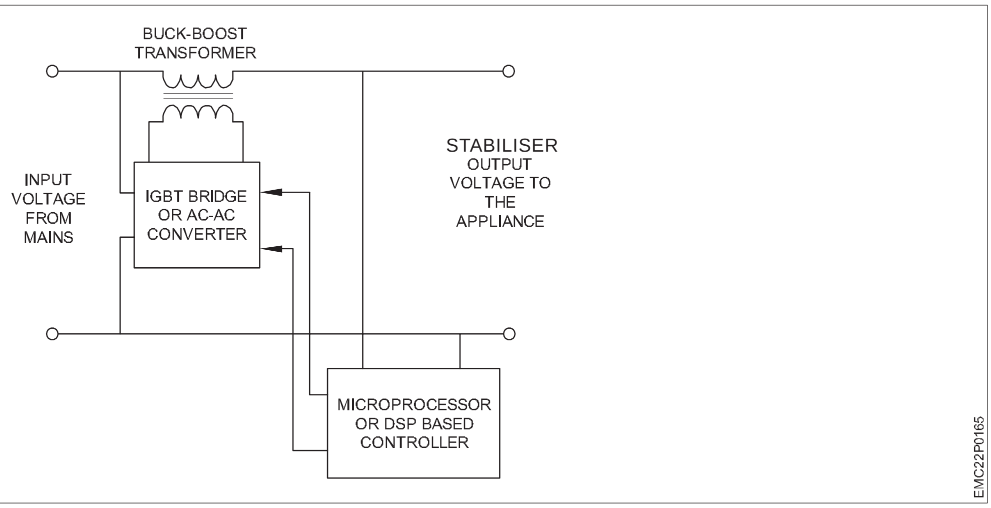


Table 4

Sl.No.	Components identified	Name of the devices	Function of the devices
1	Digital Components		
2	Major analog Components of Sensing, control and Output sections.		

6 Get the work checked by the Instructor.

— — — — —

EXERCISE 50: List the defect and symptom in the faulty SMPS

Objectives

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

- list the physical defects identified in the faulty SMPS (in cold condition) without Switching ON
- Switch On the SMPS and identify the symptoms.

Requirements

Tools/ Equipments/ Instruments

- Trainees tool kit with soldering iron - 1 Set.
- Multimeter with probes - 1 No.
- Goose neck table lamp - 1 No.
- Magnifying Lens - 1 No.
- A defective SMPS board of an electronic gadget/ Mobile phone charger - 1 No.
- Oscilloscope DSO 20 MHZ - 1 No.

Materials/ Components

- Spare components - as reqd.
- Resin cored solder - as reqd.

Safety Instructions:-

1 Disconnect the Mains power cord from SMPS before performing cold check.

2 Do not touch the SMPS - PCB with bare hand without discharging the DC Storage electrolytic capacitor.

3 Discharge the storage capacitor by using an incandescent-bulb connected with wires across the capacitor.

4 Do not use screw drivers to short the capacitor terminals for discharging static charge.

5 Measure the voltage across the big electrolytic Capacitor/ high voltage capacitor using DMM and ensure that it measures zero volts before proceeding for other tests.

Procedure

SMPS (Switch Mode Power Supply): A SMPS power supply transfers power from a source usually from an AC outlet to a DC device.

Linear regulators can provide regulated output only on buck mode, not on boost mode.

What makes the SMPS so special? It is the ability of SMPS to regulate the output voltage. It can decrease or increase the output voltage on Buck/ Boost modes to maintain a constant output regardless of changes in load. This dual ability gives it an advantage over linear regulators.

TASK 1: **List the defect in the faulty SMPS in cold condition**

1 Collect the faulty SMPS from the Instructor.

2 Note down the specifications on the cover of SMPS.

3 Remove the SMPS cover.

4 Do not power ON the SMPS unit for performing cold test.

5 Clean the PCB with ISO-Propyl alcohol solution and a brush.

6 Observe physically the condition of the PCB and the components–and list out the physical defects noticed as shown below:

- Charred / Smoke smell on PCB.
- Any component like resistor, diode, black (or) charred/ damage.
- Capacitor top bulged (or) not.
- PCB board darkened due to short/ PCB board damaged.
- Wire broken
- PCB track cut
- Connector broken
- Dry Soldering
- Switching transistor blown
- Fuse blown.

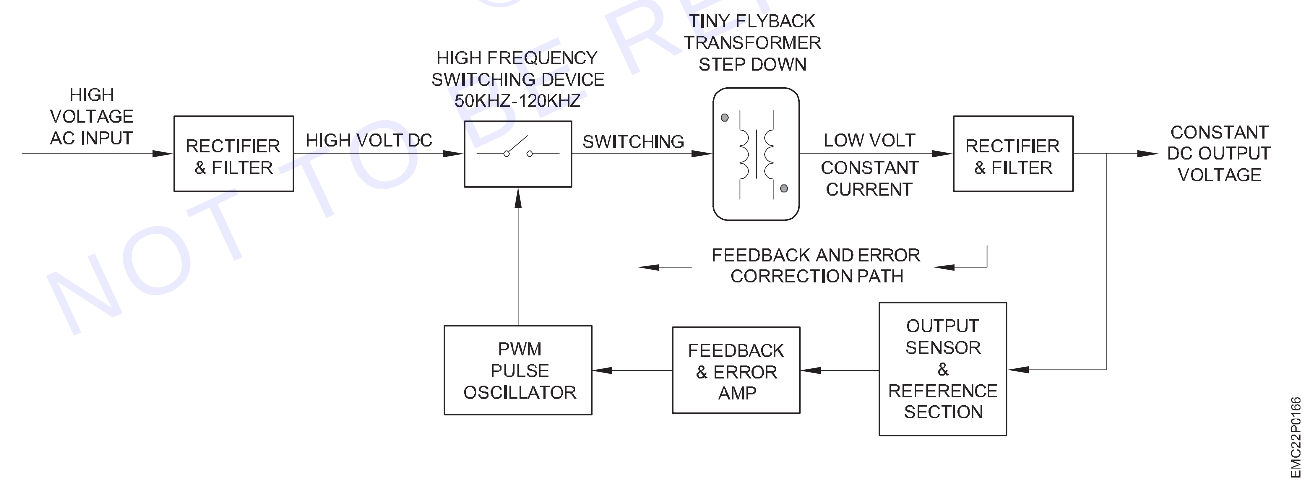
7 If any of the above defect is identified in the SMPS board, then record it in the Table-1 below.

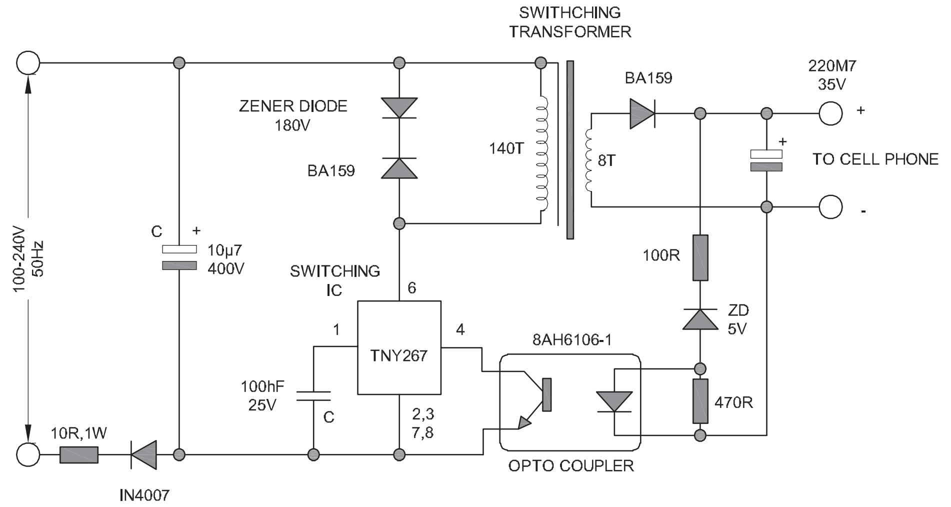
8 Get the work checked by the Instructor.

Table 1

Sl.No.	Faults noticed	Defective component	Remarks

SMPS BLOCK DIAGRAM SWITCHED MODE POWER SUPPLY





SMPS CELL PHONE CHARGER CIRCUIT

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TASK 2: **List the symptom and defect in the faulty SMPS in warm condition**

1 If there is no defective component identified during the above task, then perform warm check of SMPS unit/ PCB board.

2 For performing warm check, power ON the SMPS unit.

3 Check the output voltage of SMPS using DMM.

4 If there is no output voltage, then trace back and measure the voltages at various test points.

5 If any component voltage appears abnormal, then note down the details of the defective component in the Table -2 below.

6 Sample symptoms and faults have been shown in Table-2 below. Fill the table with the symptoms noticed and faulty components identified.

Table 2

Sl.No	Symptoms noticed	Faulty component	Remarks/ Reason
1	No output in SMPS	Switching device - Mosfet defective	
2	No output in SMPS	Weakened diode in input bridge rectifier	
3	No output in SMPS	Control circuit IC voltages are abnormal	
4	No output in SMPS	Input section capacitor filter leaky.	

7 Repeat the above procedure to check the other SMPS boards.

8 Get the work checked by the Instructor.

— — — — —

EXERCISE 51: Measure/ Monitor major test points of computer SMPS

Objectives

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

- Dismantle the SMPS unit from CPU cabinet and identify various devices/ components of SMPS unit and draw the symbols
- Identification of type of connectors in SMPS unit
- Measure & monitor major test points.

Requirements

Tools/ Equipments/ Instruments

- ESD wrist band - 1 No.
- Trainees tool kit - 1 Set.
- Digital multimeter with probes - 1 No.
- SMPS unit used in personal computer - 1 No.
- Sketch pen - 1 No.
- Aids: Chart showing Major sections of SMPS - 1 No.
- Chart showing all types of connectors used in SMPS of PC - 1 No.

Safety precautions:-

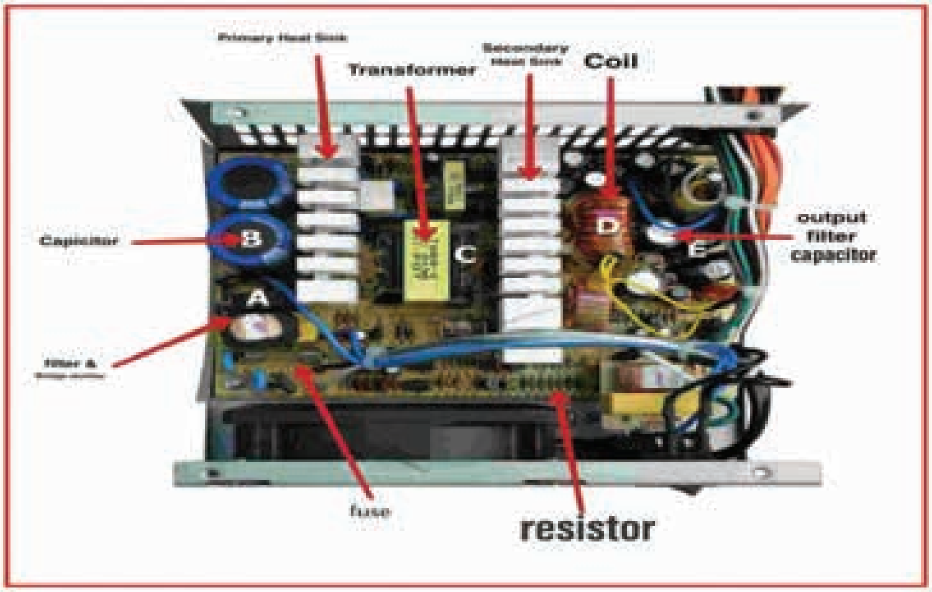
1 Ensure the power cord is removed from the SMPS.

2 Before opening CPU cabinet, touch the cabinet outer cover by wearing wrist band to discharge ESP.

Procedure

TASK 1: **Dismantling the SMPS unit from CPU cabinet and identification of sections**

- Disconnect the power cord from the mains and CPU before removing SMPS unit.
- Identify the location of wires with colour codes coming out of SMPS unit as shown in Figure.
- Note down the connections of SMPS to various sections of mother board and other devices inside the CPU, apply tags with label for each connector.
- Draw the layout of mother board and mark the sections/ location of connectors with label number.



Note:

1 **The Instructor may prepare Charts before commencing demonstration on SMPS. One Chart for various sections of SMPS unit with test points marked on it and another for the Connectors present in SMPS unit and pin details/ voltages for each.**

2 **The instructor has to label the major components / devices in each section of the SMPS before issuing to the trainees for this task.**

3 **Keep the removed screws separately for fixing SMPS and covering the CPU after completion of work.**

- Remove/ Unplug the connectors from HDD, DVD, FAN and Mother board carefully.
- Unscrew the fixing screws and remove the SMPS unit from the CPU cabinet and open it as shown in Figure.
- Draw the layout of the SMPS unit and identify the sections and major components of the given SMPS unit.
- Mark the sections and Major components/ devices with a sketch pen.
- Record the name of the major sections and major components identified in Table - 1.

Table 1

Sl. No.	Label No.	Name of the section	Name of the component	Main function of the component or device

- Get the practical work checked by the instructor.

— — — — —

TASK 2: **Identification of type of connectors in SMPS unit**

Note: The instructor has to label the connectors of the SMPS unit before issuing to trainees for this task.

- Refer to the SMPS layout diagram prepared in Task-1 and Figure, to identify the name of the connectors and purpose of using them in the computer.
- Record the name of the connector, type and number of pins in Table-2.
- Note down the shape and pin configuration of each connector.
- Also note down the voltage details for each connector with colour code of the wires.
- Repeat the steps for all the labelled connectors.

Table 2

Sl.No.	Name of the connector	Connector - Voltage details	Type of connector & no. of pins / connector	Connected to which section/ device	Purpose

- Get the practical work checked by the instructor.

— — — — —

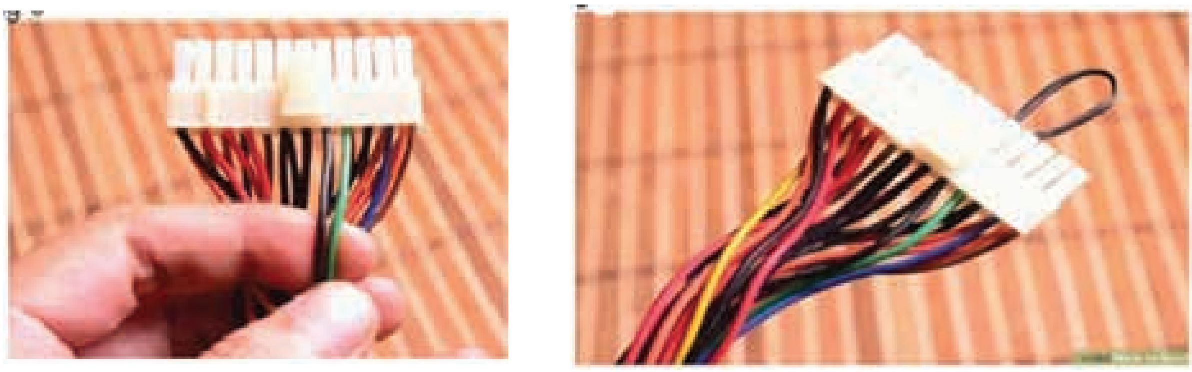
TASK 3: **Preparation of computer SMPS unit for voltage measurements**

Note:

1. **The Instructor should make use of the Charts prepared for SMPS unit, before commencing demonstration on SMPS. One Chart should contain various sections of SMPS unit with test points marked on it and the major components/ devices labelled in each section.**
2. **Another Chart for the Connectors present in SMPS unit with Name and pin Configuration and their corresponding voltage details for each connector.**

1 Identify the green colour wire at pin.No.8 (power good / power OK signal) from the bunch of wires on the 24 pin ATX connector as shown in Figure.

2 Use a piece of hookup wire, bend it as 'U' shape, and connect it across the green and black wire terminals as shown in Figure.



3 Connect the power cord to the SMPS unit and switch ON power.

4 Check whether the SMPS exhaust fan is running to confirm the working of SMPS unit.

5 If fan is not rotating, remove the hook up wire, check the fan if it is stuck/ not clean. Ensure that it is physically rotating freely.

6 Check whether SMPS power cord is good.

7 To confirm it, remove the power cord from Mains and SMPS and check continuity using Multimeter.

8 Check Continuity between one end to other end of the power cord.(Ph to Ph, Neutral to Neutral and Earth to Earth).

9 If power cord is good, connect it and switch ON the power.

10 Re-insert hook up wire between Power good pin and GND(as mentioned in step-2).

11 Ensure that fan is working now.

12 Get the work checked by the instructor.

— — — — —

TASK 4: **Measuring/ monitoring voltages at various test points**

1 Switch ON SMPS supply and measure the DC voltages across the P-4 connector (4 pin power connector shown in Figure) and record the readings in Table-3.

Table 3

Sl. No.	Description	Wire colour	Measured voltage
1	Ground	Black	
2	Ground	Black	
3	+12 VDC	Yellow	
4	+12 VDC	Yellow	

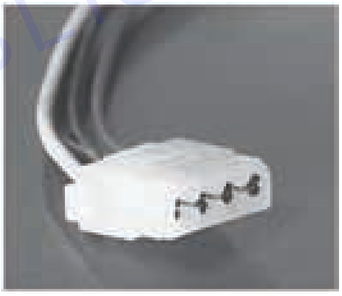
2 Refer to the chart showing voltages at various test points on 20+4 pins ATX connector and record the observations in Table-4.

Table 4

Sl. No.	Wire colour	Description of pin detail/ function	Measured voltage	Remarks
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

3 Refer to the chart details and measure test point voltage at the 4 pin molex peripheral connector and record observation in Table-5.

PIN description of the 4-PIN molex peripheral connector (Table 5)

Pin	Name	Wire colour	Description/ Voltage Level	Measured Voltage	
1	12V DC	Yellow	+12 VDC		
2	GND	Black	Ground		
3	GND	Black	Ground		
4	+5V	Red	+5 VDC		

Note: The instructor has to guide the trainees to measure voltage at additional connectors for SATA, Aux power connector etc. with preparation of suitable tables to record measurements according to the SMPS model available in the section.

AC input voltage measurement (at the mains socket)

Sl. No	Parameters to measure	Voltage (AC)	Remarks
1	Phase to neutral voltage		
2	Phase to earth		
3	Neutral to earth		

Chart showing voltages at various connectors of SMPS units of personal computer system - Table

Pin	Name	Colour	Description/ voltage level	Measured voltage
1	3.3V	Orange	+3.3 VDC	
2	3.3V	Orange	+3.3 VDC	
3	COM	Black	Ground	
4	5V	Red	+5 VDC	
5	COM	Black	Ground	
6	5V	Red	+5 VDC	
7	COM	Black	Ground	
8	PWR_OK	Grey	Power Ok is a status signal generated by the power supply ON, disconnect from GND to switch OFF.	
9	5VSB	Purple	+5 VDC Standby voltage (max 10mA)	
10	12V	Yellow	+12 VDC	
11	12V	Yellow	+12 VDC	
12	3.3V	Orange	+3.3 VDC	
13	3.3V	Orange	+3.3 VDC	
14	-12V	Blue	-12 VDC	
15	COM	Black	Ground	
16	PS_ON	Green	Power supply on (active low), short this pin to GND to switch power supply ON, disconnect from GND to switch OFF.	
17	COM	Black	Ground	
18	COM	Black	Ground	
19	COM	Black	Ground	
20	-5 V	White	Ground	
21	+5V	Red	+5 VDC	
22	+5V	Red	+5 VDC	
23	+5V	Red	+5 VDC	
24	COM	Black	Ground	

PIN description of the P-4 power cable connector

Pin	Name	Colour	Description/ Voltage Level	Measured Voltage	
1	GND	Black	Ground		
2	GND	Black	Ground		
3	12V DC	Yellow	+12 VDC		
4	12V DC	Yellow	+12 VDC		

20+4 PINS ATX CONNECTOR

Pin Number	Pin Name	Description
1	+5V	
2	GND	
3	+5V	
4	GND	
5	PG	+5V When power good
6	+5V STB	Stand-by power
7	+12V	
8	-12V	
9	GND	
10	GND	
11	PWR_ON	Connect to ground to power on
12	GND	
13	GND	
14	GND	
15	-5V	
16	+5V	
17	+5V	
18	+5V	
19	TFSC	Thermal Fan speed control.
20	+5V	

4 Get the work checked by the instructor.

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EXERCISE 52: Troubleshoot the fault in the given SMPS unit, rectify the defect and verify the output with load and use SMPS used in TVs and PCs for practice

Objectives

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

- discharge the filter capactior
- identification of fault (fuse blown) in SMPS through physical inspection
- find the probable symptoms of the given faulty SMPS
- identification of the short circuited components using different methods
- performing load test of SMPS.

Requirements

Tools/ Equipments/ Instruments

- ESD work bench - 1 No.
- Safety gloves - 1 No.
- Trainees tool kit - 1 Set.
- Digital multimeter with probes - 1 Set.
- LCR Meter - 1 No.
- SMPS Unit - 1 No.

Materials/ Components

- 100 watt/ 230V bulb with holder - as reqd.
- Wire wound resistor (1.8K or 2.2K/ 10W) - as reqd.

Safety precautions:-

1 Keep the place dry and clean.

2 Do not touch the PCB with bare hands immediately after removing the SMPS from PC.

3 Make sure you conduct this test on a table with yourself standing on a rubber mat or use an insulated material on the table to avoid static electricity destroying the computer peripherals.

4 Please note that some connections of the SMPS connectors contain a clip attached to it. Make sure to remove the clips before removing the connection.

Procedure

TASK 1: **Discharging the filter capacitor**

A Discharge using bulb method

1 Dismantle the SMPS by referring to the procedure given in the previous exercises.

2 Connect 100 watt bulb wire across the leads of the capacitor as shown in Fig 1 & 2. Filter capacitors will be discharged

B Discharge using resistor Method

1 Take a High wattage Low ohms wire wound resistor with proper insulated lead.

2 Use the resistor lead to short the capacitor to discharge as shown in Fig 3.

3 Use either a 1.8 K or a 2.2 K ohm 5 to 10 watt resistor to discharge the high voltage capacitor.

4 Get the work checked by the instructor.

Make sure the power cord is removed from the SMPS to avoid Electrical shock.

Fig 1

Fig 2

Fig 3

TASK 2: **Find the probable symptoms of the given faulty SMPS**

1 Observe the symptoms noticed in the defective SMPS in ON condition and determine which section or junction could be faulty.

2 Ref to the Chart on Faults, Probable causes and remedy given below and prepare a list of symptoms noticed in your defective SMPS unit.

Chart on Faults, Probable causes and remedy

Sl. No.	Faults	Cause	Remedy
1	SMPS dead, fuse blown	Shorted switching transistor or semiconductors, power cord defective, or switch, open fusible resistor, other bad parts. Actual cause of failure may be power surge/ brownout/ lightning strikes, random failure, or primary side electrolytic capacitor (s) with greatly reduced capacity or entirely open	Test the switching transistor Or semiconductor switch. If it fails replace it. If the semiconductor switch is good, check and replace the primary diodes. Replace the fusible resistor.
2	Supply dead, fuse not blown	Bad startup circuit - open startup resistors or open fusible resistors due to shorted semiconductors, bed controller components.	Test the switching transistor or semiconductor switch. If it fails replace it. Replace the fusible resistor
3	Supply mostly dead or takes a long time to come alive	Bad electrolytic capacitors. Visually inspect for capacitors with bulging tops or that have leaked.	If any one bad capacitor is found replace all electrolytic capacitors.
4	More ripple at the line frequency (50/ 60 Hz) or twice the line frequency (100/ 120 Hz)	Dried up main filter capacitor(s) on rectified AC input	Check the filter capacitor and replace it

5	No output supply and 300V persists in the filter capacitor after switching OFF the supply	Switching transistor or semiconductor switch short and fusible resistor or starting resistor open.	Test the switching transistor or semiconductor switch. If it fails replace it.
6	SMPS output is low	If SMPS gives low voltage output then the fault is mostly in the error amplifier, and oscillator stage. Output loading may also affect the output voltage some time	Measure voltages and compare them with normal voltage given circuit diagram. Probable parts may be faulty zener diode in the error amp, Faulty control circuit parts, transistor, IC, opto-coupler faulty.
7	SMPS output is high	If SMPS output is high first shut down set. Fault in the error amplifier, IC, oscillator section of SMPS.	Check fault either in switch off condition or by giving input supply through a variac or low voltage transformer.
8	Combusted coil	A winding coil is present on the board which sometimes gets burnt due to excessive flow of current.	This problem can be identified easily by the smell or you can identify through the burnt marks located on the external section of the winding coil. It may be possible that internal loop is damaged.

Note: In all cases, bad solder connections are a possibility as well since soldering to the component pins may not always be perfect. An excessive load can also result in more heat getting developed in the circuit and affecting the components and causing dry solder joints.

3 Get the work checked by the instructor.

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TASK 3: **Identification of fault (fuse blown) in SMPS through physical inspection**

1 The SMPS board from the CPU cabinet may be similar to the one shown in Fig 4 or 5.

Fig 4

Fig 5

2 In the above task, after identifying the symptom in your SMPS unit, identify the faulty section and component.

3 Make sure that the electrolytic capacitors on the high voltage side are discharged.

4 Remove the fuse from its holder as shown in Fig 6 and check for continuity.

5 Fig-7 shows the fuse wire blown and hence the circuit is open .

Fig 6

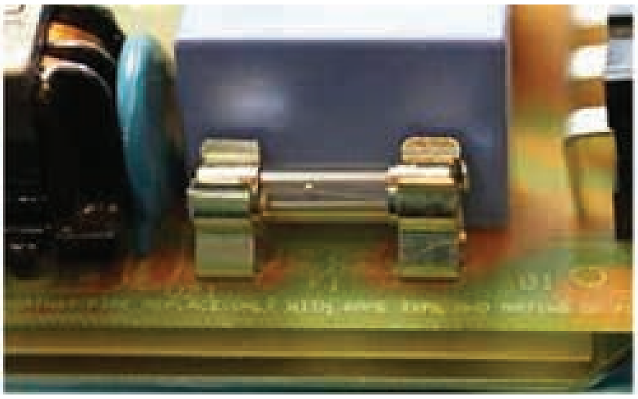


Fig 7

6 Look at the fuse carefully if any dark or metallic smear is seen inside the glass as shown in Fig 8.

Fig 8

7 If any of the above faults are found in the fuse, then replace the fuse (same current rating)with new one.

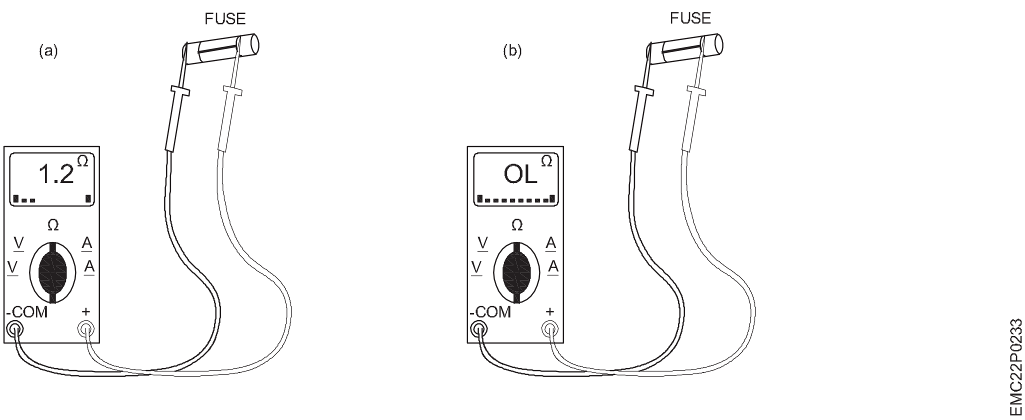
8 If there is no colour change seen in fuse then verify its condition with a DMM.

9 Set the DMM to the continuity mode as shown in Fig 9(a) and test.

10 If the meter shows continuity, then the fuse is good.

11 If the multimeter reading is OL(Over Limit) as shown in Fig 9(b), then the fuse is blown. If the fuse is blown, replace the fuse with new one, having the same current rating.

Fig 9



12 Record your observations in table 1.

13 Get the work checked by the instructor.

Table 1

Fuse condition/ physically noticed	Fuse Good/ Bad

— — — — —

TASK 4: **Identification of the short circuit fault by connecting bulb across fuse holder**

1 Connect the 100W bulb across the fuse holder as shown in Fig 10.

2 Power ON the SMPS unit.

3 The bulb should initially glow bright then gradually turn off if no other component is defective in the unit.

4 The light bulb should glow bright even after you have waited for couple of minutes as shown in Fig 11, which indicates that there is problem in the SMPS.

Fig 10

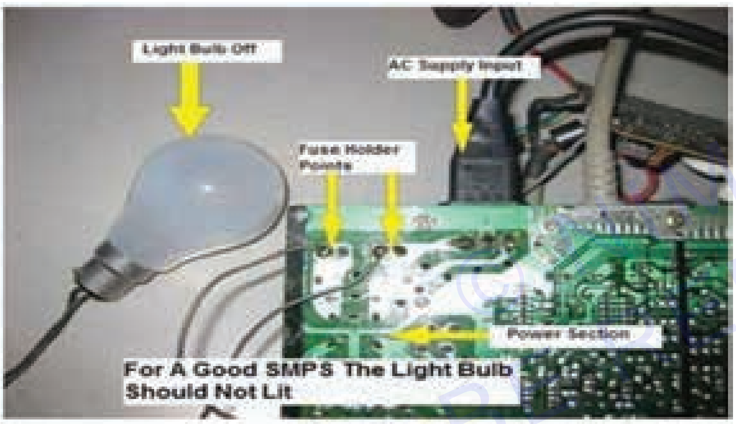
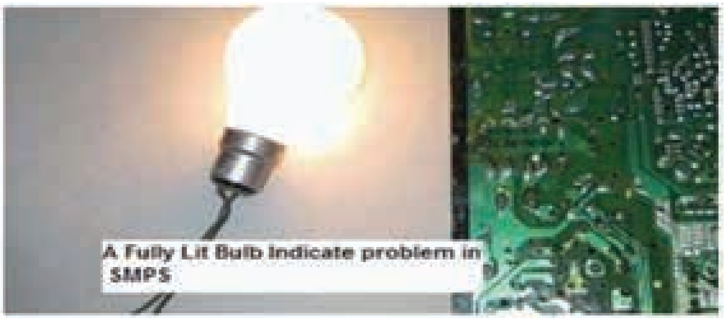


Fig 11



A It shows that there is a faulty/open device.

Note: In a normal working SMPS, where regular charging and discharging of the electrolytic Capacitors in the circuit takes place, more charge does not get stored/developed in Electrolytic capacitors (found in the input rectifier cum filter section and output section of SMPS). Hence if you perform Lamp test across the fuse or capacitor, bulb does not glow. (when current flow is more through the fuse, voltage drop is negligible.)

When there is an open circuit, the charge stored in capacitor remains as it is, as there is no discharging path. Hence if you perform Lamp test, the light bulb will glow brightly as shown in Fig 8. and slowly goes OFF, which indicates that there is problem in the SMPS.

1 Switch off the AC mains & record your observation in table 2.

2 Repeat the procedure for other SMPS boards.

3 Get the work checked by the Instructor.

Table 2

Observed bulb ststus	SMPS status

B Identification of the fault due to short circuited components using Resistance mode/diode mode.

1 Set the DMM to resistance mode.

2 A resistor becomes open when over current passes through it or gets short circuited.

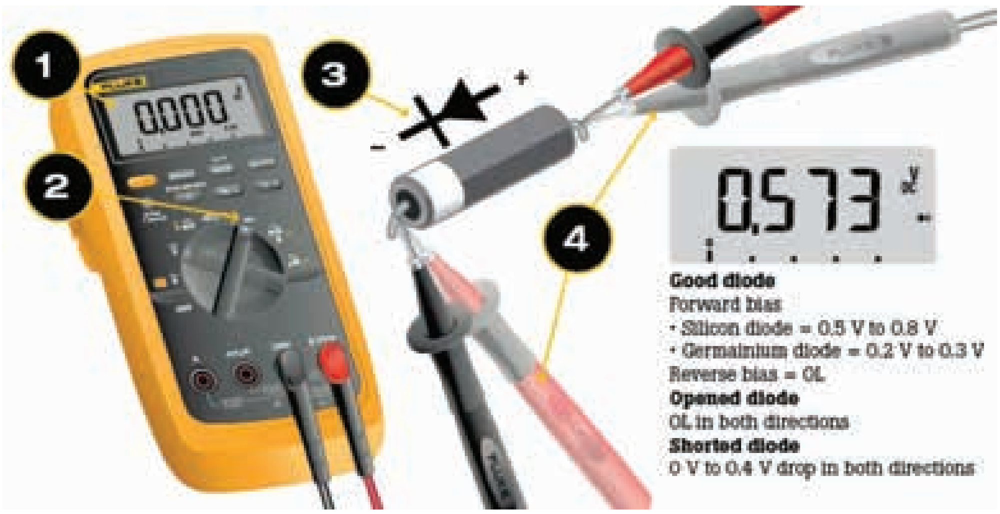
When a MOV switches ON or is triggered by a high voltage surge it shorts the voltage spike across its terminals, preventing it from entering the vulnerable electronic device attached on the other side. This action protects the electronic circuit from such accidental voltage surges and transient spikes.

3 A MOV or Varistor is normally found in input circuit of SMPS for surge protection. It becomes open circuited when accidental surge voltage appears at the mains input.

4 Check all the active components namely diode, transistor, MOSFET, optocoupler etc in diode mode and passive components namely resistors, MOV, etc in resistance mode.

- A good forward-based diode displays a voltage drop ranging from 0.5 to 0.8 volts for the most commonly used silicon diodes. Some germanium diodes have a voltage drop ranging from 0.2 to 0.3 V.
- The multimeter displays OL when a good diode is reverse-biased. The OL reading indicates the diode is functioning as an open switch.
- A bad (opened) diode does not allow current to flow in either direction. A multimeter will display OL in both directions when the diode is open/ defective.
- A shorted diode has the same voltage drop reading (approximately 0.4 V) in both directions.
- A multimeter set to the Resistance mode (Ω) can also be used as an additional test for checking diodes and transistors.
- The forward-biased resistance of a good diode should range from 5000 or higher.
- The reverse-biased resistance of a good diode is very high and is indicated as an open OL on a multimeter.
- The diode is bad if readings are same in both directions.

Fig 12

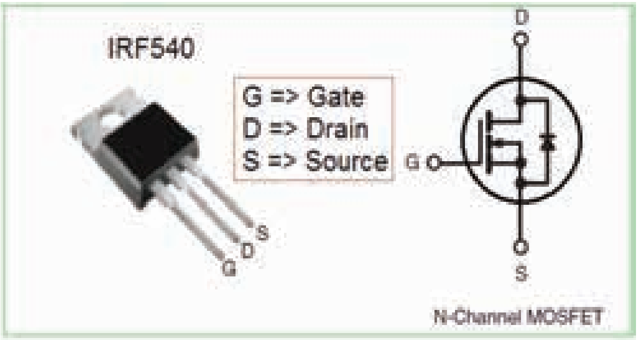


5 If any one of the active component, say a diode/ transistor /MOSFET shows same reading (forward and reverse directions) on both directions, then the component is defective.

6 If the multimeter reads low forward resistance and high reverse resistance across the diode or transistor, then the component is good.(Checking in resistance mode).

7 A MOSFET is normally checked in diode mode.

Fig 13



To test a MOSFET, assume an N-channel MOSFET. For example, IRF 540 has 3 terminals namely Gate, drain and Source. Set the DMM in diode mode.

In a MOSFET, gate to source junction is insulated and acts like a capacitor. A MOSFET can be controlled from Gate terminal. There is channel formation within the device between Drain and Source regions. To check its function, initially short all the three terminals with a probe or with fingers. The Gate-Source capacitance discharges and no charge remains in the MOSFET channel (Drain-Source Channel). Now apply voltage to Gate Source junction by connecting the positive probe to Gate and Negative probe to source. Measure the drop across Drone and source. A small drop w

8 Record your observations in table 3.

Table 3

Sl. No.	Probable defect	Tick

9 Get the work checked by the instructor.

C Isolation method:

1 Identify the B+ve and B –ve terminals of the Buck/Boost sections and break/disconnect the B+ line from the circuit as shown in Fig 14

2 Connect the 100 W bulb between the B+ line to cold ground.

3 Power ON and verify the bulb glowing condition.

4 There are five possibilities that can be expected from the light bulb.

   a The light bulb lit with a constant brightness and all of the output voltage measured normal at the secondary side this indicates the SMPS is working fine and the cause of the power problem in the load side. It maybe fly back transformer, yoke coils etc.

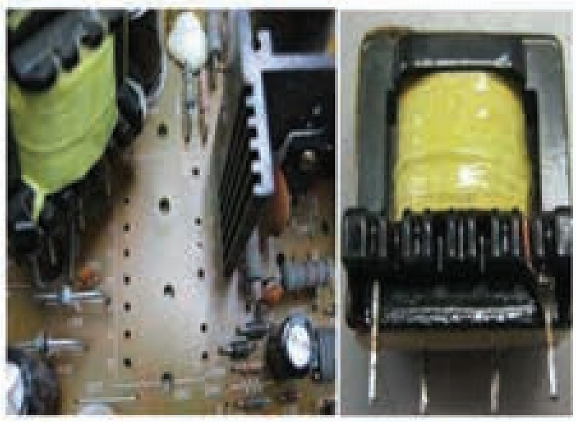
   b No light from the light bulb and no voltage measured at the output of the power supply, this indicates the problem is in the SMPS.

c The light bulb glows intermittently this could indicate components failure in the power supply like bad filter capacitor ,current sense resistor higher ohm, etc. (value would have been increased)

d The light bulb become extra bright and all the output voltages have increased .this indicates the problem is in the regulation circuit like an open resistor in feedback circuit , bad opto isolator IC faulty TLC431 IC, etc.

e The light bulb keeps cycling (continuously ON and OFF). This could indicate problem in the SMPS area and it can also mean the OPTO IC is sending an Error signal to the primary circuit of power supply through opto isolator IC causing the power supply to cycle.

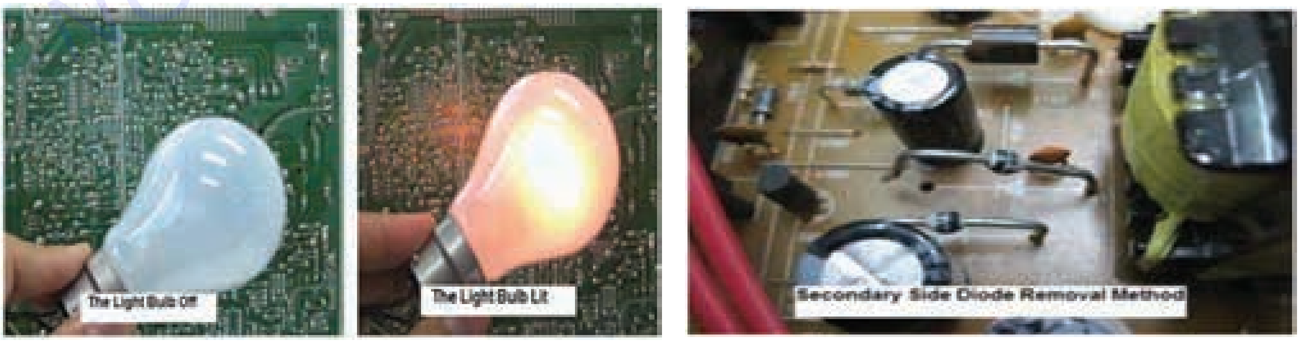
Fig 14



5 Record the observation in the table 4.

Table 4

Sl. No.	Probable defect	Tick



D Capacitor checking

1 Disconnect the power cord.

2 Discharge the main (large) capacitor.

3 Test the healthiness of diodes and capacitors at secondary section using multimeter.

4 Open the lead of capacitor and measure capacitance using LCR meter.

5 Apply the supply to board and check the output voltage without capacitor.

6 If the output voltage is less (or) no output measured, then fault may be in capacitor.

7 Switch OFF the supply and replace the capacitor.

8 Switch ON the supply and check the output voltage.

9 Record the observation in table 5.

Table 5

Measured output voltage	
Without capacitor	**With capacitor**

10 Get the work checked by the instructor.

Note: To confirm fault with switching transistor check the charge voltage across big filter capacitor in the input section. (After switching OFF the SMPS).

- **If the capacitor shows voltage considerably then the fault could be in the switching transistor.**
- **If the capacitor shows No voltage then the fault could be in some other components/ section.**

— — — — —

TASK 5: **Performing load test of SMPS**

1 Connect the circuit as shown in Fig 15 across 5V terminals.

2 Keep the rheostat in max resistance position.

3 Power ON the circuit.

4 Increase the current in steps of 200mA, note down the corresponding voltage and tabulate the reading in the table 6.

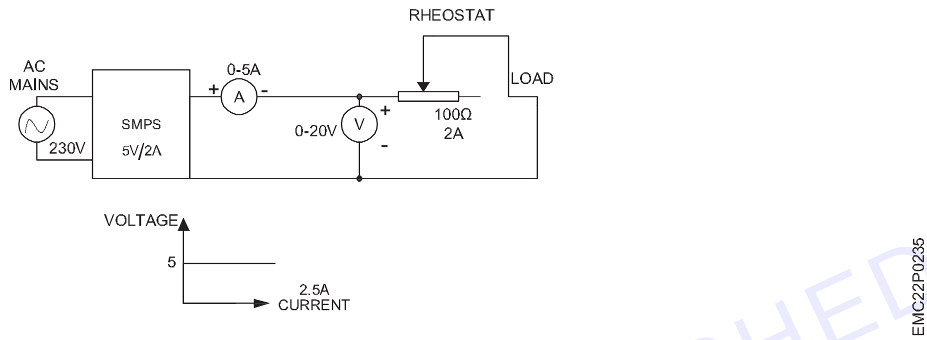
5 Observe that even when the current is varied by the load, the output of SMPS remains constant at the rated voltage.

6 Trainee should get the work checked by the instructor.

Table 6

Sl. No.	Load current(mA)	Voltage(V)

Fig 15



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EXERCISE 53: Install and test an Inverter

Objectives

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

- Connect the external battery to the inverter unit and test the inverter.

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Digital Multimeter with probes - 1 No.
- Line tester - 1 No.
- Hand gloves - 1 Set.
- Double ended spanner - as reqd.
- Inverter - 1 No.
- Battery, 12V, 150AH - 1 No.

Materials/ Components

- 240V/16A, SPST switch - 2 Nos.
- 240V/16A, 3Pin socket - 2 Nos.
- Connecting wires - as reqd.
- 100W/240V test lamp - 1 No.

Safety precaution:-

- Do not make contact with both the battery terminals simultaneously with metal parts like screw driver, spanners and bare hand.
- Heavy Sparking may occur during connection of battery cables to battery terminals.
- Use only the battery cables provided with the inverter unit to connect the external battery.

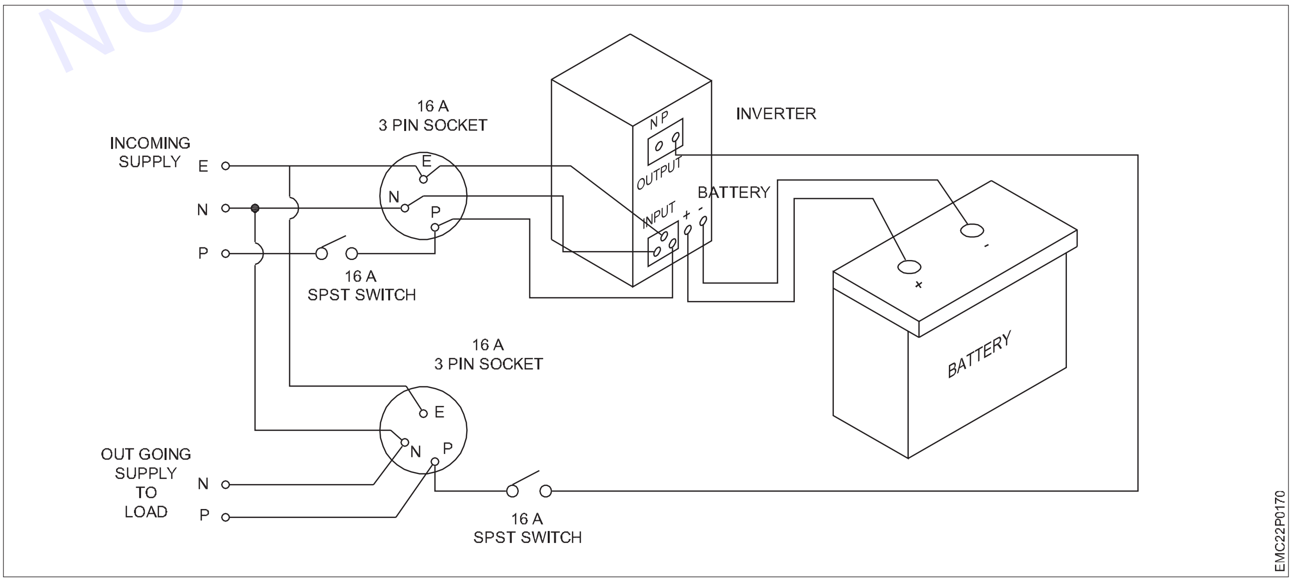
Procedure

TASK 1 : **Connection of the external battery to the inverter unit**

1 Read the user manual of the given inverter unit and check the capacity of battery given for inverter.

2 Identify the colour code used for the battery cables and polarity marked on the terminals of the battery

3 Connect the red and black colour cables of the Inverter's battery input terminals (battery input to the Inverter unit) to the +Ve and–Ve terminals of the Battery respectively one by one and tighten the connections with bolt & nuts as shown in Fig 1 carefully.



4 Use double ended spanners to tighten the bolt & nuts .

5 Connect a Computer and a lamp (as load to the Inverter) to the Inverter output terminals with an extension board before testing Inverter.

6 Get the connections checked by the Instructor.

— — — — —

TASK 2 : **Testing the inverter by connecting to mains power and load**

1 Measure the voltage across the battery terminals; record the readings in Table-1.

2 Connect the AC mains supply to the inverter unit through 16A, switch & socket by referring to Fig.1

3 Connect the power cord of the inverter to the AC mains supply, switch ON and measure the DC voltage across battery terminals; record the readings in Table-1.

Note: Ensure that battery terminals are connected properly with correct polarity to the Inverter and Load is also connected to Inverter output .

Then switch ON the 230V AC mains voltage and UPS. As battery will start charging from mains voltage. When load is connected and ON, there will be smooth charging and discharging of the battery without battery sparking.

Ensure that the inverter start/Run switch is in OFF condition before doing output connection.

4 Connect the test lamp across the output terminals, switch ON the UPS and observe the lamp is glowing.

5 Measure the AC voltage across the output of UPS, the DC voltage across the battery and record the readings in Table.

6 Switch OFF AC mains and measure output voltage battery voltage and record the readings in Table -1

Table 1

AC input supply			AC output supply			Battery voltage			
P-N	P-E	N-E	P-N	P-E	N-E	UPS OFF AC OFF	UPS OFF AC ON	Load ON AC ON	Load ON AC OFF

7 Get the work checked by the Instructor and Switch OFF the UPS.

— — — — —

EXERCISE 54.1: Troubleshoot the fault in the given inverter unit, rectify the defects and verify the output with load

Objectives

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

- identify the faulty components/section in the inverter & rectify the defects in the inverter unit
- Verify the output with load.

Requirements

Tools/ Equipments/ Instruments

• Trainees tools kit	- 1 Set.
• Defective inverter with battery	- 1 No.
• Digital multimeter with probes(DMM)	- 1 No.
• Magnifying glass	- 1 No.
• Oscilloscope, 60 MHz	- 1 No.
• Test lamp with 230V, 100W bulb	- 1 No.
• Soldering /desoldering station	- 1 No.
• PCB cleaning brush	- 1 No.

Materials/ Components

• Spare components for replacement	- as reqd.
• IPA solution	- 1 No.
• Soldering lead (60/40)	- as reqd.
• Soldering flux / liquid flux	- as reqd.
• Sketch pen	- 1 No.

Procedure

TASK 1 : **Identification of the faulty components /section in the inverter and rectifying the faults**

1 Collect the defective Inverter unit from the Instructor.

2 Switch On the Inverter unit.

3 If Inverter output is not present, press the reset button available in the Inverter front panel.

4 Resetting the inverter as mentioned above can clear the temporary faults, sometimes.

5 Check battery voltage and record it in table-1.

Note: A low battery fault in an inverter is a common issue that can interrupt the power supply and potentially damage the battery or the inverter, if battery is not checked regularly.

Preventive measures:

1 Regular Maintenance: Regularly check and maintain the battery and connections. Ensure that all connections between the battery, inverter and charger are secure and free from corrosion.

2 Proper Charging: Ensure that the battery is charged regularly and appropriately.

3 Load Management: Avoid overloading the inverter to prevent rapid battery discharge.

4 Monitor Battery Health: Use battery management systems (BMS) or monitoring tools to keep track of battery health and performance.

5 Environment Control: Keep the battery in a stable environment, avoiding extremes in temperature and humidity.

6 If battery voltage is very low, then first add distilled water to the lead-acid battery and put it on charging.

7 If there is no improvement in battery charging, then remove and replace the defective battery.

8 If battery is good, then check battery charger output voltage at the terminals and record it in table-1.

9 If charger function and output voltage are good, then Power On the Inverter.

10 If Inverter output is still not getting ON, then switch OFF the Mains input.

11 Disconnect battery input to Inverter and Inverter output to load.

12 Open the Inverter cover and carry out the visual inspection of the inverter board with the help of magnifying glass and connectors.

13 Identify if any damaged components or connectors are seen and record in Table-1.

14 Remove the damaged component and check with DMM to ensure the fault.

Table 1

Sl.No	Fault noticed	Defective component

15 A simple Inverter circuit diagram has been shown in Fig-1 for your reference.

16 Trace the Inverter circuit by referring to the user manual and identify the sections.

17 Mark the different test points by using sketch pen.

18 Connect the Battery to the inverter unit and Switch On the mains input, measure voltage at marked test points.

19 Observe the waveforms using CRO at switching the devices and measure the output voltages of switching transformer using DMM.

20 Record the measured readings in the table-2.

21 Get the work checked by the Instructor.

Table 2

Section	Test point	Description	Voltage
Battery	TP1	Battery voltage	
Inverter	TP2 TP3	Inverter feedback voltage from inverter output transformer Rectified feedback DC voltage	
PWM section	TP3 TP5	Sensed DC Voltage to PWM section Trigger pulse from PWM IC to upper switching device (AC)	
Switching section	TP7 TP8	Output AC waveform of upper switching device (AC) Output AC waveform of lower switching device (AC)	
Inverter output	TP9	Inverter output voltage (also observe output waveform)	

Common Causes

1 Low Battery Charge: The most common cause is simply that the battery has discharged below the minimum voltage level required by the inverter.

2 Aging Battery: Batteries lose their capacity over time, and an old or deteriorated battery may not hold a charge well.

3 Loose or Corroded Connections: Poor connections between the battery and the inverter can cause voltage drops.

4 Excessive Load: Drawing too much power from the inverter can deplete the battery quickly.

5 Faulty Charger or Charging Circuit: A malfunctioning charger can prevent the battery from reaching a full charge.

Troubleshooting Steps:

1 Inspect Connections: Reduce Load: Disconnect some of the loads to see if the inverter operates without fault. This can help identify if the load is too high.

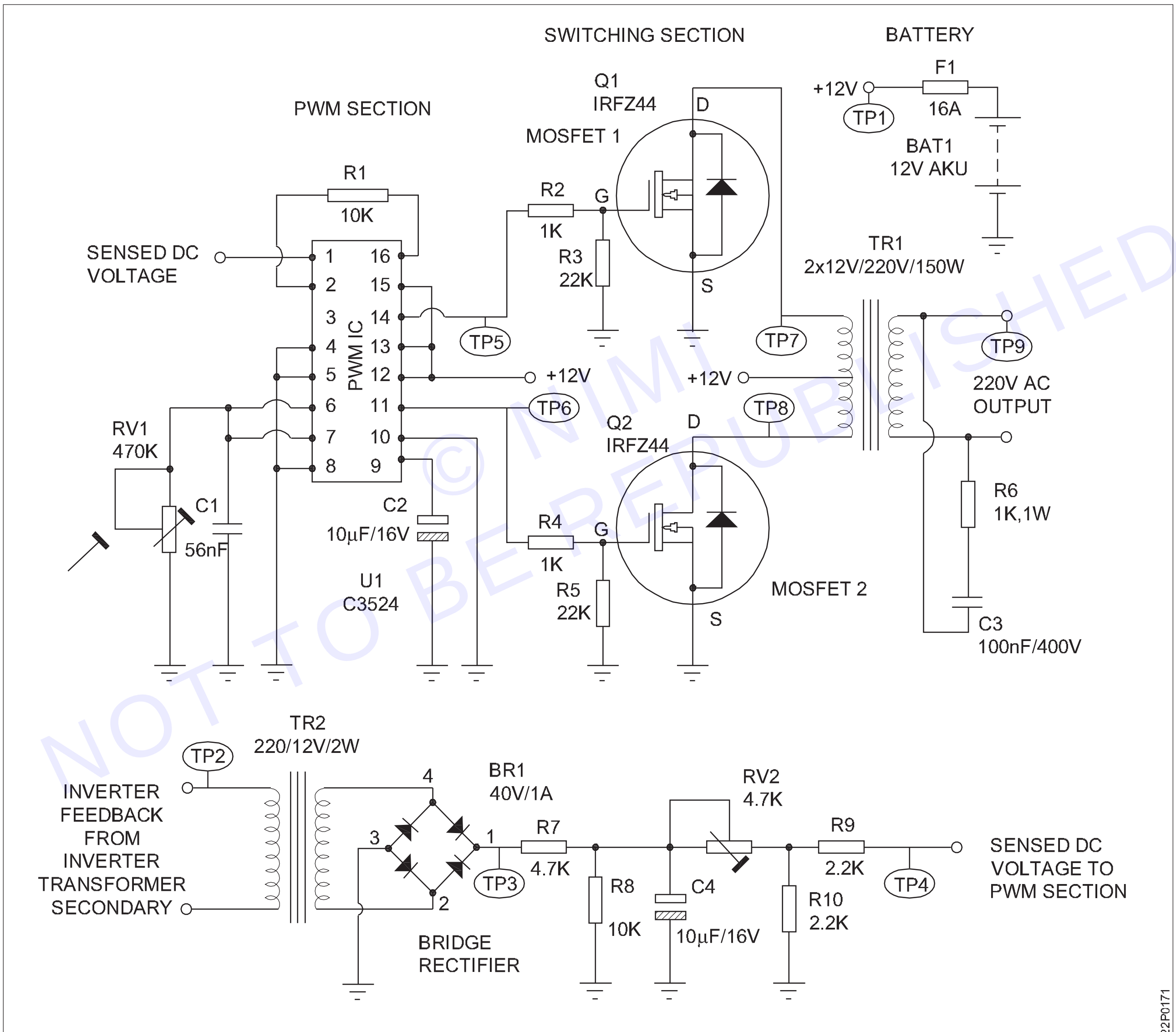
2 Test the Battery: If the battery is old, it may need to be replaced. Test the battery's capacity with a load tester.

