BUILD THIS

3-CHIP LOGIC ANALYZER

If you have ever needed a simple logic analyzer, or wanted to know more about how they work or how to use them, then try our $6 circuit.

J.J. ROBINSON II

MICROPROCESSOR SYSTEMS OFTEN monitor several signals at once, like address or data bus contents. That's often difficult to duplicate with most logic probes, and logic analyzers are too expensive for most hobbyists. One solution is to build an eight-bit, 3-chip, word-recognition logic analyzer for about $6. The low parts count keeps size and power demands low, so it can run directly off the *C*ircuit-*U*nder-*T*est (CUT).

Principles of operation

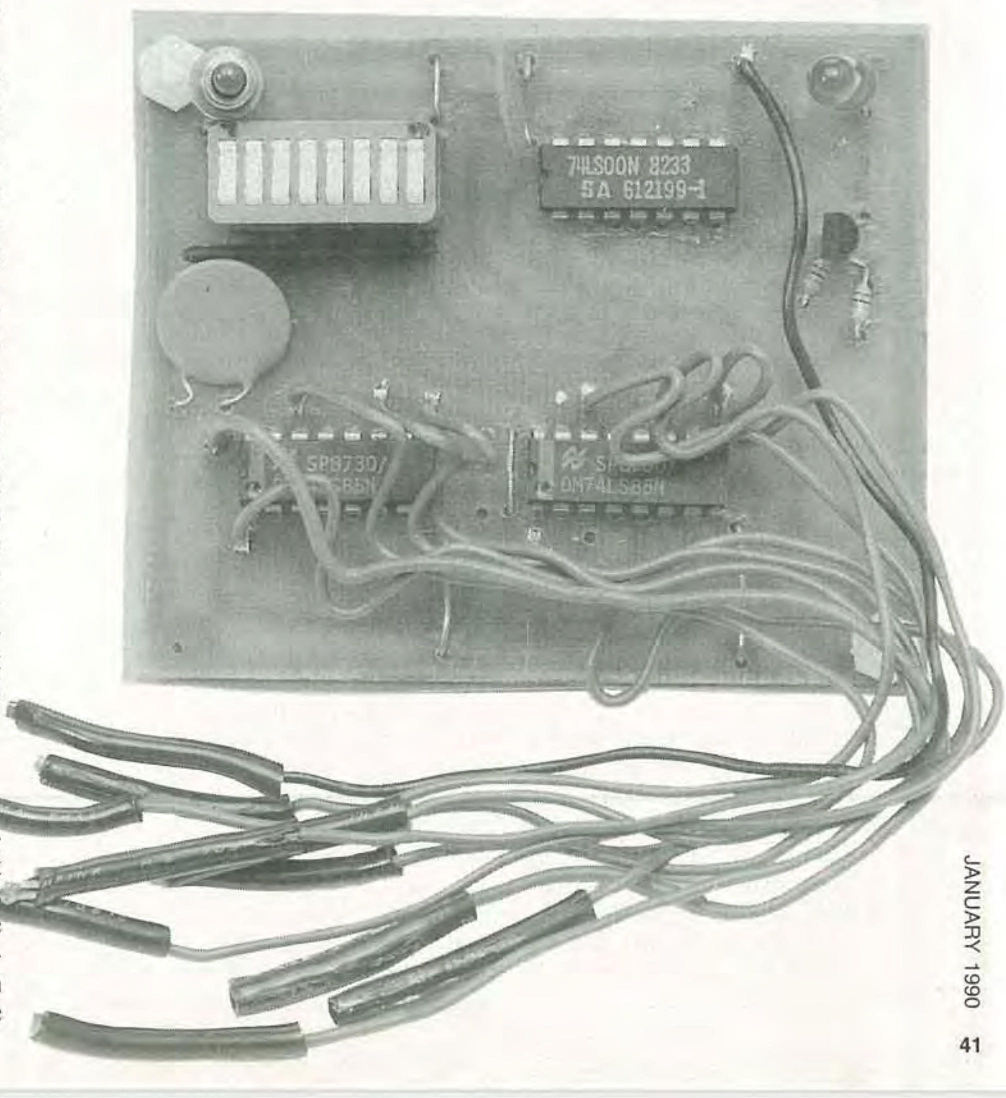
The schematic is shown in Fig. 1. It uses two cascaded four-bit 74LS85 digital magnitude comparators, IC1 and IC2, to monitor an eight-bit signal in any TTL-compatible environment. The digital word being sent is entered on a group of DIP switch inputs (S1-a–S1-h). If it's matched by signals from the test device inputs (TP0–TP7), the upper 74LS85 sets pin 6 high.

