



**MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION**  
**(Autonomous)**  
**(ISO/IEC – 27001 – 2005 Certified)**

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**SUMMER – 13 EXAMINATION**

Subject Code: **12031**

**Model Answer**

**Important Instructions to examiners:**

- 1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
- 2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
- 3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills).
- 4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
- 5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
- 6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
- 7) For programming language papers, credit may be given to any other program based on equivalent concept.

1. Attempt any ten:

20 MKS

i. Write the colour codes for following resistors.

a)  $560k \pm 5\%$

b)  $23.4k \pm 10\%$

Ans:- (1mkseach)

a)  $560 K, \pm 5\%$

$560 \times 10^3, \pm 5\%$

$560000, \pm 5\%$

$56 \times 10^4 \pm 5\%$

↓ ↓ ↓ ↘

Green Blue Yellow Gold

b)  $23.4 K \pm 10\%$

$23400 \pm 10\%$

2 3 4  $10^2 \pm 10\%$

↓ ↓ ↘ ↘ ↘

Red Orange Yellow Red Silver

ii. State two applications of electrolytic capacitors in electronic circuit.

Ans:- (any two points-2 mks)

The two applications of electrolytic capacitors in electronic circuit are

1. By pass Capacitor

2. Power supply filter

3. Starting motors

4. Tuning in Radio receiver /TV Receiver

iii. Define permeability and reluctance of magnetic material.

Ans:- (1 mark)

Permeability- It is capability of specific material to allow the flow of magnetic Flux easily

OR

$$\text{Permeability } (\mu) = \mu_0 \cdot \mu_r$$

Where

$\mu_0$  = permeability of Free space

$\mu_r$  = Relative Permeability of material

(1 mark)

Reluctivity- it is opposition or measure of resistance of a material to the establishment of magnetic field within it.

OR

It is reciprocal of permeability

$$\text{Reluctivity} = 1/\mu = 1/(\mu_0 \mu_r) \quad \text{or}$$

$$= H/B$$

iv. State two merits and demerits of IC

Ans:- **Merits**

( any 2 points-1 mks)

- i) Size is small and weight is less.
- ii) It is cheap.
- iii) It has high reliability.
- iv) Lower power consumption.
- v) Improved functional performance.
- vi) High operating speed.

**Demerits-**

(any 2 points-1 mark)

- i) Inductors and Transformers cannot be fabricated directly.
- ii) Capacitors and resistors exceeding 30pf and 1000k $\Omega$  are difficult to fabricate.
- iii) Low tolerance and small temperature coefficient are difficult to obtain.
- iv) Difficult to fabricate high grade PNP unit.
- v) Low noise and high voltage operation are not easily obtained.
- vi) Power dissipation limited to 10 watts.

v. Find out value of ceramic capacitor for following colour bands.

a) Red Orange Gray Gold

b) Orange Red Brown Red Blue

Ans:-

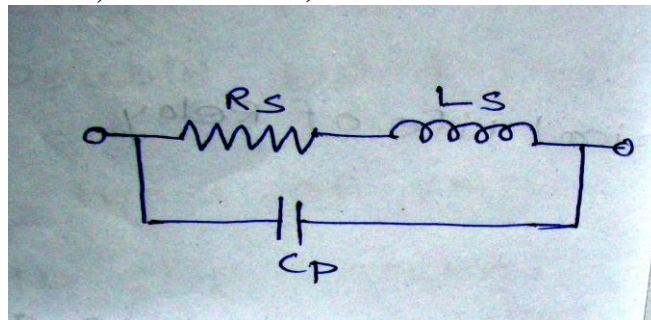
(1 marks each)

1) Red orange gray Gold.  
↓ ↓ ↓ ↓  
2 3  $\times 10^8$  p.f  $\pm 5\%$   
 $23 \times 10^8 \times 10^{-12} \pm 5\%$   
 $23 \times 10^{-4} \pm 5\%$   
 $2.3 \text{ mF} \pm 5\%$

8) Orange Red Brown Red Blue  
 ↓ ↓ ↓ ↓  
 3 2  $\times 10^1$  Tolerance operating voltage  
 $32 \times 10^1$  PF  $\pm 1\%$ , 630V  
 320 PF  
 ie 0.320 nF,  $\pm 1\%$ , 630V.

v. Equivalent circuit of Resistor

Ans:- (Diagram 1 marks, name 1 marks)



Where  $R_s$ - Series resistance of resistor  
 $L_s$ - Series inductance  
 $C_p$ - Shunt capacitance

vi. Define Q factor of inductor

Ans:- ( 2 mks)

**Q- factor**:- The ability of an inductor to store energy as compared to the dissipation of energy within the inductor is called quality or Q-factor or figure of merit .

$$Q = \frac{\text{Energy Stored}}{\text{Energy Dissipated}}$$

It is given as  $Q = X_L / R_0$ ,

Where  $X_L$  is inductive reactance and  $R_0$  is dc resistance of the coil.

vii. State the basic difference between switch and relay.

Ans:- ( 2 mks)

An electric switch is defined as a device for making ,breaking or changing connection sequence in an electric circuit ,switch thus consists of a fixed part and a moving part

A relay is a device that opens or closes an auxillary circuit under some predetermined condition in the main circuit. The object of relay is to act as a sort of electric magnifier ie to say it enables a comparatively weak current to bring into operation a much larger current.

viii. Under what condition hybrid IC are preferred ?

Ans:- ( **any two reason-2 mks**)

1. They are used in all cases where volume of IC required is small.
2. Used for precision application as D/A and A/D Converters

ix. Which two factors determine the rating of switch for a given load ?

