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Report 4

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Abstract

This experiment focuses on the study of fundamental digital logic gates using standard integrated circuits (ICs). The logic gates studied include AND, OR, NOT, NAND, NOR, and Exclusive-OR (XOR) gates. Each gate was implemented using ICs such as 7408, 7432, 7404, 7400, 7402, and 7486 on a breadboard with a +5V power supply. The outputs were observed using a LED for different input combinations. This experiment demonstrates the basic principles of digital electronics and logical operations.

Contents

1 Introduction

Digital electronics deals with systems that represent information using discrete voltage levels rather than continuous signals. Typically, two voltage levels are used: a low level (0 V) representing logical '0' and a high level (+5 V) representing logical '1'.

Logic gates are the fundamental building blocks of digital circuits. They perform logical operations based on Boolean algebra. The relationship between inputs and outputs of logic gates is represented using truth tables.

1.1 Aim

To study Boolean algebra truth tables for Logic Gate functions using AND, OR, NAND, NOR etc. ICs..

1.2 Components and Instruments

The following components are used:

1. Power supply, 1 No : +5 V (Fix +5 V from variable voltage source if constant +5 V is not available)
2. AND Gate: IC 7408, 1 No
3. OR Gate: IC 7432, 1 No
4. NOT Gate: IC 7404, 1 No
5. NAND Gate: IC 7400, 1 No
6. NOR Gate: IC 7402, 1 No
7. X-OR Gate: IC 7486, 1 No
8. 1 LED with 1K Ohm register in series, 1 Nos
9. Breadboard = 1 No
10. Single strand wires = 8 − 10 Nos.

2 Theory

Logic gates perform operations on binary inputs (unary input for NOT Gate) to produce a binary value output based on Boolean expressions. Each gate has a unique logical function and truth table.

2.1 2-input AND Gate and 7408 IC

The AND gate produces a high output only when both inputs are high.

$$Q = A \cdot B$$

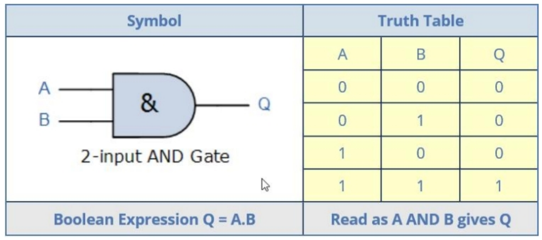


Figure 1: Boolean Expression and Truth Table of AND Gate

IC 7408 contains four independent 2-input AND gates. We have used V_{cc} as +5 Volts. The input can be defined as +5 V = 1 and 0 V = 0 states.

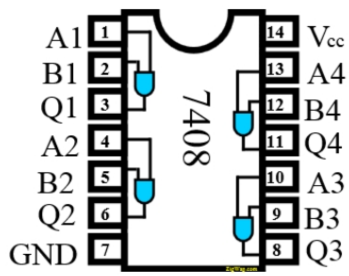


Figure 2: IC 7408

2.2 2-input OR Gate and 7432 IC

The OR gate produces a high output when at least one input is high.

$$Q = A + B$$

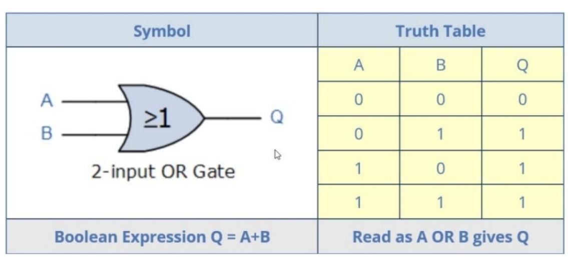


Figure 3: Boolean Expression and Truth Table of OR Gate

IC 7432 consists of four independent 2-input OR gates. We have used V_{cc} as +5 Volts. The input can be defined as +5 V = 1 and 0 V = 0 states.

