COMPUTER SCIENCE & IT

DIGITAL LOGIC

Lecture No. 08

Combinational Circuit

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K-Map

Comparator CKt

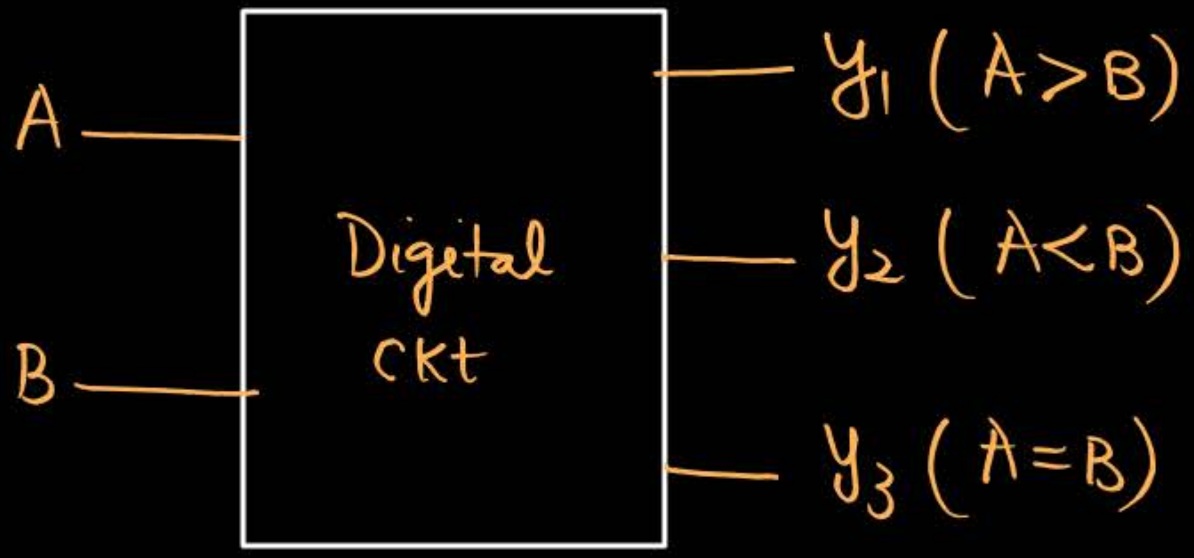
Comparator

A | B

$A > B$ $\quad$ $A < B$ $\quad$ $A = B$

- A and B are single bit number then how to design comparator ?

