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Total No. of Questions : 09

B.Tech. (AE/AI&ML/AI&DS/AI/AR/AE/BT) (Sem–1,2)
(CE/CSE/DS/EEE/EE/ECE/FT/IT/ME/Robotics & AI)

BASIC ELECTRICAL ENGINEERING

Subject Code : BTEE-101-18
M.Code : 75339
Date of Examination : 10-06-2023

Time : 3 Hrs. **Max. Marks : 60**

INSTRUCTIONS TO CANDIDATES :

1. **SECTION-A is COMPULSORY consisting of TEN questions carrying TWO marks each.**
2. **SECTION - B & C have FOUR questions each.**
3. **Attempt any FIVE questions from SECTION B & C carrying EIGHT marks each.**
4. **Select atleast TWO questions from SECTION - B & C.**

SECTION-A

1. Answer following questions in brief :

a) Define power factor. What is the power factor of a pure capacitor?

b) What is the effect of frequency on inductive reactance?

c) In a RL series circuit a voltage of 10V at 50Hz produces a current of 700mA 2 while the same voltage at 75Hz produces a 500mA current. What is the value of R' and L in the circuit?

d) What is the relation between line and phase values of voltage and current for (i) 2 Star connection (ii) Delta connection?

e) **Define** (i) Peak factor and (ii) Form factor.

f) What material are used for a transformer (i) core (ii) windings?

g) Draw the power flow diagram of an induction motor.

h) Draw the phasor diagram of an ideal transformer.

i) Transformer cannot be used on DC. Why?

j) What is impedance? Give its unit.

SECTION-B

2. Show that the instantaneous power consumed in a purely resistive circuit is not 5 constant but is fluctuating.

3. An alternating voltage is given as v=400 sin-314t determine its (a) maximum value (b) effective value (c) form factor (d) value of voltage after 0.0025 sec taking reckoning time from the instant when voltage is zero and becoming positive; (e) time after which voltage attains 200 V for the first time.

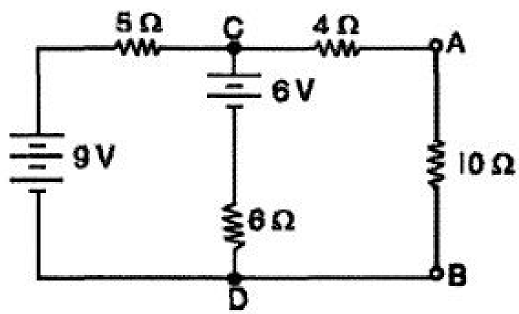
4. A 4-pole, 440V, dc motor takes an armature current of 50A. The resistance of 5 the armature circuit is 0.28 ohm. The armature winding is wave connected with 800 conductors and the useful flux is 23mWb.

   Calculate :

   a) The back emf.

   b) Speed of the motor.

5. Using Thevenin's theorem, find p.d. across terminals AB.



SECTION-C

6. Discuss the following three phase transformer connections :

   (a) Star-Delta connection

   (b) Star-star connection.

7. What is a fuse? For a one time use type of fuse what do the following convey :

   a) Fuse Current Carrying Capacity

   b) Breaking capacity

   c) I^2t value of fuse

   d) Rated voltage of fuse

8. Discuss the construction of an auto-transformer and derive the expression for the copper savings in it.

9. What is the objective of earthing? Using suitable diagrams explain the different methods of earthing.

NOTE : Disclosure of identity by writing mobile number or making passing request on any page of Answer sheet will lead to UMC against the Student.

Date of Exam
10/06/2023

Section - A

BASIC ELECTRICAL ENGINEERING

Q1→ Answer the following questions in brief:

(a) Define power factor. What is the power factor of a pure capacitor.

Ans= Power factor is the measure of how effectively the incoming power is used in an electrical circuit. There is no power factor involved in DC circuits due to zero frequency. But, in AC circuits, the value of power factor always lies between 0 to 1.

Mathematically,

$$\text{Power Factor (P.F)} = \cos\phi$$

Here ϕ = Phase difference.

- In case of capacitor, the phase difference is 90° (current leads).

Hence, P.F. in case of purely capacitive circuit:

$$P.F = \cos 90 = \underline{0}$$

(b) What is the effect of frequency on inductive reactance?

Ans= Reactance is a property of any electrical component which opposes the change in current. It is denoted by X.

