Potentiometer in a Voltage Divider

\[ V_{\text{out}} = \frac{V_s \cdot R_{\text{var}}}{R_1 + R_{\text{pot}} + R_{\text{var}}} \]

Figure 1: Potentiometer Schematic

Preliminary:
- Obtain an equation that relates \( V_{\text{out}} \) to \( V_s, R_1, R_{\text{pot}} \) and \( R_{\text{var}} \).
- Plot the \( V_{\text{out}} \) as a function of \( R_{\text{var}} \) as \( R_{\text{var}} \) varies from 0 to 5kΩ and \( R_{\text{pot}} = 5kΩ \).

Experimental:
- Measure the resistance of the potentiometer and discover how it works.
- Take measurements at different values of \( R_{\text{var}} \) and record \( V_{\text{out}} \).

Analysis:
- Compare to your predictions.
- If the input to your microprocessor (\( V_{\text{out}} \)), could not exceed 3.5 volts, what fixed resistor size would you use?
- List three applications for this circuit.

Thermometer

We will be using a thermistor as a variable resistor. The amount of resistance depends on the temperature and an equation can be determined experimentally. (not part of this lab) The resistance \( R_T \) can be determined from the voltage division equation and by measuring \( V_T \).

Preliminary:
- Obtain an equation that relates \( V_T \) to \( V_s, R_1, R_T \).

Experimental:
- For 2 different temperatures (room temp and warmed in your hands or ice bags), measure the resistance, \( R_T \) and the voltage \( V_T \). Hint: If the voltage and resistance don’t change you are measuring the fixed 10kΩ resistor.

Analysis:
- Describe an application for the thermistor and this circuit.
Wheatstone Bridge

Figure 3: Wheatstone Bridge Schematic

Preliminary:
- Solve for the difference between \( V_a \) and \( V_b \) where \( R_{POT} = R + \Delta R \) – Hint: DO NOT relabel the R’s with separate numbers. The algebra is much easier if they are the same. Assume \( R = 2.4 \, \text{K}\Omega \).
- Plot \( V_a - V_b \) for \( \Delta R \) equal to –2000 to +2000 ohms. (Done before lab)

Experimental:
- Pick 2 adjacent pins on the potentiometer, and adjust it so that the resistance is about 2.4kΩ.
- Using three 2.4kΩ resistors from the hallway and a breadboard, construct the circuit above. To install \( R_{POT} \), attach one of the two pins to ground and the other to \( V_b \).
- Note the actual values of the resistors and there locations in the bridge.
- Place your multimeter to read the voltage difference between \( V_a \) and \( V_b \).
- Balance the bridge to so \( V_a - V_b = 0 \). What is the value of the \( R_{POT} \). Show that this makes sense through calculations.
- Increase and decrease the resistance in the potentiometer to see if it matches your predictions.
- Make sure you understand the concept of measuring with respect to a non-ground node.

Analysis:
- For the same change in resistance in the voltage divider circuit and the Wheatstone bridge, the output voltage (\( V_{out} \) on the voltage divider and \( V_a - V_b \) on the Wheatstone bridge) will change by the same amount, for example, from 4 to 4.00007 on the voltage divider and from 0 to 0.00007 on the bridge. Why would the bridge circuit be preferred?
Figure 6: Breadboards have connectivity in rows/columns shown by the arrows