UNIVERSITY OF PLYMOUTH

DEPARTMENT OF COMMUNICATION AND ELECTRONIC ENGINEERING

ELECTRONIC DIE PROJECT

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Introduction

The electronic dice (or, to be correct "die"), throws up a random number from one to six each time the switch is pressed. It has no bias and can never roll on the floor and get lost. The project could be developed fairly easily into a double dice.

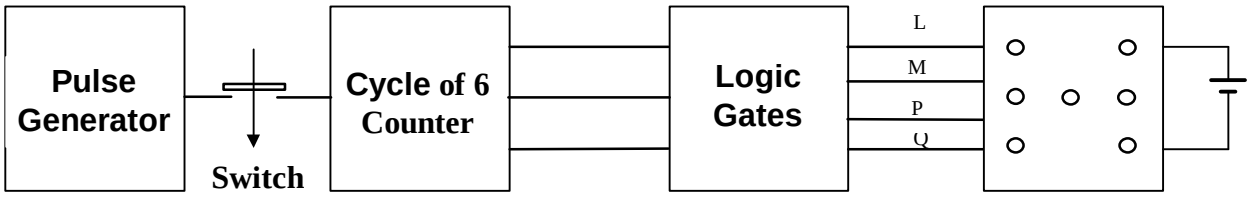
Also, it provides an interesting introduction to a range of digital circuits - oscillator, counter and logic gates.

The project originated with a Maplin kit, though the logic board has been completely redesigned, and both PCBs have been laid out in-house.

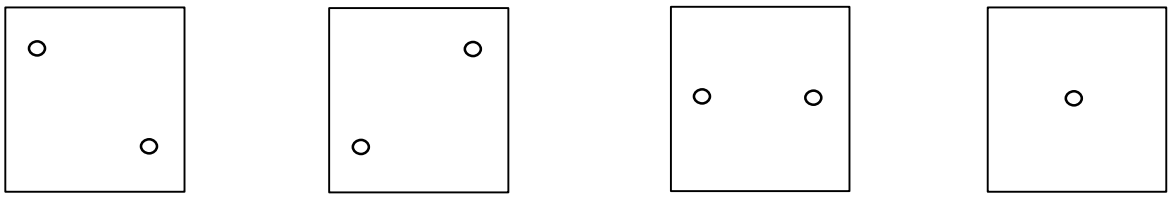
One practical challenge (apart from making it work) is to fit it neatly into the box.

Theory

The diagram below shows the general arrangement. The pulse generator runs continually at a high speed. When the switch is pressed, this drives the counter, which cycles continually from 1 to 6. When the switch is released the number displayed is effectively random because the counter is running so fast.



The seven LEDs can be divided into 4 groups labelled L, M, P and Q.



The truth table for the logic is as follows:

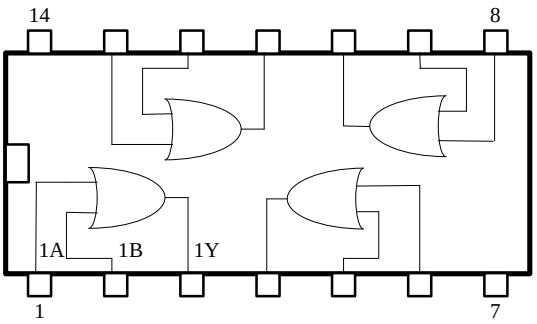
Counter State	Counter Outputs				Die Inputs			
	C	B	A		L	M	P	Q
1	0	0	0		0	0	0	1
2	0	0	1		0	1	0	0
3	0	1	0		1	0	0	1
4	0	1	1		1	1	0	0
5	1	0	0		1	1	0	1
6	1	0	1		1	1	1	0

The four logic outputs L, M, P and Q can be obtained thus:

L = B **OR** C
M = A **OR** C
P = A **AND** C
Q = **NOT** A

Another **AND** gate is also required to reset the counter on a cycle of six.

Two-input OR gates are obtainable in packs of four (IC number 4071) and also two-input AND gates in packs of four (IC number 4081). Only two gates from each of these IC's are required. Instead of using a separate IC containing NOT gates for the Q output, the inversion can be achieved by using the opposite polarity transistor on the driver board (very cunning).



