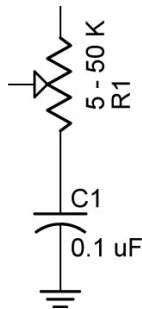


Resistive Sensors

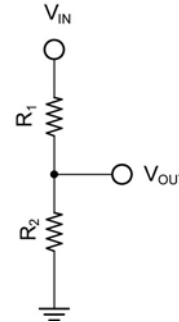
Cornerstone Electronics Technology and Robotics II

- **Administration:**
 - Prayer
- **PicBasic Pro Programs Used in This Lesson:**
 - General PicBasic Pro Program Listing:
<http://www.cornerstonerobotics.org/picbasic.php>
 - Lab 1 adc1 as a .pdf file:
<http://www.cornerstonerobotics.org/code/adc1.pdf>
 - Lab 1 adc2 as a .pdf file:
<http://www.cornerstonerobotics.org/code/adc2.pdf>
 - Lab 1 adc3 as a .pdf file:
<http://www.cornerstonerobotics.org/code/adc3.pdf>
 - Lab 2 braitenberg1 as a .pdf file:
<http://www.cornerstonerobotics.org/code/braitenberg1.pdf>
 - Lab 3 bend_sensor1.pbp as a .pdf file:
http://www.cornerstonerobotics.org/code/bend_sensor1.pdf
- **Resistive Sensors:**
 - **PicBasic Pro POT vs. ADCIN Commands:**
 - Depending upon the circuit conditions, resistive sensors may be read using the POT or ADCIN commands.
 - POT Command:
 - Resistive device normally within the 5 – 50 K ohm range.
 - The POT command measures the time it takes to charge a capacitor in a resistor/capacitor series circuit. Knowing the value of the capacitor and the charging time, the PIC converts the time value into an 8-bit resistance value of 0 - 255.
 - There is no voltage source when using the POT command therefore it does not measure a voltage drop. See the schematic comparison below.
 - Restricted to an 8-bit variable, giving outputs from 0 – 255.
 - See the following website for further discussion:
<http://books.google.com/books?id=XYwuCq5u2oEC&pg=PA189&lpg=PA189&dq=resistive+sensors+picbasic+pro&source=web&ots=d9Vra7g0Z2&sig=dZ5MI3R4vSSOCE9aeaxEronc8gw>

- ADCIN Command:
 - ADCIN, which reads an A/D converter (analog to digital converter), measures a voltage drop across a resistor.
 - There is a voltage source when using the A/D command ADCIN.
 - Variables may be 8, 10, or 12-bit, generating outputs of 0 – 255, 0 – 1024, or 0 – 4096 respectively. The ADCIN command is more accurate than the POT command.



POT Uses No Voltage Source

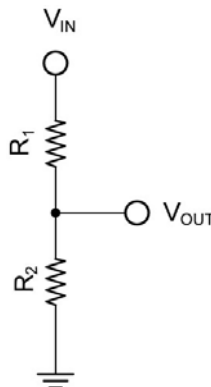


ADCIN Has a Voltage Source, V_{IN}

- This lesson will focus on the ADCIN command.

○ **Voltage Divider Review:**

- Voltage at Point A, V_A :



- Current through the series resistors:

$$V_{IN} = I R_{TOTAL}, \text{ since } R_{TOTAL} = R_1 + R_2,$$

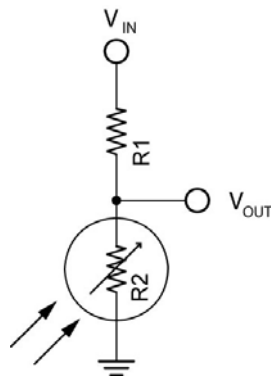
$$V_{IN} = I (R_1 + R_2)$$

Solving for I,

$$I = V_{IN} / (R_1 + R_2)$$

- V_{OUT} :
 $V_{OUT} = I R_2$, since the current, I , was solved above,
 $V_{OUT} = [V_{IN} / (R_1 + R_2)] \times R_2$, and
 $V_{OUT} = V_{IN} \times R_2 / (R_1 + R_2)$
- Cases:
 - When R_2 equals R_1 , then V_A equals $\frac{1}{2} V_{IN}$.
 - When R_2 is smaller than R_1 , then V_{OUT} will be closer to 0 volts or ground; conversely, when R_2 is larger than R_1 , then V_{OUT} will be closer to V_{IN} .
- In our application, $V_{IN} = +5V$, so V_{OUT} varies from near 0 V to near +5 V.

