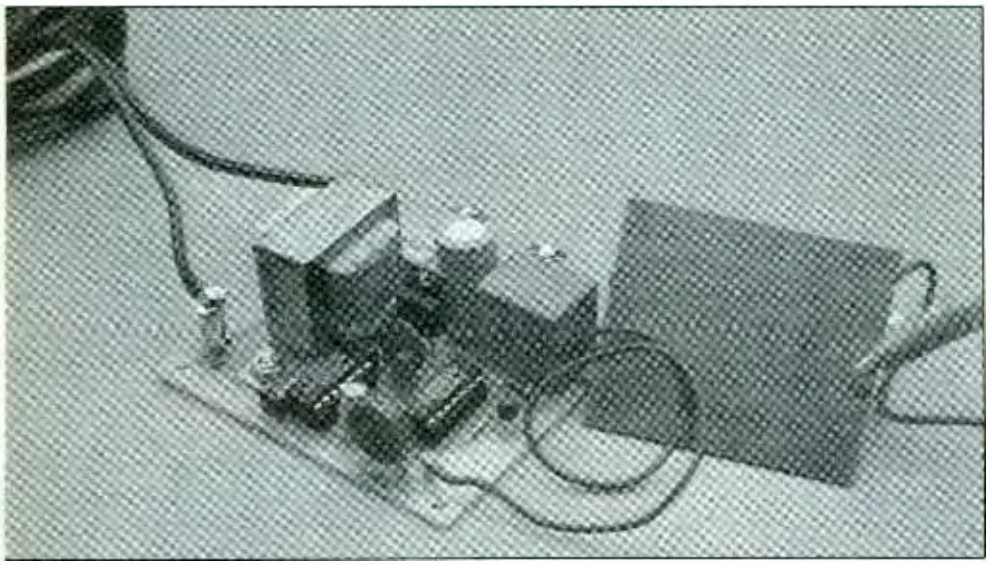
Versatile Touch Switch

High-speed CMOS circuitry solves unreliability problems that are common to other touch-switch circuit designs



By Paul E. Montgomery, Jr.

Touch switches aren't new, but most exhibit an unreliability problem. A truly reliable touch switch had to await the advent of high-speed CMOS (HCMOS) devices. Our versatile touch switch overcomes this problem and is simple in design and low in parts cost.

This touch switch employs a capacitance-sensitive design that conforms with the principles outlined in Don Lancaster's *CMOS Cookbook*. Power-up reset, good noise immunity and touch-plate debouncing are achieved with only two integrated circuits. Included are a sensitivity control that allows the project to accommodate different sizes of touch plates and a light-emitting diode that simplifies "tuning" the project. The relay that does the actual switching on and off of ac power has contacts rated at 5 amperes, which can easily switch on and off just about any electrical light or small appliance found in the average home.

The entire project wires on a compact circuit board that can be fitted inside the device to be controlled. Alternatively, you can build the touch switch into a separate box and equip it with an ac line cord and chassis-mounted ac receptacle for "portable" use with a variety of lamps and/or appliances at different times.

About the Circuit

Figure 1 is the complete schematic diagram of the touch switch circuit. Schmitt-trigger hex inverter *IC2* takes care of all housekeeping chores. All but one of the inverters in *IC2* are busy. On power-up, *C3* and *R3* enable *IC2A* (pinouts and internal details of the ICs used in this project are shown in Fig. 2) to deliver a brief low pulse to the pins 1 and 13 reset inputs for both sections of dual D flip-flop *IC3*. This ensures that the Q outputs at pins 5 and 9 of *IC3* are clamped low until *IC3A* stabilizes. Hence, if power is interrupted, the Q outputs will automatically come up in the low state when power is restored to the circuit. At all times, *IC3*'s not-Q outputs (shown with a bar over the Qs in Fig. 2) at pins 6 and 8 will be the opposite state of that of the Q outputs.

Configured as an astable oscillator, *IC2B* generates a series of pulses at a frequency of about 200 Hz at pin 4. This pulse train is inverted by *IC2C* and is delivered to the pin 3 clock input of *IC3A*. The wire for the touch plate is also tied into the circuit at this point. In this "clocked" mode, the logic level present at the data input is transferred to the output during the positive-going transition of the clock input pulse.