Inductive reactance is mathematically defined as,

$$X_L = \omega L = 2\pi f L$$

f→ frequency of AC supplied

L→ Inductance of Inductor (Henry)

$$\Rightarrow X_L \propto f$$

So, when frequency increases the inductive reactance also increases and when frequency decreases the inductive reactance also decreases.

(c) In a RL series circuit a voltage of 10V at 50 Hz produces a curre[nt] of 700 mA. While the same voltage at 75 Hz produces a 500 mA. What is the value of R and L in the circuit?

Ans: Case I → 10 V at 50 Hz   Current = 700 mA = 0.7 A

Let resistance & inductance be R and L respectively.

∴ $X_{L_1} = 2\pi f_1 L = 100\pi L$ Resistance = R

Impedance = Net Reactance $(Z_1) = \sqrt{X_{L_1}^2 + R^2}$

$$Z_1 = \sqrt{(100\pi L)^2 + R^2}$$

So, Net Current $= \frac{V}{Z_1}$ OR $V = I_1 Z_1$

$$10 = \left(\frac{7}{10}\right)\sqrt{(100\pi L)^2 + R^2}$$

$$\left(\frac{100}{7}\right)^2 = (100\pi)^2 L^2 + R^2 \quad \text{— (1)}$$

Case II. 10 V at 75 Hz   Current = 500 mA = 0.5 A

$$X_{L_2} = 2\pi f_2 L = 2\pi(75)L = 150\pi L$$

Net impedance $(Z_2) = \sqrt{(150\pi L)^2 + R^2}$

∴ $V = I_2 Z_2$

$$10 = (0.5)\sqrt{(150\pi L)^2 + R^2}$$

$$(20)^2 = (150\pi)^2 L^2 + R^2 \quad \text{— (2)}$$

For solving (1) & (2) Subtract Eqn (1) from eqn (2)

$$(20)^2 - \left(\frac{100}{7}\right)^2 = \left((150\pi)^2 L^2 - (100\pi)^2 L^2\right)$$

$$400 - 204.08 = L^2 \pi^2 (10)^2 [15^2 - 10^2]$$

$$195.92 = L^2 (100\pi^2)[225 - 100]$$

$$195.92 = L^2 (100\pi^2)(125)$$

$$195.92 = (123347.07) L^2$$

$$L^2 = \frac{195.92}{123347.07} = 0.001588$$

$$L = 0.03984 \text{ Henry}$$

$$L = 0.04\ H \text{ (Approx)}$$

Putting Value of L in Eqn (2)

$$400 = (150\pi)^2 (0.001588) + R^2$$

$$400 = 352.575 + R^2$$

$$R^2 = 47.424$$

$$R = 6.886\ \Omega \simeq 6.9\ \Omega$$

Answer = Values of R and L are → $R = 6.9\ \Omega \quad L = 0.04\ H$

(d) What is the relation between line and phase values of voltage and current for (i) Star Connection? (ii) Delta connection?

Ans = Star Connection

$$V_{Line} = \sqrt{3}\ V_{Phase}$$

$$I_{Line} = I_{Phase}$$

Delta Connection

$$V_{Line} = V_{Phase}.$$

$$I_{Line} = \sqrt{3}\ I_{Phase}$$

(e) Define (i) Peak factor (ii) Form Factor.

(i) Peak Value ⇒ It is defined as the ratio of peak value to the RMS value of current/voltage.

$$P.F = \frac{V_m}{V_{rms}} = \frac{V_m}{\frac{V_m}{\sqrt{2}}} = \sqrt{2} = 1.414$$

(ii) Form Factor ⇒ It is defined as the ratio of the RMS value to the average value of current/voltage.

$$F.F = \frac{V_{rms}}{V_{avg}} = \frac{\frac{V_m}{\sqrt{2}}}{\frac{2V_m}{\pi}} = \frac{\pi V_m}{2\sqrt{2}\,V_m} = \frac{\pi}{2\sqrt{2}} = 1.11$$

