Lab Session 10

Analyze and implement Reciprocity Theorem

Objective:

- Verify the Reciprocity's theorem theoretically and practically for a given circuit

Equipments and Components Required:

- DC Power supply
- Ammeter
- Resistors (Different values)
- Connecting wires

Theory / Statement:

The **reciprocity theorem** is applicable only to single-source networks. It is, therefore, not a theorem used in the analysis of multisource networks described thus far. The theorem states the following:

The current I in any branch of a network, due to a single voltage source E anywhere else in the network, will equal the current through the branch in which the source was originally located if the source is placed in the branch in which the current I was originally measured.

In other words, the location of the voltage source and the resulting current may be interchanged without a change in current. The theorem requires that the polarity of the voltage source have the same correspondence with the direction of the branch current in each position as shown in Figure 10.1.

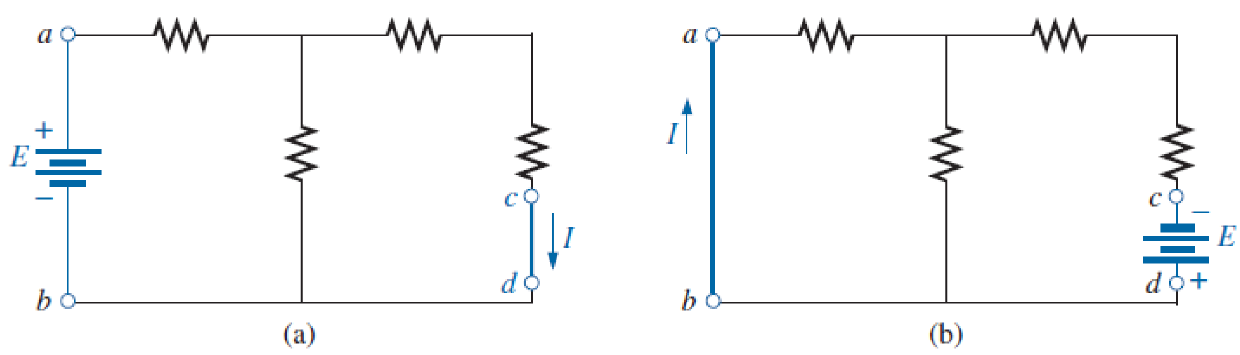

Fig.10.1 Demonstrating the impact of the reciprocity theorem.

In the representative network in Fig. 10.1 (a), the current I due to the voltage source E was determined. If the position of each is interchanged as shown in Fig. 10.1(b), the current I will be the same value as indicated.

Circuit for Analysis

To demonstrate the validity of this statement and the theorem, consider the network in Fig. 10.2, in which values for the elements of Fig. 10.1(a) have been assigned.

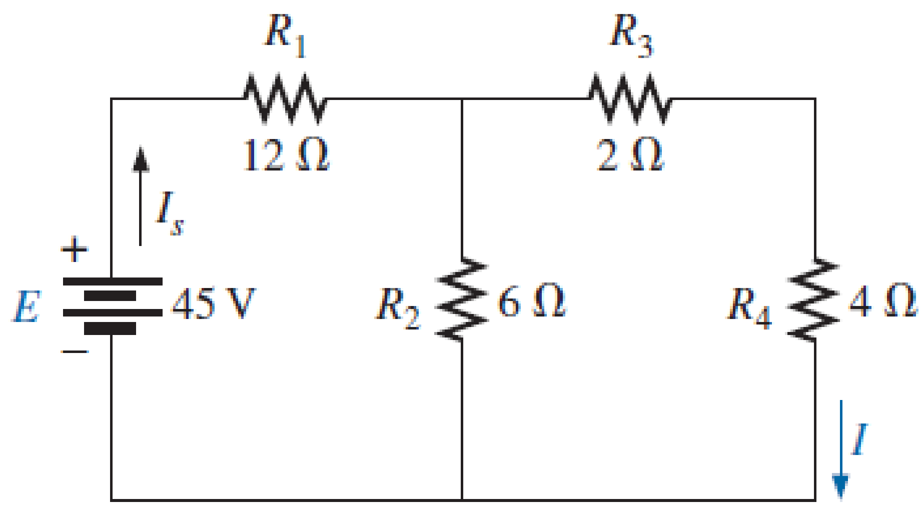

Fig. 10.2 (Finding the current I due to a source E.)

