Title: **Wheatstone Bridge with RTD** Lab: 21

Course: Electrical Applications Unit: Electrical Lab CLO: 2, 3, 4

Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Grade \_\_\_\_\_\_\_ Date \_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Objectives**

1. Student shall calculate a Wheatstone bridge balanced circuit’s resistance values.
2. Student shall construct a Wheatstone bridge and observe its behavior.
3. Student shall measure bridge voltage with an RTD and adjust bridge resistance to obtain the unknown resistance value.
4. Student shall identify the function and use of a resistance temperature detector (RTD).

**Assessment**

Students shall demonstrate a comprehension of the objectives listed above by scoring a minimum of 75% on this Lab. Grading shall be based on instructor evaluation.

**Materials**

|  |  |
| --- | --- |
| Student Provided Materials | Department Provided |
| Proto board | Power Supply |
| Multimeter | Resistance Temperature Detector (RTD) |
| Resistor Kit |  |
| Calculator |  |

**Theory**

Resistance temperature detectors (RTDs), are sensors used to measure temperature. Many RTD elements consist of a length of fine wire wrapped around a ceramic or glass core but other constructions are also used. The RTD wire is a pure material, typically platinum, nickel, or copper. The material has an accurate resistance/temperature relationship which is used to provide an indication of temperature. As RTD elements are fragile, they are often housed in protective probes.



To determine the temperature, first the value of the unknown resistance must be ascertained (refer to previous Lab assignment). Once a balanced bridge voltage is obtained and the RTDs resistance value computed, a cross-reference table that correlates ohms to ˚F can be utilized to determine the temperature that the probe is measuring.

**Table**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ˚F | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 | ˚F |
| 30 | 99.57 | 99.78 | 100.00 | 100.22 | 100.43 | 100.65 | 100.87 | 101.09 | 101.30 | 101.52 | 101.74 | 30 |
| 40 | 101.74 | 101.95 | 102.17 | 102.39 | 102.60 | 102.82 | 103.04 | 103.25 | 103.47 | 103.69 | 103.90 | 40 |
| 50 | 103.90 | 104.12 | 104.34 | 104.55 | 104.77 | 104.98 | 105.20 | 105.42 | 105.63 | 105.85 | 106.07 | 50 |
| 60 | 106.07 | 106.28 | 106.50 | 106.71 | 106.93 | 107.15 | 107.36 | 107.58 | 107.79 | 108.01 | 108.23 | 60 |
| 70 | 108.23 | 108.44 | 108.66 | 108.87 | 109.09 | 109.30 | 109.52 | 109.73 | 109.95 | 110.17 | 110.38 | 70 |
| 80 | 110.38 | 110.60 | 110.81 | 111.03 | 111.24 | 111.46 | 111.67 | 111.89 | 112.10 | 112.32 | 112.53 | 80 |
| 90 | 112.53 | 112.75 | 112.96 | 113.18 | 113.39 | 113.61 | 113.82 | 114.04 | 114.25 | 114.47 | 114.68 | 90 |
| 100 | 114.68 | 114.90 | 115.11 | 115.33 | 115.54 | 115.76 | 115.97 | 116.18 | 116.40 | 116.61 | 116.83 | 100 |
| 110 | 116.83 | 117.04 | 117.26 | 117.47 | 117.68 | 117.90 | 118.11 | 118.33 | 118.54 | 118.76 | 118.97 | 110 |
| 120 | 118.97 | 119.18 | 119.40 | 119.61 | 119.82 | 120.04 | 120.25 | 120.47 | 120.68 | 120.89 | 121.11 | 120 |
| 130 | 121.11 | 121.32 | 121.53 | 121.75 | 121.96 | 122.18 | 122.39 | 122.60 | 122.82 | 123.03 | 123.24 | 130 |
| 140 | 123.24 | 123.46 | 123.67 | 123.88 | 124.09 | 124.31 | 124.52 | 124.73 | 124.95 | 125.16 | 125.37 | 140 |
| 150 | 125.37 | 125.59 | 125.80 | 126.01 | 126.22 | 126.44 | 126.65 | 126.86 | 127.08 | 127.29 | 127.50 | 150 |
| 160 | 127.50 | 127.71 | 127.93 | 128.14 | 128.35 | 128.56 | 128.78 | 128.99 | 129.20 | 129.41 | 129.62 | 160 |
| 170 | 129.62 | 129.84 | 130.05 | 130.26 | 130.47 | 130.68 | 130.90 | 131.11 | 131.32 | 131.53 | 131.74 | 170 |
| 180 | 131.74 | 131.96 | 132.17 | 132.38 | 132.59 | 132.80 | 133.01 | 133.23 | 133.44 | 133.65 | 133.86 | 180 |
| 190 | 133.86 | 134.07 | 134.28 | 134.50 | 134.71 | 134.92 | 135.13 | 135.34 | 135.55 | 135.76 | 135.97 | 190 |