3 Check Charger: Ensure that the charger is working correctly and that the battery is receiving the appropriate charging current.

4 Check for Environmental Issues: Ensure that the battery is not exposed to extreme temperatures and is kept in an environment suitable for its operation.

5 Reset the Inverter: Sometimes, resetting the inverter can clear the fault. Turn off the inverter, disconnect the battery, wait for a few minutes, and then reconnect everything.

6 Consult the Manual: Refer to the inverter's user manual for specific troubleshooting tips and voltage thresholds.



150W INVERTER

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TASK 2 : **Verification of the output terminal with lamp load**

1 Connect a 240V, 100W lamp load at the output terminal.

2 Switch ON the inverter, observe the lamp light.

3 Measure the output AC voltage and confirm that it remains constant.

4 Get the work checked by the instructor.

EXERCISE 54.2: Practical to Construct and test IC based DC to DC converter for different voltages

Objectives

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

- construct and test IC based 5V to 12V step up converter
- construct and test IC based 9V to 5V step-down converter.

Requirements

Tools/ Equipments/ Instruments

- Trainees tools kit - 1 Set
- Regulated DC power supply 0-30V/2A - 1 No.
- DMM with probes - 1 No.

Materials/ Components

- Bread board/General purpose PCB - 1 No.
- IC LT 1073-12 - 1 No.
- IC LT 1073-5 - 1 No.
- Schottky diode 1N5818 - 1 No.
- Resistor, 50 - 1 No.
- Resistor 220 - 1 No.
- Inductor, 150H - 1 No.
- Capacitor, 100F/25V - 1 No.
- Hook-up wires - as reqd.

Procedure

TASK 1 : **Construction and testing of IC based 5V to 12V Step-up Converter**

1 Collect the components and check them for its good working condition.

2 Connect the components and construct a 5V to 12V step up convertor by referring the circuit diagram (Fig 1)

3 Set the power supply voltage to + 5V DC and apply to the circuit.

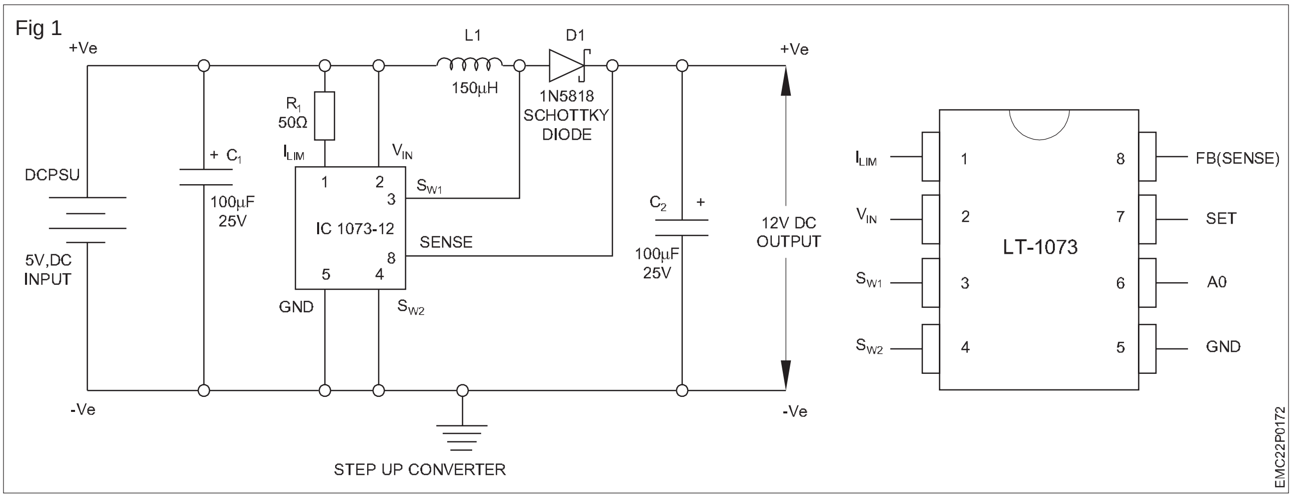
4 Measure and record the input and output voltages in table-1.

Measure the pin voltages of the IC and voltage across inductor and Schottky diode in the circuit and record in Table – 1.

Once the supply is switched ON check if any components or the IC LT1073 is getting heated - up; if yes, switch OFF DC supply and check the circuit.

Table 1

Input DC Voltage	Output DC Voltage	IC pin voltages						Voltage across inductor	Voltage across diode
		I_{LIM} (PIN-1)	V_{IN} (PIN-2)	SW_1 (PIN-3)	SW_2 (PIN-4)	GND (pin-5)	FB Sensing (PIN-8)		



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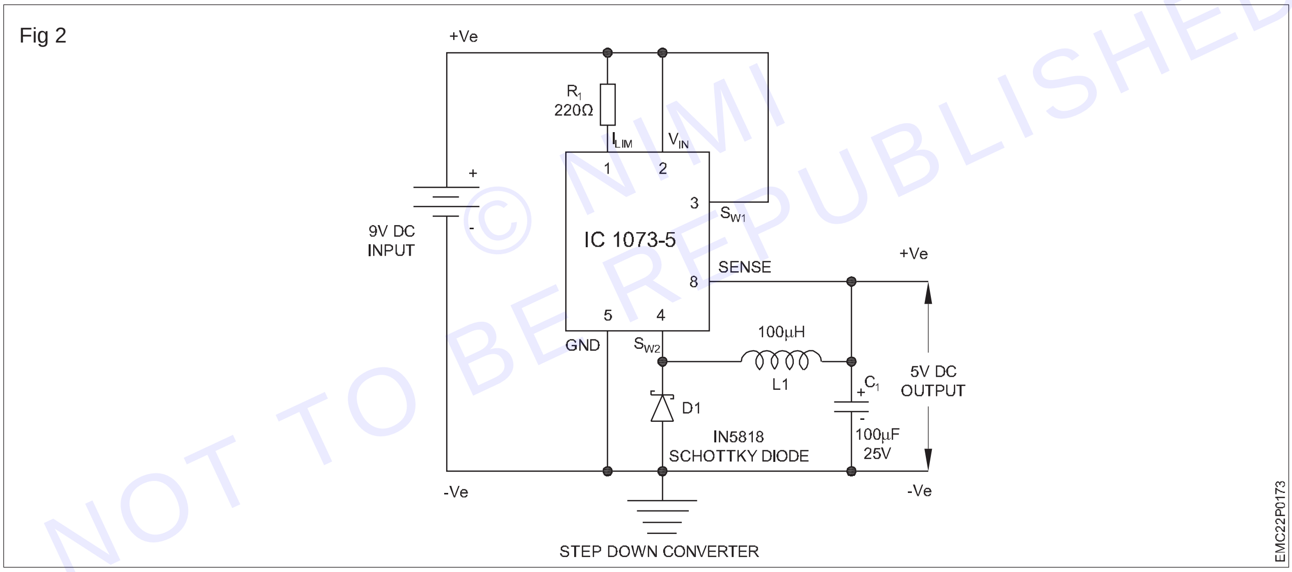
TASK 2 : **Construction and testing of IC based 9V to 5V Step- down Converter**

1 Replace the Step-up converter IC with LT-1073-5

2 Modify the step-up converter circuit into step-down converter by referring the circuit diagram (Fig 2)



3 Set the power supply voltage to +9V DC and apply to the circuit.

4 Measure and record the input and output voltage of step-down converter in table-2.

5 Measure the pin voltages of IC and voltage across inductor, and diode in the circuit and record in table 2.

Table 2

Input DC Voltage	Output DC Voltage	IC pin voltages						Voltage across inductor	Voltage across diode
		I_{LIM} (PIN-1)	V_{IN} (PIN-2)	SW_1 (PIN-3)	SW_2 (PIN-4)	GND (pin-5)	SENSE (PIn-8)		

6 Get the work checked by the instructor.

EXERCISE 55.1: Practical to construct and test a switching step down regulator using LM 2576

Objectives

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

- construct and test the regulated power supply using IC LM 2576.

Requirements

Tools/ Equipments/ Instruments

- Regulated DC Power supply 0-30V/2A - 1 No.
- Digital multimeter with probes - 1 No.
- Trainees tools kit - 1 Set.
- Soldering iron 25W/230V - 1 No.
- Semiconductor/IC LM 2576 data sheet - as reqd.

Materials/ Components

- IC LM2576(5V) - 1 No.
- Inductor 100H 2 Amps - 1 No.
- Diode 1N5822 - 1 No.
- Capacitor
  1000F/16V - 1 No.
  100F/63V - 1 No.
- Bread board/ PCB-GP - as reqd.
- Hook up wire - as reqd.
- Rosin cored solder - as reqd.

Procedure

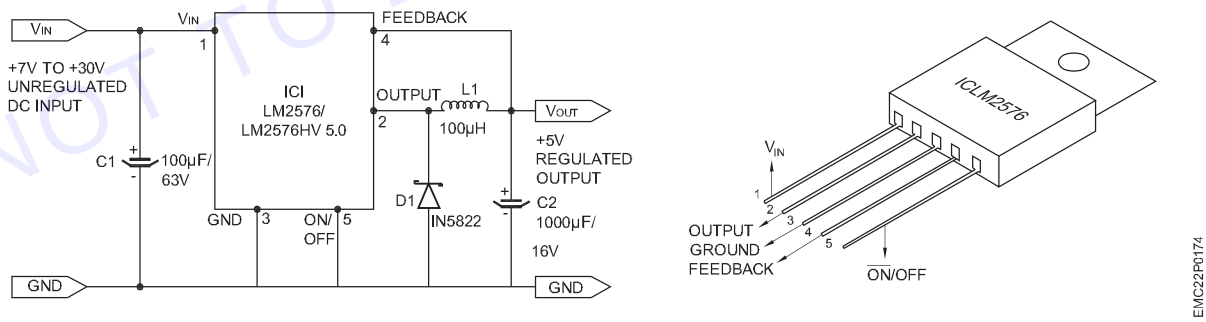
1 Collect all the components, required and check them.

2 Refer to the data sheet of the IC 2576, identify pins and test the condition.

Ensure that the output voltage remains constant.

3 Prepare the layout on the GPCB and assemble the circuit as per the diagram shown in Fig 1.

Fig 1



4 Get the assembled circuit checked by the Instructor.

5 Switch ON the DC supply to the input DC voltmeter across the output.

6 Increase the input voltage from 7V upto 30V in steps of 5 Volts.

7 Note down the corresponding output voltage and record the readings in TABLE 1.

8 Get the work checked by the instructor.

TABLE 1

Sl. No.	Input voltage	Output voltage
1	5V	
2	10V	
3	15V	
4	20V	
5	25V	
6	30V	

— — — — —

EXERCISE 55.2: Demonstrate the various test points and verify the voltages on the UPS

Objectives

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

- measure the voltage at various test points of the UPS.

Requirements

Tools/ Equipments/ Instruments

- Trainees tools kit - 1 Set
- Digital multimeter with probes - 1 No.

Materials/ Components

- Safety gloves - 1 Set
- UPS with battery and instruction manual - 1 Set

Procedure

TASK 1 : **Measurement of the voltages at various test points of UPS**

1 Open the UPS unit as demonstrated by the instructor.

2 Identify the major components/devices and sections on the assembled circuit board of UPS.

Note: Remove the power cord from the AC mains supply before starting this task. The Instructor has to mark the test points numbers using permanent marker pen.

3 Draw the sketch of layout of the sections and mark the major/important test points in each section.

4 Connect the power cord to mains supply and switch ON the UPS.

5 Measure the AC input voltage in the wall socket as shown in Fig 1.

6 Measure the voltage at transformer output section and the readings in TABLE 1.

Fig 1

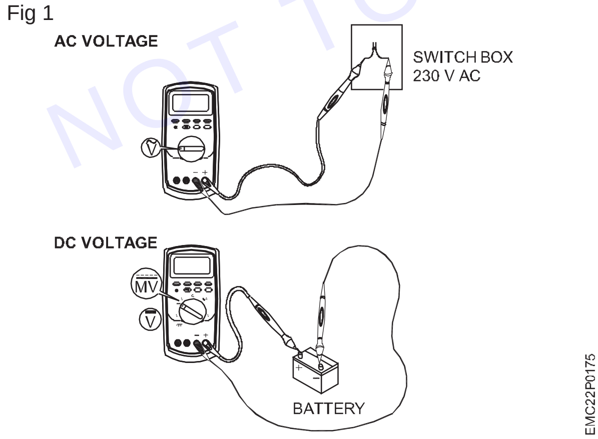


TABLE 1

Sl. No.	Name of the test points	Voltage	Remarks
1	AC input supply		
2	Transformer secondary		
3	Rectifier output		
4	Battery voltage		
5	UPS output		

7 Select the DC voltage function on multimeter & measure the rectifier voltage & note down in TABLE 1.

8 Measure the battery voltage by referring the Fig 1 and note down in TABLE 1.

9 Trainee should get the work checked by the Instructor.

— — — — —

EXERCISE 56: Connect battery stack to the UPS

Objectives

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

- interconnect the batteries to prepare a battery stack for the UPS
- connect abd test the battery stack of UPS.

Requirements

Tools/ Equipments/ Instruments

- Trainees tools kit - 1 Set.
- Safety gloves - 1 No.
- Digital multimeter with probes - 1 No
- Single phase UPS, 6KVA - 1 No.
- Double ended spanners - 1 No.

Materials/ Components

- 100W/ 230V/test lamp - 1 No.
- Battery 12V, 40AH - 13 Nos.
- Operating manual - 1 No.
- Battery connecting wires - as reqd.
- Bolt & Nuts for battery - as reqd.
- Cable connection - as reqd.
- Rack for battery - as reqd.

Procedure

TASK 1 : **Interconnection of batteries to prepare a battery stack for the UPS**

Electrical hazard: Do not make contact with both of the battery terminals simultaneously with metal parts like screw driver or spanners.

1 Read the operating manual of the UPS and find the required battery backup voltage & current rating.

2 Calculate the required level of voltage/current, arrange the batteries on the battery rack.

3 Prepare and place the battery connecting cables

4 Check the battery voltage individually and confirm its good working condition.

5 Connect the cable terminals of battery to the +ve and-ve terminal of the UPS carefully.

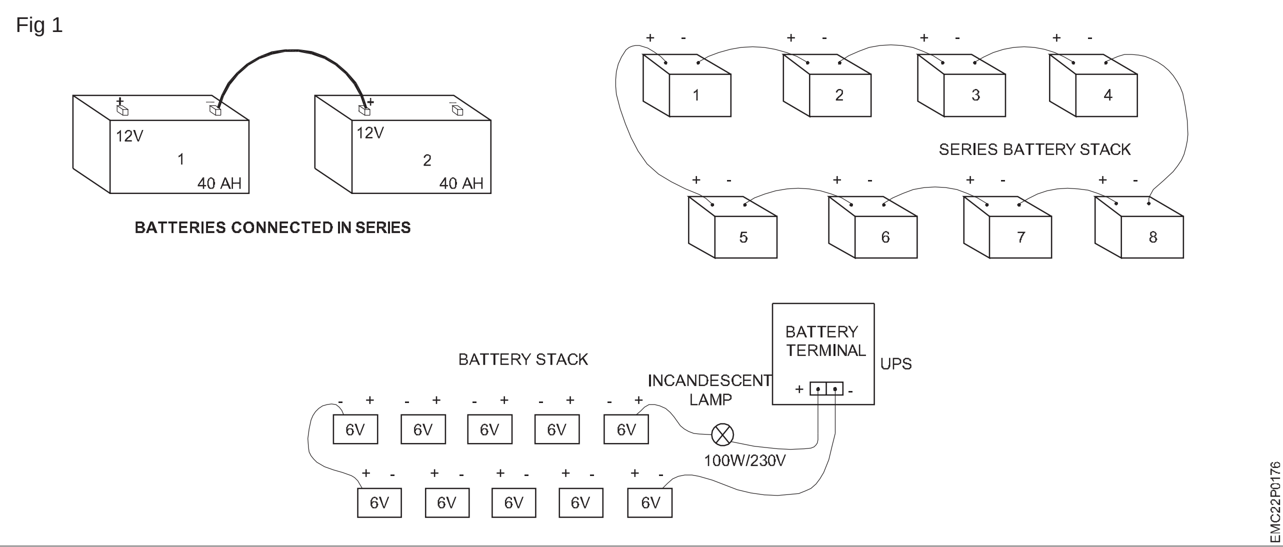
6 Check the battery voltage Fig 1 at the battery connector of the UPS.

7 Close the rear side cover and get the work checked by the instructor

8 Get the work checked by the Instructor.

- **For series connection of batteries -ve terminal of one battery should be connected with +ve terminal other battery by referring Fig 1**
- **For parallel connection of series stack of batteries connect +ve and -ve terminals of one series battery stack to the +ve and -ve terminal of the series battery stack by referring Fig 1.**
- **Sparking may occur during connection of battery cables to battery terminals.**
- **Use only the battery cables provided with the unit to connect the external battery. Do not extend the length of these cables.**

Fig 1


12V
1
40 AH
12V
2
40 AH
BATTERIES CONNECTED IN SERIES
1
2
3
4
SERIES BATTERY STACK
5
6
7
8
BATTERY STACK
INCANDESCENT LAMP
BATTERY TERMINAL
UPS
100W/230V
6V
EMC22P0176

— — — — —

EXERCISE 57: Demonstrate front panel controls & indicators of UPS

Objectives

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

- identify front panel indicators of UPS
- identify different sockets and connectors on the rear panel on the rear panel of UPS.

Requirements

Tools/ Equipments/ Instruments

- Trainees tools kit - 1 Set.
- Single phase UPS, 6KVA with manual - 1 No

Materials/ Components

- Cotton waste - as reqd.

Procedure

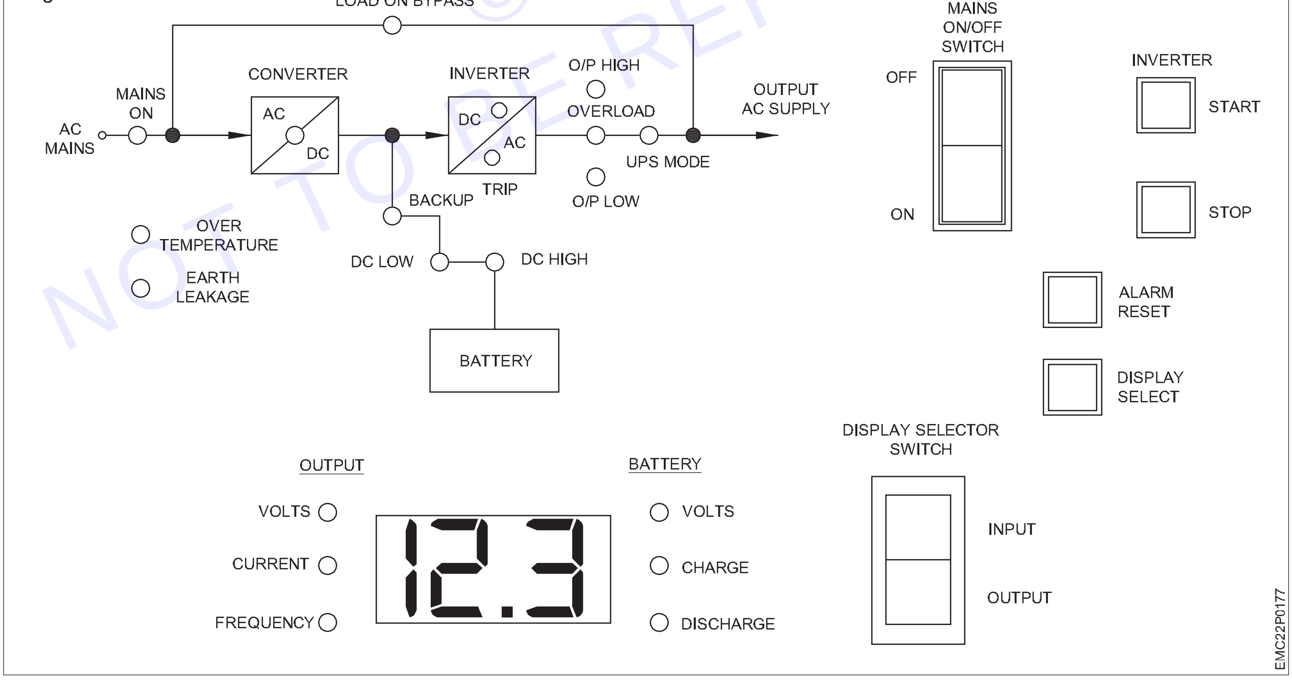
TASK 1 : **Identification of different controls and indicators on front panel of UPS**

1 Note down and record the specifications of the UPS.

2 Draw the sketch of front panel of the UPS with all indicators and switches

3 Identify each indicator and control on the front panel by referring to Fig 1/ Operating manual.

Fig 1



4 Record the observations in Table-1

5 Repeat the above steps for all indicators and controls on the front panel and record them.

6 Referring to the manual, record a brief function of the switches and the indicators.

TABLE 1

Sl. No.	Name of the indicator/control	Purpose
1		
2		
3		
4		
5		

— — — — —

TASK 2 : **Identification of different sockets and connectors on the rear panel of UPS**

1 Turn the rear panel of the UPS and identify the name of unit, record its socket and connector available in rear panel with the help of operation/Instruction manual.

2 Find out each socket in the UPS, note down in the Table-2.

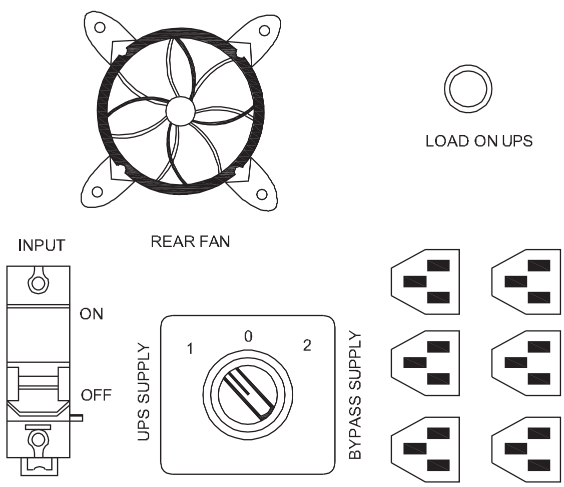
3 Repeat the above steps for all sockets and connectors and note down in Table-2.

4 Get the work checked by the Instructor.

TABLE 2

Sl. No.	Name of the Sockets/Connectors	Purpose
1		
2		
3		
4		
5		

Fig 2



EMC22P0178

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EXERCISE 58: Connect battery & load to UPS & test on battery mode

Objectives

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

- measure the total voltage of the battery stack using voltmeter
- connect the UPS and load test the battery.

Requirements

Tools/ Equipments/ Instruments

- Trainees tools kit - 1 Set.
- Safety gloves - 1 No
- DMM with probes - 1 No.
- UPS of 5 KVA with battery stack - 1 Set.
- Double ended spanner 10mm - 2 Nos.

Materials/ Components

- 100W/230V Test lamp with holder - as reqd.

Safety- Electrical hazard: Do not make contact with both of the battery terminals simultaneously with metal parts like screw drivers or spanners.

Sparking may occur during connection of battery cables with batteries which can be prevented by allowing the batteries to drain through the load initially. This can be done by keeping the mains OFF (so that batteries are not put on charging) and the load connected to the UPS to be ON, while connecting the new batteries to UPS charger terminals.

Procedure

TASK 1 : **Measurement of the total voltage of the battery stack using multimeter**

1 Disconnect the battery stack from main supply and remove the cable from main switch to the battery.

2 Prepare labels serially from 1 to N and paste them on each of the batteries.

3 Get the work checked by the Instructor.

4 Connect the multimeter across battery stack as shown in the Fig 1, and note down the observation in the Table-1.

5 Note down the first label of the battery stack, connect the multimeter to the battery as shown in the Fig 1

6 Measure the voltage of the battery and note down the observed voltage on table-1.

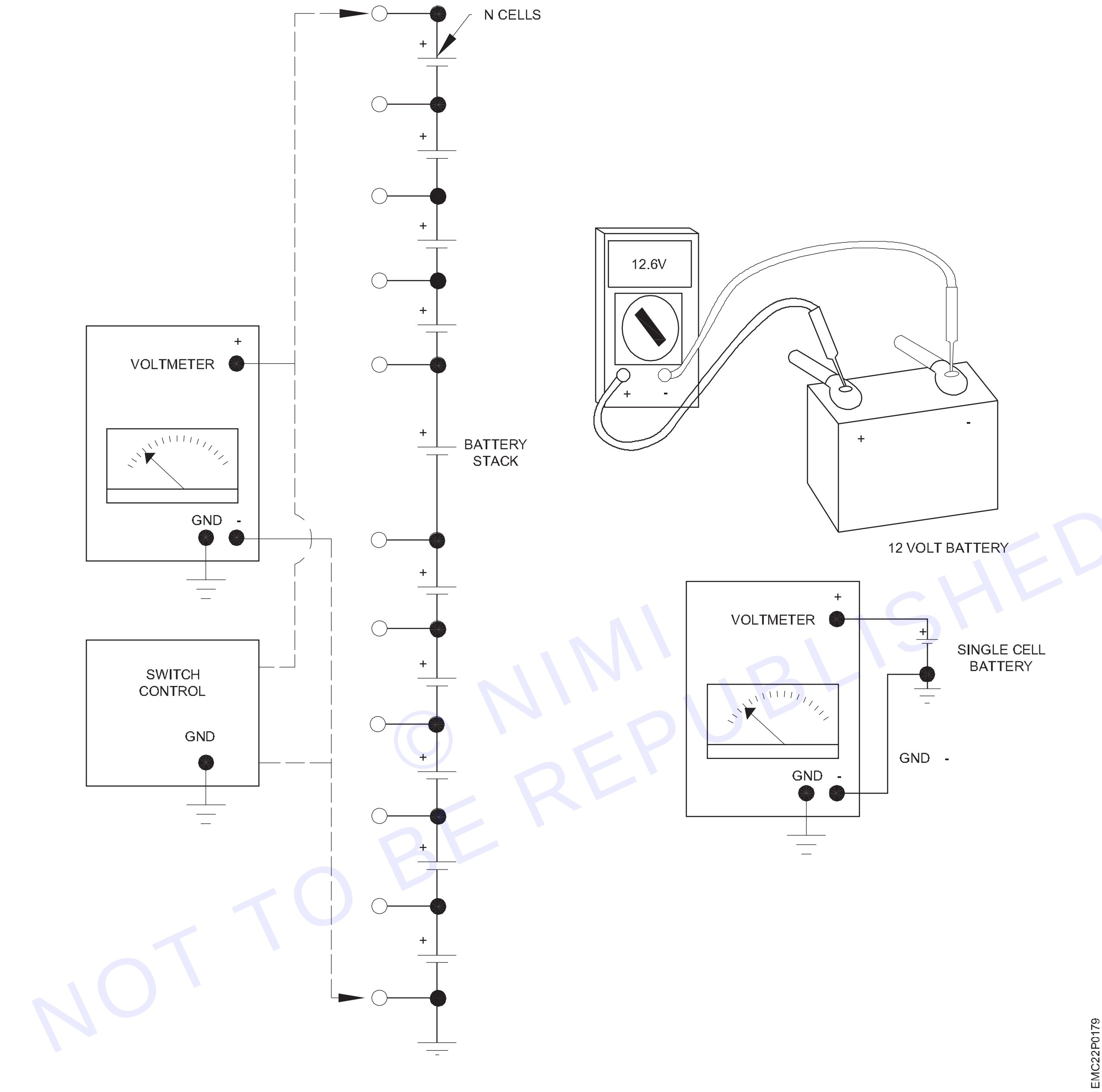
Note: In case any variation is observed in the measured voltage of the batteries, mark the battery and note down in the remarks column.

7 Repeat steps 4 to 6 for measuring the voltage on all the batteries.

8 Add all the voltages from label - 1 to N and compare with the stack voltage.

9 Get the work checked by the Instructor.

Fig 1



TASK 2 : **Connection of UPS and load testing of the battery**

1 Check the battery voltage (for 12V battery, minimum voltage can be 9.5V or above).

2 Take out the terminals of the battery cable from the UPS.

3 Observe the colour code of the cable and tightly connect the battery with correct polarity.

4 Connect the DC voltmeter across the battery, measure the voltage and record the observation in Table-2 as no load voltage.

5 Connect 2 lamps in parallel as load to the UPS output as shown in Fig 2 (Keep the lamps safely as the heat may damage the surface - avoid it).

6 Keeping the voltage probes across the battery, switch ON the UPS, observe the readings on the meter.

7 Record the observations in table-2 with lamp load.

8 Remove the lamps and repeat the step with Computers and printer to perform full load test.

9 Get the work checked by the Instructor.

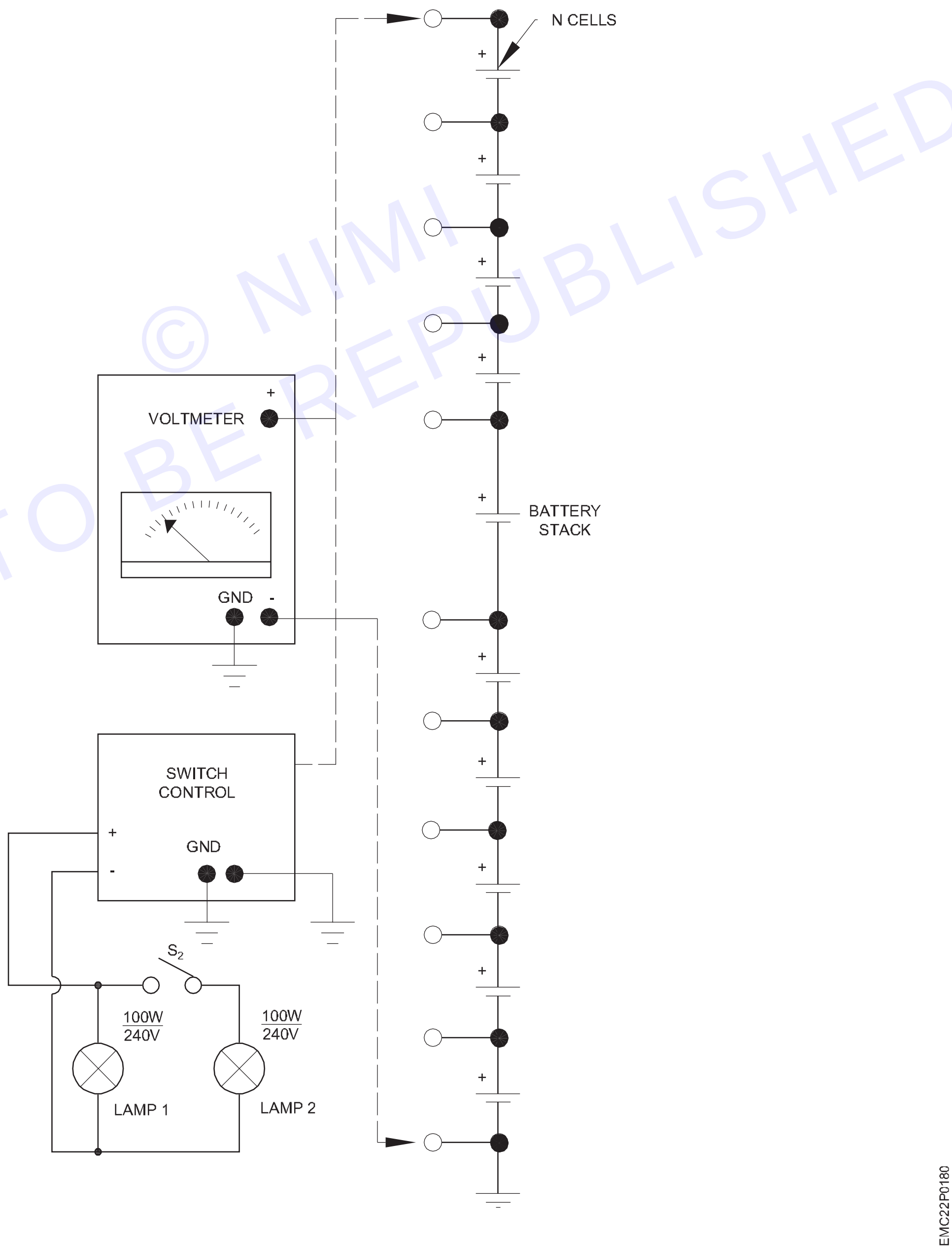
Safety precaution:-

1. **Before connecting the battery to the UPS, verify the electrode terminals symbol/ color codes on the battery**
2. **Ensure that the UPS is kept in switched OFF condition.**
3. **Connect the leads with correct polarity and tighten them.**

Table 2

Sl.No	Status of UPS	Battery voltage		Full load(200W)
		No load	Light load (100W)	
1	UPS OFF			
2	UPS ON			

Fig 2



EXERCISE 59: Open top cover of a UPS; identify its isolation transformers, the UPS transformer and various circuit boards in UPS

Objectives

At the end of this exercise you shall be able to:
- identify the major section in computer UPS
- identify the components used in computer UPS.

Requirements

Tools/Equipments/Instruments

- Computer UPS(650 VA) - 1 Set
- Trainees tool kit - 1 Set.

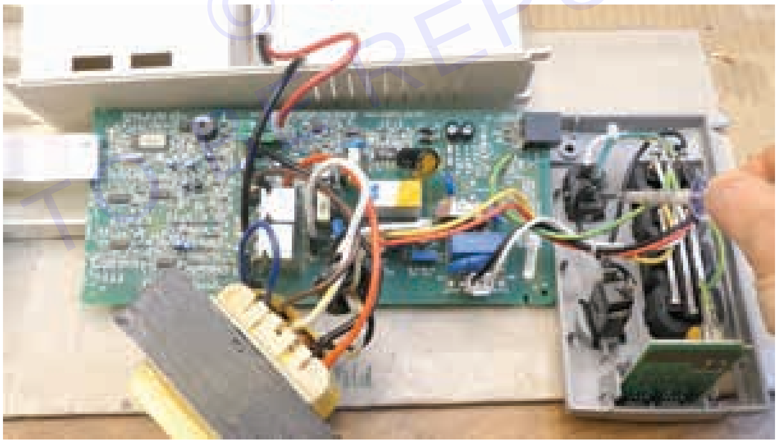
Note: The instructor has to label the major components/parts and sections of the UPS

Procedure

TASK 1 : **Identification of major sections in computer UPS**

1 Disconnect the power cable from the mains supply. Remove the screws that are present in the side panel and open the UPS unit as demonstrated by the instructor as shown in Fig 1.

Fig 1



2 Unscrew battery clamp pull out/ remove the battery terminal connectors and take out the battery.

Before opening CPU case touch cabinet outer cover to discharge ESD power.

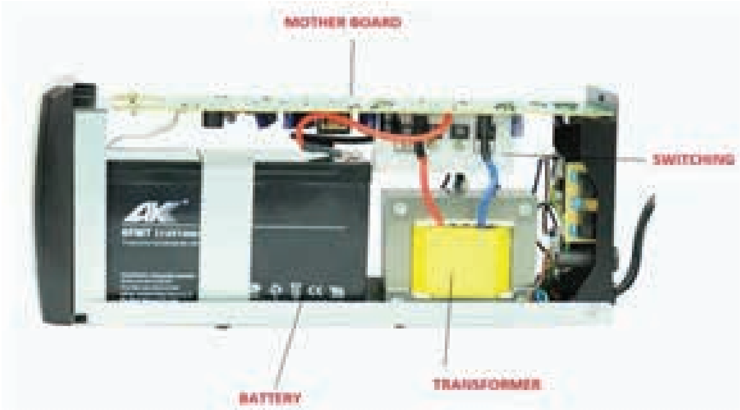
3 Note down the wirings and carefully lift the circuit board. Remove from its position.

4 Find the major sections in UPS as shown in Fig 2. Note down your observations in TABLE 1.

Table 1

Sl.No.	Major section in UPS
1	
2	
4	
5	

Fig 2



5 Get the work checked by the instructor.

— — — — —

TASK 2 : **Identification of components used in computer UPS**

1 Remove the circuit board (PCB) from the UPS cabinet.

2 Identify the listed components in the circuit board as shown in Fig 3. Record the label of the identified components in table 2 by referring to related theory.

Fig 3

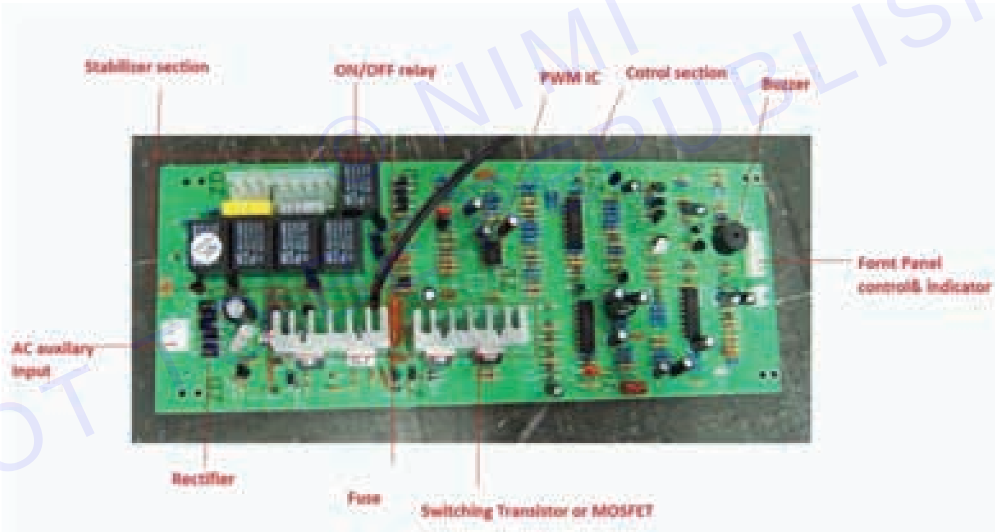


Table 2

Sl.No.	Name of sections	Components/Parts/Devices	Remarks
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

3 Repeat steps for all the other major components.

4 Trainee should get the work checked by the instructor.

EXERCISE 60: Demonstrate various test points in the UPS system and verify the voltages

Objectives

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

- measure the voltage at various test points of the UPS.

Requirements

Tools/ Equipments/ Instruments

- Trainees tools kit - 1 Set
- Digital multimeter with probes - 1 No.

Materials/ Components

- Safety gloves - 1 Set
- UPS with battery and instruction manual - 1 Set

Procedure

TASK 1 : **Measurement of the voltages at various test points of UPS**

1 Open the UPS unit as demonstrated by the Instructor.

2 Identify the major components/devices and sections in the PCB of the UPS.

Note: Remove the power cord from the AC mains supply before starting this task. The Instructor has to mark the test points and number them using permanent marker.

3 Draw the sketch of layout of the sections and mark the major/important test points in each section.

4 Connect the power cord to mains supply and switch ON the UPS.

5 Measure the AC input voltage in the wall socket as shown in Fig 1.

Fig 1

6 Measure the voltage at the input transformer secondary and rectifier section and record the readings in table 1.

7 Select the DC voltage function on multimeter & measure the rectifier and filter voltages & note down in table 1.

8 Also measure the battery voltage and note down in TABLE 1.

Table 1

Sl.No.	Name of the test points	Voltage	Remarks
1	AC input supply		
2	Transformer secondary		
3	Rectifier output		
4	Battery voltage		
5	UPS output		

9 Trainee should get the work checked by the Instructor.

— — — — —

EXERCISE 61: Practical to demonstrate various circuit boards in UPS and monitor voltages at various test points

Objectives

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

- Identify various sections of UPS and locate test points on the circuit boards
- Measure the voltages / waveforms at various circuit boards in UPS.

Requirements

Tools/ Equipments/ Instruments

- Trainees tools kit - 1 Set
- Digital multimeter with probes - 1 No.
- DSO (0-60MHz) - dual channel - 1 No.
- UPS with battery and instruction manual - 1 Set.

Materials/ Components

- Safety gloves - 1 Set
- Test lamp - 1 Set

Procedure

Note: The Instructor has to select and mark number of test points in each section based on the importance/functions on the UPS available in the Lab.

1 Keep the power cord disconnected from mains supply and switch OFF the UPS output before you open the UPS unit.

2 Identify the major sections / circuit boards of UPS referring to the UPS Technical manual.

3 Trace the different circuit boards and identify / locate the test points on each board by referring to the circuit diagram and record them in Table 1.

Table 1

Type of UPS		
Sl.No.	**Name of the Board/Section**	**Purpose**
1		
2		
3		

4 Mark the test points on each board/section using sketch pen.

5 Connect AC mains supply to UPS and Power ON the UPS to measure test point voltages of each section and record in Table-2.

Table 2

Sl.No.	Name of the Section	Test Point number	Test points in each circuit	Voltage/ waveform	Remarks
1	Charger section	TP-1,2,3	AC mains input, Charger output, Battery voltages.		
2	Inverter input section with change- over relay / Solid State Relay.	TP- 4,5,6	Rectified DC output, Inverter output, changeover Relay,		

Sl.No.	Name of the Section	Test Point number	Test points in each circuit	Voltage/ waveform	Remarks
3	Pulse width modulation (PWM) generation IC and driver section	TP-7	Input to regulator IC (DC)		
		TP-8	Regulator IC output (DC)		
		TP-9	PWM IC output voltage (AC) (Observe waveform using CRO) Gating pulses from PWM IC.		
		TP-10	Triggering pulse input to upper bank driver (AC)		
		TP-11	Triggering pulse input to lower bank driver (AC)		
		TP-12	Triggering pulse input to upper bank switching transistor (AC)		
		TP-13	Triggering pulse input to lower bank switching transistor (AC)		
4	Inverter section	TP-14	DC input to inverter section (upper bank)		
		TP-15	DC input to inverter section (lower bank)		
		TP-16	Output inverter voltages at transformer secondary tappings.		
		TP-17	DC feedback voltage from output section		
5	Annunciator board / Alarm indicator cum protection circuit	TP-18	Mains sensing voltage		
		TP-19	Low battery beep alarm		
		TP -20	Deep low battery trip circuit, etc.		
		TP-21	Shutdown pulses from PWM IC for overload and deep low battery protection.		

6 Prepare the CRO for measurements and check the output waveforms at the oscillator section and Inverter triggering and output section.

7 Get the work done checked by the Instructor.

— — — — —

EXERCISE 62 : Perform load test to measure backup time

Objectives

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

- perform load test of battery using UPS
- measure the back-up time of the UPS with battery.

Requirements

Tools/ Equipments/ Instruments

- Trainees tools kit - 1 Set
- Computer UPS (around 600VA) with Operating instruction manual - 1 No.
- Digital multimeter with probes - 1 No.
- Stop watch - 1 No.

Materials/ Components

- 100W/240V incandescent lamp (Test lamp) - 1 Set
- 12V/7AH, sealed maintenance free rechargeable battery - 1 Set

Safety precaution:-

1 Before connecting the battery to UPS, inspect the electrode terminals for symbols/ color codes on the battery.

2 Ensure that the UPS is kept in switched OFF condition.

3 Connect the leads with correct polarity and tighten them.

Procedure

1 Use DC voltmeter range of DMM to measure the terminal voltage of the battery and verify with the specification on the battery.

2 Take out the terminals of the battery cable from the UPS.

3 Observe the colour code of the cable and tightly connect the battery cable of UPS with the battery following correct polarity.

4 Connect the DMM across the battery and measure the DC Voltage and record the observation in Table-1 as no load voltage.

5 Connect the lamp load to the UPS output as shown in Fig 1

6 Switch OFF the mains supply and let the UPS provide power to the load.

7 Reset the stop watch at starting point.

8 Start the stop watch and switch ON the UPS simultaneously, with multimeter probes kept across the battery terminals.

9 Observe the readings on the meter and record in Table-1 till the low battery beep is heard or till the lamp load goes OFF.

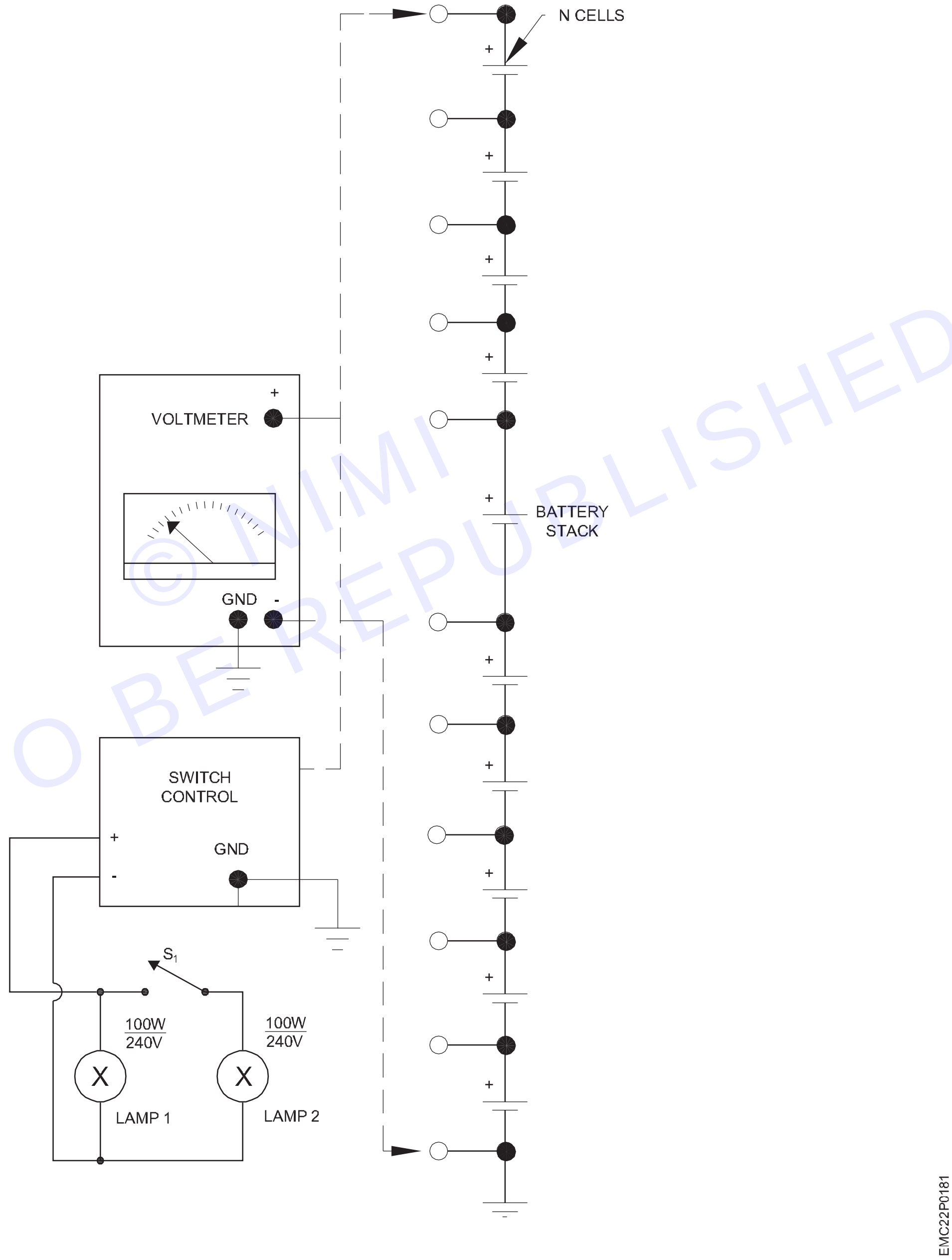
10 Observe the lamp glow with beep sound for sometime and stop the clock immediately when the lamp goes off.

11 Note down the readings on the multimeter and stop watch in Table-1.

Table 1

Sl.No	Status of UPS	Battery voltage		Full load
		No load	Light load	
1	UPS OFF			
2	UPS ON			

Fig 1



12 Repeat the experiment with a PC and a lamp (connected with an extension board) as load to the UPS for performing full load test.

13 Trainee should get the work checked by the Instructor.

— — — — —

EXERCISE 63: Perform all above experiments for three phase UPS

Objectives

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

- identify front and rear panel controls & indicators of 3 ph UPS
- measure the input and output voltages
- perform load test using lamp loads.

Requirements

Tools/ Equipments/ Instruments

- Trainees tools kit - 1 Set
- 3Ø UPS with Operating instruction manual - 1 No.
- Digital multimeter with probes - 1 No.

Materials/ Components

- 100W/240V incandescent lamp (Test lamp) - 3 Nos.
- Cotton waste - as reqd.
- Pendent holder - 3 Nos.
- Connecting wires - as reqd.
- Hook up wires - as reqd.

Safety precaution

1 Earth connection is critical before connecting the input supply. Hence, ensure proper earth connection.

2 Wait for some time before opening the UPS to allow the capacitor to discharge.

3 Do not open the terminal block cover while the inverter is ON.

Procedure

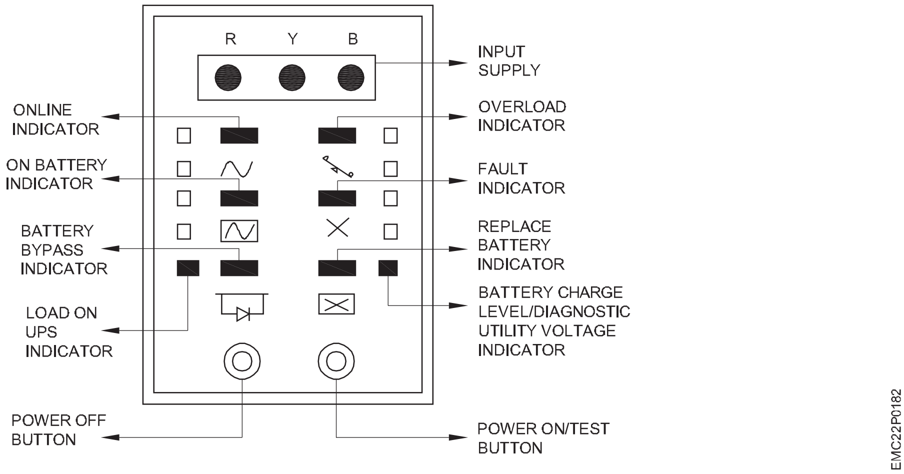
TASK 1 : **Identify front and rear panel controls**

1 Note down the specification of the UPS.

2 Draw the front panel of the UPS with all indicators and switch.

3 Identify each indicator and control on the front panel by referring to Fig 1

Fig 1



4 Record the observation in Table-1.

Table 1 (Front side)

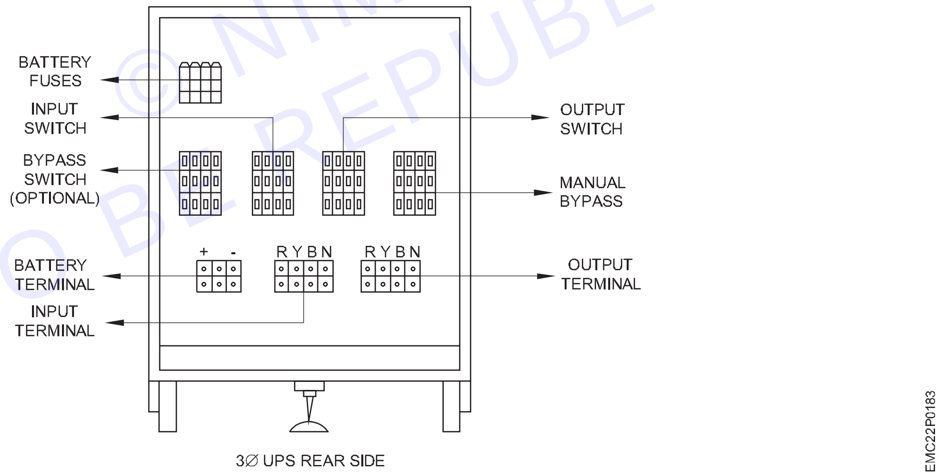
Sl.No.	Name of the indicator & switch	Purpose
1		
2		
3		
4		
5		

5 Identify and record the rear panel switches and connectors in Table - 2 by referring to Fig 2

Table 2 (Rear side)

Sl.No.	Name of the switch & connector	Purpose
1		
2		
3		
4		
5		

Fig 2



6 Referring to the operating manual, record the functions of the indicators, controls, switches and connectors.

7 Trainee should get the work checked by the Instructor.

— — — — —

TASK 2 : **Measurement of the input and output voltages**

1 Open the rear panel cover of the UPS under supervision of the instructor.

2 Switch ON the input and output switch.

3 Switch ON the inverter of the UPS.

4 Measure the AC input voltage and AC output voltage.

5 Measure the battery voltage, voltage at various test points and record the values in the table-3.

Table 3

Sl.No.	Various test points/sections	Voltage levels
1		
2		
3		
4		
5		

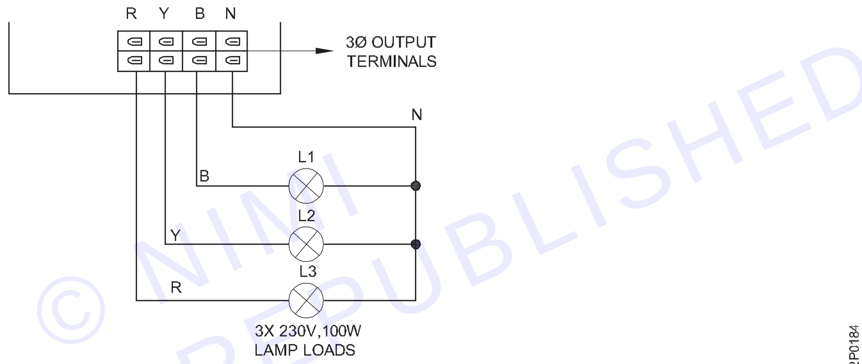
6 Trainee has to get the work checked by the instructor.

