can you beat TIC-TAC-TRONIX?

If you follow the plans and don't cheat when playing you'll never beat Tic-Tac-Tronix

by DON LANCASTER

IF YOU'RE LOOKING FOR A REALLY ADVANCED digital computer project or a sure-fire attention getter for an exhibit, promotion, or display, TIC-TAC-TRONIX is for you.

Tic-Tac-Tronix is a compact, special-purpose digital computer programmed to play an unbeatable game of Tic-Tac-Toe against all comers—unbeatable unless you have flipped the hidden GOOF SWITCH. Then, you or anyone who knows the secret can indeed beat the machine. You can build this all-solid-state project for around $45.

The program

Any digital computer follows a predetermined set of rules by way of a series of sequential steps. The rules are often called algorithms, and the steps by which these rules are obeyed are called program steps. Tic-Tac-Tronix is a permanently programmed computer that has been taught the Tic-Tac-Toe strategy by means of fixed internal connections. This is also called a hard-wired or a fixed program. One exception is provided in Tic-Tac-Tronix where the GOOF SWITCH is brought out to let you as a programmer choose one of two programs, a beatable one and an unbeatable one. The sequential thought processes or flow chart of the machine is in Fig. 1 (at top of this page).

Each square of the Tic-Tac-Toe board is identified by a letter: A through I. The game begins with the machine playing square A. You then make a move and the computer recognizes that you have played and tests to find out where you played. As a result of the testing, the machine first picks one of five strategies or program branches and then answers your move. The machine then awaits your second move, after which it again tests and plays either to win immediately or to set up a potential win on the next move. The machine always sets up a “critical square” situation and tests that square on its next move to see if you played on it. The third move is similar to the second, and the computer usually wins on the third move. Further moves are ignored by the computer.

Although it takes the computer only a few billionths of a second to move each time, a two-second time delay is introduced after each move, for effect, to let the computer “think things over”. With the goof switch in the SMART position, the computer always wins if you play anything but the middle square (E) on your first move. Even then, it can win if you are careless.

Suppose you try to beat the computer by playing the lower righthand corner (I). The game begins with the computer playing A followed by your I response. The computer tests, sees that you played I, picks strategy V, and plays C.

On the next move, if you haven’t played B, the machine does and wins. If you have played B, the machine plays G, letting it win next move either A-D-G or C-E-G. On your next move, the computer tests square D. If you played here, the computer plays E and wins. If not, it plays D and wins. The strategies for the other moves are similarly based. For variety, all possible winning forks have been set up in the computer, including three corners; two corners and the middle; and one corner, the middle, and an adjacent side. Should you answer with the middle square E, the computer decides on a defensive strategy and forces you to block its moves.

The goof switch tampers with strategy III if it is set to the DUMB position. This gives the machine one wrong move, allowing the player to win.

Tic-Tac-Tronix circuitry

The circuit is made up of five IC’s, 31 transistors, and a resistor-diode computer array. The block diagram of the
circuit is shown in Fig. 2, while the schematic is in Figs. 3 through 8, broken up into modular chunks.

The player latches and machine drivers are shown in Fig. 3. A player's move shows up as a lit blue pilot lamp; the machine's by a lit red lamp. These two illuminate a red X and a blue 0 in each display cubicle, resulting either in a black X on a blue background, or a black 0 on a red background.

Player latches are needed for squares B through H. Machine drivers are not needed at A and F since A is permanently lit and since square F never has to be played by the machine.

Each player latch consists of a set-reset flip-flop using an integrated circuit inverter and a Darlington lamp driver. Pushing a valid select pushbutton sets the flip-flop and lights the bulb. It also delivers a play pulse to the move counter via one of diodes D8 through D15. The pushbutton is interlocked
FIG. 7 (top left)—PLAY COMPUTER is DTL array used as the brain-center of the game. Three diode-resistor networks determine moves. FIG. 14 (above)—WIRING DIAGRAM shows how multi-lead cables are used to simplify the wiring and as an aid when troubleshooting.

FIG. 9—FOIL PATTERN OF COMPUTER BOARD is reproduced here exactly half-size so you can make your own if you desire.

FIG. 10 (middle right)—DRILLING GUIDE shows hole sizes and the location of jumpers to be installed on component-side of the board.

FIG. 11 (right)—COMPONENT LAYOUT shows the position of all parts. Use small iron, thin low-temperature solder and extreme care.
with the machine bulb so that the player can't cheat and attempt to play on top of a square the machine has already used. If the machine bulb is lit, no voltage is available for the pushbutton and it won't set the player latch or advance the move counter.

Diodes D18 through D25 provide a reference of what square has been played. This information is later used by the strategy latch when it has to pick a game strategy after the first move.

The player latches must be reset for each new game. This is done either by removing the inverter supply voltage or by shunting Darlington current with diodes D16 and D17, depending on the particular player latch being reset. S10 is the reset (CLEAR) switch. It does several things. It resets the player latches; it resets the move counter; and it loads a "no play" strategy into the strategy selector.

