Draft Study Material

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एन सी ई आर टी
NCERT

Field Technician – Air Conditioner

(Job Role)

(Qualification Pack: Ref. Id. ELE/Q3102)
Sector: Electronics

(Grade XII)

PSS CENTRAL INSTITUTE OF VOCATIONAL EDUCATION
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Shyamla Hills, Bhopal - 462 002, M.P., India

Preface

Vocational Education is a dynamic and evolving field, and ensuring that every student has access to quality learning materials is of paramount importance. The journey of the PSS Central Institute of Vocational Education (PSSCIVE) toward producing comprehensive and inclusive study material is rigorous and time-consuming, requiring thorough research, expert consultation, and publication by the National Council of Educational Research and Training (NCERT). However, the absence of finalized study material should not impede the educational progress of our students. In response to this necessity, we present the draft study material, a provisional yet comprehensive guide, designed to bridge the gap between teaching and learning, until the official version of the study material is made available by the NCERT. The draft study material provides a structured and accessible set of materials for teachers and students to utilize in the interim period. The content is aligned with the prescribed curriculum to ensure that students remain on track with their learning objectives.

The contents of the modules are curated to provide continuity in education and maintain the momentum of teaching-learning in vocational education. It encompasses essential concepts and skills aligned with the curriculum and educational standards. We extend our gratitude to the academicians, vocational educators, subject matter experts, industry experts, academic consultants, and all other people who contributed their expertise and insights to the creation of the draft study material.

Teachers are encouraged to use the draft modules of the study material as a guide and supplement their teaching with additional resources and activities that cater to their students' unique learning styles and needs. Collaboration and feedback are vital; therefore, we welcome suggestions for improvement, especially by the teachers, in improving upon the content of the study material.

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TABLE OF CONTENTS

Module 1 Repair and Maintenance of Air conditioner

Module Overview

In our home, an air conditioner is a basic household appliance. It runs for long periods during both day and night. Prolonged use can sometimes cause problems in the unit. When a failure occurs in the air conditioner, performing a fault diagnosis helps identify the issues. In this unit, we will learn how to identify faults in the air conditioner. After locating the fault, the faulty components are either replaced or repaired, and the unit is maintained. This is an important part of a corrective maintenance approach that can extend the life of the air conditioner. In this unit, we will discuss various common problems related to air conditioners, that are classified based on the different parts of the system.

To identify, replace, repair and maintain the faults, the technician needs many tools and equipment. Various tools and equipment required in fault identification, repairing and maintenance are explained in this unit. The filters, coils, and fins of an air conditioner must be maintained on a regular basis in order to ensure the effective and efficient functioning of the air conditioners over the years. When critical maintenance is neglected, air conditioning performance suffers and energy consumption rises. The most crucial maintenance activity for ensuring the air conditioner's efficiency is to change or clean its filters on a routine basis.

In a typical air conditioner, the condensing unit is usually located outside your house where the compressor, fan and condensing coils are located. When cooling your house, this unit rejects heat to the surrounding by blowing the fan over the condensing coils. Make sure that there are no obstructions to the fan and airflow of the condenser.

Learning Outcomes

After completing this module, you will be able to:

- Identify and use appropriate tools and equipment for the installation, maintenance, and repair of air conditioners safely and effectively.
- Recognize common faults in air conditioners and their potential causes to facilitate timely and effective repairs.
- Perform routine maintenance and systematic troubleshooting of air conditioners to ensure optimal performance and durability.

Module Structure

Session 1. Tools and Equipment

Session 2. Faults in Air-Conditioner

Session 3. Air Conditioner Maintenance & Troubleshooting

Session 1. Tools and Equipment

While cleaning the air conditioner, Adarsh saw that the door light of the air conditioner was not working. He immediately asked his father about the problem. His father brought some hand tools to replace the fused light bulb of the door. He then realized the use of common tools and equipment in household applications.

In our day-to-day life, we use common hand tools and measuring instruments for household tasks. These tools and instruments make our routine work easier. In our daily life, we also use various electrical and electronic gadgets, which require different types of tools for opening and repairing. Several tools and equipment are used for the installation of air conditioners, such as screwdrivers, phase testers, wire strippers, pliers, and many more. In this chapter, you will learn about and practice the use of basic tools and equipment. Some of the common hand tools and equipment are shown in Figure 1.1.

Fig. 1.1 Common hand tools and equipment

Testing Equipment

Testing an appliance is crucial. After testing the appliance under real-life parameters such as temperature, pressure, and more, it is launched in the market only if it meets all standards. However, over time, the performance of the appliance may decrease. To maintain its performance, the appliance should be regularly tested by a technician. Various test equipment is used by technicians for performance testing and repairing appliances. These tools and equipment are essential for monitoring, maintaining, and repairing air conditioners and their components. Some of the commonly used test equipment are explained in Table 1.

Table 1. Equipment used in the maintenance of air conditioner

Equipment	Image
Manifold Gauge - It is used to measure the pressure and temperature of air conditioner gas. It has two parts. The blue one is a compound gauge and red one is a pressure gauge (Figure 1.2). It is used in the repairing of the air conditioner. it measures the amount of pressure and temperature of refrigerant gas. The unit of pressure measurement is "psi".	 **Fig. 1.2 Manifold gauge**

Electronic Weighing Scale -

When the amount of refrigerant gas is not enough in the air conditioner then it is filled.

This refrigerant gas should be of a fixed amount. To get the fixed amount of refrigerant gas its weight is taken using an electronic weighing scale.

This weighing scale has a digital display, which gives the accurate amount of refrigerant gas. It is unit of measurement is gm/kg.

Fig. 1.3 Weighing machine

Electronic Vacuum Gauge -

It is a digital vacuum gauge, used to measure the amount of moisture content in the air conditioner pipe.

It indicates the moisture content in the pipe. It is unit of measurement is Micron.

Fig. 1.4 Electronic vacuum gauge

Vacuum Pump -

It is used to create pressure to suck the moisture content present in the pipe.

Pipes are used to filling the refrigerant gas these pipes are called flexible charging lines.

Fig. 1.5 Vacuum pump

Flexible Charging Line -

It is a durable pipe, used to connect the gauge valve at the time of measuring the pressure. These are durable and flexible to use.

Fig. 1.6 Flexible charging line

Clamp Meter -

It is a measuring instrument, used to measure the amount of current flowing in a wire.

Clamp meter can directly measure the amount of current flowing in a wire.

Its clamps are placed around the wire, and then automatically, it will measure the current value in a wire.

Fig. 1.7 Clamp meter

Temperature Meter -

High temperature of refrigerant can damage the refrigeration system.

It is an instrument used to measure the temperature of the refrigerant used in the refrigeration system. The unit of measurement of temperature is Celsius.

Fig. 1.8 Temperature meter

Let us learn, how to use this equipment in the practical activity 1.1.

Practical Activity 1.1 Demonstrate the use of a manifold gauge.

Material Required

Manifold gauge

Procedure

Step 1. Using a flexible charging line, connect the high-pressure side of the air conditioner's cooling line to the red port on the manifold gauge.

Step 2. Using a flexible charging line, connect the low-pressure side of the air conditioner's cooling line to the blue port on the manifold gauge.

Step 3. Attach a waste hose or vent hose to the center port of the manifold setup.

Step 4. Read the pressure of the refrigerant flowing through the refrigeration system.

We observed the manifold parts during Practical Activity 1.1. We learned that the manifold gauge includes a pressure gauge, which is used to measure the refrigerant pressure inside an air conditioner. Now, let's explore how to correctly read the pressure gauge on the manifold.

Practical Activity 1.2 Demonstrate the process of reading the pressure using pressure gauge.

Material Required

Manifold gauge, notepad.

Procedure

Step 1. Open the gauge and observe the internal parts of the gauge as shown in Figure 1.

Fig. 1

Step 1. Observe the indicator, stopper, and calibration screw of the gauge as shown in Figure 2.

Fig. 2

Step 3. On the white dial, the outer calibration scale measures the pressure in kg/cm^{2,} and the inner calibration scale of the pressure gauge measures the pressure in psi as shown in Figure 3.

Fig. 3

Step 4. On the dial, you can measure the pressure of the refrigerant gases such as R502, R22, and R12 respectively as shown in Figure 4.

Fig. 4

Practical Activity 1.3 To measure AC or DC using a clamp meter.

Material Required

Clamp meter, Electric wire.

Procedure

Step 1. Set the rotary selector on the clamp meter to the correct function and range as shown in Figure 1.

Fig. 1 Clamp meter

Step 2. Set the clamp meter to the voltage symbol "V" to read the voltage on the conductor. Connect the black probe to the COM jack and the red probe to the V/O jack as shown in Figure 2.

Fig. 2 Connect the black probe to the COM jack

Step 3. Push the trigger on the device to open the jaw. Clamp the device around the conductor and close it as shown in Figure 3, making sure that the electrical conductor is connected to a power source.

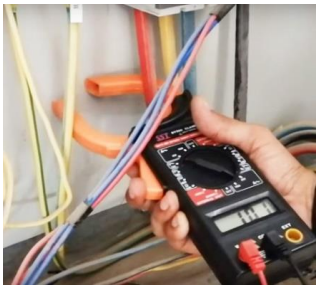


Fig. 3 Electrical conductor, connected to a power source

Step 4. Note the reading on the display of the clamp meter as shown in Figure 4.

Fig. 4 Reading on display in clamp meter

Tools

A tool is any instrument or a simple piece of equipment used to do a particular kind of work. Commonly used air conditioner tools are explained in Table 1.

Table 1. Tools used in the maintenance of air conditioner

Description of the Tools	Image
Copper Tube Cutter - It is a specialized pipe-cutting tool used to cut the copper pipe for tubing in the air conditioner as shown in Figure 1.9.	 **Fig. 1.9 Copper tube cutter**
Flaring Tool - It is used for air conditioner piping. It expands the opening of the pipe. It has a screw handle, which is used to tighten the copper tube. It is made up of aluminum. (Figure 1.10)	 **Fig. 1.10 Flaring oil**
Swagging Tool - It is a refrigeration tool used to expand the diameter of a copper tube. It is used to join two copper tubes of the same diameter. (Figure 1.11)	 **Fig. 1.11 Swagging tool**

Brazing Torch -

It permanently joins two metals.

It is used to extend the copper pipe in the refrigeration system.

Propane or butane torch gases are used in brazing. (Figure 1.12)

Fig. 1.12 Compact brazing torch

Adjustable Wrench -

It is a tool, which can be used to loosen or tighten a nut or bolt.

It has a jaw, to adjust. So, it is also called an adjustable spanner. (Figure 1.13)

Fig. 1.13 Adjustable wrench

Copper Tube Bender -

It is a copper tube bending tool used in air conditioners.

The copper tube is inserted into the tool to the required length, the lever is positioned over the tube, and the bend is created by bringing the two handles together as shown in Figure 1.14.

Fig. 1.14 Copper tube bender

Philip Screw Driver -

It is a screwdriver with a cross-driving end.

It is used to unfasten the Philip-type nut in the air conditioner as shown in Figure 1.15.

Fig. 1.15 Philip Screwdriver

Long Nose Plier -

It is a plier with a long-pointed nose.

It is useful for hard-to-reach areas like removing a clip from a fan or holding the copper tube while brazing as shown in Figure 1.16.

Fig. 1.16 Long nose plier

Slip Joint Plier -

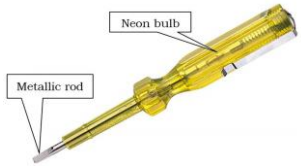
It is a mechanical plier used with a slip joint to adjust the size as shown in Figure 1.17.

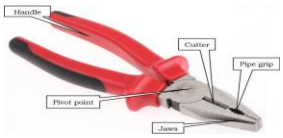
Fig. 1.17 Slip joint plier

Nut Drivers -

It is a handheld driver used to drive or remove hex nuts or bolts. It is mostly useful for reaching deep or hard-to-access places where hands cannot reach as shown in Figure 1.18.

Fig. 1.18 Nut driver

Box Wrench - It is a handheld box type wrench. It is used for assembling and disassembling mechanical parts. (Figure 1.19)	 **Fig. 1.19 Box wrench**
Open Wrench- It is useful to remove a machine bolt as shown in Figure 1.20.	 **Fig. 1.20 Open wrench**
Allen Key - It is a hand tool that helps you to fit and turn a hexagonal bolt/screw. It is also known as a hex key. (Figure 1.21)	 **Fig. 1.21 Allen key**
Flat File - It is a hand tool with two flat surfaces. It has a steel hand tool with small sharp teeth on some or all of its surfaces. It is used for smoothing wood or metal. (Figure 1.22)	 **Fig. 1.22 Flat file**
Round File - It is a hand tool, available in two forms half-round and full round surface. It has a steel hand tool with small sharp teeth on all of its surfaces. It is used for smoothing wood or metal. (Figure 1.23)	 **Fig. 1.23 Round file**
Phase Tester - It is a tool, used to identify or test the Phase/Live wire conductor. It is also called a Neon Screw Driver or Test Pin. (Figure 1.24)	 **Fig. 1.24 Phase tester**
Screwdriver - It is a hand tool; used to tighten and loosen the nuts in the air conditioner. (Figure 1.25)	 **Fig. 1.25 Parts of screwdriver**
Wire Stripper - It is a portable handheld tool used to remove the protective coating of an electric wire. (Figure 1.26)	 **Fig. 1.26 Wire stripper**

Combination Plier - It is used for cutting and gripping parts in the air conditioner as shown in Figure 1.27.	 **Fig. 1.27 Combination plier**
Tape Measure - It is used to measure the length in the workplace by the technician as shown in Figure 1.28.	 **Fig. 1.28 Measuring tape**
Electric Drill Gun - It is a hand tool used for making holes in the wall as shown in Figure 1.29.	 **Fig. 1.29 Electric drill machine**

Practical Activity 1.4 – Demonstrate to perform the flaring of copper tube.

Material Required – Copper tube, flaring clamp.

Procedure

Step 1. Consider a copper tube for flaring as shown in Figure 1.

Fig. 1 copper tube

Step 1. Take a flare nut; slide it over the copper tube with the threads facing the end of the tubing as shown in Figure 2.

Fig. 2 using flare nut with copper tube

Step 3. Take a flaring clamp, it has different sizes for tubes of different sizes as shown in Figure 3.

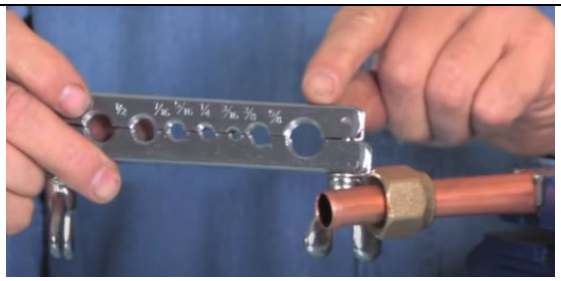


Fig. 3

Step 4. Take a clamp to attach it over the top of the tube. Leave some portion of the tube for flaring as shown in Figure 4.

Fig. 4

Step 5. Tighten the nuts of the clamp as shown in Figure 5.

Fig. 5

Step 6. Take a flaring cone to slide it over the tubing clamp. Tighten the flaring cone over the tube as shown in Figure 6.

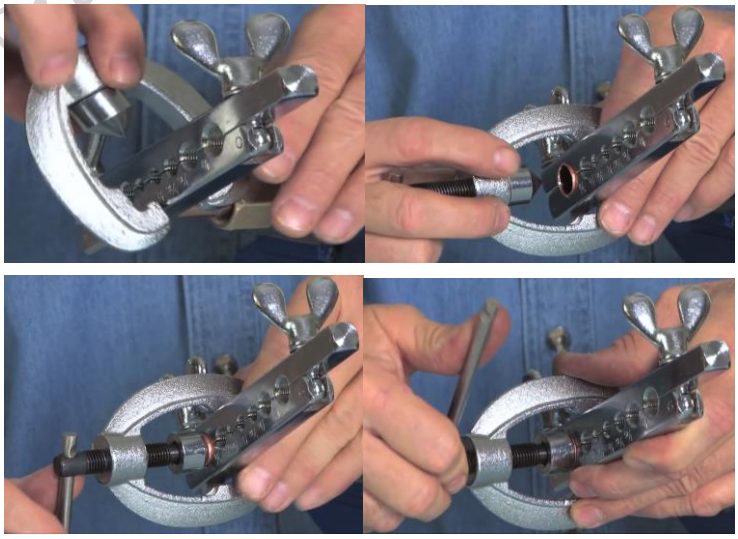


Fig. 6

Step 7. Loosen the flaring cone as shown in Figure 7.

Fig. 7

Step 8. Loosen the nuts of the tube clamp as shown in Figure 8.

Fig. 8

Step 9. Inspect for any leaks in the flaring.

Practical Activity 1.5 – To demonstrate the use of a brazing torch.

Material Required – Brazing torch, metal.

Procedure

Step 1. Use the wire brush to scuff the surface of the metal. Then clean the surfaces using soapy water.

Step 1. Position the metal as desired. In most cases, an overlapped joint will be stronger and braze together easier than a gapped joint.

Step 3. Heat the joint where the two pieces of metal will meet until the joint glows.

Step 4. Apply the brazing rod to the joint while continuing to heat the metal surfaces.

Step 5. After brazing, use a wire brush to clean the brazed surface to remove any oxidation or residue.

Practical Activity 1.6 – To demonstrate the use of an adjustable wrench.

Material Required – Adjustable wrench.

Procedure

Step 1. Identify the nut or bolt you want to tighten.

Step 1. Open the adjustable wrench by turning the screw mechanism. This will open the jaw of the wrench.

Step 3. Check if you opened it enough for the nut to fit in, or if it needs to be opened more. Make sure it is open a bit more than the size of the nut.

Step 4. Slip the open jaw over the nut and hold it in place. Turn the screw mechanism so that it clamps tightly around the nut.

Step 5. Turn the wrench in a clockwise direction to tighten it, or counter-clockwise to loosen it. Keep on turning it, until the nut is tight or loose enough to remove.

Step 6. Remove the wrench by loosening the screw mechanism.

CHECK YOUR PROGRESS

A. Multiple choice questions

1. Which of the following parameter is measured using the Manifold Gauge? (a) Pressure (b) Volume (c) Temperature (d) Area
2. Electronic Vacuum Gauge precisely measures _____in the pipe. (a) Moisture (b) Water (c) Air (d) Refrigerant gas
3. The following figure 1.30 depicts  *Fig. 1.30* (a) Vacuum pump (b) Temperature meter (c) Copper tube cutter (d) Flexible charging line
4. Flaring tool is made of _____which is lightweight and easy to use, making it easy to carry. (a) Aluminium (b) Copper (c) Brass (d) Nickel
5. Adjustable Wrench is also called an adjustable. (a) Plier (b) spanner (c) pipe (d) rod
6. Allen Key is also known as a _____key. (a) Hex (b) Oct (c) pointed (d) dec
7. What is used to cut the copper pipe for tubing? (a) Copper Tube Cutter (b) Aluminium tube cutter (c) Iron rod cutter (d) Glass rod cutter.
8. Flat File is a hand tool with (a) two flat surfaces (b) two round surfaces (c) round surfaces (d) oval surfaces
9. Which of the following hand tool is used to make a hole on the wall? (a) Plier (b) Screwdriver (c) Wrench (d) Drill machine
10. Which of the following tool is issued to then the power supply? (a) Round File (b) Phase tester (c) Wrench (d) Flaring tool

B. Fill in the blanks

1. In the repairing and maintenance of the air conditioner, a weighing machine is used to _____the volume of gas, which is to be filled in the air conditioner.
2. Electronic Vacuum Gauge is a _____ vacuum gauge.
3. Vacuum Pump is used to suck the moisture content present in the___.
4. Flexible Charging Line is the durable pipe, which is used to connect the _____at the time of measuring the pressure.
5. Clamp Meter is a measuring instrument, used to measure the amount of _____flowing in a wire.
6. Temperature Meter is an instrument used to measure the temperature of the _____used in the refrigeration system.
7. Copper Tube Cutter is a specialized pipe-cutting tool, which is available in many shapes and sizes. It is use to cut the copper pipe for_____.
8. Flaring Tool is a tool used for air conditioner _____.
9. Brazing Torch permanently joins _____ metals.

10. Combination plier can use for ____ and ____.

C. State whether the following statements are True or False

1. Manifold Gauge is a device, which has two parts blue one is the compound gauge and second red one is the pressure gauge.
2. In the repairing and maintenance of the air conditioner, a weighing machine is used to measure the volume of water, which is to be filled in the air conditioner.
3. Electronic Vacuum Gauge precisely measures the moisture content in the pipe. It indicates the moisture content in the pipe.
4. Vacuum Pump is used to suck the moisture content present in the condenser.
5. Flexible Charging Line is a durable pipe, used to connect the gauge valve at the time of measuring the pressure.
6. Clamp meter can directly measure the amount of current flowing in a wire. Its clamps are placed around the wire, and then automatically, it will measure the current value in a wire.
7. Temperature meter is an instrument used to measure the temperature of the refrigerant used in the refrigeration system.
8. Copper Tube Cutter is used to cut the aluminum pipe for tubing.
9. You can use a propane or butane torch to braze most metals to join.
10. Adjustable Wrench is also called an adjustable spanner.

D. Short answer questions

1. What is the use of the manifold gauge?
2. Demonstrate the way to read the pressure gauge?
3. What is the use of the electronic weighing scale?
4. What is the use of the Electronic Vacuum Gauge?
5. What is the role of the clamp meter?
6. Demonstrate the method to use flaring tubes?
7. What is the difference between the flat file and round file?
8. What are the main parts of a typical phase or line tester?
9. What is the use of a wire stripper?
10. How adjustable wrench can be used in the fittings?

Session 2. Faults in Air-Conditioner

Kriti bought a new air conditioner. His specialist recommended that the air conditioner parts be serviced regularly. This service includes cleaning the inner and outer body, internal components, and maintaining the compressor. Regular maintenance extends the equipment's lifespan. Since the air conditioner is used throughout the year and consumes a significant portion of the home's electricity, it must be serviced regularly. Regular servicing is important as it helps the air conditioner last longer and function more efficiently.

The air conditioner is one of the necessities in daily life for temperature control. It creates a cool environment during the hot summer and a warm one during the winter. It makes people feel comfortable by providing cool air in summer and warmth in winter. Additionally, it purifies the air and removes moisture from the room. Prolonged use of the air conditioner leads to the need for repairs and maintenance. A user must perform proper maintenance and repairs regularly. In this chapter, you will learn about preventative maintenance and repair procedures for different parts of an air conditioner, fault detection, disassembly, and identification of air conditioner components.

Preventative Maintenance of Air Conditioner

In our daily lives, we use air conditioners to regulate the room temperature in homes and offices. Maintaining this temperature requires a significant amount of electricity. However, preventive maintenance can extend the lifespan of an air conditioner. Maintenance includes cleaning both the exterior and interior components, with each part being inspected for proper functionality. Regular checking and care of the air conditioner's external and internal parts are essential. During maintenance, it is important to follow the correct procedures for cleaning and upkeep.

There are two types of air conditioners commonly used in homes: window ACs and split ACs. While they have different shapes and designs, both operate on the same refrigeration cycle. In this chapter, we will discuss the maintenance of these ACs separately. First, we will focus on the maintenance of split air conditioners.

The split air conditioner has two working units, i.e., indoor unit and an outdoor unit. To understand what the internal and external unit looks like, refer to Figure 2.1.

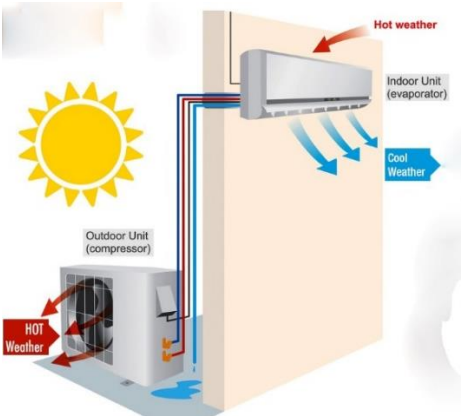


Fig. 2.1 Setup showing the indoor and outdoor unit of split AC conditioner

The copper pipe goes from the evaporator to the indoor to the outside of the compressor and from the outside of the compressor to the inside of the evaporator. The internal and external unit shown in Figure 2.2 and 2.3 need to be maintained.

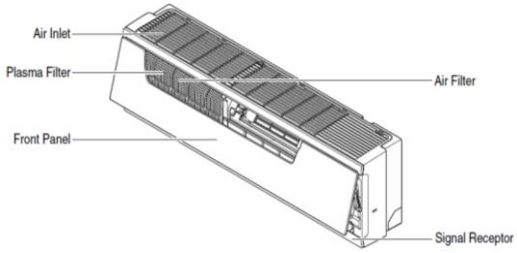


Fig.2.2 Indoor unit of split AC

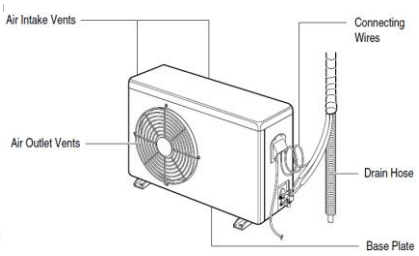


Fig.2.3 Outdoor unit of split AC

This symbol alerts you to the risk of electric shock.

This symbol alerts to hazards that may cause harm to the air conditioner

Several key points are important to ensure the proper maintenance of a split air conditioner. Regular cleaning is crucial for the unit to run smoothly and efficiently. Ideally, this maintenance should be carried out every quarter, or at the very least, twice a year. To keep the split air conditioner in optimal condition, certain components must be regularly cleaned and checked. The following activities outline the specific tasks involved in maintaining the unit.

First, let's focus on the outer body of the indoor unit. The outer casing is typically made from lightweight materials, such as plastic and other non-traditional substances, which help reduce the weight and overall cost of the unit. Although this external shell does not affect the cooling performance directly, keeping it clean is essential for both aesthetic and functional purposes.

Dust and dirt can accumulate on the outer body over time, which could affect the air quality and efficiency of the air conditioner. To maintain it, begin by wiping down the exterior surface with a clean, dry cloth to remove any dust. For more stubborn dirt or stains, use a damp cloth with mild soap. Be cautious not to use harsh chemicals that could damage the material. Ensure the air vents are clear of any obstructions that might block airflow.

After cleaning, inspect the casing for any cracks or damage, as this could affect the overall durability of the unit. By maintaining the outer body of the indoor unit, you must ensure that the split air conditioner continues to operate effectively while maintaining its longevity and appearance.

Practical Activity 2.1 Demonstrate to clean the outer plastic shell of the indoor unit.

Material Required

Hand gloves, Soap solution, soft cloth.

Procedure

Step 1. First, wear gloves for hand protection.

Step 2. Prepare a mild soap solution.

Step 3. Using a soft cloth and dip in the soap water, gently clean the outer body of the air conditioner.

Next, let's focus on the filter of the indoor unit, which plays a crucial role in maintaining the air quality inside the room. The filter is responsible for drawing in the room's air, removing dust, dirt, and other particles before circulating clean, filtered air back into the room. Over time, these particles can accumulate on the filter, reducing its effectiveness and the overall efficiency of the air conditioner.

Practical Activity 2.2 Demonstrate to clean the filter/dust filter of the indoor unit.

Material Required

Hand gloves, soap solution, soft cloth, brush

Procedure

Step 1. Wear hand gloves for protection.

Step 2. Disconnect the power supply and open the front panel over the position where it stops. (Figure 2.4)

Fig. 2.4 Open the front panel of the air conditioner

Step 3. Slightly push up the centre knob of the air filter and release the hooks. Pull out the air filter downward and remove it. (Figure 25 (a) & (b)

Fig. 2.5 (a) Unlocking the first filter (b) Unlocking the second filter

Step 4. Prepare a soap solution. Apply and clean the filters using a brush. Use a soft cloth to wipe the water. Use a dryer or keep it in the sun. Once it gets dried, place it in the indoor unit. (Figure. 2.6)

Fig. 2.6 Removing and cleaning the filter of split AC

Next, clean the evaporator fins. The evaporator is a part of the AC, which takes all the hot air from the room. And pass it to the condenser via a compressor. In this way, it cools the room. Now, we'll see the steps to clean the fins of the condenser.

Practical Activity 2.3 Demonstrate to clean the evaporator fins of the indoor unit.

Material Required

Hand gloves, soap solution, soft cloth.

Procedure

Step 1. Disconnect the power supply and open the front panel over the position where it stops. (Figure. 2.7)

Fig. 2.7 Open the front panel of the air conditioner

Step 2. Slightly push up the centre knob of the air filter and release the hooks. Pull out the air filter downward and remove it. (Figure. 2.8)

Fig. 2.8 Unlocking the filter

Step 3. Slide the right rotary shaft to the left and release it. (Figure 2.9)

Fig. 2.9 Sliding the right rotary shaft

Step 4. Slide the left rotary shaft to the right side and release it. (Figure 2.10)

Fig. 2.10 Sliding the left rotary shaft

Step 5. Unfasten the centre shaft while bending the horizontal blade slightly. (Figure 2.11)

Fig. 2.11 Unfasten the centre shaft

Step 6. Unfasten the left shaft. (Figure 2.12)

Fig.2.12 Unfasten the left shaft

Step 7. Unfasten the right shaft as shown in Figure 2.13.

Fig. 2.13 Unfasten the right shaft

Step 8. Remove the two screws as shown in Figure 2.14.

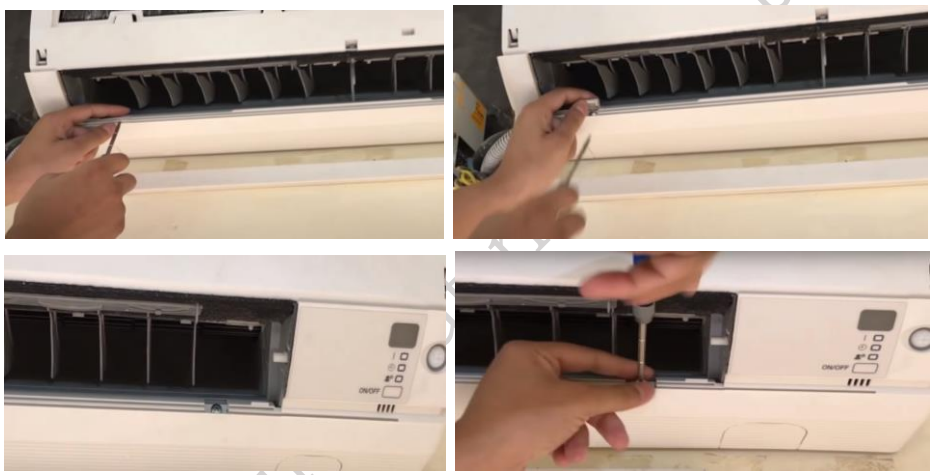


Fig. 2.14 Remove the two screws

Step 9. Unfasten the three hooks at the top as shown in Figure 2.15.

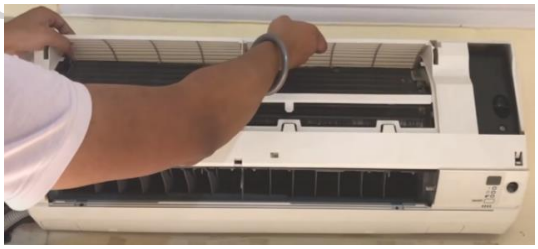


Fig. 2.15 Unfasten the three hooks at the top

Step 10. Pull the upper part of the front grille out and lift the lower part, and then remove the front grille Figure 2.16.

Fig.2.16 Pull the upper part

Step 11. Clean the coil fins using a brush. Then apply cleaning foam on the coil fins of the evaporator. Be sure the foam evenly covers the entire surface. Due to its self-rinsing formula, it cleans all the dirt of the fins. (Figure 2.17)

Fig. 2.17 Applying foam onto the evaporator fins

Step 12. Wait for about 15 minutes and then wipe the fins using cloth as shown in Figure 2.18.

Fig. 2.18 Cleaned fins of the condenser

Step 13. Repeat the reverse procedure to reassemble the parts.

Next, let's focus on the air blower of the indoor unit. The air blower is a motor-driven fan responsible for pushing the cooled or heated air through the louver panel into the room, ensuring a continuous flow of fresh air. Over time, dust and debris can accumulate on the blower, reducing airflow and decreasing the overall efficiency of the air conditioner. Regular cleaning of the air blower is essential to maintain optimal performance.

Practical Activity 2.4 Clean the blower fan of the indoor unit.

Material Required

Soap solution, soft cloth, brush, screwdriver

Procedure

Step 1. Disconnect the power supply and open the front panel over the position where it stops as shown in Figure 2.19.

Fig. 2.19 Open the front panel of the air conditioner

Step 2. Slightly push up the centre knob of the air filter and release the hooks. Pull out the air filter downward and remove it as shown in Figure 2.20.

Fig. 2.20 Unlocking the filter

Step 3. Slide the right rotary shaft to the left and release it as shown in Figure 2.21.

Fig. 2.21 Sliding the right rotary shaft

Step 4. Slide the left rotary shaft to the right and release it as shown in Figure 2.22.

Fig. 2.22 Sliding the left rotary shaft

Step 5. Unfasten the centre shaft while bending the horizontal blade slightly as shown in Figure 2.23.

Fig. 2.23 unfasten the centre shaft

Step 6. Unfasten the left shaft as shown in Figure 2.24.

Fig. 2.24 Unfasten the left shaft

Step 7. Unfasten the right shaft as shown in Figure 2.25.

Fig. 2.25 Unfasten the right shaft

Step 8. Remove the two screws as shown in Figure 2.26.

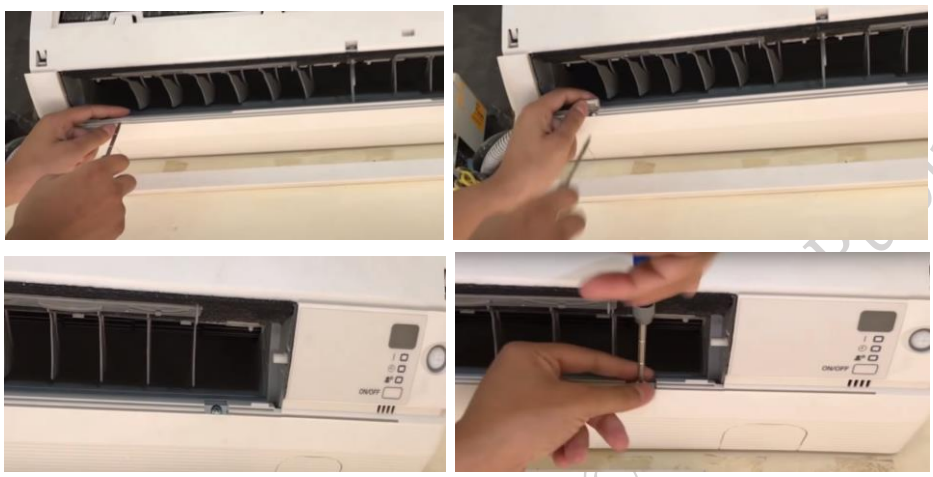


Fig. 2.26 Removing the screws

Step 9. Unfasten the three hooks at the top as shown in Figure 2.27.

Fig. 2.27 Unfasten the three hooks

Step 10. Pull the upper part of the front grille out and lift the lower part, and then remove the front grille as shown in Figure 2.28.

Fig. 2.28 Pull the upper part

Step 12. Unscrew the aircon tray of the indoor unit as shown in Figure 2.29.

Fig. 2.29 Unscrew the aircon tray of the indoor unit

Step 12. Remove the tray of the indoor unit as shown in Figure 2.30. Unscrew the blower fan of the indoor unit.

Fig. 2.30 Remove the tray of the indoor unit

Step 13. Carefully remove the blower from the indoor unit as shown in Figure 2.31. Clean the air blower blades using water. Using a soft cloth clean the area in which the air blower was fixed. Leave the blower for 15 minutes to get dry. Once it gets dry, connect it to the indoor unit.

Fig. 2.31 Removing the blower from the indoor unit

Next, let's focus on the air louver of the indoor unit. The air louver is responsible for directing the airflow coming from the air blower. It consists of both vertical and horizontal swing blades, which allow users to adjust the direction of the airflow to meet their specific needs, whether it's to cool different areas of the room or achieve uniform air distribution.

Over time, dust and dirt can accumulate on the air louver, which may obstruct airflow and reduce the efficiency of the air conditioner. Regular cleaning is essential to ensure proper functioning. Now, let's look at how to clean the air louver

Practical Activity 2.5 Clean the air louver of the indoor unit.

Material Required

Soap solution, soft cloth, brush.

Procedure

Step 1. Disconnect the power supply and open the front panel over the position where it stops as shown in Figure 2.32.

Fig. 2.32 Open the front panel of the air conditioner

Step 2. Slightly push up the centre knob of the air filter and release the hooks. Pull out the air filter downward and remove it as shown in Figure 2.33.

Fig. 2.33 Unlocking the filter

Step 3. Slide the right rotary shaft to the left and release it as shown in Figure 2.34.

Fig. 2.34 Sliding the right rotary shaft

Step 4. Slide the left rotary shaft to the right and release it as shown in Figure 2.35.

Fig. 2.35 Sliding the left rotary shaft

Step 5. Unfasten the centre shaft while bending the horizontal blade slightly as shown in Figure 2.36.

Fig. 2.36 Unfasten the centre shaft

Step 6. Carefully, unfasten the left shaft as shown in Figure 2.37.

Fig. 2.37 Unfasten the left shaft

Step 7. Unfasten the right shaft as shown in Figure 2.38.

Fig. 2.38 Unfasten the right shaft

Step 8. Remove the louvre of the indoor unit carefully as shown in Figure 2.39.

Fig. 2.39 Removing the louvre of the indoor unit

Step 9. Use a soft cloth to clean an air louver portion of the indoor unit.

Secondly, we'll look at the outer body of the outdoor unit. It is a frame made up of metal. This will make it durable for the outdoor environment. Now, we'll see how to maintain and clean the outer body of the outdoor unit.

Practical Activity 2.6 Demonstrate the cleaning process of split air conditioner outdoor unit.

Material Required

Screwdriver, soft cloth.

Procedure

Step 2. Before cleaning, be sure to stop the operation and turn off the circuit breaker.

Step 2. Remove the screw of the top panel as shown in Figure 2.40. Then lift the top panel as shown in Figure 2.41.

Fig. 2.40 Removing the screw of the top panel

Fig. 2.41 Lifting the top panel

Step 3. Remove the four screws and then remove the discharging grille as shown in Figure 2.42.

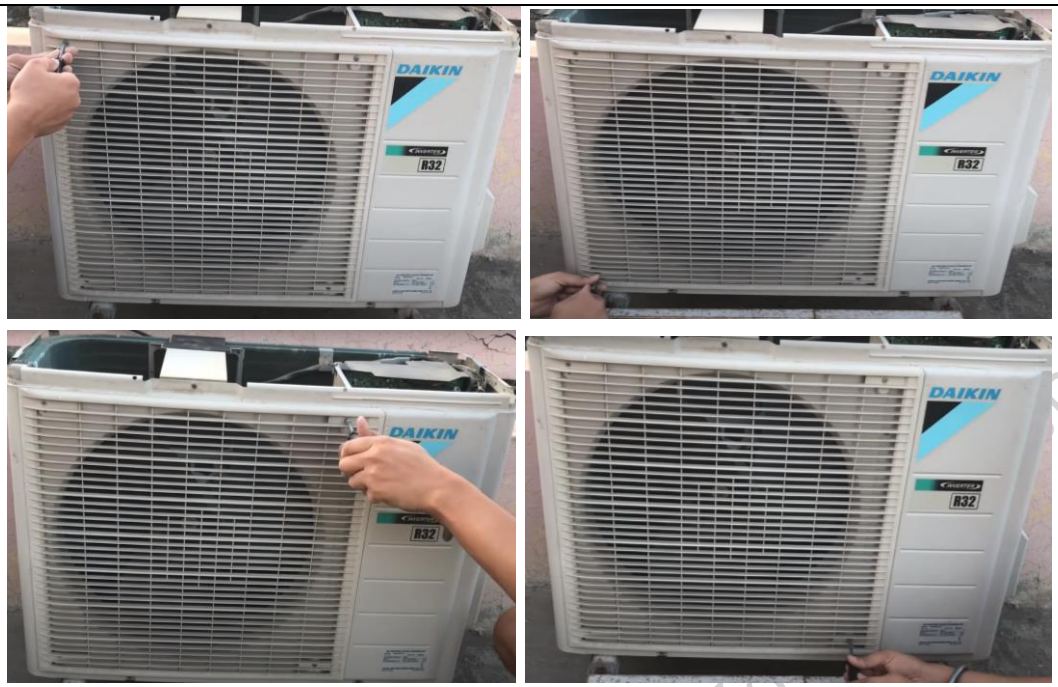


Fig. 2.42 Remove the screws and discharging grille

Step 4. Unlock the four hooks of the discharge grille and remove the discharge grille as shown in Figure 2.43.

Fig.2.43 Unlock the hooks of the discharge grille and remove the discharge grille

Step 5. Remove the screw of the front panel as shown in Figure 2.44.

Fig. 2.44 Removing the screw of the front panel

Step 6. The front panel has four hooks. Unfasten the hooks. Pull and remove the front panel as shown in Figure 2.45.

Fig. 2.45 Unfasten the hooks, pull and remove the front panel

Note: For cleaning, do not use hot water.

Step 7. Use a blower or brush to clean the outdoor unit as shown in Figure 2.46.

Fig. 2.46 Cleaning the outdoor unit

Step 8. Wash the front panel using water as shown in Figure 2.47.

Fig.2.47 Washing the front panel

Step 9. Now, repeat the same procedure in reverse to reassemble the outdoor unit's front panel, top panel, and grille.

Until now, you have learned how to maintain the indoor and outdoor units of a split air conditioner. Next, we will look at the maintenance of a window air conditioner.

Practical Activity 2.7 Demonstrate the cleaning process of the window air conditioner.

Material Required

Window air conditioner, cleaning brush

Procedure

Step 1. First, remove the front grille of the window AC. By pushing the unlock buttons as shown in Figure 2.48.

Fig. 2.48 Removing the front grille of the window AC

Step 2. Slightly move the grille to the left to detach it from the unit as shown in Figure 2.49.

Fig. 2.49 moving the grille

Step 3. Remove the filter of the unit by pushing it as shown in Figure 2.50.

Fig. 2.50 Remove the filter

Step 5. Carefully detach the front panel of the window air conditioner. If you find the screws carefully, unfasten them as shown in Figure 2.51.

Fig. 2.51 Detach the front panel

Step 6. Carefully, remove the PCB wires from the front panel of the window AC as shown in Figure 2.52.

Fig. 2.52 Remove the PCB wires

Step 7. While detaching the coupler, do not hold it using a wire and use the plastic part of the coupler to take out the connection from the front panel of the window AC as shown in Figure 2.53.

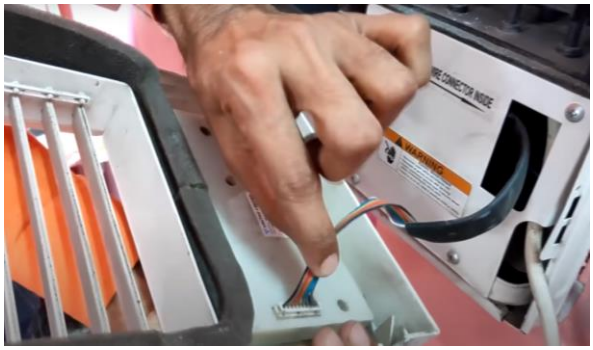


Fig. 2.53 Detaching the coupler

Step 8. Carefully remove the temperature sensor of the window AC as shown in Figure 2.54.

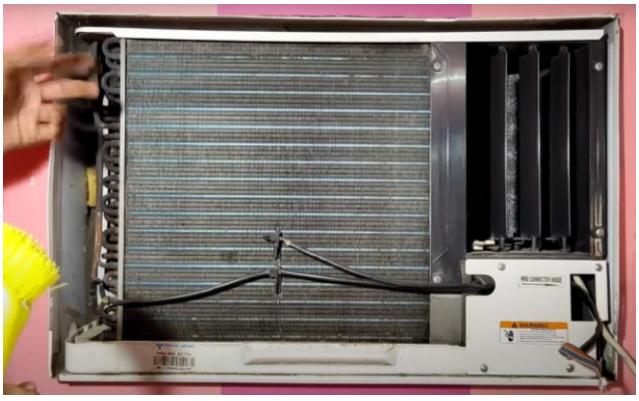


Fig. 2.54 Remove the temperature sensor

Step 9. Take a brush to dip it in a mug filled with water as shown in Figure 2.55. Gently clean the fins of the evaporator coil as shown in Figure 2.56.

Fig. 2.55 Dip the brush in mug

Fig. 2.56 Clean the fins

Step 10. Take a wet soft cloth use it to clean the dust around the window AC outside strip, clean the temperature sensor as shown in Figure 2.57.

Fig. 2.57 Clean the temperature sensor

Step 12. Take the filter and wash it with water. If it is too much dirty then use detergent and a soft brush as shown in Figure 2.58.

Fig. 2.58 Wash the filter with water

Step 12. Carefully wash the front grille as shown in Figure 2.59.

Fig. 2.59 Wash the front grille

Step 13. As the front panel has PCB (Printed Circuit Board), do not use the water pipe to wash it. Take a wet soft cloth to clean the front panel of the window AC as shown in Figure 2.60.

Fig. 2.60 Clean the front panel of the window AC

Step 14. Now we have cleaned the various parts of the front portion of the window AC as shown in Figure 2.61. Keep them for 15-30 min to get dry.

Fig.2.61 Dry the front panel of AC

Step 15. Repeat the same reverse process to reassemble the window AC.

Cleaning the condenser and rear part of a window air conditioner can be challenging and risky since it is mounted in the window. It is advisable to clean the back of the window AC only if it is easily accessible. If it is not feasible to reach the back safely, consider seeking professional assistance for cleaning and maintenance.

Fault finding in the Air conditioner

An air conditioner is a complex machine used to maintain the temperature of rooms. Multinational companies have facilities called data centres, where multiple motherboards are installed in large racks to store and manage data. A combination of these motherboards is referred to as servers. These servers run continuously and generate a significant amount of heat. To maintain the temperature of the data centres, numerous air conditioners operate day and night. Due to the rigorous use of air conditioners, they may develop issues such as cooling problems, faulty wiring, sparking from the socket, and drain blockages. In such cases, repairs are necessary. Any fault or even a small technical problem in the air conditioners can cause major disturbances in daily life. Therefore, technicians should possess skilled knowledge for repairing the air conditioners. They should be able to locate the faults in the unit. After determining the problem, the technician should fix it correctly. Incorrect fault identification can lead to further damage to the air conditioner. (Figure 2.62)

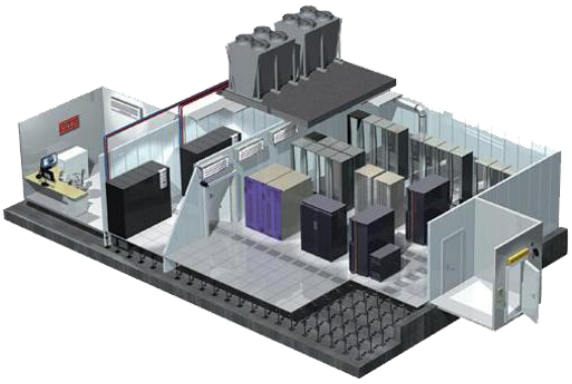


Fig. 2.62 Air conditioning system in the datacentre

The steps to identify the faults in air conditioners are:

a) Understanding the symptoms and identifying the fault

b) The faulty part is replaced or repaired

c) The functionality of the repaired unit is checked

d) Productivity and quality are achieved

As the average lifespan of an air conditioner is around 13 years. It is important to have timely servicing and repair. If servicing is maintained from time to time, a greater lifespan of the appliance can be achieved and its sudden breakdown or problems can be avoided.

Initial Identification of Fault by Customer Interaction

It is the first step to the customer site. The technician should serve the consumer graciously. Some of the following points should be followed by the technician while interacting with the customers.

a) Fault Diagnosis: Fault diagnosis is the process of identifying a fault when a failure occurs. Therefore, it is a necessary step before starting repairs on air conditioner parts. Technicians should strive to diagnose faults in home appliances.

b) Methods of Diagnosis: Fault diagnosis can be performed by detecting symptoms, applying relevant knowledge, and analyzing test results.

c) Accurate Diagnosis: An accurate diagnosis of faults can be achieved by receiving information through sensors. This information is processed using advanced signal processing algorithms, which provide the necessary features for efficient classification or identification of defects.

d) Defect Identification: Identifying defects and taking subsequent remedial actions can enhance productivity and reduce maintenance costs in various industrial applications. This process of issuing the report comprises four stages namely *(1) Identification (2) Location (3) Evaluation (4) Estimation*

Identification **–** It defines the cause of the malfunction in the system. This can be done by analyzing the fault in the system.

Location **–** It defines the fault location in the system. As the system is large report defines the fault location, which will help the technician to repair the fault.

Evaluation **–** It is done to analyze the associated fault, which can occur because of the current fault.

Estimation **–** It defines the life span of the faulty part of the system.

Initial Inspection

Inspection of the appliances is useful for understanding how common household appliance's function. This gives the technician an understanding of the normal operation controls. The correct function of the equipment can be determined by a comprehensive inspection. Hence, qualified professionals are hired in case of any apparent deficiencies. The correct inspection report of the equipment has the following points, which needs to be remembered:

- Inoperative working of the air-conditioner.
- Exterior or interior of the cabinet or components are damaged.
- Exterior or interior of the cabinet or components are rusted.
- Burnt components in the Printed Circuit Board.
- Unusual sounds or vibrations in the unit.
- Coils are dirty or damaged.

Technician do the following documentation:

- Style: _____
- Make: _____
- Model: _____
- Manufacturer: _____

- Year Manufactured: _____

History of the Problem – When the customer informs the technician about a problem with the air conditioner, the technician should investigate the cause of the issue. They should ask the customer about the appliance's history and check the air conditioners back worksheet, which contains a record of replaced parts and all the warranty details. This information will help identify the weak components of the machine and understand the actual cause of the equipment or part failure. The technician can also verbally inquire about any problems the customer has faced in the past, as this will provide additional insight into the faults in the air conditioner.

Age of the Appliance – It also places an important role in the performance of the air conditioner. It is a real fact that as the age of the device decreases, its performance automatically starts degrading. Therefore, a technician needs to know the age of the equipment before it reaches the repair side.

Electrical Operation – An air conditioner is a device that is connected via a cord and plug. Before moving the air conditioner, inspect the electrical cord and wall socket for any signs of damage or incorrect installation. The power socket should be easily accessible and located near the appliance to avoid physical damage to the flexible cord. The air conditioner's flexible cord must be properly terminated with a grounding-type attachment plug, as shown in Figure 2.63.

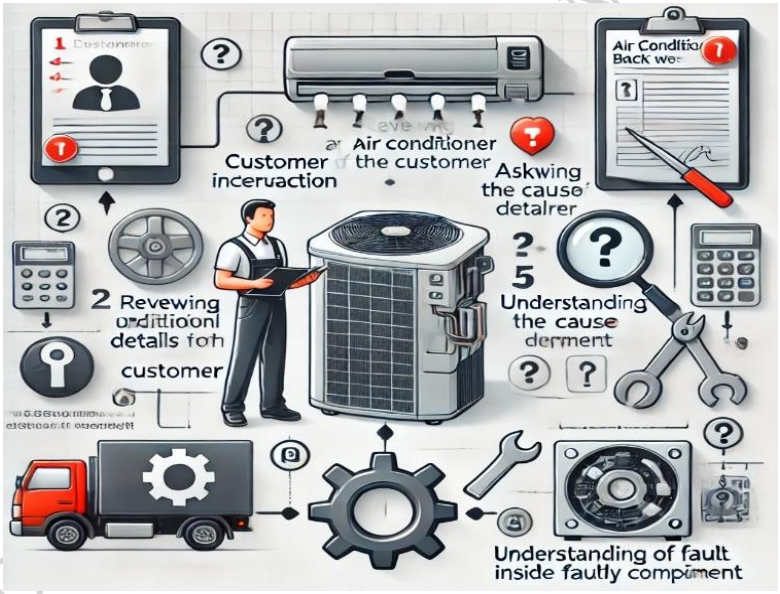


Fig. 2.63 Electrical connections and operations

Air Conditioner Component Check

All the components of the air conditioner should be checked individually. This requires correct knowledge and skills to inspect each component.

Overload Protector (OLP) **–** The overload protector is a useful tool designed to protect the compressor of the air conditioner. When the user operates the air conditioner for an extended period, the compressor's motor can overheat. The overload protector helps prevent the motor from burning out by cutting off the power supply when necessary, thereby protecting the motor from high currents.

It features three terminals, labelled 1, 2, and 3, as shown in Figure 2.64. If the bimetallic plate is removed, it will be observed that terminals 2 and 3 are internally connected through a coil.

Fig. 2.64 (a) Terminals of Overload protector (b) Bimetallic plate in the OLP

Let us now understand the procedure to test the overload protector.

Practical activities 2.10 Demonstrate the testing of overload protectors.

Material Required

Overload protector, Multimeter, Screwdriver.

Procedure

Step 1. Take an OLP to place it on the flat surface or table.

Step 2. Take multimeter turn ON it, and turn its knob to continuity mode of a multimeter as shown in Figure 2.65.

Fig. 2.65

Step 3. Insert the probes of multimeter in the respective slots i.e., 'com' slot and 'Volt (V)' slot as shown in Figure 2.66.

Fig. 2.66

Step 4. Take both the probes touch them together, a beep sound will come. This ensures the correct working of a multimeter as shown in Figure 2.67.

Fig. 2.67

Step 5. Now, touch both the probes in terminals '1' and '2', terminals '1' and '3' of overload protector. If a beeping buzzer sounds that means, the overload protector is functioning correctly as shown in Figure 2.68.

Fig. 2.68

Step 6. If no beep buzzer, then it should be replaced by a new OLP.

Thermostat – It is a device used to control the temperature of appliances namely air conditioner, air conditioner, water cooler. It has various internal parts namely body, bellow, sensor, feeler bulb, lever, contacts, phase, spring, range adjustment screw, disc, contacts.

a. Body – It is the outer portion or covering of the thermostat.

b. Bellow – It is a flexible part that can expand and contract easily.

c. Sensor – It is used to sense the temperature of the unit.

d. Feeler bulb - It is connected to the evaporator and senses the temperature inside the evaporator of the refrigeration system.

e. Lever – It has two bars one is a flexible bar and the other is a fixed bar.

f. Contacts – It is a part between the levers, using them they connect.

g. Spring – It is part that applies the equal and opposite force on the levers.

h. Range adjustment screw – This is used to set the temperature of the thermostat.

i. Disc – It is the part used to hold the spring.