With proper adjustment of sensitivity control *R7*, the data input will receive a pulse slightly before the clock input receives the same (inverted) pulse. This is due to the delay resulting from passage through *IC2C*. As long as this condition exists, the data input pulse will be low when the clock input pulse makes the low-to-high transition and forces the Q output to be off.

Touching the touch plate adds body capacitance to the circuit. This creates an RC network with *R7* that slows the pulse train to the data input. When *R7* is properly set, an in-

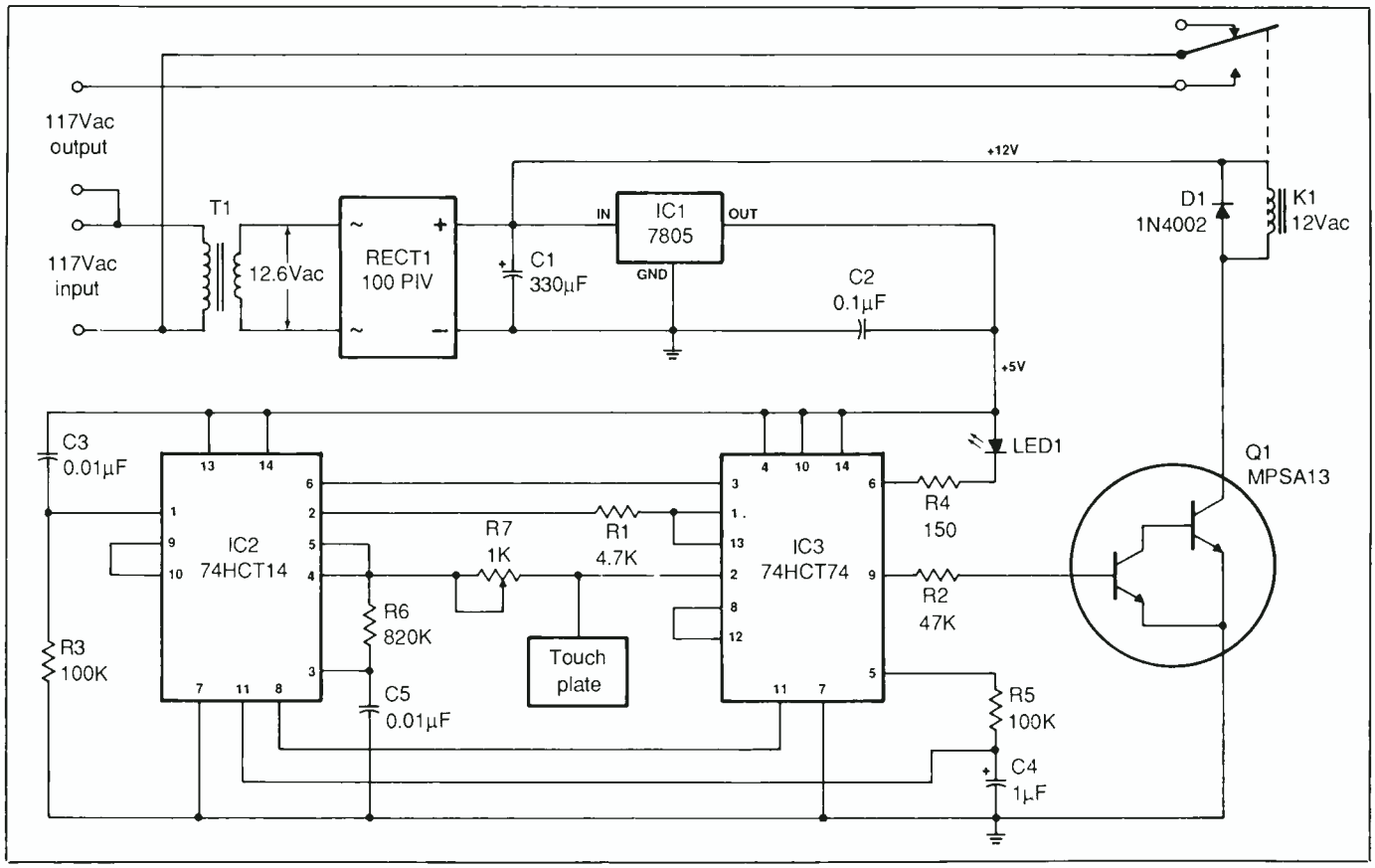


Fig. 1. Overall schematic diagram of touch switch.

put from the touch plate will slow things down enough so that the clock input pulse gets to pin 2 of *IC3*, causing the Q output to turn on. Simultaneously, the not-Q output at pin 6 of *IC3A* turns off and *LED1* lights, providing a visual indicator that aids in adjusting the setting of *R7*.

