CS & IT ENGINEERING

DIGITAL LOGIC

COMBINATIONAL CIRCUIT

Lecture No. 8

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TOPICS TO BE COVERED

01 COMPARATOR

02 QUESTION PRACTICE

03 DISCUSSION

COMPARATOR

DESIGNING OF COMBINATIONAL CIRCUIT

Step 1. Find the number of inputs and outputs. ✓
Step 2. Write the truth table. ✓
Step 3. Write the logical expression. ✓
Step 4. Minimize the logical expression. ✓
Step 5. Hardware implementation. ✓

COMPARATOR

DESIGNING OF COMBINATIONAL CIRCUIT

1. Design a one-bit comparator

Step - 1

Step – 2 Truth table.

A	B	X (A>B)	Y (A<B)	Z (A=B)
0	0	0	0	1
0	1	0	1	0
1	0	1	0	0
1	1	0	0	1

COMPARATOR

DESIGNING OF COMBINATIONAL CIRCUIT

Step 3. Logical expression

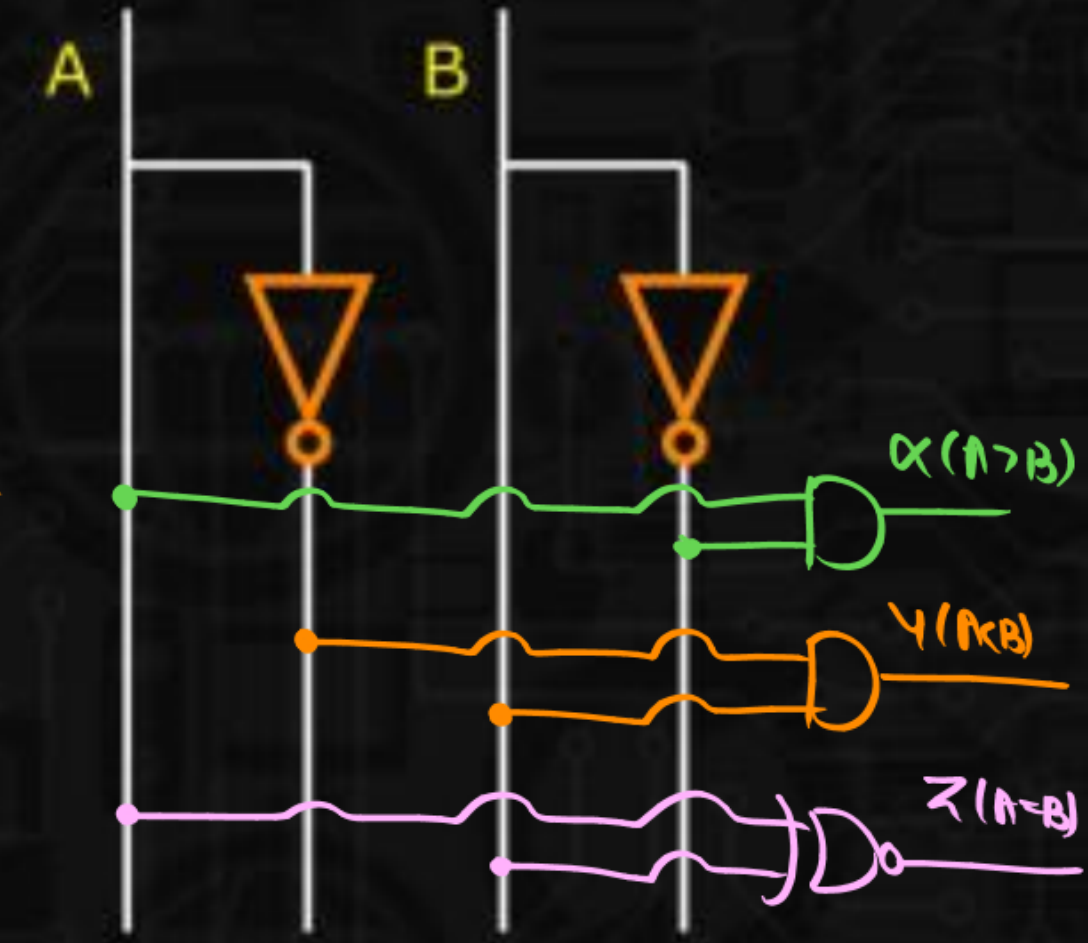
$X(A > B) = A\bar{B}$

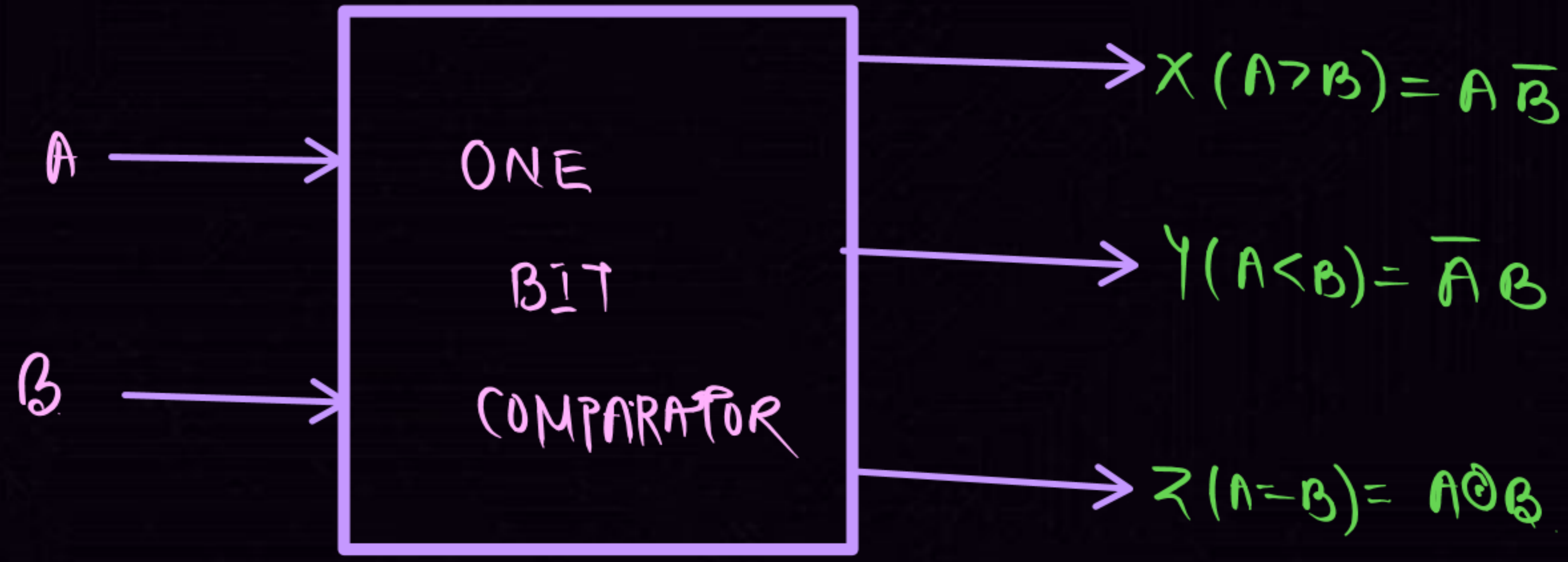
