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Faculty of Engineering
Department of Electrical and Electronic Engineering

DIGITAL LOGIC AND CIRCUITS LAB

SECTION: P

GROUP: 03

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TITLE: Studying different digital logic gates and designing of basic logic gates using Universal gates

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American International University-Bangladesh
Department of Electrical and Electronic Engineering
EEE3102: Digital Logic & Circuits Laboratory

Title: Studying different digital logic gates and designing of basic logic gates using Universal gates.

Abstract:

To become familiar with the digital trainer board and digital ICs, as well as to learn the properties of many logic gates.

Part I (Basic Logic IC's):

An integrated circuit (also referred to as an IC, a chip, or a microchip) is a set of electronic circuits on one small plate ("chip") of semiconductor material, normally silicon. This can be made much smaller than a discrete circuit made from independent components. Different integrated circuits are used to implement different logical operations in the trainer board which will be introduced in this experiment.

Theory and Methodology:

Individual logic gates can be connected to form a variety of different switching functions and combinational logic circuits. the three most basic logic gates are the: AND, OR and NOT gates, and given this set of logic gates it is possible to implement all the possible Boolean switching functions, thus making them a "full set" of Universal Logic Gates.
By using logical sets in this way, the various laws and theorems of Boolean Algebra can be implemented with a complete set of logic gates. In fact, it is possible to produce every other Boolean function using just the set of AND and NOT gates since the OR function can be created using just these two gates. Likewise, the set of OR and NOT can be used to create the AND function.
Any logic gate which can be combined into a set to realize all other logical functions is said to be a universal gate with a complete logic set being a group of gates that can be used to form any other logic functions.
For example, AND and NOT constitute a complete set of logic, as does OR and NOT as cascading together an AND with a NOT gate would give us a NAND gate. Similarly cascading an OR and NOT gate together will produce a NOR gate, and so on. However, the two functions of AND and OR on them own do does not form a complete logic set.

A logic gate is an elementary building block of a digital circuit. Most logic gates have two inputs and one output. At any given moment, every terminal is in one of the two binary conditions low (0V) and high (5V), represented by different voltage levels. The logic state of a terminal can, and generally does, change often, as the circuit processes data. In most logic gates, the low state is approximately zero volts (0 V), while the high state is approximately five volts positive (+5 V).

There are seven basic logic gates: AND, OR, NOT, NOR, NAND, XOR and XNOR. Different logic operations of different IC's will be introduced which perform the following characteristics:

Operation	Expression
AND	Y=AB
OR	Y=A+B
NOT	Y=$\bar{A}$
NOR	Y=$\overline{A+B}$ $\bar{A}\bar{B}$
NAND	Y=$\overline{AB}$= $\bar{A}$ $\bar{B}$
XOR	Y=A$\oplus B$ $\bar{A}$= B+$\bar{B}$
XNOR	Y= AB+$\bar{A}\bar{B}$ $\overline{AB}$

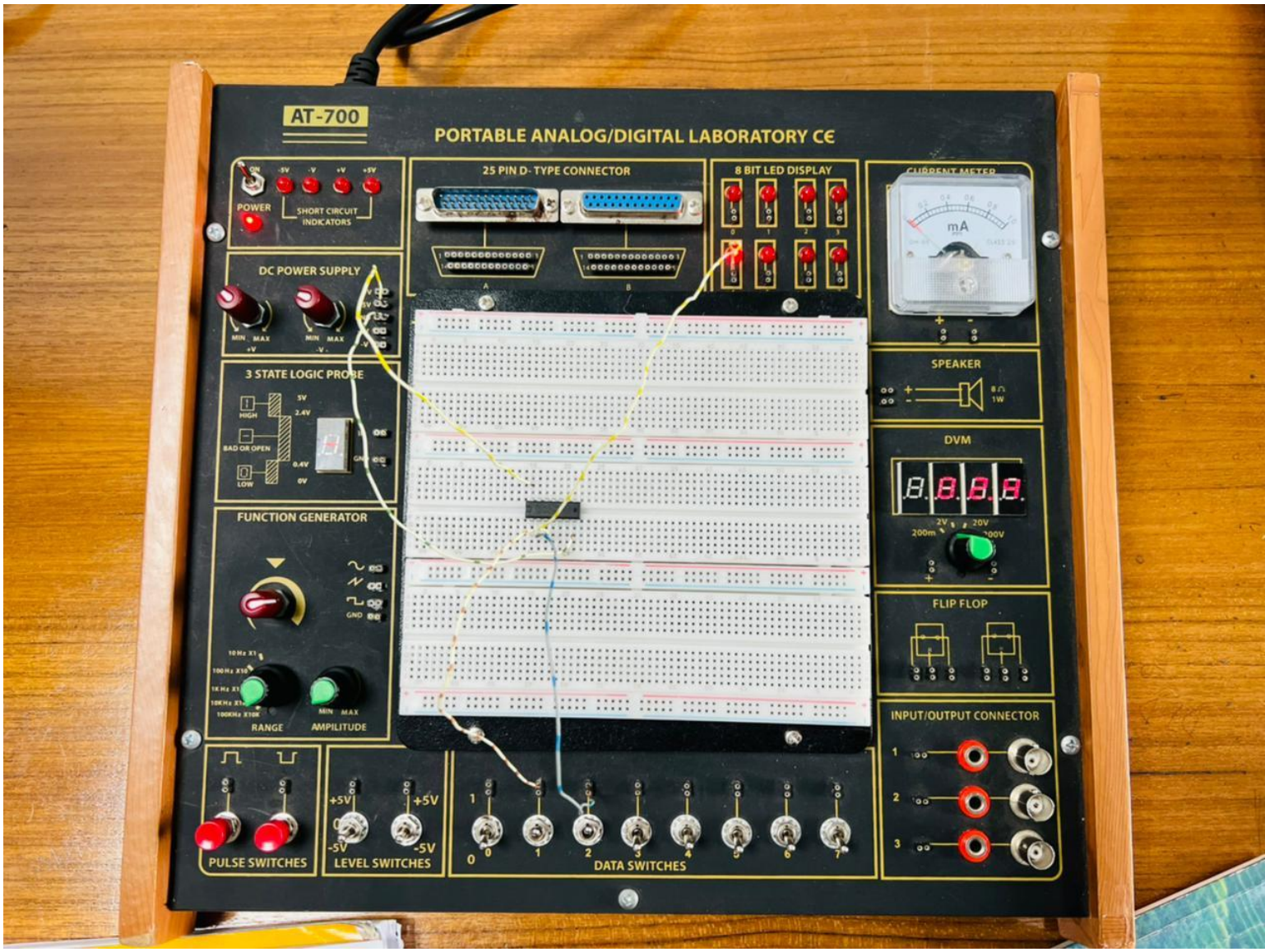
AND operation:

The AND operation produces a high if and only if all the inputs are high. An AND gate can have two or more inputs and performs AND operation or logical multiplication.

