E-Content

DEPARTMENT OF PHYSICS

GOVT. V.Y.T.PG AUTONOMOUS COLLEGE DURG 491001 CHHATTISGARH

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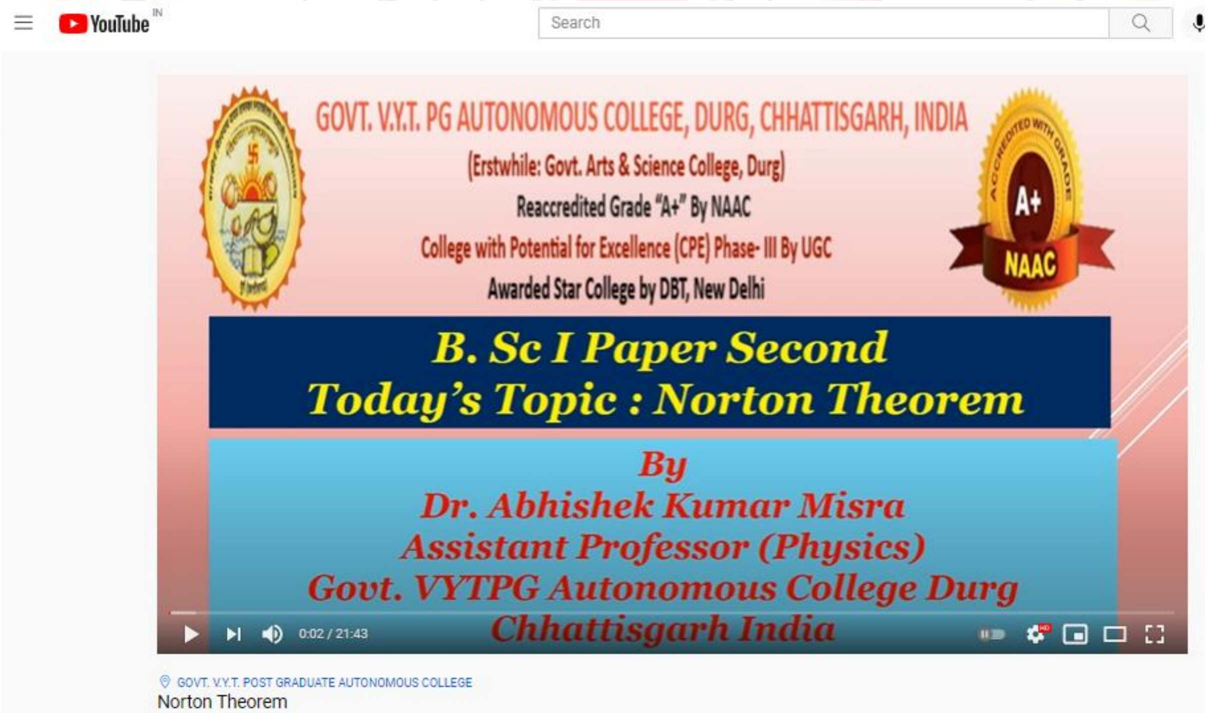
Module: Norton Theorem and its circuit diagram

Module is divided in four sections:

1. **VIDEO CONTENT**
2. **(a) NOTES**
   (b) SUPPLEMENTARY MATERIAL
3. **SUBJECTIVE ASSIGNMENT BASED ON MODULE**
4. **OBJECTIVE QUESTION BASED ON MODULE**
5. **FEEDBACK SECTION**

Video Content: https://youtu.be/LEgoTndSUSA

In this video I explained Statement and derivation of Norton theorem. The two terminal linear networks can be converted into Norton equivalent circuit.



