Experiment No 1

Introduction to Digital Logic and Equipment

1.1 Objectives:

After completing this experiment, student will be able to:

- Use the logic connection diagram (pin-out) from the data book for the 7404 inverter to the power supply and logic connections for a 7404 inverter.
- Apply correct voltage to the IC and build a simple logic probe using the 7404 inverter.
- Use this robe to test a circuit.
- Measure voltages in the circuit with digital multi-meter (DMM) and the oscilloscope, and compare them with the valid input logic levels.
- Construct a simple logic probe using a 7404 inverter.
- Use logic probe to test circuits.
- Measure logic levels with the digital multimeter (DMM) and the oscilloscope, and compare them with valid input logic levels.

1.2 Background Theory

Laboratory equipment needed for most electronics work includes a DMM, a power supply, a function generator, and a dual-trace analog or digital oscilloscope. This experiment is an introduction to these instruments and to protoboards that are commonly used to wire laboratory experiments. Since each laboratory will have instruments from different manufacturers and different models, you should familiarize yourself with your particular lab station using the manufacturer’s operating instructions or information provided by your instructor. There is a wide variety of instruments used in electronics labs; however, the directions in this experiment are general enough that you should be able to follow them for whatever instruments you are using.

1.2.1 Power Supply

All active electronic devices, such as the integrated circuits used in digital electronics, require a stable source of dc voltage to function properly as shown in Figure 1.1. The power supply provides the proper level of dc voltage. It is very important that the correct voltage be set before connecting it to the ICs on your board or permanent damage can result. The power supply at your bench may have more than one output and you can set the voltage. For nearly all of the circuits in this manual, the power supply should be set to +5.0 V. When testing a faulty circuit, one of the first checks is to verify that the supply voltage is correct and that there is no ac component to the power supply output.

Figure 1.1: DC Power Supply

1.2.2 Digital Multimeter

The DMM is a multipurpose measuring instrument that combines in one instrument the characteristics of a dc and ac voltmeter, a dc and ac ammeter, and an ohmmeter. The DMM indicates the measured quantity as a digital number, avoiding the necessity to interpret the scales as was necessary on older instruments. Because the DMM is a multipurpose instrument, it is necessary to determine which controls select the desired function. In addition, current measurements (and often high-range voltage measurements) usually require a separate set of lead connections to the meter as shown in Figure 1.2.

Figure 1.2: Digital Multimeter

After you have selected the function, you may need to select the appropriate range to make the measurement. Digital multimeters can be autoranging, meaning that the instrument automatically selects the correct scale and sets the decimal place, or they can be manual ranging, meaning that the user must select the correct scale. The voltmeter function of a DMM can measure either ac or dc volts. For digital work, the dc volts function is always used to verify that the dc supply voltage is correct and to check steady-state logic levels. If you are checking a power supply, you can verify that there is no ac component in the supply voltage by selecting the ac function. With ac voltage selected, the reading of a power supply should be very close to zero. Except for a test like this, the ac voltage function is not used in digital work. The ohmmeter function of a DMM is used only in circuits that are not powered. When measuring resistance, the power supply should be disconnected from the circuit to avoid measuring the resistance of the power supply. An ohmmeter works by inserting a small test voltage into a circuit and measuring the resulting current flow. Consequently, if any voltage is present, the reading will be in error. The meter will show the resistance of all possible paths between the probes. If you want to know the resistance of a single component, you must isolate that component from the remainder of the circuit by disconnecting one end. In addition, body resistance can affect the reading if you are holding the conducting portion of both probes in your fingers. This procedure should be avoided, particularly with high resistances.

1.2.3 Function Generator

The function generator is used to produce signals required for testing various kinds of circuits. For digital circuits, a periodic rectangular pulse is the basic signal used for testing logic circuits. It is important that the proper voltage level be set up before connecting the function generator to the circuit or else damage may occur.

Figure 1.3: Function Generator

Function generators normally have controls for adjusting the peak amplitude of a signal and may also have a means of adjusting the 0 volt level. Most function generators have a separate pulse output for use in logic circuits. If you have a TTL compatible output, it will be the one used for the experiments in this manual. A periodic rectangular pulse is a signal that rises from one level to another level, remains at the second level for a time called the pulse width, and then returns to the original level. For digital testing, it is useful to use a duty cycle that is not near 50% so that an inverted signal can be readily detected on an oscilloscope. In addition to amplitude and dc offset controls, function generators have switches that select the range of the output frequency. A vernier control may be present for fine frequency adjustments.

