Experiment - 2

Verification of Circuit Theorems

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EE102: Basic Electronics Laboratory

Expt.No.2: Verification of Circuit Theorems

Objectives:

1. To verify the Superposition Theorem, the Thevenin's Theorem and the Maximum Power Transfer Theorem

Materials Required:

1. Equipment: Breadboard, DC Power Supply, Multimeter
2. Components: 100Ω (1), 470Ω (1), 1kΩ (3), 10kΩ (2)

Pre-Lab Work:

1. For the circuit shown in Fig. 1, find the voltage V_C across resistance R where V_1 = 5V, V_2 = 5V (assuming zero source resistances).

2. Calculate the Thevenin's voltage and resistance as seen into terminals A-B of the circuit given in Fig. 2.

3. For the circuit shown in Fig. 3, find the value of the maximum power that can be delivered to the load R_L.

Part A: Superposition Theorem

1. Assemble the circuit shown in Fig. 1. Derive two connections from +25V of the DC power supply for realizing voltage sources V_1 and V_2 in the circuit. Note: The remote circuit will not accept settings more than 20V from DC Supply for the safety of the resistors.

2. To verify the superposition theorem for the voltage V_C across the resistance R, take the measurements as appropriate and fill Table 1. Verify that voltage V_C for Case-I is the sum of voltages obtained in Case-II and Case-III.

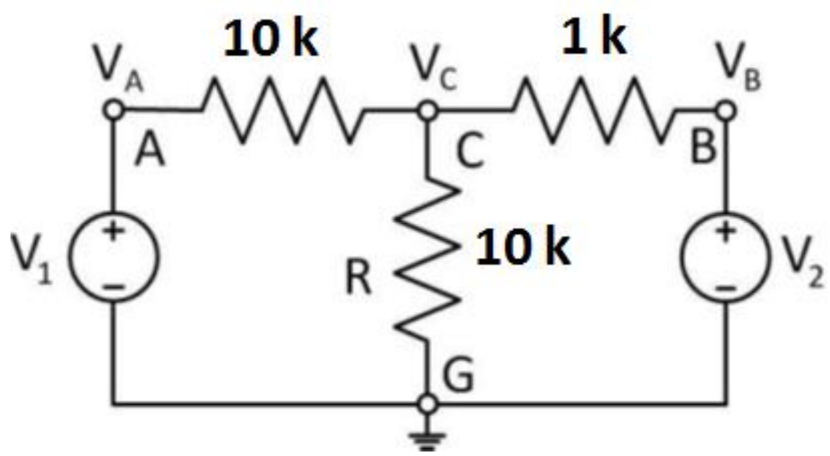


Fig. 1

	V_1 (Volt)	V_2 (Volt)	V_A (Volt)	V_B (Volt)	V_C (Volt)
Case-I	5	5			
Case-II	5	0			
Case-III	0	5			

Table 1

Part B: Thevinin's Theorem

1. Assemble the circuit as shown in Fig. 2.
2. Measure the open circuit voltage across terminals A-B (V_{OC}) with help of multimeter connected as a votlmeter.
3. Measure the short circuit current for terminals A-B (I_{SC}) with help of multimeter connected as an ammeter.
4. Calculate the values the values of V_{Th} and R_{Th} and fill Table 2.

