EE-102 (exp-02)

Lab group	L8
Experiment no	02
Date of experiment	03-02-2016
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Table no- 14

Observation Table?

2.5

OBJECTIVE:-

Verification of Superposition theorem, Thevnin theorem and maximum power transfer theorem.

CIRCUIT DIAGRAM:-

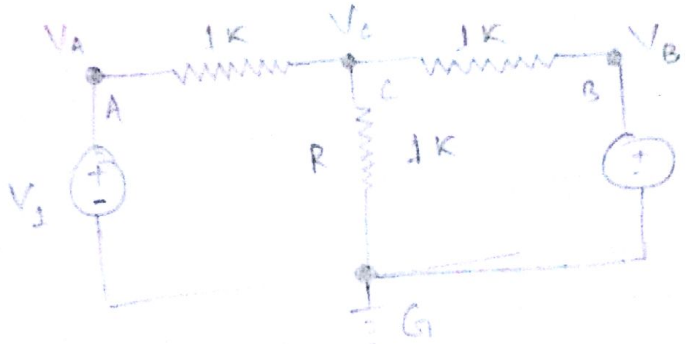


fig1. Superposition theorem

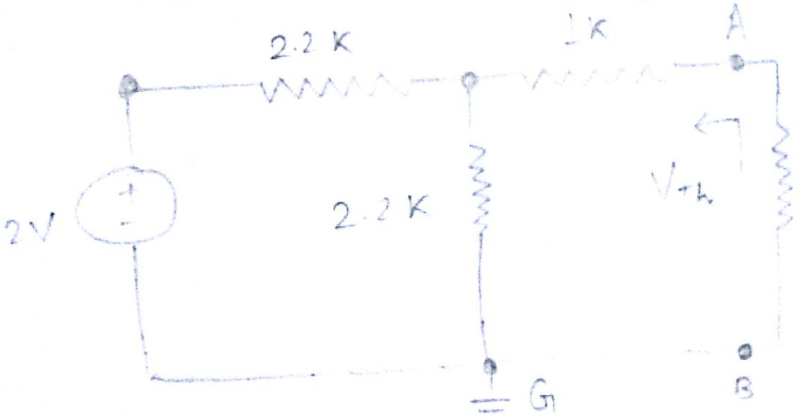


fig2 - Thevenin's Theorem

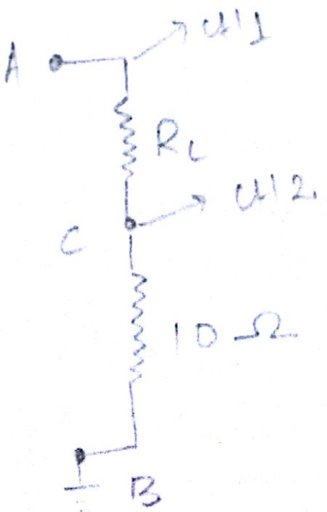
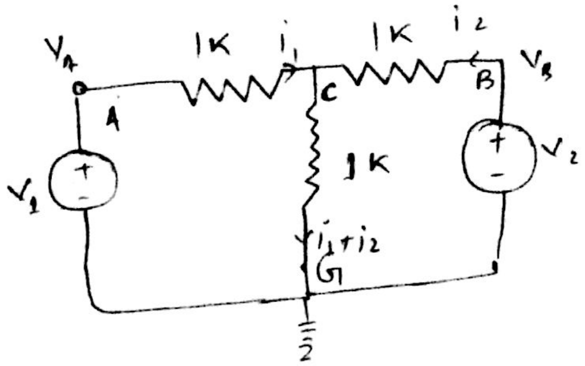


fig3 - Maximum power transfer Theorem

Pre-experiment Questions

Part A



a) $V_1 = 12V,\ V_2 = 5V$

$+12 - 1000 i_1 - 1000(i_1 + i_2) = 0$

$\Rightarrow 12 = 2000 i_1 + 1000 i_2$ — (I)

