Paper 1, TDC Part-1
Chapter– 4, Circuit Theorems
Lecture - 3

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Circuit Theorem

- In previous lectures we have discussed "Superposition Theorem" and did few examples. Today we will see next theorem i.e. Thevenin's Theorem.

- Thevenin's Theorem Statement :
- In any linear circuit with several voltage sources, current sources and resistances can be replaced by single voltage source V_{th} (called Thevenin's Voltage) in series combination of single resistance R_{th} (called Thevenin's resistance)

Circuit Theorem

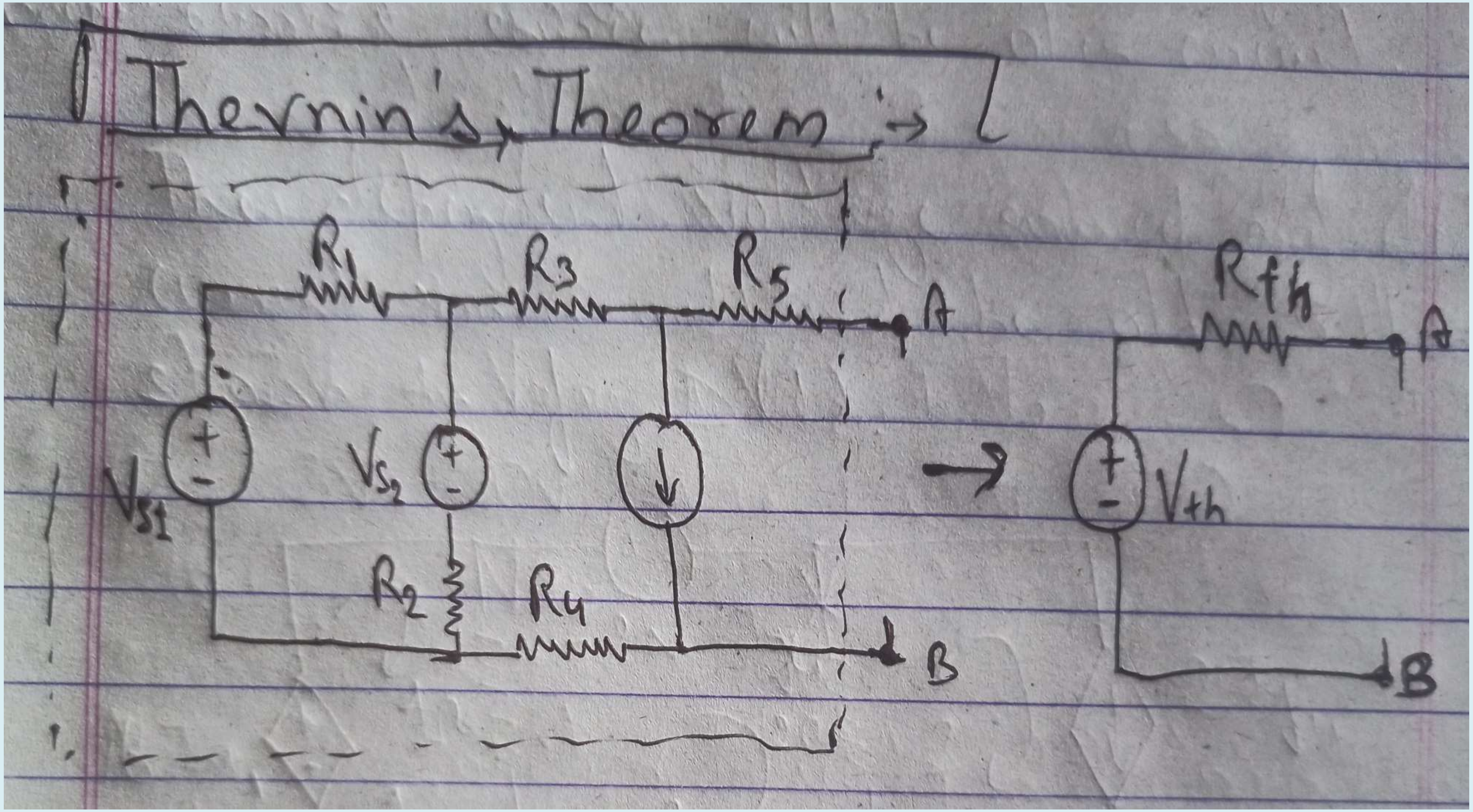


Figure E

Circuit Theorem

Thevenin voltage V_{th} is the open circuit voltage as seen from terminal A-B when the AB is open, as shown in figure E.