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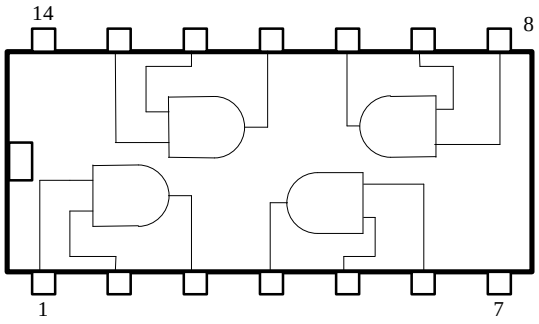

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The circuit diagram has two parts and has been made into two printed circuit boards as follows: -

Logic board and oscillator which produces the signals, circuit diagram figure 1.

LED or display board with a driver transistor for each of the four circuits, circuit diagram figure 2.

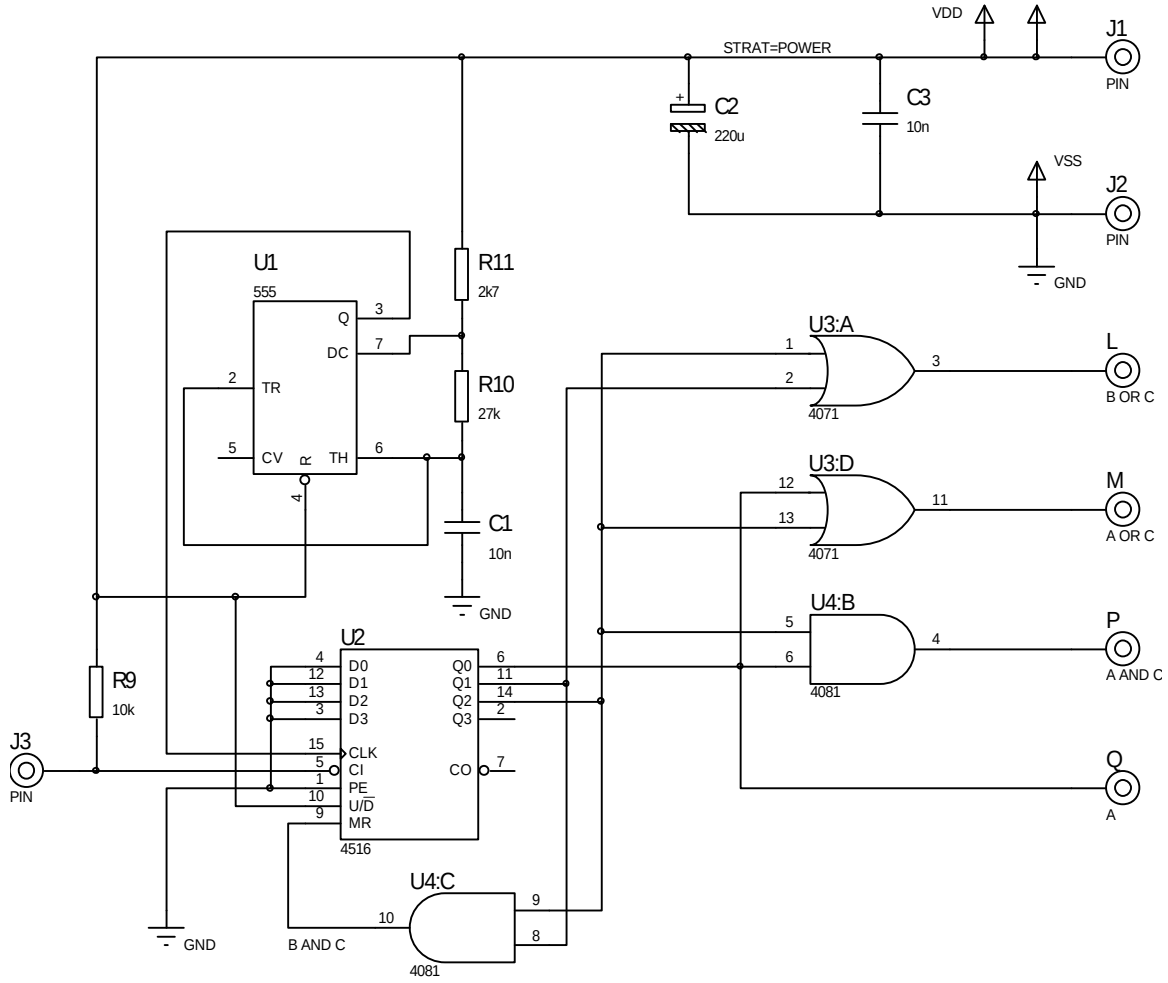


Fig. 1 - Logic and oscillator board

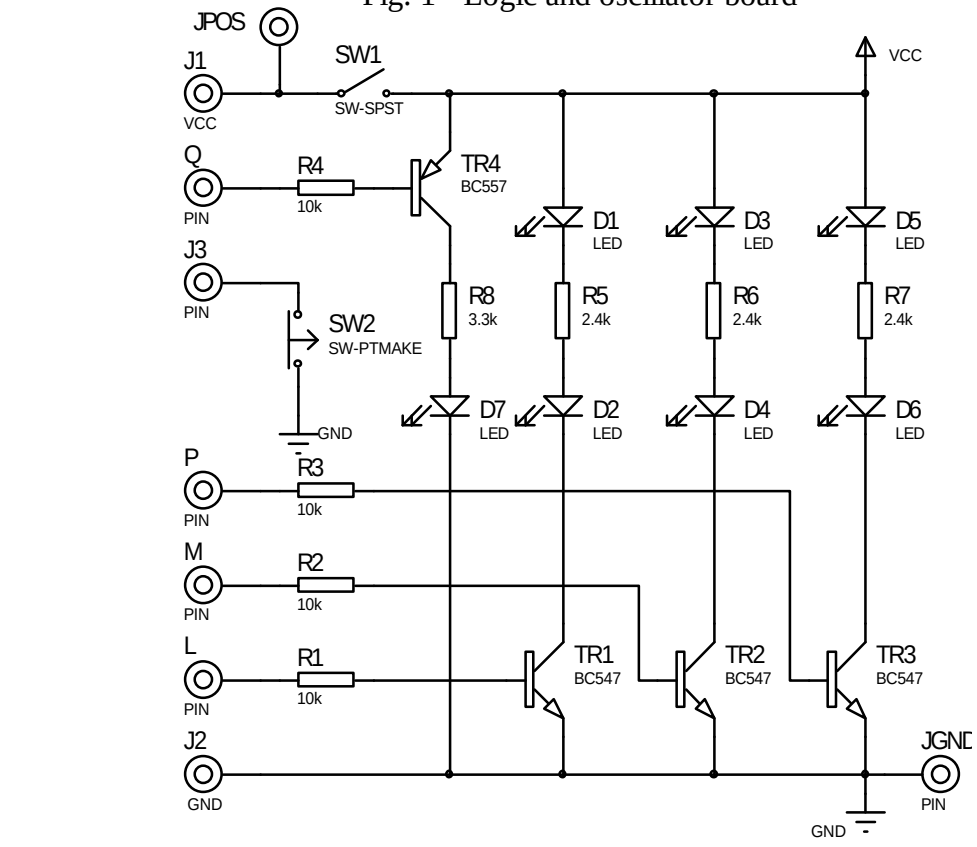


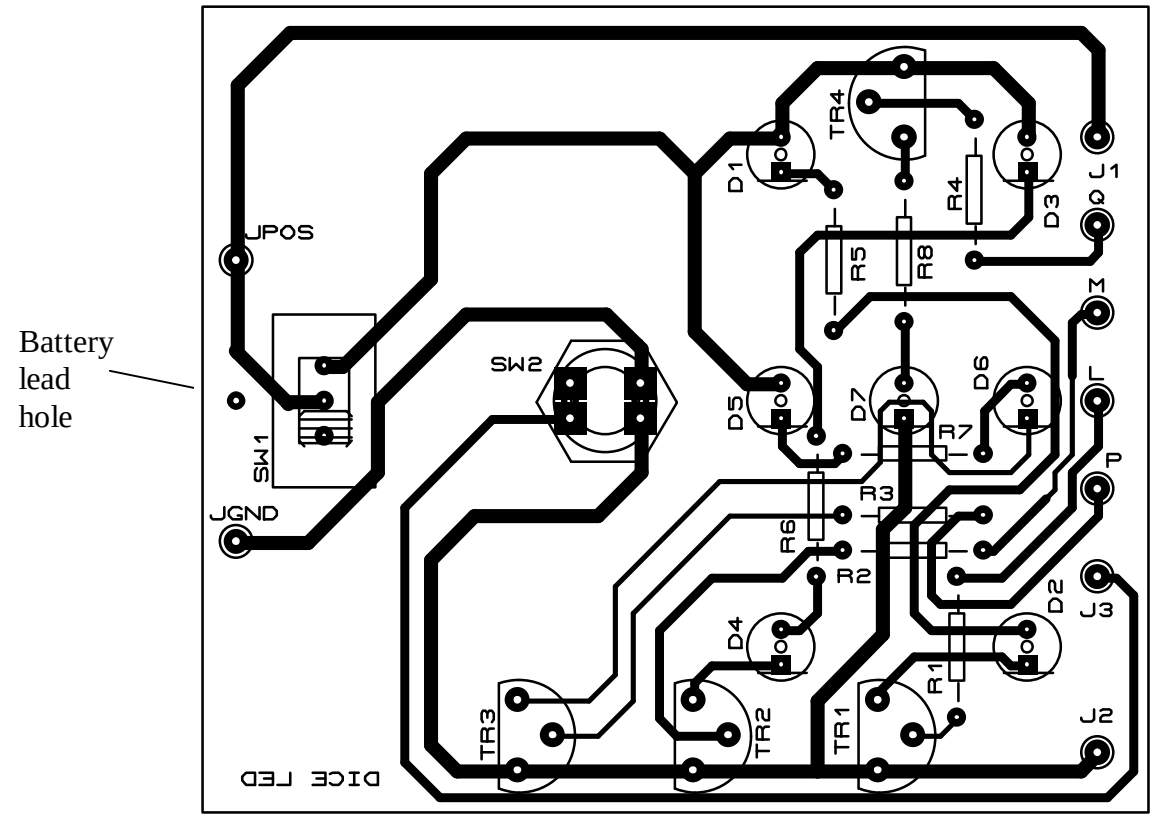
Fig 2 – Display or LED board

The Case Front Panel

Fit the metal template inside the lid to align it and clamp to **old workbench.** Using a 3mm bit, drill through all of the ten holes.
Remove the metal template and enlarge the SW2 switch-mounting hole to 5mm and then 7mm.
Use the deburring tool to remove the burrs from all the holes.