The 74LS00 is a quad 2-input NAND gate; IC3-a and IC3-b make up an R-S flip-flop, IC3-c is unused, and IC3-d is used as an inverter to drive one flip-flop input. The two flip-flop inputs are pin 1 on IC3-a, and pin 4 on IC3-b. Pin 1 on IC3-a is kept high by being tied back to +5V through R3-i. Pressing the RESET switch, S2, momentarily grounds pin 1 of IC1 and pin 6 of IC2, turning off Q1 and LED1.

The high from pin 6 of IC2 sets the flip-flop, driving pin 6 of the 74LS00 high, turning on Q1 and LED1 until the user presses S2. However, test points TP0–TP7 shouldn't have latched yet. A comparison ripples through a 74LS85 in about 32 microseconds (worst case), so each eight-bit word has to last about 64 nanoseconds for valid comparison. That shouldn't cause problems with 4–8 MHz microprocessor signals.

Construction

The prototype, shown in use in Fig. 2, was built on a PC board using wire-wrap IC sockets and a nine-element SIP-resistor array. The test leads should be about six inches long. The push-on connectors are single, break-apart, Molex IC sockets, covered with heat-shrink tubing; you could also use



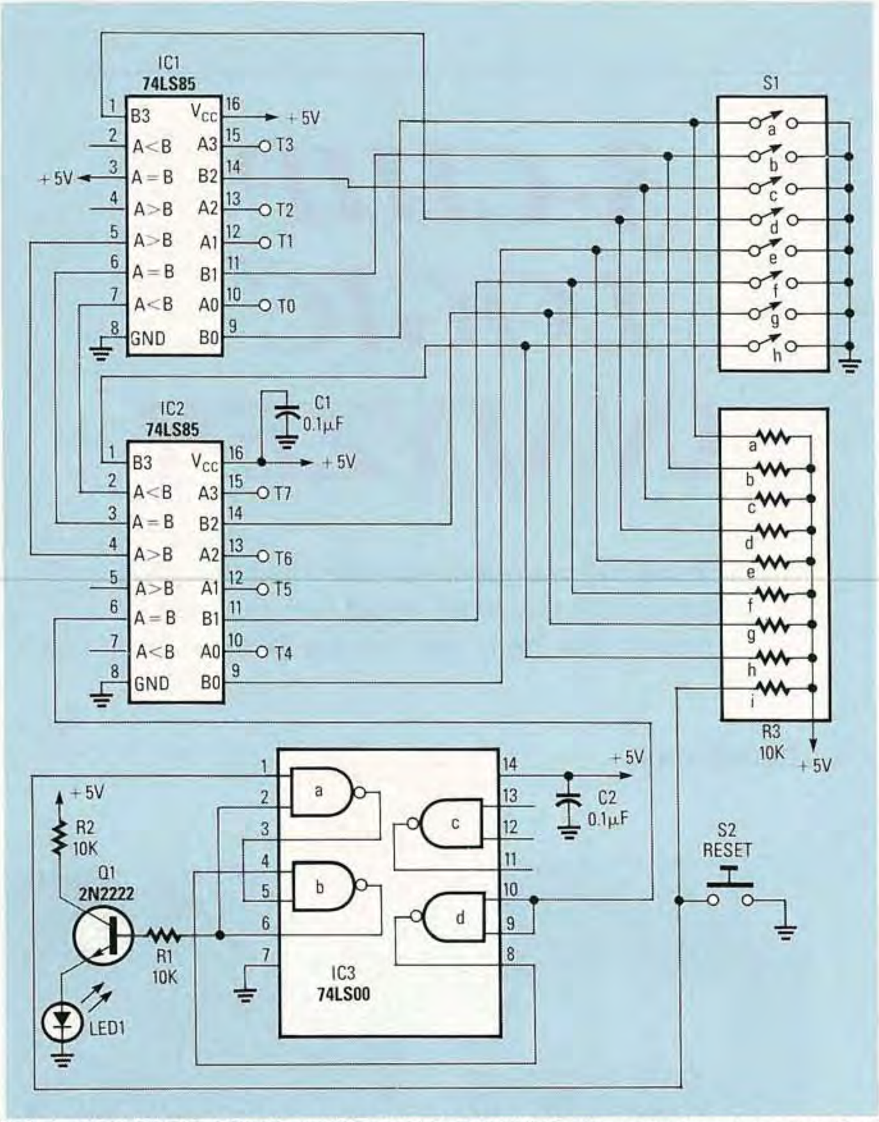


FIG. 1—SCHEMATIC OF THE 3-CHIP LOGIC ANALYZER. It's made from two cascaded 74LS85 4-bit magnitude comparators (IC1 and IC2), and uses an 8-switch SPSP DIP switch S1 and 8-resistor SIP array R3 to set the bit states compared against. The output of IC2 is fed into inverter IC3-d, which feeds into RS flip-flop IC4-a and b, which drives Q1 and LED1.

PARTS LIST

All resistors are ¼-watt, 5%.
R1, R2—10,000 ohms
R3-a–R3-i—10,000 ohms × 9 SIP network
Capacitors
C1, C2—0.1 µF, ceramic disc
Semiconductors
IC1, IC2—74LS85 magnitude comparator
IC3—74LS00 quad NAND gate
Q1—2N2222 NPN transistor
LED1—light-emitting diode
Other components
S1-a–S1-h—8-switch DIP
S2—subminiature, momentary, push-button SPST switch
TP1–TP8—Molex break-apart IC pins
Miscellaneous: PC board, wire, solder, and heat-shrink tubing.

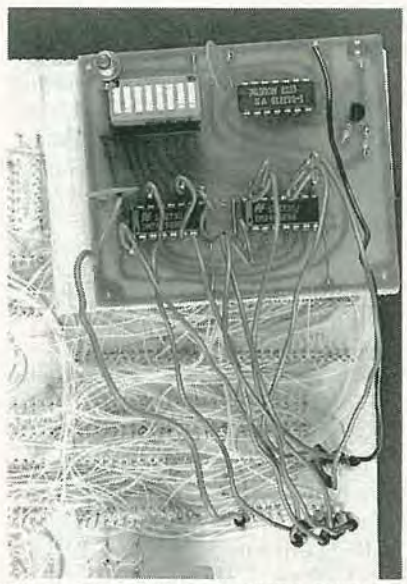


