Lab Notes

The tender touch

If you ever get involved in the design of electronic equipment, there is a fair chance that you will eventually come across a circuit that requires the use of a 'press-to-do-something' switch. You'll then have to decide whether to use an electromechanical pushbutton switch or a solid-state 'touch' switch to do the job.

Ray Marston

THE MAIN disadvantages of the pushbutton switch are that it is unreliable, tends to be a bit expensive and is available only in those designs that manufacturers care to produce. These switches are also 'noisy' in that they generate contact-bounce spikes that can play havoc with fast digital circuitry.

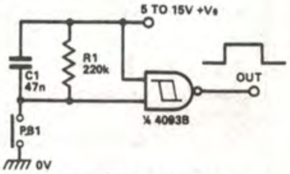

Figure 1. **Push-button debouncer circuit.**

This last-mentioned problem can be overcome by using the 'debouncer' circuit of Figure 1. Here, one quarter of a 4093B CMOS quad 2-input NAND Schmitt is used as a simple Schmitt trigger. When PB1 is closed, C1 charges rapidly to full supply volts and the Schmitt output switches high; when PB1 is released C1 discharges slowly via R1 until eventually the Schmitt output switches low again. The circuit is thus unaffected by switch contact bounce and produces a clean on/off signal at the Schmitt output.

Figure 2 shows a useful way of obtaining a toggle (alternate on-off) action from a simple pushbutton switch. The switch signal is debounced by R1-C1 and is then used to clock one half of the 4027B dual JK flip-flop, which divides the clock signal by two. Thus, the 4027B output goes high on one press, low on the next, high on the next and so on. Two of these toggle switches can be built from each 4027B IC in the dual package.

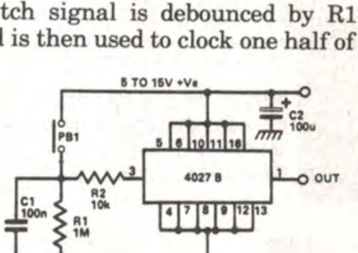

Figure 2. **Push-button toggle switch.**

Touch switch circuits

The main advantages of solid-state switches are that they are reliable (they have no troublesome mechanical parts), can be less expensive than their electromechanical counterparts and can readily be produced in almost any shape or form that the designer or home constructor wishes.

Touch switch circuits come in three basic types (ignoring 'freak' circuits such as thermo-switches, etc). The crudest and least attractive of these are the 'resistive' types, which use the 'touched' or 'untouched' resistance change that occurs between two adjacent touch contacts to give activation.

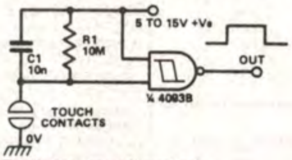

Figure 3. **Resistive touch switch.**

Figure 3 shows a typical resistive touch switch circuit. Normally with the contacts untouched, R1 holds the Schmitt input high and its output is low. When a finger is used to bridge the two contacts the resulting skin resistance (less than 3M) pulls the Schmitt input low and drives its output high. C1 is used to 'debounce' the circuit. Figure 4 shows how the circuit can be modified to give 'toggle' action.

A very serious disadvantage of the resistive touch switch is that it can be disabled by moisture or contamination bridging the contacts. Also, it may be disabled by persons with damp fingers or may be immune to operations by persons with very dry skins.

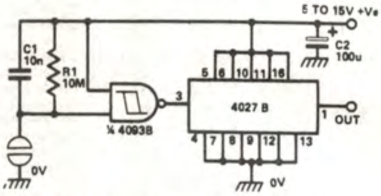

Figure 4. **Resistive touch toggle switch.**

A great improvement in reliability is given by a second type of 'hum-detecting' touch switch. This type of circuit relies for its operation the fact that the human body acts as a kind of antenna that is coupled to the mains and carries a high-impedance mains signal. Figure 5 shows an example of this type of circuit. When the input contact is touched the hum pick-up signal is fed to the input of the first Schmitt stage via limiting resistor R2 and produces a full-amplitude square wave at the Schmitt output. This square wave is converted to dc and debounced by the D1-R3-R4-C1 network, and drives the final output of the second Schmitt high. The Schmitt output goes low again some 60 mS after the input touch is removed. Figure 6 shows how the above circuit can be modified to give toggle operation; D2 and C2 prevent unwanted feedback from the 4027B to the Schmitt.

Capacitive touch proximity switches

The third and most important class of switch is those that work on the capacitive loading principle. In most simple cases, these circuits rely on the fact that the human body acts as a small

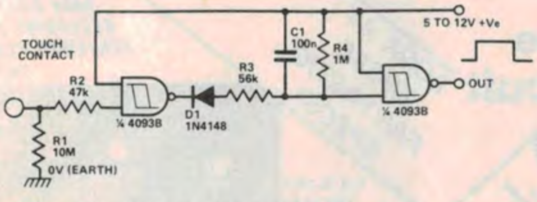

Figure 5. **Hum-detecting touch switch.**

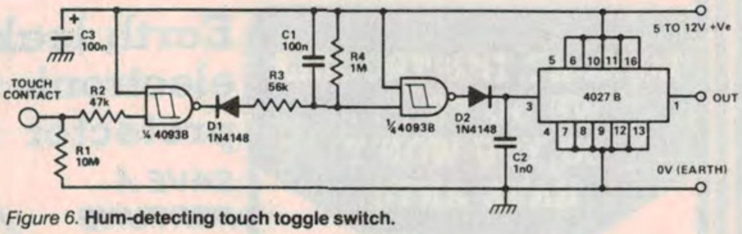

Figure 6. **Hum-detecting touch toggle switch.**

capacitor that is earthed at one end. The actual value of capacitance depends on physique and on environmental conditions, but is reckoned to have a value of 150-300p under normal domestic/industrial conditions.

