STUDY MATERIAL

SUBJECT : NETWORK THEORY (NT)

MODULE-

SEMESTER :. -3RD

BRANCH : EE / EEE

DEPARTMENT OF ELECTRICAL ENGINEERING

SRINIX COLLEGE OF ENGINEERING, BALASORE

(www.srinix.org)

NETWORK THEORY

MODULE – I

BRANCH → EEE + E

3RD SEMESTER

ER. P. K. TRIPATHY

SHORT TYPE

(1) Write properties of incidence matrix. (2011, 2012-13)

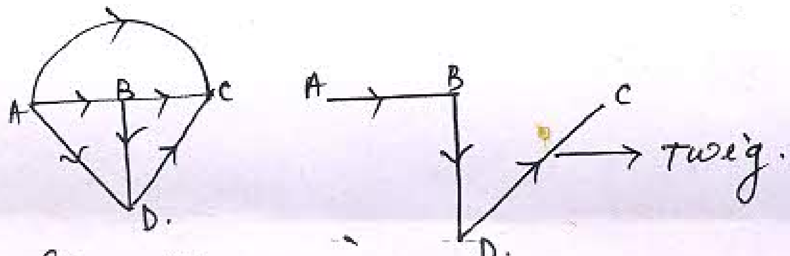
Soln → The algebraic sum of a column of A_i is zero.

→ The determinant of A_i of a closed loop is zero.

where A_i = incidence matrix.

(2) What do you understand by 'Twigs'? Briefly explain by a diagram (2012)

Soln → The branches of the tree are known as twigs.



(Graph) (Tree)

(3) Relate link, node and branch of a graph.

Soln n → no. of nodes in the graph.

Twigs = $n-1$.

l = Total number of links.

b = Total number of branches.

$$\boxed{l = b-(n-1) = b-n+1}$$

(4) State and explain Maximum power Transfer Theorem? (2012-13)

Soln In a linear bilateral network containing an independent voltage source in series with resistance (R_s) delivers maximum power to the load resistance (R_L) when R_L is equal to R_s ($R_s = R_L$)

→ Similarly the independent current source parallel with source resistance (R_s) delivers maximum power to the load resistance when ($R_L = R_s$)

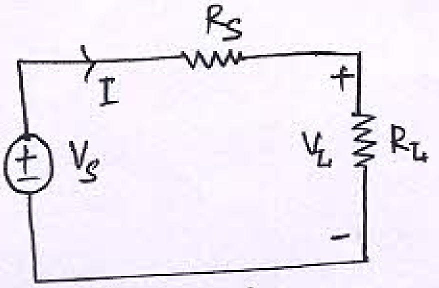


Fig (a)

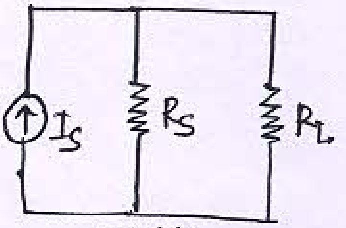


Fig (b)

(5) What do you mean by coefficient of coupling ? Explain. (2012, 13, 10)

Soluⁿ It is defind as the fraction of total flux that links the coils i.e K, the coefficient of coupling $= \frac{\phi_{12}}{\phi_1} = \frac{\phi_{21}}{\phi_2}$.

where ϕ_1 and $\phi_2 \rightarrow$ Total flux in the corresponding coils.

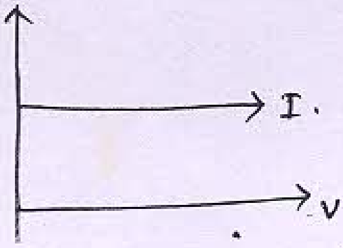
ϕ_{12} and $\phi_{21} \rightarrow$ Fluxes linked with the coils.

$\phi_{12} < \phi_1$ and $\phi_{21} < \phi_2$

Hence maximum value of 'K' is unity.

(6) Give the phasor diagram of series resonance ? (2011)

Soluⁿ



$I = \frac{V}{Z}$

Z = minimum

I = maximum under resonance condition

(7) State Tellegen's Theorem ? (2011)

Soluⁿ For any given time, the sum of power delivered to each branch of any electric network is zero.

Thus for K^{th} branch, this theorem states that

$$\sum_{K=1}^{n} V_K i_K = 0$$, 'n' being the number of branches.

$V_K \rightarrow$ is the voltage drop in the branch.

$I_K \rightarrow$ is the current through the branch.

