King Mongkut's Institute of Technology Ladkrabang
Computer Engineering International Program
01276112 Digital System Fundamentals

Lab 2 - Logic Gates and Adder Circuits

Learning Outcomes

1. Be able to use lab equipment to conduct digital circuit laboratory.
2. Understand how logic gate ICs work.
3. Implement adder circuit.

1. Introduction

This laboratory will introduce a student the equipment used to conduct digital circuit experiment called Logic Trainer and basic logic gate ICs which are AND, OR, NOT (Inverter), XOR and NAND gates.

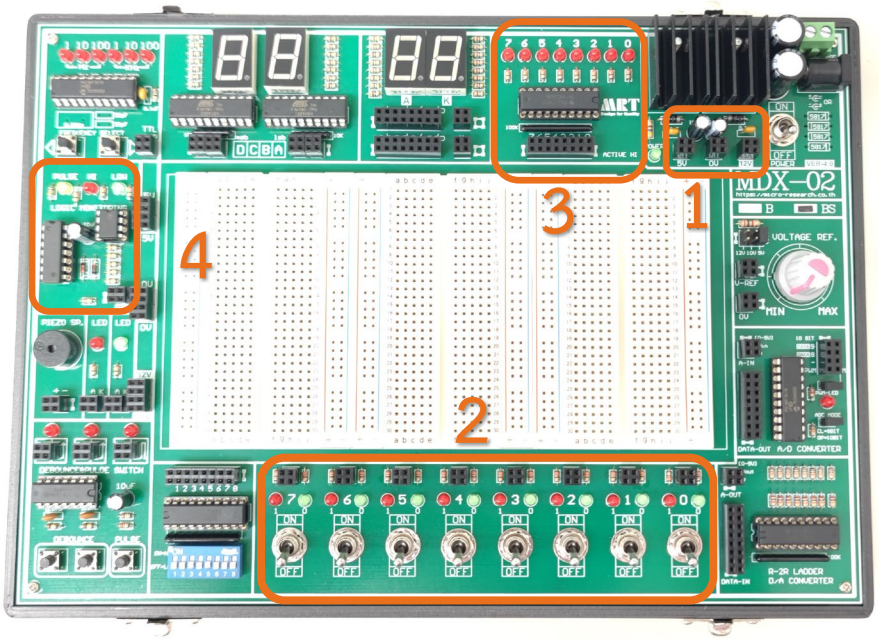


Fig 1 Logic Trainer

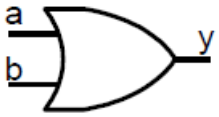
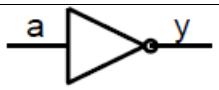
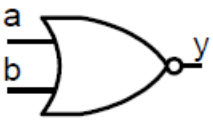
Logic Trainer**Error! Reference source not found.** Fig 1 shows a logic trainer that are composed of several units. Four units going to be used in this lab which are power supply unit, logic switch unit, logic monitor unit, and logic probe unit.

1. **Power Supply Unit** that located at top right corner **supplies electrical voltage** to digital circuit. It can supply two levels of voltage which are 5V and 12V. The 0V socket provides the ground (GND) to the circuit. Normally, all logic gate ICs used in all laboratory use 5V only.
2. **Logic Switch Unit** that located at bottom is used to **provide logic level** to digital circuit. It is composed of eight toggle switches labeled 0 to 7.
    - Move the switch up to ON position to input digital circuit the logic **"1"** or **HI** (voltage between 2.5 and 5 V). **Red LED** will be lit.
    - Move the switch down to OFF position to input digital circuit the logic "0" or LOW (voltage between 0 and 0.5 V). Green LED will be lit.
3. **Logic Monitor Unit** that located beside power supply unit is used to **examine logic level** of the certain part of digital circuit. It contains eight red LEDs to display the result.
    - Red light indicates logic "1" (HI voltage).
    - No light indicates either logic "0" (LOW voltage) or the absence of voltage.**
4. **Logic Probe Unit** that located at the left is also used to **examine logic level** of the certain part of digital circuit. However, it contains only one input.
    - Red HI LED indicates logic "1".
    - Greed LOW LED indicates logic "0".
    - Yellow Pulse LED indicates rising edge signal (signal changing from LOW to HI).