— — — — —

TASK 3 : **Performing load test using lamp loads**

1 Connect the lamp load to the UPS output terminals as shown in Fig 3

Fig 3



LOAD TEST USING LAMP LOADS

2 Switch OFF the mains & switch ON the UPS with the load. UPS works on Inverter.

3 By Switching OFF the input mains supply, the UPS load works with battery voltage.

4 Check and observe the condition of the lamp load.

5 Observe the performance of the load and battery voltage reading till low battery beep occurs.

6 Record the time taken to discharge the battery (back up time of the UPS) with load.

7 Get the work checked by the instructor.

— — — — —

MODULE 6: Internet of things and its applications

EXERCISE 64: Connect and test microcontroller to Computer and execute sample programs based on Arduino

Objectives

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

- connect and test microcontroller to computer and execute sample programs based on arduino.

Requirements

Tools / Equipments / Instruments

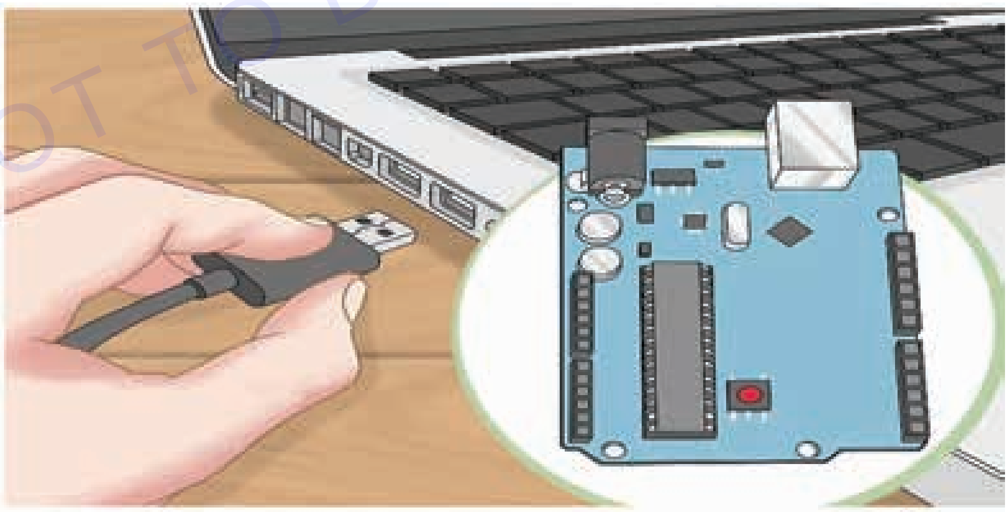
- Microcontroller board (Arduino Uno, Arduino Nano) trainer kit - 1 Set.
- USB cable (compatible with the microcontroller) - 1 No.
- Computer with Arduino IDE / S/W installed - 1 No.
- Arduino Uno - technical/ User Manual - 1 No.

Note: Instructor should guide the trainees to connect a microcontroller (such as an Arduino) to the Computer and test / execute sample programs, following these steps:

Procedure

1 Assemble a circuit with Arduino microcontroller board so as to blink an LED on the board. Connect the Microcontroller board to the PC (personal computer):

- Plug one end of the USB cable into the USB port of the microcontroller board and the other end of the USB cable into an available USB port on your computer.



2 Install Arduino IDE S/W for programming:

- If Arduino IDE is not already installed on your computer, download and install it from the official Arduino website (https: / / www.arduino.cc / en / software).

3 Open Arduino IDE:

- Launch the Arduino IDE application on your computer.

4 Select Board and Port:

- Go to the "Tools" menu in Arduino IDE.
- Select the appropriate board type from the "Board" submenu (e.g., Arduino Uno, Arduino Nano).
- Choose the correct COM port under the "Port" submenu. The port should correspond to the USB port detected after connecting the microcontroller.
- To verify Com Port, Go To device manager menu in computer. Your USB COM ports number will be displayed when you connect the Arduino board.

5 Load the Sample Program - blink sketch

- Open a Blink program - Blinks an LED (on board) connected to a specific pin on the microcontroller.

6 Review and Upload the Program:

- Review the sample program code to understand its functionality.
- Click the "Upload" button (right arrow icon) in Arduino IDE to compile and upload the program to the microcontroller board.
- Wait for the upload process to complete. You should see status messages in the Arduino IDE's console window.

7 Verify Program Execution:

- After the program is uploaded successfully, verify that it is running on the microcontroller board.
- Since you have loaded the "Blink" sketch, on execution you should see the LED available on the Arduino board blinking at regular intervals.

8 Experiment with Other Sample Programs (Optional):

- Explore other sample programs available in Arduino IDE's "File" menu or online resources.
- Load and execute different sample programs to experiment with various functionalities of the microcontroller.

9 Disconnect the Microcontroller:

- Once you have finished testing and experimenting with the microcontroller, safely disconnect it from the computer by unplugging the USB cable.
- Following the above procedure, trainee can easily connect and test a microcontroller (such as an Arduino) with Computer, upload sample programs, assemble the relevant circuit to be tested on a breadboard and execute the program to verify functionality of the application.

10 Get the work checked by your Instructor.

— — — — —

EXERCISE 65 : Upload computer code to the physical board (Microcontroller) to blink a simple LED using Arduino

Objectives

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

- Upload computer code to the physical board (Microcontroller) to blink a simple LED using Arduino.

Requirements

Tools / Equipments / Instruments

- Arduino board Trainer Kit (Arduino Uno) with USB cable - 1 Set
- Arduino Uno user Manual - 1 No

Materials/ Components

- LED - 1 No
- Resistor (220-330 ohms) - 1 No
- Breadboard - 1 No
- Jumper wires - as reqd

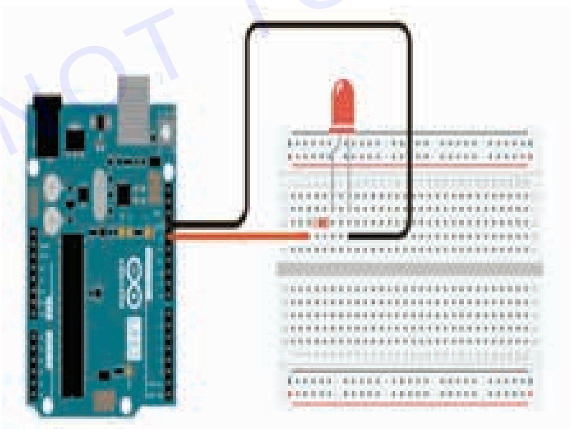
Procedure

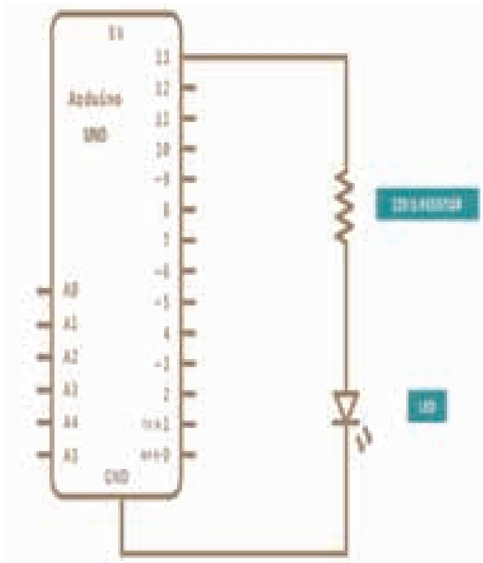
TASK1: **To upload computer code to a physical board (microcontroller) and to blink a simple LED on board, using Arduino**

Note: Instructor has to guide the trainees to follow these steps:

1 Connecting LED to the Arduino:

- Insert the LED through a resistor into the breadboard and provide VCC and GND connections.
- Connect the anode terminal of the LED to digital pin 13 on the Arduino board.
- Connect the cathode terminal of the LED to the ground (GND) pin on the Arduino board through a resistor (220-330 ohms).



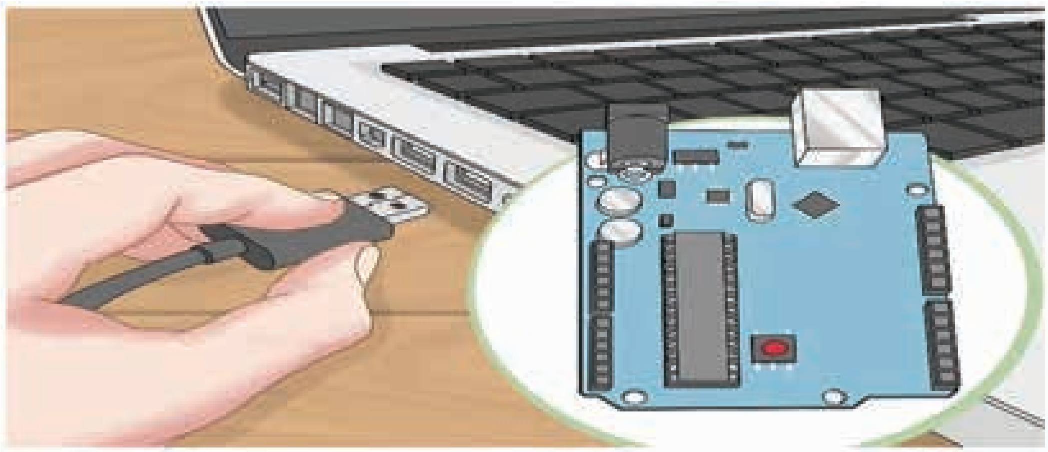


2 Connect the Arduino to the Computer:

- Plug one end of the USB cable into the USB port on the Arduino board.
- Plug the other end of the USB cable into an available USB port on your computer.

3 Open Arduino IDE:

- Launch the Arduino IDE software on your computer.



4 Select Board and Port:

- Go to the “Tools” menu in Arduino IDE.
- Select the type of Arduino board you are using (e.g., Arduino Uno) from the “Board” submenu.
- Choose the correct port under the “Port” submenu. The port should correspond to the USB port to which the Arduino is connected.

5 Write the Sketch (Code):

- In Arduino IDE, go to “File” > “Examples” > “01.Basics” > “Blink”. This will open a new window with the Blink sketch. Or just write code

```
/ *
Blink
Turns on an LED connected in the breadboard for one second, then off for one second, repeatedly.
* /
/ /  the setup function runs once when you press reset or power the board
void setup() {   / /  initialize digital pin 13 as an output.
pinMode(2, OUTPUT);
}
/ /  the loop function runs over and over again forever
void loop() {
digitalWrite(2, HIGH);  / /  turn the LED on (HIGH is the voltage level)
delay(1000);  / /  wait for a second
digitalWrite(2, LOW);  / /  turn the LED off by making the voltage LOW
delay(1000);  / /  wait for a second
}
```

- Review the Blink sketch. It contains two main functions: setup() and loop(). The setup() function runs once when the Arduino is powered on or reset, while the loop() function runs continuously in a loop.
- The Blink sketch turns the LED ON and OFF at a specified interval.

6 Upload the Sketch to the Arduino:

- Click the “Upload” button (right arrow icon) in the Arduino IDE to compile the sketch and upload it to the Arduino board.

- Wait for the upload process to complete. You should see status messages in the Arduino IDE's console window.
- Once uploaded successfully, the LED connected to pin 13 on the Arduino board should start blinking.

7 Verify LED Blinking:

- Verify that the LED connected to pin 13 on the Arduino board is blinking at the specified interval (default is 1 second on, 1 second off).
- If the LED is not blinking, double-check your connections and code, and ensure that the correct board and port are selected in Arduino IDE.

8 Experiment (Optional):

- Modify the Blink sketch to change the blinking interval or use a different pin for the LED.
- Experiment with other Arduino features and functions to further explore microcontroller programming.

9 Disconnect the Arduino:

- Once you have finished testing, disconnect the Arduino board from the computer by unplugging the USB cable.

10 Get the work checked by your Instructor.

— — — — —

EXERCISE 66: Write and Upload computer code to the physical Microcontroller board, to sound a Buzzer using Arduino

Objectives

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

- Upload computer code to the physical board (Microcontroller) to sound a buzzer using Arduino.

Requirements

Tools / Equipments / Instruments

- PC - 1 No.
- Arduino board (e.g., Arduino Uno) with USB cable - 1 Set.
- Arduino trainer kit - 1 No.

Materials/ Components

- Buzzer - 1 No.
- Breadboard - 1 No.
- Jumper wires - as reqd.

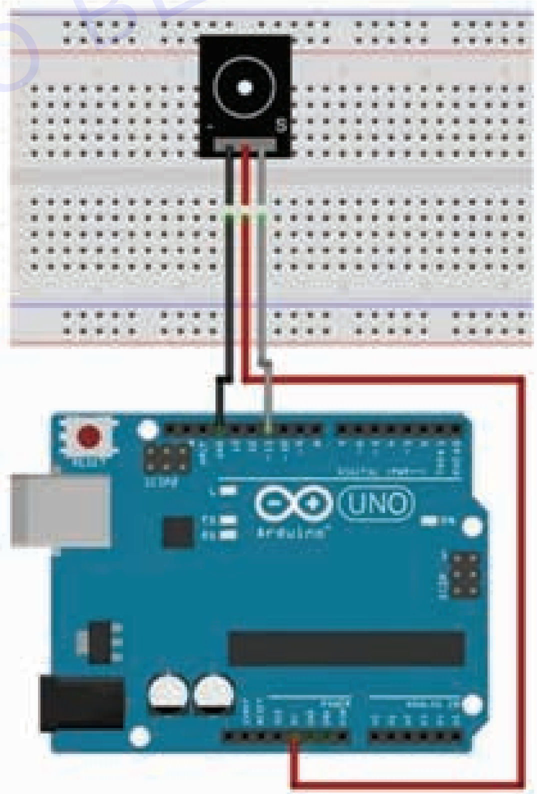
Procedure

TASK1: **To upload computer code to a physical board (microcontroller) and to sound a buzzer using Arduino**

Note: Instructor has to guide the trainees to follow these steps

1 Connecting Buzzer to the Arduino:

- Insert the Buzzer into the breadboard and provide VCC and GND connections.
- Connect the Vcc (5V DC) and GND connections from the Arduino board to the buzzer as shown in Fig 1.
- Connect the digital signal output of the Arduino board to buzzer at pin 11.



2 Connect the Arduino to the Computer USB and repeat the procedure (as mentioned in previous exercises) to establish communication between PC and Arduino board.

3 Write the Sketch (Code):

```
/ / This code is for testing the passive buzzer
#define buzzer 11;                  / /  initializing pin 11 as buzzer pin
  void setup ()                     / /  Code written in it will only run once.
{ pinMode(buzzer, OUTPUT);          / /  Setting pin 11 as output pin
  }
   void loop ()                     / / Code written in it will sound repeatedly
 {
  digitalWrite (buzzer, HIGH);      / /  This will turn the buzzer ON
  delay (1000) ;                    / /  Giving a Delay of 1s will set a frequency
  digitalWrite (buzzer, LOW);       / /  This will turn the buzzer OFF
  delay (1000) ;                    / / Giving a delay of 1sec before repeating.
 }
```

- Review the Blink sketch. It contains two main functions: setup() and loop(). The setup() function runs once when the Arduino is powered on or reset, while the loop() function runs continuously in a loop to sound the buzzer. The Blink sketch program turns the Buzzer ON and OFF at a specified interval.

4 Upload the Sketch to the Arduino & Verify:

- Click the "Upload" button (right arrow icon) in the Arduino IDE to compile the sketch and upload it to the Arduino board.
- Wait for the upload process to complete. You should see status messages in the Arduino IDE's console window.
- Once uploaded successfully, the buzzer connected to pin 11 of the Arduino board should create sound.

5 Experiment (Optional):

- Modify the Blink sketch to change the interval or use a different pin for the buzzer.
- Experiment with other Arduino features and functions to further explore microcontroller programming.

6 Disconnect the Arduino:

- Once you have finished testing, disconnect the Arduino board from the computer by unplugging the USB cable.

7 Get the work checked by your Instructor.

— — — — —

EXERCISE 67 : Write a program to interface light sensor LDR with arduino Microcontroller to Switch-ON and OFF an LED based on light intensity

Objectives

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

- Upload computer code to the physical board (Microcontroller) to Switch-ON and OFF an LED based on LDR's light intensity.

Requirements

Tools / Equipments / Instruments

- Personal Computer - 1 No.
- Arduino board (Arduino Uno) with USB cable (or) Arduino trainer kit - 1 Set.

Materials/ Components

- LDR Sensor and LED - 1 Set.
- Breadboard - 1 No
- Jumper wires - as reqd.

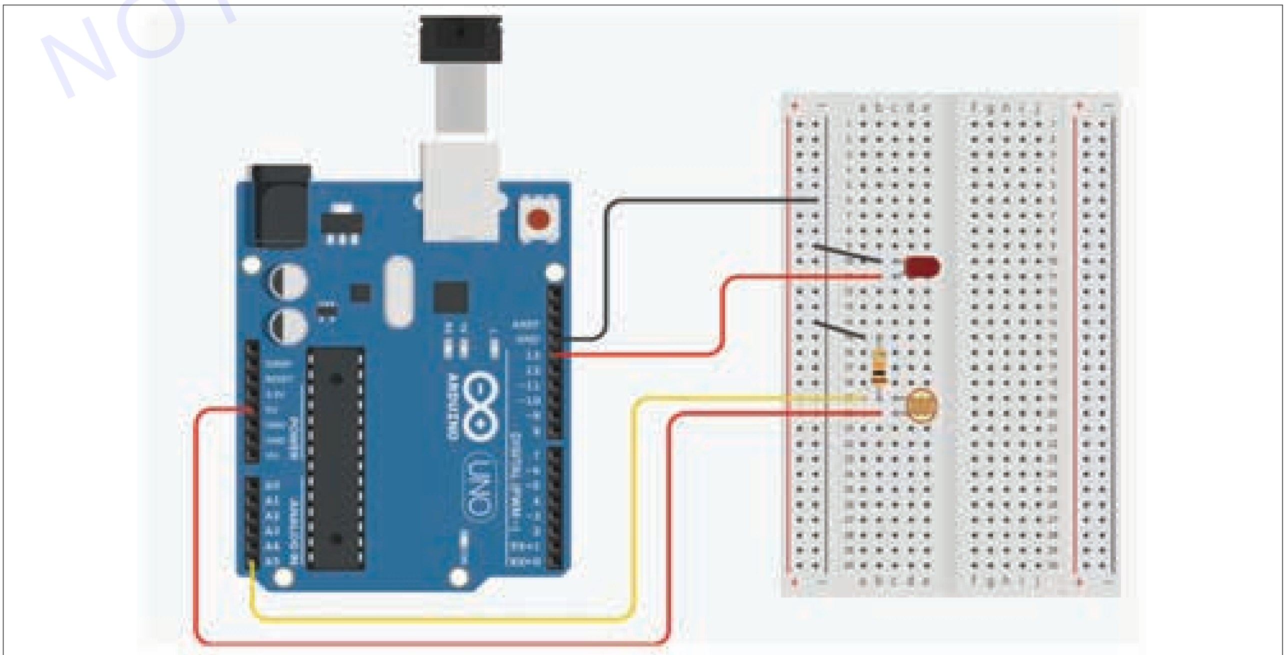
Procedure

TASK1: **To upload computer code to a physical board and to Switch-ON and OFF an LED based on LDR's light intensity using Arduino**

Note: Instructor has to guide the trainees to follow these steps:

1 Connecting a Light Dependent Resistor (LDR) and LED to Arduino:

- Connect one terminal of LDR to Vcc (5V DC) and another to GND through a series resistor. Connect LDR as input to Analog port A5 in the Arduino board as shown in fig. The voltage drop across series resistor is applied as input to analog port A5.
- The voltage appears at A5 when LDR is ON. It changes when LDR brightness changes.
- Connect the digital signal output to LED from pin 13 of the Arduino board.



2 Connect the Arduino to the Computer USB and repeat the procedure (as mentioned in previous exercises) to establish communication between PC and Arduino board.

3 Write the Sketch (Code):

```
/ / This code is for testing the LDR sensor and operating LED based on LDR's light intensity.
#define led 13;                         / /  initializing pin 13 as led pin
#define ldr A5;                         / /  initializing Analog input port A5 for sensing
                                        / /  variable light intensity from LDR
 void setup ()                          / /  Code written in it will only run once.
{    pinMode(led,OUTPUT);               / /  Setting pin 11 as output pin
Serial.begin(9600);                     / / Setting serial communication port to transfer the LDR
}                                       / /  Brightness data on the computer display at 9600 baud rate
void loop ()                            / / Code written in it will be executed repeatedly
{
int brightness=analogRead(ldr);         / /  initializing brightness as an integer to store LDR values
if (brightness>500)                     / /  Setting operating range for LED at port A5=(0 to 500)
{
digitalWrite (led,LOW);
                                        / /  if brightness goes > than 500,  then LED goes OFF.
}
else
{
digitalWrite (led,HIGH);                / /  else if brightness=0 to 500, LED becomes ON.
}
Serial.println(brightness);
delay(500)                              / / Giving a Delay of 500ms to display brightness values
}
```

4 Upload the Sketch to the Arduino:

- Click the "Upload" button (right arrow icon) in the Arduino IDE to compile the sketch and upload it to the Arduino board, after verifying communication port status.
- Wait for the upload process to complete. You should see status messages in the Arduino IDE's console window.
- Once uploaded successfully, the LED connected to pin 13 on the Arduino board should start blinking according to the LDR light intensity. Vary the LDR light intensity using a torch light focused on it and control the light falling on LDR with your hand.

5 Experiment (Optional):

- Modify the Blink sketch by connecting a different load on the breadboard to control with LDR light intensity and from Arduino board.
- Experiment with other Arduino features and functions to further explore microcontroller programming.

6 Disconnect the Arduino:

- Once you have finished testing, disconnect the Arduino board from the computer by unplugging the USB cable.

7 Get the work checked by your Instructor.

— — — — —

EXERCISE 68: Setup a circuit to interface potentiometer with Microcontroller and map to digital values

Objectives

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

- setup a circuit to interface potentiometer with arduino board mapped to digital values and Upload computer code to the physical board.

Requirements

Tools / Equipments / Instruments

- Personal Computer - 1 No.
- Arduino board (Arduino Uno) with USB cable - 1 Set.
  (Or)
- Arduino trainer kit - 1 Set.
- Potentiometer - 1 set.
- Breadboard - 1 No
- Jumper wires - as reqd.

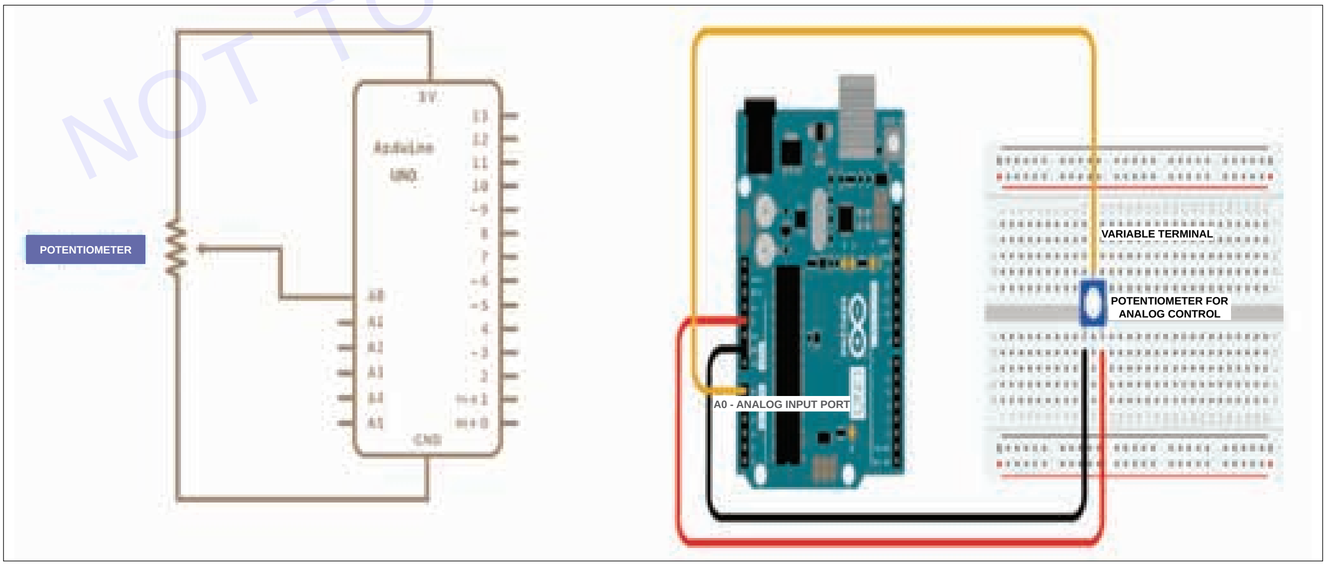
Procedure

TASK1: **To upload computer code to a physical board and to setup a circuit to interface potentiometer with Arduino Microcontroller and map to digital values**

Note: Instructor has to guide the trainees to follow these steps:

1 Connecting Potentiometer to the Arduino Board:

- Connect one terminal of Potentiometer (POT) to Vcc (5V DC) and another one to GND . Connect the variable terminal of POT to the Analog input port A0 in the Arduino board as shown in fig. The voltage drop across the POT is applied as input to analog port A0.
- The voltage changes at A0 when POT position varies.
- Observe the variable analog values of POT on a computer display using serial communication feature of Arduino.



2 Connect the Arduino to the Computer USB and repeat the procedure (as mentioned in previous exercises) to establish communication between PC and Arduino board.

3 Write the Sketch (Code):

```
#define  analogValue A0                          / /  Define the analog pin
int analogValue = 0;                              / /  Variable to store the raw analog value
int mappedValue = 0;                              / /  Variable to store the mapped value
void setup()
{
Serial.begin(9600);                               / /  Initialize serial communication at 9600 baud rate
}
void loop()
{
analogValue = analogRead(analogPin);              / /  Read the analog input from POT
mappedValue = map(analogValue, 0, 1023, 0, 100);  / /  Map the value to 0-100
                                                  / /  Print the raw and mapped values to the Serial Monitor
Serial.print("Analog Value: ");
Serial.print(analogValue);
Serial.print("  Mapped Value: ");
Serial.println(mappedValue);
delay(500);                                       / /  Delay for half a second before the next read
}
```

4 Upload the Sketch to the Arduino:

- Click the “Upload” button (right arrow icon) in the Arduino IDE to compile the sketch and upload it to the Arduino board, after verifying communication port status.
- Wait for the upload process to complete. You should see status messages in the Arduino IDE’s console window.

5 Once uploaded successfully, vary the POT connected to pin A0 on the Arduino board, so as to start sending variable voltage to the Analog input port A0.

6 Experiment (Optional):

- Apply variable voltage to the analog input port A0 of Arduino, by adjusting the Potentiometer knob (0 to 5V).
- Observe the variable analog values of range (0 to 5)V mapped to (0 to 1023) displayed on computer screen through serial communication port.
- Experiment with other Arduino features and functions to further explore microcontroller programming.

7 Disconnect the Arduino:

- Once you have finished testing, disconnect the Arduino board from the computer by unplugging the USB cable.

8 Get the work checked by your Instructor.

— — — — —

MODULE 7: Basic SMD & PCB Rework

EXERCISE 69: Demonstration of SMD devices (2,3,4 terminal components)

Objectives

At the end of this exercise you shall be able to

- identify the 2,3,4 terminal SMD components.
- decode the printed code letters and record the values of SMD components.

Requirements

Tools/ Equipments/ Instruments

- Trainees tools kit -1 Set
- ESD table with wrist strap -1 Set
- Digital multimeter (with probes) -1 No.

-1 No.

Aids: 1 SMD Component Charts.
2 SMD data sheets.

Materials/ Components

- Assorted 2,3 & 4 terminal SMD Components (Resistors capacitors, transistors, ICs) - as reqd.
- Magnifying glass - 1 No.

Procedure

Fig.shows PCB with SMD devices with their devicecode printed on each device.

Fig.shows 2,3,4 pins SMD devices of various sizes

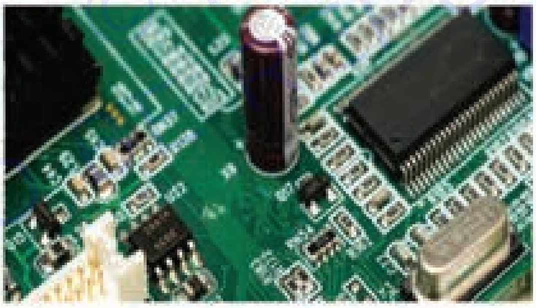
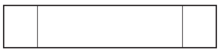
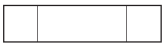
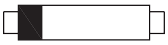
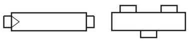
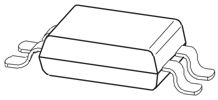


Chart 1 shows Shape and markings of some general SMDs

S.No.	Component	Shape	Markings
1	Chip resistor		Labelled with value
2	Chip capacitor		Not marked
3	Diode		Cathode end marked with notch or band
4	SOT (Small outline Transistor)		Pin one marked with dot, band or notch.
5	Diodes		If no marking, refer to data sheet.

TASK 1 : **Identification of 2,3,4 terminal SMD components**

NOTE: The instructor has to provide different SMD resistors, capacitors, diodes, transistors, bridge rectifier modules, kICs etc.

SAFETY PRECAUTION: Wear the wrist strap and ensure that the ESD belt is properly grounded before touching any SMD. components

1 Identify 2,3 or 4 terminal SMD components from the assorted group of SMD devices.

2 Separate the SMD components as per the number of terminals (i.e. 2,3 or 4 terminals).

3 Record the code marked on it in Table 1.

4 Identify the component & its value / specifications using reference Chart -1 and data sheets.

5 Repeat the above steps for all the SMD components provided.

6 Get the work checked by the Instructor.

Table 1

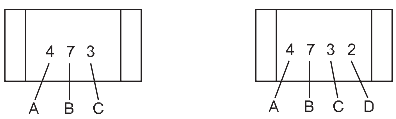
SI.No	No.of terminals	Code no. marking	Name of the component identified	Remarks

— — — — —

TASK 2 : **Identification of value of SMD resistor**

1 Pick one of the SMD resistor and refer to the Fig 1. Identify the coding marked on the component.

Fig 1



2 Decode the value referring to the Chart 2 & Chart 3

3 Record the observations in Table 2

Resistors are frequently marked with a three digit number and some typical values are shown in chart 4. The first two numbers are the significant digits of the value, and the last digit is the multiplier (the number of zeros to add to te first two digits). For example, a chip resistor labeled 102 has a value of 1000 Ohms, or 1k Ohms.

Marking on the SMD resistors

A = 1st digit of the resistors value

B = 2nd digit of the resistors value

C = number of zeros

Chart - 2

Code letters printed	Resistance value
101	100 Ω
471	470 Ω
102	1k Ω
122	1.2k Ω
103	10k Ω
123	12k Ω
104	100k Ω
124	120k Ω
474	470k Ω

Typical resistor markings and corresponding values

A = 1st digit of the resistor value

B = 2nd digit of the resistor value

C = 3rd digit of the resistor value

D = number of zeros

4 By using the above technique, find values of resistors for those components whose values are printed as below and record in Table 2

Chart - 3

Printed code letters	Resistance value
100R	100 Ω
634R	634 Ω
909R	909 Ω
1001	1k Ω
4701	4.7k Ω
1002	10k Ω
1502	15k Ω
5493	549k Ω
1004	1M Ω

Table - 2

Code letter printed	Resistance value
102	--- Ω
101	--- Ω
103	--- Ω
333	--- Ω
470	--- Ω
232	--- Ω
222	--- Ω
1243	--- Ω
4743	--- Ω

— — — — —

TASK 3: **Identification of SMD capacitors**

NOTE:

Ceramic multilayer chip capacitors are available with a very wide range of values, from 0.47 pF to 1uF.

These values are covered by seven package- forms. The forms depend on the capacitor values. The most popular packages are 0805 and 1206.

PRECAUTION:

Be very careful with non-marked components. Avoid mixing them. SMD tantalum capacitors are available in different package forms, partly without printed values. The + polarity is marked by white line, or white "M". The package forms depend on capacitance value and nominal voltage.

1 Coding with digits

1 Take one SMD capacitor, refer to the Fig 2 & 3 and identify the type, coding marked on it.

2 Decode the values referring to Chart - 4 and find the value.

3 Record the observed calculated value in Table 3.

4 Get the work checked by the instructor.

Example

Description "224" means 220 000 pF=220nF=0.22µF

2 Coding with alphanumerical characters

Chart 4

Capacitance pF	1	1.5	2.2	3.3	4.7	6.8
Code	A	E	J	N	S	W
Multiplicator	10^5	10^6	10^4	10^3	10^2	10^1
Code	5	6	4	3	2	1

Nominal voltage code (first digit from left)

Volt 4	6.3	10	16	20	25	35
Code G	J	A	C	D	E	V

Example 1

1 1.0 pF, 16V ... CA

2 2.2 pF, 6.3V ... JJ

Example 2

A6....... 1.0 x 106 pF=1..0 µF

J5........ 2.2 x 105 pF=0.22 µF

FJ6...... 2.2 x 106 pF=2.2 µF

Fig 2

Fig 3

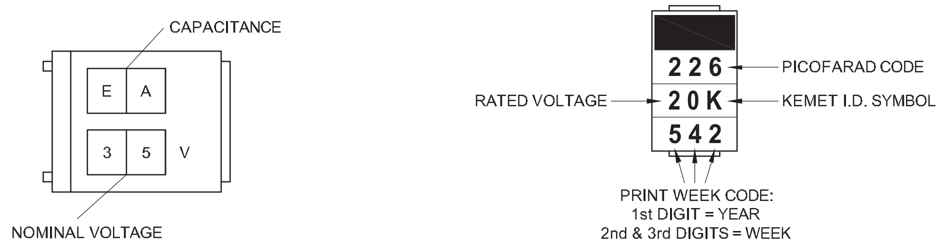


Table 3 - Capacitor Values

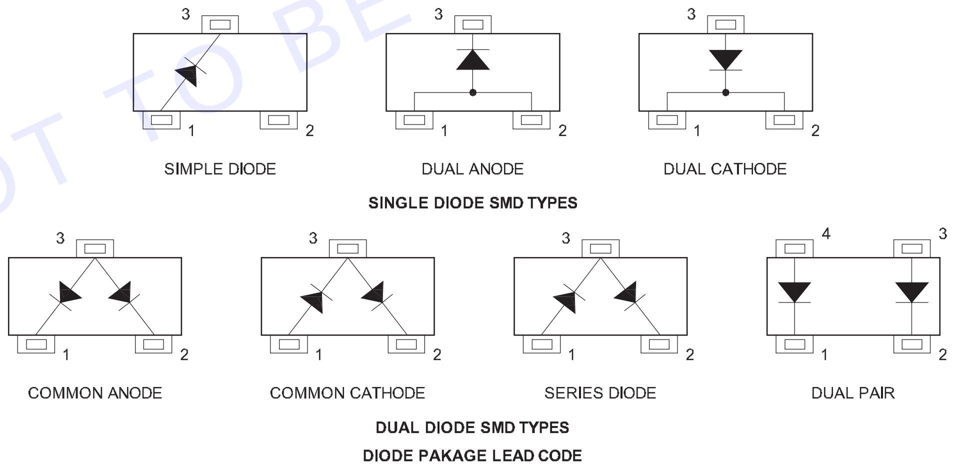
Package	Code on capacitor SMD	Calculated Value
		...... µF
		...... µF
		...... µF
		...... µF
		...... µF
		...... µF
		...... µF
		...... µF

TASK 4: **Identification of SMD Diodes and Transistor**

1 Take one of the SMD diode from SMD components using markings provided on the surface.

2 Refer to Fig 4 and identify the type. Write down the code in Table 4.

Fig 4



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

SMD LEDs are available in SOT - 23 cases.

Refer the above package types and separate the SMD diodes for testing with a multimeter.

3 Select the diode testing mode on the digital multimeter, check the diode in forward and reverse directions.

4 Note the observation on Table 4.

Table 4

Sl.No	Package type	Forward bias voltage across diode	Reverse bias voltage across diode	Diode is good / bad

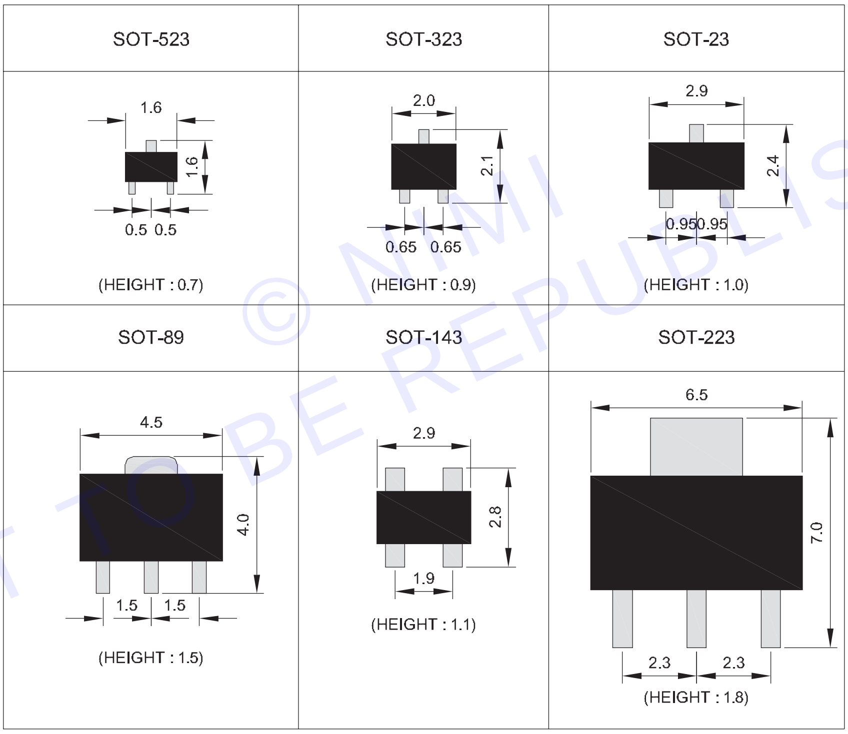
5 Repeat the above steps for all the remaining diodes.

6 Get the work checked by the instructor.

7 Pick one of the SMD transistor and with the help of Fig 5 identify the terminals.

8 Record the package type and the observations in Table- 5

Fig 5



SMALL OUTLINE TRANSISTOR (SOT)

9 Repeat the above steps for all the remaining components including transistor and fill in the table 5.

Table 5

Sl.No	Package	Types of component	Test carried out	Remarks

10 Get the work checked by the Instructor.

— — — — —

EXERCISE 70: Desolder the SMD Components from the given PCB

Objectives

At the end of this exercise you shall be able to

- demonstrate the Panel Controls/ Switches of Soldering/desoldering workstation
- desolder the SMD Components from the PCB following different methods.

Requirements

Tools/ Equipments/ Instruments

• Trainees tools kit	- 1 Set
• Magnifier with lamp	- 1 No.
• SMD rework station with Hot Air Nozzles/Temperature/Flow controller with Instruction Manual	- 1 Set
• DMM with Probes	- 1 No.

Materials/Components

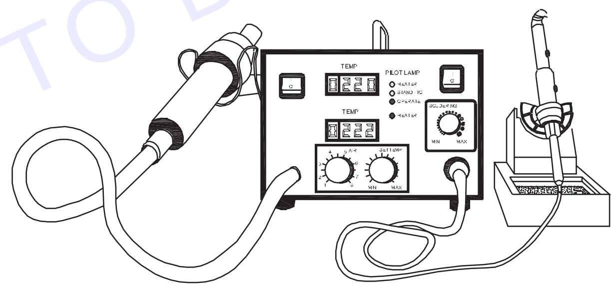
• Desoldering wick	- as reqd.
• Solder flux pen/Liquid flux	- as reqd
• IPA Cleaning solution	- 1 bottle
• Piece of Medium Density Fiber board (MDF)	- 1 No.

Procedure

TASK 1: **Demonstrate the Panel Controls/ Switches of temperature controlled SMD soldering/ desoldering workstation**

1 Refer to the operating manual for understanding the operating instructions of the Soldering/desoldering workstation to effectively and safely use the equipment. Fig 1 shows the front panel controls/switches on the soldering workstation, with reference to the operating manual.

Fig 1



EMC22P0048

2 Select and fix appropriate size of hot air nozzle suitable for the soldering work.

3 For performing desoldering, Set temperature at 200°C or higher as required for the component.

4 Adjust the hot air pressure control knob at the middle or according to the component size and pressure required for desoldering purpose.

5 When you press the switch of hot air gun, hot air flows from the nozzle.

It has replaceable nozzles so as to blow necessary amount of hot air on the component according to the thickness of terminals/pins to be removed and the nature of material used.

6 Identify the parts of the temperature controlled SMD soldering/desoldering workstation and note down in the Table 1.

Table1

Parts of the SMD solder/desolder station and description		
Temperature range		

8 Get the work checked by the Instructor.

— — — — —

TASK 2: **Desolder the defective SMD component from the PCB using hot air gun**

Note: It is recommended to set the air flow of hot air gun and temperature knobs at the middle and test on a small component on a sample PCB initially for practice, then take the defective PCB, readjust hot air gun to the required level above 200 degrees and perform desoldering.

Precautions

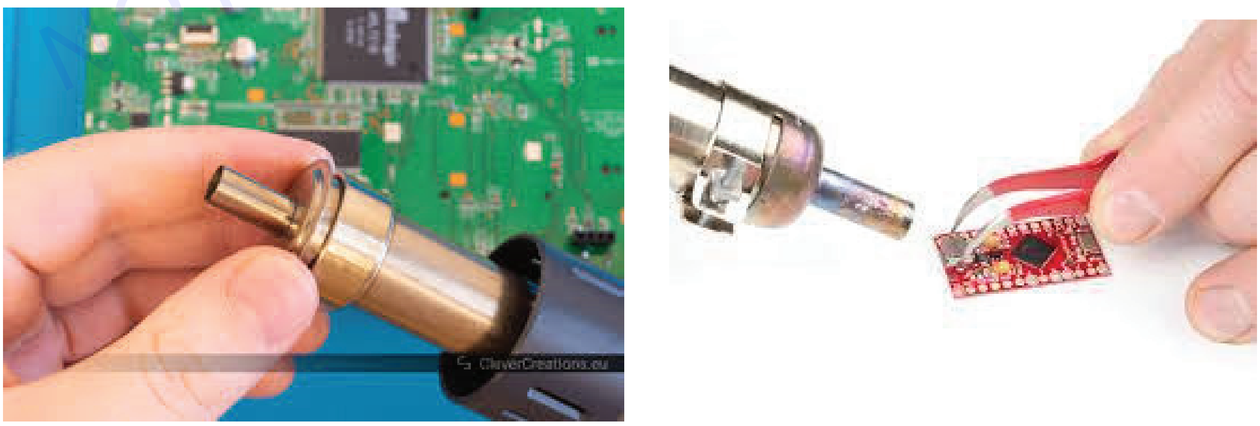
1 Focussing the hot air gun (with a high temperature) at a single point will melt the component and damage the PCB.

2 Make sure to apply the hot air only to the specific area for short intervals, to prevent over heating/melting of the components and PCB itself getting damaged.

1 Collect the defective SMD-PCB from the Instructor and identify the defective components to be removed.

2 By using magnifying glass, inspect the size of the component and the solder joints (to be removed) to select suitable nozzle for desoldering as shown in the Fig 2.

Fig 2



3 Apply a small amount of flux and solder to the pins of the surface to prepare the defective component terminals for desoldering.

4 Power ON the soldering rework station and adjust the hot air and temperature knobs for required range.

5 For performing desoldering, Set temperature at 200°C or higher as required.

Set the hot air pressure according to the component size and pressure as required for desoldering purpose.

6 Apply hot air on the component very gently little by little. Focus the hot air nozzle as shown in fig 3 towards the SMD component and move it slightly back and forth until the solder begins to melt.

7 Use tweezers and carefully grab/lift the SMD component from the PCB board.

8 Adjust the air flow and temperature setting knobs back to zero position after finishing the SMD desoldering work.

9 Switch OFF the soldering rework station and allow it to cool down.

10 Clean the PCB using IPA solution with brush.

11 Get the work checked by the Instructor.

— — — — —

TASK 3: **Desoldering of SMD IC using wicking braid**

1 Repeat Steps 1 to 3 of Task 2.

2 Apply some flux to the wick and use the desoldering wicking braid on one side of the SMD IC as shown in Fig 3.

3 Use soldering iron to heat the wick to remove the unwanted solder on the IC pins. Repeat the action for both the sides of IC till the solder is fully absorbed by the wick.

Choose a desoldering wick that is appropriate for the size of the solder joint you are working with. Using a wider wick for larger joints and a narrower wick for smaller joints can yield better results. Applying flux to the solder wick can improve its effectiveness by helping to remove solder more efficiently.

Make sure to apply heat evenly along the length of the solder joint to ensure proper melting and absorption of solder by the wick.

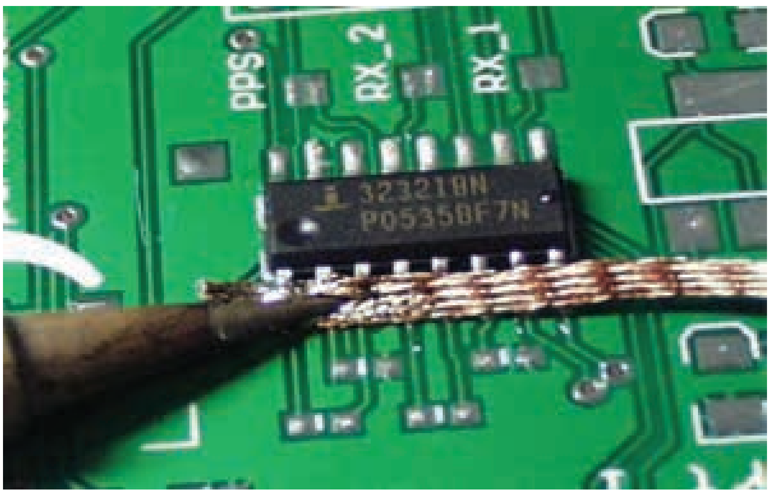
Avoid pressing too hard on the solder wick . Excessive force can damage the PCB or lift solder pads.

4 Use bent tweezers and lift the SMD IC from the PCB.

5 Clean the PCB with Iso Propyl Alcohol solution using brush.

6 Get the work checked by the Instructor.

Fig 3



EXERCISE 71: Solder the SMD components in the same PCB

Objectives

At the end of this exercise you shall be able to

- solder the SMD components on the PCB.

Requirements

Tools/Equipments/Instruments

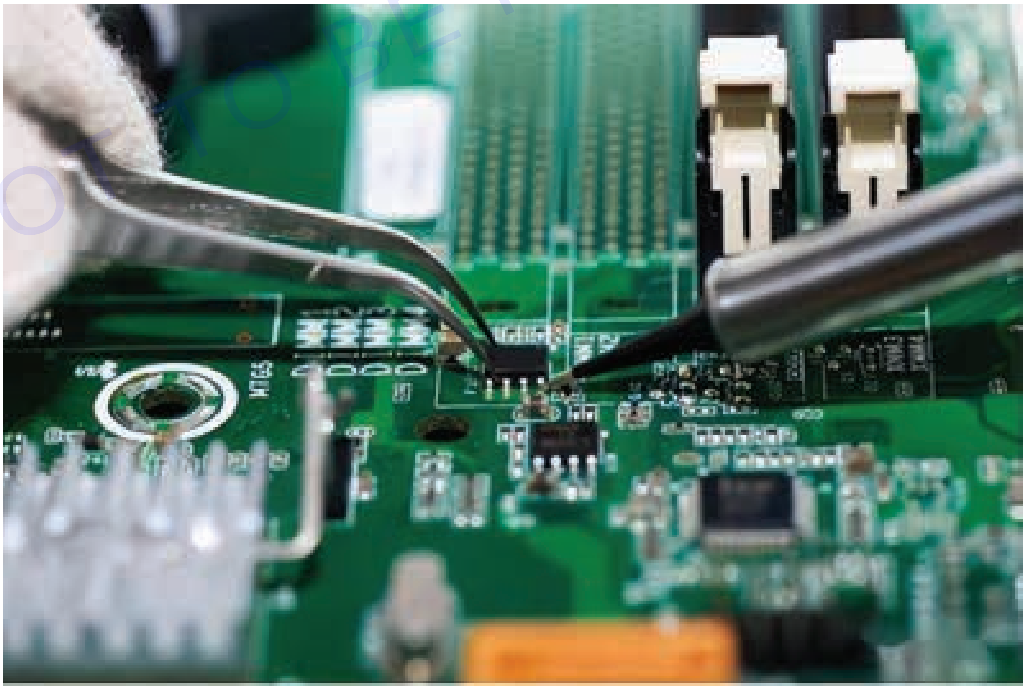
- Trainees tool kit - 1 Set
- Magnifier with lamp - 1 No.
- SMD soldering work station (hot air temperature/flow controller) with all accessories (and instruction manual) - 1 Set
- Vacuum pick up tool - 1 No.

Materials/Components

- Resin cored solder wire - as reqd.
- Flux pen/Liquid flux - as reqd
- ISO Propyl Alcohol cleaning solution - 1 bottle
- Piece of medium density fiber board - 1 No.
- Crocodile clips holder (MDF borad) - 2 Nos.
- Solder paste tube/syringe - 1 No.
- Cleaning brush - 1 No.

Procedure

Precaution: Instructor should guide the students in using the soldering station and hot air gun. To avoid thermal buildup, solder the terminals alternately with small time intervals between pins.



1 Choose and fit the appropriate tip for the soldering iron suitable to solder the SMD component onto the PCB.

2 Use crocodile clips to hold the PCB firmly on the work- bench.

3 Select the SMD components and confirm the loca tion on the PCB to be soldered.

4 Switch ON the soldering workstation and adjust the temperature setting knob above 200°C.

5 Keep the SMD component over the pads on the PCB at its position correctly.

6 Use flux pen and apply a little quantity on the points where soldering has to be done.

7 Hold the component using tweezers and apply the hot soldering iron tip over the solder pieces to melt.

8 Remove the soldering iron tip and allow the molten solder to set on the pin.

9 Repeat above steps to solder the other end of the SMD com ponent.

10 Use magnifier and inspect whether the soldered joints are free from any solder bridges.

11 Clean the board using IPA solution with brush .

12 Get the work checked by the Instructor.

EXERCISE 72 : Check for cold continuity of PCB and Demonstration of loose / dry solder / broken tracks on printed circuit board assemblies

Objectives

At the end of this exercise you shall be able to

- perform Cold Continuity check of PCB and demonstrate loose/dry solder/broken tracks /defective component on the given circuit board and record the observed defect/fault on the given circuit board.

Requirements

Tools/ Equipments/ Instruments

- Trainees tools kit - 1 Set
- Magnifier with lamp - 1 No.
- Digital multimeter DMM with probes - 1 No.

Procedure

Note: Instructor should issue Charts on Cold testing of PCBs and use data sheets while performing the task, to identify the pin details of devices.

TASK 1: **Perform cold check and demonstrate loose/dry solder/broken tracks /defective component on the given circuit board and record the observed defect/fault on the given circuit board.**

Note: The instructor may create simple faults in the circuit board using defective components if available or make a dry solder or use defective PCB for this exercise/task.

1 Collect the defective circuit board from the Instructor.

2 Clean the board using the brush (Use IPA solution if needed).

3 Visually inspect for any physical damages like PCB cracks, burns, broken wires or leads, capacitor bulge, component burnt, colour change etc on the PCB.

4 Use magnifier and carefully observe if any crack and broken tracks on the board are present.

5 Use Multimeter in Continuity mode to check and identify, if there is any short/open circuit between tracks.

Note 1: Cold continuity check has to be performed when the PCB (printed circuit board) is not powered.

Ensure that the system/equipment/PCB you're working with is completely de-energized and disconnected from the power source.

Use digital multimeter in continuity/resistance mode, to identify any PCB track open/short, fuse open, transformer good or bad, R,L,C or any other component - good or bad. By setting DMM in diode mode, you can check whether diode

Note 2: If you hear a buzzer sound in DMM while checking two points (say by keeping the probes of DMM above and below the PCB at a transistor terminal), it indicates that there is continuity and the component is intact.

OR if the resistance reading in DMM is very high "OL"(infinite) at above two points, it indicates that there is a dry solder and there's no continuity in the circuit.

6 Similarly use DMM in Continuity mode / Resistor mode to check if any component is defective (active or passive components like Resistor, Inductor, Capacitor, MOV, thermistor, transformer, fuse, diode, transistor, thyristor etc can be checked and identified if faulty).

7 Use DMM in Diode mode to check active components like Diode, LED, Transistor, MOSFET, etc.

8 Record the observations in Table 1.

9 Get the work checked by the Instructor.

Table 1

Sl.No.	Name of the component	Details of Fault/Defect Identified		Defect Types - Open/Short / leaky Circuit	Remarks
1		Dry Solder	Loose Connections		
2					
3					
4					

EXERCISE 73: Check and Repair Printed Circuit Board - Single, Double layer and important tests for PCBs

Objectives

At the end of this exercise you shall be able to

- perform soldering and rework to rectify the faults in the given Single layer/double layer PCB, test the PCB after rectifying fault to ensure good working condition.

Requirements

Tools/ Equipments/ Instruments

- Trainees tools kit - 1 Set
- Magnifier with lamp - 1 No.
- Digital multimeter with probes - 1 No.
- Soldering workstation/hot air temperature/flow controller (with instruction manual) - 1 Set

Materials/ Components

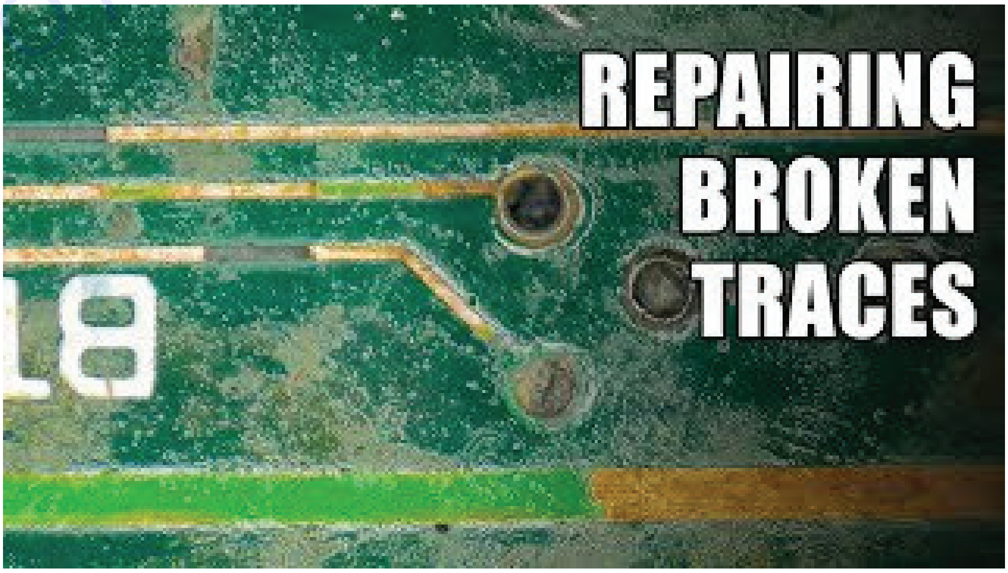
- Resin cored solder and flux - as reqd.
- IPA cleaning solution - as reqd.
- Solder flux pen/liquid flux - as reqd.
- Cleaning brush - 1 No.
- jumper wire/multistranded flexible wire pieces - as reqd.

