

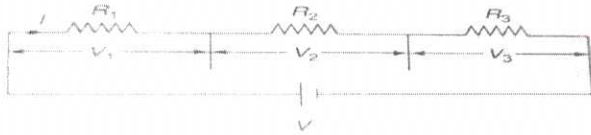
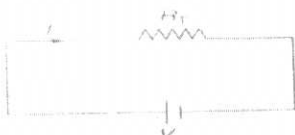
### Scoring Indicators

**FUNDAMENTALS OF ELECTRICAL ENGINEERING**  
**COURSE CODE : 3024**

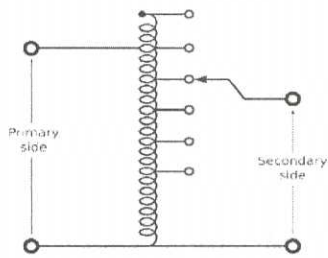
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Q No	Scoring Indicators	Split score	Sub Total	Total Score
	<b>PART A</b>			9
I. 1	Ampere (A)	1	1	
I. 2	Directly propotional	1	1	
I. 3	Time period	1	1	
I. 4	<ol style="list-style-type: none"><li>1. Split-phase motor</li><li>2. Capacitor-start motor</li><li>3. Capacitor-start capacitor-run motor</li><li>4. Permanent-split capacitor (PSC) motor</li><li>5. Shaded-pole motor (any two option from above)</li></ol>	2*0.5	1	
I. 5	Three point starter	1	1	

I. 6	Lifts. Cranes. Hoists. Large exhaust fans. Lathe machines. Crushers. Oil extracting mills.(Any two options from above)	2*0.5	1	
I.7	$K = \frac{N_2}{N_1}$	2* 0.5	1	

I. 8	Valence electrons	1	1	
I. 9	Reverse biased	1	1	
	<b>PART B</b>			42
II. 1			3	
	 <p style="text-align: center;">Figure 1.7 Series circuit.</p>  <p style="text-align: center;">Figure 1.8 Series equivalent circuit.</p> <p>Voltage across resistor <math>R_1</math> is <math>V_1 = IR_1</math>  Voltage across resistor <math>R_2</math> is <math>V_2 = IR_2</math>  Voltage across resistor <math>R_3</math> is <math>V_3 = IR_3</math></p> <p>The source voltage is</p> $V = V_1 + V_2 + V_3 = IR_1 + IR_2 + IR_3$ $= I(R_1 + R_2 + R_3)$ $= IR_T$ $R_T = R_1 + R_2 + R_3$	1		
		1		
		1		
II. 2		3	3	
	<p>a. For alternating electric current, RMS is equal to the value of the constant direct current that would produce the same power dissipation in a resistive load.</p> <p>b. Peak Value is defined as the maximum value that the alternating quantity (current or voltage) reaches in one cycle (either positive or negative).</p>	2		
		1		





- i. An **autotransformer** is a type of electrical transformer with only one winding.
- ii. An auto transformer is similar to a two winding transformer but varies in the way the primary and secondary winding of the transformer are interrelated.
- iii. The primary voltage is applied across two of the terminals. The secondary voltage is taken from two terminals, one terminal of which is usually in common with a primary voltage terminal
- iv. Since the volts-per-turn is the same in both windings, each develops a voltage in proportion to its number of turns. In an autotransformer, part of the output current flows directly from the input to the output (through the series section), and only part is transferred inductively (through the common section), allowing a smaller, lighter, cheaper core to be used as well as requiring only a single winding

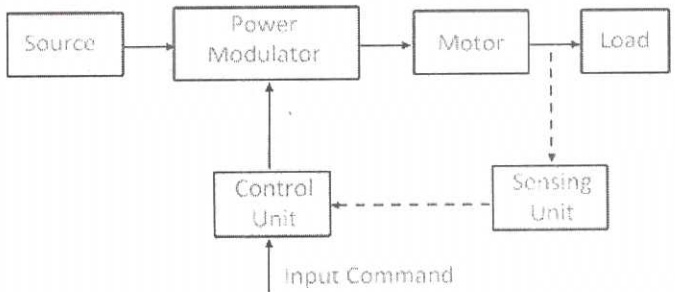
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II. 7

