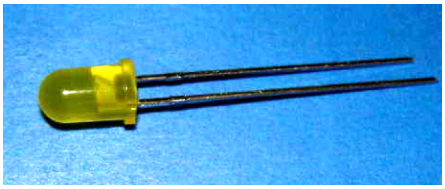
RBE1001 Introduction to Robotics
Lab 3 Appendix (Do not hand in)

Components Needed

- photosensors (x2)
- dual comparator (LM 358)
- wire, cutter/stripper
- protoboard
- potentiometers (x2 10kΩ)
- resistors (x2 470Ω, x2 68kΩ)
- LEDs (x2 - **Figure 1**)
- line follower mount assembly



1 - LED

Photosensor

The photosensor being used for this laboratory assignment is more properly known as a *photoresistor*. A photoresistor varies in resistance from a very low value (typically <5kΩ) when in bright light to a very high value (typically >200kΩ) when in total darkness.

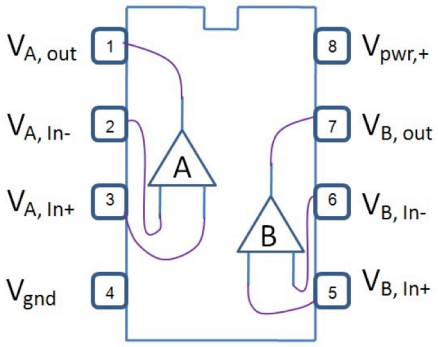
Lab Practicum Part I

Connect one of your photoresistors to the digital multi-meter (DMM) on your desktop. Measure the resistance of the device in low light conditions and bright light conditions. **Write down and interpret your results on the lab sheet at the end of this report**.

LM 358 Comparator

The basic operation of a comparator has been explained during the course lecture. The specific device we will use for this experiment is shown in **Figure 2**. Note the following:

- The comparator is encased in an 8-pin Dual-Inline-Package (DIP).
- The package is keyed by a slight notch on one end so that pin #1 can be identified.
- The connections to the package are symmetrical (output, - input, + input) for each op-amp.
- The device requires power (pin 8) and ground (pin 4) to operate.



2 - LM 358 Comparator

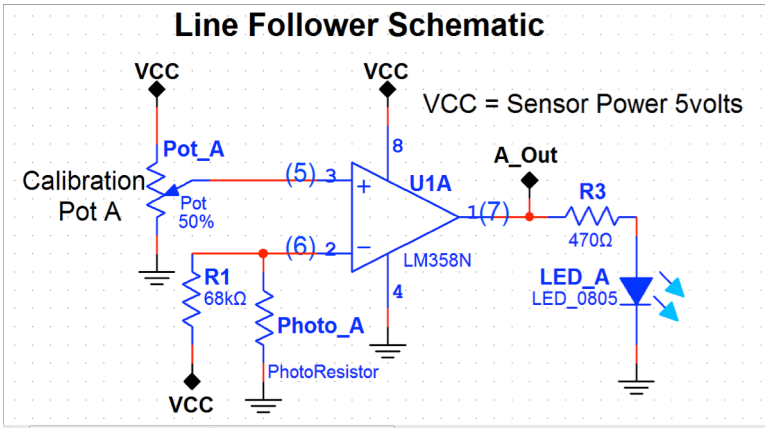
Sensor Circuit

Two complete sensor circuits are needed for this laboratory assignment. Both circuits are identical and use one of the comparators in the LM 358 (A or B). One of the circuits is shown in **Figure 3** along with the pin connections to the "A" comparator and, in parentheses "(.)" the connections to the "B" comparator for the second circuit.

Refer to your lecture notes for more detailed information on the use of the comparator.

