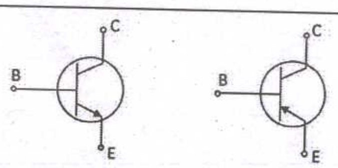
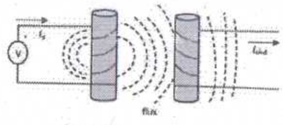
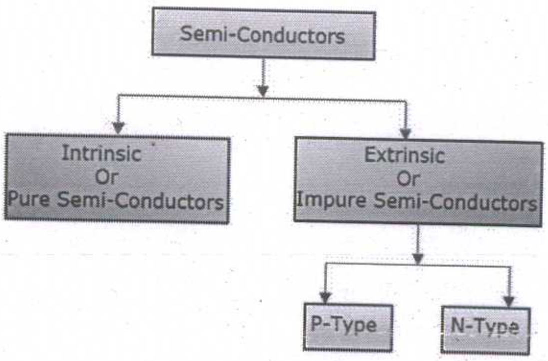
SCHEME OF VALUATION

(Scoring Indicators)

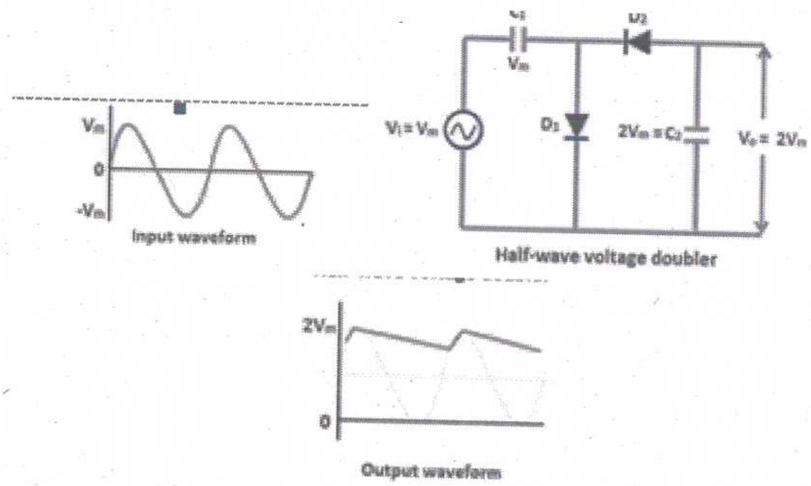
Revision :2015 **Course Title: Basic Electronics**

Course Code: 2041

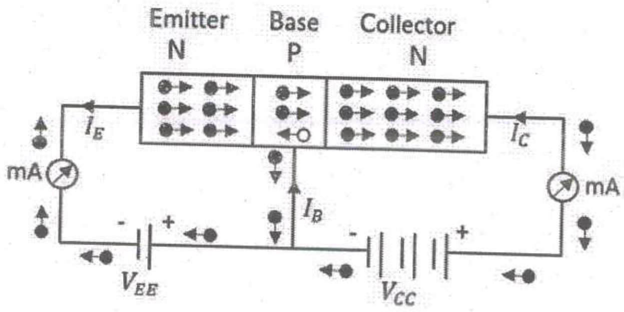
QST No	Scoring Indicator	Split up Score	Sub Total	Total
I	**PART A**			
1	**Active Components-**Components which produces the energy in the form of voltage or current are called as active components **Passive Components-** components which store the energy in the form of voltage or current are called as passive components.	1*2	2	2
2	**Resistance** is the property of opposing the flow of electrons, in a conductor or a semiconductor. The units of resistance is **Ohms**, which is indicated by Ω (omega).	1 1	2	2
3	**Doping:** The process of adding impurities to the semiconductor materials **to increase the conduction capability** of intrinsic semiconductor is termed as doping.	2	2	2
4	Filter Circuits : Shunt capacitor filter Series Inductor filter Π (Pi) Section filter	Any 2 1*2	2	2
5	 Symbol of NPN transistor Symbol of PNP transistor	1*2	2	2
II	**Part B**			
1	**Self-Inductance: When** a current flowing through a coil varies, the magnetic field also changes and this changing magnetic field, induces an EMF, opposite to the source voltage. This opposing EMF produced is the **self-induced voltage** and this method is called as **self-inductance.** $E \; \alpha \; \frac{dI}{dt}$ $E = L \frac{dI}{dt}$  Where, **E** is the EMF produced **dI/dt** indicates the rate of change of current **L** indicates the co-efficient of inductance.	3*2	6	6