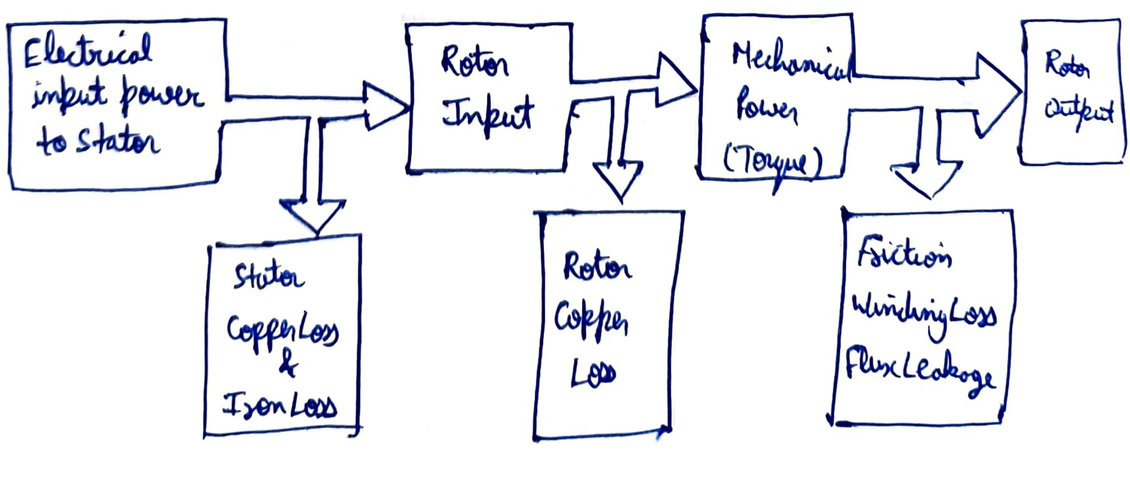
f) What material are used for a transformer (i) Core (ii) Winding?

Ans. (i) Core - Transformer core are made up of soft iron. This is because soft iron is ferromagnetic material which can be magnetised and demagnetized easily.

(ii) Winding - Transformer winding materials are made up of copper which is the best conductor of current at affordable price.

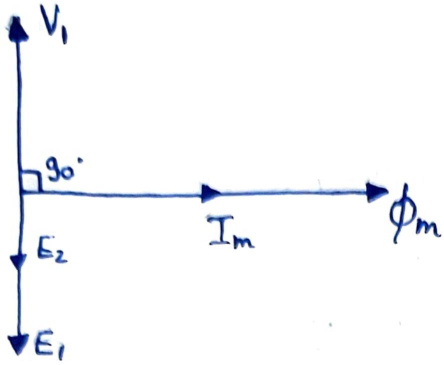
(g) Draw the power flow diagram of an ideal transformer.

Ans-



(h) Draw Phasor diagram of an ideal Transformer.

Ans =



(i) Transformer cannot be used on DC. Why?

Ans = When a dc voltage is applied across the primary of the transformer, the current in primary coil remains constant. Hence there is no change in the magnetic flux linked with the secondary. Thus there is no voltage developed across the secondary coil. That is why dc cannot be used on a transformer.

(j) What is impedance? Give its unit.

Ans = Impedance is the net resistance offered by the components of the electrical circuit. It is the net resultant of resistance and reactance. Mathematically,

$$Z = \sqrt{R^2 + X_T^2}$$

* The units of impedance is Ohm (Ω).

Section-B

Q2- Show that the instantaneous power consumed in a purely resistive circuit is not constant but is fluctuating.

Ans- In a DC supply circuit, the product of voltage and current is known as the power in the circuit. Similarly, the power is the same in the AC circuit also, the only difference is that in the AC circuit the instantaneous value of voltage and current is taken into consideration.

Instantaneous power = $(V_m \sin\omega t)(I_m \sin\omega t)$

$$P = \frac{V_m I_m}{\sqrt{2}\sqrt{2}} (\sin\omega t)(\sin\omega t)$$

$$P = \frac{V_m I_m}{2} (1 - \cos 2\omega t)$$

Average value of $\cos\omega t$ is 0

$$\therefore P = \frac{I_m}{\sqrt{2}} \frac{V_m}{\sqrt{2}} = V_{rms} I_{rms}$$

P - Average Power

V_{rms} - Root mean square value of supply voltage

I_{rms} - Root mean square value of current

The instantaneous Power, depends on the input $V_{instantaneous}$. Hence the power at any instant is not constant

Q3. An alternating voltage is given as $v = 400 \sin 314t$. Determine its (a) maximum value (b) effective value (c) ~~value of~~ form factor (d) Value of voltage after 0.0025 sec taking reckoning time from the instant when voltage is zero and becoming positive; (e) time after which voltage attains 200V for first time.

Ans.

