DEPT. OF ELECTRICAL & ELECTRONICS ENGINEERING
SRM INSTITUTE OF SCIENCE AND TECHNOLOGY, Kattankulathur – 603 203

Title of Experiment	: **2. VERIFICATION OF ALL THEOREMS- (THEVENIN, NORTON, MAXIMUM POWER TRANSFER)**
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Register Number	: RA2011026010022
Date of Experiment	: 19. 10. 2020

Sl. No.	Marks Split up	Maximum marks (50)	Marks obtained
1	Pre Lab questions	5	
2	Preparation of observation	15	
3	Execution of experiment	15	
4	Calculation / Evaluation of Result	10	
5	Post Lab questions	5	
Total		**50**	

Staff Signature

PRE LAB QUESTIONS

1. Define Lumped and distributed elements.

Ans:
Lumped element:

Lumped means to unite into one aggregation, collection, or mass to unite into one aggregation, collection, or mass. So, lumped element means a section of transmission line designed so that electric or magnetic energy is concentrated in it at specified frequencies, and inductance or capacitance may therefore be regarded as concentrated in it, rather than distributed over the length of the line. Examples: Resistor, Capacitor, Inductor etc.

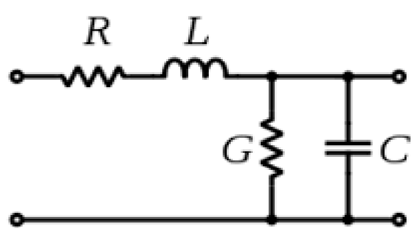
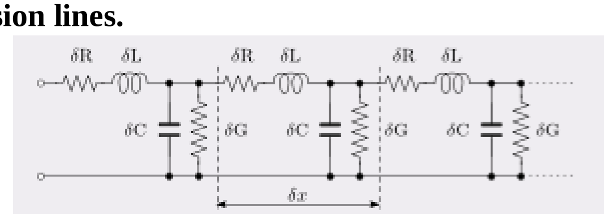


Figure 1: Lumped elements of an arbitrary section of transmission line.

Distributed element:

Distributed-element model or transmission-line model of electrical circuits assumes that the attributes of the circuit (resistance, capacitance, and inductance) are **distributed** continuously throughout the material of the circuit.
Examples: Transmission lines.



2. State Thevenin's theorem?

Ans:

Thevenin's Theorem states "Any two terminal linear circuit containing a large number of voltage and/or current sources and resistors can be replaced by a simple equivalent circuit containing a single voltage source and a series resistor".

3.State Norton's theorem?

Ans:

Norton's Theorem states "Any two terminal linear circuit containing a large number of voltage and/or current sources and resistors can be replaced by a simple equivalent circuit containing a single current source in parallel with a resistor".

3. List the applications of Thevenin's and Norton's theorems?

Ans:

Application of Thevenin's Theorem

- To determine the **Change in Load Voltage:** To predict range of load voltage variation due to change in load resistance.
- To obtain **Norton's equivalent circuit**.
- To determine the **Maximum power** that can be transferred to load from the network.

Application of Norton's Theorem

- Norton's theorem is used to **simplify a network** by introducing source transformation that is simplifying in terms of current instead of voltages.
- **The Norton's equivalent circuit** is used to represent any network of linear sources and impedances at a given frequency.

4. What are the different types of dependent or controlled sources?

Ans:

The different types of dependent or controlled sources are;

- **Voltage Controlled Voltage Source (VCVS):** The source delivers the voltage as per the voltage of the dependent element.
- **Voltage Controlled Current Source (VCCS):** The source delivers current as per the voltage of the dependent sources.
- **Current Controlled Voltage Source (CCVS):** The source delivers the voltage as per the current of the dependent element.
- **Current Controlled Current Source (CCCS):** The source delivers the current as per the current of the dependent element.

Experiment No. 2 a) Date :	THEVENIN'S THEOREM

Aim:

To verify Thevenin's theorem and to find the full load current for the given circuit.

Apparatus Required:

Sl.No.	Apparatus	Range	Quantity
1	RPS (regulated power supply)	(0-30V)	2
2	Ammeter	(0-10mA)	1
3	Resistors	1K, 330	3,1
4	Bread Board	--	Required
5	DRB	--	1

Statement:

Any linear bilateral, active two terminal network can be replaced by a equivalent voltage source (V_{TH}). Thevenin's voltage or V_{OC} in series with looking pack resistance R_{TH}.

Precautions:

1. Voltage control knob of RPS should be kept at minimum position.
2. Current control knob of RPS should be kept at maximum position

Procedure:

1. Connections are given as per the circuit diagram.
2. Set a particular value of voltage using RPS and note down the corresponding ammeter readings.

To find V_{TH}

3. Remove the load resistance and measure the open circuit voltage using multimeter (V_{TH}).

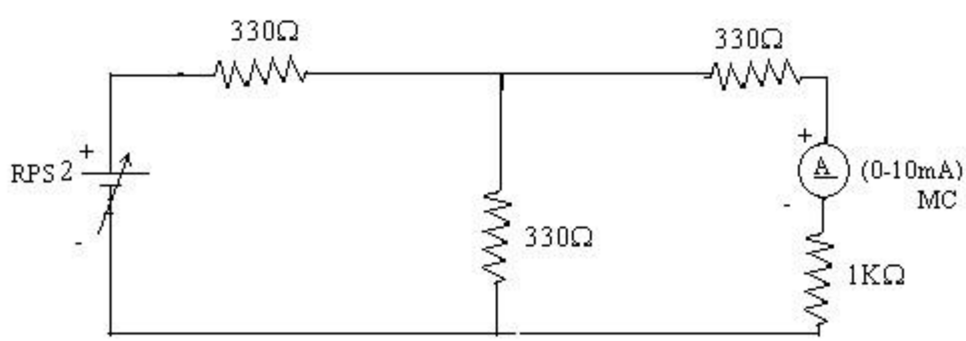
To find R_{TH}

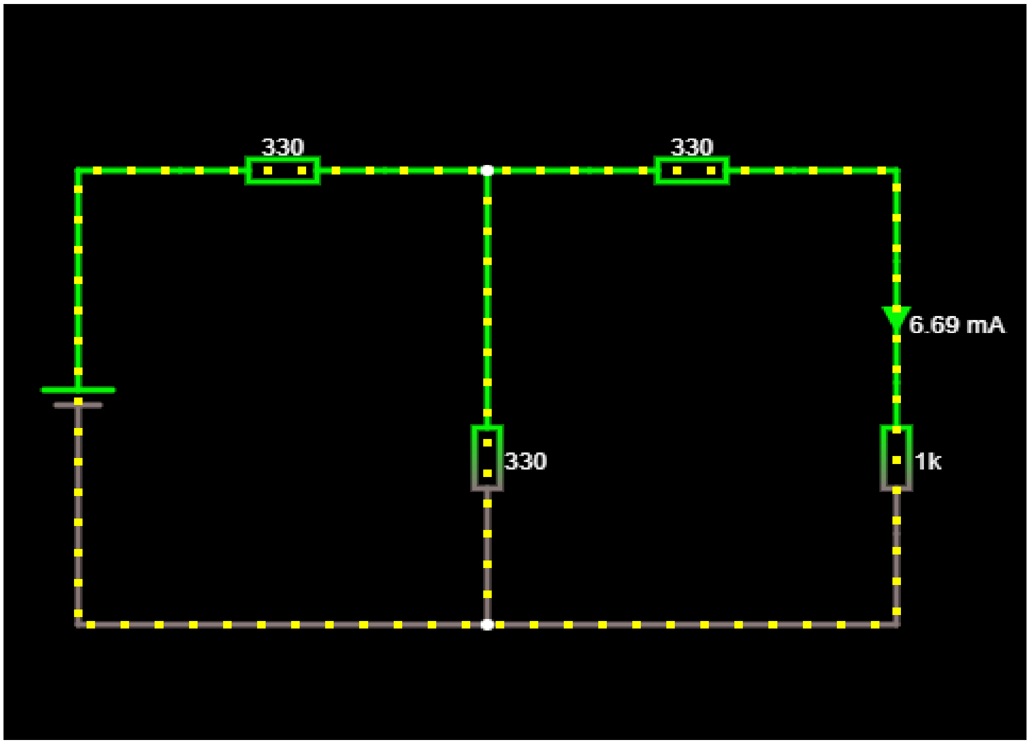
4. To find the Thevenin's resistance, remove the RPS and short circuit it and find the R_{TH} using multimeter.
5. Give the connections for equivalent circuit and set V_{TH} and R_{TH} and note the corresponding ammeter reading.
6. Verify Thevenins theorem.