$Y(A < B) = \bar{A}B$

$Z(A = B) = \bar{A}\bar{B} + AB = A \odot B.$

Step 4. Minimization ⟶ Already minimized.

Step 5. Hardware implementation




A
B
ONE
BIT
COMPARATOR
$X(A>B) = A\overline{B}$
$Y(A<B) = \overline{A}B$
$Z(A=B) = A \odot B$

COMPARATOR

DESIGNING OF COMBINATIONAL CIRCUIT

2. Design a two-Bit comparator?

Step-1

COMPARATOR

Step 2. Truth table

$X(A>B) = \Sigma m(4,8,9,12,13,14)$

$Y(A<B) = \Sigma m(1,2,3,6,7,11)$

$Z(A=B) = \Sigma m(0,5,10,15)$

	A: A_1	A_0	B: B_1	B_0	(A>B) X	(A<B) Y	(A=B) Z
0	0	0	0	0	0	0	1
1	0	0	0	1	0	1	0
2	0	0	1	0	0	1	0
3	0	0	1	1	0	1	0
4	0	1	0	0	1	0	0
5	0	1	0	1	0	0	1
6	0	1	1	0	0	1	0
7	0	1	1	1	0	1	0
8	1	0	0	0	1	0	0
9	1	0	0	1	1	0	0
10	1	0	1	0	0	0	1
11	1	0	1	1	0	1	0
12	1	1	0	0	1	0	0
13	1	1	0	1	1	0	0
14	1	1	1	0	1	0	0
15	1	1	1	1	0	0	1

