DLD Lab-07

Magnitude Compactor

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1. Objectives:

Magnitude Comparator

1. Design and implement the circuitry for 1-bit magnitude comparator.
2. Design and implement the circuitry for 2-bit magnitude comparator.
3. Design and implement the circuitry for 4-bit magnitude comparator
   - Truth Table
   - K-Map
   - Equation
   - Circuit Diagram
   - Implementation

Code Converters

Design and implement the circuitry for a BCD-to-Excess 3 Code Converter.

2. Digital Comparator

- It is a combinational (circuit without memory) logic circuit.
- Digital Comparator is used to compare the value of two binary digits.
- There are two types of digital comparator

(i) Identity Comparator

(ii) Magnitude Comparator.

- **IDENTITY COMPARATOR:**
  - This comparator has only one output terminal for when A=B, either A=B=1 (High) or A=B=0 (Low)
- **MAGNITUDE COMPARATOR:**
  - This Comparator has three output terminals namely **A>B, A=B, A<B**. Depending on the result of comparison, one of these output will be high (1)
- Block Diagram of Magnitude Comparator is shown below in Fig. 1

3. Magnitude Comparator

BLOCK DIAGRAM OF MAGNITUDE COMPARATOR

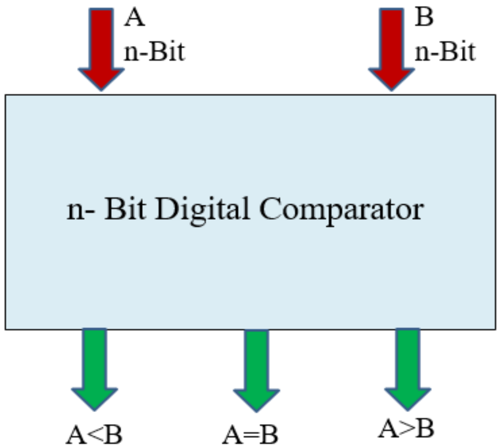


Fig. 1

4. 1-Bit Magnitude Comparator

1. This magnitude comparator has two inputs A and B and three outputs:
2. **A<B, A=B and A>B.**
3. This magnitude comparator compares the two numbers of single bits.
4. Truth Table of 1-Bit Comparator

INPUTS		OUTPUTS		
A	B	Y_1 (A<B)	Y_2 (A=B)	Y_3 (A>B)
0	0	0	1	0
0	1	1	0	0
1	0	0	0	1
1	1	0	1	0

Inputs		Outputs		
A	B	Y_1 (A<B)	Y_2 (A=B)	Y_3 (A>B)
0	0	0	1	0
0	1	1	0	0
1	0	0	0	1
1	1	0	1	0

K-Maps For All Three Outputs :

