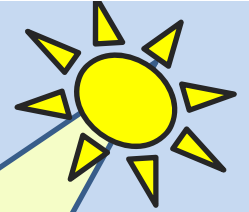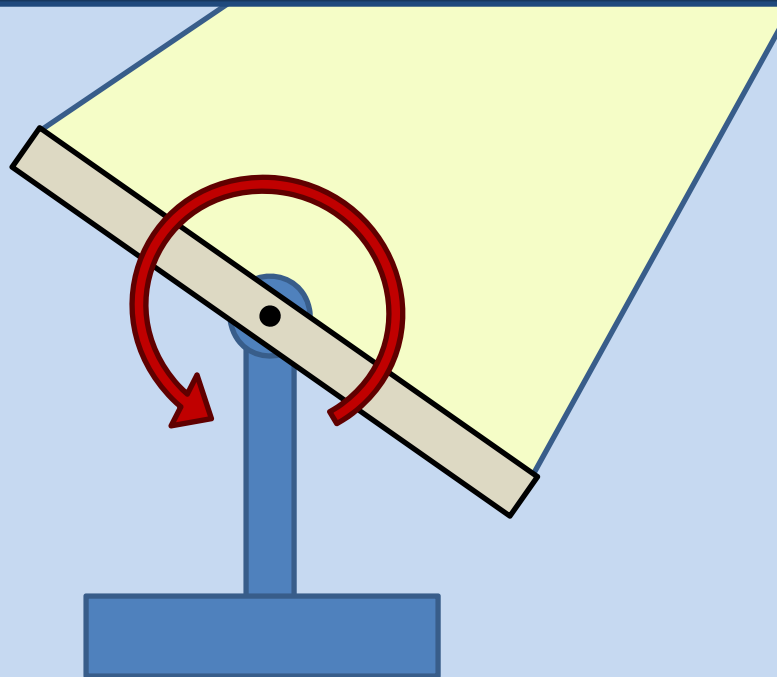# Solar Tracker

Build a Sun-Tracking Solar Panel!!

- Use an Arduino Pro Mini, a standard servo, some clever machining, and some photo resistor voltage dividers to build a one-axis Sun-Tracking Solar Panel
- The Solar Tracker aims at maximizing solar energy absorption throughout the day

Step 1 – Get supplies

You Will Need:

- 4 x Photo Resistors – I use 4 but this could be done with 2 and better logic
- 4 x Resistors – will be sized depending on photo resistors
- 1 x Arduino Pro Mini 328 5v
- 1 x FTDI Cable
- 1 x Standard Servo
- 1 x Random Servo Hardware
- 1 x Acrylic Inch 8x3in Sheet
- 1 x Roll of Electrical Tape
- 1 x Mini Breadboard
- 1 x Aluminum L-Shaped Material (4x4x6 inch sides)
- 1 x Aluminum 1/8inch 1x8inch Shank
- 1 x Solar Panel
- 2 x Industrial Strength Velcro
- 2 x Screws and Nuts - 3/4inch 440thread
- 8 x Screws and nuts - 1/2inch 440thread
- Solder

Step 2 – Tools needed

You Will Need (Power Tools):

- Miter saw
- Steel impregnated power sander
- Drill press with 1/8inch bits
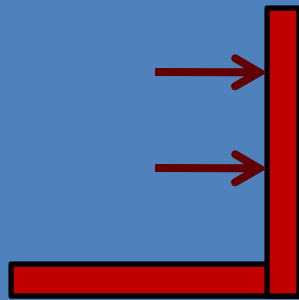- Horizontal band saw

You Will Need (Hand Tools):

- Assorted files
- Deburring tool
- Adjustable wrench
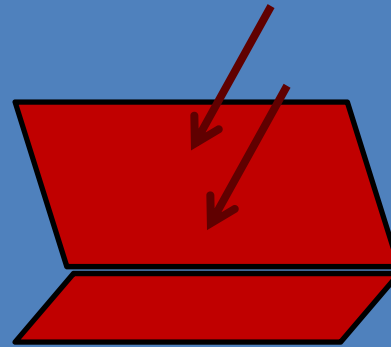- Philips head screwdrivers
- Solder tool

