



Solutions for exam IE1205 Digital Design

2022-04-21, 08:00-12:00

Part 1 (10p)

1. (2p)

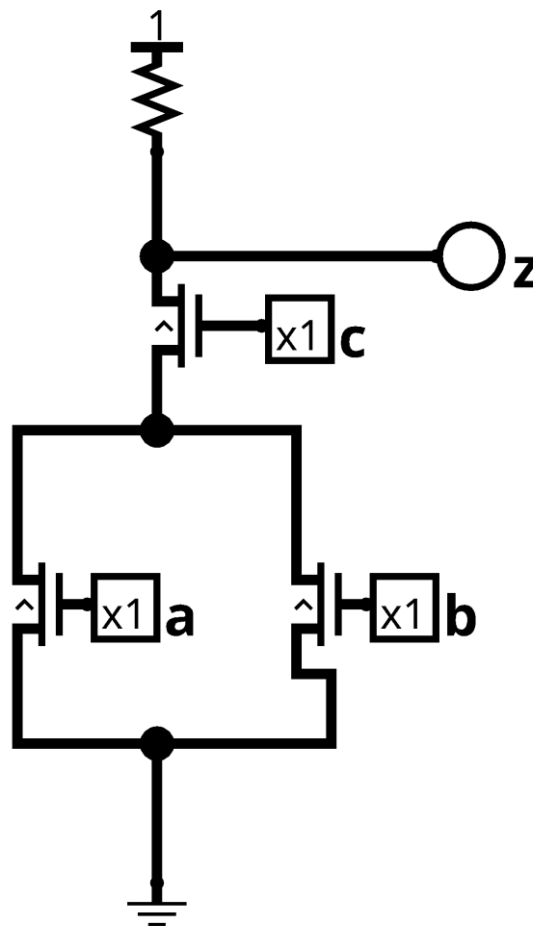
S	M	SD	C	V	KD	L	MP	Seats
1	1	0	1	0	-	-	-	201+
1	1	0	0	0	1	-	-	192+
1	1	0	0	0	0	1	-	190+
1	1	0	0	0	0	0	1	186
1	0	0	1	0	1	1	1	189

2. (2p)

(1) $f_a = 0, f_b = V_{DD}, f_c = V_{DD}, f_d = V_t$

(2) C

3. (2p)



(1) Circuit above, truth table:

a	b	c	z
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0

1	1	0	1
1	1	1	0

(2) D

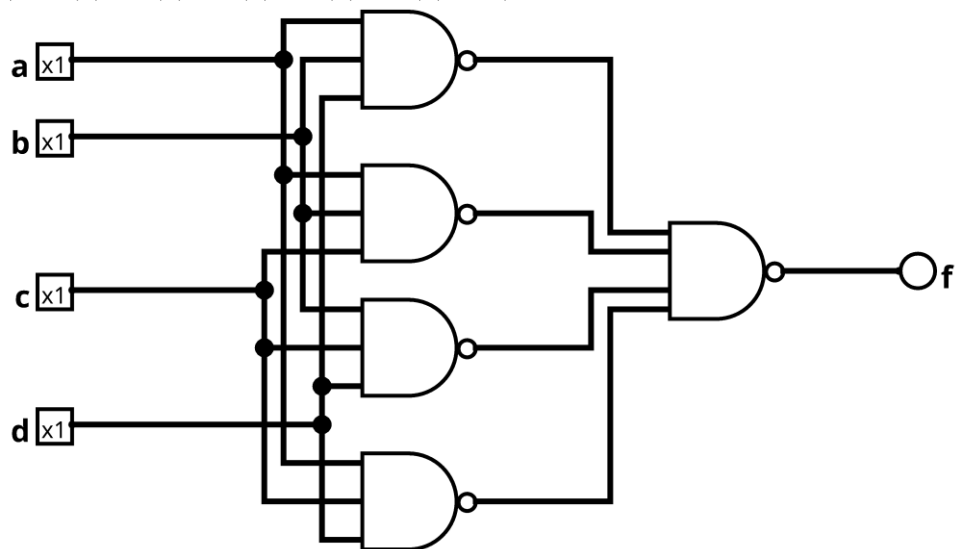
4. (4p)