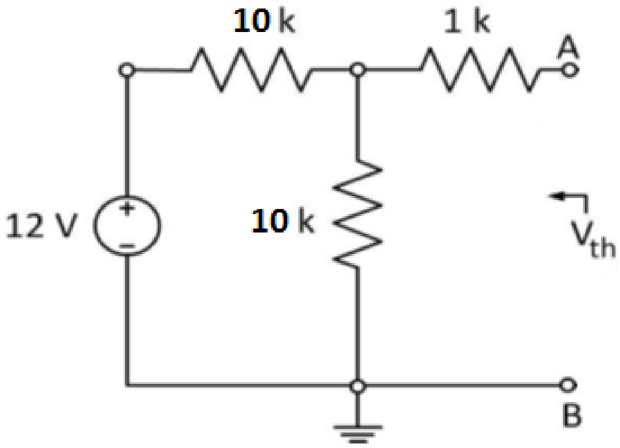


Fig. 2

V_{OC} (Volt)	I_{SC} (Amp)	V_{Th} (Volt)=V_{OC}	R_{Th} (Ω)=V_{OC}/I_{SC}

Table 2

Part C: Maximum Power Transfer Theorem

1. Build the circuit as shown in Fig. 3.
2. Connect different load resistor (R_L) across terminals A-B as shown in Fig. 3. Measure the voltage drop V_{R_L} and current I_{R_L} through the chosen R_L.
3. Make measurements by varying the value of the load resister R_L as given in Table 3. Calculate the power consumed by the load in each case.

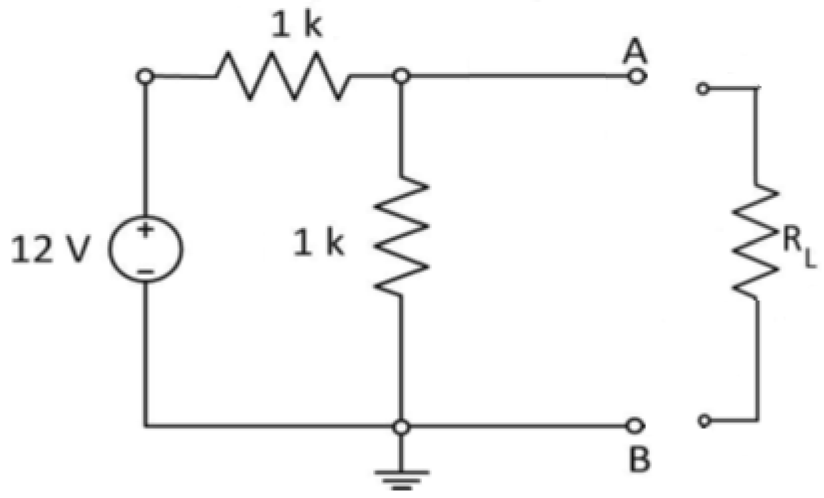


Fig. 3

R_L (Ω)	V_{R_L} (Volt)	I_{R_L} (Amp)	Power (Watt)
100			
470			
1k			
10k			

Part D: Lab Report

Prepare and submit a lab report as specified in the general instructions regarding the lab. Include the answers to the following questions in the report:

1. How accurate is the verification of superposition theorem in Part A? Why?
2. Is there a difference between the theoretical values of V_{Th} and R_{Th} and the measured value? Why?
3. Compare the measured values of power consumed by each load as in Part C and the theoretical maximum for power transfer and explain.

Prelab-2

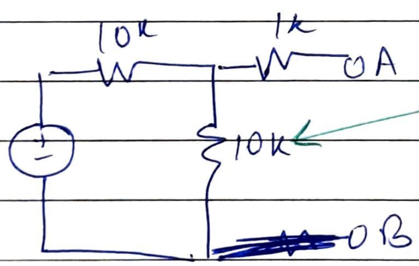
1. Using KCL, at node C

$$\frac{V_C - V_A}{10} + \frac{V_C - V_G}{10} + \frac{V_C - V_B}{1} = 0$$

we know $V_G = 0$, $V_A = V_1 + 0 = 5V$
$V_B = V_2 + 0 = 5V$

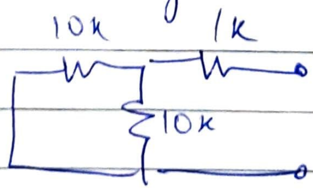
$$\Rightarrow \frac{6}{5} V_C = \frac{11}{2} \Rightarrow V_C = 4.58\,V$$

2. For thevenin voltage, the open circuit's voltage between A & B would be as developed across this resistor (since no current flows through the 1k Ω)



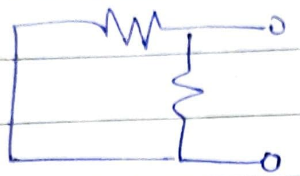
$$\Rightarrow 12V \cdot \frac{10}{10+10} = 6V$$