The two holes for the ON/OFF slide switch will need to be formed into a slot, this is best done once the **'display'** pcb has been assembled, so exact position can be seen. This front panel needs to be finished prior to soldering the LEDs.

The LED or Display Board

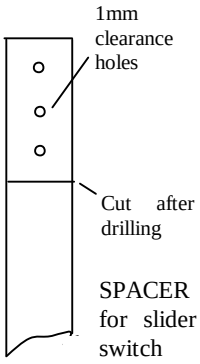
The pcb is provided and needs drilling with 0.8mm holes for the components and 1mm holes for the push switch (SW2), labelled 'J' and L, M, P and Q holes. A strain release hole is required for the battery lead and is initially drilled 1mm and enlarged to 2.5mm clearance hole using the hand drill. The diagram below shows the copper track and positions of the components. See appendix on page 8 'Printed Circuit Board'.



During assembly: -

Form the six holes for the push switch into two slots using screwdriver and scalpel. Do not twist the scalpel blade as it will break and could be dangerous. Fit the lowest profile components first, i.e. resistors, so they rest on the mat while being soldered.

Before fitting resistors check their value using the multimeter.



Note: Fit the LEDs last of all and only solder when pushed into case front.

Bend the transistor legs so that the transistor's base is within 4 - 6mm of the board and note the correct orientation of them in the above diagram.
Make sure that the three npn transistors and pnp transistor go in their respective places.

The slider switch requires a spacer to raise it higher. A piece of pcb is suitable, drill and cut.

The push switch should only be **lightly soldered** as too much heat could damage it. Its body needs to be fitted against the board.
Make sure that the long leg (anode) of the LEDs goes to the round copper pad and therefore the short leg goes to the square pad. **DO NOT SOLDER LEDs YET!** Assemble the board to the case front using only the nut of the push switch. Push the LEDs into the case front so they each protrude to a similar height. Check the board is parallel to the case front and then solder the LEDs in. Remove front panel before testing.