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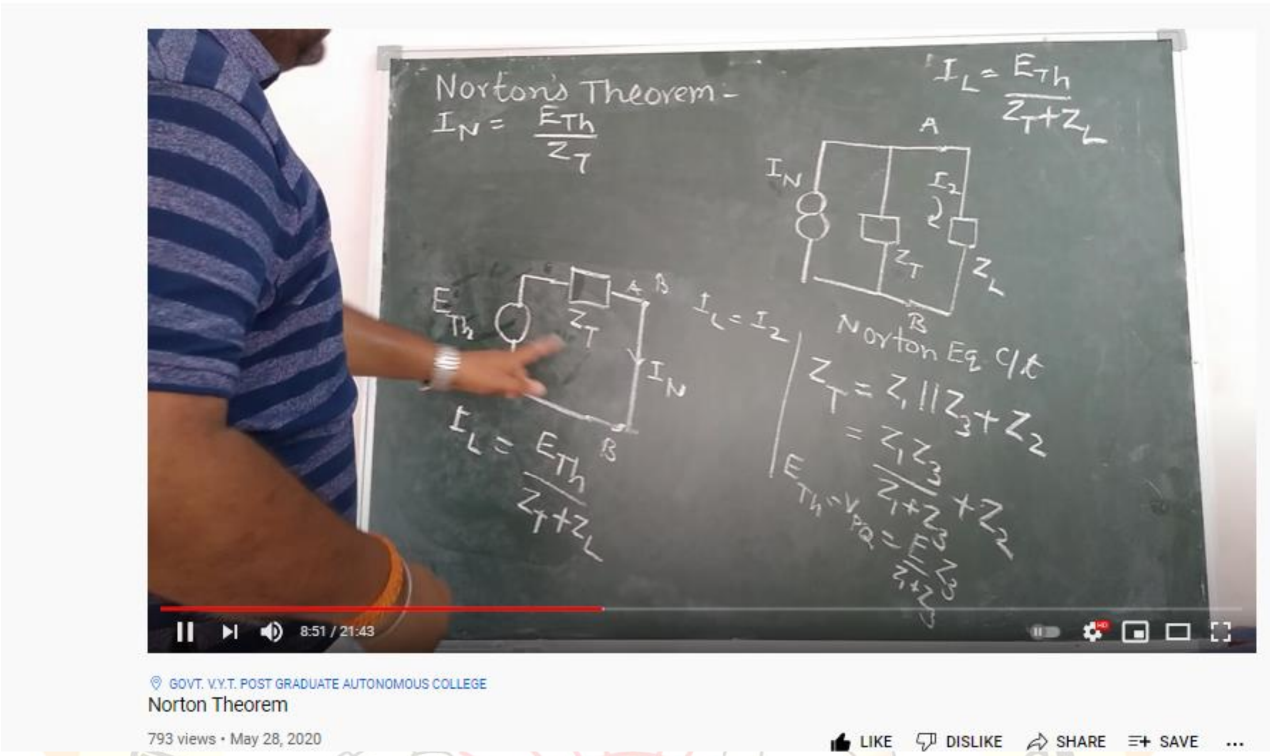