Theoretical and Practical Values

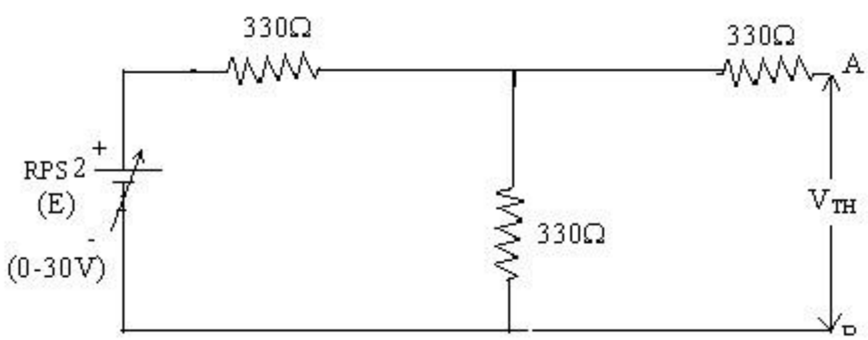
	E(V)	V_{TH}(V)	R_{TH}(□)	I_L (mA)	
				Circuit - I	Equivalent Circuit
Theoretical	5	2.5	495	8.41	1.67
	10	5	495	16.82	3.34
	12	6	495	20.19	4.01
	15	7.5	495	25.24	5.02
	20	10	495	45.41	6.69
Practical	5	2.5	495	8.41	1.67
	10	5	495	16.82	3.34
	12	6	495	20.19	4.01
	15	7.5	495	25.24	5.02
	20	10	495	45.41	6.69

