Lab Experiment 4

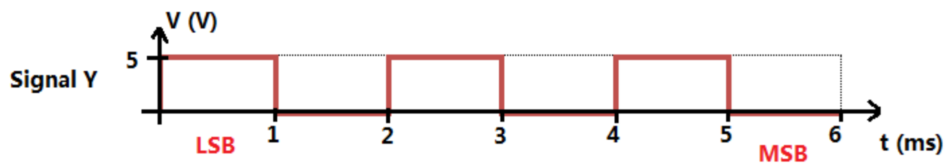
# Basic Logic Gates

## COMPONENTS

- The 74LS00 is a QUAD NAND gate.
- The 74LS02 is a QUAD NOR gate.
- The 74LS04 is a HEX inverter (NOT gate)
- The 74LS08 is a QUAD AND gate.
- The 74LS32 is a QUAD OR gate.
- The 74LS86 is a QUAD XOR gate.
- Breadboard
- Jumper wires
- Digital board

## INTRODUCTION

Digital signals is made up of series of 1's and 0's that represent numbers, letters, symbols, or control signals. Those series of 1's and 0's can be measured using an oscilloscope and plot into a ***timing diagram***. In the timing diagram, logic of 1's and 0's is represented by a HIGH and a LOW voltage level respectively. The voltage level to represent a HIGH is between 1.5 V and 5 V, and a LOW voltage level is closed to 0 V. Timing diagram is used to show the voltage level between 5 V and 0 V, which is digital logic 1 (HIGH = 5 V) and 0 (LOW = 0 V).




*Schematic 4.1 – Sample of a time diagram of signal Y*

Logic gates are integrated circuit (IC) that performs a logic operation on one or more logic inputs, and produce a single logic output. They are commonly found in digital circuit, and the five basic logic gates are AND, OR, NAND, NOR, and NOT (inverter) gate, plus two especial gates which are Exclusive-OR (X-OR) and Exclusive-NOR (X-NOR). For today's lab, you will build and experiment seven different logic gates. For each logic gate, build the circuit, observe and record the output in its respective truth table, and sketch a timing diagram of the output signal according to the truth table.

To identify the pin number on an IC chip, we can face the IC chip upward, with the reference dot on the top, and pin 1 will be the one on the top-left pin. The rest of the pin number, in increasing order, will count in a counter-clockwise direction (Figure 4.1)

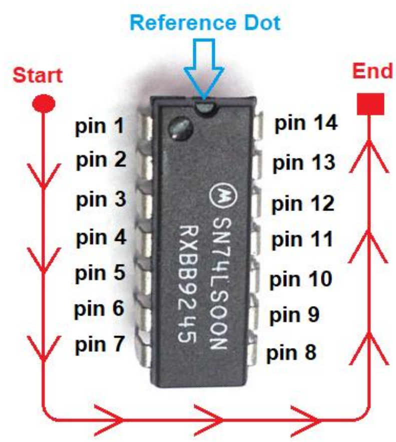



*Figure 4.1 – Pin number identification of an IC chip*

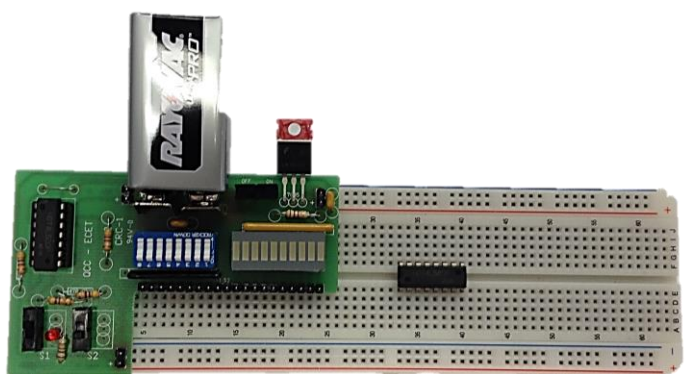
# LAB EXPERIMENT PROCEDURE

## PART 4.1 - OPERATION OF THE INVERTER (NOT GATE)

Remarks:

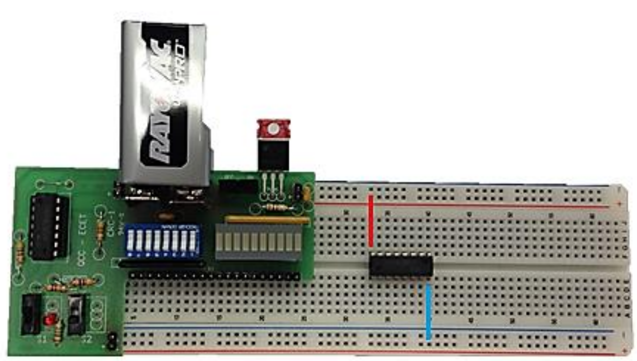
- Switch 8 will be named “variable A” and will simulate the input.
- LED 1 will show the condition of the input.
- LED 3 will show the condition of the output.
- Use 0 as OFF and 1 as ON

— Place the 7404 IC into the protoboard as shown below. Make sure that the starting point indicator is facing to the left of your protoboard:



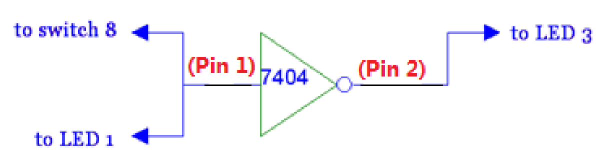
**Power IC first:**

— Connect pin 7 to GROUND (blue line (-) in the breadboard)
— Connect pin 14 to POWER (red line (+) in the breadboard)



**Pin connections:**

— Connect pin 1 of the 7404 to switch 8
— Connect switch 8 to LED 1
— Connect pin 2 of the 7404 to LED 3



- Connect the battery and turn ON the power switch.
- Operate the switch and observe what happens with the LED 3, which is $Y = \overline{A}$
- Fill in the following Table 4.1

| Truth Table for the Inverter (NOT gate) | |
|---|---|
| **A** | $Y = \overline{A}$ |
| **0** | |
| **1** | |

*Table 4.1 - Truth Table for the Inverter (NOT gate)*

- Turn OFF the power switch and remove Part 1 wiring and chip 7404 from the protoboard
- Complete the following timing diagram for the inverter according to Table 4.1

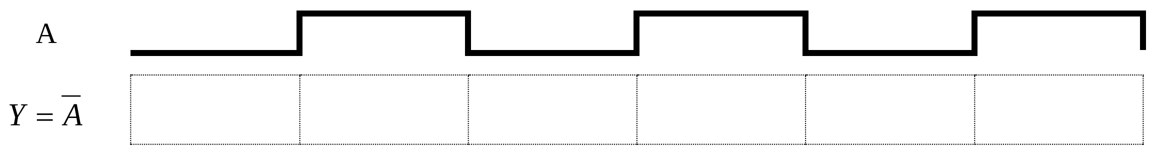


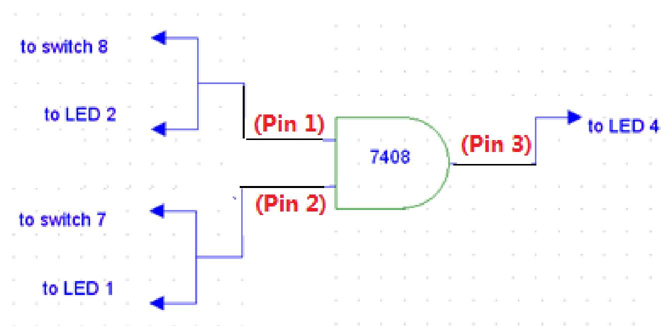

*Figure 4.1 – Time diagram for a NOT gate*

## PART 4.2 –OPERATION OF AND GATE

Remarks:

- Switch 8 will be the A input and Switch 7 will be the B input.
- LED 1 will show the state of the B input.
- LED 2 will show the state of the A input.
- LED 4 will show the state of the output.
- Use 0 as OFF and 1 as ON

- Place 7408 IC to the protoboard
- Connect pin 14 to power (+) and pin 7 (-) to ground.
- Connect switch 8 to Pin 1 of the 7408.
- Connect Pin 1 of the 7408 to LED 2.
- Connect switch 7 to pin 2 of the 7408.
- Connect pin 2 of the 7408 to LED 1.
- Connect pin 3 of the 7408 to LED 4.
- Operate the switch 7 and 8 as indicates in Table 4.2, and record if LED 4 turns ON or OFF



| Truth Table for the AND gate | | |
|---|---|---|
| **B - Switch 7**<br>**LED 1** | **A – Switch 8**<br>**LED 2** | $Y = A \bullet B$<br>**LED 4** |
| **0** | **0** | |
| **0** | **1** | |
| **1** | **0** | |
| **1** | **1** | |

*Table 4.2 – Truth table for the AND gate*

- Turn OFF the power switch
- Remove Part 2 wiring and chip 7408 from the protoboard
- Complete the following timing diagram for AND gate operation according to Table 4.2

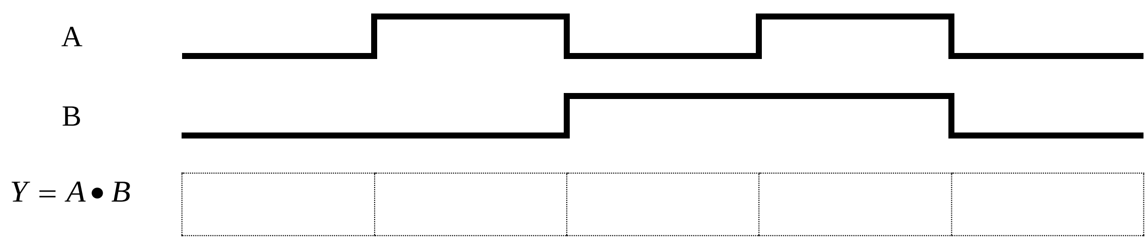


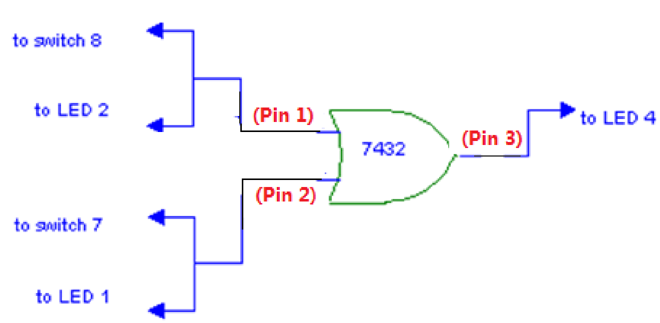

*Figure 4.2 – Time diagram for an AND gate*

## PART 4.3 –OPERATION OF OR GATE

Remarks:

- Switch 8 will be the A input, Switch 7 will be the B input.
- LED 1 will show the state of the B input.
- LED 2 will show the state of the A input.
- LED 4 will show the state of the output.

- Place 7432 IC into the protoboard
- Connect pin 14 to power (+) and pin 7 (-) to ground.
- Connect switch 8 to Pin 1 of the 7432.
- Connect switch 8 to LED 2.
- Connect switch 7 to pin 2 of the 7432.
- Connect switch 7 to LED 1.
- Connect pin 3 of the 7432 to LED 4.
- Operate the switch 7 and 8 as indicates in Table 4.3, and record if LED 4 turns ON or OFF



| Truth Table for the OR gate | | |
|---|---|---|
| **B - Switch 7**<br>**LED 1** | **A - Switch 8**<br>**LED 2** | $Y = A + B$<br>**LED 4** |
| **0** | **0** | |
| **0** | **1** | |
| **1** | **0** | |
| **1** | **1** | |

*Table 4.3 – Truth table for the OR gate*

- Turn OFF the power switch and remove Part 3 wiring and chip 7432 from the protoboard
- Complete the following timing diagram for OR gate operation using Table 4.3.

