CMOS Die has LED display

Here's a particularly elegant electronic die design which uses CMOS circuitry for long battery life. It also features automatic turn-off after each "throw" is displayed. The readout is via a seven-LED display very similar to that of a normal die.

by DAVID EDWARDS

Even with the inroads television has made, games of skill and luck, where the element of chance is provided by a die or pair of dice are still among the most popular family recreations. However, many arguments have been caused by the penchant for normal dice to give apparently biased or ambiguous answers, particularly when the fever of the game is high.

In an effort to provide an attractive way of overcoming these problems, we have developed a new solid state die. As you can see from the photographs the unit is mounted in a small plastic box, fitted with a red perspex lid, upon which is mounted a single momentary contact switch. Batteries are utilised as the power source, making the device both fully portable and safe to use.

Each press of the switch provides the equivalent of a single "throw" of a normal die. When the switch is first pressed, an array of seven LEDs is illuminated, and flashes at random. After approximately two seconds, the display stabilises, showing a number from one to six as a pattern of lit LEDs, as would normally appear on the upper face of a die.

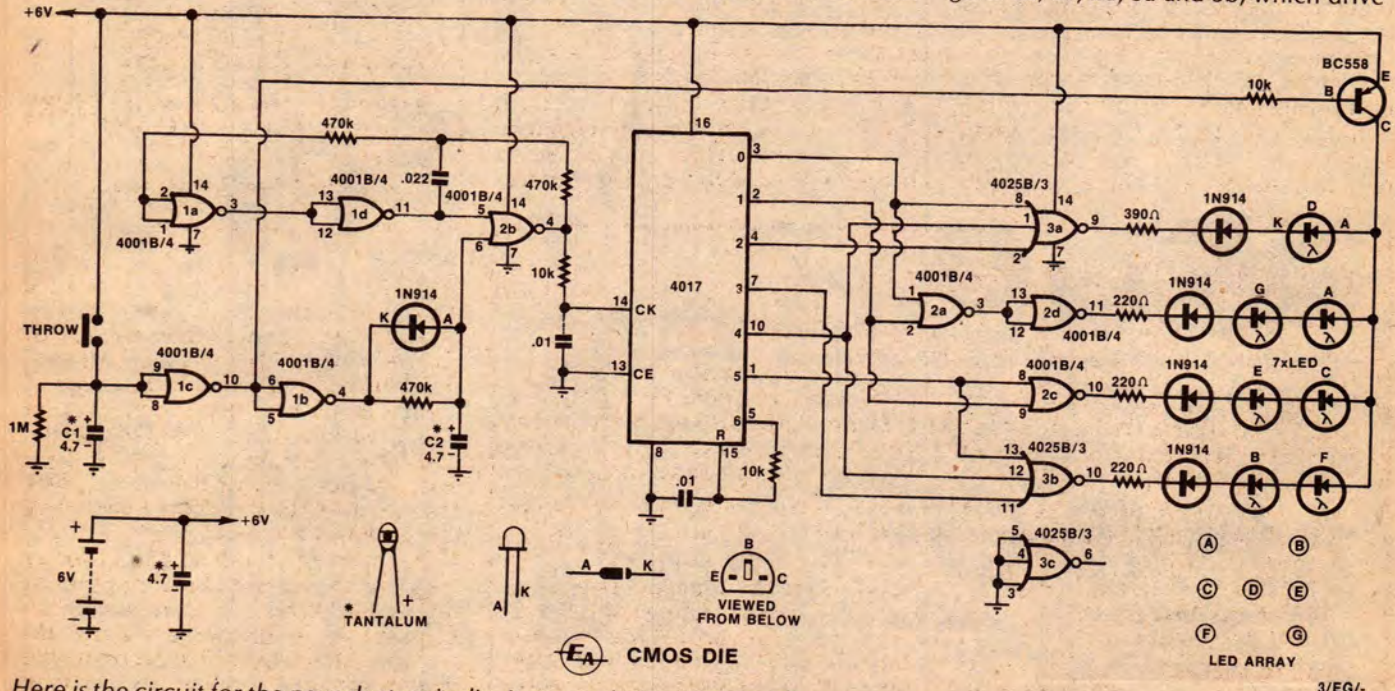
As long as the button is held depressed, the display will remain lit, and it will only disappear five seconds after the button is released. This means that if the switch is only operated momentarily, the display will flash for two seconds, stabilise for three seconds, and then disappear again.