For thevenin's resistance,
Short-circuiting the independent voltage source

$\Rightarrow$


$$\Rightarrow \frac{10k \cdot 10k}{10k + 10k} + 1k = 6\,k\Omega$$

3. Max power is developed when ~~source's~~ load resistance = thevenin's resistance across load terminals. Calculating R_{th} similarly to prev question,



$$R_{th} = \frac{1k \cdot 1k}{1k + 1k} = 0.5\,k\Omega$$

$\Rightarrow$ $R_L = R_{th}$ for max power.

$$\text{Max power} = \left(\frac{V_{oc}}{2}\right)\left(\frac{I_{sc}}{2}\right)$$

$$= \left(\frac{6V}{2}\right)\left(\frac{12mA}{2}\right) = 18\,mW$$

Observations

Part A: Table: 1

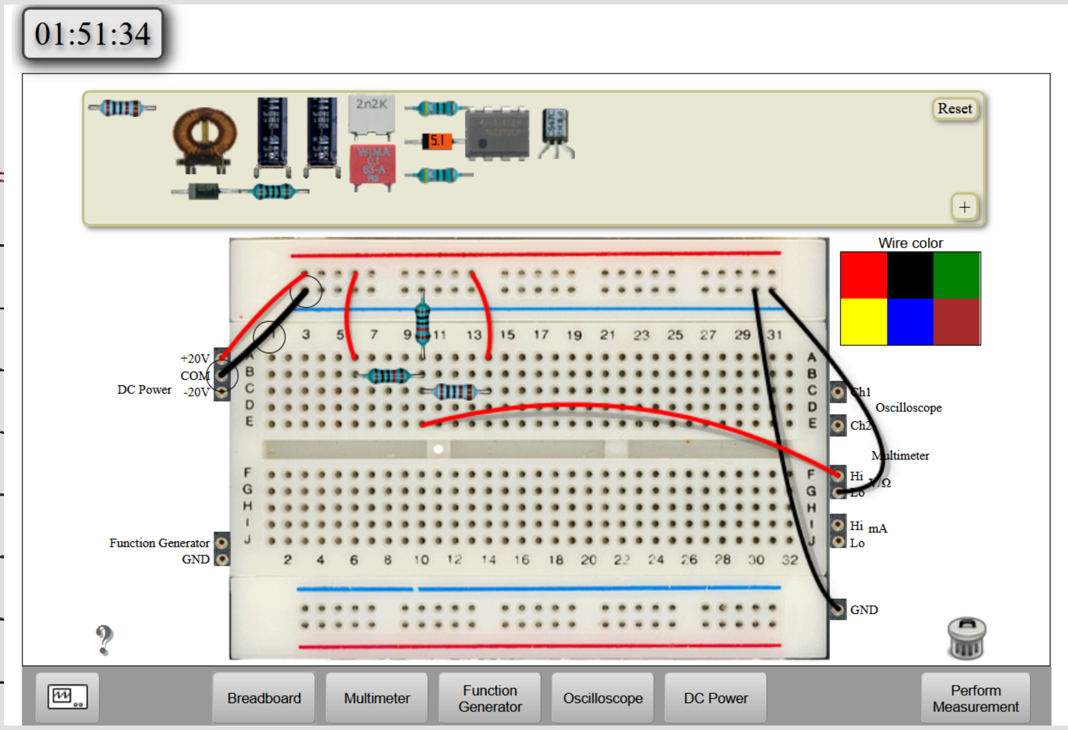
	V_1 (volt)	V_2 (volt)	V_A (volt)	V_B (volt)	V_C (volt)
Case I	5	5	5.002	5.001	4.579
Case II	5	0	5.001	−129 µV	0.420
Case III	0	5	−140 µV	5.001	4.162