Ans:- ( **any 2 points mks**)

Any two factors determine the rating of switch for a given load are-

1. Voltage rating
2. Current rating
3. Contact Resistance
4. Insulation Resistance
5. Operating Force

**xi)** State material used for manufacturing following coloured LED.

- i) Infrared Light – 1 Mark
- ii) Green Light – 1Mark

Ans:- Material used for manufacturing following coloured LEDs are

Infra red LED- Gallium Arsenide (GaAs)

Green LED - Gallium Phosphide (GaP)

**xii)** What will happen if unshielded cables are used for high frequency applications?

Ans:- ( **2 marks**)

If unshielded cables are used for high frequency applications,

1. They will radiate energy in the form of Electro- magnetic waves thus resulting in loss of signals.
2. Also this radiated energy will interfere into nearby cable resulting into EMI (Electro- magnetic interference)

**xiii)** State the criteria for selecting a display device for a particular application.

Ans:- ( **any 4 points-2 marks**)

The criteria for selecting a display device for a particular application are-

1. Resolution
2. Current requirement
3. Characters /symbols to be displayed
4. Operating Time/rise time
5. Brightness/ Contrast ratio
6. Operating voltage
7. Frequency range
8. Effective capacitance

xiv) Which types of connectors are used for following applications :

- 1) PC series port
- 2) RF signal generator

Ans:- PC series port-D Connector

- **1 mks**

RF signal generator-BNC

- **1 mks**

## 2. Attempt any Four

( 16 mks)

a) Why carbon resistors are used for high frequency applications than carbon composition resistors?

Ans:- The carbon composition resistors are predominantly capacitive, so they have limitations on frequency applications. Also they are noisy, unstable and have large TCRs (temperature coefficient of resistance) and exhibit poor long term stability. So due to their construction, they generate noise and this noise level varies with value and physical size. (2 mks)

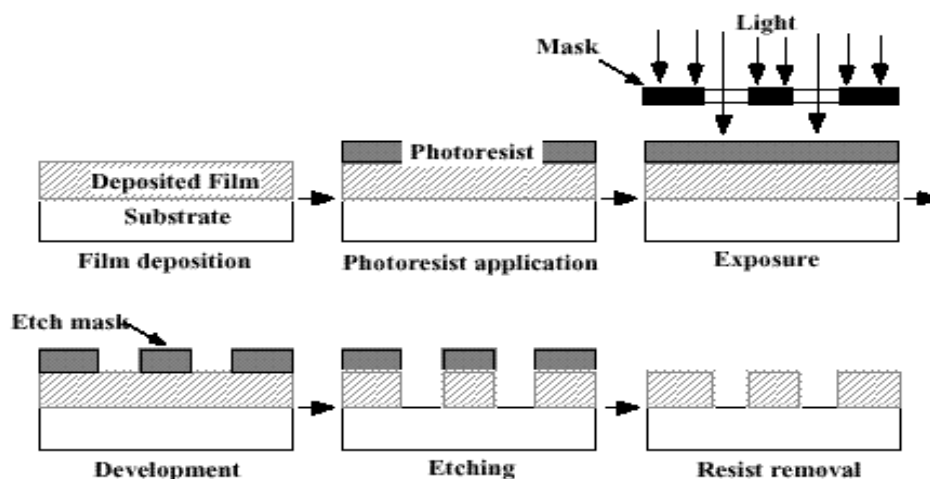
The carbon resistors i.e. carbon film resistors are made of whole resistive element rod. They are the perfect choice in high frequency circuit designs where the parasitic inductance of regular, helical trimmed resistors cannot be accepted. Typical applications are in the fields of telecommunication equipment and industrial electronics. ( 2 mks)

b) Describe photolithography of micro circuits.

Ans:- **Diagram—2Marks; Explanation—2Marks**

Isolation is nothing but removal of  $\text{SiO}_2$  layer from the surface of N-type layer and diffusion is nothing but addition of impurities.

This process will take place according to the number of components to be fabricated on Si slice or wafer. Here isolation is nothing but the removal of  $\text{SiO}_2$  by means of photolithography which is similar to etching.



1. In this process, the wafer is fully coated with a uniform film of photosensitive emulsion.
2. On this mask black and white layout is placed and reduced photographically.
3. This reduction takes place only when UV rays are passed through mask.
4. Because of diffusion of UV rays, photo-resist becomes polymerized under the transparent regions.

5. Then mask is taken out and photoresist which was under the black portion of mask is dissolved in the solution of trichlorethy .
6. Now, removal of  $\text{SiO}_2$  is done by using hydrofluoric acid. Here the portions of  $\text{SiO}_2$  which are protected by resist material will remain as it is.
7. At last, resist emulsion is removed by chemical solvent like  $\text{H}_2\text{SO}_4$  .  
Here the Photolithography will get done.

c) What is importance of characteristic impedance of cable? Why ?

Ans:- Characteristic impedance of cable is defined as ratio of the maximum voltage to the maximum current at any point on a cable of infinite length.

$$\text{i.e } Z_0 = V_0 / I_0 \quad (2 \text{ mks})$$

Energy supplied by a source at one end of such a line is transmitted through the line without being dissipated in the line itself.

Characteristic impedance is of prime importance for good cable as transmitter for sending signals over a line . **Maximum power transfer** occurs when the source has the same impedance as the load. Where impedances do not match, some of the signal is reflected back towards the source. In many cases this reflected signal causes problems and are therefore undesirable as they result in losses. (2 mks)

d) List any four methods used to protect copper patterns of PCB from scratching and corrosion.

