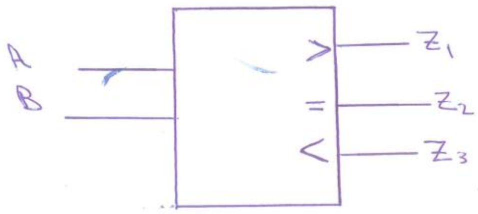
Comparators:-

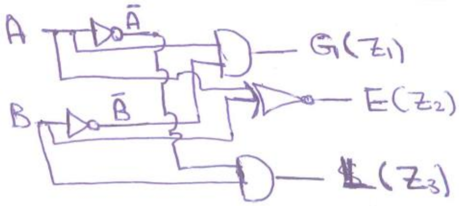
A magnitude Comparator is a combinational circuit that compares two numbers (A and B), and determines their relative magnitudes. The outputs of the comparsion are specified by three binary variables that indicate whether $A=B$ or $A>B$ or $A<B$.

The block diagram for comparator is shown below:-



- For two binary numbers, each one have one bit, the truth table:-

A	B	Z_1 (A>B)	Z_2 (A=B)	Z_3 (A<B)
0	0	0	1 ✓	0
0	1	0	0	1 ✓
1	0	1 ✓	0	0
1	1	0	1 ✓	0



$Z_1(A>B) = A\bar{B}$

$Z_2(A=B) = \bar{A}\bar{B} + AB = A \odot B$

$Z_3(A<B) = \bar{A}B$

- For two binary numbers, each one have two bits $(n=2)$

MSB ↓ MSB ↓

$A = A_1 A_0 \quad , \quad B = B_1 B_0$

Note: $X_0 = A_0 \odot B_0$
$X_1 = A_1 \odot B_1$

$A>B = (A_1 > B_1)$ or $(A_1 = B_1)$ and $(A_0 > B_0)$

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

$= (A_1\bar{B}_1) + X_1 A_0 \bar{B}_0$

* المقارنة دائماً تبدأ من ال MSB

$A<B = (A_1 < B_1)$ or $(A_1 = B_1)$ and $(A_0 < B_0)$

$= \bar{A}_1 B_1 + (A_1 \odot B_1) \cdot (\bar{A}_0 B_0)$

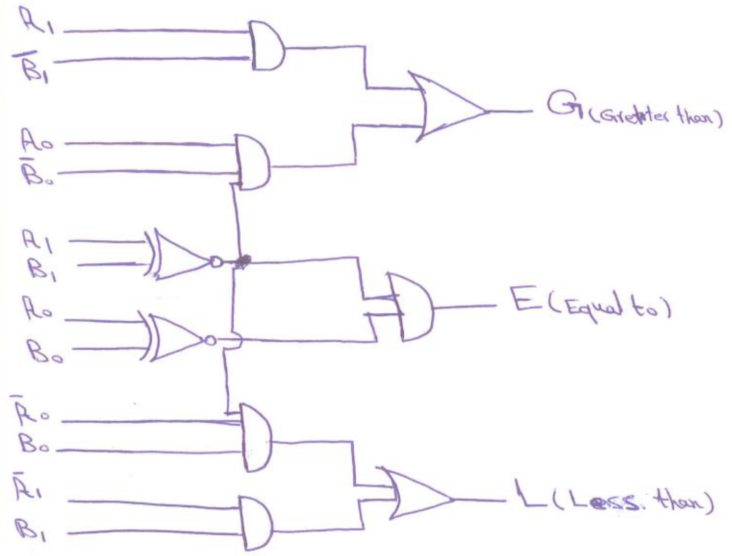
$= \bar{A}_1 B_1 + X_1 \cdot \bar{A}_0 B_0$

$A=B = (A_1 = B_1)$ and $(A_0 = B_0)$

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

$= X_1 X_0$

From the expression we may obtain the digital Comparator circuit as shown below:-



Digital Comparator circuit for 2-bits

- For two binary numbers, each one have 4-bits ($n=4$).

$A = A_3A_2A_1A_0$, $B = B_3B_2B_1B_0$

<u>Note</u>: $X_0 = A_0 \odot B_0$
$X_1 = A_1 \odot B_1$
$X_2 = A_2 \odot B_2$
$X_3 = A_3 \odot B_3$

$A>B(G)$ = $A_3>B_3$ or $A_3=B_3$ and $A_2>B_2$ or $A_3=B_3$ and $A_2=B_2$ and $A_1>B_1$ or $A_3=B_3$ and $A_2=B_2$ and $A_1=B_1$ and $A_0>B_0$

$= A_3\bar{B}_3 + (A_3 \odot B_3)A_2\bar{B}_2 + (A_3 \odot B_3)(A_2 \odot B_2)A_1\bar{B}_1 + (A_3 \odot B_3)(A_2 \odot B_2)(A_1 \odot B_1)(A_0\bar{B}_0)$

