Test Set-up For Digital Circuits

BY

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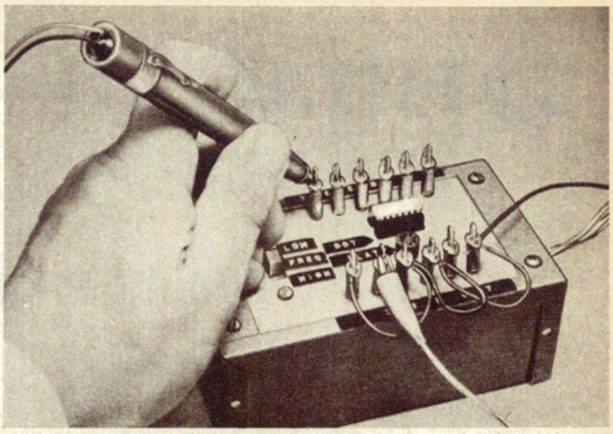


This article is published by arrangement with "Popular Electronics," U.S.A., presented more or less as it appeared in their April, 1969 issue, but with some suggested part substitutions. It describes a simple test set-up for checking digital ICs, using a simple probe and pulse generator which may be used separately or in combination.

The increasing use of digital ICs in many experimenters' projects has created a need for a low-cost in- or out-of-circuit tester for these complex semiconductor devices. Up to now experimenters have done their best using a conventional voltmeter to trace the on-off signal on a circuit board. This is a difficult process at best. Making contact with a narrow foil strip and looking at a meter at the same time is trouble enough, but most of the time the pulses are so short that they don't even register on the meter. It is even more difficult to test ICs that are not connected into known operating circuits.

The "IC Telltale" described here was designed to solve many of these testing problems. It will test, in or out of the circuit, the RTL (resistor-transistor-logic) ICs such as the Motorola MC700P series and the Fairchild uL900 series that are used in a number of "Popular Electronics" projects.

The IC Telltale consists of two assemblies: a 10,000-ohm input-impedance probe for checking ICs mounted on a circuit board; and a test set with a built-in 2Hz and 10Hz trigger pulse generator with 14-pin in-line and 8-pin round IC sockets for out-of-circuit tests. The oscillator circuit in the test set can also be used as a trigger source for finished IC boards, if desired.

The readout is built in the probe and consists of a small pilot lamp that is on when the logic is at, or near, ground level and goes "off" when the logic is at, or near, +3.6 volts. The probe can be used to trace a digital signal through foil patterns and integrated circuit connections.

Probe: The electronic part of the probe (figure 1) is assembled to fit inside a plastic tube whose inside diameter is just large enough to hold the pilot lamp, I1. The author used the empty plastic case of a large cheap felt-tip marking pen.

If you use a similar case, take out the inside and clean it thoroughly. Use a No. 27 drill to enlarge the hole at the pen tip so that it will pass a 6-32 screw. Place a nut on a 1¼in 6-32 brass screw about three-quarters of the way down its length. Using a file, make a sharp point of the end of the screw. The nut, which will secure the finished probe within the pen, will clean the threads as it is removed.

Lay all the probe components beside the pen case as shown in figure 2. Trim the component leads and assemble the circuit, making sure that you don't exceed the inside diameter of the plastic case. Use insulating tubing on leads where required to prevent accidental shorts. Note that the indicating lamp does not require a socket and the leads are soldered directly to its base.

When you have the components assembled, slide them into the case from the rear until the pointed end of the screw comes out as far as possible. Use a lockwasher and the 6-32 nut to secure the screw to the case. Be sure that you do not rotate the screw as this may break the solder connection to it. The lamp should be slightly recessed within the pen case so that it is protected and yet can still be seen. Two flexible leads (red for positive and black for ground) are bought out of the probe beside the lamp. These leads can be a couple of feet long if desired (18in is about ideal) and should be terminated with small alligator clips.

The operation of the probe is as follows. Transistors Q1 and Q2 form a high-gain current amplifier using R1 to limit the input base current to Q1 and prevent loading of the IC being tested. When Q1 is cut off, with the input either grounded or left floating, current through R2 saturates Q2. Resistor R3 reduces the voltage supplied to lamp I1 when Q2 saturates.

