PART A

1. Differentiate relays and contactors and write the applications of each.

Relay	Contactor
Relatively smaller in size.	Larger when compared to relays.
Used in circuits with lower ampacity. (Max 20A)	Used in circuits with low and higher ampacity up to 12500A.
Mainly used in control and automation circuits, protection circuits and for switching small electronic circuits.	Used in the switching of motors, capacitors, lights etc.
Consists of at least two NO/NC contacts.	Consists of minimum one set of three phase power contacts and in some cases additional auxiliary contacts are also provided.

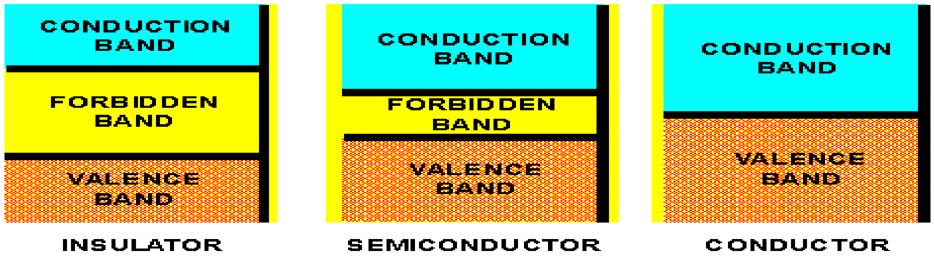
2. What is tolerance of a resistor? Find the resistance range for the carbon resistor having the colour bands: yellow, violet, red and gold.
Tolerance is the percentage of error in the resistor's resistance, or how much more or less you can expect a resistor's actual measured resistance to be from its stated resistance. A gold tolerance band is 5% tolerance, silver is 10%, and no band at all would mean a 20% tolerance.

Resistance range of the given color band is 4.7K $\pm$ 5%.

3. Write any four applications of electronics in the field of defense.

- Electronic circuits provide a means of secret communication between the head-quarter and different units
- RADAR that is Radio Detection and Ranging is the most important development in electronics field. With the help of radar, it is possible to detect and find the exact location of enemy aircraft, Radar and anti-craft guns can be linked by an automatic control system to make a complete unit
- Circuit boards and sub-assemblies for military firing simulators (anti-tank)
- Electrical distribution circuit boards for military helicopters

4. Draw the energy band diagrams of insulator, semiconductor and conductor.



5. How does an Avalanche breakdown differ from Zener break down?

Zener break down	Avalanche breakdown
1.This occurs at junctions, which being heavily doped have narrow depletion layers.	1. This occurs at junctions which being lightly doped has wide depletion layers.
2. This breakdown voltage sets a very strong electric field across this narrow layer.	2. Here, electric field is not strong enough to produce Zener breakdown.
3. Here, electric field is very strong to rupture the covalent bonds thereby generating electron hole pairs. So even a small increase in reverse voltage is capable of producing large number of current carriers, i.e. why the junction has a very low resistance. This leads to Zener breakdown	3. Here, minority carriers collide with semiconductor atoms in the depletion region, which breaks the covalent bonds and electron-hole pairs are generated. Newly generated charge carriers are accelerated by the electric field, which results in more collision and generates avalanche of charge carriers. This results in avalanche breakdown.

6. Write the type number of the following: a) Low frequency low power transistor, b) High frequency low power transistor, c) Power Transistor, d) Rectifier Diode.

Low frequency low power transistor= AC540
High frequency low power transistor=AF125
Power Transistor=TO220
Rectifier Diode

Model Number	Diode Type	Peak Inverse Voltage	Current
1N4001	Rectifier	50 V	1 A
1N4002	Rectifier	100 V	1 A

1N4003	Rectifier	200 V	1 A
1N4004	Rectifier	400 V	1 A
1N4005	Rectifier	600 V	1 A
1N4006	Rectifier	800 V	1 A
1N4007	Rectifier	1,000 V	1 A

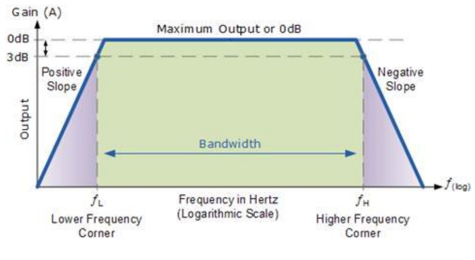
7. What is the working principle of SMPS?
SMPS means switch mode power supply. This works on the principle of switching regulation. The SMPS system is highly reliable, efficient, noiseless and compact because the switching is done at very high rate, in the order of several KHz to MHz.

8. Describe the role of different capacitors in RC coupled amplifier.

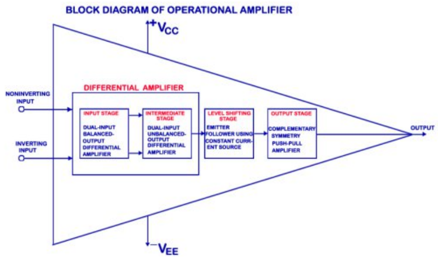
- Coupling capacitor C_C is used to connect the output of first stage to the base, i.e. input of the second stage and this continues when more stages are connected. The coupling capacitor C_C transmits AC signal but blocks DC. This prevents DC interference between various stages and the shifting of operating point.
- The emitter bypass capacitor offers a low resistance path to the signal. Without this capacitor the voltage gain of each stage would be lost.

9. Define bandwidth of an amplifier and mark the important parameters in the frequency response graph.
The bandwidth (BW) of an amplifier is the difference between the frequency limits of the amplifier, the bandwidth represents the amount or "width" of frequencies, or the "band of frequencies," that the amplifier is MOST effective in amplifying. However, the bandwidth is NOT the same as the band of frequencies that is amplified.

<u>Frequency response graph</u>



10. Draw the internal block diagram of op-amp and write the functions of each block.



Input stage: It consists of a dual input, balanced output differential amplifier. Its function is to amplify the difference between the two input signals. It provides high differential gain, high input impedance and low output impedance.

Intermediate stage: The overall gain requirement of an Op-Amp is very high. Since the input stage alone cannot provide such a high gain. Intermediate stage is used to provide the required additional voltage gain.

It consists of another differential amplifier with dual input, and unbalanced (single ended) output.

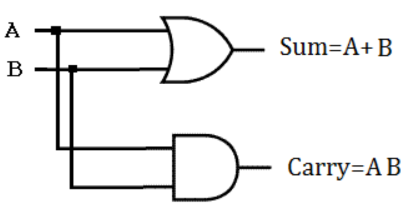
Buffer and Level shifting stage

As the Op-Amp amplifies D.C signals also, the small D.C. quiescent voltage level of previous stages may get amplified and get applied, as the input to the next stage causing distortion to the final output.

Hence, the level shifting stage is used to bring down the D.C. level to ground potential, when no signal is applied at the input terminals. Buffer is usually an emitter follower used for impedance matching.

Output stage- It consists of a push-pull complementary amplifier, which provides large A.C. output voltage swing and high current sourcing and sinking along with low output impedance.

11. Realize the logic functions: Sum $S = A + B$ and Carry $CY = AB$ using gates and prepare the truth table.



Truth table:

A	B	SUM(S)=A+B	Carry(CY)=AB
0	0	0	0
0	1	1	0
1	0	1	0
1	1	1	1

12. What are the advantages of integrated circuits?

1. Extremely small size – thousand times smaller than discrete circuits. It is because of fabrication of various circuit elements in a single chip of semiconductor material.
2. Very small weight owing to miniaturized circuit.
3. Very low cost because of simultaneous production of hundreds of similar circuits on a small semiconductor wafer. Owing to mass production of an IC costs as much as an individual transistor.
4. More reliable because of elimination of soldered joints and need for fewer interconnections.
5. Lower power consumption because of their smaller size.

13. What is frequency modulation? Write the frequency bands used for AM and FM broadcast.

Frequency modulation

It is a process in which the frequency of the carrier is varied in accordance with the instantaneous value of modulating or information signal.

Frequency bands used for AM and FM broadcast.

The Amplitude Modulated (AM radio) carrier frequencies are in the frequency range 535-1605 kHz. Carrier frequencies of 540 to 1600 kHz are assigned at 10 kHz intervals.
The FM radio band is from 88 to 108 MHz between VHF televisions. The FM stations are assigned center frequencies at 200 kHz separation starting at 88.1 MHz, for a maximum of 100 stations. These FM stations have a 75 kHz maximum deviation from the center frequency, which leaves 25 kHz upper and lower "gaurd bands" to minimize interaction with the adjacent frequency band.

