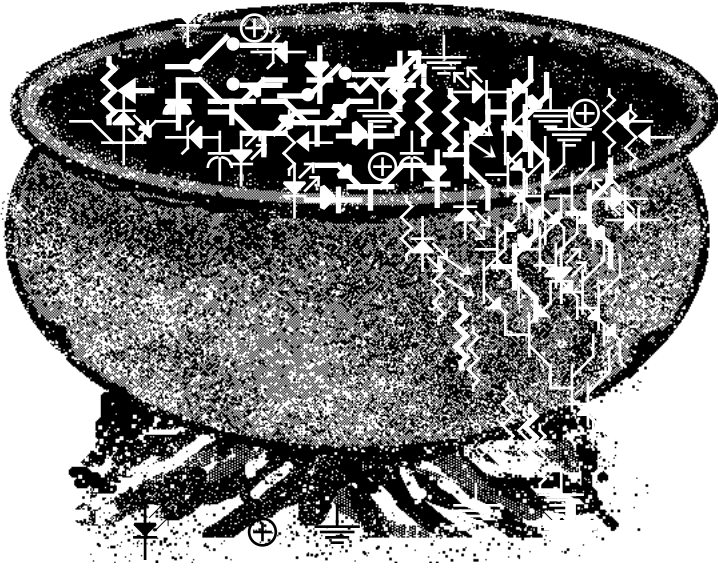


Homebrew



AN ACTIVE SOLAR TRACKING SYSTEM

Jeff Damm

In the spirit of fine home-brewing, this tracker uses cheap ubiquitous parts - a windshield wiper motor and a 555 circuit - as the guts for an efficient machine which keeps panels aimed at the sun.

How This Tracker Works:

Driving a threaded shaft attached to the tracker's underside, the windshield wiper motor is powered by a circuit controlled by two phototransistors which are turned on and off by a shading device. The phototransistors and shading device are mounted on the face of the tracker and the tracker rotates in the appropriate direction so that the shading device blocks sunlight to both phototransistors. State B in Figure 1 shows the tracker facing the sun so that both phototransistors are in shade. As the sun progresses across the sky the right hand phototransistor is turned on (state C) and the tracker moves (clockwise in Figure 1) until both phototransistors are in the shade (state B). This CBCBC...BCB pattern ends at night in state B. In the morning the tracker is in state A (it is in the same position, but the sun is on the other side!) and the motor turns on swinging the panels from their night time position until they face the sun.

The Electronic Works

The phototransistor sensing and motor control circuitry in Figure 2 has a left and right side which are mirror images of each other. When Q1 is shadowed, it is turned off, and there is no current flow

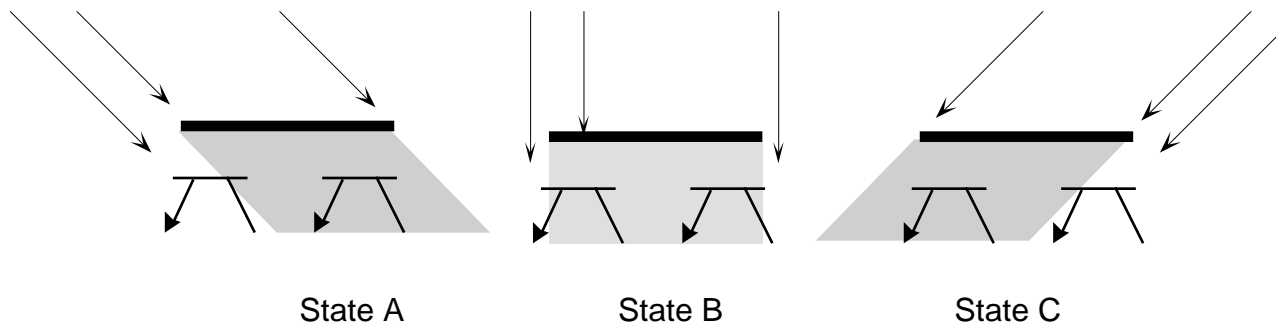


Figure 1. Phototransistor operation

through R1 and R2. The voltage on the zener's cathode is below the 5.5V threshold necessary for any current to flow through the zener, so Q3 and Q4 remain off. The 555 timer output is low, and Q9 and Q10 are turned off, leaving the motor with no applied voltage.

