

4.5.1: Thevenin's Theorem

Overview:

In this lab, we experimentally investigate Thevenin's Theorem. We will analytically determine a Thevenin equivalent for a given circuit; we will then experimentally determine the Thevenin resistance and the open-circuit voltage necessary to create the Thevenin equivalent circuit.

We will use the Thevenin equivalent to the given circuit to analytically predict the voltage which will result from loading the circuit with a resistor. We will then test our Thevenin equivalent circuit by:

1. connecting the load resistor to the original circuit and measuring the resulting load voltage, and
2. physically creating the Thevenin equivalent circuit, connecting the load resistor to this circuit, and measuring the resulting load voltage and comparing the results obtained with the Thevenin circuit and the original circuit.

Finally, we will vary the value of the load resistance and measure the power dissipated by the load resistor as a function of the load resistance. We will use this result to check our expectations based on the maximum power transfer theorem.

Before beginning this lab, you should be able to:

- Create a Thevenin equivalent of an arbitrary linear circuit
- Determine the load resistance necessary to draw the maximum power from a circuit

After completing this lab, you should be able to:

- Compare measured voltages and currents in an electrical circuit with predictions based on superposition techniques

This lab exercise requires:

- Analog Discovery module
- Digilent Analog Parts Kit
- Digital multimeter

Symbol Key:

DEMO

Demonstrate circuit operation to teaching assistant; teaching assistant should initial lab notebook and grade sheet, indicating that circuit operation is acceptable.

ANALYSIS

Analysis; include principle results of analysis in laboratory report.

SIM

Numerical simulation (using PSPICE or MATLAB as indicated); include results of MATLAB numerical analysis and/or simulation in laboratory report.

DATA

Record data in your lab notebook.

General Discussion:

This lab assignment concerns the circuit shown in Figure 1 below. We want to determine the equivalent Thevenin circuit seen at the terminals a-b.

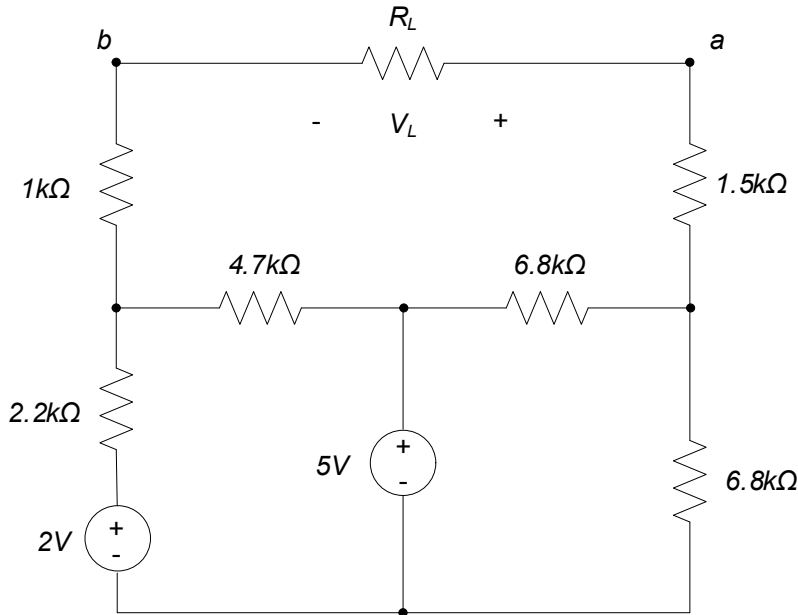


Figure 1. Circuit schematic.

Pre-lab:

ANALYSIS

Determine the Thevenin equivalent circuit (the open circuit voltage V_{OC} and the Thevenin resistance R_{TH}) seen by a resistor connected to the terminals a-b of the circuit of Figure 1. (e.g. determine the Thevenin equivalent circuit seen by the load resistor R_L .) Sketch the Thevenin equivalent circuit.

Lab Procedures:

DATA

1. Choose the six resistors (all resistors except for the resistor R_L) in the circuit of Figure 1. Record the actual resistance values.

DATA

2. Assemble the circuit of Figure 1, except for the resistor R_L . Measure the open-circuit voltage (V_{OC}) across the terminals a-b. Also measure the Thevenin resistance (R_{TH}) seen at the terminals a-b. (You will need to replace the voltage sources in the circuit with short circuits in order to determine the Thevenin resistance of the circuit.) Compare these measured values with your expectations based on the pre-lab analyses, by calculating a percent error between the actual and theoretical values.

ANALYSIS

DATA

3. Pick a random resistor for the load resistance R_L , in the range $4k\Omega < R_L < 10k\Omega$, and connect it between the terminals a and b in the circuit of Figure 1. Measure the voltage across the load

resistance and compare this voltage to your expectation based on the Thevenin equivalent circuit from your pre-lab.

DATA

4. Build the Thevenin equivalent circuit you determined in the pre-lab. Load the Thevenin circuit with the resistor R_L you used in part 4 above. Measure the voltage across the load resistor and compare it to the voltage you measured in part 4. (e.g. compute a percent difference between the load voltage produced by the original circuit and the Thevenin equivalent circuit.)

ANALYSIS

DATA

5. Connect a potentiometer between the terminals a-b. Measure and record the load voltage as a function of potentiometer resistance. Calculate the power delivered to the Vload (

ANALYSIS

$P_{Load} = \frac{V_{ab}^2}{R_L}$) as a function of the load resistance. Plot the load power as a function of the load resistance and estimate the load resistance which results in maximum power dissipation by the load. Compare this value from your expectations based on your Thevenin resistance from the pre-lab and the maximum power theorem.