Experiment (5)

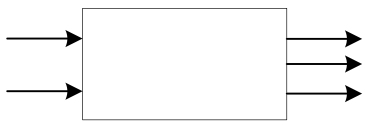
Digital Comparators

7.1 Objectives :

- Understand the function, design and operation of digital comparator.
- Learn practically how to compare two binary numbers by using the 7485 4-bit magnitude comparator chip.

7.2 Background Information :

Digital Comparator "also called Magnitude Comparator" is a combinational circuit that compares two inputs binary quantities (A and B) and generates outputs to indicate whether the inputs are equal or which input is greater than the other, therefore, the circuit has three outputs to indicate whether A=B, A>B or A<B. At any given input quantities, only one output should be equal to logic '1'. Figure 7.1 shows a block diagram of the magnitude comparator.



We will begin by discussing how to compare two single bit numbers. The truth table for the single bit comparator is as shown :

A	B	E	L	G
0	0	1	0	0
0	1	0	1	0
1	0	0	0	1
1	1	1	0	0

Table 7.1 Truth table for Single-bit comparator

From the truth table, we observe that :

$$E = A \odot B$$

$$L = A'\,B$$

$$G = A\,B'$$

Therefore, we can construct the logic circuit of the single-bit magnitude comparator as shown in figure 7.2.

A

Magr
Comp

B

Figure 7.1 Block Diagr

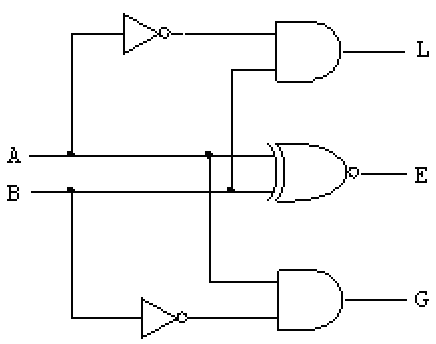


Figure7.2 Logic Diagram of The Single-Bit Comparator

Now, to compare two numbers of sizes more than one bit, a simple algorithm is used. Consider two numbers, A and B, with four digits each.

$A = A_3 A_2 A_1 A_0$
$B = B_3 B_2 B_1 B_0$

The two numbers are equal if all pairs of significant digits are equal; meaning $A_3 = B_3$ and $A_2 = B_2$ and $A_1 = B_1$ and $A_0 = B_0$. To check for this equality, we use the XNOR gate as we did previously.
Let E denotes the condition of equality; so

$E_3 = A_3 \odot B_3$

$E_2 = A_2 \odot B_2$

$E_1 = A_1 \odot B_1$

$E_0 = A_0 \odot B_0$

So, for A = B, all conditions E_3, E_2 , E_1 and E_0 together should be true. Thus,

$$E(A = B) = E_0 E_1 E_2 E_3$$

To determine if A > B or A < B, we check the relative magnitudes of pairs of digits starting from the most significant position. If the pair of digits of the same weight is equal, we compare the next lower significant pair of digits, until a pair of unequal digits is found. If the corresponding digit of A is 1 and that of B is 0, we conclude that A > B; but If the corresponding digit of A is 0 and that of B is 1, we conclude that A < B. This comparison can be expressed as Boolean functions:

$$G\,(A > B) = A_3 B_3' + E_3 A_2 B_2' + E_3 E_2 A_1 B_1' + E_3 E_2 E_1 A_0 B_0'$$
$$L\,(A < B) = A_3' B_3 + E_3 A_2' B_2 + E_3 E_2 A_1' B_1 + E_3 E_2 E_1 A_0' B_0$$

This algorithm has a regular pattern, we can follow the same procedure to obtain a magnitude comparator circuit for binary numbers with more than four bits .

The logic circuit of four-bit magnitude comparator can be constructed using the various logic gates based on to the Boolean expressions we have obtained, but commercially this circuit comes in one chip (7485 TTL 4-bit magnitude comparator). This chip provides three decoded outputs that indicates which of the two inputs nipples (4-bit) is larger than the other or if both nibbles are equal. It also include three cascade inputs to allow two or more chips to compare two inputs having eight or more bits.

In this experiment construct a single-bit magnitude comparator and test its operation, also use the 7485 chip to built a circuit that allows you to apply two 4-bit inputs and monitor the three LEDs that indicate status of the chip's outputs.

7.3 Equipments Required :

Universal Breadboard
Jumper wire kit
1x 7404 Hex INVERTERS
1x 7408 QUAD 2-INPUT AND GATES
1x 74266 QUAD 2-INPUT EXCLUSIVE-NOR GATES
1x 7485 4-BIT MAGNITUDE COMPARATORS
8x Toggle switches
1x Carbon-film Resistor (470Ω)
3x LEDs

7.4 Procedure :

Step 1 :

1. Construct the logic circuit of the single-bit magnitude comparator that shown in Figure 7.2.
2. Use different sets of inputs for A and B to check each of the outputs L,E and G.

Step 2 :

1. Construct a 4-bit magnitude comparator circuit using 7485 chip.
2. Verify the function of the circuit by applying different sets of inputs and monitoring the outputs.

Questions:

1) Design a 2-bit magnitude comparator, showing all design steps and logic diagrams?
2) Design a 4-bit magnitude comparator using 4-bit subtractor, use block diagram? And explain the way it works.
3) Give a summary of the points that you have learned from this experiment.