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:

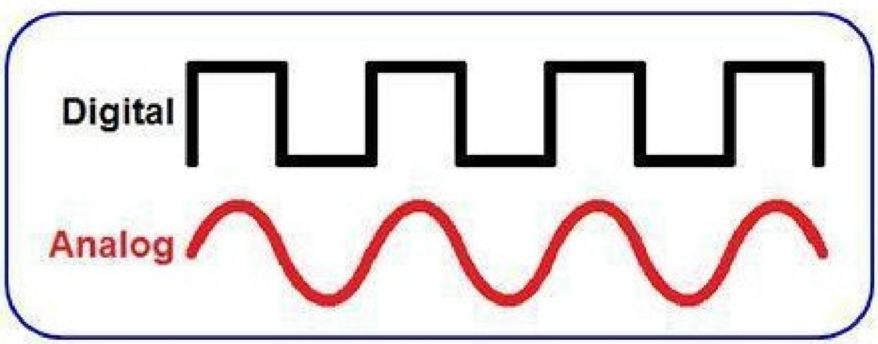
To learn the characteristics of several logic gates and to get familiar with the digital trainer board and digital ICs

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:

In analog signals, information is translated into electric pulses of varying amplitude but in case of digital, translation of information is in binary format (zero or one) where each bit is representative of two distinct amplitudes.



The main advantage of digital signals over analog signals is that the precise signal level of the digital signal is not vital. This means that digital signals are fairly immune to the imperfections of real electronic systems which tend to spoil analog signals. Codes are often used in the transmission of information. These codes can be used either as a means of keeping the information secret or as a means of breaking the information into pieces that are manageable by the technology used to transmit the code. It can convey information with greater noise immunity, because each information component (byte etc) is determined by the presence or absence of a data bit (0 or one). Analog signals vary continuously and their value is affected by all levels of noise. Digital signals can be processed by digital circuit components, which are cheap and easily produced in many components on a single chip. It uses typically less bandwidth with less electromagnetic interference. Moreover, Information storage can be easier in digital systems than in analog ones. The noise-immunity of digital systems permits data to be stored and retrieved without degradation.

There are two sorts of circuits which are known as integrated circuit and discrete circuit. The two main advantages of ICs over discrete circuits are cost and performance. Cost is low because the chips, with all their components, are printed as a unit by photolithography rather than being constructed one transistor at a time. Furthermore, much less material is used to construct a packaged IC die than to construct a discrete circuit. Performance is high because the components switch quickly and consume little power (compared to their discrete counterparts) as a result of the small size and close proximity of the components.

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	$Y=A\oplus B=\bar{A}B+A\bar{B}$
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.

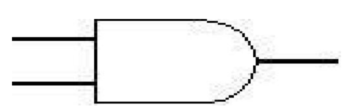


Fig1.1: Symbol of AND gate

Truth Table:

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

Pin configuration for IC-74HC08N :

For a quadrature 2input AND gate HC08 davice 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.

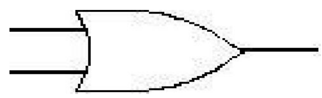


Fig 1.2: Symbol of OR gate

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 in excess of 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 .

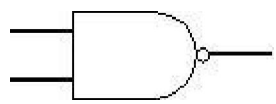


Fig 1.4: Symbol of NAND gate

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.

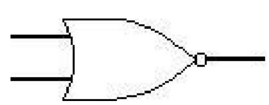


Fig 1.5: Symbol of NOR gate

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.

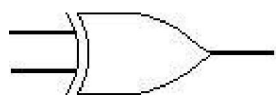


Fig 1.6: Symbol of XOR gate

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.

