IIT(BHU) VARANASI

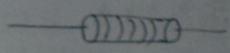
STUDENTS' NOTES

TOPIC-ELECTRICAL-III

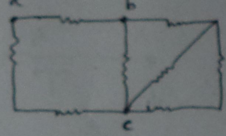
Shaurya

Red → 2, Orange → 3, Yellow → 4, Green → 5

blue → 6, violet → 7, grey → 8



Q. find resis b/w ab and bc



Sol.

$\frac{1}{2R} + \frac{1}{R}$

$\frac{1+2}{2R} \Rightarrow \frac{2R}{3} + R \Rightarrow \frac{5R}{3}$

$\frac{1}{3R} + \frac{1}{R} + \frac{3}{5R}$

$\frac{5+15+9}{15R} \Rightarrow \frac{15R}{29}$ bc

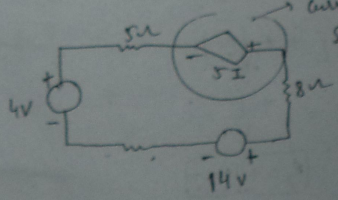
$\frac{3}{5R} + \frac{1}{R} \Rightarrow \frac{3+5}{5R} \Rightarrow \frac{5R}{8}$.

$\frac{5R}{8} + 2R \Rightarrow \frac{21R}{8}$

$\frac{8}{21R} + \frac{1}{R}$

$\frac{8+21}{21R} \Rightarrow 29 \Rightarrow \frac{21R}{29}$ ab

Q.



current dependent voltage source

find I

Sol.

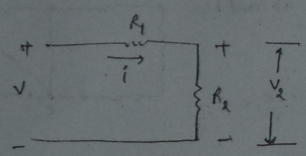
$$-46\cancel{I} \cancel{+114} \cancel{+35I} \cancel{+4} \cancel{-25I} = 0$$

$$\cancel{-106 I} \cancel{=} \cancel{10}$$

$$+114 - 8I - 5I - 5I - 4 - 7I = 0 \qquad \boxed{I = \cancel{-\frac{1}{10}}\ A}$$

$$I = \frac{10}{25} \Rightarrow 0.4\ A$$

Q. In the figure given below, it is desired to get $V_2 = \frac{3}{4} V$ find R_2 if $R_1 = 100\,\Omega$



Sol.

$$\frac{V - V_2}{R_1} = \frac{0 + V_2}{R_2}$$

$$\frac{V}{R_1} = V_2\left[\frac{1}{R_1} + \frac{1}{R_2}\right]$$

$$\frac{\cancel{V}}{R_1} = \frac{3}{4}\cancel{V}\left[\frac{1}{R_1} + \frac{1}{R_2}\right]$$

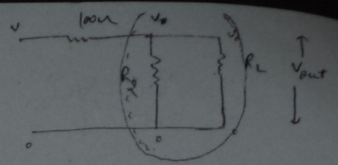
$$\frac{4}{3} = \left[1 + \frac{R_1}{R_2}\right]$$

$$\frac{4}{3} = \left[1 + \frac{100}{R_2}\right]$$

$$\frac{100}{R_2} = +\frac{1}{3}$$

$$\boxed{R_2 = +300\,\Omega}$$

Q.



what will be the % change in output voltage if

(i) $R_L = 10\,k\Omega$ (ii) $R_L = 1\,k\Omega$

Sol. $R_2 = 300\,\Omega$ from previous

$$i = i_1 + i_2$$

$$\frac{V - V_0}{100} = \frac{V_0}{R_2} + \frac{V_0}{R_L}$$

$$\frac{V}{100} = V_0\left[\frac{1}{100} + \frac{1}{R_2} + \frac{1}{R_L}\right] \quad -\text{(ii)}$$

$$\frac{V}{100} = V_0\left[\frac{1}{100} + \frac{1}{300} + \frac{1}{10000}\right] \quad -\text{(i)}$$

$$\frac{V}{100} = V_{01}\left[\frac{1}{100} + \frac{1}{300} + \frac{1}{1000}\right]$$

