The SunGuard

This compact device keeps tabs on cumulative ultraviolet energy detected over a period of time and sounds an alert when the total exceeds a preset limit for safe tanning

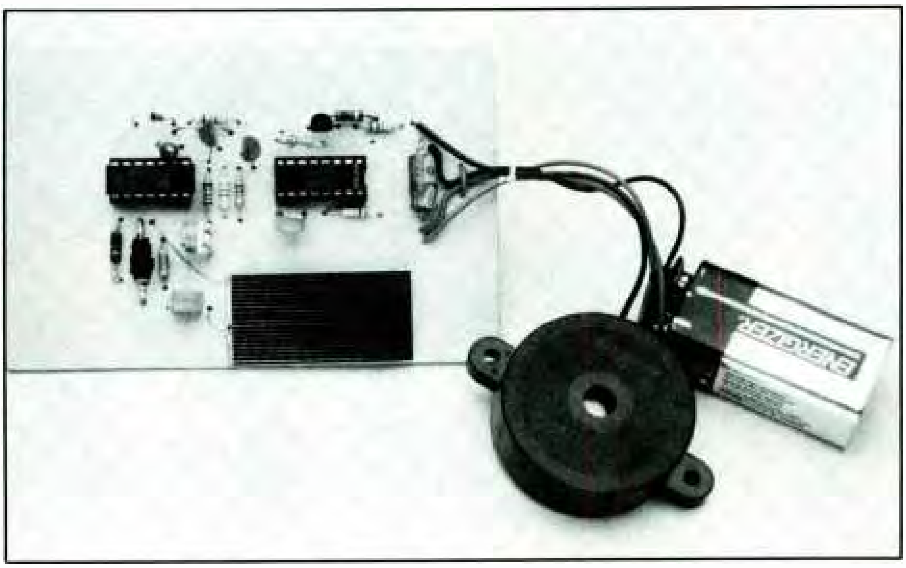
By Anthony J. Caristi

With summer almost here, millions of us will soon be flocking to the beach, where we'll bask in the sunlight. Summer sun can be very beneficial, but too much of a good thing can also be dangerous to your health, from painful sunburn to more serious sun-exposure-related ailments.

The amount of sunlight that will not cause harm varies from person to person. But even if you know your tolerance level, it is sometimes difficult to judge a safe exposure time when the sky is overcast or partly cloudy. You must also consider that the time of day and even month of the year determine how intense the sunlight will be. This is a lot to keep in mind, but "SunGuard" remembers it all effortlessly to help you stay healthy as you enjoy the sun.

SunGuard's sensing element accurately measures sun intensity. A built-in memory circuit integrates measured intensity over a period of time and totals the cumulative exposure to the sun's rays. When a safe exposure limit is reached, which you set beforehand, a piezoelectric buzzer sounds to alert you to either turn over or cover up.

SunGuard's solar-cell sensor responds to ultraviolet energy. This makes the project immune to false measurements that might otherwise occur from passing clouds or hazy sunshine that can give the appearance that the UV energy is less intense than it really is. This is important because it is UV energy, which penetrates clouds, that causes tanning and burning.



