Experiment

Study of various logic families

1 Objectives

To study and verify various Boolean logic operations and the De Morgan's laws using digital ICs.

2 Circuit components/equipment

1. Digital ICs (7404, 7408, 7400, 7486, 7432, 74266)
2. Resistors
3. DIP switch
4. DC Power supply (5 V)
5. LEDs
6. Breadboard
7. Connecting wires

3 Theory

Standard commercially available **Digital Logic Gates** are available in two basic forms, **TTL** which stands for Transistor-Transistor Logic such as the 7400 series, and **CMOS** which stands for Complementary Metal-Oxide-Silicon which is the 4000 series of Integrated Circuits, (IC) or "chips" as it is commonly called. Generally speaking, **TTL** IC's use NPN type Bipolar Junction Transistors while **CMOS** IC's use Field Effect Transistors or FET's for both their input and output circuitry.

There are a large variety of logic gate types in both the Bipolar and CMOS families of digital logic gates such as 74L, 74LS, 74ALS, 74HC, 74HCT, 74ACT etc., with each one having its own distinct advantages and disadvantages and the exact voltages required to produce a logic "0" or logic "1" depends upon the specific logic group or family. However, when using a standard +5 volt supply any TTL voltage input between 2.0 V and 5 V is considered to be a logic "1" or "HIGH" while any voltage input below 0.8 V is recognized as a logic "0" or "LOW". TTL outputs are typically restricted to narrower limits of between 0 V and 0.4 V for a "low" and between 2.7 V and 5 V. The voltage region between the maximum voltage of logic "0" and minimum voltage of logic "1" of either input or output is called the Indeterminate Region. CMOS logic uses a different level of voltages with a logic "1" level operating between 3 and 15 volts.

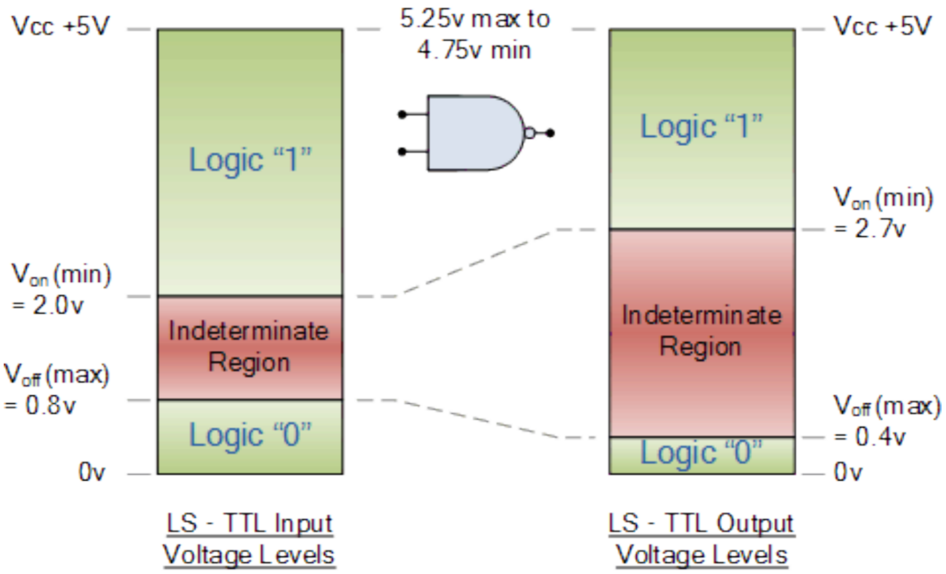


Figure 1: TTL input and output voltage levels.

There are several simple gates that you need to learn about. With these simple gates you can build combinations that will implement any digital component you can imagine.

The simplest possible gate is called an "inverter", or a **NOT gate**. It takes one bit as input and produces output as its opposite. The logic table for NOT gate and its symbol are shown below.

Use IC **7404LS** (Refer IC pin diagram from observation)

A	Q
0	1
1	0

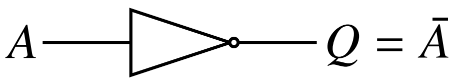


Figure 2: Truth table of the NOT gate and the logic symbol.

AND gate performs a logical "and" operation on two inputs, A and B.

Use IC 7408LS (Refer IC pin diagram from observation)

A	B	Q
0	0	0
0	1	0
1	0	0
1	1	1

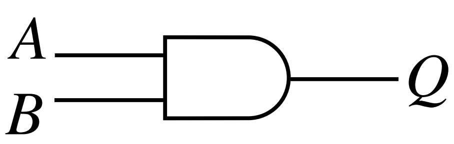


Figure 3: Truth table of the AND gate and the logic symbol.