$\Rightarrow 24 = 2000 i_2 + 4000 i_1$

$+5 - 1000 i_2 - 1000(i_1 + i_2) = 0$

$\Rightarrow 5 = 2000 i_2 + 1000 i_1$ — (II)

$\Rightarrow i_1 = \frac{19}{3}\ mA = 6.33\ mA$

$12 = \left(2000 \times \frac{19}{3} \times 10^{-3}\right) + 1000 i_2$

$\Rightarrow i_2 = 5.67\ mA.$

$V_A = 12\ V$

$V_B = 5V$

$V_C = \left(12 - \frac{19}{3} \times 10^{-3} \times 10^3\right) V$

$= (12 - 6.333)$

$= \underline{5.67\ V}$

for $V_1 = 15V$ & $V_2 = 5V$,

$30 = 2000 i_2 + 4000 i_1.$

$5 = 2000 i_2 + 1000 i_1$

$25 = 3000 i_1$

$\Rightarrow \underline{i_1 = 8.3\ mA}$

$30 = \frac{100}{3} + 2000 i_2$

$\Rightarrow i_2 = \frac{-10}{3} \times 2000$

$= -1.67 mA$ (reverse

$V_A = 15V$

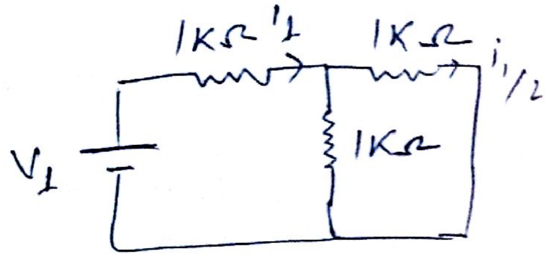
$V_B = 5V.$

$V_C = 15 - 8.3mA \times 1000$

$= 6.7V$

b) V_2 removed from circuit,

$i_1 = \frac{12V}{1500\Omega} = 8mA.$



$i_2 = \frac{i_1}{2} = 4mA.$

$V_A = 12V$

$V_B = 0V$

$V_C = 12 - 8mA \times 100$

$= 4V.$

i

$i_1 = \frac{15}{1500} = 10mA$

$i_2 = 5mA$

$V_A = 15V$

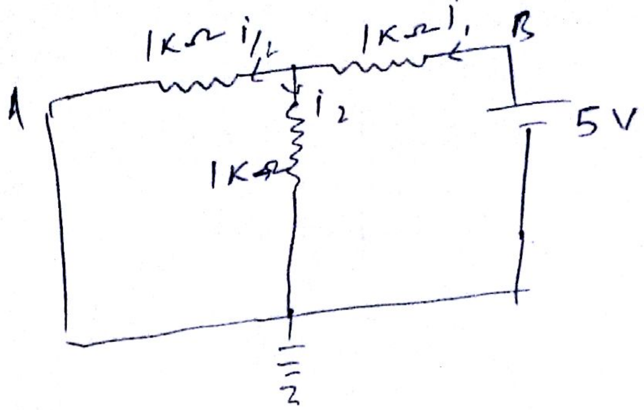
$V_B = 0$

$V_C = 15 - 10^3 \times 10mA$

$= 5V.$

Scanned by CamScanner

V_1 removed from circuit,



$i_1 = \frac{5}{1500}$ A

$= 3.33$ mA.

$V_A = 0V$

$V_B = 5V$

$V_C = 5 - \frac{10}{2}$ mA $\times 100$

$= 1.67$ mA.

i_2 = same.