Step 3 – Project Mount

L-Bracket

- Cut the L-Bracket into a 6inch length or so. Use the sander to smooth it all out
- In the center of one of the planes, mark and drill two holes. Use sander and de-burr
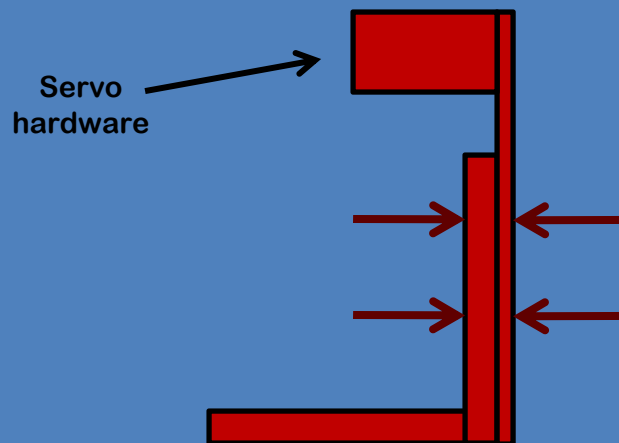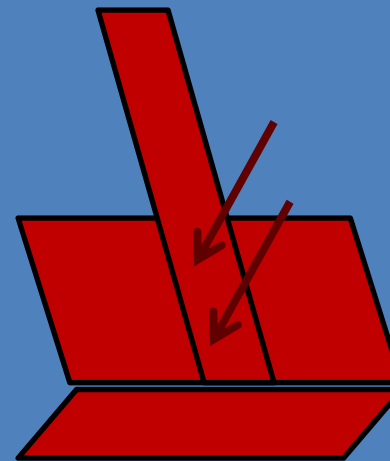
Side   **Back**

Step 3 – Project Mount

Servo to L-Bracket Connector

- Mount servo hardware to the 1x8inch shank
- Take your shank, select height, mark holes from L-Bracket and drill
- Remember that the solar panel will be rotating along the servo's axis so leave appropriate room. Sand and de-burr
- Assemble

Servo hardware

Side   Back

Step 4 – Solar Mount

Servo to Solar Assembly

- Use servo hardware that attaches to the axis
- Trace solar panel's outline on acrylic and cut it out. Make sure to make a notch for the power cord
- Countersink holes in order to attach solar assembly to servo hardware. File edges and assemble
- Mount the solar assembly onto the project mount