Thevenin resistance Rth is the resistance between the terminals A and B, when all the ideal voltage is replaced by short circuit while ideal current source is replaced by open circuit.

When any load with resistance R_L is connected between terminal A and B then the current I_L through R_L can be given

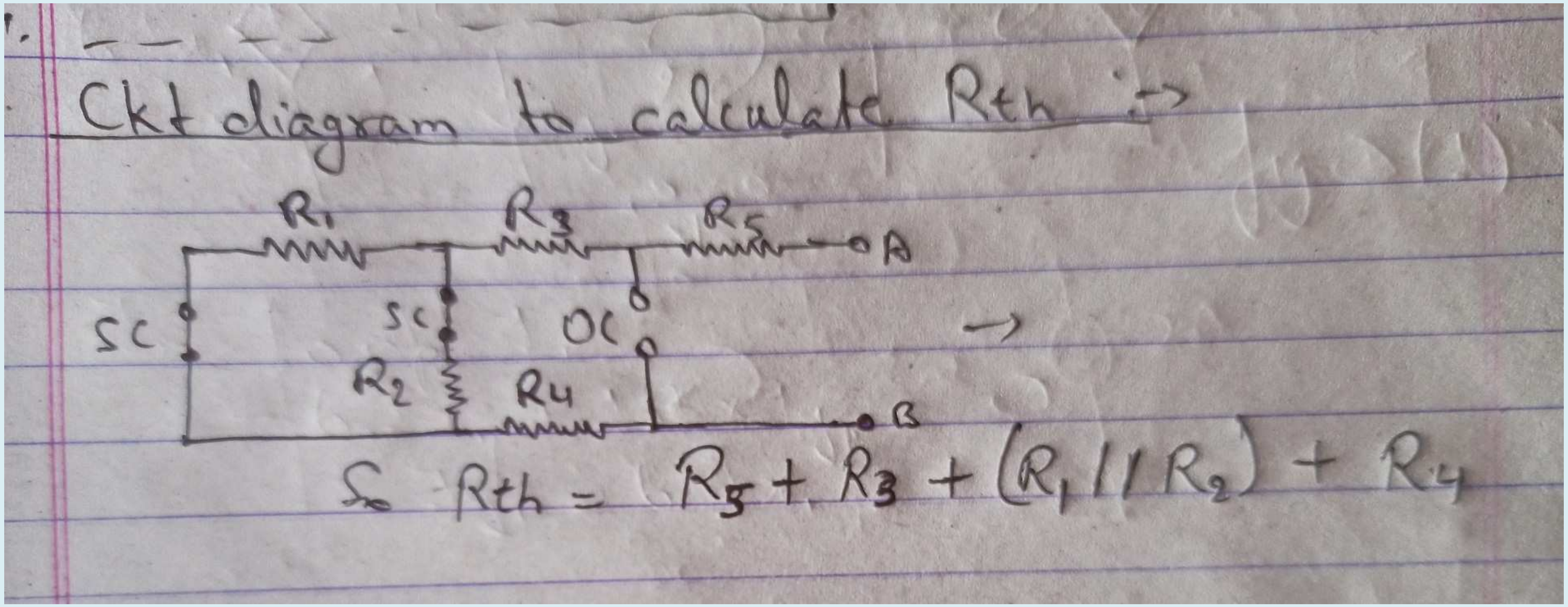
$$I_L = Vt_h/(RL + Rt_h)$$

Circuit Theorem

When R_L is replaced by short between the terminal A and B then the current $I_L = I_{SC}$

$$I_L = Is_c = Vt_h/(RL + Rt_h)$$

The below figure show the circuit diagram to obtain the value of R_{th}



Circuit Theorem

- Thevenin's Theorem is useful in the circuit analysis of power or battery systems and other interconnected resistive circuits where it will have an effect on the adjoining part of the circuit.
- Thevenin's theorem reduce any complicated circuits into a simple circuit consisting of a single voltage source, V_{th} in series with a single resistor, R_{th}.
- When looking back through terminals A and B, this single circuit behaves in exactly the same way electrically as the complex circuit it replaces.