A \ B	$\overline{B}$ 0	B 1
$\overline{A}$ 0	0	1
A 1	0	0

K-Map for Y_1 : A<B

$Y_1 = \overline{A}B$

A \ B	$\overline{B}$ 0	B 1
$\overline{A}$ 0	1	0
A 1	0	1

K-Map for Y_2 : A=B

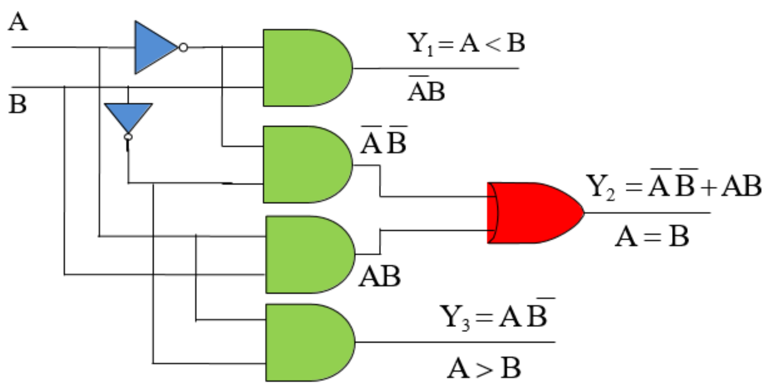
$Y_2 = \overline{A}\,\overline{B} + AB$

A \ B	$\overline{B}$ 0	B 1
$\overline{A}$ 0	0	0
A 1	1	0

K-Map for Y_2 : A>B

$Y_3 = A\overline{B}$

CIRCUIT DIAGRAM OF ONE BIT COMPARATOR

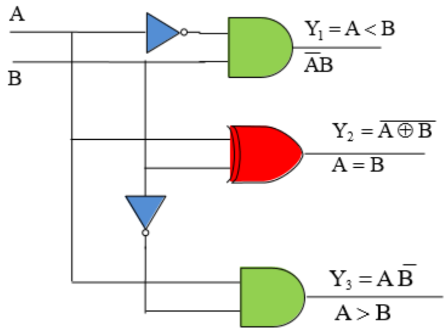


$Y_1 = \overline{A}B$

$Y_2 = \overline{A}\,\overline{B} + AB$

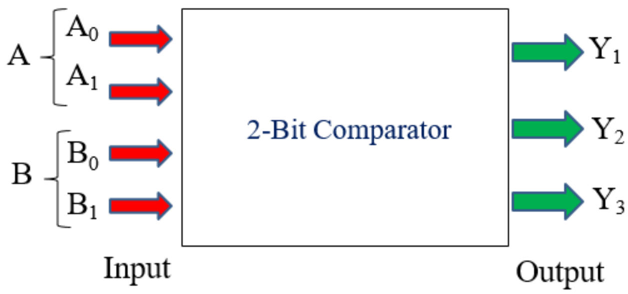
$Y_3 = A\overline{B}$

Circuit Diagram by Using AND , EX-NOR gates



5. 2-Bit Magnitude Comparator

- A comparator which is used to compare two binary numbers each of two
- bits is called a 2-bit magnitude comparator.
- Fig. 2 shows the block diagram of 2-Bit magnitude comparator.
- It has four inputs and three outputs.
- Inputs are A_0 ,A_1,B_0 and B_1 and Outputs are Y_1, Y_2 and Y_3



GREATER THAN (A>B)

A_1	A_0	B_1	B_0
1	0	0	1
1	1	1	0
0	1	0	0

1. If A_1= 1 and B_1= 0 then A>B
2. If A_1 and B_1 are same, i.e A_1=B_1=1 or A_1=B_1=0 and A_0=1, B_0=0 then A>B

LESS THAN (A<B)

Similarly,

1. If A_1= B_1=1 and A_0= 0, B_0=1, then A<B
2. If A_1= B_1= 0 and A_0= 0, B_0=1 then A<B

TRUTH TABLE

INPUT				OUTPUT		
A_1	A_0	B_1	B_0	$Y_1=A<B$	$Y_2=(A=B)$	$Y_3=A>B$
0	0	0	0	0	1	0
0	0	0	1	1	0	0
0	0	1	0	1	0	0
0	0	1	1	1	0	0
0	1	0	0	0	0	1
0	1	0	1	0	1	0
0	1	1	0	1	0	0
0	1	1	1	1	0	0
1	0	0	0	0	0	1
1	0	0	1	0	0	1
1	0	1	0	0	1	0
1	0	1	1	1	0	0
1	1	0	0	0	0	1
1	1	0	1	0	0	1
1	1	1	0	0	0	1
1	1	1	1	0	1	0

K-MAP FOR A<B:

$A_1A_0 \backslash B_1B_0$	00	01	11	10
00	0	1	1	1
01	0	0	1	1
11	0	0	0	0
10	0	0	1	0

For A<B

$$Y_1 = \overline{A_1}\,\overline{A_0}\,B_0 + \overline{A_1}\,B_1 + \overline{A_0}\,B_1\,B_0$$

K-Map for A=B:

$A_1A_0 \backslash B_1B_0$	00	01	11	10
00	1	0	0	0
01	0	1	0	0
11	0	0	1	0
10	0	0	0	1

For A=B

$$Y_2 = \overline{A_1}\,\overline{A_0}\,\overline{B_1}\,\overline{B_0} + \overline{A_1}\,A_0\,\overline{B_1}\,B_0 + A_1A_0B_1B_0 + A_1\,\overline{A_0}\,B_1\,\overline{B_0}$$