Figure 7 shows a number of basic ways of using the body capacitance effect. In Figure 7a it causes loading of an HF oscillator, in Figure 7b it causes capacitive potential division and in Figure 7c it causes filtering of oscillator harmonics. Of particular interest is Figure 7d, which shows that these effects can be obtained without physical contact, by capacitive or 'proximity' coupling.

Figure 8 shows the practical circuit of a touch/proximity switch that works on the oscillator damping principle. The oscillator is a Colpitts, working at about 300 kHz. RV1 is carefully adjusted so that oscillation is barely sustained when the contact is untouched. Under this condition the rectified output of the oscillator drives Q3 to saturation and holds the circuit's output low. When the contact is touched the resulting capacitive loading kills the oscillator, causing Q3 to turn off and switch the output high. The output has relatively slow rise and fall times, but can be speeded up with a Schmitt circuit if required.

The zero volts line of the Figure 8 circuit should (ideally) be grounded. The touch contact must be made from a conductive material, but can be any shape or size that is desired; in most cases the 'contact' face can be covered with an insulating material without detracting from the circuit's performance. Pin-head sized contacts will require actual-contact operation, but 'contacts' with surface area of a square metre or so can be proximity-operated at ranges up to 20-40 centimetres.

Finally, Figure 9 shows the circuit of a touch switch that works on the capacitive-divider principle. Here, IC1 is wired as a ring-of-three oscillator working at a frequency of a few hundred kHz. The oscillator output is fed to a capacitive potential divider formed by C2 and the stray capacitance around D1 and the touch contact. The resulting potential divider output signal is rectified by D1-D2-C3-R2 and fed to the 3140 regenerative voltage comparator, which is adjusted (via RV1) so that its output is just switched to the low state when the input contact is untouched. When the contact is touched, the resulting capacitive loading increases the effective capacitance of the lower half of the potential divider, thereby reducing the divider's output voltage and causing the 3140 output to switch high. Figure 9b shows an add-on section that can be used to convert the circuit to toggle operation.

As in the case of the Figure 8 circuit, the zero volt line of Figure 9 should be grounded. The touch contacts can again be any desired shape or size. ●

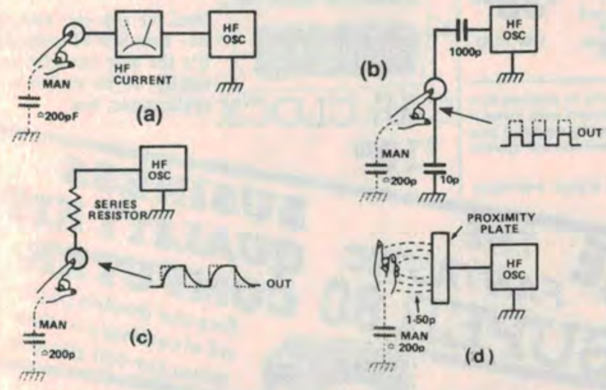

Figure 7. **Body capacitance effects on a touch contact. (a) Causes oscillator loading, (b) capacitive potential divider action or (c) degradation of oscillator waveform (harmonic filtering). (d) If contact is of sufficient area, loading and other effects can be obtained without physical contact, by capacitive or proximity coupling.**

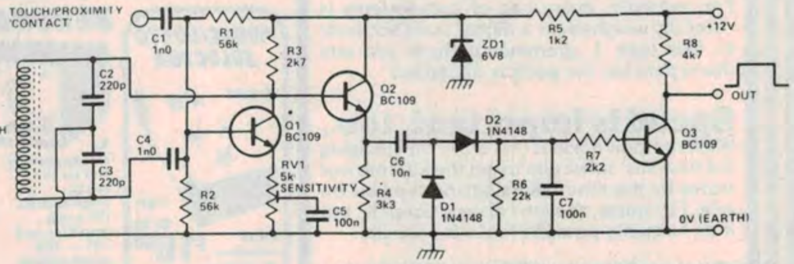

Figure 8. **Damped oscillator touch/proximity switch.**

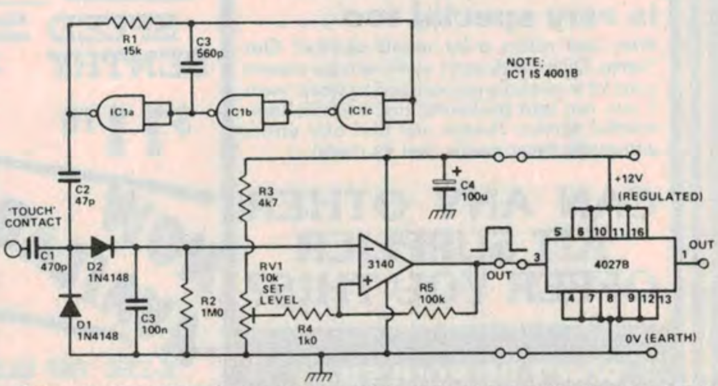

Figure 9. **Capacitive-divider touch switch (left) with modification for toggle operation (right).**