When the feeler bulb senses the temperature of the evaporator. If it is found the temperature of the evaporator is increasing, it will expand below which will push the lever to make close contact. Using this connection, the phase supply will be forwarded to the compressor through the relay. And when the feeler bulb senses the set temperature it will contract the bellow. The contacts disconnect and the supply gets off. It shown in line diagram Internal circuit of the thermostat figure 2.69.

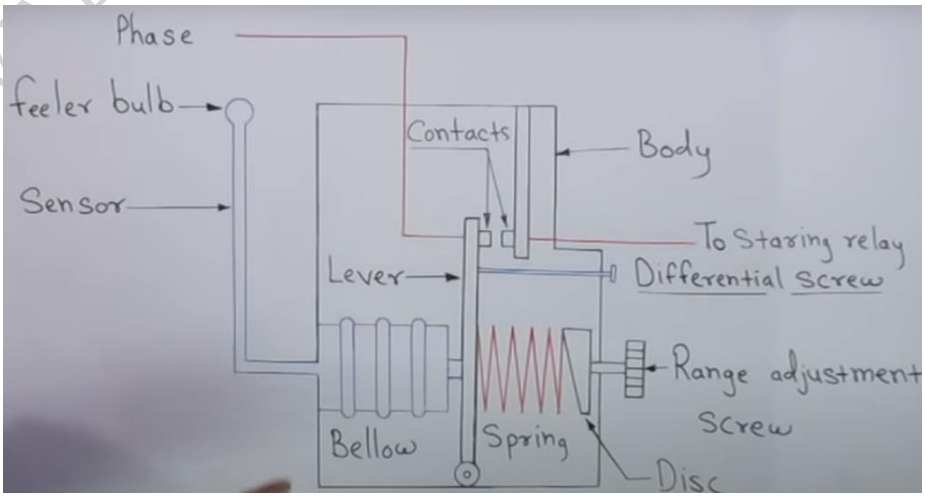


Fig.2.69 Internal circuit of the thermostat

Compressor **–** It is the heart of the refrigeration system. It maintains the refrigerant flow in the refrigeration system. It also creates pressure differences in the refrigeration system. Let us now see the practical activity to test the compressor and its motor.

Practical Activity 2.11 Test the compressor and its motor winding using a series test lamp.

Material Required

Series test lamp, multi meter, compressor, rubber gloves, rubber footwear, phase tester.

Procedure

Step 1. Wear safety gloves and safety shoes.

Step 2. Take the series test lamp to join its two terminals, if the bulb is glowing this shows the test lamp is okay as shown in Figure 2.70.

Fig. 2.70

Step 3. Next, touch the two terminals of wires in the terminals of the compressor. As shown in Figure 2.71. If the lamp glows dim, it shows the internal winding between these terminals is okay.

Fig. 2.71

Step 4. Next, touch the other terminals of the compressor by series test lamp. If the lamp glows dimly, it shows the winding between them is okay as shown in Figure 2.72.

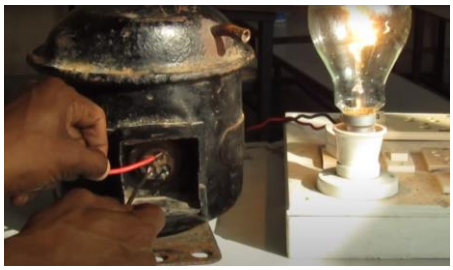


Fig. 2.72

Step 5. Now, touch the series test lamp terminals to the low terminals of the compressor as shown in Figure 2.73.

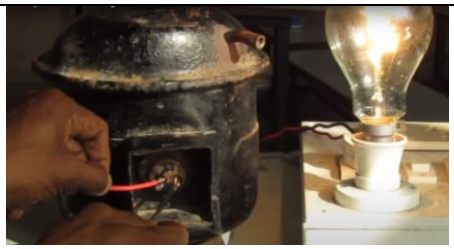


Fig. 2.73

Step 6. Now, to test the compressor body, connect one wire of a series test lamp to the compressor's body and the other wire to each terminal of the compressor, one at a time. If the bulb does not light up, it indicates that the compressor is functioning properly, as illustrated in Figure 2.74.

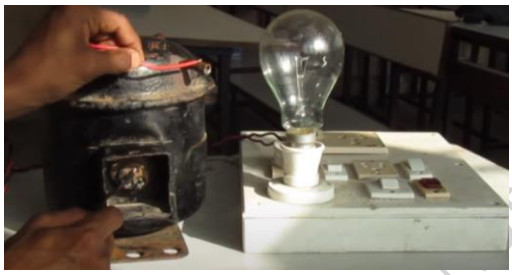


Fig. 2.74

Practical Activity 2.12 Identify the terminals of the compressor using a multimeter.

Material required

Series test lamp, multimeter, compressor, rubber gloves, rubber footwear, phase tester.

Procedure

Step 1. Set the multimeter to the ohms value.

Step 2. Place the cords of the multimeter on the two terminals of the multimeter as shown in Figure 2.75. Note down the meter reading.

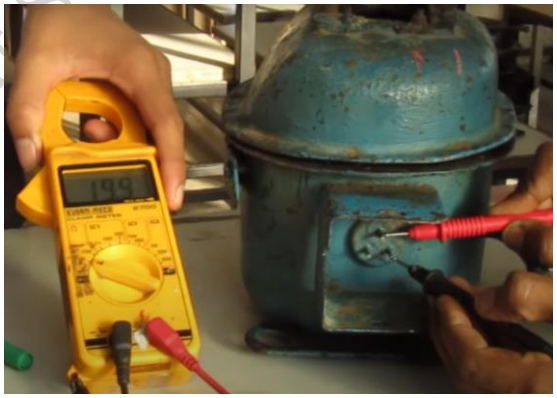


Fig. 2.75

Step 3. Place the cords of the multimeter on the two terminals of the multimeter as shown in Figure 2.76. Note down the meter reading.

Fig. 2.76

Step 4. Place the cords of the multimeter on the two terminals of the multimeter as shown in Figure 2.77. Note down the meter reading.

Fig. 2.77

Step 5. Note down the reading; if the readings are normal, they are acceptable. If the windings are shorted, the resistance between the terminals will be 1-2 ohms. If the windings are open, the resistance value will be infinite as shown in Figure 2.78.

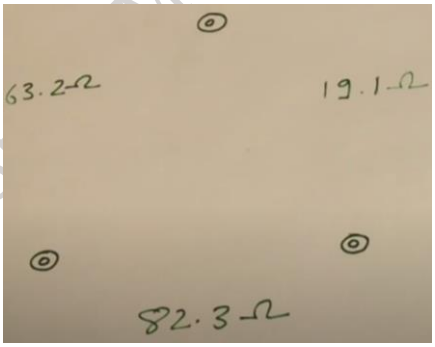


Fig. 2.78

Step 6. Perform the ground testing by connecting one terminal of the multimeter to one of the three terminals of the compressor, and the other terminal of the multimeter to the body of the compressor, as shown in Figure 2.79.

Fig. 2.79

Practical Activity 2.13 Identify the common, run, and starting terminals of the compressor.

Material required – Series test lamp, multimeter, compressor, rubber gloves, rubber footwear, phase tester.

Procedure

Step 1. Write down the reading, which is measured using a multimeter on the white paper.

Step 2. Identify the lowest reading among the three readings. Once identified, label it as "Common-Run (CR)" and write it down along with the corresponding value. (Figure 2.80)

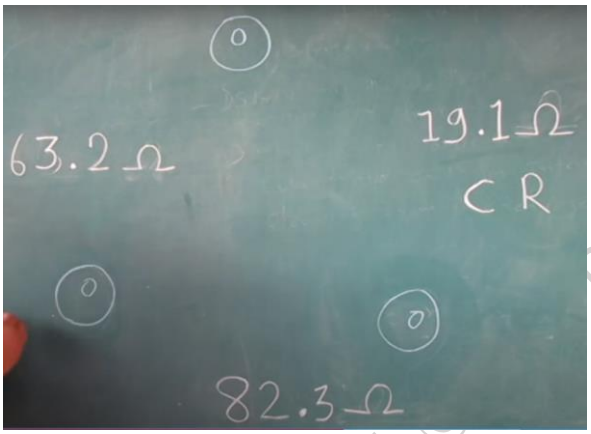


Fig. 2.80

Step 3. Identify the second-lowest reading among the three readings. Once it is identified write down the Common Start (CS) along with it. (Figure 2.81)

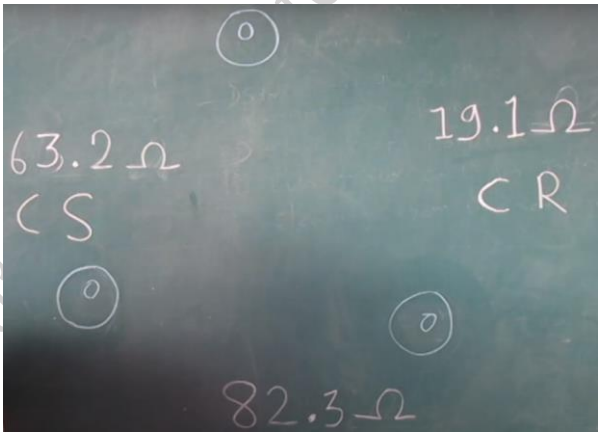


Fig. 2.81

Step 4. Identify the highest reading among the three readings. Once it is identified write down the Run Start (RC) along with it. (Figure 2.82)

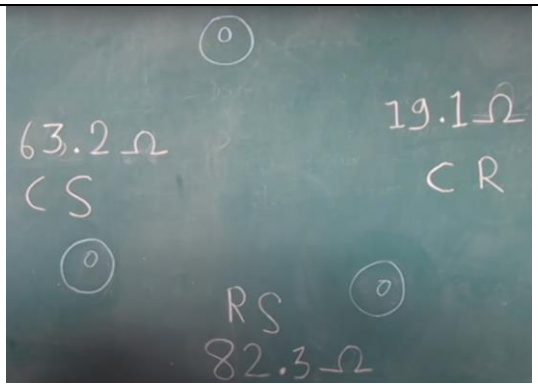


Fig. 2.82

Step 5. Now, find the common alphabet. In the top point, we found a Common 'C' as common.

Step 6. Now, find the common alphabet. We found a Common 'S' in the left point as common.

Step 7. Now, find the common alphabet. At the right point, we found a Common 'R' as common.

Temperature Sensor – It senses the temperature of the surrounding. It is mounted in the indoor of the air conditioner.

Practical Activity 2.14 Demonstrate the testing of the temperature sensor.

Material Required

Multimeter, Temperature sensor, jar with ice water

Procedure

Step 2. Take a multimeter, rotate its knob to turn it ON to measure the resistance as shown in Figure 2.83.

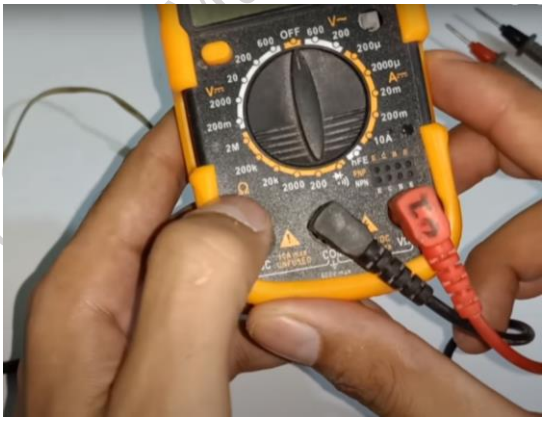


Fig. 2.83 Multimeter with connected cords

Step 2. Take a temperature sensor. Measure its resistance using a multimeter. As can be seen from Figure 2.84. that the resistance value is 3.5 ohms.

Fig. 2.84 Resistance of the temperature sensor on the display

Step 3. Consider the jug filled with ice water. Dip the temperature sensor in it as shown in Figure 2.85.

Fig. 2.85 Temperature sensor in the jug

Step 4. Again, measure the resistance value of the temperature sensor. As can be seen from Figure 2.86, the value of the resistance is 6.3 ohms. The increase in resistance may be due to a decrease in temperature. This shows the temperature sensor is okay.

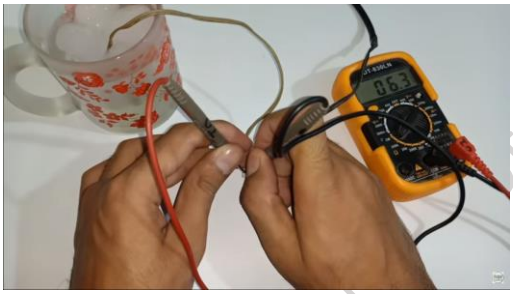


Fig. 2.86 Resistance of the temperature sensor

Voltage Relay **–** A relay is an electrical device, which is used to start an electric motor or compressor. As the starters are used to start the tube light. Likewise, relays are used to start the motor. The voltage relay has five points as shown in Figure 2.87. Voltage relay is commonly used in the compressors of the air conditioner. The compressor of an air conditioner typically uses a capacitor start, capacitor run motor. This type of motor employs two capacitors: one for starting the motor and another for running it efficiently during operation. The start capacitor provides the necessary torque to initiate motor movement, while the run capacitor helps maintain smooth and energy-efficient performance during extended use. This setup ensures optimal performance and reliability for the compressor, which is essential for air conditioning systems. (Figure 2.87)

Fig. 2.87

Practical Activity 2.15 Demonstrate the testing of voltage relay.

Material Required

Series test lamp, voltage relay, rubber gloves, rubber shoes.

Procedure

Step 1. Wear rubber hand gloves and rubber shoes.

Step 2. Take the series test lamp and touch its two terminals to pin 1 and 2 of the voltage relays as shown in Figure 2.88. The lamp should glow in this condition.

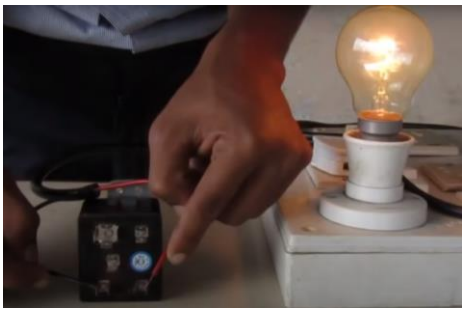


Fig. 2.88 Touching series lamp to pin 1 and pin 2 of relay

Step 2. Take the series test lamp and touch its two terminals to pin 2 and 5 of the voltage relays as shown in Figure 2.89. A tick-tick sound will come. And the lamp should not glow in this case.

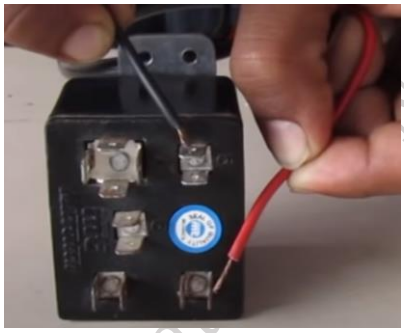


Fig. 2.89 Touching series lamp to pin 2 and pin 5 of relay

Step 3. Take the series test lamp and touch its two terminals to pin 1 and 5 of the voltage relays as shown in Figure 2.90. A buzzer sound will come. The lamp should glow in this condition. If step 1, step 2, step 3 is fulfilled then we can say that the voltage relay is okay.

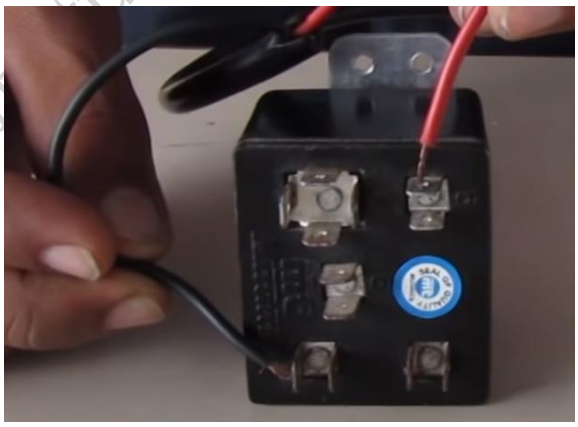


Fig. 2.90 Touching series lamp to pin 1 and pin 5 of relay

High Voltage Capacitor – It is an energy-storing component, which is used to start the electric motor of the compressor. Modern air conditioners, especially those with inverter technology, require a variable-speed compressor, which is achieved using an electric motor with variable speed capabilities. For the motor to function efficiently, the correct starting and running energy are essential. As a result, air conditioners use both a start capacitor and a run capacitor, as shown in Figure 2.91. The start capacitor typically has a value of 80-100 MFD (microfarads),

while the run capacitor's value ranges from 25-40 MFD, ensuring smooth operation and energy efficiency.

Fig. 2.91 (a) Specification of start capacitor (b) Specification of running capacitor

Practical Activity 2.16 Demonstrate the testing of high voltage capacitor.

Material Required

Power supply, rubber gloves, rubber shoes.

Procedure

Step 1. Wear rubber hand gloves and rubber shoes.

Step 2. Carefully, touch the phase and neutral wires to the terminal of the capacitor for 2 seconds 3 seconds as shown in Figure 2.92.

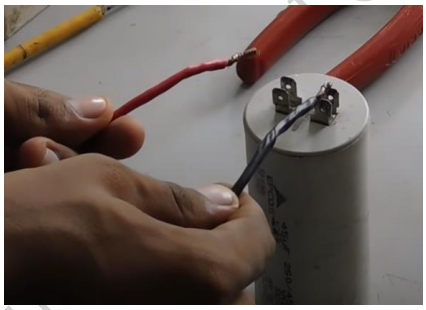


Fig. 2.92 testing of high voltage capacitor

Step 3. Take out the wires using screwdriver to shorten its terminals. If the sound with a short spark comes, it shows that the capacitor is okay as shown in Figure 2.93.

Fig. 2.93 Capacitor condition check

CHECK YOUR PROGRESS

A. Multiple choice question

1. Which of the following value of starting capacitor is used in an air conditioner? a) 80-100 MFD b) 70-80 MFD c) 100-110 MFD d) 50-60 MFD
2. Which type of relay is used in the air conditioner? a) Current relay b) box type relay c) Voltage relay d) Positive temperature coefficient (PTC) relay
3. OLP stands for _____ a) Over lug protect b) Overload point c) Over lug point d) Overload protector
4. Which of the following is not a compressor terminal? a) Common terminal b) Running terminal c) Starting terminal d) Joint terminal
5. Which type of motor is used in the air conditioner compressor? a) Capacitor start capacitor run motor b) Capacitor run motor c) capacitor start motor d) stepper motor
6. Which of the following is called the heart of the refrigeration system? a) evaporator b) Compressor c) Condenser d) expansion valve
7. Which of the following device used to control the temperature of the appliance a) relay b) expansion valve c) thermostat d) blower
8. Average life span of an air conditioner is a) 15 years b) 8-year c)10 years d)13 years.
9. Which of the following maintains the flow of refrigerant? a) Compressor b) evaporator c) condenser d) expansion valve
10. Which of the following value of the running capacitor is used in an air conditioner? a) 70-80 MFD b) 20-30 MFD c) 25-40 MFD d) 50-60 MFD

B. Fill in the blank

1. In voltage relay, when the pin 1 and pin 5 is connected to the terminals of relay a _____ sound comes.
2. Modern compressor use _____ technology.
3. Compressor has common, run, and _____ terminals.
4. In the compressor, the windings are short then the resistance value between the terminals will be _____ ohms.
5. Air conditioner use _____ sensor for temperature control.

C. True or False

1. Air blower is used in the indoor unit.
2. Evaporator is a part of the outdoor unit of the split air conditioner.
3. Condenser is a part of the indoor unit of split air conditioner
4. Louver in indoor unit is used to direct the air in the room.
5. Air filters are used to clean the room air.

D. Short answer questions

1. What is a relay? What type of relay is used in the air conditioner?
2. What are the various parts of the thermostat?
3. Perform the testing of a high voltage capacitor.
4. What is the role of an overload protector in the air conditioner?

5. What steps must a technician follow at the initial identification of fault by customer interaction?
6. Mention the cleaning steps of the window air conditioner.
7. What is the role of the air louver? Perform the cleaning steps for the air louver.
8. What is the need for an air filter in the air conditioner?
9. Perform the steps to test the compressor.
10. Write down the steps to identify terminals of the compressor.

Session 3. Air Conditioner Maintenance and Troubleshooting

The air conditioner is a commonly used household appliance, often running for long hours each day. As a result, problems may arise over time. Maintaining its performance and efficiency requires an understanding of how to repair non-working parts. Repairs are not solely reliant on professional technicians; users can also identify and troubleshoot common air conditioner issues. By using simple tools and easily obtainable, inexpensive parts, many problems can be resolved. In this chapter, we will explore common air conditioner problems, their causes, and possible solutions for effective maintenance.

Air Conditioner Circuit Diagram

An air conditioner is having various circuit components. So, it is essential to have the correct knowledge of the circuit components. These circuit components are connected according to the circuit diagram of an air conditioner. Observe the schematic diagram of the air conditioner in Figure 3.1 which includes the components such as a power supply, indoor and outdoor unit (split AC), window AC, cable, wire, Double Pole (DP) MCB, Double Pole (DP) switch etc.

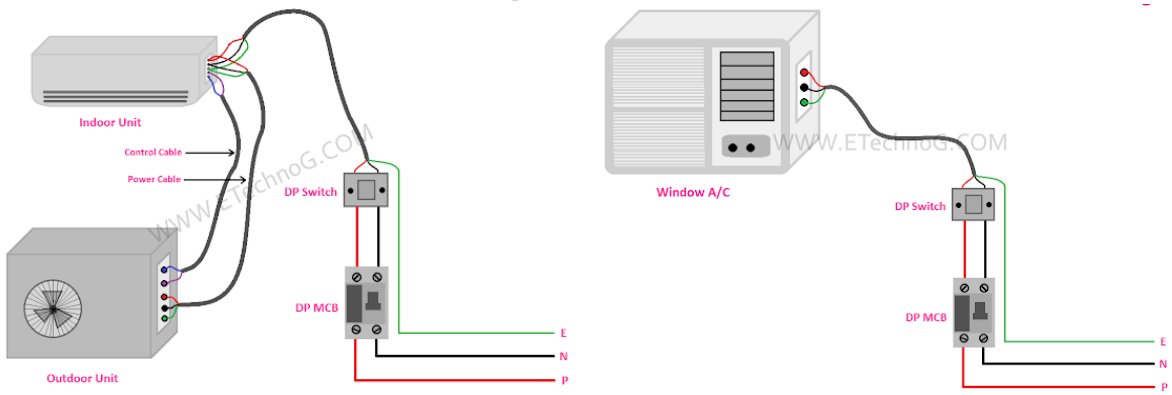


Fig. 3.1 Block diagram air conditioner (a) Split air conditioner (b) Window air conditioner

Steps to read the circuit diagram of the air conditioner

1. Check the power supply to the circuit i.e., phase, neutral and earth.
2. Connect the power supply terminals to the indoor fan motor via fuse and SSR.
3. Connect the indoor unit power supply terminals to the power supply unit, it acts as a rectifier, which converts the input AC into DC. This DC is then given to the microcontroller, which will further control the display, sensors, and various motors of the air conditioner.
4. Connect the indoor unit power supply terminals to the outdoor power supply unit via the outdoor unit relay.

5. Connect the outdoor fan motor from the power supply via an internal thermal protector.
6. Connect the power to the compressor motor via the overload protector and voltage relay.

In the diagram, the following components/devices are fitted:

Loads: Compressor motor, indoor fan motor, outdoor fan motor, swing/louver motor.

Controlling devices: Microcontroller.

Sensing devices: Thermostat, speed sensor, freeze sensor (pipe sensor), room temperature sensor.

Starting devices: Solid-State Relay (SSR), outdoor unit relay, voltage relay (for compressor motor).

Safety devices: Overload protectors, internal thermal protector, thermal fuse, fuse.

Conductors: High-gauge cables.

Power supply: Single-phase 220 V AC.

This setup ensures efficient control, protection, and operation of the air conditioner system as shown in Figure 3.2.

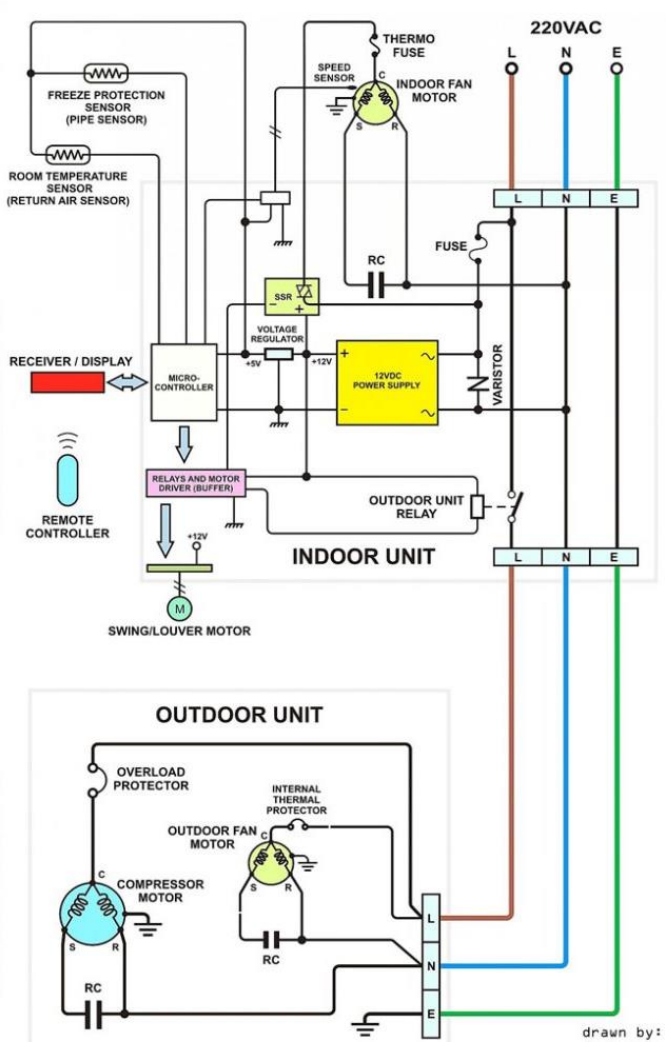


Fig. 3.2 Circuit diagram of the air conditioner

Selection of the Cable

Cable selection plays a critical role in air conditioners. Incorrect cable or wire gauge selection can lead to malfunctions in the supply circuit. Using a lower gauge wire or cable may result in

overheating or even burning of the cable. To avoid such issues, it is essential to choose the correct cable based on the tonnage of the air conditioner.

To determine the appropriate wire gauge, the tonnage of the air conditioner must first be converted into kilowatts. In the highest cooling mode, the air conditioner draws maximum power, and this wattage varies depending on the AC's star rating and Energy Efficiency Ratio (EER). Table 1 provides details on the tonnage, power consumption, star rating, and EER.

For example, consider a 1.5-ton air conditioner with a 5-star rating and an EER of 3.63. The cooling capacity of this AC is 5353 watts. By understanding these parameters, the correct gauge of wire or cable can be selected, ensuring safe and efficient operation. Its cable gauge can be calculated as –

Power (P) = Voltage (V) x Current (I)

P = V x I

5353 = 220 x I

I = 5353 / 220

I = 24.3 amp.

Therefore, it can be concluded that 1.5-ton AC of 5-star rating, 3.63 EER, draws max. 24 amps (approx.) of current.

Wire and cable come in various gauges such as 0.5 mm^2, 0.75 mm^2, 1 mm^2, 1.5 mm^2, 2.5 mm^2, 4 mm^2, 6 mm^2, 10 mm^2, 16 mm^2, 25 mm^2 and many more.

To find the value of wire and cable gauge value and their current carrying capacity, one can use the below calculations

(i) To determine wire current capacity

Current capacity = 6 x gauge of wire in square mm (mm^2)

(ii) To determine cable current capacity

Current capacity = 4 x gauge of cable in square mm (mm^2)

Using these expressions, one can say that for 1.5-ton AC with a 5-star rating and EER 3.63 wire of 4 mm^2 or cable of 6 mm^2 is required.

Table 1. Air Conditioner Energy-Saving Chart

Type of AC	Model	Star Rating	Energy Efficiency Ratio (EER)	Cooling capacity	Power - Consumption (Watts/Hr)
Split AC	1 Ton	5 Star	3.63	3568.9	984
	1.5 Ton		3.59	5353.4	1490
	2 Ton		3.59	6212	1732
	0.8 Ton	3 Star	3.11	2524	812
	1 Ton		3.20	3493	1092
	1.5 Ton		3.17	4960	1566
	2 Ton		3.12	6044	1938
	1 Ton	2 Star	3.03	3502	1154
	1.5 Ton		2.99	5118	1709
	2 Ton		3.00	6610	2210

Window AC	1 Ton	2 Star	2.81	3517	1250
	1.5 Ton		2.75	4800	1745
	1 Ton	3 Star	3.05	3530	1157
	1.5 Ton		2.92	4900	1676

Common Problems in the Air conditioner

Air conditioners are an essential part of daily life. In areas where temperatures drop is too low in winter or temperature rise is too high in summer, an efficient air conditioner is a must. It is important not to ignore its regular maintenance needs. In summer, we rely on air conditioners while sleeping, working in offices, or shopping in malls. Therefore, it is our responsibility to maintain them properly to prevent minor issues from affecting their overall efficiency. Furthermore, if a user is vigilant, they can detect early signs of developing problems and avoid costly repairs. In Table 1, common problems, possible causes, and the necessary actions are outlined for reference.

Table 1. *Common Air Conditioner problems, causes and their possible remedies*

Problem	**Possible causes**	**Remedies**
Air conditioner unit is not turning ON	a. Thermostat batteries not working b. Thermostat setting problem c. Circuit breaker inoperative	a. Replace the batteries if they are dead. If the batteries are in working condition. b. Change the thermostat settings to determine whether the cooling mode is ON at desired temperature. c. If the circuit breaker is tripped. Reset the circuit breaker by flipping the switch OFF and then ON.
Air conditioner not blowing cold air	Check the dirty air filter, which blocks the airflow of the unit	Check and clean the air filter every month. In case of completely choked filters, replace it with new one.
Air conditioner freezing up	a. Insufficient airflow b. Low refrigerant levels c. Thermostat Issues d. Blower motor problems e. Dirty Evaporator Coils	a. Dirty air filters, blocked vents, or faulty fans can reduce airflow, causing the evaporator coil to become too cold and freeze up. Clean it or replace if necessary. b. Insufficient refrigerant can lower the pressure in the system, causing the evaporator coils to freeze. Fill the refrigerant in the air conditioner to the specified limit. c. A malfunctioning thermostat may cause the air conditioner to run continuously, leading to freezing. d. Check the motor, replace it, in case of a damaged motor. e. If the coils are dirty, they can't absorb heat properly, which can result in freezing. Clean the evaporator coils.

AC refrigerant leak	a. Loose pipe fittings b. Damage in the copper pipe	a. Tightens the loose fittings. b. Braze the damaged copper pipes.
Air conditioner producing noise	a. Refrigerant leak produces Hissing sound b. Relay problem produces clicking sound c. Blower motor produces thumping noises d. Compressor or fan motor produces Screeching noise e. Faulty circuit components produce buzzing sound	a. Repair the refrigerant leak. b. Replace the relay. c. Repair/ replace the blower motor. d. Change the compressor or fan motor. e. Replace the faulty component.
Frozen evaporator coil	Lack of air circulation	Unblocking vents and ducts, cleaning dirty air filters, and replacing faulty fans can help maintain sufficient airflow in the system.
Electric control failure	Frequent turn ON and OFF the air conditioner	Make sure that the air conditioner should operate frequently. Check the electrical connections to rectify the issue.
Air conditioner leaking water outside	a. Dirty air filters b. Improper installation c. Blocked drain pipe d. Low refrigerant levels	a. Clean the air filters. b. Check the installation is okay. c. Clean the drain pipe and ensure that the slope of the drainpipe is maintained. d. Check the refrigerant level.
Drainage problem	The pipe may get clogged with dust, algae, and dirt	To prevent this, make sure your drain line is regularly maintained, cleaned, and inspected.
Sensor problem	Check the sensor position	Correct the sensor placement. It should be placed near to the evaporator coil.
Fan won't run	a. Wrong electrical supply b. Electrical connections in the motor terminal are not tight. c. For single-phase motors the capacitor is not wired in or is faulty d. Overloads have tripped out.	a. Check whether the electrical supply matches the specifications mentioned at the motor nameplate. b. Check and tighten as necessary. c. If a capacitor is fitted check with a multimeter and replace in case it is faulty. d. Replace the belts and re-align the drive.

Motor overheating or draws high current.	a. Incorrect power supply b. Excessive dirt on the motor cooling fins so the heat is not able to dissipate. c. Excessive stopping or starting - 10 starts/hour is generally accepted	a. Check whether the electrical supply matches with the guidelines indicated at the motor nameplate. b. Frequently clean the dirt and dust on the motor body and between the cooling fins. c. Check the control system and reduce the number of starts/hours as recommended.
Indoor and outdoor unit does not start	Fault in power supply	a. Check the power supply using a tester b. Check the MCB. It should be ON.
Bad smell	a. Filter is choked b. No use for a long time	a. Clean the filter. b. Use deodorizer. Using a deodorizer can help eliminate unpleasant odours from your air conditioner, improving the air quality in your home or office.
Louver not working	Louver motor	a. Check the louver motor using a multimeter.
Insufficient cooling	Sensor (Thermistor) not working	Check the variation in the resistance value of the sensor with change in temperature using the multimeter. Standard temperature – 25^0 C Standard resistance – 23 Kilo ohms
High Electricity Bill	Improper room insulation	Make sure that the room with AC should have proper insulation.
Remote control not working	Mode change	Check the mode button of the remote. Change the mode in case it does not respond in auto mode.
Insufficient Air circulation	Louver direction	Adjust the direction of the louver swing as needed. The louver can be set to either a vertical swing or a horizontal swing, depending on your preference. Vertical swing directs airflow up and down, while horizontal swing adjusts airflow side to side, providing optimal air circulation and comfort.
Low Fan speed	Remote speed controller	Check the fan motor and adjust its speed as necessary. Increasing the fan motor speed can enhance airflow and improve the overall cooling efficiency of the air conditioning system. Ensure that the

		motor is functioning properly and that any settings or controls are adjusted to the desired speed for optimal performance.

Repairing Procedures

So far, we have discussed the common problems that occur in air conditioners, their causes, and the actions needed for repairs. Now, let us focus on repairing or replacing various parts of the air conditioner. Each part of the air conditioner may require different methods for replacement or repair. The technician should listen carefully to the customer's complaints and, before proceeding, must assess the issue thoroughly before dismantling the air conditioner. For instance, if there is a problem with the outdoor unit fan motor, such as unusual noise or poor performance, the technician should dismantle the outdoor unit to repair or replace the fan motor. Let us understand the procedure for dismantling and replacing the fan motor in the outdoor unit of the air conditioner.

Practical Activity 3.1 Demonstrate the way to replace the outdoor fan motor.

Material Required

Outdoor unit, screwdriver, hammer, fan motor.

Procedure

Step 1. Unscrew the bolts of the outdoor unit of an air conditioner as shown in Figure 3.3.

Fig. 3.3 Unscrew the bolts of the outdoor unit

Step 2. Remove the top cover and front cover as shown in Figure 3.4.

Fig. 3.4 Removing the covers

Step 3. Unscrew the fan bolts as shown in Figure 3.5.

Fig. 3.5 Unscrewing of fan bolts

Step 4. Detach the connection plate as shown in Figure 3.6.

Fig. 3.6 Detaching the connection plate

Step 5. Remove all the wires of a fan as shown in Figure 3.7.

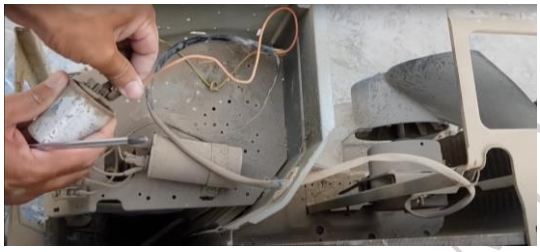


Fig. 3.7 Removing all the wires of a fan

Step 6. Carefully, pull up the fan motor assembly as shown in Figure 3.8.

Fig. 3.8 Pulling up the fan motor assembly

Step 7. Lose the bolt then hit it with a hammer as shown in Figure 3.9.

Fig. 3.9 Loosening of the bolts of fan

Step 8. Now, remove all bolts of a fan as shown in Figure 3.10.

Fig. 3.10 Removing all bolts of a fan

Step 9. Replace the fan motor with the same rating as shown in Figure 3.11.

Fig. 3.11 Replacing the fan motor

Step 10. Perform the reverse process to mantle the fan motor in the outdoor unit.

Suppose, there is a problem with the indoor unit fan blower motor if it is making some noise or the fan is not working well. In such cases, a technician should dismantle the indoor unit to replace or repair the blower fan motor. Let us understand the way to dismantle and replace the fan blower motor of the air conditioner indoor unit.

Practical Activity 3.2 Demonstrate the way to replace the fan blower motor.

Material Required

Screwdriver, fan blower motor.

Procedure

(Follow the steps from 1 to step 10 from the practical activity 1.4 of chapter 1)

Step 11. Remove the wire cover and use a flat head screwdriver to remove the wire clips as shown in Figure 3.12.

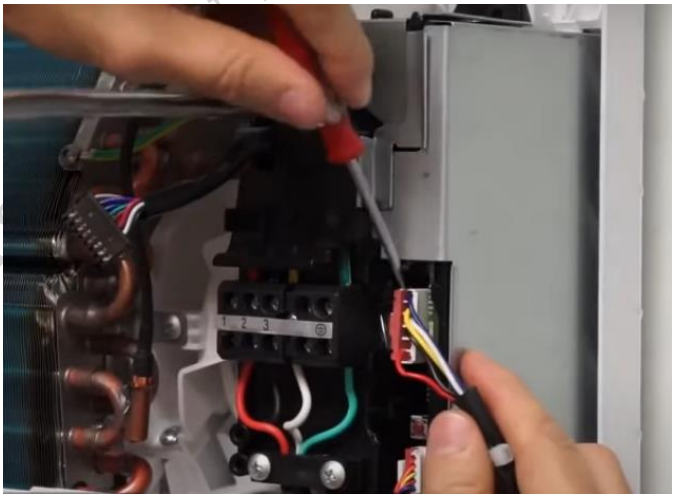


Fig. 3.12 Removal of wire clips

Note: *Take a picture of the wire connections for later reference when putting it back together.*

Step 12. Then remove the Phillips type screwdriver to remove the screws that fasten in these electrical wires as shown in Figure 3.13.

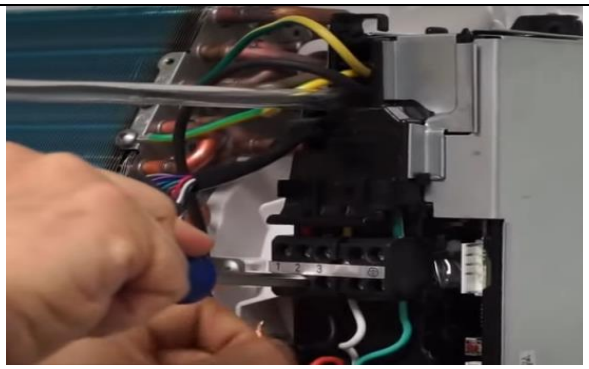


Fig. 3.13 Loosening of screws

Step 13. Remove the wires once loosen as shown in Figure 3.14.

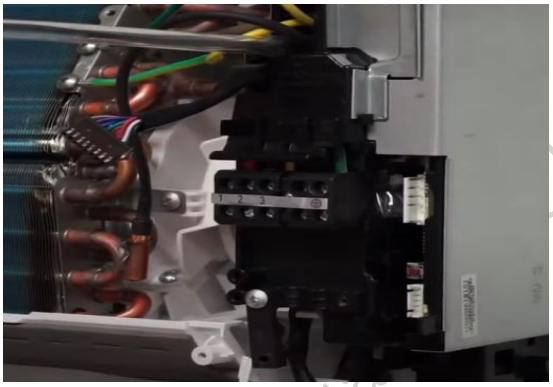


Fig. 3.14 Wire removal

Step 14. Unclip the top of the electronic control box as shown in Figure 3.15.

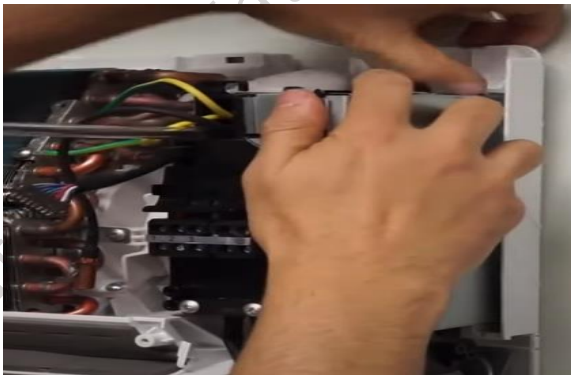


Fig. 3.15 Unclipping of electronic control box

Step 15. Remove the two screws holding the two green/yellow wires in place as shown in Figure 3.16.

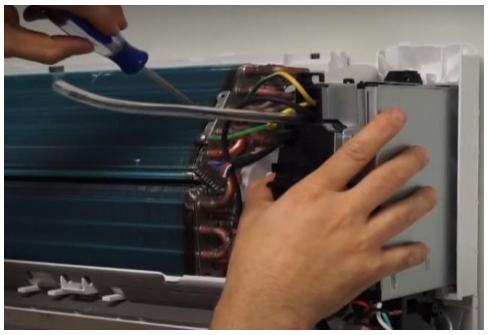


Fig. 3.16 Removal of screw holders

Step 16. Remove the control box of the indoor unit as shown in Figure 3.17.

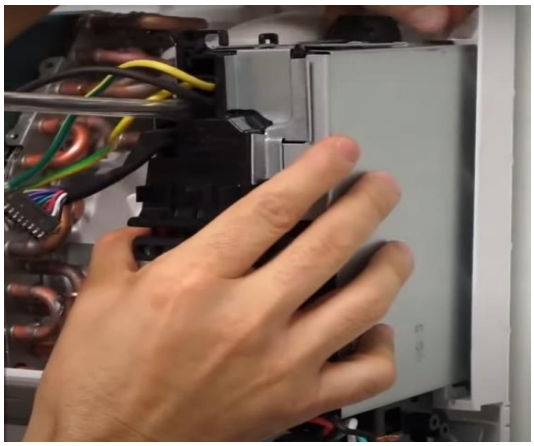


Fig. 3.17 Removal of control box

Step 17. Remove all the screws of the heat exchanger or evaporator of the indoor unit as shown in Figure 3.18.

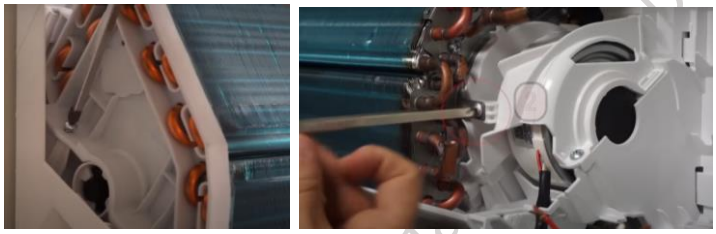


Fig. 3.18 Removal of screw of heat exchangers

Step 18. Remove the cover of the fan blower motor as shown in Figure 3.19.

Fig. 3.19 Removal of the cover of fan blower motor

Step 19. Spin the blower and remove its inside screw as shown in Figure 3.20.

Fig. 3.20 Removal of the screws

Step 20. Remove and replace the fan blower motor as shown in Figure 3.21.

Fig. 3.21 Replacement of fan blower motor

Step 21. Perform the reverse process to re-assemble (mantle) the fan motor in the indoor unit of an air conditioner.

Suppose, there is a problem with the PCB of the indoor unit. In such cases, a technician should replace the PCB of the indoor unit. Let us understand the way to replace the PCB of an air conditioner indoor unit.

Practical Activity 3.3 Demonstrate the way to replace the indoor unit PCB.

Material Required

Indoor unit of air conditioner, new PCB, screwdriver, tester.

Procedure

(Follow the steps from 1 to step 13 from the practical activity 1.4 of chapter 1)

Step 14. Switch off the main power supply. Unscrews using a tester and remove the line and neutral wires from the indoor unit as shown in Figure 3.22.

Fig. 3.22 Connection removal

Step 15. Read the instructions mention on the cover of the PCB as shown in Figure 3.23.

Fig. 3.23 PCB instructions

Step 16. Remove the side cover of the indoor unit as shown in Figure 3.24.

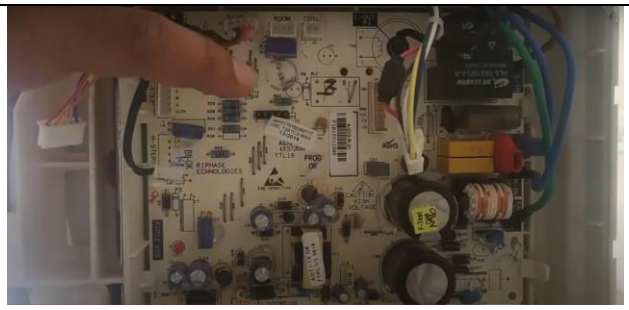


Fig. 3.24 Removal of side cover

Step 17. Detach the wires from the PCB as shown in Figure 3.25.

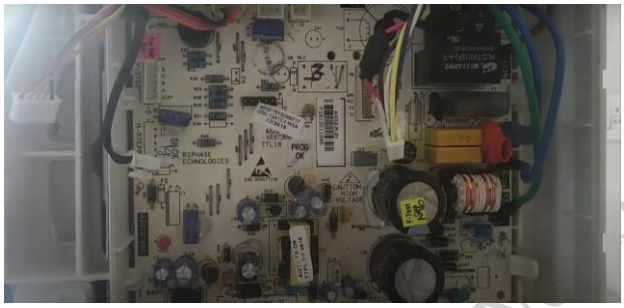


Fig. 3.25 Wire detachment

Step 18. Press the side clips on the body of the PCB box as shown in Figure 3.26.

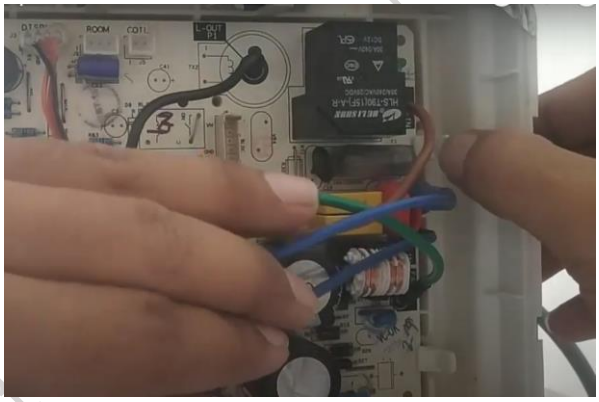


Fig. 3.26 Side clip removal

Step 19. Carefully lift the PCB as shown in Figure 3.27.

Fig. 3.27 removal of PCB

Step 20. Replace the faulty PCB with a new PCB.

Suppose, there is a problem with the room sensor of the indoor unit. In such cases, a technician should replace the room sensor of the indoor unit. Let us understand the way to replace the room sensor of an air conditioner indoor unit.

Practical Activity 3.4 Demonstrate the way to replace the room sensor.

Material Required

Screwdriver, new plastic head room sensor.

Procedure

(Follow the steps from step 1 to 10 from the practical activity 1.4 of chapter 1)

Step 11. Turn off the power supply. Read the instructions mentioned on the side cover as shown in Figure 3.28.

Fig. 3.28 Warnings of the PCB

Step 12. Open the PCB side cover as shown in Figure 3.29.

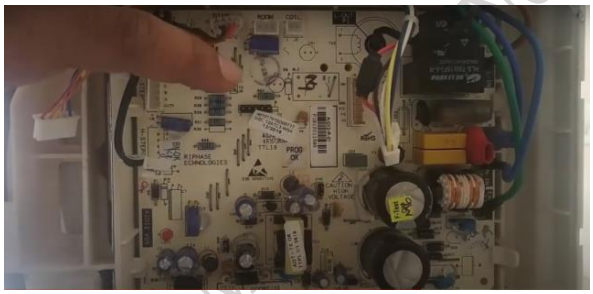


Fig. 3.29 Opening of side cover of PCB

Step 13. Detach the room sensor terminals from the PCB as shown in Figure 3.30.

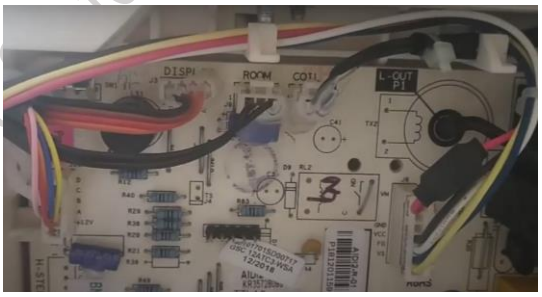


Fig. 3.30 Detachment of room sensor

Step 14. Remove the temperature sensor from the body of the indoor unit as shown in Figure 3.31.

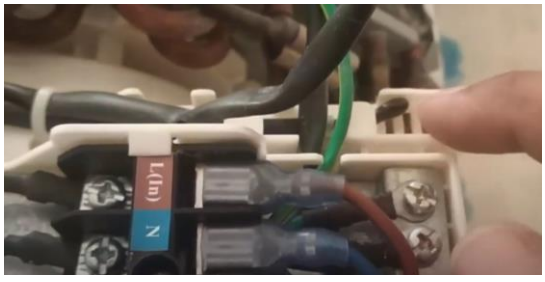


Fig. 3.31 Removal of temperature sensor

Step 15. Replace the temperature sensor with a new temperature sensor as shown in Figure 3.32.

Fig. 3.32 Replacement of temperature sensor

Suppose, there is a problem with the copper head coil sensor of the indoor unit. This sensor is attached to the evaporator coil of the indoor unit. In such cases, a technician should replace the copper head coil sensor of the indoor unit. Let us understand the way to replace the copper head coil sensor of an air conditioner indoor unit.

Practical Activity 3.5 Demonstrate the way to replace the copper head coil sensor.

Material Required

Screwdriver, new copper head coil sensor.

Procedure

Step 1. Turn off the power supply. Read the instructions mentioned on the side cover.

Step 2. Open the PCB side cover.

Step 3. Detach the coil sensor terminals from the PCB as shown in Figure 3.33.

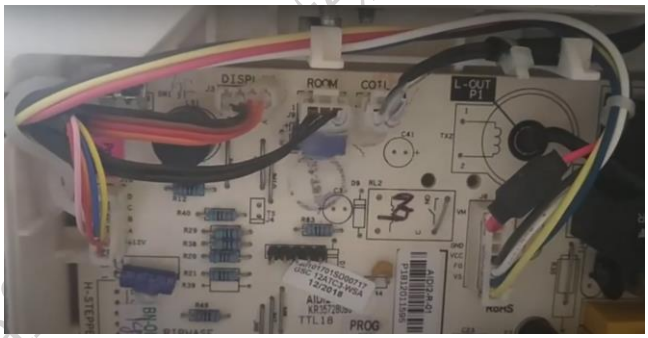


Fig. 3.33 Detachment of coil sensor terminals

Step 4. Remove the coil sensor from the evaporator coil of the indoor unit as shown in Figure 3.34.

Fig. 3.34 Removal of coil sensor

Step 5. Replace the coil sensor with a new coil sensor as shown in Figure 3.35.

Fig. 3.35 Replacement of coil sensor

Suppose, there is a leakage of gas in the copper tubes. In such cases, a technician should perform the brazing operation. Let us understand the way to perform the brazing of copper pipe of an air conditioner.

Practical Activity 3.6 Demonstrate to perform the brazing in case of gas leakage.

Material Required

Copper pipe, torch flame.

Procedure

Step 1. Cut the tube to the exact length using a tube cutter or hacksaw. Remove all inside and outside burrs with a reamer file. If a tube is out of round, it should be brought to true dimension and roundness with a sizing tool as shown in Figure 3.36.

Fig. 3.36 Reaming of copper tube

Step 2. Clean the surface which is to be joint, using a stainless-steel wire brush or by a stiff rubbing. If oil or grease is present, clean with a commercial solvent. To remove dust, clean dry cloth can be used as shown in Figure 3.37.

Fig. 3.37 Cleaning of copper tube

Step 3. At the time of brazing filler, the metal selection is required. For example, when brazing copper-to-copper, brazing filler alloy contain phosphorus and silver.

Step 4. Perform the correct fluxing using a brush as shown in Figure 3.38, because the flux absorbs oxides formed during heating and promotes the flow of filler metal.

Fig. 3.38 Flushing using brush

Step 5. Insert the fluxed tube end into the fitting as shown in Figure 3.39. Maintain support to ensure the correct alignment until the brazing alloy solidifies. The assembly is now ready to braze, using brazing alloy in rod, wire, or coil form manually fed into the joint.

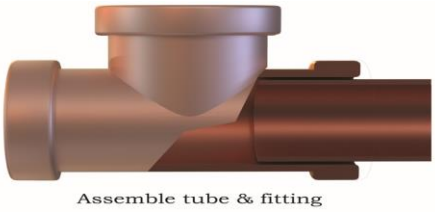


Fig. 3.39 Assemble tube and fitting

Step 6. Adjust torch flame. This flame uses oxygen-acetylene gases. The flame has a well-defined inner cone. Excess acetylene removes surface oxides from the copper. The copper will appear bright rather than have a blackened surface due to an improper oxidizing flame. (Figure 3.40)

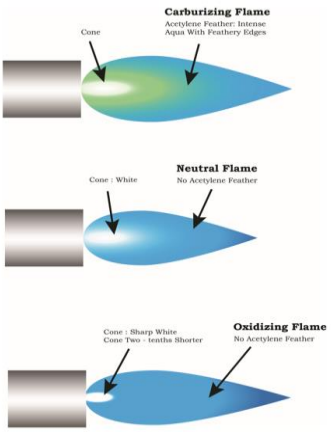


Fig. 3.40 Torch flame types

Step 7. All fluxes residues must be removed for inspection and pressure testing. Immediately after the brazing alloy has set, quench or apply a wet brush or swab to crack and remove the flux residues. Use emery (type of sandpaper) cloth or a wire brush if necessary.

