



Participant Handbook

Sector
Telecom

Sub-Sector
Handset

Occupation
Communication Electronics

Reference ID:
TEL/Q2502, Version 4.0 NSQF level: 4



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**Line Assembler -
Telecom Products**



“ Skilling is building a better India.
If we have to move India towards
development then Skill Development
should be our mission. ”

Shri Narendra Modi
Prime Minister of India





Certificate

COMPLIANCE TO QUALIFICATION PACK – NATIONAL OCCUPATIONAL STANDARDS

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TELECOM SECTOR SKILL COUNCIL

for

SKILLING CONTENT : PARTICIPANT HANDBOOK

Complying to National Occupational Standards of

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The preparation of this handbook would not have been possible without the Telecom Industry’s support. Industry feedback has been extremely encouraging from inception to conclusion and it is with their input that we have tried to bridge the skill gaps existing today in the industry.

This participant handbook is dedicated to the aspiring youth who desire to achieve special skills which will be a lifelong asset for their future endeavours.

About this book

Welcome to the “Line Assembler - Telecom Products” training programme. This PHB intends to facilitate the participants with detailed knowledge about the concept of Telecom industry, Communication Electronics profession and their functioning.

This Participant Handbook is designed based on the Qualification Pack (QP) under the National Skill Qualification framework (NSQF) and it comprises of the following National Occupational Standards (NOS)/ topics and additional topics.

1. TEL/N2506 (Preparing workspace for assembly operations)
2. TEL/N2507 (Assembly operations in production line)
3. TEL/N2508 (ESD safe procedures and practices)
4. TEL/N9101 (Organise work and resources as per health and safety standards)
5. TEL/N9102 (Communicate effectively with team members and customers)

Symbols Used



Key Learning
Outcomes



Unit
Objectives



Exercise



Tips



Notes



Activity




Summary

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1. Introduction

- Unit 1.1 - Fundamentals of Electronics
- Unit 1.2 - Active and Passive Components
- Unit 1.3 - Understanding of Diodes, Transistors, and Logic Gates
- Unit 1.4 - Fundamentals of PCB
- Unit 1.5 - Fundamentals of Copper-Clad Laminates (CCL)



Key Learning Outcomes



At the end of this module, you will be able to:

1. Evaluate the fundamentals of electronics
2. Discuss various types of active and passive electronic components
3. Analyze components like diode, transistors and logic gates
4. Demonstrate the basics of electronic circuit
5. Analyze the fundamentals of PCB (Printed Circuit Board)
6. Identify the properties, layout designs and planning of CCL (Copper-Clad Laminates)
7. Demonstrate the process of cleaning of boards before pattern transfer

UNIT 1.1: Fundamentals of Electronics

Unit Objectives

At the end of this unit, you will be able to:

1. Evaluate the fundamentals of electronics
2. Demonstrate the basics of electronic circuit

1.1.1 Fundamentals of Electricity

Defining Electricity:

In the modern world, electricity is essential for the functioning of computers, cell phones, lights, air conditioners, soldering irons, etc. Escaping electricity is impossible because it occurs naturally, from lightning to human bodies.

Electricity is a natural phenomenon that comes in various forms. Electricity is the movement of electric charge.



Fig 1.1.1: Electric bulb: an example of electronic product used in daily life

Concept of current and voltage:

All basic electrical or electronic circuits consist of three different, but very much related electrical quantities which are:

- Voltage, (v),
- Current, (i) and
- Resistance (Ω)

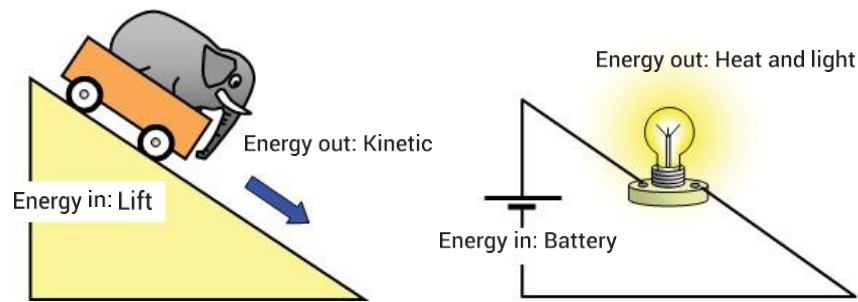
Electrical Voltage:

Fig 1.1.2: An analogy between energy lift and electronic circuit

Voltage, (V) is defined as the potential energy of an electrical supply accumulated in the form of electrical charge. Voltage can be perceived as the force that pushes electrons through a conductor and the higher the magnitude of voltage, the greater is its strength to “push” the electrons through a circuit.

What are joules?

A “Joule” is a standard unit of work or energy in the International System of Units (SI), which denotes the work done by one-Newton force when its point of application moves through one-meter distance along the direction of the force. One joule is equal to 10⁷ergs and one watt-second. It is also called Newton-meter.

The difference in voltage between the terminal points, junctions or connections in a circuit is called the Potential Difference (also known as the Voltage Drop).

The potential difference between two nodes is measured in the unit Volts (symbol “V” or “v”)

A constant source of voltage is called a DC (Direct Current) voltage while a voltage that keeps on varying periodically is known as an AC (Alternating Current) voltage. Batteries or other power supplies are used to generate a steady D.C. voltage source such as 5v, 12v, 24v, etc. in systems and electronic circuits. While A.C. voltage sources are available for industrial power, domestic house and power transmission as well as lighting.

What is an Ohm?

(The ohm is the standard unit of electrical resistance in the International System of Units (SI). Ohms are also used, when multiplied by imaginary numbers, to denote reactance in alternating-current (AC) and radio-frequency (RF) applications. Reduced to base SI (Système international) units, one ohm is the equivalent of one kilogram meter squared per second cubed per ampere squared (1 kg times m² • s⁻³ • A⁻²). The ohm is also the equivalent of a volt per ampere (V/A))

Generally circuits operate on low voltage DC battery supplies. The circuit symbol for a DC voltage source usually given as a normal battery symbol.

Voltage Symbols

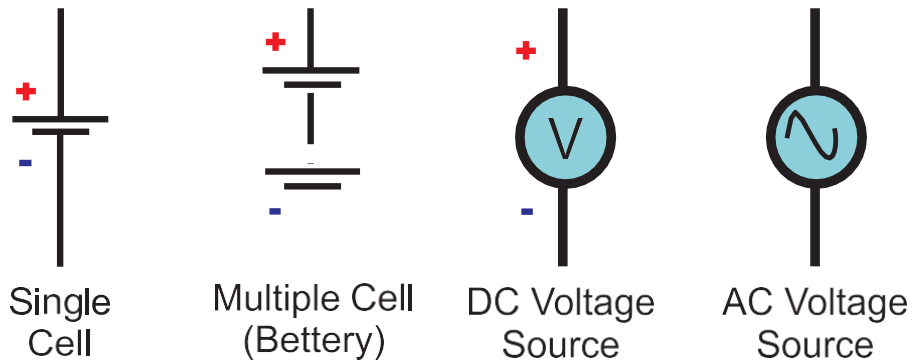


Fig 1.1.3: Symbols associated to an electronic circuit

Electric Current

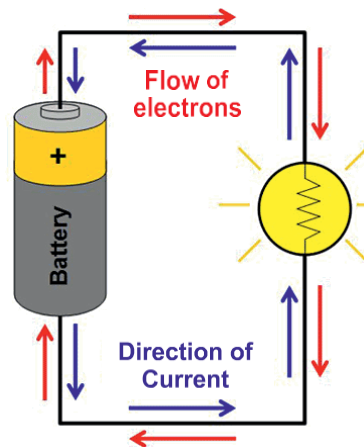


Fig 1.1.4: An example of electronic circuit

Electrical Current (I) is the flow of electric charge. Electrical current is measured in the unit **Amperes** (symbol i). It is the constant and uniform flow of electrons around a circuit which are pushed by the voltage source. In reality, electrons flow from the negative terminal to the positive terminal of the circuit. The current flows opposite to the flow of electrons.

Typically in circuit a diagram, the flow of current is usually represented by an arrow associated with the symbol, I to indicate the current flow direction.

Conventional Current Flow

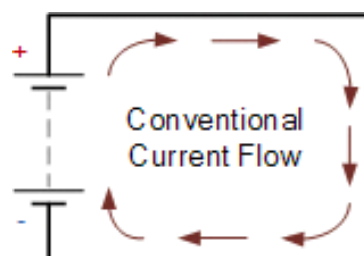


Fig 1.1.5: Fig 1.1.5: How current flows conventionally

	Alternating Current (AC)	Direct Current (DC)
Amount of energy that can be carried	Can deliver more power and is safe for long-distance transfer	DC voltage starts losing energy while travelling far
The direction of electron flow	Rotating magnetism, which can be found along and throughout the wire	Steady magnetism, which can be found along and throughout the wire
Frequency	Ranges between 50-60Hz (country-specific)	NIL
Direction	Reversed	Unidirectional
Current	Time-dependent	Constant and independent of changes in time
Flow of Electrons	Enables both backward and forward directions of electrons; the electrons keep on switching between backward and forward directions	Enables only the forward direction of electrons
Obtained from	The main power supply and AC generator	Battery or cell
Passive Parameters	Only impedance	Only resistance
Power Factor	Ranges between 0-1	Always equal to 1
Types	Sinusoidal, triangular, trapezoidal and square	Pulsating and pure
Direction of flow of electrons	Bidirectional	Unidirectional
Polarity	Has polarity (+ OR -)	Does not have polarity
Type of load	Their load is resistive, inductive or capacitive.	Their load is usually resistive in nature.
Convertible	Easily convertible into direct current	Easily convertible into alternating current
Substation	Only a few substations are needed for transmission and generation	A higher no. of substations are needed for transmission and generation
Hazardous	Dangerous	Very dangerous
Application	Factories, Industries and for domestic purposes	Electroplating, Electrolysis, Electronic Equipment, etc.

Fuses

Fuses are used in electronic circuits to protect them from electric overload. They have a protective function.

A fuse is made of a low resistance metallic wire placed in a non-combustible material. In the event of a short circuit, over current or mismatched load connection, the thin wire inside the fuse melts. This is caused by the heat generated by the heavy current flowing through it. The electrical system, which supplies current, must be disconnected from the power supply. The regular operation of the system, connected to the power supply, is not hampered by fuses. The commonly available types of fuses are: AC fuses and DC fuses.

Resistance

Resistance, (R) is the property of a material to prevent or resist the flow of current, specifically, the flow of electric charge within a circuit. The circuit element which performs this is called the Resistor.

Ohm(Ω , Omega), the unit of Resistance, comes with prefixes used to denote Kilo-ohms ($1 \text{ k}\Omega = 10^3\Omega$) and Mega-ohms ($1 \text{ M}\Omega = 10^6\Omega$). Resistance cannot be negative in value, it is always positive.

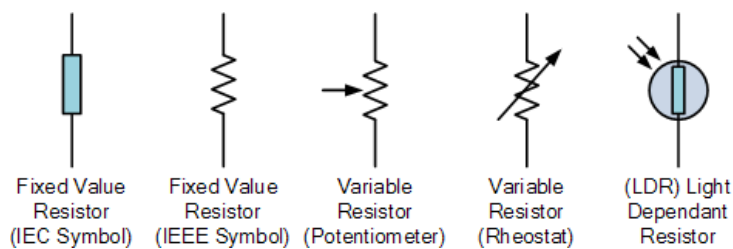


Fig 1.1.6: Resistor Symbols

The amount of resistance is controlled by the relationship of the current flowing through it to the amount of voltage across it, which decides whether the circuit element has low resistance or high resistance. Low resistance circuit is a good conductor made from materials like aluminium, copper, or carbon while a high resistance circuit is a bad conductor comprises insulating materials such as porcelain, plastic or glass.

The relationship between current and voltage in a constant-resistance circuit would generate a straight line i-v relationship with slope equal to the resistance value as depicted in the figure below:

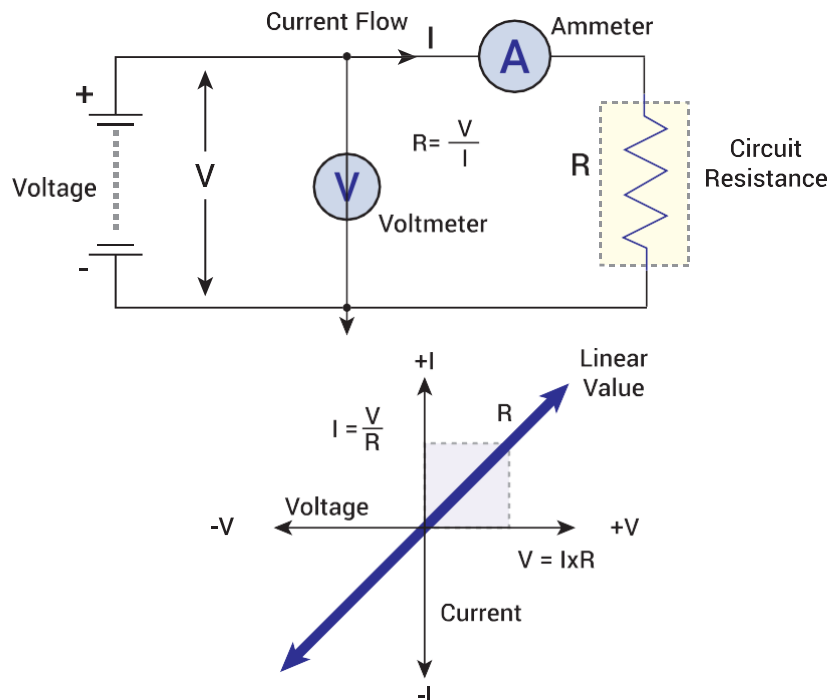



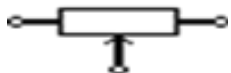

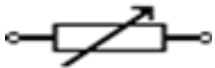




Fig 1.1.7: The relationship between Voltage, Current and Resistance

The three units can be summarized as:

- Voltage or potential difference is the measure of potential energy between two points in a circuit and is commonly referred to as its “volt drop”
- When a voltage source is connected to a closed loop circuit the voltage will produce a current flowing around the circuit
- In DC voltage sources the symbols +ve (positive) and -ve (negative) are used to denote the polarity of the voltage supply
- Voltage is measured in “Volts” and has the symbol “V” for voltage or “E” for energy
- Current flow is a combination of electron flow and whole flow through a circuit
- Current is the continuous and uniform flow of charge around the circuit and is measured in “Amperes” or “Amps” and has the symbol “I”
- Current is directly proportional to voltage
- The effective (rms) value of an alternating current has the same average power loss equivalent to a direct current flowing through a resistive element
- Resistance is the opposition to current flowing around a circuit
- Low values of resistance imply a conductor and high values of resistance implies an insulator
- Current is Inversely Proportional to Resistance ($I \propto 1/R$)
- Resistance is measured in “Ohms “and has the Greek symbol “ Ω ” or the letter “R “

Resistor Symbols		
	Resistor [IEEE] (Institute of Electrical and Electronics Engineers)	Resistor - decreases the flow of current
	Resistor [IEC] (International Electro Technical Commissions)	
	Potentiometer [IEEE]	Adjustable resistor (with three terminals)
	Potentiometer [IEC]	
	Variable Resistor / Rheostat [IEEE]	Adjustable resistor (with two terminals)
	Variable Resistor / Rheostat [IEC]	

Resistor Symbols		
	Trimmer Resistor	This is a pre-set resistor
	Photoresistor / Light dependent resistor [LDR]	Changes resistance with changes in light intensity

1.1.2 Components of Electronic Circuits and their Functions

Transmitter: Transmitters are instruments that are used to send data as radio waves in a particular band of the electromagnetic spectrum to fulfil a specific communication requirement, irrespective of voice or general data. To perform this, a transmitter consumes energy from a source and transforms it into a radio frequency. When the rapidly changing energy is directed through a conductor, electromagnetic waves are radiated outwards to be received by a receptor.

A transmitter comprises:

- **Power supply** — Power supply is an energy source used to power on the device and create energy for broadcasting.
- **Electronic oscillator** — Electronic oscillator produces a wave known as the carrier wave where data is imposed and borne through the air.
- **Modulator** — Modulator adds the actual data to the carrier wave by varying some aspects of the carrier wave.
- **RF (Radio Frequency) amplifier** — RF amplifier raises the signal power to augment the range where the waves can reach.

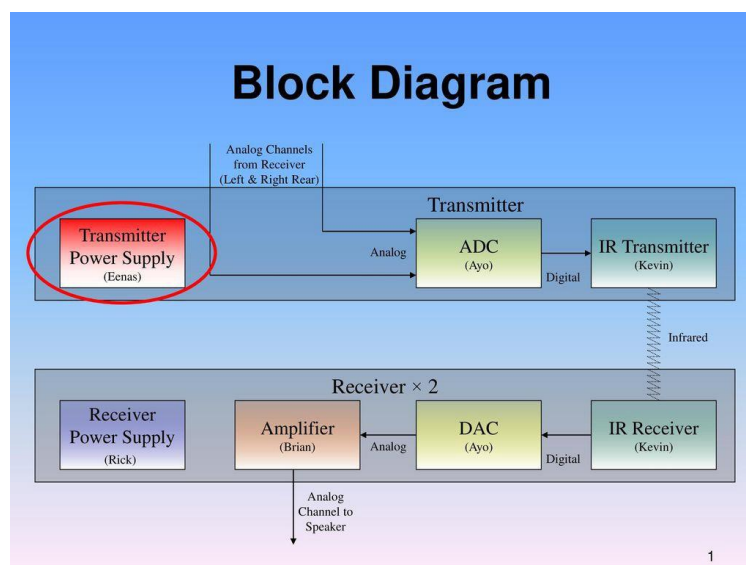


Fig 1.1.8: Block diagram of transmitter and receiver

Bridge rectifiers:

Evolution of rectifiers

Rectifiers can be broadly classified into three types:

- Bridge rectifier
- Half-wave rectifier
- Centre-tapped full-wave rectifier

The above rectifiers have a common aim of converting Alternating Current (AC) into Direct Current (DC).

In **half wave rectifier**, only a half cycle is permitted while the other half is blocked. As an outcome, almost half of the applied power is wasted. The output voltage or current produced by half wave rectifier is not beneficial because it is not purely DC.

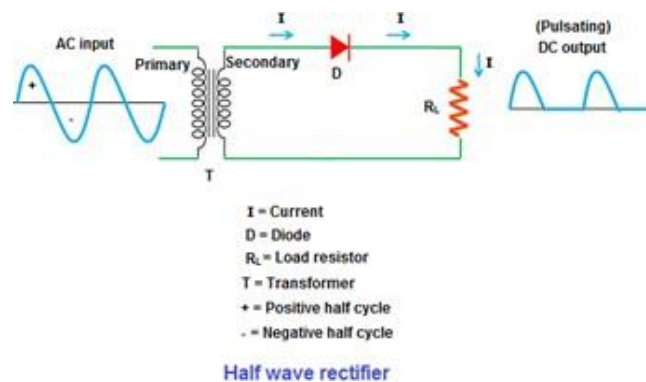


Fig 1.1.9: Circuit diagram of half wave rectifier

To overcome the above problem, the centre tapped full wave rectifier is used.

The chief advantage of **centre tapped full wave rectifier** is that it permits electric current during both positive and negative half cycles.

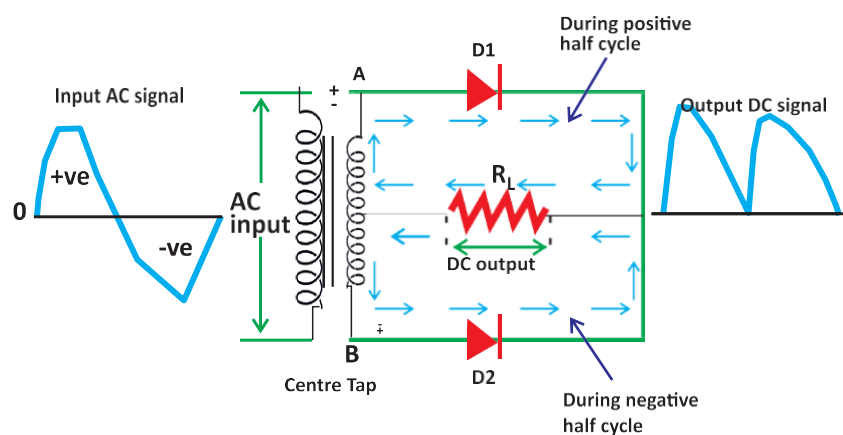


Fig 1.1.10: An illustrated diagram of the flow of current and input-output through full wave rectifier

The centre tapped full wave rectifier has one drawback, that is, the centre-tapped transformer is very costly and occupies a large amount of space. To reduce this cost, scientists have developed the bridge rectifier.

In a **bridge rectifier**, no centre tap is required. If stepping up/down of voltage is not essential, the transformer can be removed from it.

The efficiency of a bridge rectifier is almost equal to the centre-tapped full wave rectifier. The only benefit of the bridge rectifier over the centre-tapped full wave rectifier is the cost reduction.

In a bridge rectifier, instead of using the centre-tapped transformer, four diodes are used.

Working of Bridge Rectifier

When an input AC signal is applied across the bridge rectifier, during the positive half cycle, diodes D1 and D3 are forward-biased and allow electric current while the diodes D2 and D4 are reverse biased and block electric current. On the contrary, during the negative half cycle, diodes D2 and D4 are forward-biased and permit electric current while the diodes D1 and D3 are reverse-biased and hinder electric current.

Terminal A becomes positive and B becomes negative during the positive half cycle. This causes the diodes D1 and D3 to be forward-biased and simultaneously, it causes the diodes D2 and D4 to be reverse-biased.

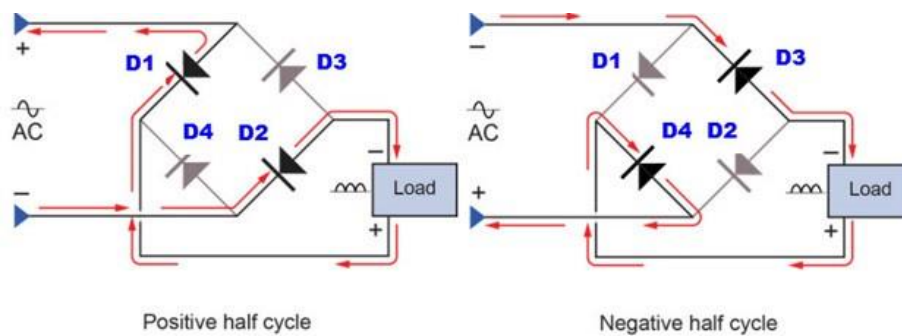


Fig 1.1.11: Flow of current through Bridge Rectifier

Terminal B becomes positive and A becomes negative during the negative half cycle. This causes the diodes D2 and D4 to be forward-biased and simultaneously, it causes the diodes D1 and D3 to be reverse-biased.

Integrated Circuits:

What is IC



Fig 1.1.12: Sample IC (Integrated Circuit)

An integrated circuit (IC), also known as a microchip or chip, is a semiconductor wafer on which tiny capacitors, resistors, and transistors are attached. An IC can function as an oscillator, timer, amplifier, computer memory, counter or microprocessor.

Digital ICs come in many different types. The following list shows the ICs used for different applications.

- Microcomputers, which are ICs that carry out various types of processing
- Memory, which comprises data-storing ICs
- Custom logic ICs, which comprise original dedicated circuitry implemented by or for the needs of a particular user

Applications and Uses of Integrated Circuits

The advantages of Integrated Circuits are:

- Very small size - Hundred times smaller than discrete circuits
- Lesser weight – Weight is reduced since a large number of components can be packed into a single chip
- Less cost - The mass production has helped in price reduction
- High reliability – The absence of soldered connection, negligible temperature surge, and less no. of interconnections, the failure rate is low in ICs
- Less power requirement – Power consumption is less since the size is
- Easy replacement – Chips are easily replaceable in case of failure

Multiplexer: The multiplexers and demultiplexers are digital electronic devices that are used to monitor applications. A multiplexer allows several input signals and generates a single output signal. In multiplexing, many embedded system devices share a single bus or transmission line while communicating with the device. Each successive device has a brief amount of time to send and receive the data.

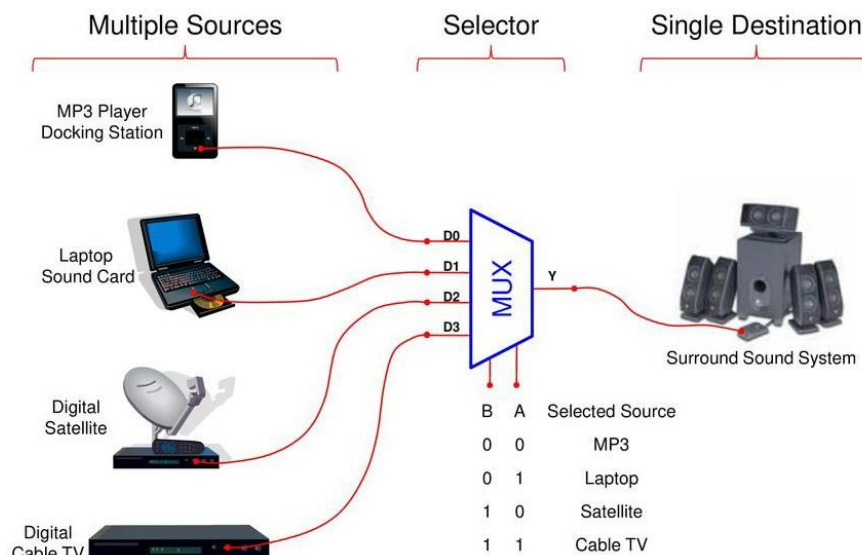


Fig 1.1.13: Various functions of a multiplexer

Sensors:



Fig 1.1.14: Sensor

What is a Sensor?

Sensor is a tool that detects the minute variations in physical, electrical or other quantities. It generates an output as per the change in the quantity.

Types of sensors and their uses:

Speed Sensor: Sensors used to detect the speed of an object are called Speed sensors. There are various types of sensors to detect speed such as speedometers, Wheel speed sensors, LIDAR (Light Detection and Ranging), pitometer logs, pitot tubes, ground speed radar, air speed indicators, Doppler radar, etc.



Fig 1.1.15: Speed Sensor

Temperature Sensor



Fig 1.1.16: Temperature Sensor

An instrument, which provides temperature measurement in the form of an electrical signal, is called Temperature sensor. The electrical signal is typically in the form of electrical voltage. There are several types of sensors available in the market used for measuring temperature such as:

- Contact type temperature sensors
- Non-contact type temperature sensors

PIR Sensor: The electronic sensor used to measure the infrared light radiation exuded from objects in its field of view is called a Pyroelectric sensor or PIR (Passive Infrared Sensor) sensor.



Fig 1.1.17: PIR Sensor

Ultrasonic Sensor



Fig 1.1.18: Ultrasonic Sensor

The concept of ultrasonic sensor is to interpret echoes from sound waves or radio to determine the attributes of a target by producing the sound waves of high-frequency.



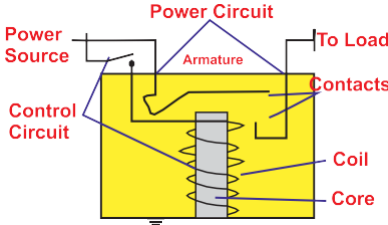
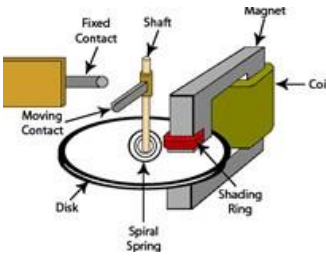

Relays and their types





What are Relays?

A relay is a switching device used to isolate or convert the state of an electric circuit into another.



Fig 1.1.19: Relays

Type of Relay	Image	Function
Electromagnetic Relays		Electromagnetic relays comprise electrical, magnetic, and mechanical components. Furthermore, they comprise mechanical contacts and an operating coil. The mechanical contacts open or close when a supply system activates the coil. This supply system can be DC or AC.
AC and DC Relays		The functioning of DC and AC relays is based on the principle of electromagnetic induction. However, their constructions are different and depend on their applications. In DC relays, the coil is deenergised by a freewheeling diode while in AC relays, eddy current losses are prevented with the help of laminated cores.
Attraction Type Relays		Attraction type relays, when supplied with DC or AC power, attract a metal piece or bar. This metal piece or bar can be in the form of an armature attracted towards electromagnet poles or a plunger drawn towards the solenoid.
Induction Type Relays		These relays are constructed with electrical, mechanical and magnetic components, and have an operating coil and mechanical contacts. When the coil gets activated by a supply system, these mechanical contacts gets opened or closed. The type of supply can be AC or DC.
Magnetic Latching Relays		Permanent magnets or high-permittance parts are used in these relays so that, on removal of the coil power supply, the armature remains at the same point.

Type of Relay	Image	Function
Solid State Relays		Solid State relays perform the switching operation, with the help of solid state components, without moving any parts.
Hybrid Relays		Hybrid relays comprise electronic components and electromagnetic relays. The output part comprises electromagnetic relay while the input part comprises electronic circuitry, which performs control functions and rectification.
Thermal Relays		In thermal relays, the rise of the ambient temperature above the stipulated limit makes the contacts switch between positions. Primarily implemented in protecting motors, thermal relays comprise control elements as well as bimetallic elements like temperature sensors.
Reed Relays		Reed relays comprise paired magnetic strips called reeds, which are sealed in a glass tube and act as both a contact blade and an armature. The reeds can be moved by applying a magnetic field to the coil around the tube. Thus, switching operations can be performed.

Registers: The microprocessor is responsible for most of the central processing unit (CPU) functions and is triggered when the computer is switched on. Registers are tiny number-storing locations, which are used by the microprocessor for performing arithmetic and logic operations.

UNIT 1.2: Active and Passive Components

Unit Objectives

At the end of this unit, you will be able to:



1. Compare various electronic part
2. Discuss various types of active and passive electronic components


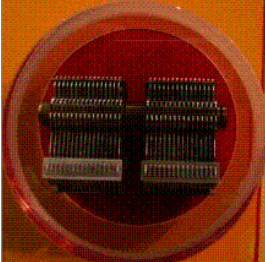

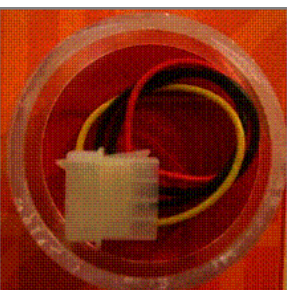

1.2.1 Introduction


Electronics is the field that involves electronic components, circuits, and device characteristics to fabricate electronic systems. Electronic components have a number of leads or electrical terminals, which connect to fabricate an electronic circuit with a given function (an amplifier, a radio receiver, an oscillator, etc.). Components can be classified as passive and active.

1.2.2 Passive Component

Passive components cannot introduce net energy into the circuit. They also cannot rely on a power source, except for what is available from the (AC) circuit they are connected to. Consequently, they cannot amplify (increase the power of a signal), although they may increase the current or voltage (as done by a resonant circuit or transformer). Passive components include two-terminal components like resistors, inductors, capacitors, and transformers.

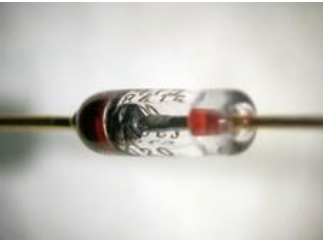

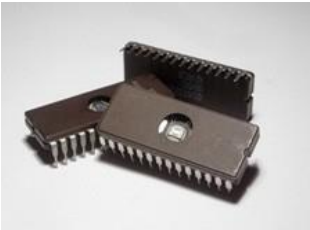
Name of the Component	Image	Function
Resistor		They resist the flow of electric current. The resistance is measured in Ohms (Ω). $R=V/I$, where: R =Resistance, V =Voltage and I =Current.
Potentiometer		It is a resistor with a tap or contact which can be moved to change the resistance.

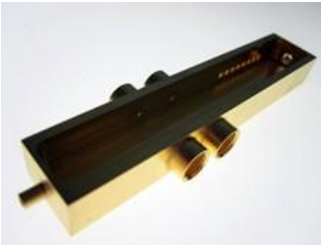

<p>Capacitor</p>		<p>Capacitors store energy in its electric field. The capacitance is measured in Farads (F). $C=Q/V$, where: C=Capacitance, Q=Charge and V=Voltage. Capacitors stop direct current flow (DC). They are an open circuit to DC.</p>
<p>Variable Capacitor</p>		<p>The capacitance of these capacitors can be changed to adjust a circuit.</p>
<p>Inductor</p>		<p>Inductors store energy in its magnetic field. They are measured in Henrys (H). $L=N$</p>
<p>Connector</p>		<p>These connect one part of an electric circuit with another. Connectors are designed for different power levels and signal types.</p>
<p>Switch</p>		<p>Switches can be on-off controls (single throw) or change the connection from one circuit to another (double throw). Complex switches can control many circuits at the same time.</p>

Relay		A relay is a switch that is turned on and off by an electromagnet, or a solid state switch controlled by an optical coupler.
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1.2.2 Active Component

Active components depend on a source of energy (usually from the DC circuit). Active components include amplifying components like transistors, tunnel diodes, and triode vacuum tubes (valves).

Name of the Component	Image	Function
Diode		The most common function of a diode is to allow an electric current to pass in one direction (called the diode's forward direction), while blocking it in the opposite direction (the reverse direction). As such, the diode can be viewed as an electronic version of a check valve.
Transistor		The transistor can amplify and switch electrical power and electronic signals. Transistors are built up of semiconductor material with three or more terminals, which are used to connect to an external circuit. A change in current can be induced by applying current or voltage to one of the pairs of the terminals.
Integrated Circuit		Commonly known as a microchip or chip, an Integrated circuit (IC) is a semiconductor-based wafer on which millions of small capacitors, resistors, and transistors are connected. An IC can function as an oscillator, amplifier, timer, computer memory, counter, or microprocessor.

Optoelectronic devices		Optoelectronic devices are optical-to-electrical or electrical-to-optical transducers, or instruments that use such devices for functioning.
Valve		Solenoid valves can measure, close, mix, or distribute the fluid (gas or liquid) flow in a pipe. The circuit function of a solenoid valve denotes its exact purpose. 2/2 way valves comprise two ports (outlet and inlet) and two positions (closed or open).

Resistor Colour Coding

Colour	Digit	Multiplier	Tolerance
Black	0	1	
Brown	1	10	± 1%
Red	2	100	± 2%
Orange	3	1,000	
Yellow	4	10,000	
Green	5	100,000	± 0.5%
Blue	6	1,000,000	± 0.25%
Violet	7	10,000,000	± 0.1%
Grey	8		± 0.05%
White	9		
Gold		0.1	± 5%
Silver		0.01	± 10%
None			± 20%

UNIT 1.3: Understanding of Diodes, Transistors, and Logic Gates

Unit Objectives

At the end of this unit, you will be able to:

1. Analyze components like diode, transistors and logic gates

1.3.1 Diodes, Transistors, and Switches

What is diode?

A semiconductor device with two terminals, typically allowing the flow of current in one direction only

What is transistor?

A semiconductor device with three connections, capable of amplification in addition to rectification

Photo Transistor

The resemblance of a phototransistor is quite similar to that of a transistor with a small exception. The base terminal is present in transistor but absent in phototransistor. Production of base current takes place when light strikes the base region (photosensitive semiconductor). The incident light is converted into photocurrent by the help of collector-base p-n junction.

Phototransistor structure

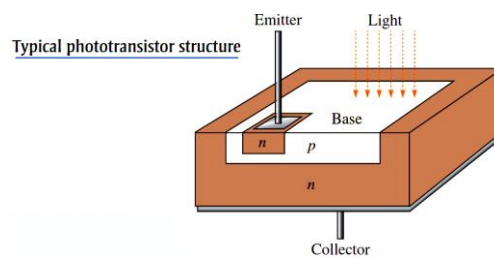


Fig 1.3.1: Phototransistor

Typical package

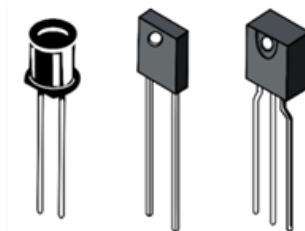


Fig 1.3.2: Package diode

Schematic symbol

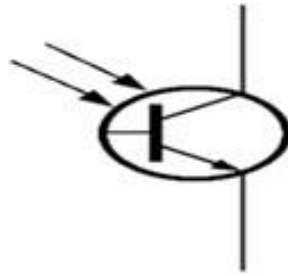


Fig 1.3.3: Diode symbol

Phototransistor circuit

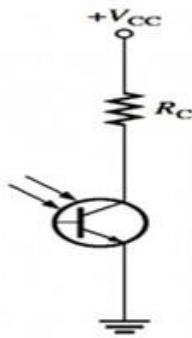


Fig 1.3.4: Phototransistor circuit

Switch types

Different types of switches are used for different applications. It is a recommended practice to use the correct switch for a specific application.

Rotary switch: Operated by rotation, rotary switches are used when more than two positions are needed. For example, while modifying bands on a radio receiver. The rotary switch comprises a spindle or rotor and there is an array of terminals, which the circular contactor makes contact with. This array is dependent upon the spindle position.



Fig 1.3.5: Rotary switch

Toggle switch: A toggle switch can be manually actuated by a mechanical lever, handle, or rocking mechanism. It generally has two positions. Once the arm is actuated the mechanical mechanism tends to hold it positively in one position or another. The internal mechanics are such that once the arm is moved it passes a certain point and it snaps into the other position. Thus, the switch is held firmly in one position or another.



Fig 1.3.6: Toggle Switch

Rocker switch: This type of switch has many similarities with the toggle switch in that it often has just two positions. However a toggle mechanism is not included and therefore the switching action is not quite as positive.



Fig 1.3.7: Rocker Switch

Electronic switch: FETs and also bipolar transistors as well as SCRs (Semiconductor Controlled Rectifiers) can be used for switching electronic and electrical circuits. When semiconductor technology alone is used to provide switching, these switches are often referred to as electronic switches.



Fig 1.3.8: Electronic Switch

List of semiconductor materials

MATERIAL	CHEMICAL SYMBOL / FORMULA	DETAILS
Germanium	Ge	Germanium, a semiconductor material, was commonly used in the first transistors as well as radar detection diodes. Germanium-based diodes exhibit a high temperature coefficient and reverse conductivity. This is why early transistors often suffered from thermal drainage.
Silicon	S	Silicon, the most common semiconductor, can be easily fabricated and exhibits good mechanical and electrical properties. When silicon is used in integrated circuits (ICs), it results in the formation of high-quality silicon oxide, which acts as an insulation layer between the IC's active elements.
Gallium arsenide	GaAs	After silicon, Gallium arsenide is the most popular semiconductor. Its high electron mobility is very useful for fabricating high-performance RF devices. Gallium arsenide is also commonly used as a substrate for a few other semiconductors like GaInNAs and InGaAs. However, its brittle nature and lower hole mobility as compared to Silicon restricts its application in P-type CMOS (Complementary Metal-Oxide Semiconductor) transistors.
Silicon carbide	SiC	Silicon carbide is commonly used in power devices where its losses are considerably lesser and operating temperatures can be greater than those of silicon-based devices. Silicon carbide has a breakdown capability about ten times that of silicon itself.
Gallium Nitride	GaN	Gallium nitride is now being commonly used in microwave transistors since these require high temperature and power. It is also being used in a few microwave ICs. GaN (Gallium nitride) is difficult to dope to create p-type regions and it is also sensitive to ESD (Electrostatic Discharge), but relatively insensitive to ionising radiation. It is also used in a few blue LEDs (Light Emitting Diodes).
Gallium phosphide	GaP	Gallium phosphide is a semiconductor material that has found many uses in LED technology. It was used in numerous early low to medium-brightness LEDs producing a variety of colours, which depended upon the addition of other dopants. Pure Gallium phosphide produces a green light. When nitrogen-doped, it emits yellow-green and when ZnO-doped it emits red.

MATERIAL	CHEMICAL SYMBOL / FORMULA	DETAILS
Cadmium sulphide	CdS	Used in solar cells and photoresistors.
Lead sulphide	PbS	Used as the mineral galena, Lead sulphide was used in the early radio detectors called 'Cat's Whiskers'. A point contact was created with the tin wire onto the galena to rectify signals.

Diodes



Fig 1.3.9: Different types of Diode

Diodes are electronic components functioning as one-way valves. This implies that they allow current to move in one direction. These diodes are produced with the help of the semiconductor materials germanium, silicon and selenium. The function of diode can be classified in two ways, if it allows the current then, it is forward-biased, otherwise it is reverse-biased.

Some of the diodes are listed below.

Small Signal Diode: An instrument with out-of-proportion features, the uses of a small signal diode are mostly involved with extremely low-current devices like radios and televisions, etc., and at high frequencies. It is enveloped with a glass in order to prevent contamination. Hence, it is also called Glass Passivated Diode, which is extensively used as 1N4148.

As compared to the power diode, the appearance of signal diode is very small. To indicate the cathode terminal, one of the edges is marked with black or red colour. For high-frequency applications, the performance of the small signal diode is very effective.



Fig 1.3.10: Small signal diode

Large Signal Diode: The PN junction layers in large signal diodes make the conversion of AC to DC voltages unlimited. This raises the reverse blocking voltage and the current forward capacity. Such large signals disrupt the operational points also. This is the reason why a large signal diode is unsuitable for high-frequency applications.



Fig 1.3.11: Large signal diode

Large signal diodes are primarily used in battery-charging devices like inverters. In these diodes, the forward resistance is measured in Ohms while the reverse blocking resistance is measured in mega Ohms.

Zener Diode: The zener diode is a passive element that works on the basis of Zener breakdown. Similar to normal diodes in forward direction, this was first produced by Clarence Zener in 1934. When the applied voltage hits the breakdown voltage, the zener diode allows current in a reverse direction. It is designed to stop the other semiconductor devices from momentary voltage pulses. The zener diode acts as voltage regulator.



Fig 1.3.12: Zener diode

Light Emitting Diode (LED): In light emitting diode, electrical energy is converted into light energy. It goes through the electroluminescence process in which electrons and holes are recombined to generate energy in the form of light in forward-bias condition. Light emitting diodes are mostly used in applications like aviation lighting, traffic signals, camera flashes, etc.



Fig 1.3.13: Light emitting diode

Constant Current Diodes: Commonly known as constant-current diode, current-limiting diode or current-regulating diode, the purpose of the diode is controlling the voltage at a given current. It works as a two-terminal current limiter.



Fig 1.3.14: Constant current diode

Schottky Diode: The junction in Schottky diode is created by contacting a metal with the semiconductor material. Thus, the forward voltage drop is reduced to minimum. The semiconductor material is N-type silicon that acts as an anode and the metal acts as a cathode. The metal may be platinum, chromium, tungsten, etc.

These diodes, due to the metal junction, enjoy high conducting capability and thus the switching time reduces. This is why Schottky is widely used for switching applications. Due to the metal-semiconductor junction, the voltage drop is low, which in turn increases the diode performance and reduces power loss.



Fig 1.3.15: Schottky diode

Shockley Diode: One of the first semiconductor devices, the shockley diode has four layers. It is also known as PNP diode. It is equivalent to a thyristor without a gate terminal, which implies that the gate terminal is disconnected. As there are no trigger inputs, the only way the diode can conduct is by providing forward voltage. The diode works in two states, namely, conducting and non-conducting. In the non-conducting state, the diode conducts with less voltage.



Fig 1.3.16: Shockley diode

Step Recovery Diodes: It is also called charge-storage or snap-off diode. These are special types of diodes that store the charge from positive pulse and use this in the sinusoidal signals' negative pulse. The current pulse's rise time is equal to the snap time. This phenomenon is responsible for the speed recovery pulses. These diodes are used in higher order multipliers and in pulse-shaper circuits. These diodes have a very high cut-off frequency, which is nearly of the Giga hertz order.

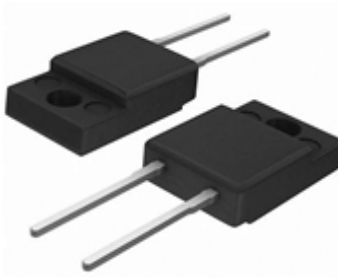


Fig 1.3.17: Step recovery diode

As a multiplier, this diode has the cut-off frequency ranging between 200 - 300 GHz. The efficiency is high for lower-order multipliers.

Tunnel Diode: It is used as high-speed switch of the nano-second order. Due to its tunneling effect, it enjoys very fast operation in microwave-frequency region. It is a two-terminal device comprising very high concentration of dopants. It is mainly used in microwave oscillators and amplifiers. It acts similar to most negative-conductance devices. Tunnel diodes can be tuned in both electrically and mechanically.



Fig 1.3.18: Tunnel diode

Varactor Diode: Also called Varicap diode, this acts like a variable capacitor. This performs mainly at the reverse-biased state. These diodes are very famous due to their capability of changing the ranges of capacitance within the circuit in the presence of a constant voltage flow.



Fig 1.3.19: Varactor diode

In a Varactor diode, by changing the reverse bias voltage, we can decrease or increase the depletion layer or barrier potential. These diodes are commonly used as voltage-controlled oscillator for cell phones, frequency multipliers, satellite pre-filters, FM (Frequency Modulation) transmitters, etc.

Laser Diode: This is similar to an LED in which active region is formed by p-n junction. Electrically, laser diode is a p-i-n diode in which the active region is in the intrinsic region. These are implemented in fiber optic communications, laser pointers, barcode readers, CD (Compact Disc)/DVD (Digital Versatile Disc)/Blu-ray reading and recording, laser printing, etc.



Fig 1.3.20: Laser diode

Types of Laser Diode:

- **Double Heterostructure Laser:** Free electrons and holes are simultaneously available in the region.
- **Quantum Cascade Lasers:** These are heterojunction lasers that enable laser action at relatively long wavelengths.
- **Distributed Bragg Reflector Lasers:** These can be VCSELS (Vertical-Cavity Surface-Emitting Lasers) or edge-emitting lasers.
- **Multi Quantum Well Lasers:** Lasers with more than one quantum well are known as multi quantum well lasers.
- **Separate Confinement Heterostructure Lasers:** Separate confinement heterostructure lasers are used to compensate for the thin-layer problem in quantum lasers.

Transient Voltage Suppression Diode:

Transients occur in semiconductor devices due to the sudden change in the state voltage. They are capable of damaging the device output response. voltage suppression diodes are used to overcome this problem. The voltage suppression diode's operation is similar to Zener diode operation.

Similar to p-n diodes, the operation of these diodes is normal but at the time of transient voltage the operation varies. These are spontaneously very fast. Used in medical fields, telecommunication, microprocessors and signal processing, these diodes respond to excess voltages faster than varistors and gas discharge tubes.



Fig 1.3.21: Transient Voltage Suppression Diode

Gold Doped Diodes: These diodes use gold as a dopant. Faster than other diodes, these diodes enjoy very less leakage current in reverse bias condition. Even at a higher voltage drop, the diode can operate in signal frequencies. In these diodes, gold helps the faster recombination of minority carriers.



Fig 1.3.22: Gold doped diode

Super Barrier Diodes: It is a rectifier diode with low forward voltage drop similar to the Schottky diode and with low reverse-leakage current and surge-handling capability like the p-n junction diode. It was fabricated for speedy switching, high power, and low-loss applications. Super barrier rectifiers come with lower forward voltage as compared to Schottky diodes.



