National Lottery PREDICTOR

XZ46A
Issue 1

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Since the introduction of the National Lottery back in November 1995, a small number of people have become very rich. The rest of us, however, must have realised by now what odds of '14 million-to-1 against' actually mean. So, can anything be done to improve ones chances of winning?

FEATURES

- Ideal beginners project
- Generates random numbers
- Simple to use - one switch operation
- Automatic switch off saves batteries
- Full source code available

APPLICATIONS

- Use to choose your lottery numbers!
- Excellent introduction to microcontrollers
- Produce random numbers for games

The idea of accurately modelling the machine used by the lottery organisers is simply out of the question. The behaviour of a single ball, bouncing around inside a Perspex sphere, would be practically impossible to predict. The paths of forty nine balls, all colliding with each other, can be considered utterly random. Would it be possible, then, to predict the next draw from analysis of previous draws? The mathematics of chance say not! The likelihood of any particular combination of numbers being drawn is precisely the same as all other combinations, and is not influenced in any way by previous events.

Although it isn't possible to increase the chances of winning, it is possible to increase your share of the prize, if your numbers come up. The idea is to avoid combinations that other people are likely to select.

Choosing numbers in any other way than completely at random, will inevitably be affected by various psychological factors. Winning combinations, for example, that consist of four or more numbers greater than 31, will completely eliminate anyone who used birth dates to make their selection!

A random number generator is therefore essential, and if nothing else, it gives the electronics enthusiast a good excuse to get started on an interesting new gadget! The unit presented here, generates numbers between 1 and 49 in a random sequence, and displays them on a two digit, 7-segment LED display. A single push-switch is used to turn the unit on, display all the numbers, and reset the device ready for a new number combination.

Circuit description

The complete circuit of the National Lottery Predictor is shown in Figure 1. IC1, a PIC16C54 microcontroller, is driven by a very simple clock circuit consisting of just one resistor and one capacitor, R3 and C2. The frequency of oscillation is about 800kHz using the values shown. The components R1, C1 and R2 generate the reset, and wake-up-from-sleep pulses.

There are two input/output (I/O) ports, one 8-bit and the other 4-bit. The 8-bit port, port B, is connected to the eight segments (seven plus decimal point) of both digits of the dual display, via resistors R6 to R13. Port A, the 4-bit port, is divided into one input bit and three output bits.

Outputs A1 (pin 18) and A0 (pin 17) are connected to the bases of PNP transistors, TR1 and TR2, via resistors R4 and R5 respectively. The display is a common anode type, which means that current must be sourced through the common anode connection, and sunk via each segment (cathode) connection.

The push-switch, S1, is read by the microcontroller by first taking output A2 (pin 1) low. Then, input A3 (pin 2) is read, after which A2 is taken high again. In this way, capacitor C1 is not discharged when the push-switch status is read at the same time as it is pressed, because output A2, does not go low for long enough.

When the microcontroller is in sleep mode, however, output A2 is left permanently low. Now, when the push-switch is pressed, C1 discharges through resistor R1 and the microcontroller is reset, which wakes it up.

Much of the circuit design, in particular the clock, reset and wake-up circuitry, is taken straight from the Microchip data book and applications book.

Software design

The program performs several distinct functions, each of which is described below and can be related to Figure 2.

Display Multiplexing

Every time the software loop is executed, only one digit is displayed, both digits taking turns. The digit whose turn it is to be displayed, is identified by testing one bit in a register. The appropriate data is then taken from either of two digit registers, and the appropriate transistor turned on by lowering either bit 0 or bit 1 of port A. As long as the software loop keeps running at a fast enough rate, both display digits appear to light continuously.

Random Number Generation

The random number variable is incremented each time the loop is executed, unless it exceeds 49, whereupon it is set back to one. When the push-switch is pressed, the current value of this variable is used as the random number. A reduced version of the software flowchart appears in Figure 3 which clarifies the method of random number generation.