Procedure

Note

1 The instructor may use a portable stand / fixture with crocodile clips to hold the PCB during soldering/desoldering work.

2 Guide the trainees to carry out this desoldering task with soldering iron/ / SMD rework station/ desolder wicking braid for the given PCB with SMD Components and IC, for this task.



TASK 1: **Check the single and double layer PCB**

1 Collect the PCB & required materials from the Instructor.

2 Identify the single and double layer PCB.

3 Physically check the PCB for any damage.

4 Use magnifying glass and observe for crack in any of the tracks on the PCB.

5 Record the observations in the Table 1.

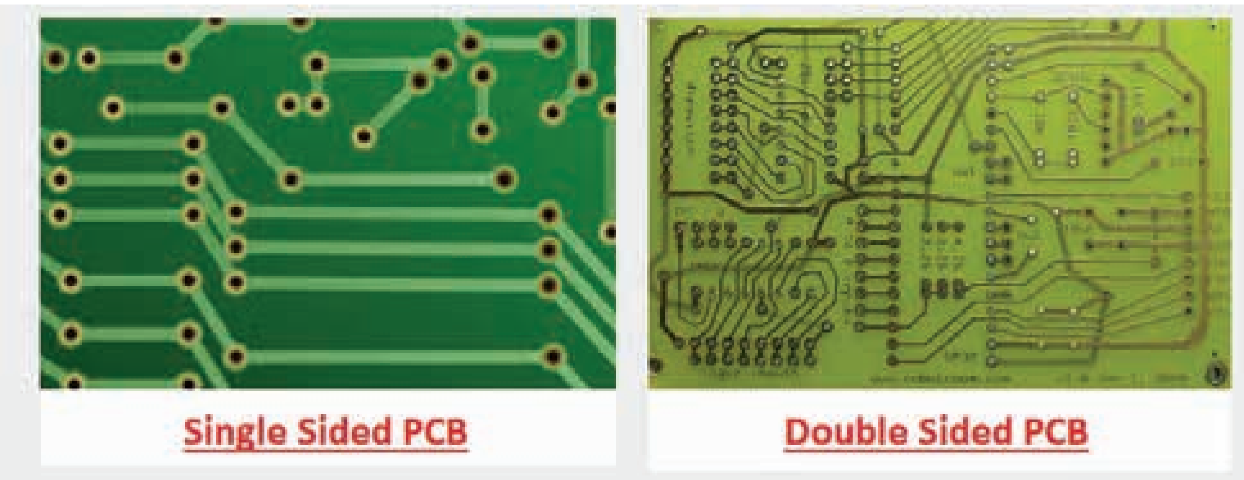


Table 1

Sl. No.	Types Of Pcb Single/Double Layer	Physical Damages Noticed Crack On Track	Crack On Pcb

— — — — —

TASK 2: **Repair the crack in the single/double layer PCB using Epoxy material**

Note

1 Mix the epoxy as per the manufacturer's instruction to use on the PCB.

2 Arrange a vibration free space to keep the PCB for the setting time.

Note: Allow 30 minutes setting time for the PCB before proceeding to the next step.

1 Apply a little quantity of epoxy on both the cracked portions of PCB (avoid excessive quantity of epoxy).

2 Hold both the sides of the cracked PCB pressed together.

3 Keep the PCB for 15 to 30 seconds time for setting, without any shake.

4 Follow the above steps for double sided PCB also.

5 Get the work checked by the Instructor.

— — — — —

TASK 3: **Repair the track-cut problem on the PCB**

Note: Reconnecting the broken track on the PCB is required to restore electrical continuity.

1 Observe the visible gap or discontinuity in the copper trace/track as shown in figure.

2 Clean the cut area with Isopropyl alcohol and a soft brush or cloth to ensure a good soldering surface.

3 Perform Continuity check using a multimeter and confirm the track cut.

4 Scrape off any solder mask or protective coating around the cut trace using a knife, till the copper print is exposed for soldering.

5 Prepare a Jumper Wire of fine-gauge slightly longer than the gap in the trace.

6 Remove a small portion of sleeve/insulation at both the ends.

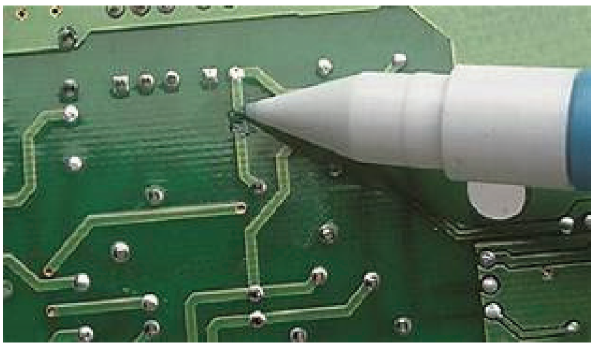
7 Tin the exposed ends of the jumper wire and solder it to the track-open portion on the PCB, bridging the gap.

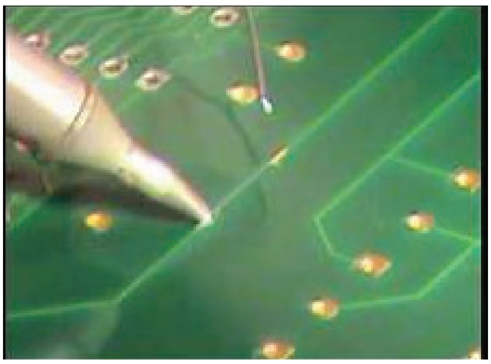
8 To strengthen the above repaired track, apply a small amount of epoxy or conformal coating to provide additional support and prevent the jumper wire from moving as shown in figure.

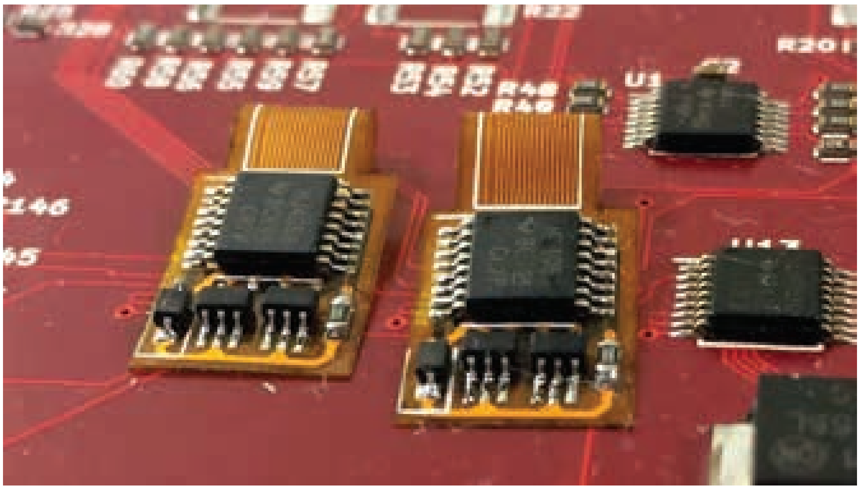
9 Use magnifying glass and check for any solder bridge formation around the repair area.

10 Once the repair is complete, test the PCB to ensure that the repaired track functions correctly.

11 Get the work checked by the Instructor







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TASK 4: **Replace the defective/dry soldered component in the single layer/ double layer PCB**

1 Collect the defective PCB from the Instructor.

2 Refer to previous exercise to perform Cold check and identify faulty component.

3 Resolder the identified defective/dry-soldered component and record the observations in Table 2.

4 Use jumper wire and join the open ends, if track open is found.

5 Get the work checked by the instructor.

Table 2

Sl.No.	PCB	Details Of Fault/Defect Identified and Rectified		Defective Section and Part /Component
	Single layer/ Double layer	Dry Solder/ Loose Connecion	Open/Short	
1				
2				
3				
4				

— — — — —

EXERCISE 74: Inspect soldered joints, detect the defects and test the PCB for rework

Objectives

At the end of this exercise you shall be able to

- inspect soldered joints , detect the defects and test the PCB for rework.

Requirements

Tools/ Equipments/ Instruments

- Trainees tools kit - 1 Set.
- Magnifier with lamp - 1 No.
- Crimping tools - 1 Set
- Digital multimeter with probes - 1 No.
- Safety goggles - 1 Set

Materials/ Components

- IPA solution - 1 bottle
- Cleaning cloth - as reqd.
- Cleaning brush - 1 No.

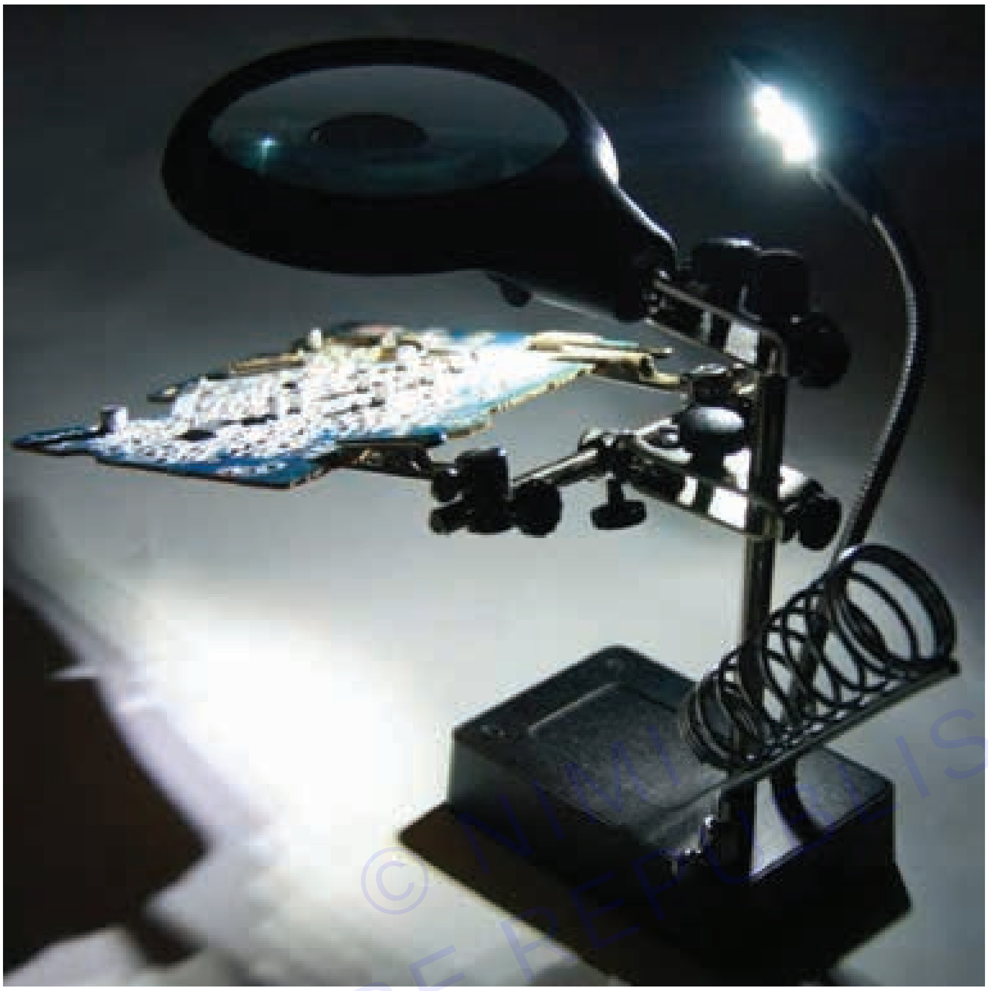
Procedure

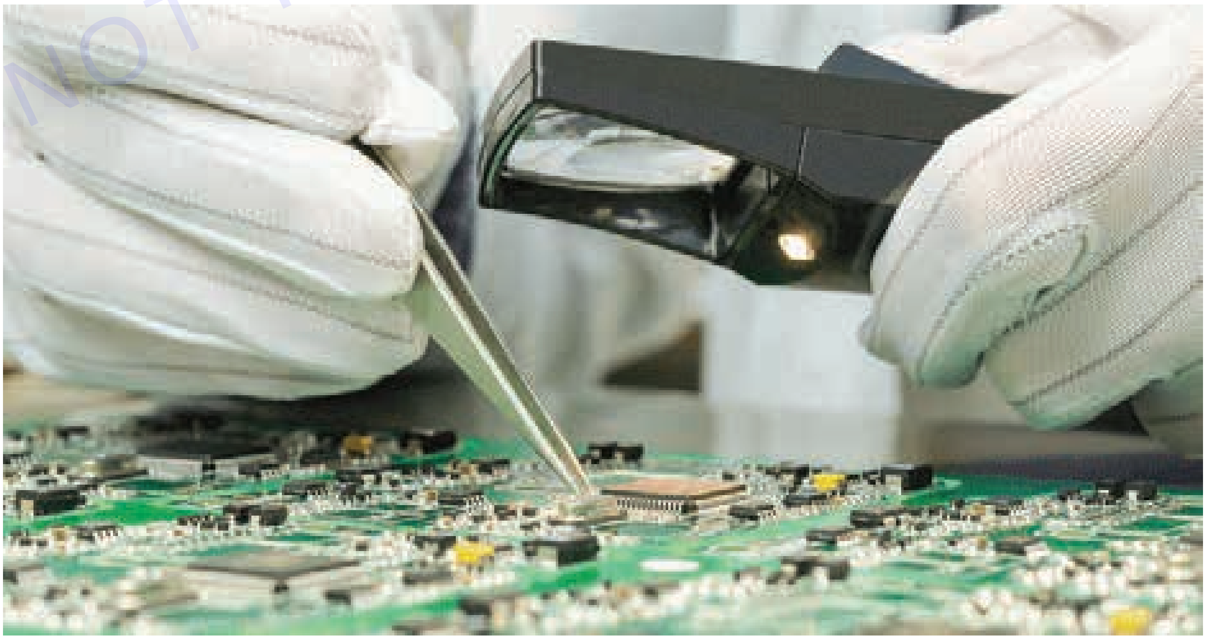
Aids: Chart showing images on different types s defects in the single layer/two layer PCB assemblies and different methods for rectifying them.

TASK 1: **Inspection of the Soldered joints**

Note: The Instructor has to show some samples of PCB with defective soldered joints and explain to the trainees.

- **Ensure that the solder has flowed evenly and formed a smooth, shiny surface around the joint.**
- **Cold joints appear dull and grainy, indicating poor bonding between the solder and the metal surfaces being joined.**
- **Use a multimeter / Continuity tester to verify that there are no short circuits or open circuits in the solder joints.**
- **A properly soldered joint should not move or crack under moderate pressure. Apply pressure gently to the solder joint using a non-conductive tool and confirm that it is good joint.**





1 Collect the repaired PCB from the Instructor.

2 Make visual inspection on the board for any physical damage/defect.

3 Clean the residual flux on the solder joint using IPA solution with brush.

4 Use magnifier with bright white light, carefully observe the shape of the joint formation with reference to the above instructions, check surface texture, mechanical bonding etc.

5 Record the detected/ observed defect in the Table 1.

6 Get the work checked by the Instructor and record the remarks for rework on the PCB.

Table 1 for recording the observation regarding soldered joint defects

Sl. No.	Name of the defect	Visual Observation	Remarks
1	Dry Joint / Cracked joint/Lifted Component		
2	Poor solder joint/ Cracked joint/Lifted Component		
3	Excess solder on joints		
4	Wetting defects/ Pin or blow holes		
5	Temperature defects/ overheating		
6	Lumps of charred flux		

— — — — —

TASK 2: **Test the PCB, detect the defect and perform rework**

1 Collect the PCB from the Instructor, for performing Warm check / Power ON testing.

2 Before Power ON, ensure that the PCB has undergone all the tests given in Ex.No.72 and 73 and rectify faults such as PCB track cut and board faults, component damage/open/short (identified through visual inspection and cold check) etc.

3 Ensure that faulty components have been replaced.

4 Perform the Power ON testing procedure to ensure that defects have been corrected and the PCB functions normally as expected.

5 Observe the voltages at various test points / major components of the PCB and record the readings in the Table 2.

6 Get the work checked by the Instructor.

Table 2

Sl. No.	Name of the sections	Major components or test points	Voltages at various test points	Abnormal voltage / mention suspected Fault

1 Note: Testing a PCB (Printed Circuit Board) involves various methods depending on the nature of the board and the defects. You can effectively test a PCB, detect defects and perform necessary rework to ensure its functionality and reliability. Testing a defective PCB for rework involves the following procedure.

Visual Inspection

- **Start with a visual inspection of the entire PCB. Look for obvious defects such as missing components, misaligned parts, solder bridges, or damaged traces.**

Functional Testing

- Power up the PCB and test its functionality using appropriate test equipment. This could involve applying power and checking for expected responses such as LEDs lighting up, displays showing information, or motors spinning etc.
- If the PCB is part of a larger system, ensure that it interacts correctly with other components.
- Thermal imaging cameras can be used to identify any hotspots on the PCB that may indicate overheating components or poor thermal management.
- X-ray inspection is performed to detect defects such as hidden solder bridges, voids in solder joints, or misalignment of ball grid arrays (BGAs).

Rework: Once defects are identified, rework may be necessary. Rework involves correcting the identified issues on the PCB:

Soldering Rework

- Use a soldering iron or rework station to remove and replace defective components.
- Correct any solder bridges or insufficient solder joints.

Trace Repair

- If traces are damaged, use techniques such as soldering jumper wires or conductive ink to repair the connections.

Component Replacement:

- Replace any faulty components with new ones.

Cleaning

- Clean the PCB thoroughly after rework to remove flux residues or other contaminants.

Re-Testing

- After rework, perform the same testing procedures to ensure that the defects have been successfully addressed and the PCB functions as expected.

— — — — —

EXERCISE 75: Remove the conformal coatings by different methods

Objectives

At the end of this exercise you shall be able to

- identify conformal coating on the SMD PCBs
- remove conformal coating on SMD PCBS, following different methods.

Requirements

Tools/ Equipments/ Instruments

- Trainees tools kit - 1 Set.
- Acrylic resin with Spray gun - 1 No.
- Hot air gun - 1 No.
- ESD safe surface - 1 No.
- ESD wrist strap - 1 No.

Materials/ Components

- Foam swab - 1 bottle
- Cleaning Brush - 1 No.
- Gloves - 1 Set
- Scraper - 1 No.
- IPA solution - as reqd.
- Marker pen - 1 No.
- General purpose PCB (or) SMD PCB - 1 No.
- Cleaning Wipes - as reqd.
- High temperature tape (50 mm x 100 mm Kapton tape) - 1 No.

Procedure

Note:

1 **Conformal coatings are commonly used in electronics to protect PCBs from environmental factors such as moisture, dust, chemicals, and temperature extremes. However it is required to remove conformal coatings for rework, repair or modification of circuit.**

2 **The instructor has to select the PCB with conformal coating and explain about the type of coating to the trainees.**

3 **To determine the appropriate coating removal procedure, first the type of coating is to be identified - whether the coating is harder or softer, or the coating is of transparent type.**

- **Safety Precautions: When choosing a method for removing conformal coatings, consider factors such as the type of coating material, the substrate material, the complexity of the PCB, and the desired level of precision.**
- **Always follow safety guidelines and manufacturer recommendations when using chemicals. Conformal coating remover chemicals are available commercially. These chemicals are typically applied to the coated surface and allowed to penetrate the coating.**
- **The softened coating can then be mechanically removed using a scraper or brush.**
- **Ensure proper safety precautions are taken, such as wearing gloves and working in a well-ventilated area, when using chemical strippers.**

TASK 1: **Inspection of the Soldered joints**

1 Check the coating physically and record the observation in the Table 1.

2 Use the hot air gun, apply the heat over the coating for a short duration and record the observation.

3 Check the hardness of the coating surface and bonding.

4 Use foam swab, apply IPA solution on the coating and record the observation.

5 Get the work checked by the Instructor.

— — — — —

TASK 2: **Removal of conformal coating using solvent by local spot removal method**

Note: Since various substances are used for coating removal, their time required to dissolve will vary. Therefore, apply the removal solution several times even after evaporation, for hard conformal coatings.

1 Use the marker pen and draw outline for the coating removal area as shown in Figure.

2 Apply High Temperature (Kapton Tape to outline the area) on all the four sides where the coating is to be removed.

3 Dip one end of a foam swab in stripping solution and apply a small quantity of the solution on the coated area which to be removed as shown in Figure.

4 Rub the solution applied on the surface carefully with a brush or wood stick to remove the coating as shown in Fig 3 & 4 and record the observation in Table1.

5 Clean the conformal coating removed area using IPA solution.

6 Get the Work checked by the Instructor.

Table1

S. No.	Test	Yes	No
1	Does the coating feel soft, rubbery, spongy or glossy?		
2	Does the coating have a noticeable reaction to heat?		
3	Is there a reaction to solvent?		
4	Is the coating hard?		
5	Does the coating have very strong surface bonding?		

— — — — —

TASK 3: **Removal of conformal coating by peeling method**

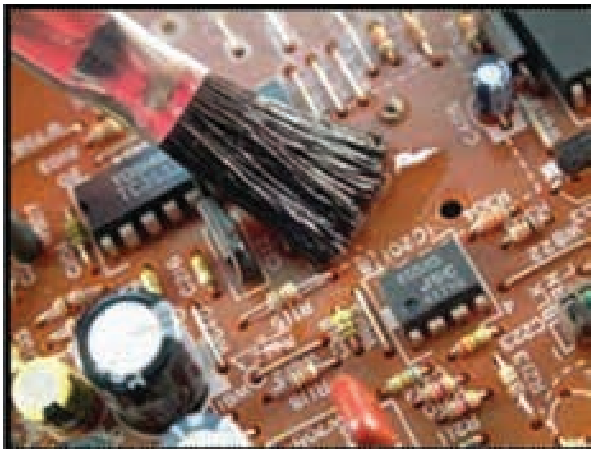
1 Use marker pen, draw outline for a coating removal area as shown in Figure.

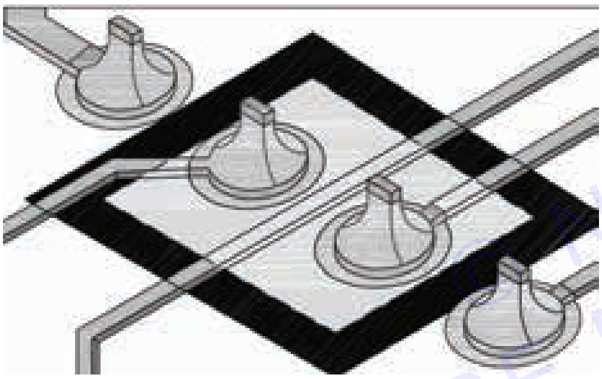
2 Use electricians knife, slit and peel off the coating material as shown in Figure.

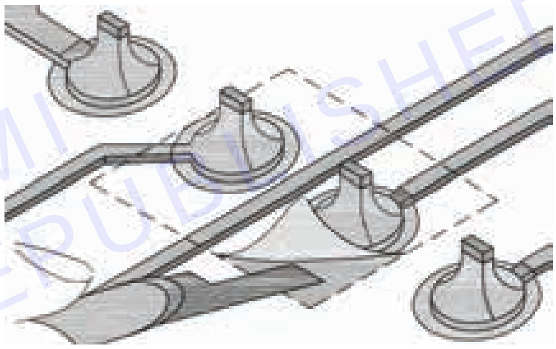
3 Repeat the above step until all the coating material is removed.

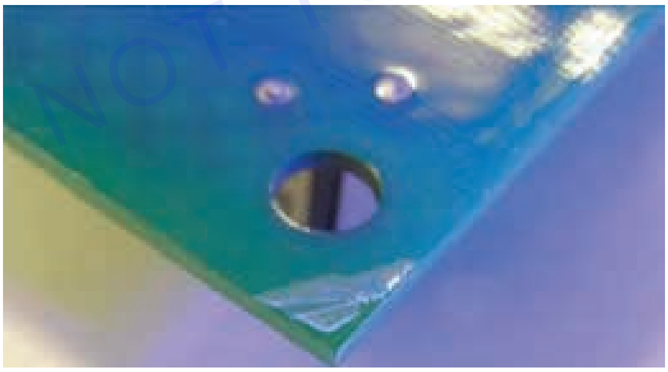
4 Clean the stripped area using cleaning solvent and cleaning wipes as shown in Figure.

5 Get the work checked by the Instructor.









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EXERCISE 76: Perform replacement of coating

Objectives

At the end of this exercise you shall be able to

- replace the conformal coating on PCB.

Requirements

Tools/ Equipments/ Instruments

- Trainees tools kit - 1 Set.
- Acrylic resin with Spray gun - 1 No.
- Hot air gun - 1 No.
- Scraper - 1 No.
- ESD safe surface with ESD wrist strap - 1 Set
- IPA Cleaning solution - 1 bottle
- Marker pen - 1 No.
- General purpose PCB (or) SMD PCB - 1 No.
- Gloves - as reqd.
- High temperature tape (50 mm x 100 mm Kapton tape) - 1 No.

Materials/ Components

- Foam swab - as reqd.
- Cleaning Brush - 1 No.

Procedure

TASK 1: **Conformal coating on local spot area of PCB**

Caution: Use the ESD safe surface/wrist strap to prevent the board from electrostatic charges.

1 Wear wrist strap and connect it on the ESD-safe surface mat as shown in Figs 1 & 2

Fig 1

2 Use foam swab/cleaning brush and clean the selected area on the given SMD PCB for any dust particles.

Note: PCB must be thoroughly cleaned and dried eight hours before applying conformal coating.

3 Use IPA solution, clean the selected area thoroughly and allow it to dry.

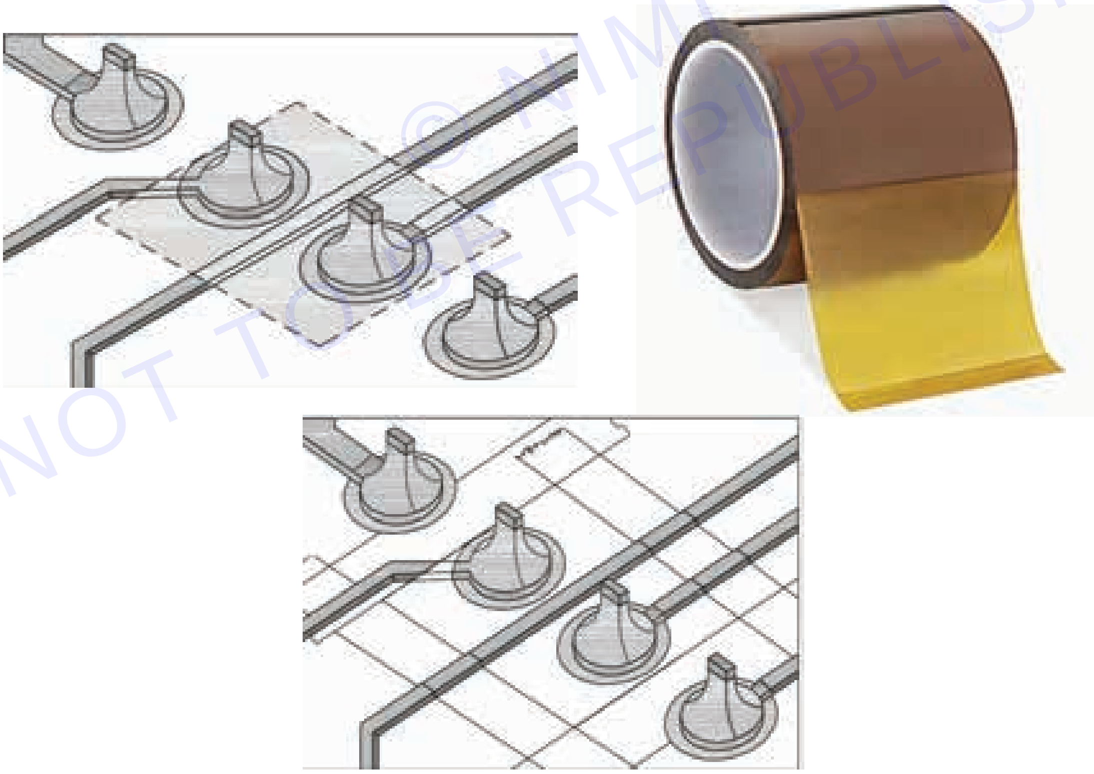
Note: Keep the cleaned board to dry completely for a minimum of one hour to 2 hours duration.

Fig 2

4 Mark the outline area using marker pen where the coating to be applied as shown in Fig 3.

5 Use the high temperature kapton tape, apply the tape on all the four sides of the outlined area as shown in Fig 3.

Fig 3



6 Use a brush or foam swab and apply the conformal coating on the board surface as shown in Fig 4.

7 Another method is to use a spray gun for spraying the coating.

8 After applying the coating, keep the board for curing and drying under a fan or in a ventilated area.

9 Get the work checked by the Instructor.

Fig 4

MODULE 8: Digital panelmeter and Light emitting diode (LED)

EXERCISE 77 & 78: Identify LED display module and its decoder/ driver ICs

Objectives

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

- identify the type of LED display used in the Digital Panel Meter
- identify various decoder/ driver IC in digital panel meter.

Requirements

Tools/ Equipments/ Instruments

• Digital panel meter with different driver ICs	- as reqd.
• Trainees tools kit	- 1 Set.
• Digital Multimeter with probes	- 1 No.

Materials/ Components

- Operating / Instruction manual

Procedure

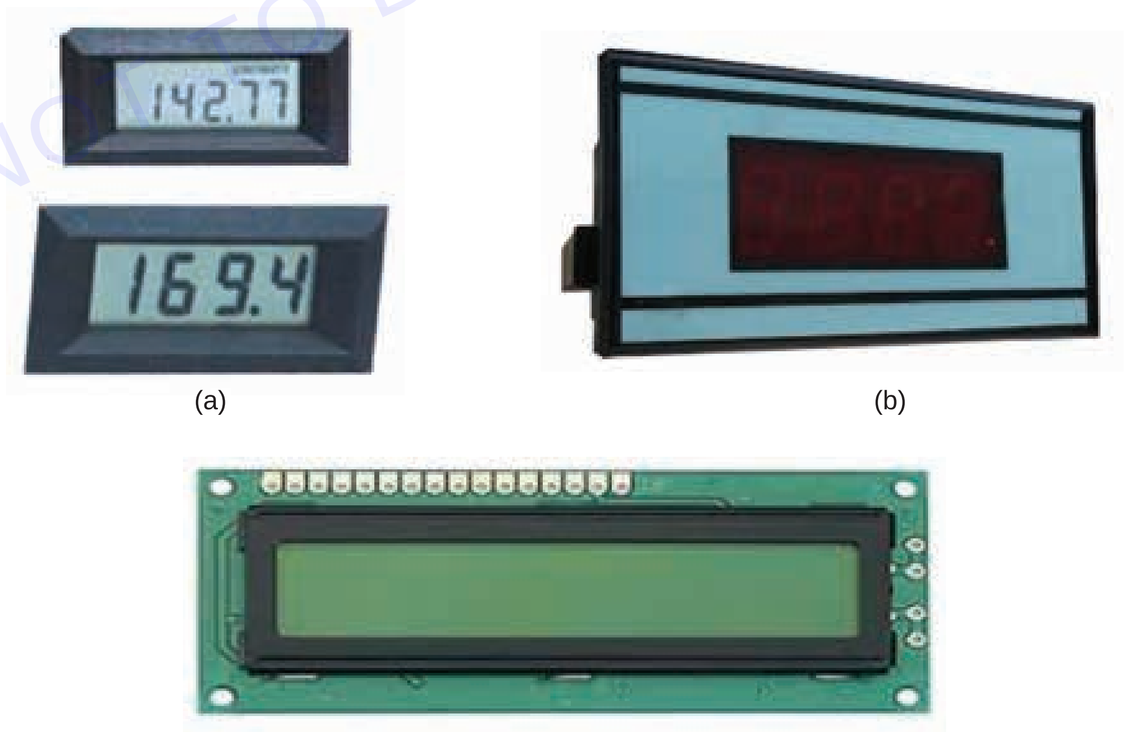
TASK 1 : **Identification of the type of LED display**

1 Pick any one of the digital panel meter from the collection provided by the instructor.

2 Note the digital panel meter's nameplate, typically located on the front or back of the device.as shown in the Fig 1a,1b,1c

Name plate contains important information such as the manufacturer's name, model number, serial number, voltage ratings, and other specifications.

Fig 1



(a) (b) (c)

3 Record all relevant details from the nameplate and fill in the table 1

4 Carefully observe the display of the digital panel meter to determine its display type, which could be LCD (Liquid Crystal Display), LED (Light Emitting Diode), Dot Matrix, or others along with the colour of display.

Table 1

Sl. No.	Name plate details	Display type	Display colour	Decoder/Driver IC

5 Repeat the above steps for all other digital panel meters.

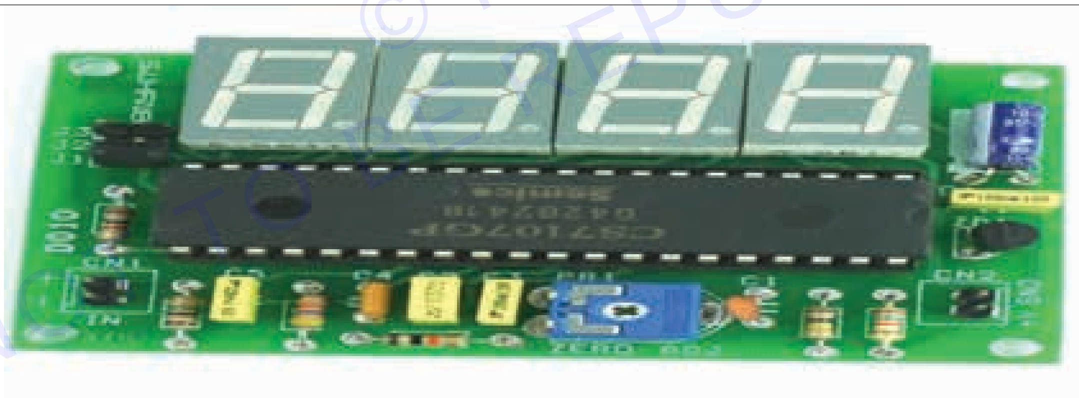
— — — — —

TASK 2 : **Identification of the Decoder/ Driver IC in Digital Panel Meter**

1 Pick any one digital panel meter from the collection provided by the instructor.

2 Carefully detach the back panel of the Digital Panel Meter (DPM) to gain access to its internal components as shown in the Fg 2.

Fg 2



Use appropriate tools and techniques to ensure safe removal without causing damage to the panel or surrounding components.

3 Remove the back panel in the DPM.

4 Identify the Decoder/Driver Integrated Circuit (IC) on the circuit board. This IC plays a crucial role in decoding signals and driving the display of the DPM.

5 Remove the circuit board in DPM cabinet

6 Record specific details of the Decoder/Driver IC in the table 1

These details may include its part number, manufacturer, pin configuration, and any other relevant information provided in the IC itself.

7 Repeat the above steps for all other panel meters.

— — — — —

EXERCISE 79 : Display a word on a two line LED

Objectives

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

- construct a two line LED circuit
- test the two line LED circuit.

Requirements

Tools/ Equipments/ Instruments

- Trainees tools kit - 1 Set.
- Digital multimeter with probes - 1 Set.
- Regulator DC Power supply 0-30V/ 2A - 1 No.
- Soldering iron 25W/230V - 1 No.

Materials/ Components

- PCB-GP - 1 No.
- Decade counter IC CD4017 - 1 No.
- Timer IC 555 - 1 No.
- Positive regulator IC 7805 - 1 No.
- Diode, IN5402 - 2 Nos.
- Diode, IN4148 - 2 Nos.
- Transistor, SL100 - 2 Nos.
- Transistor, TIP 122 with heat sink - 1 No.
- Capacitor, 10WF, 16V - 1 No.
- Capacitor, 0.1WF - 1 No.
- Capacitor, 0.01WF - 1 No.
- Pre-set, 100KW (Horizontal type) - 1 No.
- Resistor, 10KW, 0.5W - 1 No.
- Resistor, 470W, 0.5W - 3 Nos.
- Resistor, 220W, 0.5W - 5 Nos.
- LED, 5mm, Red - as reqd.
- Connecting wires - as reqd.
- Hookup wire - as reqd.
- Rosin cored solder - as reqd.

Procedure

TASK 1 : **Construction of a two line LED circuit to display a word**

1 Collect all the components required and test them for good working condition.

Use heat sink for the power transistor T3

2 Plan the layout and assemble the circuit as shown in Fig 1 on the breadboard/ general purpose PCB.

The arrangement of LED1 through LED5 is used to display 'I' as shown in Fig.1. The anodes of LED1 through LED5 are connected to point-A and the cathodes of these LEDs are connected to point-B. Similarly, connect the other letters as shown in Fig 1.

3 Get the assembled circuit checked by the Instructor.

— — — — —

TASK 2 : **Testing the two line LED circuit**

1 Apply 230V, 50Hz, single phase AC supply to the primary of the transformer.

2 Switch ON the 9V DC power supply and check the circuit operation.

3 Observe the output LED display cycle.

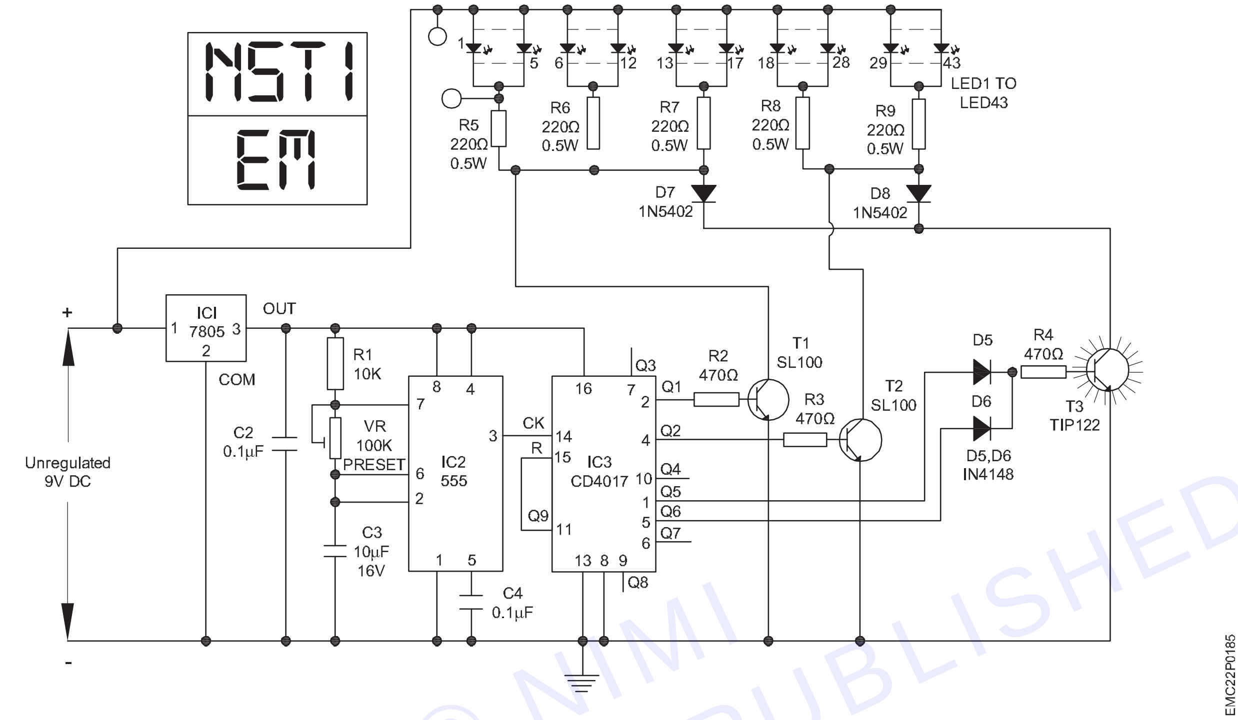
The display board displays 'ITI,' and 'EM' one after another for one second each. After that, the message "ITI EM" is displayed for 4 seconds (because Q5 and Q6 are connected to resistor R4 via diodes D5 and D6).

At the next clock input output Q9 goes high, and IC3 is reset and the display is turned off for one second. Thereafter the cycle repeats.

4 Adjust the pre-set VR of astable multivibrator to change the clock frequency of decade counter to vary the display time.

5 Observe the display output for the time/sequence of LED letters.

Fg 1



6 Get the work checked by the instructor.

EXERCISE 80: Measure current flowing through a resistor and display it on LED module

Objectives

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

- measure the voltage in simple circuit using LED module of DPM
- measure the current in simple circuit using LED module of DPM.

Requirements

Tools/ Equipments/ Instruments

- DPM with LED display 0-250 mA - 1 No.
- DPM with LED display 0-50V - 1 No.
- Regulated DC power supply 0-30V/2A - 1 No.
- Digital multimeter with probes - 1 No.
- Trainees tools kit - 1 Set.

Materials/ Components

- Breadboard - 1 No.
- Resistor 500 W/2W - 1 No.
- Hook up wires - as reqd.

Safety precaution

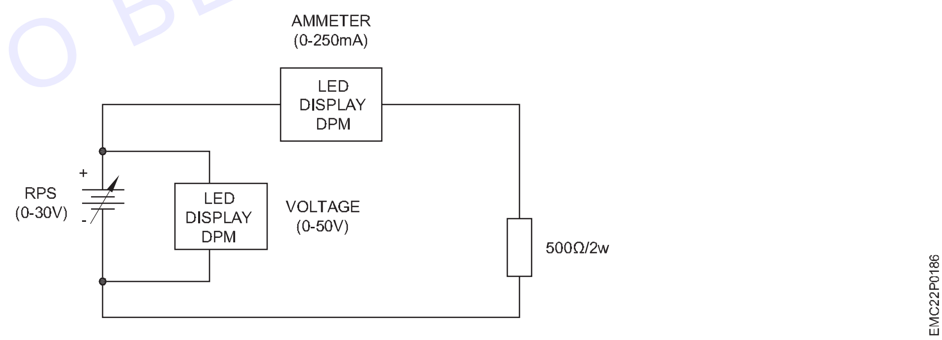
1 Avoid loose connections

Procedure

1 Collect the components required and check them for good working condition.

2 Make the simple test set-up of the circuit as shown in Fig 1.

Fg 1



3 Switch ON the DC power supply, increase to 5VDC.

4 Measure the voltage of variable power supply output and current through the load.

5 Record the observations in Table-1.

6 Increase the supply voltage in steps of 5V upto 25VDC and repeat steps 4 and 5.

Table 1

Sl. No.	Value of load resistor	Voltage across load Resistor	Current through the circuit
1			
2			
3			
4			
5			

7 Get the work checked by the Instructor.

— — — — —

EXERCISE 81: Measure current flowing through sensor and display it on LED Module

Objectives

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

- measure the current flowing through the digital panel meter.

Requirements

Tools/ Equipments/ Instruments

- Trainees tools kit - 2 Nos
- Multimeter with probes - 1 No.
- Regulator power supply 0-30V/2A - 1 No.
- Rectangular battery 9V - 1 No.

Materials/ Components

- Shunt resistor 0.1 W - 1 No.
- Shunt resitor 0.01 W - 1 No.

Safety precaution

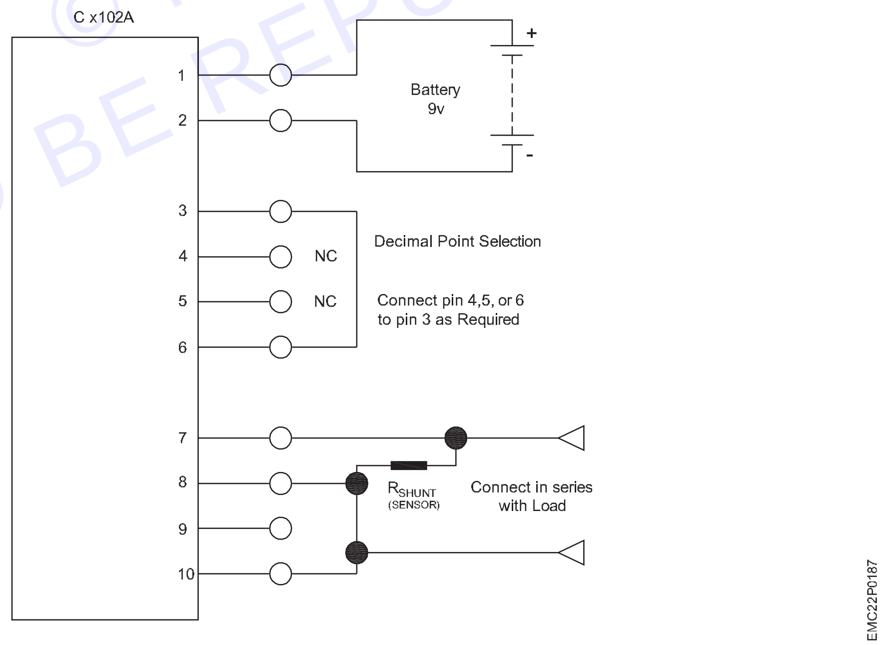
1 Keep the work area dry and clean.

2 Use proper tools for opening the digital panel meter.

Procedure

1 Connect the shunt resistor to digital panel/ meter as shown in the Fig 1

Fig 1



2 The shunt resistor is placed in series with the applied current which causes a voltage deep to occur across the shunt.

3 The shunt value depends on the maximum current flow that will be encountered. For relatively small current values (below 1 Amp) a 0.1 ohm shunt resistor is adequate. This value will minimise any loading in the circuit and produce a reasonable reading on the DPM. If higher current levels will be encountered, 0.01 ohm or lower value should be used.

4 Connect the battery to circuit as shown in the diagram.

5 Connect the Pin No.3 to Pin No.6 of DPM for proper decimal point display.

6 Note that the current value displayed on the meter can be fine-tuned by adjusting the trimmer potentiometer on the back of the DPM.

7 Short Pin No.8 and pin No.10 together and connected to the negative end of the shunt resistor.

8 Connect Rshunt across Pin No.7 and Pin No.8 and will be connected in series with the load .

9 Note down the actual and indicated current readings and record in Table-1.

Calculation

- All digital panel meters, the full scale deflection are 200 mV full- scale.
- For the measurement of 1 Amps current through DPM, correct power rating of the shunt resistor can be determined by using the Ohm's Law power formula.

  P (Power) = V (Voltage) x I (Current)

  $P = V_{max} \times I_{max} = (0.200) \times (1.0) = 0.1$ Watt
- So we should use a 1/2 watt 1% resistor to be safe.

Table 1

Value of RShunt	Actual Current Reading	Indicated Reading on DPM	Voltage & cross Rshunt

— — — — —

EXERCISE 82: Identify LCD display module and its decoder/ driver ICs

Objectives

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

- identify the type of LCD display used in digital panel meter
- identify the various decoder/driver IC in digital panel meter.

Requirements

Tools/ Equipments/ Instruments

- Trainees tools kit - 1 Set
- Digital multimeter with probes - 1 No.

Materials/ Components

- LCD digital panel meter with different driver ICs - 2 Nos

Safety precaution

1 Keep use a soft cloth and spread it on a dry and clean area on the workbench Handle the glass panel of the LCD is easily danm on the workbench.

2 Use proper tools for opening the digital panel meter.

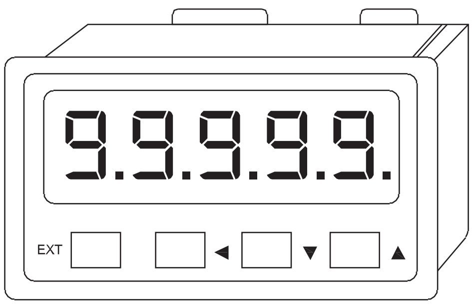
3 If pressure is applied to LCD, orientation may be distrucbed. The LCD can be broken by shock.

4 DC voltage or higher voltage than specified will reduce the life time of the LCD.

Procedure

1 Pick any one of the labelled digital panel meter from the instructor as shown in Fig 1

Fig 1



LED TYPE DPM

2 Note down the name plate details of the digital panel meter in Table -1

3 Check the display type (LCD, LED, Dot Matrix, etc.) and note down in Table -1

4 Repeat the above steps for all other digital panel meters.

Table 1

Label No.	Name plate details of DPM	Display Type	Display colour	Decorder/Driver IC
1				
2				
3				
4				
5				

— — — — —

TASK 2: **Identification of the Decoder/ Driver IC in digital panel meter**

1 Pick any one of the labelled digital panel meter.

2 Remove the back panel in the DPM.

3 Remove the circuit board in DPM cabinet.

4 Identify the Decoder/Driver IC and record in Table -2

5 Repeat the above steps for all other panel meters.

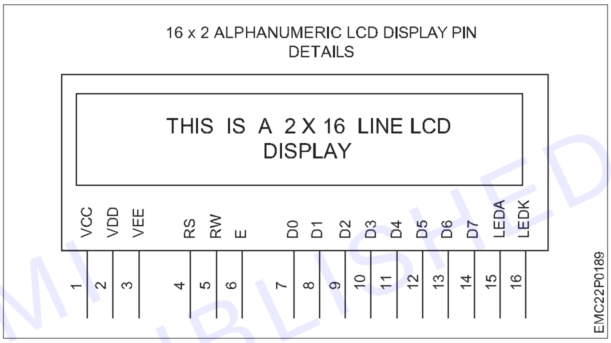


Table 2

Pin No.	Short form	Description
1	V_{SS}	Ground
2	V_{DD}	+5V Supply
3	V_{EE}	Set LCD Contrast
4	RS	LCD Controlling Pins
5	RW	Data Pins
6	E	
7	D_0	
8	D_1	
9	D_2	
10	D_3	
11	D_4	
12	D_5	
13	D_6	
14	D_7	
15	LEDA	Back light LED anode +5V
16	LEDK	Back light LED cathode ground
Terminal details of LCD DPM		

— — — — —

EXERCISE 83: Measure current flowing through a resistor and display it

Objectives

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

- measure the voltage in single circuit using LCD module
- measure the current in simple circuit using LCD module.

Requirements

Tools/ Equipments/ Instruments

- DPM with display - 2 Nos
- Regulated DC power supply 0-30V/2A - 1 No.
- Digital multimeter with probes - 1 No.
- Trainees tools kit - 1 Set.

Materials/ Components

- Breadboard - 1 No.
- Resistor 500W/2W - 1 No.
- Hookup wires - as reqd.

Safety precaution

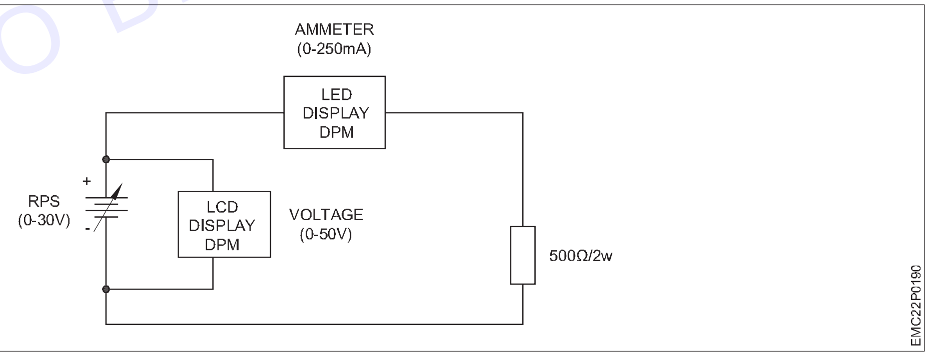
1 Avoid loose connections

Procedure

1 Collect the components and check the items for its good working condition.

2 Make the simple test set-up on the Lug board/Bread bard as shown in Fig 1

Fig 1



3 Switch ON the variable power supply.

4 Measure the voltage varying the voltage step by step and current

5 Record it on the table-1.

6 Repeat steps 4 & 5 with five different values of input voltage.

7 Switch OFF the Regulated DC Power supply and get the work checked by the instructor.

Table 1

Sl. No.	Value of load resistor	Voltage across load Resistor	Current through the circuit Resistor
1			
2			
3			
4			
5			

— — — — —

EXERCISE 84 - 86 : Dismantle the LED light, Demonstrate the Connections of LED stacks, protection circuits drivers and Regulator

Objectives

At the end of this exercise you shall be able to
- dismantle the LED lights, demonstrate the connections and parts of LED stacks
- demonstrate the protection circuits, different wattage of LED driver boards and regulator
- replace/ bypass the defective LED and repair the LED bulb.

Requirements

Tools/ Equipments/ Instruments
- Trainees tools kit - 1 Set.
- Digital multimeter with probes - 1 Set.
- Magnifying lenses with lamp - 1 Set.

Materials/ Components
- LED Lamp - as reqd.
- LED driver boards (different wattage ratings) - as reqd.

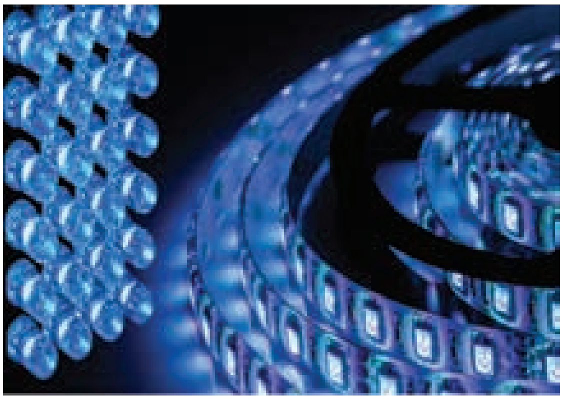
Procedure

Note: LED arrays are collections of multiple Light Emitting Diodes (LEDs) arranged in a specific pattern or configuration. These LEDs are used in a wide range of applications due to their versatility, energy efficiency, durability and low maintenance requirements.

