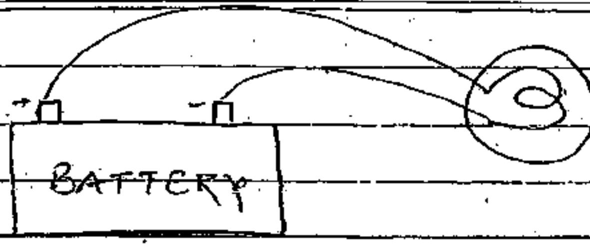
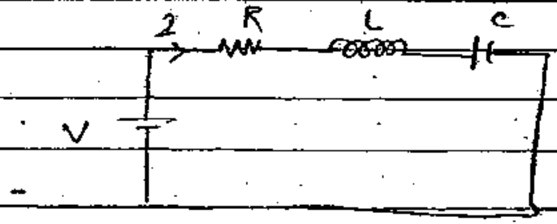


Basically our main aim is to transfer the energy from ne point to another and for this we required an nterconnection of elements and this interconnection of lements or component is called as an electrical ircuit.

Difference b/w a circuit and network.

- Circuit always form a closed path but the network may or may not be closed.



harge: It is the electrical property of the atomic particles of which metal consist and in electrical circuit the most unique quantity is charge and its unit is columns.

$$1e^- = 1.6 \times 10^{-19}\ C$$

Columns is a large unit of charge as 1 column of of charge is contributed by $6.24 \times 10^{18}\ e^-s$.

$$\because 1.6 \times 10^{-19} C = 1e^-$$

$$\therefore 1C = \frac{1}{1.6 \times 10^{-19}}\ e^-s = 6.24 \times 10^{18}\ e^-s$$

w of Conservation of Charge:
It state that charge can neither be created
r be destroyed it can only be transferred from
body to another. $\left(\nabla \cdot J = -\frac{\partial \rho_v}{dt}\right)$ (point quantity law).

rent- The flow of electrons or the time rate
change of charge is called as current and its
nit is ampere.

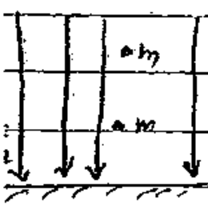
$$i = \frac{dq}{dt} \quad C/s \text{ or Ampere.}$$

e- The direction of current flow is conventionally taken
the direction of the positive charge movement

ltage- To move the electron from one point to
other point in a particular direction an external
ce is required and in an electrical circuit this
xternal force is provided by the electromotive force.
n this is given by

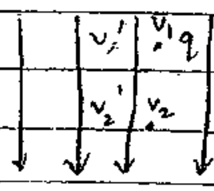
$$V = \frac{dw}{dq} \quad J/c \text{ or volt.}$$

If we place a positive charge in an electric field
will be accelerated in the direction of the field,
st like a mass place in a gravitational field gets
celerated in the direction of field.



Energy gained by the mass in the given field $= mg(h_1 - h_2)$

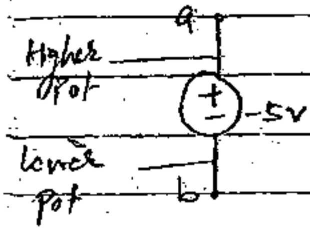
grav. pot. diff.



energy gained by the charge $= q(v_1 - v_2)$

electrical pot. diff.

Even if h_1 & h_2 are taken from top of the building rather than from the earth surface then h_1 & h_2 will be different but the difference b/w them will be the same as before similarly what matter in the electric ckt is that the potential difference b/w the two points. And Hence potential at point 1 & 2 can be arbitrarily shifted can be any value by shifting the reference



a) $V_a > V_b$

b) $V_a = V_b$

c) $V_a < V_b$

d) None

Higher pot - lower pot = -5

$$V_a - V_b = -5$$

$$\boxed{V_a = V_b - 5}$$

Power: It is the time rate of change of energy (expanding or absorbing) and its unit is watt.

$$P = \frac{dw}{dt} \quad J/c \text{ or watts}$$

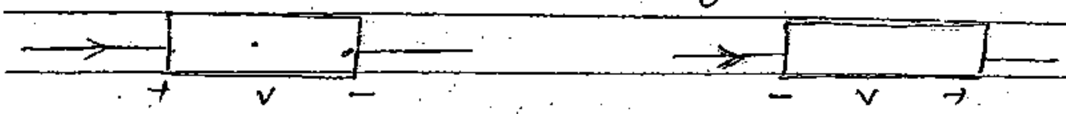
$$= \frac{dw}{dq} \cdot \frac{dq}{dt}$$

$$\boxed{p(t) = v(t) \cdot i(t)}$$

Voltage polarity and current direction are important in determining the sign of the power.

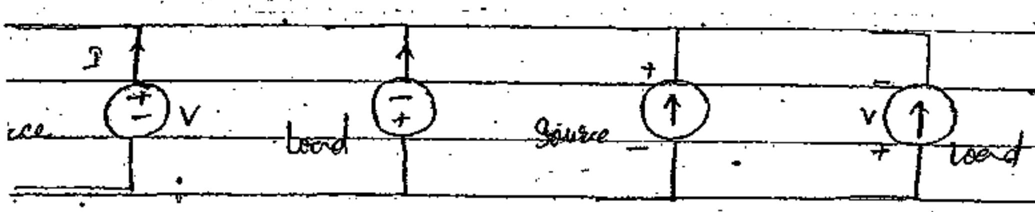
Note - 1. When the current is entering at the +ve terminal then the element is absorbing power.

When the current is leaving from the +ve terminal then the element is delivering power.



$P = +VI$ $P = -VI$

power absorbed or   power delivered.
power received or
power dissipated



Pdel   Pabs   Pdel   Pabs

Law of Conservation of Energy.

It states that energy can neither be created nor be destroyed it can only be transformed from one form to another.

For this reason the algebric sum of the power in circuit at any instant of time must be equal to zero.

i.e. $\Sigma P = 0$

$\Sigma P_{del} = \Sigma P_{abs}$

Find the power of the each element in the below shown circuit.

Energy:

The capacity to do the work is called as energy and its unit Joules.

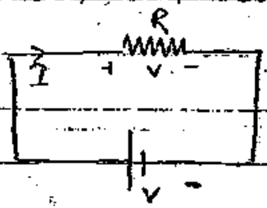
Work done $W = \int_0^t P\,dt$ W-sec or Joules.

CIRCUIT ELEMENTS

An element can be completly characterisied by which VI relationship.

Resistor: If the voltage across the element is linearly proportional to the current through it then that element is called as resistor.

Resistance - Resistance can be described as that property of circuit element which offers opposition to the flow of the current and while doing so it convert electrical energy to the heat energy.



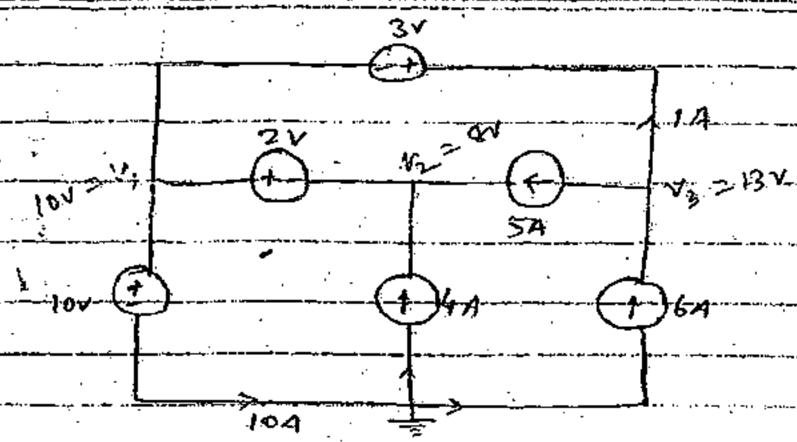
$P = VI$ $\qquad$ $W = \int_0^t P\,dt$ $\qquad$ $W = \int_0^t i^2 R\,dt$

$= (IR)I$ $\qquad$ $= I^2 R \int_0^t dt$

$\therefore \boxed{P = I^2 R}$

$W = I^2 R t$

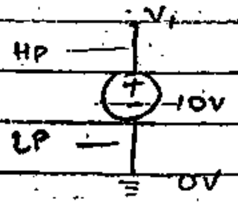
$\therefore \boxed{R = \frac{W}{I^2 R}}$ $\quad \frac{\text{Joule}}{\text{Sec}\cdot A^2}$



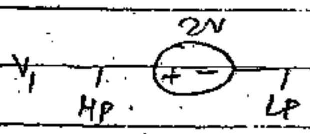
$P_{10V} = +10 \times 10$
$= 100W$ (abs)

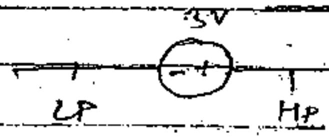
$P_{2V} = -2 \times 9$
$= 18$ (Del)

$P_{3V} = 3 \times 1$
$= 3$ (abs)



H.P. − L.P. = 10V.
$V_1 - 0 = 10$
$\therefore V_1 = 10V.$





HP − LP = 2
$V_1 - V_2 = 2$
$\Rightarrow 10 - V_2 = 2$
$\therefore V_2 = 8V$

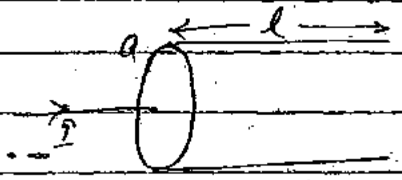
HP − LP = 3
$V_3 - 10 = 3$
$V_3 = 13V$

$P_{4A} = 32\,W$ (Del)
$P_{5A} = 25\,W$ (Abs)
$P_{6A} = 78\,W$ (Del)
...

Σ Del = Σ Abs
$(32 + 18 + 78) = (100 + 3 + 25)$
$\boxed{128\,W = 128\,W}$

Ohm's law :

It states that at constant temperature current density is directly proportional to the electric field intensity.



$$\boxed{\begin{aligned} J &\propto E \\ J &= \sigma E \end{aligned}}$$

1st form or point or microscopic form of ohm's law.

$$\frac{I}{a} = \frac{1}{\rho} \cdot \frac{V}{l}$$

$$V = I\left(\frac{\rho l}{a}\right)$$

$$\boxed{R = \frac{\rho l}{a}}$$

$V = IR$ 2nd form of ohm's law

$V \propto I$ or Circuital form of ohm's law.

i.e. at constant temperature the potential difference across the element is directly proportional to the current flowing through the element.

$V = IR$

$I = V/R$

$$\left.\boxed{\begin{aligned} I &= GV \\ I &\propto V \end{aligned}}\right\}$$ 3rd form of ohm's law

$V = IR$

$\boxed{V = R\frac{dq}{dt}}$ 4th form of ohm's law

Experiment shows that the resistance of the metallic conductor vary with the temperature as

$$\boxed{R_{T_2} = R_{T_1}\left[1+\alpha\Delta T\right]}$$

Where $\Delta T = T_2 - T_1$

R_{T_1} = Resistance at T_1

R_{T_2} = Resistance at T_2

α = temp. coefficient of resistance 2.

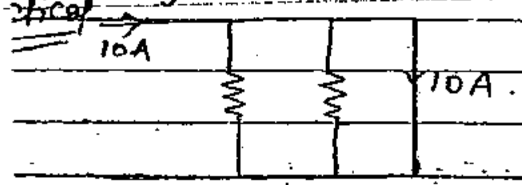
i.e. Ohm's law is valid when the temperature and conductivity of the material are constant.

Concepts Of Short Circuit:

$R = 0$

Ideally, $R=0$, $V=0$, $I=\infty$

-tically



I depends on circuit.

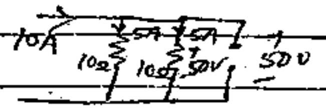
The voltage across the terminals of short circuit is always zero regardless of the value of current.

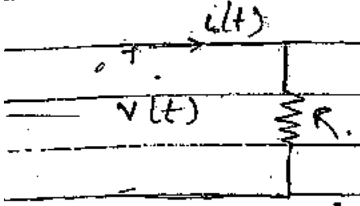
Concepts of Open Circuit:

$R=\infty$

ideally, $R=\infty$, $I=0$, $V=\infty$

practically,





$v(t) = i(t) \cdot R \rightarrow$ Time domain $\left.\begin{matrix} \\ \end{matrix}\right\}$ Non-Sinusoidal excitation
$V(s) = I(s) \cdot R \rightarrow$ laplace domain

$\bar{V} = \bar{I} R \rightarrow$ Phasor domain $\left.\begin{matrix} \\ \\ \end{matrix}\right\}$ Sinusoidal Excitation.
where $\bar{V} = |V| \angle \theta$
$\bar{I} = |I| \angle \theta$

2. Inductor:

If the terminal voltage across an element is directly proportional to the derivative of the current with respect to time, then that element is called an inductor.

Inductor is designed to store the energy in its magnetic field.

Any conductor carrying current has inductive properties and may be considered as an inductor but its inductive effect is very weak and to increase its inductive effect the no. of turns are provided.

Faraday's laws of Electromagnetic Induction:

1st:- If a flux linking a coil varies as a function of time then an emf is induced b/w its terminals. (Statically induced emf like transformer) or,

When a conductor cuts the magnetic lines of force an emf is induced (dynamically induced emf like generator or PMMC instruments) nd law - Value of induced emf is directly proportional to the rate of change of flux

$\psi = N\phi$ $\qquad \phi \propto i$

$\therefore \psi \propto i$

$v = \frac{d\psi}{dt}$ $\qquad \boxed{\psi = Li}$

$\boxed{v = N\frac{d\phi}{dt}}$ $\qquad v = \frac{d\psi}{dt} = \frac{d}{dt}(Li)$

$= L\frac{di}{dt} + i\frac{dL}{dt}$

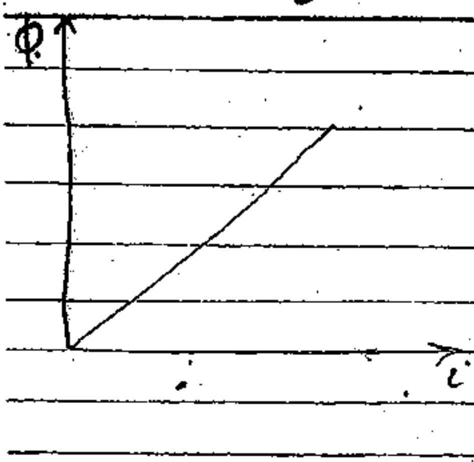
For network, $\boxed{v = L\frac{di}{dt}}$

$\therefore Li = N\phi$

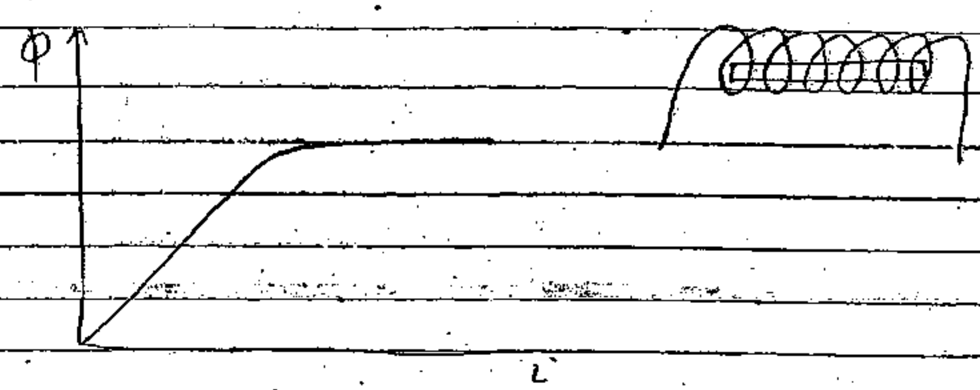
$\boxed{L = \frac{N\phi}{i}}$

inear Inductor - When inductance of inductor is indepent of the current magnitude then the inductor is called as linear inductor.

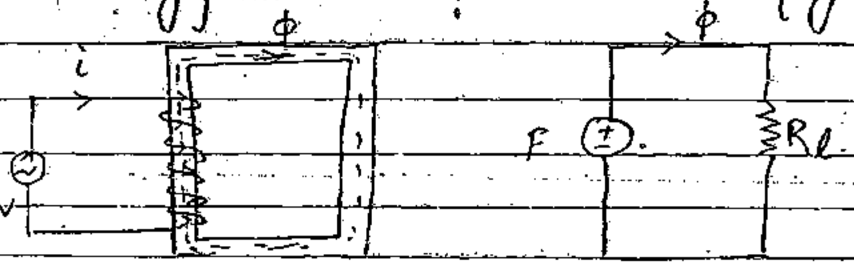
$L = N\frac{\phi}{i}$



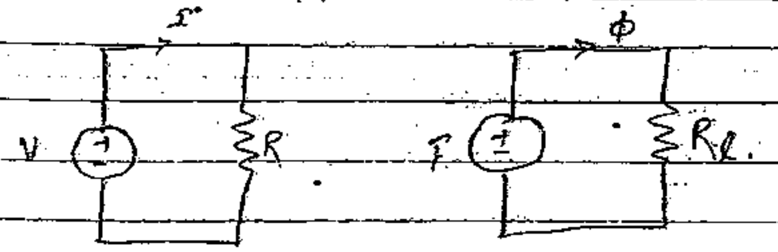
Non-linear Inductor - When inductance of the inductor depends on the current magnitude then the inductor is called as non-linear inductor.
For example - Iron cored inductor.



Analogy between Electric & Magnetic Circuit



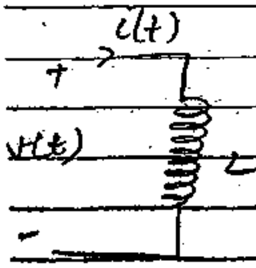
$F = $ mmf
$F = NI$ (Amp-turn)



$V \rightarrow$ Emf
$I = V/R$
$R = \rho \frac{l}{a}$

$F = $ mmf
$\boxed{\phi = \frac{F}{R_l}}$
$\boxed{R_l = \frac{l}{\mu a}}$

$\because L = \frac{N\phi}{i}$
$= \frac{N}{i} \cdot \frac{F}{R_l}$
$= \frac{N}{i} \cdot \frac{Ni}{l/\mu a}$
$\boxed{L = \frac{N^2 \mu a}{l}}$



$v = L\dfrac{di}{dt}$ ⟶ 5^{th} form of Ohm's law

$i = \dfrac{1}{L}\int_{-\infty}^{t} v\,dt$ ⟶ 6^{th} form of Ohm's law

$$i = i(0) + \frac{1}{L}\int_0^t v\,dt$$

$$W = \int p\,dt$$
$$= \int v i\,dt$$
$$= \int L\frac{di}{dt}\cdot i\,dt$$

$$\boxed{W = \frac{1}{2}Li^2}$$

The power dissipation in an ideal inductor is zero. (because its internal resistance is zero)

The energy stored in the inductor is in the form of magnetic field (Kinetic energy)

e-1. For the dc source under steady state condition inductor acts as a short circuit.

$\because v = L\dfrac{di}{dt}$

dc source $i \rightarrow$ constant

$\dfrac{di}{dt} = 0$

$\therefore \boxed{v = 0}$ (dc source).

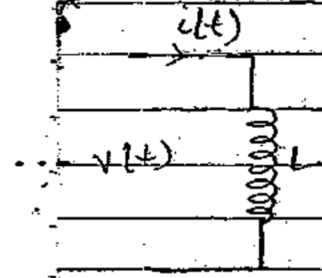
2. Inductor doesn't allow sudden change in current because for sudden change in current infinite voltage is required which is practically not fisible.

$$V = L\frac{di}{dt}$$

$di \rightarrow$ finite

$dt \rightarrow 0$

$\therefore \boxed{V = \infty}$ not fisible.



$v(t) = L\frac{di}{dt} \rightarrow$ Time domain

$V(s) = sLI(s) \rightarrow$ laplace domain

Non Sinusoidal excitation

$\bar{V} = j\omega L\bar{I} \rightarrow$ Phasor domain

Sinusoidal excitation

$\bar{V} = |V|\angle\theta$

$\bar{I} = |I|\angle\theta_1$

→ When the excitation is non-sinusoidal then the given n/w can be analysed either in time domain or in laplace domain.

→ When the excitation is sinusoidal then the n/w is analysed by using phasors.

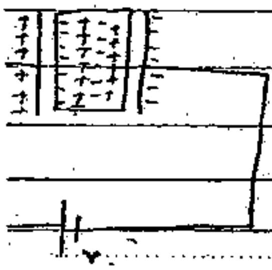
of Analysis of Circuit in S-domain

ferential or integral equation is transform into equation and hence the calculation becomes

nditions, if any, are taken automatically into tion.

CITOR :
the terminal voltage is proportional to the integral with respect to time then element is called citor.

is a device which store energy in the lectric field.



$\because Q \propto V$

$\boxed{Q = CV}$

$\frac{dq}{dt} = \frac{d}{dt}(CV)$

$\frac{dv}{dt} + V\frac{dc}{dt}$

$\frac{dv}{dt}$ $\longrightarrow$ 7^{th} form of Ohm's law

A

• (

Note
ack

$$\boxed{v = \frac{1}{c}\int_{-\infty}^{t} i\,dt}$$ — 8th form of ohm's law

Now,

$$v(t) = v(0) + \frac{1}{c}\int_{0}^{t} i(t)\,dt$$

$$P_{dissipation} = 0$$

$$\therefore W = \int P\,dt$$

$$= \int v i\,dt$$

$$W = \int v c \frac{dv}{dt} \cdot dt$$

$$\boxed{W = \frac{1}{2} C v^2}$$

- Power dissiption in an ideal capacitor is equal to zero.
- Capacitor stores energy in the form of electric field (potential energy)

Note:- For dc source under steady state conditions capacitor acts as an open circuit.

$$i = c\frac{dv}{dt}$$

dc source $v \rightarrow$ constant

$$\frac{dv}{dt} \rightarrow 0$$

$$\therefore \boxed{i = 0}$$ (open circuit)

Capacitor doesn't allow sudden change in voltage

$$i = C\frac{dv}{dt}$$

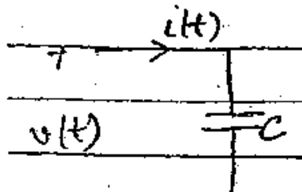
$dv \rightarrow$ finite

$t \rightarrow 0$

$\therefore \boxed{i = \infty}$ (which is not possible).

...ear Capacitor - If the capacitance value is independent ... the voltage magnitude then the capacitor is called as linear capacitor

If the capacitance value is dependent on the ...ltage magnitude then the capacitor is called ... non-linear capacitor
eg - varictor diode.



$i(t) = C\frac{dv}{dt}$ → Time domain

$I(s) = CS\,V(s)$ → Laplace dom — Non sin excitation

$\bar{I} = j\omega C\,\bar{V}$ → Phasor domain — Sin excitation

SOURCES:

If the terminal voltage is completly independent of current or the current is completly independent of voltage then the element is called as independent Source

· The element for which either the voltage or the current depends upon voltage or current elsewhere in the circuit then it is called as dependent source.

1. Voltage Source

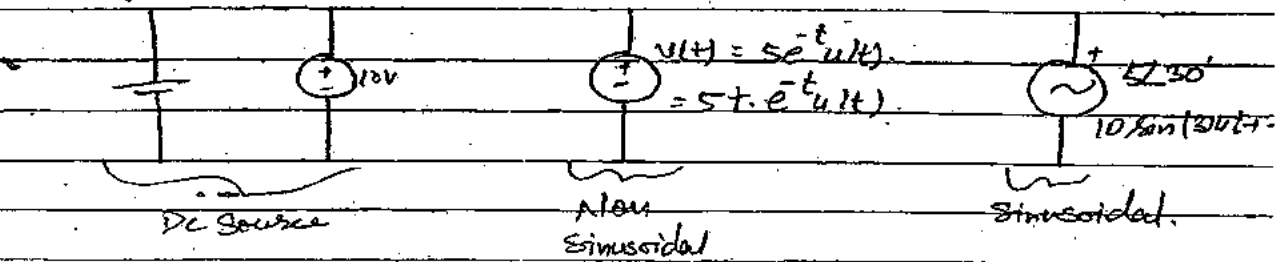
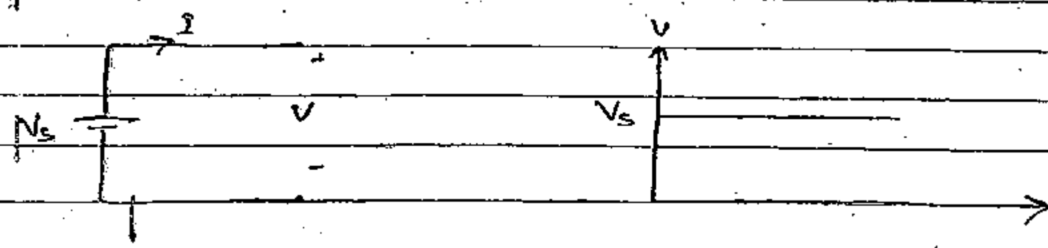
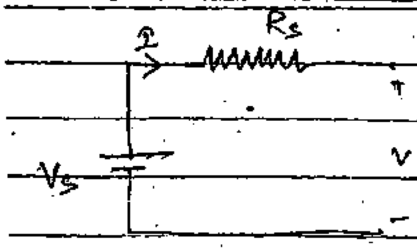


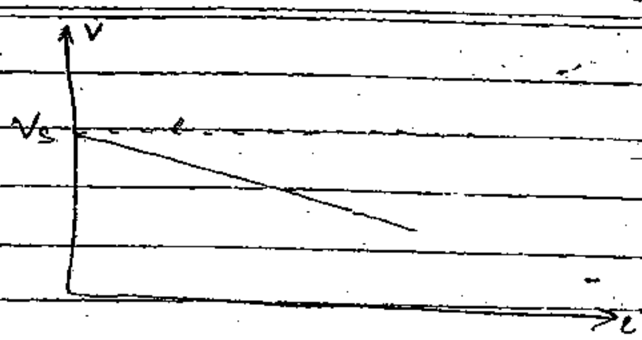
Fig: Independent voltage Source Representations.

Ideal voltage source has zero internal resistance and it deliveres energy at a specified voltage which is independent of the current delivered by the source.

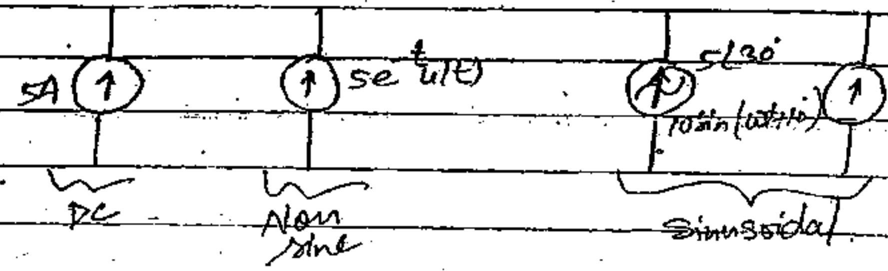


Pratical voltage source have some finite internal resistance and it delivers energy at specified voltage which depends on the current delivered by the source.



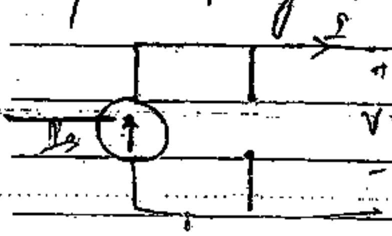


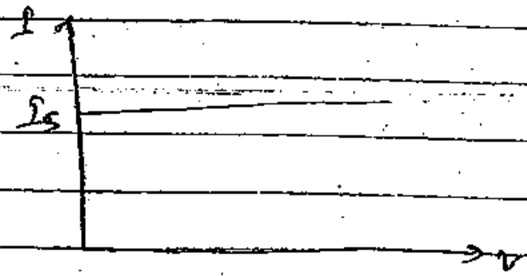
urrent Sources:



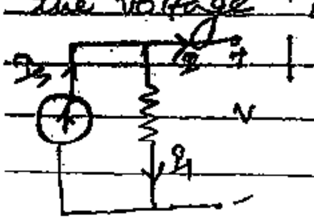
g- Independent current source representation

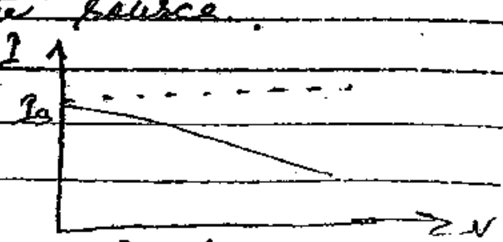
For ideal current source internal resistance is infinite and it delivers energy at a specified current which is independent of the voltage across the source.





Pratical current source has finite internal resistance & delivers energy at a specified current which depends the voltage across the source.





$I = I_s - I_1 \Rightarrow I = I_s - \frac{v}{}$

Note-: Current source doesn't have zero voltage across its terminal by providing the fixed current, it depends entirely on the circuit to which it is connected.

2. In the real time system only independent voltage source exist. To make calculation simple by using source transformation technique current source concept is introduce

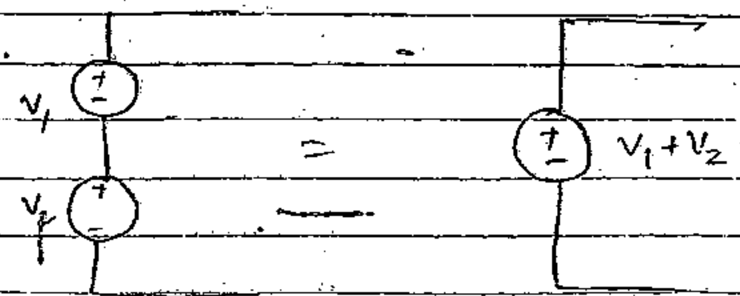
3. While analysing any electrical network using K.V.L and K.C.L equation the independent & dependent voltage & current sources are handeld exactly in the same manner except in the following two cases.

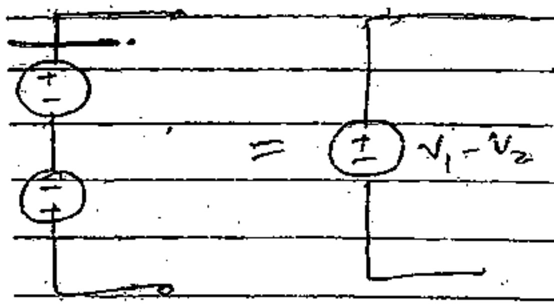
(a.) Analysis of the circuit using superposition theore

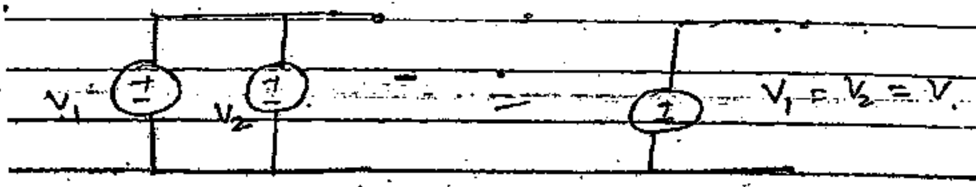
(b.) Analysis of the n/w using Thevenin & Norton theorem

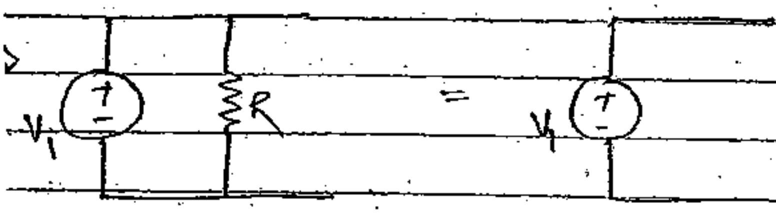
In such cases all the independent voltage & current sources are replaced by their internal resistance and all the dependent source remain as they are.

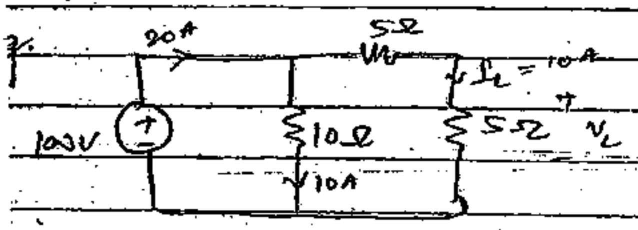
1.









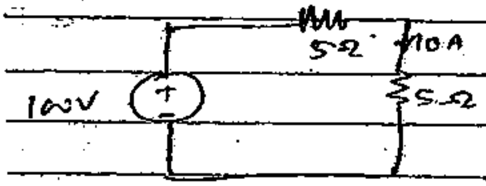


$I_L = 10A$

$V_L = 50V$

$I_s = 20A$

$P_s = 2kW$



$I_L = 10A$

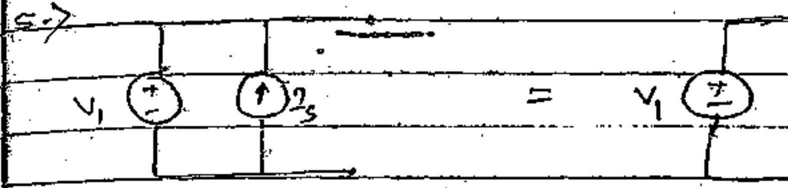
$V_L = 50V$

$I_s = 10A$

$P_s = 1kW$

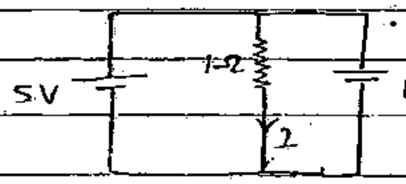
n the above ckt the resistance R can be neglected
e doing the calculations for the load current & load voltage
not for source current or source power.

5->



In above circuit the current source can be neglected while doing the calculation for the load current or load voltage but not for the source current or source power.

Q) Find the current I in the below given ckt.



a) 5 A
b) 10 A
c) 15 A
d) None ✓

Ans ->

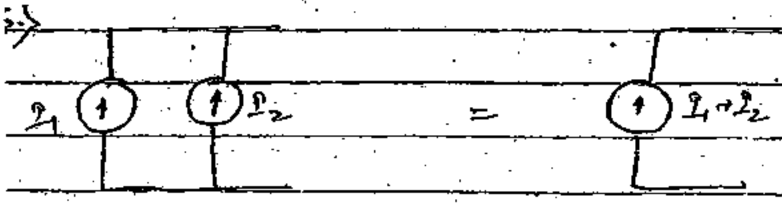
$5V - (I_1 - I_2) = 0$ $\qquad$ $10 - (I_2 - I_1) = 0$

$5V - I_1 + I_2 = 0$ $\qquad$ $10 - I_2 + I_1 = 0$

$$\boxed{\begin{aligned} I_1 - I_2 &= 5 \\ -I_1 + I_2 &= 10 \end{aligned}}$$

We cannot determine the current for this ckt.

:>



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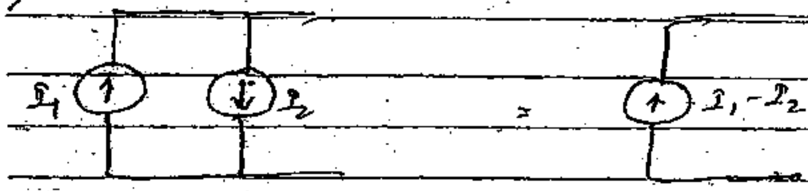

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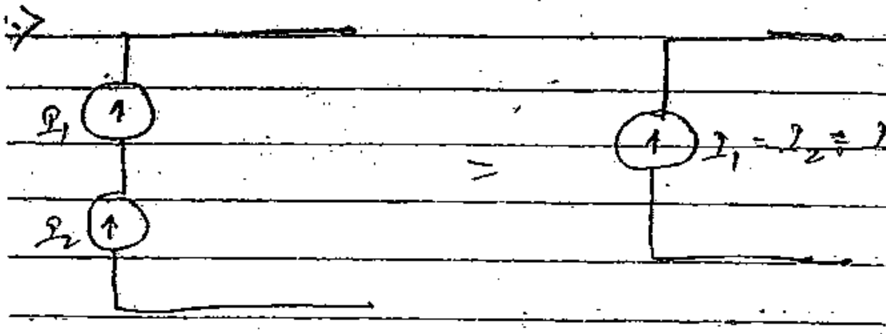

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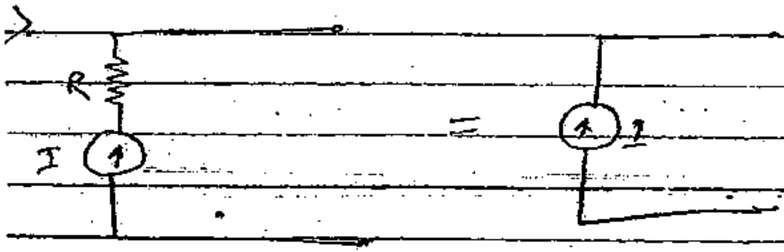

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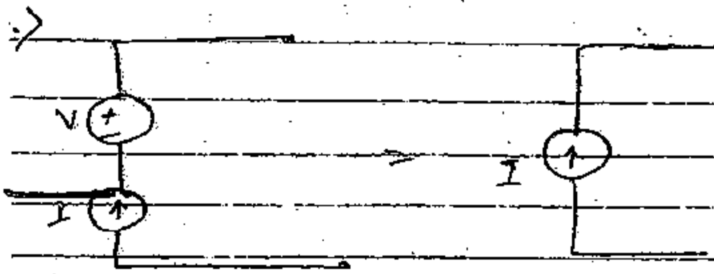
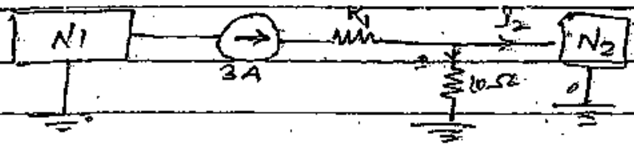


the point ⑨ & ⑩ resistance & voltage source can be neglected while calculating either load current or load voltage but if while calculating voltage across the source or power of the sour

Q.) 

In the above ckt the current I_2 is 2A when the value of R_1 is 20Ω. What will be the value of I_2 when R_1 is changed to?

a) 1A (b) 2A (c) 3A (d) 4A

Sol: (b.) 2A

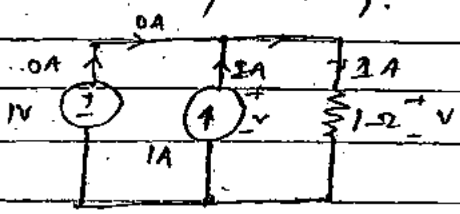
Q.) What will be the power consumed by the voltage source, current source & resistance respectively.

a) 1W, 1W, 2W

b) 0W, 1W, 1W

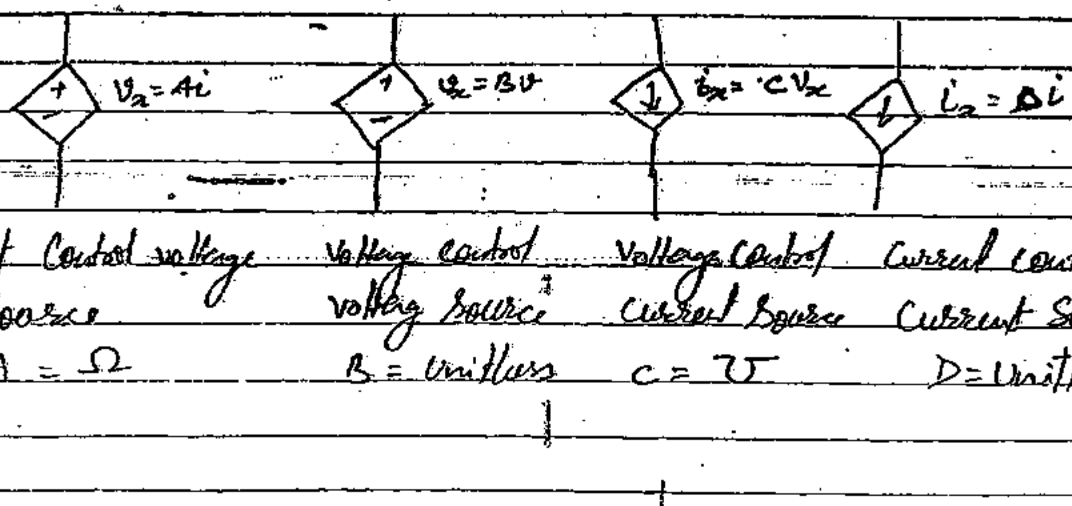
c) 1W, 0W, 1W

d) 0W, 0W, 0W



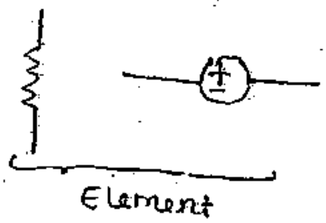
Sol: b) 0W, 1W, 1W

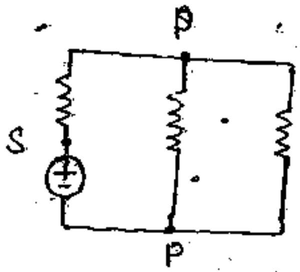
#



Current Control voltage Source	Voltage control voltage source	Voltage control Current Source	Current control Current Source
$A = \Omega$	B = Unitless	$C = \mho$	D = Unitless.

Branch: A branch is a single element or component in the crt. If several elements in the crt carrying same current they can also reffered as a single branch.



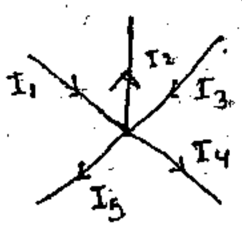


$e = b - (N-1)$

NODE: When two or more than two element are connected together. then common point called as Noade.

rincepal:

KCL:



$\boxed{I_1 - I_2 + I_3 - I_4 - I_5 = 0}$

It says that algebric sum of I entering a node or meeting at a point is zero.

Outgoing current is consider as -ve and incoming current as +ve.

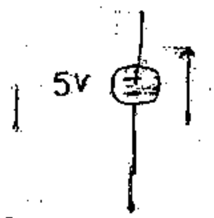
It based on law of conservation of charge.

KVL: It says that sum of all the voltages in a closed loop is zero.

It based on law of conservation of energy.

Standered Notation:

In a loop, rise in potential = -ve
Drop in potential = +ve



~~Mesh~~ Analysis:

Mesh is a loop which does not contain any inner loop. It is applicable only for the Planer n/w. A Planar n/w is one that can be drawn with no branches crossing one another.

Procedure:

1. Identify total no of Meshes
2. Assign mesh current.
3. Develop KVL eqⁿ for each mesh.
4. Solve eqⁿ to find Loop current.

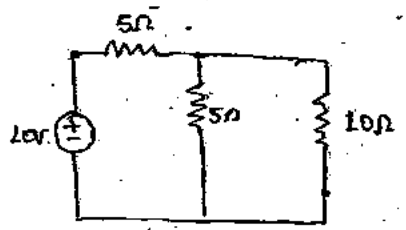
Note:-

1. The dirⁿ of mesh current can be taken any dirⁿ (↻ or ↺) But taking clock wise dirⁿ give simple Analysis.

2.

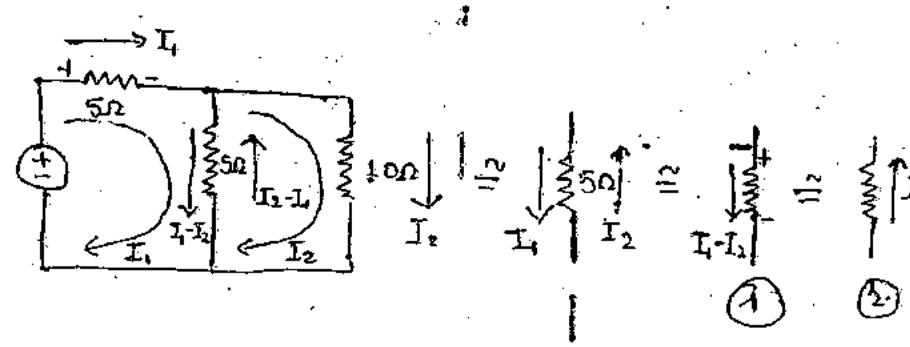
$$\text{NO of eq}^n = \text{No of mesh}$$
$$= b-(N-1)$$

Where b = total no of branches
N = total no of nodes.

Q 

using mesh analysis find the power loss in 10Ω resistor.

Solⁿ:



LOOP 1:

$-10 + 5I_1 + 5(I_1 - I_2) = 0$

$10I_1 - 5I_2 = 10$

$2I_1 - I_2 = 2 \quad \text{—} \quad (1)$

LOOP 2:

$10I_2 + 5(I_2 - I_1) = 0$

$-5I_1 + 15I_2 = 0$

$-I_1 + 3I_2 = 0 \quad \text{—} \quad (2)$

$(1) + 2 \times (2)$

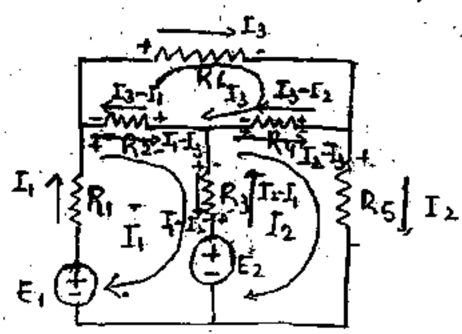
$5I_2 = 2$

$I_2 = 2/5 \, A$

$\therefore P_{10} = I_2^2 (10)$

$= \frac{4}{25} \times 10 = \frac{40}{25} \, W$ Ans

<u>Developed</u> the mesh eqn for the below given n/w?

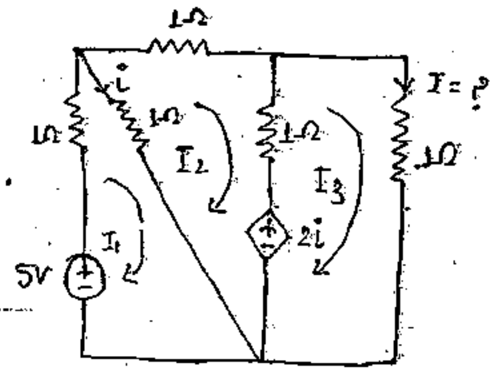


LOOP 1: $-E_1 + I_1R_1 + (I_1 - I_3)R_2 + (I_1 - I_2)R_3 + E_2 = 0$

LOOP 2: $I_2R_5 - E_2 + (I_2 - I_1)R_3 + (I_2 - I_3)R_4 = 0$

LOOP 3: $I_3R_6 + (I_3 - I_2)R_4 + (I_3 - I_1)R_2 = 0$

Q.



Find the value of I by using mesh Analysis

Soln:

(1) :- $-5 + I_1 + (I_1 - I_2)1 = 0$

$2I_1 - I_2 = 5$ — (1)

(2) :- $-I_2 + (I_2 - I_3) + 2i + (I_2 - I_1) = 0$

$-I_1 + 3I_2 - I_3 + 2i = 0$ — (2)

(3) :- $I_3 - 2i + I_3 - I_2 = 0$

$-I_2 + 2I_3 - 2i = 0$ — (3)

$i = I_1 - I_2$ — (4)

(4) → (2)

$-I_1 + 3I_2 - I_3 + 2I_1 - 2I_2 = 0$

$I_1 + I_2 - I_3 = 0$ — (5)

(4) → (3)

$-I_2 + 2I_3 - 2I_1 + 2I_2 = 0$

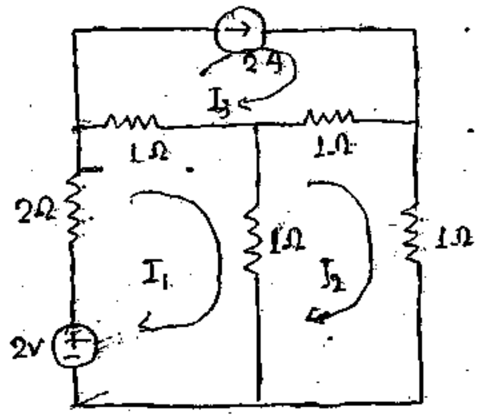
$-2I_1 + I_2 + 2I_3 = 0$ — (6)

(1) + (6)

$2I_3 = 5$

$I_3 = \frac{5}{2}$ A

(a)



Sol^n: Loop 1: $-2 + 2I_1 + (I_1 - I_3) + (I_1 - I_2) = 0$

$4I_1 - I_3 - I_2 = 2$ — (1)

Loop 2: $I_2 + (I_2 - I_1) + (I_2 - I_3) = 0$

$-I_1 + 3I_2 - I_3 = 0$ — (2)

Loop 3: $I_3 = 2A$ — (3)

(3) in eq^n (1) & (2)

$4I_1 - I_2 = 4$ — (4)

$-I_1 + 3I_2 = 2$ — (5)

$3 \times (4) + (5)$

$11 I_1 = 14$

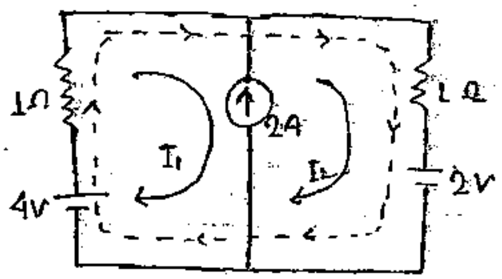
$$\boxed{I_1 = \frac{14}{11} A}$$

$-\frac{14}{11} + 3I_2 = 2$

$$\boxed{I_2 = \frac{12}{11} A}$$

Super mesh Analysis (Problems)

Q.



Soln:

$$-4 + I_1 + I_2 + 2 = 0$$

$$I_1 + I_2 = 2 \quad — (1)$$

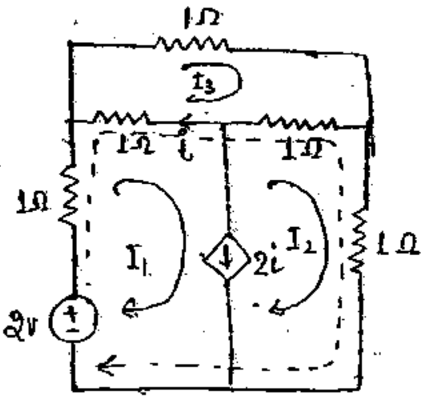
$$-I_1 + I_2 = 2 \quad — (2)$$

(1) + (2)

$$\boxed{I_2 = 2A}$$

$$\boxed{I_1 = 0}$$

Q.



Soln:

(3) :- $I_3 + (I_3 - I_2) + (I_3 - I_1) = 0$

$$-I_1 + 3I_3 - I_2 = 0 \quad — (1)$$

Supermesh

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

$$2I_1 + 2I_2 - 2I_3 = 2 \quad — (2)$$

$I_1 - I_2 = 2i$ — (3)

$i = I_3 - I_1$

$I_1 - I_2 = 2(I_3 - I_1)$

$I_1 - I_2 = 2I_3 - 2I_1$

$3I_1 - I_2 - 2I_3 = 0$ — (4)

$I_1 = \frac{5}{8}$ A $I_2 = \frac{1}{8}$ A , $I_3 = \frac{1}{2}$ A

Mesh → KVL + Ohm's law
Supermesh → KVL + KCL + Ohm's law

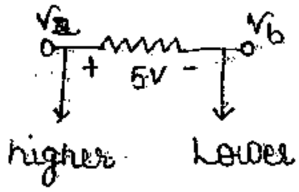
NODAL ANALYSIS

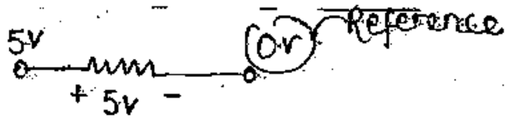
PROCEDURE:

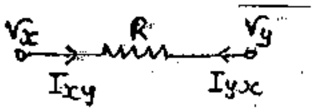
- Identify total no of nodes.
- Assign the voltage at each node.
- One of the node taken as refference (Dautam)
- Reference node potential should be equal to ground ~~node~~ potential.
5. Develop KCL eqn for each non reference node
~~6. By~~ Solving KCL Eqn find node voltages.

Note:

- It can be apply both planes and non planes n/w.
- Total no of Eqn N-1

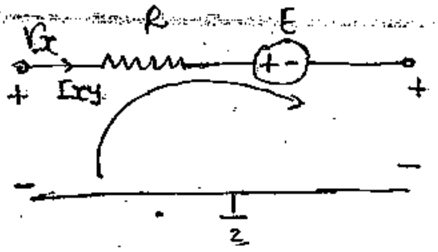






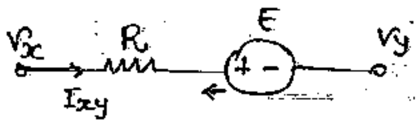
$$I_{xy} = \frac{V_x - V_y}{R} \qquad I_{yx} = \frac{V_y - V_x}{R}$$

$$\boxed{I_{xy} = -I_{yx}}$$

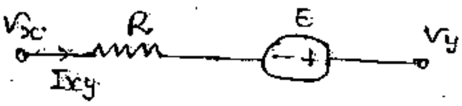


$$-V_x + I_{xy}R + E + V_y = 0$$

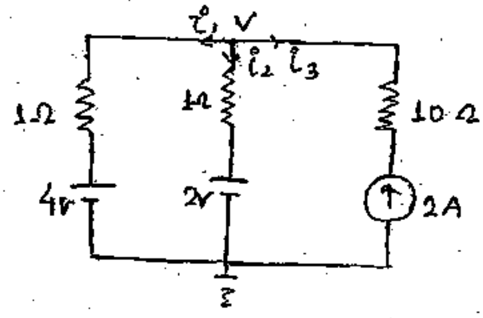
$$I_{xy} = \frac{(V_x - V_y) - E}{R}$$



$$I_{xy} = \frac{(V_x - V_y) - E}{R}$$



$$I_{xy} = \frac{(V_x - V_y) + E}{R}$$

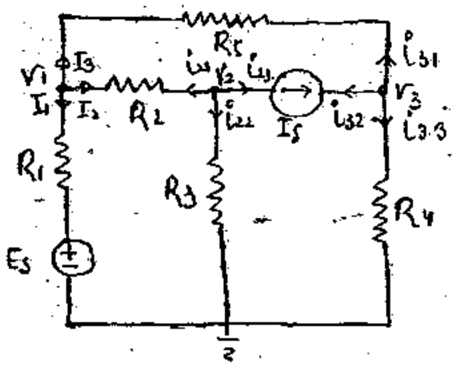


$$i_1 + i_2 + i_3 = 0$$

$$\frac{(V-0)-4}{1} + \frac{(V-0)-2}{1} - 2 = 0$$

$$2V_1 - 4 - 2 - 2 = 0$$

$$\boxed{V_1 = 4V}$$



Node 1:- $i_1 + i_2 + i_3 = 0$

$$\frac{(V_1 - 0) - E_s}{R_1} + \frac{(V_1 - V_2)}{R_2} + \frac{V_1 - V_3}{R_5} = 0$$

Node 2:-

$$i_{21} + i_{22} + i_{23} = 0$$

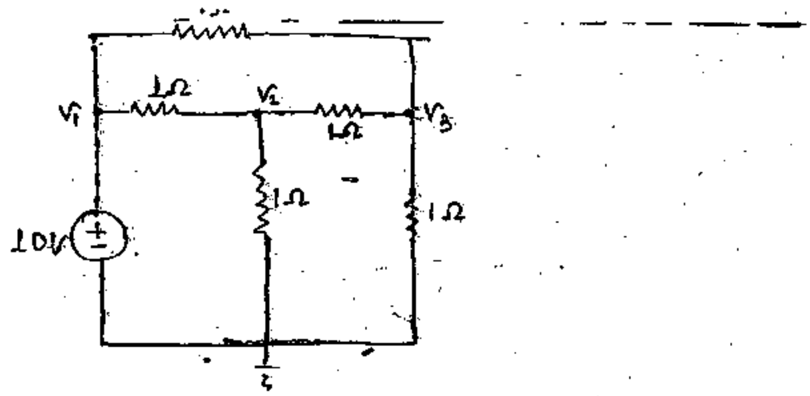
$$\frac{(V_2 - 0)}{R_3} + \frac{V_2 - V_1}{R_2} + I_s = 0$$

Node 3:-

$$i_{31} + i_{32} + i_{33} = 0$$

$$\frac{V_3 - V_1}{R_5} - I_s + \frac{V_3 - 0}{R_4} = 0$$

Q.



Node1: $\frac{V_1-10}{} + \frac{V_1-V_2}{1} + \frac{V_1-V_3}{1} = 0$ given $V_1 = 10V$

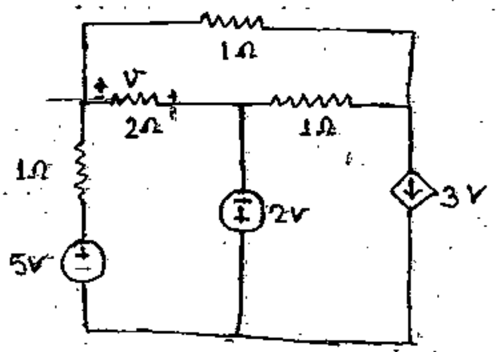
Node2: $\frac{V_2-V_1}{1} + \frac{V_2-0}{1} + \frac{V_2-V_3}{1} = 0$ — ①

Node3: $\frac{V_3-V_2}{1} + \cancel{\frac{V_3-0}{1}} + \frac{V_3-V_1}{1} = 0$ — ②

Solving eqn. ① and ②

$V_2 = V_3 = 5V$ and $V_1 = 10V$

Q.



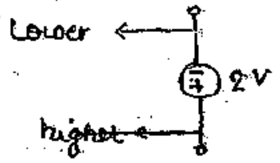
Find the power deleivered by 2V source

Soln: Node1: $\frac{V_1-5}{1} + \frac{V_1-V_2}{2\Omega} + V_1 - V_3 = 0$

$= V_1 - 5 + \frac{V_1}{2} - \frac{V_2}{2} + V_1 - V_3 = 0$

$= \frac{5V_1}{2} - \frac{V_2}{2} - V_3 = 10$

$5V_1 - V_2 - 2V_3 = 10$ — ①



$0 - V_2 = 2V$

$V_2 = -2V$ — (2)

(2) → (1)

$5V_1 - 2V_3 = 8$ — (3)

At node 3 -

$$\frac{V_3 - V_1}{1} + \frac{V_3 - V_2}{1} + 3V = 0$$

$$V = V_2 - V_1$$

$$-V_1 - V_2 + 2V_3 + 3V_2 - 3V_1 = 0$$

$$-4V_1 + 2V_3 = 4 \text{ — (4)}$$

Add (3) and (4)

$V_1 = 12V$

$V_3 = 26V$

Power delevered by 2V source is

$$i_{21} + i_{22} + i_{23} = 0$$

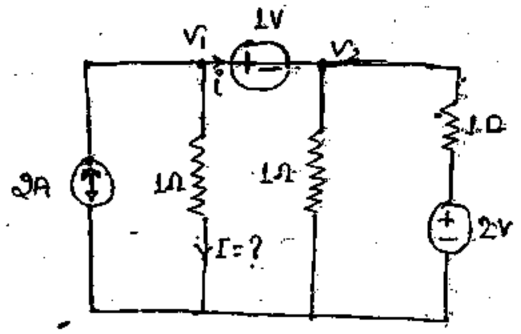
$$i_{22} = -[i_{21} + i_{23}]$$

$$= -\left[\frac{V_2 - V_1}{2} + \frac{V_2 - V_3}{1}\right]$$

$$= -\left[\frac{-2-12}{2} + \frac{-2-26}{1}\right] = 35A$$

$P_{2V} = 35 \times 2 = 70W$ (Del.)

Q.



at node 1:

$$2+\frac{V_1}{1}+i=0 \quad — (1)$$

at node 2:

$$\frac{V_2}{1}+\frac{V_2-2}{1}-i=0 \quad — (2)$$

(1) + (2)

$$2+\frac{V_1}{1}+\frac{V_2}{1}+\frac{V_2-2}{1}=0 \Big\} \text{ Super node Eqn}$$

$$V_1+2V_2=0 \quad — (3)$$

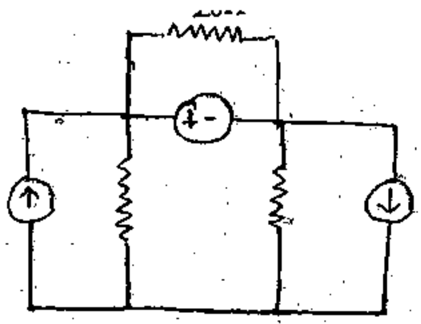
$$V_1-V_2=1V \quad — (4)$$

(3) − (4)

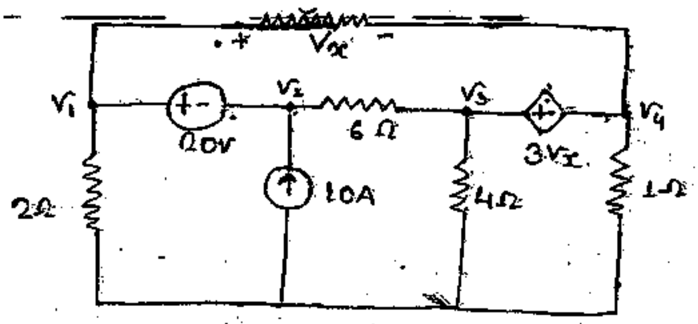
$$V_2=-\frac{1}{3}V$$

$$V_1=\frac{2}{3}V$$

$$I=\frac{V_1}{1}=\frac{2}{3}A$$



4.



Find the node voltage V_1 V_2 V_3 and V_4 ?

Soln: Supernode(1 - 2)

$$\frac{V_1}{2} + \frac{V_1 - V_4}{3} - 10 + \frac{V_2 - V_3}{6} = 0$$

$$5V_1 + V_2 - V_3 - 2V_4 = 60 \quad — (1)$$

Supernode (3 - 4)

$$\frac{V_3 - V_2}{6} + \frac{V_3}{4} + \frac{V_4}{1} + \frac{V_4 - V_1}{3} = 0$$

$$-4V_1 - 2V_2 + 5V_3 + 16V_4 = 0 \quad — (2)$$

$$V_1 - V_2 = 20 \quad — (3)$$

$$V_3 - V_4 = 3V_x$$

$$V_x = V_1 - V_4$$

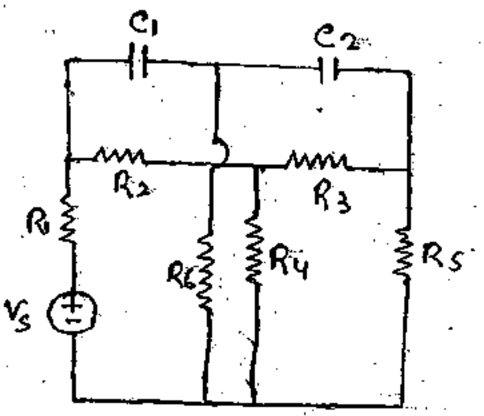
$$\therefore V_3 - V_4 = 3V_1 - 3V_4$$

$$3V_1 - V_3 - 2V_4 = 0 \quad — (4)$$

(3) → (1) & (2)

$$6V_1 - V_3 - 2V_4 = 80 \quad — (5)$$

$$6V_1 - 5V_3 - 16V_4 = 40 \quad — (6)$$

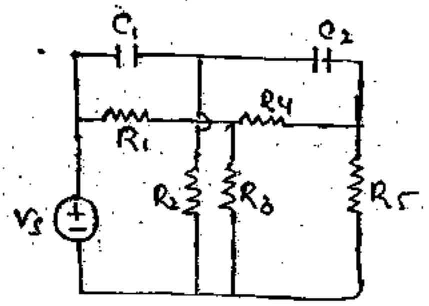


Find the min^n no of eq^n required to solve the problem?

η:

$n = 5 \quad b = 8$

$e = N - 1 = 4$



Q^n:

$N = 5$

$e = N - 1 = 4$

but Here one voltage source is already given so only 3 no of Eq^n are required to solve the problem.

Q A n/w consists of principal node and 'b' branches. If mesh analysis is simpler than nodal analysis then n is greater than ____.

(a) $b+1$ (b) $b-1$ (c) $\frac{b}{2}+1$ (d) $\frac{b}{2}-1$

Ans

$$M < e$$

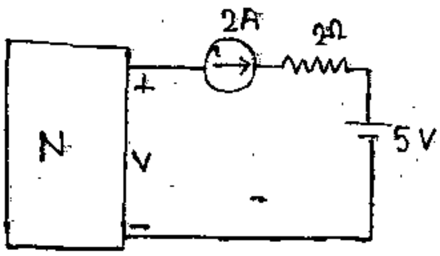
$$b-(N-1) < N-1$$

$$b-N+1 < N-1$$

$$b+2 < 2N$$

$$N > \frac{b}{2}+1$$

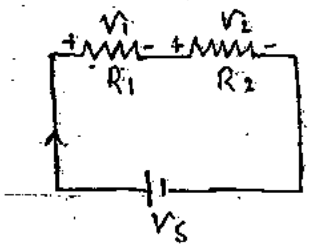
Q.