The random behaviour results from the delay between presses of the push-switch. The person

SPECIFICATION

Voltage	3.0 to 5.0V DC
Current	36.5mA (max.) 25mA (ave.) @ 3.6V DC
Standby current	14µA (max.) 5µA (typ.) @ 3.6V DC
Battery life	More than 2 years with normal use (Duracell batteries)

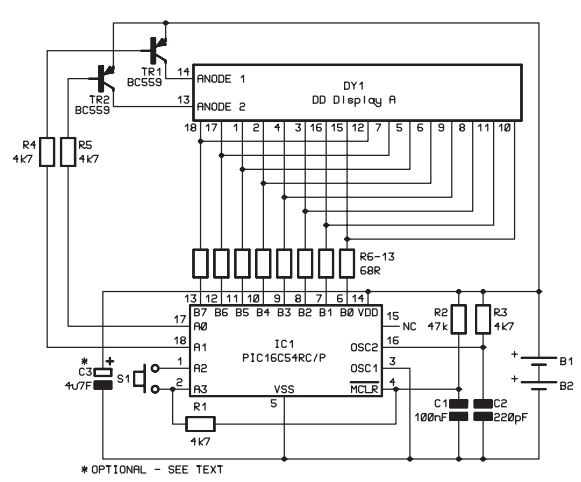


Figure 1. Circuit diagram of the National Lottery Predictor.

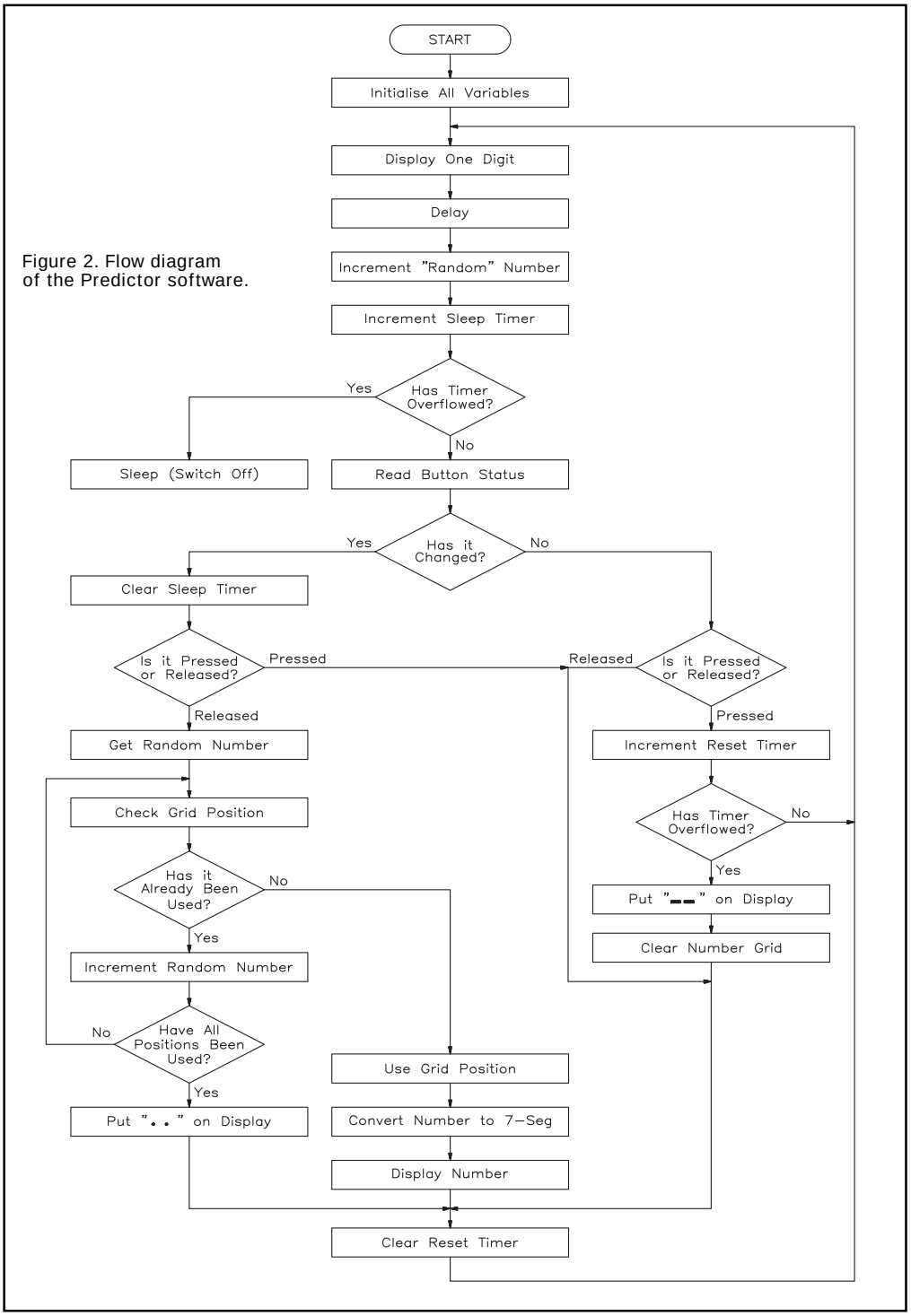


Figure 2. Flow diagram of the Predictor software.

operating the unit cannot see the value of the counter, so the random numbers cannot be influenced directly, although deliberate, rhythmic button pushing can result in sequences of similar numbers.