Fig 1.3.23: Super barrier diode

Peltier Diode: In this diode, heat is generated at the two material junction of a semiconductor, which flows from one terminal to another. This flow is in only a single direction, which is equal to the direction of current flow. Primarily used in heating and cooling applications, this type of diode is used as sensor and heat engine for thermo-electric cooling.



Fig 1.3.24: Peltier diode

Crystal Diode: Also known as Cat's whisker, this is a type of point-contact diode. Its function depends on the pressure of contact between the point and the semiconductor crystal.



Fig 1.3.25: Crystal diode

In this, a metal wire is pressed against the semiconductor crystal. The semiconductor crystal acts as cathode and the metal wire acts as anode. These diodes are obsolete in nature. They are mainly used in microwave receivers and detectors.

Avalanche Diode: This is a passive element and works under the principle of avalanche breakdown. It works in reverse bias condition. It results in large currents due to the ionization produced by p-n junction during reverse bias condition. These diodes are specially designed to undergo breakdown at specific reverse voltages to prevent the damage. These are used in **RF (Radio Frequency) Noise Generation, Microwave Frequency Generation and Single Photon Avalanche Detector.**



Fig 1.3.26: Avalanche diode

Vacuum Diodes: Vacuum diodes comprise two electrodes that act as anode and cathode. The cathode is made up of tungsten, which emits electrons in the anode's direction. The electrons will always flow from cathode to anode. Thus, it acts like a switch.



Fig 1.3.27: Vacuum diode

If the cathode is plated with oxide material, its electron emission capability is high. The anode is longer in size and in a few cases their surfaces are rough to decrease the chances of temperatures developing in the diode. The diode will conduct only when the anode is positive w.r.t to the cathode terminal.

PIN Diode: The PIN diode is the improved version of the normal P-N junction diode. In PIN diode, doping is not necessary. The intrinsic material that has no charge carriers is inserted between the P and N regions. This increases the area of depletion layer. Applications of these are RF switches, photo detectors, etc.



Fig 1.3.28: Pin diode

Point Contact Devices: A tungsten or gold wire is used to act as a point contact for fabricating a PN junction region by transmitting a high electric current. A small region of PN junction is formed around the wire edge, which is connected to the metal plate.

In the reverse bias condition, the wire acts similar to an insulator. The diode acts as a capacitor since the insulator is between the plates.



Fig 1.3.29: Point contact diode

Gunn Diode: Gunn diode is fabricated only with n- type semiconductor material. In two N-type materials, the depletion region is very thin. When the circuit voltage increases, the current also increases. The current will exponentially decrease after reaching a certain voltage level. Thus, Gunn diode exhibits negative differential resistance.

Gunn diode comprises two electrodes with Indium Phosphide and Gallium Arsenide. This results in negative differential resistance. Gunn diode is also called transferred electron device. It produces microwave RF signals. Hence, it is primarily used in Microwave RF devices. It can also be used as an amplifier.



Fig 1.3.30: Gunn diode

Types of Transistors

Bipolar Junction Transistor (BJT)

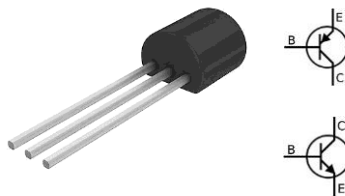


Fig 1.3.31: Bipolar junction transistors

These are transistors built of three regions, namely, the base, the emitter, and the collector. Bipolar Junction transistors are current-controlled devices. A small current entering the base region of the transistor results in more current flow from the emitter to the collector region. Bipolar junction transistors are of the below types:

- NPN (Negative, Positive, Negative) - Where the majority of current carriers are electrons
- PNP (Positive, Negative, Positive) - Where the majority of current carriers are holes

Field Effect Transistor

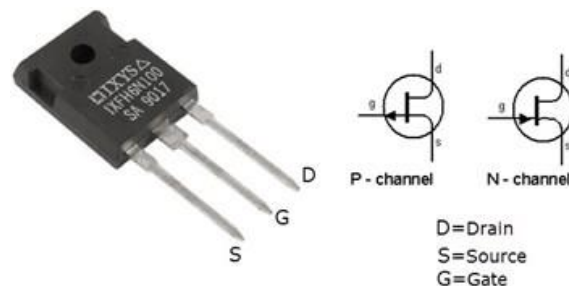


Fig 1.3.32: Field effect transistor

These comprise three regions, namely, a source, a gate, and a drain. Different from bipolar transistors, FETs are voltage-controlled devices. Field Effect Transistors enjoy very high input impedance, ranging between several mega ohms ($M\Omega$) of resistance to even larger values. Such high input impedance results in very less current running through FETs. FETs draw very little current from a power source. Field Effect Transistors can be classified into two main types:

- JFET (Junction Field Effect Transistor)
- MOSFET (Metal Oxide Semiconductor Field Effect Transistor)

MOSFETs and JFETs are very similar but MOSFETs have even higher input impedance values as compared to JFETs.

Heterojunction Bipolar Transistor (HBT)

Heterojunction bipolar transistors (HBTs) are implemented for both digital and analog microwave applications with frequencies as high as the Ku band. HBTs can supply quicker switching speeds as compared to silicon bipolar transistors mostly because of reduced base-resistance and collector-to-substrate-capacitance. HBTs are used in both high-reliability and profitable applications, like power amplifiers in laser drivers and mobile telephones.

Darlington Transistor

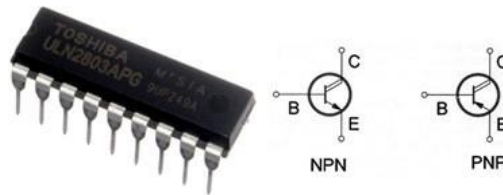


Fig 1.3.33: Darlington transistor

A Darlington transistor, commonly known as a Darlington Pair, is a transistor circuit built of two transistors. Invented by Sidney Darlington, it enjoys much higher current-gaining ability. The circuit can be inside an IC or made from two discrete transistors.

Schottky Transistor

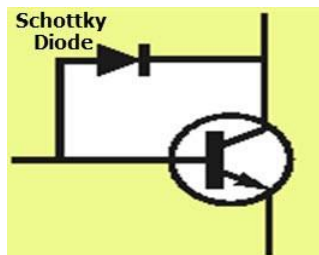


Fig 1.3.34: Schottky transistor

It is a combination of a Schottky diode and a transistor. The Schottky diode hinders the transistor from saturating by bypassing the extreme input current. It is also called a Schottky-clamped transistor.

Multiple-Emitter Transistor

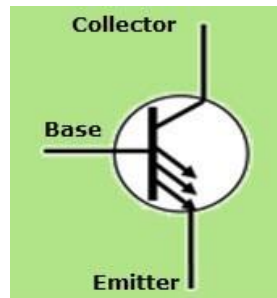


Fig 1.3.35: Multiple emitter transistor

A multiple-emitter transistor is a specialized bipolar transistor frequently used as the inputs of transistor logic (TTL) (Transistor-Transistor Logic) NAND (NOT AND) logic gates. Input signals are applied to the emitters.

Dual Gate MOSFET

The dual gate MOSFET is very popular in several RF applications. Used in many RF applications where two control gates are required in series, the dual gate MOSFET can be used in applications like RF amplifiers, RF mixers /multipliers, amplifiers with gain control, etc.

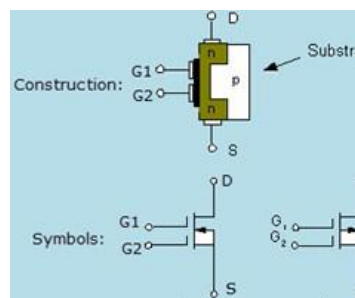


Fig 1.3.36: Dual gate MOSFET

Junction FET Transistor

Instead of PN junctions, the Junction Field Effect Transistor (JUGFET (Junction Gate Field Effect Transistor) or JFET) has a narrow high resistivity semiconductor material creating a P-type or N-type silicon channel for the majority of the carriers to flow through two ohmic electrical connections at either end. These are called the source and the drain. The N-channel JFET and the P-channel JFET are the two basic configurations of junction field effect transistor.

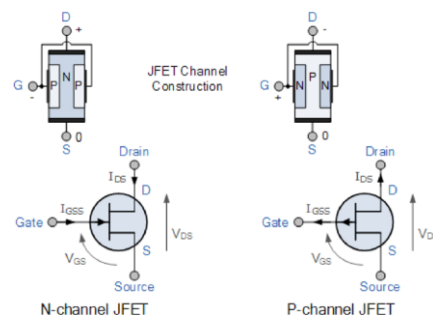


Fig 1.3.37: Junction FET transistor

Avalanche Transistor

This is a bipolar junction transistor fabricated for processing in the region of its collector-to-emitter voltage/collector-current characteristics beyond the collector-to-emitter breakdown voltage, known as the avalanche breakdown region. This region is described by the avalanche breakdown, a phenomenon similar to the negative differential resistance. Operations in the avalanche breakdown region are called avalanche-mode operation, during which avalanche transistors are empowered with the capability to switch very high currents with less than a nanosecond rise and fall times (transition times).

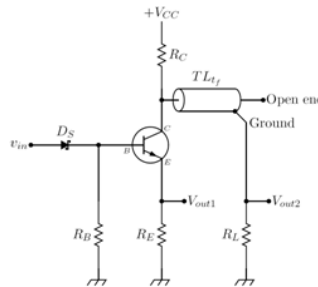
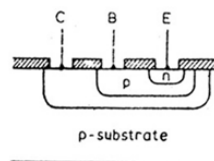


Fig 1.3.38: Avalanche transistor

Diffusion Transistor



Triple-diffused transistor cross-sectional view

Fig 1.3.39: Diffusion transistor

This is a bipolar junction transistor (BJT), which is fabricated by means of diffusing dopants onto a semiconductor substrate. Diffusion is implemented later than the alloy junction and grown junction processes.

Testing transistors using multimeter



Fig 1.3.40: Multimeter

The things you require are very simple.

Step 1 First, you need a multimeter and secondly the transistors you want to test.

Step 2 Now comes the part of testing the transistors.

The NPN (Negative, Positive, Negative) transistor has the collector and emitter as negative and the base as positive, which is just opposite in PNP (Positive, Negative, Positive) transistors.

Step 3 The multimeter must be set at the transistor-testing mode.

The leads of the multimeter must be connected to the transistor leads. The negative lead must be connected to the negative terminal while the positive lead must be connected to the positive terminal. The multimeter shows a reading.

Step 4 The negative lead must now be connected to the other negative terminal. The multimeter shows a reading.

It must be noted that the readings in both cases are almost equal.

Step 5 How to detect a bad transistor

The leads must be connected to both the negative terminals. If the multimeter reads 1, the transistor is okay. If this is not the case, the multimeter produces a buzzing sound and reads 000, thus indicating that the transistor is bad and not recommended for use.

Step 6 PNP TRANSISTORS

The leads must now be connected to the opposite terminals. The PNP transistor will show a reading only when the positive lead is connected in the middle and the negative lead at the sides.

Thus, the above tests can be used for comparing NPN and PNP transistors.

Transistor configuration

The three types of transistor configurations are:

- A. Common base transistor configuration
- B. Common collector transistor configuration
- C. Common emitter transistor configuration

Common Base Transistor Configuration (CB)

This transistor configuration produces a low input while giving high output impedance. The current gain and overall power gain is low when the voltage of the CB transistor is high, as compared to the other configurations. The main characteristic of the B transistor is that the transistor's input and output are in phase. In the given circuit, the base terminal is mutual to both input and output circuits.

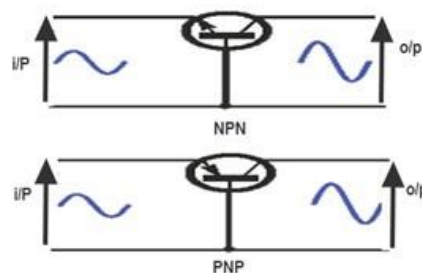


Fig 1.3.41: Common base transistor

The collector current (output current) to emitter current (input current) relationship is denoted by alpha, which is calculated by:

$$\alpha = (\Delta I_C) / \Delta I_E$$

If the input current (I_E) in a common base current changes from 2mA to 4mA and the output current (I_C) changes from 2mA to 3.8 mA, the gain of the current will be 0.90.

$$\alpha = \frac{\Delta I_C}{\Delta I_E} = \frac{18 \times 10^{-3}}{2 \times 10^{-3}} = 0.90$$

The CB current gain is < 1 when the emitter current flows into the base terminal and does not function as collector current. This current is always less than the causal emitter current. The common base configuration gain is always < 1 . The given formula is used to calculate the current gain of the CE (α) when the CB value is given i.e. (β).

Common Collector Transistor Configuration (CC)

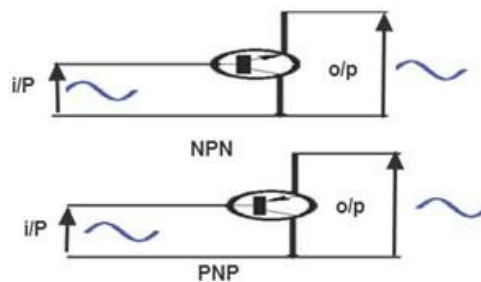


Fig 1.3.42: Common collect transistor

Also called the emitter follower, the emitter voltage of this transistor follows the base terminal of the transistor. Offering high input and low output impedances, it is used as a buffer. The transistor has a voltage gain of 1, the current gain is high and the output signals are in phase. The collector terminal is mutually shared by both input and output circuits.

The CC circuit's current gain is indicated as γ and is calculated using the below formula.

$$\gamma = \frac{\Delta I_E}{\Delta I_B}$$

This gain is related to the CB current gain beta (β), and the CC circuit gain is calculated, when the β value is given.

$$\gamma = \beta + 1$$

When the transistor is connected in any one of the CE, CB and CC configurations, there exists a relationship between beta, alpha, and gamma.

$$\alpha = \frac{\beta}{\beta + 1} \quad \beta = \frac{\alpha}{1 - \alpha} \quad \gamma = \beta + 1$$

For example, if the current gain of the common base value (α) is 0.90, the beta value is:

$$\beta = \frac{\alpha}{1 - \alpha} = \frac{0.90}{1 - 0.90} = \frac{0.90}{0.1} = 9$$

Thus, a change in the base current of this transistor will impart a change in collector current. This change in collector current will be nine times bigger. In order to use the same transistor in CC configuration, we need to calculate gamma by the following equation.

$$\gamma = \beta + 1 = 9 + 1 = 10$$

Common Emitter Transistor Configuration (CE)

One of the most widely used configurations, the circuit of CE transistor configuration provides moderate input and output impedance levels. The voltage and current gains can be defined as a medium, but the output is opposite to the input, thus indicating a 180° change in phase. This improves performance and is frequently thought of as the most commonly used configuration. The below diagram depicts the CE transistor configuration. In this type of circuit, the emitter terminal is mutually shared by both input and output.

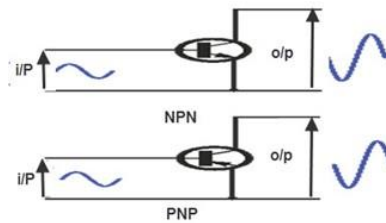


Fig 1.3.43: Common emitter transistor

The common emitter (CE) circuit's current gain is denoted by beta (β). It is the relationship between the base and collector currents. The below formula is used to calculate beta (β). Delta denotes a minor difference.

$$\beta = \frac{\Delta I_C}{\Delta I_B}$$

Let us consider an example. If the input current (I_B) in a CE changes from 50 mA to 75 mA and the output current (I_C) varies from 2.5 mA to 3.6 mA, the current gain (β) becomes 44.

$$\beta = \frac{\Delta I_C}{\Delta I_B} = \frac{11 \times 10^{-3}}{25 \times 10^{-6}} = 44$$

From the above, it can be interpreted that a change in base current results in a modification in collector current, which is 44 times larger.

Basic Conversion of Transistor

Type of Conversion	Image	Description
Transistor as amplifier		<p>The most common amplifier configuration for an NPN transistor is that of the Common Emitter Amplifier circuit.</p>
Transistor as switch: Cut-off Characteristics		<ul style="list-style-type: none"> • The input and Base are grounded (0v) • Base-Emitter voltage $V_{BE} < 0.7v$ • Base-Emitter junction is reverse biased • Base-Collector junction is reverse biased • Transistor is “fully-OFF” (Cut-off region) • No Collector current flows ($I_C = 0$) • $V_{OUT} = V_{CE} = V_{CC} = "1"$ • Transistor operates as an “open switch”
Transistor as switch: Saturation Characteristics		<ul style="list-style-type: none"> • The input and Base are connected to VCC • Base-Emitter voltage $V_{BE} > 0.7v$ • Base-Emitter junction is forward biased • Base-Collector junction is forward biased • Transistor is “fully-ON” (saturation region) • Max Collector current flows ($I_C = V_{cc}/R_L$) • $V_{CE} = 0$ (ideal saturation) • $V_{OUT} = V_{CE} = "0"$ • Transistor operates as a “closed switch”

1.3.2 Basic Logic Gates

Considered the building block of a digital circuit, a logic gate comprises two inputs and an output, which are related with the help of certain logic.

Logic gates are put to use with the help of electronic switches like diodes and transistors. Nowadays, CMOS technology, MOSFET (Metal Oxide Semiconductor FET)s and FETS are used to build basic logic gates.

Logic gates are used in microprocessors, microcontrollers, and embedded system applications and in electronic and electrical project circuits.

The basic logic gates are categorized into seven: AND, OR, XOR, NAND, NOR, XNOR and NOT. These logic gates with their logic gate symbols and truth tables are explained below.



Fig 1.3.42: Symbol of a logic gate

AND Gate

The AND gate, a digital logic gate, comes with 'n' number of inputs and only one output. The output performs logical conjunction on the basis of the input combination. The output of this gate becomes true only when all the inputs are true. The output of the AND gate becomes false only when one or more inputs are false.



Fig 1.3.43: Symbol and Truth Table of the AND gate

OR Gate

Comprising 'n' number of inputs and one output, the OR gate output becomes true only when one or more inputs are true. The output is false only when all inputs of the gate are false.

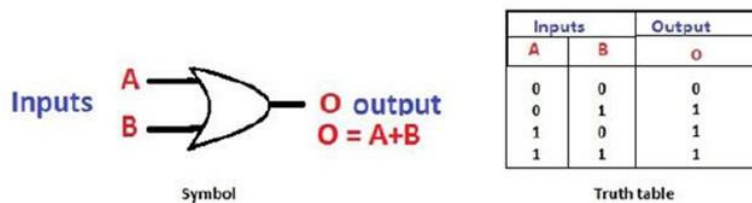


Fig 1.3.44: Symbol and Truth Table of the OR gate

NOT Gate

The NOT gate comprises one input and one output and operates an inverter operation of the input. The output of the NOT gate is the reverse of the input. When the input of the NOT gate is true then the output will be false and vice versa. With the help of this gate, the NOR and NAND gates can be constructed.

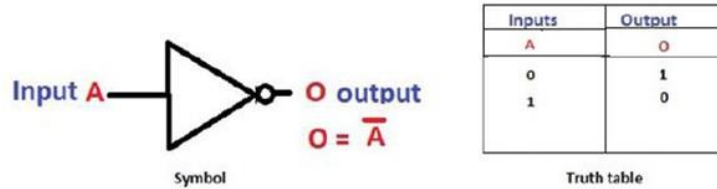


Fig 1.3.45: Symbol and Truth Table of the NOT gate

NAND Gate

Comprising 'n' inputs and only one output, the NAND gate executes the AND gate operation, which is followed by the NOT gate operation. The NAND gate is fabricated by combining the NOT and AND gates. The output will be low if the input is high.

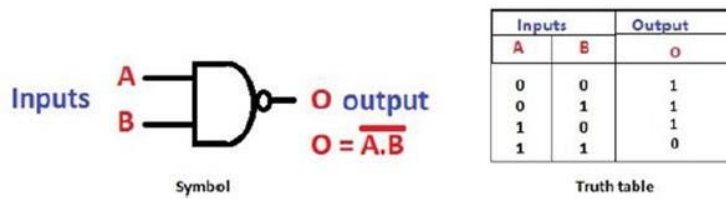


Fig 1.3.46: Symbol and Truth Table of the NAND gate

NOR Gate

Comprising 'n' inputs and one output, the NOR gate executes the OR gate operation, which is followed by the NOT gate. It is fabricated by combining the NOT and OR gates. The output is false when any one of the inputs is true.

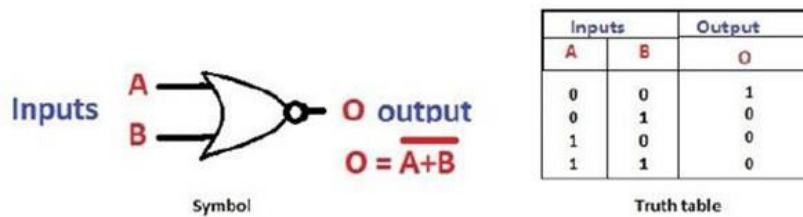


Fig 1.3.47: Symbol and Truth Table of the NOR gate

Exclusive-OR Gate

Comprising two inputs and one output, the short form of this gate is Ex-OR. It functions on the basis of OR gate operation. The output is high if any one of the inputs is high.

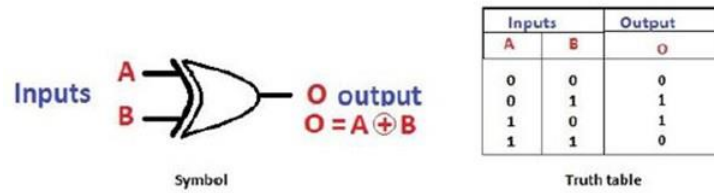


Fig 1.3.48: Symbol and Truth Table of the exclusively OR gate

Exclusive-NOR Gate

Comprising two inputs and one output, the short form of this gate is Ex-NOR. It operates on the basis of the NOR gate operation. The output of the gate is high when both the inputs are high. However, if any one of the inputs is high (but not both), the output will be low.

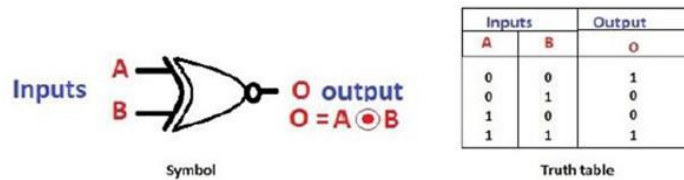


Fig 1.3.49: Symbol and Truth Table of the exclusively NOR gate

1.3.3 RF Transmitter and Receiver

RF Transceiver

A mixture of a receiver and a transmitter in a single package, the RF trans receiver is widely used in wireless communication for applications like handheld and mobile two-way radios, cellular telephones, and cordless telephone sets. It is also used in transmitter or receiver devices in optical fiber systems or cables.



Fig 1.3.50: RF Trans receiver module

In a radio transceiver, the receiver is quietened while transmitting. An electronic switch authorises the transmitter and receiver to be associated with the same antenna and prevents the transmitter output from damaging the receiver. Thus, it is difficult to receive signals while transmitting and this mode is named as half duplex.

A few types of transceivers are designed to allow signal reception via transmission periods. This full duplex mode needs the transmitter (TX) and receiver (RX) to work on different frequencies so the signal transmitted doesn't interfere with reception. Communication devices sets use this mode. Satellite communication networks frequently employ full-duplex transceivers at the surface based subscriber points. The transceiver-to-satellite (transmitted) signal is called the uplink, while the satellite-to-transceiver (received) signal is called the downlink.

Click/Scan
the QR
code for
more info
on
Transmitters
and
Receivers



Block Diagram of RF Transceivers

The size of the RF modules is quite small. RF modules operate with the help of voltage ranging from 3V to 12V.

Generally, such RF modules are 433 MHz RF TX and RX modules. The transmitter (TX) draws zero power while transferring logic zero while fully destroying the carrier frequency, thus consume considerable low power in battery operation. When logic1 is sent carrier is fully on to about 4.5mA with a 3V power supply. The information is sent serially from the transmitter (TX) which is received by the receiver. Transmitter (TX) and the receiver (RX) are duly interfaced to two Microcontrollers for transferring the data.

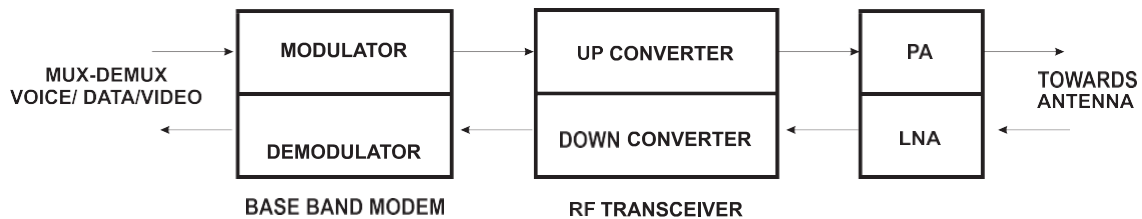


Fig 1.3.51: Block Diagram of RF Transceivers

RF modules can be used for different variants, sizes and shapes of electronic circuit boards. It can also be used for modules across a wide variety of uses and capacity. These modules generally include a PCB (Printed Circuit Board), RX or TX circuit, serial interface and antenna for communication to the main processor.

RF modules primarily comprise RF transmitter module, RF receiver module, RF transceiver module and SOC (System On a Chip) module. Three types of signal modulation techniques are popularly used in RF transmitter and RF receiver modules. These are ASK-amplitude shift keying, FSK-frequency shift keying, and OOK-On-Off Keying.

The RF transceiver module comprises both a transmitter and a receiver. The RF transceiver module circuit is designed for half-duplex operation and generally at a higher cost due to the higher complication.

RF Transmitter

An RF transmitter module is a small-size PCB used to transfer a radio wave and a modulating radio wave to transport data. RF transmitter modules are generally applied along with a microcontroller, which will offer data to the module under transmission. These transmitters are generally subject to controlling requirements that direct the maximum acceptable transmitter power output, harmonics requirements, and band edge.

RF Receiver

An RF receiver module accepts the modulated RF signal and demodulates it. Two kinds of RF receiver modules exist, namely the super-heterodyne receivers and the super-regenerative receivers. Generally, super-regenerative modules are low-power and low-cost designs deploying a series of amplifiers for getting rid of modulated data from a carrier wave. These modules change, usually inaccurate since their operation of frequency vary significantly with power supply voltage and temperature. The main advantage of the super-heterodyne receiver modules is high performance as compared to the super-regenerative variant. They offer improved accuracy and stability over a vast range of temperature and voltage. This stability is derived from a stable crystal design, which in turn, leads to a relatively more expensive product.

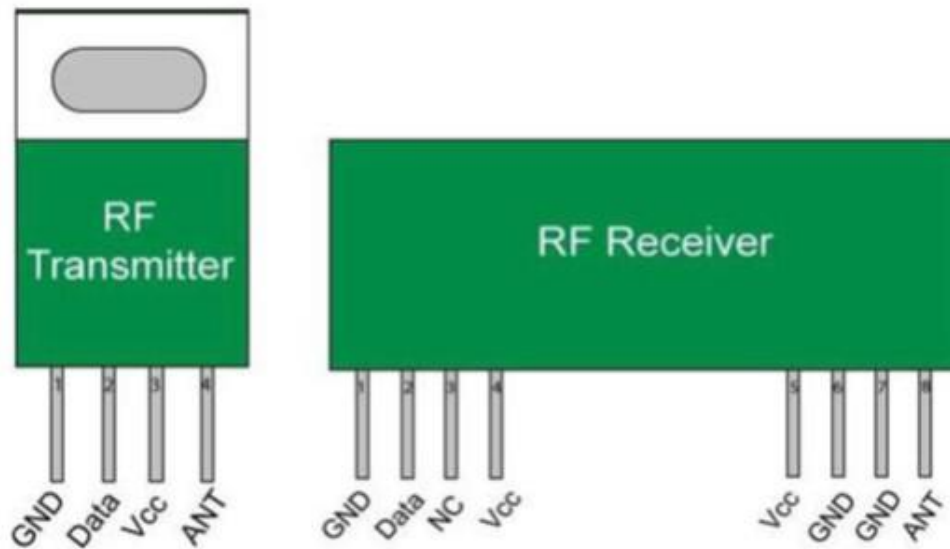


Fig 1.3.52: RF Transmitter and Receiver

RF transceiver module is used in a given device where both the transmitter and receiver remain in a single module. These devices transmit and receive RF signal and are called RF Transceivers. Generally, the position of RF transceiver module is between the Power amplifier/Low Noise Amplifier and the Baseband MODEM (Modular Demodulator) in common wireless communication systems. Baseband Modem comprises chip sets of several analogue or digital modulation techniques and analogue to digital conversion or digital to analogue conversion chips.

Applications of RF Transceiver

- RF transceiver module is used in radio transmission, satellite communication, for television signal transmission, reception and in Wimax or WLAN (Wireless Local Area Network), Zigbee or ITE (Information Technology Equipment) networks.
- Used widely in wireless communication, the transceiver is primarily used to convert data in the form of data/ voice / video suitable to be transmitted over wireless media.
- RF transceiver changes IF frequency to RF frequency and vice versa.

Radio-frequency engineering is a subset of electrical engineering that deals with devices that are designed to operate in the radio frequency (RF) spectrum. The range of operation for these devices is 3 kHz (Kilohertz) to 300 GHz (Gigahertz).

Radio-frequency engineering is assimilated into almost everything that transmits or receives a radio wave, which includes, but is not limited to, radios, mobile phones, Wi-Fi (Wireless Fidelity), and two-way radios.

Radio-frequency engineering is a highly specialized field falling typically in one of the below arenas:

1. Getting or producing signals to or from that transmission system to other communication circuitries or controls.
2. Controlling or enhancing coverage with the help of antenna/transmission systems
3. Performing tests for monitoring the performance of an electronic design

GSM MOBILE PHONE

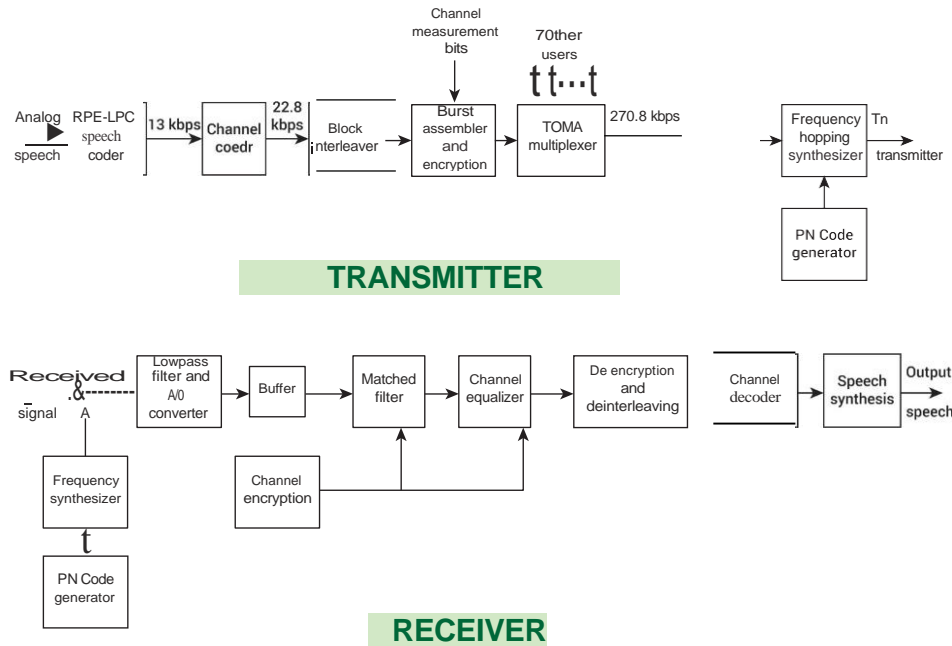


Fig 1.3.53: Usage of Transmitter and Receiver in GSM telephony

1.3.4 Amplifier, Multiplexer and Couplers

Amplifiers

An amplifier is an electronic device that enhances the voltage, current, or power of a signal. Amplifiers are used in wireless communications and broadcasting, and in all types of audio equipment. They are classified as either *weak-signal amplifiers* or *power amplifiers*.

Types of amplifiers

- **Weak-signal amplifiers** are used mainly in wireless receivers. They are also used in acoustic pickups, audio tape players, and compact disc players. A weak-signal amplifier is designed to deal with exceedingly small input signals, in some cases measuring only a few nanovolts (units of 10^{-9} volt). The most effective device for this application is the field-effect transistor.
- **Power amplifiers** are used in wireless transmitters, broadcast transmitters, and hi-fi audio equipment. The most frequently used device for power amplification is the bipolar transistor. However, vacuum tubes, once considered obsolete, are becoming increasingly popular due to its superior fidelity.

Two important considerations in power amplification are *power output* and *efficiency*. Power output is measured in watts or kilowatts. Efficiency is the ratio of signal power output to total power input (wattage demanded of the power supply or battery). This value is always less than 1. It is typically expressed as a percentage. In audio applications, power amplifiers are 30 to 50 percent efficient. In wireless communications and broadcasting transmitters, efficiency ranges from about 50 to 70 percent. *Distortion* is also an important factor, in hi-fi audio power amplifiers as it measures the extent to which output waveform is constant imitation of the input waveform.

Multiplexer

A multiplexer (MUX) is a network device that allows one or more analog or digital input signals to travel together over the same communications transmission link. The purpose of multiplexing is to combine and transmit signals over a single shared medium in order to optimize efficiency and decrease the total cost of communication. Multiplexing techniques have become useful network optimization tools during the age of the Internet of Things, edge computing and 5G. Today, the following communication applications would be prohibitively expensive without multiplexing: telecom, satellites, telemetry and broadcasting.

How multiplexing works

Frequency division multiplexing, time division multiplexing and wavelength division multiplexing are the types of multiplexing most closely associated with telecom. For analog signals in telecommunications and signal processing, a time division multiplexer may select multiple samples of separate analog signals and combine them into one pulse amplitude modulated (PAM) wide-band analog signal. For digital signals in telecommunications on a computer network or with digital video, several variable bit-rate data streams of input signals (using packet mode communication) may be combined, or multiplexed, into one constant bandwidth signal. A multiplexer requires a demultiplexer to complete the process, to separate multiplex signals carried by the single shared medium or device. Often a multiplexer and a demultiplexer are combined into a single device (also often just called a multiplexer) in order to allow the device to process both incoming and outgoing signals.

Couplers

RF couplers are passive devices that sample a small amount of signal from an RF chain. Many RF components have an input port where the signal goes in, and an output port where the signal comes out. Couplers have an additional "coupled" port which taps the main signal at a small fraction of the power of the thru line. The ratio in dB of the signal power at the input port to the output power at the coupled port is the Coupling Ratio or Coupling Coefficient. The coupling ratio is a known parameter specified by the device manufacturer and can be selected according to the user's system requirements. Different types of couplers include directional couplers, bi-directional couplers, and dual directional couplers. Directional couplers sample signal from the main line in forward direction; bi-directional couplers have two coupled ports to sample signal from the forward or reflected signal paths as needed; and dual directional couplers allow simultaneous sampling of both thru- and reflected signal power. Couplers are widely used in RF systems for a variety of functions including power monitoring, antenna reflection monitoring, automated gain control, and electrical test and measurement among many others.

UNIT 1.4: Fundamentals of PCB

Unit Objectives

At the end of this unit, you will be able to:

1. Evaluate the fundamentals of PCB
2. Analyze the troubleshooting for PCB

1.4.1 PCB Basics

Defining PCB

- A PCB provides a mechanical support and connects electrically electronic components
- Making use of conductive tracks pads and other features that consists of one or more laminated copper of a substrate that is non-conductive
- Components are usually soldered onto the PCB for obtaining mechanical fastening and electrical connection
- Printed Circuit Boards (PCB) are used in the simplest of electronic products and also simple electric products like passive switch boards
- PCBs can be single, double or multisided
- Single sided is one copper layer; double sided is two copper layers on both sides of a substrate layer; multi sided layer outer a and inner side of copper layers with alternating layers of substrate

Electronic components or parts are basically packaged in a distinct manner with two or more than two connecting leads or metallic pads. It is usually done by attaching it to the Printed Circuit Board (PCB) so that an electronic circuit is created with a specific function. Some of the important electrical component would include; resistor, capacitor, transistor, diode and others

Types of electronic components-

There are basically two types of electronic components:

1. Active Components
2. Passive Components

Components and their Functions





The functions of the components are listed below:





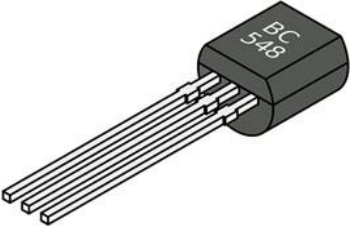


Components	Functions
Resistors	Electrical components that resist current
Capacitors	Components used to store electrical charge in electrical fields
Terminals and Connectors	Components that are used to make electrical connection
Switches	Components that are used to conduct or not to conduct (when switched off) the electricity







Magnetic or Inductive Components	Electrical components those use magnetism in their field
Network Components	Components that use one or more than one type of passive component
Piezoelectric devices, crystals, resonators	Components those are passive using piezoelectric effect
Semiconductors	Control components that are electric, with parts that are not moving A device that is a semiconductor, which has the capacity of amplification
Transistors	These are components that are capable of conducting the electricity in a specific or a single direction
Diodes	It is not a single component but rather a whole system, which is a micro-electronic computer electronic circuit that can be placed along with a chip or a semi-conductor
Integrated Circuits or ICs	An integrated circuit or monolithic circuit is also called as an IC, a chip and a microchip. It is a total set of integrated circuit on a small piece that is flat, that is a semiconductor material which is silicon

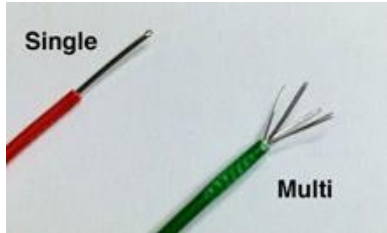
Images of the Electrical Components:

Components	Images
Resistors	
Capacitors	
Terminals and Connectors	
Switches	

Components	Images
Magnetic or inductive components	
Network components	 <p data-bbox="820 689 975 712">Networking Devices</p>
Piezoelectric components crystal resonators	
Semiconductors	
Transistors	
Diodes	
Integrated circuits or IC's	

List the wires, cables and modules- there are basically five types of wires:

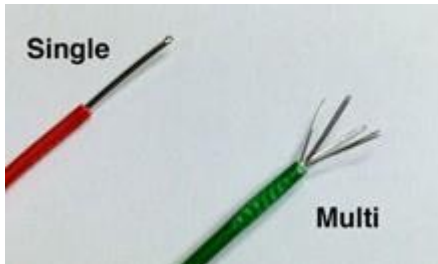
Wires	Description	Images
Triplex wires	<ul style="list-style-type: none"> • These wires are basically used as the service of single phase, and drop conductors, these form a connection between the power pole and weather heads • Their composition is mainly of two insulated wires which is wrapped with a third wire that is bare and neutral • The neutral wire is basically of a smaller gauge that is grounded at both the transformer and the electric meter 	
Main Feeder Wires	<ul style="list-style-type: none"> • These are basically wires that connect service weather head to the house • It is made or composed mainly of stranded or solid THHN (Thermoplastic High Heat-resistant Nylon-coated) wire and the capacity of the cable is 25% more than what is required 	
Panel Feed Wires	<ul style="list-style-type: none"> • These wires are generally black insulated wires that is again THHN • These are mainly used to power up the main junction box to the circuit breaker panels • These wires should also have the capacity of 25% more than what is required 	
Non-Metallic Sheathed Wires	<ul style="list-style-type: none"> • Non- metallic sheathed wire is also called romex wire • Mostly used in homes, that has 2-3 conductors, that comes with a plastic insulation and a ground bare wire • This is covered with another layer on sheathing which is non-metallic • It is relatively cheaper as compared to others and is available in 15 and 20 amps it is used in in-house wiring 	


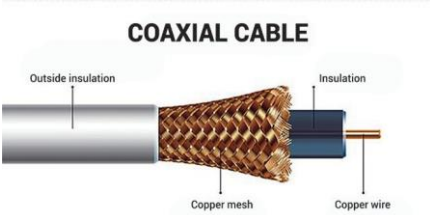

Wires	Description	Images
Single strand wires	<ul style="list-style-type: none"> • These wires also use THHN wire, and there can be or there is other variant • Each wire is separated and can be easily drawn through a pipe • Most popular that use pipes to contain the wires <p>THHN T- Thermoplastic insulation HH- High Heat resistance N- synthetic polymer, which is flame resistant</p>	

Components of Electrical Cable – the electrical cable or power cable are used to transfer electrical power. The cables form a basis of communication between the electrical gadgets and all other devices that works on electricity. All the electrical cables differ in performance, size and configuration.

- The electrical cables come with two wires that are conducting and a jacket that forms an outer protection
- The conducting wires vary from high voltage to medium voltage carrying capacity that might be sheathed with a protective jacket and an insulating sheath
- These are usually made of copper, while the synthetic polymer make the outer jacket and protective insulating sheath

There are basically four types of cables:

Types of cables	Description	Images
Shielded Cable	<ul style="list-style-type: none"> • A shielded wire cable it consists of more than one insulated wire • That are collectively enclosed with the woven braid shielding an aluminium Mylar foil • This shielding prevents external radio and interference of power frequency for passage of single transmission smoothly • Commonly shielded cables are high voltage power cables • Twisted pair cable consists of insulated copper wires that are coded with colour • Twisted around each other • The diameter of each ranges from 0.4 to 0.8 mm, the number of pairs vary accordingly 	

Types of cables	Description	Images
Twisted Pair Cable	<ul style="list-style-type: none"> • The more the amount of number of pairs the resistance of the cable is higher • Twisted pair cables are easily installed, flexible and inexpensive • This cable has a copper-plated core, that is surrounded by a di- electric insulator • These cables vary in size, performance, cost and flexibility • Hard link, leaky cable are types of coaxial cable 	
Coaxial Cable	<ul style="list-style-type: none"> • Also called multi- wire planner electrical cable or flat wire cables. It consists of multiple insulated wire running parallel to each other • It is used for multiple signals of data transmission • Commonly used to connect network services. It connects the motherboard to the CPU (Central Processing Unit) • Most commonly used to interconnect network devices 	
Ribbon cable		

A printed circuit board (PCB) helps in connecting electronic or electrical components with the help of conductive pads, tracks, and other structures etched from one or more copper sheet layers laminated onto and between non-conductive substrate sheet layers.

1.4.2 Multi layered PCB – important concepts

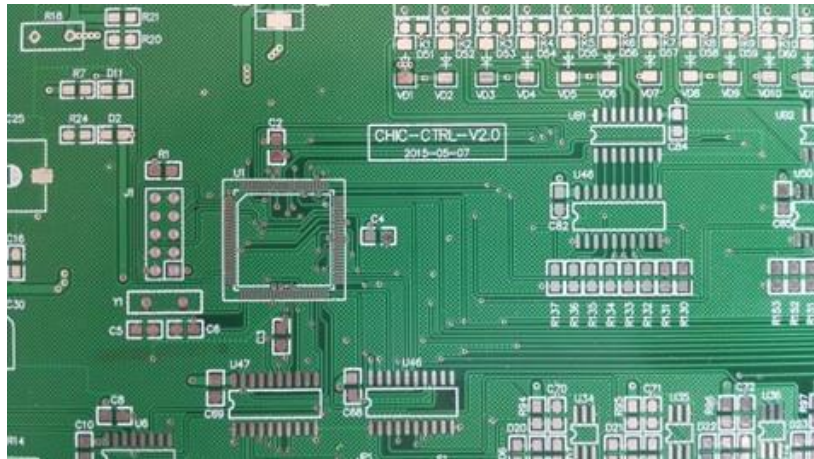


Fig 1.4.1: Sample PCB circuit board

It electrically supports and electrically connects electronic components or electrical components using conductive tracks, pads and other features. Printed circuit boards (PCBs) are implemented in almost all electronic items. PCBs are also used in some electrical products, say passive switch boxes. PCBs come in the following variants:

- double-sided, where two copper layers are on both sides of one substrate layer)
- single-sided with one copper layer
- multi-layer, where outer and inner layers of copper are placed, in alternating fashion, with layers of substrate

How to assemble PCBs and required materials:

- **RoHS compliant PCB:** The RoHS (Restriction of Hazardous Substances) is a legislature that restricts the use of hazardous substances. PCBs sold must be RoHS-compliant, which implies that all manufacturing processes must not involve the use of hazardous items like lead, the solder used must be free of lead, and all elements mounted on the PCB must be free of mercury, lead, cadmium, and other heavy metals.
- **Laminates:** Laminates are manufactured by curing under specific temperature and pressure conditions. Cloth or paper layers with thermoset resin are used to fabricate an uniform, integrated, and final piece. The size can vary up to 4 by 8 feet (1.2 by 2.4 m) in breadth and length. Various cloth thickness, weaves (threads per inch or cm), and resin percentage are used to accomplish the desired dielectric features and final thickness.
- **Substrate Parameters:** The composites contain a matrix (usually an epoxy resin) and a reinforcement (usually a woven, sometimes nonwoven, glass fibres, sometimes even paper), and in some cases a filler is added to the resin (e.g. ceramics; titan ate ceramics can be used to increase the dielectric constant).

Assembling Process:

Modern PCBs are designed with dedicated layout software, generally in the following steps:

- An electronic design automation (EDA) tool is used for schematic capture.
- Card template and dimensions are decided based on the essential circuitry and PCB case.
- The heat sink and component positions are determined.
- PCB layer stacks are determined, with one to several layers depending on the complexity. The power and ground planes are decided. A power plane is equivalent to a ground plane and behaves like an AC signal ground while supplying DC power to the PCB circuits. Signal interconnections are drawn on signal planes. Signal planes can be on the inner as well as outer layers. High frequency signals are transmitted to internal layers between ground or power planes for ensuring optimal EMI (Electromagnetic Interference) performance.



Fig 1.4.2: Layer stack on a PCB

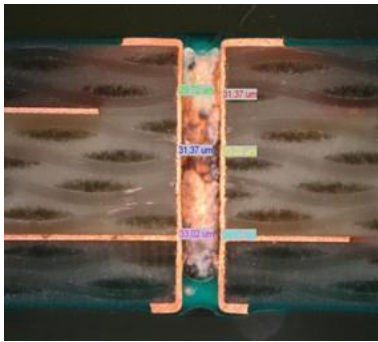
- Line impedance is calculated with the help of dielectric layer thickness, trace width, and routing copper thickness. Trace separation is considered in case of differential signals. Micro-strip, strapline or dual strapline are used for routing signals.
- Components are placed and factors like geometry and thermal considerations are considered. Lands and vias are marked.
- Signal traces are routed while electronic design automation tools help in creating clearances and connecting power and ground planes automatically.

Gerber files are generated for manufacturing.

Recording faults and passing the the faulty boards to the PCB assembly team

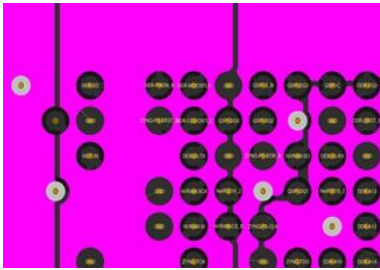
- The complications involved in the PCB manufacturing and designing processes lead to innumerable opportunities for PCB failure issues. A few failures are results of design oversights like inadequate clearances or inaccurate measurements. The other issues may result from problems in the manufacturing process like drilling errors, which can be equally dangerous

Some common faults are:



Plating Voids:

- These holes permit electricity to be carried from one side of the circuit board to the other.
- A copper layer is added to the surface material and along the walls of these holes via an electroplating process.
- While effective, the deposition process is imperfect, and can result in plating voids under certain circumstances.
- Plating voids are holes or gaps in the circuit board plating, and are usually the result of problems during the deposition process.