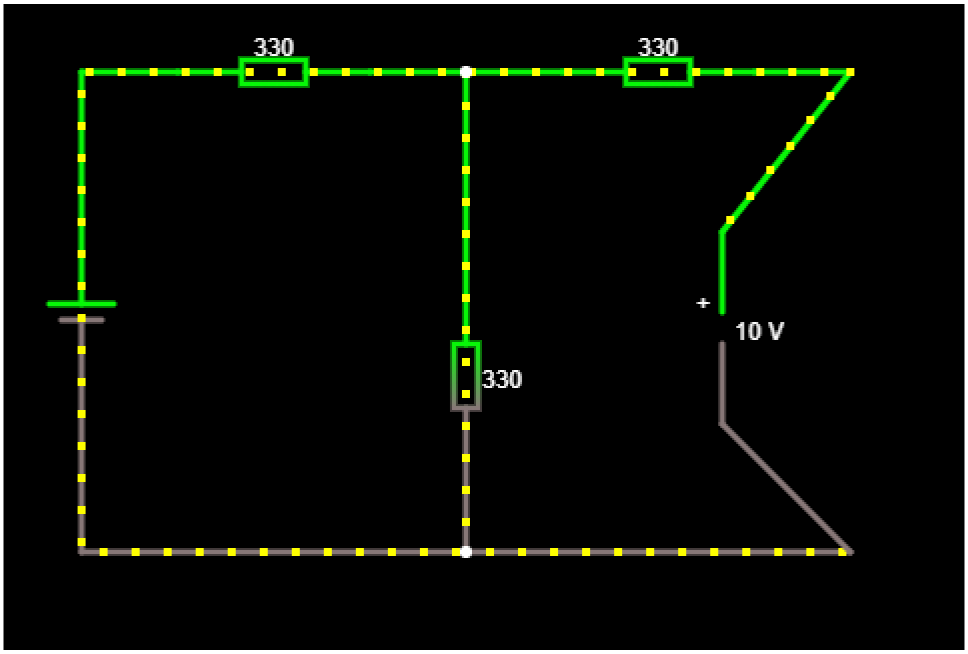
Circuit - 1 : To find load current



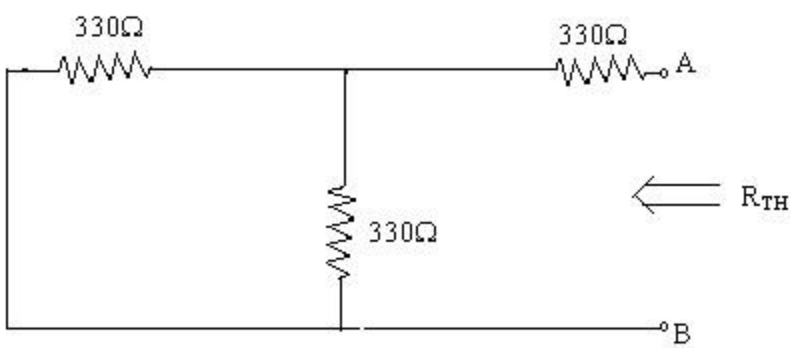


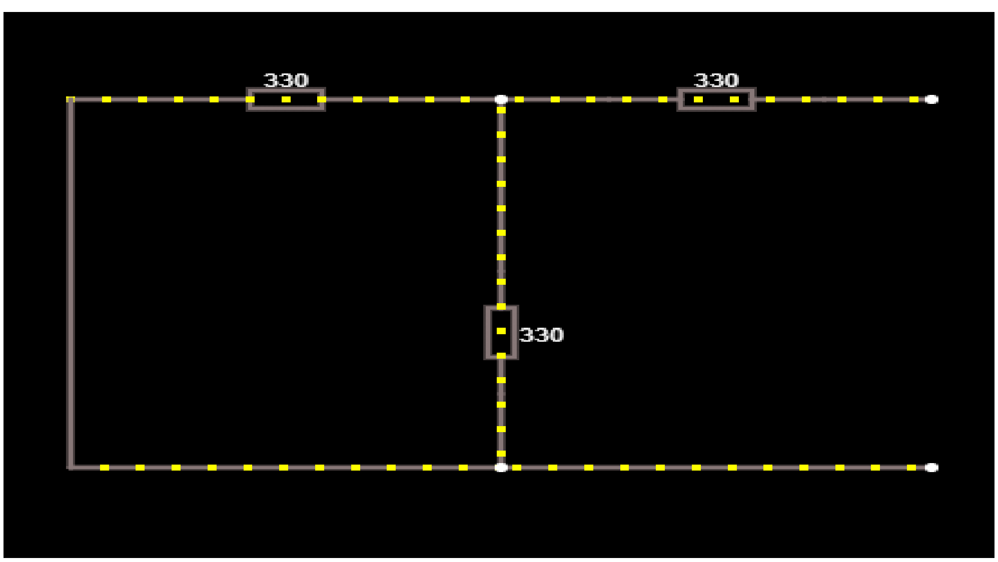
To find V_{TH}



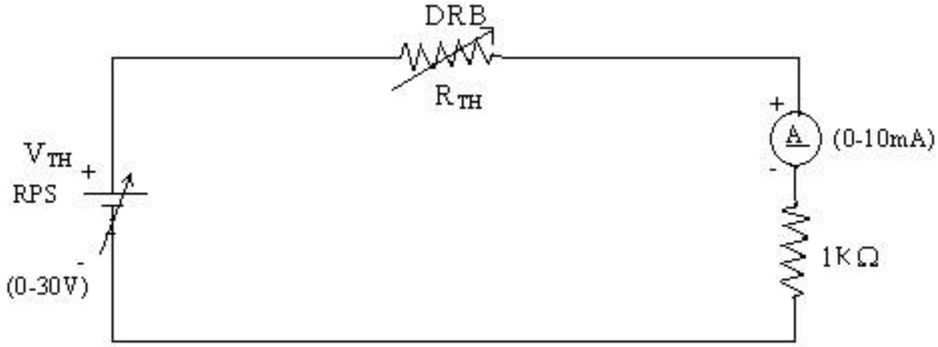


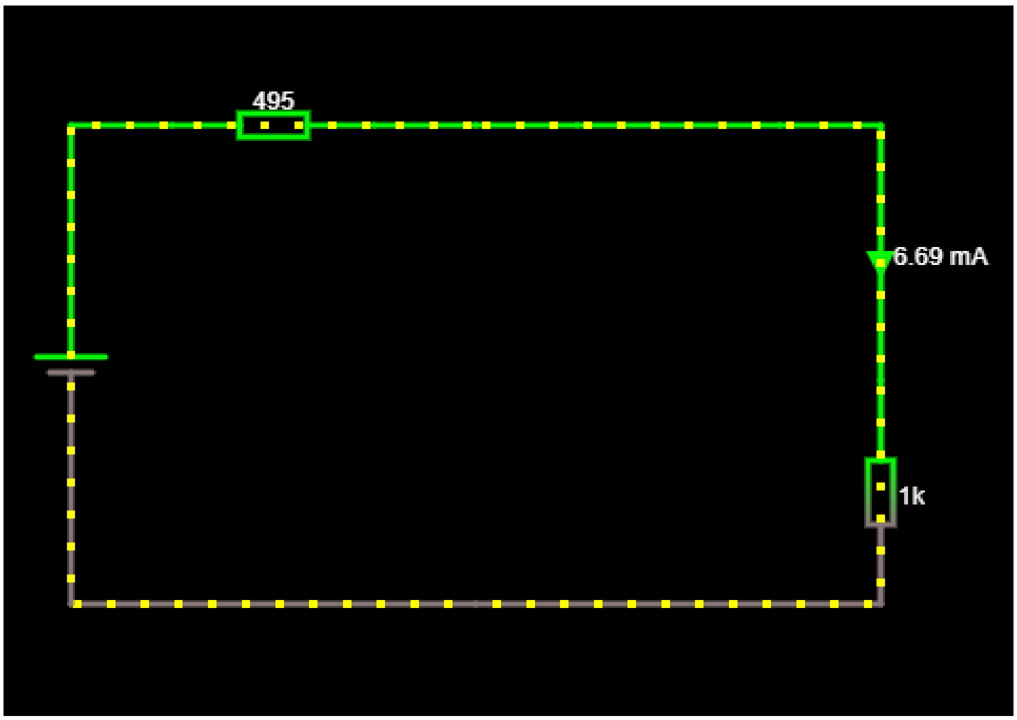
To find R_{TH}





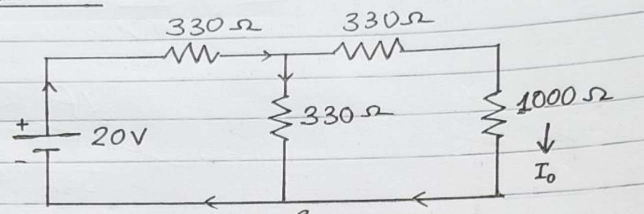
Thevenin's Equivalent circuit:





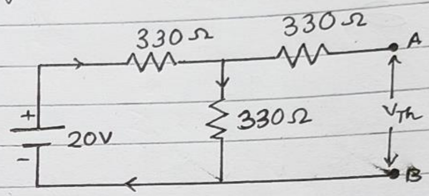
Model Calculations:

Thevenin's Theorem :-



Circuit diagram

To find V_{Th} :-

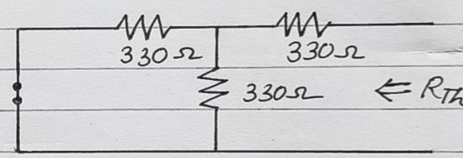


V_{Th} is the voltage across the 330Ω as current does not pass through third 330Ω as the terminal is open.

V_{Th} circuit.

$$\therefore V_{Th} = \frac{330}{(330+330)} \times 20 = 10\,V$$

To find R_{Th} :-



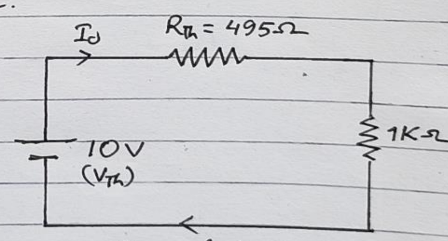
From the circuit 1st & 3rd 330Ω are in parallel while 2nd 330Ω is in series with parallel circuit. Thus,

R_{Th} circuit

$$R_p = \frac{330 \times 330}{330 + 330} = 165\,\Omega.$$

$$\therefore R_{Th} = (330 + 165) = 495\,\Omega.$$

Equivalent circuit :



so $R_{Tot} = 1000 + 495$
$= 1495\,\Omega$

Equivalent Circuit.

so $I_0 = \frac{10}{1495} = 6.69\,mA$. (Ans)

Result: The Thevenin's Theorem is verified using the theoretical calculations and practical e-circuit method.

Experiment No. 2 b) Date :	VERIFICATION OF NORTON'S THEOREM

Aim:

To verify Norton's theorem for the given circuit.

Apparatus Required:

Sl.No.	Apparatus	Range	Quantity
1	Ammeter	(0-10mA) MC (0-30mA) MC	1 1
2	Resistors	330, 1K	3,1
3	RPS	(0-30V)	2
4	Bread Board	--	1
5	Wires	--	Required

Statement:

Any linear, bilateral, active two terminal network can be replaced by an equivalent current source (I_N) in parallel with Norton's resistance (R_N)

Precautions:

1. Voltage control knob of RPS should be kept at minimum position.
2. Current control knob of RPS should be kept at maximum position.

Procedure:

1. Connections are given as per circuit diagram.
2. Set a particular value in RPS and note down the ammeter readings in the original circuit.

To Find I_N:

3. Remove the load resistance and short circuit the terminals.
4. For the same RPS voltage note down the ammeter readings.

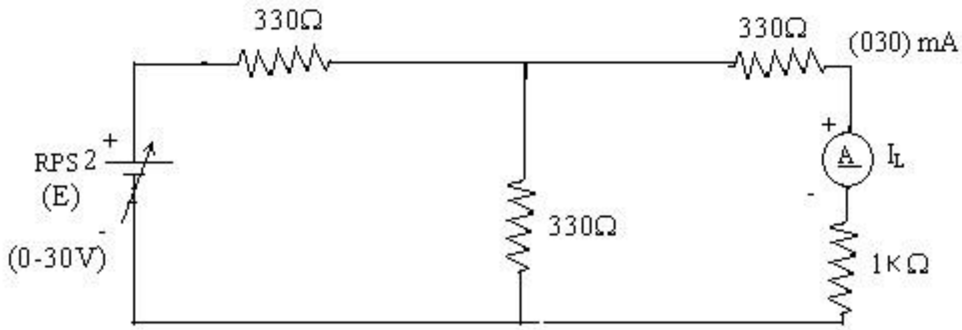
To Find R_N:

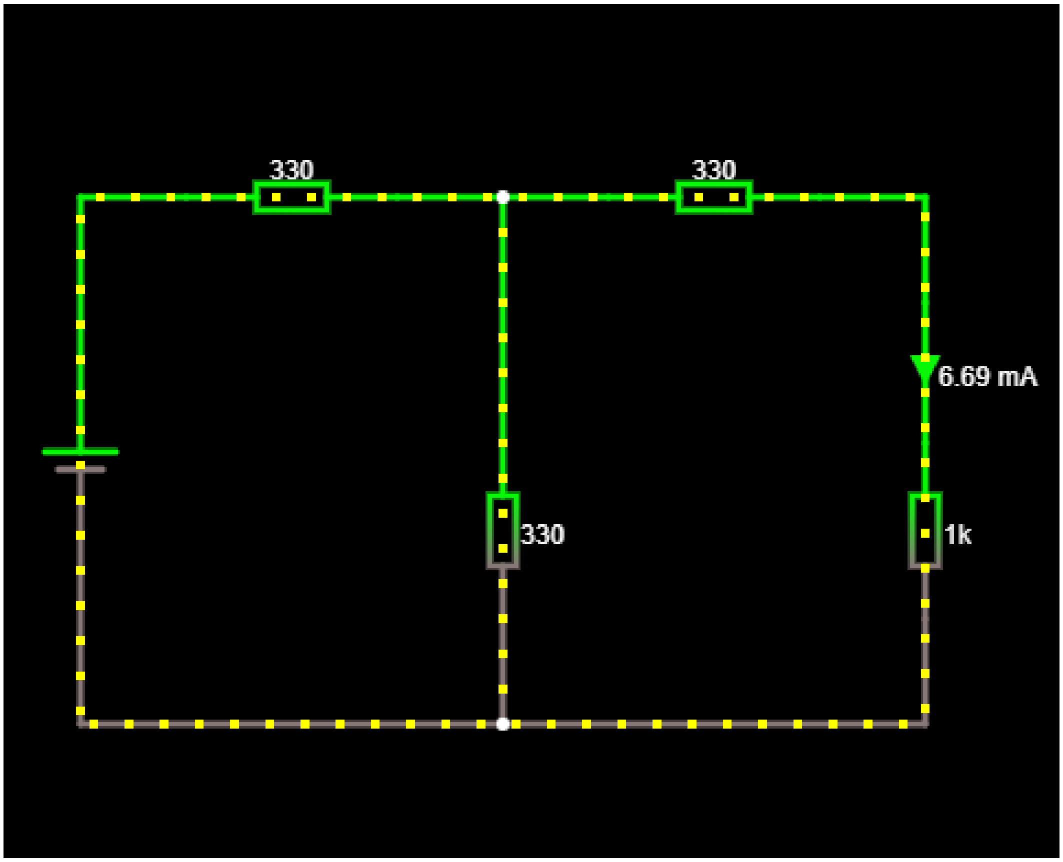
5. Remove RPS and short circuit the terminal and remove the load and note down the resistance across the two terminals.