$V_A = 0V$

$V_B = 5V$

$V_C = 1.67$ mA

Check: $V_{Anet} = V_{A_1} + V_{A_2}$

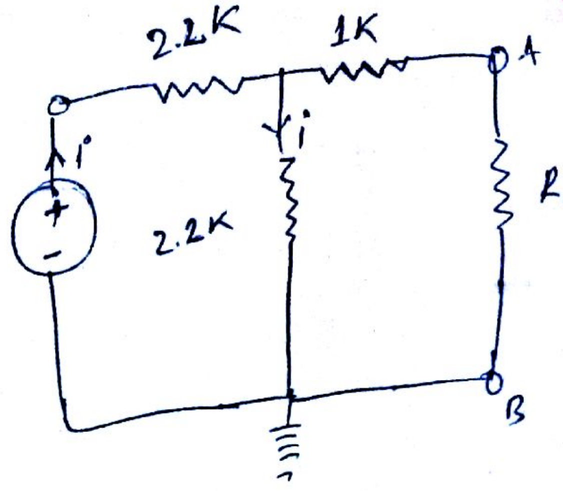
$V_{Bnet} = V_{B_1} + V_{B_2}$

$V_{Cnet} = V_{C_1} + V_{C_2}$

$5.67 = 4 + 1.67$

P.T.O →

PART-B



$+12 - 2200i - 2000i = 0$

$\Rightarrow 12 = 4400i$

$\Rightarrow i_1 = \frac{12}{4.4} mA$

$= 2.72 mA.$

$V_{TH} = iR$

$= 2.72 mA \times 2200\Omega$

$= 2.72 \times 2.2 V$

$= 6V.$

$R_{TH} = 2.1 K\Omega = 2100\Omega$

Part C Maximum power transfer theorem.

$(R_L)_{max} = R_{TH} = 2100\Omega$

$(P)_{max} = \frac{V^2}{4R_{TH}} = \frac{(12)^2}{4 \times 2100} W = 17.1 mW$

esults/OBSERVATIONS:-

1. While verifying Superposition theorem:-

$(V_c)_I = 5.6\,V$
$(V_c)_{II} + (V_c)_{III} = 5.6\,V$ } For $V_1 = 12V$ & $V_2 = 5V$

$(V_c)_I = 6.4\,V$
$(V_c)_{II} + (V_c)_{III} = 5 + 1.6 = 6.6\,V$ } For $V_1 = 15V$ & $V_2 = 5V$

2. Verifying Thervnin's Theorem:-

$V_{TH} = 6V$
$R_{TH} = 2.14 \times 10^3\,\Omega = 2140\,\Omega$ } Experimental.

Theoritically, $R_{TH} = 2100\,\Omega$

3. The max power is obtained in the range of $(1K - 2.2K)\,\Omega$.

Theoritically → Max power disspated for $2.1K\,\Omega$.

Conclusion

1. Superposition theorem is verified
2. ~~Th~~ The Thevenin's Theorem is verified
3. The maximum power transfer theorem is verified.

Post experimental Analysis:-

The scale of 'CRO' must be set carefully, so that the amplitude and time period can be studied, with greater accuracy.

The CRO is a cathod ray vaccum tube which by electrostatic means steers the beam to specific areas on screen, allowing us to study the function.

We noticed a minor difference while veryfying the superposition theorem. This might have occured because of the tolerence of the resistors used, and also if the circuit is not shorted when one source is removed, it causes incorrect results.

The Thevenin's resistance calculated experimently did not perfectly coincide with the theoritical value, as the reading taken from The CRO may not be very accurate as parallax errors and other factors like scale & sensitivity come in.

The maximum power transfer occured in between (1K - 2.2K) Ω resistance. It matches theoritically.

Precautions

1. The frequency must ~~be~~ not exceed the permissable limit.

2. The tuning of frequency must be done slowly & steadily.

3. Oscilloscope must be callibrated properly for good responce.

4. The connections to the Bread board must be made only after studying how the bread board is connected internally.

5. Voltage supplied must be within the safty limits

6. While making connection, care must be taken to connect live wire with live & neutral wire with neutral.

Observation

Part A

For $V_1 = 12V$ & $V_2 = 5V$

Case	Circuit modification	V_1	V_2	V_A (V)	V_B	V_C (V)
I	Both source connected	12	5	12	5	5.6
II	V_2 removed & B-G shorted	12	0	12	0	4
III	V_1 removed & A-G shorted	0	5	0	5	1.6

For $V_1 = 15V$ & $V_2 = 5V$

Case	Circuit modification	V_1	V_2	V_A	V_B	V_C
I	Both sources connet	15	5	15	5	6.4
II	V_2 removed & B-G shorted	15	0	15	0	5
III	V_1 removed & A-G shorted	0	5	0	5	1.6