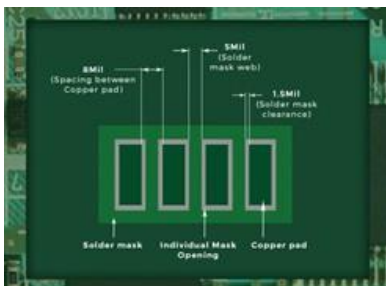
Insufficient Copper-to-Edge Clearance:

- The copper is covered with other materials for preventing corrosion and protecting the copper from interacting with its environment.
- While trimming a PCB, if the copper is very close to the edge, selected parts of this coating can be trimmed, thus exposing the copper layer underneath.
- The exposed copper planes often make contact with each other by simultaneously touching a conductive material, thus causing a short.



Slivers:

- Slivers are narrow copper wedges or solder masks fabricated during PCB manufacturing, and can lead to serious problems during circuit board fabrication.
- Slivers may float around in the chemical bath, and may land on another board, thus adding an undesired connection.



Missing Solder Mask Between Pads:

- This solder mask is placed on the top of the copper layer for insulating the traces of copper from accidental contact with solder, other metal, or conductive bits.
- In a few circuit boards, the solder mask can be wholly or partially absent between pads. This exposes more copper than required, and often result in accidental solder bridges between pins.
- This can lead to a short, as well as decreased corrosion protection, both of which can adversely affect the functionality and longevity of the circuit board.



Acid Traps:

- These are acute angles that trap acid during the PCB etching process.
- Consequently, the acid can compromise a connection, making the circuit defective and causing more serious problems later on.

DFM means “Design for Manufacturability.” In a nutshell, DFM checking is the process of inspecting a circuit board layout to reduce fabrication-related and assembly-related problems. There are several key factors in DFM, which ensure a consistent and correctly performing product. Unlike other standards that only consider how the circuit board will work, DFM focuses on how the circuit board may break.

DFM issues are topology-related problems of the circuit board. These may result in problems during the manufacturing process. A few of these problems include the ones discussed previously, like missing solder masks and slivers. Often, a majority of circuit boards manufactured with these design issues work normally, with only a small percentage reflecting defects. However, in the PCB industry, every scrapped board adds to the cost of production.

PCB Troubleshooting during assembling:

- Basic PCB troubleshooting can be done with just a few tools. The most versatile tool is a multimeter, but depending on the complexity of the PCBs and the problem, an LCR (Inductance Capacitance and Resistance circuit) meter, oscilloscope, power supply and logic analyzer may also be needed.



Fig 1.4.3: PCB sample

- Visual inspection of PCBs can find several potential issues. Overlapped traces, burnt out components, signs of overheating, and missing components can be found easily through a thorough visual inspection. Bulging components indicate problems, especially for electrolytic capacitors.



Fig 1.4.4: Multi-meter

1. Hot spots can be identified, without the involvement of expensive equipment, by touching the PCB surface and the on-board components.
2. The most apt techniques for PCB troubleshooting is to inspect each individual component. Testing each active component can be done with a multimeter or LCR meter.



Fig 1.4.5: LCR meter

3. ICs are the most challenging components to inspect. Most ICs can be detected with the help of their markings and many can be operationally tested using logic analysers and oscilloscopes.

How to troubleshoot?

It is the process of analyzing the behaviour or operation of a faulty circuit to determine what is wrong. It involves detecting the defective component(s) and repairing the circuit. Depending on the type of equipment, troubleshooting can be a very challenging task. In order to perform and record troubleshooting, an electrical technician needs to understand the key elements to be looked into.

Different modes of faults or failures during assembling:

1. Packaging failure
 2. PCB failure
 3. Relay failure
 4. Semi-conductor failure
 5. Passive element failure
 6. MEMS (Micro-electromechanical systems) failure
- Thermal expansion produces electrical stress that causes material fatigue. Humidity and corrosive or reactive chemicals can lead to the corrosion of the packaging materials and leads, potentially breaking them and damaging the inside parts, leading to electrical failure.
 - PCBs are vulnerable to environmental influences; for example, the traces are corrosion-prone and may be improperly etched leaving partial shorts, while the vias may be insufficiently plated through or filled with solder. Residues of solder flux may facilitate corrosion; those of other materials on PCBs can cause electrical leaks. CAFs (Conductive Anodic Filaments) or metallic filaments may grow within the boards along the fibres of the composite material, which can damage the affectivity of the PCB, as shown in the diagram below.



Fig 1.4.6: Metallic filaments on a PCB

- An electric arc appears between the contact points (electrodes) both during the transition from open to closed (make) or from closed to open (break). Apart from the physical contact damage, there appears a coating of carbon and other matters as well.
- Corrosion is a source of delayed failures for semiconductors and metallic interconnects. The surface of semiconductors is subjected to moisture as they have an oxide layer, as shown below.



Fig 1.4.7: Moisture coating on a PCB

- Electrostatic discharge (ESD) is an element of electrical overstress and may lead to immediate device failure, permanent parameter shifts and latent damage leading to increased degradation rate. ESD in real circuits results in an inhibited wave with rapidly alternating polarity, thus affecting performance.
- Resistors can turn open or short, along with their value changing under environmental conditions. Manufacturing defects causing recurrent problems. For example, improperly crimped caps on metal resistors can loosen and lose contact.



Fig 1.4.8: ESD discharge on a resistor

- Micro electro-mechanical systems suffer from various types of failures:
 - Particles travelling in the system and hindering their movements
 - Fractures causing loss of electrical parts.
 - Dielectric charging leading to change of functionality.

UNIT 1.5: Fundamentals of Copper-Clad Laminates (CCL)

Unit Objectives



At the end of this unit, you will be able to:

1. Identify the properties, layout designs and planning of CCL (Copper-Clad Laminates)

1.5.1 Understanding of Copper-Clad Laminates (CCL)

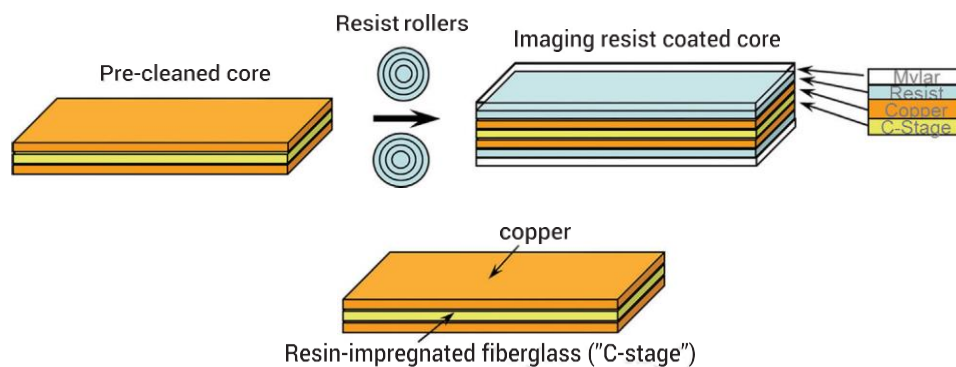
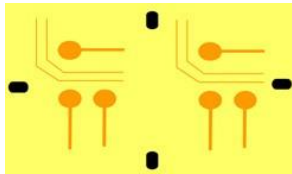
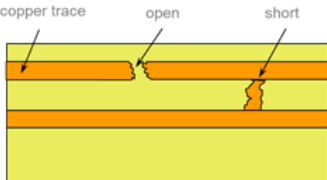
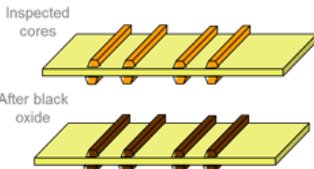
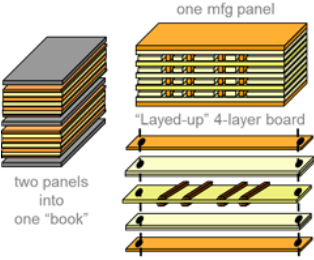
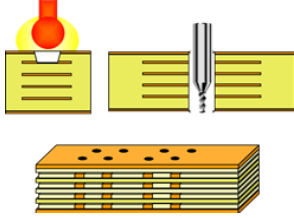
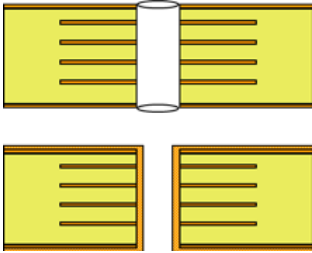


Fig 1.5.1: Copper Clad Laminates – pre-cleaning process

Name of the CCL component	Image	Description
Inner Layer Image Print of the CCL		<ul style="list-style-type: none"> • Negative polarity artwork film is laid on the resist-coated cores • The cores are exposed, on both sides, to UV light • The resist in the exposed areas is polymerised • The latest Laser Direct Imaging (LDI) technology utilises CAM (Computer Aided Manufacturing) files projected on the panel with the help of UV (Ultra Violet) light to do away with artwork film
Develop Etch Strip (DES)		<ul style="list-style-type: none"> • The protecting mylar sheet is removed • Boards are processed via a three-part conveyerised chemical line • The unexposed resist is removed, thus exposing bare copper • The unwanted copper is etched away via the subtractive process • The exposed protective resist is stripped away from the copper image

<p>Post Etch Punch (PEP)</p>		<ul style="list-style-type: none"> • This is a vital manufacturing step to drill registration in the inner layer • The etched targets in the border files are arranged linearly in an optical machine • The machine finds the best-fit target value • The punched holes or slots are used for aligning layers with the help of hard tooling pins for future steps
<p>Automated Optical Inspection (AOI)</p>		<ul style="list-style-type: none"> • AOI is the inspection process of the inner layer • Boards are examined by means of an optical machine against the known CAM files and discrepancies are reported • Defects and rework are validated by technicians, if needed • Non-conforming cores are scrapped and restarted with minimally added build cost
<p>Oxide</p>		<ul style="list-style-type: none"> • The copper surfaces are micro-roughened during the preparation of multilayer lamination • Copper roughening is done to improve the bond between the prepreg (B stage) layers and the oxidised copper • Most of the PCB manufacturing units use black oxide but a few other formulations are used as well
<p>Lamination (Press)</p>		<ul style="list-style-type: none"> • Foil, prepregs (B-stage), and etched cores are layered on pins via the PEP slots as per the stackup to create one manufacturing panel • Multiple panels are stacked together (separated by aluminium release sheets) in the form of a "book" • Several books are heated above the Tg of the material under pressure and vacuum • When the prepreg above the Tg is heated, it forms a gel, flows, and fills in between the Cu features, then pastes the layers together on cooling • Books are disintegrated into mfg panels and excess prepreg squeeze-out is cleaned up from around the panel edges

<p>Drilling</p>		<ul style="list-style-type: none"> • After lamination, holes are drilled or layered in the panel • The pads, which are already formed during the inner layer etching process, must be aligned to the drill • Smart drill machines conduct a registration pre-check to align the drill • The average no. of drills is about 25,000 per mfg panel • The boards are passed via an air knife deburr process for clearing most of the residual drill debris
<p>Electroless Copper</p>		<ul style="list-style-type: none"> • All holes and surfaces are first chemically cleaned to ensure the layer interconnects are free of any residual drill debris • The holes are also chemically conditioned for enabling activation of the resin and exposed glass • The board surface and hole walls are deposited with a thin palladium layer followed by approximately .07 mil (.00007") layer of electroless Cu • The standard processing techniques create negative etchback at the interconnect post • A specialised glass-etching processing is required for creating positive etchback

Cleaning of boards before pattern transfer

Printed circuit boards, specifically those used in Personal Digital Assistants or PDAs such as cell phones, are subjected to over-utilization. In addition to the collection of dirt and dust that penetrate the cases of mobile phones; PCBs suffer from liquid spillage or splashing from liquids in day to day use.

Different Types of Contaminants

There are numerous contaminants that can accumulate on a PCB.

- **Dry Contaminants (Dust, Dirt, etc.):** One of the most common yet annoying occurrences is the accumulation of dust or dirt in the PCB. Using a small, delicate brush like a horsehair paint brush, dirt and dust can be removed without affecting the components. There are restrictions on where even the smallest brush can reach, say below a component.

Compressed air can reach many areas but may damage vital connections, so it should be used with extreme care.

Specially designed vacuum cleaner for electronic components is also an option but cannot reach everywhere.

Summary



- In the modern world, electricity is essential for the functioning of computers, cell phones, lights, air conditioners, soldering irons, etc.
- The resemblance of a phototransistor is quite similar to that of a transistor with a small exception. The base terminal is present in transistor but absent in phototransistor.
- A PCB provides a mechanical support and connects electrically electronic components
- Line assemblers must be able to identify the properties, layout designs and planning of CCL (Copper-Clad Laminates)

Activity



1. Prepare a scrap-book by dividing a page into two columns, named “active components” and “passive components”, respectively. Collect pictures of the following components:

- Resistor
- Capacitor
- Potentiometer
- Inductor
- Connector
- Switch
- Diode
- Transistor
- Integrated Circuit
- Valve

Now, classify the components as active or passive and list them under the respective heads.

2. Draw a diagram of an electrical circuit with the following labelled components:

- Copper wire
- Battery
- Capacitor
- Resistor
- LED bulb

Exercise

Choose the correct option from the list of responses to answer the following questions:

1. Diode is a –
 - a) Conductor
 - b) Semi-conductor
 - c) Hand tool

2. PCB stands for –
 - a) Pakistan Cricket Board
 - b) Printed Cable Board
 - c) Printed Circuit Board

3. Electronic components can be categorized in –
 - a) 3 classes
 - b) 4 classes
 - c) 2 classes

4. Passive components can –
 - a) Never introduce energy to the circuit
 - b) Amplify energy to the circuit
 - c) Introduce energy to the circuit

5. Which of the followings is not an essential component of an electronic circuit?
 - a) Voltage
 - b) Capacitance
 - c) Resistance

6. What is the unit of potential difference?
 - a) Ampere
 - b) Volts
 - c) Ohm

7. AC Current stands for –
 - a) Alternative current
 - b) Alternating current
 - c) Altering current

8. In a bridge rectifier, _____ is not required.
 - a) Power source
 - b) Center tap
 - c) Resistance

9. Which of the followings is not a semi-conductor?
 - a) Silicon
 - b) Lead
 - c) Germanium

10. Multimeter measures –
 - a) Potential difference
 - b) Resistance
 - c) Can measure both of the above



2. Preparing Workspace for Assembly

- Unit 2.1 - Selection of Correct Components
- Unit 2.2 - Consumables for Soldering
- Unit 2.3 - Semi-Automatic Tools in Electronics



Key Learning Outcomes



At the end of this module, you will be able to:

1. Identify the basic electronic components from drawing
2. Discuss the types of consumables used for soldering and their applicability
3. Evaluate the types of semi-automatic tools used for electronics components

UNIT 2.1: Selection of Correct Components

Unit Objectives

At the end of this unit, you will be able to:

1. Identify the basic electronic components from drawing

2.1.1 Drawing the Correct Components

Draw Correct Components from Stores as Per the Work Instructions

Assembly drawing may include the following additional information, located either in the drawing sheet or in the title block:

- Job order number
- Surface treatment, roughness, etc.
- Key to machining and other symbols
- A general note on tolerance on dimensions, not individually tolerance
- Reference to tools, gauges, jigs and fixtures
- List of the component parts
- Alternations and revisions.



Fig 2.1.1: Specimen of a block to practise component drawing

2.1.2 Understanding of Work Instructions

Work instructions are prepared clearly and concisely for the colleagues to ensure that they are well aware of the standards that need to be complied with while performing various tasks. It decreases risk because the chance of things going wrong is reduced. It also improves efficiency; work instructions ensure the very best way of doing a job is clear and known to the people doing it. This comprehensive guide will show how to write work instructions that employees can understand and benefit from. Work instructions have to be very detailed on how to achieve a particular job, assignment or task.

For example, a work process could be developed to assemble the final product with step-by-step instructions including details as the required torque of the fastening screws. Individual work instruction is specific to a company or industry. Supplemental documentations may be used to create detailed work instructions such as:

- User's Manuals
- Engineering or Technical Manuals
- Technical Support notes
- Manufacturing Notes

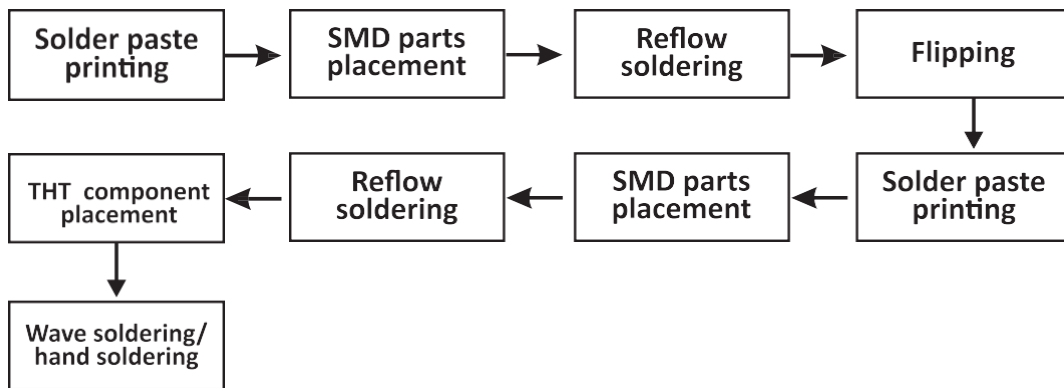


Fig 2.1.2: Double side mixed assembly workflow

Forms are used to create:

- Records
- Checklists
- Surveys

Records are a vital output of any process or work instruction. They form the base of the process communications, process improvement initiatives, and audit material.

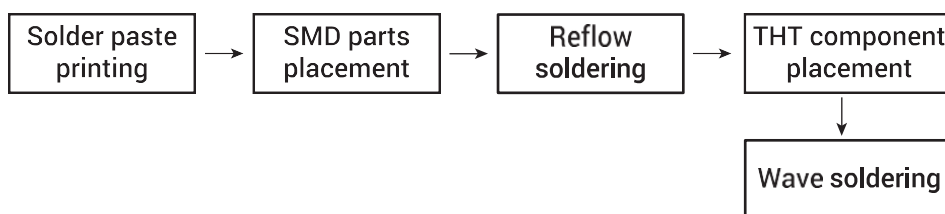


Fig 2.1.3: Single side mixed assembly workflow

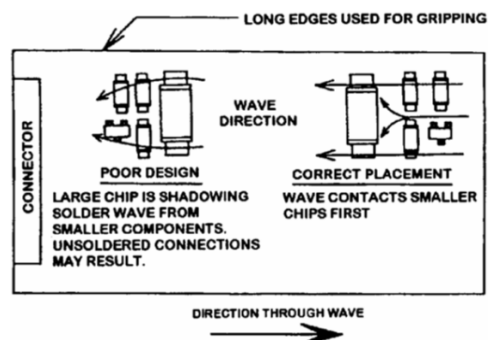


Fig 2.1.4 Bottom side wave flow

2.1.3 Arranging Components as per Assembly Instructions

Arrangement of components plays a major role in the work ethics of a line assembler. The components are assembled in a certain manner based on the usage, frequency of use and relationship between the components. For example, we keep the utensils which are used on a regular basis at a place easy to reach. However, the utensils, which are used occasionally, are kept at the back. Similarly, the components, which are used frequently, should be kept in the front.

Methodologies for Arranging Components

Two broad classes of task related information

- Information on the use of components individually
- Information on the relationships between components as they are used

Fig 2.1.5: Proper sequence of arranging components

The components are arranged in such a way that –

- It is easy to find and place again after the completion of the work
- If the component is used frequently, it should be kept in the front
- The components might react with the other components in certain cases. Hence, the relationship between the components must be considered and the inter-reactive components must not be kept at vicinity

2.1.4 Verifying Specifications of All Components

It sometimes refers to the verification of specifications of components as per Drawing.

Systematic planning of all tests or calculations is mandatory to check whether the product or design is suitable for the application. The appropriateness of the product must be proven with the help of calculations or planned tests. Technical tests, on bulk products, must be conducted on defined characteristics related to texture, appearance, handling ability and acoustics.

Problems associated with product layouts are promptly resolved so that all sampling and mass production dates may be observed.

Avoid misunderstandings by using clear specifications.

Here are some vital points that should be considered at the time of verification of the components:

- Design Verification Plan (DVP)
- Refer Product Data Sheet (PDS)
- Test reports, layout calculations and tolerance studies
- Technical and project-related data
- Follow inspection methods that have been coordinated with carefully chosen inspection equipment and customer requirements
- Provide, on schedule (Design Freeze), all drawings and specifications that are needed to observe the initial volume production sample date/start of production (SOP)

SAFE WORK INSTRUCTION TEMPLATE

TITLE/DESCRIPTION OF ACTIVITY:					
Faculty/Division			School/Unit		
Created By		Document No.		Risk Assessment No.	
Initial Issue Date		Current Version		Next Review Date	
SCOPE	<i>(List whom this procedure applies to and the specific location this work can be conducted in)</i>				
AUTHORISATION S:	<i>(List all the potential hazards and associated consequence, e.g. chemical exposure – inhalation or skin absorption, leading to irritation, burns, acute or chronic injury)</i>				
HAZARDS:	<i>List all the potential hazards and associated consequences, e.g. chemical exposure – inhalation skin absorption, leading to irritation, burns, acute or chronic injury)</i>				
SAFETY CONTROLS:	<i>(e.g. fume – hoods, biosafety cabinets, emergency equipment, machine guarding, spill kits, specific personal protective equipment requirements, first aid response, any after – hours work restrictions or rules)</i>				
PRESTART REQUIREMENTS:	<i>(List tasks to be completed before commencement of work, e.g. conduct a prestart safety check of equipment review chemical MSDS, risk assessment or lab rules; prepare work area, equipment and/or operator)</i>				
INSTRUCTIONS:	<i>(List step by step procedures for the task. You can use photos, flow charts, diagrams etc.)</i>				
CLEAN UP/SHUT DOWN PROCEDURES:	<i>(List procedures for disposal of waste, decontamination, storage, shut down of equipment)</i>				
EMERGENCY PROCEDURES:	<i>(Emergency response procedures e.g. power isolation procedures, spill containment procedures, first aid response)</i>				
FURTHER INFORMATION:	<i>(e.g. Monash procedures, relevant legislation, definitions, reference to other safety information)</i>				

Fig 2.1.6: A Sample work instruction copy, used widely in the telecom industry

2.1.5 Compliant and Correct Calibration

Calibration is the comparison of Instruments, Measuring and Testing Equipment (M&TE), Unit under Calibration (UUC), Unit under Test (UUT), a Device under Test (DUT) or a Test Instrument (TI) of unverified accuracy to an instrument with known (higher) accuracy to detect and eliminate unwanted variations.



Fig 2.1.7: Sample of calibration test

Importance of Calibration:

- All measuring, inspecting and testing equipment that can impact or determine product quality.
- Equipment which would produce unsafe products
- Measuring devices
- Equipment which needs to be calibrated because of an agreement. For example, a customer before progressing to signing contract may need to get the equipment validated by calibration.

UNIT 2.2: Consumables for Soldering

Unit Objectives

At the end of this unit, you will be able to:

1. Identify the mechanical parts and their applicability

2.2.1 Common Tools and Equipment

1. Screw

A screw is a cylindrical rod carved with one or more helical or advancing spiral threads, as a lead screw or worm screw. It has a head and a point. Common types of screws include:



Flat Head Screw



Round Head Screw



Raised Head Screw



Cross Head Screw

- Flat head screw
- Round head screw
- Raised head screw
- Square head screw
- Phillips or cross head screw

2. Precision Screw Driver Set



Set of Screwdrivers



Different Types of Screwdriver Tips

- Used to tighten and loosen screws
- Some common screwdrivers include:
 - Flat Head Screwdriver
 - Phillips Screwdriver
 - Offset Screwdriver

3. Nuts



Nuts and Bolts



Fixing Nut

Nut is a fastening tool. It has coils around its body, giving it a shape of threaded pattern. The threaded pattern helps to join the two parts of metal or wooden components. The common types of nuts are:

- Hexagonal Nut
- Square Nut
- Flanged Nut
- Cap Nut

4. Bolts



Bolts

Bolt looks similar to the head of a nut. Bolts are usually attached to the nuts as a joinery substance. The common types of bolts are:

- Hexagonal Headed Bolt
- Square Headed Bolt
- Round Headed Bolt
- Cylindrical Headed Bolt

Securing Clip



Secure clips, also called R-clips are widely used to secure the ends of round shafts such as clevis pins and axles.

5. Spanner



A spanner is an instrument used to provide mechanical advantage and grip in applying torque to turn objects such as rotary fasteners, nuts and bolts.

6. Forceps



These are used when the fingers are too large to grasp tiny items or when several items need to be held simultaneously while the hands are used to perform a task.

7. Forming Plier

Forming pliers are large-jawed pliers for forming sheet metal and wire into a variety of shapes.



2.2.2 Basic Assembly and Hand Tools

Ascertain Availability of All Parts/Components, Tools and Equipment to Carry Out Work

Work equipment may be defined as the machinery, appliance, tool or installation for use at work.

Make sure the availability of all tools and equipment to carry out work:

Equipment used at work includes the following:

- **Hand tools** - drills, hammers, handsaws, knives, sharpening tools, riveters etc.

Hammer: A good quality Steel hammer is used to drive nails in the components.



Measuring Tape: Measuring tapes are used to measure the area and extent of cutting an object.



Clamps: Clamps are used to hold the work-piece tightly to work on it. For example, if screw needs to be driven in to a delicate part of the sub-assembly, G-clamp is used to hold it in the desired angle.



Marking Tools: marking tools like pencil is used to sketch cutting lines on the object.



Screwdriver: Screwdrivers are used to tighten and loosen screws.



Plier: Pliers are mainly used to grip and twist objects like pipe or wire. The long frontal part of the plier helps to grip or squeeze the object easily, which are difficult to do manually.



Providing and using work equipment safely:

Providing a manual or a booklet is a recommended practice. It will be beneficial for employees. There may be specific requirements related to the equipment that an organisation uses at work. In this case, the booklets will point towards further information one may require.

Equipment used by employees are covered. For example, power presses, ladders, hammers, knives, drilling machines, circular saws, lifting equipment (including lifts), motor vehicles, dumper trucks, photocopiers, etc.

Dos and don'ts of machinery

As the duty holder every organization should ensure that all employees likely to use machinery understand and follow these dos and don'ts:

Do...

- Examine if the machine is well maintained and fit to be used, i.e. in proper conditions for the job and all the safety measures are in place
- Use the machine and its parts properly in accordance with the manufacturer's recommendations
- Ensure employees are using the Personal Protective Equipment (PPE), required for particular machine or process
- Ensure that workers who use machinery are competent enough to use it safely. Provide training whenever necessary

Don't...

- Use a machine that has a danger sign tagged to it. The sign should only be removed by an authorised person who can affirm that the machine is safe to use
- Remove any safeguard, even if their presence makes the job complex
- Wear loose clothing, dangling chains, rings or have loose long hair prone to get caught up in moving particles
- Distract people at work

2.2.3 Assembly Line and Equipment Maintenance

Why is maintenance of assembly line and equipment important?

Additional hazards can take place when equipment and plant becomes unreliable and develops faults. Maintenance enables these faults to get diagnosed at an early phase to manage further risks. However, proper planning and correct execution is required to carry out maintenance. Unsafe maintenance can cause fatalities and severe injuries either during the maintenance or during operating badly maintained equipment.

Effective maintenance programmes make equipment and plant more reliable. Fewer breakdowns imply to less dangerous contact with machinery is required, as well as having the cost benefits of better productivity and efficiency.

The Provision and Use of Work Equipment Regulations (1998) state equipment and plant to be maintained properly so that it remains safe and hazard-free.

Safe working areas:

One must arrange for safe and secure place of work:

- Don't focus only on the safety of maintenance workers – take the needful precautions to make sure that the safety of others who may get impacted by their work
- Set up barriers, position and signs and personnel at key points to keep others out
- Equipment and plant must be made secure before maintenance commences
- Ensure to stop moving plant and isolate them from electrical supplies. Ideally, maintenance should be done with the power off
- Lock the machines off if there is a possibility of the power to get back (even if accidentally)
- Isolate electrical lines, plant and valves which contain gas, steam, pressured fluid or hazardous material. Lock off the isolating valves as a safety precaution

2.2.4 Safe Handling Practices

- Before allowing an employee to use a machine, chalk out the risks involved and how the risks can be managed.
- Inspect if all safeguards attached are free from defects.
 - The term 'safeguard' includes:
 - Personal Gears
 - Interlocks
 - Two-Hand Controls
 - Hand Guards
 - ESD (Electrostatic Discharge) strips / mats
- By regulation, the suppliers must provide proper safeguards and inform buyers of further risks that users need to know and manage
- Produce a secure system of work by maintaining the machines properly
- Maintenance may call for regular inspections of critical features where disintegration would amount to a risk
- Ensure every proper installation of the static machines and their stability. Don't install them at a location where others are exposed to risk

Preventing access to dangerous parts:

Make use of the best material for the guards. For example, plastic is easy to see through as it is transparent but may be damaged easily. For cases where wire mesh or similar materials are used, ensure that the holes are not big enough to let the moving particles in.

If the scope of using fixed guards is faint, apply other methods. The guard must be interlocked so that the machine cannot start before the guard is closed and vice versa. In a few cases, trip systems like pressure-sensitive mats, automatic guards or photoelectric devices may be exploited if other guards are not applicable.

Where guards cannot offer full protection, jigs, holders, push sticks, etc. must be used. Remaining risks, if any, must be controlled by providing the operator with the essential information, training, instruction, supervision and proper safety equipment. Proper training should ensure that those who use the machine are capable enough to use it safely.

Untrained, unauthorised or unqualified people should not use machinery.



Fig 2.2.1: Keep the workspace tidy and clean

Sequence the Parts and Subassemblies in Correct Order: A subassembly is a part of the Bill of Material or BOM that is exploited as a component. Subassemblies are generally used as components in several BOMs, i.e. they are parts of multiple product structures. Store control depends on the time-phased nature of the master schedule. Jobs are propagated to production in the appropriate sequence of multi-level assembly.

Creating Subassembly BOMs: If one has to define subassembly specifications within other Bill of Materials and require giving them their own BOMs to align to the above guidelines, take the steps furnished below:

- Create a parent BOM item to fabricate the subassembly
- Create a specific header for the parent item of the subassembly by assigning it a particular type of BOM
- In the newly created BOM, enter the subassembly components and routing sequences
- Delete the components and routing sequences associated with the previous BOM
- In BOMs where the subassembly was defined earlier, add the parent item of the subassembly as a component

When does the quantity of the sub-assemblies differ from the parent quantity?

Whenever a subassembly has a variant magnitude of quantity than the same of the parent item, it must be well defined with its own BOM. The reason behind it is that the BOM routing is dependent on the parent quantity for costing calculations and scheduling. If one mixes subassembly sequences with parent item sequences, there is high chances of using wrong quantity, which makes costing calculations and scheduling insignificant.

Subassembly BOM – a necessity with store and MRP control:

Using subassembly BOMs is essential for store and MRP (Maximum Retail Price) control. Subassembly BOMs enable MRP to fabricate subassembly jobs as per interdependent demand. They help jobs get released in the appropriate order of multi-level assembly as subassembly jobs are completed. They enable each subassembly to get its own traveller and to have its routing sequences scheduled in sequential order within work centres.

Fitting Sub-Assemblies and Components:

- Work safely at all times by following health and safety norms and guidelines
- Plan the fitting and assembly activities before you start them
- Obtain and prepare the appropriate components, tools and equipment
- Use suitable methods of assembling and fitting the components in correct positions
- Fasten the components with the help of specified securing devices, fasteners, and connectors
- Examine the completed assembly to make sure that all operations have been finished and the finished assembly meets the desired specification
- Deal effectively with problems within your span of control and seek guidance from appropriate people, if you have come across problems that cannot be resolved
- Leave the work area in a safe and tidy condition on completion of the assembly activities





UNIT 2.3: Semi-Automatic Tools in Electronics






Unit Objectives




At the end of this unit, you will be able to:

1. Discuss the types of semi-automatic tools
2. Evaluate the types of semi-automatic tools used for electronics components

2.3.1 Hand Tools Used in PCB Assembly Area

Name of the Tool	Description	Image
Diagonal Plier/ Wire Cutter	These are intended for cutting wire and are not used for grabbing or turning any item. The plane demarcated by the jaws' cutting edges intersects the joint rivet diagonally or at an angle.	
Nose Plier	These are both holding and cutting pliers used by jewellery designers, artisans, electricians, network engineers and other tradesmen to bend, re-position and snip wire.	
Wire Stripper	This is a small-sized, hand-held device used for stripping the electrical insulation from electric wires.	
Tweezers	These are small-sized tools used to pick up objects too small to be handled by bare hands. They are derived from tongs, scissors, or pincers.	

<p>Soldering Iron</p>	<p>This is a hand tool used in soldering, which supplies heat for melting solder so that it is able to flow into the joint between two jobs</p>	
<p>De-soldering Pump</p>	<p>De-soldering Pump is used to remove solder and components from a circuit board for troubleshooting, repair, replacement, and salvage</p>	
<p>De-soldering Wick or Braid</p>	<p>This is a fine mesh of flux-coated copper strands that absorb solder when heated. Easier and more effective than a solder-sucker, the braid can be used to remove solder that bridges surface mount.</p>	
<p>Soldering Paste</p>	<p>Solder paste is a material used in the manufacture of printed circuit boards to connect surface mount components to pads on the board. It is also possible to solder through hole pin in paste components by print solder paste in/over the holes.</p>	
<p>Soldering Lead</p>	<p>This is a fusible metal alloy used for creating a long-lasting bond between metal work-pieces. In electronics, it is typically a mix (63:37) of tin and lead.</p>	
<p>Soldering Flux</p>	<p>Soldering flux is a chemical flowing agent, cleaning agent, or purifying agent. These may have more than one function at a time. These are used in both metal joining and extractive metallurgy.</p>	

<p>Thermal Wire Stripper</p>	<p>Thermal wire strippers are ideal choices for stripping stranded and solid wires up to ½ inches. In addition to that, these tools are exploited to cut through the insulators which are otherwise difficult to penetrate.</p>	
<p>Adjustable Electronic Board Holders</p>	<p>As G-clamps or Bar Clamps help carpenters to attach the work piece tightly to a holder, the adjustable electronic board holders help line assemblers to attach PCBs. Thus, the tool is often referred to as Adjustable PCB Holder. The term adjustable is used because the tool permits workers to rotate the attached PCB 360°. Normally the device is made of non-conductive materials such as plastic.</p>	
<p>Lead Free Solder</p>	<p>Lead free solders are extremely effective in soldering and wetting through holes. It also allows workers to work on parts which consist of narrow pitch. It shows high insulation and anticorrosive properties even after soldering is finished.</p>	

Summary

- Work instructions are prepared clearly and concisely for the colleagues to ensure that they are well aware of the standards that need to be complied with while performing various tasks.
- Work instructions have to be very detailed on how to achieve a particular job, assignment or task.
- Line assemblers must be able to identify and use various hand tools and equipment.

Activity

Identify the tools given below and write down their names in the blank provided below each diagram:

























Exercise

Choose the correct option from the list of responses to answer the following questions:

1. _ are both cutting and holding pliers used by artisans.
 - a) Wire strippers
 - b) Nose pliers
 - c) Diagonal pliers

2. Solder flux is a –
 - a) Metal amalgamation
 - b) Chemical agent used as purifier
 - c) Soldering iron used as connectors

3. Which of the followings is not an example of passive component?
 - a) Resistor
 - b) Capacitor
 - c) Transistor

4. Which of the followings is not an example of active component?
 - a) Transistor
 - b) Switch
 - c) Diode

5. Which one of the following options should be considered while arranging for components?
 - a) Size of the component
 - b) Frequency of usage of the components
 - c) Colour of the component

6. State TRUE or FALSE – “Screwdrivers are used to tighten and loosen screws”.
 - a) True
 - b) False
 - c) Partially true

7. DVP stands for –
 - a) Device Verification Plan
 - b) Design Validation Plan
 - c) Design Verification Plan

8. In terms of looks, bolts are similar to that of –
 - a) Nuts
 - b) Screws
 - c) Tweezers

9. Which of the followings is not a fastening tool?
 - a) Nuts
 - b) Screws
 - c) Securing clips

10. Which of the followings will you use to separate components from the PCB board?
 - a) De-soldering braid
 - b) De-soldering pump
 - c) Tweezers



3. Assembly Operations in Production Line

- Unit 3.1 - Basic Units of Measurement
- Unit 3.2 - Fundamentals of Shop Floor Productivity
- Unit 3.3 - Handling Critical Parts
- Unit 3.4 - Basic Soldering Techniques and Defects
- Unit 3.5 - Electronic Components and Connectors
- Unit 3.6 - Handset Assembly Operations
- Unit 3.7 - Uploading OS and Core Apps



Key Learning Outcomes



At the end of this module, you will be able to:

1. Analyze the role of line assembly equipment
2. Distinguish the basic units of measurements
3. Evaluate the generation of electric voltage in shop floors during production
4. Analyze the handling of critical parts during assembly and consumables
5. Evaluate the soldering techniques
6. Distinguish different types of connectors or cables
7. Analyze the handset assembly process
8. Discuss the necessary software and app to be uploaded to fire up a handset

UNIT 3.1: Basic Units of Measurement

Unit Objectives

At the end of this unit, you will be able to:

1. Distinguish the basic units of measurements

3.1.1 Units in Measurement

Types of Units in Measurement: Measurement is the process of determining the magnitude of and quantifying a physical parameter. The method of measuring physical parameters is called Metrology. Each physical parameter is estimated and expressed in numerical values, along with Units. For example, the units for temperature are Kelvin, Celsius, Fahrenheit, etc. Units of measurement are of two types: System International (SI) and the Centimeter - Gram - Second (CGS).

A. System International: This comprises the Base Units, measuring the Base Quantities and the Derived Units, measuring the Derived Quantities. Base Quantities are those physical quantities, which are distinct and are independent of other physical quantities. Derived Quantities are those physical quantities, which result from the Base Quantities.

Base Quantities: Length, Time, Mass, Electric Current, Temperature, Amount of Substance and Luminous Intensity.

Derived Quantities: Velocity, Acceleration, Area, Volume, Force, Capacitance, Density, Electric Charge, Voltage, Energy, Work, Resistance, etc.

Examples of SI units are: (Both Base and Derived Quantities)

Physical Quantity	SI Unit
Length, Width, Height, Depth	Meter
Time	Second
Mass	Kilogram
Temperature	Kelvin
Electric Charge	Coulomb
Force	Newton
Electric Current	Ampere
Electric Power	kiloWatt
Energy	Joule
Luminous Intensity	Candela
Plane Angle	Radian
Solid Angle	Steradian

- B. CGS Unit:** CGS stands for Centimeter-Gram-Second. This implies to the fact that in the CGS system, length is measured in Centimeter, mass is measured in Gram and time is measured in Second. All the other quantities like temperature, force, electric current and etc. are measured likewise in a set of pre-defined units. Some of the vital quantities and their units are discussed below:

Examples of CGS units are:

Physical Quantity	CGS Unit
Length, Width, Height, Depth	Centimeter
Time	Second
Mass	Gram
Temperature	Kelvin
Electric Charge	Franklin
Force	Dyne
Electric Current	Biot
Energy	Calorie

Units related to Telecom Sector

In dealing with electronics, there are a handful of units we'll be encountering more often than others. These include:

Name of the Quantity	Unit	Unit Abbreviation
Voltage	Volts	V
Electric Current	ampere	A
Power	Watt	W
Energy/ Work/ Heat	joule	J
Resistance	ohm	R
Capacitance	farad	F
Inductance	Henry	H
Frequency	Hertz	Hz

UNIT 3.2: Fundamentals of Shop Floor Productivity

Unit Objectives

At the end of this unit, you will be able to:

1. Evaluate the process of managing waste
2. Demonstrate the usage of effective materials for waste reduction
3. Discuss the proper procedure of cleaning the work site and tools and equipment

3.2.1 Managing Waste

A Line Assembler can effectively manage and minimize waste by the 3Rs, namely:

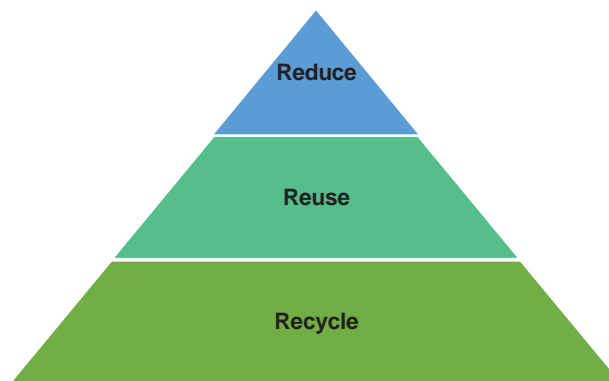


Fig. 3.2.1: 3Rs of waste removal

- Materials and Resources must be optimized and planned to Reduce wastage. Raw material must be procured only after effectively planning out the Inventory Cycle and carefully assessing the Inventory Levels.
- Cut scraps should be Reused, to carry out production operations in an eco-friendly manner.
- Anything that can be reused must be collected and stored in designated places. Scrap pieces thus put away, must be Recycled.
- Waste material, procured anytime during the process, must be classified properly and stored away in colour coded bins for safe disposal. Proper disposal system for waste and by-products must be accomplished through Mock Drills and Training Sessions.
- Magnetic and ferromagnetic waste, like Iron Needles and Sharps, can be separated using a Magnetic Roller and recycled.
- Liquid Sludge must not be emptied into neighbouring water bodies but must be filtered to separate solid particles (for recycling, reusing or incinerating) and the remaining liquid part is treated chemically.
- Organic wastes are either converted into manure or compost, or dissolved in suitable chemicals and organic solvents.
- Non-combustible scrap material must be recycled and reused.
- Combustible scrap material and debris must be incinerated.

- Flammable wastes, like oil, paper, wood etc. must be stored away carefully, away from fire and electrical circuits.
- General waste, which is non-toxic and non-hazardous, must be treated according to their inherent physical and chemical nature.
- Identifying, handling and storing hazardous substances must be done with utmost care and expert guidance.

3.2.2 Good Housekeeping

- The workplace must be freed from clutter and debris, since these can act as fuels and are fire hazards.
- The entire workplace must be a “No Smoking” zone, thus designated with the help of “No Smoking Signs”.
- Only designated areas, outside and far from the main work area, must be allowed for smoking.
- Fire Extinguishers must be maintained properly and refilled after use.
- Electrical faults may lead to fire and hence, any electrical hazards must be reported and attended to, immediately.
- There must be easy access to the Main Power Supply Control Panel, so that electrical power can be switched off in case of electrical fires.
- All powered tools, machinery and equipment must be maintained and inspected regularly by trained professionals, to prevent fire outbreak from overheating and friction sparks.
- Fuel containers, like Gas Cylinders and flammable oils, must be enclosed and stored separately, away from the main work area.
- Emergency exits, sprinklers, fire fighting apparatus, emergency exits etc. must never be blocked.
- Materials must never be stacked in a manner, so that clearances and exit routes are blocked.
- All fire alarm systems and fire fighting equipment must be inspected regularly.

3.2.3 Cleaning Equipment and Practices

The various materials to be used by the housekeeping staff for cleaning are:

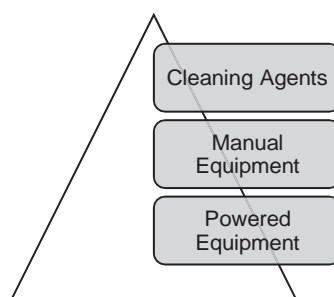


Fig. 3.2.2: Cleaning equipment

A. Cleaning Agents

- **Solvents**
 - A solvent is a liquid that is capable of dissolving a liquid or solid solute, producing a solution
 - Water is the widely used solvent in daily life

- Water can also dilute any cleaning solution for ease of usage
- Warm water dissolves solutes such as soap faster than cold water
- **Detergents & Soaps**
 - Soaps and detergents are used as cleaning objects because pure water cannot remove organic soiling or oily particles
 - Soap is one of the rare objects that allow water and oil to mix so that rinsing can take care of the removal of the oily grime
 - Detergents, in terms of properties, are similar to soap. However, they are less likely to form soap scum and are not hugely impacted by the presence of mineral particles in hard water
 - Detergents to be used depend on:
 - ◆ Material to be cleaned
 - ◆ Cleaning equipment to be used
 - ◆ Type of dirt
- **Liquid Cleaning Agents**
 - These can be either diluted in water or used directly with a dry cloth.
- **Washing Soda**
 - In strong concentration, washing soda could be injurious to skin, fabrics, wood and paint
 - Washing soda is useful as a water softener.
- **Soda bars, Powders and Flakes**
 - In recent days, normal soaps have been substituted by excellent synthetic soap which comprises less detergents and less affected by hard water
 - They give lather promptly
 - They should be made thoroughly dissolved in water
 - Should be used in right proportion and concentration for best outcomes
 - Should be kept or stored on open shelves in a dry storage area
- **Acid**
 - Acids are used to remove metal stains
 - Lemon and vinegar are used to remove the tarnish of brass and copper
 - Resistant water stains is removed with stronger acids such as hydrochloric acid or oxalic acid
 - This should be used under experienced and strict supervision to avoid risks
- **Alkali**
 - Sodium hydroxide, ammonia and caustic soda are alkalis and are used as stain removal agents and grease emulsifiers
 - Strong alkaline cleaning agents based on liquid or caustic soda in flakes are available for the cleaning of large industrial equipment, and blocked drains
- **Absorbents**
 - These perform the cleaning action by absorbing the stain or grease; for example starch, French chalk powders, and besan or gram flour.
 - Their constituents vary and many are of vegetable origin.
 - Unlike abrasives, they are not manufactured.
- **Toilet Disinfectants & Antiseptics**
 - Disinfectants & Antiseptics are not strictly cleaning agents but are often used during cleaning operations.
 - Disinfectants kill bacteria.
 - Antiseptics prevent bacterial growth.

B. Manual and Powered Equipment

Manual cleaning tools and equipment are operated by hands while Powered equipment are connected to a power supply or battery.

- Funnel
- Rubber Spatula
- Floor Mop
- Bowl Swab
- Plastic Caddie
- Spray Bottle
- Cobweb Cleaner
- Dry Vacuum Cleaner (Commercial)
- Suction Dryer
- Dust Pan and Brush
- Bucket and Mug
- Squeegees
- Scrubbing Brush
- Sponge
- Scraper

Safe Working Practices for Cleaning and the Method of Carrying Them Out

Below are a few safe working practices associated with different cleaning methods. The common cleaning methods are:

- Vacuuming
- Abrasive Blasting
- Acoustic Cleaning
- Steam Cleaning
- Flame Cleaning
- Sterilization by Autoclaving

A. Vacuuming

- Vacuum Cleaners must be disconnected from the power outlet, when not in use.
- Use of vacuum cleaners must be restricted to indoor use only.
- Vacuum cleaners must never be used on wet surfaces because this may damage the motors and exposes the user to electric shock hazards.
- A vacuum cleaner, which has been exposed to moisture, must be inspected and repaired (if needed) by a licensed electrician before the next use.
- A vacuum cleaner, once dropped accidentally, must be thoroughly inspected by a licensed electrician before the next use.
- A vacuum cleaner must never be pulled by the power cord and the cord must be kept away from sharp edges to prevent fraying and loss of insulation.
- Sharps and splinters, of glass, metal, wood, metal, etc. must never be cleaned using a vacuum cleaner.
- It is a recommended practice to avoid cleaning up toxic and flammable substances using a vacuum cleaner.

