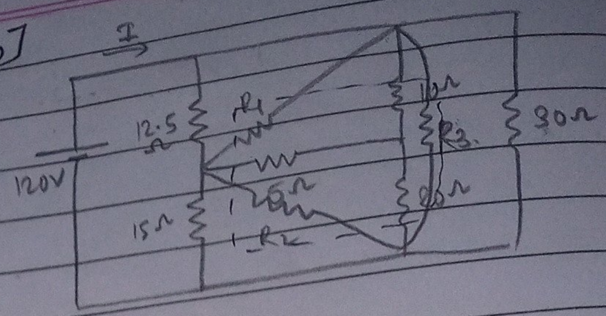
2018 Fall

[Q.No.1b]



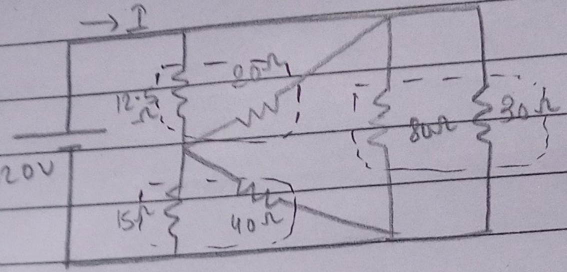
Soln.

Converting (5Ω - 10Ω - 20Ω) into delta form.

$$R_1 = \frac{5\times10 + 5\times20 + 10\times20}{20} = 20\Omega$$

$$R_2 = \frac{5\times10 + 5\times20 + 10\times20}{10} = 40\Omega$$

$$R_3 = \frac{5\times10 + 5\times20 + 10\times20}{5} = 80\Omega$$



~~Convert~~

80Ω and 30Ω are in parallel so,

$$R_{eqv_1} = \frac{80\times30}{80+30} = 21.81\Omega$$

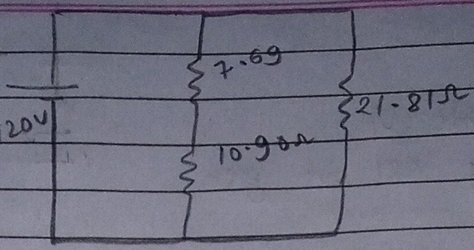
12.5Ω and 20Ω in parallel,

$$R_{eqv_2} = 12.5 \parallel 20 = 7.69\Omega$$

15Ω and 40Ω are in parallel,

$$R_{eqv_3} = 15 \parallel 40 = 10.90\Omega$$

(7.69+ 10.90Ω) is in parallel with 21.81



$\therefore R_{eq} = 18.59 \,//\, 21.81$

$= 10.035\Omega$.

Finally,

current $(I) = \frac{V}{R} = \frac{120}{10.035} = 11.958A$ Ans

Q.No.2a

KCL:-

It states that "The sum of electrical currents in any node of circuit is zero. It follows the law of conservation of energy. ~~which met~~ Therefore, total incoming current is equal to total outgoing current.

KVL:-

It states that " The sum of total emf in any loop is equal to the sum of voltage drops in the same loop."

$\Rightarrow$

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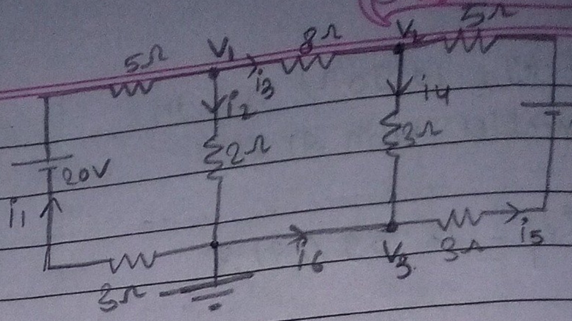


Soln.

