



Thévenin's Theorem

Objective

The objective of this exercise is to examine the use of Thévenin's Theorem to create simpler versions of DC circuits as an aide to analysis. Multiple methods of experimentally obtaining the Thévenin resistance will be explored.

Theory Overview

Thévenin's Theorem for DC circuits states that any two port linear network may be replaced by a single voltage source with an appropriate internal resistance. The Thévenin equivalent will produce the same load current and voltage as the original circuit to any load. Consequently, if many different loads or sub-circuits are under consideration, using a Thévenin equivalent may prove to be a quicker analysis route than “reinventing the wheel” each time.

The Thévenin voltage is found by determining the open circuit output voltage. The Thévenin resistance is found by replacing any DC sources with their internal resistances and determining the resulting combined resistance as seen from the two ports using standard series-parallel analysis techniques. In the laboratory, the Thévenin resistance may be found using an ohmmeter (again, replacing the sources with their internal resistances) or by using the matched load technique. The matched load technique involves replacing the load with a variable resistance and then adjusting it until the load voltage is precisely one half of the unloaded voltage. This would imply that the other half of the voltage must be dropped across the equivalent Thévenin resistance, and as the Thévenin circuit is a simple series loop then the two resistances must be equal as they have identical currents and voltages.

Equipment

- | | | |
|---|--------------|------------|
| (1) Adjustable DC power supply | model: _____ | srn: _____ |
| (1) Digital multimeter | model: _____ | srn: _____ |
| (1) 2.2 kΩ | _____ | |
| (1) 3.3 kΩ | _____ | |
| (1) 4.7 kΩ | _____ | |
| (1) 6.8 kΩ | _____ | |
| (1) 8.2 kΩ | _____ | |
| (1) 10 k potentiometer or resistance decade box | | |



Schematics

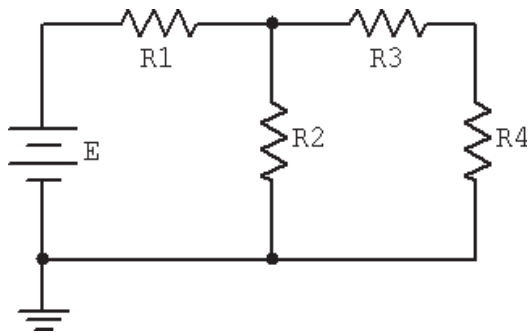


Figure 11.1

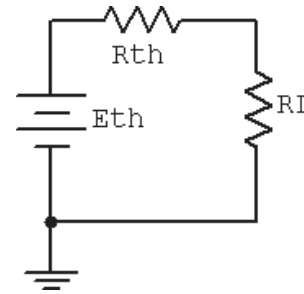


Figure 11.2

Procedure

1. Consider the circuit of Figure 11.1 using $E = 10$ volts, $R1 = 3.3$ k, $R2 = 6.8$ k, $R3 = 4.7$ k and $R4$ (R_{Load}) = 8.2 k. This circuit may be analyzed using standard series-parallel techniques. Determine the voltage across the load, $R4$, and record it in Table 11.1. Repeat the process using 2.2 k for $R4$.
2. Build the circuit of Figure 11.1 using the values specified in step one, with $R_{Load} = 8.2$ k. Measure the load voltage and record it in Table 11.1. Repeat this with a 2.2 k load resistance. Determine and record the deviations. Do not deconstruct the circuit.
3. Determine the theoretical Thévenin voltage of the circuit of Figure 11.1 by finding the open circuit output voltage. That is, replace the load with an open and calculate the voltage produced between the two open terminals. Record this voltage in Table 11.2.
4. To calculate the theoretical Thévenin resistance, first remove the load and then replace the source with its internal resistance (ideally, a short). Finally, determine the combination series-parallel resistance as seen from the where the load used to be. Record this resistance in Table 11.2.
5. The experimental Thévenin voltage maybe determined by measuring the open circuit output voltage. Simply remove the load from the circuit of step one and then replace it with a voltmeter. Record this value in Table 11.2.



6. There are two methods to measure the experimental Thévenin resistance. For the first method, using the circuit of step one, replace the source with a short. Then replace the load with the ohmmeter. The Thévenin resistance may now be measured directly. Record this value in Table 11.2.
7. In powered circuits, ohmmeters are not effective while power is applied. An alternate method relies on measuring the effect of the load resistance. Return the voltage source to the circuit, replacing the short from step six. For the load, insert either the decade box or the potentiometer. Adjust this device until the load voltage is half of the open circuit voltage measured in step five and record in Table 11.2 under “Method 2”. At this point, the load and the Thévenin resistance form a simple series loop as seen in Figure 11.2. This means that they “see” the same current. If the load exhibits one half of the Thévenin voltage then the other half must be dropped across the Thévenin resistance, in other words $V_{RL} = V_{RTH}$. Consequently, the resistances have the same voltage and current, and therefore must have the same resistance according to Ohm's law.
8. Consider the Thévenin equivalent of Figure 11.2 using the theoretical E_{TH} and R_{TH} from Table 11.2 along with 8.2 k for the load (RL). Calculate the load voltage and record it in Table 11.3. Repeat the process for a 2.2 k load.
9. Build the circuit of Figure 11.2 using the measured E_{TH} and R_{TH} from Table 11.2 along with 8.2 k for the load (RL). Measure the load voltage and record it in Table 11.3. Also determine and record the deviation.
10. Repeat step nine using a 2.2 k load.



Data Tables

Original Circuit

R_4 (Load)	V_{Load} Theory	V_{Load} Experimental	Deviation
8.2 k			
2.2 k			

Table 11.1

Thévenized Circuit

	Theory	Experimental
E_{TH}		
R_{TH}		
R_{TH} Method 2	X	

Table 11.2

R_4 (Load)	V_{Load} Theory	V_{Load} Experimental	Deviation
8.2 k			
2.2 k			

Table 11.3



Questions

1. Do the load voltages for the original and Thévenized circuits match for both loads? Is it logical that this could be extended to any arbitrary load resistance value?
2. Assuming several loads were under consideration, which is faster, analyzing each load with the original circuit of Figure 11.1 or analyzing each load with the Thévenin equivalent of Figure 11.2?
3. How would the Thévenin equivalent computations change if the original circuit contained more than one voltage source?