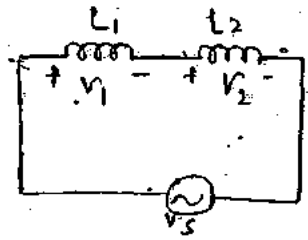


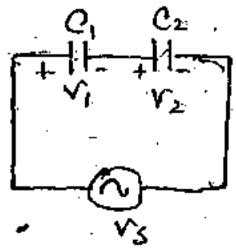
(a) 5V (b) 9V (c) 11V (d) None

Exp: The voltage ~~across~~ the current is not given the Eqn and hence we can find voltage. So the Answer is none (d)

Voltage Devision and series combination:







$R_{eq} = R_1 + R_2$

$V_1 = \frac{V_S}{R_1+R_2} \cdot R_1$

$V_2 = \frac{V_S}{R_1+R_2} \cdot R_2$

$L_{eq} = L_1 + L_2$

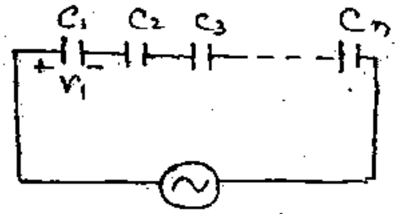
$V_1 = \frac{V_S}{L_1+L_2} \cdot L_1$

$V_2 = \frac{V_S}{L_1+L_2} \cdot L_2$

$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$

$V_1 = \frac{V_S}{C_1+C_2} \cdot C_2$

$V_2 = \frac{V_S}{C_1+C_2} \cdot C_1$



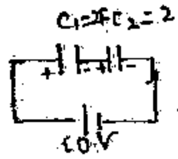
$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \dots \frac{1}{C_n}$$

$$V_1 = \frac{V_S \cdot 1/C_1}{\frac{1}{C_1} + \frac{1}{C_2} + \dots + \frac{1}{C_n}}$$

Note: voltage is equally distributed when $R_1 = R_2$, $L_1 = L_2$, C_1 C_2

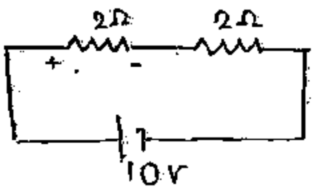
Ex:

$C_1 = 2F$ $C_2 = 2F$



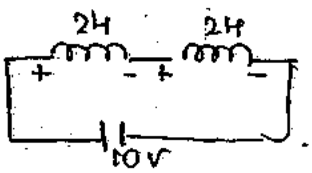
$V_{C1} = 10 \times \frac{2}{4} = 5V$

$V_{C2} = 10 \times \frac{2}{4} = 5V$



$V_{R1} = 10 \times \frac{2}{2+2} = 5V$

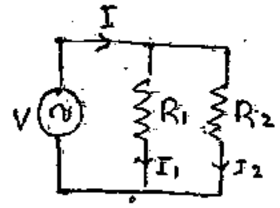
$V_{R2} = 10 \times \frac{2}{2+2} = 5V$

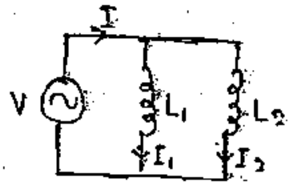


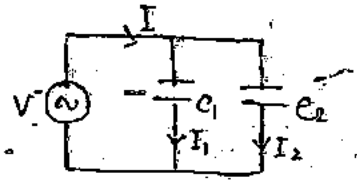
$V_{L1} = 10 \times \frac{2}{4} = 5V$

$V_{L2} = 10 \times \frac{2}{4} = 5V$

|| combination and current Division:







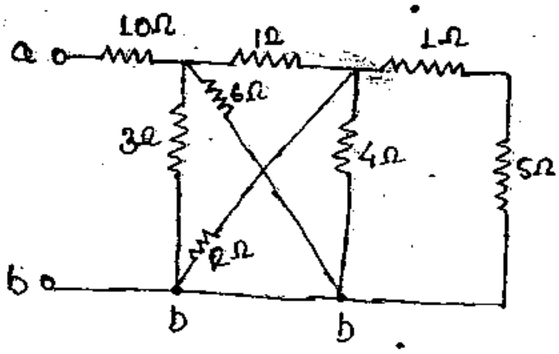
$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$ $\qquad$ $\frac{1}{L_{eq}} = \frac{1}{L_1} + \frac{1}{L_2}$ $\qquad$ $C_{eq} = C_1 + C_2$

$I_1 = \frac{I \cdot R_2}{R_1 + R_2}$ $\qquad$ $I_1 = \frac{I \cdot L_2}{L_1 + L_2}$ $\qquad$ $I_1 = \frac{I \cdot C_1}{C_1 + C_2}$

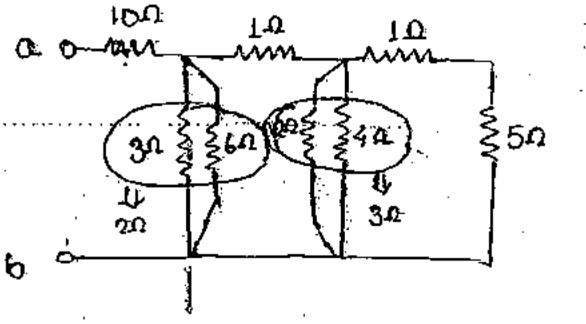
$I_2 = \frac{I \cdot R_1}{R_1 + R_2}$ $\qquad$ $I_2 = \frac{I \cdot L_1}{L_1 + L_2}$ $\qquad$ $I_2 = \frac{I \cdot C_2}{C_1 + C_2}$

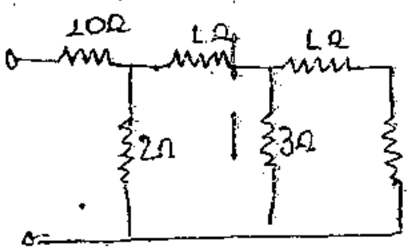
Note: Current is equally distributed when $R_1 = R_2$, $L_1 = L_2$, $C_1 = C_2$

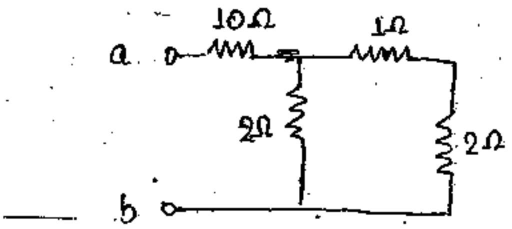
Find the equivalent resistance b/w a & b ?

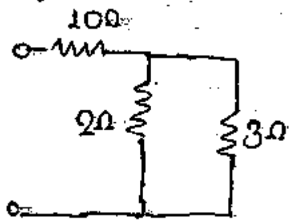


Solⁿ:





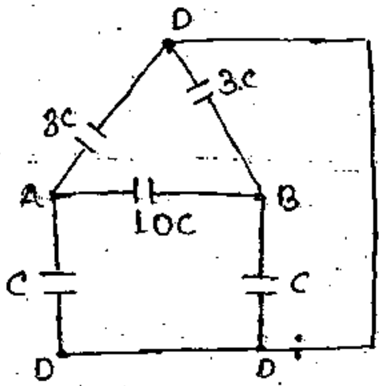


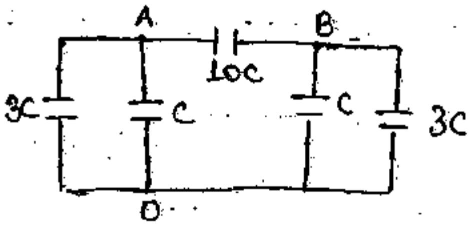


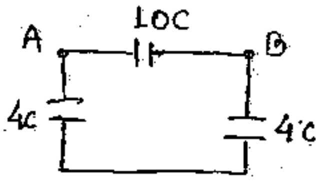
$$R_{ab} = 10 + \frac{2 \times 3}{2+3}$$

$$= 10 + \frac{6}{5} = 11.2\ \Omega$$

Q.

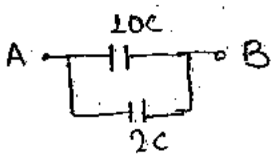






$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \dots + \frac{1}{C_n}$$

$$\frac{1}{C_{eq}} = \frac{c}{n}$$



$$C_{ab} = 10C + 2C = 12C$$

Q A n/w consists of princepal node and 'b' branches. If mesh analysis is simpler than nodal analysis then n is greater than ___

(a) b+1 (b) b-1 (c) $\frac{b}{2}+1$ (d) $\frac{b}{2}-1$

Ans

$$M < e$$

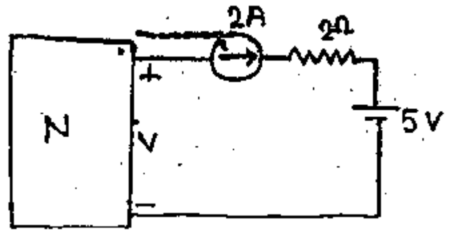
$$b-(N-1) < N-1$$

$$b-N+1 < N-1$$

$$b+2 < 2N$$

$$N > \frac{b}{2}+1$$

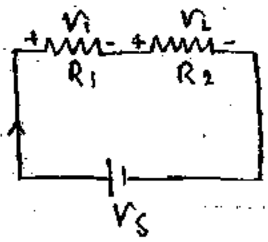
Q.

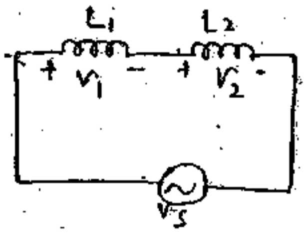


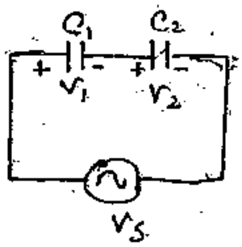
(a) 5V (b) 9V (c) 11V (d) None

Soln: The voltage across the current is not given the Eqn. and hence we can find voltage. So the Answer is none (d)

Voltage Devision and series combination:







$R_{eq} = R_1 + R_2$

$V_1 = \frac{V_S}{R_1+R_2} \cdot R_1$

$V_2 = \frac{V_S}{R_1+R_2} \cdot R_2$

$L_{eq} = L_1 + L_2$

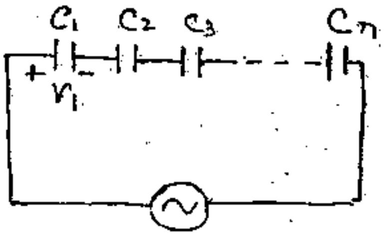
$V_1 = \frac{V_S}{L_1+L_2} \cdot L_1$

$V_2 = \frac{V_S}{L_1+L_2} \cdot L_2$

$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$

$V_1 = \frac{V_S}{C_1+C_2} \cdot C_2$

$V_2 = \frac{V_S}{C_1+C_2} \cdot C_1$

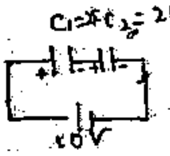


$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots \frac{1}{C_n}$$

$$V_1 = \frac{V_S \cdot 1/C_1}{\frac{1}{C_1} + \frac{1}{C_2} + \cdots + \frac{1}{C_n}}$$

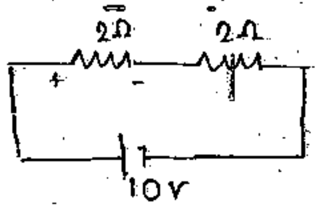
Note: voltage is equally distributed when $R_1 = R_2$, $L_1 = L_2$, C_1 C_2

Ex:



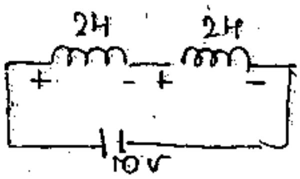
$V_{C1} = 10 \times \frac{2}{4} = 5V$

$V_{C2} = 10 \times \frac{2}{4} = 5V$



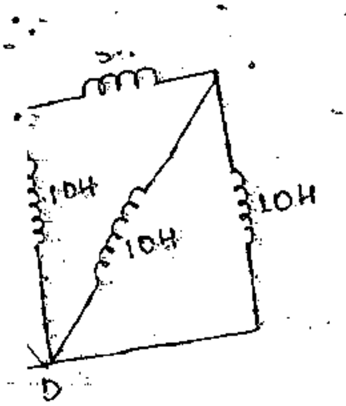
$V_{R1} = 10 \times \frac{2}{2+2} = 5V$

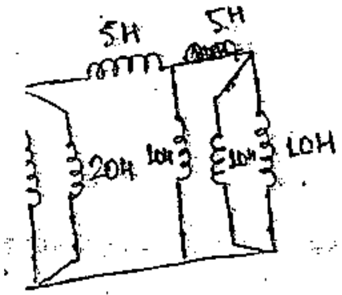
$V_{R2} = 10 \times \frac{2}{2+2} = 5V$

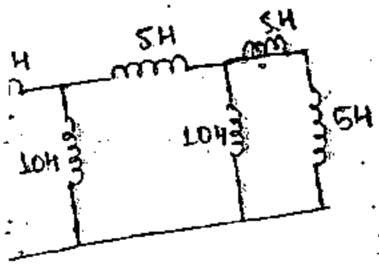


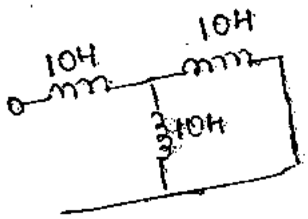
$V_{L1} = 10 \times \frac{2}{4} = 5V$

$V_{L2} = 10 \times \frac{2}{4} = 5V$





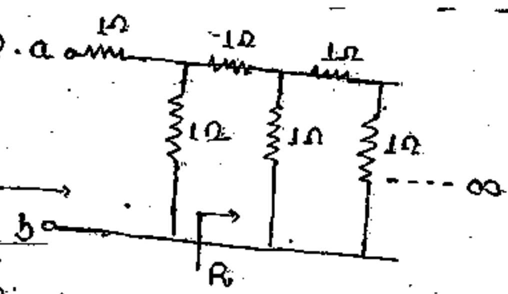




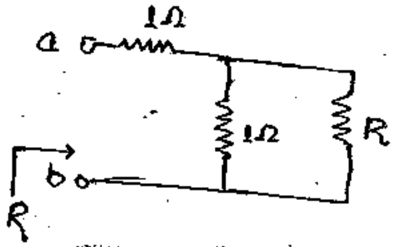
$= 10H + (10 \| 10)$

$= 10H + 5H = 15H$ Ans

Q.



Sol: Method 1:



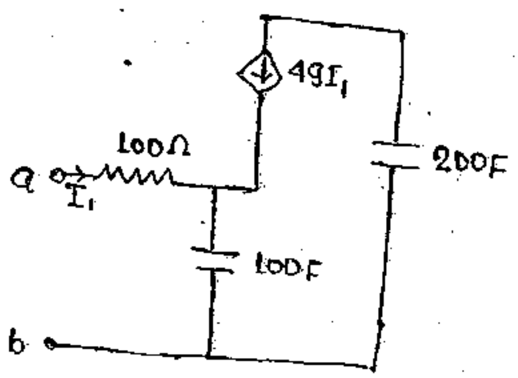
$$R = 1 + \frac{R \cdot 1}{R+1}$$

$\Rightarrow R^2 + R = 2R + 1$

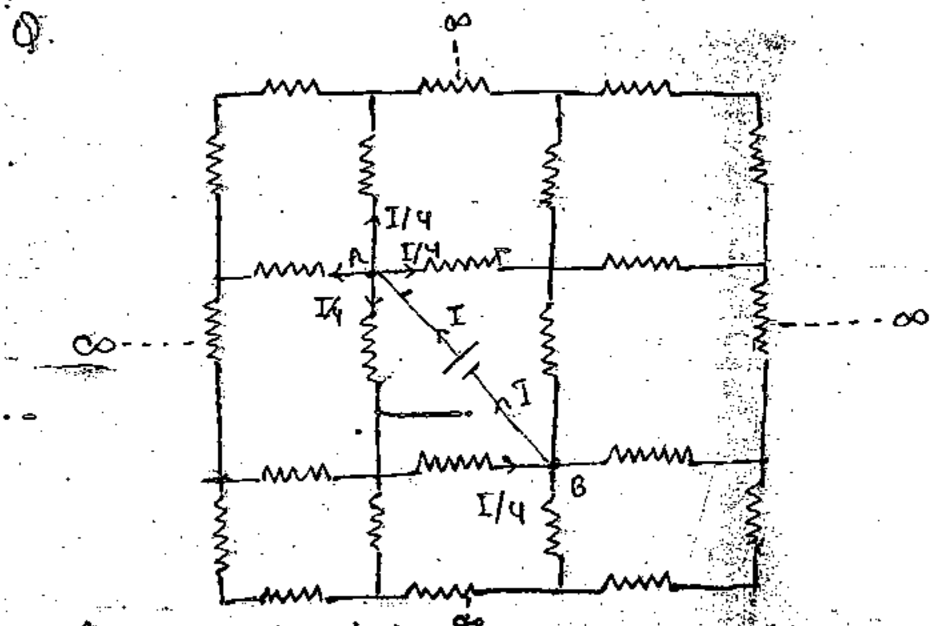
$\Rightarrow R^2 - R - 1 = 0$

$$R = \frac{1 \pm \sqrt{1+4}}{2} = \frac{1 \pm \sqrt{5}}{2}$$

$\therefore R = \frac{1+\sqrt{5}}{2}\ \Omega$



Q.



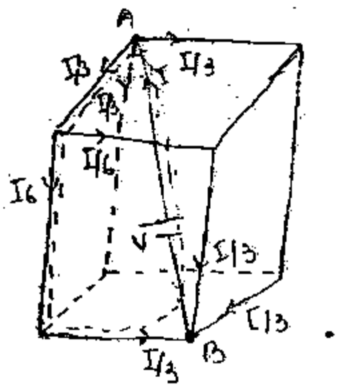
Find the eq. resistance a & b when each resistance is R Ω

Solⁿ: Assume, let battery V connected b/w a and b which draw current I

$$-V + \frac{I}{4}R + \frac{I}{4}R = 0$$

$$V = I\left[\frac{R}{4} + \frac{R}{4}\right]$$

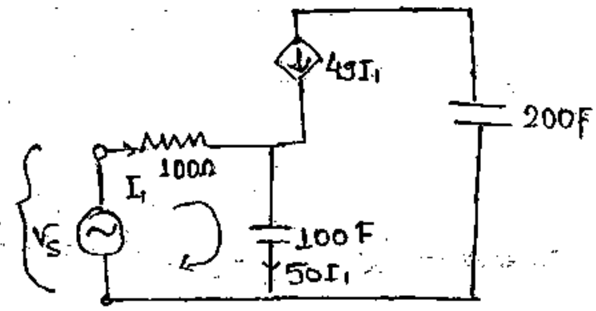
$$\frac{V}{I} = R_{eq} = \frac{R}{2} \quad \text{Ans}$$



$\frac{V_S}{I} = Z_{eq} = R + SL + \frac{1}{SC}$

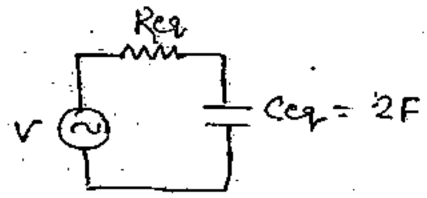
$= R + j\omega L - \frac{j}{\omega C}$

$V = iR + L\frac{di}{dt} + \frac{1}{C}\int i\,dt$



(1) $V_S = I_1(100) + \frac{1}{100}\int 50 I_1\,dt$

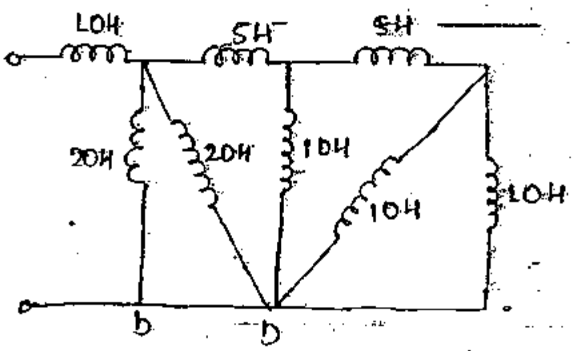
$= I_1(100) + \frac{1}{2}\int I_1\,dt$



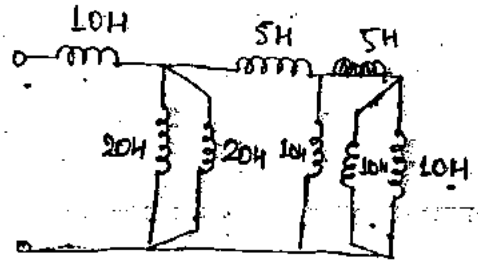
(2) $V(S) = 100\,I_1(S) + 50\,I_1(S)\cdot\frac{1}{S(100)}$

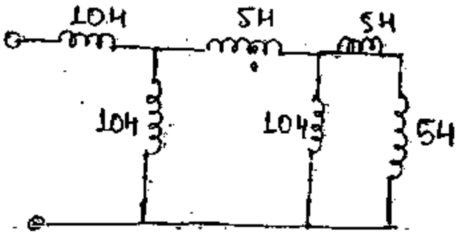
$\frac{V(S)}{I_1(S)} = 100 + \frac{1}{2S}$

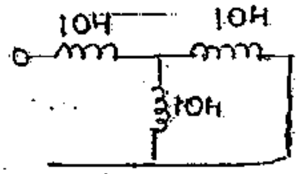
$\therefore C_{eq} = 2F$

Q. 

15H



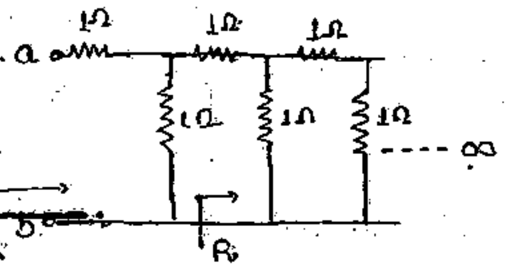




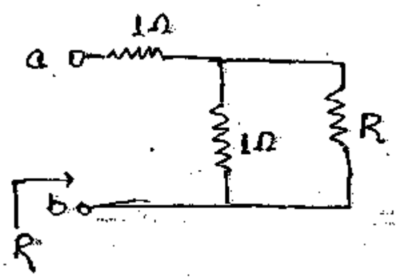
$= 10H + (10 \parallel 10)$

$= 10H + 5H = 15H$ Ans

Q.



Sol: Method 1:



$$R = 1 + \frac{R \cdot 1}{R+1}$$

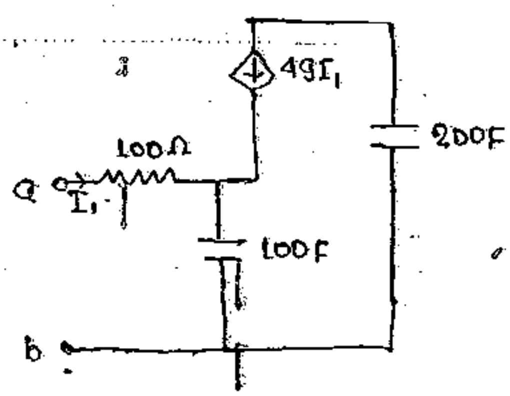
$$\Rightarrow R^2 + R = 2R + 1$$

$$\Rightarrow R^2 - R - 1 = 0$$

$$R = \frac{1 \pm \sqrt{1+4}}{2} = \frac{1 \pm \sqrt{5}}{2}$$

$$\therefore R = \frac{1+\sqrt{5}}{2}\,\Omega$$

Q.



$$-V + \frac{I}{3} R + \frac{I}{6} R + \frac{I}{3} R = 0$$

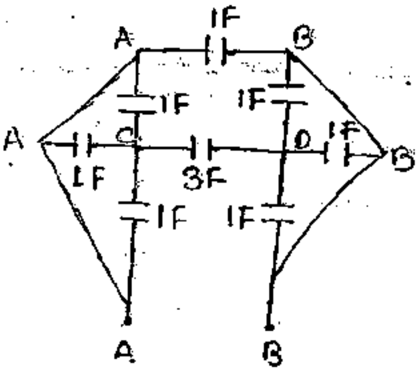
$$\frac{V}{I} = R_{eq} = \left[\frac{R}{3} + \frac{R}{6} + \frac{R}{3}\right]$$

$$R_{eq} = \frac{5}{6} R$$

- If L present in the ckt $L_{eq} = \frac{5}{6}$

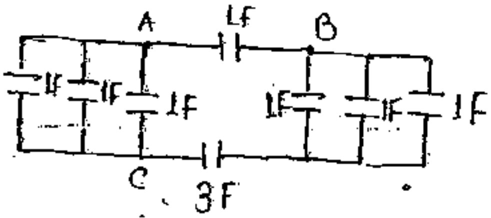
Similarly C present in the ckt $C_{eq} = \frac{6}{5} C$

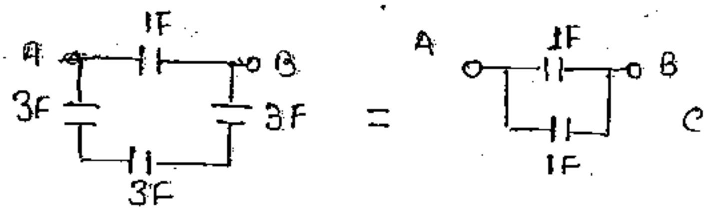
Q.



Find the equivalent capacitance b/w A and B

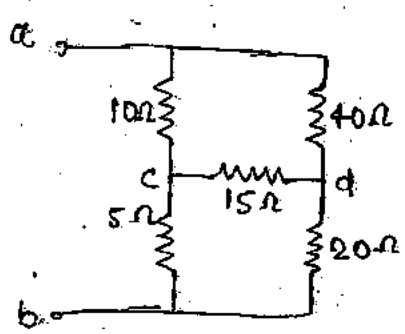
Solⁿ:



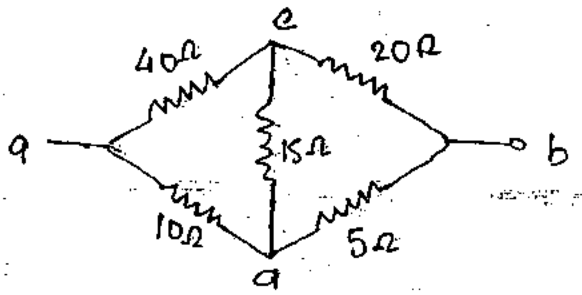


$C_{ab} = 1 + 1 = 2F$

Q.

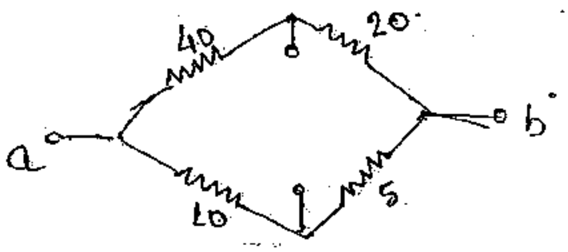


Sol:



$40 \times 5 = 20 \times 10$

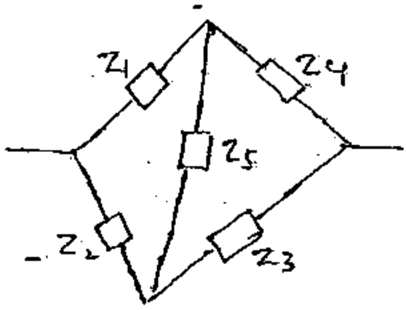
$200 = 200$ balanced



$R_{eq} = (40+20) \| (10+5)$

$= 12\ \Omega$

Note:
: If the impedences are their in the bridge it should satishfy both angle as well as magnitude



(1) $Z_1 Z_4 = Z_2 Z_3$

(2) $|Z_1||Z_4| = |Z_2||Z_3|$

&

$\angle \theta_1 + \theta_4 = \angle \theta_2 + \theta_3$

If the above bridge is balanced then find the value of Z_4

$Z_1 = 10\angle 30^\circ$ $Z_2 = 5\angle -50^\circ$ $Z_3 = 4\angle -40^\circ$ $Z_4 = ?$

a.) $2\angle 120^\circ$ (b) $2\angle -120^\circ$ (c) $10\angle 30^\circ$ (d) None

$$Z_1 Z_4 = Z_2 Z_3$$

$$10\angle 30^\circ (Z_4) = (5\angle -50)(4\angle -40^\circ)$$

$$Z_4 = \frac{(5\angle -50)(4\angle -40^\circ)}{10\angle 30^\circ} = \frac{20\angle -90^\circ}{10\angle 30^\circ} = 2\angle -120^\circ$$

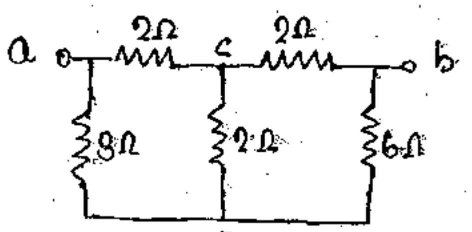
$$Z_4 = 2[\cos(-120^\circ) + j\sin(-120^\circ)]$$

$$= \boxed{-1} - j\sqrt{3}$$

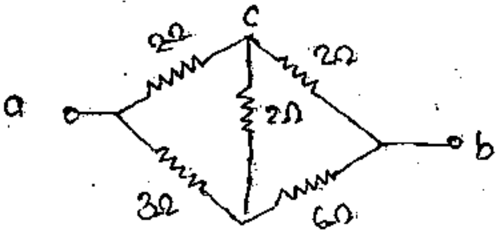
$$Z_4 = \boxed{R} - jX_c$$

R should never -ve

Q. Find the equivalent resistance a and b.

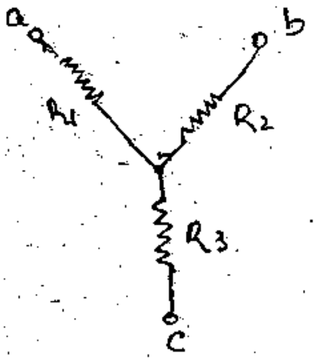


Ans:

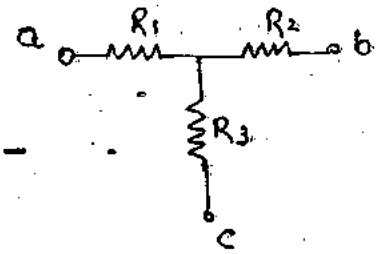


$2\Omega \times 6\Omega = 3\Omega \times 2\Omega$

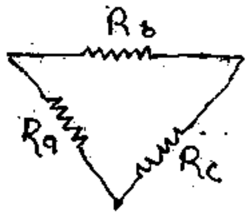
$12\Omega \neq 6\Omega$ (not balanced)



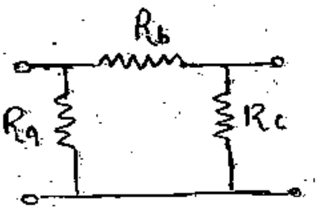
STAR/WYE



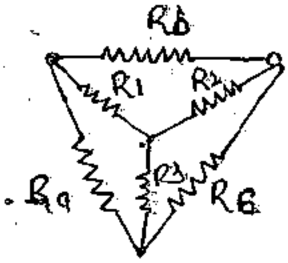
T-N/W



Delta



π- n/w



Delta to star:

$$R_1 = \frac{R_a R_b}{R_a+R_b+R_c}$$

$$R_2 = \frac{R_b R_c}{R_a+R_b+R_c}$$

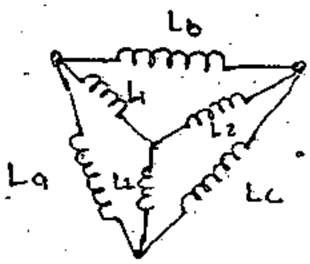
$$R_3 = \frac{R_c R_a}{R_a+R_b+R_c}$$

Star to Delta:

$$R_a = \frac{R_1R_2+R_2R_3+R_3R_1}{R_2}$$

$$R_b = \frac{R_1R_2+R_2R_3+R_3R_1}{R_3}$$

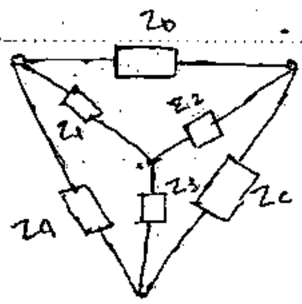
$$R_c = \frac{R_1R_2+R_2R_3+R_3R_1}{R_1}$$

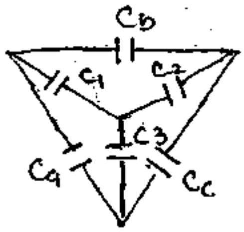


$$L_1 = \frac{L_a L_b}{L_a+L_b+L_c}$$

$$L_a = \frac{L_1L_2+L_2L_3+L_3L_1}{L_2}$$

Hints (same as above)





~~Star~~ Delta to star

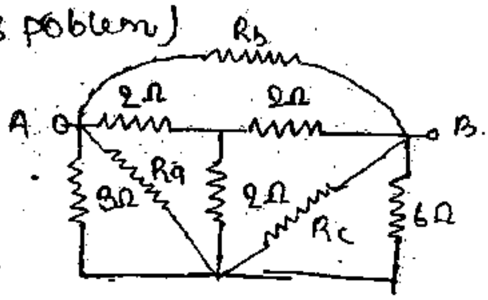
$$\frac{1}{C_1} = \frac{\frac{1}{C_a}\cdot\frac{1}{C_b}}{\frac{1}{C_a}+\frac{1}{C_b}+\frac{1}{C_c}}$$

$$\frac{1}{C_2} = \frac{\frac{1}{C_b}\cdot\frac{1}{C_c}}{\frac{1}{C_a}+\frac{1}{C_b}+\frac{1}{C_c}}$$

Star to delta.

$$\frac{1}{C_a} = \frac{\frac{1}{C_1}\cdot\frac{1}{C_2}+\frac{1}{C_2}\cdot\frac{1}{C_3}+\frac{1}{C_3}\cdot\frac{1}{C_1}}{\frac{1}{C_2}}$$

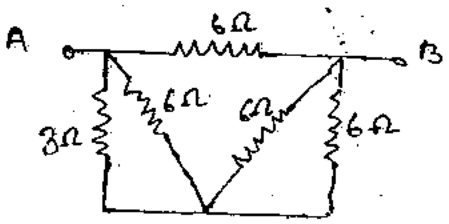
m. (Previous poblem)

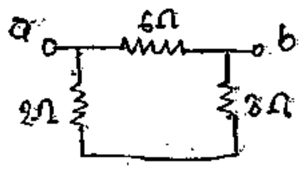


$$R_a = \frac{2\times2+2\times2+2\times2}{2} = 6\Omega$$

$$R_b = \frac{2\times2+2\times2+2\times2}{2} = 6\Omega$$

$$R_c = \frac{2\times2+2\times2+2\times2}{2} = 6\Omega$$





$$R_{ab} = 6 \| (2+3)$$
$$= 6 \| 5$$
$$= \frac{30}{11}\ \Omega$$

Note:

(i) when resistor of equal value transform from Star to delta the resistance value ↑es by 3 times. i same for inductance and impedences

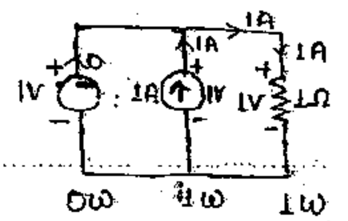
(2) when capacitor's of equal value transform from Star to delta capacitance value ↓es by 3 times.

Workbook Ques 31. Page: 7

Soln. $$R_c = \frac{R_a \cdot R_b}{R_a + R_b + R_c}$$

$$= \frac{\frac{R_a}{K} \cdot \frac{R_b}{K}}{\frac{R_a}{K} + \frac{R_b}{K} + \frac{R_c}{K}} = \left(\frac{R_a R_b}{R_a + R_b + R_c}\right)\frac{K}{K^2}$$

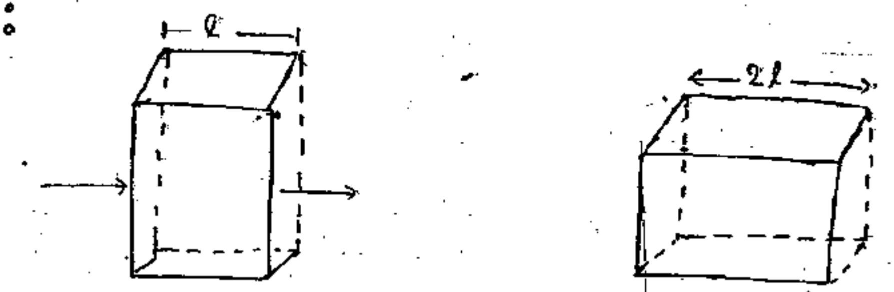
Q.B
Q.1.



Ans: b.

5. The resistance of cube shape materials any of its two faces is 2Ω. If this material is streched in one dirn by applying linear force to double its original length. Then the resistance b/w the two opposite stress faces will be.

Soln:



$V = l \times a$ $\quad\quad$ $V = 2l \times a'$

$$2l \times a' = l \times a$$

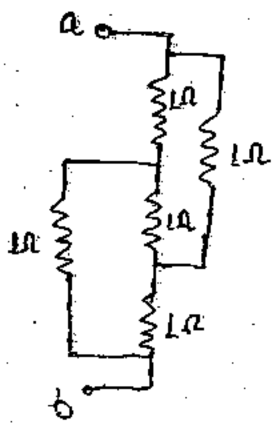
$$a' = a/2$$

$$R_1 = \frac{\rho_1 l_1}{a_1} = \frac{\rho l}{a} = 2\Omega$$

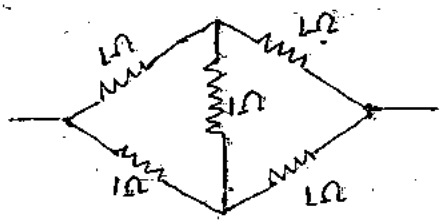
$$R_2 = \frac{\rho_2 l_2}{a_2} = \frac{\rho (2l)}{a/2} = \left(\frac{\rho l}{a}\right) 4\,\Omega$$

$$= 2 \times 4 = 8\Omega$$

6.

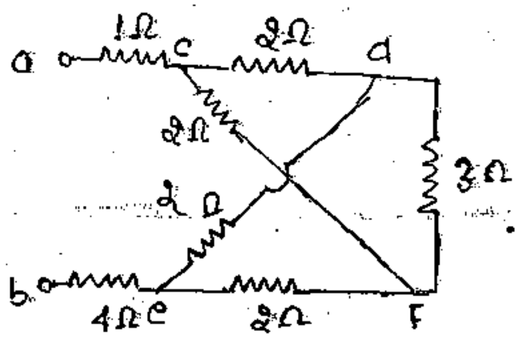


Solⁿ:



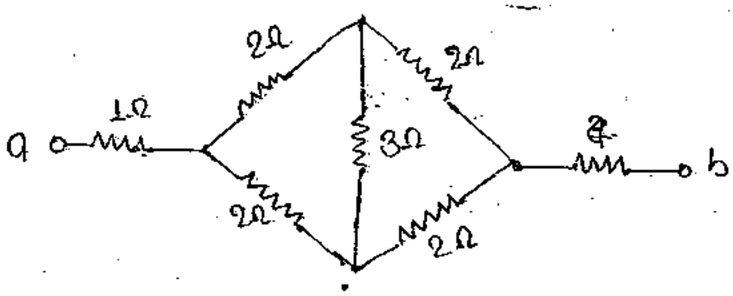
$2 \| 2 = 1\Omega$ Ans

Q.

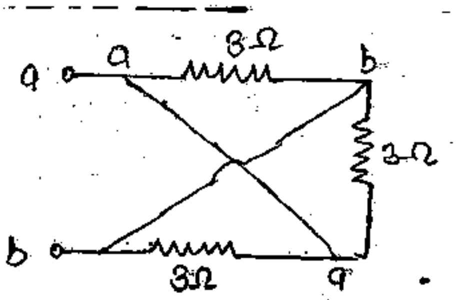


Find Equivalent resistance b/w a & b.

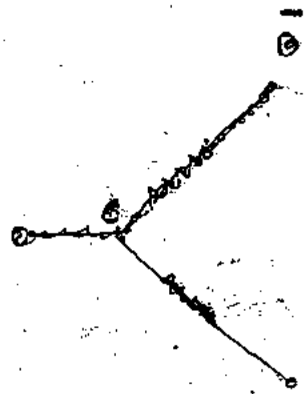
Solⁿ:

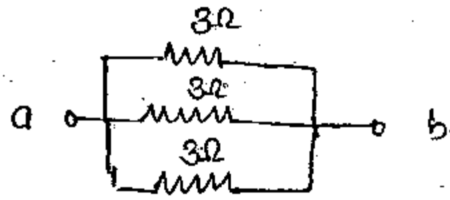


$R_{eq} : 1 + 4 \| 4 + 4\Omega = 7\Omega$

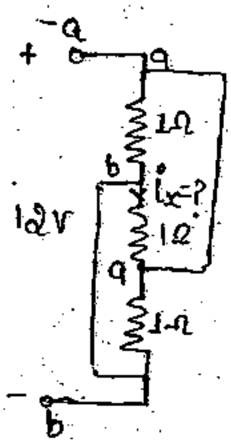


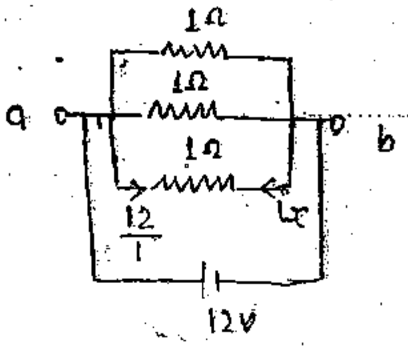
n:





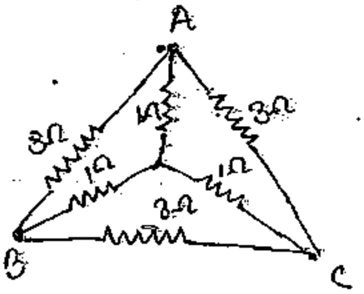
$R_{eq} = \frac{3}{3} = 1\Omega$





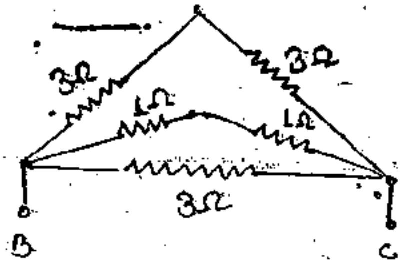
$i_x = -12A$

Q.



Find the equivalent Resistance b/w B & C

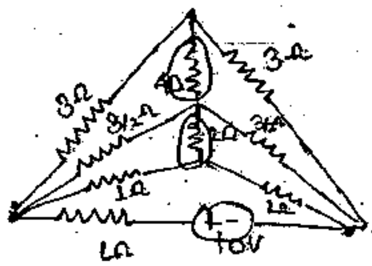
Soln:



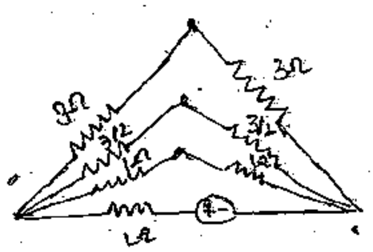
$R_{eq} := 6 \| 2 \| 3$

$= 1\Omega$ Ans

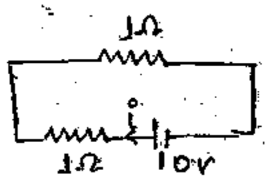
Q.



Soln:



$6 \| 3 \| 2 = 1\Omega$



$i = \frac{10}{2} = 5A$ Ans

e's OF Element's:

ive elements: When an elements is capable of delevering energy indepedently during infinite time and capable of providing power gain than element is called Active
ment.

Current source, voltage source, transistor, op-amp etc.

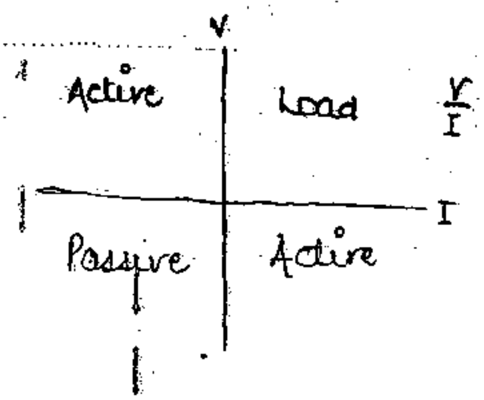
sive elements: When an element isn't capable of providing energy for infinite time and not capable of providing power gain called passive elements

Ex: Resistor, capacitor, inductor X^r etc.

ratio of voltage to current at any point of char. i-ve then element is called Active otherwise
sive.

P=VI Passive

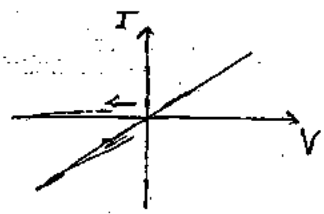
P=-VI Delevered



Bidirection element's : when element properties and char. are independent of dir^n of current then element is called bidirectional elements

Unidirectional element: when element properties and charc. depends upon dir^n of current then element is called unidirectional element.

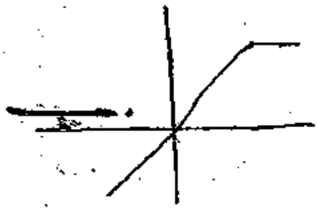
- If the charc curve is similar in opposite Quadrant then element is bidirectional otherwise unidirectional



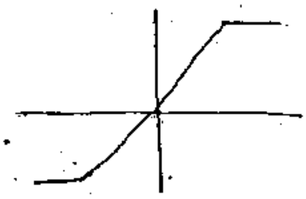
Lump elements: It consider as seprate element, which is very small in size.

Distributed element: It is electrically not seperable.

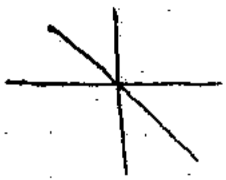
Linear & Non linear elements:
- Linearity is a property of elements describing linearity b/w excitation & response
- Every linear elements must Exhabits bidirectional property.



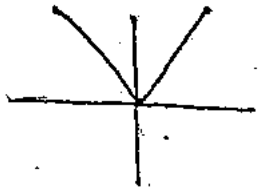
NL
P
Unidirectional



NL
Passive
Bidirectional



Active
Linear
Bidirectional

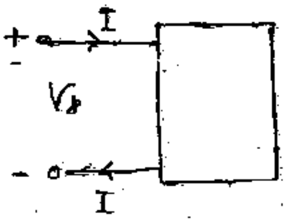


Unidirectional
Active
NL

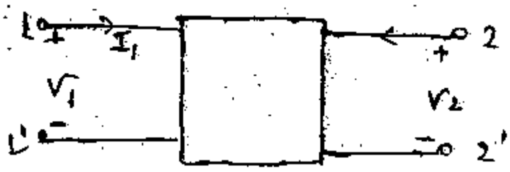
Two port n/w:

A pair of terminal through which a current may entre or leave the n/w is called port.

Two terminal devices such as resistor, inductor, capacitor results in ~~two~~ one port n/w



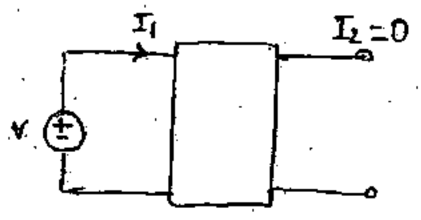
current entering one terminal of port and leaves the other so that net current entering is zero.

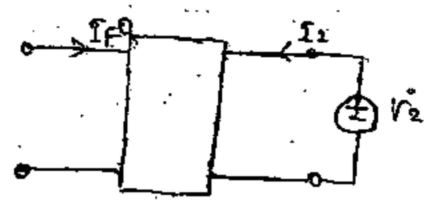


- Two port n/w has two sperate port ~~we apply i/p~~ — at one port and get o/p from other port.
- current enetering to the port in 2-port n/w.
- Here we have four variables V_1 I_1 (For i/p port) and V_2, I_2 (O/P port)
- Only 2 out of 4-variables V_1 I_1 V_2 I_2 are independent.
- The n/w inside the port is consider as black box which should consist of linear, passive and bilateral elements.
- It consist of energy storage element inductor and capacitor but initial condition zero.
- The n/w b/w the ~~source~~

concept of symmetry two port n/w:

A two port n/w is said to symmeterical. if the ratio of excitation to response is remains constant at the both the port independent w.r.t defined circuit condⁿ such as open ckt or short ckt.





$$\left.\frac{V_1}{I_1}\right|_{I_2=0}$$

$$\left.\frac{V_2}{I_2}\right|_{I_1=0}$$

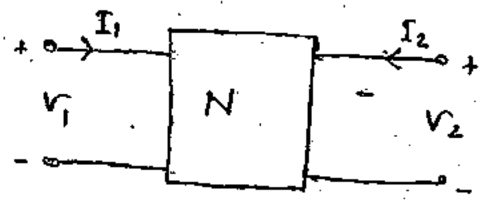
$$\frac{V_1}{I_1} = \frac{V_2}{I_2}$$

Z-parameters, or Impedence parameter or O.C-~~parameters~~.

$$(V_1, V_2) = f(I_1, I_2)$$

$$V_1 = Z_{11}I_1 + Z_{12}I_2$$

$$V_2 = Z_{21}I_1 + Z_{22}I_2$$



$$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

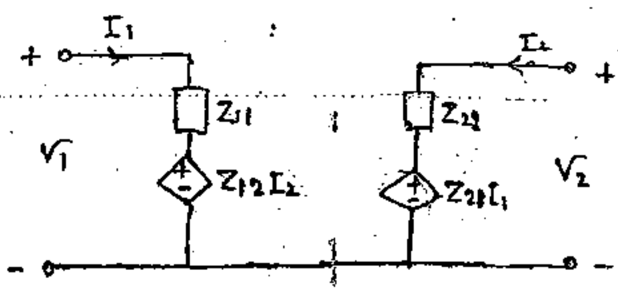
$$[V] = [Z][I]$$

$$Z_{11} = \left.\frac{V_1}{I_1}\right|_{I_2=0}$$ [driving point i/p impedence]

$$Z_{12} = \left.\frac{V_1}{I_2}\right|_{I_1=0}$$ [~~transfer point~~ O.C Reverse transfer impedence]

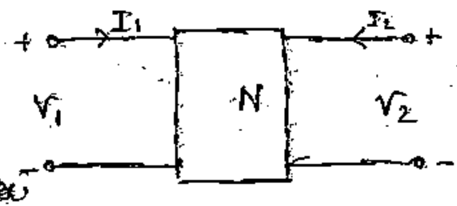
$$Z_{21} = \left.\frac{V_2}{I_1}\right|_{I_2=0}$$ [O.C forward-transfer impedence]

$$Z_{22} = \left.\frac{V_2}{I_2}\right|_{I_1=0}$$ [O.C driving point O/P impedence.



Y parameters, Admittance parameter or S.C Parameters

$$\begin{pmatrix} I_1 \\ I_2 \end{pmatrix} = f\begin{pmatrix} V_1 \\ V_2 \end{pmatrix}$$



V_1 V_2 → Independent variables &

I_1 I_2 → dependent variables

$$I_1 = Y_{11}V_1 + Y_{12}V_2$$

$$I_2 = Y_{21}V_1 + Y_{22}V_2$$

$$\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{bmatrix}\begin{bmatrix} V_1 \\ V_2 \end{bmatrix}$$

$$[I] = [Y][V]$$

$$[V] = [Y]^{-1}[I]$$

$$[V] = [Z][I]$$

$$[Z] = [Y]^{-1}$$

$$= \begin{bmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{bmatrix}^{-1}$$

$$\begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} = \frac{1}{Y_{11}Y_{22} - Y_{21}Y_{12}}\begin{bmatrix} Y_{22} & -Y_{12} \\ -Y_{21} & Y_{11} \end{bmatrix}$$

$$Z_{11} = \frac{Y_{22}}{|Y|} \qquad Z_{21} = \frac{-Y_{21}}{|Y|}$$

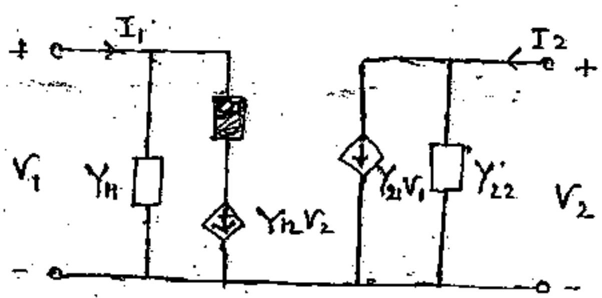
$$Z_{12} = \frac{-Y_{12}}{|Y|} \qquad Z_{22} = \frac{Y_{11}}{|Y|}$$

$Y_{11} = \frac{I_1}{V_1}\Big|_{V_2=0}$ S.C i/p admittance or driving point i/p admittance

$Y_{21} = \frac{I_2}{V_1}\Big|_{V_2=0}$ S.C Forward transfer admittance

$Y_{12} = \frac{I_1}{V_2}\Big|_{V_1=0}$ S.C Reverse " "

$Y_{22} = \frac{I_2}{V_2}\Big|_{V_1=0}$ S.C driving point o/p admittance



H- parameter's

$$\begin{pmatrix} V_1 \\ I_2 \end{pmatrix} = f\begin{pmatrix} I_1 \\ V_2 \end{pmatrix}$$

V_1 I_1 = dependent variables

V_2 I_2 = Independent variables

~~$V_1 = h_{11}V_2 + h_{12}I_2$~~

$V_1 = h_{11}I_1 + h_{12}V_2$

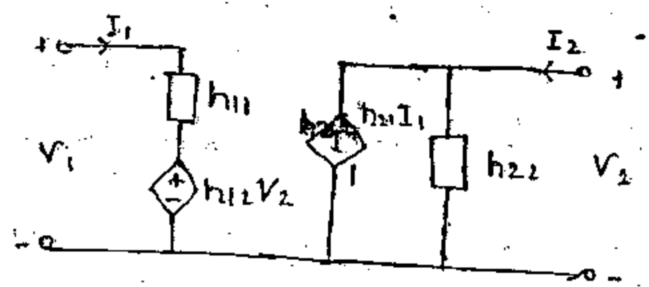
$I_2 = h_{21}I_1 + h_{22}V_2$

$h_{11} = \frac{V_1}{I_1}\Big|_{V_2=0} = \frac{1}{\frac{I_1}{V_1}\Big|_{V_2=0}} = \frac{1}{Y_{11}}$ (S.C driving point i/p impedance)

$h_{21} = \frac{I_2}{I_1}\Big|_{V_2=0}$ (S.C Forward current gain)

$h_{12} = \frac{V_1}{V_2}\Big|_{I_1=0}$ (O.C Reverse voltage gain)

$h_{22} = \frac{I_2}{V_2}\Big|_{I_1=0} = \frac{1}{\frac{V_2}{I_2}\Big|_{I_1=0}} = \frac{1}{Z_{22}}$ (O.C driving point admittance)



g- Parameters:

$$\begin{pmatrix} I_1 \\ V_2 \end{pmatrix} = f\begin{pmatrix} V_1 \\ I_2 \end{pmatrix}$$

V_1 I_2 = Independent variables
V_2 I_1 = Dependent variables

$$I_1 = g_{11}V_1 + g_{12}I_2$$
$$V_2 = g_{21}V_1 + g_{22}I_2$$

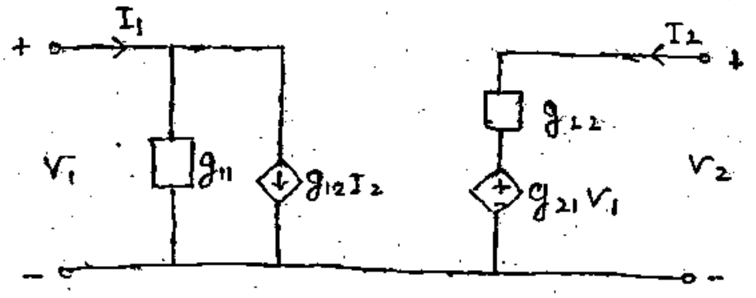
$$\begin{bmatrix} I_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{bmatrix}\begin{bmatrix} V_1 \\ I_2 \end{bmatrix}$$ $[G] = [H]^{-1}$

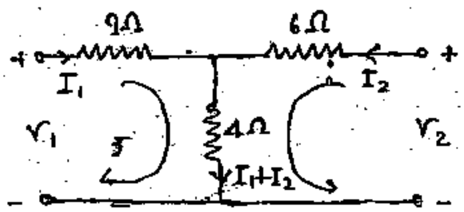
$g_{11} = \frac{I_1}{V_1}\Big|_{I_2=0}$ O/C Driving point i/p admittance

$g_{21} = \frac{V_2}{V_1}\Big|_{I_2=0}$ O.C Forward voltage gain

$g_{12} = \frac{I_1}{I_2}\Big|_{V_1=0}$ S.C Reverse current gain

$g_{22} = \frac{V_2}{I_2}\Big|_{V_1=0}$ S.C Driving point o/p impedance.





Find the Z, Y, H parameter

Method 1: (using Mesh Analysis)

$-V_1 + 2I_1 + 4(I_1+I_2) = 0$

$V_1 = 6I_1 + 4I_2$ — (1)

$\boxed{V_1 = Z_{11}I_1 + Z_{12}I_2}$

$-V_2 + 6I_2 + 4(I_1+I_2) = 0$

$V_2 = 4I_1 + 10I_2$ — (2)

$\boxed{V_2 = Z_{21}I_1 + Z_{22}I_2}$

$$Z = \begin{bmatrix} 6 & 4 \\ 4 & 10 \end{bmatrix}$$

$$[Y] = [Z]^{-1}$$

$$= \frac{1}{60-16}\begin{bmatrix} 10 & -4 \\ -4 & 6 \end{bmatrix}$$

$$[Y] = \begin{bmatrix} 5/22 & -1/11 \\ -1/11 & 3/22 \end{bmatrix}$$

From Eqn (2)

$$10I_2 = V_2 - 4I_1$$

$$I_2 = 0.1V_2 - 0.4I_1 \quad \text{--- (3)}$$

$$I_2 = h_{21}I_1 + h_{22}V_2$$

(3) → (1)

$$V_1 = 6I_1 + 4\left[0.1V_2 - 0.4I_1\right]$$

$$= 6I_1 - 1.6I_1 + 0.4V_2$$

$$V_1 = 4.4I_1 + 0.4V_2 \quad \text{--- (4)}$$

$$V_1 = h_{11}I_1 \cancel{+ h_{12}V_2}$$

$$H = \begin{bmatrix} 4.4 & 0.4 \\ -0.4 & 0.1 \end{bmatrix}$$

Using Nodal Analysis

$$\frac{V_x - V_1}{2} + \frac{V_x}{4} + \frac{V_x - V_2}{6} = 0$$

$$V_x\left[\frac{1}{2} + \frac{1}{4} + \frac{1}{6}\right] - \frac{V_1}{2} - \frac{V_2}{6} = 0$$

$$V_x\left[\frac{11}{12}\right] = \frac{V_1}{2} + \frac{V_2}{6}$$

$$V_x = \left(\frac{12}{11}\right)\left[\frac{V_1}{2} + \frac{V_2}{6}\right] \quad \text{— (1)}$$

Now

$$I_1 = \frac{V_1 - V_x}{2} = \frac{V_1}{2} - \frac{1}{2}\cdot\frac{12}{11}\left[\frac{V_1}{2} + \frac{V_2}{6}\right]$$

$$= \frac{V_1}{2} - \frac{6}{22}V_1 - \frac{V_2}{11}$$

$$\boxed{I_1 = \frac{5}{22}V_1 - \frac{1}{11}V_2} \quad \text{— (2)}$$

$$I_2 = \frac{V_2 - V_x}{6} = \frac{V_2}{6} \cdot \frac{1}{2} \cdot \frac{12}{11}\left(\frac{V_1}{2} + \frac{V_2}{6}\right)$$

$$\boxed{I_2 = -\frac{1}{11}V_1 + \frac{3}{22}V_2} \quad \text{— (3)}$$

$$Y = \begin{bmatrix} 5/22 & -1/11 \\ -1/11 & 3/22 \end{bmatrix}$$

$$Z = [Y]^{-1}$$

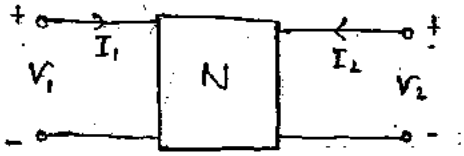
$$= \begin{bmatrix} 6 & 4 \\ 4 & 10 \end{bmatrix}$$

$$V_1 = 4.4 I_1 + 0.4 V_2$$
$$I_2 = -0.4 I_1 + 0.1 V_2$$

$$H = \begin{bmatrix} 4.4 & 0.4 \\ -0.4 & 0.1 \end{bmatrix}$$

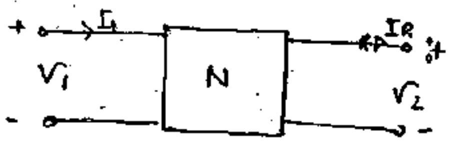
T- Parameter's or Transmission parameter or ABCD parameter :-

$$\begin{pmatrix} V_1 \\ I_1 \end{pmatrix} = f\begin{pmatrix} V_2 \\ I_2 \end{pmatrix}$$



V_1 I_1 = Dependent variables

V_2 I_2 = Independent variables



$$V_1 = AV_2 + BI_R$$
$$I_1 = CV_2 + DI_R$$

$$\boxed{\begin{aligned} V_1 &= AV_2 - BI_2 \\ I_1 &= CV_2 - DI_2 \end{aligned}}$$

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} V_2 \\ -I_2 \end{bmatrix}$$

$A = \frac{V_1}{V_2}\Big|_{I_2=0}$ O.C Reverse voltage gain

$C = \frac{I_1}{V_2}\Big|_{I_2=0}$ O.C Reverse transfer admittance

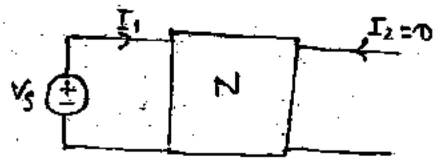
$B = -\frac{V_1}{I_2}\Big|_{V_2=0}$ S.C Reverse ,, impedence

$D = -\frac{I_1}{I_2}\Big|_{V_2=0}$ S.C Reverse trans current gain

dition for symmetry:

$V_1 = Z_{11} I_1 + Z_{12} I_2$ — (1)
$V_2 = Z_{21} I_1 + Z_{22} I_2$ — (2)

I

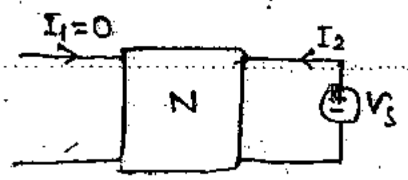


$I_2 = 0$ — (1)

$V_S = Z_{11} I_1 + (0) Z_{12}$

$Z_{11} = \frac{V_S}{I_1}$ — (3)

II



$I_1 = 0 \rightarrow$ (2)

$V_S = Z_{22} I_2$

$Z_{22} = \frac{V_S}{I_2}$ — (4)

For n/w to be symmetry

$$\frac{V_S}{I_1} = \frac{V_S}{I_2}$$

$$\boxed{Z_{11} = Z_{22}}$$

$$Z_{11} = \frac{Y_{22}}{|Y|} \qquad Z_{22} = \frac{Y_{11}}{|Y|}$$

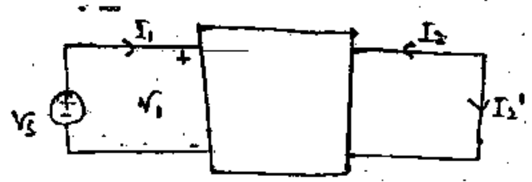
$$\frac{Y_{11}}{|Y|} = \frac{Y_{22}}{|Y|}$$

$$\boxed{Y_{11} = Y_{22}}$$

Condition of Reciprocity :

A n/w is said to be reciprocal, if the ratio of response to excitation remains the same even after posn of response and excitation are interchange

case I :



$$\frac{I_2'}{V_S}$$

$$V_1 = Z_{11}I_1 + Z_{12}I_2 \text{ — (1)}$$
$$V_2 = Z_{21}I_1 + Z_{22}I_2 \text{ — (2)}$$

$$V_S = Z_{11}I_1 - Z_{12}I_2' \text{ — (3)} \quad (\text{From Eq}^n \text{ (1)})$$
$$0 = Z_{21}I_1 - Z_{22}I_2' \text{ — (4)} \quad (\text{From Eq}^n \text{ (2)})$$

$$Z_{21}I_1 = Z_{22}I_2'$$

$$I_1 = \frac{Z_{22}I_2'}{Z_{21}} \text{ — (5)}$$

⑤ → ③

$$V_S = Z_{11}\left[\frac{Z_{22}}{Z_{21}} I_2'\right] - Z_{12} I_2'$$

$$V_S = \left[\frac{Z_{11}Z_{22} - Z_{12}Z_{21}}{Z_{21}}\right] I_2'$$

$$\boxed{\frac{I_2'}{V_S} = \frac{Z_{21}}{Z_{11}Z_{22} - Z_{12}Z_{21}}} - \alpha$$

Q80

$\frac{I_1'}{V_S}$

$$V_2 = V_S \longrightarrow ②$$

$$V_S = Z_{21} I_1' + Z_{22} I_2$$

$$V_1 = 0 \longrightarrow ①$$

$$0 = -Z_{11} I_1' + Z_{12} I_2$$

$$I_2 = \frac{Z_{11}}{Z_{12}} I_1'$$

$$V_S = -Z_{21} I_1' + \frac{Z_{11}}{Z_{12}} Z_{22} I_1'$$

$$\boxed{\frac{I_1'}{V_S} = \frac{Z_{12}}{Z_{11}Z_{22} - Z_{21}Z_{12}}} - \beta$$

— condition for Reciprocity

$$\frac{I_2'}{V_S} = \frac{I_1'}{V_S}$$

$$\frac{Z_{21}}{|Z|} = \frac{Z_{12}}{|Z|}$$

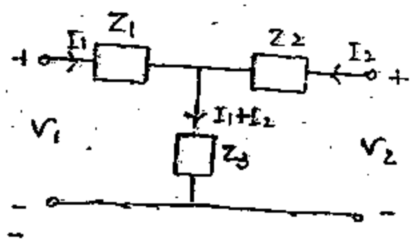
$\boxed{Z_{12} = Z_{21}}$ in term of Z-parameter

$$Z_{12} = -\frac{Y_{12}}{|Y|} \qquad Z_{21} = -\frac{Y_{21}}{|Y|}$$

$$\frac{-Y_{12}}{\cancel{|Y|}} = \frac{-Y_{21}}{\cancel{|Y|}}$$

$\boxed{Y_{12} = Y_{21}}$ in term of Y-parameter

For T-n/w



$$V_1 = (Z_1+Z_3)I_1 + Z_3 I_2$$
$$V_1 = Z_{11}I_1 + Z_{12} I_2$$

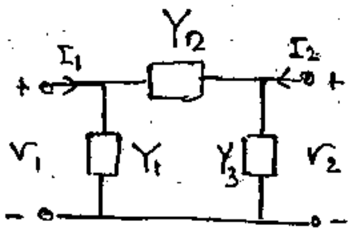
$$V_2 = (Z_2+Z_3)I_2 + Z_3 I_1$$
$$V_2 = Z_{21} I_1 + Z_{22} I_2$$

$$Z = \begin{bmatrix} Z_1+Z_3 & Z_3 \\ Z_3 & Z_2+Z_3 \end{bmatrix}$$

$Z_{11} = Z_1 + Z_3$; $Z_{12} = Z_{21} = Z_3$

$Z_{22} = Z_2 + Z_3$

π-n/w



$$I_1 = V_1 \cdot Y_1 + (V_1 - V_2) Y_2$$

$$I_1 = (Y_1 + Y_2) V_1 - V_2 Y_2$$

$$I_1 = Y_{11} V_1 + Y_{12} V_2$$

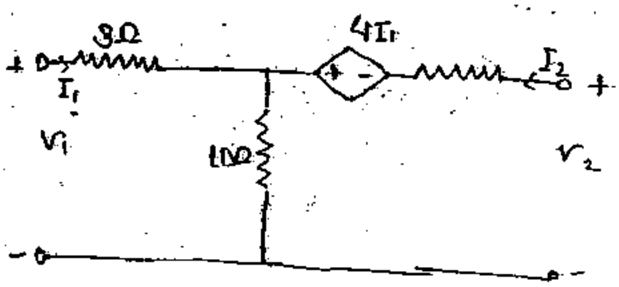
$$I_2 = V_2 Y_3 + (V_2 - V_1) Y_2$$

$$I_2 = -Y_2 V_1 + (Y_2 + Y_3) V_2$$

$$I_2 = Y_{21} V_1 + Y_{22} V_2$$

$$Y = \begin{bmatrix} Y_1 + Y_2 & -Y_2 \\ -Y_2 & Y_2 + Y_3 \end{bmatrix}$$

$$\boxed{\begin{array}{l} Y_{11} = Y_1 + Y_2 \quad ; \quad Y_{22} = Y_2 + Y_3 \\ Y_{21} = Y_{12} = -Y_2 \end{array}}$$



Find Z, Y, H, T parameter

$$-V_1 + 3I_1 + 10(I_1+I_2) = 0$$

$$V_1 = 13I_1 + 10I_2$$

$$V_1 = Z_{11}I_1 + Z_{12}I_2$$

$$-V_2 + 2I_2 - 4I_1 + 10(I_1+I_2) = 0$$

$$V_2 = \underline{6I_1} + 12I_2$$

$$V_2 = Z_{21}I_1 + Z_{22}I_2$$

$$Z = \begin{bmatrix} 13 & 10 \\ 6 & 12 \end{bmatrix}$$

$$Y = [Z]^{-1}$$

$$= \frac{1}{156-60}\begin{bmatrix} 12 & -10 \\ -6 & 13 \end{bmatrix}$$

H-parameter

$$12I_2 = V_2 - 6I_1$$

$$\boxed{I_2 = \frac{1}{12}V_2 - \frac{1}{2}I_1}$$

$$V_1 = 13I_1 + 10\left[\frac{1}{12}V_2 - \frac{1}{2}I_1\right]$$

$$= 13I_1 + \frac{5}{6}V_2 - 5I_1$$

$$\boxed{V_1 = 8I_1 + \frac{5}{6}V_2}$$

$$H = \begin{bmatrix} 8 & 5/6 \\ -1/2 & 1/12 \end{bmatrix}$$

T parameter

$$6I_1 = V_2 - 12I_2$$

$$I_1 = \frac{1}{6}V_2 - 2I_2$$

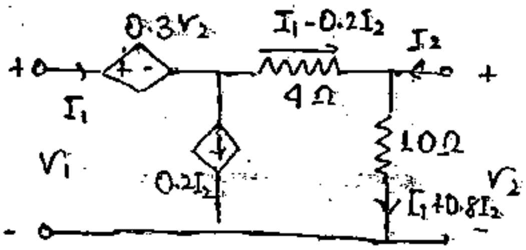
$$= \frac{1}{6}V_2 + 2(-I_2)$$

$I_1 = 13\left[\frac{1}{6}V_2 - 2I_2\right] + 10I_2$

$= \frac{13}{6}V_2 - 26I_2 + 10I_2$

$V_1 = \frac{13}{6}V_2 + 16(-I_2)$

$$T = \begin{bmatrix} 13/6 & 16 \\ 1/6 & 2 \end{bmatrix}$$



$V_2 = 10(I_1 + 0.8I_2)$

$V_2 = 10I_1 + 8I_2$

$-V_1 + 0.3V_2 + 4(I_1 - 0.2I_2) + V_2 = 0$

$V_1 = 1.3V_2 + 4I_1 - 0.8I_2$

$V_1 = 1.3(10I_1 + 8I_2) + 4I_1 - 0.8I_2$

$V_1 = 13I_1 + 10.4I_2 + 4I_1 - 0.8I_2$

$V_1 = 17I_1 + 9.6I_2$

$$Z = \begin{bmatrix} 17 & 9.6 \\ 10 & 8 \end{bmatrix}$$

$Y = [Z]^{-1}$

$$\Rightarrow 8I_2 = V_2 - 10I_1$$

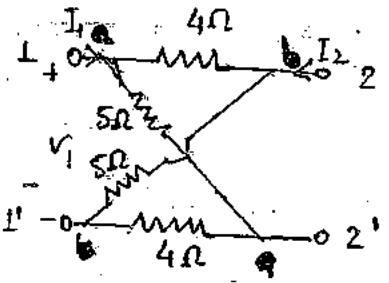
$$I_2 = \frac{1}{8}V_2 - \frac{5}{4}I_1$$

$$V_1 = 17I_1 + \frac{48}{5}\left[\frac{1}{8}V_2 - \frac{5}{4}I_1\right]$$

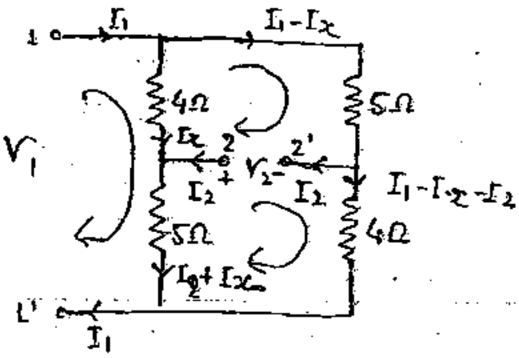
$$= 17I_1 + \frac{6}{5}V_2 - 12I_1$$

$$V_1 = 5I_1 + \frac{6}{5}V_2$$

$$H = \begin{bmatrix} 5 & 6/5 \\ -5/4 & -1/8 \end{bmatrix}$$

Q. 