K-MAP FOR A>B

A_1A_0 \ B_1B_0	00	01	11	10
00	0	0	0	0
01	1	0	0	0
11	1	1	0	1
10	1	1	0	0

$$Y_3 = A_0\,\overline{B_1}\,\overline{B_0} + A_1\,\overline{B_1} + A_1A_0\,\overline{B_0}$$

FOR A=B FROM K-MAP

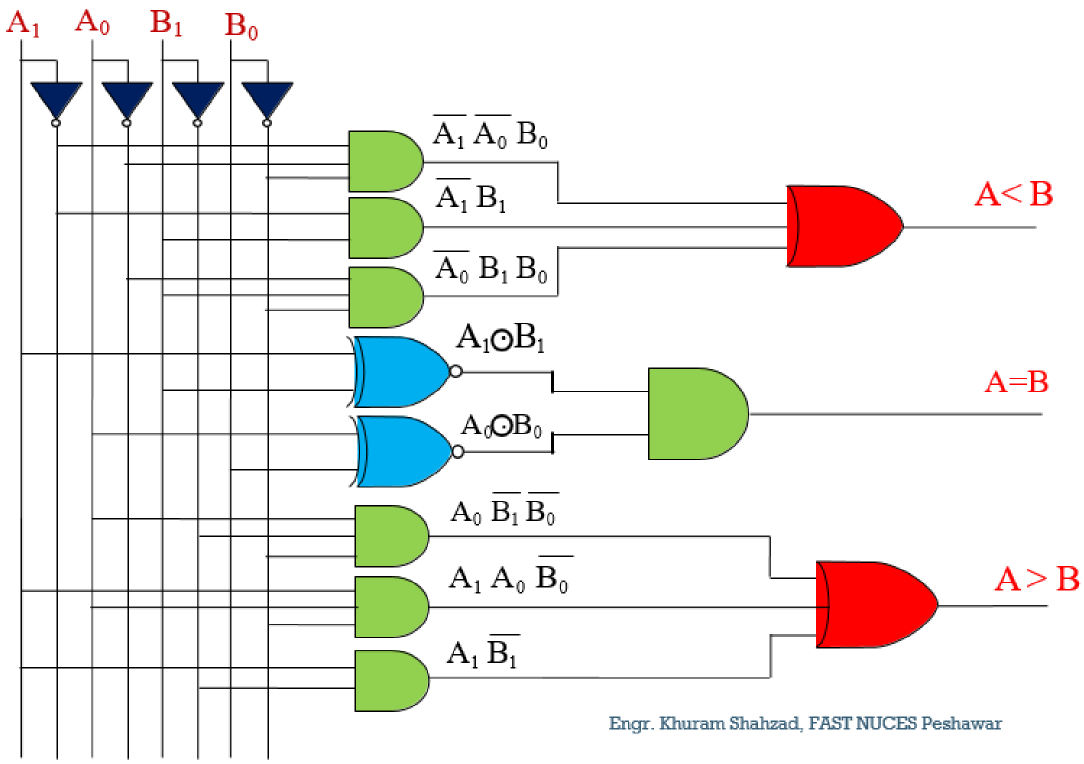
$$Y_2 = \overline{A_1}\,\overline{A_0}\,\overline{B_1}\,\overline{B_0} + \overline{A_1}\,A_0\,\overline{B_1}\,B_0 + A_1A_0B_1B_0 + A_1\,\overline{A_0}\,B_1\,\overline{B_0}$$

$$Y_2 = \overline{A_0}\,\overline{B_0}(\overline{A_1}\,\overline{B_1} + A_1B_1) + A_0B_0(\overline{A_1}\,\overline{B_1} + A_1B_1)$$

$$Y_2 = (\overline{A_1}\,\overline{B_1} + A_1B_1)\;(\overline{A_0}\,\overline{B_0} + A_0B_0)$$

$$Y_2 = (A_1 \odot B_1)(A_0 \odot B_0)$$

LOGIC DIAGRAM OF 2-BIT COMPARATOR:



6. How to design a 4–bit comparator?

The truth table for a 4-bit comparator would have 4^4 = 256 rows. So we will do things a bit differently here. We will compare each bit of the two 4-bit numbers, and based on that comparison and the weight of their positions, we will draft a truth table.

