DIPLOMA BOARD EXAMINATION – APRIL 2024

ANSWER KEY FOR THE QUESTION CODE – 587

SUBJECT CODE / NAME: EE232120 - BASICS OF ELECTRICAL AND ELECTRONICS ENGINEERING

BRANCH: EEE **SEMESTER: 2** **MAXIMUM MARKS: 100**

N.B 1. Answer any fifteen questions under Part -A. All questions carry equal marks. (15x2=30)

2. Answer all questions, choosing any two sub-divisions from each question under Part-B. All questions carry equal marks. (5x14=70) (7+7)

PART - A

1. Define electric charge. 2 Marks

Charge the physical property of matter that causes it to experience a force when placed in an electromagnetic field. Electric charge can be positive or negative. It's symbol is Q. It's unit is coulomb.

2. State Coulomb's first law. 2 Marks

The Coulomb's first law states that like charges repel each other whereas unlike charges attract each other.

3. Define potential difference. 2 Marks

✓ The difference in the potentials of 2 charged bodies is called potential difference.

✓ If two bodies have different electric potentials a potential difference exists between the bodies.

✓ The current will flow in a circuit if potential difference exists. The unit of potential difference is also Volt.

4. Write the formula for calculating electric power and electric energy. 2 Marks

Power is the rate of doing work. In other words, Power is the work done per unit time.
Power = Work done / Time.
The unit of power is joules/ sec or watts.

Energy is the capacity to do work.
Energy = power x time = P x t watt sec.
The unit of electrical energy is watt sec or joules.

5. Expand the term TANGEDCO. 2 Marks

Tamilnadu Generation and Distribution Corporation Limited.

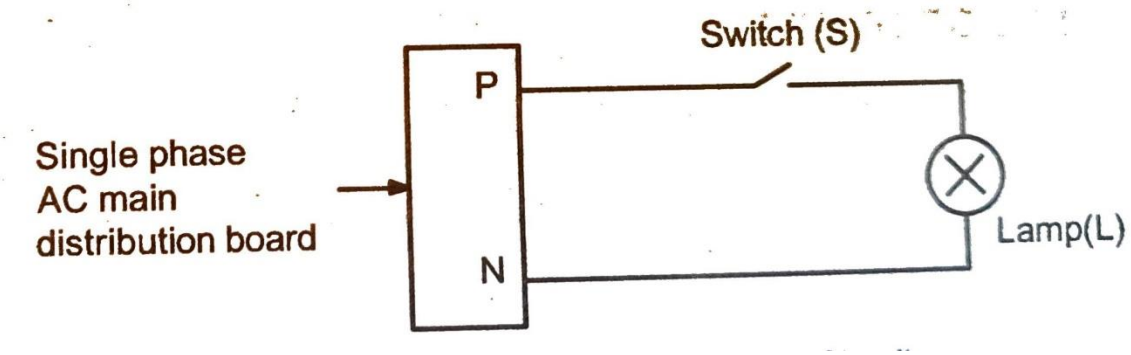
6. List out the main parts of transformer. 2 Marks

- ✓ Primary winding
- ✓ Secondary winding
- ✓ Laminated iron core

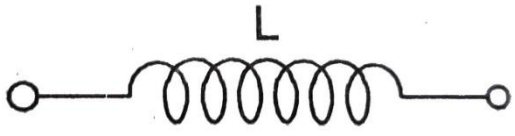
7. Write about the different types of lamps. (Any 2 Points) 2 Marks

- ✓ Incandescent Lamp
- ✓ Tungsten Halogen Lamp
- ✓ Fluorescent Lamp
- ✓ Compact Fluorescent Lamp
- ✓ Mercury Vapour Lamp
- ✓ Metal Halide Lamp
- ✓ High Pressure Sodium Vapour Lamp
- ✓ Low Pressure Sodium Vapour Lamp
- ✓ Led Lamp

8. Draw a simple lamp circuit diagram and label its parts. 2 Marks



9. Draw the symbol of inductor. 2 Marks



10. Mention the uses of capacitor. (Any 2 Points) 2 Marks

- ✓ To store electric charges
- ✓ To oppose any changes in voltage
- ✓ To block dc
- ✓ To bypass ac
- ✓ To couple circuits
- ✓ To filter unwanted electrical signals
- ✓ To filter unwanted electrical signals
- ✓ To tune the frequency in lc oscillators

11. Write the colour coding for resistor of value 2.5 kilo ohm. 2 Marks

Red, Green and Red

25 x 100 = 2500 = 2.5 Kilo ohms.

12. What are the different types of resistor? 2 Marks

Fixed resistors

Carbon composition resistors
Wire wound resistors
Metal film resistors
Carbon film resistors

Variable resistors

Wire wound resistors
Potentiometers
Trimmers

13. What is energy band? 2 Marks

The energy band is the way of representing the energy in orbits. Each orbit has fixed amount of energy associated with it. The electrons moving in a particular orbit possesses the energy of that orbit. The larger the orbit, greater is its energy. So the electrons placed in the outer orbit possesses more energy.

14. What is meant by Fermi level? 2 Marks

- ✓ The highest energy level that an electron can occupy at absolute zero temperature is known as Fermi level.
- ✓ The Fermi level lies between valence band and conduction band because at absolute zero temperature the electrons are all in the lower energy state.

15. Differentiate drift and diffusion current. 2 Marks

Drift current	Diffusion current
It is the flow of current due to drifting of free electrons towards the positive terminal under the influence of applied voltage.	It is the flow of current due to movement of charge carriers in a nonuniformly doped semiconductor.
In this direction of current is opposite to the direction of moving electrons.	The diffusion current exists without external voltage applied.

16. Mention any two applications of PN junction diode. (Any 2 Points) 2 Marks

- ✓ Rectifiers in power supplies
- ✓ Switches in digital logic circuits
- ✓ Clamping networks used as DC restorer in TV receivers and voltage multipliers. Clipping circuits used as wave shaping circuits in computers, radars, radio and TV receivers.
- ✓ Demodulation circuits

17. What are the effects of electricity on the human body? (Any 2 Points) 2 Marks

- ✓ Electrical hazard may even cause death of human beings.
- ✓ Severe injuries and disabilities may occur in human body.
- ✓ Severe current flow through human body may result in cardiac arrest.
- ✓ Electricity may cause severe skin damage, loss of hearing and blindness.
- ✓ Electricity affects the nervous system.

18. Why Earthing need to be done? 2 Marks

- ✓ Earthing or grounding means connecting electrical equipment to earth using a wire of very low resistance.
- ✓ The purpose of earthing the electrical equipment is to bring it to zero potential and thereby to avoid the shock to the operator.

19. Why lightning arresters is used? 2 Marks

- ✓ A lightning arrester or surge diverter is a protective device which diverts high voltage lightning surge to ground and protect the equipment.
- ✓ One end of lightning arrester is connected to the terminal of the equipment to be protected on the other end is effectively grounded.

