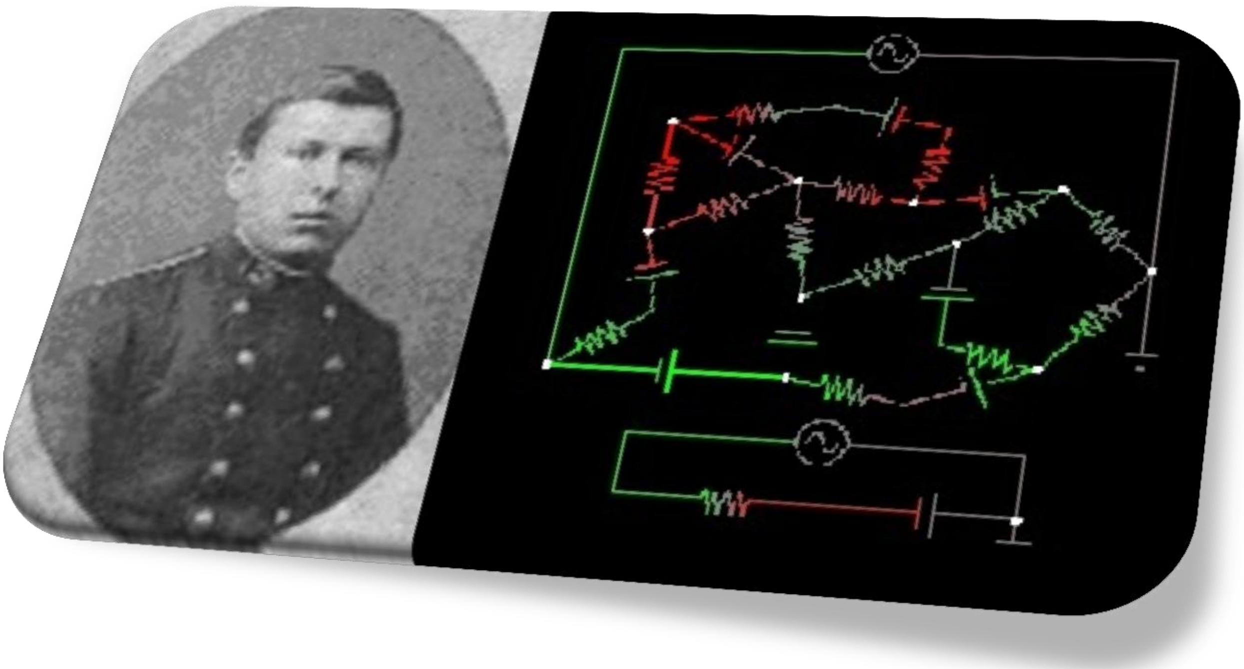
Fall | 2011

Experiment 3

Voltage Dividers and Thévenin's Theorem



American University of Beirut

Table of Contents

I. OBJECTIVES

In this experiment you will learn how to:

- Determine analytically the effects of a load on the voltage relationships in a resistive voltage-divider circuit.
- Design a voltage divider which will meet specified voltage and current requirements.
- Investigate the operation of real voltage and current sources, and calculate and measure the Thévenin voltage and resistance of a circuit.