Suppose there is a problem with the remote control of the air conditioner. In such cases, a technician should repair the remote control. Sometimes, the remote doesn't work, or some buttons work while others don't. We can solve this problem easily at home. Let us understand how to repair the remote control of an air conditioner.

Practical Activity 3.7 Demonstrate the way to repair the remote-control pad of an air conditioner.

Material Required

Remote control, CTC cleaner, toothbrush.

Procedure

Step 1. First, change the battery and check again. If it still doesn't work, open the remote cover by unscrewing it as shown in Figure 3.41.

Fig. 3.41 Removal of battery of remote

Step 2. Check the point where the battery is connected. If the point is rusty, clean the rust and check again, as shown in Figure 3.42.

Fig. 3.42 Remote inspection

Step 3. Wash the PCB kit with CTC (Carbon tetrachloride) or Petrol using tooth brush as shown in Figure 3.43 and check again.

Fig. 3.43 Cleaning of PCB kit

If the remote control still doesn't work, it's better to purchase a new one.

Customer Feedback

It refers to data collected directly from customers regarding their satisfaction or dissatisfaction with a certain product or service. In other words, it is about the information generated by consumers and/or buyers of a particular brand of the air conditioner. This data is distributed in a variety of formats (e.g., text or speech) in various ways. Common sources of customer feedback are –

a. Surveys and questionnaires

b. Emails and letters

c. Phone calls and call centre data

d. Ratings and reviews

a. Surveys and Questionnaires – It is a way to gather a collection of people's thoughts and experiences on a given topic. While it may not introduce new information, it relies on asking questions to collect insights. A questionnaire, on the other hand, is a set of printed or written questions with predefined responses, designed to achieve the objectives of a statistical study.

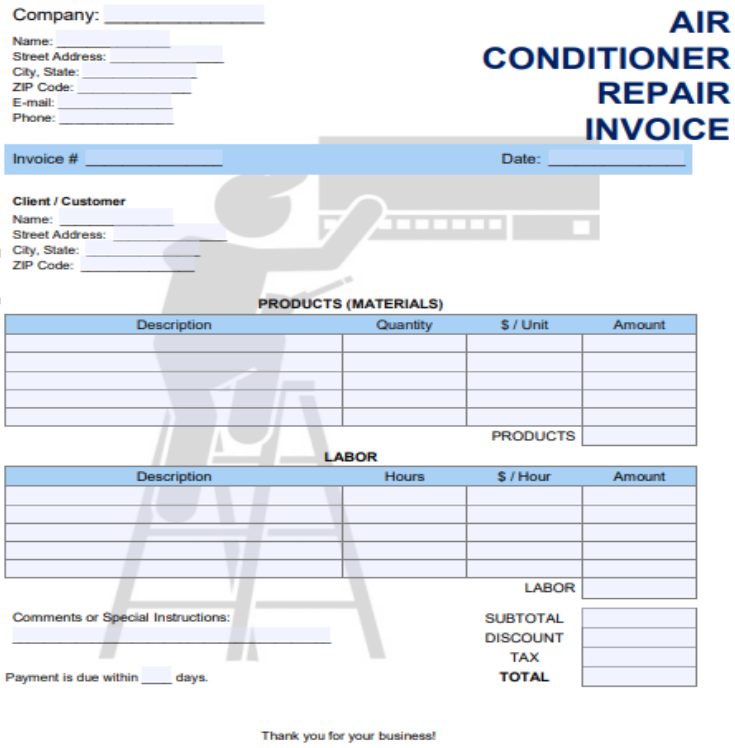
b. Emails – E-mails are another popular way for customers to provide feedback. After purchasing or using a product or service, some customers e-mail companies to share their experiences. They use e-mails to express either their appreciation or their dissatisfaction.

c. Call Centre – A call center is a centralized location that manages large volumes of phone and electronic inquiries. It is responsible for handling inbound product support queries and information requests from users.

d. Ratings and Reviews – Online consumer product reviews are written by people who have used a particular product or service. For brands offered through online retailers, these reviews are a valuable source of customer feedback.

Invoice of Repair Work

It is a statement of the money owed for maintenance work performed by an individual or service organization specializing in air conditioners. Whether the item is being repaired or replaced, the technician will include their hourly rate, transportation charges, and any materials needed to service the equipment. The invoice is issued only after the successful completion of the work. Once the repairs are completed, they are explained to the customer, and upon the customer's satisfaction, the company proceeds to finalize the invoice. All repairs and materials used, along with their corresponding charges, will be listed on the invoice. The total amount due, along with the payment deadline, will be provided at the bottom of the statement. A sample invoice format is shown in Figure 3.44.



Company: _____

Name: _____
Street Address: _____
City, State: _____
ZIP Code: _____
E-mail: _____
Phone: _____

AIR CONDITIONER REPAIR INVOICE

Invoice # _____ Date: _____

Client / Customer
Name: _____
Street Address: _____
City, State: _____
ZIP Code: _____

PRODUCTS (MATERIALS)

Description	Quantity	$ / Unit	Amount
		PRODUCTS	

LABOR

Description	Hours	$ / Hour	Amount
		LABOR	

Comments or Special Instructions:

SUBTOTAL	
DISCOUNT	
TAX	
TOTAL	

Payment is due within ____ days.

Thank you for your business!

Fig. 3.44 Air conditioner repair invoice

Check Your Progress

A. Multiple Choice Questions

1. Which of the following can be the reason for the bad smell in the air conditioner? (a) Filter choked (b) Louver direction (c) Fan motor (d) Room insulation
2. Which of the following can be the reason for a high amount of electricity consumption? (a) Fan motor (b) Louver direction (c) Filter choked (d) Room insulation
3. Which of the following can be the reason for a drainage problem? (a) Pipe clogged (b) Louver direction (c) Filter choked (d) Low refrigerant level
4. Which of the following can be the reason for an AC refrigerant leakage? (a) Fan motor (b) Loose pipe fittings (c) Filter choked (d) drainage pipe
5. Which of the following can be the reason for an air conditioner not blowing the cold air? (a) Fan motor (b) Louver direction (c) Dirty air filter (d) Room insulation

B. Fill in the blanks

1. To change the direction of the blown air ____ is used.
2. To clean the choked filter ____ is used.
3. Temperature sensor is placed near to _____ coil.
4. Lack of air circulation may result in _____ evaporator coil.
5. To repair the damage pipe fittings ___ is performed.

C. State True or False

1. Blower motor produces thumping noises
2. Printed circuit board produces a buzzing sound.
3. Frequent turn ON and OFF the air conditioner can be a reason for AC unit failure.
4. MCB is used with the AC unit.
5. Outdoor unit of the AC do not fan.

D. Short answer type

1. Demonstrate the way to replace the outdoor fan motor?
2. What are the steps to replace the indoor unit PCB?
3. Demonstrate the way to replace the room sensor?
4. What are the steps to replace the copper head coil sensor?
5. How the brazing operation is done in case of gas leakage?

Module 2 Advanced Technologies in Air conditioner

Module Overview

Over the years, the air conditioning industry has undergone significant advancements, transitioning from basic cooling units to the development of Smart Air Conditioners (ACs). This shift has been driven by the growing integration of the Internet of Things (IoT), which has revolutionized how appliances operate and interact. IoT has emerged as a transformative force in home appliances, enabling devices to be interconnected through sensors, processors, and wireless networks. This connectivity allows appliances to collect, process, and exchange data, fostering automation and enhanced user experience.

The introduction of IoT in air conditioners has allowed manufacturers to incorporate innovative features that improve both the performance and convenience of these systems. Smart ACs are designed to maintain a comfortable indoor environment while offering users control over their systems via smartphones or voice assistants. By linking air conditioners to mobile apps and the internet, users can remotely adjust temperature settings, monitor energy consumption, and even schedule operations based on their preferences. The ability to control the air conditioning system from a distance ensures that users can optimize their energy usage and ensure that their home is at the desired temperature by the time they arrive.

One of the standout features of IoT-enabled air conditioners is their ability to communicate with other smart devices and adapt to user behaviours. For instance, smart ACs can be programmed to integrate with GPS technology, which allows the system to automatically turn on or off based on the user's proximity to their home. This is achieved by setting a geographical boundary; once the user's GPS-enabled smartphone enters or exits that boundary, the air conditioner responds accordingly, interacting with the unit via Wi-Fi to adjust the temperature or power status. This feature not only adds convenience but also contributes to energy savings by ensuring the AC is only running when needed.

Furthermore, smart air conditioners allow users to predefine operational settings that match their specific preferences. These settings can be customized within the mobile application and adjusted on the go. For instance, users can set their preferred temperature for different times of the day or week, ensuring a comfortable environment while optimizing energy efficiency. This level of personalization ensures that users can enjoy the comfort of their air conditioning system while minimizing unnecessary power consumption.

The integration of artificial intelligence and real-time analytics within the IoT framework has further enhanced the capabilities of smart air conditioners. These systems can now analyze usage patterns, adjust cooling output based on room occupancy, and even predict maintenance needs before issues arise. As a result, IoT-enabled ACs offer more than just comfort; they provide users with valuable insights into their energy consumption and help reduce operating costs through intelligent automation.

Overall, the combination of IoT and air conditioning has significantly enhanced the value of these systems, providing users with greater control, energy efficiency, and convenience.

By incorporating advanced technologies like GPS, Wi-Fi, and smart automation, air conditioner manufacturers have succeeded in creating devices that are more user-friendly, environmentally friendly, and technologically advanced than ever before. Smart ACs are a clear example of how IoT is reshaping the landscape of household appliances, making homes more connected, efficient, and adaptive to the needs of their occupants.

Learning Outcomes

After completing this module, you will be able to:

- Explain the integration of IoT technology in air conditioners and its role in enhancing operational efficiency and remote accessibility.
- Identify the features and functionalities of smart air conditioners, including energy-saving modes and advanced connectivity options.

Module Structure

Session 1. IoT in Air Conditioner

Session 2. Smart Air Conditioner

Session 1. IoT in Air Conditioner

Priyanka saw her aunt operating the air conditioner using the touchscreen of her mobile phone. She then asked her aunt how this air conditioner could be operated using a mobile phone. Her aunt explained that they could operate the air conditioner even from outside the house. Priyanka learned that such air conditioners are also available in the market, allowing remote operation without being present at home.

Priyanka then searched for information about these air conditioners and discovered that they operate using internet technology and can be controlled from anywhere. Today, we are connected to the whole world from the comfort of our homes. In the same way, we can connect to our homes and the appliances within them, no matter where we are in the world. We are making good use of the internet in our everyday lives. With the advent of the internet and its decreasing costs, we continue to use it extensively.

In this chapter, we will learn about the use of the internet for various purposes, including home appliances like air conditioners, which can be controlled via internet services using a wireless network.

Internet in the Appliance

The internet is an interconnected network that links the entire world in today's modern era. Various organizations, including schools, colleges, offices, airports, railways, multinational companies, and nearly all institutions, rely on internet technology. With the help of the internet, people can communicate with IoT-based home appliances, enabling monitoring and control from anywhere.

This concept of remotely connecting to appliances is made possible by Internet of Things (IoT) technology. IoT-based appliances, such as air conditioners and refrigerators, can be controlled from anywhere in the world, providing users with convenience and flexibility in managing their home environments.

Internet-related Terminologies

As we know that IoT-based appliances use the internet to connect and operate remotely. Some of the terms, which are used in the IoT based air conditioner s are discussed below.

World Wide Web – The World Wide Web is also termed as the "www" or "The Web". It contains websites and web pages to access the Internet.

Web Page – It is a page, which can be accessed on World Wide Web. The web Pages are stored on a web server. This can be seen using a web browser.

Website – A website is a collection of web pages. In IoT-based air conditioners, one can access websites or can play songs with just one command.

Homepage – The first page of the website is called the homepage.

Web Browsers – The web pages display is called web browsers. The commonly used web browsers are Chrome by Google, Firefox by Mozilla, and Internet Explorer by Microsoft. Using the Browser app, you can access web content such as news, weather, and so much more.

Web Services – Some of the web services used in customer care services of IoT-based appliances are chat, email, E-shopping.

- **Chat –** This means that using text messages one can have a conversation with the customer care representative of the company.
- **Email –** It stands for electronic mail. Using it, one can give feedback or post any complaint or query regarding the IoT-based appliance.
- **E-shopping –** This platform helps to purchase the parts or an appliance from a site of the company or any of the e-commerce companies.

Assignment

Use the internet to search for IoT-based air conditioners. Visit the company's website and locate the customer care services information.

Appliance Connectivity using Internet Technology

In IoT-based appliances, wireless connections are utilized to link the devices without the need for dedicated cables or wires. Instead, a Wi-Fi network connects the IoT-enabled smartphone to the IoT-based appliance. Users operate a dedicated mobile application remotely to monitor and control the appliance's functionality.

Additionally, IoT-based air conditioners can be integrated with smart home systems, allowing users to control them using voice commands. Smart home systems like Google Assistant and Alexa can be paired with smart ACs, enhancing convenience and enabling hands-free operation.

Different Types of Internet Connections

Internet speed is very useful for IoT-based appliances as we need remote connectivity. In this sense, it is necessary to know about the various connections, which is possible to give a high-speed internet connection. Some of the internet connections are as follows:

1. Dial-up Connection

a. Landline telephones were used for internet connection (Figure 1.1).

b. A specific number has to be dialled and the respective internet service provider generates a line for you.

c. Its speed is also very slow from 28 Kbps to 56 Kbps.

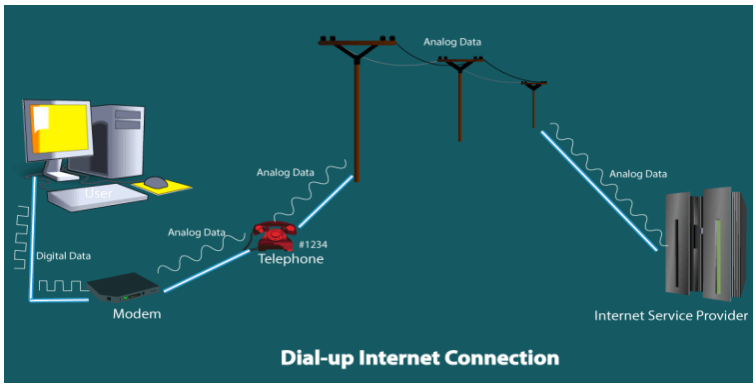


Fig. 1.1 Dial-up internet connection

2. Digital Subscriber Line (DSL)

a. In this DSL modem is used, it allows both voice and internet data can flow over the same telephone line at the same time (Figure 1.2).

b. DSL represents a high-speed connection.

c. Speed of DSL ranges from 5 Mbps to 100 Mbps.

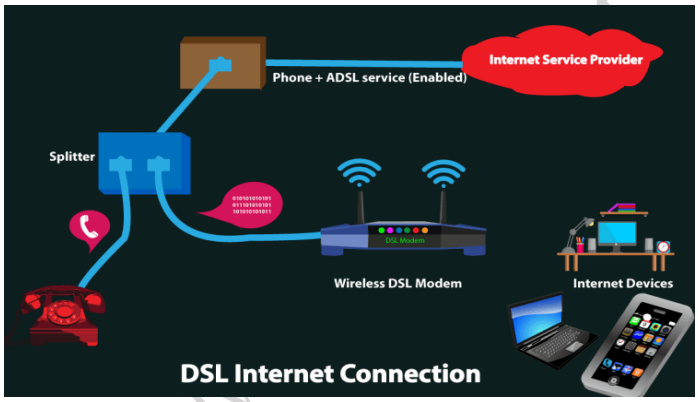


Fig. 1.2 Digital Subscriber Line (DSL) internet connection

3. Cellular

a. In this network, radio waves are used to transfer signals to and from the mobile phone (Figure 1.3).

b. Cellular towers are connected through a wire or more specifically optical fiber cable.

c. During the use of the internet, the phone transmits a signal in the form of electromagnetic waves.

d. Internet speed is 10 Mbps to 500 Mbps.

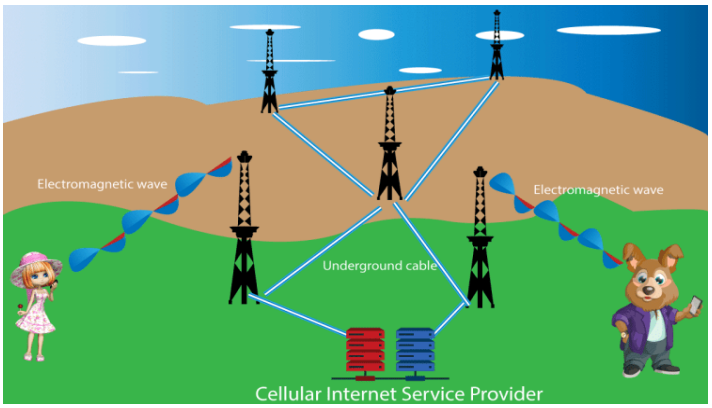


Fig. 1.3 Cellular mobile communication to access the internet services

Assignment

Students are required to study the different types of internet connections at home. Make its list and comment that which internet is best based on speed, network coverage.

Connecting appliance to the Internet

Connecting the IoT-based appliance to the internet makes life easy and comfortable. Now, we will see the steps to connect the IoT-based air conditioner to the IoT-based phone. The steps to connect the IoT-based air conditioner are as follows:

Practical Activity 1.1 Connect the IoT-based air conditioner to a mobile phone-based application

Material Required

Smartphone, Wi-Fi network, IoT-Based air conditioner.

Procedure

Step 1. Before connecting the appliance, make sure that the air conditioner and the router are powered ON and the IoT-based application is installed in the mobile phone.

Step 2. Open the IoT-based app on your mobile phone.

Step 3. Touch the Add (+) button on the home screen and then touch the device.

Step 1. Then select the brand and type of air conditioner from the list. Follow the instructions on the screen.

Step 5. Tap on the start button, select the room and location for the air conditioner. And then tap next, you will be redirected to the air conditioner screen.

Step 6. GO to the display tap settings>connections>easy connection.

Step 7. Tap connects. It will take little time to connect to your phone.

Step 8. After a few seconds, a pin number is generated on the screen of the air conditioner. Enter this pin in the mobile phone and tap on done.

Step 9. Select the Wi-Fi network on the phone, using it air conditioner will work. Tap on the connect.

Step 10. Now, the air conditioner is connected to your phone successfully. Tap on the done button.

Internet of Things (IoT) Technology

The Internet of Things (IoT) is significantly influencing our lifestyle, from air conditioners that can be controlled via IoT-based applications on smartphones to IoT-based watches that track daily activities. IoT represents a vast network of interconnected appliances, which gather and share data about their usage and the environments in which they operate. These appliances are equipped with embedded sensors that continuously transmit data regarding their operational status.

A crucial question arises, how do these devices share the vast amounts of data they collect, and how is this data utilized. IoT provides a common platform for these appliances to store their data and a standardized language for devices to communicate with one another. Data is transmitted from various sensors to an IoT platform, which ensures security. This platform integrates the collected data from multiple sources, enabling further analytics to extract valuable information as needed.

Each product is typically attached with a barcode containing essential information, including the product code, manufacturer details, and special instructions. For instance, the compressor

of an air conditioner features an embedded sensor that transmits data regarding its health and temperature.

While the internet connects humans, the IoT extends this connectivity beyond human interaction, allowing appliances and devices to communicate autonomously. This technology—termed the Internet of Things—enables devices with embedded software, hardware, and sensors to interact using internet technology. Such devices are referred to as IoT-based devices, showcasing the transformative potential of IoT in our everyday lives (Figure 1.4).

Fig. 1.4 Internet of things explanation as per the text

Building Blocks of IoT

The basic building blocks of the IoT system are:

- Sensors
- Processors
- Gateways
- Applications

All these nodes have their own characteristics to make the IoT system.

Sensors

- These are at the front end of the IoT devices. These are the "Things" of the system. The main purpose of the sensor is to either collect data from its surroundings or to send out data to its surrounding (actuators).
- These have to be uniquely identifiable devices with a unique IP address so that they can be easily identifiable over a large network.
- These have to be active in nature which means that they should be able to collect real-time data. These can either work on their own (autonomous in nature) or can be made to work by the user depending on their needs (user-controlled).
- For example – Motion detection sensors are used to sense the presence of the human being in the room or office. Using the data given by the motion sensor air conditioner can turn off or on automatically. This will save a large amount of electricity.

Processors

- Processors are the brains of the IoT system. The data collected by the sensors is processed by the processor, which extracts valuable information from the raw data. Therefore, it can be said that processors provide intelligence to the data.
- Processors operate on a real-time basis and can be easily controlled by applications. They are also useful for securing the data.

- Embedded hardware devices, such as microcontrollers, contain processors that process the data.

Gateways:

- Gateways are responsible for routing the processed data and sending it to the correct location for the correct utilization of it.
- In other words, we can say that gateway helps in transmitting and receiving the data. It provides network connectivity to the data. Network connectivity is essential for any IoT system to communicate.
- LAN, WAN, PAN are examples of network gateways.

Applications

- It is the graphical user interface (GUI) for a user. This will help to operate the machine or appliance remotely.
- It has bundles of instructions that are used to achieve certain features.
- It is having the code at its back end, which will run when we operate the app.

IoT-Based Air conditioner

IoT-based air conditioners feature a touchscreen interface and the ability to connect to the internet through Wi-Fi to provide a number of additional features. IoT-based air conditioners include smart devices connection options, more flexible user-controlled cooling options, and the ability for you to interact with its features using your IoT-based phone or tablet when away from home. Some IoT-based air conditioners can even connect with other IoT-based devices in your home; such as smart speakers, smart TVs etc.

IoT-based Air conditioner Features

IoT-based air conditioner's features may vary by brand and model. Some of the features of the IoT-based air conditioner are discussed below:

a. Use the touchscreen interface to:

- Coordinate schedules for every member of the family.
- On one-touch it can generate the power consumption report and send the details on the mobile phone.
- On one-touch filter status can be seen.
- Multi modes are available.
- Set the On and Off time of the air conditioner.
- It also capability to connect various smart devices.
- Auto clean feature.
- Create individual profiles for each family member to send them personal notes.

b. Apart from this, you can also use your IoT-based air conditioner features to:

- Customize temperature.
- Use a motion sensor that will detect the presence of humans in the room.
- Alert you when the air filter needs to be changed.
- It has rust-free technology.

Fuzzy Logic Technology

The term "fuzzy" refers to something that is unclear or ambiguous. Fuzzy logic is a method of reasoning that resembles human reasoning. This approach is similar to how humans make

decisions, as it encompasses various intermediate possibilities between a guess and the unknown.

For example, consider the question: "Is the room getting cooler because of the air conditioner?" In Boolean logic, the answer can only be "yes" or "no," corresponding to the values 1 or 0. However, when using fuzzy logic, the same question might yield different responses, such as "it's getting very cold" or "it's getting a little cold." This means that fuzzy logic allows for intermediate possibilities between "yes" and "no."

Thus, fuzzy logic provides a way to capture these intermediate possibilities in decision-making processes. This approach is particularly useful in IoT-based air conditioners, where appliances can make informed decisions based on fuzzy logic, as illustrated in Figure 1.5.

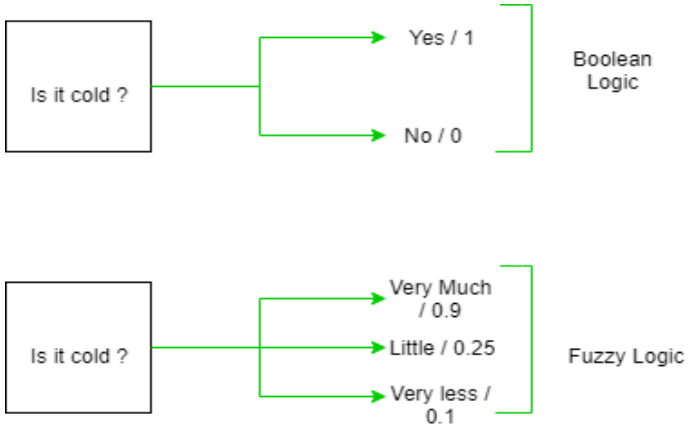


Fig. 1.5 Use of fuzzy logic

Implementation of Fuzzy Logic

Fuzzy logic can be implemented in systems of various sizes and capabilities, including IoT-based appliances. It can be utilized in hardware, software, or a combination of both. Generally, fuzzy logic systems are employed for both commercial and practical purposes, such as controlling machines. While it may not always provide precise reasoning, it offers acceptable reasoning.

For instance, when you say "certainly yes" or "possibly yes," it may not deliver an accurate answer of either "yes" or "no," but it does provide acceptable reasoning by suggesting that an outcome might occur or is likely. This ability to find a middle ground is beneficial in dealing with uncertainty. For these reasons, fuzzy logic is commonly used in advanced appliances.

Implementation of the Fuzzy Logic for the Air conditioner

This describes a quick and precise control method for domestic air conditioners. The controller, based on fuzzy logic, is designed to maintain a constant internal temperature and improve the efficiency of the air conditioner. The fuzzy logic controller ensures that the room temperature remains stable despite environmental variations, such as changes in outdoor temperature.

Fuzzy logic can effectively maintain the air conditioner's constant temperature, resulting in better performance and energy savings. In the event of environmental fluctuations, such as changes in outdoor temperature, fuzzy logic helps maintain a consistent room temperature. Therefore, it can be concluded that the use of a fuzzy logic controller provides enhanced performance, energy efficiency, and a stable temperature for the air conditioner.

Conventional Temperature Controller for Air conditioner

In air conditioners, one can set various modes of temperature. These modes are managed using high tech refrigerants. Gases like R-12 and R-22 are used as a refrigerant of the air conditioner, but nowadays because of ozone depletion potential and global warming potential, R-410A and

R-32 are used. If we see the refrigerant R-290 and R-600A, they have zero ozone depletion potential and very low global warming potential. As already studied the compressed refrigerant in the compressor flows through the heat-dissipating pipe and the capillary tube is evaporated in the evaporator. It then flows back to the compressor by the suction pipe. The evaporated refrigerant in the evaporator decreases the evaporator temperature. The fan installed in front of the evaporator ventilates the cooling air. The circulation of the cooling air is done by the on-off control of the fan. The conventional temperature control method of the air conditioner is on-off control of the compressor and the air-blowing fan.

As shown in Figure 1.6, the on-off controller in the air conditioner compares the real-time temperature of the room with the desired temperature or pre-set temperature. After comparison, the signal is generated, which is forward to the control input of the switch block of the controller. This conventional on-off control is easy to implement but is difficult to adapt to the temperature variation when there is an outer temperature change frequently. This results in temperature disturbance and more energy consumption.

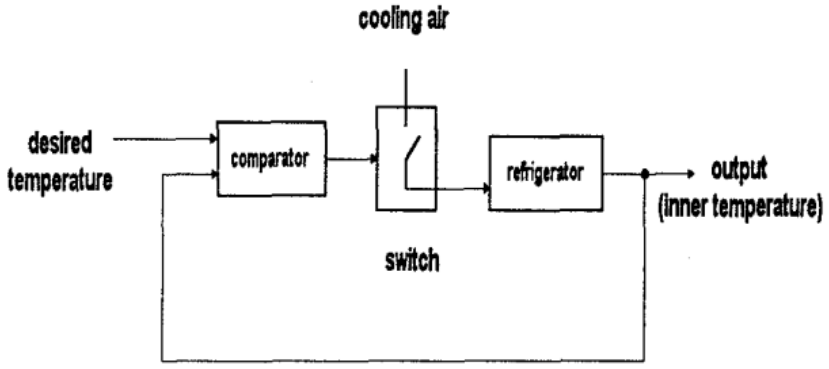


Fig. 1.6 Refine it as per the paragraph

Fuzzy Logic Controller (FLC)

The new Fuzzy Logic Controller overcomes these kinds of problems. FLC is a system that is used to control the working of a physical system with the help of fuzzy logic. Hence, it is used to control the operation of an IoT-based air conditioner as shown in block diagram of the FLC for Refrigeration Control.

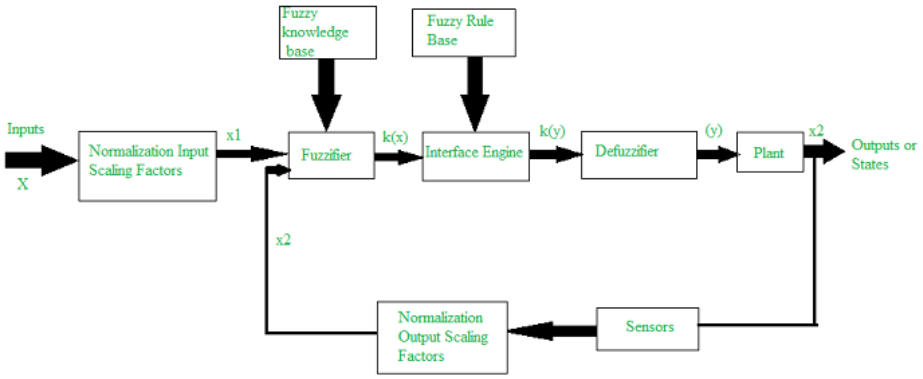


Fig. 1.7 Block Diagram of the FLC for Refrigeration Control

Block Diagram of the FLC for Refrigeration Control

a. Suppose, we assumed some target temperature 1 degree Celsius (x1) which we need to get in the air conditioner. Whereas, suppose the actual temperature (response output) is 15 degrees Celsius (x2).

b. The system will first compare both the temperatures i.e., target and response temperature. This comparison generates some difference between the two temperatures, which here we call an error.
c. This error value will go into the fuzzification module from there the crisp values are converted into the fuzzy value using a knowledge database K(x).
d. These fuzzy variables will be the input variable for the fuzzy interference system, which uses the fuzzy-based rule and takes the decision according to the predefined condition for temperature control.
e. This will generate possible actions in the form of the output variable K(y). Then the defuzzification module converts back the fuzzy output variables to the output crisp values.
f. This value will go to the air conditioner. And the air conditioner turns on the compressor. This reduces the temperature of the inside temperature of the air conditioner.
g. This further reduction in the indoor temperature is sensed by the sensor. The sensor then relays this information back to the fuzzy logic system, which adjusts the desired temperature accordingly.
h. Once the desired temperature is achieved and the error value is zero, the fuzzy system commands to stop the air conditioner's compressor.

Components of the Fuzzy Logic Controller

a. **Fuzzification –** Converts crisp values to fuzzy values using knowledge base data. It uses membership functions to define the input variables into fuzzy variables.
b. **Fuzzy Interference System (FIS) –** It consists of a fuzzy rule base set that takes fuzzy variables as inputs and generates possible fuzzy outputs, given as input to defuzzifier.
c. **Defuzzification –** Converts the fuzzy values into crisp values using various deification variables. These crisp values are used in the physical machine.

Check Your Progress

A. Multiple Choice Questions

1. Which of the following is not the building block of the IoT system (a) Sensors (b) input device (c) Processor (d) Gateways
2. The first page of the website is called the ____. (a) website (b)homepage (c) World wide web (d) document
3. Which of the following refrigerant is used in the air conditioner. (a) R-12 (b) R-22 (c) R-20 (d) R-134a
4. When the customers use electronic means to purchase the IoT-based appliance is ___. (a) E-shopping (b) Email (c) E-commerce (d) E-banking
5. FLS stands for – (a) Fuzzy Interior System (b) Filtering Interference System (c) Fuzzy Interference System (d) Fuzzy Interrupt System

B. Fill in the blanks

1. Fuzzy logic is a method of _____ that resembles human reasoning.
2. Gateways are responsible for routing the _____and sending it to correct locations for its (data) proper utilization.
3. Processors are the brain of the _____ system.

4. Sensors are used either to collect ____ from their surroundings or to send out data to its surrounding.
5. In the process of fuzzification crisp values are converted into ____ values.

C. State whether the following statements are True or False

1. Email means electronic mail.
2. The World Wide Web is also termed as the "WWW" or "The Web".
3. Fuzzification, Defuzzification are only components of the fuzzy logic controller.
4. Cellular internet network has internet speed ranging from 10 Mbps to 500Mbps.
5. In IoT-based appliances, wired connections are used for connecting the appliance.

D. Short Answer Questions

1. What is internet technology?
2. What is IoT?
3. How fuzzy logic technology can be used in the IoT-Based air conditioner?
4. What are the roles of sensors in the air conditioner?
5. Write the name of the components used in the fuzzy logic controller?

Session 2. Smart Air Conditioner

Geeta shared her busy routine and hectic schedule with her friend. After listening to her struggles, her friend suggested using smart appliances and highlighted their benefits. Following her friend's advice, Geeta purchased and began using smart appliances.

As a result, Geeta realized how much free time she gained by incorporating these devices into her life. She started managing her tasks more efficiently, allowing her routine to be completed more quickly and on time, ultimately saving a significant amount of time.

In this chapter, we will explore smart air conditioners, their advantages, and the latest technologies being integrated into IoT-based air conditioners.

Smart Air Conditioner

In the market, you will find a number of smart appliances such as air conditioners, washing machines, smart lights, and smart refrigerators. The smart air conditioner can smartly manage the functions like temperature control, humidity, sensing the freshness of the air inside the room. Nowadays, Wi-Fi enabled air conditioners are available in the market. They can be connected to the mobile phone using the internet (Wi-Fi).

Smart air conditioners come equipped with motion sensors and voice command capabilities, allowing them to intelligently respond to user commands and detect the presence of people in the room. Even when the user is not at home, they can still issue commands to their IoT-based air conditioners through a dedicated application. (Figure 2.1)

Additionally, a smart air conditioner can connect with other smart devices in the home, such as speakers, smart TVs, and microwaves. These high-tech air conditioners are programmed to automatically detect the most suitable mode based on the outside environmental temperature. They also provide valuable information about common issues, such as air filter blockages or drainage problems, ensuring optimal performance and convenience.

Fig. 2.1 Smart air conditioner (Person is in the office and remotely operating the smart air conditioner, which is at home)

A smart air conditioner uses various advanced technologies such as Auto clean Technology, Anti-corrosive technology, Sixth Sense technology, Taste guard technology, Convertible technology, Bluefin technology which makes them suitable appliances to function easily. Let us see one by one.

Auto Clean Technology

- ✓ The term auto clean refers to the air conditioner that cleans itself without using manual work.
- ✓ Air conditioner having this technology has the capability to clean themselves. They are designed to monitor gases leakage and many more.
- ✓ The self-cleaning air conditioner is a highly intelligent appliance. It detects contaminated air inside the room and, based on the set parameters, changes the mode of the air conditioner accordingly.
- ✓ Smoke and leak detectors are integrated into these air conditioners, allowing them to sense potential problems. When an issue is detected, the system immediately generates a notification, sending a message to the registered mobile phone. Additionally, it alerts users through a voice message or an error code displayed on the air conditioners buzzer. (Figure 2.2)

Fig. 2.2 Smoke and leak detection

Anti-corrosive Technology

- ✓ Corrosive means the chemical that deteriorates the surface of the objects.
- ✓ It acts by chemically destroying the surface of the metal. It is a natural process. In air conditioners, corrosion occurs when the moisture combines with environmental dust, dirt, or salt.
- ✓ Slowly this excessive dust accumulation combines with the moisture to create a chemical reaction resulting in the destruction of the metallic surface.

- ✓ Hence, anti-corrosive technology is needed to prevent the surface of the appliances from corrosion.
- ✓ Some of the factors that are used in corrosion prevention are as follows.
- ✓ *Material Selection* – Steel is a combination of iron and carbon. But when the material named chromium is added to this steel the stainless steel is made. Chromium is an invisible chemical layer that protects the metal from heat, moisture, and chemical exposure. It is an anti-corrosive material used for making the body of the indoor and outdoor unit of an air conditioner.
- ✓ *Design of the equipment* – Corrosion can frequently occur in dead places or crevices and hence it is necessary to eliminate or minimize it while designing.
- ✓ *Correct Cleaning* – Only use mild soap or cleaners designed for stainless steel to clean appliances. Use soft cloths and wipe in the direction of the steel grain. Never use abrasive materials such as steel wool, scouring pads, or other abrasive materials that can scratch the steel and remove the protective chromium layer. (Figure 2.3)

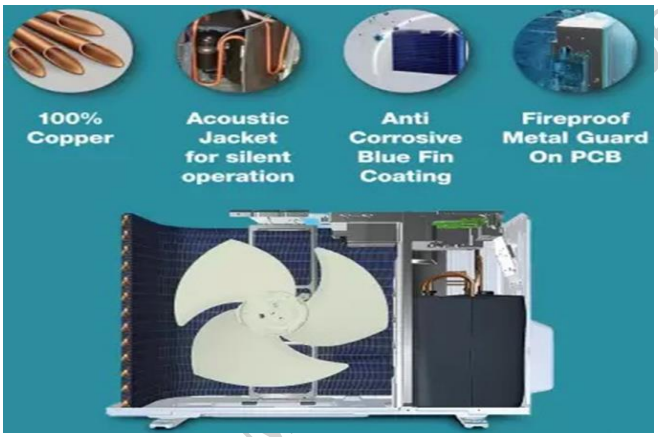


Fig. 2.3 Cleaning of AC parts

Sixth Sense/Smart Cooling Technology

This technology helps maintain optimal temperatures in the room by automatically adjusting the temperature based on external environmental conditions and the number of occupants present. Equipped with motion sensors, it can detect movement in the room and provide information about occupancy. This cutting-edge technology is a hallmark of modern air conditioners (Figure 2.4). Some features of sixth sense technology include:

- ✓ It is technology to discover an extra sense for long-lasting air freshness.
- ✓ Constantly checks the temperature and humidity levels.
- ✓ When the sensor detects the temperature increase. The compressor is activated. And the temperature is restored five times faster.
- ✓ To offer an optimal temperature in the room.
- ✓ The sensor also detects the humidity variation.
- ✓ Aallows the fan to distribute humidity according to this feedback.

Fig. 2.4 Smart cooling technology

Air Guard Technology

This technology helps maintain the freshness of the incoming air by being placed at the air inlet of the indoor unit. It utilizes UV LED light to kill harmful airborne bacteria and viruses. Additionally, it is equipped with a sensor that monitors the overall air quality in the room. This cutting-edge technology is a key feature of modern air conditioners. Some of the features of the air guard technology are:

- ✓ For Maintaining the freshness of the air is essential for a healthy lifestyle.
- ✓ This technology is particularly beneficial for densely populated metro cities, where air pollution is a significant concern. The additional filtration helps purify the air in the room.
- ✓ It keeps the air fresh for an extended period.
- ✓ Air Guard filters also eliminate unpleasant odors in the room. This is especially important during the rainy season when humidity levels rise, leading to increased bad smells as shown in Figure 2.2.
- ✓ Furthermore, it disinfects the indoor air we breathe, making this technology especially valuable for public buildings such as hospitals.

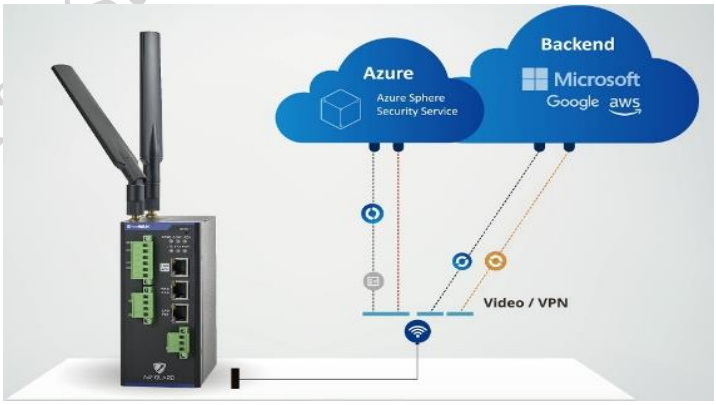


Fig. 2.5 Air guard filter

Dual Inverter Technology

This revolutionary technology enhances the performance of air conditioners, allowing them to operate more efficiently. A dual inverter air conditioner is an improved version of the standard inverter air conditioner available on the market, showcasing innovative advancements in air conditioning technology.

The dual inverter system utilizes a twin rotary compressor, which enables a single compressor to achieve increased compression at a lower RPM (revolutions per minute). The operation of the twin rotary compressor is similar to that of two compressors in a standard inverter air conditioner (Figure 2.6). This design helps to avoid high-speed operation, thereby reducing vibration and power consumption. Some of the features of the dual inverter technology are as follows:

- ✓ There are various air conditioners in the market.
- ✓ The goal is to achieve quick cooling with maximum power efficiency.
- ✓ This technology also reduces the electricity bills
- ✓ This technology also helps to works in silent mode.
- ✓ It has reduced the vibration of the compressor in the cooling mode.

Fig. 2.6 Dual inverter technology

Blue Fin Technology

Blue Fin technology utilizes an epoxy coating on the coils of the air conditioner, which helps prevent corrosion of the condenser caused by humidity, salty air, harsh climates, and moisture. This technology enhances the efficiency and longevity of the air conditioner (Figure 2.7).

- ✓ It prevents all types of corrosion.
- ✓ It prevents the accumulation of salt and acid deposits but also provides the protection of the coils from water droplets.
- ✓ It allows the refrigerant to conduct better heat and increases the cooling capacity of the air conditioner.
- ✓ It also keeps the dust and wastes out of the coils. Hence, the coil is protected from atmospheric salinity. This helps in the conservation of energy in the air conditioner.

Fig. 2.7 Bluefin coating on the condenser of the air conditioner

Air Curtain Technology

An air curtain is a fan-powered device that creates an invisible air barrier over a doorway, effectively separating two environments while allowing people to pass through. This innovative air screen can save up to 80% on heating and cooling costs, protecting the interior environment and enhancing overall comfort. It helps prevent the entry of pests and insects, dust, airborne pollutants, odors, and drafts, as well as controlling the influx of cold or hot air.

The operation of an air curtain relies on a high-velocity jet of air that covers the entrance. Heated air curtains generate a jet of air that provides comfort to individuals as they pass through while helping to maintain the temperature at the doorway (Figure 2.8).

Internal fans compress the air entering through the intake grille, filtering it before forcefully directing it through an air outlet aimed at the entryway. The filter safeguards the internal components, such as the heat exchanger and fans, from dust and particles. The fans in an air curtain can be either direct or belt-driven.

Some features of air curtain technology include:

- ✓ It maintains the heat inside the mall or an area.
- ✓ It maintains the cleanliness and hygiene inside an area.
- ✓ In the days of summer, it maintains the cooling inside an area.

Fig. 2.8 Air curtain technology

Four-Dimensional (4D) Airflow in Air Conditioner

Traditional air conditioners use a two-way swing blade, primarily up and down, to distribute cool air in a space. However, most air conditioner brands now provide air conditioners with 4D airflow, which incorporates up, down, and right-to-left movement and better distributes the cooler air in the room as shown in Figure 2.9. A motorized horizontal and vertical swing feature is included in the 4D airflow in air conditioners. The omnidirectional airflow mechanism also ensures that the room is kept cool in a uniform manner. Some of the features of the 4D airflow technology are as follows:

- ✓ It uniformly distributes the air in the room.
- ✓ It takes less time to cool the room.
- ✓ It is more energy-efficient technology.
- ✓ It maintains the air circulation in the room and air conditioner.

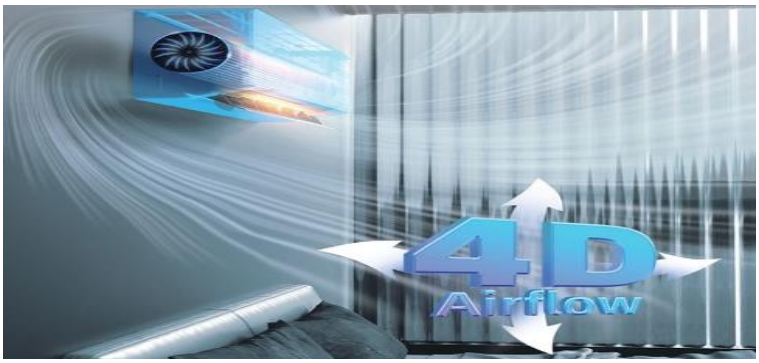


Fig. 2.9 4D air flow technology

Voltage Stabilization Technology

The power fluctuation, due to any reason, will result in a sudden rise and fall in the input power. These fluctuations can damage the appliance such as the air conditioner, refrigerator, television etc. Air conditioners are very commonly affected appliances due to power fluctuations (Figure 2.10). To stabilize, this issue an additional device is used called a voltage stabilizer. If the supply voltage is low or fluctuating, the stabilizer detects it, raises it to the required amount of voltage, and then feeds it to the connected air conditioner. So, it can work without problems. Some of the features of the voltage stabilizer are as follows:

- ✓ It provides a constant voltage to an air conditioner even during voltage fluctuations.
- ✓ It increases the life of the appliance.
- ✓ It reduces circuit failure.

Fig. 2.10 AC stabilizer

Acoustic Insulation Compressor Jacket

It is special technology designed for the compressor. Their primary aim is to reduce the noise generation of the compressor. A specially designed acoustic jacket is provided with the compressors to reduce unwanted noise and vibration to experience silent cooling.

Compressor acoustic enclosures are constructed using an acoustic construction panel system for walls and roofs (Figure 2.11). The acoustic panel can be provided with different ratings designed as per the noise reduction requirements. This acoustic panel can be easily and fast installed on time due to its prefabricated nature. The acoustic panels can be reused or rebuilt in a different location of the compressor.

- ✓ It reduces the noise in the outdoor unit
- ✓ It increases the life of the compressor

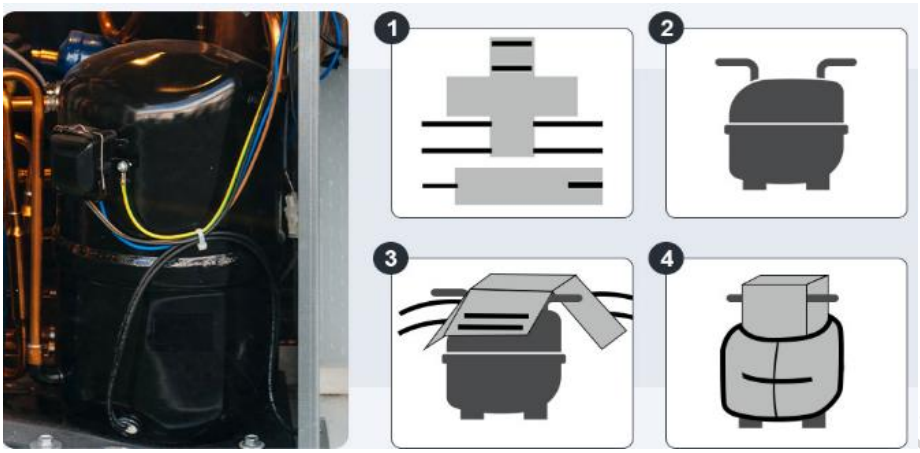


Fig. 2.11 Acoustic Insulation Compressor Jacket

Check Your Progress

A. Multiple choice questions

1. Smart air conditioner can be connected through the ___. (a) Internet (b) Laptops (c) Tablets (d) MAC
2. Which of the following device is used for voltage stabilization? (a) Compressor (b) Voltage stabilizer (c) Suction inlet (d) Fan motor
3. Corrosive means the chemical that _____the surface of the objects. (a) is painted (b) deteriorates (c) protects (d) erodes
4. Smart air conditioner has the capability to clean itself using (a) Anti-corrosive Technology (b) Taste guard Technology (c) Auto Clean Technology (d) Convertible technology
5. Prevention of corrosion is done by ___. (a) Anti-corrosive technology (b) Taste guard Technology (c) Auto Clean Technology (d) Convertible technology
6. One of the best anti-corrosive materials used for making the body of the air conditioner is ___. (a) Plastic (b) Copper (c) Stainless steel (d) Steel
7. Which of the following part is covered with an acoustic insulation jacket. (a) Fan motor (b) Electrical panel (c) Compressor (d) Evaporator
8. The Blue Fin technology prevents ___. (a) Corrosion (b) Moisture (c) Dust (d) Oder

B. Fill in the Blanks

1. Smart air conditioner can be connected to the_____ through the Wi-Fi using the touchscreen interface of the air conditioner.
2. The term auto clean refers to the air conditioner that ____itself out without using manual work.
3. The Self-cleaning air conditioner detects the _____by its odor or bad smell.
4. Corrosion can frequently occur in the ____or crevices and hence it is necessary to eliminate or minimize it while designing.
5. The air guard technology uses _____ to kill airborne bacteria and viruses.

C. State whether the following statements are True or False

1. The Blue Fin technology means the coating of the coils of the air conditioner with anti-corrosive materials.
2. 6th sense technology is intelligent enough to become accustomed itself to the varying temperatures.
3. Air curtain technology is used at home.
4. One of the best anti-corrosive materials used for making the body of the air conditioner is Stainless steel.
5. An insulated jacket is used to cover the evaporator of the indoor unit.

D. Short answer questions

1. What are Smart Air conditioners?
2. What is Auto Clean Technology?
3. What is Anti-corrosive Technology?
4. What is Sixth Sense Technology?
5. How the four-dimensional cooling is done in IoT based AC.
6. What is Air Guard Technology?
7. What is Air curtain Technology?
8. What is Blue Fin Technology?
9. How dual inverter technology is better than inverter technology?

Module 3 Troubleshooting of IoT based Air Conditioners

Module Overview

The primary goal of technology is to simplify people's lives. For instance, if someone misplaces the AC remote control or wants to manage the air conditioning system in a building from anywhere, there is now a straightforward solution that doesn't require any hardware modifications to the air conditioner.

To meet the demands of modern living, IoT-based devices offer a solution for connecting and controlling gadgets via internet-enabled devices. An IoT-based solution has been developed that allows users to control air conditioners remotely from anywhere in the world using their smartphones.

An application may be created to facilitate the monitoring of air conditioners. Authorized personnel can access the application to oversee the air conditioning units at any time and from any location. The web server stores all data in the cloud, providing resources for further analysis.

While operating the application, users may encounter common problems that can be resolved through the app itself. This unit also addresses issues related to software and hardware. Additionally, various network cables and connectors used in IoT-based air conditioners are discussed. A home automation application is included to demonstrate how home automation functionality works.

Learning Outcomes

After completing this module, you will be able to:

- Analyze the role of IoT applications in air conditioners to improve automation, monitoring, and user convenience.
- Diagnose and resolve common software-related issues in air conditioners using systematic troubleshooting methods.
- Identify and repair hardware faults in air conditioners by applying effective diagnostic techniques.
- Understand the types and functionalities of network cables and connectors used in IoT-enabled air conditioning systems.
- Explore the features of IoT mobile applications for air conditioners, including device control, monitoring, and maintenance scheduling.

Module Structure

Session 1. IoT Application in Air Conditioner

Session 2. Troubleshooting Software Issues

Session 3. Troubleshooting Hardware Issues
Session 4. Network Cables and Connectors
Session 5. IoT Mobile App

Session 1. IoT Application in Air Conditioner

In recent years, the Internet of Things (IoT) network has been integrated into various smart gadgets, which are advancing rapidly. Modern appliances, such as smart air conditioners, have transformed the way we control, maintain, and monitor these devices remotely. Given that these appliances operate for long hours, real-time problems may arise during their use.

Identifying and resolving these common issues through an IoT application is essential. Interfacing with the application enables users to troubleshoot problems effectively. In this chapter, you will learn how to rectify issues in a smart air conditioner using an IoT application.

IoT-based Air Conditioner

An IoT-based air conditioner represents the next generation of refrigeration technology. In the past, appliances like air conditioners needed to be operated through physical connections. However, with advancements in Internet of Things (IoT) technology, managing appliances at home or in the office has become much easier. IoT enables remote operation of these devices, transforming simple gadgets into smart appliances.

Despite these advancements, some issues may arise during the installation of an air conditioner. These problems can be addressed using an IoT-based application. Such an application allows users to monitor and manage the IoT-based air conditioner effectively. Through the app, users can receive notifications from the air conditioner and perform actions remotely.

Now, let us explore how to navigate and utilize the IoT-based application for managing air conditioners.

Smartphone Application of IoT-based Air conditioner

Each brand of IoT-based air conditioner typically comes with its own dedicated smartphone app. In this textbook, we will focus on the Samsung IoT-based air conditioner, which is operated using the "SmartThings" application. Now, let's explore the role and architecture of this application.

SmartThings

SmartThings is one of the largest platforms for connected devices, encompassing over a billion Samsung devices and appliances and serving millions of customers. This technology is driving the transformation of traditional homes into smart homes.

SmartThings provides a platform that allows IoT devices to interoperate and communicate, enabling smarter living solutions that enhance our everyday lives. It features a unified set of capabilities, an intuitive mobile user interface (UI), and voice control compatibility with Amazon Alexa, Bixby, and Google Assistant.

SmartThings Architecture

It is important to understand the basic principles behind the SmartThings Platform. In this section, we will define several key components pf SmartThings Platform.

SmartThings Platform

This platform has all of the components required to execute the functions and capabilities of the SmartThings ecosystem. This includes executing a user's request, enabling device and cloud-to-cloud communication, running automation, monitoring events in a user's home.

SmartThings Cloud

It is the part of the platform, which is responsible for ensuring automation is executed, for maintaining appliance health. The SmartThings Cloud is built using standard data entities. Appliance and connected services use these data entities to display data, track events, trigger automation.

For example, a door sensor of an IoT-based air conditioner will send the information to the SmartThings Cloud. The SmartThings Cloud will notify the motion event, send notifications, and perform any other actions.

Users and Accounts

An account is required to access the SmartThings Platform. Multiple users, or members, may have access to a shared location, but only one user is considered the owner of a Location. Any member of a given location typically has access to all properties and associations of the location.

Location

Locations are created by users within the SmartThings app to logically group hubs, devices, and automations together. Each location is typically tagged with geolocation and can include rooms, devices, hubs, and automation scenes. Additionally, each location is associated with a location owner and may include other SmartThings user accounts, referred to as "Members."

Locations can be identified and managed using a unique Location ID, with a user allowed to associate up to 10 locations. Modes are always linked to locations and represent the user-specified state of a location, such as "Away," "Home," or "Night." These modes are particularly useful for automation purposes.

Rooms

They are also typically created by users in the SmartThings app, are a subgroup that exists inside a Location. A room is used to group Devices and Hubs.

Devices and Hubs: They are physical products that connect to the SmartThings Platform. Types of Devices include-

- **Cloud Connected Device –** Devices that communicate with the SmartThings Cloud through a third-party cloud.
- **Direct Connected Device –** Devices that connect directly to the SmartThings Cloud via Wi-Fi.
- **Mobile Connected Device –** Devices that communicate with the SmartThings Platform via a mobile device.
- **Hub Connected Device –** Devices that connect directly to a SmartThings Hub to communicate with the SmartThings Platform.
- **Hub –** It connects to the SmartThings Cloud and provides Platform connectivity for Hub Connected Devices.