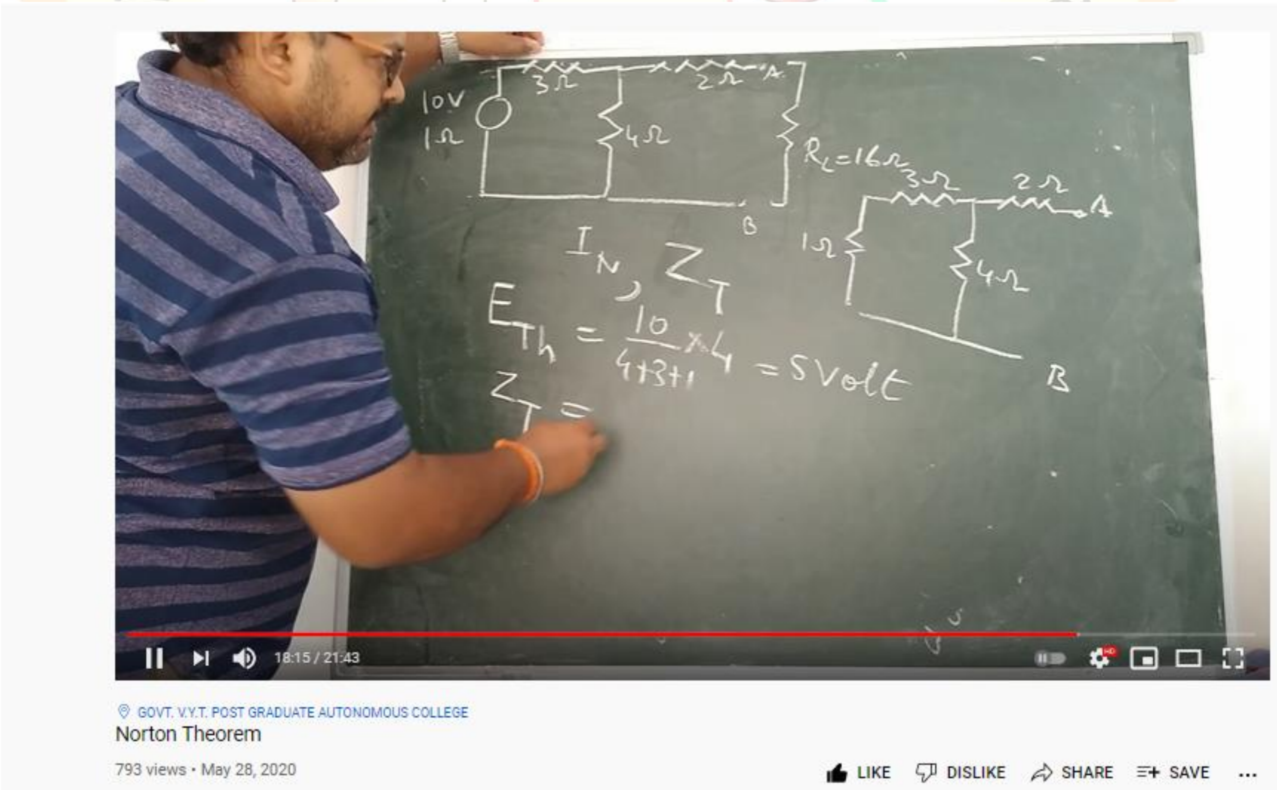

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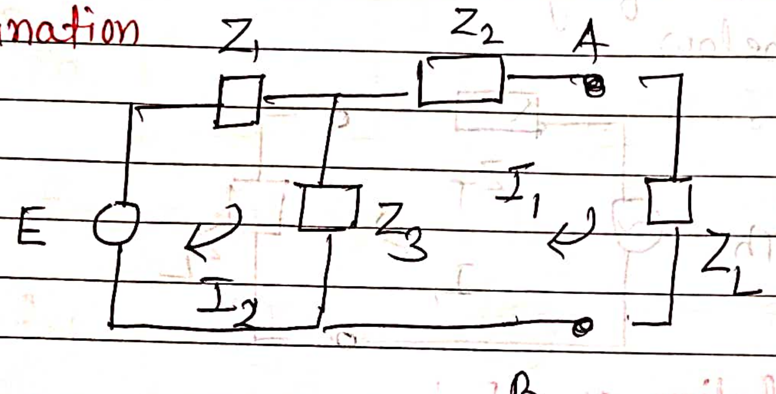
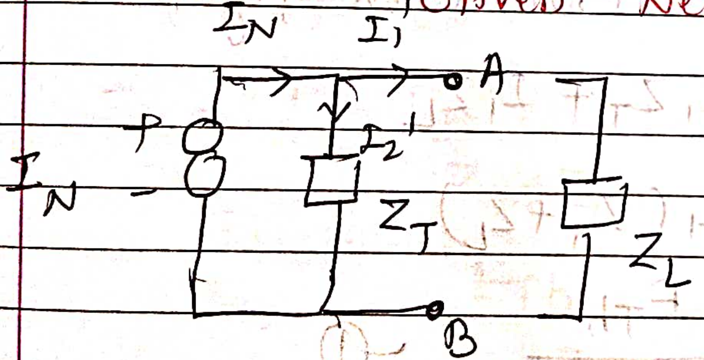
Norton Theorem:-

Statement:- According to this theorem any two terminal linear network containing energy source can be replaced by its equivalent circuit consisting of a current source I_N and impedance Z_T acting parallel to each other. Here I_N is short circuit current across the terminals of given network and Z_T is equivalent impedance across the terminals of given network when energy source is replaced by its internal impedance.