20. What are the types of solder? 2 Marks

- ✓ Lead alloy solder
- ✓ Lead free solder
- ✓ Flux core solder
- ✓ Silver alloy solder

PART – B

21. (a) An electric heater is rated 1 KW, 250V. Find the current drawn and the resistance of the heating element. 7 Marks

Power (P) = 1 KW = 1000 Watts

Voltage (V) = 250 V

Power (P) = V x I

Current (I) = P / V = 1000/ 250 = **4 Amps.**

Resistance (R) = V / I = 250 / 4 = **62.5 Ohms**.

21. (b) Explain about DC supply and AC supply. 7 Marks

(DC supply 4 Marks + AC supply 3 Marks)

Direct Current

Current that flows continuously in One Direction is called direct current (DC). The current supplied by a battery and DC generator are direct current.

The DC supply is obtained from the following sources.

1. Batteries
2. Power supplies.
3. Solar cell.
4. DC Generator

Types of DC supply

DC power supplies are classified into two

1. Unregulated DC power supply.
2. Regulated DC power supply.

Unregulated DC power supply.

Unregulated DC power supply has no voltage regulator. They are designed to produce a specific voltage at a specified load current.

Regulated DC power supply

Regulated DC power supply contains an unregulated power supply and a voltage regulator. This power supply maintains a constant voltage even the load current changes.

Alternating Current(AC)

Alternating current (AC) is the current that flows first in one direction for a brief time then reverses and flows in the opposite direction for a similar time. The source for alternating current is called AC generator or Alternator.

Types of AC Supply

AC supply is classified into two

1. Single phase AC supply - It has one line (phase) and neutral then it is called single phase.

2. Three phase AC supply – if it has only three lines (phases) it is called three phase three wire system. Meanwhile if it has three phases and one neutral it is called three phase four wire system.

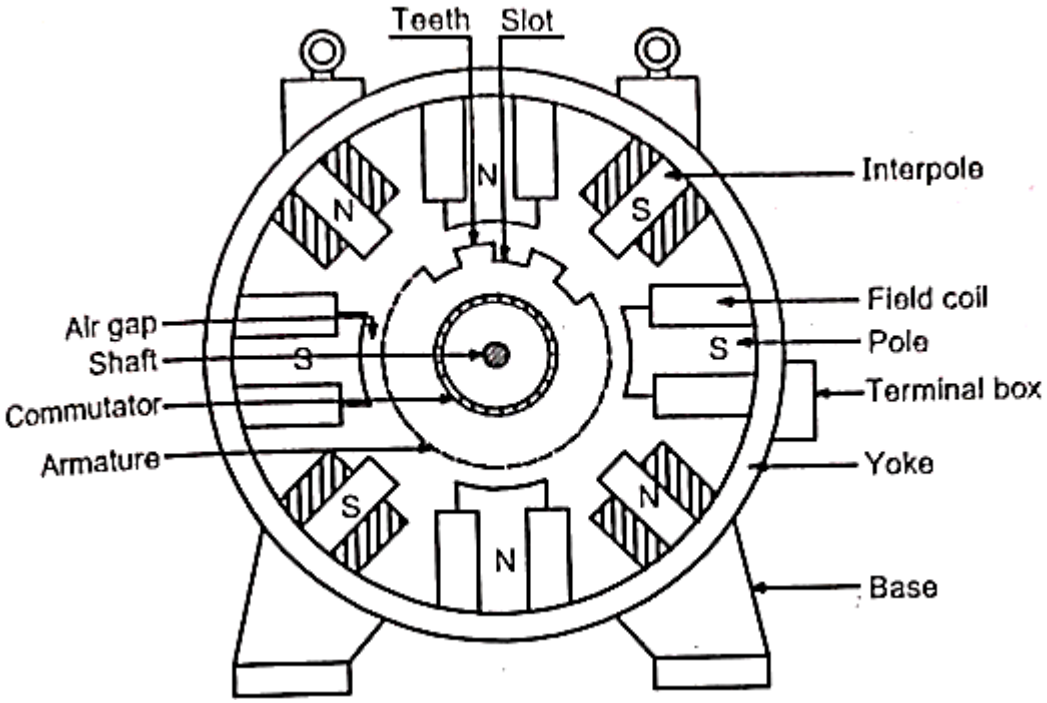
21. (c) Describe the duties and responsibility of electrical engineer. 7 Marks

(Any 7 points describing the question correctly)

- ✓ The role of an electrical engineer is to design, develop, test and supervise the manufacturing of electrical equipment and systems.
- ✓ Electrical engineers work with various technologies including power generation, transmission, distribution, control systems and communication systems.
- ✓ Electrical engineers inspect, repair, replace, adjust, install and maintain the electrical equipment in the plant.
- ✓ Establish the manufacturing processes.
- ✓ Evaluating the system's safety, reliability and performance.
- ✓ Work together with engineers and technicians to design and apply new system processes.
- ✓ Prepare product reports by collecting, analyzing and summarizing information.

22. (a) Explain the main parts of DC machine with suitable sketch. 7 Marks

(Diagram 4 Marks + Explanation 3 Marks)



The DC machine has the following parts

1. Yoke 2. Pole 3. Field coil 4. Inter pole 5. Armature 6. Commutator 7. Brushes 8. Bearings and end cover

1. Yoke or magnetic frame

Provides mechanical support for the machine and acts as cover for machine.

Carries magnetic flux produced by the poles.

2. Magnetic poles – Consist of pole cores and pole shoes.

- They spread out the flux in the air gap.
- They support the field coils.

The pole cores and pole shoes are built with thin laminations of steel. These laminations are held together using rivets.

The cores are laminated to reduce the eddy current loss. The magnetic poles are fitted inside the yoke by means of screws.

3. Field coils

Field coils are usually wound with enamelled copper wire. Field coils are wound over the pole core. The magnetic field strength depends upon the current flowing through the coil. The north and south pole depend upon the direction of current flow through the field coil.

4. Inter poles (or) commutating poles

The function of inter pole is to improve commutation and to reduce the armature reaction. The coils on the interpoles are connected in series with the armature.

5. Armature

The armature core is keyed to the machine shaft and it rotates between the field poles. It consists of slotted steel laminations. These laminations are stacked to form a cylindrical core.

The laminations are insulated from each other by thin coating of varnish. The purpose of laminating the core is to reduce the eddy current loss. The laminations are slotted to accommodate the armature winding.

6. Commutator

The emf induced in the armature is AC in nature. Commutator converts this AC into DC. The commutator is made up of copper segments insulated from one another by mica sheets. The armature conductors are soldered to the commutator segments in a suitable manner.

7. Brushes

Brushes are made up of carbon and rest on the commutator. The function of the brushes is to collect current from the commutator to the external stationary load. The brushes are put inside the brush holders. The brush holders are kept pressed against the commutator by a spring.

8. Bearings and end cover

End covers are made up of cast iron or steel. They are fitted to both ends of the yoke. Ball bearings or roller bearings are fitted inside the end cover. Armature shalt is mounted over these bearings.

22. (b) Explain about the various applications of solar panel. 7 Marks

(Any 7 points)

1. Powering homes and buildings. – it is the smallest PV modules can be used for powering torches, flashlight, wrist watches, calculators etc.…

2. Lighting up remote areas – it is the best one for use in remote locations, where there is no access to an electricity grid. They can be used to power remote communication systems, lighting systems, and other essential services.

