UAF
UNIVERSITY OF ALASKA
FAIRBANKS

COLLEGE OF ENGINEERING AND MINES
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

COURSE CODE	EE F102 F01 (CRN: 34544)

COURSE NAME	INTRODUCTION TO ELECTRICAL AND COMPUTER ENGINEERING

SEMESTER	SPRING	YEAR	2022

LABORATORY LOCATION	ELIF 331 (ELECTRONICS LAB)

LAB SESSION DATE AND TIME	MONDAY 24 JAN 2022

TYPE OF SUBMISSION	LABORATORY REPORT	NUMBER OF SUBMISSION	1

TITLE OF SUBMISSION	MEASURING RESISTANCE

METHOD OF SUBMISSION	ONLINE TO: maher.albadri@alaska.edu

DUE DATE OF SUBMISSION	MONDAY 31 JAN 2022	DUE TIME OF SUBMISSION	23:59

STUDENT NAME	Jacob Guenther

MAKE THIS FORM A "COVER PAGE" FOR YOUR REPORT SUBMISSION.

FOR THE TA USE ONLY
REMARKS:

1 Objective

In this lab we review how to decode through hole resistors, how to measure resistance, and calculate the percent difference between values. We also apply the Steinhart-Hart equation (equation 2) to calculate the expected value of a thermistor. Further we gain experience plotting data.

2 Equipment

- Agilent 34501A Multimeter
- Alligator Clips
- 680 Ω Resistor x4
- 1 kΩ Resistor
- 47 kΩ Resistor
- Digital Thermometer
- NTC-103 Thermistor
- Hot water
- Snow

3 Setup

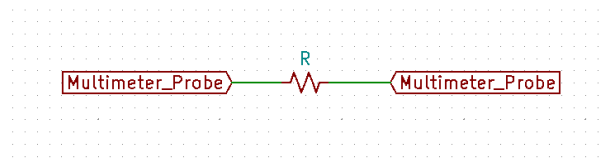For each resistor and the thermistor we use the following wiring diagram.

Figure 1: On either side of the resistor is a one of the multimeter probes.

4 Observations and Results

As part of this lab we decode the color bands of the resistors provided using figure 2.

Color	Digit	Multiplier	Tolerance
Silver		x 0.01 Ω	±10%
Gold		x 0.1 Ω	±5%
Black	0	x 1 Ω	
Brown	1	x 10 Ω	±1%
Red	2	x 100 Ω	±2%
Orange	3	x 1 kΩ	
Yellow	4	x 10 kΩ	
Green	5	x 100 kΩ	±0.5%
Blue	6	x 1 MΩ	±0.25%
Violet	7	x 10 MΩ	±0.1%
Grey	8	x 100 MΩ	
White	9	x 1 GΩ	

Figure 2: Resistor color code

In table 1 we show or the decoded nominal values of the resistors, resistance measurements of the 680 Ω resistors, the 1 kΩ resistor, and the 47 kΩ resistor. Also in table 1 is the percent differences between the labeled value and measured value of each of the resistors calculated using equation 1.

Component	Component Marking	Decoded Value	Measured Resistance (Ω)	% Difference
680 Ω Resistor	blu, gry, brn, gold	$68 \times 10^1 = 680\Omega 5\%$	672.17	1.151
680 Ω Resistor	blu, gry, brn, gold	$68 \times 10^1 = 680\Omega 5\%$	671.9	1.191
680 Ω Resistor	blu, gry, brn, gold	$68 \times 10^1 = 680\Omega 5\%$	678.33	0.246
680 Ω Resistor	blu, gry, brn, gold	$68 \times 10^1 = 680\Omega 5\%$	675.31	0.69
1 kΩ Resistor	brn, blk, red, gold	$10 \times 10^2 = 1k\Omega 5\%$	992.45	0.755
47 kΩ Resistor	ylw, vlt, org, gold	$47 \times 10^3 = 47k\Omega 5\%$	46444	1.183

Table 1: Displays the decoded nominal value, measured resistance, and percent difference between the nominal and measured values for each of the resistors.

