Nalanda Open University

B.Sc Part-III

Course – Physics

Paper – VIII

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Topic – Thevenin's theorem (Electronics)

Thevenin's theorem : Thevenin's theorem states that any linear active network with output terminals A and B as shown in fig.1(a) can be replaced by a single voltage source E in series with single impedance Z' as shown in fig.1(b) .

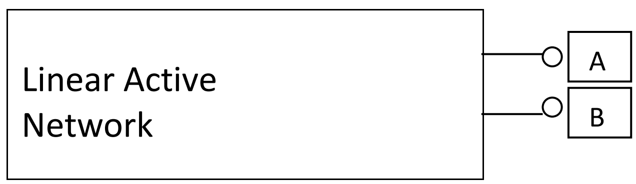

Figure – 1 (a)

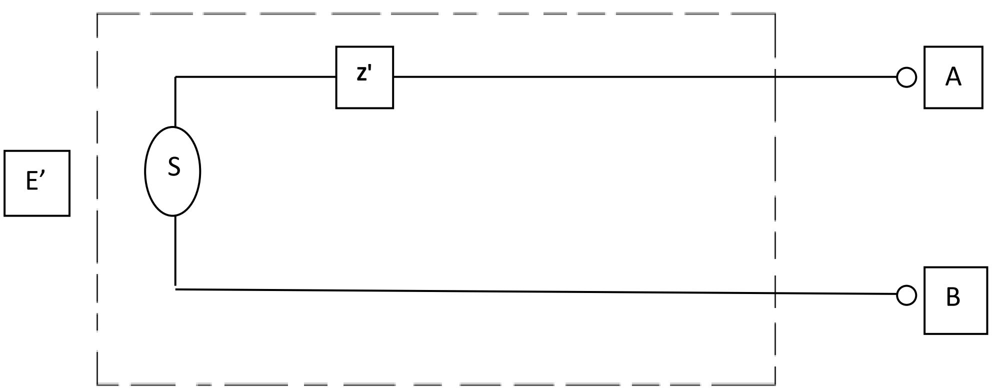

Figure – 1 (b)

In order prove this theorem, let us consider the following figure 2(a) and 2(b) :-

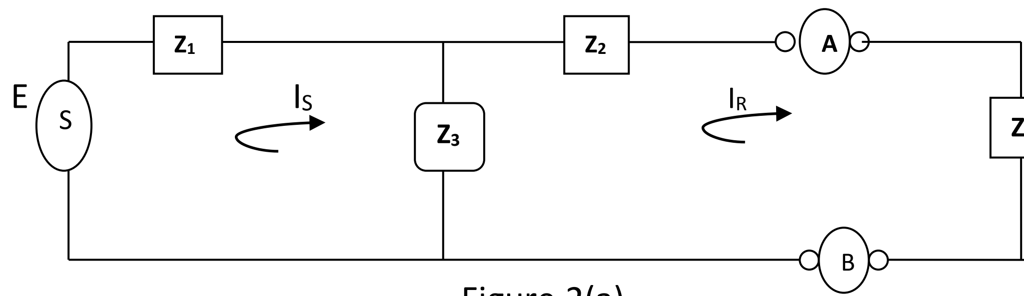

Figure.2(a)

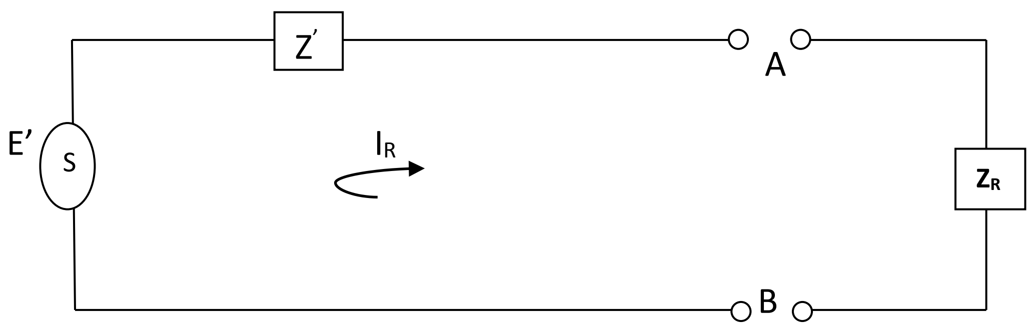

Figure.2(b)

Let us consider a two terminal network, containing one active mesh and other passive mesh. Let us also assume that load impedance ZR is appearing between two terminals as shown in fig.-2(a). Fig.-2(b) represents the Thevenin's equivalent network. I_S and I_R represent the loop current flowing a active and passive networks respectively . We have to calculate E' and Z' from fig.2 (a) and then to show that it is equivalent to a circuit shown in fig.2 (b). We have for the circuit of fig.2 (a)

$$(Z_1 + Z_3) I_s - Z_3 I_R = E \quad \text{........................(1)}$$

$$(Z_2 + Z_3 + Z_R) I_R - Z_3 I_s = 0 \quad \text{........................(2)}$$

From equation 2, we have

$$I_s = \frac{(Z_2+Z_3+Z_R) I_R}{Z_3} \quad \text{...(3)}$$

Using (3) in 1 , we get

$$E = \frac{(Z_2 + Z_3 + Z_R)\, I_R}{Z_3}\,(Z_1 + Z_3) - Z_3 I_R$$

or,

$$E = \frac{(Z_2 + Z_3 + Z_R)(Z_1 + Z_3)\, I_R - Z_3^2\, I_R}{Z_3}$$

Therefore ,

$$EZ_3 = (Z_2 + Z_3 + Z_R)(Z_1 + Z_3)\, I_R - Z_3^2\, I_R$$

$$I_R = \frac{EZ_3}{(Z_2 + Z_3 + Z_R)(Z_1 + Z_3) - Z_3^2}$$

$$I_R = \frac{EZ_3}{Z_2 (Z_1 + Z_3) + Z_R(Z_1 + Z_3) + Z_1 Z_3 + Z_3^2 - Z_3^2}$$

$$I_R = \frac{EZ_3 / (Z_1 + Z_3)}{Z_2 + Z_R + Z_1 Z_3 / (Z_1 + Z_3)}$$

$$I_R = \frac{EZ_3 / (Z_1 + Z_3)}{Z_2 + Z_1 Z_3 / (Z_1 + Z_3) + Z_R} \qquad \text{.......................(4)}$$

$$I_R = \frac{E'}{Z' + Z_R} \qquad \text{.....................(5)}$$

Where, $E' = E Z_3 / (Z_1 + Z_3)$

and $Z' = Z_2 + \frac{Z_1 Z_3}{Z_1 + Z_3}$

The current equation for the circuit of fig. 2(b) is Equation (5) and (6) are the same, hence theorem has been proved.