	Mutual Inductance A current carrying coil (primary coil) will produces magnetic field around it. If another coil is brought near to the magnetic flux region of the primary, then the varying magnetic flux induces an EMF in the second coil. First coil is called as **Primary coil**, the second one can be called as a **Secondary coil.** When the EMF is induced in the secondary coil due to the varying magnetic field of the primary coil, then such phenomenon is called as the **Mutual Inductance**.  Image showing Mutual Inductance $M = \frac{N_1 L_2}{N_2}$ and $\frac{M}{\sqrt{L_1 L_2}} = K$ Where K is known as the coefficient of coupling.			
2	 **Intrinsic Semiconductors:** A Semiconductor in its extremely pure form is said to be an **intrinsic semiconductor**. The properties of this pure semiconductor are as follows – • The electrons and holes are solely created by thermal excitation. • The number of free electrons is equal to the number of holes. • At room temperature, due to the thermal of energy, some electrons break the covalent bond and they are free to move. The conduction capability is small at room temperature.	3*2	6	6

	Extrinsic Semiconductor: An impure semiconductor, which is formed by **doping a pure semiconductor,** is called as an extrinsic semiconductor. There are two types of extrinsic semiconductors depending upon the type of impurity added. They are N-type extrinsic semiconductor and P-Type extrinsic semiconductor.			
3	**Zener Break down: Zener** breakdown occurs in heavily doped junctions which produces a narrow depletion region. Under a high reverse-bias voltage ,a high-strength electric field is formed across the junction. Electric field intensity is given as $E = \frac{V}{d}$ where V is the reverse bias voltage and'd' is the depletion region width. As'd' is small, electric field intensity E will be high. This high electric field will cause covalent bonds to break and more charge carriers are formed. This will give rise to large current. Diode junction breakdowns occurring below 5 volts are caused by the Zener effect. Zener breakdown voltage is found to occur at electric field intensity of about 2×10^7 V/m **Avalanche break down :** Avalanche breakdown occurs in lightly doped junctions, which produce a wider depletion region.The reverse bias increases the electrical field across the depletion region. Due to the high electric field across the depletion, the velocity of minority charge carriers crossing the depletion region increases. These carriers collide with the atoms of the crystal and because of the violent collision, more electrons are released. The collision increases the electron-hole pair. The process is continuous, and the electric field becomes so much higher and the reverse current starts flowing in the PN junction. The process is known as the Avalanche breakdown. Breakdowns occurring above 5 volts are caused by the avalanche effect	3*2	6	6
4	**Rectifier Efficiency :**Efficiency of a rectifier is defined as the ratio of the output power to the input power. The rectifier efficiency is defined as $\eta = \frac{d.c.power\ delivered\ to\ the\ load}{a.c.input\ power\ from\ transformer\ secondary} = \frac{P_{ac}}{P_{dc}}$ **Ripple Factor (γ):** The rectified output contains some amount of AC component present in it, in the form of ripples. Ripple factor can be defined as the ratio of the effective value of ac component of voltage or current to the direct value or average value. $\gamma = \frac{ripple\ voltage}{d.c\ voltage} = \frac{rms\ value\ of\ a.c.component}{d.c.value\ of\ wave} = \frac{(V_r)_{rms}}{v_{dc}}$ **Transformer Utilization Factor (TUF)** : The transformer	2 *3	6	6

	utilization factor is defined as $$TUF = \frac{d.c.\,power\ to\ be\ delivered\ to\ the\ load}{a.c.\,rating\ of\ the\ transformer\ secondary}$$ $$= \frac{P_{d.c}}{P_{a.c(rated)}}$$			
5	**Half-wave voltage doubler:** A half-wave voltage doubler is a voltage multiplier circuit whose output voltage amplitude is twice that of the input voltage amplitude. During the positive half cycle, diode D_1 is forward biased and current flows to the capacitor C_1 and charges it to the peak value of input voltage i.e. V_m. Current does not flow to the capacitor C_2 because the diode D_2 is reverse biased.Therefore, during the positive half cycle, capacitor C_1 is charged whereas capacitor C_2 is uncharged.  During the negative half cycle, diode D_1 is reverse biased. So the diode D_1 will not allow electric current through it.On the other hand, the diode D_2 is forward biased during the negative half cycle and current will flow to the capacitor C_2 and charges it. The capacitor C_2 charges to a value $2V_m$. Thus, the half-wave voltage doubler drives a voltage of $2V_m$ to the output load.	Fig 3 Exp:3	6	6
6	**Effect of temperature in Leakage current:** Flow of current in the collector circuit produces heat at the collector base junction. This increases the temperature. Due to increase in temperature, more minority carriers are generated in base collector region. In other words, leakage current increase when temperature increases. i.e I_{CBO} increases which in turn increases the collector current (**$I_C = \alpha I_E + I_{CBO}$**). As collector current increase, the temperature further increases giving rise to more I_{CBO}. This process is known as **thermal runaway.**	Exp:6	6	6
7	**Operation NPN Transistor :** The operation of an NPN transistor	Fig:3	6	6

	can be explained by having a look at the following figure, in which emitter-base junction is forward biased and collector-base junction is reverse biased.	Exp:3		