1.2.4 Breadboard

Breadboards are a convenient way to construct circuits for testing and experimenting. While there are some variations in the arrangement of the hole patterns, most breadboards are similar to the one shown in Figure 1.4.

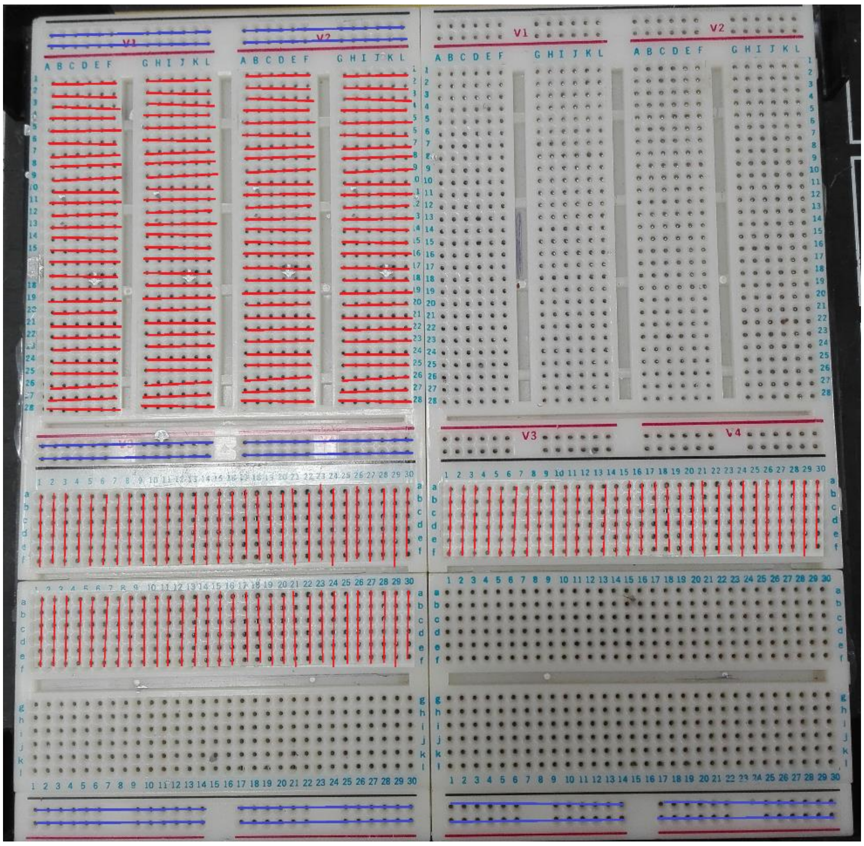

Figure 1.4: Breadboard

Notice that the top and bottom horizontal rows are connected as a continuous row. Vertical groups of five holes are connected together; the vertical group above the center strip is not connected to the vertical group below the center strip. The holes are 0.1 inch apart, which is the same spacing as the pins on an integrated circuit DIP (dual in-line pins). Integrated circuits (ICs) are inserted to straddle the center; in this manner, wires can be connected to the pins of the IC by connecting them to the same vertical group as the desired pin.

1.2.5 Oscilloscope

An oscilloscope is easily the most useful instrument available for testing circuits because it allows you to see the signals at different points in the circuit. The best way of investigating an electronic system is to monitor signals at the input and output of each system block, checking that each block is operating as expected and is correctly linked to the next. With a little practice, you will be able to find and correct faults quickly and accurately.

