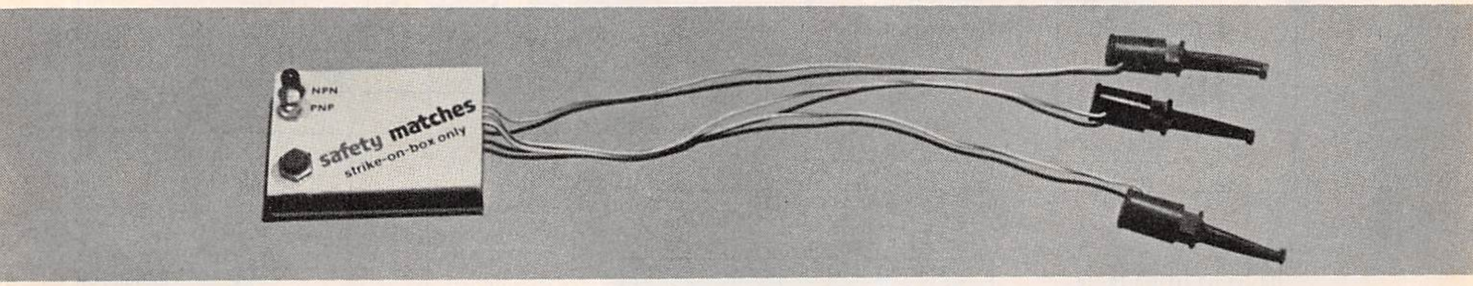
Matchbox In-Circuit



Transistor Checker

This little transistor tester, with features like the commercial models, can save time, money, and otherwise wasted energy!

By D.E. Patrick

☐IF YOU'VE EVER BUILT OR TESTED ANY TYPE OF EQUIPment containing transistors, then you probably know what a blessing a good transistor checker can be. While some low-priced models sell for \$6 or \$7 or so, you can just as easily build your own for about a buck, depending on how well your junkbox is stocked. In order for our junkbox transistor checker to be worth while, however, certain guidelines must be met.

First, we want the tester to check transistors both in and out of circuit, so that you don't have to extract the suspected faulty unit from its circuit. That eliminates the possibility of wiping out printed-circuit foil patterns; or damaging the transistor if it's not defective, or damaging other components with excessive heat. Second, the tester should have provisions for determining transistor type, either NPN or PNP. And finally, its parts count should also be low; it should be made as small as possible so as not to lend additional clutter to your work bench or area.

Well, the circuit that we'll show you meets those criteria, and if so desired, it can be modified to include a couple of "bells and whistles." Things like an audio indicator may be added to tell you (without a glance) that the transistor is good. Or you may want to add various sockets so that transistors with different package outlines may be plugged into the circuit for testing.

General Description

The Matchbox In-Circuit Transistor Checker is a 15-minute project that can be built from parts that are probably in your junkbox. The Checker's schematic diagram is shown in Fig. 1. That circuit uses two light-emitting diodes (LED's) to indicate the the condition of the unit-under-test (UUT); for instance, the PNP indicator, LED2, flashes when a good PNP unit is connected, and the NPN indicator, LED1, flashes for a good NPN. On the other hand, if both LED's flash or both LED's are extinguished, you know the transistor is "shot."

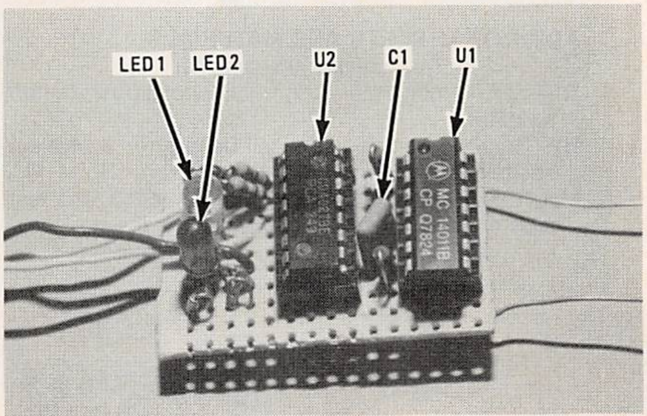
Circuit Operation

The schematic in Fig. 1 shows an astable multivibrator (oscillator) formed by two CMOS (Complementary Metal-Oxide Semiconductor) NAND gates, U1-a and U1-b. Although the author used a 4011 quad NAND gate, any inverting CMOS logic device can be substituted. The approximate output frequency of the multivibrator is calculated:

$$f \approx (R2C1)/2.2$$

where $10R2 \geq R1 \geq 5R2$. Resistor R2 can be a fixed 100,000-ohm unit for an output frequency of about 10 Hz or adjustable (using a 100,000-ohm potentiometer as shown) from about 10 Hz to 20 Hz; however, that frequency is not critical. The multivibrator's output is fed to U2, half of a 4027 dual J-K, master-salve flip-flop. That unit, like the inverting logic used, can be any number of CMOS flip-flops, not just the one shown. All that's needed are complementary outputs, Q and $\overline{Q}$, which drive the base (B), collector (C), and emitter (E) of the unit-under-test (UUT) and the light-emitting diodes, LED1 and LED2.

