Digital Logic Design (EL-1005)

LABORATORY MANUAL

Spring-2022

LAB 03
Universal Logic Gates

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STUDENT NAME ROLL NO SEC

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INSTRUCTOR SIGNATURE & DATE

MARKS AWARDED: /02

NATIONAL UNIVERSITY OF COMPUTER AND EMERGING SCIENCES (NUCES), KARACHI

Date: 14th Feb 2022

Lab Session 03: Universal Logic Gates

OBJECTIVES:

The objectives of this lab is:

- To study the realization of basic gates using universal gates (NAND gate & NOR gate)
- To learn technology mapping (NAND-NAND & NOR-NOR implementation) and its significance in order to obtain cost effective circuit for implementation

APPARATUS:

- Logic trainer
- Logic probe

COMPONENTS:

ICs 74LS02, 74LS00, Jumper Wire

Introduction:

The design of a combinational circuit starts from the specification of the problem and culminates in a logic diagram or net-list that describes a logic diagram. The procedure involves the specification, formulation, optimization, & technology mapping.

Technology mapping is actually transformation of logic diagram or net-list to a new diagram using the available implementation technology. Typically NAND and NOR gates are more desirable to use in technology mapping due to the following reasons:

1. NAND and NOR gates are said to be universal gates where universal gate is a gate which can implement any Boolean function without needing any other type of gate.
2. Using universal gate in technology mapping may further reduce cost of optimized logic diagram.
3. Universal gates are easier to fabricate with electronic components.

A convenient way to implement a Boolean function with NAND gates only (NAND-NAND implementation) is to begin with the optimized logic diagram of the circuit consisting of AND, OR and NOT gates. The function is converted to pure NAND logic by replacing each gate in logic diagram with its representation using NAND gates only as shown in figure 5-1. After that, all inverter pairs are cancelled. The same conversion procedure is applied to implement a Boolean function with NOR gates only (NOR-NOR implementation).

Universal Logic Gates:

A. **NAND Gate:**

"It is a device whose output is 1 if at least one or all of the inputs are low (0)"

Symbol:

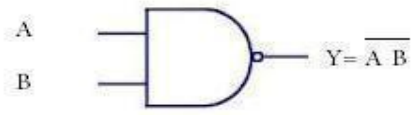

Figure 2 NAND Gate Symbol

Function Table:

Inputs		Output
A	**B**	**Y**
L	L	H
L	H	H
H	L	H
H	H	L

Table: 1 NAND Gate Truth Table

H= Logic High, L= Logic Low

Connection Diagram:

74LS00 IC contains four 2-input NAND gates. The connection diagram for this IC are shown below:

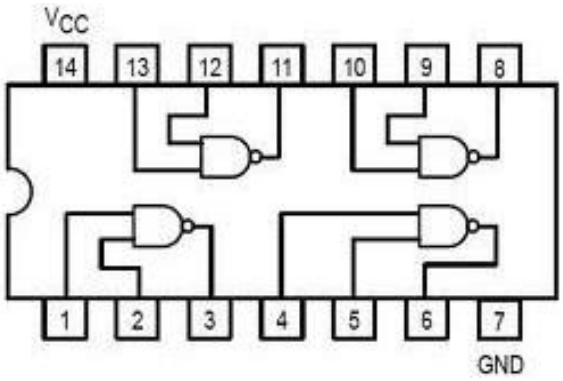

Figure 2 NAND Gate Connection diagram

B. **NOR Gate:**

"It is a device whose output is 1 if all the given inputs are low (0)".

Symbol:

Figure 3 NOR Gate Symbol

Function Table:

Inputs		Output
A	**B**	**Y**
L	L	H
L	H	L
H	L	L
H	H	L

Table: 2 NOR Gate Truth Table

H= Logic High, L= Logic Low

Connection Diagram:

74LS02 IC contains four 2-input NOR gates. The function table and connection diagram for this IC are shown below:

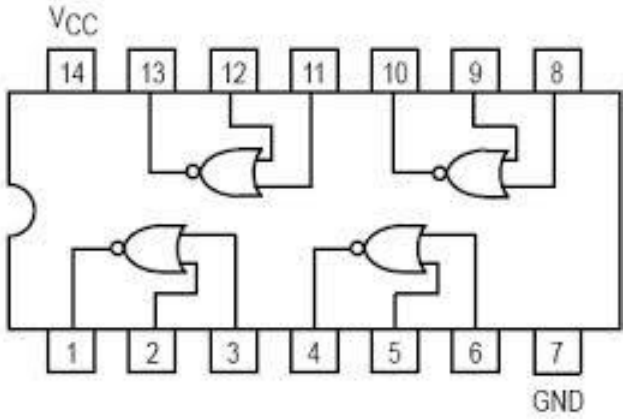

Figure 4 NOR Gate Connection diagram

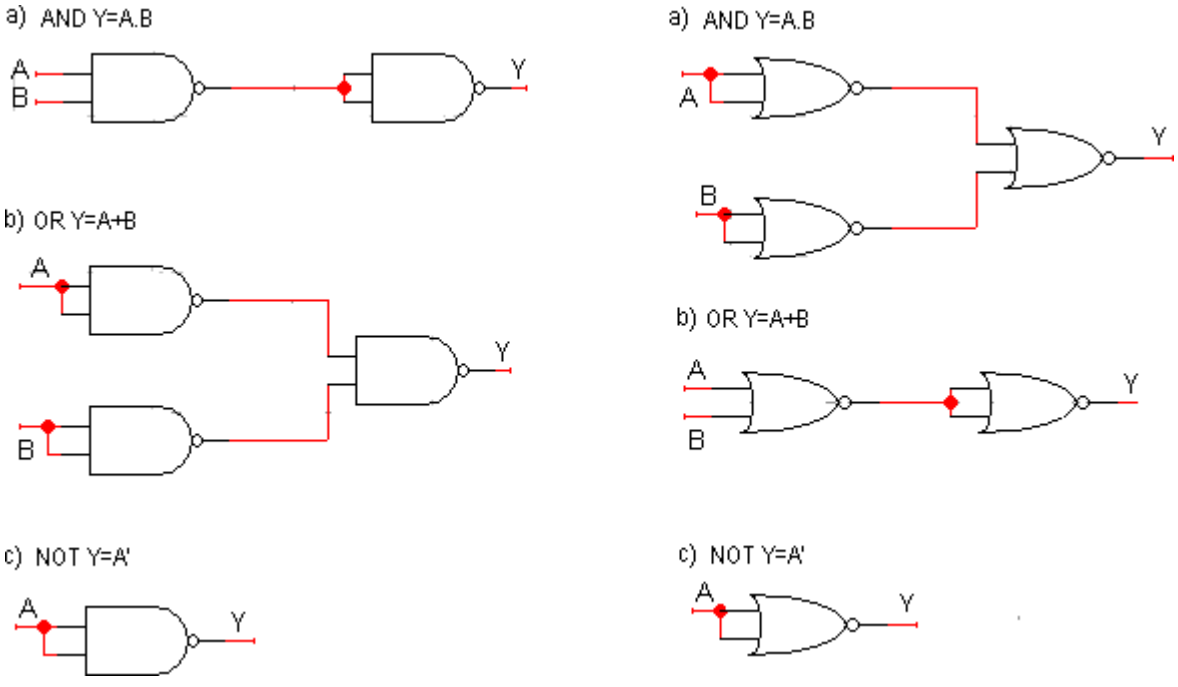

Figure 5 NAND-NAND and NOR-NOR representation of basic logic gates

Application of Universal Gates:

1. **Burglar alarm**

When the switch is closed one input of the NAND gate is LOW. When the LDR is in the light the other input is LOW. This means that if either of these things happen, i.e. the switch is closed or the light is on one of the inputs is LOW, the output is HIGH and the buzzer sounds.

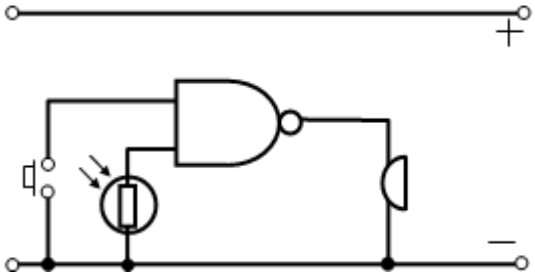

Figure 6 NAND- Gate Based Burglar alarm

2. **Freezer warning buzzer**

When the thermistor is COLD its resistance is LARGE and the input to the NAND gate is high. Since the NAND gate is connected as an INVERTER the output is LOW. As the thermostat warms up its resistance decreases, the voltage across it falls and the input to the NAND gate falls.