- Perform Resistive Sensors LAB 1 – Reading a Potentiometer
- **Photoresistor Sensors (Cadmium Sulfide, CdS, Photo Sensor):**
 - Cadmium sulfide changes in resistance when exposed to varying degrees of light. The resistance of a CdS photoresistor or photocell decreases as it receives more light (an inverse relationship).
 - Photocells have a relatively slow response to changes in light. The characteristic blinking of overhead fluorescent lamps, which turn on and off at the 60 Hertz line frequency, is not detected by photocells.
 - Demonstrate 60 Hz frequency using a photocell and phototransistor circuits and a frequency counter and oscilloscope. Video?
 - If a photoresistor is substituted for R_2 in the voltage divider above and it is illuminated brightly, its resistance will be low and V_A will be near 0V.
 - In contrast, if the same photoresistor is shielded from light, its resistance will be high and V_A will be near +5V.
 - Photoresistors normally require shielding because they are sensitive to ambient or surrounding light.
 - Use the photoresistor as R_2 in the voltage divider. See below:



CdS Photocell in Voltage Divider

- Use the following formula to calculate the value for R_1 :

$$R_1 = \text{SQRT}(\text{CdS}_{\text{DARK}} * \text{CdS}_{\text{BRIGHT}})$$

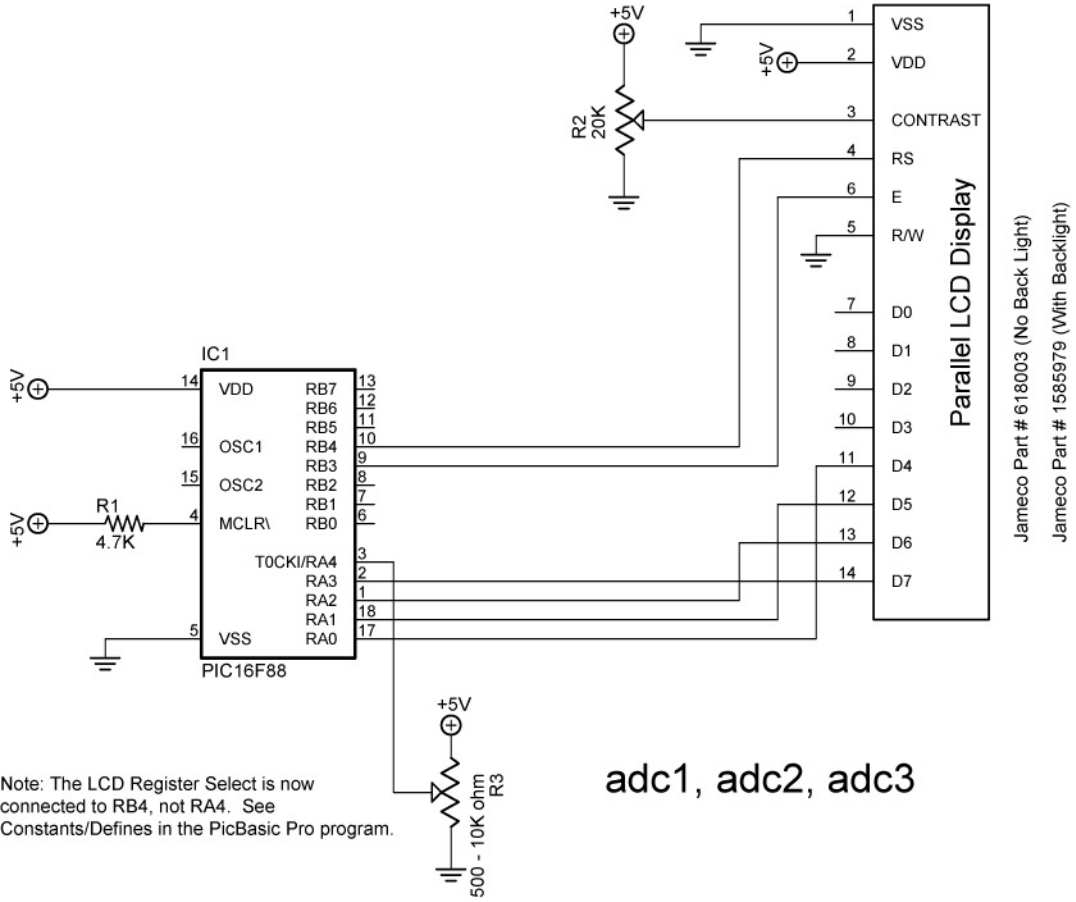
Where:

R_1 = Resistance of Resistor 1,
 CdS_{DARK} = Resistance of the CdS photocell in the darkest condition the photocell will operate,
 $\text{CdS}_{\text{BRIGHT}}$ = Resistance of the CdS photocell in the brightest condition the photocell will operate

- Source and derivation of the equation:
http://www.societyofrobots.com/schematics_photoresistor.shtml
- Complete Resistive Sensors LAB 2 – CdS Photoresistors
- **Other Resistive Sensors:**
 - Bend Sensors:
 - The resistance of the sensor increases in proportion to the degree of bending or flexing. For the Jameco #150551, 0 degrees is about 10K ohms and 90 degrees is 30K – 40K ohms.
 - Perform Resistive Sensors Lab 3 – Bend Sensors
 - Source for bend sensors:
<http://www.robotshop.ca/home/products/robot-parts/sensors/stretch-bend-sensors/>

Cornerstone Electronics Technology and Robotics II Resistive Sensors LAB 1 – Reading a Potentiometer

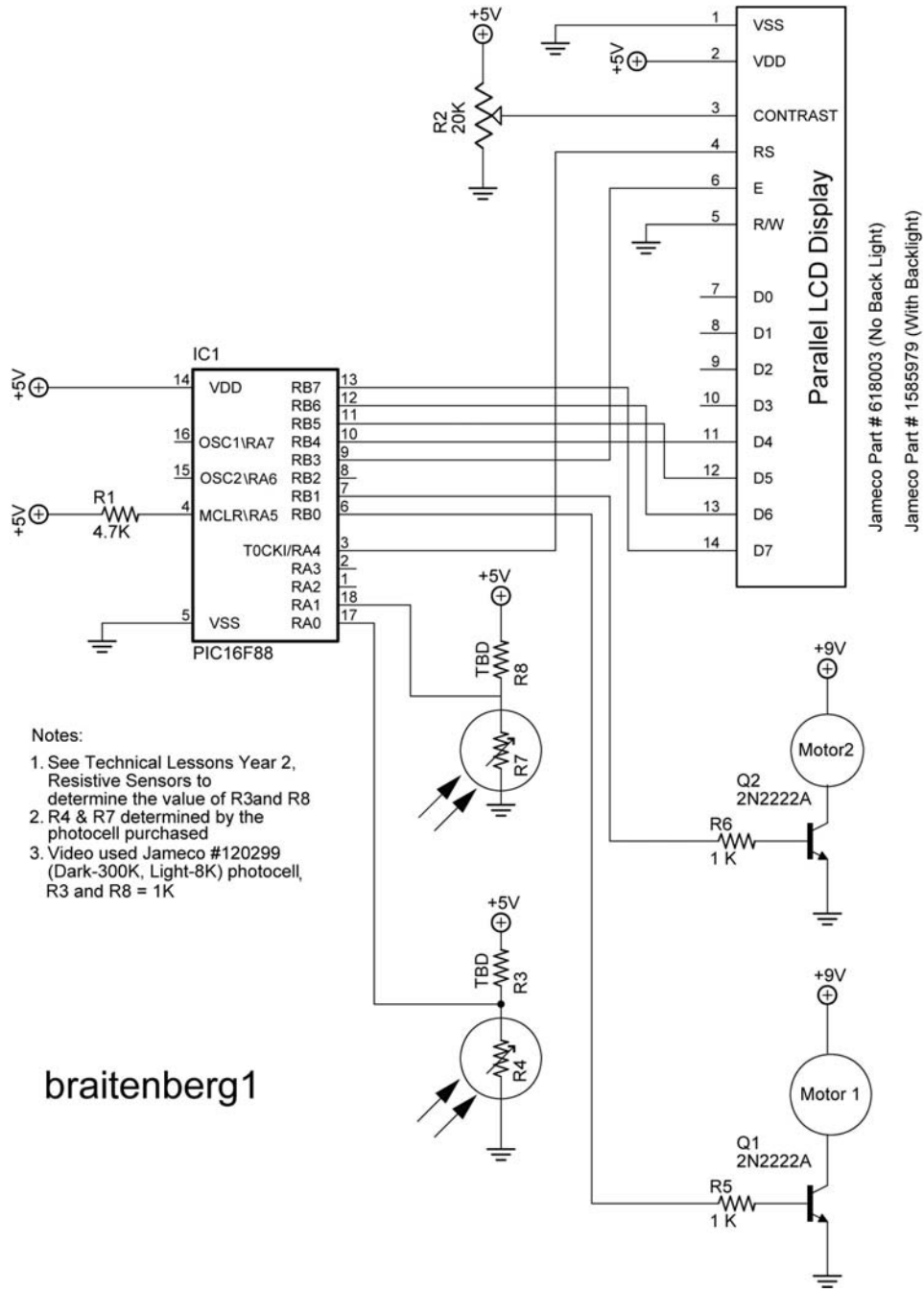
- **Purpose:** The purpose of this lab is to acquaint the student with wiring a PIC16F88 for analog/digital conversion and to expose the student to the PicBasic Pro command ADCIN and to a linear slide sensor.
- **Apparatus and Materials:**
 - 1 – Breadboard with +5V supply or an Analog/Digital Trainer
 - 1 – PIC 16F88 Microcontroller
 - 1 – 10 K Tripot
 - 1 – Phidgets Slide Sensor, Product # RB-Phi-20 from:
<http://www.robotshop.ca/home/products/robot-parts/sensors/linear-rotary-resistors/index.html>
 - 2 – 150 Ohm, ½ Watt Resistors
 - 1 – 10 K Ohm, ½ Watt Resistor
 - 1 – 1K, ½ Watt Resistor
 - 1 – NO Momentary Switch
 - 2 – LEDs
- **Procedure:**