Find the z-parameter



$$V_1 = 4I_x + 5(I_x + I_2)$$

$$V_1 = 9I_x + 5I_2 \quad \text{— (1)}$$

$$V_2 = -4I_x + 5(I_1 - I_x)$$

$$V_2 = 5I_1 - 9x \quad \text{— (2)}$$

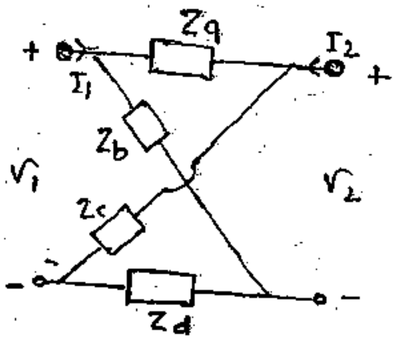
$$V_2 + 4(I_1 - I_x - I_2) - 5(I_2 + I_x) = 0$$

$$V_2 + 4I_1 - 9I_2 = 9I_x$$

$$V_1 = \frac{9}{2} I_1 + \frac{1}{2} I_2$$

$$V_2 = \frac{1}{2} I_1 + \frac{9}{2} I_2$$

N.B.



$$\left.\begin{aligned} Z_a &= Z_d \\ Z_b &= Z_c \end{aligned}\right\} \text{symmetrical}$$

$$Z_{11} = Z_{22} = \frac{Z_a + Z_b}{2}$$

$$Z_{12} = Z_{21} = \frac{Z_b - Z_a}{2}$$

Similarly:

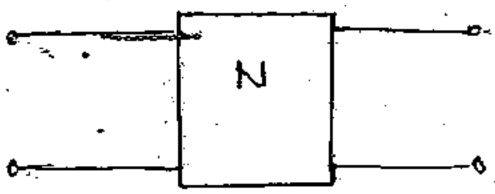
$$Y_{11} = Y_{22} = \frac{Y_a + Y_b}{2}$$

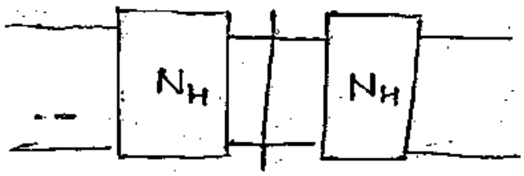
$$Y_{12} = Y_{21} = \frac{Y_b - Y_a}{2}$$

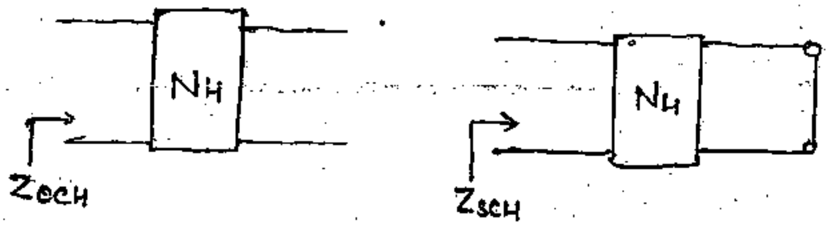
$$\left.\begin{aligned} Y_a &= Y_d \\ Y_b &= Y_c \end{aligned}\right\} \text{symmetrical}$$

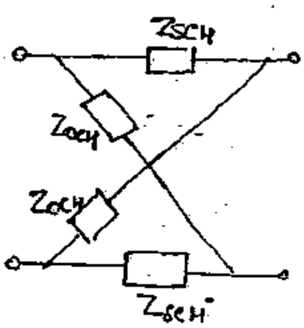
Bartlette Bisection theorom:-

- It is used for desiging lattic n/w.
- It is applicable for symmetrical n/w.
- In this theorom, we will seprate the n/w in two equal part and then we will bisect the n/w from middle





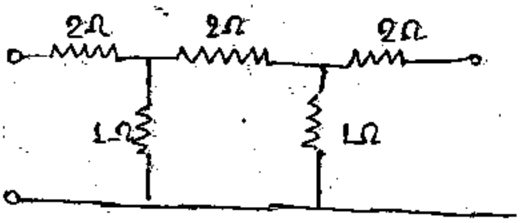




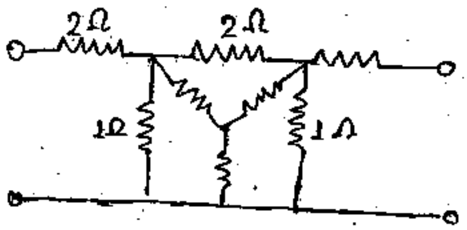
$$Z_{11} = \frac{Z_{scH} + Z_{ocH}}{2} = Z_{22}$$

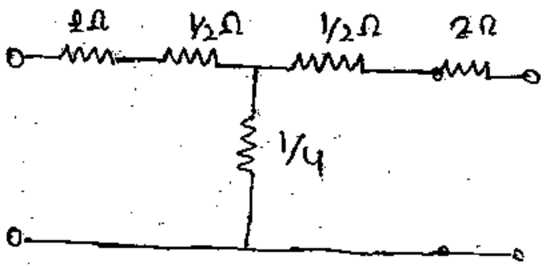
$$Z_{21} = Z_{12} = \frac{Z_{ocH} - Z_{scH}}{2}$$

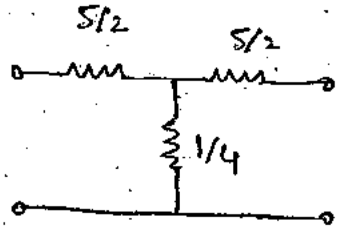
33



Method 1



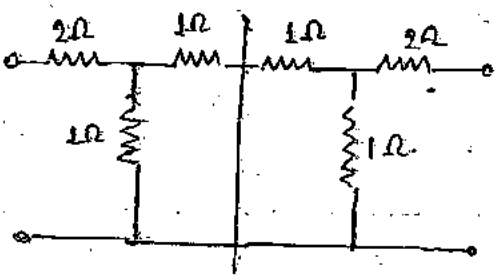


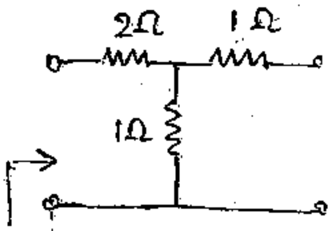


$Z_{11} = 5/2 + 1/4 = 11/4 = 2.75$

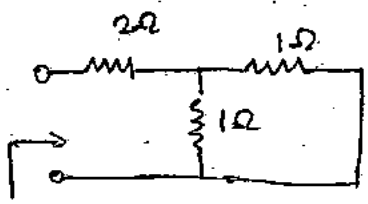
$Z_{12} = 1/4 = 0.25$

2nd method

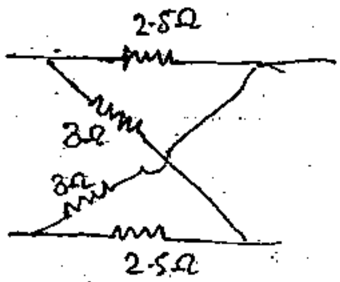




$Z_{OCH} = 2+1 = 3\Omega$

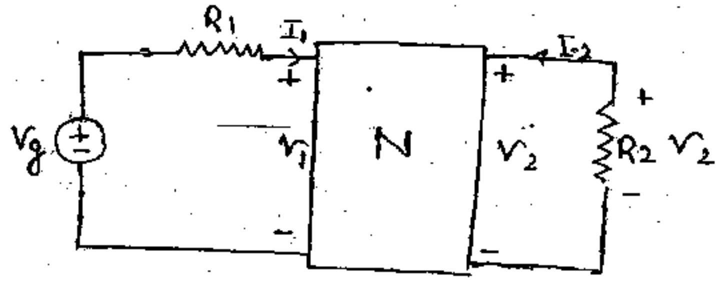


$$Z_{SCH} = 2 + (1 \| 1)$$
$$= \underline{2.5\Omega}$$

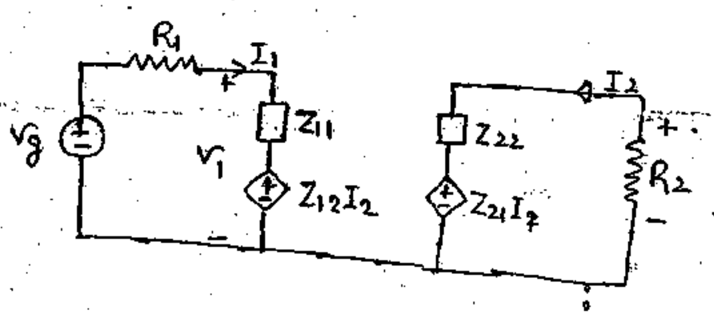


$$\left.\begin{aligned} Z_{11} = Z_{22} &= \frac{2.5+3}{2} = 2.75\Omega \\ Z_{12} = Z_{21} &= \frac{3-2.5}{2} = 0.25 \end{aligned}\right\} \text{Ans}$$

Q. In the below given n/w find $\frac{V_2}{V_g}$ in term of Z-parameter.



Soln: Method 1



$V_2 = -I_2R_2$

$$-V_g + I_1R_1 + I_1Z_{11} + I_2Z_{12} = 0$$

$$V_g = (R_1+Z_{11})I_1 + I_2Z_{12} \quad \text{--- (1)}$$

$$I_2Z_{22} + Z_{21}I_1 + I_2R_2 = 0$$

$$I_1 = -\frac{(R_2+Z_{22})}{Z_{21}} I_2 \quad \text{--- (2)}$$

$$\therefore \quad V_g = -(R_1+Z_{11}) \times \frac{(R_2+Z_{22})}{Z_{21}} I_2 + Z_{12}I_2$$

$$V_g = I_2 \left[\frac{-(R_1R_2 + R_1Z_{22} + Z_{11}R_2 + Z_{11}Z_{22}) + Z_{12}Z_{21}}{Z_{21}} \right]$$

$$V_g = \frac{-V_2}{-R_2}\left[\frac{|Z| + R_1 Z_{22} + R_2 Z_{11} + R_1 R_2}{Z_{21}}\right]$$

$$\frac{V_2}{V_g} = \frac{R_2 Z_{21}}{|Z| + R_1 Z_{22} + R_2 Z_{11} + R_1 R_2}$$

2nd method :-

$$V_1 = Z_{11} I_1 + Z_{12} I_2 \quad \text{—— (1)}$$

$$V_2 = Z_{21} I_1 + Z_{22} I_2 \quad \text{—— (2)}$$

$$V_g = V_1 + I_1 R_1$$

$$= (Z_{11} I_1 + Z_{12} I_2) + I_1 R_1$$

$$= (Z_{11} + R_1) I_1 + Z_{12} I_2 \quad \text{—— (3)}$$

$$V_2 = -I_2 R_2$$

$$I_2 = -\frac{V_2}{R_2}$$

$$V_g = (Z_{11} + R_1) I_1 + Z_{12}\left(-\frac{V_2}{R_2}\right) \quad \text{—— (4)}$$

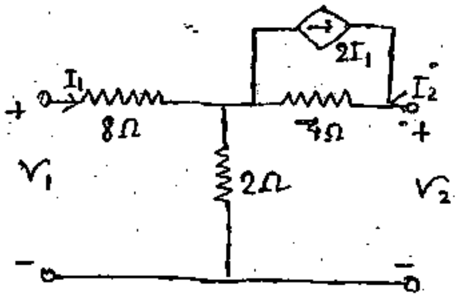
$$Z_{21} I_1 = \left(\frac{R_2 + Z_{22}}{R_2}\right) V_2$$

$$I_1 = \left(\frac{R_2 + Z_{22}}{R_2 \cdot Z_{21}}\right) V_2 \quad \text{—— (5)}$$

$$V_g = (R_1 + Z_{11}) \cdot \frac{(R_2 + Z_{22})}{R_2 \cdot Z_{21}} V_2 - \frac{Z_{12}}{R_2} \cdot V_2$$

$$V_g = V_2 \left[\frac{R_1 R_2 + R_1 Z_{22} + R_2 Z_{11} + Z_{11} Z_{22} - Z_{12} Z_{21}}{R_2 Z_{21}}\right]$$

$$\frac{V_2}{V_g} = \frac{R_2 Z_{21}}{|Z| + R_1 R_2 + R_1 Z_{22} + R_2 Z_{11}} \quad \text{Ans}$$



Calculate Y and Z Parameter.

Sln:

$$-V_1 + 8I_1 + 2(I_1+I_2) = 0$$

$$V_1 = 10I_1 + 2I_2 \quad — (1)$$

$$-V_2 + 4(2I_1+I_2) + 2(I_1+I_2) = 0$$

$$V_2 = 10I_1 + 6I_2$$

$$Z = \begin{bmatrix} 10 & 2 \\ 10 & 6 \end{bmatrix}$$

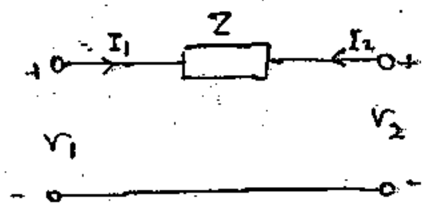
$$Y = [Z]^{-1}$$

$$Y = \frac{1}{40}\begin{bmatrix} 6 & -2 \\ -10 & 10 \end{bmatrix}$$

$$= \begin{bmatrix} \frac{3}{20} & -\frac{1}{20} \\ -\frac{1}{4} & \frac{1}{4} \end{bmatrix}$$

$$\cancel{I_2} \neq \cancel{V_2} - \cancel{10 I_1}$$

Q.



Calculate Y and Z parameters.

Solⁿ:

$$I_1 = \frac{V_1 - V_2}{Z} = \frac{V_1}{Z} - \frac{V_2}{Z}$$

$$I_2 = \frac{V_2 - V_1}{Z} = -\frac{V_1}{Z} + \frac{V_2}{Z}$$

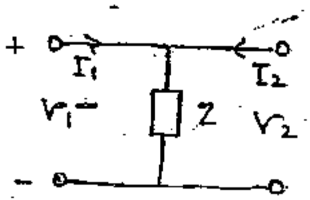
$$Y = \begin{bmatrix} \frac{1}{Z} & -\frac{1}{Z} \\ -1/Z & 1/Z \end{bmatrix}$$

$$[Z] = [Y]^{-1}$$

$$|Y| = 0$$

inverse not possible

Q.



Calculate [illegible] Param[illegible]

Solⁿ

$$-V_1 + (I_1 + I_2)Z = 0$$

$$V_1 = Z I_1 + I_2 Z$$

Similarly $V_2 = Z I_1 + \frac{1}{Z} I_2$

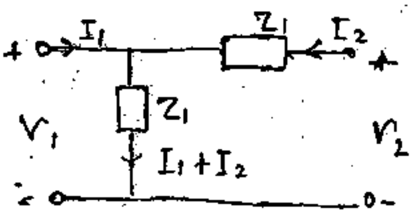
$$Z = \begin{bmatrix} Z & Z \\ Z & Z \end{bmatrix}$$

$Y = [Z]^{-1}$

$|Z| = 0$

inverse not possible.

$\therefore$ Y- parameter does't possible.



calculate Z- parameter?

$V_1 = I_1 Z_1 + I_2 Z_1$

$V_2 = Z_1 I_1 + (Z_1+Z_2) I_2$

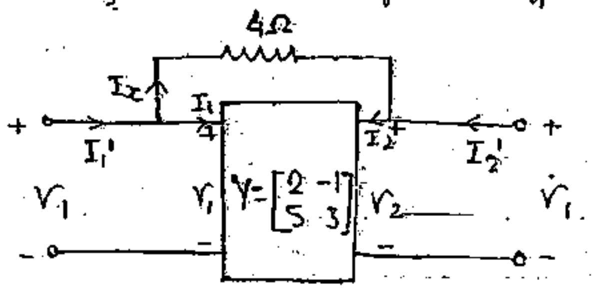
$$Z = \begin{bmatrix} Z_1 & Z_1 \\ Z_1 & Z_1+Z_2 \end{bmatrix}$$

$|Z| = Z_1^2 + Z_1 Z_2 - Z_1^2 = Z_1 Z_2$

$Y = [Z]^{-1}$

$$= \frac{1}{Z_1 Z_2} \begin{bmatrix} Z_1+Z_2 & -Z_1 \\ -Z_1 & Z_1 \end{bmatrix}$$

Q. Find the y parameters of the n/w given



Soln.

$$I_1 = 2V_1 - V_2 \quad \text{--- (1)}$$
$$I_2 = 5V_1 + 3V_2 \quad \text{--- (2)}$$

$$I_x = \frac{V_1 - V_2}{4} = \frac{V_1}{4} - \frac{V_2}{4} \quad \text{--- (3)}$$

$$I_1' = I_1 + I_x$$
$$= 2V_1 - V_2 + \frac{V_1}{4} - \frac{V_2}{4}$$
$$I_1' = \frac{9V_1}{4} - \frac{5V_2}{4}$$

$$I_2' + I_x = I_2$$
$$I_2' = I_2 - I_x$$
$$= 5V_1 + 3V_2 - \frac{V_1}{4} - \frac{V_2}{4}$$
$$I_2' = \frac{19}{4}V_1 + \frac{13}{4}V_2$$

$$Y = \begin{bmatrix} 9/4 & -5/4 \\ 19/4 & 13/4 \end{bmatrix}$$ Ans

conversion of parameter

Γ to Z-parameter:

$$V_1 = AV_2 - BI_2 \quad \text{--- (1)}$$
$$I_1 = CV_2 - DI_2 \quad \text{--- (2)}$$

$\rightarrow$ $CV_2 = I_1 + DI_2$

$$\boxed{V_2 = \frac{1}{C}I_1 + \frac{D}{C}I_2}$$

$$V_1 = AV_2 - BI_2$$
$$= A\left(\frac{1}{C}I_1 + \frac{D}{C}I_2\right) - BI_2$$
$$= \left(\frac{A}{C}\right)I_1 + \left(\frac{AD}{C} - B\right)I_2$$

$$\boxed{V_1 = \left(\frac{A}{C}\right)I_1 + \left(\frac{AD-BC}{C}\right)I_2}$$

$Z_{11} = \frac{A}{C}$; $Z_{12} = \frac{AD-BC}{C}$

$Z_{21} = \frac{1}{C}$ $Z_{22} = \frac{D}{C}$

Symmetricity

$Z_{11} = Z_{22}$

$\frac{A}{C} = \frac{D}{C}$

$\boxed{A = D}$

Reciprocity

$Z_{12} = Z_{21}$

$\frac{AD-BC}{C} = \frac{1}{C}$

$\boxed{AD - BC = 1}$

2. H to Y-parameter:

$$V_1 = h_{11}I_1 + h_{12}V_2 \quad \text{--- (1)}$$
$$I_2 = h_{21}I_1 + h_{22}V_2 \quad \text{--- (2)}$$

(1) $\rightarrow$

$$h_{11}I_1 = V_1 - h_{12}V_2$$
$$I_1 = \frac{1}{h_{11}}V_1 - \frac{h_{12}}{h_{11}}V_2$$

Substitute this value in Eqn (2)

$$I_2 = h_{21}\left[\frac{1}{h_{11}}V_1 - \frac{h_{12}}{h_{11}}V_2\right] + h_{22}V_2$$

$$= \frac{h_{21}}{h_{11}}V_1 - \frac{h_{12}h_{21}}{h_{11}}V_2 + h_{22}V_2$$

$$I_2 = \frac{h_{21}}{h_{11}}V_1 + \frac{h_{11}h_{22} - h_{12}h_{21}}{h_{11}}V_2$$

$$Y_{11} = \frac{1}{h_{11}} \qquad Y_{12} = \frac{-h_{12}}{h_{11}}$$

$$Y_{21} = \frac{h_{21}}{h_{11}} \qquad Y_{22} = \frac{h_{11}h_{22} - h_{12}h_{21}}{h_{11}}$$

Symmetricity

$$Y_{11} = Y_{22}$$
$$\frac{1}{\cancel{h_{11}}} = \frac{h_{11}h_{22} - h_{12}h_{21}}{\cancel{h_{11}}}$$
$$h_{11}h_{22} - h_{12}h_{21} = 1$$
$$\boxed{|H| = 1}$$

Reciprocity

$$Y_{12} = Y_{21}$$
$$\frac{h_{21}}{\cancel{h_{11}}} = -\frac{h_{12}}{\cancel{h_{11}}}$$
$$\boxed{h_{12} = -h_{21}}$$

ortant point:

SYMMETRY

RECIPROCITY

) $Z_{11}=Z_{22}$

$Y_{11}=Y_{22}$

(i) $Z_{12}=Z_{21}$

$Y_{21}=Y_{12}$

) $|H|=1$

$|G|=1$

(ii) $h_{12}=-h_{21}$

$g_{12}=-g_{21}$

) $A=D$

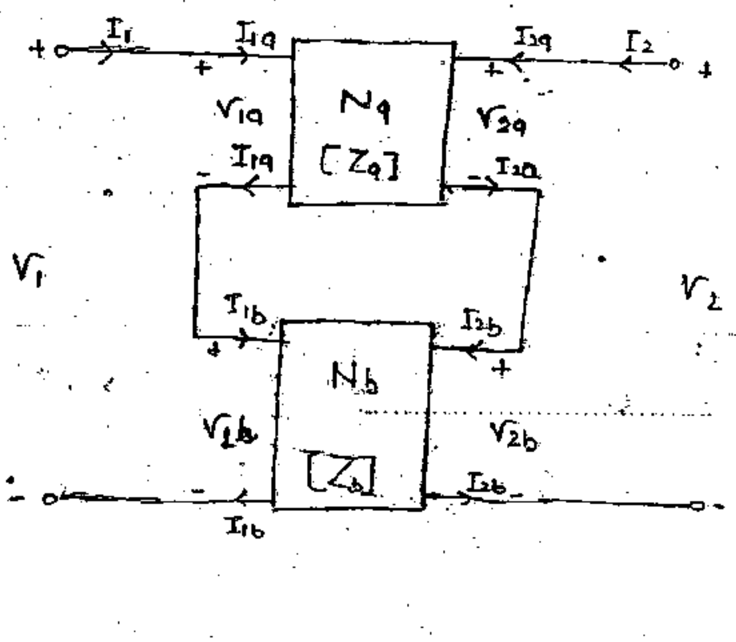
$a=d$

(iii) $|T|=1$

$|t|=1$

nterconnection of n/w:-

Series - Series Interconnection:



$$I_{1a} = I_{1b} = I_1 \qquad I_{2a} = I_{2b} = I_2$$

$$V_1 = V_{1a} + V_{1b} \qquad V_2 = V_{2a} + V_{2b}$$

$$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} V_{1a} \\ V_{2a} \end{bmatrix} + \begin{bmatrix} V_{1b} \\ V_{2b} \end{bmatrix}$$

$$\begin{bmatrix} V_{1a} \\ V_{2a} \end{bmatrix} = \begin{bmatrix} Z_{11a} & Z_{12a} \\ Z_{21a} & Z_{22a} \end{bmatrix} \begin{bmatrix} I_{1a} \\ I_{2a} \end{bmatrix}$$

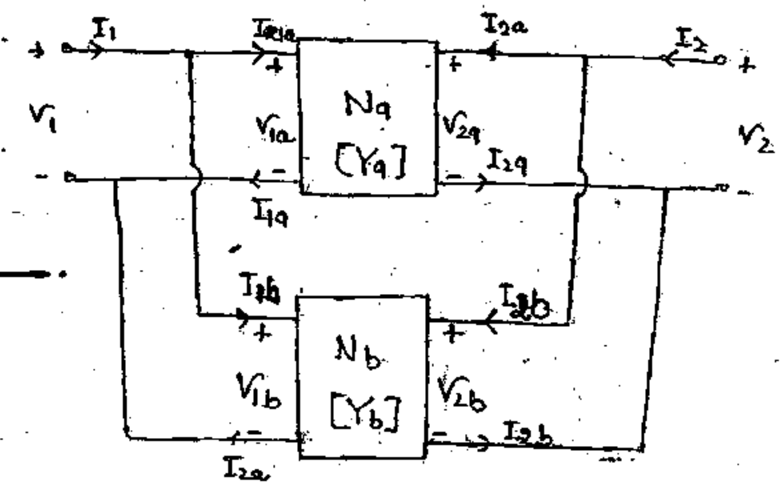
$$\begin{bmatrix} V_{1b} \\ V_{2b} \end{bmatrix} = \begin{bmatrix} Z_{11b} & Z_{12b} \\ Z_{21b} & Z_{22b} \end{bmatrix} \begin{bmatrix} I_{1b} \\ I_{2b} \end{bmatrix}$$

$$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = [Z_a] \begin{bmatrix} I_{1a} \\ I_{2a} \end{bmatrix} + [Z_b] \begin{bmatrix} I_{1b} \\ I_{2b} \end{bmatrix}$$

$$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \left\{ [Z_a] + [Z_b] \right\} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

$$\boxed{[Z] = [Z_a] + [Z_b]}$$

11-11 Interconnection



$V_1 = V_{1a} = V_{1b}$; $V_2 = V_{2a} = V_{2b}$

$I_1 = I_{1a} + I_{1b}$ $\quad$ $I_2 = I_{2a} + I_{2b}$.

$$\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} I_{1a} \\ I_{2a} \end{bmatrix} + \begin{bmatrix} I_{1b} \\ I_{2b} \end{bmatrix}$$

$$\begin{bmatrix} I_{1a} \\ I_{2a} \end{bmatrix} = \begin{bmatrix} Y_{11a} & Y_{12a} \\ Y_{21a} & Y_{22a} \end{bmatrix} \begin{bmatrix} V_{1a} \\ V_{2a} \end{bmatrix}$$

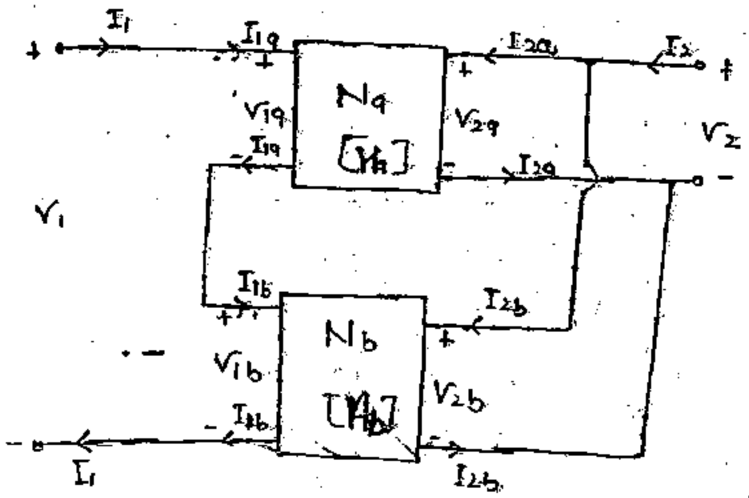
$$\begin{bmatrix} I_{1b} \\ I_{2b} \end{bmatrix} = \begin{bmatrix} Y_{11b} & Y_{12b} \\ Y_{21b} & Y_{22b} \end{bmatrix} \begin{bmatrix} V_{1b} \\ V_{2b} \end{bmatrix}$$

$$\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = [Y_a] \begin{bmatrix} V_{1a} \\ V_{2a} \end{bmatrix} + [Y_b] \begin{bmatrix} V_{1b} \\ V_{2b} \end{bmatrix}$$

$$\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \left\{ [Y_a] + [Y_b] \right\} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix}$$

$$[Y] = [Y_a] + [Y_b]$$

3. Series-|| Interconnection



$$V_1 = V_{1a} + V_{1b} \qquad V_{2a} = V_{2b} = V_2$$

$$I_{1b} = I_{1a} = I_1 \qquad I_2 = I_{2a} + I_{2b}$$

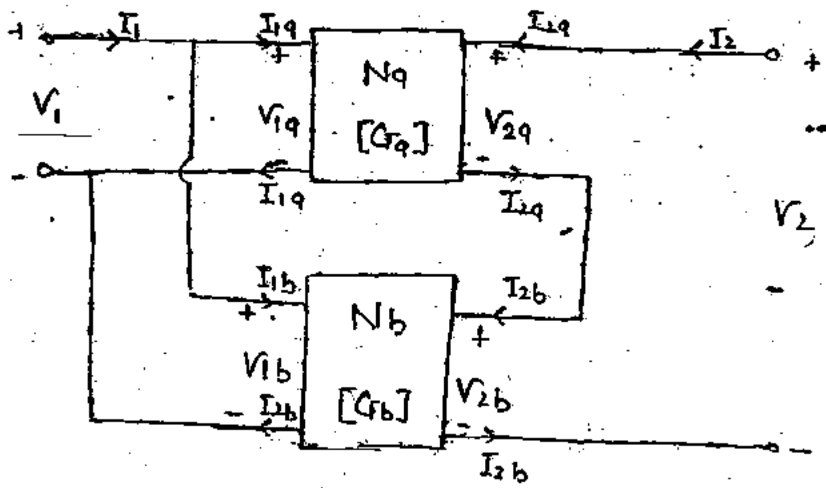
$$\begin{bmatrix} V_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} V_{1a} \\ I_{2a} \end{bmatrix} + \begin{bmatrix} V_{1b} \\ I_{2b} \end{bmatrix}$$

$$= [H_a]\begin{bmatrix} I_{1a} \\ V_{2a} \end{bmatrix} + [H_b]\begin{bmatrix} I_{1b} \\ V_{2b} \end{bmatrix}$$

$$\begin{bmatrix} V_1 \\ I_2 \end{bmatrix} = \left\{ [H_a] + [H_b] \right\} \begin{bmatrix} I_1 \\ V_2 \end{bmatrix}$$

$$[H] = [H_a] + [H_b]$$

II - Series Interconnection



$V_1 = V_{1a} = V_{1b}$; $V_2 = V_{2a} + V_{2b}$

$I_1 = I_{1a} + I_{1b}$ $\quad$ $I_2 = I_{2a} = I_{2b}$

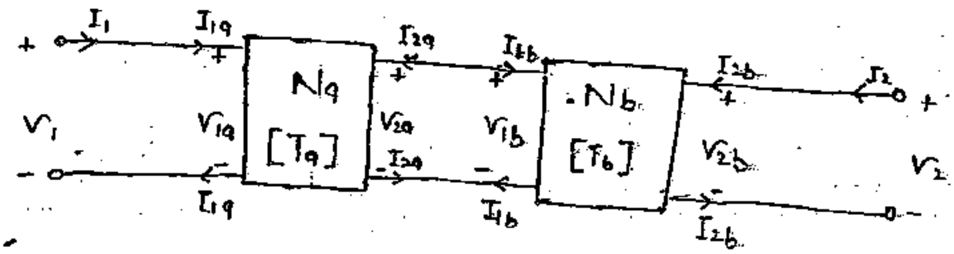
$$\begin{bmatrix} I_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} I_{1a} \\ V_{2a} \end{bmatrix} + \begin{bmatrix} I_{1b} \\ V_{2b} \end{bmatrix}$$

$$= [G_{1a}] \begin{bmatrix} V_{1a} \\ I_{2a} \end{bmatrix} + [G_{1b}] \begin{bmatrix} V_{1b} \\ I_{2b} \end{bmatrix}$$

$$\begin{bmatrix} I_1 \\ V_2 \end{bmatrix} = \left\{ [G_{1a}] + [G_{1b}] \right\} \begin{bmatrix} V_1 \\ I_2 \end{bmatrix}$$

$$[G] = [G_{1a}] + [G_{1b}]$$

5. Cascade Interconnection :-



$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} V_{1a} \\ I_{1a} \end{bmatrix}$$

$$= [T_a] \begin{bmatrix} V_{2a} \\ -I_{2a} \end{bmatrix}$$

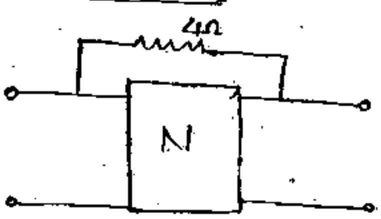
$$= [T_a] \begin{bmatrix} V_{1b} \\ I_{1b} \end{bmatrix}$$

$$= [T_a] \left\{ [T_b] \begin{bmatrix} V_{2b} \\ -I_{2b} \end{bmatrix} \right\}$$

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = [T_a][T_b] \begin{bmatrix} V_2 \\ -I_2 \end{bmatrix}$$

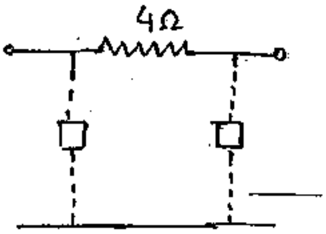
$$\boxed{[T] = [T_a][T_b]}$$

Q.



$$[Y] = \begin{bmatrix} 2 & -1 \\ 5 & 3 \end{bmatrix}$$

11n:

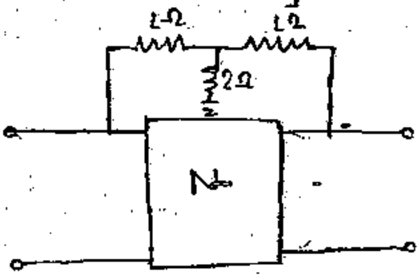


$$Y' = \begin{bmatrix} 1/4 & -1/4 \\ -1/4 & 1/4 \end{bmatrix}$$

$$Y = [Y'] + [Y_N]$$

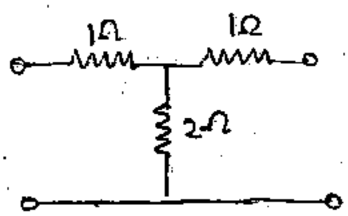
$$= \begin{bmatrix} 1/4 & -1/4 \\ -1/4 & 1/4 \end{bmatrix} + \begin{bmatrix} 2 & -1 \\ 5 & 3 \end{bmatrix}$$

$$= \begin{bmatrix} 9/4 & -5/4 \\ 19/4 & 13/4 \end{bmatrix}$$



$$Y_N = \begin{bmatrix} 2 & -1 \\ 5 & 3 \end{bmatrix}$$

n:



$$Z = \begin{bmatrix} 3 & 2 \\ 2 & 3 \end{bmatrix}$$

$$Y' = [Z]^{-1}$$

$$= \frac{1}{5} \begin{bmatrix} 3 & -2 \\ -2 & 3 \end{bmatrix}$$

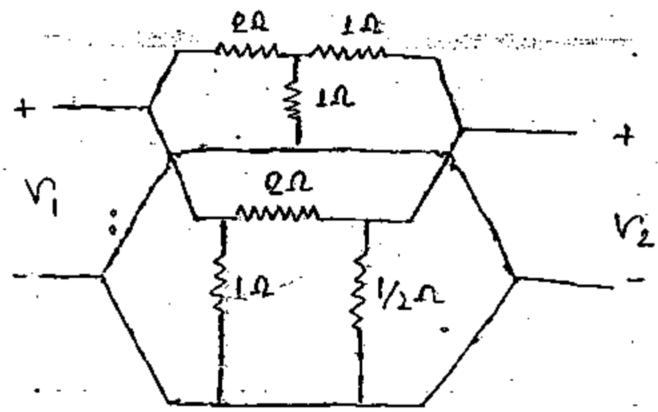
$$Y' = \begin{bmatrix} 3/5 & -2/5 \\ -2/5 & 3/5 \end{bmatrix}$$

$$[Y] = [Y_N] + [Y']$$

$$= \begin{bmatrix} 2 & -1 \\ 5 & 3 \end{bmatrix} + \begin{bmatrix} 3/5 & -2/5 \\ -2/5 & 3/5 \end{bmatrix}$$

$$[Y] = \begin{bmatrix} \frac{13}{5} & -7/5 \\ \frac{23}{5} & \frac{18}{5} \end{bmatrix}$$

Q.



Find the overall Z-parameter of the n/w

Soln:

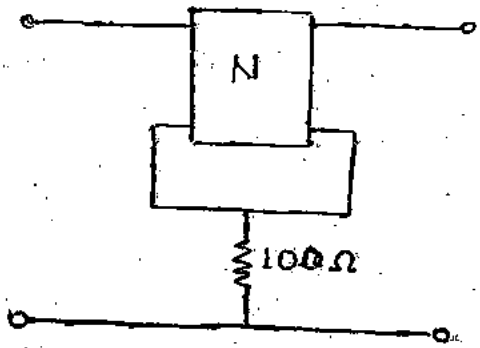
$$\cancel{Z_a} = Z = \begin{bmatrix} 3 & 1 \\ 1 & 2 \end{bmatrix}$$

$$Y_a = \frac{1}{5}\begin{bmatrix} 2 & -1 \\ -1 & 3 \end{bmatrix}$$

$$Y_b = \begin{bmatrix} 3/2 & -1/2 \\ -1/2 & 5/2 \end{bmatrix}$$

$$[Y] = \begin{bmatrix} 2/5 & -1/5 \\ -1/5 & 3/5 \end{bmatrix} + \begin{bmatrix} 3/2 & -1/2 \\ -1/2 & 5/2 \end{bmatrix} = \begin{bmatrix} 19/10 & -7/10 \\ -7/10 & 31/10 \end{bmatrix}$$

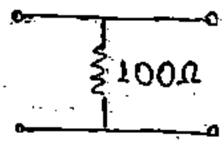
$$= \begin{bmatrix} \cancel{8}/\cancel{5}0 & -7/\cancel{1}0 \end{bmatrix}$$



$Y_N = \begin{bmatrix} 2 & 0 \\ 0 & 10 \end{bmatrix} mS$

Find overall Y-parameters.

Sln:



$$Z_b = \begin{bmatrix} 100 & 100 \\ 100 & 100 \end{bmatrix}$$

$$Y_N = \begin{bmatrix} 2 & 0 \\ 0 & 10 \end{bmatrix} mS$$

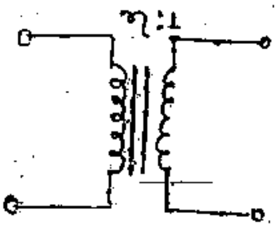
$$Z_n = \begin{bmatrix} 500 & 0 \\ 0 & 100 \end{bmatrix}$$

$$Z = [Z_n] + [Z_b]$$

$$= \begin{bmatrix} 600 & 100 \\ 100 & 200 \end{bmatrix}$$

$$Y = [Z]^{-1}$$

Q. Find the Z, Y and T-parameter of ~~Ideal x^r~~ :



From above n/w it is not possible to find impedence & Admittance value since for Ideal x^r self & mutual inductance are ∞. Therefore Y and Z-parameter not defined.

$$\frac{V_1}{V_2} = \frac{n}{1} \quad ; \quad \frac{I_1}{I_2} = \frac{1}{n}$$

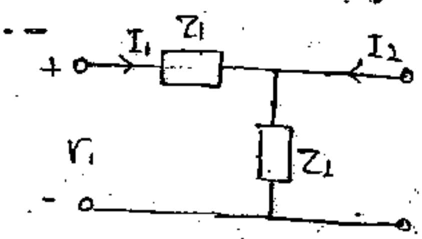
$$V_1 = AV_2 - BI_2$$

$$I_1 = CV_2 - DI_2$$

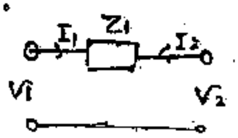
$$A = \left.\frac{V_1}{V_2}\right|_{I_2=0} \qquad \therefore \boxed{A = n}$$

$$D = \left.\frac{-I_1}{I_2}\right|_{V_2=0} \qquad \boxed{D = 1/n}$$

Q. Find the T- parameter of the given n/w



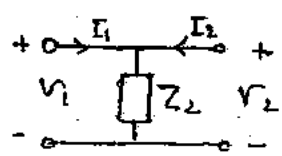
Soln



$$V_1 = -I_2 Z_1 + V_2$$

$$I_1 = -I_2$$

$$T_a = \begin{bmatrix} 1 & Z_1 \\ 0 & 1 \end{bmatrix}$$



$$V_1 = V_2$$

$$I_1 = \frac{V_2}{Z_2} - I_2$$

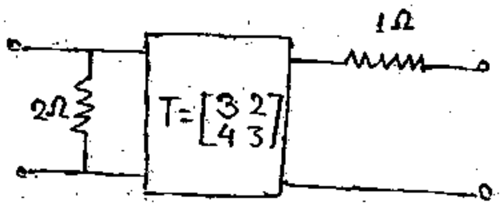
$$T_b = \begin{bmatrix} 1 & 0 \\ 1/Z_2 & 1 \end{bmatrix}$$

$[T] = [T_a][T_b]$

$$= \begin{bmatrix} 1 & Z_1 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 \\ 1/Z_2 & 1 \end{bmatrix}$$

$$[T] = \begin{bmatrix} 1+\frac{Z_1}{Z_2} & Z_1 \\ 1/Z_2 & 1 \end{bmatrix} \text{ Ans}$$

1.



Find over all T- parameter of the n/w

soln.

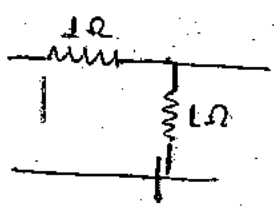
$$[T] = \begin{bmatrix} 1 & 0 \\ 1/2 & 1 \end{bmatrix} \begin{bmatrix} 3 & 2 \\ 4 & 3 \end{bmatrix} \begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 3 & 2 \\ 11/2 & 4 \end{bmatrix} \begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix}$$

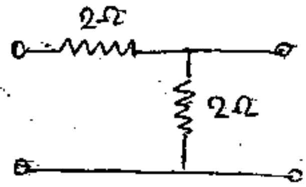
$$= \begin{bmatrix} 3 & 5 \\ 11/2 & 19/2 \end{bmatrix}$$

The T- parameter of n/w consisting of only impedences is ABCD. if all impedences of n/w is double then the new T- parameters are ____ ?

soln: let



$$T = \begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix} = \begin{bmatrix} \overset{A}{2} & \overset{B}{1} \\ \overset{C}{1} & \overset{D}{1} \end{bmatrix}$$

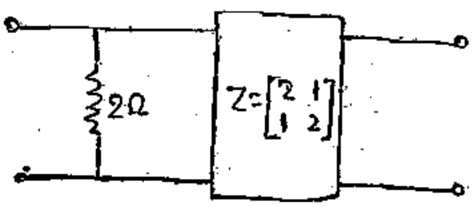


$$T = \begin{bmatrix} 1 & 2 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 \\ 1/2 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} \overset{A'}{2} & \overset{B'}{2} \\ 1/2^{\,C'} & \overset{D'}{1} \end{bmatrix}$$

$A = A'$ $\quad B' = 2B \quad C' = C/2 \quad D' = D$

Q.

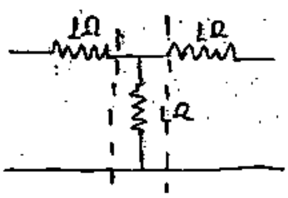


Find overall T m/w of the n/w

Soln:

$$T_a = \begin{bmatrix} 1 & \\ 1/2 & \end{bmatrix}$$

$$Z = \begin{bmatrix} 2 & 1 \\ 1 & 2 \end{bmatrix}$$



$$T_b = \begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix} \begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix}$$

$$T = \begin{bmatrix} 1 & 0 \\ 1/2 & 1 \end{bmatrix} \begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix} \begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix}$$

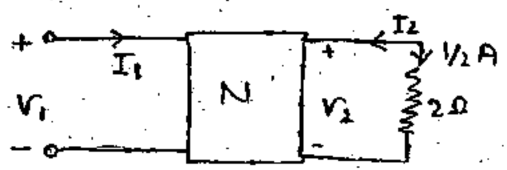
$$= \begin{bmatrix} 2 & 3 \\ 2 & 7/2 \end{bmatrix}$$

). A. Z- parameter of n/w a given as

$$[Z] = \begin{bmatrix} 4 & 2 \\ 3 & 1 \end{bmatrix}$$

if the port 2 of this n/w is terminated by 2Ω. It draws a current of 1/2 A from the n/w. then determine the i/p supply voltage at port 1.

Soln:



$V_1 = 4I_1 + 2I_2$

$V_2 = 3I_1 + I_2$

given

$$\boxed{\begin{aligned} V_2 &= \tfrac{1}{2} \times 2 = 1V \\ I_2 &= -\tfrac{1}{2}\,A \end{aligned}}$$

$1 = 3I_1 - \frac{1}{2}$

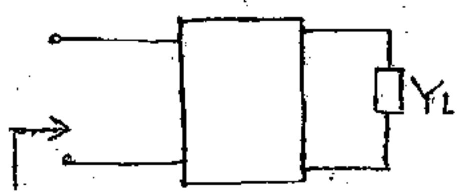
$3I_1 = \frac{3}{2}$

$I_1 = 1/2\,A$

$V_1 = 4 \times \frac{1}{2} + 2 \times -1/2$

$\boxed{V_1 = 1V}$ Ans

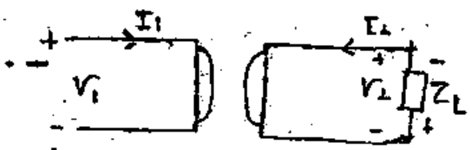
GYRATOR:-



$Z_{in} = a^2 Y_L$

$a \to \Omega$
↳ gyration Resistance

It is 4-terminal device or two port device. Dir^n of gyration is important as it is non reciprocal device. If load is capacitive then I/P impedence inductive. It is difficult to use in IC chips because it is bulky. So we can simullate this with gyrator. It is made up of OP-amp & RC elements.



$$\frac{V_1}{I_1} = Z_{in} = a^2 Y_L = \frac{a^2}{Z_L}$$

As $V_2 = -I_2 Z_L$

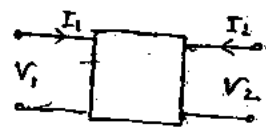
$$\frac{V_1}{I_1} = \frac{a^2}{-V_2/I_2}$$

$$\frac{V_1}{I_1} = -\frac{I_2 a^2}{V_2} = \frac{-a I_2}{V_2/a}$$

$$V_1 = -aI_2 \qquad \boxed{\begin{matrix} V_1 = -aI_2 \\ V_2 = aI_1 \end{matrix}}$$
$$I_1 = V_2/a$$

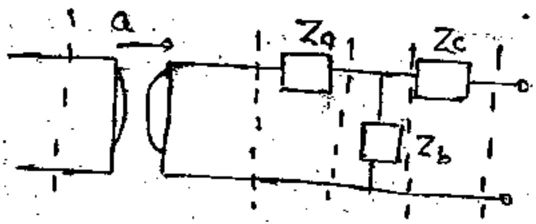
$$T = \begin{bmatrix} 0 & a \\ 1/a & 0 \end{bmatrix}$$

is passive and lossless.



$$V_1I_1 + V_2I_2 = -aI_2 \times \frac{V_2}{a} + V_2I_2$$
$$= 0 \quad \text{Passive \& lossless.}$$

Find overall T-parameter of n/w shown in figure.



$$T = \begin{bmatrix} 1 & Z_a \\ 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 \\ 1/Z_b & 1 \end{bmatrix} \begin{bmatrix} 1 & Z_c \\ 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 1 + Z_a/Z_b & Z_a \\ 1/Z_b & 1 \end{bmatrix} \begin{bmatrix} 1 & Z_c \\ 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} \frac{Z_a+Z_b}{Z_b} & \frac{Z_aZ_b + Z_bZ_c + Z_cZ_a}{Z_b} \\ 1/Z_b & \frac{Z_c+Z_b}{Z_b} \end{bmatrix}$$

$$T = \begin{bmatrix} 0 & a \\ 1/a & 0 \end{bmatrix}$$

$$\therefore \quad T = \begin{bmatrix} 0 & a \\ 1/a & 0 \end{bmatrix} \begin{bmatrix} \frac{Z_a+Z_b}{Z_b} & \frac{Z_aZ_b + Z_bZ_c + Z_cZ_a}{Z_b} \\ 1/Z_b & \frac{Z_c+Z_b}{Z_b} \end{bmatrix}$$

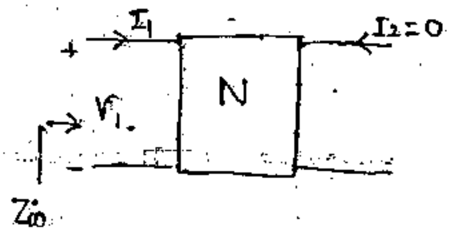
$$T = \begin{bmatrix} \frac{a}{Z_b} & \frac{a(Z_b+Z_c)}{Z_b} \\ \frac{Z_a+Z_b}{aZ_b} & \frac{Z_aZ_b+Z_bZ_c+Z_cZ_a}{aZ_b} \end{bmatrix}$$

Short circuit & open circuit in terms of ABCD parameter

$$V_1 = AV_2 - BI_2$$

$$I_1 = CV_2 - DI_2$$

1. Oc i/p impedence

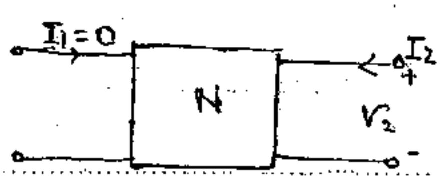


$$Z_{io} = \left.\frac{V_1}{I_1}\right|_{I_2=0}$$

$$= \left.\frac{AV_2 - BI_2}{CV_2 - DI_2}\right|_{I_2=0}$$

$$\boxed{Z_{io} = \frac{A}{C}}$$

2. oc O/P impedence



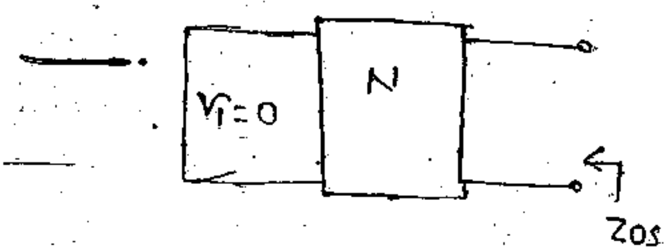
$$Z_{oo} = \left.\frac{V_2}{I_2}\right|_{I_1=0}$$

$$0 = CV_2 - DI_2$$

$$\frac{V_2}{I_2} = \frac{D}{C}$$

$$\boxed{Z_{oo} = \frac{D}{C}}$$

i) S.C O/P impedence :



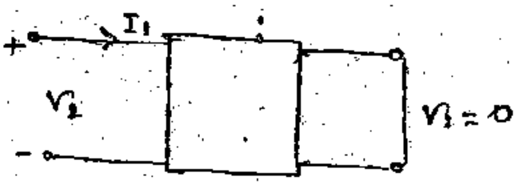
$$0 = AV_2 - BI_2$$

$$AV_2 = BI_2$$

$$\frac{V_2}{I_2} = \frac{B}{A}$$

$$\boxed{Z_{os} = \frac{B}{A}}$$

i) S.C I/P impedence :

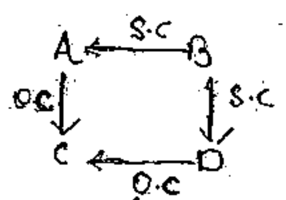


$$Z_{is} = \frac{V_1}{I_1}\Big|_{V_2=0}$$

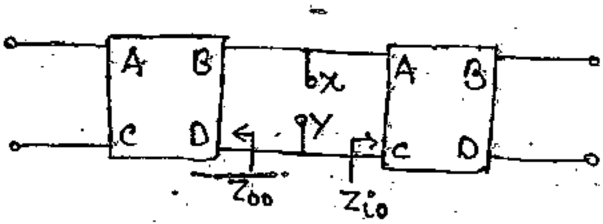
$$Z_{is} = \frac{AV_2 - BI_2}{CV_2 - DI_2}\Big|_{V_2=0}$$

$$\boxed{Z_{is} = \frac{B}{D}}$$

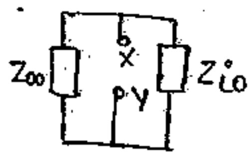
Short cuts



Q. Find the equivalent impedence b/w x & y



Soln:

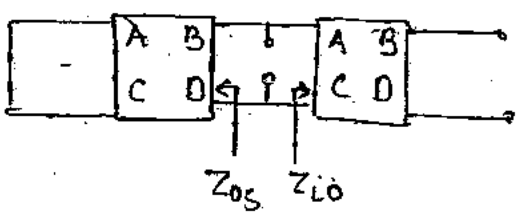


$$Z_{oo} = \frac{D}{C} \qquad Z_{io} = \frac{A}{C}$$

$$Z_{xy} = Z_{oo} \| Z_{io}$$

$$= \frac{AD}{C(A+D)}$$

Q. Find the equivalent impedence b/w x & y

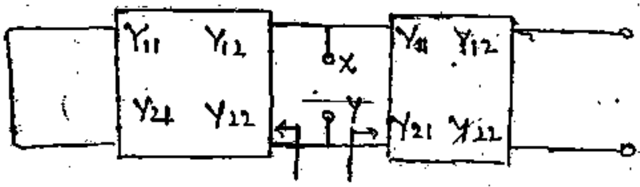


Soln:

$$Z_{os} = \frac{B}{A} \qquad Z_{io} = \frac{A}{C}$$

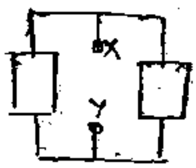
$$Z_{xy} = \frac{\frac{B}{A} \cdot \frac{A}{C}}{\frac{B}{A} + \frac{A}{C}} = \frac{BA}{BC + A^2}$$

Find the equivalent impedence with x & y.



Sol:

$Z_{22} = \frac{1}{Y_{22}}$

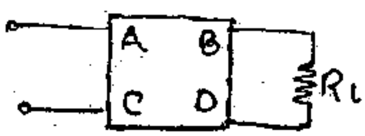


$Z_{11} = \frac{Y_{22}}{|Y|}$

$$Z_{xy} = \frac{\frac{1}{Y_{22}} \cdot \frac{Y_{22}}{|Y|}}{\frac{1}{Y_{22}} + \frac{Y_{22}}{|Y|}}$$

$$Z_{xy} = \frac{Y_{22}}{|Y| + Y_{22}^2}$$

Find the i/p impedence



Sol:

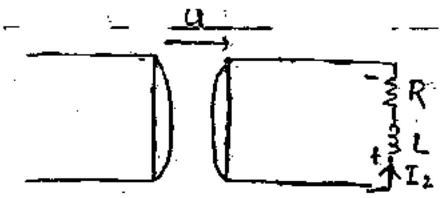
$$\frac{V_1}{I_1} = \frac{AV_2 - BI_2}{CV_2 - DI_2}$$

$V_2 = -I_2 R_L$ given

$$\frac{V_1}{I_1} = \frac{-AI_2 R_L - BI_2}{-CI_2 R_L - DI_2}$$

$$Z = \frac{AR_L + B}{CR_L + D}$$

Q



Find the ~~imp~~ i/p impedence.

Soln: $Z_{in} = a^2 Y_L$

$$= \frac{a^2}{R+LS}$$

2nd method

$$V_1 = -a I_2$$

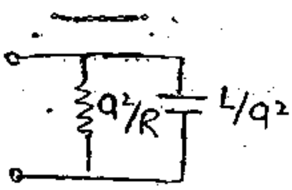
$$I_1 = V_2/a = -\frac{I_2 (R+SL)}{a}$$

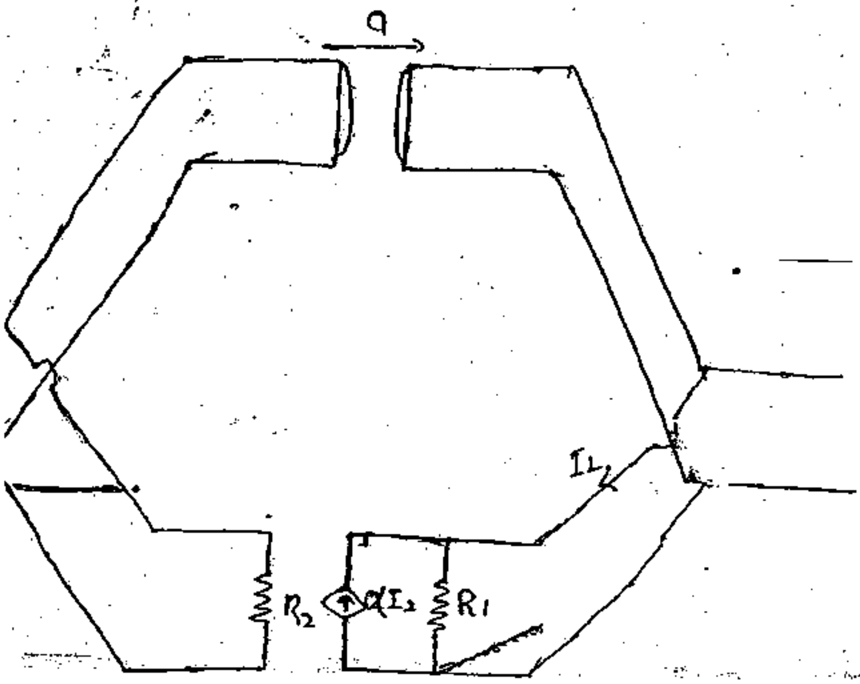
$$Z_{in} = \frac{V_1}{I_1} = \frac{-a \cancel{I_2}}{-\frac{\cancel{I_2}(R+SL)}{a}} = \frac{a^2}{R+SL}$$

$$Z_{in} = \frac{1}{\frac{R}{a^2} + \frac{SL}{a^2}} = \frac{1}{Y_{in}}$$

$$\therefore Y_{in} = \frac{R}{a^2} + \frac{SL}{a^2}$$

$$= G + SC$$



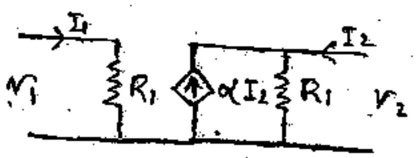


Find overall y-parameter?

Ans:-

$$V_1 = -aI_2 \Rightarrow I_2 = -\frac{V_1}{a}$$
$$V_2 = aI_1 \Rightarrow I_1 = \frac{V_2}{a}$$

$$Y_a = \begin{bmatrix} 0 & 1/a \\ -1/a & 0 \end{bmatrix}$$



$I_1 = \frac{V_1}{R_2}$ and $V_2 = (I_2 + \alpha I_2) R_1$

$$\therefore I_2 = \frac{V_2}{R_1(1+\alpha)}$$

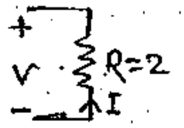
$$Y_b = \begin{bmatrix} 1/R_2 & 0 \\ 0 & \frac{1}{R_1(1+\alpha)} \end{bmatrix}$$

$$Y = Y_a + Y_b$$

$$= \begin{bmatrix} \frac{1}{R_2} & \frac{1}{a} \\ -1/a & \frac{1}{R_1(1+\alpha)} \end{bmatrix}$$

Chapter 1

4. $V = 4I - 9$



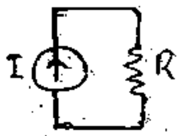
$V = -2I$

$-2I_1 = 4I - 9$

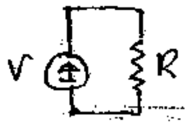
$6I_1 = 9$

$I_1 = 1.5$ (c)

7.



$18W = I^2R$



$4.5 = I^2/R$

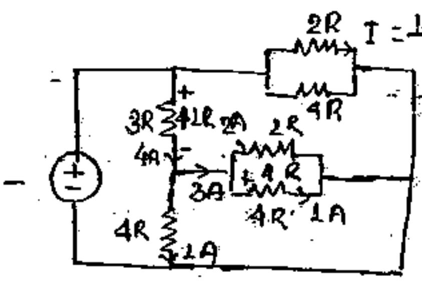
$I^4 = 18 \times 4.5 = 81$

$I = 3A$

$R = 2\Omega$

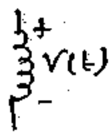
9.

$I = \frac{16R}{2R} = 8A$



Ans 8 A

14.



$V(t) = L\frac{di}{dt}$

$= L\frac{d}{dt}[e^{at} + e^{bt}]$

$= a e^{at} + b e^{bt}$

Q15. Ans (a).

Q16 Ans: $\frac{V_x - 4}{2} + \frac{V_x}{2} + \frac{V_x + 2}{2} = 0$

$$\frac{3V_x}{2} - 1 = 0$$

$$V_x = \frac{2}{3}$$

$$V_0 = -V_x$$

$$V_0 = -\frac{2}{3}V \text{ Ans.}$$

Q17 Ans 80W (Nodal Analysis)

Q20 Ans: P, V, f

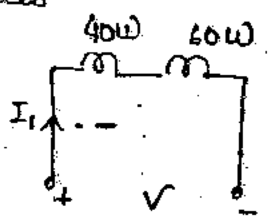
$$\uparrow P = \frac{V^2}{R\downarrow}$$

40W 60W :

$$R_{40W} < P_{60W}$$

$$R_{40} > R_{60}$$

(a) Series



$P_1 = I^2 R_{40}$

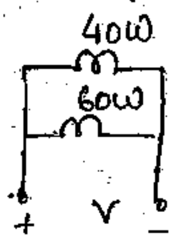
$P_2 = I^2 R_{60}$

As $R_{40} > R_{60}$

$$I^2 R_{40} > I^2 R_{60}$$

40W brighter.

Parallel



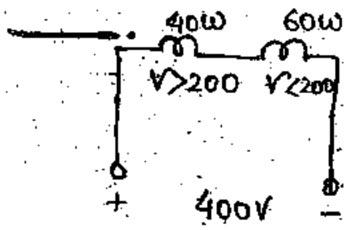
$P_1 = \frac{V^2}{R_{40}}$

$P_2 = \frac{V^2}{R_{60}}$

$P_{60} > P_{40}$

60W brighter

40W 200V 60W 200V



$R_{40W} > R_{60W}$

40W bulb distroy first.