FIG. 2—PROTOTYPE OF THE 3-CHIP logic analyzer; note SPST DIP switch S1 and the SIP resistor array R3 at upper left. The eight pins covered with heatshrink tubing are made from Molex break-apart IC pins.

an IC test clip. The space between the PC board and the tested circuit has to be insulated with a sheet of plastic or small block of wood. At high frequencies, use a shielded enclosure. The prototype PC board operated reliably when unshielded near a 16-MHz video PC board.

Testing

The circuit can be tested with a static input word on the test leads. When the analyzer's switches (S1–S8) match it, LED1 should light. If the switches are then changed so they no longer match, LED1 should stay lit. If S2 (RESET) is now pressed, LED1 should go out. If that doesn't happen, carefully check your work for wiring errors.

Applications

There are three tests for which the analyzer is quite useful:

- Data bus: Connect the test leads in the correct order to the microprocessor data bus, and check for the desired eight-bit test word. They can be elements of the machine language program, data transmitted to the microcomputer by another device, etc.
- Address bus: Connect the test leads to the address bus; since it's often 16 bits long, only half can be monitored at once. The upper half will usually be the most significant, and will show what parts of the address space the system is accessing under program control.
- Control signals: Connect the test leads to monitor a selection of control signals, like chip-, write-, and read-enable (CE, WE, and RE) pins of memory devices, I/O selects, etc. That can show whether the CE, WE, and/or RE are simultaneously active, whether multiple memories are simultaneously selected, and happens to be very useful in debugging address decoding algorithms.

To use the analyzer, connect the power and ground to the test circuit points, and the eight test leads to the appropriate signals. When a positive match is found, the LED glows. For the next test, enter a new search word and press S2. R-E