Light shining on Q1 will turn it on, applying 12 Volts across R1 and R2 and the 10k current limit resistor. R1 and R2 are sensitivity adjustments allowing the user to accommodate various photo-transistors. Q3's threshold is determined by the sum of the zener voltage and two base-emitter diode drops through Q3 and Q4 or Q5 (whichever is greater). When Q4 and Q5 turn on, Q4 will discharge the 4.7µf capacitor connected to pins 2 and 6 of the 555 timer. When pins 2 and 6 of the timer are below 4 Volts (1/3 of the supply voltage) the timer output (pin 3) will go high. Pin 3 will source current into the base resistors of motor driver transistors Q9 and Q10, turning both of them on. The motor will begin to turn, moving the PV panel in the proper direction to shadow Q1 from the sunlight and turn off the motor. The 555 timers were used to generate a pulse extension that would ensure a small amount of mechanical overshoot for the motor so that the system will not draw current during shadow mode. Total idling current is on the order of a few milliamps.

The right side of the circuit works almost identically as the left. Close inspection of the right channel circuit reveals that the motor control transistors have been "swapped" in terms of the polarity. This makes the motor run in reverse when needed.

The two transistors (Q5 & Q8) provide insurance against short-circuiting the power supply through Q9/Q12 and Q11/Q10 by assuring that only one channel may operate at any time. Q5 disables the right channel when the left channel Q1 is turned on and the reverse scenario happens with Q8 when the left side is energized.

The circuit as it stands is flexible. It will run on supply voltages between 6 Volts and 16 Volts without any modifications or performance degradation. The 2N3904 transistors are not critical. They may be replaced with virtually any small signal switching transistors, like the 2N2222A. The zener diodes could easily be replaced with versions having zener voltage anywhere between 3V to 9V. I used heat sinks on the motor control transistors for reliability. With the present circuit it should not be necessary to bother with heat sinks on Q9-Q12. There is nothing special about the 2N5294 transistors. They were cheap and readily available. I did like the TO-220 case outline since a single 4-40 screw is the only necessary hardware. Substitutions for Q9-Q12 only need to have collector current maximum ratings that will accommodate the specific motor used. All resistors used can be 1/4 watt dissipation. Add some series resistance to the motor if you want it to operate more slowly. This will allow you to use motors that have high RPM at rated voltage.

The schematic of Figure 2 is one that I developed back in 1978. It is by no means perfect and there are many ways to accomplish the