Binary-to-Decimal Conversion

When the random number has been generated, it is converted into two decimal digits by repeatedly subtracting 10 from the number until it underflows (goes negative).

Each time the subtraction is carried out, another register is incremented, indicating the number of times 10 has been subtracted. This number becomes the ten digit.When the number does underflow, ten is added back restoring the remainder, which becomes the data for the units digit.

Digit Character Generation

Character data for the 7-segment display is taken from a table, indexed by the decimal number to be displayed. The table contains ten items corresponding to the digits 0 to 9.

The table is read twice, once for the tens digit and again for the units digit.
Leading zero suppression is achieved by replacing the tens digit with a blank character whenever it is zero.

Forty-nine bits of RAM hold the data indicating whether a number has already been used. When a number is displayed, the corresponding bit is set. If the unit attempts to use that number again, it must move on to the next available unused number. Two variables are used to address the grid. See Figure 4.

A pointer is used to index one of the seven bytes in the grid, and a mask selects one bit out of the eight in each byte. Each time the random number is incremented, the mask bit is rotated into the next highest significant bit position. If the bit is rotated out of bit seven, it is put back into bit zero and the pointer is incremented. This pair of variables operate like an octal (base-8) counter.

Push-switch Reading and De-Bounce

The push-switch has to be read in a special way so that it can also be used to bring the microcontroller out of sleep mode. One side of the switch is connected to an input which is pulled high. The other side is connected to an output, see Figure 1.

If the output is high, pressing the switch has no effect. When the push-switch is to be read, the output is briefly taken low, but only long enough for the read function. This prevents the microcontroller being reset, even if the push-switch is held down.When the microcontroller is in sleep mode, however, the output is left at a low level. Pressing the push-switch then causes the capacitor C1 to discharge.

De-bounce is achieved by reading the push-switch input at intervals of no less than about two milliseconds. This allows time for the bounce signals to stabilise between one read and the next.

Auto-Sleep Timing

A 16-bit counter increments continuously while the push-switch remains inactive. When the counter eventually overflows, after about 15 seconds, the I/O pins are all put into a condition which uses least power, after which the controller goes to sleep.When the PIC microcontroller is woken up, the program is executed from the beginning.

Clearing the Grid

All bits in the number grid must be cleared or set to zero when the push-switch is held for a couple of seconds.

The file select register (FSR) is initially set to register 16 (hexadecimal 10). This is the first register in the number grid. A general purpose counter (gp_counter) is then given the value 7, as there are seven registers in the grid that need to be cleared. The indexed grid register is then cleared indirectly using the FSR as a pointer.

The counter is then decremented and tested for a zero value. If the counter is not yet zero, the FSR is incremented ready for the next grid register to be cleared. When all seven registers have been cleared, a dash symbol is put onto both digits of the display.

Construction

Because the microcontroller integrates all the essential elements of a computer system into one tiny chip, the design of the printed circuit board (PCB) layout is made very simple. The PCB legend is found in Figure 5.

All the components mount directly on the small, single sided PCB, including the double-digit display and the push-switch. Remember, there is no on/off switch.

Construction of the PCB is very straightforward. Start by fitting all the resistors that lay flat to the board but save two of the cut-off legs to make the wire links. Next fit the two wire links and then the two capacitors, C1 and C2.

C3 (not provided in the kit) is used to decouple the supply rails and will be needed if a DC power supply is used for testing.

Fit the remaining resistors R6 to R13 noting that they are all the same value. These are mounted on end as shown in Figure 8.

The PIC chip should be fitted next. This is soldered directly into the board so double check that it is fitted the correct way round, see Figure 8 and component legend. Do not uses an IC socket as this will make the PIC too high to fit into the case.

CAUTION – Wait a few seconds between soldering each pin of the PIC. This will stop the chip being damaged by overheating.

Fit the display with the decimal points toward the PIC chip and then solder switch S1 in place.

Turn the PCB component side down and fit each of the battery clips to the solder side. The pads and the battery clips are quite large and so require a substantial amount of heat. They should be soldered with a high, 25 Watt plus, soldering iron.