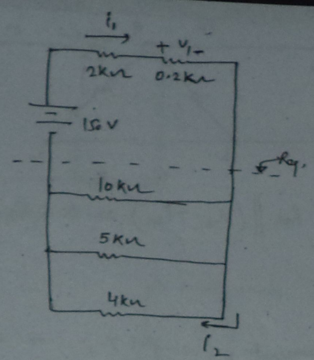
$$\frac{V_0 - V_{01}}{V_0} \Rightarrow 1 - \frac{V_{01}}{V_0}$$

$$\Rightarrow 1 - \frac{\left[\frac{1}{100} + \frac{1}{300} + \frac{1}{10000}\right]}{\left[\frac{1}{100} + \frac{1}{300} + \frac{1}{1000}\right]}$$

$$\Rightarrow \frac{\frac{1}{1000} - \frac{1}{10000}}{\left[\frac{1}{100} + \frac{1}{300} + \frac{1}{1000}\right]} = \frac{9 \times 10^{-4}}{0.041} \times \frac{100 \times 100}{10000}$$

$$\Rightarrow \frac{90}{41} \Rightarrow 2.19\ \%$$

Q. Find v_1 and I_2



Sol.

$$\frac{1}{R_{eq}} = \frac{1}{10} + \frac{1}{5} + \frac{1}{4} = 0.55 \Rightarrow 1.82\,k\Omega = R_{eq}.$$

$$\text{Current } I_1 = \frac{150 \text{ volt}}{2k\Omega + 0.2k\Omega + 1.82k\Omega}$$

$$= \frac{150}{4.02\,k\Omega} = 37.3 \text{ mA}$$

$$V_1 = 0.2k\Omega \times I_1 = 0.2k\Omega \times 37.3\,mA = 37.3 \times 0.2V$$
$$= 7.46 \text{ V}$$

$$\text{Voltage across } R_{eq} = R_{eq} \times i_1 = 1.82\,k\Omega \times 37.3\,mA$$
$$= 67.886 \text{ volt}$$

$$\text{Current through } 4k\Omega = \frac{\text{Voltage across } 4k\Omega}{4k\Omega}$$

$$= \frac{67.886\,V}{4k\Omega}$$

$$= 16.97 \text{ mA}$$

Sol. Ans of previous question.

(i) when $R_L = 10k\Omega$

$$V_2 = \frac{R_2'}{R_1 + R_2'} \text{ V}$$

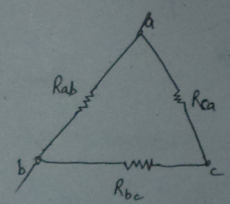
$$= \frac{291.26}{100 + 291.26} \text{ V} = \frac{291.26}{391.26} \text{ V}$$

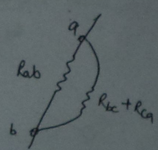
$$= 0.744$$

$$\frac{0.75 - 0.744}{0.75} \times 100 \quad \text{Ans}$$

(ii) when $R_L = 1k\Omega$

Q. Y-Δ Conversion, star-Δ conversion





For pair of nodes ab $\quad R_a + R_b = R_{ab} \parallel (R_{bc} + R_{ca}) \quad$ —(1)

for bc Similarly $\quad R_b + R_c = R_{bc} \parallel (R_{ca} + R_{ab}) \quad$ —(2)