Automation

They are used to automate Devices and Connected Services that are on the SmartThings Platform.

Conceptual Architecture of SmartThings

Here's an overview of how these concepts work together on the SmartThings platform. The connection diagram of the complete smart home setup is shown in Figure 1.1. In this example, there is one user account associated with a location named "Location1." Within this location, the user has allocated two rooms, referred to as Room 1 and Room 2.

In Room 1, mobile-connected devices and the SmartThings hub are linked to the SmartThings cloud. Similarly, Room 2 contains both directly connected and cloud-connected devices that are also connected to the SmartThings cloud. Users can control these devices using the SmartThings application on their smartphones.

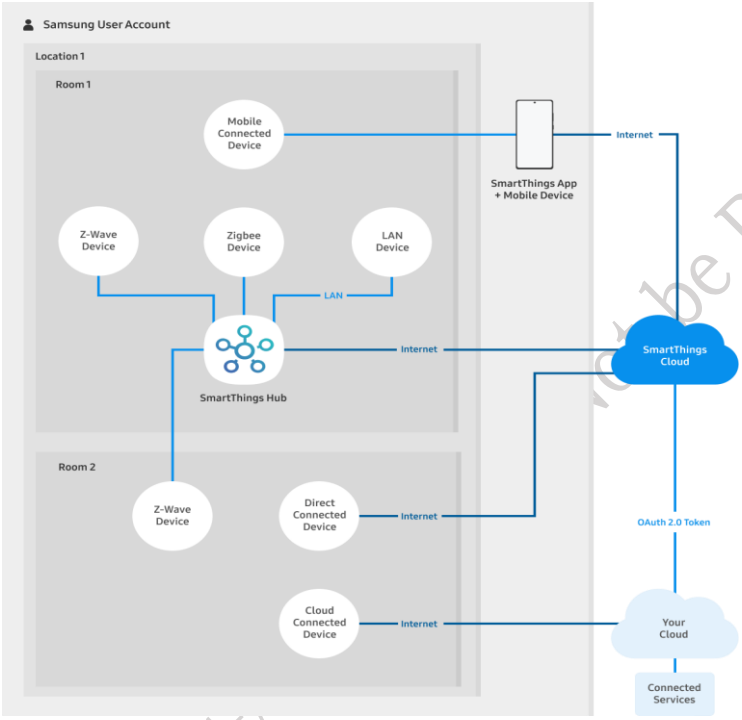


Fig. 1.1 Connection diagram for smart things complete setup

Interfacing of SmartThings

Now, we understand and explore the interfacing of the application. This will help the way to operate the IoT-based application. Firstly, we will see the steps to install the IoT-based application from the play store.

Practical Activity 1.1 Demonstrate to install the application on the mobile phone.

Material Required

Mobile phone, Internet connectivity, google account Id.

Procedure

Step 1. Open the Google Play store with registered Google account on your phone.

Google Play

Fig. 1 Google play store symbol

Step 2. Select the search box and write the "SmartThings". You will see an application having an icon as shown in Figure 2.

SmartThings

Fig. 2 SmartThings icon

Step 3. To check that the app is reliable, under the app's title, check the star ratings and the number of downloads.

Fig. 3 Star ratings of the app

Step 4. Click and install the application.

Fig. 4 Installation icon

Now, let us see the interfacing of this application in our mobile phones. When you click on the icon of the SmartThing's application, it will take you to the application. In the beginning, a home page will open. It contains options like, (a) My home, (b) Add option, (c) Favourites, (d) Devices, (e) Life, (f) Automation, (g) Menu as shown in the Figure 1.2.

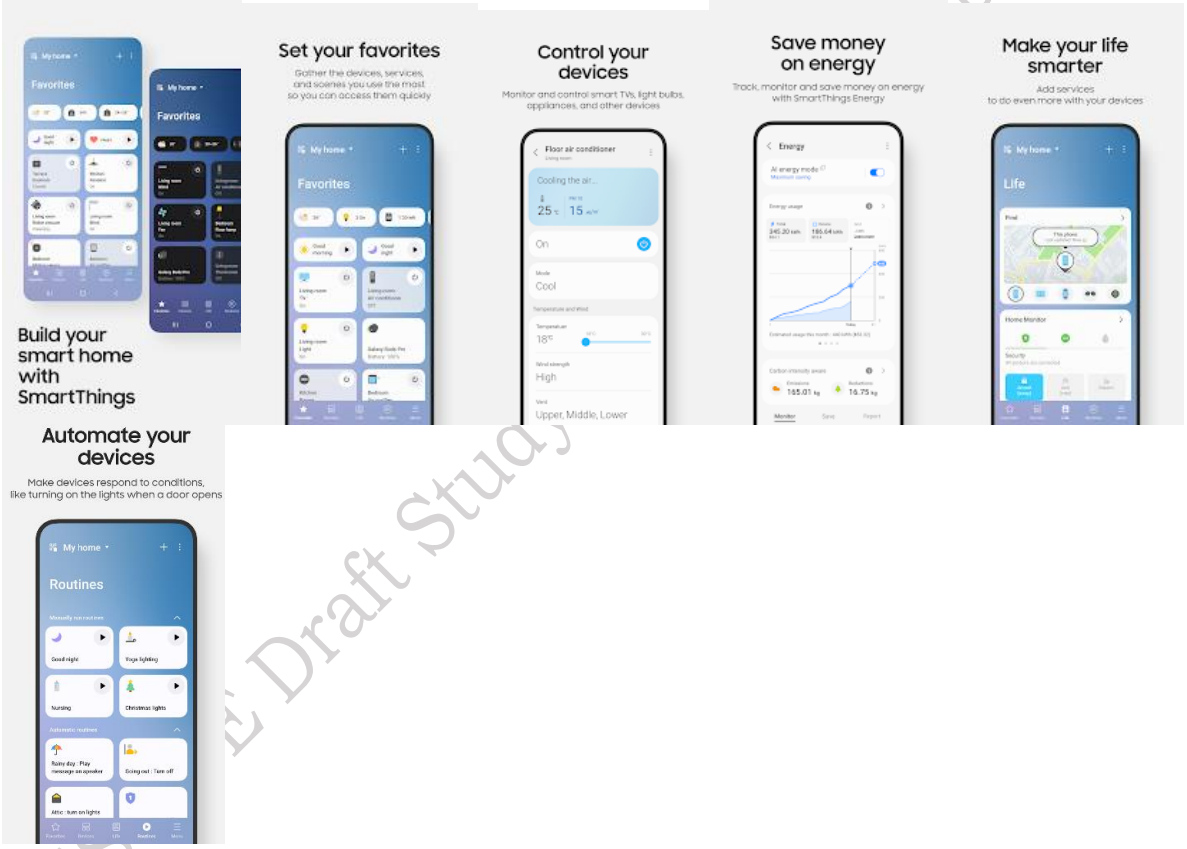


Fig. 1.2 Interface of SmartThings app

My home – This option is used to manage the locations. Tap on my home>manage locations, to get the information about the number of members and rooms. The owner can change the settings. To change the settings, tap on my home, from here you can manage you home such as location name, geo-location, location mode, manage members, manage rooms, wallpaper etc. Apart from this, you can also remove the locations.

Add option – Tab it to add icons on the home screen like device, services, scene, routine, member.

Favourites – This helps the application to gather information like the number of devices, scenes, and services that you use most often here.

Devices – This will use to add the devices. Devices can be added based on the device type or brand. Device type includes air conditioner, refrigerator or washing machine. Brand include Samsung, LG, Bosch etc.

To connect the device to the application, scan the QR code mentioned on the device and connect using Wi-Fi and Bluetooth technology.

Life – You can manage the home appliances using the latest AI technology by connecting them to smart things to make life smarter. It has a homecare Wizard, smart things home monitor, smart things cooking, and smart things energy etc.

Automation – This option will make the device to respond automatically to different circumstances.

Menu – It includes the history, notifications, how to use, notices, Android auto, voice assistant, Labs etc.

Tap the 3 dots on the top right side of the screen to further explore the home page then you will get two options i.e., "edit favourites" and "show status information".

1. When you click on the edit favorites you will get the option to add the items to the favorites list. Apart from this it also has an option of home care wizard.
2. When you click show status information, you can enable or disable it. If you enable it, then it will show your location at the top of the screen. This information includes weather, low battery, security alerts, appliance status, and many more.

Way to Use Air conditioner with SmartThings Application

Connect your Samsung air conditioner to the SmartThings app and manage it with just the touch of a finger. The SmartThings app allows you to control the air conditioner's temperature and discover the most efficient ways to keep your room fresh using your mobile device.

The SmartThings app serves as a simple, user-friendly remote controller for your appliance. To access the various convenient functions of your air conditioner via the app, connect the air conditioner to the SmartThings app on your smartphone. Simply tap the desired function categories to manage your settings.

Before you start, ensure that both the air conditioner and smartphone are connected to a Wi-Fi network. All functions require a Wi-Fi connection. Additionally, synchronise your Samsung account and the SmartThings app with the air conditioner. Please note that the connection process and available features may vary depending on your air conditioner model.

Practical Activity 1.2 Demonstrate to the IoT based air conditioner to pair your smartphone.

Material Required

Wi-Fi enabled mobile phone, IoT based air conditioner, Smart thing app. installed on mobile phone.

Procedure

Step 1. Turn on the Wi-Fi function to pair your smartphone with the air conditioner.

Step 2. Press and hold the timer button for 5 or more seconds.

Step 3. When you turn on the Wi-Fi function, your smartphone pairs with the air conditioner, the (Transmit) indicator blinks and AP (AP) appears on the remote-control display for a few seconds.

Step 4. Once your smartphone is connected to the air conditioner, you can control it via the wireless Internet using the SmartThings app installed on smartphone (Figure 1.3).

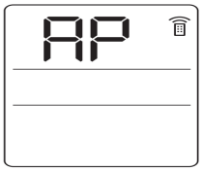


Fig. 1.3 AP display on remote control

Table 1.1 Common Problems in Handling SmartThings app

Peripherals	**Android**	**iOS (iPhone)**
OS	Android 1.0 or more	iOS 10.0 or more
Device Type	Smartphone, Tablet	iPhone 6 or more, iPad
Ram Size	2 GB or more	2 GB or more
Support resolution	1280*720 (HD) 1920*1080 (FHD) 2560*1440 (WQHD)	1334*750 1920*1080
App preload criteria	RAM 2 GB or more Bluetooth profile 4.0 or higher Terminal capable of Wi-Fi mirroring	RAM 2 GB or more Bluetooth profile 4.0 or higher Terminal capable of Wi-Fi mirroring

Users often face difficulties in establishing a connection between the SmartThings app and their Samsung air conditioner or other smart devices.

SmartThings is a function that conveniently controls and manages smart home appliances and Internet of Things (IoT) devices using a smartphone. From outside, you can monitor and control the status of various devices (Figure 1.4). However, users often face some problems when handling the SmartThings app. Here, we will learn the systematic way to connect to an air conditioner.

Fig. 1.4 AC handling and maintenance

Connect SmartThings app to Air Conditioner

Step 1. Sometimes peoples use the wrong mobile configuration, which does not support the features of the application. Check the requirements for the connection. Before connecting your smartphone to the air conditioner, make sure that all the connection requirements are met:

Step 2. Once configuration check is done. Connect your smartphone to the Wi-Fi network.

On a smartphone: Tap Settings → Connection → Wi-Fi → Select a router to connect to (enter the password). When connected correctly, the selected router in the current network is confirmed as "connected".

Note. Check the below configuration

- Router name (SSID) is set in English, symbols, and numbers (special characters are not supported).
- 2.4 GHz connection available when connecting to an air conditioner to the Wi-Fi network.
- At least 3 Wi-Fi network receiving antennas should be displayed.
- When connecting your home appliance to your smartphone with SmartThings, ensure both devices are connected to the same router.

Step 3. Once the Wi-Fi setup is complete on your mobile phone, download and install the SmartThings app from the relevant app store (Google Play Store, Apple App Store, or Samsung Galaxy Apps). After the installation is complete, locate the app by searching for the keyword "SmartThings.

Step 4. This step is crucial because entering the wrong username or details may prevent the user from operating the app. To set up a Samsung account, users must sign in before using the SmartThings app. Users can follow the instructions provided by the SmartThings app to create a Samsung account. Alternatively, if a user has a Samsung smartphone, they can add their Samsung account through the settings app on their device. Once added, the smartphone will automatically sign in to the Samsung account.

Step 5. Connecting smartphone to the air conditioner

1. First, make sure that air conditioner and Wi-Fi router are connected to the power.

2. Launch the SmartThings app. Tap the plus button and select [Add a device] on the home view as shown in Figure 1.5.

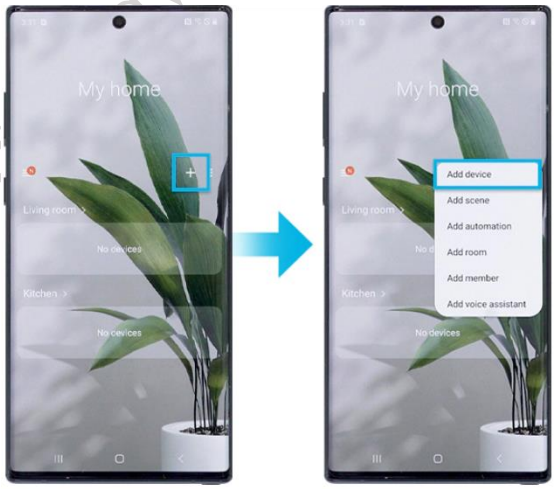


Fig. 1.5 SmartThings app on mobile phone

3. Select the "Air conditioner" "Room air conditioner" in order as shown in Fig. 1.1.

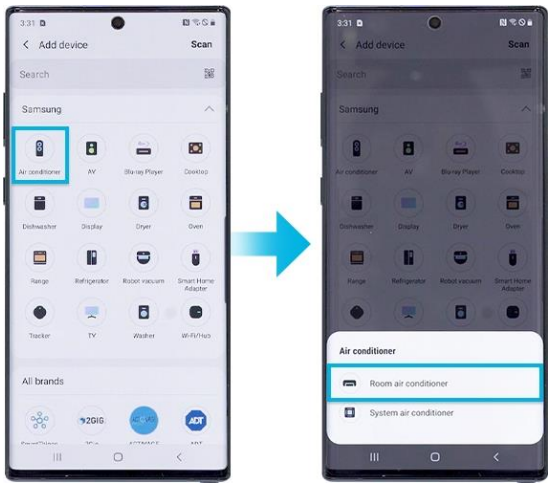


Fig. 1.6 Selection of appropriate icon for air conditioner

4. Tap the "Start" button.

5. Select your preferred location and room for the air conditioner and tap Next on the bottom screen as shown in Figure 1.7.

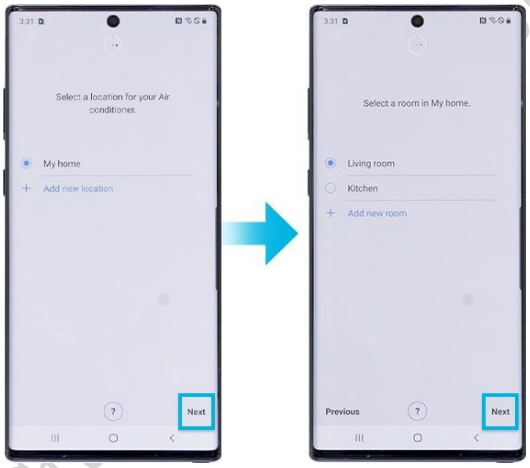


Fig. 1.7 Preferred location selection

1. Press and hold the Timer button on the remote control until the air conditioner icon appears in the app. It may take some time to connect the device to the Internet as shown in Figure 1.8.

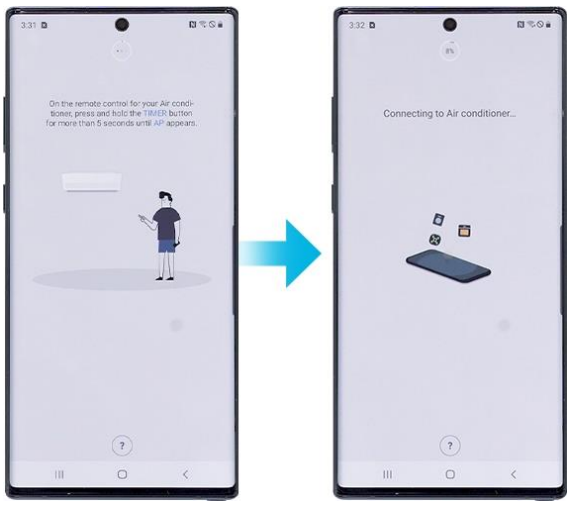


Fig. 1.8 App connection with AC

7. Press the power button on the air conditioner as shown in Figure 1.9.

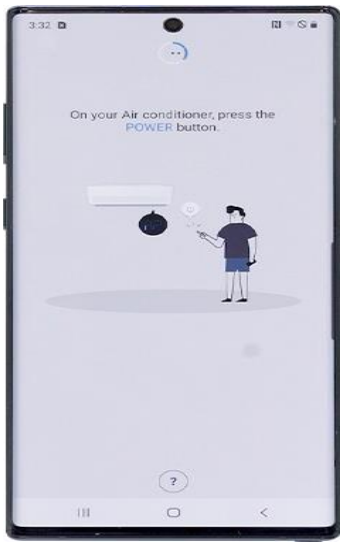


Fig. 1.9 Powering the AC

8. Enter the Wi-Fi information to connect both of them as shown in Figure 1.10.

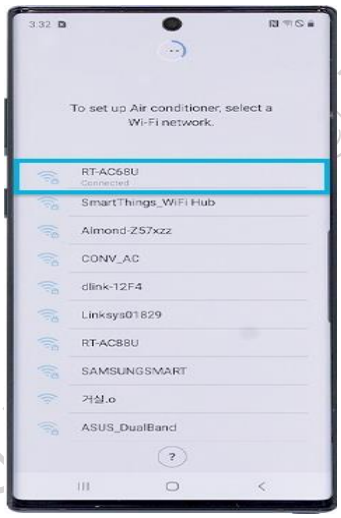


Fig. 1.10 Selecting a Wi-Fi network

9. Please, wait until the air conditioner is registered with your Samsung account.
10. The registration is complete. Set the name of the air conditioner as shown in Figure 1.11.

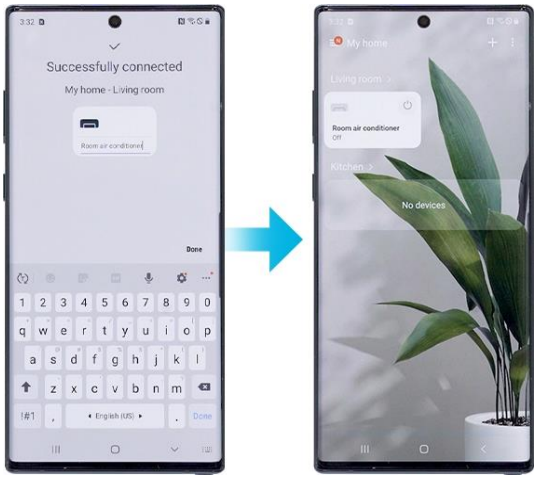


Fig. 1.11 Naming the air conditioner

Note:

a. All functions and step descriptions related to the SmartThings app differ depending on the software version.

b. When using mobile data, costs may be incurred depending on downloads and wireless communication between devices.

c. Available technologies and functions may vary depending on the country, service provider, network environment, or product.

Features of SmartThings Application

The SmartThings home screen categories may vary depending on the local circumstances or the device model you have.

1. Basic Settings

Tap the air conditioner card and tap the three dots on the top right side of the screen to manage the basic settings (Figure 1.12). It includes-

a. App settings – Search and set your country and location.

b. Energy Monitor – You can monitor energy usage with the Energy Monitor here.

c. Self-Diagnosis – You can check the troubleshooting instructions on your smartphone directly.

d. Information – You can see the model number, information, and device type, here.

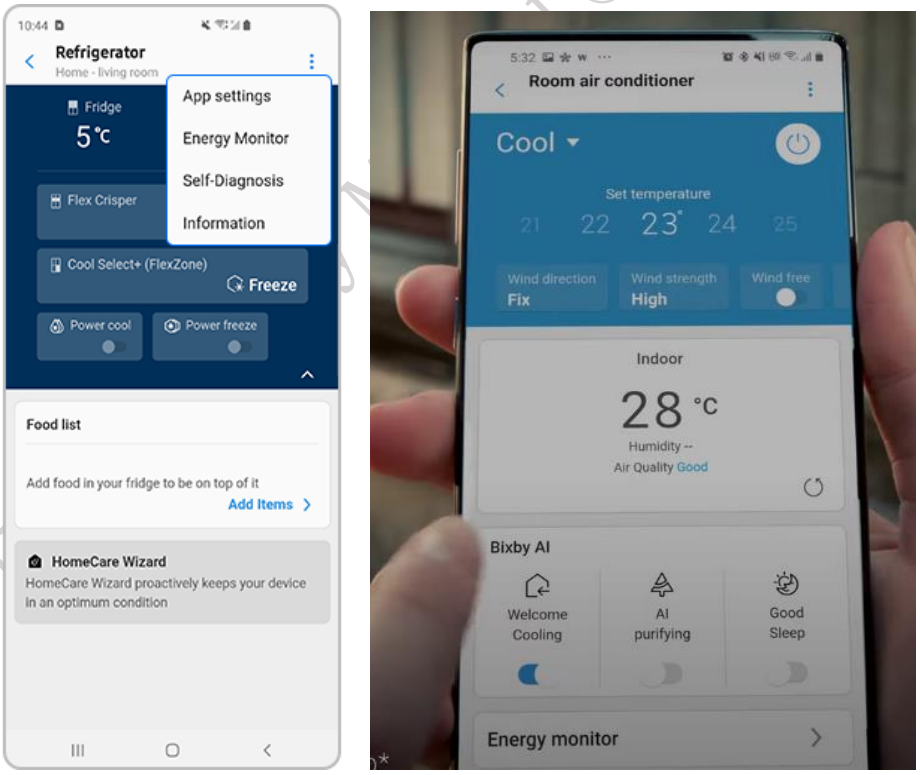


Fig. 1.12 Basic information portal

2. Basic features

a. Set Temperature - Users can see the set temperature of the room air conditioner as shown in Figure 1.13.

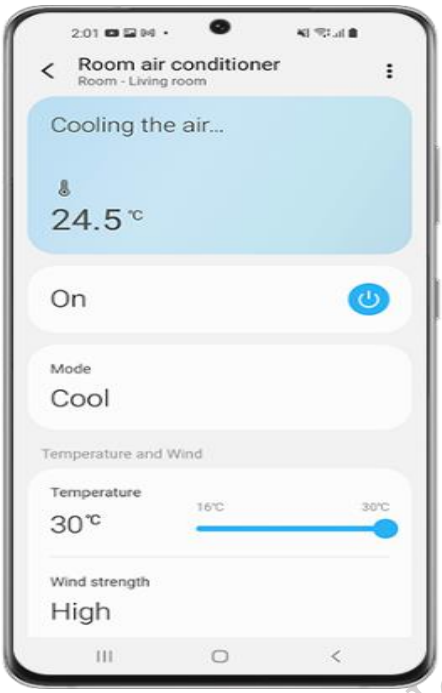


Fig. 1.13 Setting of room temperature

b. Mode - Select operation modes on your appliance as shown in Figure 1.14. All five modes are available (Auto, Cool, Dry, Purify, Heat). When you select Auto mode, the appliance will automatically adjust the temperature.

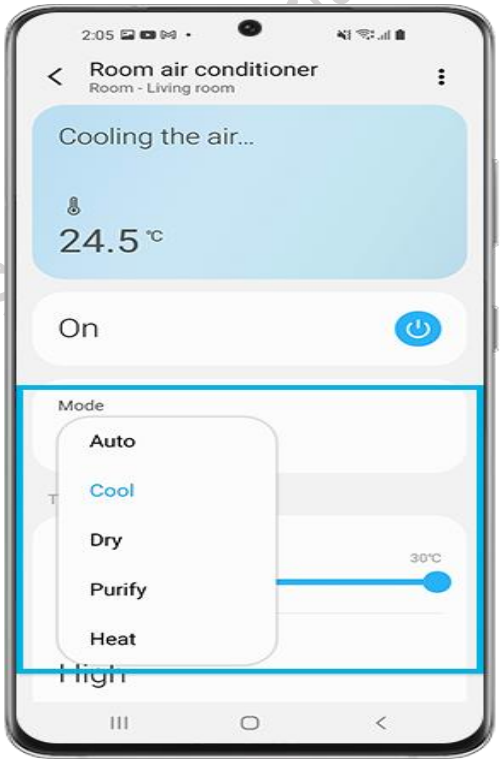


Fig. 1.14 Operation mode selection

c. Wind strength - Depending on the selected mode, some of the Wind strength options may show as grey text as shown in Figure 1.15 (cannot be tapped).

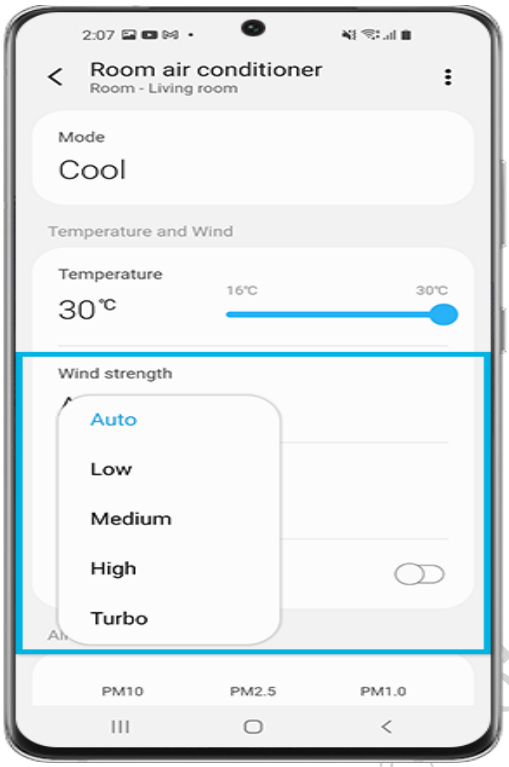


Fig. 1.15 Wind strength

d. Wind direction- Users can choose the Wind directions of the operation mode as shown in Figure 1.11. (Fixed, Horizontal, Vertical, All).

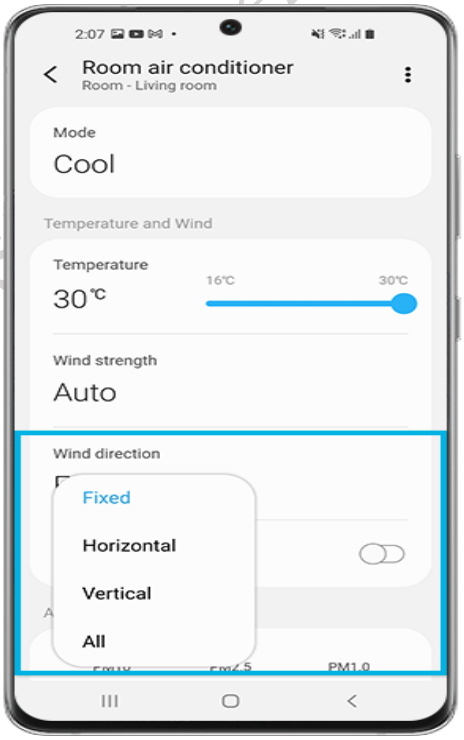


Fig. 1.16 Wind direction

3. Auto feature - Under the Auto features category, you can set more personal options that fit to user.

a. Schedule- You can set the desired schedule to turn on/off. The maximum number of schedules you can set using the Time on/off function is 10. Once the Time on/off function is

set, the setting remains even if you unplug the room air conditioner and plugin it again. (Figure 1.17)

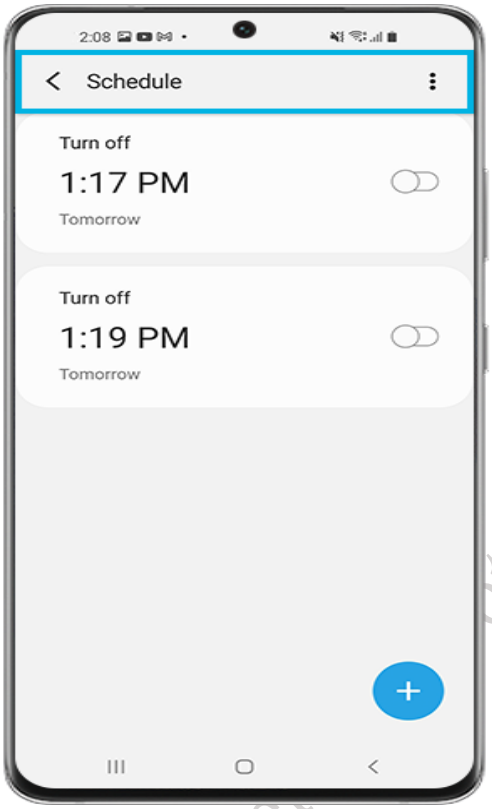


Fig. 1.17 Scheduling

b. Motion detection - The room air conditioner will automatically change wind direction while tracking motion or save power when no motion is detected. Users can set the saver mode to Standby or Keep cool (heating) when no motion is detected. If you set the switching time, it will help to save energy. (Figure 1.18)

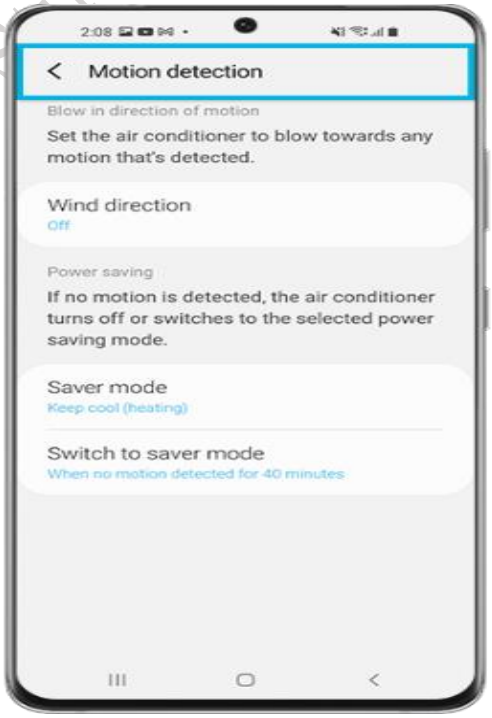


Fig. 1.18 Motion detection

c. Welcome cooling- As you get closer to home, you will receive a notification so you can turn on the room air conditioner in advance. (Figure 1.19)

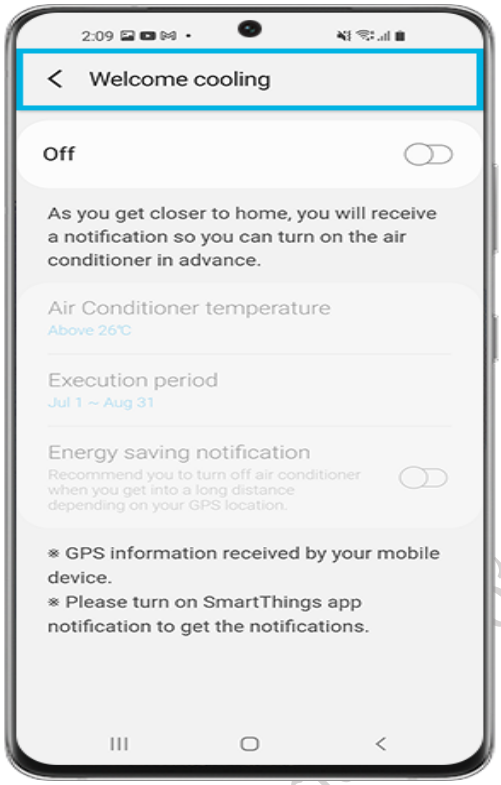


Fig.1.19 Welcome cooling

d. Good Sleep - Automatically change the temperature for consistent and comfortable cooling at night. (Figure 1.20)

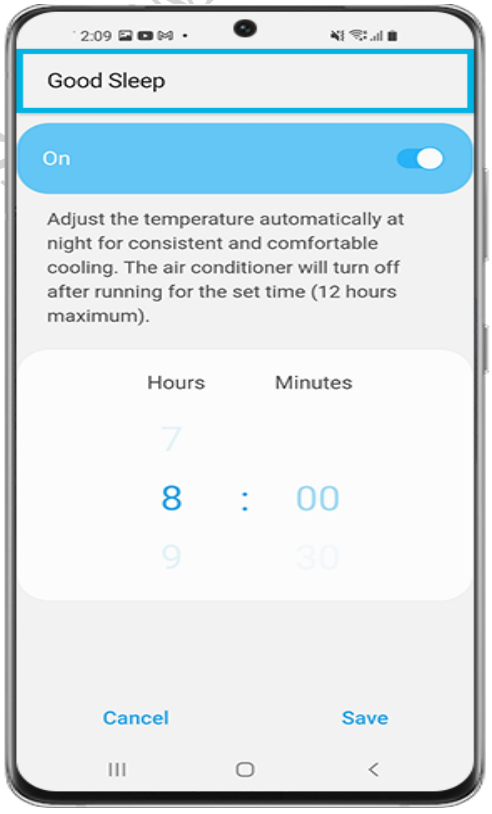


Fig. 1.20 Selection for comfortable sleeping

4. Device Care -It will be much easier and cleaner to manage your appliance with SmartThings.

- **Auto dry –** Hygienically dry all internal moisture after cooling is complete. Tap the 'On' and 'Start' buttons on the screen. It will take about 10-30 minutes.
- **Freeze Wash –** Clean and deodorize your room air conditioner's heat exchanger.

5. Home Care Wizard -The user can see the weekly report for device management as shown in Figure 1.21.

Fig. 1.21 Homecare Wizard

Note:

a. Before you try out the app connection, be sure to check if your device's software and related apps are updated to the latest version.

b. Mobile screen images on this content may vary depending on the device model you have.

Table 1.2 Some of the functions of the buttons, which are used for the operation of the air conditioner.

Category	Function	Description
Monitoring	Set temperature	Displays the set temperature.
	Current temperature	Displays the current temperature.

Control	Power	Turns the air conditioner on or off.
	Mode	Selects the desired operation.
	Temperature	Adjusts the indoor set temperature.
	Fan speed	Sets the fan speed of operation mode.
	Wind direction	Sets the fan directions of operation mode.
	Schedule	Sets the timed on/off function. • The maximum number of schedules you can set using the timed on/off function is 10. • The set times for the timed on and timed off functions must be different. • Once the timed on/off function is set, the setting remains even if you unplug the air conditioner and plug in it again.
	Options	Selects an option function of operation mode. • The available options might be different depending on the air conditioner model. • The fan speed and airflow direction are set automatically according to the selected options.
	Settings	Sets additional functions. • Press the Settings button on the control screen to check or set detailed information on the air conditioner. • The functions like Clean, Filter, and Beep can be set. • When the Beep function is off, the beep sound from the device will be mute.

Error codes on the indoor unit air conditioner

When your indoor unit indicator blinks, check the code type first. In most cases, it is not a product defect. However, some cases may require an authorized repair person for further service. Check the cases and instructions below. If the error codes keep appearing, contact the nearest Samsung service centre for professional repairs. Frequently displayed error codes on the indoor unit as shown in Figure 1.22.

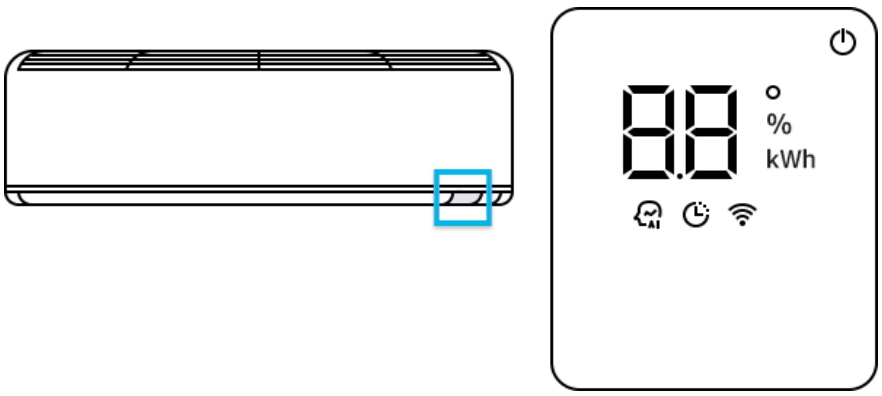


Fig. 1.22 Error codes displayed on indoor units

Table 1.3 Displayed Error codes

Displayed error codes	Cause	Remedies
CF	Filter cleaning reminder Filter reset indicator	Clean or replace the inner filters of the indoor unit
CL	Auto clean indicator (Indoor unit produces odors)	Operate the Auto clean function to remove the odors
dF	Automatic Defrost function (During the defrost function or steam is produced on the outdoor unit)	This is not manufacturing defect (when the Heat mode is off this function will be turned off.)

Guide for Indicators

CF function

When the indoor air filter accumulates too much dust, your air conditioner may struggle to draw in an adequate amount of air. This can lead to issues with temperature regulation and increased noise levels. We recommend cleaning the filter every two weeks or whenever the CF display code appears on the indoor unit's display. (The CF display code indicates that it's time to clean the filter.)

Please refer to your air conditioner model below and follow the guide to clean the air filter. This will ensure you receive cool and fresh air.

dF (Defrost function)

When the Defrost function is activated, the "df" indicator will appear on the indoor unit display, and steam may be visible on the outdoor unit. During this time, the air conditioner will temporarily stop running to prevent cold air from being emitted from the indoor unit.

Automatic Defrost

When the outdoor temperature is low and the humidity is high, frost can accumulate on the outdoor heat exchanger, reducing heating efficiency. In such conditions, when the Heat mode is activated, the air conditioner will initiate the defrost function for a duration of 5 to 12 minutes to remove the frost from the outdoor heat exchanger.

Table 1.4 Displayed Error codes

Displayed error codes	***Cause***	***Remedies***
E1 or 21	Defective of the room temperature sensor	Contact authorized Samsung service center
E1 or 22	Defective of the heat exchanger temperature sensor	Contact authorized Samsung service center
E1 or 54	Defective fan motor or capacitor	Contact authorized Samsung service center
E1 or 63	Defective EEPROM	Contact authorized Samsung service center
E5	Short of indoor heat exchanger sensor	Check the exchanger sensor departure of the indoor unit

	Indoor heat exchanger sensor open	(Sensor replacement may be required)
E6	Short of the outdoor heat exchanger sensor Outdoor heat exchanger sensor open	Check exchanger sensor departure of the outdoor unit (Sensor replacement may be required)
E7	Short of the heater temperature sensor Heater temperature sensor open	Check of the heater temperature sensor departure (Sensor replacement may be required)

Additional tips about error codes

Error code starting with the numbers

- The product model with the numbers will display error codes starting with the numbers.
- However, in this case, the major cause of the error situation and solution will be the same as the alphabet error codes.
- Error codes with the numbers will blink the 2-digit codes on the display panel.

Auto-clean function

The auto-clean function will prevent the growth of harmful micro-organisms by eliminating the moisture inside the indoor unit. This function prevents rusting on the evaporator coil. Activate this function to provide cleaner and healthier air. The use of the auto-clean function depends entirely on the user and their usage frequency. We recommend utilizing the auto-clean feature regularly for optimal performance. As shown in Figure 1.23 displayed Cl code in the indoor unit

- If the Auto-Clean function is turned on, Cl will be displayed in the indoor unit.
- When the operation is off, auto-clean runs for 10 min. (in a few models for 15-30 min.)
- The indoor unit display shows the cleaning progress (from 1 to 99%).
- After auto clean, the air conditioner will turn off automatically.

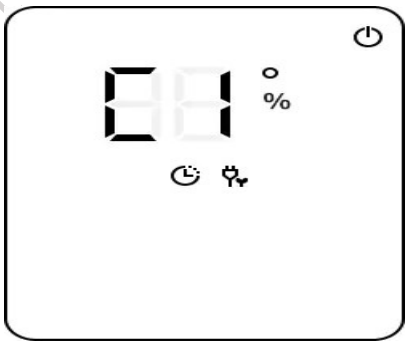


Fig. 1.23 C1 code on display

When you set the auto-clean function, it will start immediately after the air conditioner is turned off. If you start a function while in auto-clean operation, the auto-clean function will reset, and will be restarted when that function has stopped or been completed.

Activate the auto-clean function

Step 1. Press and hold the Options button for 3 seconds or more as shown in Figure 1.24.

Fig. 1.24 Setting up auto clean function

Step 2. Go to the directional buttons (right or left arrow) to select the clean function on the remote-control display as shown in Figure 1.25.

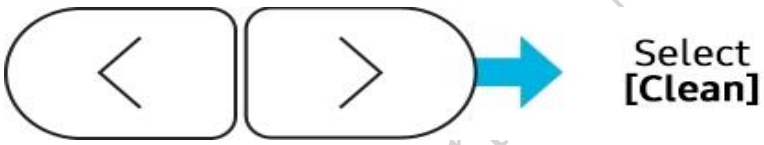


Fig. 1.25 Selection of appropriate button for cleaning action

Step 3. Click the Settings button to confirm as shown in Figure 1.21.

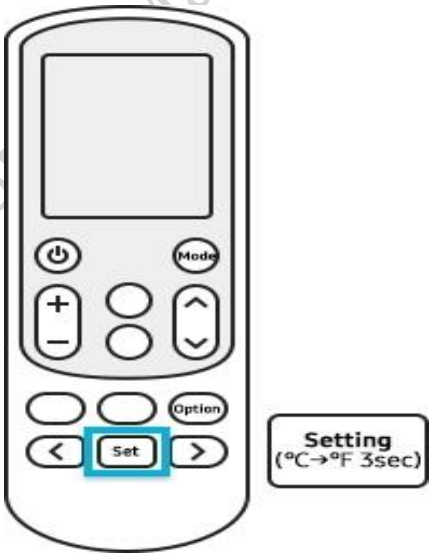


Fig. 1.26 Settings button

Deactivate the Auto clean Function

Method 1. Press and hold the Options button for 3 seconds or more.

Method 2. Press the Options button and then go to the directional buttons (right or left arrow) to select the clean function on the remote-control display (Figure 1.27). Finally, click the Settings button to confirm.

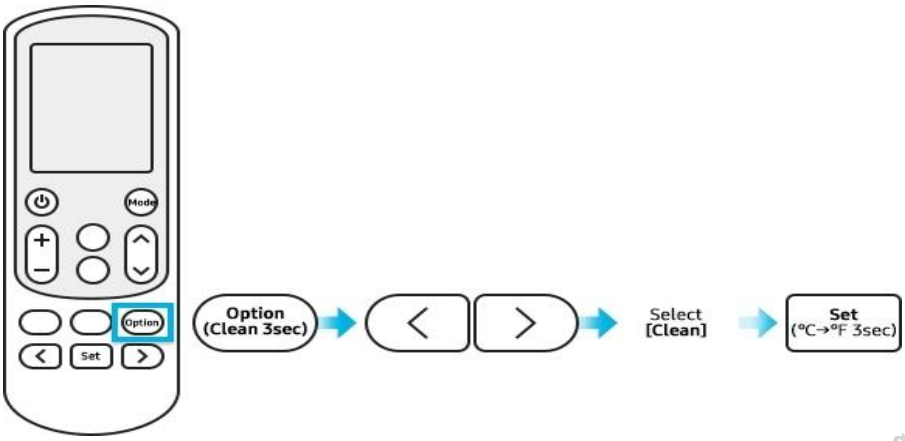


Fig. 1.27 Deactivation of auto clean function

Cancel the Auto Cleaning Mode

To cancel auto clean while it is running, press the power button on the remote control twice within 20 seconds as shown in Figure 1.28.

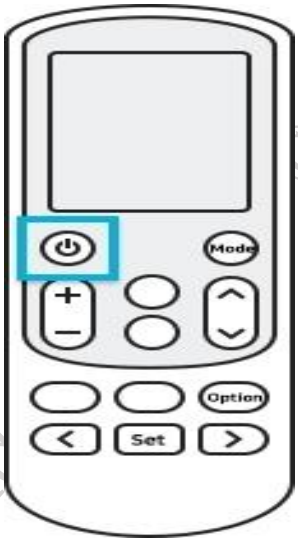


Fig. 1.28 Cancelling the Auto Cleaning Mode

Check Your Progress

A. Multiple choice questions

1. Which of the following indicator given by the indoor unit for air filtering cleaning. (a) VF (b) CF (c) DF (d) EF
2. Which of the following indicator given by the indoor unit for auto cleaning. (a) Cl (b) Dl (c) Fl (d) Jl
3. Which of the following is not included in the basic setting of the smart thing's application? (a) App setting (b) Energy monitoring (c) Self-diagnosis (d) Set temperature
4. Which of the following is not the operation mode of an air conditioner? (a) Cool (b) Dry (c) Auto (d) Humidity
5. Motion detection in an air conditioner helps to reduce the __. (a) Heat (b) Power (c) Motion (d) Humidity

B. Fill in the blanks

1. To turn on or off the air conditioner _____ button is used.
2. To automatically change the temperature the cooling at night _____ function is used.
3. Users can choose the _____ directions of the operation mode.
4. Self-diagnosis is used to check the ___ Instructions on your smartphone directly.
5. When user turn on the Wi-Fi function, your smartphone pairs with the air conditioner, ____ appears on the remote-control display.

C. State whether the following statements are True or False

1. dF indication is used for automatic defrost function.
2. User cannot be able to set the schedule for an air conditioner.
3. Smart things app is used to control the IoT based refrigerator.
4. Devices and hubs are the physical products that connects to smart things platform.
5. Android OS version of 5.0 is required to operate the smart things app in the mobile phone.

D. Short answer questions

1. Briefly describe the architecture of the IoT-based air conditioner application.
2. Discuss the steps to connect the smart things app to an air conditioner.
3. Tabulate the common error codes in the AC.
4. Tabulate the function of various buttons in the AC remote.
5. What are the features of smart things applications?

Session 2. Troubleshooting Software Issues

The Internet of Things (IoT) is a software-based system that keeps the appliance and its user constantly connected. Maintaining this connection is crucial. While using this IoT service, various issues may arise. A technician should be capable of troubleshooting any issues and ensuring the connection between the IoT system and the user remains intact. In this chapter, you will learn how to troubleshoot software issues.

Software in IoT

We know that software is a set of instructions, while hardware refers to the physical components of any electronic device. Observing software, we see it comprises a vast collection of programs that require significant memory space. In contrast, handheld electronic gadgets or IoT control devices are comparatively small, making it impractical to install large software on them. Instead, a specialized type of software known as firmware is utilized.

In small electronic devices or gadgets, integrated circuits (ICs) are used, that consists of tiny chips. These chips have specific programs embedded within them to perform designated tasks. Firmware is a small piece of software that enables hardware to function as intended by its manufacturer. It consists of programs written by developers to facilitate the operation of hardware devices. Without firmware, these electronic devices would not work.

Firmware acts as an intermediary between hardware and the user. An IoT-based appliance can be controlled remotely and requires the ability to collect data from various sensors, access the Internet, connect to a smartphone, and present complex outputs on the appliance's display. In

such cases, Raspberry Pi or Arduino boards are often suitable options. The manufacturing company will decide whether to use Raspberry Pi or Arduino boards.

Therefore, the central component of most IoT-enabled devices is a microcontroller board with internet connectivity. Two types of boards commonly used in IoT applications are:

(1) Raspberry pie board

(2) Arduino Uno board

Fig. 2.1 (a) Logo of Raspberry Pi foundation (b) Logo of Arduino foundation

(1) Raspberry Pi boards – They are small single-board computers and are widely used in the development of IoT-based appliances. They are compatible with various circuits and appliances. They are typically used in computers and electronics, due to their adoption of HDMI and USB devices.

Setting up Raspberry Pi

To set up the raspberry Pi board we need a *computer monitor, television, USB Keyboard, USB mouse, power supply, Micro SD card, Ethernet cable.*

HDMI Cable – Best result is viewed by using HDMI input. You will also need an appropriate display cable, to connect your monitor to your Raspberry Pi.

Keyboard – A USB port keyboard is required to do the programming in the Raspberry Pi.

Mouse – A USB port mouse is required to do the programming in the Raspberry Pi.

Power supply – It is recommended to have official Raspberry Pi Power Supply, which has been specifically designed to consistently provide + 5.1 V. For the Raspberry Pi 4, Model B, and Raspberry Pi 400 use the type C power supply. For all other models, use the micro-USB power supply.

SD card – It is recommended to use a minimum of 8 GB micro-SD card. Use the Raspberry Pi Imager to install an operating system onto it.

Ethernet Cable – A network cable is used to connect Raspberry Pi to your local network and the Internet.

Audio system – If you are not using an HDMI monitor with speakers you might also need some form of sound hardware. Audio can be played through speakers or headphones by connecting them to the AV jack. (Figure 2.2)

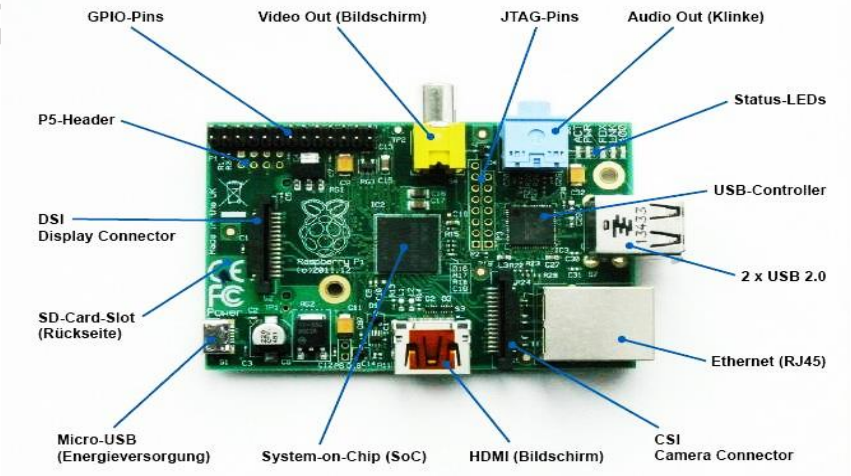


Fig. 2.2 Parts of Raspberry Pi board

Raspberry Pi OS

Raspberry Pi needs an operating system to work. Raspberry Pi OS (Previously called Raspbian) is the officially supported operating system. A Raspberry Pi Imager is used to install the Raspberry Pi OS and other operating systems to a microSD card. Once the OS is written on the SD card, then directly use the microSD card on the raspberry board.

More to Know ...

Raspberry Pi has developed a graphical SD card writing tool that works on Mac OS, Ubuntu 18.04, and Windows. This is the easiest option for most users. Users download the Raspberry Pi Imager tool and install it on the SD card of the raspberry board.

Practical Activity 2.1 Demonstrate to install the raspberry OS on the raspberry board.

Material Required

Micro SD card, Raspberry board, Desktop/laptop with internet connection.

Procedure

Step 1. Open the official website of "Raspberry Pi" i.e. raspberrypi.org.

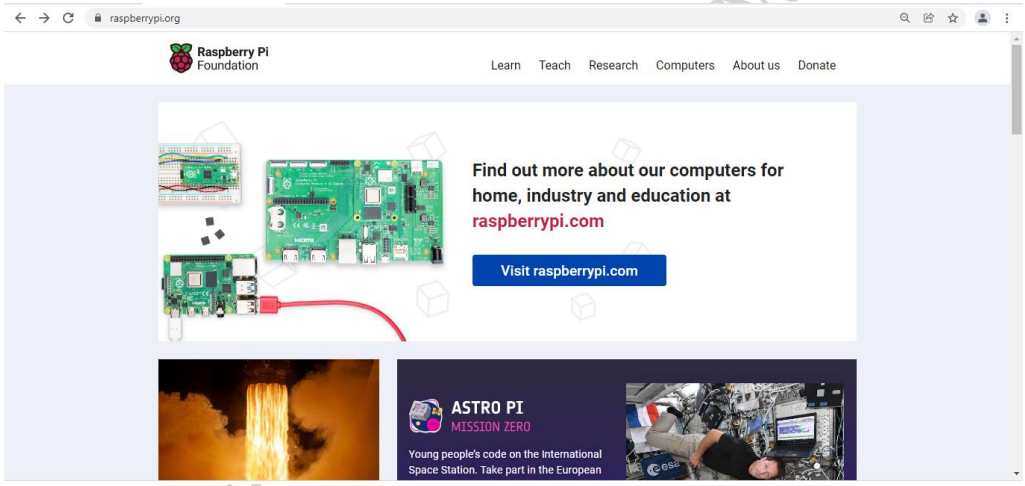


Fig. 1 Raspberry Pi web page

Step 2. Go to computers > software.

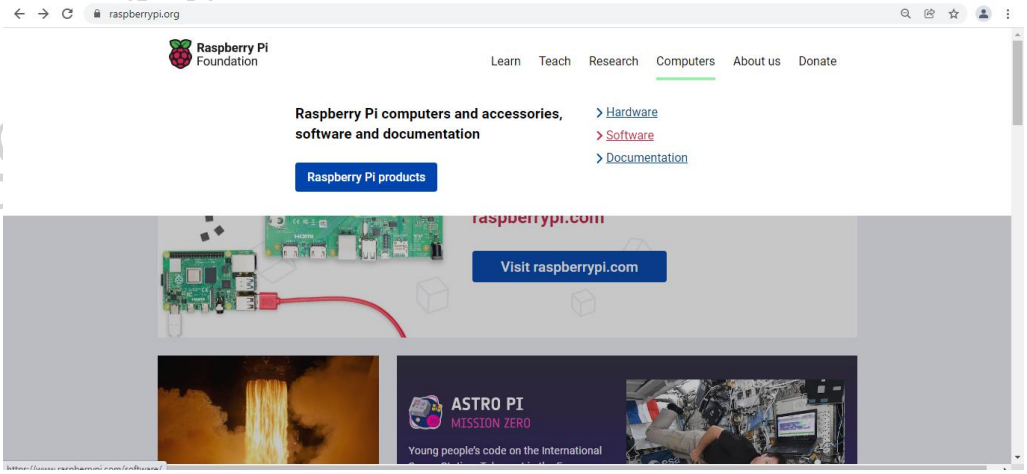


Fig. 2 Raspberry Pi software and documentation

Step 3. Download the latest version of Raspberry Pi Imager for Windows/ macOS/

Ubuntu.