3. Solar panels can power the water irrigation pumps – It is widely used in agriculture, as they provide a clean and renewable energy source for irrigation systems, water pumping and other farm operations.

4. Power stations – they are used in large scale power stations, where they are used to generate electricity for the grid.

5. Used for electric vehicle charging.

6. Street lighting.

7. Solar energy helps in turning the salty water into fresh water.

8. Heating and cooling.

22. (c)Explain about electric vehicles and its types. 7 Marks

(Diagram 3 Marks + Explanation 7 Marks) or (Detailed explanation alone – 7 Marks)

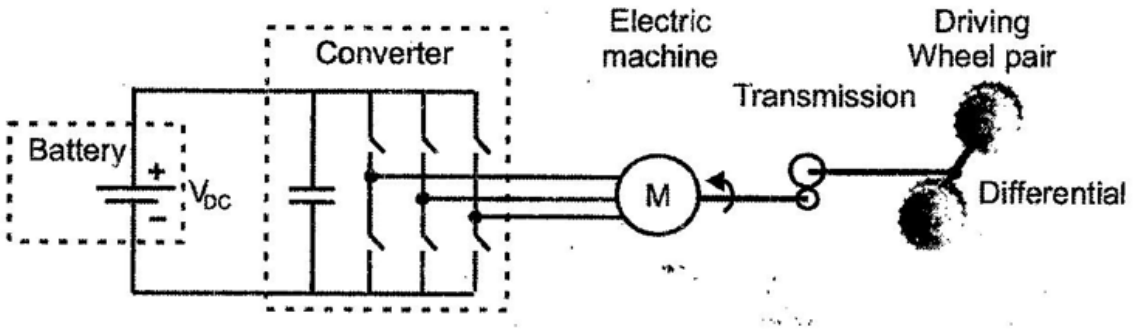
An Electric vehicle is a one that operates on electric motor instead of an internal combustion engine. Battery packs are used to supply power to the electric motors. Since it runs on electricity, the vehicle emits no exhaust.

Types

The different categories of electric vehicle are:

1. Battery Electric Vehicle (BEV)

An Electric vehicle that provides power to the drivetrain only from the battery pack is called battery electric vehicle (BEV). It operates only on stored electricity. The main parts are: a high-voltage battery, one or more electric motors (either AC motor or DC motor) and transmission.



Block diagram of BEV

The battery generates power and it is transferred to electric motor through converters. The electric machine used in BEV may be either induction motor or DC motor. The rotational torque generated by the motor is transferred to driven wheels through transmission and differential arrangement.

Advantages:

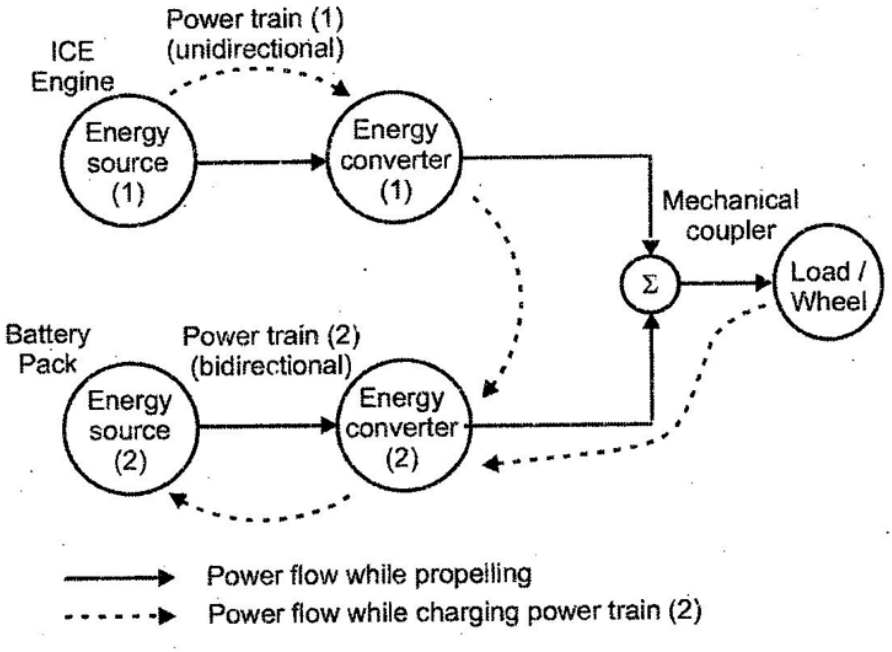
Cost of BEV is low compared to conventional ICE, Maintenance cost and fuel cost is low, No emission of toxic gases so they are environment friendly, BEV produces less noise, Easy to manufacture.

Disadvantages:

Refueling time is more, Distance covering range is low compared to internal combustion engines.

2. Hybrid Electric Vehicle (HEV)

A vehicle that has two or more energy sources and energy converters is called a hybrid vehicle. A hybrid vehicle with an electrical power train is called an HEV.



Block diagram of HEV

It consists of two energy sources.

Energy source 1-ICE: Energy from ICE Engine is transferred to mechanical coupler through energy converter (transmission).

Energy source 2 Battery pack: Energy from battery pack is

transferred to mechanical coupler through energy converter. Here energy converter represents combined action of regulator, inverter and motor.

The mechanical coupler either delivers the rotational torque produced from Energy source 1/Energy source 2 (ICE/ battery) alone to wheels or it may combine the torque produced from energy source 1 & 2 and deliver the same to the wheels. By adopting effective energy management system (EMS) the efficiency of HEV can be increased.

Advantages:

Low toxic exhaust emission, Distance covered by HEV is high, It has different modes of operation.

Disadvantages:

Need efficient energy management system to optimize the energy sources (Battery & ICE).

3. Plug-in Hybrid Electric Vehicle (PHEV)

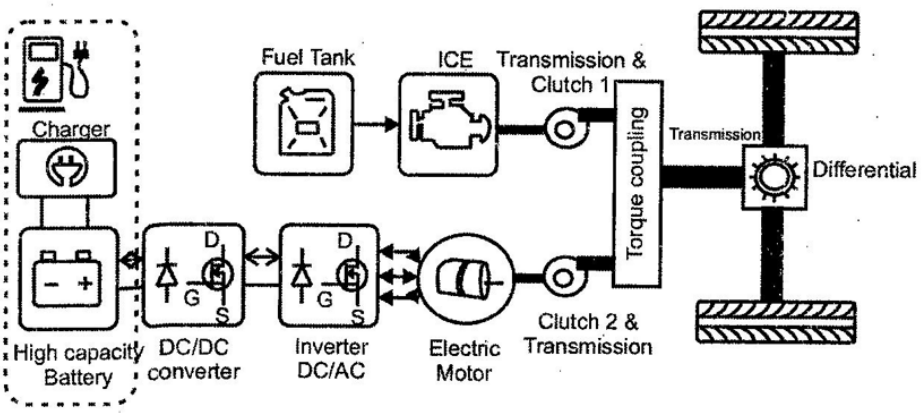
The PHEV uses both an ICE and an electrical power train, like a HEV, but the difference between them is that the PHEV can be directly connected to the electrical grid for charging the batteries. It uses electric propulsion as the main driving force. So these vehicles require a bigger battery capacity than HEVs. There are different modes of operation in PHEV some of them are

Battery alone mode: Only battery provides the power.