Here,

At node V_1,

Applying KCL we get,

$$i_1 - i_2 - i_3 = 0.$$

or, $$\frac{0 - V_1 + 20}{8} - \frac{V_1 - 0}{2} - \frac{V_1 - V_2}{8} = 0.$$

or, $\cancel{-8V_1 + 160 - 20V_1 - 5V_1 + 5V_2 = 0}$

or, $\cancel{-28V_1 = -8}$ $-V_1 + 20 - 4V_1 - V_1 + V_2 = 0$

or, $-6V_1 + V_2 + 20 = 0$ —— (I)

At node V_2, applying KCL,

$$i_3 - i_4 + i_5 = 0$$

or, $$\frac{V_1 - V_2}{8} - \frac{V_2 - V_3}{3} + \frac{V_3 - V_2 + 25}{8} = 0$$

or, $3V_1 - 3V_2 - 8V_2 + 8V_3 + 3V_3 - 3V_2 + 75 = 0$

or, $3V_1 - 14V_2 + 11V_3 + 75 = 0$ —— (II)

Applying KCL at node V_3,

$$i_6 + i_4 - i_5 = 0$$

or, $$0 - V_3 + \frac{V_2 - V_3}{3} - \frac{V_3 - V_2 + 25}{8} = 0.$$

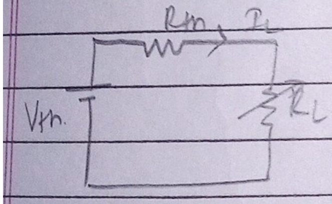
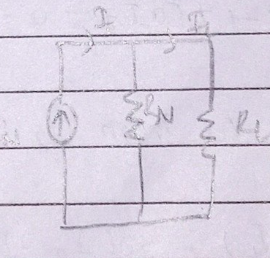
or, $-24V_1 + 8V_2 - 8V_3 - 3V_3 + 3V_2 - 75 = 0.$

or, $-24V_1 + 11V_2 - 11V_3 - 75 = 0.$ ———— (iii).

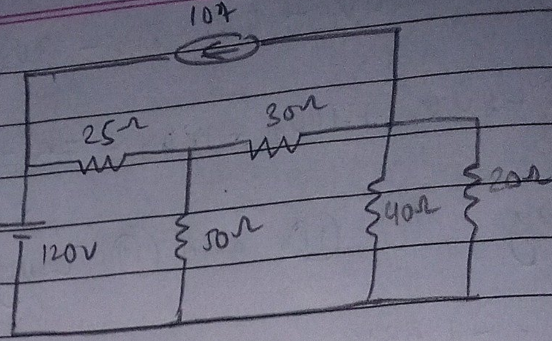
Solving (i), (ii) and (iii) using calculator we get

$V_1 = -1.53V$
$V_2 = 10.76V$
$V_3 = 20.944V.$
Ans

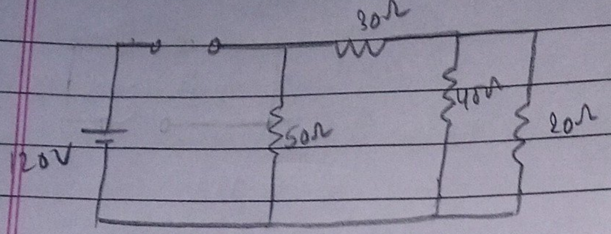
[Q.No.2b]

Thevenin theorem.	Norton's theorem.
- They are used in parallel circuit	- They're also used in parallel circuit
- They're used in solving electric circuit where circuit part is fixed & load is variable.	- They're also used in solving the electric circuit where circuit part is fixed & load is variable.
- It is similar to that of practical current source	- It is similar to that of practical current source
	
$I_L = \frac{V_{th}}{R_{th} + R_L}$	$I_L = \frac{R_N}{R_N + R_L} \times I_N.$

Next part :-



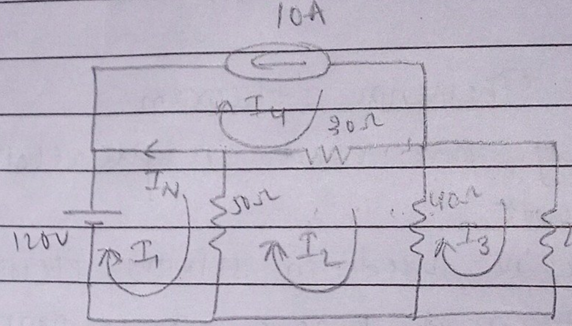
Here,
finding R_N,



$R_N = (50+30) \parallel [40 \parallel 20]$

$= 80 \parallel 13.33$

$= 11.42 \Omega$



Now
finding I_N :-
current in mesh I_4 is,
$I_4 = -10A$.

