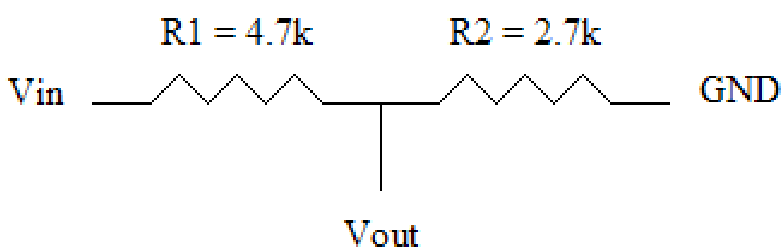
OPEN-ROBOT's Analog to Digital Sensors

Introduction:

This paper will explain how to interpret OPEN-ROBOT's analog-to-digital sensor readings. The battery level, GP2D120 infrared sensors and cadmium sulfide light sensors comprise this sensor array.

OPEN-ROBOT's Battery Voltage Measuring Circuit:

Battery voltage cannot be measured directly by one of the PIC18F4520's analog-to-digital capable pins since we are using 6-AA batteries and the output voltage will vary from about 7 to 9 volts. The PIC18F4520 is setup to measure input voltage by using a +5volt reference, so we need to map the 7 to 9volts over to 5 volts. To accomplish this we have created a simple voltage divider circuit by placing (2) appropriately sized resistors in series as shown below. The output voltage from the 6-AA batteries is Vin and the Vout and is measured by the PIC18F4520 and then compared against the +5 volt reference to generate an 8-bit digital value.



Figure#1. Voltage Divider for Battery Voltage Measurement.

To solve for the battery voltage, Vin, we can use the following formula.

Vin = [(8-bit digital value)*(R1 + R2)*5volts] / (R2 *255)

If the OPEN-ROBOT returns a 128 for the battery voltage, we can convert this 8-bit number to volts.

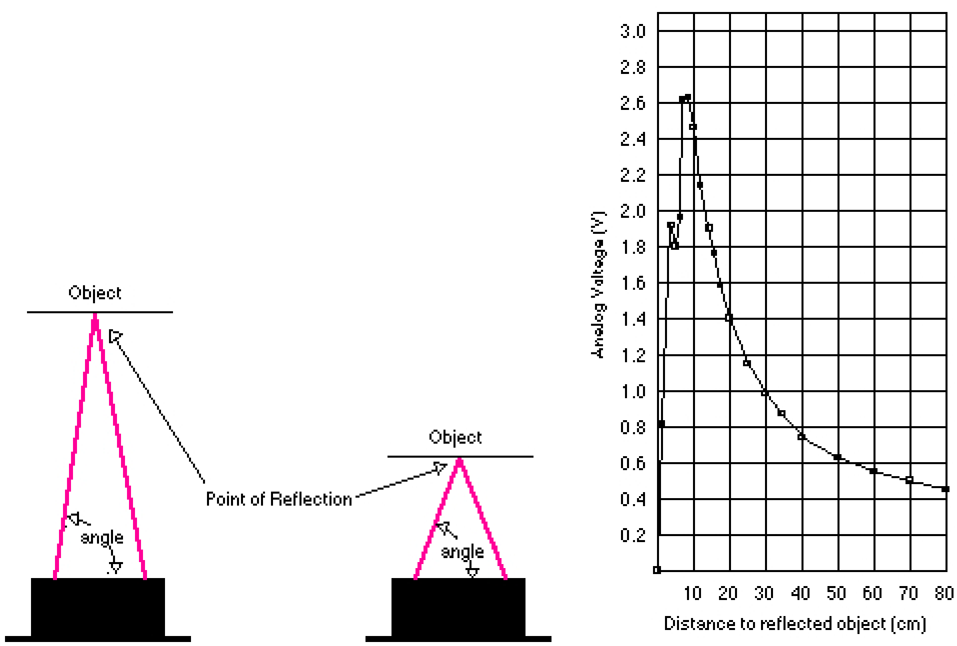
Vin = [(128)*(7.4kohms)*5volts] / (2.7kohms*255)= 6.87 volts

When using rechargeable batteries you should recharge at around 6.87 volts or 128.

<u>OPEN-ROBOT's GP2D120 IR Sensors:</u>

Figure#2. GP2D120 IR Sensor.