OR gate performs a logical "or" operation on two inputs, A and B.

Use IC 7432 (Refer IC pin diagram from observation)

A	B	Q
0	0	0
0	1	1
1	0	1
1	1	1

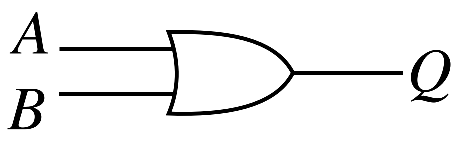


Figure 4: Truth table of the OR gate and the logic symbol.

It is quite common to recognize two others as well: the **NAND** and the **NOR** gate. These two gates are simply combinations of an AND or an OR gate with a NOT gate.

NAND Gate: Perform logical operation using IC 7400 (Refer IC pin diagram from observation).

A	B	Q
0	0	1
0	1	1
1	0	1
1	1	0

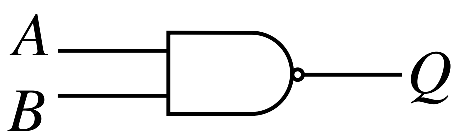


Figure 5: Truth table of the NAND gate and the logic symbol.

NOR Gate: Perform logical operation using IC 7402 (Refer IC pin diagram from observation).

A	B	Q
0	0	1
0	1	0
1	0	0
1	1	0

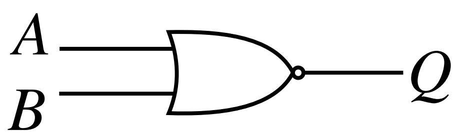


Figure 6: Truth table of the NOR gate and the logic symbol.

The final two gates that are sometimes added to the list are the **XOR** and **XNOR gates**, also known as "exclusive or" and "exclusive nor" gates, respectively.

XOR Gate: Use IC-7486.

A	B	$Q = A \oplus B$
0	0	0
0	1	1
1	0	1
1	1	0

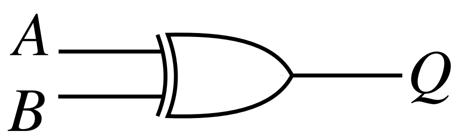


Figure 7: Truth table of the XOR gate and the logic symbol.

XNOR Gate: Use IC 74266 or basic gates.

A	B	$Q = \overline{A \oplus B}$
0	0	1
0	1	0
1	0	0
1	1	1

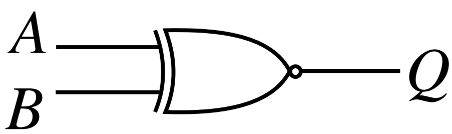


Figure 8: Truth table of the XNOR gate and the logic symbol.

4 Circuit diagrams

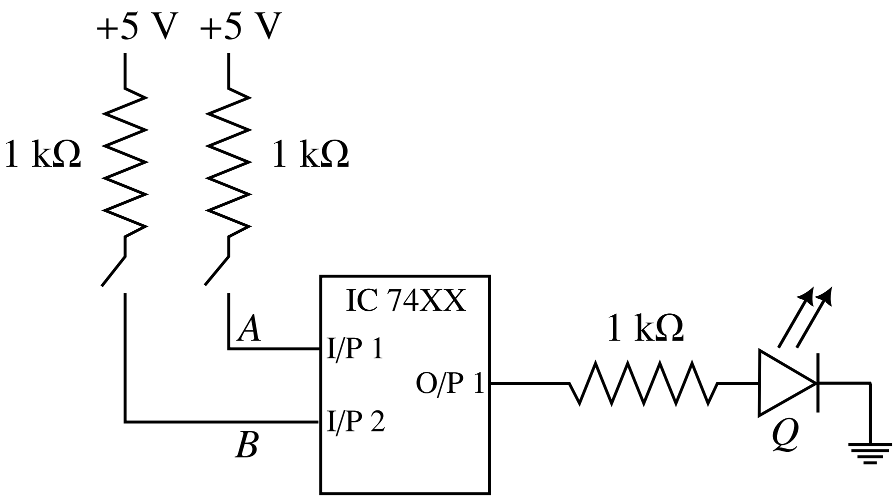


Figure 9: General circuit for all ICs.

