

Experiment 18

Ohmic and Non-ohmic Resistances

Advanced Reading:

(Serway) Chapter 27
Sections 27-1 to 27-3

Equipment:

- 1 universal circuit board
- 1 1-15 volt power supply
- 1 Kelvin DMM with leads
- 1 150 Ω resistor
- 1 330 Ω resistor
- 1 560 Ω resistor
- 1 unknown resistor
- 1 14 volt light bulb and socket
- 1 jumper
- 2 wire leads
- 1 Triple-scale milliammeter

Objective:

The object of this lab is to determine the resistance of several resistors by applying Ohm's Law. Students will also be introduced to the resistor color code.

Theory:

Ohm's law states that the current I that flows in a circuit is directly proportional to the voltage V across the resistance R of the circuit, or in mathematical form:

$$I = \frac{V}{R} \quad \text{Eq. 18-1}$$

A device is said to be " Ohmic" if the current I that flows through the circuit is directly proportional to the potential difference across the resistance. In other words, if V is doubled then I is doubled. If an "ohmic" device obeys the preceding criteria , then it follows that a "non-ohmic" device does not.

In this lab, the current flow through a resistor will be measured when the voltage across the resistors is varied and from this data, the resistance

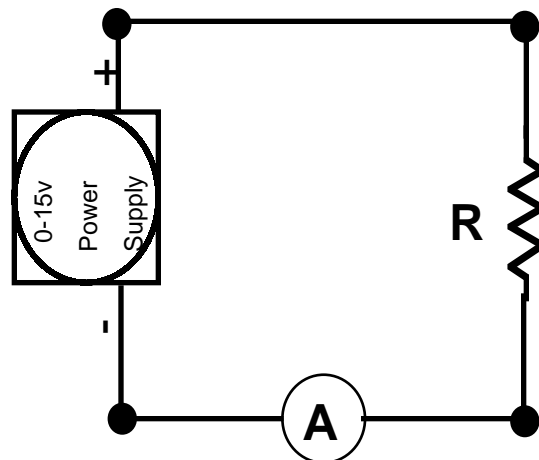


figure 18-1

determined. The current is measured using a triple-scale milliammeter.

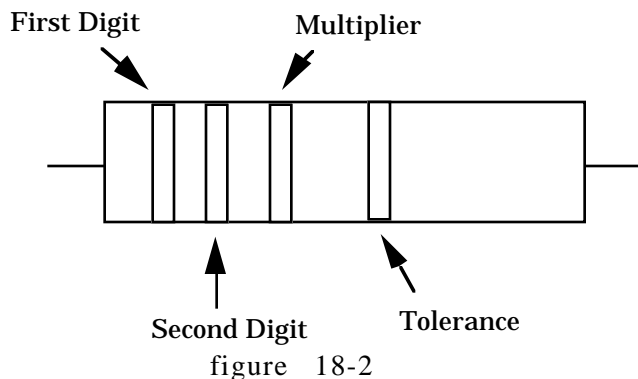
Ammeters are connected so that the current is through them. (see fig. 18-1) The ideal ammeter would have a resistance of zero so that it had no effect on the current. In reality ammeters have some resistance. On the other hand, the ideal voltmeter (the DMM in this case) has an infinite resistance. (approximately $10^7 \Omega$ in reality) This keeps the voltmeter from becoming an alternate path of current flow around the circuit element being measured.

The potential difference will be measured with the Digital multimeter, as in the Electric Field experiment. Voltmeters are connected in parallel to resistive elements in the circuit so that it measures the potential difference on each side of the element. The ideal voltmeter has an infinite resistance so that only a minuscule amount of current is through the voltmeter.

Resistor Color Code

There is a color coding scheme used to identify the value of the resistance of a resistor. The first two color bands give

the first two digits in the resistance value. The third band gives the multiplier for the first two in powers of ten. The last color is the tolerance. For example, a resistor that has two red bands and a black multiplier band, has a resistance of 22Ω . The figures below give the color code.



| Color | Number | Multiplier |
|------------------|--------|------------|
| Black | 0 | 10^0 |
| Brown | 1 | 10^1 |
| Red | 2 | 10^2 |
| Orange | 3 | 10^3 |
| Yellow | 4 | 10^4 |
| Green | 5 | 10^5 |
| Blue | 6 | 10^6 |
| Violet | 7 | 10^7 |
| Gray | 8 | 10^8 |
| White | 9 | 10^9 |
| <u>Tolerance</u> | | |
| Gold | 5% | |
| Silver | 10% | |
| no band | 20% | |

figure 18-3

Procedure:

1. Make a simple series circuit with the 150Ω (as shown in fig. 18-1), using the power supply, milliammeter, shunts, and wire leads. **Have the circuit approved by your**

instructor before turning anything on.

CAUTION: NEVER HOOK AN AMMETER IN PARALLEL WITH A POWER SUPPLY. IT HAS A RESISTANCE CLOSE TO ZERO AND COULD BE DAMAGED.

2. Plug in the power supply and adjust the voltage until the DMM reads a one volt potential difference across the resistor. Measure the current at this voltage. (Have the input wires to the milliammeter in such a position so that the meter reads as close to full scale as possible.)

3. Increase the voltage in one volt increments up to 12 volts, measuring the current through the resistor at each voltage level. Record all values of current I in amperes and voltage V in volts.

4. Repeat this procedure for the 330Ω , 560Ω , and unknown resistors

5. Graph I vs. V and plot a best fit line for each of the resistors on the same graph. Calculate the slope of each line. From these slopes, obtain the value of the resistances R for the resistors. Be sure to label each of the slopes appropriately.

6. Measure the resistance of each resistor using the ohmmeter function of the DMM. Do this by placing the input wires in the correct holes on the DMM and turning the dial to the ohms (Ω) position. The DMM provides a potential difference between the leads and measures the amount of current through the resistance.

7. Replace the resistors with the light bulb and repeat steps 2 and 3 for the light bulb. Plot a graph of I vs. V for the light bulb, only this time connect each data point with a best fit curve.

Questions/Conclusions:

1. Calculate the percent difference between the color code value and the experimental value found in this experiment for each resistor. Do these values fall within the bounds of the precision printed on the sides of the resistors? If they do not, what might be the reason for this?

2. What is the value of the unknown resistor determined from the graph? Calculate the percent difference between the value obtained from the graph and the ohmmeter value.

3. The resistors used in this experiment are 2 watt resistors. What is the maximum power output of the 150Ω resistor when 12 V is applied across it?

4. The power output of a circuit is given by

$$P = i^2 R = \frac{V^2}{R} = iV \quad \text{Eq. 18-2}$$

Calculate the power output of each resistive element when a potential of 12 volts is applied.

5. Verify dimensionally that equation 18-2 is correct. What are the units of power output?

6. Is the graph of I vs. V for the light bulb linear? What does this tell you about the resistance of a lightbulb as the filament gets hotter?