- A vacuum cleaner must always be stored in a cool, dry location.



Fig 3.2.3: Vacuum Cleaner

B. Abrasive Blasting

- Abrasive Blasting is used in removing bulk material and contaminants from a given surface.
- The most common items used in Abrasive Blasting are:

- Silica sand (crystalline)
- Coal slag
- Garnet sand
- Nickel slag
- Copper slag
- Glass (beads or crushed)
- Steel shot
- Steel grit
- Specular hematite (iron ore)
- Ice cubes
- Dry ice (solid CO₂)
- Plastic bead media
- Sponge
- Sodium bicarbonate (baking soda)

- A toxic abrasive material must be, if possible, replaced with a less toxic one.
- Abrasives, which can be delivered with water, must be used in cleaning.
- The Abrasive Blasting operations must be safely contained and conducted within a restricted work area, enclosed by barriers and protective walls.
- These enclosures must be equipped with Exhaust Ventilation Systems to capture the dust thus released in the process.



Fig 3.2.4: Abrasive Blasting

- Abrasive Blasting must not be conducted under stormy or windy weather, in order to prevent the spread of toxic and hazardous materials.
- People working near the Abrasive Blasting area must wear PPE (Personal Protective Equipment) appropriate for the protection of Eyes, Ears, Face, Head, Hand and Arms and Feet.

C. Acoustic Cleaning

- Acoustic Cleaning involves the use of Sound Waves to bombard with contaminants and particulate matter on a surface and shaking them off the surface on loosening.
- The air supply to the Acoustic Cleaner must never be obstructed because cool air helps in dissipating the heat, thus, in turn, protecting the membrane against damage.
- Ear Protectors must be worn, when one is close to an acoustic cleaner.
- An acoustic cleaner must be switched on only after adopting adequate safety measures in advance.
- One must ensure that the air pressure supply to an acoustic cleaner must be shut down before service and maintenance operations.
- Under above circumstances, the power supply to the magnetic valves must be turned off as well.
- The location for acoustic cleaning must always be equipped with a platform or scaffolding.
- Maintenance work must be done by wearing protective gloves (heat resistant) and ear protectors.



Fig 3.2.5: Acoustic cleaners

D. Steam Cleaning

- Steam Cleaning involves cleaning workshop floors, walls and machines by removing accumulated dirt and grease.
- The user must read the Instruction Manual / Directions for Use very diligently, before using Steam Cleaners.
- Few items, like Electronic goods, Untreated Wood, Marble floors, Laminate floors, etc. cannot be cleaned by Steam Cleaners.
- One must avoid cleaning up chemical spills using Steam Cleaners because certain chemicals react with water.
- It is advisable to wear protective and heat-resistant gloves while using Steam Cleaners, because steam can cause severe burns.



Fig 3.2.6: Steam cleaning

E. Flame Cleaning

- Flame Cleaning involves cleaning a structural steel / metal / alloy surface by treating with intensely hot Oxyfuel gas flame over it, thus removing rust, mill scale, lubricants, grease and accumulated dirt from the surface.
- PPE appropriate for handling Oxyfuel, like Protective Masks, Safety Welding and Gas Cutting Goggles, Heat-resistant safety gloves, Aprons, Respirators (for emergencies), etc. must be worn during Flame Cleaning.
- Adequate ventilation must be provided in the work area, to prevent the accumulation of toxic fumes and explosion and fire hazards.
- The Flame Cleaning apparatus must be checked in advance, in order to avoid Backfeeding and Flashback hazards.
- Inspection, service and maintenance must be done by a licensed and experienced technician with the required training and experience in Gas safety
- Safety devices, like Flashback Arrestors, Non-return Valve, Vent and Purge device, Pressure Relief device, etc. must be used to prevent hazards like fire and explosion.
- Gas Leakage detecting devices, fire alarm and fire fighting equipment must be kept handy while using Flame Cleaning operations.

F. Sterilization by Autoclaving

- Autoclaving is one of the most efficient methods of sterilisation (the elimination of pathogens and microorganisms from given equipment or surface).
- The process of Autoclaving involves application of pressurized steam to heat and sterilize the material that requires cleaning.
- Appropriate PPE, like Apron, heat-resistant gloves, safety eyegear, etc. must be worn during the Autoclaving process.
- Sealed containers must never be autoclaved to prevent explosion hazards.
- Before operating an Autoclave, one must thoroughly read the Instruction Manual and learn about the safety lock-out mechanisms.
- The door of an Autoclave must never be opened if there is water getting drained at its bottom; this may result in accumulation of scalding water and even Superheated Steam.
- At the end of the cycle, one must wait for the Autoclave pressure to reach zero and the temperature at or below 121 degree Celsius, to prevent burns.
- Sharps, hazardous chemicals, radioactive materials and biomedical samples must never be autoclaved.

3.2.4 Cleaning the Site and Equipment

Cleaning the workshop / site, as the Line Assembler proceeds with the assembly and installation processes, is extremely crucial. The following aspects must be considered while cleaning the site, tools and equipment:

A. Procedure of choosing cleaning tools and equipment

- Powered tools, meant for cleaning the floor, must be equipped with guards and filters.
- Powered scrubbing machines should come with appropriate control methods, to regulate the flow of cleaning fluids.
- Cleaning equipment, powered with Propane, are recommended for use only when the site is vacant and unoccupied, thus allowing for adequate ventilation and air circulation.
- Propane-powered cleaning tools should be equipped with ecofriendly, low-emission engines.
- All cleaning equipment, especially the powered ones, must not operate at a sound level exceeding 70 decibels.

B. Procedure of choosing cleaning agents

- Cleaning agents and fluids must have a neutral pH (Potential of Hydrogen) value (7 or closer to 7) so that they do not corrode the surfaces.
- Cleaning agents should be ecofriendly and biodegradable.
- Cleaning agents with dyes must be avoided, in order to prevent discolouration and staining of surfaces and products. In case such materials cannot be avoided, the Line Assembler should resort to dyes, which are approved for food and cosmetics.
- Cleaning agents should have a high Ignition Point and the Ignition Point must be clearly mentioned in the Material Safety Data Sheet (MSDS).
- Cleaning agents should have minimum hazard rating (HMIS Rating). The Hazardous Materials Identification System comprises four colour codes, each representing a hazard category.

Colour Code	Meaning	Rating Scale
Blue	Health	0 - 4, with 4 being the most hazardous
Red	Flammability	
Orange	Physical Hazard	
White	Personal Protection	

- For cleaning wood and stone surfaces, cleaning agents should ideally contain water and epoxy-based (comprising epoxides) ingredients.
- For stain and spot removal, the recommended ingredients are citrus-based materials like d-Limonene and Methyl esters.
- Recommended ingredients for scale removal agents are citric, acetic and lactic acids.
- Hydrogen peroxide is the most common ingredient in Disinfectants.

UNIT 3.3: Handling Critical Parts

Unit Objectives

At the end of this unit, you will be able to:

1. Demonstrate the process of collection of components
2. Examine modern wiring materials
3. Evaluate the assembling process and faults, if any

3.3.1 Standing Operating Procedures

In electrical sub-system assembling, there are several scenarios that can arise due to malfunction or improper process flow. Hence, it is important to follow a standard set of protocols to ensure that the SOP (Standard Operating Procedure) is maintained. The following flow chart well describes the exact process to be followed.

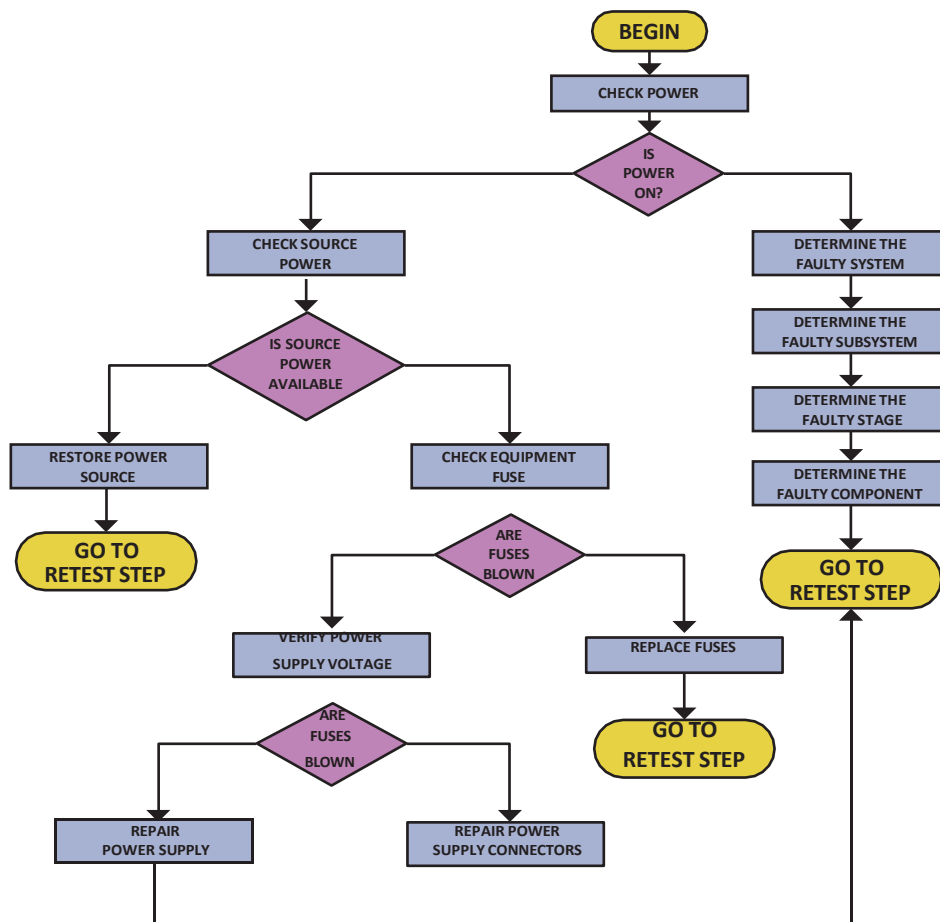


Fig 3.3.1: SOP chart for assembling operations

This not only shows the standard operating procedure, it also shows the decision making scenarios that has to be kept in mind while assembling.

Follow standard assembly procedure to assemble the electrical sub systems & integrate the electrical and electrical sub systems

Always follow the blueprint of the machine while assembling the sub-assemblies. In case of any issues of confusion, the electrical technicians should consult with the sub assembly electrical sub system assemblers. Verify the necessary assembly tools like fixtures and hand tools. The appropriate threaded fasteners (washers, nuts, bolts, screws) should be used in the correct places. The assembling of electrical sub systems should be accurate and the connections in place. When joining the wires to the various parts of the assembled machinery, it is imperative to use protective equipment and gears. Use of appropriate voltage outlet is a must. This should be in sync with the voltage capability of the finished product.

Place the assembled system in bins assigned and ensure that it is moved to testing area

Before the electrical technician assembles all the sub-assemblies and the electrical sub systems to produce the final product, it is important that all the sub-assembled parts are thoroughly tested.

These initial tests are extremely important as it can reduce the chances of future malfunctioning.

Added to this, pre-testing of assembled system also gives the chance to the technicians to scrutinise and see for any fault or snag.

It is a necessity that before the assembled parts are sent for testing, they should be stored in segregated bins.

The sub assemblies that require being stored in bins are in the form of:

Packing Gland Assembly Unit

- Locking ring
- Hexagonal nut
- Housing cover
- Packing gland packing
- Packing gland press
- Washer

Bearing Block Assembly

- Key shaft
- Splash ring
- Shaft
- Radial ball bearing
- Splash ring
- Hexagonal head screw
- Nuts
- Bolts
- Bearing block
- Feather key
- Corrugated spring

3.3.2 Safety Instructions and Procedures

This procedure is adopted for the safe use of equipment and plant and ensures that they are in good operating condition, and proactive measures are taken to identify possible faults.

Things to be followed while using hand tools

- Use hand tools only for the jobs they are meant for. For example, a slot screw driver should not be used as a chisel, punch, pry bar, wedge, hammers, or wrenches.
- Avoid applying excessive force or pressure on tools.
- Avoid cutting towards yourself while using cutting tools.
- Avoid holding the stock in your palms while using a screwdriver or a cutting tool. Always remember to place it in a vice or on a workbench.
- Avoid wearing bulky gloves for using hand tools.
- Avoid throwing tools. Hand them over directly to other employees.
- Avoid carrying tools in a way that affects the use of both hands on a ladder, while climbing on a structure, or while doing any hazardous work. While working on a ladder or scaffold, tools should be raised and lowered with the help of a hand line and a bucket.
- Avoid carrying sharp tools in the pockets.
- Avoid using tools for electrical work unless they are meant exclusively for electrical work and are properly insulated.
- Do not leave tools lying around on raised structures like a scaffold or a platform as employees may bump against them and fall.

Safety procedures in the company: A method sets out the steps to be taken for work activities. One must consult with impacted workers while developing methods for:

- Consulting workers regarding health and safety at the workplace
- Resolving work health and safety issues
- Monitoring employees' health and workplace conditions
- Providing information
- Carrying out training activities

Procedures should be furnished in written documents to ensure clarity at the workplace and exhibit compliance. They should clearly define the role of health and safety representatives, and other parties involved in the activity. The procedures should be accessible; for example, by displaying them on the intranet and the notice boards.

These norms are related to the working environment. They place a responsibility on the employers to ensure that the workplace is safe and the tasks can be carried out there, without imposing risks on the employees and others at the site.

The regulations cover all aspects of the working environment, including:

Taking necessary measures while handling electrical equipment:

It is important to adopt safety measures while working with electricity. Safety should not be negotiated at any cost and the ground rules must be followed. The rudimental guidelines on safe handling of electricity are documented:

- Avoid contact with water while working with electricity
- Always use insulated tools while working

- Electrical hazard includes unguarded electrical equipment and exposed energized components which may get energized abruptly
- Use goggles and proper insulated rubber gloves while working on any electrical circuit
- Always de-energize an equipment before repairing it
- Don't use steel or aluminium ladder while working with an electrical circuit. As a matter fact, any ladder made of conductive material incorporate the risk of electric shock. Use ladders made of insulating materials like fibre glass or plastic
- Be aware of the wire code of the native country
- Inspect all the GFCIs (Ground Fault Circuit Interrupters) at least once a month
- Work with a fuse or circuit breaker with the accurate current rating
- Wear a cap on the live / hot wire while working on a service panel or electric board. Deviating from this norm can lead to short circuit
- Take utmost care and safety precautions while removing a capacitor from the circuit. Capacitors store energy and, if not properly discharged during removal, can cause a violent electric shock
- Ensure care while soldering circuit boards. Wear goggles and stay away from the fumes. Place the solder iron on its stand when not in use since it can get extremely hot and can cause burns.

UNIT 3.4: Basic Soldering Techniques and Defects

Unit Objectives

At the end of this unit, you will be able to:

1. Evaluate the soldering techniques

3.4.1 Soldering Techniques

1. Solder requires a clean surface on which components are attached
 - Polish the copper foil of a printed circuit board with steel wool prior to soldering
 - Remove any paint, wax, oil, etc. with a steel wool, solvent, or fine sandpaper
2. To begin soldering, apply heat to the connection with the tip of the soldering iron before applying the solder
 - Apply heat to the connection but not to the solder
 - Hold the soldering iron near the base of the handle like a pen
 - The soldered parts have to be hot to build a good connection

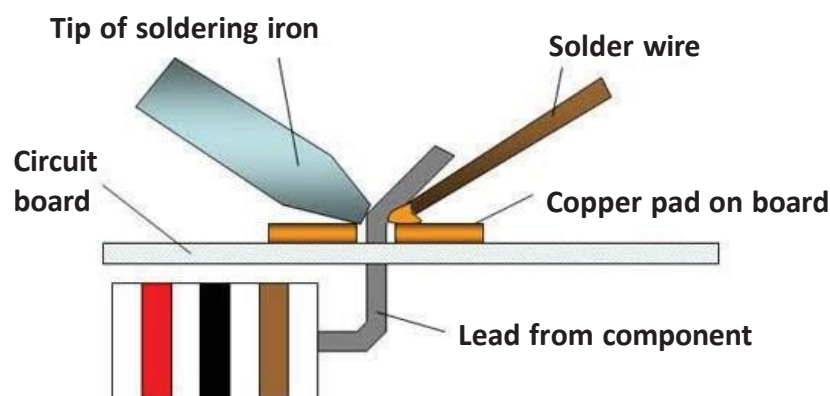


Fig 3.4.1: The tip of the soldering iron heats both the copper pad and the lead from the electronic component

3. Place the soldering tip on the connection during the application of the solder
 - Solder will flow on and around the connections
 - Use enough solder to ensure a stable connection
4. Take away the tip from the connection as soon as the solder flows to the desired place. First remove the solder followed by the iron
5. Do not displace the connection during the solder is cooling

6. Do not apply excess to the connection, as it might damage the electrical parts one is soldering

- Transistors and some other parts might be damaged by overheating when soldering. A crocodile clip should be used as a heat sink to preserve these components

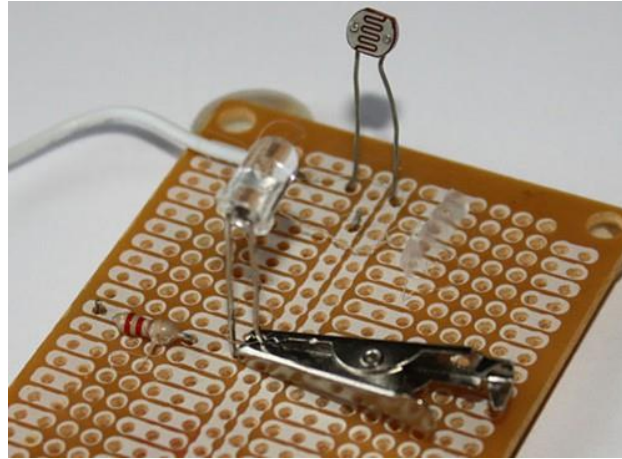


Fig 3.4.2: By absorbing heat, the crocodile clip will reduce the heat that flows to the component

7. Soldering a connection takes just a few seconds

- If it takes longer, troubleshoot as discussed below in the table

8. Examine the joint minutely. It should appear shiny

- If a wire (called the lead) is soldered onto a PC board, it should take the shape of a volcano
- If the connection is bad, try again by reheating

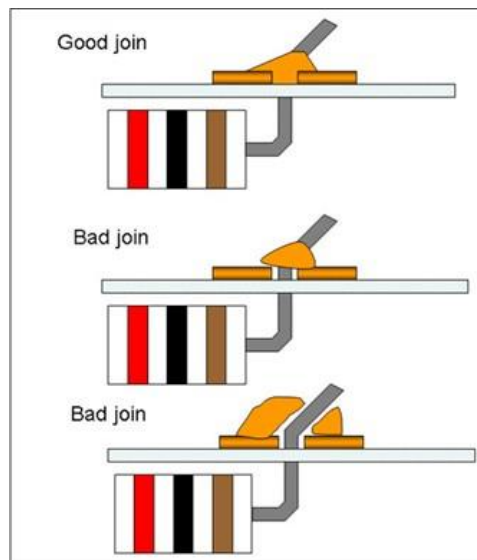


Fig 3.4.3: The solder in a good joint will be shaped like a cone, with solid contact between the solder and all surfaces to be joined.

9. Wipe the tip of the iron on a damp sponge to clean it. The tip should now be shiny

10. Unplug the soldering iron when it is not in use

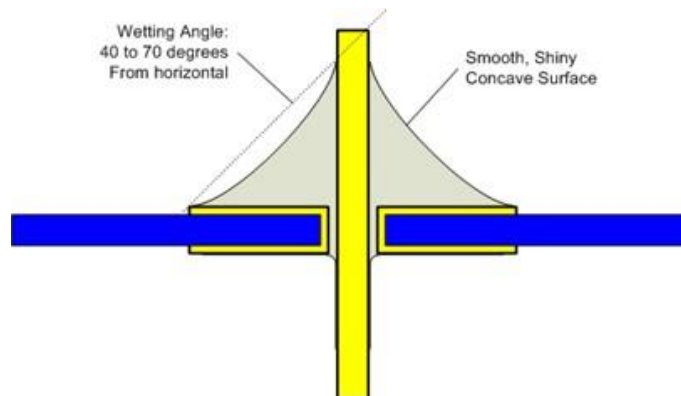
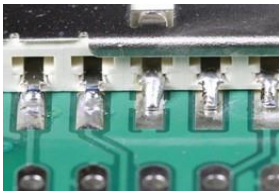



Fig 3.4.4: The ideal solder joint

3.4.2 Soldering Defects and Remedies

Type of Defect	Image	Repair	Prevention
<p>Disturbed Joint: A disturbed joint has been exposed to movement when the solder was still solidifying. The joint surface may appear frosted, rough, or crystalline.</p>		<p>Can be repaired with the help of reheating and allowing it to cool undisturbed.</p>	<p>Proper preparation, involving immobilising the joint and stabilising the work in a vice can hinder such joints.</p>
<p>Cold Joint: Results from incomplete melting of the solder. It is often characterised by a lumpy or rough surface. Such joints are not reliable. The solder bond is poor and may result in cracks in the joint over time.</p>		<p>Can be repaired by re-heating the joint with a hot iron until the solder flows. Several cold joints also suffer from excess solder. The excess solder can generally be drawn-off with the tip of the iron.</p>	<p>A properly pre-heated soldering iron with adequate power will help in preventing cold joints.</p>

Type of Defect	Image	Repair	Prevention
<p>Overheated Joint: Here, the solder has not yet flowed well and the residue of burnt flux will make fixing this joint difficult.</p>		<p>Can be repaired by cleaning. Careful scraping with a knife's tip, or a little isopropyl alcohol and a soft toothbrush will take away the burnt flux.</p>	<p>A hot, clean, soldering iron, appropriate preparation and clean joint can prevent overheated joints.</p>
<p>Insufficient Wetting (Pad): These joints show signs of inadequately wet solder pad. The solder has been able to wet the leads, but it has not created a stable bond with the pad. This is caused by a dirty circuit board or by failing to apply heat to the pad as well as the pin.</p>		<p>Can be repaired by placing the tip of the hot iron at the joint base until the solder flows to cover the pad.</p>	<p>Cleaning the board and heating both the pad as well as the pin can prevent this problem.</p>
<p>Insufficient Wetting (Pin): The solder in this joint has only been able to partially wet the pad. The pin was not sufficiently heated and the solder was not given sufficient time to flow.</p>		<p>Can be repaired by re-heating and using more solder. Ensure that the tip of the hot iron touches both the pad and the pin.</p>	<p>Heating both the pad and the pin can prevent this problem.</p>

Type of Defect	Image	Repair	Prevention
<p>Insufficient Wetting (Surface Mount): The solder has not flowed on to the solder pad. This is the result of heating the pin instead of the pad.</p>		<p>Can be repaired by heating the solder pad with the tip of the iron, and applying solder until it flows and melts along with the solder on the pin.</p>	<p>The pad must be heated first.</p>
<p>Solder Starved: A solder starved joint does not have adequate solder. This may lead to a good electrical contact, but it is tough to verify by checking. It is a weak joint and may lead to stress cracks over time.</p>		<p>Add more solder and re-heat the joint to make a strong joint.</p>	<p>N/A</p>

UNIT 3.5: Electronic Components and Connectors

Unit Objectives



At the end of this unit, you will be able to:

1. Distinguish different types of connectors or cables

3.5.1 Various Connectors and Cables

A cable is a cord, plug, or connector. A cable comprises one or more wires covered in a plastic covering that connects a computer to a power source or other device.

The two main types of cables are:

- **Data cable** - cable that enables communication between devices
- **Power cable** - cable that powers the device



Fig 3.5.1: Different types of cables

Specifications about different types of cables

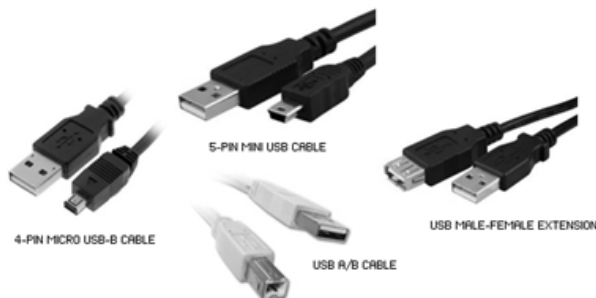


Fig 3.5.2: Cables with specifications

Parallel ATA (Advanced Technology Attachment) (PATA) cables are used to connect storage devices such as hard drives and CD-ROM (Compact Disc-Read Only Memory) drives to a computer's motherboard. These ribbon cables have two or three connectors, only one of which plugs into the motherboard. The remaining 40-pin or 44-pin connectors plug into the drives.

Serial ATA (SATA) cables are also designed to connect storage devices to motherboards. They provide higher data transfer speeds and have two 8-pin connectors, one on each end.

Extended SATA (eSATA) cables are used to connect external hard drives or optical drives. They provide transfer speeds that are approximately three times faster than FireWire 400 and USB (Universal Serial Bus) 2.0.

USB cables use the universal serial bus (USB) protocol for connecting standard PC peripherals like keyboards and mouse, as well as digital cameras and mass storage devices. USB versions include USB 2.0, USB 1.1, and USB 3.0.

FireWire cables are used to connect PCs to digital camcorders, set-top boxes and other digital devices that use FireWire, an interface standard developed by Apple and adopted by the IEEE. FireWire supports hot swapping and allows the transmission of data, video and audio over a single cable at very high bit rates.

VGA (Video Graphics Array) cables are used to connect personal computers (PCs) to computer monitors. They have connectors that consist of 15 contacts arranged in three rows. Each row corresponds to a separate channel: red (R), green (G), and blue (B).

DVI (Digital Visual Interface) cables are used to provide high-quality outputs to display devices such as LCD (Liquid Crystal Display) monitors, plasma TVs (televisions), and projectors. DVI is faster than VGA.

Network Cabling

Cable is the medium through which information is transmitted from one network device to another. There are many types of cable, which are commonly used with LANs (Local Area Networks). In a few cases, a network will utilise only one type of cable, while the others will use a variety of cable types. The cable selected for a network is dependent on the network's size, topology, and protocol. An understanding of the characteristics of various types of cables and how they are related to other aspects of a network is essential for the development of a successful network.

A few common types of cables used in networks are:

- Unshielded Twisted Pair (UTP) Cable
- Coaxial Cable
- Shielded Twisted Pair (STP) Cable
- Fiber Optic Cable
- Cable Installation Guides
- Unshielded Twisted Pair (UTP) Cable
- Wireless LANs

Click/Scan the QR code for more information on Network Cable types



Twisted pair cabling comes in two varieties - shielded and unshielded. The unshielded twisted pair (UTP) variant is the most popular one and the best option for school networks.

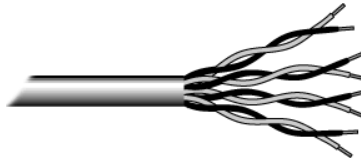


Fig 3.5.3: Unshielded twisted pair

The grade of UTP may vary from telephone-grade wire to very high-speed cable. There are four pairs of wires in the cable jacket. Each pair is twisted with different number of twists per inch for eliminating interference from other electrical devices and adjacent pairs. The tauter the twisting, the higher the supported transmission rate and the greater the cost per foot.

Categories of Unshielded Twisted Pair

Category	Speed	Use
1	1 Mbps (Megabits per second)	Voice Only (Telephone Wire)
2	4 Mbps	LocalTalk & Telephone (Rarely used)
3	16 Mbps	10BaseT Ethernet
4	20 Mbps	Token Ring (Rarely used)
5	100 Mbps (2 pair)	100BaseT Ethernet
	1000 Mbps (4 pair)	Gigabit Ethernet
5e	1,000 Mbps	Gigabit Ethernet
6	10,000 Mbps	Gigabit Ethernet

Unshielded Twisted Pair Connector

The standard connector for unshielded twisted pair cabling is an RJ-45 connector. This is a plastic connector that looks like a large telephone-style connector. A slot allows the RJ-45 to be inserted only one way. RJ stands for Registered Jack, implying that the connector follows a standard borrowed from the telephone industry. This standard designates which wire goes with each pin inside the connector.



Fig 3.5.4: RJ-45 connector

Shielded Twisted Pair (STP) Cable

Although UTP cable is the most cost-effective cable, it is prone to radio and electrical frequency interference. It should not be positioned very close to fluorescent lights, electric motors, etc. If you have to keep cable in environments with a great deal of potential interference or in extremely sensitive environments that may be prone to the UTP's electrical current, the shielded twisted pair cable is the solution. Shielded cables can help extend the maximum cable distance.

Shielded twisted pair cable is available in 3 separate configurations:

1. Each pair of wires is individually protected with foil
2. A foil or braid shield in the jacket covers all wires in the form of a group
3. A shield exists around each individual pair, as well as around the whole group of wires

Coaxial Cable

Coaxial cabling is characterised by a single copper conductor at its centre. A plastic layer insulates the centre conductor from the braided metal shield. The metal shield helps in blocking any external interference from motors, computers, fluorescent lights, etc.



Fig 3.5.5: Coaxial cable

Coaxial cabling is tough to install but is resistant to signal interference. Furthermore, it can support greater cable lengths between network devices as compared to twisted pair cables. The two variants of coaxial cabling are thin and thick coaxial cables.

The thin coaxial cable is also called the thinnet. 10Base2 defines the specifications for thin coaxial cable carrying ethernet signals. It also indicates the approximate maximum segment length, which is 200 meters. In fact, the maximum segment length is 185 meters. Thin coaxial cable is very popular in school networks, especially in the linear bus variants.

Thick coaxial cable is also called thicknet. 10Base5 defines the specifications for thick coaxial cable, which carry Ethernet signals. It also indicates the maximum segment length, which is 500 meters. The thick coaxial cable has an extra protective plastic cover that helps in keeping moisture away from the centre conductor. This is why thick coaxial is considered a good option while running longer lengths in a linear bus network. One of the cons of thick coaxial cable is that it does not bend easily and is tough to install.

Coaxial Cable Connectors

The Bayone-Neill-Concelman (BNC) connector is the most common type of connector used with coaxial cables. Various adapters are available for BNC connectors, like a barrel connector, T-connector, and terminator. Cable connectors are the weakest points in any network. One must always use the BNC connectors that crimp onto the cable. This helps in avoiding problems with the network.

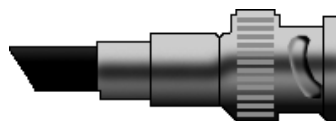


Fig 3.5.6: BNC connector

Fiber Optic Cable

Fiber optic cabling comprises a centre glass core enclosed by many layers of protective materials. It transmits light, thus doing away with the electrical interference problem. This makes it suitable for certain environments that involve electrical interference. It is also the standard choice for connecting networks between buildings, due to its immunity to the effects of lighting and moisture.

Fiber optic cable has the ability to conduct signals over much longer distances as compared to coaxial and twisted pair. It can also carry information at vastly greater speeds. This capacity broadens communication possibilities to include services such as video conferencing and interactive services. The cost of fiber optic cabling is comparable to copper cabling; however, it is more difficult to install and modify. 10BaseF refers to the specifications for fiber optic cable carrying Ethernet signals.

The centre core of fiber cables is made of plastic or glass fibers. A plastic coating cushions the fiber centre, and kevlar fibers help in strengthening the cables and stop breakage. The outer insulating jacket is built of PVC or teflon.



Fig 3.5.7 Fiber optic cable

There are two common types of fiber cable, namely, single mode and multimode. The multimode cable has a bigger diameter. Both cables provide high-speed and reliable bandwidth. The single mode can provide more distance, but it is costlier.

Specification	Cable Type
10BaseT	Unshielded Twisted Pair
10Base2	Thin Coaxial
10Base5	Thick Coaxial
100BaseT	Unshielded Twisted Pair
100BaseFX	Fiber Optic
100BaseBX	Single mode Fiber
100BaseSX	Multimode Fiber
1000BaseT	Unshielded Twisted Pair
1000BaseFX	Fiber Optic
1000BaseBX	Single mode Fiber
1000BaseSX	Multimode Fiber

UNIT 3.6: Handset Assembly Operations

Unit Objectives

At the end of this unit, you will be able to:

1. Analyze the handset assembly process

3.6.1 Assembling Mobile Phones

Disassembling and Assembling are the first two important things one should know in case of Mobile repairing. You need to be confident and if you are unable to assemble or dismantle correctly, you may not be able to diagnose the problem or the fault. Proper knowledge is essential or else, the mobile phone may get damaged. Different phones have different methods of disassembling and assembling and you should know the tools used for the same.

In the following lines, you will get to know about the tools as well as the correct method to assemble a handset. Besides, you will also find here the parts identification guide that will help you to understand different components of a handset.

Tools

Following is the set of tools that you need in order to assemble and dismantle a handset:

1. Philips screwdriver,
2. Flat screw driver, and
3. Plastic Separation tool.
4. Undertake assembly operation
5. Line Assembler (Tools and Equipment)

Sl. No.	List of Tools	Quantity
1	Electric / Pneumatic Torque Screwdriver	1
2	Soldering Gun (Temperature controlled)& iron tips	2 (Stations)
3	Desoldering Pump	2
4	Electronics components Forming Tool	1
5	Axial components lead cutting Tools	1
6	PCB repair Kit	2
7	Strippers	3
8	Squeezing Forceps	4
9	Vacuum Pick-Up Tools	2
10	Dipliner	1
11	Glue Stick Melter/ guns	2
12	Soldering Tester	1
13	Magnifying Lamp	2

14	PCBA (Printed Circuit Board Assembly) pneumatic Tools	2
15	Digital Multimeter	2
16	High voltage tester	1
17	Hot air gun/ blower	2
18	Conveyor Pallet	1
19	Radial Lead Formation Tool	1
20	Axial Lead Formation Tool	1
21	Component Former	1
22	PPE(ESD proof)	2
23	ESD wrist strip	1
24	RF Testing Instrument	1
25	Weighing Scale	1
26	Air driller / Miller / Puncher	1
27	Lead screws with ultra-fine pitch	25 pcs
28	Model with sub sub-assemblies (Keypad phone)	2
29	Model with sub-assemblies (Smartphone)	2

Line Assembler Material Used:

Sl. No.	List of Tools	Quantity
1	Liquid Dispensers (Liquid flux, epoxy)	2
2	Adhesives and Cleaning Products	2
3	Finger cuts full & Half	10
4	Apron (SD (Secure Digital) proof)	3
5	Anti-electrostatic Floor	3
6	Components tray/bins/strips bobbin (all sizes (ESD Protective))	1 each
7	Foot Switch	2
8	Testing Jig (sample)	1
9	Schematics & Designs	2
10	Specification Charts (for critical components like ICs, Microphone, Ear piece, Connectors)	1 each
11	Document Pads/ Files	2
12	Master Design file	2
13	IPC (Institute of Printed Circuits) /IEC (International Electro-technical Commission)/CE (Current Era) Standard Documents	2
14	EMI /ROHS/WEEE Standard Documents	1 for each stage

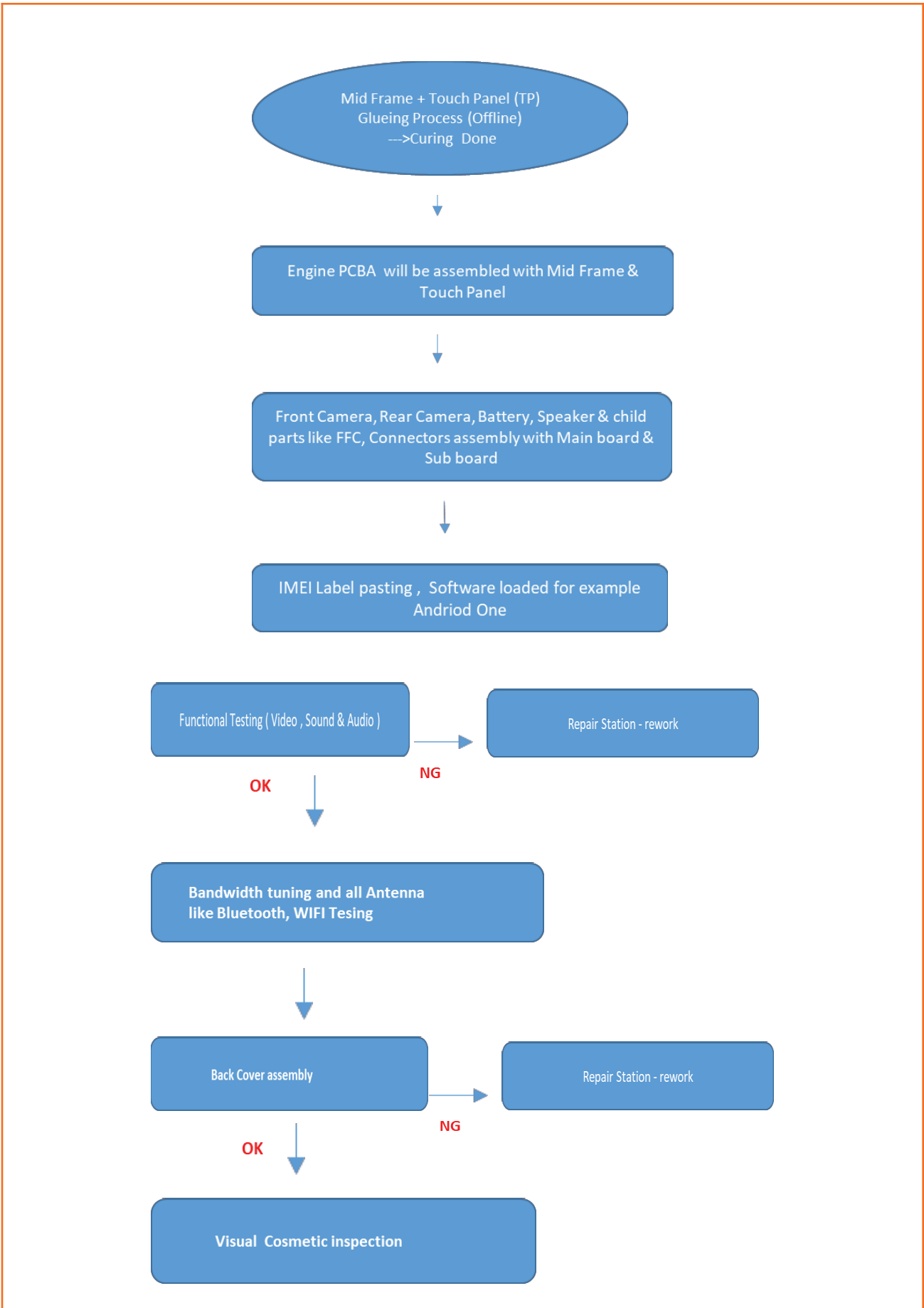
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15	lead free Solder Paste (with / without flux)	3
16	5S Items, Charts, Checklists	2
17	Preventive Do's & Don'ts placards from Industry	1 each
18	Internal Quality Control (IQC)/ QMS (Quality Management System) /TQM (Total Quality Management) covering all stages	1
19	Soldering Tip Polisher	2
20	Stencil sets & Racks	2
21	Solder Mask (ppe)	4
22	Through-Hole Component Insertion module (with SMT (Surface-mount Technology) components mounted – reject PCBs)	3 PCB boards
23	PCB Cleaning Solution (IPA (Isopropyl Alcohol))	2
24	Electronic components storage cabinet (small, medium and big one (ESD protective)	1

Smart Phone Manufacturing Assembly Flow Chart

- Mid frame + touch panel (tp) gluing process (offline) ---> curing done
- Engine PCBA (Printed Circuit Board Assembly) will be assembled with mid frame & touch panel
- Front camera, rear camera, battery, speaker & child parts like FFC (Flexible Flat Cable), connectors assembly with main board & sub board (discussed below in the table)
- IMEI (International Mobile Equipment Identity) label pasting , software loaded for example android one
- Functional testing (video , sound & audio) [in case the product does not qualify the quality test, it is sent back to the repair station for rework]
- If the functional testing is ok, bandwidth tuning and all antenna like Bluetooth, Wi-Fi testing are performed
- Next, back cover assembly is done
- In case the back cover assembly is not up to the mark, it is sent back to the repair station for rework
- Post back cover assembly, visual cosmetic inspection is carried out
- The next phase is cat or camera testing. Both front and back camera are tested and if the quality does not match the industrial standard, it is sent back to the repair station for rework
- After the successful camera testing, antenna testing & audio testing are performed [in case the product does not qualify the quality test, it is sent back to the repair station for rework]
- After this phase, another cosmetic visual inspection is carried out to ensure the quality of the product. For faulty items, it requires further repair work
- IMEI check and all function tests as per customer requirement is the last phase of testing. In case the back cover assembly is not up to the mark, it is sent back to the repair station for rework
- The next step is laser marking as per customer requirement
- In the next phase, packing sleeve folding & accessory packing and MRP label pasting are done



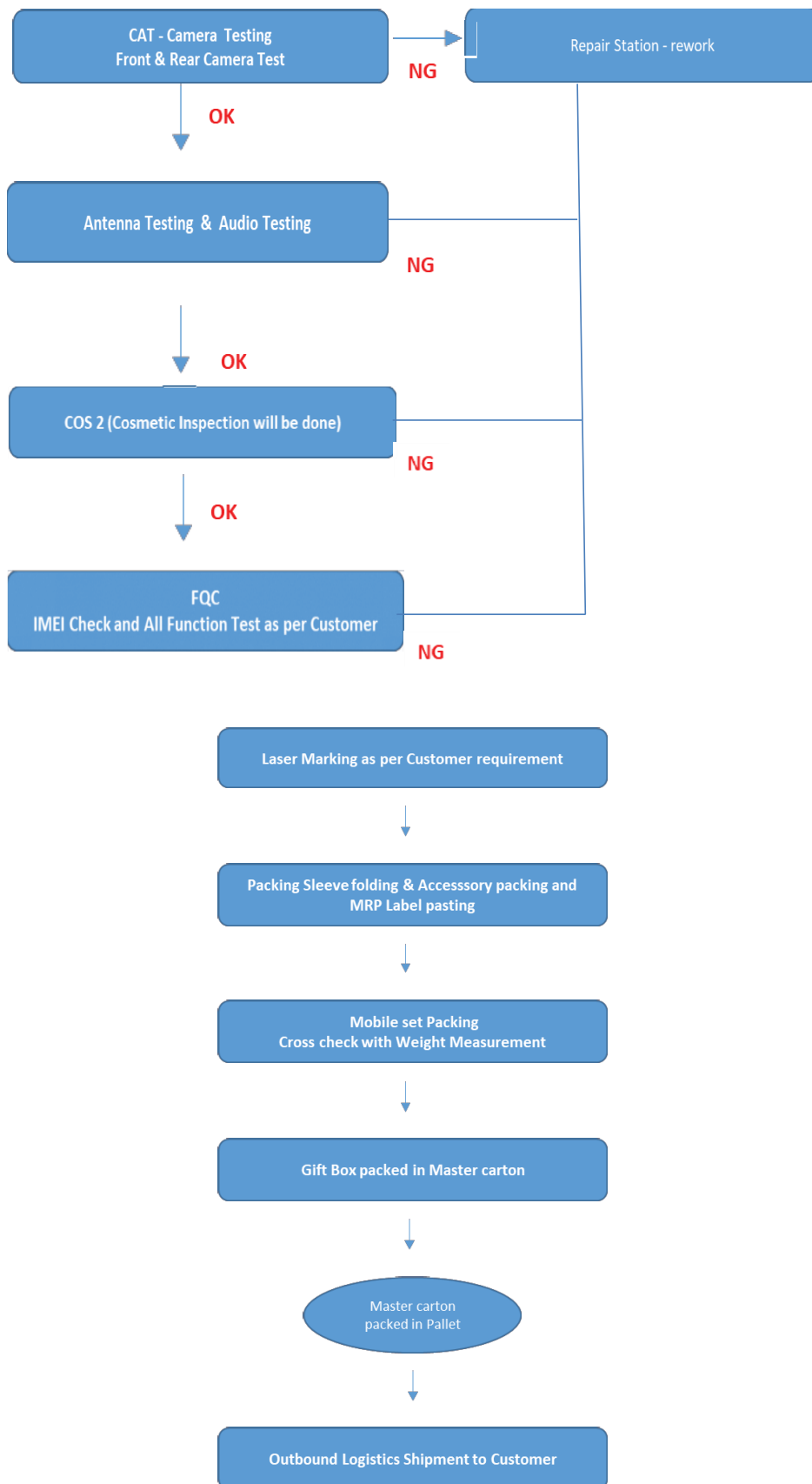








Fig 3.6.1: Smartphone manufacturing assembly flowchart

Mobile set Packing

- Cross check with Weight Measurement is the thing that a line assembler should perform at the beginning of the packing
- In special cases, Gift Boxes are packed in Master carton
- Master carton is then packed in Pallet
- The last stage is Outbound Logistics Shipment to Customer

Step	Image
<p>Fix the Vibrator, Strips of Speaker and Volume button assembly</p>	
<p>1. On Motherboard, perform the following steps sequentially:</p> <ul style="list-style-type: none"> • Fix main Camera • Place Motherboard on LCD and connect its Strip • Attach SIM (Subscriber Identification Module) and Memory Card strip on board 	

Step	Image
<p>1. Connect the following wires:</p> <ul style="list-style-type: none"> • Antenna with wire • Wire of Speaker – Volume Strip • Place front camera and connect it 	
<p>1. Put Camera cover</p>	
<p>2. Now before you place the screw in your handset, make sure that its LCD is working by switching it on, after that, fix it with the help of screws</p>	
<p>3. Finally put battery and battery cover</p>	

IMEI Number Generation

What is an IMEI Number?

- IMEI stands for International Mobile Equipment Identity
- It is an unique fifteen- digit identification number of the mobile handset and resembles a vehicle's registration number
- IMEI is part of the GSM (Global System For Mobile Communications) and 3GPP (3rd Generation Partnership Project) standards for mobile devices
- The IMEI no of the mobile handset can be checked by pressing *#06#
- IMEI numbers are being allotted by fourGSMA (Global System For Mobile Communications Association) -authorised bodies
- Mobile handsets should not share the same IMEI number
- The model and make of a handset can be determined from its IMEI number
- IMEI number is an important tool for tracking handsets
- The IMEI only detects the device and has no particular relationship with the subscriber. The phone detects the subscriber by transmitting the International Mobile Subscriber Identity (IMSI) number, which it stores on a SIM card that can, in theory, be transferred to any handset. However, the network's ability to know a subscriber's current, individual device enables many network and security features

IMEI Number Structure

TAC - Type Allocation Code		Serial Number	Check Digit
NN	XXXXXX	ZZZZZZ	A
Reporting Body Identifier, e.g. MSAI	Type Identifier defined by MSAI	Number range allocated by MSAI but assigned to individual mobile stations by the manufacturer.	Defined as a function of all other digits (calculated by the manufacturer).