14. Write the RADAR range equation and list the factors affecting the range.

Maximum RADAR range equation is

$$R_{max} = \sqrt[4]{\frac{PS.G^2.\lambda^2.\sigma}{PE_{min}.(4\pi)^3}}$$

List the factors affecting the range

1. The maximum range at which it can see a target of a specified size.
2. The accuracy of its measurement of target location in range and angle.
3. The ability to distinguish one target from another.

15. Distinguish between LEO, MEO and GEO satellites.

Parameter	LEO	MEO	GEO
Satellite Height	500-1500 km	5000-12000 km	35,800 km
Orbital Period	10-40 minutes	2-8 hours	24 hours
Number of Satellites	40-80	8-20	3
Satellite Life	Short	Long	Long
Number of Handoffs	High	Low	Least(none)
Gateway Cost	Very Expensive	Expensive	Cheap
Propagation Loss	Least	High	Highest

16. Discuss the basic principle of GPS.

GPS is a satellite based navigation system. It uses a digital signal at about 1.5 GHz from each satellite to send data to the receiver. The receiver can then deduce its exact range from the satellite, as well as the geographic position (GP) of the satellite. The GP is the location on the Earth directly below the satellite. This establishes a line of position (LOP) on the Earth.

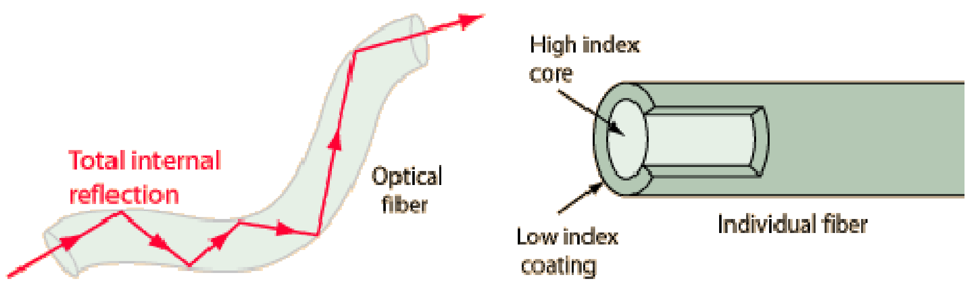
17. Compare the features of GSM and CDMA.

GSM	CDMA

• Global System for Mobile Communication	• Code Division Multiple Access
• GSM operates on the wedge spectrum called a carrier	• CDMA is based on spread spectrum technology, which makes the optimal use of available bandwidth
• Less security is provided than CDMA technology	• More security is provided in CDMA technology
• The GSM network operates in the frequency spectrum of GSM 850 MHz and 1900 MHz	• The CDMA network operates in the frequency spectrum of CDMA 850 MHz and 1900 MHz
• GSM uses EDGE data transfer technology that has a maximum download speed of 384 kbps, which is slower as compared to CDMA.	• Data transfer technology is used in CDMA, which offers a maximum download speed of 2 mbps.
• GSM phones emit about 28 times more radiation on average as compared to CDMA phones	• CDMA cell phones do not produce that much radiation.

18. Explain the total internal reflection in optical fiber with the help of a diagram.

Total internal reflection is the reflection of the total amount of incident light at the boundary between two media. The field of fiber optics depends upon the total internal reflection of light rays traveling through tiny optical fibers. The fibers are so small that, once the light is introduced into the fiber with an angle within the confines of the numerical aperture of the fiber, it will continue to reflect almost lossless off the walls of the fiber and thus can travel long distances in the fiber.



19. What is the need for cell splitting in cellular communication system?
Cell splitting is the process of dividing the radio coverage of a cell site in a wireless telephone system into two or more new cell sites. Cell splitting may be performed to provide additional capacity within the region of the original cell site, the cells are divided in hexagonal shape to cover all the area.

20. What are the characteristics of Plasma Display?

- It is also called as gas discharge display
- Flat-screen technology that uses tiny cells lined with phosphor that are full of inert ionized gas (typically a mix of xenon and neon)
- Three cells make up one pixel (one cell has red phosphor, one green, one blue). The cells are sandwiched between x- and y-axis panels, and a cell is selected by charging the appropriate x and y electrodes
- The charge causes the gas in the cell to emit ultraviolet light, which causes the phosphor to emit color. The amount of charge determines the intensity, and the combination of the different intensities of red, green and blue produce all the colors required Plasma monitors consume significantly more current than LCD-based monitors

PART B

21. Discuss the construction, working and application of electrolytic capacitor.

Explain the working of electrolytic capacitor.

Introduction:

- An electrolytic capacitor is a polarized capacitor, which uses an electrolyte to achieve a larger capacitance than other capacitor types.
- An electrolytic capacitor is a type of capacitor that uses an electrolyte to achieve a larger capacitance than other capacitor types.
- An electrolyte is a liquid or gel containing a high concentration of ions. Almost all electrolytic capacitors are polarized, which means that the voltage on the positive terminal must always be greater than the voltage on the negative terminal.
- The benefit of large capacitance in electrolytic capacitors comes with several drawbacks as well.
- Electrolytic capacitors can be either wet-electrolyte or solid polymer. They are commonly made of tantalum or aluminum, although other materials may be used.

Definition:

- An electrolytic capacitor is a polarized capacitor, which uses an electrolyte to achieve a larger capacitance than other capacitor types

Characteristics:

1. Capacitance drift:

- The capacitance of electrolytic capacitors drifts from the nominal value as time passes, and they have large tolerances, typically 20%. This means that an aluminum electrolytic capacitor with a nominal capacitance of 47μF is expected to have a measured value of anywhere between 37.6μF and 56.4μF. Tantalum electrolytic capacitors can be made with tighter tolerances, but their maximum operating voltage is lower so they cannot be always used as a direct replacement.

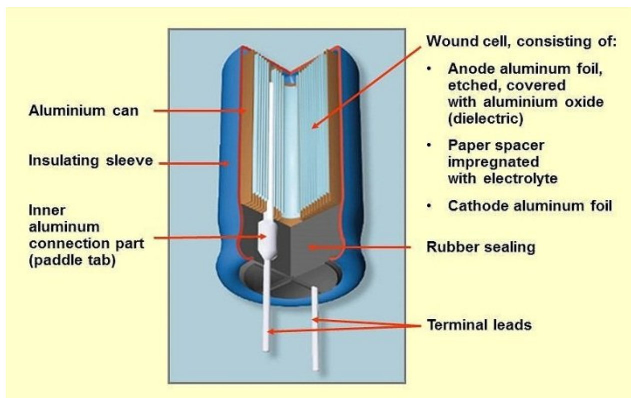
2. Polarity and safety:

- Due to the construction of electrolytic capacitors and the characteristics of the electrolyte used, electrolytic capacitors must be forward biased. This means that the positive terminal must always be at a higher voltage than the negative terminal.
- If the capacitor becomes reverse-biased (if the voltage polarity on the terminals is reversed), the insulating aluminum oxide, which acts as a dielectric, might get damaged and start acting as a short circuit between the two capacitor terminals. This can cause the capacitor to overheat due to the large current running through it.
- As the capacitor overheats, the electrolyte heats up and leaks or even vaporizes, causing the enclosure to burst. This process happens at reverse voltages of about 1 volt and above.
- To maintain safety and prevent the enclosure from exploding due to high pressures generated under overheat conditions, a safety valve is installed in the enclosure. It is typically made by making a score in the upper face of the capacitor, which pops open in a controlled manner when the capacitor overheats.
- Since, electrolytes may be toxic or corrosive, additional safety measures may need to be taken when cleaning after and replacing an overheated electrolytic capacitor.
- There is a special type of electrolytic capacitors for AC use, which is designed to withstand reverse polarization. This type is called the non-polarized or NP type.

Construction and properties of electrolytic capacitors:

- Aluminum electrolytic capacitors are made of two aluminum foils and a paper spacer soaked in electrolyte. One of the two aluminum foils is covered with an oxide layer, and that foil acts as an anode, while the uncoated one acts as a cathode.
- During normal operation, the anode must be at a positive voltage in relation to the cathode, which is why the cathode is most commonly marked with a minus sign along the body of the capacitor.

- The anode, electrolyte-soaked paper and cathode are stacked. The stack is rolled, placed into a cylindrical enclosure and connected to the circuit using pins. There are two common geometries: axial and radial. Axial capacitors have one pin on each end of the cylinder, while in the radial geometry; both pins are located on the same end of the cylinder.
- Electrolytic capacitors have a larger capacitance than most other capacitor types, typically 1μF to 47mF. There is a special type of electrolytic capacitor, called a double-layer capacitor or a super capacitor, whose capacitance can reach thousands of farads.