Equivalent Circuit:

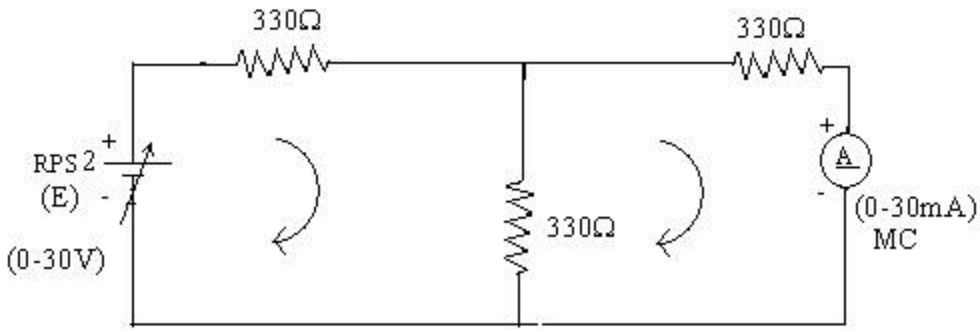
6. Set I_N and R_N and note down the ammeter readings.
7. Verify Norton's theorem.

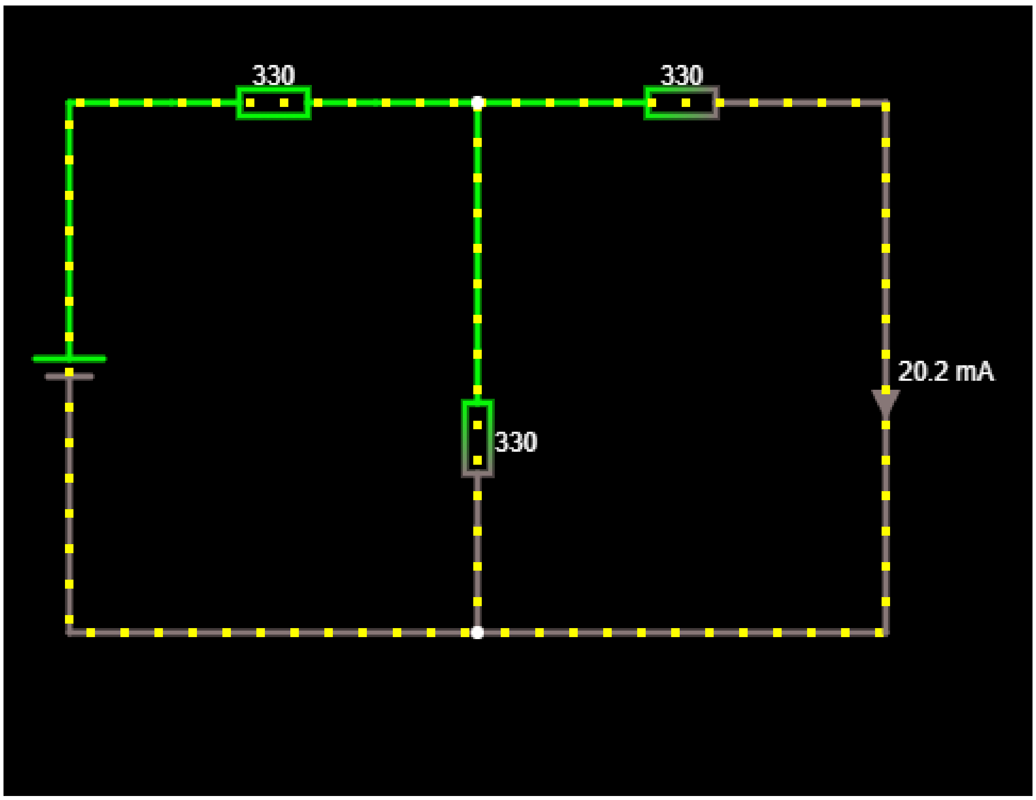
To find load current in circuit 1:



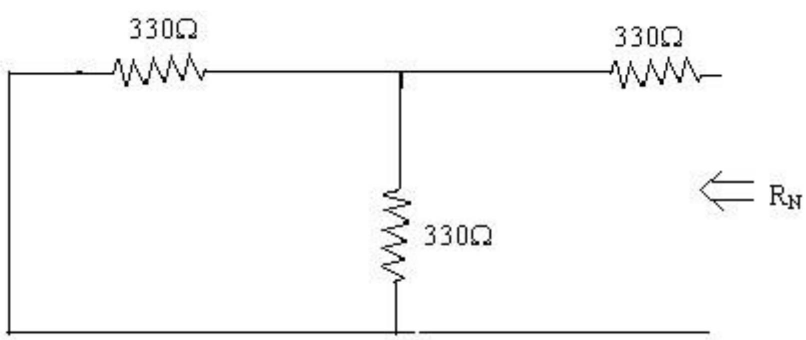


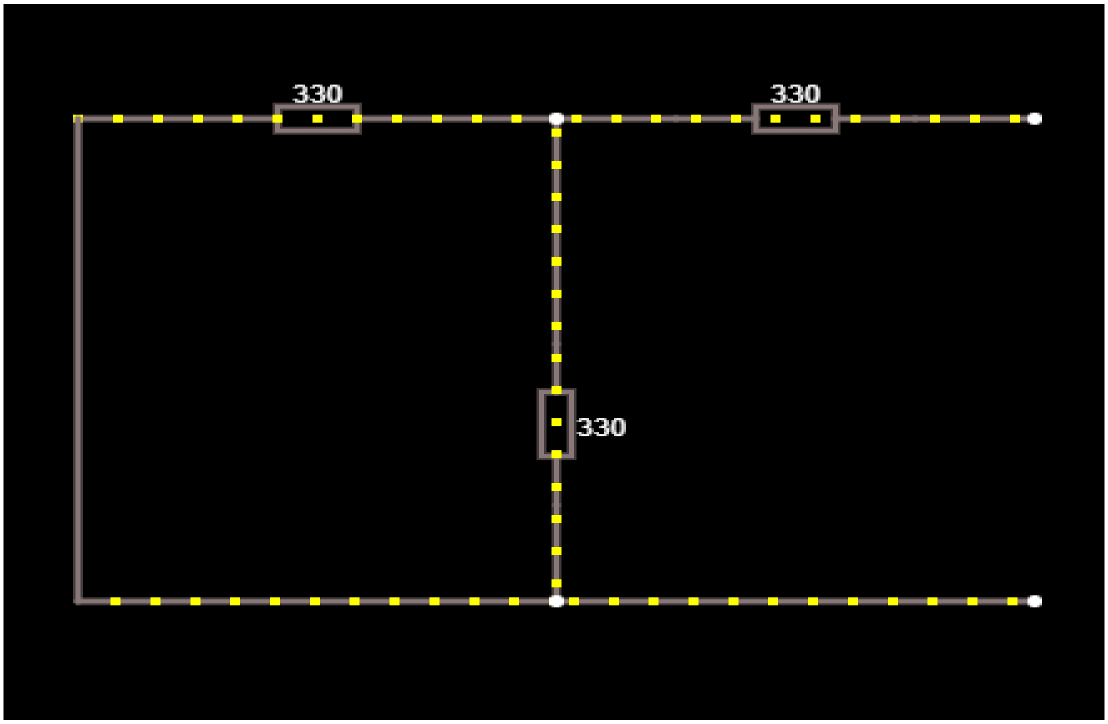
To find I_N



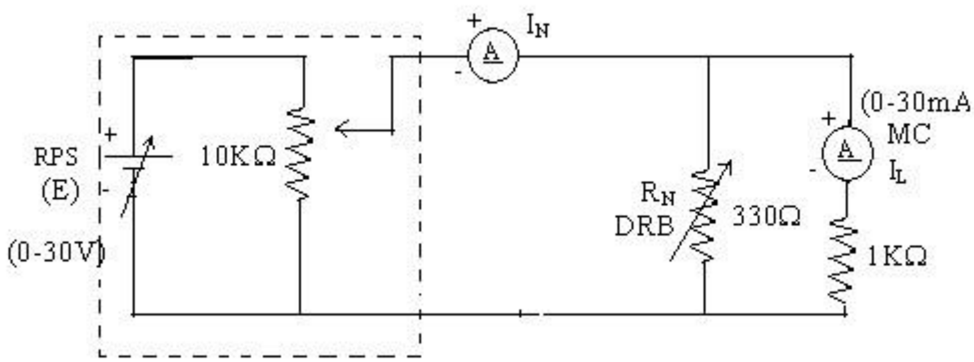


To find R_N

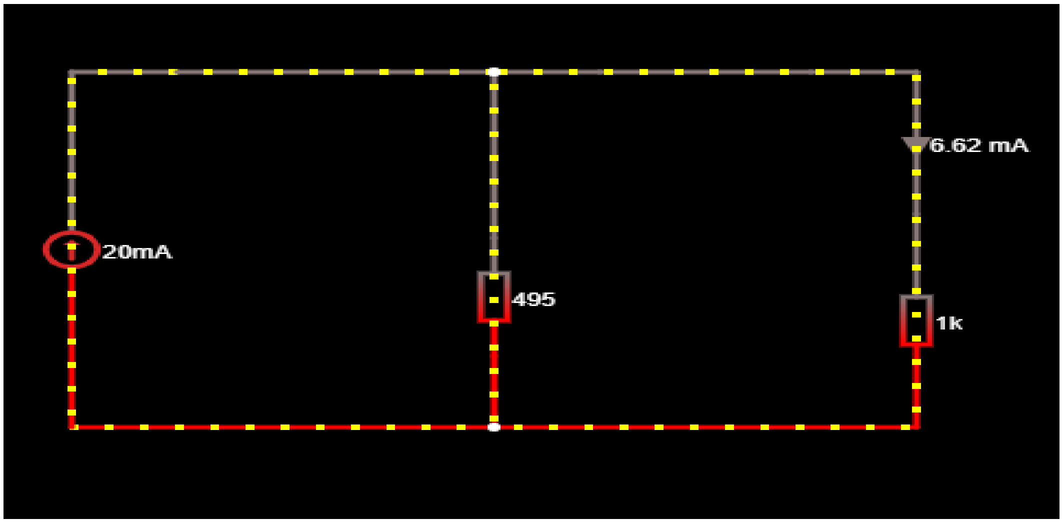




Norton's equivalent circuit



Constant current source

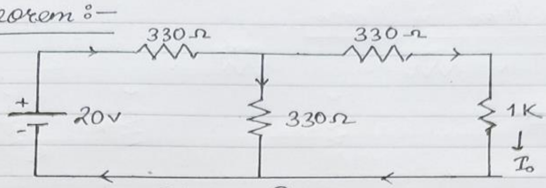


Theoretical and Practical Values

	E (volts)	I_N (mA)	R_N (□)	I_L (mA)	
				Circuit - I	Equivalent Circuit
Theoretical Values	5	5.05	495	1.67	1.65
	10	10.01	495	3.31	3.26
	15	15.15	495	5.02	4.97
	20	20.2	495	6.69	6.62
	25	25.25	495	8.36	8.31
Practical Values	5	5.05	495	1.67	1.65
	10	10.01	495	3.31	3.26
	15	15.15	495	5.02	4.97
	20	20.2	495	6.69	6.62
	25	25.25	495	8.36	8.31

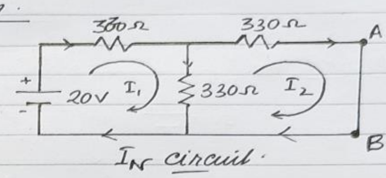
Model Calculations:

Norton's Theorem :–



Circuit Diagram.

To find I_N :-



I_N circuit.

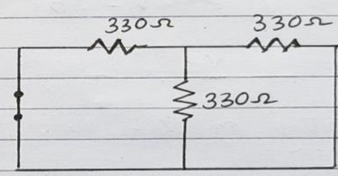
$$R_P = \frac{330 \times 330}{330 + 330} = 165\,\Omega$$

$$R_T = 330 + 165 = 495\,\Omega$$

So current through circuit, $I = \frac{20}{495} = 40\ mA$

$\because$ current gets equally divided between two branches, so current through AB (I_N) = 20 mA.

To find R_N :-



R_N Circuit

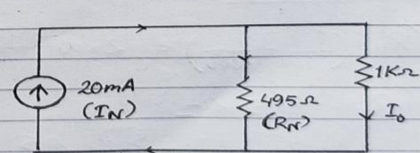
$$1/R_P = \frac{1}{330} + \frac{1}{330} = \cancel{330 + 330}$$

$$= \frac{2}{330} = \frac{1}{165}$$

$\therefore\ R_P = 165\,\Omega$

So $R_N = 330 + 165 = 495\,\Omega$.

Equivalent circuit :



$$I_o = I_N \times \frac{R_N}{R_{TOT}} = \frac{495}{1495} \times 20$$

$$= 6.62\ mA.$$

Result: The Norton's Theorem is verified using the theoretical calculations and practical e-circuit method.

Experiment No. 2 c) **Date :**	**VERIFICATION OF MAXIMUM POWER TRANSFER THEOREM**

Aim:

To verify maximum power transfer theorem for the given circuit

Apparatus Required:

Sl.No.	Apparatus	Range	Quantity
1	RPS	(0-30V)	1
2	Voltmeter	(0-10V) MC	1
3	Resistor	1K□, 1.3K□, 3□	3
4	DRB	--	1
5	Bread Board & wires	--	Required

Statement:

In a linear, bilateral circuit the maximum power will be transferred from source to the load when load resistance is equal to source resistance.

Precautions:

1. Voltage control knob of RPS should be kept at minimum position.
2. Current control knob of RPS should be kept at maximum position.

Procedure: Circuit – I

1. Connections are given as per the diagram and set a particular voltage in RPS.
2. Vary R_L and note down the corresponding ammeter and voltmeter reading.
3. Repeat the procedure for different values of R_L & Tabulate it.
4. Calculate the power for each value of R_L.

To find V_{TH}:

5. Remove the load, and determine the open circuit voltage using multimeter (V_{TH})

To find R_{TH}:

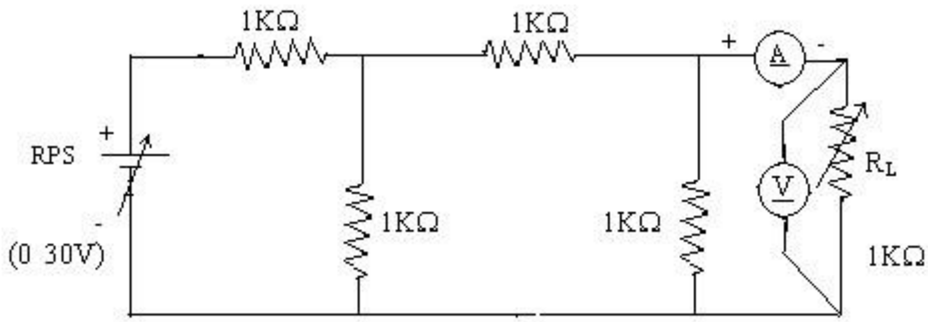
6. Remove the load and short circuit the voltage source (RPS).
7. Find the looking back resistance (R_{TH}) using multimeter.