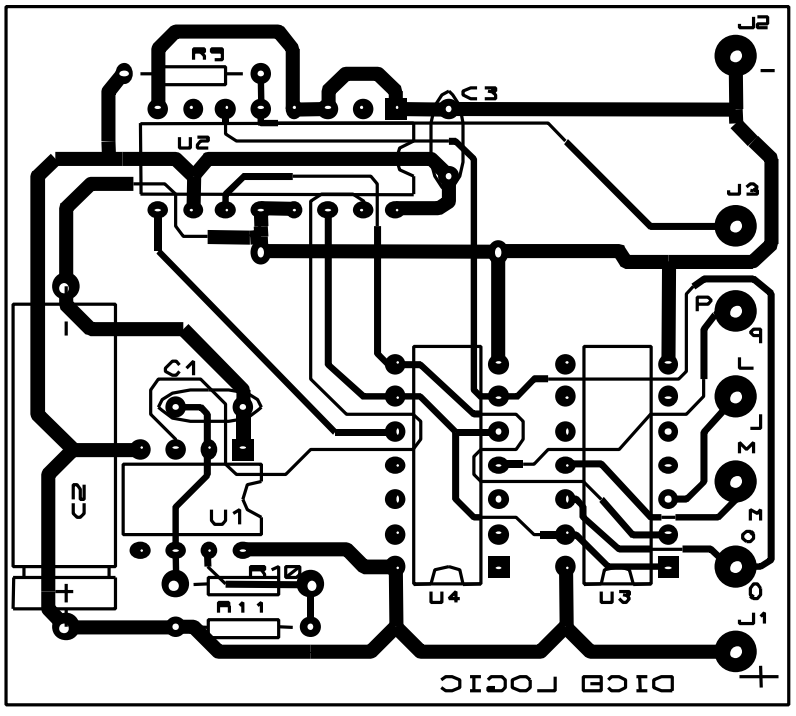
Testing the LED board

To test the board, solder on red and green power-supply wires, plus four signal wires (LMPQ) and J3 trigger wire. Use 50mm of each colour wire. All these wires should be stranded wires, type 7/0.2, rather than single core, as they will stand more flexing before they break. The wire ends should be stripped, twisted, tinned and be, say 4mm in length and then soldered to board.

Connect the red and black wires to a 6V-power supply. The three npn transistor's input pins P, M and L require a logic '1', i.e. connection to +6V, to light their respective LEDs. The pnp transistor input pin Q (central LED), requires connection to logic '0', i.e. the green power supply wire. Why is one different? No - it is not because there is only one LED - see theory above.

The Logic Board

The pcb requires drilling, component holes, 0.8mm and wire holes 1mm. Fit link and resistors first.

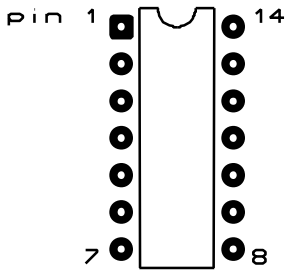


Green wire

Red wire

The four IC's will require mounting on DIL sockets. These DIL sockets are soldered into the pcb first and must be orientated correctly. These pins **should not** be trimmed once soldered. Please note the following diagram: -

Pin 1 of the DIL socket is soldered to the square pad of the PCB for correct orientation



The only other component which is polarised (that means it must be fitted the correct way around, is C_2, the electrolytic capacitor). On the capacitor, the negative pin is labelled and the positive pin is shown on the drawing so make sure the negative pin goes to the negative hole.

Testing the logic board

When all the components have been soldered in and **before the IC's are fitted** the panel should be tested. Connect +9V to positive end of C_2 and the ground to negative end of C_2. Using the multimeter check that +9V and GND are present on the correct DIL sockets. Use the layout diagram to check this out.

Disconnect the 9V power leads and carefully insert the IC's in their correct sockets, correctly orientated. You may need to roll them lightly on the bench to bend the legs inwards slightly. Re-connect the power leads.