About the Circuit

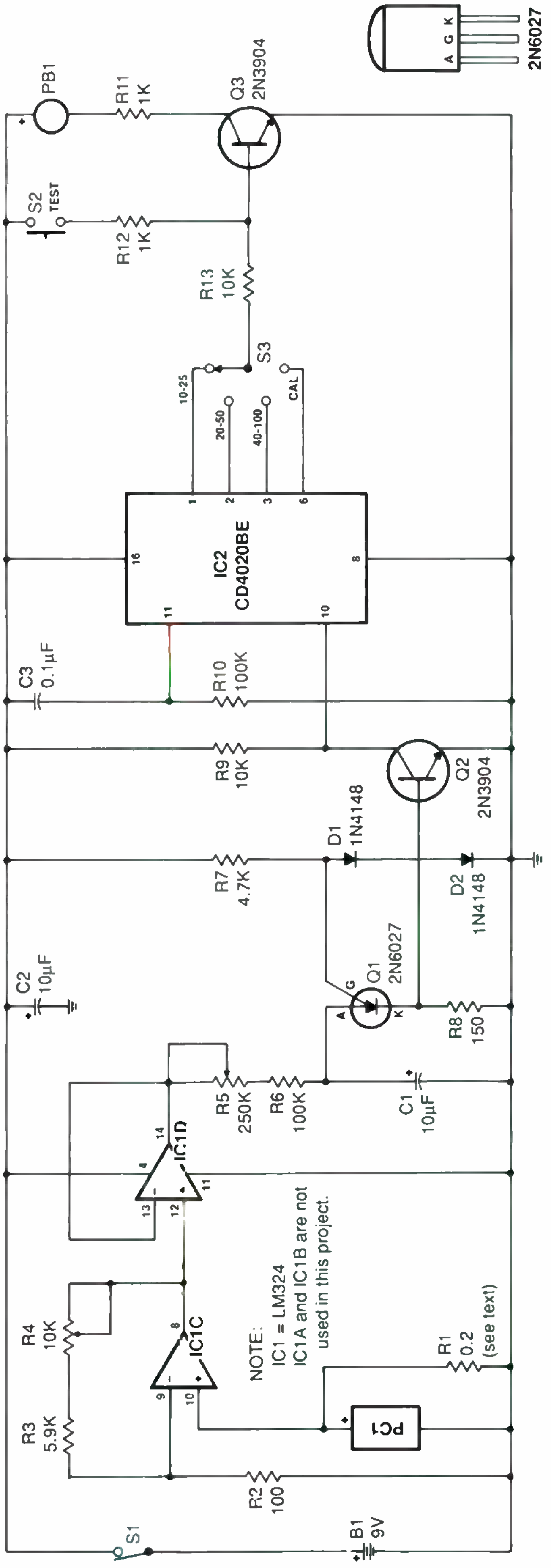
The sensing element used in SunGuard produces an output that is directly proportional to the intensity of the detected ultraviolet energy from the sun. This controls the rate of a built-in clock that counts the number of minutes of relative exposure. With the way the circuit is designed, the warning signal will be generated at the desired amount of exposure whether the sun is shining through a clear sky, intermittent cloudiness or a hazy sky. Thus, SunGuard automatically takes into account variations in sun intensity and totals the cumulative amount of exposure.

You manually set the desired amount of time of exposure to the sun before you begin a sunbathing session. An adjustment range of less than 10 minutes to almost 2 hours is possible with the circuit as shown in the Fig. 1 schematic diagram.

Power to operate the circuit is provided by a common 9-volt transistor radio battery. Current drain of the circuit is very low; so one alkaline battery should easily last through the entire summer season. Also, a handy pushbutton switch allows you to quickly check battery condition to determine if there is sufficient energy to operate the circuit.

Referring to the complete schematic diagram shown in Fig. 1, the heart of SunGuard is photocell *PC1*, which is the reference that continuously monitors the intensity of the sun's energy and generates a current that is directly proportional to the de-

Fig. 1. Complete schematic diagram of SunGuard's circuitry.



tected intensity at every given moment. On a day of unobstructed bright sunlight when the sun is directly overhead, the sun's energy intensity is at its maximum and is referred to as 1 full sun. As the sun traces its path across the sky from east to west, this intensity will vary, increasing in the morning and becoming less than 1 full sun as the day progresses. Of course, any haze or clouds in the sky will obscure (filter) the sunlight to some degree, resulting in less than 1 full sun of intensity.

Under 1 full sun conditions, *PC1* generates about 0.3 ampere (or 300 milliamperes) of current. Because there will be variations in output from one solar cell to another under identical detecting conditions, SunGuard's circuit is equipped with calibration potentiometer *R4* that allows you to adjust for the particular solar cell used in the project.

The open-circuit output generated by *PC1*, about 0.5 volt, is of no consequence, since it is the generated current that is proportional to the intensity of the sun's energy. To provide a voltage that is proportional to the detected energy, *PC1* is loaded with a very low 0.2-ohm resistance by *R1*. The potential that appears across *R1* will be approximately 60 millivolts under conditions of 1 full sun and will vary linearly with changes in sun energy intensity: 45 millivolts at ¾ sun, 30 millivolts at ½ sun, and so on.

To provide a usable voltage source for the circuit, as well as a means for calibrating the solar cell, *IC1A* is connected as an operational amplifier with its gain determined by the values of *R2*, *R3* and *R4*. Potentiometer *R4* covers a range that is sufficient to provide an output at pin 8 of *IC1* of 5.5 volts under conditions of 1 full sun exposure of *PC1*. Once *R4* is adjusted for this output voltage, the solar cell has been calibrated.