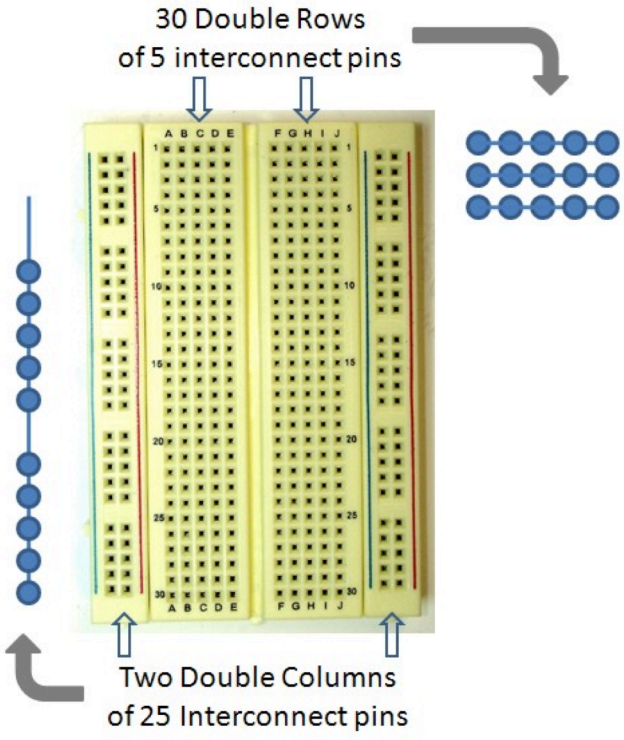
Building Your Circuit

You will be building your dual photo-sensor circuit on the protoboard handed out during the previous laboratory assignment. This board is shown in **Figure 4** along with a key to the interconnections on the board. As you can see in this figure, the board has two sets of connectors along the edges of the board that can be used for routing power, ground and other global signals. The board also has two columns consisting of 30 rows of five-pin connectors for interconnecting individual parts, integrated circuits, and other devices and components.



3 - Sensor Circuit.
Two complete identical circuits are required (but only a single dual-comparator).

While it may seem confusing at first, this protoboard is actually quite easy to use and is specifically designed to make DIP connections easy.



4 - Protoboard Connections and Layout

Lab Practicum Part II

Build two complete photosensor circuits. We suggest you lay out your circuit in a manner similar to that shown in **Figure 5** so that the sensors are on the side of the board (pointing downwards) and so that the layout is relatively symmetric.

Use the edge connections for power (**red**) and ground (**blue**). You might want to follow the steps below to wire your board.

1. Place the LM 358 dual comparator on the board.
   a. Connect power and ground to the comparator.
2. Fold the edge pins of the 10k potentiometers under the parts and place the pots on the board (if necessary, mount them at an angle).
   a. Connect power and ground to the potentiometers.
3. Place the photoresistors on the board.
   a. Place the 68kΩ resistor (blue, gray, orange) on the board and connect it to the photoresistor.
   b. Connect power to the 68kΩ resistor and ground to the photoresistor.
4. Place the LEDs on the board (the negative lead is the lead nearest the flat when looking from below).

a. Place the 470Ω resistor (yellow, purple, brown) on the board and connect it to the LED.