for Ca

$$R_c + R_a = R_{ca} \parallel (R_{ab} + R_{bc}) \quad \text{—(3)}$$

solving eqⁿ ①, ②, ③

$$R_{ab} = \frac{R_a R_b + R_b R_c + R_c R_a}{R_c}$$

Similarly

$$R_{bc} = \frac{R_a R_b + R_b R_c + R_c R_a}{R_a}$$

$$R_{ca} = \frac{R_a R_b + R_b R_c + R_c R_a}{R_b}$$

Y-Δ Conversion
Star-delta Conversion

and

$$R_a = \frac{R_{ab} R_{ac}}{R_{ab} + R_{bc} + R_{ca}}$$

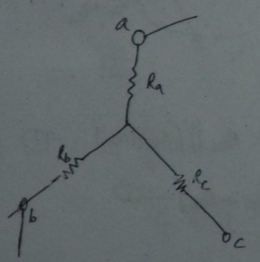
Similarly

$$R_b = \frac{R_{ba} R_{bc}}{R_{ab} + R_{bc} + R_{ca}}$$

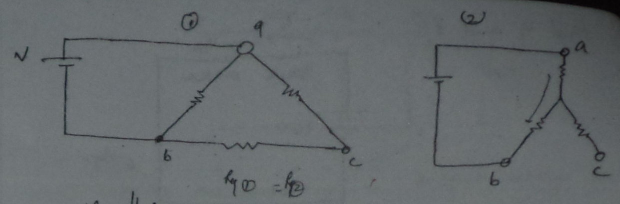
$$R_c = \frac{R_{ca} R_{cb}}{R_{ab} + R_{bc} + R_{ca}}$$

Δ-Y Conversion
Delta-Star Conversion

Q.



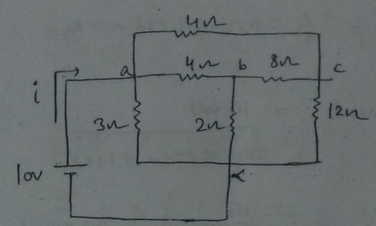
$R_{eq} = R_a + R_b$



$R_{eq①} = R_{eq②}$

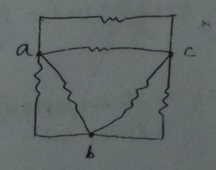
$$R_{ab} \parallel (R_{bc} + R_{ca}) = R_a + R_b$$

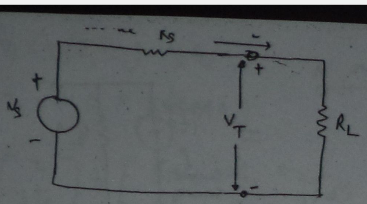
Q. Find current i using Y-Δ or Δ-Y conversion.



Sol.

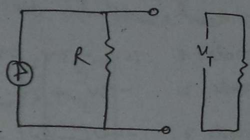
Star-delta conversion





Practical voltage source

$$V_T = \frac{V_S}{R_S + R_L} R_L$$

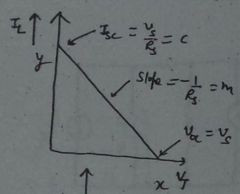


KVL $\rightarrow V_T = V_S - I_L R_S \leftarrow$ V-I characteristic

$$\overset{y}{I_L R_S} + \overset{x}{V_T} = V_S$$

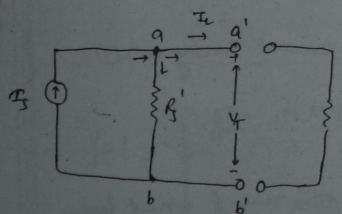
$$I_L R_S = V_S - V_T \Rightarrow y = mx + C$$

Terminal characteristic

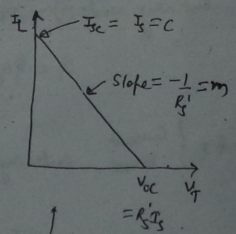


KCL $\rightarrow$ $\overset{y}{I_L} = \overset{c}{\frac{V_S}{R_S}} - \overset{x}{\frac{V_T}{R_S}}$

$$= \underbrace{\left(-\frac{1}{R_S}\right) V_T}_{mx} + \underbrace{\frac{V_S}{R_S}}_{c} \longrightarrow V_T - I_L \text{ characteristic}$$



Practical Current source



V-I Characteristic

KCL at node a $\quad I_S = \frac{V_T}{R_S'} + I_L$

$$I_L = -\frac{1}{R_S'} V_T + I_S$$

$$y = mx + c$$

I_{SC} = Short circuit current (when $V_T = 0$)