PARTS LIST

Semiconductors
D1,D2—1N4148 or similar silicon diode
IC1—LM324 operational amplifier
IC2—CD4020BE 14-stage binary divider
Q1—2N6027 programmable unijunction transistor
Q2,Q3—2N3904 or similar npn silicon transistor
Capacitors
C1—10-μF, 16-volt low-leakage electrolytic or tantalum
C2—10-μF, 16-volt electrolytic
C3—0.1-μF, 50-volt ceramic disc
Resistors (¼-watt, 10% tolerance)
R2—100 ohms, 1% metal-film
R3—5,900 ohms, 1% metal-film
R6—100,000 ohms, 1% metal-film
R7—4,700 ohms
R8—150 ohms
R9,R13—10,000 ohms
R10—100,000 ohms
R11,R12—1,000 ohms
R1—0.2-ohm wirewound (see text)
R4—10,000-ohm pc-mount cermet potentiometer
R5—250,000-ohm linear-taper panel-mount potentiometer
Miscellaneous
B1—9-volt battery
P1—Piezoelectric sound element (Radio Shack Cat. No. 273-065 or similar)
PC1—Silicon solar cell (Radio Shack Cat. No. 276-124 or similar 0.3-ampere solar cell)
S1—Spst slide or toggle switch
S2—Spst normally open pushbutton switch
S3—Single-pole 3- or 4-position switch (optional—see text)
Printed-circuit board or perforated board with holes on 0.1-inch centers and suitable soldering or Wire Wrap hardware (see text); clear plastic enclosure (see text); DIP sockets for IC1 and IC2; snap connector and holder for B1; pointer-type control knob (2); silicone adhesive or fast-setting epoxy cement (see text); double-sided thick foam tape; machine hardware; hookup wire; solder; etc.

Note: The following items are available from A. Caristi, 69 White Pond Road, Waldwick, NJ 07463: Ready to wire pc board, $9.95; LM324, $2; CD4020BE, $3.50; 2N6027, $3; 0.2-ohm wire-wound resistor, $1.50; set of three metal-film precision resistors, $1.50. Add $2.00 postage/handling. New Jersey residents, please add state sales tax.

Connected as a voltage follower *IC1B* provides a low-impedance driving source for the clock circuit. After calibration, the output at pin 14 of *IC1B* will be 5.5 volts under conditions of 1 full sun, and will vary linearly, from zero to 5.5 volts, with changes in sunlight intensity. Programmable unijunction transistor *Q1* and its associated components, which make up a relaxation oscillator circuit, are used to convert the voltage generated by *IC1* into a time-dependent function.

Capacitor *C1* is charged through *R5* and *R6* by the voltage generated at the pin 14 output of *IC1B*. The rate at which *C1* charges is proportional to the voltage delivered by *IC1B* and the total resistance of *R5* plus *R6*. With increasing sunlight intensity *C1* charges faster, and with less intensity it charges slower. Also, greater values of resistance result in slower charging, and lesser values speed up the charging rate.

Programming of *Q1* is accomplished with a voltage (about 1.4 volts) fed to its gate, which is provided by the series-connected, forward-biased *D1-D2* silicon diode pair. The forward-biasing voltage is delivered from the circuit's positive supply bus through *R7*. The voltage fed to the gate of *Q1* will remain essentially constant as the terminal voltage of the battery falls with use.

The anode of *Q1* is connected to the positive side of the charging capacitor *C1*. When the voltage across the capacitor exceeds the programmed 1.4-volt potential at the gate of *Q1*, the transistor suddenly triggers into conduction and dumps most of the charge stored in the capacitor into *R8*. As a result, the voltage across *C1* falls to near zero, at which point, the capacitor begins charging again to repeat the cycle.

As you can see, the frequency of oscillation of *Q1* is proportional to the charging rate of *C1*, which, in turn, is a function of the intensity of sunlight striking the solar cell. An increase in sunlight intensity causes the frequency of the signal generated by the *Q1* oscillator to increase, and vice-versa. TIME potentiometer *R5* also controls the operating frequency of the oscillator and provides a 3.5:1 adjustment range that allows you to manually adjust the desired time of exposure.