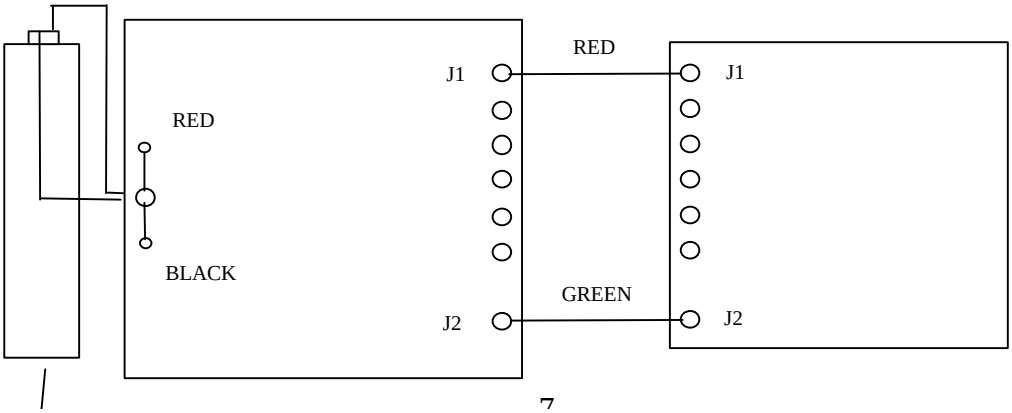
The 555, integrated circuit U1, should oscillate continuously. Connect an oscilloscope between pin 3 and ground to check this.

The counter, integrated circuit U2, should 'run' when the push switch is pressed. Connect the scope to each output, pins 6, 11, and 14 in turn to see if the lines are bouncing up and down.

Assembly and Testing

Solder the wires from the LED pcb to the logic pcb. Turn the Logic pcb around to align the pins correctly, as shown in the diagram below.

Connect up the battery lead as shown in the following diagram: -

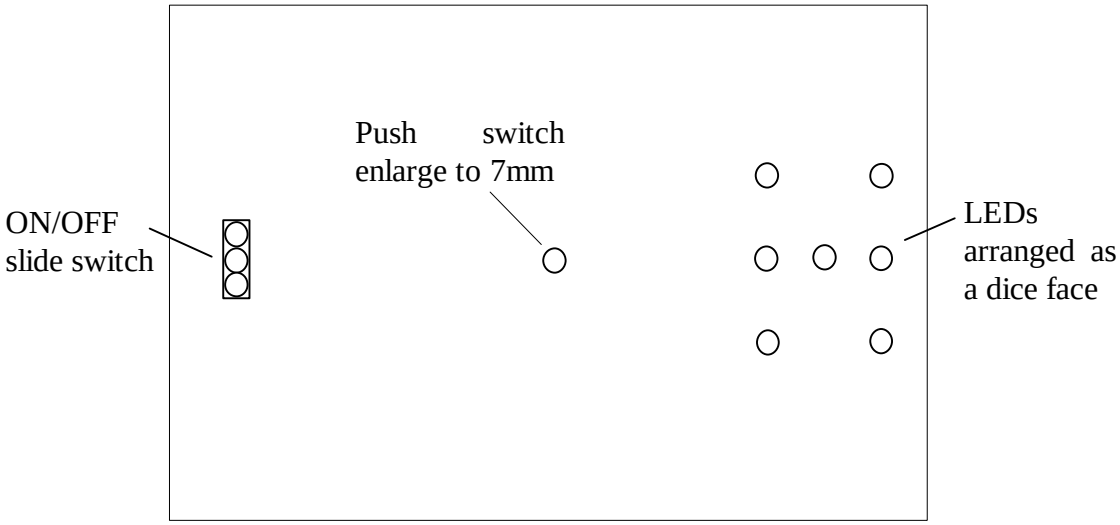


The final test is to make say 100 throws to see if the die throws random numbers. If it throws only a few numbers then the die could be referred to as a 'loaded die' and would require fault finding.

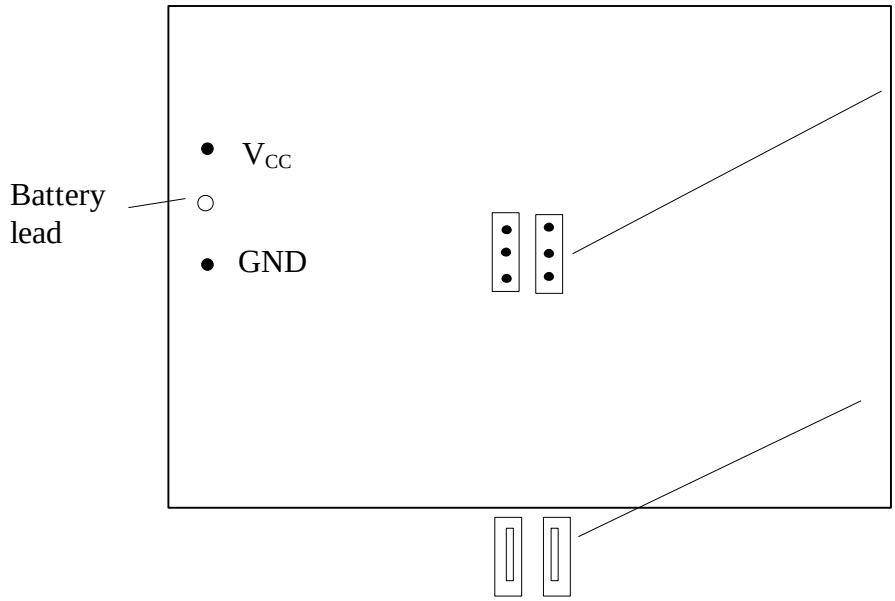
If all seems OK, the two boards need to be fitted together, using a piece of polystyrene between them to prevent short circuits between the boards.