Apply a small amount of solder to the tip of the iron and then press it firmly to the bottom of the battery clip where it contacts the board. Wait a few seconds and then try applying solder to the outside edge of the clip at the point where it meets the PCB pad. The solder should melt and be drawn under the clip giving a secure bond to the PCB. If the solder will not melt after 10 seconds then a larger soldering iron is required.

When all the clips are soldered in place and have cooled enough to touch, place a length of the heatshrink sleeving over the positive, +, terminals. Shrink the sleeving tightly over the terminals.

This is normally done with a hot-air gun but you can use a (very hot) hairdryer instead. If neither of these is available use a soldering iron held close but not touching the sleeving. As a final resort a match or gas-lighter flame held close will do the job but be careful not to burn the board or components.

Trim the stand-offs as shown in Figure 8 and fit these from the component side of the board. The PCB is now complete and ready for testing.

Carefully check all components are the correct type and value and fitted the right way round. Check all solder joints for poor workmanship as per the constructor guide. Look out for any solder bridging joints and tracks.

Finally fit the two AAA batteries, observing the polarity. The correct orientation is labelled on the solder side of the PCB and shown in Figure 8.

Fit C3 (not supplied) if testing is going to be carried out with a DC power supply.

Figure 3. Reduced flowchart clearly showing the random number generation.

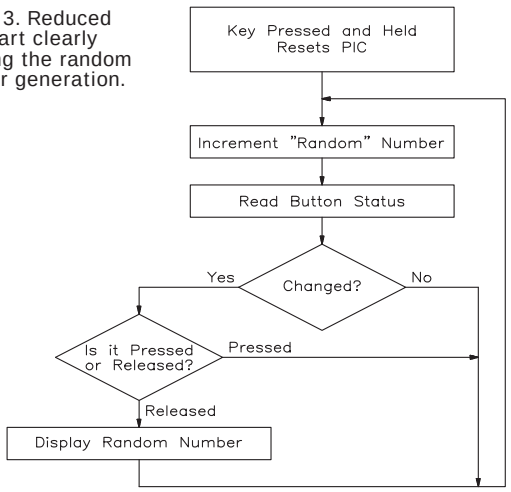
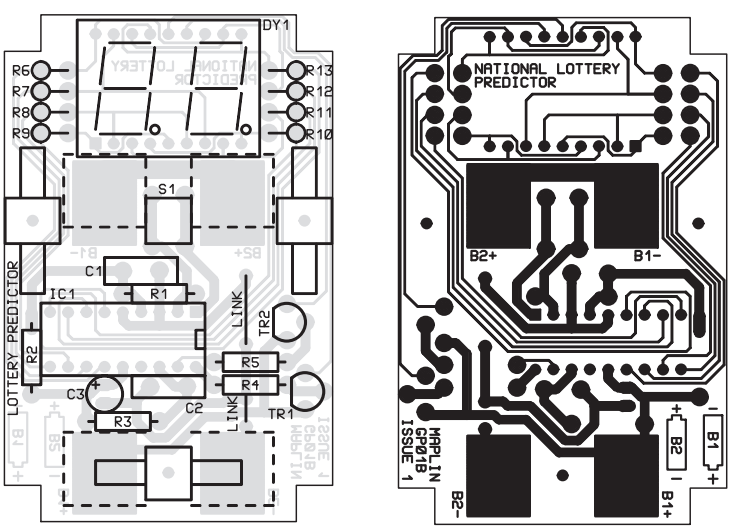


Figure 4. Storing the 49 numbers in 7 data bytes.

Reg No. (Hex)	Bit Position 0	1	2	3	4	5	6	7
10	1	2	3	4	5	6	7	8
11	9	10	11	12	13	14	15	16
12	17	18	19	20	21	22	23	24
13	25	26	27	28	29	30	31	32
14	33	34	35	36	37	38	39	40
15	41	42	43	44	45	46	47	48
16	49							

Figure 5. Track layout and component overlay for the National Lottery Predictor.



Operation

Inserting the batteries switches the National Lottery Predictor on. The display initially shows '- -', indicating that it is reset and ready to start a new number sequence. Pressing the switch again displays the first random number. Subsequent presses generate further numbers until all 49 numbers have been displayed. With no more numbers available the display shows '• •', although normally, only the first six numbers will be required.

At any time, the push-switch may be held down for a couple of seconds which will clear the grid ready for a new set of numbers. If the unit is left for more than about 15 seconds without the push-switch being pressed, the National Lottery Predictor goes into sleep mode, effectively switching itself off. All these functions are achieved using just one switch!

