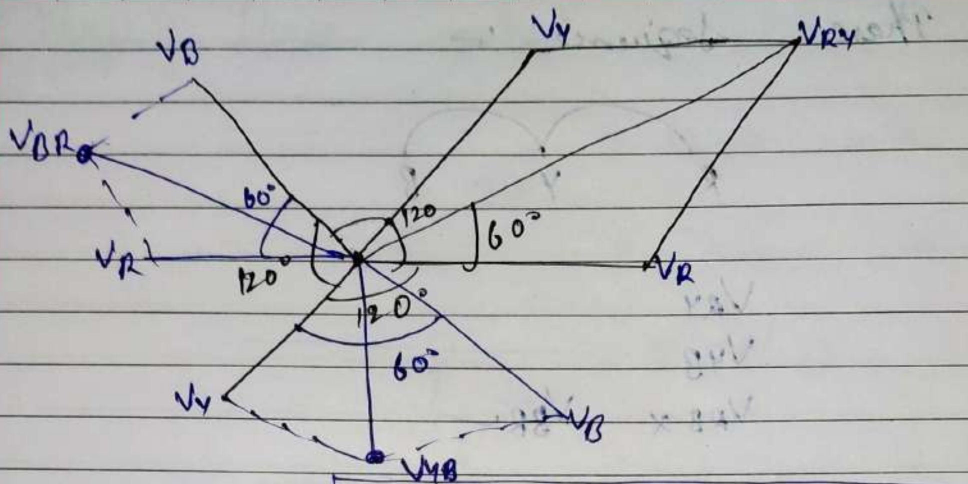
Date |
Page |



$$V_{RY} = \sqrt{V_R^2 + V_Y^2 + 2 V_R V_Y \cos 60°}$$

$$V_R = V_Y = V_B = V_P$$

$$V_{RY} = V_{YB} = V_{BR} = V_L$$

$$V_L = \sqrt{V_P^2 + V_P^2 + \cancel{2} V_P \cdot V_P \frac{1}{\cancel{2}}}$$

$$V_L = \sqrt{3 V_P^2}$$

$$\boxed{V_L = \sqrt{3}\, V_P} \qquad \boxed{I_L = I_P}$$

Active Power (P) $= V_{rms} I_{RMS} \cos\phi$

$$P = V_P I_P \cos\phi$$

$$\boxed{P = 3 V_P I_P \cos\phi}$$ – {This is for three phase}

$$P = 3 \times \frac{V_L}{\sqrt{3}} \times I_L \cos\phi$$

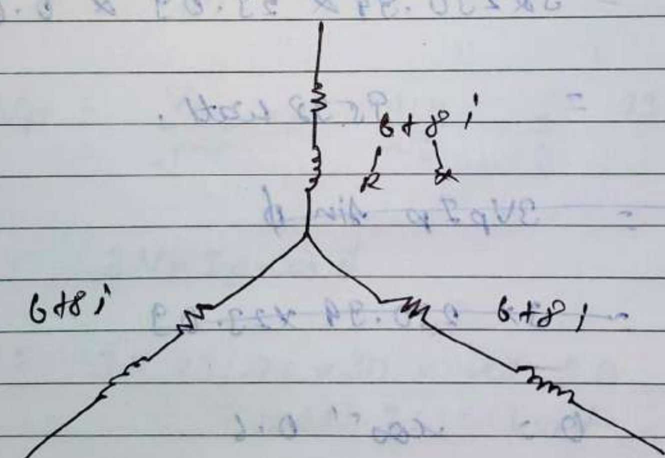
$$P = \sqrt{3}\, V_L I_L \cos\phi$$

Reactive Power (Q) = $V_{rms} I_{rms} \sin\phi$

$$= V_p I_p \sin\phi$$

$$= 3 V_p I_p \sin\phi$$

Qu) 2 A star connected system have impedence of 6+8i in each phases and ~~its~~ is connected across balanced 400 V 3 phase supply obtain the line current and total real power, ~~active power~~) Reactive power.



Solu) Given, $V_L = 400$.

(i) : Impedance $(Z_p) = \sqrt{R_p^2 + X_p^2}$

$$= \sqrt{6^2 + 8^2}$$

$$= 10\ \Omega$$

(ii) $V_p = \frac{V_L}{\sqrt{3}} = \frac{400}{\sqrt{3}} = 230.9$ V

Date |
Page |

(3.) $I_p = \frac{V_p}{Z_p} = \cancel{\frac{230}{}} \frac{230.94}{10}$

$= 23.09 A$

(4.) $I_p = I_L$

$I_p = 23.09\ A$

(5.) $\cos\phi = \frac{R_p}{Z_p} = \frac{6}{10} = 0.6$ lagging

(6.) $P = 3 V_p I_p \cos\phi$

$= 3 \times 230.94 \times 23.09 \times 0.6$

$= 9598$ watt.

~~(7) $Q = 3 V_p I_p \sin\phi$~~

~~$= 3 \times 230.94 \times 23.09$~~

$\theta = \cos^{-1} 0.6$

(7) $Q = 3 V_p I_p \sin \cos^{-1} 0.6$

$= 3 \times 230.94 \times 23.09 \times \sin 53.13$

$= 12799$ VAR

Date |
Page |

Qn) A balance star connected load supplied from a symmetrical 3 phase 410 V system the current in each phase is 30 A and lag 30° behind the phase voltage. Calculate

(i) Phase voltage
(ii) Total power (Active power)
(iii) Reactive power.

Soln ⇒ Given,

$V_L = 410\ V$
$I_P = 30\ A$
$\phi = 30°$

$\therefore$ (1) $V_P = \frac{V_L}{\sqrt{3}} = \frac{410}{\sqrt{3}} = 236.71\ V$

(2) $P = 3 V_P I_P \cos\phi$

$= 3 \times 236.71 \times 30 \times \cos 30$
$= 18449.71$ watt

(3) $Q = 3 V_P I_P \sin\phi$
$= 3 \times 236.71 \times 30 \times \sin 30°$
$= 10651.95\ V_{AR}$.

Qn) 3 equal star connected inductor (impedance) take 9KW at power factor of 0.8 lagging connected to 960 v supply. calculate
(i) per phase load resistance ~~&~~ inductance?

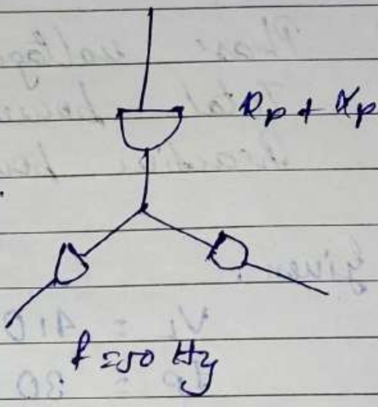
Soln Given,

$V_L = 960\,V$

$\cos\phi = 0.8$ lagging

$f = 50\,Hz$

$p = 9\,kW = 9\times10^{-3}\,W$



$V_p = \frac{960}{\sqrt{3}} = 554.2$

$\because P = 3 V_p I_p \cos\phi$

$\frac{9\times10^{-3}}{3\times\frac{960}{\sqrt{3}}\times0.8} = I_p$

$\frac{9\times10^{-3}}{1330.2} = I_p$

$I_p = 6.76$

$\because V_p = I_p Z_p$ — (ohm's law)

$\therefore Z_p = \frac{V_p}{I_p}$

$= \frac{554.2}{6.76} = 81.98$.

$$\cos\phi = \frac{R_P}{Z_P}$$

$$0.8 = \frac{R}{81.98} \Rightarrow R_P = 65.584.$$

$$\therefore Z_P = \sqrt{R_P^2 + X_P^2}$$

$$\cancel{= \sqrt{(65.584)^2 +}}$$

$$X_P = \sqrt{Z_P^2 - R_P^2}$$

$$= \sqrt{(81.98)^2 - (65.584)^2}$$

$$= 49.188.$$

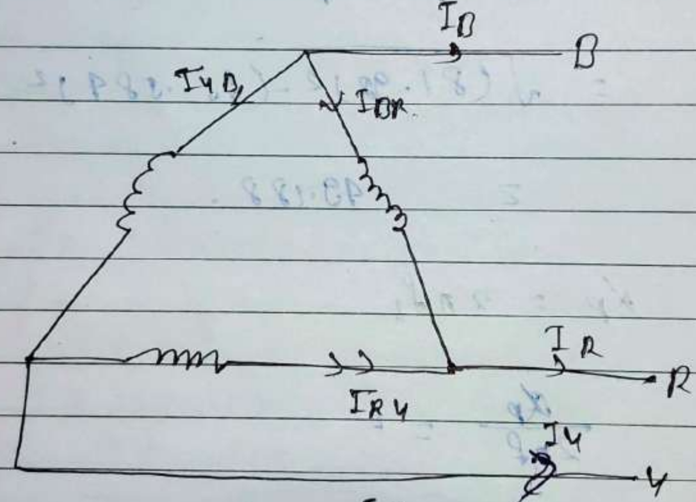
$$X_P = 2\pi f L$$

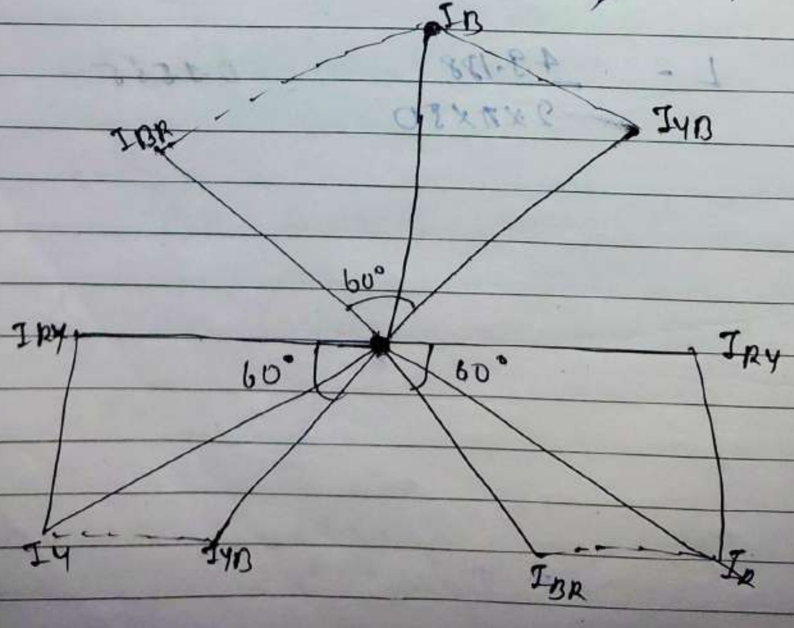
$$\frac{X_P}{2\pi f} = L$$

$$L = \frac{49.188}{2 \times \pi \times 50} = 0.1565$$

Q.) Relation b/w Line current and phase current in Delta connected system :-

Star connected system	Delta connected system
$V_R = V_Y = V_B = V_p$	$I_R = I_Y = I_B = I_L$
$V_{RY} = V_{YB} = V_{BR} = V_L$	$I_{RY} = I_{YB} = I_{BR} = I_p$





$$I_R = \sqrt{I_{RY}^2 + I_{BR}^2 + 2 I_{RY} 2 I_{BR} \cos 60^\circ}$$

$$I_L = \sqrt{I_p^2 + I_p^2 + 2 I_p I_p \frac{1}{2}}$$

$$I_L = \sqrt{3 I_p^2}$$

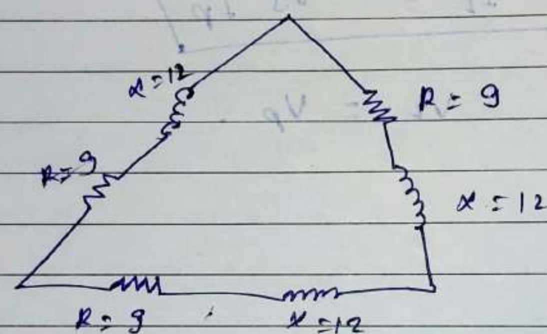
$$\boxed{I_L = \sqrt{3} I_p}$$

$$V_L = V_p$$

Date |
Page |

Qu) Three similar coil A, B, C are available each coil has 9Ω resistance and 12 Ω reactance. They are connected in Delta. Three phase 440 volt 50 Hz supply. Calculate (i) line current (I_L)
(ii) Power factor ($\cos\phi$)
(iii) Total kilo volt ampere.
(iv) Total kWatts

soln



$$9 + 12i$$

$$V_L = 440$$

$$\therefore \; Z_p = \sqrt{R_p^2 + X_p^2}$$

$$= \sqrt{9^2 + 12^2}$$

$$= \sqrt{81 + 144}$$

$$= \cancel{\sqrt{225}}\ 15.$$

$$I_p = \frac{V_p}{Z_p} = \frac{440}{15} = 29.33.$$

(i) $I_L = \sqrt{3}\, I_p$

$= \sqrt{3} \times 29.33 = 50.80$

Date |
Page |

(ii) $\cos\phi = \frac{R_p}{Z_p}$

$= \frac{9}{15} = 0.6$

(iii) $S = \sqrt{3}\, V_L I_L$

$= \sqrt{3} \times 440 \times 50.80$

$= 38714.79 \text{ VA} \Rightarrow 38.714 \text{ kVA}$

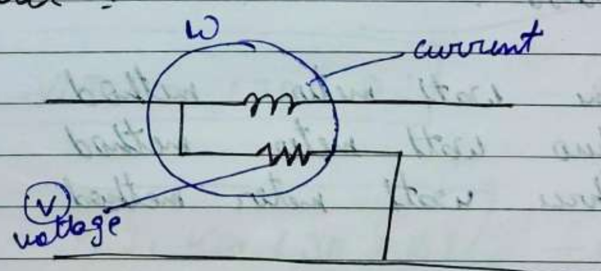
(iv) $P = \sqrt{3}\, V_L I_L \cos\phi$

$= \sqrt{3} \times 440 \times 50.80 \times 0.6$

$= 23228.8 \text{ W}$

$= 23.228 \text{ kW}$. Ans

A.) Watt Meter :-



1.) Watt meter is the instrument which is used for measuring the power in the circuit.