A voltage spike appears across *R8* when *C1* suddenly discharges. This spike is applied to the base of *Q2* to forward-bias the transistor into conduction. As collector current flows in *Q2*, a narrow negative pulse whose amplitude is equal to the voltage of battery *B1* is used as a clock for counter *IC2*.

Integrated circuit *IC2* is a 14-stage binary ripple counter/divider. In this project, it serves as both a memory device and a clock. The counter has all but two of its binary stages available at output pins. For this application, only output pins 6, 1, 2 and 3 are of interest. These represent clock signals that have been divided by 128, 4,096, 8,192 and 16,384.

When power is first applied to the circuit, the sudden application of voltage is fed through *C3* to the master reset input of *IC2* at pin 11 to cause the counter to be set to zero. At the same time, the clock input at pin 10 is being triggered by the pulses that appear at the collector of *Q2*, assuming *PC1* is intercepting sufficient sunlight intensity to cause the oscillator to run. Clock pulses cause the counter to advance one count at a

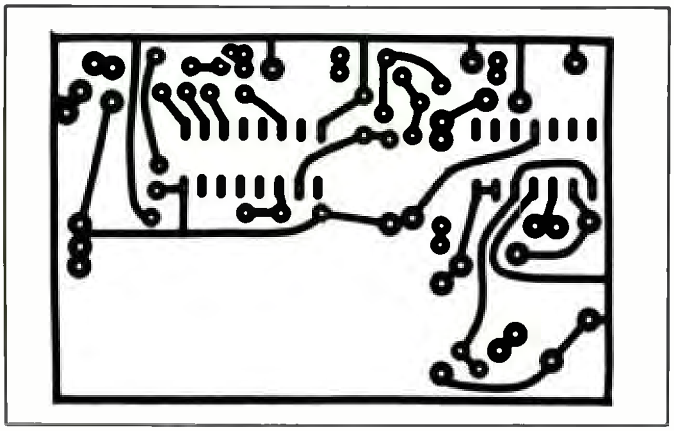


Fig. 2. Actual-size etching-and-drilling guide for project's printed-circuit board.

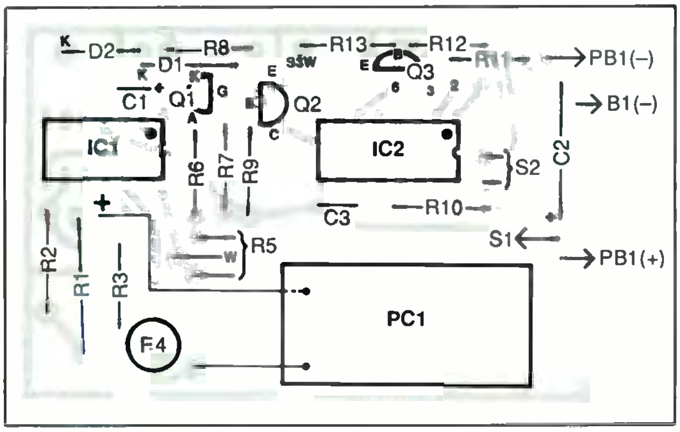


Fig. 3. Wiring guide for printed-circuit board. Use this as a rough guide to component layout on perforated board.

time, at a rate that represents the amount of UV energy striking the solar cell.

The unijunction oscillator operates at a frequency in the 0.25-Hz range; hence, a predictable amount of time is required before any of the outputs of *IC2* can be advanced to a logic 1 level. In this circuit, pin 1 of *IC2* would go to logic 1 after a delay of about 8 minutes in full sunlight with *R5* set to minimum resistance. Similarly, pins 2 and 3 would not reach a logic 1 condition until 16 or 32 minutes of time, respectively, have elapsed. This time delay, which is a function of the unijunction oscillator frequency, provides the trigger signal that operates the warning device, *PB1*.

Resistor *R13* is connected to one of the pin 1, 2 or 3 outputs of *IC2*. When that output assumes a logic 1 condition, *Q3* is forward biased. This causes current to flow into piezoelectric sound element *PB1*. The high-pitched warning signal emitted by *PB1* then tells you that the selected elapsed time is up.

Resistor *R13* is connected to the outputs of *IC2* through single-pole, three-position switch *S3* to provide three possible time-delay ranges that can be selected. If you require only one time-delay range, you can wire *R3* directly to the appropriate output pin of *IC2* and eliminate switch *S3*. A fourth output, at pin 6 of *IC2*, provides a means for quickly checking time-delay calibration without having you wait the full 8 minutes. This output, because of the internal division of the clock frequency by 128, will assume a logic 1 condition in full sunlight after a time delay of about 15 seconds.

