Week 3

Experiment # 7

Objective: To Build and Test Photosensitive Eyes

Required parts: Figure 3.1 shows the new parts introduced in this experiment along with their schematic symbols. Below is a list of the parts you'll need. Both parts types of parts are non-polar, meaning that terminals 1 and 2 as shown may be swapped without affecting the circuit.

Sr. no	Part	Number
1	Piezoelectric speaker	1
2	Photo resistors	2
3	0.1 µF capacitors	2
4	0.01 µF capacitors	2
5	220 ? resistors	2
6	jumper wires	

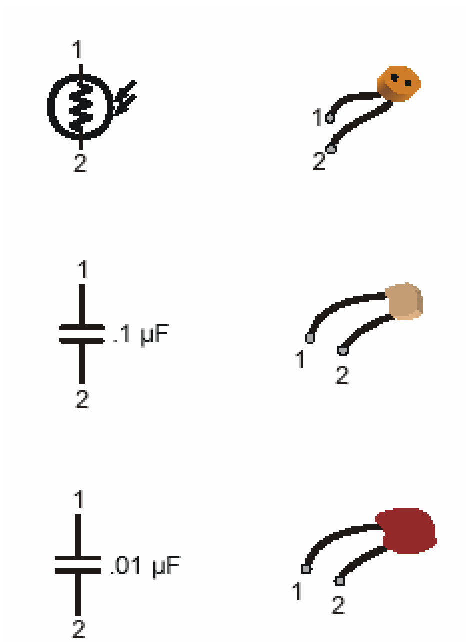

Figure 3.1 : Photo resistor and capacitor circuit symbols and parts.

Circuit building: Figure 3.2 shows (a) the resistor/capacitor (RC) circuit for each photoresistor and (b) a breadboard example of the circuit. A photoresistor is an analog device. Its value varies continuously as illuminance, another analog value, varies. The photoresistor's resistance is very low when its light-sensitive surface is placed in direct sunlight. As the light level decreases, the photoresistor's resistance increases. In complete darkness, the photoresistor's value can increase to more than 1 M? . Even through the photoresistor is analog, its response to light is nonlinear. This means if the input source (illuminance) varies at a constant rate, the photo resistor's value does not necessarily vary at a constant rate.

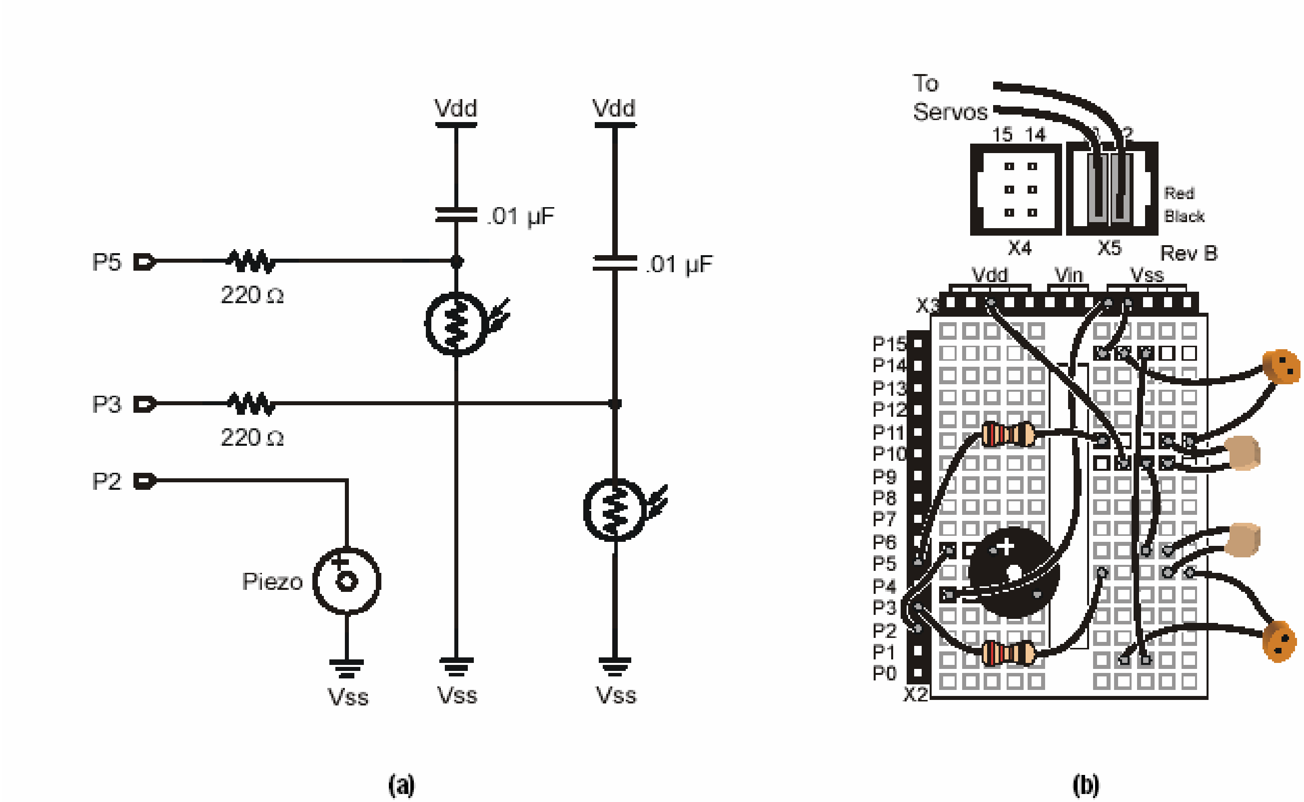

Figure 3.2: (a) Two photoresistor RC circuits for measurement of resistance that varies with light, and (b) breadboard example of the circuit.