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XIII			7	
	 <pre> graph LR     Source[Source] --&gt; PM[Power Modulator]     PM --&gt; Motor[Motor]     Motor --&gt; Load[Load]     InputCommand[Input Command] --&gt; CU[Control Unit]     CU --&gt; PM     Motor -.-&gt; SU[Sensing Unit]     SU -.-&gt; CU   </pre> <p>The main parts of the electrical drives are power modulator, motor, controlling unit and sensing units.</p> <p><b>Power Modulator</b> – The power modulator regulates the output power of the source. It controls the power from the source to the motor in such a manner that motor transmits the speed-torque characteristic required by the load.</p> <p><b>Control Unit</b> – The control unit controls the power modulator which operates at small voltage and power levels. The control unit also operates the power modulator as desired.</p> <p><b>Sensing Unit</b> – It senses the certain drive parameter like motor current and speed. It mainly required either for protection or for closed loop operation.</p>	3		
XIV				

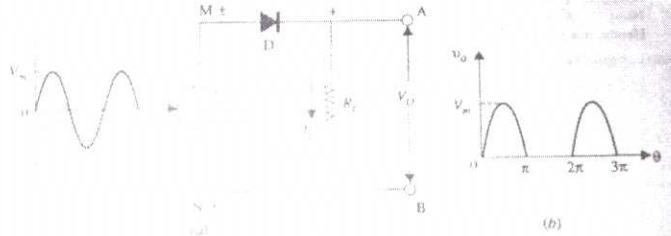
IV	<p>Given load</p> <p>① 20W LED tube 10 numbers working 12hrs a day  Energy Consumption for one day  <math>E_1 = \frac{W \times t}{1000} = \frac{20 \times 10 \times 12}{1000} = 2.4 \text{ kWh}</math></p> <p>② 80W fan 5 number working 8 hrs/day  Energy Consumption for one day  <math>E_2 = \frac{W \times t}{1000} = \frac{80 \times 5 \times 8}{1000} = 3.2 \text{ kWh}</math></p> <p>③ 250W AC, 2 numbers working 6 hrs/day  Energy Consumption for one day  <math>E_3 = \frac{W \times t}{1000} = \frac{250 \times 2 \times 6}{1000} = 3 \text{ kWh}</math></p> <p>Total Energy for one day <math>E = E_1 + E_2 + E_3 = 8.6 \text{ kWh}</math></p> <p>Total Energy Consumption for one month: 30 days  <math>= 30 \times 8.6 = 258 \text{ kWh}</math></p> <p>Energy bill = 258 × 4  = 1032/-  <u>          </u>  = 1032/-</p>	3	7	
V		4+3	7	

28.3. Half-wave Rectifier

Though such a circuit is not much used, yet we will discuss it here for the sake of explaining the basic principle involved in the working of a rectifier. The simple circuit of a half-wave rectifier is shown in Fig. 28.6 along with the input and output voltage waveforms. An a.c. voltage is applied to a single diode connected in series with a load resistor  $R_L$ .

Working

During the positive half cycle of the input a.c. voltage (i.e., when point  $M$  is positive, the diode  $D$  is forward-biased (ON) and conducts. While conducting, the diode acts as a short-circuit so that circuit current flows and hence, positive half-cycle of the input a.c. voltage is dropped across  $R_L$ . It constitutes the output voltage  $v_o$  as shown in Fig. 28.6 (b). Waveform of the diode current (which equals load current) is similar to the voltage waveform.



