Experiment 7

Thevenin's Theorem and Maximum Power Transfer

Introduction

A two terminal network resistive network can be replaced by a voltage source in series with an equivalent resistor. The value of the source voltage equals the open circuit voltage of the two terminals under consideration. The value of the equivalent resistor equals the resistance measured between the open terminals when all the sources of the circuit are deactivated (voltage source shorted and current source opened). This is termed as the Thevenin's theorem. The voltage source is called Thevenin's voltage (E_{TH}) and the equivalent resistor, the Thevenin's resistance (R_{TH}).

The maximum power output to a variable output resistance occurs when the value of the output resistance equals the Thevenin's resistance.

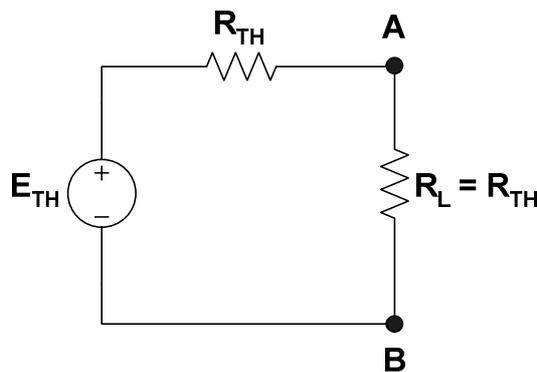

Figure 1: Maximum power output condition

The value of the maximum output power or transferred power is given as,

$$P_o = \frac{E_{TH}^2}{4R_{TH}}$$

Objectives

1. To construct Thevenin's equivalent using Workbench.
2. To verify the equivalent obtained in step 1 using hardwired components.
3. To determine maximum power transfer condition experimentally.

Materials

Two dc power sources
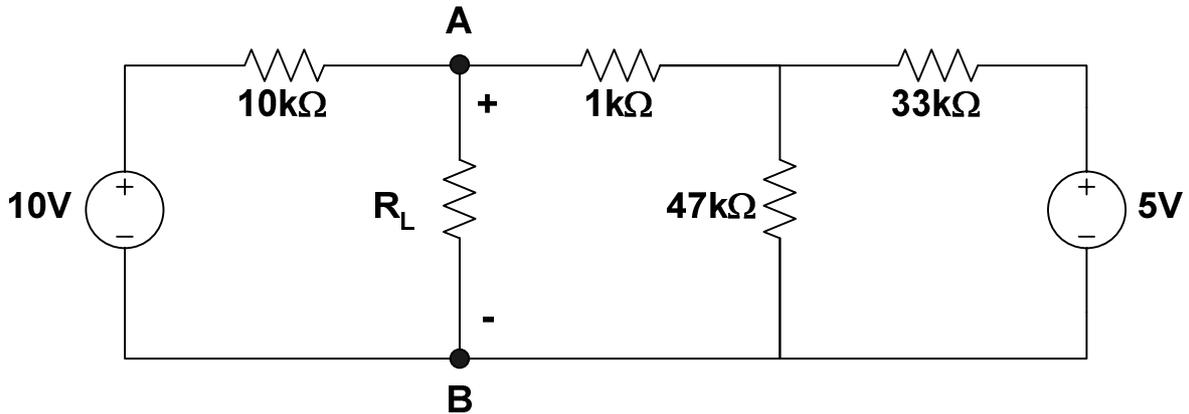One multimeter
Assorted resistors
One decade resistor

Figure 2: Circuit for Thevenin's equivalent

Procedure

Simulation

1. Construct the circuit given in Figure 2 on *Multisim Electronics Workbench.*

2. Remove the load resistor R_L and connect a multimeter (or voltmeter) to read the open circuit voltage between A and B. Simulate and record the voltage. This is E_{TH} for this circuit between A and B.

3. Remove the 10-V source. Replace it by a short circuit.

4. Remove the 5-V source. Replace it by a short circuit.

5. Connect a mutimeter in the resistance measurement mode (ohmmeter) between A and B. Run the simulation and record the value of the resistor. This is R_{TH} in Figure 1.

Hardwired Experiment

6. Build circuit of Figure 2 with hardwired components in the laboratory.

7. Repeat step 2-5 and find the values of E_{TH} and R_{TH} experimentally. Considering the Workbench results as the base compute the percentage errors.