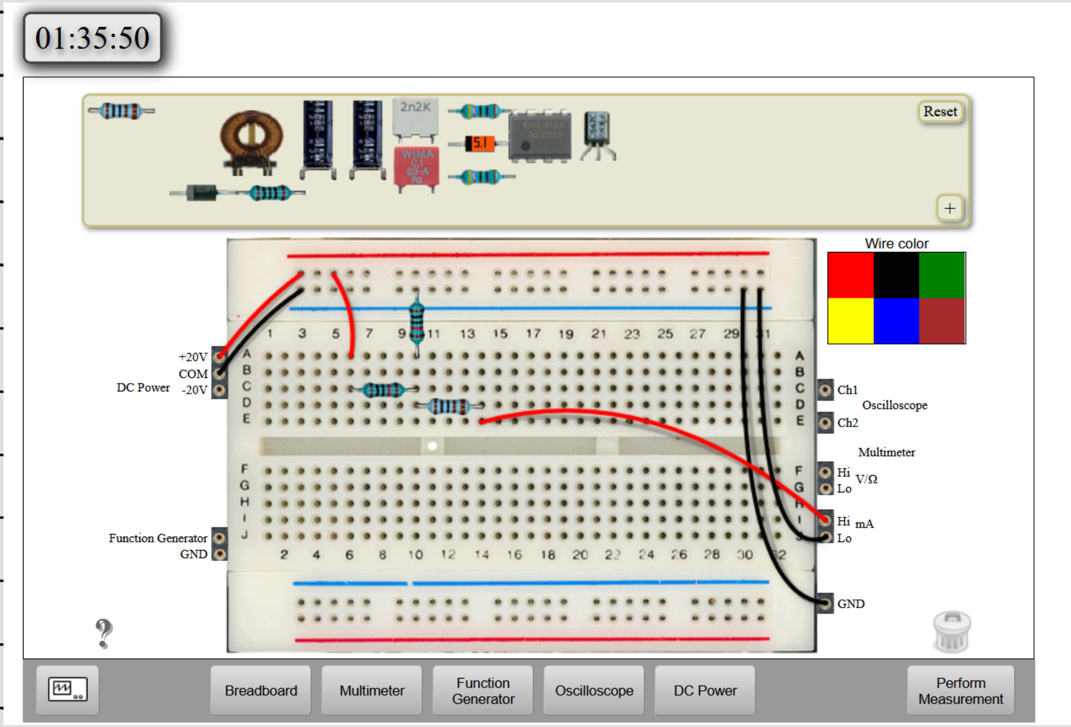
Part B: Table: 2

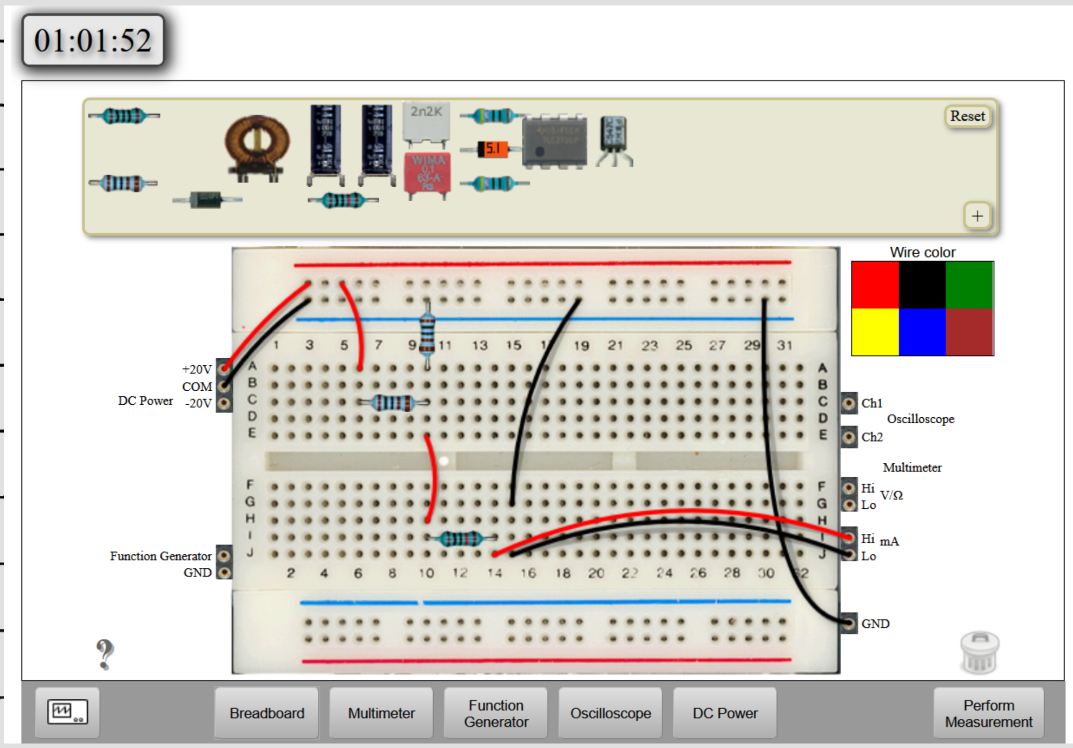
V_{oc} (volt)	I_{sc} (mA)	$V_{TH} = V_{oc}$ (volt)	$R_{TH} = V_{oc}/I_{sc}$ (kΩ)
6.015	1.003	6.015	5.997