(1)

a	b	c	d	f
0	0	0	0	0
0	0	0	1	0
0	0	1	0	0
0	0	1	1	0
0	1	0	0	0
0	1	0	1	0
0	1	1	0	0
0	1	1	1	1
1	0	0	0	0
1	0	0	1	0
1	0	1	0	0
1	0	1	1	1
1	1	0	0	0
1	1	0	1	1
1	1	1	0	1
1	1	1	1	1

(2) $bcd + acd + abd + abc$

(3) $(a + b)(a + c)(a + d)(b + c)(b + d)(c + d)$



(4)

Part 2 (14p)

5. (2p)

(1) $-6 = 111010b$

(2) $-0.5625 = 11.0111b$

6. (3p)

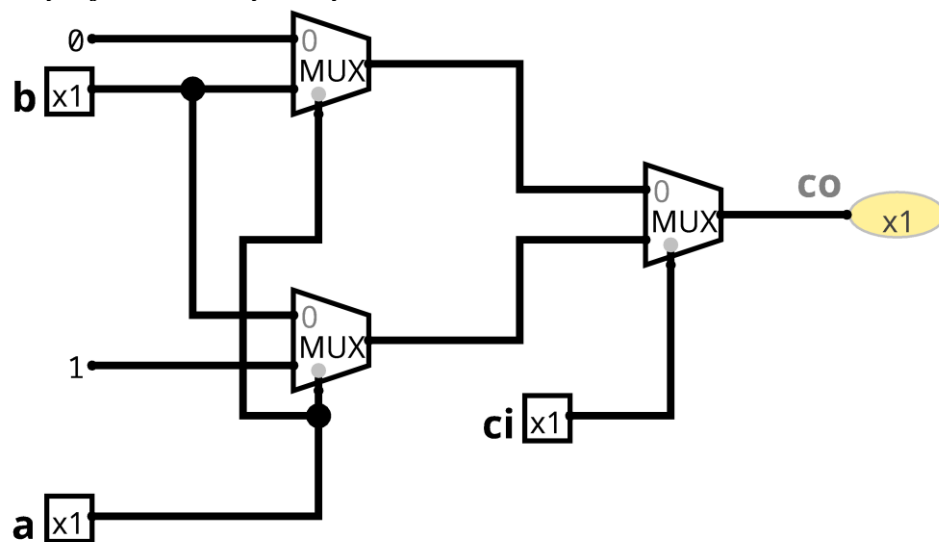
(1)

a1	a0	b1	b0	c	s1	s0
a1	a0	0	0	0	a1	a0
0	0	b1	b0	0	b1	b0
0	1	0	1	0	1	0
1	0	0	1	1	0	0
0	1	1	0	1	0	0
1	0	1	0	1	0	1

(2) $c = a_1(b_1 + b_0) + b_1(a_1 + a_0)$, $s1 = a1*b1'*b0' + b1*a1'*a0' + a0*b0$,
 $s0 = a1'*a0'*b0 + b1'*b0'*a0 + a1*b1$

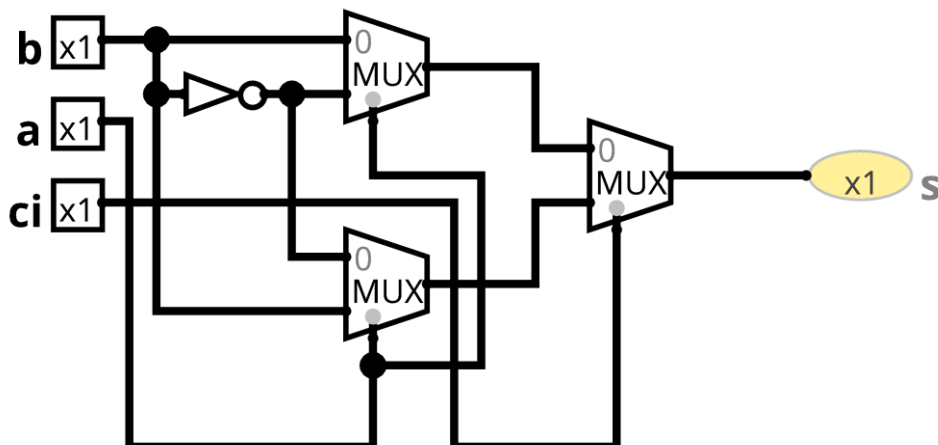
7. (3p)