- The capacitance of an aluminum electrolytic capacitor is determined by several factors, such as the plate area and the thickness of the electrolyte. This means that a large capacitance capacitor is bulky and large in size.
- It is worth mentioning that electrolytic capacitors made using old technology didn't have a very long shelf life, typically only a few months. If left unused, the oxide layer deteriorates and has to be re-built in a process called capacitor reforming.
- This can be performed by connecting the capacitor to a voltage source through a resistor and slowly increasing the voltage until the oxide layer has been fully rebuilt. Modern electrolytic capacitors have a shelf life of 2 years or more. If the capacitor is left unpolarised for longer periods, they must be reformed prior to use.

Applications for electrolytic capacitors:

- There are many applications, which do not need tight tolerances and AC polarization, but require large capacitance values. They are commonly used as filtering devices in various power supplies to reduce the voltage ripple. When used in switching power supplies, they are often the critical component limiting the usable life of the power supply, so high quality capacitors are used in this application.

- They may also be used in input and output smoothing as a low pass filter if the signal is a DC signal with a weak AC component. However, electrolytic capacitors do not work well with large amplitude and high frequency signals due to the power dissipated at the parasitic internal resistance called equivalent series resistance (ESR). In such applications, low-ESR capacitors must be used to reduce losses and avoid overheating.
- A practical example is the use of electrolytic capacitors as filters in audio amplifiers whose main goal is to reduce mains hum. Mains hum is a 50Hz or 60Hz electrical noise induced from the mains supply, which would be audible if amplified.

22. What is the basic working principle of transformer? List at least four different types of transformers and its applications:

- Transformer is a device, which transfers electrical power from one electrical circuit to another electrical circuit.
- It works without changing the frequency.
- It works through electric induction when both circuits take effect of mutual induction.
- Can't step up or step down the level of DC voltage or DC Current.
- Can step up or step down the level of AC voltage or AC Current.

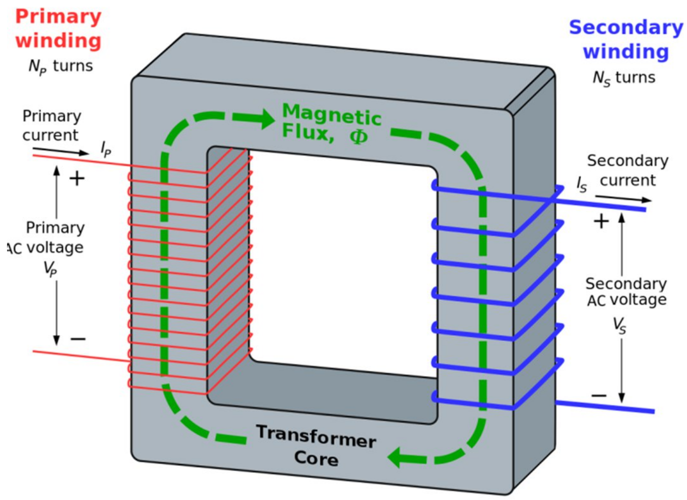
Definition:

- A device that transfers an alternating current from one circuit to one or many other circuits, usually with an increase (step-up transformer) or decrease (step-down transformer) of voltage. The input current is fed to a primary winding, the output being taken from a secondary winding or windings inductively linked to the primary.

Operating & Working Principle of a Transformer:

- A Transformer is a static device (and doesn't contain on rotating parts, hence no friction losses), which converts electrical power from one circuit to another without changing its frequency. It Step up (or Step down) the level of AC Voltage and Current.
- Transformer works on the principle of mutual induction of two coils or Faraday Laws of Electromagnetic induction. When current in the primary coil is changed the flux linked to the secondary coil also changes. Consequently an EMF is induced in the secondary coil due to Faraday laws of electromagnetic induction.

- The transformer is based on two principles: first, that an electric current can produce a magnetic field (electromagnetism), and, second that a changing magnetic field within a coil of wire induces a voltage across the ends of the coil (electromagnetic induction). Changing the current in the primary coil changes the magnetic flux that is developed. The changing magnetic flux induces a voltage in the secondary coil.



- A simple transformer has a soft iron or silicon steel core and windings placed on it (iron core). Both the core and the windings are insulated from each other. The winding connected to the main supply is called the primary and the winding connected to the load circuit is called the secondary.
- Winding (coil) connected to higher voltage is known as high voltage winding while the winding connected to low voltage is known as low voltage winding. In case of a step up transformer, the primary coil (winding) is the low voltage winding, the number of turns of the windings of the secondary is more than that of the primary. Vice versa for step down transformer.
- As explained earlier, EMF is induced only by variation of the magnitude of the flux.
- When the primary winding is connected to ac mains supply, a current flows through it. Since the winding links with the core, current flowing through the winding will produce an alternating flux in the core. EMF is induced in the secondary coil since the alternating flux links the two windings. The frequency of the induced EMF is the same as that of the flux or the supplied voltage.

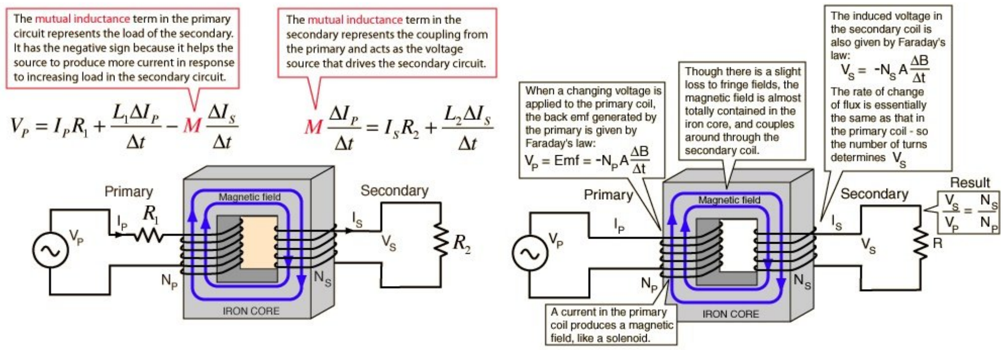


Fig: Working of a Transformer

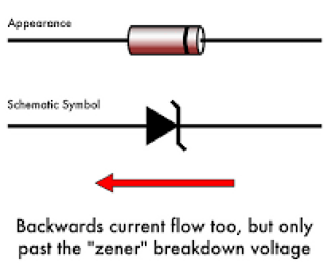
Uses and Applications of a Transformer:

The most important uses and applications of a Transformer are:

- It can rise or lower the level of level of Voltage or Current (when voltage increases, current decreases and vice versa because P =V x I, and Power is same) in an AC Circuit
- It can increase or decrease the value of capacitor, an inductor or resistance in an AC circuit. It can thus act as an impedance transferring device
- It can be used to prevent DC from passing from one circuit to the other
- It can isolate two circuits electrically

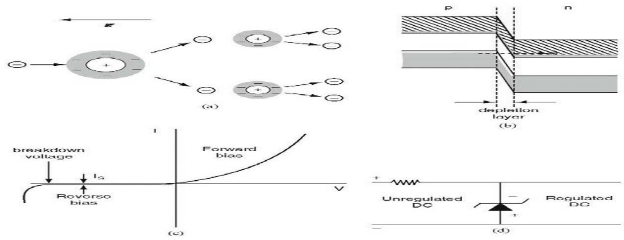
23. Draw the VI characteristics of Zener diode and explain the principle of working.

Zener diode:



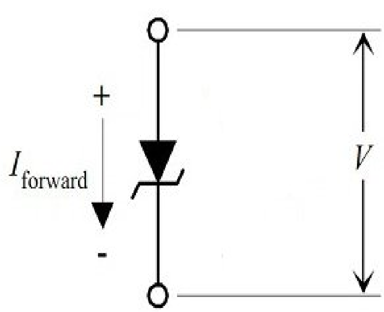
- Zener diodes are a special kind of diode, which permits current to flow in the forward direction
- What makes them different from other diodes is that, Zener diodes allow current to flow in the reverse direction when the voltage is above a certain value. This breakdown voltage is known as the Zener voltage.
- In a standard diode, the Zener voltage is high, and the diode is permanently damaged if a reverse current above that value is allowed to pass through it

Working Principle of Zener diode:



- Working of the Zener diode is similar to a PN junction diode in forward biased condition, but the uniqueness lies in the fact that it can also conduct when it is connected in reverse bias above its threshold / breakdown voltage.
- Zener breakdown occurs for a reverse bias voltage between 2 to 8V. Even at this low voltage, the electric field intensity is strong enough to exert a force on the valence electrons of the atom such that they are separated from the nuclei. This results in formation of mobile electron hole pairs, increasing the flow of current across the device.
- As temperature increases, the valence electrons gain more energy to disrupt from the covalent bond and less amount of external voltage is required. Thus, Zener breakdown voltage decreases with temperature.
- Avalanche breakdown occurs at the reverse bias voltage above 8V and higher. It occurs for lightly doped diode with large breakdown voltage. As minority charge carriers (electrons) flow across the device, they tend to collide with the electrons in the covalent bond and cause the covalent bond to disrupt. As voltage increases, the kinetic energy (velocity) of the electrons also increases and the covalent bonds are more easily disrupted, causing an increase in electron hole pairs. The avalanche breakdown voltage increases with temperature.