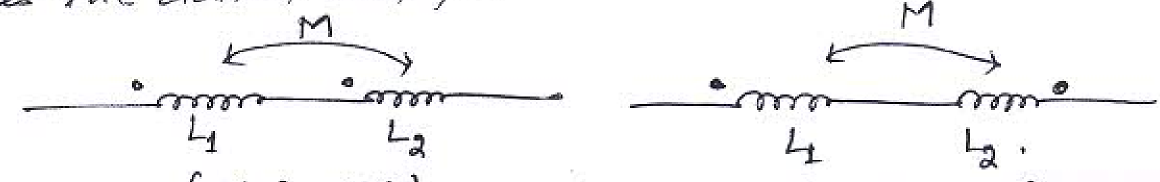
(8) Explain dot convention in coupled coils. (2011, 2007)

Solⁿ To determine the relative polarity of the mutually induced voltage a convention is used. This is known as dot convention.

→ According to this convention,

polarity of mutual inductance of a couple coil may be treated as +ve, if the loop currents enter into the respective coils at the dotted ends of respectively coils or simultaneously coming out from the dotted ends of the respective coils and -ve if current enters the dotted end for one coil and leaves the dotted end for other coil.

Exa

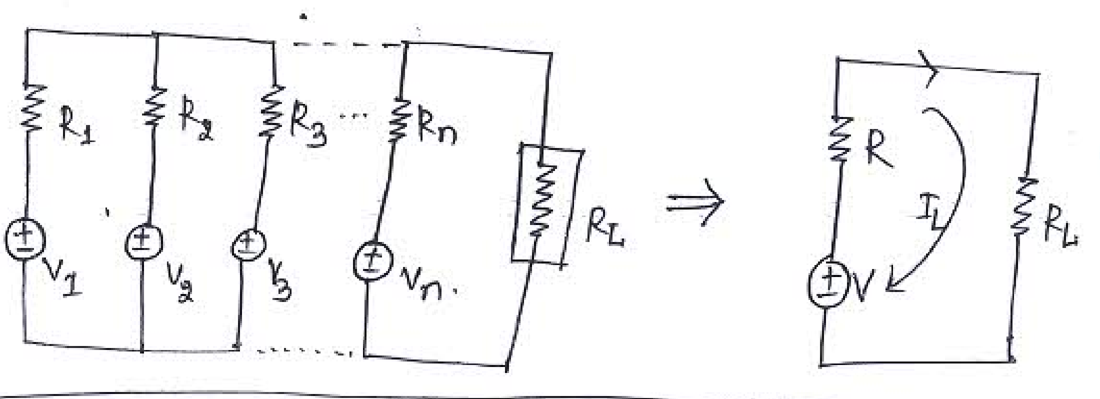


(M is +ve) (M is -ve)

(In both cases coupled coils are connected in series.)

(9) State Millman's Theorem and explain with a suitable examples?

Solⁿ When a number of voltage source $V_1, V_2 \ldots V_n$ are in parallel having resistances $R_1, R_2 \ldots R_n$ respectively. The arrangement can be replaced by a single equivalent voltage source 'V' with series a equivalent resistance 'R'.



$$\boxed{V = \frac{V_1G_1 \pm V_2G_2 \pm V_3G_3 \pm \cdots \pm V_nG_n}{G_1 + G_2 + G_3 + \cdots + G_n}}$$

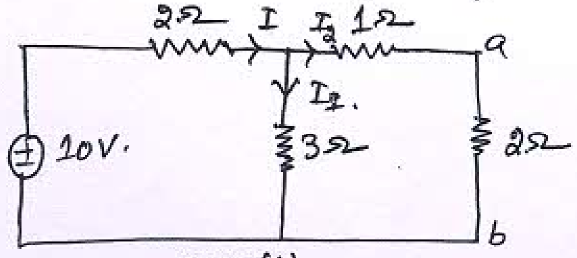
$G = \frac{1}{R}$ = Conductance

$$\boxed{R = \frac{1}{G} = \frac{1}{G_1 + G_2 + G_3 + \cdots + G_n}}$$

(10) State and explain Reciprocity Theorem with a suitable exam. (2010, 2011)

Solu^n Statement :→ If a source of emf located at one point in a network composed of linear bilateral circuit elements, produces a current I' at a selected point in the network, the same source of emf acting at the second point will produce the same current at the first point.

Problem



Show Reciprocity Theorem.