A3B3	**A2B2**	**A1B1**	**A0B0**	**A>B**	**A<B**	**A=B**
A3>B3	x	x	x	1	0	0
A3<B3	x	x	x	0	1	0
A3=B3	A2>B2	x	x	1	0	0
A3=B3	A2<B2	x	x	0	1	0
A3=B3	A2=B2	A1>B1	x	1	0	0
A3=B3	A2=B2	A1<B1	x	0	1	0
A3=B3	A2=B2	A1=B1	A0>B0	1	0	0
A3=B3	A2=B2	A1=B1	A0<B0	0	1	0
A3=B3	A2=B2	A1=B1	A0=B0	0	0	1

- **In a 4-bit comparator the condition of A>B can be possible in the following four cases:**

If A3 = 1 and B3 = 0
If A3 = B3 and A2 = 1 and B2 = 0
If A3 = B3, A2 = B2 and A1 = 1 and B1 = 0
If A3 = B3, A2 = B2, A1 = B1 and A0 = 1 and B0 = 0

- **Similarly the condition for A<B can be possible in the following four cases:**

If A3 = 0 and B3 = 1
If A3 = B3 and A2 = 0 and B2 = 1
If A3 = B3, A2 = B2 and A1 = 0 and B1 = 1
If A3 = B3, A2 = B2, A1 = B1 and A0 = 0 and B0 = 1

- **The condition of A=B is possible only when all the individual bits of one number exactly coincide with corresponding bits of another number.**
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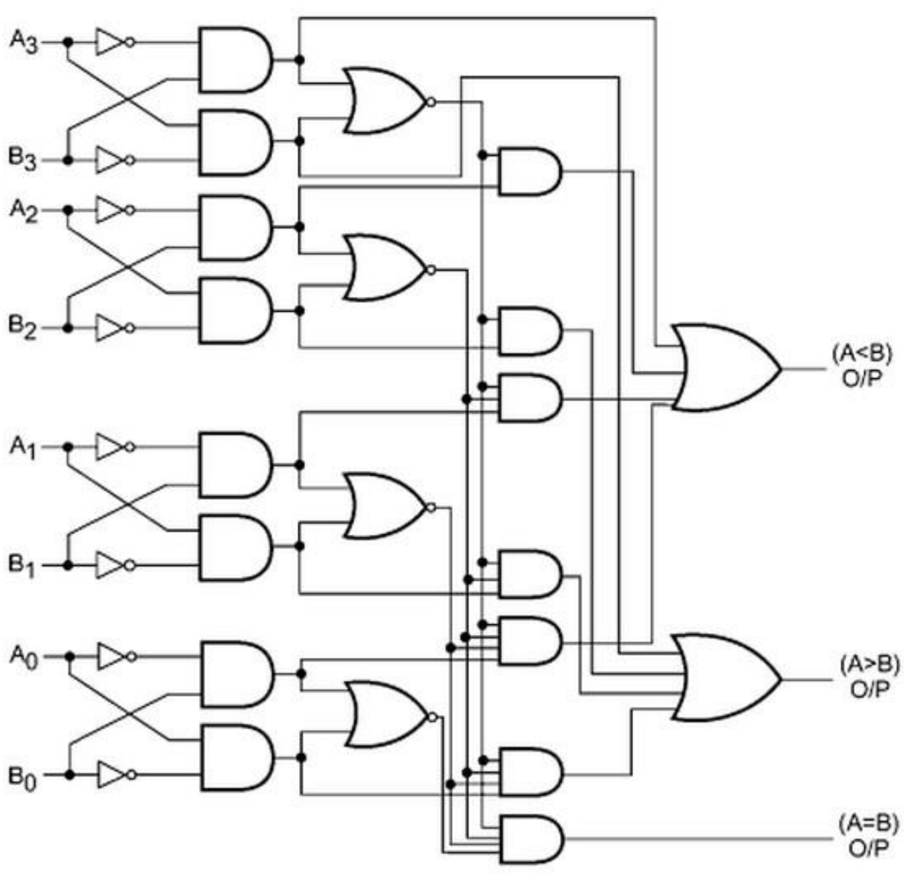
  A=B: (A3 Ex-Nor B3) (A2 Ex-Nor 82) (Al Ex-Nor BI) (AO Ex-Nor BO)



