# Five-mode logic pulser probe

Undoubtedly, one of the most useful and convenient test instruments for designing and trouble-shooting digital circuitry is the logic probe. However, regardless of its sophistication it can only observe the circuit under test. The solution to this problem is a logic pulser used in conjunction with the logic probe.

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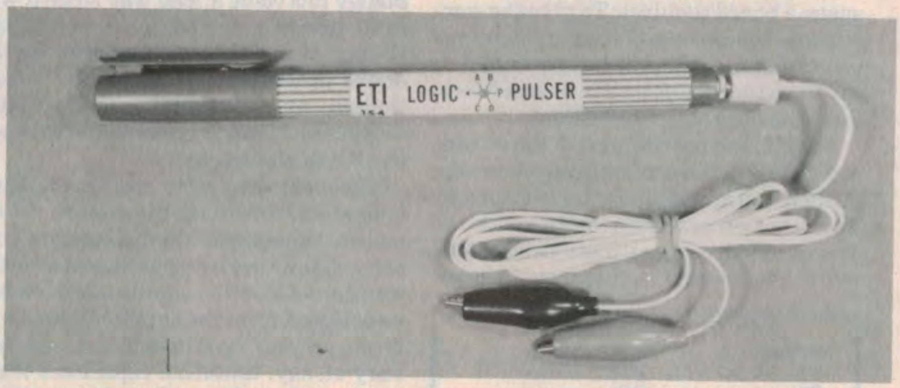
A LOGIC PULSER is an instrument which injects pulses into a digital circuit. These pulses are of opposite state to the point being injected and are of very short duration to avoid damage to the logic element whose output is being forced to the opposite state. Ideally, both single pulses and pulse trains of various frequencies should be available.




The completed probe — smart and business-like!

The logic pulser has many uses. Say, for example, a four-stage binary counter is suspected of being faulty. A pulse to the reset pin will reset it; single pulses are then fed to the clock and the four outputs are observed with the logic probe. Any counting fault will become evident as the various counts are cycled through. If a seven-stage counter is under test, the pulses are most conveniently injected in the form of a pulse train of the required frequency. Further examples will suggest themselves during use.

The pulser described here operates from a wide range of supply voltages and is compatible with both CMOS and TTL ICs. It has five modes: a single pulse mode and four pulse trains of frequencies 1, 10, 100 and 1000 Hz. The frequencies are largely dependent on the supply voltage, but in practice a precise value is not required. Single pulse injection and mode selection are achieved through the use of a touch switch. Briefly touching the switch injects a single pulse, whilst touching the switch for more than one second advances the pulser to the next mode. The current mode is shown on an LED display.

Pulse width is 4 $\mu$s, which represents a compromise between the much shorter width acceptable for normal IC inputs and the longer width required for, say, an interrupt to a microprocessor. The pulser obtains its power from the power supply of the circuit under test, which is assumed to be sufficiently regulated and filtered.

## Construction

Construction of the pulser is largely left to the reader due to the varying nature ▶


The completed probe — but disassembled! No pc board is used, the components are wired directly together.

**SPECIFICATIONS ETI-154**

- CMOS or TTL compatible
- Supply voltage: 5 to 15 volts (18 V max.)
- Output impedance: approx. 10M
- Pulse width: 4 $\mu$s
- Five modes:
  - — single pulses
  - — four pulse trains of approx. frequencies 1, 10, 100 and 1000 Hz
- Current mode displayed on seven-segment LED display
- Pulse injection and mode selection by single touch switch

of pulser housings, etc, although a detailed description of the prototype construction is given for those who wish to make a normal pen-sized pulser. Many of the details given will be applicable to most forms of construction.

The pulser housing used was a Pilot "Ball Liner" pen obtainable from stationery stores, which has a length of 120 mm and an internal diameter of 8.5 mm. Whatever housing is chosen it is essential that it be made of plastic or a similar non-conducting material.

Direct point-to-point wiring has been employed in favour of a printed circuit board due to the prohibitive amount of space a board requires. To give the components the necessary support, a unique construction technique has been used. It involves the use of the ICs themselves to form the base for construction!

Firstly, the narrow part of the IC pins are cut off and the remaining stems are pushed up tight against the IC package. Then the corners of the top face of the IC are rounded. This is most easily done with an electric sander or grinder.