11.) It consists of two coils one is the low resistance coil connected in series with the line carrying the current. The coil is known as current coil

Date |
Page |

iii.) Second coil has high resistance and connected across terminal the coil is known as voltage coil or pressure coil

$$R = \frac{\rho l}{A}$$

$$R \propto \frac{1}{A}$$

where, $\rho =$

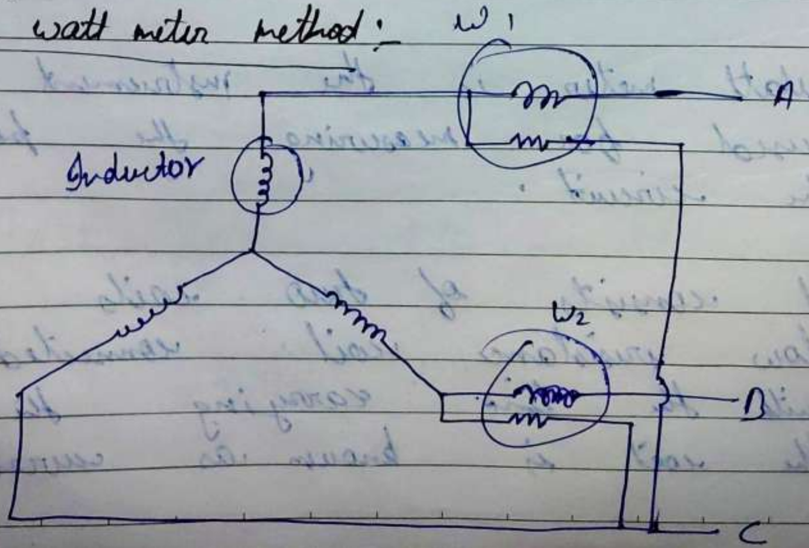
$l =$

$A =$

4.) Measurement of power by Watt meter method :-

1.) One watt meter method
V.V.I 2.) Two watt meter method
3.) Three watt meter method

2.) Two watt meter method :-

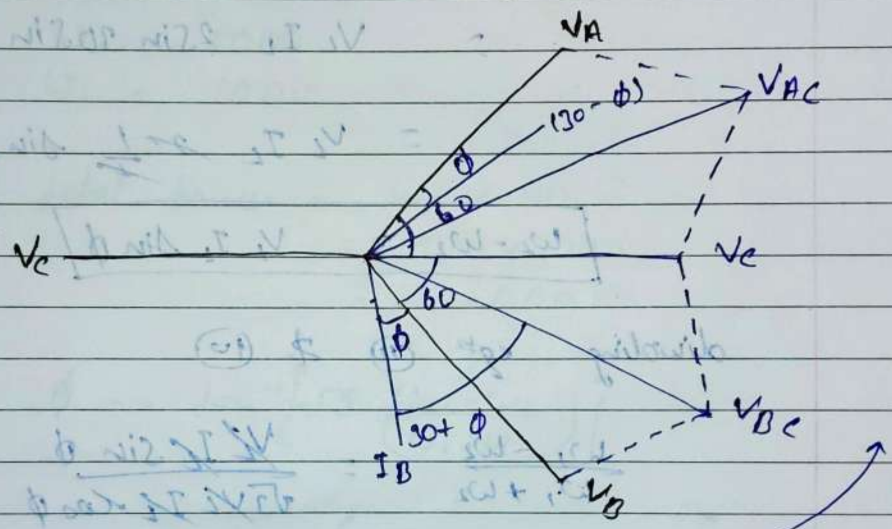


Active power (P) = $V_{rms} I_{rms} \cos\phi$

$\therefore \; W_1 = V_{AC} I_A \cos\phi$

&

$W_2 = V_{BC} I_B \cos\phi$



$$\boxed{W_1 = V_L I_L \cos(30-\phi)} \quad \text{— (I)}$$

$$\boxed{W_2 = V_L I_L \cos(30+\phi)} \quad \text{— (II)}$$

Now adding eq^n (I) & (II)

$$W_1 + W_2 = V_L + I_L [\cos(30-\phi) + \cos(30+\phi)]$$

$$= V_L + I_L (2 \cos 30 \cos\phi)$$

$$= V_L + I_L \left(2 \times \frac{\sqrt{3}}{2} \cos\phi\right)$$

$$W_1 + W_2 = V_L \; I_L \sqrt{3} \cos\phi$$

$$\boxed{W_1 + W_2 = \sqrt{3}\, V_L I_L \cos\phi} \leftarrow \text{(iii)}$$

Subtracting eq^n (i) & (ii),

$$W_1 - W_2 = V_L I_L [\cos(30-\phi) - \cos(30+\phi)]$$

$$= V_L I_L \, 2\sin 30 \sin\phi$$

$$= V_L I_L \, \cancel{2} \cdot \frac{1}{\cancel{2}} \sin\phi$$

$$\boxed{W_2 - W_2 = V_L I_L \sin\phi} \leftarrow \text{(iv)}$$

dividing eq^n (iii) & (iv)

$$\frac{W_1 - W_2}{W_1 + W_2} = \frac{\cancel{V_L} \cancel{I_L} \sin\phi}{\sqrt{3}\cancel{V_L}\cancel{I_L}\cos\phi}$$

$$\Rightarrow \frac{W_1 - W_2}{W_1 + W_2} = \frac{\tan\phi}{\sqrt{3}}$$

$$\therefore \tan\phi = \sqrt{3}\,\frac{W_1 - W_2}{W_1 + W_2}$$

&

$$\phi = \tan^{-1}\sqrt{3}\,\frac{W_1 - W_2}{W_1 + W_2}.$$

Date |

Page |

Ans) In a power measurement the wattmeter reading where 5000 & 1000 watt. Calculate the total power and power factor. If the both meter read positive value.

Solu) Given

$W_1 = 5000$

$W_2 = 1000$

$\therefore$ total power $= W_1 + W_2$

$= 5000 + 1000$

$= 6000$

&

$\phi = \tan^{-1}\left[\sqrt{3}\left(\frac{W_1 - W_2}{W_1 + W_2}\right)\right]$

$\Rightarrow \tan^{-1}\left(\sqrt{3}\left(\frac{5000-100}{600}\right)\right)$

$\Rightarrow \tan^{-1}\left[\sqrt{3}\left(\frac{4000}{6000}\right)\right]$

$= \tan^{-1}\left(\sqrt{3} \times \frac{4}{6}\right)$

Date |
Page |

Ques) Three phase balanced load connected across ~~300~~ three phase 400 V a.c. Draw a line current of 10A. ($V_L = 400V$) Two watt meter are used to measure input the ratio of two watt meter is 2:1. find the reading of 2 wattmeter.

Solu => Given,

$V_L = 400$

$I_L = 10$

$\frac{W_1}{W_2} = \frac{2}{1}$

$\therefore \phi = \tan^{-1} \sqrt{3} \frac{W_1 - W_2}{W_1 + W_2}$

$\Rightarrow \cancel{\tan^{-1} \sqrt{3} \frac{W_2/W_1 \; W_1(1 - W_2/W_1)}{W_1(1 + \frac{W_2}{W_1})}}$

$\Rightarrow \cancel{\tan^{-1} \sqrt{3} \left(\frac{1 - \frac{2}{1}}{1 + \frac{2}{1}}\right)}$

$\Rightarrow \cancel{\tan^{-1} \sqrt{3}}$

$\Rightarrow \cancel{\tan^{-1} \sqrt{3} \frac{W_1 (1 - \frac{W_2}{W_1} - 1)}{W_1 (1 \cdot}}$

$\Rightarrow \cancel{\tan^{-1} \sqrt{3} \frac{W_1 (1 - W_2/W_1)}{W_1 (1 + W_2/W_1)}}$

$\Rightarrow \frac{1 - 2}{1}$

$\Rightarrow \tan^{-1}\frac{1}{\sqrt{3}}$

$\phi \Rightarrow 30°$ lagging.

$\therefore W_1 = V_L I_L \cos(30 - \phi)$

$= 400 \times 10 \times \frac{\sqrt{3}}{2} \times \frac{\sqrt{3}}{2}$

$=$

$\cancel{400 \times 10 \times \frac{3}{4}}$ 100 4000 watt. Ans

$\Rightarrow$ ~~3000 watt.~~

$W_2 = V_L I_L \cos(30 + \phi)$

$= 400 \times 10 \cos 60°$

$=$ 2000 watt. Ans.

Date |
Page |

Qn.) The power input to a 2000 V, 50 Hz three phase motor running at full load at an efficiency of 90% is measured by ~~which~~ 2-wattmeter which indicates 300 kW and 100 kW respectively. Calculate,

1. Input power
2. Power factor
3. Line current
4. Hp output (Horse power)

Given,

$V_L = 200 V$

(η) efficiency = 90%

$W_1 = 300 kW$

$W_2 = 100 kW$

Active power /

(1) Input power (P) = $W_1 + W_2$

$= 300 + 100$

$= 400 kW$

$= 400 \times 10^3 W$

(11) $\phi = \tan^{-1} \sqrt{3} \left(\frac{W_1 - W_2}{W_1 + W_2} \right)$

$= \tan^{-1} \sqrt{3} \left(\frac{300 - 100}{300 + 100} \right)$

$= \tan^{-1} \sqrt{3} \frac{1}{2}$

$= \tan^{-1} \frac{\sqrt{3}}{2}$ $=$ ~~30~~ 40.89.

$$\boxed{1\ H.P = 746\ V}$$

Date |
Page |

$\therefore \cos\phi = \cos(40.89)$

$\cos\phi = 0.75$

(iii) ~~Line current (I_L)~~ =

$P = \sqrt{3}\, V_L I_L \cos\phi$

$$I_L = \frac{400 \times 10^3}{\sqrt{3} \times 2000 \times .756}$$

$= 152.73$

(iv) $\because \eta = \frac{\text{Output power}}{\text{Input power}}$

$$\frac{90}{100} = \frac{\text{Output power}}{400 \times 10^3}$$

O/P power $= 0.9 \times 400 \times 10^3$

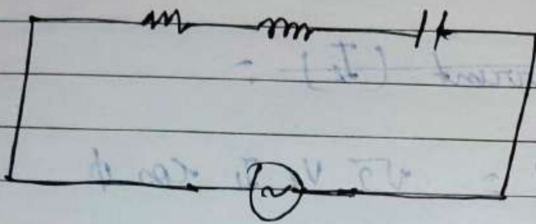
$= 360000$

So, H.P output $= \frac{360000}{746}$

$= 482.57$ Hp.

$\boxed{X_L = X_C}$

Series Resonance circuit / Resonance frequency / Resonance condition :-



$$X_L = X_C$$

$$2\pi f L = \frac{1}{2\pi f C}$$

$$f^2 = \frac{1}{4\pi^2 L C}$$

$$\boxed{\therefore f = \frac{1}{2\pi\sqrt{LC}}}$$

Advantages of three phase system over a single phase system :-

1.) Single phase motor used only domestic purpose, three phase motor used only industrial purpose.

11.) Single phase motor are not self starting motor. They need special arrangement for starting three phase motor are self starting motor.

iii.) Three phase system is more capable and reliable as compair to single phase motor.

iv.) Efficiency and power factor of three phase motor are more as compair to single phase motor.

v.) Three phase system is widely used in generation, transmission and distribution, single phase system is only used to operat small electrical appliances.

vi.) Three phase motor will have uniform torque, single phase motor will have pulsatting torque.

vii.) The output of three phase machine is always greater than the single phase machine.

Date 14/05/25

Unit → 03

Transformer

1.) What is transformer :-
2.) Basic principle of single phase transformer
3.) Emf equation of " " "
4.) construction of Transformer
5.) Equivalent circuit for single phase transformer
6.) Voltage Regulation OR Regulation of transformer
7.) Efficiency of single phase transformer.
8.) Open circuit and short circuit test of single phase transformer.
9.) phasor diagram of single phase transformer.

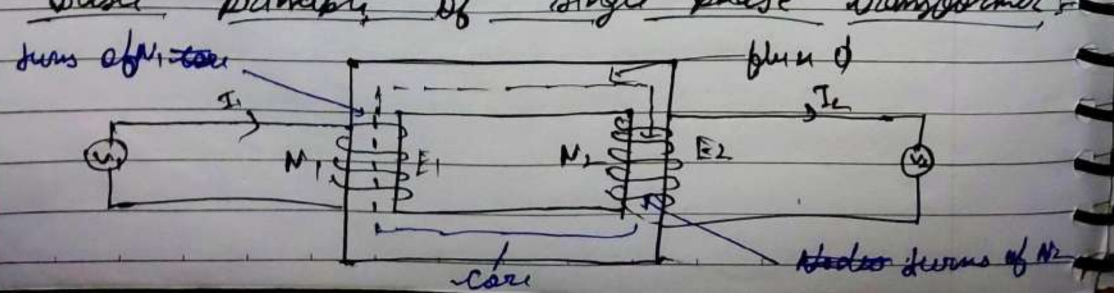
1.) What is transformer ?

Ans → Transformer is a device which convert high voltage to low voltage and low voltage to high voltage at constant frequency.

$$V = e = -N\frac{d\phi}{dt} \qquad \boxed{V \propto N}$$

fareaday's law to electromagnetic Induction :-

2.) Basic principle of single phase transformer :-



Date |
Page |

1.) Transformer is based on the principle of Farraday's law of electromagnetic induction or mutual induction.

11.) A transformer consist of two binding :-
a.) Primarry binding b.) Secondary binding

that are electrically isolated from each other.

111.) When a alternating voltage is applied to one binding (primarry binding) it setup an alternating flux in the core most of the flux linked with the other binding (secondary binding).
According to farradays law of electromagnetic induction emf. will be induced in secondary winding of the coil.

IV.) If the other winding (secondary winding) is connected to load the induced emf circulate a current in it (I_2).

V.) Thus, the power is transfered from one winding to other through the magnetic flux in the core.

Date |
Page |

*.) Emf Equation of single phase transformer:-

#.) Voltage Ratio, current Ratio, turn ratio:-

$$\boxed{K = \frac{V_2}{V_1} = \frac{N_2}{N_1} = \frac{I_1}{I_2}}$$

$$Emf = 4.44 f \phi N$$

for primary voltage,

$$V_1 = V_p = E_1 = E_p = 4.44 f \phi N_1$$

for secondary voltage,

$$V_2 = V_s = E_1 = E_s = 4.44 f \phi N_2$$

Maximum magnetic flux density,

$$B_{max} = \frac{\phi}{A} = \frac{weber}{m^2} = Tesla.$$

Ques) Single phase 50 Hz has 80 turns on the primary winding & 280 on the secondary winding. The voltage applied across the primary winding is 240 V. Calculate
(i) Induced emf in the secondary winding?
ii) Max flux density. The net crossectional area of the core can be taken 200 cm².

Solu:
$f = 50$ Hz
$N_1 = 80$
$N_2 = 280$

0.013

Date |
Page |

$V_1 = 240$

$\therefore \quad \frac{V_2}{V_1} = \frac{N_2}{N_1}$

$$V_2 = \frac{280 \times 240}{80}$$

$$V_2 = 840$$

$$\therefore \phi = \frac{V_1}{4.44 f N_1}$$

$$= \frac{240}{4.44 \times 50 \times 80}$$

$$= 0.0135.$$

(I) $\therefore$ emf $= 4.44 \times 50 \times 0.0135 \times 280$

$= 839.16.$

(II) $B_{max} = \frac{\phi}{A}$

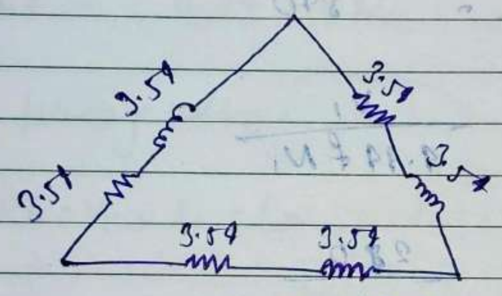
$$= \frac{0.0135}{200 \text{ cm}^2}$$

$$\frac{0.0135}{0.02 \text{ m}} \Rightarrow 0.675 \text{ . Tesla .}$$

Qn) A 3-ϕ balanced system supplies 110V to a delta connected load whose phase impedance is equal to $(3.54 + j3.54)\ \Omega$. Determine the line current and draw the phasor diagram.