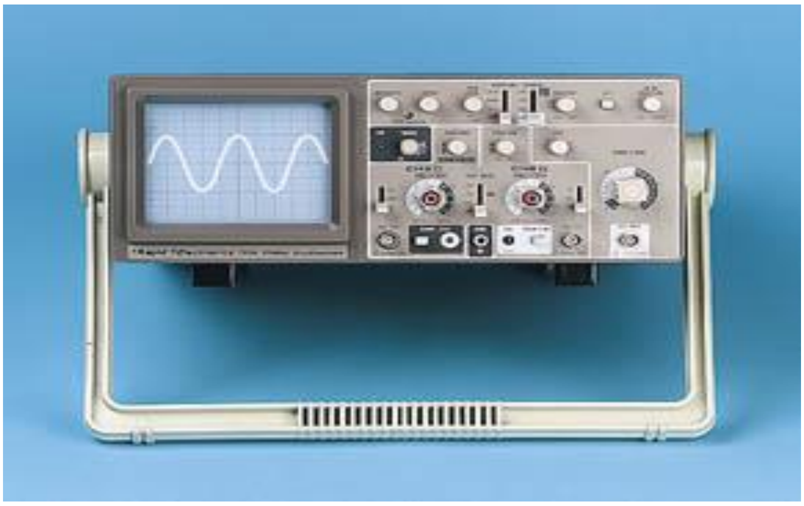

Figure 1.5: Oscilloscope

The function of an oscilloscope is extremely simple: it draws a V/t graph, a graph of voltage against time, voltage on the vertical or Y-axis, and time on the horizontal or X-axis.

1.2.6 A Simple Logic Probe

The circuit in this experiment is a simple logic probe. Logic probes are useful for detecting the presence of a HIGH or a LOW logic level in a circuit. The logic probe in this experiment is designed only to illustrate the use of this tool and the wiring of integrated circuits. The probe shown in Figure 1.6 works as follows: If the probe is not connected, the top inverter is pulled HIGH (through the 2.0 kΩ resistor) and the bottom inverter is pulled LOW (through the 330Ω resistor). As a result, both outputs are HIGH and neither LED is on. (A LOW is required to turn on either LED). If the probe input is connected to a voltage above approximately 2.0 V, the voltage at the input of the lower inverter is interpreted as a logic HIGH through diode D_2. As a result, the output of the lower inverter goes LOW, and the lower LED, representing a HIGH input, turns on. If the probe input is connected to a voltage below approximately 0.8 V, the upper input inverter is pulled below the logic threshold for a LOW, and the output inverter is LOW. Then the upper LED, which represents a logic LOW input, turns on. A more sophisticated probe could detect pulses, have a much higher input impedance, and be useful for logic families other than TTL; however, this probe will allow you to troubleshoot basic gates.