Applying KVL at mesh I_1

$120 - 50(I_1 - I_2) = 0$

or, $120 - 50I_1 + 50I_2 = 0$ ——— (1)

Applying KVL at mesh I_2,

$-50(I_2 - I_1) - 30(I_2 - I_4) - 40(I_2 - I_3) = 0$

or, $-50I_2 + 50I_1 - 30I_2 + 30I_4 - 40I_2 + 40I_3 = 0$

$50I_1 - 120I_2 + 40I_3 - 300 = 0$

Applying KVL at mesh I_3,

$$-40(I_3 - I_2) - 20I_3 = 0$$

or, $40I_2 - 60I_3 = 0$ —— (iii)

Solving (i), (ii) and (iii) using calculator we get,

$$I_1 = 1.75A$$
$$I_2 = 4.175A$$
$$I_3 = 2.46A$$

$\therefore I_N = I_1 = -1.75A(\leftarrow) = 1.75A(\rightarrow)$

finally,

$$I_{25} = \frac{R_N}{R_N + R_L} \times I_N$$

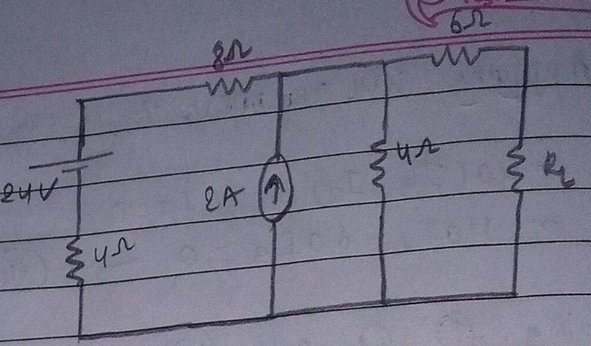
$$= \frac{11.42}{11.42 + 25} \times 1.75$$

$= 0.54A$ Ans

[Q.No.3a]

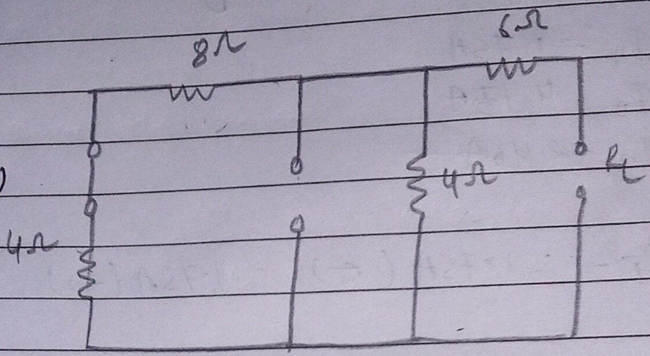
$\Rightarrow$

Soln.



Here,
$R_L = ?$
Max power = ?

Now,
Finding R_L,



$R_L = (4+8) \parallel (4+6)$

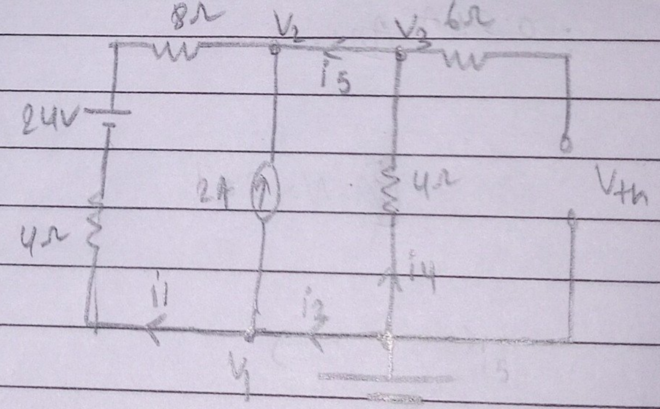
$= 12 \parallel 10$

$= 5.45\Omega$

~~Now~~ We know, for maximum power transferred to the load, load resistance must be equal to thevenin resistance.

$\therefore R_{th} = R_L = 5.45\Omega$

Finding V_{th} :-



$V_{th} = V_3 - 0$.