 - Wire the circuit below. Use a 10K tripot for R3. Make sure to read the note in the schematic.
 - Program the PIC16F88 with **adc1.pbp**, **adc2.pbp**, and then **adc3.pbp**. Adjust R3 and note the values on the LCD screen for each program.
 - Now substitute the slide sensor for the 10K tripot. Note the changes in the LCD value as the linear position of the slide sensor moves.



Cornerstone Electronics Technology and Robotics II

Resistive Sensors LAB 2 – CdS Photoresistors

- **Purpose:** The purpose of this lab is to acquaint the student with the use of a CdS photocell as a resistive sensor.
- **Apparatus and Materials:**
 - 1 – Robotic Car Platform
 - 1 – PIC 16F88 – I/P Microcontroller
 - 1 – LCD Screen, Jameco #618003
 - 1 – 20 K Ohm Potentiometer
 - 2 – CdS Photoresistors, Jameco #120299 (300K-Dark, 8K-Light)
 - 1 – 4.7K Resistor
 - 4 – 1K Resistor, Includes R3 and R8
 - 2 – 2N2222A NPN Transistors
- **Procedure:**
 - Wire the following circuit.
 - Program the PIC16F88 with **braitenberg1.pbp**.
 - Adjust the CdS photocells for the car to be attracted to the light.
See: http://www.youtube.com/watch?v=N_X4_VVxOrE
- **Challenges:**
 - **Line-follower:** Mount CdS sensors on your robotic car for the car to follow a taped line. See: <http://www.youtube.com/watch?v=ut0iTLZykog>
 - **Light-Steering:** Use one photocell to activate steering or forward motion for the robotic car. Use a second photocell to turn the robotic car off. The car must begin in the starting box and come to a complete stop in the finish box.
 - **CdS switch:** Wire a circuit and program a PIC16F88 to serve as a light activated switch which turns on and off an LED.