Pressing the push-switch while the National Lottery Predictor is in sleep mode will switch it back on. Operation is then the same as above from the point where the batteries were inserted.

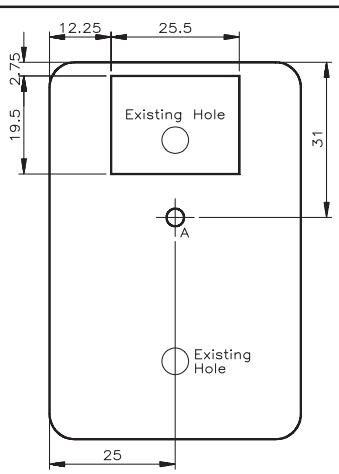
On the case

The case used to house the National Lottery Predictor requires 1 cut-out and 1 drill hole in the front panel (actually the base). The provided case holes are not used although one of them makes a good starting place for the display cut-out. The dimensions of the cut-out are detailed in Figure 7. The panel label covers the cut-out and fits quite snugly around the display. This should help hide any ragged edges or accidental scratches! Remove all burrs from the cut-out as these will lift the label and spoil the finish.

Before fitting the panel label, clean

Figure 6. The front panel label.

Figure 7. Case dimensions, drilling and cutting details. The front panel label is used as a template for the switch hole.



Hole Data		
Ref	Size	No.
A	ø3.5	1

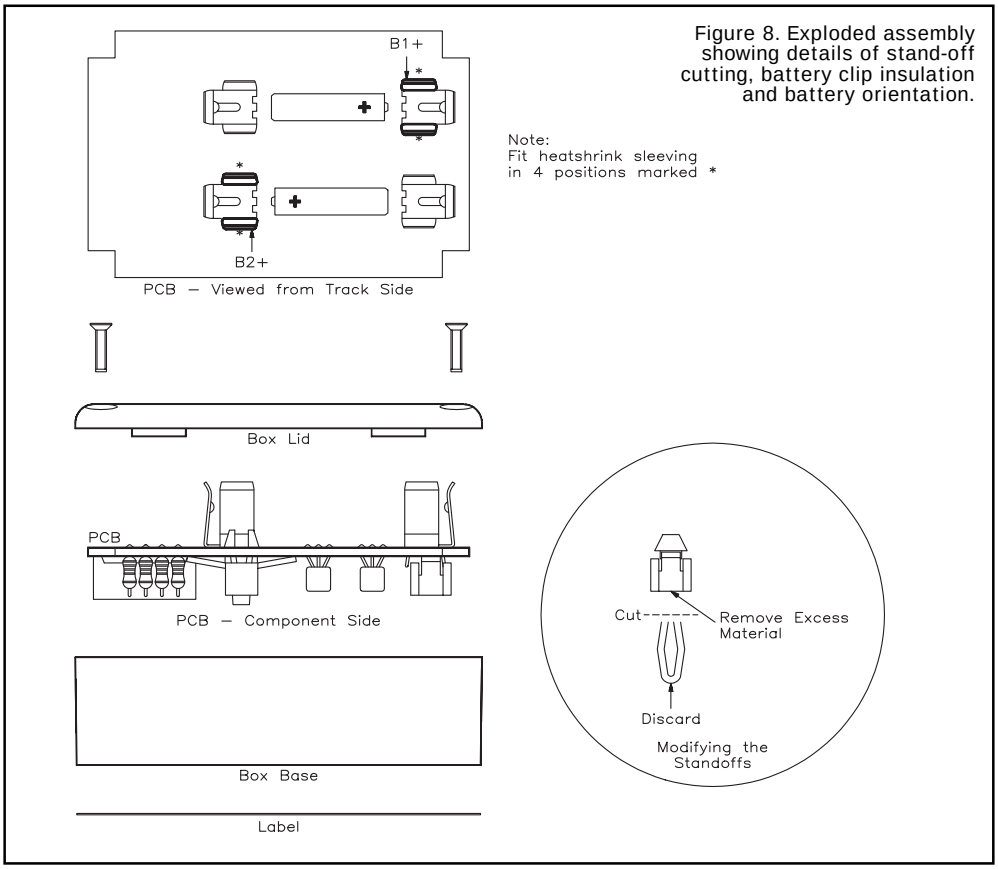
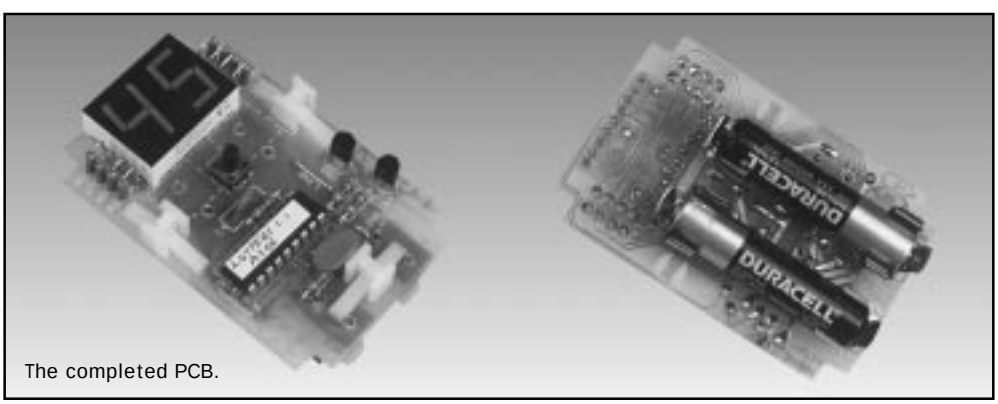