Now,

⇒

Applying KCL at node V_1

$i_2 - i_1 - 2 = 0$

or, $0 - V_1 - \frac{V_1 - V_2 + 24}{12} - 2 = 0$

or, $\cancel{-V_1} - 12V_1 - V_1 + V_2 + 24 - 24 = 0.$

or, $-13V_1 + V_2 = 0.$ ——— (I)

$\therefore \cancel{V_2 = 13V_1}$ ——— (I).

Applying KCL at node V_2,

$i_5 + 2 + i_1 = 0$

or, $V_3 - V_2 + 2 + \frac{V_1 - V_2 + 24}{12} = 0$

or, $12V_3 - 12V_2 + 24 + V_1 - V_2 + 24 = 0$

or, $V_1 - 13V_2 + 12V_3 + 48 = 0$ ——— (II)

Applying KCL at node V_3,

$i_4 - i_5 = 0$

or, $\frac{0 - V_3}{4} - \frac{V_3 - V_2}{} = 0$

or, $-V_3 - 4V_3 + 4V_2 = 0$

or, $-5V_3 + 4V_2 = 0$ ——— (III)

Solving (i), (ii) and (iii) using calculator.

$V_1 = -1.11V$

$V_2 = -14.44V$

$V_3 = -11.56V$

$\therefore V_{th} = V_3 - 0 = -11.56V.$

Now,

The maximum power dissipated is,

$$P_{max} = \frac{(V_{th})^2}{4R_{th}} = \frac{(-11.56)^2}{4 \times 5.45} = 6.129 \text{ watt}$$ Ans

[Q.No. 4a]

~~Phase~~ Sol^n

Given,

$Z_1 = (20 + j5)\ \Omega$

$Z_2 = (30 + j8)\ \Omega$

$\therefore Z = (20 + j5) + (30 + j8)$

$= 51.66 \angle 14.57\ \Omega$

~~Active power (P) = VIC~~

$$\text{Current } (I) = \frac{V_{ph}}{Z_{ph}} = \frac{400}{51.66 \angle 14.57} = 7.74 \angle -14.57 A \text{ (lag).}$$

(ii) power factor $= \cos\phi$
$= \cos 14.57$
$= 0.96.$

(iii) Active power (P) $= VI \cancel{\sin\phi} \cos\phi$
$= 200 \times 7.74 \times 0.96$
$= 1486.08$ Watt

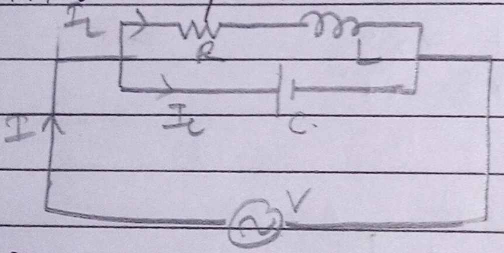
(iv) Reactive power (Q) $= VI\sin\phi$
$= 200 \times 7.74 \times \sin(14.57)$
$= 387$ VAR

(v) Apparent power (S) $= \sqrt{P^2 + Q^2}$
$= \sqrt{1486.08^2 + 387^2}$

$= 1535.644$ VA. Ans

[Q.No.4b]

Resonance in parallel RLC circuit:-



Let a circuit where capacitance C is connected in parallel with an inductive coil of resistance R & inductive inductance X_L as shown in figure.

where,

I_L = current through ~~resistance~~ resistor & inductor.

I_C = current through capacitor.

I = total current.

Under resonance, pf is unity, reactive component of total current is zero. The reactive component of the ~~...~~ current is $\cancel{X_C}$ $(I_C - I_L \sin\phi) = 0$.

where, ϕ is the power factor angle of coil.