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2

II.10

3

3

	<b>PART C</b>			42
III		7	7	
	<p>Given data,</p> <p style="text-align: center;">Number of turns, <math>N = 250</math></p> <p style="text-align: center;">Initial flux, <math>\phi_1 = 1.4 \text{ Wb}</math></p> <p style="text-align: center;">Final flux, <math>\phi_2 = 2 \text{ Wb}</math></p> <p><math>\therefore</math> Change in flux, <math>d\phi = \phi_2 - \phi_1 = 2 - 1.4 = 0.6 \text{ Wb}</math></p> <p style="text-align: center;">Time interval, <math>dt = 0.45 \text{ s}</math></p> <p>Now, according to Faraday's law, we have,</p> <p style="text-align: center;">Induced emf in the coil, <math>e = N \frac{d\phi}{dt} = 250 \times \frac{0.6}{0.45}</math></p> <p style="text-align: center;"><span style="border: 1px solid black; padding: 2px;"><math>e = 333.33 \text{ V}</math></span></p>			
		4+3		

**8. Types of D.C. Motors**

Like generators, there are three types of d.c. motors characterised by the connections of field winding in relation to the armature (17):

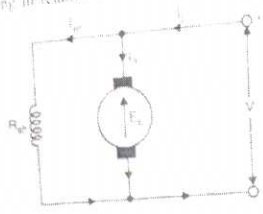


Fig. 18.4

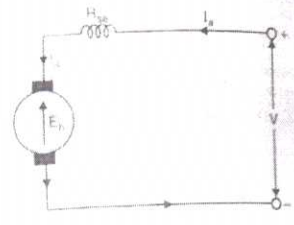


Fig. 18.5

- (i) shunt-wound motor in which the field winding is connected in parallel with the armature (See Fig. 18.4)
- (ii) series-wound motor in which the field winding is connected in series with the armature (See Fig. 18.5)
- (iii) compound-wound motor which has two field windings, one connected in parallel with the armature and the other in series with it. There are two types of compound motor connections. When the shunt field winding is directly connected across the armature terminals (See Fig. 18.6) it is called short-shunt connection. When the shunt field winding is so connected that it carries the series combination of armature and series field (See Fig. 18.7) it is called long-shunt connection.

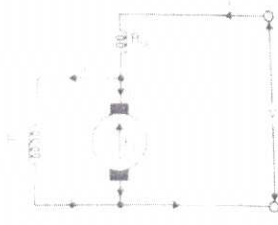


Fig. 18.6. Short-Shunt Connection

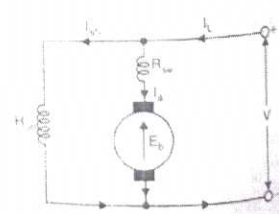


Fig. 18.7. Long-Shunt Connection

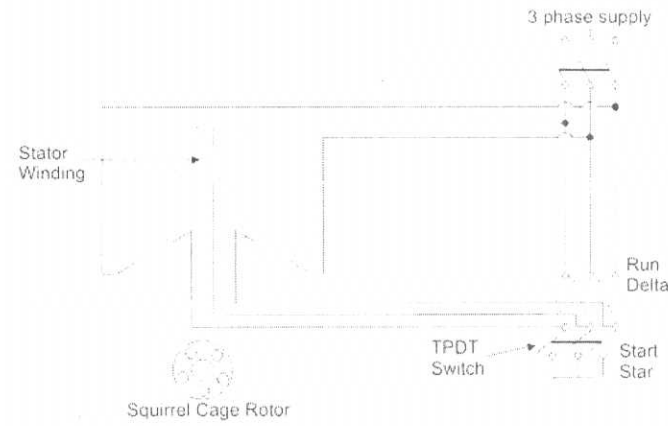
Figure (4 marks)

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VI

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	 <p data-bbox="295 638 1045 862"> <b>A star delta starter</b> is the most commonly used method for the starting of a <u>3 phase induction motor</u>. In star delta starting an <u>induction motor</u> is connected in through a <u>star connection</u> throughout the starting period. Then once the motor reaches the required speed, the motor is connected in through a <u>delta connection</u>.         </p> <p data-bbox="295 873 1045 1019">           A star delta starter will start a motor with a star connected stator winding. When motor reaches about 80% of its full load speed, it will begin to run in a delta connected stator winding.         </p>	4		
		3	7	

A Bipolar Junction Transistor (BJT) is a three-terminal device which consists of two pn-junctions formed by sandwiching either p-type or n-type semiconductor material between a pair of opposite type semiconductors.