No separate ON/OFF switch is provided, as the quiescent current drain of the unit is less than 50uA. The battery life is thus essentially the normal shelf life. When the display is activated, current consumption rises to about 20mA, but as this normally only occurs in five second bursts, battery life is not unduly prejudiced.

Our estimate, at the time of writing, of the total cost of the components required is only about $16.00. Even inexperienced constructors should be able to build the unit, as all components are mounted on a single circuit board. The battery is clamped beneath the circuit board, which is supported on threaded pillars.

Turning now to the circuit diagram, we can discuss the operation of the unit in greater detail. Gates 1a, 1d and 2b are connected as a gated oscillator whose operating frequency is 50Hz. The oscillator supplies clock pulses to a 4017 decade counter, which is arranged by means of the RC network on the reset pin to function as a divide by six counter.

The six counter states are decoded by gates 2a, 2c, 2d, 3a and 3b, which drive



Here is the circuit for the new electronic die. It uses only four CMOS ICs, together with a transistor and seven LEDs. No on-off switch is required, as the circuit automatically reverts to a low-current quiescent state a short time after each throw.

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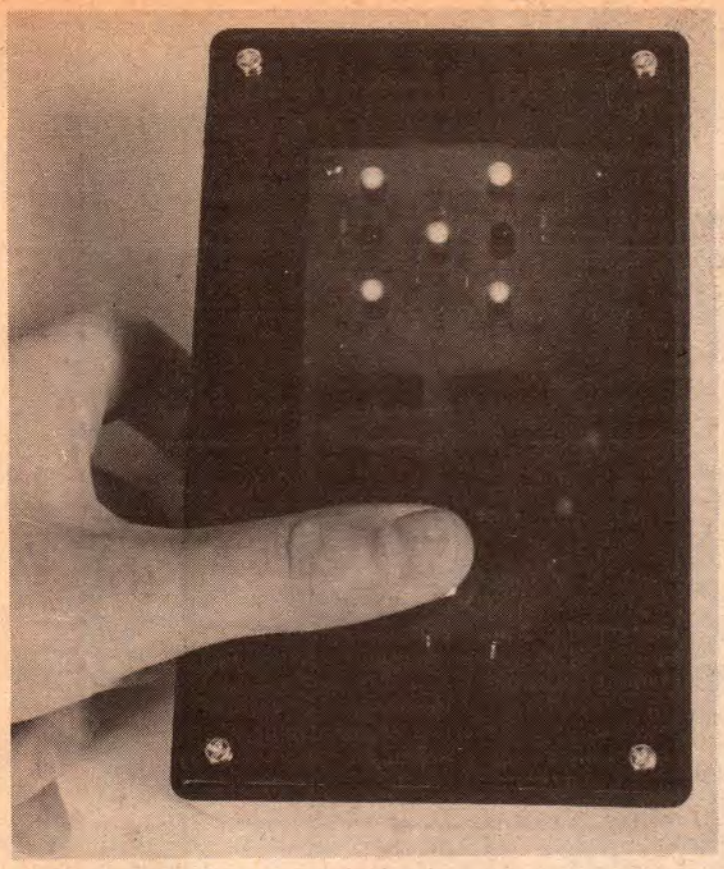
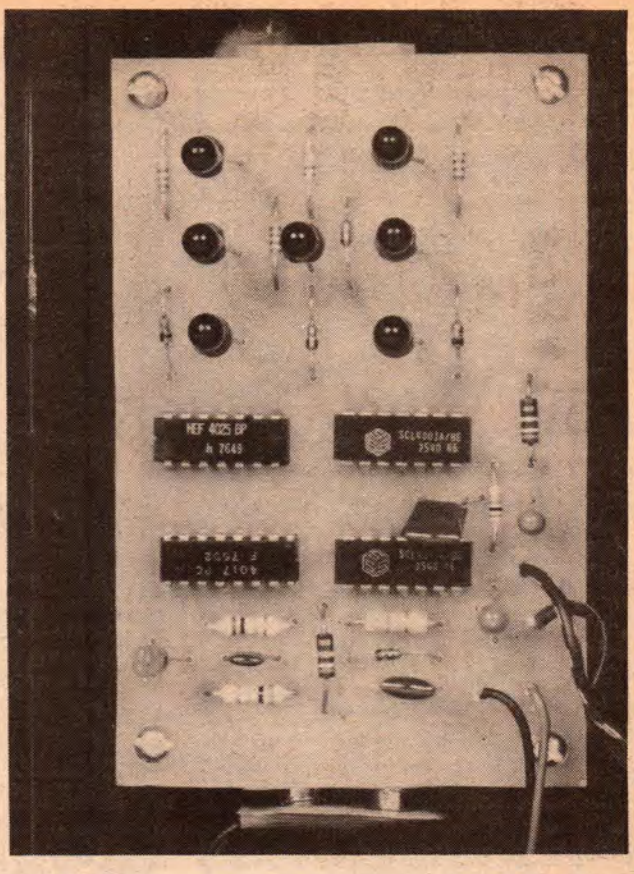
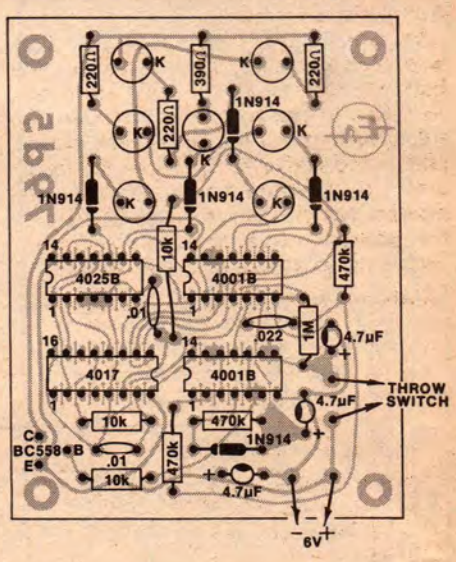




