2.4 SOURCE TRANSFORMATION TECHNIQUE

A voltage or current source is used for energizing the circuit. In analyzing some types of circuits, it is sometimes necessary to convert one type of source to another. Source transformation techniques are used for this conversion.

A source behaves ideally in the absence of any internal resistance. In practice, all the sources have some internal resistance as shown in Fig. 2.7(a) and (b). A practical voltage source consists of an internal resistance R_s in series with it, as represented in Fig. 2.7(a). Similarly, a practical current source inherits an internal resistance R_p in parallel with it, as represented in Fig. 2.7(b).

Unlike the ideal sources, the practical sources have small fluctuations in their output. When a practical current or voltage source is connected to a load resistance, R_L as shown in Fig. 2.7(c) and (d), respectively, the resultant current from such a source produces a fluctuating potential drop across the internal resistance. The magnitude of this voltage fluctuation depends on the variations in the current flowing through the internal resistor.

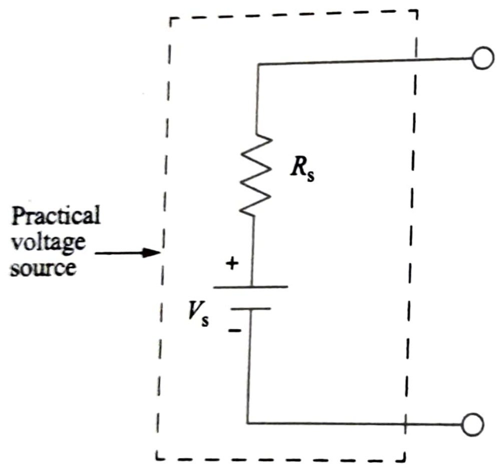

FIG. 2.7(a) A practical voltage source

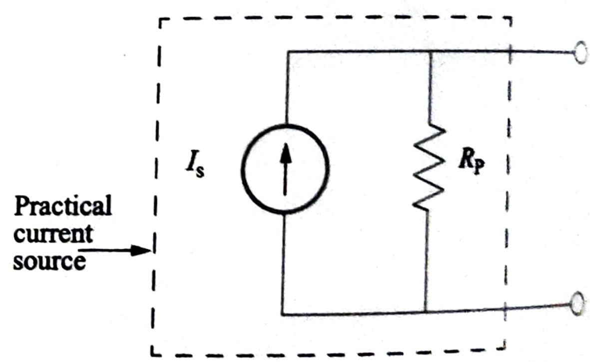

FIG. 2.7(b) A practical current source

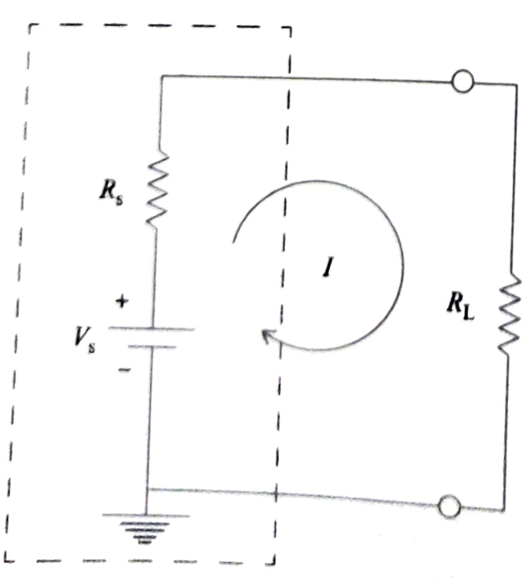

FIG. 2.7(c) A practical voltage source connected to a load resistance R_L

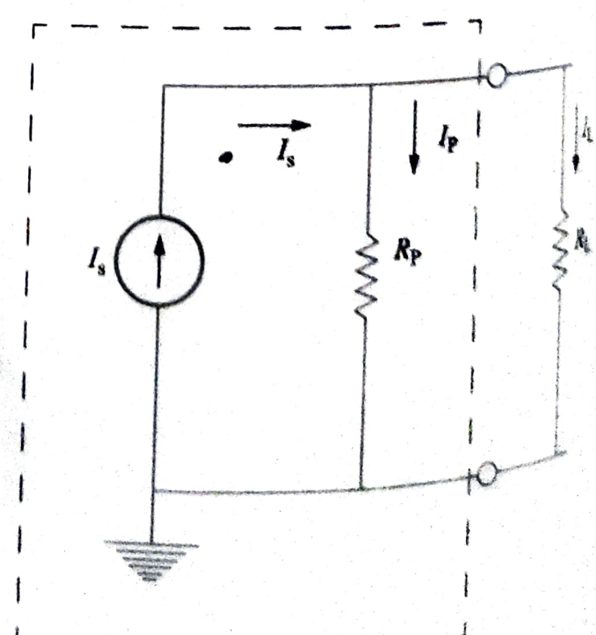

FIG. 2.7(d) A practical current source connected to a load resistance R_L

A practical voltage source becomes an ideal source if it does not have any series internal resistance, i.e., $R_s = 0$. Similarly, a practical current source becomes an ideal source if it has infinite parallel internal resistance $R_p = \infty$.