2. Logic Gate Integrated Circuits (Logic Gate ICs)

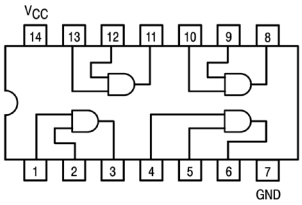
The inside of logic gate IC contains different type of logic gates, for example, AND, OR and NOT gate. This lab uses six types of logic gates as the following:

No.	Symbol & IC No.	Truth Table	Description
1	 7408	a b | y 0 0 | 0 0 1 | 0 1 0 | 0 1 1 | 1	**2-input AND gate** Output is logic "1" iff all inputs are logic "1". Otherwise, output is logic "0".

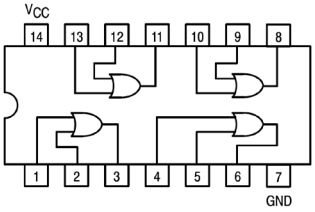
No.	Symbol & IC No.	Truth Table	Description
2	 7432	a b | y 0 0 | 0 0 1 | 1 1 0 | 1 1 1 | 1	**2-input OR gate** Output is logic "0" iff all inputs are logic "0". Otherwise, output is logic "1".
3	 7404	a | y 0 | 1 1 | 0	**NOT gate or Inverter** Output is the complement of input.
4	 7400	a b | y 0 0 | 1 0 1 | 1 1 0 | 1 1 1 | 0	**2-input NAND gate** Output is the complement of AND gate output.
5	 7402	a b | y 0 0 | 1 0 1 | 0 1 0 | 0 1 1 | 0	**2-input NOR gate** Output is the complement of OR gate output.
6	 7486	a b | y 0 0 | 0 0 1 | 1 1 0 | 1 1 1 | 0	**2-input XOR gate** Output is logic "1" iff both inputs are different logic. If inputs are same logic, output is logic "0".

3. Precaution

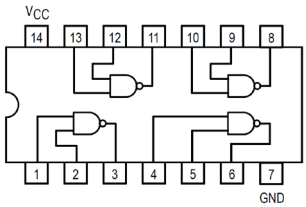
1. Before staring the experiment, all equipment and ICs should be in good condition.
2. IC Vcc pin connects to 5V and GND pin connects to 0V.
3. Logic "0" (LOW) voltage ranges between 0 - 0.5 V and logic "1" (HI) voltage ranges between 2.5 – 5 V.
4. Do not damage IC pins while placing it into a protoboard.
5. Turn off logic trainer while wiring.
6. Use the screwdriver to remove an IC out of the protoboard by insert its tip underneath the top of the IC (between pin 1 and 14) and lift the IC up a little. Repeat the process at the bottom of the IC (between pin 7 and 8). Be careful, do not damage IC pins.