## PARTS LIST — ETI-154

| | |
|---|---|
| **Resistors** | all ¼W, 5% |
| R1 | 390k |
| R2 | 2k2 |
| R3 | 1M |
| R4, R7 | 10M |
| R5 | 6M8 |
| R6 | 680R |
| R8 | 1M2 |
| R9 | 100k |
| R10 | 10k |
| **Semiconductors** | |
| IC1 | 4081 |
| IC2 | 40106 |
| IC3 | 4017 |
| IC4 | 4016 |
| Q1, Q3 | BC548 |
| Q2 | BC558 |
| D1 | 1N914 or similar |
| LED.D | Small, common-cathode 7-segment display |
| **Capacitors** | |
| C1, C2 | 150n/16V tantalum |
| C3 | 220n/16V tantalum |
| C4 | 10p ceramic |
| C5, C6 | 2n2 ceramic |

**Miscellaneous**

Twin lead with black and red alligator clips or E-Z hooks; 2.5 mm plug and socket (optional); pulser casing, tip, and two pins.

### Price estimate

We estimate that the cost of purchasing all the components for this project will be in the range:

**$9 - $11**

Note that this is an **estimate** only and **not** a recommended price. A variety of factors may affect the price of a project such as — quality of components purchased, type of pc board (fibreglass or phenolic base), type of front panel (if used) supplied etc — whether bought as separate components or made up as a kit.

**To fit inside the small pen barrel, each IC has the top ground down to a round shape and the pins cut back, as shown.**

Finally, the IC packages are glued end-to-end with epoxy resin or other suitable glue. This procedure is really quite straightforward and is illustrated in the diagrams on page 56.

Now, a note on the vulnerability of the CMOS ICs involved. CMOS technology has come a long way since it was first introduced and as a result the chance of an IC being damaged by the above procedure is very small. Nevertheless, as a safeguard against later disappointment, it is advisable to check the ICs at this stage.

The next step is to mount the components and wire up the circuit. As far as the components themselves are concerned, they are best purchased over the counter so that the smallest of each can be selected from the supplier's stocks. It is surprising how much the size can vary of, say, tantalum capacitors of the same value from the same manufacturer. The hookup wire should be the single strand, plastic-coated type and have a total thickness of about 0.5 mm.

The component leads should be bent and cut before soldering with a minimum of solder. It is important to hold, rather than press, the components in position while soldering, as joints soldered under stress may come apart. With care, all the components including the LED display can be mounted on top of the IC base except for the output transistors and the zener diode, which are best mounted at either end. The transistors may be filed down to make fitting easier.

At this stage, the unit should be tested. Upon applying power, segment 'd' should light up, and briefly touching the two touch wires should result in a pulse at the output. Advancing to the pulse train modes should result in the corresponding LED segments lighting and the corresponding pulse trains appearing at the output. Finally, after the 1 kHz pulse mode, the pulser should return to the single pulse mode. If some, or all, of these functions fail to work correctly, read the circuit description and track the fault down with a multimeter or logic probe. The most likely faults are incorrect wiring and dry joints.

With the pulser now functioning correctly, construction of the housing can proceed. This involves providing a window for the LED display and fitting the contacts for the touch switch. The display window can be provided as follows: drill an oversized hole with diameter, say, 4-5 mm. Insert a soft, transparent plastic disc (the plastic used in Kodak slide boxes is ideal) of sufficient diameter to ensure a tight fit. Due to the curvature of the housing, the disc will have protruding edges which can be trimmed with a razor blade. Finally, a paper label with the correct sized window cut in it can be fixed over the disc with Contact or a similar transparent, adhesive plastic covering. The circuit should be fitted in place before the plastic disc is positioned. The purpose of the oversized hole masked by the correct-sized paper window is to reduce the precision required when positioning the circuit and LED display.

The contacts for the touch switch are made from two pins. Cut each pin about 3 mm below the head. Then solder fine