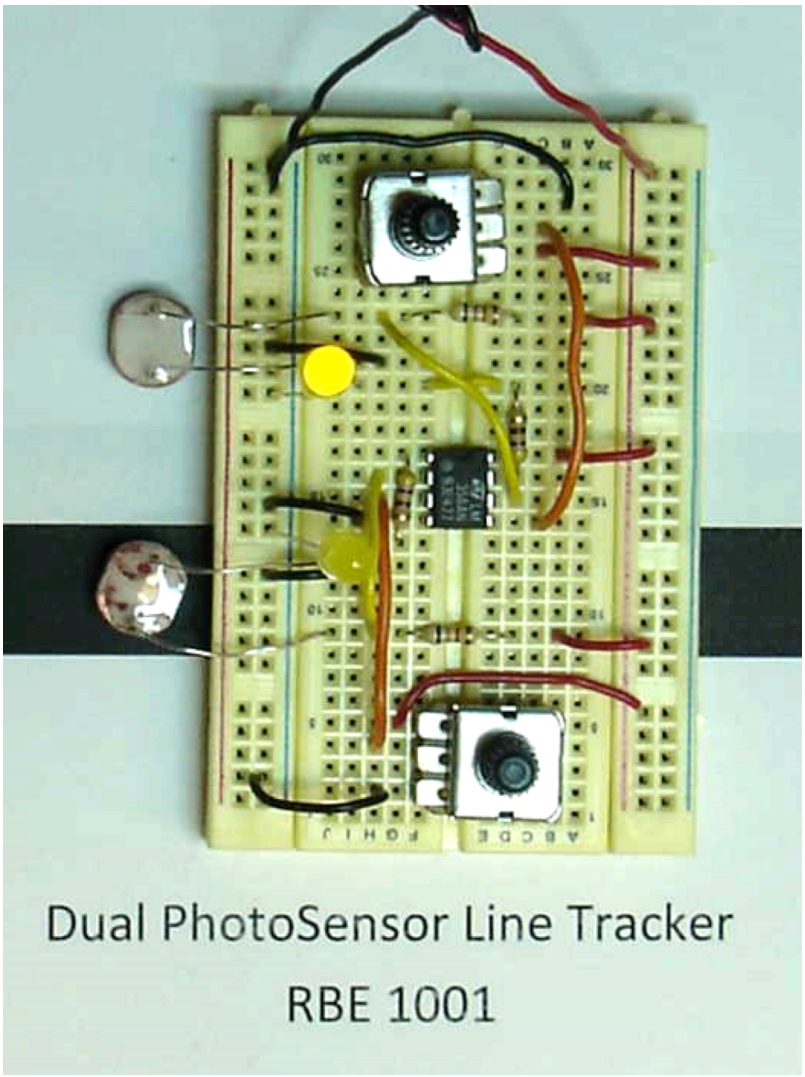
5. Connect the photoresistor to the correct comparator negative input terminal (-).
6. Connect the center wiper of the appropriate potentiometer to the correct comparator positive input terminal (+).
7. Connect the LED current limiting resistor to the appropriate comparator output terminal.

You are almost done!

8. Connect power to the center pin on any of the unused ports on the Arduino shield.
9. Connect ground to one of the ground ports.

Hints

- Short wires work best.
- Double check everything you do - it is *very* easy to miss a pin and think you have made a connection.
- Cut the resistor leads so that the parts are nearly flat on the protoboard.

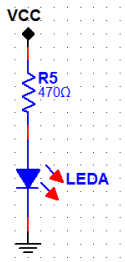


5 - Sample Circuit Board Layout

Testing

1. You will need a white piece of paper with a dark line on it (custom made testing sheets are available in the lab).
2. Place the circuit board on top of the paper and make sure power and ground are connected to your Controller.
3. Use an oscilloscope (channel 1 for example) to measure the voltage across the photoresistor as you pass the sensor over the white part of the paper and then over the black part of the paper. What are the voltages you determined?
4. Put the scope probe on the center wiper of the potentiometer. Set the voltage to about halfway between the two voltages you measured in the previous test.
5. If you wired your circuit properly, the channel you testing should now work. The LED should turn on and off as you pass the sensor over the black and white lines on the test paper.
6. Repeat the tests for the second channel.

Hints



- Also you can use the included LEDs to make “flashlights” for your sensors and then block out ambient light.
- You may need to adjust the detection threshold for the sensors as you run your base-bot on the more reflective surface of the test track.