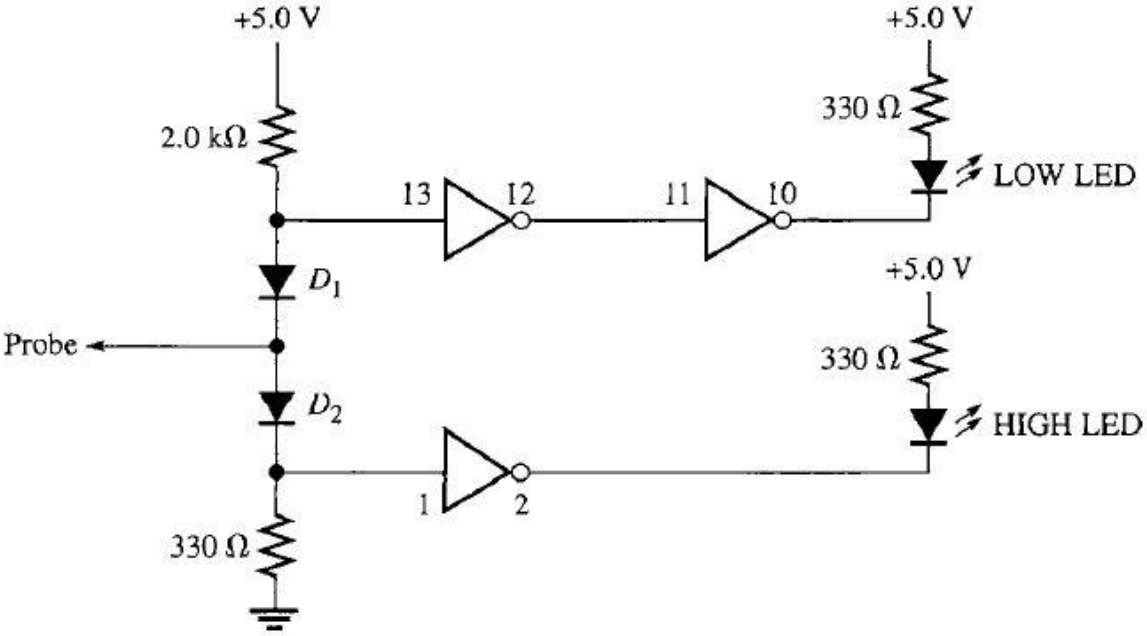

Figure 1.6: A Simple Logic Probe

1.2.7 TTL Specifications

Digital circuits have two discrete voltage levels to represent the binary digits (bits) 1 and 0. All digital circuits are switching circuits that use high-speed transistors to represent either an ON condition or an OFF condition. Various types of logic, representing different technologies, are available to the logic designer. The choice of a particular family is determined by factors such as speed, cost, availability, noise immunity, and so forth. The key requirement within each family is compatibility; that is, there must be consistency within the logic levels and power supplies of various integrated circuits made by different manufacturers. The experiments in this lab book use primarily transistor-transistor logic, or TTL. The input logic levels for TTL are illustrated in Figure 1.7.

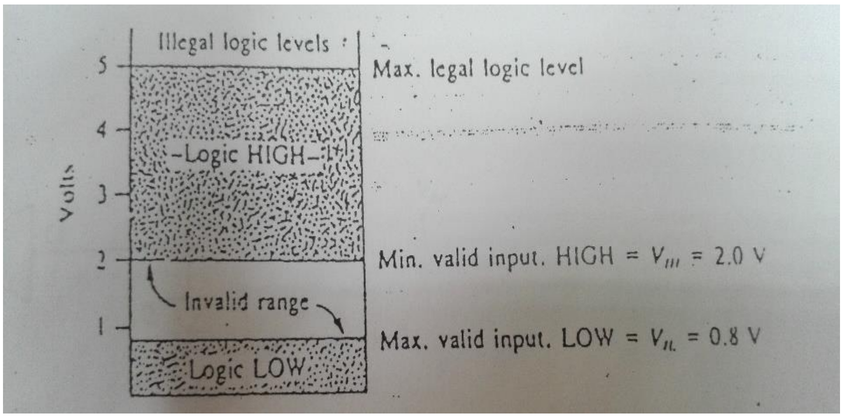

Figure 1.7: TTL Logic Levels

For any integrated circuit (IC) to function properly, power and ground must be connected. The connection diagram for the IC shows these connections, although in practice the power and ground connections are frequently omitted from diagrams of logic circuits. Figure 1.8 and figure 1.9 shows the connection diagram for a 7404 hex inverter, which will be used in this experiment. Pins are numbered counterclockwise from the top, starting with a notch or circle at the top or next to pin 1; see Figure 1.9.

