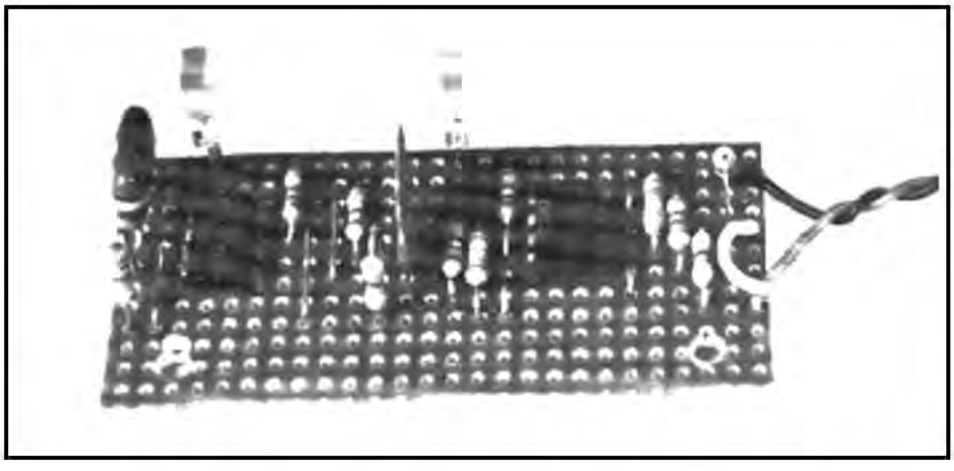
CMOS LOGIC PROBE

by Robert Penfold

* **Build this practical, low cost test instrument.**



CMOS logic integrated circuits are extremely versatile devices which are used a great deal in modern electronic circuits. Like any logic circuits, those which employ CMOS devices can be difficult to test using an ordinary multimeter as both static and pulsing voltages are involved. A voltage reading of half the supply potential could be a static voltage and indicative of a fault, or it could be produced by a high frequency square wave signal giving an average voltage of half the supply voltage with no fault present in this part of the circuit.

Ideally an oscilloscope should be used for testing this type of equipment, but where this is not possible for some reason a logic probe makes an excellent alternative. This simple logic probe is intended for use with CMOS logic circuits, is powered from the circuit under investigation, and has a current consumption of only around 0 to 20 mA (depending on the supply voltage and logic state indicated by the probe). The logic state detected by the unit is indicated by a two LED display: one of the display LED's is a multicolour type and the other is an ordinary green type. The following table shows the display obtained from various input signal conditions.

Input state	D1	D2
Low	Green	Off
High	Red	Off
Intermediate	Yellow	Off
Pulsing fast	Yellow	On
Pulsing slowly	Red/Green Slowly Pulsing	

When the input is pulsing at high speed it is possible that D1 will be red or green instead of yellow, and this simply indicates that the mark-space-ratio of the input signal is far from being one-to-one. D1 will be red if the input is high for the majority of the time, or green if it is predominantly low. If the input is pulsing slowly, unless the pulses are extremely brief, D1 will be seen to switch from red to green and so on in sympathy with the input signal.

The Circuit

Separate stages are used to drive the two indicator LED's, a dual operational amplifier being used to drive D1 and a 555 monostable driving D2. Figure 1 shows the circuit diagram of the CMOS Logic Probe.

Both sections of IC1 are used as voltage comparators rather than operational amplifiers, and these each have one input connected to a reference voltage and the other taken to the input of the probe. The unit must indicate a high input state if the input voltage is more than about 70% of the supply voltage, and a low input state if the input is at less than about 30% of the supply potential. R3 to R5 form a potential divider which gives reference voltages of approximately 30% and 70% of the supply voltage.