Solu» Given,

$$V_L = 110V$$



$3.54 + 3.54j$

$$\therefore Z_p = \sqrt{R_p^2 + X_p^2}$$

$$= \sqrt{(3.54)^2 + (3.54)^2}$$

$$= \cancel{16.07}\ 5.$$

$$I_p = \frac{V_p}{Z_p} = \frac{110}{5\ \cancel{16.07}} \Rightarrow \cancel{6.84\ A}\ 22\ A$$

$$I_L = \sqrt{3}\, I_p$$

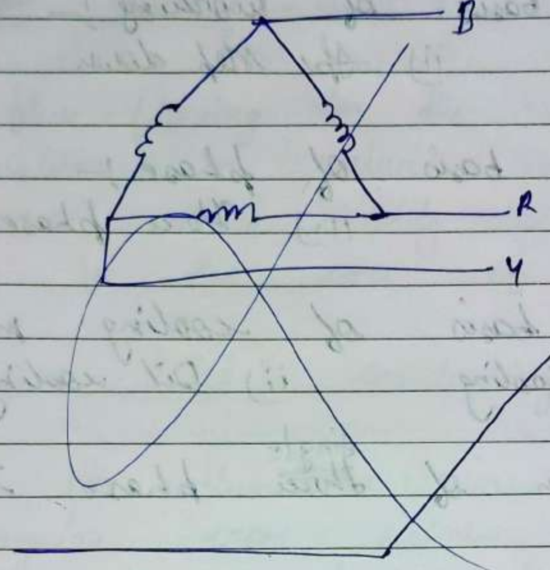
$$= \sqrt{3} \times \cancel{6.84}\ 22$$

$$= \cancel{11.84\ A}\ 38.105.$$

II

Date |

Page |



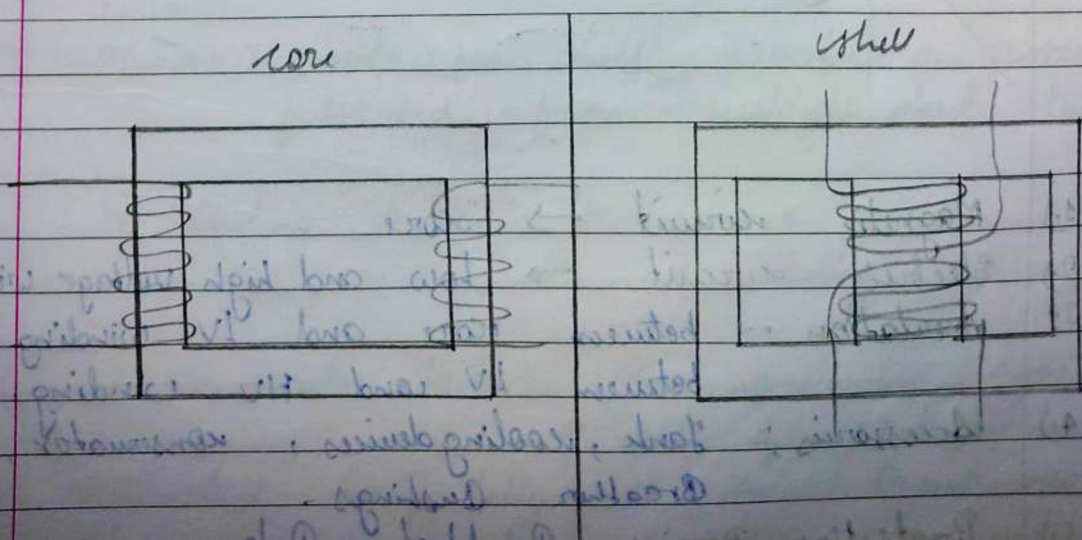
$I_1 - I_2 = 10$

$I_1 = 10 + I_2$

A.) Construction of transformer :-

1.) On the basis of construction

i.) core type ii.) shell type

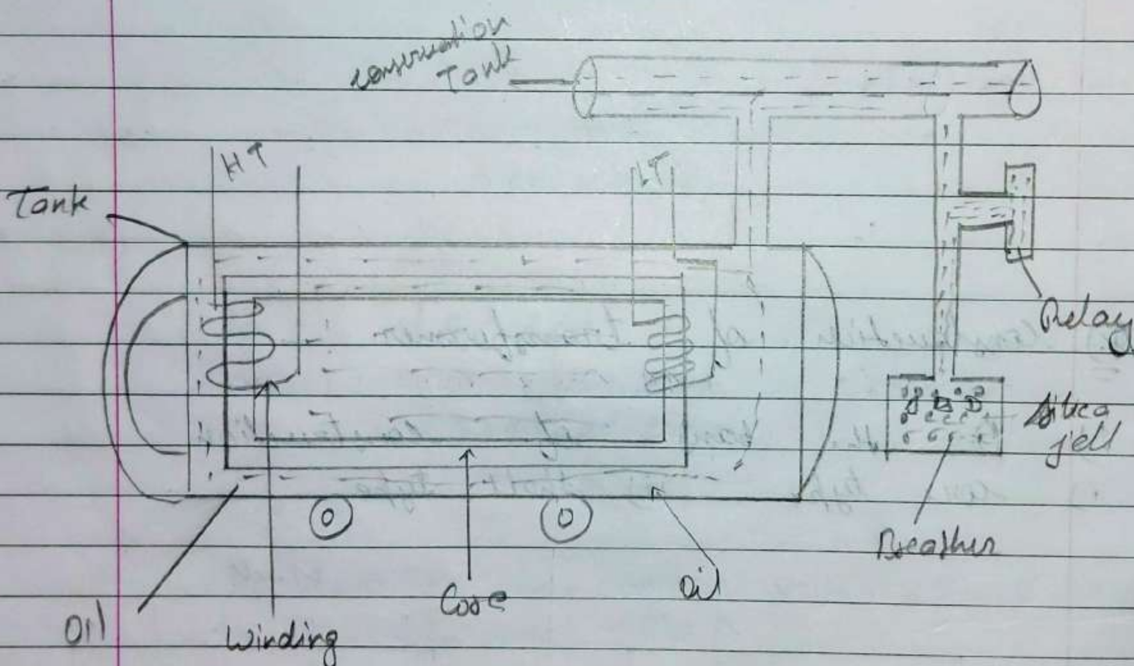


2.) On the basis of working :-
i.) Step-up ii.) ~~Sp~~ step down

3.) On the basis of phase :-
i.) One-phase ii.) Three phase.

4.) On the basis of cooling method :-
i.) Natural cooling ii.) Oil cooling

★) construction of ~~three~~ single phase transformer :-



1.) Magnetic circuit → core
2.) Electric circuit → Low and high voltage winding
3.) Insulation → between core and LV winding, between LV and HV winding.
4.) Accessories :- Tank, cooling devices, conservator, Breather Bushings.
5.) Protection Device :- Buchholz Relay.

1.) Magnetic circuit :- Core ;

The flux flowing in the magnetic frame is alternating in nature and as a result hysteresis and eddy current losses will occur in the core of the transformer.

2.) Electric circuit :- conducting material :-

Copper or alluminium wires of round or rectangular cross section are used for making toward high voltage winding of transformer.

3.) Insulation :- The choice of the insulating material depends on the heat produced due to different losses in the transformer.
Press boards or press papers etc are these material and used as a insulating materials

4.) Accessories :-

a.) Tank :- Tanks for small transformer are fabricated from welded sheet steal.

b.) cooling devices :- Transformer oil is used as a cooling purpose.

c.) Conservator Tank :- The conservator consists of an airtight cylindrical metal dram supported horizontally on the transformer. It is used for maintain the oil level.

d.) Breather :- A breather mounted on the transformer tank contains calcium chloride or silica gel which has the tandency to absorb extrac moisture from air.

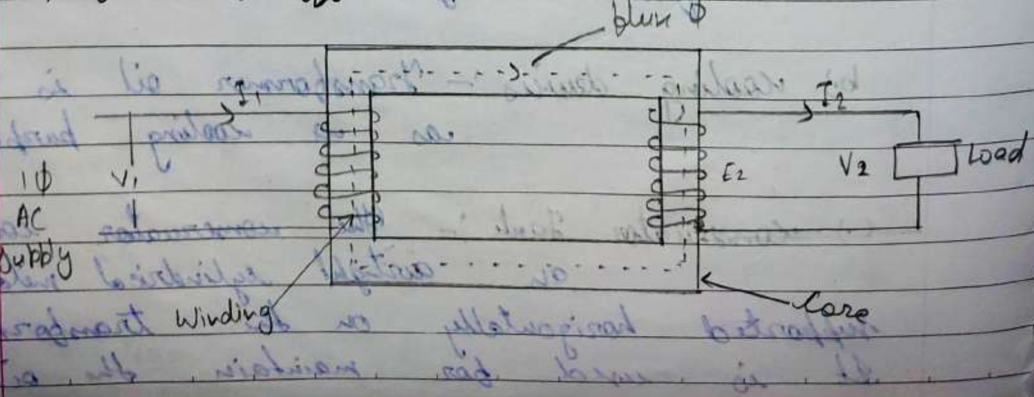
e.) Bushings :-

The terminal connection of the winding are taken to the insulator bushings mounted on the transformer tank top.
The bushings consist of a current carrying part in the form of the conduction rod.

f.) Protection Device :-

Bucholz Relay is a electromagnetic device. It use as a protection ~~of~~ of transformer.

→ Basic Principle / Working Principle of 1 Phase transformer :-



Date |
Page |

Faraday's law of electromagnetic Induction

$$e = -N \frac{d\phi}{dt}$$

$$\boxed{e \propto N}$$

where,

e = Induced emf

N = No. of turns

ϕ = flux.

i.) Transformer is based on principle of electromagnetic induction or mutual induction.

ii.) The winding to which the alternating voltage is applied is called the primary winding. The winding that delivers power to the load is called the secondary winding.

iii.) A transformer consist of two windings that are electrically isolated from each other.

iv.) When a time varying voltage is applied to one winding

v.) It setup an alternating flux in the magnetic core due to the high permeability of the core.

vi.) Most of the flux links the other winding (secondary) and Induces an alternating emf in that winding

Date |
Page |

VII.) The frequency of the induced emf in the winding is same as that of the voltage in the first winding.

VIII.) If the other winding (secondary) is connected to load the induced emf in the winding circulates a current in it (I_2)

IX.) Thus the power is transformed from one winding to the other through the magnetic flux in the core.

☆.) Derive Emf equation of single phase Transformer :-

$$Emf = 4.44 f \phi_m N$$

where,

f = frequency of AC supply
ϕ_m = maximum flux in weber
N = No. of turns
emf = Electromotive force.

for primary voltage :- $E_1 = 4.44 f \phi_m N_1$
for secondary voltage :- $E_2 = 4.44 f \phi_m N_2$

E_1 = Primary side voltage $= V_1 = E_P = V_P$
E_2 = Secondary side voltage $= V_2 = E_S = V_S$

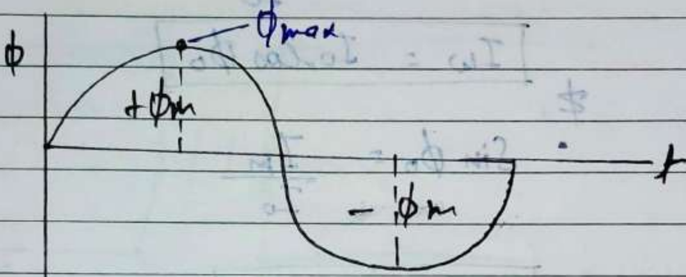
4.) Maximum Magnetic flux density :-

$$B_{max} = \boxed{\frac{\phi_{max}}{A}} \ \frac{\text{webre}}{m^2} = \cancel{\text{Tesla unit}} \ \text{Tesla unit}$$

where,

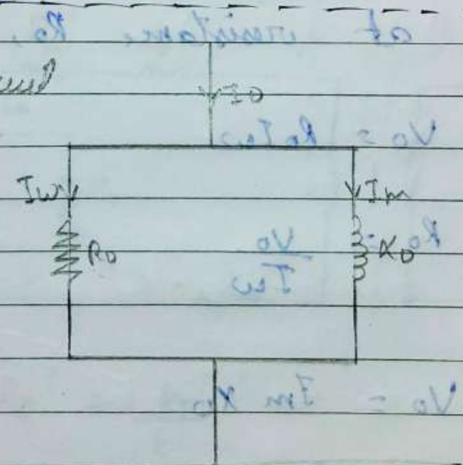
A = cross sectional area of the core in m^2

ϕ_{max} = maximum flux in weber.



5.) No Load Circuit & No Load Phasor Diagram:-

No Load Circuit



where,

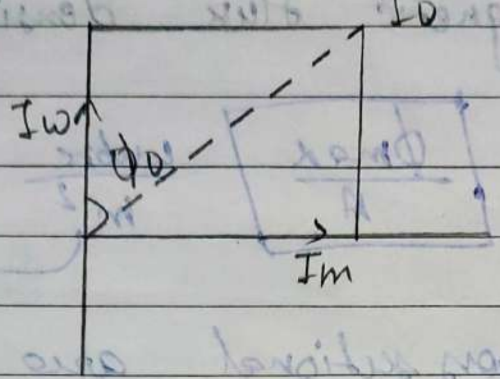
I_0 = No load current at primary side

I_w = Active current

I_m = Magnetising current

R_0 = No load ~~reactance~~ resistor

X_0 = No load reactance



$$\cos\phi_0 = \frac{I_w}{I_0}$$

$$\boxed{I_w = I_0 \cos\phi_0}$$

&

$$\sin\phi_0 = \frac{I_m}{I_0}$$

$$\boxed{I_m = I_0 \sin\phi_0}$$

Voltage at resistance R_0,

$$V_0 = R_0 I_w$$

$$R_0 = \frac{V_0}{I_w}$$

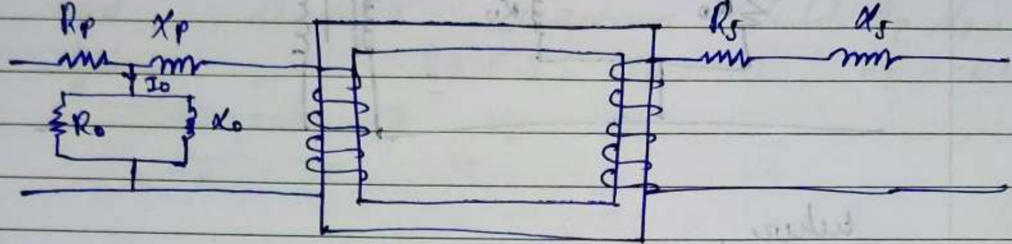
&

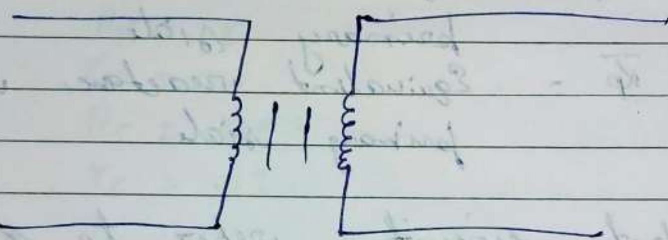
$$V_0 = I_m X_0$$

$$\boxed{X_0 = \frac{V_0}{I_m}}$$

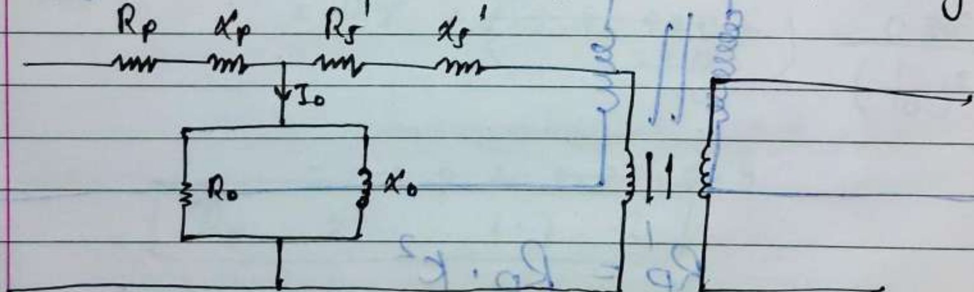
Date |
Page |

A.) Equivalent circuit for single phase Transformer :-





i.) Equivalent circuit Refer to primary side :-



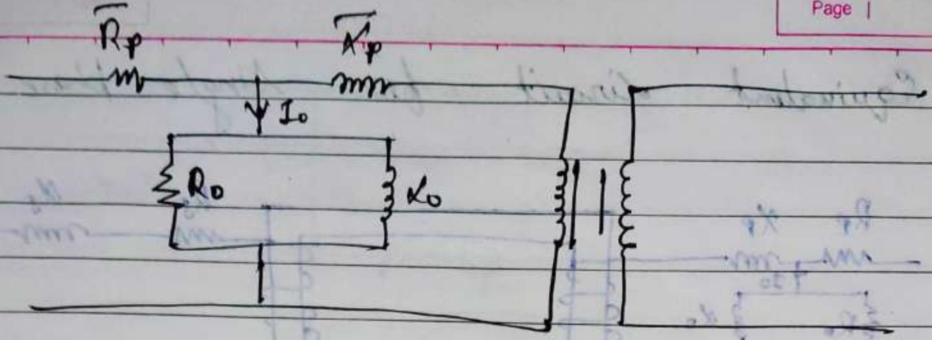
$$R_s' = \frac{R_s}{K^2}$$

$$X_s' = \frac{X_s}{K^2}$$

Now,

$$\overline{R_p} = R_p + R_s'$$

$$\overline{X_p} = X_p + X_s'$$

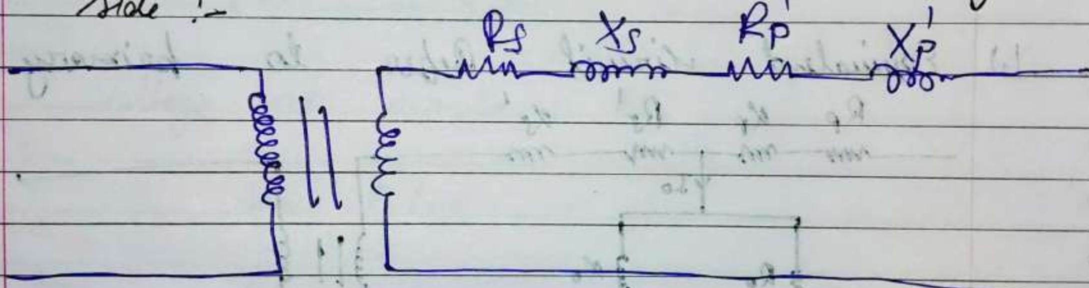


where,

$\overline{R_p}$ = Equivalent resistance refer to primary side

$\overline{X_p}$ = Equivalent reactance refer to primary side

2.) Equivalent circuit refer to secondary side :-

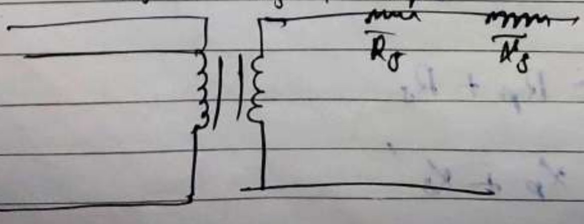


$$R_p' = R_p \cdot K^2$$

$$X_p' = X_p \cdot K^2$$

$$\overline{R_s} = R_s + R_p'$$

$$\overline{X_s} = X_s + X_p'$$



$R_p + R_s'$ $R_?$, $\bar{X}_p = X_p + X_s'$ $R_s' = R_p k^2$

Date |
Page |

Qns) 25 kVA 2200 / 220 V . 50 Hz single phase transformer has the following resistance and leackage reactance, calculate $\bar{R}_p, \bar{X}_p, \bar{R}_s, \bar{X}_s$!