7. Applications of Comparators

- *These are used in the address decoding circuitry in computers and microprocessor based devices to select a specific input/output device for the storage of data.*
- *These are used in control applications in which the binary numbers representing physical variables such as temperature, position, etc. are compared with a reference value. Then the outputs from the comparator are used to drive the actuators so as to make the physical variables closest to the set or reference value.*
- *Process controllers*
- *Servo-motor control*
- *Used in password verification and biometric applications.*

8. Code converters

- The Code converter is used to convert one type of binary code to another.
- There are different types of binary codes like BCD code, gray code, excess-3 code, etc. Different codes are used for different types of digital applications.
- To get the required code from any one type of code, the simple code conversion process is done with the help of combinational circuits.
- A code converter circuit will convert coded information in one form to a different coding form.

9. BCD, Excess-3 code

BCD or 8421 code:-

It is composed of four bits representing the decimal digits 0 through 9. The 8421 indicates

The Excess-3 code:-

It is an important BCD code , is a 4 bit code and used with BCD numbers

To convert any decimal numbers into its excess-3 form ,add 3 to each decimal digit and then convert the sum to a BCD number

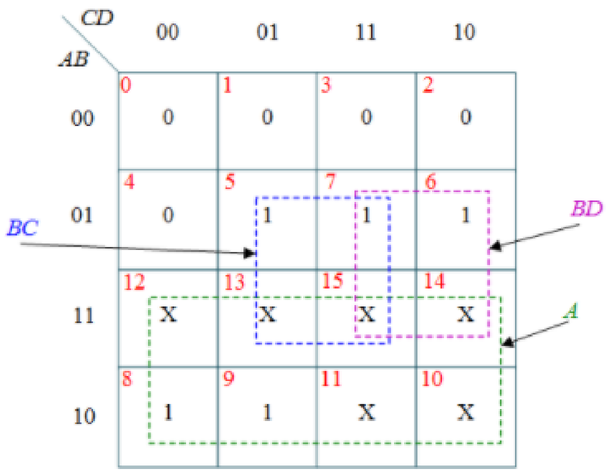
As weights are not assigned, it is a kind of non weighted codes.

Decimal Digit	BCD Code	Excess-3 Code
0	0000	0011
1	0001	0100
2	0010	0101
3	0011	0110
4	0100	0111
5	0101	1000
6	0110	1001
7	0111	1010
8	1000	1011
9	1001	1100

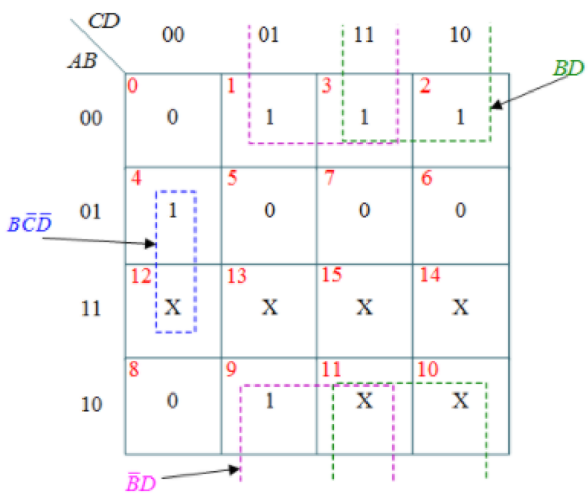
10. Binary, BCD, Excess-3 code

Decimal	Binary	BCD	Excess-3	Gray
0	0	0000	0011	0000
1	1	0001	0100	0001
2	10	0010	0101	0011
3	11	0011	0110	0010
4	100	0100	0111	0110
5	101	0101	1000	0111
6	110	0110	1001	0101
7	111	0111	1010	0100
8	1000	1000	1011	1100
9	1001	1001	1100	1101