Fig-(1)

$$R_{eq} = \{(2+1) \parallel 3\} + 2 = \frac{9}{6} + 2 = \frac{21}{6} = 3.5$$

$$I = \frac{V}{R_{eq}} = \frac{10}{3.5} = \frac{20}{7} \text{ Ampere.}$$

$$I_2 = I \times \frac{3}{3+1+2} = \frac{20}{7} \times \frac{3}{6} = \frac{10}{7} \text{ Amp.}$$

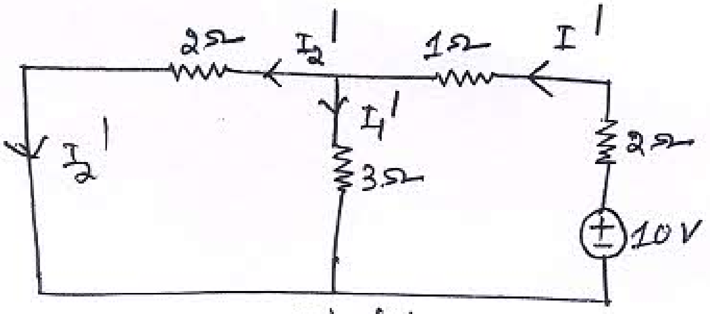


Fig-(2)

$$R_{eq} = (2 \parallel 3) + 1 + 2 = \frac{6}{5} + 3 = \frac{21}{5}\,\Omega$$

$$I' = \frac{V}{R_{eq}} = \frac{10}{21/5} = \frac{50}{21} \text{ Amp.}$$

$$I_2' = \frac{50}{21} \times \frac{3}{3+2} = \frac{10}{7} \text{ Amp.}$$

$$\boxed{I_2 = I_2'}$$

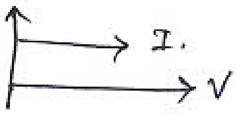
So reciprocity Theorem is verified.

(11) Give at least four properties of parallel resonance circuit?

Solu^n → power factor of circuit is unity.

→ current at resonance is minimum and it is in the phase of applied voltage.

→ Net impedance at resonance is maximum (L/CR)



→ The admittance is minimum.

(12) Define Q-factor, Band width and selectivity and how they are related. (2010, 2011, 2013)

Solu^n Quality factor (Q-factor).

It is defind as the ratio of voltage across the inductor or capacitor to the applied voltage. It is denoted by Q_0.

$$Q_0 = \frac{V_L}{V}, \quad Q_0 = \frac{V_C}{V}.$$

V_L and V_C → voltage across inductor and capacitor.

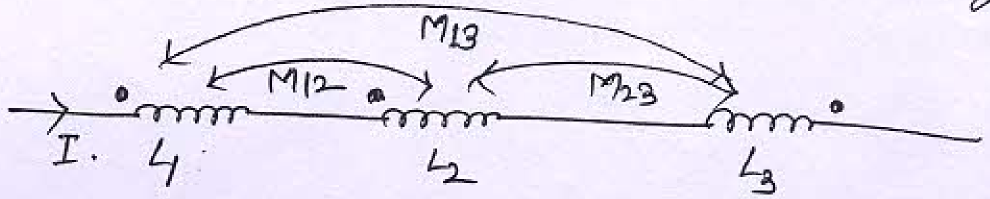
$$Q_0 = \frac{\omega_0 L}{R}, \quad Q_0 = \frac{1}{\omega_0 C R}$$

Band width $= f_2 - f_1$.

f_1 and f_2 → Lower and upper half frequency.

Selectivity It is defind as the ratio of resonance frequency to Quality factor $= \frac{f_0}{Q_0}$.

(13) What is the expression for the total inductances of the three series connected coupled coils as shown in figure. (2007)



Soln

$$V_{Total} = V_{L_1} + V_{L_2} + V_{L_3}.$$

$$V_{L_1} = L_1 \frac{dI}{dt} + M_{12}\frac{dI}{dt} - M_{13}\frac{dI}{dt} = (L_1 + M_{12} - M_{13})\frac{dI}{dt}.$$

$$V_{L_2} = (L_2 + M_{12} - M_{23})\frac{dI}{dt}.$$

$$V_{L_3} = (L_3 - M_{23} - M_{13})\frac{dI}{dt}.$$

$$L_{eq}\cancel{\frac{dI}{dt}} = (L_1 + L_2 + L_3 + 2M_{12} - 2M_{13} - 2M_{23})\cancel{\frac{dI}{dt}}.$$

$$\Rightarrow \boxed{L_{eq} = L_1 + L_2 + L_3 + 2M_{12} - 2M_{13} - 2M_{23}}$$

(14) Write down the limitation of reciprocity Theorem and also mention its application? (2010).