$$\%difference = \frac{|expected - measured|}{expected} \times 100 \tag{1}$$

In this lab we measured the resistance of a thermistor at three different temperatures. The temperatures where taken at room temperature, in a bucket of snow, and on the side of an electric kettle full of water. Table 2 shows the measured temperatures, the measured resistance at each temperature, the expected resistance at each temperature calculated from equation 2, and the percent difference between the measured and expected resistances calculated from equation 1.

$$R_{T1} = R_{T0}exp[B(\frac{1}{T_1} - \frac{1}{T_0})] \tag{2}$$

From the NTC-103 thermistor datasheet we find that R_{T0} is 1000 Ω, T_0 is 25 C, and B is 4100 K. To calculate the expected resistance (R_{T1}) we enter our measured temperature T_1 into the equation along with the values we found in the datasheet.

Environment	Temp C	Temp K	Temp F	Measured Resistance (Ω)	Expected Resistance (Ω)	% Difference
Cold	2.6	275.75	36.68	27200	30558	10.99
Room	30.7	303.85	87.26	10145	7726	31.31
Hot	54.5	327.65	130.1	5370	2899.3	85.22

Table 2: Contains the measured temperature and resistance of the thermistor at three different temperatures, the expected resistance at the temperature, and the percent differences between the expected and measured temperatures.

The final part of the lab we create a histogram(figure 3) of the entire classes measured resistance of the resistors and a plot of the classes thermistor data. The thermistor data shows the measured data overlayed over a plot of the expected values.
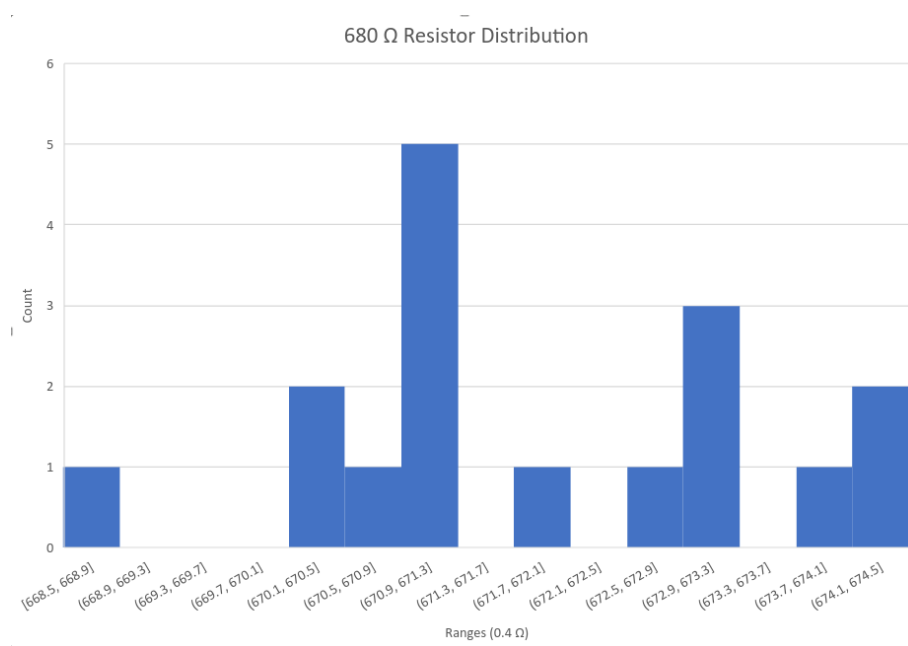
Figure 3: Count vs Resistance - 680 Ω resistor histogram with 0.4 Ω bins.
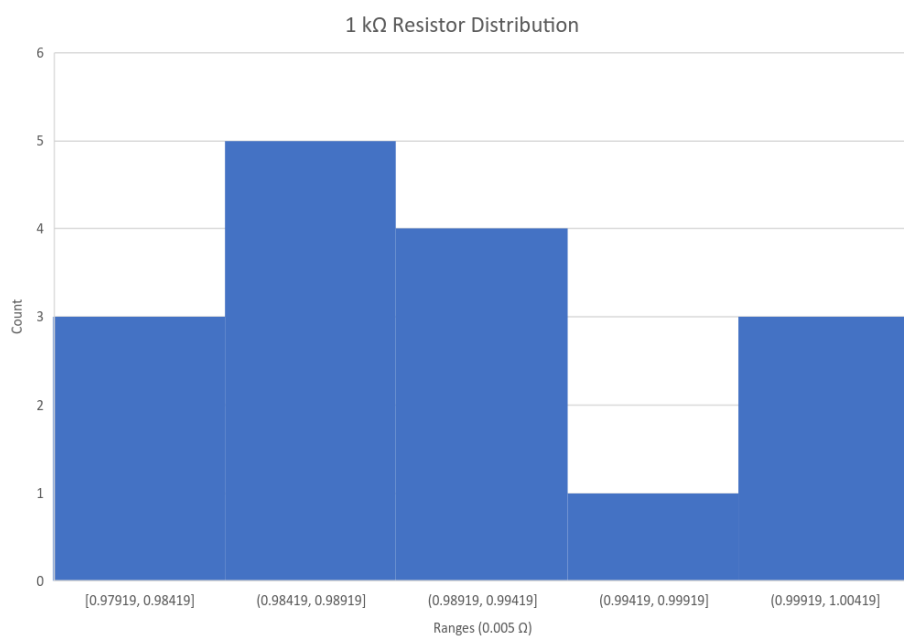

