**A-7.**

**Thevenin’s Theorem**

**OBJECTIVES:**

After performing this experiment, you will be able to:

1. Change a linear resistive network into an equivalent Thevenin circuit.

2. Prove the equivalency of the network in objective 1 with the Thevenin circuit by comparing the effects of various load resistors.

**READING:**

Nisson, Electric Circuits，Section 4.10

**MATERIALS NEEDED:**

Resistors:

One 150 Ω, one 270 Ω, one 470 Ω, one 560 Ω, one 680 Ω, one 820 Ω,

One 1 kΩ potentiometer

For Further Investigation: LED, resistors specified by student

**SUMMARY OF THEORY:**

Combining series and parallel components is one way to form an equivalent circuit. Equivalent circuits simplify the task of solving for current and voltage in a network. The concept of equivalent circuits is basic to solving many problems in electronics.

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| **(a)** | **(b)** |
| **Figure 1** | | |

Thevenin’s theorem provides a means of reducing a complicated, linear network into an equivalent circuit when there are two terminals of special interest (usually the output). The equivalent Thevenin circuit is composed of a voltage source and a series resistor. (In ac circuits, the resistor may be represented by opposition to ac called impedance.) Imagine a complicated network containing multiple voltage sources, current sources, and resistors such as that shown in Figure 1(a). Thevenin’s theorem can reduce this to the equivalent circuit shown in Figure l(b). The circuit in Figure 1(b) is called a Thevenin circuit. A device connected to the output is a load for the Thevenin circuit. The two circuits have identical responses to any load!

Two steps are required in order to simplify a circuit to its equivalent Thevenin circuit. The first step is to measure or compute the voltage at the terminals of interest with any load resistors removed. This open-circuit voltage is the Thevenin voltage. The second step is to compute the resistance seen at the same open terminals if sources are replaced with their internal resistance. For voltage sources, the internal resistance is usually taken as zero and for current sources the internal resistance is infinite (open circuit).

**PROCEDURE:**

1. Measure and record the resistance of the 6 resistors listed in Table 1. The last three resistors represent different load resistors that will be tested in the experiment.

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| figure12-2 |
| **Figure 2** |

2. Construct the circuit shown in Figure 2. Calculate an equivalent circuit seen by the voltage source. Use the equivalent circuits shown in Figure 3 to compute the expected voltage across the load resistor, . Do not use Thevenin’s theorem at this time. Show your computation of the load voltage in the space provided in the report.

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| figure12-3_a | figure12-3_b |
| **(a)** | **(b)** |
| **Figure 3** | |

3. Measure the load voltage to verify your calculation. Enter the computed and measured load voltage in Table 2. They should agree within experimental uncertainty.

4. Replace with Compute the expected voltage, , across the load resistor in the same manner as before. Then measure the actual load voltage. Enter the computed and measured voltage in Table 2.

5. Repeat step 4 using for the load resistor.

6. Remove the load resistor from the circuit. Calculate the open circuit voltage at the AB terminals. This open circuit voltage is the Thevenin voltage for this circuit. Record the open circuit voltage in Table 2 as .

7. Mentally replace the voltage source with a short (0 Ω). Compute the resistance between the AB terminals. This is the computed Thevenin resistance for this circuit. Then disconnect the voltage source and replace it with a jumper. Measure the actual Thevenin resistance of the circuit. Record your computed and measured Thevenin resistance in Table 2.

8. In the space provided in the report, draw the Thevenin equivalent circuit. Show on your drawing the measured Thevenin voltage and resistance.

9. For the circuit you drew in step 8, compute the voltage you expect across each of the three load resistors. Since the circuit is a series circuit, the voltage divider rule will simplify the calculation. Enter the computed voltages in Table 3.

10. Construct the Thevenin circuit you drew in step 8. Use a 1 kΩ potentiometer to represent the Thevenin resistance. Set it for the resistance shown on your drawing. Set the voltage source for the Thevenin voltage. Place each load resistor, one at a time, on the Thevenin circuit and measure the load voltage. Enter the measured voltages in Table 3.

11. Remove the load resistor from the Thevenin circuit. Find the open circuit voltage with no load. Enter this voltage as the computed and measured .in Table 3. Enter the measured setting of the potentiometer as in Table 3.

**FOR FURTHER INVESTIGATION: (생략)**

Sometimes it is useful to compute a Thevenin equivalent circuit when it is not possible to measure the Thevenin resistance directly. A simple method is to use a variable resistor as a load resistor and adjust it until the load voltage has dropped to one-half the open-circuit voltage. The variable load resistor and the internal Thevenin resistance of the source will then be equal.

