Ex:

Design a digital circuit that accepts a 3-bit number and produce the square of that no.

Solution

maximum number that can be represented in 3-bit is 7_{10} $\Rightarrow$ the square of 7_{10} is 49_{10} $\Rightarrow$ need at least 6-bit, namely, $49 \Rightarrow (110001)_2$

A_2	A_1	A_0	C_5	C_4	C_3	C_2	C_1	C_0
0	0	0	0	0	0	0	0	0
0	0	1	0	0	0	0	0	1
0	1	0	0	0	0	1	0	0
0	1	1	0	0	1	0	0	1
1	0	0	0	1	0	0	0	0
1	0	1	0	1	1	0	0	1
1	1	0	1	0	0	1	0	0
1	1	1	1	1	0	0	0	1

C_0

A_2 \ A_1A_0	00	01	11	10
0		1	1	
1		1	1	

$$C_0 = A_0$$

C_1

A_2 \ A_1A_0	00	01	11	10
0				
1				

$$C_1 = 0$$

C_2

A_2 \ A_1A_0	00	01	11	10
0				1
1				1

$$C_2 = A_1\overline{A_0}$$

C_3

A_2 \ A_1A_0	00	01	11	10
0			1	
1		1		

$$C_3 = \overline{A_2}A_1A_0 + A_2\overline{A_1}A_0$$

C_4

A_2 \ A_1A_0	00	01	11	10
0				
1	1	1	1	

$$C_4 = A_2\overline{A_1} + A_2A_0$$

C_5

A_2 \ A_1A_0	00	01	11	10
0				
1			1	1

$$C_5 = A_2A_1$$

$C_0 = A_0$

$C_1 = 0$

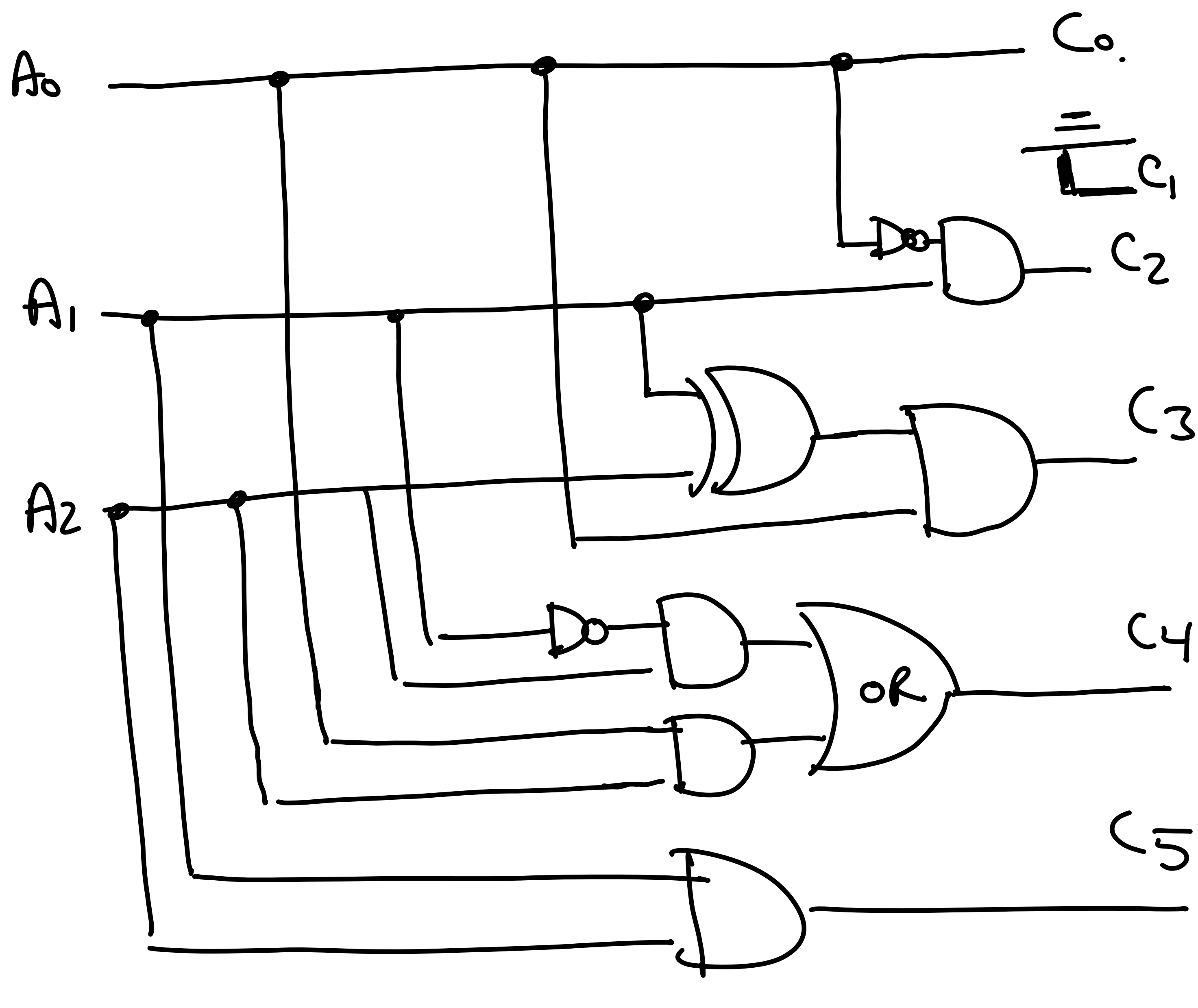
$C_2 = A_1 \overline{A_0}$

$C_3 = \overline{A_2} A_1 A_0 + A_2 \overline{A_1} A_0$

$= A_0 (A_2 \oplus A_1)$

$C_4 = A_2 \overline{A_1} + A_2 A_0$

$C_5 = A_2 A_1$



Ex

Design a digital circuit that can add two bits in addition to one bit called carry

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X	Y	Z	C	S
0	0	0	0	0
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	1	0
1	1	1	1	1