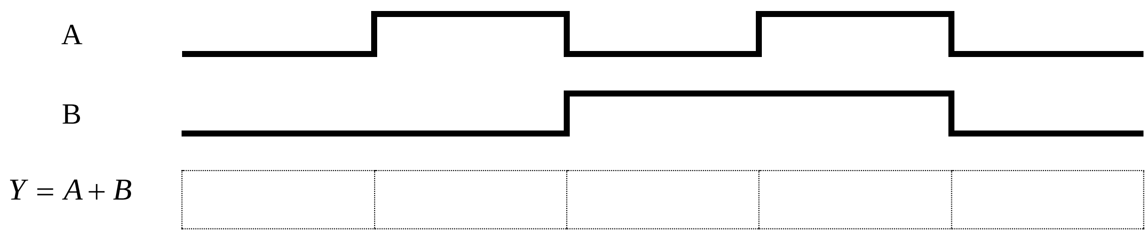


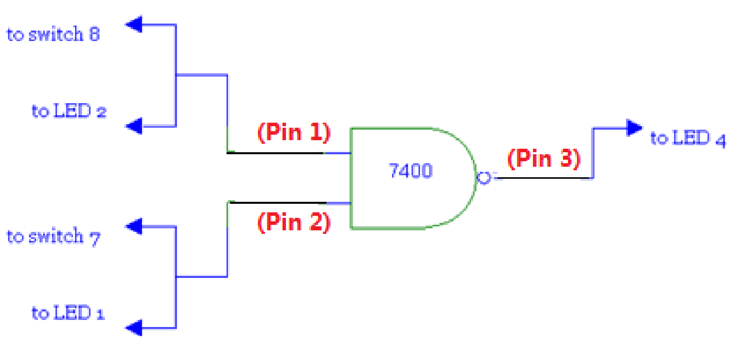

*Figure 4.3 – Time diagram for a OR gate*

Describe what the truth table tells you about the operation of the OR gate. ______________________________

______________________________________________________________________________________

### PART 4.4 - OPERATION OF NAND GATE

- Insert the 7400, PROPERLY onto the protoboard. Make sure pin 1 is on the lower left.
- Connect pin 14 to power (+) and pin 7 (-) to ground.
- Connect switch 8 to Pin 1 of the 7400 (Switch 8 will be the A input)
- Connect switch 8 to LED 2 (Switch 7 will be the B input)
- Connect switch 7 to pin 2 of the 7400 (LED 1 will show the state of the B input)
- Connect switch 7 to LED 1 (LED 2 will show the state of the A input)
- Connect pin 3 of the 7400 to LED 4 (LED 4 will show the state of the output)



— Operate the switches in binary order as shown in Table 4.4 and fill in the table.
— Remove the wires from the 7400 using Table 4.4

| Truth Table for the NAND gate | | |
|---|---|---|
| **B - Switch 7**<br>**LED 1** | **A - Switch 8**<br>**LED 2** | $Y = \overline{A \cdot B}$<br>**LED 4** |
| **0** | **0** | |
| **0** | **1** | |
| **1** | **0** | |
| **1** | **1** | |

*Table 4.4 – Truth table for the NAND gate*

— Turn OFF the power switch and remove Part 4 wiring and chip 7400 from the protoboard
— Complete the following timing diagram for NAND gate operation.