Engine alone mode: Only ICE engine propels the vehicle.

Combined mode: Both the ICE and battery provide the required power.

Power split mode: The ICE power is split to drive the vehicle and charge the battery.



Block diagram of plug-in Hybrid Electric Vehicle

Energy from ICE Engine is transferred to Torque coupler through clutch1 and transmission assembly. Energy from the battery pack is regulated by DC-DC converter and it is converted into AC by an inverter. The inverter will drive the electric motor. The torque produced by the motor is transferred to the torque coupler through clutch2 and transmission assembly. The Torque coupler either delivers the rotational torque produced from ICE / battery alone to wheels or it may combine the torque produced from energy source 1 &2 (ICE & battery pack) and deliver the same to the wheels through differential.

PHEVs start in Battery alone mode and runs on electricity. When the batteries are low in charge, it calls on the ICE to charge up the battery pack. The ICE is used here to extend the range of the vehicle. Plug-in HEV has an internal charging unit that helps to charge the battery by

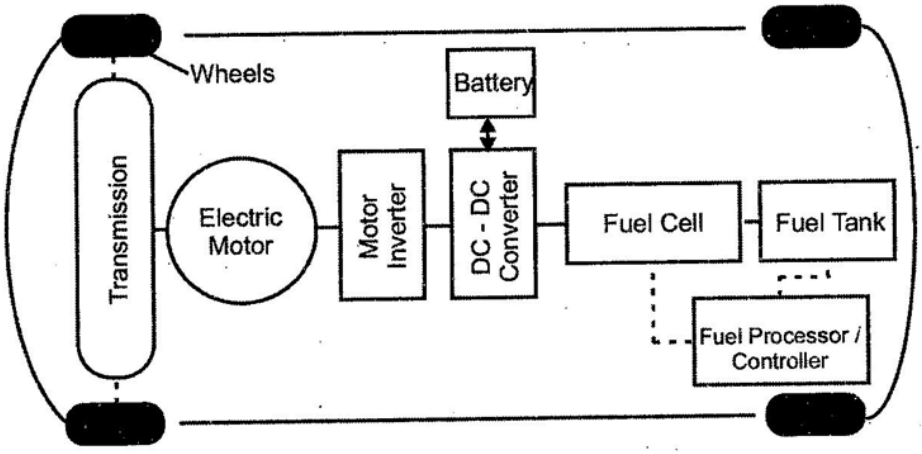
directly connecting them to the electrical grid and they also have the facility to utilize regenerative braking.

Advantages: PHEV consumes less fuel and emits less toxic gasses to the atmosphere, Cheaper than ICE cars.

Disadvantages: Plug-in hybrid batteries' cost is more compared to normal hybrid batteries, Recharging takes time, and Mileage gets reduced due to additional weight (High capacity batteries).

4. Fuel Cell Electric Vehicle (FCEV)

The Electric vehicle that uses fuel cell as the primary energy source to drive the vehicle is known as Fuel cell electric vehicle. FC generates electrical energy as long as a fuel supply is maintained in the fuel cell, it won't stores the energy like batteries.



Block diagram of fuel cell Electric vehicle

The chemical reaction between Hydrogen and Oxygen in fuel cell produces electricity. This reaction is controlled by a fuel processor. The fuel cell produces DC current, it is then regulated using DC-DC converter. Generally induction motors are used, so DC is converted into AC by motor inverter circuit and it is fed to the electric motor. The electric motor which is connected to the transmission will deliver the required torque to drive the vehicle. The exhaust of this vehicle is only heat and water.

Advantages: No toxic exhaust pollutant, Refueling time is same as that of conventional ICE engine, High efficiency.

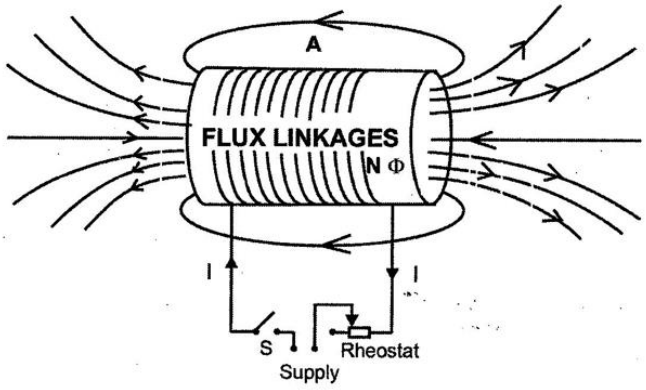
Disadvantages: Cost of fuel is high, Lack of availability of refueling facility.

Applications: Used in slow speed vehicles like trams, and submarines.

23. (a) Explain about self and mutual inductance. 7 Marks

(Diagram 3 Marks + Explanation 4 Marks)

Self Inductance:



Self induced EMF

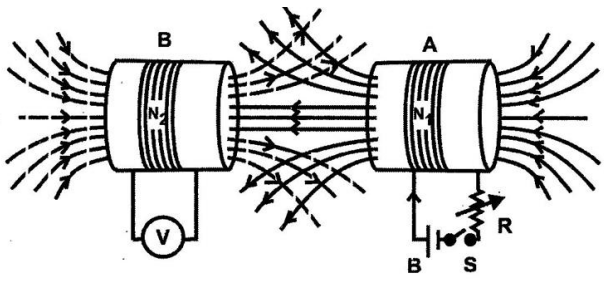
Self induction is a phenomenon in which a change in current in a coil induces an emf in the coil itself.

When a coil A is given current, flux will be produced. If the current in coil A is changed, the flux also changes. As per Faraday's law when there is a change in flux, an emf will be induced in the same coil. This is called self induction. The induced emf will be always opposite in direction to the applied emf. The opposing emf thus produced is called the counter emf of self induction.

Uses of Self Induction

- Used in fluorescent tubes for starting purpose and to reduce the voltage.
- Used in regulators to give reduced voltage to the fans.
- Used in lightning arrester
- Used in auto transformer
- Used in smooth choke which is used in welding plant.
- Used in rectifiers

Mutual Induction



Mutually induced EMF

Mutually induction is a phenomenon in which an emf induced in second coil due to the variation of current in the first coil.

Consider two coils A and B lying close to each other. Coil A is connected to a battery through a switch and a variable resistor. Coil B is connected to a sensitive voltmeter. When we give supply to the coil A, and it is changed, then it will produce a flux across it and this flux starts linking to the coil B and as a result an EMF is induced in the coil B. This induced EMF is called mutually induced EMF.

