3 Measurement of Resistance

OBJECTIVES:

After performing this experiment, you will be able to:

1. Determine the listed value of a resistor using the resistor color code.
2. Use the DMM (or VOM) to measure the value of a resistor.
3. Determine the percent difference between the measured and listed values of a resistor.
4. Measure the resistance of a potentiometer and explain its operation.

READING:

Floyd, *Principles of Electric Circuits,* Sections 2–5 through 2–8

MATERIALS NEEDED:

Resistors: Ten assorted values

One potentiometer (any value)

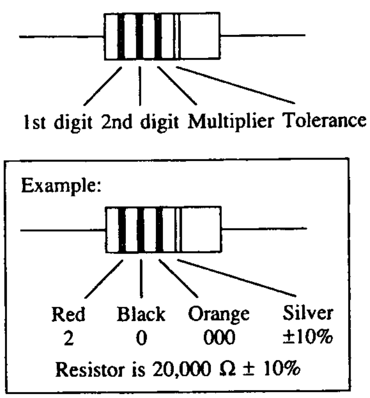
SUMMARY OF THEORY:

Resistance is the opposition a substance offers to current. The unit for resistance is the *ohm,* symbolized with the Greek letter capital omega (Ω). A resistor is a component designed to have a specific resistance and wattage rating. Resistors limit current but in doing so, produce heat. The physical size of a resistor is related to its ability to dissipate heat, *not* to its resistance. A physically large resistor can dissipate more heat than a smaller resistor; hence the larger one would have a higher wattage rating than the smaller one.

Resistors are either fixed (constant resistance) or variable. Fixed carbon and film resistors are usually color-coded with a four-band code that indicates the specific resistance and tolerance. Each color stands for a number. The conversion between numbers and colors is given in Table 3–1. Figure 3–1 shows how to read the resistance and tolerance of a four-band resistor.

Table 3–1

	Digit	Color
Resistance value, first three bands	0	Black
	1	Brown
	2	Red
	3	Orange
	4	Yellow
	5	Green
	6	Blue
	7	Violet
	8	Grey
	9	White
Tolerance, fourth band	5%	Gold
	10%	Silver
	20%	No band



Note: In the multiplier band, Gold = X 0.1
Silver = X 0.01

Figure 3–1

The resistance of resistors is measured using a DMM or VOM by placing the leads across the resistor. If you are using a VOM, the zero reading should be checked whenever you change ranges on the meter by touching the test leads together. If you are using a nonautoranging DMM, a suitable range needs to be selected. Resistance normally should not be measured in a circuit, because other resistors in the circuit will affect the reading. The resistor to be measured is removed from the circuit and the test leads are connected across the resistance. The resistor under test should not be held between the fingers because body resistance can affect the reading, particularly with high-value resistors. (It is okay to hold one end of the resistor under test.)

The most common form of variable resistor is the potentiometer. The potentiometer is a three-terminal device with the outer terminals having a fixed resistance between them and the center terminal connected to a moving contact. The moving contact is connected to a shaft that is used to vary the resistance between the moving contact and the outer terminals. Potentiometers are commonly found in applications such as volume controls.

PROCEDURE:

1. Obtain 10 four-band fixed resistors. Record the colors of each resistor in Table 3–2 in the report. Use the resistor color code to determine the color-code resistance of each resistor. Then measure the resistance of each resistor and record the measured value in Table 3–2. The first line has been completed as an example.

2. Compute the percent difference between the measured and color-coded values using the equation:

$$\% \text{ diff} = \frac{R_{\text{measured}} - R_{\text{color code}}}{R_{\text{color code}}} \times 100$$

   Enter the computed differences in Table 3–2.

3. Obtain a potentiometer. Number the terminals 1, 2, and 3, as illustrated in Figure 3–2. Vary the potentiometer's shaft while you monitor the resistance between terminals 1 and 3. Notice that the resistance between the outside terminals does not change as the shaft is varied. Record the resistance between terminals 1 and 3 of the potentiometer (the outside terminals) in Table 3–3 of your report.

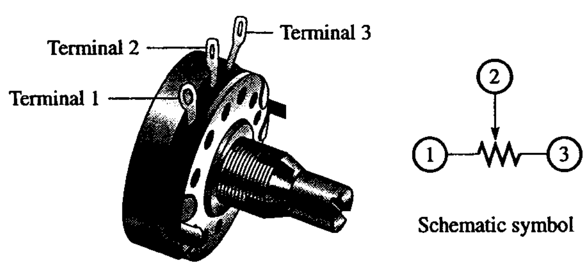


Figure 3–2

4. Turn the potentiometer completely counterclockwise (CCW). Measure the resistance between terminals 1 and 2. Then measure the resistance between terminals 2 and 3. Record the measured resistances in Table 3–3. Compute the sum of the two readings and record it in Table 3–3.

