**Name of the Experiment:**

**(a) Prove the Universality of NOR Gate**

**(b) Realize Ex-NOR Gate Using NAND Gates Only**

**Theory:** A logic gate is an idealized or physical device implementing a Boolean function; that is, it performs a logical operation on one or more logical inputs, and produces a single logical output. A logic gate, using only which any other gate can be realized, is called universal gate. To prove the universality of a gate, it is enough to show that the three basic gates (OR gate, AND gate and NOT gate) can be realized by using only that gate. Because any logic gate is a combination of these gates. Following is an introduction to these three gates:

OR Gate: A logic gate that gives a high output (1) if **one or more** of its inputs are high, otherwise it gives low output (0).

AND Gate: A logic gate that gives a high output (1) only if all its inputs are high, otherwise it gives low output (0).

NOT Gate: A logic gate that that gives an inverted version of it’s input to it’s output. It always has only one input. If the input is high (1), the output is low (0); if the input is low (0), the output is high (1).

NOR gate and NAND gate are universal gates. Following is an introduction to these two gates:

NOR Gate: A logic gate that gives a high (1) output only if all it’s inputs are low (0), otherwise it gives a low (0) output. Actually it operates like an OR gate followed by an inverter. An IC-7402 has four NOR gates.

NAND Gate: A logic gate that gives a low (0) output only if all it’s inputs are high (1), otherwise it gives a high (1) output. Actually it operates like an AND gate followed by an inverter. An IC-7400 has four NAND gates.

In this experiment, we’ll show that by using only NOR gate(s), we can realize OR gate (figure 2a), AND gate (figure 2b) and NOT gate (figure 2c). We’ll also show that we can realize Ex-NOR gate using only NAND gates (figure 2d and 2e). Following is an introduction to the Ex-NOR gate:

Ex-NOR Gate: A logic gate that gives a low (0) output only if an odd number of it’s inputs are high (1), otherwise it gives a high (1) output. For simplicity, we can say that, an Ex-NOR gate with only two inputs gives a low (0) output only if both it’s inputs are same. If the two inputs are different, it gives a high (1) output.

**Instruments:**

1. Trainer Board,
2. Connecting wires,
3. IC’s: IC-7402 (NOR gate), IC-7400 (NAND gate) (two).

**Procedure:**

1. First, we placed the IC-7402 (NOR gate) on the bread board of the trainer board. It was placed on the gap of the bread board so that all the pins were disconnected to each other.
2. Then we connected +5V source to pin-14, ground voltage to pin-7.
3. To realize OR gate, AND gate and NOT gate, we connected the inputs to the IC-7402 and the output to a small red bulb such that the connections were similar with the connections in figure 2a, 2b and 2c.
4. Then we verified the outputs for all possible combinations of the input with the help of the truth tables of OR gate, AND gate and NOT gate. We considered the red bulb on as high (1) and red bulb off as low (0).
5. Next, we placed two IC-7400 (NAND gates) in the same way as described in step no. 1 and step no. 2.
6. To realize Ex-NOR gate, first we simplified the expressions of Ex-NOR gate for two inputs. The immediate step before simplification is given in figure 2d. Then we connected the inputs to the IC’s and the output to a small red bulb such that the connection was similar with the connection in figure 2e.
7. Again, we verified the outputs for all possible combinations of the input with the help of the truth table of Ex-NOR gate. This time also we considered the red bulb on as high (1) and red bulb off as low (0).

**Result:**

//The truth tables…

The outputs for all combinations of the inputs matched the truth tables of NOT gate, NOR gate, NAND gate and Ex-NOR gate. This proves that NOR gate is a universal gate and Ex-NOR gate can be realized using only NAND gates.

**Discussion:** Through the whole experiment we found that it is possible to realize any gate by using only NOR gate(s) or by using only NAND gate(s). However, we faced some problems while doing the experiment. To realize Ex-NOR gate we needed two IC-7400. But we received a wrong IC and it took us some time to find out which IC was the wrong one. We analyzed the output’s from all the gates to find if the gate is working properly. This way we successfully found the wrong IC and continued with a new correct one.