Uses of Mutual Induction

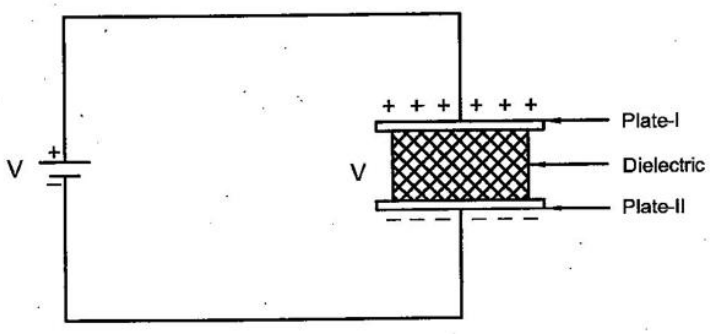
- Used in ignition coil which is used in motor car.
- Used in inductance furnace.
- Used for the principle of transformer.

23. (b) Discuss the types, working principles and properties of Capacitors. 7 Marks

(Types – 2 Marks, Working principle – 3 Marks, Properties – 2 Marks)

A capacitor consists of two conducting plates separated by an insulating medium. The capacitor can store electric charges, in the form of voltage in electric field. The capacitor blocks direct current. The capacitor opposes any sudden change of voltage applied to it.

Working principle of capacitor



Working principle of Capacitor

When we connect a DC voltage source (Battery) across the capacitor, one plate (Plate 1) gets attached to the positive terminal and another plate (Plate II) to the negative terminal of the battery as shown in the fig. 3.4. Now the potential of that battery is applied across that capacitor.

At that situation Plate-I is in positive potency with respect to the Plate II. At steady state condition the current from the battery tries to flow through this capacitor from its positive plate (Plate-1) to negative plate (Plate-II) but cannot flow due to the separation of these plates with an insulating material.

An electric field appears across the capacitor. As time goes on positive plate (Plate-l) will accumulate positive charges from the battery and negative plate (Plate-II) will accumulate

negative charges from the battery. After a certain time the capacitor holds maximum amount of charges as per its capacitance with respect to the applied voltage. The time span is called charging time of the capacitor.

After removing the voltage source from this capacitor, these two plates hold positive and negative charges for a certain time. Thus the capacitor acts as a source of electrical energy.

If two ends of the capacitor are connected to the load, a current will flow though the load from Plate I to Plate II until all charges get vanished from both plates. This time span is known as discharging time of the capacitor.

Properties of Capacitor:

Capacitor is an electrical component used for conserving electrical energy. The properties of capacitor are discussed below.

i) Capacitance

It is the capability of a capacitor to store electrical energy for the given amount of voltage.

ii) Working temperature

It is the operating temperature of capacitor. Normally its value is in between 30°C and 125°C.

iii) Temperature co-efficient

It is generally calculated by determining the largest charge throughout capacitance over a certain temperature interval.

iv) Working voltage

It is the maximum working voltage either DC or AC that can be applied to the capacitor during the entire life of the capacitor without causing damage.

v) Tolerance

It is the extent to which the capacitance is allowed to vary from the nominal value. The tolerance rating is expressed as plus or minus.

vi) Leakage current

The dielectric used in the capacitors are not perfect insulators. A small amount of current leaks through the dielectric this is called leakage current.

vii) Polarization

The voltage connected to the capacitor terminals must have the correct polarity. i.e Positive to positive and Negative to negative.

Types of Capacitors:

Capacitors are broadly classified into two major types. They are fixed capacitors and variable capacitors. The fixed capacitors are then subdivided into the following types.

(1) Electrolytic capacitors.

This capacitor has a metallic anode, and an oxide film layer acts as dielectric. It is surrounded by electrolyte, which acts as cathode.

(i) Polarized electrolytic capacitors

(ii) Non-polarized electrolytic capacitors

(a) Aluminum type

(b) Tantalum type

(II) Non-electrolytic capacitors

Non-electrolytic capacitors have no polarity. They can be connected in either directions in a circuit. They can be then subdivided into the following types.

(A) Ceramic capacitors

(a) Disc capacitors (b) Tubular capacitors (c) Monolithic capacitors

(d) Barrier layer capacitors

(B) Plastic capacitors

(a) Polystyrene capacitors (b) Polyster capacitors (c) Polycarbonate capacitors

(C) Mica capacitors

(a) Stacked mica capacitors (b) Silvered mica capacitors.

(D) Paper capacitors

(a) Impregnated paper capacitors (b) Metalized paper capacitors.

23. (c) Discuss the symbols, working principles and applications of Resistors. 7 Marks

(Symbol – 2 Marks, Working Principle – 3 Marks, Application – 2 Marks)

A resistor is a passive two terminal electronic component. It introduces resistance. Resistance is defined as the property of the material which opposes the flow of current. Since the resistors have no polarity, they can be connected in the circuit in either direction,

The resistor is used to limit (resist) the flow of current or divide the voltage in a circuit. The unit of resistance is ohm (Ω).

The resistance R of any material is proportional to its length L and inversely proportional to its area of cross section A.

Resistance, R = $R = \frac{\rho L}{A}$

A p Specific resistance or resistivity of the material.

Symbol of Resistor

The symbol of resistor is shown in the figure. The value of resistor is measured in ohms and it is symbolized by the Greek letter Ω (omega).

Working principle of resistor

Resistors are used to resist the flow of current. When resistor is placed in a circuit, it reduces the flow of current passes through it. The part of current energy dissipate in the form of heat in resistor, thus decreases the total current. Resistors are the fundamental components in electrons. Its purpose is to impede flow of current and impose voltage reduction.

Applications of Resistors

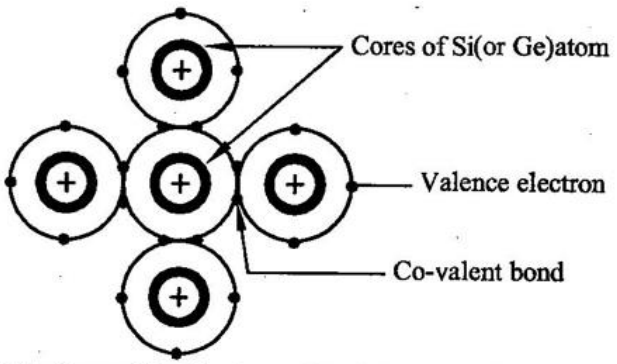
i) Limit the flow of current
ii) Divide voltage
iii) Adjust signal levels
iv) Bias active components
v) Terminate transmission lines
vi) Control gains
vii) Fix time constants

24. (a) Explain about intrinsic and extrinsic semiconductors. 7 Marks

(Intrinsic Semiconductor – 3 Marks, Extrinsic Semiconductor – 4 Marks)

INTRINSIC SEMICONDUCTORS

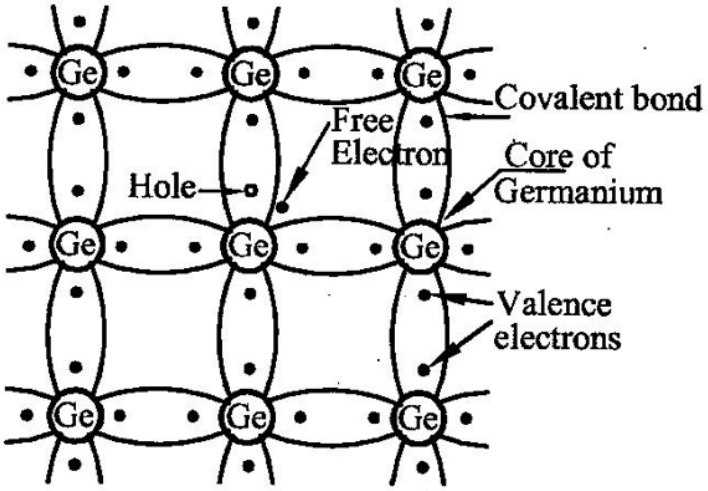
A pure semiconductor is called intrinsic semiconductor. The silicon and germanium atoms contains only four electrons in the outermost orbit. So, they are called tetravalent atoms. The co-valent bond structure of germanium atom is shown in the fig below.