With no transistor connected to points B, C, and E, the Q output at a logic 0 and the $\overline{Q}$ output at logic 1, LED1 lights thru current limiting resistor R5. When Q is at logic 1 and $\overline{Q}$ at logic 0, LED2 will light. Thus, as U2 toggles back and forth



The author's prototype of the Transistor Checker is shown laid out on perfboard. Note that the resistors and diodes are vertically mounted to reduce the size of the board. Its small size allows it to easily fit into a matchbox.

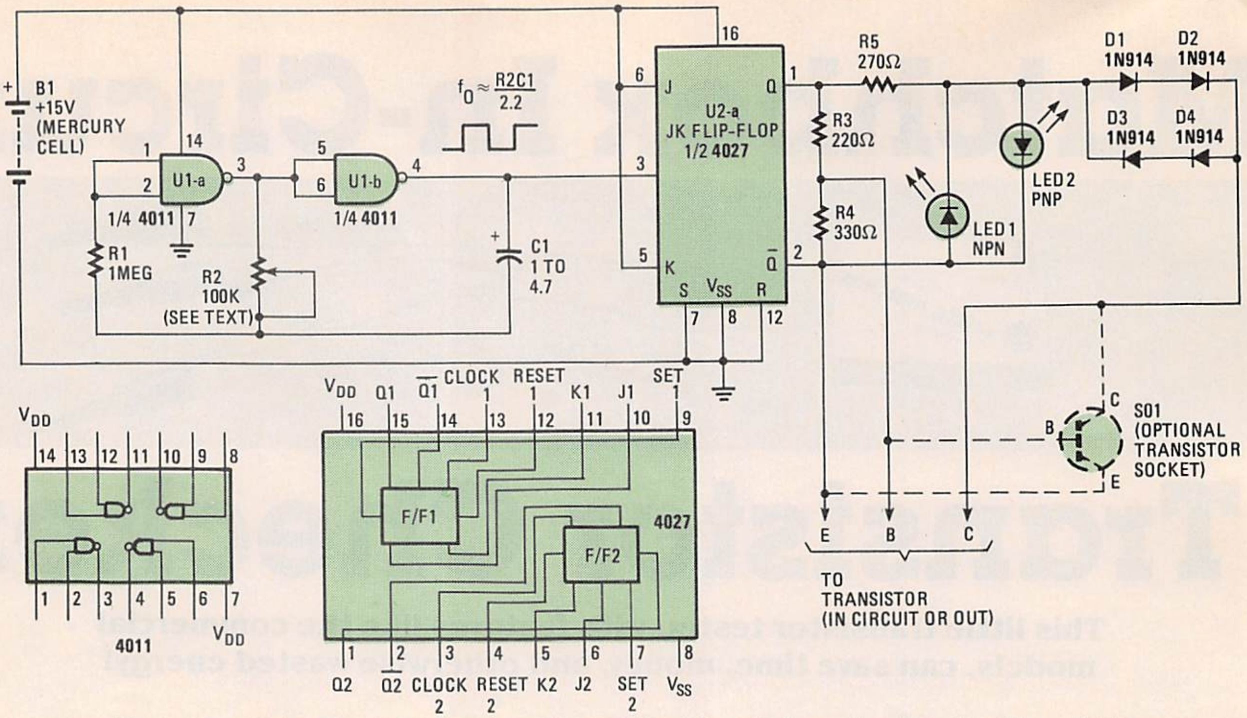


Fig. 1—The MatchBox In-circuit Transistor Checker circuit is made from a handful of readily available parts and there's nothing critical about them. U1 may be replaced by any inverting logic integrated circuit, and most any flip-flop can be substituted for U2. Note that both the J and K input are tied to +V. As always, when dealing with any CMOS components, all unused inputs should be tied to ground. Resistor R1 can be a 100,000-ohm fixed or variable unit and C1 can vary anywhere between 1–4.7-µF.