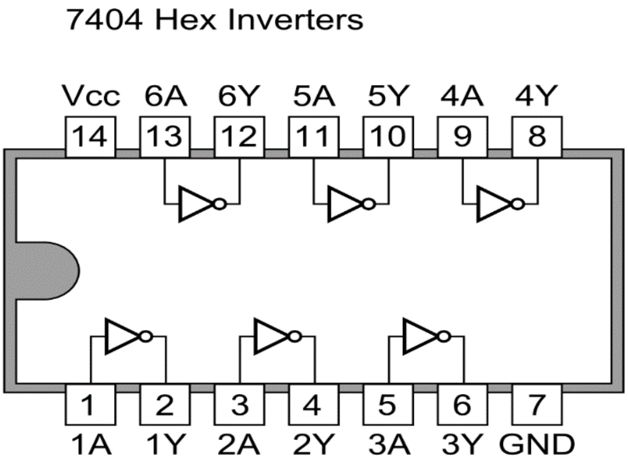

Figure 1.8: 7404 IC Pinout

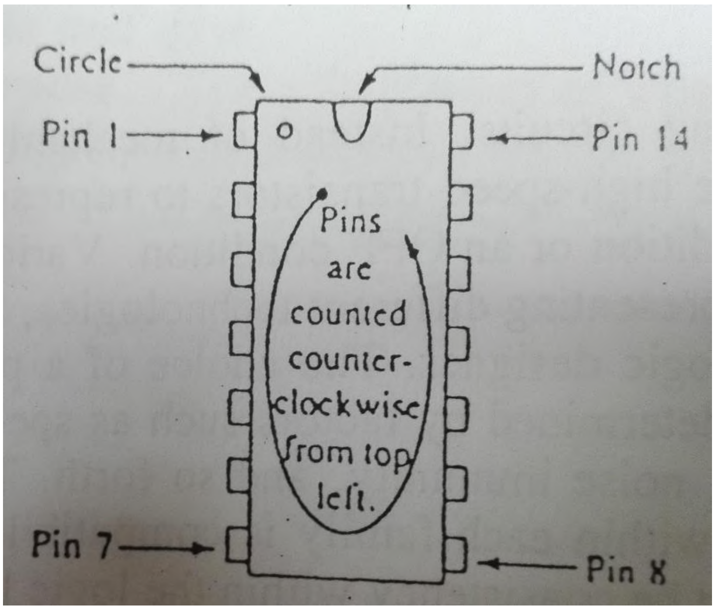

Figure 1.9: Connection Diagram

1.3 Lab Activities

1.3.1 Lab Task-1: Constructing a Logic Probe

Procedure:

1. Using the pin numbers shown, construct the simple logic probe circuit shown in Figure 1.6. Pin numbers are included on the drawing but frequently are omitted from logic drawings. Note that the LEDs and the signal diodes are polarized; that is, they must be connected in the correct direction. The arrow on electronic components always points in the direction of conventional current flow, defined as from plus to minus. Signal diodes are marked on the cathode side with a line. The LEDs generally have a flat spot on the cathode side or are the longer element inside the diode.
2. Test your circuit by connecting the probe to +5.0 V and then to ground. One of the LEDs should light to indicate a HIGH, the other, a LOW. When the probe is not connected, neither LED should be on. If the circuit does not work, double-check your wiring and the direction of the diodes.

1.3.2 Lab Task-2:

Connect two inverters in series (cascade) as shown in Figure 1.10. Move the logic probe to the output of the second inverter (pin 6). Check the logic when the input is connected to a logic LOW, OPEN, and HIGH as before. Record your observations for these three cases in Table 1.1.

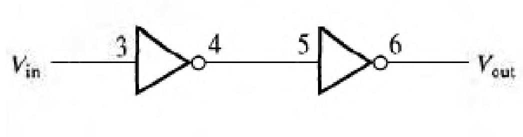

Figure 1.10: Cascaded Configuration of Inverter

Table 1.1: Table for Figure 1.10

Sr. #	**HIGH Input Logic**	
1.	Output logic level of first inveter	
2.	Output logic level of second inveter	
3.	**LOW Input Logic**	
4.	Output logic level of first inveter	
5.	Output logic level of second inveter	

1.3.3 Lab Task-3:

Connect the two inverters as cross-coupled inverters as shown in Figure 1.11. This is a basic latch circuit, the most basic form of memory. This arrangement is not the best way to implement a latch but serves to illustrate the concept. This latch works as follows: the input signal is first inverted by the top inverter. The original logic is inverted a second time by the lower inverter which restores the logic back to the original input logic level. This is a “feedback” signal which forms the latch. If the input is now removed, the feedback signal keeps the input from changing and the circuit remains stable. You will test this in the next step.

Touch the input to +5.0 V, test the output again, and record the output logic level.

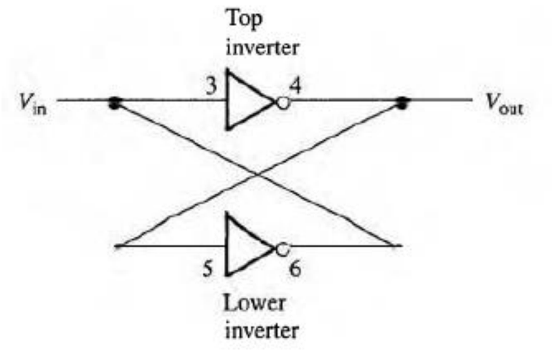

Figure 1.11

Output Logic Level: ________________

Place a fault in the circuit of Figure 1.11 by removing the wire that is connected to pin 5, the input of the lower inverter. Now momentarily touch the input, pin 3, to ground. Test the logic levels at each point in the circuit and record them in Table 1.3.