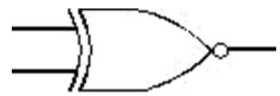


Fig 1.7: Symbol of XNOR gate

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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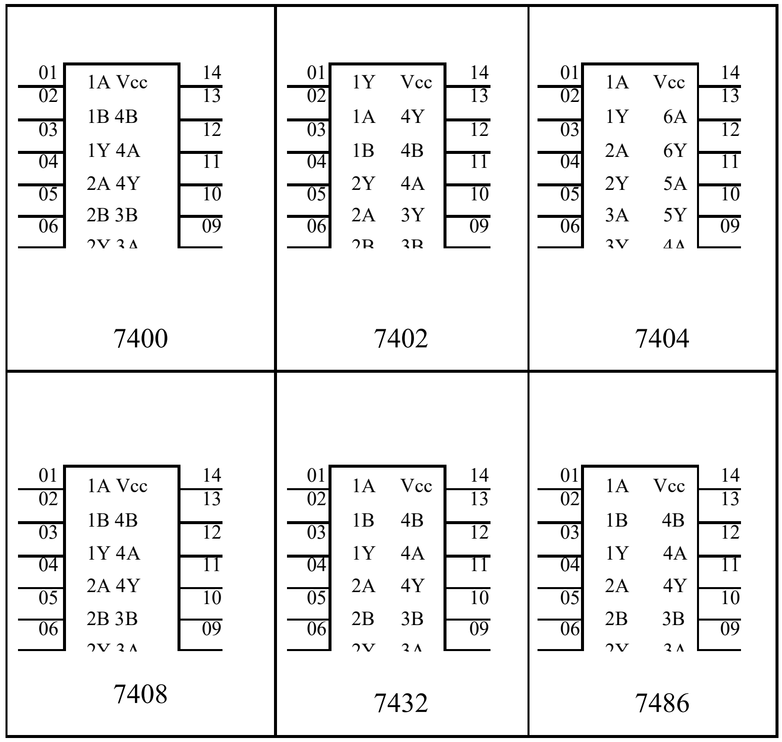
IC configurations:



<u>Part II:</u> 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.

<u>Theory and Methodology:</u>

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.

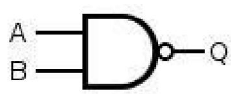


Fig 2.1: Symbol of NAND gate

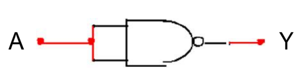
Output, Q= = +

Truth Table		
Input A	**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.

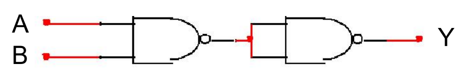
Implementing various logic functions using NAND Gates:

1) <u>Implementing NOT gate using NAND gate</u>:



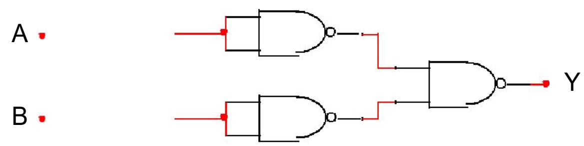
NOT gate using NAND gate

2) Implementing AND gate using NAND gate:

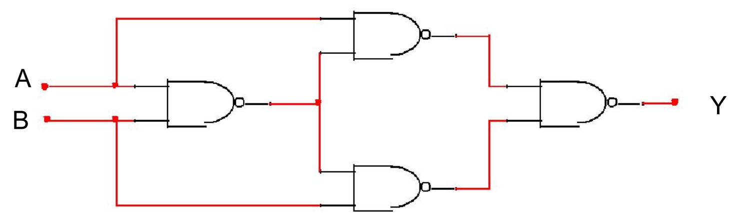


AND gate using NAND gates

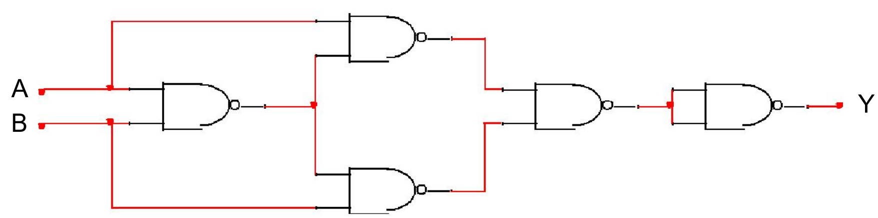
3) Implementing OR gate using NAND gate:



4) Implementin



5) Implementin



NOR gate:

The **NOR** gate repr n. It’s name is an abbreviation of NOT **OR**. The gı f an OR symbol with a bubble on the output, deno rmed on the output of the OR gate. The truth table own in the figure.