Resistor *R12* and TEST switch *S2* permit you to check battery condition. When you push *S2*, *R12* draws a current that exceeds the normal operating current of the circuit. If the battery has sufficient energy to supply this current, *Q3* is forward-biased and *PB1* sounds. If *PB1* does not sound, you know that it is time to replace the battery.

Construction

There is nothing critical about component placement or conductor routing in this project. Therefore, just about any traditional means of wiring the circuit can be employed. If you wish, you can fabricate a printed-circuit board for the project, using the actual-size etching-and-drilling guide given in Fig. 2. Otherwise, you can purchase a ready-to-wire pc board from the source given in the Note at the end of the Parts List. Alternatively, you can use perforated board that has holes on 0.1-inch centers and suitable Wire Wrap or soldering hardware. Whichever way you go, though, it is a good idea to use sockets for the integrated circuits.

From here on, we will assume you are building the project on a printed-circuit board. Start assembly by placing the pc board in front of you in the orientation shown in Fig. 3 and follow this wiring guide exactly when installing components in the various locations. If you elect to use perforated-board construction, use Fig. 3 as a general layout guide, and make sure to keep the wiring between *PC1*, *R1*, *R2* and *IC1* as close as possible to that shown in Fig. 3 since the op amp operates on a very small input voltage produced by the solar cell and *R1*.

Begin wiring the board by installing and soldering into place the IC sockets. This done, install and solder into place the resistors and potentiometers, followed by the diodes and capacitors. Make certain that diodes *D1* and *D2* and electrolytic capacitors *C1* and *C2* are properly polarized before soldering their leads into place. Install the transistors in their respective locations and double check their basing before soldering their leads to the copper pads on the bottom of the board.

When assembling the pc board, do *not* mount the solar cell or remove it

Wire Length Chart for R1

Wire Size	Length in Inches
28	38
30	24
32	15½
34	10¼
36	6¼

Time-Delay Range for IC2 Outputs

Output Pin	Time Delay Minimum	Time Delay Maximum
6	15 seconds	52 seconds
1	8 minutes	28 minutes
2	16 minutes	56 minutes
3	32 minutes	112 minutes

from its protective package until instructed to do so later. This component is extremely fragile and is easily damaged by careless handling.

Be sure to use the components specified in the Parts List for *R2*, *R3* and *R6*. The values of these metal-film resistors, which remain relatively stable as the temperature changes, determine calibration accuracy, which is something you do not want to change once you have calibrated the project. Ordinary carbon resistors do not have the value stability required for this part of the circuit.

Resistor *R1* is specified at 0.2 ohm, which is not a readily available value. However, it is easy to make the required value resistor from enameled (magnet) wire and a resistor. The Wire Length Chart specifies lengths of wires of various gauges that can be used to fabricate this resistor. Cut the wire whose gauge you have chosen to the length specified for it in the Chart. Then scrape ½ inch of enamel insulation from each end.

Now wind ½ inch of one end of the magnet wire onto the bare lead of any ½-watt resistor that has a medium to high resistance value. Start near the body of the resistor. Solder this wire end into place. Then wind the entire length of wire except for the last ½ inch onto the body of the resistor. It does not matter if you wind in a random fashion and end up with more than one layer. Wind the remaining bare portion onto the resistor wire opposite the soldered end, and solder it in place.

Paint a smooth layer of coil dope or a fast-setting epoxy cement over the coil to hold the windings in place. After the coil dope has dried or the epoxy cement has set, plug the leads of the resistor into the R1 holes in the circuit-board assembly and solder them to the copper pads on the bottom of the board.

As mentioned above, you have the option of using a three- or four-position, single-pole switch in your project for switch *S3* if you wish to have a wide range of exposure times. A four-position switch allows you to be able to include a CALIBRATE position that connects *R13* to pin 6 of *IC2* to be able to quickly check SunGuard's accuracy.