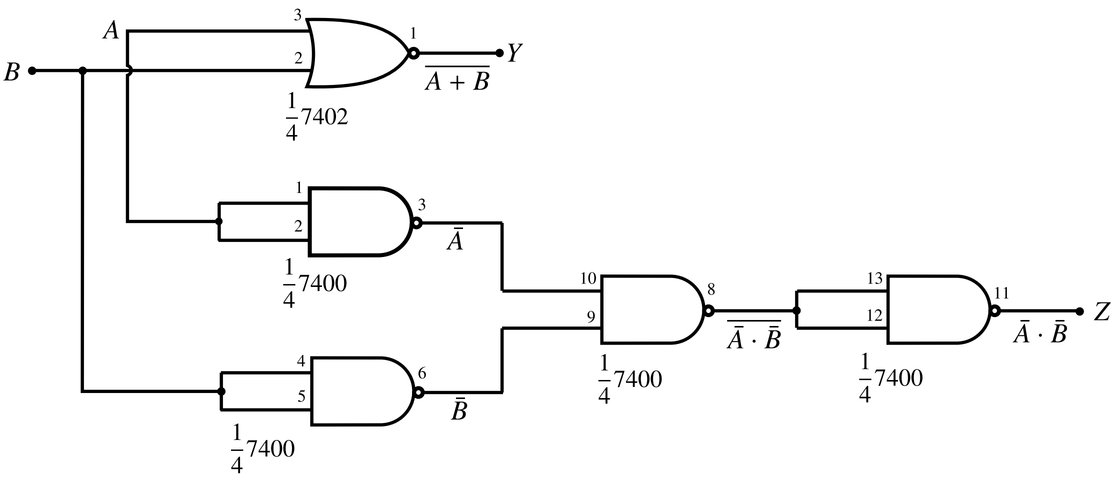


Figure 10: De Morgan's law: $\overline{A + B} = \overline{A} \cdot \overline{B}$.

5 Procedure

1. Verify the individual logic gates operation using gate ICs.

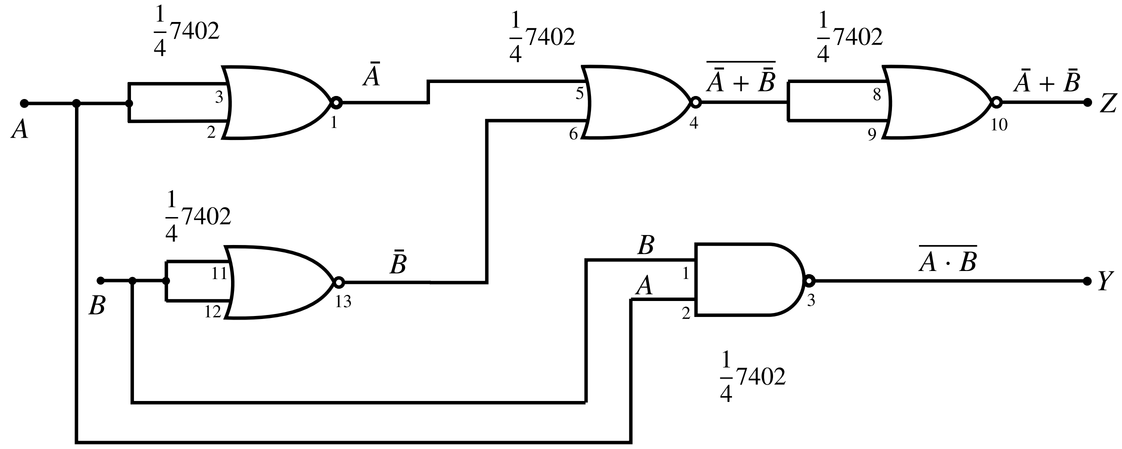


Figure 11: De Morgan's law: $\overline{A \cdot B} = \overline{A} + \overline{B}$.

2. Make the connection on the breadboard as shown in the circuit diagram.

3. Connect pin 14 (V_{CC}) to 5 V and pin 7 (ground) to 0 V terminal of the power supply.

4. Following the general circuit diagram facilitate all possible combinations of inputs from the power supply, using DIP switch, connecting wire and resistors. Connect the output pin to ground through a resistor and LED.

5. Turn on power to your experimental circuit.

6. For each input combination, note the logic state of the outputs as indicated by the LEDs (ON = 1; OFF = 0), and record the result in the table.