Explanation



Given Network



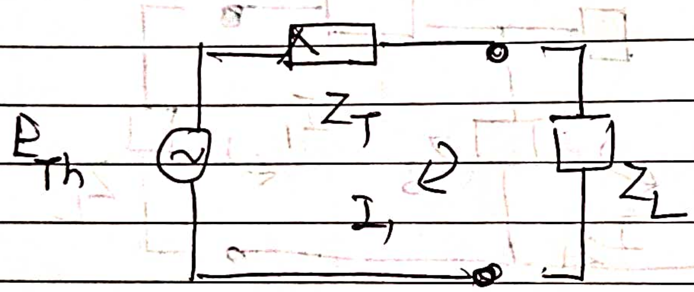
Norton equivalent circuit

Consider a two terminal linear network consisting of three impedances Z_1, Z_2, Z_3 and energy source E is shown in figure. Let I_1 is current through the load impedance Z_L across its output

Second figure represents the equivalent circuit of given network which consists of current source I_N and an equivalent impedance Z_T acting parallel to each other. Let I_1' is the current through load impedance Z_L then according to Norton theorem

$$I_1 = I_1'$$

Proof:- To prove Norton theorem, first of all we made Thevenin equivalent circuit of given network which is shown below



Calculation of I_1:- From above figure

$$E_{Th} = I_1 Z_T + I_1 Z_L$$

$$E_{Th} = I_1 (Z_T + Z_L)$$

$$I_1 = \frac{E_{Th}}{Z_T + Z_L} \quad \text{--- (1)}$$

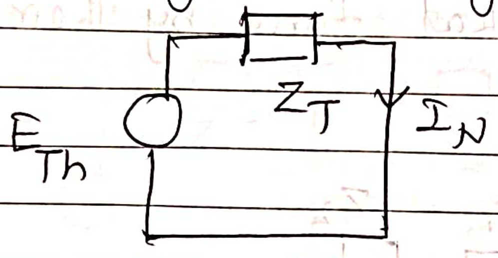
Calculation of I_1':- From Norton equivalent circuit

$$I_N = I_1' + I_2'$$

$$I_1' = \frac{Z_T}{Z_T+Z_L} \cdot I_N \quad \text{--- (2)}$$

$$I_2' = \frac{Z_L}{Z_T+Z_L} \cdot I_N \quad \text{--- (3)}$$

Calculation of I_N:- Here I_N is short circuit current across the terminal of given network. To calculate I_N from Thevenin circuit by following method



$$E_{Th} = I_N \cdot Z_T$$

$$I_N = \frac{E_{Th}}{Z_T} \quad \text{--- (4)}$$

From eq^n (2) and (4)

$$I_1' = \frac{Z_T}{Z_T+Z_L} \cdot \frac{E_{Th}}{Z_T}$$

$$I_1' = \frac{E_{Th}}{Z_T+Z_L} \quad \text{--- (5)}$$

From eq^n (1) and (5)

$$I_1 = I_1'$$

This is statement of Norton theorem.

2 . (b) SUPPLEMENTARY MATERIAL

Norton's Theorem

Norton's Theorem states that – A linear active network consisting of the independent or dependent voltage source and current sources and the various circuit elements can be substituted 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 the resistance being the internal resistance of the source network.

The Norton's theorems reduce the networks equivalent to the circuit having one current source, parallel resistance and load. Norton's theorem is the converse of Thevenin's Theorem. It consists of the equivalent current source instead of an equivalent voltage source as in Thevenin's theorem.