(a) Maximum value - Maximum Value = $V_m = 400V$

(b) Effective Value - $V_{rms} = \frac{V_m}{\sqrt{2}} = \frac{400}{\sqrt{2}} = 200\sqrt{2} = 282.84V$

(c) Form Factor - $FF = \frac{V_{rms}}{V_{avg}} = \frac{\pi}{2\sqrt{2}} = 1.11$

(d) Voltage after 0.0025 sec →

$$V = 400 \sin 314t$$

$$V = 400 \sin 100\pi t$$

$$V_{0.0025} = 400 \sin(100\pi \times 0.0025)$$

$$= 400 \sin(0.25\pi) = 400 \sin\left(\frac{\pi}{4}\right)$$

$$= \frac{400}{\sqrt{2}} = 200\sqrt{2} = 282.84V$$

(e) time after which V = 200 →

$$200 = 400 \sin(100\pi t_1)$$

$$\frac{1}{2} = \sin(100\pi t_1)$$

$$\sin\left(\frac{\pi}{6}\right) = \sin(100\pi t_1)$$

$$100\pi t_1 = \frac{\pi}{6}$$

$$t_1 = \frac{1}{600}$$

$t_1 = \frac{1}{600}$ sec = 0.001667 sec

Q4 A 4-Pole, 440V, dc motor takes an armature current of 50A, The resistance of the armature circuit is 0.28 ohm. The armature winding is wave connected with 800 conductors and the useful flux is 23 mWb.

Calculate:

(a) The back emf

(b) speed of the motor

Ans

Number of poles = 4

Supply voltage = 440 V

Armature Current I_a = 50 A

Armature Resistance = 0.28 ohm

Armature Conductor (Z) = 800

Wave Connected [winding] - [A = 2]

flux ϕ = 0.023 wb

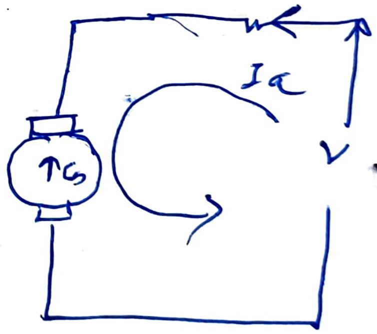
[For dc Machine]

$$E_b = \frac{P\phi NZ}{60A}$$

To find:

Back Emf E_b = ?

Speed of Motor = ?



$$E_b = V - I_aR_a$$

$$= 440 - 50 \times 0.28$$

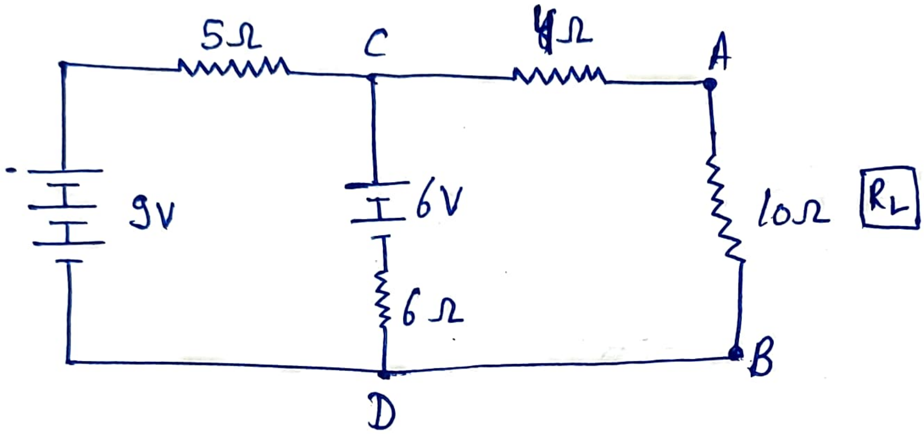
$$\boxed{E_b = 426\ V}$$

$$E_b = \frac{P\phi NZ}{60A} = \frac{4 \times 0.023 \times N \times 800}{60 \times 2}$$