Ans:- ( Any 4 methods -4 points)

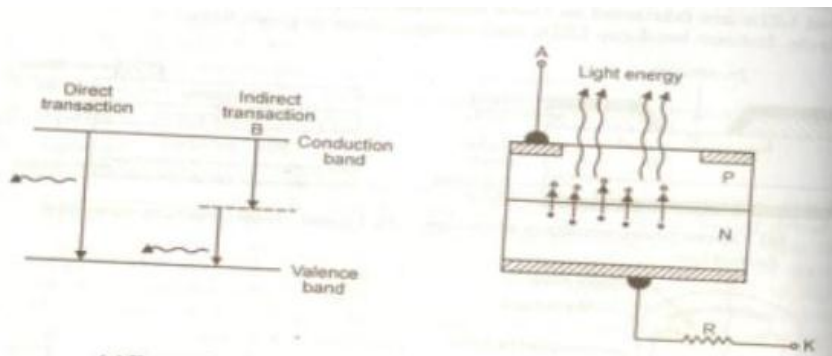
Methods used to protect copper patterns of PCB from scratching and corrosion are-

1. Tinning
2. Electroplating
3. Immersion plating
4. Electroless copper plating

e) Draw and explain constructional details of LED with principle and operation.

Ans:- **Diagram—2Marks; Explanation—2Marks**

Constructional details of LED



**LED (Light emitting diode)** -The LED is a PN junction device which emits light when a current passes through it in the forward direction. By using elements like gallium, arsenic and phosphorous, the LEDs can be manufactured to radiate red, green, yellow, orange and invisible infra-red rays. LEDs that radiate visible radiations are used in instrument displays such as calculators, digital watches, panel meters etc.

N-type layer is grown on a P-type substrate by diffusion process. Then a thin P-type layer grown on the N-type layer. The metal connection to both the layers make anode and cathode terminal. The energy is released at the junction, when the recombination of electrons and holes take place. Window is provided at the top of the surface, through which light is emitted. When the LED is forward biased, the electrons and holes move towards the junction and recombination takes place. After recombination, the holes lying in the valance band of a P-region and electron lying in the conduction band as N-region. The difference of energy between the conduction band and valance band is radiated in the form of light energy.

The LED radiates light in different colours such as red, green, yellow, blue, etc.

**3. Attempt any four:**

**(4X4)**

a. What are advantages and disadvantages of optical fiber cable?

Ans a. **Advantages— 2marks; Disadvantages— 2marks**

**Advantages (Any Two points)**

- Good information carrying capacity, which depends on bandwidth of the cable and fiber optical cable have much greater bandwidth.
- Lower loss as there is less signal attenuation over long distances.
- Fiber optical cable has lightweight and small size as compared to electrical cable.



- Optical cable does not cause interference because they do not carry the signals, which cause interference.
- Fiber optical cable cannot be tapped as easily as electrical cables.
- Fiber optical cables do not carry electricity. Therefore, there is no shock hazard.
- Fiber optical cables are stronger than electrical cables.
- Materials required for fiber optical cables are easily available.
- They are simple in construction.

**Disadvantages: (Any Two points)**

- Fiber optical cable has small size and brittleness, which make it difficult to work with
- Expensive tools and technique are required.
- An external loss is taking place because of misalignments.
- Fiber optic cable only suitable for point to point communication
- If certain defects are present in the material of an optical fiber, then the light rays get scattered.

b. What precautions are to be taken while handling mercury wetted reed relay? Why?

Ans b. **4Marks**

- i) While handling a mercury wetted reed relay, the precautions to be taken are that the relay should be held only vertically.
- ii) Inability to function at low temperature
- iii) Inability to function where there is severe shock or vibration

c. State specifications of SMD capacitor.

Ans c. **(Each Specification—1mark)**

**Specifications of SMD capacitor are as follows:**

- i) Capacitance range : 1pF to 1.5 $\mu$ F
- ii) Capacitance tolerance : 1% to 2%
- iii) Working voltage : 25,50,100,200 Vdc
- iv) Temperature range : -55<sup>0</sup>C to 125<sup>0</sup>C

d. State the procedural steps to identify defects and check the faults in the manufactured PCB.

Ans d. ANY 4 Points **4Marks**

Some of the important problems affecting the performance of PCB are as given :

1. The improper physical size and thickness of PCB may pose the serious problem of mechanical stress. It will be difficult for efficient testing and repair.

2. The larger length of conductivity path and spacing between them govern the effect of parasitic elements, namely inductors and capacitors.
3. The improper conductor width will not sustain the flow of current and hence it may damage the PCB.
4. A common ground for analog and digital signals may give rise to voltage drop along the conductor and results into noise and false signals.
5. The packing density of components on PCB has direct effect on the cooling requirement. The improper packing density leads to less reliability, higher cost of maintenance and repair problems.
6. The scale of layout affects the accuracy and decides the component density.
7. Does the board have mounting holes? Are they big enough?
8. Are physically large components separated enough to clear?
9. Can power transistors and voltage regulators accept a heat sink? Is there room?
10. Are all holes large enough? Some items (for example, power connectors) may have thick leads.
11. Are all test points and interconnections labeled?
12. Do you have a large number of vias? If so, make a copy of the board and try rearranging things to reduce vias.

e. Compare paper and ceramic capacitors on the range of values, voltages rating, power factor and temperature coefficient.

Ans e. **(Each parameter –1mark)**

Sr.no	Parameters	Paper Capacitor	Ceramic Capacitor
1.	Range of values	1000pF to 1 $\mu$ F	1000 to 1300pF
2.	Voltage rating	400V,600V,1200V,1800V	500V
3.	Power factor	0.005 to 0.01 at 1KHz	0.0003
4.	Temperature coefficient	+100 to 200ppm/ $^{\circ}$ C	-800 to 100ppm/ $^{\circ}$ C

**4. Attempt any four:****(4X4)**

a. State the meaning of chattering of relay and why the relay coil is vacuum impregnated.

Ans a.

**Chattering of relay – 2 Marks**

Electromagnetic coil in relays are excited by ac. When the alternating flux passes through zero values, the armature tends to chatter.

