BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI - K. K. BIRLA GOA CAMPUS

DIGITAL DESIGN Tutorial 5

Ex 1: Design a combinational circuit with three inputs and one output.

(a) The output is 1 when the binary value of the inputs is less than 3. The output is 0 otherwise.

(b) The output is 1 when the binary value of the inputs is an even number.

Ex 2: Design a combinational circuit with three inputs, x , y , and z , and three outputs, A, B , and C . When the binary input is 0, 1, 2, or 3, the binary output is one greater than the input. When the binary input is 4, 5, 6, or 7, the binary output is two less than the input.

Ex 3: A majority circuit is a combinational circuit whose output is equal to 1 if the input variables have more 1's than 0's. The output is 0 otherwise. Design a 3-input majority circuit by finding the circuit's truth table, Boolean equation, and a logic diagram.

Ex 4: Design a combinational circuit that converts a four-bit Gray code to a bit four- binary number.

Ex 5: Design a code converter that converts a decimal digit from

(a) The 8, 4, -2, -1 code to BCD

(b) The 8, 4, -2, -1 code to Gray code.

Ex 6: Design a four-bit combinational circuit 2's complementer. (The output generates the 2's complement of the input binary number.) Show that the circuit can be constructed with exclusive-OR gates. Can you predict what the output functions are for a five-bit 2's complementer?

Ex: 1

A	B	C	(a) Y_1	(b) Y_2
0	0	0	1	1
0	0	1	1	0
0	1	0	1	1
0	1	1	0	0
1	0	0	0	1
1	0	1	0	0
1	1	0	0	1
1	1	1	0	0

(a)

A \ BC	00	01	11	10
0	1	1	0	1
1	0	0	0	0

$$Y_1 = \bar{A}\bar{B} + \bar{A}\bar{C} = \bar{A}(\bar{B}+\bar{C})$$

(b)

A \ BC	00	01	11	10
0	1	0	0	1
1	1	0	0	1

$$Y_2 = \bar{C}$$

Ex: 2

x	y	z	A	B	C
0	0	0	0	0	1
0	0	1	0	1	0
0	1	0	0	1	1
0	1	1	1	0	0
1	0	0	0	1	0
1	0	1	0	1	1
1	1	0	1	0	0
1	1	1	1	0	1

A

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

$$A = yz + xy = y(x+z)$$

B

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

$$B = \bar{x}y\bar{z} + x\bar{y} + \bar{y}z$$
$$= y\bar{x}\bar{z} + \bar{y}(x+z)$$
$$= y\,\overline{(x+z)} + \bar{y}(x+z) = y \oplus (x+z)$$

C

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

$$C = \bar{x}\bar{z} + xz = \overline{x \oplus z}$$

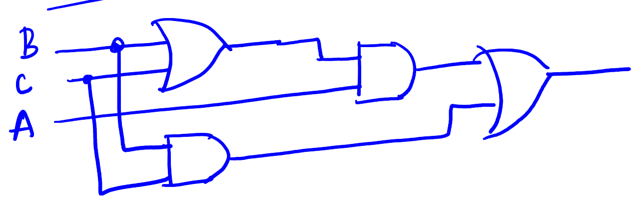
Ex: 3

A	B	C	Y
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

Y

A \ BC	00	01	11	10
0	0	0	1	0
1	0	1	1	1

$$Y = AC + AB + BC = A(B+C) + BC$$



Ex: 4

A	B	C	D	Y_3	Y_2	Y_1	Y_0
0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	1
0	0	1	1	0	0	1	0
0	0	1	0	0	0	1	1
0	1	1	0	0	1	0	0
0	1	1	1	0	1	0	1
0	1	0	1	0	1	1	0
0	1	0	0	0	1	1	1
1	1	0	0	1	0	0	0
1	1	0	1	1	0	0	1
1	1	1	1	1	0	1	0
1	1	1	0	1	0	1	1

1	0	1	0	1	1	0	0
1	0	1	1	1	1	0	1
1	0	0	1	1	1	1	0
1	0	0	0	1	1	1	1

Y_3

AB \ CD	00	01	11	10
00	0	0	0	0
01	0	0	0	0
11	1	1	1	1
10	1	1	1	1

$$Y_3 = A$$

Y_2

AB \ CD	00	01	11	10
00	0	0	0	0
01	1	1	1	1
11	0	0	0	0
10	1	1	1	1

$$Y_2 = \bar{A}B + A\bar{B} = A \oplus B$$

Y_1

AB \ CD	00	01	11	10
00	0	0	1	1
01	1	1	0	0
11	0	0	1	1
10	1	1	0	0

$$Y_1 = \bar{A}\bar{B}C + \bar{A}B\bar{C} + ABC + A\bar{B}\bar{C}$$
$$= \bar{A}(\bar{B}C + B\bar{C}) + A(BC + \bar{B}\bar{C})$$
$$= \bar{A}(B \oplus C) + A(\overline{B \oplus C})$$
$$= A \oplus B \oplus C$$

