

Name _____

Section _____

PURPOSE

To become familiar with the use of potentiometers.

To use a variable resistor first as a potentiometer to control voltage and then as a rheostat to control current.

EQUIPMENT

LAB SUPPLIED PARTS

DC power supply
DMM

PARTS KIT PARTS

Set of meter leads
Set of clip to clip jumper leads
2 - 4.7 kΩ resistor
1 - 10kΩ linear potentiometer (R103)

INTRODUCTION

Sometimes it is desirable to change the value of the resistor once it has been installed in a circuit. For these applications, we use a variable resistor.

The resistance of a variable resistor can be adjusted by turning a knob, rotating the screw, or adjusting a slider. There are two major classes of variable resistors: *rheostats and potentiometers*.

Often these two classes are actually the same physical device; it is the electrical connection that distinguishes the two types of variable resistors.

The volume control on a receiver or amplifier is an example of variable resistor used as a potentiometer.

As a general rule, potentiometers are used to control voltage levels and rheostats are used to control current levels.

Figure 1 shows a cutaway view of potentiometer. A sliding contact is moved along the strip of resistive material to adjust the value of the component.

The 2 outer solder terminals (A & C) are fixed to the end of the resistive material. The sliding contact can be set anywhere along the resistive material.

Potentiometers How they Work

With potentiometers, the resistance between terminals A and C (R_{AC}) is always constant.

As an example, let's say that the resistive material between terminals A and C has a resistance of 1k Ω.

See Figure 2.

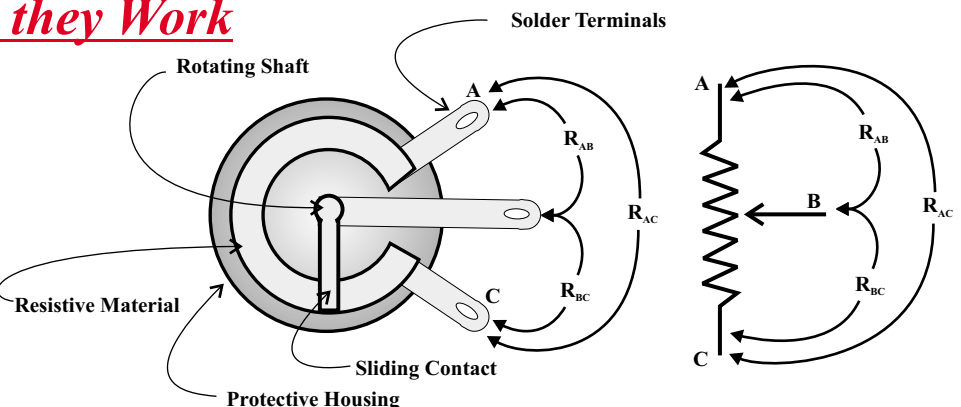
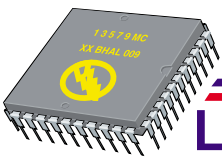


Figure 1 Cutaway view of a potentiometer and its schematic symbol



As you can see in Figure 2, the slider (or wiper arm) is closer to terminal C than it is to terminal A. In our example, approximately 75 % of the resistive material is between the wiper arm and terminal A with the remaining 25% between the wiper arm and terminal C.

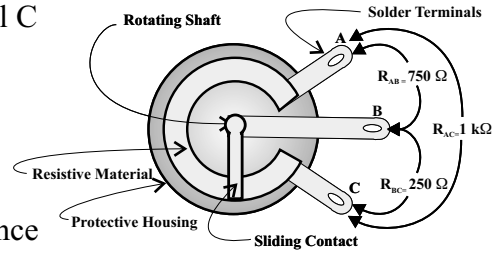


Figure 2 - 1 kΩ Pot

If we were to take an ohmmeter and measure the resistance between terminals A & B (R_{AB}), we would read approximately 750Ω. The resistance between terminals B & C (R_{BC}) would read approximately 250Ω.