The Time Delay table illustrates the range of exposure times that are obtainable for each of the selected outputs of *IC2* at pins 6, 1, 2 and 3 using the specified values for *R5*, *R6* and *C1* in the oscillator circuit. If you wish to modify the specified timing ranges, change the value of *C1*. The time relationship is linear with the value of *C1*. That is, doubling the value of this capacitor doubles the time specified in the table and halving its value halves the time. It is not recommended that the value of either *R5* or *R6* be changed from those specified for these resistors in the Parts List since the oscillator transistor places a restraint on the maximum and minimum values of resistance used in the circuit.

Strip ¼ inch of insulation from both ends of 11 (9 if you are planning on using a single range for your project) 5-inch hookup wires. If you are using stranded hookup wire, tightly twist together the fine conductors at both ends and sparingly tin with solder. Plug one end of two of these wires into the holes labeled R5 and solder into place.

Plug one end of another wire into the hole labeled S3W between *Q2* and *R13* on the board and solder this into place. Now, depending on whether you are using a single range or three ranges, plug three wires or one wire into the holes labeled 3, 2 and 1 or the appropriate hole for the single range and solder into place.

Plug one end of another pair of wires into the holes labeled S2 and solder them into place. Then do the same for the remaining two wires and the holes labeled S1 and B1 – .

If you omit *S3*, temporarily solder a jumper wire between the hole labeled S3W and pin 6 of the *IC2* socket to make a quick calibration of your project. Then, once *R5* is calibrated, permanently wire *R13* to the desired output terminal of *IC2* in accordance with the selected time delay listed in the Time-Delay Range chart.

When you have completed wiring of the circuit-board assembly, carefully examine both sides of it to make sure all components are installed in the proper locations and orientations. Check the solder side of the board, keeping an eye out for missed connections, poor soldering and solder bridges, the latter especially between the closely spaced IC socket pin pads. Solder any connections missed, reflow the solder on any point that appears to be suspicious and use desoldering braid or a vacuum-type desoldering tool to remove any bridges.

When you are satisfied that the circuit-board assembly has been properly wired, place the solar cell on the board. Very carefully remove it from its protective package. Note that one side has a series of lines stopping short at each end, leaving a clear strip about ¹⁄₃₂ inch wide. This is the negative terminal of the cell. The back side is the positive terminal.

Scrape ³⁄₁₆ inch of insulation from one end of two 2-inch lengths of enamel-insulated magnet wire (not

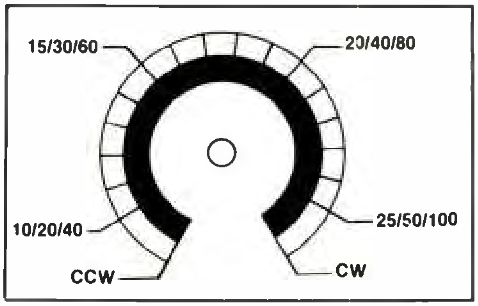


Fig. 4. Actual-size artwork for calibrating potentiometer control.

heavier than 24 gauge). Use a low-wattage iron to carefully solder the stripped ends to the clear portion on the front of the solar cell and the back of the cell.

Place the solar cell with its front, or negative, side up in the indicated location on the circuit-board assembly and trim the two magnet wires to proper length. Carefully scrape away about ⅜ inch of insulation from the free end of each. Then insert the wires into the proper holes in the board, making sure to observe correct polarity, and solder into place. Cut off any excess wire on the bottom of the board.

Secure the solar cell to the top surface of the board with a drop of silicone or any other suitable adhesive. Set the circuit-board assembly in a safe place until the adhesive sets.

Tightly twist together the fine wires at the free ends of the leads of the battery snap connector and tin with solder. Plug the black-insulated (negative) connector lead into the hole labeled B1− in the board and solder it into place. Crimp and solder the red-insulated (positive) lead to one lug of *S1*. Then plug the free ends of the wires coming from the buzzer into the PB1 holes, making certain that you observe correct polarity, and solder them into place.

Be sure to connect the free ends of the R5 wires to the lugs of this potentiometer so that clockwise rotation results in increasing resistance. Otherwise, you will not be able to properly calibrate the circuit.

Crimp and solder the free end of the wire coming from hole S3W to the common wiper lug on this switch (if you are using it). Then crimp and solder the free ends of the wires coming from holes 6, 3, 2 and 1 to the remaining lugs of the switch in the proper sequence. Finally, crimp and solder the free ends of the wires coming from the S2 holes to the lugs of the pushbutton switch.