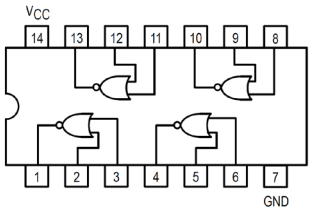
74LS08 | 2-Input AND Gate IC



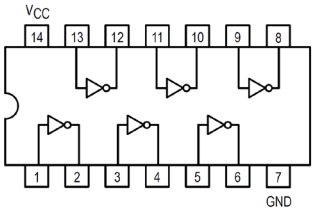
74LS32 | 2-Input OR Gate IC



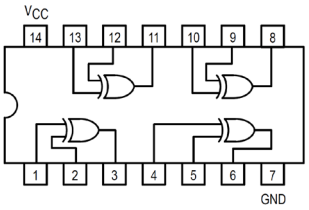
74LS00 | 2-Input NAND Gate IC



** 74LS02 | 2-Input NOR Gate IC **

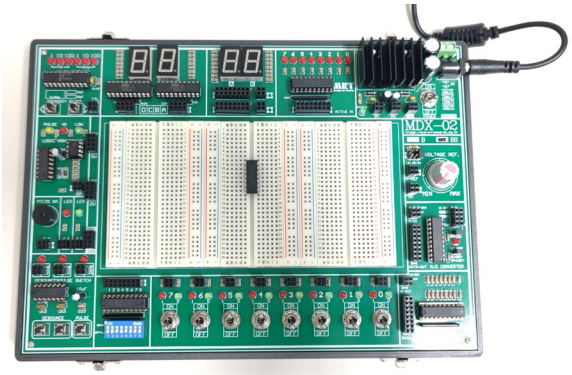


74LS04 | NOT Gate IC

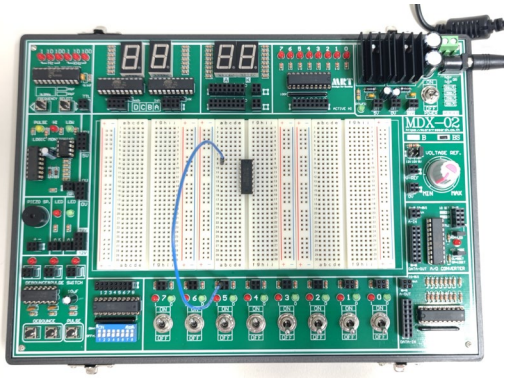


74LS86 | 2-Input XOR Gate IC

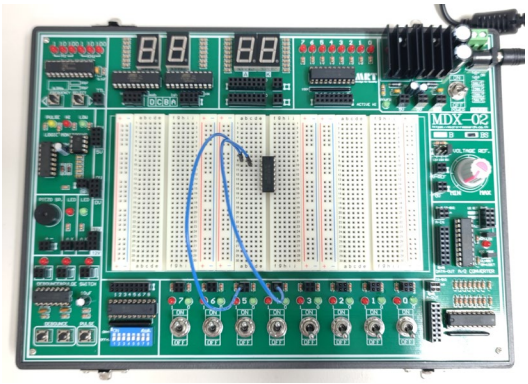
Fig 2 Internal organization of six logic gate ICs



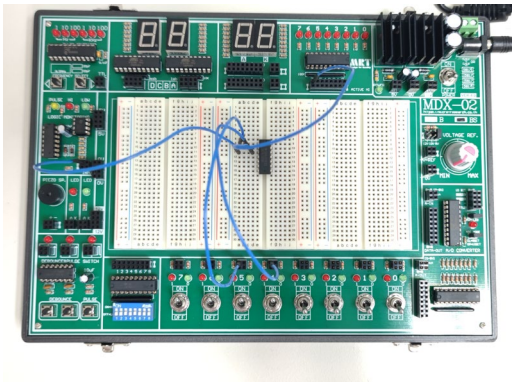
1. Place IC on a protoboard.



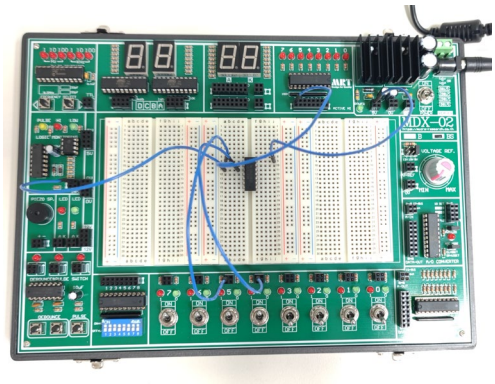
2. Connect Pin No.1 to any logic switch.