~~Solu⇒ Given,~~ $R_p = .8$, $X_p = 3.2$, $R_s = .009$

~~$R_p = 8$~~ & $X_s = .03$

~~$X_p = 32$~~

Solu⇒ Given,

$R_p = .8$

$X_p = 3.2$

$R_s = .009$

$X_s = .03$

$\therefore \bar{R}_p = R_p + R_s'$

$= 0.8 + \cancel{\left(.8 \times \frac{220}{2200}\right)} \frac{0.009}{\left(\frac{1}{10}\right)^2}$

$= \cancel{0.8 + 0.08}\ 0.9$

$$\boxed{\bar{R}_p = 1.7\ \Omega}$$

$\bar{X}_p = X_p + X_s'$

$= 3.2 + \frac{0.03}{\left(\frac{1}{10}\right)^2}$

$\Rightarrow 3.2 + 3$

$$\boxed{\bar{X}_p \Rightarrow 6.2}$$

Date |
Page |

$$R_p' = R_p \cdot k^2$$
$$= 0.8 \times \frac{1}{100}$$
$$= 0.008$$

$$\bar{R_s} = R_s + R_p'$$
$$= 0.009 + 0.008$$
$$\boxed{\bar{R_s} = 0.017\ \Omega}$$

$$\bar{X_s} = X_s + X_p'$$
$$= 0.03 + X_p \cdot k^2$$
$$= 0.03 + 3.2 \times \frac{1}{100}$$
$$= 0.03 + 0.032$$
$$\boxed{\bar{X_s} = 0.062\ \Omega}$$

Voltage Regulation or Regulation of transformer :-

Like efficiency the voltage regulation is also a performance index of a transformer but its value should be as low as possible.

Voltage Regulation no load to full load upon no load × 100

Date 107/01/25
Page 107/01/25

i.e., $\boxed{V_R = \frac{V_n - V_f}{V_n} \times 100}$

where,

V_n = no load voltage at secondary side,
V_f = full load voltage at secondary side.

$$\boxed{V_R = I_p \left(\frac{\overline{R_p} \cos\phi \pm \overline{X_p} \sin\phi}{V_p} \right) \times 100}$$

$$\boxed{V_R = I_s \left(\frac{\overline{R_s} \cos\phi \pm \overline{X_s} \sin\phi}{V_s} \right) \times 100}$$

Qn.) 2KVA, 400/200 V, 50hz Single phase transformer has the following parameter refers to primary side.

$\overline{X_p} = 4$, $\overline{R_p} = 3$

Determine the Regulation of transformer when operation of

① full load with .8 power factor lagging
② full load with .8 power factor leading.

Soln.) $S = 2kVA$; $V_P = 400$

$S = V \cdot I$

$2 \times 10^3 = V_p \cdot I_p$

$\frac{2 \times 10^3}{V_p} = I_p$

$I_p = 5A$

$$V_R = I_p\left(\frac{\bar{R}_p\cos\phi + \bar{X}_p\sin\phi}{V_p}\right)\times 100$$

$$= 5\left(\frac{3\times 0.8 + 4\times 0.6}{400}\right)\times 100$$

$$V_R = 6\ \%.$$

&

$$V_R = I_p\left(\frac{\bar{R}_p\cos\phi - \bar{X}_p\sin\phi}{V_p}\right)\times 100$$

$$= 5\left(\frac{3\times 0.8 - 4\times 0.6}{400}\right)\times 100$$

$$= 0\ \%.$$

Date |
Page |

Imp. Losses in single Phase transformer :-

→ Iron Loss (P_i) :- Iron loss caused by varrying magnetisation occurs in transformer core.

Iron losses are called constant losses because these are practically independent of the load. Iron losses can be further classified as hysteresis losses and eddy current losses.

•) hysteresis losses (HL) :- Occuring in the magnetic frame of the transformer depends upon the following :-

$$\boxed{HL = \eta v f (B_{max})^n}$$

where,

η = constant

V = (Volume of the core)

f = frequency

(B_{max}) = maximum flux density.

n = 1.6 to 2.1

•) Eddy current losses :- Eddy current losses is due to the flow of eddy current in the magnetic core of the transformer caused by small emf induced in the magnetic frame or core.

Eddy current losses depends of the following quantity.

$$EL = KV(B_{max})^2 f^2 t^2$$

where,

k = constant

Date |
Page |

V = volume of the core.
(B_{max}) = Maximum magnetic flux density.
f = frequency
t = thickness of laminated magnetic frame.

→ Copper losses (P_c) :-

In general copper losses occurs in all those parts of the transformer that carry electric current.

$$P \propto I^2 R$$

Copper losses are directly proportional, square of current and resistance

→ Copper losses occurs in the primary winding.

$$I_p^2 R_p$$

→ Copper losses occurs in the secondary winding,

$$I_s^2 R_s$$

Total copper losses occurs in the primary and secondary winding,

$$\boxed{P_c = I_p^2 R_p + I_s^2 R_s.}$$

Date |
Page |

3.) Fraction of Load :-

$x = 0$ (No load)

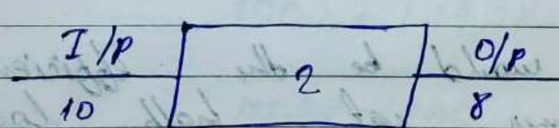
$x = 1$ (full load)

$x = \frac{1}{2}$ (Half load)

$x = \frac{1}{4}$ (Quarter load)

$x = 3/4$ (3/4 load)

4.) Efficiency of a single Phase Transformer :-



$\% \eta = \frac{O/P}{I/P}$

$= \frac{8}{8+2}$

$= \frac{O/P}{O/P \; losses}$

Date |
Page |

$$\boxed{\eta = \frac{x\, VI \cos\phi}{xVI \cos\phi + P_i + P_c\, x^2} \times 100}$$

Q.) 220 / 400 V 10 KVA 50 Hz single phase transformer has it full load copper losses of 120 V. If it has an efficiency of 98 %. at full load ($x = 1$). Unity power factor ($\cos\phi = 1$). Calculate Iron loss?

Soln. What would be the efficiency of the transformer at half load and at 0.8 power factor lagging.

Soln:) Given,

$\cos\phi = 1$

$P_c = 120\ W$

$\eta = 98\%$

$VI = 10 KVA$

$= 10 \times 10^3$

$x = 1$

$$\therefore \eta = \frac{x\, VI \cos\phi}{xVI \cos\phi + P_i\ P_c\, x^2} \times 100$$

Date |
Page |

$$0.98 = \frac{1 \times 10 \times 10^3 \times 1}{1 \times 10 \times 10^3 \times 1 + P_i + 120 \times 1^2}$$

$$0.98 = \frac{10\,000}{10\,000 + P_i + 120}$$

$$\boxed{P_i = 84.08 \text{ watt}}$$

&

Here,
$x = 1/2$
& $\cos\phi = 0.8$

$$\eta = \frac{x VI \cos\phi}{x VI \cos\phi + P_i + P_c x^2} \times 100$$

$$= \frac{1/2 \times 10 \times 10^3 \times 0.8}{1/2 \times 10 \times 10^3 \times 0.8 + 84.08 + 120 \times (1/2)^2} \times 100$$

$$\Rightarrow \frac{4000}{4000 + 114.08} \times 100$$

$\Rightarrow$ ~~115.08 × 100~~

$\Rightarrow 97.22\%$ Ans

V.V.V.I

Ques 100 kVA 440/220 V single phase 50 Hz core type transformer has an efficiency of 98.5% when supply full load at 0.8 power factor ~~&~~ lagging.

~~Soln Given, $\cos\phi = 0.8$~~ An efficiency of 99% when supply half load at unity power factor.
Calculate Iron loss and copper loss.

Date |
Page |

Soln: Given,

$VA = 100\ kVA = 100 \times 10^3$.

$\cos\phi = 0.8$

$f = 50\ Hz$

$\eta = 98.5\%$

$x = 1$

$$\therefore \eta = \frac{x VI \cos\phi}{xVI \cos\phi + P_i + P_c x^2}$$

$$\Rightarrow \frac{98.5}{100} = \frac{1 \times 100 \times 10^3 \times 0.8}{1 \times 100 \times 10^3 \times 0.8 + P_i + P_c}$$

$$\Rightarrow \frac{98.5}{100} = \frac{80000}{80000 + P_i + P_c}$$

$$\Rightarrow 0.985 = \frac{80000}{80000 + P_i + P_c}$$

$$\Rightarrow 80000 + P_1 + P_c = \frac{80000}{0.985}$$

$$\Rightarrow 80000 + P_i + P_c = 81218.2$$

$$\Rightarrow P_1' + P_c = 81218.2 - 80000$$

$$\Rightarrow P_1' + P_c = 1218.2 \quad \text{—(1)}$$

#

$$\eta = \frac{x VI \cos\phi}{x VI \cos\phi + P_i' + P_c x^2} \times 100$$

$$\frac{99}{100} = \frac{1/2 \times 100 \times 10^3 \times 1}{1/2 \times 100 \times 10^3 \times 1 + P_i + P_c (1/2)^2}$$

Date |
Page |

$$\Rightarrow 0.99 = \frac{50000}{50000 + P_i + P_c \frac{1}{4}}$$

$$\Rightarrow 50000 + P_i + P_c\, 1/4 = \frac{50000}{0.99}$$

$$\Rightarrow 50000 + P_i + P_c \frac{1}{4} = 50505.05$$

$$\Rightarrow P_i + P_c \frac{1}{4} = 50505.05 - 50000$$

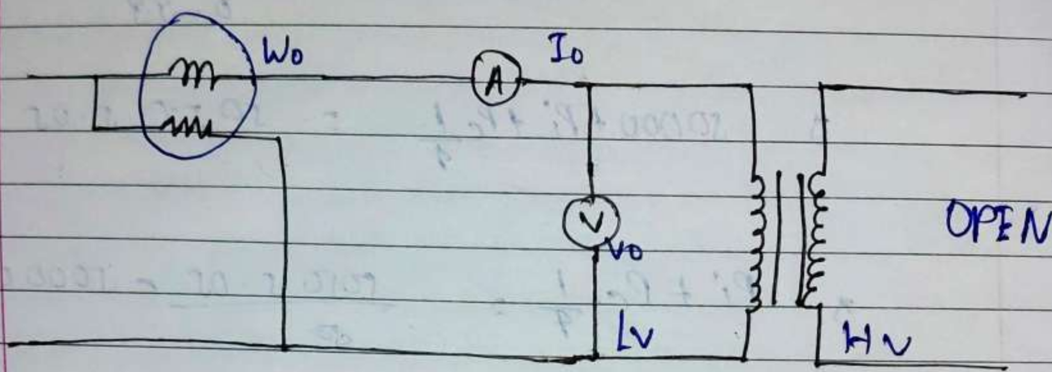
$$\Rightarrow P_i + P_c\, 1/4 = 505.05 \quad \text{—(1)}$$

$$\left.\begin{aligned} P_i &= 267.33 \\ P_c &= 95.08 \end{aligned}\right\} \text{Ay}$$

Date |
Page |

*) Open circuit and short circuit test :-

1.) Open circuit test of single phase transformer :- (Iron loss) :-



$P = V \cdot I \cos\phi_0$ (P = Active power)

$W_0 = V_0 I_0 \cos\phi_0$ $\{P = W_0,\ I = I_0,\ V = V_0,\ \cos\phi_0\}$

$\cos\phi = \dfrac{W_0}{V_0 I_0}$

$I_w = I_0 \cos\phi_0$

$I_m = I_0 \sin\phi_0$

$R_0 = \dfrac{V_0}{I_w}$ (R_0 = No load resistance)

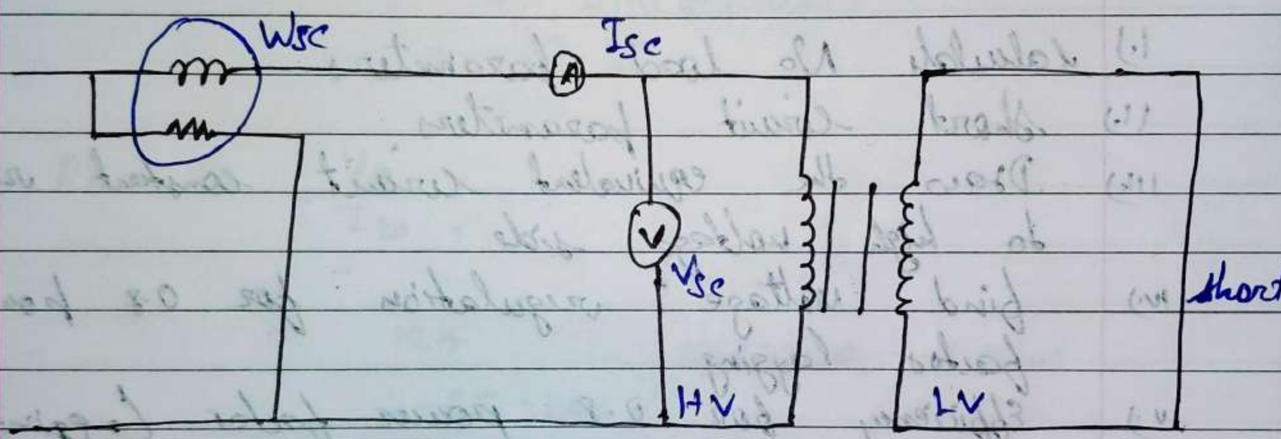
$X_0 = \dfrac{V_0}{I_m}$ (X_0 = No load reactance)
(R_0 & X_0 = No load parameter)

1.) The reading of the watt meter connected in the circuit of will indicate the iron loss occuring in the transformer case.

ii.) The copper losses under this test will be negligible.

Note :- Maximum voltage, Minimum voltage

2.) Short circuit test of single phase Transformer :-



$$P = I^2 R$$

$$W_{sc} = I_{sc}^2 R_{sc}$$

$$\boxed{R_{sc} = \frac{W_{sc}}{I_{sc}^2}}$$ {R_{sc} = short circuit resistance}

&

$$V_{sc} = I_{sc} Z_{sc}$$

$$Z_{sc} = \frac{V_{sc}}{I_{sc}}$$

$$X_{sc} = \sqrt{Z_{sc}^2 - R_{sc}^2}$$ {X_{sc} = short circuit reactance}

N.V.I
Imp

Date |
Page |

Qn.) The following reading were obtained for Oc and Sc test, on 8 KVA 400 / 120 V) 50Hz transformer.