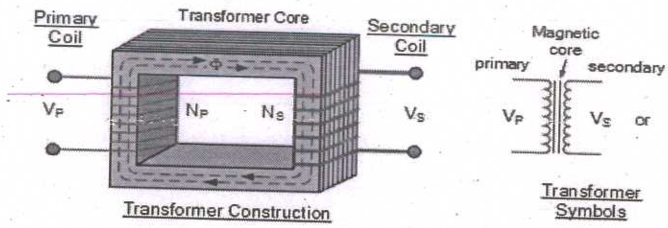
Operation of a NPN transistor

The voltage V_{EE} provides a negative potential at the emitter which repels the electrons in the N-type material and these electrons cross the emitter-base junction, to reach the base region. There a very low percent of electrons recombine with free holes of P-region. This provides very low current which constitutes the base current I_B. The remaining holes cross the collector-base junction, to constitute the collector current I_C.

$$I_E = I_B + I_C$$

III a	**Part C**	Fig:2 Exp :4 Any 3 Appln :3	9	9

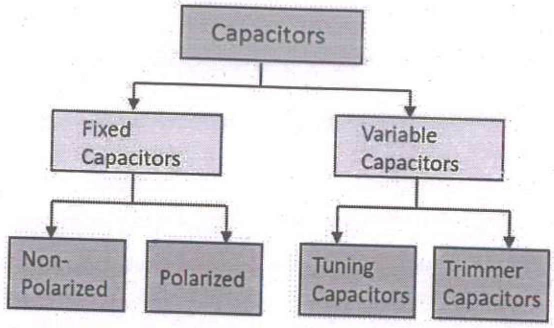
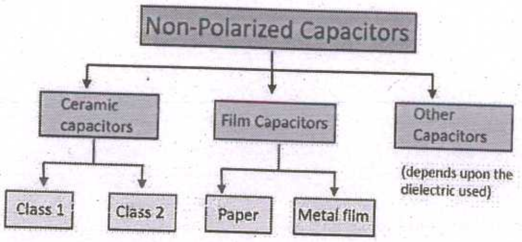
A transformer has a primary coil to which input is given and a secondary coil from which the output is collected. Both of these coils are wound on a core material. Usually an insulator forms the **Core** of the transformer

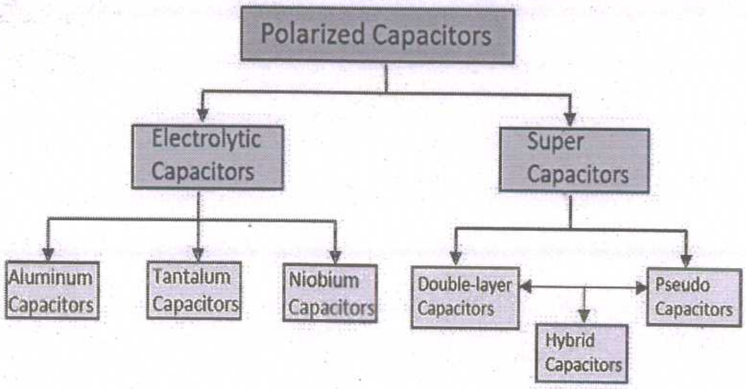


According to the principle of **Electromagnetic Induction**,a varying flux can induce an EMF in a coil. By the principle of **Mutual induction**, when another coil is brought near to such coil, the flux induces EMF into the second coil.Now, the coil which has the varying flux is called as the **Primary Coil** and the coil into which EMF is induced is called as the **Secondary Coil**, while the two coils together makes a unit called as a **Transformer**

Application of transformer

- The transformer used for impedance matching.
- The transformer used for isolate two circuits electrically.

	• It is used to increase or decrease the alternating voltages in electric power applications. • The transformer used in **rectifier.**			
b	**a) Req = 2k+2k+5k = = 7k** **b) Req = 1k+(4K ∥ 4K)** **= 1k+2k =3k**	3*2	6	6
IV a	**Types of Capacitors**  Variable capacitors value can be changed either electrically or mechanically . Capacitors whose value is fixed while manufacturing and cannot be altered later are called as **Fixed Capacitors.** **Non-Polarized Capacitors :** These are the capacitors that have **no specific polarities**, which means that they can be connected in a circuit, either way without bothering about the placement of right lead and left lead.  Polarized Capacitors are the ones that have specific positive and negative polarities. While using these capacitors in circuits, it should always be taken care that they are connected in **perfect polarities.**	7	7	7

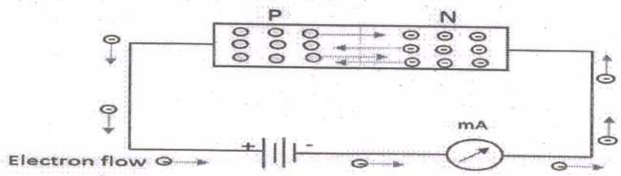
<table>
<tr><td></td><td>
</td><td></td><td></td><td></td></tr>
<tr><td>b</td><td>Color Coding: A process called color coding is used to determine the value of resistance for a resistor.A resistor is coated with four color bands where each color determines a particular value. The below table shows a list of values which each color indicates.