Generation of IMEI Generation in Smartphone Manufacturing organization

- The Manufacturer of Smartphone assigns one stage in assembly for IMEI generation and the stage is configured in their IT (Information Technology) system which is based on the Smartphone model , manufacturer's name , PCBA , Software Kit, and transceiver part
- Against a Smartphone product & transceiver, a customer related software is generally configured and released in the manufacture's IT system
- IMEI Number, Wi-Fi ranges are allocated based on the Country & Smartphone Model
- Based on the track ID (Identity) in the manufacture's IT information system and Smartphone model, IMEI query will be sent to the customer GPS (Global Positioning System) Server. IMEI number will be assigned in customer GPS server & stored in the manufacture's IT system
- In the finished goods packing area of the manufacturer and through their information stored in IT system, the IMEI number will be written in the Smartphone product
- The IMEI written information will be read from the Smartphone and it will be cross checked with the customer GPS server
- The IMEI number is also printed at the back on a few phones, or underneath the battery housing for older phones that have removable batteries

Gift Box Packing

Kitting- this is more or less like assembling. It is a process where the individual separates the tools, but usually all the related items are packed, grouped and finished together as one unit. In other words group of some materials from which a finished product is achieved through assembling.

For example; a computer assembled from kit

The components and modules according to the bill of materials (BOM)-

Bill of Materials (BOM) - bills of materials, is a well-rounded list that not only contains the raw materials but also a list of assemblies, raw materials, sub- assemblies, quantity, parts and component needed to construct an equipment or machine. Virtually every item that is needed by the manufacturer is included in a BOM. Basically BOM depends exactly on what kind of equipment is being manufactured. But basically BOM is of two types- one is when the equipment is getting engineered for the manufacturers, and the other one is when the product has been shipped and rolled out for the customers.

Let us discuss the key items of BOM firstly; a good BOM would definitely include all these items:

Key items		Description
1.	BOM level	Each and every part or assembly in the BOM must get the number or level, that will explain all in itself where it will fit in the hierarchy of the BOM, for easier understanding of the BOM
2.	Part number	It is very important that the BOM parts must be numbered properly, so that anyone who is involved in the manufacturing process will have an ease to refer and identify parts in an instant. It is important and critical that each part will have only one number for easy identification and avoiding confusion
3.	Part name	Every part name must have a unique name of itself that will help the manufacturer to identify the parts at one instance, without taking help from other sources
4.	Phase	It is to be made sure that all the parts in the BOM must be marked with a life cycle stage, the parts that are in the verge or in the process of being completed , a term like devising can be used , and for parts that are not yet approved terms like in process or not released can be used. These terms are helpful when new manufacturing is in process, for an easier understanding and for tracking easily
5.	Description	A general information must be attached to every part, so that it is easier for the manufacturers to identify and make a comparison between similar parts
6.	Quantity	The number of parts that is provided for an assembly must be specified so that purchasing of the BOM is feasible
7.	Unit of measure	It is very essential that the unit of measure is specified how much quantity is used for every part or material must be mentioned. This information will provide that correct quantities are purchased and provided to the assembly lines

Key items		Description
8.	Procurement type	Every part or material must be recognised as something that is bought off the shelf or the manufacturing has taken place according to project specification
9.	Reference designators	When an item or product includes a circuit board that is printed or printed circuit board assemblies(PCBA's) the BOM must include reference designators as to how the PCBA's fit into it
10.	BOM notes	Lastly note that carries additional information must be included so that whoever uses the BOM

Components are the list of items needed for the various processes to make a product. Components according to the BOM would include:

Component type		Description
1	Sub-assemblies	A sub- assembly is an item that has been manufactured, which is used as a constituent, in a level higher in BOM. Every sub-assembly has its own BOM and is manufactured according to the jobs(components, revision, routing)
2	Phantom- assemblies	Phantom- assemblies stand for components and are used for products that are manufactured in a customised manner. Phantom-assemblies does not include revision or routing specified
3	Raw materials	Raw materials are items that will be incorporated with the BOM parent BOM parent- it is a multi- level BOM, also known or referred to as indented BOM, it gives us a picture of parent and child relation, and depicts the structure of hierarchy of assemblies and the other component's attached to it
4	Purchased parts	These are simply raw materials that are bought or purchased from an outside supplier, simply to be assembled with a BOM parent

Speed entry for facilitating component entry-

- Components are entered within the components tab in the BOM main screen
- To facilitate rapid selection of components to the main screen of BOM speedy entry function is used

Assigning of components to associated routing sequences-

- it is important to assign components to associated routing sequence when they are being used
- when a job is processed, print of the components are associated with the job traveller
- sequence assignments also enables job materials and sequence to appear on the job issues screen which are selectively issued

Facility to import CAD programme to other source-

- File- data format- BOM- BOM components can be used for utilising to import materials or component from CAD (Computer Aided Design) program or other source
- Components must be existing among themselves as stock items
- This must be revised from time to time and edited with the source file for assigning of components to associated sequence

Determining the sort order-

- The line number field is used to determine the sort order on the screen
- The programme allots a value on the basis of 10 in the order that components are made to entered

The quantity of usage depends on the BOM –

- the component usage quantity entry depends on two types :
 - If the type of BOM is 'BOM" "Phantom" or "one off" enter the net quantity that is required for a unit of item parent
 - If the type of BOM is batch, it is required to enter the total quantity in order to specify the batch size in the upper panel

Select the fixed quantity when usage is not varying with the job quantity –

- For the selection of the fixed quantity, checkbox is to be selected when there is no varying in job quantity
- For example- a tool may be used for one job type and the disposed of. In this case a fixed quantity usage will be applied

Using of component references-

- There is an option of printing on the job traveller by attaching multiple references to it
- For example- the manufacturers of circuit board uses references to designate the location of the component

Using of component job notes in alteration to references-

- It is an informal alternative way to use reference
- Job notes can be entered for any reference

Using of component replace screen for maintenance of mass-

- Whenever there is a need to replace a mass of the existing component with the other component
- It is recommended to use the component replace screen for doing this in batch process

UNIT 3.7: Uploading OS and Core Apps

Unit Objectives

At the end of this unit, you will be able to:

1. Discuss the necessary software and app to be uploaded to fire up a handset

3.7.1 Core Apps in Handsets

The ever-growing mobile market is flooded with apps that never stop to explore beyond the known boundaries for a better user experience. For every category, there are innumerable choices to make. Below is a list of a few apps a subscriber should access. They are of a few categories, namely, Security, Communication, Backup, Browsers, Launcher, Tools, and Entertainment.

For every category, there are hundreds of choices to pick. Below is a list of some Apps an user should access. They are broken down to a few categories, namely Security, Backup, Communication, Browsers, Tools, Launcher and Entertainment.

Security

- **AVG Antivirus:** A free antivirus app for Android, the AVG (Anti-Virus Guard) Antivirus comes free of cost and provides you with many features to protect your Android phone from viruses, threats, and malwares.

By enabling the Find/Locate Option, you can easily secure your Phone from theft. It connects to Google Maps and shares the location of the phone. Other features include killing running tasks to free up memory, lock and wipe data to protect privacy, and scheduled scans.



Fig 3.7.1: Upload Antivirus

Backup

- **Go Backup:** Go Backup is a holistic app that backs up your data. It can prepare backups for your phone contacts, call log, messages, and also the applications installed with app data to your SD Card. You can restore full backup or choose what to restore manually.

Communication

- **Facebook:** Facebook for Android is the official Facebook App which allows you to communicate with your friends, family and clients right from your Phone. With the Facebook Android App, you can send messages to anybody on your friends' list anytime, and you can do real-time chat too.

The app also gives you the option to update your status and photos. It also syncs your Phone contacts with Facebook friends and shows Facebook data in your Contact.



Fig 3.7.2: Install Facebook app

- **Twitter:** Tweet right from your Android Phone and update your status instantly. You can follow your friends to see what's going on with them.

Other features of this app include Tweets, Retweets, the Follow option, photo and link sharing, and direct messages to your Followers.



Fig 3.8.3: Install Twitter

- **WhatsApp:** WhatsApp Messenger is a cross-platform, proprietary, encrypted instant messaging client for smartphones. It takes the help of the Internet for sending text messages, documents, multimedia, user location and audio messages to others using standard cellular mobile numbers.



WhatsApp

Fig 3.7.4: Install WhatsApp

Browsers

- **Opera Mini:** Opera Mini is one of the speediest and most popularly used browsers for Android phones. It comes with a simple-to-use Interface, which provides you with the option to see either Phone View or Desktop View.



Fig 3.7.5: Opera Mini

It also helps you save your data bandwidth with the help of Unique Compression Technology. Like Firefox and Chrome, it has the tab functionality to open multiple tabs at the same time.

- **UC (Universal Control) Browser:** UC Browser is another advanced browser. Additionally, it supports multi-touch and also can recognize and navigate through voice commands. You need to Install Google Voice to make Voice Control work.



Fig3.7.6: UC Browser

- UC Browser uses Cloud Acceleration technique to load webpages immediately.
- You can download files through UC Browser at high speeds

Dolphin Browser HD (High Definition): Dolphin Browser HD is a feature-rich browser for Android. It provides you with the most cutting-edge features and plugin integration that no other Android browser gives. Its range of features include Voice Navigation, Add-Ons, Gesture Control, Speed Dial, Tabbed Browsing and Sidebars.



Fig 3.7.7: Dolphin Browser

Different Mobile OS (Operating System) to Boost the Handset

OS	Image
<p>Symbian</p> <p>Officially the property of Nokia, the name means that any other company will have to take permission from Nokia before implementing this operating system.</p>	 <p>Renewing Symbian smartphones NOKIA</p>
<p>Android</p> <p>Being one of Google's mobile operating systems, Android has several versions, namely, 'Astro', 'Bender', 'Cupcake', Ice Cream Sandwich and Jelly Bean, and Marshmallow (Android 6.0) is so far the latest Android version from Google.</p>	
<p>Apple iOS (iPhone Operating System)</p> <p>This was introduced in 29th June, 2007 with the launch of the first iPhone. Since that date, iOS has undergone many upgrades and the recent one is the iOS 9. To date, the iOS has been used in all iPhones, iPods&iPads.</p>	 <p>Phone Mail Safari Music</p>
<p>Blackberry OS (Operating System)</p> <p>Blackberry OS first got released in 1999. Blackberry OS 7.1 is the recent release of this operating system. It was introduced in May 2011 and is used in Blackberry Bold 9930. It is a highly reliable OS and is immune to almost all known viruses.</p>	
<p>Windows OS</p> <p>Windows OS is most commonly used by computers across the globe. Windows OS is also used in mobile phones.</p> <p>Nokia Lumia series is completely windows based. A few of the latest Windows Phones are Nokia Lumia 900, Nokia Lumia 800, HTC (High Tech Computer) Titan 2, and Samsung Focus.</p>	 <p>Windows Phone</p>

OS	Image
<p>BADA</p> <p>Samsung owns the BADA operating system. It is designed for high-end and mid-range smartphones. Bada is a user-friendly and efficient operating system.</p>	
<p>Palm OS (Garnet OS)</p> <p>Developed by Palm Inc in 1996, particularly for PDAs (Personal Digital Assistance), the Palm OS was fabricated to function on touchscreen GUI (Graphical User Interface). A few years later, its upgraded version was able to support smartphones.</p>	
<p>Open WebOS</p> <p>Also known as HpWebOS, it was developed by Palm Inc. After a few years, it became the property of Hewlett-Packard. WebOS was launched in 2009 and was put to use in a number of tablets and smartphones.</p>	
<p>Maemo</p> <p>Nokia and Maemo Community joined hands to produce an operating system for smartphones and tablets, known as Maemo. Like other devices, the user interface of Maemo also comprised a menu from which the user can go to any location.</p>	

Summary

- Measurement is the process of determining the magnitude of and quantifying a physical parameter.
- The method of measuring physical parameters is called Metrology.
- Units of measurement are of two types: System International (SI) and the Centimeter - Gram - Second (CGS).
- A Line Assembler can effectively manage and minimize waste by the 3Rs, namely reduce, reuse, and recycle.
- It is important for line assemblers to follow a standard set of protocols to ensure that the SOP (Standard Operating Procedure) is maintained.
- A cable is a cord, plug, or connector.
- A cable comprises one or more wires covered in a plastic covering that connects a computer to a power source or other device.
- Disassembling and Assembling are the first two important things one should know in case of Mobile repairing.
- The ever-growing mobile market is flooded with apps that never stop to explore beyond the known boundaries for a better user experience.
- For every category, there are innumerable choices to make.

Activity

1. Collect various types of defectively soldered items. Identify the defects in each of them. With the help of a black marker, write down the name of defect(s) on each soldered item. Show your work to the trainer in the next class for verification.
2. Arrange the following steps in proper order:
 - a. Attach SIM and memory card strip on board.
 - b. Put camera cover.
3. Put battery and battery cover.
4. Fix the vibrator, strips of speaker and volume button assembly.

Notes



A large rectangular area enclosed by an orange border, containing 25 horizontal lines for writing notes.

Exercise

Choose the correct option from the list of responses to answer the following questions:

1. If the surface of a soldering appears to be frost, then it refers to –
 - a) Disturbed Joint
 - b) Cold Joint
 - c) Starved Joint

2. In a cold joint, the solder does not –
 - a) Melt completely
 - b) Evaporate completely
 - c) Frosts completely

3. Which of the following is not an essential component of an electronic circuit?
 - a) Voltage
 - b) Capacitance
 - c) Resistance

4. What is the unit of potential difference?
 - a) Ampere
 - b) Volts
 - c) Ohm

5. AC Current stands for –
 - a) Alternative current
 - b) Alternating current
 - c) Altering current

6. FireWire cables are used to connect PCs to _____
 - a) Analogue camcorders
 - b) Digital camcorders
 - c) Server

7. SOP stands for –
 - a) Standard Organizational Policy
 - b) Standard Operations Procedure
 - c) Standard Operating Procedures

8. Which of the following cables provide fastest service?
 - a) VGA
 - b) DVI
 - c) eSATA

9. The tip of an ungrounded soldering iron can accumulate a voltage of up to _____ of the iron's supply voltage.
 - a) Triple
 - b) Twice
 - c) Half

10. Find the odd one out.
 - a) Heat – Joule
 - b) Time – Hour
 - c) Mass – Kilogram

4. RF Measurements and Electronic Component Specifications and Testing



Unit 4.1 - Specifications and Testing of Components
Unit 4.2 - RF Measurement



Key Learning Outcomes



At the end of this module, you will be able to:

1. Estimate the electronic components and their specifications
2. Analyze the Radio Frequency measure process
3. Discuss the equipment related to RF measurement

UNIT 4.1: Specifications and Testing of Components

Unit Objectives

At the end of this unit, you will be able to:

1. Estimate the electronic components and their specifications

4.1.1 Steps of Testing Electronic Components

Motherboard-

- The assembler must find the spacer (case) of the mother board that comes attached with it.
- These are basically screws, brass; having large heads of hexagonal figure they are usually tapped so that it is possible to fasten the screws into the top.
- These screws hold the mother board up off the case so that a short circuit is avoided
- The I/O Shield must be removed from the case back, where the ports on the motherboard shall fit, and fit the I/O shield that comes with the motherboard
- Few cases make it difficult to install because of the power supply that has been installed
- Locate the holes of the screws on the motherboard and find the corresponding hole on the plate
- Bring the position of the motherboard so that the holes in the top are visible through the motherboard screw holes.
- make sure the ports on the motherboard the motherboard are perfectly aligned with the back plate that has been just installed and make any necessary adjustment that is important
- The small metal tabs are intended so that it can make contact with the metal parts of the connections that are on the back of the motherboard and the grounding must be done to them
- A screw must be fastened through each of the motherboard screw holes into the standoffs that are underneath.
- These screws should be protected but not very tight, there should not be unnecessary tightening with the torque screw
- Tightening by hand is alright, or else the mother board can be damaged

Hard drive

Installing the hard drive is similar for all, like the hard drive only thing that matters is the type of hard drive that you are installing whether it is SATA or PATA. The steps will vary accordingly,

- SATA is the short for Serial Advanced Technology Attachment, it is an IDE (Integrated Development Environment) which was released in the year 2001 for connecting of devices like optical drives and hard drives to the motherboard
- PATA is the short for Parallel Advanced Technology Attachment, it is a standard for connecting the hard drives to the computer system
- There are basic steps that recognises the installation of the hard drive
- Configuring the drive as the master or the slave device
- Mounting the drive on the chassis
- Connection of the data cable to the hard drive to the PATA or SATA interface
- Connection of the power cable to the drive, before removal of case panels to the hard drive

- The system must be started and the BIOS (Basic Input Output System) setup must be run. The current configuration of the which the SATA or PATA port are in use and the description of the devices that are attached to them
- If a PATA or SATA card has been inserted then the card must be configured accordingly

4.1.2 Components of Mobile Phone

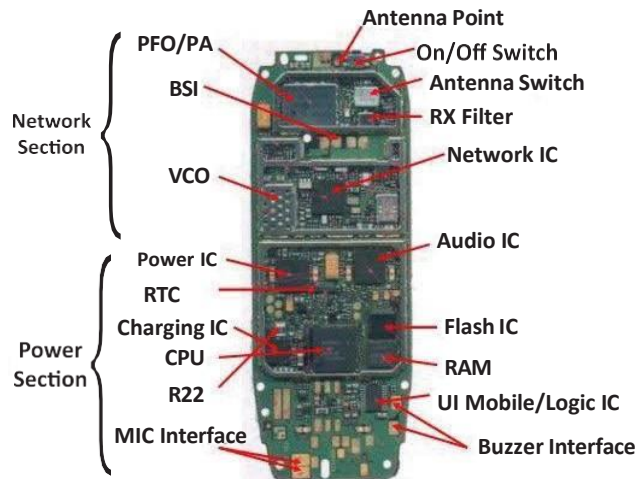







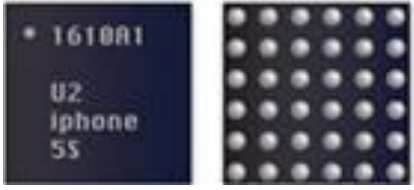


Fig 4.1.1: Different components of a mobile phone

The different components of a mobile phone are:

Component	Image
<p>1. Charging system: A mobile phone can be charged by means of an adapter or a USB cable. Once it is charged, open the charging plug. It is harmful for both the battery and charger to charge a mobile throughout the night. After buying a new mobile set, the battery should be charged from 12 to 18 hours at a stretch.</p>	
<p>2. Battery: A container comprises one or more cells, in which chemical energy is converted into electricity and utilised as a power source. The battery of mobile phone is 3.6 volts and current is 500Amps (Amperes)-1800Amps.</p>	
<p>3. Backup battery: It looks like the battery of a clock. Being rounded and silver coloured, it acts as a backup power supply to control the date and time of a mobile phone.</p>	
<p>4. SIM Driver IC: It is square in shape and blue in colour. It is usually found below the SIM socket and side of key board interface IC. Below this IC cover, there are 3 rows with 8 nodes. By making jumper, we can remove the problem of SIM faults.</p>	

Component	Image
<p>5. Keyboard interface IC: It is square in shape and blue in colour like SIM IC. Normally, it is larger than the SIM IC. It has 5 rows with node points above 20 (Keys Number).</p>	
<p>6. FM IC: It is square in shape. In nokia 2760, this IC stays below the vibrators. The function of this IC is to control the FM in mobile phones.</p>	
<p>7. Display Socket Track: This socket makes the connection between the display (LCD) and the motherboard. It is usually placed on the back side of the motherboard.</p>	
<p>8. Network amplifier: It is rectangular and comes with a metal cover. PF (Power Factor)/RF is written on it. Black in colour, it amplifies the outgoing signal of the mobile. If it is damaged, 'no access' symbol will come in display. At first, we have to re-solder it. If the problem is not solved, then it needs to be changed.</p>	
<p>9. LED (Light Emitting Diode) and LCD (Liquid Crystal Display): LED is a diode which is used on the light in the motherboard. It acts in forward bias. This diode is fabricated by the materials like As (Arsenic), Ga (Gallium), , etc. In case of mobile phones,, LED is present in keypad, display, etc. Actually LED transfers the electrical energy to light energy. Therefore, it is known as Light Emitting Diode. The full form of LCD is a Liquid Crystal Display.</p>	
<p>10. SIM socket: Black in colour and rectangular in shape, a sim socket has 6 pins. It is used for the purpose of contact as well as activated SIM card, Rejected SIM card, SIM card etc.</p>	
<p>11. SIM card: GSM mobile phones need a little microchip called the Subscriber Identity Module or SIM card, for functioning. The SIM card is about the size of a small postage stamp and is generally placed below the at the back of the unit. The SIM safely houses the service-subscriber key (IMSI) used to identify a subscriber on mobile telephony devices. The SIM card permits users to change phones by simply removing it from one mobile phone and inserting it into another one or broadband telephony device.</p>	

Component	Image
<p>12. Audio IC: It is the second largest IC in the mobile mother board. It is rectangular and has 48 to 60 pins. Some audio IC has more than 60 pins. The functions of speaker, microphone and ringer are almost dependent by audio IC.</p>	



Arrange and handle specific precision tools to mount the components / module without physical damage

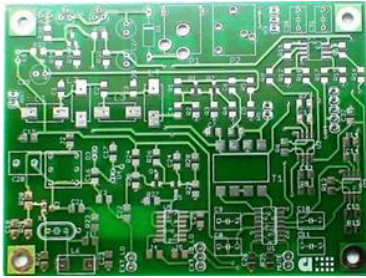

Proper care of specific precision tools are important while mounting the components of hardware. The guidelines that are there is in a generalised form:

- Measurement of the work piece must be carried out only after the work piece have stopped working or else there can be a wear out on the face of the work piece and the accuracy of the tool has to be sacrificed
- The measuring faces of the measuring tools must be wiped properly so that the measurement is not compromised for dirt and dust
- Precision tools should never be put together with the hand tools
- The precision tools must never be put near to any magnetic worktable to avoid getting magnetized
- Tools must be cleaned thoroughly after the use. Perspiration can be caustic that might slow down and affect the accuracy of the tools. Store them in dry place and never leave them outdoors

4.1.3 Modules for Assembling

The modules required to be assembled are described below with illustration:

Components and characteristics	Image
<p>Metal casing</p> <ul style="list-style-type: none"> • The metal casing or the metal case shelters the components of the computer • Usually it comes with its own set of connectors, cables and screws 	
<p>Power supply</p> <ul style="list-style-type: none"> • A regulated power supply is a circuit that has been embedded that converts the unregulated AC into constant DC • It is done by the help of a rectifier that helps to convert the AC to DC • Its function is basically to stable the voltage to the circuit that has to be operated within a specified amount of current or voltage • The output might be near to Direct Current or Dc • This type of stabilization is important so that the equipment remain stable within the various loads of current 	

Components and characteristics	Image
<p>PCBs</p> <ul style="list-style-type: none"> • A PCB provides a mechanical support and connects electrically electronic components • Making use of conductive tracks pads and other features that consists of one or more laminated copper of a non-conductive substrate • The parts are usually soldered onto the PCB to connect mechanically and electrically fasten it to them • Printed Circuit Boards or PCB are used in the simplest of electronic products and also simple electric products like passive switch boards • PCBs can be single, double or multisided • Single sided is one copper layer; double sided is two copper layers on both sides of a substrate layer; multi sided layer outer a and inner side of copper layers with alternating layers of substrate 	
<p>Fusers</p> <ul style="list-style-type: none"> • A fuser unit is basically a pair of heated rollers within the printer • Its work is to fuse the toner onto the paper printed on • The toner particles are pulled onto the paper for creating the desired text or images as the paper keeps passing onto the imaging drum • After the paper gets passed through the fuser assembly it is rolled out to the output tray 	

Central Processing Unit

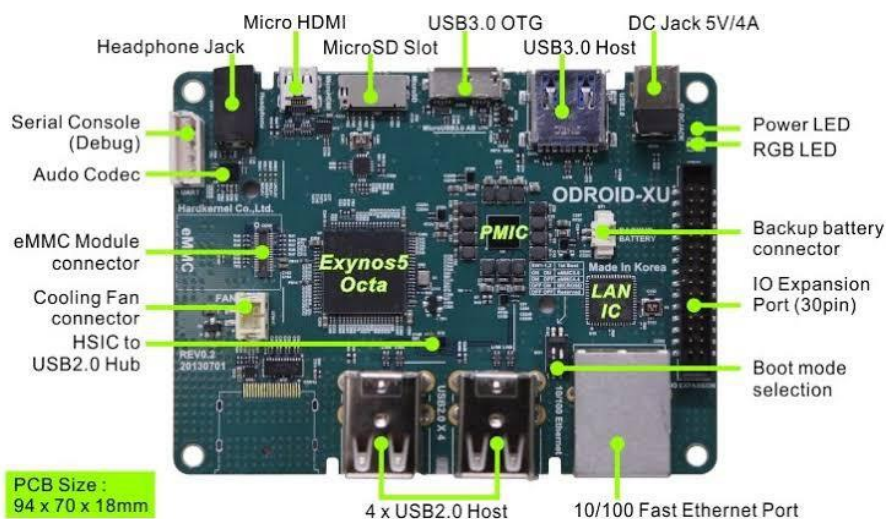








Fig 4.1.2: A sample central processing unit of handset

Hand phones comprise Central Processing Units (CPUs), similar to the CPUs in computers, but devised to perform in low-power surroundings.

Mobile CPU performance depends on the clock rate (in multiples of hertz) as well as the memory hierarchy that hugely determines the overall performance. Due to these problems, the performance of mobile phone CPUs is often more appropriately given by scores derived from various standardised tests to measure the real effective performance in commonly used applications.

Other Components

Component	Image
<p>Camera: Most new phones have a built-in digital camera (see camera phone), that can have resolutions as high as 38Megapixels. This leads to a few concerns about privacy, w.r.t possible voyeurism, for example in swimming pools.</p>	
<p>Recording System: Sound recording and video recording are also possible. Most people do not walk around with a video camera but do carry a phone. The arrival of video camera phones has now largely eliminated the need of carrying video cameras separately.</p>	
<p>Headphone: Headphones (or headphones in the early days of telephony and radio) are a pair of small listening devices that has been designed to be worn on or around the head over a user's ear. They are electroacoustic transducers, which convert an electrical signal to a corresponding sound in the user's ear.</p>	
<p>Mobile Case: Cases that are designed to attach, support, or hold a mobile phone, are popular accessories for many phones, especially mainstream smartphones.</p>	
<p>'System-on-a-chip' or SoC: The SoC is perhaps the most important component present in a smartphone, and some users might confuse it as being the processor of the device. However, it is far more than that; the SoC not only comprises up of the smartphone's CPU, but GPU (Graphics Processing Unit), LTE (Long Term Evolution) modem, display processor, video processor, and other bits of silicon that turn it into a functional 'system' in a phone.</p>	

Component	Image
<p>Modems: Since smartphones are just phones at the end of the day, they need communication components to receive and send text messages and calls. That's where modems come in, and every SoC manufacturer has their own brand of modems, and this includes Qualcomm, Samsung, Huawei and several others.</p>	

4.1.4 Steps of Replacing Accessories

Inserting Memory Card

- Step 1.** Switch off the device
- Step 2.** Open the back cover of the mobile phone pressing the slot at the top of the phone with the fingernail, then lift up the cover of the phone
- Step 3.** Disassemble the cover from the phone
- Step 4.** Now battery can be removed, however, removing battery is not mandatory, as it does not affect memory card insertion
- Step 5.** Insert the memory card properly, at the rear of the handset
- Step 6.** If the battery has been removed, replace the same
- Step 7.** Put back the case in its original place from the bottom



Fig 4.1.3: Inserting memory card

Removing the Memory Card

- Step 1.** To begin with, unmount the memory card from the handset by following the steps stated below:
 - Unlock the notification panel by swiping the screen of the mobile phone with the finger from up to down
 - Click "Settings"
 - Click "Storage"
 - Click "Unmount SD card"

- Click “OK”. Now the memory card has been successfully unmounted and it’s time to remove it

- Step 2.** Disassemble the back cover of the handset. To remove it, insert a finger in the slot at the top of the device, press it with the nail to let it come out
- Step 3.** Tap the memory card from the place of insertion. It will dismantle the mechanism that locks it with a clicking sound
- Step 4.** Hold it and remove it carefully from the handset
- Step 5.** Fix the back cover of the handset in its place
- Step 6.** Press the cover from down and along the edge of the handset until it is in the right position



Fig 4.1.4: Removing battery card

4.1.5 New Product Specifications

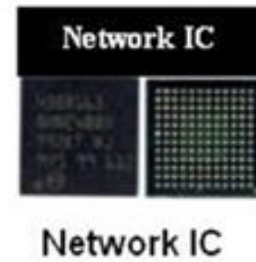
There are various parts and electronic components present in a cell phone. In order to learn how to repair a mobile phone, it is very important to identify its parts as well as functions. Initially, one needs to know that a PCB of a mobile is divided into two parts

- Network Section
- Power Section

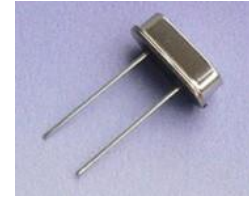
The important parts of a mobile phone and their functions:-

Parts	Image
<p>Antenna Switch- In case of GSM sets, it is available in white colour and in CDMA (Code Division Multiple Access) sets, it is available in golden metal. This searches network and proceeds after tuning. If there is any fault in the antenna switch, there would not be any network in the mobile phone.</p>	<p>Antenna Switch</p>
<p>P.F.O (Power Frequency Oscillator) – This is found near the Antenna switch of the PCB of a mobile in the Network Section. It is also known as Power Amplifier and Band Pass Filter. It strains and boosts network frequency in order to select the home network. If there is any fault in it, the mobile phone will not respond.</p>	<p>PFO</p> <p>PFO of a Mobile Phone</p>

Network IC – It is an electronic component that is found near the PFO (Power Frequency Oscillator) in the Network Section of the mobile phone. This is also known as RF signal processor. Network IC works as a broadcaster and receiver of audio and radio waves as per the instructions from the CPU. There will be a network issue in the phone in case there is a problem in the network IC.



26 MHz (Megahertz) Crystal Oscillator – This is found in the network section of a Mobile phone near the PFO. It is also known as Network Crystal. This creates frequency in times of outgoing calls. If there is any fault in this crystal, there will be no outgoing calls and there won't be any network in the mobile phone.



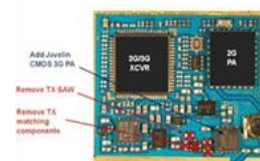
VCO (Voltage Controlled Oscillator)- In the network section of a mobile phone, VCO is found near the Network IC. It is meant for sending time, date and voltage to the RF IC/Hager as well as to the CPU as well. This also generates frequency from the CPU after taking the command. If any fault is identified in the VCO, the mobile phone will display "Call End" or "Call Failed".



RX Filter- This is available in the network section of the mobile phone. It strains frequency during incoming calls. If any fault is identified in it, there will be hindrances while taking the calls.



TX Filter- This is also available in the network section of a mobile phone. It helps to strain the frequency of the outgoing calls. If there is any problem in the TX Filter then there will be hindrances during the outgoing calls.



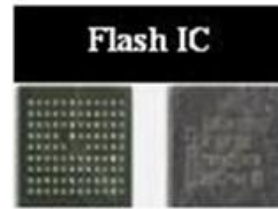
ROM (Read Only Memory)- This is available in the Power section of a mobile phone. It installs the current operating system within a mobile phone. If there is any problem in the ROM, there will be some software issues which will make the phone go dead.



RAM (Random Access Memory)- This is available in the Power Section of a mobile phone. It helps to send and receive commands of the operating system in a mobile phone. If there is any fault in the RAM, there is going to be software issues in the phone by frequently getting hanged. The mobile phone may also not respond at all.



Flash IC- This is available in the Power section of a mobile phone. Flash IC is also known as EEPROM (Electrically Erasable Programmable Read Only Memory) IC, Memory IC, RAM IC and ROM IC. All the software applications of the mobile phone are installed in the Flash IC. If there is any fault identified in it, the mobile phone may then not work properly. It might also get dead.



Power IC- This is available in the Power Section of the mobile phone. It is composed of many small components, especially the capacitor which is around IC. RTC (Real-Time-Clock) is also found near the Power IC. Power IC consumes power from the battery and it is supplied to the other parts of a mobile phone. If there is any fault in the Power IC, the phone set will not respond.



Charging IC- This is available in the Power Section near R22. It consumes current from the charger to charge the battery. If there is any fault found in the Charging IC, then the mobile phone cannot be charged.



RTC (Simple Silicon Crystal)- This is the Real Time Clock, which rests near the Power IC in the Power Section. It can be composed of either metal or may be non-metal and also has a long shape. This helps to display the date and time in the mobile phone. If there is any fault in the RTC, then the date and time will not be displayed in the mobile phone.



CPU- This is available in Power Section. It can also be referred as MAD IC, RAP IC and UPP. It is one of the largest ICs on the PCB of a mobile phone, which looks absolutely different from the other ICs. CPU helps to keep in control all the other sections of a mobile phone. If there is any fault in the CPU, then the mobile phone will not respond or it might get dead as well.



Logic IC/ UI IC- This can be observed in any section of the mobile phone. It is composed of 20 pins or legs. It can also be known as Interface IC. This controls the ringer, vibrator and LED of a mobile phone. If there is any fault observed, the ringer, vibrator and LED will not work.



Audio IC- This is found in the Power Section of a mobile phone and is also known as Cobba IC and Melody IC. It helps to control the Speaker and Microphone of a mobile phone. If there is any fault in the Audio IC, the speaker and the microphone of the mobile phone will not work.

6S audio IC
33831285



4.1.6 Common Charging Issues

- Charging Speed:** Over the past decade, cell phone manufacturers have standardised the micro-USB port for charging. With the standardised charging ports across most smartphones, it's become easier to find a spare charger. Apple's iPhone is an exception. iPhones use a distinctive charging port called "Lightning".

While a standard charging port has made it much easier to find an alternative charger, it's introduced some confusion with charging speeds depending on the charger and charging method used. With the wrong charger, a phone can take an incredibly long time to charge.

Mobile phone charging methods compare as follows:

Current	Voltage	Power	
0.5A	5V	2.5W	Charging from a computer (USB 2.0). If you're charging from a computer (USB 2.0 port), the maximum current it can provide is 0.5A. This is much slower than charging from the mains.
0.9A	5V	4.5W	Charging from a computer (USB 3.0). If you're charging from a computer (USB 3.0 port), the maximum current it can provide is 0.9A.
1A	5V	5W	Charging from the mains (most smartphones). Most smartphones come with a 1A charger.
2A	5V	10W	Charging from the mains (tablets). Many tablets, including the iPad, require a 2A charger. Some smartphones can also use a 2A charger (e.g. Samsung Galaxy Note II).

- Thing to remember:** Check the charger that you're using: it'll tell you the output voltage and current. The charger on the left outputs 1A of current whereas the charger on the right outputs 2A of current (image given below). To get the best charging speeds, make sure you're using a charger that's suitable for your phone.



- Prolonging Lifetime of Battery:** Batteries have a limited lifetime: they're only good for a certain number of charge cycles. In case of Nickel-Cadmium batteries, used in old days, it was necessary to drain the entire charge out before recharging it. However, the recommendation is not applicable to the modern smartphones, which contain Lithium-ion batteries.

With a lithium-ion battery, lifetime is prolonged by topping up the phone's charge on a frequent basis. According to the Battery University, a person who drains their battery fully often before recharging will only procure 300-500 charge cycles from the battery. If one has to charge phone every time the charge fall below 50%, this would increase the charge cycles to 1200-1500. By charging a handset on regular basis, the number of charge cycles can be increased.

Depth of Discharge	Number of Charge Cycles
10% (drain to 90%, then recharge)	3,750 – 4,700
25% (drain to 75%, then recharge)	2,000 – 2,500
50% (drain to 50%, then recharge)	1,200 – 1,500
100% (drain fully then recharge)	300 – 500

3. Wastage of Power and Money: It has been scientifically proved that if a charger is plugged in without a phone attached to it, it consumes power. As a result, it increases electricity bill. Thus, it is advisable to put off the switch from the wall if phone is completely charged.

4. Portable Chargers: Portable chargers and alternative battery pack increases the longevity of a charge cycle. In case of a trip, one can use either of the two.

Portable chargers are commonly known as power banks which provide charge to the cell phones without the requirement traditional wall switches. Extra battery packs are replaceable battery packs which users can insert to the battery slot if the existing battery pack is drained out.

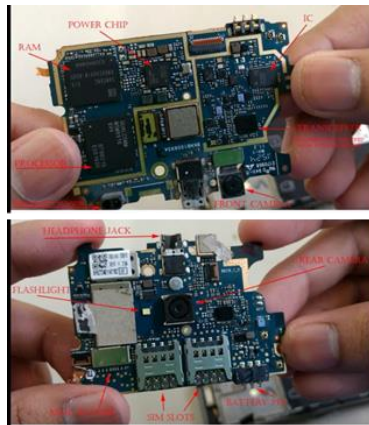


Fig 4.1.5: Different parts of a mobile phone PCB

4.1.7 Cell Phone Frequencies

Frequency Hopping: In frequency hopping systems (FHS), the transmitter alters the frequency of the carrier according to a certain “hopping” pattern. The benefit is that the signal goes through a different set of interfering signals and a different channel during each hop. This avoids the issues of failing communication at a particular frequency, because of a fade or a particular interferer.

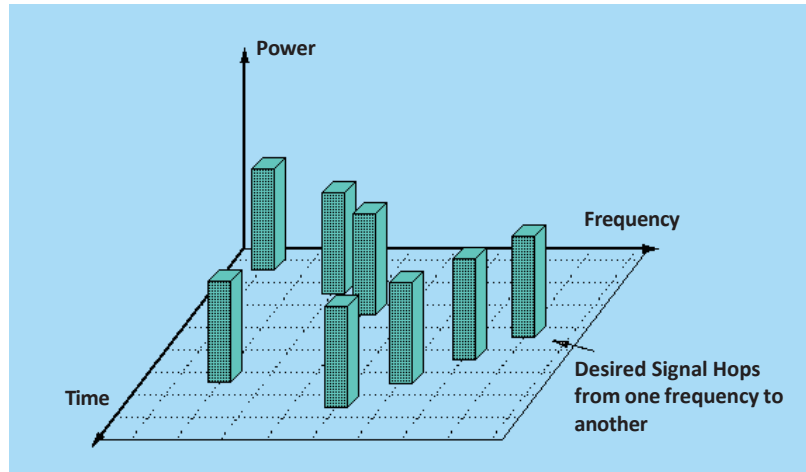


Fig 4.1.6: Frequency Hopping

There are two types of frequency hopping:

Slow Frequency Hopping (SFH): In the case of SFH, one or more data bits are transmitted within one hop. A benefit of this is that coherent data identification is possible. Often, systems exploiting slow hopping engage (burst) error control coding to restore loss of bits in one hop.

Fast Frequency Hopping (FFH): In the cases of FFH, one data bit is divided over multiple hops. In fast hopping, coherent signal identification is difficult, and used lesser than SFH.

- SFH is a widely used technique for wireless LANs
- In GSM, SFH can be used, at the discretion of the network control software

Here is a table for the different frequency bands in India for mobile technology 2G, 3G and 4G:

S.N	Mobile Technology in India	Frequency bands in India	Major Operators
1	GSM (2G)	900 MHz, 1800 MHz	Airtel, Idea Vodafone, Aircel, BSNL
2	CDMA	850 MHz	Reliance, BSNL, Tata
3	WCDMA (Wideband Code Division Multiple Access) (3G)	2100 MHz, 900 MHz	Airtel, Idea Vodafone
4	WiMAX (Worldwide Interoperability for Microwave Access)	2300 MHz	BSNL
5	4G (4th Generation) LTE (4G)	1800MHz	Airtel, Idea Vodafone, Jio
		850 MHz	Jio
		2300 MHz	Airtel, Idea Vodafone, Jio

4.1.8 Handling Components and Modules

There is a recognised handling and storage method of components used in assembling; it is discussed in the table below

Handling and storage methods

- Circuit board assemblies must be handled at areas that are designated properly
- All the designated areas must be checked thoroughly and periodically
- Areas of main concern would be:
 - Ensuring of proper methods of grounding
 - Proper static dissipation of floor
 - Operation of the ion blowers and the air guns
 - Proper static dissipation of work surfaces
- The designated work areas must be kept free of the materials that produce static energy like vinyl, plastic and fabrics
- There must not be any smoking or eating in the work area in order to avoid contamination of the assembly of the circuit
- When work is not in progress then sensitive components and circuit boards must be enclosed in bags and boxes that is shielded
- The assembler must be properly grounded during working with the ESD components
- All the circuit board assemblies must be handled in edges avoiding to touch the component leads
- Stacking of the boards must be avoided in order to get rid of physical damage trays and racks must be used instead for handling
- Special lotions that avoid contamination of the circuit board must be used

Surface Mount Components (SMT)

Defining SMT Devices

The majority of commercial electronics cover complex circuitry fitting in minute spaces. To perform this, components require being directly mounted onto the circuit board. This is called surface mount technology.

SMDs or Surface Mount Devices are tools that use surface mount technology. The components used are fabricated particularly to be soldered directly to a board rather than wired between two points. There are three main categories of SMT components:

- Integrated Circuit
- Passive SMDs
- Transistor
- Diode

Advantages of SMT

- The advantage of SMT is to allow soldering and automated production. This is time-saving, less-expensive and also permits more consistent circuit
- Lesser number of holes require to be drilled on circuit boards
- Costs are quite lower than the equivalent parts of the through-hole
- Both sides of a circuit board can have components placed on them
- SMT components are smaller in size

- The component density is higher in SMT
- Better performance under vibration and shake conditions

Passive SMDs (Surface-Mount Devices): Passive SMDs are resistors or capacitors that build the major bulk of the SMDs. The package sizes for passive SMDs are standardised while the other components include coils and crystals.

Integrated Circuits: An integrated circuit (IC), also known as a microchip or chip, is a semiconductor wafer on which tiny capacitors, resistors, and transistors are attached. An IC can function as an oscillator, timer, amplifier, computer memory, counter or microprocessor.

Transistors and Diodes: Diodes and Transistors are often found in a small plastic package. Leads form connections and touch the board. Such packages make use of three leads.



Fig 4.1.7: SMD or Surface Mounted Devices are essential part of modern technology

There are several different sizes available - physical sizes are shown below:-

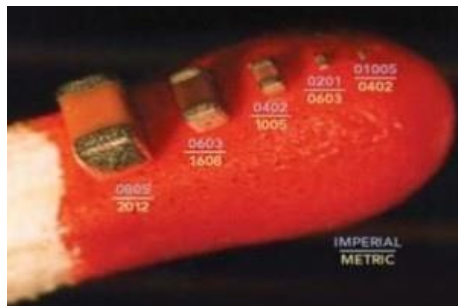
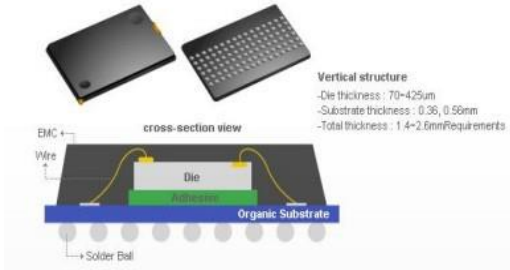

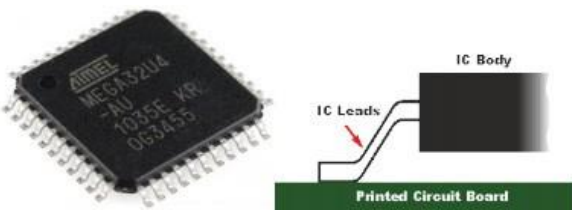



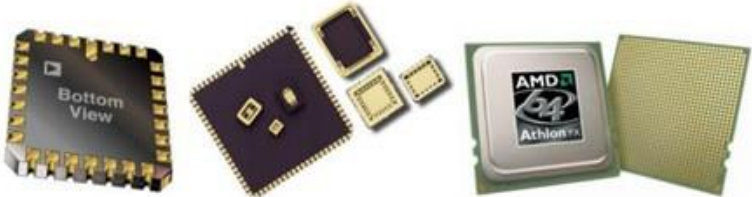

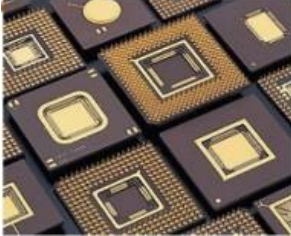



Fig 4.1.8: SMT component packages table and sizes in mm

Various IC Packages

Type of IC Package	Image
BGA or Ball Grid Array	<p>The image contains three parts: a 3D diagram of a BGA with flip-chip showing labels for 'Flip-Chip solder balls', 'Underfill', 'Silicon Device', 'BGA Substrate', 'BGA solder balls', and 'Printed Wiring Board'; a photograph of a BGA component held by blue gloves; and a photograph of a BGA component next to a ruler.</p>

Type of IC Package	Image
<p>PBGA or Plastic Ball Grid Array</p>	 <p>Vertical structure: -Die thickness : 70-425µm -Substrate thickness : 0.36, 0.58mm -Total thickness : 1.4-2.6mm Requirements</p>
<p>SOP or Small Outline Package</p>	
<p>TSOP or Thin Small Outline Package</p>	
<p>Thin Quad Flat Pack IC Package</p>	
<p>BQFP or Bumpered Quad Flat Pack</p>	
<p>SOJ or Small Outline J-lead</p>	

Type of IC Package	Image
LCC or Leadless Chip Carrier	
PLCC or Plastic Leaded Cheap Carrier	
PGA or Pin Grid Array Package	
LGA or Land Grid Array Package	

UNIT 4.2: RF Measurement

Unit Objectives

At the end of this unit, you will be able to:

1. Analyze the Radio Frequency measurement process
2. Discuss the equipment related to RF measurement

4.2.1 Radio Frequency (RF) Measurement Parameters

Rx Level and Rxquality: Full form of Rx Level is Receiver Level. Rx Level implies to the Strength of Signal that a mobile phone receives from a BTS (Base Transceiver Station) or commonly termed as mobile tower.

The mathematical formula to calculate Rx Level is:

Rx Level = EIRP (Equivalent Isotropically Radiated Power) – Path Loss

The unit to measure Rx Level is dBm or decibel-milliwatt.

- It is calculated by the power referenced to one milliwatt (mW).
 - Its value is $10 \times \log [P(W) / 1mW]$
1. **EIRP:** ERIP stands for Effective/ Equivalent Isotropically Radiated Power. It refers to the amount of power that an antenna (which evenly distributes power in all directions) would radiate to generate the peak power density observed in the direction of maximum antenna gain.
 2. **Path Loss:** Path Loss refers to the distance between the source of the signal and the antenna (where the signal gets captured). In technical terms, the source of the signal is called as the transmitting point of the signal and the antenna is the receiving point of the signal. The distance between the receiving and transmitting points of the signal is inversely proportional to the strength of the received signal. More is the path loss, less is the signal strength.

Path Loss ~ 1/ Signal Strength

The numeric value of Path Loss is always greater than the numeric value of the ERIP. Therefore, the Rx Level is always a negative value.

For example,

Path Loss = 25 decibel

EIRP = 15 decibel-milliwatt

Rx Level = EIRP – Path Loss = 15 – 25 = -10 decibel-milliwatt

Rxquality is the average quality of the signal strength coming from the serving cell. Rxquality is calculated all time slots and the subset of the time slots. In case of hopping, the numeric value of Rxquality should be less than 5 and without hopping, it should be less than 4.

Click/Scan the QR code for understanding RF in detail



C/I: C/I stands for Carrier over Interference ratio. In other words, the ratio between the level of the signal strength (of the serving cell) and the signal strengths of the impedimental components is known as C/I. In the Path Loss, there will be various other components emitting an array of signals which are considered as interference to the main signal.

Generally, C/I is updated in every two seconds.

