Digital Logic Design
(EL-1005)
LABORATORY MANUAL
Spring-2024

LAB 02
Getting Started with Apparatus & Basic Logic Gates

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MARKS AWARDED: /10

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Lab Session 01: Getting Started with Apparatus & Basic Logic Gates

OBJECTIVES:

The objectives of this lab are:

- To get familiar with the apparatus that would be used in rest of the semester for the implementation and testing of logic circuits
- Explain basic Circuit connection procedure and function usage of logic probe
- To learn and understand the working of basic gates (AND, OR, NOT).
- To learn and understand troubleshooting of logic circuits
- Identify gates by their symbols
- Write logical expressions of gates and draw their truth tables

APPARATUS:

- Logic trainer
- Logic probe

COMPONENTS:

- IC 74LS08 (AND Gate)
- IC 74LS32 (OR Gate)
- IC 74LS04 (NOT Gate)
- Jumper Wire

Section 1: Getting Started with Hardware/Apparatus

Introduction:

Integrated Circuit usually called a ***chip*** or ***microchip*** is a small electronic device made up of semiconductor material. IC's contain the electronic components for the digital gates. The chip is mounted in a ceramic or plastic container and connections are welded to external pins to form the IC. The number of pins may range from 14 in a small IC package to 64 or more in a larger IC.

The following figures show an IC with 14 pins, both the Device package and the pin layout in its top view. If you are looking at the IC from above you will see a circle or notch. This is the top of the chip. The top-left pin is almost always Pin 1:

Basic Diagram:

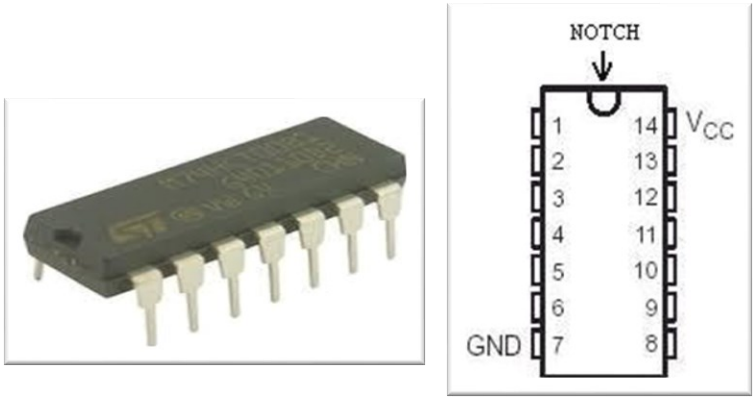

Figure 1: Left is the 3D view of IC and right one is the top view of IC

In coming labs, we will be using various series of ICs for the self-learning, and the functionality of all kinds of gates like NOT, AND, OR gates, etc. Later on, we will implement the circuitry of Binary Adder, Subtractor, and Multiplexers, which help us to build the concepts needed for further courses upcoming in the next semester.

Analogue & Digital Electronic Trainer (ETS-7000):

ETS-7000 logic trainer is a low cost, high performance complete digital electronics workstation and have a huge number of features in one compact unit. It is designed to provide all the basic tools necessary to conduct logic experiments. This trainer is housed in a compact and robust casing, and is equally ideal for constructing and testing both analogue and digital electronics circuits . It is also ideally suited for developing, debugging, integrating and testing digital systems. Figure 1-1 shows the front panel of ETS-7000 logic trainer. It has DC Power Supplies, Function Generators for generating various types of Waves with different frequencies, Logic & Pulse Switches, 7-Segment Display and Breadboard etc.