***Describe how this circuit works on the lab write-up.**

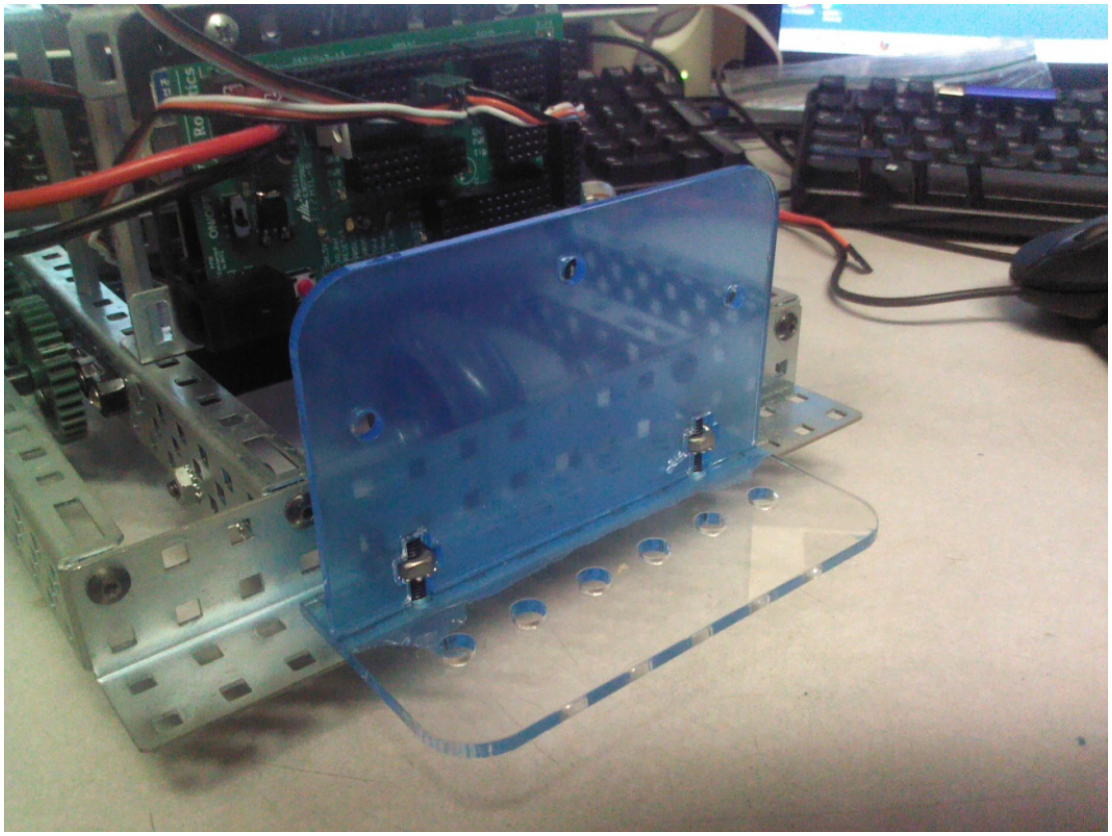
Interfacing and Operation

For this section, you will need to do complete three tasks. First, you will need to mount your circuit on your base-bot. Second, you will need to interface your circuit to the controller digital input ports. Third, you will have to write programs to use the data from the sensors to track a line.