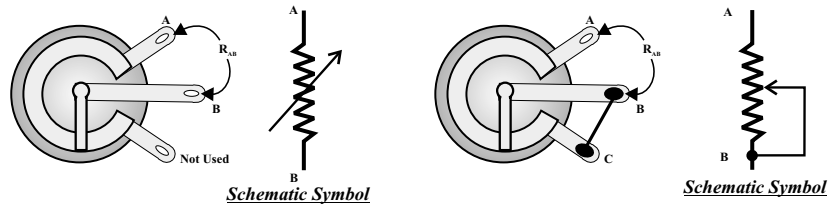
If we were to move the slider, we would find that (R_{AB}) and (R_{BC}) will change however they will always add up to 1kΩ.

If we moved the wiper arm towards terminal A, then (R_{AB}) would decrease. At the same time (R_{BC}) would increase by the same amount.

Added together, $R_{AB} + R_{BC}$ always equal R_{AC} in this case 1kΩ.

Rheostats

Figure 3 shows two ways to wire a variable resistor has a rheostat.



Use only Terminals A & B.

Connect terminals B & C together with a wire.

Figure 3 Two Ways to wire a Potentiometer as a Rheostat

The Potentiometers In Your 1st Year Kit

Figure 4 shows a top and side view of the potentiometer you will use. This potentiometer is designed to fit exactly into your breadboard. Note that the pins A, B, C will fit exactly into your board.

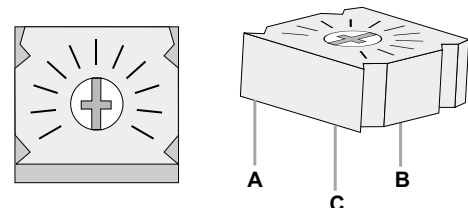


Figure 4 Top & Side view of Miniature Pot.

Adjustment to the potentiometer is made by using a screwdriver (blade or Philips). You can adjust the position of the wiper arm by turning the centre white screw of the potentiometer.

Note the circular graduations that surround the centre screw. They can be used to locate an approximate position of the wiper arm.

Figure 5, shows a cutaway view of the inside of the potentiometer. Note that pins A and C are the two ends of the resistive material in the potentiometer. Pin B is attached to the wiper arm.

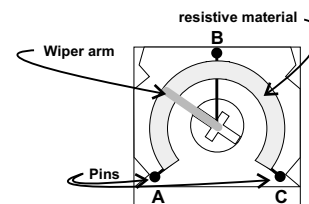
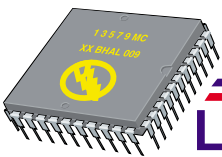


Figure 5 Inside the Pot

How to Read the Value of Miniature Potentiometers

If you look on the side of these potentiometers you will see a 3 digit number. (This number may or may not be preceded by a letter) A 1 kΩ potentiometer is identified by the number 102. The first two digits (10) are the most significant digits of its value. The last digits (2) is the number of zeros that must be added. In our case the most significant digits are 10 - then add two zeros. This gives the number 1000 or 1 kΩ.



Electro - Principles I

Lab 7 Potentiometers & Rheostats

How to Use Miniature Potentiometers

These small potentiometer will fit directly into your breadboard as shown in Figure 6.

Wires can be inserted into the appropriate holes to connect the potentiometer to the circuit.

The points marked A, B, C indicate the pin positions on the potentiometer.

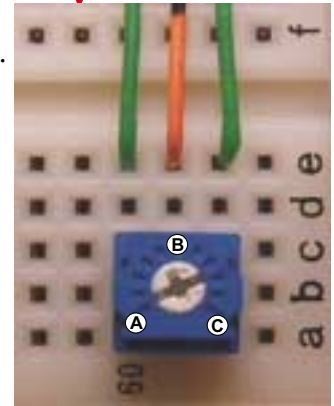


Figure 6 - A miniature potentiometer mounted on a breadboard

Procedure Potentiometer Characteristics

- 1) Mount the 10 kΩ potentiometer on your breadboard. Using a screwdriver, familiarize yourself with the travel of the wiper arm by carefully turning the adjustment from stop to stop.
- 2) Breakdown the region between full CW and full CCW of the potentiometer as shown in Figure 7. Your locations for 1/4, 1/2, and 3/4 turn should be similar to Figure 7.
- 3) Connect the DMM to the terminals indicated in Table 1 and record the resistance value for each setting.