Linear and matrix arrays are used for Architectural lighting, for making Indoor and outdoor signs for advertising and information display. Also used for dynamic lighting effects and pixel-level control in LED Video Display. It is possible to have large-scale screens for outdoor advertising, sports stadiums and events.

Circular arrays are used for Automotive lighting and decorative lighting.

Grid LED arrays consist of LEDs arranged in a grid pattern with uniform spacing between each LEDs and used for interior decoration, street lighting etc.



Note: Instructor has to provide different types of LED arrays and stacks, of different wattage to the trainees.

TASK 1: **Dismantling the LED light, identification of connections and the regulator/ driver section in LED lights**

Use the appropriate screwdriver or tool to carefully remove any screws or fasteners securing the casing. Place them in a safe location for reassembly later.

1 Dismantle the LED light/ lamp with care while opening casing and removing screws or otherwise it will lead to breaking down the physical structure of the light as shown in Fig 1.

2 The LED driver is typically fixed near the base or within the housing of the lamp.(Fig 2)

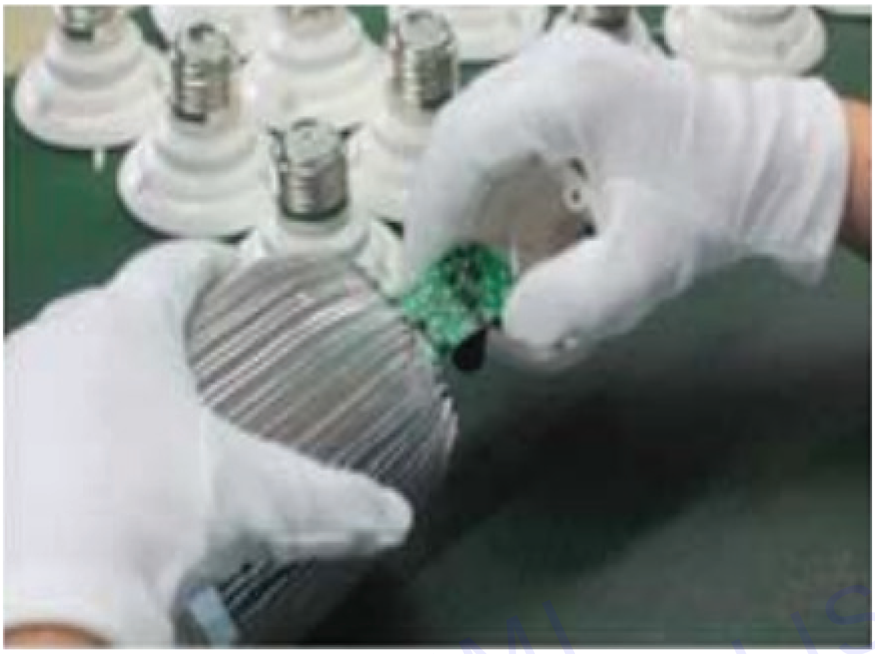
Fig 1

Fig 2

3 Note down the connections before disconnecting the wires connected to the LED driver. This may include input AC and output DC wires leading to the LED board and any control wires from the driver circuit.

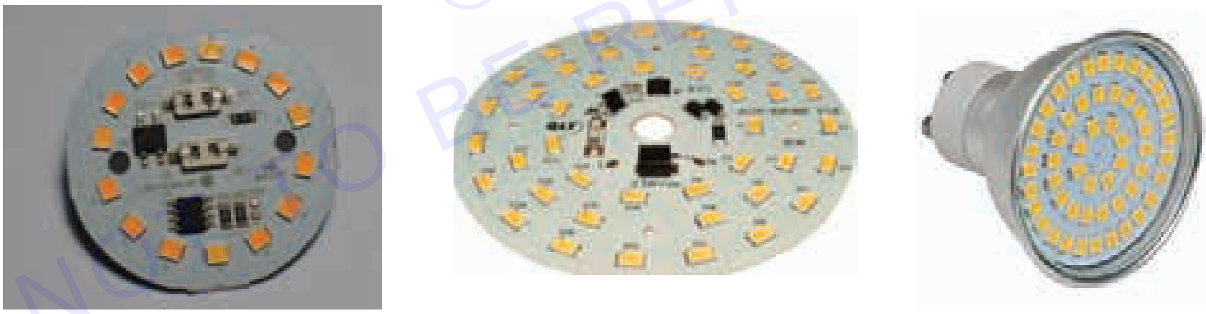
4 Remove the driver board from the LED lamp as shown in Fig 3.

Fig 3



5 Identify the type of LED array shown in Fig 4.

Fig 4



6 The parts of the sample LED light are shown in the Fig 5. Accordingly note down the parts of the LED light issued to you and record it in the table 1.

Fig 5

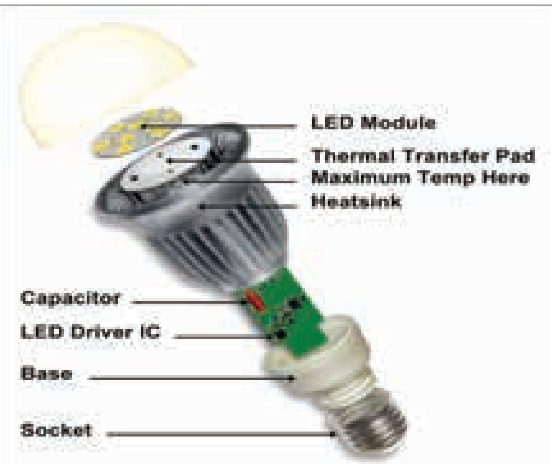
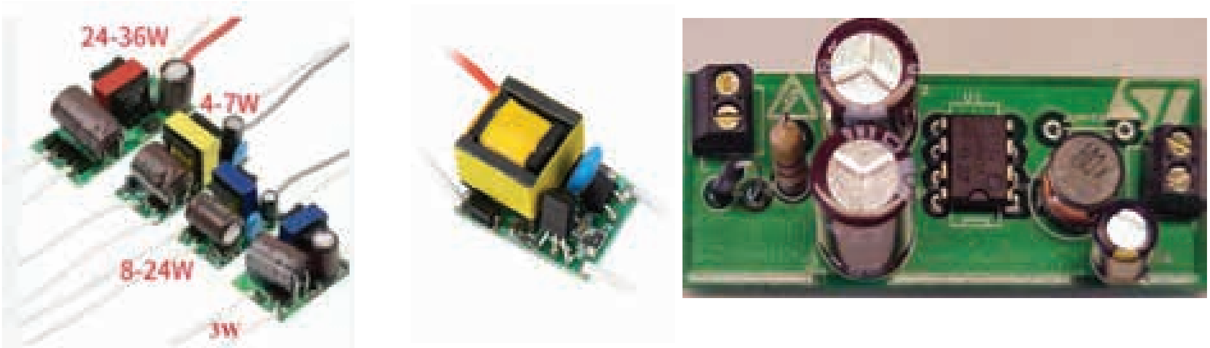


Table 1

Sl. No.	Parts of the LED lights /LED lamps	Remarks

7 Identify the different wattage and types of LED driver boards as shown in Fig 6.

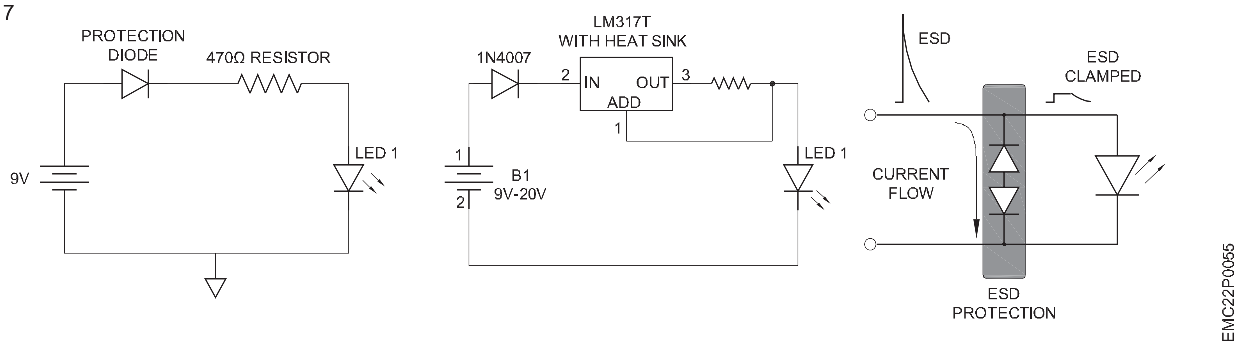
Fig 6



- **Note: An LED bulb—also called a luminaire—is made up of three basic subsystems: an LED power supply, a power-input connection to the grid, and an LED engine. The LED engine can be further split into LED arrays, LED drivers, and control units (driver cum protection units).**
- **There are five key threats that affect the reliability of LED lighting systems: Electrostatic discharge (ESD) events, include lightning,Transient overcurrent and surges, Current and voltage spikes, Thermal issues such as operating at high temperatures for long periods etc. Diodes and voltage-dependent resistors, also known as varistors, are developed to protect LEDs against certain types of surge currents. Varistors provide bidirectional protection compared to TVS diodes which is unidirectional.**
- **An ESD diode, is an ESD protection diode used for static electricity discharge in ICs. It absorbs the abnormal voltages and suppresses the ESDs and transient voltage pulses.**
- **Smart-networked lighting systems have also been introduced nowadays, which can maximize the efficiency and quality of lighting, and can also track the status of each luminaire for maintenance purposes.**

8 Identify the components such as protection diode, Regulator IC, Protection IC etc and other devices including current limiting resistor in the LED driver boards shown the above sample circuits in Fig 7 and record the observations in Table 2.

Fig 7



9 Repeat the process for all other LED drivers.

Table 2

Different wattage of the LED driver	Components name	Components specification	Uses

10 Identify the LED stack and arrays with different wattage/ type as shown in Fig 8 below and record it in the table.

A LED array is a configuration of a small Chip-on-Board (COB) LEDs that are arranged in a precise pattern. This arrangement offers several advantages for lighting applications.

Stack lights, also known as tower lights, provide clear and immediate status updates in industrial environments. These lights enhance safety and efficiency in factories, warehouses, manufacturing, and assembly lines. Their color-coded lights offers an intuitive way to monitor machinery and operational processes.

Fig 8

11 Record the types of LED stack/array available with number of LEDs in each string, number of strings, issued to you.

Different wattage of the LED lights-LED arrays/LED stack	No. of LEDs in stack/array	Purpose/Application

12 Get the work checked by the instructor.

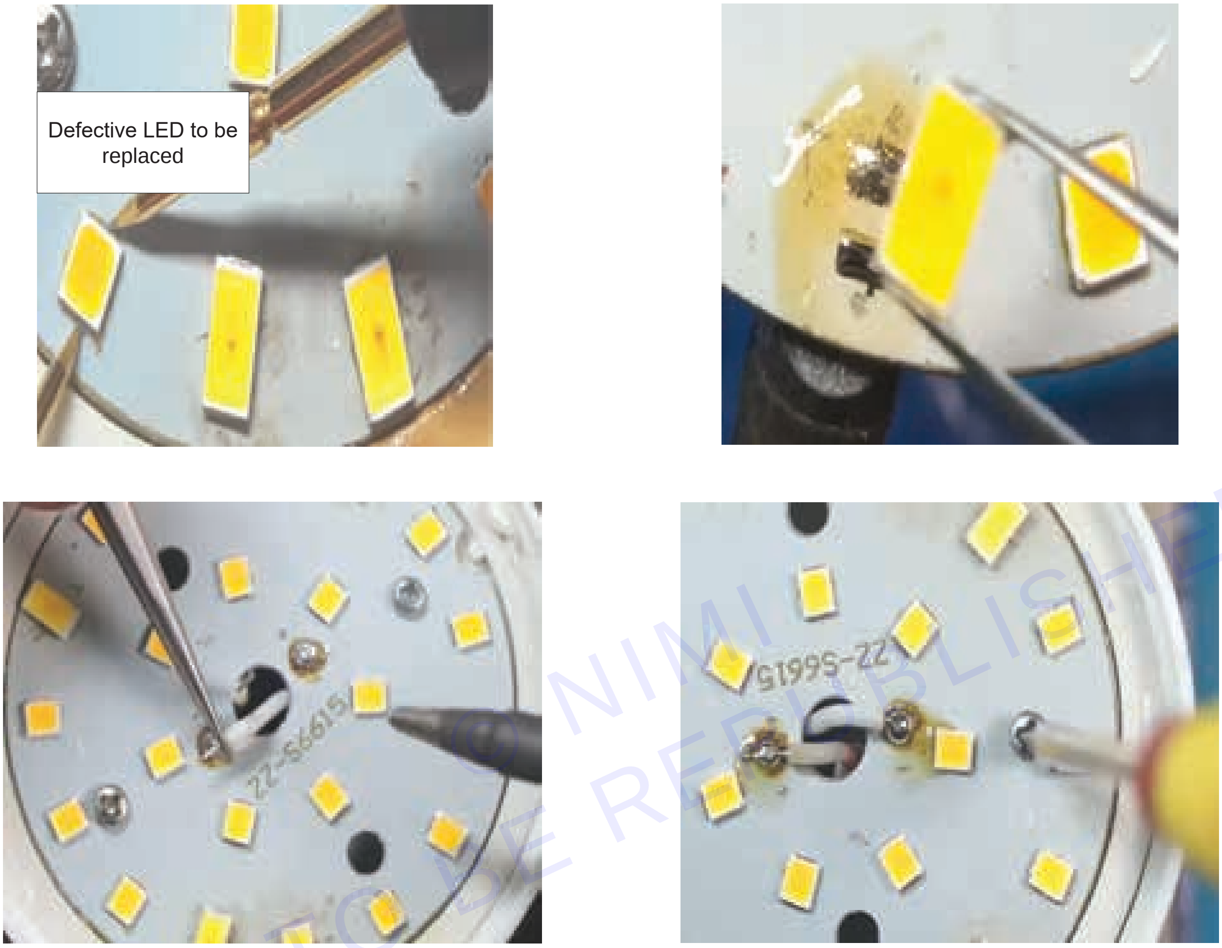
— — — — —

TASK 2: **Replace/bypass the defective LED and repair the LED bulb**

Fig 9

To verify the faulty LED, short the doubtful LEDs one by one with a tweezer or wires as shown in Fig 9. When Power is ON, good LED glows. Faulty LED does not glow. Replace that LED with new one or bypass it as shown in Fig 10.

Fig 10



EXERCISE 87: Make series strings connection of six LEDs and connect four series strings in parallel

Objectives

At the end of this exercise you shall be able to

- construct a LED array with series string connection of 6 LEDs and connect 4 such series strings in Parallel
- test and observe the circuit operation.

Requirements

Tools/ Equipments/ Instruments

- Trainees tools kit - 1 Set.
- Digital multimeter with probes - 1 Set.

Materials / Components

- Step down transformer 230V/24V, 1A - 1 No.
- Diode -IN4007 - 2 Nos.
- Electrolytic capacitor 1000μF/50V - 1 No.
- White LED 5mm - 24 Nos.
- Resistor 120Ω,1/2W - 4 Nos.
- Power cord, 2 mtrs - 1 No.
- Hook-up wire - as reqd.
- General purpose PCB - 1 No.

Procedure

A LED array is a configuration of a small Chip-on-Board (COB) LEDs that are arranged in a precise pattern. This arrangement offers several advantages for lighting applications.

Stack lights, also known as tower lights, provide clear and immediate status updates in industrial environments. These lights enhance safety and efficiency in factories, warehouses, manufacturing, and assembly lines. Their color-coded lights offers an intuitive way to monitor machinery and operational processes.

1 Collect and check all components to ensure that they are in good condition and free from any damage or defects.

2 Assemble the DC power supply with step-down transformer, rectifer and capacitor filter on the PCB /bread board as shown in Fig 1.

3 Construct series strings of six LEDs each. Ensure correct polarity (anode to cathode connection).

4 Construct four such series strings and connect them in parallel, ensuring proper connections and avoiding any loose connections.

5 Mount the LEDs with a series resistor for each string on the PCB.

6 Connect the above four LED strings/ LED array to the DC power supply with the correct polarity/ direction as shown in Fig 1.

7 Switch on the DC power supply.

8 Observe the lighting of LED strings. Ensure that all LED strings glow.

9 Measure and record the LED string voltage in Table 1.

Fig 1

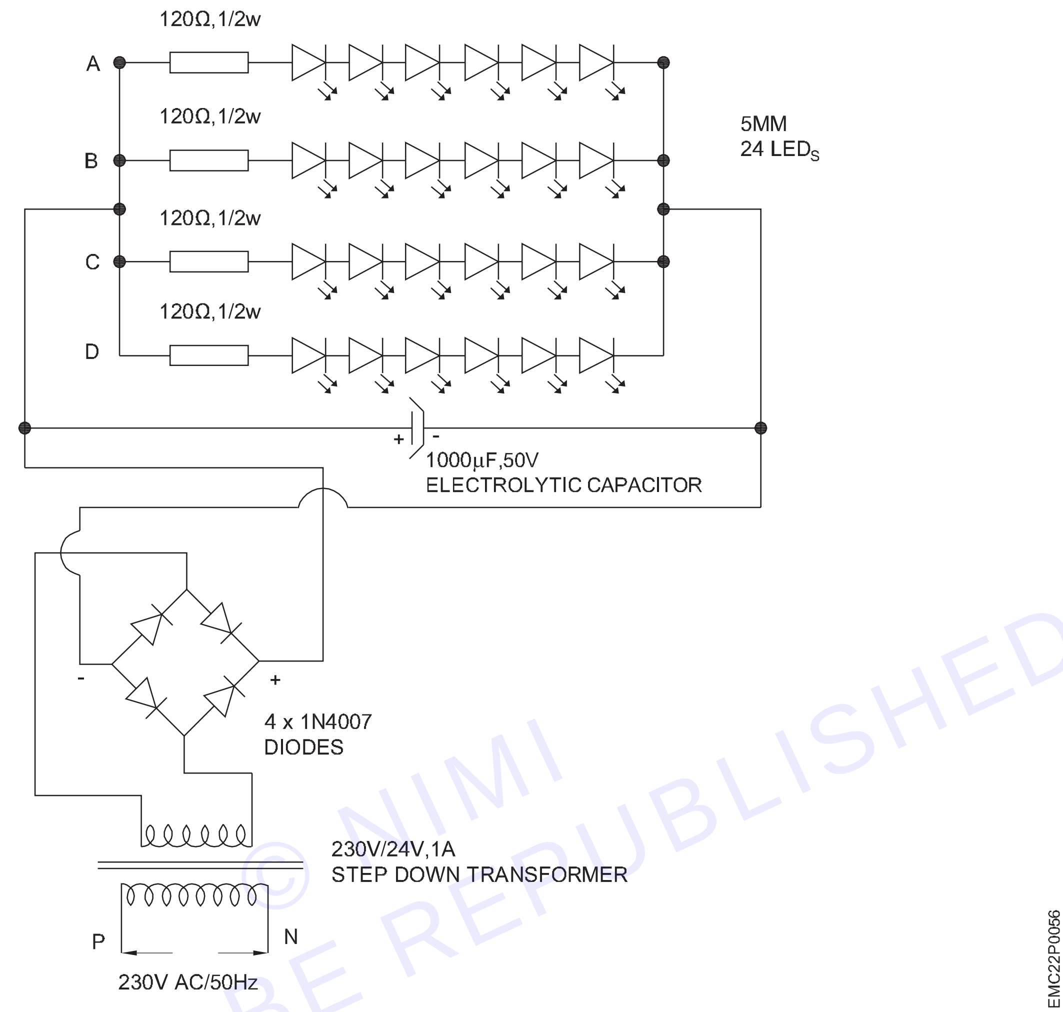


Table 1

LED String	Voltage (V)
String 1	
String 2	
String 3	
String 4	

10 Get the work checked by the instructor.

EXERCISE 88&89: Connect four parallel sets of 6X4 matrix LED strings in series to create a matrix of LEDs and check voltage across the series strings

Objectives

At the end of this exercise you shall be able to

- construct a 6x4 matrix LEDs
- assemble 4 Nos. of 6x4 matrix LEDs to create a LED array and observe the output voltage.

Requirements

Tools/ Equipments/ Instruments

- Regulated DC power supply unit (0-30)V, 2A - 1 No.
- Digital multimeter with probes - 1 No.

Materials/ Components

- White,Red,Green, Blue LEDs (5mm) - as reqd.
- Connecting wires - each 25 Nos.

Procedure

TASK 1: **Construct four sets of 6x4 matrix LEDs using PCBs.**

1 Construct four sets of 6x4 matrix LEDs using different coloured LEDs for each matrix, following the procedure from the previous exercise.

2 Interconnect the four number of 6x4 matrix LEDs using hook-up wires as shown in the Figure.

3 Set the DC regulated power supply voltage to 24V.

4 Connect the above power supply unit to the assembled array with correct polarity and Power ON.

5 Check and observe the uniform intensity of the LED matrix.

6 Observe and record the following readings:

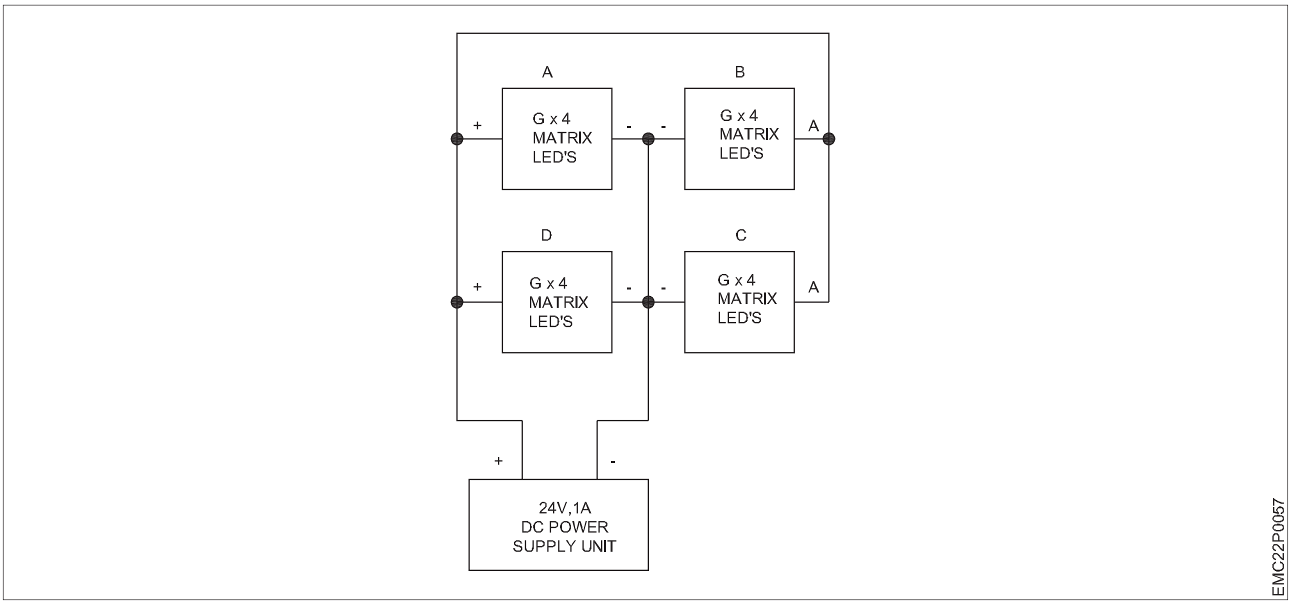
a Input DC voltage to LED matrix.

b Voltage across each 6x4 matrix LEDs.

c Voltage across series strings.

d Voltage across any LED.

7 Connect an ammeter in series to the LED matrix to measure the current drawn by the matrix LED unit.



8 Calculate the power consumed by the matrix LED unit and record it in the table.

For example:

If you have a small LED array consisting of 10 LEDs connected in series. Each LED has the following specifications:

Voltage(V): 5 volts, Current(I): 20 milliamperes(mA) or 0.02 amperes(A).

then the power consumption of a single LED would be: $P_{LED} = P_{LED} \times P_{LED}$

$$\text{ie. } P_{LED} = 5V \times 0.02A$$

$$P_{LED} = 0.10W$$

So, the power consumption of a single LED is 0.10 watts.

Now, since we have 10 LEDs connected in series, the total power consumption of the LED array would be:

$$P_{total} = P_{LED} \times \text{Number of LEDs}$$

$P_{total} = 0.10W \times 10 = P_{total} = 1W$

Therefore, the total power consumption of the LED array would be 1 watt.

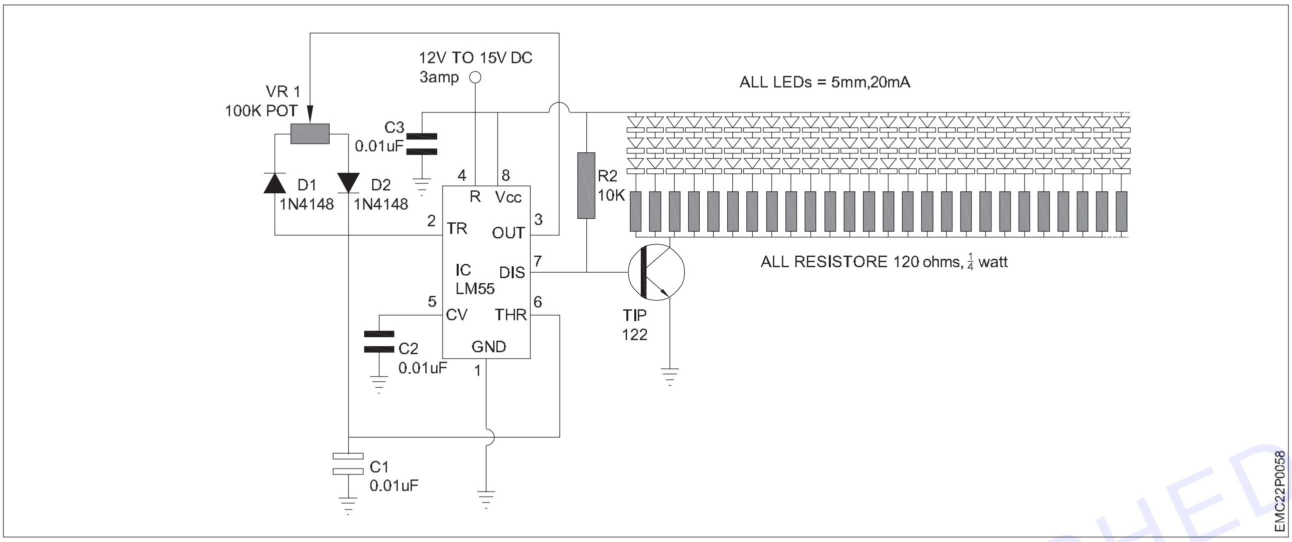
Table 1

Input DC Voltage	Voltage across matrix				Voltage across Series string	Voltage across any one LED in each matrix				Total Current measured	Total Power consumed by the matrix LED unit
	A	B	C	D							

7 Get the work checked by the instructor.

TASK 2: **Assemble 4 Nos. of 6x4 matrix LEDs to create a LED array and observe the output voltage**

The Instructor may guide the trainees to assemble and test the following LED array with Driver circuit as a Project work so as to gain confidence in assembling and testing of LED arrays which is useful for the Lab and to create interest in developing such projects.



- Get the work checked by the instructor.

— — — — —

MODULE 9: Solar power (renewable energy system)

EXERCISE 90: Install and wire the solar panel, Charge controller, battery and inverter

Objectives

At the end of this exercise you shall be able to

- select the suitable location on the roof to install solar PV panel
- wire the battery and Solar panel to Charge controller
- connect the storage battery and charge controller to inverter.

Requirements

Tools/ Equipments/ Instruments

- Trainees tools kit - 1 Set
- Digital multimeter with probes - 1 Set
- Solar panel 18V/300W - 1 No.
- Suitable Solar charge controller (with manual) - 1 No.
- Inverter, 12V/ 500VA - 1 No.

Materials / Components

- Connecting wires with lug - as reqd.
- Battery 12V /60 AH(minimum) - 1 No.
- CFL lamps -15W - 2 Nos.
- Insulation tape - as reqd.
- Cables - as reqd.

Procedure

Note: : Instructors should provide guidance to trainees before they start any tasks related to PV module installation, wiring, operation, or maintenance.

Fig 1

TASK 1 **: Selection of location on the roof to install solar PV panel**

1 Choose a roof with sufficient sunlight exposure for the solar panels throughout the day, ensuring that there is no shading.

2 Leaving a safe working space between the edge of the roof and the solar array allows for safe installation and maintenance activities.

NOTE:

Wear appropriate protective gear, such as non-slip gloves and suitable clothing, to prevent direct contact with 30V DC or higher, and to safeguard your hands from sharp edges during installation.

Mounting of the solar panel can be on the stand oriented towards South and at a tilting angle equal to the latitude of the location..

After securing the frame to the mounting surface, it's important to verify that it is stable and properly aligned. This step ensures that the frame can adequately support the SPV panel.

PRECAUTIONS:

Remove all metallic jewellery before installation to minimize the risk of accidental exposure to live circuits.

Use insulated electrical tools to prevent electric shock

Cover the front of the PV array modules with a non-transparent material to halt electricity production when working with modules or wiring.

Fig 2

SOLAR PANELS

3 Once the frame is confirmed to be stable and aligned, proceed with installing the SPV panel onto the frame. Follow the manufacturer's instructions carefully to ensure that the panel is mounted securely and correctly.

4 Before starting the connection process, ensure that the SPV panel is not generating power and that there is no sunlight hitting the panel to prevent electric shock.

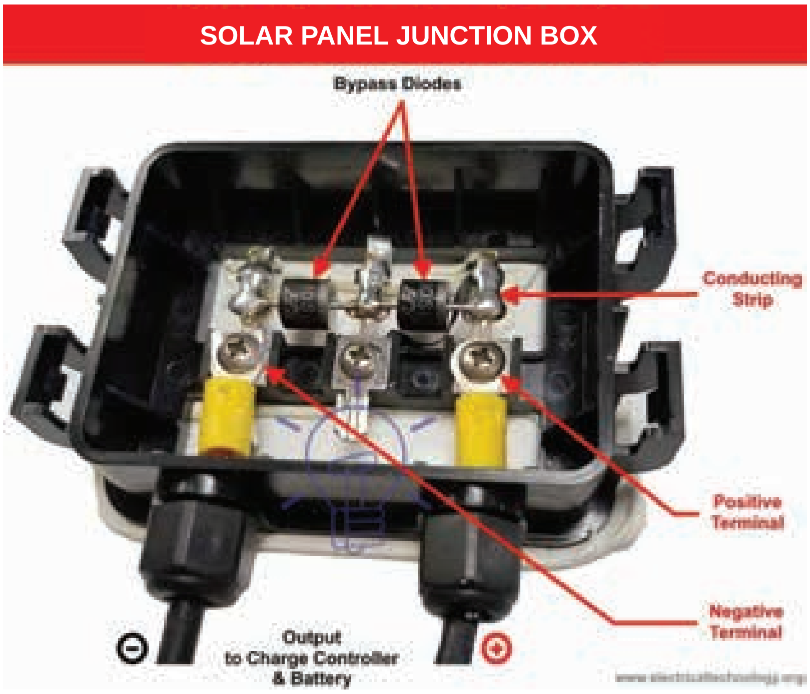
5 Locate the terminals on the back or side of the SPV panel where the cables will be connected. These terminals are typically labeled as positive (+) and negative (-).

6 Carefully strip the insulation from the ends of the cables that will be connected to the SPV (Solar Photo Voltaic) panel. Strip an appropriate length according to the terminal size and connector type.

7 Connect the positive (+) cable to the positive (+) terminal and the negative (-) cable to the negative (-) terminal on the panel. Tighten the screw or terminal connector securely.

8 Route the cables from the SPV panel to the Solar charge controller.

Fig 3



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TASK 2: **Wiring of Charge Controller to Battery Station**

Note: Ensure that proper tools are used to connect and tighten the battery terminals with the charge controller securely. Refer to the instructions provided by the manufacturer for proper connection details of the solar charge controller.

1 Select the tools to solar charge controller to the SPV panel.

2 Now select suitable Lead-Acid or Gel-cell battery based on the requirements.

3 Connect the positive (+) cable from the SPV panel to the positive (+) terminal of the solar charge controller and the negative (-) cable from the SPV panel to the negative (-) terminal as shown in Fig 4.

4 Connect the terminal marked battery positive (+) on the solar charge controller to the positive (+) battery terminal and the terminal marked battery negative (-) on the solar charge controller to the negative (-) terminal of the battery.

Note: To make battery connections according to load requirement:-

If more voltage is required by the load, then connect the batteries in series, during installation.

If more current is needed, connect the batteries in parallel.

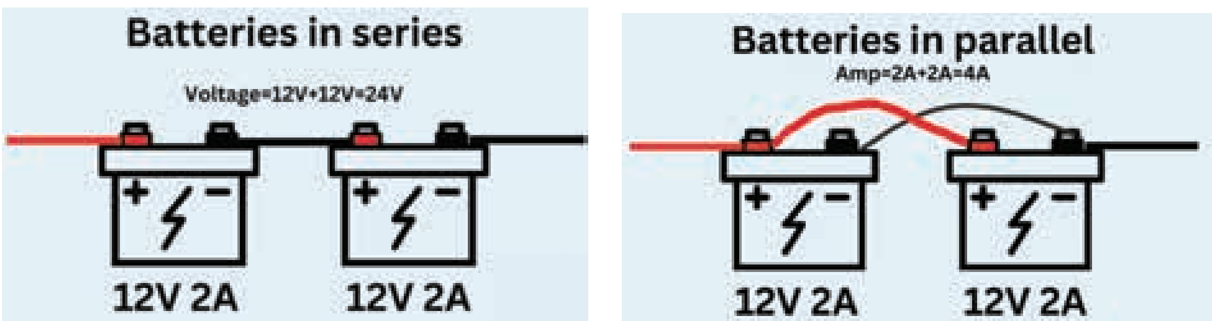
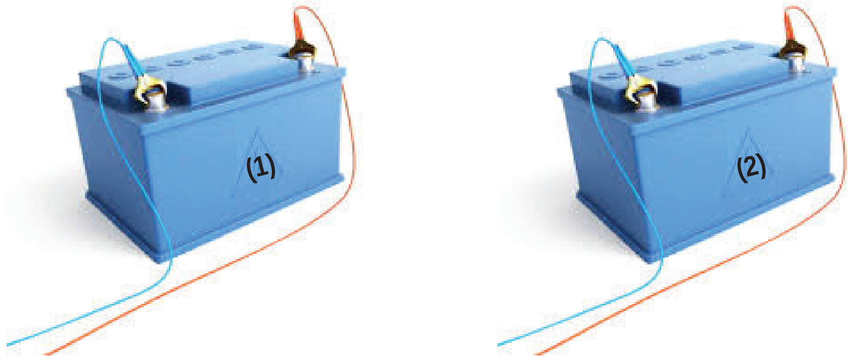


Fig 4



TASK 3: **Connection of storage battery to Inverter.**

1 Measure and cut battery cables to the appropriate length, ensuring that they are long enough to reach from the batteries to the power inverter as shown in Fig 5.

2 Connect the positive (+) terminal of the battery to the positive (+) input terminal of the power inverter (using a battery cable) and connect the negative (-) terminal of the battery to the negative (-) input terminal of the inverter.

Ensure that all connections are tight and secure. Use appropriate tools, such as wrenches or pliers, to tighten the battery terminals and inverter cables.

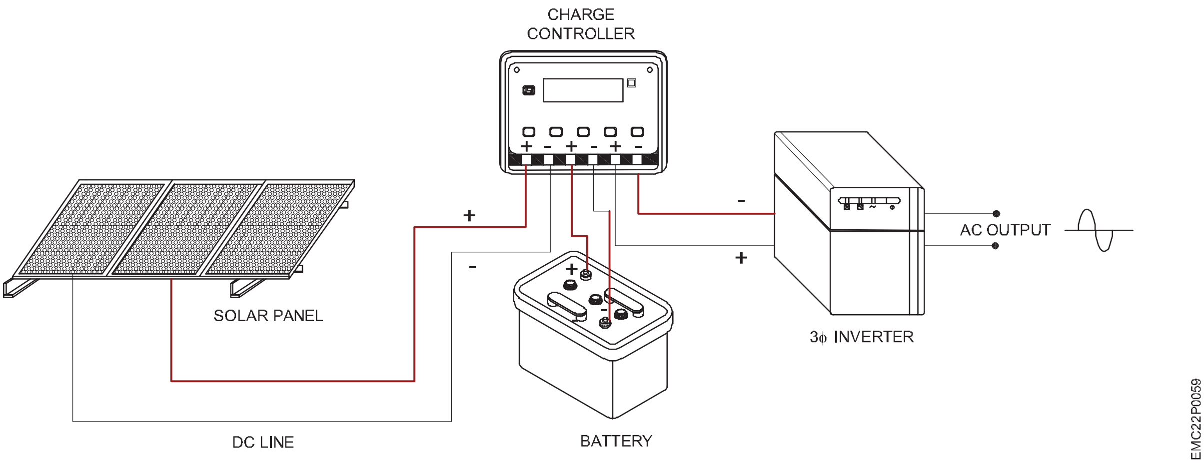
3 After connecting the batteries to the inverter, perform a test to ensure that the system is functioning correctly. Check the inverter display for any error messages or warnings.

4 After installing and wiring the full setup record your observation in table 1 and it is also important to have the work inspected by the instructor to receive feedback.

Table 1

Observation	Remarks

Fig 5



EXERCISE 91: Install a solar power panel to charge a rechargeable 12V DC battery and find out the charging time

Objectives

At the end of this exercise you shall be able to

- install a solar panel to operate a 15W LED/ CFL lamp
- calculate the changing time of the battery.

Requirements

Tools/ Equipments

- Trainees tools kit - 1 Set.
- Digital multimeter with probes - 1 No.
- Solar photo voltaic power generation (300W) setup / trainer kit with manual - 1 Set.
- Solar battery 12V DC/ 100 AH - 1 No.

Materials / Components

- Wires with lugs and patch cords - 1 Set.
- Insulation tape - 1 No.

Procedure

1 Refer to the previous exercise. You will see that the charge controller is receiving power from the solar panel, and the battery is receiving charge from the solar charger controller.

2 Make sure that the multimeter is set at 10A.

3 Measure the short circuit SPV current by connecting +ve lead on the multimeter to the +ve on the panel and the -ve from the multimeter to the -ve on the panel and record the readings in TABLE 1.

Charging time (in hours) = (Battery capacity in ampere-hours) / (Solar panel output in amperes)

Note: Example

a Battery capacity:, if you have a 12V battery with a capacity of 100Ah, you would use 100Ah into the formula.

b Solar panel output: Solar panels produce a certain amount of current, usually measured in amperes (A). if your solar panel generates 5A of current, you would use 5A in the formula. Then Charging time would be = 100Ah/ 5A = 20Hrs.

4 Confirm the battery capacity and solar panel output by recording the readings in table 1. Then, use the above-mentioned formula to calculate the charging time.

Table 1

Battery capacity (A-H)	
Solar panel output (A)	
Charging time	
DC load current	

5 Connect the DC output terminals of the charge controller to the DC load 10W or 15W LED/CFL bulbs, ensure that the positive and negative terminals are correctly matched to avoid any polarity issues.

6 Connect the battery +ve terminal to fuse holder as shown in Fig 1

7 Connect the fuse holder to DC circuit breaker as shown in Fig 2

Fig 1

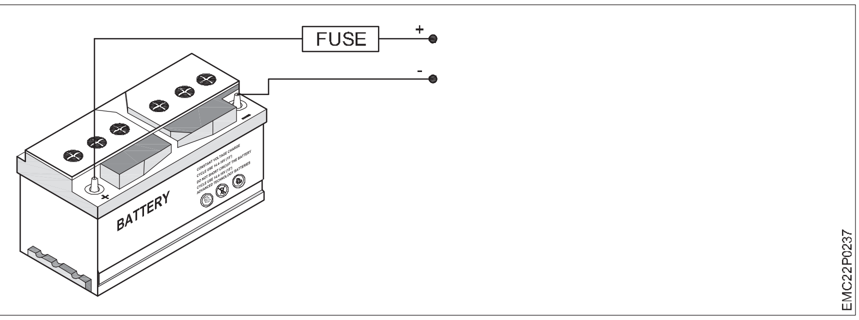
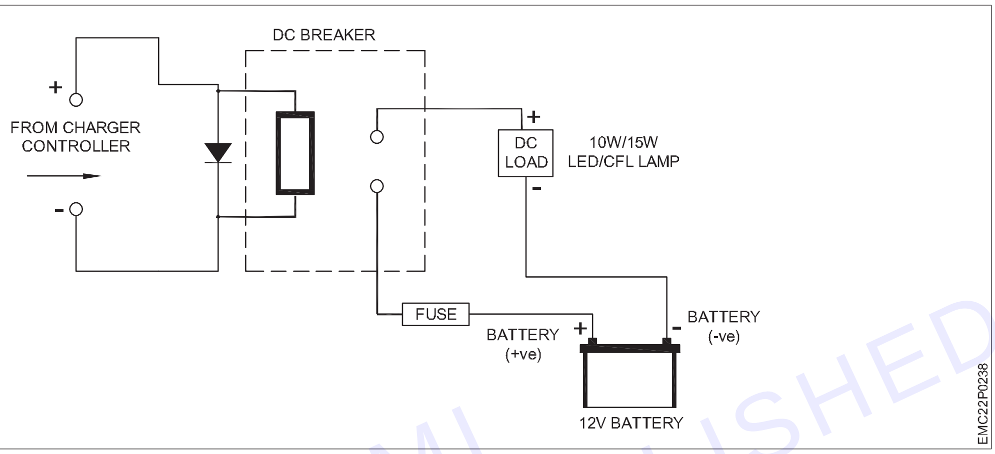


Fig 2



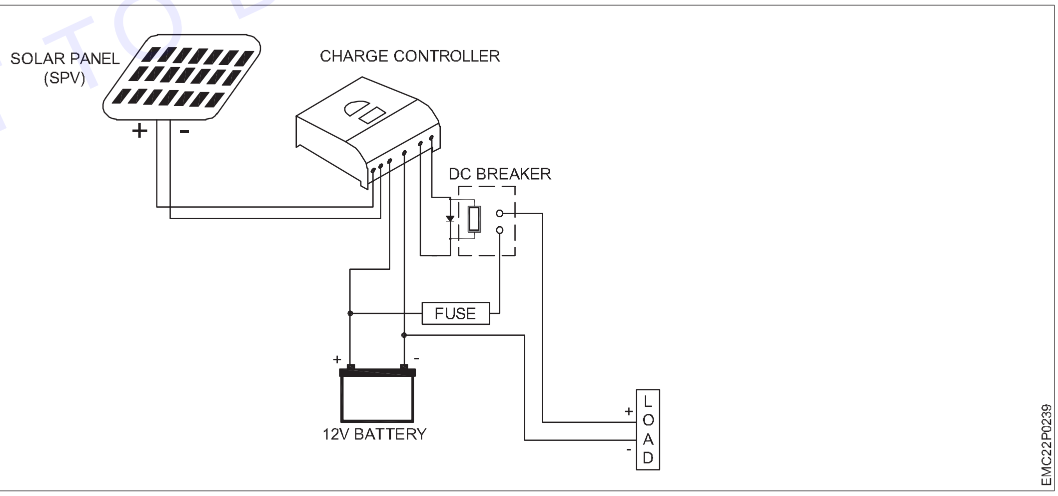
8 Check the nominal voltage of batteries

9 Connect the + ve and - ve terminals of charge controller to the corresponding battery terminals and tighten the screws.

10 Connect the DC breaker to one end of charge controller (+) terminal as shown in Fig 3

11 Connect the DC lamp load to one end of the ciruit breaker and -ve terminal of battery as shown in Fig 3

Fig 3



12 Power on the charge controller & observe the lamp status, which should be ON.

13 Measure voltage across the 12V battery.

14 Get the work checked by the instructor.

EXERCISE 92: Connect and test solar panel to the Inverter through the charge controller & battery and run the load

Objectives

At the end of this exercise you shall be able to

- measure the voltage across the solar panel, battery, inverter and load
- measure the current through the panel and the load.

Requirements

Tools/ Equipments

- Trainees tools kit - 1 Set
- Digital multimeter with probes - 1 No.
- Solar photo voltaic power generation (300W) setup / trainer kit with manual - 1 Set.
- Solar charge controller (with manual) - 1 No.

Materials / Components

- Connecting wires with lug - as reqd.
- Battery 12V /100AH(minimum) - 1 No.
- LED lamps -3W - 2 Nos.
- CFL lamps -15W - 2 Nos.
- Insulation tape - as reqd.

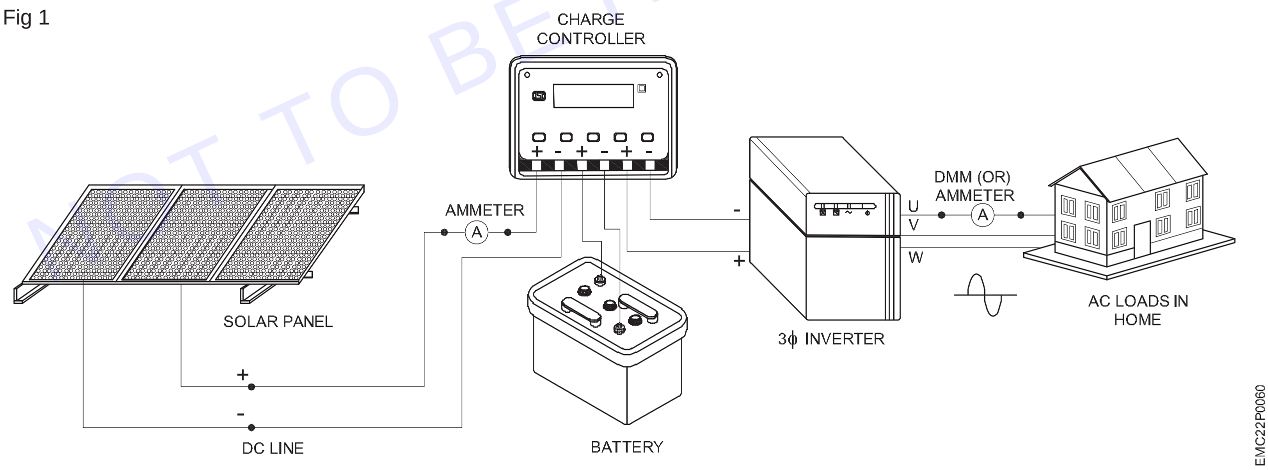
Procedure

1 Refer to the previous exercise for installation and wiring to ensure that the setup is done correctly.

2 Set the DMM to measure DC voltage at 20V range

3 Connect the multimeter probes to the SPV panel by observing the correct polarity as shown in Fig 1.

Fig 1



4 Measure the open circuit SPV voltage and record this voltage measurement in Table 1.

5 Ensure that the multimeter is set at 10A.

6 To measure the solar panel (SPV) current, connect +ve lead of the multimeter to the +ve terminal of the panel and the -ve load of the multimeter to the +ve terminal of change controller unit and record the readings in Table 1.

7 Calculate the maximum wattage that can be dissipated by the SPV panel using the formula. P = V x I watts

8 Confirm that the charge controller is receiving power from the solar panel, and verify if the battery is receiving a charge from the solar charger.

9 Use a multimeter to measure the voltage across the battery, and record the measured voltage in Table 1.

10 Switch on the inverter and connect an AC load to the inverter output.

11 Measure the voltage across the load 1 (say a lamp load) and the current passing through the load 1 using a multimeter.

12 Record the observed voltage and current readings in Table 1.

13 Repeat same for other load (say a computer) and both the loads.

Table 1

Solar panel system measurements	
Solar panel voltage	Voltage : ____________ (V)
Solar panel current	Current : ____________ (A)
Solar panel Power	Power : ____________ (W)
Solar battery voltage	Voltage : ____________ (V)
Solar inverter voltage	Voltage : ____________ (V)
AC load 1	Voltage : ____________ (V)
Current through the load 1	Current : ____________ (A)
AC load 2	Voltage : ____________ (V)
Current through the load 2	Current : ____________ (A)
Overall current	Current : ____________ (A)

EXERCISE 93: Install an ON- GRID solar inverter

Objectives

At the end of this exercise you shall be able to

- install the solar inverter and connect the solar inverter to grid (AC)
- commission the solar inverter.

Requirements

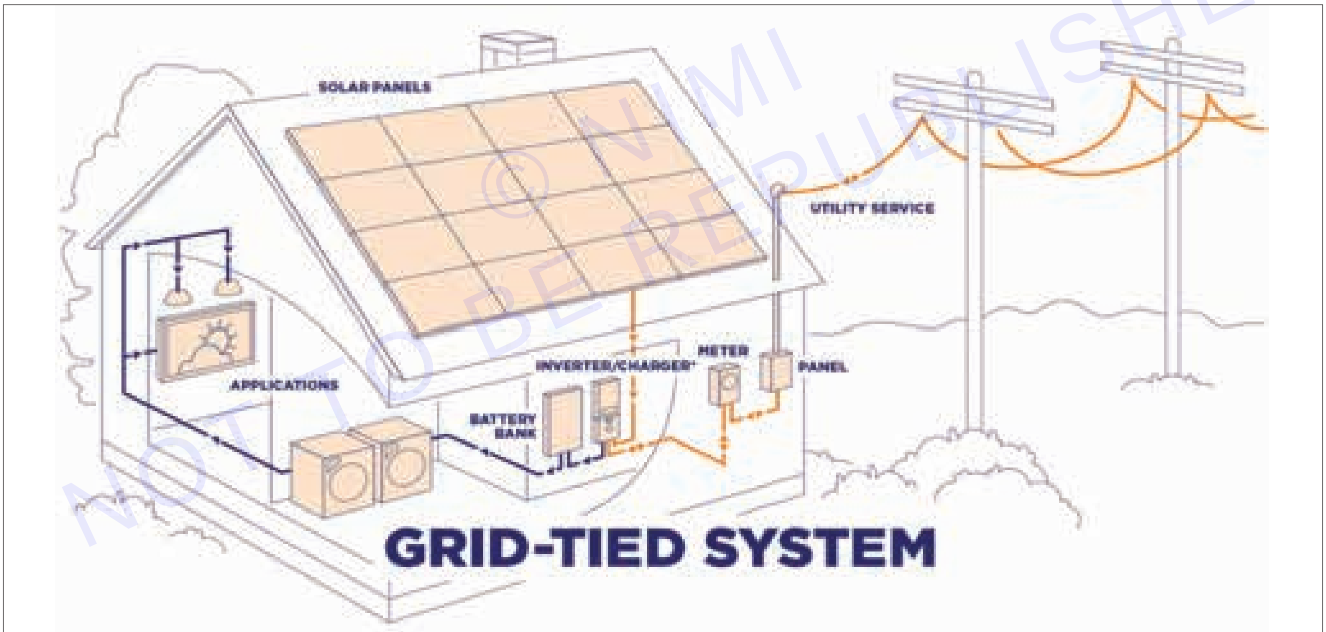
Tools/ Equipments

- Trainees tools kit - 1 Set.
- DSO/ CRO 20MHz - 1 No.
- Solar ON Grid inverter trainer with multiple lamp load arrangement and technical / user manual - 1 Set.
- Digital multimeter with probes - 1 No.
- Clamp meter - 1 No.
- Charts necessary for the given solar inverter - 1 Set.

Materials / Components

- Connecting wires - as reqd.
- Battery cables - as reqd.

Procedure



Grid-tied pv inverters connect your home and supplement the electrical grid in case of surplus power generation. The inverter delivers power to your home appliances directly from the solar panel when the solar energy is available for use. It switches back to grid power in case there is insufficient solar energy.

If solar energy is insufficient, a grid-tied pv inverter switches and starts drawing power from the grid into your home. It acts as a power backup in case solar energy is inadequate. It ensures there is a seamless power supply at your home. Grid-tied inverters are multi-functional and work energetically and powerfully.

A grid-tied inverter converts the constantly varying dc solar power and feeds it into the grid. It synchronizes the frequency and the output voltage to its connected grid. When solar energy increases, the inverter output increases too, injecting into the grid. The state electricity board will pay for the extra power we export into the grid. Your regular payment of eb bill will reduce.

TASK 1:

Note: A GRID TIED SOLAR PANEL INVERTER installation system allows the connection of solar panels directly to the electical grid. This system helps in selling all excess power to the State Electricity Board utility providers.

Before connecting to PV modules, please install separately a DC circuit breaker between inverter and PV modules.

1 Connect the inverter unit to the solar panel without charge controller and solar battery.

2 Mount the solar ON Grid inverter in a suitable location, preferably close to your electrical panel and solar panels.

3 Follow the instructions as per technical manual for proper installation and wiring.

4 Read, label and note down rated voltage and current of the given solar inverter.

Make sure that the electrical circuits you are connecting to the solar inverter, are not overloaded. Follow the manufacturer's recommendations and local electrical codes when sizing electrical components and wiring.

5 Check the grid voltage with DMM it should be the same as "V_{AC}" value on the product label.

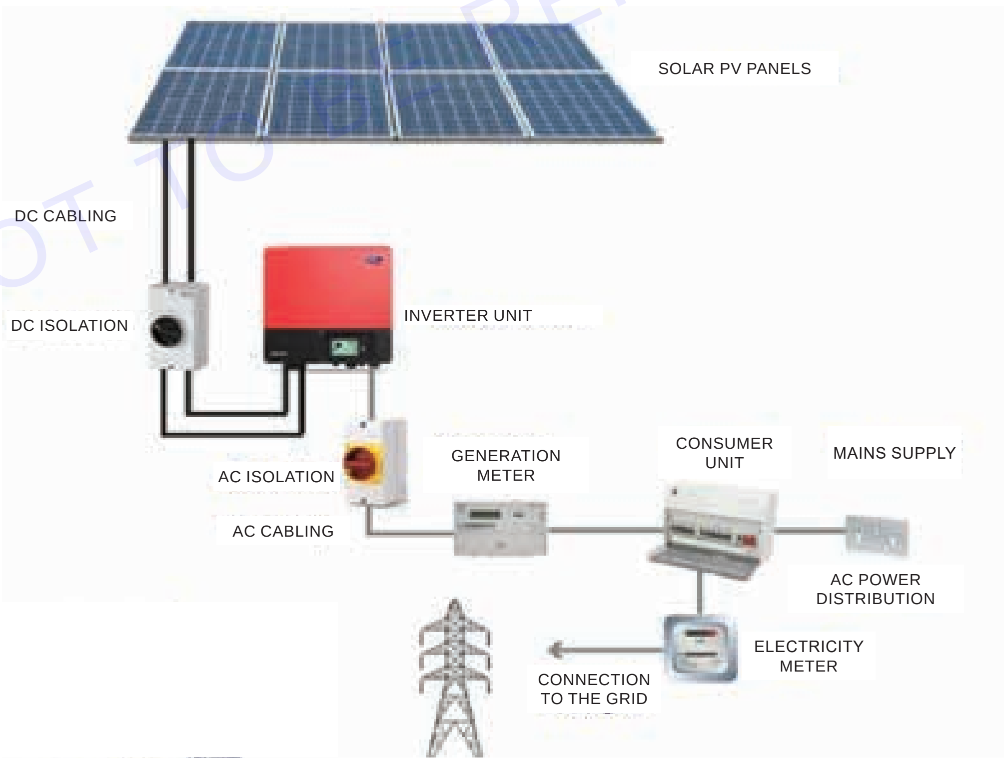
6 Turn off the circuit breakers 1 and 2.