$$S = \sum(1,2,4,7)$$

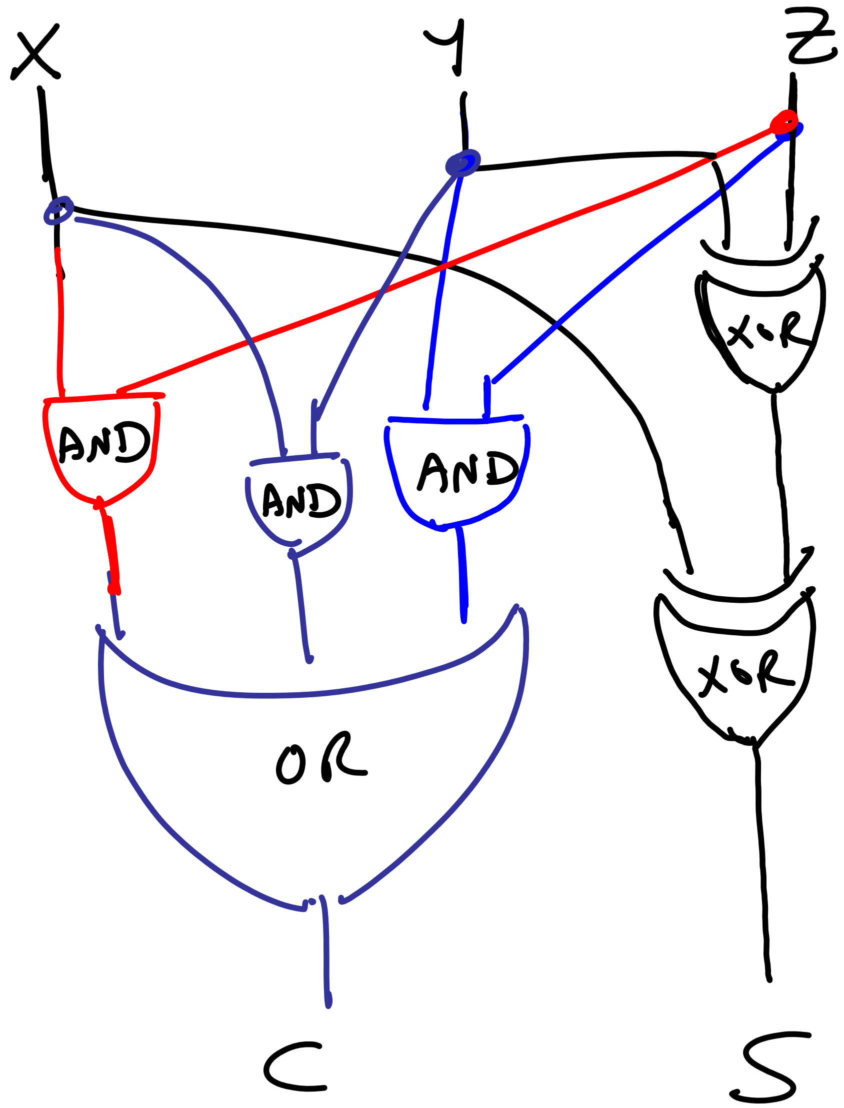
$$C = \sum(3,5,6,7)$$

x \ yz	00	01	11	10
0		1		1
1	1		1	

$$S = X \oplus (Y \oplus Z)$$

x \ yz	00	01	11	10
0			1	
1		1	1	1

$$C = XZ + XY + YZ$$



Don't care conditions

↳ where some input variable combinations are not allowed

- in BCD, there are six invalid combinations: 1010, 1011, 1100, 1101, 1110, 1111

- Since these Combinations are not allowed — will never occur in an application involving the BCD.

⇓

they can be treated as

don't care

↳ with respect to their effect on the output

↓

You may consider "don't care" terms either a 1 or 0 — it really does not matter since they will never occur → advantage to Karnaugh map

Ex

Design a digital circuit that has a 1 output only when the BCD code for 2 or 6 is present on the inputs

