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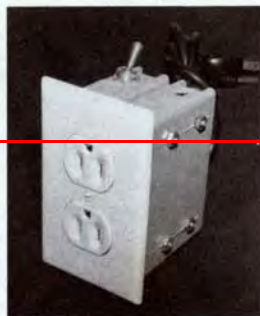


# BUILD A HIGH-EFFICIENCY LIGHTING SYSTEM



*Lower the cost of your monthly lighting bill by 90 percent!*

the latter consists of two identical current pulses of opposite polarity per cycle; eliminating one pulse decreases current by fifty percent. Also, the second pulse may arrive prior to the full release of heat energy, thereby wasting the energy released by the second bipolar current pulse. With pure resistive loads, heating continues after the pulse ends (the pulse actually used by the Lighting System is from 151 to 168 degrees). By correcting for these problems found in standard lamps, the High-Efficiency Lighting System (when used with the lamp specified in the Parts List) manages to use 90% less electricity.



BY STEVEN R. ROSENBERG

**A**re you wasting electricity? If you're using standard light fixtures in your home or office, then you definitely are spending more for illumination than you have to. The truth of the matter is that conventional lamps are nowhere near efficient. For that reason, in this article we'd like to introduce you to a more economical source of light: *The High-Efficiency Lighting System*.

With this easy-to-build unit you'll save a bundle on electric bills in no time. That's because the Lighting System uses about 10% of the electricity that a standard lamp uses! Just think how much you'll save if you build one for every room.

**Lamp Efficiency.** When dealing with lamps, as well as many other

types of electrical devices, achieving efficiency requires reducing the amount of energy used up, without weakening the output. Performing this with a transformer has been done, but it is rather ineffective. We needed to find a better way.

When solid-state components are used to simulate a step-down transformer, a secondary voltage is produced with the reliability of a transformer, but at a much more efficient rate. You see, as a generator rotates through its 360-degree cycle, sine-wave energy is produced. At any given fraction of a degree this energy can be conducted through a thyristor. That will result in an instantaneous voltage, unipolar power pulse.

A unipolar pulse is more efficient than a bipolar pulse. That's because

The bar graph shown in Fig. 1 demonstrates how much less power is used by a 30-volt, 50-watt lamp connected to the Lighting System, as opposed to that used by a standard light fixture. Keep in mind that the light output by the Lighting System lamp is equal in brightness to that of the conventional light fixture.

The efficiency of the System can translate into very tangible savings on your electric bill. For example, if you have a lamp that needs to stay on 24 hours a day, seven days a week, you should save approximately \$100 a year.

**Circuit Description.** The schematic for the Lighting System is shown in Fig. 2. Plug PL1 connects to a standard 117-VAC outlet to provide power for the circuit. A capacitive/resistive filter made up of C6 and R5 eliminates SCR tracking of



TABLE 1

Conduction Angle (Degrees)	Lamp Voltage (Volts)	Lamp Current (Amperes)	Power Used (Watts)	Lumens (Foot Candles)	Lamp Simulated (Watts)
151.10	12.30	0.60	7.38	1750	100
152.00	10.81	0.57	6.16	1190	75
158.70	9.28	0.50	4.64	870	60
159.70	8.85	0.48	4.24	810	50
162.50	7.69	0.45	3.46	505	40
167.60	5.42	0.36	1.95	190	25

the AC source voltage; S1 is the power switch.

Capacitors C2-C4 are used to prevent undesirable triggering of SCR1-SCR3 from transient voltage, and for this reason are connected between the gates and cathodes

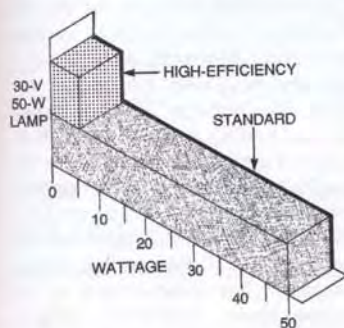


Fig. 1. As shown in this bar graph, a 30-volt, 50-watt lamp connected to the High-Efficiency Lighting System uses only 10 percent of the power used by a conventional light fixture.

of the thyristors. Decoupling against line-voltage transients acting on unijunction-transistor Q1 is provided by capacitor C5. As a result, positive or negative transients on the unijunction supply voltage will not trigger Q1.

Transistor Q1 is connected through resistor R3 to the voltage "low side" and directly to the gate of SCR1. The other base of Q1 connects through the serial combination of resistors R1 and R2 to the "hot side" of the supply. Resistor R1 drops the AC source voltage to the supply voltage of the timing circuit, while resistor R2 serves to compensate Q1 from thermal variations. Potentiometer R4 can be used to vary the brightness of the circuit as it determines the charging voltage on timing capacitor C1, and the

range of conduction angles available (more on this later).