Debouncing for the input to *IC2E* at pin 11 is provided by *R5* and *C4*. The pin 10 output of *IC2E* is inverted by *IC2D* and delivered to clock input pin 11 of *IC3B*. Flip-flop *IC3B* is wired for toggle operation so that a low-to-high transition causes its Q output at pin 9 to change state. This allows high-gain Darlington transistor *Q1* to energize *K1*. Diode *D1* provides protection from transient spikes for *Q1*.

Power for the touch switch and device being controlled by the project is tapped from the same point of the 117-volt ac power line and is shown

PARTS LIST

Semiconductors

D1—1N4002 silicon rectifier diode
IC1—7805 + 5-volt regulator
IC2—74HCT14 hex Schmitt buffer
IC3—74HCT74 dual D flip-flop
LED1—Red light-emitting diode
Q1—MPSA13 npn Darlington transistor
RECT1—1-ampere, 100-PIV mini-bridge rectifier

Capacitors

C1—330-µF, 25-volt radial-lead electrolytic
C2—0.1-µF disc
C3,C5—0.01-µF polyester or metal-film (5% tolerance)
C4—1-µF, 35-volt radial-lead electrolytic

Resistors (¼-watt, 5% tolerance)

R1—4,700 ohms
R2—47,000 ohms
R3,R5—100,000 ohms
R6—820,000 ohms
R7—1,000-ohm trimmer potentiometer

Miscellaneous

K1—12-volt dc relay with 5-ampere spst contacts (Digi-Key, P.O. Box 677, Thief River Falls, MN 56701; specify Cat. No. Z411ND)
T1—12-volt transformer (Mouser Electronics, 11433 Woodside Ave., Santee, CA 92071; specify Cat. No. 4PG006)
Printed-circuit board or perforated board and suitable soldering or Wire Wrap hardware (see text); sockets for IC2 and IC3; suitable enclosure (optional; see text); ac line cord and plug (optional; see text); sheet metal for touch plate; 4-40 or 6-32 machine hardware; hookup wire; solder; etc.

Note: The following items are available from Verdemont Radio, P.O. Box 329, Westcliffe, CO 81252 (Tel.: 303-783-2617): Etched and drilled pc board for $7.00 and kit of all parts but not including optional items like enclosure and line cord for $24.95, all orders postpaid. Colorado residents, please add state sales tax.

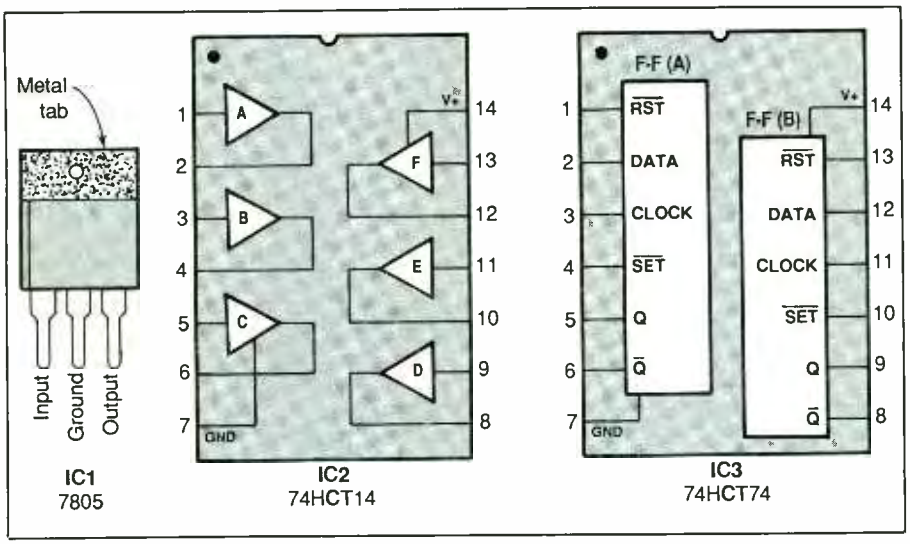


Fig. 2. Pinouts and internal details for ICs used in project.