**Relay coil is vacuum impregnated –2 Marks**

To protect the relay coils from moisture present in air, they are adequately sealed. If the air from surrounding atmosphere enters the coil, then it will suffer from corrosion and insulation will be weakened. To avoid such effects on coil, relay coils are vacuum impregnated.

b. State appropriate type of capacitor for the following applications:

- i) Power supply filter
- ii) Coupling and decoupling
- iv) Oscillator
- v) Starting and running of motors.

Ans b. (1Mark each)

Sr.No	Applications	Types of capacitors
1.	Power supply filter	Aluminium electrolytic
2.	Coupling and decoupling	Ceramic
3.	Oscillators	Polystyrene
4.	Starting and running of motors	Metallized paper

c. State selection criteria for selection of PCB laminate for high frequency analog circuits, digital circuits and power electronics applications.

Ans c.

- Polytetrafluorethylene is a thermoplastic which is reinforced with glass results in a laminate with low dielectric constant and low dissipation factor PTFE laminates are an excellent electrical insulation under severe environment conditions. PTFE laminates are often used for very high frequency and microwave applications Eg input stages for high impedance/ low current measuring instruments and amplifiers.
- A low dielectric constant PCB can support good performance in high speed digital circuits and multilayer circuits typical of digital design.

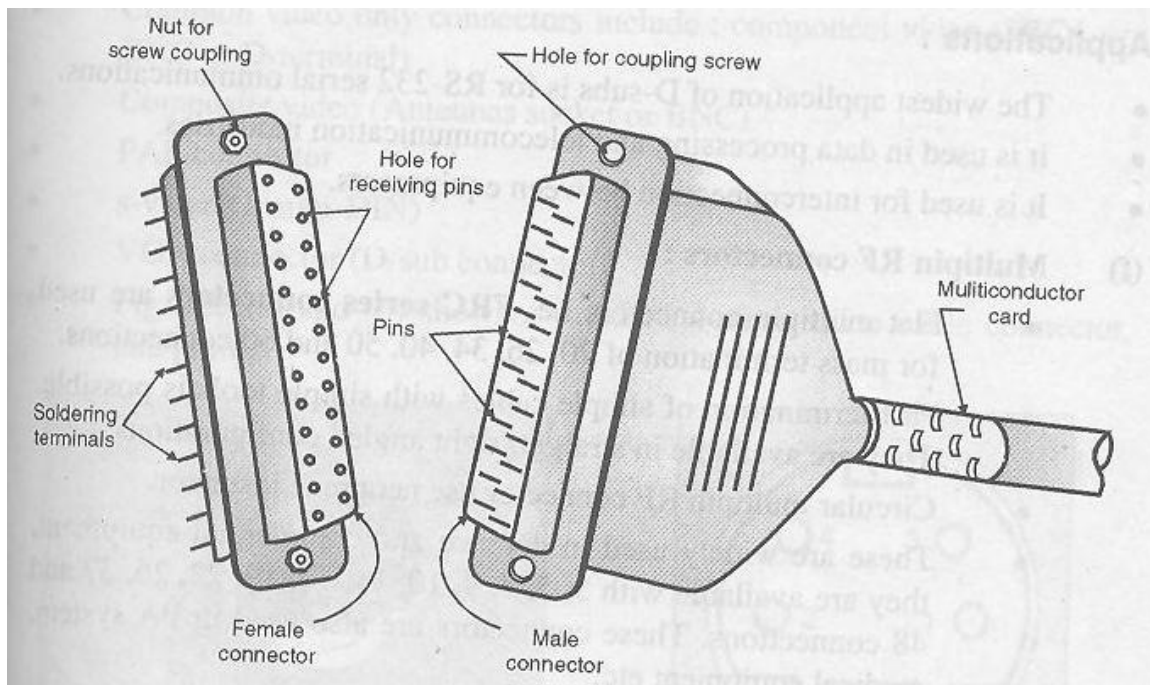
Some of laminates suited for digital applications

1. FR4
  2. FR408
  3. BT Epoxy
  4. Cyanate ester
  5. Polyimide.
- Power electronic devices dissipate a certain amount of heat which usually calls for suitable heat sinks. If the heat sink is directly mounted on the PCB, the whole board will also be heated up to the same temperature. Therefore, the base material selected has to withstand the continuous operation of the equipment under worst case condition.

A very common device is glass epoxy laminates.

d. Draw a neat sketch of D- type connector used in computers and state its two applications.

Ans d. (Neat Diagram- 2marks ; Two Application—2 Marks)



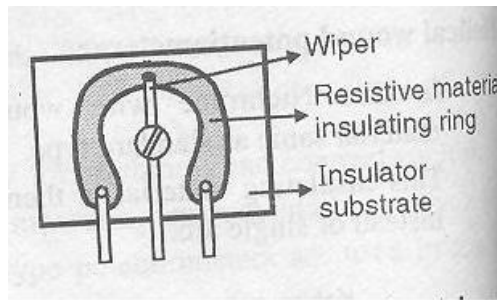
### D- Type connector

#### Applications:

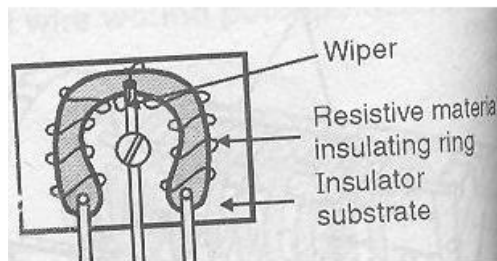
- The widest application of D- subs is for RS-232 serial communications.
- It is used in data processing and telecommunication industries.
- It is used for interconnection between equipments.

e. Give the constructional details of preset and state its application

Ans e. (**Constructional Details –2marks; Application—2marks**)



**Carbon composition trimmer**



**Wire wound trimmer**

- A trimmer or preset is a variable resistor having three terminals. Its working principle is same as that of potentiometer, but the rotating shaft is absent.
- Instead of rotating shaft, value is adjusted by using special tool or screwdriver in the slot provided on trimmer.
- Trimmer are used in devices which require infrequent adjustments. Trimmers are generally present, on the circuit board, rather than keeping on the front panel.
- Trimmers are need to be adjusted only when the equipment is serviced. Unlike many other control variables.
- With screw adjustments, trimmers are used to provide very high degree of accuracy.