Circuit Theorem

Steps for solving a circuit using Thevenin's Theorem is as follows:

1. Remove the load resistor R_L or component concerned.

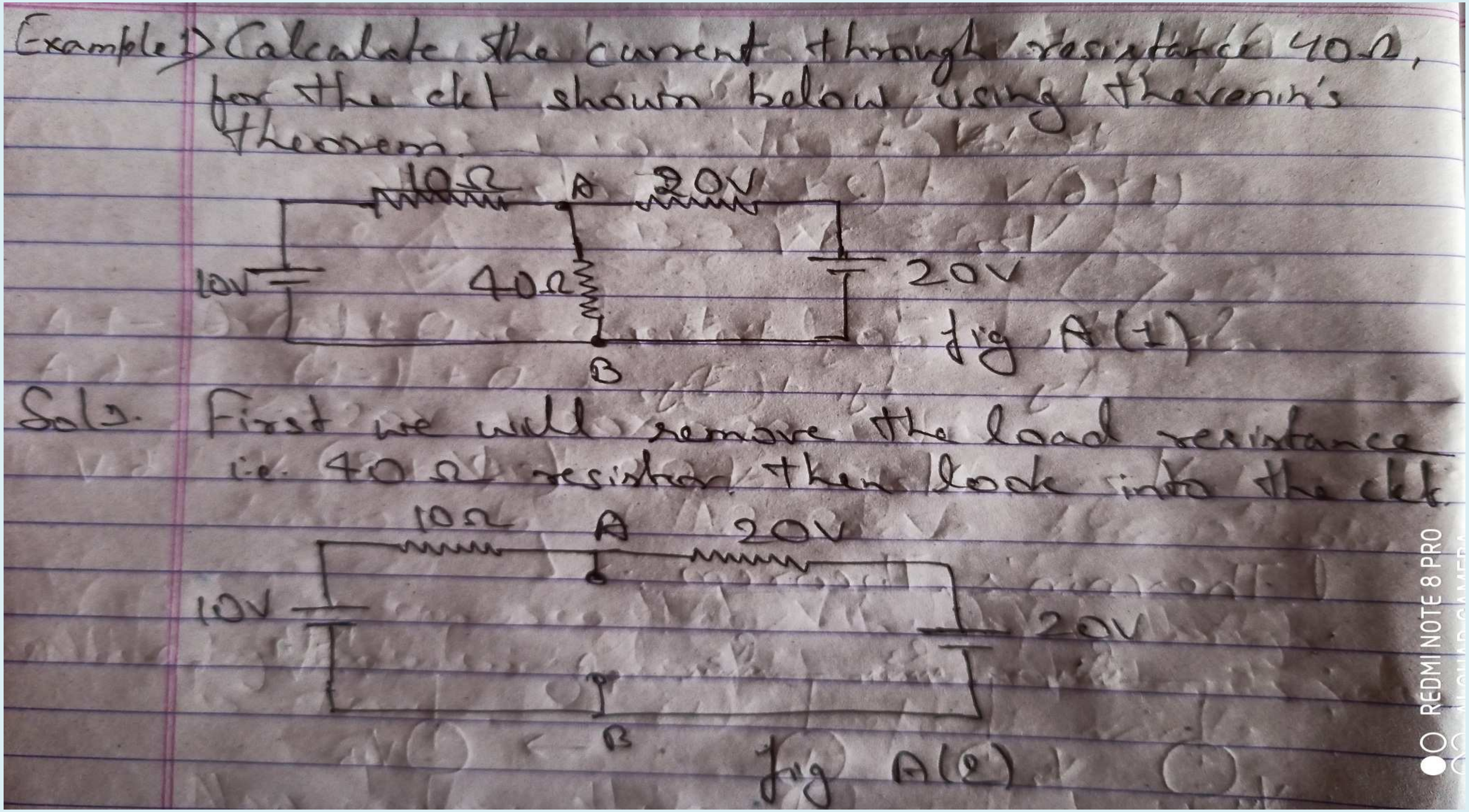
2. Find R_{th} by shorting all voltage sources or by open circuiting all the current sources.