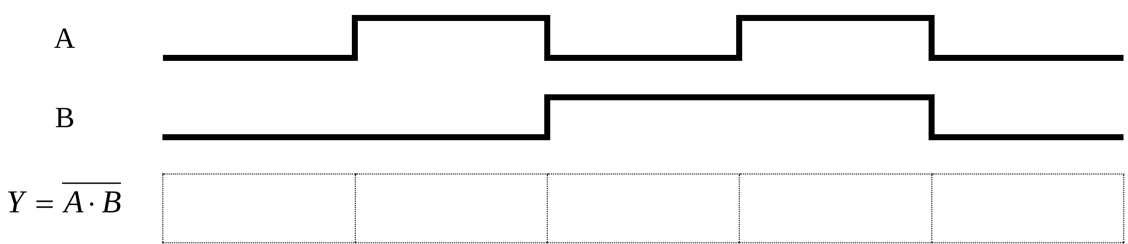
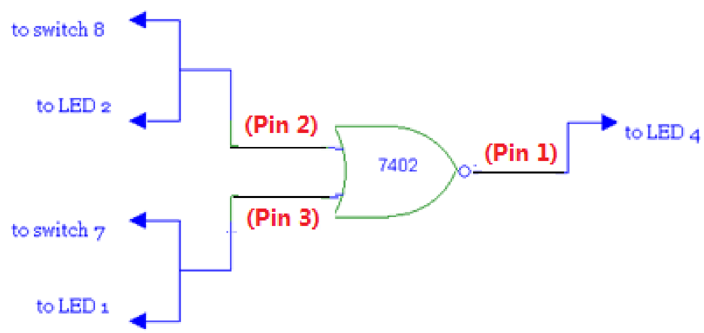



*Figure 4.4– Time diagram for a NAND gate*

## PART 4.5 - OPERATION WITH NOR GATE

— Insert the 7402, PROPERLY onto the protoboard. Make sure pin 1 is on the lower left.
— Connect pin 14 to power (+) and pin 7 (-) to ground.
— Connect switch 8 to Pin 2 of the 7402 (Switch 8 will be the A input)
— Connect switch 8 to LED 2 (Switch 7 will be the B input)
— Connect switch 7 to pin 3 of the 7402 (LED 1 will show the state of the B input)
— Connect switch 7 to LED 1 (LED 2 will show the state of the A input)
— Connect pin 1 of the 7402 to LED 4 (LED 4 will show the state of the output)




- Operate the switches in binary order as shown in Table 4.5 and fill in the table.
- Turn OFF the power switch and remove the wiring and chip 7402 from the protoboard

| **Truth Table for the NOR gate** | | |
|---|---|---|
| **B - Switch 7**<br>**LED 1** | **A - Switch 8**<br>**LED 2** | $Y = \overline{A + B}$<br>**LED 4** |
| **0** | **0** | |
| **0** | **1** | |
| **1** | **0** | |
| **1** | **1** | |

*Table 4.5 – Truth table for NOR gate*

- Complete the following timing diagram for NOR gate operation using Table 4.5

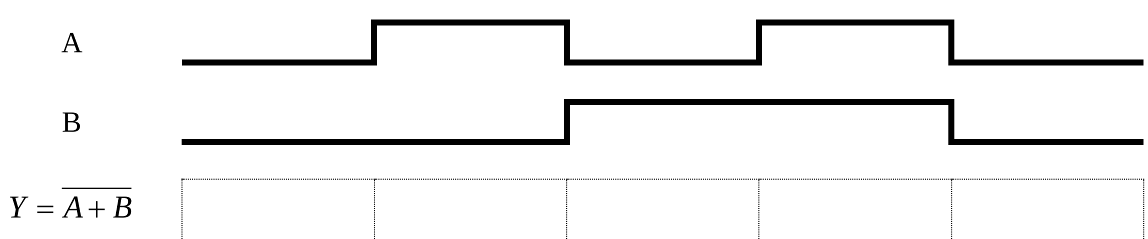
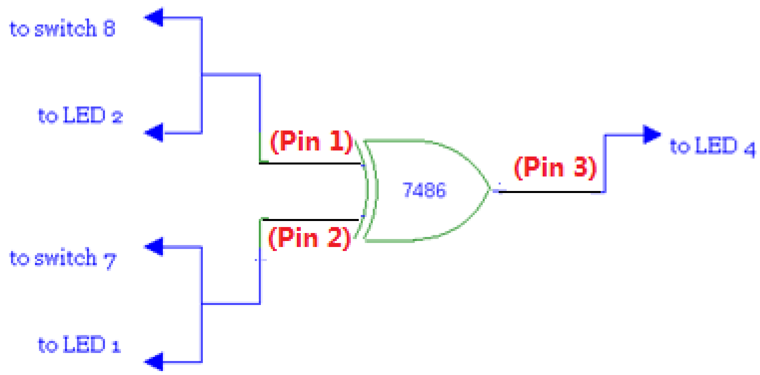