A	B	$y_1 (A>B)$	$y_2 (A<B)$	$y_3 (A=B)$
0	0	0	0	1
0	1	0	1	0
1	0	1	0	0
1	1	0	0	1

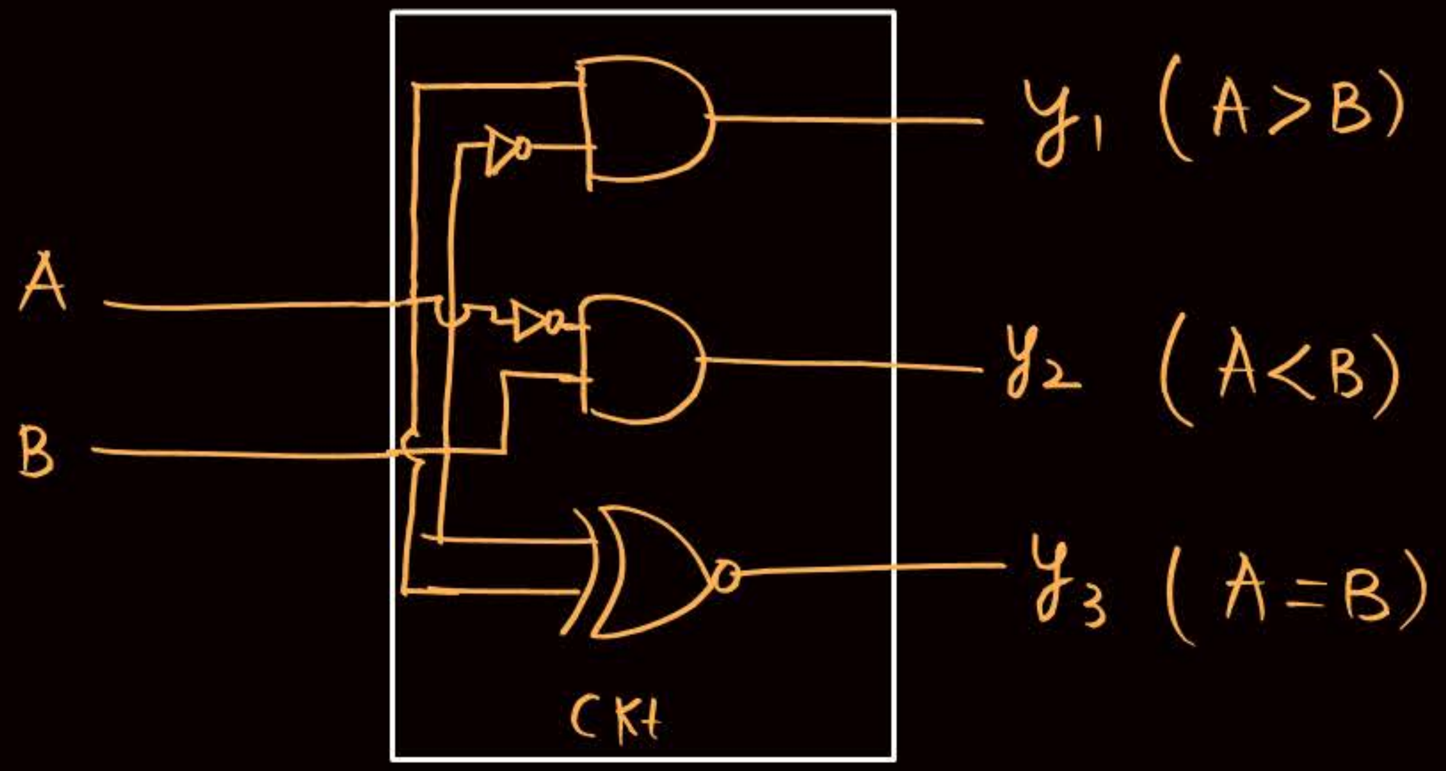


$y_1(A,B) = \Sigma(2)$, $y_2(A,B) = \Sigma 1$, $y_3(A,B) = \Sigma(0,3)$

$= A\bar{B}$

$= \bar{A}B$

$= \bar{A}\bar{B} + AB = A \odot B$



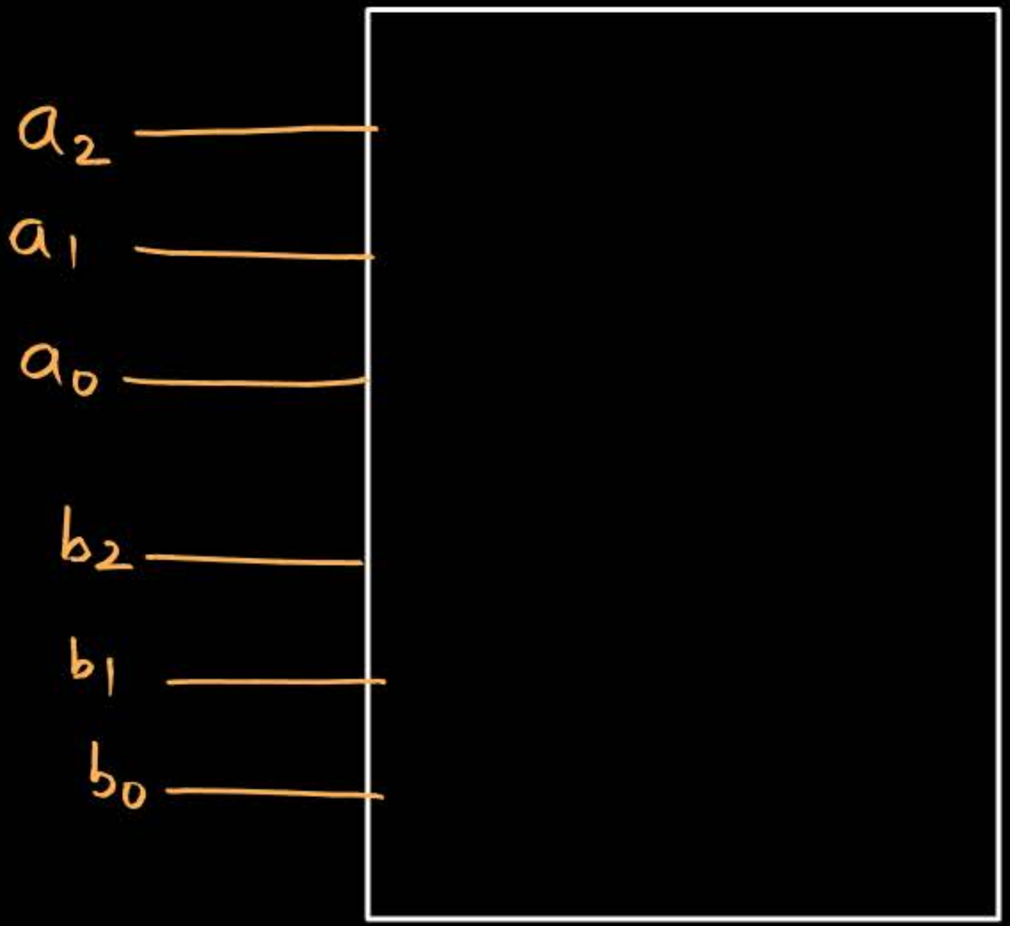
- When A and B are 3-bit number then how to write the output of a comparator :

$A = a_2 a_1 a_0$

$B = b_2 b_1 b_0$

$$y_1(A>B) = (a_2>b_2) + (a_2=b_2)\cdot(a_1>b_1) + (a_2=b_2)\cdot(a_1=b_1)\cdot(a_0>b_0)$$

$$= a_2\overline{b_2} + (a_2 \odot b_2)\cdot(a_1\overline{b_1}) + (a_2 \odot b_2)(a_1 \odot b_1)\, a_0\overline{b_0}$$



$$y_2(A<B) = (a_2<b_2) + (a_2=b_2)(a_1<b_1) + (a_2=b_2)(a_1=b_1)(a_0<b_0)$$

$$= \overline{a}_2 b_2 + (a_2 \odot b_2) \cdot \overline{a}_1 b_1 + (a_2 \odot b_2)(a_1 \odot b_1) \cdot \overline{a}_0 b_0$$

$$y_3(A=B) = (a_2=b_2) \cdot (a_1=b_1) \cdot (a_0=b_0) \quad = (a_2 \odot b_2)(a_1 \odot b_1)(a_0 \odot b_0)$$

$A = a_2 a_1 a_0$

$B = 0 b_1 b_0$

$\boxed{b_2 = 0}$

$$y_1(A>B) = (a_2>b_2) + (a_2=b_2)(a_1>b_1) + (a_2=b_2)(a_1=b_1)\,a_0>b_0$$

$$= a_2 + \overline{a}_2 (a_1 \overline{b}_1) + \overline{a}_2 (a_1 \odot b_1)\, a_0 \overline{b}_0$$

$$y_2(A<B) = (a_2<b_2) + (a_2=b_2)(a_1<b_1) + (a_2=b_2)(a_1=b_1)\,a_0<b_0$$

$$= 0 + \overline{a}_2 \overline{a}_1 b_1 + \overline{a}_2 \cdot (a_1 \odot b_1)\, \overline{a}_0 b_0$$