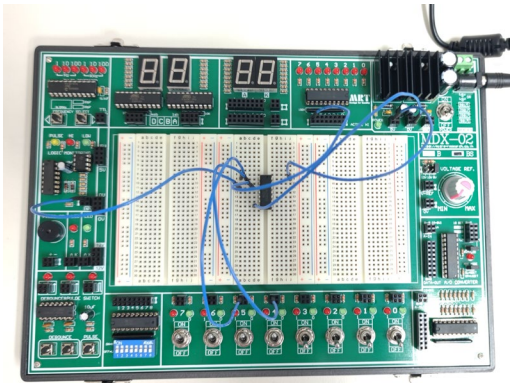
3. Connect Pin No.2 to another logic switch.



4. Connect Pin No.3 to both logic monitor socket and logic probe input socket.



5. Connect Pin No.14 to 5V socket.



6. Connect Pin No.7 to 0V.

Fig 3 Step-by-step wiring one of AND gates inside 74LS08 IC on logic trainer

4. Experiment

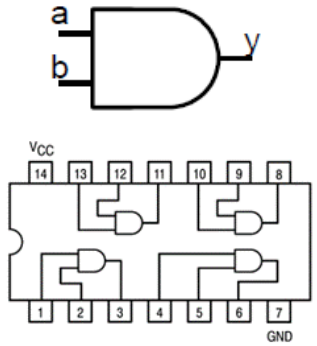
1. Study internal organization of logic gate ICs according to Fig 2. Notice that IC 74LS02 (NOR Gate IC) has different organization compare to the others.

2. Connect the first AND gate of 74LS08 IC to logic switches, logic monitor, and logic probe as shown in Fig 3. Then flipping two logic switches connected to AND gate inputs according to the following table as shown in the following clip

https://www.youtube.com/shorts/_qZMQHO3EFE.

Record the output y.

74LS08



AND GATE

Input		Output			
a	b	y (pin 3)	y (pin 6)	y (pin 8)	y (pin 11)
0	0	0	0	0	0
0	1	0	0	0	0
1	0	0	0	0	0
1	1	1	1	1	1

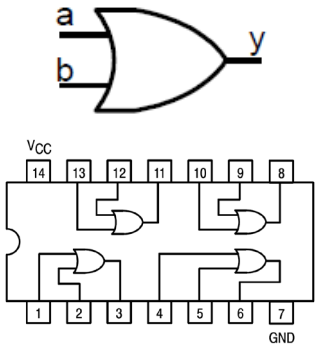
3. Connect three other AND gates to logic switches and logic monitor. Compare between each AND gate outputs to recoded output from the table in Experiment 2.

4. Repeat the process of Experiment 2 and 3 but change from AND gate IC to five other gate ICs as the following:

Tip: Remove and replace ICs on the exact same position instead of rewiring except IC No. 74LS02 and 74LS04.

OR GATE

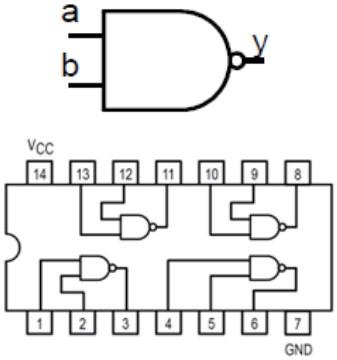
74LS32



Input		Output			
a	b	y (pin 3)	y (pin 6)	y (pin 8)	y (pin 11)
0	0	0	0	0	0
0	1	1	1	1	1
1	0	1	1	1	1
1	1	1	1	1	1

NAND GATE

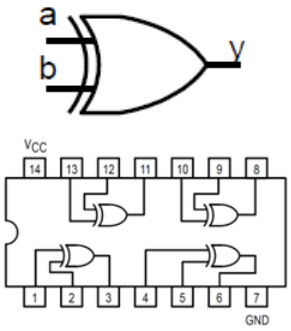
74LS00



Input		Output			
a	b	y (pin 3)	y (pin 6)	y (pin 8)	y (pin 11)
0	0	1	1	1	1
0	1	1	1	1	1
1	0	1	1	1	1
1	1	0	0	0	0