V-I Characteristics of Zener diode:



- Zener diode is same as that of ordinary PN diode under forward bias condition hence there is a small increase in current

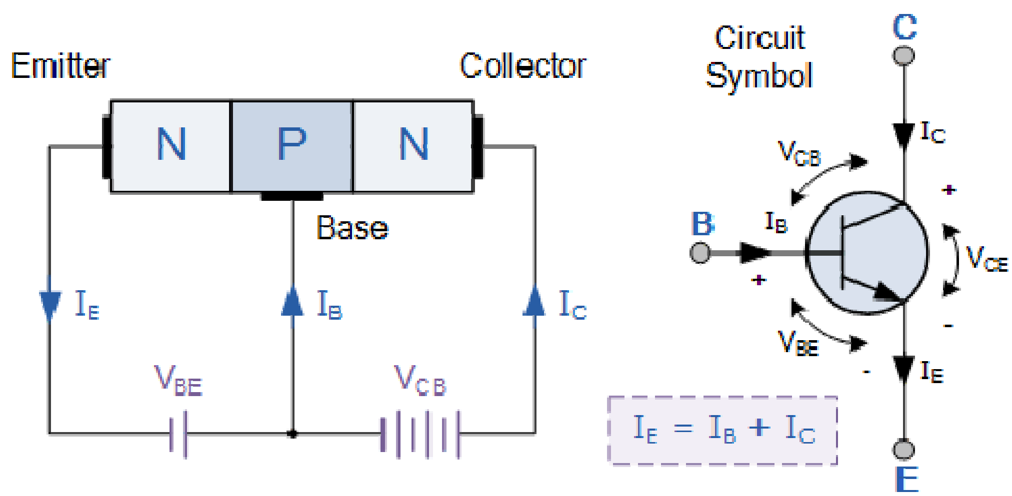
- In the reverse bias direction, there will be no reverse current flow until the breakdown voltage is reached. When this breakdown occurs, there is a sharp increase in reverse current
- When a Zener diode is placed in the opposite direction against the flow of current, it will prevent current from flowing until it reaches a certain voltage, depending on the diode rating
- The diode will also try to keep the outgoing voltage at its rated level
- If the voltage value goes beyond the rated level, then it will break down and fail

Applications:

- Zener diode as a voltage
- Zener diode as a voltage reference
- Zener diode as a voltage clamper

24. Draw a sketch to show all the current components of an NPN transistor and derive the relation between currents.

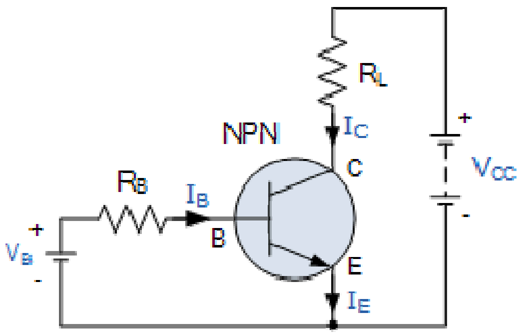
A Bipolar NPN Transistor Configuration



(Note: Arrow defines the emitter and conventional current flow, “out” for a Bipolar NPN Transistor.)

The construction and terminal voltages for a bipolar NPN transistor are shown above. The voltage between the Base and Emitter (VBE), is positive at the Base and negative at the Emitter because for an NPN transistor, the Base terminal is always positive with respect to the Emitter. Also, the Collector supply voltage is positive with respect to the Emitter (VCE).

So, for a bipolar NPN transistor to conduct the Collector is always more positive with respect to both the Base and the Emitter.



NPN Transistor Connection

Then the voltage sources are connected to an NPN transistor as shown. The Collector is connected to the supply voltage V_{CC} via the load resistor, RL which also acts to limit the maximum current flowing through the device. The Base supply voltage V_B is connected to the Base resistor R_B, which again is used to limit the maximum Base current.

So in a NPN Transistor, it is the movement of negative current carriers (electrons) through the Base region that constitutes transistor action, since these mobile electrons provide the link between the Collector and Emitter circuits. This link between the input and output circuits is the main feature of transistor action because the transistors amplifying properties come from the consequent control, which the Base exerts upon the Collector to Emitter current.

Then, we can see that the transistor is a current operated device (Beta model) and that a large current (Ic) flows freely through the device between the collector and the emitter terminals when the transistor is switched "fully-ON". However, this only happens when a small biasing current (Ib) is flowing into the base terminal of the transistor at the same time thus allowing the Base to act as a sort of current control input.

The transistor current in a bipolar NPN transistor is the ratio of these two currents (Ic/Ib), called the *DC Current Gain* of the device and is given the symbol of hfe or nowadays Beta, (β). The value of βcan be large up to 200 for standard transistors, and it is this large ratio between Ic and Ib that makes the bipolar NPN transistor a useful amplifying device when used in its active region as Ib provides the input and Ic provides the output. Note that Beta has no units as it is a ratio.

Also, the current gain of the transistor from the Collector terminal to the Emitter terminal, Ic/Ie, is called Alpha, (α), and is a function of the transistor itself (electrons diffusing across the junction). As the emitter current Ie is the sum of a very small base current plus a very large collector current, the value of alpha α, is very close to unity, and for a typical low-power signal transistor this value ranges from about 0.950 to 0.999 .

α and β Relationship in a NPN Transistor:

$$\text{DC Current Gain} = \frac{\text{Output Current}}{\text{Input Current}} = \frac{I_C}{I_B}$$

$$I_E = I_B + I_C \;\ldots\ldots\; (\text{KCL}) \quad \text{and} \quad \frac{I_C}{I_E} = \alpha$$

$$\text{Thus:} \quad I_B = I_E - I_C$$

$$I_B = I_E - \alpha I_E$$

$$I_B = I_E(1 - \alpha)$$

$$\therefore \; \beta = \frac{I_C}{I_B} = \frac{I_C}{I_E(1-\alpha)} = \frac{\alpha}{1-\alpha}$$

By combining the two parameters α and β, we can produce two mathematical expressions that gives the relationship between the different currents flowing in the transistor.

$$\alpha = \frac{\beta}{\beta + 1} \quad \text{or} \quad \alpha = \beta(1-\alpha)$$

$$\beta = \frac{\alpha}{1-\alpha} \quad \text{or} \quad \beta = \alpha(1+\beta)$$

$$\text{If} \quad \alpha = 0.99 \qquad \beta = \frac{0.99}{0.01} = 99$$

The values of Beta vary from about 20 for high current power transistors to well over 1000 for high frequency low power type bipolar transistors. The value of Beta for most standard NPN transistors can be found in the manufactures data sheets but generally range between 50 – 200.

The equation above for Beta can also be re-arranged to make Ic as the subject, and with a zero base current (Ib = 0) the resultant collector current Ic will also be zero, (β x 0). Also when the base current is high the corresponding collector current will also be high resulting in the base current controlling the collector current. One of the most important properties of the Bipolar Junction Transistor is that, a small base current can control a much larger collector current. Consider the following example.

25. Compare CB, CE and CC configurations of a transistor. Enumerate the applications of each configuration.

Transistor CB (Common Base) configuration

It is a transistor circuit, in which base is kept common to the input and output circuits.

Characteristics:

- It has low input impedance (on the order of 50 to 500 Ohms)
- It has high output impedance (on the order of 1 to 10 Mega Ohms)
- Current gain (alpha) is less than unity

Transistor CE (Common Emitter) configuration

It is transistor circuit in which emitter is kept common to both input and output circuits.

Characteristics (applications):

- It has high input impedance (on the order of 500 to 5000 Ohms)
- It has low output impedance (on the order of 50 to 500 Kilo Ohms)
- Current gain (Beta) is 98
- Power gain is upto 37 dB
- Output is 180 degree out of phase

Transistor CC (Common Collector) configuration

It is a transistor circuit, in which collector is kept common to both input and output circuits. It is also called as emitter follower.