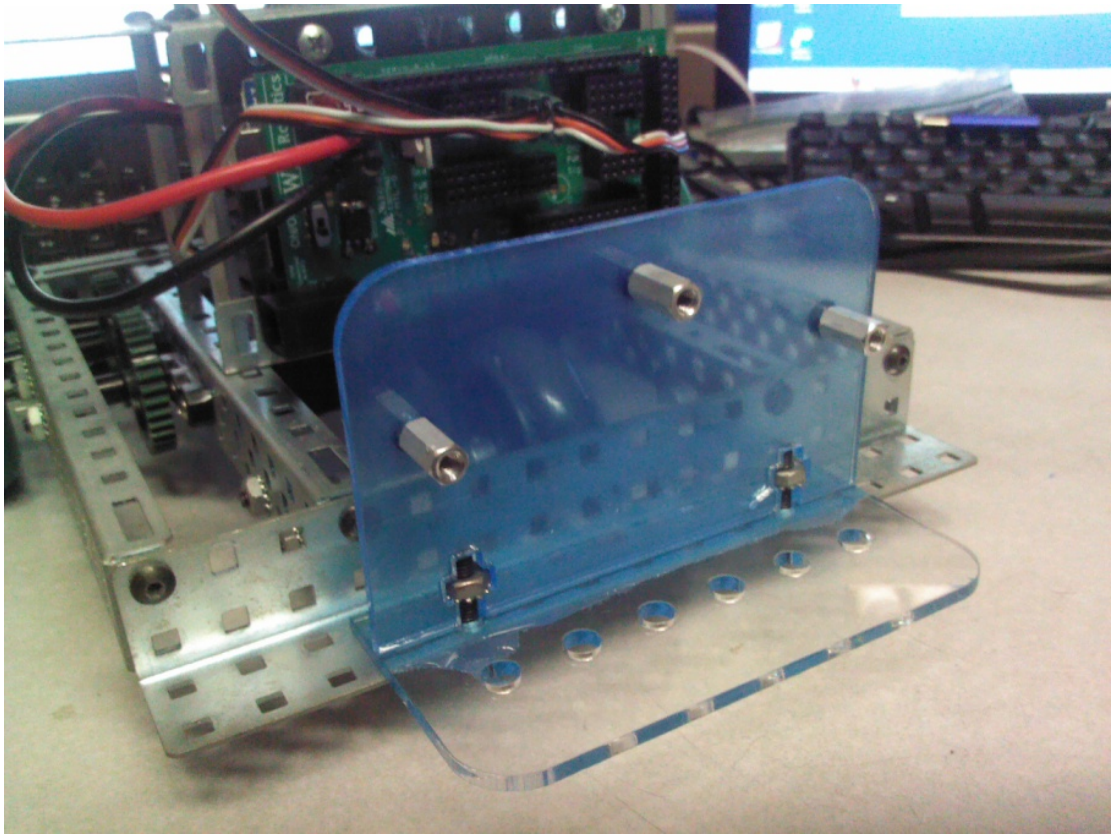
Lab Practicum Part III

Installing Line Follower Mount Assembly

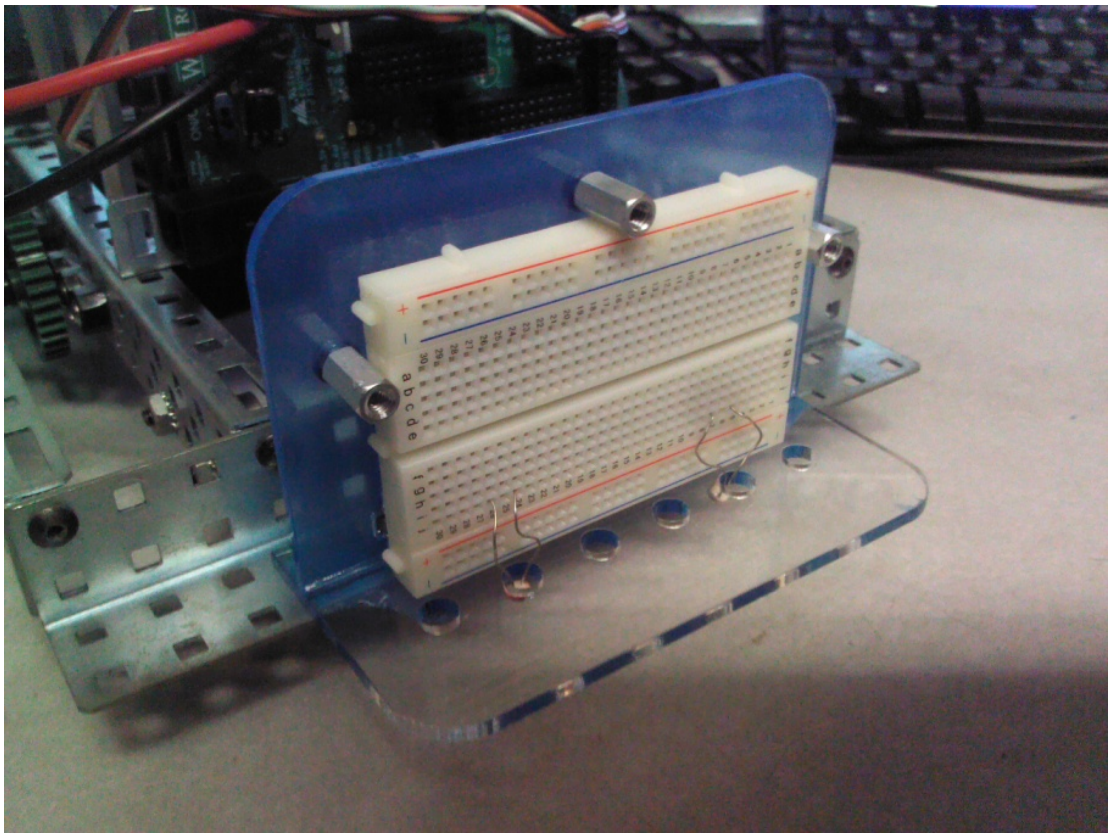
Insert the kep nuts into the slots, and put the 8-32 x 5/8” screws up through the front bumper throught the bottom plate and into the kep nuts.