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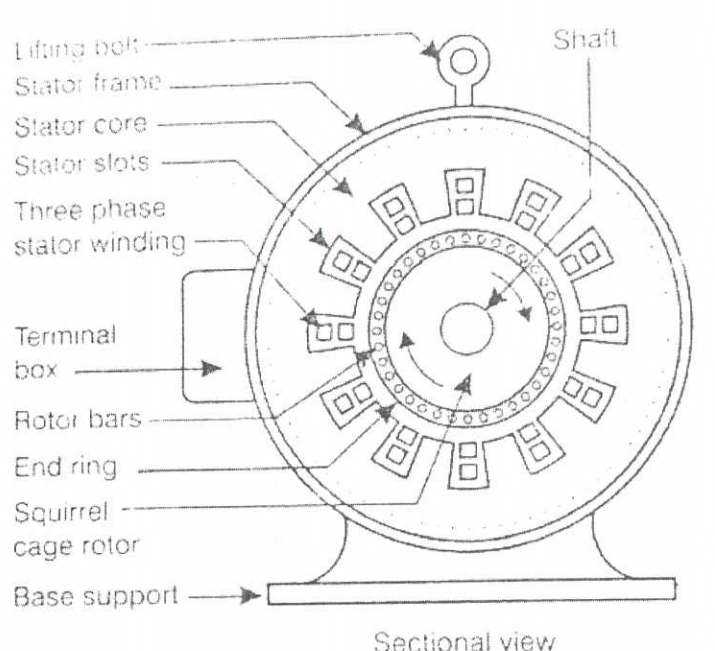
The primary function of BJT is to increase the strength of a weak signal, i.e., it acts as an amplifier. A BJT can also be used as a solid state switch in electronic circuits.

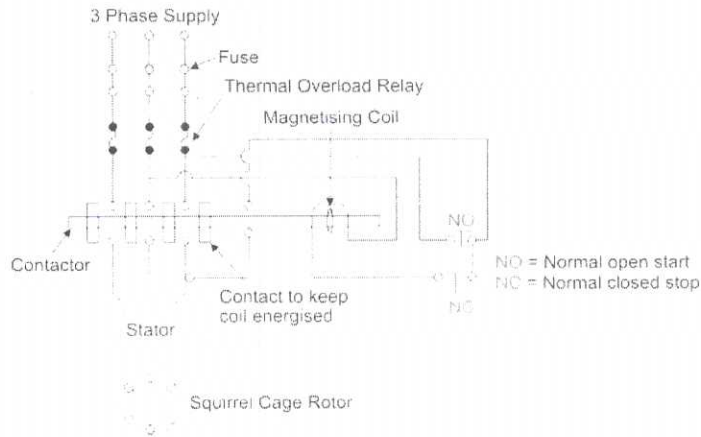
#### Types of BJT

There are two types of BJTs –

- NPN Transistor :An npn-transistor is composed of two n-type semiconductor materials which are separated by a thin layer of p-type semiconductor. The two terminals viz. Emitter and Collector are taken out from the two n-type semiconductor and the Base terminal is from the p-type semiconductor.
- PNP Transistor: A pnp-transistor is composed of two p-type semiconductors which are separated by a thin layer of n-type material. The two terminals viz. Emitter and Collector are taken out from the two p-type semiconductor layers and the Base terminal is from the n-type semiconductor.