The determination of internal resistance of the source network is identical in both the theorems.

In the final stage that is in the equivalent circuit, the current is placed in parallel to the internal resistance in Norton's Theorem whereas in Thevenin's Theorem the equivalent voltage source is placed in series with the internal resistance.

Explanation of Norton's Theorem

To understand Norton's Theorem in detail, let us consider a circuit diagram given below

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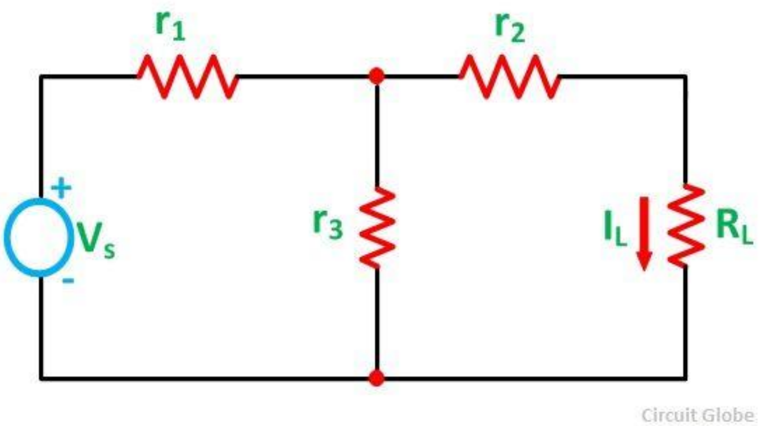
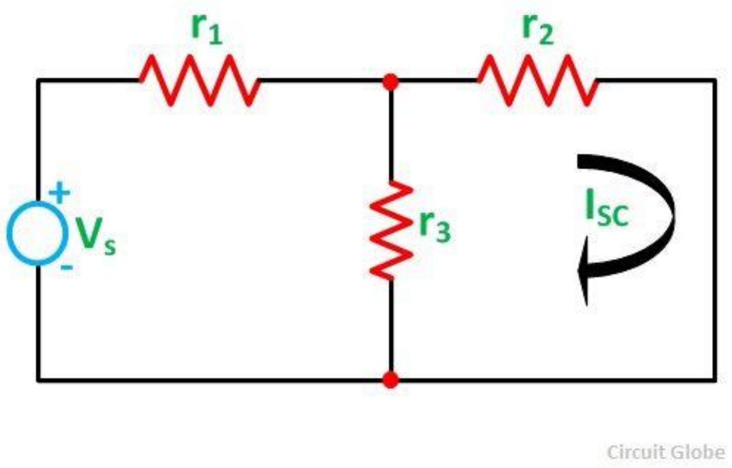


To find the current through the load resistance IL as shown in the circuit diagram above, the load resistance has to be short-circuited as shown in the diagram below:



Now, the value of current I flowing in the circuit is found out by the equation

$$I = \frac{V_S}{r_1 + \frac{r_2 r_3}{r_2 + r_3}}$$

And the short-circuit current I_{SC} is given by the equation shown below:

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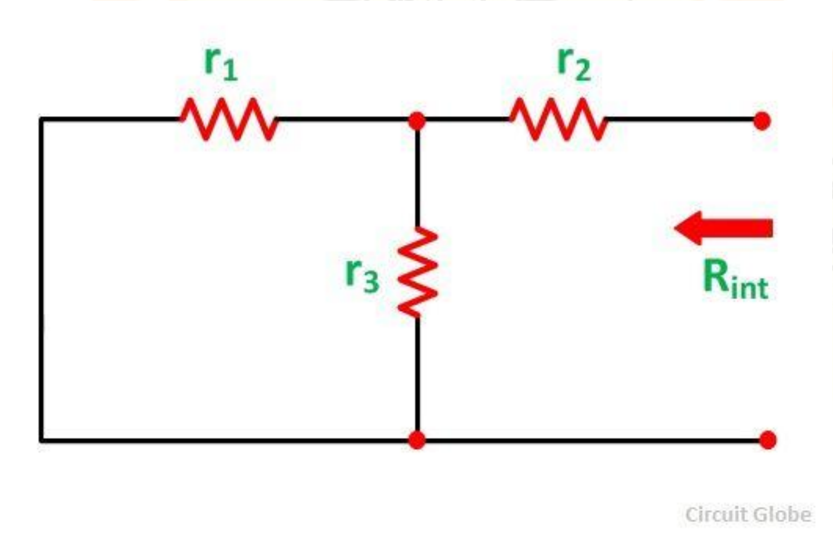
$$I_{sc} = I \frac{r_3}{r_3 + r_2}$$