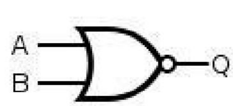


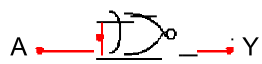
Fig 2.2: Symbol of NOR gate

Output,Q= =

Truth Table		
Input A	Input B	Output Q
0	0	1
0	1	0
1	0	0
1	1	0

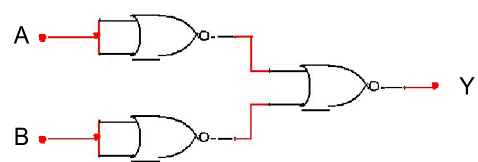
Implementing various logic functions using NOR Gates:

1) Implementing NOT gate using NOR gate:



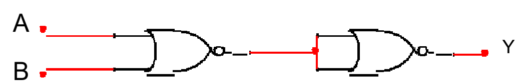
NOT gate using NOR gate

2) Implementing AND gate using NOR gate:



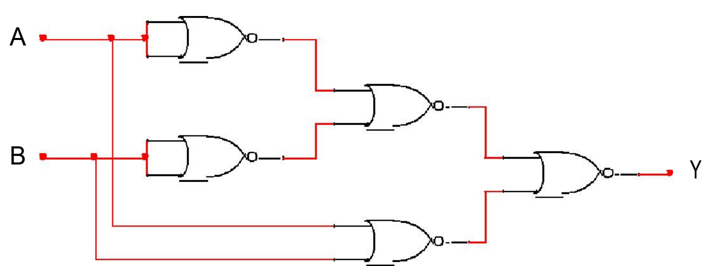
AND gate using NOR gates

3) Implementing OR gate using NOR gate:



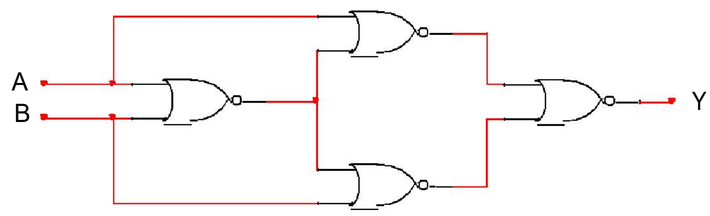
OR gate using NOR gates

4) Implementing XOR gate using NOR gate:



XOR gate using NOR gates

5) Implementing XNOR gate using NOR gate:



XNOR gate using NOR gates

Pre-Lab Homework:

Students must study the Boolean algebra rules and universal gates, perform simulation of the circuits shown in the circuit diagram section using Power Sim 9.1.1 (PSIM) and MUST present the simulation results to the instructor before the start of the experiment.

Apparatus:

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

Precautions:

Have your instructor check all your connections after you are done setting up the circuit and make sure that you apply only enough voltage to turn on the chip, otherwise it may get damaged.

Experimental Procedure:

1. Construct an X-OR and X-NOR gate in your trainer board by using NAND gates only. Use required IC to construct the circuit.
2. Find out the equivalent NOT, OR and AND gate by using NOR gates only. Now construct an X-OR and X-NOR gate in your trainer board by using NOR gates only. Use required IC to construct the circuit.
3. Convert the following expressions using universal gates and implement them in the trainer board. Compare the results with the truth table of the equations.
   i) A (+) B
   ii) (A(+)B) +C
   iii) (AB +CD)'

Simulation and Measurement:

Construct the circuit using your simulation software and compare the simulation results with experimental data and comment on the differences (if any).

Questions with answers for report writing:

1) What do you mean by universal gate?
2) What are the ICs required in this experiment?
3) Construct a circuit of output F, where F=AB + BC + CA, by using NAND gates only in the PSIM Software and show the output states for each of the available conditions.

Discussion and Conclusion:

Interpret the data/findings and determine the extent to which the experiment was successful in complying with the goal that was initially set. Discuss any mistake you might have made while conducting the investigation and describe ways the study could have been improved.

Reference(s):

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