7 Connect the Solar panel to Solar inverter through the circuit breaker 1. as shown in Fig 2

8 Connect the (L - LINE (brown or black) next - ground (yellow - green) and N - Neutral (blue)) wires from the inverter output to the circuit breaker 2 and the other end of the circuit breaker is connect to the ON line grid as shown in the Fig 2

Fig 1

GRID TIED SOLAR POWER SYSTEM



9 Make sure the wires are securely connected.

— — — — —

TASK 2: **Identify the parts of the grid tie ON GRID solar power system (shown in Fig 1) and fill the table 1**

Table 1

Sl. No.	Parts of the Grid tie Solar power system	Specifications	Purpose
1			
2			
3			
4			
5			

— — — — —

TASK 3: **Commissioning of ON GRID - grid tied solar inverter**

Fig 2

ON GRID SOLAR SYSTEM

1 Switch ON the circuit breaker 1.
2 Switch ON the circuit breaker 2 and wait for few minutes.
3 Read and record the values of voltage, current and frequency if any displayed in the inverter display.
4 Increase the load step by step, using multiple lamp load arrangement.
5 Measure the current through the inverter, grid and load using clamp meter in each steps and record it.
6 Determine the relation between the measured currents.

Load current = Grid current + Inverter current

7 Switch OFF the circuit breaker 2 and observe the ON- grid inverter output.
8 Vary the load and record your observations in table 2 and get it checked by the instructor.

Table 2

Sl. No.	Number of Lamps ON in Lamp load	Grid current	Inverter current	Load current
1				
2				
3				
4				
5				

MODULE 10: Fiber optics communication

EXERCISE 94: Demonstrate the resources and their need on the given fiber optic trainer kit

Objectives

At the end of this exercise you shall be able to:
- identify different cables used in OFC
- identify different connectors used in OFC
- identify various sections in the OFC trainer kit.

Requirements

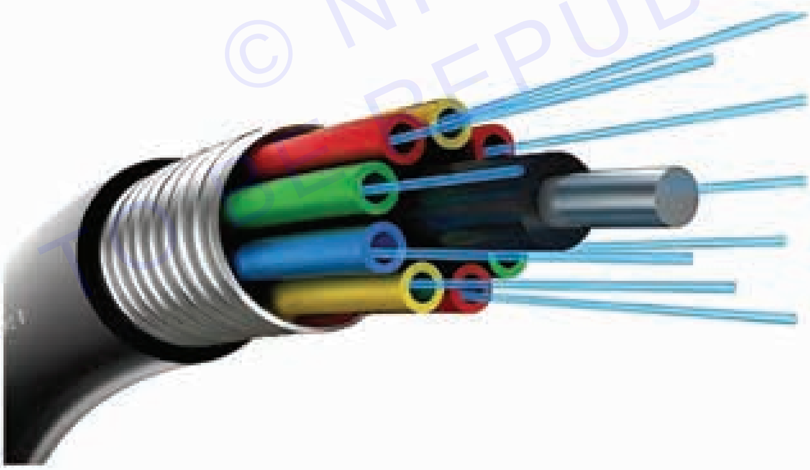
Tools/ Equipments/ Instruments

- Trainees tools kit - 1 Set.
- DSO/ CRO 60MHz - 1 No.
- Optical fiber trainer kit with instrumental manual - 1 Set.
- Digital multimeter - 1 No.

Materials/ Components

- Assorted OFC cables - 1 No each.
- Assorted OFC connectors - 1 No each.

Procedure



Optical fiber cables (OFC): A fiber-optic cable is composed of very thin strands of glass or plastic known as optical fibers; one cable can have as few as two strands or as many as several hundreds of them. These optical fiber cables carry information in the form of data between two places using optical or light-based technology. Tthe light beams travel down the optical fiber cable (OFC) due to total internal reflection and reached the other end. A photoelectric sensor will convert these pulses of light back into electrical information for processing.

Fiber cable offers higher bandwidth and reach. They are now preferred over old copper telecom cables as they provide high-speed broadband services. Optical fibre loses 3% of the signal over 100 meters of distance.

Based on materials, OFC is of two types:

- **Plastic Optical Fibers:** The poly (methyl methacrylate) is used as a core material for the transmission of light.

- **Glass Fibers:** This fiber cable consists of extremely fine glass fibers.

Based on the mode of propagation of light, OFC is divided into:

- **Single-Mode Fibers:** Used for long-distance transmission of signals.
- **Multimode Fibers:** Used for short-distance transmission of signals.

TASK 1 : **Identify different cables used in OFC**

FIBER CABLES WITH PATCH CORD & PIGTAIL

1 Pick any one of the optical fiber cable from the given assorted cables based on the requirements of your experiment or setup.

2 Refer to the user manual provided with the trainer kit to identify the specific name or type of the optical fiber cables

3 Record the name of the cable and its application in the Table 1.

4 Repeat the above steps for all other cables.

Table 1

SI.No	Name/ Type of the cable	Application

— — — — —

TASK 2 : **Identify different connectors used in OFC**

Note: SC connectors are widely used in optical network applications such as cable TV (CATV), inside of optical cabinets, media converters, FTTX (EPON, GPON, etc.)

LC connecters are ideal for use in data centers and high-density mounting cabinets. It is commonly used in Fiber To The Home (FTTH) connections, local networks, etc. MU connectors are miniature connectors with push-pull mechanisms. It is commonly used in data centers, telecommunications, cabling, LAN, etc. FC connectors have 2.5 mm diameter ceramic ferrules and use metal screw attachment mechanisms. They are used in calibration and reference cables for optical devices.

1 Pick any one of the connector from the given assorted OFC connectors.

2 Refer to the user manual provided with the trainer kit to identify the specific name or type of connectors.

3 Record the identified connector name / type along with its application in Table 2.

Note: This could include information on where and how the connector is used within an optical fiber communication system

4 Repeat above steps for all other connectors

Table 2

Sl.No	Name / Type of the Connectors	Application

— — — — —

TASK 3 : **Identify various sections of the OFC trainer kit**

1 Refer to the instruction manual, which should contain information regarding the different sections or components of the kit as shown in Fig 1

2 Identify each section based on its physical appearance or descriptions provided in the manual.

3 Record the name of the sections and its descriptions in the table 3

Note:Different manufacturers may have their own unique designs, components, and features for their OFC trainer kits.

Fig 1

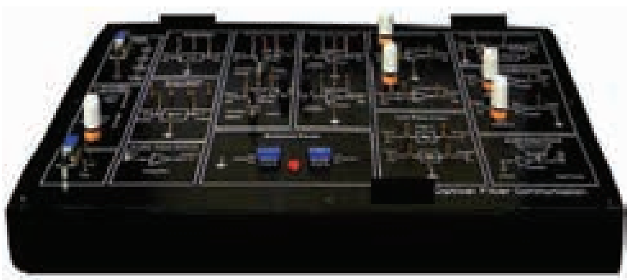


Table 3

Sl.No	Section	Description

— — — — —

EXERCISE 95: Make optical fiber setup to transmit and receive analog and digital data

Objectives

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

- prepare the set-up of optical fiber trainer kit to transmit and receive analog and digital data
- observe the input and output waveforms at different sections.

Requirements

Tools/ Equipments/ Instruments

- Optical fiber trainer kit with instrumental manual - 1 Set.
- CRO/ DSO 60 MHz (Dual trace) with probes kit - 1 No.
- Trainees tools kit - 1 Set.
- Digital multimeter with probes - 1 No.

Materials/ Components

- OFC cables - as reqd.
- Patch cords - as reqd.

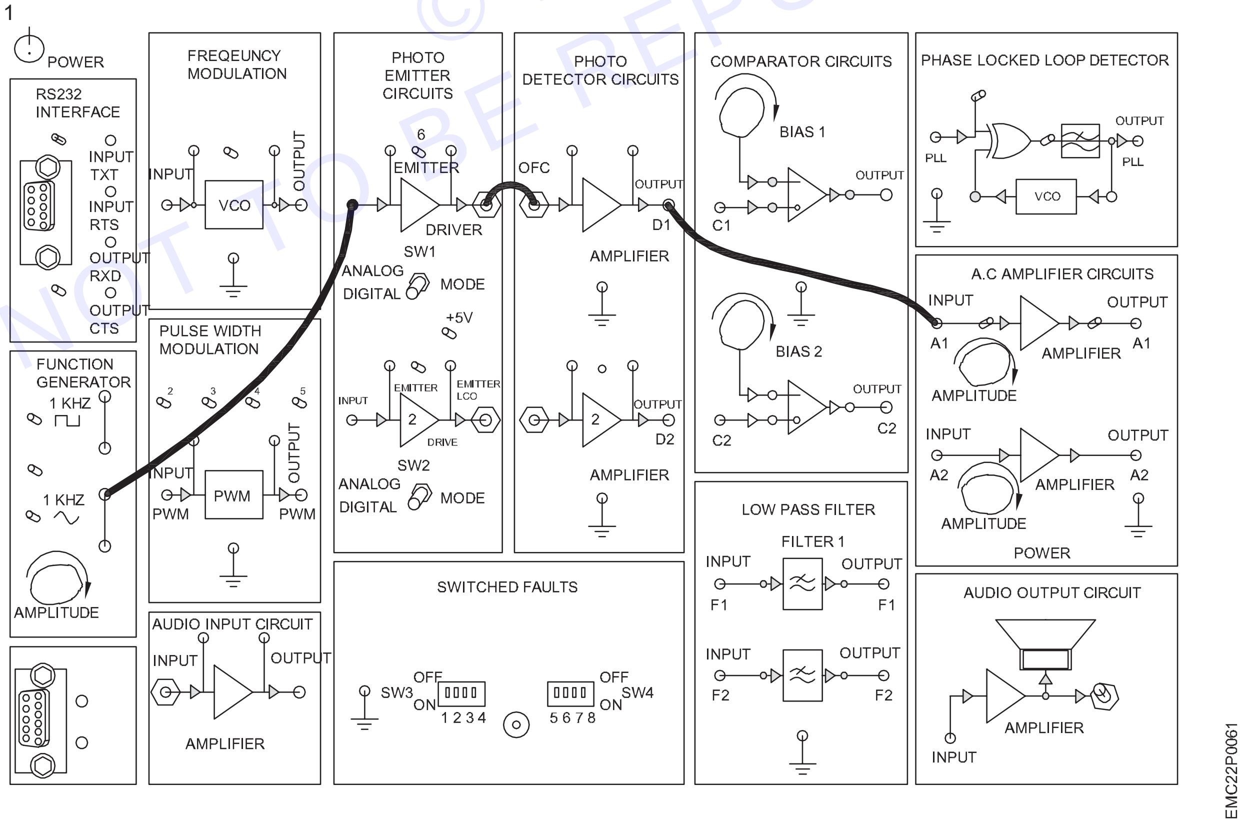
Procedure

TASK 1 : **Setting up of optical fiber trainer kit to transmit and receive analog signal**

1 Confirm that the optical fiber trainer kit is in working condition.

2 Ensure all necessary components are present (Fig 1)

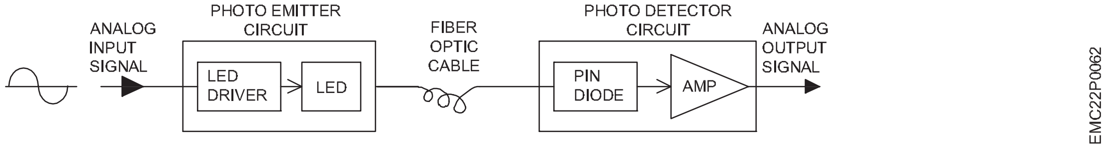
Fig 1



3 Use patch cord and connect the sine wave (1kHz / 1Vp-p) output of the function generator to input of photo emitter circuit as shown in Fig 1 (Photo Emitter circuit converts electrical input into light / optical output Fig 2).

4 Use the optical fiber cable , connect output of the photo emitter circuit and input of the photo detector circuit. (Photo detector circuit converts the light input into electrical output Fig.2)

Fig 2



5 Use patch cord connect output of the photo detector circuit to input of the AC amplifier.

6 Connect the function generator output to CH1 and AC amplifier output to CH2 of CRO.

This setup allows you to observe the signals from both the photo detector circuit and the function generator simultaneously on the CRO.

7 Turn the mode selector switch SW1 in the photo emitter circuit to analog mode.

8 Switch ON the trainer kit and set the CRO and the Function Generator for measurement.

9 Observe and trace the input signal at CH1 and transmitted output signal at CH2 of the CRO.

10 Modify the connection of CRO CH1 and measure the output voltages of the photo detector circuit and observe the waveform.

11 Record the observed waveforms and measured voltages in the TABLE 1 and compare with the amplifier output signal.

TABLE 1

Phot emitter input Signal waveform / voltages	Photo detector output signal waveform / voltages	AC amplifier output -V_{p-p} waveform / voltages

Note:If the input and output waveforms are similar, optical link has been established between the transmitter and the receiver

12 After completing the steps outlined for the measurement and observation, it's advisable to get the work checked by the instructor to ensure accuracy and understanding.

— — — — —

TASK 2 : **Setting up of optical fiber trainer kit to transmit and receive digital signal**

1 Confirm that the optical fiber trainer kit is in working condition.

2 Ensure all necessary components are present. (Fig 3) & (Fig 4)

3 Use patch cord connect the output of the function generator (1kHz / 1Vp-p square wave) to the input of photo emitter as shown in Fig 3.

4 Use the optical fiber cable (OFC), connect ouput of photo emitter circuit to the input of photo detector circuits as shown in Fig 3.

5 Use patch cord, connect the output of the detector circuit to the input of comparator circuits and connect the output of the comparator circuits to input of the AC amplifier circuit.

6 Connect the output of the function generator to CH1 and output of the amplifier to CH2 of CRO.

7 Turn the mode selector switch SW1 in the photo emitter circuit to digital mode

8 Switch ON the trainer kit, set the Function Generator and CRO for measurement.

Fig 3

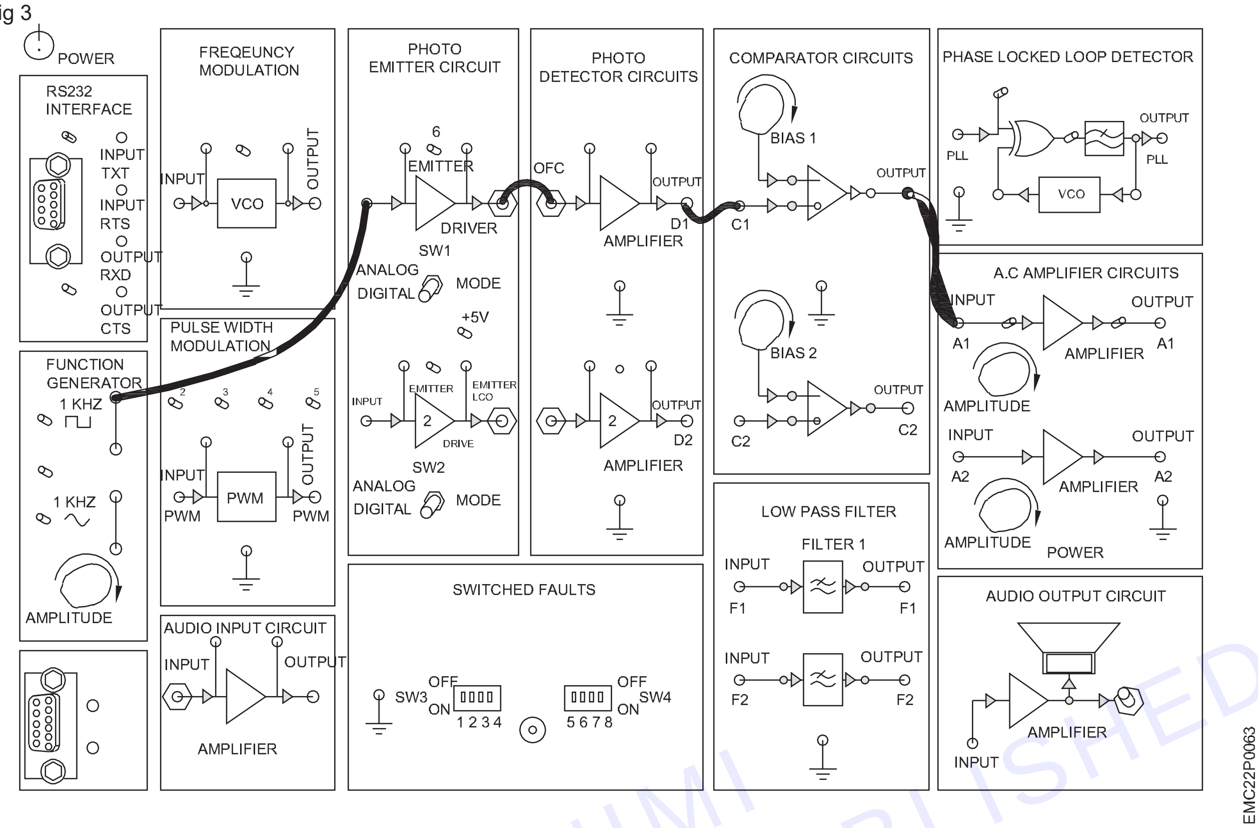
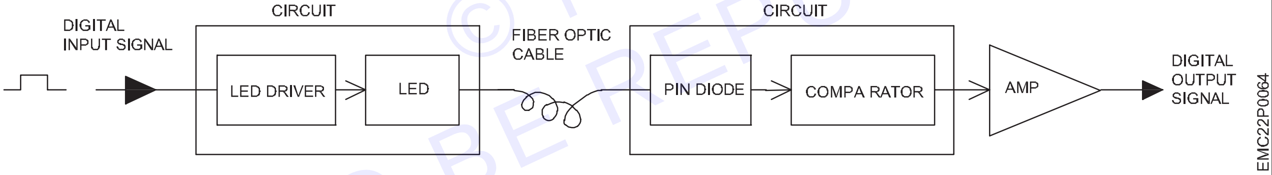


Fig 4



9 Observe and trace the digital square wave Input at CH1 and output signal at CH2 on CRO.

10 Modify the connection of CH1 of CRO to output of the photo detector and observe the signal waveform.

11 Now connect CH1 of CRO to output of the comparator and observe the (received digital) output signal of comparator.

12 Record the and measured voltage observed waveforms in Table 2 and compare with the amplifier output signal.

Table 2

Phot emitter input Signal waveform/ voltages	Photo detector output signal waveform/ voltages	AC amplifier output waveform/ voltages

Note: If the input and output waveforms are same, optical link has been established between the transmitter and the receiver.

13 After completing the steps outlined for the measurement and observation, it's advisable to get the work checked by the instructor to ensure accuracy and understanding.

EXERCISE 96: Set up the OFC trainer kit to study AM, FM, PWM modulation and demodulation

Objectives

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

- demonstrate amplitude modulation and demodulation using OFC trainer kit
- demonstrate frequency modulation and demodulation using OFC trainer kit
- demonstrate pulse width modulation and demodulation using OFC trainer kit.

Requirements

Tools/ Equipments/ Instruments

- Optical fiber trainer kit with instrumental manual - 1 Set.
- CRO 20 MHz (Dual trace) with probes kit - 1 No.
- Trainees tools kit - 1 Set.
- Digital multimeter with probes - 1 No.
- Microphone(Dynamic) - 1 No.
- Loud speaker / Headphone - 1 No.
- AM / FM signal generator - 1 No.

Materials / Components

- OFC cables -1 No.
- Patch cords - as reqd.

Procedure

TASK 1 : **Setting up of amplitude modulation and demodulation using OFC trainer kit**

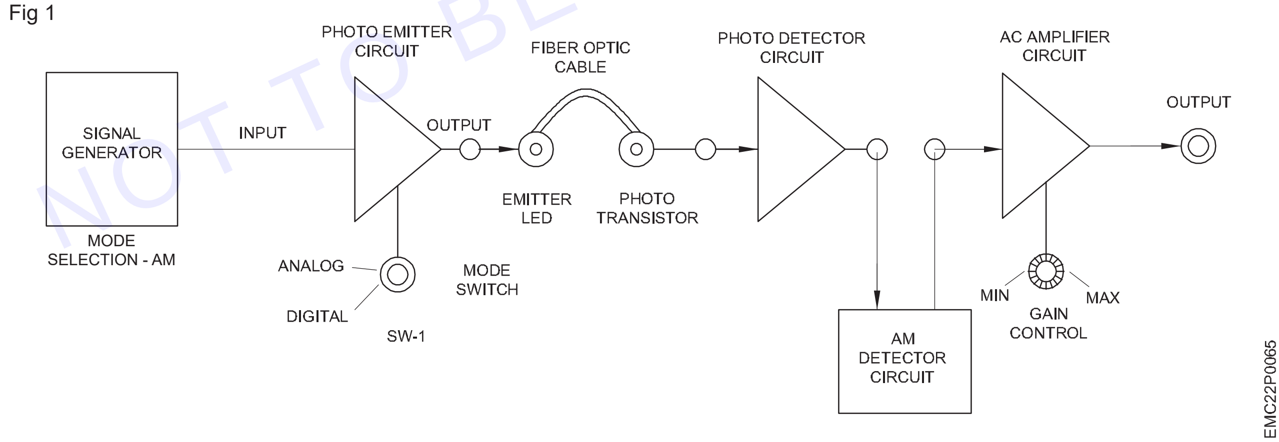
1 Ensure all necessary components are present and properly connected.

2 Power on the trainer kit and check for any indicators or display screens that confirm it's working condition

3 Note down the sections and record it in the table 1

4 Make the connections by referring to the user manual carefully as shown in Figure 1

Fig 1



a Use the patch cord connect from output of the AM wave signal generator to the input of the photo emitter

b Use the optical cable to connect between the photo emitter output and the photo detector input.

This connection establishes the optical link between the transmitter and receiver.

c Connect the photo detector output to AM detector circuit.

d Connect the AM detector output to AC amplifier input.

5 Turn the mode selector switch SW1 of photo emitter to the analog mode.

6 Switch ON the power supply of the trainer kit and prepare Oscilloscope for measurements.

7 Set the AM mode selection of the signal generator to internal mode.

8 Observe the input and output signal waveform on oscilloscope, record them in Table - 1.

Table - 1

SI.NO	Name Of The Section	Input / Output waveform	Remarks

9 Turn off and remove the setup.

10 Get the work checked by the instructor.

— — — — —

TASK 2 : **Setting up of frequency modulation and demodulation using OFC trainer kit**

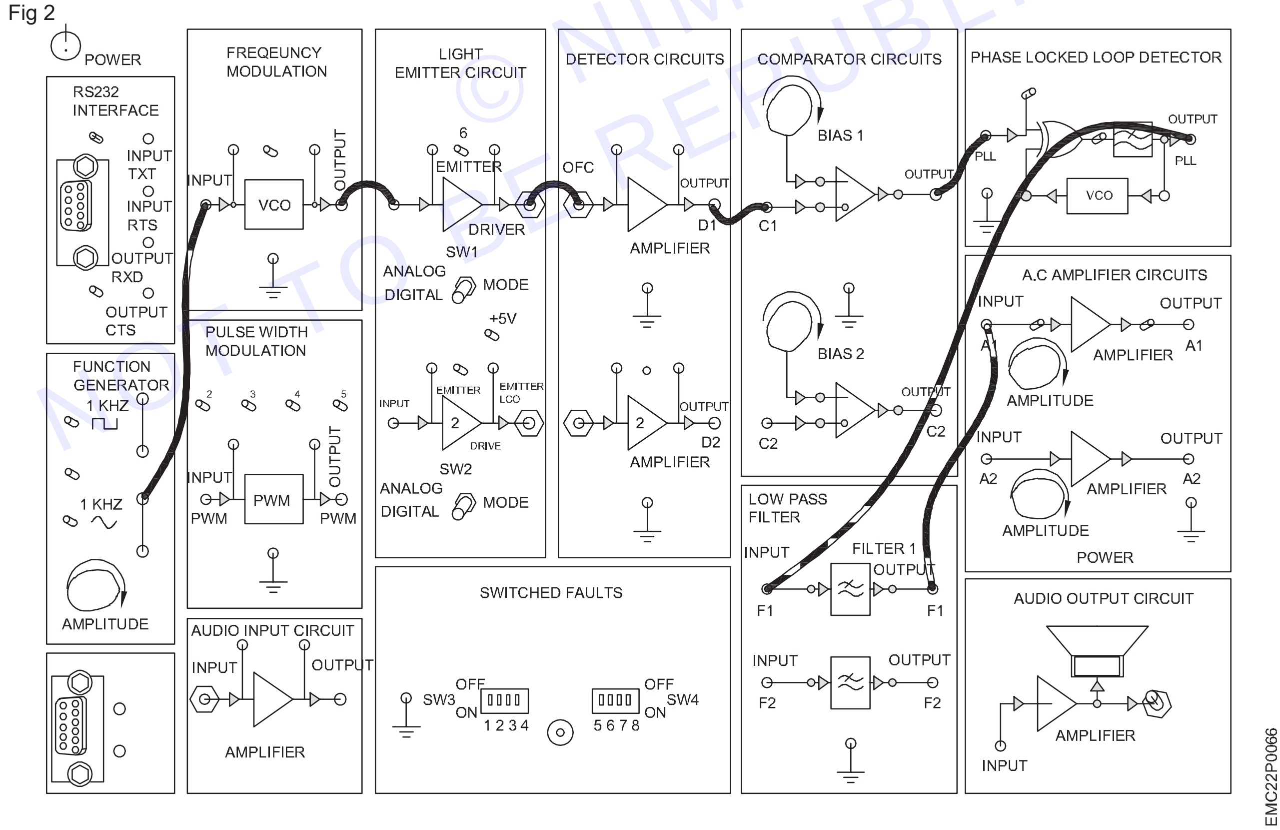
1 Ensure all necessary components are present and properly connected.

2 Power on the trainer kit and check for any indicators or display screens, that confirm it's working condition.

3 Note down the sections of the OFC trainer kit in Table-2.

4 Referring to the user manual carefully make the connections as shown in Figure 2

Fig 2



5 Use the patch cord for connect the output of the function generator to the input of the FM modulator section.

6 Use a suitable patch cord for connect the output port of the FM modulator section to the input port of the light emitter circuit.

7 Use an OFC cable for connect the output of the light emitter circuit to the input of the FM detector terminal.

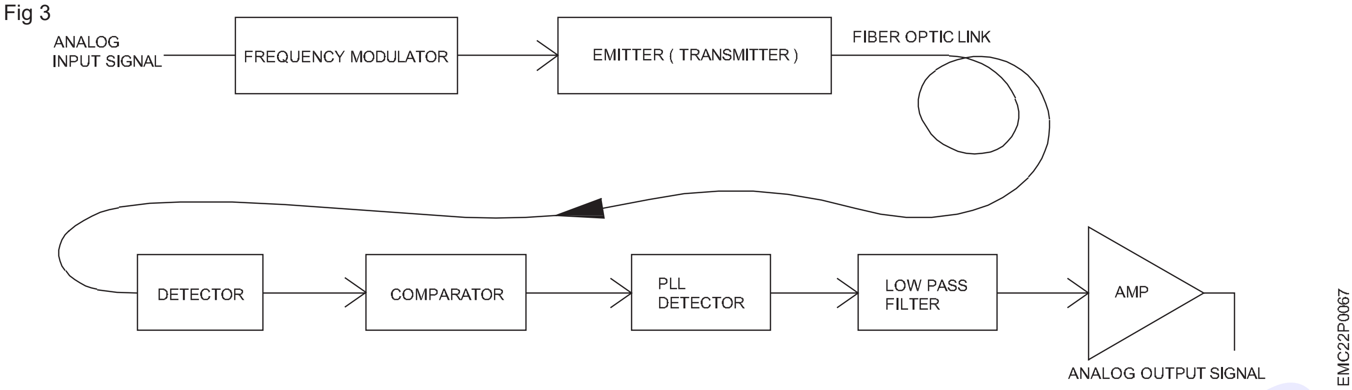
8 Use patch cords for connect output of the detector to the input of the comparator.

9 Connect the comparator output to the PLL detector input, and connect the PLL detector output to the low pass filter input.

The PLL detector circuit is often used to demodulate frequency-modulated signals, and connecting it to a low pass filter helps in filtering out the high-frequency components and recovering the baseband signal.

10 Connect the low pass filter output to the AC amplifier input as shown in Figure 2 and Figure 3.

Fig 3



11 Prepare the CRO for measurement and connect the function generator output to channel 1 and the amplifier output to channel 2 of the CRO.

12 Set the function generator for a 1 KHz / 1 Vp-p sine wave signal output.

13 Set the mode selector switch SW1 in the emitter circuit to analog mode and observe the input and output signals on the CRO, record the observations in Table-2.

Note: The instructor may follow the step as per the trainer kit available in the section

14 Set the mode selector switch SW1 in the emitter circuit to digital mode and observe the input and output signals on the CRO, record the observations in Table-2.

Table - 2

Mode switch position	i / p signal V_{p-p}	wave form	Output signal	Waveform
Analog				
Digital				

15 Get the work checked by the Instructor.

— — — — —

TASK 3 : **Setting up of pulse width modulation and demodulation using OFC trainer kit**

1 Check and confirm that the OFC trainer kit is in working condition.

2 Set the function generator to generate a 1 kHz / 1Vp-p sine wave signal output.

3 Use patch cords to connect:

a The output of the function generator to the input of the pulse width modulator.

b The output of the pulse width modulator to the input of the light emitter circuit.

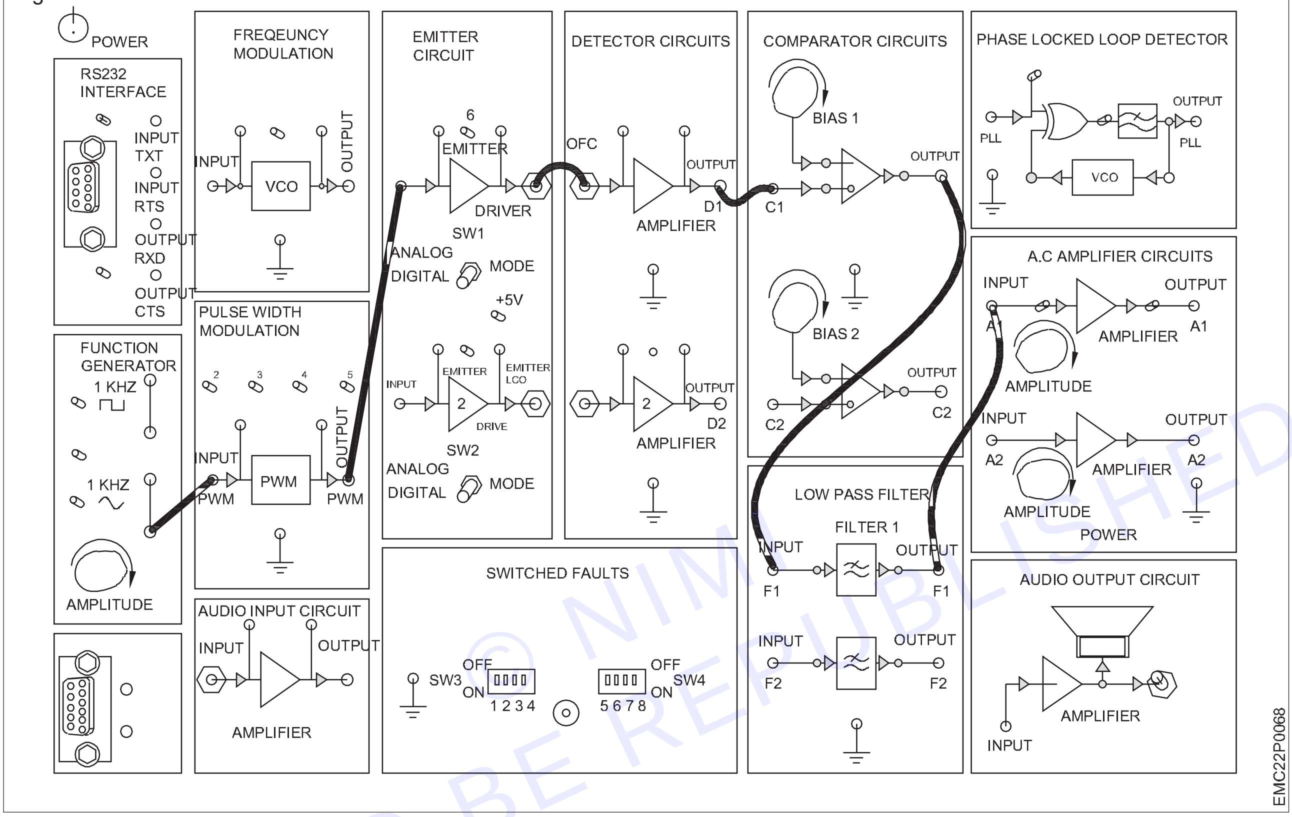
c An OFC cable between the output of the light emitter circuit and the input of the detector circuit, establishing the optical link.

d The output of the detector circuit to the input of the comparator circuit.

e The output of the comparator circuit to the input of the low pass filter.

f The output of the low pass filter to the input of the AC amplifier as shown in Fig 4.

Fig 4



4 Set the CRO for steady output

5 Connect the function generator output and amplifier output to channel 1 and channel 2 of the CRO (Cathode Ray Oscilloscope), respectively.

6 Turn the mode selector switch in the emitter circuit to digital mode.

7 Switch ON the trainer kit and CRO to power up the equipment.

8. Observe and trace the input and output signals on the CRO, recording the observations in Table 3.

9 Get the work checked by the Instructor.

Table - 3

Mode switch position	Emitter circuit input signal V_{p-p}	Waveform	A / C amplifier output siganl V_{p-p}	Waveform	Remark

— — — — —

EXERCISE 97: Perform FM modulation and demodulation using OFC trainer kit using audio signal and voice link

Objectives

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

- demonstrate frequency modulation and demodulation using OFC trainer kit by audio signal and voice link.

Requirements

Tools/ Equipments/ Instruments

• Optical fiber trainer kit with instrumental manual	- 1 Set.
• Trainees tools kit	- 1 No.
• Digital multimeter with probes	- 1 No.
• Microphone(Dynamic)	- 1 No.
• Loud speaker / Headphone	- 1 No.
• Audio signal source	- 1 No.

Materials/ Components

• OFC cables	- as reqd.
• Patch cords	- as reqd.
• 3.5mm step EP to EP cable	- 1 No.
• 6mm to 3.5 mm phono adapter	- 1 No.

Procedure

Note: The instructor has to provide audio signal from any available signal sources like/ CD player/ mobile phone/ mic - connect audio signal source to the input amplifier.

TASK 1 : **Frequency modulation and demodulation of audio signal using OFC trainer kit**

1 Check and confirm the OFC trainer kit is in working condition

2 Turn the mode switch SW1 in the emitter circuit to digital mode.

3 Connect the audio signal source (microphone or audio playback device) to the input of the OFC trainer kit.

4 Use patch cords to connect

a The output of the audio input amplifier to the input of the frequency modulator..

b The output of frequency modulator to the input of the photo emitter circuit.

c Use OFC cable, connect the photo emitter output to the input of photo detector

d The output of the Photo detector to the input of the comparator.

e The output of the comparator to the input of the PLL detector

f The output of the PLL detector to the input of the low pass filter and

g The output of the Low pass filter to the input of the AC amplifier

h The output of AC amplifier circuit to the input of audio output circuit (loudspeaker) as shown in Fig 1 & 2.

5 Get the connections checked by the instructor.

6 Switch ON the trainer kit and confirm the audio from the loudspeaker / headphone that the corresponding output of the microphone or any other sound source.

7 Record the observation in table 1.

If built-in speaker is not available connect speaker or headphone externally to audio output block

Note: If the speech sound is not clear or there are any disturbances with transmission, check the connections, modulation settings, and equipment functionality.

Make any necessary adjustments to improve the quality of the transmitted speech sound.

Fig 1

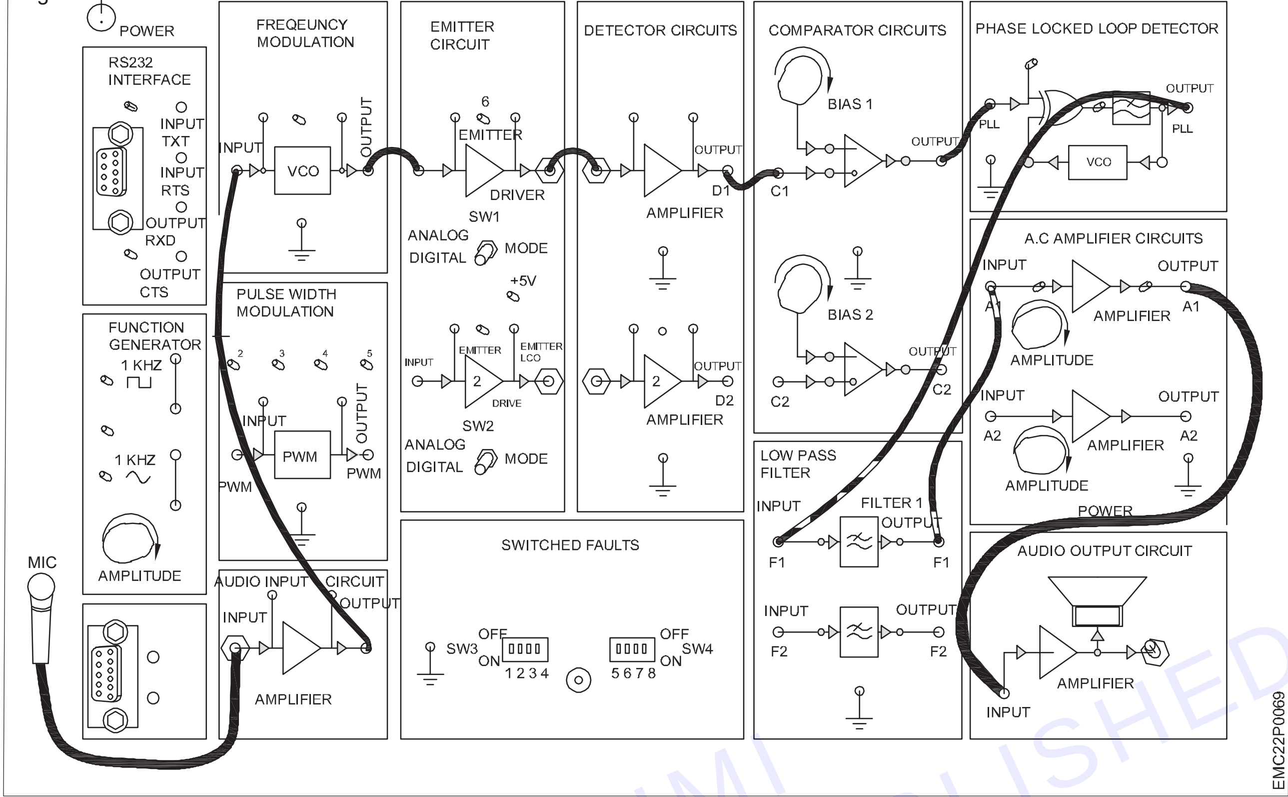


Fig 2

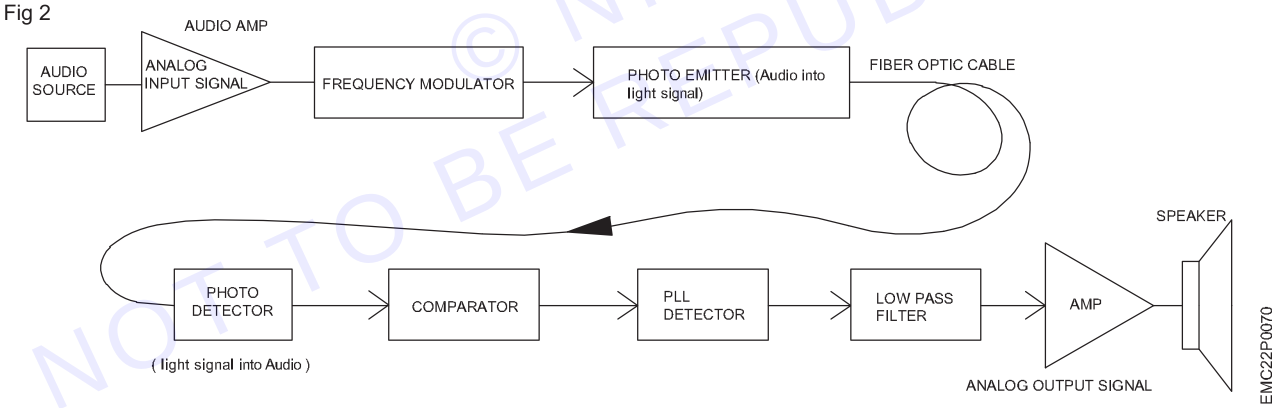


Table 1

Conclusion	Remarks

EXERCISE 98: Perform PWM modulation and demodulation using OFC trainer kit using audio signal and voice link

Objectives

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

- demonstrate pulse width modulation and demodulation using OFC trainer kit by using audio signal and voice link signal.

Requirements

Tools/ Equipments/ Instruments

- Optical fiber trainer kit with instrumental manual - 1 Set.
- Trainees tools kit - 1 Set.
- Digital multimeter with probes - 1 No.
- Microphone(Dynamic) - 1 No.
- Loud speaker / Headphone - 1 No.
- Audio signal source - 1 No.

Materials/ Components

- OFC cables - as reqd.
- Patch cords - as reqd.
- 3.5mm step EP to EP cable - 1 No.
- 6mm to 3.5 mm phono adapter - 1 No.

Procedure

Note: The instructor has to provide audio signal from any available signal source like CD/ DVD player/ Mobile phone/ mic

1 Check and confirm the OFC trainer kit is in working condition

2 Connect the audio signal source (microphone or audio playback device) to the input of the OFC trainer kit.

3 Use patch cords to connect

a The output of the audio input amplifier to the input of the pulse width modulator.

b The output of the pulse width modulator to the input of the photo emitter circuit.

c Use OFC cable between the photo emitter output to the input of photo detector

d The output of the Photo detector to the input of the comparator.

e The output of the comparator to the input of the low pass filter and

f The output of the Low pass filter to the input of the AC amplifier

g The output of AC amplifier circuit to the input of audio output circuit (loudspeaker) as shown in Fig 1 & 2.

4 Turn the mode switch SW1 in the photo emitter circuits to digital mode.

5 Get the work checked by the instructor.

If built-in speaker is not available connect speaker or headphone externally to the audio output block.

6 Switch ON the trainer kit and confirm the audio from the loudspeaker / headphone that the corresponding output of the microphone or any other sound source.

7 Record the observation in table 1.

Table 1

Conclusion	Remarks

Fig 1

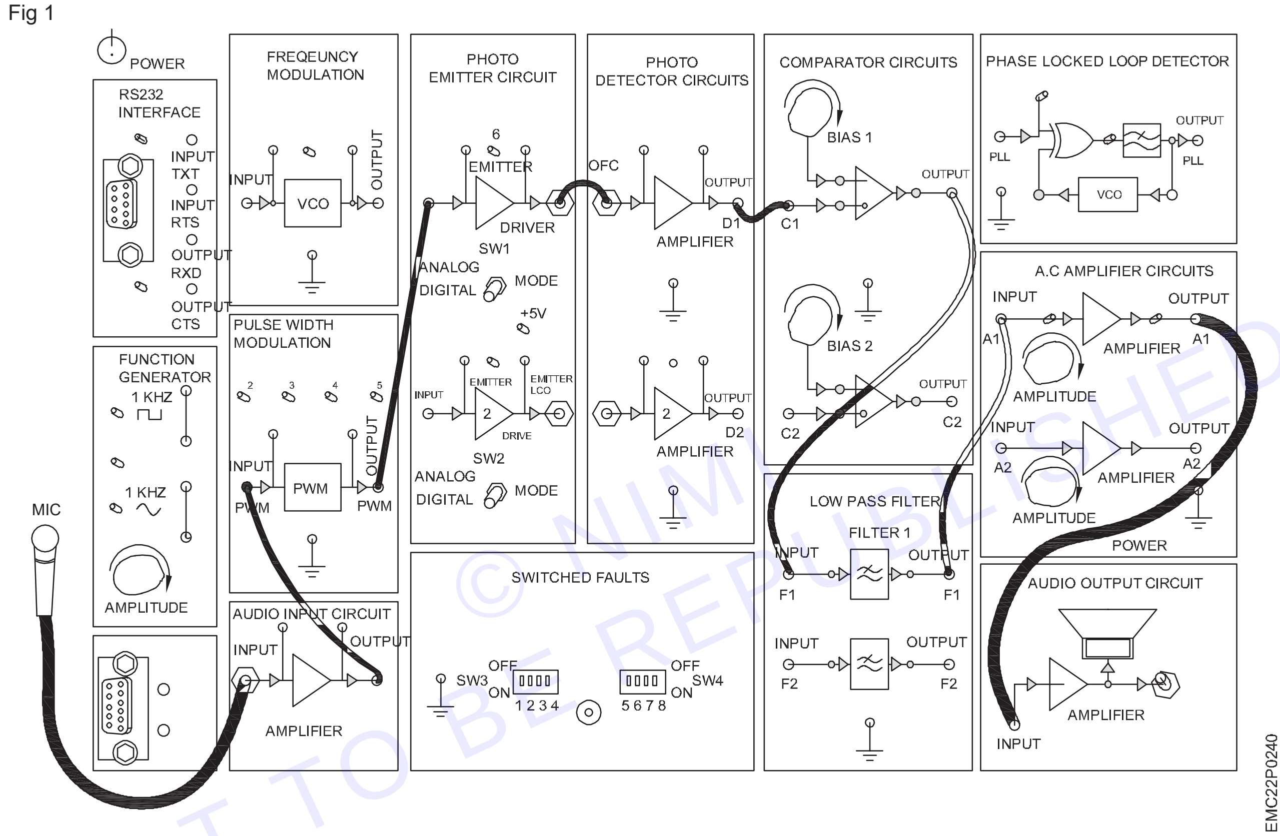
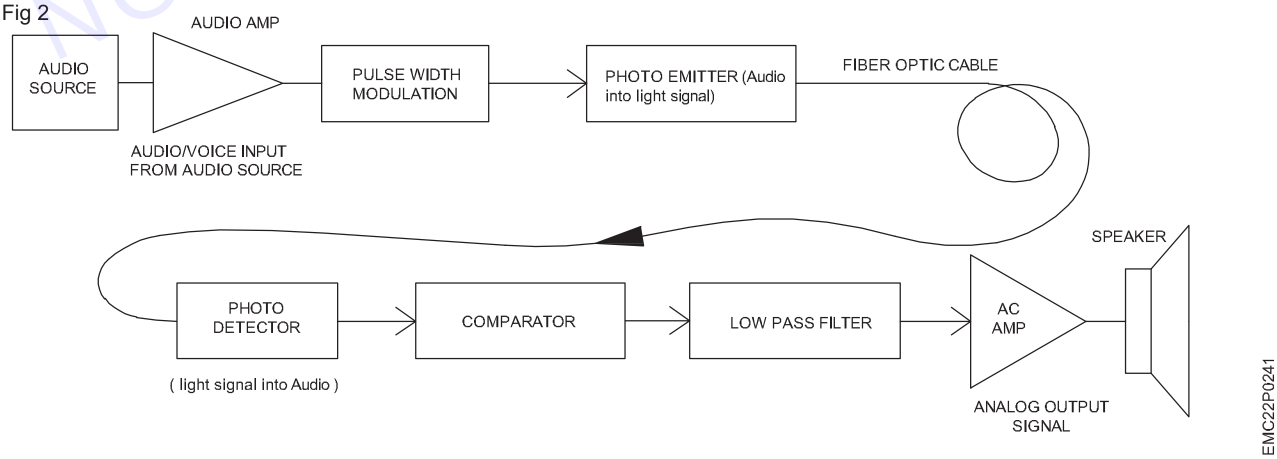


Fig 2



EXERCISE 99: Perform PPM modulation and demodulation using fiber optic communication trainer kit using audio signal and voice link

Objectives

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

- demonstrate pulse position modulation and demodulation using OFC trainer kit by using audio signal and voice link signal.

Requirements

Tools/ Equipments/ Instruments

- Optical fiber trainer kit with instrumental manual - 1 Set.
- Trainees tools kit - 1 Set.
- Digital multimeter with probes - 1 No.
- Microphone(Dynamic) - 1 No.
- Loud speaker / Headphone - 1 No.
- Audio signal source - 1 No.

Materials/ Components

- OFC cables - as reqd.
- Patch cords - as reqd.
- 3.5mm step EP to EP cable - 1 No.
- 6mm to 3.5 mm phono adapter - 1 No.

Procedure

Note: The instructor has to provide audio signal from any available signal source like CD / DVD player mobile phone / MIC.

TASK 1 : **Pulse Position Modulation and demodulation of audio signal using OFC trainer kit.**

1 Check and confirm the given OFC trainer kit is in working condition.

2 Connect the audio signal source (microphone or audio playback device) to the input of the OFC trainer kit.

3 Use patch cords to connect

a The output of the audio input amplifier to the input of the pulse position modulator.

b The output of the pulse position modulator to the input of the photo emitter circuit.

c Use OFC cable, connect the photo emitter output to the input of photo detector

d The output of the Photo detector to the input of the comparator.

e The output of the comparator to the input of the PLL detector

f The output of the PLL detector to the input of the low pass filter and

g The output of the Low pass filter to the input of the AC amplifier

h The output of AC amplifier circuit to the input of audio output circuit (loudspeaker) as shown in Fig 1 & 2.

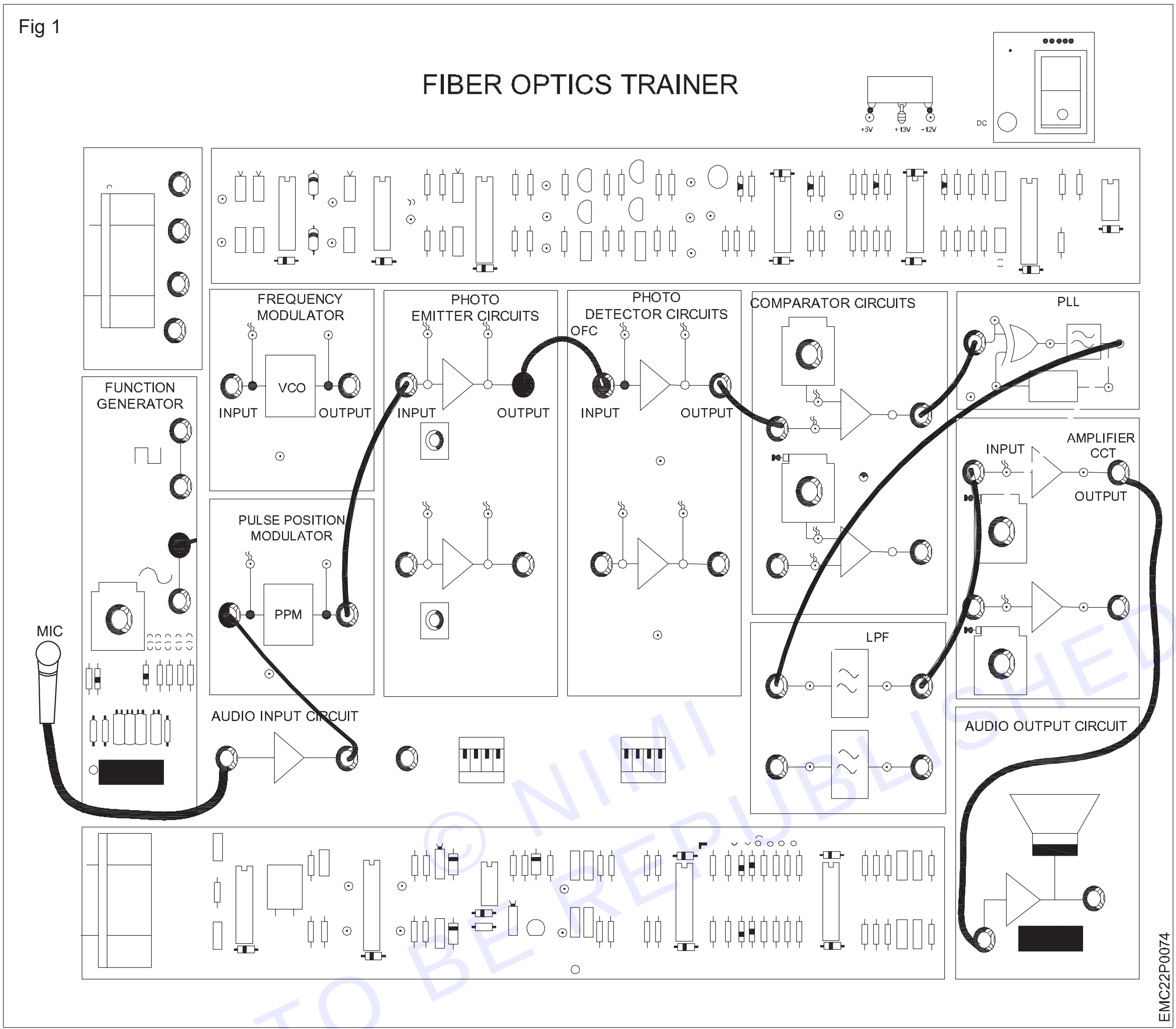
4 Turn the mode switch SWI in the photo emitter circuits to digital mode.

5 Switch ON the trainer kit and confirm the audio from the loudspeaker / headphone that the corresponding output of the microphone or any other sound source.

6 Record the observation in table 1.

If built-in speaker is not available connect speaker or headphone externally to the audio output block.