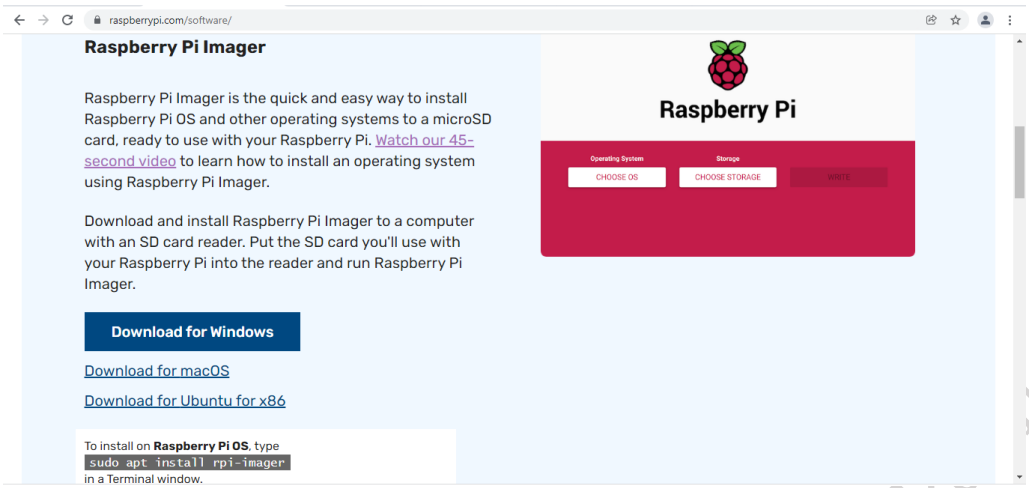


Fig. 3 Raspberry Pi manager

Step 4. Check the downloaded "imager_1.6.2.exe file" in the *Downloads folder*.

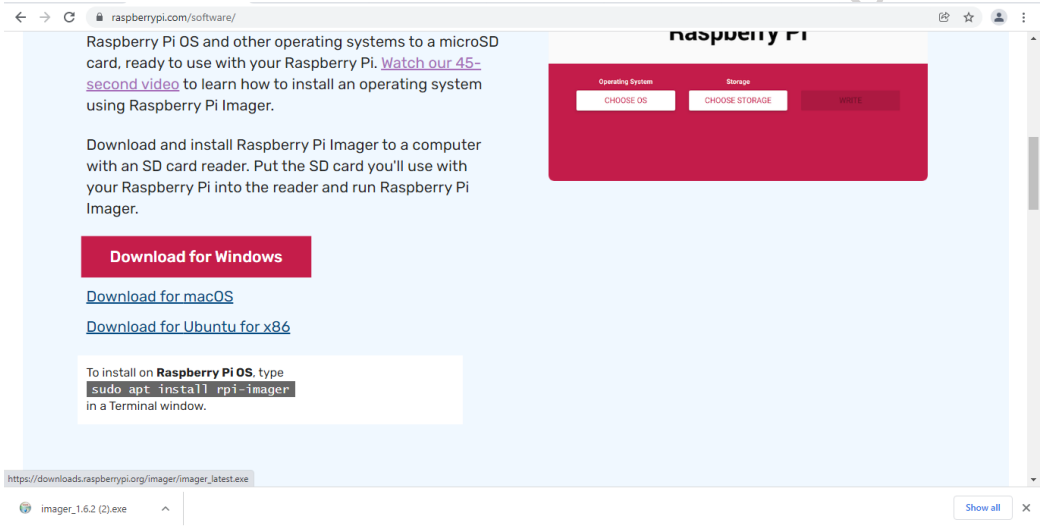


Fig. 4 Downloads for windows

Step 5. Open the imager_1.6.2.exe file, you will get a popup window, click on the install button.

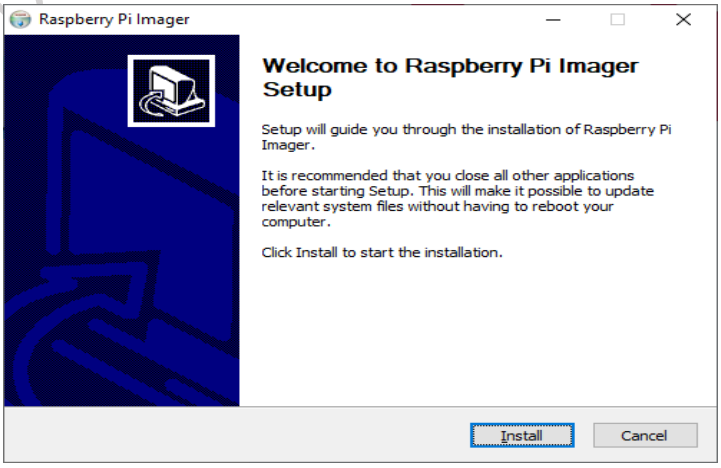


Fig. 5 Raspberry Pi imager setup

Step 6. After a few minutes, you will get a popup window with a message that *"Raspberry*

Pi Imager has been installed on your computer". After that click on the finish button.

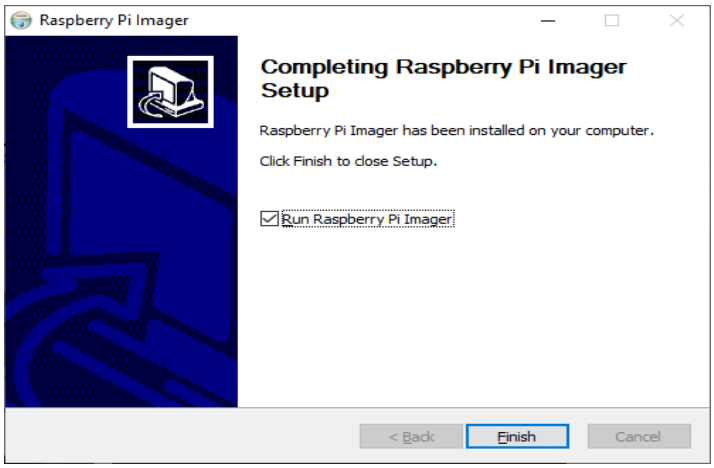


Fig. 6 Completing Raspberry Pi imager setup

Step 7. Insert the Micro SD card (Minimum storage of 8 GB) in the card reader.

Fig. 7 Micro SD card

Step 8. Insert the card reader in the USB slot of the desktop/laptop.

Fig. 8 Fitting of SD card in the respective slot

Step 9. Open the Raspberry Pi Imager.

Fig. 9 Raspberry Pi imager V1.6.2

Step 10. Select the operating system (OS) from the drop-down list. The most common OS is Raspberry Pi OS (32-bits).

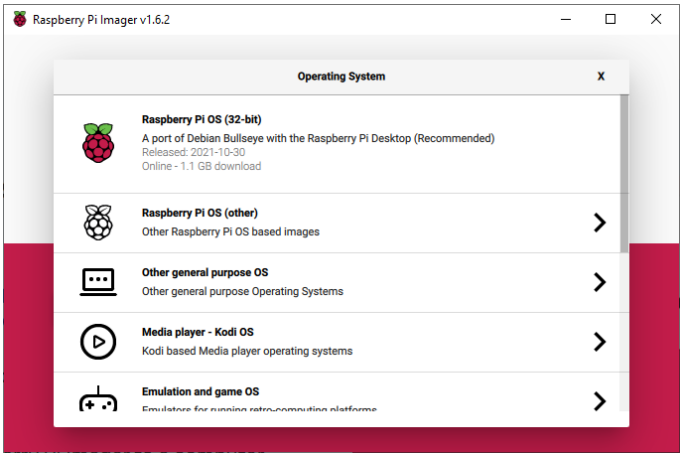


Fig. 10 Raspberry Pi OS

Step 11. Select the storage space i.e. Micro SD card, which is inserted in the laptop using a card reader.

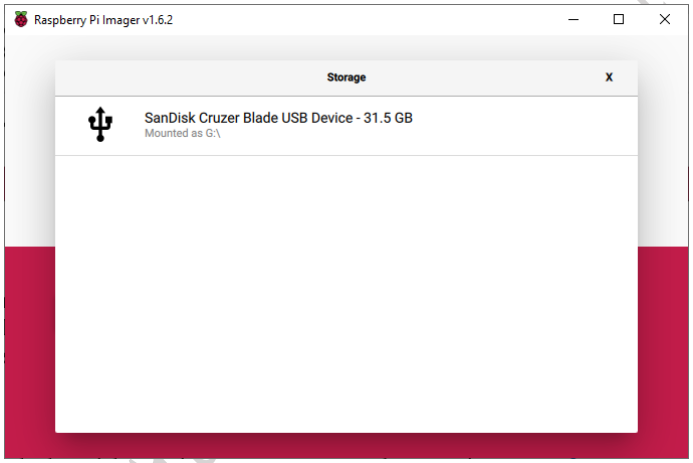


Fig. 11 Raspberry Pi storage space

Step 12. Click on the write button.

Fig. 12 Writing the Raspberry Pi

Step 13. Click on the YES button to format all the data in the Micro SD card.

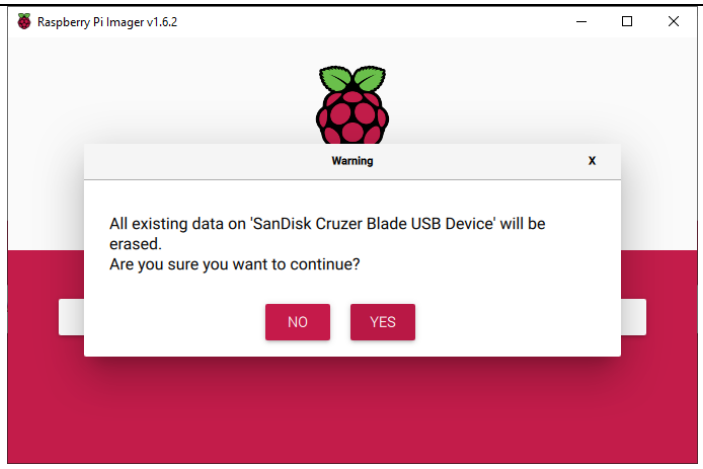


Fig. 13 Formatting of data in the Micro SD card

Step 14. Review your selections and click on the Write button to begin writing data to the SD Card.

Fig. 14 Writing data to SD card

Step 15. A window will appear that shows the "Raspberry Pi OS has been written to Generic Flash Disk".

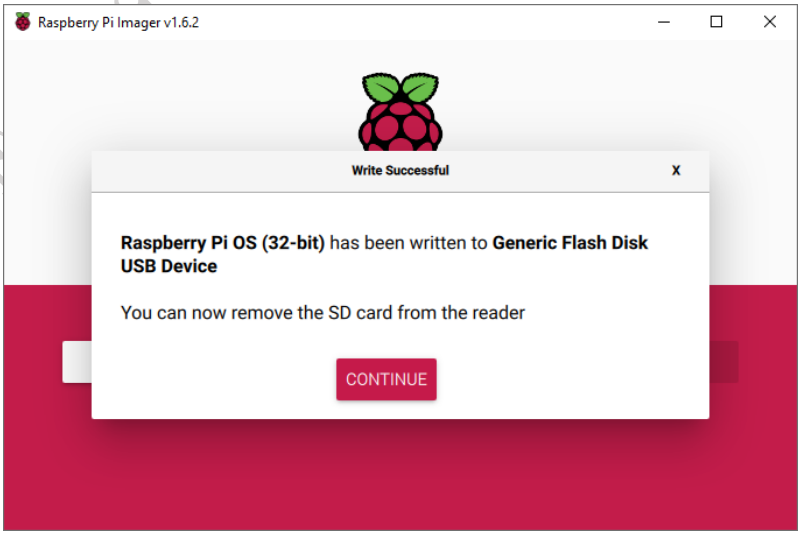


Fig. 15 Status of writing of Raspberry Pi OS

Step 16. Now, you can use this Micro SD card in the Raspberry Pi board for programming.

(2) Arduino Uno Boards – Arduino is an open-source electronics platform. It is based on easy-to-use hardware and software. Arduino boards are able to read inputs and can control the connected appliance. The most commonly used prototype board for IoT-enabled devices/systems is the Arduino Uno Board. This board takes the Atmega328 Microcontroller. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started.

"Uno" means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0. The Uno board and version 1.0 of Arduino Software (IDE) were the reference versions of Arduino, now evolved to newer releases. The Uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform; for an extensive list of current, past or outdated boards see the Arduino index of boards.

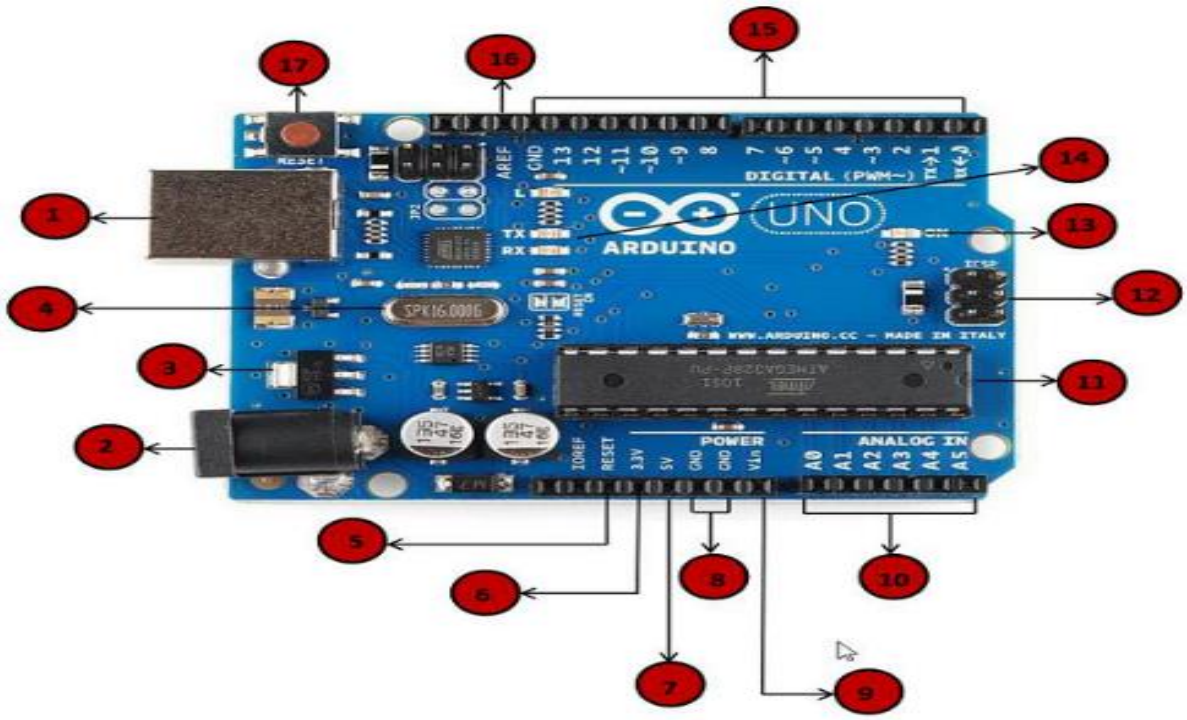


Fig. 2.3 Arduino Uno board

Setting up the Arduino

To set up the Arduino board we need a *computer monitor, or television, USB Keyboard, USB mouse, power supply, Micro SD card, Ethernet cable.*

1	**Power USB –** Arduino board can be powered by using the USB cable from the computer by connecting the USB cable to the USB connection.
2	**Power (Barrel Jack) –** Arduino board can also be powered directly from the AC mains power supply by connecting it to the Barrel Jack.
3	**Voltage Regulator –** The function of the voltage regulator is to control the voltage given to the Arduino board and stabilize the DC voltages used by the processor and other elements.

4	**Crystal Oscillator –** The crystal oscillator helps Arduino in dealing with time issues. How does Arduino calculate time? The answer is, by using the crystal oscillator. The number printed on top of the Arduino crystal is 16.000 H 9 H. It tells us that the frequency is 16,000,000 Hertz or 16 MHz.
5,17	**Arduino Reset –** This helps in resetting the Arduino board, i.e., it starts the program from the beginning. UNO board can be reset in two ways. First, by using the reset button (17) on the board. Second, by connecting an external reset button to the Arduino pin labelled RESET (5).
6,7 8,9	**Power Supply Pins (3.3, 5, GND, Vin)** • 3.3V (6) − Supply 3.3 output volt • 5V (7) − Supply 5 output volt • Most of the components used with Arduino board works fine with 3.3 volt and 5 volts. • GND (8) (Ground) − There are several GND pins on the Arduino, any of which can be used to ground circuit. • Vin (9) − This pin also can be used to power the Arduino board from an external power source, like AC mains power supply.
10	**Analog Pins –** The Arduino UNO board has six analog input pins A0 through A5. These pins can read the signal from an analog sensor like the humidity sensor or temperature sensor and convert it into a digital value that can be read by the microprocessor.
11	**Main Microcontroller –** Each Arduino board has its own microcontroller (11) which is the brain of the board. The main IC (integrated circuit) on the Arduino is slightly different from board to board. The microcontrollers are usually of the ATMEL Company. But one must know which IC the board has before loading up a new program from the Arduino IDE. This information is available on the top of the IC. Datasheet can be referred for more details about the IC and functions
12	**ICSP Pin –** ICSP is "In-Circuit Serial Programming". It is a tiny programming header for the Arduino consisting of MOSI, MISO, SCK, RESET, VCC, and GND pins. It is often referred to as an SPI (Serial Peripheral Interface), which could be used to program an Arduino instead of the USB port.
13	**Power LED Indicator –** This LED lights up when the Arduino Uno board is plugged into a power source to indicate that the board is powered up correctly. If this light does not turn on, then there is something wrong with the connection.

14	**TX and RX LEDs –** On the board, one will find two labels: TX (transmit) and RX (receive). They appear in two places on the Arduino UNO board. First, at the digital pins 0 and 1, to indicate the pins responsible for serial communication. Second, the TX and RX led (13). The TX led flashes with different speed while sending the serial data. The speed of flashing depends on the baud rate used by the board. RX flashes during the receiving process.
15	**Digital I/O –** The Arduino UNO board has 14 digital I/O pins (15) of which 6 provide PWM (Pulse Width Modulation) output. These pins can be configured to work as input digital pins to read logic values (0 or 1) or as digital output pins to drive different modules like LEDs, relays, etc. The pins labelled "~" can be used to generate PWM.
16	**AREF –** AREF stands for Analog Reference. It is sometimes, used to set an external reference voltage (between 0 and 5 Volts) as the upper limit for the analog input pins.

Arduino OS

Arduino itself has no real operating system. The user develops code for the Arduino using the Arduino IDE, which can be downloaded from Arduino - Home. Versions are available for Windows, Mac, and Linux.

The Arduino Software (IDE) allows to write programs and upload them to board. On the Arduino Software page, you will find two options:

- ✓ You should Use the online IDE (Arduino Web Editor) with fast Internet connection otherwise.
- ✓ It would rather work offline.

Installation of Arduino Software (IDE)

Practical Activity 2.2 Demonstrate to install Arduino software on Windows machine.

Material Required

Desktop/laptop with internet connection.

Procedure

Step 1. Open the official website of "Arduino" i.e. https://www.arduino.cc.

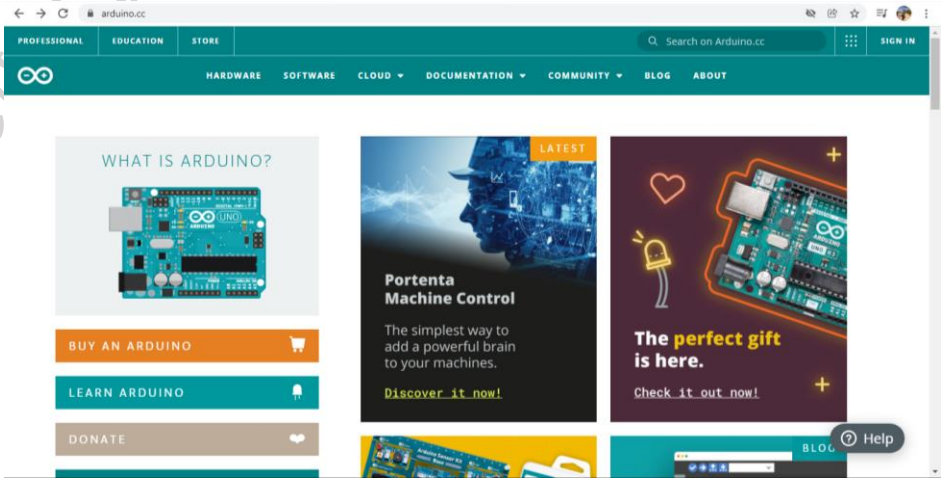


Fig. 1 Official website of Arduino

Step 2. Go to software, click on it. This will open the new page.

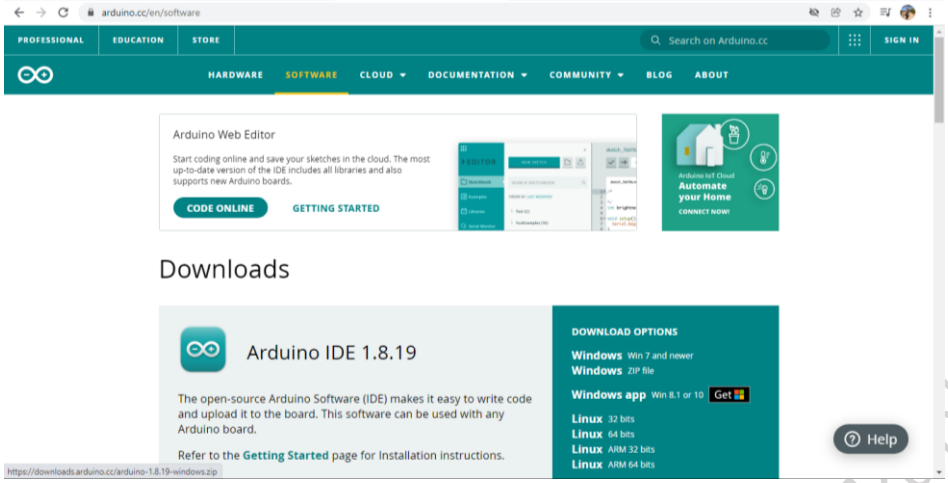


Fig. 2 Arduino software details

Step 3. Download the latest version of Arduino for Windows.

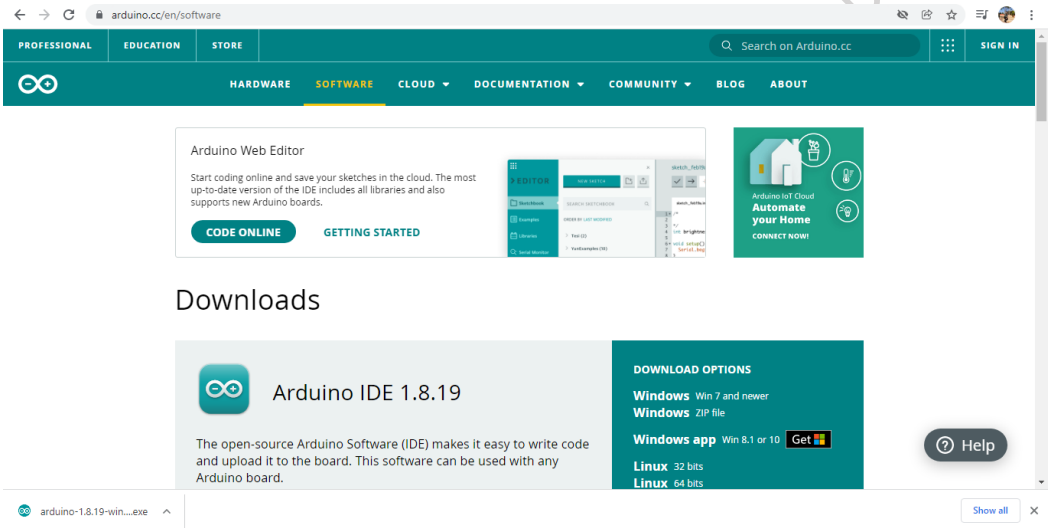


Fig. 3 Downloading the latest version of Arduino for Windows

Step 4. Open the Arduino-1.8.19-windows.exe file, you will get a popup window, click on the I Agree button.

Fig. 4 Installation wizard

Step 5. Choose the components to install.

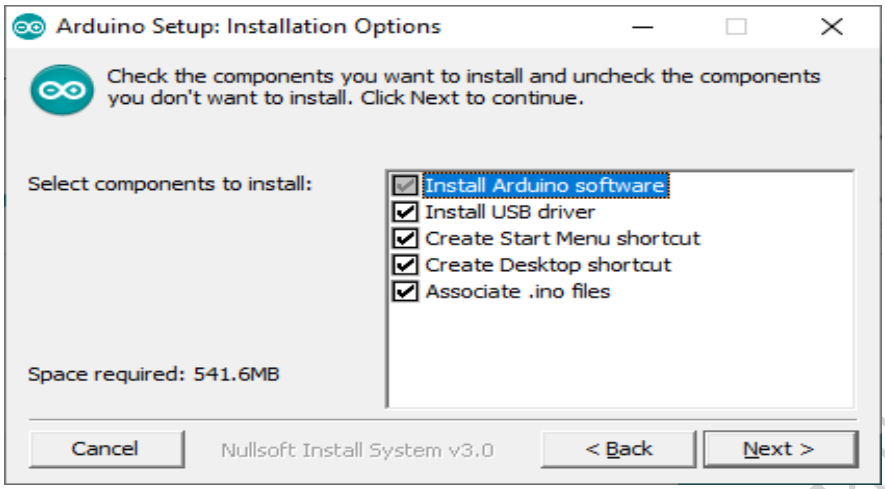


Fig. 5 Selection of components to install

Step 6. Choose the folder or path in which installation has to be done.

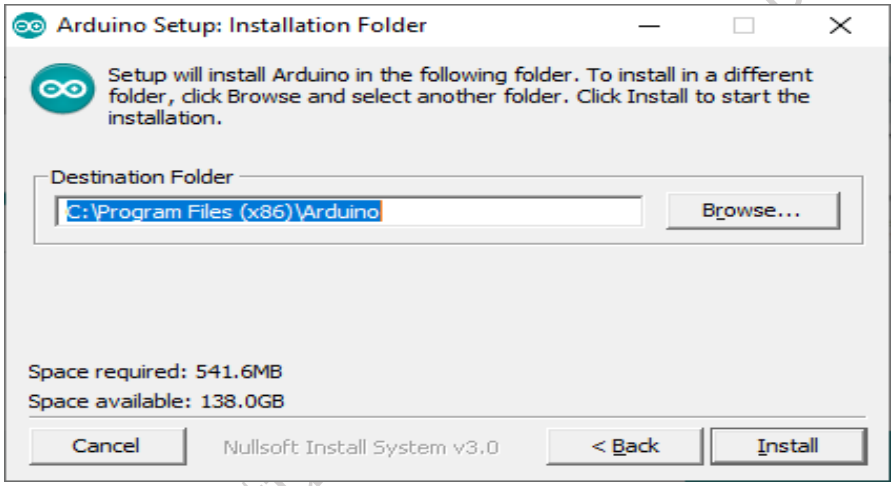


Fig. 6 Destination folder path for installation

Step 7. Process will extract and install all the required files to execute correctly the Arduino Software (IDE).

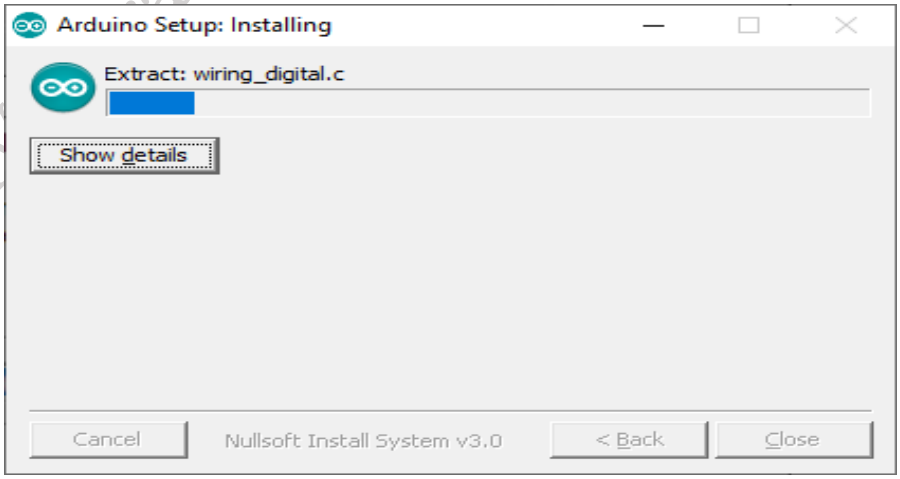


Fig. 7 Extraction and installation of files to execute the Arduino Software (IDE).

Step 8. Pop up window will appear, allow them to install the device software.

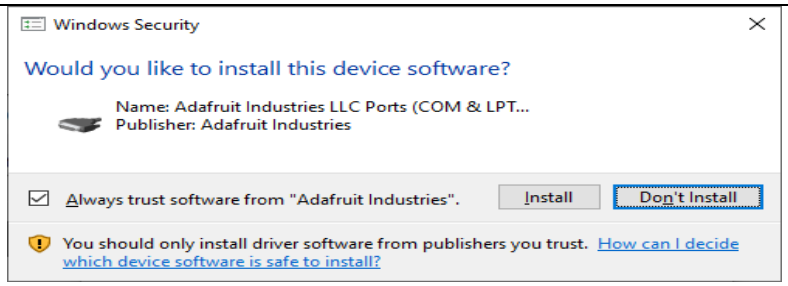


Fig. 8 (a) Pop up about window security

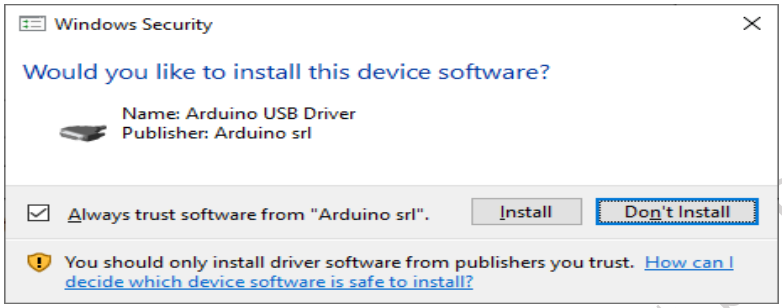


Fig. 8 (b) Checking up of windows security

Step 9. After a few minutes, you will get a popup window with a message that *"Arduino Setup – Completed"*. After that click on the close button.

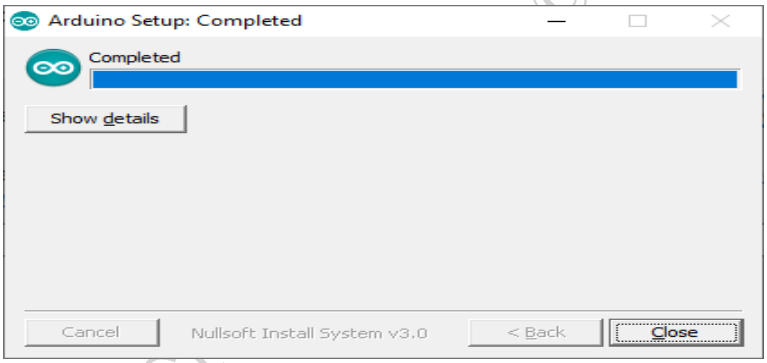


Fig. 9 Arduino set up completion message

Communicating with the Arduino

When we learn a new programming language in computer science (say C, PHP or Java), we begin the learning curve with the classic "**Hello World**" program. We learn some essential keywords used in the programming language, then we learn the structure of the language and finally, we begin to play with the language by making it display the two words "***hello world***" on our computer screen. So that's how we begin to learn a programming language used to build computer applications. We create software to control hardware. To learn how the program is written and compiled in the Arduino boards, we will take an example of the blink LED program.

Practical Activity 2.3 Demonstration of blinking LED Program on Arduino board.

Material Required

Arduino Uno board, an LED, a resistor, and a breadboard.

Procedure

Step 1. Connect Arduino board to computer and power it up. For that, Arduino IDE is set up on the computer. Connect the Arduino Uno Board to the computer using a USB cable the green power LED (labelled PWR) will glow as shown in Figure 1.

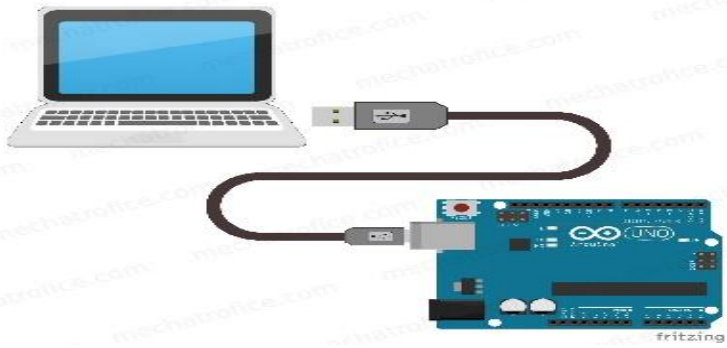


Fig. 1 Connecting Arduino board

Step 2. Launch Arduino IDE. Double-click the icon to as shown in Figure 2 to start the IDE.

Fig. 2 Launching the Arduino IDE

Step 3. Open your first project. For that, there are two options once the software starts –

a. Create a new project.

b. Open an existing project

To create a new project, select File → New. (Figure 3)

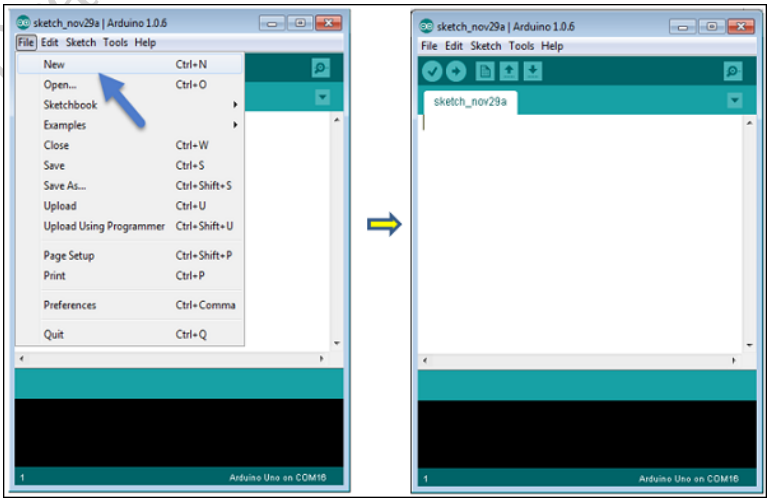


Fig. 3 Opening a project or creating new project

To open an existing project, select File → Example → Basics → Blink. (Figure 4)

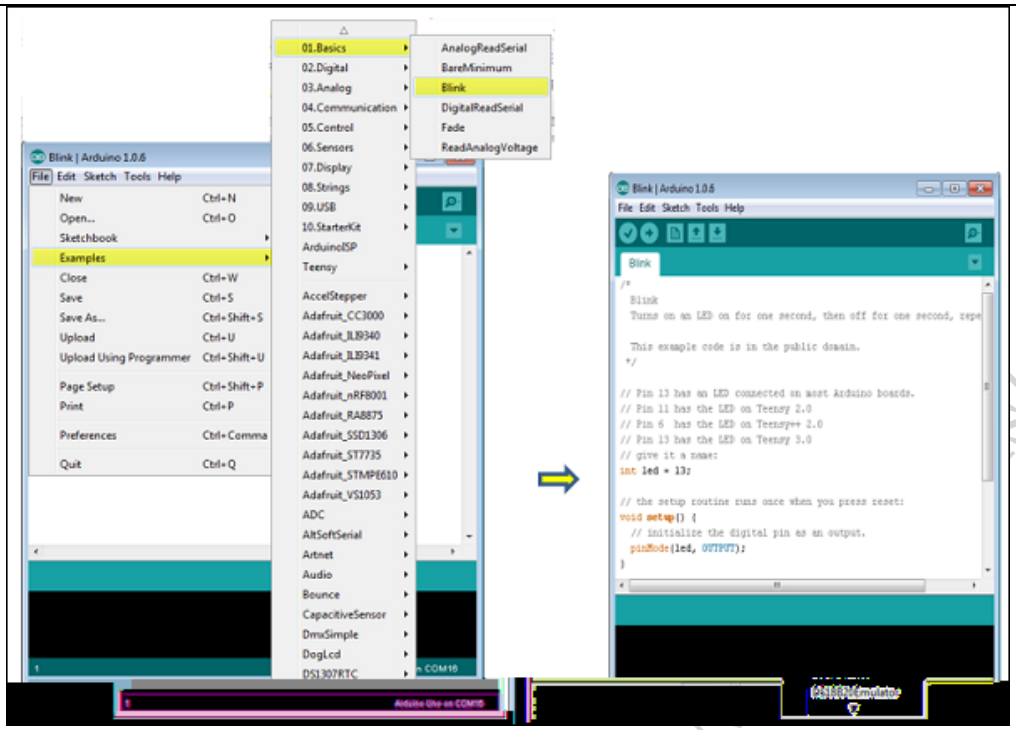


Fig. 4 Opening of an existing project

Step 4. We select an example with name Blink. It turns the LED on and off with some time delay. Its code is shown in Figure 5.

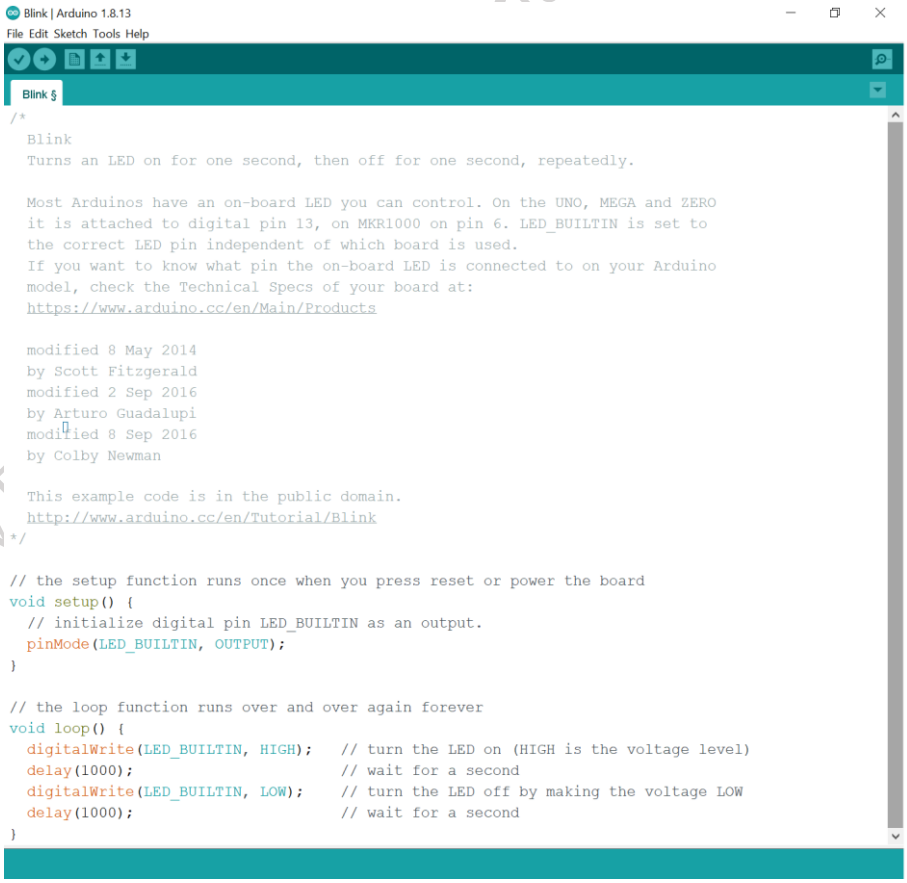


Fig. 5 Example of a program

Step 5. Select your Arduino board. To avoid any error while uploading your program to the

board, you must select the correct Arduino board name, which matches with the board connected to computer. For that, Go to Tools → Board and select your board. (Figure 6)

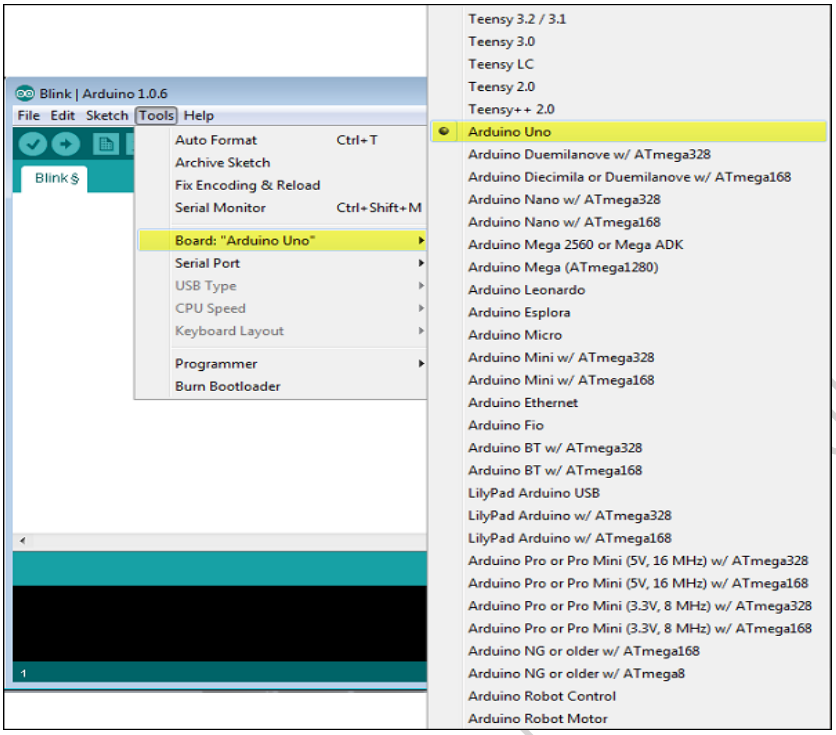


Fig. 6 Selection of Arduino board

Step 6. Select the serial port. For that, go to the Tools → Serial Port menu. This is likely to be COM3 or higher (COM1 and COM2 are usually reserved for hardware serial ports) as shown in Figure 2.

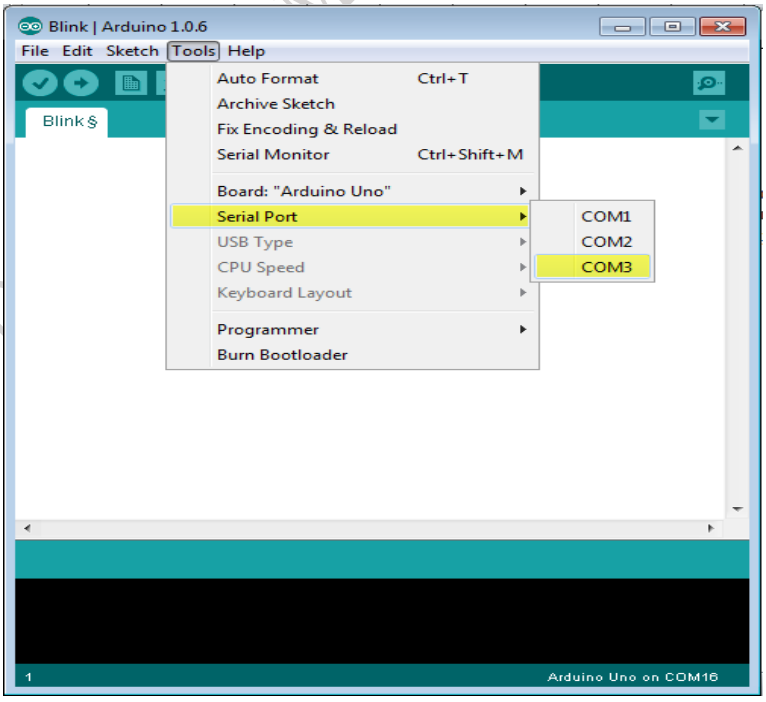


Fig. 7 Selection of COM port

Step 7. Compile the Sketch. For that, in the Arduino IDE, compiling is called as "**verify**". So, hit the verify button in your IDE (see the button with tick mark just below menu bar) as shown in the Figure 8. If no error occurs, proceed to step 8.

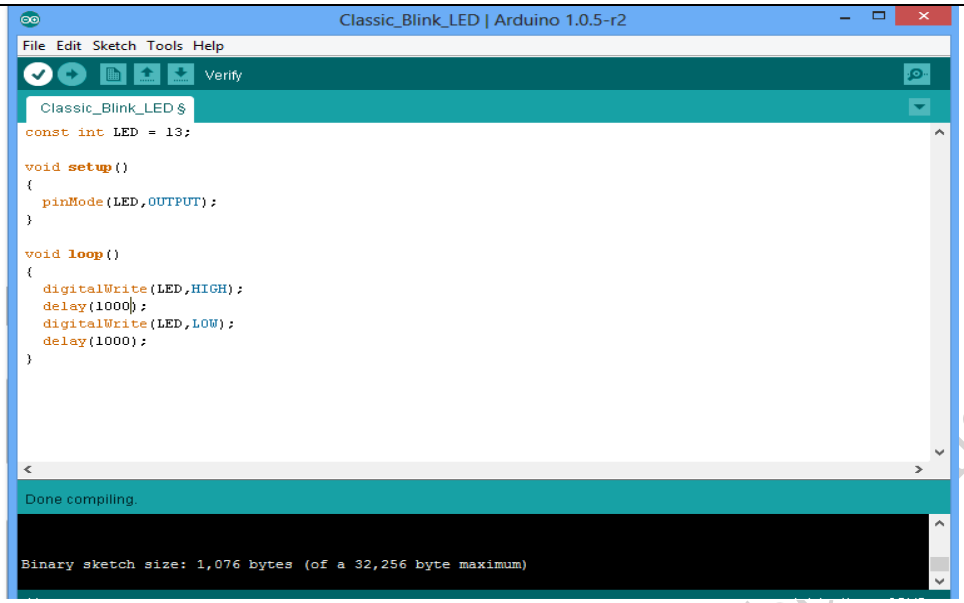


Fig. 8 Compilation of the program

Step 8. Upload the program to the board (Figure 9). For that, click on the forward arrow button (Figure 10).

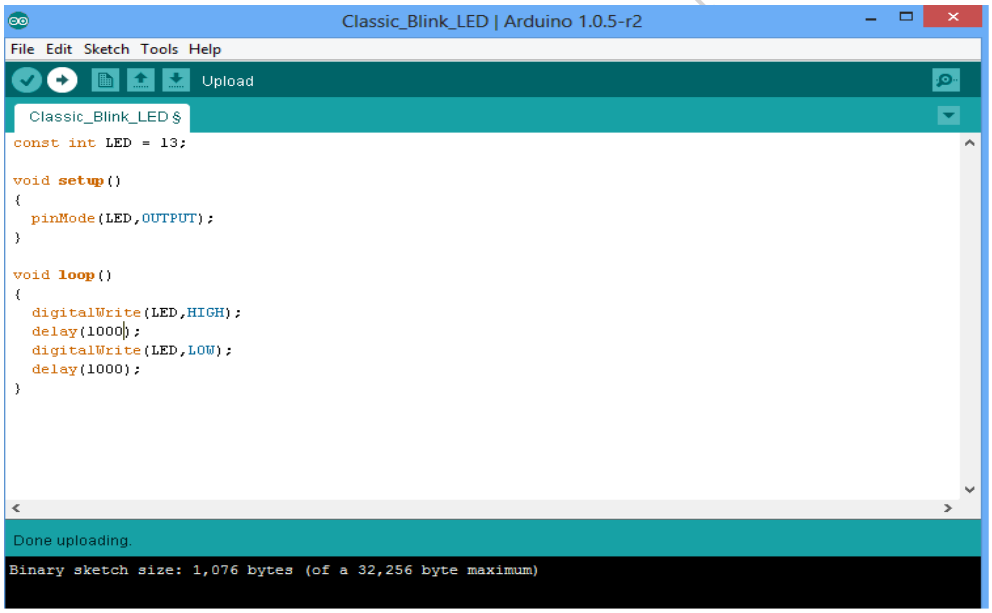


Fig. 9 Uploading the program

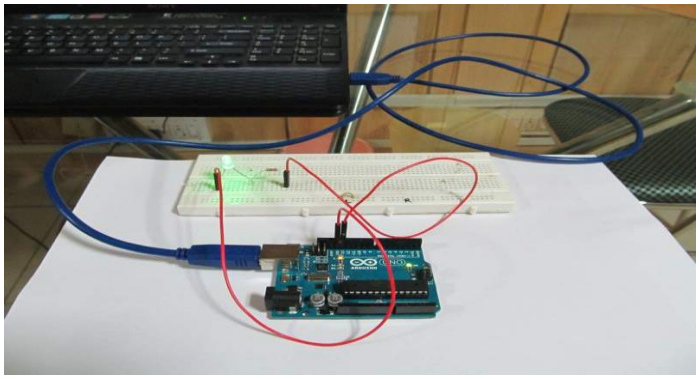
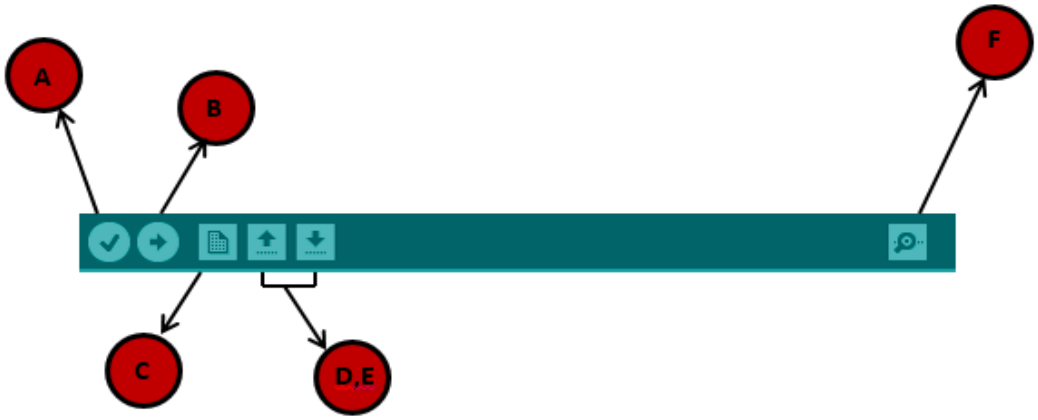


Fig. 10 Photograph of blinking LED using Arduino

More to Know....

Before explaining how we can upload the program to the board, we must understand the function of each symbol appearing in the Arduino IDE toolbar.



A – Used to check if there is any compilation error.

B – Used to upload a program to the Arduino board.

C – Shortcut used to create a new sketch.

D – Used to directly open one of the example sketches.

E – Used to save your sketch.

F – Serial monitor used to receive serial data from the board and send the serial data to the board.

Update IoT application

App updates improve the security of your device. If some apps on the device are out of date, hackers can exploit their outdated design. As a result, they may hack your phone and steal your personal information. They can also send fake messages on your behalf. To prevent this, update the apps and install the latest versions.

For instance, if an app crashes when you click its menu button, once this problem is reported to the app developers, they will find a solution and introduce an app update. Thus, updating may fix that problem and improve the performance and features of the application.

Updating IoT applications is very necessary. Let us see the steps to manually update an application in the Android OS.

Update Android apps manually

To update apps individually or in bulk using the Google Play Store app on your mobile device:

Step 1. Open the Google Play Store app.

Step 2. At the top right, tap the profile icon.

Step 3. Tap Manage apps & device. Apps with an update available are labelled "Update available."

Step 4. Tap Update.

Update apps in Windows OS manually

To update apps using the laptop/ desktop are as follows:

Step 1. Go to the search box at the left corner of the desktop. Search the word program as shown in Figure 2.4.

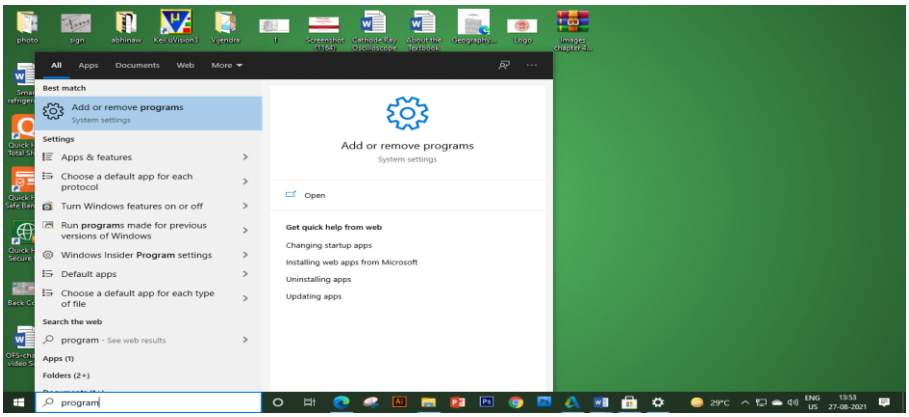


Fig. 2.4 Search box in the desktop

Step 2. Next, select the app and features. There you find an option of updating app as shown in Figure 2.5.

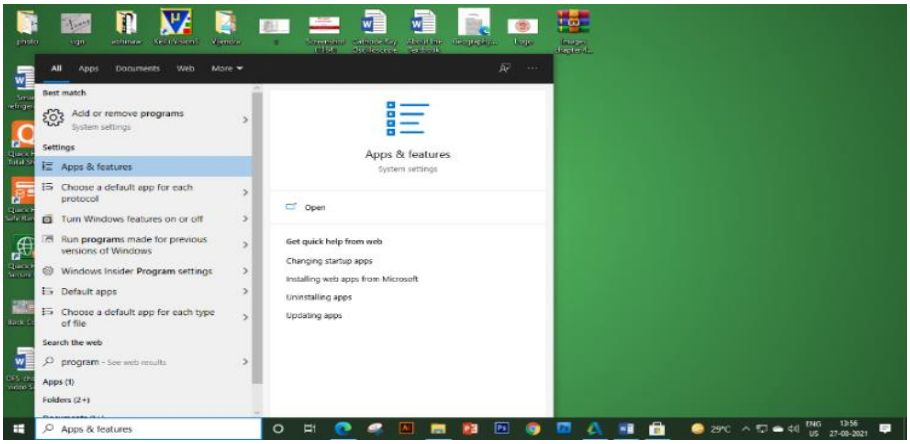


Fig. 2.5 App and feature option in the desktop

Step 3. Click on the update app option. The system will take you to the browser of the operating system as shown in Figure 2.6.

