The Touchmaster

A touch-sensitive lamp controller that can be added to any lamp

By J. Daniel Gifford

You've probably seen—and played with—one of those fascinating lamps that are controlled by the touch of a finger on their metal surfaces. They seem to be irresistible to everyone. As an electronics hobbyist, you've probably wondered how they work or, more likely, how you could build one. Here's how.

The "Touchmaster" discussed here is a small module that can be added to any lamp that has room to hide it in. It will control an ordinary 3-way bulb or, if you like, two separate bulbs, all with the barest touch of a finger.

The first touch will light the 3-way bulb's low-wattage filament or the first of two bulbs, depending on which type of lamp you use it in. The second touch will light the high-wattage filament or second bulb, and the third will light both filaments or bulbs. Either filament or bulb (or both, in the latter case) can be as much as 100 watts. (If you can contrive adequate heatsinking, much higher wattage bulbs can be used, but it's not recommended unless you're expert at this.)

The Touchmaster is also completely safe: the ac and dc halves of the circuit are completely isolated from each other via the power supply transformer and the output optocouplers. Just follow the construction precautions noted in the article.

Circuit Description

There are four parts to the Touchmaster circuit (Fig. 1). The first is the power supply for the control side. A 12-volt center-tapped transformer supplies approximately 9 volts dc to the circuit through full-wave rectifier *D2* and *D3*. Capacitors *C2* and *C3* filter and smooth the dc; since the circuit is all CMOS, no regulator is needed.

This simple 3-way lamp is controlled by the touch of a finger on the brass band of the wooden base that contains the Touchmaster module.

The second part of the circuit is the touch switch, formed from the four gates of *IC1*, a CD4093B Quad CMOS Schmitt Trigger NAND gate. All four gates have their inputs tied together and thus act as Schmitt Trigger inverters. (If desired, a CD4584B or 74C14 Hex CMOS Schmitt Trigger Inverter IC may be used instead; be certain to tie the two unused inputs to circuit ground.)

The four inverters are used in pairs to form two Schmitt Trigger buffers. The input of the first buffer is tied to circuit ground via *R2*, a 5 to 15 megohm resistor, and to the touch control surface via *R1*, a 100k resistor. *R1* limits the input current and prevents possible static damage to *IC1*'s inputs, while *R2* determines the input impedance and, thus, the touch sensitivity of the circuit. *R2*'s value must be found experimentally once the circuit has been built and installed: generally, the larger the area of the touch surface, the smaller the value of this resistor.

The output of the first buffer is normally low until the touch-control surface is touched. Then the body of the person touching it acts as an antenna and picks up the 60-Hz power line hum that radiates from the lamp itself and from the power lines of the building around it. This hum is rectified and amplified by the first buffer and emerges as a 60-Hz square wave. This waveform is rectified into dc by *D1* and charges *C1* until it reaches the input threshold (about 6 volts) of the second buffer. When this threshold is reached, the second buffer switches high and remains high until the finger is removed from the control surface. At this time, the 680k resistor, *R3*, rapidly discharges *C1* until the second buffer's low threshold (about 4 volts) is reached, whereby its output again drops low. The charging and discharging of *C1* takes about 0.05 sec-