3. Find V_{th} by the usual circuit analysis methods.

4. Find the current flowing through the load resistor R_L.

Circuit Theorem

Now let us look one example to understand the Thevenin's Theorem.



Circuit Theorem

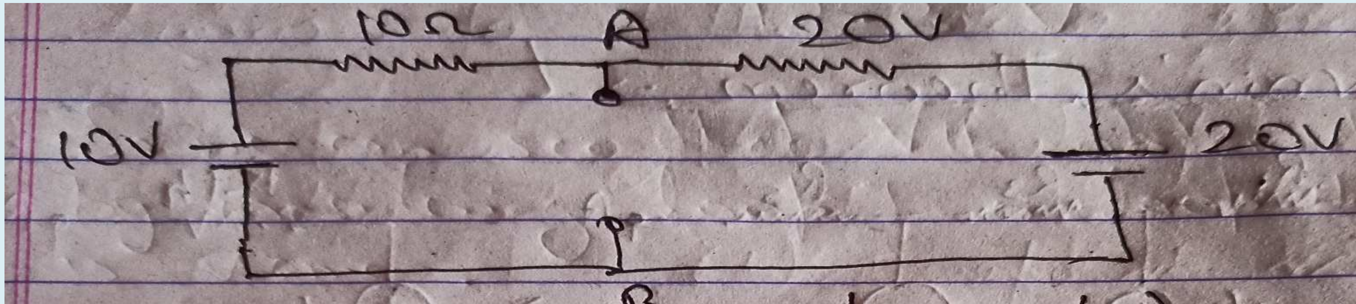


fig A(2)

Now we will find the thevenin's resistance R_{th} as below, by short circuiting the voltage source and open circuiting the current source so the ckt is as below.

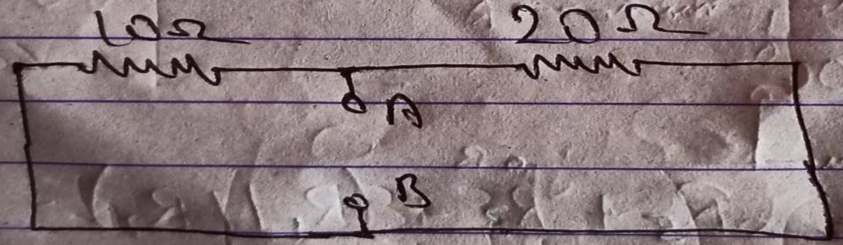


fig A(3)

Looking into the ckt through terminal A & B we will find that 10 Ω & 20Ω are in ||nl

so

Circuit Theorem

$R_{th} = 10\Omega \parallel 20\Omega$

$$R_{th} = \frac{10\times 20}{(10+20)} = \frac{20}{3}\ \Omega = 6.67\Omega$$

Now we will ~~find~~ solve the ~~V_{th}~~ ckt ~~by apply~~ through KVL or KCL by reconnecting back the voltage sources that have been replaced.

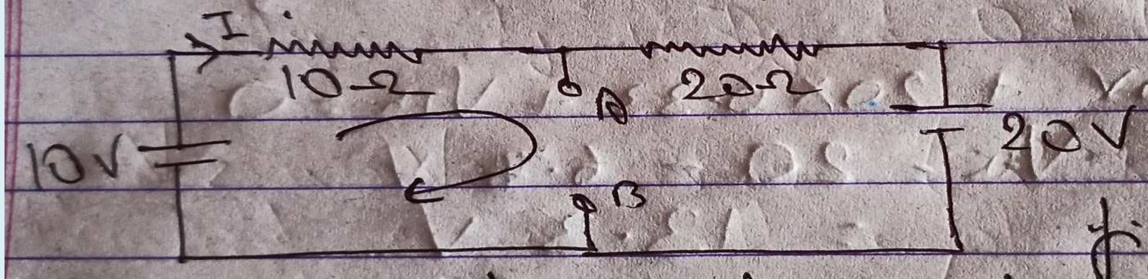


fig A (4)

