

2 LAB EXPERIMENT

OBJECT:

To analyze the measuring techniques for resistance and capacitance.

LEARNING OUTCOME:

In this lab students will be able to understand the following points:

- Measuring Techniques for Resistance.
- Measuring Techniques for Capacitance.

INTRODUCTION:

1. MEASURING TECHNIQUES FOR RESISTANCE:

Resistance is the measure of difficulty electrons have in flowing through a particular object. It is similar to the friction an object experiences when moving or being moved across a surface. Resistance is measured in ohms; 1 ohm is equal to 1 volt of electrical difference per 1 ampere of current. Resistance can be measured with an analog or digital multimeter or ohmmeter or it can also be measured manually with the help of resistor's colour coding.

1.1. MEASURING RESISTANCE WITH A DIGITAL MULTIMETER:

1. Choose the item whose resistance you wish to measure. For the most accurate measurement, test the resistance of a component individually. Remove the component from the circuit or test it before you install it. Testing the component while still in the circuit can cause inaccurate readings from other components.
 - If you are testing a circuit or even just removing a component, be sure that all power to the circuit is turned off before proceeding.

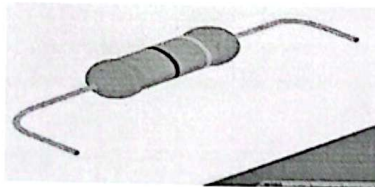


Figure 1: Resistor

2. Plug the test leads into the correct test sockets. On most multimeters, one test lead will be black and the other will be red. A multimeter often has multiple testing sockets, according to whether it is being used to test for resistance, voltage, or amperage (current). Usually the right sockets to test for resistance are

labeled "COM" (for common) and one labeled with the Greek letter omega, Ω , which is the symbol for "ohm".

- Plug the black lead into the socket labeled "COM" and the red lead into the socket labeled "ohm", as shown in figure 2.

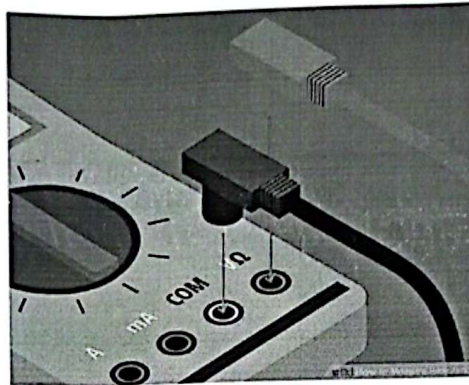


Figure 2: Plugging the probe into the correct socket of Multimeter.

3. Turn on the multimeter and select the best testing range. The resistance of a component can range from ohms (1 ohm) to megaohms (1,000,000 ohms). In order to get an accurate reading of resistance you must set the multimeter to the proper range for your component. Some digital multimeters will automatically set the range for you, but others will need to be set manually. If you have a general idea of the range of resistance just set it to that range. If you're unsure, you can determine the range through trial and error.
 - If you don't know the range, start with the middle range setting, usually 20 kilo-ohms ($k\Omega$).
 - Touch one lead to the end of your component and the other lead to the opposite end.
 - The number on the screen will either be 0.00, OL, or the actual value of resistance.
 - If the value is zero, the range is set too high and needs to be lowered.
 - If the screen reads OL (overloaded) the range is set too low and needs to be increased to the next highest range. Test the component again with the new range setting.
 - If the screen reads a specific number such as 58, that is the value of the resistor. Remember to consider the range applied. On a digital multimeter the upper right-hand corner should remind you of your range setting. If it has a $k\Omega$ in the corner, the actual resistance is 58 $k\Omega$.
 - Once you get in the right range, try lowering the range one more time to see if you can get a more accurate reading. Use the lowest range setting for the most accurate resistance readings, as depicted in figure 3.

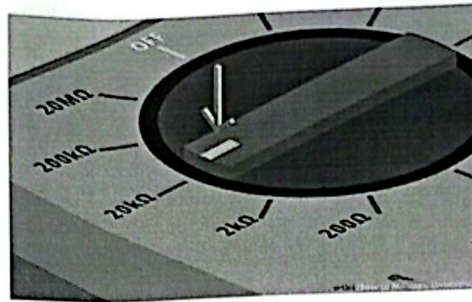


Figure 3: Turning the regulator to nearest value of resistance.

1. Touch the multimeter leads to the ends of the component you are testing. Just as you did when you were setting the range, touch one lead to one end of the component and the other lead to the opposite end. Wait until the numbers stop going up or down and record that number. This is the resistance of your component.
 - For example, if your reading is .6 and the upper right corner says $M\Omega$ the resistance of your component is 0.6 mega-ohms.

1.1. MEASURING RESISTANCE WITH A RESISTORS COLOR CODING:

The value of the resistor is marked on the body using colors. Every color is different number and you can remember these numbers or you can just use the table below.