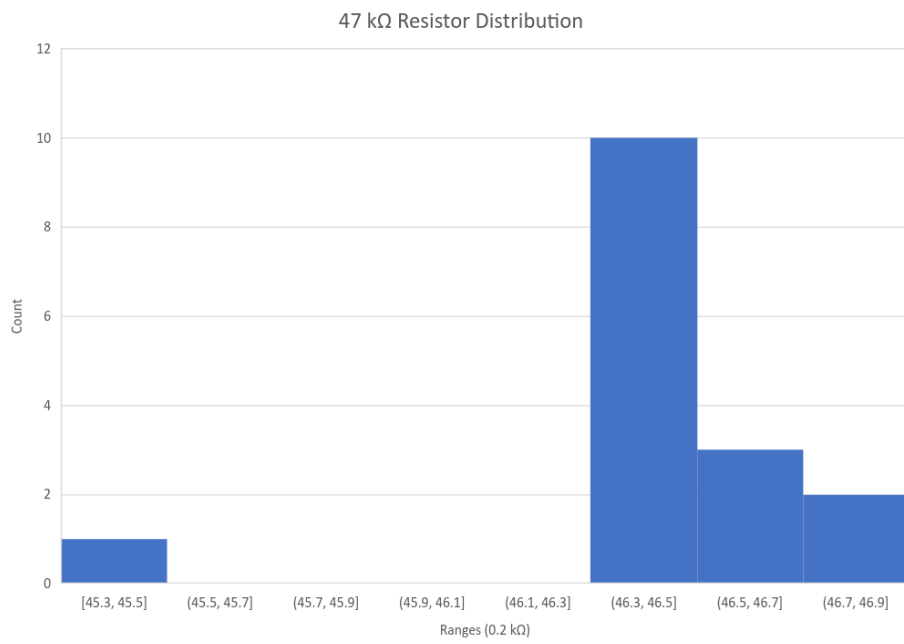Figure 4: Count vs Resistance - 1 kΩ resistor histogram with 0.005 Ω bins.
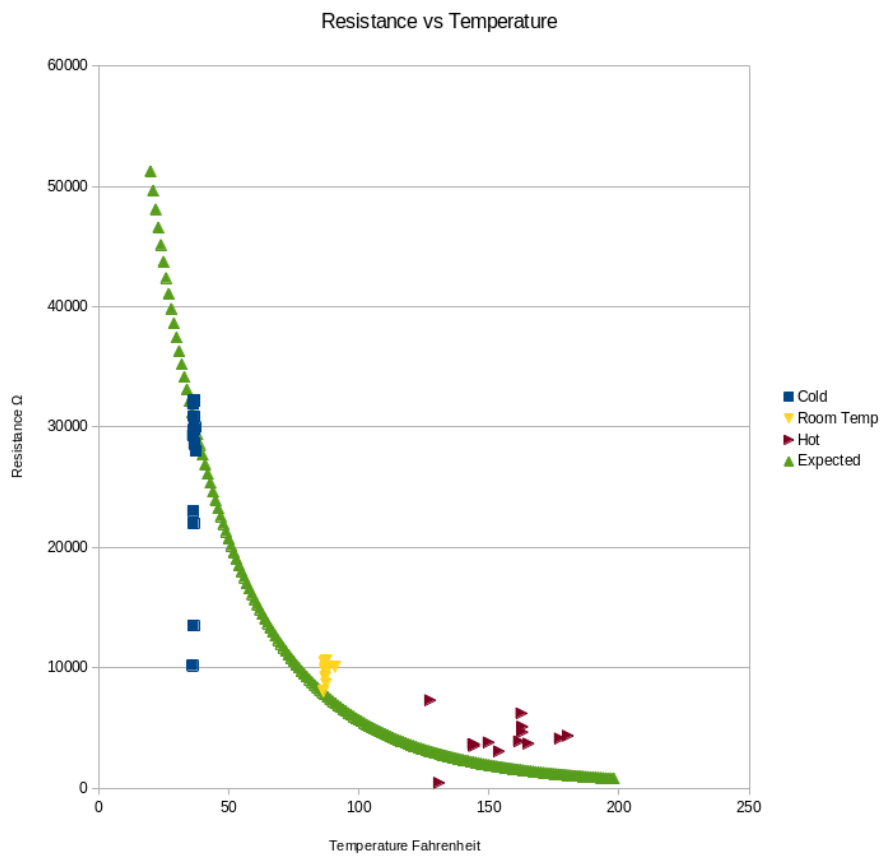
Figure 5: Count vs Resistance - 47 kΩ Resistor