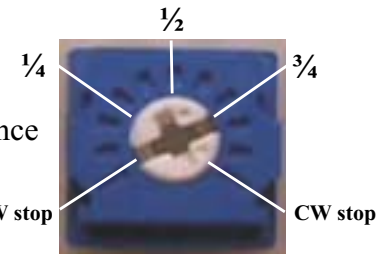


Figure 7 Wiper arm positions

Table 1

Potentiometer Setting	Resistance to be Measured		
	R_{AC}	R_{AB}	R_{BC}
CCW stop			
1/4 turn			
1/2 turn			
3/4 turn			
CW stop			

- 4) Plot the resistances R_{AC} , R_{AB} , R_{BC} versus wiper position on the graph shown as Figure 8

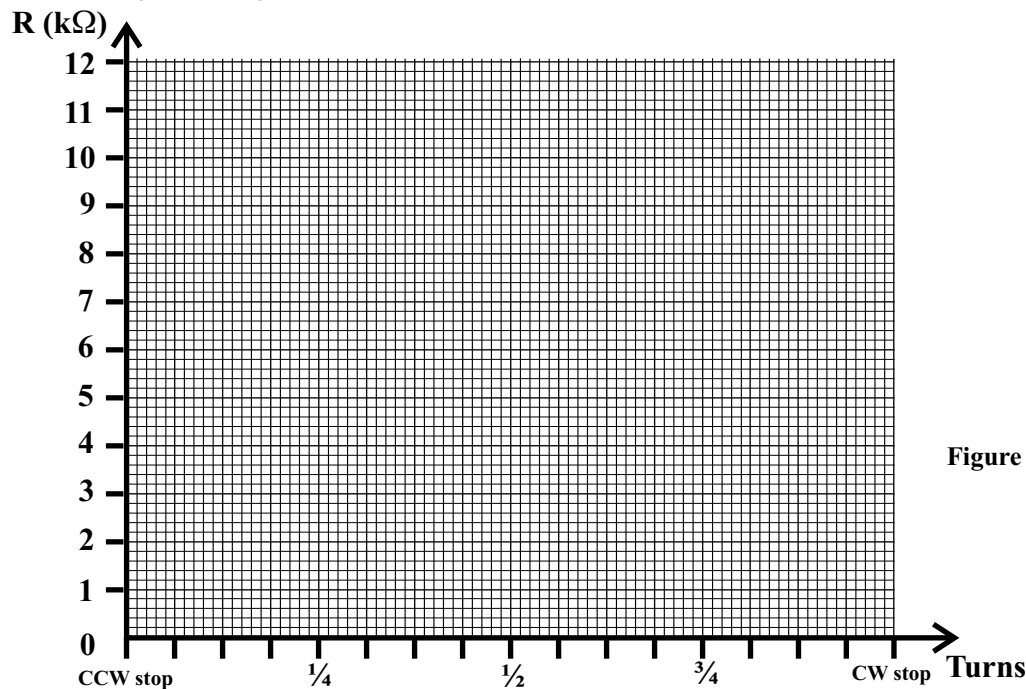
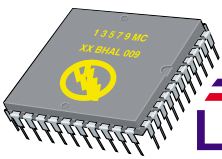


Figure 8 Graph



Questions

a) Determine R_{AC} from $R_{AC} = R_{AB} + R_{BC}$ at the $\frac{1}{4}$ turn position.

$$R_{AC} = R_{AB} + R_{BC} = \underline{\hspace{2cm}} + \underline{\hspace{2cm}} = \underline{\hspace{2cm}}$$

b) Repeat the above for the $\frac{1}{2}$ turn position

$$R_{AC} = \underline{\hspace{2cm}}$$

c) How does the values obtained above for R_{AC} compare to the measured value of R_{AC} at each location.

d) Does R_{AC} (the resistance between the two outermost terminals) remain fairly constant throughout the measurement span? Why?

e) Does the resistance R_{AB} increase at the same rate as the resistance R_{BC} decreases as the control knob is turned from the CCW to CW position? Should it?

f) At $\frac{1}{2}$ turn, does $R_{AB} = R_{BC}$? Should they be equal? Why?