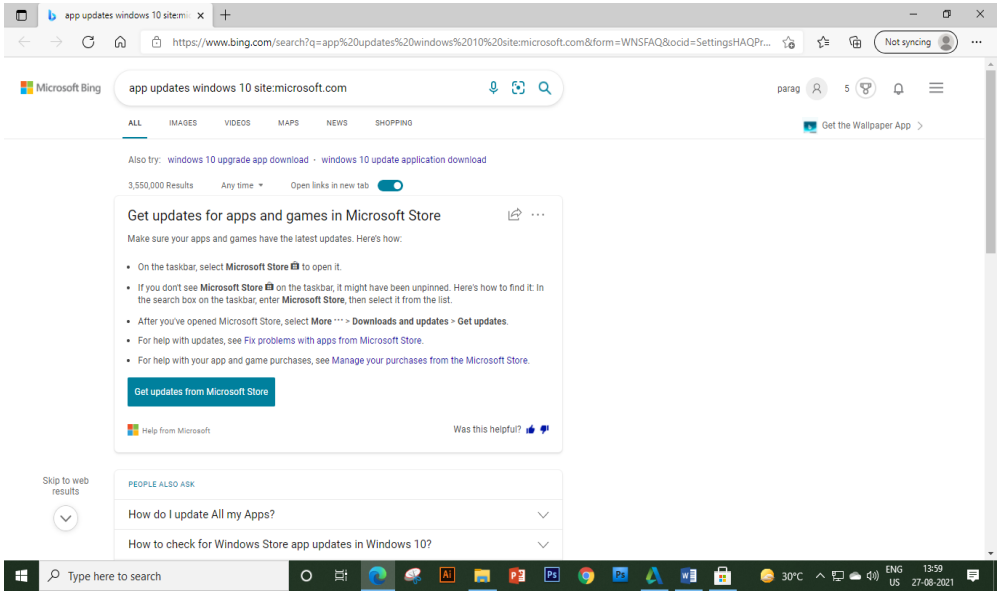


Fig. 2.6 Updating link in the browser

Step 4. Click on the "Get options from Microsoft store". You get all the app of the system as shown in Figure 2.2.

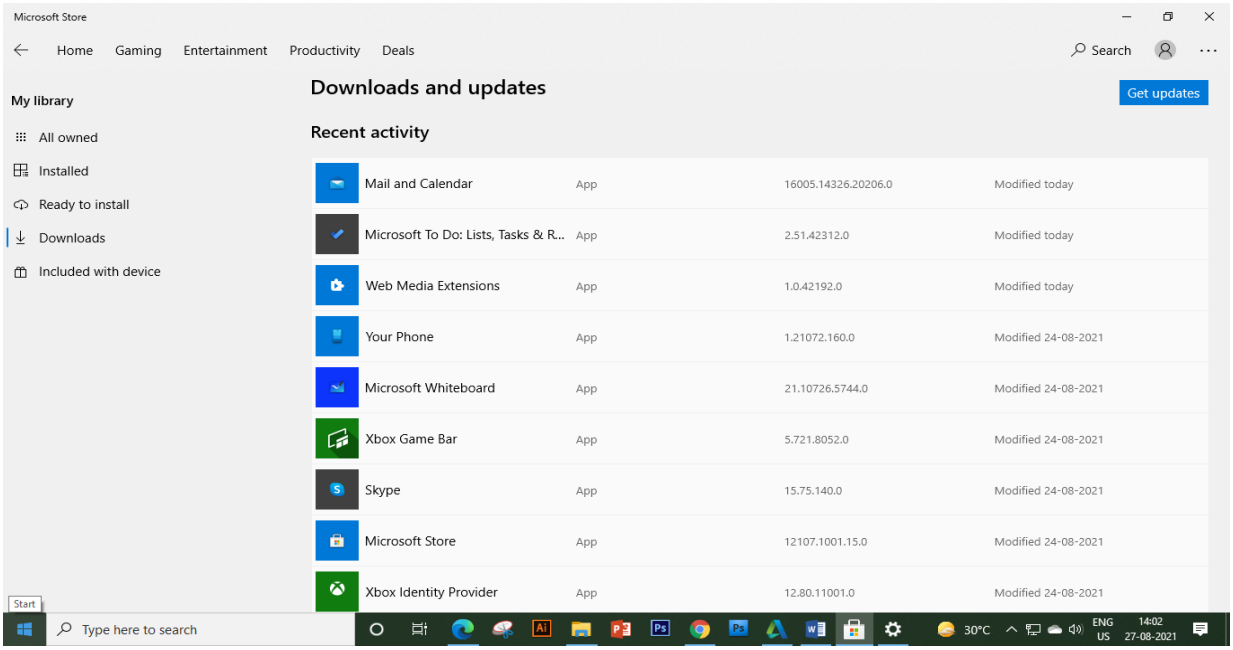


Fig. 2.7 Applications for updates

Updating Android

Step 1. Make sure the device is connected to Wi-Fi.

Step 2. Open Settings.

Step 3. Select About Phone.

Step 4. Tap Check for Updates. If an update is available, an Update button will appear. Tap it.

Step 5. Install the updated version. Depending on the OS, you will see Install Now, Reboot and install, or Install System Software. Tap it.

Steps to resolve software issues

Here are some common software issues that can arise in a system, along with practices to help resolve them:

a. In Windows, press Ctrl + Alt + Delete, then, choose the Start Task Manager option. From the window that appears, click the Processes tab, then click the Memory menu item. This sorts all open processes based on the amount of RAM they are using. You can shut down a runaway process by clicking the End Process button.

b. Restart the software. Shutting the program down and restarting it can sometimes resolve these issues.

c. Shut down and restart your computer. If restarting the software does not resolve the issue, try rebooting your system. Once the system has fully restarted, re-launch the application in question and see if the problem has been resolved.

d. Undo any recent hardware or software changes. Changes to software and hardware can sometimes cause software problems.

e. Uninstall the software, and then re-install it. Sometimes, software problems occur because critical application files have been removed, updated, or deleted.

f. Scan the computer using antivirus software.

g. Check the firewall's settings. Change the firewall's settings to allow the software to run, and then check to see if you are still having issues with your software.

h. Defragmenting will probably be most useful if you are experiencing an overall slow response on your computer. Note that defragmenting a hard drive applies primarily to Windows-based computers. To do this, go to Start > All Programs > Accessories > System Tools > Disk Defragmenter.

i. In case the internet browsing is unresponsive, it could be due to Wi-Fi or LAN network connection. The lag could result from conflicts in the IP address registration. That can be fixed by rebooting modem or router.

j. If the internet browsing is slow over time due to a large browsing history and cache, make a practice of clearing internet search history and cache regularly.

k. Windows has not automatically restarted after displaying a blue screen, press the Ctrl + Alt + Del keys on keyboard at the same time to restart the machine. Switch it back on and, if you get a Windows start-up menu upon reboot, choose 'Start Windows Normally'.

l. You can restore Windows to an earlier point in time using these snapshots, allowing you to revert to a state before you began experiencing problems.

Start > All Programs > Accessories > System Tools > System Restore.

Choose a date and restore point that you would like Windows to restore to.

m. Cannot log in to Windows.

- Ensure you are using correct username and password.
- Check that Caps Lock/Num Lock is not on by mistake.
- Check that the password matches your expectations by typing it into the username box. This allows you to see what you are entering.
- Check the network cable is securely plugged in at both ends.
- Try logging on to another computer to see if your account works on that.

n. Cannot access the Internet or web browsing is slow: Reset Internet Explorer (IE) back to its default settings and clear the temporary internet files. To do this: in the Internet Explorer, click on Tools > Internet Options > advanced tab > Reset > Delete Personal Settings.

Connect your Raspberry Pi to the network

Raspberry Pi has two Network Interface Card i.e., one for LAN/Ethernet and the other for Wi-Fi. Using an Ethernet cable or Wi-Fi, connect your Raspberry Pi to your local network. Make sure the device is powered ON.

Use `ping` to find your Raspberry Pi's IP

Open the Command Prompt on Windows and run the following command: ***ping raspi***

This should ping Raspberry Pi and return its IP address. If you see an error similar to *cannot resolve raspi: Unknown host*, try running the following instead: ***ping raspberrypi***

If you are running RetroPie, you can try the following hostname: ***ping retropie***

The easiest way to find the MAC address on a Raspberry Pi is to use the command “ifconfig”. The MAC address just after the keyword “ether” in the section corresponding to your network interface. It’s represented as a 12-digit hexadecimal number (AA:BB:CC:DD:EE: FF). This MAC address must some IP address using this IP address, one can trace the network path in the system. One can use the IP address, using it internet connection can be check. Because in the IoT-based appliance most common problem is the loss of internet connection.

Check Your Progress

A. Multiple Choice Questions

1. Which of the following are commonly used boards in IoT application (a) Raspberry pie (b) Arduino Uno board (c) Both a and b (d) FPGA kit
2. Which of the following hardware is not present on the raspberry pie. (a) Pen drive (b) USB keyboard (c) USB mouse (d) Ethernet port3. The programs
3. At mega 328 microcontroller is ___ pins controller. (a) 10 (b) 15 (c) 12 (d) 14
4. Arduino needs ___ power supply. (a) AC (b) DC (c) Pulsating DC (d) Filtered AC
5. Which of following part is not present on the Arduino board. (a) Power supply (b) Joystick (c) Micro SD card (d) USB mouse

B. Fill in the blanks

1. Arduino is an _____ electronics platform.
2. Minimum storage of ____ is required in raspberry.
3. Raspberry Pi ____ is a graphical SD card writing tool that works on Mac OS, Ubuntu 18.04, and Windows.
4. In ICSP -In _____ Programming
5. RaspiCam is _____ app.

C. State whether the following statements are True or False

1. Open the Command Prompt on Windows and run the following command:
2. *ping raspi.*
3. MAC is a hexadecimal number (AA:BB:CC:DD:EE: FF).
4. The easiest way to find the MAC address on a Raspberry Pi is to use the command “configuration”.
5. Connect the Arduino Uno Board to computer using a USB cable the green power LED (labelled PWR) will glow.
6. Large gadgets use firmware for their operation and do not require OS.

D. Short answer questions

1. Define firmware with example?
2. Define Raspberry pie board. Discuss its components.
3. Define Arduino board. Discuss its components.
4. Write down the steps to install the raspberry OS in the raspberry board.
5. What is the role of OS in the Arduino Uno board?

Session 3. Troubleshooting Hardware Issues

In every household appliance, various electronic components are fixed onto a printed circuit board. These components perform specific tasks to accomplish the functions of the appliance. They are part of the hardware unit; therefore, hardware plays an important role in operating the IoT system. To maintain the IoT system, proper maintenance of the hardware is essential.

The hardware utilized in IoT systems includes devices for a remote dashboard, control devices, servers, routing devices, and sensors. These devices manage many tasks and functions, such as appliance activation, action specifications, appliance security, communication with the appliance, and error detection and resolution. In this chapter, you will learn about hardware-related issues and their solutions.

Hardware

Any electronic appliances, houses the various components placed on the board. These components are tangible which of us needs a compact appliance. To build such an appliance, the designer uses their logic to make the hardware unit as compact as possible. Therefore, the hardware design is viewed as a critical component for the success of the IoT product. IoT hardware includes a wide range of devices such as devices for routing, bridges, sensors. These IoT devices manage key tasks and functions such as system activation, security, action specifications, communication, and detection of support-specific goals and actions. In Figure 3.1, it can be seen that hardware in the IoT works as a platform to perform data sensing, controlling, processing, decision-making, and many more.

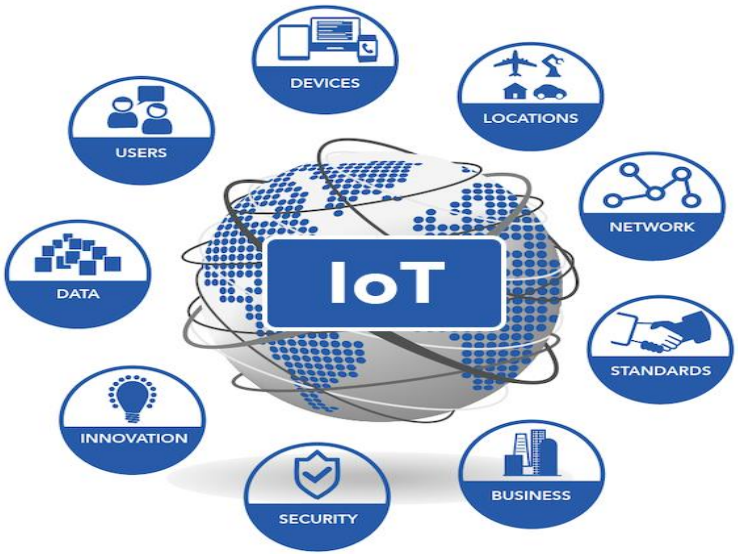


Fig. 3.1 Basic logical representation of IoT hardware work

Now, we will see the criteria, which need to be followed in the manufacturing of IoT hardware namely (i) Power management, (ii) Connectivity, (iii) Integration, (iv) Hardware.

(i) Power Management – It is a big challenge because IoT-based devices are active for a whole day. In case of power failure, power backup is a must. So, the requirement of power is fulfilled by the batteries.

(ii) Integration – It defines the interlinked of IoT-based systems, which means data from one component to another are moving continuously. This movement of data must be monitored using sensors.

(iii) Connectivity – In order to establish a strong IoT network, appliances or things should be connected to a server. This server can receive, send and process the data. Generally, Wi-Fi is used for connectivity in IoT-based systems.

(iv) Hardware – A basic IoT-based circuit, many devices or components are available. However, there is a requirement for a well-defined architecture for an IoT-based appliance. Some points should be considered while dealing with the hardware. Designers keep in mind the design of the Printed Circuit Board (PCB), types of connectors, components, power supply.

Common PCB Issues

The various components are mounted on a PCB. In an IoT-based air conditioner, either of the two boards, *Arduino or Raspberry Pi*, can be used. These boards incorporate a combination of various components used in the air conditioner. Figure 3.2 shows the PCB for the Arduino board and the Raspberry Pi board.

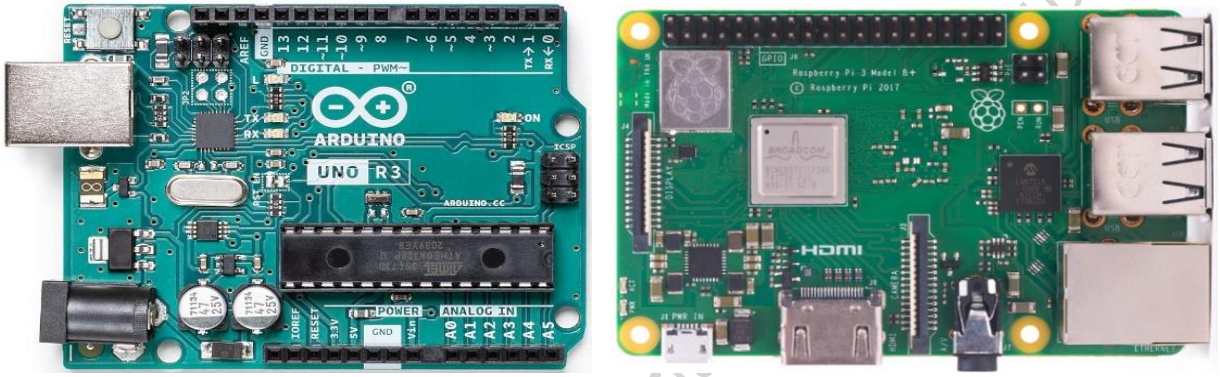


Fig. 3.2 (a) Arduino UNO Board (b) Raspberry Pi board

As many components are mounted on the PCB, this may cause certain issues in its operation. Therefore, understanding the causes of PCB and component failures and learning how to prevent them is critical. Some of the common issues are discussed below:

1. Physical Damage – This is the most common cause of PCB failure and occurs due to physical pressure or shock. The appliance might have been dropped from a height or hit by another object (Figure 3.3).

Fig. 3.3 Body of air conditioner hit on the wall

2. Component Failure – Faulty components are the most common cause of failure. In such cases, there may be no visible physical damage, but the device fails to operate. The primary reason for this is the failure of the component (Figure 3.4).

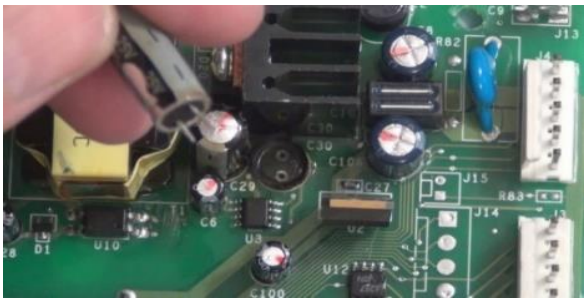


Fig. 3.4 Component failure in the PCB

3. Trace Damage – Traces on a circuit board are the conductive pathways made of copper. If traces are damaged, either through regular use or physical impact, it can lead to significant issues with PCB conductivity. Some common causes of trace damage include excessive power supply, dust contamination, and overheating (Figure 3.5).

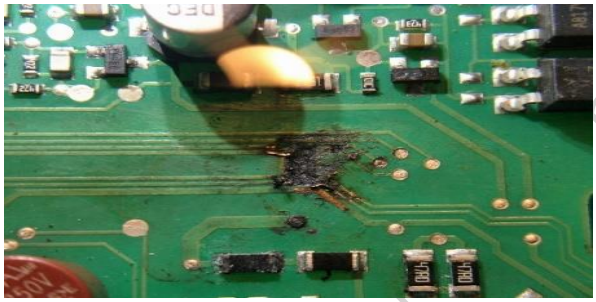


Fig. 3.5 Trace damage in the PCB

4. Poor Design – Sometimes, the design of the PCB and the selection of components can be the cause of the failure of the electronic system. For example, the trace width for signals and power supply may be interchanged, or there may be poor area planning for the placement of components (Figure 3.6).

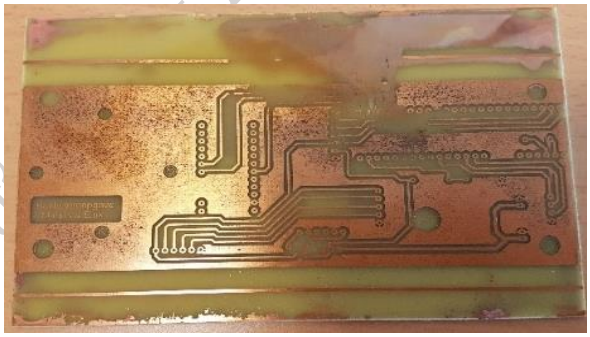


Fig. 3.6 Poor design of trace in the PCB

5. Power Failure – Fluctuating power supply can damage the PCB. A major power failure to the board can harm the components. One of the components may have been exposed to a higher voltage than normal, causing it to overheat (Figure 3.7).

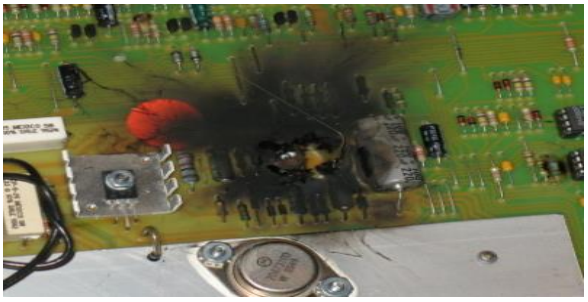


Fig. 3.7 Power failure in the PCB

6. Burnt Printed Circuit Board – It is common for PCB components to burn due to the high temperatures they experience, especially if there is insufficient space around the component. Each component can only absorb a certain amount of heat, which depends on its size and structure (Figure 3.8).

Fig. 3.8 Burnt solder in printed circuit board

7. Poorly Manufactured Components – On the PCB, various components are used in the manufacturing process. Therefore, it is possible that some components may be poorly manufactured. Some signs and symptoms include loose components, connection issues, or even poor solder joints (Figure 3.9).

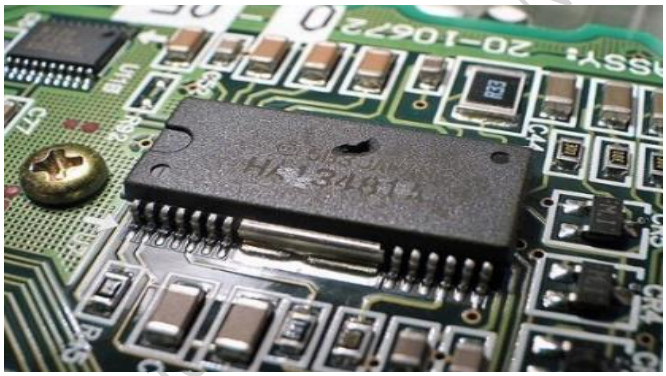


Fig. 3.9 PCB Component Failure

3. Environmental Factors – Exposure to heat, dust, and moisture can cause circuit board failure. Temperature changes can also lead to PCB malfunctions. At high temperatures, circuit components may not function properly, which can alter the specific tasks the PCB was designed to perform (Figure 3.10).

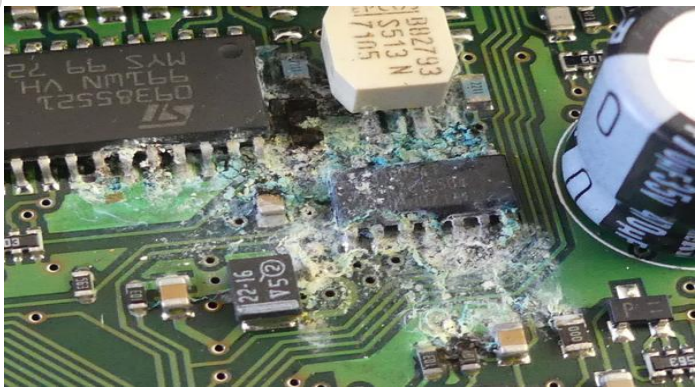


Fig. 3.10 Environmental Damaged to a PCB

9. Age of Appliance – Vintage air conditioners have low efficiency. Over time, these components lose their ability to perform effectively. Fig. 3.11 shows an Old capacitor with the damaged body on the PCB.

Fig. 3.11 Old capacitor with the damaged body on the PCB

Practical Activity 3.1 Demonstrate to repair the common problems in the printed circuit board.

Material Required

Sharp knife, Adhesive copper tape, soldering station, De soldering Pump, Hot air gun, Scissors or craft knife, Pen, Cotton swab and rubbing alcohol, Tweezers, Paper clip

Procedure

Step 1. Take out the faulty PCB and fix it on the PCB holder.

Step 2. Remove the components from the PCB using a hot air gun. Place the hot air gun near the faulty component.

Step 3. Use tweezers to lift out the faulty component. If it does not come out, continue applying heat for a few more seconds and then try again.

Step 4. Use the de-soldering pump to remove the melted solder. Clean the PCB and its tracks, ensuring that the tracks are fully exposed, free of any remaining solder, and appear shiny and clean.

Step 5. After removing the damaged track and cleaning the area, place the adhesive copper tape over the affected area. The tape should overlap the existing track and cover the gap.

Step 6. Solder the joints where the new copper tape connects with the existing track on the restored PCB.

Step 7. Once all the above steps are completed, solder the components onto the restored circuit board.

Step 3. Use scissors to trim the excess tape from the repaired area.

Common issues with sensors

The sensor is an important hardware component in IoT-based refrigerators. The sensing module manages the sensing process using both active and passive sensing devices. Below is a list of some of the measurement devices used in IoT-based air conditioners.

Table 3.1 Sensor in the air conditioner

S. No.	Sensor
1.	Temperature sensors
2.	Proximity sensors
3.	Pressure sensors
4.	Motion sensors

5.	Gas RFID sensors
6.	Humidity sensors

The human body is known to be the most complicated machine. It is a biological circuit with various parts. To operate the human body, sensory organs play a major role. We have sensory organs such as the eyes, ears, nose, tongue, and skin. These organs provide information to our brain, allowing it to make decisions. Our brain continuously uses the information received from the sensory organs to ensure the body functions properly. Similarly, in electronic appliances, sensors are used to control their operation. A sensor is a device that measures physical input from its environment and converts it into data that can be interpreted by a circuit. In an IoT-based system, these sensors are very useful. Information retrieval using sensors is employed in IoT-based air conditioners.

Need of sensors

In the world of digital electronics, every household appliance is becoming smarter day by day. Sensors act as the eyes, nose, and hands of electronic appliances. They guide the appliance to perform its functions smartly and accurately. Most sensors generally provide electrical output signals as feedback to a display or control system. Figure 3.12 shows the various types of sensors that can be wired to a control system and displayed for specific applications.

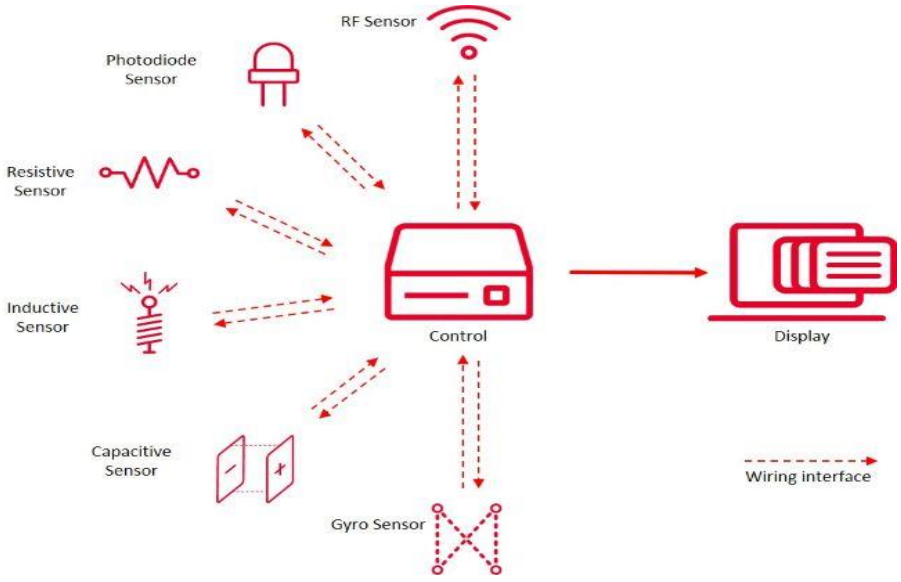


Fig. 3.12 Sensor wiring to a control system and display

Troubleshoot a Sensor

Its failure requires mechanical tools to remove the protective shields or components, allowing you to access the faulty sensor. For safety reasons, it is important to wear appropriate personal protective equipment (PPE), such as insulated gloves and safety glasses. Most sensors have electrical outputs or specific values for resistance, voltage, current, capacitance, temperature, and more. These parameters can be tested by measuring them with a digital multimeter.

Setup for troubleshooting the sensor

The circuitry of the sensor has three main parts: the sensor, the cable and connections, and the control system. Figure 3.13 shows a troubleshooting path for sensor circuitry.

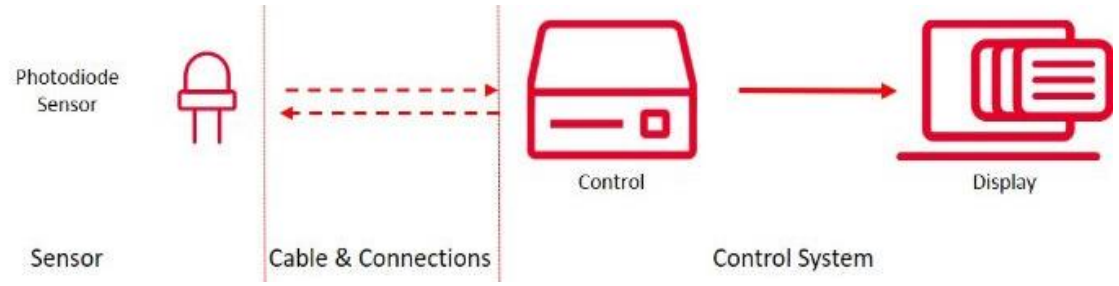


Fig. 3.13 Sensor path troubleshooting

To start troubleshooting, the first part to check is the wiring and the connections between the sensor and the control system. You can use a Digital Multimeter (DMM) to perform a continuity or resistance check on the wiring. In some cases, the internal parts of the cable may have ruptured or suffered worn-out insulation due to movement, trapped water, bending, or prolonged exposure to sunlight and rain. Be sure to check the wire connection interface, as microcracks on solder joints or loose screws are also possible.

Failures in a sensor can be caused by excessive temperature, excess current or voltage, ionizing radiation, mechanical shock, stress, impact, and many other factors. Sensor failure can be categorized as catastrophic failure, offset error, or unstable readings. Some of the most common issues in sensors are:

Catastrophic Failure – In this case, the sensor does not provide any measurement, or the measurement values received are completely out of range. This could be due to sensor failure or a short or open circuit in the sensor or the wiring.

Offset Error – In this case, the measurements obtained from the sensor are stable, but the readings are slightly above or below the expected value. This indicates an offset error in the measurement. It may be due to poor wiring connections or contamination on the sensor or wiring.

Unstable Readings – The readings obtained are unstable. This could be due to low temperature, the presence of foreign particles on the sensor, or low or unstable voltage at the sensor.

Now, let us study how sensors are used in IoT-based refrigerators. Sensors are small devices used in cars, kitchens, smart refrigerators, and many other applications. These sensors feed information to the microcontroller module, which is the heart of the system. Let's look at some details of the sensors used in smart refrigerators.

(i) Temperature Sensor – It is used to measure the temperature in the room and is also used to compare the room temperature to automatically turn off the air conditioner.

Practical Activity 3.2 Test the functionality of the temperature sensor in an air conditioner.

Material Required

Temperature sensor, Multimeter, Jar with ice cubes

Procedure

Step 1. Turn the knob of the multimeter to ohm mode.

Step 2. Connect the multimeter terminals to the temperature sensor leads and note down the reading at room temperature.

Step 3. Fill the jar with ice cubes and dip the temperature sensor into it. Then, check the resistance value using a multimeter. If the resistance value is greater than the previous value, this indicates that the temperature sensor is working well.

(ii) Gas Sensor – A gas detector is a device that detects refrigerant gas leakage. In some models, gas detectors are also used to detect combustible, flammable, and toxic gases. In IoT-based air conditioners, gas sensors are used to detect gases produced by dirt and germs present in the evaporator and air filters. These sensors enable air conditioners to display alerts, notify users via their smartphones, and even trigger active deodorizing systems.

(iii) Proximity sensor – It is a sensor capable of detecting the presence of nearby objects without any physical contact. In IoT-based air conditioners, these sensors are used to detect the presence of persons in the room.

Practical Activity 3.3 Testing the functionality of proximity sensors in an air conditioner.

Material Required

Proximity sensor, general-purpose battery of 9V, lamp bulb

Procedure

Step 1. Hold the proximity sensor and observe its three terminals. Refer to the circuit diagram of the sensors (Figure 1).

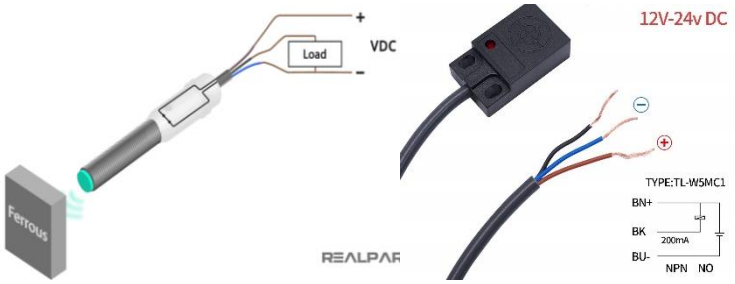


Fig. 1 Proximity sensors

Step 2. Connect the two terminals of the sensor to the positive and negative terminals of the battery, respectively (Figure 2).

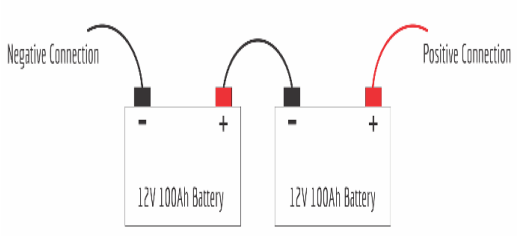


Fig. 2 Terminal connection

Step 3. Bring some objects near the sensor, and the light on the back of the sensor will turn ON (Figure 3).

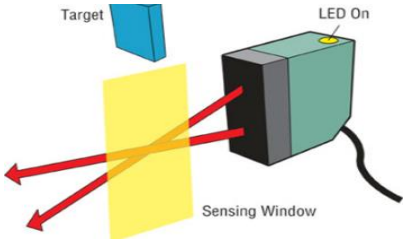


Fig. 3 Turn ON the sensor

Step 4. Bring the bulb, connect one terminal to the center wire, and connect the other terminal to the negative terminal of the lamp bulb (Figure 4).

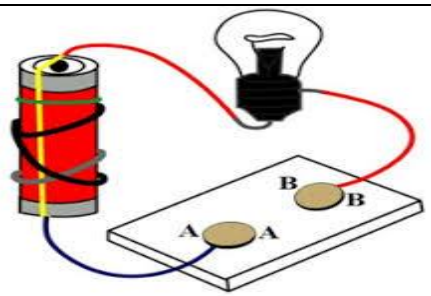


Fig. 4 Lamp connection

Step 5. When an object is brought near the sensor, the lamp glows. This indicates that the proximity sensor is working well (Figure 5).

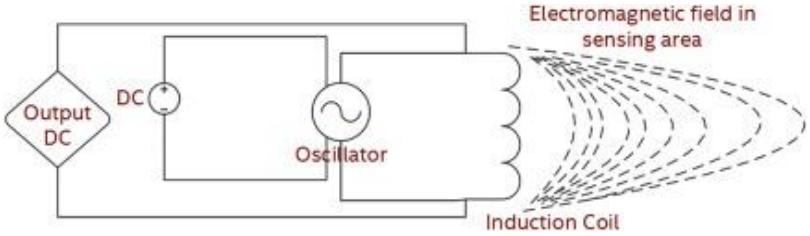


Fig. 5 Lamp glows while the object comes near the sensor

(iv) Motion sensor – It is a sensor used to detect the motion of a person in the room. Using a motion sensor, the air conditioner provides both direct and indirect cooling. It tracks the movement of the person with its intelligent sensor. When it detects the person's movement, it cools the space where the person is sitting (Figure 3.14).

Fig. 3.14 Motion sensor

Practical activity 3.4 – Demonstrate to replace the faulty temperature sensor.

Material required – Wire cutter, screwdriver, new temperature sensor

Procedure

Step 1. Open the cover of the IoT based air conditioner and remove the air filter.

Step 2. Take the screwdriver and remove the cover of it.

Step 3. Locate the temperature sensor of the air conditioner.

Step 4. Take out the temperature sensor clip from the electrical panel.

Step 5. Replace the faulty temperature sensor with a new temperature sensor.

Step 6. Reassemble the unit.

Issues in Network Cables

The network cable is a very important part of an IoT system. It plays a vital role in providing strong connectivity between the appliance and the user. Some issues that can occur in network cables are discussed below.

1. Electromagnetic Interface – Cables are used to transmit data from one place to another. When these cables are placed side by side, there is a possibility of interference between them.

The signal from one cable can interfere with the signal of another, which can harm both the data transmission and the lifespan of the cables.

The electrical cabling near the network cable could cause interference, making the data on the network cable unreadable. There could be numerous collisions on the network, leading to distorted signals. To avoid interference, the wires and cables used for interfacing must be correctly routed, meaning they should be placed as far away as possible from electromagnetic interference sources.

2. Moisture – This environment is tough for electronic products because it can harm the components. Airborne chemicals and air conditioner cleaning agents can result in corrosion of metal contact parts in terminal blocks. As a result, this can affect the integrity of the connections.

3. Labelling and Identification – People use various wire orientation patterns. Sometimes, technicians in a hurry may take shortcuts to get a system back up and running. When troubleshooting, the first step is to find the problem in the wire and where it goes, which can waste a lot of time. Therefore, labeling the terminal blocks above the termination point and labeling wires based on their destination is an easy way to simplify troubleshooting and repair.

4. Atmospheric Temperature – The environment in which cables are set up makes a huge difference. If the cables heat up too much, it could lead to the failure of the entire network. Similarly, moisture can also cause network failure and compromise the safety of nearby workers.

5. Loose Wiring – Loose connections can lead to problems in the network. Due to vibration or external pressure, the joints may become loose over time, which can result in system failure.

Issues with Power Connection

Power is a basic necessity for any circuit. Without it, the system is useless. Some issues that can occur with the power connection are discussed below.

Bad Connection – During the assembly of the circuit on a breadboard or a general-purpose PCB, some wires may remain open, or two or more wires may short-circuit when soldered. This can lead to incorrect output from the circuit.

Wrong Connection – Electronic circuits use a DC power supply. While making a power connection, if the positive terminal of the circuit is connected to the negative terminal of the power supply and vice versa, powering the connection can lead to the failure of the circuit.

Noisy Circuit – Electric power is supplied to various components through copper traces or wires on the PCB or within the system. Signals nearby may interfere with the power supply in the traces or wires. This interference can damage the circuit in use, especially amplifiers and microcontrollers, as they are highly sensitive to noise.

Bad Power Supply – Make sure the power supply is providing power to the correct places and is not faulty. If the power supply is inadequate for the circuit, there will be variations in the circuit's performance.

Bad Filter – Filters are used to smooth the power supply. However, a faulty filter fails to perform its task, resulting in noise in the circuit. A large-value capacitor near the power supply can help reduce the voltage ripple.

Floating Inputs – Inputs to logic circuits and microcontrollers should either be grounded (0) or connected to Vcc (1) to ensure proper operation.

Overheating

If the circuit is ON and some of the components are too hot to touch, this could indicate excessive voltage or current. In such cases, using a high-wattage resistor can help by dropping

the excessive voltage, thus reducing the power dissipation and preventing damage to sensitive components. Make sure the resistor is rated for the appropriate power handling to avoid overheating. Additionally, consider improving the cooling or ventilation of the system to ensure components stay within safe operating temperatures.

Common Sensor

Some of the common sensors are used in electronic appliances are diode, Resistive/capacitive sensors, Light-dependent resistor (LDR), Thermistor.

a. Diode sensor – Diode sensors are used in many applications such as sensing light intensity, sensing object proximity. Some diode sensors are DC-biased, and some are not.

b. Resistive sensors – These sensors are used to measure many physical parameters such as position and displacement, force, human interface devices.

c. Temperature sensors – These are thermistors and resistance temperature detectors (RTD). These sensors can be damaged due to overcurrent or faulty current. DMMs can measure resistance accurately with a wide enough range Ω to GΩ.

Practical Activity 3.5 Test the diode sensor using a multimeter.

Material Required

Multimeter, Diode sensor

Procedure

Step1. "A digital multimeter typically has a test function called 'diode test,' where it injects current and measures the voltage across the diode under test."

Step 2. When the positive terminal of the diode is connected to the red cord and the negative terminal of the diode is connected to the black cord, the diode will show a reading on the multimeter display.

Step 3. When the positive terminal of the diode is connected to the black cord and the negative terminal of the diode is connected to the red cord, the diode will show no reading on the multimeter display.

Step 4. Test the diode sensor by changing the polarity during the diode test, as we did in steps 2 and 3. If the diode sensor works as described in steps 2 and 3, then the diode sensor can be considered functional.

Thermistor

It is a resistor, which is widely used in the air conditioner circuit. A thermistor is a type of resistor whose resistance is dependent on temperature. The word thermistor is a combination of thermal and resistor. Thermistors can be *Negative Temperature Coefficients* (NTC) and *Positive Temperature Coefficients* (PTC).

NTC – NTC stands for "*Negative Temperature Coefficient*". In this thermistor, resistance decreases with an increase in temperature. They are primarily used as temperature sensors. A typical, NTC thermistor is shown in Figure 3.15.

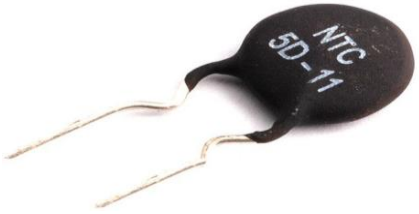


Fig. 3.15 Negative temperature coefficient thermistor

PTC – PTC stands for "*Positive Temperature Coefficient*". In this thermistor, resistance decreases with an increase in temperature. A typical, PTC thermistor is shown in Figure 3.16.

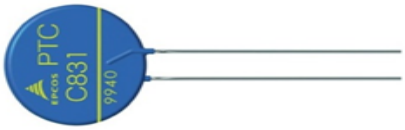


Fig. 3.16 Positive temperature coefficient

Testing Thermistor using DMM

Practical Activity 3.6 – Testing of an NTC Thermistor

Material Required – NTC Thermistor, Multimeter

Procedure

Step 1. Turn the knob of the multimeter to ohm mode as shown in Figure 1.

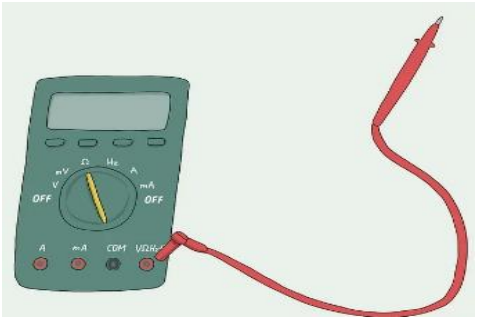


Fig. 1 ohm mode

Step 2. Connect the multimeter terminals to the NTC thermistor leads as shown in Figure 2.

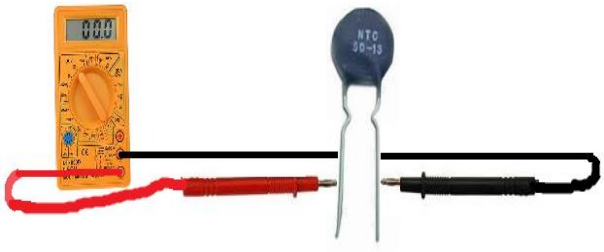


Fig. 2 Connect the multimeter terminals NTC thermistor leads

Step 3. Check its rated value. For example, 120Ω as shown in Figure 3.

Fig. 3 NTC 120D-9

Step 4. Produce some heat around the NTC thermistor as shown in Figure 4.

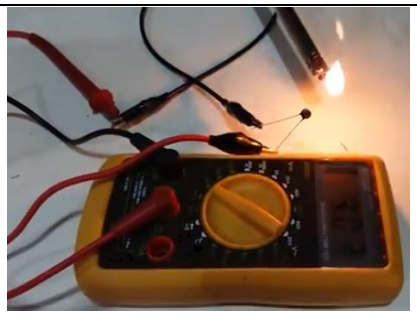


Fig. 4 Heat around the NTC thermistor

Step 5. Observe the reading on the ohmmeter; the resistance should decrease as the temperature increases.

Fig. 5 Reading on the ohmmeter

A thermistor is a type of resistor whose resistance changes in response to the temperature it is exposed to. Now, let's see how to test a thermistor using a multimeter.

Practical Activity 3.7 – Testing of a PTC Thermistor

Material Required – PTC Thermistor, Multimeter

Procedure

Step 1. Turn the knob of the multimeter to ohm mode.

Step 2. Connect the multimeter terminals to the PTC thermistor leads.

Step 3. Check its rated value. For example, 120Ω.

Step 4. Produce some heat around the PTC thermistor.

Step 5. Observe the reading of the ohmmeter it should increase as the temperature is increased.

Light Dependent Resistor (LDR) – A light-dependent resistor (LDR) is used in various circuits for operation. Its resistance value changes according to the intensity of light falling on it. LDRs are commonly used in many IoT-based appliances.

A relay is an electromechanical switch used to safely control the operation of machines. In refrigerators, relays are commonly used in the input power circuit of the compressor. Relays come in various forms, including PTC relays, voltage relays, current relays, and electronic relays. In all these relays, the coil generates a magnetic field that attracts a movable lever to change the switch position.

The PTC relay is used to provide power to the air conditioner compressor. The voltage relay is typically used to start the capacitor-start, capacitor-run motor of the compressor. A voltage relay generally has five points as shown in Fig. 3.17.

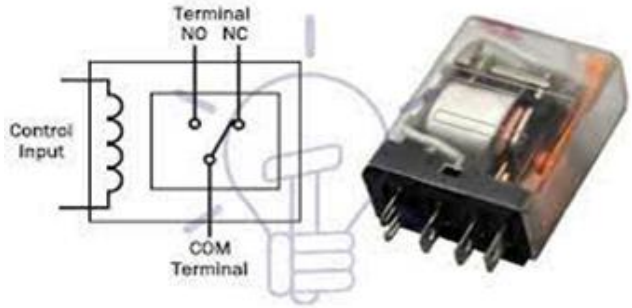


Fig. 3.17 Voltage Relay terminals

Practical Activity 3.8 – Testing of a Light Dependent Resistor.
Material Required – Light Dependent Resistor (LDR), Multimeter
Procedure
Step 1. Turn the knob of the multimeter to ohm mode.
Step 2. Keep the LDR in the bright room. Connect the multimeter terminals to the LDR leads.
Step 3. Observe the resistance value of the LDR.
Step 4. Now, maintain darkness over the LDR by covering it with opaque paper.
Step 5. Observe the reading on the multimeter; it should increase as the darkness increases. In other words, as the light intensity on the LDR (Light Dependent Resistor) decreases, its resistance increases. This describes the typical behavior of an LDR: as light intensity increases, the resistance decreases, and as light intensity decreases (darkness increases), the resistance increases.

Practical Activity 3.9 – Test the 5-pin voltage relay.
Material Required – Multimeter, 5-Pin PTC relay, series test lamp
Procedure
Step 1. Check the test lamp.
Step 2. Take the series test lamp cords. And connect them to terminals 1 and 2, the lamp will glow.
Step 4. Connect the cords of the series test lamp between points 2 and 5.
Step 5. Observe the beep sound, if it appears then the relay is okay.

Check Your Progress

A. Multiple choice questions

1. Which of the following is not the criteria for the deployment of an IoT network? (a) Power management (b) Connectivity (c) Hardware (d) Network
2. Which of the following can be the issue in the network cabling? (a) Loose Wiring (b) Soldering (c) Bad weather (d) high temperature
3. The circuitry of the sensor has the following parts namely____. (a) sensor, cable wiring, and control system (b) Microcontroller, Circuit Board (c) Control system, electronics components (d) Microcontroller, cable wiring

4. Testing of a light-dependent resistor can be done by ____. (a)voltmeter (b) Ammeter (c) multi-meter (d) Thermometer
5. Which type of relay is used in the refrigerator. (a) Voltage relay (b) Current relay (c) PTC relay (d) Electromagnetic relay

B. Fill in the blanks

1. To operate the IoT system _____plays an important role in working of IoT system.
2. Hardware is the part in which required_____ are installed in the hardware.
3. In "Internet of Things," the things must be able to connect to a _____that can capture and process the data.
4. The full form of PCB is _____.
5. LDR stands for Light _____ Resistor.

C. State whether the following statements are True or False

1. Thermistors are of two types i.e., NTC and PTC.
2. IoT technology is wired technology.
3. Printed circuit boards are integral components in all electronics from medical devices and wearables to satellites and airplanes.
4. Temperature change does not affect PCB's malfunction
5. Sensors are devices that detect external information, replacing it with a signal that humans and machines can distinguish.

D. Short answer questions

1. What are the hardware issues in the IoT-based refrigerator?
2. What are the causes of the PCB failures?
3. What are the common issues with the sensors?
4. How the sensors are tested?
5. What is a thermistor and how to test it using DMM?
6. How to test the PTC Relay using DMM?
7. What is the role of the proximity sensor?
8. Discuss the issues with the power connection.
9. Discuss the issues in the network cable.

Session 4. Network Cables and Connectors

Akshay went to the market. While in the market, his mother received a message on her phone. It was a reminder from the IoT-based refrigerator regarding the food to be purchased. She immediately went to the grocery store and bought the required items. This surprised Akshay. He asked his mother, 'How did this message come to you automatically? Can machines talk to us? His mother smiled and explained to him about high-speed internet and advanced communication technologies.

The above example illustrates the importance of communication technology in our daily lives. Today, communication has become the backbone of the digital world. The IoT-based network is also a part of this communication technology. For the establishment of IoT-based appliances,

such as an IoT-based refrigerator and IoT air conditioner, various cables and connectors are used. In this chapter, we will learn about communication technology, transmission media, network cables, and connectors used in IoT-based appliances.

Communication Technology

Communication refers to the 'sharing of information.' Combining both terms, it can be defined as the exchange of information to distant locations using electronic devices. It is a broad term that encompasses a wide range of information-transmitting technologies such as mobile communication, microwave communication, and optical fiber communication.

To understand the process of communication, let us consider an example: if one makes a call to a friend, one will act as the transmitter (i.e., cellular A), and the friend receiving the call will act as the receiver (i.e., cellular B). This simple communication process is illustrated in Figure 4.1. In this example, the air serves as the medium for signal transmission, which represents a wireless method of communication. In the case of wired media, cables are used as the medium of communication, which can be twisted wire or optical fiber cables.

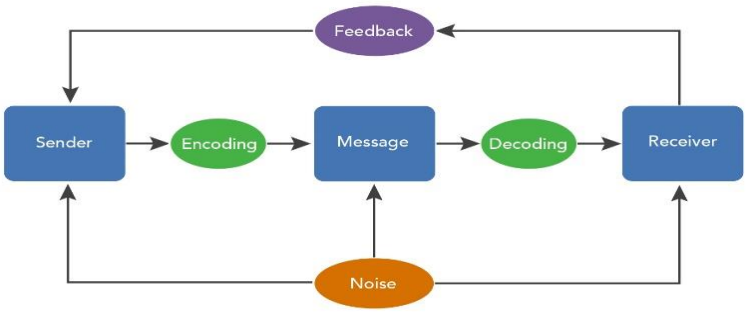


Fig. 4.1 Basic communication process

IoT-based Technology in India

IoT in India is projected to increase year after year. With initiatives like smart manufacturing, industry 4.0, and smart cities, we can estimate that India will be one of the most fast-developing IoT ecosystems in the world.

Increased use of smart devices, combined with cloud computing, analytics is rising consumer expectations. This will boost the rapid growth of the IoT market.

India has undergone a transformation from an agriculture-based economy to a technology-driven economy. The Indian telecom industry has been active for the past 165 years. This sector continues to evolve daily, striving to meet global communication standards, which has significantly contributed to the growth of India's economy.

India is fast growing country to implements smart technology in every sector such as health, finance, media, education, home automation, and many more. (Figure 4.2)

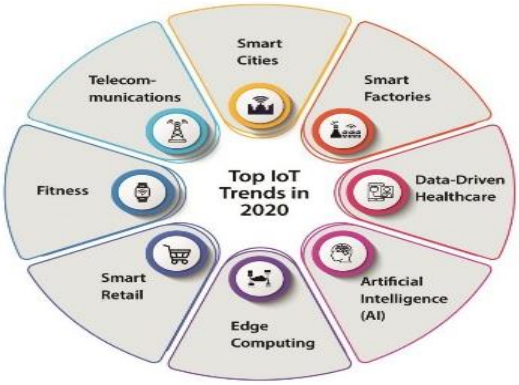


Fig. 4.2 IoT Trends

Internet Service Provider (ISP)

Internet is the backbone of IoT-based systems. A fast and reliable internet connection enables users to work efficiently. To support this, the establishment of high-speed internet connections is increasing every day. In India, internet services are available at minimal prices. This is possible because of many internet service providers and their strong networks.

Nowadays, telecom companies use optical fiber cables (OFC) for high-speed internet connectivity. The use of OFC reduces signal attenuation. Figure 4.3 illustrates the setup, where the ISP provides internet services to a Wi-Fi switch, which then allows users to wirelessly access the internet on various appliances and gadgets, such as mobiles, laptops, desktops, and smart appliances.

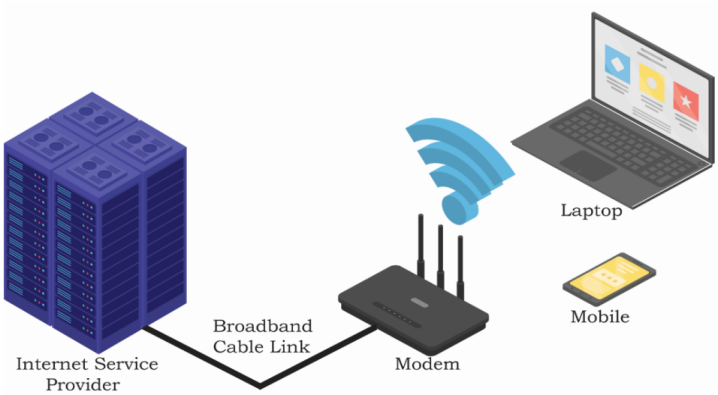


Fig. 4.3 Broadband communication

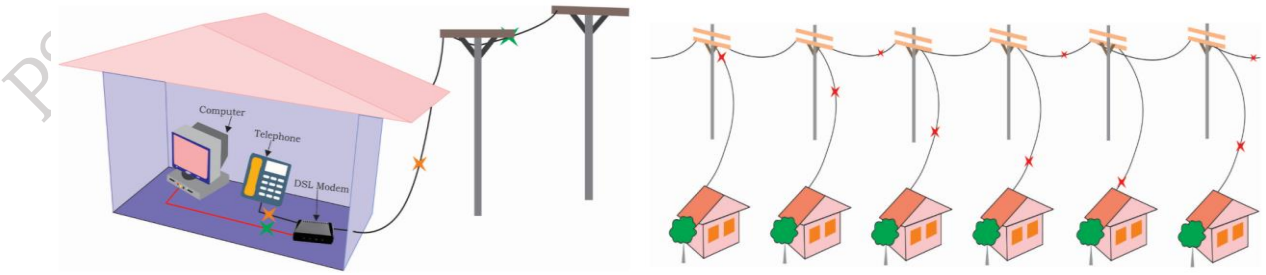
Broadband includes several high-speed transmission techniques such as:

1. Digital Subscriber Line (DSL)
2. Cable Modem
3. Optical Fibre Cable (OFC)
4. Wireless Broadband
5. Satellite Broadband

1. Digital Subscriber Line (DSL) – It is a communication medium that carries both voice and internet data over a telephone line. The data transmission speed ranges from 10 Mbps to 35 Mbps and is used for short-distance communication. DSL does not share bandwidth, as it provides dedicated connections. (Figure 4.4) DSL can be further classified into Asymmetric Digital Subscriber Line (ADSL) and Symmetric Digital Subscriber Line (SDSL).

Asymmetric digital subscriber line (ADSL) – It offers different uploading and downloading speeds.

Symmetric digital subscriber line (SDSL) – It offers equal uploading and downloading speeds.