as the 117 Vac Input in Fig. 1. This ac power is stepped down to 12 volts ac by transformer *T1* and is filtered to 12 volts dc by *C1*. The 12 volts dc is used directly to power the *K1/Q1* circuit and is further reduced to and regulated at 5 volts dc by *IC1* to power the rest of the project.

Lines in parallel with the primary of *T1* provide the circuit path from the ac line to the lamp or appliance being controlled. Note, however, that in one side of this line are the relay contacts. Alternate touches of the touch plate will close and open these contacts, causing ac power to be delivered to and removed from the device being controlled.

Construction

There is nothing critical about construction of the touch plate. You can use a printed-circuit board on which to mount the various components or substitute perforated board and suitable solder or Wire Wrap hardware. In either case, you should make the circuit board the same size and use sockets for *IC2* and *IC3*.

If you decide to use a pc board, you can etch and drill your own, using the actual-size artwork shown at the left in Fig. 3. Alternatively, you can purchase a ready-to-wire pc board from the source given in the Note at the end of the Parts List.

Wire the board exactly as shown in the diagram at the right in Fig. 3. (If you've decided to use perforated board, use the Fig. 3 layout as a rough guide to component placement on it.) Do not install *IC2* and *IC3* in their sockets until the entire circuit has been wired. Even

