Paper 1, TDC Part-1
Chapter– 4, Circuit Theorems
Lecture - 5

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Circuit Theorem

- In previous lectures we have seen some problems based on Thevenin's theorem. Today we will look next theorem that is Norton's Theorem

- Norton's Theorem is complementary of Thevenin's Theorem or vice versa (we can also say that Thevenin's Theorem is complementary of Norton's Theorem).

- It consists of the equivalent current source instead of the equivalent voltage source as in Thevenin's Theorem

Circuit Theorem

- In Norton's Theorem we will replace the entire network across load by the equivalent current source in parallel with the resistance called Norton's resistance.

- Norton's Theorem states that any linear network containing of independent and dependent energy sources and various circuit elements can be replaced by an equivalent circuit consisting of a current source in parallel with a resistance.

Circuit Theorem

- The current source is the short circuited current through the load terminal.

- The resistance being the internal resistance of the source network.

- Both Thevenin’s and Norton’s Theorem reduce the complex circuit into simpler circuit and also it is easy to find out the current or voltage through the load in case variable load.

Circuit Theorem

➢ Explanation of Norton’s Theorem

Explanation of Norton's Theorem →

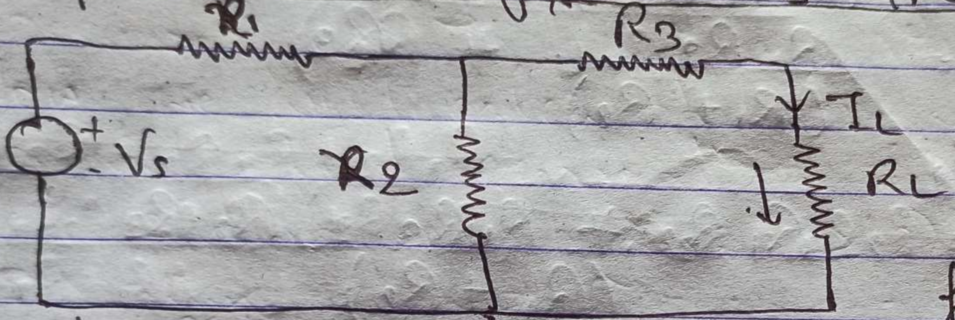
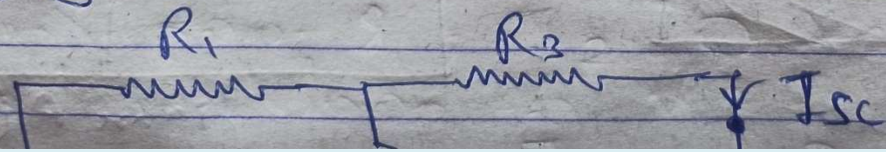


figure A(1)

find the current through load R_L using Norton's Theorem.

Ans. To find the current through R_L we will first remove the resistor R_L and then short circuit the terminal containing R_L as shown in ~~fig~~ figure A(2).



Circuit Theorem

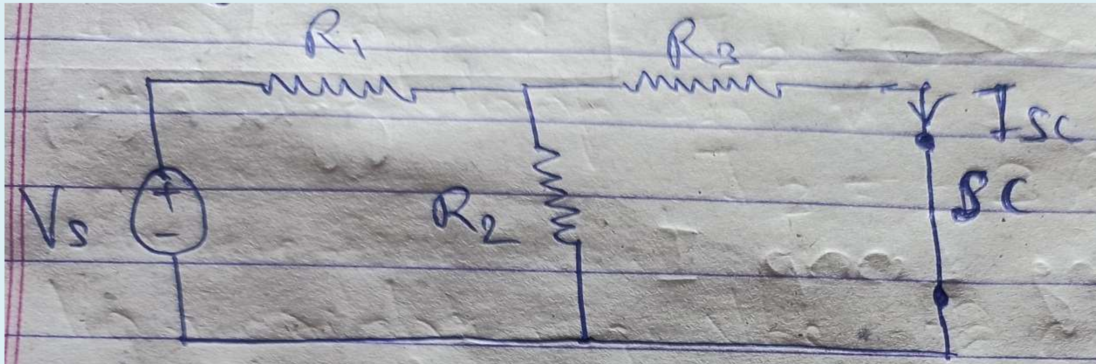


figure A(2)

Now to draw Norton's equivalent ckt we will find the internal resistance as below by short circuiting the voltage source. and opening at terminals of load resistance.