Soln Limitations of Reciprocity Theorem :→

→ This theorem is not applicable when network consisting of any time varying element.

→ This theorem is not applicable of non-linear elements like diode, transistor etc.

→ This theorem is not applicable more than one energy source.

Application of Reciprocity Theorem :→

→ This theorem is applicable to linear, time invariant n/w consisting of passive n/w elements.

→ This theorem is applicable in dc as well as ac circuit.

→ This theorem allows interchange the position of excitation and response.

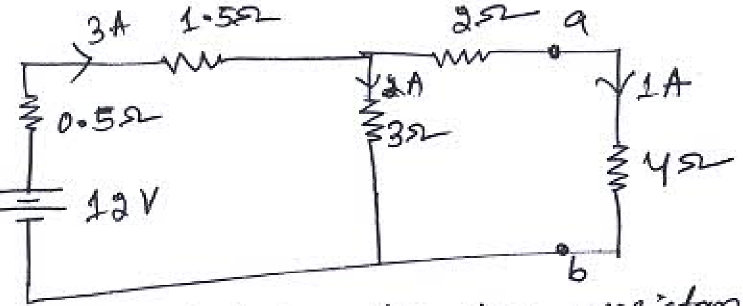
→ It provides bilateral property of the network.

→ It provides great convenience in design and measurement problems

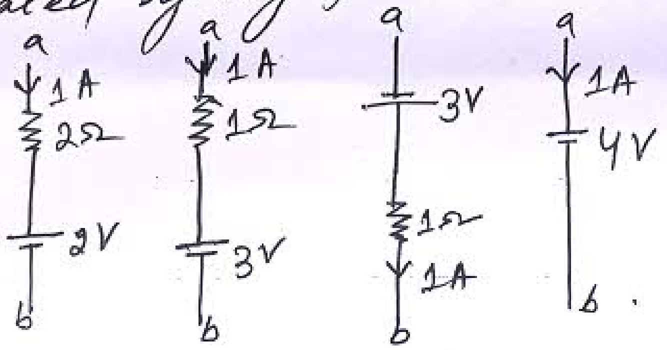
15) State and explain substitution Theorem with a suitable examples?

Solu^n Statement :→ In a network any branch may be substituted by another branch without disturbing the current and voltages in other branches of the network. Provided the new branch has the same internal voltage when carrying the same current.

Explanation :→ Consider a circuit as shown in figure.



The branch containing the 4Ω resistance has a current of 1A. According to Substitution theorem this branch may be replaced by any of the branches as shown in figure.



——— xox ———

LONG TYPE

(1) For the given matrix draw the graph and also calculate the total number of possible trees.

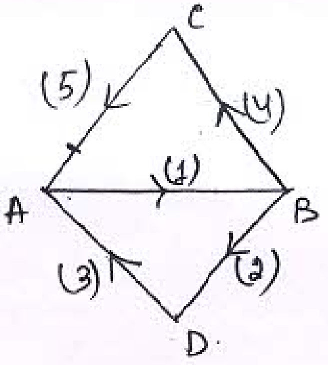
$$A = \begin{bmatrix} +1 & 0 & -1 & 0 & -1 \\ -1 & +1 & 0 & +1 & 0 \\ 0 & 0 & 0 & -1 & +1 \end{bmatrix}$$

Solution :→

incidence matrix

$$A_i = \begin{array}{c} \\ A \\ B \\ C \\ D \end{array} \begin{array}{c} \begin{array}{ccccc} 1 & 2 & 3 & 4 & 5 \end{array} \\ \begin{bmatrix} +1 & 0 & -1 & 0 & -1 \\ -1 & +1 & 0 & +1 & 0 \\ 0 & 0 & 0 & -1 & +1 \\ 0 & -1 & +1 & 0 & 0 \end{bmatrix} \end{array}$$

graph



The no. of possible trees $= \det\{[A][A]^T\}$

$$[A][A]^T = \begin{bmatrix} +1 & 0 & -1 & 0 & -1 \\ -1 & +1 & 0 & +1 & 0 \\ 0 & 0 & 0 & -1 & +1 \end{bmatrix} \times \begin{bmatrix} +1 & -1 & 0 \\ 0 & +1 & 0 \\ -1 & 0 & 0 \\ 0 & +1 & -1 \\ -1 & 0 & +1 \end{bmatrix}$$