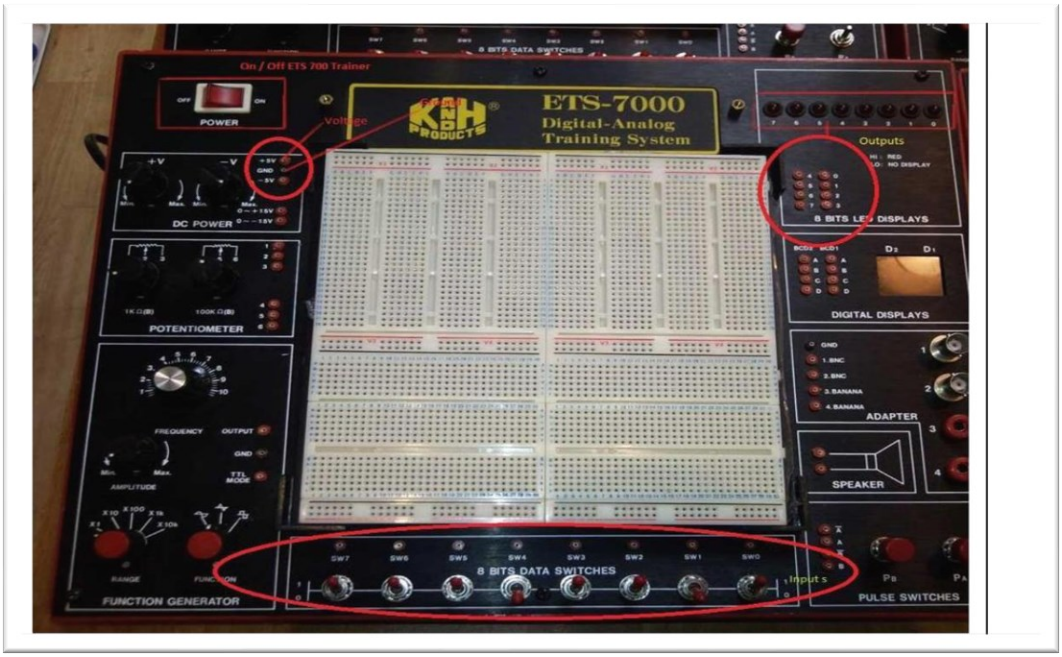

Figure 2: Front Panel of Digital Training System ETS-7000

Components of ETS-7000 Trainer:

1. **Power Switch:** A switch to turn ON/OFF the logic trainer.
2. **Variable Positive Power:** A variable DC power supply with DC output from 3V to 15V, 500mA.
3. **Variable Negative Power:** A variable DC power supply with DC output from -3V to -15V, 500mA.
4. **Pulse Switches:** Two pulse switches (push buttons) A and B along with their complements $\overline{A}$ and $\overline{B}$
5. **Frequency Range:** A knob to select one of the frequency ranges which are as follows:
    a) 1Hz – 10Hz
    b) 10Hz – 100Hz
    c) 100Hz – 1kHz
    d) 1kHz – 10kHz
    e) 10kHz – 100kHz
    f) 100kHz – 1MHz

6. **Mode Selector:** Using mode selector switch the mode can be selected between TTL logic and CMOS logic. TTL logic will be used throughout in this manual.
7. **Bits Data Switches:** Eight binary switches from SW0 -- SW7 are available to provide binary input to the logic circuit. The output level of a switch in correspondence to the logic level will be as follows:

Logic Level	Output Level
LO	0V
HI	5V

8. **Digital Displays:** Two digits of BCD to 7-segment LED display are available on the logic trainer. The output on 7-segment display in correspondence to the BCD input applied at the input connections will be as follows:

DECIMAL	BCD INPUT			
	D	C	B	A
0	L	L	L	L
1	L	L	L	H
2	L	L	H	L
3	L	L	H	H
4	L	H	L	L
5	L	H	L	H
6	L	H	H	L
7	L	H	H	H
8	H	L	L	L
9	H	L	L	H

H= Logic High, L= Logic Low

9. **Digital Probe:** Digital probe is available on the trainer to troubleshoot the logic circuit. The logic level in correspondence to the input level applied at digital probe will be as follows:

Logic Level	Input Level	Display
LO	$< 0.8V \pm 0.2V$	L
HI	$> 2.3V \pm 0.2V$	H
OPEN	0.8V - 2.3V	0
TRANSIT	LO → HI	P

Breadboard:

A breadboard is used to make up temporary circuits for testing or to try out an idea. No soldering is required so it is easy to change connections and replace components. Parts will not be damaged so they will be available to re-use afterwards. The photograph shows a circuit on a typical small breadboard which is suitable for beginners building simple circuits with one or two ICs

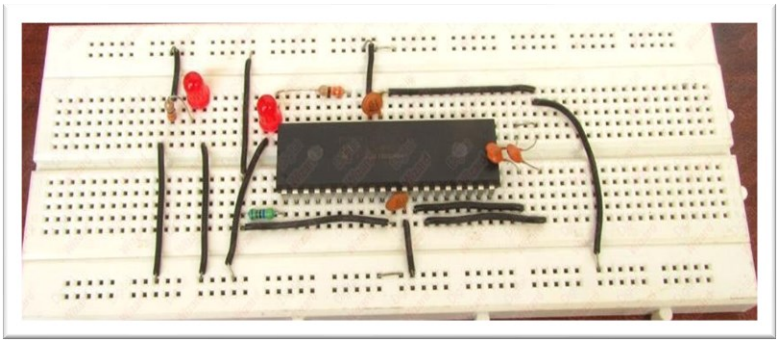

Figure 3: Breadboard Connection

Connections on Breadboards:

Breadboards have many tiny sockets (called 'holes') arranged on a 0.1" grid. The leads of most components can be pushed straight into the holes. ICs are inserted across the central gap with their notch or dot to the left. Wire links can be made with single-core plastic-coated wire of 0.6mm diameter (the standard size). Stranded wire is **not** suitable because it will crumple when pushed into a hole and it may damage the board if strands break off. The diagram shows how the breadboard holes are connected.

The top and bottom rows are linked **horizontally** all the way across. The other holes are linked **vertically** in blocks of 5 with no link across the centre. Notice how there is separate blocks of connections to each pin of ICs.

Logic Probe:

A logic probe can be very handy for troubleshooting and analysis of a digital logic circuit. As compared to a DC voltmeter or an oscilloscope, it needs to distinguish between the states of LOW and HIGH, and so it can be very simple and inexpensive. Its features include two LED indicators: HI (red LED) and LO (green LED).

Figure 4: Logic Probe

Operation:

1. Connect the black alligator clip to ground or common of the circuit under test.
2. Connect the red alligator clip to VCC (4V DC minimum to 18V DC maximum) of the circuit under test.
3. Touch the probe tip to the circuit point under test. The LEDs on probe indicate the logic level or signals present when the circuit node is probed.
4. The LED response is noted below:

Input signal	LEDs
Logic "1"	HI (Red) ON
Logic "0"	LO (Green) ON
Bad Logic Level or Open circuit	Amber LED indicates a pulse
Square Wave < 200kHz	HI and LO blinking at frequency rate
Square Wave > 200kHz	HI and LO blinking at frequency rate

Basic Circuit Connection Procedure:

The components used to build digital circuits are very delicate and can easily be damaged if not handled properly. Following are the steps to build a digital circuit:

- Turn power switch OFF.
- Place diode / transistor / IC chip on the breadboard. Make sure their pins are not short circuited.
- Connect the GND pins of all IC chips to ground.
- Connect the VCC pins of all chips to +5V on your trainer.
- Connect all other input and output signals
- Turn power ON.

Precautions:

- Be careful not to connect any circuit output to VCC or any other output.
- Check IC diagram before making any connections.
- Turn power OFF before you modify the circuit.
- Handle components from their top plastic part. Avoid touching the pins

Section 2: Basic Logic Gates

Introduction:

Digital circuits are the electronic circuits that manipulate binary information. Logic gates are the basic building blocks in constructing digital circuits. Logic gate has one output and one or more inputs. Each logic gate performs a specific logical operation. The interconnection between inputs and outputs of gates form a digital circuit. Any digital circuit can implement using three basic logical operations called AND, OR, and NOT. That is why AND, OR, and NOT gates are referred as basic logic gates. AND OR logic functions exhibit the phenomenon of dominance. In both cases, there is an input value that will force the output of the gate to a known value regardless of the state of other inputs. This value is known as the dominant value of the gate. The dominant value of an AND gate is zero, while the dominant value of an OR gate is one. The **Output** of logic gate also provides two nominal values of voltage only e.g. 0V and 5V representing logic 0 and logic 1 respectively. There is always a time delay between an input being applied and the output responding

In this experiment, we will use 74LS08, 74LS32, and 74LS04 ICs for the implementation of AND, OR, and NOT logical operations.