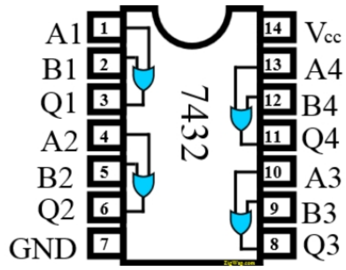


Figure 4: IC 7432

2.3 1-input NOT Gate and 7404 IC

The NOT gate inverts the input signal.

$$Q = \overline{A}$$

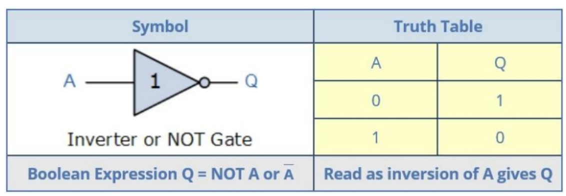


Figure 5: Boolean Expression and Truth Table of NOT Gate

IC 7404 contains six independent 1-input NOT gates. We have used V_{cc} as +5 Volts. The input can be defined as +5 V = 1 and 0 V = 0 states.

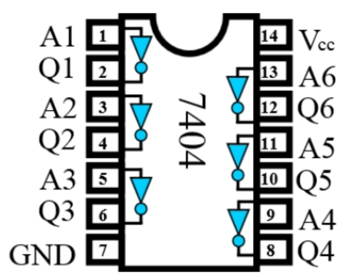
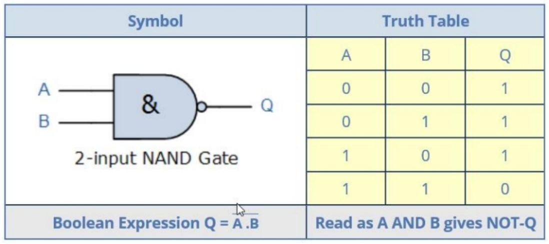


Figure 6: IC 7404

2.4 2-input NAND Gate and 7400 IC

The NAND gate is the complement of the AND gate.

$$Q = \overline{A \cdot B}$$



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

Figure 7: Boolean Expression and Truth Table of NAND Gate

IC 7400 contains four independent 2-input NAND gates and is widely used due to its universality. We have used V_{cc} as +5 Volts. The input can be defined as +5 V = 1 and 0 V = 0 states.

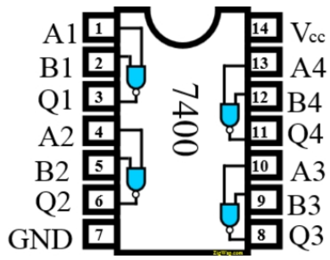
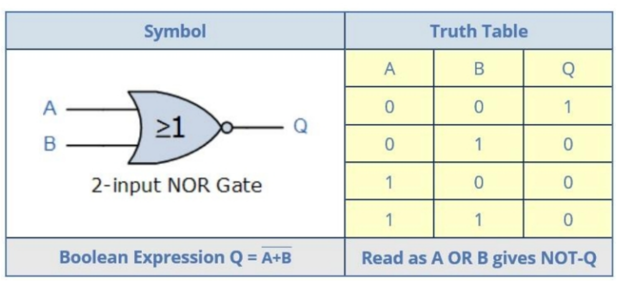


Figure 8: IC 7400

2.5 2-input NOR Gate and 7402 IC

The NOR gate is the complement of the OR gate.

$$Q = \overline{A + B}$$



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

Figure 9: Boolean Expression and Truth Table of NOR Gate

IC 7402 contains four independent 2-input NOR gates. We have used V_{cc} as +5 Volts. The input can be defined as +5 V = 1 and 0 V = 0 states.

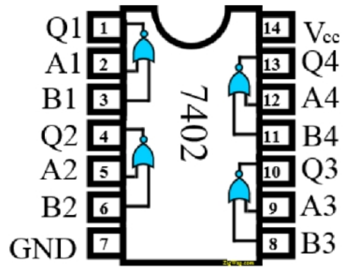
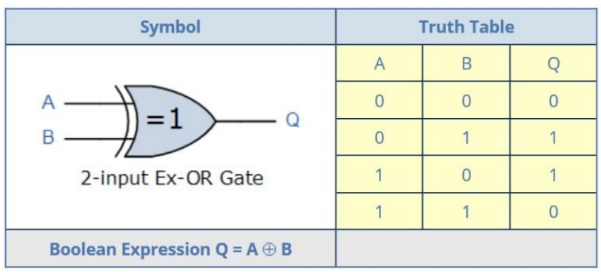


