Voltage Dividers and Thévenin's Theorem

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.

A. Voltage Divider Circuits

Circuit Diagrams

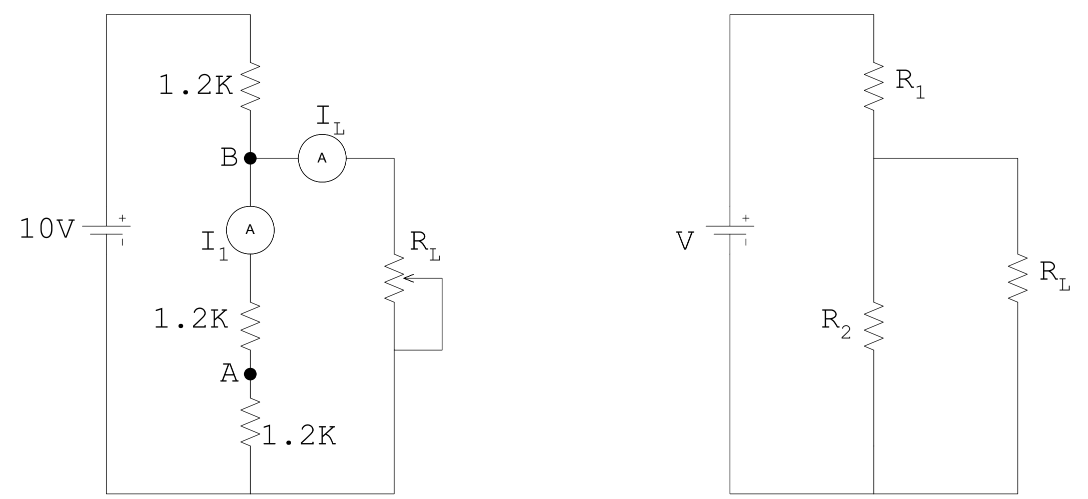


Fig. A.1 Fig. B.1

Procedure

- Connect the circuit of Fig. A.1. Maintain a *constant* voltage of 10V at the input.
- With zero load current, (i.e. rheostat open), measure the bleeder current I_1 (in mA) and record in Table A.1. 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 2 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 2 mA of load current. Reconnect R_L after this measurement.
- Repeat the pervious step for conditions of 4 mA and 6 mA of load current.
- Compute and record in Table A.1, the bleeder current I_1, the voltages V_B and V_A, and the load resistance R_L for each of the load conditions in the experiment. Show your computations.

TABLE A.1

Measured						Computed			
V (V)	I_L (mA)	I_1 (mA)	V_B (V)	V_A (V)	R_L (Ω)	I_1 (mA)	V_B (V)	V_A (V)	R_L (Ω)
10	0								
10	2								
10	4								
10	6								

B. Voltage Divider Design

Procedure

- Design a voltage-divider circuit, similar to that shown in Fig. B.1, for a 6-V regulated power supply which must feed a 3 mA load at 4.4V. The bleeder current should be 2 mA (approximately). Draw the circuit diagram, showing all values of voltage, current, and resistance. Show your computations.

Note *Ask your instructor to check your solution before you connect the circuit.*

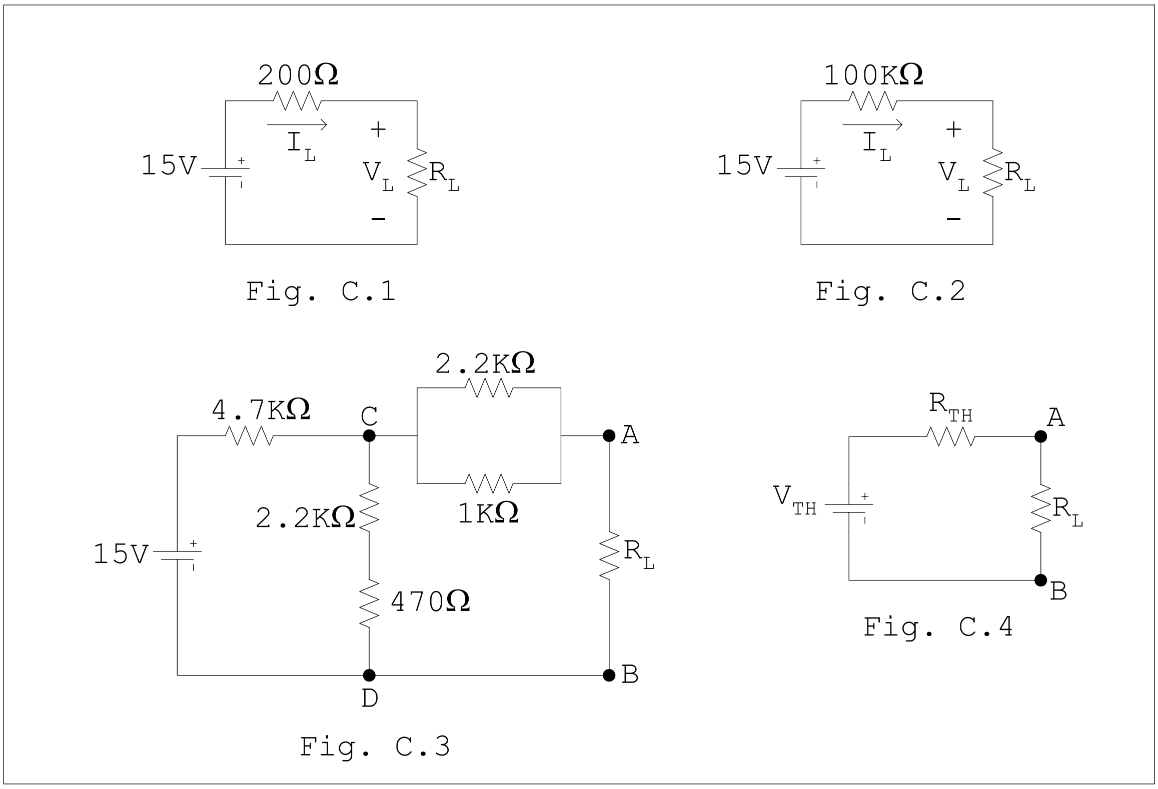
- Select the required resistors from your kit. If your kit does not contain a design-value resistor, adjust a potentiometer connected as a rheostat to the desired value, or make up the resistor from a combination (series, parallel) of the other resistors.
- Connect the circuit. Measure the required voltages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

Discussion on Parts A and B

- Refer to the data of Table A.1. How does the load current vary with the load resistance R_L? Explain why.
- Refer to Table A.1. 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)? Explain why.
- Compare the computed values in Table A.1 with the measured values. Explain any differences.
- Compare the design values and the measured values of the circuit in Fig. B.1. Explain any differences.

C. Thévenin's Theorem

Circuit Diagrams



Procedure

- The resistor R_L in the circuits of Fig. C.1 and Fig. 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 multimeter, 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.
- Calculate the Thévenin voltage V_{TH} and the Thévenin resistance R_{TH} for the circuit of Fig. C.3.
- 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 =4.7 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.

- With the 15 V source in Fig. C.3 replaced by a short-circuit, measure the resistance between the AB terminals with the digital multimeter.
- Connect the load resistances of 1 KΩ and 4.7 KΩ in turn in the circuit of Fig. C.3 and measure the corresponding load voltages.
- Find R_{TH} using the matched-load method; that is, use a 5 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 and measure its resistance with the multimeter.

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 and 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 2.2 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.