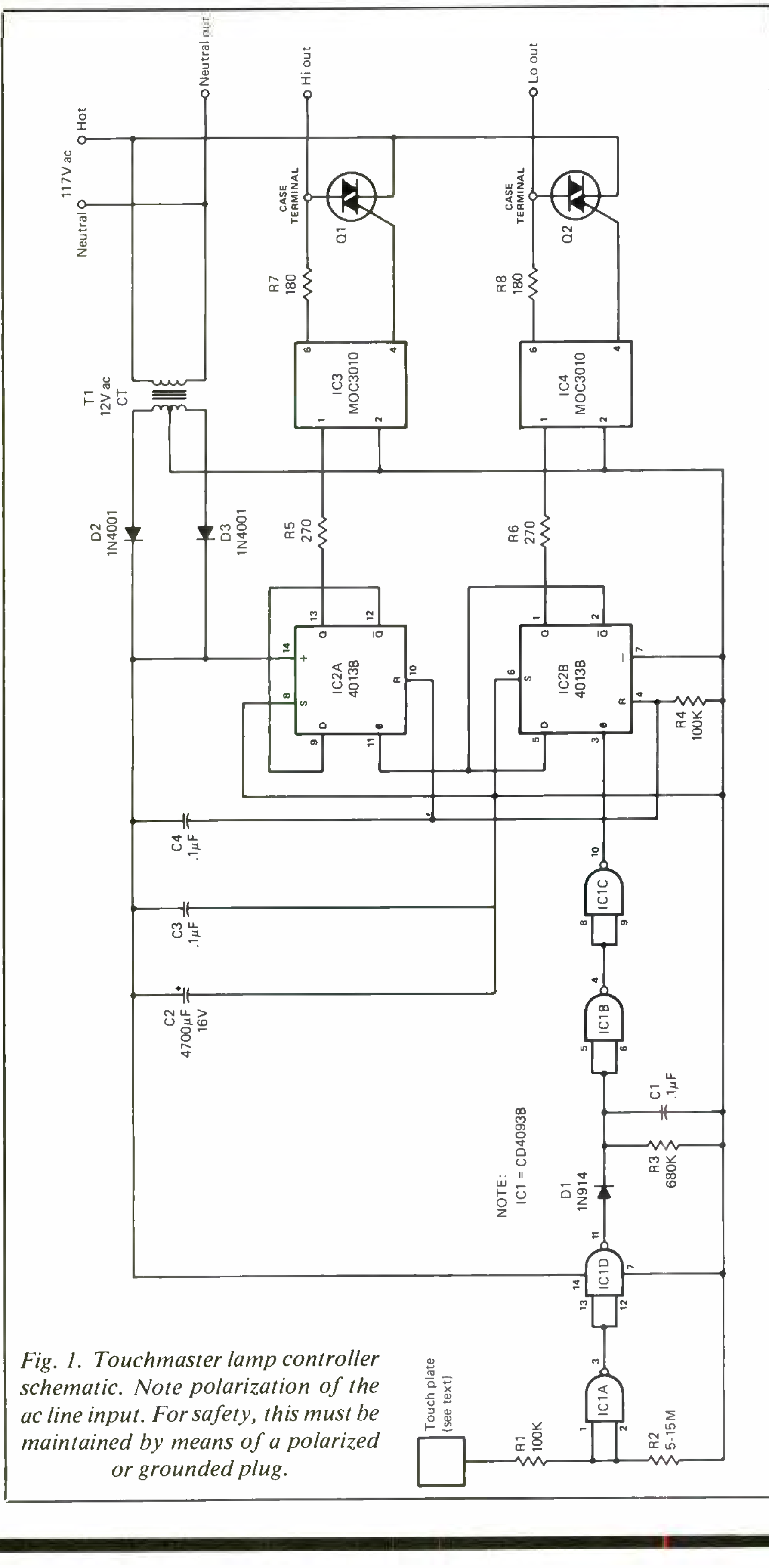

Fig. 1. Touchmaster lamp controller schematic. Note polarization of the ac line input. For safety, this must be maintained by means of a polarized or grounded plug.