OC (LV)	120 V (V_0)	4 A (I_0)	75 W (W_0)
SC (HV)	9.5 V V_{sc}	20 A I_{sc}	110 W W_{sc}

i.) Calculate No load parameters
ii.) Short circuit parameters
iii.) Draw the equivalent circuit constant refer to high voltage side
iv.) find voltage regulation for 0.8 power factor lagging
v.) Efficiency for 0.8 power factor lagging at full load and half load.

solu ⇒ Given, $V_0 = 120\,V$

~~$I_0 =$~~

$$W_0 = V_0 I_0 \cos\phi_0$$

$$\cos\phi_0 = \frac{W_0}{V_0 I_0}$$

$$= \frac{75}{120 \times 4}$$

$$\cos\phi_0 = 0.156.$$

$\phi_0 = \cos^{-1} 0.156$

$\Rightarrow \phi_0 = 81.025$

$I_w = I_0 \cos\phi$

$= 4 \times \cancel{81.025}\ 0.156$

$= \cancel{324.1}\ 0.625$

$I_m = I_0 \sin\phi$

$= 4 \times \sin(81.025)$

$= 3.95$

i.) $R_0 = \dfrac{V_0}{I_w}$

$= \dfrac{120}{\cancel{3.95}\ 324.1} = \cancel{30.37\,\Omega}\ 192\,\Omega$

~~ii.) W_{sc}~~ $\neq$ $X_0 = \dfrac{V_0}{I_m}$

$= \dfrac{120}{3.95} = 30.37\,\Omega$

ii.) $W_{sc} = I_{sc}^2 R_{sc}$

$R_{sc} = \dfrac{W_{sc}}{I_{sc}^2}$

$= \dfrac{110}{(20)^2} = 0.275$.

$$V_{sc} = I_{sc} Z_{sc}$$

$$Z_{sc} = \frac{V_{sc}}{I_{sc}}$$

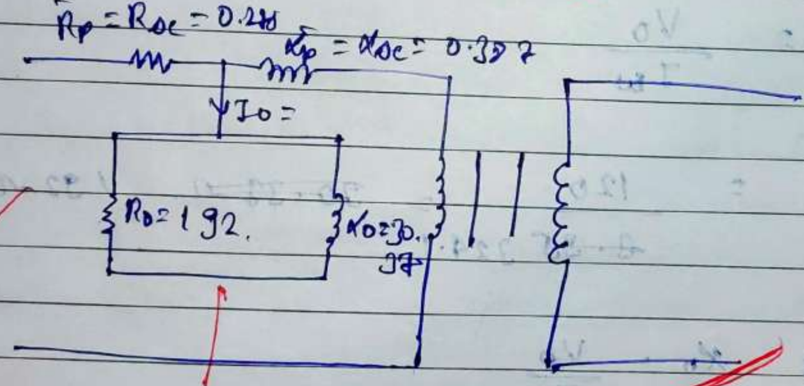
$$= 0.475\ \Omega$$

$$X_{sc} = \sqrt{Z_{sc}^2 - R_{sc}^2}$$

$$= \sqrt{(0.475)^2 - (0.275)^2}$$

$$= 0.387$$

III.)



IV.) $$VR = \frac{I_p(\bar{R}_p \cos\phi \pm \bar{X}_p \sin\phi)}{V_p} \times 100$$

$$= \frac{20(0.275 \times 0.8 + 0.387 \times 0.6)}{\cancel{400}} \cancel{\times 100}$$

$$= \frac{9.044}{4}$$

$$= 2.261\ \%.$$

Date |
Page |

Full Load

V.) Efficiency $\eta = \frac{x \ V.I.\cos\phi}{x\ VI\cos\phi + P_i + P_c . x^2} \times 100$

$= \frac{1 \times 8 \times 10^3 \times 0.8}{1 \times 8 \times 10^3 \times 0.8 + 75 + 100 \times 1^2} \times 100$

$= \frac{640000}{6575}$

$= 97.33\ \%$

Half Load :-

$\eta\ \% = \frac{1/2 \times 8 \times 10^3 \times 0.8}{1/2 \times 8 \times 10^3 \times 0.8 + 75 + 100 + (1/2)^2} \times 100$

$= 96.89\ \%$

Ques) 5kVA 400/200 V 50Hz single phase transformer then the following ~~case~~ A70 load test OC & SC test

OS	400 V	1 A	60 W
SC	15 V	12.5 A	50 W

Calculate
i.) No load parameters
ii.) Short circuit parameters
iii.) Draw the equivalent circuit diagram refer to high voltage side
iv.) Voltage Regulation with 0.8 power factor leading.

Date |
Page |

v) find efficiency with unity power factor at half load.

Solu→ $W_0 = V_0 I_0 \cos\phi_0$

$\cos\phi = \frac{W_0}{V_0 I_0}$

$\cos\phi = \frac{60}{400 \times 1} = 0.15$

$\therefore \phi = \cos^{-1} 0.15$
$= 81.37$.

$\therefore I_w = I_0 \cos\phi$
$= 1 \times 0.15$
$= 0.15$

$I_\mu = I_0 \sin\phi$
$= 1 \times \sin 81.37$
$= 0.988$

i.) $R_0 = \frac{V_0}{I_w}$

$= \frac{400}{0.15} = 2666.66\ \Omega$

$X_0 = \frac{V_0}{I_\mu} = \frac{400}{0.988} = 404.85\ \Omega$

(ii) $W_{sc} = I_{sc}^2 V_{sc}$

$$R_{sc} = \frac{W_{sc}}{I_{sc}^2} = \frac{50}{(12.5)^2} = 0.32\ \Omega .$$

$$V_{sc} = I_{sc} \cdot Z_{sc}$$

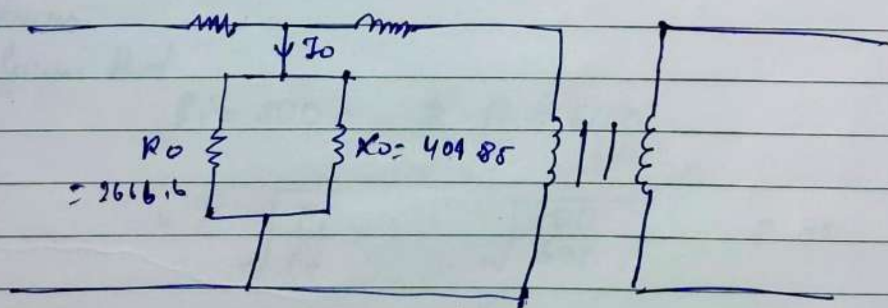
$$Z_{sc} = \frac{V_{sc}}{I_{sc}} = 1.2 .$$

$$X_{sc} = \sqrt{Z_{sc}^2 - R_{sc}^2}$$

$$X_{sc} = \sqrt{(1.2)^2 - (0.32)^2}$$

$$X_{sc} = 1.156\ \Omega$$

(iii.) $R_{sc} = 0.32$, $X_{sc} = 1.156$



(iv.) $V_R = \dfrac{I_p (R_p \cdot \cos\phi - X_p \sin\phi)}{V_p} \times 100$

$$I_p = \frac{5}{V_p} \Rightarrow 12.5\ A .$$

Date |

Page |

$$V_R = \frac{12.5\ (0.32 \times 0.8 - 1.156 \times 0.6)}{400} \times 100$$

$$V_R = -1.36$$

Date |
Page |

*) Efficiency :-

#) Condition for Maximum Efficiency :-

$$\boxed{\eta_{max} = \frac{x \cdot V \cdot I \cos\phi}{x\, V \cdot I \cos\phi + P_i + P_c} \times 100}$$

$$P_i = P_c$$

$$P_i = x^2 P_c$$

$$x = \sqrt{\frac{P_i}{P_c}}$$

Qn.) 50KVA, transformer has on full load copper losses of 600 V, Iron loss of 500 W calculate the maximum efficiency and the load at which maximum efficiency occurs.

Solun Given that,

$$P_i = 500 \quad \& \quad P_c = 600$$

$$x = \sqrt{\frac{P_i}{P_c}} = \sqrt{\frac{500}{600}} = 0.91.$$

$$\eta_{max} = \frac{0.912 \times 50 \times 10^3 \times 1}{0.912 \times 50 \times 10^3 \times 1 + 500 + 500} \times 100$$

$$= \frac{45600}{45600 + 1000} \times 100$$

$$= 97.85$$

Date |

Page |

Qn.) A coil of inductance 0.06 henry and resistance 12 Ω is connected in ca series with a capacitor of 120 P.F. The combine circuit is connected to 240 V, 50 hz frequency calculate,

1. Inductive Resistance
2. Capacitive Resistance
3. Impedence
4. Irms
5. Power factor
6. Active power
7. Reactive power
8. Aparant power
9. Voltage drop across each element.

Solu⇒ Given that,

$L = 0.06$
$R = 12\,\Omega$
$C = 120$ P.F

① $X_L = 2\pi f L = 2 \times \pi \times 50 \times 0.06$
$= 18.84$

② $X_C = \dfrac{1}{2\pi f c} = \dfrac{1}{2 \times \pi \times 50 \times 10^{-12}}$

$= 26.53 \times 10^{6}$.

③ $Z = \sqrt{R^2 + (X_C - X_L)^2}$

$= \sqrt{144 + (26.53 \times 10^{6} - 18.84)^2}$

$\Rightarrow 26.52 \times 10^{6}$

④ $I_{rms} = \frac{V_{rms}}{Z} = \frac{240}{26.52 \times 10^{6}} = 9.04 \times 10^{-6}$

⑤ Power factor =

$$\cos\phi = \frac{R}{Z}$$

$$= \frac{12}{26.52 \times 10^{6}} = 4.52 \times 10^{7}.$$

⑥ Active Power,

$$P = V \cdot I \cos\phi$$
$$= 9.86 \times 10^{-10}$$

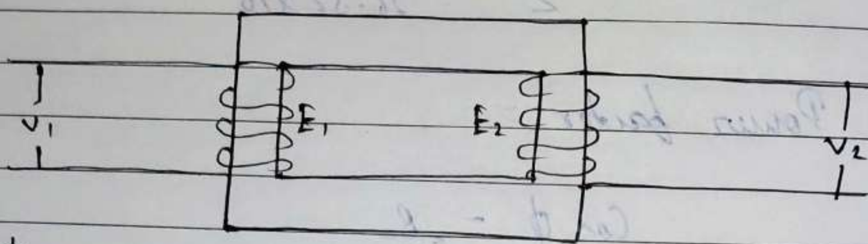
⑦ Reactive Power,

$$Q = VI \sin\phi$$
$$= 2.169 \times 10^{-3}$$

⑧ Apparant Power,

$$S = VI$$
$$= 2.169 \times 10^{-3}.$$

✱) Phasor Diagram of Single Phase Transformer :-

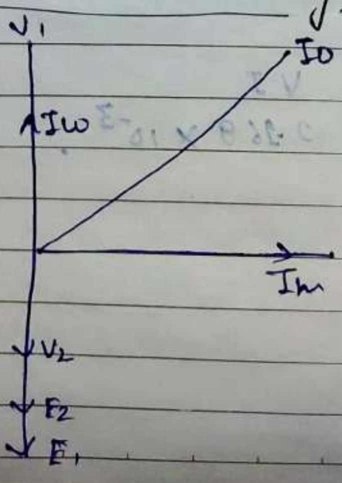


$V_1 = -E_1$

1.) for Ideal Transformer

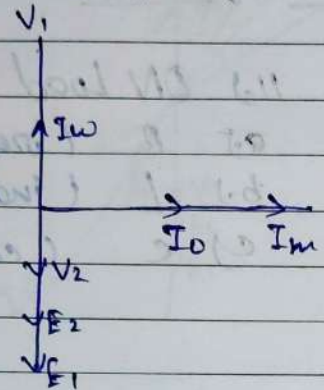
- No Load
- ON Load
  - R (Resistive)
  - L (Inductive)
  - C (Capacitive)

i.) <u>No Load Phasor Diagram :-</u>



{ Note: I_2 is not mentioned due to the no load, i.e. $I_2 = 0$ }

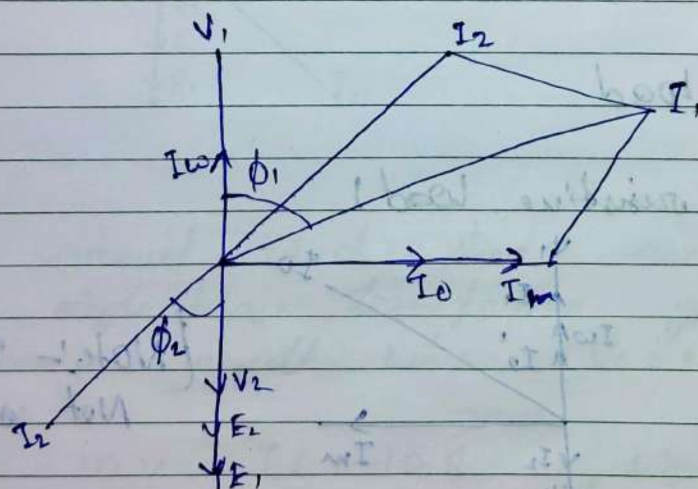
→ for Ideal,



$$\left\{ \begin{aligned} I_w &= 0 \\ I_m &= I_0 \end{aligned} \right\}$$

(*) Ideal transformer :-

(ii) ON Load :- for inductive load (for lagging power factor)



$$\boxed{I_1 = I_2' + I_0}$$

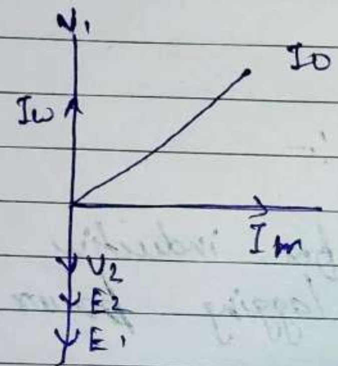
Date |
Page |

2.) for Practical Transformer :- ($I_w \neq 0$)

i.) No Load

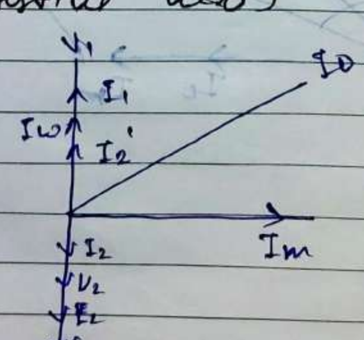
ii.) ON Load
a.) R (resistive)
b.) L (inductive)
c.) C (capacitive)

i.) No Load :-



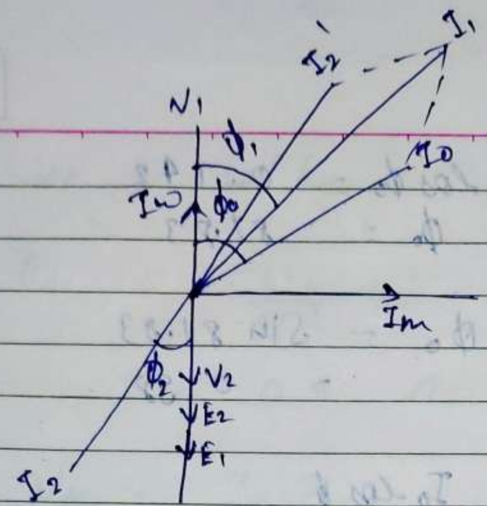
ii.) ON Load

a.) R(for resistive load)



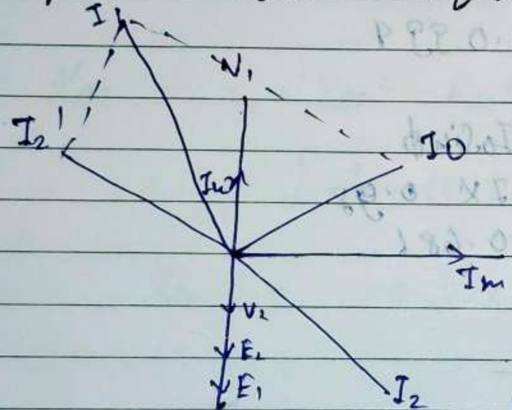
{Note :- $I_2' + I_0 = I_1$
Not satisfy }

(b.) (L) for inductive load (for lagging power factor) :-



$$\boxed{I_1 = I_2' + I_0}$$

b.) Capacitive load (for leading power factor):-



$$\boxed{I_1 = I_2' + I_0}$$

Imp

Ons) Open circuit and short circuit test on single phase transformer give the following result where $V_0 = 200$, $I_0 = 0.7$ & $W_0 = 20$.