COMPARATOR

DESIGNING OF COMBINATIONAL CIRCUIT

Step 3. Logical expression

$X(A > B) = \Sigma m(4, 8, 9, 12, 13, 14)$

$Y(A < B) = \Sigma m(1, 2, 3, 6, 7, 11)$

$Z(A = B) = \Sigma m(0, 5, 10, 15)$

2 bit

Total combination = 16

Equal = 4

UnEqual = 16 - 4 = 12

Greater = Less = 6

COMPARATOR

DESIGNING OF COMBINATIONAL CIRCUIT

$$Y(A<B) = \bar{A}_1 B_1 + \bar{A}_1 \bar{A}_0 B_0 + \bar{A}_0 B_1 B_0$$

$$\boxed{Y(A<B) = \bar{A}_1 B_1 + (\bar{A}_1 + B_1)\bar{A}_0 B_0}$$

Step 4. Minimization

Minimized Expression

$$X(A>B) = A_1 \bar{B}_1 + A_1 A_0 \bar{B}_0 + A_0 \bar{B}_1 \bar{B}_0$$

$$\boxed{X(A>B) = A_1 \bar{B}_1 + (A_1 + \bar{B}_1) A_0 \bar{B}_0}$$

For X $(A>B)$

$A_1A_0 \backslash B_1B_0$	$\bar{B}_1\bar{B}_0$ 00	$\bar{B}_1B_0$ 01	B_1B_0 11	$B_1\bar{B}_0$ 10
$\bar{A}_1\bar{A}_0$ 00				
$\bar{A}_1A_0$ 01	1			
A_1A_0 11	1	1		1
$A_1\bar{A}_0$ 10	1	1		

For Y $(A<B)$

$A_1A_0 \backslash B_1B_0$	$\bar{B}_1\bar{B}_0$ 00	$\bar{B}_1B_0$ 01	B_1B_0 11	$B_1\bar{B}_0$ 10
$\bar{A}_1\bar{A}_0$ 00		1	1	1
$\bar{A}_1A_0$ 01			1	1
A_1A_0 11				
$A_1\bar{A}_0$ 10			1	