Part B

a) Thevenin's equivalent voltage $V_{Th} = 6V$

b) Thevenin's equivalent resistance

$$R_{Th} = 10 \times \left(\frac{V_{oc}}{V_{10\Omega}}\right) \Omega$$

$V_{10\Omega} = 28 \times 10^{-3}$ V

$$= 10 \times \frac{6}{28 \times 10^{-2}}$$

$$= \frac{6 \times 10^{4}}{28} \Omega$$

$$= 2.14 \times 10^{3} \Omega$$

Part C

R_L Ω	V_A (V) to Ch 1	V_L (mV) to Ch2	$I_{RL} = (V_L/10\Omega)$ mA	Power (Milli watt)
560	1.2	22	2.2	2.64
1K	2.0	18	1.8	3.6
2.2K	3.0	14	1.4	4.2
3.9K	3.8	10	1.0	3.8
4.7K	4.0	8	0.8	3.2

03/02/2016

INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
Department of Electronics & Electrical Engineering
EE102: Basic Electronics Laboratory
EXPT. NO 2 : Circuit Theorems

OBJECTIVE: Verification of superposition theorem, Thevenin's theorem and maximum power transfer theorem

MATERIALS REQUIRED

- Breadboard
- Equipment : Multi-output DC Power Supply, Oscilloscope
- Components : Resistances: One 10 Ω, One 560 Ω, Three 1 kΩ, Three 2.2 kΩ, One 3.9 kΩ, One 4.7 kΩ

PRECAUTIONS AND GUIDELINES

1. Make sure the ground terminals of the oscilloscope probes and power supplies are connected together in the circuit.

2. While switching on the set-up, switch on the oscilloscope first, followed by the power supply.

Pre-experiment observation

Part A: For the circuit shown in Fig. 2.1, find the voltage V_C across resistance R for the cases listed in Table 2.1. Assume $V_1 = 12$ V, $V_2 = 5$ V and zero source resistances. Also repeat the same for $V_1 = 15$ V and $V_2 = 5$ V.

Part B: Calculate the Thevenin's voltage and resistance a seen into terminals A-B of the circuit given in Fig 2.2.

Part C: For the circuit in Fig 2.2, find the value of R_L for which maximum power transfer would take place and also find the value of maximum power transferred.

Part A: SUPERPOSITION THEOREM

The response of any circuit variable in a multi-source linear memory-less circuit containing 'n' independent sources can be obtained by adding the responses of the same circuit variable in 'n' single-source circuit with i^{th} independent source active and all the remaining independent sources deactivated.

1. Assemble the circuit shown in Fig. 2.1. Use 0-32V and 5V sources of the multi-output DC power supply for realizing voltage sources V_1 and V_2 in the circuit.

2. For the safety of resistors, do not apply more than 20 V from 0-32V source for the experiment purpose.

3. Verify the superposition theorem for the voltage V_C developed across the resistance R due to voltage sources V_1 and V_2.

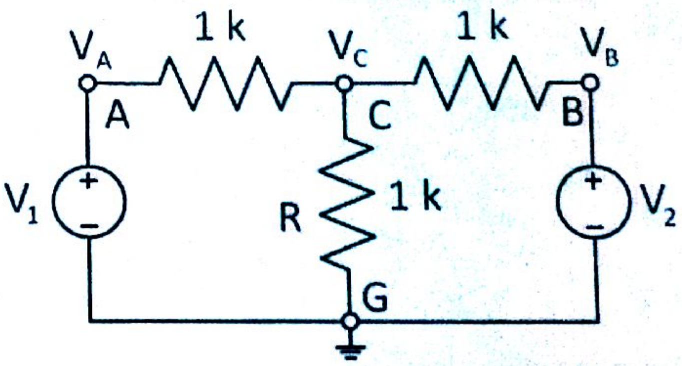


Fig. 2.1

Take the measurements listed in Table 2.1. Verify that voltage V_C for Case I is the sum of voltages obtained in Case II and III.