(a) **(b)**

Fig. 4.4 (a) DSL modem connection distributing the voice and internet signal (b) DSL having a dedicated line for every user

2. Cable Modem – It is a hardware device that allows your computer to establish a connection with Internet Service Provider (Figure 4.5). A modem converts an analog signal to a digital signal. Data transmission has a speed of 20 Mbps to 100 Mbps. But in peak hours, speed becomes too low and it is used in long-distance communication.

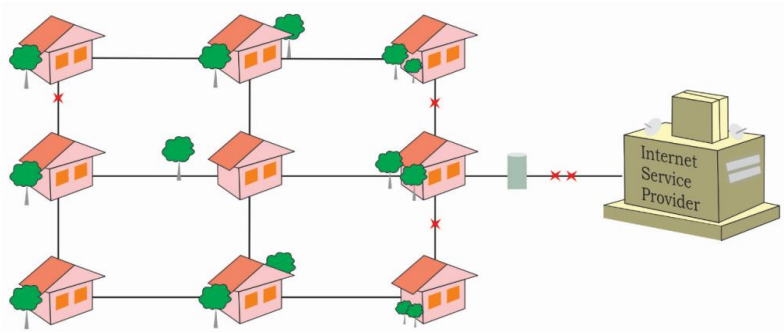


Fig. 4.5 Internet service provider connected to all users through a single line

3. Optical Fibre Cable (OFC) – In optical communication, information in electrical form is converted into light signals and transmitted through an optical fiber. The diameter of the fiber is equal to that of human hair. Data transmission has a speed of 100 Mbps to 1000 Mbps (Figure 4.6).

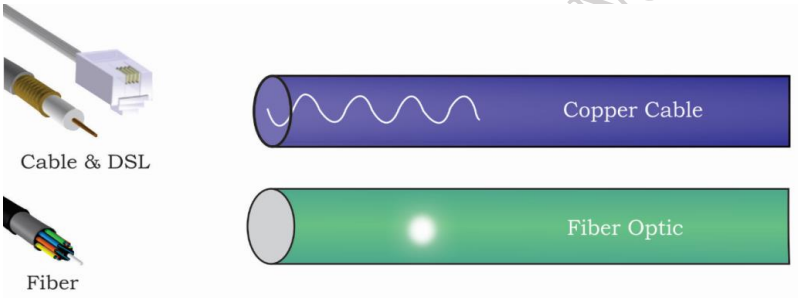


Fig. 4.6 Fibre optics cable in comparison of copper wire

4. Wireless Broadband – It connects customers and service providers through a radio link. Its speed is comparable to that of DSL and cable modem. An external antenna is usually required for connectivity (Figure 4.7).

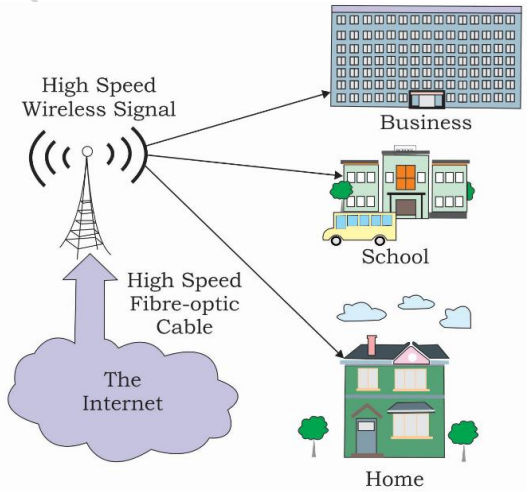


Fig. 4.7 Wireless broadband network

5. Satellite Broadband – It is another form of wireless broadband, and is also useful for providing services in remote and populated areas. Satellites orbiting the earth provide necessary links to telephone and television services links for broadband (Figure 4.7).

Fig. 4.8 Satellite broadband connection

Transmission Media

It is one of the important components of a network for the transmission of data from source to destination. The basic communication system is shown in Figure 4.4.

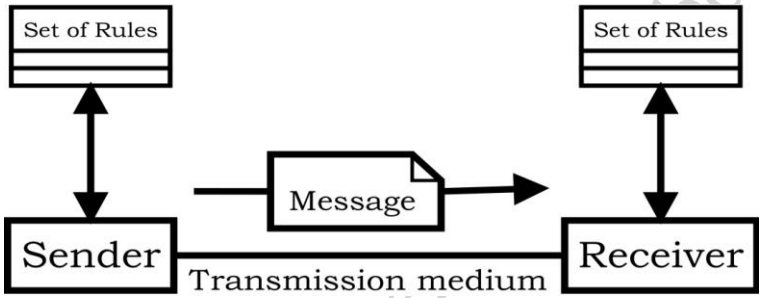


Fig. 4.9 Transmission of data from sender to receiver through a medium

There are two types of transmission media: wired (guided) media and wireless (unguided) media. Wired media include twisted-pair cables, coaxial cables, and optical fiber cables (OFCs). Wireless media include electromagnetic waves, such as radio waves. The quality and characteristics of data transmission can be determined by the characteristics of the medium and the signal. Figure 4.10 shows the classification of transmission media.

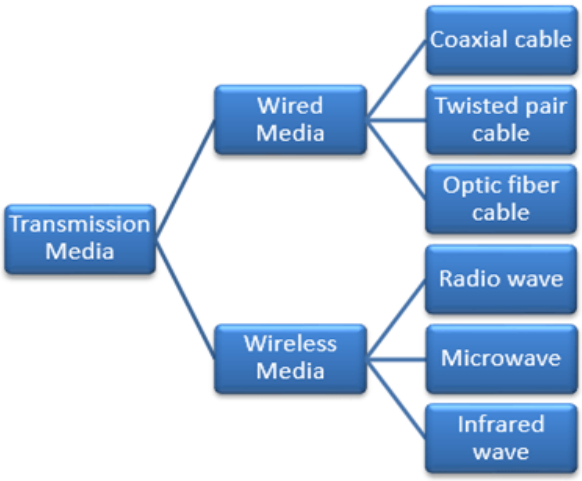


Fig. 4.10 Classification of Transmission Medium

1. Guided Media

Guided transmission media use a cabling system that guides the data signals. It is also known as wired or bounded media. This media is secure, high-speed, and used for small distances.

The signals can be transmitted directly through physical links via Ethernet cabling. There are three types of cables that are commonly used namely – (a) Coaxial cables, (b) Twisted-pair cables, and (c) Optical fiber cables.

(a) Coaxial Cables – It has two parallel conductors: a central copper conductor in the form of a solid wire, surrounded by a PVC insulating layer, a conducting shield, and an outermost plastic sheath. The outer part serves as a shield against noise and also acts as a conductor, completing the circuit. The outermost plastic cover protects the entire cable (Figure 4.11).

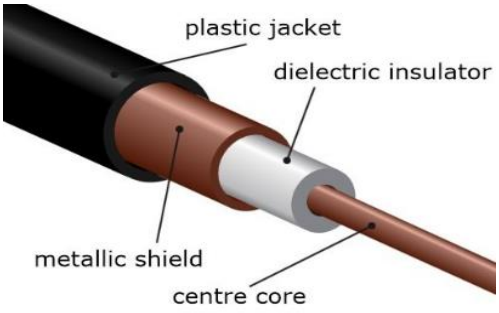


Fig. 4.11 Coaxial cable

(b) Twisted Pair Cables – It consists of two insulated copper wires arranged in a regular spiral pattern. A wire pair functions as a single communication link. Each twisted pair cable contains four pairs. Each pair consists of two copper conductors, each with separate plastic insulation, twisted together as shown in Figure 4.12. One conductor is grounded, and the other is used to carry signals from the sender to the receiver. Separate pairs are used for sending and receiving.

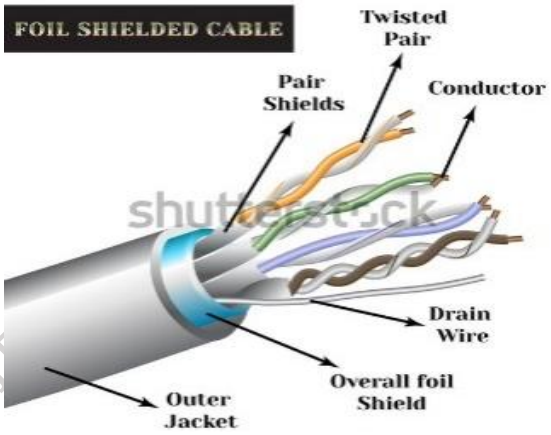


Fig. 4.12 Twisted-pair cable

There are two types of twisted pair cable – *Unshielded Twisted Pair (UTP)* and *Shielded Twisted Pair (STP).*

Unshielded Twisted Pair (UTP) **–** It is the most common type of cabling used in computer networks for small offices, homes, and many commercial networks. Each pair consists of twisted copper wires. However, there is no metal shield to protect the twisted pairs. (Figure 4.13)

Fig. 4.13 Unshielded Twisted Pair Cable

Shielded Twisted Pair (STP) – In this cable, the pairs of wires are surrounded by metallic shielding (such as foil), as shown in Figure 4.14. This shielding prevents electromagnetic interference leakage, which results in higher data transmission speeds. It also increases the security and reliability of the cable.

Fig. 4.14 Shielded Twisted Pair Cable

(c) Optical Fibre Cables (OFC) – It is constructed using a glass or plastic core at the center of the cable, surrounded by transparent cladding (Figure 4.15). Optical fibers use light waves for transmission. Light is confined in the core by total internal reflection, causing the fiber to act as a waveguide. To send data from one end of the cable to the other, light from a Light Emitting Diode (LED) or LASER is used to transmit the signal down the glass fiber at the center of the cable.

Fibers are used instead of metal wires, which results in minimal signal loss from the sender to the receiver and makes them immune to electromagnetic interference. Thus, optical fibers offer high efficiency, reliability, and are very lightweight.

Fig. 4.15 Fiber Optic Cable

They also have a large bandwidth, measured in gigabits or even terabits per second, and data transmission occurs at the speed of light. There are two types of fiber cables: single-mode and multimode fiber.

There are four types of connectors commonly used in fiber optic cables as shown in Figure 4.16.

- ST (Straight-tip Connector)
- SC (Subscriber Connector)
- FC (Fiber Channel)
- LC (Lucent Connector)

Fig. 4.16 Connectors for optical fiber cables (a) ST connector (b) SC connector (c) FC connector (d) LC connector

Twisted Pair LAN Cable Connection

These are used to establish an Ethernet cable LAN in the appliance. Ethernet cable terminals can be formed using the following methods: Straight-through cables and Crossover cables.

The straight-through cable is the most common type of twisted pair cable, used to connect computers to hubs, switches, or routers in local area networks. It is also called a patch cable. A straight-through cable uses one wiring standard (T568A or T568B) at both ends. It has a wire arrangement such that Pin 1 on connector A goes to Pin 1 on connector B, similarly for Pin 2, Pin 3, and so on, as shown in Figure 4.17.

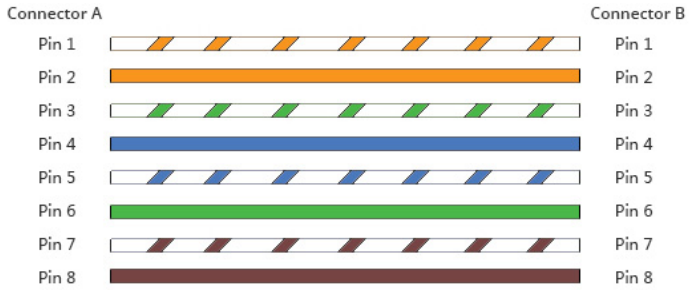


Fig. 4.17 Straight through cable wiring scheme

A crossover cable, as the name suggests, crosses over or swaps connections on its way from one end to the other. The two ends of the cable use two different wiring standards, such that one end uses T568A and the other end uses T568B wiring standards. The internal wiring of Ethernet crossover cables reverses the transmit and receive signals. Both sides (connector A and B) of the crossover cable have a wire arrangement such that Pin 1 on connector A goes to Pin 3 on connector B, Pin 2 to Pin 6, Pin 3 to Pin 1, Pin 6 to Pin 2, and so on, as shown in Figure 4.18. A crossover cable is used to connect two computing devices of the same type via a NIC (Network Interface Controller), such as connecting computer to computer, router to router, or hub to hub.

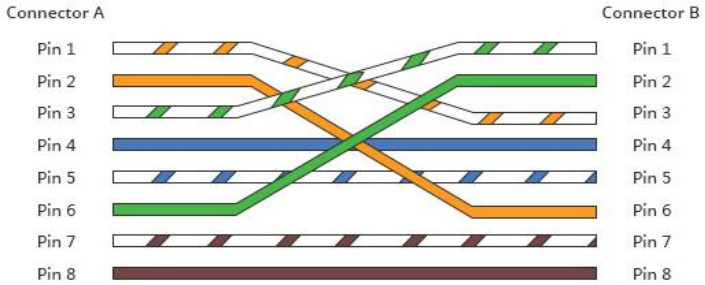


Fig. 4.18 Crossover cable wiring scheme

Table 4.1 Types of LAN cable and specifications

Cable Category (CAT)	Supported Internet Speed	Number of Twisted Pairs	Supported Bandwidth	Cable Laying Length
CAT 5	100 Mbps	2 Pairs	100 MHz	100 Meters
CAT 5E	1000 Mbps (1Gbps)	4 Pairs	100 MHz	100 Meters
CAT 6	10 Gbps	4 Pairs	250 MHz	55 Meters
CAT 6A	10 Gbps	4 Pairs	500 MHz	100 Meters
CAT 7	10 Gbps	4 Pairs	600 MHz	100 Meters
CAT 8	40 Gbps	4 Pairs	2000 MHz	30 Meters

Unguided Transmission Media

This media transmits electromagnetic signals without using any physical medium. The signals are transmitted through the air and are received by the authenticated person. The frequency used for wireless communication is from 3 kHz to 400 THz. The wireless transmission media is categorized as -

(a) Radio waves

(b) Microwaves

(c) Infrared waves

(a) Radio Waves **–** These are electromagnetic waves that travel at the speed of light in a vacuum. They are omnidirectional, meaning they send signals in all directions. These signals have transmitting frequencies ranging from 3 KHz to 1 GHz. When an antenna transmits radio waves, they are propagated in all directions in free space, which means the sending and receiving antennas do not have to be aligned. Since the signals are transmitted through radio waves, they can be received by the receiver. Figure 4.19 shows the application of radio links for the transmission of signals, where the signal is broadcasted by the tower and received by antennas mounted in the nearby residential area.

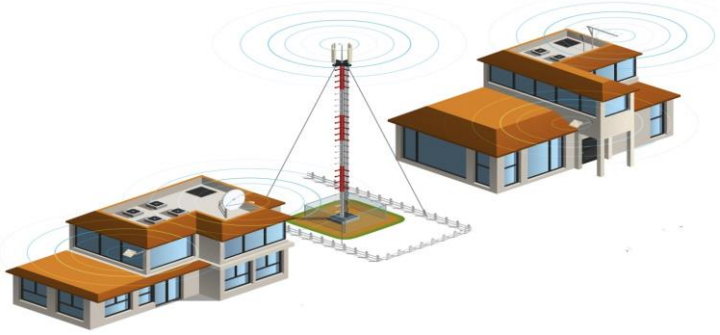


Fig. 4.19 Antenna broadcasting the radio signal to residential areas

(b) Microwaves – It is used for unicast communication, such as cellular phones, satellite networks, and wireless LANs. They have transmitting frequencies ranging from 1 GHz to 300 GHz. The sending and receiving antennas need to be correctly aligned at both ends. Microwaves are used for long-distance communication, as they can carry large amounts of voice and data simultaneously.

Microwave transmission is used in places where installation of physical transmission media is not possible. They are commonly used in our mobile phones. This is also used for IoT-enabled devices (Figure 4.20).

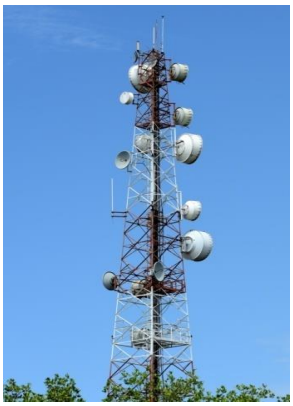


Fig. 4.20 Microwaves are used in the mobile tower for signal transmission

There are two types of Microwave Transmission – *Terrestrial Transmission* and *Satellite Transmission*

(i) Terrestrial Transmission

In these systems, the signals are extremely concentrated, and the physical route must be a line of sight. The signals are extended with the help of relay towers. Terrestrial microwave systems require directional parabolic antennas to broadcast and receive signals in the lower gigahertz range (Figure 4.21).

Fig. 4.21 Terrestrial towers with relay towers

(ii) Satellite Transmission

A satellite can transmit signals from any point on the globe using satellite transmission. It requires satellites in geostationary orbit, approximately 36,000 km above the Earth. The satellite receives the signal transmitted from the earth station, amplifies it, and then re-transmits the amplified signal to another earth station in a straight line. This provides high-quality transmission to and from any location on Earth. Satellite communication is used in a variety of applications, such as radio/TV signal broadcasting, weather forecasting, mobile communication, and wireless communication. However, deploying satellite microwaves for orbiting satellites is challenging, and transmission can be disrupted in bad weather (Figure 4.22).

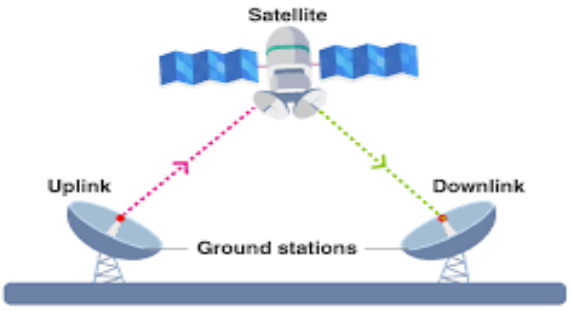


Fig. 4.22 Transmission using satellite

(c) Infrared Waves – Infrared signals can be used for short-range communication in a closed area using line-of-sight propagation. These signals have transmitting frequencies ranging from 300 GHz to 400 THz. High-frequency infrared waves cannot penetrate walls, which prevents interference between one system and another. This means that a short-range communication system in one room cannot be affected by another system in an adjacent room. Remote controls use infrared light waves to control electronic appliances, as shown in Figure 4.23.

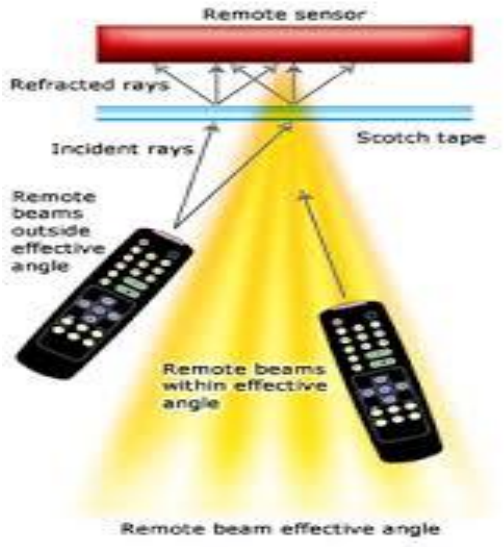


Fig. 4.23 Infrared light wave used in television remote

Electro-Magnetic Interference (EMI)

Interference refers to the amount of noise produced by adjacent cables and wires. When comparing all the cables, we can observe the level of interference in each of them. Table 1 shows the EMI rating for various types of cables.

Table 4.2 EMI rating for various types of cables

Cables	**Electro-Magnetic Interference**
Coaxial	Good
Twisted Pair UTP (Unshielded)	Poor
Twisted Pair UTP (Shielded)	Fair
Fiber Optic	Best

Connectors

Connectors in networking are just as important as the various cables used to set up computer servers, transfer important data, and operate computer networks. Even in your home, there can be many types of connectors and cables. They are used for telephone service, cable television, internet connections, dish TV setups, security cameras, and more. When installing a network, you need plenty of cable connectors to connect patch panels to network switches, computers, and servers. The types of wiring connectors used depend on the network cable types. In this section, we will explore the types of cable connectors, namely: (1) Unshielded Twisted Pair (UTP) cable connector, and (2) Coaxial cable connector.

(1) Unshielded Twisted Pair (UTP) Cable Connectors – It is used to terminate the UTP cable. They do not have any metallic shield. It ensures proper connectivity of the LAN cable. Commonly used UTP connectors are: (a) RJ45 connector, and (b) RJ11 connector.

The naming convention for Registered Jacks is RJ-xx, where 'xx' is a two-digit number. The two digits indicate the type of interface and the area of its application. For example, RJ11, RJ14, and RJ25 are used for terminating telephone lines, whereas RJ45 is used in computer networking.

(a) RJ 45 – This is a plastic connector. Four-pair UTP horizontal cables are terminated with an 8-position modular connector. It is an 8-conductor, compact, modular jack used to terminate

UTP and STP data cables. RJ45 jacks are used to terminate LAN cables of categories (CAT) CAT 5, CAT 5E, CAT 6, or CAT 6A as shown in Figure 4.24 and 4.25.

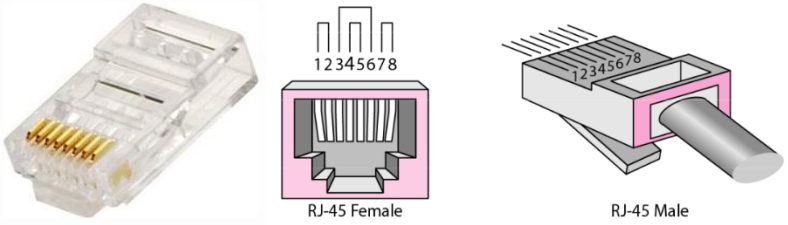


Fig. 4.24 Registered Jack-45 (RJ45) Connector **Fig.4.25 RJ-45 Female and Male connectors**

(b) RJ 11 Connector **–** RJ 11 is the most common phone jack. RJ 11 connectors are used to terminate phone lines.

Fig. 4.26 RJ 11 Connector

Practical Activity 4.1 Prepare a CAT 6 Ethernet cable using an RJ 45 connector.

Material Required

Crimping tools (RJ 45), CAT 6 cable, LAN cable tester.

Procedure

Step 1. Insert the RJ45 strain relief into the cable, it will protect the cable when it is pulled.

Step 2. Strip 2 cm - 2.5 cm of the jacket at the end of the cable.

Step 3. Cut the core of the STP/UTP cable.

Step 4. Straighten the four pairs of twisted wires.

Step 5. Arrange the wires in any of the two orders i.e., T568-A and T568-B.

Step 6. Cut off about 0.5 cm of the wires using the cutter section of the crimping tool.

Step 7. Insert the wires into the RJ45 connector.

Step 8. Crimp the RJ45 connectors using the RJ 45 crimping tool.

Step 9. Slide the strain relief and make sure the contacts of the connectors are entirely connected with the wires.

Step 10. Test the cable using a cable tester. It will assure the cable is working correctly when both ends are crimped.

(2) Coaxial Cable Connector – The most common type of connector used with coaxial cable is the Bayonet-Neill-Cancelman (BNC) connector (Figure 4.27). A BNC connector connects various coaxial cables. One of the benefits of the BNC connector is its close-fitting connection. The connection is locked by the BNC male connector, which has a pin that fits into the main conducting wire. It is then secured in place with an external ring that turns to a locked position. BNC is also used in high-grade analog communications test equipment due to its low signal loss architecture. Coaxial Ethernet cabling is nearly always terminated with BNC connectors. BNC connectors are used to connect the cable, networking devices, and computers.

Fig. 4.27 BNC Plug (Male and Female)

(3) Optical Fibre Connector – Optical fiber cables can be terminated with various types of fiber optic connectors, which can be plugged into the ports of different devices. Figure 4.28 shows some common optical fiber connectors, such as LC, SC, FC, and ST, which are the most commonly used types. The LC connector is used for multiple fiber termination, the SC connector is typically used for connecting cable TVs, and the ST connector is used for establishing a connection between networking devices.

Fig. 4.28 Common optical fiber connectors

Straight Tip (ST) – The Straight Tip (ST) connector is a keyed bayonet connector used for both multimode and single-mode fiber-optic cables. It allows quick insertion and removal from a fiber optic cable. The installation method is also simple. ST connectors are available in two versions: the standard ST connector and the ST connector-II (Figure 4.29). These connectors are keyed and feature a spring-loaded, push-in, and twist mechanism. ST connectors have a metal housing with a nickel-plated construction and ceramic ferrules, rated for 500 mating cycles. The typical insertion loss for matched straight tip connectors is 0.25 dB.

Fig. 4.29 Straight Tip (ST) Connector

Subscriber Connector (SC) – The Subscriber Connector (SC) is commonly used with both Multimode Fiber (MMF) and Single-mode Fiber (SMF). It offers low cost, simplicity, and durability. SC connectors ensure accurate alignment through their ceramic ferrules. The SC connector is a push-on, pull-off type with a locking tab. Typical matched SC connector are rated for 1,000 mating cycles and have an insertion loss of 0.25 dB. The push-pull latching mechanism in SC connectors allows for quick insertion and removal while ensuring a secure connection (Figure 4.30).

Fig. 4.30 Subscriber Connector (SC)

Know more....

The number of times a connector can be connected and disconnected with its counterpart, while maintaining all of its specified performance characteristics, is referred to as 'mating cycles.'

Lucent Connector (LC)/ Little Connector – The Lucent Connector (LC) is used with both single-mode fiber-optic (SMF) and multimode fiber-optic (MMF) cables (Figure 4.31). LC connectors feature a plastic housing construction and utilize ceramic ferrules for precise alignment. They are equipped with a locking tab and have a mating cycle rating of 500. The typical insertion loss for matched LC connectors is 0.25 dB. Developed for high-density deployments, the LC connector is designed for applications where multiple fibers need to be terminated in a confined space. Unlike SC and ST connectors, the LC connector is always used as a duplex connector, which means it connects a pair of fibers at a time.

Fig. 4.31 Lucent Connector (LC)

FC Connector (FC) – The FC (Ferrule Connector) features a threaded body, making it ideal for use in high-vibration environments. It is commonly used with both single-mode optical fiber (SMF) and multimode optical fiber (MMF). The FC connector is popular in various applications, including Datacom, telecommunications, and measurement equipment. The threaded design ensures a secure and stable connection, which is particularly valuable in environments where there is a high degree of mechanical movement or vibration (Figure 4.32).

Fig. 4.32 FC Connector

Check Your Progress

A. Multiple Choice Questions

1. Which of the following is not belong to the category of Twisted Pair Cable? a) CAT 5 b) CAT 5E c) CAT 6 d) CAT 10
2. LC (Lucent Connector) is a connector used in ____. (a) Optical fiber cables (b) Coaxial cables (c) Shielded Twisted pair cable (d) Unshielded Twisted pair cable
3. In STP cable the pairs of wires is _____. (a) surrounded by a metallic shielding (like foil) (b) two parallel conductors, a central copper conductor in the form of solid line wire, surrounded by PVC insulating layer, a conducting metal shield, and then outermost plastic jacket (c) consists of a glass or plastic core at the center of the cable that is surrounded by several protective layers (d) no metal shield for the protection of twisted pairs

4. Which of the following cable has the least EMI? (a) Optical fiber cable (b) Unshielded Twisted Pair (c) Coaxial cable (d) Shield Twisted Pair
5. BNC connector is the most popular form of ___. (a) coaxial cable connector (b) UTP connector (c) STP connector (d) OFC connector
6. The core of the OFC cable at the center of the cable is made up of (a) Copper (b) glass or plastic (c) Iron (d) Brass
7. Which of the following cable has the highest internet speed? (a) CAT 5 cable (b) CAT 6 cable (c) CAT 6A cable (d) CAT 8 cable
8. Which of the following is not an optical fiber connector (a) SC connector (b) ST connector (c) TP connector (d) FC connector
9. RJ 45 connector is used with (a) UTP cable (b) Fiber optics cable (c) Coaxial cable (d) Single-mode optical fiber cable
10. Lucent Connector (LC)/ Little Connector is used with (a) UTP Cable (b) STP Cable (c) single-mode fiber-optic (SMF) and multimode fiber-optic (MMF) cables (d) only Single mode fiber cable

B. Fill in the blanks

1. There are two types of transmission media, one is _____and other is_____.
2. There are two types of twisted pair cable namely _____ and _____.
3. In Shielded Twisted Pair (STP) cable, the pairs of wires are surrounded by a _____ (like foil).
4. RJ-45 connector is used in an _____network.
5. Little connector (LC) is used with _____and _____.

C. State whether the following statements are true or false

1. Optical fiber cable is the fastest means of data communication.
2. CAT 5E Ethernet cable has a speed of 10 Gbps.
3. RJ-45 connector used in a telephone.
4. The Bayone Neill Concelman (BNC) connector is the most popular form of optical fiber connector.
5. ST (Straight-tip connector) is a type of OFC connector.

D. Short answer questions

1. What do you mean by the term Transmission media? Discuss its types?
2. What is the difference between UTP and STP types of cables?
3. Explain the connector used for the twisted pair of cables.
4. How to make the Ethernet cable with the connector.
5. What is Coaxial cable? How it is better than a twisted pair cable?
6. What do you mean by the OFC? Where is used?
7. What do you mean by the Wireless Network?
8. What are various UTP connectors?

Session 5. IoT Mobile App

In the digital age of the 21st century, almost all operations are becoming automated. Automation is making the processes easier, safer, and faster in an efficient manner. Implementing automation in homes can unlock new dimensions of this advanced technology.

At the tap of a smartphone, users can control everything at their fingertips, such as monitoring and managing appliances, turning on lights, playing their favorite music, or adjusting room temperatures. Users can also create and run personalized schedules, such as having coffee ready when they wake up or automatically turning everything off when leaving for work. This enables users to experience the true intelligence of machines.

In this chapter, you will learn how to handle home automation applications. Additionally, you will explore functional testing of the various features in the application, ensuring that users can access all the app's features and functionalities without any issues.

Home Automation

It is a general term that encompasses a range of technological capabilities that can be installed and used in homes. It includes the ability to remotely control various aspects of the home using a computer or smartphone. It acts as a single control center programmed to respond automatically to specific conditions. With a single app, users can manage all IoT-based appliances in their homes, such as IoT-enabled refrigerators, air conditioners, and washing machines.

Home Automation Mobile App

Firstly, a smart phone with internet access is required to use any mobile application for controlling the device. The most important feature of an app is its user-friendly interface. User understand how to use them without any confusion. By clicking on the button's user can easily access a number of options at any time. A typical mobile app project is made-up of three integral parts – *(a) Back-End/ Server Technology, (b) Application Programming Interface (API), and (c) Mobile App Front-End.*

(a) Back-End/Server Technology – The backend, or server-side, is the portion of an application that users do not see (Figure 5.1). It is responsible for storing and organizing data and ensuring that everything on the client-side functions properly. The backend communicates with the frontend by sending and receiving information to be displayed on the application.

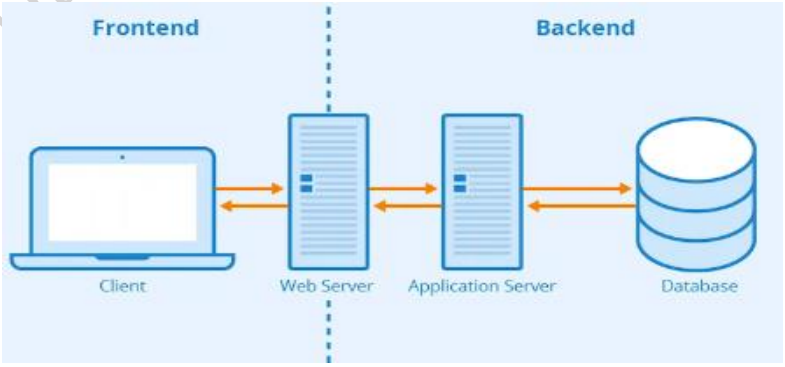


Fig. 5.1 Frontend and Backend of server

(b) Application Programming Interface (API) – It refers to the services offered by a third-party company that are integrated into the home automation application (Figure 5.2). For example, if a user wants to know the temperature of the city they are in, this information can be retrieved from an API provided by the third-party company.

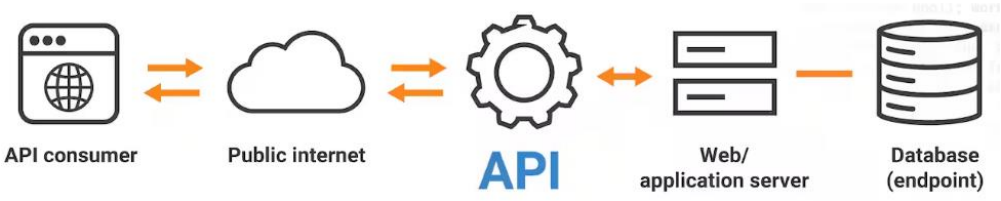


Fig. 5.2 Application Programming Interface

(c) Mobile App Front-End – It is the Graphical User Interface (GUI) of the application. It serves as the interface of the application, defining the layout and design of icons and other visual elements within the application (Figure 5.3).

Fig. 5.3 Integral parts of mobile application

To control any IoT-based appliance, install the home automation application on your smartphone. This application can either be downloaded from the Apple Store or Play Store, or it may be provided by the supplier as an .apk file along with the device. The steps to install the app are as follows:

Step 1. Search the application the google play store/run the .apk file in smart phone.

Step 2. Select the respective application (Figure 5.4).

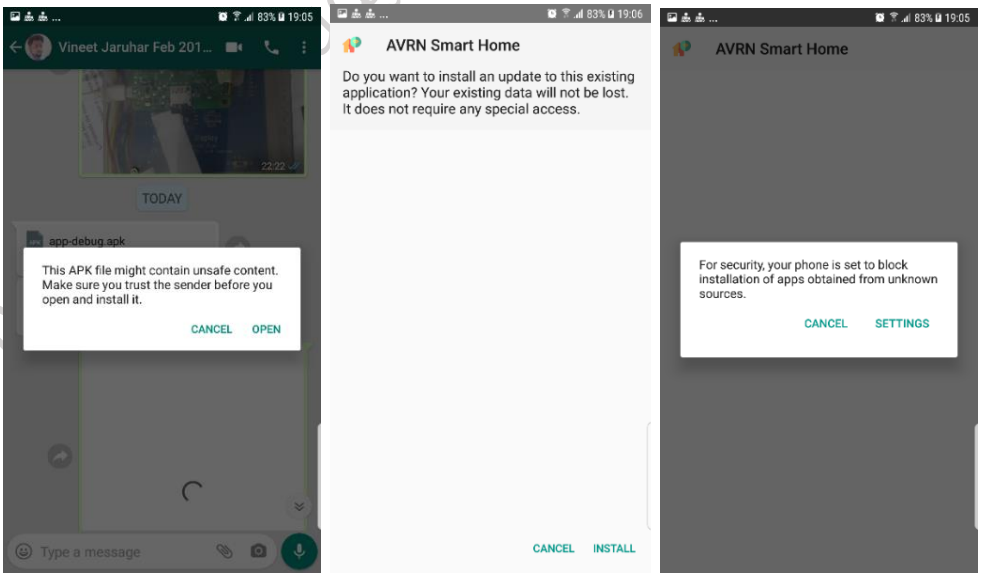


Fig. 5.4 AVRN Smart Home App

Step 3. The AVRN Smart Home App is discussed here. If all security features of the mobile phone are enabled, the app will request the necessary permissions from the user to ensure a systematic installation (Figure 5.5).

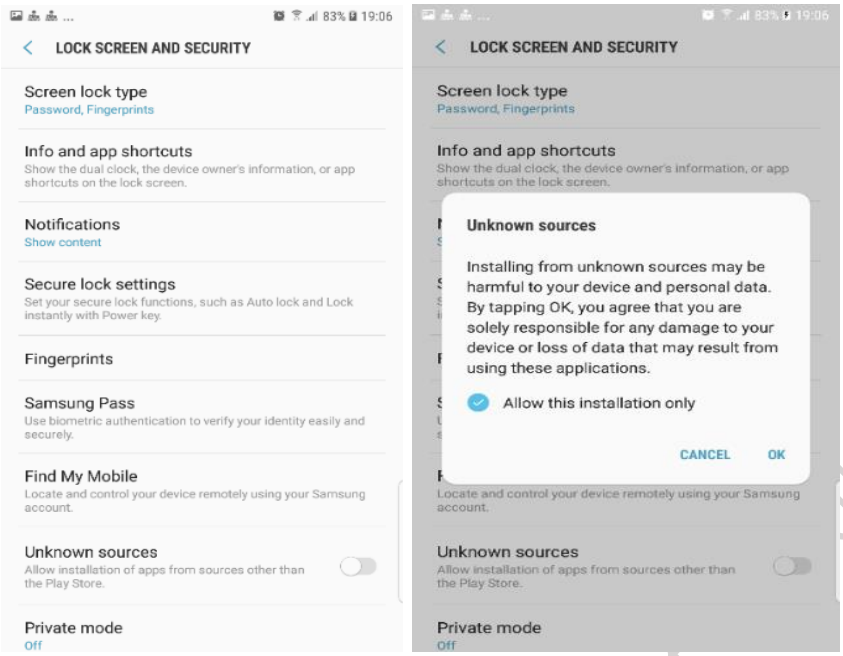


Fig. 5.5 Installation of the app

Step 4. Click on the install button to install the application.

Step 5. After installation, the application will prompt the user to either select "DONE" to complete the process or "OPEN" to launch the app immediately. The app can also be opened later through its icon, which will appear on the mobile phone after installation (Figure 5.6).

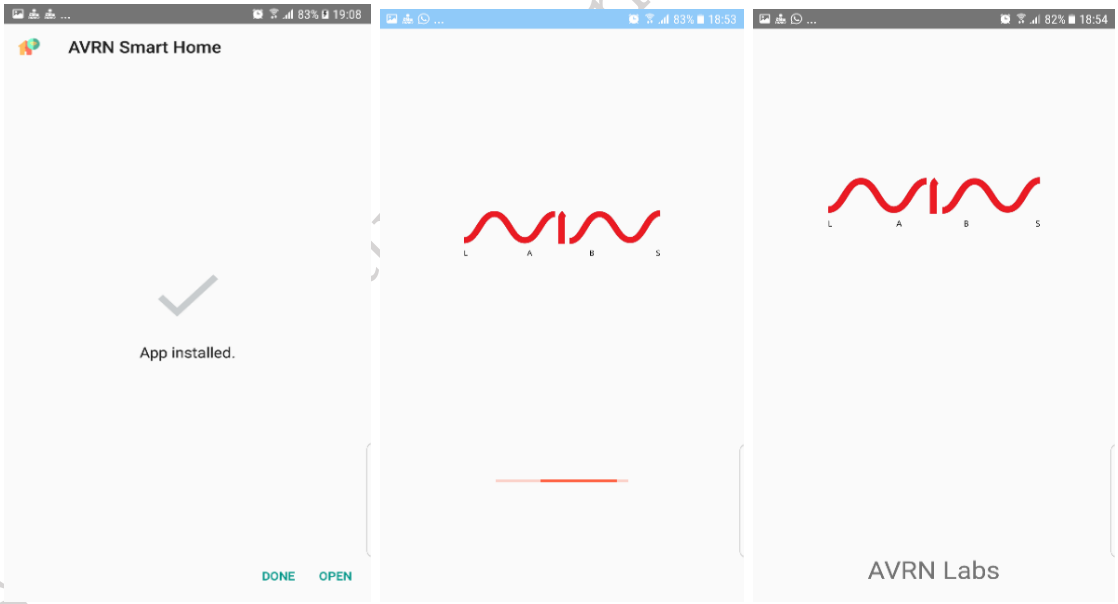


Fig. 5.6 Home automation application in the mobile phone

Once the installation of the home automation application is complete, the user needs to familiarize themselves with the app's features and test their functionality.

Features of Home Automation App

It is an automation app designed to operate home appliances remotely. The app uses the internet to provide users with access to control appliances from anywhere. It features an intuitive user interface with easy-to-use controls. The app automates various systems, including switchboards, power plugs, water management systems, video doorbell systems, and many other appliances, all manageable through a mobile device.

Some of the key features of the application are as follows:

a. Location Management – Using the "geo-fencing" feature, the app can detect your location and send alerts to help manage the appliances accordingly.

b. Time Saver – The app also supports widgets that help you control appliances directly from your mobile home screen, saving you time by allowing you to turn them on or off without opening the app.

c. Energy Saver – The app is perfect for saving unnecessary electricity consumption, thereby reducing costs. Using the mobile application, you can monitor gas and electricity consumption from your device and configure usage according to your requirements and budget. The app is ideal for planning your monthly budget across various appliances. It also sends push notifications to any configured appliance, alerting you about usage and consumption.

d. User Authentication – The app offers the ability to grant limited access or full control of operations to other family members or friends. All devices can be monitored from anywhere in the world.

e. Voice Assistance – It also features a voice command function that takes audio input from the user and executes the corresponding functionality.

f. Security – This app supports a QR code feature to ensure the security of your appliances. Register yourself on the app by providing your personal details, such as name, email ID, and mobile number (Figure 5.7).

Fig. 5.7 QR (Quick response) code for profile details

g. Grouping of Appliance – It displays all the appliances owned by the app's owner, as well as any groups of appliances created by the owner. To add a device to the app, the owner can use the "+" button displayed in the black circle. After pressing the "+" sign, a device can be added by scanning the QR code on the device or by entering the unique device ID (Figure 5.8).

Fig. 5.8 Grouping applications

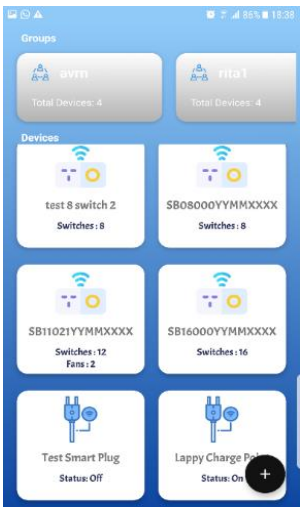


Fig. 5.9 QR code present on the device

h. Remote Controlling – Once the device to be controlled is added to owners account, it will have a unique page for operation (Figure 5.10). Owner can than control any of the switches in this page by touching individual touch button or use All ON or All OFF to either switch ON/OFF all the switches.

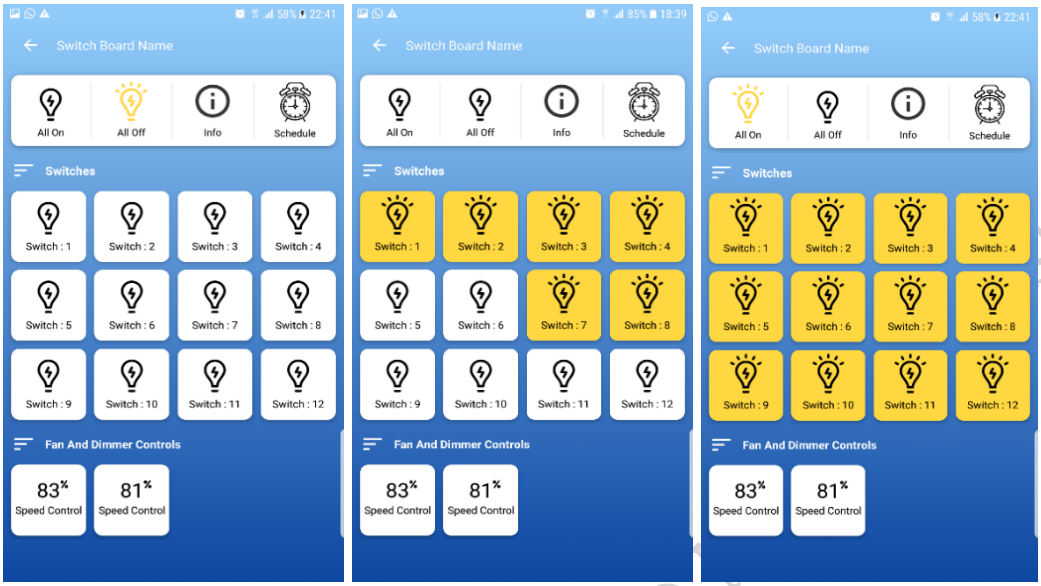
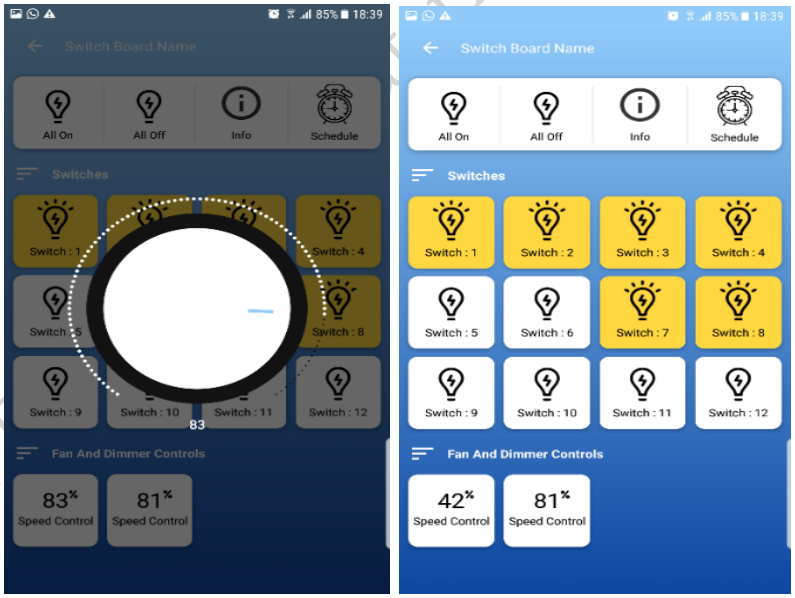


Fig. 5.10 Remote access and control

This device also has Fan and Dimmer Control Switches. The speed of the fan can be controlled through this App along with the intensity of the Dimming devices (Figure 5.11).



(a) **(b)**

Fig. 5.11 (a) Regulator to control the speed of fan, (b) Dimmer control

i. Time Scheduler – This app also provides the ability to switch appliances on or off at scheduled times, which can be programmed by the user for a specific day or multiple days. This Android app allows users to schedule on/off events for individual devices. For example, the owner can schedule the bulb to switch off at 11 PM daily, on weekdays, or on chosen days, and turn it on before sunset. Any switch can be turned on or off according to the owner's preference through the Time Scheduler (Figure 5.12 and Figure 5.13).

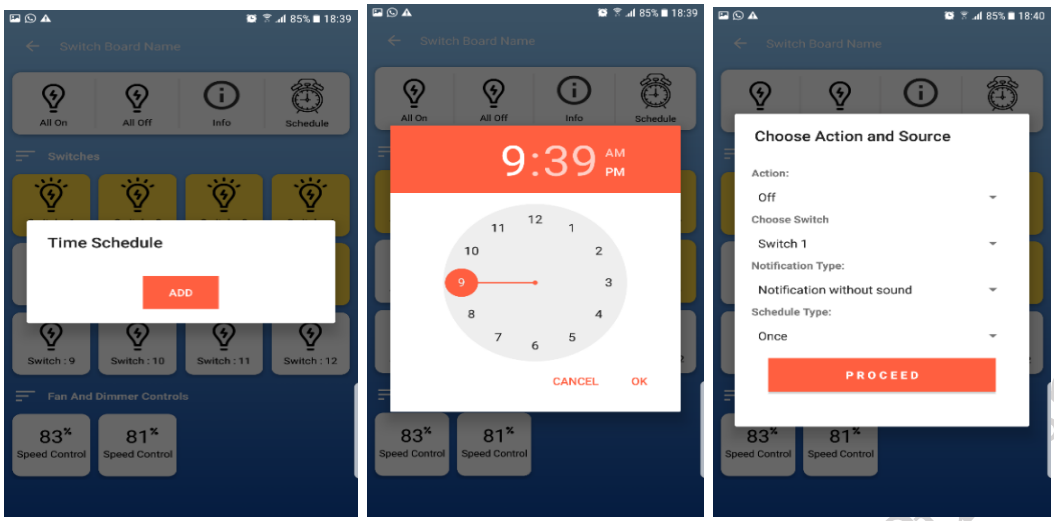


Fig. 5.12 Scheduling the time slot

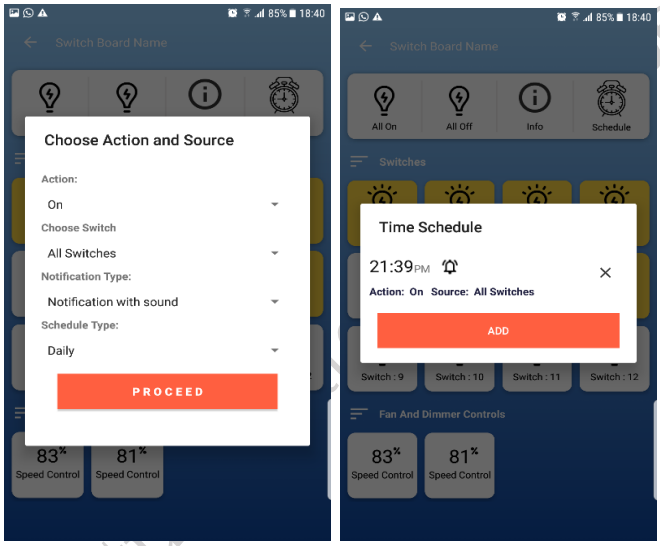


Fig. 5.13 Freezing the time slot

Additional Features – By tapping on the "Settings" icon, other features in the mobile application can be explored, including options to drag up/down to arrange items, edit labels, log activities, and manage notifications (Figure 5.14).

The name of any device or switch can be changed by selecting "Edit Labels" in the settings. After this, select the switch whose name needs to be changed. Update the name by typing the new name and press the tick icon next to it.

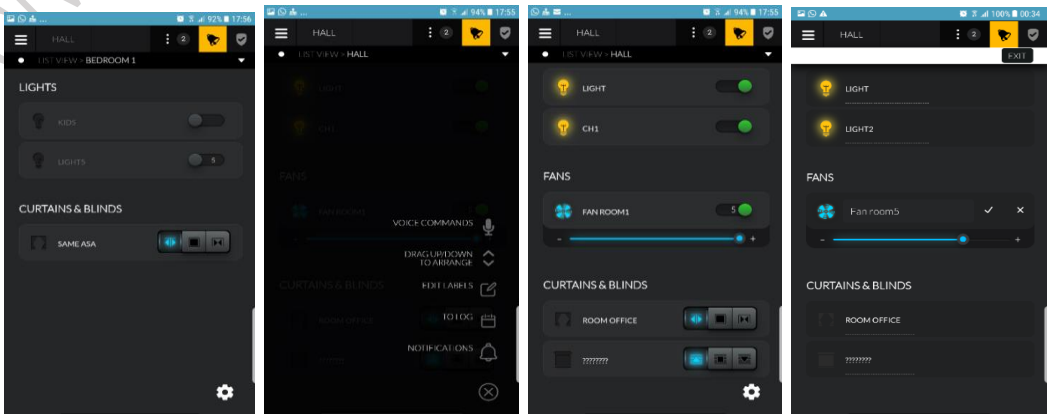


Fig. 5.14 Settings

Groups of devices can be formed by using the three dots on top right corner of the page. It has tab for *Profile, Manage Group, Transfer Devices, Remove Devices, Logout* (Figure 5.16 - 5.18).

- Profile: It gives owner's details in the QR code
- Manage Group: This helps in adding/editing devices to a group.
- Transfer Devices: This option helps in transferring the devices to members of the family, friends, staff members etc.
- Remove Devices: This option helps in removing devices from the group.
- Logout: For logging out of the App.

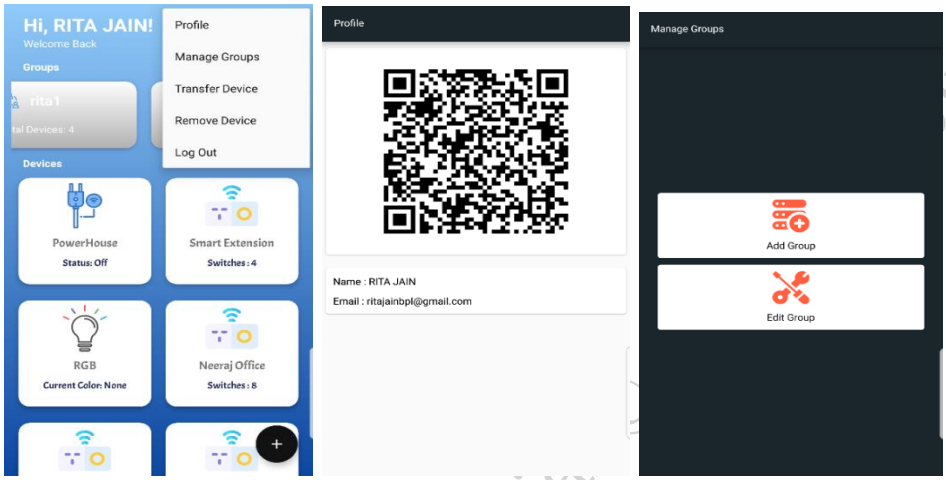


Fig. 5.16 Various profile settings

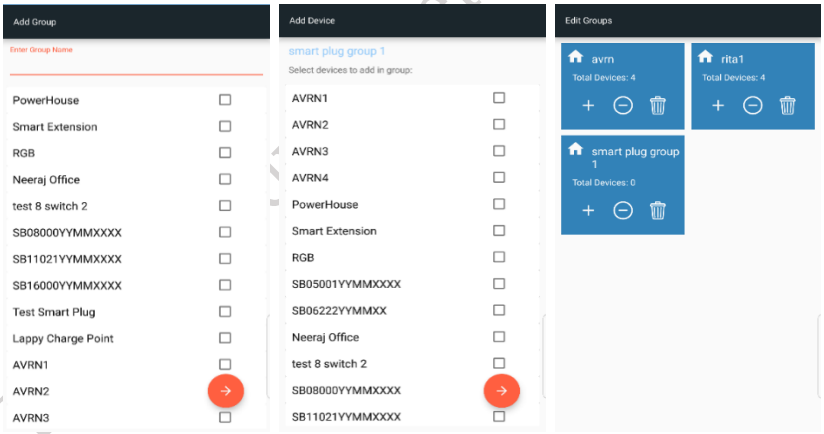


Fig. 5.17 Preparing a device group

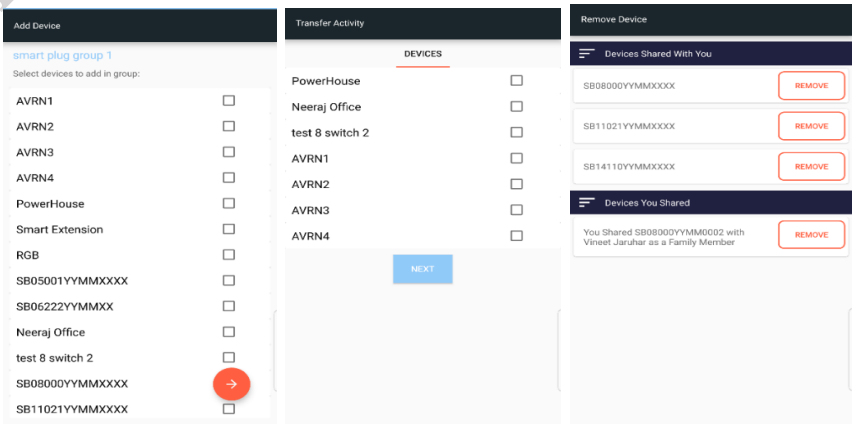


Fig. 5.18 Add, transfer and remove devices

Trouble Notifications

When the app remotely controls appliances, some real-time issues may occur. These issues can be notified to the user by the app (Figure 5.19). Some of the possible causes and notifications received through the app are as follows:

- ✓ If the device does not have power, the app immediately notifies the user with the message, "Switchboard power is switched OFF." This notification may be triggered by one of the following reasons:
  a. Failure of Power Supply Module of the Switchboard
  b. Failure of Electricity of the device under test

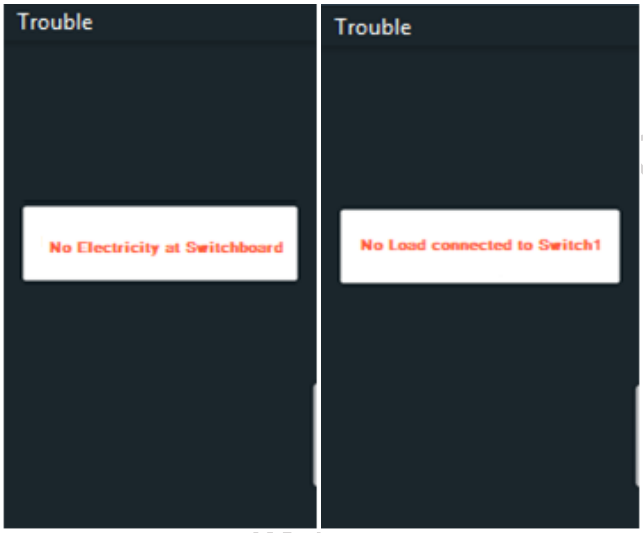


Fig. 5.19 Troubles notifications

- ✓ If the device is not connected to Wi-Fi Network, the App immediately notifies that "Switchboard not connected to Wi-Fi Network" (Figure 5.20).
- ✓ If load is not connected to switchboard, the App notifies it as "No Load connected to Switch1". This notification helps in troubleshooting the cause as:
  - Either the load connected at Switch1 has been removed or
  - The load, which may have some fault

Fig. 5.20 Wi-fi problem

✓ If the app fails during loading, the app will either ask to close the app or for open app again (Figure 5.21).