As depicted in Figure 4, Band 'A' represents the 1st Digit, Band 'B' is the 2nd digit and Band 'C' is the Multiplier and Band 'D' represents Tolerance.

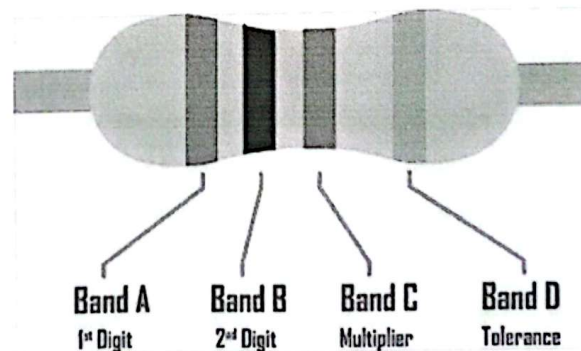


Figure 4: Different Bands of Resistor

Figure 5, represents the color coding associated with each Band. By using the color coding table we can decode the resistor value.

Color	Value	Multiplier	Tolerance
Black	0	$\times 10^0$	$\pm 20\%$
Brown	1	$\times 10^1$	$\pm 1\%$
Red	2	$\times 10^2$	$\pm 2\%$
Orange	3	$\times 10^3$	$\pm 3\%$
Yellow	4	$\times 10^4$	- 0, + 100%
Green	5	$\times 10^5$	$\pm 0.5\%$
Blue	6	$\times 10^6$	$\pm 0.25\%$
Violet	7	$\times 10^7$	$\pm 0.10\%$
Gray	8	$\times 10^8$	$\pm 0.05\%$
White	9	$\times 10^9$	$\pm 10\%$
Gold	-	$\times 10^{-1}$	$\pm 5\%$
Silver	-	$\times 10^{-2}$	$\pm 10\%$

4-band resistor



270 ohms $\pm 5\%$

5-band resistor



100k ohms $\pm 1\%$

Figure 5: Color Coding Chart

The first band is the first digit and the second band is the second digit of the resistor value. The third band is the multiplier, which is multiplied by the 1st and 2nd digit. The last band represents tolerance. This can also be observed in the below figure 6.

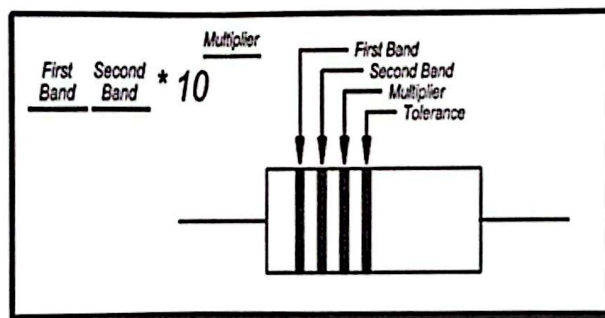


Figure 6: Label diagram of resistance.

View the resistors and based on the color bands determine its value. Below is an example:

Example 1:

Band	Color Code	Numeric Value
1 st Band	Brown	1
2 nd Band	Black	0
3 rd Band	Orange	10^3
4 th Band	Gold	$\pm 5\%$
The Resistor Value is 10K		The tolerance is $\pm 5\%$

The first band is a one (1), the second band is a zero (0), and the multiplier band or third band is one time raise to the third power or one thousand (1000). Multiply 10 times 1000.

2. MEASURING CAPACITOR WITH A DIGITAL MULTIMETER

A multimeter determines capacitance by charging a capacitor with a known current, measuring the resulting voltage, then calculating the capacitance.

2.1. Warning: A good capacitor stores an electrical charge and may remain energized after power is removed. Before touching it or taking a measurement, a) turn all power OFF, b) use your multimeter to confirm that power is OFF and c) carefully discharge the capacitor by connecting a resistor across the leads. Be sure to wear appropriate personal protective equipment.

2.2. To safely discharge a capacitor: After power is removed, connect a 20,000 Ω , 5-watt resistor across the capacitor terminals for five seconds. Use your multimeter to confirm the capacitor is fully discharged.

1. Use your digital multimeter (DMM) to ensure all power to the circuit is OFF. If the capacitor is used in an AC circuit, set the multimeter to measure ac voltage. If is used in a dc circuit, set the DMM to measure dc voltage.
2. Visually inspect the capacitor. If leaks, cracks, bulges or other signs of deterioration are evident, replace the capacitor.
3. Turn the dial to the Capacitance Measurement mode (Capacitance symbol). The symbol often shares a spot on the dial with another function. In addition to the dial adjustment, a function button usually needs to be pressed to activate a measurement.
4. For a correct measurement, the capacitor will need to be removed from the circuit. Discharge the capacitor as described in the warning above.
5. Connect the test leads to the capacitor terminals. Keep test leads connected for a few seconds to allow the multimeter to automatically select the proper range.
6. Read the measurement displayed. If the capacitance value is within the measurement range, the multimeter will display the capacitor's value. It will display OL if a) the capacitance value is higher than the measurement range or b) the capacitor is faulty.