II. MATERIAL AND PROCEDURE

A. VOLTAGE DIVIDER CIRCUITS

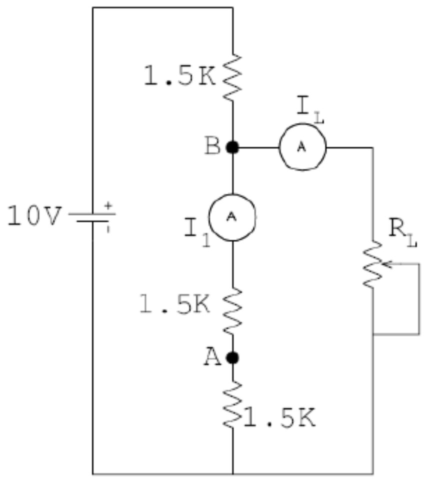


Figure A-1: Voltage Divider

Procedure

- Compute and record in Table A-1, the bleeder current I1, the voltages V_B and V_A, and the load resistance R_L for each of the load conditions given. (Refer to figure A-1).
- Connect the circuit of Figure A-1. Maintain a constant voltage of 10V at the input.
- With zero load current, (i.e. rheostat open), measure the bleeder current I1 (in mA) and record in Table A.2 (In-Lab). Measure also and record the voltages V_B to ground, and V_A to ground.
- Connect the rheostat in the circuit and adjust it to draw 1 mA of load current while maintaining V=10V, measured. Measure and record the bleeder current and the voltages V_B and V_A. Open the load resistor R_L, but do not vary the setting of the arm. Measure and record the resistance to which it was set to draw 1 mA of load current. Reconnect R_L after this measurement.
- Repeat the pervious step for conditions of 3 mA and 5 mA of load current.

Exercise
- Refer to in-lab 3 exercise A-1

Discussion on Part A

- Refer to the data of Tables A-1 and A-2. How does the load current vary with the load resistance R_L? Explain why.
- Refer to tables A-1 and A-2. What is the effect on bleeder current I_1 as the load current increases? Explain why.
- What is the effect on the voltages V_A and V_B at the divider taps as the load current increases (Table A-1 and A- 2)? Explain why.
- Compare the computed values in Table A.1 with the measured values. Explain any differences.

B. VOLTAGE DIVIDER DESIGN

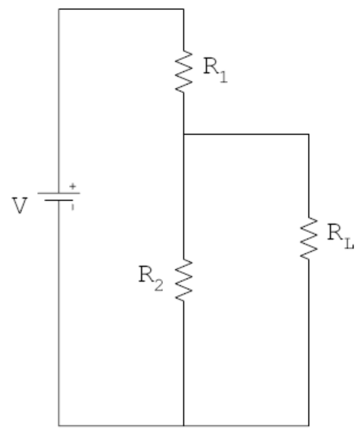


Figure B-1

Procedure

- Design a voltage-divider circuit, similar to that shown in Figure B-1, for a 4-V regulated power supply which must feed a 2 mA load at 1 V. The bleeder current should be 1 mA (approximately). Draw the circuit diagram, showing all values of voltage, current, and resistance. Show your computations and record them in table B.1. ***Ask your instructor to check your solution before you connect the circuit.***

- Select the required resistors from your kit. If your kit does not contain a design-value resistor, adjust a potentiometer connected as a rheostat to the desired value, or make up the resistor from a combination (series, parallel) of the other resistors.
- Connect the circuit. Measure the required voltages and currents and record them in a table B.2 (In lab).

Exercise
- Refer to in-lab 3 exercise B-1

Discussion on Part B

- Compare the design values and the measured values of the circuit in Fig. B.1. Explain any differences.

C. THÉVENIN'S THEOREM

Circuit Diagram

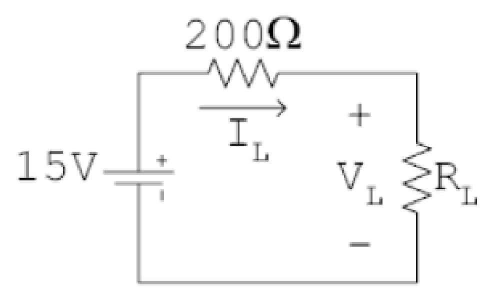


Figure C-1

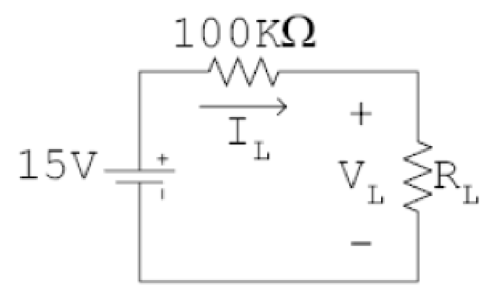


Figure C-2

Procedure

- The resistor RL in the circuits of Figure C-1 and Figure C-2 takes the values 100 KΩ, 56 KΩ, 22 KΩ, 5.6 KΩ, 2.2 KΩ, 1 KΩ, 560 Ω, 220 Ω, and 100 Ω. Measure each of the resistor values using the digital multi-meter, then connect the circuit, and measure V_L in each case. Calculate the value of I_L and plot V_L vs. I_L for both circuits. For the circuit of Fig. C.2, transform the voltage source and the 100 KΩ resistor to an equivalent current source before plotting V_L vs. I_L.