The total resistance (theoretically) is

$$R_T = R_1 + R_2 \| (R_3 + R_4) = 12\,\Omega + 6\,\Omega \| (2\,\Omega + 4\,\Omega)$$
$$= 12\,\Omega + 6\,\Omega \| 6\,\Omega = 12\,\Omega + 3\,\Omega = 15\,\Omega$$

$$I_s = \frac{E}{R_T} = \frac{45\text{ V}}{15\,\Omega} = 3\text{ A}$$

$$I = \frac{3\text{ A}}{2} = \mathbf{1.5\ A}$$

Theoretically result

Simulation Results shown in Fig 10.3 below

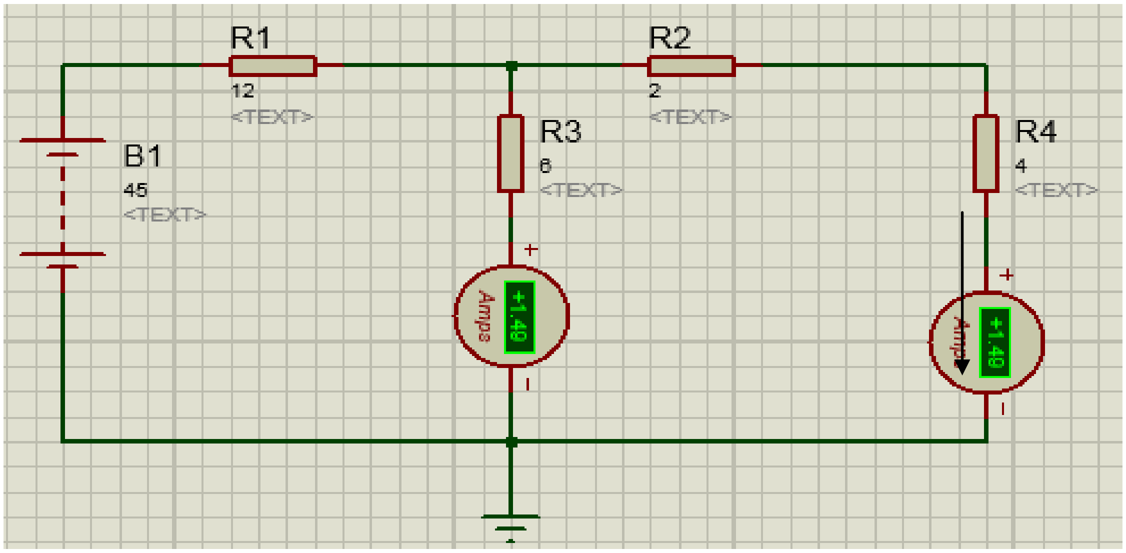

Fig. 10. 3 (Simulation Results)

Now

Interchanging the location of E and I of Fig. 10.2 to demonstrate the validity of the reciprocity theorem.