Now the short circuit is removed, and the independent source is deactivated as shown in the circuit diagram below and the value of the internal resistance is calculated by:



So,

$$R_{int} = r_2 + \frac{r_1 r_3}{r_1 + r_3}$$

As per Norton's Theorem, the equivalent source circuit 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. The Norton's Equivalent circuit is represented as

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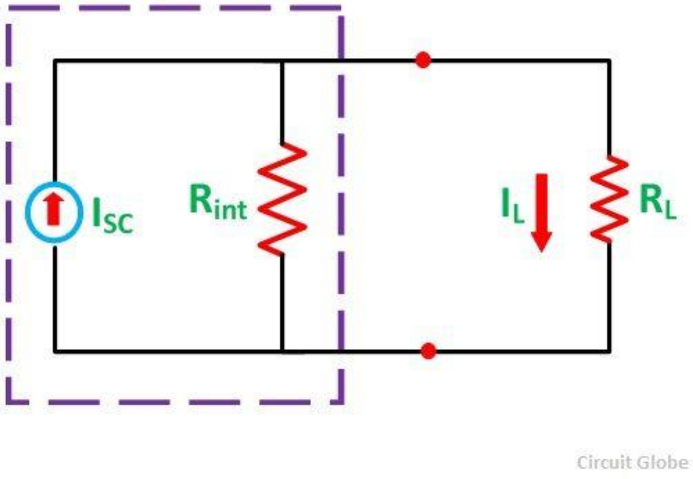

Finally, the load current I_L calculated by the equation shown below

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

here,

- I_L is the load current
- I_{sc} is the short circuit current
- R_{int} is the internal resistance of the circuit
- R_L is the load resistance of the circuit

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Steps for Solving a Network Utilizing Norton's Theorem

Step 1 – Remove the load resistance of the circuit.

Step 2 – Find the internal resistance R_{int} of the source network by deactivating the constant sources.

Step 3 – Now short the load terminals and find the short circuit current I_{SC} flowing through the shorted load terminals using conventional network analysis methods.

Step 4 – Norton's equivalent circuit is drawn by keeping the internal resistance R_{int} in parallel with the short circuit current I_{SC}.

Step 5 – Reconnect the load resistance R_L of the circuit across the load terminals and find the current through it known as load current I_L.

Reference:

https://circuitglobe.com/what-is-nortons-theorem.html

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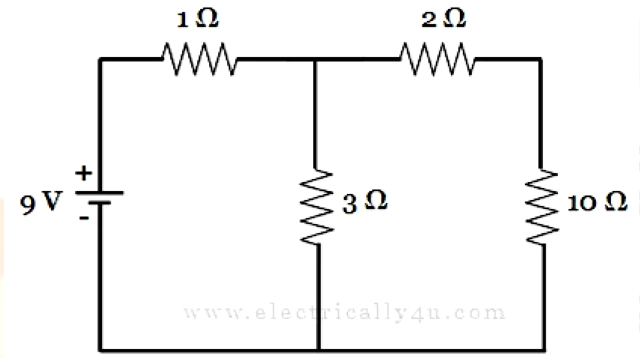
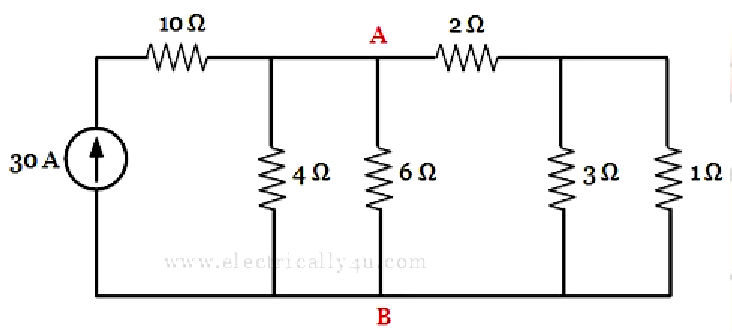
3. ASSIGNMENT