Thyristors SCR2 and SCR3 are connected in parallel to improve stability and to allow two lamps to be powered by the circuit. The lamps, I1 and I2, plug into AC sockets SO1 and SO2. Note that the cathodes of SCR2 and SCR3 are connected to the sockets, while the anodes connect to the hot side of the AC supply. This configuration removes the low-voltage load from the power supply of Q1 and supplies the load through the thyristors.

**Construction.** The author's prototype for the Lighting System was built on a printed-circuit board. If you'd like to do the same you can either etch your own board using the template shown in Fig. 3, or order a board from the source mentioned in the Parts List (complete kits of parts are available from the source as well). Another option is to build the circuit on a piece of perforated board.

For those using a PC board, refer to the parts-placement diagram while building the unit. To begin

assembly, attach two wires to the board to allow for connections to toggle-switch S1 and AC-sockets SO1 and SO2. The wire leading to S1 should be red, signifying a direct connection to the house wiring.

Install R5, C3, C4, C6, SCR2, and SCR3 to the board, being careful to orient correctly the last two parts. The thyristors have an on-state current of 4-8 amps and a peak reverse voltage of 200-600 volts maximum. These parts are strongly recommended because the high conduction angle of the switching in the circuit could lead to component failure. Only use the highest-rated (in terms of amperage) SCR available; heatsink material is recommended for extended service.

Make the following off-board connections shown in the parts-placement diagram. Attach switch S1 to the red wire you installed, then connect the other terminal of the switch to PL1 with one lead of an AC line cord (make sure to use the lead that is *not* connected to the wide blade of PL1). Connect the other lead of the line cord (the one connected to the wide blade of

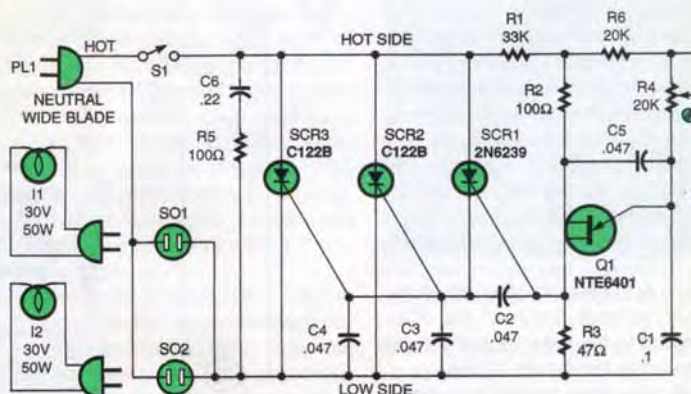


Fig. 2. Here's the schematic for the Lighting System. Lamps I1 and I2 plug into AC sockets SO1 and SO2, providing two efficient sources of light.



## PARTS LIST FOR THE HIGH-EFFICIENCY LIGHTING SYSTEM

### SEMICONDUCTORS

Q1—NTE6401 or EGC6401 N-channel unijunction transistor  
 SCR1—2N6239 200-volt, 4-ampere silicon-controlled rectifier  
 SCR2, SCR3—C122B 200-volt, 8-ampere silicon-controlled rectifier

### RESISTORS

(All fixed resistors are 1/2-watt, 5% units.)  
 R1—33,000-ohm  
 R2—100-ohm  
 R3—47-ohm  
 R4—20,000-ohm, trimmer potentiometer  
 R5—100-ohm  
 R6—20,000-ohm

### CAPACITORS

C1—0.10- $\mu$ F, 50-WV, Mylar  
 C2—C4—0.047- $\mu$ F, 200-WV, Mylar  
 C5—0.047- $\mu$ F, 50-WV, ceramic-disc  
 C6—0.22- $\mu$ F, 250-WV, Mylar

### ADDITIONAL PARTS AND MATERIALS

I1, I2—30-volt, 50-watt lamp, General Electric order code 16385, description 50A21, or equivalent  
 SO1, SO2—Two-terminal AC socket  
 PL1—Two-terminal AC plug, polarized  
 S1—SPST toggle switch  
 Printed-circuit materials, plastic electrical box, AC receptacle cover plate, AC line cord, wire, solder, hardware, etc.