$V_S = 10\,V$, $I_S = 10\,A$, $W_S = 40$ Watt

Determine the of equivalent circuit parameters refer to primary side?

Solves $W_0 = V_0 I_0 \cos\phi_0$

$20 = 200 \times 0.7 \times \cos\phi_0$

$\therefore \cos\phi_0 = 0.142$

$\phi_0 = 81.83$

$\sin\phi_0 = \sin 81.83$

$= 0.98$

$\therefore I_w = I_0 \cos\phi$

$= 0.7 \times 0.142$

$= 0.0994$

$I_m = I_0 \sin\phi$

$= 0.7 \times 0.98$

$= 0.686$.

Now,

(a) $R_0 = \dfrac{V_0}{I_w}$

$= \dfrac{200}{0.0994}$

$= 2012.07$.

(b)

$\therefore X_0 = \dfrac{V_0}{I_m}$

$= \dfrac{200}{0.686}$

$= 291.50$.

$$W_{sc} = I_{sc}^2 R_{sc}$$

$$R_{sc} = \frac{W_{sc}}{I_{sc}^2}$$

$$= 0.4\ \Omega$$

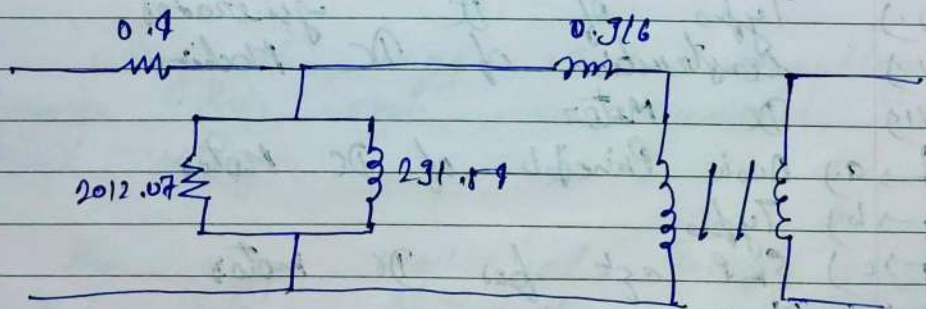
$$V_{sc} = I_{sc} Z_{sc}$$

$$Z_{sc} = 1\ \Omega$$

$$X_{sc} = \sqrt{Z_{sc}^2 - R_{sc}^2}$$

$$= \sqrt{1^2 - (0.4)^2}$$

$$X_{sc} = 0.916\ \Omega$$



Date
03/08/25

Unit → 04

Date |
Page |

Rotating Machine

1.) DC Machine OR DC Generator.

DC generator / DC Machine
DC Motor

2.) AC Machine :-

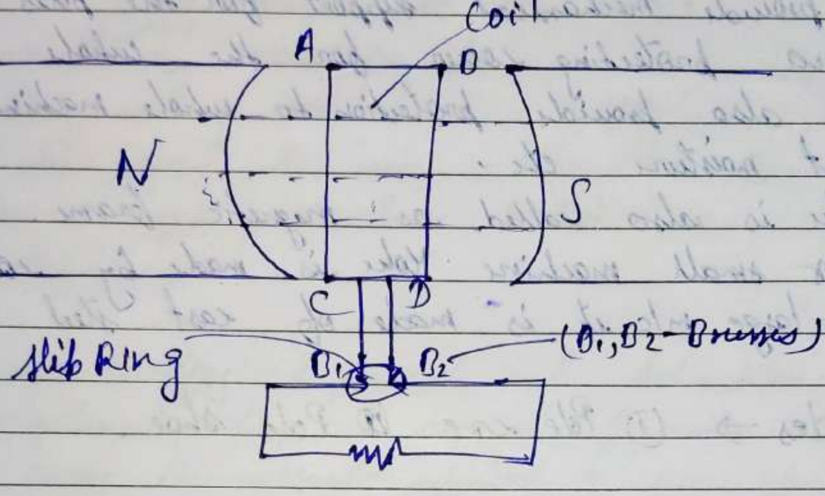
I.) Basic Principle of DC generator
II.) Types of Armature winding
III.) Emf eqⁿ for DC generator
IV.) Types of DC generator
V.) Construction of DC Machine
VI.) DC Motor
→ a.) Basic Principle of DC Motor
→ b.) Types
→ c.) Emf eqⁿ for DC motor
→ d.) Torque eqⁿ.

(comutator)

Date |
Page |

Imp

A.) Basic Principle of DC Generator :- / Machine :-

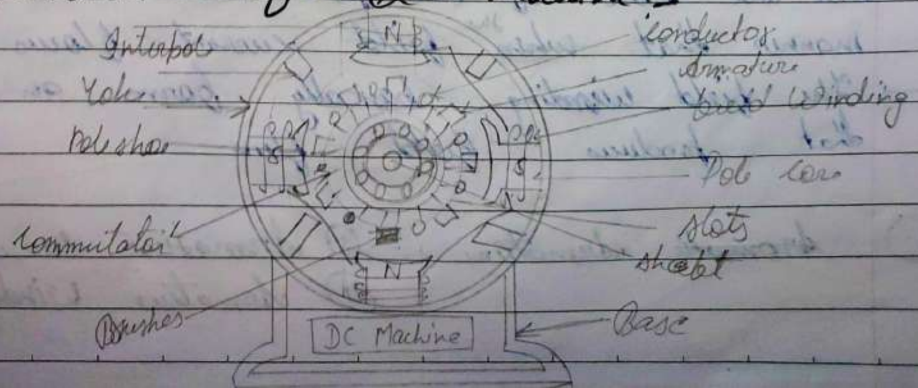


I.) When a coil ABCD rotating in a uniform magnetic field according to faradays law of electromagnetic induction emf (A.V) will be induced in that coil.

II.) By using slip ring and connecting (B1 & B2) brusses this emf is converted into direct voltage.

III.) In this way mechanical energy is converted into electrical energy.

B.) Construction of DC machine :-



Date |
Page |

① Magnetic frame or Yoke :-

i.) It provide mechanical support for the poles and act as a protecting cover for the whole machine.

ii.) It also provide protection to whole machine from dust moisture etc.

iii.) Yoke is also called as magnetic frame.

iv.) For small machine Yoke is made by cast iron.

v.) for large m/c it is made of cast steel or rolled steel.

② Poles → (I) Pole core (II) Pole shoe.

(I) Pole core :- a.) Pole of a generator is an electromagnet.
b.) The field winding is wrapped ( ) on the pole itself.
c.) Pole provides magnetic flux when field winding excited
d.) Pole core made of cast iron.

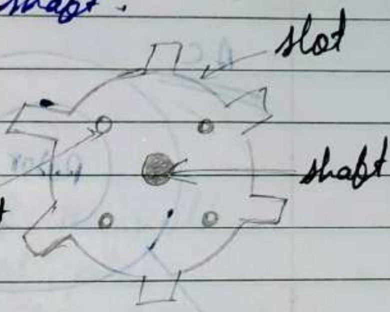
(II) Pole shoe :- a.) It is extended part of pole it enlarge area of pole.
b.) Due to this enlarge area flux is spread out in the air gap and more flux can pass through the air gap to aromature.

③ Field Winding :- The field winding of Dc motor are made with field axis (copper wire) wound over the slots of the pole shoes in such a manner that ~~when~~ the field current flows through it.
→ The field winding basically form an electromagnetic that produces field flux.

④. ~~Aromatt~~ Armature :- (I) Armature core
(II) Armature winding.

(1) Aromatic core :- a) Armature core is cylindrical in shape mounted on the shaft.

b) It consists of slots on its periphery and ~~air~~ duct to its permit the air flow through armature winding.



(2) Armature winding :- (i) generate emf takes place in the armature winding in case of Generator.

(ii) To carry the current supplied in case of DC motor.

(iii) To do the useful work in the external circuit.

(5) Commutator :- a) The basic nature of Emf induced in the armature conductor is alternating. This needs rectification in case of DC Generator. This device is called the commutator.

(b) its convert AC to DC.

(6.) Brushes :- a) Bruses are stationary part.

b) To collect current from commutator and make it available to the stationary external circuit are used.

c) Brushes are made of soft material like carbon.

(7) Bearing :- a) Ball bearing are ~~usually~~ used because they are more reliable. for heavy duty machine Roller bearings are preferred.

(b) Bearing is use to Redu… losses.

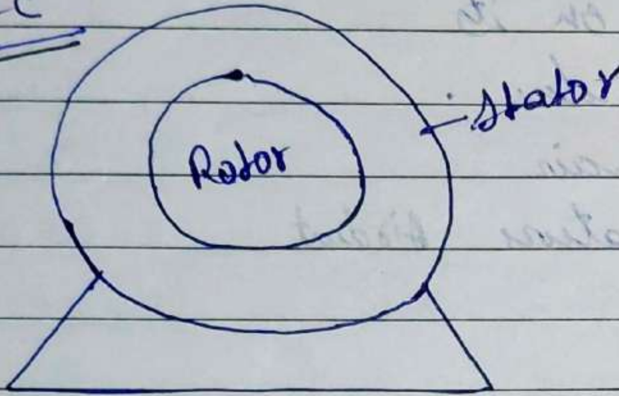
Lab :- 1 turn = two conductor (Z)

If P is not given than take P = 2

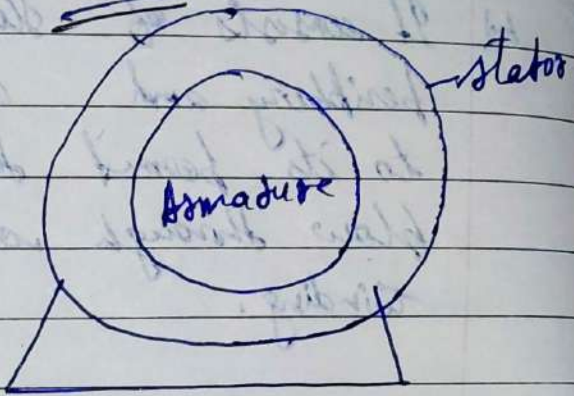
Date |
Page |

★) Types of Armeture Winding :-

AC



DC



→ There are basically two types of Armeture winding :-

Date |
Page |

A) Emf equation for DC Generator (→ Machine) :—

$$\boxed{E_g = \frac{P \phi N Z}{60 A}} \text{ volt}$$

where,

E_g = generated emf in volt
P = Total no of poles
ϕ = flux per pole in webre
N = speed in rpm.
Z = total no of conductor
A = total No of parallel pathes

$\boxed{A = P \text{ (in lap)}}$ & $\boxed{A = 2 \text{ (in wave)}}$

Q) 6 pole lap wound armature has 840 conductor and flux per pole of ·018 webre. calculate the generated emf when the machine is running at 600 rpm.

Solu) $E_g = \frac{P \phi N Z}{60 A}$

$$= \frac{6 \times \cdot 018 \times 840 \times 600}{60 \times 6}$$

$$= 151.2 \text{ volt}$$

Q) 8 pole wave connected dc generator has 900 armature conductor and flux per pole of .04 w at what speed it must be driven to generate 500 V.

Date	
Page	

Solun Given,

$P = 8$
$A = 2$
$Z = 900$
$\phi = .04\ \omega$
$E_g = 500$

$$\therefore E_g = \frac{P\phi N Z}{60 A}$$

$$500 = \frac{8 \times .04 \times N \times 900}{60 \times 2}$$

$$\boxed{\therefore N = 208.33 \text{ rpm}}$$

Imp

Que. 4 pole DC generator has 51 slots each slots contain 20 conductor the flux per pole is 75 miliwebre run at 1500 rpm find the induced emf of a machine if its armature is wave connected.

Solun ⇒ $P = 4$,
$Z = 51 \times 20 = 1020$
$A = 2$
$N = 1500$
$\phi = 75 \times 10^{-3}$

$$\therefore E_g = \frac{P\phi N Z}{60 A}$$

$$= \frac{4 \times 75 \times 10^{-3} \times 1500 \times 1020}{60 \times 2}$$

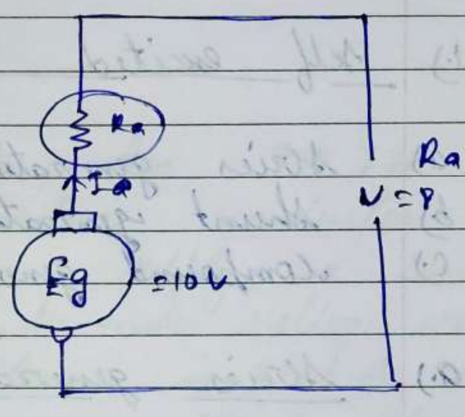
Date |
Page |

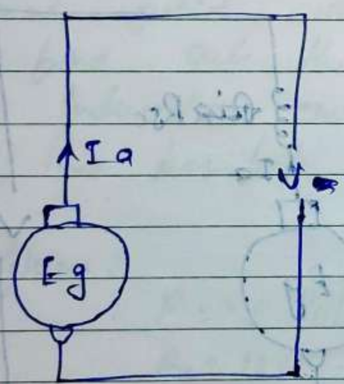
$Eg = 3825\ V$

Types of DC generator :-

$Eg - I_a R_a = V$

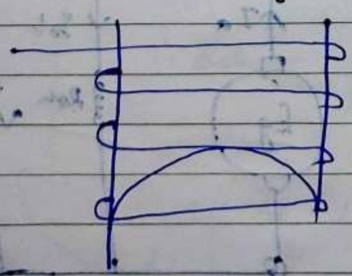
$10 - 2 = 8$

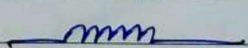




$$\boxed{Eg - I_a R_a = V}$$

→ Field Winding :-





Date |
Page |

→ There are basically two types of DC generator:-

1.) self Excited DC generator
2.) separate Excited DC generator

1.) self excited DC generator :- These are 3 types:-

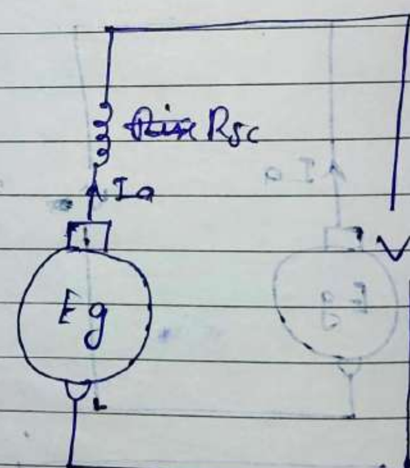
a.) series generator
b.) shunt generator
c.) compound generator

a.) series generator :-

$E_g - I_a R_a - I_a R_{sc} = V$

I/P Power = $E_g \cdot I_a$

O/P Power = $V \cdot I_a$



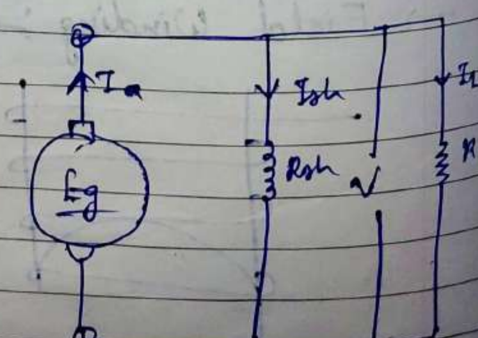
Imp b.) DC shunt Generator :-

$I_a = I_{sh} + I_L$

$E_g - I_a R_a = I_{sh} R_{sh} = V = I_L R_L$

$E_g - I_a R_a = V$

$E_g = V + I_a R_a$



$$E_g = \frac{P\phi N Z}{60A}$$

I/P power $= E_g I_a$

O/P Power $= V I_L$

Imp Q.) 8 Pole DC shunt generator has ~~700~~ 778 wave connected armature conductor, running at 500 rpm supply a load of 12.5 Ω at a terminal voltage 250 volt. The armature resistance is 0.24 Ω and shunt field resistance is 250 Ω, calculate
i.) find out the armature current (I_a)
ii.) Induced emf (E_g)
iii.) flux per pole (ϕ).