PARTS LIST

Semiconductors

D1—1N914 diode

D2,D3—1N4001 rectifier diode

IC1—CD4093B quad CMOS Schmitt trigger NAND gate

IC2—CD4013B dual D-type flip-flop

IC3,IC4—MOC3010 triac-output optocoupler (Radio Shack No. 276-134)

Q1,Q2—200-volt, 4-ampere triac (Radio Shack No. 276-1001 or similar)

Capacitors

C1,C3,C4—0.1-µF polypropylene/disc

C2—4000-µF, 16-volt electrolytic

Resistors (¼-watt, 10%)

R1,R4—100,000 ohms

R2—5M to 15M ohms (see text)

R3—680,000 ohms

R5,R6—220 ohms

R7,R8—180 ohms

Miscellaneous

T1—12-volt center-tapped, 120-mA transformer (Radio Shack No. 274-1360 or similar); case (see text); perforated board; 14-pin IC sockets (3); 5-point barrier strip; 2 pc-board pins; MOV transient suppressor (Radio Shack No. 276-570 or similar—see text); machine hardware; hookup wire; solder; etc.

onds each way, so even three very fast taps on the touch surface will bring the lamp to full brightness.

The third part—and core of the Touchmaster—is a two-bit binary counter formed from the CD4013B CMOS Dual D-type flip-flop. The two flip-flops are connected to divide by two or toggle: the first clock impulse will drive the Q output high (and the $\overline{Q}$ output low); the second impulse will drive the Q output low. The touch switch is connected to the clock input of the first flip-flop (the low filament controller), and the $\overline{Q}$ output of the first flip-flop is connected to the clock input of the second (the high filament controller). We now have a 4-state binary counter that is clocked by successive touches on the touch surface.

The counter starts at 00, or off, and the first touch will advance it to 01 (low filament on), the second to 10

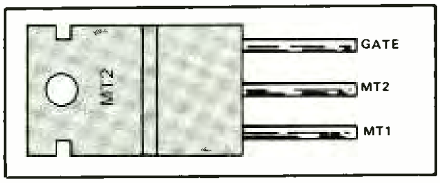

Fig. 2. Pinout of the triacs specified.

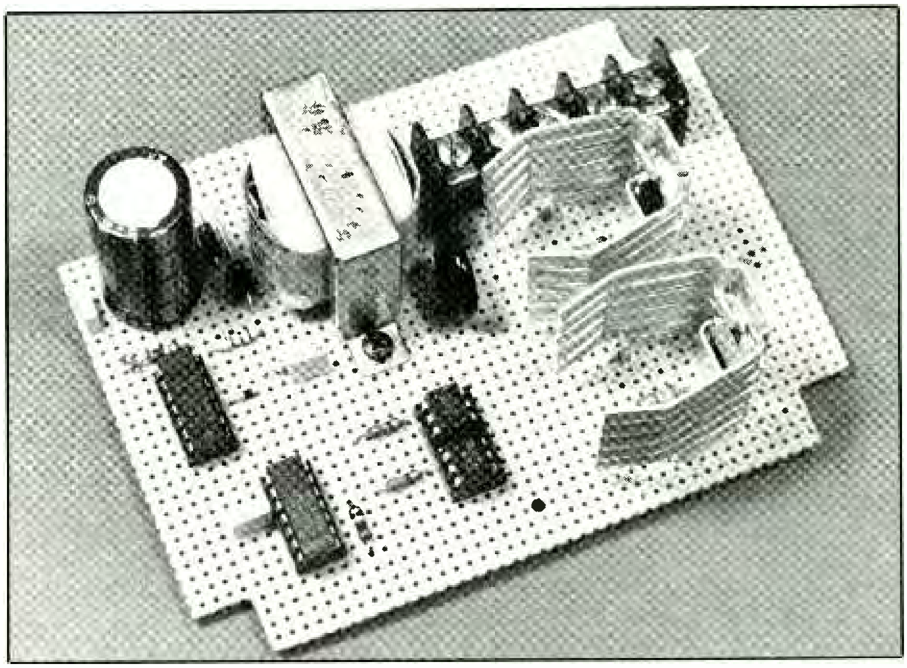

Fig. 3. The Touchmaster module. Note how the two opto devices share a common 14-pin socket. The screw-terminal barrier strip could be replaced with solder pins instead. Note also the MOV spike-suppressor (black disc near transformer) used on this prototype to prevent false switching from line transients.

