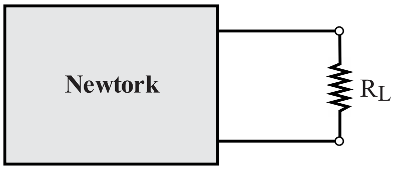
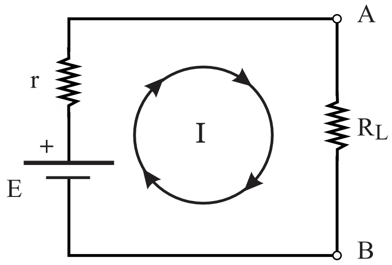
Maximum power transfer theorem

Statement: The maximum power transfer theorem states that maximum power is transferred from source to the load when the internal resistance of the source is equal to the load resistance. That is the power $P = I^2 . R_L$ will be maximum when $r = R_L$.





Proof: The power transferred from the source to the load is given by:

$$P = I^2 . R_L \quad \ldots \ldots \ldots (1)$$

From the above circuit, the current I can be calculated as follows:

$$I = \frac{E}{r + R_L}$$

Putting this value of current in equation (1), we get –

$$P = \left(\frac{E}{r + R_L}\right)^2 \times R_L$$

$$\therefore \quad P = \frac{E^2 . R_L}{r^2 + 2r . R_L + {R_L}^2} \quad \ldots \ldots \ldots (2)$$

$$\therefore \quad P = \frac{E^2}{\frac{r^2}{R_L} + (2r + R_L)}$$

The power will be maximum when denominator of equation (2) is minimum. So equating the derivative of denominator as follows:

The power will be maximum when $P = P_{max}$ i.e.

$$\frac{d}{dR_L}\left(\frac{r^2}{R_L} + 2r + R_L\right) \quad \text{or} \quad \frac{d}{dR_L}\left(\frac{r^2}{R_L} + 2r + R_L\right) = 0$$

Taking derivative, we get –

$$\frac{-r^2}{{R_L}^2} + 0 + 1 = 0$$

$$\frac{r^2}{{R_L}^2} = 1 \qquad i.e. \qquad r^2 = {R_L}^2$$

So finally we get –

$$r = R_L$$

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