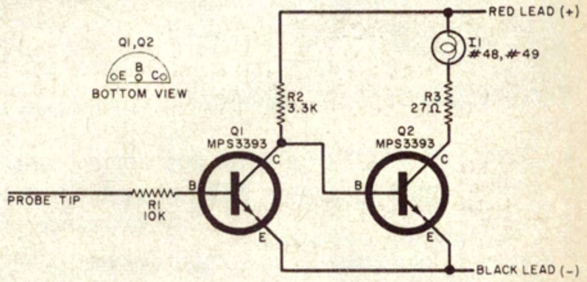


Figure 1. The probe is a simple two-transistor lamp driver arrangement. With no signal applied, the lamp is lit. When a positive voltage is applied to the tip, the lamp goes out.

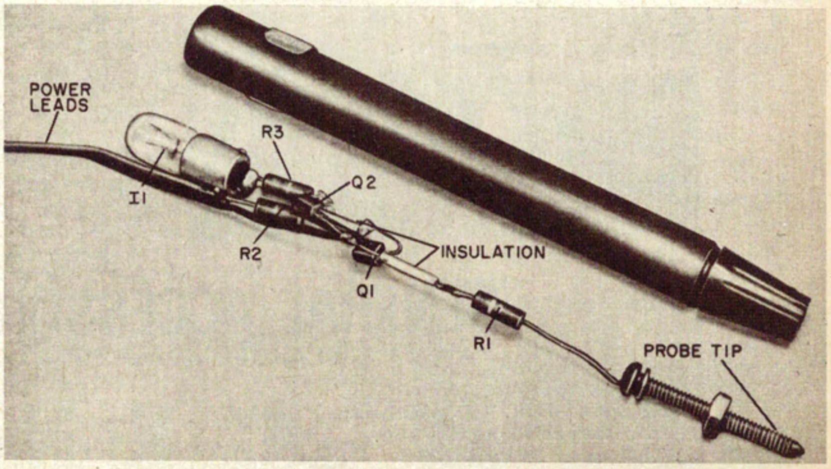


Figure 2. The complete probe is housed in a plastic tube, in this case an old felt-tip marker pen. Assemble the components with care, and gently fit into the housing.

When the input to Q1 exceeds about +0.6 volt, Q1 conducts and removes the base drive from Q2, cutting off this stage and extinguishing I1.

Since most RTL (resistor-transistor-logic) ICs require more than 0.8 volt to guarantee turn on and less than 0.46 volt to turn off, the 0.6-volt threshold of the IC Telltale falls in the correct place to indicate the state of the input or output.

To test the probe, connect the black lead to ground and the red lead to a source of 3.6 volts (the same voltage used for the IC circuit). The lamp should glow and be plainly visible at the top of the probe. Touch the probe tip to the +3.6-volt source and note that the lamp goes off. If the lamp either doesn't light or doesn't go off when it is supposed to, remove the circuit from the probe and check for accidental shorts that may have occurred during assembly.

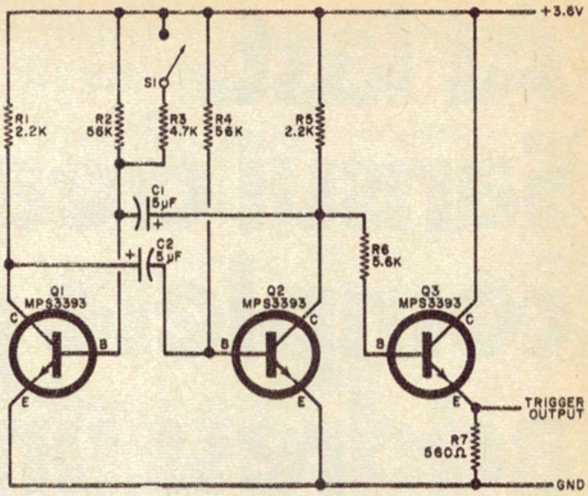
Test Set: There are two circuit boards in the test set: an oscillator and a socket-contact board. The oscillator section, whose schematic is shown in figure 3, is assembled on the PC board with the foil pattern shown in figure 4. Mount the components on the board as shown in figure 5.