V_{OC} = open circuit current (when $I_L = 0$)

Comparing eqn 1 and 2

$$R_S' = R_S$$

$V_S = I_S R_S = V_{OC} \rightarrow$ source terminal open

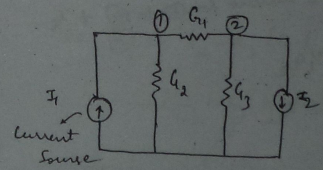
$I_S = \frac{V_S}{R_S} = I_{SC} \rightarrow$ short circuit current

i.e.
current through zero resistance lead connecting source terminals.

Nodal analysis :-

Basic electrical engineering $\rightarrow$ I-J. Nagrath

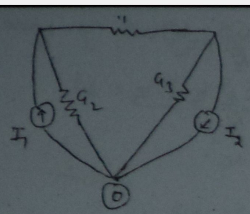
1



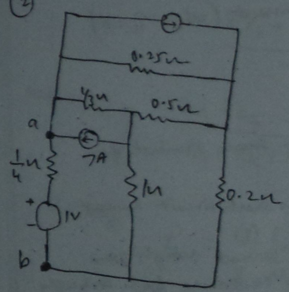
$G = 1/R$ = Conductance

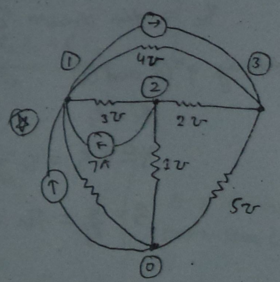
KCL

- Node 1 :
- Node 2 :



2





Sol: 1

$\frac{V - V_1}{G_2}$ *

Current from ① to ② = current from ② to ⓪ + I_2

node ① * $I_1 = (V_1 - V_2)G_1 + V_1 G_2$

$(V_1 - V_2)G_1 = V_2 G_3 + I_2$

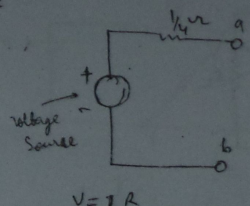
Given $i_1 = 2A$, $i_2 = -3A$

* $G_1 = 0.2$ ℧ (mho) ; $G_2 = 1$℧ ; $G_3 = 0.5$℧

$V_1 = ?$

$V_2 = ?$

Sol. 2



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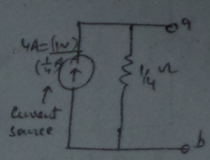


$V = IR$

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

$V = IR$

$I = \frac{V}{R} = \frac{1}{1/4} = 4A$

node: 1 $\quad 11V_1 - 3V_2 - 4V_3 = 5$

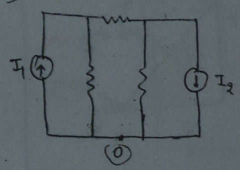
node: 2 $\quad -3V_1 + 6V_2 - 2V_3 = -7$

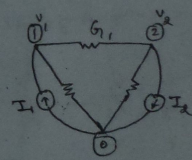
node 3: $\quad -4V_1 - 2V_2 + 11V_3 = 6$

$$\begin{bmatrix} 7+4-6 \\ -7 \\ 6 \end{bmatrix} = \begin{bmatrix} 4+3+4 & -3 & -2 \\ -3 & 3+1+2 & -2 \\ -4 & -2 & 4+2+5 \end{bmatrix} \times \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix}$$

later

Q.