House your project inside a small clear plastic enclosure that is capable of preventing sand and other contaminants from entering. Use of a clear plastic enclosure is mandatory to permit the solar cell to get full exposure from the sun.

Machine the enclosure by drilling mounting holes for the three switches (two switches if you opted to omit *S3*), potentiometer *R5* and the clip that will hold the battery in place. Do not drill mounting holes for the circuit-board assembly; it will be mounted with strips of thick double-sided foam tape.

Mount the piezo-buzzer element inside the enclosure, securing it in place with a daub of silicone adhesive or fast-setting epoxy cement. There is no need, nor is it recommended, for you to drill holes in the enclosure to allow the sound to escape since the intensity of the alerting tone is sufficient to be heard through the enclosure's walls. When mounting the components on and inside the enclosure, do not forget to allow room for the battery.

Shown in Fig. 4 is actual-size artwork you can cement on the outside of the enclosure for use in calibrating *R5*. Make a photocopy of this artwork instead of cutting up the page if you wish. If you need a slightly smaller or larger illustration, many photocopy machines permit reduction and enlargement of the original. After cementing the artwork to the enclosure spray over it two or three light coats of clear acrylic to protect it from wear and abrasion. Allow each coat to dry before spraying on the next. Place suitable pointer-type control knobs on the shafts of the potentiometer and multiple-position switch (*S3*).

Checkout & Calibration

If you installed the integrated circuits in their sockets during assembly, carefully remove and set them aside. Snap a fresh 9-volt battery into its connector and set POWER switch *S1* to its "on" position. Use an ordinary dc voltmeter or multimeter set to the dc volts function to perform voltage checks before installing the ICs in their sockets. This meter should have an input resistance of not less than 1 megohm.

Clip the meter's common probe to the negative (−) lead of electrolytic capacitor *C2*. Then touch the meter's positive probe to pin 14 of the *IC1* socket and pin 16 of the *IC2* socket. In both cases, you should obtain a meter reading of approximately 9 volts. If not, power down the circuit and carefully check your work for wiring errors, components installed in the wrong locations and/or wrong orientations, etc. Do not proceed until you have rectified the problem.

Once you are certain that everything is okay, install the ICs in their respective sockets. Make you properly orient each and that no pins overhang the sockets or fold under between the ICs and sockets. Now proceed to calibrating the project.

SunGuard is easily calibrated with the aid of the meter you used to perform checkout, a watch or clock with a sweep second hand or a seconds counting function, and a regulated dc power supply that is capable of supplying 5.5 volts. The last is a convenience but not a necessity.

The first part of the circuit to be calibrated is the solar cell and operational amplifier *IC1*. For calibration of this circuit, you must have clear-sky conditions and the sun at full brightness.

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The SunGuard

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Perform the calibration procedure as close as possible to June 21 (the summer solstice in the northern hemisphere), when the sun's energy is at maximum intensity to obtain maximum accuracy. Otherwise, any clear, sunny day in June or July will be fine for calibration purposes. However, wait until the sun is overhead, about noontime, when adjusting trimmer control *R4*.

Set the meter to a 10- or 20-volt dc full-scale range. Connect its common probe to the negative lead of *C2*. Clip the positive probe to pin 14 of *IC1*. Place the project so that the sunlight falls directly on the solar cell, with the plane of the cell held as close as possible to perpendicular with the sun (do not look into the sun itself!).

Turn on power to the project and adjust *R4* for a reading between 5.4 and 5.6 volts. Note that as you orient the project for best exposure to the sun, the voltage will vary slightly. Set *R4* so that the maximum voltage obtainable is between 5.4 and 5.6 volts as you orient the project for the best exposure. This completes the calibration of the solar cell and amplifier; *R4* will need no further adjustment.

If you do not obtain the correct voltage reading at pin 14 of *IC1*, check to make certain that the solar cell is wired into the circuit in the correct polarity. If it is, measure the value of *R1* to be sure it is about 0.2 ohm, and measure the voltage across it with the solar cell exposed to full sunlight. You should obtain a reading of about 60 millivolts dc. Also, check the values of the components associated with *IC1*, and, as a final step, try a new LM324 in the socket.

Final adjustment for the project is for proper setting of *R5*. Set the project to the "calibrate" mode, either by temporarily connecting *R13* to pin 6 of *IC2* or setting *S3* to its CALIBRATE position if you incorporated this switch into your project. Set *R5* to maximum counterclockwise (minimum resistance) and place the control knob on its shaft so that the pointer is at the counterclockwise (CCW) limit of the scale—not the 10/20/40 index shown in Fig. 4. Tighten the knob's setscrew and adjust the knob so that the pointer is at the 15/30/60 minute point.

