Experiment 4
Lab Activity

Pre-Lab Activity

Read the above sections, the laboratory activity and the post-lab before coming to the Laboratory. Also, read the Protoboard and the DC Analysis with Multisim Units. Solve the following problems and submit your solution to your instructor.

Problems

1. Duplicate the results in Figure 5 using Multisim.
2. Derive the formulas in Equation (2) for the current divider circuit.
3. Refer to Figure 7 and assume i = 30 mA and $R_1 = R_2 = 47\Omega$. Solve for i_1 and i_2, assuming an ideal ammeter. Repeat, assuming that the ammeter has a 10Ω input resistance.
4. Repeat Problem 3 using Multisim. The virtual ammeter in Multisim allows you to set its input resistance.
5. What are the values of i_1 and i_2 in Problem 3, if each resistor has a series ammeter measuring its current? Assume $R_A = 10\Omega$ for both ammeters.
6. Verify your answers for Problem 5 employing Multisim.
7. Refer to Figure 9 and assume v = 5V and $R_1 = R_2 = 4.7\text{M}\Omega$. Solve for v_1 and v_2, assuming an ideal voltmeter. Repeat, assuming that the voltmeter has a $10\text{M}\Omega$ input resistance.
8. Repeat Problem 7 using Multisim.
9. What are the values of v_1 and v_2 in Problem 7 if each resistor has a voltmeter connected across it? Assume $R_V = 10\text{M}\Omega$ for both voltmeters. Solve this problem using Multisim.
10. Derive Equation (8).

Laboratory Activity

Required components:

One 10MΩ resistor (±5%, ½ W)

One 4.7MΩ resistor (±5%, ½ W)

One 10kΩ resistor (±5%, ½ W)

One 4.7kΩ resistor (±5%, ½ W)

One 1kΩ resistor (±5%, ½ W)

One 470Ω resistor (±5%, ½ W)

One 100Ω resistor (±5%, ½ W)

One 47Ω resistor (±5%, ½ W)

One 10kΩ potentiometer (±10%, ½ W)

One DO-35 Thermistor (rated 10kΩ ±10% at 25^{o}C)

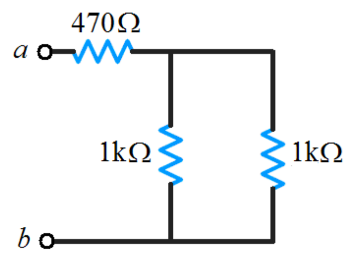
Note:

- All circuits in this experiment (and in all future experiments) should be constructed on the protoboard.
- When making current measurements, set the ammeter to display the reading in mA. Record your measurement with two significant digits to the right of the decimal point (employ rounding).
- When making voltage measurements, set the voltmeter to display the reading in Volts. Record your measurement with two significant digits to the right of the decimal point (employ rounding).
- When measuring resistance, set the Ohmmeter to *auto-range* and record the displayed reading accurate to two significant digits to the right of the decimal point.

1. Obtain the above resistive components from your instructor and measure and record their actual resistance. For the potentiometer,

measure its total resistance. Postpone the measurement of the thermistor resistance until Step 10.

2. Connect the 1kΩ and the 470Ω resistors in *series*. Measure and record the *equivalent* resistance.
3. Connect the 1kΩ and the 470Ω resistors in *parallel*. Measure and record the *equivalent* resistance.
4. Build the circuit shown below. Measure the resistance across the *a-b* terminals.



5. Build the *current divider* circuit in Figure 6 with R_1 = 470Ω and R_2 = 1kΩ. Use the +30V supply on the DC power source and set its supply current to 30 mA. Use the multimeter to verify and monitor the value of the supply current, *i*. Record *i*. Measure and record the currents i_1 and i_2 in resistors R_1 and R_2, respectively.
6. Repeat Step 5 with R_1 = 47Ω and R_2 = 100Ω . Make sure the supply current stays at 30 mA. Turn the DC power supply off when replacing the resistors.
7. Built the *voltage divider* circuit in Figure 8. Use the 5V supply port of the DC power source to set *v* to 5V DC, and use R_1 = 470Ω and R_2 = 1kΩ . Use the voltmeter to verify the value of *v*. Measure and record the voltage drops v_1 and v_2 across resistors R_1 and R_2, respectively.
8. Repeat Step 7 with R_1 = 4.7MΩ and R_2 =10MΩ. Make sure the supply voltage stays at 5V.
9. Build the *voltage divider* circuit based on the 10kΩ potentiometer, as shown in Figure 11. Use the DC power source to set *v* to 5V DC. Connect the voltmeter to monitor v_1. Turn the potentiometer knob until the voltmeter reads 2V. Disconnect the power supply.

Measure and record the resistance of the potentiometer's R_1 portion (refer to Figure 10).

10. Measure and record the resistance of the thermistor at lab temperature (do not touch any part of the thermistor for at least 1 min before you make your measurement). Repeat the measurement while (firmly) holding the glass part of the thermistor between your thumb and index fingers (record the measurement after the ohmmeter reading stops changing).
11. Build the temperature sensor circuit shown in Figure 13. Measure and record the voltage v_T across the thermistor (at lab temperature). Repeat the measurement while (firmly) holding the glass part of the thermistor between your thumb and index fingers (record the measurement after the voltmeter reading stops changing).

12. Sort all components and give them back to your instructor.

Post-Lab Activity

Write a technical report that discusses your observations and includes analysis and justifications of all steps in this activity. Tabulate and/or plot experimental data whenever possible. More specifically, your report should address the following points:

Note:

- Use the actual (measured) resistor values in all theoretical calculations and in Multisim simulations.
- When you are asked to "compare" measured values to theoretical values, always compute the error in percent.

- Steps 2, 3 and 4: Calculate the theoretical value of the resistance of the three resistive networks. Also, employ Multisim to compute the resistance of each network. Compare the theoretical, the simulated and the experimental values.

- Steps 5 and 6: Compare the sum of the measured currents, $i_1(t) + i_2(t)$, to the source current value. Compare the measured current, $i_1(t)$, to the theoretical values obtained from Equations (1) and (2). Assume $R_A = 10\Omega$ in Equation (2).
- Steps 7 and 8: Compare the sum of the measured voltages, $v_1(t) + v_2(t)$, to the source voltage value. Compare the measured voltage, $v_1(t)$, to the theoretical values obtained from Equations (3) and (4). Assume $R_V = 10M\Omega$ in Equation (4).
- Step 9: Use the measured values for R, R_1 and v = 5V in Equation (5) to compute v_1. Compare it to 2V.
- Step 10: Give a rough approximation for the lab temperature and the temperature of your fingers, by comparing the measured thermistor resistances to the T-R_T values in the thermistor's data sheet.
- Step 11: Derive the temperature sensor T-v_T model in Equation (8). Employ the measured thermistor voltage in Equation (8) to compute the lab temperature and the temperature of your fingers.
- Consider the thermistor data presented in the Thermistor Section. Use your scientific calculator in STAT mode and apply regression analysis with various analytical functions (linear, quadratic, polynomial, logarithmic, exponential etc.) Try to arrive at a model that is more accurate than that in Equation (6). Use plots to compare your best result to the regression model in Equation (6).