- Good C/I output: 25 to 15
- Fair C/I output: 15 to 9
- Bad C/I output: anything less than 9

SQI: SQI refers to the Speech Quality of a call. It reflects the quality of speech (as opposed to radio environment conditions). SQI is the parameter to check when troubleshooting the quality of speech of a call under question.

SQI is updated in every 0.5 second.

- Good SQI output: 18 to 30
- Bad SQI output: 0 to 18

RSCP denotes the Received Signal Code Power, which is the strength of a signal received by a receiver from a specific physical communication channel. It indicates the signal strength of a signal and helps to measure the Path Loss of that particular signal. RSCP is often termed as Receiver Side Call Power.

Ec/No (Energy per chip over the noise spectral density) indicates the clarity and quality of a signal from the cell tower to the handset or modem. It is measured as signal-tonoise (the ratio between the good/ received signal and the bad/ interference signal). The unit of measurement of Ec/No is decibel.

Ec/No = Received Signal Strength/ Interference Signal strength

In a perfect (arbitrary) scenario, where no interference occurs in the path loss, the numerical value of the Ec/ No is 0 decibel. However, this is an ideal scenario and mostly hypothetical. If the value of the Ec/ No is more than 7 decibel, the connection or the quality of the signal is considered to be poor.

Factors that can affect Ec/ No are:

- Buildings
- Walls
- Power supplies
- Shortened connectors
- Inaccurate antenna alignment
- Wrong antenna polarization
- Florescent lighting
- Electric motors
- Bad/poor cabling
- Trees
- Hills
- Congestion at the tower

RSRP stands for Reference Signal Receiver Power. RSRP is also measured in decibel-milliwatt. The mathematical formula to measure RSRP is:

$$\text{RSRP (dBm)} = \text{RSSI (dBm)} - 10 * \log (12 * N)$$

Where,

- RSSI implies to Received Signal Strength Indicator
- N implies to the number of RBs across the RSSI

RSRP is the most fundamental of the handset's physical layer measurements and is the linear average power of the downlink reference signals (RS) across the channel bandwidth for the Resource elements that bear cell specific Reference Signals.

Knowledge of absolute RSRP offers the UE with vital information about the strength of cells from which path loss can be measured and used in the algorithms for obtaining the optimum power settings for managing the network. RSRP is used both in idle and connected states.

Range of RSRP value: -44dBm to -140dBm

RSRQ stands for Reference Signal Receive Quality. RSRQ is measured in decibel. The mathematical formula to measure RSRP is:

$$\text{RSRQ} = \text{RSRP} / (\text{RSSI} / \text{N})$$

Where,

- N is the number of resource blocks over which the RSSI is measured
- RSSI is wide band power, including intra cell power, interference and noise

It offers the Indication of Signal Quality. Measuring RSRQ becomes specifically important near the cell edge when decisions ought to be taken, regardless of absolute RSRP, to carry out a handover to the next cell. RSRQ is used only during connected states.

Range of RSRQ value: -3 to -19.5 dB

SINR stands for Signal to Noise Ratio. The mathematical formula to measure SINR is:

$$\text{SINR} = S / I + N$$

Where,

- S = Average Received Signal Power
- I = Average Interference power
- N = Noise Power

SINR is a way to calculate the Quality of LTE Wireless Connections. As the energy of signal dissolves with distance i.e. Path Loss due to environmental impediments (e.g. interfering strength of other simultaneous transmission, background noise etc.)

PCI implies to Physical Cell Id. PCI identifies the cell and is used transmits the data. The mathematical formula to measure PCI is:

$$\text{PCI} = \text{PSS} + 3 \times \text{SSS}$$

Where,

- PSS implies to Primary Synchronization Signal (Identifies Cell Id)
- PSS value can be 0, 1 and 2
- SSS is Secondary Synchronization Signal (identifies Cell Id group).
- SSS value can be 0 to 167

The ideal range for PCI is: 0 to 503

4.2.2 Important Telecommunication Links

Uplink:

- The uplink in case of radio communication (UL or U/L) is a feeder link segment used for signal transmission from an earth station to a space-based radio system, a space-based radio station, or high-altitude platform stations
- In the case of the GSM and the cellular networks, the radio uplink is considered to be the transmission path from the mobile station to a base station

Downlink:

- In the field of the radio communication service, a downlink (DL or D/L) is the segment of a feeder link used for the transmission of signals from a space radio system, a space radio station, or high altitude platform stations to an earth station
- In the case of cellular networks, the radio downlink is the transmission path from a cell site to the cell phone

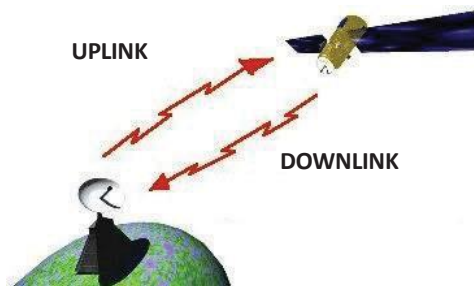






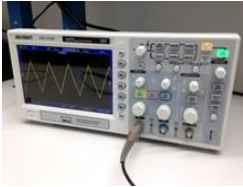
Fig 4.2.1: An illustration of uplink and downlink

Forward Link:

- A forward link is referred to the link from a fixed location (i.e. a base station) to a mobile user
- If the link contains a communications relay satellite, the forward link will be comprised of both a downlink (satellite to the mobile user) and an uplink (base station to the satellite)

4.2.3 Equipment for RF Tests

Equipment Required for RF Tests

Tool	Application	Image
Network Analyzer	<p>A network analyzer (also called a protocol analyzer or packet analyzer) is a combination of programming and hardware, or in a few cases a stand-alone hardware device, which can be installed in a network or computer to improve protection against malicious activity.</p>	
Spectrum Analysers	<p>A spectrum analyzer is a device that is capable of displaying signal amplitude (strength) as it varies with signal frequency. The frequency appears on the horizontal axis while the amplitude is displayed on the vertical axis.</p>	
Signal Generators	<p>A signal generator is an electronic instrument, which produces repeating or non-repeating electronic signals in both the analog and the digital modes. It is popularly used in testing, designing, troubleshooting, and repairing electronic or electroacoustic devices.</p>	
Power Meters	<p>Power meter is a device that measures the amount of electric energy consumed by a residence, a business, or an electrically powered device.</p>	
Oscilloscopes	<p>An oscilloscope is an instrument used to display and analyse the waveforms of electronic signals. The device draws a graph of the instantaneous signal voltage as a function of time.</p>	

Summary

- Kitting- this is more or less like assembling. It is a process where the individual separates the tools, but usually all the related items are packed, grouped and finished together as one unit
- bills of materials, is a well-rounded list that not only contains the raw materials but also a list of assemblies, raw materials, sub- assemblies, quantity, parts and component needed to construct an equipment or machine
- Basically BOM depends exactly on what kind of equipment is being manufactured. But basically BOM is of two types- one is when the equipment is getting engineered for the manufacturers, and the other one is when the product has been shipped and rolled out for the customers
- Components are the list of items needed for the various processes to make a product
- Full form of Rx Level is Receiver Level. Rx Level implies to the Strength of Signal that a mobile phone receives from a BTS or commonly termed as mobile tower
- ERIP stands for Effective/ Equivalent Isotropically Radiated Power
- Path Loss refers to the distance between the source of the signal and the antenna (where the signal gets captured)
- The distance between the transmitting and the receiving points of the signal is inversely proportional to the strength of the received signal
- Rxquality is the average quality of the signal strength coming from the serving cell
- C/I stands for Carrier over Interference ratio. In other words, the ratio between the level of the signal strength (of the serving cell) and the signal strengths of the impedimental components is known as C/I
- SQI refers to the Speech Quality of a call. It reflects the quality of speech (as opposed to radio environment conditions)
- RSCP denotes the Received Signal Code Power, which is the strength of a signal received by a receiver from a specific physical communication channel
- Ec/No indicates the clarity and quality of a signal from the cell tower to the handset or modem
- RSRQ stands for Reference Signal Receive Quality

Activity

1. Calculate the Rx level of a signal that has a path loss of 45 decibel and EIRP value of 23 decibel-milliwatt.
2. Calculate the signal to noise ratio based on:
 - a. average received signal power = 15
 - b. average interference power = 6.5
 - c. noise power = 7

Exercise

Choose the correct option from the list of responses to answer the following questions:

1. Unit of Rxlevel is –
 - a) Decibel
 - b) Decibel-milliwatt
 - c) Milliwatt

2. If the Path Loss is increases, the Strength of Signal should –
 - a) Increase
 - b) Decrease
 - c) Will not be affected

3. If Path Loss is 30 decibel and ERIP is 18 decibel-milliwatt, the strength of signal will be –
 - a) 12 decibel-milliwatt
 - b) -12 decibel milliwatt
 - c) 48 decibel milliwatt

4. SQI is updated in every –
 - a) 1 second
 - b) 0.5 second
 - c) 1.5 second

5. If the C/I strength is less than 9, the quality of the signal is considered to be –
 - a) Good
 - b) Fair
 - c) Bad

6. Full form of RSSI is –
 - a) Reverse Signal Strength Interferences
 - b) Received Signal Strength Interference
 - c) Received Signal Strength Indicator

7. The ideal range for PCI is –
 - a) 0 to 503
 - b) 100 to 503
 - c) 0 to 203

8. Uplink sends signal –
 - a) from a space radio system to an earth station
 - b) from an earth station to a space radio system
 - c) from a space radio system to another space radio station

9. Which of the followings denotes the physical identity of a handset?
 - a) ERIP
 - b) PCI
 - c) Ec/No

10. Which of the following tools measure the waveform of the electronic signals?
 - a) Spectrometer
 - b) Signal Generator
 - c) Oscilloscope



5. ESD Safe Procedures and Practices

- Unit 5.1 - ESD and Its Effects on Electronic Components
- Unit 5.2 - Classification of ESD Materials
- Unit 5.3 - ESD Safety Procedures
- Unit 5.4 - Levels of Electrostatic Voltage Generation
- Unit 5.5 - Grounding



Key Learning Outcomes



At the end of this module, you will be able to:

1. Analyze the basic concept of ESD (Electrostatic Discharge) and its effects
2. Evaluate the classifications of ESD materials
3. Identify the documents that refer to ESD safety in workplace
4. Evaluate the relevance of safe handling, storage of assembly/ sub-assembly
5. Evaluate the generation of electric voltage in shop floors during production
6. Analyze the grounding and various other methods used for grounding

UNIT 5.1: ESD and Its Effects on Electronic Components

Unit Objectives

At the end of this unit, you will be able to:

1. Analyze the basic concept of ESD and its effects

5.1.1 ESD Fundamentals

We go through occurrences of static electricity daily. For instance, walking on a carpeted in a heated/warm room during winter produces sufficient static electricity.

Although this sudden discharge of static electricity does not result in any harm to the human body, it can cause heavy damage to electronic equipment as they are sensitive to electrical discharge (ESD). It may happen that electronic equipment to get damaged by electrical charges that is imperceptible to us.

Certain components are very sensitive to static electricity that can definitely destroy the component. Static charges are created when there is a separation of non- conductive materials friction between synthetic clothes, combing your dry shampooed hair for a long period of time during winter sparks up static electricity is called Electro static Discharge (ESD)

- Destructive static charges are followed on nearby conductors like human skin that develops a spark when the surface of the printed board is touched by a person who has developed a static charge
- If the board is touched at the right solder joint, the circuit board will be damaged because of the discharge of the static electricity. It is damaged because it passes through a conductive pattern to a component which is static sensitive
- It is very important to note that, this is not felt by human beings, as it is less than 3,000 volts(the static level of damage of components)
- Apart from designing the circuit correctly for suppression of ESD the layout and the design of PCB (Printed Circuit Board) is also important, as it will save money later if it is ensured that the ESD is according to the layout of the PCB as there will be no costly debugging

There are guidelines to ensure that the PCB design will be able to reduce the problem of the ESD to the minimum range.

Guidelines	Steps/ procedure
Removing of circuit loops	<ul style="list-style-type: none"> • Unwanted current is risen, from loops in a line that arises from induction • The performance level is picked up from unwanted pick up of current • For general protection of ESD it is important because unwanted increase of current hence voltage is evoked in the loops • Ultimate care must be taken so that current cannot be induced into loops and that no loops is existing

Click/Scan the QR Code for
ESD Basics



Guidelines	Steps/ procedure
Utilising the ground plane layers in the Printed Circuit Board(PCB)	<ul style="list-style-type: none"> • One way of reduction of ground loop is by using a ground plane layer in the designing of the PCB • This ensures and enables that any signals shall be effectively grounded so that there is no chance of ground loops
Reduction of line lengths	<ul style="list-style-type: none"> • Any kind of wire acts as an antenna and has the capacity of receiving high spikes of voltage, with the very short rise of voltage spike • If the line lengths are reduced then, the level of energy that is received is reduced and the spikes resulting from lower electrostatic discharge shall be lower
Reduction of parasitic induction around protection circuits	<ul style="list-style-type: none"> • Many electronic circuits are induced with ESD protection circuits • These can only result effectively if the induction of parasite is kept low • It is possible to keep it low(parasitic induction) arising from the design of the PCB, if the length of the line is short, keeping the width of the track broad • Conductors of measurable dimensions that is moving through a magnetic field which is uniform; or stagnant under a magnetic field that is changing shall have current generated within them • Inductive coils specifically uses magnetic cores to lessen the parasitic induction within them
Prevent running of the sensitive tracks near PCB	<ul style="list-style-type: none"> • As current pick up shall be close to the circuit area it is very wise to keep away the sensitive lines or tracks from this area • The input and the output lines will have to join the edge of the PCB at some stage, but it must be routed away where ever possible

Application of the correct guidelines of preparing the ESD for the layout or designing the PCB is important during the assembly, that will ensure it to be resilient to any voltage or current discharge that might occur. Applying the ESD design at the earliest of stages, saves a lot of money for not having to rework or redesigning

List the number of components and modules received from the stores and take sign off from stores department-

A receipt is an acknowledgment which is documented, that something valuable has been transferred from one person to another. It is typically received by the customer for the service that has been rendered to them. There must be an invoice even from the stores department.

Invoices must include:

- The word invoice must be written clearly on the document. And it must specifically contain all these information
- The company's name, address and contact number must be provided
- The unique identification number of the company
- The name of the company and their address for whom the invoicing is taking place
- The date on which the goods were supplied to the company
- List of the components that has been supplied
- A clear detailed description for what is being charged
- The amount of charge must be clearly mentioned
- Date of the invoice
- The GST (Goods and Services Tax) that is applicable
- The amount that is owed in total

Sole trader invoice- a sole trader invoice must include these things:

- Name of the individual person or the name of the company if any
- A particular address where any document whether legal or not can be delivered perfectly

Limited company invoices- A limited company invoice must include the invoice must contain the name of the company as it is on the certificate of incorporation. The names of all the directors must be present too, if there is a mention of the directors name

TECH(S):8273	18.00
Parts of Motorcraft	
er, Multi-Point	
eck, Brake	
axes, diesel	
battery test	
-----UNIT PRICE-----	
0	6.99
E	3.09
JOB # 1 TOTAL PARTS	25.53
JOB # 1 TOTAL LABOR & PARTS	43.53
-----TECH(S):8273-----	0.00
D.	
ICLE AND PROVIDE A	
LEVELS, INSPECT	
AND BRAKE WEAR,	
LEAKS AND DAMAGE.	
-----UNIT PRICE-----	
JOB # 2 TOTAL PARTS	0.00
JOB # 2 TOTAL LABOR & PARTS	0.00
-----CONTROL NO-----	3.99
TOTAL - MISC	7.98

STATEMENT OF DISC
The factory warranty c
all of the warranties wi
to the sale of this it
The Seller hereby exp

Fig 5.1.1: Sample invoice it will differ according to list and components

There are six principles of static control and six key elements of ESD to be focus:

1. Design assemblies and products to be reasonable and robust from the effects of ESD.
2. Describe the level of control required in the environment.
3. Define and identify the electrostatic protected areas (EPAs), the areas one needs to handle ESD sensitive parts (ESDS).
4. Decrease the generation of electrostatic charge by reducing and eliminating static generating processes, keeping processes and items at the same electrostatic potential, thus enabling proper ground paths to decrease charge generation and build-up.
5. Neutralize and dissipate by proper ionization, grounding, and the usage of dissipative and conductive static control materials.
6. Protect items/ tools from ESD with accurate shunting or grounding and the usage of static control packaging.

ESD can cause permanent damage to the component it is important to follow certain rules to avoid it

- All components must be kept in antistatic bags till the time the assembler is ready to install the components
- Make use of the grounded mats while on the workbenches.
- Make use of grounded floor mats including the work areas.
- Make use of antistatic wrist straps while working on the computer system

UNIT 5.2: Classification of ESD Materials

Unit Objectives

At the end of this unit, you will be able to:

1. Evaluate the classifications of ESD materials

5.2.1 Classifying ESD Materials

To control ESD, materials are categorized by how quickly electricity passes through the material. The speed is implied as the “resistance” of the material i.e. how firmly the material prevents charge movement.

The speed is measured in Ohms and is typically displayed in powers of 10 (example 10^3). The lower the number, the more conductive the material and may be considered “Antistatic”.

Classification	Charge Movement	Description	Resistance	Ohms	Is it Antistatic?
Conductive	Very Fast	Conductive materials: With a low magnitude of electrical resistance, electrons pass smoothly through the surface or across the bulk of these materials. Charges go to another conductive object or to ground that the material comes close to or contacts. Conductive materials have a surface resistivity a tick less than $1 \times 10^5 \Omega/\text{sq}$. Conductive materials are categorized as “Antistatic”.	Low Resistance	$10^3 - 10^5$	Yes
Dissipative	At a controlled speed. Fast but Slower than Conductive	Dissipative materials: For dissipative materials, the charges slowly pass through the material in a more controlled manner than that of conductive materials. Dissipative materials possess a surface resistivity greater than or equal to $1 \times 10^5 \Omega/\text{sq}$ and less than $1 \times 10^{12} \Omega/\text{sq}$. Dissipative materials are categorized as “Antistatic” and are accounted as the ideal range for ESD materials.	Medium Resistance	$10^6 - 10^{10}$	Yes

Classification	Charge Movement	Description	Resistance	Ohms	Is it Antistatic?
Insulative	Slow or No Movement	Insulative materials: These materials limit or prevent the flow of electrons across their surface or through their volume. Insulative materials exhibit a high electrical resistance and are hard to ground. Static charges stay in place on such materials for a very long time. Insulative materials are those with a surface resistivity of at least $1 \times 10^{12} \Omega/\text{sq.}$ or a volume resistivity of $1 \times 10^{11} \Omega\text{-cm}$ (minimum). Insulative materials cannot be classified as "Antistatic".	High Resistance	$10^{11} - 10^{12}$	No

Anti-Static: It is a term used to describe materials that prevent the build-up of static electricity. Both conductive and dissipative materials are classified as Antistatic. Insulative materials are not.

Typical Static Charge Sources:

Source	ESD Producing Material
Work Surfaces	<ul style="list-style-type: none"> Waxed, painted or varnished surfaces Untreated vinyl and plastic Glass
Floors	<ul style="list-style-type: none"> Sealed concrete Waxed or finished wood Floor tie and carpeting
Clothes and Personnel	<ul style="list-style-type: none"> Non ESD smocks Synthetic material Non-ESD shoes Hair
Chairs	<ul style="list-style-type: none"> Finished wood Vinyl Fibreglass Non-conductive wheels

Source	ESD Producing Material
Packaging and Handling Materials	<ul style="list-style-type: none"> • Plastic bags, wraps, envelopes • Bubble wrap • Foam • Styrofoam • Non-ESD totes, trays, boxes and parts bin
Assembly Tools and Materials	<ul style="list-style-type: none"> • Pleasure sprays • Compressed air • Synthetic brushes • Heat guns and blowers • Copiers and printers

Typical Static Voltage Generation:

Source	10-20% Humidity (in Volts)	65-90% Humidity (in Volts)
Walking on carpet	35000	1500
Walking on vinyl flooring	12000	250
Worker at a bench	6000	100
Vinyl envelopes (work instruction)	7000	600
Plastic bag picked up from the bench	20000	1200
Work chair with foam pad	18000	1500

UNIT 5.3: ESD Safety Procedures

Unit Objectives

At the end of this unit, you will be able to:

1. Evaluate the relevance of safe handling, storage of assembly/ sub-assembly

5.3.1 Safe Cleaning Practices

The various materials to be used by the housekeeping staff for cleaning are:

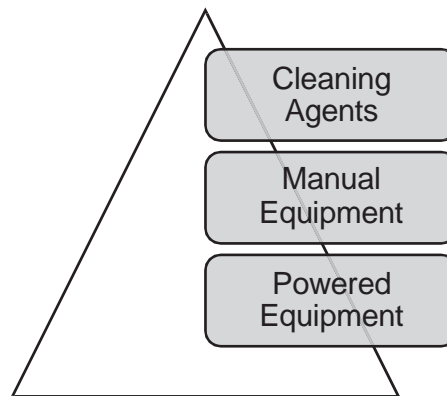


Fig. 5.3.1: Cleaning process

A. Cleaning Agents

- **Solvents**
 - A solvent is a liquid that is capable of dissolving a liquid or solid solute, producing a solution
 - Water is the widely used solvent in daily life
 - Water can also dilute any cleaning solution for ease of usage
 - Warm water dissolves solutes such as soap faster than cold water
- **Detergents & Soaps**
 - Soaps and detergents are used as cleaning objects because pure water cannot remove organic soiling or oily particles
 - Soap is one of the rare objects that allow water and oil to mix so that rinsing can take care of the removal of the oily grime
 - Detergents, in terms of properties, are similar to soap. However, they are less likely to form soap scum and are not hugely impacted by the presence of mineral particles in hard water
 - Detergents to be used depend on:
 - ◆ Material to be cleaned
 - ◆ Cleaning equipment to be used
 - ◆ Type of dirt
- **Liquid Cleaning Agents**
 - Liquid cleaning agents can be either diluted in water or used directly with a dry cloth.
- **Washing Soda**
 - It is useful for emulsifying grease on drainpipes, gutters or stone surfaces.

- In strong concentration, it could be an irritant and injurious to skin, fabrics brushes, wood and paint.
- Washing soda is useful as a water softener.
- **Soda bars, Powders and Flakes**
 - In recent days, normal soaps have been substituted by excellent synthetic soap which comprises less detergents and less affected by hard water
 - They give lather promptly
 - They should be made thoroughly dissolved in water
 - Should be used in right proportion and concentration for best outcomes
 - Should be kept or stored on open shelves in a dry storage area
- **Acid**
 - Acids are used to remove metal stains
 - Lemon and vinegar are used to remove the tarnish of brass and copper
 - Resistant water stains is removed with stronger acids such as hydrochloric acid or oxalic acid
 - This should be used under experienced and strict supervision to avoid risks
- **Alkali**
 - Sodium hydroxide, ammonia and caustic soda are alkalis and are used as stain removal agents and grease emulsifiers
 - Strong alkaline cleaning agents based on liquid or caustic soda in flakes are available for the cleaning of large industrial equipment, and blocked drains
 - Extreme care is to be taken in their use as they are very strong and are highly corrosive.
- **Absorbents**
 - These perform the cleaning action by absorbing the stain or grease; for example starch, French chalk powders, and besan or gram flour.
 - Their constituents may differ and many are of vegetable origin.
 - Unlike abrasives, they are not manufactured.
- **Toilet Disinfectants & Antiseptics**
 - Disinfectants & Antiseptics are not strictly cleaning agents but are often used during cleaning operations.
 - Disinfectants kill bacteria.
 - Antiseptics prevent bacterial growth.

B. Manual and Powered Equipment

Manual cleaning tools and equipment are operated by hands while Powered equipment are connected to a power supply or battery.

- Funnel
- Rubber Spatula
- Floor Mop
- Bowl Swab
- Plastic Caddie
- Spray Bottle
- Cobweb Cleaner
- Dry Vacuum Cleaner (Commercial)
- Suction Dryer
- Dust Pan and Brush

- Bucket and Mug
- Squeegees
- Scrubbing Brush
- Sponge
- Scraper

5.3.2 Safe Handling and Storage

Uses of Personal Protective Gear

- Personal Protective Equipment, commonly termed as PPE, is specialized clothing or equipment worn and used by employees for safeguarding themselves against Occupational Health and Safety hazards.
- Such clothing are aimed at protecting different parts of the body, like hands, eyes, ears, face, feet, head etc.

Here is a table of personal protective equipment that are widely used.

- **Hand Gloves** – Used for protecting the hands from harmful and corrosive chemicals, extreme temperatures, sharp and contaminated objects. For example, Nitrile gloves are used for protecting the hands against solvents, oils, greases, tar, acids and alkalis. Gloves made of natural rubber or Latex are used for protection against contaminations and biohazard risks. Asbestos gloves are worn while dealing with extremely hot materials.
- **Safety Shoes** – These are made of highly durable and robust material and protect the feet from injuries due to cuts and bruises.
- **Safety Goggles** – These protect the eyes from harmful radiation, dust particles and splinters.
- **Masks and Face Shields**- These are worn especially during welding, gas cutting and brazing operations, in order to protect the face from direct flame, extreme temperatures, dust particles and splinters.
- **Apron** – This protects the clothes from dust and other impurities. These are often heat-resistant and anti-abrasive in nature.
- **Ear Muffs** – These are used in extremely noisy places like workshops and factories, to protect the ears from damages.
- **Respirators** - The masks of the Filtering Face Piece Grade-3 (FFP3) specification that allow only 5% air pollutant leakage and filter around 99% of the particles up to 0.6 μm .

People are one of the prime sources of static electricity. The motions required to repair a circuit board or the act of walking around can produce several thousand volts of static electricity on the human body. If it is not controlled accurately, this can discharge into an ESD sensitive device similar to a typical Human Body Model discharge. A person (human body) can also transfer charge to a circuit board or other items making those vulnerable subsequently.

Even in test processes and highly automated assembly, people need to handle ESDS in repair, in the warehouse, in transport, in the lab. Thus, ESD control programmes put considerable emphasis on regulating personnel generated static electricity. On a similar note, the movement of mobile equipment and other wheeled tools also can produce substantial electrostatic charges that transfer to the products attached to the equipment.

Head Protection



Safety Helmet

Head injury can impair a worker for the lifetime. Wearing safety helmet is the easiest way to avoid such situations. Safety helmet is used to –

- Protect head from falling objects and knocks
- Reduce risk of head bumping against fixed objects like exposed pipes and beams
- Protect head from accidental electrical hazards

Safety helmet comes in different forms. Some helmets include other protective elements such as goggles, earmuffs attached to it. Safety helmet should be worn on the head, not on any hat or cap.

Eye Protection



Safety Goggle



Safety Spectacle



Facemask

Eye is one of the most delicate organs of the body. Assembling is a job which comes with various hazards related to eye damage. For example, saw dust, small pieces of sharp objects may cause damage to the eye. Therefore, eye protection must be used. Some widely used eye protection are –

- Safety Goggle
- Safety Spectacle
- Facemask

These protections should be worn to avoid any damage owing to wood dust, metal chips in the process of sawing, drilling, grinding, and chiselling.

Hearing Protection



Single Use Earplug



Pre-formed or Modelled Earplug



Ear Defender or Earmuff

Assembling machines such as drilling machine, circular saw, and jigsaw create a lot of noise. Short exposure to the noise may cause temporary hearing loss and long exposure may lead to permanent hearing loss. Therefore, hearing protection is an essential PPE for a line assembler. Some important hearing protection are –

- **Single Use Earplug:** They are made of waxed cotton, foam, silicon rubber or fibre glass wool. When properly inserted, they work like most modelled earplugs.
- **Pre-formed or Modelled Earplugs:** These are small fibre plugs that are inserted to the ear and used in case of severe noise. They can be either disposable or reusable. Reusable plugs should be cleaned after using. Never use plugs which are used by somebody else.
- **Ear Defender or Earmuff:** These are used to cover the entire ear and connected to a band that fits over the top of the head. These are used when the noise is excessively high.

Hand Gloves



Hand Gloves

These are used for protecting the hands from harmful and corrosive chemicals, extreme temperatures, sharp and contaminated objects. For example, Nitrile gloves are used for protecting the hands against solvents, oils, greases, tar, acids and alkalis. Gloves made of latex or natural rubber are used for protection against contaminations and biohazard risks. Asbestos gloves are worn while dealing with extremely hot materials.

Safety Shoes



Safety Shoes

Assemblers, who face possible foot or leg injuries from the falling or rolling objects or from penetrating or crushing materials, should wear protective footwear.

- Safety shoes are used to protect the feet from heavy objects, such as tools that might roll onto or fall on the workers' feet
- It is also used while working with sharp objects such as nails or spikes that could pierce the soles or uppers of ordinary shoes
- It also protects feet from hot, wet or slippery objects

5.3.3 Safe Handling of Semi-Finished Products

ESD safe Plastics are used as the raw ingredient for a variety of high-quality components and final products in fields such as the semi-conductor technology, aerospace industry and in the automotive and mechanical engineering.

To safeguard the functionality and quality of the materials, the recommendations for storage and transportation of semi-finished products need to be observed. This can resist external parameters enforcing a significant change on the material properties. In cases of the end products, the user or manufacturer must submit an individual confirmation of this.

Handling guideline for semi-finished parts

1. Storage and handling should occur in such a way such that the material designations and product numbers (batch number) are clearly identifiable on semi-finished products and can be maintained. Clear traceability and identification of products eases the process of determining the root causes of faults in the event of a complaint.
2. Weathering effects can affect the properties of plastics. As result of solar radiation (UV radiation), atmospheric oxygen and moisture (precipitation, humidity) can exert a lasting negative impact on material characteristics. These effects can lead to colour changes, oxidation of surfaces, swelling, warping, brittleness or even a change in mechanical properties. Hence, semi-finished products should not be exposed to direct sunlight or the effects of weather over protracted periods. Semi-finished products should ideally be stored in closed rooms under normal climatic conditions (23 °C / 50 %rH).

3. Wherever possible, plastics should not be exposed to low temperatures over long periods. However, particular care should be taken to avoid excessive fluctuations in temperature. These lead to brittleness and to warping of the semi-finished products. The materials must also be protected from heavy impacts, and should never be thrown, as collisions will result in spalling and fracture damage. In addition, semi-finished products stored in cold conditions should be allowed sufficient time to reach room temperature before processing. This will prevent debris, cavities and other defects during processing. This also compensates for any shrinkage or expansion which occurs in plastics due to their high coefficient of thermal expansion.
4. Semi-finished products made of plastic should consequently always be stored flat or on a suitable support (in the case of rods and tubes) and with the greatest possible surface contact in order to avoid deformation through their own intrinsic weight.
5. When handling plastic semi-finished products, ensure that suitable warehousing equipment is used. This includes stable slinging equipment and secure hoists. Semi-finished products must be stacked so as to prevent any possibility of tilting or falling. Bear in mind here that plastics often have a low coefficient of friction and are consequently easily able to slip out of load suspension devices, with the possibility of serious injury to staff members.
6. Avoid the effects of high-energy radiation. The molecular degradation caused by gamma and X rays can result in microstructure damage.
7. Keep semi-finished products away from all kinds of chemicals and also water. Depending on the material, any such contact can result in chemical decomposition, tension crack formation or swelling through the absorption of moisture.
8. As organic substances, plastics are combustible. The combustion or decomposition products may have a toxic or corrosive effect. If correctly stored, plastics themselves do not pose a fire risk. However, they should not be stored together with other combustible substances. On this subject, observe the product handling information sheets for the individual materials.
9. Under normal conditions, semi-finished or finished products do not release any toxic constituents and permit risk-free surface contact. Tobacco products should not be allowed in the vicinity when handling and machining plastics, as particles of some plastics (in particular fluoropolymers) In respect of health protection, please also note the product handling information sheets for the individual materials.
10. If the above recommendations are followed, it may be assumed that no significant changes to typical plastic properties will occur during the storage period. Due to environmental influences, it is possible that minimal surface discolouration may occur. However, this does not represent any significant deterioration of material properties, as the surface is generally only affected down to a few microns in depth

Avoiding damage of components due to negligence in ESD procedures

ESD Handling Procedures Checklist:

Only handle unpackaged ESD sensitive items [ESDS] in the ESD protected area [EPA].

When grounded only trained or escorted people in the EPA. Ground all conductors including people in the EPA. Use continuous monitors or test wrist straps at least daily. If ESD footwear is used, test at least daily. Visually check that grounding cords are connected. Keep wristband snug, foot grounder grounding tab in shoe, and ESD smocks fastened. Keep work area clean and clear of all non-essential insulators. Neutralize essential insulators with ionizers with the airflow directed towards the work. Area Use packaging with shielding property to store or transport ESDS outside the EPA

UNIT 5.4: Levels of Electrostatic Voltage Generation

Unit Objectives

At the end of this unit, you will be able to:

1. Evaluate the generation of electric voltage in shop floors during production

5.4.1 Electrostatic Voltage Generation

Human body conducts electricity and thus is susceptible to electrostatic charges. As a matter of fact, electrostatic charges are generated by movements and collisions of particle. Therefore, while working in a workstation, the possibility of electrostatic discharge, a Line Assembler should always be careful. If not controlled, the static charge can easily discharge into an ESD sensitive device – a typical Human Body Model discharge. Also, a person can transmit charge to a circuit board or other item making it susceptible to Charged Device Model incidents in a subsequent process.

What is ESD?

We experience occurrences of static electricity every day. For example, walking along a carpeted floor in a heated room during winter generates sufficient static electricity.

Although this sudden discharge of static electricity does not result in any harm to the human body, it can cause heavy damage to electronic devices as they are sensitive to electrostatic discharge (ESD). It is possible for electronic devices to be damaged by ESD that is imperceptible to the human body.

In order to prevent any component damage from to electrostatic discharge, it is better to adopt precautionary measures. The precautionary aspect to ensure zero damage can be achieved by two means.

Circumstances under which electro-static discharge takes place are as follows:

- During welding process there is flow of current in a conductor. If a person touches a, current may flow through the body to the ground and cause a shock.
- The more there is increased electrical contact with the ground; more is the risk of shock.
- Avoid standing on wet surfaces, in water, or working with wet hands or wearing sweaty garments.
- Small shocks could cause you to slip and fall.

Let us see what precautions you can take to avoid ESD.

- Wear clothing made from tightly woven, heavyweight, 100% wool or cotton to protect from UV radiation, hot metal, sparks and open flames.
- Keep clothing hygienic and free of oils, greases and combustible contaminants.
- Wear full-sleeved shirts with buttoned cuffs and a collar to protect the neck.
- Keep your shirt pockets closed and covered to avoid collecting sparks or metals scraps.
- Pant legs must be without cuffs and must cover the tops of the boots.

- Repair all edges, tears or holes in clothing.
- Wear high-top boots completely laced to prevent sparks from entering the boots.
- Use fire-resistant boot protectors to prevent sparks from bouncing in the top of the boots.
- Do not keep lighters or matches in pockets.
- Direct spark sprays away from clothing.
- Wear leather aprons to secure your lap and chest from sparks while standing or sitting. Protect your forearms and wrists by wearing leather gloves and sleeves.
- Wear layers of clothing. But you must make sure that you do not sweat.
- Wear a fire-resistant cap under your helmet to protect your head from burns and UV radiation.
- Wear a welder's face shield to secure your face from UV radiation and flying particles.

The 5S standard that any organization follows comprises of "Sort", "Set In Order", "Shine", "Standardize" and "Sustain". This helps to maintain smooth working and avoid confusion during work. But along with this another S has been added to the list, that is, 'Safety'. As a welder you must be aware of personal safety as well.

The potentially sensitive tip of the soldering iron comes in contact with the voltage during soldering. Therefore, it is generally assumed that the tip causes ESD. However, the soldering iron and its tip are a few of the components used at a workbench. Various other components that lay on the workbench like tweezers, test equipment, wiring, etc. can also be sources of ESD/EOS since they come in contact with the component or board.

What is EOS?

EOS stands for Electrical Over-Stress. Every form of energy ultimately converts to Thermal Energy, and Electrical Energy is no exception. When a device is subjected to Electrical energy for a long time, it produces heat. A simple analogy is the monitor or CPU of a computer, which get heated if used for a long time.

However, every electronic device is safeguarded up to a certain level from the generation of heat. In case, the limit or the capacity is crossed, it can cause damages to the device.

The incident, where a tool gets distorted from excessive electrical energy consumption or conduction, is classified as Electrical Over-Stress or EOS.

There are several sources of electrostatic energy during the soldering process, which include:

- **Loss of Ground:** The tip of an ungrounded soldering iron is capable of building up a voltage of up to $\frac{1}{2}$ of the iron's supply voltage. This build-up can occur within the soldering iron or in power outlets.
- **Noise on Ground:** If a noise signal exists on ground, the tip of the solder iron will carry noise, too. These high-frequency signals, or electromagnetic interference (EMI), are disturbances that affect an electrical circuit, due to either electromagnetic induction or electromagnetic radiation emitted from an external source.
- **Noise on Power Lines:** Noise not only generates via ground but in power lines, too. Transformers and power supplies that convert voltages to 24V are the main culprit. They regularly carry high-frequency spikes which end up on the tip of the soldering iron.
- **Power Tools:** Although not technically related to the soldering process itself, it's worth mentioning that the tips of power tools (e.g. electric screwdrivers) may not be properly grounded during rotation. This can result in high voltage on the tip itself.

- **Missing/Inadequate ESD Protection:** ESD can be a cause of EOS damage. Therefore, it is essential to have proper ESD Protection in place. A voltage on the operator or the PCB board can otherwise lead to an ESD Event and expose the components on the PCB to EOS.

For maximum allowable resistance and discharge times for static safe operations, refer to the following table:

Rending from Operator through	Maximum Tolerable Resistance (in Mega Ohms)	Maximum Acceptable Discharge Time (in Second)
Floor mat to ground	1000	Less than 1
Table mat to ground	1000	Less than 1
Wrist strap to ground	35	Less than 0.1

UNIT 5.5: Grounding

Unit Objectives



At the end of this unit, you will be able to:

1. Analyze the grounding and various other methods used for grounding

5.5.1 Grounding Fundamentals

Grounding is important for effective ESD control. It should be clearly defined, and assessed regularly.

The device “grounding conductor” provides a path to bring personnel and ESD protective materials to an equal electrical potential. All dissipative materials and conductors in the atmosphere, including workers, should be electrically connected and attached to a known ground, or build an equipotential balance between personnel and all other items. ESD protection is usually maintained at a charge above “zero” voltage. It is crucial to note that insulators, by nature non-conductors, do not lose the electrostatic charge by grounding.

ANSI (American National Standards Institute)/ESD S6.1-Grounding or the ESD Association Standard suggests a two-step method to ground ESD control items. The first step of the procedure is to ground each and every component of the workplace and the personnel (equipment, work surfaces, etc.) to the equipotential electrical ground point, known as the “common point ground.” This common point ground is described as a “method or system to connect several grounding conductors to the same electrical potential.”



Fig 5.5.1: Common Point Ground Symbol

This ESD common point ground should be properly identified. ESD Association standard ANSI/ESD S8.1 – Symbols, recommends the use of the symbol to identify the common point ground.

The next (second) step is connecting the common point ground to the equipment grounding conductor (AC ground) or the third wire (typically green) to the electrical ground connection. It is the preferred ground connection as all electrical devices or tools at the workplace are already connected to this ground. Connecting the equipment or the ESD control materials to the equipment ground brings all components of the workplace to an equal electrical potential, reducing the risk of further electrostatic discharges.

Tips



1. If a soldering iron, which is used to repair an ESDS item were connected to the electrical ground and the surface of the ESDS item were connected to an auxiliary ground, an electrical potential could occur between the iron and the ESDS item. This potential difference could cause damage to the item.
2. Any auxiliary ground (water pipe, ground stake, building frame, etc.) present and used at the workstation must be bonded to the equipment grounding conductor to minimize differences in potential between the two grounds.

5.5.2 ESD Tools and Equipment

Wrist Straps: Usually, wrist straps are the rudimental means of grounding personnel. When properly connected to ground and worn, a wrist strap keeps the worker wearing the wrist strap close to the ground potential. As other grounded components and the person in the workstation are at or close to the same potential, there will ideally be no hazardous electrostatic discharge between them. Furthermore, static charges are eliminated from the person to ground and do not get accumulated. When a person sits on a chair which is not EPA resistant, he should be grounded via a wrist strap.

Wrist straps are comprised of two major parts, the ground cord that bridges the wristband to the common point ground and the wristband that goes around the worker's wrist. Most wrist straps comprise a current limiting resistor placed into the ground cord on the far end that connects to the wristband. This resistor is usually one mega-ohm, rated at least 1/4 watt with a working voltage of 250 volts.

Wrist straps come with several failure mechanisms and thus should be diagnosed on a regular basis. Either daily testing or a continuous monitoring at the workbench is recommended.

Floors, Floor Mats, Floor Finishes: Another method of grounding personnel is the Footwear/ Flooring System using ESD flooring along with foot grounders or ESD control footwear. This combination of dissipative or conductive footwear and floor materials provide a secure ground path for the precipitation of the electrostatic charge, thus decreasing the accumulation of charge on personnel. Adding to the dissipating charge, several floor finishes and floor materials also decrease triboelectric charging.

The usage of a Footwear/ Flooring System is specifically appropriate in the areas where increased personnel mobility is inevitably necessary. Moreover, floor materials minimize charge accumulation on chairs and other mobile equipment such as carts, lift trucks and trolleys, and other objects/ devices that move across the floor. However, those items need conductive or dissipative wheels to make electrical connection with the floor. When exploited as the personnel grounding system, the resistance to ground including the footwear, floor and the person should be the same as specified for wrist straps.

Shoes, Grounders, Casters: Used in conjunction with the ESD flooring, foot grounders, casters, wheels, and static control shoes supply the needful electrical contact between the object or the person and the flooring. Insulated footwear, wheels, or casters resist static charges from passing from the body or the equipment to the ground and, therefore, must be avoided.

Clothing: Clothing is a mandatory consideration in the ESD protective areas, particularly in dry environments and cleanrooms. Clothing materials, precisely those made of synthetic, generate electrostatic charges that discharge ESDS or create electrostatic fields that induce charges. Because clothing typically is electrically isolated or insulated from the body, charges on clothing fabrics are not always dissipated to the skin and then subsequently to the ground. Static control garments suppress and affect an electric field from the clothing worn underneath. As per ANSI/ESD S20.20 and the Garment standard ANSI/ESD STM (Synchronous Transport Module)2.1, there are three classes of ESD garment

which are discussed below:

- **ESD Category 1 garment:** A static control garment without being attached to ground. However, without grounding, a charge may accumulate on conductive or dissipative elements of a garment, if present, resulting in a charged source.
- **ESD Category 2 garment:** A groundable static control garment, when connected to ground, provides a higher level of suppression of the effects of an electric field from clothing worn underneath the garment.
- **ESD Category 3 garment:** A groundable static control garment system also bonds the skin of the person to an identified ground path. The total system resistance including the person, garment and grounding cord shall be less than 35 megohms.

Workstations and Work surfaces

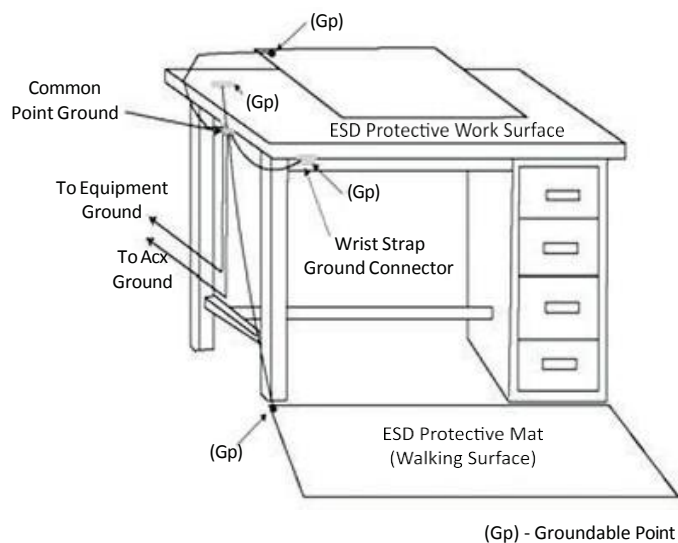


Fig. 5.5.2: Typical ESD Workstation

- An ESD protective workstation refers to the work area of a single individual that is constructed and equipped with materials and equipment to limit damage to ESD sensitive items
- It may be a stand-alone station in a stockroom, warehouse, or assembly area, or in a field location such as a computer bay in commercial aircraft
- A workstation also may be located in a controlled area such as a cleanroom
- The key ESD control elements comprising most workstations are a static dissipative work surface, a means of grounding personnel (usually a wrist strap), a common point ground, and appropriate signage and labelling

The workstation supplies the means for connecting all fixtures, work surfaces, grounding devices, and handling equipment to a common point ground. Moreover, there are provisions for connecting additional personnel grounding equipment, accessories, and devices such as continuous monitors and ionizers.

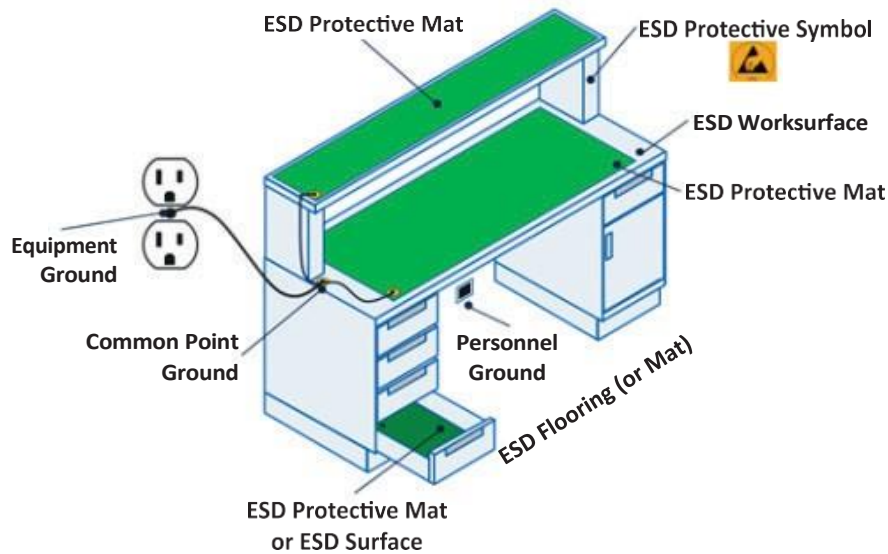


Fig 5.5.3: An ideal ESD protective work station specimen

5.5.3 Impact of Handling ESD-Sensitive Items in a Non-ESD Safe Area

Although personnel can be the prime generator of electrostatic charge, automated manufacturing and test equipment also can pose an ESD problem.

For example, an ESDS device may become charged from sliding down a component part feeder. **If the device then contacts the insertion head or another conductive surface, a rapid discharge occurs from the device to the metal object — a Charged Device Model (CDM) event.**

If charging of the ESDS cannot be avoided – which is quite often the case in modern assembly lines due to the insulative IC packages – charge storage should be reduced by the use of ionizers. In addition, various production aids such as hand tools, tapes, or solvents can also be ESD concerns.