7 Get the work checked by the instructor.



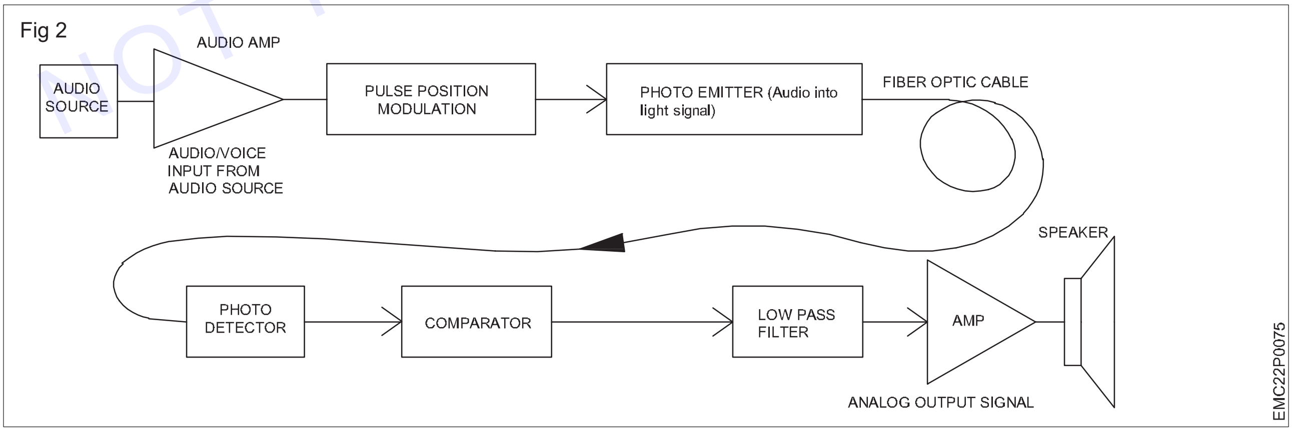


Table 1

Conclusion	Remarks

MODULE 11: LCD TV/ LED TV/ Smart TV

EXERCISE 100: Demonstrate and operate different Controls on LCD, LED, Smart TV

Objectives

At the end of this exercise you shall be able to
- identify the different indicators/controls on LCD and LED TV
- identify the different connectors in LCD and LED TV.

Requirements

Tools/ Equipment
- Trainees tools kit - 1 Set.
- LCD or LED TV with user manual - 1 No.

Procedure

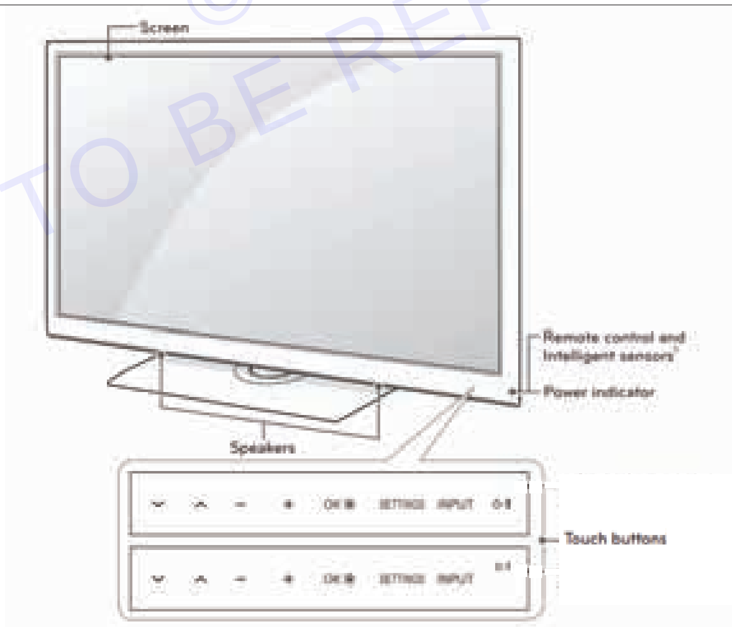
TASK 1: **Identify the different front panel indicators and controls of LCD and LED TV**

Note: The instructor should provide the TV manual to the trainees and guide them in locating the indicators and controls.

1 Pick up any one of the TVs from the lab and see the front panel as shown in Fig 1

2 Identify the various front panel indicators and controls available on the TV, note down their names and functions, and record them in TABLE 1.

Fig 1



Touch button	Description
⏻/I	Turns the power on or off
INPUT	Changes the input source.
SETTINGS	Accesses the main menus, or saves your input and exits the menus.
OK	Selects the highlighted menu option or confirms an input.
- +	Adjusts the volume level.
V Λ	Scrolls through the saved channels.

Note:

- **Intelligent sensor - Adjusts the image quality and brightness based on the surrounding environment.**
- **All of the buttons are touch sensitive and can be operated through simple touch with your finger**

TABLE 1

Sl No	Front panel Controls name	Functions

3 Get the work checked by the instructor.

— — — — —

TASK 2: **Identify the different input and output or audio and video connectors in LCD TV**

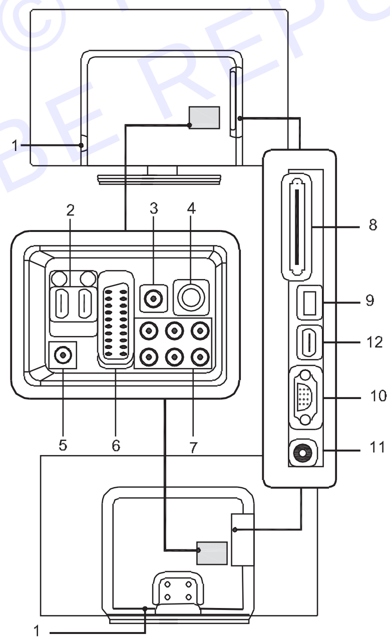
1 Pick up any one of the TVs from the lab and see the back side and side view of the TV panel as shown in Fig 2

2 Identify the input and output connectors, or audio and video connectors, in the TV. Note down their names and usage, and record them in TABLE 2.

3 Get the work checked by the instructor.

4 Repeat the above steps for other TVs

Fig 2



EMC22P0077

Table 2

Sl No	Connector name	Uses

— — — — —

EXERCISE 101 : Demonstrate components and different sectors of LCD / LED / Smart TV

Objectives

At the end of this exercise you shall be able to

- dismantle the back panel cover of the LCD TV / LED / SmartTV
- identify the internal sections in LCD / LED / Smart TV.

Requirements

Tools/ Materials

- LCD TV with user manual - 1 No.
- Trainees tools kit - 1 Set.
- ESD table - 1 No.
- Soft cloth (to keep the screen protected from scratches) - as reqd.

Procedure

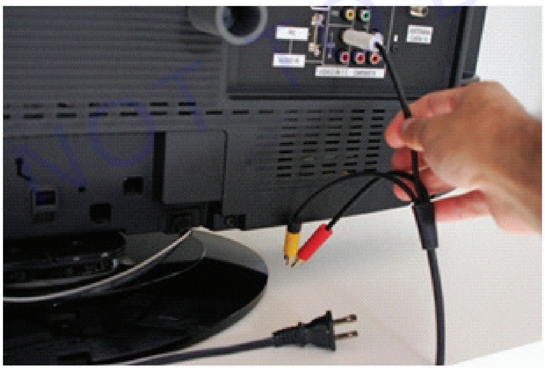
TASK 1: **Remove the back panel cover of the LCD / LED TV /Smart TV**

Note: The trainee should open the back cover of the TV in front of the instructor to prevent damage.

1 Pick up any one of the LCD / LED /Smart TV from the Lab.

2 Disconnect the TV from the electrical outlet or power source and detach any other cables connected to the TV. This could include HDMI cables, audio cables, or any other peripherals shown in Fig 1.

Fig 1



3 Prepare an ESD (Electrostatic Discharge) table or any other flat surface and then lay a soft cloth on it.

4 Protect the screen from potential damage by placing the TV with its screen facing down on a soft cloth.

Note: Select appropriate tools, such as screwdrivers for removing screws or other fasteners.

5 Locate and remove the screws that secure the TV base, as shown in Fig 2.

6 Remove the stand from the back of the LCD TV and set it aside.

7 Using a screwdriver, gently insert it between the covers, as shown in Fig 3.

8 Apply a small amount of force to twist and open a gap.

9 Turn the screwdriver to unlock and open the panel. Apply this technique around all sides of the TV monitor shown in Fig 4.

10 Remove the outer cover to expose the main body of the TV monitor, as shown in Fig 5.

Fig 2

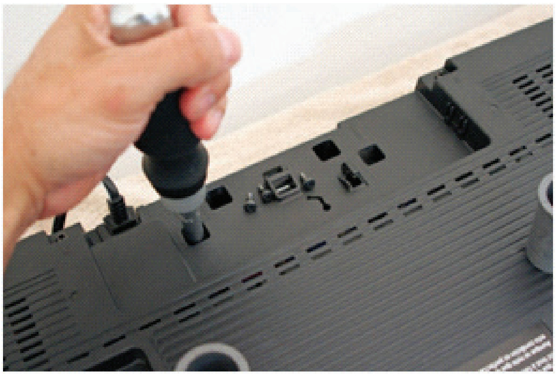


Fig 3

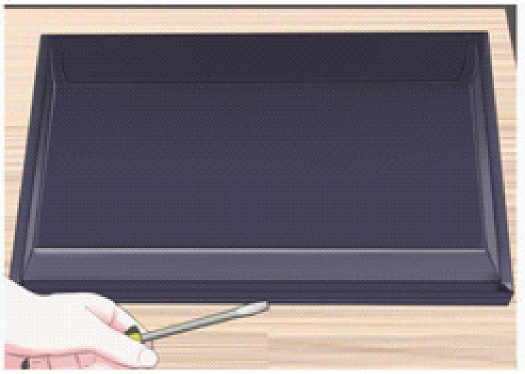


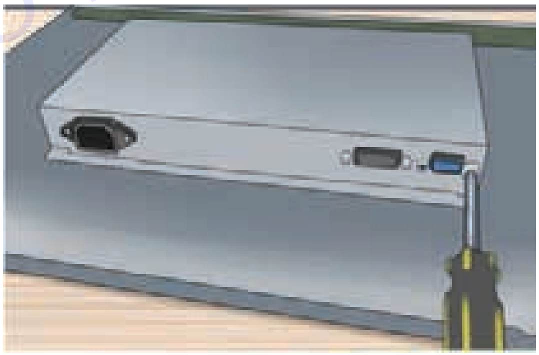
Fig 4

Fig 5

11 Remove the side panel screws as shown in Fig 6

12 Get the work checked by the instructor

Fig 6



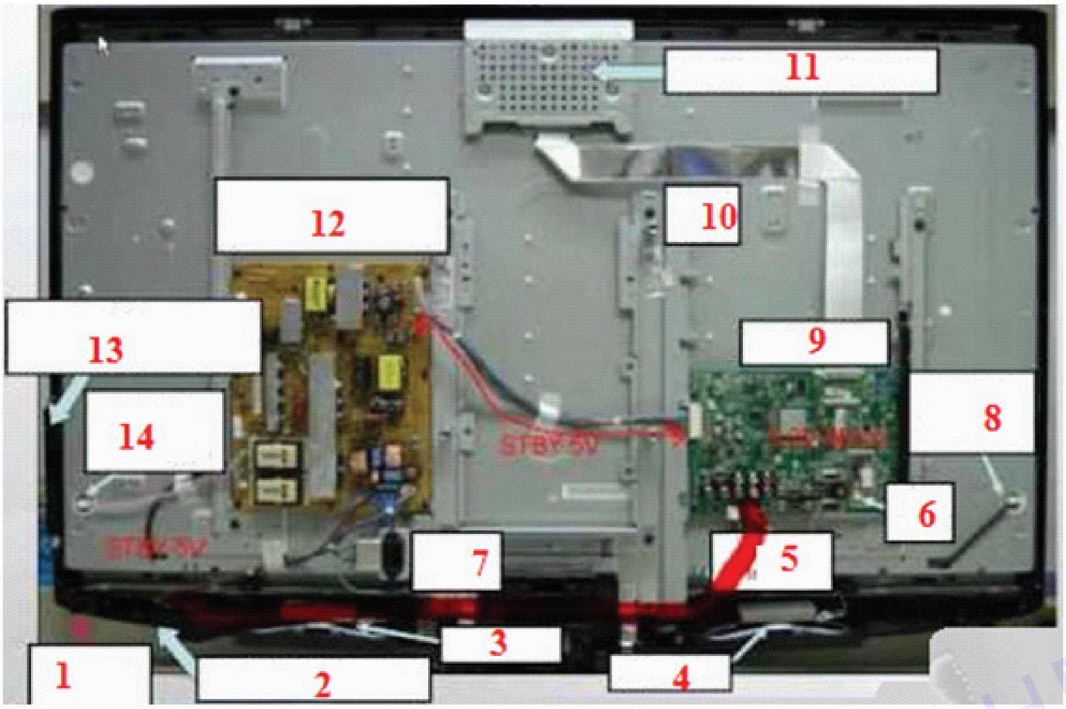
— — — — —

TASK 2 : **Identify the different internal sections of LCD / LED /SmartTV**

1 Identify the different internal section in TV as shown in Fig 7.

2 Note down the name of different section and each section having main components note down and record it in the TABLE 1.

Fig 7



INTERNAL SECTION IN TV

Precaution: Don't remove any cable from the TV. Do not touch the components with wet hand/ bare hand.

Table -1

Sl No	Name of the section	Components

3 Get the work checked by the instructor.

— — — — —

EXERCISE 102 : Demonstrate the parts of the remote control

Objectives

At the end of this exercise you shall be able to

- identify the remote control model and the function keys
- dismantle the TV remote control handset
- identify the internal section of TV remote control and assemble it.

Requirements

Tools/Materials

- Trainees tool kit - 1 Set.
- Magnifier lens - 1 No.
- TV Remote control handset with user manual - 1 No.
- Cleaning brush - 1 No.
- Remote control checker, tester - 1 No.
- IPA cleaning solution - 1 bottle.

Procedure

TASK 1: **Identify the remote control model and the function keys**

Note: The instructor has provided different models of remote control handsets used for this exercise.

1 Pick any one of the TV remote controls from the lab.

2 Note down the model number of the TV remote control and record it in TABLE 1.

TABLE 1

Sl No	Model No	Type

3 Repeat the same steps for the remaining remote controllers.

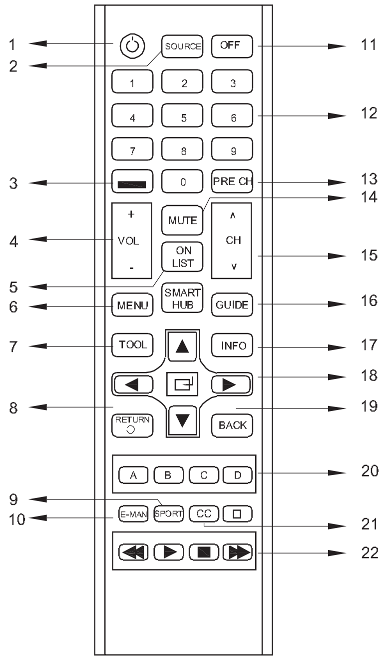
4 Take one of the remote control handset, identify the name/function of the keys as shown in Fig 1 with reference to the user manual.

5 Record the name of each key on the remote control keypad and its function in TABLE 2

TABLE 2

Sl No	Button Name	Function

Fig 1



6 Get the work checked by the Instructor.

— — — — —

TASK 2 : **Dismantle the TV remote control handset**

1 Open the battery compartment cover of the remote control/ handset and remove batteries out.

2 Locate and remove the fixing screws from the back cover, as shown in Fig 2.

Note: In some models there are no screws used for fitting both top and bottom cover. Only a press type locking mechanism is used. Open it carefully without damaging the locking arrangement.

3 Open the remote control from its side by using a blunt knife or similar tool as shown in Fig 3.

4 Take out the moulded rubber key pad from its PCB.

5 Clean the tracks and contact points on the PCB and the rubber keypad using IPA cleaning solution and a brush as shown in Fig 4

Fig 2

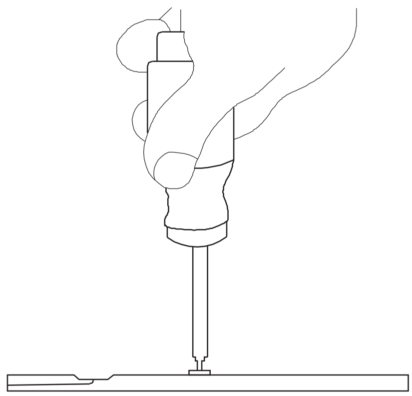


Fig 3

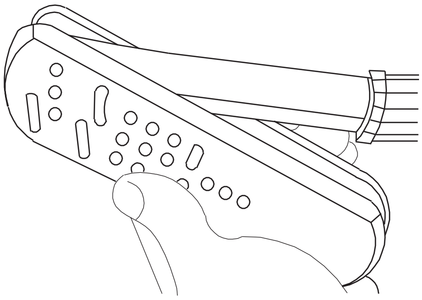
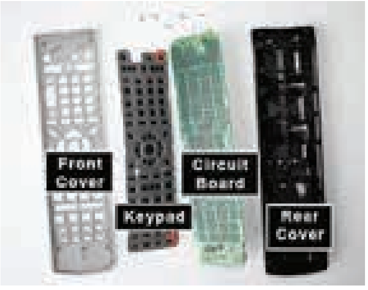


Fig 4



6 Identify all the components on the PCB and record them in Table-3,

Table 3

Sl No	Name of the components

7 Insert the keypad buttons correctly into the slotted holes on the front panel cover of the remote control.

8 Align the PCB over the rubber keypad, insert the battery contacts into the back cover and fix the remote control handset.

9 Insert batteries, close cover, and test the functioning of buttons using the remote control checker/tester. Mobile phone Apps are available to test remote control (or) Use mobile phone camera to sense the IR (Infra Red) signals on pressing each button of the remote control unit.

10 Get the work checked by the instructor.

— — — — —

EXERCISE 103 : Dismantle the given LCD, LED, Smart TV to find faults with input stages through connectors

Objectives

At the end of this exercise you shall be able to

- remove the back panel cover of LCD/LED TV
- Identify the input terminals and check them
- troubleshoot the input terminal through connectors.

Requirements

Tools/ Equipments/ Instruments

- Trainees tools kit - 1 Set.
- Magnifier lens - 1 No.
- LCD/LED TV - 1 No.
- Home theatre system - 1 Set.
- DVD player with remote controls & user manual - 1 Set.
- Set-top box with user manuals - 1 No.
- HDMI cable - 2 Nos.
- RCA cable 3RCA - 3RCA - 1 Set.
- Optical cable(S/PDIF) - 1 No.
- Coaxial cable 2RCA - 2RCA - 1 Set.

Procedure

TASK 1: **: Remove the back panel cover and identify the input terminals / connectors of the LCD/LED TV**

Note: The instructor has to provide the LCD/ LED TV with known faults in input stages

1 Continue with the previous exercise by detailing the steps to remove the back panel cover of the LCD/LED TV. Follow the same set of instructions as before.

Keep the screws and stand aside carefully

2 Locate the input stage of the LCD/LED TV and identify the types of sockets or connectors available for various inputs such as HDMI, VGA, USB, etc. as shown in Fig 1.

Fig 1

3 Note down the type of socket along with any relevant details for each input and record it in table 1

Table 1

Sl. No	Name of the socket/ connector	Uses/Purpose	Remarks

4 Use a magnifying lens to closely inspect the terminal sockets and connecting wires leading to the motherboard. Look for any signs of desoldering or disconnection, such as loose wires or visibly damaged connections.

5 If you find any problems while looking closely, fix them by resoldering or correcting the issues. After you have solved the problems, ask the instructor to check and ensure that everything is correct and in normal conditions

6 Carefully lift the LCD/LED TV and securely position it at a 45-degree angle, ensuring that it has full support to prevent any damage during the process.

7 Connect the appropriate signal source using the specific type of connecting cable, ensuring a secure and proper connection to the identified input socket of the LCD / LED TV corresponding to the source device as shown in Fig 2.

Fig 2

Note: DVD player/ set top box/ laptop computer with HDMI output may be selected as the signal source for the above step

8 Turn on the LCD/LED TV, verify that the TV is receiving the signal correctly, and ensure that the display functions as expected without any issues with reception as shown in Fig below.

9 Get the approval of the instructor, switch OFF the setup, disconnect the signal source/cable.

10 Reposition, close the back cover on the LCD/LED TV and fix the base stand.

EXERCISE 104 & 105 : Detect the defect and Troubleshoot the faults in the given LED/LCD TV receiver and Rectify the faults

Objectives

At the end of this exercise you shall be able to

- identify the internal sections of LCD/LED TV
- identify the faults in the LED TV
- rectify the fault in LCD/LED TV using flowchart method.

Requirements

Tools/ Equipments/ Instruments

- LCD/LED TV - 1 No.
- Trainees tools kit - 1 Set.
- Digital multimeter with probes - 1 No.
- User manual of LCD/LED TV - 1 No.
- Pattern generator with operating/instruction manual - 1 No.
- ESD table - 1 No.

Procedure

Precaution: Note down the colours of wires and position/location of connectors on the main board. Avoid touching the screen at all times as this may result in damage to the screen

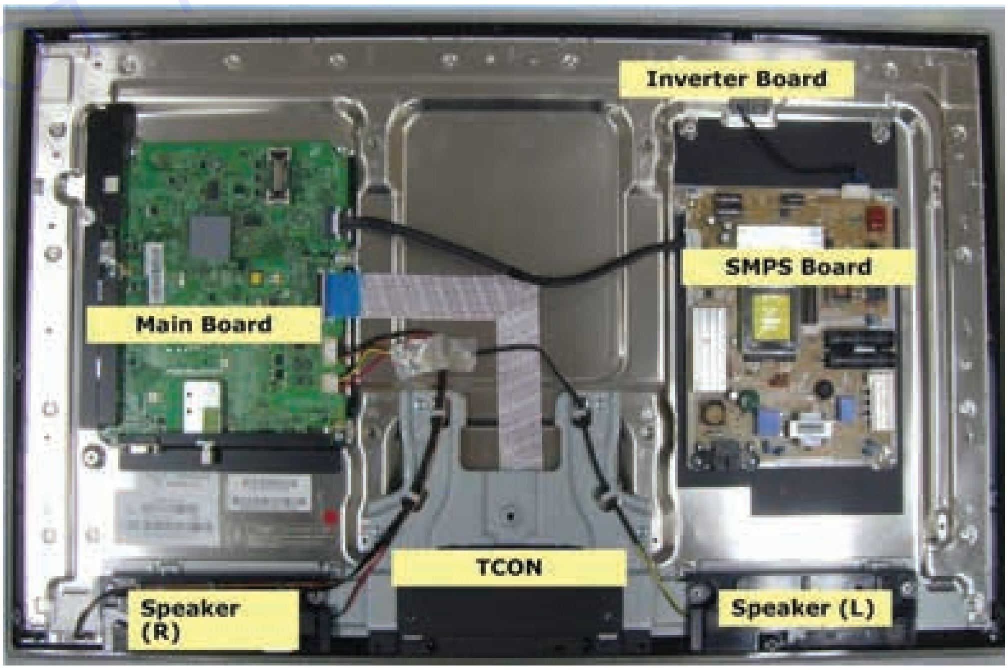
TASK 1: **Identify the internal sections of LCD/LED TV**

1 Continue with the previous exercise by detailing the steps to remove the back panel cover of the LCD/LED TV. Follow the same set of instructions as before.

Keep the screws and stand aside carefully

2 Identify the different internal sections of LCD/LED TV as shown in Fig 1

Fig 1



3 Note down the name of different sections in Table-1.

Table 1

Sl.No	Name of the internal section	Description

— — — — —

TASK 2: **Identify the faults in the LCD / LED TV**

a) If there is no power, follow this troubleshooting chart.

1 First, visually inspect the PCB board of the LCD/LED TV for any burnt components or wires.

2 Switch on the TV and observe the screen for any display. If either is not present, turn off the TV.

3 Connect the color pattern generator output to the LCD/LED TV.

4 After completing this setup, switch on the TV again and observe the screen for any display, then turn it off.

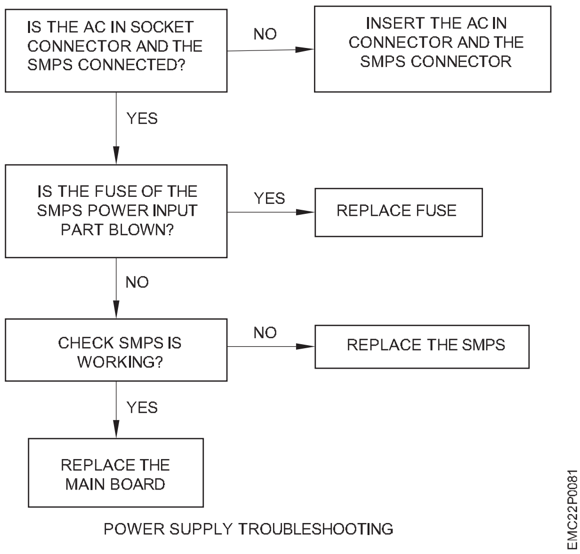
5 Remove the screws securing the chassis or main PCB to the cabinet. It is important to keep all associated screws, nuts, fasteners, etc., in a transparent cover to prevent loss as fig 2 and facilitate an easier reassembly process.

6 Disconnect any connectors that are attached to the PCB, and then gently take out the PCB from the cabinet. It's important to handle the process with care to avoid damage to soldered wires.

7 Place the removed PCB in a way that provides easy visibility and access to all components. This positioning is essential for troubleshooting and reference during the inspection.

8 Refer to the circuit diagram of the SMPS stages of the LCD/LED TV and follow the troubleshooting flow chart as shown in below.

Fig 2

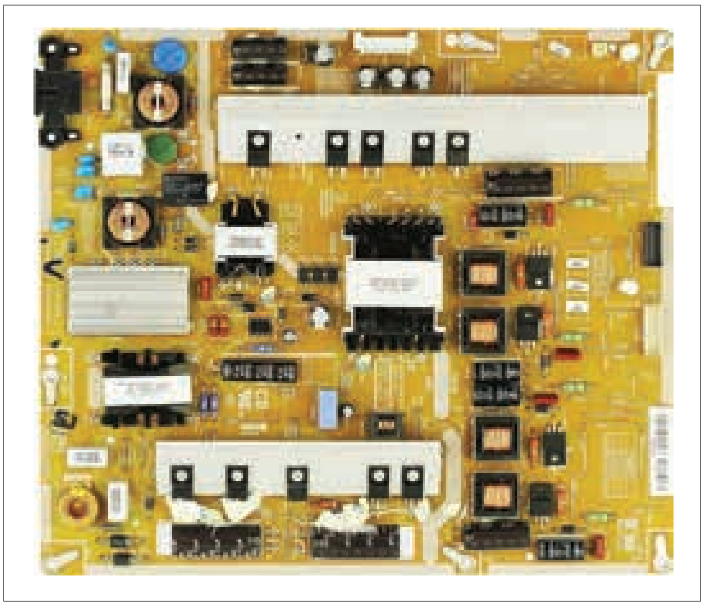


POWER SUPPLY TROUBLESHOOTING

9 Identify the components of the SMPS stage on the PCB as per fig 4 and verify the output voltage of 24V is present. This process is important for detecting any issues within the power supply. Fig 4.

Table - 1

No power	Yes/No
Whether display present	
Power board output	
Power key under control	
IR receiver normal	



b) If there is No sound, follow this troubleshooting chart

1 Switch on the TV and carefully observe for sound, if either is not present, turn off the TV.

2 Connect the colour pattern generator output to the LCD/LED TV.

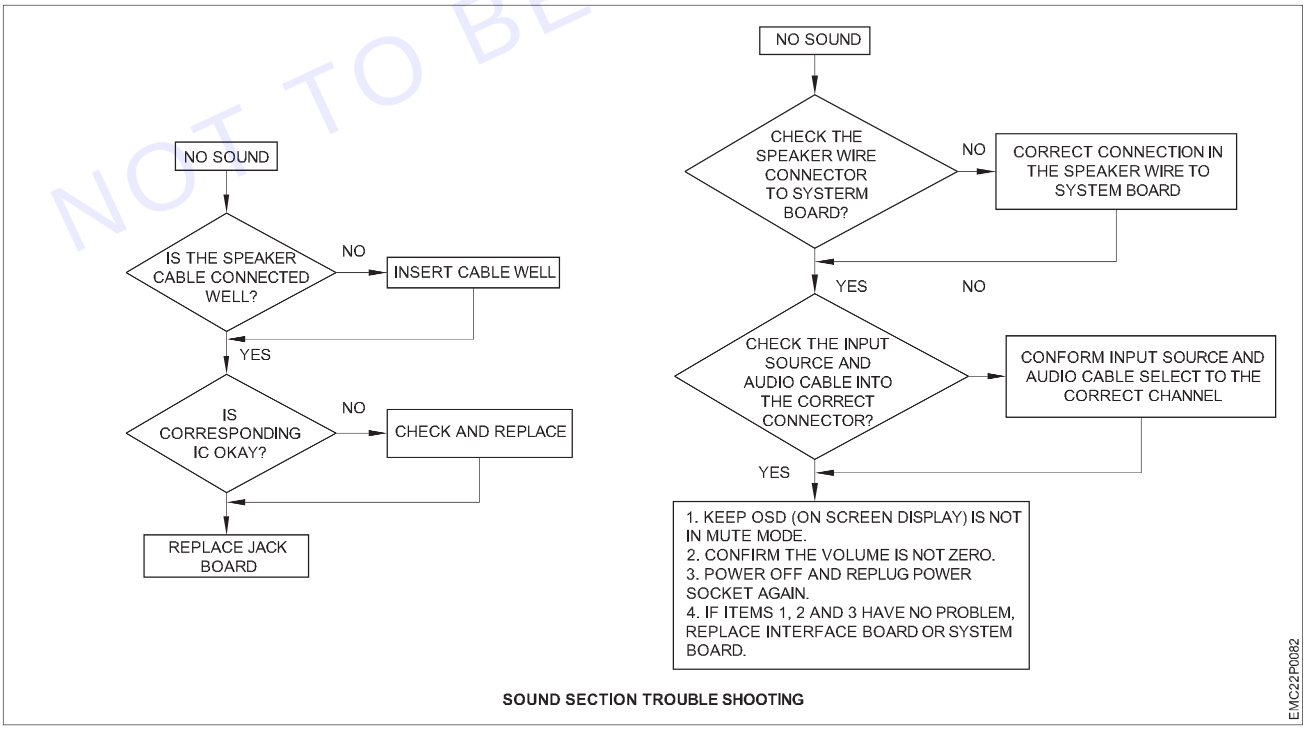
3 Switch on the setup, and check for the presence of sound and visual display. If they are still not present, switch off the TV once again

4 Remove the screws securing the chassis or main PCB to the cabinet. It is important to keep all associated screws, nuts, fasteners, etc., in a transparent cover to prevent loss and facilitate an easier reassembly process

5 Disconnect the speaker wire from the TV's circuit.

6 Check the speaker cable for any loose or improperly connected wires. If any issues are identified, reconnect the speaker cable with connector and then observe the audio performance.

7 Check the voltages of the IC related to the TV's audio system. If the expected voltages are not present, consider replacing the faulty IC. Utilize the troubleshooting chart as shown Fig 5(a & b) to identify and rectify any possible faults in the given TV set. Fig . 5(a) Fig . 5(b)



SOUND SECTION TROUBLE SHOOTING

Other trouble shooting chart for general faults are as follows

Sl. No	Symptom	Solutions
1	No picture on screen but LCD/LED TV still has sound.	The problem is caused by defective SMPS board and replacing SMPS/Power supply board will solve the problem
2	Screen flash ON and OFF between 1/2 to a few seconds, but power indicator light stays ON and TV still has sound.	The problem is caused by defective mother board
3	Blue screen but no picture.	The problem is caused by defective main board (AD board). In some cases, this problem may be caused by defective screen controller board (T CON board). This board is mounted on the back of LCD TV screen.
4	Power light stays ON but no display and sound.	The problem is caused by defective main board. (AD board) or power supply board.
5	No power or power indicator light does not get ON.	The problem could either be defective power supply board or defective main board (AD board).
6	No picture but TV still has sound	Check the driver output voltage to side LED/Back light LED. If there is no voltage from the driver board. check the test point at the board and replace it If voltage is available in the driver board, then problem in display. Replace the suitable display
		Check the power supply T-CON board and main board and replace it.

8 Get the work checked by the Instructor.

— — — — —

EXERCISE 106 : Test LCD, LED And Smart TV after troubleshooting the defects

Objectives

At the end of this exercise you shall be able to

- connect and test the LCD/LED TV with input device
- verify the visual display and sound quality.

Requirements

Tools/ Equipments/ Instruments

- LCD/LED TV - 1 No.
- Trainees tools kit - 1 Set.
- Media source with HDMI, RCA, USB output - as reqd.
- Digital multimeter with probes - 1 No.

Procedure

Safety precaution:

1 Make sure to connect mains cable is properly connected with ground earth pin.

2 Do not plug too many electrical devices into a single multiple electrical outlet. Otherwise, this may result in fire due to over-heating.

3 Avoid touching the screen at all time, as this may result in damage to the screen.

1 Switch on the LCD / LED TV to check if it powers up without any issues.

2 Verify that the visual display is clear, without any distortions or irregularities. Ensure that colors are accurate and that there are no disturbances on the screen.

3 Test the sound output to ensure that it is clear and at the desired volume. Check for any distortion or abnormalities in the audio.

4 Test various input sources (HDMI, USB, etc.) to confirm that the TV can properly receive signals from different devices as per Fig 1.

Fig 1

5 Refer to the LCD / LED TV manual. Access the TV's menu options to ensure that the on-screen menu is responsive, and that all settings can be adjusted as needed as shown in Fig 2.

Fig 2

6 Check the functionality of the remote control to ensure that all buttons are working correctly and that commands are being received by the TV properly.

7 Connect the external devices and test their functionality to ensure proper compatibility with the TV.

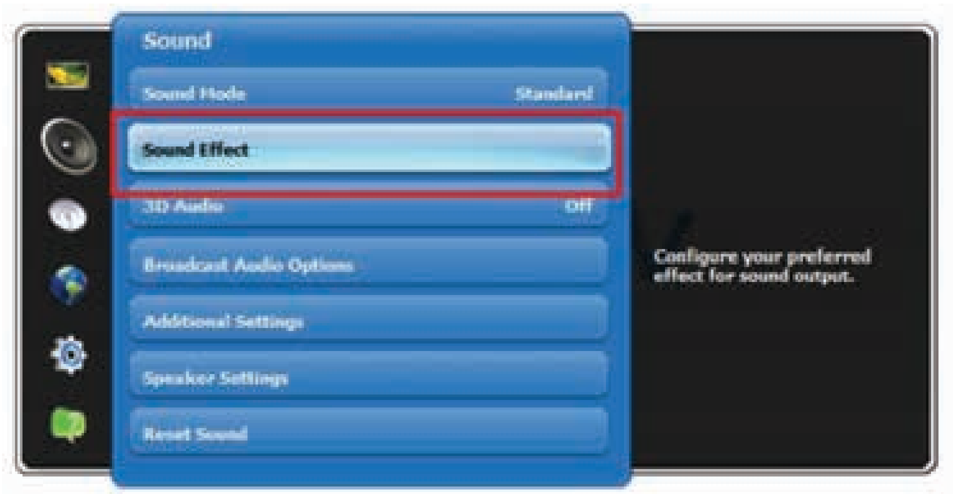
8 Verify that any settings adjusted during the troubleshooting process, such as those related to picture quality or audio settings, have been configured correctly as per Fig 3.

9 Some TVs offer built-in diagnostic tests. Run these tests if available to check the overall health and performance of the TV.

10 Check if there are any available firmwares or software updates for the TV and install them if necessary as per below figure.

11 Get the work checked by the instructor.

Fig 3



EXERCISE 107 : Demonstrate various connectors and connect the cable operator's external decoder (set top box) to the TV

Objectives

At the end of this exercise you shall be able to
- identify different input/output connectors in set-top box
- identify different front panel indicators/controls on set-top box
- connect the set top box to the TV.

Requirements

Tools/ Equipments/ Instruments

- Trainees tools kit - 1 Set.
- Set - top box with user manual - 1 Set.
- Cable set (3 RCA to 3 RCA/ HDMI cable) - as reqd.
- LCD/LED TV with remote control handset - 1 Set.
- DTH connectivity - as reqd.

Procedure

Note: The Instructor has to provide the set of box with user manual to the trainees.

TASK 1: **Identification of different input/output connectors in set-top box**

1 Collect the set-top boxes from the Instructor and examine the rear panel as shown in Fig 1.

2 Identify different input /output connectors in rear panel on set-top box and note down in TABLE 1.

Fig 1

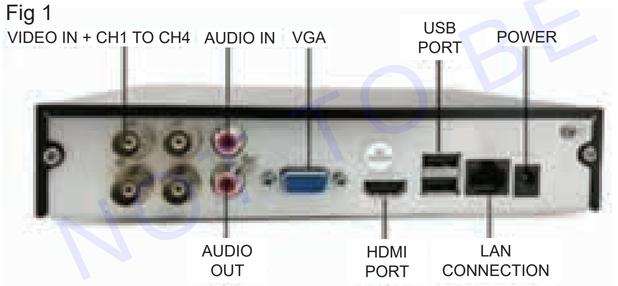


TABLE 1

Sl No	Name the connectors	Usage / Functions

3 Repeat the above steps for other set-top box models.

— — — — —

TASK 2: **identify different indicators/controls on set-top box**

1 Identify different front panel indicators/controls on set-top box as shown in the Fig 2 and note down in TABLE 2.

Fig 2

TABLE 2

Sl No	Name the indicators / controls	Usage / Functions

2 Repeat the above steps for other set-top boxes.

TASK 3: **Connect the set-top-box to the TV.**

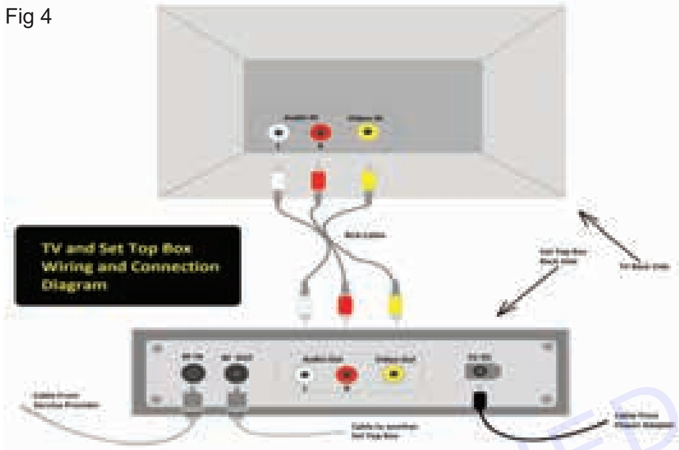
1 Place the set-top box near the TV receiver at a convenient location.

2 Connect the coaxial cable from dish antenna terminated with the F-connector to the set-top box as shown in Fig 3.

3 Use the 3RCA to 3RCA cable, connect the output of set-top box following the colour code, connect the video input, left channel and right channel of audio inputs on the TV as shown in Fig 4

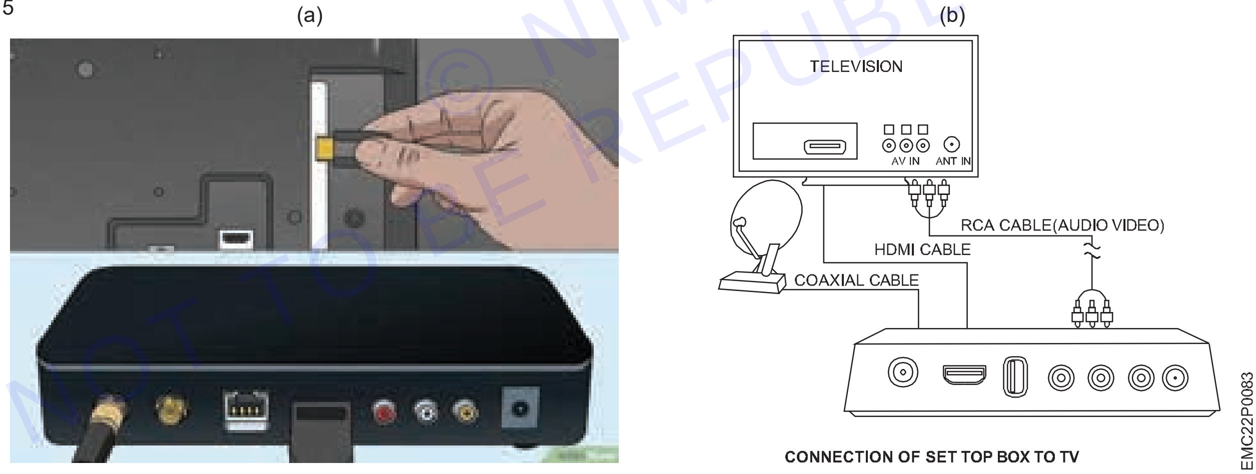
Fig 3

Fig 4



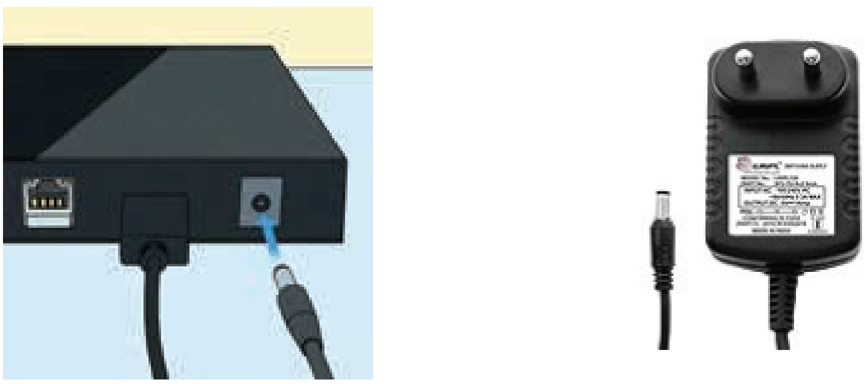
4. If HDMI terminal is available on the set-top box, use HDMI cable and connect it to the HDMI-1 input of LCD/ LED TV as shown in Fig 5 (a & b).

Fig 5 (a) (b)



5 Plug the Adapter to AC supply as shown in Fig 6a & 6b

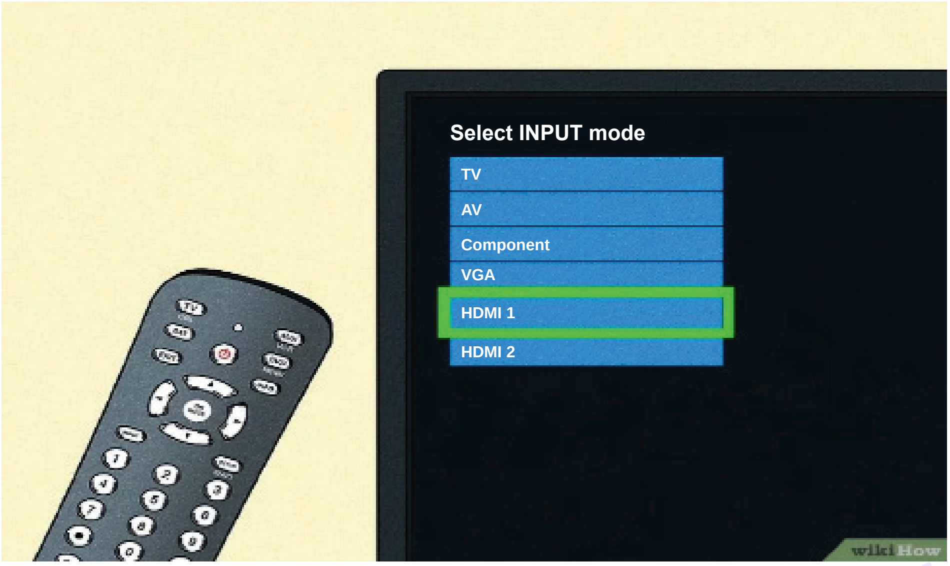
Fig 6 (a) (b)



6 Get the connections checked by the instructor.

7 Switch ON the LCD/LED TV and Set-top box, use the remote control and select the AV input/HDMI-1 mode as shown in Fig 7.

Fig 7



8 Use the remote control of the set-top box and select the organize button, view the channel on the LCD/ LED TV

9 Change channels using the remote control of the set-top box and get the work checked by the instructor.

10 Switch OFF both the set-top box and LCD/ LED TV after assembling the DTH system.

11 Get the work checked by the instructor.

MODULE 12: DTH system

EXERCISE 108: Demonstration & use of DTH system Assembly

Objectives

At the end of this exercise you shall be able to

- identify the components of DTH system
- understand the need for the components of DTH system before installation.

Requirements

Tools/Equipments/Instruments

- Trainees tools kit - 1 Set.
- DTH system with accessories - 1 Set.

Note: Instructor should provide the user manual of the DTH to the trainees and guide them to properly use the tools to demonstrate DTH system.

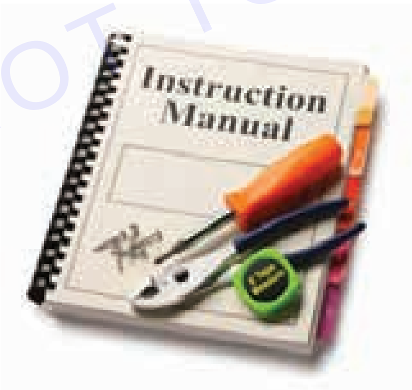
Procedure

TASK 1:

1 Identify the different components used in the DTH system.

2 Check the user manual and verify that all components are present as per Fig 1&2.

Fig 1&2



3 Note down the components names and their functions used to assemble the DTH system. Record it in Table 1

4 Group similar components together for easier identification and assembly.

5 Separate the DTH Set-Top Box, satellite dish, LNB, cables, and accessories.

6 Choose a clean and spacious area to assemble the DTH system.

7 Ensure there is enough space to lay out and organize the components.

8 Follow the assembly instructions provided by the specified manufacturer to properly assemble the DTH system.

9 Once assembled, as per Fig 2, get the work checked by your instructor.

Fig 2

Table 1

Sl. No.	Name of the components used in DTH system	Usage /functions

— — — — —

EXERCISE 109: Demonstration & use of different tools and equipments used in DTH Installation procedure & Cabling procedure

Objectives

At the end of this exercise you shall be able to
- identify the various components and accessories of DTH system and the Tools & Equipments used during installation
- install a DTH system.

Requirements

Tools/ Equipments/ Instruments

- Trainees Tools kit - 1 Set
- DTH system - 1 Set
- Compass - 1 No.
- Drilling machine - 1 No.
- T Spanner set - 1 No.
- Allen key - 1 Set
- Nut and Bolts - as reqd.

Materials/ Components

- Cleaning brush - 1 No.
- Coaxial cable (LNB) - as reqd.

Safety Precaution

1 Instructor may use the Instruction manual of DTH system to demonstrate the procedure for Installation.

2 Use proper tools for installing the DTH.

3 Avoid loose connections.

Procedure

TASK 1: **Identify the various Components and accessories used in DTH system**

1 Pick the DTH system available in the lab comprising of the parts as shown in Fig 1a and identify the name of the parts as per procedure given in previous exercise.

2 Identify and Record various Tools & Equipments given in Fig 1b, required for installation of DTH system in table 1.

Fig 1a

Fig 1b

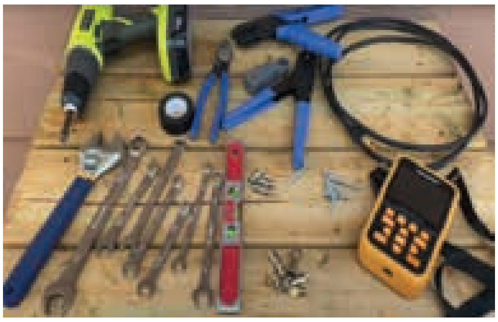


Table 1

Sl. No.	Tools & Equipments used during installation of DTH	Purpose

3 Get the work checked by the instructor.

— — — — —

TASK 2: **Installation procedure for DTH system**

1 Locate the Place for the Dish antenna installation.

2 Choose the location where there is no tree, building, or any other object in the direction where satellite is available, near the site , where the antenna is to be installed. It may cause obstruction for the satellite signals falling on the Dish Antenna.

3 Hence choose proper open area for the signals as shown in Fig 1.

Fig 1

Note: Do not install antenna on poor walls or roof.

4 Mount antenna on the wall or roof as in Fig 2a & 2b, first check wall quality, preferably strong walls which can provide better grip and strength to the DTH setup.

5 Mark holes on wall/terrace, using drilling machine and assemble the Dish antenna - mounting unit.

6 Tight all Nuts, Bolts and screws and washer up to maximum depth using the proper screw driver. Make sure it should not be loose at all.

7 Fit the Dish antenna to the mounting unit as shown in Fig 3a & 3b.

8 Now fit properly LNB holder (Plastic clamp). Also fit LNBF on the LNB holder as shown in Fig 4, keep the output connector direction towards the ground side.

9 Mount the entire antenna assembly on the wall mounted stand & keep Nuts and Bolts of Az-El mount partly loose , till the dish antenna alignment/positioning gets completed.

Fig 2a shows Dish Antenna installed on wall

Fig 2b shows Dish Antenna installed on roof

Fig 3a

Fig 3b

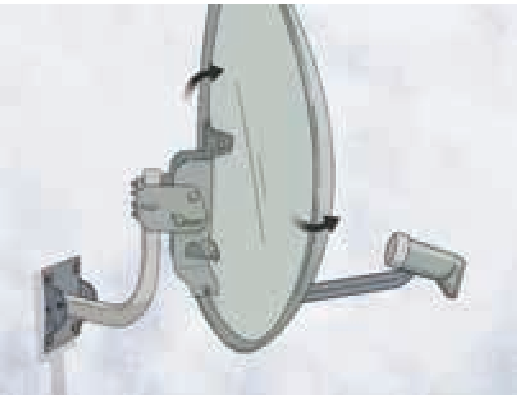


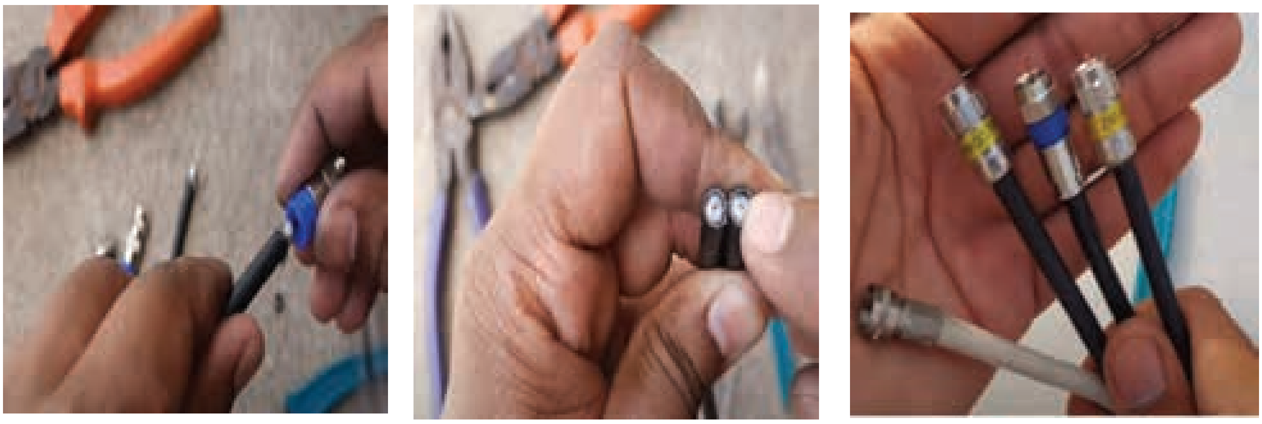
Fig 4

— — — — —

TASK 3: **Cabling Procedure**

1 Now insert the connectors to the cables and tighten or crimp as required, shown in Fig 1.

Fig 1



2 Connect the LNB to the arm of the satellite dish.

3 Interconnect the cables. Connect one end of the coaxial cable at the LNB output and the other end to the input port of the STB (satellite receiver).

4 Make sure that distance between antenna and receiver should not be more than 25 mtrs. Do not directly join both the cables without connectors as in Fig 2.

Fig 2

DO'S & DON'TS while performing task.

Instructor should instruct trainees to follow the tips.

1 Use proper tools for installation.

2 Do not alter the position / orientation of the antenna after final installation.

3 Do ensure that cable is routed and harnessed properly to prevent any damage.

— — — — —

EXERCISE 110: Practical Demonstration of various types of connectors and cables

Objectives

At the end of this exercise you shall be able to

- identify various connectors in DTH system
- identify various Cables in DTH system.

Requirements

Tools/ Equipments/ Instruments

- Trainees tools kit - 1 Set.
- DTH Dish Antenna - 1 Unit.
- DTH Receiver - 1 Unit.
- LED TV Receiver - 1 Unit.
- Allen key - 1 Set.

Materials/ Components

- Coaxial Cable (RG6 or RG11) - as reqd.
- F-Type Connector - as reqd.
- HDMI Cable, HDMI Connectors - as reqd.
- RCA Cable, RCA Connectors - as reqd.
- Power cables for DTH Receiver - as reqd.

Procedure

Here is step by step procedure for trainees regarding DTH connectors and cables.