Par C: Table: 3

R_L (Ω)	V_{R_L} (volt)	I_{R_L} (mA)	Power (mW)
100	0.9928	9.988	9.916
470	2.882	6.199	17.866
1k	3.971	4.003	15.896
10k	5.676	0.5508	3.126


01:51:34
2n2K
WIMA
5.1
Reset
Wire color
DC Power
+20V
COM
-20V
Function Generator
GND
Oscilloscope
Ch1
Ch2
Multimeter
Hi
Lo
V/Ω
mA
GND
Breadboard
Multimeter
Function Generator
Oscilloscope
DC Power
Perform Measurement


01:35:50
2n2K
WIMA
5.1
Reset
Wire color
DC Power
+20V
COM
-20V
Function Generator
GND
Oscilloscope
Ch1
Ch2
Multimeter
Hi
Lo
V/Ω
mA
GND
Breadboard
Multimeter
Function Generator
Oscilloscope
DC Power
Perform Measurement


01:01:52
2n2K
WIMA
5.1
Reset
Wire color
DC Power
+20V
COM
-20V
Function Generator
GND
Oscilloscope
Ch1
Ch2
Multimeter
Hi
Lo
V/Ω
mA
GND
Breadboard
Multimeter
Function Generator
Oscilloscope
DC Power
Perform Measurement

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Answers

to questions given in Part: D

(1) In part A, the superposition theorem gives that Voltage ~~Current~~ in Case I should be sum of voltages in Case II & III, which is

$$4.162 + 0.420$$
$$= 4.582\ V$$

But in case I we got Voltage $= 4.579\ V$
and theoretical value is $= 4.583\ V$

So % error in experimental (case I) $= \left(\frac{4.579 - 4.583}{4.583}\right) \times 100 = -0.087\%$

% error in experimental for Case II + Case III $= \left(\frac{4.582 - 4.583}{4.583}\right) \times 100 = -0.022\%$

Thus ~~our~~ these experimental values are very close to the theoretical ones. The reason there is a difference between the two could be due to the unknown resistances of wires, DC power source, the multimeter, and it can be seen from the negative and greater than 5V values of V_A and V_B in some cases.

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(2) Theoretical value of $V_{TH} = 6V$
but experimentally we got $6.015\,V$
and
Theoretical value of $R_{TH} = 6k\Omega$
but experimentally we got $5.997\,k\Omega$

These values are pretty close, but not the same, and that could be due to unaccounted wire resistance and DC source's internal resistance and the resistance of multimeter used to measure the values.

(3) The theoretical maximum power is $18mW$ at resistance $= 500\,\Omega$

In our experiment, the resistance closest to $500\,\Omega$ is the $470\,\Omega$, and the power at that is maximum amongst the four calculated, and is pretty close to the theoretical maximum
(theo. max $18mW$, power at $470\Omega = 17.866\,mW$)