Table 1.2: table for Figure 1.11

Sr. #	Input logic level of top inveter	
1.	Output logic level of top inveter	
2.	Input logic level of bottom inveter	
3.	Output logic level of bottom inveter	

Lab Exercise and Summary

Summary should cover Introduction, Procedure, Data Analysis and Evaluation.

Student’s Signature: ________________ **Date:** ________________

LABORATORY SKILLS ASSESMENT (Psychomotor)

Total Marks: 100

Criteria (Max Marks)	Level 1 $0\% \le S < 50\%$	Level 2 $50\% \le S < 70\%$	Level 3 $70\% \le S < 90\%$	Level 4 $90\% \le S \le 100\%$	Score (S)
Procedural Awareness (20)	Selects inappropriate skills and/or strategies required by the task	Selects and applies appropriate skills and/or strategies required by the task with some errors	Selects and applies the appropriate strategies and/or skills specific to the task without significant errors	Selects and applies appropriate strategies and/or skills specific to the task without any error	
Practical Implementation (30)	Makes several critical errors in applying procedural knowledge of constructing a logic probe using 7404 inverter	Makes few critical errors in applying procedural knowledge of constructing a logic probe using 7404 inverter	Makes some non-critical errors in applying procedural knowledge of constructing a logic probe using 7404 inverter	Applies the procedural knowledge of constructing a logic probe using 7404 inverter in perfect ways	
Safety (10)	Requires constant reminders to follow safety procedures	Requires some reminders to follow safety procedures	Follows safety procedures with only minimal reminders	Routinely follows safety procedures	
Use of Tool/Equipment (20)	Uses tools, equipment and materials with limited competence	Uses tools, equipment and materials with some competence	Uses tools, equipment and materials with considerable competence	Uses tools, equipment and materials with a high degree of competence	
Participation to Achieve Group Goals (10)	Shows little commitment to group goals and fails to perform assigned roles	Demonstrates commitment to group goals, but has difficulty performing assigned roles	Demonstrates commitment to group goals and carries out assigned roles effectively	Actively helps to identify group goals and works effectively to meet them in all roles assumed	
Interpersonal Skills in Group Work (10)	Rarely interacts positively within a group, even with prompting	Interacts with other group members if prompted	Interacts with all group members spontaneously	Interacts positively with all group members and encourages such interaction in others	
Marks Obtained					

Instructor's Signature: ________________ **Date: ________________**

LABORATORY SKILLS ASSESMENT (Affective)

Total Marks: 40

Criteria (Max. Marks)	**Level 1** **0% ≤ S < 50%**	**Level 2** **50% ≤ S < 70%**	**Level 3** **70% ≤ S < 90%**	**Level 4** **90% ≤ S ≤ 100%**	**Score (S)**
Introduction (5)	Very little background information provided or information is incorrect	Introduction is brief with some minor mistakes	Introduction is nearly complete, missing some minor points	Introduction complete and well-written; provides all necessary background principles for the experiment	
Procedure (5)	Many stages of the procedure are not entered on the lab report.	Many stages of the procedure are entered on the lab report.	The procedure could be more efficiently designed but most stages of the procedure are entered on the lab report.	The procedure is well designed and all stages of the procedure are entered on the lab report.	
Data Record (10)	Data is brief and missing significant pieces of information.	Data provides some significant information and has few critical mistakes.	Data is almost complete but has some minor mistakes.	Data is complete and relevant. Tables with units are provided. Graphs are labeled. All questions are answered correctly.	
Data Analysis (10)	Data is presented in very unclear manner. Error analysis is not included.	Data is presented in ways (charts, tables, graphs) that are not clear enough. Error analysis is included.	Data is presented in ways (charts, tables, graphs) that can be understood and interpreted. Error analysis is included.	Data are presented in ways (charts, tables, graphs) that best facilitate understanding and interpretation. Error analysis is included.	
Report Quality (10)	Report contains many errors.	Report is somewhat organized with some spelling or grammatical errors.	Report is well organized and cohesive but contains some grammatical errors.	Report is well organized and cohesive and contains no grammatical errors. Presentation seems polished.	
				Marks Obtained	

LABORATORY SKILLS ASSESSMENT (Cognitive)

Total Marks: 10

(If any) **Marks Obtained**	

Instructor's Signature: ________________ **Date: ________________**