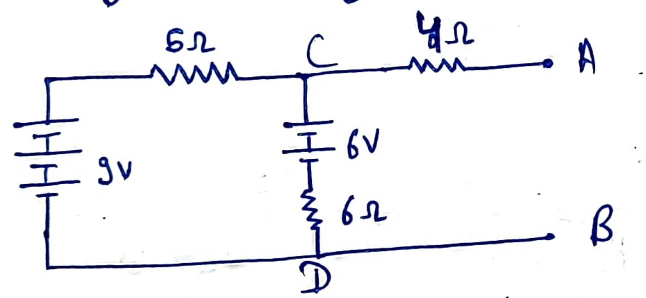
$$\frac{426 \times 60 \times 2}{4 \times 0.023 \times 800} = N$$

$$\boxed{N = 694\ rpm}$$

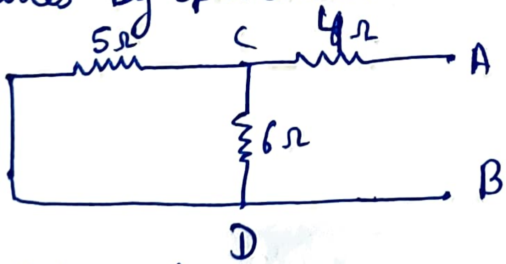
Q5- Using thevenin's theorem, find P.D. across terminals A B.



Sol: ① Removing R_L & Replacing with Open Circuit



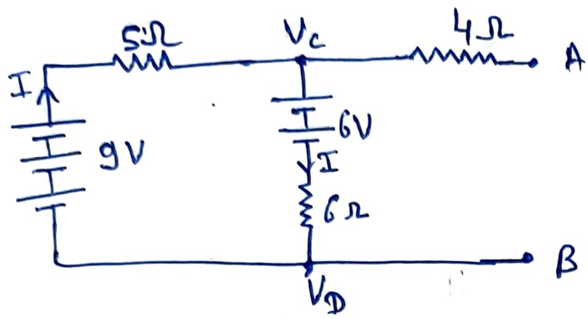
② Replacing Voltage sources by internal resistance and current sources by open circuit.



③ Calculate Equivalent Resistance across A & B terminals -

$$R_{Th} = \frac{30}{11} + 4 = 6.72\Omega = 6.72\Omega$$

(4.) Calculate the value of E_{TH}.



$9 - 5I - 6 - 6I = 0$

$3 - 11I = 0$

$3 = 11I$

$I = \frac{3}{11} = 0.2727$

$V_C = 9 - 5(0.272) = 7.63$

$E_{TH} = V_C - V_D = 7.63V$

$I_{Load} = \frac{V_{TH} \text{ OR } E_{TH}}{R_{TH} + R_L} = \frac{7.63}{6.72 + 10} = \frac{7.63}{16.72}$

$I_L = 0.456A$

P.D across AB $= I_L \times R_L$

$= 0.456 \times 10$

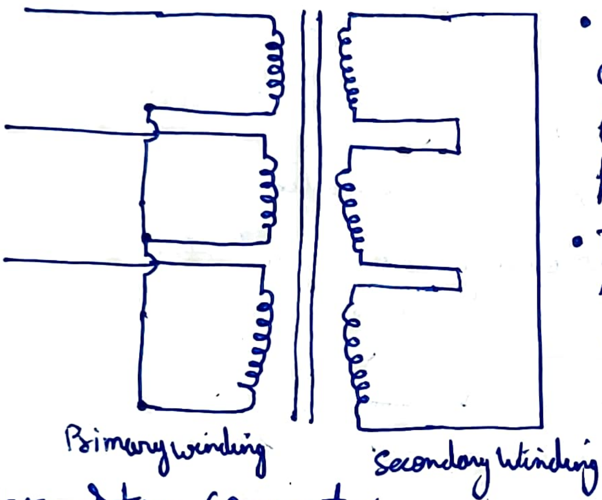
$= 4.56V$

Section-C

Q6→ Discuss the following three phase transformer connections:

(a) Star-Delta connection

In star-delta connection of a transformer, the primary winding of the transformer is connected in star while the secondary winding is connected in delta.

