American International University- Bangladesh
Faculty of Engineering (EEE)
Digital Logic Design Laboratory

Title: Studying different digital Integrated Circuits (ICs)

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

Introduction:
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.
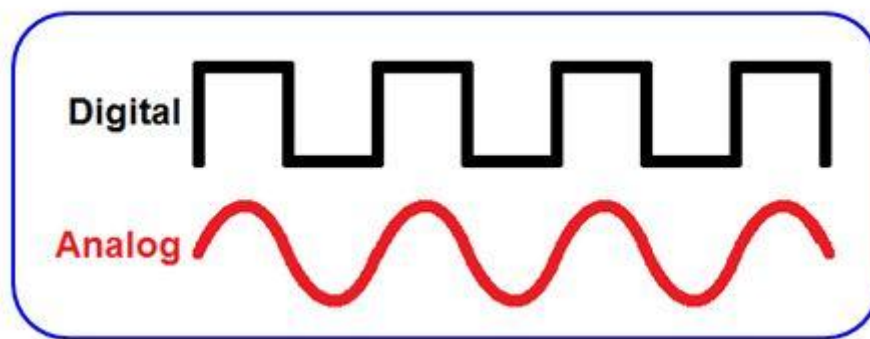
The main advantage of digital signals over analog signals is that the precise signal level of the digital signal is not vital. This means that digital signals are fairly immune to the imperfections of real electronic systems which tend to spoil analog signals. Codes are often used in the transmission 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.
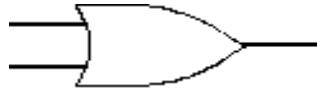

Fig 1.2: Symbol of OR gate

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.
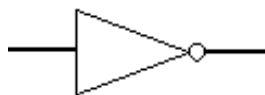
Fig1.3: Symbol of NOT gate

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.
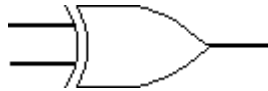
Fig 1.6: Symbol of XOR gate

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.
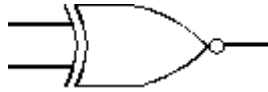
Fig 1.7: Symbol of XNOR gate

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.

Experimental Procedure:

Set all the ICs in the trainer board one by one and connect the Vcc to the 5V power supply and ground pin to the ground terminal. Now by verifying all possible values of i/ps for one gate of the ICs, find out the truth tables. Also verify your results.

Results and Discussion:

Compare your practical data with the theoretical ones. Are there any discrepancies?

Report:
1. What do you mean by Vcc and ground of an IC?
2. How to construct a 4 I/p AND gate by using 2 I/p AND gate?
3. From the truth table of an X-OR gate write the X-OR equivalent equation by using NOT, OR and AND gate?
4. To construct a two –bit comparator (o/p will be high if the i/ps are equal) which gate is used?

Reference(s):
1) Whatis.techtarget.com
2) digital-signal-process.blogspot.com
3) www.jameco.com
List the references that you have used to answer the Report section above.

IC configurations:

Pin	7400		Pin
01	1A	Vcc	14
02	1B	4B	13
03	1Y	4A	12
04	2A	4Y	11
05	2B	3B	10
06	2Y	3A	09
07	GND	3Y	08

7400

Pin	7402		Pin
01	1Y	Vcc	14
02	1A	4Y	13
03	1B	4B	12
04	2Y	4A	11
05	2A	3Y	10
06	2B	3B	09
07	GND	3A	08

7402

Pin	7404		Pin
01	1A	Vcc	14
02	1Y	6A	13
03	2A	6Y	12
04	2Y	5A	11
05	3A	5Y	10
06	3Y	4A	09
07	GND	4Y	08

7404

Pin	7408		Pin
01	1A	Vcc	14
02	1B	4B	13
03	1Y	4A	12
04	2A	4Y	11
05	2B	3B	10
06	2Y	3A	09
07	GND	3Y	08

7408

Pin	7432		Pin
01	1A	Vcc	14
02	1B	4B	13
03	1Y	4A	12
04	2A	4Y	11
05	2B	3B	10
06	2Y	3A	09
07	GND	3Y	08

7432

Pin	7486		Pin
01	1A	Vcc	14
02	1B	4B	13
03	1Y	4A	12
04	2A	4Y	11
05	2B	3B	10
06	2Y	3A	09
07	GND	3Y	08

7486