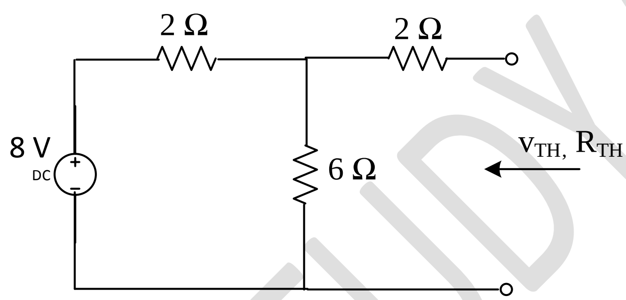
Network Theorems (Part I)-Numerical Problems

Key points: - The problems considered in this set are involving both dependent and independent sources. Following points may be noted

- Dependent sources are voltage or current sources whose output is function of another parameter in the circuit.
- Dependent sources only produce a voltage or current when an independent voltage or current source is in the circuit.
- Dependent sources are treated like independent sources when using nodal or mesh analysis but not with superposition.

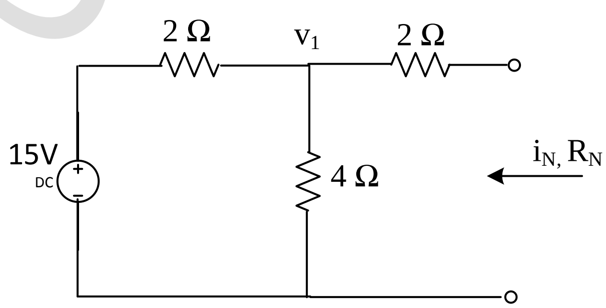
1. In the following circuit find the value of v_{TH} and R_{TH} i_{sc}



Ans. $\boldsymbol{V_{th} = \frac{8}{(2+6)} \times 6 = 6V}$

$\boldsymbol{R_{th} = (2\|6) + 2 = 3.5\Omega}$ **(Replacing voltage source by it's internal impedance)**

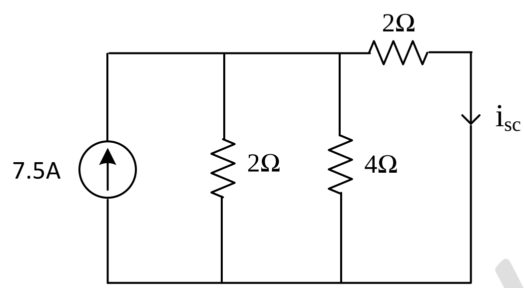
2. In the following circuit find the value of i_N and R_N



Ans. $R_N = 2\|4 + 2$

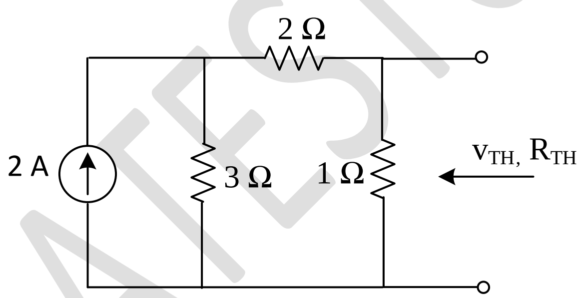
$= \frac{10}{3}\Omega$

i_N **= short circuit current** (i_{s_c})**, By source transformation the equivalent circuit is**



$$i_{s_c} = \frac{7.5\times(2\|4)}{2+2\|4} = \frac{7.5\times4}{3\left(\frac{10}{3}\right)} = \frac{30}{10} = 3\ amps$$

3. In the following circuit find the value of v_{TH} and R_{TH}



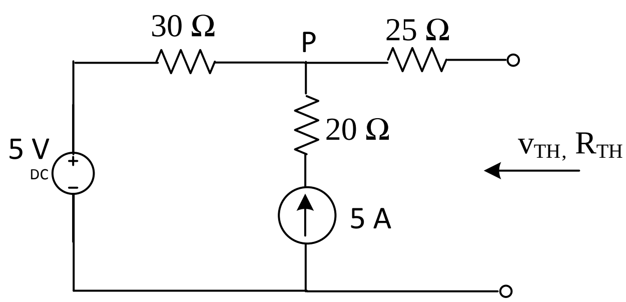
Ans. **Current through 1Ω resistor (using current division)** $= \frac{2\times3}{3+3} = 1amp$