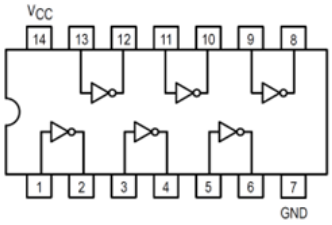
XOR GATE

74LS86



Input		Output			
a	b	y (pin 3)	y (pin 6)	y (pin 8)	y (pin 11)
0	0	0	0	0	0
0	1	1	1	1	1
1	0	1	1	1	1
1	1	0	0	0	0

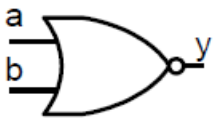
74LS04

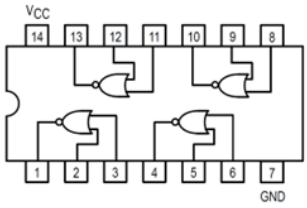


NOT GATE

Input	Output					
a	y (pin 2)	y (pin 4)	y (pin 6)	y (pin 8)	y (pin 10)	y (pin 12)
0	1	1	1	1	1	1
1	0	0	0	0	0	0

74LS02

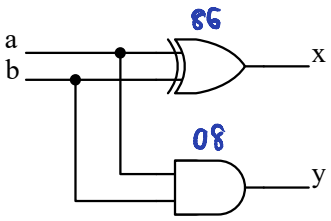




NOR GATE

Input		Output			
a	b	y (pin 1)	y (pin 4)	y (pin 10)	y (pin 13)
0	0	1	1	1	1
0	1	0	0	0	0
1	0	0	0	0	0
1	1	0	0	0	0

5. Building digital circuit according to the figure below using IC No. 74LS86 and 74LS32. The LSB must be on the rightmost of occupied switches or LEDs. Connect output x to both logic monitor and logic probe. Vary input a and b according to the table. **Record the output x and y.**



86
08

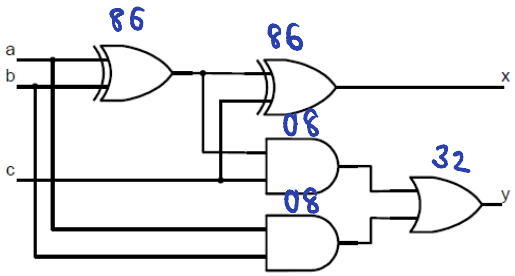
74LS86 & 74LS~~32~~

XOR GATE & AND GATE

HALF ADDER

Input		Output	
a	b	x	y
0	0	0	0
0	1	0	1
1	0	0	1
1	1	1	0

6. Build digital circuit as the figure below using logic gate ICs. The LSB must be on the rightmost of occupied switches or LEDs. Connect output x to both logic monitor and logic probe. Vary input a, b, and c according to the table. **Record output x and y.**



Specify all IC No. used for the circuit

74LS86, 74LS08, 74LS32

XOR GATE, AND GATE, OR GATE

FULL ADDER

Input			Output	
a	b	c	x	y
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

Lab 2 Submission

Date 17/12/2024 Group No. 13

1. Student ID 67011380 Name Watcharathorn kvachangmon

2. Student ID 67011385 Name Worawalun Somputphotiudom

3. Student ID 67011594 Name Chuthathip Termchaikul

Checkpoint

Experiment 1-4 _____ (0 pts)

Experiment 5 _____ (10 pts)

Experiment 6 _____ (10 pts)

Questions

1. Specify IC No. for logic gates below and draw their symbols.

OR gate IC No. 74LS32	NOR gate IC No. 74LS02
NAND gate IC No. 74LS00	XOR gate IC No. 74LS86

2. Give the name of the digital circuit in Experiment 5 Half-Adder

3. Give the name of the digital circuit in Experiment 6 Full-Adder