Characteristics:

• It has high input impedance (on the order of about 150 to 600 Kilo Ohms)

• It has low output impedance (on the order of about 100 to 1000 Ohms)

• Current gain (Beta) is about 99

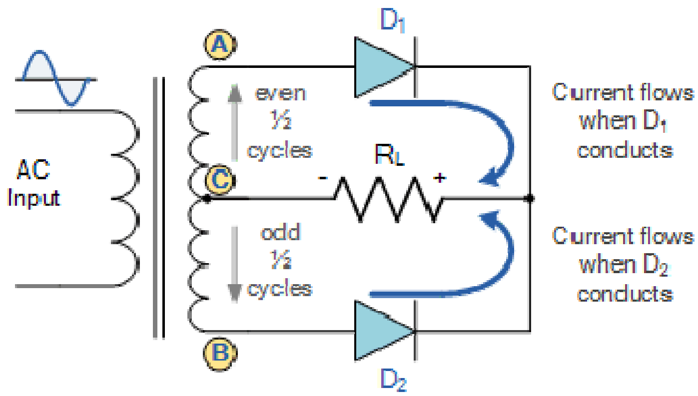
• Voltage and power gain is equal to or less than one

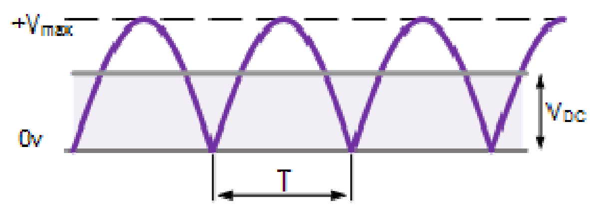
Following table summarises important points about CB,CE,CC transistor configurations.

Parameter	Common Base	Common Emitter	Common Collector
Voltage Gain	High, Same as CE	High	Less than Unity
Current Gain	Less than Unity	High	High
Power Gain	Moderate	High	Moderate
Phase inversion	No	Yes	No
Input Impedance	Low (50 Ohm)	Moderate (1 KOhm)	High (300 KOhm)
Output Impedance	High (1 M Ohm)	Moderate (50 K)	Low (300 Ohm)

26. What is a full wave rectifier? Derive the expression for rectifier efficiency and ripple factor.
In a Full Wave Rectifier circuit, two diodes are now used, one for each half of the cycle. A multiple winding transformer is used whose secondary winding is split equally into two halves with a common center tapped connection, (C). This configuration results in each diode conducting in turn when its anode terminal is positive with respect to the transformer center point C producing an output during both half-cycles, twice that for the half wave rectifier so it is 100% efficient as shown below.

Full Wave Rectifier Circuit





Resultant Output Waveform

The full wave rectifier circuit consists of two *power diodes* connected to a single load resistance (R_L) with each diode taking it in turn to supply current to the load. When point A of the transformer is positive with respect to point C, diode D_1 conducts in the forward direction as indicated by the arrows.

When point B is positive (in the negative half of the cycle) with respect to point C, diode D_2 conducts in the forward direction and the current flowing through resistor R is in the same direction for both half-cycles. As the output voltage across the resistor R is the phasor sum of the two waveforms combined, this type of full wave rectifier circuit is also known as a "bi-phase" circuit.

Ripple Factor

The ripple factor for a Full Wave Rectifier is given by,

$$\gamma = \sqrt{\left(\frac{V_{rms}}{V_{dc}}\right)^2 - 1}$$

The average voltage or the dc voltage available across the load resistance is,

$$V_{dc} = \frac{1}{\pi}\int_0^{\pi} V_m \sin \omega t \, d(\omega t)$$

$$= \frac{V_m}{\pi}\left[-\cos \omega t\right]_0^{\pi} = \frac{2V_m}{\pi}$$

$$I_{dc} = \frac{V_{dc}}{R_L} = \frac{2V_m}{\pi R_L} = \frac{2I_m}{\pi} \quad and \quad I_{rms} = \frac{I_m}{\sqrt{2}}$$

RMS value of the voltage at the load resistance is,

$$V_{rms} = \left[\frac{1}{\pi}\int_0^{\pi} V_m^2 \sin^2 \omega t \, d(\omega t)\right]^{1/2} = \frac{V_m}{\sqrt{2}}$$

$$\therefore \gamma = \sqrt{\left(\frac{V_m/2}{2V_m/\pi}\right)^2 - 1} = \sqrt{\left(\frac{\pi}{8}\right)^2 - 1} = 0.482$$

Efficiency

Efficiency, h is the ratio of dc output power to ac input power,

$$\eta = \frac{dc\ output power}{ac\ input power} = \frac{P_{dc}}{P_{ac}}$$

$$\frac{V_{dc}^2/R_L}{V_{rms}^2/R_L} = \frac{\left[2V_m/\pi\right]^2}{\left[V_m/\sqrt{2}\right]^2} = 8/\pi^2 = 0.812 = \underline{\underline{81.2\%}}$$

The maximum efficiency of a Full Wave Rectifier is 81.2%.

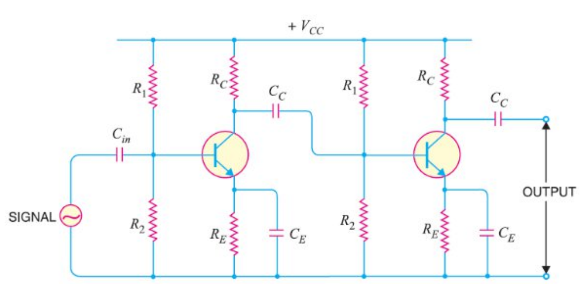
27. Draw the circuit diagram of a single stage RC coupled amplifier and explain the significance of each component.

RC Coupled Amplifier:

Due to its low cost and excellent audio fidelity over a wide range of frequencies, an RC Coupled Amplifier is the most popular type of coupling used in a multi stage amplifier.

It is usually used for voltage amplification.

The figure below shows two stages of an RC coupled amplifier.



As you can see in the fig above, a coupling capacitor C_C is used to connect the output of first stage to the base, i.e. input of the second stage and this continues when more stages are connected.

Since here, the coupling from one stage to next is achieved by a coupling capacitor followed by a connection to a shunt resistor, therefore, such amplifiers are known as resistance-capacitance coupled amplifier or simply RC coupled amplifier.

The resistances R_1, R_2 and R_E form the biasing and stabilisation network.
The emitter bypass capacitor offers a low resistance path to the signal. Without this capacitor the voltage gain of each stage would be lost.

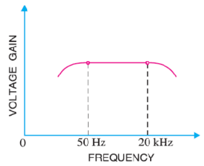
The coupling capacitor $C_{C\ transmits}$ AC signal but blocks DC. This prevents DC interference between various stages and the shifting of operating point.

Working of RC Coupled Amplifier

When AC signal is applied to the base of the first transistor, it is amplified and appears across its collector load $R_{C.}$
Now, the amplified signal developed across R_C is given to the base of the next transistor through a coupling capacitor C_C .
The second stage again amplifies this signal and the more amplified signal appears across the second stage collector resistance. In this way, the cascaded stages amplify the signal and the overall gain is considerably increased. However, the total gain is less than the product of the gains of individual stages. It is because, when a second stage follows the first stage, the effective load resistance of first stage is reduced due to the shunting effect of the input resistance of second stage. This reduces the gain of the stage which is loaded by the next stage. To explain it better, let us take an example of 3-stage amplifier. The gain of first and second stage will be reduced due to loading effect of the next stage. But the gain of the third stage, which has no loading effect due to subsequent stage, remains unchanged. The overall gain is equal to the product of the gains of three stages.

Frequency Response of RC Coupled Amplifier

The figure below shows the frequency response of a typical RC coupled amplifier.



28. Draw the circuit and explain the working of an inverting amplifier with op-amp and derive the expression for its closed loop gain.

