



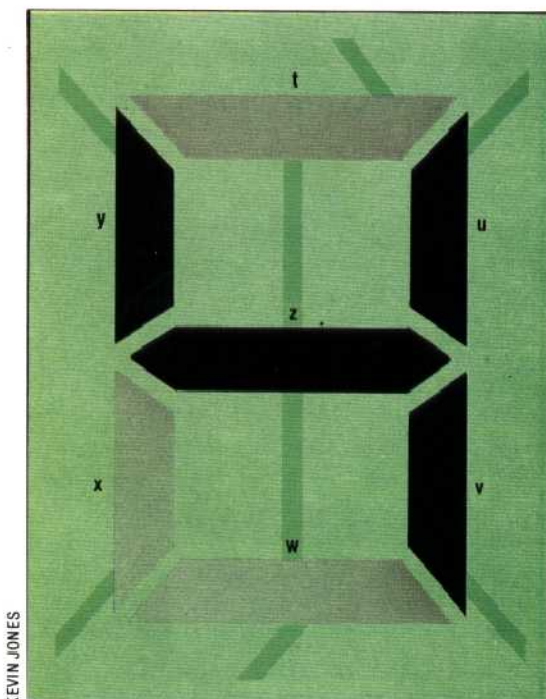
# YOUR NUMBER'S UP

Seven-segment displays are used on calculators, watches and some portable computers to represent decimal digits. In this instalment of the logic course, we design a 'binary to seven-segment display converter' — a circuit that will convert the binary signals used by computers into the decimal digits that humans normally use.

In our circuit design we shall assume that the binary representations of decimal numbers are in a code known as binary coded decimal, or BCD. That is, each decimal digit is stored as a group of four binary digits, as shown in the table.

Binary Coded Decimal	Decimal
0000	0
0001	1
0010	2
0011	3
0100	4
0101	5
0110	6
0111	7
1000	8
1001	9
1010 to 1111	unused

The LCD display comprises seven individually switchable bars, here labelled 't' to 'z'



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A seven-segment display represents decimal numbers by illuminating certain light-emitting diodes, in the case of an LED display, or by changing the polarity of certain bars (LCDs) in a liquid crystal display. The illustration shows how we have chosen to name the seven segments (the top bar is termed 't', the lower bar 'w', and so on). We also give the various combinations of bars required to form the digits 0 to 9.

This is all the information that we require to assemble a truth table for our converter. We can tell from the illustration on the opposite page what bars need to be activated when the circuit receives each individual input. For example, if the binary input is 0100 (decimal 4), the circuit will activate the bars labelled u, v, y and z. Similarly, the input 1000 (decimal 8) will cause all of the bars to be illuminated. The truth table for the circuit will be:

Decimal	Inputs				Outputs						
	A	B	C	D	t	u	v	w	x	y	z
0	0	0	0	0	1	1	1	1	1	1	0
1	0	0	0	1	0	1	1	0	0	0	0
2	0	0	1	0	1	1	0	1	1	0	1
3	0	0	1	1	1	1	1	1	0	0	1
4	0	1	0	0	0	1	1	0	0	1	1
5	0	1	0	1	1	0	1	1	0	1	1
6	0	1	1	0	1	0	1	1	1	1	1
7	0	1	1	1	1	1	1	0	0	0	0
8	1	0	0	0	1	1	1	1	1	1	1
9	1	0	0	1	1	1	1	1	0	1	1
	1	0	1	0	X	X	X	X	X	X	X
	1	0	1	1	X	X	X	X	X	X	X
	1	1	0	0	X	X	X	X	X	X	X
	1	1	0	1	X	X	X	X	X	X	X
	1	1	1	0	X	X	X	X	X	X	X
	1	1	1	1	X	X	X	X	X	X	X

Unfortunately there is no easy way to analyse this truth table, and consequently each output — t, u, v, w, x, y and z — must be simplified separately. We can construct a Karnaugh map for each output, placing on each map the 'don't care' (X) conditions. These may aid simplification in some cases. The seven k-maps, one for each line, are given here. By circling groups, we can produce a simplified expression for each output line. Further simplification is possible in some cases by factorisation.

The first k-map, for example, deals with those inputs that will cause the bar 't' to be activated (this bar is used in all but two of the numbers). Having simplified expressions for all the output lines, we can then draw up the final circuit.