Y_0

AB \ CD	00	01	11	10
00	0	1	0	1
01	1	0	1	0
11	0	1	0	1
10	1	0	1	0

$$Y_0 = \bar{A}\bar{B}\bar{C}D + \bar{A}\bar{B}C\bar{D} + \bar{A}B\bar{C}\bar{D} + \bar{A}BCD + AB\bar{C}D + ABC\bar{D} + A\bar{B}\bar{C}\bar{D} + A\bar{B}CD$$
$$= \bar{A}\bar{B}(\bar{C}D + C\bar{D}) + \bar{A}B(\bar{C}\bar{D} + CD) + AB(\bar{C}D + C\bar{D}) + A\bar{B}(\bar{C}\bar{D} + CD)$$
$$= (\bar{C}D + C\bar{D})(\bar{A}\bar{B} + AB) + (\bar{C}\bar{D} + CD)(\bar{A}B + A\bar{B})$$
$$= (C \oplus D)(\overline{A \oplus B}) + (\overline{C \oplus D})(A \oplus B)$$
$$= A \oplus B \oplus C \oplus D$$

Ex: 5

(a)

8	4	-2	-1	BCD				Gray			
A	B	C	D	Y_3	Y_2	Y_1	Y_0	Y_3	Y_2	Y_1	Y_0
0	0	0	0	0	0	0	0	0	0	0	0
0	1	1	1	0	0	0	1	0	0	0	1
0	1	1	0	0	0	1	0	0	0	1	1

0	1	0	1	0	0	1	1	0	0	1	0
0	1	0	0	0	1	0	0	0	1	1	0
1	0	1	1	0	1	0	1	0	1	1	1
1	0	1	0	0	1	1	0	0	1	0	1
1	0	0	1	0	1	1	1	0	1	0	0
1	0	0	0	1	0	0	0	1	1	0	0
1	1	1	1	1	0	0	1	1	1	0	1

Y_3

AB \ CD	00	01	11	10
00	0	X	X	X
01	0	0	0	0
11	X	X	1	X
10	1	0	0	0

$$Y_3 = AB + A\bar{C}\bar{D}$$

Y_2

AB \ CD	00	01	11	10
00	0	X	X	X
01	1	0	0	0
11	X	X	0	X
10	0	1	1	1

$$Y_2 = \bar{B}D + \bar{B}C + B\bar{C}\bar{D}$$
$$= \bar{B}(C+D) + B\overline{(C+D)}$$
$$= B \oplus (C+D)$$

Y_1

AB \ CD	00	01	11	10
00	0	X	X	X
01	0	1	0	1
11	X	X	0	X
10	0	1	0	1

$$Y_1 = \bar{C}D + C\bar{D} = C \oplus D$$

Y_0

AB \ CD	00	01	11	10
00	0	X	X	X
01	0	1	1	0
11	X	X	1	X
10	0	1	1	0

$$Y_0 = D$$

(b)

Y_3

AB \ CD	00	01	11	10
00	0	X	X	X
01	0	0	0	0
11	X	X	1	X
10	1	0	0	0

$$Y_3 = AB + A\bar{C}\bar{D} = A\left[B + \overline{(C+D)}\right]$$

Y_2

AB \ CD	00	01	11	10
00	0	X	X	X
01	1	0	0	0
11	X	X	1	X
10	1	1	1	1

$$Y_2 = A + B\bar{C}\bar{D}$$
$$= A + B\,\overline{(C+D)}$$

Y_1

AB \ CD	00	01	11	10
00	0	X	X	X
01	1	1	0	1
11	X	X	0	X
10	0	0	1	0

$$Y_1 = B\bar{C} + B\bar{D} + \bar{B}CD$$
$$= B(\bar{C}+\bar{D}) + \bar{B}CD$$
$$= B\,\overline{CD} + \bar{B}CD$$
$$= B \oplus (CD)$$

Y_0

AB \ CD	00	01	11	10
00	0	X	X	X
01	0	0	1	1
11	X	X	1	X
10	0	0	1	1

$$Y_0 = C$$

Ex: 6

A	B	C	D	Y_3	Y_2	Y_1	Y_0
0	0	0	0	0	0	0	0
0	0	0	1	1	1	1	1
0	0	1	0	1	1	1	0
0	0	1	1	1	1	0	1
0	1	0	0	1	1	0	0
0	1	0	1	1	0	1	1
0	1	1	0	1	0	1	0
0	1	1	1	1	0	0	1
1	0	0	0	1	0	0	0
1	0	0	1	0	1	1	1
1	0	1	0	0	1	1	0
1	0	1	1	0	1	0	1
1	1	0	0	0	1	0	0
1	1	0	1	0	0	1	1
1	1	1	0	0	0	1	0
1	1	1	1	0	0	0	1

Y_3

AB \ CD	00	01	11	10
00	0	1	1	1
01	1	1	1	1
11	0	0	0	0
10	1	0	0	0

$$Y_3 = \bar{A}B + \bar{A}D + \bar{A}C + A\bar{B}\bar{C}\bar{D}$$
$$= \bar{A}(B+C+D) + A(\overline{B+C+D})$$
$$= A \oplus (B+C+D)$$

Y_2

AB \ CD	00	01	11	10
00	0	1	1	1
01	1	0	0	0
11	1	0	0	0
10	0	1	1	1

$$Y_2 = B\bar{C}\bar{D} + \bar{B}D + \bar{B}C$$
$$= B(\overline{C+D}) + \bar{B}(C+D)$$
$$= B \oplus (C+D)$$

Y_1

AB \ CD	00	01	11	10
00	0	1	0	1
01	0	1	0	1
11	0	1	0	1
10	0	1	0	1

$$Y_1 = \bar{C}D + C\bar{D}$$

$$= C \oplus D$$

Y_0

AB \ CD	00	01	11	10
00	0	1	1	0
01	0	1	1	0
11	0	1	1	0
10	0	1	1	0

$$Y_0 = D$$