$= A_3\bar{B}_3 + X_3A_2\bar{B}_2 + X_3X_2A_1\bar{B}_1 + X_3X_2X_1A_0\bar{B}_0$

$A<B(L)$ = $A_3<B_3$ or $A_3=B_3$ and $A_2<B_2$ or $A_3=B_3$ and $A_2=B_2$ and $A_1<B_1$ or $A_3=B_3$ and $A_2=B_2$ and $A_1=B_1$ and $A_0<B_0$

$= A_3'B_3 + (A_3 \odot B_3)(A_2'B_2) + (A_3 \odot B_3)(A_2 \odot B_2)A_1'B_1 + (A_3 \odot B_3)(A_2 \odot B_2)(A_1 \odot B_1)(A_0'B_0)$

$= A_3'B_3 + X_3A_2'B_2 + X_3X_2A_1'B_1 + X_3X_2X_1A_0'B_0$

$A = B\ (E) = (A_3 = B_3)$ and $(A_2 = B_2)$ and $(A_1 = B_1)$ and $(A_0 = B_0)$

$= (A_3 \odot B_3)(A_2 \odot B_2)(A_1 \odot B_1)(A_0 \odot B_0)$

$= X_3X_2X_1X_0$

Ex:- Implement a comparator of two binary numbers each one have four bits, Let $A = \overset{8421}{0101}$ and $B = \overset{8421}{1101}$

Solution:- $A = A_3A_2A_1A_0$

$B = B_3B_2B_1B_0$

by substitute the values of A and B in the previous equations:-

$G = 0 + 0 + 0 + 0 = 0$

$L = 1 + 0 + 0 + 0 = 1$ $\quad \therefore A < B$

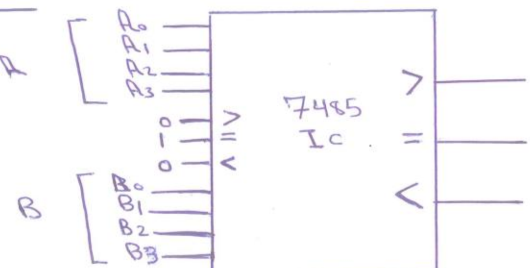
$E = 0 * 1 * 1 * 1 = 0$

H.w:- For each of the binary numbers, determine the output states for the comparator:-

A) $A_3A_2A_1A_0 = 1100$ $\quad$ B) $A_3A_2A_1A_0 = 0100$

$B_3B_2B_1B_0 = 1001$ $\quad$ $B_3B_2B_1B_0 = 0100$

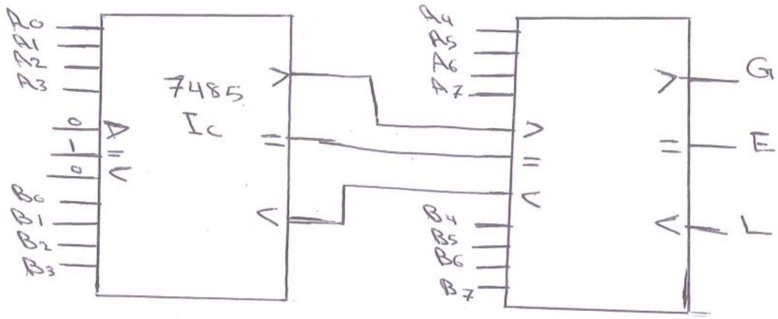
7485 IC:-



Two binary numbers of four bits comparator 7485 IC

Ex:- Use 7485 Ic to compare two binary numbers each one have eight bits:- $A = A_7A_6A_5A_4A_3A_2A_1A_0$
$B = B_7B_6B_5B_4B_3B_2B_1B_0$

Solution:-



Ex:- Design H.A. using Comparators only:-

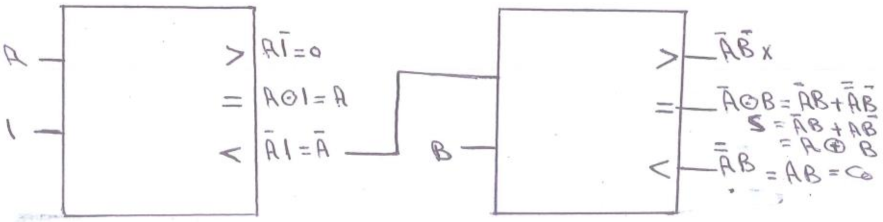
> **Note:-**
> $A \odot 1 = A$
> $A \odot 0 = \bar{A}$

Solution:- H.A

$$\left.\begin{aligned} S &= A\bar{B} + \bar{A}B = A \oplus B \\ C_o &= AB \end{aligned}\right]$$ المعادلات المطلوبة

Comparator

$$\left.\begin{aligned} A > B\,(G) &= A\bar{B} \\ A = B\,(E) &= AB + \bar{A}\bar{B} = A \odot B \\ A < B\,(L) &= \bar{A}B \end{aligned}\right]$$ المعادلات الموجودة



H.W:- Design F.A, using Comparators only.

H.w:- Design H.A by using Comparators and any gate.

H.w:- Design F.A by using Comparator and one gate.

H.W:- Verify all logic gates using Comparator only.
AND, NOR, OR, EX-OR - EX-NOR, NAND, NOT.