Figure 6: Resistance vs Temperature - Thermistor

5

5   Conclusion

Reviewing the 680 Ω resistors reveals that one students samples had an average of 668.5 ohms. This has the largest percent difference from the nominal value. The % difference for their samples was 1.9%. This is still within the 5% tolerance. From looking at the histogram (figure 3) this appears to be an outlier.

Reviewing the measurements for the 1 kΩ resistors shows us that the greatest percent difference from the nominal value is 2.08%. The next greatest percent difference is 1.74%. The histogram (figure 4) does not appear to indicate that this is an outlier, however I opted to use a a resolution that doesn't show as much of the spread.

Reviewing the measurements for the 47 kΩ resistors shows us that the greatest percent difference from the nominal value is 3.62%. The value 45.3 kΩ is still within the tolerance. Referring to the histogram (figure 5) shows us that most measured values where 46.3 kΩ and 46.5 kΩ.

All of the reported values for the resistor are within their tolerance.

5.1   Thermistor Plot

The resistance of the cold measurements has the widest range. This could be caused by students being impatient and not letting the thermistor cool all the way. The room temperature measurements are the most consistent. The hot temperature measurements have the largest spread of temperatures. This could be caused by the kettle turning on and off. The variation between the measured resistance and the expected resistance could be due to the students not letting the thermistor stabilize, or because the thermister might not have had as good of a contact with the kettle as the temperature probe.

5.2   Sources of Error

There are many possible sources of error in our measurements. Below is an incomplete list of the sources.

- The Sternhart-Hart equation (equation 2) is an approximation that may not be an exact match for our thermistor.

- Humans may be impatient waiting for the thermistor to stabilize.

- The digital thermometer's probe is much smaller and less rounded than the thermistor allowing it to make better contact with the kettle allowing it to have better heat transfer.

6 References

[1] Denise Thorsen, Maher Al-Badri, INTRODUCTION TO ELECTRICAL AND COMPUTER ENGINEER-ING, University of Alaska Fairbanks, 2022.

[2] NTC THERMISTOR, Jameco