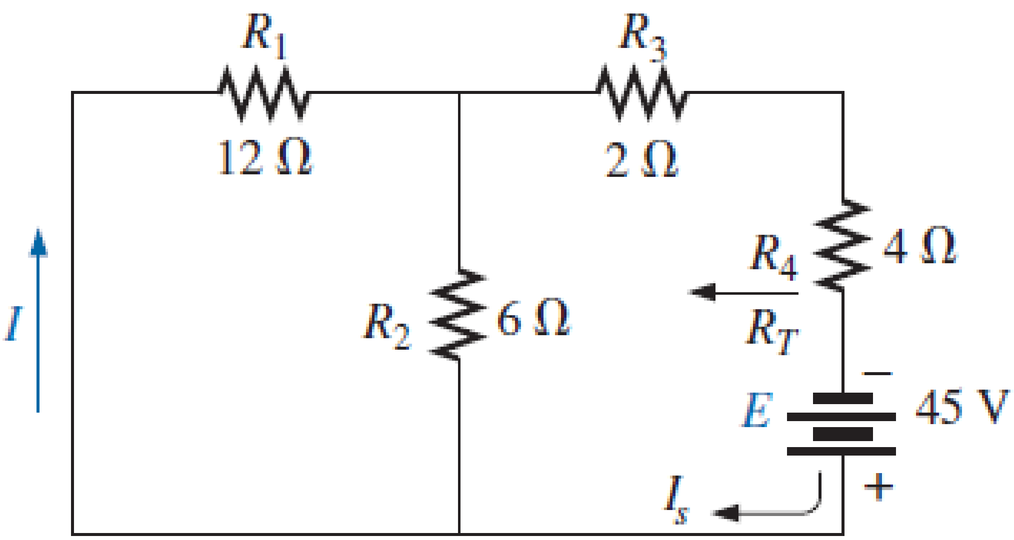

Fig 10.4

For the network in Fig. 10.4 we find results

Theoretically

$$R_T = R_4 + R_3 + R_1 \parallel R_2$$
$$= 4\,\Omega + 2\,\Omega + 12\,\Omega \parallel 6\,\Omega = 10\,\Omega$$

$$I_s = \frac{E}{R_T} = \frac{45\text{ V}}{10\,\Omega} = 4.5\text{ A}$$

Current Division Rule

$$i_1 = \frac{R_2\, i}{R_1 + R_2}, \qquad i_2 = \frac{R_1\, i}{R_1 + R_2}$$

so that $$I = \frac{(6\,\Omega)(4.5\text{ A})}{12\,\Omega + 6\,\Omega} = \frac{4.5\text{ A}}{3} = \mathbf{1.5\text{ A}}$$

Simulation Results shown in Fig 10.5 below

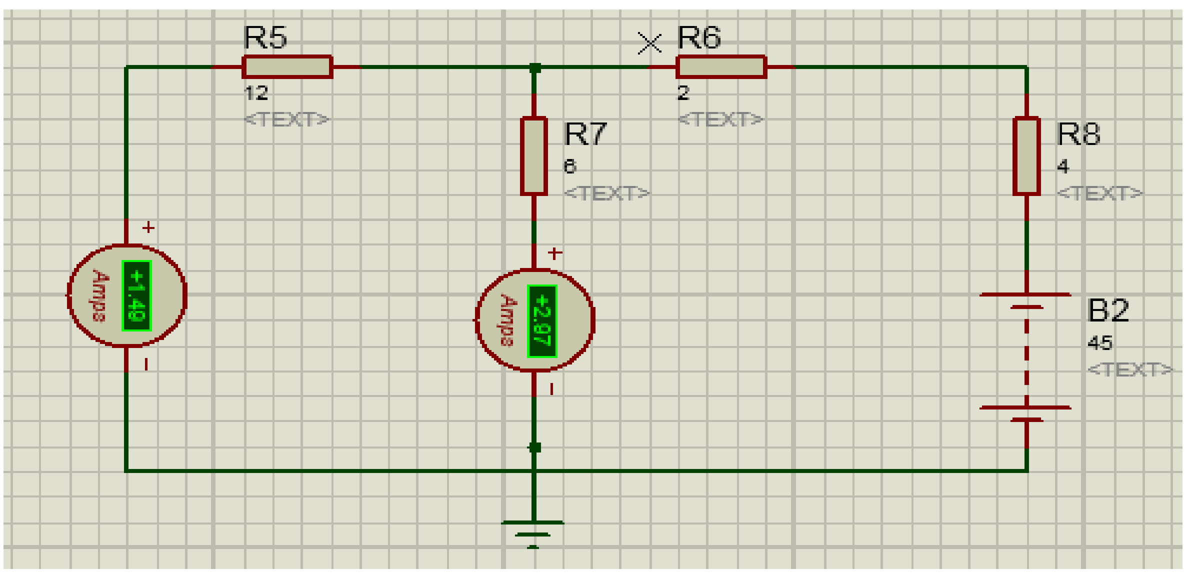

Fig. (10.5 Simulation result of Fig 10.4)