<table>
<tr><th>COLOUR</th><th>DIGIT</th><th>MULTIPLIER</th><th>TOLERANCE</th></tr>
<tr><td>Black</td><td>0</td><td>$10^0 = 1$</td><td></td></tr>
<tr><td>Brown</td><td>1</td><td>$10^1 = 10$</td><td>1</td></tr>
<tr><td>Red</td><td>2</td><td>$10^2 = 100$</td><td>2</td></tr>
<tr><td>Orange</td><td>3</td><td>$10^3 = 1000$</td><td></td></tr>
<tr><td>Yellow</td><td>4</td><td>$10^4 = 10000$</td><td></td></tr>
<tr><td>Green</td><td>5</td><td>$10^5 = 100000$</td><td>0.5</td></tr>
<tr><td>Blue</td><td>6</td><td>$10^6 = 1000000$</td><td>0.25</td></tr>
<tr><td>Violet</td><td>7</td><td>$10^7 = 10000000$</td><td>0.1</td></tr>
<tr><td>Gray</td><td>8</td><td>$10^8 = 100000000$</td><td></td></tr>
<tr><td>White</td><td>9</td><td>$10^9 = 1000000000$</td><td></td></tr>
<tr><td>Gold</td><td></td><td>$10^{-1} = 0.1$</td><td>5</td></tr>
<tr><td>Silver</td><td></td><td>$10^{-2} = 0.01$</td><td>10</td></tr>
<tr><td>(none)</td><td></td><td></td><td>20</td></tr>
</table>
The first two coloured bands indicate the first and second digit of the value and the third colour band represents the multiplier (number of zeroes added). The fourth colour band indicates the tolerance value.

Tolerance is the range of value up to which a resistor can withstand without getting destroyed. This is an important factor. The following figure shows how the value of a resistor is determined by colour code.</td><td>8</td><td>8</td><td>8</td></tr>
<tr><td>V a</td><td>Working under Forward Biased : When positive terminal of the battery is connected to P-side and negative terminal to N-side the diode is said to be forward biased. The negative voltage pushes or repels electrons in the N side and positive voltage repels holes towards the junction giving them the energy. Now the depletion layer's width decreases. As depletion layer decreases, potential barrier also decreases. As there is no depletion layer, large number</td><td>Fig:5

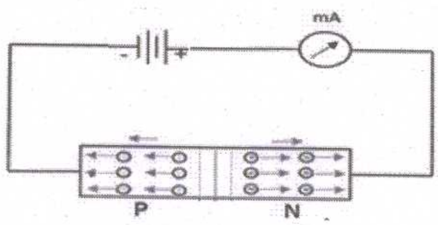
Exp:4</td><td>9</td><td>9</td></tr>
</table>

of electrons and holes cross the junction. They recombine and large current flows through the diode.

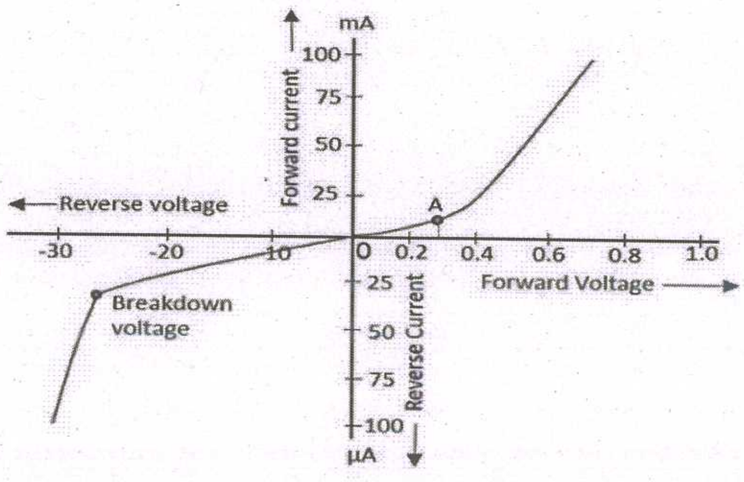


PN junction forward biased

Working under Reverse Biased: When anode and cathode are connected to negative and positive terminals respectively, the electrons are attracted towards the positive terminal and holes are attracted towards the negative terminal. Hence increasing the width of depletion layer. As the depletion layer increases, potential barrier also increases. Majority charge carriers cannot move across the junction, hence current will not be allowed to flow across the diode. That is, on reverse biasing, P-N junction diode acts as insulator