2

<p>VII</p>	 <p style="text-align: center;">Sectional view</p> <p><b>3 Phase Induction Motor Construction</b></p> <p>Like any other type of electrical motor induction motor, a 3 phase induction motor is constructed from two main parts, namely the rotor and stator:</p> <ol style="list-style-type: none"> <li>1. Stator: As its name indicates stator is a stationary part of induction motor. A stator winding is placed in the stator of induction motor and the three phase supply is given to it.</li> <li>2. Rotor: The rotor is a rotating part of induction motor. The rotor is connected to the mechanical load through the shaft.</li> </ol> <p>The rotor of the three phase induction motor are further classified as</p> <ol style="list-style-type: none"> <li>1. Squirrel cage rotor</li> <li>2. Slip ring rotor or wound rotor or phase wound rotor.</li> </ol>	4	
<p>VIII</p>			7



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A **DOL starter** (also known as a **direct on line starter** or **across the line starter**) is a method of starting a 3 phase induction motor. In a DOL Starter, an induction motor is connected directly across its 3-phase supply, and the DOL starter applies the full line voltage to the motor terminals.

3

Despite this direct connection, no harm is done to the motor. A DOL motor starter contains protection devices, and in some cases, condition monitoring.

Since the DOL starter connects the motor directly to the main supply line, the motor draws a very high inrush current compared to the full load current of the motor (up to 5-8 times higher). The value of this large current decreases as the motor reaches its rated speed.

A direct on line starter can only be used in circumstances when the high inrush current of the motor does not cause an excessive voltage drop in the supply circuit. If a high voltage drop needs to be avoided, a star delta starter should be used instead. Direct on line starters are commonly used to start small motors, especially 3 phase squirrel cage induction motors.

IX

7

2. Induced e.m.f. in the primary

Consider that an alternating voltage  $V_1$  of frequency  $f$  is applied to the primary of a transformer. Fig. 19.2 (i). The sinusoidal flux  $\phi$  produced by the primary can be represented by:

$$\phi = \phi_m \sin \omega t$$

The instantaneous e.m.f.  $e_1$  induced in the primary is

$$e_1 = -N_1 \frac{d\phi}{dt} = -N_1 \frac{d(\phi_m \sin \omega t)}{dt} \\ = -N_1 \phi_m \omega \cos \omega t = -2\pi f N_1 \phi_m \cos \omega t \\ = 2\pi f N_1 \phi_m \sin (\omega t - 90^\circ)$$

From the above equation that maximum value of induced e.m.f. is

$$E_m = 2\pi f N_1 \phi_m$$

The rms value  $E_1$  of the primary e.m.f. is

$$E_1 = \frac{E_m}{\sqrt{2}} = \frac{2\pi f N_1 \phi_m}{\sqrt{2}}$$

or  $E_1 = 4.44 f N_1 \phi_m$

Similarly,  $E_2 = 4.44 f N_2 \phi_m$

For an ideal transformer,  $E_1 = V_1$  and  $k = 1$ .

So, it is clear from eqn. (i) above that e.m.f.  $E_1$  induced in the primary lags behind the flux  $\phi$  by  $90^\circ$ . Similarly, e.m.f.  $E_2$  induced in the secondary lags behind flux  $\phi$  by  $90^\circ$ .

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X

28.4. Full-Wave Rectifier

In this case both half-cycles of the input are utilized with the help of two diodes working alternately. For full-wave rectification, use of a centre tap transformer is essential (though it is optional for half-wave rectification).

The full-wave rectifier circuit using two diodes and a centre tapped transformer is shown in Fig. 28.9. The centre tap is usually taken as the ground or zero voltage reference point.

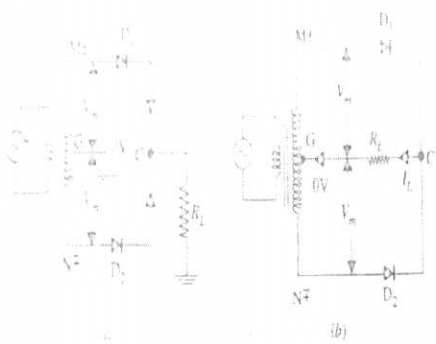
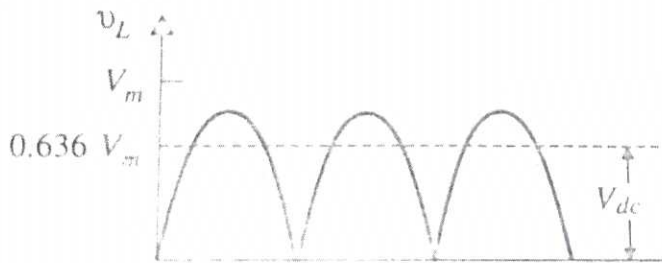


