EXPERIMENT # 5

SUPERPOSITION & THEVENIN / NORTON THEOREMS

OBJECTIVE:

1- To experimentally verify the superposition.
2- To experimentally verify the Thevenin and Norton Theorems.
3- To experimentally verify the Maximum Power Transfer Theorem for resistive circuits.

Pre- Lab Assignment:

For the circuit shown Figure 1:

1- Find the V_L and I_L using superposition.
2- Find the Thevenin's equivalent circuit between A and B (i.e. as seen by R_L)
3- Find the Norton's equivalent circuit as seen by R_L.
4- Vary R_L from 2.5 K to 10.5 K in steps of 1 K Ohms. Calculate V_L in each case. For (this purpose, use the Thevenin's equivalent circuit you obtained).
5- Calculate the power P_L absorbed by R_L in each case of steps 4.
6- Find the value of R_L for maximum power transfer and the value of the maximum power.

Summarize your results in Tables 2, 3 and 4.

APPARATUS: HF 6216 A, 0-3-V, Power Supply (Two)
Triplet Multimeter, Type 630.
Carbon Resistors: 10 kΩ, 22 kΩ, 33 kΩ, 47 kΩ, and 1 kΩ.
Decade Resistors.

THEORY:

- **Superposition Theorem**:

The voltage and current responses in a network from two or more sources acting simultaneously can be obtained as the sum of the responses from each source acting alone with other sources deactivated. A deactivated current source is an open circuit. A deactivated voltage source is a short circuit.

- **Thevenin's Theorem:**

A two–terminal network can be replaced by a voltage source with the value equal the open circuit voltage across its terminals, in series with a resistor with the value equal to the equivalent resistance of the network.

Norton's Theorem:

A two terminal network can be replaced by a current source with the value equal to the short–circuit current at its terminal, in parallel with a resistor with the value equal to the equivalent resistance of the network. The equivalent resistance of a two–terminal network is equal to the open circuit voltage divided by the short circuit current.

Maximum Power Transfer Theorem:

In a resistive circuit, a resistive load receives maximum power when the load resistance is equal to the Thevenin's equivalent resistance of the circuit (i.e. RL = R_{TH}). The maximum power can be calculated using the expression:

$$p = \frac{V_{OC}^2}{4R_{TH}}$$

Where V_{OC} is the open circuit voltage.

Procedure:

1- Check the values of the resistors using the multimeter. Record the values in Table 1.
2- Connect the circuit of Figure 1 and measure V_L and I_L.
3- Deactivate the 10 V source and measure V'_L and I'_L.
4- Reactive the 10 V sources and deactivate the 5 V source. Measure V''_L and I''_L
5- Record the results in Table 2.

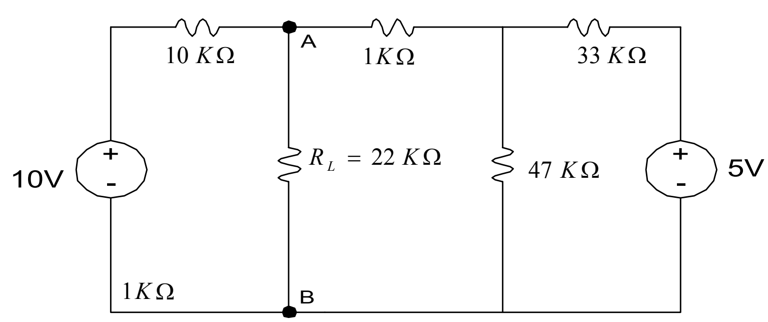

Figure 1

Thevenin and Norton Theorems:

6- Remove R_L from the original circuit and measure the open circuit voltage Voc.
7- Measure the short circuit current I_{sc}. This is accomplished by placing an Ammeter between A and B. In this manner, <u>the Ammeter will act as a short circuit</u>.
8- Replace the voltage sources with short circuits. With R_L removed from the circuit, measure R_{th} using a multimeter.
9- Record the results in Table 3.

Maximum Power Transfer:

10- Reconnect the circuit as shown in Figure 1, but replace the 22 KΩ resistor between A and B and by a variable resistor (i.e. R_L in this case is the variable resistor).
11- Vary RL from 2.5 KΩ to 10.5 KΩ in steps of 1 KΩ and measure V_L in each case.
12- Record the results in Table 4.

Report:

1- Compare the theoretical and experimental values of the voltages and currents obtained using superposition. Calculate the percentage error.
2- Draw the Thevenin's and Norton's equivalent circuit obtained experimentally.
3- Compare step 2 with theoretical Thevenin and Norton's equivalent circuits obtained in pre-lab.
4- Calculate P_L from step 11 above and record the results in Table 5.
5- Plot the theoretical and experimental values of P_L versus R_L (on the same graph).
6- Compare the two graphs of step 5.
7- Discuss the reasons for any discrepancies between the theoretical and experimental values for all cases.

Questions:

1- Thevernin's and Norton's Theorem are very useful. List at least two reasons for it
2- Is the Maximum Power Theorem verified experimentally? Explain.

TABLE 1

Resistor Values:

Resistor	R1	R2	R3	R4	R5
Nominal value (Ohm)	10K	22K	1K	47K	33K
Ohmmeter Reading					

TABLE 2

Superposition Theorem:

	V_L(V)	V'_L (V)	V''_L (V)	I_L (mA)	I'_L (mA)	I''_L (mA)
Theory						
Experiment						
% Error						

TABLE 3

Thevenin’s and Norton’s Equivalent Circuits:

	V_{oc} (V)	I_{sc} (mA)	R_{TH} (K Ohm)
Theory			
Experiment			
Error			

THEVENIN’S EQUIVALENT CIRCUIT	**NORTON’S EQUIVALENT CIRCUIT**

TABLE 4

Load Voltage Results:

R_L (K Ohm)	2.5	3.5	4,5	5.5	6.5	7.5	8.5	9.5	10.5
V_L (Theoretical)									
V_L (Experimental)									

TABLE 5

Maximum Power Transfer Results:

R_L (K Ohm)	2.5	3.5	4,5	5.5	6.5	7.5	8.5	9.5	10.5
P_L (Theoretical)									
P_L (Experimental)									
% Error									