Source transformation can be applied only to the practical sources having definite internal resistances. In other words, this technique is not valid for ideal sources as the internal resistances of them are either negligible ($R_s = 0$, for a voltage source) or too large ($R_p = \infty$ for a current source).

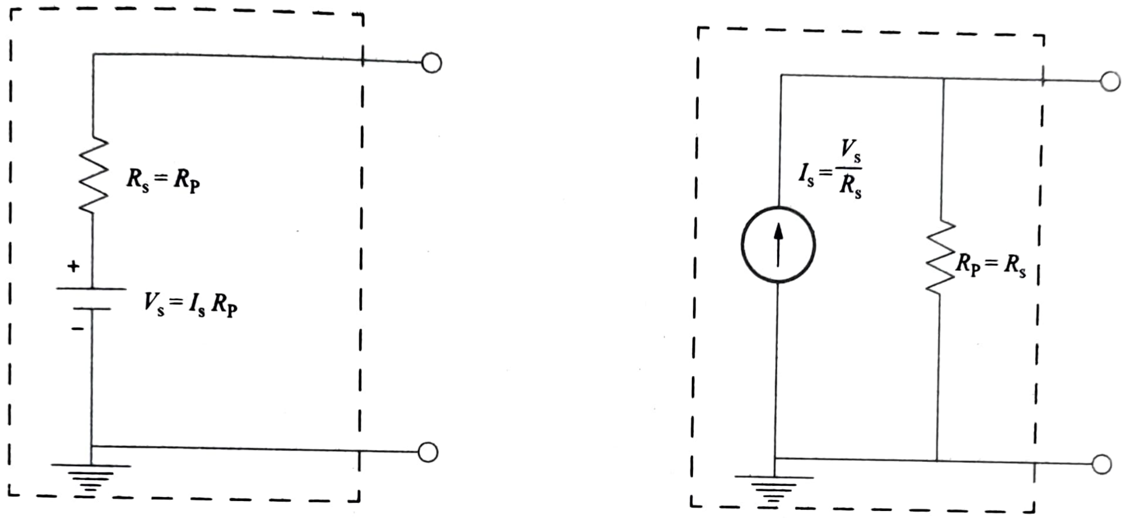

FIG. 2.7(e) Source transformation applied to a practical voltage source and a practical current source

To convert a practical voltage source into a current source and vice versa, the first and foremost assumption has to be made is that the internal resistances of both of these sources are equal. i.e., $R_s = R_p$.

To convert a current source into an equivalent voltage source, we can apply the Ohm's law relationship,

$$V_s = I_s R_p \text{ , where } R_p = R_s.$$

Similarly, to convert a voltage source into equivalent current source, we can apply the relationship

$$I_s = \frac{V_s}{R_s}, \text{ where } R_s = R_p$$

Figure 2.7(e) shows the representation of source transformation from a voltage source to equivalent current source and vice versa. It is shown that a practical current source with a parallel internal resistance R_p can be converted into a practical voltage source having a voltage $V_s = I_s R_p$ in series with a resistor R_s (where $R_s = R_p$). Similarly, a practical voltage source with series internal resistance R_s can be converted into a practical current source having a current value $I_s = \frac{V_s}{R_s}$ in parallel with a resistor R_p (where $R_p = R_s$).