- Grounding is the primary means of controlling static charge on equipment and many production aids
- Much electrical equipment is required by the National Electrical Code to be connected to the equipment ground (the green wire) in order to carry fault currents
- This ground connection also will function for ESD control purposes
- All electrical tools and equipment used to process ESD sensitive hardware require the 3 prong grounded type AC (Alternating Current) plug
- Hand tools that are not electrically powered, i.e., pliers, wire cutters, and tweezers, are usually grounded through the ESD work surface and the grounded person using the conductive/dissipative tools
- Holding fixtures should be made of conductive or static dissipative materials when possible. Static dissipative materials are often suggested when very sensitive devices are being handled
- A separate ground wire may be required for conductive or dissipative fixtures not in contact with an ESD work surface or handled by a grounded person
- For those items that are composed of insulative materials, the use of ionization or application of topical antistats may be required to control electrostatic charge generation and accumulation of static charges.

UNIT 5.6: ESD Audit

Unit Objectives

At the end of this unit, you will be able to:

1. Understand ESD Audit, its types and importance.

5.6.1 ESD Audit

An ESD audit is a critical part of the ESD control program. This involves evaluating ESD control practices and products, providing a reminder to employees of their responsibilities, and projecting the corrective action to the management

An audit is subject to an approved ESD control program to be implemented at all operating levels. The current Electrostatic Control Discharge Program is developed and controlled by ANSI/ESD S20.20-1999[2].

Audit encompasses the check on various aspects of the program in correspondence with company procedures. Supervisors and respective management personnel should be notified of the inconsistencies. In order to understand and analyze the actionable areas, visual summaries of the findings are effective.

While a company's audit procedures are incomparable to the local control program, however certain aspects need to be covered. Some of the aspects are work area integrity, conformance to procedures, work area and floor condition, and some generic parts of the program.

To get an unprejudiced audit finding, it is suggested to include external consultants, auditors, or employees from other work areas.

TYPES OF AUDITS

There are three types of ESD audits:

- Program management audits
- Quality process checking
- ESD Control Program compliance verification (workplace) audits

Program management

- This audit incorporates the check on the management of the program and the consistent involvement of the management.
- It underlines whether an effective implementation plan is there, whether program requirements are for real, training programs, the need for compliance audits, etc.
- This audit procedure is done through a survey encompassing the factors mentioned above without visiting the actual site. Thus, it measures work area compliance.

Quality process

- This audit incorporates statistical quality control techniques applied to the ESD process and is executed by operations personnel.
- Frequency of this audit is daily, weekly, or monthly rather than periodic
- Certain things which are evaluated are visual and electrical checks of the procedures and materials, wrist strap testing, etc.

ESD Control Program Compliance Verification

- This audit incorporates checking the adherence of procedures and that equipment and protective materials are functioning as per the standards.
- Frequency of these audits is often monthly and operates on sampling techniques and statistical investigation of the outcomes. Detailed checklists are utilized by an auditor.

5.6.2 Areas of Audit**Work Area**

Work area audit includes the following checks:

- The partition of ESD-protected (ESDP) areas from non- ESDP areas.
- Signs, directional arrows, aisle marking tape, and other methods for workers and visitors.
- To store or transport ESD-sensitive device shelves that are electrically connected and grounded to the ESD ground via a drag chain to minimize tribocharging.
- Whether cleaning crews, contractor personnel, and maintenance workers are trained enough on safety practices to enter ESDP areas and should be instructed not to touch ESD-Sensitive (ESDS) devices. If they need to access ESD-Sensitive (ESDS) devices, they have to be accordingly trained.
- Whether a varied color badge or smock is available for visitors to demarcate them
- Training of the assembly workers to clean workbenches. If visitors are there, they should not be allowed to touch workbenches unless trained

Operators

As per the internal ESD control plan, each employee should undergo certified training or orientation on ESD Safe practices along with refreshers on yearly basis. A list of certified people should be properly made and available to auditors and area supervisors.

Procedural checks should be audited and operators need to display their awareness. Following is an instance of a procedure:

- verify work area for charge generators
- personal grounding devices testing
- identify insulators and remove them from work area
- ensure proper ESDP packaging and labeling of sensitive devices
- ensure with ESDS items there are no static generators
- ensure approved cleaners are utilized
- check grounding of discharge devices wires
- verify positioning and functioning of ionizer

Auditor to ensure that operator must wear continuous monitor, which tests the wrist strap and static mat connections uninterruptedly, and echoes an alarm when there is a problem. Same is applicable to heel straps.

Auditors must verify smocks are worn properly as it assists to minimize problems with street clothing and hair. To secure the smock at the opening and cover the sleeves, proper donning is essential. A clean look of smock increases professionalism and regularity.

Workbenches and Floors

Specifically, in high-traffic areas, floors in an ESDP area must be examined for surface resistance. As per ANSI/ESD-S7.1 standards, high-end limit for this is 1 GW per. Auditors will use megohmmeter to ascertain it meets both ESD S4.1 and ANSI/ESD-S7.1. The best electrical check for a floor is surface resistance to ground (RTG) as this ensures a connection to ground as well.

Each workbench must be assessed for ESD prevention, which includes removal of non-essential insulators, such as coffee cups, radios, food wrappers, etc., or the control of important insulators via ionization such as some tools and jigs.

Standards indicate the use of conformity sticker (always located in the same spot for each workstation) that states bench meets the ESD control requirements. In case it is missing, it indicates that infraction occurred and bench should not be used. If bench is repositioned, sticker needs to be removed till its reinspection is completed.

Trash holders are audited to verify that they are ESDP containers. Dissipative holders or binders are used to store documents. By using field meter, Packaging or general-purpose tapes found at the ESDP bench should be verified that they are ESD safe.

Other Audit Concerns

For the work area, evaluation of types of cleaning materials and the cleaning practices are undertaken by auditors. Cleaners should not contain insulators such as silicon, soap, lanolin, free-salts, mineral oil, etc.

All sensitive components must be protected both as they are brought and as they leave the ESD Sensitive area. Equipment to be shipped is particularly exposed, thus those goods must be packed from worst.

5.6.3 Report to management and Others

Archive test records are required to be consulted to check the control devices in question were tested and adhered to the internal specs, in case any discrepancy arises. Proper recording of correction needs to be administered on the audit form.

On completion of the audit process per the time frame, auditor must present to the respective supervisor and the plant management the findings/observations recommending the corrective suggestions and their impact on the ESD Control program.

5.6.4 Test Schedule for ESD Control Products

For the proper functioning of the ESD Control products, ESD coordinator, chairman, or whomsoever is in charge should regularly test to ensure proper functionality. Following table shows the frequency of the products to be tested per Electronics Industry Association, Standard ANSI/EIA-625 [3].

ESD Protective Item Checks

Frequency	Items
Daily	Wrist straps, Footwear, Smocks (properly worn)
Weekly	Workstations, Floor mats, ESD ground connections
Monthly	Static surveys of ESDP areas and workstations, Smocks (electrical tests)
Quarterly	RTG of work surface, RTG of floor, Wrist strap monitor check, ESD ground continuity
Semi - annually	Ionizer balance and charge decay
Annually	Ionizer balance and charge decay

ESD Checklists

ESD checklist comprises over 500 questions on topics like:

Management; Training; Engineering; Procurement; Receiving area; Storage area; Work areas; Shipping area; Intra-plan and inter-plant movement; ESDS protected work stations; and Quality functions.

The checklist is customized as per the need of the ESD control program as well as complement the program plan.

Summary



- Static charges are created when there is a separation of non-conductive materials friction between synthetic clothes, combing your dry shampooed hair for a long period of time during winter sparks up static electricity is called Electro static Discharge (ESD)
- Certain components are very sensitive to static electricity that can definitely destroy the component
- For ESD control purposes, materials are classified by how quickly electricity moves through the material
- The speed is referred to as the “resistance” of the material i.e. how strongly the material resists charge movement
- Resistance or resistivity measurements help define the material’s ability to provide electrostatic shielding or charge dissipation
- People can be one of the prime generators of static electricity
- Grounding is important for effective ESD control
- Typically, wrist straps are the primary means of grounding personnel
- A second method of grounding personnel is a Flooring/Footwear System using ESD flooring in conjunction with ESD control footwear or foot grounders
- Used in combination with ESD flooring, static control shoes, foot grounders, casters and wheels provide the necessary electrical contact between the person or object and the flooring
- Clothing is a consideration in some ESD protective areas, especially in cleanrooms and very dry

Activity



1. Draw a diagram, illustrating a typical ESD workstation, and labelling the following:
 - a. Common Point Ground
 - b. Equipment Ground
 - c. ACX Ground
 - d. Groundable Point (GP)
 - e. ESD protective mat (walking surface)
 - f. Wrist strap ground connector
 - g. ESD protective work surface
2. Identify the safety equipment given below. Write down their names in the blanks provided.



Exercise

Choose the correct option from the list of responses to answer the following questions:

- ESD stands for –
 - Electric Standard Discharge
 - Electro Static Discharge
 - Environmental Safety Dossier
- In which season, static electricity sparks up during combing?
 - Summer
 - Monsoon
 - Winter
- How many principles are there to control ESD?
 - 4
 - 5
 - 6
- _____ measurements help define the material's ability to provide electrostatic shielding.
 - ESD
 - Resistance
 - Potential difference
- PPE stands for –
 - Personal Protective Equipment
 - Personal Protective Environment
 - Personal Protection from Electrostatic charges
- Respirators filter –
 - 99% of all particles measuring up to $0.6\ \mu\text{m}$.
 - 50% of all particles measuring up to $0.6\ \mu\text{m}$.
 - 75% of all particles measuring up to $0.6\ \mu\text{m}$.
- "People can be one of the prime generators of static electricity."
 - True
 - False
 - Cannot be determined
- "A workstation also may be located in a controlled area such as a cleanroom."
 - True
 - False
 - Cannot be determined
- Which of the following substances can be cleaned using a vacuum cleaner?
 - flammable
 - Corrosive
 - Toxic
- Acoustic Cleaning involves the use of _____ Waves.
 - Electric
 - Light
 - Sound



6. Industrial Education

Unit 6.1 - Communicating Effectively

Unit 6.2 - Basic Store Management

Unit 6.3 - Industrial Act and Company Standards



Key Learning Outcomes



At the end of this module, you will be able to:

1. Evaluate the importance of communicating properly with co-workers
2. Discuss the significance of store management
3. Discuss the organizational hierarchy as per industry (Telecom Sector)

UNIT 6.1: Communicating Effectively

Unit Objectives

At the end of this unit, you will be able to:

1. Evaluate the importance of communicating properly with co-workers
2. Analyze the significance of liaison and coordination

6.1.1 Communicating Effectively at the Workplace

The foremost thing regarding giving clear information is respecting the audience. When you communicate and put forth the information to the listener, you should be clear about the message that you would be giving to them.

The next aspect is to stick to the instruction that you want to give to the workers working in the line assembly facility.

Information exchange makes the process of imparting information smoothly. If the speaker knows what they want to convey, they should also know what the audience is grasping. This decreases the chance of confusion as the listener gets the opportunity to ask about the instruction or about correct selection of tools and clearing their doubts then and there.

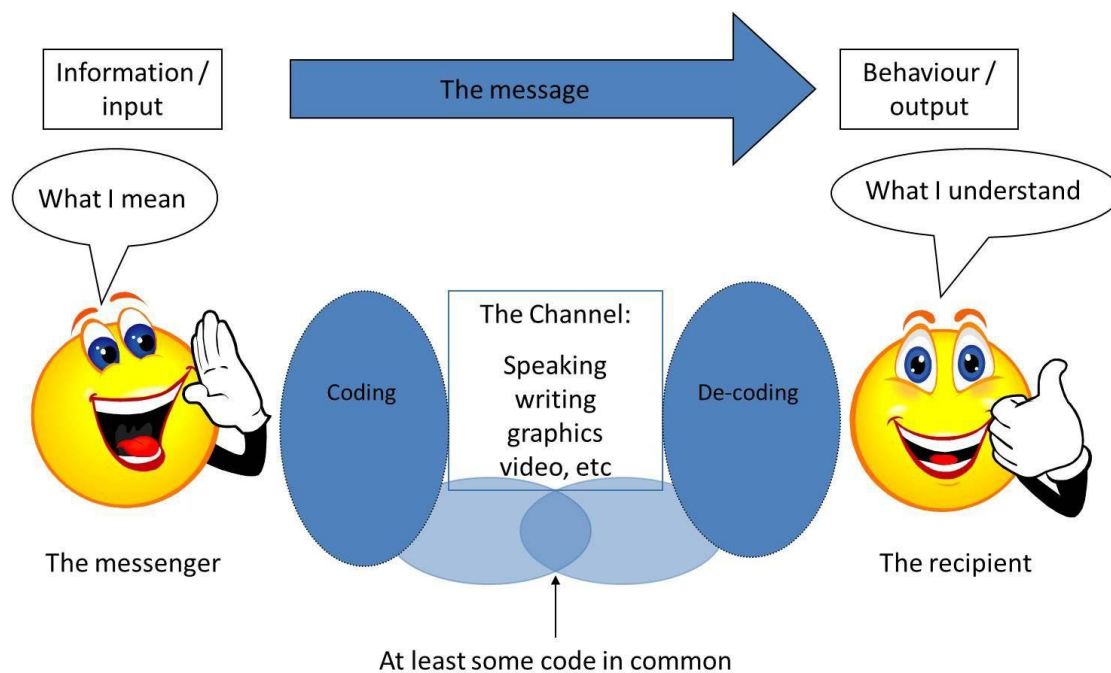


Fig. 6.1.1: Clear information Exchange

6.1.2 Communicating Accurately

A workplace is an area where people from different backgrounds and perspective come to work together. An individual working at a work place or work site doesn't work alone. He or she works with a team – colleagues, supervisor, trainer and others (as per requirement). In this case, good communication and mutual bonding make the workflow smooth and uninhibited. In fact, effective communication allows us to understand the problems that our colleagues are facing, and them to portray it clearly.

- **Ensures a positive attitude**
 - Communication amongst employees with a positive attitude ensures that change or the development is towards a prospective change (positive).
 - It also motivates the employees, thereby ensuring that they provide cost-effective, productive, and valuable services.
- **Ensures proper comprehension regarding strategy and goal accomplishment**
 - It gives the employees the correct perception regarding their work.
 - It also makes sure that the employees know how their work is directly influencing the profitability of the company
 - It gives employees the true impression of working as a team
- **Ascertain that everybody complies with the company's regulatory bodies**
 - Talking with colleagues and sharing information on any new updates on company policy or project ensures that everyone stays on the same page.
 - Added to this, this makes the team more responsive and positively engaged in the work.

6.1.3 Liaison and Coordination

Listening to the information attentively that you receive from your fellow workers and supervisor



Grasping the content well



Analysing the instructions that you are given



Putting forth the queries regarding the provided information



Clearing the doubts regarding the given task or instruction

A line assembler must communicate and coordinate with peers and supervisors in the organization for smoother work flow. The elements of communicating effectively with peers / colleagues and supervisors are:

- Effectively communicate with team members and customers
- Manage Expectations
- Write and Speak Persuasively

- Watch your tone
- Deliver the message clearly
- Listen to your audience reframe communication if needed
- Communicate effectively with team members, supervisors, managers etc.

1. Coordinate and cooperate with colleagues to achieve work objectives

- Listen actively with minimal barriers
- Build trust, but do not get too casual
- Be aware of your tone
- Watch your body language
- Participate and coordinate
- Ask questions to clarify
- Discuss task lists, schedules and activities
- Share best practices with peers

2. Effectively Communicate with Supervisors

- The tone of the communication
- Amicable but professional approach
- Knowing what you speak
- Thinking before you speak
- Building rapport, based on mutual trust and respect

Tips to effectively communicate with supervisors:

- **Seek assistance from supervisor or any such appropriate authority as and when required**

One's supervisor is supposed to be one's mentor and guide at work. Assistance and guidance must be sought from the supervisor whenever needed. Ask questions to clarify doubts.

- **Ask questions and seek clarifications on work tasks whenever required**

Question must be asked to clarify doubt and to narrow down communication gaps with one's supervisor. This must be done to get a clear idea about the responsibilities expected by one's supervisor. Having a clear idea about one's tasks helps in fulfilling targets successfully is compulsory. Seek and obtain clarifications on procedures and policies, from the supervisor or other authorized personnel. Address the issues and report if needed to immediate supervisor. Identify and report any deviations to the authority. Receive instructions clearly from the seniors and respond to the same. Accurately receive instructions and information from the seniors/ supervisor, related to one's work.

6.1.4 QC Tools

Quality checking is the method of conducting visual inspection for any errors or damages to the cut components. It is important to undertake quality checks at regular intervals to avoid any error detection at later stage. The quality checking parameters are as follows:

- Recheck measurement, alignments as per design drawing to avoid any damage during installation
- Conduct post installation visual and quality check with respect to placement, levelling, functioning etc. and perform touch up, cleaning /sanding/ finishing as needed for the installed product
- Rectify any error or faults observed to comply with organizational quality standards
- There should be an ideal procedure for quality checking. The set-up is discussed below

In telecom sector, quality check plays a pivotal role in assuring the quality of service provided by the sector. The main QC tools in the telecom sector –

- Flow Diagram
- Check Sheets
- Pie Diagram
- Histogram
- Chart

UNIT 6.2: Basic Store Management

Unit Objectives

At the end of this unit, you will be able to:

1. Discuss the significance of store management

6.2.1 Concepts of Store Management

A professional store management has a method and a space within, to receive the incoming materials (Receiving Bay), stack them for as long as they are not needed for use and then to move them out of stores for use.

In a manufacturing hub, this process forms a cycle to run and the maintain activities of Stores.

The basic responsibilities of a store are to act as custodian and regulating agent for materials, parts, and supplies, and to provide service to users of the goods.

Usually and at times essentially, a store has to follow certain activities that are regulated through use of different resources and are thus called Stores Management.

The duty of storekeeping relates to the safe custody and the preservation of the materials stocked, to their receipts, issue and accounting.

The objective is to economically and efficiently provide the right materials at the time when it is required and in the situation in which it is needed.

The primary job of the Store Manager hence is to receive the products and act as a caretaker of the goods and issue them when required. It is needless to say that storekeeping activity does not add extra value to the product. In fact it only adds to the cost. The organization has to spend money on space i.e. expenditure on land, building, machinery, equipment, roads and other facilities provided such as electricity, manpower and respective wages and salaries, maintenance costs, insurance, communication expenses, stationary and the cost to maintain the inventory etc. All of these expenses are added to the organizational overheads and get reflected in the costing of the completed product. However, it is an important function in any manufacturing or marketing organization.

Thus, the basic functions, to manage stores, carried out are:

- Receiving of incoming consignments (goods)
- Safe-keeping of goods (Custody)
- Disposal of undesirable goods
- Inventory Management
- Housekeeping and record maintenance

Receiving Bay: It all begins with a suitable lay out design of stores. Depending upon the nature of items used for processing by the organization, the lay out and the type of stores are selected. For example, a process that needs to use raw materials, not expensive, an open and nearby stores with truck / rail inside movement possibility can be adequate. Similarly, for stacking costly material, a closed and restricted type of store shall be required.

However, irrespective of the lay out and the type, any store would have, as its starting activity, receiving and accounting the incoming goods. This part of stores is known as Receiving Bay.

Custody and Issue of Goods: Once the goods has been received and cleared through inspection (quality check) and accepted for use, it requires safe custody till it's actually used.

It demands a separate physical storage space, open or closed, as per requirement. It maintains all documents that are capable to trace an item, show all its details and protect it up to its shelf life in the prescribed manner or till it is issued for use.

This part of stores is called Custody. Thus the role of Custody is to receive and protect the material and then to issue it to the user, as and when required. A stage comes when the material is required for further usage. A store thus releases the material from its custody to the user department and the process is known as 'issue of goods'. It might happen that after partial use, some materials having re-useable value in future are returned to the stores and thus they become part of the custody again (by the virtue of recycling).

Disposal of Goods: In the long drawn process of protecting the goods till its use, some materials might get unserviceable and obsolete and may require removal from stores, to clear space for new and fresh incoming goods. This activity is known as Disposal of goods for which auction etc. is done.

The unused materials with future economic value form inventory which requires professional handling. Inventory control and management thus are very important aspects of any stores function. One of the fundamental functions of stores is to account for every material received in the stores by regulating proper records of all the incoming, outgoing and stored materials to ensure audit trail and accounting is maintained.

Hence, record keeping is a vital function of stores. Obviously, it also goes along the activities and with development in the domain of the information technology, the record keeping in stores performed too is through electronic medium making the whole process smooth and efficient.

Any Stores as such is a physical entity which deals with material receipt, preservation and issue. Material handling therefore is another vital function.

Just as Lay out of a store is formulated considering the nature of material the store has to handle, material movement equipment and implementation of the same also are important.

Within a typical manufacturing organization, its store is seen having Forklifts, Trolleys, and Overhead Cranes etc. inside the stores and trucks, Dumpers and Railway wagons as outside Stores equipment to handle goods.

UNIT 6.3: Industrial Act and Company Standards

Unit Objectives

At the end of this unit, you will be able to:

1. Discuss the organizational hierarchy as per industry (Telecom Sector)

6.3.1 Organizational Context for a Line Assembler

Organizational Context, as the name suggests, is defined as the knowledge of the organization and its processes. The various elements of organizational context are:

- Mission
- Vision
- Organizational Structure
- Standard Operating Procedures and Policies
- Organizational Behaviour

Mission

- A formal summary of the aims, goals (long and short term) and values of an organization
- Describes the fundamental purpose (why it exists) behind running an organization, in terms of benefits to itself and the public

Vision

- An organization's road map, which indicates its plans and directions for transformation and growth

Organizational Structure

- Defines how task allocation, coordination and supervision are routed towards achieving organizational goals and targets
- Example: In a Divisional Structure, an organization groups all the workers into teams, based on similar or same products, projects or clients

Standard Operating Procedures and Policies

- Commonly known as SOP, this is a set of stepwise instructions to help workers in carrying out routine functions
- Before one works on any routine task, it is recommended that he / she refers to the relevant SOP first

Organizational Behaviour

- Defines the way people interact within teams
- This helps the management in getting maximum output from each worker within a team

Vision of Telecom Sector

The Telecom Sector Skill Council is committed to develop world class skilled manpower for the Telecom industry.

Mission of Telecom Sector

Telecom Sector Skill Council, a non-profit industry driven body set up under the aegis of the NSDC (National Skill Development Corporation) would strive to:

- Create a convenient ecosystem by incorporating an “integrated approach” by focusing on the initiatives that have a positive impact to develop competency-dependent framework of world class standard for quality assurance and skill development of personnel in the Telecom sector
- Narrow down the gap between demand-supply of skills by augmented collaboration between the three primary stakeholders i.e. Industry, HR (Human Resources), and academia
- Up-skill and certify forty five Lacs persons in one fifty trades, train twenty four thousand trainers, accredit five hundred training organizations and to cover the whole nation progressively over a time span of ten years by signing contracts with around two hundred industries
- Facilitate Training of the Trainer
- Develop necessary frameworks for curriculum, quality and standards assurance at all levels in technical/ vocational programmes to meet the requirements of the industry
- Participate in local and global vocational development initiatives taken by the telecom sector

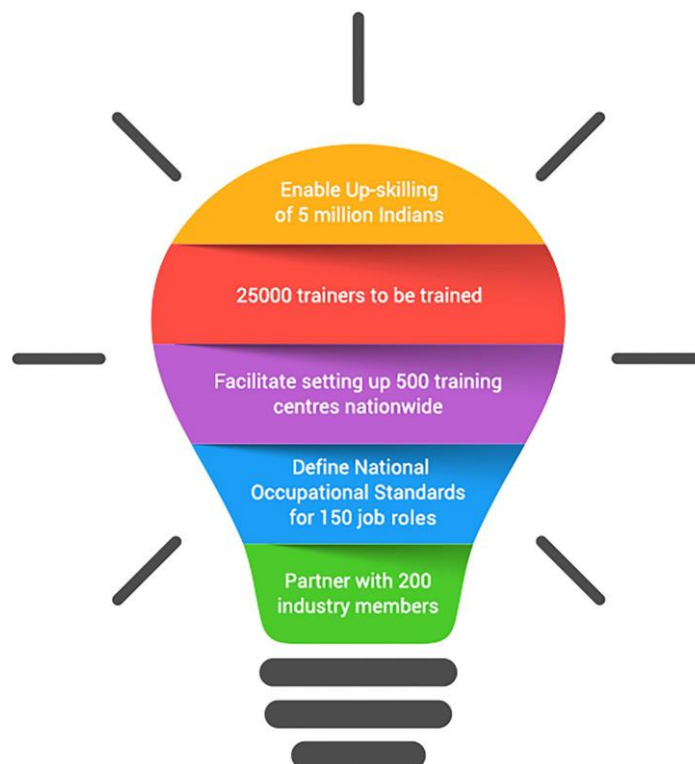


Fig 6.3.1: Missions of Telecom Sector Skill Council

Objectives of Telecom Sector

This is accomplished by a Line Assembler in the following manner:

- Set up a comprehensive pan- India Labour Market Information System (LMIS) i.e. preparing a web based compendium of job roles and skill types to assist in planning for re-skilling, delivery of training and employability
- Undertake occupational mapping and skill gap analysis i.e. identification of skill development needs based on LMIS and emerging technologies
- Rationalize and maintain a skill inventory
- Create a skill development plan in coordination with Electronic and IT (Information Technology) sector skill councils
- Review and identify emerging skill gaps by trend analysis
- Develop National Occupational Standards (NOS) that feature skill competency standards and qualifications
- Refine the existing curricula to align it with NOS, obtain approval from an industry led body of experts and facilitate building of delivery capacity
- Plan and institutionalise an effective system for training of trainers
- Steer the affiliation and accreditation processes to enable quality assurance in training in par with international standards. Steer the affiliation and accreditation processes to enable quality assurance in training in par with international standards
- Create an assessment framework to award tamper proof certifications to trainees
- Promote academies of excellence by nurturing state of vocational training
- Manage resources efficiently to achieve results and value for money

Understand the organizational context while maintaining the work area, tools and machines

This is accomplished by a Lead Installer in the following manner:

- Abiding by the relevant legislation, standards, policies, and procedures followed in the company
- Understanding the expectations and responsibilities of the job role
- Knowing the organization's rules, codes, guidelines and standards
- Recognizing statutory responsibilities, organizational legislation and regulations
- Knowing the details of the contact person in case of queries on procedure or products
- Learning about the method to handle tools and equipment safely and the health and safety implications of not doing so
- Knowing and abiding by the relevant health and safety requirements applicable in the work place
- Knowing who to approach for support in order to obtain work related instructions, clarifications and support
- Learning the importance of following health, hygiene, safety and quality standards

Hierarchy of an Organization

Organizational hierarchy refers to the pyramid of ranks or posts in an organization. In an organization, every employee has to report to the immediate boss. In case of escalations, the employee should put it forward to the immediate boss. Here, we will see the escalation hierarchy in the telecom industry.

GOVERNANCE STRUCTURE

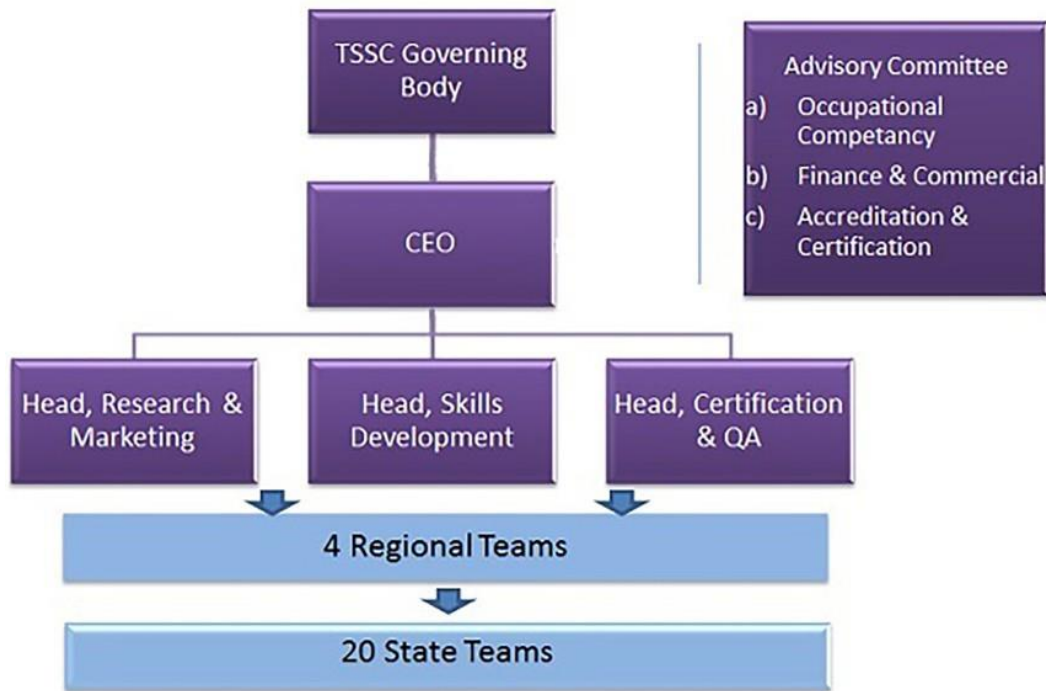


Fig 6.3.2: Organizational Hierarchy of Telecom Sector Skill Council

Summary

- The foremost thing regarding giving clear information is respecting the audience
- When you communicate and put forth the information to the listener, you should be clear about the message that you would be giving to them
- Information exchange makes the process of imparting information smoothly
- If the speaker knows what they want to convey, they should also know what the audience is grasping
- A workplace is an area where people from different backgrounds and perspective come to work together. An individual working at a work place or work site doesn't work alone
- A professional store management has a method and a space within, to receive the incoming materials (Receiving Bay), stack them for as long as they are not needed for use (Custody) and then to move those out of stores for use (Issue)
- The basic functions, to manage stores, carried out are:
 - Receiving of incoming consignments (goods)
 - Safe keeping of goods (Custody)
 - Disposal of undesirable goods
 - Inventory Management
 - Housekeeping and record maintenance
- Organizational Context, as the name suggests, is defined as the knowledge of the organization and its processes
- A formal summary of the aims, goals (long and short term) and values of an organization is known as mission
- An organization's road map, which indicates its plans and directions for transformation and growth is the vision of an organization
- Organizational hierarchy refers to the pyramid of ranks or posts in an organization
- In case of escalations, the employee should put it forward to the immediate boss

Activity

1. Read the below points carefully. Underline the point(s), which do not indicate basic function(s) of managing stores.
 - Receiving of incoming consignments (goods)
 - Safe-keeping of goods (Custody)
 - Disposal of undesirable goods
 - Inventory Management
 - Housekeeping and record maintenance
 - Recheck measurement, alignments as per design drawing to avoid any damage during installation
2. Read the below points carefully. Strike off the point(s), which do not indicate way(s) in which a line assembler should work:
 - Effectively communicate with team members and customers
 - Manage expectations
 - Listen actively with minimal barriers
 - Write and speak persuasively

Exercise

Choose the correct option from the list of responses to answer the following questions:

1. Which of the followings is not an essential element of the organizational context?
 - a) Mission
 - b) Safety
 - c) Organizational structure
2. How many trainers are to be trained as per Telecom sector?
 - a) 20,000
 - b) 24,000
 - c) 16,000
3. The organizational road-map is referred to as –
 - a) Vision
 - b) Mission
 - c) Moto
4. SOP stands for –
 - a) Standard Organizational Policy
 - b) Standard Operations Procedure
 - c) Standard Operating Procedures
5. Telecom Sector Skill Council intends to partner with _____ industry members.
 - a) 150
 - b) 200
 - c) 600
6. Effective Communication is also possible via Smartphone and _____.
 - a) Visa
 - b) Pen drive
 - c) Computer
7. The language we use on a daily basis at home is known as –
 - a) Professional language
 - b) Slang language
 - c) Colloquial language
8. Custody is a place where goods are –
 - a) Stored
 - b) Received
 - c) Recycled
9. Which of the followings is not an outcome of effective communication?
 - a) Rapport building
 - b) Trust building
 - c) Incentive raise
10. QC tools comes into the scenario –
 - a) Prior to the assembling
 - b) At the time of assembling
 - c) Post the assembly work

7. Plan Work Effectively, Optimize Resources and Implement Safety Practices



Unit 7.1	Workplace Health and safety
Unit 7.2	Different types of Health Hazards
Unit 7.3	Importance of Safe Working Practices
Unit 7.4	Reporting Safety Hazards
Unit 7.5	Waste Management
Unit 7.6	Organizations' focus on the Greening of jobs



Key Learning Outcomes

At the end of this module, you will be able to:

- Explain about the work place health and safety
- Differentiate various health hazards
- Demonstrate various first aid techniques
- Importance of safety at workplace
- Understand Basic hygiene Practices and hand washing techniques
- Explain the need for social distancing
- Understand the reporting of hazards at workplace
- Explain e-waste and process of disposing them
- Explain Greening of jobs

UNIT 7.1: Workplace health & safety

Unit Objectives

At the end of this unit, you will be able to:

- Understand about workplace health and safety
- Explain tips to design a safe workplace
- Explain precautions to be taken at a workplace

7.1.1 Safety: Tips to Design a Safe Workplace

Every organization is obligated to ensure that the workplace follows the highest possible safety protocol. When setting up a business some tips to remember:

- Use ergonomically designed furniture and equipment to avoid stooping and twisting
- Provide mechanical aids to avoid lifting or carrying heavy objects
- Have protective equipment on hand for hazardous jobs
- Ensure presence of emergency exits and they are easily accessible
- Set down health codes and ensure they are implemented
- Follow the practice of regular safety inspections in and around the workplace
- Get expert advice on workplace safety and follow it
- Get regular inspection of electrical wiring and also the electrical switches and gadgets
- Install fire extinguishers and fire alarms.

7.1.2 Precautions to be taken while at work

Every employee is obligated to follow all safety protocols put in place by the organization.

All employees must make it a habit to:

- Immediately report unsafe conditions to the supervisor
- Recognize and report safety hazards that could lead to slips, trips and falls
- Report all injuries and accidents to the supervisor
- Wear the correct protective equipment when required
- Learn how to correctly use equipment provided for safety purposes
- Be aware of and avoid actions that could endanger other people
- Always be alert
- Educate the employees about the first/emergency exits on the floor, and also where the fire extinguishers are kept.

TIPS

- Be aware of what emergency number to call at the time of a workplace emergency
- Practice evacuation drills regularly to avoid chaotic evacuations

UNIT 7.2: Different types of Health hazards

Unit Objectives

At the end of this unit, you will be able to:

1. Understand the health hazards
2. Demonstrate First Aid Techniques

7.2.1 First Aid

Illness, injuries, and pain are part of human life. This can happen anyway. Every individual is prone to illness and injuries at any time and anywhere.

In case of any of these, some kind of immediate medical attention or treatment is needed to reduce the discomfort, pain, and deterioration of the condition. The medical attention that is given at the first instance before seeking professional medical help is called “First Aid”. First aid is the immediate and temporary treatment given to the victim of an accident or sudden illness while awaiting the arrival of “Medical Aid”. First Aid means providing the initial treatment and life support for people with an injury or illness. However, First Aid has its limitations and does not take the place of professional medical treatment. Proper early assistance given by First Aider helps in saving the life of a patient.

Illness and injuries can happen anywhere, be at home, the workplace, or in the market place.

Whatever safety measures we adopt, we are all prone to illness sometime or the other.

Some common injuries and their rescue techniques:

7.2.2 First Aid Techniques

- Direct pressure must be applied to the cut or wound with a clean cloth, tissue, or piece of gauze, until bleeding stops.
- If blood soaks through the material, it is highly recommended not to remove it.
- More cloth or gauze must be put on top of it, and pressure must be continued.
- If the wound is on the arm or leg, the limb must be raised above the heart to help slow the bleeding.
- Hands must be washed again after giving first aid and before cleaning and dressing the wound.
- A tourniquet must not be applied unless the bleeding is severe and not stopped with direct pressure.



Click / Scan the QR code for
First Aid Techniques



Fig.7.2.2a: Clean cut or wound



Fig. 7.2.2b: Clean cut or wound

Protect the wound

- Antiseptic cream or solution must be applied to the wound to reduce the risk of infection.
- Then the wound must be gently covered with a sterile bandage.
- Till the wound heals, the bandage must be changed (dressed) daily to keep the wound clean and dry.



Fig.7.2.2c: Protect the wound

Call the Emergency Helpline if:

- The bleeding is severe and deep
- You suspect Internal Bleeding
- Abdominal or Chest wound exists
- Bleeding continues even after 10 minutes of firm and steady pressure

For Burns:

- Immediately put the burnt area under cold water for a minimum of 10 minutes
- If the burned area is covered, take clean scissors, cut and remove the fabric covering the area
- In case clothing is stuck to the burned area, leave it as it is
- Before sterile dressing application, remove jewellery (if any)
- It is better to leave the burned area open
- Do not apply any medication or ointment
- Breaking a blister – it is an absolute no-no!



Fig. 7.2.2d: Put Burnt Area under Water

For Broken Bones and Fractures

- **Protruding bone must be left alone**
 - If a bone has broken through the skin, it must not be pushed back into place.
 - The area must be covered with a clean bandage and immediate medical attention must be sought.
- **Bleeding must be stopped**
 - Steady and direct pressure must be applied with a clean piece of cloth for 15 minutes and the wound must be elevated.
 - If a blood soaks through, one must apply another cloth over the first and seek immediate medical attention.
- **Swelling must be controlled**
 - The RICE (Rest, Ice, Compression and Elevation) therapy must be applied to control and reduce swelling.
 - Rest the injured part by having the person stay off of it.
 - Ice must be applied on the area with the help of an ice pack or by wrapping the ice in a clean cloth. Ice must not be directly placed against the skin.

For Heart Attack/Stroke

- Think FAST. Face: is there weakness on one side of the face? Arms: can they raise both arms? Speech: is their speech easily understood? Time: to call Emergency helpline
- Immediately call medical/ambulance helpline or get someone else to do it

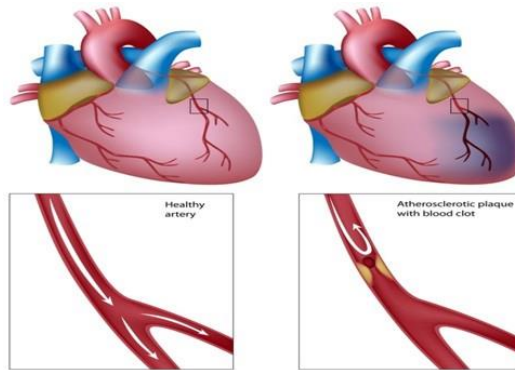


Fig 7.2.2e: Anatomy of Heart Attack

For Head Injury

- Ask the victim to rest and apply a cold compress to the injury (e.g. ice bag)
- If the victim becomes drowsy or vomits, call Medical helpline or get someone else to do it

Steps of using breathing apparatus:



Check the parts of the breathing apparatus thoroughly.



Check the bypass knob (red). Close it if you see it open. After this, press the reset button (area above bypass nob – black)



Inspect the facemask to see that it is undamaged.



Lift the cylinder ensuring that on the top the cylinder valve should be present.

The back plate of the cylinder should face the wearer. Wear the breathing apparatus on the shoulder like a bag pack and by the neck strap, hang the facemask.



After wearing the breathing apparatus tighten shoulder straps and fasten the waist belt.



The cylinder valve should be opened slowly to inspect the pressure gauge.



Make sure that 80% of the cylinder is full.



Wear the mask slowly by resting your chin in the resting cusp and pull the head strap slowly over your head.

Pull the head straps for a snug but comfortable fit.



Breathe in and normally to see if you can breathe normally or not.



Now insert a finger sideways of the facemask for easy outward airflow.



Slowly close the cylinder valve without leaving the knob.

Be steady for 10 minutes and hold your breath or extremely slow to listen to any wheezing sound.

Also, check the pressure gauge for any dip in the pressure.



Normally Breathe to vent system
Listen for a whistle alarm while observing the pressure gauge
at 55 bar (+/-5 bar)

Briefing and Guidance for Fire Fighters

There are basically three methods with the help of which people can be rescued from a building engulfed in a blazing fire. To ensure on-site reception, here are two of the important steps that we will discuss now. These come under the best safe lifting and carrying practices.

Conventional Technique: This is a good method if there is an open area close by. The first rescuers will make the victim sit reach under their armpits and finally, grab their wrist. The other rescuer will cross the ankle (victim), pull up that person's legs on his shoulder. Finally, on the count of 3, both will lift the person up and move out.



Fig.7.2.2f: Fast Strap

Fast Strap: In case the victim is completely incapable of moving out of the fire zone. The rescuers should follow this method. One of the rescuers will place their knee between victim's shoulder and head. Pin the loop of webbing to the ground with the help of the knee. This acts as an anchor. With the non- dominant hand hold the other end of the webbing and make a loop. With steady hands, pull the victim's hand in from the loop, tie it securely and finally clip the webbing loops.



Figure 2-29: Fall strap

Essentials for Smooth Evacuation: The following are essential to have a smooth evacuation during an outbreak:

- Clear passageways to all escape routes
- Signage indicating escape routes should be clearly marked
- Enough exits and routes should be present to allow a large number of people to be evacuated quickly
- Emergency doors that open easily
- Emergency lighting where needed
- Training for all employees to know and use the escape routes
- A safe meeting point or assembly area for staff
- Instructions on not using the Elevator during a fire

Special Evacuation Requirements For Specially Abled Persons

- **The Visually Impaired**
 - Announce the type of emergency
 - Offer your arm for help
- **With Impaired Hearing**
 - Turn lights on/off to gain the person's attention, or indicate directions with gestures, or write a note with evacuation directions
- **People with Prosthetic Limbs, Crutches, Canes, Walkers**
 - Evacuate these individuals as injured persons.
 - Assist and accompany to evacuation site if possible.
 - Use a sturdy chair, or a wheeled one, to move the person to an enclosed stairwell
 - Notify emergency crew of their location

7.2.3 Importance of Fire Safety Drills

Fire drills are indispensable in any workplace or public building for rehearsing what to do in the event of a fire. They are also a lawful obligation under the Fire Safety Order of 2005 and all workers in a company must partake. Here's how to get the most out of your fire practice.

Why have fire drills?

There are numerous reasons why fire drills are vital; first of all, fire drills are a chance to practice evacuation techniques to make sure all staff are acquainted with them. The staff will vacate the building quickly and therefore in a real life situation panic will be decreased, as everyone will know what they need to do. Fire drills are also beneficial for testing escape methods to assess their efficiency.

During fire drills, checks can also be carried out on alarm systems to make certain they are working properly and that emergency exits are passable. Overall fire drills help increase safety, so that you will be best equipped if a real fire does happen.

How often?

Ideally there should be two fire drills a year, although this may vary according to the workplace and after checking the firm's risk assessment. If there are people who work in shifts, suitable preparations should be made to ensure all staff partake in at least one fire drill per year and to educate them as to how to handle the situation.

Should you inform staff beforehand?

There are arguments for and against making people conscious of fire drills before they take place. Some people contend that not notifying staff gives an element of surprise, so that people take drills more sincerely. However, this can also have the reverse effect in a real fire, as on overhearing the alarm people may reason that it's only a drill.

The benefit of notifying all staff of fire drills in advance is that initially, they will not panic, which circumvents potential injuries that could be instigated in a rush to exit a building. Furthermore, if the alarm sounds, lacking a prior warning, there will be no uncertainty as to if it is a drill or not and people will act correctly. In public places such as shopping centres, it is prudent to make members of the public alert when a drill is about to happen.



UNIT 7.3: Importance of Safe Working Practices

Unit Objectives

At the end of this unit, you will be able to:

1. Explain Basic Hygiene Practices
2. Understand the importance of Social Distancing
3. Demonstrate the safe working practices

7.3.1 Basic Hygiene Practices

We are living in an environment with millions of germs and viruses. And our body can be a breeding space for these microbial organisms. They grow and multiply and cause many diseases which sometimes can prove to be fatal for the human beings. These disease-causing microbial organisms kill over 17 million people every year. Some simple hacks and little changes of basic personal hygiene habits can bring amazing changes to all of us. We can prevent contracting these diseases if we follow these hygiene practices every day.

Personal Hygiene

Personal hygiene is all about managing your body hygiene, essentially caring for your well-being incorporating some physical hygiene habits. Also, there are mental health benefits as well, as they affect each other immensely.

What are good personal hygiene habits?

Good personal hygiene includes but not limited to-

- Take regular shower
- Maintain oral hygiene
- Wash your hands frequently
- Wash your genitals
- Keep your clothes and surrounding dry and clean

These habits should be practiced on a regular basis, at home, at work, basically where you are! That's the whole idea of preventing your body system collapse over a tiny microbe!

Personal Hygiene Practices at Home

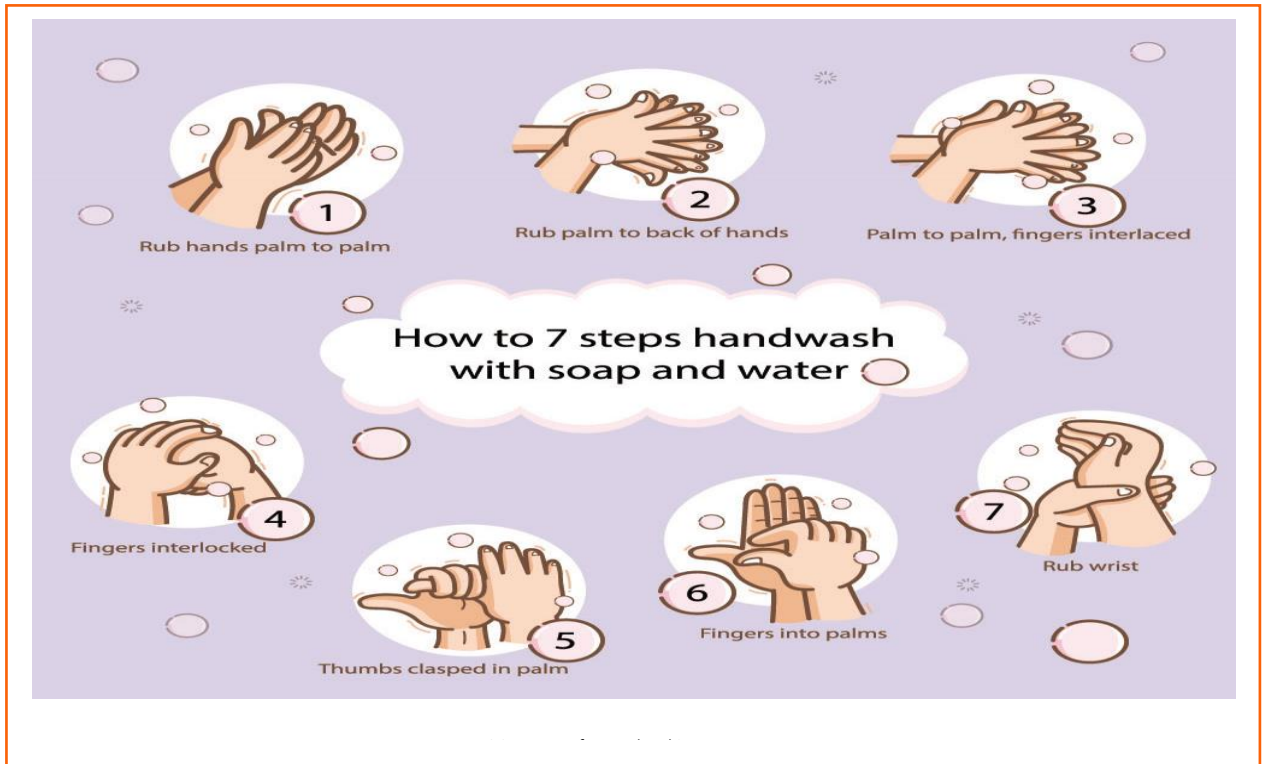
Your home should be the most comfortable and convenient for you to keep up your personal hygiene level to a standard, yet, we find ourselves procrastinating over hygiene issues when we are at home. Even though some of these tasks barely take a minute.