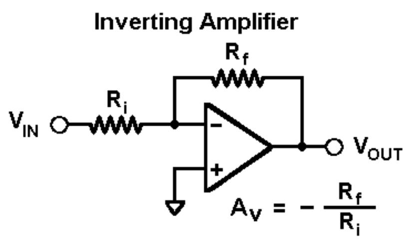
Inverting amplifier:

Definition:

- Inverting amplifier is one, in which the output is exactly 180^0out of phase with respect to the input (i.e. if you apply a positive voltage, output will be negative)
- Output is an inverted (in terms of phase) amplified version of input

Circuit operation:

- The inverting amplifier using opamp is shown in the figure below:



- Assuming the opamp is ideal and applying the concept of virtual short at the input terminals of opamp, the voltage at the inverting terminal is equal to thenon-inverting terminal.
- The simplified circuit is shown in the figure below:

Applying KCL at theinverting node we get,

$(0-V_i)/R_i+(0-V_o)/R_f = 0$

- By rearranging the terms we will get,

Voltage gain $A_v = V_o/ V_i = – R_f/R_i$

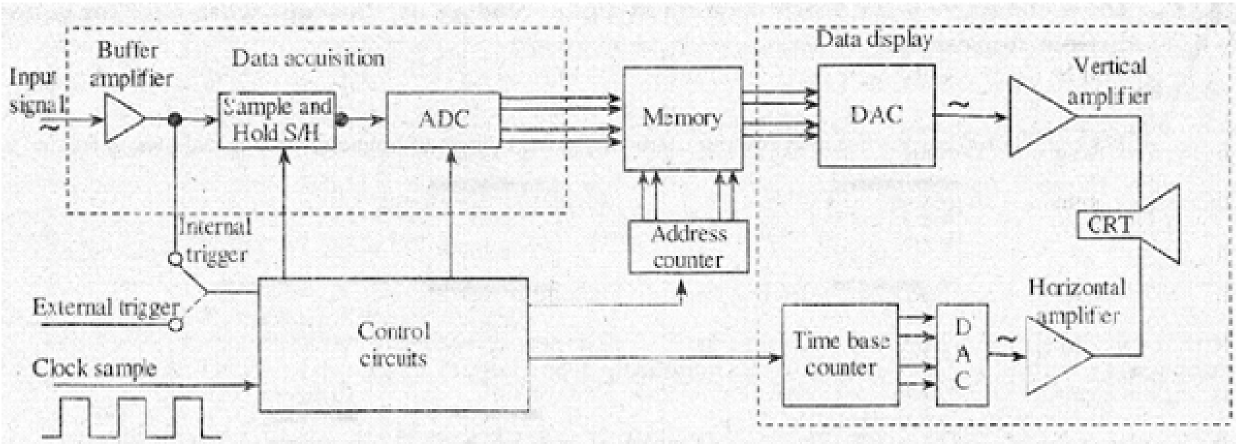
Gain:

- Gain of inverting amplifier $A_v= – R_f/R_i$

29. Differentiate between analog and digital integrated circuits. Write at least four application specific integrated circuits from each group.

Analog Circuits	Digital Circuits
These circuits operate on continuous valued signals (commonly referred to as analog signals).	These circuits operate on signals that exist only at two levels, i.e. 0's and 1's (binary number system).
No conversion of input signals are required before processing, i.e. input signal is analog, the circuit directly performs various logical operations and produces an analog output.	In digital circuits, the input signals are converted from analog to digital form before it is processed, i.e. the digital circuit is capable of processing digital signals only, and produces output which is again converted back from digital to analog signals
In analog circuits, since there are no conversions involved at the input or at the output side there is no loss of information that is available for processing.	Due to the conversion process at the input side (analog to digital) and at the output side, some amount of information is lost during the conversion process.
The man power available to design analog circuits is very low, this results in long time to market the finished products.	The available man power to design digital circuits is significantly large compared to that of analog circuit designers.
An analog circuit is mostly custom made and lacks flexibility.	Digital circuits have high degree of flexibility.
Applications of Analog IC 1.It is used for active filtering 2.Used to distributing power 3.Frequency mixer	Applications of Digital IC 1. Power amplifiers 2. Small-signal amplifiers 3. Operational amplifiers 4. Microwave amplifiers 5. RF and IF amplifiers 6. Voltage comparators

30. Draw the block diagram of a digital storage oscilloscope and specify the functions of each block.



Block diagram of DSO as consists of,
1. Data acquisition
2. Storage
3. Data display

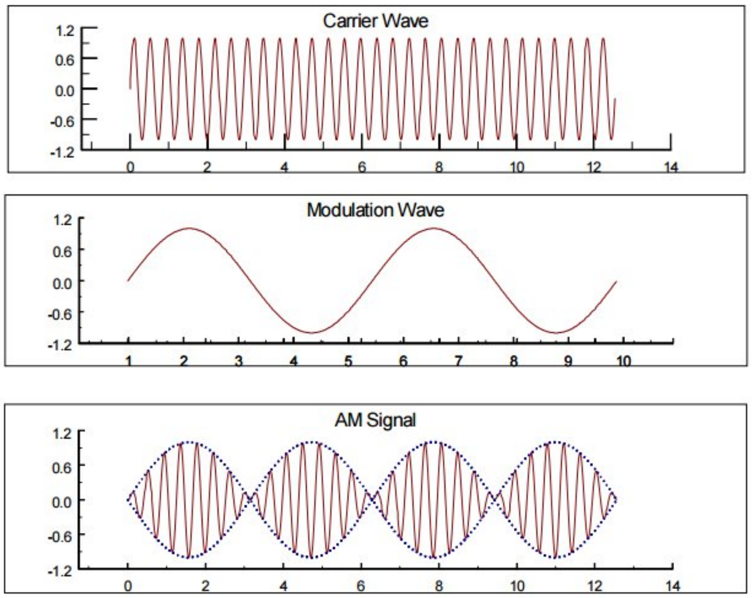
Data acquisition is earned out with the help of both analog to digital and digital to analog converters, which is used for digitizing, storing and displaying analog waveforms. Overall operation is controlled by control circuit which is usually consists of microprocessor.
Data acquisition portion of the system consist of a Sample-and-Hold (S/H) circuit and an analog to digital converter (ADC), which continuously samples and digitizes the input signal at a rate determined by the sample clock and transmit the digitized data to memory for storage. The control circuit determines whether the successive data points are stored in successive memory location or not, which is done by continuously updating the memories.

When the memory is full, the next data point from the ADC is stored in the first memory location writing over the old data. The data acquisition and the storage process is continues till the control circuit receive a trigger signal from either the input waveform or an external trigger source. When the triggering occurs, the system stops and enters into the display mode of operation, in which all or some part of the memory data is repetitively displayed on the cathode ray tube. In display operation, two DACs are used which gives horizontal and vertical deflection voltage for the CRT Data from the memory gives the vertical deflection of the electron beam, while the time base counter gives the horizontal deflection in the form of staircase sweep signal. The screen display consist of discrete dots representing the various data points but the number of dot is very large as 1000 or more that they tend to blend together and appear to be a smooth continuous waveform. The display operation ends when the operator presses a front-panel button and commands the digital storage oscilloscope to begin a new data acquisition cycle.

31. Define amplitude modulation. Draw the AM signal and its spectrum. Derive an expression for

modulation index and total power in an AM signal.

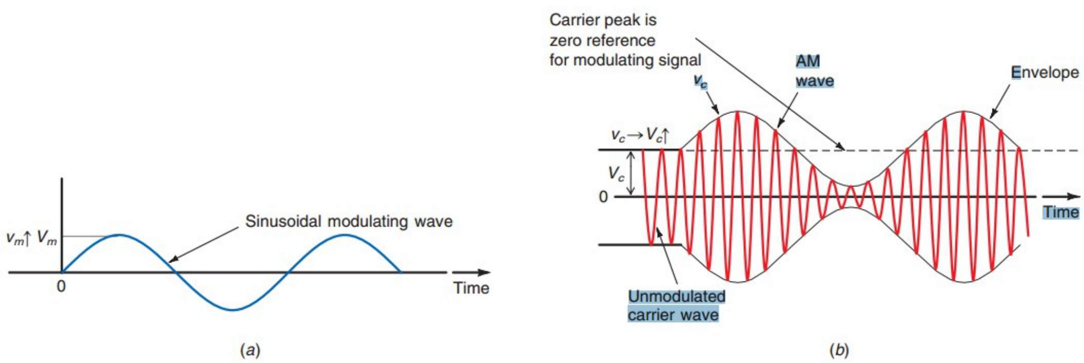
It is process of changing amplitude of carrier signal according to the instantaneous value of modulating or information or message signal.



Amplitude modulation.

&

Amplitude modulation. (*a*) The modulating or information signal. (*b*) The modulated carrier.



<u>Expression for total power of AM signal</u>

In radio transmission, the AM signal is amplified by a power amplifier and fed to the antenna with a characteristic impedance that is ideally, but not necessarily, almost pure resistance. The AM signal is really a composite of several signal voltages, namely, the carrier and the two sidebands, and each of these signals produces power in the antenna. The total transmitted power P_T is simply the sum of the carrier power P_c and the power in the two sidebands P_{USB} and P_{LSB}:

$$P_T = P_c + P_{\mathrm{LSB}} + P_{\mathrm{USB}}$$

You can see how the power in an AM signal is distributed and calculated by going back to the original AM equation:

$$v_{\mathrm{AM}} = V_c \sin 2\pi f_c t + \frac{V_m}{2} \cos 2\pi t(f_c - f_m) - \frac{V_m}{2} \cos 2\pi t(f_c + f_m)$$

where the first term is the carrier, the second term is the lower sideband, and the third term is the upper sideband.