Source Conversion in AC Circuit

Source conversion in an AC circuit is similar to that of a DC circuit except that the phasors and impedances are used instead of real numbers and resistors.

Example. 2.1 For the circuit shown in Fig. E2.1(a), perform source transformation and obtain its equivalent current source.

Solution

The voltage source and resistance to be transformed are indicated by dotted lines in Fig. E2.1(b).

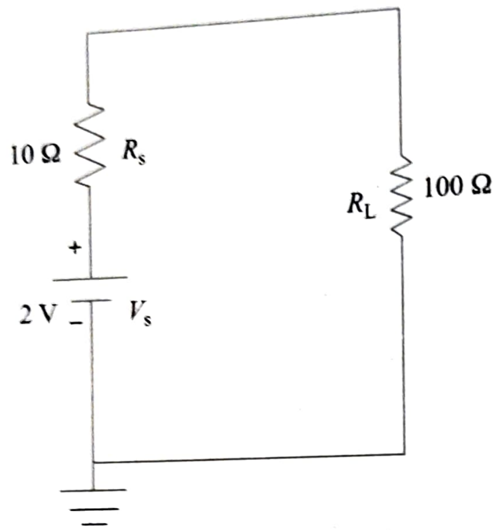

FIG. E2.1(a)

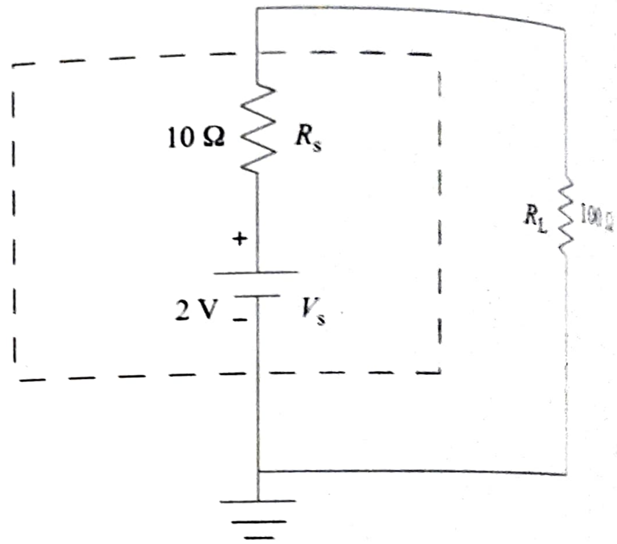

FIG. E2.1(b)

According to Ohm's law, the current through R_s is

$$I_{R_S} = \frac{2}{10} = 0.2\,\text{A}$$

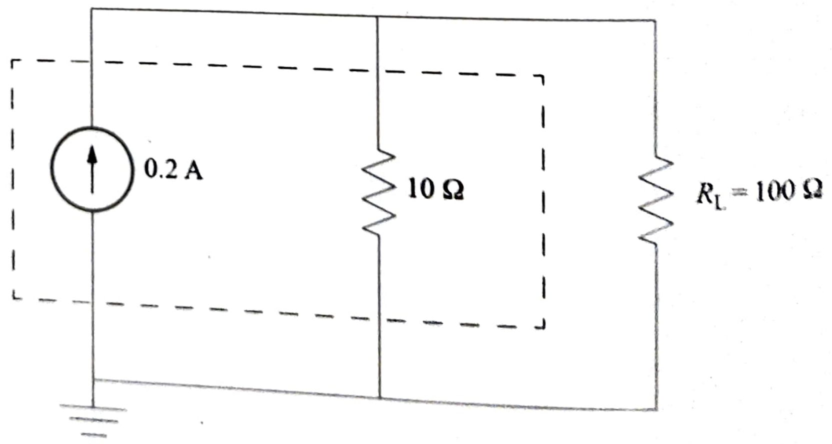

FIG. E2.1(c)

Therefore, the equivalent source current, $I_s = I_{R_s} = 0.2\,\text{A}$

The equivalent resistance of current source, $R_p = R_s = 10\Omega$

The equivalent current source can be drawn as shown in Fig. E2.1(c).