Figure 8. Exploded assembly showing details of stand-off cutting, battery clip insulation and battery orientation.



The completed PCB.

the mounting surface of the case thoroughly to remove any grease or oil. Again ensure that there are no raised surfaces from burrs, scratches etc.

Peel back 1 inch of the protective film from the top of the panel label. Carefully position each top corner without allowing too much of the label to make contact with the case. Once stuck, removal is difficult and may damage the label. If the worst happens then a replacement label, NV71N, can be purchased. Smooth the label down gently onto the case using even pressure and working from the middle to the edges. Gradually peel back more of the protective film, pressing down as you go. This process should prevent air bubbles and give good adhesion.

When all of the label is in place, drill the hole for the switch. The hole position is marked on the label and the drilling must be done from the label side. This prevents damage to the label as the drill comes through the case but doesn't prevent damage if the drill slips (be careful).

The PCB is mounted on three stand-offs which set it at the correct height. Before fixing, remove the top of these and file them flat as shown in Figure. 8. The assembled PCB, with stand-offs, should drop neatly into the case with the display fitting almost flush to the label window. The switch knob should protrude far enough through the case to allow unrestricted operation. If the switch is difficult to operate, or cannot be operated, then remove the PCB and file a little more off the top of the stand-offs.

Finally, fit the box cover and fasten with the four self-tapping screws. The National Lottery Predictor is now ready to help choose that winning combination!

Disclaimer

Winners of large sums of money, who choose their numbers with the Predictor, are advised that Maplin cannot be responsible for future misery. Nor can Maplin be held responsible for the unfortunates who never win!

Acknowledgement

Design originally published in Everyday Practical Electronics magazine.

PROJECT PARTS LIST

RESISTORS: All 0·6W 1% Metal Film (Unless specified)			
R1,3,4,5	4k7	4	M4K7
R2	47k	1	M47K
R6-13	68Ω	8	M68R
CAPACITORS			
C1	100nF Ceramic	1	YR75S
C2	220pF Ceramic	1	WX60Q
SEMICONDUCTORS			
IC1	Lottery Predictor PIC	1	NV72P
TR1,2	BC559	2	QQ18U
DY1	Double, 7 segment LED Display	1	BY66W
MISCELLANEOUS			
S1	Click Switch	1	KR91Y
	PCB Battery Clip AAA/N	4	GU65V
	Stand-off	3	JK44X
	Box 321	1	FK73Q
	Heat Shrink CP 48★	1m	BF89W
	Lottery Predictor PCB	1	GP01B
	Lottery Predictor Label	1	NV71N
	Lottery Predictor Leaflet	1	XZ46A
	Constructors Guide	1	XH79L
OPTIONAL ITEMS (Not in Kit)			
C3	10uF 63V Radial Electrolytic	1	AT77J
B1, B2	Duracell AAA	2	JY50E

Fully commented source code for the National Lottery Predictor is available from the Maplin web site at **http://www.maplin.co.uk**

The Maplin 'Get-You-Working' service is available for this project,see Constructors' Guide or current Maplin Catalogue for details.

The above items (excluding optional) are available as a kit.

Order as LU61R (National Lottery Predictor Kit)
GP01B PCB

Please note: Items in the Parts List marked with a ★ are supplied in 'package' quantities (e.g., packet strip, reel etc.), see current Maplin Catalogue for full ordering information.

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