**Applications :**

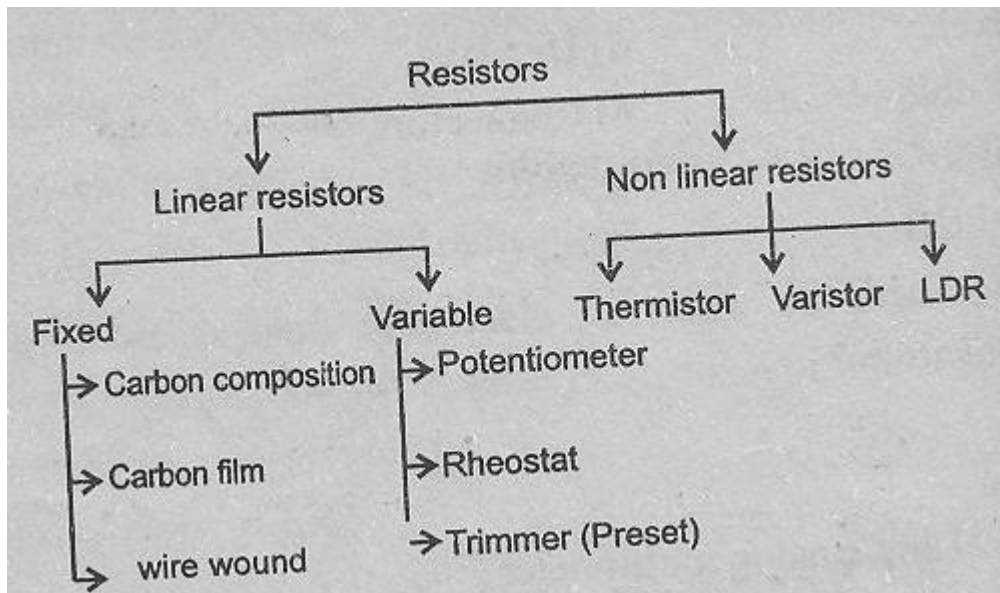
- Used in integrated circuits and TV receiver.
- Used in consumer electronics

**Q5) Attempt any four**

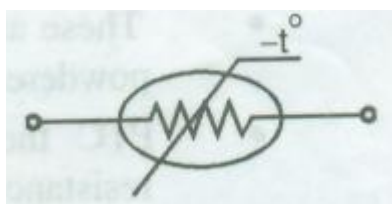
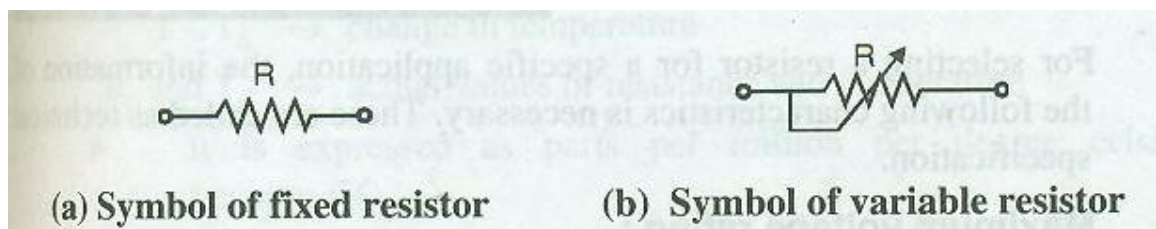
**(4X4)**

a) Give the detail classification of resistors & draw their small symbols.

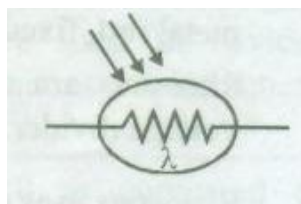
Ans : **(Detail Classification—2 Marks; Symbol—2marks)**



**Classification of resistors**



**TDR**



**LDR**

**Symbol**

b) Explain the following soldering techniques in briefs:

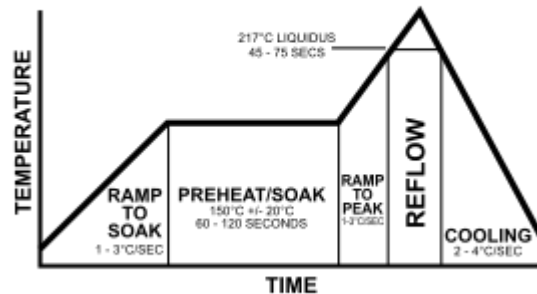
- (i) Reflow soldering -- **2Marks**
- (ii) Laser soldering -- **2Marks**

Ans b:

**Reflow soldering** is a process in which a solder paste (a sticky mixture of powdered solder and flux) is used to temporarily attach one or several electrical components to their contact pads, after which the entire assembly is subjected to controlled heat, which melts the solder, permanently connecting the joint. Heating may be accomplished by passing

the assembly through a reflow oven or under an infrared lamp or by soldering individual joints with a hot air pencil.

Reflow soldering is the most common method of attaching surface mount components to a circuit board. The goal of the reflow process is to melt the solder and heat the adjoining surfaces, without overheating and damaging the electrical components. In the conventional reflow soldering process, there are usually four stages, called "zones", each having a distinct thermal profile: *preheat*, *thermal soak* (often shortened to just *soak*), *reflow*, and *cooling*.



## Laser Soldering

*Laser soldering* is a technique where a ~30-50 W laser is used to melt and solder an electrical connection joint. Diode laser systems based on semiconductor junctions are used for this purpose.