To test this circuit, connect the board to ground and +3.6 volts at the indicated places and connect an oscilloscope across the TRIGGER OUTPUT terminals. Depending on the position of S1, you should see either a 2Hz or 10Hz pulse train.

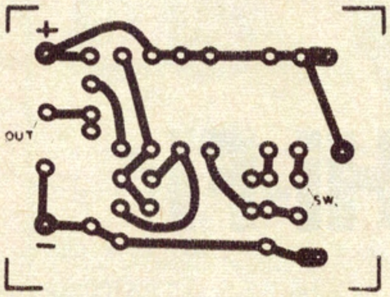
Make the socket-contact board using the foil pattern shown in figure 6. Solder the 12 spring-contact terminals and the two IC sockets in place as shown in figure 7. Looking at the top (non-foil) side of the socket-contact board, orient the 8-pin round socket so that pin 8 (identified by a small projection on the socket) is in the position shown in figure 7. Make some sort of marks on the board to identify pin 8 and to identify the dot and notch end of the in-line socket. At the same time, mark the LOW and HIGH frequency positions for switch S1. The hole for this switch can be cut to fit the switch used.

The oscillator board is mounted on the socket-contact board using three pieces of stiff wire about ½in long. Insert the three wires in the indicated holes on the smaller board (figure 5) and solder them in place. Insert the other ends of these wires in the appropriate holes in the larger board and solder them in place. Clip any excess wire from the top of the board. Connect S1 to its leads.

Right: Figure 3. The trigger generator is a conventional multivibrator whose frequency is changed by resistor variation. Output stage is an emitter follower.



Below: Figure 4. Actual size foil pattern for the emitter follower multivibrator and circuit.



On the upper surface of the metal chassis, cut out a rectangle 4in by 2in so that the larger board can be mounted within the chassis and secured with appropriate hardware at each corner. Drill a hole in one end of the chassis to accept a small rubber grommet. After tying them in a knot to provide a strain relief, pass the three test leads from the smaller board through this grommet. Attach a small alligator clip to the end of each lead. Use a black lead for ground, red for + and another colour for trigger.

Assemble the cover on the metal chassis. Using some type of marker, identify each spring clip on the metal lip adjacent to it, as shown in the photograph. Note that pins 4 and 11 are missing since they are connected internally.

In-Circuit Tests: To check ICs on a finished board, apply the required DC power to the board (usually +3.6 volts) and introduce a trigger signal. If no trigger source is available in the

PARTS LIST

PROBE

2 volt, 50-60mA pilot lamp (No. 48, No. 49, or similar).

Q1, Q2 — Transistors MPS3393.
R1—10,000-ohm, ½-watt
R2—3300-ohm, ½-watt
R3—27-ohm, ½-watt

Misc.—Plastic tube or felt-tip marker pen ½in inside diameter; 1½in-long brass screw with lockwasher and nut; flexible test leads 18in long (one red, one black); small alligator clips; insulation.

TEST SET

C1, C2—5uF, low-voltage electrolytic capacitor.

Q1, Q2, Q3—Transistors MPS3393.
R1, R5—2200-ohm, ½-watt
R2, R4—56,000-ohm, ½-watt
R3—4700-ohm, ½-watt
R6—5600-ohm, ½-watt
R7—560-ohm, ½-watt
S1—S.p.s.t. switch

Misc.—5¼in x 3in x 2 1/8in enclosed metal box (Bud CU2106-A or similar); 8-pin IC socket (Cinch-Jones 8-ICS, Allied No. 47FO155 or similar); 14-pin in-line IC socket (Augat 314-AG5D-2, Allied No. 47F6225 or similar); spring-clip terminals (Vector T30N2, 12 needed); three lengths of colour coded flexible test leads; three small alligator clips; small rubber grommet; 2in bare stiff wire; mounting hardware, etc.

Note: The Motorola transistor MPS3393 is not available in Australia. It can be replaced by low power audio types, such as the BC108, 2N3565, TT3565.