SINUSOIDAL STEADY STATE ANALYSIS :

Sinusoidal → Sine

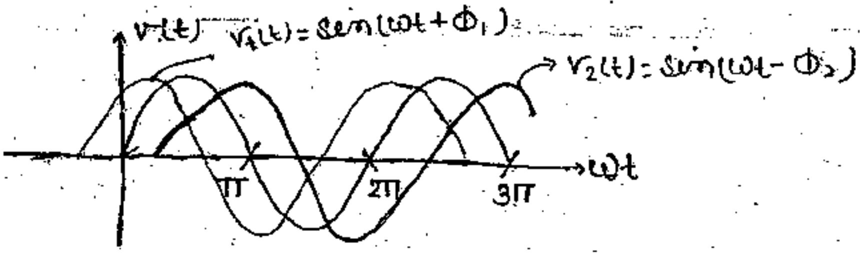
Sinusoidal → cosine

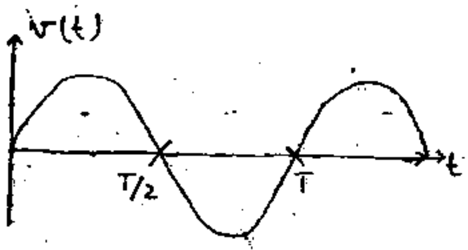
$v(t) = V_m \sin\omega t$

$V_m \rightarrow$ Max^m amplitude

$\omega \rightarrow$ Angular frequency (Rad/s)

$\omega t \rightarrow$ Argument





We compair phases of two sinusoidal

1. both $v_1(t)$ and $v_2(t)$ have same frequency
2. both $v_1(t)$ and $v_2(t)$ are expressed as either sine or cosine function.
3. Both $v_1(t)$ and $v_2(t)$ are written with +ve amplitude

$$v(t) = V_m \cos(\omega t + \theta)$$

$$= Re\{V_m e^{j(\omega t+\theta)}\}$$

$$= Re\{V_m e^{j\theta} \cdot e^{j\omega t}\}$$

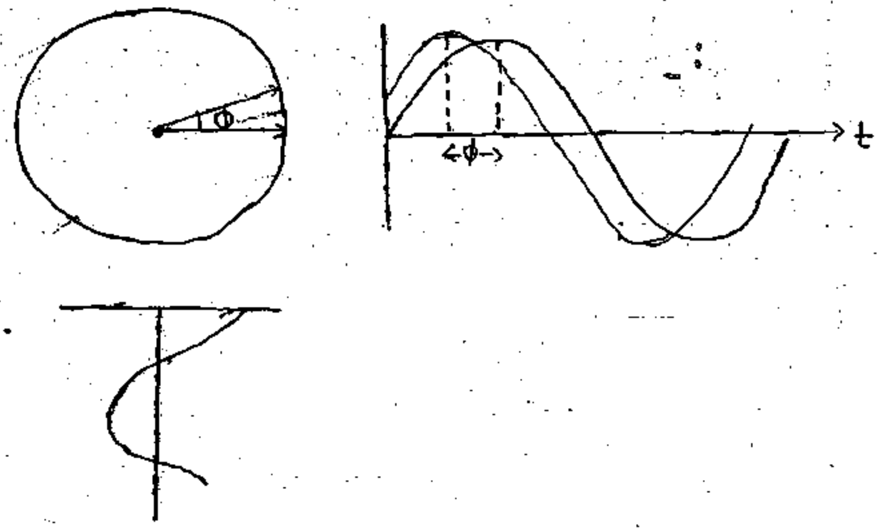
$$\boxed{V_m e^{j\theta} = V_m \angle\theta}$$

Hints: $e^{j\theta} = \cos\theta + j\sin\theta$

$$= \sqrt{\cos^2\theta + \sin^2\theta} \angle \tan^{-1}\frac{\sin\theta}{\cos\theta}$$

$$e^{j\theta} = 1\angle\theta$$

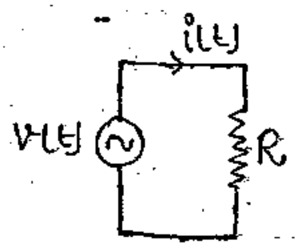
By supressing the time factor, we transform sinusoide from the time domain to the phasor domain. Thus the phasor transform sinusodial s/g from the time domain to the complex domain which is also called as frequency domain.



Difference b/w $v(t)$ & $\bar{V}$

- $v(t)$ is the instantanious or time domain representation while $\bar{V}$ is frequency or phasor domain ,,.
- $v(t)$ in time dependent while $\bar{V}$ is not
- $v(t)$ is genrally real while $\bar{V}$ is complex.

1. Resistor:



$$v(t) = V_m \sin \omega t$$

$$i(t) = \frac{V_m}{R} \sin \omega t$$

$$P_{av} = \frac{1}{T}\int_0^T v(t) \cdot i(t)\, dt$$

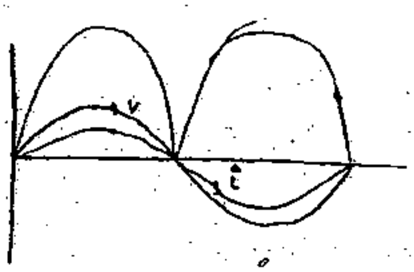
$$= \frac{1}{T}\int_0^T V_m \sin\omega t \cdot I_m \sin\omega t\, dt$$

$$= \frac{V_m I_m}{T}\int_0^T \sin^2 \omega t\, dt$$

$$= \frac{V_m I_m}{2T}\int_0^T (1 - \cos 2\omega t)\, dt$$

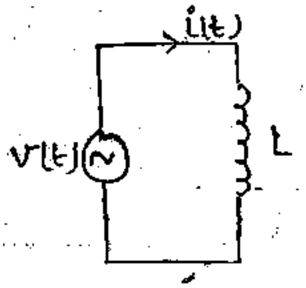
$$P_{av} = \frac{V_m I_m}{2} = \frac{V_m}{\sqrt{2}} \cdot \frac{I_m}{\sqrt{2}} = V_{rms} \cdot I_{rms}$$

$$\boxed{P_{av} = V_{rms} \cdot I_{rms}}$$



$$\boxed{\begin{array}{l} f_{vi} = \omega \\ f_p = 2\omega \end{array}}$$

INDUCTOR:



$i(t) = I_m \sin \omega t$

$v(t) = L\frac{di}{dt}$

$= L \frac{d}{dt}(I_m \sin \omega t)$

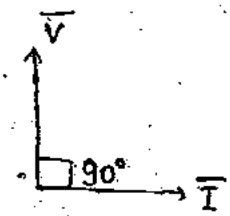
$= L I_m \omega \cos \omega t$

$= L\omega I_m \sin(\omega t + \pi/2)$

$= L\omega I_m \sin \omega t \cdot j$

$\therefore v(t) = j\omega L I_m \sin \omega t$

$v(t) = j X_L I_m \sin \omega t$



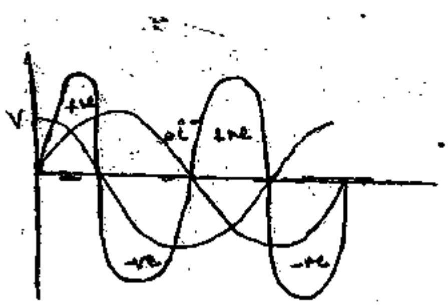
X_L = Inductive reactance

$X_L = \omega L$

$P_{av} = \frac{1}{T}\int_0^T v(t)\, i(t)\, dt \qquad = \frac{1}{T}\int_0^T V_m \cos \omega t \cdot I_m \sin \omega t \, dt$

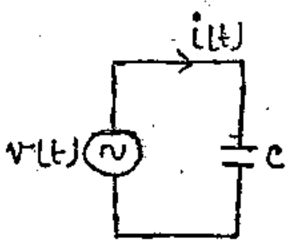
$= \frac{V_m I_m}{T}\int_0^T \sin 2\omega t \, dt$

$\boxed{P_{av} = 0}$



$\boxed{f_p = 2 f_{v/i}}$

3. CAPACITOR :



$v(t) = V_m \sin\omega t$

$$i = C\frac{dv}{dt}$$

$$= C\frac{d}{dt}(V_m \sin\omega t)$$

$$= C V_m \omega \cos\omega t$$

$$= C V_m \omega \sin(\omega t + 90^\circ)$$

$$= j\omega C V_m \sin\omega t$$

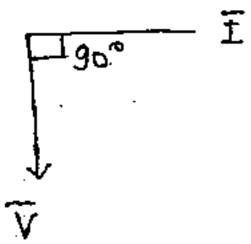
$$i = j\frac{1}{1/\omega C} V_m \sin\omega t$$

$$i = j\frac{V_m}{X_c}\sin\omega t$$

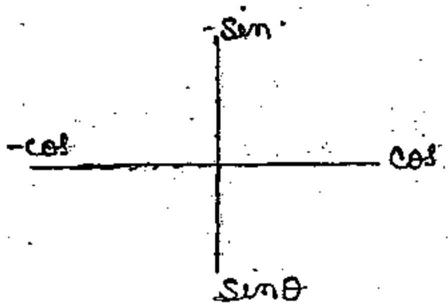
where $\frac{1}{\omega C} = X_c$ → capacitive reactance

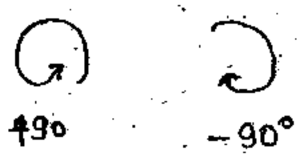
$\boxed{P_{av} = 0}$

$\boxed{f_p = 2 f_{v/i}}$

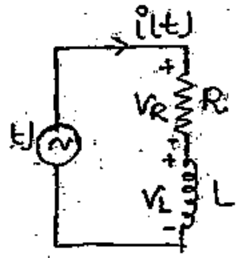


Hint: trigometric conversion





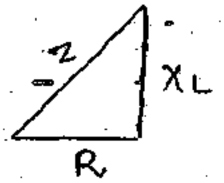
Series R-L circuit:

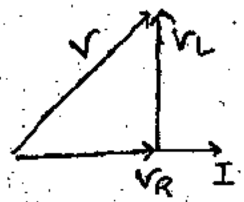


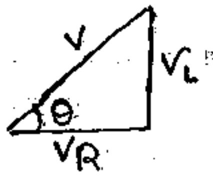
$$\bar{V} = \bar{V}_R + \bar{V}_L$$

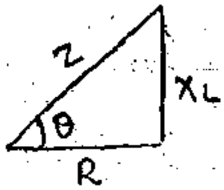
$$\bar{I}Z = \bar{I}R + \bar{I}(jX_L)$$

$$Z = R + jX_L$$









$$V = \sqrt{V_R^2 + V_L^2}$$

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

$$\theta = \tan^{-1}\frac{V_L}{V_R}$$

$$\theta = \tan^{-1}\frac{X_L}{R}$$

$$S = \sqrt{P_{av}^2 + Q_L^2}$$

$$\theta = \tan^{-1}\frac{Q_L}{P_{av}}$$

$$P_{av} = \frac{1}{T}\int_0^T v(t)\, i(t)\, dt$$

$$= \frac{1}{T}\int_0^T V_m \sin(\omega t + \theta) \cdot I_m \sin\omega t\, dt$$

$$= \frac{V_m I_m \cos\theta}{2} = \frac{V_m}{\sqrt{2}} \cdot \frac{I_m}{\sqrt{2}} \cos\theta = V_{rms} \cdot I_{rms} \cos\theta$$

$$\boxed{P_{av} = V_{rms} \cdot I_{rms} \cdot \cos\theta}$$

POWER FACTOR:

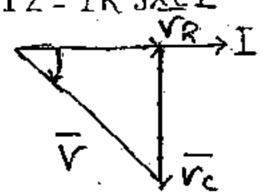
- Power factor indicates position of current phasor w.r.t voltage phasor.
- By defining P.F, voltage is always taken as reference phasor, because real time system load connected in ||.
- It tell us how much apperant power is utilized
- If P.F is high then active power delivered to the load is high.

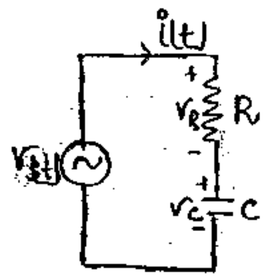
$\cos\theta = \frac{V_R}{V}$ (lagging) ; $\cos\theta = \frac{R}{Z}$ (lagging) ; $\cos\theta = \frac{P}{S}$ (lagging)

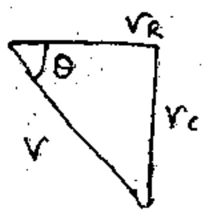
Series RC circuit:-

$\bar{V} = \bar{V}_R + \bar{V}_C$

$IZ = IR - jX_C I$



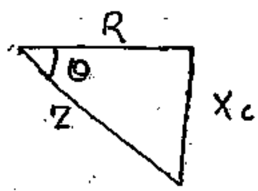




$V = \sqrt{V_R^2 + V_C^2}$

$\tan\theta = -\frac{V_C}{V_R}$

$\cos\theta = \frac{V_R}{V}$ (leading)

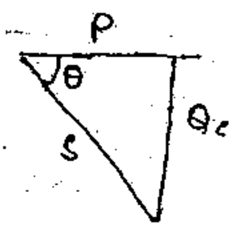


$Z = R - jX_C$

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

$\tan\theta = -\frac{X_C}{R}$

$\cos\theta = \frac{R}{Z}$ (leading)

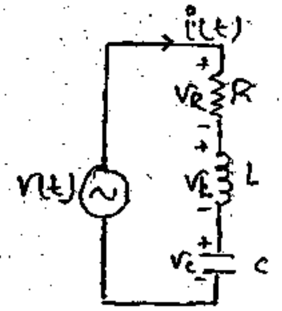


$S = \sqrt{P^2 + Q_C^2}$

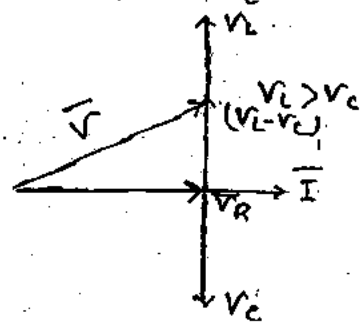
$\tan\theta = -\frac{Q_C}{P}$

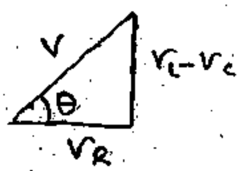
$\cos\theta = \frac{P}{S}$ (leading)

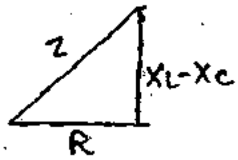
Series RLC circuit :-

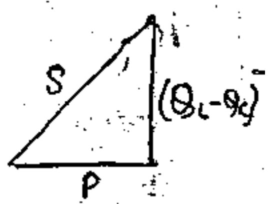


$$V = \overline{V_R} + \overline{V_L} + \overline{V_C}$$







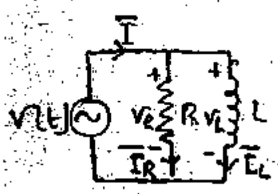


$$V = \sqrt{V_R^2 + (V_L - V_C)^2} \qquad Z = \sqrt{R^2 + (X_L - X_C)^2} \qquad S = \sqrt{P^2 + (Q_L - Q_C)^2}$$

$$\tan\theta = \frac{V_L - V_C}{V_R} \qquad \tan\theta = \frac{X_L - X_C}{R} \qquad \tan\theta = \frac{Q_L - Q_C}{R}$$

$$\cos\theta = \frac{V_R}{V} \text{ (lagging)} \qquad \cos\theta = \frac{R}{Z} \text{ (lagging)} \qquad \cos\theta = \frac{P}{S} \text{ (lagging)}$$

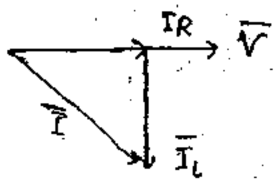
|| RL circuit :



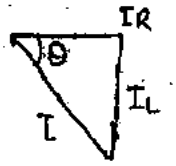
$$\overline{I} = \overline{I_R} + \overline{I_L}$$

$$\frac{V}{Z} = \frac{V}{R} + \frac{V}{jX_L}$$

$$\frac{1}{Z} = \frac{1}{R} - \frac{j}{X_L}$$



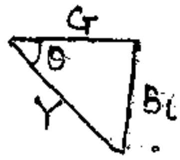
$$\boxed{Y = G - jB_L}$$



$I = \sqrt{I_R^2 + I_L^2}$

$\tan\theta = -\dfrac{I_L}{I_R}$

$\cos\theta = \dfrac{I_R}{I}$ (lagging)



$Y = \sqrt{G^2 + B_L^2}$

$\tan\theta = \dfrac{B_L}{G}$

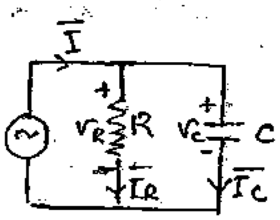
$\cos\theta = \dfrac{G}{Y}$ (lagging)

$S = \sqrt{P^2 + Q_L^2}$

$\tan\theta = \dfrac{Q_L}{P}$

$\cos\theta = \dfrac{P}{S}$ (lagging)

II RC circuit:

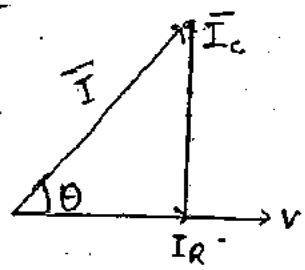


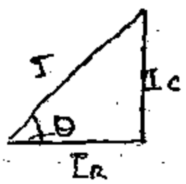
$\bar{I} = \bar{I}_R + \bar{I}_C$

$\dfrac{V}{Z} = \dfrac{V}{R} + \dfrac{V}{-jX_C}$

$\dfrac{1}{Z} = \dfrac{1}{R} + j\dfrac{1}{X_C}$

$\boxed{Y = G + jB_C}$

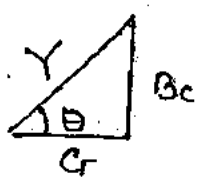




$I = \sqrt{I_R^2 + I_C^2}$

$\tan\theta = \dfrac{I_C}{I_R}$

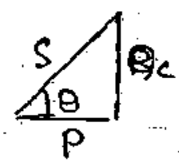
$\cos\theta = \dfrac{I_R}{I}$ (leading)



$Y = \sqrt{G^2 + B_C^2}$

$\tan\theta = \dfrac{B_C}{G}$

$\cos\theta = \dfrac{G}{Y}$ (leading)

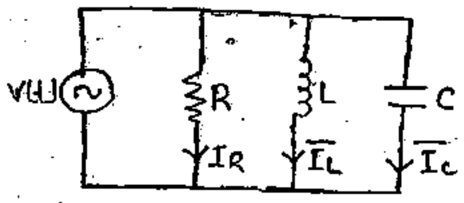


$S = \sqrt{P^2 + Q_C^2}$

$\tan\theta = \dfrac{Q_C}{P}$

$\cos\theta = \dfrac{P}{S}$ (leading)

arallel R-L-C circuit:

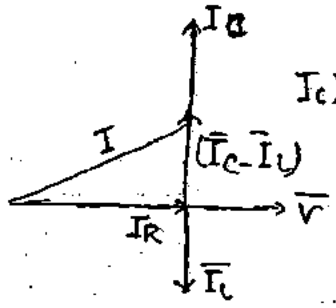


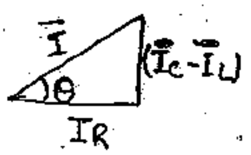
$$\bar{I} = \bar{I}_R + \bar{I}_L + \bar{I}_c$$

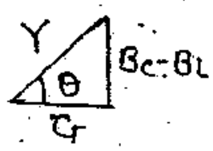
$$\frac{V}{Z} = \frac{V}{R} + \frac{V}{jX_L} + \frac{V}{-jX_c}$$

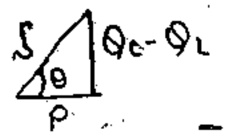
$$\frac{1}{Z} = \frac{1}{R} - \frac{j}{X_L} + \frac{j}{X_c}$$

$$\boxed{Y = G + j(B_c - B_L)}$$









$$I = \sqrt{I_R^2 + (I_c - I_L)^2}$$

$$\tan\theta = \frac{I_c - I_L}{I_R}$$

$$\cos\theta = \frac{I_R}{I}$$

$$Y = \sqrt{G^2 + (B_c - B_L)^2}$$

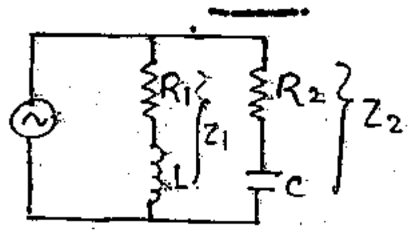
$$\tan\theta = \frac{B_c - B_L}{G}$$

$$\cos\theta = \frac{G}{|Y|}$$

$$S = \sqrt{P^2 + (Q_c - Q_L)^2}$$

$$\tan\theta = \frac{Q_c - Q_L}{P}$$

$$\cos\theta = \frac{P}{S}$$



$$Z_1 = R_1 + jX_L$$

$$Y_1 = \frac{1}{R_1 + jX_L} \times \frac{R_1 - jX_L}{R_1 - jX_L}$$

$$= \frac{R_1 - jX_L}{R_1^2 + X_L^2}$$

$$Y_1 = \frac{R_1}{R_1^2 + X_L^2} - j\frac{X_L}{R_1^2 + X_L^2}$$

$$Y_1 = G_1 - jB_L$$

Similarly

$$Z_2 = R_2 - jX_C$$

$$Y_2 = \frac{1}{R_2 - jX_C} \times \frac{R_2 + jX_C}{R_2 + jX_C}$$

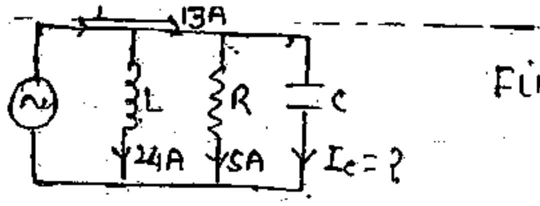
$$= \frac{R_2 + jX_C}{R_2^2 + X_C^2} = \frac{R_2}{R_2^2 + X_C^2} + j\frac{X_C}{R_2^2 + X_C^2}$$

$$Y_2 = G_2 + jB_C$$

Total admittance of n/w

$$Y = Y_1 + Y_2$$

$$= (G_1 + G_2) + j(B_C - B_L)$$

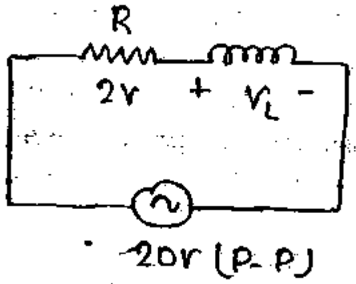


Find I and I_c?

In: $13 = \sqrt{5^2 + I_c^2}$

$\therefore I_c = \sqrt{13^2 - 5^2} = 12A$

$I = \sqrt{5^2 + (12-24)^2} = 13A$



Find the voltage across inductor?

Soln: $V = \sqrt{V_R^2 + V_L^2}$

$V_L = \sqrt{V^2 - V_R^2}$

$= \cancel{\sqrt{20^2 - 2^2}} = \cancel{\sqrt{196}} = \cancel{14V}$

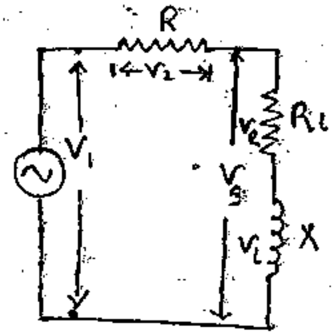
$2V_m = 20V$

$V_m = 10V$

$V_{rms} = \frac{10}{\sqrt{2}}$

$V_L = \sqrt{\left(\frac{10}{\sqrt{2}}\right)^2 - 2^2} = \sqrt{50-4} = \sqrt{46}$ volts workbook Page 20:

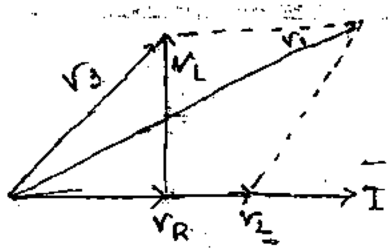
47 Q.



(a) $V_1 = 220V$ $\quad V_2 = 112V$ $\quad V_3 = 136V$

$Z = R_L + jX_L$

$\bar{V_1} = \bar{V_2} + \bar{V_3}$



$V_1 = \sqrt{V_2^2 + V_3^2 + 2V_2V_3\cos\phi}$

$(220)^2 = (122)^2 + (136)^2 + 2(122)(136)\cos\phi$

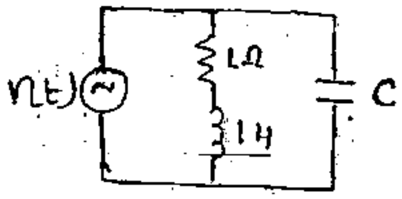
$\cos\phi = 0.45$

(b) $\cos\phi = \dfrac{V_R}{V_3}$

$V_R = 0.45 \times 136V = 61.2V$

$P = \dfrac{V_R^2}{R_L} = \dfrac{(61.2)^2}{5} = 750\,W$

9. Find the value of 'c' when p.f ~~of the circuit~~ 0.8 lagging :-



$v(t) = \sin t$

Soln: $Y_1 = G_1 - jB_L$

$G_1 = \frac{R_1}{R_1^2 + X_L^2}$

$X_L = \omega L = 1 \times 1 = 1$

$G_1 = \frac{1}{1+1} = \frac{1}{2}$

$B_L = \frac{1}{1+1} = \frac{1}{2}$

$Y_1 = \frac{1}{2} - j\frac{1}{2}$

$Y_2 = jB_C = jC$

$Y = Y_1 + Y_2$

$= \frac{1}{2} + j\left(C - \frac{1}{2}\right)$

$\cos\phi = \frac{G}{|Y|}$

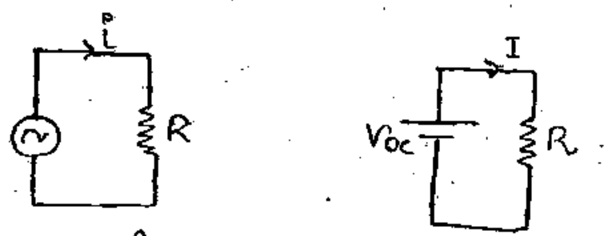
$0.8 = \frac{1/2}{\sqrt{\frac{1}{4} + (C - 1/2)^2}}$

$C = \frac{1}{8}, \frac{7}{8}$

$C = \frac{1}{8}$ F lagging.

— RMS value: RMS value is defined based on heating effect of the waveform..

- The voltage at which heat dissipation in a.c crt is equal to heat dissipated in D.C crt. is called as RMS value provided both a.c & D.C have equal value of R and operated for same time



$W_{ac} = i^2 R t$ $\qquad$ $W_{D.C} = I^2 R t$

$$V_{RMS} = \sqrt{\frac{1}{T}\int_0^T v^2 dt} = \sqrt{\frac{1}{2\pi}\int_0^{2\pi} v^2 d\omega t}$$

AVERAGE VALUE :-

- It is based on the charge transfer in ckt
- The voltage at which charge transfer in a.c crt is equal to charge transfer in D.C crt is called average value provided both a.c & D.C have same value of R and operated for same time.

Symmetric

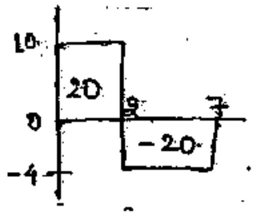
$V_{av} = \frac{1}{T/2}\int_0^{T/2} v\,dt$ Half cycle

$= 0 \longrightarrow$ Full cycle

nsymmetric

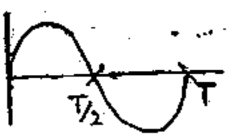
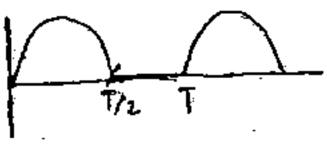
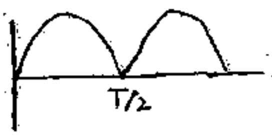
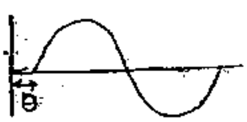
$$V_{av} = \frac{1}{T}\int_0^T v\,dt$$

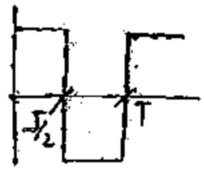
* $|A_1| = |A_2|$ ~~then the~~ waveform is symmetric *



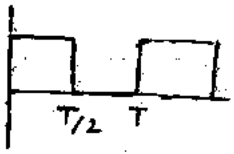
m Factor:
is the ratio of r.m.s value of waveform ~~to the~~
erage value of wave form.

ak factor:
is the ratio of max^m value of waveform to the r.m.s
lue of waveform.

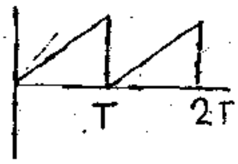
	RMS	Average value
	$\frac{V_m}{\sqrt{2}}$	$\frac{2V_m}{\pi}$
	$\frac{V_m}{2}$	$\frac{V_m}{\pi}$
	$\frac{V_m}{\sqrt{2}}$	$\frac{2V_m}{\pi}$
	$\frac{V_m}{\sqrt{2}}$	$\frac{2V_m}{\pi}$

5) 

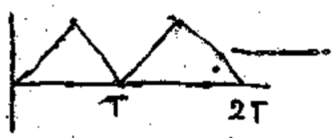
V_m $\quad$ V_m

6) 

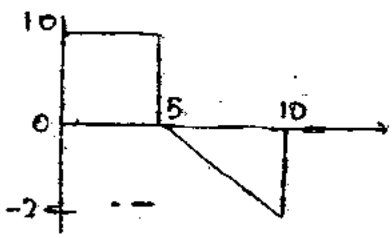
$\frac{V_m}{\sqrt{2}}$ $\quad$ $\frac{V_m}{2}$

7) 

$\frac{V_m}{\sqrt{3}}$ $\quad$ $\frac{V_m}{2}$

8) 

$\frac{V_m}{\sqrt{3}}$ $\quad$ $\frac{V_m}{2}$

Q. 

Find average value & RMS value.

Soln: $v(t) = 10 \qquad 0 \le t \le 5$

$y = mx + c$

$v(t) = -\frac{2}{5} t + c$

At $t = 5$ $v(t) = 0$

$0 = -\frac{2}{5} \times 5 + c$

$c = 2$

$v(t) = -\frac{2}{5} t + 2$

$$V_{rms} = \sqrt{\frac{1}{10}\left[\int_0^5 10^2 dt + \int_5^{10}\left(-\frac{2}{5}t+2\right)^2 dt\right.} = 7.118$$

$$V_{av} = \frac{1}{T}\int_0^T v\,dt = \frac{1}{10}\left[\int_0^5 10\,dt + \int_5^{10}\left(-\frac{2}{5}t+2\right)dt\right] = 4.5 \text{ Ans}$$

$v(t) = V_0 + V_1 \sin\omega t + V_2 \sin 2\omega t$ (for diff^n frequency)

$V_{av} = V_0$

$V_{rms} = \sqrt{V_0^2 + V_{rms_2}^2 + \cdots + V_{rms_n}^2}$

$= \sqrt{V_0^2 + \left(\frac{V_1}{\sqrt{2}}\right)^2 + \left(\frac{V_3}{\sqrt{2}}\right)^2}$

$v(t) = V_0 + V_1 \sin(\omega t + \phi_1) + V_3 \sin(\omega t - \phi_2)$ (For same frequency)

$\quad\quad\quad\quad \downarrow \quad\quad\quad\quad\quad \downarrow$

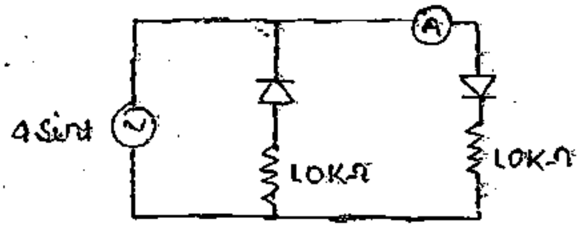
$\quad\quad\quad V_1\angle\phi_1 \quad\quad\quad V_3\angle\phi_2$

$v(t) = V_0 + (V_1\angle\phi_1 + V_2\angle -\phi_2)$

$= V_0 + V\angle\phi = V_0 + V\sin(\omega t + \phi)$

$V_{rms} = \sqrt{V_0^2 + \left(\frac{V}{\sqrt{2}}\right)^2}$

* $P_{av} = \frac{V_{RMS}^2}{R}$
* $P_{DC} = I_{av}^2 R$
* $P_{ac} = I_{rms}^2 R$



The given ckt having ideal diodes and arameter which reads the average value. Find reading of the ammeter.

Soln: $i = \frac{v(t)}{10K} = \frac{4\sin t}{10K} = 0.4 \sin t \, mA$

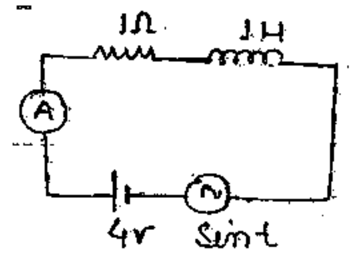
$I_{av} = \frac{0.4}{\pi} \, mA$

Q. Find the power of an element, if the voltage across it
$v(t) = 100\sin\omega t + 40\cos(3\omega t - 30^\circ) + 5\sin(5\omega t + 45^\circ)$
and current through it, $I(t) = 8\sin(\omega t + 10) + 6\sin(3\omega t + 40^\circ)$
$+ 2\cos(5\omega t - 120^\circ)$

Soln: $v(t) = 100\sin\omega t + 40\sin(3\omega t + 60^\circ) + 5\sin(5\omega t + 45^\circ)$
$I(t) = 8\sin(\omega t + 10) + 6\sin(3\omega t + 40^\circ) + 2\sin(5\omega t - 30^\circ)$

$P_{av} = \frac{100}{\sqrt{2}} \times \frac{8}{\sqrt{2}} \cos 10^\circ + \frac{40}{\sqrt{2}} \times \frac{6}{\sqrt{2}} \cos 20^\circ + \frac{5}{\sqrt{2}} \times \frac{2}{\sqrt{2}} \cos 75^\circ$

$= 507.99 W$

Q. 

Find the reading of Ammeter and power factor of ckt.

Soln: Case I : 4V

As DC L→S.C

$I_{DC} = \frac{4}{1} = 4A$

Case 2 : Sint

$Z = R + j\omega L$
$= 1 + j1$

$$I_{ac} = \frac{\frac{1}{\sqrt{2}}}{\sqrt{2}} = \frac{1}{2}\,A$$

$$I_{rms} = \sqrt{I_{Rms1}^2 + I_{rms2}^2}$$ (Current through Ammeter)

$$= \sqrt{4^2 + (1/2)^2} = \sqrt{16.25}\,A$$

$$\cos\phi = \frac{P}{S} = \frac{I^2 R}{VI} = \frac{I_{rms}\cdot R}{V_{rms}}$$

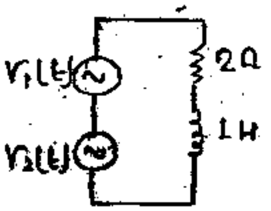
$$V_{rms} = \sqrt{4^2 + \left(\frac{1}{\sqrt{2}}\right)^2}$$

$$= \sqrt{16.5}\,V$$

$$\cos\phi = \frac{\sqrt{16.25}\cdot 1}{\sqrt{16.5}}$$

$$\cos\phi = 0.9923$$

$$\phi = 7.07^\circ$$



$v_1(t) = 10\sin 4t$

$v_2(t) = 20\sin 2t$

Find average power in the ckt.

Case I $v(t) = 10\sin 4t$

$$Z = R + j\omega L$$
$$= 2 + j4$$

$$i_1 = \frac{10\sin 4t}{4.47\angle 63.43^\circ} = \frac{10\angle 0}{4.47\angle 63.43^\circ} = 2.23\sin(\omega t - 63.43^\circ)$$

case 2: $v_2(t) = 20\sin 2t$

$Z = 2 + j2$

$= 2\sqrt{2} \angle 45^\circ$

$i_2(t) = \dfrac{20\angle 0^\circ}{2\sqrt{2}\angle 45^\circ}$

$= 7.07\angle -45^\circ$

$i_2(t) = 7.07 \sin(\omega t - 45^\circ)$

$P = \dfrac{10}{\sqrt{2}} \times \dfrac{2.23}{\sqrt{2}} \cos 63.43^\circ + \dfrac{20}{\sqrt{2}} \times \dfrac{7.07}{\sqrt{2}} \cos 45^\circ$

$= 55W$ Ans

Complex power:

$S = VI^*$

$S = |S| \angle \theta$

$\downarrow$

Apperant power

Q. ~~v(t) = 60~~ The voltage across load is $v(t) = 60\cos(\omega t - 10^\circ)$ and the current in the dirn of voltage drop $i(t) = 1.5\cos(\omega t + 50^\circ)$. Find complex and apperent power and real & reactive power?

Soln: $V(t) = 60\angle -10^\circ$, $I(t) = 1.5\angle 50^\circ$

$S = \dfrac{60}{\sqrt{2}}\angle -10 \times \dfrac{1.5}{\sqrt{2}}\angle -50^\circ$

$= 45\angle -60^\circ$

$|S| = 45$ VA

$S = 45\angle -60^\circ$

$= 22.5 - j38.97^\circ$

$S = P + jQ$

$P = 22.5\ W$

$Q = -38.97\ VAR$

THEOROMS:

Superpossition theoroms:

$V = IR$

$V_1 = I_1 R$

$V_2 = I_2 R$

$V' = (I_1 + I_2) R$
$= I_1 R + I_2 R$
$= V_1 + V_2$

(Principal of Additive)

$V'' = (\alpha I) R$
$= \alpha V$

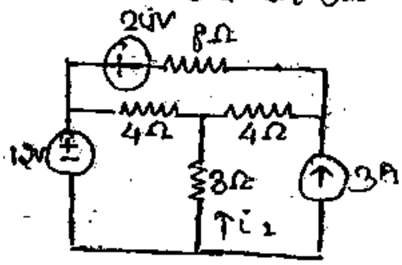
In linear bilateral n/w containing more than one independent voltage & current source, The response in any element is the sum of response obtained with one source acting at a time and other source being deactivated.

Deactivation means all independent sources is replace by their internal resistance. voltage source by S.C and current source replace by O.C.

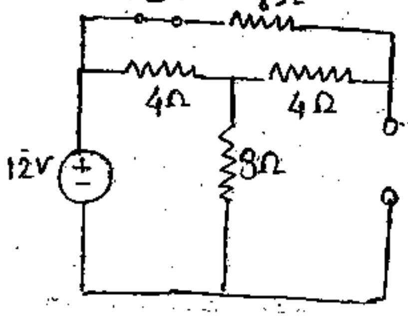
N.B Dependent source is as remain as it is

- Superposition ~~theorom~~ theorom not applicable for power calculation.

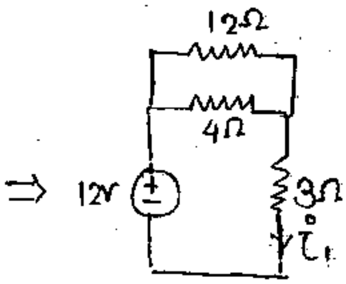
Q. Find the current in 3Ω resistor?



Soln: - Case 1: 12 V

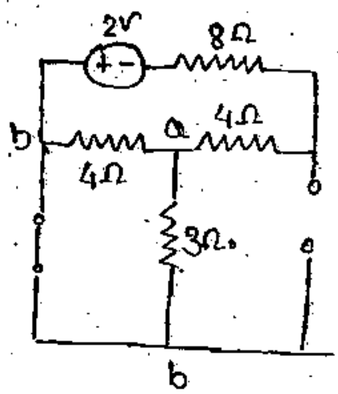


⇒

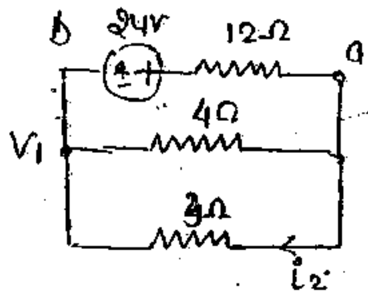


$$i_1 = \frac{12}{6} = 2A$$

Case 2: 24 V



⇒



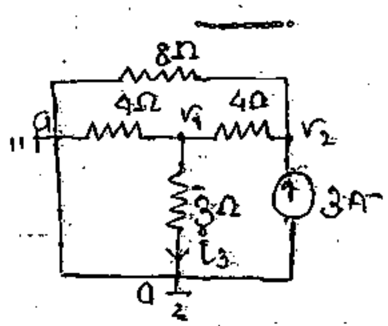
$$\frac{V_1 - 24}{12} + \frac{V_1}{4} + \frac{V_1}{3} = 0$$

$$V_1 = 3V$$

$$i_2 = \frac{0 - V_1}{3} = \frac{0-3}{3} = -1A$$

N.B. when ever find current in the ckt always prefer super position-theorem.

case 3 3A



NOTE: Point a is equipotential take the both point as reference.

$$\frac{V_1}{4}+\frac{V_1}{3}+\frac{V_1-V_2}{4}=0$$

$$V_1\left[\frac{10}{12}\right]=\frac{V_2}{4}$$

$$V_2=\frac{10}{3}V_1 \quad \text{--- (1)}$$

$$\frac{V_2}{8}+\frac{V_2-V_1}{4}=3$$

$$V_2+2V_2-2V_1=24$$

$$3\left[\frac{10}{3}V_1\right]-2V_1=24$$

$$V_1=3V$$

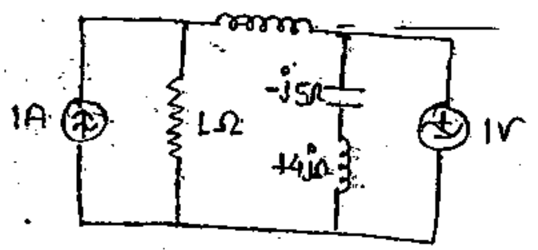
$$i_3=\frac{3}{3}=1\,A$$

By using superposition theorom

$$i=i_1+i_2+i_3$$
$$=2-1+1=2A \quad \text{Ans}$$

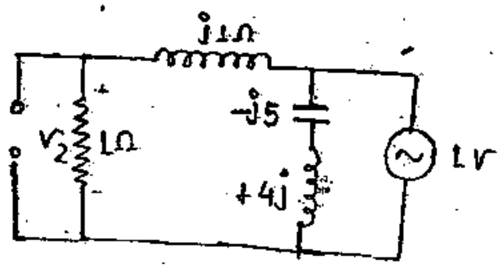
N.B. For incoming current take -ve sign.
For outgoing current take +ve sign.

1.



calculate voltage drop across 1Ω resistor ..

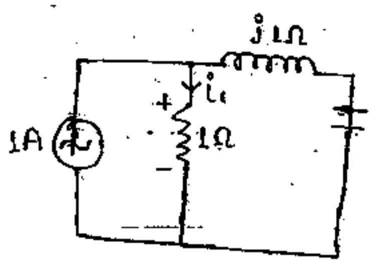
Ans: case 1V



$$V_2 = \frac{1}{1+j} \times 1$$

$$V_2 = \frac{1}{1+j} \text{ volts}$$

Case: 1A



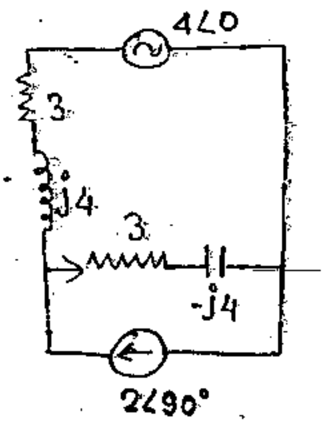
$$i_1 = \frac{1 \times j}{1+j}$$

$$V_1 = \frac{j}{1+j} \times 1 = \frac{j}{1+j} \text{ volts}$$

$$V = V_1 + V_2$$

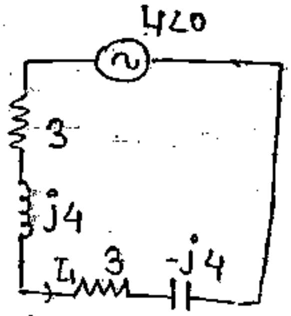
$$= \frac{1+j}{1+j} = 1 \text{ volts}$$

Q.



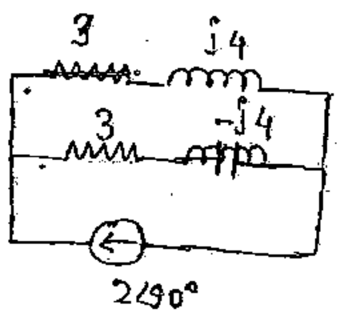
Determine using superposition theorem.

Soln: Case I $4\angle 0$



$$I_1 = \frac{4\angle 0}{6 + j(4-4)} = \frac{4}{6}\angle 0 = \frac{2}{3} \text{ A}$$

Case $2\angle 90°$



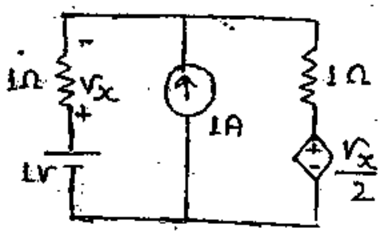
$$I_2 = 2\angle 90° \cdot \frac{3+4j}{3+j4+3-j4}$$

$$= \frac{-4+j3}{3}$$

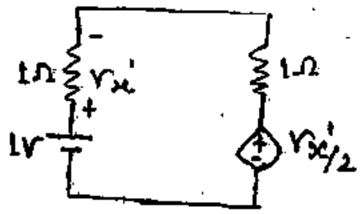
$$I = I_1 + I_2$$

$$= \frac{2}{3} - \frac{4}{3} + j$$

$$= -\frac{2}{3} + j \text{ A}$$



Case I : 1 V



$$-1 + I \times 1 + I \times 1 + \frac{V_x'}{2} = 0$$

$$-1 + I + I \times 1 + \frac{V_x'}{2} = 0$$

$$2I = 1 - \frac{V_x'}{2}$$

$$2I = 1 - \frac{V_x'}{2}$$

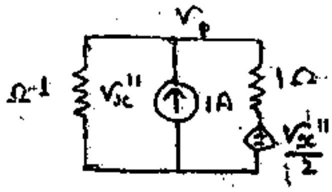
$$V_x' = I$$

$$2V_x' = 1 - \frac{V_x'}{2}$$

$$4V_x' = 2 - V_x'$$

$$V_x' = \frac{2}{5} \text{ V}$$

Case II : 1 A

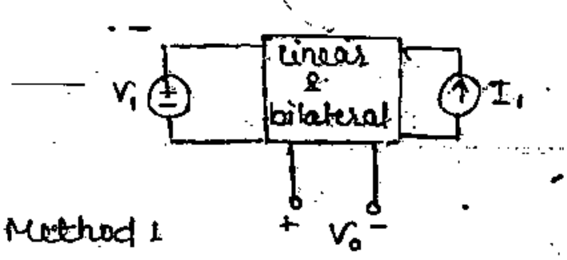


$$\frac{V_1}{1} + \frac{V_1 - V_x''/2}{1} = 0$$

$$2V_1 - \frac{V_x''}{2} = 0$$

Ex: $V_1 = 5V$ $\quad I_1 = 0A$ $\quad$ ~~$V_0 = 3V$~~

$V_1 = 0$ $\quad I_1 = 2A$ $\quad V_0 = 6V$



Find the O/P voltage when $V_1 = 10V$ and $I_1 = 8A$

Method 1

Soln:

(1) $V_1 = 5V \quad V_0 = 3V$

$\downarrow (2) \quad \downarrow (2)$

$V_1 = 10 \quad V_{01} = 6V$

(2) $I_1 = 2A \quad V_0 = 6V$

$\downarrow (4) \quad \downarrow (4)$

$I_1 = 8A \quad ; V_{02} = 24V$

$V_0 = V_{01} + V_{02}$

$= 6 + 24 = 30V$

Method 2:

$V_0 = \alpha V_1 + \beta I_1$

$3 = 5\alpha + \beta(0)$

$\alpha = \frac{3}{5}$

$V_0 = \alpha V_1 + \beta I_1$

$6 = 0 + 2\beta$

$\beta = 3$

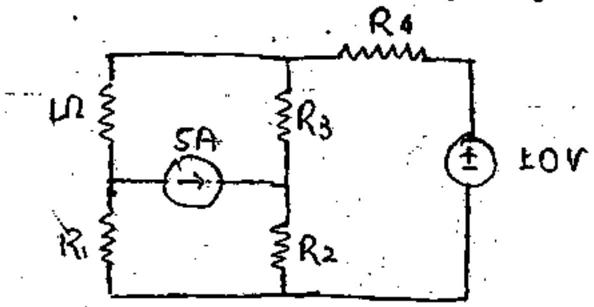
$V_0 = \alpha V_1 + \beta I_1$

$= \frac{3}{5} \times 10 + 3 \times 8$

$= 30V$ Ans

in n/w having linear and bilateral n/w then based the homogity principal if excitation (source) is multiply constant (K), then response of each element is also multiply with constant K

Power dissipation in 1Ω resistor is 576W, when the voltage source acting along and the power dissipation is 1W, when current source acting alone. Find the total power dissipation in 1Ω resistor when both source acting together?



Formula: $\boxed{P_t = (\pm\sqrt{P_1} \pm \sqrt{P_2} \pm \sqrt{P_3} \pm \dots \sqrt{P_n})^2}$

$P_1 = i_1^2 R$

$i_1 = \sqrt{\frac{P_1}{R}}$

$P_2 = i_2^2 R$

$i_2 = \sqrt{\frac{P_2}{R}}$

$i = \pm i_1 \pm i_2$

$P = i^2 R$

$P = (\pm i_1 \pm i_2)^2 R$

$P = \left(\pm\sqrt{\frac{P_1}{R}} \pm \sqrt{\frac{P_2}{R}}\right)^2 R$

$$P = (\pm\sqrt{P_1} \pm \sqrt{P_2})^2$$

$$= (\pm\sqrt{576} \pm \sqrt{1})^2$$

$$= 625\,W \quad \text{Ans}$$

Chapter 7:

Q8. $P = (\pm\sqrt{P_1} \pm \sqrt{P_2} \pm \sqrt{P_3})^2$

For max^m power

$$P = (\sqrt{P_1} + \sqrt{P_2} + \sqrt{P_3})$$

$$= (\sqrt{18} + \sqrt{50} + \sqrt{98})^2 = 475\,W$$

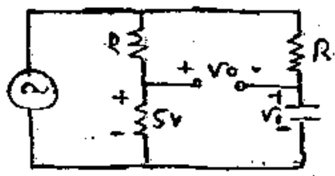
For min^m Power

$$P = (\sqrt{P_1} - \sqrt{P_2} - \sqrt{P_3})^2$$

$$= (\sqrt{98} - \sqrt{50} - \sqrt{18})^2 = 2\,W$$

Chapter 4

Q 4: $-V_1 - V_0 + V_R = 0$



$$V_0 = V_R - V_1$$

$$V_1 = \frac{10 \times (-jX_c)}{R - jX_c}$$

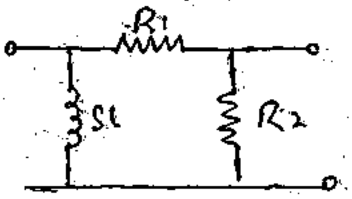
$$V_0 = 5 + \frac{j10X_c}{R - jX_c}$$

$$= \frac{5R + j5X_c}{R - jX_c}$$

$$V_0(j\omega) = 5\left[\frac{R + jX_c}{R - jX_c}\right]$$

$$|V_0(j\omega)| = 5\,\frac{\sqrt{R^2 + X_c^2}}{\sqrt{R^2 + X_c^2}} = 5V$$

8.



$$Z_{11} = \frac{SL(R_1+R_2)}{SL+R_1+R_2}$$

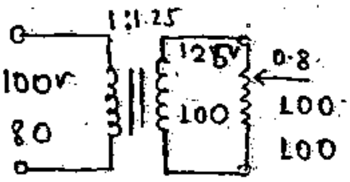
$$= \frac{S(R_1+R_2)}{S+\frac{R_1+R_2}{L}}$$

$$Z_{22} = \frac{R_2(R_1+SL)}{R_1+R_2+SL}$$

$$= \frac{R_2(S+R_1/L)}{S+\frac{R_1+R_2}{L}}$$

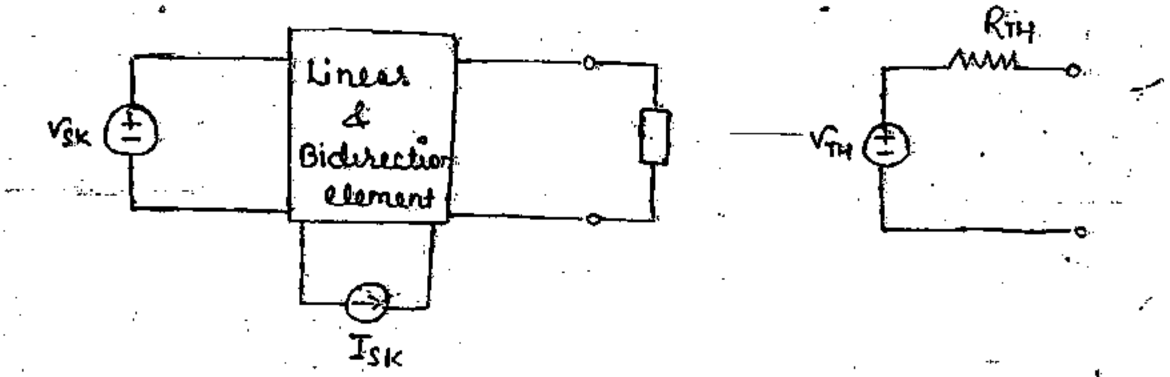
(c) Ans

2.



$\frac{100}{100}$ and $\frac{80}{100}$ Ans

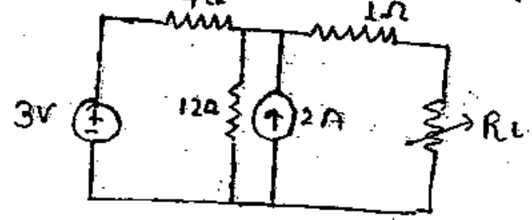
THEVENIN THEOROM: (HELMHOLTZ)



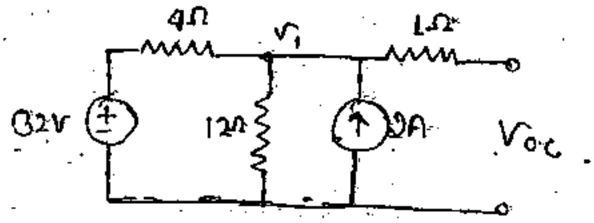
A two terminal n/w N_A containing linear & bidirectional element and independent source is equivalent to a single n/w containing an equivalent voltage source V_{TH} in series with the resistance R_{TH}.

The source voltage is the O.C voltage across the terminal of n/w N_A and Resistance R_{TH} is the O/P terminal of N_A measured it terminal after deactivating all independent source in N/w (N_A).

Q Find the current through R_L when R_L is 6Ω and 36Ω by using thevenin theorom.



Sol: Case V_{TH}



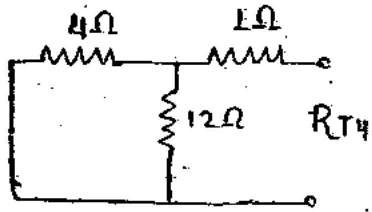
$$\frac{V_1-32}{4}+\frac{V_1}{12}-2A=0$$

$$3V_1-96+V_1=24$$

$$4V_1=120$$

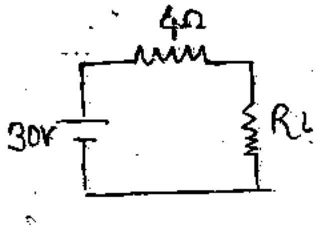
$$V_1=V_{oc}=30V$$

Case II R_{TH}



$$R_{TH}=(12\|4)+1\Omega$$

$$=3+1=4\Omega$$



$$I_b=\frac{30}{4+R_L}$$

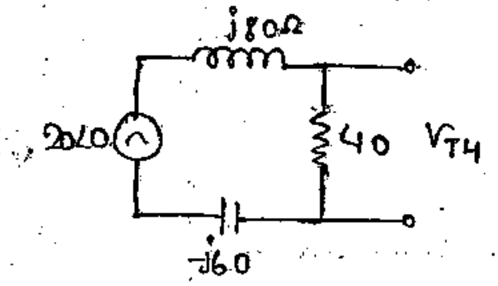
(a) $R_L=6\Omega$

$$I=\frac{30A}{10}=3A$$

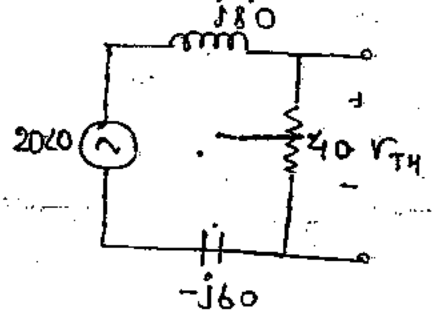
(b) $R_L=36\Omega$

$$I=\frac{30}{40}=0.75A$$

Q. Find V_{TH} and R_{TH}.



Soln: Case: V_{TH}



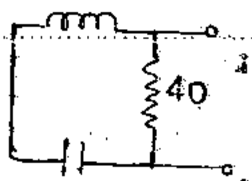
$$I = \frac{20\angle 0}{40+j20}$$

$$= \frac{1\angle 0}{2+j} = 0.448\angle -26.5°$$

$$V_{TH} = 40 \times 0.448\angle -26.5°$$

$$= 17.8\angle -26.5°$$

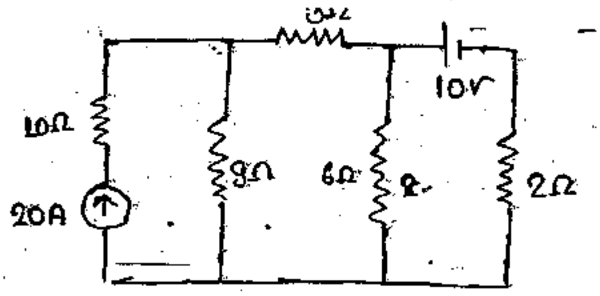
Case R_{TH}



$$R_{TH} = 40 \,||\, (j80 - j60)$$

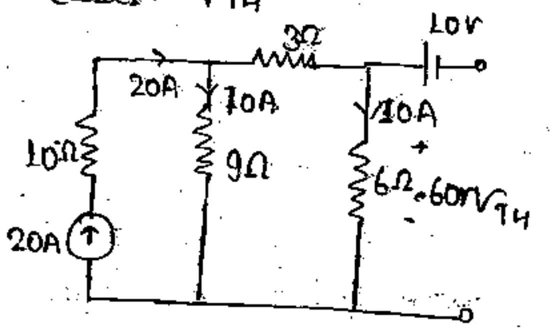
$$= \frac{j20 \times 40}{40+j20} = \frac{j40}{2+j}$$

Q.



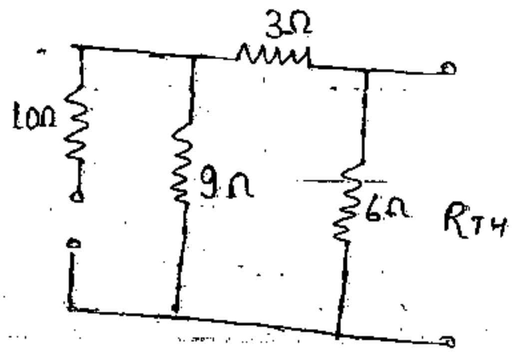
Find current following through 2Ω resistor using thevenin theorem

Soln: Case1: V_{TH}



$V_{TH} = 60 - 10 = 50$ volts

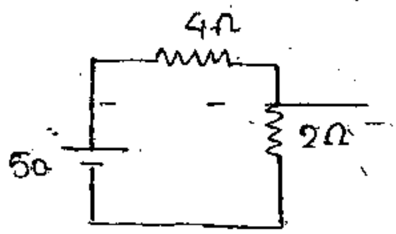
Case 2: R_{TH}



$R_{TH} = (9+3) \parallel 6$

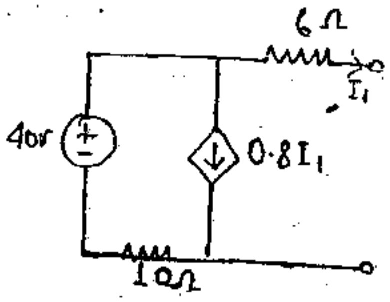
$= 12 \parallel 6$

$= \frac{12 \times 6}{18} = 4\Omega$



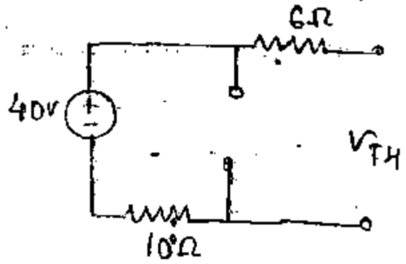
$$I = \frac{50}{6} = 8.33A$$

Q.



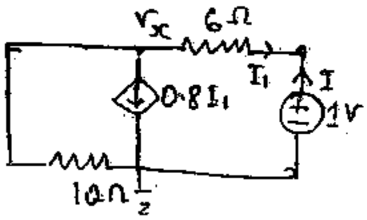
Soln:

case I . V_{TH}



$$V_{TH} = 40V$$

case II _ R_{TH}



$$\frac{V_x}{10} + 0.8I_1 + \frac{V_x - 1}{6} = 0$$

$$\frac{V_x}{10} + 0.8\left(\frac{V_x}{6} - \frac{1}{6}\right) + \frac{V_x - 1}{6} = 0$$

$$24V_x = 18$$

$$V_x = 3/4 \text{ volts}$$

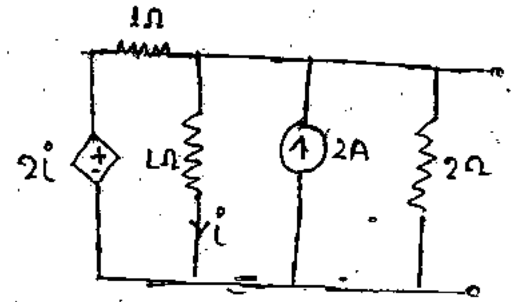
$$I = \frac{1 - V_x}{6}$$

$$= \frac{1 - 3/4}{6}$$

$$= \frac{1}{24} \ A$$

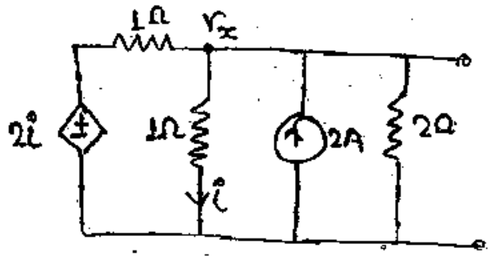
$$R_{TH} = \frac{V}{I} = \frac{1}{1/24} = 24\Omega$$

Q.



Find thevenin resistances

Soln Cases V_{TH}



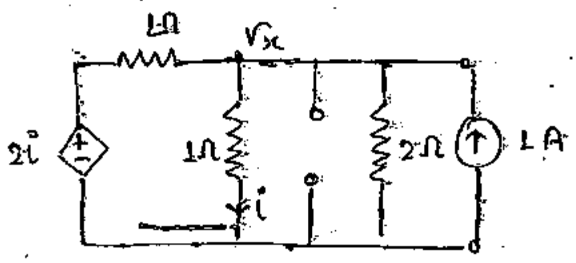
$$\frac{V_x - 2i}{1} + \frac{V_x}{1} + \frac{V_x}{2} = 2$$

$$i = \frac{V_x}{1}$$

$$2V_x + \frac{V_x}{2} - 2V_x = 2$$

$$\therefore V_x = 4V$$

Case R_{TH}



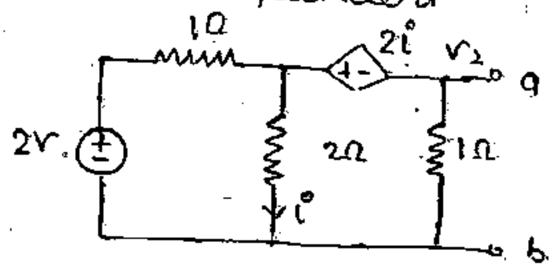
$$\frac{V_x - 2i}{1} + \frac{V_x}{1} + \frac{V_x}{2} = 0$$

$\because i = \frac{V_x}{1}$ $\quad V_x = 2V$

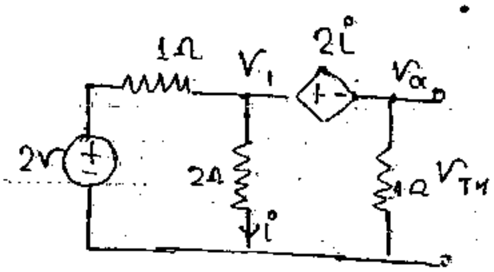
$V = 2V$

$$R_{TH} = \frac{V}{I} = \frac{2}{1} = 2\,\Omega$$

Q. Develop thevenin equivalent



Soln: Case V_{TH}



$$\frac{V_2}{1} + \frac{V_1 - 2}{2V} + \frac{V_1}{2} = 0$$

$$\frac{3V_1}{2} + \frac{V_2}{2} - 2 = 0$$

$V = 4$

$\frac{2i}{1} = 0 \qquad V_1 - V_2 = 2i$

$V_1 - V_2 = 2\frac{V_1}{2}$

$V_2 = 2V_1$

$$\frac{3V_1}{2} + 2V_1 = 2$$

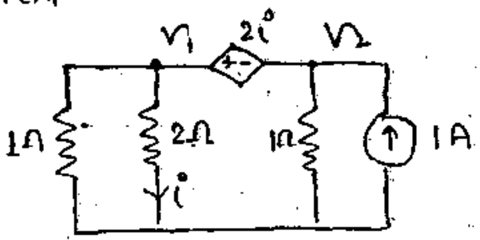
$$7V_1 = 4$$

$$V_1 = \frac{4}{7}$$

$$V_2 = \frac{4}{7} \times 2 = \frac{8}{7}$$

$$V_{TH} = \frac{8}{7}$$

Case 2: R_{TH}



$$\frac{V_1}{1} + \frac{V_1}{2} + \frac{V_2}{1} = 1$$

$$V_2 + \frac{3V_1}{2} = 1$$

$$i = \frac{V_1}{2}$$

$$V_2 - V_1 = 2i$$

$$V_2 - V_1 = 2\frac{V_1}{2}$$

$$V_2 = 2V_1$$

$$2V_1 + \frac{3V_1}{2} = 1$$

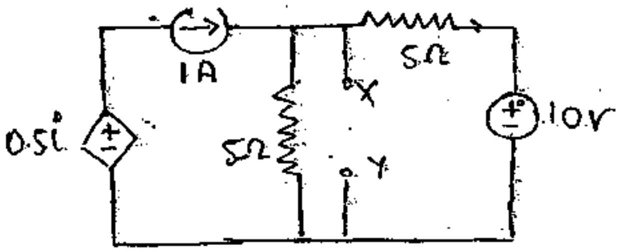
$$\frac{7V_1}{2} = 1$$

$$V_1 = \frac{2}{7}$$

$$V_2 = \frac{4}{7}$$

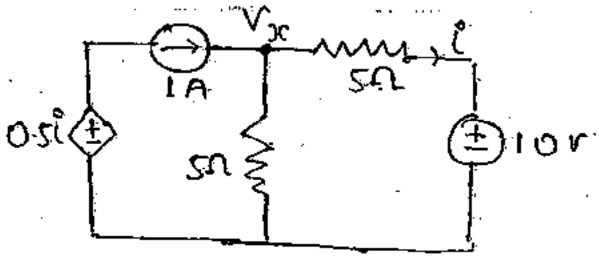
$$R_{TH} = \frac{V}{I} = \frac{4}{7}$$

1.