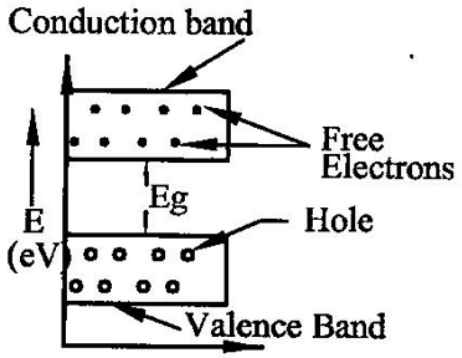
(Positive core -It is formed by Nucleus with tightly bound electrons)

Germanium crystal

At low temperature (0°K), the semiconductor behaves as a perfect insulator. Now no electrons get away from the co-valent bond. So the current flow (electron flow) is zero. At room temperature, some of the valence electrons may acquire sufficient energy. The bonds may be broken, the electrons become free and are shifted to the conduction band, as shown in the figure.



Germanium crystal with a broken covalent bond



Energy band diagram of intrinsic semiconductor

The motion of electrons constitutes electron current. The vacancy created by this electron in the valence band is known as holes, and acquires a positive charge. The combination of electron and hole is known as electron-hole pair. In the intrinsic semiconductors, the number of electrons is equal to the number of holes. The amount of current flow depends upon the number of electron-hole pairs broken, depends upon the applied electric field (voltage).

When an external electric field is applied across the intrinsic semiconductor, more number of electron-hole pair combinations will be broken. According to the amount of electric field, many free electrons are generated in the valence band. The free electrons are moved to the positive potential through holes, called electron current. Now the holes are moved towards the negative potential, called hole current. The sum of electron current and hole current is known as electric current.

EXTRINSIC SEMICONDUCTORS

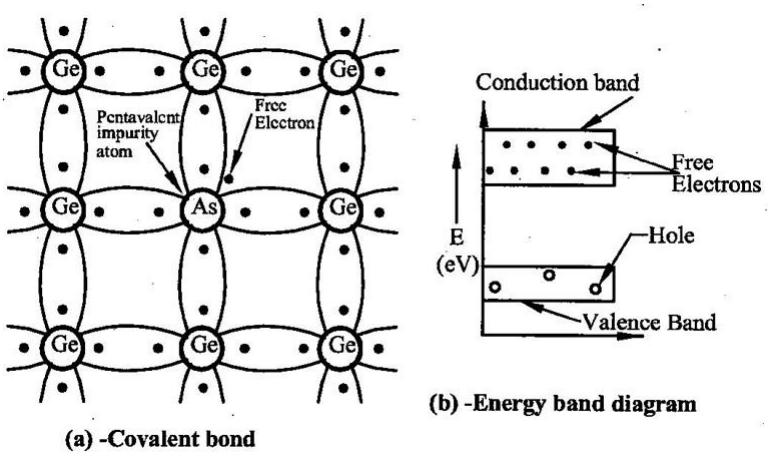
The electrical conductivity of pure semiconductor is increased by adding some impurities in it. The resultant semiconductor is called extrinsic semiconductor. The process of adding impurities to a pure semiconductor is known as doping. The purpose of adding impurities in the pure semiconductor is to increase the number of free electrons or holes, for increasing their conductivity.

The extrinsic semiconductors are divided into two types. They are N-type semiconductors and P-type semiconductors.

N-TYPE SEMICONDUCTOR

N-type semiconductor is formed by adding a small amount of pentavalent impurities (such as arsenic, antimony or phosphorous) to a semiconductor (such as Silicon or Germanium) material. The added impurities are called donar impurities because they will donate electrons.

Germanium atom has four valence electrons, and antimony has five valence electrons. The antimony atom forms co-valent bonds with their surrounding four germanium atoms. The co-valent bond structure and energy band diagram of N-type semiconductor is shown in the figure below. The four valence electrons of antimony atom form co-valent bonds with four valence electrons of individual germanium atom. The fifth valence electron of antimony is left free, loosely bound to the antimony atom.



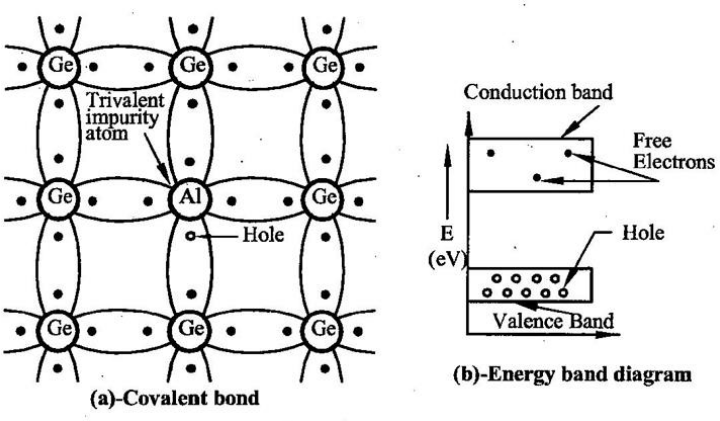
N-type semiconductor

This loosely bound electron can be easily excited from the valence band to the conduction band by the application of small electric field. The extra electron creates impurity because it can donate one electron for conduction.

Thus, the addition of pentavalent impurities increases the number of electrons in the conduction band, thereby increasing the conductivity of the semiconductor. Now the semiconductor contains more electrons and less holes. Hence it is called N-type semiconductor. So, the electrons are called majority carriers and holes are called minority carriers.

P-TYPE SEMICONDUCTOR

P-type semiconductor is formed by adding a small amount of trivalent impurities (such as Aluminium or Boron) to a pure semiconductor (such as Silicon or Germanium) material. Three valence electrons in aluminium form co-valent bond with four surrounding atoms of Ge. Now one co-valent bond is incomplete, which gives rise to a hole. The co-valent bond structure and energy band diagram are shown in the figure.



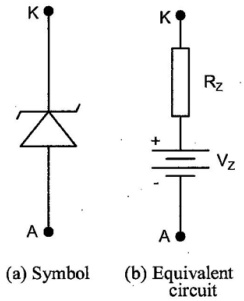
For this, more number of holes (positive charge) are generated. The holes increase the conductivity of the P-type semiconductor. These impurities are known as acceptor Impurities, because the holes created can accept electrons

The number of holes is more than the number of electrons. In P-type semiconductors holes are majority carriers and electrons are minority carriers.