7. Compare your results with the truth table for operation.

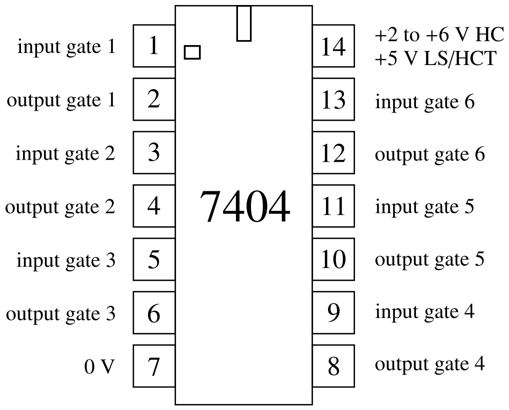
8. For verification of De Morgan's laws, follow the respective circuit diagrams using appropriate ICs. Follow the general circuit diagram for connections for input and output using connecting wires and LEDs.

9. Monitor the outputs Y and Z using LEDs and confirm that Y and Z are the same for any states of A and B.

10. When you are done, turn off the power to your experimental circuit.

6 Observations

Verification of Boolean Logic Operations.

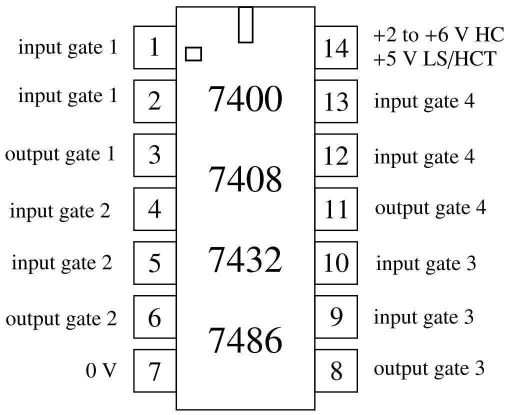


I/P A	O/P Q
0	
0	
1	
1	

Figure 12: IC7404LS pin diagram and truth table for NOT gate operation.

6.1 Inverter gate (NOT): IC7404LS

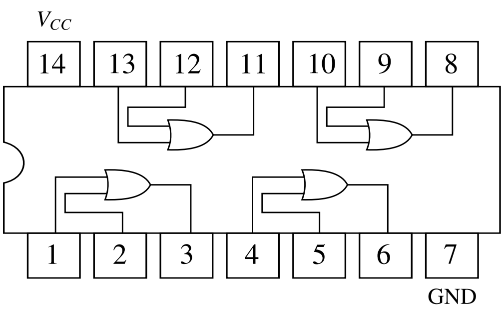
6.2 2-input AND gate: IC 7408LS



I/P A	I/P B	O/P Q
0	0	
0	1	
1	0	
1	1	

Figure 13: IC7400-7486 pin diagram and truth table for AND gate operation.

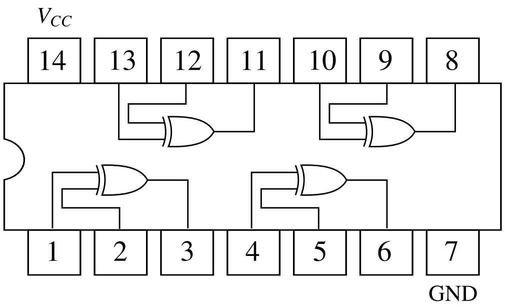
6.3 2-input OR gate: IC 7432



I/P A	I/P B	O/P Q
0	0	
0	1	
1	0	
1	1	

Figure 14: IC7432 pin diagram and truth table for OR gate operation.

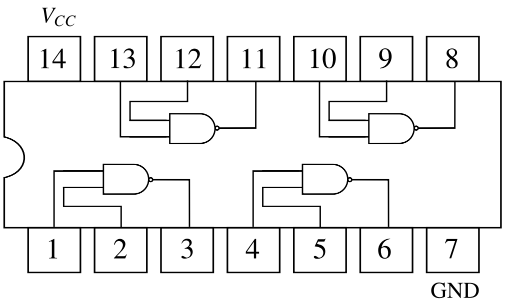
6.4 2-input XOR gate: IC 7486



I/P A	I/P B	O/P Q
0	0	
0	1	
1	0	
1	1	

Figure 15: IC7486 pin diagram and truth table for XOR gate operation.

6.5 2-input NAND gate: IC7400LS



I/P A	I/P B	O/P Q
0	0	
0	1	
1	0	
1	1	

Figure 16: IC7400LS pin diagram and truth table for NAND gate operation.

7 Results

8 Precautions

1. Do not short the V_{CC} and GND connection.
2. Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.
3. Connect the limiting resistor of value in kΩ range before LED.
4. Do not exceed voltage supply more than the IC maximum operating voltage. (Recommended Operating voltage: 3 - 6 V).
5. Switch off the power supply after experiment completion.