Find thevenin Equivalent

Soln: case V_{TH}



$$\frac{V_x - 0.5i}{5} + \frac{V_x - 10}{5} = 1$$

$$\frac{V_x - 0.5 \times \frac{V_x}{5}}{5} + \frac{V_x - 10}{5} = 1$$

$$\frac{V_x}{5} + \frac{V_x - 10}{5} = 1$$

$$\frac{2V_x}{5} - 2 = 1$$

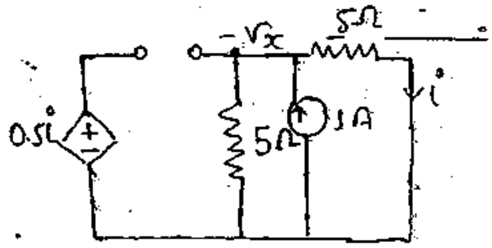
$$2V_x = 15$$

$$V_x = \frac{15}{2} = 7.5$$

$V_{TH} = V_x - V_y$

$= 7.5 - 0 = 7.5V$

case R_{TH}



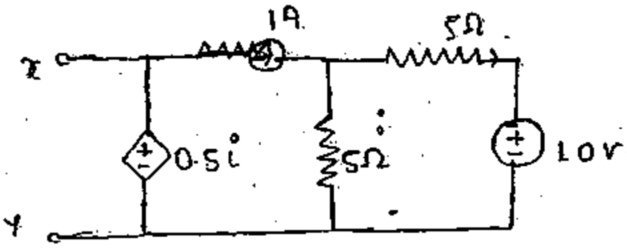
$$\frac{V_x}{5} + \frac{V_x}{5} = 1$$

$$\frac{2V_x}{5} = 1$$

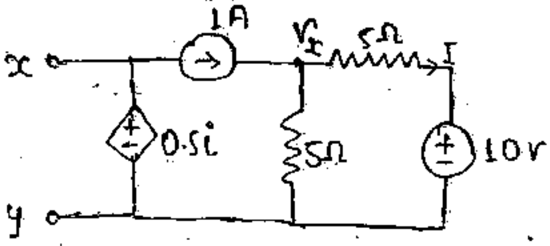
$$V_x = 5/2$$

$$R_{TH} = \frac{V}{I} = \frac{5}{2}\,\Omega$$

Q.



Soln: Case V_{TH}



$$\frac{V_x}{5} + \frac{V_x - 10}{5} = 1$$

$$\frac{2V_x}{5} = 3$$

$$V_x = 7.5\,V$$

$$i_1 = \frac{V_x}{5} = \frac{\cancel{15}\,3}{2\times\cancel{5}} = \frac{3}{2}$$

$$V = V_x - V_y$$

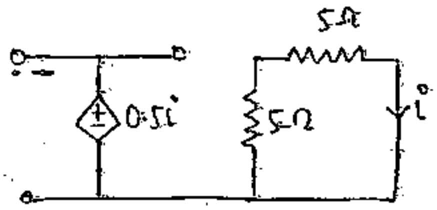
$$= 7.5 - 1.5 = 6.8\,V$$

$V_{TH} = 0.5\,i$

$= 0.5\left(\frac{7.5-10}{5}\right)$

$= 0.1 \times 2.5 = -0.25$ Volts

Case R_{TH}



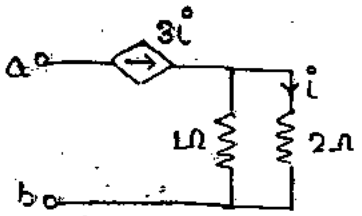
As $i = 0$

$0.5i = 0$

$R_{TH} = 0\,\Omega$ Ans

N.B For calculating R_{TH} never connected voltage source in || with dependent sources.

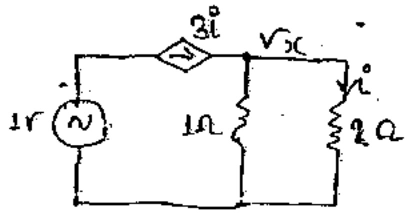
Q.



N.B: When there is no independent source present in the n/w. V_{TH} is always zero.

$V_{TH} = 0$

- Never connected current source in series with dependent current source while calculating R_{TH}



$\frac{V_x}{1} + \frac{V_x}{2} = 3i$

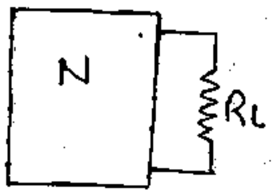
$\frac{3V_x}{2} = 3i$

$\frac{3V_x}{2} = \frac{3V_x}{2}$

$V_x = 0$

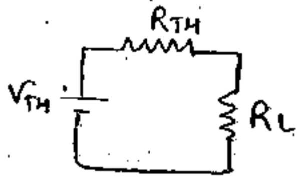
∴ R_{TH} can be not be determined.

when a complex n/w N is connected to load resistor R_L. the power dissipation in load is Pw. when two identical n/w N is connected to load resistor R_L. find power dissipation in the load.



(a) P
(b) 2P
(c) 4P
(d) P to 4P

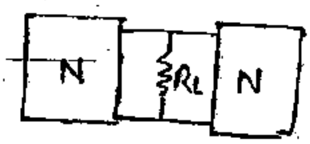
17:

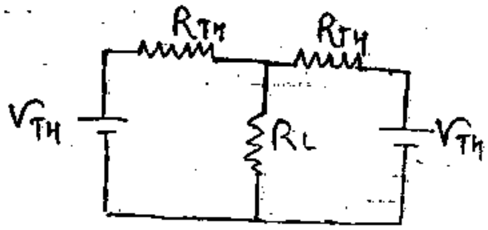


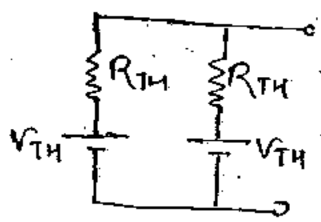
$$I = \frac{V_{TH}}{R_{TH}+R_L}$$

$$P = I^2 R_L$$

$$= \left(\frac{V_{TH}}{R_{TH}+R_L}\right)^2 \cdot R_L$$

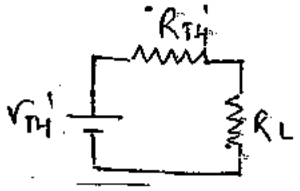






$$V_{TH}' = V_{TH}$$

$$R_{TH}' = \frac{R_{TH}}{2}$$



$$P = I^2 R_L$$

$$= \left(\frac{V_{TH}'}{R_{TH}' + R_L}\right)^2 \cdot R_L$$

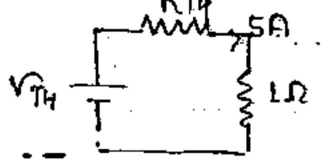
$$= \left(\frac{V_{TH}}{\frac{R_{TH}}{2} + R_L}\right)^2 R_L$$

$$P = \left(\frac{2V_{TH}}{R_{TH} + 2R_L}\right)^2 \cdot R_L$$

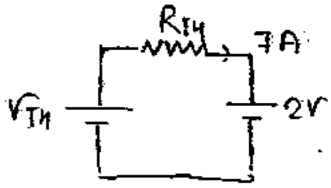
Ans $P + 0.4P$

Q. A Battery ~~charger~~ charger drives a current of 5A. the load resistance $R_L = 1\Omega$. When same battery charger is used for charging of ideal 2v source at current of 7A. Find V_{TH} and R_{TH}.

Soln.



$$5 = \frac{V_{TH}}{1 + R_{TH}} \quad \therefore V_{TH} = 5 + 5R_{TH} \text{ — } (1)$$



$$V_{TH} = 7R_{TH} + 2 \text{ — } (2)$$

$$5R_{TH} + 5 = 7R_{TH} + 2$$

$$3 = 2R_{TH}$$

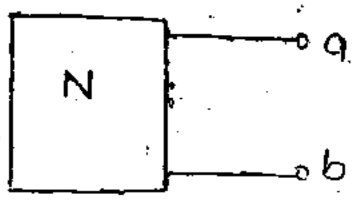
$$\therefore R_{TH} = 3/2$$

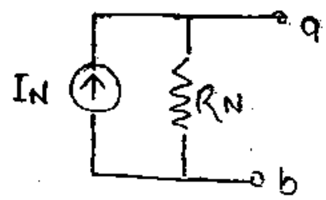
$V_{TH} = 7 \times \frac{3}{2} + 2 = 12.5$ volts.

NORTON'S THEOROM :-

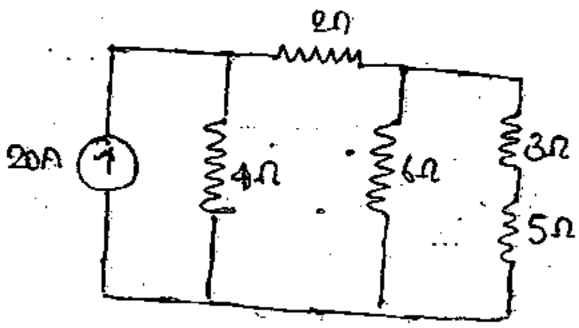
A two terminal N/W NA containing linear, bidirectional elements, and independent source is equivalent to similar N/W containing an independent current source (I_N) in || with a resistance R_N.

Source current is the s.c current across NA and R_N is resistance looking into the terminal after deactivating all independent sources in a N/W NA.

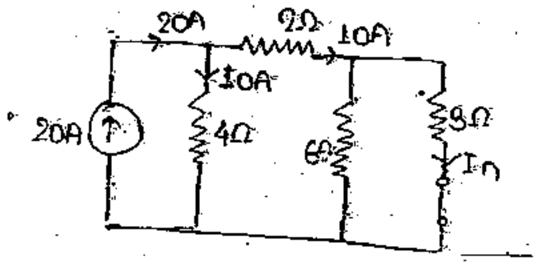




Q. Find the current flowing 5Ω resistance by using Norton's theorom.

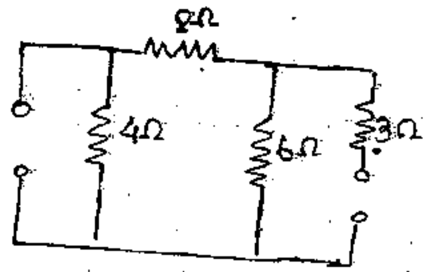


Solⁿ: Case I_N

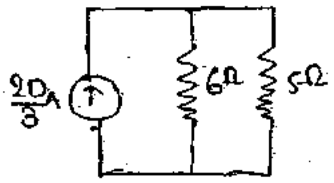


$$I_N = 10 \times \frac{\cancel{6}\,2}{\cancel{9}\,3} = \frac{20}{3}\,A$$

Case R_N

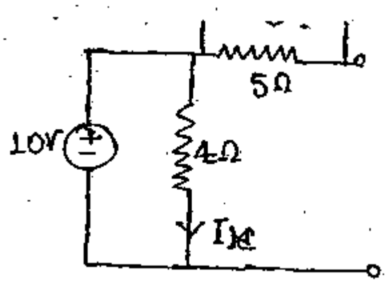


$R_N = 6\,\Omega$



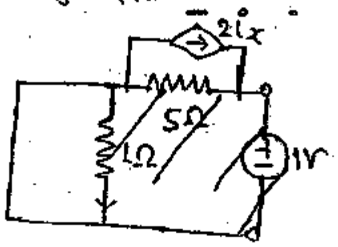
$$I = \frac{20}{3} \cdot \frac{6}{11} = \frac{40}{11}\,A$$

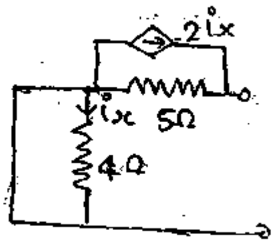
Q.



Develop the Norton equivalent across the terminal ?

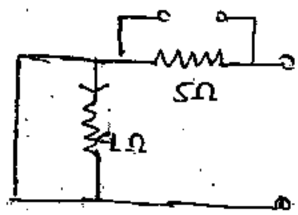
Soln. Case of R_N





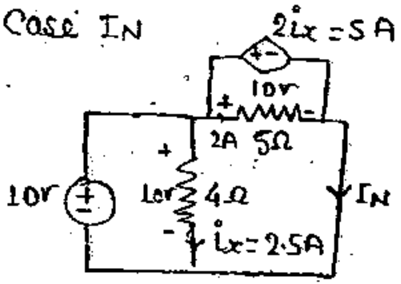
1.B. 1

As $i_x = 0$



$R_N = 5\Omega$

Case I_N

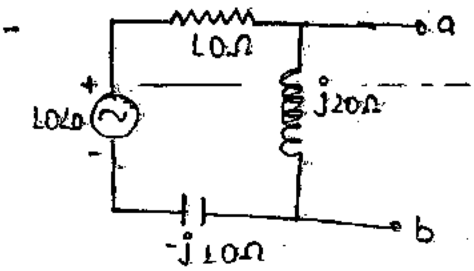


$2i_x + 2 = I_N$

$I_N = 2 \times 2.5 + 2 = 7A$

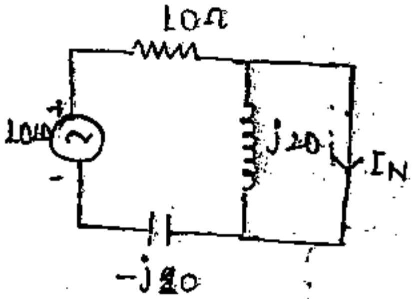
V.G When short circuit voltage source connected in || to the resistance then internal resistance of voltage source is 0 zero. since voltage source and Resistance connected in ||. then equivalent resistance Zero.

Q. -



Soln: case I_N

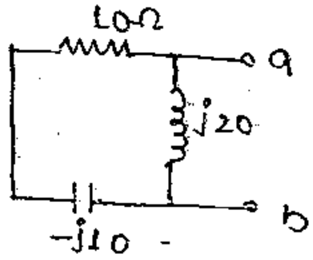
$$I = \frac{10\angle 0}{10+j10} = \frac{10\angle 0}{10-10j}$$



$$= \frac{1\angle 0}{1-j} = \frac{1}{\sqrt{2}}\angle 45^\circ$$

case. R_N

$$\frac{1}{Z_n} = \frac{1}{10-j10} + \frac{1}{j20}$$



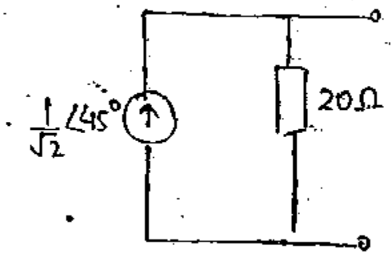
$$= \frac{1}{20}\left[\frac{2}{1-j} + \frac{1}{j}\right]$$

$$= \frac{1}{20}\left[\frac{2j+1-j}{(1-j)j}\right]$$

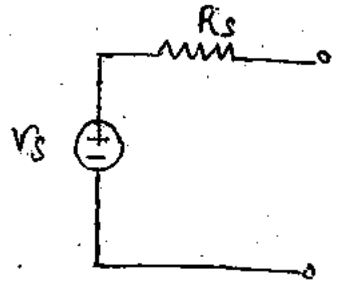
$$= \frac{1}{20}\left[\frac{1+j}{1-j} \times \frac{j}{j^2}\right]$$

$$= \frac{1}{20}\left[\frac{1+j}{1+j}\right]$$

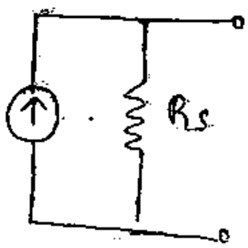
$Z_n = 20\Omega$

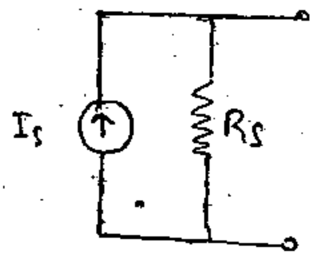


Source transformation:-

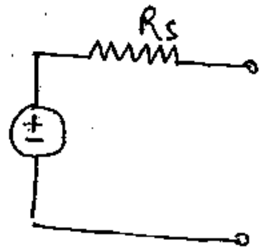


$= I_N = \frac{V_S}{R}$





$= V_S = I_S R_S$



$R_{TH} = \frac{V_{Th}}{I_A} = \frac{V_{oc}}{I_{sc}}$

Q. Find the current from 4Ω resistor by using following data:

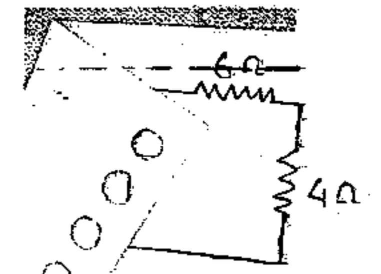
V	60V	0
I	0A	10A

Soln:

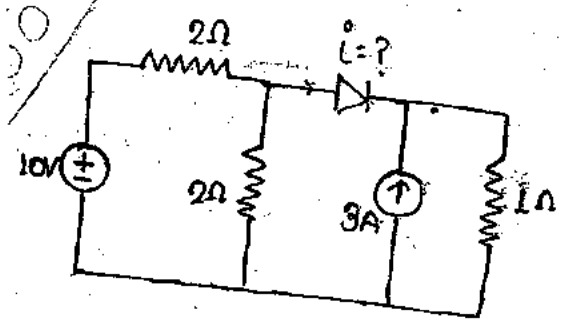
$V_{oc} = 60A = V_{TH}$

$I_{sc} = 10A = I_N$

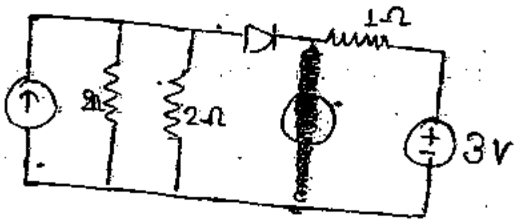
$R_{TH} = \frac{V_{oc}}{I_{sc}} = \frac{60}{10} = 6\Omega$

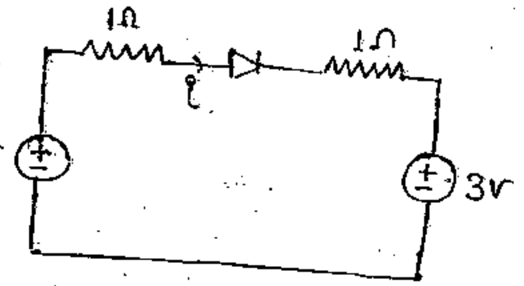


$I = \frac{60}{10} = 6A$



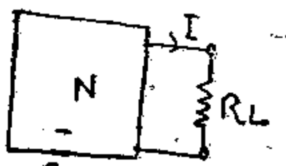
Soln:



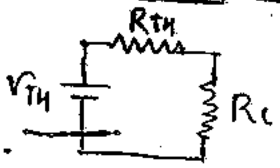


$i = \frac{5-3}{1+1} = \frac{2}{2} = 1A$

Q. The N/W N contains Recistor and independent source. for R=0 Ω I = 3A, § A. Find the value of I. R=1Ω



Soln:



$3 = \frac{V_{TH}}{R_{TH}}$

$\therefore V_{TH} = 3R_{TH}$

$$1.5 = \frac{V_{TH}}{R_{TH}+2}$$

$$1.5R_{TH}+3 = V_{TH}$$

$$1.5R_{TH} + \cancel{3 = 3R_{TH}}$$

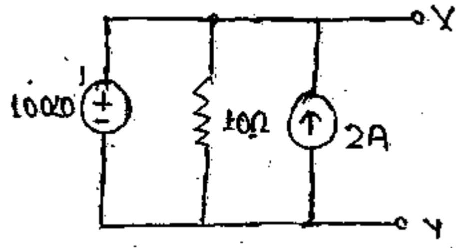
$$3 = 1.5R_{TH}$$

$$R_{TH} = 2\Omega$$

$$V_{TH} = 6V$$

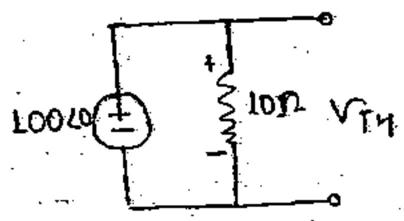
$$I = \frac{6}{2+1} = 2A \quad \underline{\text{Ans}}$$

Q.



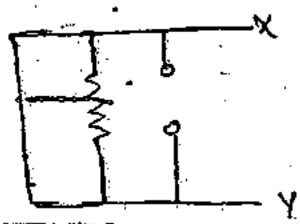
Develop the thevenin and Norton equivalent crt.

Soln. case V_{TH}



$V_{TH} = 100$ volts

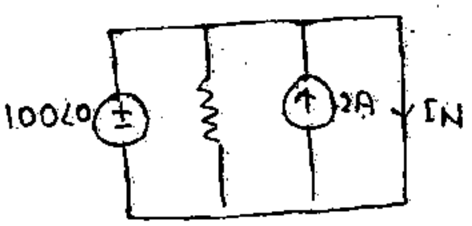
case R_{TH}



$i = 0$

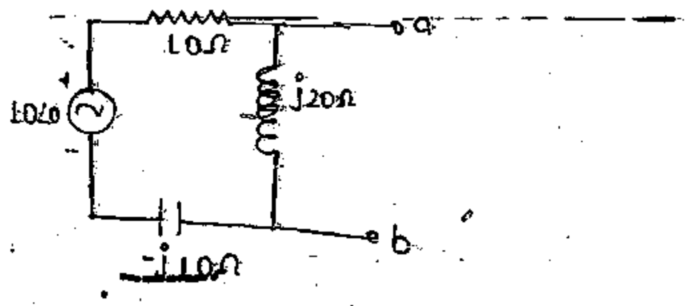
$R_{TH} = \cancel{\frac{100}{0}} = \cancel{\infty}\ 0$

case I_N

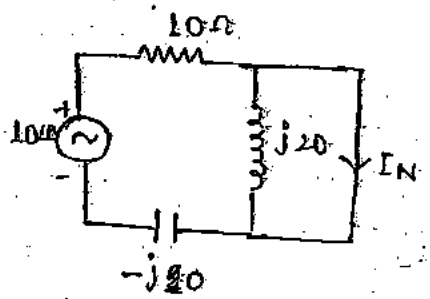


Norton can be develop

Q.



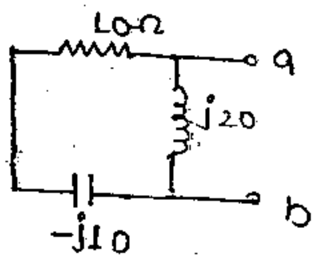
Soln: case I_N



$$I = \frac{10\angle 0}{10 + j10} = \frac{10\angle 0}{10 - 10j}$$

$$= \frac{1\angle 0}{1-j} = \frac{1}{\sqrt{2}}\angle 45°$$

Case R_N



$$\frac{1}{Z_n} = \frac{1}{10 - j10} + \frac{1}{j20}$$

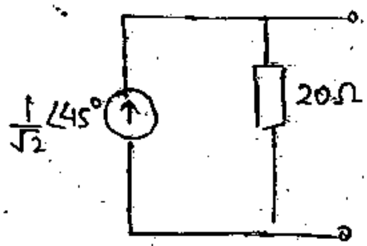
$$= \frac{1}{20}\left[\frac{2}{1-j} + \frac{1}{j}\right]$$

$$= \frac{1}{20}\left[\frac{2j + 1 - j}{(1-j)j}\right]$$

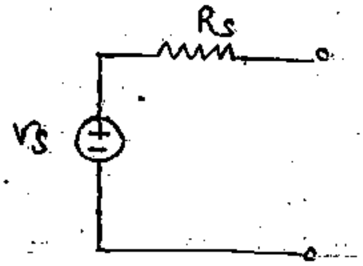
$$= \frac{1}{20}\left[\frac{1+j}{1-j} \times \frac{j}{j^2}\right]$$

$$= \frac{1}{20}\left[\frac{1+j}{1+j}\right]$$

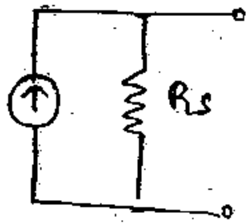
$Z_n = 20\Omega$

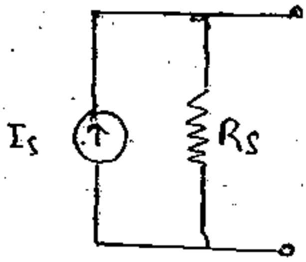


Source transformation :-

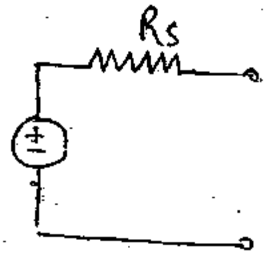


$= I_N = \frac{V_s}{R}$





$= V_s = I_s R_s$



$$R_{TH} = \frac{V_{Th}}{I_A} = \frac{V_{oc}}{I_{sc}}$$

Q. Find the current from 4Ω resistor by using following data:

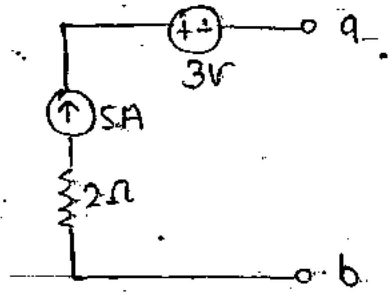
V	60V	0
I	0A	10A

Solⁿ:

$V_{oc} = 60A = V_{TH}$

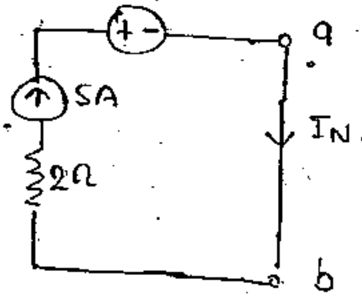
$I_{sc} = 10A = I_N$

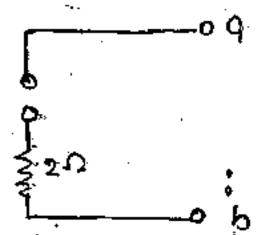
$$R_{TH} = \frac{V_{oc}}{I_{sc}} = \frac{60}{10} = 6\Omega$$

Q. 

- Develop the Norton ~~and~~ thevenin Equivalent Crt.

Soln.

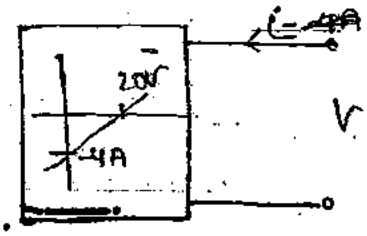




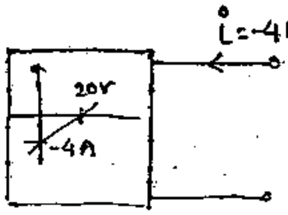
~~$R_{TH} = \frac{V_{TH}}{0} \neq 0$~~

$R_{TH} =$

Thevenin equivalent ~~to~~ crt can not valid because it does not obey the KCL law.

Q. 

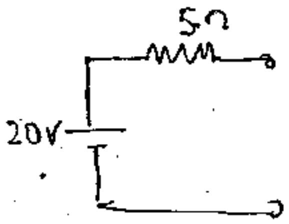
Soln.

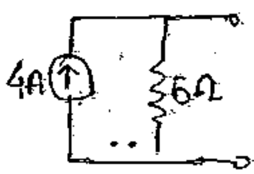


$V_{TH} = 20V$

$I_N = 4A$

$R_N = R_{TH} = \frac{V_{TH}}{I_N} = \frac{20}{4} = 5\Omega$





RECIPROCITY THEOROM:

In linear bilateral single source n/w. ratio of the response to Excitation is constant. even when the position the response & excitation is interchanged.

In any linear bilateral n/w, if single voltage Source V_x in branch x produces current response I_y in branch y. then the removal of voltage source from branch x and insertion in branch y will produces the current I_y in branch x.

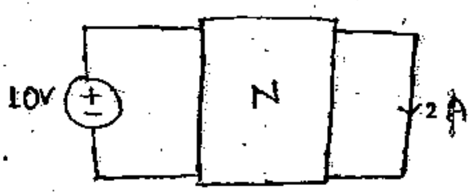
It is not applicable

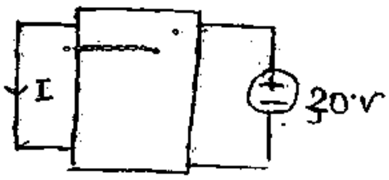
(i) When more than one independent voltage & current Source present.

(2) When dependent source is present.

(3) When ratio of response & Exitation is not Ω & mho.

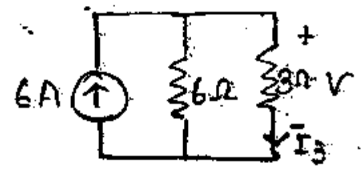
Q. Find I





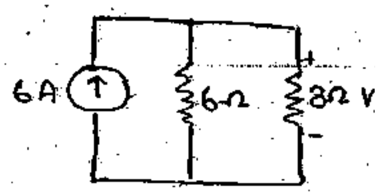
$$\frac{2}{10} = \frac{I}{30}$$

$I = 6A$

Q. 

Verify the reciprocity theorem

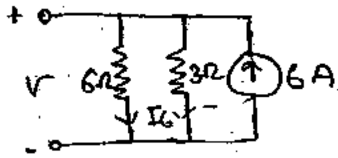
Soln: $I_3 = 6 \cdot \frac{6}{9} = 4\,A$



$V = I_3 R \cdot 4 \times 3 = 12$ volts

$\frac{\text{Response}}{\text{Excitation}} = \frac{12}{6} = 2$

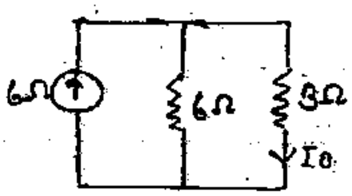
$I_6 = 6 \times \frac{3}{9} = 2\,A$



$V = I_6 \times 6$

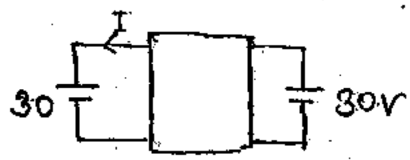
$= 2 \times 6 = 12$ volts

$\frac{\text{Response}}{\text{Excitation}} = \frac{12}{6} = 2\,A$

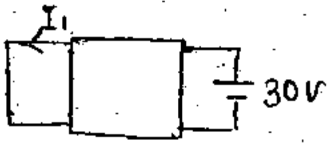
Q. 

Soln: Reciprocity theorem not valid because ratio of Excitation & response is not Ω or ℧

Q. The given N/W N satisfy reciprocity theorem then find value of I.



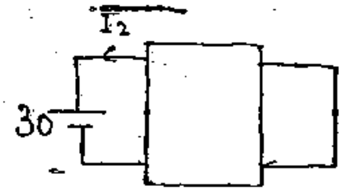
Soln: case I 30V



$$\frac{2}{10} = \frac{I_1}{30}$$

$I_1 = 6A$

case 2 30V

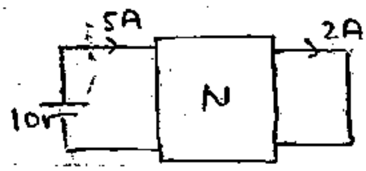


$$\frac{I_2}{30} = -\frac{5}{10}$$

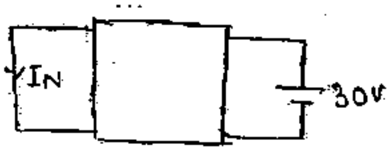
$I_2 = -15A$

$$I = I_1 + I_2$$
$$= -15 + 6 = -9A$$

Q. The given n/w N satisfy reciprocity theorem then find value of I.



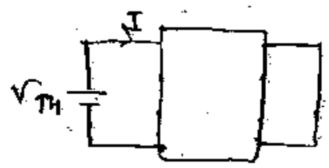
Soln: Case I 30 V



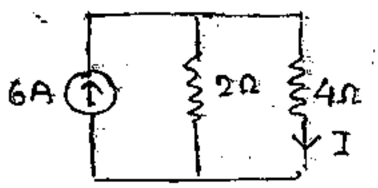
$$\frac{I}{30} = \frac{2}{10}$$

$I_N = 6A$

case 4Ω

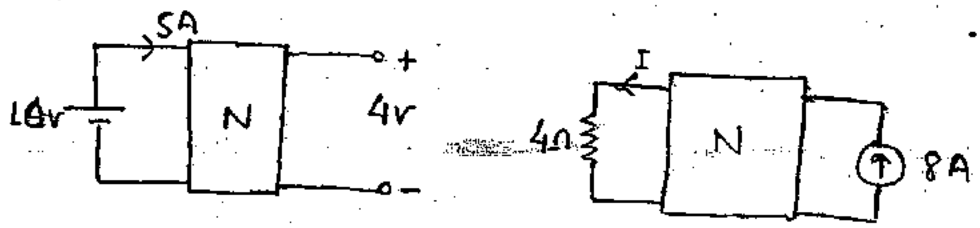


$$R_{Th} = \frac{10}{5} = 2\Omega$$

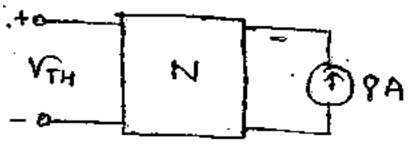


$I_{4\Omega} = \frac{6 \times 2}{6} = 2A$

Q. The below n/w satisfy the Reciprocity theorem then find value of I



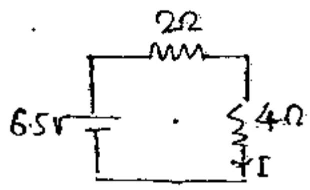
Soln :



$$\frac{4}{5} = \frac{V_{TH}}{8}$$

$$V_{TH} = \frac{32}{5} = 6.5 \text{ volts}$$

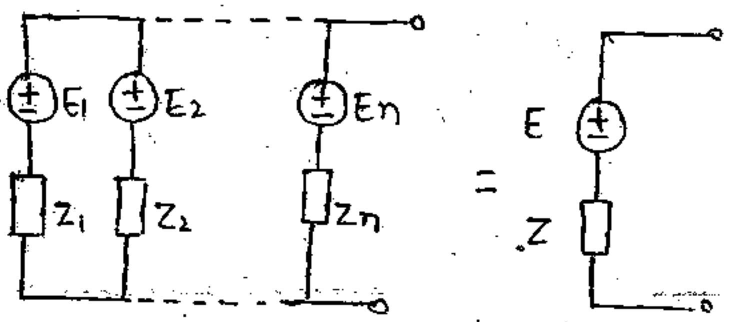
$R_{TH} = \frac{10}{5} = 2\Omega$

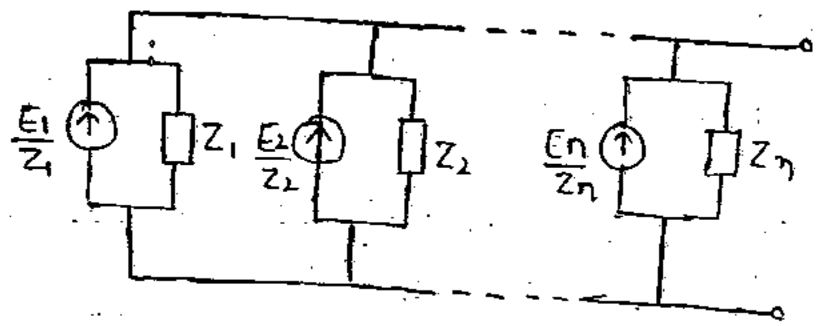


$$I_1 = \frac{6.5}{6} = 1.08 A$$

MILLMANN'S THEOROM :-

If n voltage sources having voltages $E_1, E_2 \dots E_n$ and internal impedences Z_1 $Z_2 \dots$ Z_n are connected in ∥ then this voltage sources can be replaced by single voltage source E with series impedences Z.





$$I_N = \frac{E_1}{Z_1} + \frac{E_2}{Z_2} + \dots + \frac{E_n}{Z_n}$$

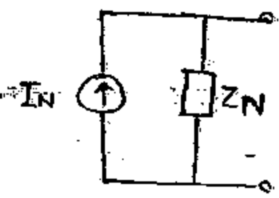
$$Z_n = \frac{1}{\frac{1}{Z_1} + \frac{1}{Z_2} + \dots + \frac{1}{Z_n}}$$

$$E = I_N \cdot Z_N = \frac{\frac{E_1}{Z_1} + \frac{E_2}{Z_2} + \dots + \frac{E_n}{Z_n}}{\frac{1}{Z_1} + \frac{1}{Z_2} + \dots + \frac{1}{Z_n}}$$

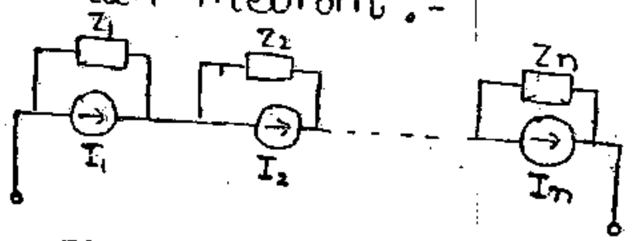
$$E = \frac{E_1Y_1 + E_2Y_2 + \cdots + E_nY_n}{Y_1 + Y_2 + \cdots + Y_n}$$

$$E = \frac{\sum_{i=1}^{N} E_iY_i}{\sum_{i=1}^{n} Y_i}$$

$$Z = Z_n = \frac{1}{Y_1 + Y_2 + \cdots + Y_n} = \frac{1}{\sum_{i=1}^{n} Y_i}$$



Dual Millman theorom :-



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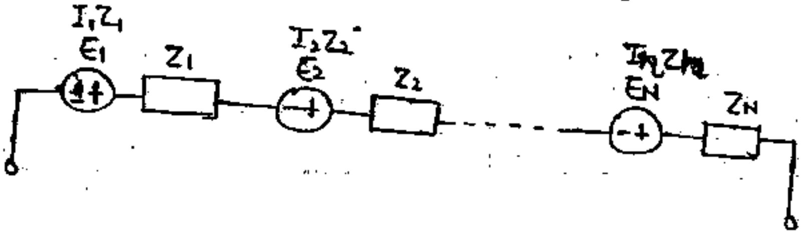

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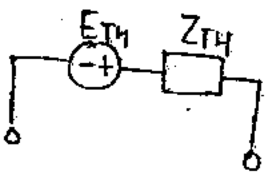
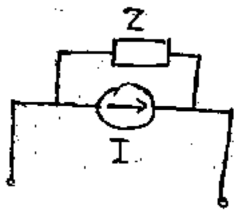


$$E_{TH} = E_1 + E_2 + \cdots + E_n$$

$$= I_1 Z_1 + I_2 Z_2 + \cdots + I_n Z_n$$

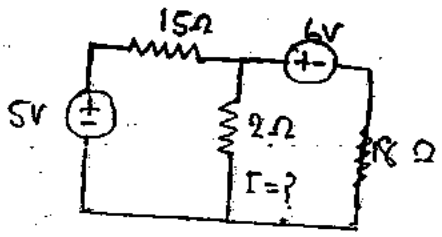
$$Z_{TH} = Z_1 + Z_2 + \cdots + Z_n$$



$$I = \frac{E_{TH}}{Z_{TH}} = \frac{I_1 Z_1 + I_2 Z_2 + \cdots + I_n Z_n}{Z_1 + Z_2 + \cdots + Z_n}$$

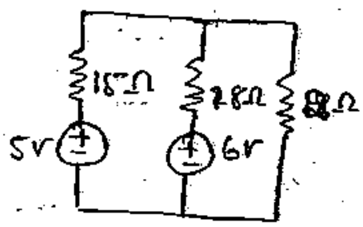
$$\boxed{I = \frac{\sum_{i=1}^{n} I_i Z_i}{\sum_{i=1}^{n} Z_i}}$$

Q.



Find the value of I using millman theorom

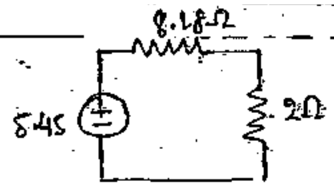
Soln.



$$E = \frac{\frac{E_1}{Z_1} + \frac{E_2}{Z_2}}{\frac{1}{Z_1} + \frac{1}{Z_2}} = \frac{\frac{5}{15} + \frac{6}{18}}{\frac{1}{15} + \frac{1}{18}} =$$

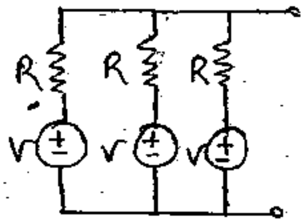
$$E = 5.45\,V$$

$$R = \frac{1}{\frac{1}{15} + \frac{1}{18}} = \frac{15 \times 18}{15 + 18} = 8.18\,\Omega$$



$I = 0.535\,A$

Q.



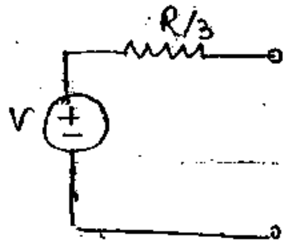
Soln:

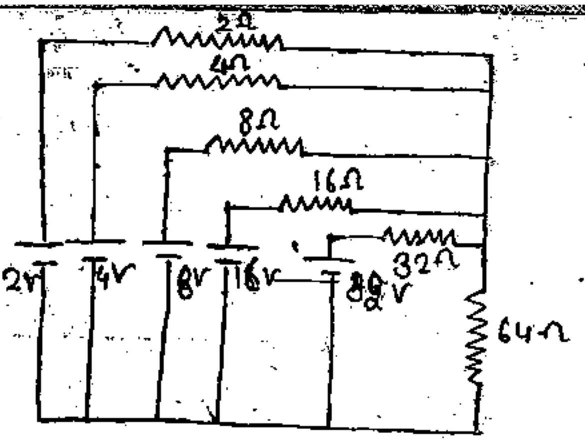
$$E = \frac{\frac{V}{R} + \frac{V}{R} + \frac{V}{R}}{\frac{1}{R} + \frac{1}{R} + \frac{1}{R}}$$

$$= \frac{3V/R}{3/R}$$

$$\boxed{E = V}$$

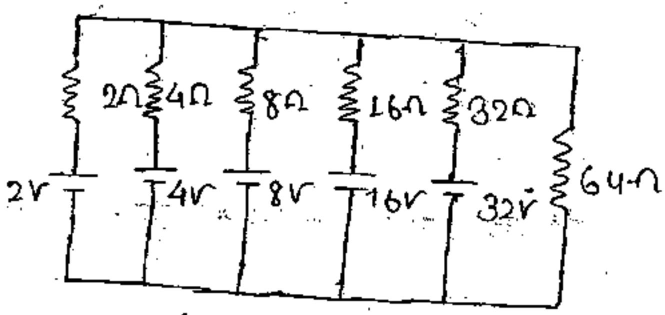
$$R_{Th} = \frac{1}{\frac{1}{R} + \frac{1}{R} + \frac{1}{R}} = \frac{R}{3}$$



Q. 

Find the current through 64Ω resistor

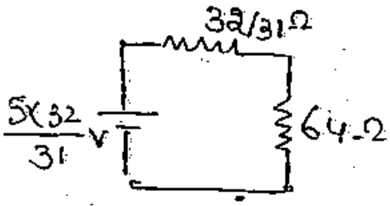
Soln:



$$E = \frac{\frac{2}{2}+\frac{4}{4}+\frac{8}{8}+\frac{16}{16}+\frac{32}{32}}{\frac{1}{2}+\frac{1}{4}+\frac{1}{8}+\frac{1}{16}+\frac{1}{32}}$$

$$E = \frac{5 \times 32}{31}$$

$$R = \frac{1}{\frac{1}{2}+\frac{1}{4}+\frac{1}{8}+\frac{1}{16}+\frac{1}{32}} = \frac{32}{31}\,\Omega$$

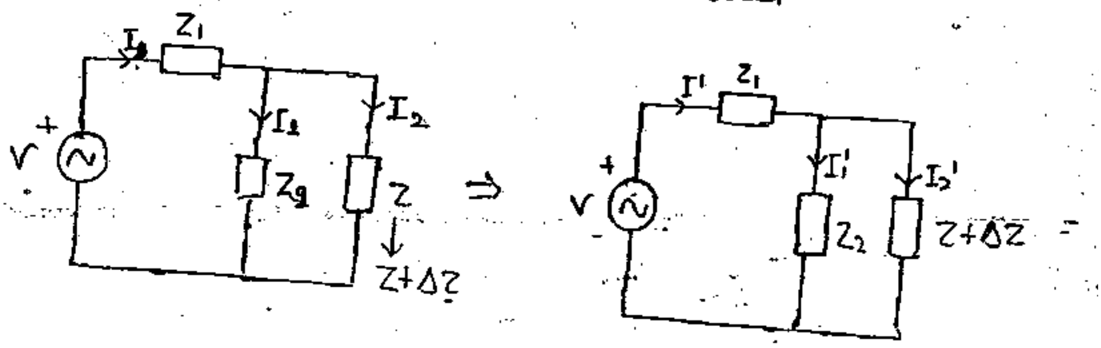


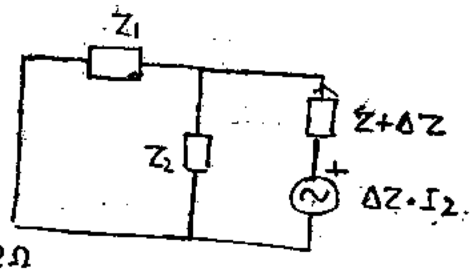
$$I = \frac{5 \times 32/31}{\frac{32}{31}+64}$$

I

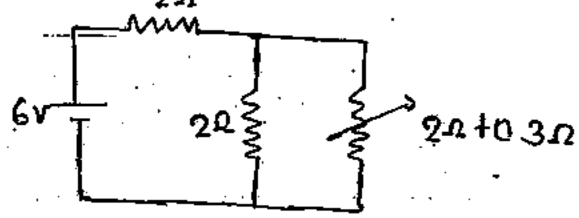
Compensation theorom :

In a linear n/w acted upon by idependent sources. if an impedence is Z carrying current I'. if change to $Z+\Delta Z$ - the incremental changes will be identicalto those produced by voltage source $\Delta Z \cdot I$ in series with the altered impedences $Z+\Delta Z$ with all the independent source deactivated

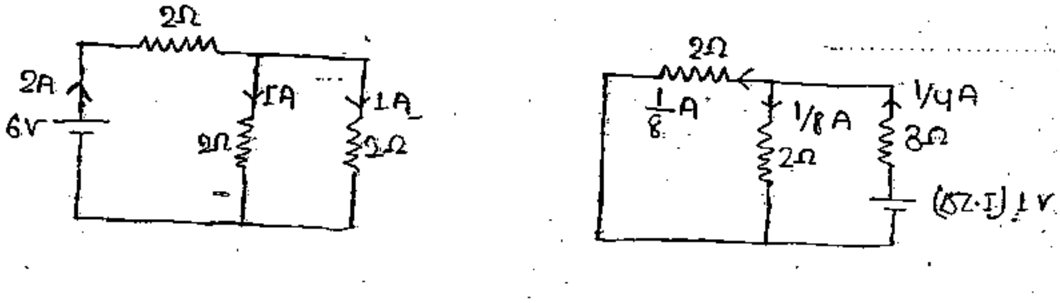


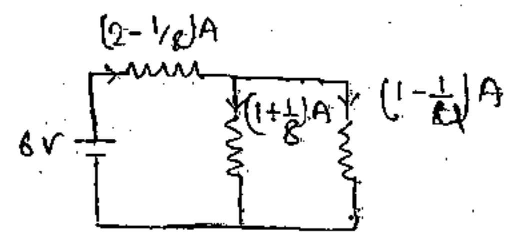


Q.



Soln:



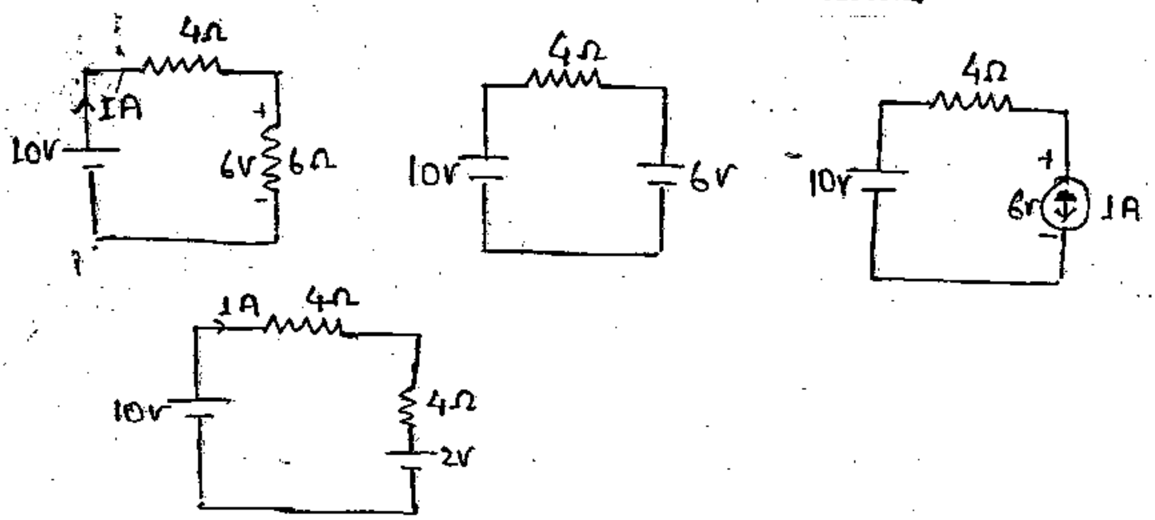


NOTE

1. This theorom is used to determined the steady state error introduced in the system by measuring instrument and obtained null deflection in the galvenometer of the bridge crt.

SUBSTITUTION THEOROM:

Any branch in a n/w may be substituted by different branch without disturbing the voltages and current in the entire n/w provided that a new branch of set of same terminal voltage and current as the original branch.



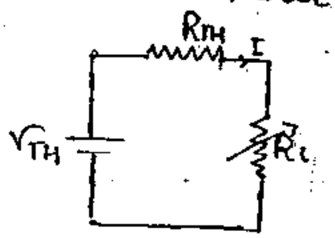
TELLEGEN'S THEOROM: -

In any n/w (linear, non linear, unidirectional, bidirectional, time invarient, time varient) the sum of total instantaning power consume by various element in various branches of ckt is always zero. this implies that total power delivered ~~by~~ active element is equal to total power absorbed by passive element's of the branches of n/w.

N.B

- For verification of ~~dck~~ tellegen's theorom, KVL & KCL theorom are used.
- It is based on the law of conservation of energy.

Maximum POWER TRANSFER:



$$I = \frac{V_{TH}}{R_{TH}+R_L}$$

$$P = I^2 R_L$$

$$P = \left(\frac{V_{TH}}{R_{TH}+R_L}\right)^2 \cdot R_L$$

$$\frac{dP}{dR_L} = V_{TH}^2 \left[\frac{(R_{TH}+R_L)^2 - R_L \cdot 2(R_{TH}+R_L)}{(R_{TH}+R_L)^4}\right] = 0$$

$$R_{TH} + R_L - 2R_L = 0$$

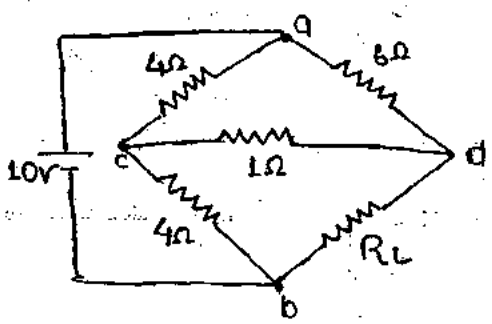
$$\boxed{R_{TH} = R_L}$$

$$P_{max} = \left(\frac{V_{TH}}{R_{TH}+R_L}\right)^2 \cdot R_L$$

$$P_{max} = \left(\frac{V_{TH}}{R_{TH}+R_{TH}}\right)^2 \cdot R_{TH}$$

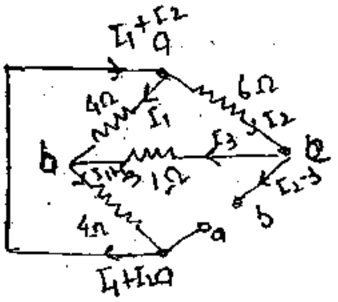
$$\boxed{P_{max} = \frac{V_{TH}^2}{4R_{TH}}}$$

Q.



for what value of R_L maxm power transfer.

Soln:



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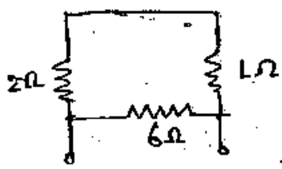

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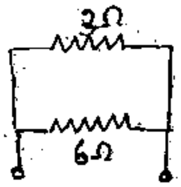
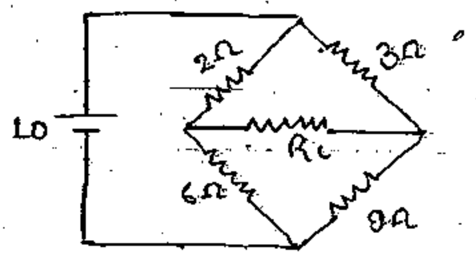


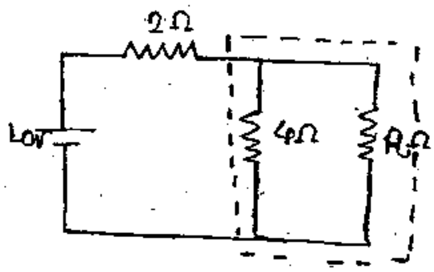
$$R_{TH} = R_L = \frac{3 \times 6}{9} = 2\Omega$$

Q. Find the value of R_L so that max^m ~~power transfer~~ to the load and also find max^m power.



Sol^n: As the bridge is balanced, no current will flow from R_L and hence power dessipation across R_L is zero.

Q - Find the value R so that max^m power is transfer.



Soln:

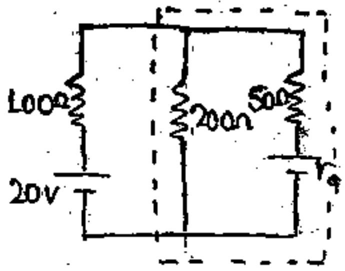
$R_L = R_{TH}$

$2 = \frac{4 \times R}{4 + R}$

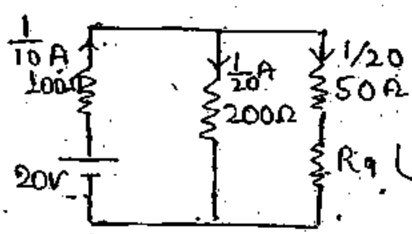
$8 + 2R = 4R$

$R = 4\,\Omega$

Q. What should be value of r_q that max^m power transfer



Soln:



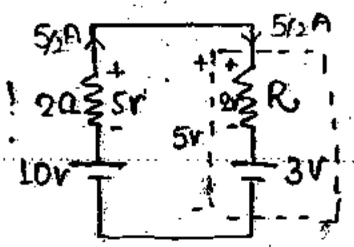
$R_L = 200 \| (50 + R_q)$

$100 = 200 \| (50 + R_q)$

$\therefore R_q = 150\Omega$

$V_q = IR_q = \frac{1}{20} \times 150 = 7.5V$

Q.



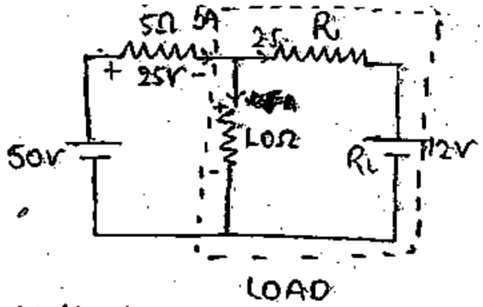
Find the value of R so that max^m power transfer

As we know $R_L = R_{TH}$

Voltage ~~across~~ R_L = Voltage across R_{TH}

Soln:

$R = \frac{2}{5/2} = \frac{4}{5} = 0.8\ \Omega$

Q. 

For what value of R max^m power transfer.

Sol^n. Method 1:

$$R_L = \frac{12}{5/2} = \frac{24}{5}\,\Omega$$

$\because$ $R + R_L = 10$

$$R = 10 - \frac{24}{5} = \frac{26}{5} = 5.2\,\Omega$$

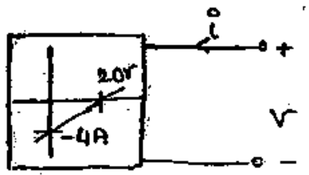
Method 2:

$$\frac{25-50}{5} + \frac{25}{10} + \frac{25-12}{R} = 0$$

$$-5 + 2.5 + \frac{13}{R} = 0$$

$$-2.5 + \frac{13}{R} = 0$$

$$R = \frac{13}{2.5} = 5.2\,\Omega$$

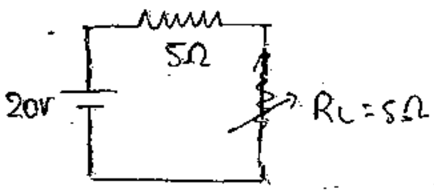
Q 

Find the max^m power that can be drawn from n/w

$V_{TH} = 20\,V$

$I = 4\,A$

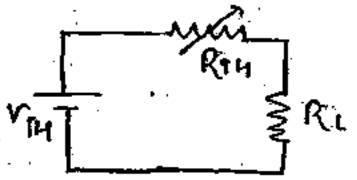
$$R_{TH} = \frac{20}{4} = 5\,\Omega$$



$$P_{max} = \frac{20^2}{4 \times 5}$$

$$= \frac{20 \times 20}{20} = 20\,W$$

Q. Proof the max^m power transfer not valid if R_{TH} is variable.



Soln: $$I = \frac{V_{TH}}{R_{TH}+R_L}$$

$$P = I^2 R_L$$

$$= \left(\frac{V_{TH}}{R_{TH}+R_L}\right)^2 R_L$$

$$\frac{dP}{dR_{TH}} = V_{TH}^2 R_L \left(\frac{-2}{(R_{TH}+R_L)^3}\right) = 0$$

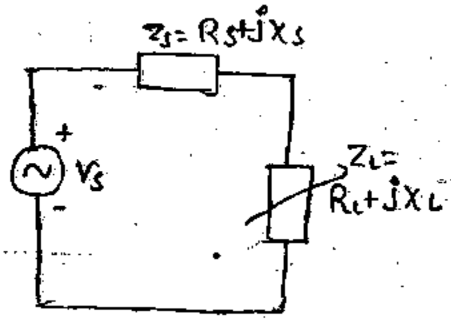
$$\boxed{R_{TH} \neq R_L}$$

MPT is not valid.

v.v.g

Max^m Power transfer (AC)

$$|I| = \frac{V_s}{\sqrt{(R_s+R_L)^2 + (X_L+X_s)^2}}$$



$$P = |I|^2 R$$

$$= \frac{V_s^2 R_L}{(R_s+R_L)^2 + (X_L+X_s)^2} \quad \text{— (1)}$$

case 1: when R_L X_L variables

$$\frac{\partial P}{\partial X_L} = V_s^2 R_L \left[\frac{-1}{(R_s+R_L)^2 + (X_s+X_L)^2}\right]^2 [0 + 2(X_s+X_L)] = 0$$

$$2(X_S + X_L) = 0$$

$$\boxed{X_L = -X_S} \quad \text{--- (2)}$$

(2) → (1)

$$P = \frac{V_S^2 \cdot R_L}{(R_S + R_L)^2}$$

$$\frac{\partial P_L}{\partial R_L} = 0$$

$$R_L = R_S$$

$$Z_L = R_L + jX_L = R_S - jX_S = Z_S^*$$

$$\boxed{Z_L = Z_S^*}$$

Note:

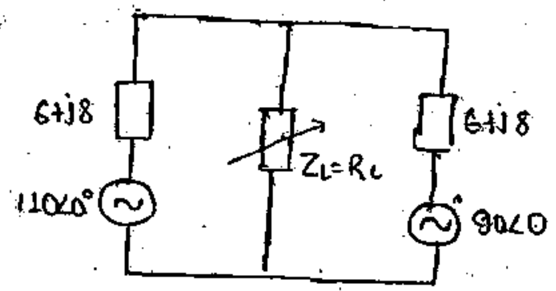
case I only R_L X_L variables (X_L is constant)

$$R_L = \sqrt{R_{TH}^2 + (X_{TH} + X_L)^2}$$

case II when load impedence is only resistive

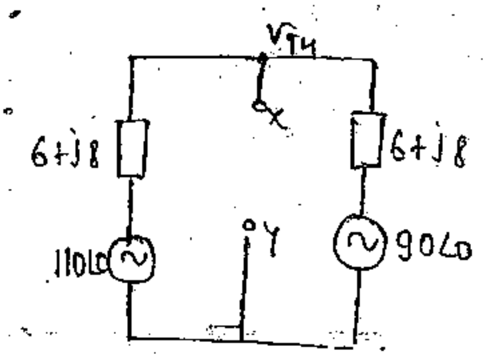
$$R_L = \sqrt{R_{TH}^2 + X_{TH}^2}$$

Q.



Find max^m power dessipation in load impedence.

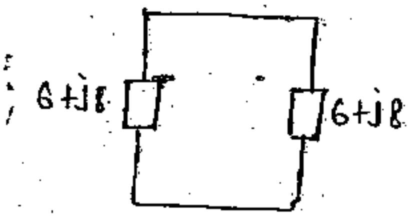
Soln:



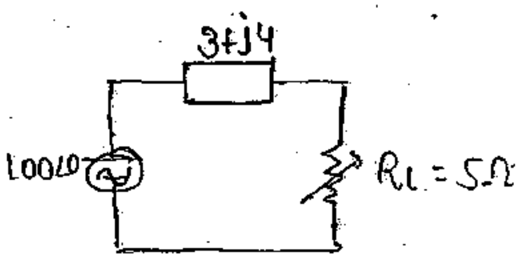
$$\frac{V_{TH} - 110\angle 0}{6+j8} + \frac{V_{TH} - 90\angle 0}{6+j8} = 0$$

$$2V_{TH} = 200\angle 0$$

$$V_{TH} = 100\angle 0$$



$Z_{TH} = 3+j4$



$$R_L = \sqrt{3^2+4^2} = 5$$

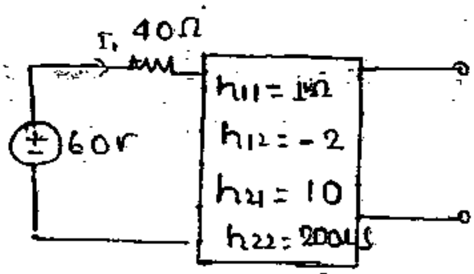
$$|I| = \frac{100\angle 0}{8+j4} = \frac{25\angle 0}{2+j}$$

$P = |I|^2 R_L$

$$= \left(\frac{25}{\sqrt{2^2+1}}\right)^2 \cdot 5$$

$$= \frac{25 \times 25}{\cancel{5}} \times \cancel{5} = 625W$$

Determine the thevenin equivalent at O/P port of crt?



Soln:

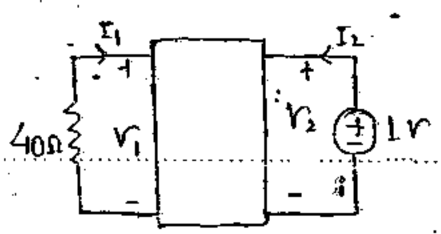
$\cancel{V_1 = 1k\Omega I_1 + -2V_2}$

$\cancel{V_2 = 10 I_1 + 200\mu S V_2}$

$V_1 = h_{11}I_1 + h_{12}V_2$

$I_2 = h_{21}I_1 + h_{22}V_2$

case Z_{TH}



$V_1 = -40I_1 \qquad V_2 = 1V$

$-40I_1 = h_{11}I_1 + h_{12}$

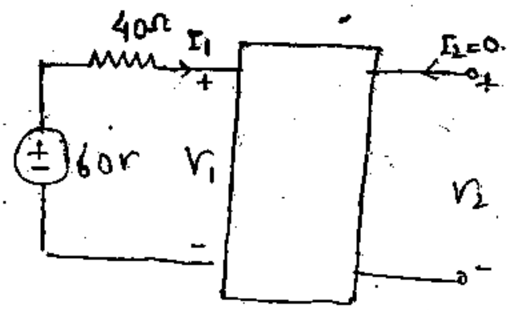
$$I_1 = \frac{-h_{12}}{-(40+h_{11})}$$

$$I_2 = h_{21}\left(\frac{-h_{12}}{40+h_{11}}\right) + h_{22} \times 1$$

$$Z_{TH} = \frac{V_2}{-I_2} = \frac{1}{I_2}$$

$$Z_{TH} = 51.46\,\Omega$$

Case 2: V_{TH}



$$I_2 = 0$$

$$60 = 40I_1 + V_1$$

$$60 = 40I_1 + h_{11}I_1 + h_{12}V_2$$

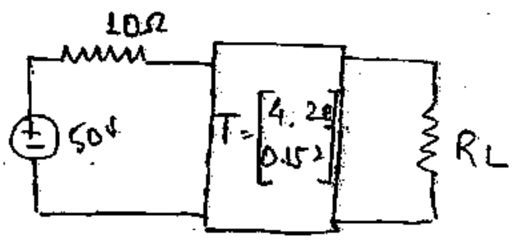
$$h_{12}V_2 = (60) + (-40 - h_{11})I_1$$

$$0 = h_{21}I_1 + h_{22}V_2$$

$$I_1 = -\frac{h_{22}}{h_{21}}V_2$$

$$V_2 = V_{TH} = -29.69\,V.$$

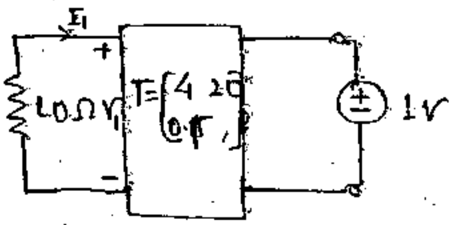
Q. Find the maxm power that can be transfer to the load.



$$V_1 = AV_2 - BI_2$$

$$I_1 = CV_2 - DI_2$$

~~Sol^n: Case~~ R_{TH} —



~~$V_1 = -10I_1$~~ ~~$V_2 = 1V$~~

$V_1 = 4V_2 - 20I_2$ — (1)

$I_1 = 0.1V_2 - 2I_2$ — (2)

~~$-10I_1 = 4V_2 - 20I_2$~~

~~$-10I_1 = 4 - 20I_2$~~

~~$I_1 =$~~

$V_1 = -10I_1$

$V_1 = -10(0.1V_2 - 2I_2)$

$V_1 = -V_2 + 20I_2$ — (3)

(3) → (1),

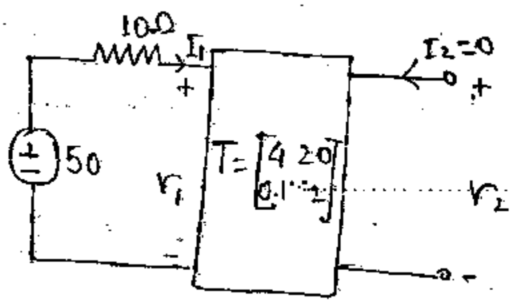
$-V_2 + 20I_2 = 4V_2 - 20I_2$

$40I_2 = 5V_2$

$\frac{V_2}{I_2} = \frac{40}{5} = 8\Omega$

$Z_{TH} = 8\Omega$

Case V_{TH}



$I_2 = 0$

$50 = 10I_1 + V_1$ — (1)

$V_1 = 4V_2 - 20I_2$

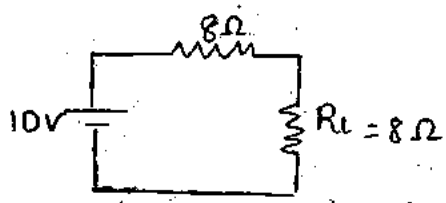
$V_1 = 4V_2$

$50 = 10I_1 + 4V_2$

$50 = 10I_1 + 4V_2$

$50 = 10(0.1)V_2 + 4V_2$

$V_{TH} = 10V$.