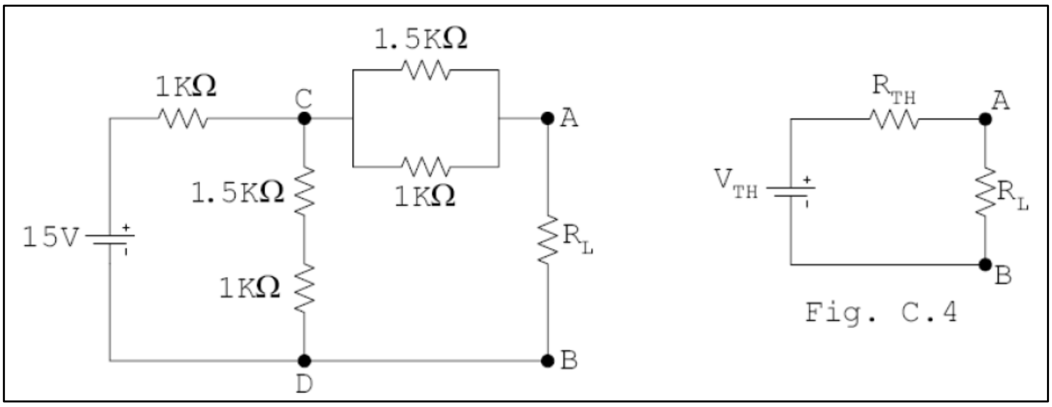


Figure C-3

Figure C-4

- Calculate the Thévenin voltage V_{TH} and the Thévenin resistance R_{TH} for the circuit of Fig. C-3 and record them in table C-1.

- With the Thévenin values just found, calculate the load voltage V_L across the load resistance across R_L, for R_L = 1 kΩ and R_L =1.5 KΩ using the circuit of Fig. C-4.

- Connect the circuit of Fig. C-3 and measure the open-circuit voltage between points A and B of this circuit. Record the measurement in table C-2.

- With the 15 V source in Fig. C-3 replaced by a short-circuit, measure the resistance between the AB terminals with the digital multi-meter. Record the measurement in table C-3.

- Find R_{TH} using the matched-load method; that is, use a 10 KΩ potentiometer as a variable resistance between the AB terminals of the circuit of Fig. C-3. Vary the resistance until load voltage drops to half of the measured V_{TH} (open-circuit voltage.) Then disconnect the load resistance, measure its resistance with the multi-meter and record it in table C-4.

- Connect the load resistances of 1 KΩ and 1.5 KΩ in turn in the circuit of Fig. C-3. Measure the corresponding load voltages and record them in table C-5.

- From the measured values above, find Vth and Rth and record them in table C.6.

Exercise

- Refer to in-lab 3 exercise C-1

Discussion on Part C

- Over what range of values of R_L can the source of Fig. C-1 be considered to closely approximate an ideal voltage source?
- Over what range of values of R_L can the source of Fig. C-2 be considered to closely approximate an ideal current source?
- Convert the source in Fig. C.2 to an ideal current source in parallel with a source resistance using Norton's theorem; prove the equivalence by writing the circuit equations.
- Compare the measured and theoretical values obtained for V_{TH} and R_{TH} of Fig. C-3. Explain any differences in the values of V_{TH} and R_{TH}.
- With the 1 KΩ resistor in branch CD of Fig. C-3 opened; calculate V_{TH} and R_{TH} of the modified circuit. Explain any differences in the values of V_{TH} and R_{TH}.
- In the Procedure of Part C, R_{TH} was derived by shorting the 15 V source in Fig. C-3 and measuring the resistance between A and B. In the statement of Thévenin's theorem, R_{TH} is derived from the current that flows when R_L is shorted. Verify the equivalence of these two methods.

D. OUTCOMES

By the end of Experiment III, students:

- Should understand the effect of a load on voltage relationship in a voltage divider circuits.
- Are able to design a voltage divider circuit that meet the specified voltage and current requirements
- Are familiar with the real operation of voltage and current sources
- Are able to measure and calculate the Thévenin voltage and resistance using multiple methods.