Fig1.1: Symbol of AND gate

Truth Table:

Input, A	Input, B	Output, F
0	0	0
0	1	0
1	0	0
1	1	1


AT-700
PORTABLE ANALOG/DIGITAL LABORATORY CE
POWER
SHORT CIRCUIT INDICATORS
25 PIN D- TYPE CONNECTOR
8 BIT LED DISPLAY
DC POWER SUPPLY
3 STATE LOGIC PROBE
HIGH
BAD OR OPEN
LOW
FUNCTION GENERATOR
RANGE
AMPILITUDE
SPEAKER
DVM
FLIP FLOP
INPUT/OUTPUT CONNECTOR
PULSE SWITCHES
LEVEL SWITCHES
DATA SWITCHES

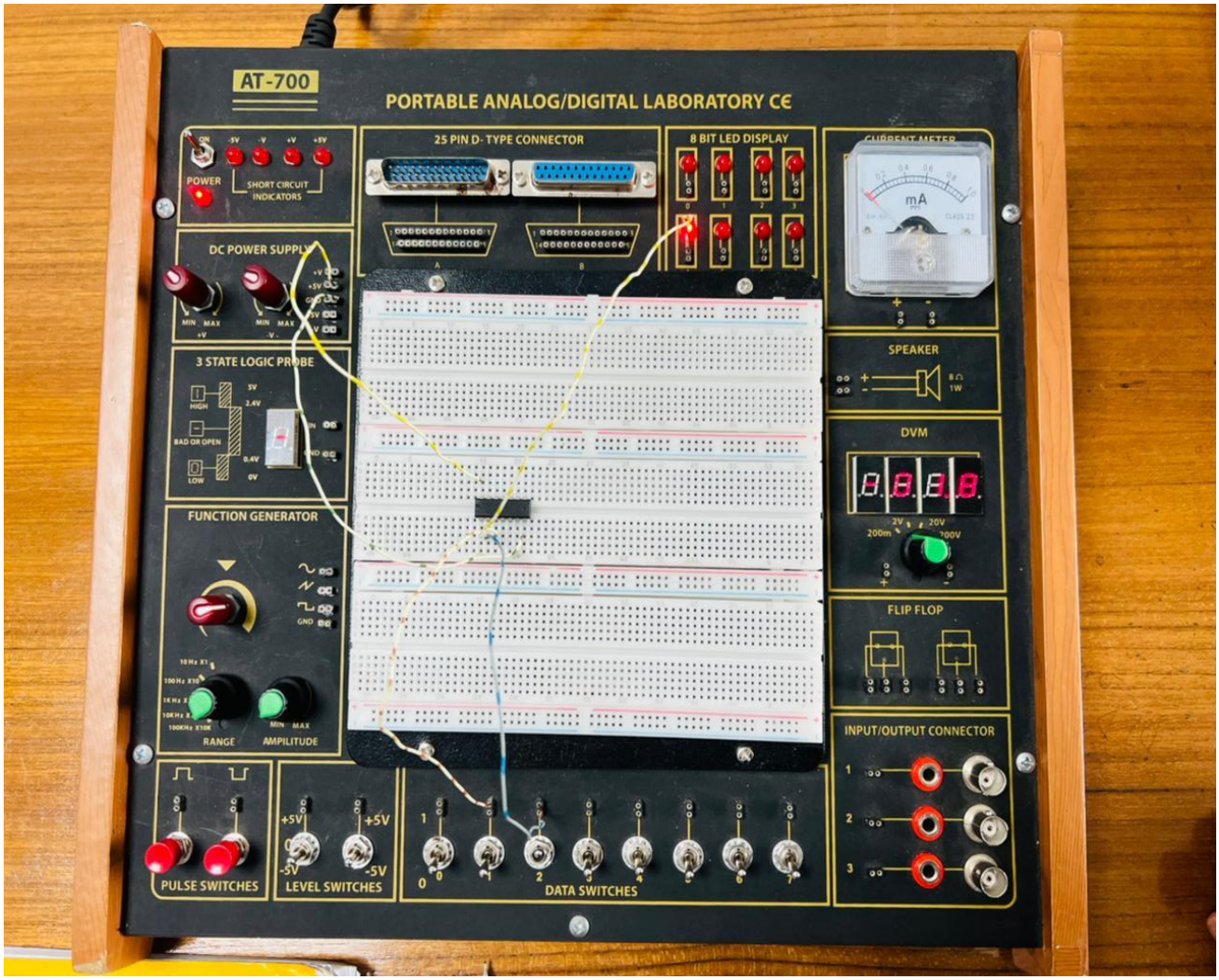
Pin configuration for IC-74HC08N:
For a quadrature 2input AND gate HC08 device code is used. 74HC series devices are designed to work with a 5 V power supply, voltages from 2 V to 5 V are allowed and most circuits work well using 5 V.

OR operation:
The OR operation produces a high output when any of the inputs are high. It has two or more inputs and one output which performs OR operation or logical addition.

Fig 1.2: Symbol of OR gate

Truth Table:

Input, A	Input, B	Output, F
0	0	0
0	1	1
1	0	1
1	1	1



Pin configuration for IC-74HC32N:

HC32 is the device code. 74HC32 is a Quad 2-input OR gate (High Speed CMOS version) which has lower current consumption/wider Voltage range from 2 to 5V. It requires low input current of 1μA with high noise immunity characteristics of CMOS devices.

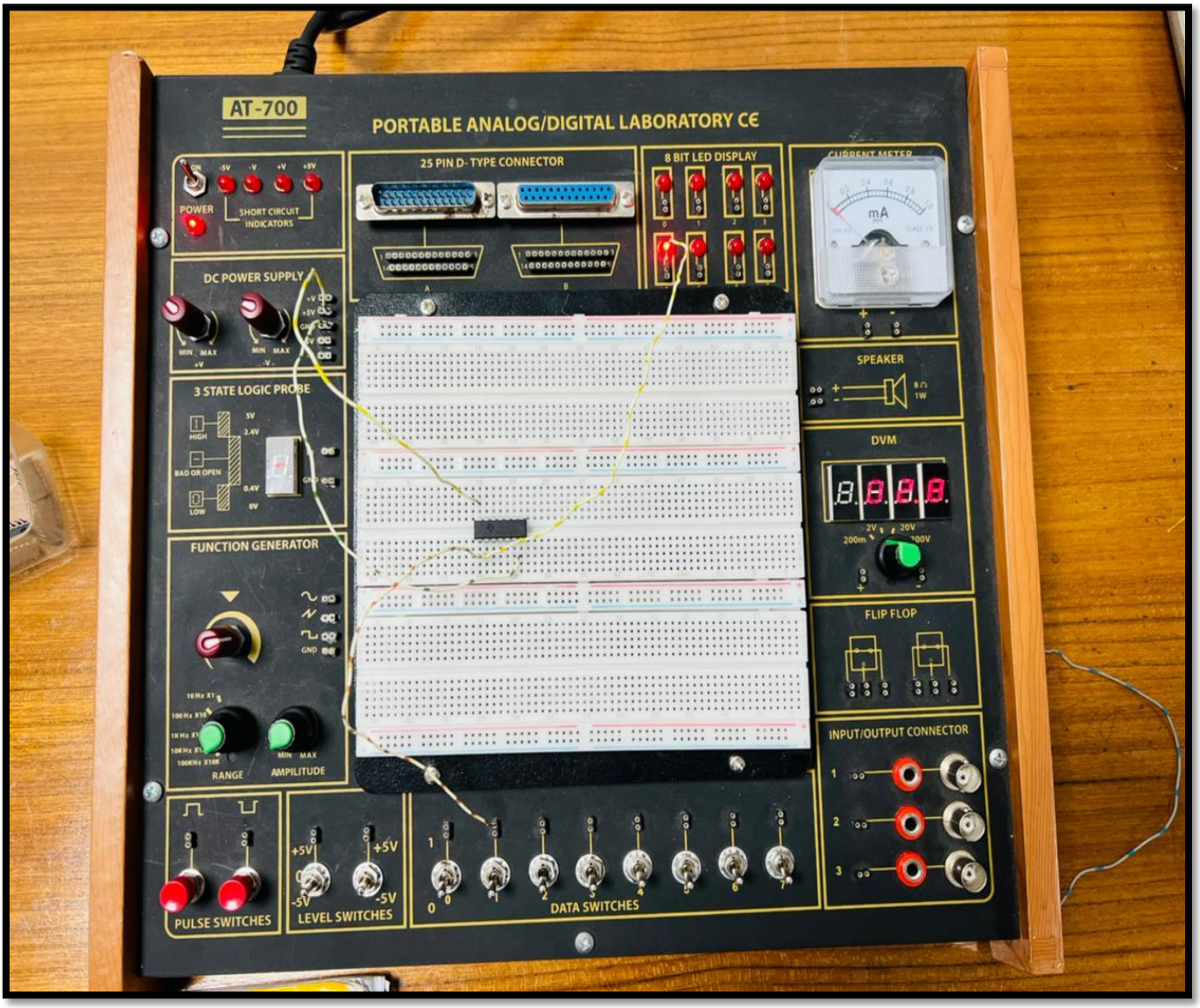
NOT operation:

The NOT operation changes one logic level to the opposite logic level. It is implemented by a logic circuit known as an inverter.

Fig1.3: Symbol of NOT gate

Truth Table:

Input, A	Output, F
0	1
1	0



Pin configuration for IC-74HC04N:

The 74HC04 is a hex inverter which consists of six inverters which perform logical invert action. The inputs include clamp diodes that enable the use of current limiting resistors to interface inputs to voltages more than V_{CC}. The Input level for 74HC04 is CMOS level.

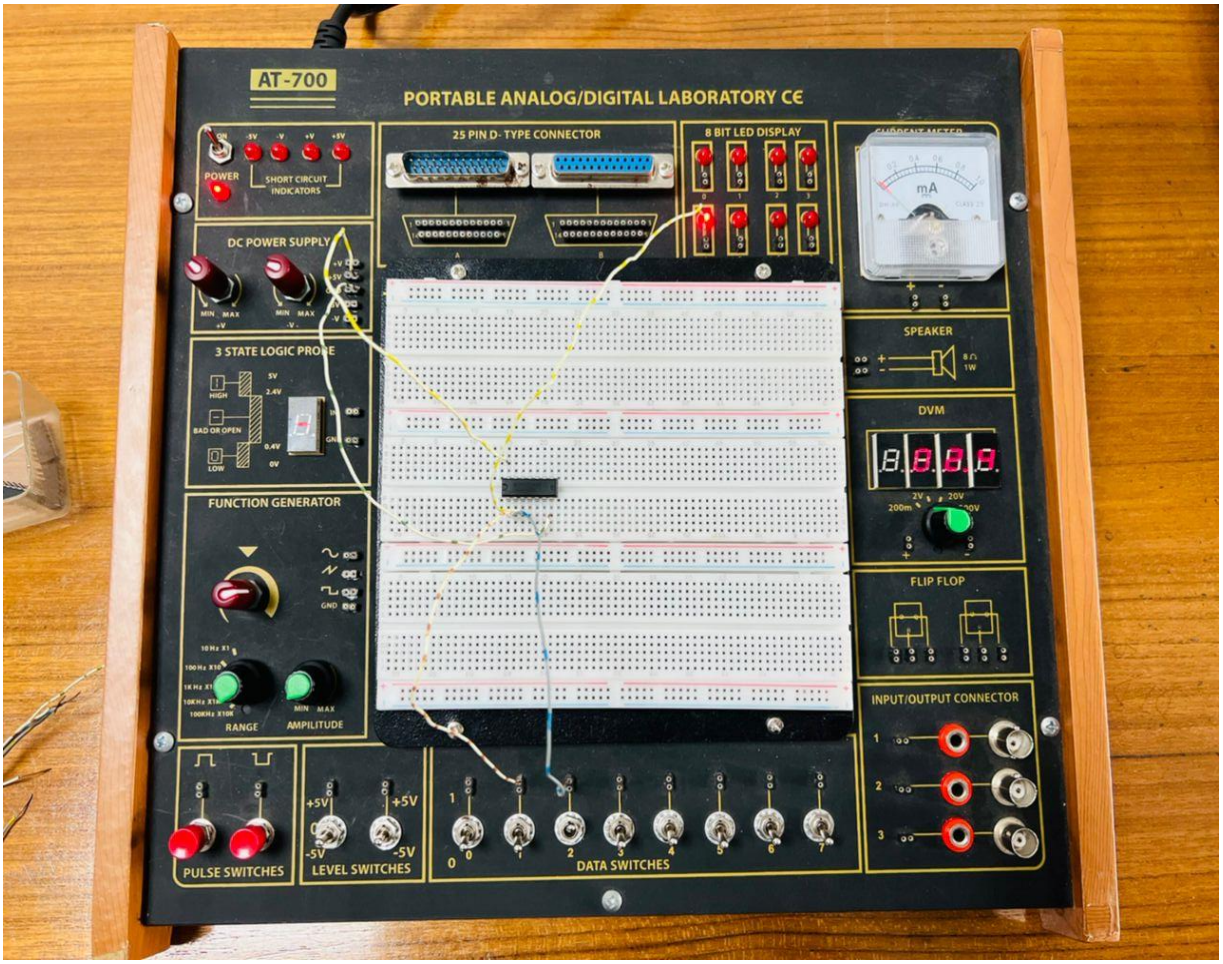
NAND operation:

The NAND gate operates as an AND gate followed by a NOT gate. It acts in the manner of the logical operation "AND" followed by negation. The output will be low if both inputs are high. Otherwise, the output is high.

Fig 1.4: Symbol of NAND gate

Truth Table:

Input, A	Input, B	Output, F
0	0	1
0	1	1
1	0	1
1	1	0



Pin configuration for IC-74HC00N:

HC00 is the device code. The device inputs are compatible with Standard CMOS outputs, with pullup resistors. The operating voltage range is 2.0 to 5.0 V and low input current is 1.0 μA.