**Note:** The following are available from Advance Power System (1307 Maple Ave., South Plainfield, NJ 07080; Web: <http://members.aol.com/Apsinfo/Apsinfo.html>; e-mail: [apsmail@aol.com](mailto:apsmail@aol.com)): etched and drilled PC board—\$9.50; kit of parts including everything except the lamps—\$25.50; assembled and tested kit, not including lamps—\$35.50; two lamps—\$6. Add \$2.50 for shipping and handling; NJ residents please include appropriate sales tax. Please allow 4 to 6 weeks for delivery.

PL1) to one terminal of each of the two AC sockets. Connect the other terminals to the remaining lead you soldered to the board earlier.

You now have to test the partially assembled board before you can proceed with assembly. Plug a stan-

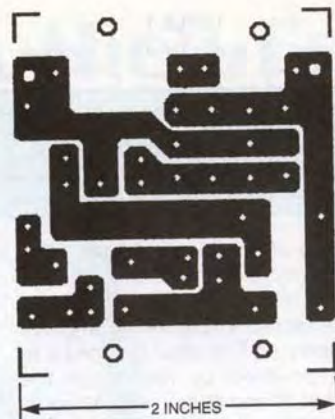


Fig. 3. This is a full-size foil pattern for the Lighting System PC board.

dard 120-volt lamp into SO1 and plug PL1 into an AC outlet.

Use an alligator-clip-equipped jumper to briefly connect the gates of SCR2 and SCR3 to the AC hot side. The lamp should light. If the lamp is on all the time, or it does not light, check that the SCRs are installed correctly and not overheating, and the circuit components are of the correct voltage rating.

Unplug the circuit from the outlet and connect SCR1 and C2 to the board. Plug in PL1 again and test the circuit as just described. Once you're sure the aforementioned components are working properly, mount the remaining components to the PC board as shown in Fig. 4.

Verify that you can vary the conduction angle with R4 (although it is board-mounted in the prototype, potentiometer R4 can be replaced with an off-board component).

**Setup and Use.** As hinted at earlier, you will need to select a conduction angle using R4. To do this, connect a standard 100-watt, 120-volt AC lamp to the circuit. Adjust R4 until the standard lamp is almost extinguished.

Disconnect the 120-VAC lamp and connect the 30-volt lamp specified in the Parts List (make sure you don't use a three-way lamp, as it will drastically reduce the life of the bulb). Connect a DMM across the lamp's terminals. As you perform the next step, be certain to keep the voltage of the lamp below 15 VDC. Adjust R4 until the values measured across the lamp are 12.3-volts DC at 0.6 amperes. These values will result in a conduction angle of 151.1 degrees, which results in a 1750-foot-candle measurement. This is equivalent to a conventional 100-watt lamp's advertised initial lumens. The average power used at this setting is 12.3 volts  $\times$  0.6 amperes, or 7.38 watts.

It is possible to simulate conventional lamps that have other wattage values by setting a different  
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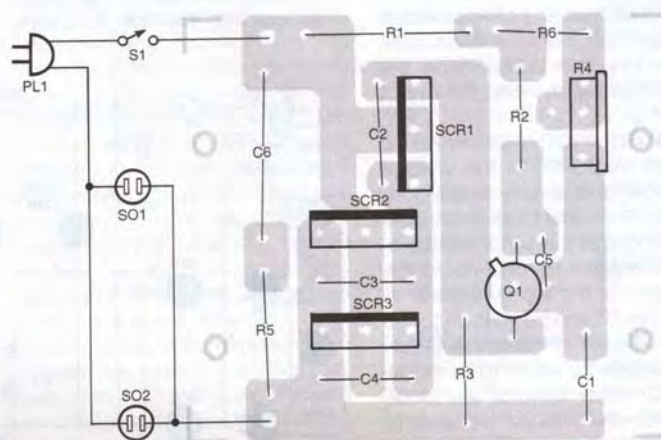


Fig. 4. If you're building the System on a PC board, use this parts-placement diagram as a guide.

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### **BUILD A LIGHTING SYSTEM**

*(Continued from page 44)*

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conduction angle. Use Table 1 to set your Lighting System for light levels that mimic 75-, 60-, 50-, 40-, and 25-watt lamps.

With the potentiometer set, you can complete the Lighting System by mounting it in a plastic electrical box with an AC receptacle cover. You can also modify a small project box. No matter what enclosure you use, however, *never touch any of the components while the circuit is plugged in and turned on!*

If the glow of the lamp seems to waver, check that other appliances on the circuit are in good condition. Also check that all outlets have the proper polarity (house-wiring testers are available for this purpose); appliances with reverse polarity can adversely affect the circuit. ■