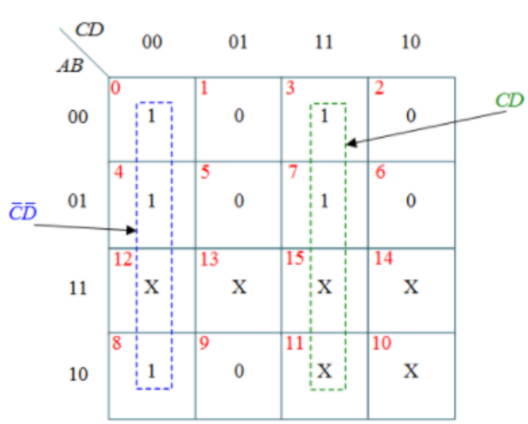
BCD(8421)				Excess-3			
A	B	C	D	w	x	y	z
0	0	0	0	0	0	1	1
0	0	0	1	0	1	0	0
0	0	1	0	0	1	0	1
0	0	1	1	0	1	1	0
0	1	0	0	0	1	1	1
0	1	0	1	1	0	0	0
0	1	1	0	1	0	0	1
0	1	1	1	1	0	1	0
1	0	0	0	1	0	1	1
1	0	0	1	1	1	0	0
1	0	1	0	X	X	X	X
1	0	1	1	X	X	X	X
1	1	0	0	X	X	X	X
1	1	0	1	X	X	X	X
1	1	1	0	X	X	X	X
1	1	1	1	X	X	X	X



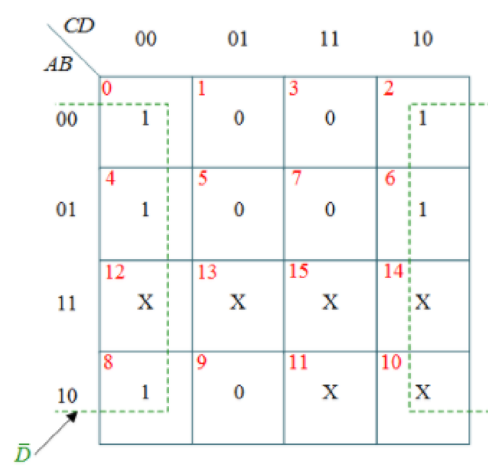
(a) *k-map for W*



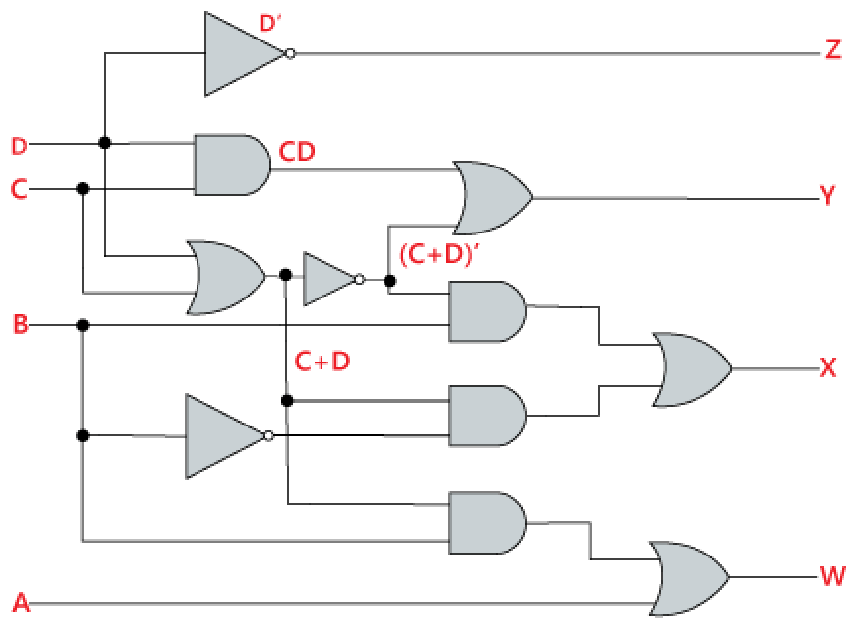
(b) *k-map for X*



(c) *k-map for Y*



(d) *k-map for Z*



11. Students Task

- Implement 1 bit, 2 bit and 4 bit comparator on logic lay
- Implement Excess 3 Converter circuit on on logic lay
- Design K-map and circuit diagram for Gray Code like Excess 3