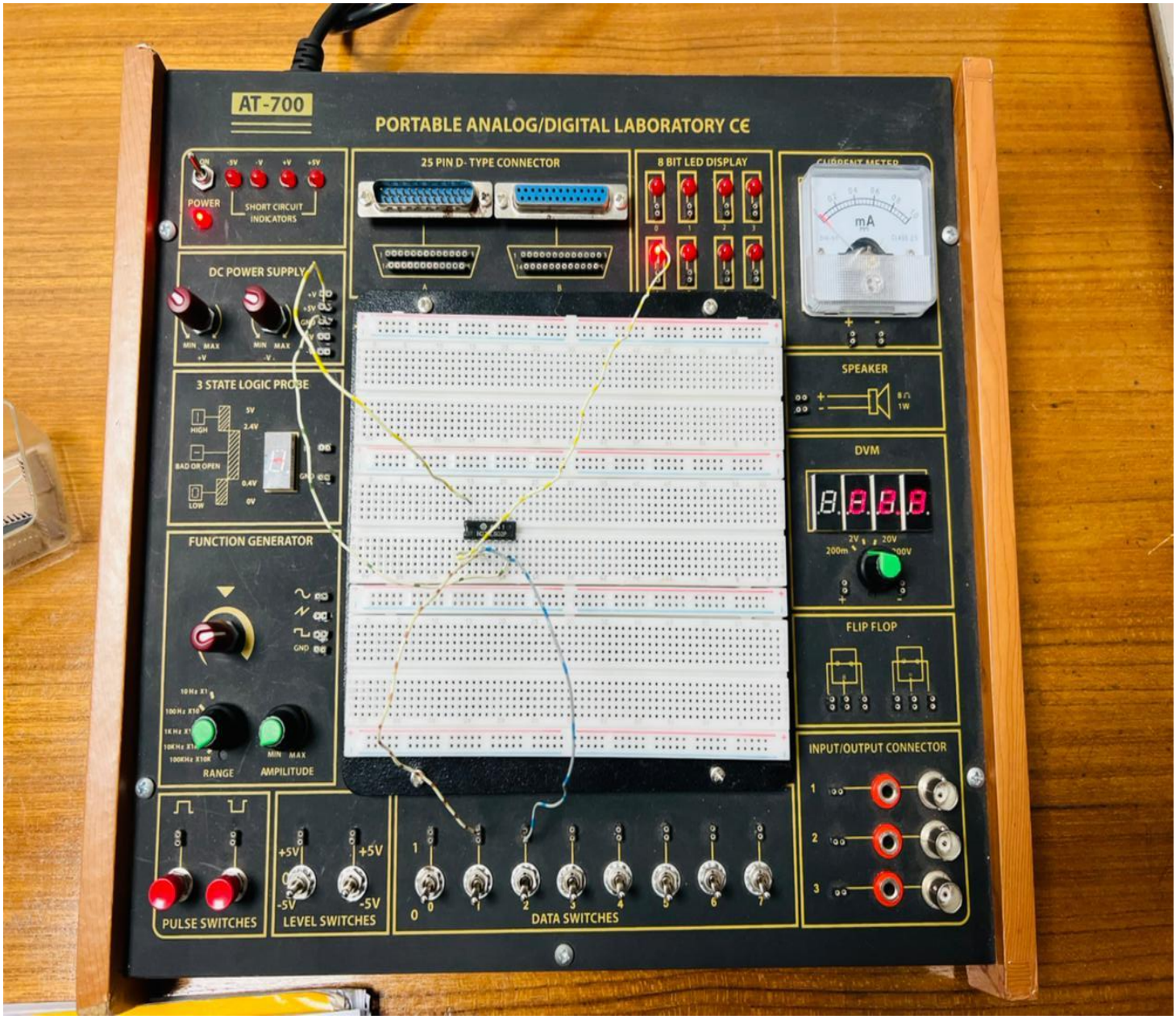
NOR operation:

The NOR gate is a combination OR gate followed by an inverter. Its output is high if both inputs are low. Otherwise, the output is low.

Fig 1.5: Symbol of NOR gate

Truth Table:

Input, A	Input, B	Output, F
0	0	1
0	1	0
1	0	0
1	1	0



Pin configuration for IC-74HC02N:

The 74HC02 is a high-speed Si-gate CMOS device that provides a quadrature 2 –input NOR function. CMOS level is the input level for this sort of IC's. The operating Voltage Range is 2.0 to 5.0 V and low input current is 1.0 µA.

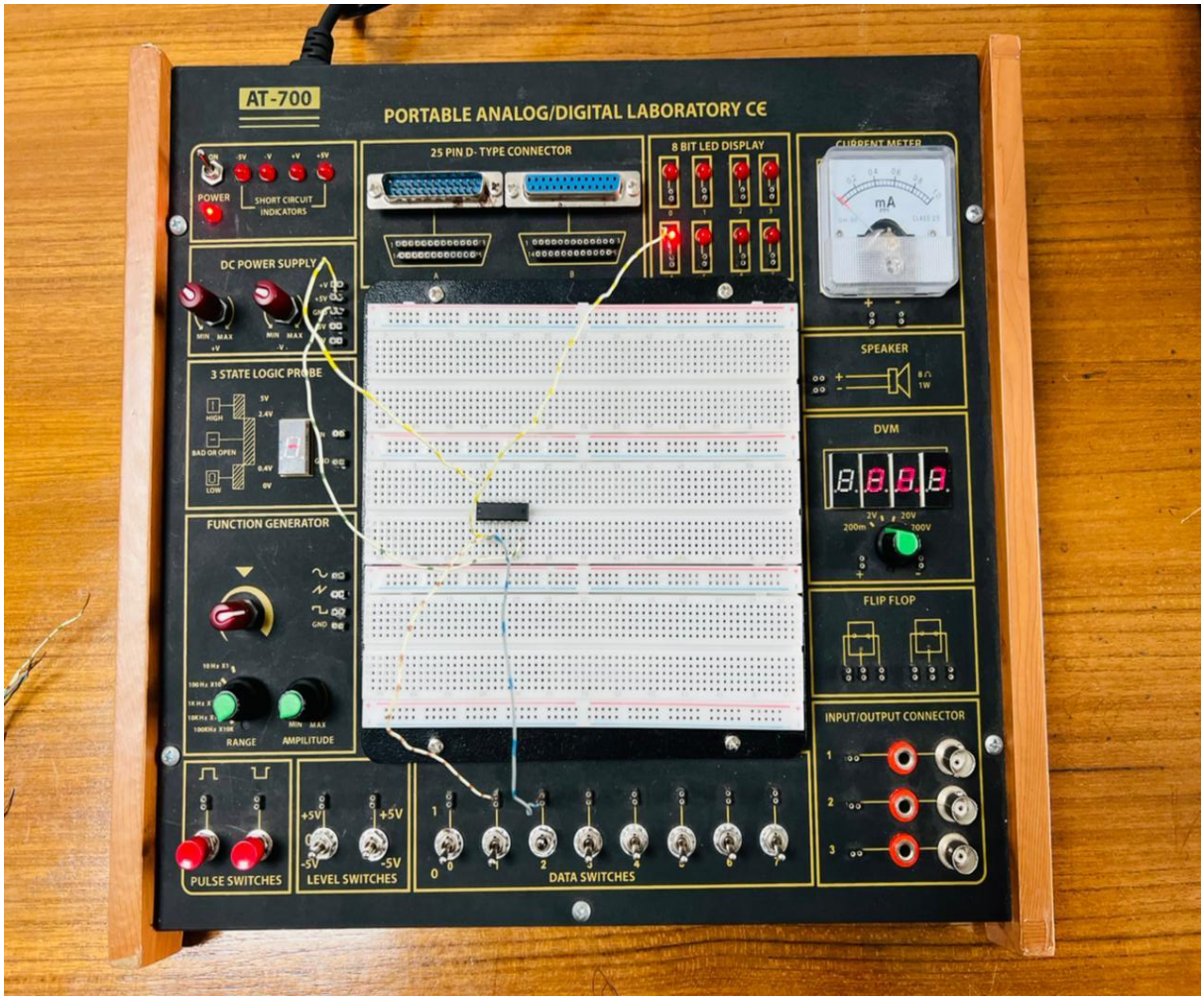
XOR operation:

The XOR (exclusive OR) gate acts in the same way as the logical "either/or". The output is high if either, but not both, of the inputs are high. The output is low if both inputs are low or if both inputs are high. Another way of looking at this circuit is to observe that the output is 1 if the inputs are different, but 0 if the inputs are the same.

Fig 1.6: Symbol of XOR gate

Truth Table:

Input, A	Input, B	Output, F
0	0	0
0	1	1
1	0	1
1	1	0



Pin configuration for IC-74HC86N:

HC86 is the device code for a quad 2-input XOR gate which utilizes advanced silicon gate CMOS technology. It maintains low power consumption and high noise immunity characteristic of standard CMOS integrated circuits. The 74HC logic family has a voltage range of 2V to 5V and the operating temperature is -40°C to 125°C with input current of 1μA.