The preceding method requires a variable resistor. A more general method, using a fixed resistor, is as follows:

1. Measure the no-load voltage, from the generator.

2. Add a load resistor, ，(330 Ω is satisfactory) and measure the load voltage, .

3. Calculate the load current from Ohm’s law, .

4. Compute .

Use one of these two methods to measure the Thevenin resistance of your function generator. Report your results, describe the method you used, and compare your measured resistance to the accepted value of generator resistance.

**APPLICATION PROBLEM: (생략)**

The circuit in Figure 4 presents an interesting problem in which the application of Thevenin’s theorem can provide a ready solution. The circuit is similar to circuits used for bipolar transistor biasing although the particulars for this problem are different. The output of the voltage divider is connected to a light- emitting diode (LED), as indicated in Figure 4. The LED allows current to flow in only one direction and drops approximately 1.65 V when it is conducting. Given the circuit, it is a simple matter to determine the current in the diode by applying Thevenin’s theorem, as shown in Figure 5. The current is found by subtracting 1.65 V from the Thevenin voltage (due to the LED voltage drop) and dividing by the Thevenin resistance of the circuit.

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| |  | | --- | | Z:\임시 인터넷 파일\Content.Word\figure12-4.jpg | | **Figure 4** | | |  |  | | --- | --- | | Z:\임시 인터넷 파일\Content.Word\figure12-5.jpg |  | | **Figure 5** | | |

The question is, “Can you reverse the procedure?” That is, given a required Thevenin resistance, can you find an equivalent circuit using the divider and series resistor? The problem is illustrated in Figure 6. The required Thevenin resistance is 600 Ω and the required current in the LED is 12 mA. is given as 270 Ω and the supply voltage is +15 V. Calculate values for and that meet these conditions. Then construct the circuit, measure the voltages across each resistor, and prove that your design meets these requirements. Incidentally, three of the fixed resistors used in this experiment can be used to meet the design requirements. Summarize your findings in your lab report.

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| figure12-6 | | |
| **Figure 6** | | |
| **Report for**  **Experiment A-7** | **Name**  **Date**  **Class** |

**ABSTRACT:**

**DATA:**

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| |  |  |  | | --- | --- | --- | | **Table 1** | | | | Component | Listed  Value | Measured  Value | |  | 270 Ω |  | |  | 560 Ω |  | |  | 680 Ω |  | |  | 150 Ω |  | |  | 470 Ω |  | |  | 820 Ω |  | | |  | | --- | | **Load Voltage Calculation (Step 2)** | |  | |

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| **Table 2** | | |
|  | Computed | Measured |
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| |  |  |  | | --- | --- | --- | | **Table 3** | | | |  | Computed | Measured | |  |  |  | |  |  |  | |  |  |  | |  |  |  | |  |  |  | | |  | | --- | | **Thevenin Circuit (Step 8)** | |  | |

**RESULTS AND CONCLUSION:**

**FURTHER INVESTIGATION RESULTS: (생략)**

**APPLICATION PROBLEM RESULTS: (생략)**

**EVALUATION AND REVIEW QUESTIONS:**

1. Compare the measured voltages in Tables 2 and 3. What conclusion can you draw about the two circuits?

2. Compute the load current you would expect to measure if the load resistor in Figure 2 were replaced with a short circuit. Then repeat the computation for the Thevenin circuit you drew in step 8.

3. What advantage does Thevenin’s theorem offer for computing the load voltage across each of the load resistors tested in this experiment?

4. Figure 7(a) shows a circuit and 7(b) shows its equivalent Thevenin circuit. Explain why the has no effect on the Thevenin circuit.

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| figure12-7_a | **=** | figure12-7_b |
| **(a)** | **(b)** |
| **Figure 7** | | |

5. Figure 8 shows a load resistor connected to a Thevenin circuit. Calculate the power in if is adjusted to each value listed in Table 4. Explain the result.

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| |  | | --- | | Z:\임시 인터넷 파일\Content.Word\figure12-8.jpg | | **Figure 8** | | |  |  | | --- | --- | | **Table 4** | | |  | **Power in** | | 0.7 kΩ |  | | 1.7 kΩ |  | | 2.7 kΩ |  | | 3.7 kΩ |  | | 4.7 kΩ |  | |

6. Draw the Thevenin circuit for the circuits shown in Figure 9(a) and (b).

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| figure12-9_a |
| **(a)** |
| figure12-9_b |
| **(b)** |
| **Figure 9** |