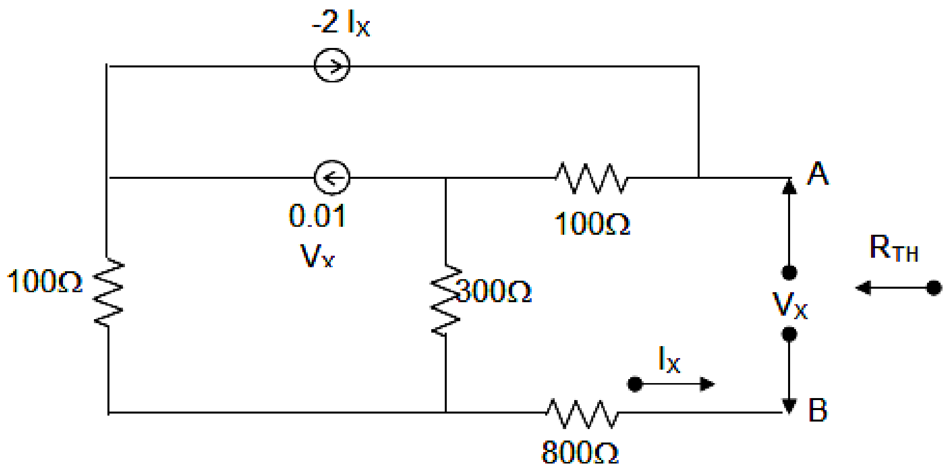
1. **For the given circuit, determine the current flowing through 10 Ω resistor using Norton's theorem.**



2. **Determine the current through AB in the given circuit using Norton's theorem.**



3. **In the following circuit, the value of Norton's resistance between terminals a and b are?**