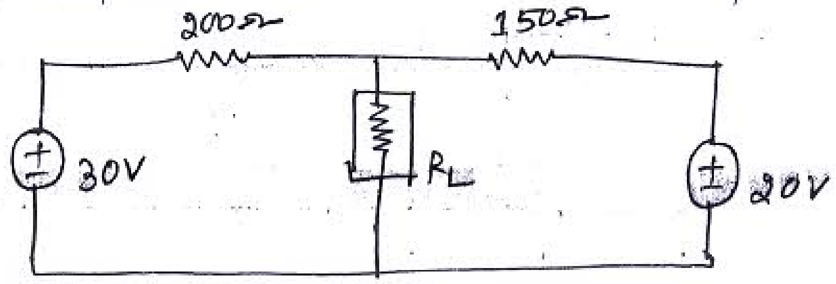
$$= \begin{bmatrix} 3 & -1 & -1 \\ -1 & 3 & -1 \\ -1 & -1 & 2 \end{bmatrix}$$

$$\det\{[A][A]^T\} = \begin{vmatrix} 3 & -1 & -1 \\ -1 & 3 & -1 \\ -1 & -1 & 2 \end{vmatrix} = 3(6-1)+1(-2-1) -1(1+3)$$

$$= 15-3-4 = 8$$

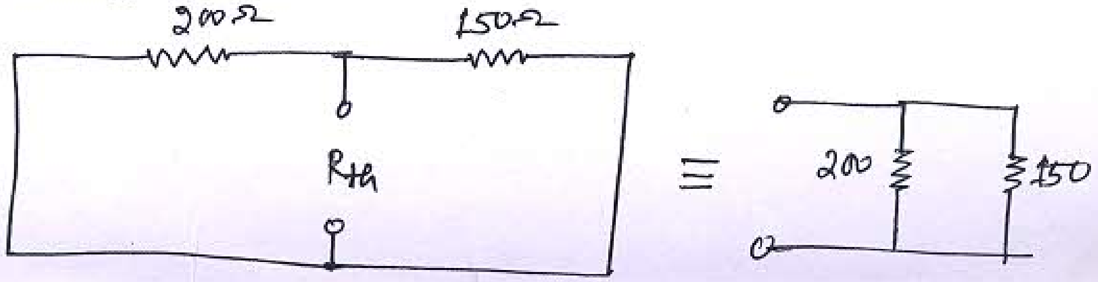
$$\boxed{\text{The no. of possible trees} = 8}$$

(2) For the given network calculate the value of load for maximum power flow and also calculate the value of maximum power!



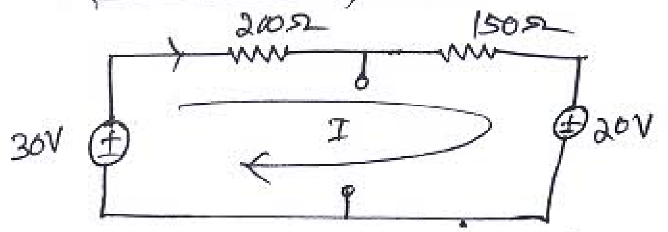
Solⁿ We know $\boxed{P_{max} = \frac{V_{th}^2}{4R_{th}}}$

calculation of R_{th} :→



$$R_{th} = 200 \parallel 150 = \frac{200 \times 150}{200 + 150} = 85.714\,\Omega$$

Calculation of V_{th} :→



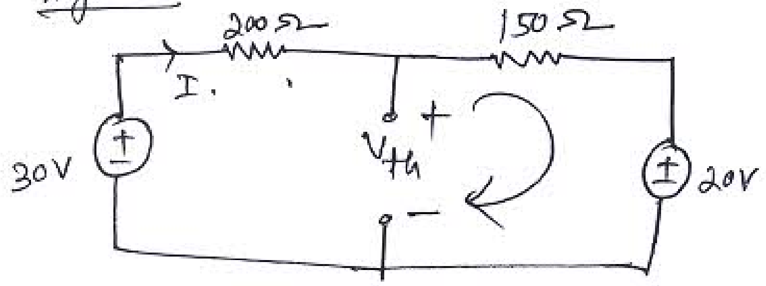
Apply KVL to the Loop.

$$30 - 200I - 150I - 20 = 0$$

$$10 = 350I.$$

$$\Rightarrow I = \frac{10}{350} = 0.02857 \text{ Amp.}$$

Again:



$$V_{th} - 150I - 20 = 0$$

$$V_{th} = 20 + 150I.$$

$$= 20 + 150 \times 0.02857$$

$$= 24.2855 \text{ Volt.}$$

Hence

$$P_{max} = \frac{(24.2855)^2}{4 \times 85.714} = 1.7202 \text{ watt.}$$