$$V_{th} = 1\ volt$$

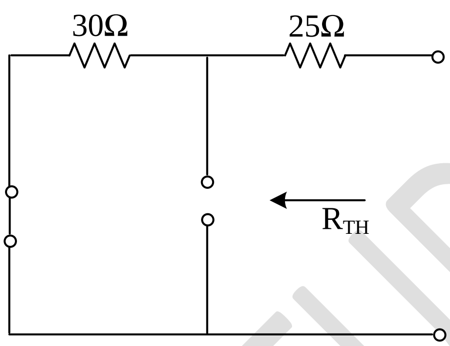
$$R_{th} = 1\|5 = \frac{1\times5}{6} = \frac{5}{6}\Omega$$

(Replacing current source by it's internal impedance i.e. open circuit)

4. For the following circuit find the value of v_{TH} and R_{TH}

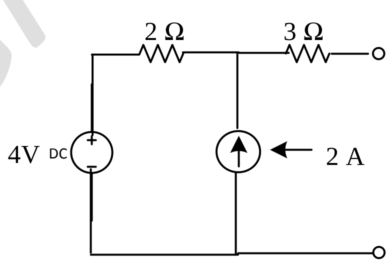


Ans. **To calculate R_{th} , deactivate all independent sources i.e, replace them by their internal impedances.**



$$R_{th} = 30 + 25 = 55\Omega$$
$$V_{th} = voltage\ at\ node\ P$$
$$= 5 \times 30 + 5$$
$$= 155\ V$$

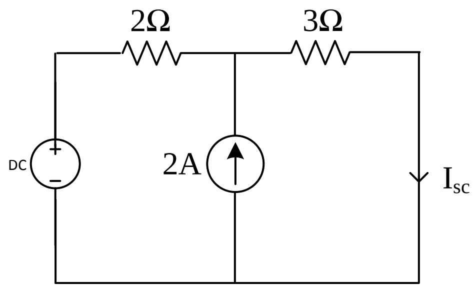
5. In the following circuit find its Thevenin and Norton equivalent

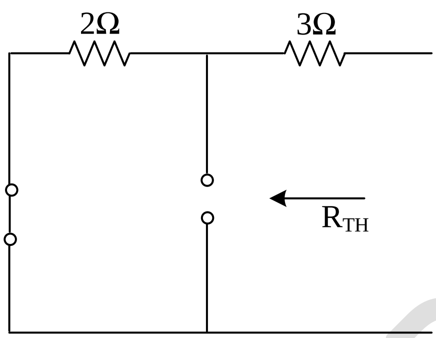


Ans. $V_{th} = 4 + 2 \times 2$

$$= 8V$$

$$R_{th} = 2 + 3 = 5\Omega$$





Short circuit current is due to voltage source (4 Volts) and current source(2 Amp.)

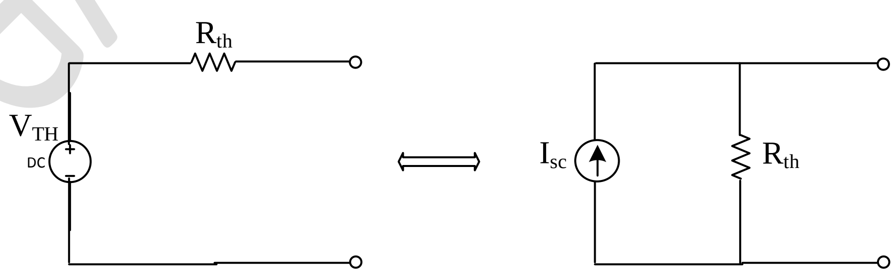
Using superposition

Short circuit current due to voltage source $= \frac{4}{5}$

Short circuit current due to current source $= \frac{2\times2}{2+3} = \frac{4}{5}$

$$I_{sc} = \frac{4}{5} + \frac{4}{5} = \frac{8}{5}\,amp$$

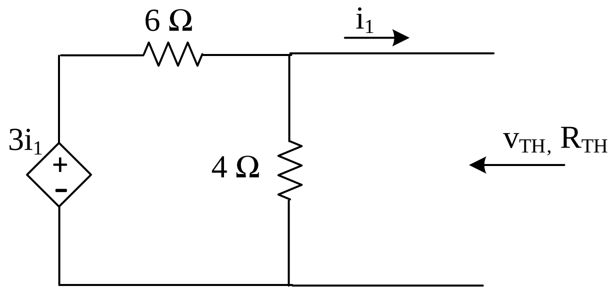
Thevenin's and Norton's equivalents are shown below:



Thevenin's equivalent

Norton's equivalent

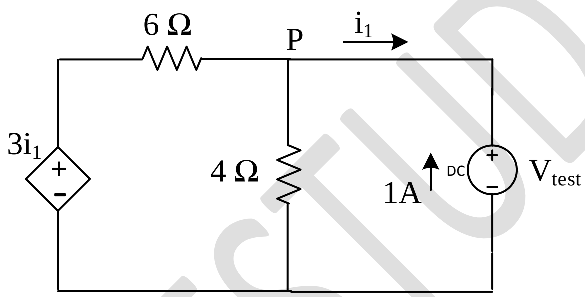
6. For the following circuit find the value of v_{TH} and R_{TH}



Ans. Circuit does not have any independent source, So, $V_{th} = 0$.

For finding R_{th} connect test voltage source V_{test} at terminals XY supplying 1A

$i_1 = -1A$



Writing node equation at node P

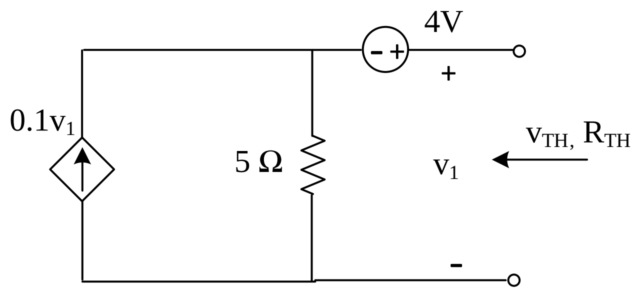
$$\frac{V_{test}}{4} + \frac{V_{test} - 3i_i}{6} + i_1 = 0$$

$$5\,V_{test} = -6\,i_1 = 6$$

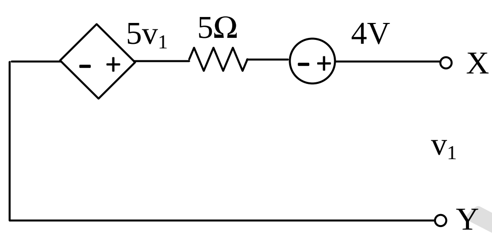
$$V_{test} = \frac{6}{5}$$

$$R_{th} = \frac{V_{test}}{1} = \frac{6}{5} = 1.2\Omega$$

7. In the circuit shown in following figure find the value v_{TH} and R_{TH}



Ans. **By source transformation**



$$V_{th} = v_1$$

$$0.5\, v_1 + 4 = v_1$$

$$0.5\, v_1 - v_1 = -4$$

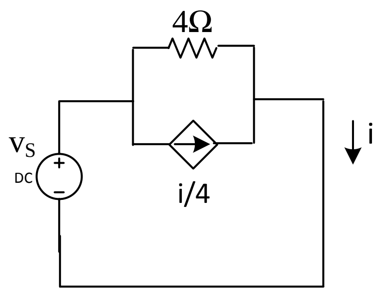
$$v_1 = \frac{4}{0.5} = 8$$

$$V_{th} = 8\ volts$$

$R_{th} = \frac{V_{th}}{I_{SC}}$, i_{sc} **is short circuit current.**

By putting short across $XY, v_1 = 0$, so dependent voltage source $0.5\, v_1 = 0$, $i_{sc} = \frac{4}{5}$ so $R_{th} = \frac{V_{th}}{i_{sc}} = \frac{8}{4/5} = 10\Omega$