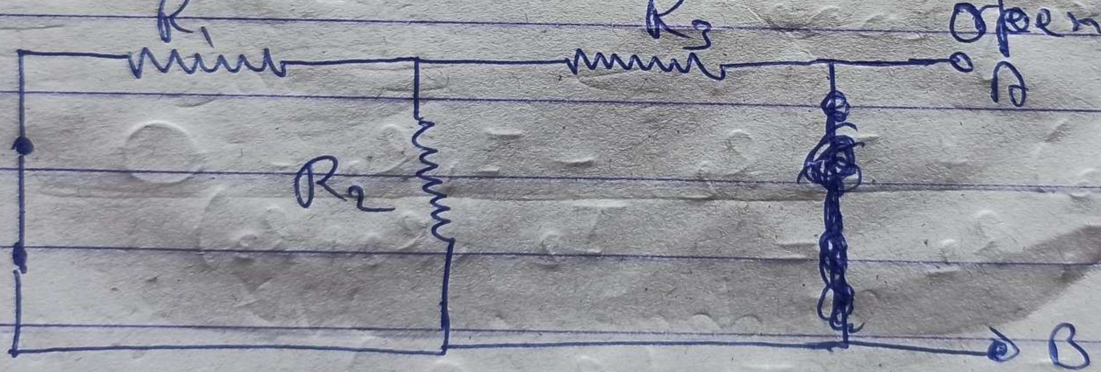


figure A(3)

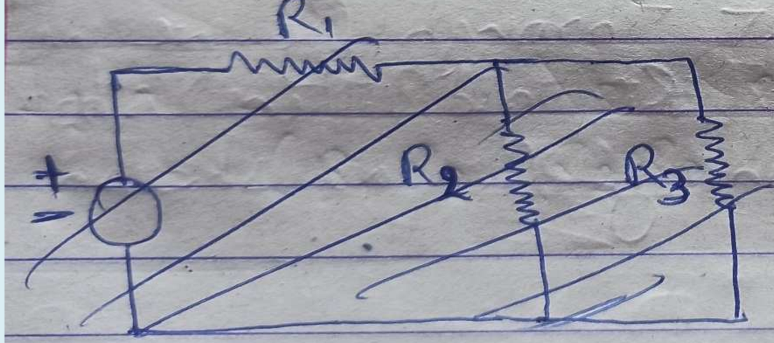
Circuit Theorem

$$R_{int} = (R_1 \parallel R_2) + R_3$$

$$= \frac{R_1 R_2}{(R_1 + R_2)} + R_3$$

$$= \frac{R_1 R_2 + R_1 R_3 + R_2 R_3}{(R_1 + R_2)}$$

Now finding the current I_{sc} through the load resistance terminal as shown in figure A(4)



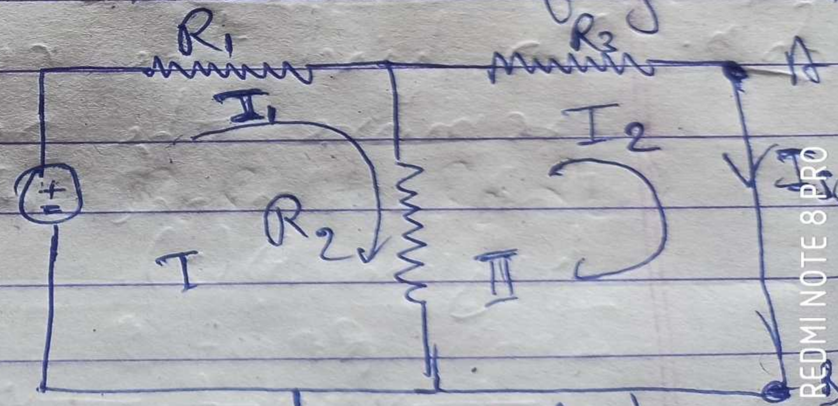


figure A(4)

Circuit Theorem

Considering Loop I

$$I_1 R_1 + I_1 R_2 - I_2 R_2 - V_s = 0$$

$$I_1 (R_1 + R_2) - I_2 R_2 = V_s \quad \text{——— (i)}$$

Now taking Loop II

$$I_2 (R_3) + I_2 R_2 - I_1 R_2 = 0$$

$$I_1 R_2 = I_2 (R_2 + R_3)$$

$$I_1 = \frac{I_2 (R_2 + R_3)}{R_2}$$

Circuit Theorem

putting value of I_1 in eqn (i) we get.