The GP2D120 IR sensor is a small and powerful sensor. Triangulation is used to measure the distance to an incident object. The infrared output is modulated at 40KHz to prevent erroneous measurements due to ambient infrared. Measurements are taken approximately every 30 to 40ms.



Figure#3. GP2D120 Triangulation and output.

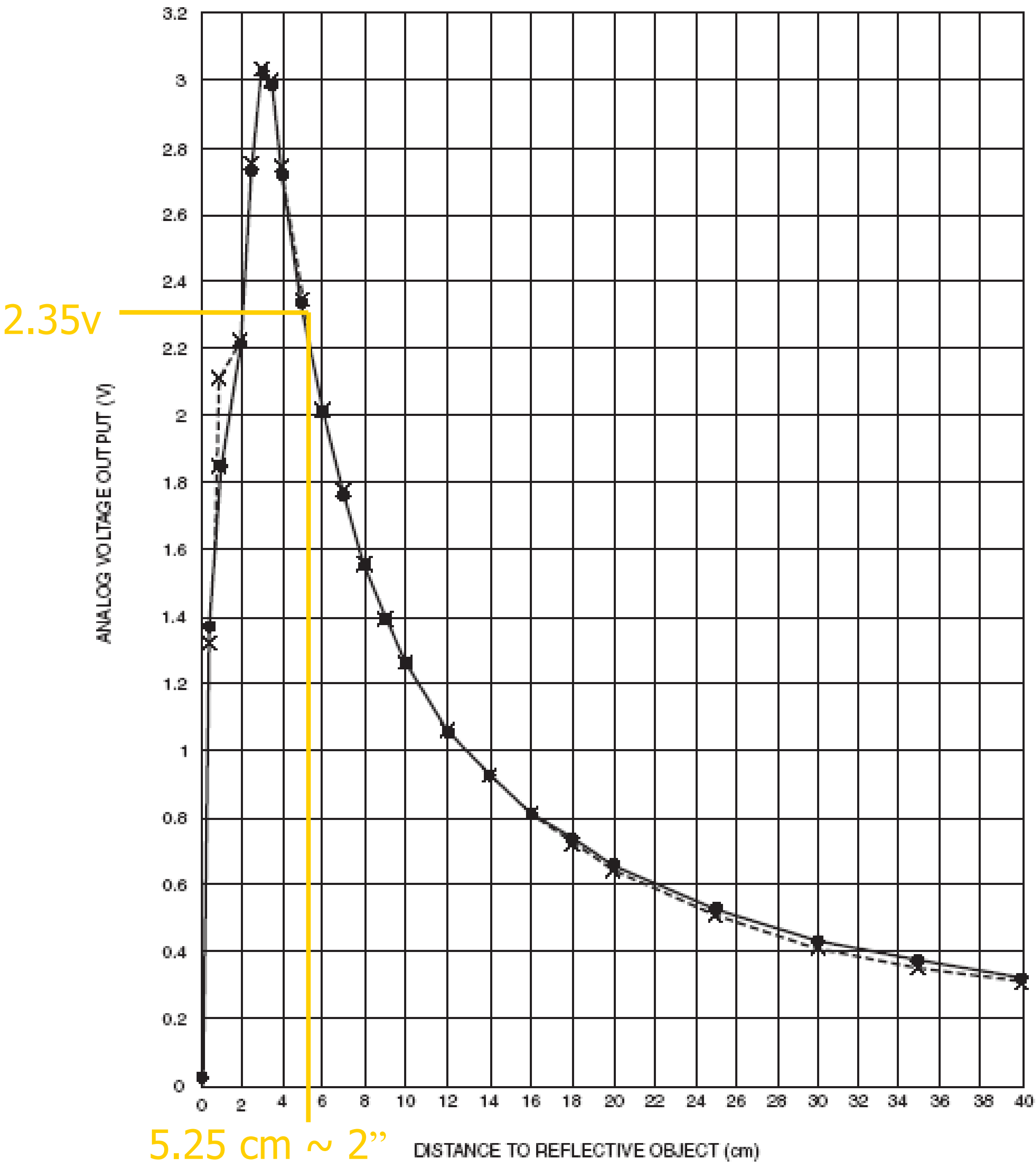
The output from a GP2D120 is a varying voltage level. The PIC18F4520 can directly measure the output of a GP2D120 since it is within the acceptable 0 to 5 volt range. The PIC18F4520 converts the voltage output to an 8-bit value. This 8-bit value can be converted to a distance reading in units of inches, centimeters, or any other unit of length. The output from a GP2D120 is non-linear and can be seen above in figure#3. To convert the 8-bit value to a distance we must first convert the 8-bit digital value back to a voltage reading. We can do this using the formula below.

