2006 Paper 11 Question 2

Digital Electronics

(*a*) An electronic die may be constructed from seven LEDs laid out in the pattern below. The LEDs are to be driven by signals (a,b,c,d).

a		c
b	d	b
c		a

A binary-to-die decoder is described in the left-hand table below with inputs (n2,n1,n0) and outputs (a,b,c,d). X represents *don't care.*

(*i*) What are the minimum sum-of-product equations mapping the inputs to the outputs? [4 marks]

(*ii*) If the inputs to the decoder were to be driven by a three D flip-flop state machine, what are the minimum sum-of-products equations for the next state functions for (n2,n1,n0) to count continuously $1, 2, 3, 4, 5, 6, 1, \ldots$? [6 marks]

(*b*) An alternative implementation is to use a 1-hot state machine plus a different decoder to form a rolling die (see right-hand table below). The states are (h1,h2,h3,h4,h5,h6) and the die output this time is (A,B,C,D).

(*i*) What is the minimal free running 1-hot state machine constructed from D flip-flops? You may assume that the D flip-flops have preset and clear inputs. [3 marks]

(*ii*) What are the minimum sum-of-product equations for mapping the 1-hot states to die outputs? [4 marks]

(*iii*) Is the first implementation in part (*a*) quicker or slower than the one in part (*b*)? [3 marks]

binary to die decoder

input			output			
n2	n1	n0	a	b	c	d
0	0	0	X	X	X	X
0	0	1	0	0	0	1
0	1	0	1	0	0	0
0	1	1	1	0	0	1
1	0	0	1	0	1	0
1	0	1	1	0	1	1
1	1	0	1	1	1	0
1	1	1	X	X	X	X

1-hot to die decoder

input						output			
h6	h5	h4	h3	h2	h1	A	B	C	D
0	0	0	0	0	1	0	0	0	1
0	0	0	0	1	0	1	0	0	0
0	0	0	1	0	0	1	0	0	1
0	0	1	0	0	0	1	0	1	0
0	1	0	0	0	0	1	0	1	1
1	0	0	0	0	0	1	1	1	0