Servo hardware

Acrylic

Servo

Solar Panel and Acrylic

Servo

Solar Panel

Servo

Side

Back
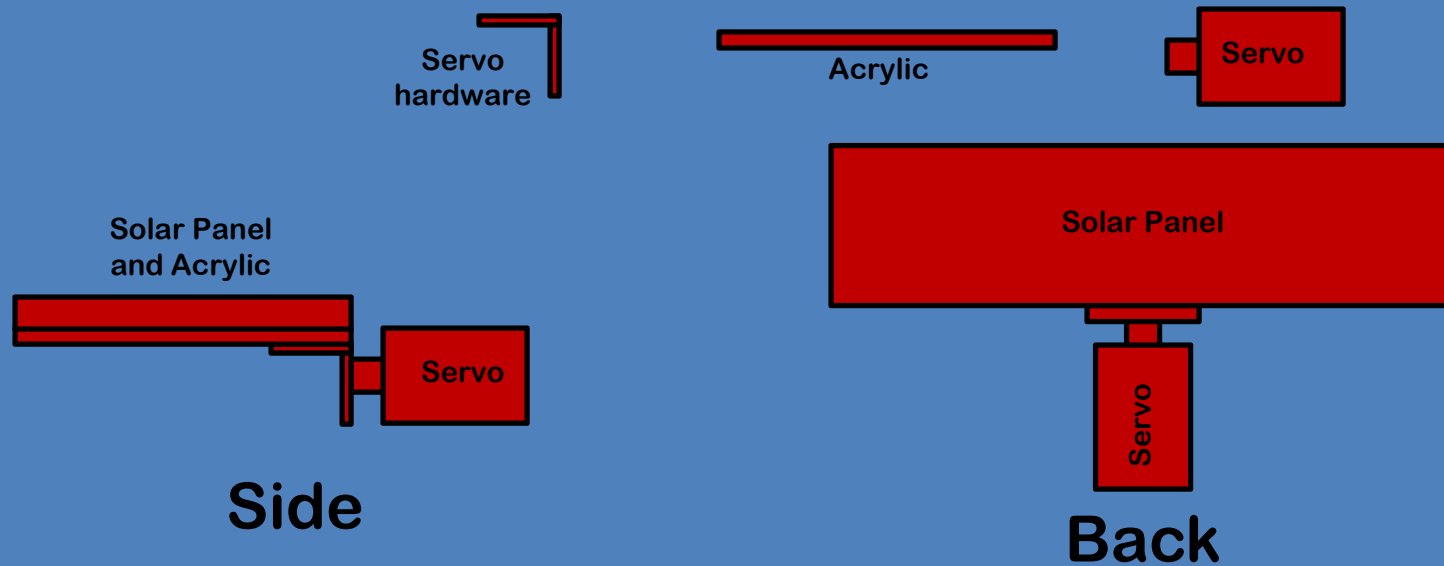
Step 4 – Sensor Array

Can't Adapt without them:

• Use the ohmmeter to measure the resistivity of the photo resistors both in a dark and in a sunny area. Then use a voltage divider to determine the most accurate scope by maximizing the voltage change between the resistors

Maximize the change in this voltage

(Vcc) →**+5v**→ (Photo Resistor) → (Resistor) →**0V**→ (Ground)
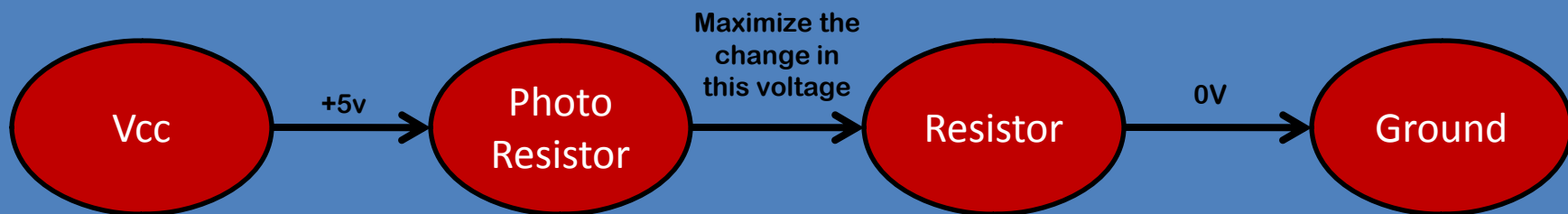
From Testing		
Dark	12000Ohm	(Finger over photo resistor)
Ambient	1100Ohm	(Classroom)
Simulated Sun	78Ohm	(12 inches from bright work light)

Step 4 – Sensor Array

	Sun	Dark		Sun	Dark	Sun	Dark	
	Min	Max	R	V-pR	V-pR			
Vcc	(kOhm)	(kOhm)	(kOhm)	(high)	(low)	V-R	V-R	Difference
5	78	12000	1	4.937	5.000	0.063	0.000	0.063
5	78	12000	100	2.191	4.959	2.809	0.041	2.768
5	78	12000	500	0.675	4.800	4.325	0.200	4.125
5	78	12000	1000	0.362	4.615	4.638	0.385	4.254
5	78	12000	2000	0.188	4.286	4.812	0.714	4.098
5	78	12000	600	0.575	4.762	4.425	0.238	4.187
5	78	12000	800	0.444	4.688	4.556	0.313	4.243
5	78	12000	900	0.399	4.651	4.601	0.349	4.252
5	78	12000	1000	0.362	4.615	4.638	0.385	4.254
5	78	12000	1050	0.346	4.598	4.654	0.402	4.252
5	78	12000	1100	0.331	4.580	4.669	0.420	4.249
5	78	12000	1200	0.305	4.545	4.695	0.455	4.240
5	78	12000	1500	0.247	4.444	4.753	0.556	4.197
5	78	12000	2000	0.188	4.286	4.812	0.714	4.098

From Testing

Greatest Difference
$900\Omega < R < 1050\Omega$

Step 4 – Sensor Array

Results

Going in series (Vcc-pR-R-GND) tie the pR-R node to the ADC pin

Vmax of pR-R node is about 4.7V and Vmin is about 0.35

Use R of 1k and +/-10% will keep difference in greatest region

All resistors are **0.98x kOhms** which is within standards and will create similar readable voltages