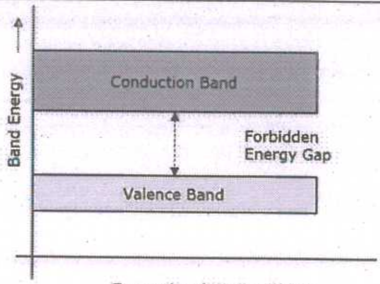


With the increasing reverse bias, the junction has few minority carriers which cross the junction giving rise to **reverse saturation current**. This current is normally negligible and is almost constant when the temperature is constant. But when the reverse voltage increases further, then a point called **reverse breakdown occurs,** where an avalanche of current flows through the junction. This high reverse current damages the device.



b		Fig: 4	6	6

Exp:2

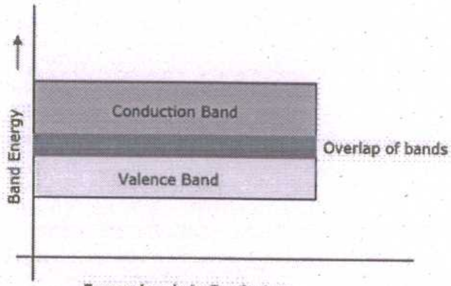


Energy bands in Insulators

Insulators: Insulators are materials in which the conduction cannot take place, due to the large forbidden gap. Examples: Wood, Rubber.

The following are the characteristics of Insulators.

- The Forbidden energy gap is very large.
- Valance band electrons are bound tightly to atoms.
- The value of forbidden energy gap for an insulator will be of 10eV.

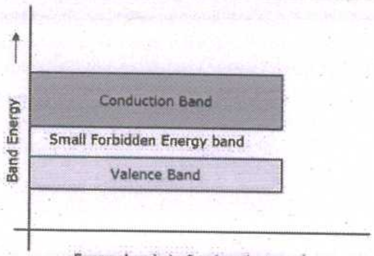


Energy bands in Conductors

Conductors: Conductors are such materials in which the forbidden energy gap disappears as the valence band and conduction band become very close that they overlap. Examples: Copper, Aluminium.

The following are the characteristics of Conductors.

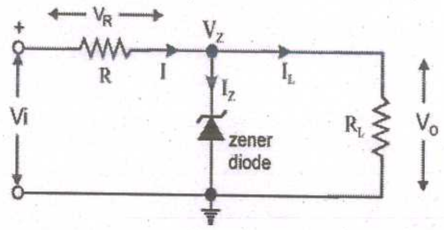
- There exists no forbidden gap in a conductor.
- The valance band and the conduction band gets overlapped.
- The free electrons available for conduction are plenty.
- A slight increase in voltage increases the conduction.

<table>
<tr><td></td><td>

Energy bands in Semiconductors

Semiconductors: Semiconductors are such materials in which the forbidden energy gap is small and the conduction takes place if some external energy is applied. Examples: Silicon, Germanium.

The following are the characteristics of Semiconductors.
• The Forbidden energy gap is very small.
• A Semiconductor actually is neither an insulator, nor a good conductor.

As the temperature increases, the conductivity of a semiconductor increases</td><td></td><td></td><td></td></tr>
<tr><td>VI a</td><td>Zener as voltage regulator


Voltage Regulator means the output voltage remains almost constant irrespective of variations in input voltage or load resistance. To get effective regulation, the zener diode should operate in reverse bias condition and in break down region.
The value of series resistor R must be as such that to protect the zener diode from over current. There are 3 currents in the circuit, I, Iz and I_L.

$I=Iz+I_L$ ... using Kirchhoff's Current Law

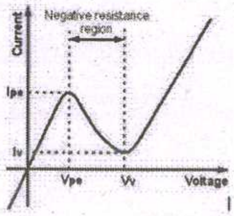
$I=(Vi-Vz)/R$ ... using Ohm's law

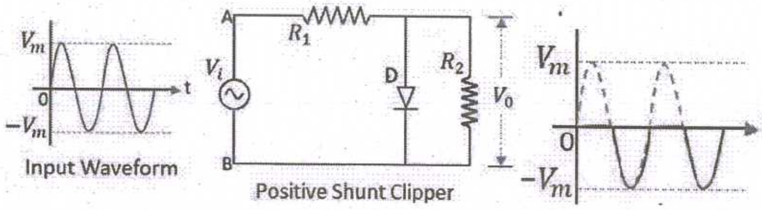
$I_L=Vo/R_L=Vz/R_L$ ...because, $Vz=Vo$ as Zener diode is connected in parallel with the load resistor R_L