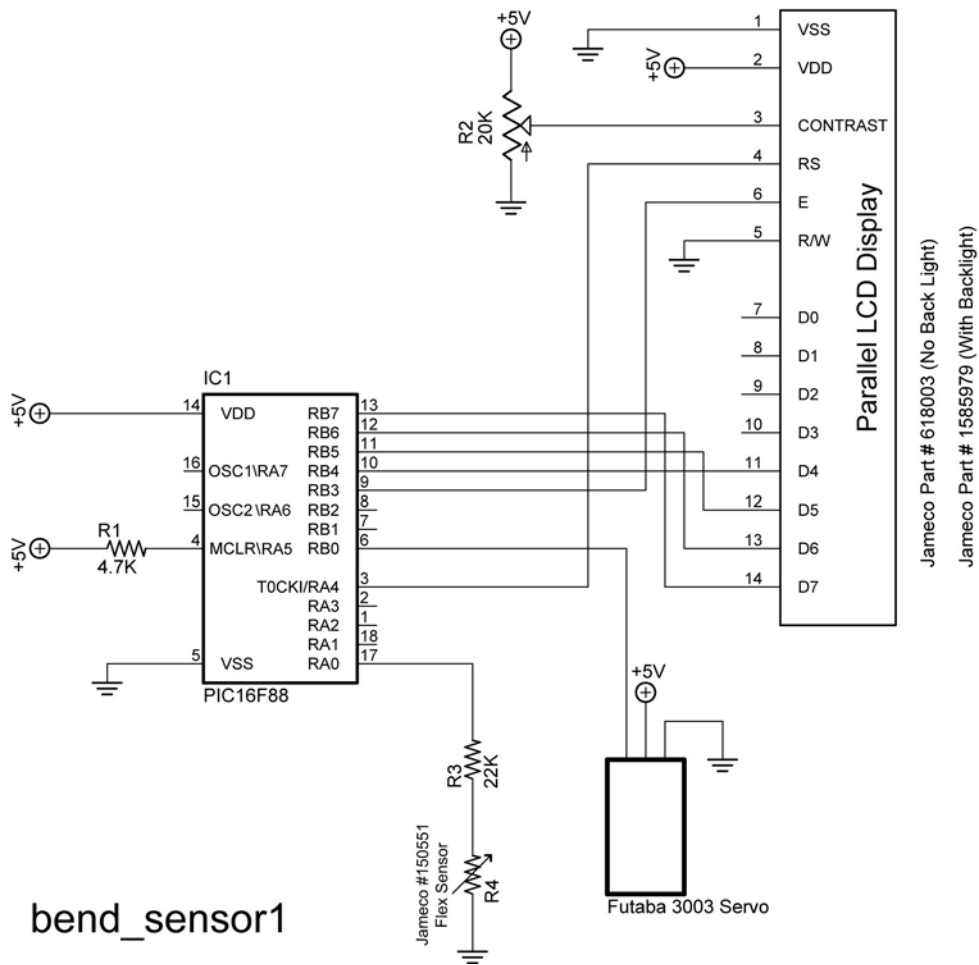
Cornerstone Electronics Technology and Robotics II

Resistive Sensors LAB 3 – Bend Sensors

- **Purpose:** The purpose of this lab is to acquaint the student with the function of a bend sensor.

- **Apparatus and Materials:**
 - 1 – Breadboard
 - 1 – PIC 16F88 Microcontroller
 - 1 – 4.7K Ohm Resistor
 - 1 – 22K Resistor
 - 1 – 20K Tripot
 - 1 – Bend Sensor, Jameco #150551
 - 1 – LCD Screen, Jameco # 618003
 - 1 – Futaba 3003 Hobby Servo

- **Procedure:**
 - Wire the circuit bend_sensor1.
 - Program the PIC16F88 with **bend_sensor1.pbp**
 - Bend flex sensor and note servo movement.
 - Review the derivation of the equation in the graph below.



bend_sensor1

Derivation of Formula Used in bend_sensor1.pbp