Fig. 28.9

When input ac supply is switched on, the ends M and N of the transformer secondary become positive and negative alternately. During the positive half-cycle of the ac input terminal M is positive, G is at zero potential and N is at negative potential. Hence, being forward-biased, diode  $D_1$  conducts (while  $D_2$  which is reverse-biased) and current flows along  $MD_1CABG$  (Fig. 28.9). As a result positive half-cycle of the voltage appears across  $R_L$ .

During the negative half-cycle when terminal N becomes positive then  $D_2$  conducts (while  $D_1$ ) and current flows along  $ND_2CABG$ . So, we find that current keeps on flowing through  $R_L$  in the same direction (i.e. from A to B) in both half-cycles of the ac input. It means that both half-cycles of the input ac supply are utilized as shown in Fig. 28.9 (b). Also, the frequency of the rectified output voltage is twice the supply frequency.



XII

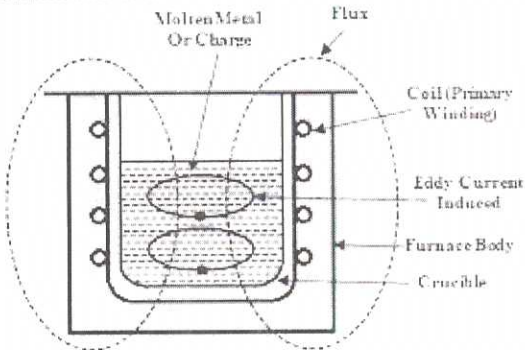
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Fig. 28.10 shows two different ways of drawing the circuit. In Fig. 28.10 (a),  $R_L$  becomes connected to point G via the earth whereas in Fig. 28.10 (b), it is connected directly to G.

When input ac supply is switched on, the ends M and N of the transformer secondary become positive and negative alternately. During the positive half-cycle of the ac input terminal M is positive, G is at zero

	<p>In the induction furnace, a coil carrying alternating electric current surrounds the container or chamber of metal. Eddy currents are induced in the metal (charge), the circulation of these currents producing extremely high temperatures for melting the metals and for making alloys of exact composition.</p> <p>An induction furnace consists of a nonconductive crucible holding the charge of metal to be melted, surrounded by a coil of copper wire. A powerful alternating current flows through the wire. The coil creates a rapidly reversing magnetic field that penetrates the metal. The magnetic field induces eddy currents, circular electric currents, inside the metal, by electromagnetic induction.<sup>[9]</sup> The eddy currents, flowing through the electrical resistance of the bulk metal, heat it by Joule heating. In ferromagnetic materials like iron, the material may also be heated by magnetic hysteresis, the reversal of the molecular magnetic dipoles in the metal. Once melted, the eddy currents cause vigorous stirring of the melt, assuring good mixing.</p> <p>An advantage of induction heating is that the heat is generated within the furnace's charge itself rather than applied by a burning fuel or other external heat source, which can be important in applications where contamination is an issue.</p>  <p style="text-align: center;">Coreless Induction Furnace</p>	4		
XI		3		7