*Figure 4.5 – Time diagram for a NOR gate*

## PART 4.6 - OPERATION WITH XOR GATE

- Insert the 7486, PROPERLY onto the protoboard. Make sure pin 1 is on the lower left.
- Connect pin 14 to power (+) and pin 7 (-) to ground.
- Connect switch 8 to Pin 1 of the 7486 (Switch 8 will be the A input)
- Connect Pin 1 of the 7486 to LED 2 (Switch 7 will be the B input)
- Connect switch 7 to pin 2 of the 7486 (LED 1 will show the state of the B input)
- Connect switch 7 to LED 1 (LED 2 will show the state of the A input)

— Connect pin 3 of the 7486 to LED 4 (LED 4 will show the state of the output)




— Operate the switches in binary order as shown in Table 4.6 and fill in the table.
— Turn OFF the power switch and remove the wiring and chip 7486 from the protoboard

| Truth Table for the XOR gate | | |
|---|---|---|
| **B - Switch 7**<br>**LED 1** | **A - Switch 8**<br>**LED 2** | $Y = A \oplus B$<br>**LED 4** |
| **0** | **0** | |
| **0** | **1** | |
| **1** | **0** | |
| **1** | **1** | |

*Table 4.6 – Truth table for the XOR gate*

— Complete the following timing diagram for XOR gate operation using Table 4.6.