COMPARATOR

DESIGNING OF COMBINATIONAL CIRCUIT

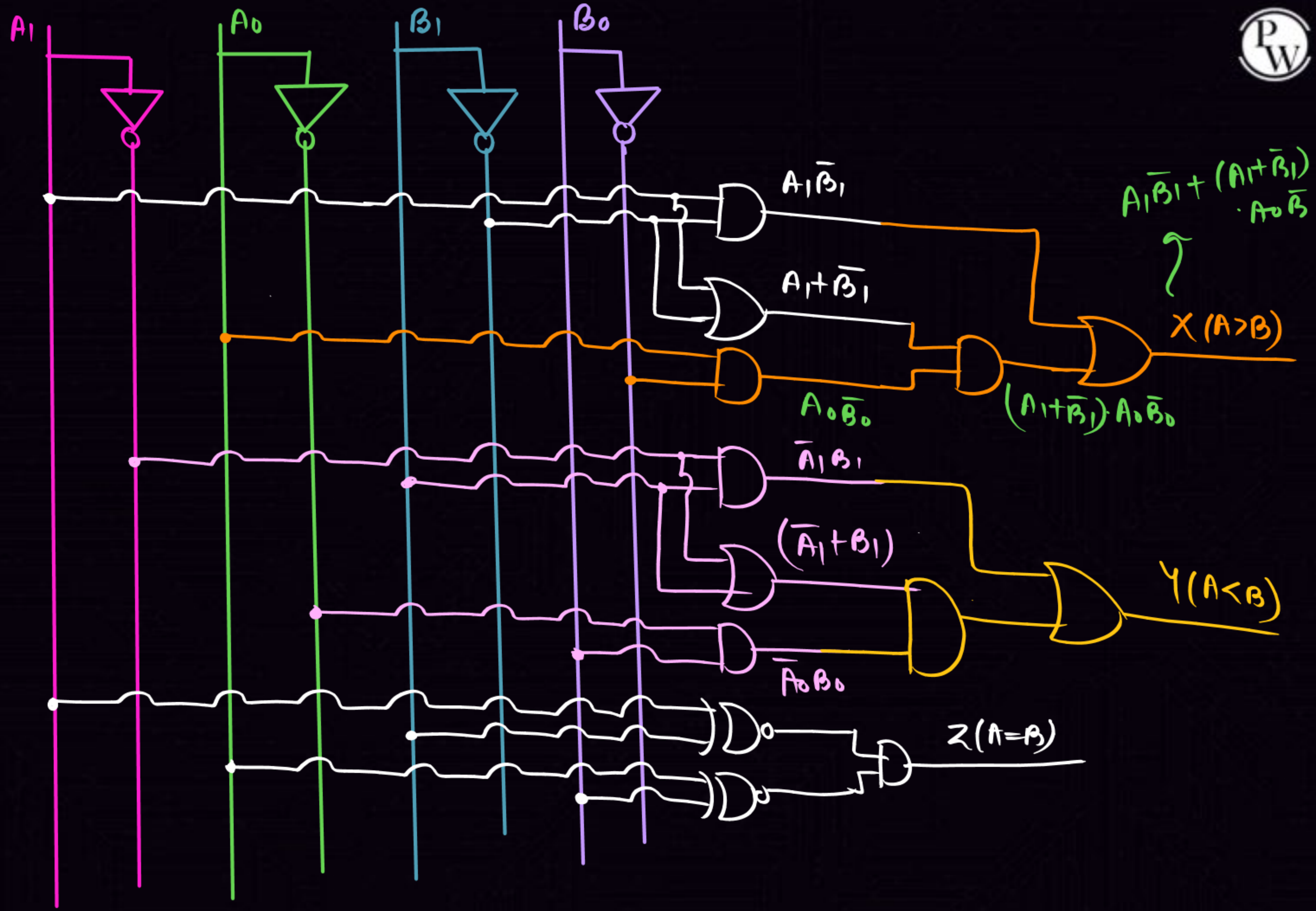
Step 4. Minimization

For Z

$A_1A_0 \backslash B_1B_0$	00	01	11	10
00	1			
01		1		
11			1	
10				1

$$\boxed{Z(A=B) = (A_1 \odot B_1) \cdot (A_0 \odot B_0)}$$

Step 5. :



A_1
A_0
B_1
B_0
$A_1\bar{B}_1$
$A_1\bar{B}_1 + (A_1+\bar{B}_1) \cdot A_0\bar{B}_0$
$A_1+\bar{B}_1$
$X\ (A>B)$
$A_0\bar{B}_0$
$(A_1+\bar{B}_1) \cdot A_0\bar{B}_0$
$\bar{A}_1B_1$
$(\bar{A}_1+B_1)$
$Y\ (A<B)$
$\bar{A}_0B_0$
$Z\ (A=B)$

Semiminimized

$X(A>B)$

$A_1A_0 \backslash B_1B_0$	$\bar{B}_1\bar{B}_0$	$\bar{B}_1B_0$	B_1B_0	$B_1\bar{B}_0$
$\bar{A}_1\bar{A}_0$				
$\bar{A}_1A_0$	1			
A_1A_0	1	1		1
$A_1\bar{A}_0$	1	1		

$Y(A<B)$

$A_1A_0 \backslash B_1B_0$	$\bar{B}_1\bar{B}_0$	$\bar{B}_1B_0$	B_1B_0	$B_1\bar{B}_0$
$\bar{A}_1\bar{A}_0$		1	1	1
$\bar{A}_1A_0$			1	1
A_1A_0				
$A_1\bar{A}_0$			1	