$$\frac{I_2(R_2+R_3)\times(R_1+R_2)}{R_2} - I_2R_2 = V_s$$

or, $$\frac{I_2(R_1R_2+R_1R_3+\cancel{R_2^2}+R_3R_2)-\cancel{I_2R_2^2}}{R_2} = V_s$$

$$I_2 = \frac{V_sR_2}{(R_1R_2+R_1R_3+R_3R_2)} = I_{sc}$$

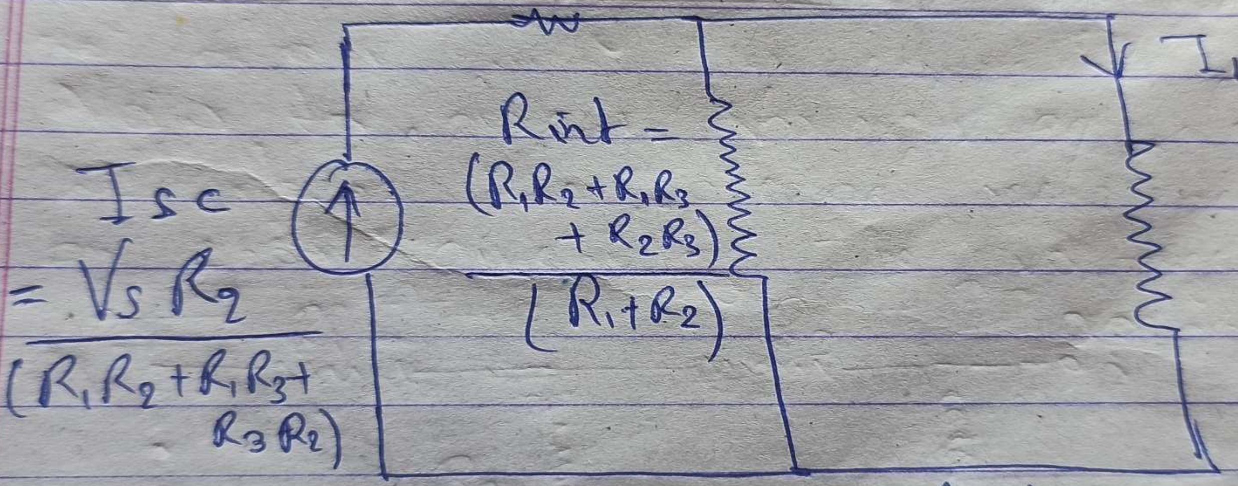
As I_2 is the current flowing through the short circuited terminal AB. So $I_2 = I_{sc}$ (5)

or, $$I_{sc}\ (\text{or } I_N) = \frac{V_sR_2}{(R_1R_2+R_1R_3+R_3R_2)}$$

Circuit Theorem

or, I_{sc} (or I_N) $= \dfrac{V_s R_2}{(R_1 R_2 + R_1 R_3 + R_3 R_2)}$

Now drawing Norton's equivalent ckt. of problem



(I_L)

So to find the current through R_L we can write I_L by dividing current I_{sc} among two branches as per current division rule;

Circuit Theorem

$$I_L = \frac{I_{sc} \times R_{int}}{(R_{int} + R_L)}$$

$$= \frac{V_s R_2}{\cancel{(R_1R_2 + R_2R_3 + R_3R_1)}} \times \frac{\cancel{(R_1R_2 + R_2R_3 + R_3R_1)}}{(R_1 + R_2)\left[\frac{(R_1R_2 + R_2R_3 + R_3R_1)}{(R_1 + R_2)} + R_L\right]}$$

$$= \frac{V_s R_2}{\cancel{(R_1 + R_2)}} \times \frac{\cancel{(R_1 + R_2)}}{(R_1R_2 + R_2R_3 + R_3R_1 + R_LR_1 + R_2R_L)}$$

$$\boxed{I_L = \frac{V_s R_2}{(R_1R_2 + R_2R_3 + R_3R_1 + R_LR_1 + R_2R_L)}}$$

Circuit Theorem

- Steps to use Norton's Theorem in a circuit:-

1. Remove the load resistance of the circuit.
2. Find the internal resistance of the circuit in the same way as find out in Thevenin's Theorem. By short circuiting the voltage source and open circuiting the current source.
3. To find the short circuit current or Norton's Current source, short the load terminals and find the current through the shorted terminals using conventional network analysis method

Circuit Theorem

4. Norton's equivalent circuit is drawn by connecting the internal resistance in parallel with the short circuit current.

5. Now connect the load resistance across the terminals and find the current through the load resistance by simple current division method in among parallel circuit elements that is among parallel internal resistance and load resistance.