Over all result of simulation

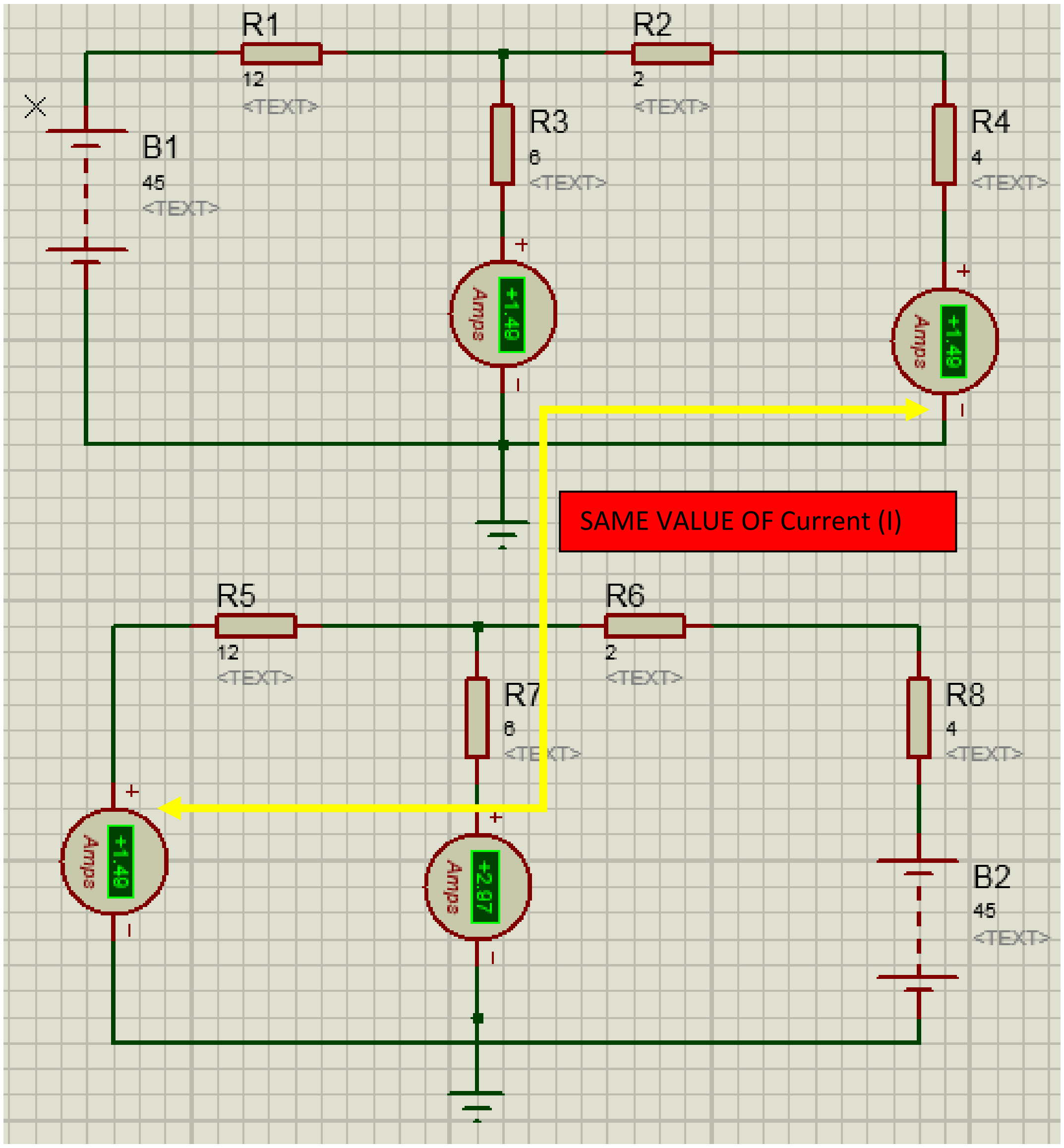

Fig 10.5 (Overall Simulation Results)

Results and Observations

Voltage applied	R1	R2	R3	Value of Ammeter observed as required	Circuit 1 (Before swapping)
					Circuit 2(after swapping)

Task :

Change the Value of Voltage Source and resistor and observe the result at least 3 times.

Comments & Discussion