Now, remember that V_c and V_m are peak values of the carrier and modulating sine waves, respectively. For power calculations, rms values must be used for the voltages. We can convert from peak to rms by dividing the peak value by $\sqrt{2}$ or multiplying by 0.707. The rms carrier and sideband voltages are then

$$v_{\mathrm{AM}} = \frac{V_c}{\sqrt{2}} \sin 2\pi f_c t + \frac{V_m}{2\sqrt{2}} \cos 2\pi t(f_c - f_m) - \frac{V_m}{2\sqrt{2}} \cos 2\pi t(f_c + f_m)$$

The power in the carrier and sidebands can be calculated by using the power formula $P = V^2/R$, where P is the output power, V is the rms output voltage, and R is the resistive part of the load impedance, which is usually an antenna. We just need to use the coefficients on the sine and cosine terms above in the power formula:

$$P_T = \frac{(V_c/\sqrt{2})^2}{R} + \frac{(V_m/2\sqrt{2})^2}{R} + \frac{(V_m/2\sqrt{2})^2}{R} = \frac{V_c^{\,2}}{2R} + \frac{V_m^{\,2}}{8R} + \frac{V_m^{\,2}}{8R}$$

Remembering that we can express the modulating signal V_m in terms of the carrier V_c by using the expression given earlier for the modulation index $m = V_m/V_c$; we can write

$$V_m = mV_c$$

If we express the sideband powers in terms of the carrier power, the total power becomes

$$P_T = \frac{(V_c)^2}{2R} + \frac{(mV_c)^2}{8R} + \frac{(mV_c)^2}{8R} = \frac{V_c^2}{2R} + \frac{m^2V_c^2}{8R} + \frac{m^2V_c^2}{8R}$$

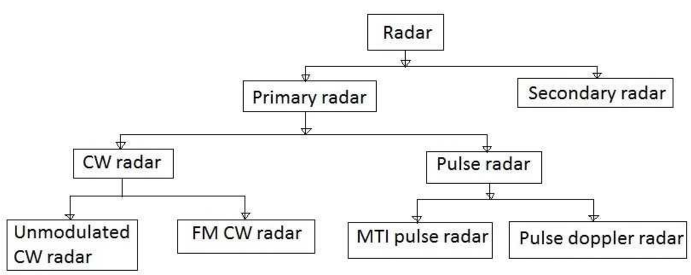
Since the term $V_c^2/2R$ is equal to the rms carrier power P_c, it can be factored out, giving

$$P_T = \frac{V_c^2}{2R}\left(1 + \frac{m^2}{4} + \frac{m^2}{4}\right)$$

Finally, we get a handy formula for computing the total power in an AM signal when the carrier power and the percentage of modulation are known:

$$P_T = P_c\left(1 + \frac{m^2}{2}\right)$$

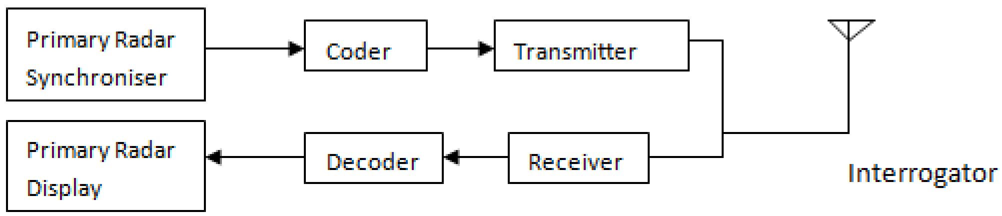
32. What are the different types of RADARs and explain any one type with a block diagram.

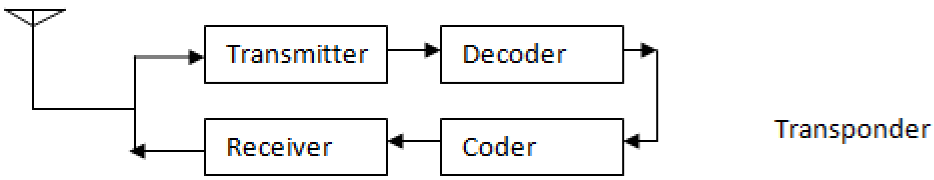


Secondary Radar:

Secondary radar units work with active answer signals. In addition to primary radar, this type of radar uses a transponder on the airborne target/object.

A simple block diagram of secondary radar is shown below.





The ground unit, called interrogator, transmits coded pulses (after modulation) towards the target. The transponder on the airborne object receives the pulse, decodes it, induces the coder to prepare the suitable answer, and then transmits the interrogated information back to the ground unit. The interrogator/ground unit demodulates the answer. The information is displayed on the display of the primary radar.

The secondary radar unit transmits and also receives high-frequency impulses, the so called interrogation. This isn't simply reflected, but received by the target by means of a transponder which receives and processes. After this the target answers at another frequency.

Various kinds of information like, the identity of aircraft, position of aircraft, etc., are interrogated using the secondary radar. The type of information required defines the MODE of the secondary radar.

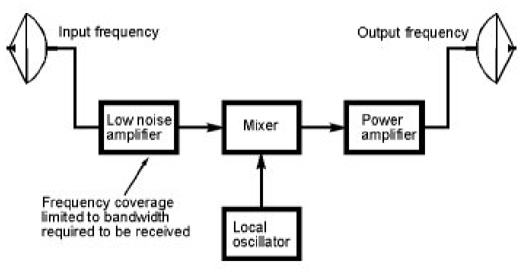
33. What is satellite transponder? Explain its working with a block diagram.

Transponders:-

- A transponder is an electronic device that produces a response when it receives a radio-frequency interrogation

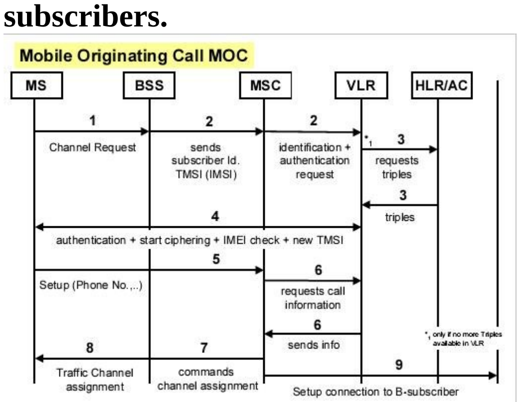
- In telecommunication, the term transponder (short-for Transmitter-responder and sometimes abbreviated to XPDR, XPNDR or TPDR) has the following meanings:

- An automatic device that receives, amplifies, and retransmits a signal on a different frequency (see also broadcast translator)
- An automatic device that transmits a predetermined message in response to a predefined received signal
- A receiver transmitter that will generate a reply signal upon proper electronic interrogation
- A communications satellite's channels are called transponders, because each is a separate transceiver or repeater. With digital video data compression and multiplexing, several video and audio channels may travel through a single transponder on a single wideband carrier. Original analog video only has one channel per transponder, with subcarriers for audio and automatic transmission identification service ATIS. Non-multiplexed radio stations can also travel in single channel per carrier (SCPC) mode, with multiple carriers (analog or digital) per transponder. This allows each station to transmit directly to the satellite, rather than paying for a whole transponder, or using landlines to send it to an earth station for multiplexing with other stations



Block diagram of a basic satellite transponder

34. Describe with the help of diagrams, how a call is established between two mobile phone subscribers.



- Base Station: It is a fixed station that consists of transmitters and receivers mounted on tall towers strategically placed at different locations
- Control Channel: Radio channel used for transmission of control signals
- Voice Channel: Radio channel used for transmission of voice signals
- Forward Channel: Radio channel used for transmission of information from base station to

mobile phone. (Includes Control and Voice Channels)

- Reverse Channel: Radio channel used for transmission of information from mobile phone to base station (Includes Control and Voice Channels)

Before a mobile phone can establish a call, it first needs to establish a connection to the available service providers network. Whenever a mobile phone is switched on, it first scans the group of forward control channels to determine the strongest one. Then it keeps on monitoring the same channel until the signal level drops below a minimum level after which it again starts to scan. Every mobile phone repeats this process as long as it is kept switched on. The signal level of the current channel which the phone is locked to will be displayed on the handset.

So now, let's see the steps that occur when a mobile phone user dials a number to make a call. First of all, a call initiation request is sent on the reverse control channel. Along with this request, the mobile phone also sends its Mobile Identification Number (MIN), Electronic Serial Number (ESN) and the dialed telephone number. The base station receives this data and sends it to the Mobile Switching Center (MSC). The MSC validates the request by checking the MIN with the records on its database. If it is valid, a connection to the called party is made through Public switched Telephone network (PSTN). Then the MSC requests the base station to move the mobile phone to an unused voice channel so that the conversation can begin. Once a call is in progress, the MSC adjusts the power transmitted by the mobile phone as it moves in and out of the coverage area of each base station. When a mobile phone with a call in progress moves from one base station to another, the process is called handoff.