PARTS LIST FOR THE MATCHBOX IN-CIRCUIT TRANSISTOR CHECKER

SEMICONDUCTORS

- D1–D4—1N914 general-purpose, silicon, switching diode
- LED1, LED2—Jumbo light-emitting diodes (see text)
- U1—4011 quad two-input NAND gate, integrated circuit
- U2—4027 J-K master/slave flip-flop (or any J-K flip-flop) integrated circuit

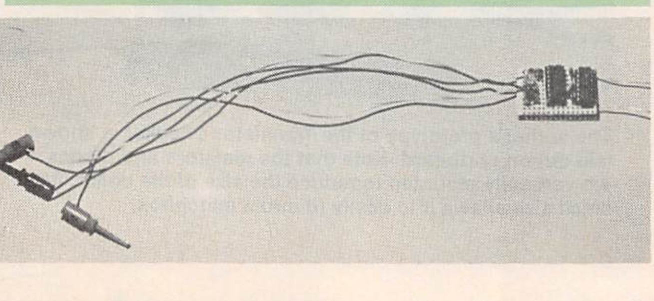
RESISTORS

(All resistors are 1/4-watt, 5% units unless otherwise noted.)

- R1—1-Megohm
- R2—100,000-ohm (fixed or adjustable, see text)
- R3—220-ohm
- R4—330-ohm
- R5—270-ohm

ADDITIONAL PARTS AND MATERIALS

- C1—1-µF–4.7-µF electrolytic capacitor
- S1—SPST, momentary, normally-open, push-button switch
- B1—Small 15-volt, mercury-cell battery (or equivalent see text).
- Matchbox (or project box), hookup wire, perfboard, test clips or alligator clips, integrated and transistor sockets (optional), hardware, epoxy, solder, etc.



◀ Connections from the circuit to the transistor can be nothing more than three lengths of wire terminating in test clips as shown; or, if you prefer, alligator clips may be used.

repeatedly, LED1 and LED2 alternately cycle on and off under a no-load condition. But when the B, C, and E leads are connected to a good transistor, bias is provided to the base of the unit via R3 and R4.

The transistor will be turned on or off depending on the polarity of voltages established at the Q and $\overline{Q}$ outputs. And the light-emitting diodes are either short circuited, or one or the other will be turned on, but not both at once. That is, when a good PNP transistor is properly connected and Q is at logic 0 (low) while $\overline{Q}$ is a logic 1 (high), the transistor turns on shorting LED1 and reverse biasing LED2, holding both light-emitting diodes off for the first half of the cycle.

When Q goes to logic 1 and $\overline{Q}$ to a logic 0 on the other half of the cycle, LED1 will be reverse biased. But, the PNP transistor is now in cut off and LED2 will light. Therefore, with a good PNP in circuit, LED2 will flash at the rate ½*f*, while LED1 is held off. It may be shown that the reverse happens for an NPN transistor—i.e., LED1 flashes at the rate of ½*f*, while LED2 is held off.

In the case of bad transistors, a collector-to-emitter short turns both LED1 and LED2 off, while an open transistor causes them to flash on and off alternately. If the transistor has a base-to-emitter or base-to-collector short, both LED1 and LED2 turn on alternately, because half the transistor is acting like a diode and would be indicated as a good transistor. However, diodes D1 through D4 in series with the collector (C) prevents that from happening. The voltage drop across the forward-biased pair, D1/D2 or D3/D4, establishes a 1.2 volt drop. That voltage drop adds to the voltage drop across the transistor being tested. For a good transistor, the total voltage

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drop will be on the order of 1.3 to 1.4 volts, not enough to turn the LED's on. But, with a base-emitter or base-collector short, total voltage drop will be on the order of 1.8 volts, alternately lighting LED1 and LED2.

Generally, the heavy base drive provided by R3 and R4 is sufficient to overcome low-valued resistors in a in-circuit transistor. Thus, in-circuit resistances across base-emitter or base-collector junctions of as little as 50 ohms can be overcome. On the other hand, even more base current could be garnered using emitter followers at Q and $\overline{Q}$ if desired.

There is nothing critical about construction. The entire circuit and battery can be placed on a small piece of perfboard (see Photo) or pre-etched experimenters board or printed-circuit board and housed in a matchbox, or a mini-project box if desired.

If you decide to use the matchbox case, be sure to go over it first with some 5-minute epoxy to strengthen and waterproof it. Then you can drill or cut out holes for S1, LED1, and LED2, which protrude out the top. Base (B), collector (C) and emitter (E) hookups can be clip leads. ■