$$y_3(A=B) = (a_2 \odot b_2)(a_1 \odot b_1)(a_0 \odot b_0)$$

$$= \overline{a}_2 (a_1 \odot b_1)(a_0 \odot b_0)$$

$A = a_1 a_0$

$B = b_1 b_0$

A	B
0	0
1	1
2	2
3	3

$N_1(A>B) = 0+1+2+3 = 6$

$N_2(A<B) = 0+1+2+3 = 6$

$N_3(A=B) = 4 = 2^2$

$A = n \text{ bit} \longrightarrow 0 \text{ —— } (2^n-1)$

$B = n \text{ bit} \longrightarrow 0 \longrightarrow (2^n-1)$

$2^{2n} \longrightarrow$ combinations

$$\boxed{\begin{aligned} N_1(A>B) &= 0+1+2+3+\cdots(2^n-1) \\ N_2(A<B) &= 0+1+2+3+\cdots(2^n-1) \\ N_3(A=B) &= 2^n \end{aligned}}$$

$A = a_3 a_2 a_1 a_0 \Rightarrow 4$ bit

$B = b_1 b_0 \Rightarrow 2$ bit

$\Rightarrow$

6 bits $\longrightarrow 2^6 \longrightarrow 64$

A	B
0	0
1	1
2	2
3	3
⋮	
14	
15	

$N_1(A>B) = 0+1+2+3+4+11\times4$
$= 54$

$N_2(A<B) = 3+2+1 = 6 = (1+2+3)$

$N_3(A=B) = 4$

$N_2(B>A) = 0+1+2+3 = 6$

$A = n_1$ bit $\Rightarrow 0 — (2^{n_1}-1)$

$B = n_2$ bit $\Rightarrow 0 — (2^{n_2}-1)$

(n_1+n_2) bit

$2^{(n_1+n_2)}$

$(n_1 > n_2)$

$N(B>A) = 0+1+2+ \ldots + (2^{n_2}-1)$

less bit, higher

$M(B=A) = 2^{n_2}$

$N'(A>B)$
$= 2^{(n_1+n_2)} - (N+M)$

$$A = 6 \text{ bit}, \quad B = 3 \text{ bit} \Big\} \rightarrow \text{Total } 9 \text{ bits}$$

$$0 - (2^6 - 1)$$

$$0 - 63 \rightarrow A$$

$$0 - 7 - B$$

$$\text{Total} = 2^3 = 8$$

$$N_1 (A > B) = 2^9 - (28 + 8) = 512 - 36 = 476$$

$$N_2 (A < B) = 0 + 1 + 2 + 3 + 4 + 5 + 6 + 7 = \frac{7 \times 8}{2} = 28$$

$$N_3 (A = B) = 8$$

$$\boxed{1 + 2 + 3 + + \cdot\, n = \frac{n(n+1)}{2}}$$

Question

We have two number A and B both A and B are 2-bit numbers then in how many combination A > B.

(a) 5

(b) 6

(c) 7

(d) 8

$N_1(A>B) = N_2(A<B) = 0+1+2+3 = 6$

$A - 0 - 3$

$B - 0 - 3$

[Question]

We have two 4-bit number A and B then number of combinations in which A < B ________

Number of combinations in which A = B ________.

$N_1(A>B) = N_2(A<B) = 0+1+2+\cdots(2^4-1) = 0+1+2+ \quad +15 = \frac{15\times16}{2} = 120$