Case	Circuit modification required	V_1 (V)	V_2 (V)	V_A (V)	V_B (V)	V_C (V)
I	Both sources connected	12	5			
II	V_2 removed from circuit and port B-G shorted	12	0			
III	V_1 removed from circuit and port A-G shorted	0	5			

Table. 2.1

Repeat the experiment for $V_1 = 15$ V while keeping $V_2 = 5$ V.

4. Comment on the possible cause if the superposition theorem is not verified exactly.

Part B: THEVENIN'S THEOREM

Any linear electrical network with voltage and current sources and resistances can be replaced at terminals A-B by an equivalent voltage source V_{th} in series connection with an equivalent resistance R_{th}.

- ***This equivalent voltage V_{th} is the voltage obtained at terminals A-B of the network with terminals A-B open circuited.***
- ***This equivalent resistance R_{th} is the resistance obtained at terminals A-B of the network with all its current sources open circuited and all its voltage sources short circuited.***

1. Assemble the circuit as shown in Fig. 2.2. Find the Thevenin's equivalent as seen into terminals A-B.
2. To find Thevenin's equivalent voltage V_{th}, remove load R_L and measure the open circuit voltage cross terminals A-B (V_{oc}) with help of CRO.
3. To find Thevenin's equivalent resistance R_{th}, first determine the current through the terminals A-B when shorted. As we cannot directly measure current using CRO so connect a small resistance 10 Ω across A-B terminals and measure the voltage drop $V_{10\Omega}$ .Now the R_{th} can be computed as $R_{th} = 10 \times (V_{oc} / V_{10\Omega})$ Ω.

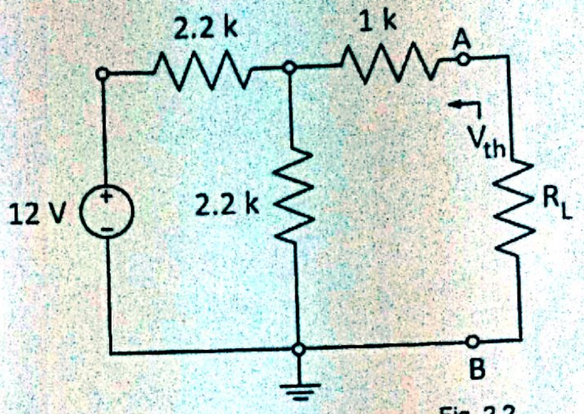


Fig. 2.2

4. Give comment for any difference observed among the values obtained by following the above procedure and the theoretically computed ones.

Part C: MAXIMUM POWER TRANSFER THEOREM

The power delivered by a linear time invariant memory-less circuit containing independent DC sources is a maximum when the value of the load is equal to the Thevenin's equivalent resistance seen by it.

1. Re-assemble the circuit as shown in Fig. 2.2. Now the objective is to verify the maximum power transfer theorem for the load R_L connected across terminals A-B. The power transferred to a load is product of voltage drop across it and the current flowing through it.
2. To measure the current through load R_L using CRO, a small resistance10 Ω is connected in series as shown in Fig. 2.3 and measure the voltage drop across terminals C-B (Ch2). The voltage drop across terminals A-B is to be approximated for the voltage drop across the load R_L.
3. Find out the power for varying values of the load R_L as suggested in Table 2.2.
4. Note the value of the load resistance for which the power turns out to be the maximum among the load resistance values considered. Compare it with the Thevenin's equivalent resistance determined in Part B.

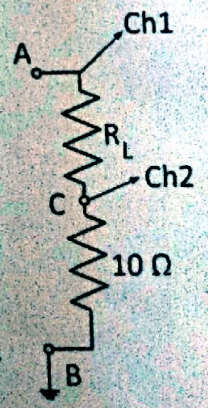


Fig. 2.3

R_L (Ω)	V_A (V) to Ch1	V_C (V) to Ch2	I_{RL} (= V_C / 10Ω)	Power (Watt)
560				
1 k				
2.2 k				
3.9 k				
4.7 k				

Table. 2.2

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