5. Turn the shaft ⅓ turn clockwise (CW) and repeat the measurements in step 4.

6. Turn the shaft to the ⅔ position (CW) from the starting point and repeat the measurements in step 4.

FOR FURTHER INVESTIGATION:

This experiment described how to read 5% and 10% tolerance resistors. The same idea is used for most 1% and 2% resistors except that 1% and 2% will have one more color band than 5% and 10% resistors. The first three bands represent the first, second, and third significant figures. The fourth band represents the multiplier band. The decimal point is assumed to be after the third significant figure and then moved by the amount shown in the multiplier band. The fifth band represents the tolerance band. A 1% resistor has a brown tolerance band and a 2% resistor has a red tolerance band. There is a space between the fourth and fifth bands to avoid mistaking the tolerance band for the first significant figure and mistakenly reading the resistor backwards. For each of the resistors shown in Table 3–4, find the remaining information and complete the table. The first line is completed as an example.

APPLICATION PROBLEM:

At room temperature, all known materials have some resistance. Usually the resistance of wire can be ignored, but not always. Sometimes, when it is necessary to obtain a very small resistance, the resistance of wire is used. Each substance has a specific resistivity, which is characteristic of the material. The resistivity of copper, for example is $1.69 \times 10^{-8}\ \Omega\cdot\text{m}$. The resistance of a wire depends on its resistivity, length, and its cross sectional area as given in the equation:

$$R = \frac{\rho l}{A}$$

where R = resistance in ohms
ρ = resistivity, in ohm-meters
l = length of the wire in meters
A = area of wire in square meters

Assume you need a 0.5 Ω resistor and you have available #22 gauge wire with a diameter of 6.38×10^{-4} m. Compute the length of wire needed for the resistor. If you have a means of measuring the result, cut a piece based on your calculation and report the measured result.

Report for Experiment 3

Name ______________
Date ______________
Class ______________

ABSTRACT:

DATA:

Table 3–2

Resistor	Color of Band				Color-Code Value	Measured Value	% Difference
	1st	2nd	3rd	4th			
0	brown	green	red	silver	1.5 kΩ ± 10%	1.46 kΩ	−2.7%
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

Table 3–3

Step 3: Total resistance between terminals 1 and 3 = ______________				
Step	Shaft Position	Resistance Measured Between: Terminals 1–2	Resistance Measured Between: Terminals 2–3	Sum of Resistance Readings
4				
5				
6				

RESULTS AND CONCLUSION:

FURTHER INVESTIGATION RESULTS:

Table 3–4

Resistor	Color of Band					Color-Code Value	Minimum Value	Maximum Value
	1st	2nd	3rd	4th	5th			
0	brown	red	violet	brown	red	1.27 kΩ ± 2%	1.24 kΩ	1.30 kΩ
1						536 Ω ± 1%		
2						3.30 MΩ ± 2%		
3						97.6 kΩ ± 1%		
4	violet	green	black	gold	red			
5	brown	green	black	black	brown			

APPLICATION PROBLEM RESULTS:

EVALUATION AND REVIEW QUESTIONS:

1. (a) Identify any of the resistors measured in Table 3–2 that are out of tolerance.

   (b) You suspect that the percent difference between color-coded and measured values could be due to error in the meter. How could you find out if you are correct?

2. Predict the resistance between terminals 1–2 and 2–3 for the potentiometer if the shaft is rotated fully CW.

3. Determine the resistor color code for the following resistors. The tolerance is 10%.
   - (a) 12 Ω ____________
   - (b) 6.8 kΩ ____________
   - (c) 910 Ω ____________
   - (d) 4.7 MΩ ____________
   - (e) 1.0 Ω ____________

4. Determine the expected value for resistors with the following color codes.
   - (a) red-red-black-gold ____________
   - (b) violet-green-brown-silver ____________
   - (c) green-brown-brown-gold ____________
   - (d) white-brown-gold-gold ____________
   - (e) grey-red-yellow-silver ____________

5. A resistor is color-coded red-violet-orange-gold.

   (a) What is the largest value the resistor can be and still be in tolerance?

   (b) What is the smallest value the resistor can be and still be in tolerance?

6. Explain why experimental calculations should use measured values of resistors rather than color-coded values.