Solu→ Given,

$P = 8$ Pole $\quad R_{sh} = \cancel{778}\ 250$

$R_L = 12.5\ \Omega$

$N = 500$ rpm

$V = 250$ V

$\therefore \cancel{I_{sh} R_{sh}} = V$

$\therefore I_{sh} = \frac{V}{R_{sh}} = \frac{250}{250} = 1$

$V = I_L R_L$

$I_L = \frac{R_L}{V} = \frac{12.5}{250}$

Date |
Page |

$I_{sh} R_{sh} = V$

$I_{sh} = \frac{V}{R_{sh}}$

$= \frac{250}{250} = 1$ A

$V = I_L R_L$

$I_L = \frac{V}{R_L}$

$= \frac{250}{12.5} = 20A$

$\cancel{E_g = V + I_a R_a}$

$I_a = I_{sh} + I_L$

$= 1 + 20$

$= 21$ A

$E_g = V + I_a R_a$

$= 250 + 21 \times 0.24$

$E_g = 255.04$ V.

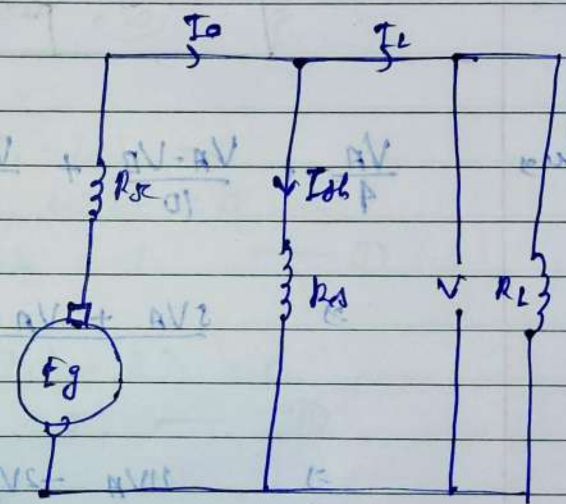
$E_g = \frac{P \phi N Z}{60 A}$

③

$$= 255.04 = \frac{250 \times \phi \times 800 \times 778}{60 \times 2}$$

$$\therefore \phi = 9.83 \times 10^{-3} \text{ webre.}$$

4.) c.) Compound Generator :-



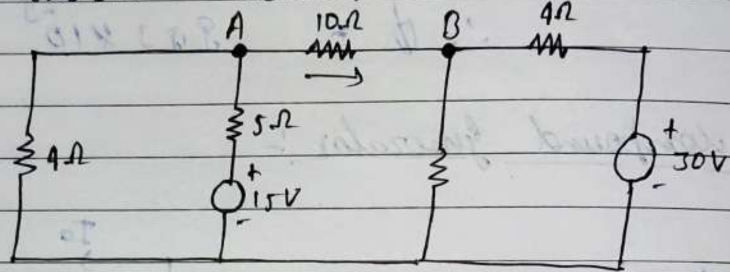
I/P Power = $E_g \cdot I_a$

O/P Power = $V \cdot I_L$

$$E_g - I_a R_a - I_a R_{sc} = V$$
$$= I_L R_L = R_{sh} I_{sh}$$

Assignment - 01

Qn.) Using Nodal analysis, find the current through the 10Ω resistor in the figure shown below.



Solu.

$$\frac{V_A}{4} + \frac{V_A - V_B}{10} + \frac{V_A - 15}{5} = 0$$

$$\Rightarrow \frac{5V_A + 2V_A - 2V_B + 4V_A - 60}{20} = 0$$

$$\Rightarrow 11V_A - 2V_B = 60 \quad \text{— (I)}$$

&

$$\frac{V_B - V_A}{10} + \frac{V_B - 30}{4} + \frac{V_B}{5} = 0$$

$$\Rightarrow \frac{2V_B - 2V_A + 5V_B - 150 + 4V_B}{20} = 0$$

$$\Rightarrow -2V_A + 11V_B = 150 \quad \text{— (II)}$$

So,

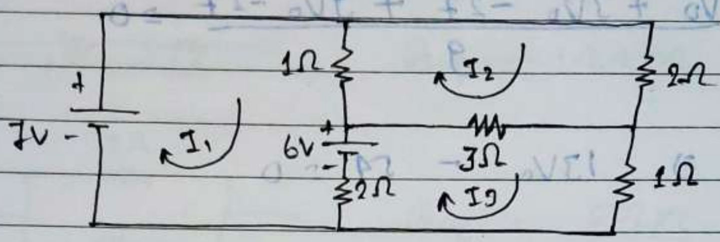
$$V_A = 8.205$$
$$V_B = 15.12$$

$$\therefore I = \frac{15.12 - 8.205}{10}$$

$$\Rightarrow 0.6915\ A. \quad \text{Ans}$$

Date |
Page |

Qn.2.) Use Mesh analysis to determine the three mesh current in the circuit of the figure below :-



Solu

$$7 - (I_1 - I_2) - 6 - 2(I_1 - I_3) = 0$$

$$\Rightarrow 1 - I_1 + I_2 - 2I_1 + 2I_3 = 0$$

$$\Rightarrow -3I_1 + I_2 + 2I_3 = -1 \quad \text{—— (I)}$$

$$-3(I_2 - I_3) - 1(I_2 - I_1) - 2I_2 = 0$$

$$\Rightarrow I_1 - 6I_2 + 3I_3 = 0 \quad \text{—— (II)}$$

$$-2(I_3 - I_1) + 6 - 3(I_3 - I_2) - I_3 = 0$$

$$\Rightarrow -2I_3 - 2I_1 + 6 - 3I_3 + 3I_2 - I_3 = 0$$

$$\Rightarrow 2I_1 + 3I_2 - 6I_3 = -6$$

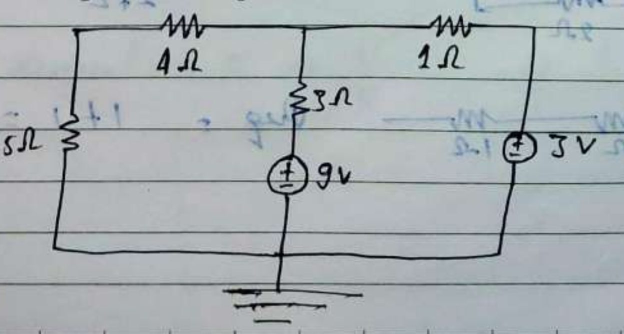
So,

$I_1 = 3A$

$I_2 = 2A$

$I_3 = 3A$

Qn.3.) find V_0 by using nodel analysis method ?



Date |

Page |

Sol:: $\frac{V_0}{9} + \frac{V_0 - 9}{3} + \frac{V_0 - 3}{1} = 0$

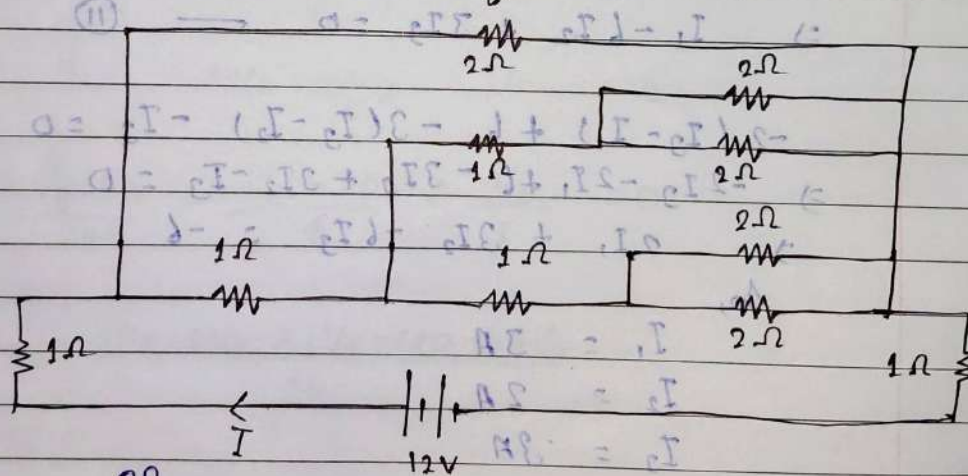
$\Rightarrow \frac{V_0 + 3V_0 - 27 + 9V_0 - 27}{9} = 0$

$\Rightarrow 13V_0 - 54 = 0$

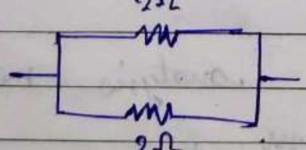
$\therefore V_0 = \frac{54}{13}$

$\Rightarrow V_0 = 4.15$ Ans

Ques 4.) Find the value of current 'I' ?

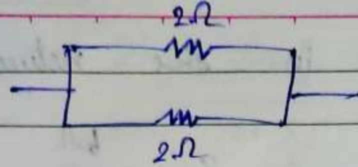


Sol::

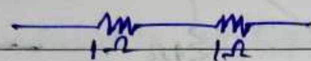


$R_{eq} = \frac{2 \times 2}{2+2} = 1\Omega$

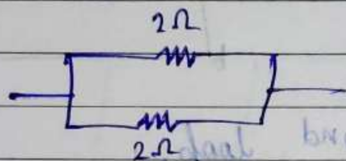
$R_{eq} = 1 + 1 = 2\Omega$



$$R_{eq} = \frac{2\times 2}{2+2} = 1\Omega$$

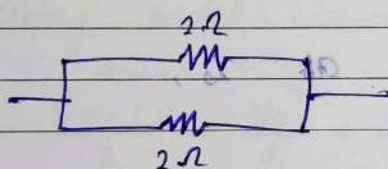


$$R_{eq} = 1\Omega + 1\Omega = 2\Omega$$

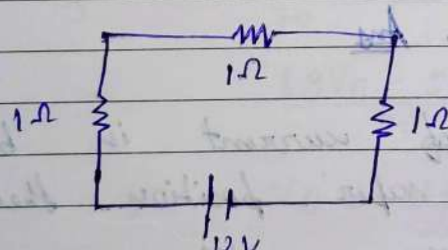


$$R_{eq} = \frac{2\Omega\times 2}{2+2} = 1\Omega$$

$$R_{eq} = 1+1 = 2\Omega$$



$$R_{eq} = \frac{2\times 2}{2+2} = 1\Omega$$



$$R_{eq} = \cancel{\frac{2+2}{2\times 2} = 1\Omega}$$

$$R_{eq} = 1+1+1 = 3\Omega$$

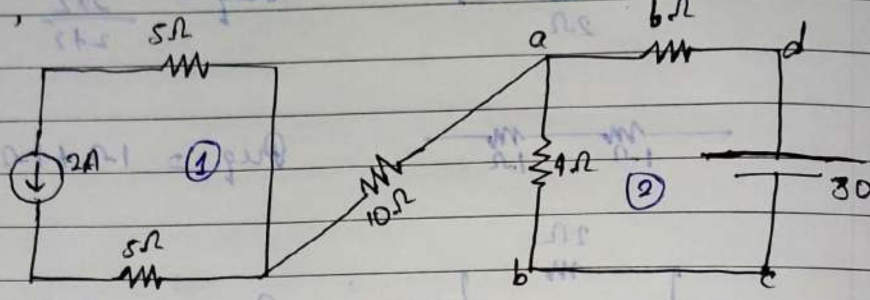
So,

Current, $I = \frac{V}{R} = \frac{12}{3} = 4$ Amp. Ans

Assignment — 02

Date |
Page |

Qn.1) find the voltage V_{ab} in the network shown below,



Solu: Current across 2nd loop.

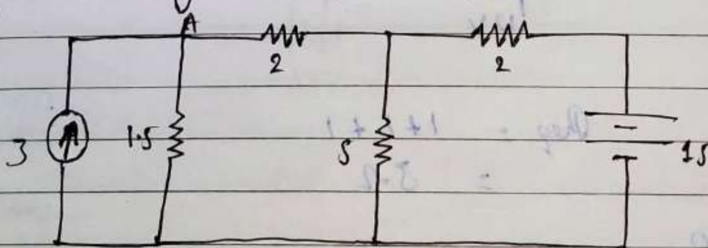
$$I = \frac{V}{R} = \frac{30}{6+4} = \frac{3\cancel{0}}{1\cancel{0}} = 3\,A$$

Now,

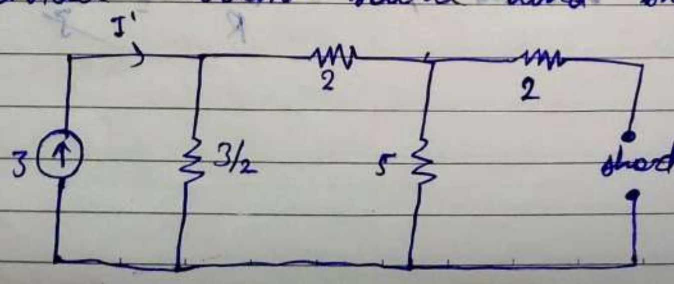
Voltage across ab is,

$$V_{ab} = I \times 4$$
$$= 3 \times 4$$
$$= 12\ V. \quad \underline{\text{Ans}}$$

Qn.) 2.) find the value of current in branch AB by using super position theoram,



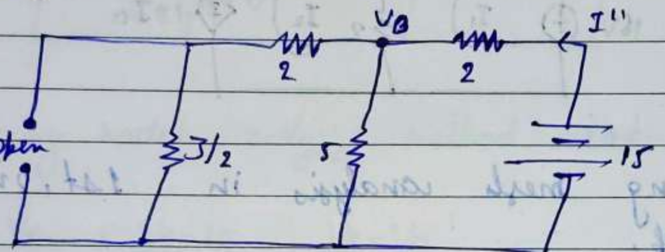
Solu: first consider current source and short the battery,



$$I' = \frac{3 \times \frac{3}{2}}{2 + \frac{3}{2}} = \frac{9/2}{7/2} = \frac{9}{7}$$ {By using division rule}

Now,

consider voltage source and open current source,



Using nodal analysis method,

$$\frac{V_B - 15}{2} + \frac{V_B}{5} + \frac{2V_B}{7} = 0$$

$$\Rightarrow \frac{35V_B - 525 + 14V_B + 20V_B}{70} = 0$$

$$\Rightarrow \frac{69V_B - 525}{70} = 0$$

$$\Rightarrow V_B = \frac{\cancel{525}^{175}}{\cancel{69}_{23}}$$

$$\therefore I'' = \frac{V_B}{2} = \frac{175/23}{2} \Rightarrow \frac{175}{46}$$

Since,

the direction of I' & I'' is opposite,

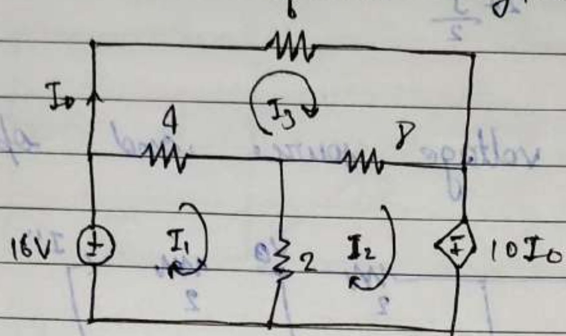
so,

$$I = I'' - I'$$

$$I = \frac{175}{46} - \frac{9}{7} \Rightarrow 2.51\ A.$$ Ans

Date |
Page |

Q.) 3.) Using the mesh analysis method find the I_0 in the circuit given below,



Soln: Using mesh analysis in 1st, 2nd and 3rd loop,

1st loop.

$$16 - 4(I_1 - I_3) - 2(I_1 - I_2) = 0$$
$$16 - 6I_1 + 4I_3 + 2I_2 = 0$$
$$-6I_1 + 2I_2 + 4I_3 = -16 \quad \text{— ①}$$

2nd loop,

$$-2(I_2 - I_1) - 8(I_2 - I_3) + 10 I_0 = 0$$

Here,

$$I_0 = I_3.$$

$$2I_1 - 10I_2 + 18I_3 = 0 \quad \text{— ②}$$

3rd loop,

$$-4(I_3 - I_1) - 6I_3 - 8(I_3 - I_2) = 0$$
$$4I_1 + 8I_2 - 18I_3 = 0 \quad \text{— ③}$$

Solving eqn ①, ② & ③, we get,

$I_1 = -2.57A$, $I_2 = -7.71\,A$ & $I_3 = -4\,A$.