Wavelengths are typically 808 nm through 980 nm. The beam is delivered via an optical fiber to the work piece, with fiber diameters 800  $\mu\text{m}$  and smaller. Since the beam out of the end of the fiber diverges rapidly, lenses are used to create a suitable spot size on the work piece at a suitable working distance. A wire feeder is used to supply solder.

Both lead-tin and silver-tin material can be soldered. Process recipes will differ depending on the alloy composition. For soldering 44-pin chip carriers to a board using soldering preforms, power levels were on the order of 10 Watts and solder times approximately 1 second. Low power levels can lead to incomplete wetting and the formation of voids, both of which can weaken the joint.

c) State the precaution for proper PCB layout design.

Ans:

**Precautions for proper PCB layout design: -- (Any four points -4marks)**

The precautions for proper PCB layout design are as follows:

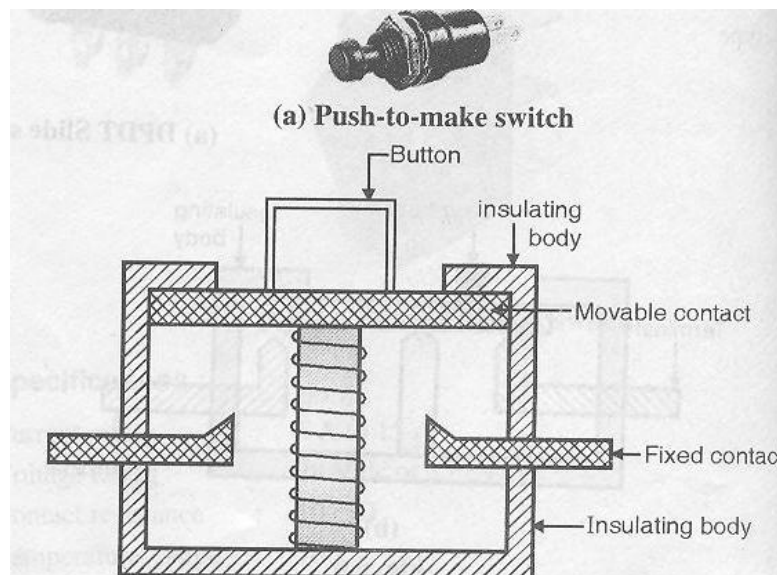
- The type of PCB, the type of components & their size, the amount of heat generated & cooling provision needed should be considered while designing the PCB.
- The schematic diagram should be drawn properly by taking care of physical design aspects like spurious signals, undesirable coupling, etc.
- The PCB of proper physical size & thickness should be selected to provide sufficient mechanical stress.



- The conductor length for connectivity path should be minimum.
- The spacing between the two connectivity paths should be proper to avoid the effects of parasitic elements such as inductors & capacitors.
- The width of connectivity path should be properly designed by knowing the current carrying requirements of specific signals.
- The separate ground should be used for analog signals and digital signals as analog ground and digital ground.
- The packing density of components to be mounted on the PCB should be minimum.
- The scale of layout for proper artwork should be selected to avoid the accuracies and improper component density.
- For low impedance signals, wide connectivity paths should be used and for high impedance signals, narrow connectivity path should be used.

d) Draw & explain PUSH to ON & PUSH to OFF switch.

Ans d.



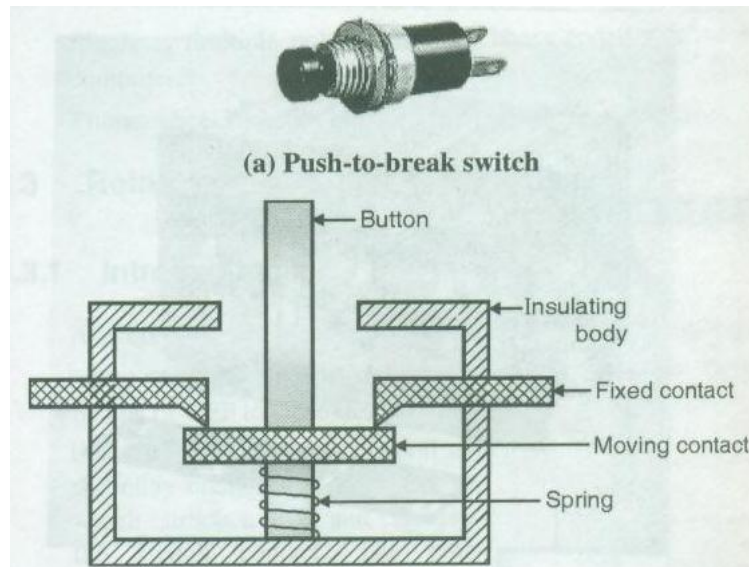
**Construction of push to ON switch**

**PUSH to ON switch : (-- 2Marks)**

- It consists of two fixed metal contacts and one variable metal contact.
- It uses the spring to connect & disconnect the metal contact.
- The assembly is enclosed in insulating body.
- The construction of push-to-on switch is as shown in fig.
- When button is pushed inward, movable metal bar moves towards the fixed contact and it will make the contact. When both contacts movable and fixed meet, the circuit becomes closed, i.e., on state of the circuit.



- When button is released the circuit becomes open because the spring pushes metal bar in the reverse direction away from fixed contact.



**Construction of Push to OFF switch**

**PUSH to OFF switch : (-- 2Marks)**

- It is similar to push-to-ON switch except the position of movable metal contact and fixed metal contacts are changed.
- When the button is pushed inwards, the metal bar which is movable, moves away from fixed contacts & circuit becomes opened, i.e., OFF position of circuit.
- When button is released, circuit becomes closed, i.e., ON state of the switch.
- Construction of push-to-OFF switch is as shown in fig.

e) Which inductor is more effective from iron core inductor & ferrite core inductor?  
Why?