datum node or reference node

datum node or KCL At node ① } current source

entering node ① = sum of current leaving node ①

$I_1 = V_1 G_2 + (V_1 - V_2)G_1$ — ①

KCL at node 2 } current source entering node ② = sum of current leaving node ②

$-I_2 = V_2 G_3 + (V_2 - V_1)G_1$ — ③

$$I_1 = v_1(G_2+G_3) - v_2 G_1$$

$$-I_2 = -v_1 G_1 + v_2 (G_1+G_3)$$

$$\begin{bmatrix} I_1 \\ -I_2 \end{bmatrix} = \begin{bmatrix} G_1+G_2 & -G_1 \\ -G_1 & G_1+G_3 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix}$$

from previous

** node admittance matrix

$$\begin{bmatrix} 5 \\ -7 \\ 6 \end{bmatrix} = \begin{bmatrix} 11 & -3 & -4 \\ -3 & 6 & -2 \\ -4 & -2 & 11 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \\ v_3 \end{bmatrix}$$

$$G^{-1} I = G^{-1} G V$$

$$G^{-1} I = V$$

Cramer's rule :

$$v_1 = \frac{\begin{vmatrix} 5 & -3 & -4 \\ -7 & 6 & -2 \\ 6 & -2 & 11 \end{vmatrix}}{|G|}$$

$$\Rightarrow \frac{115+88}{|G|}$$

$$\Rightarrow \frac{203}{|G|}$$

$$\Rightarrow$$

$$|G| = \begin{vmatrix} 11 & -3 & -4 \\ -3 & 6 & -2 \\ -4 & -2 & 11 \end{vmatrix}$$

$$= 439$$

$$\Rightarrow v_1 = \frac{203}{439} = 0.462$$

$$v_2 = \frac{\begin{vmatrix} 11 & 5 & [illegible] \\ -3 & -7 & -2 \\ -4 & 6 & 11 \end{vmatrix}}{|G|} = -0.743$$

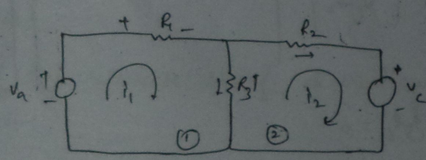
$$v_3 = 0.579$$

Conductance

$$G = \frac{1}{R} \rightarrow \text{Resistance}$$

$$Y = \frac{1}{\boxed{R+jX}} \rightarrow \text{Impedance}$$

admittance



KVL (1) : $v_a - R_1 i_1 - R_3(i_1 - i_2) - v_b = 0$

KVL (2) : $v_b - R_3(i_2 - i_1) - R_2 i_2 - v_c = 0$

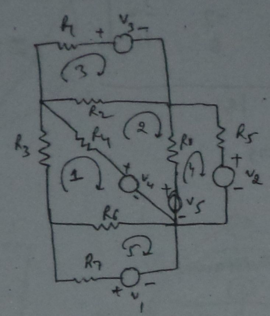
$$-R_1 i_1 - R_3(i_1 - i_2) = v_b - v_a$$

$$+R_3(i_2 - i_1) + R_2 i_2 = v_b - v_c \quad - (2)$$

$$R_1 i_1 + R_3(i_1 - i_2) = v_a - v_b \quad - (1)$$

$$\begin{bmatrix} \overset{a_{11}}{R_1+R_3} & -R_3 \\ -R_3 & \underset{a_{22}}{R_3+R_2} \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} v_a - v_b \\ v_b - v_c \end{bmatrix}$$

Q



Sol

$$V_{n\times1} = Z_{n\times n} \times I_{n\times1}$$

$$\begin{bmatrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{bmatrix} = \begin{bmatrix} -v_4 \\ v_4 - v_5 \\ -v_3 \\ v_5 - v_2 \\ v_1 \end{bmatrix} = \begin{bmatrix} \\ \\ \\ \\ \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \\ I_4 \\ I_5 \end{bmatrix}$$

$$v_1 - i_5 R_7 - i_5 R_6 = 0$$

$$-\cancel{R_2 i_4} - R_3 i_1 - R_4(i_1 - i_2) + v_4 - R_6(i_1 - i_5) = 0$$

$$-(i_2 - i_3)R_2 + v_4 - R_4(i_2 - i_1) - (i_2 - i_4)R_8 - v_5 = 0$$

$$-i_4 R_5 - v_2 + v_5 - R_8(i_4 - i_2) = 0$$

$$-i_3 R_1 - v_3 - R_2(i_3 - i_2) = 0$$