8. In the following circuit find the effective resistance faced by the voltage source



Ans. $i = \frac{V_S}{4} + \frac{i}{4}$

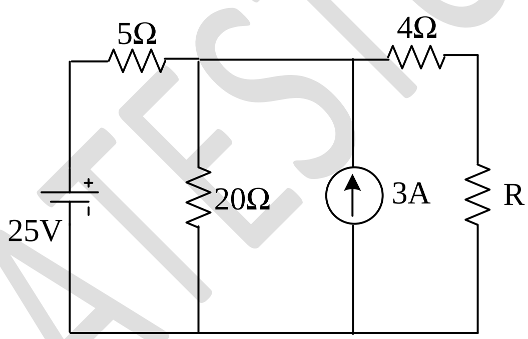
$4i = V_S + i$

$3i = V_S$

$i = \frac{V_S}{3}$

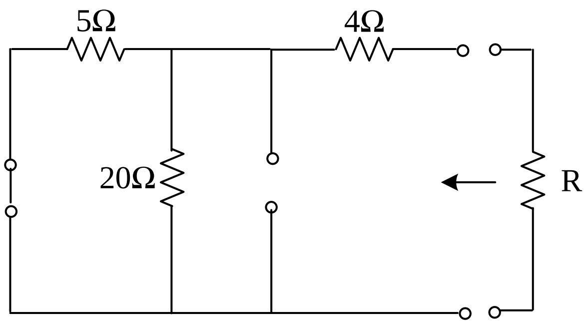
The effective resistance faced by the voltage source is 3Ω

9. Find the value of R (in ohms) for maximum power transfer in the network shown in the figure.



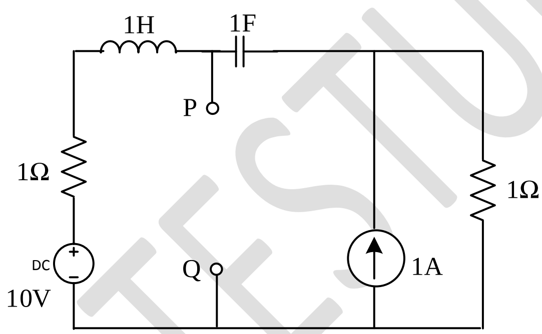
Ans. **For maximum power transfer $R_L = R_S$ (resistance looking into the network)**

Replacing independent sources by their internal impedances.

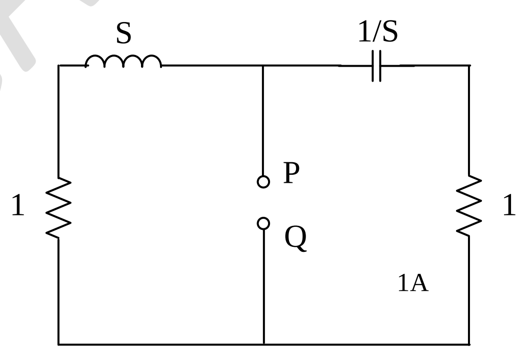


$$R_S = 5\|20 + 4$$
$$= 4 + 4$$
$$= 8\Omega$$
$$R = 8\Omega$$

10. Find the Thevenin equivalent impedance Z_{Th} between the nodes P and Q in the following circuit



Ans. **For finding Z_{th} deactivate all the active sources**

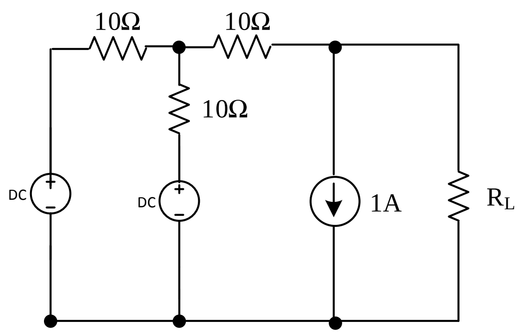


Z_{th} (Between P & Q nodes)

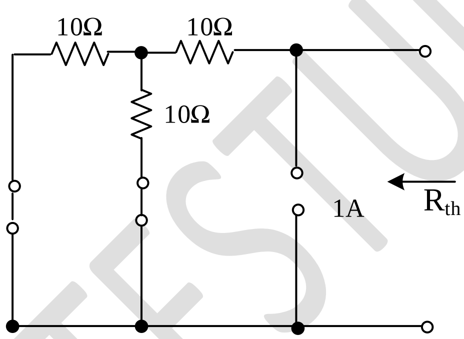
$$= (S+1) \,\|\, \left(1+\frac{1}{S}\right)$$

$$= 1\Omega$$

11. Find the value of R_L such that the power transferred to R_L is maximum.



Ans. **For maximum power transfer $R_L = R_{th}$**



$$R_{th} = 10\|10 + 10$$

$$= 5 + 10$$

$$= 15\Omega$$

$$R_L = 15\Omega$$

12. A source $v_s(t)$=Vcos100 πt has an internal impedance of (4+j3)**Ω**. If an purely resistive load connected to this source has to extract the maximum power out of the source, find it's value

Ans. **For pure resistive load R_L to extract the maximum power**

$$R_L = \sqrt{R_S^2 + X_S^2}$$

$$= \sqrt{4^2 + 3^2}$$

$$= 5\Omega$$