A	B	C	D	Y
0	0	0	0	0
0	0	0	1	0
0	0	1	0	1
0	0	1	1	0
0	1	0	0	0
0	1	0	1	0
0	1	1	0	1
0	1	1	1	0
1	0	0	0	0
1	0	0	1	0
1	0	1	0	X
1	0	1	1	X
1	1	0	0	X
1	1	0	1	X
1	1	1	0	X
1	1	1	1	X

1 or 0

AB \ CD	00	01	11	10
00				1
01				1
11				
10				

Don't care as 0

$$\Rightarrow f = \bar{A} C \bar{D}$$

AB \ CD	00	01	11	10
00				1
01				1
11	1	1	1	1
10			1	1

Don't care as 1

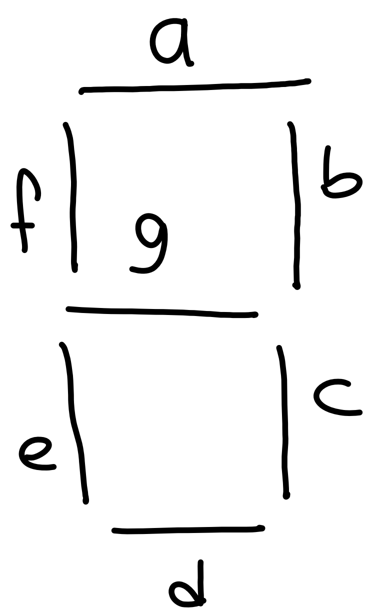
$$f = C\bar{D} + AB + AC$$

AB \ CD	00	01	11	10
00				1
01				1
11	X	X	X	X
10			X	X

Don't care as Don't care

$$f = C\bar{D}$$

Ex 7-segment Display



A	B	C	D	a	b	c	d	e	f	g
0	0	0	0	1	1	1	1	1	1	0
0	0	0	1	0	1	1	0	0	0	0
0	0	1	0	1	1	0	1	1	0	1
0	0	1	1	1	1	1	1	0	0	1
0	1	0	0	0	1	1	0	0	1	1
0	1	0	1	1	0	1	1	0	1	1
0	1	1	0	1	0	1	1	1	1	1
0	1	1	1	1	1	1	0	0	0	1
1	0	0	0	1	1	1	1	1	1	1
1	0	0	1	1	1	1	1	0	1	1