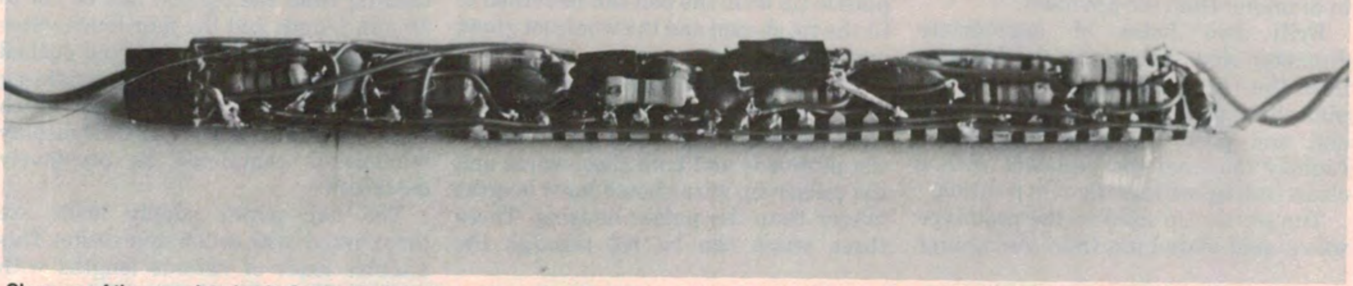
## HOW IT WORKS — ETI-154

**In the single pulse mode, touching the touch switch contacts makes the output of IC2a go low, with R1 and C1 eliminating switch bounce. The output of IC1b then goes low, producing a short, positive pulse at the output of IC2b. The pulse width is determined by R2 and C5 and is approximately 4 µS. This pulse is then fed to the two AND gates, IC1c and IC1d, one of which is enabled and thus switches on the appropriate output transistor. The AND gate enabled is determined by the state of the point being injected. If it is high, the output of IC1a is high, which enables gate IC1d through R3. Thus, TR3 turns on and injects the required negative pulse. The complementary situation occurs if the point being injected is low. The RC combination, R3 and C4, prevents the pulser from responding to its own pulses. Base resistors are not required for the output transistors due to the very short pulse width.**

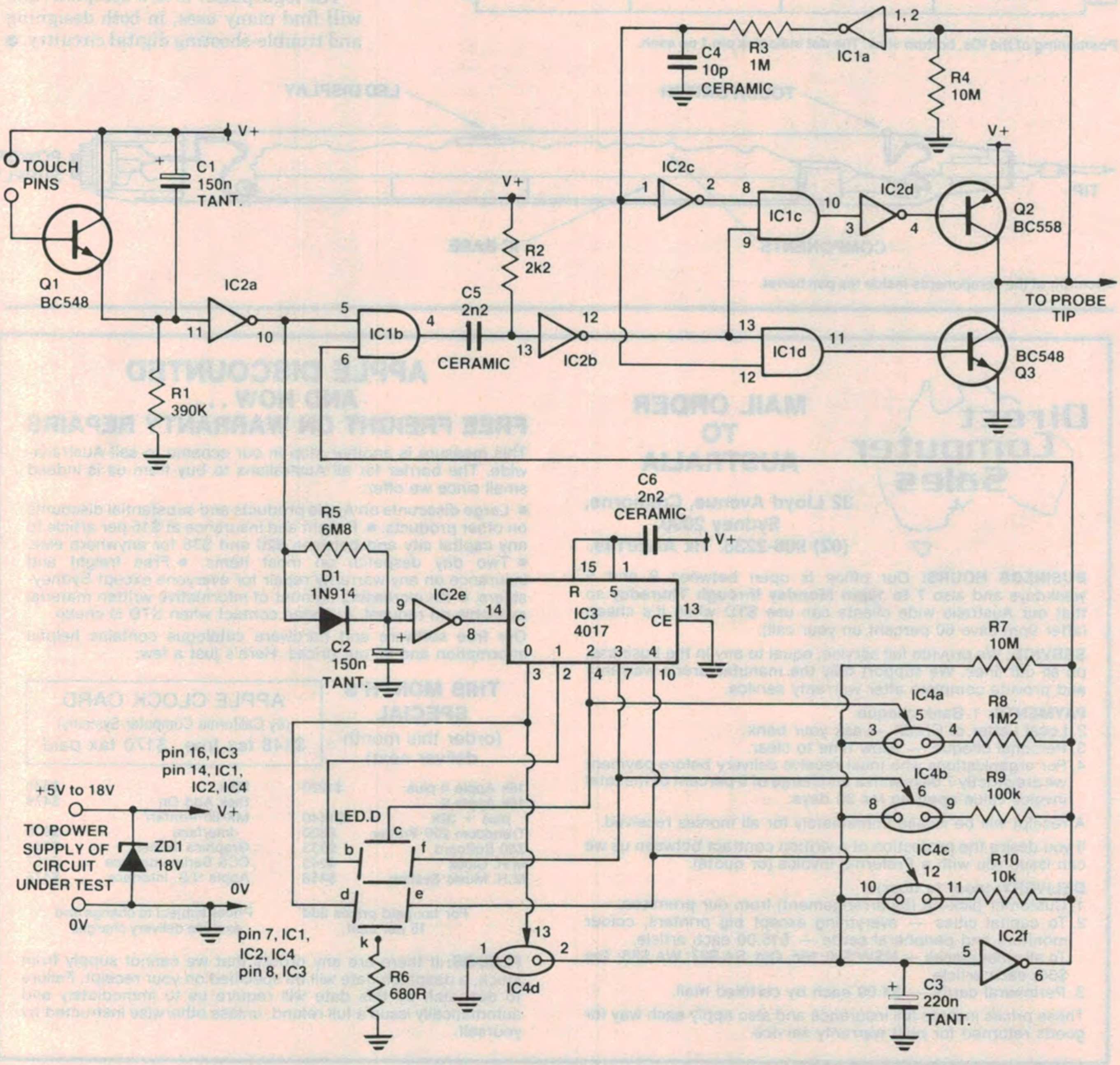
**In the single pulse mode of operation, the zero output of the 4017 is high, which closes switch IC4d, thereby disabling the Schmitt oscillator. However, touching the switch for more than one second charges C2 sufficiently to cause the output of IC2e to go high, which advances the 4017 counter. Switch IC4d opens and IC2f begins to oscillate at 1 Hz. The square wave at the output is fed to the remaining input of IC1b and hence a 1 Hz pulse train is injected.**