24. (b) Explain the working principle of Zener diode and also discuss its VI characteristics. 7 Marks

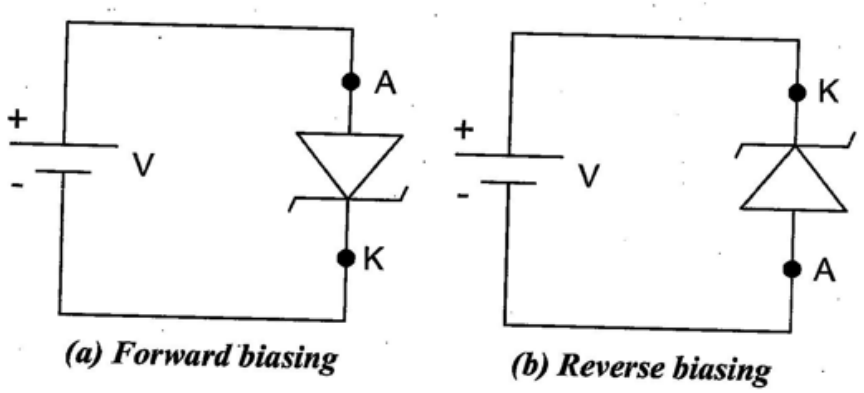
(Working of Zener diode – 4 Marks, VI Characteristics – 3 Marks)

Zener diode is a specially designed PN junction diode. It is a heavily doped PN junction diode. The symbol and equivalent circuit of Zener diode is shown below



Working of Zener Diode

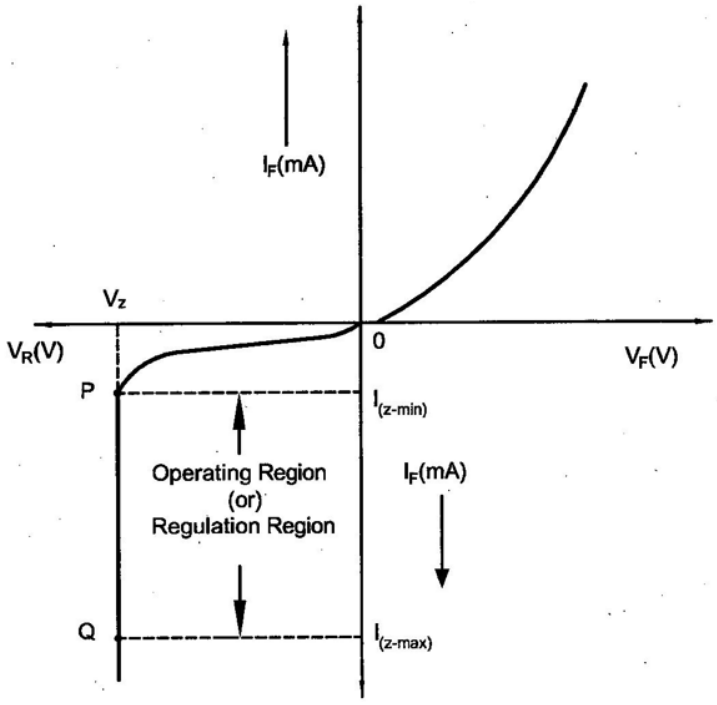
In forward biasing the positive terminal of the battery is connected to the Anode (A) and the negative terminal of the battery is connected to the Cathode (K) as shown in the figure (a). Similarly, during reverse biasing the positive terminal of the battery is connected to the Cathode (K) and the negative terminal of the battery is connected to the Anode (A) as shown in the figure.



Biasing of Zener diode

During forward biasing, when the voltage is increased the potential barrier is reduced and the current starts flowing through the diode. Its operation is same as other ordinary PN junction diode.

The forward current increase slowly up to the knee voltage. Beyond this voltage the current increases sharply with increase in applied voltage.



VI characteristics of Zener diode

Under reverse bias condition a small reverse current flows through the zener diode. When the reverse voltage across the zener diode is increased, a critical voltage called breakdown voltage is reached at which the reverse current increases sharply as shown by the curve PQ. The minimum voltage at which breakdown occurs and current increases rapidly is called **zener breakdown voltage**. The VI characteristics of zener diode is shown in the figure above.

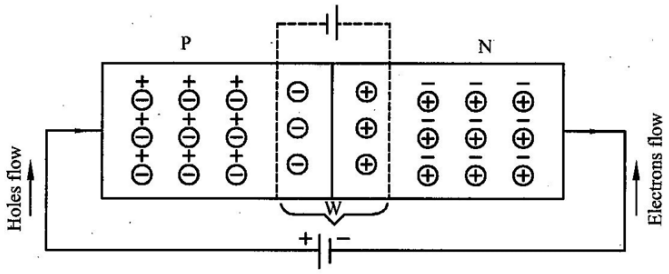
24. (c) Explain about forward and reverse bias of PN junction diode. 7 Marks

(Diagram – 4 Marks, Explanation – 3 Marks)

The conduction of any diodes, depends on their biasing. There are two types of biasing, known as Forward biasing and Reverse biasing.

(i) Forward biasing

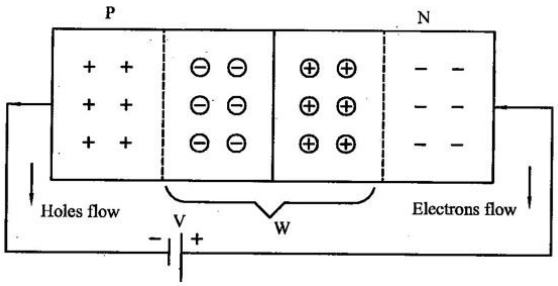
In forward biasing, the positive terminal of the battery is connected to the P-type and the negative terminal of the battery is connected to the N-type materials of the diode, as shown in the figure below.



PN-junction under forward bias

Under the forward bias condition, the applied positive potential repels the holes in P-type region. The negative potential repels the electrons in N-type region. Now the electrons in N-type region and the holes in the P-type region move towards the junction. This reduces the width of the depletion region and also the barrier potential.

(ii) Reverse biasing



PN junction under reverse bias

In reverse biasing, the positive terminal of the battery is connected to the N-type and the negative terminal of the battery is connected to the P-type materials of the diode, as shown in the figure.

Under reverse bias condition, the majority carriers with P and N regions are moved towards the battery respectively. The holes in P type and the electrons in N type regions move to the negative and positive terminals of the battery respectively. Hence the width of the depletion region is increased, which prevents the flow of majority carriers through the junction.

According to the operations, the diode is a unidirectional device. The diode generally permits the current in only one direction. Hence it is used in rectifiers, clippers, clampers etc.

25. (a) Explain about various protective devices used to provide electrical safety. 7 Marks

The personal protective device is used to prevent or reduce the severity of the accident.

There are a number of protective devices for head, eye, ear, hand, legs, lungs, body etc. Some of the standard personal protective devices are discussed below.