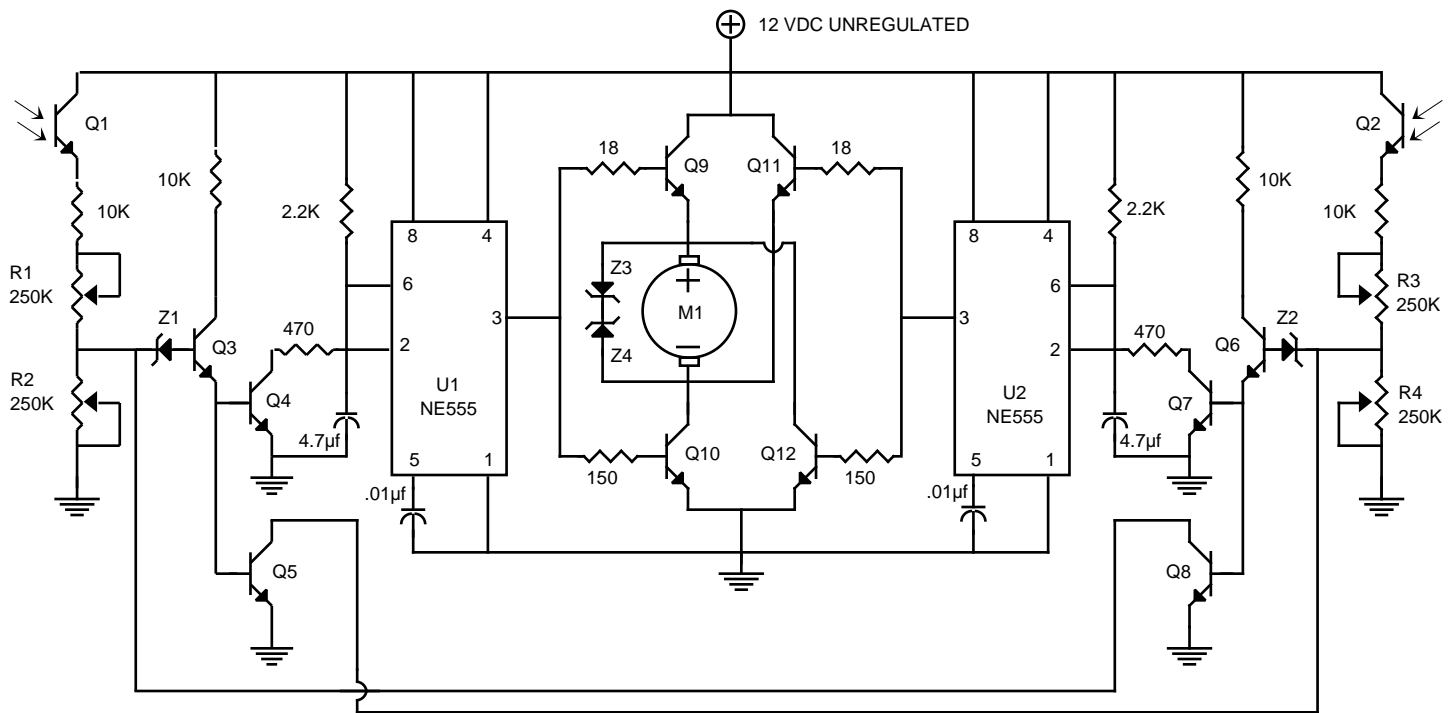


Figure 2. Schematic for an active tracker

same thing. I am presenting this design as an experimental version that does work. The point here is that a circuit like this is destined for some evolutionary changes, especially if enough people start experimenting with the idea. I have used this exact circuit to drive a windshield wiper motor and a threaded shaft hooked to a piece of plywood. It all worked just fine. Watching a piece of plywood track the sun was real satisfying, even though it sounds rather demented. Actually it really WAS demented, but electronics tends to do that to it's practitioners. I did not have any PV panels back in '78 either!!

Parts List

Integrated Circuits

U1 & U2 NE555 Timer, in 8 pin DIP

Transistors

Q1 & Q2 Phototransistors ECG 3031- \$10.84, ECG 3032- \$11.13, ECG 3034- \$1.68

Phototransistors from slotted optocouplers- SDP 8403-301 Radio Shack Infrared phototransistor - \$1.98

(See HP#12 , page 35 for mail order parts addresses.)

Q3 - Q8 2N3904 or any small npn 2N2222A, etc

Q9 - Q12 2N5294 or any NPN with $I_c >$ motor current

Zeners

Z1 & Z2 3V-9V zener

Z3 & Z4 18V - 24V zener current rated $>1/2$ motor current

I was motivated to get this idea out so that guys like Bob McCormick in British Columbia can have a possible alternative to manual tracking. See HP#13 (page 20)

Special thanks to my sister, Pamela Damm, for loaning out her Mac to generate this article, and my AE buddy Mark Schonbrod for technical and motivational support. And especially Richard and Karen Perez for a wonderful weekend of shop talk and advice on how to do these articles.

Access

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