Digital Electronics

Combinational Logic Functions

Comparators

The comparison of two numbers is an operation that determines if one number is greater than, less than, or equal to the other number. A magnitude comparator is a combinational circuit that compares two numbers, A and B, and determines their relative magnitudes. The outcome of the comparison is specified by three binary variables that indicate whether

$A > B, A = B,$ or $A < B$.

One Bit Comparator:

The 1-bit comparator compares two 1 bit numbers and gives an output based on the magnitude of two bits. The truth table for the circuit is as shown:

A	B	$A > B$	$A = B$	$A < B$
0	0	0	1	0
0	1	0	0	1
1	0	1	0	0
1	1	0	1	0

$$(A > B) = AB'$$

$$(A = B) = A'B' + AB = (A'B + AB')'$$

$$(A < B) = A'B$$

4 Bit Magnitude Comparator:

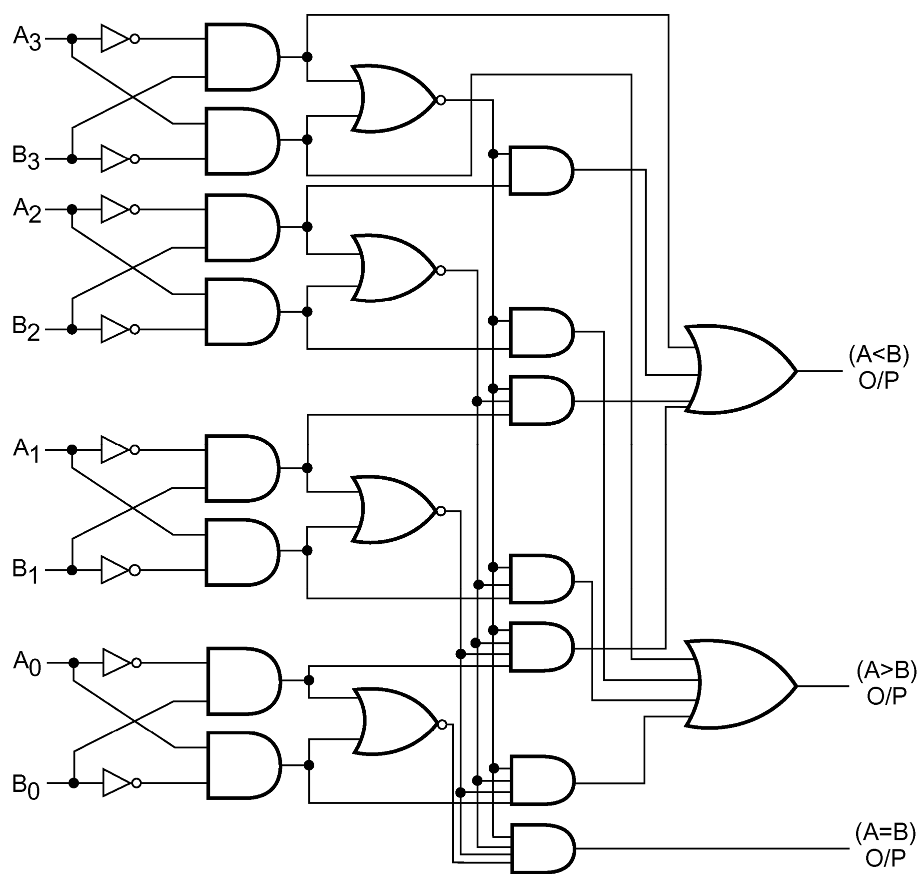
Consider two numbers, A and B, with four digits each.

$$A = A_3A_2A_1A_0; \quad B = B_3B_2B_1B_0$$

The two numbers are equal if all pairs of significant digits are equal, i.e., if $A_3 = B_3$ and $A_2 = B_2$ and $A_1 = B_1$ and $A_0 = B_0$. The equality of the two numbers A and B, is displayed in a combinational circuit by an output variable that is designated as $(A = B)$. This binary variable is equal to 1 if the two input numbers A and B are equal, and it is equal to 0, otherwise.

$$(A = B) = x_3x_2x_1x_0$$

The binary variable $(A = B)$ is equal to 1 if all pairs of digits of the two numbers are equal. To determine if A is greater than or less than B, the relative magnitudes of pairs of significant digits is inspected starting from the most significant position.