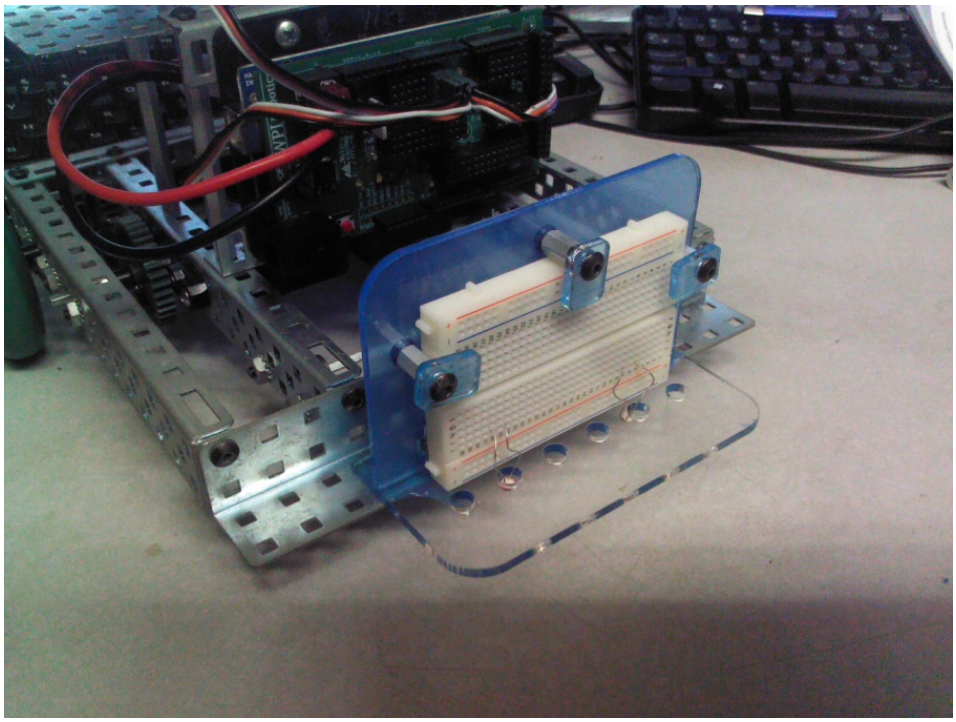
Add ½” in standoffs to the vertical plate with 8-32x1/2" screws.



Insert the breadboard



Attach the three holding tabs with 8-32 x 3/8” screws as shown or 1/2" screws and a flat washer (spacer).



Push the photo resistors through the bottom plate.

Connecting the Comparator to the Controller

The comparator outputs generate signals that are compatible with the digital inputs (ports 22 through 32) on the robot controller. The comparator outputs should be connected to the signal sockets of the two selected ports. Power and ground for your circuit board can be connected to any ports that are unused and convenient. Then you can use the Portable Line Segment (PLS) moving the sensors over the line to see it working.

*** Does a Digital Input value of 1 indicate the sensor is on or off the line? And why? Explain on the lab write-up.**

Programming the Line Following Algorithm

Sensing the status of the sensors is accomplished by using the DigitalInput. The values returned will either be 0 or 1 depending on whether the sensor is on or off the line. You should write a function called **LineTrack** that will cause your robot to follow the line on the white board. The function should assume it is starting with the line between the two sensors. It should drive either straight ahead, turn left, or turn right depending on which sensor is currently seeing the line. You will have to pick forward speeds that don’t go so fast that the robot overshoots the line. The function should return when it sees a perpendicular line across the course. You can call LineTrack function from the main function in your project.