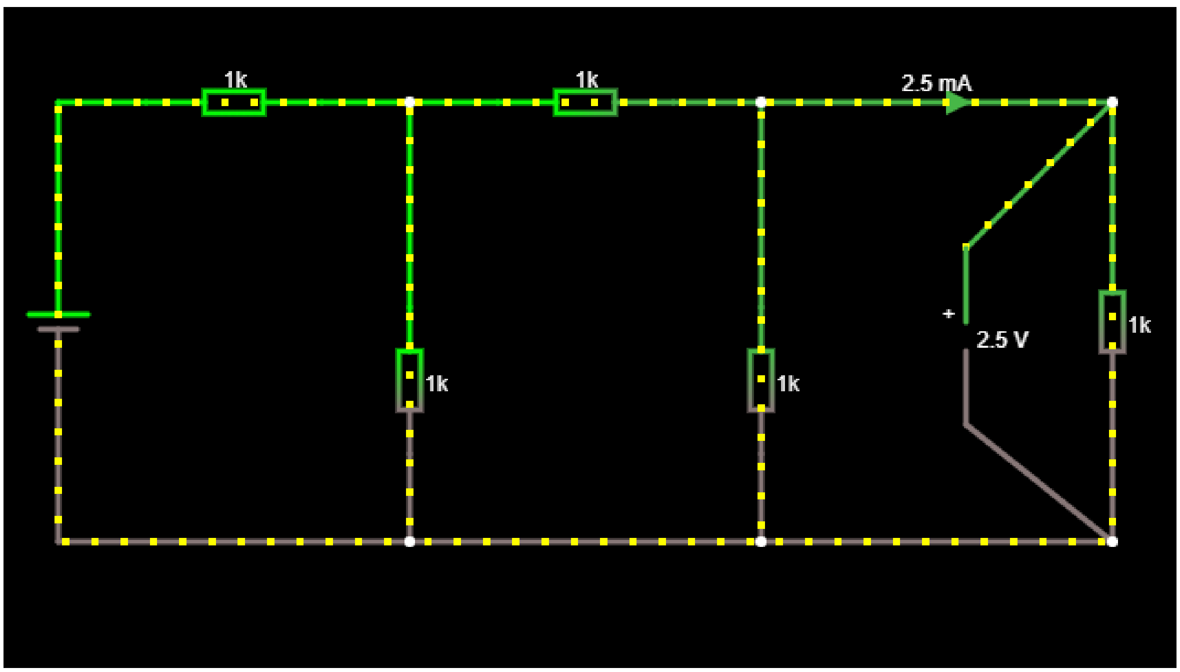
Equivalent Circuit:

8. Set V_{TH} using RPS and R_{TH} using DRB and note down the ammeter reading. 9. Calculate the power delivered to the load ($R_L = R_{TH}$)

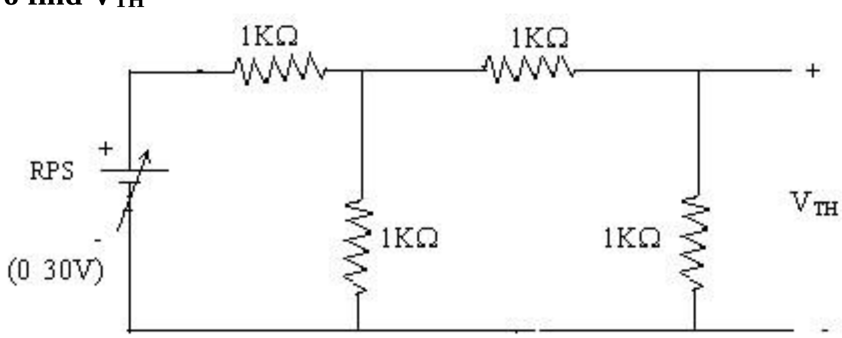
10. Verify maximum transfer theorem.