Hence,

$$I_C = I_L \sin\phi$$

$$\frac{V_L}{X_C} = \frac{V}{Z_L} \times \frac{X_L}{Z_L}$$

$$\text{or, } X_L X_C = Z_L^2$$

$$\text{or, } \frac{wL}{wC} = Z_L^2 = R^2 + (wL)^2$$

$$\text{or, } (wL)^2 = \frac{1}{C} - R^2$$

At resonance, $w_r = \sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$

At resonance frequency,

$$f_r = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$$

If resistance is neglected,

$$w_r = \frac{1}{\sqrt{LC}}$$

and,

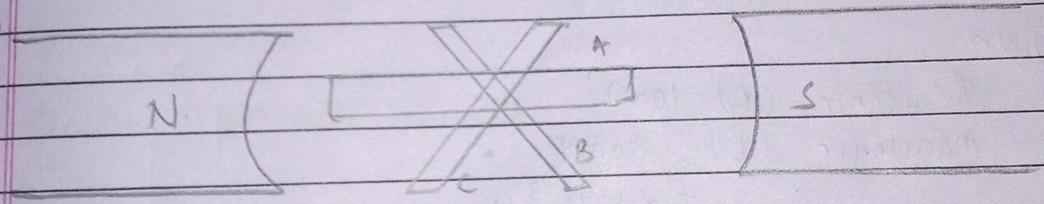
$$f_r = \frac{1}{2\pi\sqrt{LC}}.$$

If resistance is neglected, resonance frequency of parallel RLC circuit is equal to the series RLC circuit.

At resonance:-

- Resonance frequency, $f_r = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$.
- Pf is unity.
- Net ~~susp~~ susceptance is zero i.e. $\left(w_L - \frac{1}{w_L}\right) = 0$

[Q.No.5a]



Three phase voltage can be generated by placing three rectangular coils displaced in space by 120° in a uniform magnetic field. When these coils rotate with uniform angular velocity of ω rad/sec, a sinusoidal emf displaced by 120° is induced in these coils.

Next part:-
Advantages of 3ϕ over 1ϕ:-

- Power in 3 phase is always almost constant i.e. power never falls to zero. But in single phase power may falls to zero.
- 3ϕ requires less copper i.e. only $3/4^{th}$ the total copper than 1ϕ system.
- Efficiency in polyphase generator is very high than single phase.
- 3ϕ motors can be made self starting.

For the given size of frame, output in 3 phase machine is very high.

[Q No. 5b]

Soln.

Given,

Resistance $(R) = 100\Omega$

Inductance $(L) = 20mH$

$= 20 \times 10^{-3} H$

$= 0.02 H$

$\therefore X_L = 2\pi f L = 6.28\Omega$

$\Rightarrow$

Case I :-
In delta connected load:-

We know,

$\cancel{V_L}$ $V_L = V_{ph} = V = 400V.$

$I_L = \sqrt{3} I_{ph}.$

Now,

$Z_{ph} = R + jX_L = 100 + j6.28 \Omega = 100.196 \angle 3.59 \Omega$

(i) $I_{ph} = \dfrac{V_{ph}}{Z_{ph}} = \dfrac{400 \angle 0°}{100.196° \angle 3.59 \Omega} = 3.992 \angle -3.59° A (lag)$

(ii) $I_L = \sqrt{3} I_{ph} = \sqrt{3} (3.992 \angle -3.59°)$
$= 6.914 \angle -3.59° A (lag)$

(iii) $pf = \cos\phi = \cos 3.59° = 0.99.$

i) Active power(P) = $VI\cos\phi = 400 \times \cancel{6.914}\ 3.992 \times 0.99$
$= 1580.832$ Watt.

ii) Reactive power(Q) = $VI\sin\phi = 400 \times 3.992 \times \sin(3.59)$
$= 99.0016$ VAR

iii) Apparent power (S) $= \sqrt{P^2 + Q^2}$

$= \sqrt{1580.832^2 + 99.0016^2}$

$= 1583.929$ VA Ans

Case II :-
By star connected load.

We know,
$V_L = \sqrt{3} V_{ph}$ and $I_L = I_{ph}$

~~(i) $I_L = I_{ph} = 9.99\angle -3.59° A$.~~

~~(ii) Active power = VI~~

Now,
$V_L = \sqrt{3} V_{ph}$

$V_{ph} = \frac{400}{\sqrt{3}} = 230.94 V$

$\therefore I_{ph} = \frac{V_{ph}}{Z_{ph}} = \frac{230.94}{100.196\angle 3.59} = 2.30\angle -3.59$

(i) $I_L = I_{ph} = 2.30\angle -3.59° A$ (lag)

(ii) Active power = VI cos ϕ
= $230.94 \times 2.30 \times 0.99$
= 525.85 Watt

(iii) Reactive power = VI sin ϕ
= $230.94 \times 2.30 \times \sin 3.59$
= 32.932 VAR

(iv) Apparent power = $\sqrt{P^2 + Q^2}$
= $\sqrt{525.85^2 + 32.932^2}$
= 526.8801 VA

[Q.No. 6b]

Soln.