Fit front panel and pad case so assembly is supported from the base of the case and the battery is supported.

Appendix



Front Panel



Use centre punch to make indentation for central hole and drill six holes in trigger switch pads and form into two slots using a screwdriver pushed from copper side first. The slot may be widened by rocking the screwdriver from side to side from the component side of board.

Printed Circuit Board

DICE - POSSIBLE FAULTS

Gap in track due to faulty layout; e.g. track stops short of pad

Hairline break in track (processing fault)

Break in track caused by badly drilled hole

Incorrect or missing tracks (faulty layout)

Tracks touching due to faulty layout

POOR SOLDERING

Wrong resistor values

IC incorrectly fitted

LMPQ wires incorrectly connected

Power supply wires to boards soldered incorrectly

SOME FAULT FINDING TIPS

The LED or display board should have been tested after assembly. If not, do it now. Connect L, M, and P to the battery positive. The appropriate pair of LEDs should light. Connect Q to battery negative to light the middle LED.

Also, make sure that the single LED in the middle has a different current-limiting resistor, R_8, 330Ω. The values are chosen so that all LEDs light equally brightly.

If no LEDs light, check the power supply wires.

If you can only get one pattern on the display, use an oscilloscope to check the output (pin 3) of the 555 IC. There should be a square wave at pin 3 at all times.

This signal passes to pin 15 of the counter IC 4516.

Press the push switch and look for uneven square waves on the outputs of the 4516 - pins 6, 11 and 14.

If you are getting some patterns on the LEDs, but the dice appears biased or produces wrong patterns: -

Check the LMPQ connections
Check that the logic gates are switching correctly
Slow the 555 down by soldering a 22uF capacitor between pins 1 and 2 (pin 1 negative) hold down the push switch, and the LEDs should cycle slowly through the patterns 1 to 6.
Check for soldering or tracking faults on the ICs 4071 and 4081.

Stocklist for die

Led board		**Supplier Rapid**	**Cost**
R1 - 4	10k		0.04
R5 - 7	2.4k		0.03
R8	3.3k		0.01
D1 - 7	3mm green led, low current, pitch 2.5mm	56-0405	0.35
TR1 - 3	BC547B	81-0064	0.09
TR4	BC557B	81-0070	0.03
Switch	Slider type spdt	76-0200	0.39
Switch	Push-to-make, red button	78-0100	0.10
PCB	Composite type 2.5”x2.3”	UoP	0.68
Logic board			
R9	10k		0.01
R10	27k		0.01
R11	2.7k		0.01
C1, C3	10nF disc 50V pitch 5mm	08-0230	0.28
C2	220uF x 16V axial pitch 0.5”	11-0020	0.16
U1	555 timer IC	NE555	0.14
U2	4516B Cmos IC binary up-down counter	83-0444	0.36
U3	4071B Cmos IC quad 2-input OR gate	83-0402	0.17
U4	4081B Cmos IC quad 2-input AND gate	83-0414	0.17
DIL Skt	DIL8	22-0150	0.03
DIL Skt x2	DIL14	22-0155	0.06
DIL Skt	DIL16	22-0160	0.03
PCB	Composite 2.2”x2.3”	UoP	0.46
Miscellaneous			
Battery	PP3 9V	18-1020	0.36
Battery Clip	PP3 battery clip	18-0105	0.06
Case	Black 100x75x40mm	30-0505	0.76
		Total	£4.79