Let the current I flow into the ckt then as per KVL

$$10I + 20I + 20 - 10 = 0$$

$$30I + 10 = 0$$

$$I = -\frac{10}{30} = -0.33\ A$$

−ve value of current means the direction of current is opposite

Circuit Theorem

Let the current I flow into the [illegible]
as per KVL

$$10I + 20I + 20 - 10 = 0$$

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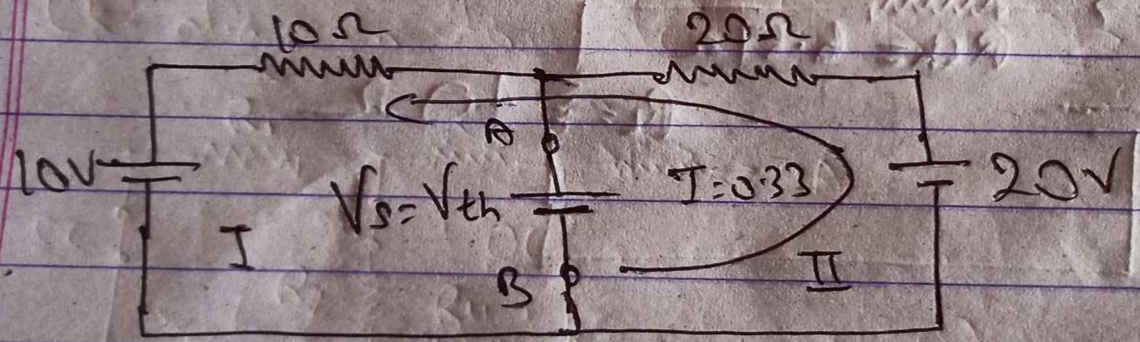
−ve value of current means the direction of current is opposite

To Calculate V_{th} we will connect a voltage source V_s between terminal A & B as below



V_{th} can be obtained by taking any loop i.e. either I or II.

Circuit Theorem

Let us consider loop I first,

$$10 \times 0.33 + 10 - V_{th} = 0$$

$$V_{th} = 10 + 3.3$$

$$= 13.3 \text{ V}$$

Or, when we consider loop II then,

$$-20V + 20 \times 0.33 + V_{Th} = 0$$

$$V_{th} = 20 - 6.7 \text{ V}$$

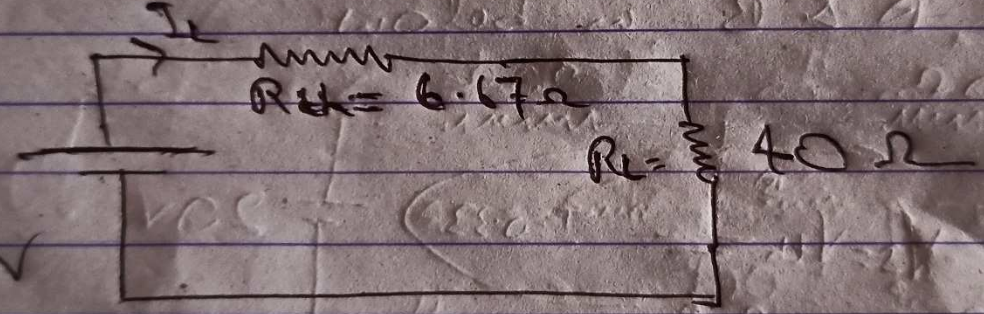
$$= 13.3 \text{ V}$$

So we can see that Vth obtain through either by considering loop I or loop II, its value is same.

Circuit Theorem

So we can see that V_{th} obtained through either by considering loop I or loop II, its value is same.

Now drawing thevenin's equivalent ckt to calculate current to load resistance ($R_L = 40\Omega$).



$V_{th} = 13.3V$

So

$$I_L = \left(\frac{13.3}{6.67 + 40}\right) A$$

$$I_{40\Omega} = I_L = \frac{13.3}{46.67} = 0.28\ A \quad \text{ans}$$