by Dan Gravatt

Two Axis Sun Tracker
for Small Solar Panels

Solar panels are gaining popularity and coming down in price, but they still aren't cheap. If you have a satisfactory panel which isn't quite big enough for your application, buying a second panel for more power may represent a significant cost.

This project is designed to maximize the output from your existing panel by turning it to keep it pointing at the sun, and (hopefully) making the purchase of another panel unnecessary. The circuit can be built for much less than the cost of most solar panels.

Theory

This project works by comparing the light intensities falling on two pairs of sensors: one oriented vertically and the other horizontally. The sensors are separated by opaque dividers that will throw a shadow on one sensor in each pair if the array of sensors isn't pointing directly at the sun. If the sensor outputs are not equal, the circuit comparing the sensor outputs will move the sensors horizontally and/or vertically until the outputs are equal again.

An analog implementation of this project would be very straightforward, consisting of the sensors, an LM339 quad comparator, and two H-bridges to drive DC motors. I did build a one axis sun tracker in this manner just to evaluate different sensors, and to illustrate the major drawback of analog comparators for this application: the lack of hysteresis.

The comparators will always drive the motor one way or the other, leading to a continuous "jitter" when the sensors are pointed at the sun. Thus, to be practical, the circuit must compare the sensor outputs and then determine if the difference is large enough to require moving the sensors.

Sensor Selection

I had hoped to use phototransistors as the sensors for this project, and got good results with them using a flashlight in a dark room. However, the phototransistors were completely overloaded or saturated in direct sunlight. Similar results were obtained using LEDs as light sensors. Miniature photovoltaic cells would have worked, but the added cost was more than I had hoped. This left one inexpensive option: cadmium-sulfide photoresistors.

These work very well in direct sunlight when used in series with another resistor to form a voltage divider (Figure 1). Each pair of photoresistors must be well matched to provide identical resistance at a given light intensity.

Circuit Design

The circuit is based on a Microchip PIC16F876A microcontroller which includes (among other things) a five-channel, 10-bit analog-to-digital (A-to-D) converter which we can use to "read" the photoresistors. While this chip has far more features and horsepower than the circuit requires, it does have two distinct advantages for the low-budget builder: it is supported by the free trial version of microEngineering Labs' PICBasic Pro compiler; and you may be able to get free engineering samples from Microchip. The overall schematic is shown in Figure 2.

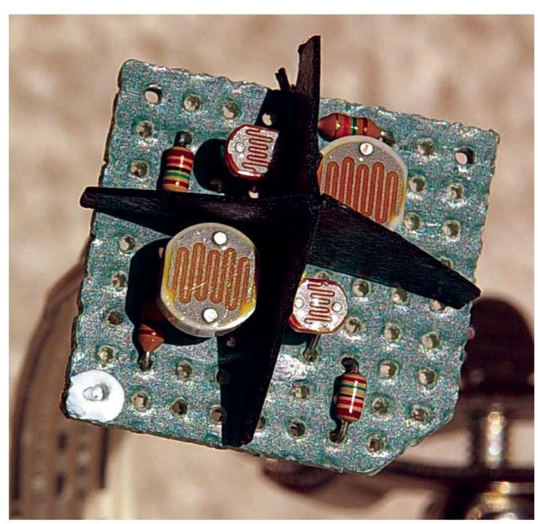

FIGURE 1. Close-up of sensor array with opaque dividers.

The four photoresistor voltage dividers are connected to the first four channels (RA0-RA3) of the PIC's A-to-D converter in the order shown. Outputs RB0 and RB1 send pulse width modulated (PWM) signals to the vertical axis and horizontal axis servos to move the solar panel. For simplicity's sake, if your solar panel is very small, you may be able to power the servos from the same five-volt supply which powers the PIC. If your servos need more torque or if you suspect the motors are causing supply voltage dips which affect the circuit operation, it's best to use separate regulators as shown.

How it Works

The program code (available on the *Nuts & Volts* website at **www.nutsvolts.com**) starts out with a loop to sample the analog output from each photoresistor voltage divider, convert it into a 10-bit value, and store it in a four-word array variable. Next, the values from the top and bottom sensors are compared to

finished, mount it on the edge of your solar panel, keeping the faces of the sensors in the same plane as the panel.

Figure 3 shows my prototype sun tracker in testing, illustrating how one servo was mounted on the other to move the sensor array in two axes. I recommend testing your sensor array's behavior in this way prior to building your solar panel mount, as it will be much easier to correct any problems at this stage. Note that it is not necessary for all four photosensors to be matched; only the two in each pair need to have their outputs match.

I won't go into great detail on the construction of the solar panel mount and servo adjustment linkages because everyone's setup will be different. I plan to mount my panel on a post at the panel's center of gravity, with a horizontal rotary bearing and a hinge between the post and the panel to allow two axes of movement. One servo will mount on the fixed post just below the bearing to turn the panel horizontally, and the other servo will mount on the back of the panel to move the hinge joint vertically.

If your solar panel is fairly large or heavy, servos will be too weak to reliably position the panel. In that case, the portions of the code which adjust pulse widths can easily be modified to control an H-bridge and drive DC gearmotors of whatever size your panel requires.

Fine-tuning

After your circuit is complete and the PIC is programmed, test its behavior to make sure you have wired everything properly. If the array turns away from the sun in either axis, or otherwise acts strangely, check that the sensors are connected to the proper A-to-D converter channels and that you haven't reversed the servo outputs.

You may also need to fine-tune the hysteresis value in the code to match your particular sensors. I found that the behavior of the circuit indoors is very different from its behavior in full sunlight, so test your sensors outside!

The code as written won't move the solar panel unless the digitized sensor values in either pair disagree by more than ±10. Increase this value if you observe "jitter" in the servos when pointed at the sun. If you find that the sun moves a long way across the sky before the sensors react, the dividers between your sensors may need to be adjusted, or your sensor pairs may not be matched well enough.

Now you're ready to get maximum power output from your solar panel all day! **NV**

Contact the Author

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