(1) $s = a \oplus b \oplus c_i$, $c_o = ab + ac_i + bc_i$

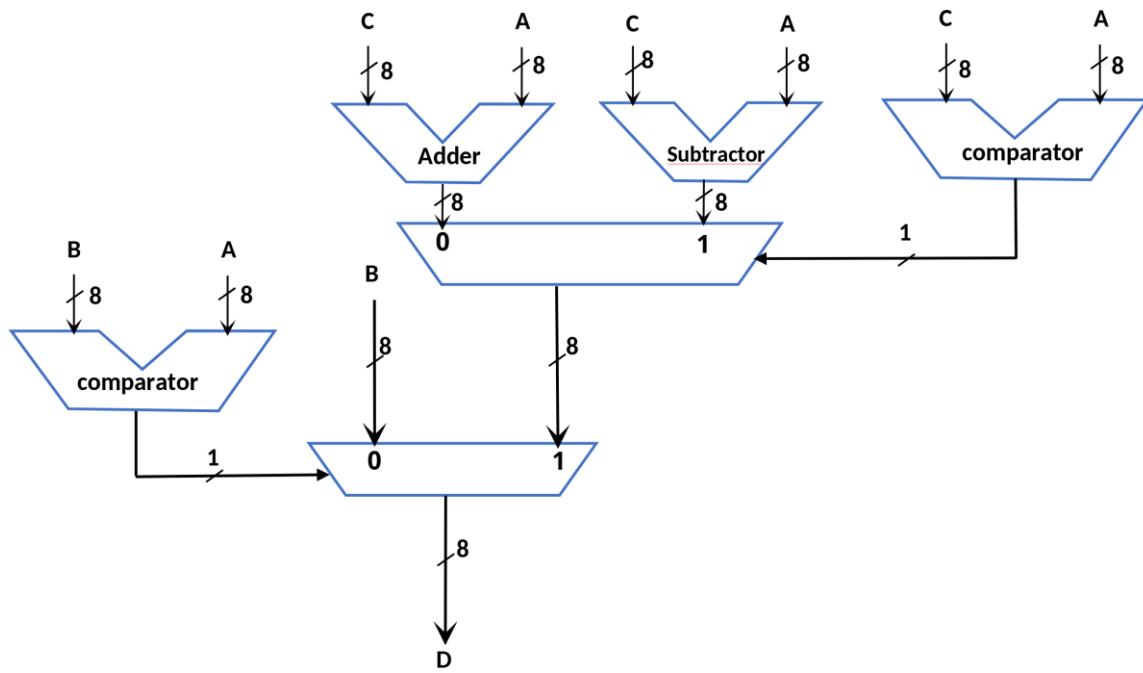


(2) Carry out:

Sum:

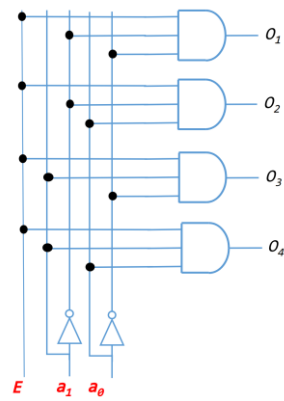


8. (3p)



