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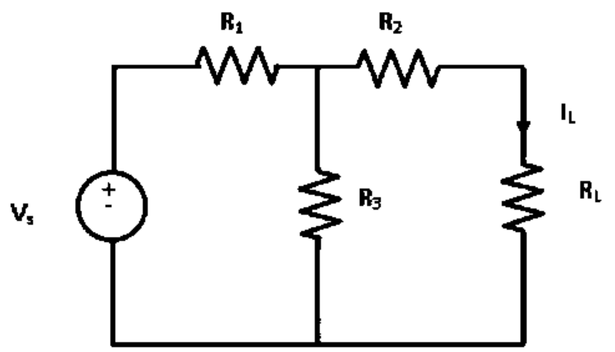
Experiment 3

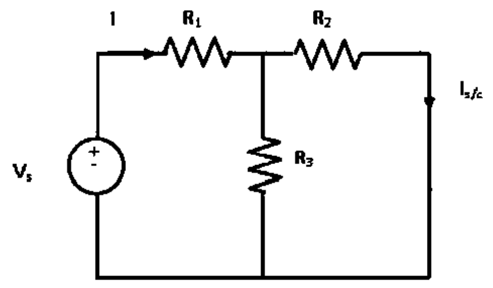
Aim:

To Verify Norton's Theorem.

Theory:

A linear active network consisting of independent and (or) dependent voltage and current sources and linear bilateral network elements can be replaced by an equivalent circuit consisting of a current source in parallel with a resistance, the current source being the short circuited current across the load terminal and resistance being the internal resistance of the source network looking through the open circuited load terminals. In order to find the current through R_L, the load resistance of the figure 1 by Norton's theorem, let us replace R_L by short circuit as shown in figure 2.





Obviously, in figure 2;

$$i = \frac{V_S}{R_1 + \frac{R_2 * R_3}{R_2 + R_3}}$$

$$i_{S/C} = i * \frac{R_3}{R_3 + R_2}$$

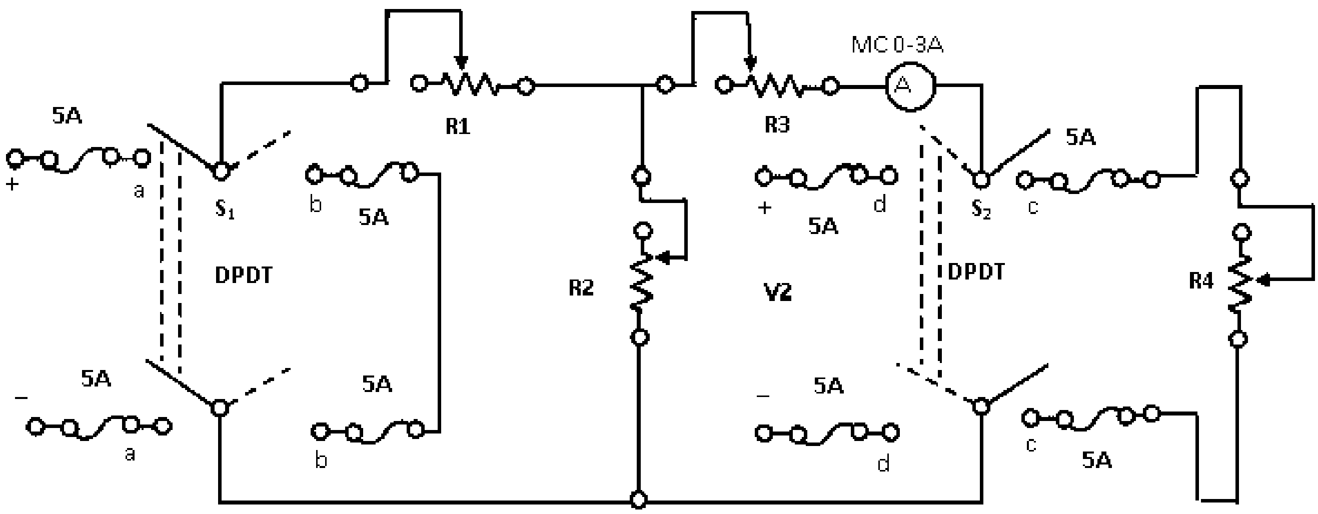
Next, the short circuit is removed and the independent source is deactivated as shown in figure 3.
From Figure 3;

$$R_{int} = R_2 + \frac{R_1 * R_3}{R_1 + R_3}$$

As per Norton’s theorem, the equivalent circuit as shown in figure 4, would contain a current source in parallel to the internal resistance, the current source being the short circuited current across the shorted terminals of the load resistor.
Obviously, from figure 4;

$$i_L = i_{S/C} * \frac{R_{int}}{R_{int} + R_L}$$

Procedure:



1. Keep all the resistance close to their maximum respective values.
2. Close the switch S_1 to “aa” and S_2 to “cc” positions. Observe the load current (I_L) and voltage (V_L) readings.
The load resistance, $R_L = \frac{V_L}{I_L}$
3. Short the load terminals and find the short circuited current ($I_{S/C}$).
4. Next, compute the resistance (R_{int}) of the network as seen from the load terminals,
(i) Replace the 220 V source by a short by closing S_1 to “bb”.
(ii) Apply V = 110 V at the output terminals by closing S_2 to “dd”.
Read the current from ammeter (I) and get $R_{int} = \frac{V}{I}$
5. Now compute the load current (I_L) applying Norton theorem.