Step 4 – Sensor Array

Build the Servo Array:

- We're going to use 4 sensors. Get out that soldering iron and use this schematic
- Use the electrical tape to cover any exposed wiring
- Test with a power source and ohm meter

Photo Resistor

Resistor

VCC   **ADC**   **GND**

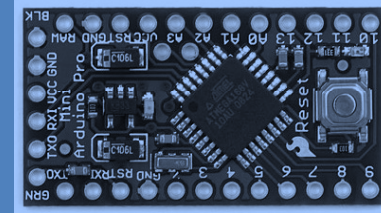Arduino
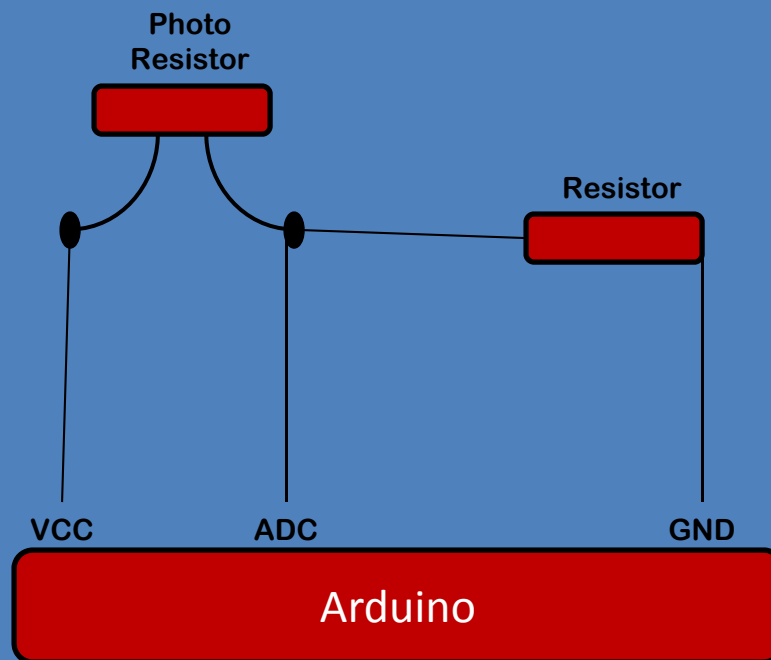
Step 4 – Sensor Array

Assemble the Array:

- Take the four sensors and attach them to the assembled project mount and solar assembly
- Take some extra wire and electrical tape and build "solar blinders" for the sensors
- The blinders allow for better calibration and sensing

