Experiment 3

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.

❶ *H*ow do we find the bleeder current I_1?

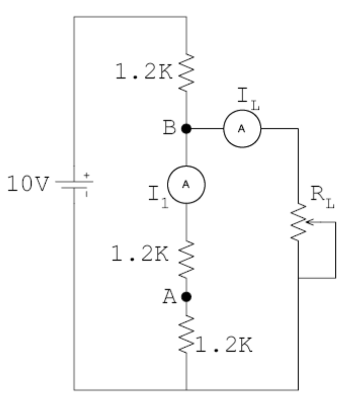
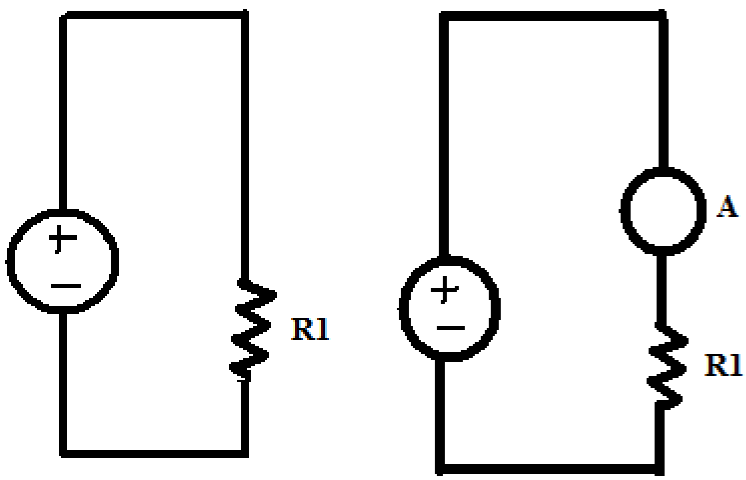


Fig. A.1

We first connect the circuit of Fig A.1 maintaining a *constant* voltage of 10V at the input. With zero load current, (i.e. rheostat open), we measure the bleeder current I_1 (in mA). We also measure and record the voltages V_B to ground, and V_A to ground.

- **We measure the bleeder current I_1 with the use of the digital multimeter.**
- **All currents in the circuit must pass through the ammeter. We connect them (components- especially the bleeder current I_1 and the ammeter)) in series not in parallel because if we connect them in parallel the current would be divided.**
- **An ammeter must have a low resistance.**
- **To measure the current, the circuit must be broken to allow the ammeter to be connected in series.**



The connection of the ammeter

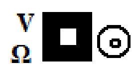
❷ How do we find the load resistance R for different load conditions?

Definitions:

- **A rheostat is an adjustable resistor used in applications that require adjustments of current or the varying resistance in electric circuits.**
- **The voltmeter= potentiometer is what measures unknown voltages by balancing it.**

We connect the rheostat in the circuit and adjust it to draw 2 mA by the digital multimeter of load current while maintaining V=10V, measured. We measure and record the bleeder current and the voltages V_B and V_A. We open the load resistor R_L, with out *varying the* setting of the arm. We measure and record the resistance to which it was set to draw 2 mA of load current. We reconnect RL after this measurement (by the digital multimeter).

❸ *I*n the circuit of figure A.1, how can we find a bleeder current of a certain value without changing the given resistances or using any new ones?

Connect a rheostat across the bleeder resistors. Connect the ammeter across nodes B and C (in series with I_1) and vary the arm of the rheostat until we get the required current (2mA for example) on the ammeter as a bleeder current.
Remove the rheostat from the circuit and measure its resistance value by plugging the probes in the 

socket in the digital multimeter and press the ohm bottom.