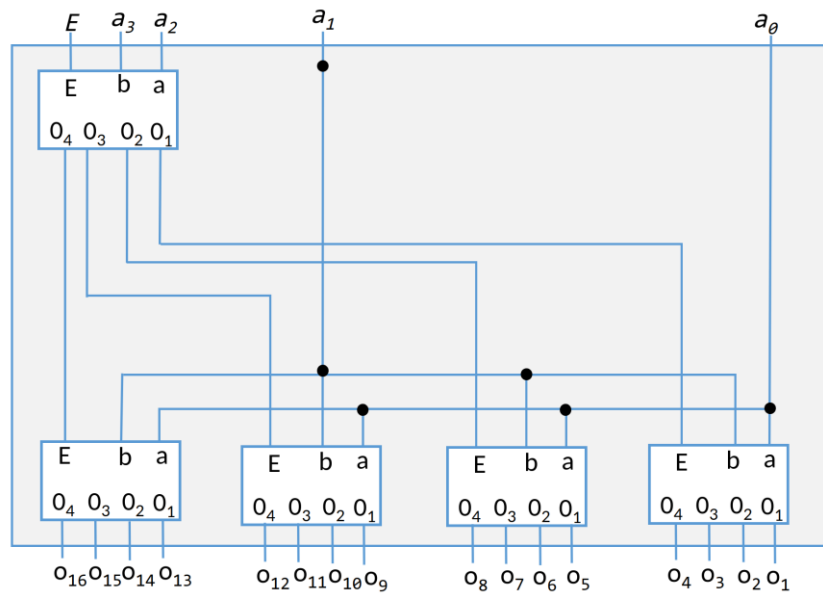
9. (3p)

(1p) 2-to-4 Decoder



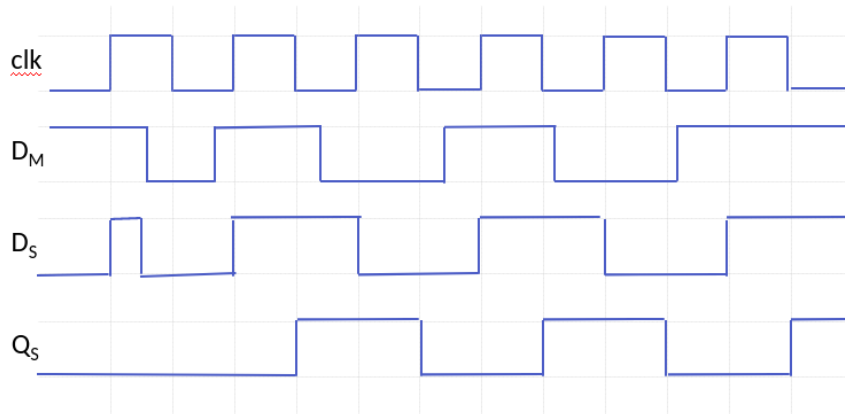
(2p) 4-to-16 Decoder

E	a_3	a_2	a_1	a_0	O_{16}	O_{15}	O_{14}	O_{13}	O_{12}	O_{11}	O_{10}	O_9	O_8	O_7	O_6	O_5	O_4	O_3	O_2	O_1
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
1	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
1	0	1	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
1	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
1	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
1	1	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
1	1	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0



Part 3 (16p)

10. (2p)



11. (4p)

(1) (1p) Setup constraint $\implies clk + skew \geq T_{clk-2-Q} + T_{crit} + T_{SU}$
 $Skew \geq 1 + 10 + 1 - 10 \implies skew \geq 2$

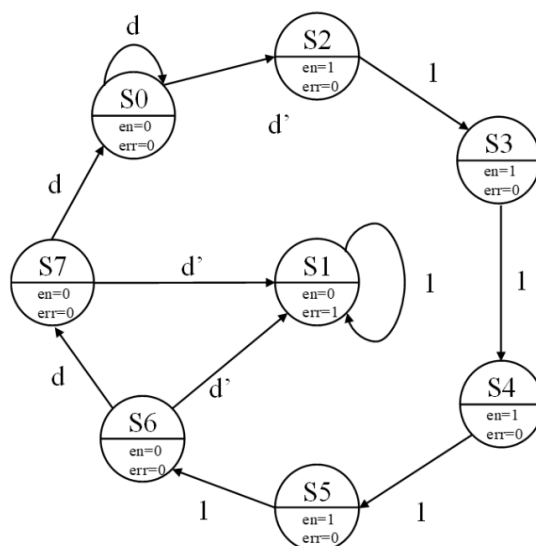
(2) (2p) Hold constraint $\implies T_{hold} + skew < T_{clk-2-Q} + T_{short}$
 $0.1 + 2 < 1 + 2$

The calculate skew in previous part would not cause hold violation.