Now, let us also see the steps that occur when a call is made from a land line to a mobile phone. Whenever a call is made through PSTN to a mobile, the request is transferred to the MSC. The MSC dispatches the request to all the base stations. Then the MIN, which is the subscribers number is transmitted as a message through all the base stations in the system. The mobile identifies the message and responds to it. The base station then relays the acknowledgement to the MSC. Then the MSC requests the base station to move the phone to an unused voice channel. During this process, a control signal is also send which triggers the mobile phone to start ringing. The MSC connects the call to the PSTN and the conversation can begin as soon as the mobile user accepts the call.

When a call is made and there is no free voice channel available then you will probably hear a message that the network is busy. This happens when a large numbers of calls are made from within the coverage area of a single base station. All these steps described above happens within a few seconds that the user is not able to identify it. They almost start hearing the ringing tone as soon as the call is placed.

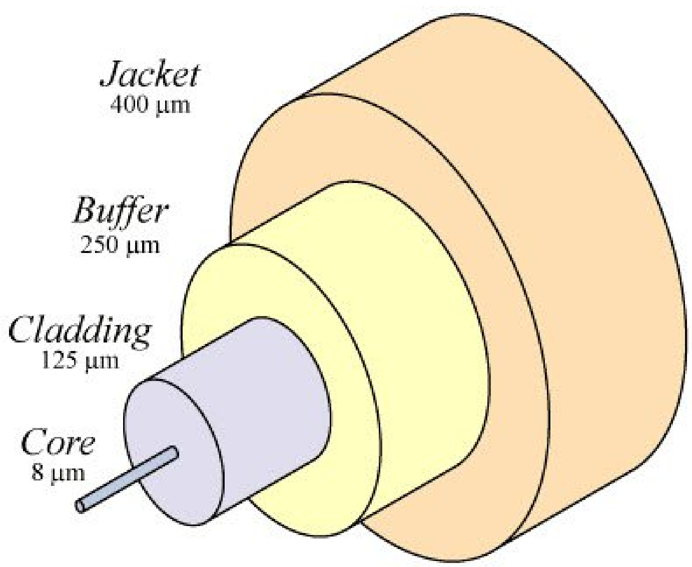
35. Sketch the elements associated with an optical fiber communication system and describe the different types of optical fiber cables available for establishing the link.

- There are three main basic elements of fiber optic communication system. They are:
  1. Compact Light Source
  2. Low loss Optical Fiber

3. Photo Detector

- Accessories like connectors, switches, couplers, multiplexing devices, amplifiers and splices are also essential elements in this communication system

1. **Compact Light Source:**
   - Depending on the applications like local area networks and the long haul communication systems, the light source requirements vary. The requirements of the sources include power, speed, spectral line width, noise, ruggedness, cost, temperature, and so on. Two components are used as light sources: light emitting diodes (LED's) and laser diodes.
   - The light emitting diodes are used for short distances and low data rate applications due to their low bandwidth and power capabilities. Two such LEDs structures include Surface and Edge Emitting Systems. The surface emitting diodes are simple in design and are reliable, but due to its broader line width and modulation frequency limitation edge emitting diode are mostly used. Edge emitting diodes have high power and narrower line width capabilities.
2. **Low Loss Optical Fiber:**
   - Optical fiber is a cable, which is also known as cylindrical dielectric waveguide made of low loss material. An optical fiber also considers the parameters like the environment in which it is operating, the tensile strength, durability and rigidity. The Fiber optic cable is made of high quality extruded glass (si) or plastic, and it is flexible. The diameter of the fiber optic cable is in between 0.25 to 0.5mm (slightly thicker than a human hair).



   - A Fiber Optic Cable consists of four parts
     a. Core
     b. Cladding

c. Buffer
d. Jacket

A. **Core:** The core of a fiber cable is a cylinder of plastic that runs all along the fiber cable's length, and offers protection by cladding. The diameter of the core depends on the application used. Due to internal reflection, the light travelling within the core reflects from the core, the cladding boundary. The core cross section needs to be a circular one for most of the applications.
B. **Cladding:** Cladding is an outer optical material that protects the core. The main function of the cladding is that it reflects the light back into the core. When light enters through the core (dense material) into the cladding(less dense material), it changes its angle, and then reflects back to the core.
C. **Buffer:** The main function of the buffer is to protect the fiber from damage and thousands of optical fibers arranged in hundreds of optical cables. These bundles are protected by the cable's outer covering that is called jacket**.**
D. **JACKET:** Fiber optic cable's jackets are available in different colors that can easily make us recognize the exact color of the cable we are dealing with. The color yellow clearly signifies a single mode cable, and orange color indicates multimode.

Types of Optical Fibers:

- **Single-Mode Fibers:** Single mode fibers are used to transmit one signal per fiber; these fibers are used in telephone and television sets. Single mode fibers have small cores.
- **Multi-Mode Fibers:** Multimode fibers are used to transmit many signals per fiber; these signals are used in computer and local area networks that have larger cores.

3. **Photo Detectors:**

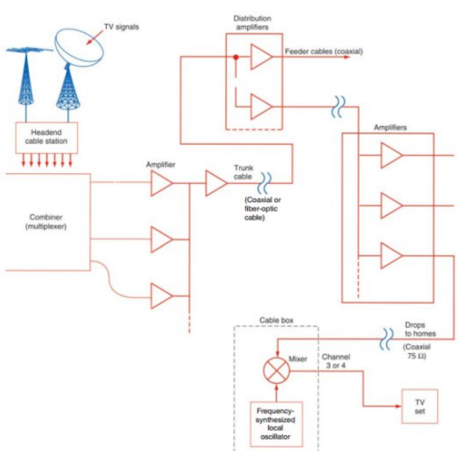
- The purpose of photo detectors is to convert the light signal back to an electrical signal. Two types of photo detectors are mainly used for optical receiver in optical communication system: PN photo diode and avalanche photo diode. Depending on the application's wavelengths, the material composition of these devices vary. These materials include silicon, germanium, InGaAs, etc.
- This is all about the basic elements of the fiber optic communication system.

36. Sketch the elements associated with a cable TV system and explain the functions of each.

Cable TV, sometimes called CATV, is a system of delivering the TV signal to home receivers by way of a coaxial cable rather than over the air by radio wave propagation. A cable TV company collects all the available signals and programs and frequency-multiplexes them on a single coaxial cable that is fed to the homes of subscribers.

A special cable decoder box is used to receive the cable signals, select the desired channel, and feed a signal to the TV set. Today, most TV reception is by way of a cable connection instead of an antenna. CATV Background Many companies were established to offer TV signals by cable. They put up very tall high-gain TV antennas. The resulting signals were amplified and fed to the subscribers by cable.

Similar systems were developed for apartments and condominiums. A single master antenna system was installed at a building, and the signals were amplified and distributed to each apartment or unit by cable. Modern Cable TV Systems Today, cable TV companies, generally referred to as multiple (cable) systems operators (MSOs), collect signals and programs from many sources, multiplex them, and distribute them to subscribers. The main building or facility is called the headend. The antennas receive local TV stations and other nearby stations plus the special cable channel signals distributed by satellite. The cable companies use parabolic dishes to pick up the so-called premium cable channels. A cable TV company uses many TV antennas and receivers to pick up the stations whose programming it will redistribute. These signals are then processed and combined or frequency-multiplexed onto a single cable. The main output cable is called the trunk cable. In older systems it was a large, low loss coaxial cable. Newer systems use a fibre-optic cable. The trunk cable is usually buried and extended to surrounding areas. A junction box containing amplifiers takes the signal and redistributes it to smaller cables, called feeders, which go to specific areas and neighbourhoods. From there the signals are again rejuvenated with amplifiers and sent to individual homes by coaxial cables called drops. The overall system is referred to as a hybrid fibre cable (HFC) system. The coaxial cable (usually) comes into a home and is connected to a cable decoder box, which is essentially a special TV tuner that picks up the cable channels and provides a frequency synthesizer and mixer



to select the desired channel. The mixer 75 RG-6/U CATV (cable TV) Headend Feeders Drops Trunk cable Coaxial cable Hybrid fibre cable (HFC) system Television 21 output is heterodyned to TV channel 3 or 4 and then fed to the TV set antenna terminals. The desired signal is frequency-translated by the cable box to channel 3 or 4 that the TV set can receive. Cable TV is a popular and widely used service in the United States. More than 80 percentage of U.S. homes have cable TV service. This service eliminates the need for antennas. And because of the direct connection of amplified signals, there is no such thing as poor, weak, noisy, or snowy signals. In addition, many TV programs are available only via cable, e.g., the specialized content and premium movie channels. The only downside to cable TV is that it is more expensive than connecting a TV to a standard antenna.