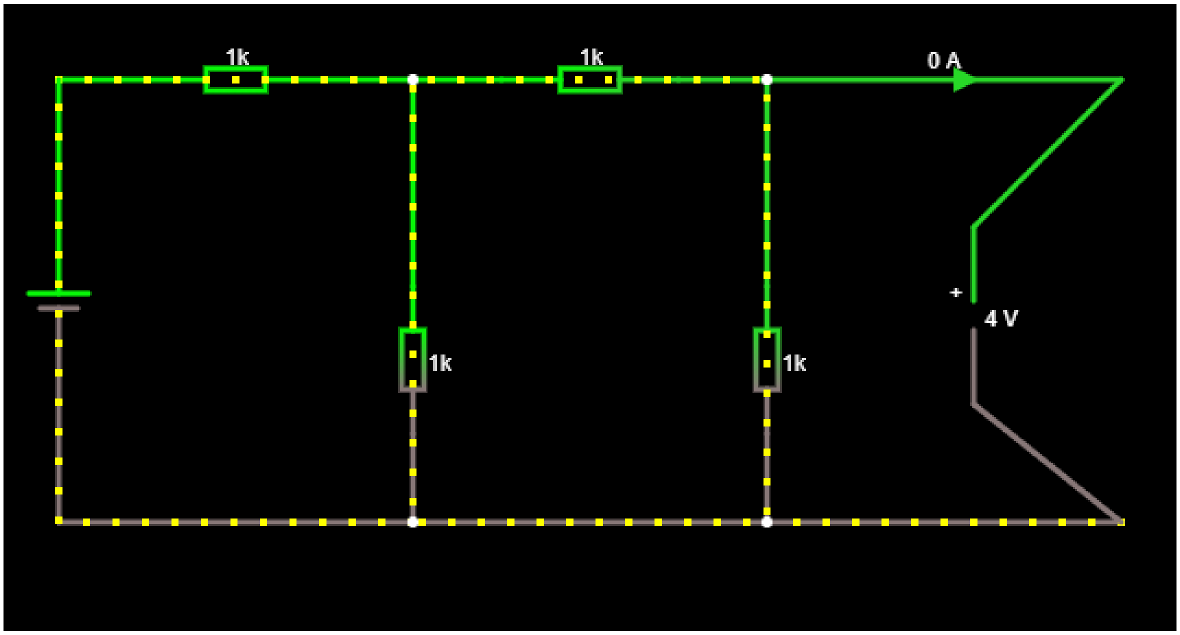
Circuit - 1



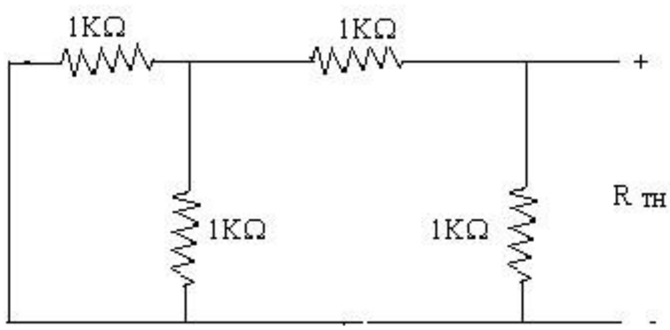


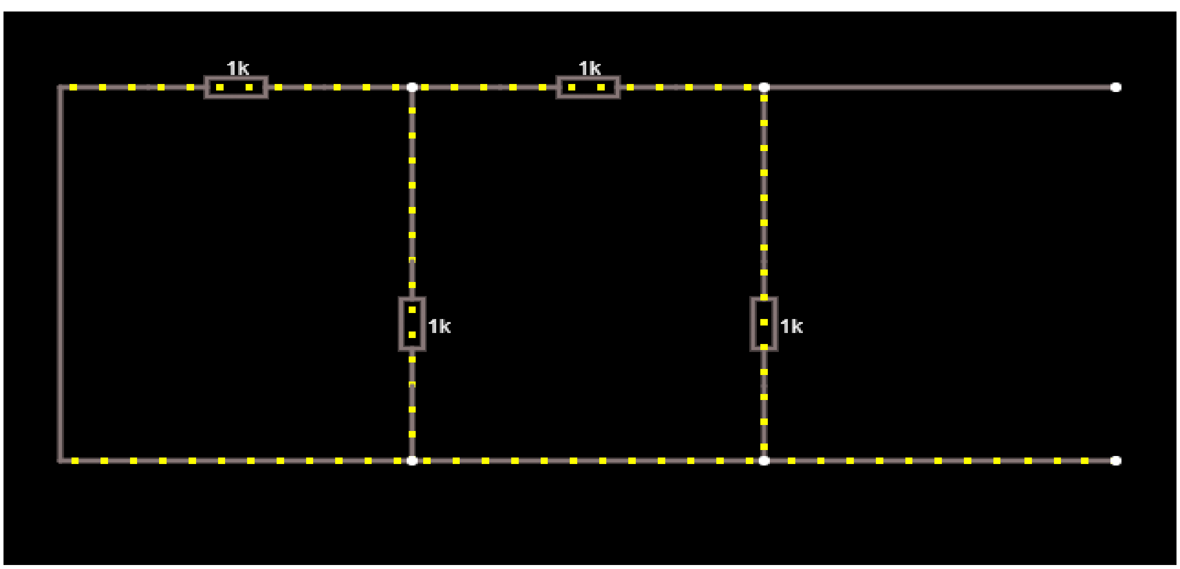
To find V_{TH}



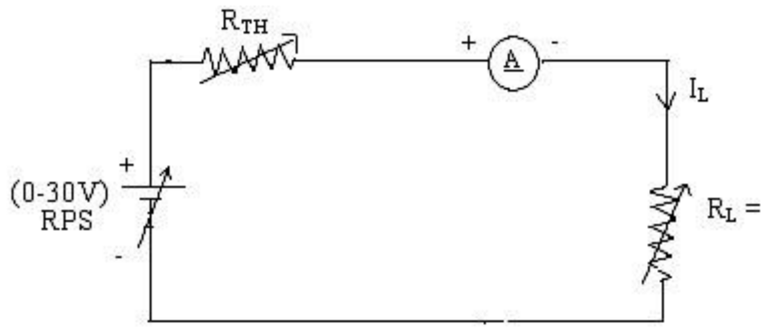


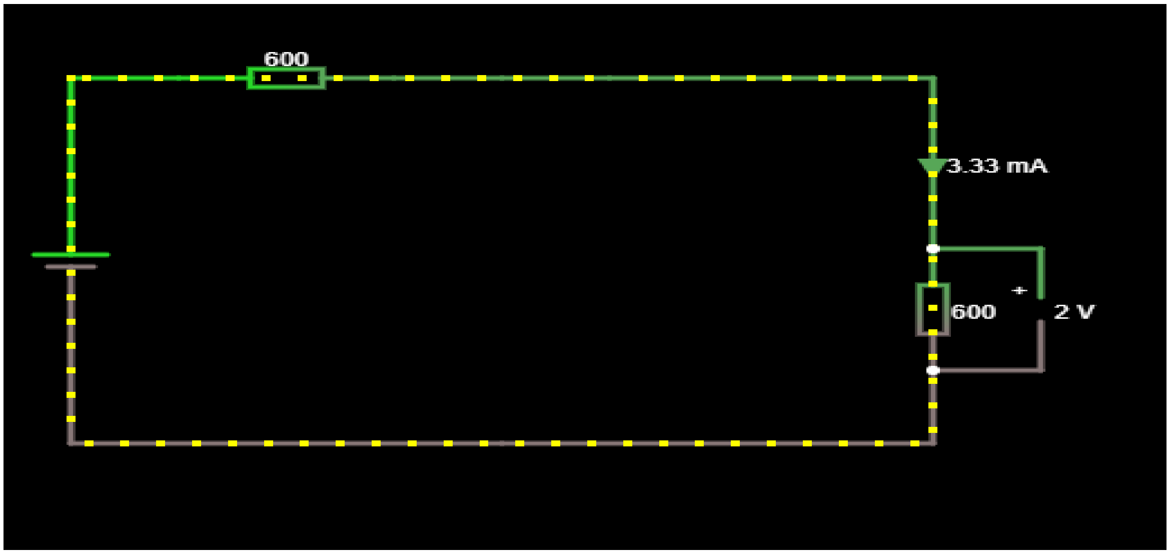
To find R_{TH}



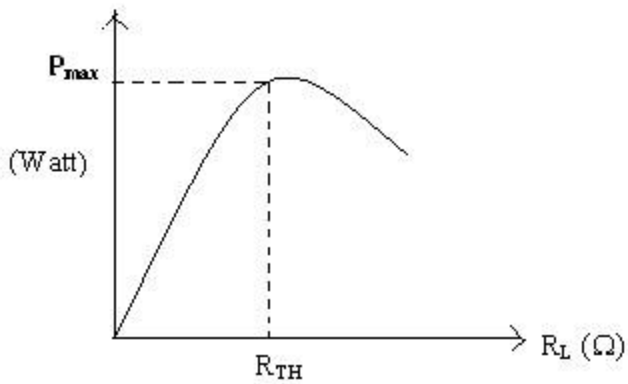


Thevenin's Equation Circuit





Here R_L = 600 ohm
Power vs R_L



Circuit – I

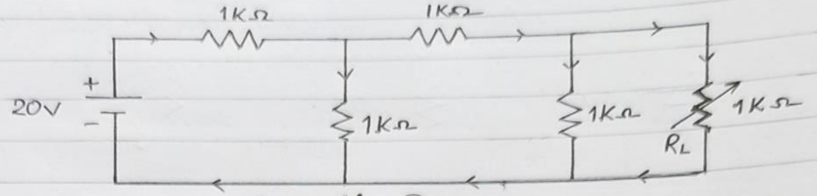
Sl.No.	RL (Ω)	I (mA)	V(V)	P=VI (watts)
1.	100	5.71	0.57	3.20
2.	200	5.00	1.00	5.00
3.	300	4.44	1.30	5.70
4.	400	4.00	1.60	6.40
5.	500	3.63	1.80	6.50
6.	600	3.33	2.00	6.60
7.	700	3.07	2.10	6.40
8.	800	2.85	2.20	6.20
9.	900	2.66	2.30	6.10
10.	1000	2.50	2.50	6.25

To find Thevenin's equivalent circuit

	V_{TH} (V)	R_{TH} (Ω)	I_L (mA)	P (milli watts)
Theoretical Value	4	600	3.33	6.6
Practical Value	4	600	3.33	6.6

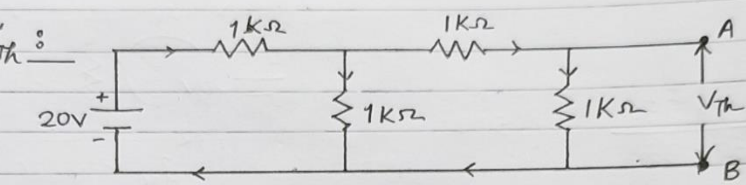
Model Calculations:

Maximum Power Transfer Theorm



Circuit Diagram :

To find V_{Th} :



V_{Th} circuit

Using nodal analysis :-

$$\frac{20 - V_1}{1000} = \frac{V_1}{1000} + \frac{V_1 - V_{Th}}{1000}$$

$$\Rightarrow 20 - V_1 = V_1 + V_1 - V_{Th}$$

$$\Rightarrow V_{Th} = 3V_1 - 20 \quad \text{— ①}$$

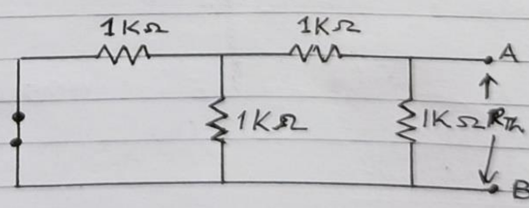
& $\frac{V_1 - V_{Th}}{1000} = \frac{V_{Th}}{1000} \Rightarrow V_1 = 2V_{Th}$ — ②

Putting eq. ② in (i) ; $V_{Th} = 6V_{Th} - 20$

$\therefore V_{Th} = 20/5 = 4\ V$

So $\boxed{V_{Th} = 4V.}$

To find R_{Th} :