If the input is low, IC1a's non inverting input will be at a higher potential than the inverting input so that the output goes high and switches on D1b. IC1b has the opposite input states so that its output

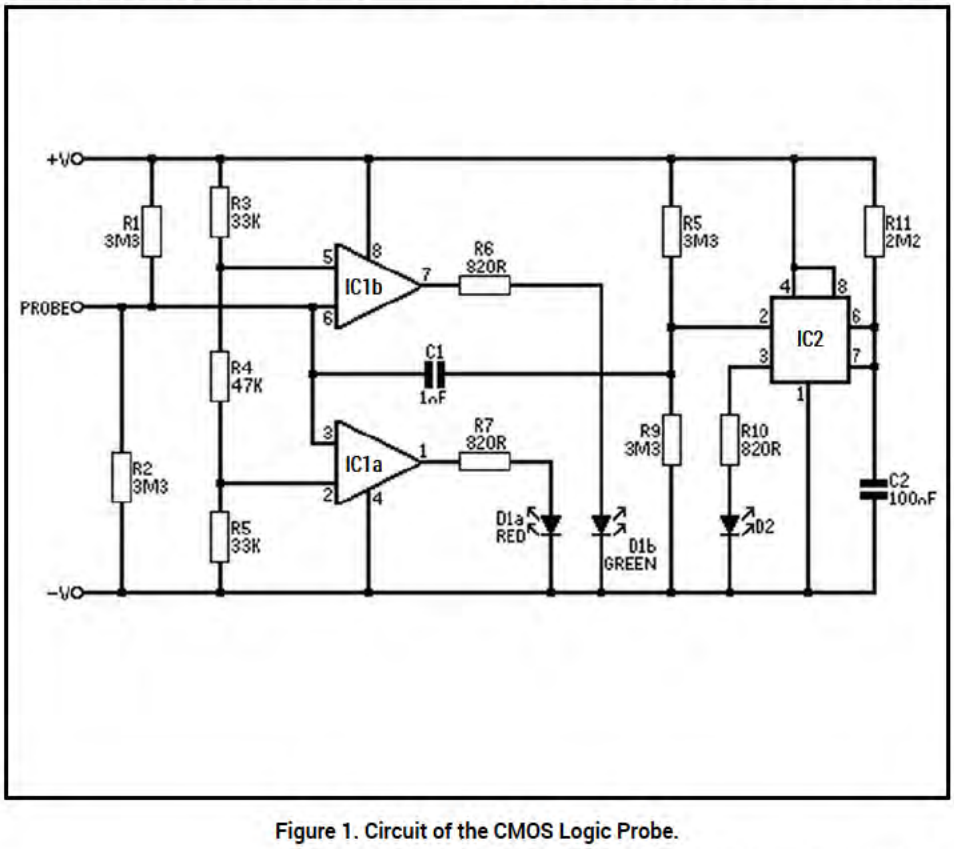


Figure 1. Circuit of the CMOS Logic Probe.