If the two digits are equal, the next lower significant pair of digits is compared. This comparison continues until a pair of unequal digits is reached. If the corresponding digit of A is 1 and that of B is 0, we conclude that $A > B$. If the corresponding digit of A is 0 and that of B is 1, we have that $A < B$. The sequential comparison can be expressed logically by the following Boolean functions:

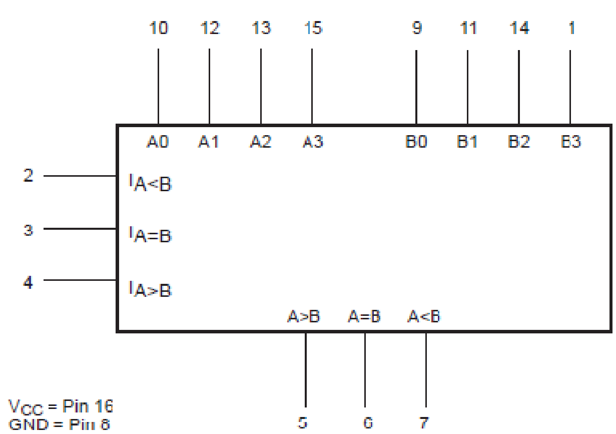
$$(A > B) = A_3B_3' + x_3A_2B_2' + x_3x_2A_1B_1' + x_3x_2x_1A_0B_0'$$

$$(A < B) = A_3'B_3 + x_3A_2'B_2 + x_3x_2A_1'B_1 + x_3x_2x_1A_0'B_0$$

The symbols $(A > B)$ and $(A < B)$ are binary output variables that are equal to 1 when $A > B$ or$A < B$, respectively.

Magnitude Comparator using 7485:

Magnitude comparators are available in IC form. For example, 7485 is a four-bit magnitude comparator of the TTL logic family. The logic circuit inside these devices determines whether one four-bit number, binary or BCD, is *less than*, *equal to* or *greater than* a second four-bit number. It can perform comparison of straight binary and straight BCD (8-4-2-1) codes. These devices can be cascaded together to perform operations on larger bit numbers without the help of any external gates. This is facilitated by three additional inputs called cascading or expansion inputs available on the IC. These cascading inputs are also designated as A = B, A > B and A < B inputs.



The functional table for 7485 is as shown below:

Comparison inputs				Cascading inputs			Outputs		
A_3,B_3	A_2,B_2	A_1,B_1	A_0,B_0	A > B	A < B	A = B	A > B	A < B	A = B
$A_3 > B_3$	X	X	X	X	X	X	HIGH	LOW	LOW
$A_3 < B_3$	X	X	X	X	X	X	LOW	HIGH	LOW
$A_3 = B_3$	$A_2 > B_2$	X	X	X	X	X	HIGH	LOW	LOW
$A_3 = B_3$	$A_2 < B_2$	X	X	X	X	X	LOW	HIGH	LOW
$A_3 = B_3$	$A_2 = B_2$	$A_1 > B_1$	X	X	X	X	HIGH	LOW	LOW
$A_3 = B_3$	$A_2 = B_2$	$A_1 < B_1$	X	X	X	X	LOW	HIGH	LOW
$A_3 = B_3$	$A_2 = B_2$	$A_1 = B_1$	$A_0 > B_0$	X	X	X	HIGH	LOW	LOW
$A_3 = B_3$	$A_2 = B_2$	$A_1 = B_1$	$A_0 < B_0$	X	X	X	LOW	HIGH	LOW
$A_3 = B_3$	$A_2 = B_2$	$A_1 = B_1$	$A_0 = B_0$	HIGH	LOW	LOW	HIGH	LOW	LOW
$A_3 = B_3$	$A_2 = B_2$	$A_1 = B_1$	$A_0 = B_0$	LOW	HIGH	LOW	LOW	HIGH	LOW
$A_3 = B_3$	$A_2 = B_2$	$A_1 = B_1$	$A_0 = B_0$	LOW	LOW	HIGH	LOW	LOW	HIGH
$A_3 = B_3$	$A_2 = B_2$	$A_1 = B_1$	$A_0 = B_0$	X	X	HIGH	LOW	LOW	HIGH
$A_3 = B_3$	$A_2 = B_2$	$A_1 = B_1$	$A_0 = B_0$	HIGH	HIGH	LOW	LOW	LOW	LOW
$A_3 = B_3$	$A_2 = B_2$	$A_1 = B_1$	$A_0 = B_0$	LOW	LOW	LOW	HIGH	HIGH	LOW

Cascading of Magnitude Comparators:

Magnitude comparators available in IC form are designed in such a way that they can be connected in a cascade arrangement to perform comparison operations on numbers of longer lengths. In cascade arrangement, the A = B, A > B and A < B outputs of a stage handling less significant bits are connected to corresponding inputs of the next adjacent stage handling more significant bits. Also, the stage handling least significant bits must have a HIGH level at the A = B input. The other two cascading inputs (A > B and A < B) may be connected to a LOW level.

Ex: Design an 8 bit magnitude comparator using 7485.