XNOR operation:

The XNOR *(exclusive-NOR) gate* is a combination XOR gate followed by an inverter.
Its output is high if the inputs are the same, and low if the inputs are different.

Fig 1.7: Symbol of XNOR gate

Truth Table:

Input, A	Input, B	Output, F
0	0	1
0	1	0
1	0	0
1	1	1

Using combinations of logic gates, complex operations can be performed. Arrays of logic gates are found in digital integrated circuits (ICs). As IC technology advances, the required physical volume for each individual logic gate decreases and digital devices of the same or smaller size become capable of performing ever more complicated operations at ever-increasing speeds.

Apparatus:

1. Digital trainer board.
2. Integrated Circuits (ICs).
3. Power supply.
4. Connecting wires.

Integrated Circuits (ICs):

7400: 1 pcs
7402: 1 pcs
7404: 1 pcs
7408: 1 pcs
7432: 1 pcs
7486: 1 pcs

Precautions:

The IC contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages. For proper operation, Vin and Vout should be constrained to the range GND (Vin or Vout) to VCC.

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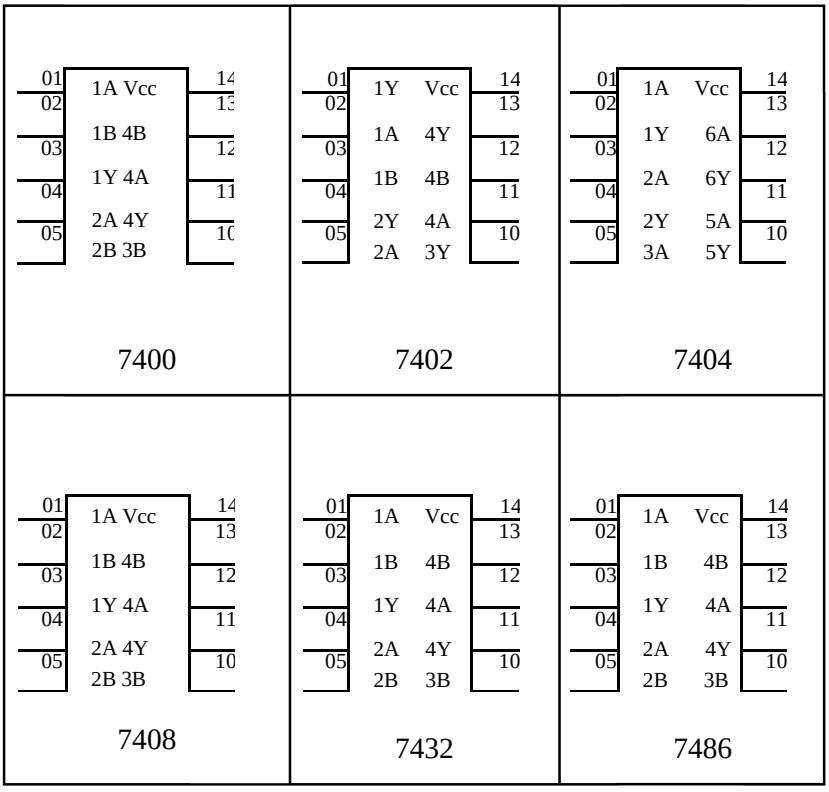
IC configurations:



Part II: Study of Universal Gates

A Logic Gate which can infer any of the gate among Logic Gates or a gate which can be used to create any Logic gate is called Universal Gate. **NAND** and **NOR** Gates are called Universal Gates because all the other gates such as NOT, AND, OR XOR, XNOR etc. can be created by using these gates.

The Objective of this lab is to implement different logic functions using universal gates.

Theory and Methodology:

NAND gate:
The graphic symbol for the NAND gate consists of an AND symbol with a bubble on the output, denoting that a complement operation is performed on the output of the AND gate.

Fig 2.1: Symbol of NAND gate

Output, Q= = +

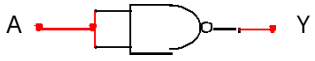
Truth Table

Input	Input B	Output Q
0	0	1
0	1	1
1	0	1
1	1	0

It is possible to construct other gates using NAND gates which are shown in Experimental procedure part.

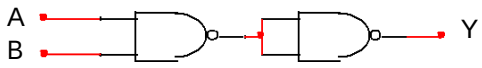
Implementing various logic functions using NAND Gates:

1) Implementing NOT gate using NAND gate:



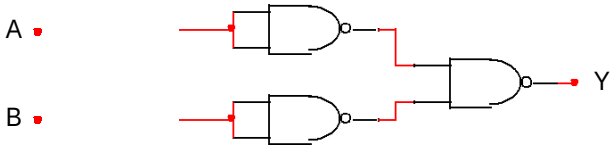
NOT gate using NAND gate

2) Implementing AND gate using NAND gate:



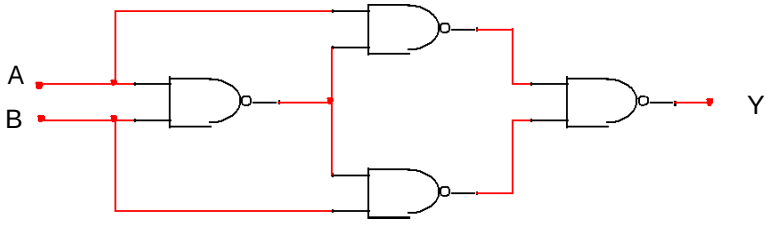
AND gate using NAND gates

3) Implementing OR gate using NAND gate:



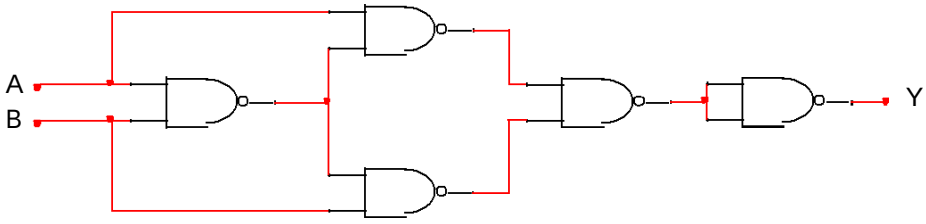
OR gate using NAND gates

4) Implementing XOR gate using NAND gate:



XOR gate using NAND gates

5) Implementing XNOR gate using NAND gate:



XNOR gate using NAND gates

NOR gate:

The **NOR** gate represents the complement of the OR operation. Its name is an abbreviation of **N**OT **OR**. The graphic symbol for the NOR gate consists of an OR symbol with a bubble on the output, denoting that a complement operation is performed on the output of the OR gate. The truth table and the graphic symbol of NOR gate is shown in the figure.