Working of the circuit : There are 2 possible conditions

• When input voltage Vi is changing but load resistance RL</td><td>Fig :4

Exp: 5</td><td>9</td><td>9</td></tr>
</table>

	*i*s constant. • When input voltage *Vi* is constant but load resistance *RL* is changing. **Condition #1: *Vi* is changing, but *RL* is constant:** In this condition, input current *I* is changing, but I_L remains constant, since R_L is constant. Here also there are two possible conditions. 1. ***Vi* increases**: Then *I* increases. But load current I_L remains constant, because RL is constant. And as $I=Iz+I_L$ so *Iz* increases proportionally to adjust this 2. ***Vi* decreases:** Then *I* decreases. But load current I_L remains constant, as R_L is constant. And as $I=Iz+I_L$ so *Iz* decreases proportionally to adjust this **Condition #2: *Vi* is constant, but *RL* is changing:** In this condition, input current *I* is constant, but I_L is changing, since R_L is changing. There are two possible conditions here. 1. R_L **increases**: Then I_L decreases. But input current *I* is constant, because *Vi* is constant. And as $I=Iz+I_L$ so *Iz* increases proportionally to adjust this. R_L **decreases:** Then *IL* increases. But input current *I* is constant as *Vi* is constant. And as $I=Iz+I_L$ so *Iz* decreases proportionally to adjust this			
b	**Tunnel diode :** Tunnel diode is a highly doped semiconductor device and is used mainly for low voltage high frequency switching applications. It works on the principle of Tunnelling effect. It is also called as Esaki diode. The tunnel diode is a two terminal device with p type semiconductor acting as anode and n type semiconductor as cathode. **VI characteristics of Tunnel diode:**   For small forward voltages owing to high carrier concentrations in tunnel diode and due to tunnelling effect the forward resistance will be very small. As voltage increase the current also increases till the current reaches Peak current. If the voltage applied to	Fig: 3 Exp:3	6	6

<table>
<tr><td></td><td>tunnel diode is increased beyond the peak voltage the current will start decreasing. This is negative resistance region. It continues till valley point. At valley point the current through the diode will be minimum. Beyond valley point the tunnel diode acts as normal diode. In reverse biased condition also Tunnel diode is an excellent conductor due to its high doping concentrations. Tunnel diodes are made from Germanium or gallium arsenide</td><td></td><td></td><td></td></tr>
<tr><td>VII
a</td><td>
<table>
<tr><th>Terms</th><th>HWR</th><th>Centre Tap</th><th>Bridge</th></tr>
<tr><td>No of Diodes</td><td>1</td><td>2</td><td>4</td></tr>
<tr><td>Transformer Tapping</td><td>No</td><td>Yes</td><td>No</td></tr>
<tr><td>Peak inverse voltage</td><td>Vm</td><td>2Vm</td><td>Vm</td></tr>
<tr><td>Maximum Efficiency</td><td>40.65</td><td>81.2%</td><td>81.2%</td></tr>
<tr><td>Avarage/ Dc Curernt</td><td>I_m/π</td><td>$2\ I_m/\pi$</td><td>$2\ I_m/\pi$</td></tr>
<tr><td>DC Voltage</td><td>V_m/π</td><td>$2V_m/\pi$</td><td>$2V_m/\pi$</td></tr>
<tr><td>RMS Current</td><td>$I_m/2$</td><td>$I_m/\sqrt{2}$</td><td>$I_m/\sqrt{2}$</td></tr>
<tr><td>Ripple Factor</td><td>1.21</td><td>0.48</td><td>0.48</td></tr>
<tr><td>Output Frequency</td><td>f_m</td><td>$2f_m$</td><td>$2f_m$</td></tr>
</table>
</td><td>Any 6
6*1.5</td><td>9</td><td>9</td></tr>
<tr><td>b</td><td>Positive Shunt Clipper : A Clipper circuit in which the diode is connected in shunt to the input signal and that attenuates the positive portions of the waveform, is termed as Positive Shunt Clipper


During positive cycle diode is forward biased and conducts like a closed switch. Thus the voltage across the load resistor becomes zero as no current flows through it and hence Vo will be zero.

During the negative cycle of the input the diode is reverse biased and behaves like an open switch. Thus the voltage across the load resistor will be equal to the applied input voltage as it completely appears at the output Vo</td><td>Fig 4
Exp :2</td><td>6</td><td>6</td></tr>
</table>