$$X(A>B) = A_1\bar{B}_1 + \bar{A}_1A_0\bar{B}_1\bar{B}_0 + A_1A_0B_1\bar{B}_0$$

$$= A_1\bar{B}_1 + (\bar{A}_1\bar{B}_1 + A_1B_1)A_0\bar{B}_0$$

$$\boxed{X(A>B) = A_1\bar{B}_1 + (A_1 \odot B_1)A_0\bar{B}_0}$$

$$Y(A<B) = \bar{A}_1B_1 + \bar{A}_1\bar{A}_0\bar{B}_1B_0 + A_1\bar{A}_0B_1B_0$$

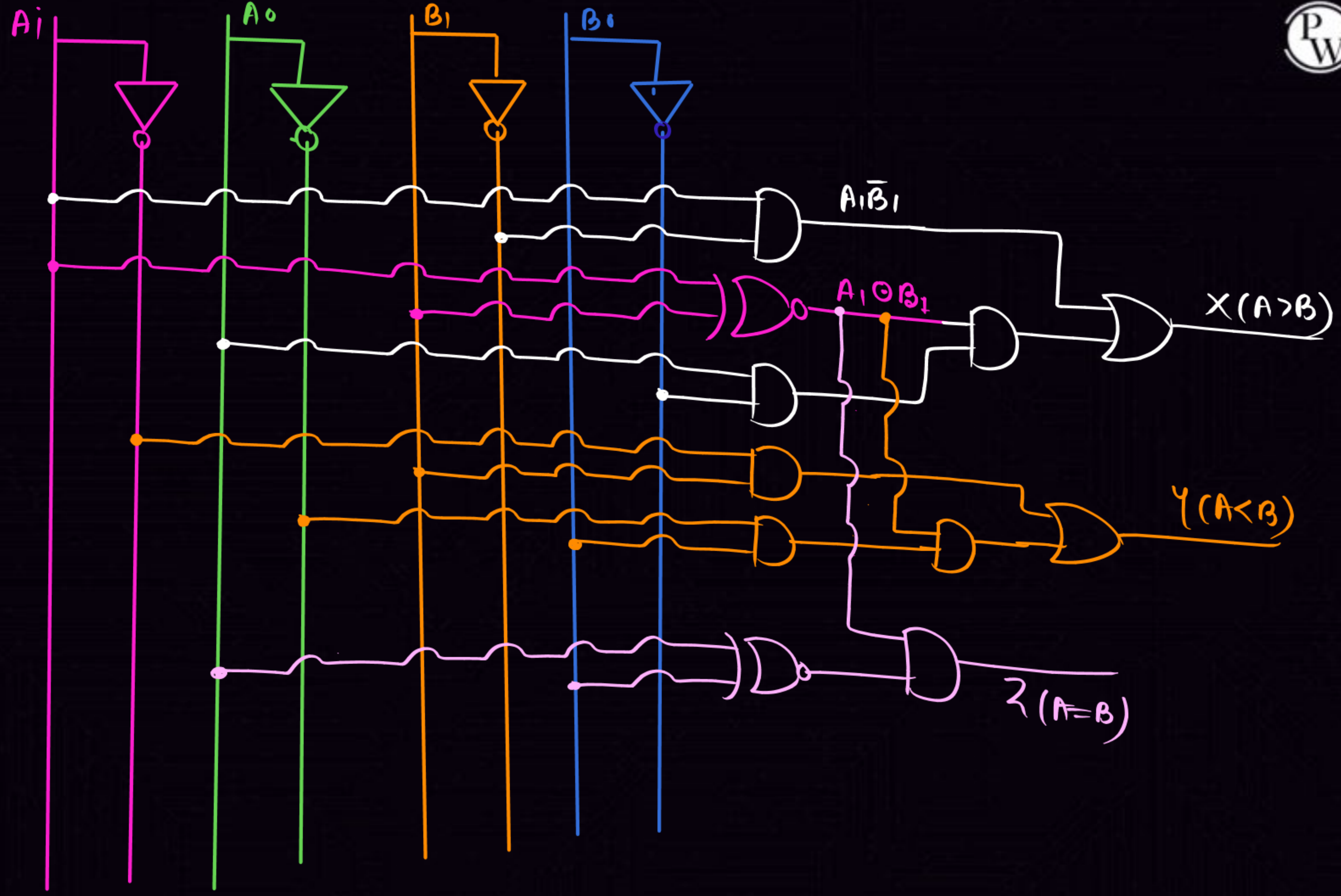
$$Y(A<B) = \bar{A}_1B_1 + (\bar{A}_1\bar{B}_1 + A_1B_1)\bar{A}_0B_0$$

$$\boxed{Y(A<B) = \bar{A}_1B_1 + (A_1 \odot B_1)\cdot\bar{A}_0B_0}$$

$$X(A>B) = A_1\overline{B_1} + (A_1 \odot B_1)\cdot A_0\overline{B_0}$$

$$Y(A<B) = \overline{A_1}B_1 + (A_1 \odot B_1)\cdot \overline{A_0}B_0$$

$$Z(A=B) = (A_1 \odot B_1)\cdot(A_0 \odot B_0)$$



A1
A0
B1
B0
A1B̄1
A1⊙B1
X(A>B)
Y(A<B)
Z(A=B)