Potentiometer Control of Voltage Levels

1) Construct the circuit shown in Figure 9. Set the supply voltage with a DMM.

2) Using the DMM, read the voltages V_{CA} , V_A , V_{CB} at each step of the sequence indicated in Table 2. Be sure to read both voltages before changing the setting. Do not change the setting based on your readings.

Leave the setting as determined by your judgments made earlier for wiper position.

3) Plot the voltages V_{CA} , V_{BA} , V_{CB} versus position on the graph shown as Figure 10.

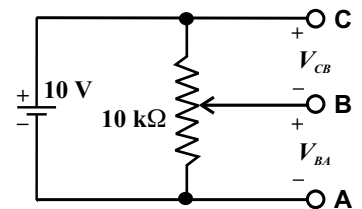


Figure 9

Table 2

Potentiometer Setting	Voltage to be Measured		
	V_{CA}	V_{BA}	V_{CB}
CCW stop			
$\frac{1}{4}$ turn			
$\frac{1}{2}$ turn			
$\frac{3}{4}$ turn			
CW stop			

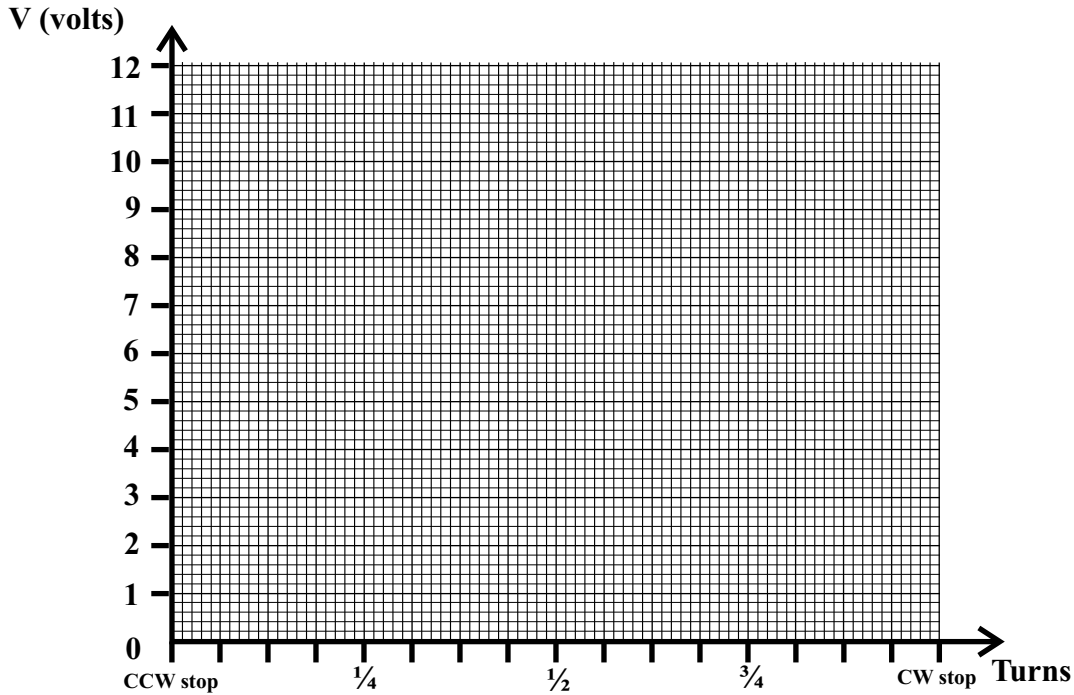
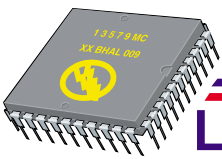


Figure 10 - Linear control of potential levels

Questions

a) Which voltage remains independent of the position of the rotor? Why?

b) What are the minimum and maximum values of V_{BA} and V_{CB} . Why?

c) At the $5/8$ turn position on the Figure 10 graph, does $V_{CA} = V_{CB} + V_{BA}$ using the graphical data.