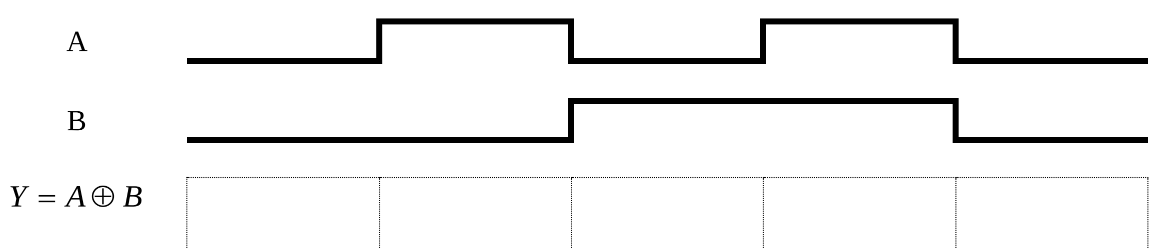


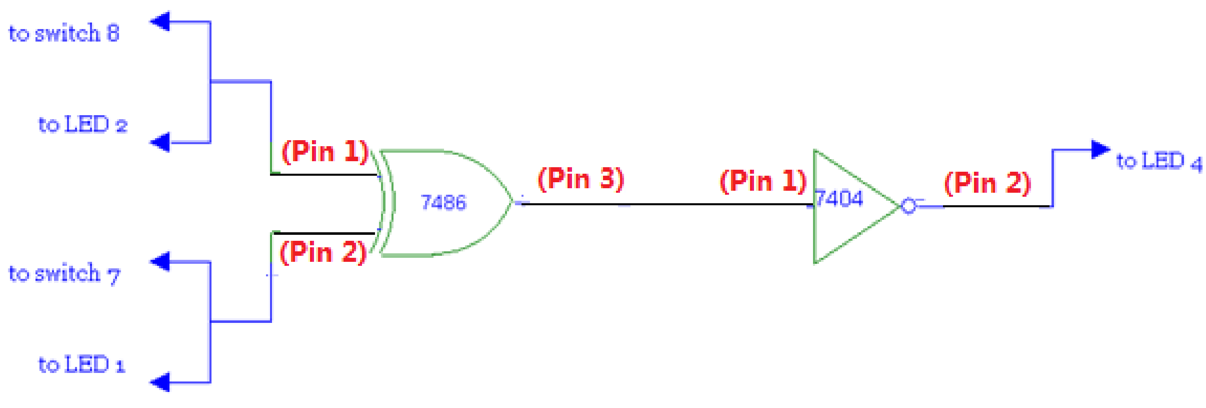

*Figure 4.6 – Time diagram for a XOR gate*

### PART 4.7 - OPERATION WITH XNOR GATE

Remarks:

- The XNOR function can be implemented by connecting the output of a XOR gate to an inverter.

- Insert the 7404, PROPERLY next to the 7486 onto the protoboard. Make sure pin 1 is on the lower left.
- Connect pin 14 to power (+) and pin 7 (-) to ground.
- Connect switch 8 to Pin 1 of the 7486 (Switch 8 will be the A input)
- Connect Pin 1 of the 7486 to LED 2 (Switch 7 will be the B input)
- Connect switch 7 to pin 2 of the 7486 (LED 1 will show the state of the B input)
- Connect switch 7 to LED 1 (LED 2 will show the state of the A input)
- Connect pin 3 of the 7486 to pin 1 of the 7404
- Connect pin 2 of the 7404 to LED 4 (LED 4 will show the state of the output)




- Operate the switches in binary order as shown in Table 4.7 and fill in the table.
- Turn OFF the power switch and remove the wiring and chip 7486 and 7404 from the protoboard

| Truth Table for the XNOR gate | | |
|---|---|---|
| **B - Switch 7**<br>**LED 1** | **A - Switch 8**<br>**LED 2** | $Y = \overline{A \oplus B}$<br>**LED 4** |
| **0** | **0** | |
| **0** | **1** | |
| **1** | **0** | |
| **1** | **1** | |

*Table 4.7 - Truth table for the XNOR gate*

— Complete the following timing diagram for XNOR function using Table 4.7.

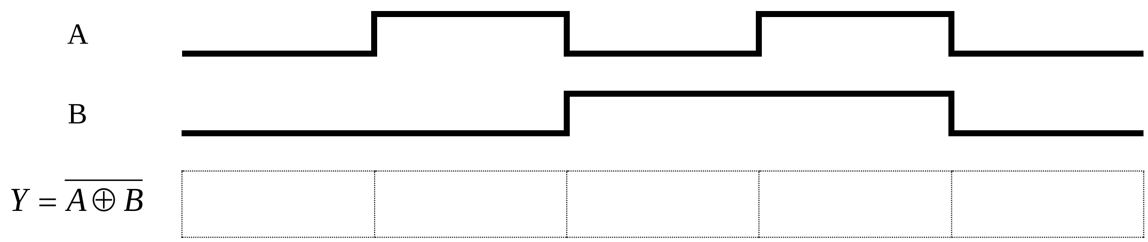



*Figure 4.7 – Time diagram for a XNOR gate*

## QUESTIONS

1. What difference do you notice about the pin numbers of a NOR gate, 7402, when compared to the other IC chips' pin numbers in this experiment?
2. If a student by mistake used a 7486 chip instead of a 7432, how would this mistake affect this experimental result? Explain your answer
3. If a student by mistake used a 7400 chip instead of a 7402, how would this mistake affect this experimental result? Explain your answer
4. According to this experiment, what is a timing diagram? What does a timing diagram represent?
5. During a lab experiment, a student swapped the inputs of a truth table when she constructed the digital circuit. For example, switch 8 should represent input A and switch 7 should represent input B, but the student recorded switch 8 as input B and switch 7 as input A. Would this mistake affect her experimental result for OR, AND, NOR, NAND, XOR, and XNOR gate experiment? Explain your answer

Student's name:________________________ Lab instructor's signature__________________________

**--------------- LAB EXPERIMENT 4 ENDS HERE ---------------**