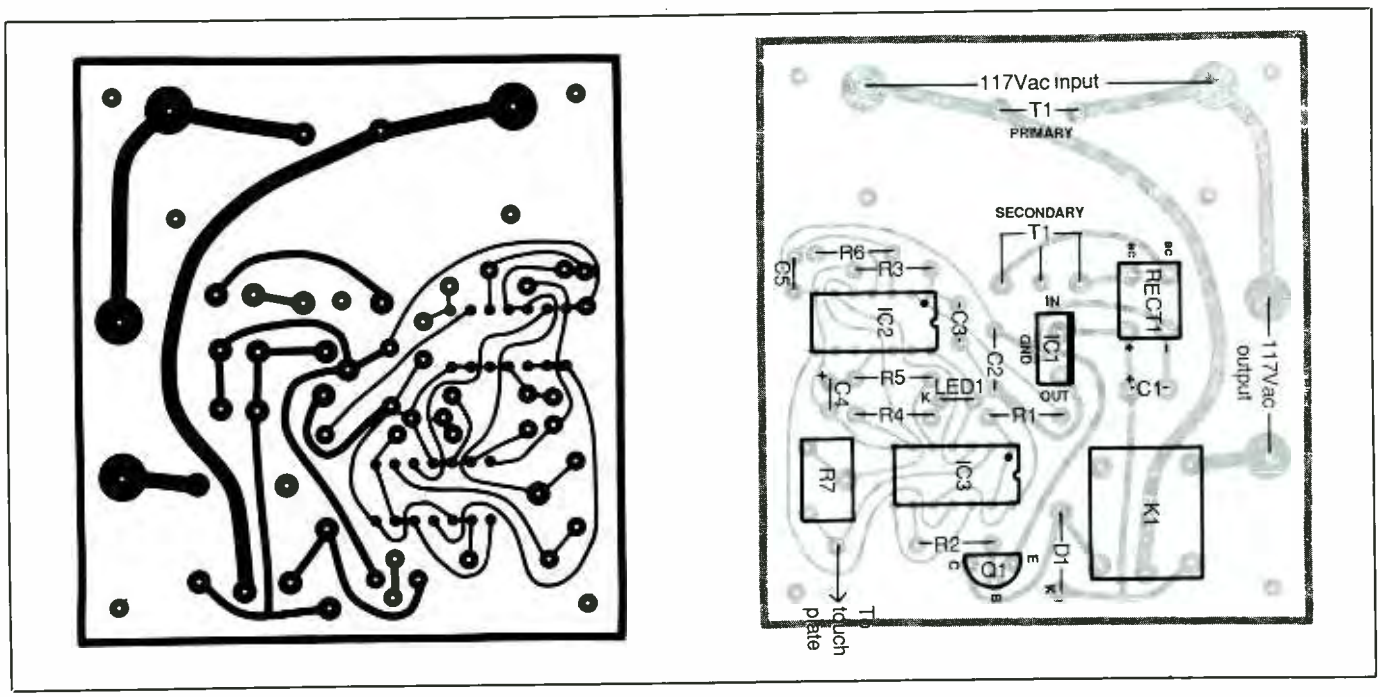


Fig. 3. Actual-size etching-and-drilling (left) and wiring (right) guides for printed-circuit board. Use the layout shown as a rough component-placement guide if you use perforated board and soldering or Wire Wrap hardware.

though these two CMOS ICs are gate-protected devices, they can be damaged by the heat of soldering and static electricity resulting from careless handling.

As you install each component on the board, double check it against Fig. 1 for value and/or identification. Make sure the electrolytic capacitors, diode, LED and transistors are properly oriented before soldering any leads to the pads on the bottom of the board. Also, as you install *IC2* and *IC3* in their respective sockets, practice safe handling procedures for CMOS devices, and make sure they're properly oriented and that no pins overhang the sockets or fold under the IC cases as you push these devices home.

You can make the touch plate from any piece of metal that's 9 square inches or less in surface area. Make the wire that connects the touch plate to the circuit board no longer than 36". Too large a touch plate or too long an interconnecting wire will make the circuit more vulnerable to false triggering.

If you've decided to build the touch switch into the lamp or appliance with which it is to be used, find a suitable location near the route taken by its ac line cord. Disconnect the device's line cord from the ac line and cut through it at a point near where the center of the touch plate board passes under it. Separate the conductors of the line cord at both cut ends for a distance of about 3" and strip ¼" of insulation from each. Then tightly twist together the fine wires in each conductor and lightly tin with solder.

Plug the conductors that go back to the ac line plug into the holes labeled "117 Vac Input" in the Fig. 3 wiring guide and solder them into place. Do the same for the conductors that go to the lamp or appliance and the holes labeled "117 Vac Output." Then mount the circuit board in the selected location, using ½" spacers and 4-40 or 6-32 × ¾" machine screws, nuts and lockwashers. Use at least 1" spacers and appropriate-length machine screws if you used Wire Wrap hardware to wire the circuit.

If you plan on using the touch switch in a "portable" mode with different lamps and/or appliances at different times, mount the circuit inside a plastic enclosure that can accommodate both it and a chassis-

mountable ac receptacle. Wire this receptacle to the points on the board labeled "117 Vac Output" and a separate ac line cord with plug to the points labeled "117 Vac Input."

If you wish, you can use a metal enclosure or a plastic box with a metal top panel. However, make absolutely certain that you don't allow any portion of the circuit, including the metal touch plate and its interconnect wire, to touch the metal.

Setup and Use

Only one thing must be done to get the touch plate circuit up and running: set sensitivity control *R7* for positive and reliable on/off operation. To do this, the circuit must be plugged into an ac outlet. (*Warning:* Various points in the circuit are at 117 volts ac line potential when the project is plugged in and can present a hazard. Avoid touching the 117 Vac Inputs and Outputs and relay contacts or their circuit-board traces.)

Plug the line cord into an ac outlet and touch tour finger to the touch plate. Adjust *R7* until *LED1* turns on. When you remove your finger from the touch plate, the LED should extinguish. If it doesn't, repeat the adjustment procedure as often as necessary until you obtain the proper results. When the circuit is operating properly, successive touches of the touch plate should turn on, off, on, etc. the lamp or appliance being controlled.

The relay specified for *K1* in the Parts List has contacts that can accommodate loads of up to 300 watts at 117 volts ac. This should be sufficient for most small consumer appliances. However, if you wish to use this project to switch heavier loads, you should use an optical isolator and a high-power triac in place of the relay, or use the specified relay to drive another heavy-duty relay whose contacts are rated for the amount of power the device will draw.