Servo

Side

Front
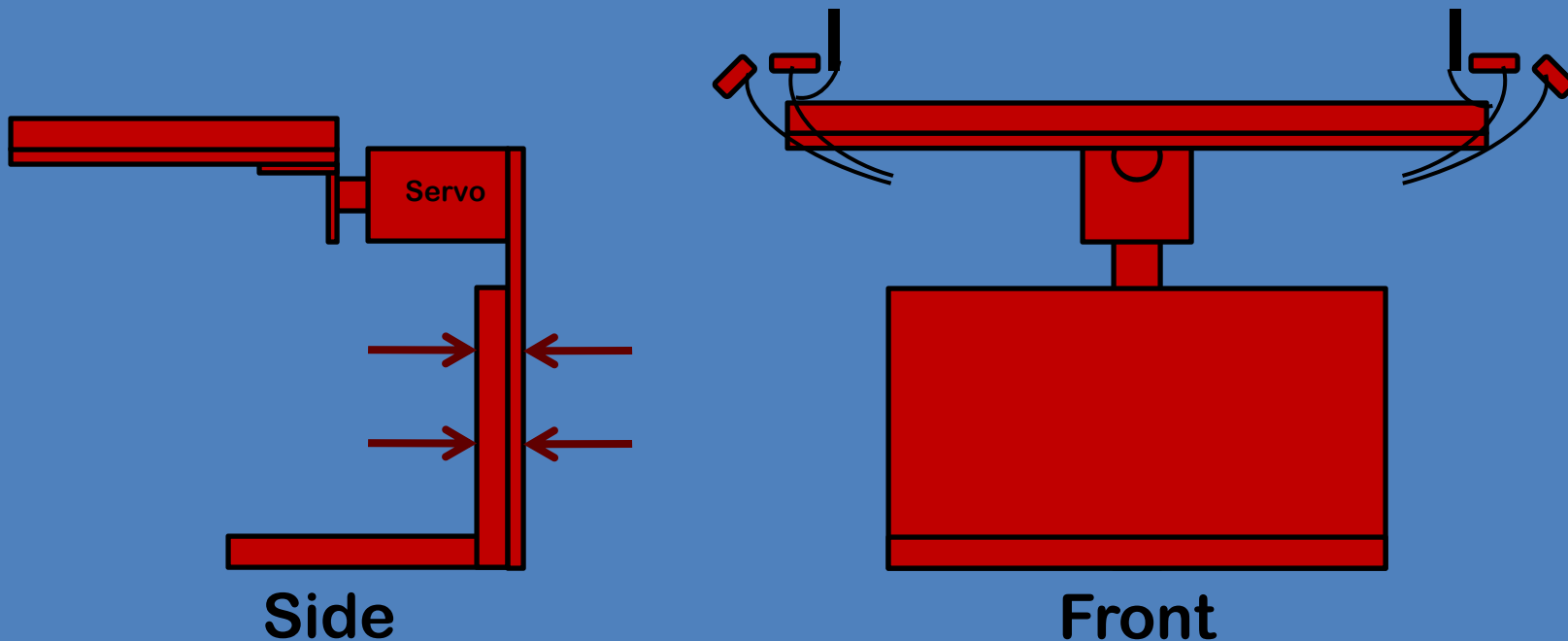
Step 5 – Microcontroller

Get your program on

**Arduino Pro Mini
arduino.cc**

- Solder leads to your Arduino
- Get the FTDI cable installed and functional
- Upload a test program to the Arduino (verify functionality)
- Attach four sensors to ADCs 1-4 (analog to digital conversion)
- Attach servo to one of the PWM (pulse width modulation) ports
- Use the UART to check values of ADC readings through Serial.println("sdfsdf");
- Use the Servo class to initialize and test your servo
- Set up an initialization routine where the servo moves the solar panel so the sensor array can determine the angle of maximum sunlight and then move there
- Set up tracking logic. I used a minimum of a 10% difference between any two sensors to move them and a long settling time indicative of a slow moving sun. This reduces oscillations due to noise.
- With four sensors, the panel can move in small amounts (difference between the center looking sensors) or large amounts (if the side view sensors indicate a large differential)
- Be careful with casting and scaling.

Step 5 – Microcontroller

Program more…

• Cloud Mode - If clouds are present or the day is overcast, you can look at the rate the sun has been moving and as soon as it appears again move directly to the maximum angle

$$\int \left(\frac{d\theta_1}{dt}\right) dt = \theta_2$$

• Night mode – If the device is in Cloud Mode for a long while and the panel is facing the setting sun, you can implement another predictive case where the panel can either be moved parallel to the ground or reflected across the vertical axis to prepare for sunrise.

$$\theta_2 - 90 = \theta_2$$

Step 6 – Testing

Attach the Solar Panel and Increase Efficiency!

- Set up a voltage divider similar to the sensors and attach the solar panel to one of the unused ADCs
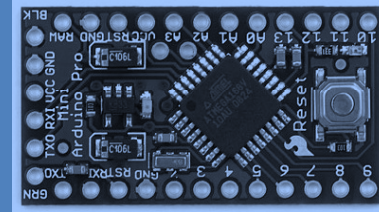- Watch the voltage change in proportion to the angle of the solar panel

$$\left(\sum' Emf\right) \alpha\ (\theta)$$

- Is the system really worth it? Grab a couple more stationary solar panels, build some more voltage dividers, attach to the ADCs, and look at the differences over a few week period. You be the judge!

Sources

Give Credit

- from http://arduino.cc/en/Reference/Libraries
  - servo library, and corresponding example code
  - serial library , and corresponding example code
- variable casting - http://www.mkssoftware.com/docs/man3/itoa.3.asp

Arduino Pro Mini
arduino.cc