(high filament on), the third to 11 (both on), and the fourth back to 00. The components *R4* and *C4* act as a power-on reset. Therefore, when the lamp is plugged in or after a power failure, the lamp will be in the 00 or off state. The time constant of the RC pair is such that a power-line flicker or momentary power loss will not cause the lamp to reset.

The fourth and final part of the Touchmaster circuit is the power output section. Outputs of the counter drive the input sides of the two triac optocouplers, *IC3* and *IC4*. Output sides of the optocouplers drive the two power triacs, *Q1* and *Q2*, that, in turn, control power to the lamp(s). Triacs are fairly efficient devices, so very small heatsinks can be used with output loads up to the recommended 100-watt limit. About 1 to 1½ square inches of dissipation area for each device is needed; if insulators are used, a common 2 to 3 square-inch heatsink may be used instead.

As mentioned earlier, there is no limit to the amount of power that the Touchmaster can control, as long as adequately rated triacs are used and adequate heat sinking is provided them. The devices specified in the parts list can handle up to 500 watts each with adequate heatsinking. Most lamps, however, have limited space for heatsinks and even more limited ventilation to carry away the heat, so 100 watts per bulb or filament will be the practical limit for most applications.

Construction

Construction of the Touchmaster revolves around two points: space and safety. The space available to mount the module and the shape that the circuit board must be will be dictated by the lamp that the Touchmaster will be mounted in.

The shape of the perfboard may need to be square, rectangular, long and narrow, or even circular in order to fit into the base or body of the chosen lamp. It's best to pick or design the lamp first and then build the Touchmaster to fit: don't make the (author's) mistake of building the module to fit a standard board or case and then try to fit it into a lamp. (Incidentally, the prototype in the photos was built about twice as large as necessary, both to allow possible reworking of the circuit and to more plainly show the layout.)

The second construction point, safety, is by far more important. What we have here is an ungrounded metal surface on one end and an ac power line at the other: a dangerous combination if strict precautions are not followed. The Touchmaster is inherently safe by virtue of its isolated design, but if it is improperly constructed, a chance accident could result in the touch surface and the ac power coming in contact.

The primary protection against this happening is clearly shown in Fig. 4. A gap is left on the circuit board between the ac and dc halves, bridged only by the transformer and optocouplers. No matter how the layout is modified, this "no-man's land" must be maintained, and no wire may cross it or come near it. This wide and total separation of the circuit's halves ensures that no fluke of loose wire or faulty insulation can result in a mishap.

The second safety precaution is that the complete ac side of the module, if not the entire device, must be enclosed in a nonconducting environment. In some lamps, a separate case for the Touchmaster may be unnecessary if a hiding place enclosed in wood, plastic, or ceramic is available. If the lamp is metal or the space is tight, a separate plastic case should be used to shield the module against metal parts.

No matter how the ac circuitry is shielded, some provision for ventilation must be provided. The transformer and triacs do not produce much heat, even with a full 100-watt load on both outputs, but the heat they do produce must have an outlet. If a case is used, a number of small holes will preserve the safety of the enclosure, yet permit the heat to escape. Most lamps, even well-constructed ones, have enough gaps between their parts to dissipate the released heat without additional holes.

One addition may be needed on the Touchmaster module. If you have a noisy ac environment (lamps flicker, TVs and radios exhibit static, etc.) some protection against transients may need to be included to prevent such transients from causing the lamp to switch states by itself. If you have such a noisy environment, or if you want to guard against such occurrences, a metal-oxide varistor (MOV) such as Radio Shack's #276-570 or -571 should be installed across the incoming ac power conductors. Such a device will eliminate most, if not all such false switching.