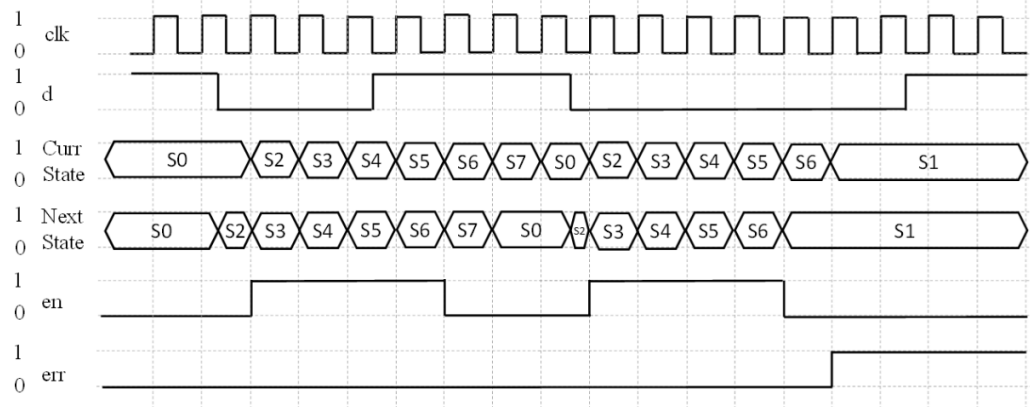
(3) (1p) Increase the shortest path delay by inserting buffers.

12. (4p)

(1) (2p)



(2) (2p)



13. (4p)

(1) (1p)

X Y	Present state $Q_2Q_1Q_0$	Next state $Q_2^+Q_1^+Q_0^+$	T_2	T_1	T_0
0 0	A (000)	E (100)	1	0	0
0 1	A (000)	D (011)	0	1	1
1 0	A (000)	A (000)	0	0	0
1 1	A (000)	B (001)	0	0	1
0 -	B (001)	B (001)	0	0	0
1 -	B (001)	D (011)	0	1	0
-0	C (010)	D (011)	0	0	1
-1	C (010)	C (010)	0	0	0
—	D (011)	E (100)	1	1	1
—	E (100)	E (100)	0	0	0

(2) (2p)

$$T_2 = X'Y'Q_2'Q_1'Q_0' + Q_2'Q_1Q_0$$

$$T_1 = X'YQ_2'Q_1'Q_0' + XQ_2'Q_1'Q_0 + Q_2'Q_1Q_0$$

$$T_0 = X'YQ_2'Q_1'Q_0' + XYQ_2'Q_1'Q_0' + Y'Q_2'Q_1Q_0' + Q_2'Q_1Q_0$$

(3) (1p) I

Illegal states are:

$$Q_2Q_1Q_0 = 101 : T_2T_1T_0 = 000 \implies \text{Next State} = 101$$

$$Q_2Q_1Q_0 = 110 : T_2T_1T_0 = 000 \implies \text{Next State} = 110$$

$$Q_2Q_1Q_0 = 111 : T_2T_1T_0 = 000 \implies \text{Next State} = 111$$

14. (2p)

(1) (1p)

$$JA = X'B$$

$$KA = 1$$

$$JB = X'$$

$$KB = X \text{ XOR } A$$

$$Z = X'A'B$$

(2) (1p)

current state (AB)	JA		KA		JB		KB		next state		Z	
	X=0	X=1	X=0	X=1	X=0	X=1	X=0	X=1	X=0	X=1	X=0	X=1
00	0	0	1	1	1	0	0	1	01	01	0	0
01	1	0	1	1	1	0	0	1	11	00	1	0
10	0	0	1	1	1	0	1	0	01	00	0	0
11	1	0	1	1	1	0	1	0	00	01	0	0