$N_3(A=B) = 2^4 = 16$

Question

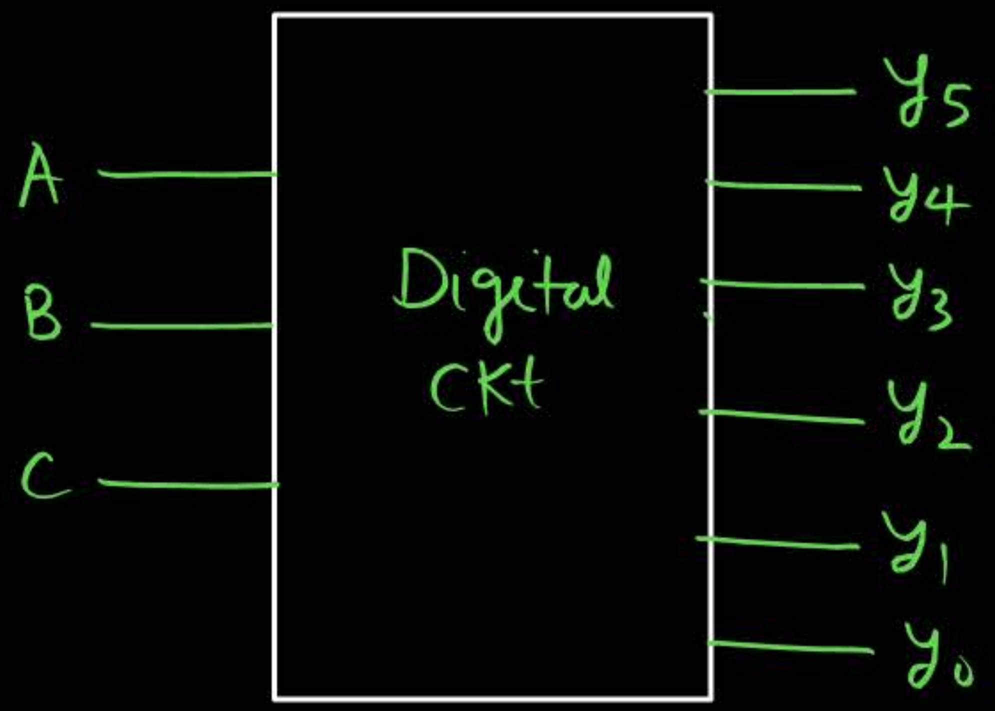
Design a combinational circuit having 3-input and 1-output line. The output is high when majority of input lines are at logic '0'.

$\boxed{\text{H.W.}}$

[**Question**] (H.W.)

Design a combinational circuit where input is 3-bit input and output is square of input number.

y_5 y_0



Question

H.W.

Design a combinational circuit where input is BCD code and output is '1' when input is divisible by 2.

Question

$A\bar{B}$

$1\ 0\ 0 \rightarrow 4$

$1\ 0\ 1 \rightarrow 5$

A logic circuit implements the Boolean function :

$$f(A, B, C) = A\bar{B} + \underset{0\,0\,0}{\bar{A}\bar{B}\bar{C}} = \Sigma(0, 4, 5)$$

It is found that the input combination $\boxed{B = 1 \text{ and } C = 0}$ can never occur. Then the simplified output $f(A, B, C)$ will be

(a) $\bar{B}\bar{C} + \bar{A}\bar{C}$

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

(c) $\bar{A}\bar{B} + \bar{B}\bar{C}$

(d) None of these

A				
0	B=1, C=0		→	2
1	1	0	→	6

→ will never occure

$f(A, B, C) = \Sigma(0, 4, 5) + d\Sigma(2, 6)$

	$\bar{B}\bar{C}$	$\bar{B}C$	BC	$B\bar{C}$
$\bar{A}$	1			X
A	1	1		X

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

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

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

H.W

Q.1. $A = 6$ bit number
$B = 8$ bit number $\longrightarrow$ $N_1 (A < B)$ ________.

Q.2. $A = 8$ bit no. $\longrightarrow$ $N_2 (A > B)$ ________.
$B = 3$ bit no.

Q.3. A is a 3 bit no. $a_2 a_1 a_0$ and B is a 5-bit no. $b_4 b_3 b_2 b_1 b_0$. Then logical O/P $y_1 (A > B)$, $y_2 (A < B)$ & $y_3 (A = B)$ will be?

2 Minute Summary

- Comparator CKt and analysis
- Question Discussion.

Thank you

GW Soldiers !