VIII a	**Analysis of Half-Wave Rectifier :**To analyze a half-wave rectifier circuit, consider the equation of input voltage. *vi=Vmsinωt ; Vm* is the maximum value of supply voltage. Let us assume that the diode is ideal. • The resistance in the forward direction, i.e., in the ON state is *Rf* • The resistance in the reverse direction, i.e., in the OFF state is *Rr* The current **i** in the diode or the load resistor *RL* is given by *i =Im*sin*ωt* *for* 0≤*ωt*≤2*π* ; Where *Im=Vm/(Rf+RL)* *i*=0 *for π≤ωt≤2π* **DC Output Current** The average current *Idc* is given by $I_{dc} = \frac{1}{2\pi}\int_0^{2\pi} i\, d(\omega t)$ $= \frac{1}{2\pi}\left[\int_0^{\pi} I_m \sin\omega t\, d(\omega t) + \int_0^{2\pi} 0\, d(\omega t)\right]$ $= \frac{1}{2\pi}[I_m\{-\cos\omega t\}_0^{\pi}]$ $= \frac{1}{2\pi}[I_m\{+1-(-1)\}] = \frac{I_m}{\pi} = 0.318 I_m$ Substituting the value of I_m, we get $I_{dc} = \frac{V_m}{\pi(R_f+R_L)}$ If $R_L >> R_f$, then $I_{dc} = \frac{V_m}{\pi R_L} = 0.318\frac{V_m}{R_L}$ **DC Output Voltage** The DC output voltage is given by $V_{dc} = I_{dc}\times R_L = \frac{I_m}{\pi}\times R_L$ $= \frac{V_m \times R_L}{\pi(R_f+R_L)} = \frac{V_m}{\pi\{1+(R_f/R_L)\}}$ If $R_L >> R_f$, then $V_{dc} = \frac{V_m}{\pi} = 0.318 V_m$	Exp:9	9	9

RMS Current and Voltage

The value of RMS current is given by

$$I_{rms} = \left[\frac{1}{2\pi}\int_0^{2\pi} i^2 d(\omega t)\right]^{\frac{1}{2}}$$

$$I_{rms} = \left[\frac{1}{2\pi}\int_0^{2\pi} I_m^2 \sin^2 \omega t \, d(\omega t) + \frac{1}{2\pi}\int_\pi^{2\pi} 0 \, d(\omega t)\right]^{\frac{1}{2}}$$

$$= \left[\frac{I_m^2}{2\pi}\int_0^{\pi}\left(\frac{1-\cos 2\omega t}{2}\right) d(\omega t)\right]^{\frac{1}{2}}$$

$$= \left[\frac{I_m^2}{4\pi}\left\{(\omega t) - \frac{\sin 2\omega t}{2}\right\}_0^{\pi}\right]^{\frac{1}{2}}$$

$$= \left[\frac{I_m^2}{4\pi}\left\{\pi - 0 - \frac{\sin 2\pi}{2} + \sin 0\right\}\right]^{\frac{1}{2}}$$

$$= \left[\frac{I_m^2}{4\pi}\right]^{\frac{1}{2}} = \frac{I_m}{2}$$

$$= \frac{V_m}{2(R_f + R_L)}$$

RMS voltage across the load is

$$V_{rms} = I_{rms} \times R_L = \frac{V_m \times R_L}{2(R_f + R_L)}$$

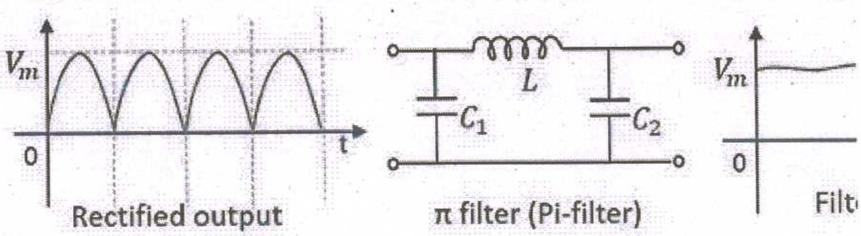
$$= \frac{V_m}{2\{1 + (R_f/R_L)\}}$$

If $R_L >> R_f$, then

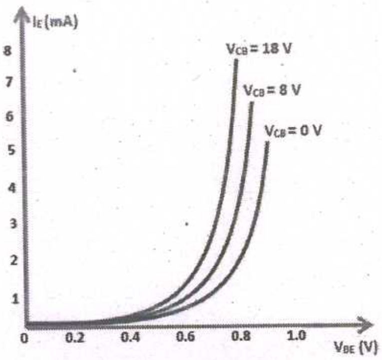
$$V_{rms} = \frac{V_m}{2}$$

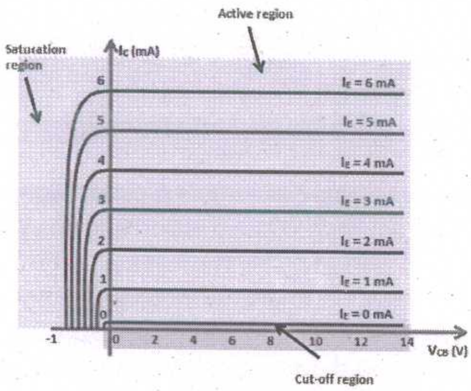
b | Fig :4 Exp :2 | 6 | 6

π- Filter (Pi filter) : It has capacitor at its input and hence it is also called as a **Capacitor Input Filter**. Two capacitors and one inductor are connected in the form of π shaped network. A capacitor in parallel, then an inductor in series, followed by another capacitor in parallel makes this circuit.