$$I_L = I_{S/C} * \frac{R_{int}}{R_{int} + R_L}$$

6. Compare the above computed load current with its observed value in step (2) and verify the theorem.

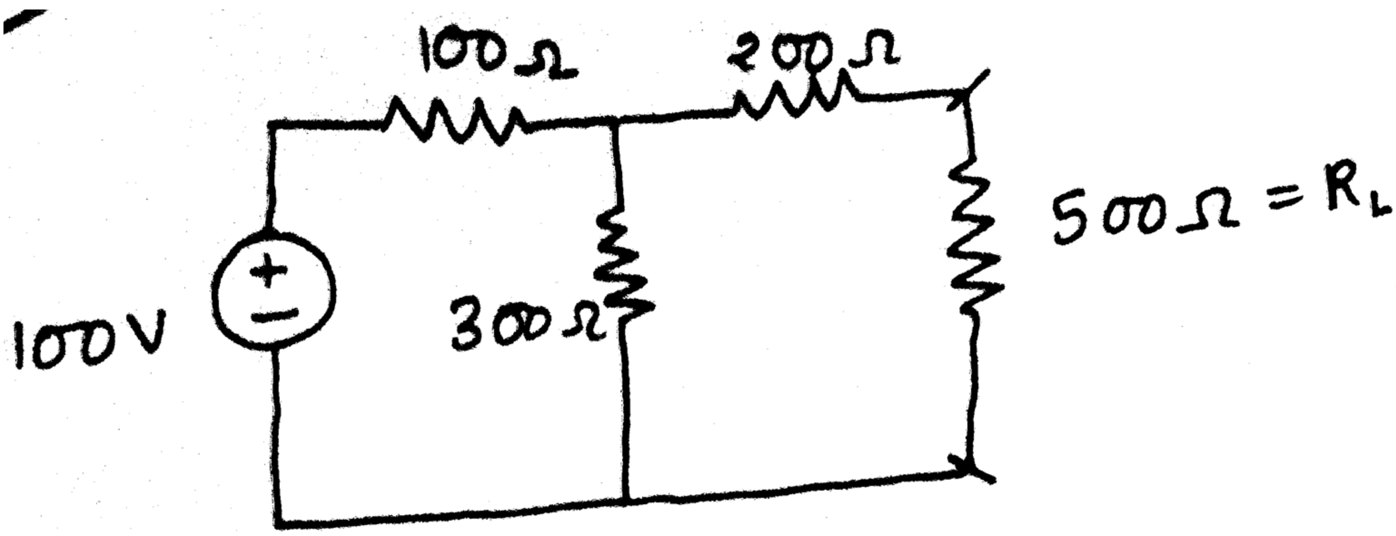
Observations:

Serial no. of Observation	Load Current(I_L) from case 1	Load Voltage(V_L)	Load Resistance (R_L)=V_L/I_L	Norton current(I_{sc}) from case 2(a)	2nd Voltage source(v) from case 2(b)	Ammeter Reading(I) from case 2(b)	Norton Resistance R_n=V/I	Load current (I_L)=I_{sc}*R_n/(R_n+R_L)
1st	0.096774	48.387	500	0.27273	200	0.72727	275.00	0.096775
2nd	0.19355	96.775	500	0.54545	100	0.36364	275.00	0.19355
3rd	0.14516	72.580	500	0.40909	150	0.54545	275.00	0.14516
4th	0.24194	120.97	500	0.68182	100	0.36364	275.00	0.24194
5th	0.29032	145.16	500	0.81818	250	0.90909	275.00	0.29032

Calculations:

1st observation:

$$V = 100V \, , R_1 = 100 \; ohm \, , R_2 = 200 \; ohm \, , R_3 = 300 \; ohm \, , R_L = 500 \; ohm$$



Current from the source 100V,

$$i = \frac{V}{R_1 + \frac{R_3 * (R_2 + R_L)}{R_2 + R_3 + R_L}} = \frac{100}{100 + \frac{700 * 300}{700 + 300}} = \frac{10}{31} A$$

Load Current,

$$i_L = \frac{R_3}{R_2 + R_3 + R_L} i = \frac{300}{1000} * \frac{10}{31} = \frac{3}{31} = 0.096774 \; A$$

Using Norton's theorem:

Current when R_L is short circuited,

$$i = \frac{V_S}{R_1 + \frac{R_2 * R_3}{R_2 + R_3}} = \frac{100}{100 + \frac{200 * 300}{500}} = \frac{10}{22} \; A$$

Open circuit current,

$$i_{S/C} = i * \frac{R_3}{R_3 + R_2} = \frac{10}{22} * \frac{300}{500} = 0.2727273\ A$$

Resistance of network seen from load terminals,

$$R_{int} = R_2 + \frac{R_1 * R_3}{R_1 + R_3} = 200 + \frac{100 * 300}{400} = 275\ ohm$$

Load Current,

$$i_L = i_{S/C} * \frac{R_{int}}{R_{int} + R_L} = \frac{10}{22} * \frac{3}{5} * \frac{275}{275 + 500} = 0.096774\ A$$

As Load current from both cases are same,
So, Norton's theorem is verified.

Similarly we can verify Norton's theorem for all of the other cases.
In all of the cases the load current from case 1 is same as we get from Norton's theorem.
So, Norton's theorem is verified for all of the cases.

Results:

We have successfully verified Norton's Theorem.
All of the observations are verified.