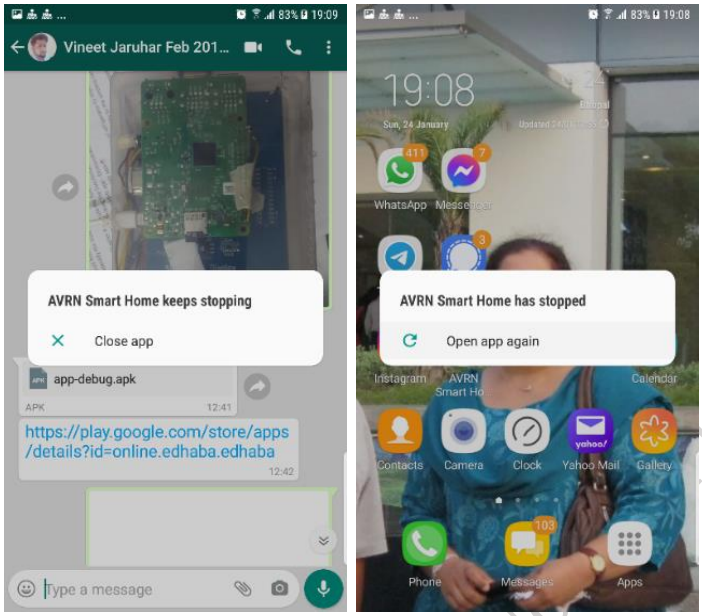


Fig. 5.21 Popup window to close the app

✓ If the speed of the regulator does change then it means, the regulator circuit has failed or there is some problem in appliance as shown in Figure 5.22.

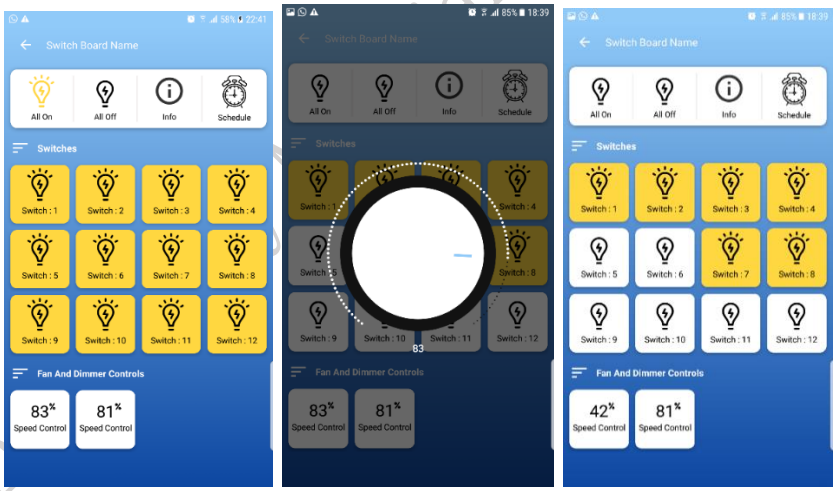


Fig. 5.22 Controlling the speed of the fan

When updates are available for the installed app, it is a good idea to update both the app and the device's operating system. New versions often include security patches that protect the device and its information from the latest malware.

Air Conditioner Remote Handling

- In this current era of technology, one can remotely access and monitor or control appliances. This is made possible by the use of Internet of Things (IoT) technology, which has simplified controlling appliances to the point where they can be accessed and managed from anywhere. Some basic requirements at the premises are necessary to manage the application control. It requires an internet connection and a wireless LAN router.
- Use a wireless LAN router that can set WPA2 or WPA. The communication standards need to correspond to any of IEEE 802.11b / g / n (2.4 GHz only).

- The application is free, but a communication cost is charged when downloading and using the application.
- Please use it after agreeing to the terms of use and the privacy policy of the respective application.
- The contents of services, screen design, functions of the application may change without notice. Also, the service provided may be terminated without notice.

Let us understand the different functionalities of the mobile application. The mobile application, developed for a specific model of air conditioner, may have different features based on the requirements of that model. The generalized features of the mobile application include notifications, remote control, support, and energy management.

Notifications: The app notifies the user if the air filters and coils have been forgotten for cleaning. To check, select the Control Panel tab and tap the Info button. This will display the operating condition and notifications. The user can also view the on/off counts for the past 10 days (Figure 5.23).

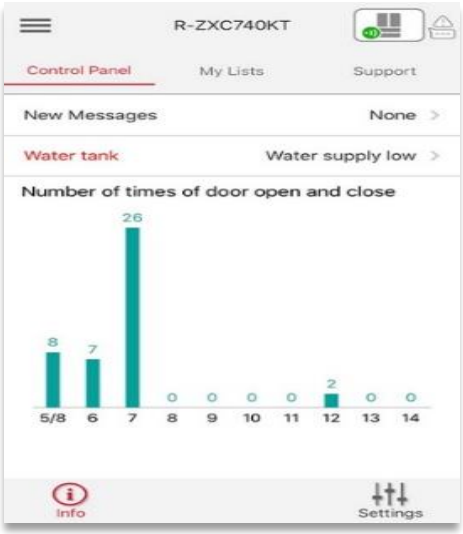


Fig. 5.23 Control panel tab in the application

Remote Control: Tap on the settings icon to adjust the air conditioner settings, such as temperature and energy-saving mode, from anywhere. To make remote control settings, select the Control Panel tab and tap the Setup button. Here, you can configure air conditioner settings, including temperature adjustments (Figure 5.24).

Fig. 5.24 Air conditioner settings in the control panel

Supports: User can check instruction manual and contacts. Select the support tab, user can browse instruction manual and how-to maintenance on your smartphones (Figure 5.25).

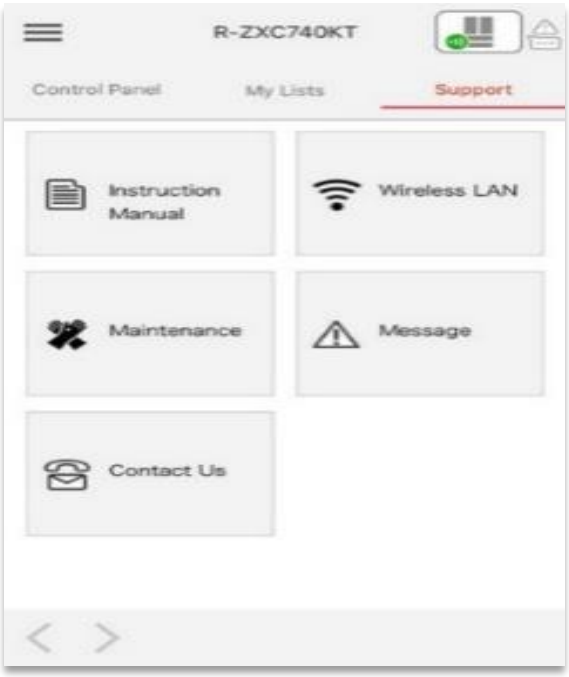


Fig. 5.25 Way to maintain the smart phone

Intelligent Management: It automatically senses the presence of humans in the room. Based on this, it commands the compressor to operate. If the AC motion sensor detects no one in the room, it turns off the compressor and stops cooling the room. This way, the air conditioner manages energy consumption efficiently (Figure 5.26).

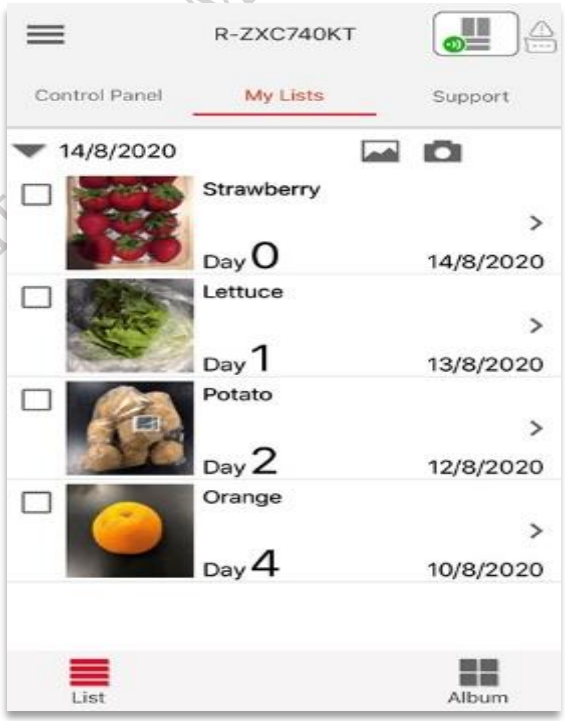


Fig. 5.26 Intelligent management

Check Your Progress

A. Multiple choice questions

1. The basic requirements in order to manage the application control is (a) Requires an internet connection and a wireless LAN router. (b) Dial up connection like telephone lines (c) Coaxial cable 4. Fiber cable
2. In QR code, QR stands for (a) Quick reader (b) Quick response (c) Quality reader (d) Quality response
3. Which of the following is not the feature of the home automation application? (a) Location management (b) Energy saver (c) Time saver (d) Regulator control
4. Which of the following file is used in the install of application in android is (a). dpl (b). pdl (c) .apk (d). mpk
5. Which of the following not the integral parts of the application (a) Back-End/Server Technology (b) Application Programming Interface (c) Mobile App Front-End (d) Graphic User Interface

B. Fill in the Blanks

1. In API stands for Application _____ Interface.
2. Backend technology is also called as ____ technology.
3. GUI stands for _____ User Interface.
4. Geo fencing is a _____ feature.
5. To secure the appliance ___ code is use.

C. State whether the following statements are True or False

1. The purpose of functional testing of Mobile App is to ensure that users can use your app's features and functionality without any issues.
2. A smart phone with internet access is not necessary to use a Mobile Application for controlling a device.
3. The App of Home Automation System supports QR Code feature to ensure the security of your devices.
4. This Android App allows to schedule on/Off event on individual devices.
5. Temperature of the air conditioner can be changed using an application.

D. Short answer questions

1. Give the block representation of the home automation mobile app.
2. Write down the steps to install the home automation app in the mobile phone.
3. How to control air conditioner using smart phone App?
4. Discuss the various features of the mobile application.
5. What are the different functionalities of mobile application?

Module 5 Occupational Health and Safety

Module Overview

Workplace safety is a broad term that refers to the safety, health, and well-being of employees. It encompasses the plans and practices in place to ensure employee health and safety in the workplace. Employees should understand basic safety principles, workplace dangers, the risks associated with hazards, the implementation of hazard prevention measures, and the application of safer methods, techniques, processes, and a safety culture in the workplace.

It also includes safety standards and regulations based on current government policies. Every company has a set of safety standards and regulations in place for its employees. Employees receive safety training and instruction regularly to keep them informed about and updated on the latest safety precautions.

The risks associated with the use of refrigerants in refrigeration may include toxicity, flammability, and physical hazards. Technicians should carefully handle refrigerants, refrigerant cylinders, and tools. A technician must store and transport refrigerants correctly.

Learning Outcomes

After completing this module, you will be able to:

- Understand and apply the correct procedures for handling refrigerant cylinders, including storage, transportation, and usage.
- Ensure compliance with safety standards to prevent accidents and environmental hazards.
- Demonstrate the ability to use tools and equipment safely by following recommended guidelines and precautions.
- Minimize risks of injury and equipment damage through proper handling techniques.

Module Structure

Session 1. Safe Handling of Refrigerant Cylinder

Session 2. Safe Handling of Tools and Equipment

Session 1. Safe Handling of Refrigerant Cylinder

To ensure the trouble-free and safe operation of refrigeration systems, refrigerants must meet quality standards. A major quality concern regarding refrigerants is their purity. One critical parameter is the moisture content in the refrigerant. Even a single drop of water entering a refrigeration system can cause serious operational problems.

An air conditioner operates 24/7, which means it requires proper maintenance on a regular basis. Technicians should exercise caution when refilling or recovering refrigerant gas cylinders, as mishandling may result in injury to the fingertips or other body parts. In this chapter, you will learn how to handle refrigerants properly.

Safe Handling of Refrigerant Cylinder

Refrigeration is the process of removing heat from a space to lower its temperature below that of its surroundings. When the refrigerant absorbs unwanted heat, its temperature rises, causing it to change from a liquid to a gas as it evaporates. The system then uses condensation to release the heat and transform the refrigerant back into a liquid. To achieve this, the refrigerant is pumped through a closed-loop pipe system. Thus, the refrigerant serves as a working fluid in the refrigeration cycle of an air conditioner.

Using correct and approved refrigerants in cooling systems is essential for the safety of homeowners and technicians. The Environmental Protection Agency (EPA) issued a press release on July 1, 2013, regarding the potential safety hazards associated with the use of propane or other unapproved refrigerants in-home air-conditioning systems. A subsequent safety warning was issued on July 21, 2014.

The world of refrigeration is becoming less colorful but clearer for HVAC technicians. Nowadays, refrigerant cylinders will no longer have distinct colors to identify the type of refrigerant inside. The number of colors used for refrigerant cylinders has been reduced to just one—an “off-white” color. Cylinders containing flammable refrigerants will continue to have a red band.

The Indian Society of Heating, Refrigerating, and Air-conditioning Engineers (ISHRAE) provides guidelines for low Global Warming Potential (GWP) alternative refrigerants for various RAC sectors, as outlined in Table 1.

Table 1. Low GWP Refrigerants for Various RAC Sectors

Sector	Current Refrigerant Used	Alternative Refrigerants	ISHRAE Assessment of Low GWP options for India
Domestic Refrigeration Single/Double Door	HC-600a, HFC-134a		HC-600a
Room AC	HCFC-22, R-410A, HFC-32, HC-290	HFC-161, HFC-32, HC-290, R-410A, R-407C	HFC-32, HC-290
Commercial Refrigeration Stand-alone units (Display cabinet, Water cooler, Bottle cooler, Ice cream cabinet)	HC-600a, HFC-134a, HCFC-22, R-404A, HFC-32, HC-290	HC-600a, HFC-134a, HCFC-22, R-404A, HFC-32, HC-290	HC-600a, HC-290, R-744

An important revision has been made by the Air-conditioning, Heating, and Refrigeration Institute (AHRI) regarding the refrigerants used in cooling systems. Some of the key facts announced by AHRI are as follows:

1. On June 28, 2016, AHRI first announced changes regarding the color of refrigerant containers.
2. It specifies that all refrigerant containers should have the same paint color, which will eliminate confusion between similarly colored cylinders.
3. Under the new system, refrigerant cylinders will be clearly marked, and refrigerants will be identified by the product number on the cylinder say for example R-134a, R-22, R-404A, R-32 as shown in Figure 1.1.

Fig. 1.1 Refrigerant cylinder color codes as per AHRI

4. The product number must be marked on the cylinder.
5. In the early days, there were only a few refrigerants, but today, there are multiple shades of some colors, such as blue or green, which can cause confusion.
6. Technicians should no longer rely on the color of the cylinder to identify the refrigerant.
7. One of the benefits is that firefighters and other emergency personnel will now know that an off-white cylinder contains refrigerant.
8. If the technician finds a red band on the cylinder, it indicates that the refrigerant inside is flammable.
9. Technicians must verify the product number on the cylinder. Misidentifying refrigerants can lead to serious safety issues, as different refrigerants have varying operating pressures and physical properties as shown in Figure 1.2.

Fig. 1.2 New refrigerant container guidelines (Flammable refrigerants cylinder have a red band)

General guidelines and Principal

1. No one can repair any leak in the body of a smooth gas cylinder as shown in Figure 1.3.

Fig. 1.3 Wrong way of eradicating leak of refrigerant cylinder

2. Do not expose cylinders to temperatures above 45°C (113°F). Store as compressed gas and keep in a well-ventilated area as shown in Figure 1.4.

Fig. 1.4 Storing of refrigerant cylinders

3. Keep the cylinder away from open flames, hot surfaces, and other ignition sources as shown in Figure 1.5. The gas is normally filled under pressure in gas cylinders.

Fig. 1.5 Do not expose cylinders to open flames

4. Do change the color of a cylinder as shown in Figure 1.6.

Fig. 1.6 Changing the color of the cylinder

5. Do not use oil or similar lubricant on the valve or other fittings of the gas cylinder as shown in Figure 1.7.

Fig. 1.7 Do not use oil or similar lubricant

6. Do not overfill the gas cylinder as shown in Figure 1.8.

Fig. 1.8 Avoid overfilling the cylinder

7. Please, look for the next date of testing the cylinder as shown in Figure 1.9.

Fig. 1.9 Checking the expiry date of the cylinder

8. Place leaking gas cylinder to open space to avoid the risk of life and property as shown in Figure 1.10.

Fig. 1.10 Placing of leaking gas cylinder to open space

9. Do not slide, drop or play with the gas cylinder as shown in Figure 1.1.

Fig. 1.11 Do not play with cylinder

Safety Measures for Service Personnel

1. Always, wear eye protection and insulated gloves as shown in Figure 1.12.

Fig. 1.12 Wearing safety glasses and safety gloves

2. Protective clothing should be worn if there is a possibility of direct contact or splashes as shown in Figure 1.13.

Fig. 1.13 Wearing PPE kit

3. Wear safety boots when handling refrigerant cylinders as shown in Figure 1.14.

Fig. 1.14 Wearing safety boot

4. Never, lift a cylinder by the top valve as shown in Figure 1.15.

Fig. 1.15 Wrong practice to lift the gas cylinder

5. To move the cylinder, one should use a gas cylinder trolley as shown in Figure 1.16.

Fig. 1.16 Right practice to lift the gas cylinder

6. When storing or moving cylinders, keep their caps on as shown Figure 1.17.

Fig. 1.17 Keep caps on while storing

7. Always, assume that the cylinder contains gas.

8. Wear self-contained breathing apparatus in high gas concentrations as shown in Figure 1.18.

Fig. 1.18 Wearing of breathing apparatus

9. Do not slide the gas cylinder it will damage the bottom of the gas cylinder as shown in Figure 1.19.

Fig. 1.19 Wrong way of moving cylinder

Handling and Storage

Some of the safety instructions that must be followed while handling and storage the refrigerant at the workplace are as follows.

Storage – Do not expose cylinders to temperatures above 45°C. Store as compressed gas. Keep in a well-ventilated place. Keep away from open flames, hot surfaces, and other sources of ignition. The gas is normally transported under pressure in gas cylinders. In case of a leak, prevent sparks and open flames.

Safety Measures to Protect the Environment – Do not release refrigerants into the atmosphere, and always use recovery equipment. Outdated cylinders should be returned to an approved reception facility.

Proper Methods for Damage Limitation and Clean-up – Stop leaks immediately, if possible, without compromising personal safety. Move leaking cylinder(s) to an open area, where the leak will not pose a risk to personal safety.

Exposure Control – Refrigerant gases are heavier than air and will accumulate on the ground. They may cause suffocation by reducing the oxygen available for breathing. Wear a self-contained breathing apparatus in confined spaces.

Accidental human exposure to gas or liquid

During the repair and maintenance of refrigerants, accidental human exposure to gas or liquid may occur. Some of the possible exposures are as follows:

General – Provide fresh air, and keep the patient warm and at rest. If in doubt, seek immediate medical advice.

Inhalation – High concentrations or prolonged exposure may cause headache, dizziness, unconsciousness, and other central nervous system disorders. Provide fresh air, and keep the patient warm and at rest.

Skin Contact – First aid treatment for frostbite after skin contact with liquid refrigerant: flush with large amounts of lukewarm water (about 40°C, 104°F). Do not remove clothing if frostbitten.

Note: Frostbite is an injury caused due to freezing of the skin.

Eye Contact – Contact with gas or vapor has no effect. In case of splashes or symptoms due to high vapor concentrations, flush the eyes immediately with a gentle stream of preferably lukewarm water for at least 15 minutes. Seek immediate medical attention and continue rinsing.

Charging and Recovery Unit

Some suggestions for charging and recovery operations of refrigerants are as follows:

1. Read the Safety Data Sheets (SDS) on all compounds including refrigerants and compressor oils that you are likely to come in contact with.
2. Never overfill recovery cylinders. Overfilling may cause the recovery cylinder to burst. Safety codes specify that recovery cylinders should be filled to a maximum of 80% of their volume with liquid. The remaining 20% is reserved for thermal expansion.
3. Use only approved recovery cylinders and ensure that the cylinders have the correct pressure rating.
4. Do not mix refrigerants in a recovery cylinder.
5. Keep the lengths of recovery hoses as short as possible. When increased throughput is required, use hoses with a larger diameter.
6. The key to quick recovery is to recover the liquid refrigerant first." (No changes needed)

Refrigerant Recovery Package

The refrigerant recovery package consists of high-quality equipment designed to handle recovery from a vessel's refrigeration systems (Figure 1.20). This cost-saving solution is suitable for all types of refrigerants and helps technicians reuse refrigerants during system maintenance and service.

Fig. 1.20 Refrigerant Recovery Package

Moisture in Refrigeration Systems

Excessive moisture in refrigeration systems may cause four major issues: freeze-ups, corrosion, oil sludging, and sludge formation, which can affect system quality.

Freeze ups – It occurs when moisture picked up by the refrigerant starts to freeze, forming ice crystals that block the refrigerant passage in narrow passageways, such as in the expansion valve. The compressor stops due to the blockage in the expansion valve and restarts once the ice crystals have melted, allowing the refrigerant to pass through again. This creates a periodic process of constant freezing and melting of moisture inside the system, causing the compressor to repeatedly stop and start.

Corrosion – Moisture in the form of water can cause corrosion. However, when moisture combines with a refrigerant containing chlorine (such as R-22 and its mixtures), it creates more serious corrosion. The chlorine will slowly hydrolyse with the water to form hydrochloric acid (HCl), which is highly corrosive to most metals.

Oil Sludging – Refrigeration oil rapidly absorbs moisture. When moisture combines with a refrigerant to form acid, it can be dangerous, as it greatly reduces the lubrication properties of the compressor oil, potentially leading to serious compressor damage.

Sludge Formation – Due to the high acid content inside a system, a solid product can form. It exists as fine powders or sticky solids, commonly known as sludge. This sludge can cause various problems, such as blockages in fine strainers, expansion valves, and capillary tubes.

Quality – Rectifying problems caused by excessive moisture inside refrigeration systems can be a costly exercise. If moisture enters the system with the refrigerant, it will lead to continuous, costly repairs that address the consequences but do not eliminate the cause.

Guidelines on Refrigeration Oils

Correct lubricant selection for a refrigeration system is important not only for the compressor itself but also to ensure that the oil does not separate from the refrigerant gas in any part of the system. If the recommended oil type is not used, incompatibility may cause problems within the refrigeration system. With the wide range of mineral and synthetic products available in the market, along with different additive technologies, it is crucial to check the oil-mixing properties before adding any additives. An alternative would be to drain the oil completely from the refrigeration system, which can be very difficult or even impossible without significant effort. During the warranty period, compressor and/or system manufacturers often prohibit the use of non-approved refrigeration oils.

Oil Testing

A field test of oil can be done by visually inspecting the oil and using an oil acid test kit to determine if the system has been exposed to moisture. Oil samples can also be sent to a laboratory for analysis; this routine requires clean sample bottles. An oil acid test kit provides a quick way to test the refrigerant oil. In this test, the change in color of the test paper indicates the need for an oil change in the system. It is important to periodically obtain oil samples to check the health of the lubricant and the machine. Let's look at how to test for the presence of acid in refrigerant oil.

Practical Activity 1.1 Demonstrate to detect inorganic acid in the refrigerant oil.

Material Required

Oil acid test kit, refrigerant oil.

Procedure

Step 1. Fill the refrigerant oil in the container.

Step 2. Take the oil test kit and observe the colour of the test paper. It will be in golden yellow colour.

Step 3. Put 2-3 drops of the refrigerant oil.

Step 4. If the colour of the test paper turns to pink/red, then it symbolises that refrigerant has acid content and cannot be suitable for the refrigeration system.

Oil Changing Procedures

The normal oil change procedure is as follows:

1. Run the pump-down and shut down the unit.
2. Close the service valves on the compressor.
3. Ensure that any crankcase oil heaters are switched off.
4. Drain the oil carefully from the compressor crankcase.
5. If the oil has been drained with the compressor pressurized, new oil can be charged using an oil-filling pump capable of working against pressure.
6. Fit the oil pump to the oil container according to the manufacturer's instructions, attach the pump to the compressor with a charging hose, and leave the hose connection to the

compressor loose. Pump oil into the charging hose until it is filled. This is necessary to prevent air from entering the system and to ensure proper pump function when working against a pressurized system."

7. If the compressor has been opened for inspection or repair: ensure that the compressor crankcase is clean.
8. Run deep vacuum on the compressor using a vacuum pump, preferably down to 500 microns.
9. Charge oil using the vacuum to suck up the oil from the container into the crankcase.

Practical Activity 1.2 Demonstrate to replace the oil of the compressor.

Material Required

Compressor, pipe cutter, pump, screwdriver.

Procedure

Step 1. Remove the connections or cut the copper pipe using a pipe cutter. Make sure to leave a small piece of copper so you can attach another connection.

Step 2. Using a screwdriver, unbolt the bolts that are holding the compressor.

Step 3. Put the compressor on a table.

Step 4. Hold and bend the compressor in such a way that oil starts to come out of the suction line, not the high-pressure line. Collect the used oil in a container.

Step 5. Weigh the oil; this will provide an idea of the amount of new oil that needs to be refilled in the compressor.

Step 6. Fill the oil using the pump with the hose connected to the suction pipe of the compressor.

CHECK YOUR PROGRESS

A. Multiple Choice Questions

1. When refrigerant absorbs the unwanted heat, this raises the (a) Refrigerant's temperature (b) Refrigerant's pressure (c) Refrigerant's volume (d) Refrigerant's heat
2. The Environmental Protection Agency (EPA) issued a press release on (a) July 1, 2014 (b) July 1, 2013 (c) July 2, 2013 (d) July 2, 2013
3. The cylinders containing flammable refrigerants will continue to have a (a) Blue band (b) Yellow band (c) Red band (d) Pink band
4. An important revision is made by AHRI (Air-conditioning, Heating and Refrigeration Institute) for the refrigerants used in (a) Cooling (b) Heating (c) Vaporizing (d) Evaporating
5. Frostbite is an injury caused due to the freezing of_____. (a) Skin (b) Mouth (c) Nose (d) Hand

B. Fill in the blanks

1. Refrigeration is the removal of ___ from space so that its temperature is lower than that of it is surroundings.
2. The Environmental Protection Agency (EPA) issued a press release on _____.

3. An important revision is made by AHRI (Air-conditioning, Heating and Refrigeration Institute) for the refrigerants used in_____.
4. Refrigerant gases are _____ than air and will accumulate on the ground.
5. Moisture in the form of water can cause _____of the air conditioner.
6. Sludge can cause a variety of problems such as _____of fine strainers, expansion valves and capillary tubes.
7. A field test of oil can be done by visually inspecting the oil and using an oil acid test kit to determine if the system has been exposed to_____.

C. State whether the following statements are True or False

1. Freeze ups occur when moisture picked up by the refrigerant starts to freeze, building ice crystals that block the refrigerant passage in narrow passageways.
2. Moisture in the form of water cannot cause corrosion.
3. Sludge exists as fine powders or sticky solids.
4. Correct lubricant selection for a refrigeration system is not important for the compressor.
5. Refrigerant gases may cause suffocation by reducing oxygen available for breathing.

D. Short answer questions

1. How to safely handle the refrigerant cylinder?
2. What is the cause of the Moisture in refrigeration systems?
3. What is oil sludging?
4. What Guidelines are to be followed to handle the Refrigeration Oils.?
5. What is Freeze up in the refrigeration system?

Session 2. Safe Handling of Tools and Equipment

Every day, technicians operate with tools and equipment at the workplace. However, interacting with these tools and equipment can pose the potential for serious injuries or fatalities if they are not used and maintained correctly. To avoid such injuries or fatalities, technicians must be knowledgeable about the possible causes of accidents and the safe handling of tools and equipment. In this chapter, you will learn about the safe handling of tools and equipment.

Refrigeration Handy Tools Case- The kit contains both specialized refrigeration tools and general tools that are necessary for day-to-day shipboard operation and maintenance of refrigeration systems (Figure 2.1).

Fig. 2.1 Refrigeration tool kit

Collection of Fittings -An assorted collection of the most common types of brass fittings that are used in various refrigeration piping and connection applications. Items are not sold individually (Figure 2.2).

Fig. 2.2 Brass fitting

Safe Handling of Hand Tools

Some of the key points to remember when handling tools at the workplace are as follows:

a. Right Tool for the Job – It defines the proper use of hand tools for the right tasks. Examples of unsafe practices include striking the hardened faces of hand tools together, such as using a carpenter's hammer to strike another hammer, hatchet, or metal chisel.

b. Maintenance of Tools – It defines the correct maintenance of hand tools. For example, wrenches with cracked jaws, screwdrivers with broken tips or handles, hammers with loose heads, dull saws, and extension cords or electric tools with broken plugs or improper insulation.

c. Operate Tools in Right Way – It defines the correct way to operate hand tools. For example, screwdrivers should not be applied to objects held in the hand, and pliers should not be used to open nuts, as it may damage the threads. These are common causes of accidents.

d. Placing the Tools – It defines the designated places to store hand tools. For example, many accidents have been caused by tools falling from overhead, as well as by knives, chisels, and other sharp tools.

Safe Handling of Power Tools

Power tools can be hazardous when used incorrectly. There are several types of power tools, based on the power source they use: electric, pneumatic, liquid fuel, hydraulic, and more. The following general precautions should be observed by power tool users:

1. Never carry a tool by the cord or hose.
2. Never pull the cord or hose abruptly to disconnect it from the receptacle.
3. Keep cords and hoses away from heat, oil, and sharp edges.
4. Cords must be free from cuts. If the cord is damaged, the equipment should be removed from service immediately.
5. Disconnect tools when not in use, before servicing, and when changing accessories such as blades, bits, and cutters.
6. All observers should remain at a safe distance from the work area.
7. Secure the work with clamps or a vise, keeping both hands free to operate the tool.
8. Avoid accidental starting. The employee should not keep a finger on the switch button while carrying a plugged-in tool.
9. Tools should be maintained with care. They should be kept sharp and clean to ensure optimal performance.

Safe Handling of Hand Tools

Hand tools are non-powered and include axes, wrenches, screwdrivers, hammers, and many others. Most hazards associated with hand tools result from misuse and improper maintenance. Technicians should participate in short training courses to learn how to handle and maintain hand tools properly for their specific area of operation. Attention will be given to tool selection, proper use, and the required personal protective equipment (PPE).

Safe Handling of Vacuum Pump

Design, safety, and technology used in vacuum pumps have improved significantly in the last few decades. However, vacuum pumps and other related devices in vacuum systems still present the risk of injury to those working with them if not properly installed or managed. Here are some best practices for the safe handling of vacuum pumps:

1. Read the operating manual of the vacuum pump to understand the correct operating temperature, power supply, and capacity.
2. Check the quality of the vacuum pump oil. When refilling, also check the expiration date of the oil.
3. Ensure that the airline is correctly connected to the right point and that the fan cover is clean.
4. Check the oil level using the specified oil level mark.
5. When refilling the oil due to a low oil level, the technician should know the correct slot for refilling.
6. Read the specification plate mounted on the vacuum pump. Additionally, ensure that the listed specifications meet the requirements.
7. When using or refilling the vacuum pump, it must be placed on a flat surface.
8. It should provide the required power supply.
9. When refilling, the vacuum pump should be placed in a tray to prevent dirt from spreading on the floor.

When carrying the vacuum pump, it should be held using the handle.

Fig. 2.3 Parts of vacuum pump

Safe Handling of Leak Detector

It is a handy device for a technician, providing precise information that helps pinpoint the location of leaks and determine the refrigerant leakage rate. Here are some best practices for the safe handling of the leak detector.

1. The technician must read the specifications of the leak detector and ensure its capacity to handle the situation.
2. It should be properly placed on its cover and safely kept in the toolbox.
3. It is a battery-operated device; always keep spare batteries in the toolbox as a backup.

4. Make sure that the testing pipe of the leak detector is not cut.
5. Check the sensitivity of the leak detector to ensure it is functioning correctly.
6. Carefully press the ON button and then adjust the sensitivity of the detector.
7. Carefully place the fusible probe of the detector on the refrigerant pipe.

Fig. 2.4 Parts of a Leak detector

Safe Handling of Micron Gauge

Micron gauges are essential tools for technicians to ensure that refrigeration systems are properly evacuated before charging with refrigerant. They measure the vacuum pressure in microns, providing accurate readings of the system's vacuum level. This is crucial to ensure the system is free of moisture and air, which can cause issues such as freezing, corrosion, or poor system performance. Here are some best practices, which can be performed for the safe handling of micron or vacuum gauges.

1. Since the micron gauge is a portable device with a plastic body, always place it on a protective cover when not in use. This prevents potential damage from impacts, dust, or moisture, ensuring that the gauge remains in good condition and provides accurate readings when needed.
2. The valve of the gauge should be free from dust particles.
3. Carefully clean the sensor of the micron gauge by applying rubbing alcohol to it.
4. The tubing must be kept clean and dry throughout the entire installation.
5. To check the capability of the vacuum gauge, attach the micron gauge directly to the vacuum pump via the 1/4" connection and verify that the pump is capable of achieving a vacuum level of 100 microns or lower.

Fig. 2.5 Vacuum/Micron gauge

Safe Handling Manifold Gauge

Gauges are used to measure the pressure of various gases in a refrigeration system. They are also essential for checking the refrigerant pressure during testing or charging procedures. Manifold gauges, in particular, are characterized by the number of ports, which are used for attaching accessories. These gauges can also be categorized by the pressure levels they are designed to withstand, which is critical when working with different refrigerants. A typical manifold gauge is shown in Figure 2.6.

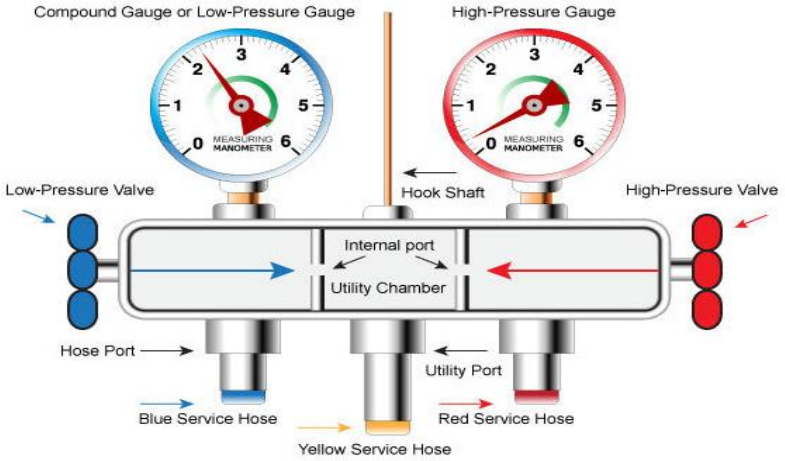


Fig. 2.6 Manifold gauge

The gauges used with a refrigeration gauge manifold are either analog or digital. In an analog gauge, the position of the needle in relation to the numbers on the gauge face indicates the pressure or vacuum in the refrigeration system. On the other hand, the digital gauges provide a numerical reading, indicating system pressure or vacuum. All manifold gauges have high- and low-pressure gauges.

Table 2.1 Analog Manifold

		Analog gauges have been used for generations for the purpose of heating and cooling measurement. An experienced HVAC technician is able to tell what pressures the unit is reading, without even ever looking at a chart.
		Due to some approximation, analog gauges are more prone to error.

Table 2.2 Digital Manifold

		Digital gauges are much more accurate and have some additional functions as compared to analog gauges. They are more accurate; thus, errors are less.
		Digital gauges are new to HVAC technicians, who certainly require training to use them properly.

Here are some best practices, which can be performed for the safe handling of the manifold gauges:

1. Connect the high-pressure side of the cooling line to the red port on the gauge. The red port and red gauge are always high-pressure gauges.
2. Connect the low-pressure side to the blue port of the gauge. The blue port and blue gauge are always the low-pressure gauges.
3. Attach a waste hose or vent hose to the centre of the manifold set up.
4. Attach micron meters or other gauges to the additional ports.
5. Use the fitting as per the refrigerant used in the refrigeration system.
6. Remember the use of appropriate protective equipment. (Figure 2.7)

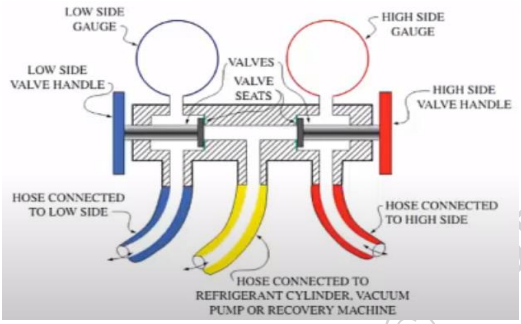


Fig. 2.7 Cross-sectional view of valves in the manifold gauge

7. Make sure the position of valves is in case of measurement of low and high pressure as shown in Figure 2.8.

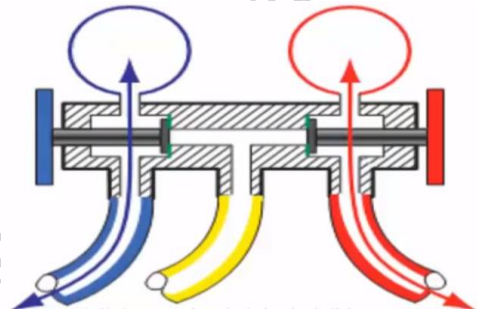


Fig. 2.8 In this picture, we see the two hand-valve closed, with the gauges reading both high side and low side system pressures

8. Make sure the valve is a half-open low side (blue) when there is a need for a charging cylinder, recovery cylinder or to perform vacuum in refrigeration pipe as shown in Figure 2.9.

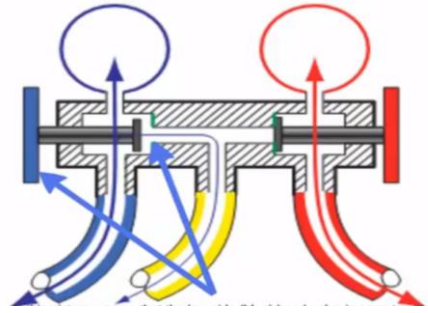


Fig. 2.9 In this picture, we see that the low side (blue) hand-value is open to either the charging cylinder, recovery cylinder or vacuum pump

9. Make sure the valve is fully open low side (blue) when there is a need for a charging cylinder, recovery cylinder or to add vacuum in refrigeration pipe as shown in Figure 2.10.

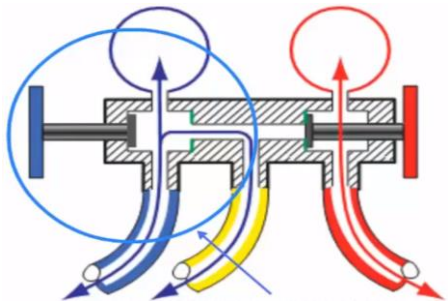


Fig. 2.10 In this picture, we see that the low side (blue) hand–value is open to either the charging cylinder, recovery cylinder or vacuum pump

10. Make sure the valve is half-open high side (red) when there is a need of recovery cylinder or to perform vacuum in refrigeration pipe as shown in Figure 2.11.

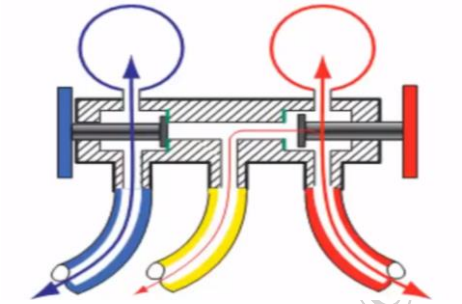


Fig. 2.11 In this picture, we see that the high side (red) hand-valve is open to either the recovery cylinder or using a vacuum pump

11. Make sure the valve is a fully-open high side (red) when there is a need for a recovery cylinder or to perform a vacuum in the refrigeration pipe as shown in Figure 2.2.

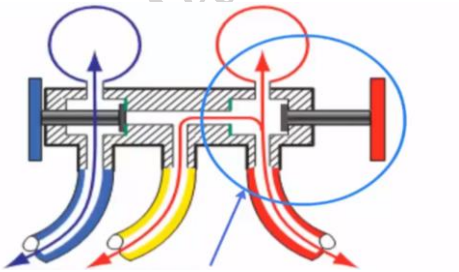


Fig. 2.12 In this picture, we see that the high side (red) hand-valve is open to either the recovery cylinder or vacuum pump

2. Make sure both the valves are open. In this position, it is used for either pressure testing, recovery cylinder or to perform vacuum in refrigeration pipe as shown in Figure 2.13.

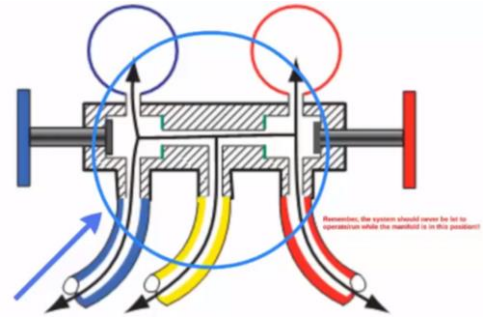


Fig. 2.13 In this picture, we see both hand-valve is open, usually when in this position it is for either pressure testing recovery cylinder or using vacuum pump

13. Different operations of manifold gauge are shown in Figure 2.14.

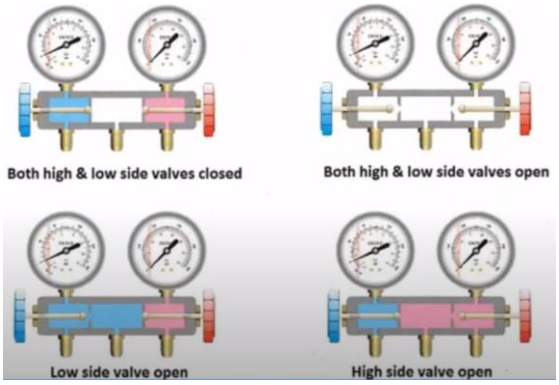


Fig. 2.14 Gauge manifold operation

14. The way to connect a vacuum pump or recharging or recovery cylinder in the manifold valve is shown in Figure 2.15.

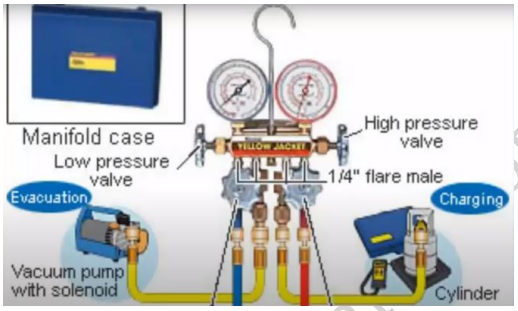


Fig. 2.15 Connection of gauge manifold to vacuum pump and cylinder

15. Make sure, that the pipe of the manifold does not have any cut.

CHECK YOUR PROGRESS

A. Multiple Choice Questions

1. Which point to be followed while handling the Vacuum pump? (a) Read the operating manual of the vacuum pump for correct operating temperature, power supply, and capacity. (b) Keep cords and hoses away from heat, oil, and sharp edges. (c) Cords are required to be free from cuts. If the cord is damaged, the equipment shall be removed from service immediately. (d) Tools should be maintained with care. They should be kept sharp and clean for the best performance.
2. Leak Detector determines (a) the pressure rate of refrigerant. (b) the leakage rate of refrigerant. (c) The volume of the refrigerant. (d)The fluid of the refrigerant
3. Micron Gauge is also known as (a) vacuum gauge (b) Wire gauge (c) pressure gauge (d) Leak Detector
4. Gauges are used to read the pressure of various _____in a refrigeration system. (a) gases (b) air (c) water (d) fluids
5. The ratio of work-done per cycle to the stroke volume of the compressor is known as..... (a) Compressor capacity (b) Compression ratio (c) Compressor efficiency (d) Mean effective pressure

B. Fill in the blanks

1. Leak Detector provides precise information that helps the technician to point out _____and to determine the leakage rate of refrigerant.

2. Micron Gauge is also known as_____.
3. To check the capability of the vacuum gauge, attach the_____ directly to the vacuum pump.
4. Gauges are used to read the pressure of various gases in a _____.
5. Analog gauges have been used for generations for the purpose of _____and cooling measurement.
6. Digital gauges as compare to analog are much _____and have some additional functions.

C. State whether the following statements are True or False

1. Digital gauges are new to HVAC technicians, who certainly do not require training to use them properly.
2. Digital gauges as compared to analog are much accurate and have some additional functions.
3. Due to some approximation, Digital gauges are more prone to error.
4. The gauges used with a refrigeration gauge manifold are either analog or digital.
5. Gauges are also used to measure the pressure of refrigerant in the process of testing or charging the device.

D. Short answer questions

1. What types of tools are there in the refrigeration tool kit?
2. How to safely handle the hand Tools of the air conditioner?
3. What is a leak detector?
4. What is Gauge? How to Safely Handle the Micron Gauge?
5. How to safely handle the Manifold Gauge?

Glossary

Compressor: A device in the air conditioner that compresses refrigerant gas to facilitate cooling.

Refrigerant: A substance used for heat exchange in cooling systems.

Evaporator Coil: A component that absorbs heat from the indoor air to cool the space.

Condenser: The part of the air conditioner that releases absorbed heat to the outside air.

Preventive Maintenance: Routine inspections and servicing to prevent unexpected breakdowns.

Inverter Technology: A system that adjusts compressor speed for efficient energy consumption.

Smart Sensors: Devices that detect temperature, humidity, or presence to enhance performance.

Variable Refrigerant Flow (VRF): A technology that adjusts refrigerant flow based on cooling needs.

Zoning System: Dividing a building into sections for customized cooling in each area.

AI Integration: Use of artificial intelligence to optimize and automate air conditioner operations.

IoT (Internet of Things): A network of devices interconnected to exchange data for smarter functionality.

Firmware Update: Software upgrades to improve device performance or fix bugs.

Connectivity Issues: Problems related to the air conditioner's network connection.

Diagnostic Code: Error codes displayed to indicate specific issues in IoT-enabled devices.

Remote Monitoring: Checking and controlling air conditioners via IoT apps.

Personal Protective Equipment (PPE): Safety gear worn to minimize risk, such as gloves and goggles.

Hazard Assessment: The process of identifying potential workplace dangers.

First Aid: Immediate care provided for injuries or emergencies.

Ventilation: Ensuring proper airflow to prevent exposure to hazardous substances.

Workplace Ergonomics: Designing tools and tasks to reduce strain and injury risks.

Answer Key

Module 1. Repair and Maintenance of Air conditioner

Session 1. Tools and Equipment

A. Multiple Choice Questions

1. (a) 2. (a) 3. (d) 4. (a) 5. (b) 6. (a) 7. (a) 8. (a) 9. (d) (b)

B. Fill in the blanks

1. Measure 2. Digital 3. Refrigerant pipe 4. Manifold gauge valve 5. Current 6. Refrigerant 7. Tubing 8. Piping 9. Two 10. Cutting and gripping

C. State whether the following statements are True or False

1. (T) 2. (F) 3. (T) 4. (F) 5. (T) 6. (T) 7. (T) 8. (F) 9. (T) 10. (T)

Session 2. Faults in Air-Conditioner

A. Multiple Choice Questions

1. (a) 2. (d) 3. (d) 4. (d) 5. (a) 6. (b) 7. (c) 8. (c) 9. (d) 10. (c)

B. Fill in the blanks

1. Clicking 2. Inverter 3. Start 4. Lower 5. Thermostat

C. State whether the following statements are True or False

1. (T) 2. (F) 3. (F) 4. (T) 5. (T)

Session3. Air Conditioner Maintenance & Troubleshooting

A. Multiple Choice Questions

1. (a) 2. (d) 3. (a) 4. (b) 5. (c)

B. Fill in the blanks

1. Louver 2. deodorizer 3. evaporator 4. Frozen 5. Brazing

C. State whether the following statements are True or False

1. (T) 2. (F) 3. (T) 4. (T) 5. (F)

Module 2. Advanced Technologies in Air conditioner

Session 1. IoT in Air Conditioner

A. Multiple Choice Questions

1. (b) 2. (b) 3. (d) 4. (d)

B. Fill in the blanks

1. Reasoning 2. Processed data 3. IoT 4. Data 5. Fuzzy

C. State whether the following statements are True or False

1. (T) 2. (T) 3. (F) 4. (T) 5. (F)

Session 2. Smart Air Conditioner

A. Multiple Choice Questions

1. (a) 2. (a) 3. (b) 4. (c) 5. (a) 6. (c) 7. (c) 8. (a)

B. Fill in the blanks

1. Internet 2. Cleans 3. Contaminated air filters 4. Dead places 5. UV led light

C. State whether the following statements are True or False

1. (T) 2. (T) 3. (F) 4. (T) 5. (F)

Module 3. Troubleshooting IoT Air Conditioner

Session 1. IoT Application Air Conditioner

A. Multiple Choice Questions

1. (b) 2. (a) 3. (d) 4. (d) 5. (b)

B. Fill in the blanks

1. Power 2. Good Sleep 3. Wind directions 4. Troubleshooting 5. AP

C. State whether the following statements are True or False

1. (T) 2. (F) 3. (T) 4. (T) 5. (F)

Session 2. Troubleshooting Software Issues

A. Multiple Choice Questions

1. (c) 2. (a) 3. (d) 4. (b) 5. (b)

B. Fill in the blanks

1. open-source 2. 8 GB 3. Imager 4. Circuit Serial 5. Remote mobile

C. State whether the following statements are True or False

1. (T) 2. (T) 3. (F) 4. (T) 5. (F)

Session 3. Troubleshooting Hardware Issues

A. Multiple Choice Questions

1. (d) 2. (a) 3. (a) 4. (c) 5. (c)

B. Fill in the blanks

1. Hardware 2. Software 3. Server 4. Printed Circuit Board 5. Dependent

C. State whether the following statements are True or False

1. (T) 2. (F) 3. (T) 4. (F) 5. (T)

Session 4. Network Cables and Connectors

A. Multiple Choice Questions

1. (d) 2. (a) 3. (a)) 4. (a) 5. (a) 6. (b) 7. (a) 8. (c) 9. (a) 10. (c)

B. Fill in the blanks

1. Wired media, wireless media 2. Unshielded Twisted Pair (UTP), Shielded Twisted Pair (STP) 3. Metallic shielding 4. Ethernet 5. Single-mode fiber-optic (SMF), multimode fiber-optic (MMF) cables.

C. State whether the following statements are True or False

1. (T) 2. (T) 3. (F) 4. (F) 5. (T) 6. (T) 7. (F) 8. (T) 9. (T) 10. (T)

Session 5. IoT Mobile App

A. Multiple Choice Questions

1. (a) 2. (b) 3. (d) 4. (c) 5. (d)

B. Fill in the blanks

1. Programming 2. Server 3. Graphical 4. Location management 5. QR

C. State whether the following statements are True or False

1. (T) 2. (F) 3. (T) 4. (T) 5. (T)

Module 4. Occupational Health and Safety

Session 1. Safe Handling of Refrigerant Cylinder

A. Multiple Choice Questions

1. (a) 2. (b) 3. (c) 4. (a) 5. (a)

B. Fill in the blanks

1. heat 2. July 1, 2013 3. Cooling 4. Heavier 5. Corrosion 6. blockages 7. moisture

C. State whether the following statements are True or False

1. (T) 2. (F) 3. (T) 4. (F) 5. (T)

Session 2. Safe Handling of Tools and Equipment

A. Multiple Choice Questions

1. (a) 2. (b) 3. (a) 4. (a) 5. (b)

B. Fill in the blanks

1. leakage location 2. vacuum gauge 3. micron gauge 4. refrigeration system 5. heating 6. accurate

C. State whether the following statements are True or False

1. (F) 2. (T) 3. (F) 4. (T) 5. (T)