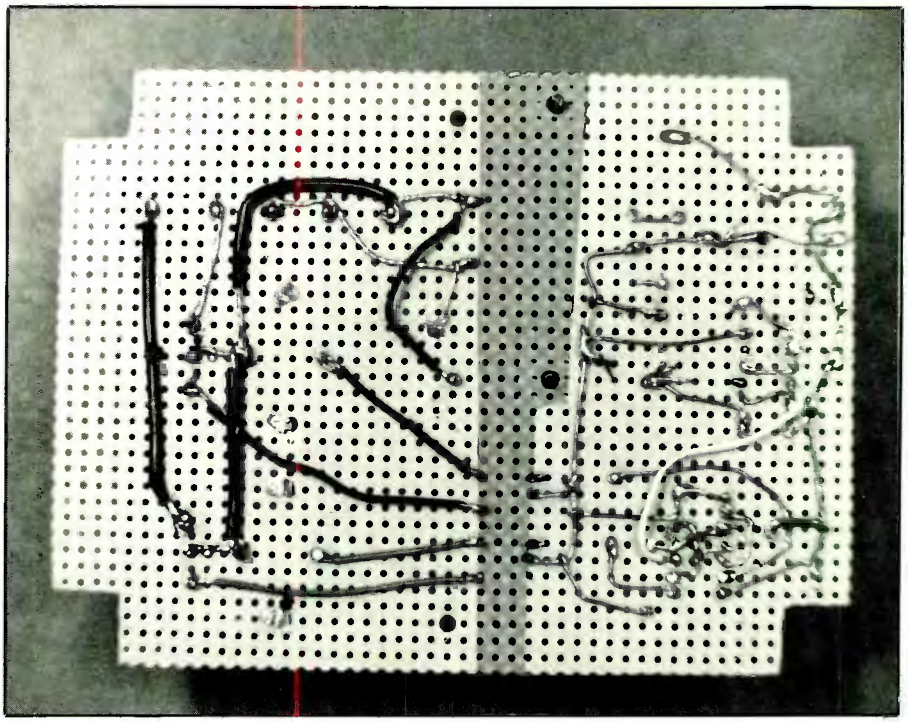

Fig. 4. Underside of the module shows the required "no-man's land" between the ac and dc halves of the circuit. Eliminating this gap means risking a shock!

Installation

Once a space has been found or made for the Touchmaster and the module has been built to fit, it should be firmly mounted in the space using screws and standoffs or a strong adhesive such as epoxy. Some provision should be left to remove the circuit board for repairs. Use of a barrier strip like that on the prototype is recommended for the ac and lamp connections.

The touch surface must be of metal, of course, but it must be isolated from any other metal parts of the lamp that are grounded or in contact with the lamp sockets. This isolation can be achieved a number of ways, the simplest of which would be a metal band, patch, or decorative piece on a wooden or ceramic surface. Something along this line can be added to or designed into almost any sort of lamp. A good second choice is to use an existing metal part of the lamp, such as a base, support, or separator and, if necessary, isolate it using fiber or plastic washers, sheet plastic, electrician's tape, or other means. If an all-metal lamp is used, the lamp socket and its support tube can be isolated from the rest of the lamp. Then, a touch on the lamp anywhere from its base to the shade finial will control it.

When the board is constructed, resistor R2 should not be soldered in. Instead, a pair of pins spaced about 0.6" apart should be installed in its place. When the module is installed and the touch surface is connected, temporarily install a 15-meg resistor across the pins and check the touch response of the lamp. If it switches before the finger actually reaches the surface or jitters through several states on one touch, reduce the value of R2 and try again. When a value is found that lets the lamp switch cleanly without either jitter or hesitation, solder it in place and finish assembling the lamp.

Note that in the schematic, a distinction is made between the hot and neutral conductors of the ac cord. This polarization must be maintained; in keeping with standard wiring safety practice, the outgoing neutral connection must be made to the lamp socket shell, *not* the center contact. (A 3-way bulb will not work properly unless the neutral connection is made to the shell.) For 3-way lamps, the standard switched socket must be replaced with a switchless 3-wire socket. The center terminal is for the high filament, and the ring terminal is for the low.

A polarized plug must be used to keep the hot and neutral connections straight. Even better would be a grounded plug, with the ground lead connected to all the metal parts not used for touch control. **ME**