And Gate IC And Its Functionality:

74LS08 IC contains four 2-input AND gates. AND gate is an electronic circuit that gives a high output only when all of its inputs are high & if there is a single input which is low its output is low. So basically, AND gate works on the principle of multiplication.

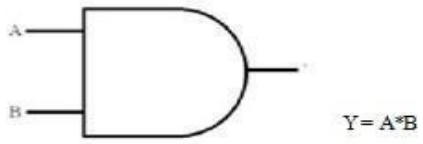

Figure 1: AND Gate Symbol

Function Table:

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

Table 1: AND Gate Truth Table

H= Logic High, L= Logic Low

Procedure:

1. Install the IC 74LS08 on the ETS-7000 Trainer's breadboard.
2. Wire the circuit according to the ICs pin configuration given in its data sheet. 3. Use the logic switches S0 and S1 for input to the AND gate.
4. For output indication use any one of the LEDs
5. Supply the VCC = +5V and GND as indicated in the diagram
6. Test at least two gates of the IC being used
7. Test the output for all possible combination of inputs and record your results in above Truth Table

Connection Diagram:

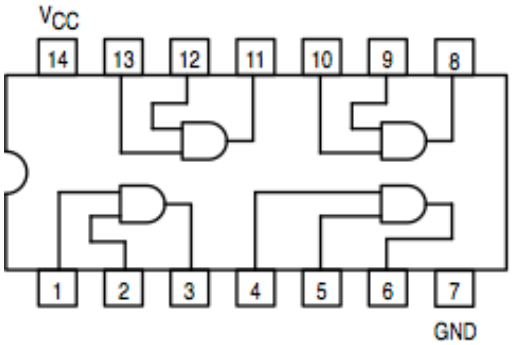

Figure 2: AND Gate IC Configuration

OR Gate IC And Its Functionality:

74LS32 IC contains four 2-input OR gates. OR gate is an electronic circuit that gives a high output if one or more of its inputs are high & gives low output when all of its inputs are low. So basically, OR gate works on the principle of addition.

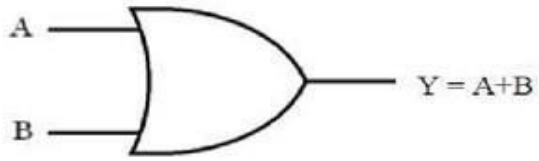

Figure 3: OR Gate Symbol

Function Table:

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

Table 2: OR Gate Truth Table

H= Logic High, L= Logic Low

Procedure:

1. Install the IC 74LS32 on the ETS-7000 Trainer's breadboard.
2. Wire the circuit according to the ICs pin configuration given in its data sheet. 3. Use the logic switches S0 and S1 for input to the AND gate.
3. For output indication use any one of the LEDs
4. Supply the VCC = +5V and GND as indicated in the diagram
5. Test at least two gates of the IC being used
6. Test the output for all possible combination of inputs and record your results in above Truth Table

Connection Diagram:

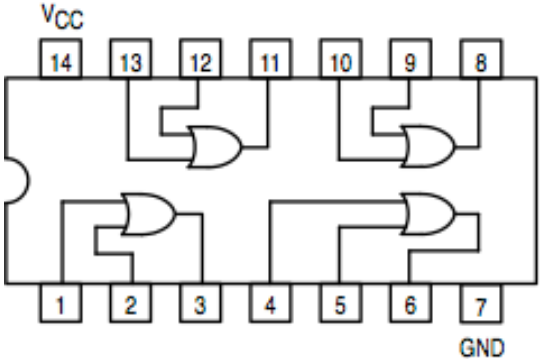

Figure 4: OR Gate IC Configuration

NOT Gate IC And Its Functionality:

74LS04 IC contains Six 1-input NOT gates. NOT gate is an electronic circuit that is used to invert a digital logic, hence called as an **inverter**. It always has exactly a single input and a single output. Whatever logical state is applied to the input, the opposite state will appear at the output.