1 DTH Dish Antenna Setup

- **Steps**

1 Identify the “LNB” (Low-Noise Block Downconverter) on the DTH Dish Antenna.

2 Connect one end of the Coaxial Cable to the threaded connector on the LNB.

3 Tighten the connection by twisting the F-Type Connector clockwise until snug.

4 Ensure that the dish is properly fixed and aligned for optimal signal reception before proceding to the next step.

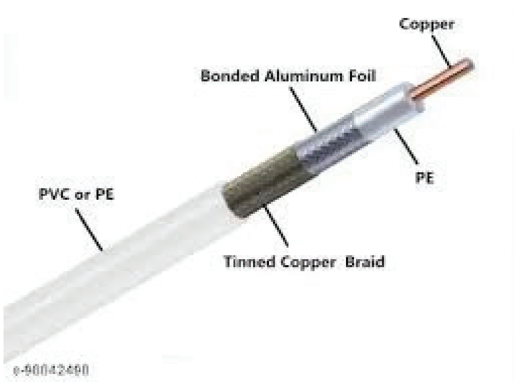
2 Run Coaxial Cable to DTH Receiver

- **Steps**

1 Run the Coaxial Cable from the DTH Dish Antenna to the DTH Receiver location.

2 Connect the other end of the Coaxial Cable to the “LNB IN” or similar input port on the DTH Receiver.

3 Tighten the F-Type Connector on the DTH Receiver to secure the connection.



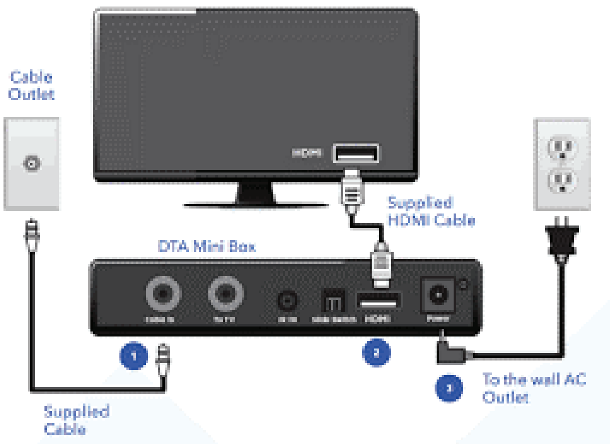
3 Connect DTH Receiver to TV - HDMI Connection

- **Steps**

1 Locate the HDMI output port on the DTH Receiver.

2 Connect one end of the HDMI Cable to the HDMI output port of DTH Receiver and the other end to the HDMI input port of TV as shown in fig.below.

3 Ensure a secure connection by pushing the HDMI connectors into place.



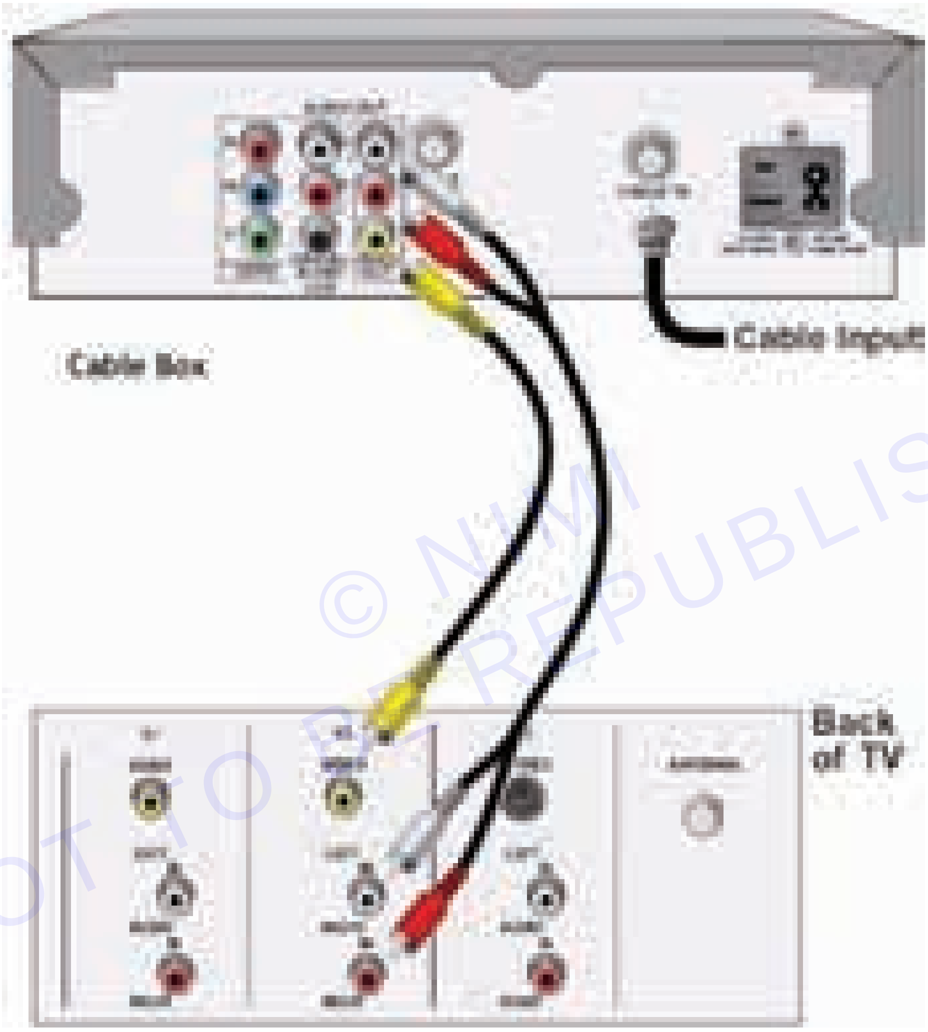
4 **Connect DTH Receiver to TV - RCA Connectors (another method of connecting the two equipments):**

- **Steps**

1 Identify the color-coded RCA output ports on the DTH Receiver (usually red, white, and yellow) as shown in Fig below.

2 Connect the corresponding color-coded RCA plugs to the matching input ports on the TV.

3 Ensure a secure connection by pushing the RCA connectors into place.



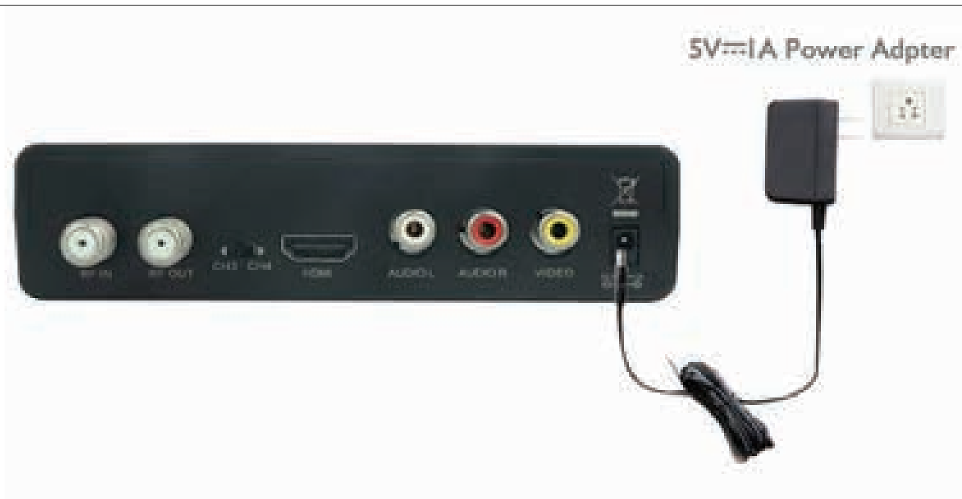
5 **Power Up and Configure**

Note: High-Definition Multimedia Interface (HDMI) is a proprietary audio/video interface for transmitting video and digital audio data. It is used in computer monitor, video projector, digital television, or digital audio device. HDMI is a digital replacement for analog video standards.

- **Steps**

1 Plug in the power cable for the DTH Receiver and connect it to a power source.

2 Power on the TV and select the correct input source (HDMI or RCA) based on your connection.



Precautions

1 Avoid sharp bends that can damage cables and lead to signal loss.

2 Keep coaxial cables away from power cables to minimize signal interference.

3 Minimize excess cable length to reduce signal loss.

4 Label and mark name in cable connections for easy identification and troubleshooting.

EXERCISE 111: Demonstrate DTH Installation & Connection procedure

Objectives

At the end of this exercise you shall be able to

- identify parts of DTH system, Cables and connectors and demonstrate the connecting procedure for DTH installation.

Requirements

Tools/ Equipments/ Instruments

- DTH Set-Top Box/Satellite receiver - 1 No.
- LED/LCD/HDTV/SMART TV receiver - 1 No.
- Dish antenna with fixture and STB (set top box) Remote control and batteries - 1 Set.

Materials/ Components

- HDMI Cable (or AV cables, depending on the available ports) - as reqd.
- Coaxial Cable (to connect Dish antenna to TV) and connectors - as reqd.
- HDMI Cable, AV cables, RCA cables - as reqd.

Procedure

1 **Remember to follow all safety guidelines and consult the specific documentation provided by the DTH service provider for accurate and detailed instructions.**

2 **Choose a DTH Service Provider in your location.**

3 **Instructor may demonstrate the DTH installation & connection procedure before**

1 Positioning of the Satellite Dish

a Dish needs to be placed in a location with a clear line of sight to the sky, ensuring minimal obstruction by trees or buildings, to get a strong signal from the Satellite as shown in Fig 1.

b Dish needs to be mounted securely using appropriate brackets.

Fig 1

2 Connecting the Coaxial Cable

a Connect one end of the coaxial cable to the LNB (Low-Noise Block downconverter) output on the dish as Fig 2.

b Run the coaxial cable to the location where the DTH set-top box will be placed.

3 Connecting the Coaxial Cable to the Set-Top Box

a Connect the other end of the coaxial cable to the “LNB IN” or “SAT IN” port on the back of the DTH set-top box.

4 Connecting the Set-Top Box to the TV

a Determine the available ports on your television (HDMI or AV).

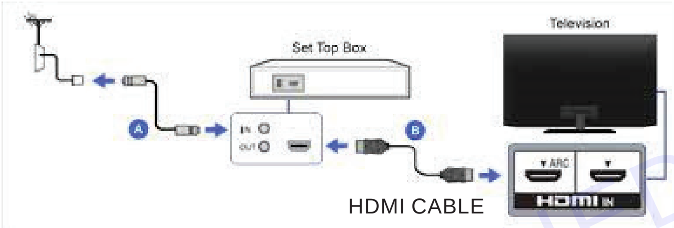
b If one using HDMI

i Connect one end of the HDMI cable to the “HDMI OUT” port on the DTH set-top box.

ii Connect the other end of the HDMI cable to an available HDMI port on the television as per Fig 3

Fig 2

Fig 3

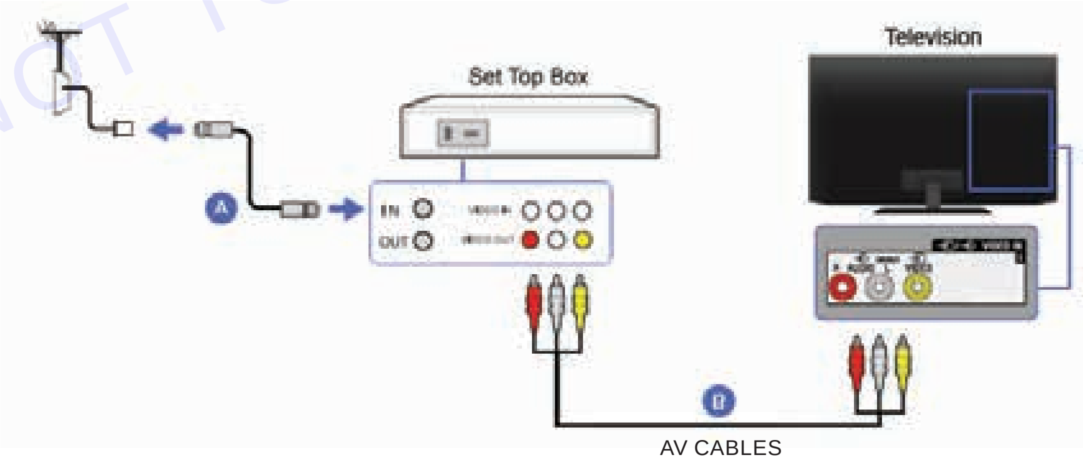


c While using AV cables:

i Connect the AV cables (red, white, and yellow) to the corresponding color-coded ports on the DTH set-top box as Fig 4.

ii Connect the other end of the AV cables to the matching ports on the television.

Fig 4



5 Power On

a Connect the power adapter to the DTH set-top box.

b Plug the power adapter into a power outlet.

c Power on the television and the DTH set-top box.

6 Initial Setup

a Follow the on-screen instructions on the TV to complete the initial setup process for the DTH system.

b This may include language selection, channel scanning, and activation.

7 Testing

a Use the remote control to navigate through channels and settings.

b Ensure that the channels are displaying correctly on the TV.

c Test the remote-control functions, such as volume control and channel changing as Fig 5.

Fig 5

8 Optional: Internet Connection (if supported)

a If your DTH set-top box supports internet connectivity, you may connect it to network using an Ethernet cable or Wi-Fi.

9 By following above steps have a successfully connected DTH system. Get the work checked by the instructor.

EXERCISE 112: Install a DTH system and get a TV station

Objectives

At the end of this exercise you shall be able to

- install a DTH system and get a TV station.

Requirements

Tools/ Equipments/ Instruments

- DTH Set-Top Box/Satellite receiver - 1 No.
- LED/LCD/HDTV/SMART TV receiver - 1 No.
- TV and STB (set top box) Remote control and batteries - 1 Set.
- Dish antenna with fixture - 1 Set.

Materials/ Components

- Coaxial Cable (to connect Dish antenna to TV) and connectors - as reqd.
- HDMI Cable, AV cables, RCA cables - as reqd.
- SAT meter - 1 No.
- Compass - 1 No.

Procedure

1 Remember to follow all safety guidelines and consult the specific documentation provided by the DTH service provider for accurate and detailed instructions.

2 Choose a DTH Service Provider in your location.

3 As per the Installation & Connecting procedure demonstrated by the Instructor in the previous exercise DTH installation may be carried out.

4 Adhere to the step-by-step installation instructions provided by the DTH system manufacturer. Ensure that all connections are secure and the dish is correctly aligned for optimal signal reception.

Fig 1

1 **Install the Satellite Dish**

- Mount the satellite dish securely on a stable surface. Use a compass to align it with the satellite's position. Follow the manufacturer's guidelines for proper installation. (Fig 2)

2 **Connect the Set-Top Box**

- Connect the set-top box to your TV using HDMI or RCA cables. Follow the instructions provided by the DTH service provider for specific connections. (Fig 3)

Fig 2

Fig 3

3 **Connect to Power**

- Connect the set-top box to a power source using the provided power adapter. (Fig 4)

Fig 4

4 **Activate the DTH Service**

- Contact the DTH service provider to activate your subscription. They will guide you through the activation process, which may involve providing details like your account number or the set-top box serial number.

5 **Tune Channels**

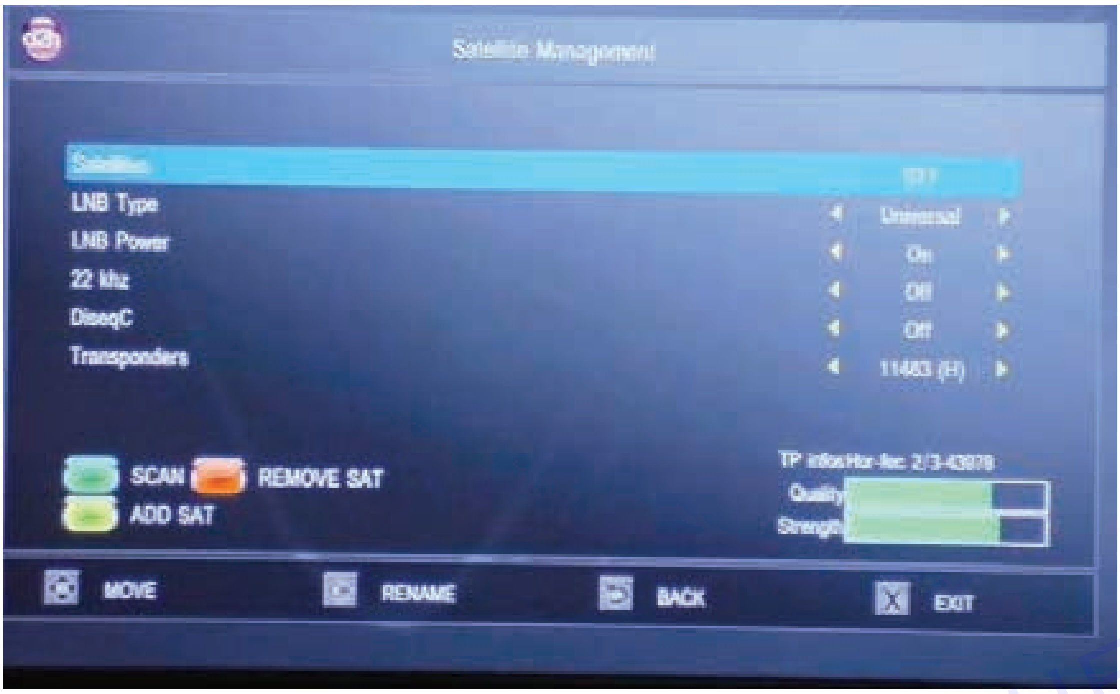
- Use the remote control provided with the set-top box to scan and tune channels. Follow the on-screen instructions or refer to user manual for this process as shown in Fig 5.

6 Observations on the procedure followed for the DTH installation, Cable connections from DTH antenna to the STB ports and connections between the STB and TV etc are to be noted down by the Instructor and students team.

7 If any signal connectivity problem happens while switch ON TV for channel reception, Disconnect the power to STB and TV & again switch the Power ON in both systems, to Reboot the set-top box and TV and to establish smooth communication/binding between STB and TV.

8 After the completion of Installation procedure and recording the Observations, get your work checked by instructor.

Fig 5


Satellite Management
LNB Type
LNB Power
22 khz
DiseqC
Transponders
Universal
On
Off
Off
11483 (H)
SCAN
REMOVE SAT
ADD SAT
Quality
Strength
MOVE
RENAME
BACK
EXIT

EXERCISE 113: Practical on the site selection, installation mounting tracking for Azimuth and Elevation angles using SAT meter

Objectives

At the end of this exercise you shall be able to

- perform the Site selection for DTH
- perform installation, mounting, tracking for azimuth and elevation angles using SAT meter.

Requirements

Tools/ Equipments/ Instruments

- DTH Set-Top Box - 1 No.
- Television - 1 No.
- Remote control and batteries - 1 Set.
- Dish antenna with fixture - 1 No.

Materials/ Components

- HDMI Cable (or AV cables, depending on the available ports) - as reqd.
- Coaxial Cable (from the satellite dish) - as reqd.
- SAT meter - 1 No.

Procedure

Site Selection

1 Clear Line of Sight

- Choose a location for the satellite dish with a clear line of sight to the sky. Ensure there are no obstructions like tall buildings or trees blocking the view of the satellite.

2 Southward Orientation

- In the Northern Hemisphere, point the satellite dish southward. In the Southern Hemisphere, point it northward. This is the general direction of geostationary satellites.

Fig 1 shows DTH antenna facing Southward

Fig 1

3 Mounting the Satellite Dish

- Mount the satellite dish securely using an appropriate bracket or mount. Ensure it is stable and doesn't sway in the wind.

4 Leveling the Dish

- Use a level to ensure that the satellite dish is mounted horizontally. This step is crucial for accurate alignment.

Azimuth and Elevation Angle Setup

5 Finding Azimuth Angle

- Use a compass to find the general direction of the satellite. The azimuth angle is the compass direction in which the satellite is located. Adjust the satellite dish horizontally (left or right) to align with this azimuth angle.

6 Setting Elevation Angle

- Use a SAT meter to measure the elevation angle. This is the vertical tilt of the dish. Start with a rough estimate based on your location, and then fine-tune using the SAT meter.

Fig shows - Setting of Azimuth/Elevation Angle for intercepting/collecting satellite signals.

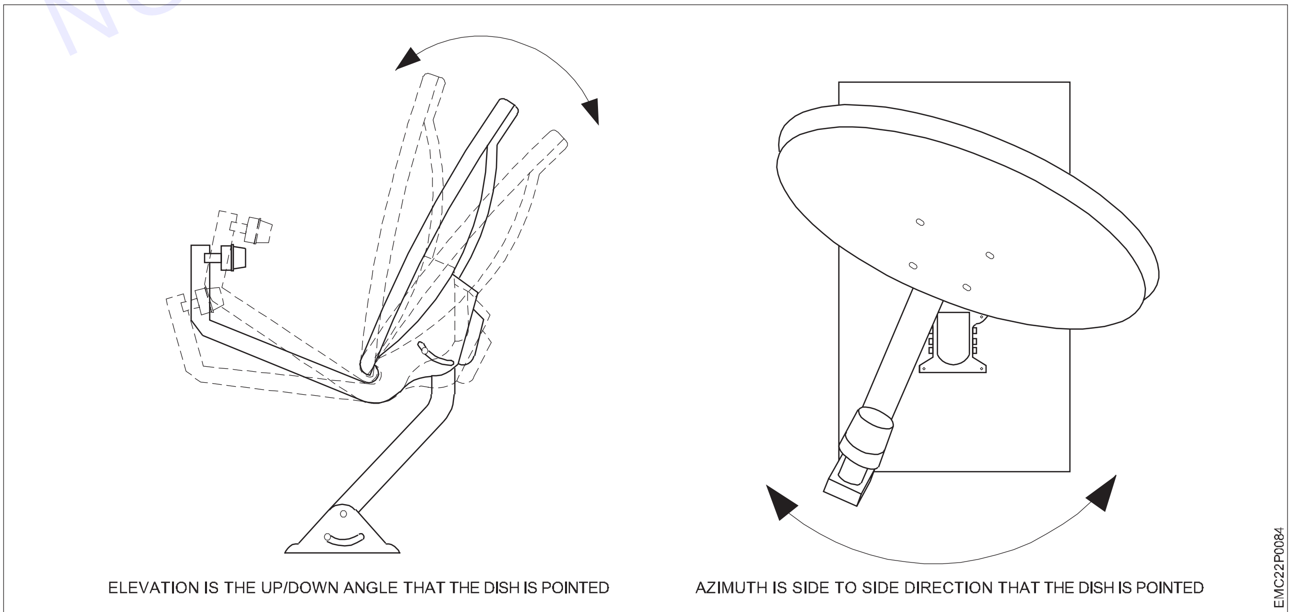
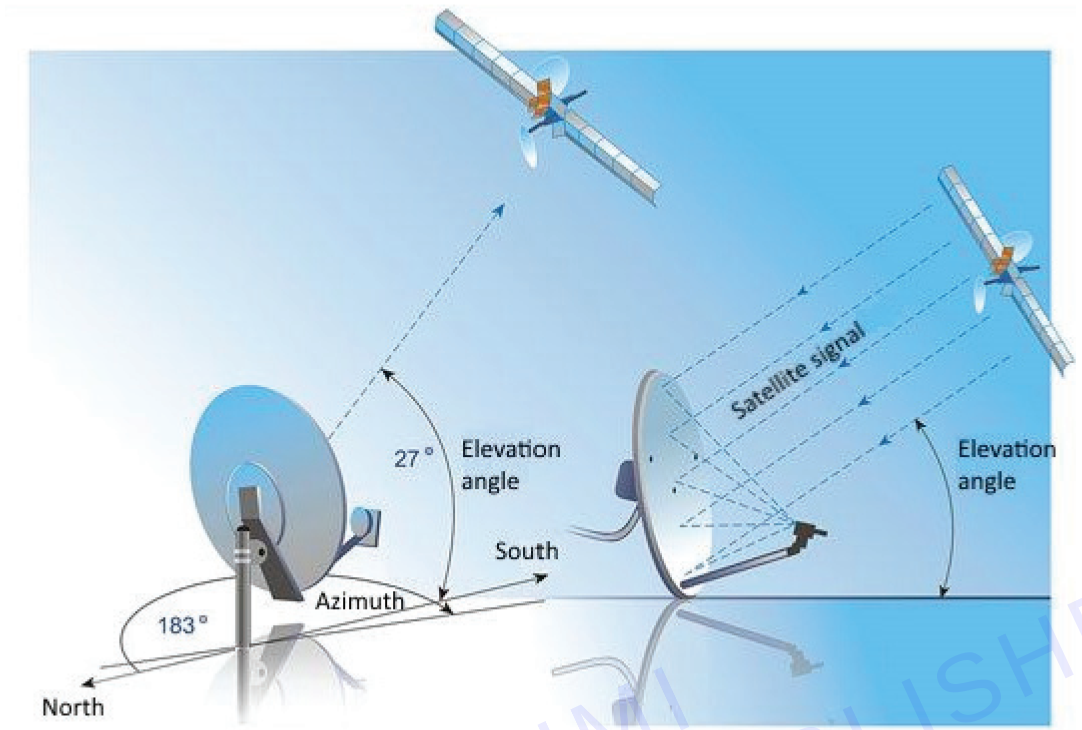


Fig shows - Setting of Azimuth/Elevation Angle for intercepting/collecting satellite signals.



7 Connect SAT Meter

- Connect the SAT meter to the LNB (Low-Noise Block downconverter) on the satellite dish using a short coaxial cable

8 Power Up SAT Meter

- Power on the SAT meter and set it to the satellite you are aligning with. Input the satellite information provided by your DTH service provider.

9 Adjust Azimuth

- While observing the SAT meter signal strength, slowly adjust the azimuth angle of the satellite dish until you achieve the highest signal strength.

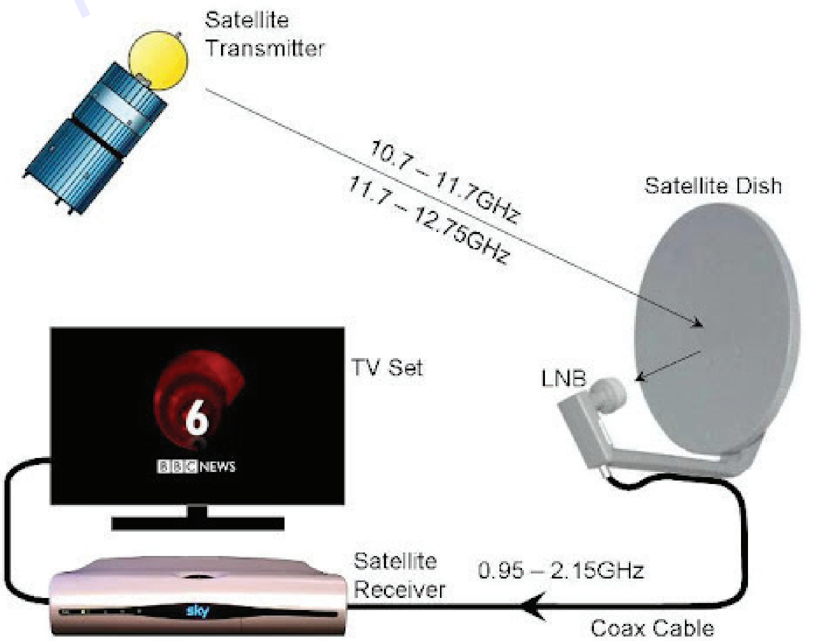
10 Adjust Elevation

- Fine-tune the elevation angle using the SAT meter. Slowly adjust the tilt vertically until you maximize the signal strength for better channel quality.

11 Signal strength and quality indicator

- Use the DTH receiver's signal strength and quality indicators to assess the signal reception.


Outdoor Connection
Male-to-Male
F Cable Coupler
(Not Supplied)
SATELLITE
FINDER
dB
Connect to
Receiver
Existing Coaxial Cable


Satellite
Transmitter
10.7 – 11.7GHz
11.7 – 12.75GHz
Satellite Dish
TV Set
LNB
Satellite
Receiver
0.95 – 2.15GHz
Coax Cable

12 Securing the Dish

- Once you achieve the maximum signal strength, secure the satellite dish in position. Tighten all mounting bolts to prevent any movement.

13 Verify Signal

- Connect the coaxial cable from the LNB to the DTH set-top box. Verify that the DTH channels are displaying correctly on the TV.

14 Final Checks

- Trainees should ensure that all connections are secure and weatherproof. Perform a final check of signal quality during different weather conditions.

Precautions

- **Check the signal strength and quality on the SAT meter during the alignment process.**
- **Avoid over-tightening bolts or adjusting mechanisms to prevent damage.**
- **Periodically check satellite dish, especially after severe weather events, to maintain signal quality.**

15 Get the work checked by the Instructor.

EXERCISE 114 : Detect the faults in DTH system & rectify

Objectives

At the end of this exercise you shall be able to

- identify the faults in the DTH system
- identify the different ways for rectification of faults in DTH system.

Requirements

Tools/ Equipments/ Instruments

- Signal Meter - 1 No.
- Multimeter - 1 No.
- Cable Tester - 1 No.
- Spare Cables - 1 No.
- Compass - 1 No.
- Ladder and Tools - 1 No.
- User Manual - 1 No.
- Smart Card Reader - 1 No.
- Computer or Smartphone - 1 No.
- Weather Protection Gear - 1 No.
- Flashlight - 1 No.
- Spare Parts - as reqd.

Procedure

Instructions

1 Check Signal Strength

- Ensure that the dish is properly aligned and free from any obstructions like trees or buildings.

2 Inspect Cable Connections

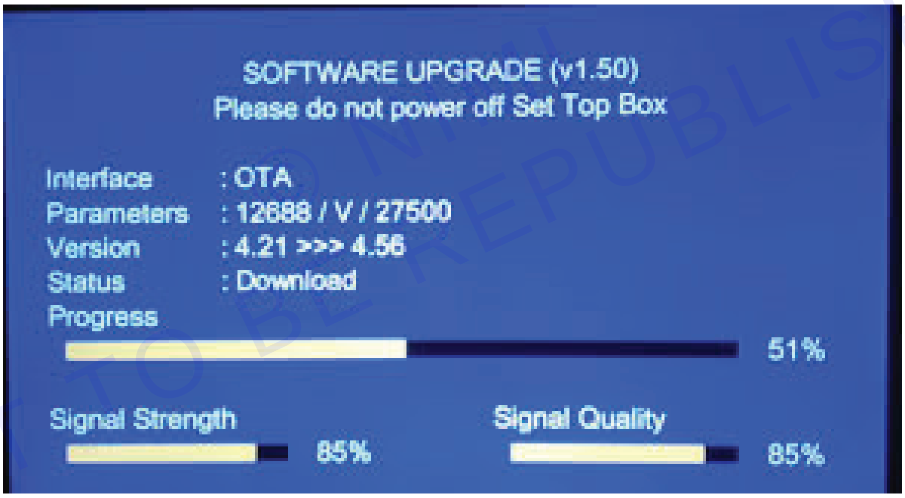
- Examine all cable connections, including the cables connecting the dish to the receiver and the receiver to the television.
- Make sure all connectors are securely attached and there are no visible damages to the cables.
- If still there is no signal, replace the HDMI cable with new/good cables and power ON.

3 Power Cycle the System

- Turn off the DTH receiver, unplug it from the power source, and wait for a few minutes.
- Plug it back in and turn it on. Booting process takes place.This simple power cycle can resolve minor software or communication issues.

4 Check for Software Updates

- Ensure that the DTH receiver has the latest firmware or software updates installed. Check the user manual for instructions on how to update the software.

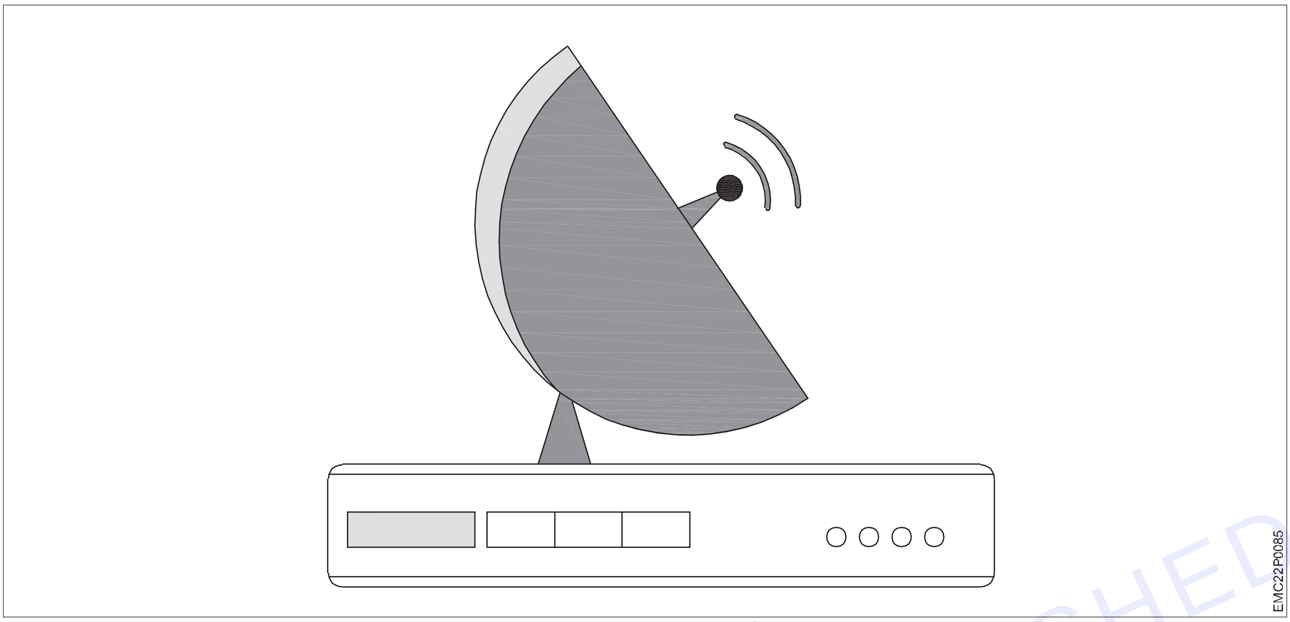


5 Verify Smart Card and Subscription

- Ensure that the smart card is properly inserted into the receiver and is not damaged.
- Confirm that the DTH subscription is active and paid up to date.

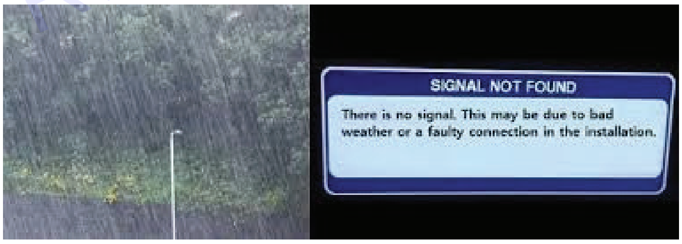
6 Perform System Diagnostics

- Most DTH systems have a diagnostic menu that provides information about signal strength, quality, and other parameters. Access this menu and analyze the diagnostic data.



7 Weather Conditions

- Inclement weather, such as heavy rain or thunderstorms, can affect the DTH signal. Wait for the weather to clear up and see if the issue persists.



8 Check for Local Interference

- If TV programme is received using an APP through WIFI, then loss of signal may be due to local WIFI connectivity failure or interference from other wireless signals. Sometimes tall buildings and cloudy weather or rainfall near Dish Antenna can affect DTH reception. Identify and eliminate potential sources of interference.

EXERCISE 115&116: Demonstration of a DTH (Direct-to-Home) set-top box, use of various input/ output (I/O) ports, STB connection & first Installation

Objectives

At the end of this exercise you shall be able to

- identify the DTH Set Top Box
- identify the various input output ports and connections used in STB.

Requirements

Tools/ Equipments/ Instruments

- DTH Set-Top Box with power adapter - 1 No.
- Television - 1 No.
- Remote control and batteries - 1 No.

Materials/ Components

- HDMI Cable , RCA & AV cables, depending on the available ports - as reqd.
- Coaxial Cable (from the satellite dish to STB) - as reqd.

Procedure

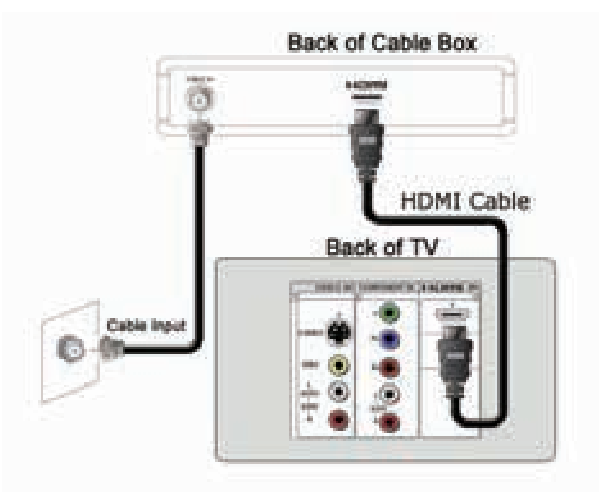
DTH Set-Top Box Demonstration , input/output (I/O) ports, STB connection & Installation.

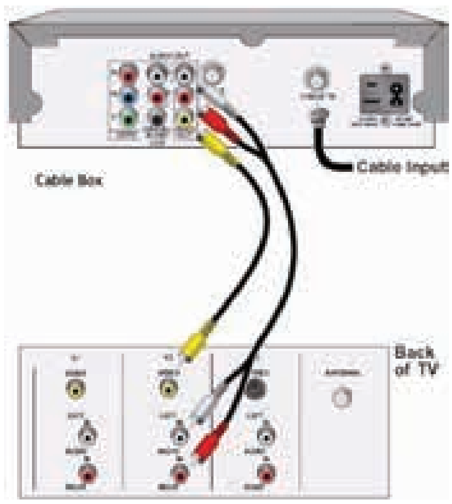
Here are the following steps for getting to know about various I/O ports.

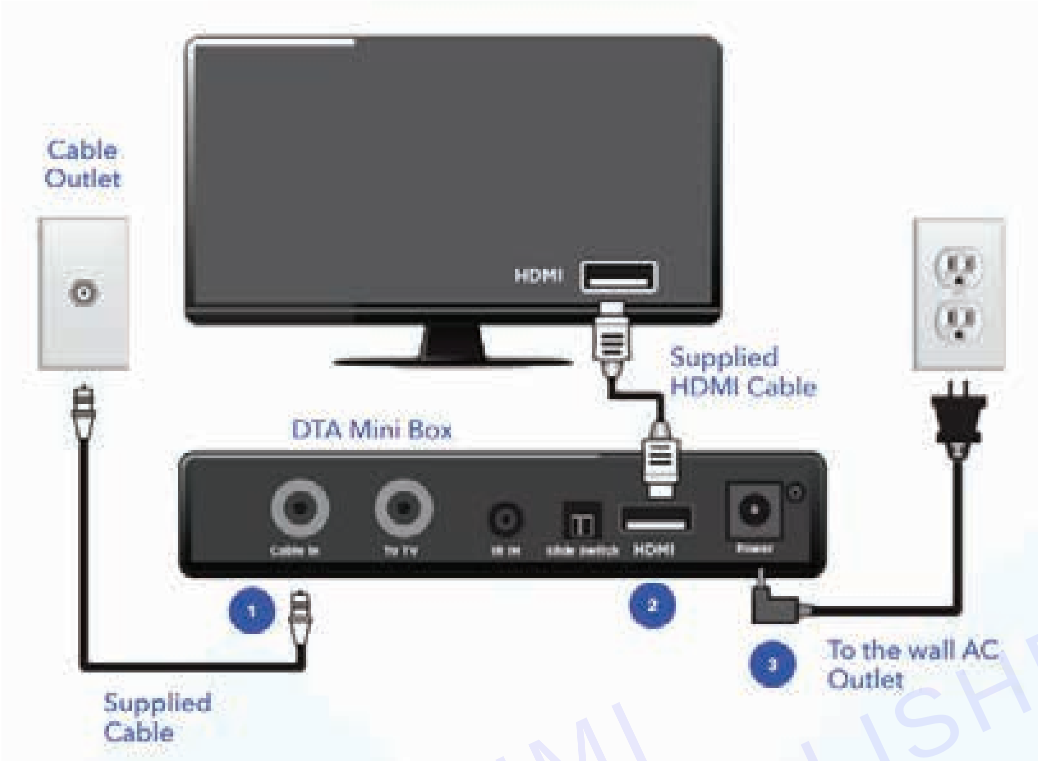
Steps

1 Connecting the Set-Top Box to the TV

- Determine the available ports on your television (HDMI or AV) as shown in fig below.
- Some STBs have RCA port, where one end is connected to STB and the other end of the cable having two sets of AV connectors - connected to the corresponding Audio and Video ports of TV.



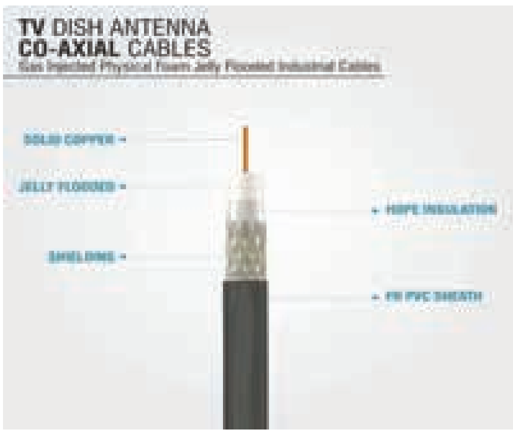




- If you are using HDMI:
  - Connect one end of the HDMI cable to the “HDMI OUT” port on the DTH set-top box and other end of the HDMI cable to HDMI port on the television.
- If you are using AV cables:
  - Connect the AV cables (red, white, and yellow) to the corresponding color-coded ports on the DTH set-top box.
  - Connect the other end of the AV cables to the matching ports on the television.

2 Connecting the Coaxial Cable

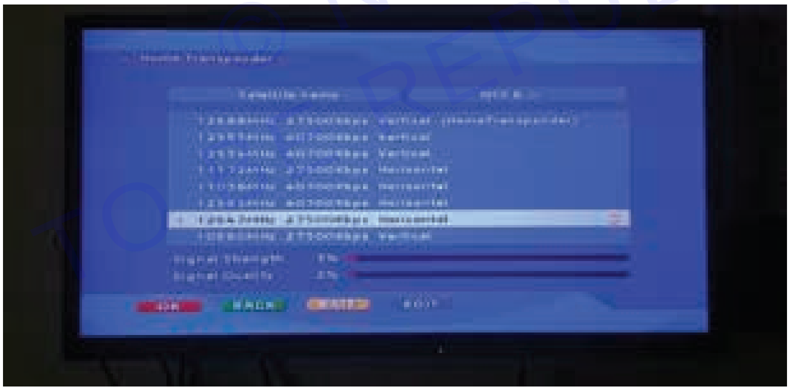
- Connect the coaxial cable from the satellite dish to the “LNB IN” or “SAT IN” port on the back of the DTH set-top box.



3 Powering Up

- Connect the power adapter to the DTH set-top box.
- Plug the power adapter into a power outlet.
- Power on the television and the DTH set-top box.

4 Initial Setup



- Follow the on-screen instructions on the TV to complete the initial setup process for the DTH system.
- This may include language selection, channel scanning, and activation.

5 Using the Remote Control

- Familiarize yourself with the remote control functions by the help of print text or icons on remote or via instruction manual.
- Use the remote control to navigate through channels, access the electronic program guide (EPG), and adjust settings.

6 I/O Ports on the Set-Top Box

- Explore the various I/O ports on the back or side of the set-top box. Common ports include:
  - **HDMI OUT:** Connects to the TV for high-definition video and audio.
  - **USB:** For connecting external storage devices or accessories (e.g., USB flash drives).
  - **Ethernet:** Allows for a wired internet connection (if supported).
  - **Audio/Video Out:** For connecting to older TVs using AV cables.
  - **Coaxial Out:** For connecting to audio systems or soundbars.
  - **Power:** Connects to the power adapter.

7 Accessing Settings and Features

- Use the set-top box menu to access settings such as display resolution, audio output, and parental controls.
- Explore additional features, such as video-on-demand, interactive services, and apps (if available).

8 Additional HDMI Ports on TV (if applicable)

- If your TV has multiple HDMI ports, explore connecting other devices (e.g., gaming consoles, Blu-ray players) to different HDMI ports on the TV.

9 Disconnecting

- Safely power off the DTH set-top box and the TV before disconnecting any cables.

Precautions

1. Mark ports to make it easier to identify and troubleshoot connections later.
2. Avoid using excessive force, as this can damage the connectors or the ports on the devices.
3. Ensure that the connectors and cables are appropriate for the specific I/O ports.

EXERCISE 117: Demonstrate the faults in STB & rectify

Objectives

At the end of this exercise you shall be able to

- identify the faults in the STB
- identify the different ways for rectification of faults in STB.

Requirements

Tools/ Equipments/ Instruments

- DTH Set-Top Box - 1 No.
- Television - 1 No.
- Remote control and batteries - 1 No.
- SAT meter - 1 No.

Materials/ Components

- HDMI Cable (or AV cables, depending on the available ports) - as reqd.
- Coaxial Cable (from the satellite dish) - as reqd.

Procedure

Fault 1: No Signal on TV

1 Scenario

- TV screen shows "No Signal" or is blank.

2 Rectification Steps

- Check the power supply to the set-top box and the TV.
- Verify that the satellite dish is properly aligned.
- Inspect the coaxial cable connection from the satellite dish to the set-top box.
- Ensure the HDMI or AV cable is securely connected to both the set-top box and the TV.

Fault 2: Poor Signal Quality

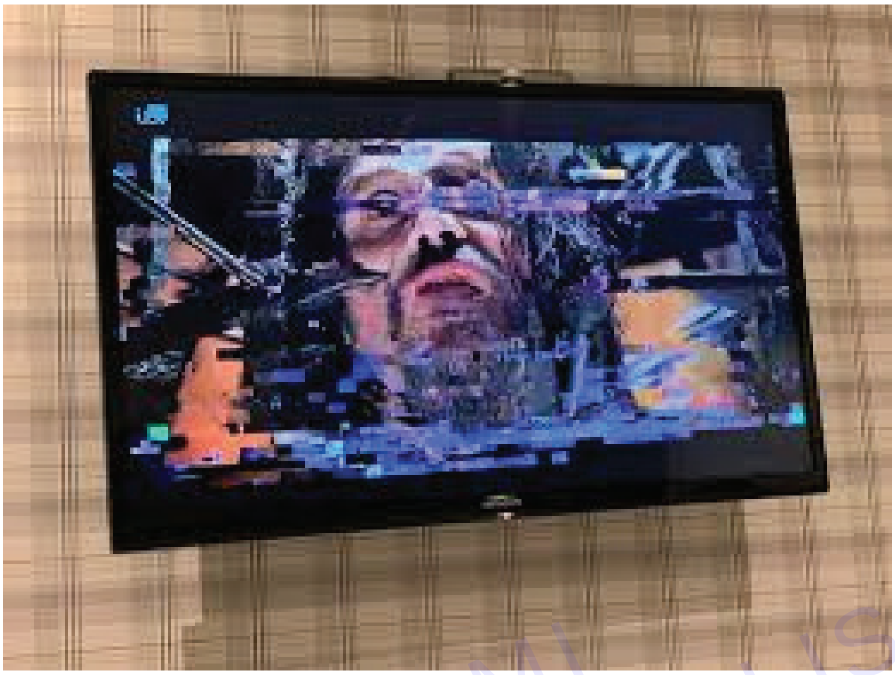
1 Scenario

- Channels are blurry, freezing, or showing a low signal quality.

2 Rectification Steps

- Use the signal strength/quality indicator on the TV screen or set-top box to assess signal strength.

- Recheck the alignment of the satellite dish using a SAT meter.
- Ensure there are no obstacles blocking the line of sight to the satellite.



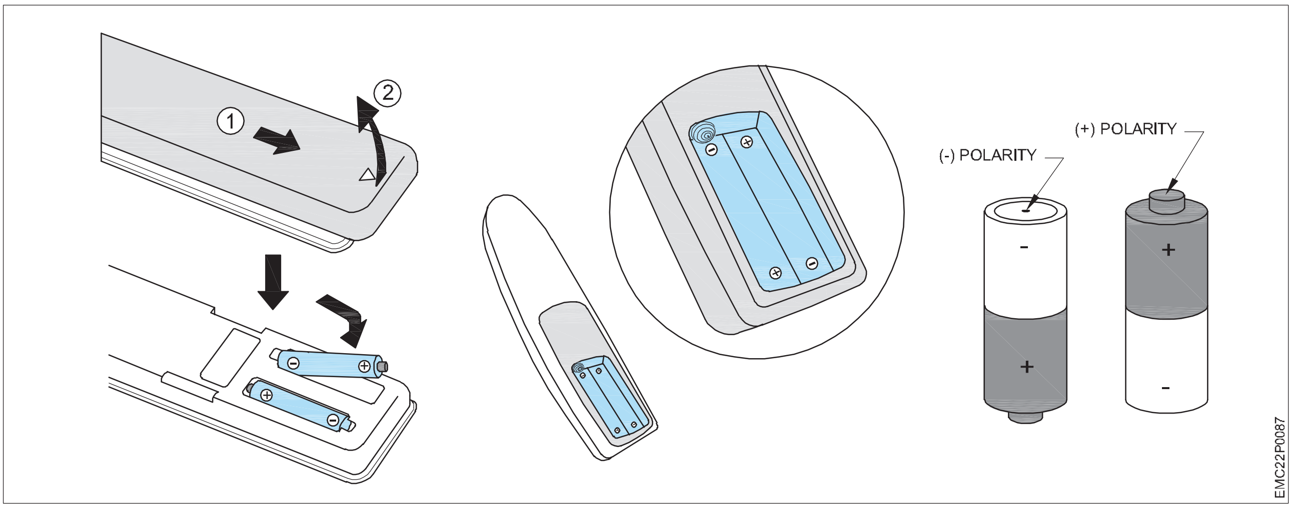
Fault 3: Missing Channels or No Audio/Video

1 **Scenario**
   - Some channels are missing, or there is no audio/video.

2 **Rectification Steps**
   - Verify that the subscription is active and payments are up-to-date.
   - Perform a channel scan on the set-top box to ensure all available channels are detected.
   - Check the audio and video cables for any damage or loose connections.

Fault 4: Remote Control Issues

1 **Scenario**
   - Remote control is not responding.



2 **Rectification Steps**

- Check the batteries in the remote control and replace them if necessary.
- Ensure there are no obstacles blocking the line of sight between the remote control and the set-top box.
- If available, try using the remote control of another compatible device or try with Cell phone to confirm faulty remote control.
- Repair remote control unit or replace it with new one.

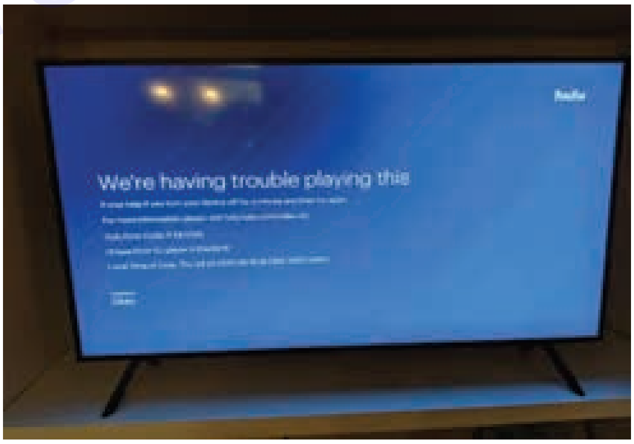
Fault 5: Internet Connectivity Issues (if applicable)

1 **Scenario**

- Unable to access internet-related features on the set-top box.

2 **Rectification Steps**

- Check the network settings on the set-top box.
- Verify the Wi-Fi password or Ethernet connection.
- Reboot the router and set-top box to refresh the network connection.



Fault 6: Error Messages on Screen

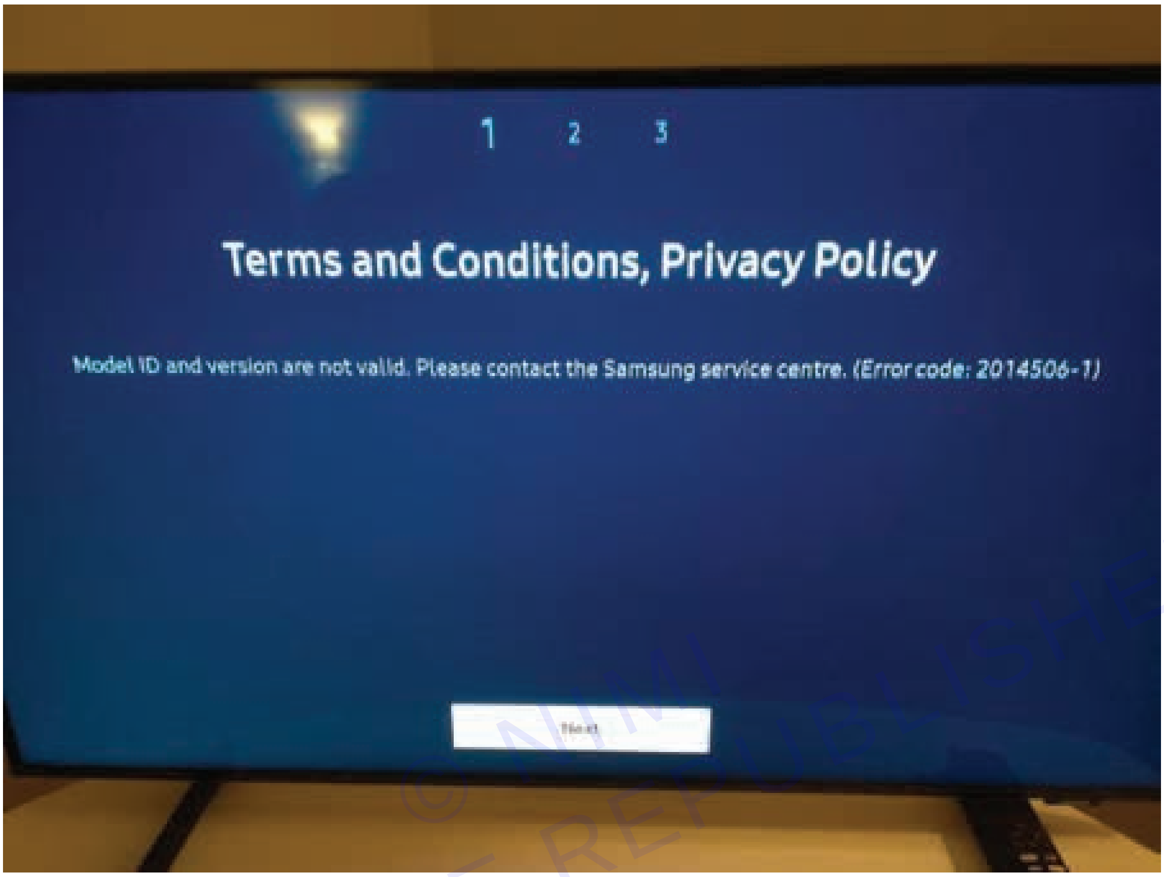
1 **Scenario**

- Error messages are displayed on the TV screen.

2 **Rectification Steps**

- Take note of the error messages and refer to the DTH user manual for resolving the issue.

- Perform a power cycle by turning off the set-top box, unplugging it, waiting for a few minutes, and then plugging it back again.



Instructions

1 Ensure that all external cables, such as HDMI or RCA, are securely connected to the STB and the TV.

2 While checking, trying to rectify the faults with internal components of STB without proper knowledge may cause irreversible damage.