Above is a view of the completed die in operation; its display is very similar to a conventional die. At above right is a close-up of the PC board (or more accurately, an early prototype which was slightly different). At right is the final PCB overlay, showing all parts.



the four LED strings. The LEDs are arranged in the pattern shown, and a little thought will show that they can be divided into four groups (D, C & E, A & G, F & B), which can be combined together so as to produce displays having from one to six LEDs alight.

Illumination of the display is controlled by the BC558 transistor. This is normally held in the off state by the output of gate 1c. The 1N914 diodes in series with the LEDs are to prevent reverse voltages from being applied to the LEDs. Current limiting resistors are provided also, to set the LEDcurrent at 8mA.

Control of both the oscillator and the display is achieved by gates 1c and 1b. In the quiescent state, ie, when the throw button is not pressed, the oscillator is enabled by gate 1b, and the display is disabled by gate 1c.

When the throw button is pressed, capacitor C1 is charged immediately. This forces the output of gate 1c to change state, and this enables the display. The output of gate 1b also changes state, and C2 commences to charge via the 470k resistor. The 1N914 diode is reverse biased at this stage.

After about two seconds, the voltage on C2 reaches the threshold of gate 2b. This forces the output of gate 2b low, and disables the oscillator. The 4017 counter stops at a random count, and this is shown by the display.