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### Parts List

- **R1** thru R7, R15 thru R48, R52 thru R56, R69 thru R72—1000 ohms, 1/4 watt (48 total)
- **R8** thru R14, R47 thru R51—330 ohms, 1/4 watt (12 total)
- **R25 thru R66—470 ohms, 1/4 watt**
- **R67—10 ohms, 2 watts**
- **R68—15,000 ohms, 1/4 watt**
- **C1—100 μF, 6-volt electrolytic**
- **C2, C3—100 μF, 6-volt electrolytic**
- **C4, C5—0.01 μF, mylar**
- **D1 thru D25—N 1914 or equal (50 total)**
- **D60 thru D64—1 amp, 50 pis, silicon power diode**
- **D65—1N4735, 1-watt Zener diode, 5.1 volts**
- **F1—0.5-amp fuse & holder**
- **IC1, IC2—MC780P MRTL Hex Inverter**
- **IC3—SN745 or MC747 Quad Latch TTL**
- **IC4—SN7400 or MC7400 Quad Gate TTL**
- **IC5—SN7407 dual JK flip-flop TTL**
- **LM1 thru LM16—No. 47 pilot light, 6.3 volts, 150 mA**
- **Q1 thru Q31—2N5129**
- **S10—spot pushbutton**
- **S11—spot slide**
- **T1—Rheostat transformer: primary, 117 Vac; secondary, 12.6 Vd, 2 amps**

Miscellaneous: PC Board (see text and Fig. 9, 10, 11); No. 24 wire jumper; 20 terminal (33; collared); flat cable or wiring harness (see Fig. 12); subchassis assembly: N° ID grommet (16); Silchrome lamp filters: A8, Heilpact No. 1813/27-85 RED (8) and No. 1813/27-81 BLUE (8); front viewing filter Kit, front panel: vinyl-clad case, line cord and strain relief: switch hardware: misc. hardware: wire, solder; lacing twine.

**NOTE:** The following lamps are available from Southwest Technical Products, 219 W. Rhapsody, San Antonio, Texas, 78201:

- **PC-962**—$8.65
- **No. 962X**—S4.25

Postage & Insurance additional. Shippilg weight: 3 lbs, 5 oz.

The machine drivers do not have to latch as they are continuously driven by the play computer. They are also Darlington lamp drivers. If the input from the play computer is made positive, the lamps light. A new game starts when the reset switch returns the play computer and the strategy selector to an all-outs-low condition.

Diodes D1 through D7 serve an important function. They are the way the computer tests to see if a square is occupied. If the player lamp is lit, the diode robs the machine driver of its base current and prevents the computer from playing on top of the player.

The machine keeps track of the moves with the move counter, shown logically in Fig. 4 and schematically in Fig. 5. The move counter is made up of a 2-second delay monostable IC2, a four-counter IC5, and a strategy select pulser Q31.

Depressing any valid play pushbutton trips the monostable in IC2 and provides a two-second delay. At the end of the two-second delay, the move counter advances one state. The move counter starts out in a reset condition. On the first move, the strategy-selector is pulsed by half-monostable Q31, while both the move-2 and move-3 logic lines are grounded, preventing any premature move-2 and move-3 plays. On the next play, the move-2 line is allowed to go positive and the second play moves are made. On the next play, the move-3 line is released and allowed to go positive, completing the play.
move counter then remains in this last state regardless of any additional plays until it is reset.

Although the move-3 logic output is positive during the reset time, no move-3 lamps will light prematurely as this occurs before a strategy is selected.

The strategy selector is shown in Fig. 6. Its purpose is to pick and hold one of five possible program branches or strategies in response to a test made during move one and is aimed at finding the initial player response. On the player's first move, one and only one red player lamp will be lit, and one of diodes D18-25 will be grounded at the lamp end and allowed to conduct. These diodes are OR'ed together to form five strategy lines, with the computer playing the same game with a B or an H initial response; for a D or a G; or for an F or an I.

At the end of move-1, a move-1 output pulse is generated by the move counter. This causes the strategy latch to catch and hold whichever input was grounded, thus remembering where the player went on his first move.

A quad latch is used for IC3, forming four of the strategy lines, while a quad two-input gate IC4 is connected as a fifth latch. On all five latches, the complimentary output connection is used. Thus, before a strategy is selected, all outputs are grounded. After a strategy is selected and for the remainder of the game, one selected output is positive, while the remaining four stay grounded. Depressing reset button S11 returns the latches to an all-outputs-grounded state.

Looking back over Figs. 4 through 6, we see that there are seven logic lines provided by these circuits. One of five strategy lines goes positive after the first move. A move-two line goes positive after the second move and stays there, and
finally a move-three line goes positive after the third move.

The logic states on these seven lines are converted into moves by the play computer shown in Fig. 7. This diode-transistor logic array is the brain center of Tic-Tac-Tronix. Move-one and after move-one, a single resistor is allowed to go positive. During move-one, the move-two and move-three logic lines keep their resistors clamped to ground. On move-two, the move-two line goes positive allowing completion of the second move, and finally on move-three. The move-three line goes positive, allowing completion of the game.

The play computer’s outputs are used in conjunction with diodes D1 through D7, which provide the required testing for the second and third moves. Goof switch S11 operates by tampering with the second computer response of strategy III. In the SMART position, things are normal, while in the DUMPS position, the wrong square is played, allowing the player to win.

The power supply is shown in Fig. 8. It provides 6.3 volts of moderately filtered dc for the lamps and a regulated 5 volts for the logic and the rest of the circuit.

How to build it

A printed circuit board is essential for this project. The foil pattern of the board is in Fig. 9.

Fig. 10 is a drilling guide that shows how the 18 jumpers of No. 24 solid wire are positioned on the component side. PC terminals may also be optionally set on the component side.
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