$\therefore \; I_3 = I_0 = -4A$. Ans

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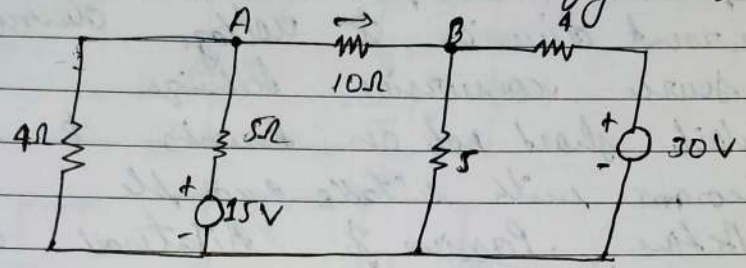
3rd loop,

Date |
Page |

Qn.) 4.) Using Nodel analysis, find the current through the 10Ω resistor in the fig. shown below;



Soln. Applying nodel analysis method at node A,

$$\frac{V_A}{4} + \frac{V_A - 15}{5} + \frac{V_A - V_B}{10} = 0$$

$$5V_A + 4V_A - 60 + 2V_A - 2V_B = 0$$

$$11V_A - 2V_B = 60 \quad \text{--- (1)}$$

&

Applying nodel analysis at node B,

$$\frac{V_B - V_A}{10} + \frac{V_B}{5} + \frac{V_B - 30}{4} = 0$$

$$2V_B - 2V_A + 4V_B + 5V_B - 150 = 0$$

$$-2V_A + 11V_B = 150 \quad \text{--- (2)}$$

Now,

solving eqn (1) & (II), we get,

$V_A = 8.20$ V & $V_B = 15.12$ V.

So, current across 10Ω resistor is,

$$I = \frac{V_B - V_A}{10} = 0.692 \text{ A}$$

Date |
Page |

1. KCL & KVL
2. Dependent & Independent source
3. Current division & voltage division Rule
4. Source conversion technique.
5. Write short note on thevenin & Superposition theoram with suitable example.
6. Active, Passive & Bilateral elements
7. Star Delta conversion.
8. Ideal & Practical current sources,

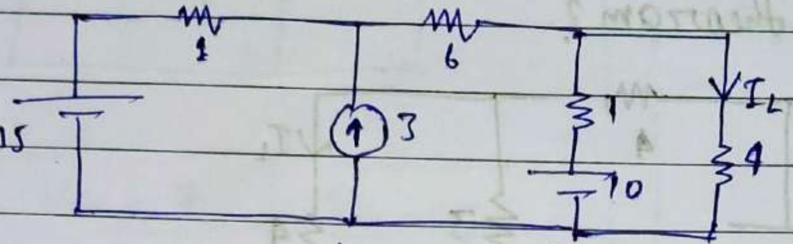
UNIT - 2

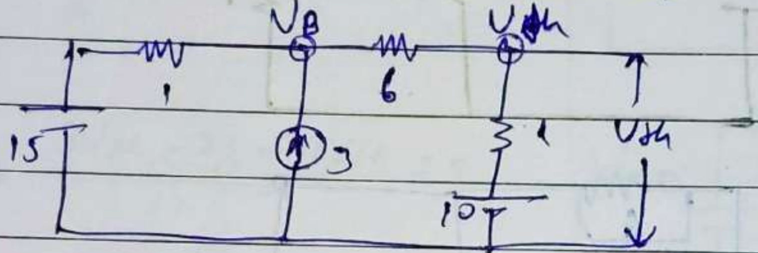
1. Instantaneous value of current (Alternating current)
2. Average current and RMS current.
3. form factor, crest factor
4. Power factor,
5. Active, Reactive & Apparent power
6. Properties of R, L, C circuit.
7. Series RL circuit, Series RC circuit, Series RLC circuit.

Date |

Page |

find current across 4Ω resistance by using thevenin's theorem





⇒ ~~$V_{th} - V_A$~~ $\frac{V_{th}-V_B}{6} + \frac{V_{th}-10}{1} = 0$

$\Rightarrow 7V_{th} - V_B = 60$

$$\frac{V_B-\cancel{V_{th}}15}{1} + \frac{V_B-V_{th}}{6} - 3 = 0$$

$\Rightarrow 7V_B - V_{th} = 108$ — ②

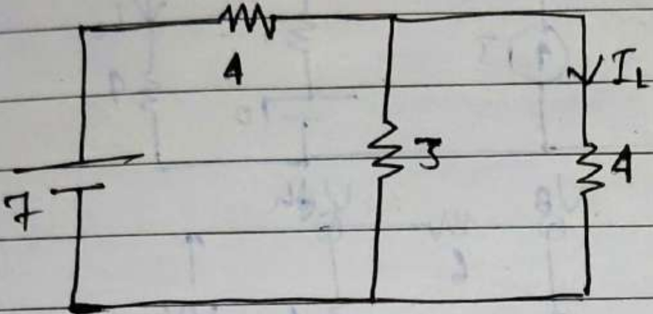
$V_B = 17\ V$

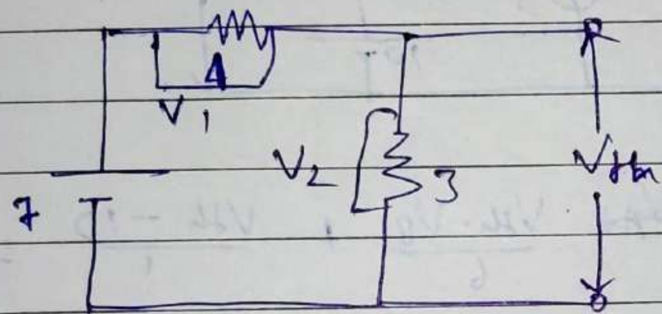
$V_{th} = 11\ V$.

Date |

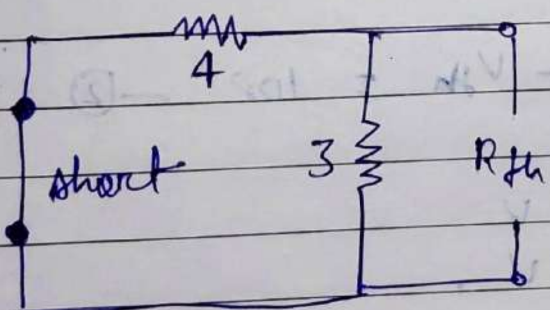
Page |

find current across 4 Ω resistance using thevenin's theoram?

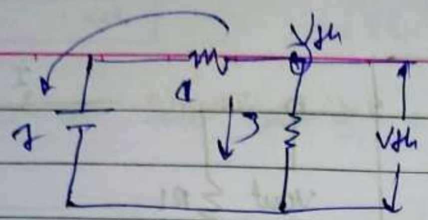




$$V_{th} = \frac{E \times R_2}{R_1 + R_2} = \frac{7 \times 3}{4 + 3} = 3.$$



$$R_{th} = \frac{R_1 \times R_2}{R_1 + R_2} = \frac{4 \times 3}{4 + 3} = 1.71$$

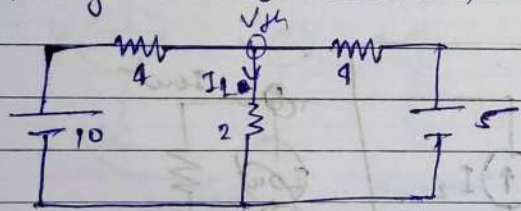


$\Rightarrow \frac{V_{th}-7}{4} + \frac{V_{th}}{3} = 0$

$\Rightarrow \frac{3V_{th}-21-4V_{th}}{12} = 0$

$\Rightarrow V_{th} = 3$

Q) find I across 2Ω resistance by using thevenin's theorem



Solu» $\frac{V_{th}-10}{4} + \frac{V_{th}-5}{4} = 0$

~~Vth =~~

$\Rightarrow \frac{V_{th}-10+V_{th}-5}{4} = 0$

$\Rightarrow V_{th} = 7.5$

∴ $R_{th} = \frac{4\times4}{4+4} = 2$

∴ $I = \frac{V_{th}}{R_{th}+R_L} = \frac{7.5}{2+2}$

$\Rightarrow 1.875\,A$

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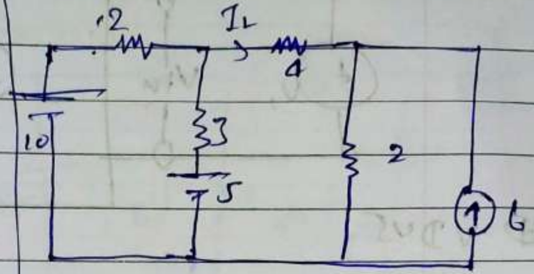
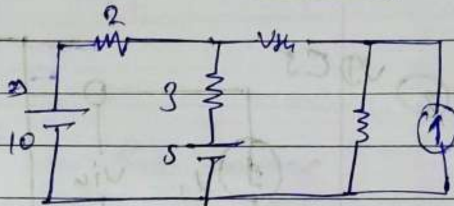
Q) find current across 4Ω resistance by using thevenin's theorem?



Solu»



$V_A - V_B = V_{th}$

$\frac{V_A-10}{2} + \frac{V_A-5}{3} = 0$

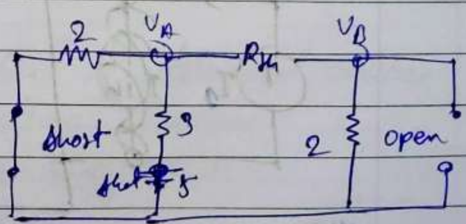
$\frac{3V_A-30+2V_A-10}{6} = 0$

$V_A = 8$

& $V_B = 12$

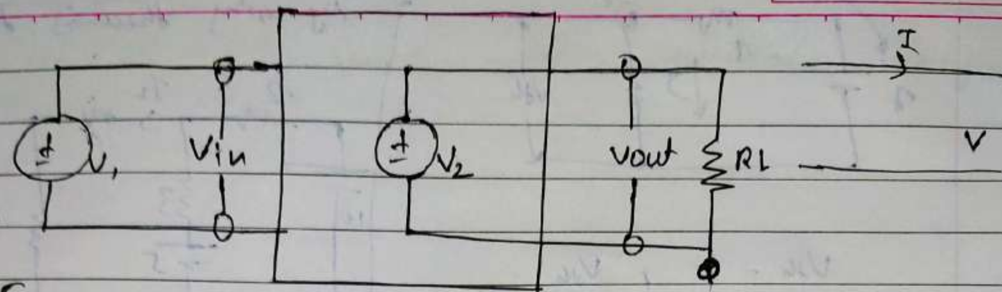
$V_{th} = 12-8 \Rightarrow 4\,V$

∴ $I = \frac{V_{th}}{R_{th}+R_L} = \frac{4}{3.2+4} \Rightarrow 0.55\,A$



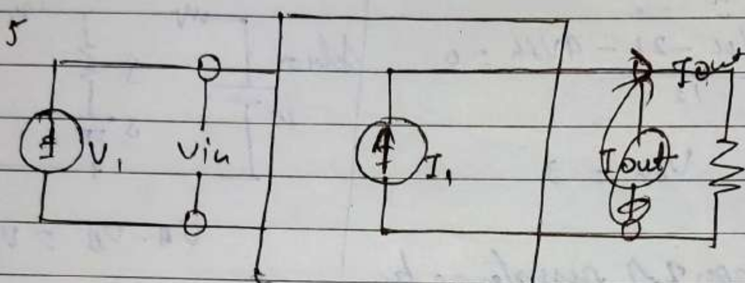
$R_{th} = \frac{3\times2}{5} \Rightarrow \frac{6}{5}+2$

$\frac{2\times3}{2+3}+2 \Rightarrow 3.2\,\Omega$

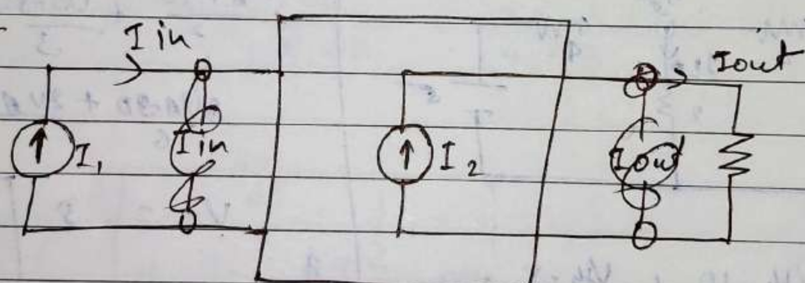


① VDVS

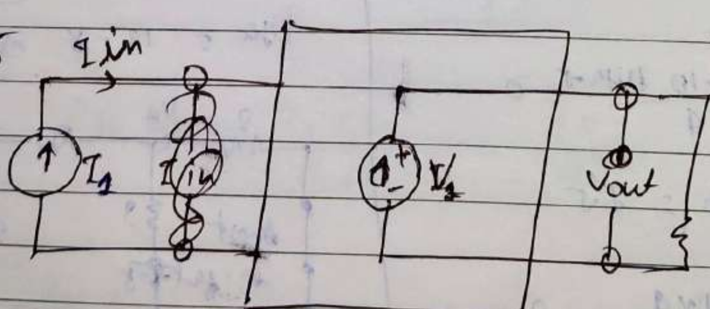
② VDCS



③ CDCS



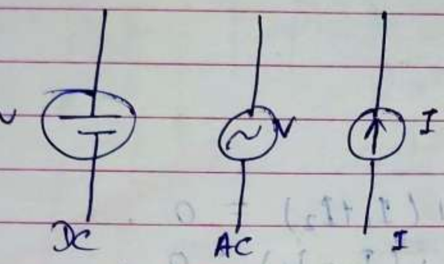
④ CDVS

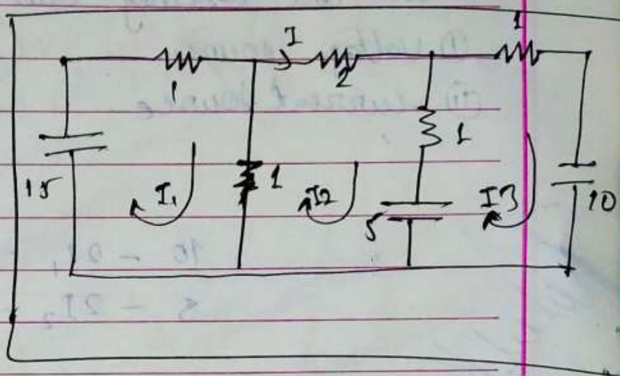


The algebraic sum of the products of the current and resistance in each of the conductor in a closed path (or mesh) in a network plus the algebric sum of the emf of the path is zero.

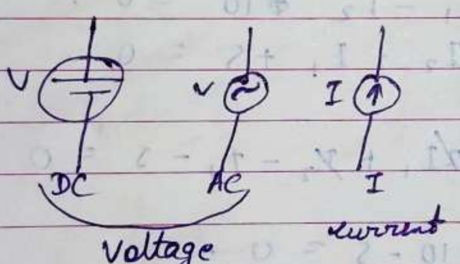
Notes.

(.) There are two types of current source:



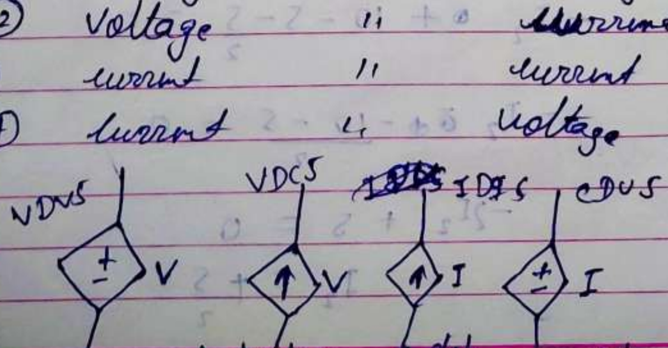


Independent source :- Independent source are those source which does not depends on any other quantity. (Voltage & Current)



Dependent source : dependent sources are those source which depends on any other quantity (current & voltage).

There are basically four types of dependent source
1. Voltage dependent voltage source
2. Voltage " current "
3. current " current "
4. current " voltage "



voltage Voltage dependent   voltage dep cur   I dep I   I dep v.