Protective devices

1. Goggles:

Goggles are meant for eye protection. There are different types of goggles are used according to the work done. Goggles for protection aganist dust and splashes of liquids should be properly ventilated. For protection against fumes and gases, there should be no holes for ventilation. Goggles should enclose the eye completely. Goggles for protection against chemicals should be of material resistant to chemicals. For welders and other works exposed to glare, goggles should have suitable filter lenses.

2. Respirators

These are meant for lung protection. They filter the inhaled air and protect the lungs from gases, fumes, mists or dust. Usually mechanical filters are provided in respirators. However these filters donot give protection from gases. To over come this drawback, gas masks (or) Chemical cartridge respirators are used which are of special design.

3. Saftety shoes

These are used for the protection of legs or feet from heavy objects dropping on feet, protruding nails, molten metals, acids etc. Workers in explosive factories should wear non sparking shoes (also without nails). Electricians should wear non conducting shoes, that is shoes without metal nails.

4. Safety clothing

The dress of the worker should not be too flabby. Otherwise it may be caught in moving machinery. The safe clothes must be of asbestos for fire protection. The dress must be of rubber (or) rubberised clothing for electrical protection.

5. Gloves

These are used for protection from electric shocks, chemicals, fire etc. The gloves should allow free movement of fingers and hand.

6. Helmets

Helmets are used to protect the head from falling or flying objects. They should be strong but not heavy. Plastic hard hats with cloth linings are very suitable.

25. (b) Explain about various hazards caused due to electrical accidents. 7 Marks

HAZARDS OF ELECTRICITY

Electric Shock

Human body is a conductor. When the live wire touches the body, current completes its path through body and earth. Hence the muscular functions of the body are paralysed due to the current's action on the nervous system and causing breathing to stop, severe burns and resulting in death.

Electric Burns

An electric burn is a skin burn that happens when electricity comes in contact with the human body. When this happens, the electricity can damage the tissues and organs of the human body. The severity of damage to the human body depends on the duration and intensity of the current flow to the human body.

Arc blast

When an electric arc occurs, immediately the surrounding air is super heated. Hence high pressure is developed in that area. The level of the pressure developed will be very high, that it may cause explosion of the equipments and causes severe injuries to the workers: The arc blast can cause serious damage to brain and organs of the human body.

Thermal radiation

Thermal radiation occurs due to inisation of air when arc is produced. Thermal radiation causes skin burns, eye injuries and fire hazards.

Explosions

A high current fault can create an electrical explosion. Due to this a high energy arc is formed which vapourises the metal and insulation material. An electrical explosion is the sudden release of energy due to short circuit between the phases or a phase to ground.

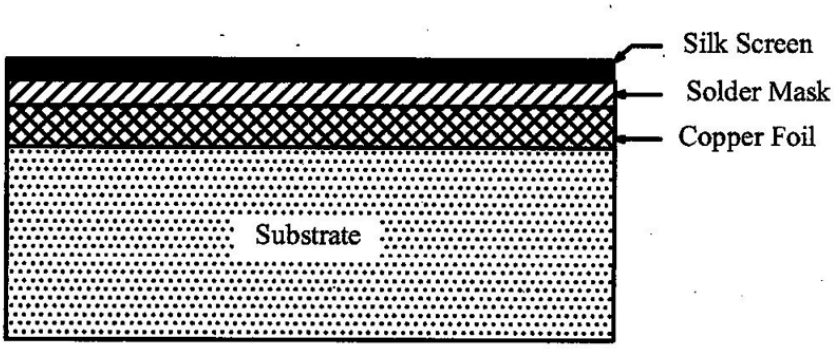
Fires

Electrical fire occurs due to ignitions coming from overheating, malfunctioning, or damaged electrical components, equipment or wiring. This is harmful to the surrounding residential, commercial and industrial areas.

25. (c) Explain about various types of PCB. 7 Marks

(Diagram – 4 Marks, Explanation – 3 Marks)

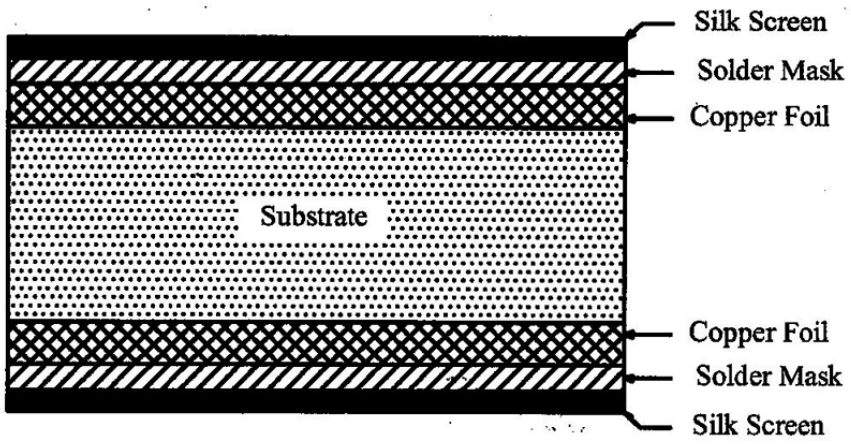
1. Single sided PCB



It is the basic type of circuit board, which contains only one layer of substrate. The substrate is non conducting material. The layer is covered with a thin layer of copper. Copper is a good conductor of electricity. These PCBs also contain a protective solder mask, which is applied on the top of the copper layer along with a silk screen coat. These type PCBs are used in simple circuits such as sensors, relays and electronic toys.

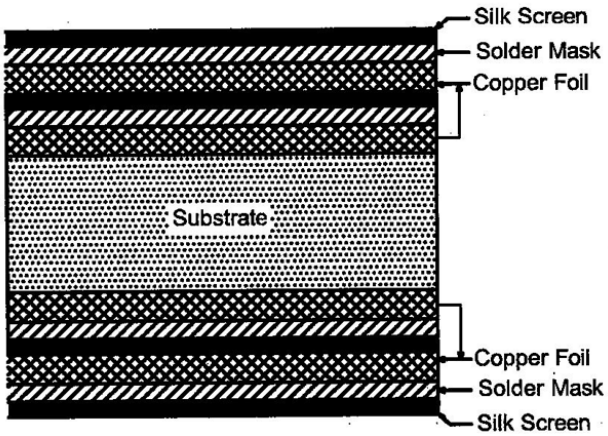
2. Double sided PCB

It has conductive copper layers on both sides of the board. The components are mounted on both sides of the PCB.



All the other layers used in double sides PCBs are same as that of single sided PCB. But these layers are laminated on both sides of the board. The double sided PCB is shown in fig.(5.4). These PCBs are used in car dash board LED lighting, cell phones, UPS system and amplifers.

3. Multi sided PCB



It has three or more layers of copper foil insulated from each other. These are joined together to form a single piece. By using this PCB more components can be mounted in a smaller space. Multi layer PCBs are used in computers laptops, mobile phones, medical equipment's and many other complex circuits.

4. Rigid PCB

In this type, the substrate is fabricated by a solid material which cannot be bent.

5. Flexible PCB

In this type, the substrate is fabricated by a flexible material. This PCB can be bent to any desired shapes.

6. Rigid flexible PCB

In this type, the substrate is the combination of rigid and flexible material.

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