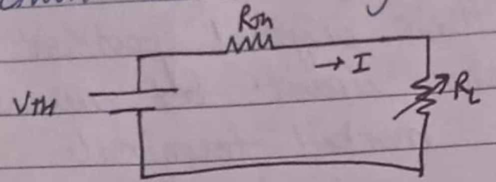
<Num. No. 57/58/59 : In numericals copy>

Maximum Power Transfer Theorem:

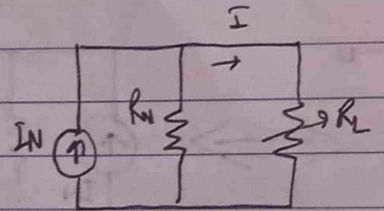
A load will receive maximum power from a linear bilateral DC network when its total resistance value is exactly equal to Thevenin's resistance of a network as seen by the load.



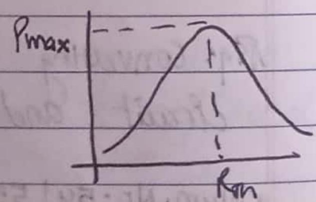
$$I = \frac{V_{TH}}{R_{TH} + R_L}$$

From the network, maximum power delivered when $R_L = R_{TH}$

For Norton's circuit,



From figure, maximum power delivered when $R_L = R_N$.



Now,

$$P = I^2 R_L = \left(\frac{V_{TH}}{R_{TH}+R_L}\right)^2 R_L$$

For power to be maximum,

$$\frac{dP}{dR_L} = 0 \quad \text{or,} \quad \frac{d}{dR_L}\left\{\left(\frac{V_{TH}}{R_{TH}+R_L}\right)^2 R_L\right\} = 0$$

$$\text{or,} \quad \frac{(V_{TH})^2}{(R_{TH}+R_L)^2}\frac{dR_L}{dR_L} + R_L \cdot \frac{d}{dR_L}\left(\frac{V_{TH}}{R_{TH}+R_L}\right)^2 = 0$$

$$\text{or} \quad \frac{(V_{TH})^2}{(R_{TH}+R_L)^2} + R_L \cdot V_{TH}^2 \times \frac{d(R_{TH}+R_L)^{-2}}{dR_L} = 0$$

$$\text{or} \quad \frac{(V_{TH})^2}{(R_{TH}+R_L)^2} + R_L \cdot V_{TH}^2 \cdot \frac{-2}{(R_{TH}+R_L)^3} = 0$$

$$\text{or,} \quad \cancel{\frac{(V_{TH})^2}{(R_{TH}+R_L)^2}} = \frac{2R_L \cdot \cancel{V_{TH}^2}}{(R_{TH}+R_L)^{\cancel{3}}}$$

$$\text{or,} \quad \frac{R_{TH}}{R_L} + \frac{R_L}{R_L} = 2$$

$$\therefore R_{TH} = R_L.$$

Thus, the maximum power is

$$P_{max} = \left(\frac{V_{TH}}{R_{TH}+R_L}\right)^2 R_L = \left(\frac{V_{TH}}{R_L+R_L}\right)^2 R_L = \frac{V_{TH}^2}{4R_L}$$

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