Programming to Measure the Resistance: The circuit in Figure 3.2 (a) was designed for use with the PBASIC **rctime** command. This command can be used with an RC circuit where one value, either R or C, varies while the other remains constant. The **rctime** command lends itself to measuring the variable values because it takes advantage of a time varying property of RC circuits. The time it takes for the voltage on an RC circuit to change voltage depends on R × C, the RC time constant. The RC time constant is often denoted by the Greek letter Tau (?). For one of the RC circuits shown in Figure 3.2 (a), the first step in setting up the **rctime** measurement is charging the lower plate of the capacitor to 5 V. Setting the I/O pin connected to the lower capacitor plate by the 220? Resistor high for a few *ms* takes care of this. Next, the **rctime** command can be used to take the measurement of the time it takes the lower plate to discharge from 5 to 1.4 V. Why 1.4 V? Because that's the BASIC Stamp I/O pin's threshold voltage. When the voltage at an I/O pin set to input is above 1.4 V, the value in the input register bit connected to that I/O pin is “1.” When the voltage is below 1.4 V, the value in the input register bit is “0.”

The **rctime** command for the circuit shown in Figure 3.2 measures how long it takes for the voltage at the lower plate of the capacitor to fall from 5 to 1.4 V. This time varies according to the formula:

$$\frac{t}{R \times C} = \ln\left(\frac{V_{initial}}{V_{final}}\right)$$

$$\frac{t}{R \times 0.01 \times 10^{-6}} = \ln\left(\frac{5\ V}{1.4\ V}\right)\ \ s$$

$$t = \ln(3.57) \times R \times 0.01 \times 10^{-6}\ \ s$$

$$t = 1.27 \times 10^{-8} \times R\ \ s \qquad \text{..............................}\mathbf{1.1}$$

Equation 1.1 indicates that the time it takes the voltage at the lower plate of the capacitor in one of the Figure 3.2 (a) RC circuits to drop from 5 to 1.4 V is directly proportional to the photoresistor’s resistance. Since this resistance varies with illuminance (exposure to varying levels of light), so does the time. By measuring this time, relative light exposure can be inferred.

The **rctime** command changes the I/O pin from output to input. As soon as the I/O pin becomes an input, the voltage at the lower plate of the capacitor starts to fall according to the time equation just discussed. The BASIC Stamp starts counting in 2 µs increments until the voltage at the capacitor’s lower plate drops below 1.4 V.

Run Program Listing 3.1. It demonstrates how to use the **rctime** command to read the photoresistor.

This program makes use of the Debug Terminal, so leave the serial cable connected to the BOE while Program Listing 3.1 is running.

Program Listing 3.1

```
' Robotics! v1.5, Program Listing 3.1: Photoresistor rctime Display
' {$Stamp bs2} ' Stamp Directive.
'----- Declarations --------------
left_photo var word ' For storing measured RC times of
right_photo var word ' the left & right photoresistors.
'----- Initialization ------------
debug cls ' Open and clear a Debug Terminal.
'----- Main Routine --------------
main:
' Measure RC time for right photoresistor.
high 3 ' Set P3 to output-high.
pause 3 ' Pause for 3 ms.
rctime 3,1,right_photo ' Measure RC time on P3.
' Measure RC time for left photoresistor.
high 5 ' Set P5 to output-high.
pause 3 ' Pause for 3 ms.
rctime 5,1,left_photo ' Measure RC time on P5.
' Display RC time measurements using Debug Terminal.
debug home, "L ", dec5 left_photo, " R ", dec5 right_photo
goto main
```

How Photoresistor Display Works : Two word variables, **left_photo** and **right_photo** are declared for storing the RC time values of the left and right photoresistors. The **main** routine then measures and displays the RC times for each RC circuit. The code for reading the right RC circuit is shown below. First, the I/O pin P3 is set to output-high. Next, a 3 ms pause allows enough time for the capacitor to discharge. After 3 ms, the lower plate of the capacitor is close enough to 5 V and is ready for the **rctime** measurement. The **rctime** command measures the RC time on I/O pin P3, with a beginning state of "1" (5 V), and stores the result in the **right_photo** variable. Remember, the value stored in **right_photo** is a number. This number tells how many 2 µs increments passed before the voltage at the lower plate of the capacitor passed below the I/O pin's 1.4 V threshold.

```
high 3
pause 3
rctime 3,1,right_photo
```

Tasks:

1. Try replacing one of the 0.01 µF capacitors with a 0.1 µF capacitor. Which circuit fares better in bright light, the one with the larger (0.1 µF) or the one with the smaller (0.01 µF) capacitor? What is the effect as the surroundings get darker and darker? Do you notice any symptoms that would indicate that one or the other capacitor would work better in a darker environment?

2. Make sure to restore your circuit to its original state before moving on to the next activity.