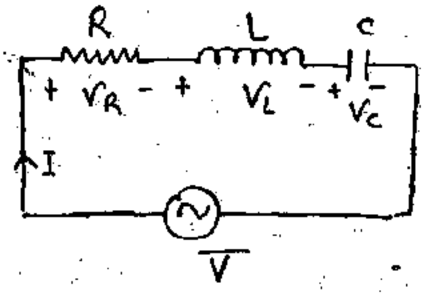


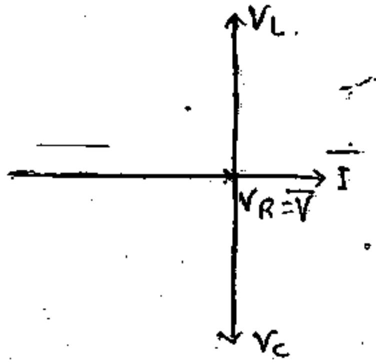
Maxm power transfer $R_L = R_{TH}$

$$P_{max} = \frac{10^2}{4 \times 8} = \frac{100}{4 \times 8} = \frac{100}{32} = 3.125W$$

Zero state response :-

RESONANCE :





At Resonance

$V_C = V_L$

$IX_L = IX_C$

$$\boxed{X_L = X_C}$$

$$\omega_0 L = \frac{1}{\omega_0 C}$$

$$\omega_0^2 = \frac{1}{LC} \Rightarrow \boxed{\omega_0 = \frac{1}{\sqrt{LC}} \text{ rad/sec}}$$

$$\boxed{f_0 = \frac{1}{2\pi\sqrt{LC}} \text{ Hz}}$$

- Incase of Resonance voltage across L and C is zero there phase difference is opposite so cancel each other.

At Resonance

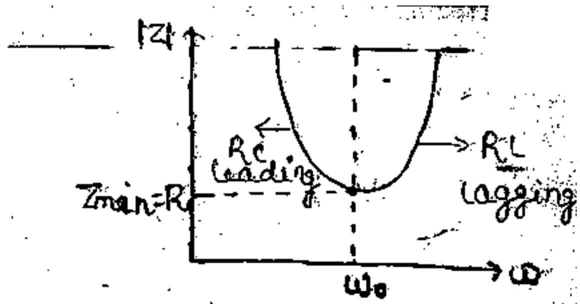
$$\boxed{Z = R}$$

- For occurance of Resonance in any system, two energy are required. In an electrical system these two energy provided by L & C in the form magnetic & electrical field.
- The ckt is said to be resonance, when $\bar{V}$ and $\bar{I}$ are in phase.
- It indicates, the rate at which energy transformation takes place b/w L & C.

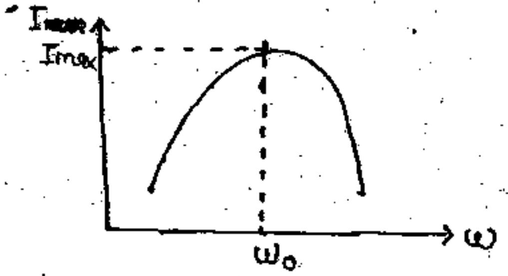
(1) $Z = R + j(X_L - X_C)$

$= R + j\left(\omega L - \frac{1}{\omega C}\right)$

$|Z| = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$

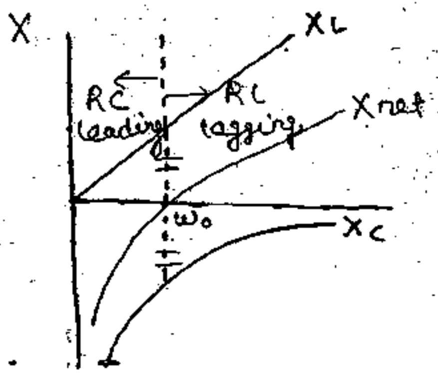


(2) $I = \frac{V}{|Z|}$



(3) $X_L = \omega L$ $\quad X_C = \frac{1}{\omega C}$

$X_{net} = X_L - X_C = \omega L - \frac{1}{\omega C}$



For $\omega < \omega_0$

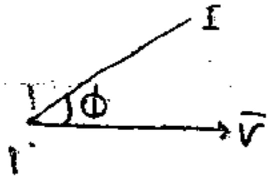
$Z = R - jX_C$

For: $\omega = \omega_0$

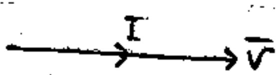
$Z = R$

For $\omega > \omega_0$

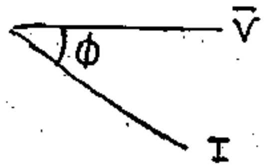
$Z = R + jX_L$



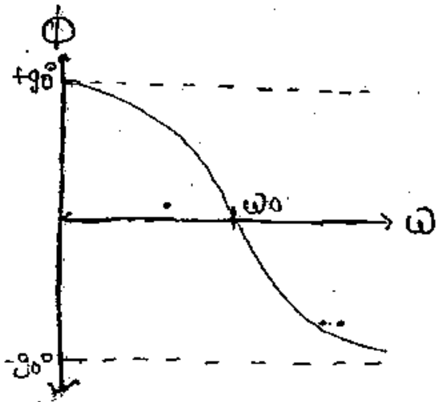
$\cos\phi$ = leading



$\cos\phi = 1$



$\cos\phi$ = lagging



Form the graph we conclude following points:

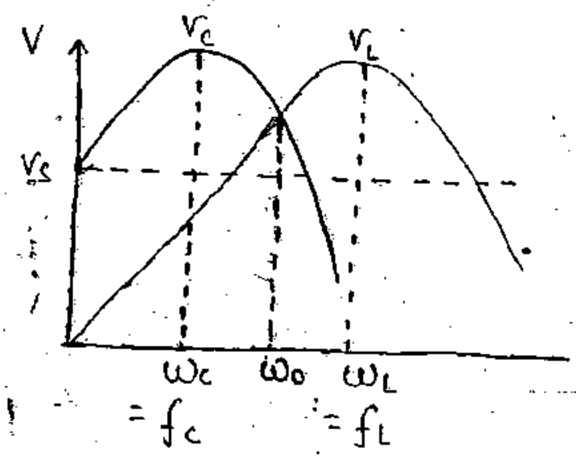
1. For $\omega < \omega_0$, the capacitive reactance is higher than X_L — ie $X_C > X_L$. therefore net reactance is capacitance in nature. hence I lead's applied voltage V and give leading P.F.

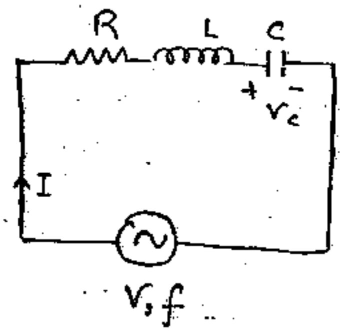
2. At $\omega = \omega_0$, $X_L = X_C$ and hence $Z_{min} = R$, the I and $\bar{V}$ are in phase hence $\cos\phi = 1$.

3. For $\omega > \omega_0$, $X_L > X_C$ therefore net reactance is inductive in nature and current I lags the applied voltage V and giving lagging P.F.

N.B At Resonance Reactive power is zero.

$\boxed{Z = R}$





$$I = \frac{V}{Z} \quad ; \; Z = R + j(X_L - X_C)$$

$Z = \cancel{I \times X_L}$

$$I = \frac{V}{R + j(X_L - X_C)}$$

$$|I| = \frac{V}{\sqrt{R^2 + (\omega L - \frac{1}{\omega C})^2}}$$

$$V_C = I \cdot X_C$$

$$V_C = \frac{V \cdot X_C}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}}$$

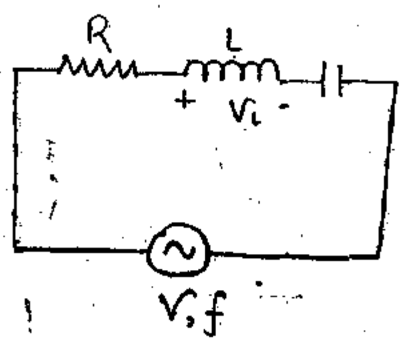
$$V_C = \frac{V}{\omega C \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}}$$

since V_C is changes with ω. hence

$$\frac{dV_C}{d\omega} = 0$$

$$\boxed{f_C = \frac{1}{2\pi\sqrt{LC}} \sqrt{1 - \frac{R^2 C}{2L}}}$$

N.B. At resonance, ie $\omega = \omega_0$, V_L and V_C is equal and may be greater than V_S. It may be happenen – $V_L = V_C = V_S$ which depends upon quality factor.



$$I = \frac{V}{Z}$$

$$Z = R + j(X_L - X_C)$$

$$|I| = \frac{V}{R + j(X_L - X_C)} = \frac{V}{R + j\left(\omega L - \frac{1}{\omega C}\right)^2}$$

$$V_L = I \cdot X_L$$

$$= \frac{V \cdot X_L}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}} = \frac{V \cdot \omega L}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}}$$

$$\frac{dV_L}{d\omega} = 0$$

$$\boxed{f_L = \frac{1}{2\pi\sqrt{LC}} \sqrt{\frac{1}{1 - \frac{RC}{2L}}}}$$

$$\boxed{f_C < f_0 < f_L}$$

f_C = frequency at which V_C is max^m

f_L = frequency at which V_L is max^m

f_0 = Resonant frequency.

Quality factor:

Quality factor is the ratio of the max^m energy stored in the crt to the energy dessipated in crt in one time period.

$$Q = 2\pi \times \frac{\text{Max}^m \text{ energy stored in ckt}}{\text{Energy dissipated percycle of sec.}}$$

Let

$$I(t) = i_m \sin\omega t$$

$$W_S = \frac{1}{2} L i^2 + \frac{1}{2} C V_C^2$$

$$V_C = \frac{1}{C}\int i\,dt$$

$$= \frac{1}{C}\int i_m \sin\omega t\,dt$$

$$V_C = -\frac{i_m}{C\omega}\cos\omega t$$

$$W_S = \frac{1}{2} L\, i_m^2 \sin^2\omega t + \frac{1}{2} C \cdot \frac{i_m^2}{\omega^2 C^2}\cos^2\omega t$$

$$W_S = \frac{1}{2} L\, i_m^2 \sin^2\omega t + \frac{1}{2}\frac{i_m^2}{\omega^2 C}\cos^2\omega t$$

$\because \omega = \frac{1}{\sqrt{LC}} \Rightarrow L = \frac{1}{\omega^2 C}$

$$W_s = \frac{1}{2} L i_m^2 \sin^2 \omega t + \frac{1}{2} L i_m^2 \cos^2 \omega t$$

$$\boxed{W_s = \frac{1}{2} L i_m^2}$$

$$Q = 2\pi \cdot \frac{\frac{1}{2} L i_m^2}{\left(\frac{i_m}{\sqrt{2}}\right)^2 R \cdot \frac{1}{f}}$$

$$\boxed{Q = \omega \cdot \frac{L}{R}} = \frac{1}{R} \frac{L}{\sqrt{LC}}$$

$$\boxed{Q = \frac{1}{R}\sqrt{\frac{L}{C}}}$$

$$Q = \frac{\omega L}{R} = \frac{X_L}{R} = \frac{I X_L}{I R} = \frac{V_L}{V_R}$$

At Resonance $V_L = V_C$

$$Q = \frac{V_C}{V_R} = \frac{\cancel{I} X_C}{\cancel{I} R} = \frac{1}{\omega R C}$$

$$\boxed{Q = \frac{\omega L}{R} = \frac{1}{\omega R C}}$$

$$\boxed{Q = \frac{\text{Reactive component of voltage}}{\text{Active component of voltage}}}$$

At $\omega = \omega_0$.

(1) $V_R = I_R \cdot R = I \cdot R = \frac{V}{R} \cdot R = V$ $\boxed{V_R = V}$

(2) $V_C = -jX_C \cdot I_C = -jX_C \cdot I = -j\left(\frac{1}{\omega RC}\right)V = -j\underbrace{Q}V$

(3) $V_L = jX_L \cdot I_L = j\left(\frac{\omega L}{R}\right)V = j\overbrace{Q}V$ → Amplifaction factor

$V = V_R + V_C + V_L$

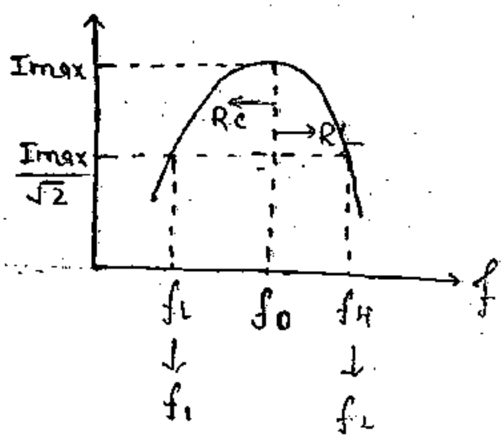
$V = V_R + \cancel{jQV} - \cancel{jQV}$

$\boxed{V = V_R}$ at $\omega = \omega_0$

BANDWIDTH:

Bandwidth represent the range of freq. for which power level is at least half of the max^m power.

$$\boxed{Q = \frac{\omega_0}{B.W}}$$



$f_0 \rightarrow I = I_{max}$ $Z = R$

$f_1 f_2 \rightarrow I = \frac{I_{max}}{\sqrt{2}}$ $Z = \sqrt{2}R$

$Z = R + jx$

$\sqrt{R^2 + x^2} = \sqrt{2}R^2$

$R^2 + x^2 = 2R^2$

$$R^2 = X^2$$

$$\boxed{X = \pm R}$$

At f_1 $\quad Z_1 = R - jR$

At f_2 $\quad Z_2 = R + jR$

$$\omega_1 L - \frac{1}{\omega_1 C} = -R \quad (1)$$

$$\omega_2 L - \frac{1}{\omega_2 C} = +R \quad (2)$$

(1) + (2)

$$L(\omega_1 + \omega_2) - \frac{1}{C}\left(\frac{1}{\omega_1} + \frac{1}{\omega_2}\right) = 0$$

$$L(\omega_1 + \omega_2) - \frac{1}{C}\left(\frac{\omega_1 + \omega_2}{\omega_1 \omega_2}\right) = 0$$

$$L - \frac{1}{C\omega_1\omega_2} = 0$$

$$L = \frac{1}{C\omega_1\omega_2}$$

$$\omega_1\omega_2 = \frac{1}{LC}$$

$$\boxed{\begin{array}{c} \omega_1\omega_2 = \omega_0^2 \\ \omega_0 = \sqrt{\omega_1\omega_2} \end{array}}$$

(1) − (2)

$$L(\omega_1 - \omega_2) + \frac{1}{C}\left(\frac{1}{\omega_2} - \frac{1}{\omega_1}\right) = 2R$$

$$L(\omega_2 - \omega_1) + \frac{1}{C}\left(\frac{1}{\omega_1} - \frac{1}{\omega_2}\right) = 2R$$

$$L(\omega_2 - \omega_1) + \frac{1}{C}\left(\frac{\omega_2 - \omega_1}{\omega_1\omega_2}\right) = 2R$$

$$(\omega_2 - \omega_1)\left(L + \frac{1}{C\omega_1\omega_2}\right) = 2R$$

$$(\omega_2-\omega_1)\left[L+\frac{1}{C\cdot\frac{1}{LC}}\right]=2R$$

$$(\omega_2-\omega_1)(2L)=2R$$

$$\boxed{\omega_2-\omega_1=\frac{R}{L}}$$ rad/sec

Where $\omega_2-\omega_1 = B.W$

$$B.W=\frac{R}{L}$$

As we know $Q=\omega\frac{L}{R}$

$$\therefore \frac{R}{L}=\frac{\omega}{Q}$$

$$\boxed{Q=\frac{\omega_0}{B.W}}$$

$$\boxed{\begin{aligned}\omega_1&=\omega_0-\frac{B.W}{2}\\ \omega_2&=\omega_0+\frac{B.W}{2}\end{aligned}}$$ Q-high

Q>>>7

*"For higher value of Q it consider as Resonant frequency is equal to arthemetic mean of the corner frequency".

$$\omega_1+\omega_2=2\omega_0$$

$$\boxed{\omega_0=\frac{\omega_1+\omega_2}{2}}$$

$\therefore \omega_0^2 = \omega_1 \omega_2$

$$\boxed{\omega_2 - \omega_1 = \frac{R}{L} = B.W} \text{ --- } (\alpha)$$

$\because (\omega_2+\omega_1)^2 - (\omega_2-\omega_1)^2 = 4\omega_1\omega_2$

$$\boxed{\omega_2 + \omega_1 = \sqrt{(\omega_2-\omega_1)^2 + 4\omega_1\omega_2}} \text{ --- } (\beta)$$

Solving α and β we get ω_1 and ω_2.

Objectives

(1) w.r.t $\omega = \omega_1$ $\quad Z_1 = R - jR$ (capacitive in nature)

$\theta_1 = \tan^{-1} \frac{-R}{R}$

$\theta_1 = -45^\circ$

$\cos\theta_1 = \frac{1}{\sqrt{2}} = 0.707$ (leading)

(2) w.r.t $\omega = \omega_2$ $\quad Z_2 = R + jR$ (inductive in nature)

$\theta_2 = \tan^{-1} \frac{R}{R}$

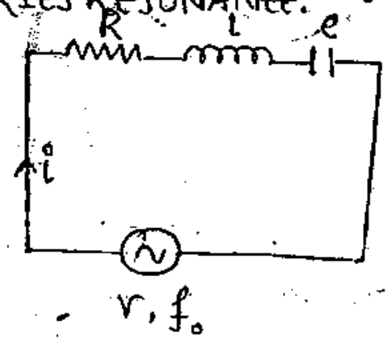
$\theta_2 = 45^\circ$

$\cos\theta_2 = \frac{1}{\sqrt{2}} = 0.707$ (lagging)

N.B. (1) If P.F angle is opposite to impedence angle then P.F is leading

(2) If P.F angle is same as impedence angle then P.F is lagging.

SERIES RESONANCE:



$$v = iR + L\frac{di}{dt} + \frac{1}{C}\int i\,dt$$

$$\frac{dv}{dt} = R\frac{di}{dt} + L\frac{d^2i}{dt^2} + \frac{i}{C}$$

$$\frac{d^2i}{dt^2} + \frac{R}{L}\frac{di}{dt} + \frac{i}{LC} = \frac{1}{L}\frac{dv}{dt}$$

characteristic eqn

$$s^2 + \underbrace{\frac{R}{L}}_{B\omega\ rad/sec} s + \underbrace{\frac{1}{LC}}_{\omega_n^2} = 0$$

$$s^2 + 2\xi\omega_n s + \omega_n^2 = 0$$

$$\boxed{\omega_n = \frac{1}{\sqrt{LC}}}$$

$$2\xi\omega_n = \frac{R}{L}$$

$$\xi = \frac{R}{2L}\cdot\frac{1}{\omega_n}$$

$$\xi = \frac{R}{2L}\cdot\sqrt{LC}$$

$$\boxed{\xi = \frac{R}{2}\sqrt{\frac{C}{L}}} \quad \text{or} \quad \boxed{\xi = \frac{1}{2Q}}$$

objectives

$R\uparrow$ $\quad B.W = \frac{R\uparrow}{L}$ $\quad Q\downarrow$ $\quad f_1\downarrow$ $\quad f_2\uparrow$ (At resonance)

$$\boxed{\text{Losses} \propto \frac{1}{Q}}$$

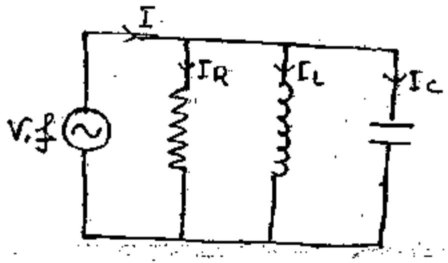
$$Q = \frac{V_L \text{ or } V_C}{V_R} = \frac{V_L \text{ or } V_C}{V_R} > 1$$

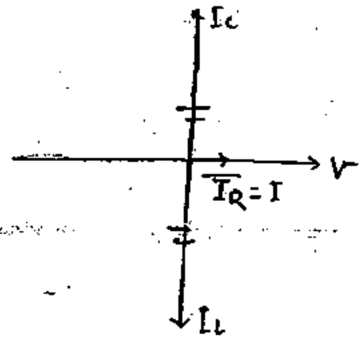
$\therefore Q = \frac{X_L \text{ or } X_C}{R} > 1$

interview question

$X_L > R$ } condition for
$X_C > R$ } Series resonance

|| Resonance crt:-





$I = I_R + I_L + I_C$

$$\frac{V}{Z} = \frac{V}{R} + \frac{V}{jX_L} + \frac{V}{-jX_C}$$

$$Y = G + j(B_C - B_L)$$

At $\omega = \omega_0$

$$B_C = B_L$$

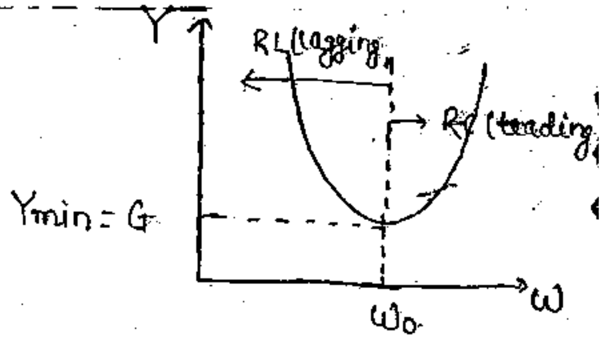
$$\omega_0 C = \frac{1}{\omega_0 L}$$

$$\boxed{\omega_0 = \frac{1}{\sqrt{LC}}} \text{ rad/sec} \qquad \boxed{f_0 = \frac{1}{2\pi\sqrt{LC}} \text{ HZ}}$$

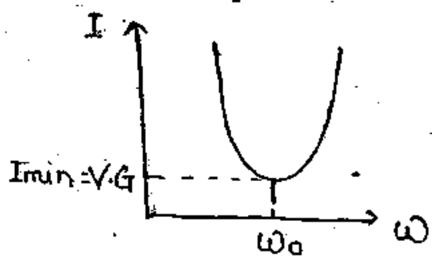
(1) $Y = G + j(B_C - B_L)$

$Y = G + j\left(\omega C - \frac{1}{\omega L}\right)$

$|Y| = \sqrt{G^2 + \left(\omega C - \frac{1}{\omega L}\right)^2}$

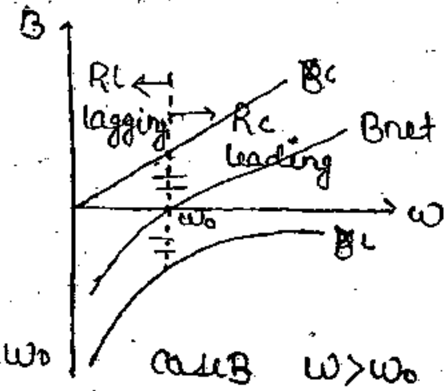


(2) $I = \frac{V}{|Z|} = V|Y|$



(3) $B_{net} = B_C - B_L = \omega C - \frac{1}{\omega L}$

$B_C = \omega C$ $\quad B_L = \frac{1}{\omega L}$



~~case~~ 1 $\omega < \omega_0$

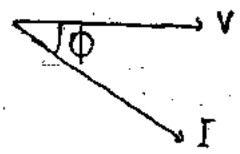
$Y = G - jB$

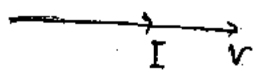
Case 2: $\omega = \omega_0$

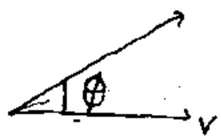
$Y = G$

case 3 $\omega > \omega_0$

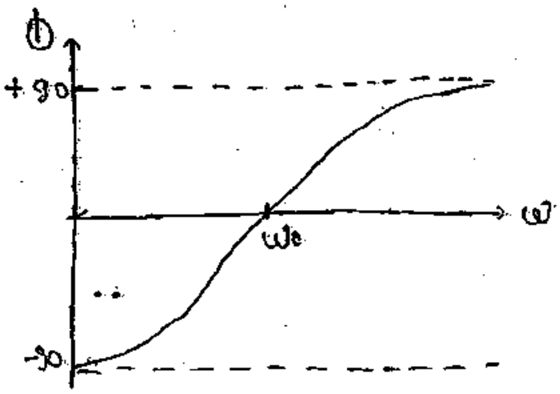
$Y = G + jB$







$\cos\phi$ = lagging. $\quad \cos\phi = 1$ $\quad \cos\phi$ = leading



$$Q = \frac{\text{Reactive component of current}}{\text{Active component of current}}$$

$$Q = \frac{I_L \text{ or } I_C}{I_R} = \frac{\frac{V}{X_L} \text{ or } \frac{V}{X_C}}{V/R}$$

$$Q = \frac{R}{X_L} \text{ or } \frac{R}{X_C}$$

$$\boxed{Q = \frac{R}{\omega L} \qquad Q = \omega R C}$$

$$Q = \frac{R}{L} \cdot \sqrt{LC}$$

$$\boxed{Q = R \cdot \sqrt{\frac{C}{L}}}$$

At $\omega = \omega_0$

$$I_R = V_R \cdot G = G \cdot V = \left(\frac{IR}{R}\right) G = I$$

$$I_L = -jB_L V_L = -jB_L \cdot V = -j\frac{1}{\omega C} \cdot IR = -j\left(\frac{R}{\omega C}\right) I = -j\underbrace{Q}_{}I$$

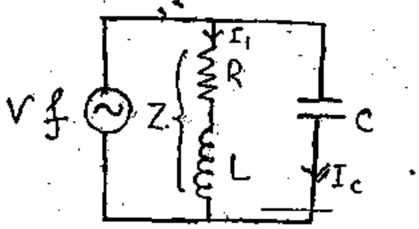
$$I_C = jB_C V_C = jB_C V = j(\omega CR)I = jQI$$

→ Amplification factor

$$I = I_R + I_L + I_C = I_R - jQI + jQI = I_R$$

$\boxed{I = I_R}$ at $\omega = \omega_0$

→ Practical tank crt :-



$$Y = Y_1 + Y_2$$

$$= R + jB_L + jB_C$$

$$= \cancel{R} \; R + j(B_C - B_L)$$

At $\omega = \omega_0$

$$B_L = B_C$$

$$\frac{X_L}{R^2 + X_L^2} = \frac{1}{X_C}$$

$$R^2 + X_L^2 = X_L X_C$$

$$\Rightarrow \quad R^2 + \omega^2 L^2 = \omega L \cdot \frac{1}{\omega C}$$

$$\Rightarrow \quad R^2 + \omega^2 L^2 = \frac{L}{C}$$

$$\Rightarrow \quad \omega^2 L^2 = \frac{L}{C} - R^2$$

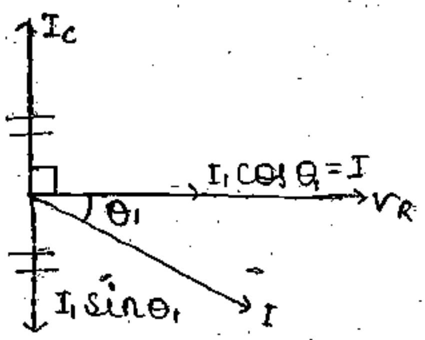
$$\Rightarrow \quad \omega^2 = \frac{1}{LC} - \frac{R^2}{L^2}$$

$$\Rightarrow \quad \omega = \sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$$

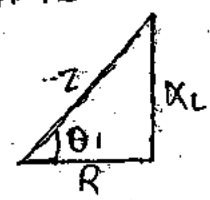
$$f = \frac{1}{2\pi} \sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$$

$$\boxed{f = \frac{1}{2\pi\sqrt{LC}} \sqrt{1 - \frac{R^2 C}{L}}}$$

Calculation of ~~Zoy By tank~~ crt:



~~At re~~



$\tan\theta_1 = \frac{X_L}{R}$

$\cos\theta_1 = \frac{R}{Z_1}$

$\sin\theta = \frac{X_L}{Z_1}$

At Resonance frequency $\omega = \omega_0$

$I_C = I_1 \sin\theta$

$\frac{V}{X_C} = \frac{V}{Z_1} \cdot \frac{X_L}{Z_1}$

$Z_1^2 = X_L \cdot X_C = \omega L \cdot \frac{1}{\omega C}$

$\boxed{Z_1 = \sqrt{\frac{L}{C}}}$

$I = I_1 \cos\theta$

$I = \frac{V}{Z_1} \cdot \frac{R}{Z_1}$

$\frac{V}{I} = \frac{Z_1^2}{R} = \frac{L}{CR}$

$\boxed{Z_{Dy} = \frac{L}{RC}}$

* Zoy is the impedence feels by tank crt at Resonance frequency $(\omega = \omega_0)$.*

Calculation of Quality factor or Q-factor

$$Q = \frac{I_c}{I} \text{ or } \frac{I_1 \sin\theta_1}{I}$$

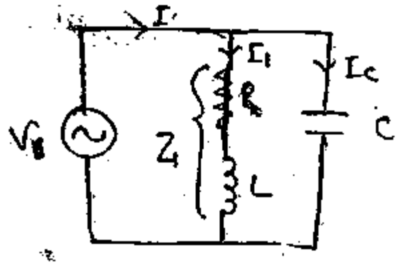
$$= \frac{V/X_C}{V/Z_{DY}} \text{ or } \frac{\frac{V}{Z_1}\cdot\frac{X_L}{Z_1}}{V/Z_{DY}}$$

$$= \frac{Z_{DY}}{X_C} \text{ or } \frac{Z_D X_L}{Z_1^2}$$

$$\boxed{Q = \frac{\omega L}{R}}$$

objectives

Ideal tank crt :- (R = 0)

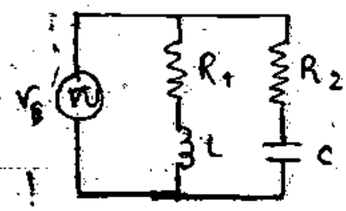


At $\omega = \omega_0$

$$\boxed{Z_{DY} = \infty}$$

* tank crt acts as open crt *

ie there is no current flow through crt



$$Y = Y_1 + Y_2$$

$$= (G_1 + G_2) + j(B_C - B_L)$$

At Resonance $\omega = \omega_0$

$$B_C = B_L$$

$$\frac{X_C}{R^2 + X_C^2} = \frac{X_L}{R^2 + X_L^2}$$

$$\boxed{f = \frac{1}{2\pi\sqrt{LC}}\sqrt{\frac{R_1^2 - L/C}{R_2^2 - L/C}}}$$

This crt ~~is~~ is in ~~resonance at any frequency~~

when $\boxed{R_1^2 = R_2^2 = L/C}$

$$\frac{1/\omega C}{\frac{L}{C} + \frac{1}{\omega^2 C^2}} = \frac{\omega L}{\frac{L}{C} + \omega^2 L^2}$$

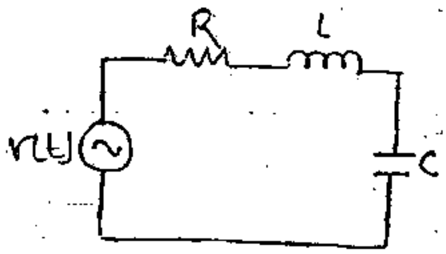
$$\boxed{\frac{1}{\omega L + \frac{1}{\omega C}} = \frac{\omega L}{\omega L + \frac{1}{\omega C}}}$$

Q. In the given crt.

(a) ω_0 and Half power frequency,

(b) B.W and Q- factor,

(c) Amplitude of current at $\omega = \omega_0$ and Half power frequency :



$v(t) = 20 \sin \omega t$

$R = 2\Omega \quad L = 1mH$

$C = 0.4\mu F$.

Sol^n. (a) $\omega_n = \omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{0.4 \times 10^{-6} \times 1 \times 10^{-3}}} = \frac{1}{\sqrt{4 \times 10^{-10}}}$

$= \frac{1}{2 \times 10^{-4}} = \frac{10^5}{2} = 50K\ Rad/sec$

(b) $B.W = \frac{R}{L} = \frac{2}{1 \times 10^{-3}} = 2000 = 2K\ rad/sec$

$Q = \frac{\omega L}{R} = \frac{\omega_0}{B\omega} = \frac{50}{2} = 25$

(a) for Half power frequency

At $Z_1 = \sqrt{2} R$ $\omega_1 \omega_2$

$$\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2} = \sqrt{2} R$$

$$\omega_1 = -\frac{R}{2L} + \sqrt{\left(\frac{R}{2L}\right)^2 + \frac{1}{LC}}$$

$$\omega_2 = +\frac{R}{2L} + \sqrt{\left(\frac{R}{2L}\right)^2 + \frac{1}{LC}}$$

(b) $\omega_1 = \omega_0 - \frac{B.\omega}{2} = 50 - 1 = 49K \text{ rad/sec}$

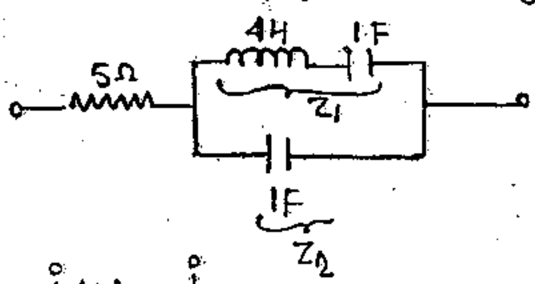
$\omega_2 = \omega_0 + \frac{B\omega}{2} = 50+1 = 51 K \text{ rad/sec}$

this is valid when $Q \geq 7$

(c) $I\omega_0 = \frac{V}{R} = \frac{20}{2} = 10 A$

$I\omega_1 \omega_2 = \frac{V}{\sqrt{2} R} = \frac{20}{\sqrt{2} \times 2} = \frac{10}{\sqrt{2}} = 7.07 A$

Q. Find the Resonant frequency of the given crt:



Soln. $Z_1 = j4\omega - \frac{j}{\omega} =$

$Z_2 = \frac{-j}{\omega}$

$Z_{eq} = Z_1 \| Z_2$

$= j\left(4\omega - \frac{1}{\omega}\right) \| -j/\omega$

$$Z_{eq} = \frac{\left(j4\omega - j/\omega\right) \cdot -j/\omega}{j4\omega - \frac{j}{\omega} - \frac{j}{\omega}}$$

$$Z_{eq} = \frac{j(1-4\omega^2)}{\omega^2(4\omega - 2)}$$

$\bar{Z} = 5 + Z_{eq}$

$$= 5 + j\frac{(1-4\omega^2)}{\omega^2(4\omega-2)}$$

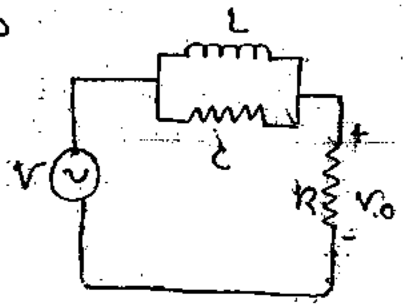
ω_0 $\quad 1 - 4\omega^2 = 0$

$$\omega^2 = \frac{1}{4}$$

$$\omega = \frac{1}{2} = 0.5 \text{ rad/sec}$$

Q. Find the v_0 from the crt at $\omega = \omega_0$ of tank crt.

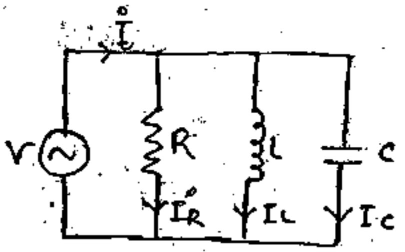
(a) v (b) $v/2$ (c) 0 (d) ∞



Ans $V_0 = 0$ because $R = 0$

$$Z_{0y} = \frac{L}{CR} = \infty$$

|| RLC ckt:



$$i = I_R + I_L + I_C$$

$$= \cancel{\frac{v}{R}} + L\cancel{\frac{di}{dt}} + \cancel{\frac{1}{C}}\int i\,dt + \cancel{\frac{dv}{dt}}$$

$$\cancel{\frac{di}{dt}} = \cancel{\frac{1}{R}\frac{dv}{dt}} + \cancel{L\frac{d^2 i}{dt^2}} + \cancel{\frac{i}{C}}$$

$$i = \frac{v}{R} + \frac{1}{L}\int v\,dt + C\frac{dv}{dt}$$

$$\frac{di}{dt} = \frac{1}{R}\frac{dv}{dt} + \frac{v}{L} + C\frac{d^2v}{dt^2}$$

$$\frac{1}{C}\frac{di}{dt} = \frac{1}{RC}\frac{dv}{dt} + \frac{v}{LC} + \frac{d^2v}{dt^2}$$

$$S^2 + \frac{1}{RC}S + \frac{1}{LC} = 0$$

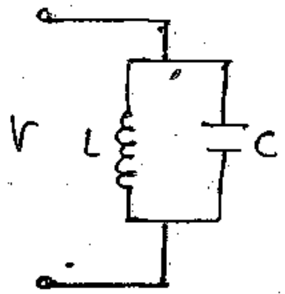
compair with $S^2 + 2\xi\omega_n S + \omega_n^2 = 0$

$$2\xi\omega_n = \frac{1}{RC} \quad ; \quad \omega_n = \frac{1}{\sqrt{LC}} \text{ rad/sec}$$

$$\xi = \frac{1}{2\omega_n}\frac{1}{RC}$$

$$\boxed{\xi = \frac{1}{2R}\sqrt{\frac{L}{C}}} \quad \text{or} \quad \boxed{\xi = \frac{1}{2Q}}$$

Q. In the given tank crt the circulating current at Resonance will be equal to



(a) $\frac{VC}{L}$

(b) $V\sqrt{\frac{C}{L}}$

(c) $V\sqrt{\frac{L}{C}}$

(d) 0.

Soln: $I = \frac{V}{X_L}$

$= \frac{V}{\omega L}$

$= \frac{V}{\frac{L}{\sqrt{LC}}} = V\sqrt{\frac{C}{L}}$ Ans

Q Page 7, 29, 32

W.B Page 9:

Q46: $P = V_{rms} I_{rms} \cos\phi$

$= \frac{1}{\sqrt{2}} \cdot 1$

Page 10, 51, 50, 52

TRANSIENT PERIOD:

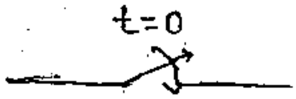
Defn:
Transient will be present in crt, when crt is subjected to any changes either by source magnitude or any crt elements provided, the crt consist of energy storage elements becoz.

(1) L doesnot allow sudden change in current and store energy in the form of ~~electrical force~~ magnetic field.

(2) C doesnot allow sudden change in voltage and store energy in the form electrical field.

(3) When crt is purely resistive, then no transient are present because resistor allow sudden change in current & voltage.

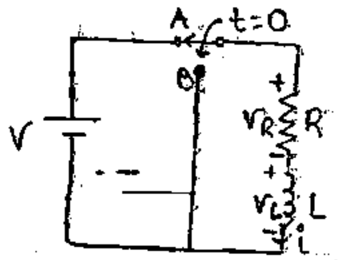
$t(0^-)$ = just before the switch operation
$t(0)$ = exact instant of switch operation
$t(0^+)$ = just after the switch operation.
$t(\infty)$ = Steady state after the switch operation



$i_L(0^-) = i_L(0) = i_L(0^+)$ [because L doesnot allow sudden change in current]

$V_C(0^-) = V_C(0) = V_C(0^+)$ [because C doesnot allow sudden change in voltage]

Source free RL crt:



In case of DC, L is short circuited

$\therefore \quad I_0 = \frac{V}{R}$

$i(0^-) = i(0) = i(0^+)$

For $t>0$

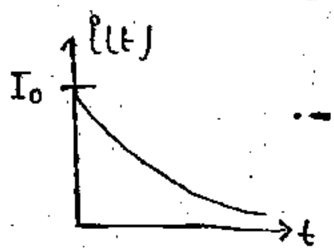
$V_R + V_L = 0$

$iR + L\frac{di}{dt} = 0$

$iR = -L\frac{di}{dt}$

$\int_0^t \frac{-R}{L}\,dt = \int_{I_0}^{i(t)} \frac{1}{i}\,di$

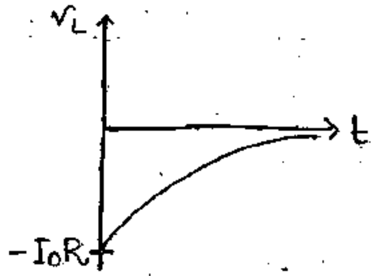
$$\boxed{i(t) = I_0 e^{-R/L\, t}}$$



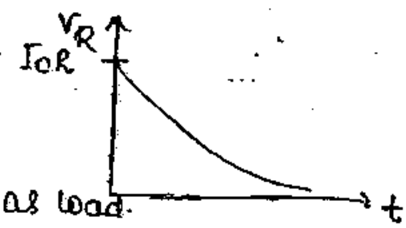
$V_L = L\frac{di}{dt}$

$= L I_0 e^{-\frac{R}{L}t}\left(-\frac{R}{L}\right)$

$$\boxed{V_L = -I_0 R e^{-\frac{R}{L}t}}$$



$$\boxed{V_R = I_0 R e^{-\frac{R}{L}t}}$$



N.B: • During charging L acts as load.
• During discharging L acts as source.

• In discharging L, the current dirⁿ does not change but polarity of voltage across the L changes

Proof. ~~IES~~ The amount of energy lost by inductor is same as the amount of energy dessipated in inducto Resistor?

Soln. $W_L(t) = \frac{1}{2} L i^2(t)$

$= \frac{1}{2} L (I_0 e^{-R/L t})^2$

$= \frac{1}{2} L I_0^2 e^{-\frac{2R}{L}t}$

$W_L(0) = \frac{1}{2} L I_0^2$

$W_L(t) = W_L(0) e^{-\frac{2R}{L}t}$ — (1)

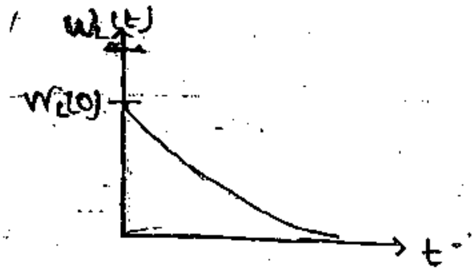
$W_R(t) = \int P dt$

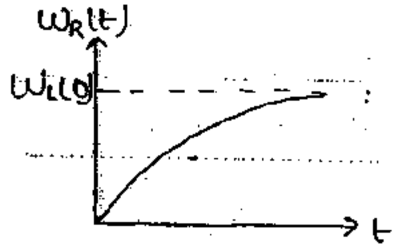
$= \int V_R(t)\, i(t) dt$

$= \int_0^t (I_0 R e^{-\frac{Rt}{L}})(I_0 e^{-\frac{Rt}{L}}) dt$

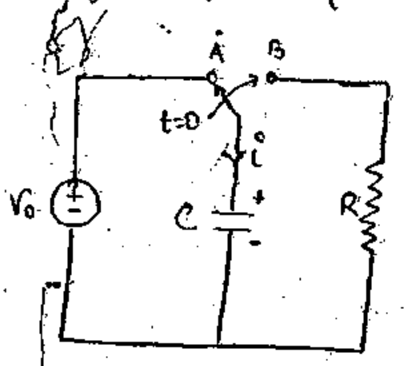
$= \dfrac{I_0^2 \cancel{R} \cdot e^{-\frac{2R}{L}t}}{-\frac{R}{L}} = \frac{1}{2} L I_0^2 (1 - e^{-\frac{2R}{L}t})$

$W_R(t) = W_L(0)(1 - e^{-\frac{2R}{L}t})$ — (2)



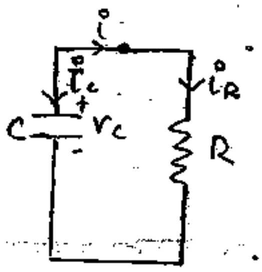


SOURCE FREE RC CIRCUIT:



$$v(0^-) = v(0) = v(0^+) = V_0$$

For $t>0$



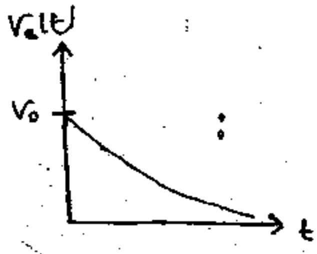
$$i_c + i_R = 0$$

$$C\frac{dv_c}{dt} + \frac{v_c}{R} = 0$$

$$-\frac{v_c}{R} = C\frac{dv_c}{dt}$$

$$-\int_0^t \frac{1}{RC}\,dt = \int_{V_0}^{v(t)} \frac{1}{v_c}\,dv_c$$

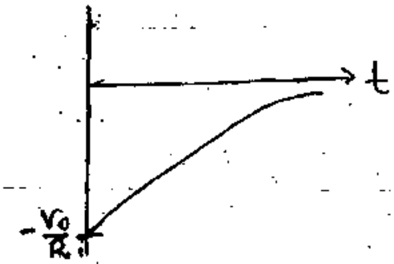
$$\boxed{v(t) = V_0 e^{-t/RC}}$$



$$i_c = C\frac{dv_c}{dt}$$

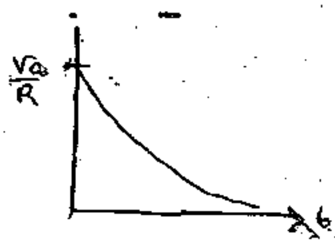
$$= C\frac{d}{dt}\left(V_0 e^{-t/RC}\right)$$

$$\boxed{i_c = \frac{-V_0}{R} e^{-t/RC}}$$



$$i_c = -i_R$$

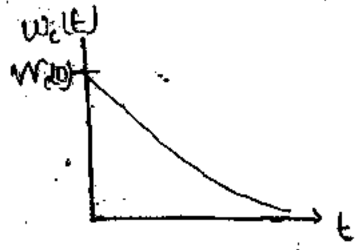
$$\boxed{i_R = \frac{V_0}{R} e^{-t/RC}}$$

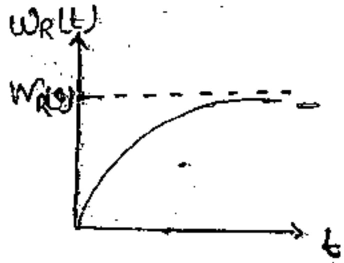


- during discharging, C acts as source.
- during charging, C acts as load.
- During discharge, the polarity of cap voltage across capacitor does not change but the ~~current~~ dirⁿ get reversed.

IES The amount of energy of capacitor is lost is same as the amount of energy dessipated in

Proof:
$$W_C(t) = \frac{1}{2} C V_C^2$$
$$= \frac{1}{2} C \left(V_0 e^{-t/RC}\right)^2$$
$$W_C(t) = \frac{1}{2} C V_0^2 e^{-2t/RC}$$
$$W_C(0) = \frac{1}{2} C V_0^2$$
$$\therefore \boxed{W_C(t) = W_C(0) e^{-2t/RC}} \quad \text{— (1)}$$
$$W_R(t) = \int_0^t P\,dt$$
$$= \int_0^t V_R(t)\, i_R(t)\,dt$$
$$= \int_0^t \left(V_0 e^{-t/RC}\right)\left(\frac{V_0}{R} e^{-t/RC}\right)dt$$
$$= \frac{1}{2} C V_0^2 \left[1 - e^{-2t/RC}\right]$$
$$\boxed{W_R(t) = W_R(0)\left[1 - e^{-2t/RC}\right]} \quad \text{— (2)}$$





Time constant:

$$e^{-at} = e^{-t/\tau} \quad \text{--- (1)}$$

$$i(t) = I_0 e^{-Rt/L}$$

$$\boxed{\tau = L/R}$$

$$i(t) = I_0 e^{-t/RC}$$

$$\boxed{\tau = RC}$$

It is the time taken by the response to reach 36.7% of its initial value while discharging or decaying.

or

It is the time taken by the response to reach 63.3% of its steady state value while charging.

$$i(t) = I_0 e^{-t/\tau}$$

$$i(\tau) = I_0 e^{-\tau/\tau}$$

$$\boxed{i(\tau) = 0.367 I_0}$$

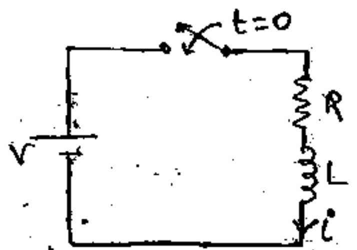
→ Total Response = Natural Response + Forced Response

Natural Response ↓ Zero i/p ↓ transient (CF)

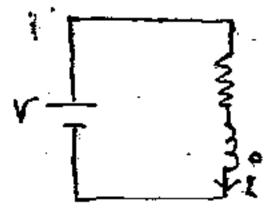
Forced Response ↓ Zero state ↓ Steady state (S.S) (PI)

1. Response of the ckt & n/w with source present in it is called forced response which leads to forced S.S response. This response independent of the nature of passive element and it only depends upon the type of i/p's. In the D.E this part found out by determining the P.I soln.

2. The response of ckt or n/w without source in it is called as Natural response which leads to transient response. this response purely depends on nature of passive element and independent from the i/p type. In the differential eqn this part found out by determing the C.F soln.



$i(0^-) = i(0^+) = 0A$



$$\frac{di}{dt} + \frac{R}{L} i = \frac{V}{R}$$

T.R = CF + PI

(1) CF -

$$\frac{di}{dt} + \frac{R}{L} i = 0$$

$$i(t)_{CF} = Ae^{-R/L\, t}$$

(2) PI -

$$i(t)_{P.I} = \frac{V}{R}$$

$$i(t) = i(t)_{CF} + i(t)_{PI}$$

$$= Ae^{-\frac{Rt}{L}} + \frac{V}{R}$$

At $t = 0$ $i = 0\,A$

$$A = (0 - V/R)$$

$$\boxed{A = [i(0^+) - i(\infty)]}$$

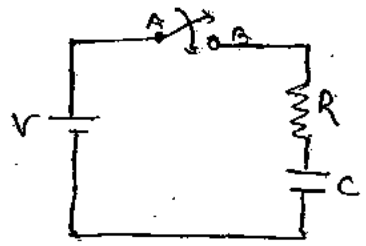
$$i(t) = Ae^{-\frac{Rt}{L}} + \frac{V}{R}$$

$$\boxed{i(t) = \frac{V}{R}\left(1 - e^{-\frac{Rt}{L}}\right)}$$

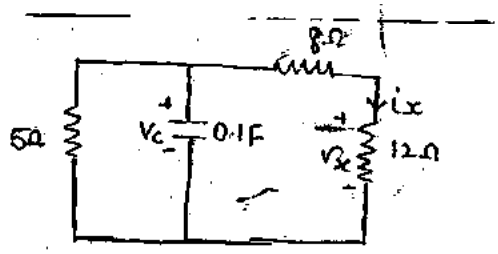
*
$$\boxed{\begin{aligned} i(t) &= i(\infty) + [i(0^+) - i(\infty)]\, e^{-\frac{Rt}{L}} \\ i(t) &= (F.V) + [(I.V) - (F.V)]\, e^{-\frac{Rt}{L}} \end{aligned}}$$

* This is applicable for dc & u(t) & also RC crt.

$$\boxed{V(t) = V(\infty) + [V(0^+) - V(\infty)]\, e^{-t/RC}}$$ for RC n/w



Q. If the initial voltage on the C=15V Find v_c, i_x $t>0$

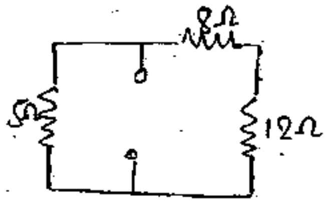


Sol $t>0$ $\quad V_0 = 15V$

$V_c(t) = V_0 e^{-t/RC}$

$\tau = R_{eq} C$

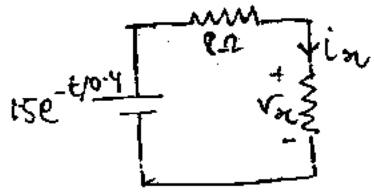
Calculate Req



$R_{eq} = 20 \| 5 = \frac{20 \times 5}{25} = 4\Omega$

$\tau = 4 \times 0.1 = 0.4 sec$

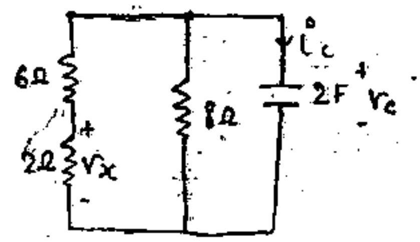
$\therefore V_c = 15 e^{-t/0.4}$



$V_x = \cancel{15}^{3} e^{-t/0.4} \cdot \frac{\cancel{12}^{3}}{\cancel{20}_{\cancel{4}}}$

$i_x = \frac{V_x}{20} = 0.75 e^{-t/0.4}$

Q. Find the value of v_c, v_x, i_c w.r.t time when $V_c = 3V$



$R_{eq} = 8 \| 8 = \frac{8 \times 8}{16} = 4\Omega$

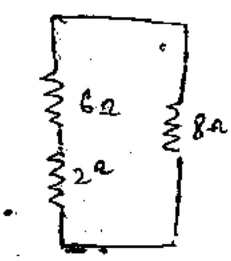
$\tau = 4 \times 2 = 8 sec$

$V_c(t) = V_0 e^{-t/RC} = 3 e^{-t/8}$

$i_c = -\frac{V_0}{R} e^{-t/RC} = -\frac{3}{4} e^{-t/8}$

$V_x = \frac{3}{4} e^{-t/8}$

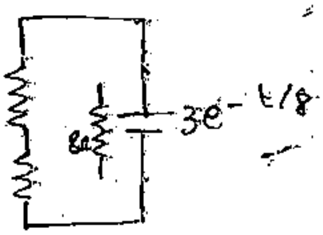
For Req (C is open ckt)



$\cancel{-V_x = -\frac{3}{4}e^{t/8}\cdot\frac{2}{8}}$

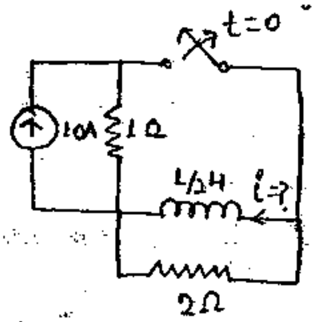
$$V_x = V_c(t)\cdot\frac{2}{8}$$

$$= 3e^{-t/8}\cdot\frac{2}{8} = \frac{3}{4}e^{-t/8}$$

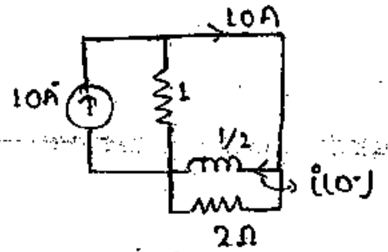


(because C and Resistor in ||)

Q. Find the value current when $t > 0$

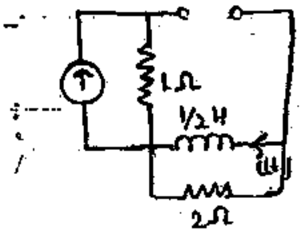


Soln: At $t = 0^-$



$$i(0^-) = i(0^+) = 10A$$

At $t > 0$



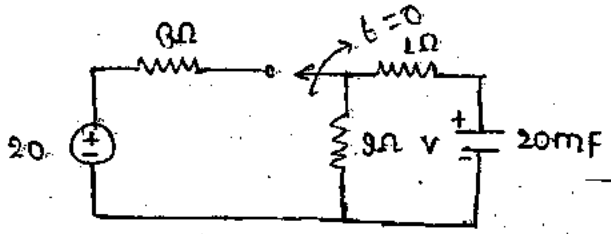
$$I = I_0 e^{-R/L\,t}$$

$R = 2\Omega \quad L = 1/2$

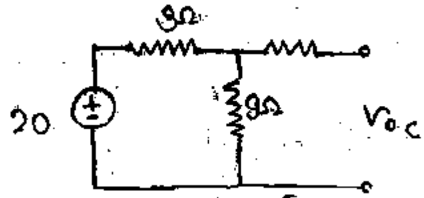
$$\tau = \frac{1}{2}\cdot\frac{1}{2} = \frac{1}{4}$$

$I = 10e^{-4t}$ Ans

Q. Find $v_c(t)$ when $t>0$



Soln: $t<0$

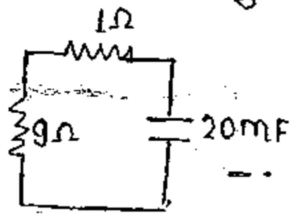


$V_c(0^-) = V_c(0^+) = 15V$

$V_c(0^-) = 20 \cdot \frac{9}{12} = 15V$

$t>0$

$v(t) = V_0 e^{-t/RC}$

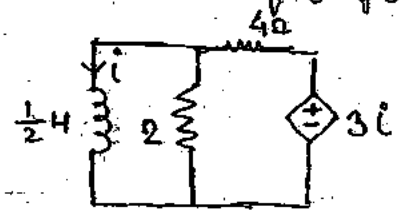


$R_{eq} = 10\Omega \quad C = 20mF$

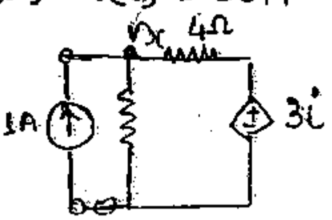
$RC = 10 \times 20 \times 10^{-3} = 0.2$ sec

$v(t) = 15\, e^{-t/0.2} = 15 e^{-5t}$

Q. The initial value of current through inductor 10 A. Find the value of i for $t>0$



Soln: $i(0^-) = i(0^+) = 10A$



$1 = \frac{V}{2} + 3i$

$1 = \frac{V}{2} + 3 \times 1$

$V = 6$

$1 = \frac{V_x}{2} + \frac{V_x - 3i}{4}$

$1 = \frac{V_x}{2} + \frac{V_x - 3}{4}$

$$\frac{3V_x}{4} = \frac{1}{4}$$

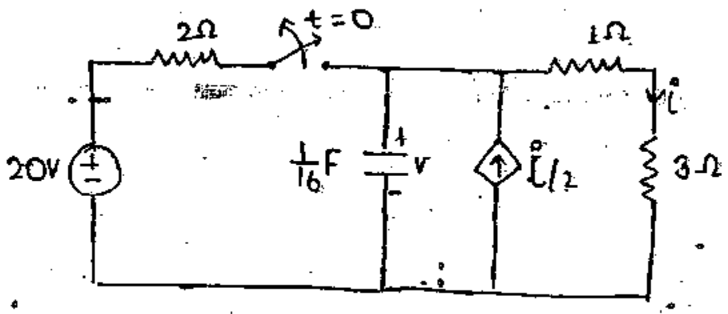
$V_x = 1/3$ volts

$$R_{TH} = \frac{V_x}{I} = \frac{1/3}{1} = \frac{1}{3}\ \Omega$$

$$\frac{1}{\tau} = R_{TH}/L = \frac{1}{3} \times 2 = \frac{2}{3}\ sec$$

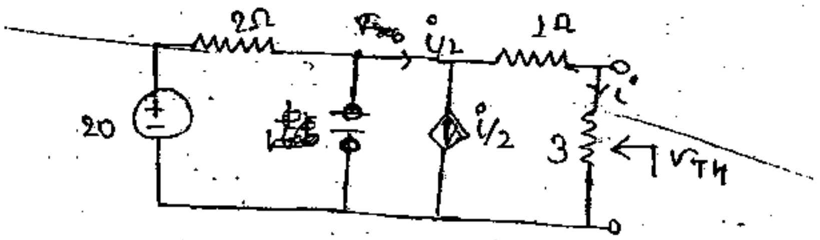
$$\boxed{I(t) = 10e^{-2/3 t}}\ \text{Ans}$$

Q.



determine the current i in the given ckt.

Soln: At $t(0^-)$



$$-20 + 2i/2 + 4i = 0$$

$$5i = 20$$

$$i = 4\ A$$

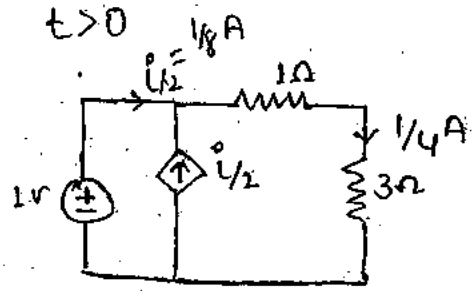
$$-20 + 2\, i/2 + V_c = 0$$

$$-20 + 2 \times 2 + V_c$$

$$V_c = 16\ V$$

$v(0^-) = v(0^+) = 16\ V$

$t > 0$



$R_{TH} = \frac{1}{1/8} = 8\Omega$

$\cancel{\frac{1}{\tau} = \frac{R}{C} = 8 \times \frac{1}{16} = \frac{1}{2} sec}$ $\quad \tau = RC = 8 \times \frac{1}{16} = \frac{1}{2}\ sec$

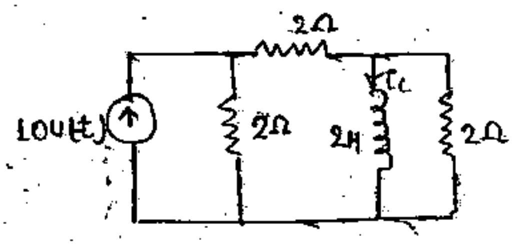
$v_c(t) = v_0 e^{-t/\tau} = 16e^{-\cancel{2}t/\frac{1}{2}}\ V_c$

$i_c(t) = \frac{16e^{-2t}}{3+1} = 4e^{-2t}\ Amp$

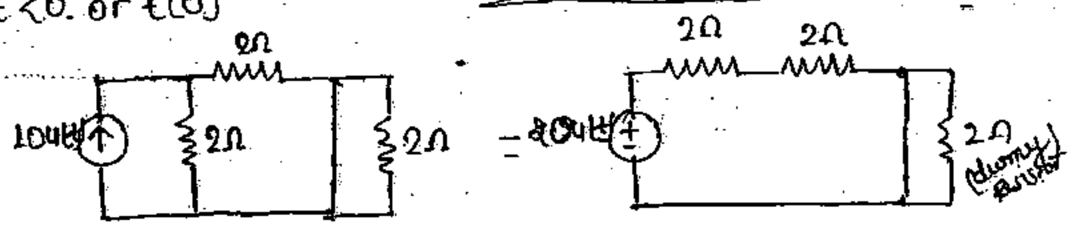
N.B (i) we never connected voltage source in || with dependent voltage source.

(2) we never connected current source in series with dependent current source.

Q. Find the current response on the inductor



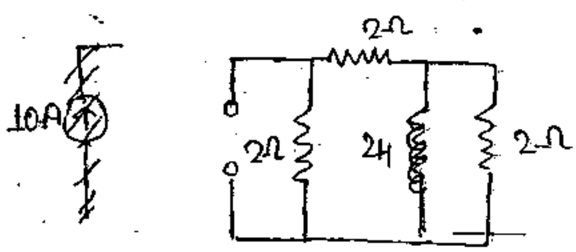
Soln: $t < 0$ or $t(0^-)$



$\therefore I = \frac{20}{4} = 5A$

$I(0^-) = I(0^+) = 5A$

$t > 0$



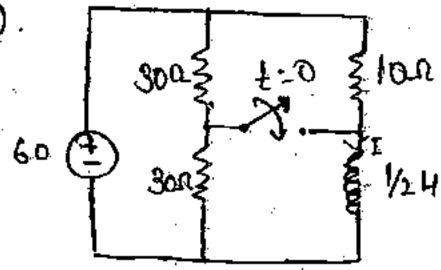
$R_{eq} = 4 \parallel 2 = \frac{4\times 2}{\cancel{6}\,3} = \frac{4}{3}$

$\frac{1}{\tau} = \frac{R}{L} = \cancel{\frac{4}{3\times 2}}\ \cancel{\frac{2}{4/3}}\ \frac{4}{3\times 2} = \frac{2}{3}$ sec

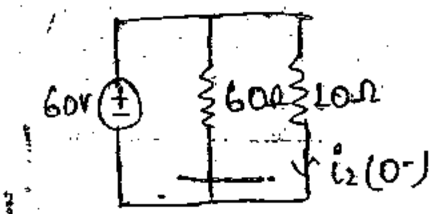
$i(t) = I_0 e^{-t/\tau}$

$i(t) = 5 e^{-\frac{2}{3}t}$ Ans

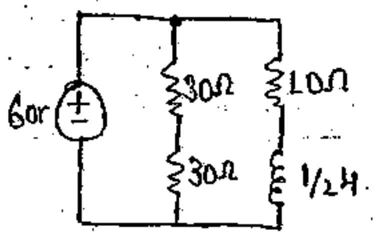
Q. find the current through inductor?



Soln. $t(0^-)$



$\Leftarrow$

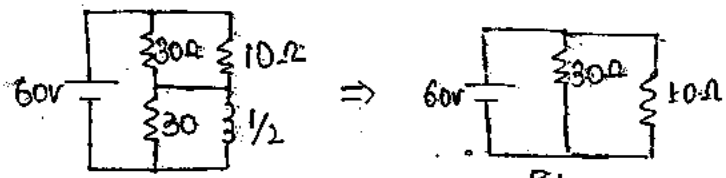


~~$I = 60 \times \frac{60\times 10}{60+10} = 60 \times \frac{600}{70} =$~~

$i_2(0^-) = \frac{60}{10} = 6A$

$i_2(0^-) = i_2(0^+) = 6A$

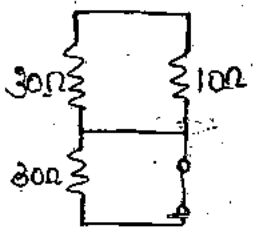
$t>0$



$i(t) = i(\infty) + [i(0^+) - i(\infty)]e^{-\frac{R}{L}t}$

$i(\infty) = \frac{60}{30 \| 10}$

$i(\infty) = \frac{60}{30 \times 10} \times 40 = 8A$



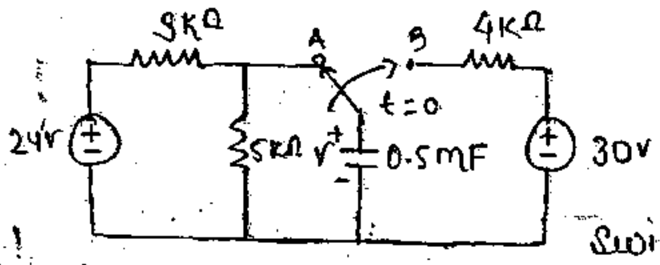
$R_{eq} = 30 \| 30 \| 10$

$= \frac{30 \times 30}{60} \| 10$

$= 15 \| 10 = \frac{15 \times 10}{25} = 6\ \Omega$

$i(t) = 8 + [6 - 8]e^{-\frac{R}{L}t}$

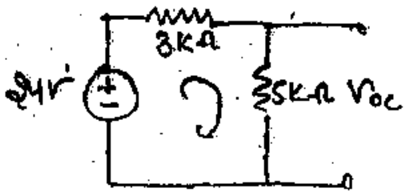
Q.