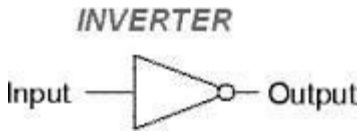

Figure 5: NOT Gate Symbol

Function Table:

Input	Output
A	**Y**
L	
H	

Table 3: NOT Gate Truth Table

H= Logic High, L= Logic Low

Procedure:

1. Install the IC 74LS04 on the ETS-7000 Trainer's breadboard.
2. Wire the circuit according to the ICs pin configuration given in its data sheet. 3. Use the logic switches S0 and S1 for input to the AND gate.
3. For output indication use any one of the LEDs
4. Supply the VCC = +5V and GND as indicated in the diagram
5. Test at least two gates of the IC being used
6. Test the output for all possible combination of inputs and record your results in following Truth Table

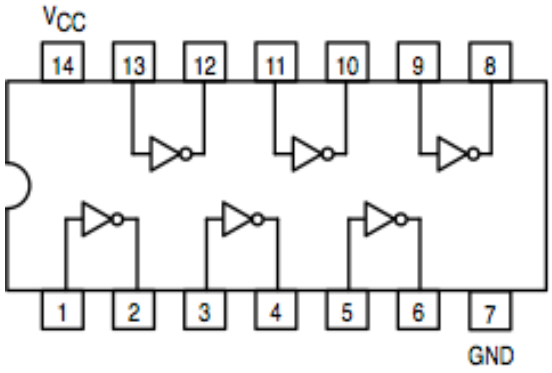

Figure 6: NOT Gate IC Configuration

Testing of ICs:

Before starting implementation of a specific logic circuit, all basic gate ICs should be tested in order to make sure that the ICs are working properly. Using the function table (truth table) for each gate, in a particular IC, apply all input combinations one by one and check its output logic level on LED.

Troubleshooting:

After testing all required number and type of ICs we need to implement a digital circuit, we start implementing the circuit on logic trainer. Once we complete the implementation, we need to test the output of the circuit to make sure that whether the circuit is working accurately or not. Using the truth table that represents the functionality of the logic circuit, we apply all input combinations one by one and check its output logic level on LED.

Lab Tasks

Lab Task#1:

Implement the AND, OR, NOT Gates logic circuit on logic trainer, and write truth tables of each gate.

Lab Task#2:

Implement the following logic circuit on logic trainer, and write truth table in the space provided below:

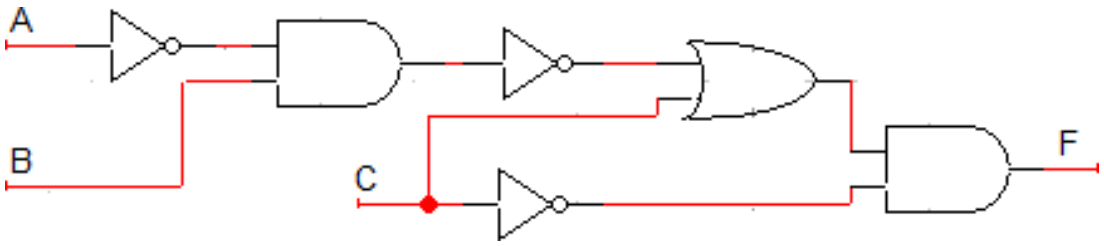

Figure 7: Combinational Circuit

Lab Task#3:

Display the number 35 on the two BCD-to-seven segment displays available on logic trainer. What BCD input should be applied at the two BCD-to-seven segment displays?

Lab Task#4:

Q1: What are the generations of IC's?

Q2: What is TTL?

Q3: Difference between Analog and Digital?

Q4: Write the advantages of ETS logic trainer

Q5: Make list of important ICs that we are going to use in DLD lab?