This state of affairs continues for as long as the throw button remains depressed. When it is released, C1 commences to discharge via the 1M resistor. After about five seconds, the gate threshold is reached, and the gate changes state. This turns off the display, and also discharges C2, via the diode.

THE PARTS YOU'LL NEED . . .

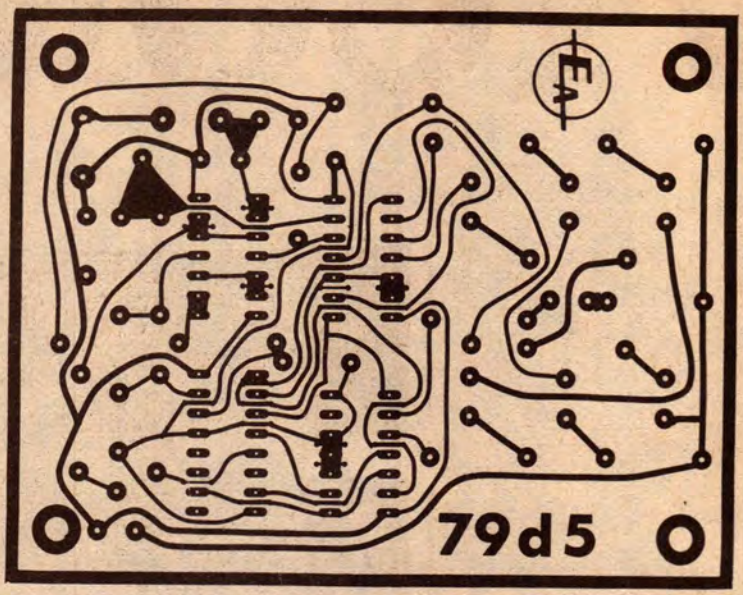
SEMICONDUCTORS
- *2 4001B buffered CMOS NOR gates*
- *1 4017 CMOS decade counter*
- *1 4025B buffered CMOS NOR gate*
- *1 BC558 or similar PNP transistor*
- *5 1N914 or similar silicon diodes*
- *7 red LEDs*

RESISTORS AND CAPACITORS
- *1 1M, 3 470k, 3 10k, 1 390 ohm, 3 220 ohm*
- *3 4.7uF tantalum electrolytics*
- *1 0.022uF polyester*
- *2 0.01uF polyester*

MISCELLANEOUS
- *1 printed circuit board, coded 79d5, 91 x 71mm*
- *1 momentary contact pushbutton switch*
- *1 Zippy box, 95 x 50 x 160mm*
- *1 piece red perspex, 153 x 90mm*
- *4 19mm tapped spacers, with machine screws to suit*
- *4 AA cells, with holder to suite*

Solder, hookup wire, PCB pins, foam packing

NOTE: Resistor wattage ratings and capacitor voltage ratings are those used for our prototype. Components with higher ratings may generally be used provided they are physically compatible.



Here is the PC pattern for the die, reproduced actual size to permit tracing if you desire. However PC boards should be available from commercial suppliers shortly after this issue is published.

This starts the oscillator again.

The unit is constructed on a single printed circuit board, coded 79d5, and measuring 91 x 71mm. Use the overlay diagram as a guide when mounting the components. The LEDs should be mounted as far as possible from the board, to bring them up close to the front panel of the box. Leave the CMOS devices until last, remembering to solder their power supply pins first, and to have your iron earthed.

Use a small piece of foam packing to secure the battery underneath the board. Mount the throw button at the opposite end of the perspex from the display, and connect it to the board with short lengths of hookup wire.

To test the completed die, simply press the throw button. One to six LEDs should remain illuminated, after a two second period during which all the LEDs should flash. If the unit fails to operate correctly, check for solder bridges and dry joints. Operation of the various sections of the circuit can be checked with a multimeter.

If you wish to construct a pair of dice, you will need to use a larger case. Two complete individual boards can be powered from the same battery, and connected to the same throw switch. Mount the boards across either end of the box, with the switch in the middle. The battery assembly can be clamped under one of the boards.