The switch in the as in posn A for long time. At t=0 Switch is move to B posn

Determine v(t) for t>0

Soln: At t(0-)



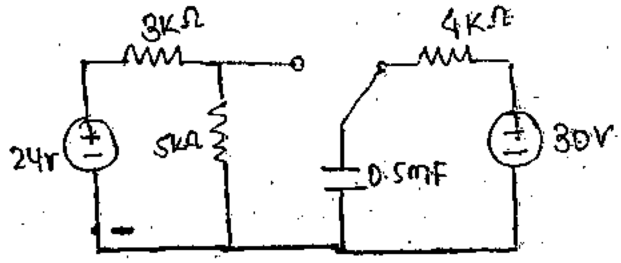
$I = \frac{24}{8} = 3mA$

$V_{oc} = 5 \times 3 = 15V$

$V(0^-) = 15V$

$v(0^-) = v(0^+) = 15V$

At $t>0$



~~i(t) = i(∞) + [i(0+)~~

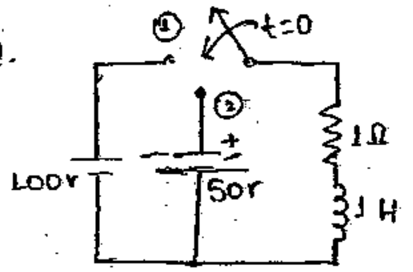
$$v(t) = v(\infty) + [v(0^+) - v(\infty)]e^{-t/RC}$$

$$v(t) = \frac{30}{4} + [15 - \frac{30}{4}]e^{-\frac{t}{4\times0.5}}$$

$$= 30 - 15e^{-t/2} \text{ volts}$$

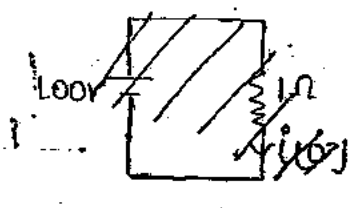
$$= 15$$

Q.



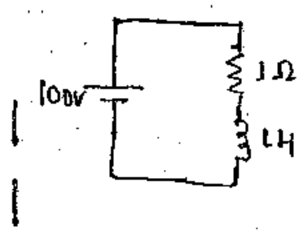
In the crt at t = 0sec the Switch connected to posn 1 after one time constant the switch connected to ②. find the current response when switch connected to position ②.

Soln: ~~i(0-) = for t≤0~~



$i(0^-) = 100A = i(0^+)$

$t>0$



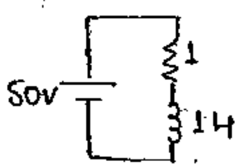
$$i(t) = i(\infty) + [i(0^+) - i(\infty)]e^{-\frac{t}{1/1}}$$

$$i(\infty) = 100A$$

$$i(0^+) = i(0^-) = 0A$$

$$i(t) = 100(1 - e^{-t}) \quad — ①$$

~~t>1 sec~~



$i(t) = i(\infty) + [i(1^+) - i(\infty)]e^{-\frac{(t-1)}{\tau}}$

$i(\infty) = 50\,A$

$i(1^+) = 100[1 - e^{-1}]$

$\simeq 100[1 - 0.367]$

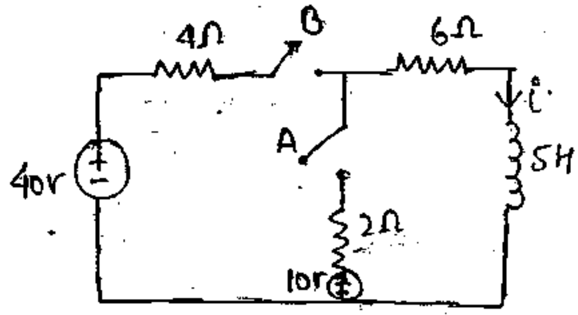
$= 63.3\,A$

~~i(t) = 63.3 A~~

$i(t) = 50 + [63.3 - 50]e^{-(t-1)}$

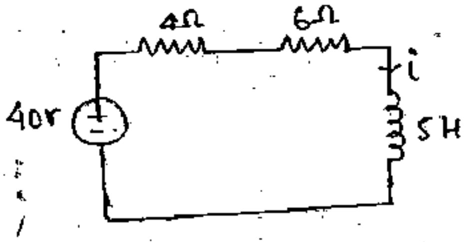
$i(t) = 50 + 13.3e^{-(t-1)}\,A$ Ans

Q.



At $t=0$ switch B in the figure is closed and switch A 4 sec later find $i(t)$ for $t>0$?

Soln: $t < 4\,sec$ $t>0$



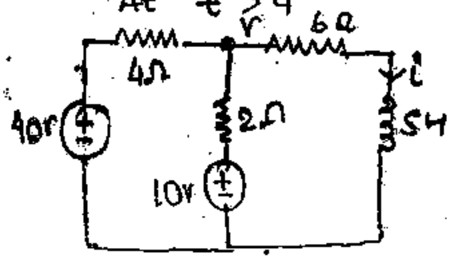
$i(0^-) = i(0^+) = 0\,A$

$I = \frac{40}{10} = 4\,A$

$I(\infty) = 4\,A$ ∴ $i(4) = 4[1 - e^{-8}] \simeq 4\,A$

$i(t) = 4 - 4e^{-2t}$

At $t > 4$



~~$i(\infty) = \frac{10}{6}$~~ =

$\frac{V-40}{4} + \frac{V-10}{2} + \frac{V}{6} = 0$

$V\left[\frac{1}{4} + \frac{1}{2} + \frac{1}{6}\right] = 10+5$

$V\left[\frac{3+6+2}{12}\right] = 15$

$$V = 15 \times \frac{12}{11} = \frac{180}{11} \text{ volts}$$

$$i(\infty) = \frac{15 \times 12}{11 \times 6} = \frac{30}{11} \text{ A}$$

$$\tau = \frac{C}{R_{eq}}$$

$$R_{eq} = (4 \parallel 2) + 6 = \frac{22}{3}$$

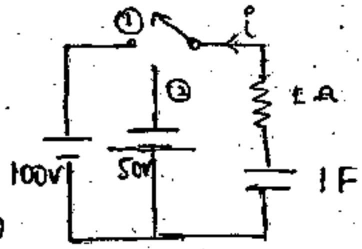
$$\tau = \frac{5}{\frac{22}{3}} = \frac{15}{22} \text{ sec}$$

$$i(t) = i(\infty) + [i(4^+) - i(\infty)] e^{-\frac{22}{15}(t-4)}$$

$$= \frac{30}{11} + \left(4 - \frac{30}{11}\right) e^{-\frac{22}{15}(t-4)}$$

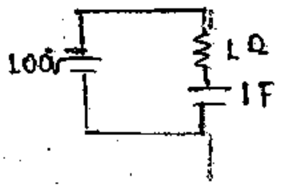
$$= 2.727 + 1.272\, e^{-\frac{22}{15}(t-4)} \quad \text{Ans.}$$

Q. In the ckt show $t = 0$ sec the switch is connected at posn 1 after 1 time constant the switch is move to (2). Find current response when switch at posn (1).



Soln: $v(0^-) = v(0^+) = 0V$ at $t < 0$

$t > 0$



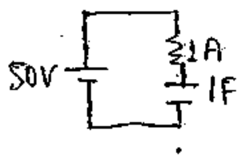
$$V(\infty) = 100V$$

$$V(t) = 100 + (0 - 100) e^{-t}$$

$$= 100(1 - e^{-t})$$

$$V(1^+) = 100(1 - e^{-1}) = 63.3 \text{ volts}$$

$t > 1$ sec



$$\cancel{V(t) = 50 + (63.3 + 50) e^{-(t-1)}}$$

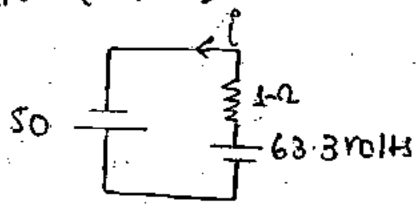
$$\cancel{= 50 + 13.3 e^{-(t-1)} \text{ volts}}$$

$\therefore i(t) = i(\infty) + [i(1^+) - i(\infty)]e^{-(t-1)/\tau}$

$i(\infty) = 0$

$\cancel{At}\ i(1^+) = \cancel{\frac{V}{R}}$

At $t = 1^+$

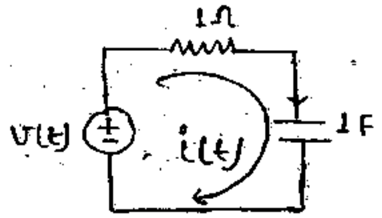


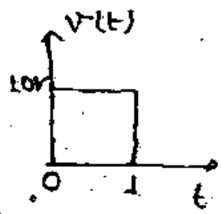
$i = 63.3 + 50 = 113.3\,V$

$i(t) = 0 + [113.3V - 0]e^{-(t-1)}$

$i(t) = 113.3e^{-(t-1)}$ Amp

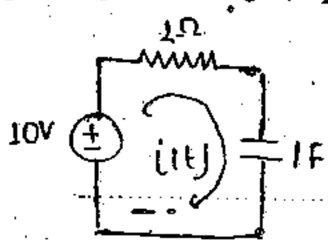
Q. Find the current responese of $i(t)$ for $t>0$ when capacitor ~~of~~ was initially unenergised.





Soln: $t > 0$

$v(0^-) = v(0^+) = 0V$



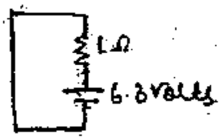
$v(t) = v(\infty) + [v(0^+) - v(\infty)]e^{-t/RC}$

$= 10 + [0 - 10]e^{-t} = 10 - 10e^{-t}$

$i(t) = 10e^{-t};\ 0 \le t \le 1$

$t > 1$ sec

$v(1^+) = 10V - 10e^{-1} = 10(1 - 0.372) = 6.3$ volts



$v(t) = v(\infty) + [v(1^+) - v(\infty)]e^{-(t-1)}$

$= 0 + [6.32 - 0]e^{-(t-1)}$

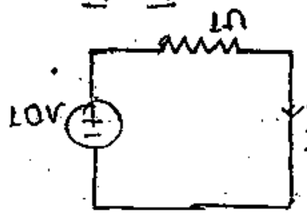
$= 6.32e^{-(t-1)}$

$I(t) = C\frac{dv}{dt} = 1 \times -6.32e^{-(t-1)}$

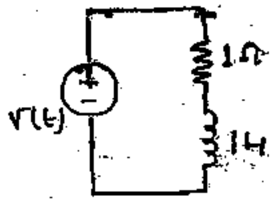
$= -6.32e^{-(t-1)}$ Amp

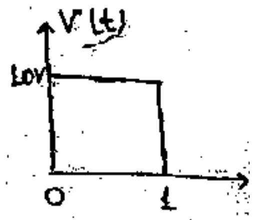
Q Find the current response $i(t)$ $t>0$ when initially inductor is unergised.

Soln: $0 \leq t \leq 1$ $\quad i(0^+) = i(0^-) = 0A$



$i(\infty) = \frac{10}{1} = 10A$



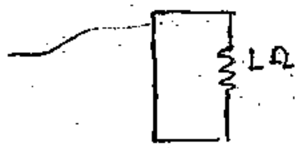


$i(t) = 10 + (0-10)e^{-t}$

$= 10 - 10e^{-t}$

$t > 1$ sec

$i(1^+) = 10 - 10e^{-1} = 6.32$ A

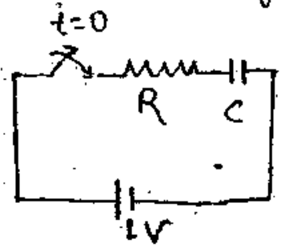


$i(\infty) = 0$

$i(t) = 0 + (6.32 - 0)e^{-(t-1)}$

$= 6.32\,e^{-t}$ Ans

Q Find the rate of rise of voltage across the capacitor at $t(0^+)$



Soln: $v(t) = 1 + (0-1)e^{-t/RC}$

$= 1 - e^{-t/RC}$

$\frac{dv}{dt} = \frac{1}{RC}e^{-t/RC}$

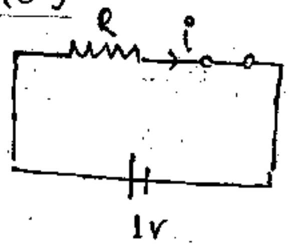
$\frac{dv(0^+)}{dt} = \frac{1}{RC}$ Ans

Method : 2:

At $t(0^-)$

$$V(0^-) = V(0^+) = 0\,V$$

At $t(0^+)$



$$i = \frac{1}{R}$$

$$i = C\frac{dv}{dt}$$

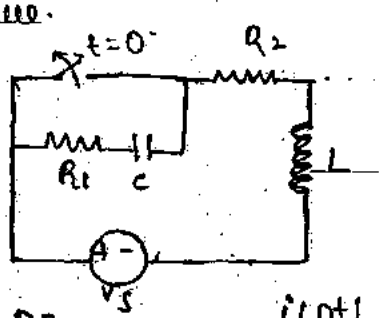
$$\frac{1}{R} = C\frac{dv}{dt} \qquad \therefore \frac{dv}{dt} = \frac{1}{RC}$$

N.B. In this type Question at $t(0^+)$

(1). Inductor is replaced by current source of its initial value.

(2) capacitor is replaced by voltage source of its initial value.

Q.



Find the voltage across the switch for $t = 0^+$

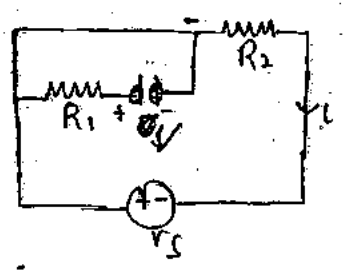
Soln:

At $t = 0^-$

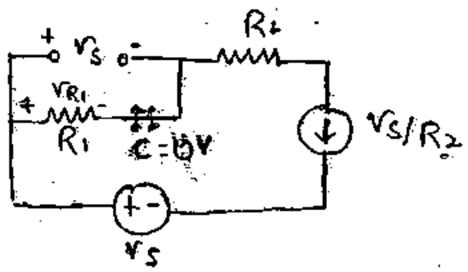
$$i = \frac{V_s}{R_2}$$

$$i(0^-) = i(0^+) = V_s/R_2$$

$$V(0^-) = V(0^+) = 0\,V$$



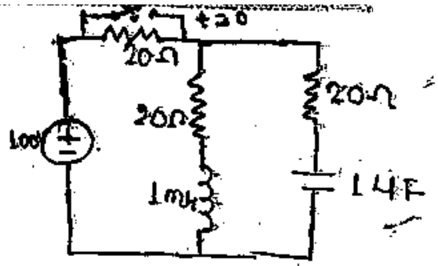
At $t = 0^+$



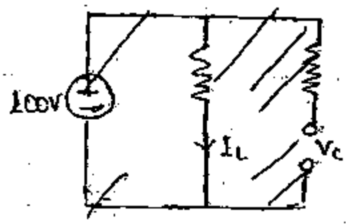
$$V_{R1} = \frac{V_s}{R_2} \times R_1$$

$$V_S = V_{R1} = \frac{V_s}{R_2} \cdot R_1$$

Q. Find the rate of rise of current through inductor at $t=0^+$



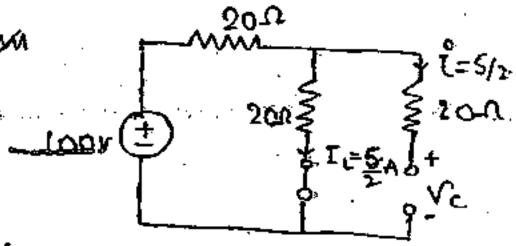
Soln: $\cancel{t=0^-}$



$\cancel{I_L(0^-) = I_L(0^+) = \frac{100}{20} = 5A}$

$\cancel{V(0^-) = V(0^+) = 100V}$

$\cancel{t=0^+}$ $t=0^-$



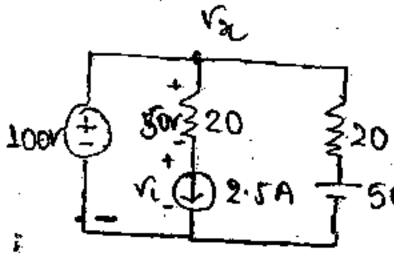
$I_L = \frac{100}{40} = 2.5A$

$I_L(0^-) = I_L(0^+) = 2.5A$

$V(0^-) = V(0^+) = 50V$

$V_c = 20 \times \frac{5}{2} = 50\ V$

$t=0^+$



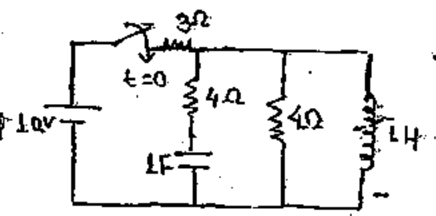
$V_L = 50V$

$V_L = L\frac{di}{dt}$

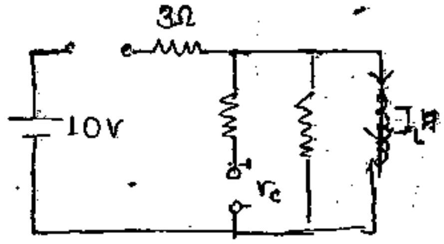
$50 = L \times \frac{di}{dt}$

$\frac{di}{dt} = 50 \times 10^3$ Ans

Q. Find the current flowing through capacitor and voltage across inductor at $t=0$ and also calculated the energy stored at $t(\infty)$?



Soln: $t=0^-$



$I(0^-) = I(0^+) = 0A$

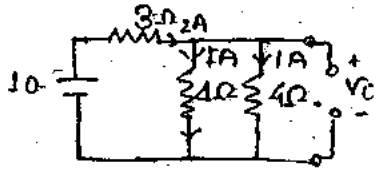
$V(0^-) = V(0^+) = 0V$

$t=0^+$

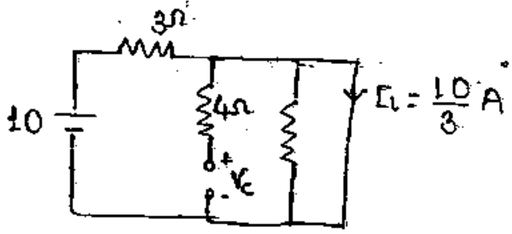
$V_L = 10V$

$I_e = \frac{10}{5} = 2A$

$I_c = 1A$



At $t=\infty$



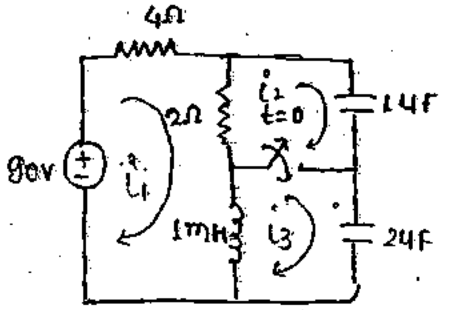
$I_L(\infty) = \frac{10}{3}A$

$V_c(\infty) = 0V$

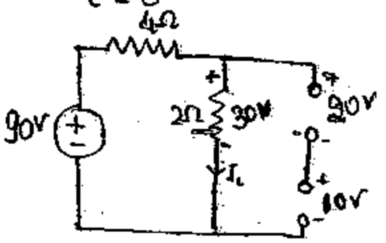
$W_L(\infty) = \frac{1}{2}LI^2 = \frac{1}{2}\times\frac{10}{3}^2\times 1 = \frac{100}{18} = \frac{50}{9}J$

$W_c(\infty) = \frac{1}{2}cv^2 = 0J$

Q. Find the current through i_1, i_2 and i_3



Soln: $t=0^-$

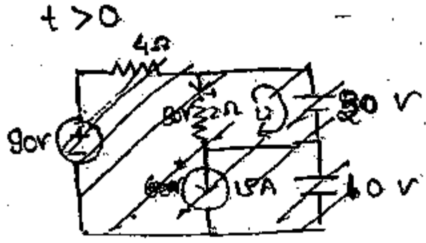


$I_L = \frac{\overset{30}{\cancel{90}}}{\cancel{6}_2} = 15A$

$I_L(0^-) = I_L(0^+) = 15A$

To easy ...

$t > 0$



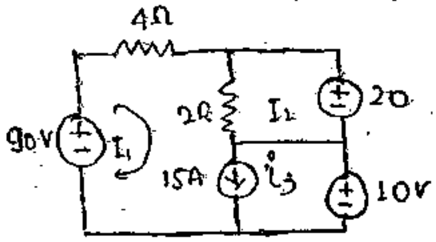
$V_{c1} = \frac{30}{3} \times 2 = 20V$

$V_{c2} = \frac{30}{3} \times 1 = 10V$

$V_{c1} = \frac{V_s}{C_1+C_2} \cdot C_2$

$V_{c2} = \frac{V_s}{C_1+C_2} \cdot C_1$

At $t = 0^+$



Loop1: $-90 + 4i_1 + 20 + 10 = 0$

$4i_1 = 60$

$i_1 = \frac{60}{4} = 15A$

Loop2: $20 + (i_2 - i_1)2 = 0$

$20 + 2i_2 - 30 = 0$

$2i_2 = 10A$

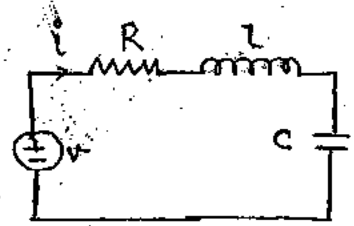
$i_2 = \frac{10}{2} = 5A$

Loop3:

$15 = i_1 - i_3$

$i_3 = 0A$

Series RLC ckt:



$$V = iR + L\frac{di}{dt} + \frac{1}{C}\int i\,dt$$

$$0 = \frac{dv}{dt} = \frac{di}{dt}R + L\frac{d^2i}{dt^2} + \frac{i}{C} = 0$$

$$\frac{d^2i}{dt^2} + \frac{R}{L}\frac{di}{dt} + \frac{i}{LC} = 0$$

taking laplace

$$s^2 + \frac{R}{L}s + \frac{1}{LC} = 0$$

$$s_{12} = -\frac{R}{2L} \pm \sqrt{\left(\frac{R}{2L}\right)^2 - \frac{1}{LC}}$$

$$\alpha = -\frac{R}{2L} \qquad \beta = \sqrt{\left(\frac{R}{2L}\right)^2 - \frac{1}{LC}}$$

case 1. For overdamped $\left[\left(\frac{R}{2L}\right)^2 > \frac{1}{LC}\right]$

$$i(t) = C_1 e^{(\alpha+\beta)t} + C_2 e^{(\alpha-\beta)t}$$

Case 2: For critical damped

$$\left(\frac{R}{2L}\right)^2 = \frac{1}{LC}$$

$$s_{12} = -\frac{R}{2L}$$

$$i(t) = (C_1 + C_2 t)e^{\alpha t}$$

case 3: underdamped

$$s_{12} = \underbrace{-\frac{R}{2L}}_{\alpha} \pm j\underbrace{\sqrt{\frac{1}{LC} - \left(\frac{R}{2L}\right)^2}}_{\beta}$$

$$\left(\frac{R}{2L}\right)^2 < \frac{1}{LC}$$

$$i(t) = (C_1\cos\beta t + C_2\sin\beta t)e^{\alpha t}$$

$$\omega_d = \sqrt{\frac{1}{LC} - \left(\frac{R}{2L}\right)^2} = \frac{1}{\sqrt{LC}}\sqrt{1 - \frac{R^2C}{4L}}$$

$$\boxed{\omega_d = \omega_0\sqrt{1 - \frac{R^2C}{4L}}} \quad \text{or.} \quad \boxed{\omega_d = \omega_0\sqrt{1-\xi^2}}$$

~~Damping~~ coefficient $= \alpha = \frac{R}{2L}$

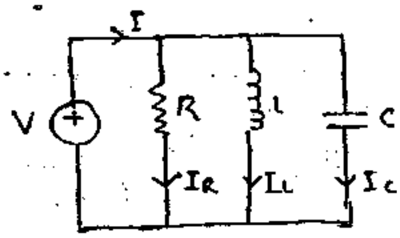
$$\boxed{\tau = \frac{2L}{R} = \frac{1}{\alpha}}$$

case 4: undamped $(R=0)$

$$s = \pm j\frac{1}{\sqrt{LC}}$$

$$\boxed{i(t) = C_1\cos\beta t + C_2\sin\beta t}$$

|| RLC crt:



$I = I_R + I_L + I_c$

$$I = \frac{v}{R} + \frac{1}{L}\int v\,dt + C\frac{dv}{dt}$$

$$C\frac{d^2v}{dt^2} + \frac{1}{R}\frac{dv}{dt} + \frac{v}{L} = 0$$

$$\frac{d^2v}{dt^2} + \frac{1}{RC}\frac{dv}{dt} + \frac{v}{LC} = 0$$

$$\boxed{s^2 + \frac{1}{RC}\cdot s + \frac{v}{LC} = 0}$$

$$s_{12} = \underbrace{-\frac{1}{2RC}}_{\alpha} \pm \underbrace{\sqrt{\left(\frac{1}{2RC}\right)^2 - \frac{1}{LC}}}_{\beta}$$

Case 1: Overdamped $\left[\left(\frac{1}{2RC}\right)^2 > \frac{1}{LC}\right]$

$$v(t) = C_1 e^{(\alpha+\beta)t} + C_2 e^{(\alpha-\beta)t}$$

Case 2: critically damped $\left[\left(\frac{1}{2RC}\right)^2 = \frac{1}{LC}\right]$

$$S_{12} = \frac{-1}{2RC}$$

$$v(t) = (C_1 + C_2 t)e^{\alpha t}$$

Case 3: underdamped $\left[\left(\frac{1}{2RC}\right)^2 < \frac{1}{LC}\right]$

$$S_{12} = -\frac{1}{2RC} \pm j\sqrt{\frac{1}{LC} - \left(\frac{1}{2RC}\right)^2}$$

$$v(t) = (C_1 \cos\beta t + C_2 \sin\beta)e^{\alpha t}$$

$$\omega_d = \sqrt{\frac{1}{LC} - \left(\frac{1}{2RC}\right)^2}$$

$$= \frac{1}{\sqrt{LC}}\sqrt{1 - \frac{L}{4R^2C}}$$

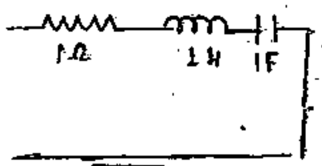
$$\omega_d = \omega_0\sqrt{1 - \frac{L}{4R^2C}}$$

$$\boxed{\omega_d = \omega_0\sqrt{1 - \xi_p^2}}$$

where $\boxed{\xi_p = \frac{1}{RC}\sqrt{\frac{L}{C}}}$

$$\boxed{\tau = 2RC}$$

Q. The given n/w is
(a) underdamped
(b) overdamped
(c) critically damped
(d) undamped



Sol: $S_{1,2} = -\frac{1}{2} \pm \sqrt{\left(\frac{1}{2}\right)^2 - 1}$

$\left(\frac{1}{2}\right)^2 < 1$ underdamped

or $\xi = \frac{R}{2L}\sqrt{\frac{C}{L}} = \frac{1}{2}$ when $0 < \xi < 1$ underdamped

Ac transient:

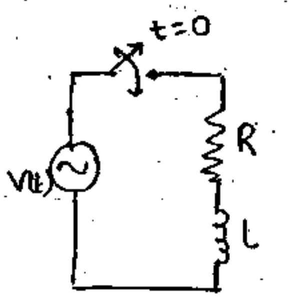
- DC transient are most severe than Ac transient
- In the A.C ckt based on selection of crt parameters, operating frequency & switching operation, it is possible to obtained transient free response but in D.C crt it is not so.

Series RL crt:

$v = iR + L\frac{di}{dt}$

$\frac{di}{dt} + \frac{R}{L}i = \frac{V}{L}$

$i(t) = i(t)_{CF} + i(t)_{P.I}$



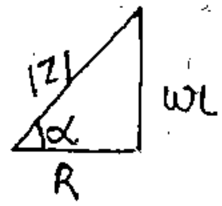
$V(t) = V_m \sin(\omega t + \theta)$

(1) $\frac{di}{dt} + \frac{R}{L}i = 0$

$i_{cf}(t) = A \cdot e^{-\frac{Rt}{L}}$.

$$i_{PI}(t) = \frac{V}{Z} = \frac{V}{|Z|\angle\alpha}$$

$$i_{PI} = \frac{V_m \sin(\omega t + \theta)}{|Z|\angle\alpha}$$



$\alpha = \tan^{-1}\frac{\omega L}{R}$

$$i_{PI}(t) = \frac{V_m}{|Z|}\sin(\omega t + \theta - \alpha)$$

$$i(t) = A e^{-\frac{Rt}{L}} + \frac{V_m}{|Z|}\sin(\omega t + \theta - \alpha) \quad \text{— (1)}$$

At; $t = 0$

$$0 = A \cdot 1 + \frac{V_m}{|Z|}\sin(\theta - \alpha)$$

$$A = -\frac{V_m}{|Z|}\sin(\theta - \alpha)$$

Substitutes this value in eq^n (1)

$$\therefore i(t) = \underbrace{-\frac{V_m}{|Z|}\sin(\theta-\alpha)\, e^{-\frac{Rt}{L}}}_{\text{tr. response}} + \underbrace{\frac{V_m}{|Z|}\sin(\omega t + \theta - \alpha)}_{S.S}$$

To make the trainsient response zero.

$$\theta - \alpha = 0$$

$$\theta = \alpha$$

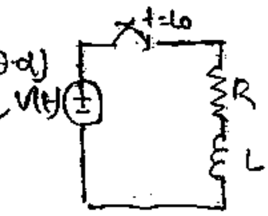
$$\therefore \boxed{\theta = \tan^{-1}\frac{\omega L}{R}}$$

(ii) → if we take $v(t) = V_m \cos(\omega t + \theta)$

$$\boxed{\theta = \tan^{-1}\frac{\omega L}{R} + \pi/2}$$

(iii) if switching is happen at $t = t_0$ when $v(t) = V_m \sin(\omega t + \theta)$

$$i(t) = \underbrace{-\frac{V_m}{|Z|}\sin(\omega t_0 + \theta - \alpha)\, e^{-\frac{R}{L}(t - t_0)}}_{\text{tr response}} + \underbrace{\frac{V_m}{|Z|}\sin(\omega t + \theta - \alpha)}_{S.S}$$



To make transient zero

$\omega t_0 + \theta - \alpha = 0$

$$\boxed{\omega t_0 = -\theta + \alpha = \tan^{-1}\frac{\omega L}{R} - \theta}$$

Case 4: if $v(t) = V_m \cos(\omega t + \theta)$ and switching at $t = t_0$

$\omega t_0 + \theta - \alpha = \frac{\pi}{2}$

$\therefore \omega t_0 = \frac{\pi}{2} + \alpha - \theta$

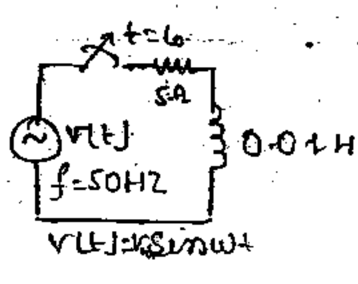
$$\boxed{\omega t_0 = \frac{\pi}{2} + \tan^{-1}\left(\frac{\omega L}{R}\right) - \theta}$$

Generalised formula for RC ckt:

1. $t = 0$, $v(t) = V_m \sin(\omega t + \theta)$, $\theta = \tan^{-1}\omega\tau$ or $\theta = \tan^{-1}(\omega RC)$
2. $t = 0$, $v(t) = V_m \cos(\omega t + \theta)$, $\theta = \tan^{-1}(\omega\tau) + \frac{\pi}{2}$ or $\theta = \tan^{-1}(\omega RC) + \frac{\pi}{2}$
3. $t = t_0$, $v(t) = V_m \sin(\omega t + \theta)$, $\omega t_0 = \tan^{-1}(\omega RC) - \theta$ or $\omega t_0 = \tan^{-1}(\omega\tau) - \theta$
4. $t = t_0$, $v(t) = V_m \cos(\omega t + \theta)$, $\omega t_0 = \tan^{-1}(\omega\tau) - \theta + \frac{\pi}{2}$ or $\omega t_0 = \tan^{-1}(\omega RC) - \theta + \frac{\pi}{2}$

N.B: For ∥ RL & RC ckt the formula is same but here derived the expression for $I(t) = I_m \sin(\omega t + \theta)$ or $I_m \cos(\omega t + \theta)$ either at $t = 0$, or $t = t_0$

Q. At what switching instant t the current in the ckt free from transient



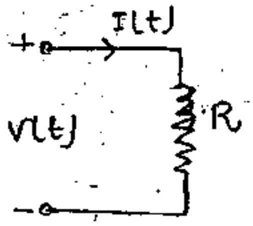
Soln: $\omega t_0 = \tan^{-1}\frac{\omega L}{R} - \theta$

$\omega t_0 = \tan^{-1}\frac{\omega L}{R}$

$t_0 = \frac{\tan^{-1}\omega L/R}{\omega} = \frac{\tan^{-1}\left(\frac{2\pi \times 0.01}{5}\right)}{2 \times 3.14 \times 50}$ (3.14×50)

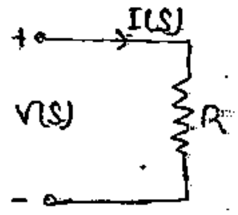
$t_0 = 1.786$ msec

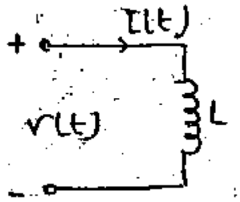
Laplace transform:-

- 

$\Rightarrow$ $v(t) = I(t) \cdot R$

$v(s) = I(s) \cdot R$ $\Rightarrow$

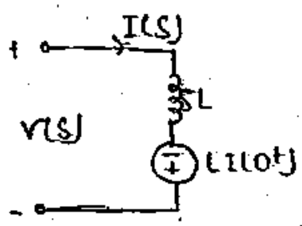


- 

$\Rightarrow$ $v(t) = L\frac{di}{dt}$

$v(s) = L[sI(s) - i(0^+)]$ $\Rightarrow$

$v(s) = LsI(s) - LI(0^+)$

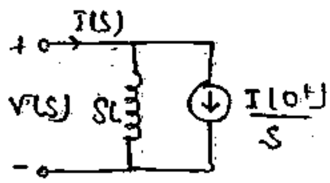


- Transform impedence

$$Z(s) = \frac{V(s)}{I(s)} = Ls - \frac{Li(0^+)}{I(s)}$$

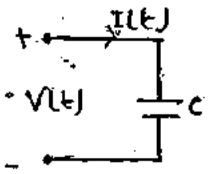
- $sLI(s) = V(s) + LI(0^+)$

$$I(s) = \frac{V(s)}{sL} + \frac{I(0^+)}{s}$$



- Transformed Admittance

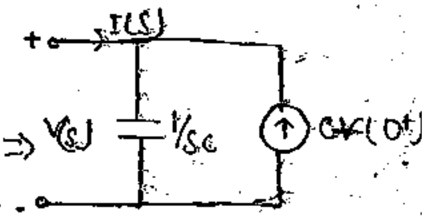
$$Y(s) = \frac{I(s)}{V(s)} = \frac{1}{sL} + \frac{i(0^+)}{sV(s)}$$

- 

$i(t) = C\frac{dv}{dt}$

$\Rightarrow I(S) = C[SV(S) - V(0^+)]$

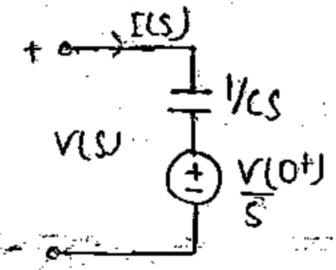
$I(S) = \frac{V(S)}{1/SC} - CV(0^+)$

$\Rightarrow$ 

- $\frac{I(S)}{V(S)} = SC - \frac{CV(0^+)}{V(S)}$ (Transformed Admittance)

- $CSV(S) = I(S) + CV(0^+)$

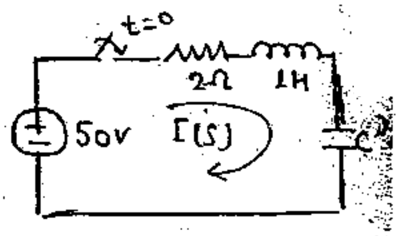
  $V(S) = \frac{I(S)}{CS} + \frac{V(0^+)}{S}$



- Transform impedence

  $\frac{V(S)}{I(S)} = \frac{1}{CS} + \frac{V(0^+)}{SI(S)}$

Q. Find current response i(t) in the crt



Soln: $50 = 2i + \frac{di}{dt} + 2\int i\,d(t)$

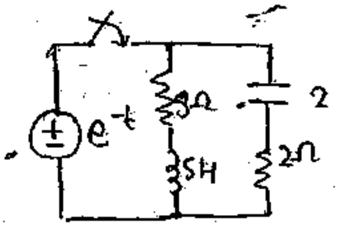
$\frac{50}{S} = I(S)\left[2 + S + \frac{2}{S}\right]$

$\frac{50}{\cancel{S}} = \frac{I(S)[2S + S^2 + 2]}{\cancel{S}}$

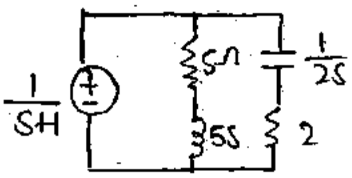
$I(S) = \frac{50}{S^2 + 2S + 2}$

$I(t) = 50 \cdot e^{-t} \sin t$

Q. For the crt shown in the below obtained an expression, by the current delivered by source as function of time when switch is closed t=0. Assume the crt initially unenergised



Soln:



$$Z(s) = (5+5s) \,||\, (2 + 1/2s)$$

$$= \frac{(5+5s) \times \left(\frac{4s+1}{2s}\right)}{\frac{10s+10s^2+4s+1}{2s}} = \frac{20s^2+25s+5}{10s^2+14s+1}$$

$$Z(s) = \frac{V(s)}{I(s)} = 1 \; ;$$

or: $$I(s) = \frac{V(s)}{Z(s)} = \frac{1}{s+1} \times \frac{10s^2+14s+1}{20s^2+25s+5}$$

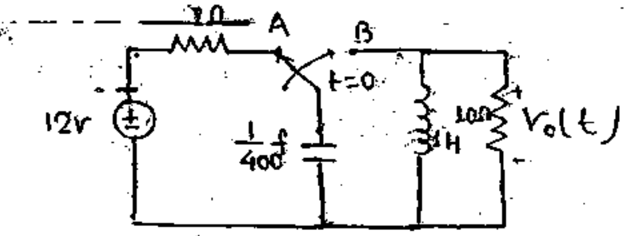
$$I(s) = \frac{10s^2+14s+1}{5(s+1)^2(4s+1)}$$

$$\frac{10s^2+14s+1}{5(s+1)^2(4s+1)} = \frac{A}{(s+1)^2} + \frac{B}{s+1} + \frac{C}{4s+1}$$

$$= \frac{1}{5(s+1)^2} + \frac{2}{3(s+1)} - \frac{2}{3(4s+1)}$$

$$i(t) = \frac{1}{5} te^{-t} + \frac{2}{3} e^{-t} - \frac{2}{3} e^{-\frac{1}{4}t}$$

Q

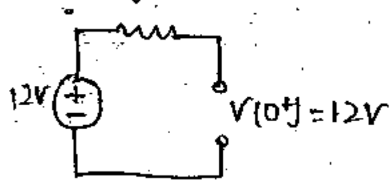


Find $V_o(t)$ for $t>0$, if the switch change at $t=0$ After having remain in the posn A for the long time.

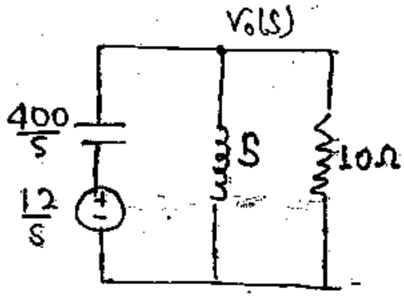
At $t=0^{-1}$

Soln: $i(0^+) = i(0^-) = 0\,A$

$V(0^+) = V(0^-) = 12V$



$t>0$



$$\frac{V_o(S) - 12/s}{\frac{400}{S}} + \frac{V_o(S)}{S} + \frac{V_o(S)}{10} = 0$$

$$\frac{S V_o(S)}{400} + \frac{V_o(S)}{S} + \frac{V_o(S)}{10} = 12/400$$

$$= V_o\left[\frac{S^2 + 400 + 40S}{400S}\right] = \frac{12}{\cancel{400}}$$

$$= V_o(S) = \frac{12S}{S^2 + 400 + 40S}$$

$$V_o(S) = \frac{12S}{(S+20)^2} = \frac{A}{(S+20)^2} + \frac{B}{S+20} = \frac{A + BS + 20B}{(S+20)^2}$$

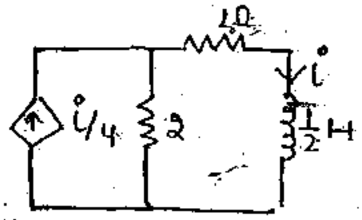
$A = 12S \quad B = 12$

$B = 12 \qquad A + 20B = 0$

$A = -240°$

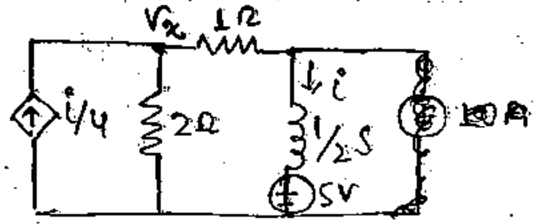
$$V_o(S) = \frac{-240}{(S+20)^2} + \frac{12}{S+20} = 12e^{-20t} - 240\,t\,e^{-20t} \text{ Ans}$$

Q. If the initial value of current through the inductance is 10A then find the current $t>0$



Soln: $i(0^-) = i(0^+) = 10A$

$t>0$



Wrong Attempt

$$i = \frac{V_x+5}{1+1/2S}$$

$$\frac{V_x}{2} + \frac{V_x+5}{1+\frac{1}{2}S} = i/4$$

$$\frac{V_x(1+\frac{1}{2}S)+2V_x+10}{2\cancel{(1+\frac{1}{2}S)}} = \frac{V_x+5}{(4+2S)} = \frac{V_x+5}{4\cancel{(1+1/2S)}}$$

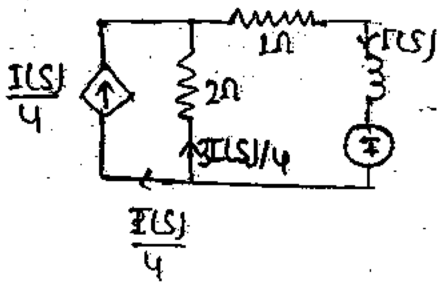
$$V_x + \cancel{2V_x} + \frac{V_x}{2}S + \cancel{10} = \cancel{2V_x} + \cancel{10}$$

$$V_x + \frac{V_x}{2}S = 0$$

$$V_x = 0$$

$$i = \frac{5}{1+1/2S} = 10e^{-2t}$$

Soln:



$$2\times\frac{3I(S)}{4} + I(S) + \frac{S}{2}I(S) = 5$$

$$I(S)\left[\frac{3}{2}+1+\frac{S}{2}\right] = 5$$

$$I(S)[5+S] = 10$$

$$I(S) = \frac{10}{S+5} = 10e^{-5t} \text{ Ans}$$

- Response of Impluse excitation but $v(t) = \delta(t)$ —

(1) $i = \frac{1}{L}\int_{-\infty}^{t} v\,dt$

$= \frac{1}{L}\left[\int_{-\infty}^{0^-} v\,dt + \int_{0^-}^{\infty} v\,dt\right]$ — (1)

$i(t) = i(0^-) + \int_{-0^-}^{\infty} v\,dt$

$\boxed{i(0^-) = i(0^+)}$

Substitutes this value in eq^n

$i(0^+) = i(0^-) + \frac{1}{L}\int_{0^-}^{0^+} v\,dt$

$\boxed{i(0^-) = 0}$ $\boxed{i(0^+) = \frac{1}{L}}$

$W_L(0^+) = \frac{1}{2} L\, [i(0^+)]^2 = \frac{1}{2L}$

$\boxed{W_L = \frac{1}{2L} \text{ Joules}}$

Hence the L allow instantanious change in current for voltage impulse function.

(2) Capacitor:

$v = \frac{1}{C}\int_{-\infty}^{t} i\,dt = \frac{1}{C}\int_{-\infty}^{t} i\,dt$

$v = \frac{1}{C}\int_{-\infty}^{0^+} i\,dt + \int_{0^+}^{-\infty} i\,dt$

$v(0^+) = v(0^-) + \frac{1}{C}\int_{-0^-}^{0^+} i\,dt$ — (1)

$\boxed{v(0^-) = v(0^+)}$

let $i = \delta(t)$

$v(0^+) = v(0^-) + \frac{1}{C}\int_{0^-}^{0^+} \delta(t)\,dt$

$\boxed{v(0^-) = 0}$ $\boxed{v(0^+) = \frac{1}{C}}$

$W_C(0^+) = \frac{1}{2} C\, v(0^+)^2$

$\boxed{W_C(0^+) = \frac{1}{2C} \text{ Joules}}$

Hence the capacitor allows instantious changes in voltage for the current impulse function.

NETWORK SYNTHESIS:

Possitive Real function

ex: $1+2j$, $1-2j$

but $-1+2j$ is not PRF because Real function in -ve.

Properties of Hurwitz polynomials: (always says about simple pole)

1. All the coefficient of the polynomial should be real & positive
   $P(S) = S^3+3S^2+5S+1$

2. Polynomial $P(S)$ should be real for real value of S.
3. odd & ~~even~~ ~~of~~ even part of $P(S)$ should gives roots On $j\omega$ axis. ex: $M(S)=S^2+5$, $N(S)=S^3+5S$

4. The continued fraction of even & odd part should be +ve residue.
5. Their should not be any missing power b/w highest and lower power of S except all the power either even or odd.
6. if two polynomial are hurwitz, then their multiplication also hurwitz.
   $P(S) = P_1(S) \cdot P_2(S)$

Thus a polynomial is hurwitz if

ⓐ $P(S)$ is real when S real

ⓑ The roots of $P(S)$ have real parts which are to be zero or -ve

Properties of PRF:

$F(s) = \frac{P(s)}{Q(s)}$

1. Both P(s) & Q(s) are hurwitz polynomials
2. Only simple poles with +ve real residue can exist on $j\omega$ axis
3. The highest and lowest of power of P(s) & Q(s) differ by unity. This condn prohabited multiple poles and zero at $s=0, \infty$

   Ex: $F(s) = \frac{s+4}{s^2+3s+2}$

4. if F(s) is +ve real function then reciprocal of F(s) is also +ve real function
   [This implies that if driving point impedance is a +ve real function then driving point admittance +ve real function]
5. if $F_1(s) = 2+j1$
   $F_2(s) = 3+j1$

   The sum of +ve real function is also +ve real function but their difference may or may not be +ve real function

6. Procedures for testing of PRF:

1) If $F(s) = \frac{P(s)}{Q(s)}$ then P(s) & Q(s) must be Hurwitz
2) F(s) must have simple pole on $j\omega$ axis with +ve and real residue.
3) if $F(s) = \frac{P(s)}{Q(s)} = \frac{M_1(s)+N_1(s)}{M_2(s)+N_2(s)}$

   where M(s) = even part
   N(s) = odd part

~~.then the realness of F(S)~~

$$\boxed{A(S) = M_1M_2 - N_1N_2}$$

$$\boxed{Re[A(j\omega)] \geq 0 \; \forall \omega}$$

Find whether the below given polynomial is Hurwitz or not

(1.) $P(S) = S^4 + S^3 + 2S^2 + 3S + 2$

Soln: $M(S) = S^4 + 2S^2 + 2$

$N(S) = S^3 + 3S$

Case1: $\dfrac{M(S)}{N(S)}$

$$S^3+3S \overline{)\, S^4+2S^2+2 \,} \left(S \right.$$
$$\underline{S^4+3S^2}$$
$$-S^2+2 \overline{)\, S^3+3S \,} \left(-S \right.$$

sign not be change

it is not Hurwitz polynomials due * condition

(2) $P(S) = S^4 + S^3 + 5S^2 + 3S + 4$

$M(S) = S^4 + 5S^2 + 4$

$N(S) = S^3 + 3S$

$\dfrac{M(S)}{N(S)}$;

$$S^3+3S \overline{)\, S^4+5S^2+4 \,} \left(S \right.$$
$$\underline{S^4+3S^2}$$
$$2S^2+4 \overline{)\, S^3+3S \,} \left(\frac{S}{2} \right.$$
$$\underline{S^3+2S}$$
$$S \overline{)\, 2S^2+4 \,} \left(2S \right.$$
$$\underline{2S^2}$$
$$4 \overline{)\, S \,} \left(S/4 \right.$$
$$\underline{S}$$
$$0$$

Hence it Hurwitz polynomials.

(iii) — $P(S) = \cancel{S^4 + S^3} + 6S + 4$ case 2:

Soln: As s power of $P(S)$ is missing in the above polynomial Hence above polynomial is not Hurwitz

(iv) $P(S) = S^4 + 3S^2 + 4$

Soln: case 3:

$$\frac{dP(S)}{dS} = 4S^3 + 6S$$

Let

$$4S^3+6S \overline{)\, S^4 + 3S^2 + 4\,} \left(\frac{S}{4}\right.$$

$$\underline{S^4 + \frac{3}{2}S^2}$$

$$\frac{3}{2}S^2 + 4 \overline{)\, 4S^3 + 6S\,} \left(\frac{8S}{3}\right.$$

$$\underline{4S^3 + \frac{32}{3}S}$$

$$-\frac{14}{3}S \overline{)\, \frac{3}{2}S^2 + 4\,} \left(-\frac{9}{28}S\right.$$

Sign changes

Hence Above polynomial is not Hurwitz.

(v) $P(S) = S^4 + 3S^2 + 2$

$$\frac{dP(S)}{dS} = 4S^3 + 6S$$

$$4S^3+6S \overline{)\, S^4 + 3S^2 + 2\,} \left(S/4\right.$$

$$\underline{S^4 + \frac{3}{2}S^2}$$

$$\frac{3}{2}S^2 + 2 \overline{)\, 4S^3 + 6S\,} \left(\frac{8}{3}S\right.$$

$$\underline{4S^3 + \frac{16}{3}S}$$

$$\frac{2}{3}S \overline{)\, \frac{3}{2}S^2 + 2\,} \left(\frac{9}{4}S\right.$$

$$\underline{\frac{3}{2}S^2}$$

$$2 \overline{)\, \frac{2}{3}S\,} \left(S/3\right.$$

$$\underline{\frac{2}{3}S}$$

$$\times$$

Above polynomials is Hurwitz.

(VI) $P(S) = 5S^3 + 6S^2 + 9S + 4$

$M(S) = 6S^2 + 4$

$N(S) = 5S^3 + 9S$

$5S^3+9S \,)\, 6S^2+4 \,(\, \cancel{\tfrac{6}{5}S}$ $\quad$ $\cancel{6S^2}$

$6S^2+4 \,)\, 5S^3+9S \,(\, \frac{5}{6}S$

$5S^3 + \frac{10}{3}S$

$\frac{17S}{3} \,)\, 6S^2+4 \,(\, \frac{18}{17}S$

$6S^2 +$

$4 \,)\, \frac{17}{3} \,(\, \frac{17}{12}S$

$\frac{17}{3}S$

Hurwitz polynomial.

Short cuts: (1) $as^3 + bx^2 + cx + d$ (only valid for this eqn)

* $\boxed{bc > ad}$ * stable

$\underline{54 > 20}$ above question

Stable

$\boxed{bc < ad \text{ unstable}}$

$\boxed{bc = ad \text{ marginally stable}}$

(II) $as^2 + bs + c = 0$

a, b, c should be real then system is stable

(vii) $P(S) = S^5 + 2S^4 + 3S^3 + 6S^2 + 4S + 8$

Soln: Case 3: $2S^4 + 6S^2 + 8 \overline{)\, S^5 + 3S^3 + 4S} \; (S/2$

$\underline{S^5 + 3S^3 + 4S}$

$0 \; \overline{)\, 2S^4 + 6S^2 + 8} \; (\tfrac{2}{3}S^3$

Since instant termination then another method to solve this question.

$$\boxed{\begin{array}{l} P_1(S) = \dfrac{P(S)}{W(S)} \\ P(S) = P_1(S) \cdot W(S) \end{array}}$$

$2S^4 + 6S^2 + 8 \overline{)\, S^5 + 2S^4 + 3S^3 + 6S^2 + 4S + 8} \; (S/2 + 1$

$\underline{S^5 + 3S^3 \quad + 4S}$

$2S^4 + 6S^2 + 8$

$\underline{2S^4 + 6S^2 + 8}$

$\times$

$P_1(S) = \frac{S}{2} + 1$ Hurwitz (Pole in the $-j\omega$ axis or Pole is -ve value)

$W(S) = 2S^4 + 6S^2 + 8$

$\frac{dW(S)}{dS} = 8S^3 + 12S$

$8S^3 + 12S \overline{)\, 2S^4 + 6S^2 + 8} \; (\tfrac{S}{4}$

$\underline{2S^4 + 3S^2}$

$3S^2 + 8 \overline{)\, 8S^3 + 12S} \; (\tfrac{8}{3}S$

$\underline{8S^3 + \tfrac{64}{3}S}$

$-\frac{28}{3}S \overline{)\, 3S^2 + 8} \; (-\frac{9}{28}S$

W(S) is not Hurwitze

$P(S) = P_1(S) \cdot W(S)$ is not Hurwitz.

$P(s) = s^3 + 4s^2 + 2s + 8$

$M(s) = 4s^2 + 8$

$N(s) = s^3 + 2s$

$$4s^2+8 \,\big)\, s^3 + 2s \,\big(\, 4s/4$$
$$\underline{4s^3 + 8s}$$
$$\times$$

$P_1(s) = \dfrac{P(s)}{W(s)}$

$$4s^2+8 \,\big)\, s^3 + 4s^2 + 2s + 8 \,\big(\, s/4 + 1$$
$$\underline{s^3 + 2s}$$
$$4s^2 + 8$$
$$\underline{4s^2 + 8}$$
$$\times$$

$P_1(s)$ is Hurwitz

$W(s) = 4s^2 + 8$ Hurwitz ~~(no missing terms)~~ $s = \pm j\sqrt{\frac{8}{4}} = s = \pm j\sqrt{2}$

Simple pole, one $j\omega$ axis

$P(s) = P_1(s) \cdot W(s)$. Hurwitz

Q. Find a for which $P(s)$ is Hurwitz:

$P(s) = 2s^4 + s^3 + as^2 + s + 2$

$M(s) = 2s^4 + as^2 + 2$

$N(s) = s^3 + s$

$$s^3+s \,\big)\, 2s^4 + as^2 + 2 \,\big(\, 2s$$
$$\underline{2s^4 + 2s^2}$$
$$(a-2)s^2+2 \,\big)\, s^3 + s \,\big(\, \frac{s}{a-2}$$
$$\underline{s^3 + \frac{2s}{a-2}}$$
$$s\left(1 - \frac{1}{a-2}\right) \,\big)\, (a-2)s^2 + 2 \,\big(\, \frac{(a-2)^2}{a-3}$$
$$\underline{(a-2)s^2}$$
$$2 \,\big)\, \frac{a-3}{a-2}s \,\big(\, \frac{a-3}{2(a-2)}s$$
$$\underline{\frac{a-3}{a-2}s}$$

Q. $F(S) = \frac{S^2+10S+4}{S+2}$ Find the wheather the below given function is a PRF or not?

Soln: $P(S) = S^4+10S+4$

$Q(S) = S+2$

$M_1(S) = S^4+4$ $N_1(S) = 10S$

$M_2(S) = 2$ $N_2(S) = S$

$A(S) = M_1M_2 - N_1N_2$

$= (S^2+4)2 - 10S \cdot S$

$= 2S^2+8-10S^2$

$A(S) = -8S^2+8$

$A(j\omega) = -8(-j\omega)^2+8 = 8\omega^2+8$

$A(j\omega) \geq 0 \ \forall \omega$ P.RF.

Q. $F(S) = \frac{S^3+5S^2+9S+3}{S^3+4S^2+7S+9}$

Soln: $P(S) = S^3+5S^2+9S+3$ $M_1(S) = 5S^2+3$ $N_1(S) = S^3+9S$

$Q(S) = S^3+4S^2+7S+9$ $M_2(S) = 4S^2+9$ $N_2(S) = S^3+7S$

$A(S) = \cancel{M_1M_2} - N_1\cancel{N_2}$

$= (5S^2+3)(4S^2+9) - (S^3+9S)(S^3+7S)$

$= 20S^4+12S^2+45S^2+27 - S$

in case of P(S).

$bc > ad \Rightarrow 46 > 3$ stable Hurwitz

in case of Q(S)

$bc < ad \Rightarrow 28 > 9$ stable Hurwitz

$F(S) = \frac{P(S)}{Q(S)}$ Hurwitz

$$A(s) = (5s^2+3)(4s^2+9) - (s^3+2s)(s^3+7s)$$
$$= 20s^4+57s^2+27 - (s^6+16s^4+63s^2)$$
$$= -s^6+4s^4-6s^2+27$$
$$A(j\omega) = \omega^6+4\omega^4+6\omega^2+27$$

$A(j\omega) \geq 0 \; \forall \omega$ PRF Ans

(1)
1) Foster I $\longrightarrow Z(s) \longrightarrow$ Series
II) Foster II $\longrightarrow Y(s) \longrightarrow$,,
} Partial fraction

(2)
Cauer - I
Cauer - II
] $\rightarrow$ ladder N/w $\rightarrow$ continued fraction

IES

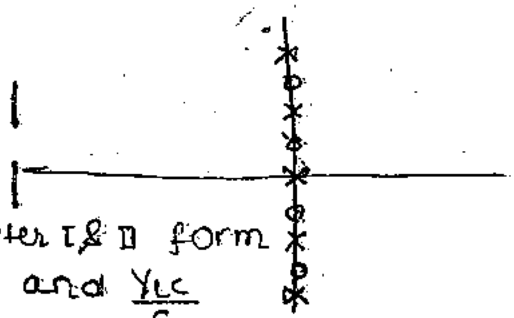
Properties of LC n/w :-

(1) Either pole or zero should be present in origin.
(2) ,, ,, ,, ,, ,, ,, ,, at infinity
(3) Poles and zero are arranged alternatively on $j\omega$ axis.
(4) The transfer function consist of

$\frac{\text{even}}{\text{odd}}$ or $\frac{\text{odd}}{\text{even}}$ power of s

(5) In the partial faction of expansion Residue should be possitive Real.

(6) $\frac{dX}{d\omega} > 0$ ie slope is possitive

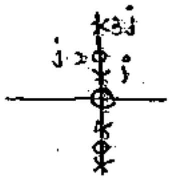


N.B In case Foster I & II form devide $\frac{Z_{LC}}{s}$ and $\frac{Y_{LC}}{s}$

Q. $Z(s) = \frac{s(s^2+4)}{2(s^2+1)(s^2+9)}$ Synthesis the n/w in Foster I, Foster II, Cauer I and Cauer II forms.

Soln: Foster I

$S_z = 0, \pm j2$, $S_p = \pm j, \pm j3$



$$\frac{Z(s)}{s} = \frac{1}{2}\left[\frac{s^2+4}{(s^2+1)(s^2+9)}\right]$$

$$\frac{s^2+4}{(s^2+1)(s^2+9)} = \frac{a}{s^2+1} + \frac{b}{s^2+9}$$

Put $s^2 = x$

$$\frac{x+4}{(x+1)(x+9)} = \frac{a}{x+1} + \frac{b}{x+9}$$

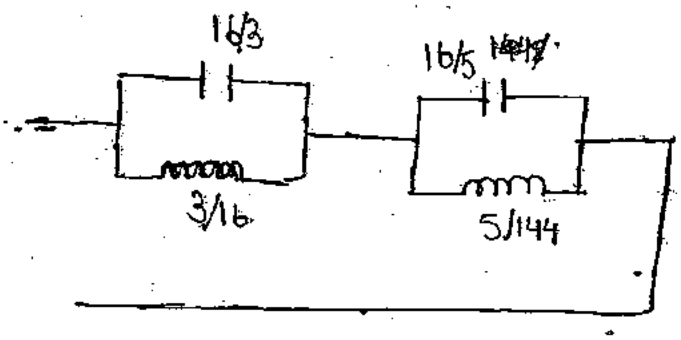
$\therefore a = \frac{3}{8}$ $b = \frac{5}{8}$

Z	Y
Ls	$1/Ls$
$\frac{1}{Cs}$	Cs
R	R

$$\frac{Z(s)}{s} = \frac{1}{2}\left[\frac{3/8}{s^2+1} + \frac{5/8}{s^2+9}\right]$$

$$Z(s) = \frac{3/16\, s}{s^2+1} + \frac{\frac{5}{16} s}{s^2+9}$$

$$Z(s) = \underbrace{\frac{1}{\underbrace{\frac{16}{3}s + \frac{1}{\frac{3}{16}s}}_{Y_1(s)}}}_{Z_1} + \underbrace{\frac{1}{\underbrace{\frac{16}{5}s + \frac{1}{\frac{5}{144}s}}_{Y_2(s)}}}_{Z_2}$$



Foster II

$$Y(s) = \frac{2(s^2+1)(s^2+9)}{s(s^2+4)}$$

$$\frac{Y(s)}{s} = 2\left[\frac{(s^2+1)(s^2+9)}{s^2(s^4+4)}\right]$$

Put $s^2 = x$

$$\cancel{\frac{(x+1)(x+4)}{x+(x^2+2)}} = \cancel{\frac{A}{x} + \frac{b}{x+4}}$$

$$\frac{(x+1)(x+9)}{x(x+2)} = \frac{x^2+10x+9}{x^2+4x} = 1 + \frac{6x+9}{x^2+4x}$$

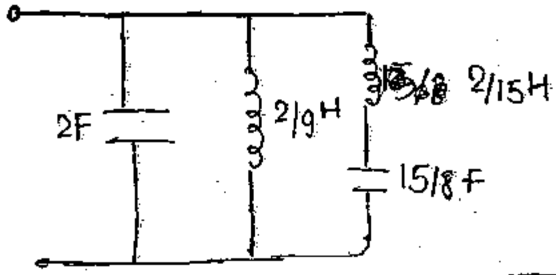
$$\frac{6x+9}{x^2+4x} = \frac{A}{x} + \frac{B}{x+4}$$

$$A = 9/4 \qquad B = 15/4$$

$$\frac{Y(s)}{s} = 2\left[1 + \frac{9/4}{s^2} + \frac{15/4}{s^2+4}\right]$$

$$Y(s) = 2s + \frac{9}{2s} + \frac{15/2\, s}{s^2+4}$$

$$= \underbrace{2s}_{Y_1} + \underbrace{\frac{1}{\frac{2}{9}s}}_{Y_2} + \underbrace{\frac{1}{\underbrace{\frac{2}{15}s}_{Z_1} + \underbrace{\frac{1}{\frac{15}{8}s}}_{Z_2}}}_{Y_3}$$



Cauer I

$$Z(s) = \frac{s^3+4s}{2s^4+20s^2+18}$$

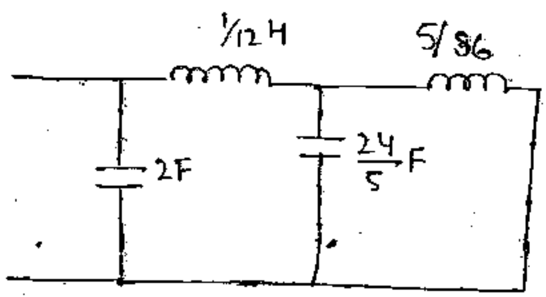
$$Z(s) = \frac{1}{Y\left[\dfrac{2s^4+20s^2+18}{s^3+4s}\right.} = \frac{1}{\quad}$$

$$\begin{array}{l}
s^3+4s \,\big)\, 2s^4+20s^2+18 \,\big(\, 2s \to Y \to C \\
\qquad \underline{2s^4+8s^2} \\
\qquad 12s^2+18 \,\big)\, s^3+4s \,\big(\, s/12 \to Z \to L \\
\qquad\qquad \underline{s^3+\tfrac{3}{2}s} \\
\qquad\qquad \tfrac{5}{2}s \,\big)\, 12s^2+18 \,\big(\, \tfrac{24}{5}s \to Y \to C \\
\qquad\qquad\qquad \underline{12s^2} \\
\qquad\qquad\qquad 18 \,\big)\, \tfrac{5}{2}s \,\big(\, \tfrac{5}{36}s \to Z \to L \\
\qquad\qquad\qquad\qquad \underline{\tfrac{5}{2}s} \\
\qquad\qquad\qquad\qquad \times
\end{array}$$

$$Z(s) = \frac{1}{\dfrac{2s^4+20s^2+18}{s^3+4s}} = \frac{1}{2s+\dfrac{12s^2+18}{s^3+4s}} = \frac{1}{2s+\dfrac{1}{\dfrac{s^3+4s}{12s^2+18}}}$$

$$= \frac{1}{2s+\dfrac{1}{\dfrac{s}{12}+\dfrac{5/2\,s}{12s^2+18}}} = \frac{1}{2s+\dfrac{1}{\dfrac{s}{12}+\dfrac{1}{\dfrac{12s^2+18}{5/2\,s}}}}$$

$$= \frac{1}{2s+\dfrac{1}{\dfrac{s}{12}+\dfrac{1}{\dfrac{24s}{5}+\dfrac{18}{5/2\,s}}}} = \frac{1}{Y\,2s+\dfrac{1}{Z\,\dfrac{s}{12}+\dfrac{1}{Y\,\dfrac{24}{5}s+\dfrac{1}{Z\,\dfrac{18}{\frac{5}{2}s}}}}} = \frac{1}{2s+\dfrac{1}{\dfrac{s}{12}+\dfrac{1}{\dfrac{24}{5}s+\dfrac{1}{\frac{5}{36}s}}}}$$



Cauer II

$$Z(S) = \frac{S^3+4S}{2S^4+20S^2+18} = \frac{1}{\frac{2S^4+20S^2+18}{S^3+4S}} = \frac{1}{\frac{18+20S^2+2S^4}{4S+S^3}}$$

$4s+s^3 \,)\, 18+20s^2+2s^4 \,\left(\frac{9}{2s}\right. \rightarrow Y \rightarrow L$

$18 + \frac{9}{2}s^2$

$\frac{31}{2}s^2+2s^4 \,)\, 4s+s^3 \,\left(\frac{8}{31 s}\right. \rightarrow Z \rightarrow C$

$4s+\frac{16}{31}s^3$

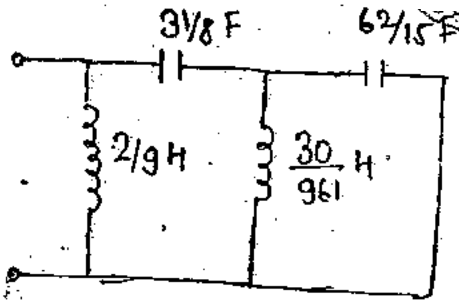
$\frac{15}{31}s^3 \,)\, \frac{31}{2}s^2+2s^4 \,\left(\frac{961}{30s}\right. \rightarrow Y \rightarrow L$

$\frac{31}{2}s^2$

$2s^4 \,)\, \frac{15}{31}s^3 \,\left(\frac{15}{62s}\right. \rightarrow Z - C$

$\frac{15}{31}s^3$

$\times$

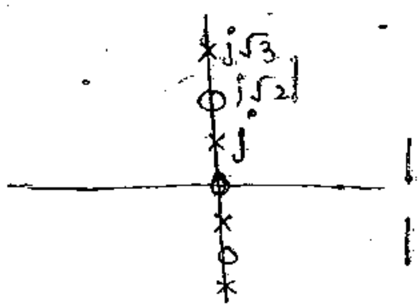


Q. Synthesis the n/w in foster I, foster II cauer I and cauer II form:

$$Z(S) = \frac{S(S^2+2)}{(S^2+1)(S^2+3)}$$

Soln: $S_z = 0 \,,\ \pm j\sqrt{2}$

$S_p : \pm j \quad \pm j\sqrt{3}$



Foster I

$$\frac{Z(s)}{s} = \frac{s^2+2}{(s^2+1)(s^2+3)}$$

Put $s^2 = x$

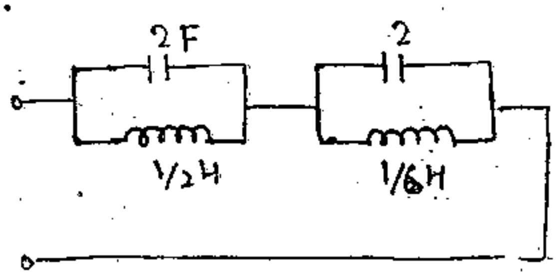
$$\frac{x+2}{(x+1)(x+3)} = \frac{A}{x+1} + \frac{B}{x+3}$$

$$A = \frac{1}{2} \qquad B = 1/2$$

$$\frac{Z(s)}{s} = \frac{1/2}{s^2+1} + \frac{1/2}{s^2+3}$$

$$Z(s) = \left[\frac{1/2\, s}{s^2+1} + \frac{s/2}{s^2+3}\right]$$

$$Z(s) = \underbrace{\frac{1}{2s + \frac{1}{s/2}}}_{Y_1} + \underbrace{\frac{1}{2s + \frac{1}{\frac{2}{6}s}}}_{Y_2}$$



Foster II For

$$Y(s) = \frac{(s^2+1)(s^2+3)}{s(s^2+2)}$$

$$\frac{Y(s)}{s} = \frac{(s^2+1)(s^2+3)}{s^2(s^2+2)}$$

Put $s^2 = x$

$$\frac{(x+1)(x+3)}{x(x+2)} = \frac{x^2+4x+3}{x^2+2x} = 1 + \frac{2x+3}{x^2+2x}$$

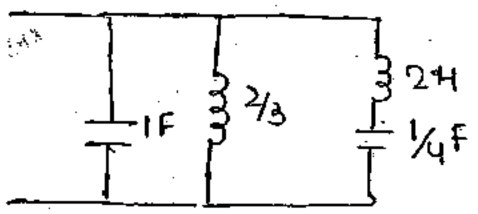
$$\frac{2x+3}{x^2+2x} = \frac{A}{x} + \frac{B}{x+2}$$

$$A = 3/2 \qquad B = 1/2$$

$$\frac{Y(s)}{s} = \left[1 + \frac{3/2}{s^2} + \frac{1/2}{s^2+2}\right]$$

$$Y(s) = \left[s + \frac{3/2\, s}{s^2} + \frac{1/2\, s}{s^2+2}\right]$$

$$Y(s) = \left[s + \frac{1}{\frac{2}{3}s} + \frac{1}{2s + \frac{1}{1/4\, s}}\right]$$



– Cauer I

$$Z(s) = \frac{s(s^2+2)}{(s^2+1)(s^2+3)} = \frac{s^3+2s}{s^4+4s^2+3}$$

$$Z(s) = \cfrac{1}{Y - \left[\cfrac{s^4+4s^2+3}{s^3+2s}\right]}$$

$s^3+2s \,)\, \cancel{s^4}+4s^2+3 \,(\, s \to Y \to C$

$\underline{\cancel{s^4}+2s^2}$

$2s^2+3 \,)\, \cancel{s^3}+2s \,(\, \frac{1}{2}s \to Z \to L$

$\underline{\cancel{s^3}+\frac{3}{2}s}$

$\frac{1}{2}s \,)\, 2\cancel{s^2}+3 \,(\, 4s \to Y \to C$

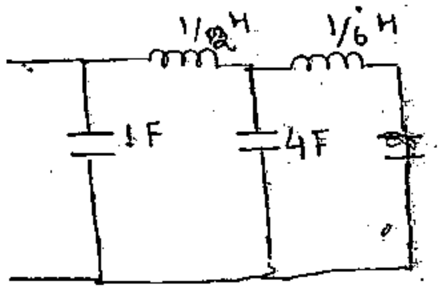
$\underline{\cancel{2s^2}}$

$3 \,)\, \frac{1}{2}s \,(\, \frac{1}{6}s \to Z \to L$

$\underline{\frac{1}{2}s}$

$\times$

$$Z(s) = \cfrac{1}{s + \cfrac{1}{\frac{1}{2}s + \cfrac{1}{4s + \cfrac{1}{\frac{1}{6}s}}}}$$



Cauer II

$$Z(s) = \frac{1}{\dfrac{3+4s^2+s^4}{2s+s^3}}$$

$2s+s^3 \,)\, \cancel{3}+4s^2+s^4 \,(\, \frac{3}{2s} \to Y \to L$

$\cancel{3}+\frac{3}{2}s^2$

$\frac{5}{2}s^2+s^4 \,)\, 2\cancel{s}+s^3 \,(\, \frac{4}{5s} \to Z \to C$

$\cancel{2s}+\frac{4}{5}s^3$

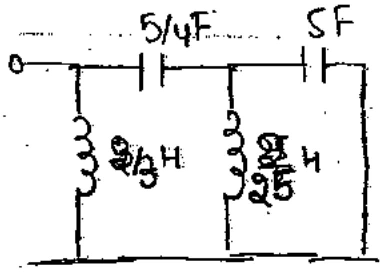
$\frac{1}{5}s^3 \,)\, \frac{5}{2}\cancel{s^2}+s^4 \,(\, \frac{25}{2s} \to Y \to L$

$\frac{5}{2}s^2$

$s^4 \,)\, \frac{1}{5}s^3 \,(\, \frac{1}{5s} \to Z \to C$

$\frac{1}{5}s^3$

X



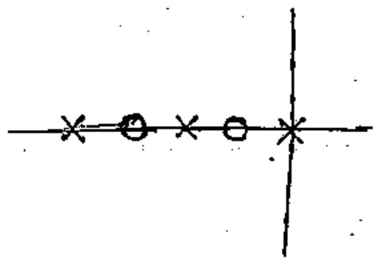
Properties of Z_{RC} Y_{RL}

(1) The lowest frequency is due to pole and it may ~~be~~ present at origin or nearer to origin.