Question: Compare the values obtained with Workbench with that carried out using hardwired components. Comment on the accuracy of the methods.

8. In the circuit of Figure 2 connect a variable resistor (R_L) between A and B.

9. Vary R_L between 2.5 KΩ to 10.5 KΩ in steps of 1 KΩ. Measure voltage between A and B (V_L) in each case. Enter your results in Table 2.
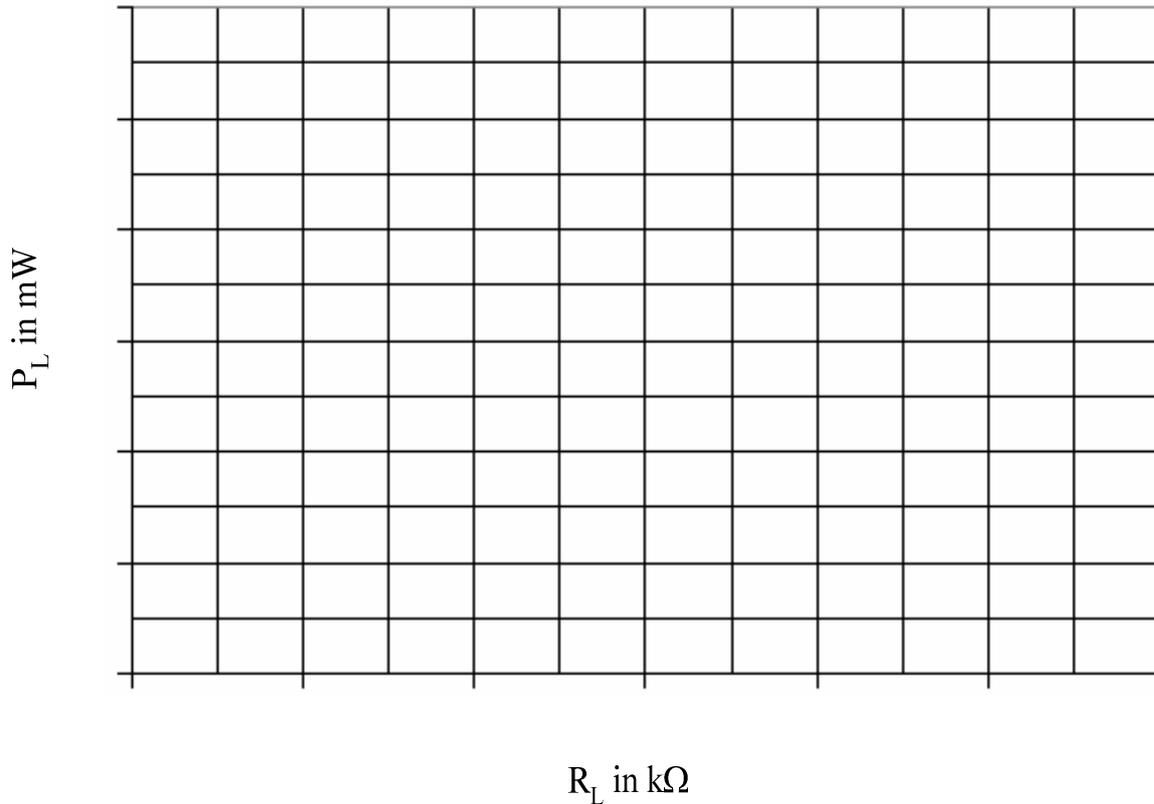
Table 1: Simulation and experimental results for Thevenin voltage and resistance

	E_{TH}	R_{TH}
Workbench		
Hardwired		
% Error		

Table 2: Experimental results for maximum power transfer

$R_L(K\Omega)$	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5
V_L									
P_L									

10. Plot R_L vs. P_L

P_L in mW

R_L in kΩ

Questions

1. At what value of R_L the maximum value of P_L occurs in the graph?

2. Does this value of R_L compare with R_{TH} you obtained experimentally or through Workbench?

3. If not, how much is the error in either case (take workbench result as the base)?

4. Draw the Norton's equivalent of the circuit in Figure 1.

5. Suppose you did not know the Thevenin's equivalent circuit, what procedure would you follow in the laboratory to get the Norton's equivalent?

Any other observations or comments