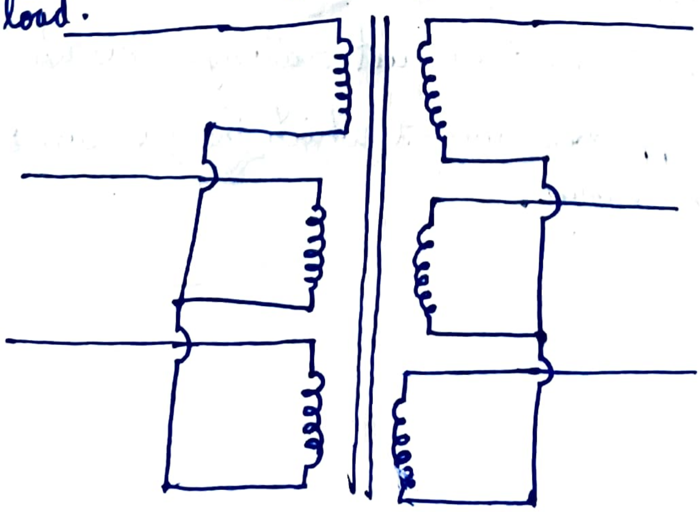


- Since the primary winding is connected in star fashion, the primary line voltage is $\sqrt{3}$ times the phase voltage on the primary side
- The secondary winding is connected in delta, the line current will be $\sqrt{3}$ times the phase current on the secondary side.

(b) Star-Star Connection

In case of star-star connection:

↳ In primary winding as well as secondary winding, each phase is 120° electrical degrees out of phase with the other two phases. In both the sides the line voltage is $\sqrt{3}$ times the phase voltage. Hence less number of turns is required. Also the stress on insulation is less. This makes the connection economical for small-high voltage purposes. It can also handle very heavy load.



Q7. What is a fuse? For a one time use type of fuse what do the following convey:

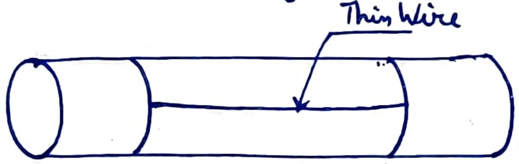
(a) Fuse Current carrying capacity

(b) Breaking Capacity

(c) I^2t Value of fuse

(d) Rated voltage of fuse.

Sol: A fuse is a safety device connected in series in the main circuit. It works on the principle of heating effects of electric current. It contains of a very thin piece of wire which melts when any excess current flows due to overloading, short circuit etc.



A small Fuse

(a) Fuse Current carrying capacity

Fuse current carrying capacity determines the amount of current the given fuse can handle easily. Current carrying capacity depends on the metal used and the cross sectional area and also depends upon the length. More the cross sectional area, more the current carrying capacity.

(b) Breaking Capacity

It is also known as short circuit rating. This refers to the maximum approved current which the fuse can safely break at rated voltage.

(c) I^2t value of fuse

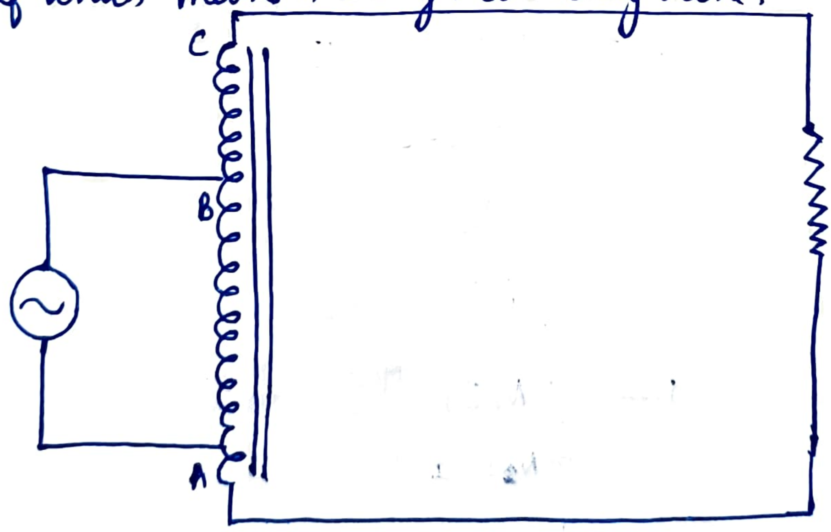
It is an expression of the available thermal energy resulting from current flow. It refers to the required thermal energy for the melting of the fuse wire.

(d) Rated voltage of fuse

Rated voltage of a fuse determines the maximum voltage a fuse can safely be used. The rated voltage of a fuse must be greater than or equal to the operating voltage of the fuse, otherwise, the fuse will malfunction.

Q8- Discuss the construction of an auto-transformer and derive the expression for the copper savings in it.

Ans- Auto-transformer is a type of transformer with only one (type) winding. The "Auto" word in its name refers to the greek meaning "self" which means the single coil acting alone.