(2) The highest critical frequency is due to zero and it may be present at infinity or near ~~to~~ infinity.

(3) Poles and zero are arranged alternatively in -ve real axis.

(4) Slop $\left(\frac{dZ_{RC}}{ds} < 0 \quad \frac{dY_{RL}}{ds} < 0\right)$ -ve.



Properties of Z_{RL} & Y_{RC}

1. Highest critical frequency is due to pole and it may be present at either at ∞ or nearer to ∞.
2. The lowest crictical f is due to zero and it may be present at origin or nearer to origin.
3. Poles and zero are arranged alternatively in -ve real axis
4. Slop is +ve

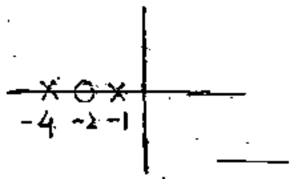
$$\frac{dZ_{RL}}{ds} > 0, \quad \frac{dY_{RC}}{ds} > 0$$

Note: For foster I & II form we will do partial fraction expansion for Z_{RC} Y_{RL} $\frac{Z_{RL}}{S}$ $\frac{Y_{RC}}{S}$

Q. $Z(s) = \dfrac{3(s+2)}{(s+1)(s+4)}$

Soln: Foster I

$S_z = -2 \qquad S_p = -1, -4$



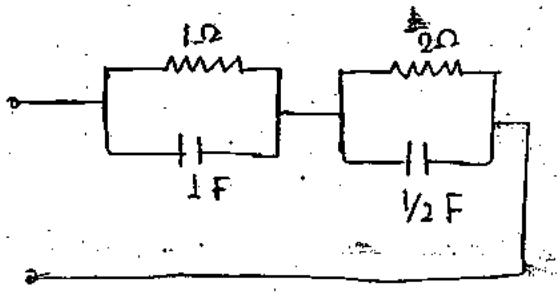
$$Z(s) = \frac{3(s+2)}{(s+1)(s+4)}$$

$$Z_{RC} = \frac{a}{s+1} + \frac{b}{s+4}$$

$a = 1 \qquad b = 2$

$$Z_{RC} = \frac{1}{s+1} + \frac{2}{s+4}$$

$$= \underset{Y_1}{\frac{1}{s+1}} + \underset{Y_2}{\frac{1}{2 + s/2}}$$



Foster II –

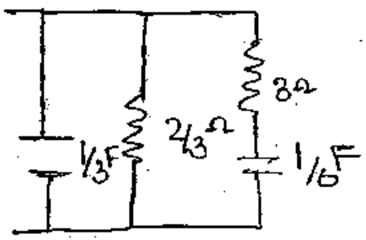
$$Y(s) = \frac{s^2+5s+4}{3(s+2)}$$

$$\frac{Y(s)}{s} = \frac{s^2+5s+4}{s^2+2s} = \frac{1}{3}\left[1 + \frac{3s+4}{s^2+2s}\right]$$

$$\frac{3s+4}{s^2+2s} = \frac{A}{s} + \frac{B}{s+2} \quad ; \quad A = 2 \quad B = 2$$

$$Y(s) = \left[\frac{s}{3} + \frac{2}{3} + \frac{s}{3s+6}\right]$$

$$Y_{RC} = \frac{2}{3} + \frac{1}{3}s + \frac{1}{3 + \frac{1}{\frac{1}{6}s}}$$

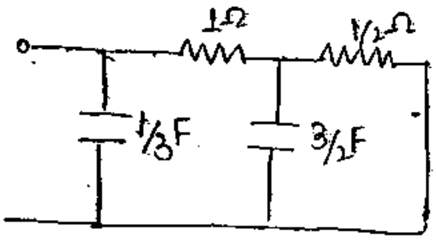


Cauer I.

$$Z = \frac{1}{Y} = \frac{1}{\frac{S^2+5S+4}{3S+6}}$$

$$\begin{array}{l}
3S+6\,\big)\,\cancel{S^2}+5S+4\,\big(\tfrac{1}{3}S \to Y \to C \\
\quad \cancel{S^2}+2S \\
\quad\quad 3S+4\,\big)\,\cancel{3S}+6\,\big(1 \to Z \to R \\
\quad\quad\quad \cancel{3S}+4 \\
\quad\quad\quad\quad 2\,\big)\,\cancel{3S}+4\,\big(\tfrac{3}{2}S \to Y \to C \\
\quad\quad\quad\quad\quad 3S \\
\quad\quad\quad\quad\quad\quad 4\,\big)\,2\,\big(\tfrac{1}{2} \to Z \to R \\
\quad\quad\quad\quad\quad\quad\quad 2 \\
\quad\quad\quad\quad\quad\quad\quad \times
\end{array}$$

$$Z_{RC} = \cfrac{1}{\frac{1}{3}S + \cfrac{1}{1 + \cfrac{1}{\frac{3}{2}S + \cfrac{1}{\frac{1}{2}}}}}$$

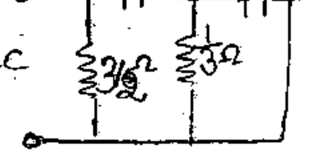


Cauer II f

$$Z = \frac{1}{\frac{4+5S+S^2}{6+3S}}$$

$$\begin{array}{l}
6+3S\,\big)\,\cancel{4}+5S+S^2\,\big(\tfrac{2}{3} \to Y \to R \\
\quad \cancel{4}+2S \\
\quad\quad 3S+S^2\,\big)\,\cancel{6}+3S\,\big(2/S \to Z \to C \\
\quad\quad\quad \cancel{6}+2S \\
\quad\quad\quad\quad S\,\big)\,\cancel{3S}+S^2\,\big(3 \to Y \to R \\
\quad\quad\quad\quad\quad 3S \\
\quad\quad\quad\quad\quad\quad S^2\,\big)\,S\,\big(1/S \to Z - C \\
\quad\quad\quad\quad\quad\quad\quad S \\
\quad\quad\quad\quad\quad\quad\quad \times
\end{array}$$

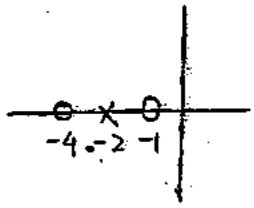
$$Z_{RC} = \cfrac{1}{\frac{2}{3} + \cfrac{1}{\frac{2}{S} + \cfrac{1}{3 + \cfrac{1}{S}}}}$$



$$\cancel{Z(S) = \frac{(S+1)(S+4)}{(S+2)}}$$

Soln: $S_z = -1, -4$

$S_p = -2$



$$Z_{RL} = \frac{S^2+4S+4}{S+2}$$

Foster I

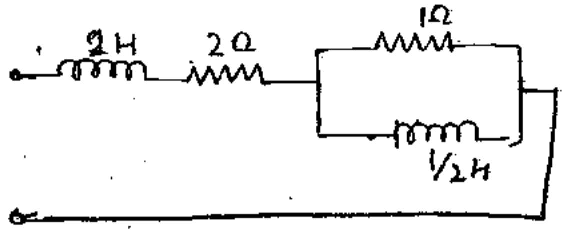
$$\cancel{\frac{Z(S)}{S} = \frac{S^2+4S+4}{S(S+2)} = \frac{A}{S} + \frac{BS+C}{S+1}}$$

$$\frac{Z(S)}{S} = \frac{S^2+4S+4}{S^2+2S} = 1 + \frac{2S+4}{S^2+2S}$$

$$\frac{2S+4}{S^2+2S} = \frac{A}{S} + \frac{B}{S+2} = \frac{2}{S} + \frac{1}{S+2}$$

$$Z(S) = \left[S+2+\frac{S}{S+2}\right] = \left[S+2+\frac{1}{\underset{Y_1}{1}+\underset{Y_2}{2/S}}\right]$$

=



Foster II

$$\cancel{\frac{Y(S)}{S} = \frac{S+2}{(S+1)(S+4)}}$$

$$\frac{Y(S)}{S} = \frac{S+2}{S(S+1)(S+4)} = \frac{A}{S} + \frac{B}{S+1} + \frac{C}{S+4}$$

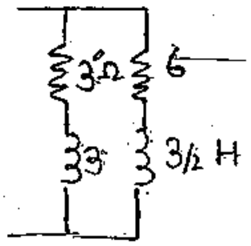
A =

Foster II

$$Y_{RC}(S) = \frac{S+2}{(S+1)(S+4)} = \frac{A}{S+1} + \frac{B}{S+4}$$

$$A = 1/3 \qquad B = 2/3$$

$$\therefore \; Y_{RC}(S) = \frac{1}{3S+3} + \frac{1}{\frac{3}{2}S+6}$$



Cauer I

$$\cancel{Z = \frac{1}{\frac{S+2}{(S+1)(S+4)}}}$$

$$Z(S) = \frac{S^2+5S+4}{S+2}$$

$S+2 \,)\, S^2+5S+4 \,(\, S \rightarrow Z$

S^2+2S

$3S+4 \,)\, S+2 \,(\, 1/3 \rightarrow Y$

$S+\frac{4}{3}$

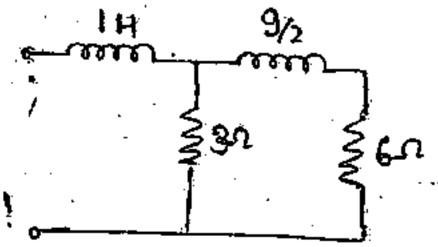
$\frac{2}{3} \,)\, 3S+4 \,(\, \frac{9}{2}S \rightarrow Z$

$3S+$

$4 \,)\, 2/3 \,(\, 1/6 \rightarrow Y$

$2/3$

$\times$



Cauer II

$$Z(S) = \frac{4+5S+S^2}{2+S}$$

$2+S \,)\, 4+5S+S^2 \,(\, 2 \rightarrow Z$

$4+2S$

$3S+S^2 \,)\, 2+S \,(\, \frac{2}{3S} \rightarrow Y$

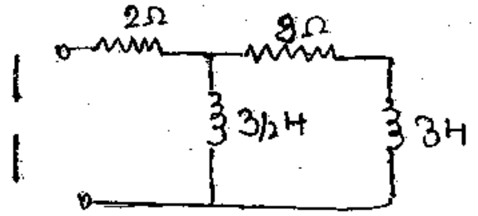
$2+\frac{2}{3}S$

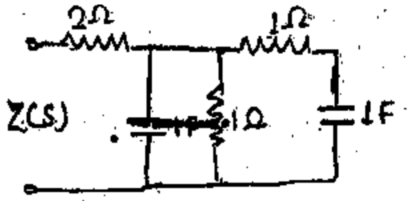
$\frac{1}{3}S \,)\, 3S+S^2 \,(\, \frac{9}{S} \; Z$

$3S+$

$S^2 \,)\, S/3 \,(\, \frac{1}{3S} \; Y$

$S/3$



Q. 

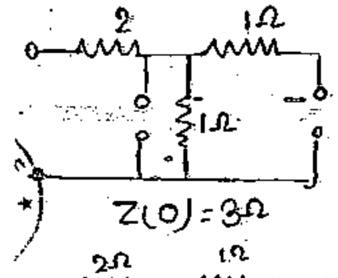
Realization of driving point impedence $Z = \frac{\alpha s^2 + 7s + 3}{s^2 + 3s + \beta}$ is given above find the value of α and β.

Soln:

Note: In this type Question alway find Z(s) value at $s = 0, \infty$ where capacitor acts as O.C and S.C respectively.

$Z(0) = \frac{3}{\beta} = 3$

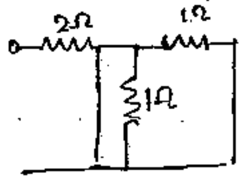
$\boxed{\beta = 1}$



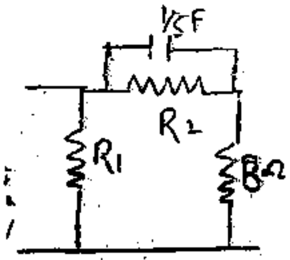
$Z(0) = 3\Omega$

$Z(\infty) = \frac{\alpha}{\beta} = 2$

$\boxed{\alpha = 2}$



$Z(\infty) = 2$

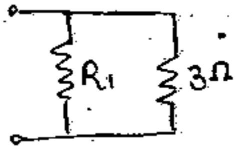
Q. 

$Z(0) = 3$

$Z(\infty) = 2$

Find the value of R_1 & R_2

Soln: $Z(\infty)$

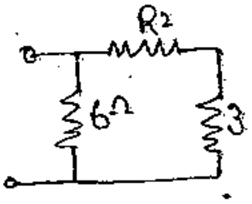


$Z(\infty) = \frac{R_1 3}{R_1 + 3} = 2$

$= 2R_1 + 6 = 3R_1$

$R_1 = 6$

$Z(0)$



$Z(0) = \frac{6(R_2 + 3)}{9 + R_2} = 3$

$= 6R_2 + 18 = 27 + 3R_2$

$= 3R_2 = 9$

$R_2 = 3$

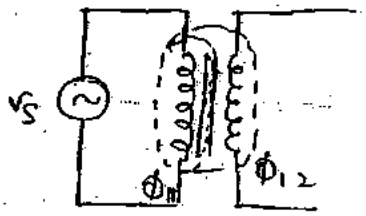
Dot polarity:

- Princepal of induction states that if we have current carrying coil near each other then they affect one and another.

- Faraday's law of Induction states that whenever a coil in M.F and field is time varrying. then voltage induced in the coil.

$$\phi_1 = \phi_{11} + \phi_{12}$$

ϕ_{11} → leakage flux, ϕ_{12} → Magnetising flux



$$e_2 = N_2 \frac{d\phi_{12}}{dt}$$

$$e_2 = N_2 \frac{d\phi_{12}}{di_1} \times \frac{di_1}{dt}$$

where $\boxed{M_{12} = N_2 \frac{d\phi_{12}}{di_1}}$

$\cancel{e_2 = M_{12} \frac{d\phi_{12}}{dt_1}}$ $\quad e_2 = M_{12} \frac{di_1}{dt_1}$

Similarly

$\cancel{e_1 = M_{21} d\phi_2}$ $\quad e_1 = M_{21} \frac{di_2}{dt_2}$

$$\boxed{M_{21} = N_1 \frac{d\phi_{21}}{dt_2}}$$

$$M_{12}\cdot M_{21} = N_2\frac{d\phi_{12}}{di_1}\cdot N_1\frac{d\phi_{21}}{di_2}$$

$$M_1\cdot M_2 = N_2K_1\frac{d\phi_1}{di_1}\cdot N_1K_2\frac{d\phi_2}{di_2}$$

$$= K_1K_2\left(N_1\frac{d\phi_1}{di_1}\right)\left(N_2\frac{d\phi_2}{di_2}\right)$$

$$= K_1K_2\cdot L_1L_2$$

Let $M_{12}=M_2=M$

$K=K_1=K_2$

$$M^2 = K_1K_2\,L_1L_2$$

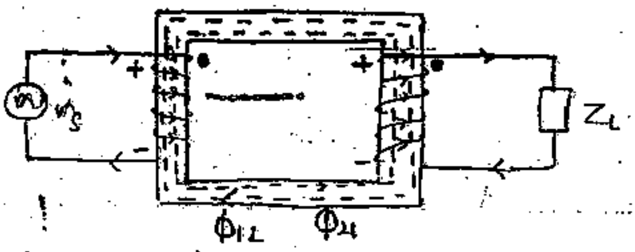
$$M^2 = K^2\,L_1L_2$$

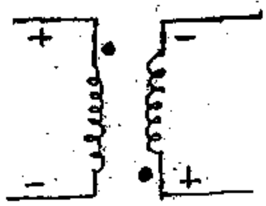
$$\boxed{M = K\sqrt{L_1L_2}}$$

where $K = \frac{\text{useful flux}}{\text{Total flux}}$ (coupling coefficient)

$$\boxed{0\le K\le 1}$$

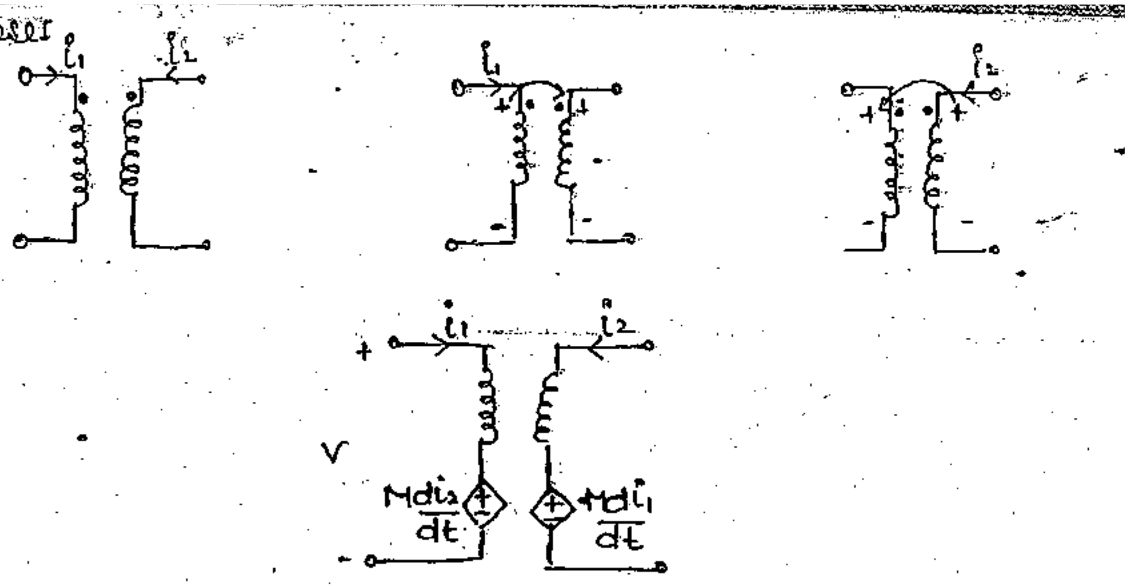
Polarity concept



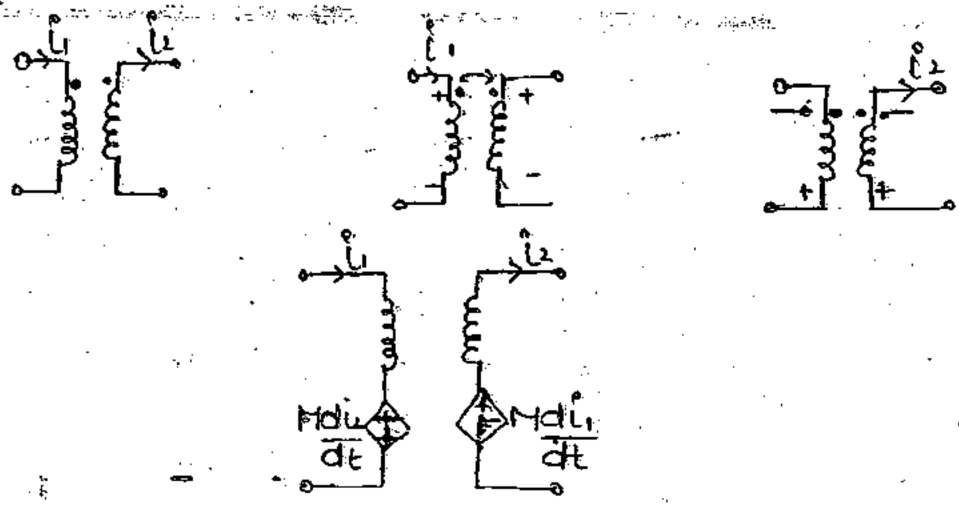


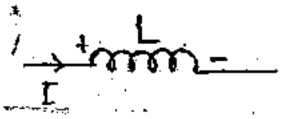
Dot polarity should have same polarity.

Case 1



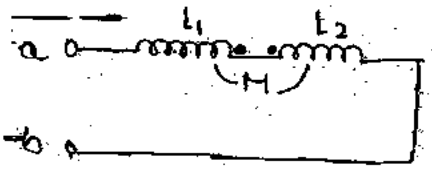
Case 2



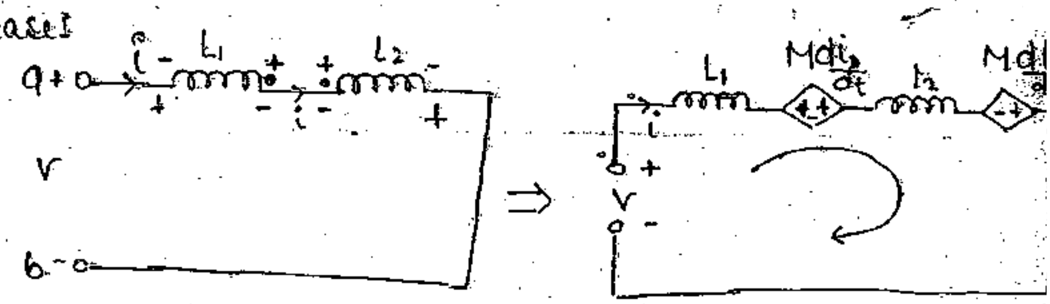
* 

$$V = L\frac{di}{dt}$$
$$= j\omega L i$$
$$= sLi$$

Q: Find equivalent inductance



Solⁿ: Case I



V = Apply KCL

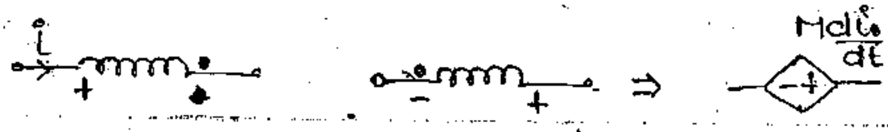
$$-V + L_1\frac{di}{dt} - M\frac{di}{dt} + L_2\frac{di}{dt} - M\frac{di}{dt}$$

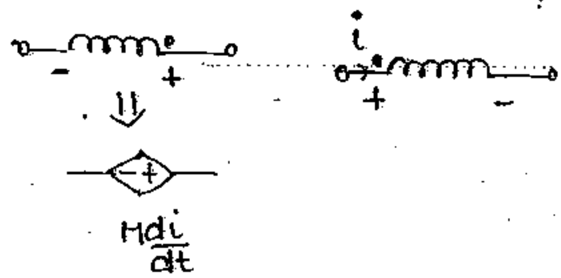
$$V = (L_1 + L_2 - 2M)\frac{di}{dt}$$

$$V = L_{eq}\frac{di}{dt}$$

where

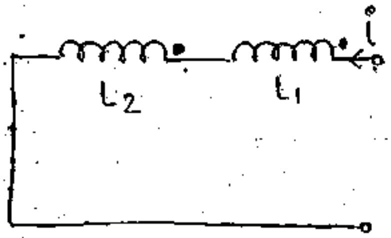
$$\boxed{L_{eq} = L_1 + L_2 - 2M}$$

① 

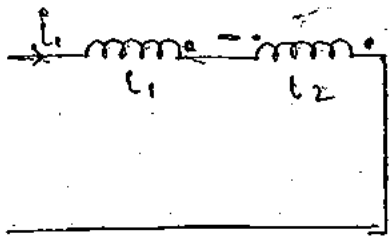
② 

Note :

1. If the I enters or exist both dots, then mutual inductance M is additive

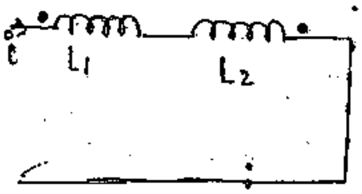


$L_{eq} = L_1 + L_2 + 2M$

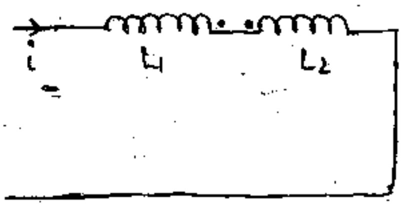


$L_{eq} = L_1 + L_2 + 2M$

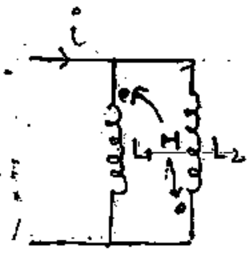
2. if the I enters from one dot and leaves at the other then mutual inductance is subtractive in nature



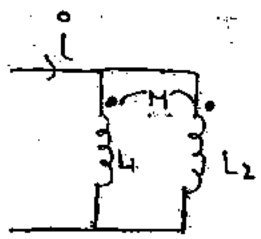
$L_{eq} = L_1 + L_2 - 2M$



$L_{eq} = L_1 + L_2 - 2M$

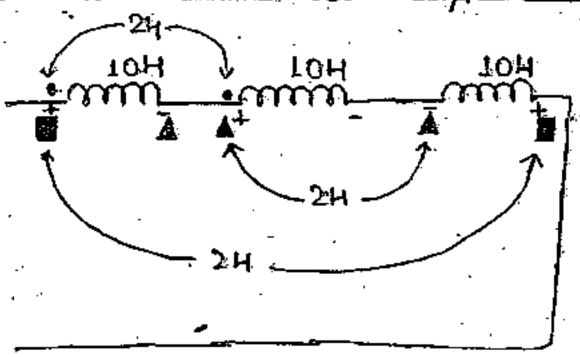


$$L_{eq} = \frac{L_1 L_2 - M^2}{L_1 + L_2 + 2M}$$

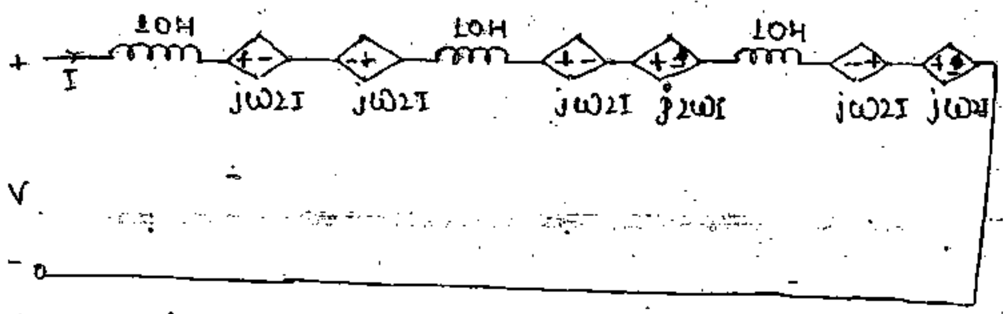


$$L_{eq} = \frac{L_1 L_2 - M^2}{L_1 + L_2 - 2M}$$

Q. Find the inductance at i/p terminals



Soln:



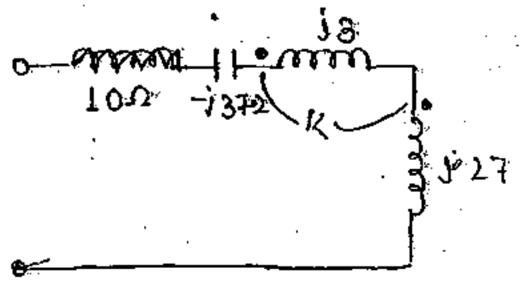
$$V = (j\omega 10I + \cancel{j\omega 2I} - \cancel{j\omega 2I}) + (j\omega 10I + \cancel{j\omega 2I} + \cancel{j\omega 2I})$$
$$+ (j10\omega I - \cancel{j\omega 2I} + \cancel{j\omega 2I})$$

$V = j\omega 34I$

$\boxed{L_{eq} = 34H}$

$L_{eq} = L_1 + L_2 + L_3 + \cancel{2M} - \cancel{2M} + 2M$
$= 10 + 10 + 10 + 2 \times 2$
$= 34H$

Determine the K for series resonance?



Soln:

$L_{eq} = L_1 + L_2 + 2M$

$\omega L_{eq} = \omega L_1 + \omega L_2 + 2\omega M$

$X_L = (3+27) + 2X_m$ — (1)

As we know

$M = K\sqrt{L_1 L_2}$

$\omega M = K\sqrt{\omega L_1 \cdot \omega L_2}$

$X_m = K\sqrt{3 \times 27} = 9K$

$X_L = (3+27) + 2 \times 9K$

$X_L = 30 + 18K$

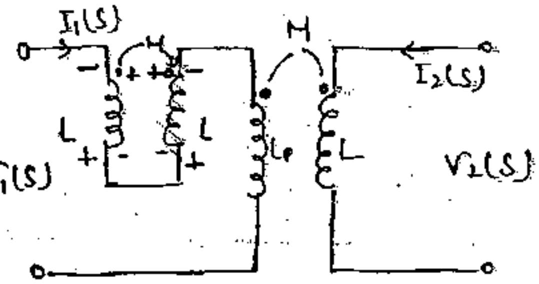
At series resonance

$X_L = X_c$

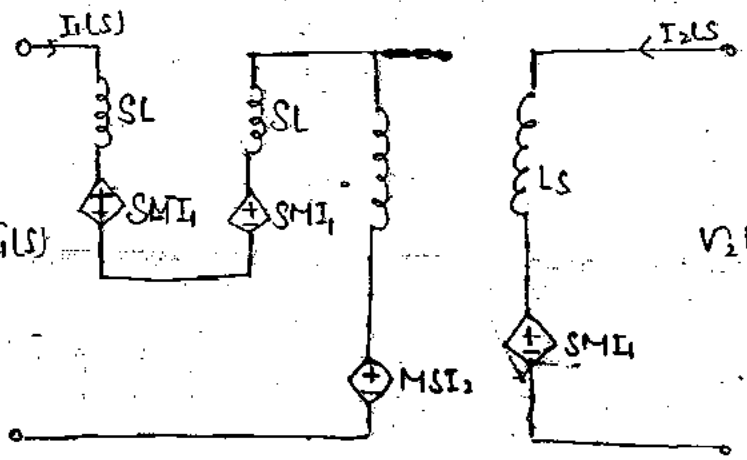
$30 + 18K = 37.2$

$\boxed{K = 0.4}$ Ans

Find the Z parameter of two port n/w given



Soln:



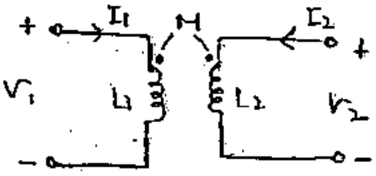
$$V_2(S) = I_2(S)SL + SMI_1$$

$$V_1(S) = SLI_1 - SMI_1 - SMI_1 + SLI_1 + SLI_1 + SMI_2$$

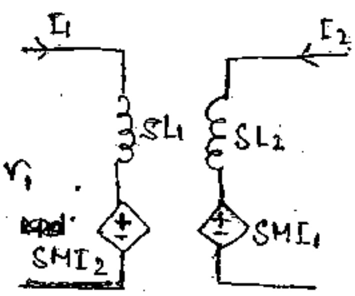
$$V_1(S) = I_1(3SL - 2SM) + SMI_2$$

$$Z = S\begin{bmatrix} 3L-2M & M \\ M & L \end{bmatrix}$$

Q. Determine the equivalent ckt of x^r



Soln:



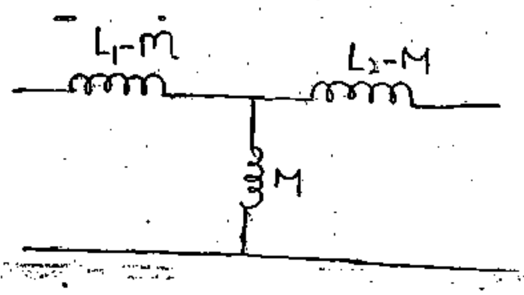
$$V_1 = sL_1I_1 + sMI_2$$
$$V_2 = sMI_1 + sL_2I_2$$

$$Z = \begin{bmatrix} L_1 & M \\ M & L_2 \end{bmatrix}$$

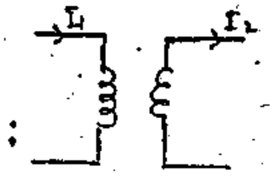
$Z_{11} = L_1$

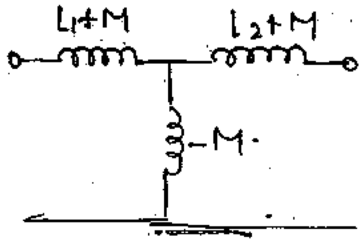
$Z_{12} = Z_{21} = M$

$Z_{22} = L_2$

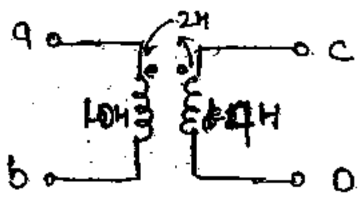


In case



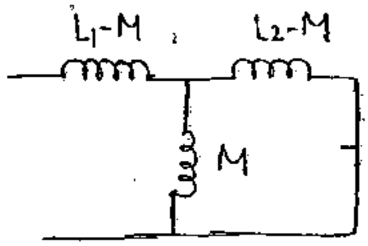


Q. Find the equivalent inductance b/w a & b when terminal c & d short circuited.



Soln: case I (supporting)

$$L_{eq} = L_1 - M + \frac{M(L_2 - M)}{M + L_2 - M}$$

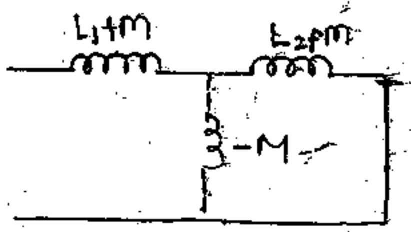


$$= L_1 - M + \frac{ML_2 - M^2}{L_2}$$

$$= \frac{L_1L_2 - \cancel{L_2M} - M^2 + \cancel{ML_2}}{L_2} = L_1 - \frac{M^2}{L_2}$$

case (opposing current)

$$L_{eq} = L_1 - \frac{M^2}{L_2}$$



$$\therefore \quad 10 - \frac{4}{4B} = 9.H$$

• Notes:

1. If both dots are positive or negative same sign w.r.t to each other

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

If different sign then

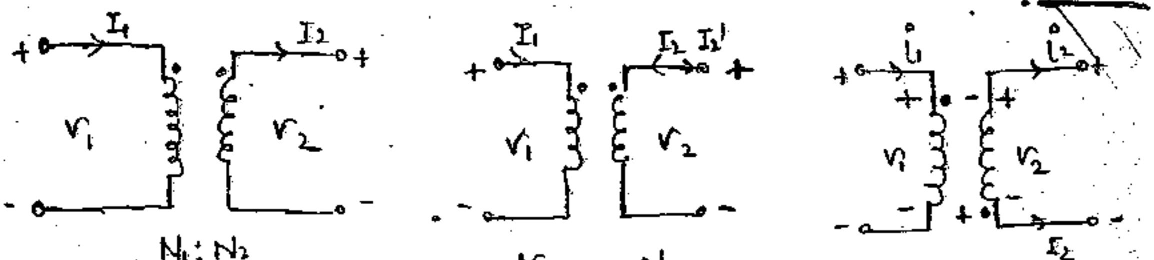
$$\frac{V_1}{V_2} = -\frac{N_1}{N_2}$$

2. If I_1 and I_2 both leaves or enter the doted termine then

$$\frac{I_2}{I_1} = -\frac{N_1}{N_2}$$

if one current enters at doted terminal & other current leaves doted terminals

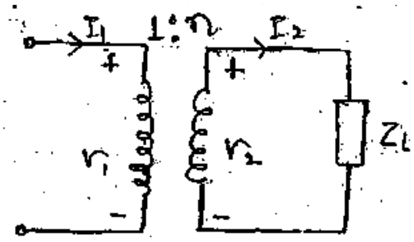
$$\frac{I_2}{I_1} = \frac{N_1}{N_2}$$



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

$$\frac{V_1}{V_2} = \frac{N_1}{N_2} \qquad \frac{I_2}{I_1} = -\frac{N_1}{N_2}$$

$$\frac{V_1}{V_2} = -\frac{N_1}{N_2} \qquad \frac{I_2}{I_1} = -\frac{N_1}{N_2}$$



$$\frac{V_1}{V_2} = \frac{N_1}{N_2} = \frac{1}{n}$$

$$Z_{in} = \frac{V_1}{I_1} = \frac{V_2}{n} \cdot \frac{1}{n I_2}$$

$$V_1 = V_2/n$$

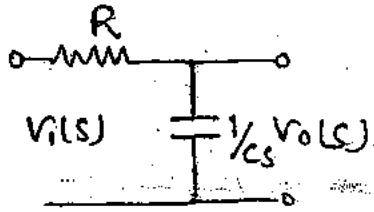
$$\boxed{Z_{in} = \frac{Z_L}{n^2}}$$

FILTER'S

1. Based on the components present in the filter ~~they~~ classified as active or passive elements.
2. In the passive filter it is not possible to ↑ the gain.

1. Low pass filter:

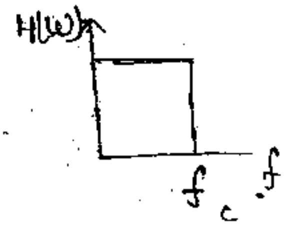
$$\frac{V_o(S)}{V_i(S)} = \frac{1/cs}{R + 1/cs}$$



$$= \frac{1}{1+RCS}$$

$$\boxed{\frac{V_o(S)}{V_i(S)} = \frac{1}{1+\tau S}}$$

Shortcuts:



$f = S = j\omega = j2\pi f$

$S \propto f$

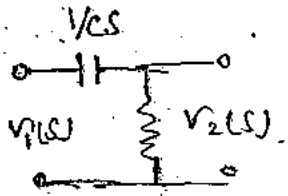
At $S=0$ $f=0$ capacitor acts as open cr tie $V_i(S)=V_o(S)$

$S=\infty$ $f=\infty$ " " S.Ckt $V_o(S)=0$

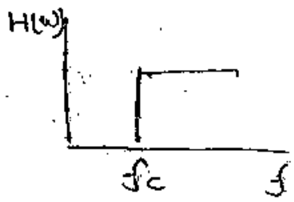
∴ low pass filter.

2. High pass filter

$$\frac{V_2(S)}{V_1(S)} = \frac{R}{R+\frac{1}{CS}}$$

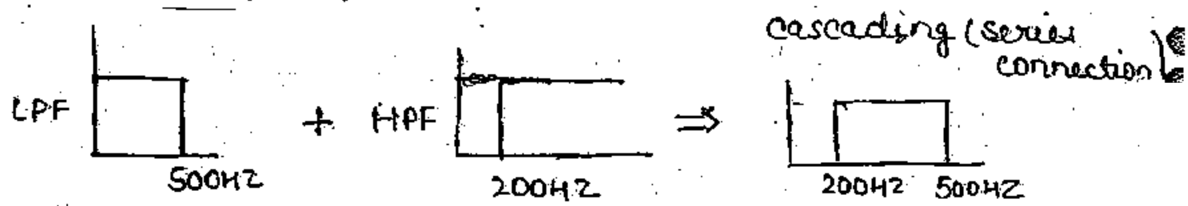


$$= \frac{RCS}{1+RCS} = \frac{\tau S}{1+\tau S}$$



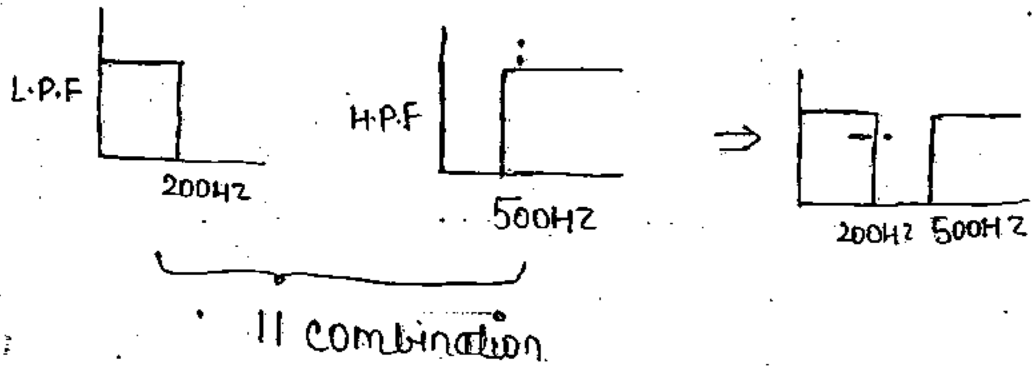
3. Band pass filter

Band pass filter can be obtained by the combination of LPF and HPF. and the fc of lowpass filter is greater than fc of HPF.

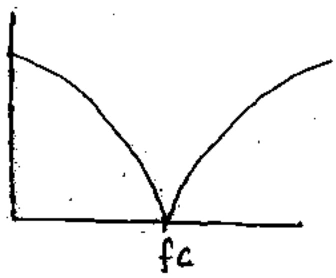


Band elemination

Band elemination filter can be obtained by LPF and HPF. and fc of low pass filter should be less than H.P.F.



4. Notch filter



1st order filter:

1. $\frac{1}{1+\tau s}$ LPF

2. $\frac{\tau s}{1+\tau s}$ HPF

3. $\frac{1-\tau s}{1+\tau s}$ All pass filter

Note:

In the APF poles and zero are symmetric to imaginary axis. and poles are present left hand of S-plane and zero's are present at right hand of S-plane.

2nd order filter:

1. $\frac{p}{s^2+as+b}$ LPF

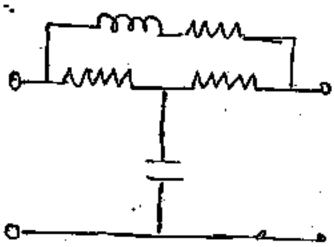
2. $\frac{ps^2}{s^2+as+b}$ = H.P.F

3. $\frac{ps}{s^2+as+b}$ = BPF

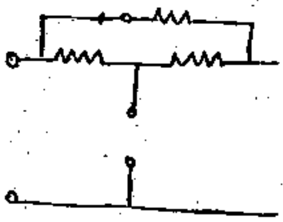
4. $\frac{ps^2+q}{s^2+as+b}$ = BEF

5. $\frac{s^2-ps+q}{s^2+as+b}$ = All pass filter

Q.

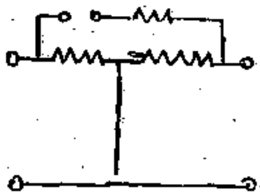


Soln: $S=0$



Pass

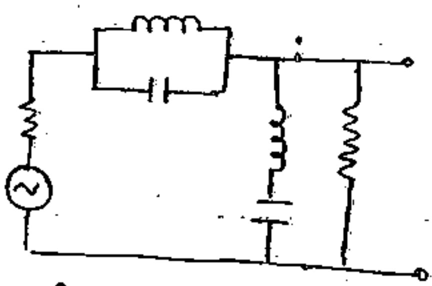
$S=\infty$



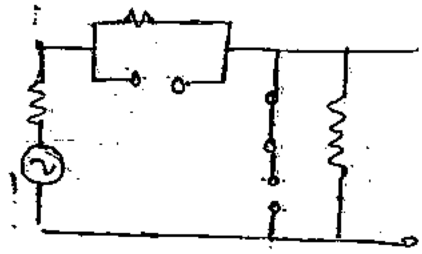
Stop

→ LPF

Q.

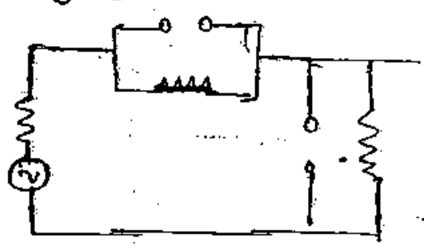


Soln: $S=0$



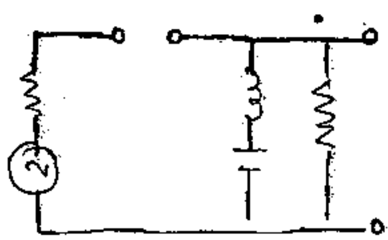
Pass

$S=\infty$

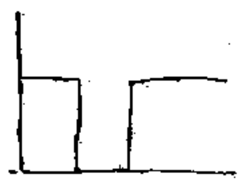


Pass

$f = f_r$

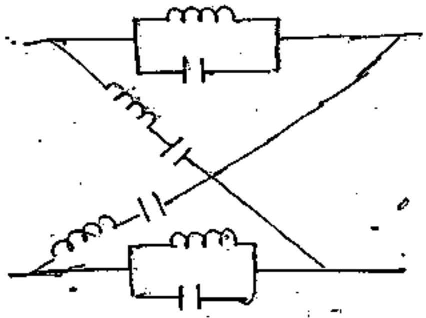


Stop



BE

Q.



All pass filter

Q1. $\left(\frac{1}{1+\tau s}\right)\cdot\left(\frac{1}{1+\tau s}\right)$

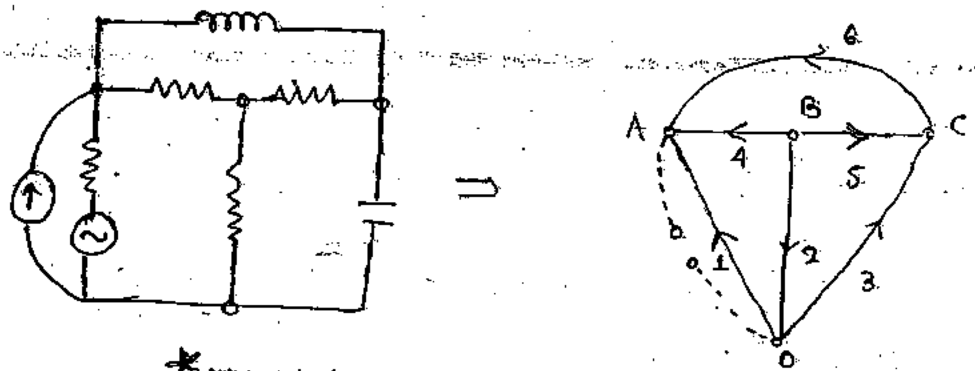
$\frac{1}{(\tau s+1)^2}$ = $s = -\frac{1}{\tau}, \frac{1}{\tau}$ critically damped

: Graph theory and n/w Topology

- N/w topology is the study of n/w properties by investing the interconnection b/w branches and node.

- In the n/w topology any n/w is replaced by the graph, to develop the graph, each element is replaced by st and arc is replaced by semi-circle and independent source are replaced by internal resistance. The graph retain all the node of original n/w.

Ex:



* No of branch of n/w ≥ no of branch in the graph.

Agumented incidence matrix

Notes: incoming → +ve
outgoing → -ve

$[A_a]$ =

	1	2	3	4	5	6
A	+1			+1		+1
B		-1		-1	-1	
C			+1		+1	-1
D	-1	+1	-1			

For given graph. A_a matrix is always unique.

Properties of $[A_a]$:

1. The unique entry in a coulom identifly nodes of branch which is connectced.

2. The unique entry in a row identify the branches incident at node.

3. If the degree of the node two, then it implies that two branches are incident at node & these are in series

4. coulom of $[A_a]$ with unique entry into identical row crosspond to two branches with same end node and hence they are ∥ connected

5. Given the $[A_a]$ the crossponding graph can be eaisly constructed, since $[A_a]$ is complet mathamatical discription of n/w.

Reduce incidence matrix

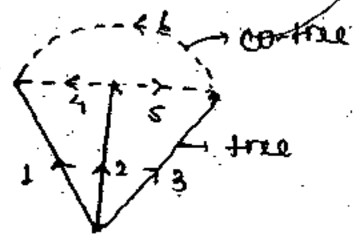
$[A_r]=$

	1	2	3	4	5	6
A	+1			+1		+1
B		-1		-1	-1	
C			+1		+1	-1

0 → reference node

Tree and co-tree:

- Tree is connected subgraph, it connect all node of n/w but it doesnot consist of any closed path.
- The set of branches which are disconnected to form a tree is called co-tree



tree branch and co-tree branches:

The branch which forms a tree is called twigs or tree branch. it is genrally represented by solid or thick line.

$\boxed{\text{Total no tree branches} = N-1}$ where n = no of nodes

ex: Tree → {1, 2, 3}

The branch which disconnected to form a tree is called link or chord. it is genrally represented by doted line.

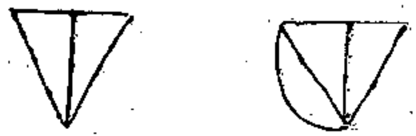
$\boxed{TNL = b-(N-1)}$ Ex. Co-tree branches = {4,5,6}

b = total no of branches
N = total no of nodes

Total no of possible tree $= N^{n-2}$

The above formula can be applied when,

1. All the node should be connected wheather at least one.
2. No repeated branch should be present b/w node.



{The above formula

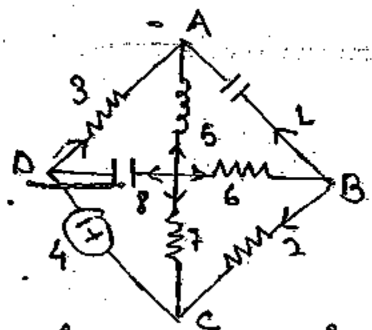
Total no of possible tree of any graph

$\mathrm{Det}(A\,A_r^T)$ A_r = reduce incident matrix

$$\boxed{\text{Total no of node pair voltages} = {}^{N}C_2 = \frac{N(N-1)}{2}}$$

$$\boxed{\text{Total no of } \frac{\text{edges}}{\text{branches}} = {}^{N}C_2 = \frac{N(N-1)}{2}}$$

Q1.

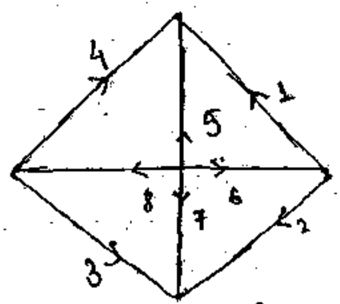


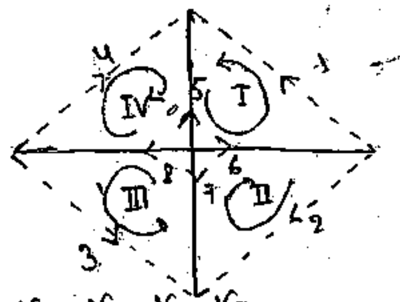
Develop tie-set matrix for the N/w

Procedure:

1. Develop the graph from n/w
2. Select the tree & co-tree from directed graph.
3. Identify the total no of links
4. The no of tie set current to be assign is equal to total no of links
5. Identify the fundamental loop or f-loop or basic loop. (basic loop is a loop which consist of only one link)
6. The dir^n of tie set current (basic loop current) in the same as the dir^n of link

7. Assign the +1 in the matrix if the dirn of tie-set current and branch is same





[B] =

	V_1 1	V_2 2	V_3 3	V_4 4	V_5 5	V_6 6	V_7 7	V_8 8
I	+1				−1	−1		
II		+1				−1	+1	
III			+1				+1	+1
IV				+1	−1			+1

KVL

$V_1 - V_5 - V_6 = 0$

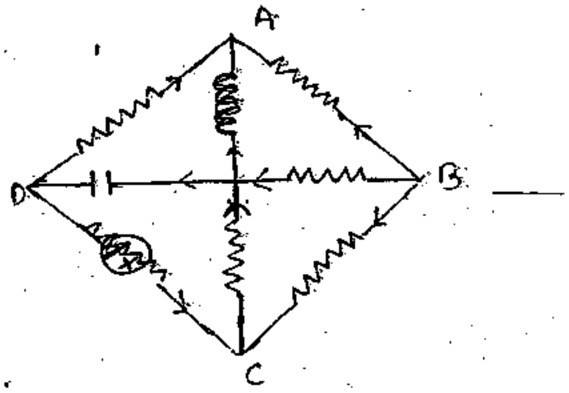
$V_2 - V_6 + V_7 = 0$

$V_3 + V_7 + V_8 = 0$

$V_4 - V_5 + V_8 = 0$

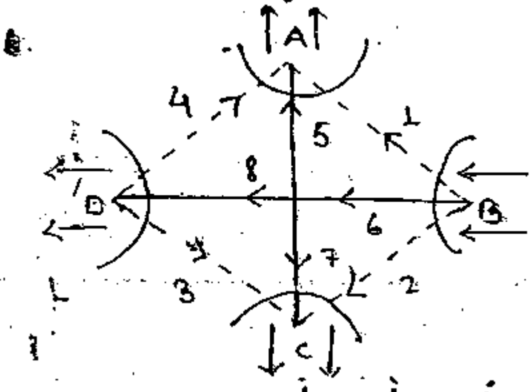
$$\boxed{[B] = \{[U] : [B_c]\}}$$

Q. Develop the cut set matrix for given n/w:- -



Procedure.

1. Develop the graph for n/w.
2. Develop the tree from graph.
3. Identify total no of basic cut set, FC'S, or F-cut set.
4. Basic cut set consist of only one tree-branch. Total no basic cut set is equal to total no tree branch = N-1
5. Basic cut-set dirn is same as the tree-branch current dirn.



$[C] =$

	i_1 1	i_2 2	i_3 3	i_4 4	i_5 5	i_6 6	i_7 7	i_8 8
A	+1			+1	+1			
B	+1	+1				+1		
C		-1	-1				+1	
D			-1	-1				+1

K.C.L

$i_1+i_4+i_5=0$

$i_1+i_2+i_6=0$

$-i_2-i_3+i_7=0$

$-i_3-i_4+i_8$

$[C]=\{[C_b]:U\}$

Conclusion:

1. Total no of possible tree $= N^{n-2}$
2. tie-set matrix is not unique. it is equal to ~~N^{n-2}~~ N^{n-2}
3. Cut-set matrix is not unique it is equal to N^{n-2}
4. $[B]=[U:B_L]$

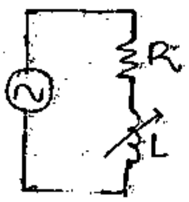
   $[C]=[C_b:U]$

   $$\boxed{\begin{aligned}[C_b]&=-[B_L]^T\\ [B_L]&=-[C_b]^T\end{aligned}}$$

5. Rank of cut-set matrix is equal to tree branches ie $N-1$
6. Rank of tie-set matrix is equal to total no of links. ie $b-(N-1)$
7. Rank of incident matrix $=N-1$

LOCUS DIAGRAM:

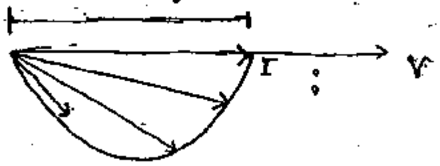
The path traced by the terminals of trace vector by varying any one of the crt elements or by varying frequency is called current locus.

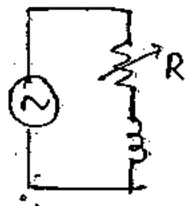


Initially

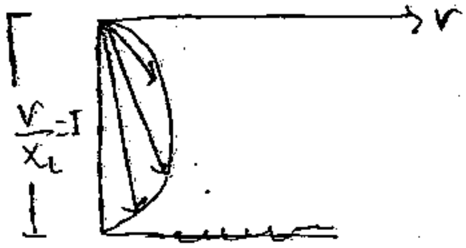
$l = 0 \quad \omega = 0$	$L\uparrow \quad \omega\uparrow$	$L = \infty \quad \omega = \infty$
$X_L = 0$	$X_L\uparrow$	$X_L = \infty$
$Z = R$	$Z\uparrow$	$Z = \infty$
$I = \frac{V}{R}$	$I\downarrow$	$I = 0$
$\theta = \tan^{-1}\frac{\omega L}{R} = 0°$	$\theta\uparrow$	$\theta = 90°$

$D = V/R$

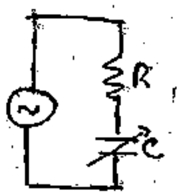




$R = 0$	$R\uparrow$	$R = \infty$
$Z = X_L$	$Z\updownarrow$	$Z = \infty$
$I = \frac{V}{X_L}$	$I\downarrow$	$I = 0$
$\theta = \tan^{-1}\frac{\omega L}{R} = 90°$	$\theta\downarrow$	$\theta = 0$

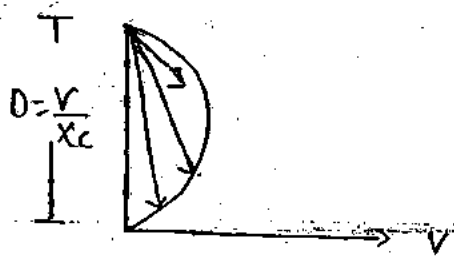


Q.

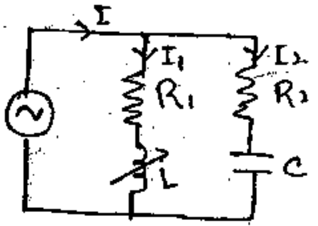


$X_C = \frac{1}{\omega C}$

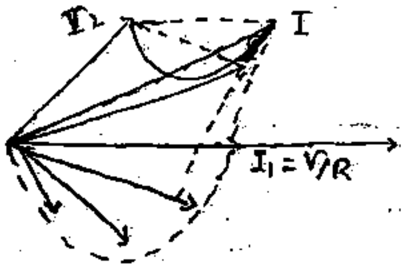
At $C = 0$	$C \uparrow$	$C = \infty$
$X_C = \infty$	$X_C \downarrow$	$X_C = 0$
$Z = \infty$	$Z \downarrow$	$Z = R$
$I = 0$	$I \uparrow$	$I \uparrow$
$\theta = \tan^{-1}\left(\frac{X_C}{R}\right) = 90^\circ$	$\theta \downarrow$	$\theta = 0^\circ$



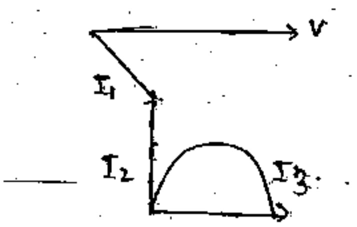
Q.



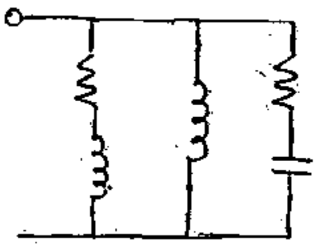
$L = 0$	$L \uparrow$	$L = \infty$
$X_L = 0$	$X_L \uparrow$	$X_L = \infty$
$Z_1 = R$	$Z_1 \uparrow$	$Z = \infty$
$I_1 = \frac{V}{R}$	$I_1 \downarrow$	$I_1 = 0$
$\theta_1 = 0^\circ$	$\theta = \uparrow$	$\theta = 90^\circ$
$\bar{I} = \bar{I_1} + \bar{I_2}$	$\bar{I} \downarrow$	$I = I_2$



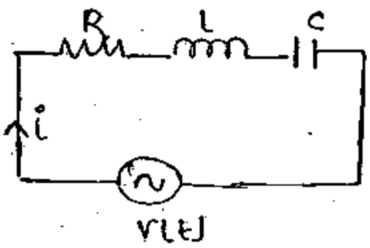
Ex: Design the approximate ckt for ~~the given~~ CLD ?



Soln:



Dual N/W :



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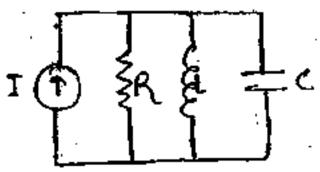


$V = iR + L\frac{di}{dt} + \frac{1}{C}\int i\,dt$ $\qquad$ $i = \frac{V}{R} + C\frac{dV}{dt} + \frac{1}{L}\int V\,dt$

Duality

Series → ||

Voltage → current

KVL → KCL

Loop → node

R, L, C → G, C, L

O.C → S.C

~~Thevenin~~ → Norton

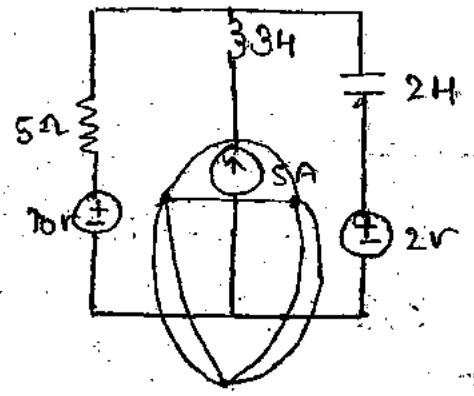
Foster I → Foster II

$\frac{dV}{dt}$ → $\frac{di}{dt}$

$V\int dt$ → $I\int dt$

Cut-Set → tie Set

Duality doesnot mean equivalence but it means mathamatical representation of both n/w is same.



Notes :

1. When voltages source drives the I in ↻ dirn Arrow mark of current source is indicated towards respective node

2. When current source drives the current in ↻ dirn the sign is given to respective node.