Do not care

$$a = \sum(0,2,3,5,6,7,8,9)$$

$$b = \sum(0,1,2,3,4,7,8,9)$$

$$c = \sum(0,1,3,4,5,6,7,8,9)$$

$$d = \sum(0,2,3,5,6,8,9)$$

$$e = \sum(0,2,6,8)$$

$$f = \sum(0,4,5,6,8,9)$$

$$g = \sum(2,3,4,5,6,7,8,9)$$

AB \ CD	00	01	11	10
00	1		1	1
01		1	1	1
11	X	X	X	X
10	1	1	X	X

$$a = \overline{B}\,\overline{D} + BD + C + A$$

Quiz

- Draw the logic diagram for the segment a
- use karnaugh map to get simplified expression for other segments
- Draw logic diagram

(b)

AB \ CD	00	01	11	10
00				
01				
11	X	X	X	X
10			X	X

(c)

AB \ CD	00	01	11	10
00				
01				
11	X	X	X	X
10			X	X

(d)

AB \ CD	00	01	11	10
00				
01				
11	X	X	X	X
10			X	X

(e)

AB \ CD	00	01	11	10
00				
01				
11	X	X	X	X
10			X	X

(f)

AB \ CD	00	01	11	10
00				
01				
11	X	X	X	X
10			X	X

(g)

AB \ CD	00	01	11	10
00				
01				
11	X	X	X	X
10			X	X

Report

- use MultiSim
- use Proteus
- Getting started ⇒ MultiSim
- Getting started ⇒ Proteus

Ex

Develop a circuit that converts a BCD digit into Excess-3 code

A	B	C	D	W	X	Y	Z
0	0	0	0	0	0	1	1
0	0	0	1	0	1	0	0
0	0	1	0	0	1	0	1
0	0	1	1	0	1	1	0
0	1	0	0	0	1	1	1
0	1	0	1	1	0	0	0
0	1	1	0	1	0	0	1
0	1	1	1	1	0	1	0
1	0	0	0	1	0	1	1
1	0	0	1	1	1	0	0

W

AB \ CD	00	01	11	10
00				
01		1	1	1
11	X	X	X	X
10	1	1	X	X

X

AB \ CD	00	01	11	10
00		1	1	1
01	1			
11	X	X	X	X
10		1	X	X

$$W = A + BD + BC$$

$$X = B\bar{C}\bar{D} + \bar{B}D + \bar{B}C$$

Y

AB \ CD	00	01	11	10
00	1		1	
01	1		1	
11	X	X	X	X
10	1		X	X

$$Y = \bar{C}\bar{D} + CD$$

Z

AB \ CD	00	01	11	10
00	1			1
01	1			1
11	X	X	X	X
10	1		X	X

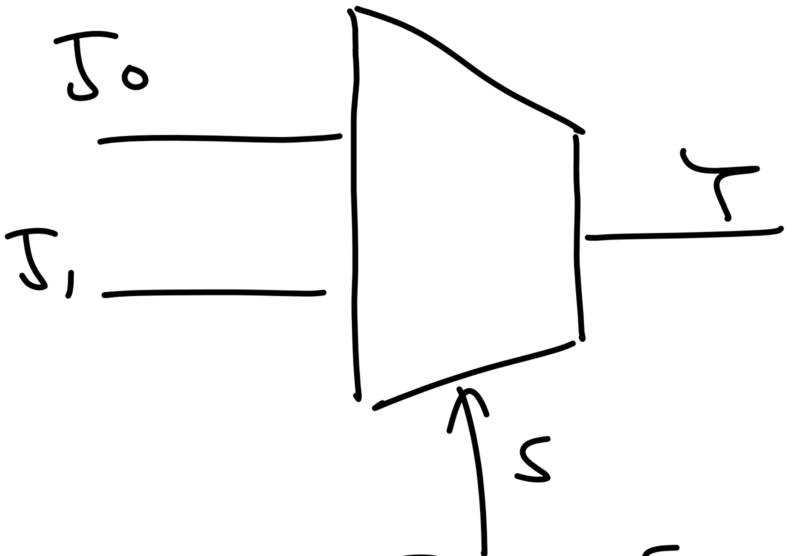
$$Z = \bar{D}$$

Report

Design a BCD to Gray Code converter

Ex

Design a digital circuit that produce Y output equal to I_0 if selection bit $S = 0$. Y equal to I_1 if $S = 1$



$$Y = \begin{cases} I_0 & S = 0 \\ I_1 & S = 1 \end{cases}$$