Figure 7: Measuring capacitor value

2.3. CAPACITOR CODING:

Same as resistors, most of the capacitors have their nominal value printed directly on them using digital/alphabet code according to the EIA coding system. This code is generally given in Pico-farads (pF), which means that we need to manipulate the value if we want the value in microfarads (μF) or Nano-farads (nF). Some capacitors have polarity (positive and negative) which must be connected according to their polarity in order for the capacitor to operate such as the electrolytic capacitors. Normally the negative leg of electrolytic capacitor could be recognized by the white stripes at the body and/or the negative leg is shorter than the positive leg.

Some types of capacitors are shown in Figure 8 below.

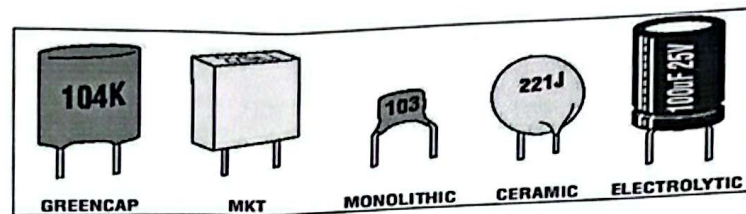


Figure 8: Various types of Capacitor construction.

2.3.1. Example 1:

- Capacitor marked 104 has value of 10 with 4 zeroes after it, or 100,000pF (equivalent to 100 nF or $0.1\mu\text{F}$)
- Capacitor marked 681 = 68 with single zero or 680 pF
- Capacitor marked 472 = 47 with 2 zeroes or 4700 pF (equivalent to 4.7nF)
- Alternatively, the value may be given directly in Nano-farads with three significant digits but the thirds generally '0'. In this case there is generally also a small 'n' which can be used in place of decimal points.

2.3.2.Example 2:

- Capacitor marked 220n has 220nF capacitances (equivalent to 0.22F)
- Capacitor marked 3n3 has 3.3nF capacitances (equivalent to 3300pF)
- Some of the capacitors have a capital letter to indicate their tolerance rating. Below is capacitor tolerance marking codes:

F	G	J	K	M	Z
$\pm 1\%$	$\pm 2\%$	$\pm 5\%$	$\pm 10\%$	$\pm 20\%$	-20%, +80%

Table 1: Capacitor Tolerance

2.3.3.Example 3:

$$104K = 0.1\mu\text{F} \pm 10\%,$$

$$4n7J = 4.7\text{nF} \pm 5\%$$

3. TASK 1:

Determine the value and tolerance of the 10 resistors as shown in the following tables:

Band	Color Code	Numeric Value
1 st Band	Orange	3
2 nd Band	Orange	3
3 rd Band	Orange	3×10^3
4 th Band	Silver	± 10
The Resistor Value is <u>33 KΩ</u>		The Tolerance is <u>± 10 %</u>

Band	Color Code	Numeric Value
1 st Band	Orange	3
2 nd Band	Orange	3
3 rd Band	Red	3×10^2
4 th Band	Silver	± 10
The Resistor Value is <u>3.3 KΩ</u>		The Tolerance is <u>± 10 %</u>

Band	Color Code	Numeric Value
1 st Band	Red	2
2 nd Band	Violet	7
3 rd Band	Brown	27×10
4 th Band	Gold	± 5
The Resistor Value is <u>270 Ω</u>		The Tolerance is <u>± 5 %</u>

Band	Color Code	Numeric Value
1 st Band	Brown	1
2 nd Band	Brown	1
3 rd Band	Red	11×10^2
4 th Band	Gold	± 5
The Resistor Value is <u>1.1 KΩ</u>		The Tolerance is <u>± 5 %</u>

Band	Color Code	Numeric Value
1 st Band	Yellow	4
2 nd Band	Violet	7
3 rd Band	Red	47×10^2
4 th Band	Silver	± 10
The Resistor Value is <u>4.7 KΩ</u>		The Tolerance is <u>± 10 %</u>

4. TASK 2:

Determine the nominal value of a particular capacitors based on digital/alphabet coding technique for each case given in Table below.

DIGITAL/ALPHABET CODE	NOMINAL VALUE (in nano-farad)
33J	0.033
15	0.015
104	100
220n	220
3n3J	3.3
103	10
103Z	10

EXERCISE:

QUESTION 1:

Describe some real-life applications of capacitors.

Capacitors are used to store electrical energy for a short time. They help smooth voltage in power supplies and reduce noise in circuits. They are also used in timers, motors, and radios to control signals and improve performance.

QUESTION 2:

Write the color coding of a 10k ohm resistor.

$$10 \text{ K}\Omega = 10,000 \Omega$$

- * First digit = 1 → Brown
- * Second digit = 0 → Black
- * Multiplier (10^3) → Orange
- * Tolerance is typically ($\pm 5\%$) which is gold, or silver which is $\pm 10\%$.