The easiest way to calibrate *R5* is to remove *IC1* from its socket and connect a dc power supply, set to 5.5 volts, between circuit common and pin 14 of the *IC1* socket (be sure to observe polarity). This eliminates any variation in drive voltage to the oscillator as a result of varying sunlight intensity. If you do not have a suitable supply available, using the solar cell and amplifier to generate the voltage in full sunlight is perfectly satisfactory, though you will have to position the project so that it remains stable while exposed to full sun.

With the supply set to 5.5 volts or the solar cell positioned so that it receives full direct sunlight, turn on the project and measure the amount of time required for the piezo buzzer to sound. Measure the delay from the time the POWER switch is thrown to when you hear the alert tone. This should be about 28 seconds. If the time is more than 1 second off, slightly reposition the knob's pointer with reference to the 15/30/60 minute index and repeat the test.

When you have obtained a time delay between 27 and 29 seconds, calibration of the project is complete. Check the time delay for the 10/20/40 and 25/50/100 minute index points. You should obtain about 19 and 47 seconds, respectively.

When you are satisfied that the setting of the knob for *R5* is reasonably accurate, press TEST switch *S2*; the piezo-buzzer element should sound immediately and continue to sound for as long as the button is held down.

Using the Project

Before using your SunGuard project, you should have a fair idea on how much sun exposure your body will tolerate. This will depend a lot on skin type. In general, the fairer your skin, the less tolerant you will be to the sun's energy. Generally, your first day's exposure should be as little as 15 minutes. From there, you can lengthen your exposure time each day by 5 minutes or so until you develop a full tan.

Always check battery condition before you use SunGuard to monitor your sunbathing. When you are ready to sunbathe, set the desired exposure time and switch on the project at the start of exposure to the sun's rays. Thereafter, when the alarm sounds, you have had your specified amount of sun. Keep in mind that SunGuard's clock will almost always run slower than your watch does because the sun's intensity will usually be less than maximum and is likely to vary during a sunbathing session.

Reader's Solar Observations

- The SunGuard sunlight monitor project (May 1989) is described as a detector of the sun's ultraviolet radiation. However, the silicon solar cell recommended for this project has negligible response below 400 nanometers. The action spectrum of human erythema (sunburn) ranges from around 295 to 320 nm in the so-called UV-B region of the spectrum. While the SunGuard will apparently function as a dosimeter for the broad range of wavelengths received by its solar cell, it will not necessarily provide a reliable indication of safe tanning time. Variations in ozone, water vapor and other atmospheric parameters can cause significant nonlinearities in the relationship of UV-B and the spectrum of 400 to 1,100 nm detected by a common solar cell.

Solar cells and photodiodes sensitive to UV are available. However, they must be used in conjunction with an expensive UV-B filter to provide a usable sunburn meter. Incidentally, the SunGuard can be simplified and given a more linear response by using IC1C as a current-to-voltage converter. This can be accomplished by eliminating R1 and R2 and connecting the solar cell directly across the inputs of IC1C. Pin 10 of IC1C should be tied to ground.

Name Withheld

You are correct that the silicon solar cell I specified responds to a broad band of wavelengths and not specifically to UV radiation. Solar cells that are responsive to UV radiation are indeed available and when used with the required filter become very expensive to be used in a low-cost project. SunGuard was never intended to be a laboratory-grade UV meter but a device that responds to cumulative sunlight that strikes the solar cell. It measures relative exposure, which varies with the angle of radiation as determined by the time of day and month of the year. As such, the project will measure the degree of relative *UV exposure.*

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LETTERS . . .

(from page 7

I disagree with your circuit simplification in which IC1C can be used as a current-to-voltage converter. The solar cell is a device that develops a current, up to 300 mA, that is proportional to sunlight energy. Its terminal voltage is not significant. Thus, the cell must *be loaded down with a low value of resistance (R1 in the project) to absorb the current. In this circuit, R1 is a simple, perfect current-to-voltage converter and eliminates the problem of absorbing the heavy 300-mA current in the IC amplifier circuit, which then must be offset by the 9-volt battery. —Tony Caristi.*