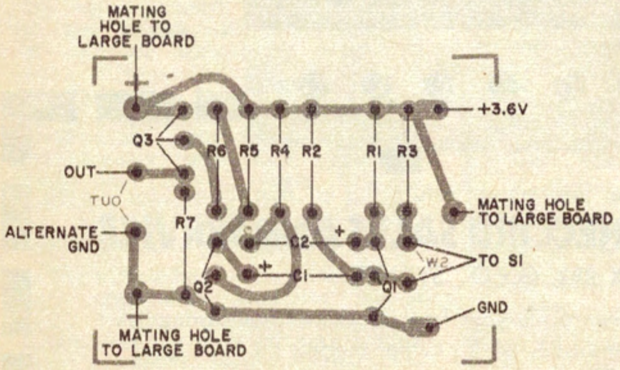


Figure 5. Component installation on the oscillator board. This board is supported from the large board by three stiff wire leads whose locations are also shown here. Two of these leads carry the power supply.

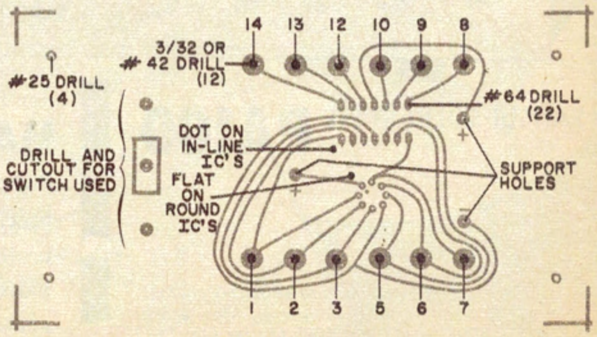


Figure 7. Parts layout for the socket-contact board. Note the three support holes for oscillator board.

equipment itself, use the oscillator in the test set. Connect the black lead of the test set to the PC board ground and the red lead to +3.6 volts. Connect the test set TRIGGER OUTPUT terminals to the PC board's input terminal. Switch S1 can be in either the LOW or HIGH frequency position.

Connect the black lead from the probe to the PC board ground and the red lead to +3.6 volts. The probe lamp should be on. Check for the presence of +3.6 volts at the IC (usually pin 11 of the in-line type and pin 8 of the TO-5 can). When the probe makes contact with +3.6 volts, the lamp should go out. If it doesn't, check back along the foil pattern and locate any break.

Note that, when using the probe, it isn't necessary to watch the lamp directly as it is in your line of vision when your attention is on the probe tip. Since the lamp stays on when the probe tip is grounded, it is also possible to check the ground pattern of the foil.

Once it has been determined that the positive DC and ground are correct, place the probe tip on the signal input terminal and observe that the lamp blinks on and off in step with the applied trigger signal. It is easier to see the lamp blinking if S1 is in the LOW frequency position. You can now trace the trigger signal directly to the IC terminal.

When checking flip-flops, observe that the signal at the output (1 or Q, 0 or $\overline{Q}$) is usually at a slower rate than the applied trigger. Using the probe and a schematic of the circuit board, it is possible to trace the path of the signal and note where the signal stops (if the board is faulty). If a number of flip-flops are involved (as in a countdown circuit), the probe lamp will blink more slowly as you move down the chain. In this case, place S1 in the HIGH frequency position to speed up the counting. You can trace the signal through gates or inverters by observing the presence of signals at the inputs and output.

Out-of-circuit Tests: To test unmounted (loose) ICs, remove the power from the test set and insert the IC in its socket, observing the notch and dot code on in-lines and the flat, tab, or colour dot on round ICs.

The only direct connections to the ICs are +3.6 volts to pin 11 of the in-line and pin 8 of the round socket and ground to pin 4 of both types. The rest of the contacts to the IC are made through the 12 spring clips.