**Circuit**



Where;

Calculations

If R3 was set to 6.8kΩ, complete the following table using the given quantities above.

**NOTE:** Do not measure the RTD. This exercise is to determine the resistance without measuring the RTD with your ohmmeter.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | P | I | R | E |
| R1 |  |  |  |  |
| R2 |  |  |  |  |
| R3 |  |  |  |  |
| R4 |  |  |  |  |
| Total |  |  |  |  |

1. Based on the calculations above, what should be the expected bridge voltage (EEF)? \_\_\_

Measurement

Adjust R3 to 6.8kΩ. Build the circuit should above. Measure and record each component in the circuit and complete the following table.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | P | I | R | E |
| R1 |  |  |  |  |
| R2 |  |  |  |  |
| R3 |  |  |  |  |
| R4 |  |  |  |  |
| Total |  |  |  |  |

1. Measure and record the bridge voltage (EEF)? \_\_\_\_\_\_\_\_\_\_

**NOTE:** When taking readings like EEF, the red lead of your meter is placed on the first reference point *“E”* and the black lead is placed on the second reference point *“F”*. Bridge voltages can be negative.

1. Is the bridge voltage calculated in step 2 comparable to the measured bridge voltage in step 3? Why or why not?
2. Using the measured quantities above, calculate the appropriate value that R3 should be adjusted to obtain a balanced bridge.

Calculated R3 \_\_\_\_\_\_\_\_\_\_\_\_\_\_.

1. Place your voltmeter to measure bridge voltage and adjust R3 until the voltmeter reads zero volts. Turn off your power supply, remove R3 and measure the resistance value.

Measured R3 \_\_\_\_\_\_\_\_\_\_\_\_\_\_.

1. Using the measured value for R3, calculate the resistance value of the RTD.

Measured R4 (RTD) \_\_\_\_\_\_\_\_\_\_\_\_\_\_.

1. Using the table on page 2, determine the temperature being measured by the RTD.

Measured Temp. \_\_\_\_\_\_\_\_\_\_\_\_\_\_.

1. Collect a cup of cold water. Place the RTD in the cold water and repeat the above steps to determine the new temperature value.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | P | I | R | E |
| R1 |  |  |  |  |
| R2 |  |  |  |  |
| R3 |  |  |  |  |
| R4 |  |  |  |  |
| Total |  |  |  |  |

Measured Temp. \_\_\_\_\_\_\_\_\_\_\_\_\_\_.

Evaluations

1. If the bridge is balanced and the temperature increased, to obtain a balance bridge R3 would have to?
   1. Increase
   2. Decrease
   3. Remain the same
2. If the bridge is balanced and the temperature remained the same but the value of R3 decreased, the bridge voltage would?
3. Increase in magnitude
4. Decrease in magnitude
5. Remain the same
6. If the bridge voltage was negative, which voltage would have more potential?
7. EE
8. EF
9. EEF
10. If the bridge is positive and the temperature increases, the following if true.
11. The circuit moved closer to being balanced
12. The circuit moved farther way from being balanced
13. The circuit will be balanced