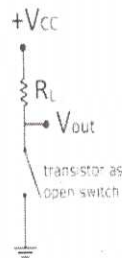
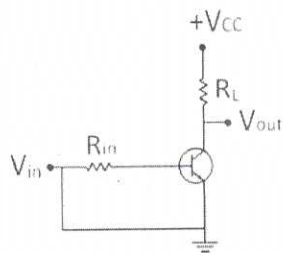
	<p><i>Induction heating</i> is the process of heating the materials which are electrically conductive by electromagnetic induction like metals.</p> <p>Working Principle of Induction Heating</p> <p>Induction heating makes use of the induced current by the electromagnetic induction in the charge to be heated. The induction heating works on the principle of transformer action, in which the primary winding which is supplied from an AC source is magnetically coupled to the charge, to be heated, which acts as a short-circuited secondary of a single turn.</p> <p>When the AC supply is connected to the primary winding, it induces currents in the charge. As the secondary, i.e., the charge has some resistance, thus the induced currents in the charge heats it up.</p>	1		
II. 8		3	3	
	<p>Construction of Single Phase Transformer</p> <p><i>A single phase transformer</i> consists of two windings viz. <i>primary winding</i> and <i>secondary winding</i> put on a magnetic core. The magnetic core is made from thin sheets (called <i>laminations</i>) of <i>high graded silicon steel</i> and provides a definite path to the magnetic flux. These laminations reduce the <i>eddy-current losses</i> while the silicon steel reduces the <i>hysteresis losses</i>.</p> <p>The laminations are insulated from each other by <i>enamel insulation coating</i>. The thin laminations are stacked together to form the core of the transformer. The air-gap between the laminations should be minimum so that the excitation current being minimum.</p> <p>For a single phase transformer, there are two types of transformer constructions viz. the <i>core type</i> and the <i>shell type</i>.</p>	2		
II.9		3	3	

A transistor can be used as a **solid state switch**. If the transistor is operated in the **saturation** region then it acts as closed **switch** and when it is operated in the **cut off region** then it behaves as an open switch.

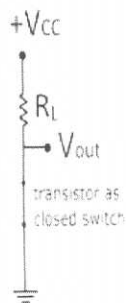
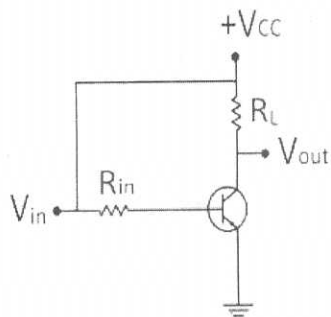
The transistor operates as a **Single Pole Single Throw (SPST)** solid state switch. When a zero input signal applied to the base of the transistor, it acts as an open switch. If a positive signal applied at the input terminal then it acts like a closed switch.

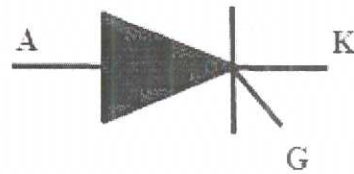
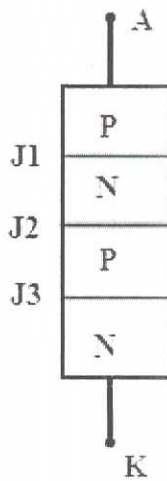
When the transistor operating as switch, in the cut off region the current through the transistor is zero and voltage across it is maximum, and in the saturation region the transistor current is maximum and voltage across is zero. Therefore, both the on – state and off – state power loss is zero in the transistor switch.

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SCR is a three terminal device; anode, cathode and gate as shown in figure. SCR has built in feature to turn ON or OFF and its switching is controlled by biasing conditions and gate input terminal.

The SCR is a four layer and three terminal device. The four layers made of P and N layers, are arranged alternately such that they form three junctions J1, J2 and J3. These junctions are either alloyed or diffused based on the type of construction.

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The outer layers (P and N-layers) are heavily doped whereas middle P and N-layers are lightly doped. The gate terminal is taken at the middle P-layer, anode is from outer P- layer and cathode is from N- layer terminals. The SCR is made of silicon because compared to germanium leakage current in silicon is very small.

Depending on the biasing given to the SCR, the operation of SCR is divided into three modes. They are

1. Forward blocking Mode
2. Forward Conduction Mode and
3. Reverse Blocking Mode