COMPARATOR

FOR ONE BIT COMPARATOR

Total condition = 4

Equal condition = 2

Unequal condition = 2

Greater = Less condition = 1

COMPARATOR

FOR TWO BIT COMPARATOR

Total condition = 16

Equal condition = 4

Unequal condition = 12

Greater = Less condition = 6

COMPARATOR

FOR THREE BIT COMPARATOR

Total condition = 64

Equal condition = 8

Unequal condition = 56

Greater = Less condition = 28

COMPARATOR

'n' BIT COMPARATOR

Total condition = 2^{2n}

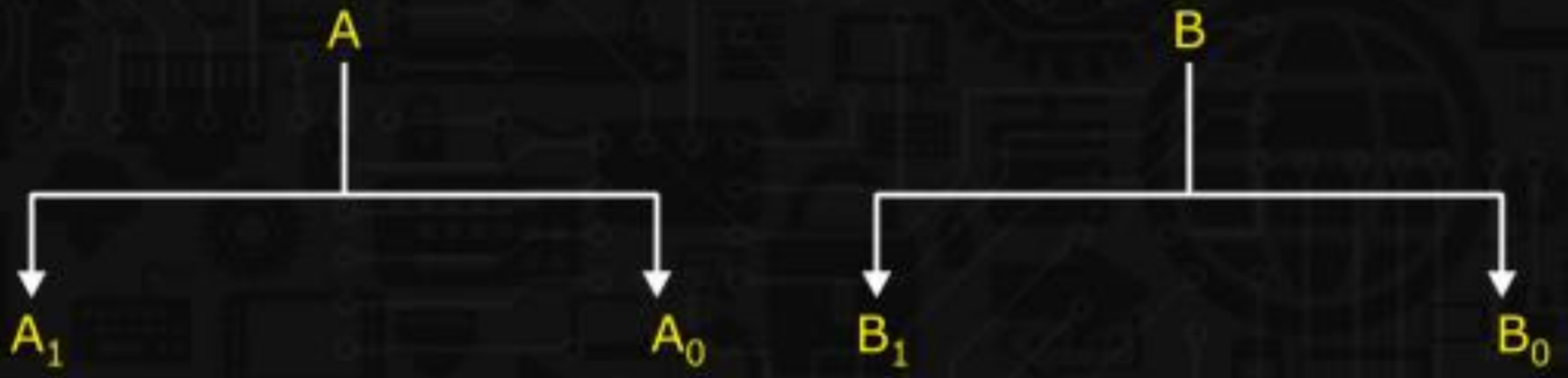
Equal condition = 2^{n}

Unequal condition = $2^{2n} - 2^{n}$

Greater = Less condition = $(2^{2n} - 2^{n})/2$

COMPARATOR

SHORT TRICK TO USE SEMI MINIMIZED EXPRESSION



A: A_1 A_0 = B: B_1 B_0

3 5 3 5

Semiminimized

$$X(A>B) = A_1\overline{B_1} + (A_1 \odot B_1)\cdot A_0\overline{B_0}$$

$$Y(A<B) = \overline{A_1}B_1 + (A_1 \odot B_1)\cdot \overline{A_0}B_0$$

$$Z(A=B) = (A_1 \odot B_1)(A_0 \odot B_0)$$

Minimized

$$X(A>B) = A_1\overline{B_1} + (A_1 + \overline{B_1})\,A_0\overline{B_0}$$

$$Y(A<B) = \overline{A_1}B_1 + (\overline{A_1} + B_1)\cdot \overline{A_0}B_0$$

$$Z(A=B) = (A_1 \odot B_1)(A_0 \odot B_0)$$

3bit semiminimized

A: $A_2 \quad A_1 \quad A_0$

B: $B_2 \quad B_1 \quad B_0$

$$X(A>B) = A_2\overline{B_2} + (A_2 \odot B_2)A_1\overline{B_1} + (A_2 \odot B_2)\cdot(A_1 \odot B_1)A_0\overline{B_0}$$

$$Y(A<B) = \overline{A_2}B_2 + (A_2 \odot B_2)\overline{A_1}B_1 + (A_2 \odot B_2)\cdot(A_1 \odot B_1)\cdot\overline{A_0}B_0$$

$$Z(A=B) = (A_2 \odot B_2)\cdot(A_1 \odot B_1)\cdot(A_0 \odot B_0)$$

HW

Design a 2bit comparator by using one bit comparator?