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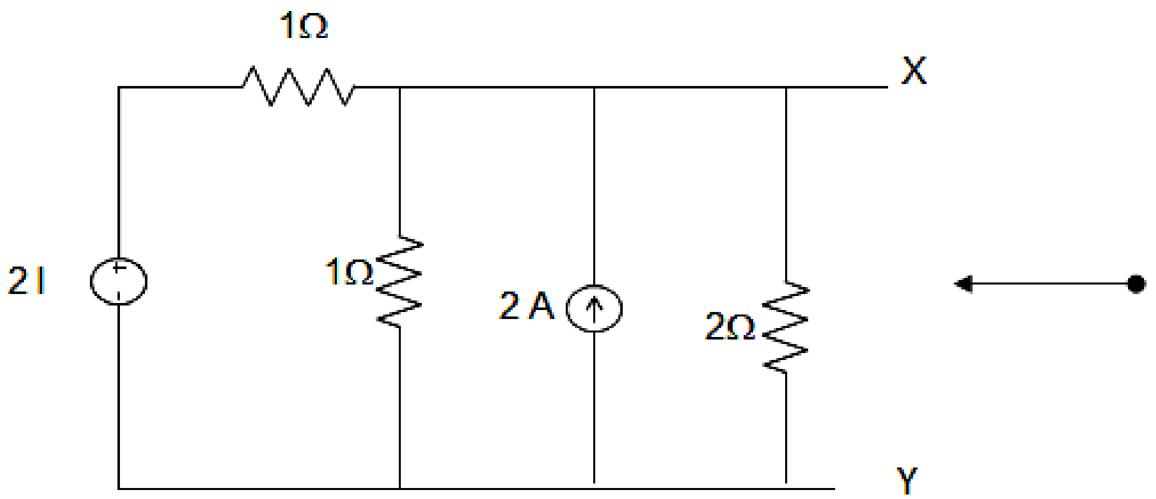
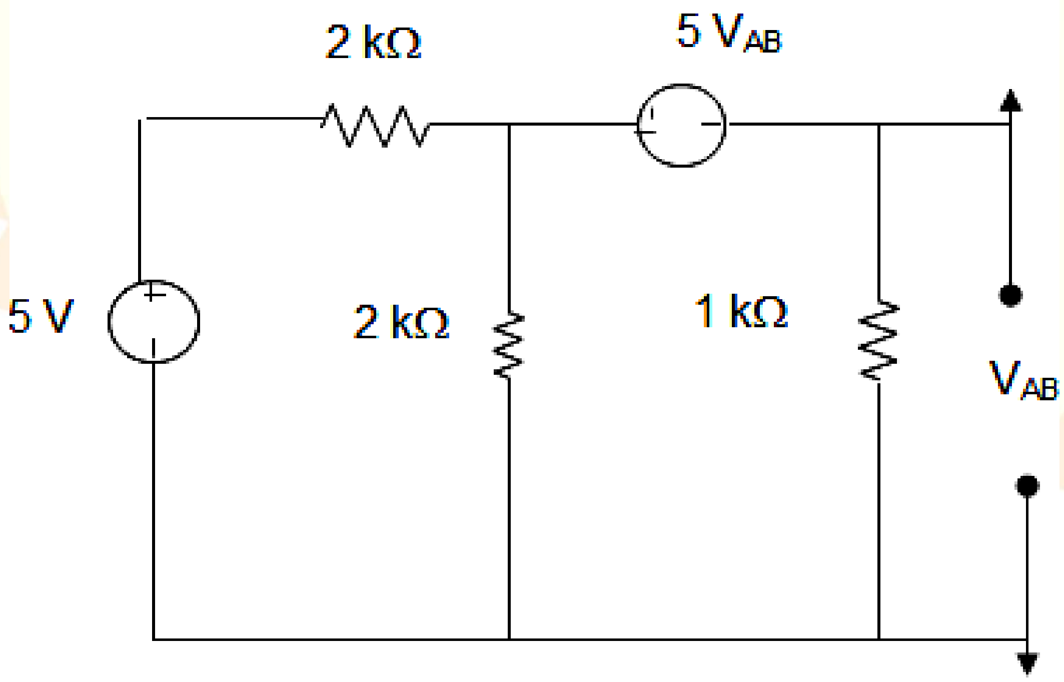
4. **For the circuit shown in the figure below, the Norton Resistance looking into X-Y is**



5. **For the circuit given below, the Norton's resistance across the terminals A and B is**



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4. MULTIPLE CHOICE QUESTIONS

1. The Norton current is the_______

a) Short circuit current

b) Open circuit current

c) Open circuit and short circuit current

d) Neither open circuit nor short circuit current

2. Norton resistance is found by?

a) Shorting all voltage sources

b) Opening all current sources

c) Shorting all voltage sources and opening all current sources

d) Opening all voltage sources and shorting all current sources

3. Isc is found across the ____________ terminals of the network.

a) Input b) Output

c) Neither input nor output d) Either input or output

4. Can we use Norton's theorem on a circuit containing a BJT?

a) Yes b) No

c) Depends on the BJT d) Insufficient data provided

5. In Norton's theorem Isc is__________

a) Sum of two current sources b) A single current source

c) Infinite current sources d) 0

Ans: 1 (a), 2. (c), 3. (b), 4. (b), 5. (b)

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5. FEEDBACK QUESTIONS

1. Did the lecture cover what you were expecting?
2. What is your opinion about the video lecture?
3. How much this session was useful from the knowledge and information point of view
4. Are you satisfied with the content of the video lecture and given questions?
5. If you could change one specific thing what would that be?

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