V_{CA} _____ V_{CB} _____ V_{BA} _____

If it does - explain why?

Rheostats

1) Build the circuit shown in Figure 11. Use the DMM as an ammeter to measure the circuit current. Measure the maximum and minimum circuit currents by turning the potentiometer adjustment from stop to stop and taking the measurement.

Measured $I_{(max)}$ _____ Measured $I_{(min)}$ _____

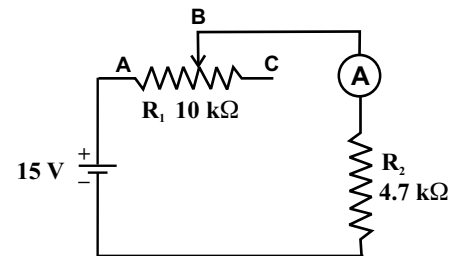


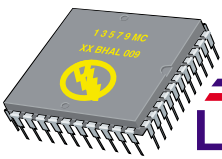
Figure 11 The Rheostat

2) Remove the rheostat from the circuit and measure the maximum and minimum resistance

Measured $R_{(max)}$ _____ Measured $R_{(min)}$ _____

3) Using the measured values of resistance, calculate the minimum and maximum value of circuit current.

Calculated $I_{(max)}$ _____ Calculated $I_{(min)}$ _____



Unloaded and Loaded Potentiometers

The Unloaded Potentiometer

- 1) Build the circuit as shown in Figure 11.
- 2) Measure the maximum and minimum values of V_{BA} & record them below.

$V_{BA(min)}$ _____ $V_{BA(max)}$ _____

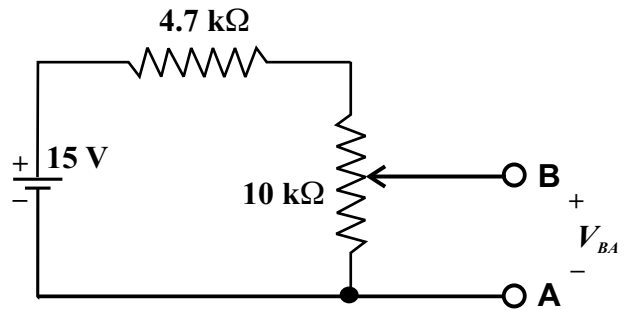


Figure 11 Unloaded Potentiometer

Questions

a) Why is V_{BA} maximum less than the supply voltage of 15 V ? _____

b) Calculate the value of $V_{BA(max)}$ here.

The Loaded Potentiometer

If a load is connected across the output of a potentiometer circuit, it will tend to reduce the maximum available output voltage.

With the wiper at the top of the potentiometer (the maximum output voltage position) a load resistance provides an additional path for current increasing the current through the resistor R_1 .

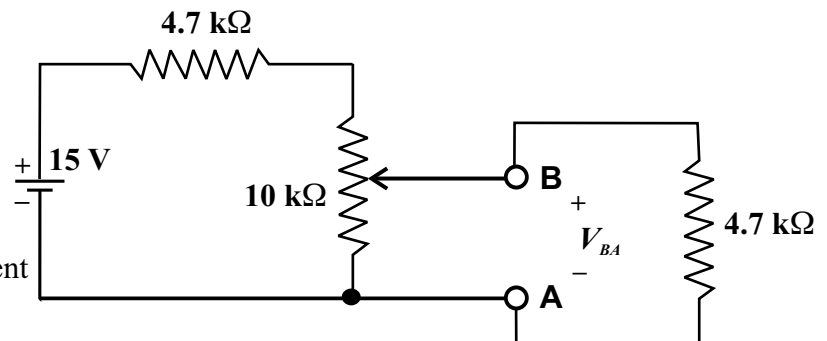


Figure 12 Loaded Potentiometer

The increased current through R_1 causes a greater voltage drop decreasing the maximum voltage available at the wiper terminal.

- 1) Add the load resistor as shown in Figure 12.
- 2) Measure the maximum and minimum values of V_{BA} & record them below.

$V_{BA(min)}$ _____ $V_{BA(max)}$ _____

3) Calculate the loaded value of $V_{BA(max)}$ here.