Ans : **(4Marks)**

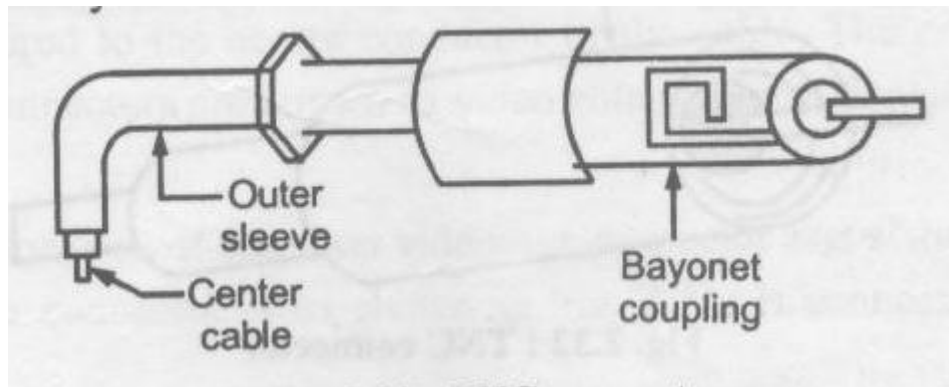
- The ferrite core inductors are more effective.
- This is because the ferrite possesses high magnetic permeability and high resistivity to eddy currents.
- They are used in the coils in the frequency range covering audio and radio frequencies.
- In case of iron core inductor, there occurs large eddy current losses which are to be removed by using laminations. This type of core is found to work more efficiently at low frequency.

**Q. 6) Attempt any four**

**(4X4)**

- a) Draw BNC & TNC connector with one application each.

**Ans : BNC—2Marks ; TNC—2Marks**



**BNC connector**

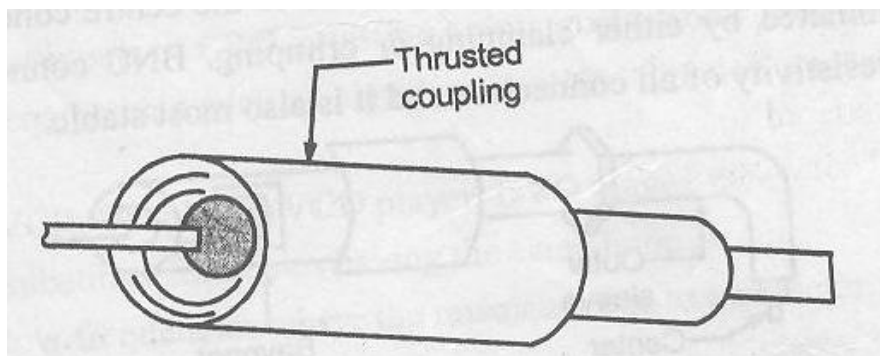
**BNC connector:**

**Application: (Any ONE)**

Some of the important applications of BNC connectors are as given below:

- It is extensively used in test equipments.
- It is used to connect the input of CRO to the testing points in electronic circuits.

**TNC connector:**



**TNC connector**

**Application: (Any ONE)**

Some of the important applications of TNC connectors are as given below:

- They are extensively used in test equipments at very high frequencies upto 15 GHz and under vibration conditions.
- They are used to connect input of CRO to testing points in the electrical & electronic circuits.

- b) Why double sided PTH type glass epoxy PCB is preferred than general single sided PCB in high density electronic component circuits?

Ans : **Any 4 Points 4marks**

Due to the following advantages, the double-sided PTH type glass epoxy PCB is preferred over single-sided PCB in high density electronic component circuit:

- They are tougher than single-sided PCB.
- Chemical nature of epoxy gives good adhesion.
- They have high alkali resistance.
- They exhibit good electrical properties over different temperature and frequency.
- They have better mechanical strength.

- c) Give method of testing switches using ohm meter.

Ans : **4marks**

**Method of testing switches using ohmmeter:**

- A switch, when open or off should have infinite resistance and should have zero resistance when closed or on.
- Switches can be checked using ohmmeter.
- If the closed contacts does not show zero resistance, then oxidation of contact points might have resulted due to sparking.
- If the open does not show infinite resistance then the switch is shorted or faulty.

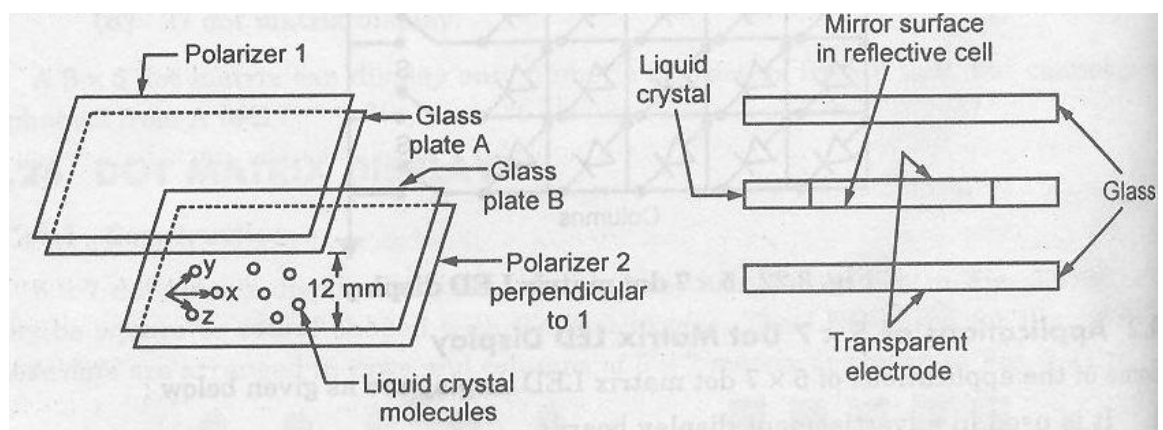
- d) State two types of LCD & draw neat labelled cross sectional diagram of LCD.