Given,

primary leakage reactance (X_1) $= 0.7\Omega$

secondary leakage reactance (X_2) $= 0.9\Omega$

~~pry~~ primary ~~reat~~ resistance (R_1) $= 0.5\Omega$

secondary resistance (R_2) $= 0.8\Omega$

$$K = \frac{250}{500} = 0.5$$

) Equivalent ~~reactance~~ resistance referred to primary side :-

$$R_{01} = R_1 + \frac{R_2}{K^2}$$

$$= 0.5 + \frac{0.8}{(0.5)^2} = 3.7\Omega$$

~~pri~~ equivalent reactance referred to secondary side :

$$X_{01} = X_1 + \frac{X_2}{K^2} = 0.7 + \frac{0.9}{(0.5)^2} = 4.3\Omega$$

$$Z_{01} = \sqrt{R_{01}^2 + X_{01}^2} = \sqrt{3.7^2 + 4.3^2}$$

$$= 5.67\Omega$$

(b) Equivalent parameter referred to secondary side.

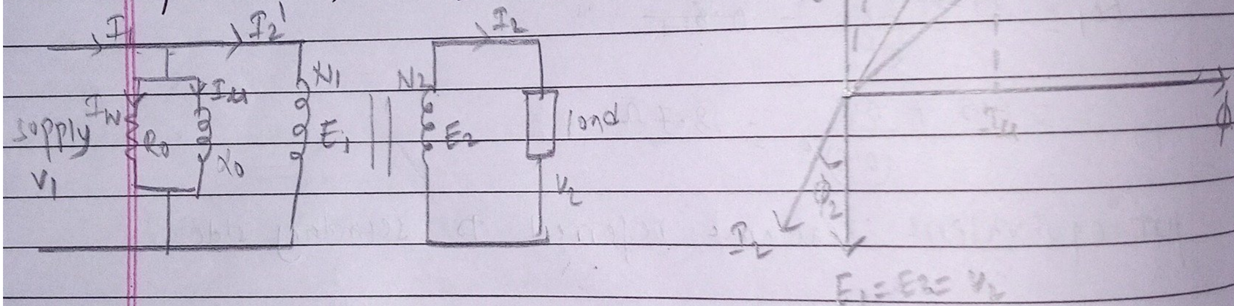
$$R_{01} = R_2 + K^2 R_1$$
$$= 0.8 + (0.5)^2 \times (0.5)$$
$$= 0.925\Omega$$

$$X_{01} = X_2 + K^2 X_1 = 1.075\Omega$$

$$Z_{01} = \sqrt{X_{01}^2 + R_{01}^2} = 1.41\Omega$$ Ans

[Q. No. 7b]

⇒ Operation of transformer on load:-



When the load is connected to the secondary, the load current flows through the load as well as secondary winding (I_2). ~~It~~

It includes the self mmf ($N_2 I_2$) which produces the flux ϕ_2, that opposes the main flux ϕ, and weakens it hence tries to reduce ~~the~~ E_1. If E_1 falls below the mitial level, the extra current flowing from source to primary winding (I_2') produces the flux (ϕ_2') which neutralize the main flux (ϕ_2). Hence the main flux ϕ_1 remains unchanged irrespective of load.

[Q.No.7c]

<u>Working principle of 3 phase induction motor:-</u>

When a 3ϕ supply is given to the stator, ~~of~~ rotating magnetic field is produced in stator. The rotating magnetic field produced by stator. cuts the rotor conductor and hence emf will be induced on the rotor conductor as per law of electromagnetic induction.

As the rotor conductor are short circuited, current will circulate within the rotor conductor. Since these currents carrying rotor conductor are lying in the magnetic field produced by the stator, hence, force will develop on rotor conductor and the rotor starts rotating under the action of this force.