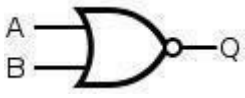


Fig 2.2: Symbol of NOR gate

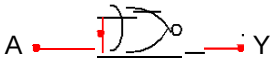
Output,Q= =

Truth Table

Input A	Input B	Output Q
0	0	1
0	1	0
1	0	0
1	1	0

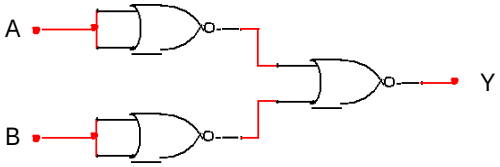
Implementing various logic functions using NOR Gates:

1) Implementing NOT gate using NOR gate:



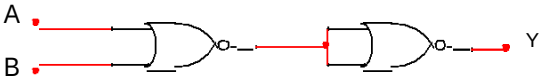
NOT gate using NOR gate

2) Implementing AND gate using NOR gate:



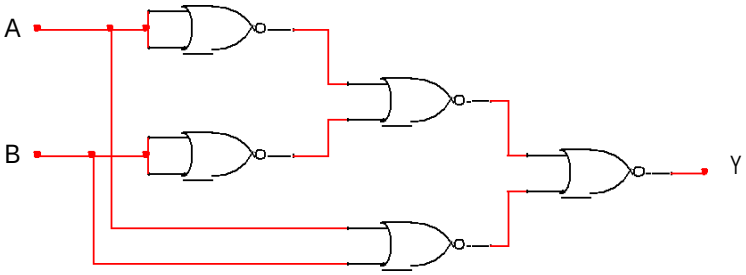
AND gate using NOR gates

3) Implementing OR gate using NOR gate:



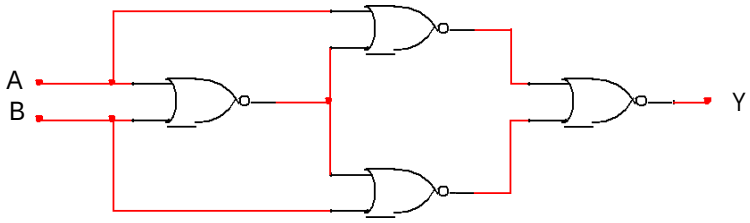
OR gate using NOR gates

4) Implementing XOR gate using NOR gate:



XOR gate using NOR gates

5) Implementing XNOR gate using NOR gate:



XNOR gate using NOR gates

Apparatus:

1. Digital trainer board.
2. Integrated Circuits (ICs).
3. Power supply.
4. Connecting wires.

Precautions:

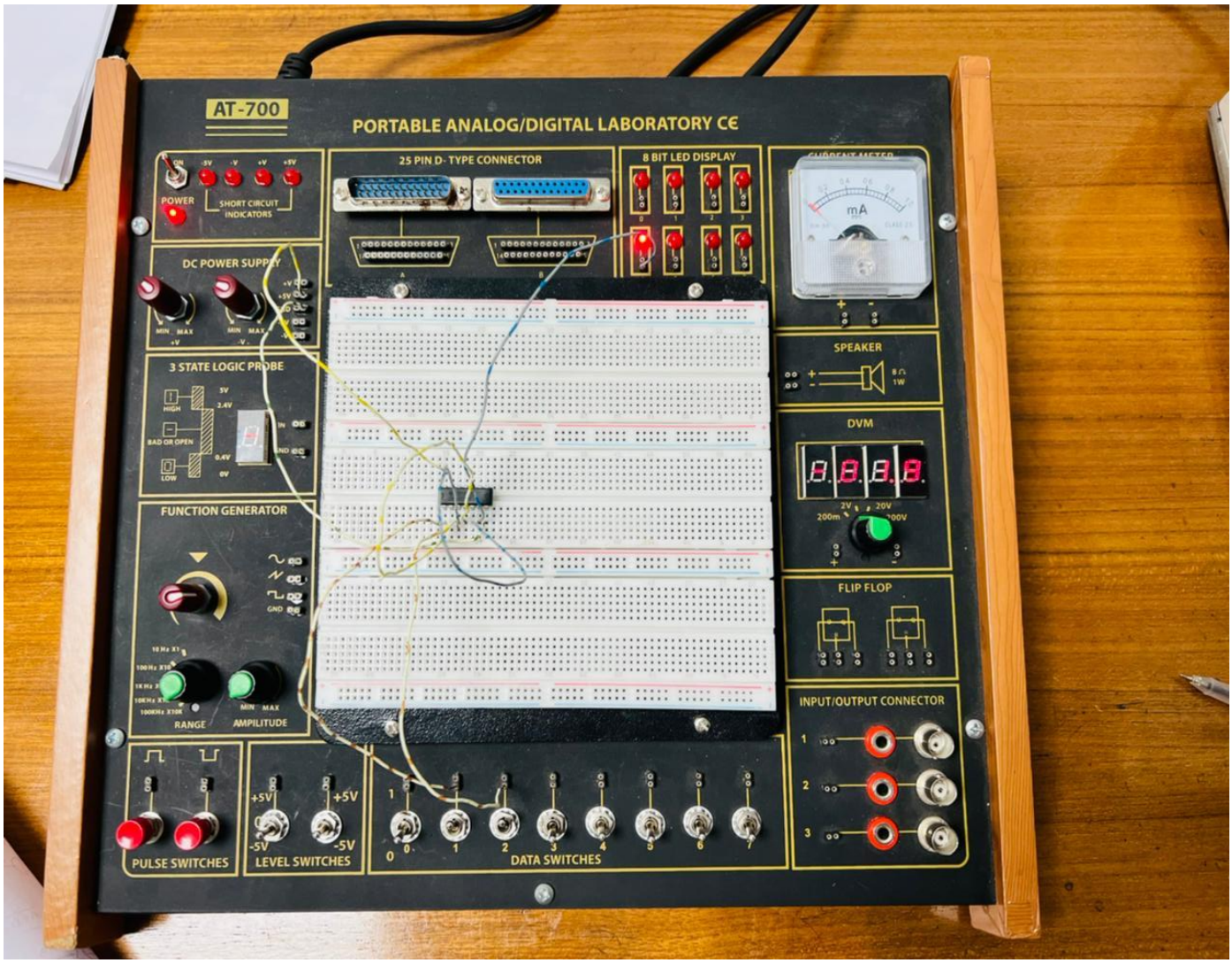
From instructor we have checked all connections after we have done setting up the circuit and made sure that we apply only enough voltage to turn on the chip, otherwise it may get damaged.

Simulation:

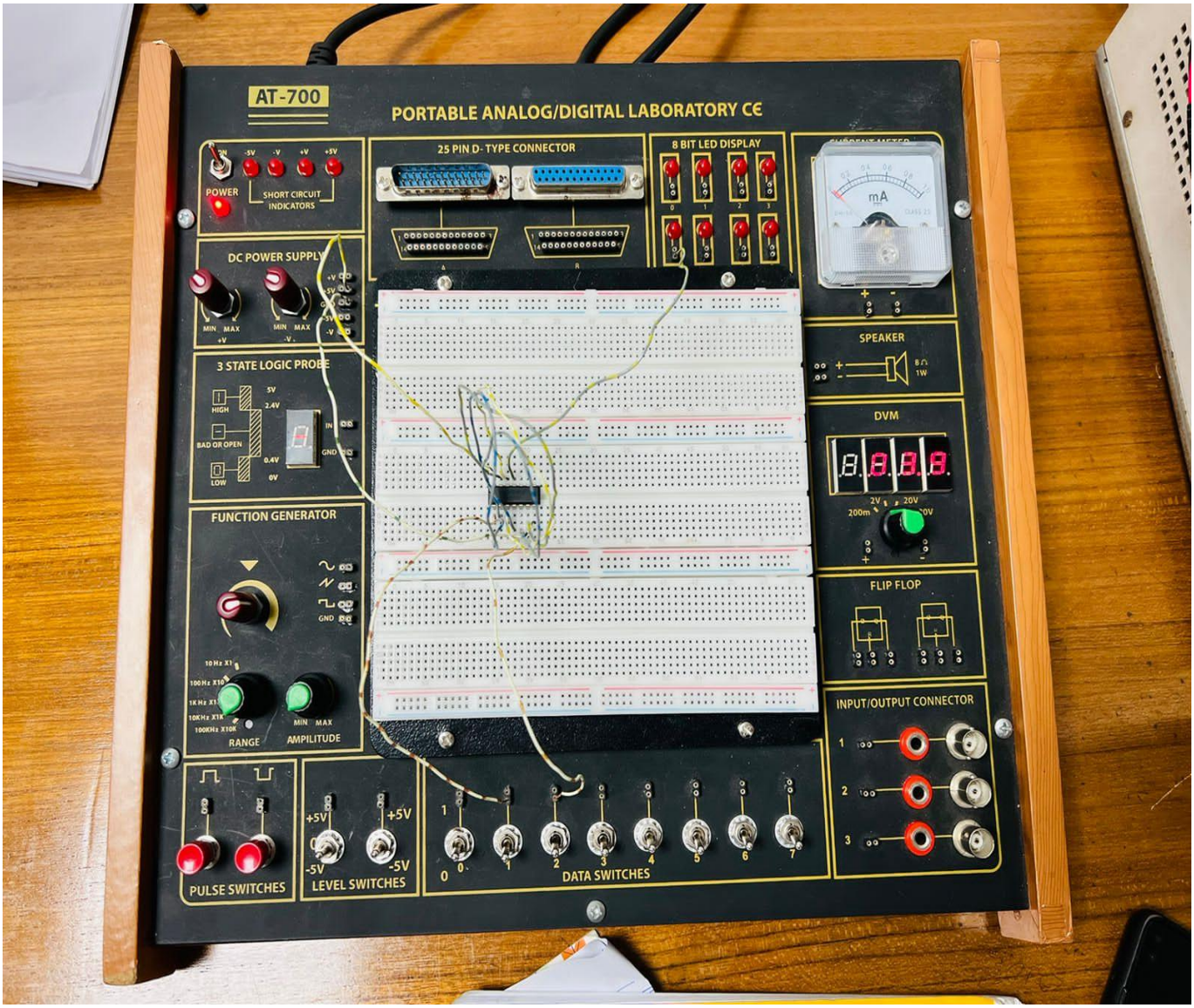
NAND:

1) **Implementing NOT gate using NAND gate:**

2) Implementing AND gate using NAND gate:

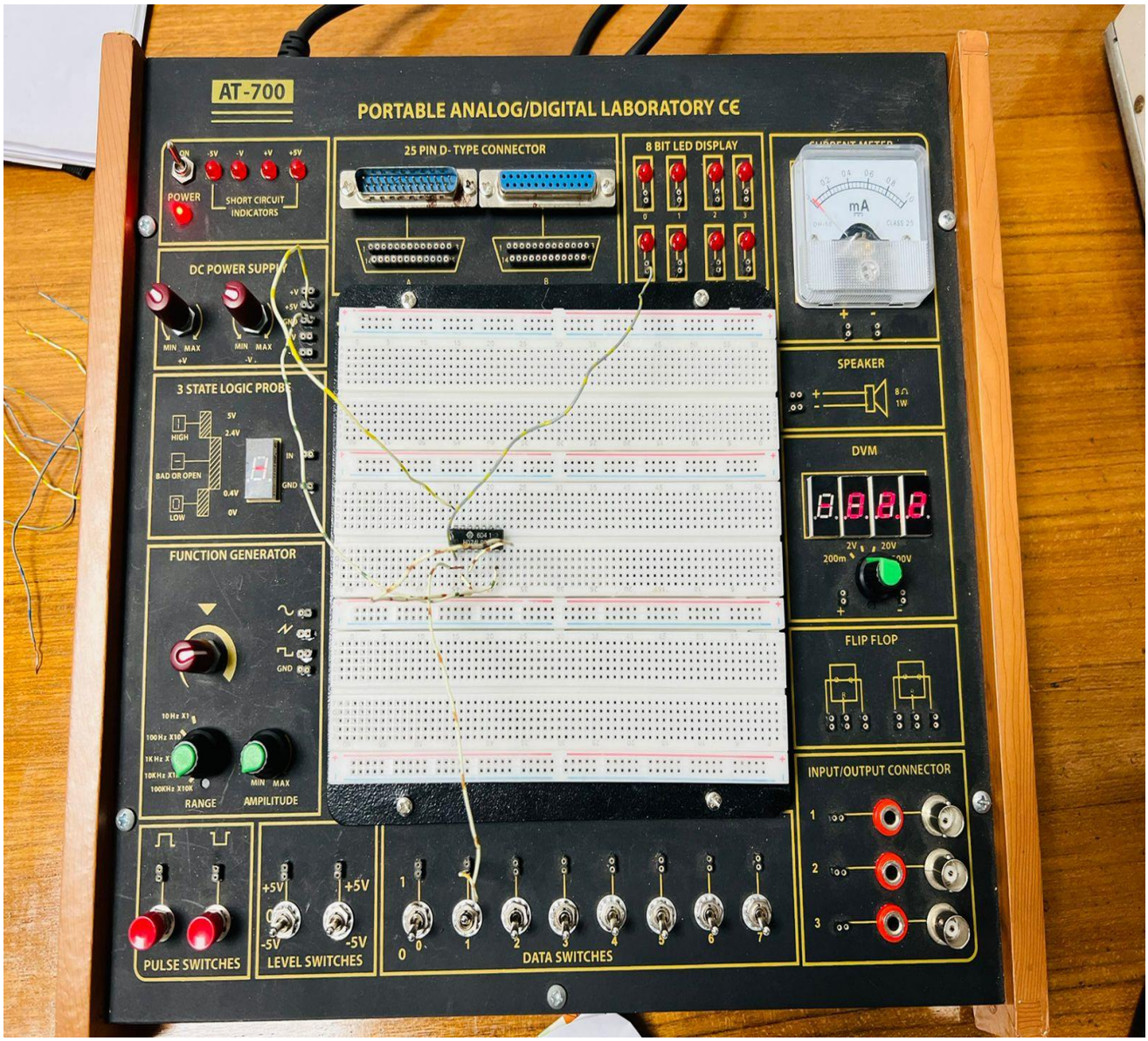


3) Implementing OR gate using NAND gate:

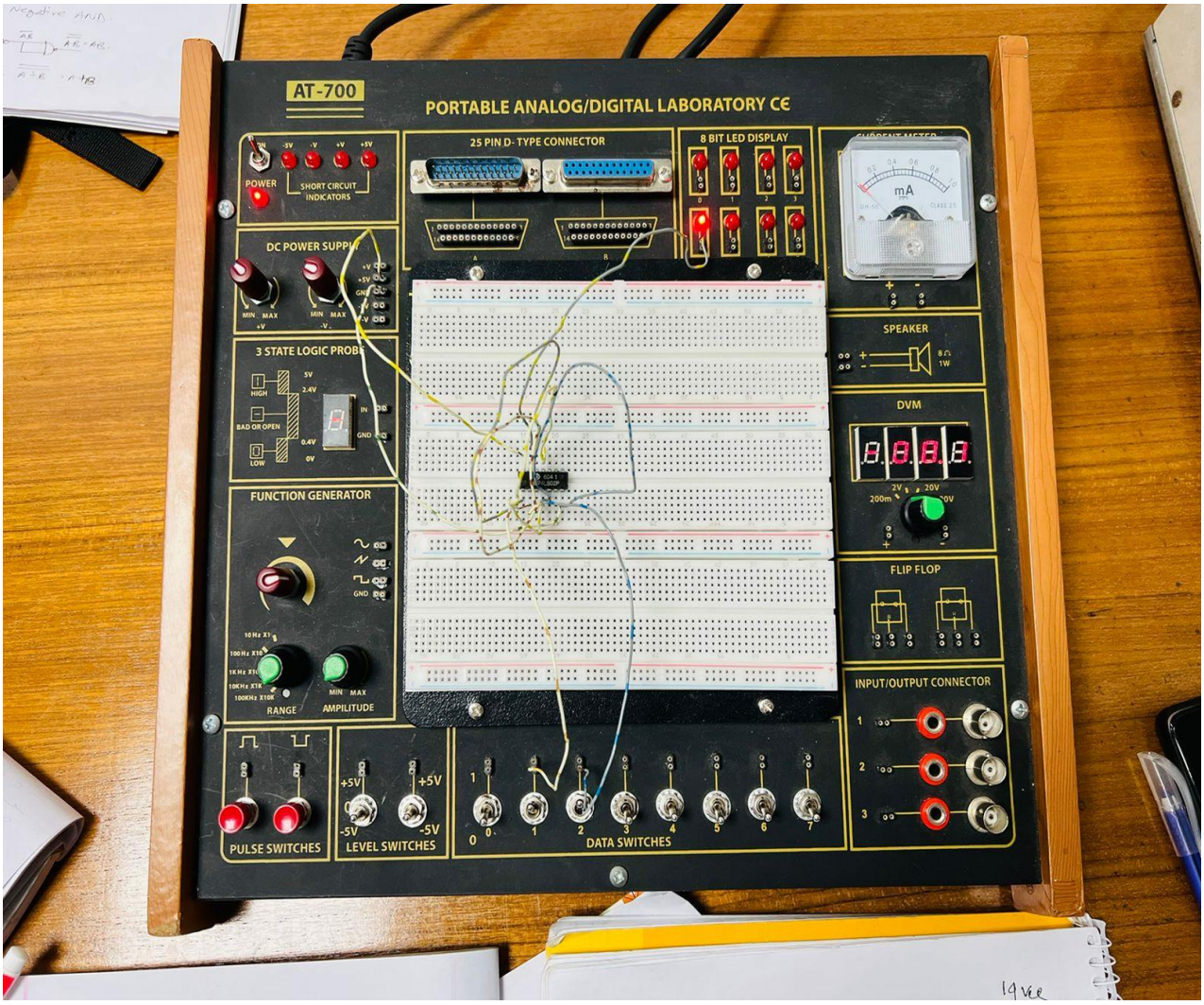


NOR:

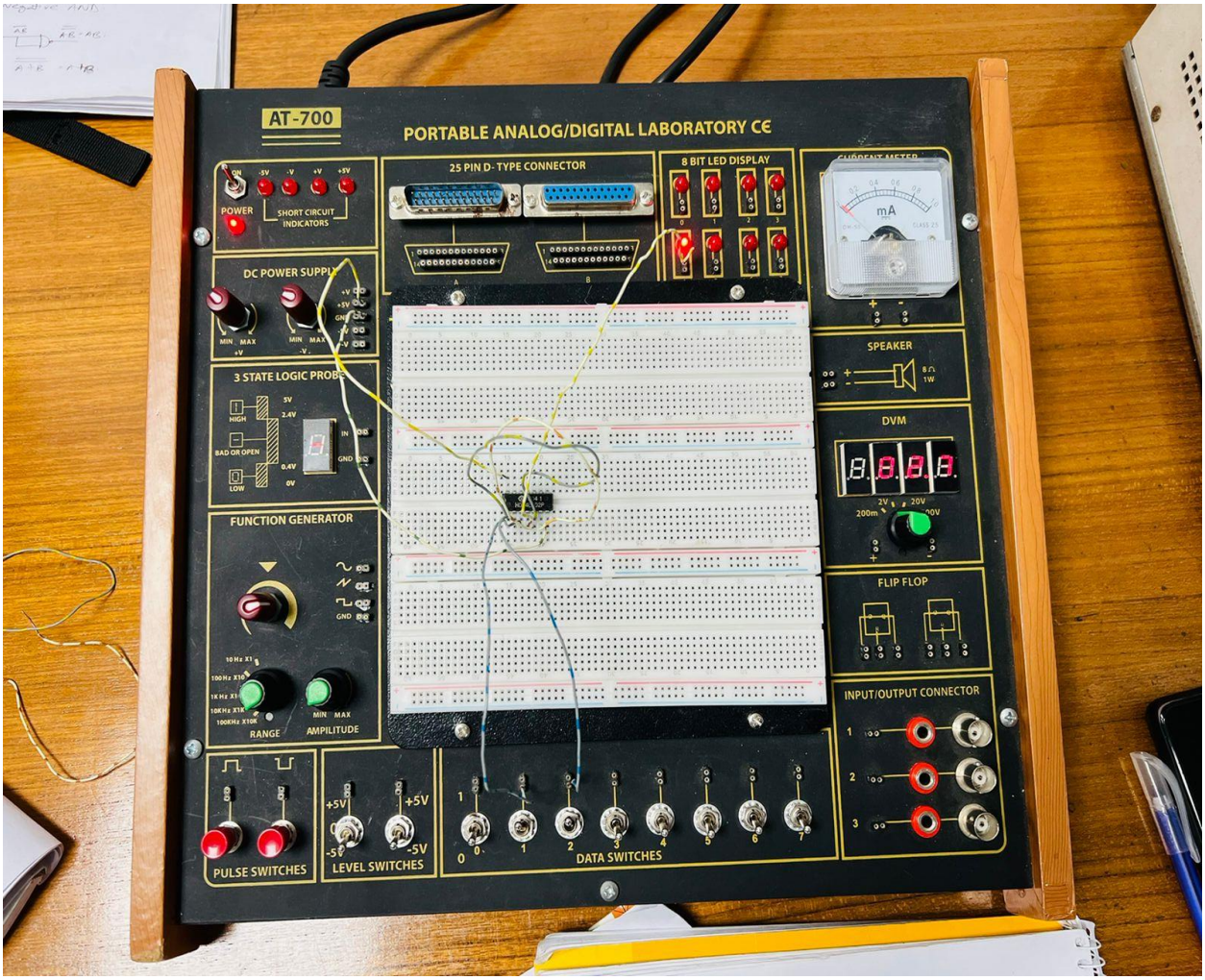
1) Implementing NOT gate using NOR gate:



2) Implementing AND gate using NOR gate:



1) Implementing OR gate using NOR gate:



Discussion:

In this lab first, we have implemented all the Basic logic gates and recorded the results in truth tables. Then we have also implemented all the basic logic gates using both universal gates. And then we have solved experiments given in the lab manual.

Conclusion:

After completing the experiment now, we can easily define what is logic gate and now have a better understanding of the properties of various logic gates, as well as the digital trainer board and digital ICs. We've studied the logic gate operations like AND Gate, OR Gate, NOT Gate, NAND Gate, and X-OR Gate, X-NOR Gate.
After running the simulation, we now understand how the truth table truly works and how to build truth table as well. All our theoretical truth table findings coincided with the Simulation results.

Reference(s):

1) www.tutorialspoint.com
2) www.electronics-tutorials.ws
3) faculty.kfupm.edu.sa
4) "Digital Fundamentals" by Thomas L. Floyd