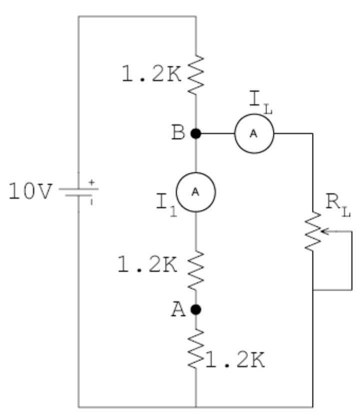


Fig. A.1

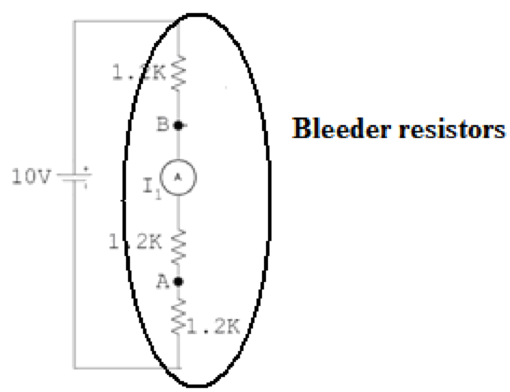


Fig. A.1

❹ How do we get the required value of a certain resistor?

If we didn't have the required design-value resistor, we 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. Or simply measure the value using a digital multimeter (according to the current value).

❺ How does the load current vary with the load resistance R? Explain why.

The load current decreases as the load resistance increases. This is a logical observation since current and resistance are inversely proportional with respect to voltage (By Ohm's law).

❻ What is the effect on bleeder current I_1 as the load current increases? Explain why.

As the load current increases, the bleeder current I1 decreases. Even though the source current is not constant, we can see that the general sense of linear relationship between the three currents conserved: $I_S = I_1 + I_L$.

❼ What is the effect on the voltages V_A and V_B at the divider taps as the load current increases? Explain why.

Both V_A and V_B decrease as the load current increases. This is valid since these voltages are constant multiples of the bleeder current and the bleeder current decreases with the increase in load current.

❽ What are the methods for finding V_{th} and R_{th}?

Method 1:

Measure open circuit voltage (V_{th}) and put a short circuit in the place of the supply to measure R_{th} (across A and B) with a digital multimeter. So open circuit V_{th} and keep R_L in place and measure R_{th} using multimeter across A and B.

Method 2:

Apply two different resistors on RL and measure the voltage across it. In the circuit below:

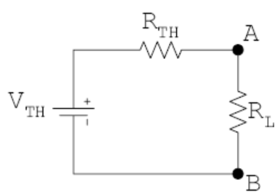


Fig. C.4

We find

$$V_{L(1)} = \frac{R_{L1} \times V_{th}}{R_{L1} + R_{th}} \quad \text{and} \quad V_{L(2)} = \frac{R_{L2} \times V_{th}}{R_{L2} + R_{th}}$$

Solve two equations with two unknowns and find V_{th} and R_{th}.

Method 3- The Matched Impedance Method:

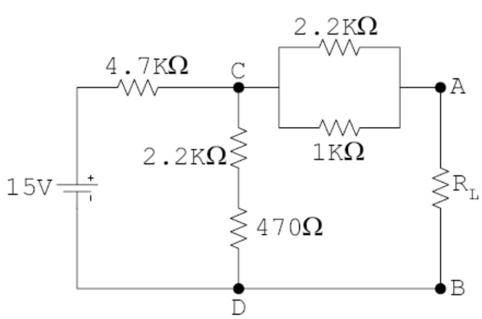


Fig. C.3

We use a potentiometer as a variable resistance between the AB terminals of the circuit of the above figure. We vary the resistance until load voltage drops to half of the measured VTH (open-circuit voltage.) Then we disconnect the load resistance and measure its resistance with the multimeter.

R_L=R_{th} → VL=V_{th}/2 and thus V_{th}= V_{oc} and R_L=R_{th}

Simplified Procedure:

- **open circuit V and measure V_{th}**
- **vary the arm of the rheostat until $V_L = \frac{1}{2} V_{th}$ and this $R_L = R_{th}$ since $V_{th} = V_{OC}$ (from circuit C.4 and by voltage division)**

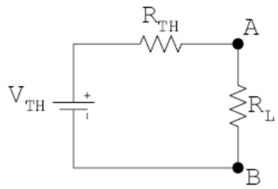


Fig. C.4