Apply power to the test set by connecting the black test lead to ground and the red test lead to a source of +3.6 volts. Test the IC using the accompanying table as a guide. Use small lengths of insulated wire with bare ends to make any necessary interconnections. The two-speed oscillator built into the test set serves as the signal source. ■

TEST TABLE FOR ICs* OUT OF CIRCUIT

Function	Input				Output †	
Inverter	signal				blinks	
Gate	all gnd				off	
	any +				on	
	one to signal, others to gnd				blinks	
Flip-flop	Reset	S	T	C	1 or Q	0 or $\overline{Q}$
	gnd	gnd	signal	gnd	blinks	blinks
	gnd	+	signal	gnd	off	on
	gnd	gnd	signal	+	on	off
	gnd	+	signal	+	on or off	
	+ then gnd	gnd	gnd	gnd	on	off

*For Motorola MC700P and Fairchild μL900 series ICs.
† As indicated by probe lamp.
+ Indicates +3.6 volts.

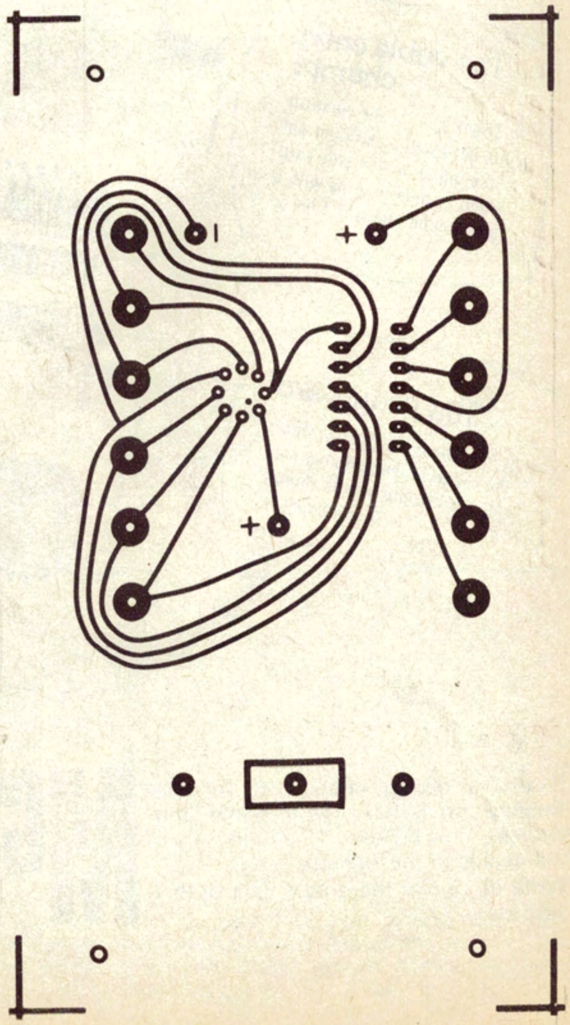
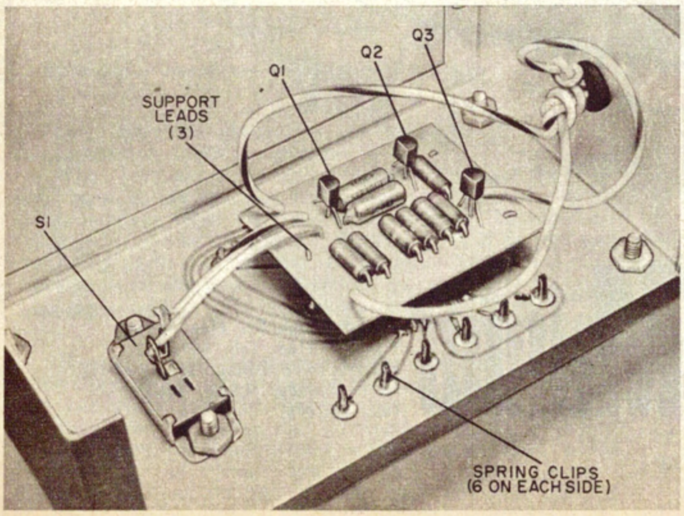


Figure 6. Actual-size foil pattern for the socket-contact board. Switch S1 cutout and mounting holes are dependent on the particular switch you are using.



Interior of a completed test set. The three leads (one for positive, one for ground, and one for trigger output) are knotted to provide a strain relief,