**Further advancing the counter increases the pulse frequency by switching in resistors R8 to R10. The counter outputs are also used to drive a seven-segment LED display, which indicates the current mode. The '5' output (pin 1) from the counter is connected to the reset input, hence returning the pulser to the single pulse mode. Capacitor C6 ensures that the pulser will come on in the single pulse mode when the power is applied.**

**Zener diode, D1, provides overvoltage protection and reverse polarity protection should the power be incorrectly applied.**



Close-up of the completed unit. Connections to the probe tip and the touch contact pins are to the left, power supply connections to the right. All the components are wired directly in place and small gauge insulated hookup wire used for interconnections. The ICs are glued end-to-end to form a solid 'base'. This form of construction is only necessary if you wish to construct the unit and house it in a pen barrel as the author has done. Otherwise, matrix board could well be used to support the components.



enamelled or silk-covered wire to the bottom of the cut pins, ensuring that the resultant joint is not appreciably larger in diameter than the pin itself.

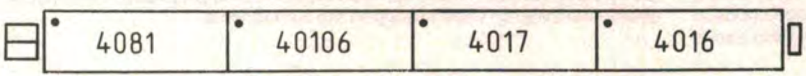
Drill two holes of appropriate diameter and spacing in the housing near the tip. Feed the wires from the pins through the holes and out the tip end and push the pins in position. Lightly touching the pinheads with a clean iron tip will set them in position.

The pulser tip used in the prototype was a gold-plated pin from a computer plug. It certainly looks the part, but a metal darning needle or similar object could equally well be used. The original plastic tip from the pen can be drilled to fit the tip chosen and the whole lot glued at the appropriate stage.

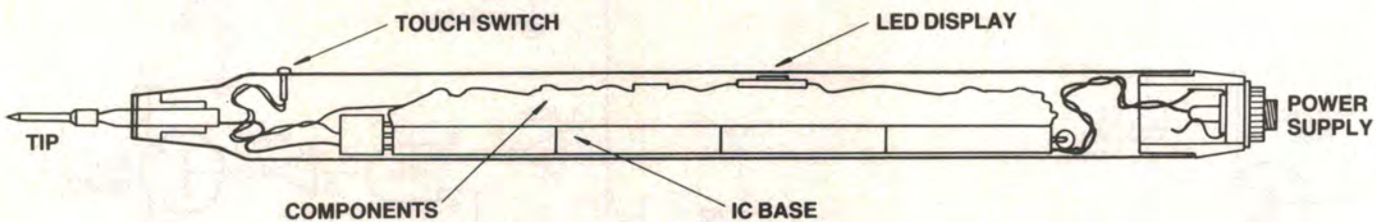
The circuit can now be positioned. The two wires from the touch switch circuitry should be of the type used for the pinheads and both these wires and the pulser tip wire should have lengths longer than the pulser housing. These three wires can be fed through the housing and the circuit then pushed into position with the LED display below the oversized hole. The five wires now protruding from the tip end can be cut to 20 mm length and the four touch wires paired, soldered, insulated, and pushed back into the housing. The remaining wire is soldered to the pulser tip, which is then glued in place. The LED display window is completed as previously described.

The two power supply leads are terminated with a 2.5 mm socket.This enables leads of various lengths with various clips to be substituted; however, the use of the plug and socket is optional.

The logic pulser is now complete, and will find many uses, in both designing and trouble-shooting digital circuitry. ●




Positioning of the ICs, bottom view. The dot indicates pin 1 on each.




Location of the components inside the pen barrel.