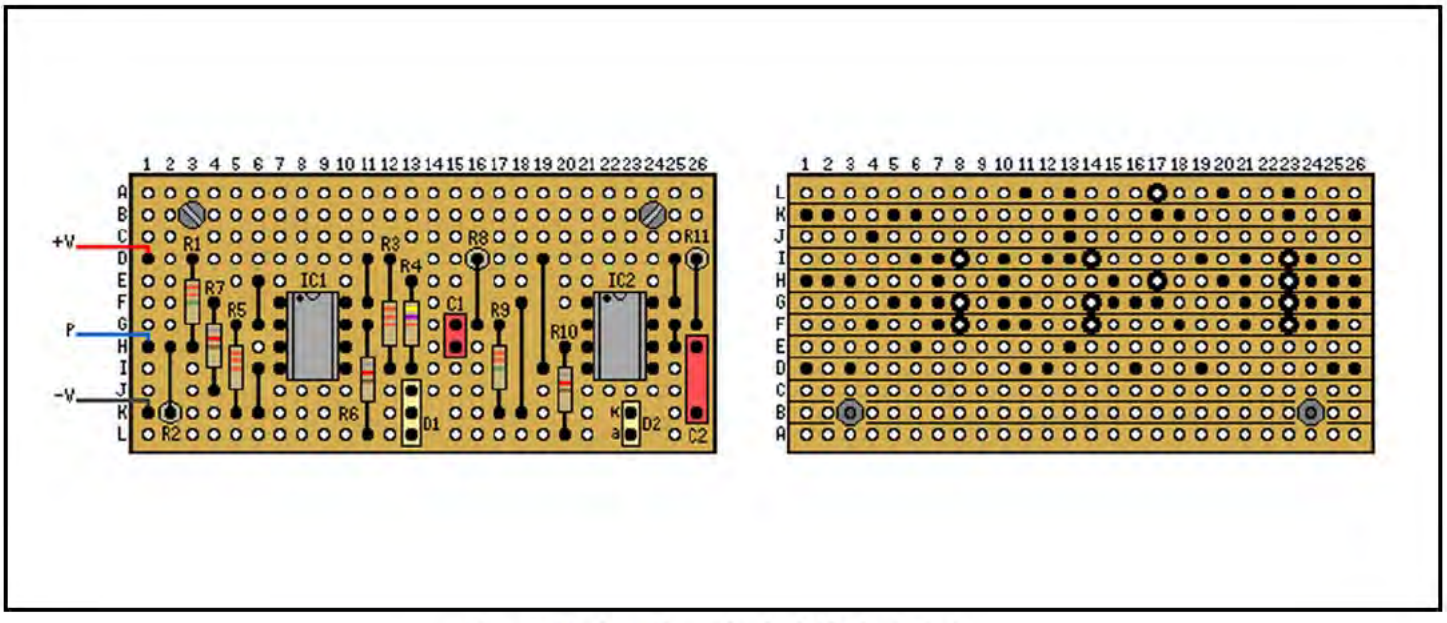


Figure 2. Veroboard layout for the CMOS Logic Probe.

goes low and D1a is switched off. This gives a green indication from D1. With the input in the high state IC1a's inverting input is taken to a higher voltage than the non inverting input, causing the output to go low and switch off D1b. IC1b's non inverting input will now be at a higher voltage than the inverting input, causing IC1b's output to go high and switch on D1a so that a red indication is obtained from D1.

If the input is between the two logic states the outputs of the two comparators will both assume the high state so that the red and green sections of D1 switch on to produce a yellow display. R1 and R2 bias the input between the two logic levels so that the unit will indicate a fault condition (with D1 in the yellow state) if the input is taken to an open circuit test point.

This section of the circuit does not enable the user to differentiate between a static level between the two logic states and a high frequency pulse signal, since the latter will cause both sections of D1 to switch on in turn and give the impression of a yellow display due to the switching action being too fast to be seen. This is overcome by applying the input signal to the trigger input of a 555 monostable. Normally R8 and R9 hold the input of IC2 above the trigger threshold, but if there is a pulsing input signal it will be coupled to the input of IC2 by C1 and on negative transitions IC2 will be activated. LED indicator D2 is then switched on for about 0.25 seconds each time IC2 is triggered, but with a high frequency input signal the circuit will be retriggered almost as soon as each output pulse ceases, and D2 will appear to light continuously. C1 blocks steady state inputs so that IC2 is not triggered, except possibly for a single triggering when the input is taken to a new logic state, with a consequent brief flash from D2.

PARTS LIST FOR THE CMOS LOGIC PROBE

Resistors - all ¼ watt except where specified

R1, R2, R8, R9	3M3 10%	(4 off)	Orange Orange Green
R3, R5	33K	(2 off)	Orange Orange Orange
R4	47K		Yellow Violet Orange
R6, R7, R10	820R	(3 off)	Grey Red Brown
R11	2M2 10%		Red Red Green

Capacitors

C1	1nF Ceramic plate
C2	100nF Polyester

Semiconductors

IC1	CA3240E
IC2	ICM7555
D1	2 colour LED Common cathode
D2	LED Green Rectangular

Miscellaneous

Small case
Veroboard 26 holes x 12 strips
Pair of crocodile clips

Construction

The Veroboard layout for the CMOS Logic Probe is shown in Figure 2 and this is based on a board having 12 copper strips by 26 holes. Construction of the board is quite straightforward apart from the fact that IC1 is a MOS device, and the normal MOS handling precautions must be taken with this device. IC2 is a CMOS device but due to its internal protection circuitry it does not require any handling precautions.

In use the unit will probably be most convenient if it is fitted in a small case that can be comfortably hand-held. The probe tip, which can simply consist of a long M3 bolt, is fitted at the front end of the case and the two display LEDs are mounted off-board at the rear end of the case. The case is drilled to take the two supply leads, and these are about half a metre long and terminated in crocodile clips to permit easy connection to the circuit under test. The crocodile clips are different colours (red for the positive lead and black for the negative one) so that the two leads are easily identified.