Vout = (8-bit digital value)*5volts/255

If the returned 8-bit value is 120 we can calculate the voltage as follows.

Vout = (120)*5volts/255 = 2.35 volts

To convert this to a distance reading we need to look at the GP2D120 data sheet.



Figure#4. GP2D120 Voltage Output versus Object Distance Data Sheet.

Looking at the data sheet in figure#4 it can be seen that 2.35 volts corresponds to an object distance of approximately 5.25cm or 2.07 inches. This method works fine if you are only interested in converting a few distance readings, but what if you want to be able to convert these on the fly? There are several different ways to accomplish this. You could take all the data points from figure#4 and build a spreadsheet of output voltage versus object distance. Then use the spreadsheet to create a 2-D plot. Now we simply have a plot similar to the one in figure#4, but what good is this? Now we can perform a regression fit of the plot and attain an equation for the line. You can then use this equation to calculate object distance in inches or centimeters on the fly. You must of course be careful with regard to how you fit the regression line i.e. would it be best to use a n-degree polynomial, logarithmic, power, or linear fit? Using the wrong fit will simply calculate erroneous distance measurements.

You could also use the same spreadsheet information as a look-up table in your program. After converting the 8-bit reading to a voltage measurement simply look up that value in your table. What if the value falls in-between the values in your spreadsheet? For a coarse calculation you could approximate by using the closest value. For example, suppose you had an 8-bit value of 120, which is equal to 2.35 volts. You also have the following spreadsheet data.

2.38 volts = 5.0cm
2.00 volts = 6.0cm

We would pick the closer spreadsheet value and use 2.35 volts, which corresponds to 5.0cm. To attain a more precise value we can perform a linear interpolation using the spreadsheet data and the formula for linear interpolation, which can be found below.

Y2 = [(X2 – X1)(Y3 – Y1) / (X3 – X1)] + Y1

Where X1 = 2.38volts, Y1 = 5.0cm, X2 = 2.35volts, X3 = 2.00volts, and Y3 = 6.0cm

Solving for Y2 yields.

Y2 = [(2.35volts – 2.38volts)(6.0cm – 5.0cm) / (2.00volts – 2.38volts)] + 5.0cm = 5.08cm

The GP2D120 data sheet can be downloaded from the following location.

http://www.abotics.com/OPEN_ROBOT_DOCS/GP2D120_SS.pdf

OPEN-ROBOT's Light Sensors:

OPEN-ROBOT has (2)-frontward facing cadmium-sulfide cells that are capable of measuring the amount of ambient light. A cadmium-sulfide (cds) cell is simply a photo-resistor and changes resistance based upon the amount of incident light. As the amount of light increases the cds cell's resistance drops and as the amount of light decreases the resistance increases. To measure this change in resistance with the PIC18F4520 we need to place the cds cell into a voltage divider with a 4.7kohm resistor. We can calculate the cds cell's resistance value for the current voltage reading by using the voltage divider formula from before.

Vin = [(8-bit digital value)*(R1 + R2)*5volts] / (R2 *255)

Where Vin = 5 volts, R1 = cds cell resistance, R2 = 4.7kohms

Vin = [(8-bit digital value)*(R1 + R2)*5volts] / (R2 *255)

R1 + R2 = (R2 *255*Vin) / (8-bit digital value)*5volts

R1 = [(R2 *255*Vin) / (8-bit digital value)*5volts] – R2

cds cell resistance = [(4.7kohms *255) / (8-bit digital value)] – 4.7kohms

It is possible to convert this resistance value back to a reading in units of illuminance (lux), but I will leave that up to you. The cds cell data sheet can be downloaded from the following location.

http://www.abotics.com/OPEN_ROBOT_DOCS/202403-PhotoCell.pdf