Ans : **(Types of LCD—2marks; Neat labelled diagram – 2marks)**

**Types of LCD displays:**

There are two types of LCD displays. They are as given below.

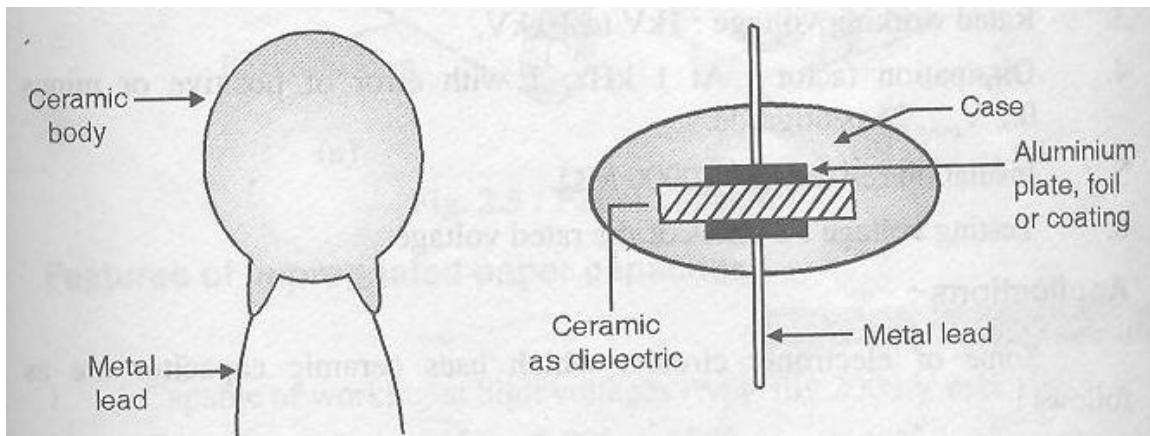
- Dynamic scattering type LCD display.
- Field effect type LCD display.



**Liquid crystal display (LCD)**

e) Draw a neat sketch of disc ceramic capacitor & give the constructional features.

Ans : **(Diagram—2marks ; Constructional features—2Marks)**



**Disc ceramic capacitor**

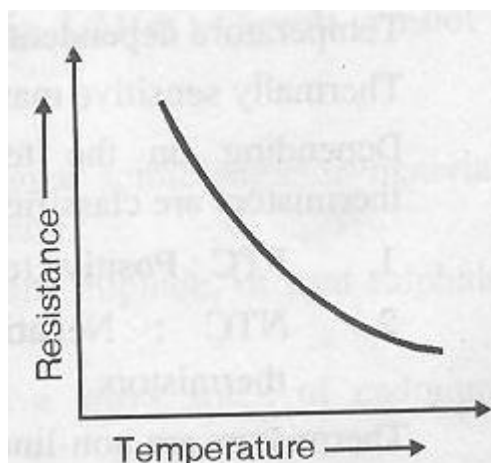
**Disc ceramic capacitor:**

- Ceramic capacitors make use of ceramic as the dielectric material. Basic ceramic materials are formed from titanium dioxide. Some of the dielectric materials used are barium titanate, magnesium titanate and sirconium titanate. The cross section of a typical ceramic disc capacitor is shown in fig.
- For manufacturing of disc type capacitor, the required ceramic material is mixed with resin and binders and shaped into tiny disc of required diameter typically 0.5 cm or less as shown in fig.
- Then a thin aluminum coating is made on either side of the ceramic surfaces and end connections are taken as shown in fig. The whole unit is then immersed in wax to give a protective covering.

f) Explain NTC and PTC resistors with T-R characteristics.

Ans : **NTC – 2Marks ; PTC—2Marks**

**NTC Thermistors:**



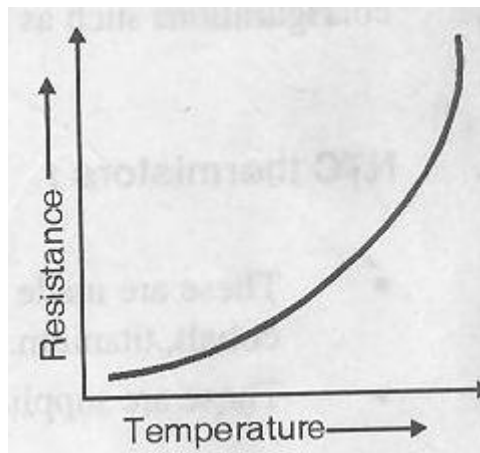
**NTC Thermistors**

- These are made of oxides of metals such as manganese, nickel, cobalt, titanium.
- These are supplied in glass bead, disc and probe formats.
- NTC thermistors have negative temperature co-efficient of resistance where resistance of the resistive material decreases with increase in temperature.
- NTC thermistors are used when continuous change of resistance is required over wide temperature range.
- NTC thermistors offer mechanical, thermal and electrical stability together with high degree of sensitivity.
- NTC have inversely proportional relationship between resistance and temperature and characteristics curve is as shown in fig.

$$R \propto 1/T$$

- It has excellent combination of price and performance.
- NTC thermistors can operate over + 200° c to + 1000° c.

#### PTC Thermistor:



**PTC Thermistor**

- These are manufactured from barium titanate, titanium oxide, powdered barium carbonate, etc.
- PTC thermistors have positive temperature co-efficient of resistance in which resistance value decreases with decrease in temperature.
- PTC thermistors are used when a drastic change in resistance is required at specific temperature.
- PTC thermistors operate over 60° c to 180° c.
- PTC have directly proportional relation between temperature and resistance and the characteristics curve is as shown in fig.

$$T \propto R$$