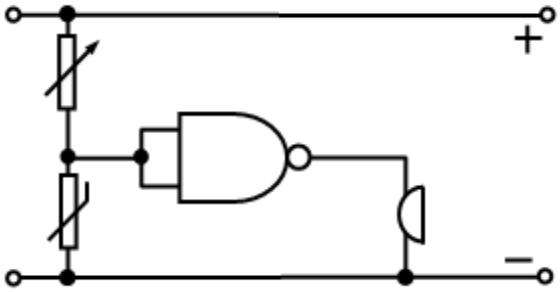

Figure 7 NAND- Gate Based Freezer warning buzzer

3. **Car Door Open System of an Automobile**

A car needs to be designed that the driver gets a visual indication if any of the doors of the car is open so that it helps to avoid accident and injury to the passengers. Assuming there are two doors (just for simplicity, it works for more doors as well) where this system is fitted, the circuit can be designed using a NAND gate as follows You can see from the figure that when any of the switches is open due to the door position, the NAND gate energies the lamp inside the car, hence warning the driver.

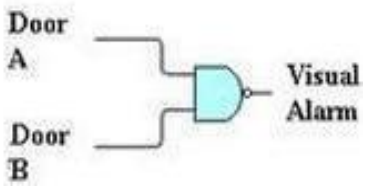

Figure 8 NAND- Gate Based Car Open System of an Automobile

Report for Experiment 03

Name_____StudentID_____Section_____Date_____

Exercise#01 Implement the Secondary/Advanced Logic (2-INPUT) Gates on Logic Works.

Exercise#02 Implement the Secondary/Advanced Logic (2-INPUT) using IC on Logic Works.

Exercise#03 Design the circuit for XOR Logic circuit using Basic Gates (AND-OR-NOT) on Logic Works.

Exercise#04 Design the circuit for XNOR Logic circuit using Basic Gates (AND-OR-NOT) on Logic Works

Exercise#05 Implement the following scenario/ Logic on Logic Works

Two tanks store certain liquid chemicals that are required in a manufacturing process. Each tank has a sensor that detects when the chemical level drops to 25% of full. The sensors produce a HIGH level of 5 V when the tanks are more than one-quarter full. When the volume of chemical in a tank drops to one-quarter full, the sensor puts out a LOW level of 0 V.

It is required that a single red light-emitting diode (LED) on an indicator panel show when both tanks are more than one-quarter full. Show how a NAND gate can be used to implement this function.

Exercise#06 Analysis and Design Logic Circuit on Logic Works for the following scenario/ Logic.

For the process described in Exercise 05 it has been decided to have a red LED display come on when at least one of the tanks falls to the quarter-full level rather than have the green LED display indicate when both are above one quarter. Design circuit on logic works that shows how this requirement can be implemented.

Exercise#07 Analysis and Design Logic Circuit on Logic Works for the following scenario/ Logic.

As part of an aircraft's functional monitoring system, a circuit is required to indicate the status of the landing gears prior to landing. A green LED display turns on if all three gears are properly extended when the "gear down" switch has been activated in preparation for landing.

A red LED display turns on if any of the gears fail to extend properly prior to landing. When a landing gear is extended, its sensor produces a LOW voltage. When a landing gear is retracted, its sensor produces a HIGH voltage. Implement a circuit to meet this requirement.

Exercise#08 Design the circuit following scenario/ Logic on Works

A certain system contains two identical circuits operating in parallel. As long as both are operating properly, the outputs of both circuits are always the same. If one of the circuits fails, the outputs will be at opposite levels at some time. Devise a way to monitor and detect that a failure has occurred in one of the circuits **design the circuit following scenario/ Logic on Logic Works**.

TRUE/FALSE

1. An inverter performs a NOT operation.
2. A NOT gate cannot have more than one input.
3. If any input to an OR gate is zero, the output is zero.
4. If all inputs to an AND gate are 1, the output is 0.
5. A NAND gate can be considered as an AND gate followed by a NOT gate.
6. A NOR gate can be considered as an OR gate followed by an inverter.
7. The output of an exclusive-OR is 0 if the inputs are opposite.