Working of a Pi filter : In this circuit, we have a capacitor in parallel, then an inductor in series, followed by another capacitor

	in parallel. • **Capacitor C_1** – This filter capacitor offers high reactance to dc and low reactance to ac signal. After grounding the ac components present in the signal, the signal passes to the inductor for further filtration. • **Inductor L** – This inductor offers low reactance to dc components, while blocking the ac components if any got managed to pass, through the capacitor C_1. • **Capacitor C_2** – Now the signal is further smoothened using this capacitor so that it allows any ac component present in the signal, which the inductor has failed to block. Thus we, get the desired pure dc output at the load.			
IX a	**Input characteristics:** The input characteristics describe the relationship between input current (I_E) and the input voltage (V_{BE}). To determine the input characteristics, the output voltage V_{CB} (collector-base voltage) is kept constant at zero volts and the input voltage V_{BE} is increased from zero volts to different voltage levels. For each voltage level of the input voltage (V_{BE}), the input current (I_E) is recorded on a paper or in any other form. This is repeated for different values of V_{CB}  I/p characteristics CB configuration When the output voltage (V_{CB}) is increased from zero volts to a certain voltage level (8 volts), the emitter current flow will be increased which in turn reduces the depletion region width at emitter-base junction. As a result, the cut in voltage will be reduced. Therefore, the curves shifted towards the left side for higher values of output voltage V_{CB}. **Output characteristics :** The output characteristics describe the relationship between output current (I_C) and the output voltage (V_{CB}). To determine the output characteristics, the input current or emitter current I_E is kept constant at zero mA and the output voltage V_{CB} is increased from zero volts to different voltage levels. For each voltage level of the output voltage V_{CB}, the output	Fig :6 Exp:3	9	9

	current (I_C) is recorded.. A curve is then drawn between output current I_C and output voltage V_{CB} at constant input current I_E (0 mA). This is repeated for different values of I_E. When the emitter current or input current I_E is equal to 0 mA, the transistor operates in the cut-off region.  O/P characteristics CB configuration			
b	**Relation between γ, α, β** $\beta = \frac{IC}{IB}$ $I_E = I_B + I_C$ $I_B = I_E - I_C$ Therefore $\beta = \frac{IC}{IE - IC}$ Divide Numerator and Denominator by I_E $\beta = \frac{(IC/IE)}{1 - IC/IE}$ We Know $\alpha = \frac{IC}{IE}$ $\beta = \frac{\alpha}{1-\alpha}$ From this $\alpha = \frac{\beta}{1+\beta}$ $\gamma = \beta + 1$ $\gamma = \frac{1}{1-\alpha}$	6 (4*1.5)	6	6

<table>
<tr><td>X a</td><td>
<table>
<tr><th>Parameter</th><th>CB</th><th>CE</th><th>CC</th></tr>
<tr><td>Voltage gain</td><td>High</td><td>High</td><td>Less than unity</td></tr>
<tr><td>Current Gain</td><td>Less than unity</td><td>High</td><td>High</td></tr>
<tr><td>Power Gain</td><td>Moderate</td><td>High</td><td>Moderate</td></tr>
<tr><td>Phase inversion</td><td>No</td><td>Yes</td><td>No</td></tr>
<tr><td>Input Impedance</td><td>Low (50 ohm)</td><td>Moderate (1Kohm)</td><td>High (300kohm)</td></tr>
<tr><td>Output impedance</td><td>High (1 mega)</td><td>Moderate (50kohm)</td><td>Low (300 ohm)</td></tr>
</table>
</td><td>6*1.5</td><td>9</td><td>9</td></tr>
<tr><td>b</td><td>
Dynamic input resistance (r_i): Dynamic input resistance is defined as the ratio of change in input voltage or base voltage (V_{BE}) to the corresponding change in input current or base current (I_B), with the output voltage or collector voltage (V_{CE}) kept at constant.
$$r_i = \frac{\Delta V_{BE}}{\Delta I_B}, \quad V_{CE} = \text{constant}$$
In CE configuration, the input resistance is very low.
Dynamic output resistance (r_o) : Dynamic output resistance is defined as the ratio of change in output voltage or collector voltage (V_{CE}) to the corresponding change in output current or collector current (I_C), with the input current or base current (I_B) kept at constant.
$$r_o = \frac{\Delta V_{CE}}{\Delta I_C}, \quad I_B = \text{constant}$$
In CE configuration, the output resistance is high.
</td><td>3*2</td><td>6</td><td>6</td></tr>
</table>