Figure 10: IC 7402

2.6 2-input Ex-OR (Exclusive OR) Gate and 7486 IC

The XOR gate produces a high output only when the inputs are different.

$$Q = A\overline{B} + \overline{A}B$$



Symbol	Truth Table		
2-input Ex-OR Gate (A, B → =1 → Q)	A	B	Q
	0	0	0
	0	1	1
	1	0	1
	1	1	0
Boolean Expression Q = A ⊕ B			

Figure 11: Boolean Expression and Truth Table of Ex-OR Gate

IC 7486 contains four independent 2-input XOR gates. We have used V_{cc} as +5 Volts. The input can be defined as +5 V = 1 and 0 V = 0 states.

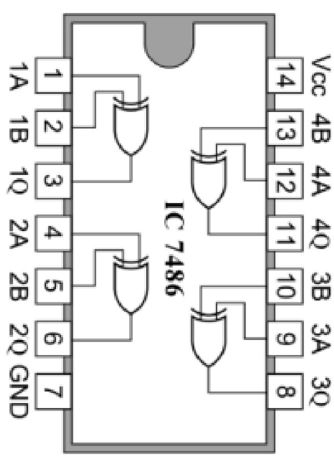


Figure 12: IC 7486

3 Circuit Diagrams and Observation Table

3.1 Circuit Diagrams

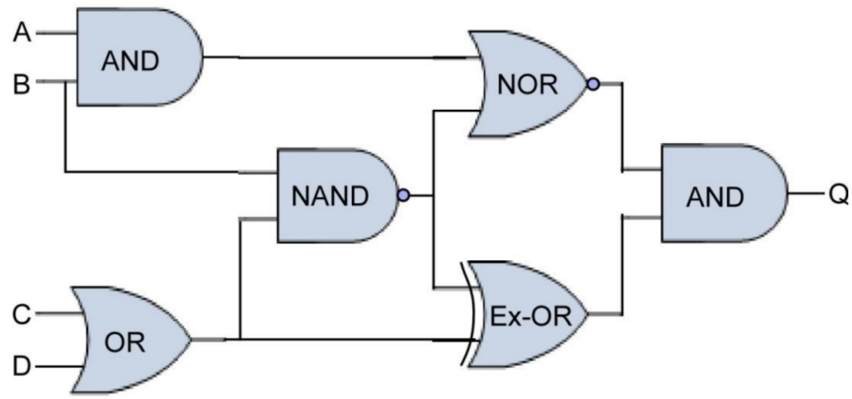


Figure 13: Example-1

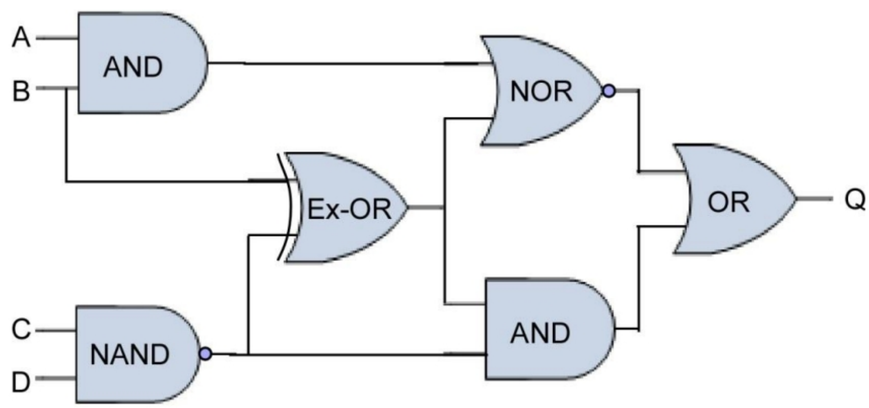


Figure 14: Example-2

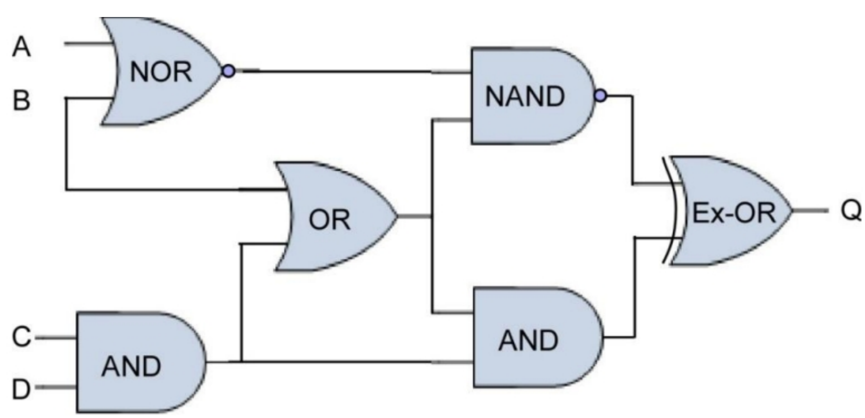


Figure 15: Example-3

3.2 Observation Table

Sl.No.	A	B	C	D	Example-1 Q	Example-2 Q	Example-3 Q
1	0	0	0	0	0	1	1
2	0	0	0	1	0	1	1
3	0	0	1	0	0	1	1
4	0	0	1	1	0	1	1
5	0	1	0	0	0	1	1
6	0	1	0	1	1	1	1
7	0	1	1	0	1	1	1
8	0	1	1	1	1	0	0
9	1	0	0	0	0	1	1
10	1	0	0	1	0	1	1
11	1	0	1	0	0	1	1
12	1	0	1	1	0	1	0
13	1	1	0	0	0	0	1
14	1	1	0	1	0	0	1
15	1	1	1	0	0	0	1
16	1	1	1	1	0	0	0

4 Sources of Error

4.1 Systematic Errors

1. **Power Supply Variations:** The logic ICs used in this experiment require a stable +5V supply. Any deviation from this voltage can alter the logic threshold levels, leading to incorrect outputs.

2. **Incorrect IC Pin Configuration:** Each IC (7408, 7432, etc.) has a specific pin diagram. Misconnecting input/output pins or power pins (Vcc and GND) can result in faulty or no output.

3. **Faulty or Damaged ICs:** Integrated circuits may be internally damaged due to electrostatic discharge, overheating, or prolonged usage, causing incorrect logic operation.

4. **Improper Breadboard Connections:** Breadboards have internal conductive strips. Misunderstanding their layout may lead to unintended open or short circuits.