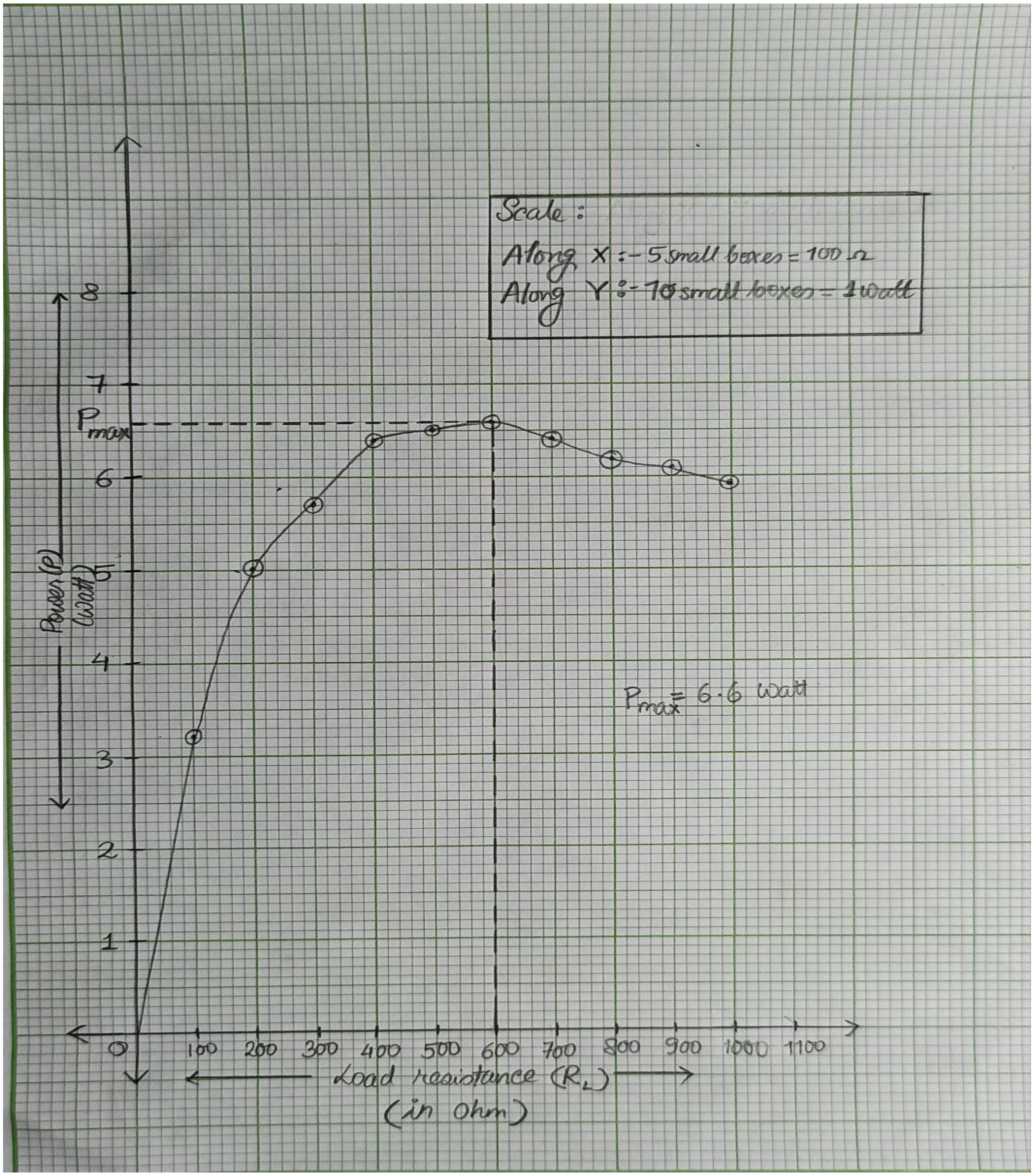


$$1/R_P = \left(\frac{1}{1000} + \frac{1}{1000}\right) = 2 \times 10^{-3}$$

$\therefore R_P = 0.5\ K\Omega$.

Now $R_S = 1 + 0.5 = 1.5\ K\Omega$

so $R_{TH} = \frac{1 \times 1.5}{2.5} = 0.6\ K\Omega = 600\ \Omega$



Graph of Power (P) vs Load Resistance (R_L)

Result: The Maximum Power Transfer Theorem is verified using the theoretical calculations with Graph and practical e-circuit method.

POST LAB QUESTIONS

1. **State Thevenin's Theorem.**
   Ans:

   Thevenin's Theorem states "Any two terminal linear circuit containing a large number of voltage and/or current sources and resistors can be replaced by a simple equivalent circuit containing a single voltage source and a series resistor".

2. **Draw the Thevenin's equivalent circuit**
   Ans:

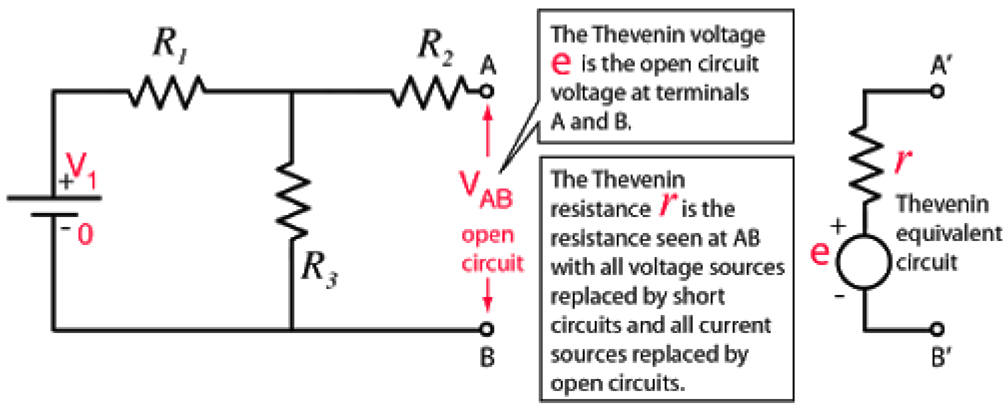


Diagram of Thevenin's Equivalent Circuit.

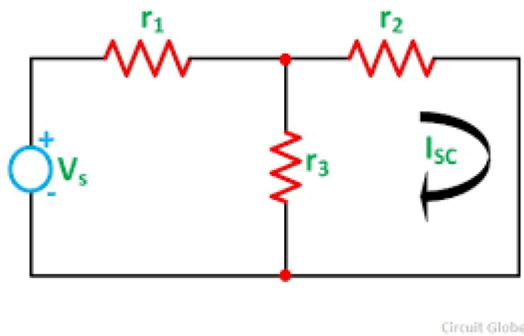
3. **State maximum power transfer theorem.**
   Ans:
   Maximum Power Transfer Theorem states that "maximum power is transferred from the source to the load when the load resistance is equal to the Thevenin's equivalent resistance." that is $R_L = R_{Th}$ [where R_L = Load Resistance and R_{Th} = Thevenin's equivalent resistance.]

4. **Write some applications of maximum transfer theorem.**
   Ans:
   - The practical applications of maximum power transfer theorem include audio systems such as stereo, radio and public address. In these systems the resistance of the speaker is the load. The circuit that drives the speaker is power amplifier. The systems are typically optimized for maximum power to the speaker. Thus, the resistance of the speaker must be equal to the internal source resistance of the amplifier.

- It is also applicable on car engine where power needed for the motor starter will depend on motor resistance as well as battery resistance. While both of these resistances are equal, power transferred toward the engine will be maximum.

5. Write the steps to find I_N

Ans:



- Remove the R_L and short terminals A and B.
- Now R_2 and R_3 are in parallel where as R_1 in series. So total resistance $R_T = R_1+(R_2 \parallel R_3)$
  $= R_1+((R_2xR_3)/(R_2+R_3))$
- **Total current**, $I_T = V/R_T$
  $= V/(R_1+((R_2xR_3)/(R_2+R_3)))$
- Therefore, the **Norton's current** between A and B;

  $I_N = (V \text{ x } R_3)/((R_1x(R_2+R_3)) + R_2xR_3)$

6. What are the steps to solve Maximum power transfer Theorem?

Ans:

Step 1: Remove the load resistance of the circuit (consider open terminals at A & B)

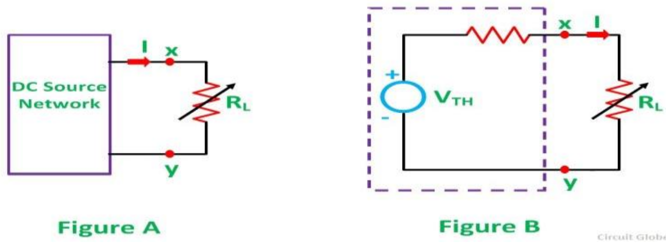
Step 2: Find the value of $V_{Th,}$ using the nodal analysis. (for points A & B open terminals.)

Step 3: Find the Thevenin's resistance (R_{Th}) of the source network looking through the open-circuit load terminals.

Step 4: As per the maximum power transfer theorem, R_{Th} is the load resistance of the network, that is $R_{Th} = R_L$ that allows maximum power transfer.

Step 5: Maximum Power Transfer is calculated by the below equation (P_{max}) = V^2_{Th} / $4R_{Th}$

Step 6: A P_L vs R_L graph is to be plotted.



Circuit diagram for Max Power Transfer Theorem.