1. Take Regular shower

Do not wait up to feel the dried sweat in your body to feel the urge to take shower, make it a routine, you have the choice to either take them before you head to work or after the long day or even before you head to sleep, whichever one suits your routine. Make sure to rinse your body thoroughly, especially the genitals and underarms as they produce more sweat and are more prone to fungal activities.

2. Wash your hands frequently

We use our hands to do our most physical acts, from picking up the keys, browsing through our phones, cooking or eating to attending our pets. While we agree and accept the importance of washing hands before eating and after visiting the toilet, it is also **important to wash our hands** with soap or sanitizer every now and then. The pandemic covid-19 which crippled the life all over the world has taught us an important lesson that sanitizing our hands regularly is the only way we can avoid transmission of the disease. Use **alcohol based sanitizer** to wash hands well to prevent the spread of communicable diseases



3. Maintain oral hygiene practices

It is very important to take care of the teeth and gum, to prevent tooth decay and bad odour. Just brushing them twice a day is not enough, but using fluoride toothpaste and brushing properly is very essential. And wash it well with water to remove any food particles that is stuck in the gap in between the teeth. It is advised to wash the teeth everyday twice to maintain healthy teeth and gum.

Click/Scan the QR Code to know more about handwash techniques



4. Nails and hairs hygiene

The cleanliness of nails and hair is also very important. They store dirt and grease. And even the microbes could be in there stuck and spreading. If the nail is not clean they can cause severe food poisoning, as we use our hands to eat food. Trim the nails once in a fortnight and wash hair at least twice a week with a shampoo to keep them healthy

5. Nose and ears hygiene

Wherever we are most likely to breathe in some pollutants, and most of the particles are bound to be stuck in the nasal hair. So, rinse the nose and ear with warm water once you return from outside.

6. Wear fresh and clean clothes

Changing into neat and clean clothes will prevent many infectious diseases. It will also give the mental effect immediately and it will boost the mind. Wash clothes with a good detergent every day and dry it in the sun. This will ward off any microbes attached to the clothes. If possible, Dettol can be used while rinsing which is an anti-disinfectant.

7. Food hygiene

You can get severely sick from food-borne diseases, as most of your foods are raw, purchased from outside, they risk being cross-contaminated with harmful microbes. Food hygiene is basically the idea of better storage, handling, and preparation of food to prevent contamination and to prevent food poisoning.

7.3.2 Importance of Social Distancing

Preventing communicable diseases:

All these above practices will help us to prevent communicable diseases. These diseases are highly infectious and contagious and spread through air, urine, feaces, saliva, skin (through touch) and using same towels and utensils.

Social Distancing and isolation, Self-Quarantine:

Ever since the spread of the pandemic covid-19, several health organisations have been insisting on following social distancing and isolation. Communicable diseases mainly spread through coming close to the infected individual and through physical touch. If a person is infected with diseases like normal flu or cold and spread it to others, the symptoms and may remain with the infected person for a day or two. The virus may be destroyed by taking an antibiotic. But in severe cases like corona virus the infection is severe and can prove fatal to the affected people. To prevent the spread of the virus, the entire world adopted lockdown, **social distancing** and compulsory face mask. And the infected person has to be in **self isolation** and **quarantine** till the time the symptoms are over. This was the advisory from the World Health Organisation, and the entire world followed it to prevent the rapid spread of the virus. The same can be applicable to all types of communicable diseases that are spread mainly through air and touch.

As communities reopen and people are more often in public after the pandemic, the term “physical distancing” (instead of social distancing) is being used to reinforce the need to stay at least 6 feet from others, as well as wearing face masks. Historically, social distancing was also used interchangeably to indicate physical distancing which is defined below. However, social distancing is a strategy distinct from the physical distancing behavior.

What is self-quarantine?

Self quarantine was imposed on people who have been exposed to the new covid-19 and who are at risk for getting infected with the virus were recommended to practice **self-quarantine**. Health experts advised the self-quarantine for 14 days or two weeks. Two weeks provides enough time for them to know whether or not they will become ill and be contagious to other people.

self-quarantine was also recommended for people who have recently returned from traveling to a part of the country or the world where COVID-19 was spreading rapidly, or if a person has knowingly been exposed to an infected person.

Self-quarantine involves:

- Using standard hygiene and washing hands frequently
- Not sharing things like towels and utensils
- Staying at home
- Not having visitors
- Staying at least 6 feet away from other people in your household

Once your quarantine period has ended, if the symptoms are not there, then the person may return to normal routine as per doctor’s advice.

What is isolation?

Anybody who is infected with a contagious disease needs to practice isolation in order to prevent the spread of the germs to their near and dear ones. This became very popular and was strictly adhered to during the covid-19 pandemic. People who were confirmed to have COVID-19, **isolation** was mandatory. Isolation is a health care term that means keeping people who are infected with a contagious illness away from those who are not infected. Isolation can take place at home or at a hospital or care facility. Special personal protective equipment will be used to care for these patients in health care settings. They are attended by well trained nurses and specialised doctors. And these people have to be in the PPE kits all through their presence in the hospital.



Complete PPE Kit

Disposing off the PPE Kits

The PPE kits are worn by health workers and doctors who are attending to patients with highly infectious diseases and who are kept in isolation in order to arrest the spread. They have to wear it every time they go near the patient and have to remove it once their duty is over. Most of the PPE components are used for single use, however the face mask and goggles can be reused provided they are sanitised properly. The PPE kits have to be disposed off safely as they might have contaminants stuck to them and they may infect the healthy person if they are not discarded properly. The health workers may be all the more vulnerable to contact the disease.

7.3.1 Safe Workplace Practices

Every company has the provision of first aid box. As you have already read about the types of injuries that technicians can receive in their field of work, it is imperative for the companies to have appropriate first aid accessories.

The basic first aid supplies and accessories that a first aid box should have are:

Supplies and Accessories in the First Aid Box



Splint



Elastic wraps



Latex gloves



Adhesive tape



Tweezers



Blanket



Scissors



Wound cleaning agent



Triangular bandages



Gauze roller bandage



Adhesive bandages



Gauze pads



Antiseptic cleansing wipes



Burn cream or gel



Eyewash liquid



CPR Kit

Chemical hazards are caused by toxic materials, which are poisonous. And being poisonous in nature, they can either be fatal or cause serious damages in case the preventive actions are not taken on time. Now, the exposure to chemicals can be in 3 forms.

They can be:

- Inhaled (entering the body through nose)
- Directly in contact with skin
- Ingested (consumed)

The symptoms, in this case, will be:

- Seizures
- Partial or complete loss of responsiveness
- Burning sensation
- Stomach Cramping with bouts of excruciating pain
- Nausea
- Vomiting (and in times with blood-stains)



Now, where there are problem, their solutions come side by side. In such situations, the person giving first aid requires to be calm and take certain preventative actions.

Some of the essential actions are:

- Using insulated equipment
- Wearing protective clothing, goggles, masks, shoes and gloves
- Ensuring the place has enough ample ventilation

Remedial action

- The foremost thing that one should do is to provide immediate first aid. However, it is to be remembered that the victim should not be given any kind of fluid (water, milk) until doctors from Poison control unit gives a green signal.
- Aside from this, there are a few things a person can perform to the victim of toxic material exposure.
- Remove the victim from the toxic zone or vicinity
- Call for an ambulance
- Remove contaminated clothing
- Splash water in the eyes
- If ingested, do not try to make the victim puke (vomit)
- Wash their mouth with water



Fig. 7.3.2: CPR

- In case the victim's breathing has stopped, give CPR (Cardiopulmonary resuscitation)
- In case of burning due to toxic material, apply burn gel or water gel on that area.
- Avoid any cream based or oil based lotion or ointment

Even though giving first aid is the right thing to do in the first place, it is also important to report the incident to their supervisor.

Exercise

1. Burnt area should be kept under _____ for a minimum of 10 minutes
2. _____ exits should be easily accessible in case of fire.
3. _____ or _____ must be applied to the wound to reduce the risk of infection
4. The RICE which is _____, _____, _____ and _____ therapy must be applied to control and reduce swelling.
5. CPR is _____.

Click/Scan the QR code to know
CPR better



UNIT 7.4: Reporting Safety Hazards

Unit Objectives

At the end of this unit, you will be able to:

- Discuss the process of reporting in case of emergency (safety hazards)
- Understand methods of reporting hazards

7.4.1 Methods of Reporting Safety

Every organization, from every industry, has a standard reporting protocol, comprising the details of people in the reporting hierarchy as well as the guidelines to be followed to report emergencies. However, the structure of this reporting hierarchy varies between organizations, but the basic purpose behind the reporting procedure remains same.

The general highlights of the Organizational Reporting Protocol, commonly known as the 6Cs, are:

- **Communicate First**
 - The first source of information during emergency is the preferred source.
 - Crises situations are time-bound and hence it is important to communicate promptly.
- **Communicate Rightly**
 - Distortion of information due to panic must be avoided.
 - Proper, accurate information must be provided to concerned authorities and this can save lives.
- **Communicate Credibly**
 - Integrity and truthfulness must never be forgotten during emergencies.
- **Communicate empathetically**
 - One must wear the shoes of the victims while communicating emergencies.
- **Communicate to instigate appropriate action**
 - Communicating to the right authorities help in taking the necessary action.
- **Communicate to promote respect**
 - Communicating with the victims with respect help in earning their trust and thus eases the disaster management process.

Hazards and potential risks / threats can be identified and then reported to supervisors or other authorized persons in the following ways:

While identifying and reporting a hazard / potential threat / potential risk, one must describe the following:

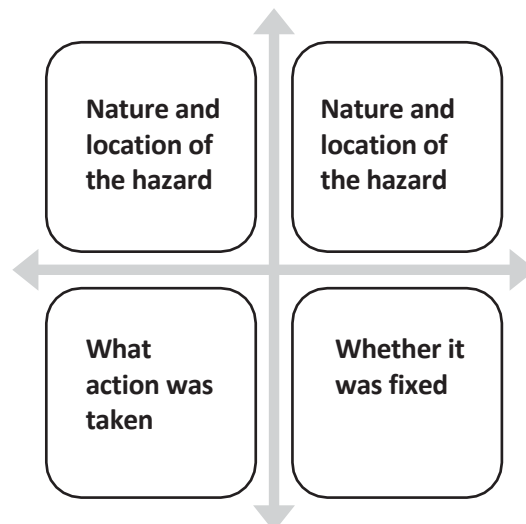


Fig. 7.4.1a: Describing hazard matrix

Part A: To be completed by the Worker Details Required:

- Name of Worker
- Designation
- Date of filling up the form
- Time of incident / accident
- Supervisor / Manager Name
- Work Location / Address
- Description of the hazard / what happened (Includes area, task, equipment, tools and people involved)
- Possible solutions to prevent recurrence (Suggestions)

Part B: To be completed by the Supervisor / Manager Details Required:

- Results of Investigation (Comment on if the hazard is severe enough to cause an injury and mention the causes of the incident / accident)

Part C: To be completed by the Supervisor / Manager Details Required:

- Actions taken / Measures adopted (Identify and devise actions to prevent further injury, illness and casualty)

Action	Responsibility	Completion Date

Any job role and any occupation in this world have some hazards, in varying severity, associated with it. These are called Occupational Hazards. Occupational Hazard can be defined as “a risk accepted as a consequence of a particular occupation”. According to the Collins English Dictionary, it is defined as “something unpleasant that one may suffer or experience as a result of doing his or her job”. Occupational Hazards are caused by the following:

Hazard Report Form	
Name:	Date:
Location:	
Tool/Equipment:	
Description of the hazards:	
Suggested corrective action:	
Signature:	
Supervisor's remarks:	
Corrective action taken:	
Signature of Supervisor:	Date:

Fig 7.4.1b: Sample form of reporting hazards

UNIT 7.5: Waste Management

Unit Objectives

At the end of this unit, you will be able to:

- Understand what is e-waste
- Understand the concept of waste management
- Explain the process of recycling of e-waste

7.5.1 Introduction to E-Waste

Electrical and electronic products are all around us. We can't imagine a world without these gadgets. Our life is indispensable without electricity and electronic devices. Growth in the IT and communication sectors has increased the usage of electronic equipment immensely. Frequent change on the technological features of electronic products is forcing consumers to discard their old electronic products very quickly, which, in turn, adds to e-waste to the solid waste pool. What this translates to is mountainous masses of electrical and electronic waste which has a high potential to pollute the environment. This growing menace of e-waste calls for a greater focus on recycling e-waste and better e-waste management.

E-waste means electrical and electronic equipment, whole or in part discarded as waste by the consumer or bulk consumer as well as rejects from manufacturing, refurbishment, and repair processes. E-waste usually is made up of usable and non-usable material. Some of the waste if left unattended will be destructive to the environment. E-waste is made up of hazardous substances like lead, mercury, toxic material, and gases.

There are many companies these days who are engaged in the collection, handling, and disposal of this e-waste in a safer and more secure place to protect the environment.

7.5.2 What is E-Waste?

The amount of e-wastes comprising computers and computer parts, electronic devices, mobile phones, entertainment electronics, refrigerators, microwaves, TV, fridges, and industrial electronics that are obsolete or that have become unserviceable is growing. All these electronic devices contain plastics, ceramics, glass, and metals such as copper, lead, beryllium, cadmium, and mercury and all these metals are harmful to humans, animals, and the earth. Improper disposal only leads to poisoning the Earth and water and therefore all life forms. Our effort is meant to preserve the environment and prevent pollution by proper handling of e-waste. While it will take a lot of effort to educate people to dispose of such wastes in the right way, we are doing our part by providing a channel to collect e-wastes and dispose off them in a sustainably safe manner. We convert waste to usable resources.

The electronic industry is not only the world's largest industry but also a fast-growing manufacturing industry. It has been instrumental in the socio-economic and technological growth of the developing society of India.

At the same time, it poses a major threat in the form of e-waste or electronics waste which is causing harmful effects on the whole nation

e-waste is creating a new challenge to the already suffering Solid waste management, which is already a critical task in India.

7.5.3 Electronic goods/gadgets are classified under three major heads:

White goods: Household appliances,

Brown goods: TVs, camcorders, cameras etc.,

Grey goods: Computers, printers, fax machines, scanners etc.

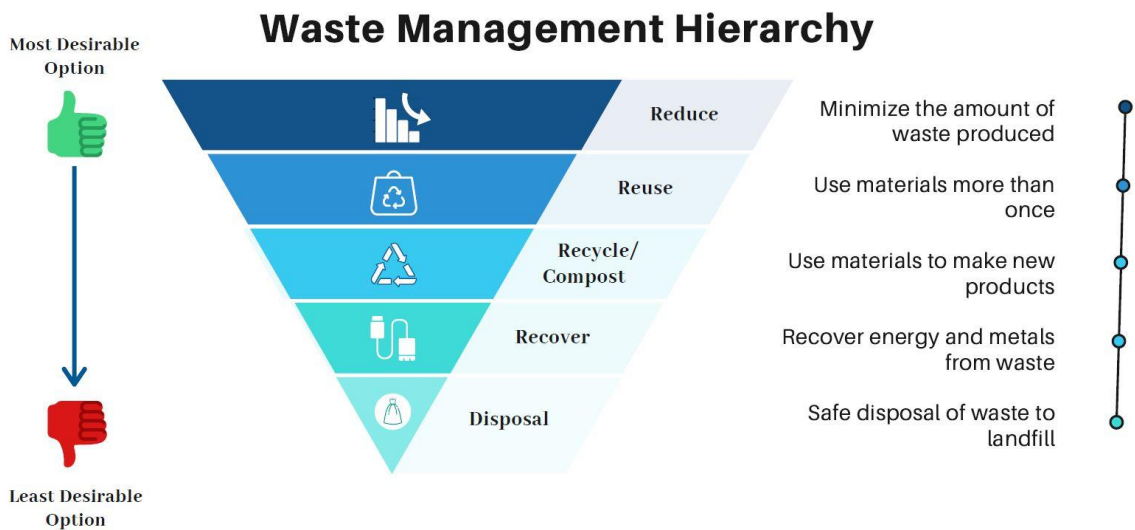
The complete process is carried out as per the government guidelines.

7.5.4 E-waste Management Process

- Collection of e-waste from all the electronic stores, manufacturing companies, etc.
- Transport of e-waste to the disposal units
- Segregation of e-waste at the disposal unit
- Manual dismantling of e-waste to segregate components into various types such as metal, plastics and ceramics
- Convert into raw material (recycle and reuse)
- Supply recovered raw material to processors and electrical/electronic industries
- Dispatch hazardous e-waste for safe disposal

7.5.4 E-waste Management Process (contd.)

Waste management is carried out to ensure that all types of waste and garbage are collected, transported, and disposed of properly. It also includes recycling waste so that it can be used again



Click/Scan the QR code to understand more about E-Waste management process



7.5.5 Recyclable and Non-Recyclable waste

Recyclable waste is **renewable or can be reused**. This means that the waste product is converted into new products or raw material, like paper, corrugated cardboard (OCC), glass, plastics containers and bags, hard plastic, metal, wood products, e-waste, textile, etc. Recycling not only conserves important areas in our landfills but also assists decrease greenhouse gas emissions.

Contrary to this, Non-recyclable waste cannot be recycled and cause a major threat to the environment.

The following items cannot be recycled:

Shredded paper, aerosol cans, paper coffee cups, milk and juice cans, used baby diapers, and bottle caps.

Recycling is one of the best ways to have a favorable influence on the world where we live. Recycling will greatly help us to save both the environment and us from pollution. If we take immediate action, we can control this, as the quantity of waste we are accumulating is increasing all the time.

7.5.6 Colour codes of waste collecting bins

Waste collecting bins colour code

India's urban population of 429 million citizens produce a whopping 62 million tonnes of garbage every year. Out of this, 5.6 million tonnes is the plastic waste, 0.17 million tonnes is the biomedical waste, 7.90 million tonnes is hazardous waste and 15 lakh tonnes is e-waste.

According to an estimate, 40% of municipal waste in the city is 'wet' waste, which can easily be composted and used as manure. Nearly 30% of the municipal waste comprises of plastic and metal, which can be sent to an authorized dealer for recycling, and about 20% of it is e-waste, from which precious metals can be taken apart and recycled. However, out of the total municipal waste collected, 94% is dumped on land and only 5% is composted. To gather the garbage two color bin system was suggested. Green bin for wet waste and blue for dry waste. However, there is a drawback in that system. People do through the sanitary napkins and children's diaper along with wet waste causing the contamination of things. Hence the government has come up with three colored garbage collection bins.



1. Green Bin

The green coloured bin is used to dump biodegradable waste. This bin could be used to dispose off wet/organic material including cooked food/leftover food, vegetable/fruit peels, egg shell, rotten eggs, chicken/fish bones, tea bags/coffee grinds, coconut shells and garden waste including fallen leaves/twigs or the puja flowers/garlands will all go into the green bin.

2. Blue bin

The blue coloured bin is used for segregating dry or recyclable left over. This category includes waste like plastic covers, bottles, boxes, cups, toffee wrappers, soap or chocolate wrapper and paper waste including magazines, newspapers, tetra packs, cardboard cartons, pizza boxes or paper cups/plates will have to be thrown into the white bin. Metallic items like tins/cans foil paper and containers and even the dry waste including cosmetics, hair, rubber/thermocool (polystyrene), old mops/dusters/sponges.

3. Black bin

Black bin, make up for the third category, which is used for domestic hazardous waste like sanitary napkins, diapers, blades, bandages, CFL, tube light, printer cartridges, broken thermometer, batteries, button cells, expired medicine etc.

7.5.7 Waste disposal methods:

- **Incineration:** Combusting waste in a controlled manner to minimize incombustible matter like waste gas and ash.
- **Waste Compaction:** Waste materials are compacted in blocks and are further sent away for recycling.
- **Landfill:** Waste that can't be recycled or reused can be thinly spread out in the low-lying areas of the city.
- **Composting:** Decay of organic material over time by microorganisms.
- **Biogas Generation:** With the help of fungi, bacteria, and microbes, biodegradable waste is converted to biogas in bio-degradation plants.
- **Vermicomposting:** Transforming the organic waste into nutrient-rich manure by degradation through worms.

7.5.8 Sources of Waste

1. **Construction waste** – waste coming from construction or demolition of buildings.
2. **Commercial waste**- waste from commercial enterprises
3. **Household waste**- garbage from households is either organic or inorganic
4. **Medical or clinical waste** -wastes from the medical facilities- like used needles and syringes, surgical wastes, blood, wound dressing
5. **Agricultural waste**- Waste generated by agricultural activities that include empty pesticide containers, old silage packages, obsolete medicines, used tires, extra milk, cocoa pods, wheat husks, chemical fertilizers, etc.
6. **Industrial waste**-The waste from manufacturing and processing industries like cement plants, chemical plants, textile, and power plants
7. **Electronic waste**-The defective, non-working electronic appliances are referred to as electronic waste. These are also called e-waste. Some e-waste (such as televisions) contains lead, mercury, and cadmium, which are harmful to humans and the environment
8. **Mining waste**- chemical gases emitted in mine blasting pollutes the environment. And the mining activity greatly alters the environment and nature.
9. **Chemical waste**-waste from the chemical substance is called chemical waste.
10. **Radioactive waste:** radioactive waste includes nuclear reactors, extraction of radioactive materials, and atomic explosions.

7.5.9 Source of Pollution

All these above-mentioned waste also adds to environmental pollution. The contaminants that cause detrimental change to the environment are called pollution. It is one of the most serious problems faced by humanity and other life forms on our planet. The earth's physical and biological components have been affected to such an extent that normal environmental processes could not be carried out properly.

7.5.10 Types of Pollution

Types of Pollution	Detail/Pollutants involved
Air pollution	<ul style="list-style-type: none"> ▪ Solid particles and gases mixed in the air cause air pollution ▪ Pollutants: emissions from the car, factories emitting chemical dust, and pollen
Water pollution	<ul style="list-style-type: none"> ▪ Water gets polluted when toxic substances enter water bodies such as lakes, rivers, oceans, and so on. They get dissolved in it and cause it unfit for consumption. ▪ Pollutants that contaminate the water are discharges of untreated sewage, and chemical contaminants, release of waste and contaminants into surface
Soil pollution	<ul style="list-style-type: none"> ▪ It is the presence of toxic chemicals (pollutants or contaminants) in soil, in high enough concentrations to pose a risk to human health and/or the ecosystem ▪ Sources of soil pollution include metals, inorganic ions, and salts (e.g. phosphates, carbonates, sulfates, nitrates),
Noise pollution	<ul style="list-style-type: none"> ▪ Noise pollution happens when the sound coming from planes, industry or other sources reaches harmful levels ▪ Underwater noise pollution coming from ships has been shown to upset whales' navigation systems and kill other species that depend on the natural underwater world
Light pollution	<ul style="list-style-type: none"> ▪ Light pollution is the excess amount of light in the night sky. ▪ Light pollution, also called photo pollution, is almost always found in urban areas. ▪ Light pollution can disrupt ecosystems by confusing the distinction between night and day.

UNIT 7.6: Organizations' focus on the Greening of jobs

Unit Objectives

At the end of this unit, you will be able to:

- Understand the concept of ESG
- Explain the different factors of ESG

7.6.1 What is ESG?

The ESG is the short form of environmental, social, and governance. ESG guidelines are used to evaluate businesses on how well they control emissions, governance, human rights, and other factors of their business.

Several companies audit these companies for ESG compliance. They will let the companies know how well the ESG policies are implemented in their company that let companies know how well their ESG policy is working.

Every business enterprise is deeply intertwined with Environmental, Social, and Governance (ESG) issues. ESG has been looked at seriously by the corporate, government establishments and stakeholders.

ESG is important as it creates high value, drives long-term returns, and global stakeholders are paying attention to the topic.

ESG is said to have created high value, and focuses on long-term returns, and stakeholders are focusing more on this concept.

7.6.2 Factors of ESG

Several factors are used to determine how well a business is doing in maintaining its ESG policies. For creating the ESG Policy, thorough knowledge of these factors are critical.

The factors are divided into three categories; environmental, social, and governance. Knowing about these factors come a long way in designing the effective ESG policy.

Environmental

Environmental factors relate to a business's impact on the environment. Examples include:

- Usage of renewable energy
- Effective waste management
- Policies for protecting and preserving the environment

Social

Social factors relate to the people of the organization. How they are treated in the organization is what it focuses on. The major entities are the stakeholders, employees, and customers. Examples include:

- diversity and inclusion
- proper work conditions and labor standards
- relationships with the community

Governance

Governance factors relate to the company policies for effectively running it. They include:

- tax strategies
- structure of the company
- relationship with stakeholders
- payments to the employees and CEO

Every factor is important and matters a lot to the overall rating of the company in ESG compliance. Ignoring one aspect in favor of another can affect the rating and in turn the reputation of the company.

The companies make a clear communication about these policies to all the employees, and to the public, they should mention what their various activities are that will protect the environment, people, and the governing factors.

Exercise



1. ESG stand for _____, _____, _____.
2. Governance factors include _____, _____, _____, _____.
3. The three causes of air pollution _____, _____ and _____.
4. Mining waste includes _____.
5. Landfill is a _____.

8. Communication and Interpersonal Skills



Unit 8.1 – Interaction with supervisor, peers,
customers, and differently-abled persons

Unit 8.2 – Explain the importance of developing
sensitivity towards disabled persons



Key Learning Outcomes

At the end of this module, you would be able to

- Understand what is communication and the importance of communication in the workplace
- Understand effective communication and communicate effectively for success
- Discuss types of communication -verbal and non-verbal
- Communicate at workplace
- Communicate effectively with superiors
- Communicate effectively with colleagues and customers using different modes viz face-to face, telephonic and email communication
- Understand the hurdles for effective communication
- Conduct professionally at work place
- Respect differences in gender and ability
- Communicate effectively with person with disabilities
- Respect for disable people

UNIT 8.1: Interaction with supervisor, peers and customers

Unit Objectives

At the end of this unit you will be able to:

1. Understand the importance of communication
2. Understand types of communication

8.1.1 Why is Communication Important?

- Communication Skills are more important than ever, for all fields of endeavor.
- Whatever the role a person is holding in the organization, having a firm grasp of effective communication will undoubtedly be a key role in the individual's as well as the organization's success
- Oftentimes, people with excellent technical skills don't get promoted to higher roles because of their inability to communicate effectively
- Hence one fundamental skill everybody should be proficient along with the technical skill is **Communication Skills**

8.1.2 What is Communication?

- Communication is the process of sending and receiving information among people.
- It is imparting or exchanging of information by speaking, writing, or using some other medium
- The purpose of communication is to convey your thoughts and opinions to others.
- Communication is said to be successful only when both the sender and the receiver perceive it in the same way.
- In your personal and professional life, you would be communicating with the following people-
 - Colleagues
 - Customers

8.1.3 Effective Communication

Effective communication is the process of delivering messages to a target audience in a way that guarantees satisfactory reception and understanding. If the communication is effective, both the sender and the receiver will share the same information at the end of the process. Effective communication is about more than just exchanging information. It's about understanding the emotion and intentions behind the information

8.1.4 Effective Communication for Success

Effective Communication is critical to a business's success. From top to bottom, among colleagues, from subordinates to superiors, and from the organization to the outside, several messages are delivered daily. All the people must communicate these messages properly. Content, language, remarks, tone of voice, and non-verbal communication are elements that affect the effectiveness of messages

Clear and effective communication will

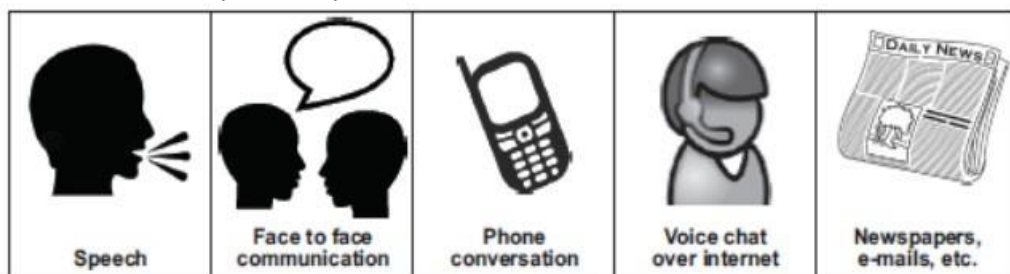
- Increase customer satisfaction
- Bring more business to the company
- Increase productivity among team members

8.1.5 Types of Communication

Communication has been divided into two types:-

- Verbal Communication
- Non-Verbal Communication

Verbal communication takes place when people exchange words with each other, either spoken or written. It includes the **choice and use of words and language to convey a message**. Examples of verbal communication are face-to-face conversation, telephonic conversation, and a speech or presentation.



Click/Scan the QR code to understand types of communication



Speech has certain characteristics which will affect the message that is being spoken:

- Volume – loud speech may sound bossy, very quiet speech cannot be heard.
- Tone – use warm tones without sounding over-friendly. Cool tones are very unwelcoming.
- Pace – fast speech is not easy to follow. Speak at a reasonable pace so that the other person has a chance to understand.

Correct body language also plays an important role in effective communication. For example, a warm smile accompanying 'Have a nice day' or looking directly at the person who is being spoken to give a positive image of the organisation.

Non –Verbal Communication

Non-verbal communication includes the overall body language of a person. There are two kinds of non-verbal communication:

1. **Signs and symbols:** for example pictures, or notices, or signboards, or even photographs, sketches and paintings. Here are some examples of different signs and symbols:



2. **Gestures and expressions:** hand signs, facial expressions, body postures or body language that can help to convey a message. You can learn to communicate better with others if you learn to recognise some of these.

Facial expressions - A smile or a frown

Gestures - movements of hands and body to help explain or emphasize the verbal message

Body posture - how we stand or sit. Maintain a good posture. When you are talking to a colleague or guest, remember to stand up straight, look professional and be positive. Do not slouch, lean against something or fidget with equipment or your hands.

Orientation - whether we face the other person or turn away

Eye contact - whether we look at the other person and for how long

Proximity - the distance we are from a person

Head nods - for encouragement, indication of agreement or disagreement



These non-verbal clues are important as they can be used to improve the quality of communication. They can be used to reinforce any verbal communication; for example, leaning forward and looking at the person you are speaking to and smiling naturally. Your expressions, posture and appearance must be appropriate and should tell the guest that you are professional, competent and willing to help.

8.1.6 Communication at workplace

In every situation, while interacting with people, we make use of both verbal and Non-Verbal Communication. It is the key to the success of any organization. Be it communication with customers, supervisors, or peers. In today's scenario having technical skills alone is not enough to get the work done, but communication skill is also equally important. Completing the task must require the support of the whole team, and without proper communication, it cannot happen. Effective Communication helps managers to perform their jobs and responsibilities and it serves as a foundation for planning.

8.1.7 Communication with supervisors

Effective and open communication within a team will build a common purpose among team members that will allow them to reach their goals. Team leaders know that group communication enhances organizational efficiency. The team members should always follow the communication guidelines. Some of the points to remember while interacting with supervisors:

1. Be aware of the communication guidelines of the organization.
2. Understand and interpret clearly, the work requirements from the supervisor.
3. Keep the supervisor informed about the progress of the task assigned.
4. Participate in all the discussions which call for decision-making, and provide facts and figures
5. Give/ accept suggestions during the discussions.
6. Accept the feedback positively and work towards rectifying errors if any. Make sure the same mistakes are not repeated.

8.1.8 Communication with colleagues and customers

- The main responsibility of a Customer Care Executive is to handle customers' concerns.
- Interaction with colleagues/peers is also equally essential and it enhances productivity in the workplace.
- Be polite in speaking to your peers at the office.
- Value other people's time as much as you value your own.
- Before you begin discussing something, ask your coworker if it is the right time to talk, and give a true picture of how much time you expect to take. Always start the conversation
- Communication with colleagues/customers can be through face-to-face, telephonic, or email.
- Keeping a few points in mind while communicating will make the interaction pleasant and fruitful.

Click/Scan the QR Code to know more about
Communication with Colleagues and Customers



8.1.9 Face-to-face Communication

This is an important medium of oral communication, wherein two or more persons talk to each other and see each other physically. This form of communication is direct or straight.

Things to remember while you are communicating face to face

1. Adjust the tone of voice, don't be too loud
2. Make eye contact
3. Use appropriate language
4. Maintain adequate distance
5. Acknowledge, nod during interaction
6. Use appropriate non-verbal gestures to communicate with persons with disabilities

Benefits of face-to-face communication

1. Instant feedback
2. Information conveyed clearly
3. Build rapport

8.1.10 Telephonic Communication

Another widely adopted mode of communication is through the telephone. This is the person-to-person conversation where nobody sees others but hears each other and interacts instantly. Nowadays mobile phones are becoming more popular along with landlines as a mechanical media of oral communication.

The following suggestions are recommended to follow while making telephone calls-

1. Make the call at the appropriate time
2. Provide details about your identity like name, company, department, etc.
3. Discuss the purpose of the call
4. Think about the tone of your voice
5. Listen carefully
6. Speak clearly
7. If you don't understand something, ask
8. Use please, thank you, sorry wherever necessary
9. Follow the organization's policies and procedures while interacting on the telephone.

Click/Scan the QR code to know more about telephone communication



8.1.11 Email Communication

Email or Electronic mail is a method of exchanging messages using electronic media. The official or business communication between colleagues or inter-department communication usually happens through email. The advantage of email is you can send communication to many people at the same time.

Points to remember in email communication

1. Be clear and concise
2. Keep the content short and to the point
3. Avoid using jargon and short forms
4. Re-read the message, before sending it for grammar and spelling mistakes
5. The subject line should describe the main mail content
6. Use readable font size (don't keep it too small)
7. Add signature at the bottom of the mail body
8. Check the attachments for viruses before sending

8.1.12 Importance of timely completion of tasks

Time is a major factor that evaluates **the success or failure of a project**. Even when the whole team has done a wonderful job and produced high-quality results, with half the cost allotted to the project, everything will be a waste if it was not delivered on time. Any deviation from the timeline will call for a penalty and sometimes may result in losing the project and eventually the customer. so adhering to the timeline is important when it comes to any organization who are into products and services.

Benefits of adhering to timelines:

1. Increased and improved customer satisfaction
2. Increased productivity and efficiency of the individual
3. Team feels motivated
4. Sense of adhering to the SLA's and Standard Operating Procedures
5. Shows the commitment toward the work and the organization
6. Good word of mouth from the customers

8.1.13 Standard Operating Procedure

A **Standard Operating Procedure (SOP)** is a standardized process that outlines a set of detailed instructions to help workers perform complex tasks properly and safely. The main objective of standard operating procedures is to develop an effective quality system and comply with industry-specific regulations and standards. Failure to follow SOPs can cause significant errors in operations and services.

For a mobile repairing center, the SOP defines the different process of operations, namely handling customer, repairs, sales and interaction among the staff within the repair center.

SOP also clearly defines the responsibility of each and every designated person in the organisation and what is expected from them. It further defines what the various levels of engineers will handle with respect to the handsets coming for repair.

The escalation matrix specifies how the different levels escalate the issue to the next level and adhere to the timelines for repair and communication to the customer.

SOP is created keeping in mind the customer satisfaction as a main motive.

Each and every person in the organisation is expected to read the SOP thoroughly and work accordingly. Because every customer when they go for purchasing a product, one of the main things they see is the post-sales Support. If they find the brands deliver good service support then they don't mind even spending few extra moneys.

8.1.14 Escalation Matrix

An Escalation matrix is made up of several levels of contact based on the specific problem at hand. This is being followed by all who are working on that product and have to adhere to the service guidelines. And the problem must be closed at a minimum turnaround time, and for any reason the repair is taking time proper reason has to be mentioned and notified to all the people concerned including the customer.

8.1.15 Escalation Mechanism

Customer service is a very important aspect of a typical service industry. Giving committed service to customers every time and on time is very crucial for the success of the brand. In recent times, customers do research on how the after-sales support of a product is, and based on that rating they will decide which brand to buy. If the customer service is not good, they will not go for that product even though the product is very good. Hence customer service is a second important aspect of a product and services organization.

For electrical home appliances, the customer logs a complaint and the service engineer is sent to the site for looking into the problem and repairing.

For electronic devices like mobile phones and tablets, the customer is expected to take the product to their service center to get it checked and repaired.

The resolution time matters a lot, as mobile phones have become an indispensable device for people. Their business cannot function without that. Hence too much downtime is also not good.

Once at the service center, the technicians at L1 level look for the problem and try to resolve it. If it's beyond their area of resolution the same is escalated to the next level. Every organization has **Standard Operating Procedures** clearly state the workflow for the repair of the smart phones. Every individual working there must be aware of the same and adhere to the deadline for faster service and enriched customer satisfaction.

8.1.16 Escalation through CRM

Customer Relationship Management is a software, through which most of these companies who are into customer service, manage their customers. The customer details are entered in the system and also the services which are logged against a particular customer. This is the automated system, which takes a particular action after a period of time. For example, if a service request is assigned to an engineer for rectifying a problem of a client, and if the engineer does not update the status of the service in the system within a specified period of time, the problem is automatically escalated to the next level for resolution. Then the new engineer who is responsible for resolving pick it and try to find a solution. This system helps to maintain a track of a particular problem and the current status which will help the organization in effectively managing the customer queries. The complete escalation route is mentioned in the SOP and the same is implemented through the CRM software. This eases the manual escalation procedure which is time consuming and slow.

8.1.17 Escalation issues at work

Whether an issue arises among team members or with customers, sometimes the severity of the circumstance requires an escalation to management. Understanding how to approach an escalation can help you better find a solution when conflicts arise. We explore what it means to escalate an issue in the workplace and provide tips for how to do so successfully.

What does it mean to escalate an issue at work?

Escalating an issue in the workplace is the process of bypassing those involved by contacting upper/senior management. It involves raising awareness of the context to the right people in order to resolve a challenging situation. Typically, escalation occurs when there is an issue that the current staff working on the problem can't resolve and requires assistance from those with more authority and resources

When should you escalate an issue at work?

Deciding when to escalate an issue depends on the amount of risk it can bring to the company. Because escalating an issue can lead to difficult meetings and cause disruptions in work, you should reserve them for issues that truly require escalation. You can often avoid escalating an issue by solving the problem with the individual first.

However, some issues require support from those with higher authority. Consider escalating an issue at work when:

- You have already tried other strategies but that did not work.
- Resolving may incur additional cost to the company or the customer, while rectifying the problem.
- Because of the non-availability of certain parts the repair work is taking longer than usual.
- The engineer broke another part while repairing a part. So escalation is required to get the approval to replace the broken part by the company.

8.1.18 Hurdles for Effective Communication

Following are factors contribute to communication not being effective.

Stress and out-of-control emotion. When you are stressed or emotionally disturbed, you're more likely to misread other people and send confusing non-verbal signals. Calm down before continuing the conversation.

Lack of focus. You can't communicate effectively when you're multitasking. If you're checking your phone, planning what you're going to say next, or daydreaming, you're almost certain to miss nonverbal cues in the conversation. To communicate effectively, you need to avoid distractions and stay focused.

Inconsistent body language. Nonverbal communication should support what is being said, not contradict it. If you say one thing, but your body language says something else, your listener will likely feel that you're being dishonest. For example, you can't say "yes" while shaking your head no.

Negative body language. If you disagree with or dislike what's being said, you might use negative body language to ignore the other person's message, such as crossing your arms, avoiding eye contact, or tapping your feet. You don't have to agree with, or even like what's being said, but to communicate effectively and not put the other person on the defensive, it's important to avoid sending negative signals.

8.1.19 Professional Conduct

There are six basic rules to be followed for professional conduct:

- **Be on time:** Being late impedes a company's operations and demonstrates a lack of consideration of the time concerns of others. If you are constantly late for work, meetings, or are always late with your reports and other tasks; it demonstrates to others that you are probably not executive material because you disregard the value of time.
- **Be discreet:** Keep company secrets such as new product designs, sales figures or any other confidences to yourself.
- **Be courteous, pleasant, and positive:** No matter how demanding your clients, customers, co-workers or employees might be; always remain upbeat and positive. Projecting a positive company image has the same effect.
- **Be concerned with others, not just yourself:** Finding out a customer or client's point of view naturally helps you get ahead in any industry. Concern for others should include your superiors, co-workers and subordinates as well.
- **Dress appropriately:** Dress to be comfortable in your environment. Dressing poorly or too casually does not convey a good image, neither does overdressing, which breeds suspicion and mistrust, and will be seen as inappropriate.
- **Use proper written and spoken language:** People who can express themselves clearly are at an advantage. This goes beyond using good grammar, proper spelling, and appropriate diction in all your communications; you should also speak and write to the point.

8.1.20 Respect Gender Differences

In any business, be it a small company to a big corporate, the workforce is a mix of both genders. The ratio of men vs. women varies from 70:30 or 60:40. Studies show that business teams with an equal gender mix perform significantly better than male-dominated teams when it comes to both sales and profits. No two women or men are alike and yet at the same time there are some work related traits that are gender specific. Both men and women approach their work in a different way and deal with many hurdles that come their way. Since they all share the same workspace every organization has devised a policy as to how they treat the opposite gender at the workplace and what are the implications of any abuses

Some of the points to remember while interacting with female colleagues

1. Treat them with respect
2. Support them in case they approach you
3. Value their opinion and suggestions
4. Involve and include the opposite gender in all the discussions

Unit 8.2: Explain the importance of developing sensitivity towards disabled persons

Unit Objectives

At the end of the unit, you will be able to

- Respect differences in gender and ability
- Communicate effectively with person with disabilities
- Respect people with disability at work

8.1.21 Communication with Disabled Person

A **disability** is any condition that makes it more difficult for a person to do certain tasks or interact with the people around them (socially or materially). These conditions, or defects, may be cognitive, developmental, intellectual, mental, physical, sensory, or a combination of multiple conditions. Defects may be present from birth or can be acquired during a person's lifetime. Often, disabled people are excluded from full participation in any activity.”

But things are changing; every organization has allotted some percentage of employees from this section of the society. They are also allowed to exhibit their skills in a few jobs which they can perform without putting their life at risk

General tips for communication with disabled people

1. Speak to them as you would speak to anyone else in a soft and low tone.
2. Respect the person first, not their disability. For example, use the term ‘a person with disability’ rather than ‘a disabled person’.
3. Do not use phrases such as ‘suffers from’ and ‘crippled’ rather the phrase should be ‘people who use a wheelchair’ rather than ‘wheelchair bound.
4. Don’t drag or push a person’s wheelchair, and don’t move their crutches or walking stick without their permission. It has to be in their personal space.
5. When talking to a person who is in a wheelchair, try to sit in such a way you could reach their eye level. This would not strain them much, to lift their head and talk.

8.1.22 Communicating with people with a hearing impairment

Keep these points in mind while interacting with people with a hearing problem

1. Draw the person's attention before you speak. Give a gentle tap on their shoulder, a wave of some other visual signal to the person's attention
2. Stand in front of the person and maintain eye contact
3. Don't cover the mouth while talking. They can figure out what is being said by just looking at the lip movement
4. Speak at a normal pace don't speak fast or slow
5. Choose the words wisely
6. Use short sentence
7. Be gentle while speaking don't raise the tone

8.1.23 Respect people with disability

Learn the proper way to act and speak around someone with a disability.

1. Do not use offensive or derogatory words like 'handicapped', 'crippled', and retarded etc.
2. Don't criticize or blame them. Don't shout at them or use abusive language
3. Talk slowly with a low tone. Pause while talking
4. Avoid excessive whispering, joking and laughing unnecessarily
5. Assuming things about them or their situation.
6. Don't make jokes about their condition or be sarcastic
7. Don't look down upon them because of their disability
8. Appreciate them for their efforts and work, and motivate them to perform better

8.1.24 Safety at workplace for people with disability

Disabilities of all types affect employees and can pose various mental or physical challenges. In many situations, a disability may impact the amount of time it takes for an employee to complete a task or get from one part of a facility to another. Some disabilities may be known while others remain unknown to an employer.

Health and safety legislation should not prevent disabled people from finding or staying in employment so it should not be used as an excuse to justify discrimination against them.

Disabled people and those with health conditions, including mental health conditions, should be given the opportunity to both get into and stay in work.

Responsibilities of an employer towards disabled people

The employer is responsible for the health, safety and welfare of all of their employees, whether they have a disability or not.

Disability is not always obvious so one might not realise a worker is disabled or they might choose not to tell you, particularly if their disability has no impact on their ability to do their job.

Workers do not have to tell anybody unless they have a disability that could foreseeably affect the safety of themselves or anyone else connected to their work. If they do not reveal and there are no obvious indicators of any disability, then the organization are not under any obligation to make workplace adjustments.

Periodically, consult with the employees (whether directly or through their representatives) on issues relating to health and safety. These discussions reflect good safety practice because employees have day-to-day understanding of the job, so they are likely to have good ideas on keeping themselves and others safe.

8.1.25 Workplace adaptations for people with disability

Few changes in the workplace to make it a safe place for the disabled people will go a long way in the employee satisfaction for an organisation.

Workplace Adaptations

Workplace should be easily accessible for these people with special needs. One major compliance concern deals with accessibility. For example, if workplaces have been adjusted or created more accessible entrances and exits to their facilities, allowing more independence for persons in wheelchairs, would be a great idea. Other subtle changes may include the width of bathroom stalls, hand rails inside the stalls and long ramps instead of stairs. The path of travel that employees take should never be obstructed; there should be no barriers to prevent someone from getting to safety in an emergency.

Workstations easily can be adapted to follow this universal design. Many companies now use slide-out keyboard trays and monitors on swinging arms to allow employees to adjust to their needs. Desks can accommodate wheelchairs in place of regular chairs, and general work spaces can be lowered to allow easier access. The main goal is to remove all barriers and allow everyone to concentrate more on completing their tasks.

The biggest challenge with universal design is accommodating the multitude of challenges that different disabilities present. Not all disabilities are the same, and not all will present the same challenges for employees. Some employees may have issues with their right hand while others have issues with their left. For some, it may involve not being able to stand or sit. Some may need low lighting, while others need bright lighting. Designing a facility to accommodate all is always going to be a challenge.

Complying with government guidelines can be more difficult in regards to employees with disabilities. This difficulty lies with ensuring that employees are aware of all hazards in the workplace. Multiple disabilities will create multiple reasons that may keep employees from recognizing hazards. Employees with impaired vision, for example, must have other means of identifying hazards. This may be remedied with audible alarms or touch-activated devices that warn employees not to go in an area. Other employees may have difficulties reading and may benefit from shapes or colors to further identify hazardous areas. For workers who lack hearing ability, employers can utilize signs to demonstrate hazards or use flashing strobes to identify when employees need to evacuate an area and head to safety.

Every organization has to make few adaptations in order to make it a better place to work even for people with disabilities. It should provide an environment where they feel they are safe and can carry out their work rather than worrying about their safety.

Exercise

1. What are the three points you will focus on when you talk to people face to face?

Fill in the blanks











1. Before sending the mail it's important to check the _____ and _____ of the content.
2. When you interact through phone, provide your identity details like _____, _____ and _____.
3. Add your _____ at the bottom of your mail.
4. The Customer Care Executive is mainly responsible for handling _____.

Note







A large rectangular area with a thin orange border, containing 25 horizontal lines for writing notes.

Annexure

Chapter No.	Unit No.	Topic Name	Page No.	QR Code
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Annexure (Contd.)

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Employability Skills				 <p>Click/Scan the QR code to access the related video</p>



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