5. **Loading Effects:** Connecting multiple outputs or excessive load (e.g., LED without proper resistors) may affect the output voltage levels of logic gates.

6. **Incorrect Logic Level Definition:** Improper distinction between logic HIGH and LOW (e.g., floating inputs) may cause unstable or undefined outputs.

7. **Component Tolerances:** The resistor (1 kΩ) used with LED has tolerance limits, which may slightly affect current and brightness, influencing output indication.

4.2 Random Errors

1. **Loose Connections:** Slight movement or improper insertion of wires in the breadboard can cause intermittent contact, leading to fluctuating outputs.

2. **Electrical Noise:** External electromagnetic interference or internal circuit noise may affect signal stability, especially at logic thresholds.
3. **Human Observation Error:** Misinterpretation of LED glow (especially dim light) may lead to incorrect recording of logic states.
4. **Contact Resistance Variations:** Variations in contact resistance at junctions can slightly affect voltage levels.
5. **Ambient Conditions:** Temperature and humidity variations may influence semiconductor behavior and circuit performance.
6. **Switching Delays:** Small propagation delays in ICs may cause transient incorrect readings if observed too quickly.

5 Results

The truth tables for all the logic gates were verified experimentally. The observed outputs matched the theoretical Boolean expressions for each gate and also for the whole circuits, confirming correct operation of the ICs.

6 Conclusion

The experiment successfully demonstrated the functioning of basic logic gates using ICs. The observed truth tables were in agreement with theoretical predictions, validating Boolean algebra principles. This experiment provides a strong foundation for understanding digital circuit design.

References

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