An auto-transformer is usually constructed from a single winding with multiple taps. AB refers to the primary winding and AC act as the secondary winding. This works on the principle of self induction.

* Copper saving

- **Two winding transformer**

Weight of Cu required $= (I_1 N_1 + I_2 N_2)$

- **Auto Transformer**

weight of Cu required in A to B section $= I_1 (N_1 - N_2)$

weight of Cu required in section B-C $= (I_2 - I_1) N_2$

Total weight of Cu in auto-transformer →

$$I_1 (N_1 - N_2) + (I_2 - I_1) N_2$$

$$\frac{\text{Weight of Cu in auto-transformer}}{\text{weight of Cu in ordinary transformer}} = \frac{W_A}{W_o} = \frac{I_1 (N_1 - N_2) + (I_2 - I_1) N_2}{I_1 N_1 + I_2 N_2}$$

$$\frac{W_A}{W_o} = \frac{N_1 I_1 - N_2 I_1 + N_2 I_2 - N_2 I_1}{N_1 I_1 + N_2 I_2}$$

$$\frac{W_A}{W_o} = \frac{N_1 I_1 + N_2 I_2 - 2 N_1 I_1}{N_1 I_1 + N_2 I_2}$$

$$\frac{W_A}{W_o} = 1 - \frac{2 N_2 I_1}{N_1 I_1 + N_2 I_2}$$ (But $N_1 I_1 = N_2 I_2$)

$$= 1 - \frac{2 N_2 I_1}{2 N_1 I_1}$$

$$\frac{W_A}{W_o} = 1 - \frac{N_2}{N_1} = 1 - K$$

$W_A = (1-K)\ W_o$

∴ <u>Saving in copper:</u>

$$\text{Saving} = W_o - W_A = W_o - (1-K)W_o$$

$$= KW_o$$

⇒ Saving in Copper = $K \times W_{ordinary}$.

<u>Q9</u>- What is the objective of earthing? Using suitable diagrams explain the different methods of earthing.

<u>Ans</u>- Electricity has a lot of uses and applications in our lives but it is no doubt very dangerous for human beings to handle. Every year, several millions of people experience serious electric shocks and several thousands loose their lives due to this.

The objective of earthing is to provide an alternate path for any leaked current and protecting human body from the electric shocks.

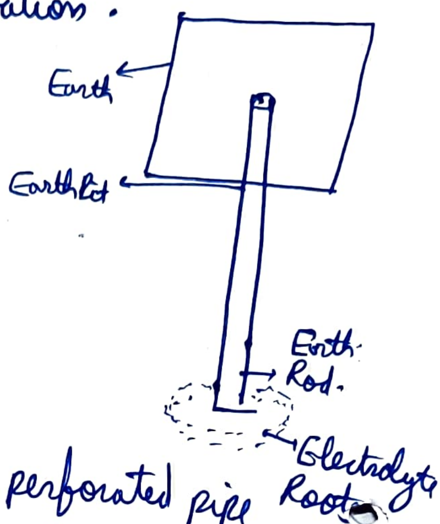
Earthing also prevents damage caused by the lightening.

<u>Various methods of earthings are:</u>

1.) <u>Strip Earthing</u>: In this method of earthing, strip electrodes of cross section not less than 25 mm × 1.6 mm is burried in a horizontal trenches of a minimum depth of 500m. The length of conductor burried must be greater than 15m. This type of earthing is used where the earth bed has rocky soil and excavation is difficult.

2.) <u>Rod Earthing</u> - It is the cheapest method of Earthing and is employed in sandy areas. In this method, a copper rod is hammered directly into the ground without excavation.

Rod is 12.5mm in diameter of galvanised steel of length 2.5m.



3.) <u>Pipe Earthing</u> - A galvanized steel and a perforated pipe of approved length and diameter is placed vertically in wet soil. In this kind of system of earthing, the size of the pipe to use depends upon the magnitude of current and the type of soil.

Dimension of Pipe in Ordinary Soil ⇒ length → 2.75m, diameter → 40mm.

4.) <u>Plate Earthing</u> - In this method of Earthing a plate made up of copper with dimension 60cm × 60cm × 3.18mm or galvanised iron of dimension 60cm × 60cm × 6.35mm is burried vertical in the earth which should not be less than 3m from the ground. The layer of charcoal shall be placed immediately over the plate and thereafter successive layers of salt and these alternate layers are laid to keep the surroundings sufficiently moist.