Heaven's Light is Our Guide

Rajshahi University of Engineering & Technology

Department of Electrical & Computer Engineering

Assignment

❖ Course Code	ECE 2111
❖ Course Title	Digital Techniques
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- **OBJECTIVE:** The objective of this assignment is to design and simulate a 4-bit Arithmetic Logic Unit (ALU) using digital logic gates. The ALU should be capable of performing basic arithmetic and logical operations.

- **Theory:**

The central processing unit (CPU) of a computer is essentially made up of an Arithmetic Logic Unit (ALU). It is in charge of performing arithmetic and logical operations, which are necessary for a digital system's instructions to be executed. Addition, subtraction, multiplication, division, and logical comparisons (AND, OR, XOR, NOT) are among the operations that the ALU may execute.

- **Structure of an ALU**

An ALU typically consists of:

Operand Inputs: Accept numerical or logical values.

Arithmetic Unit: Performs mathematical computations.

Logic Unit: Executes Boolean operations.

Control Signals: Determine which operation to execute.

Output Register: Stores the result of the computation.

- **Importance of ALU in Digital Systems:**

Core of Processing: The ALU is essential for executing instructions in microprocessors and microcontrollers.

Data Manipulation: Enables mathematical and logical operations crucial for computing tasks.

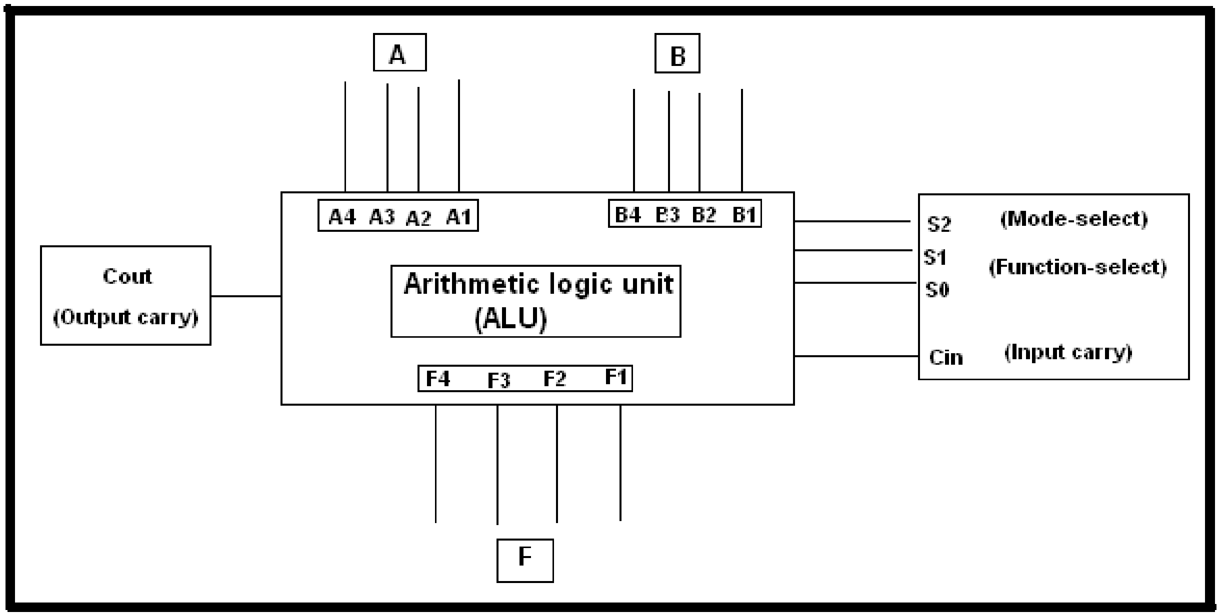
Decision-Making: Logical operations help in decision-making processes in control systems.

Performance Optimization: The efficiency of an ALU impacts the overall speed and capability of a digital system.

Embedded Systems: ALUs are found in various devices, from smartphones to industrial automation systems.

In summary, the ALU is a critical component of digital computing systems, enabling both simple and complex operations that drive modern technology.

- **Block Diagram:**

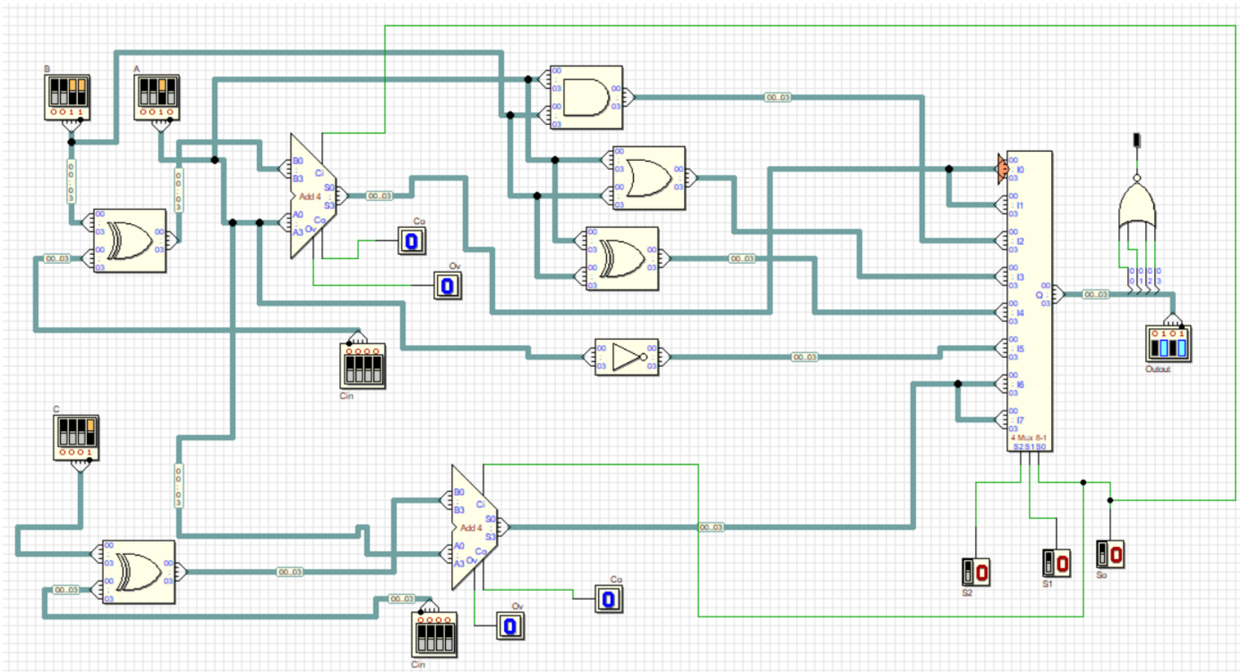


- **Truth Table:**

S2	S1	S0	Operation
0	0	0	A + B
0	0	1	A - B
0	1	0	A AND B
0	1	1	A OR B
1	0	0	A XOR B
1	0	1	NOT A
1	1	0	A + 1
1	1	1	A - 1

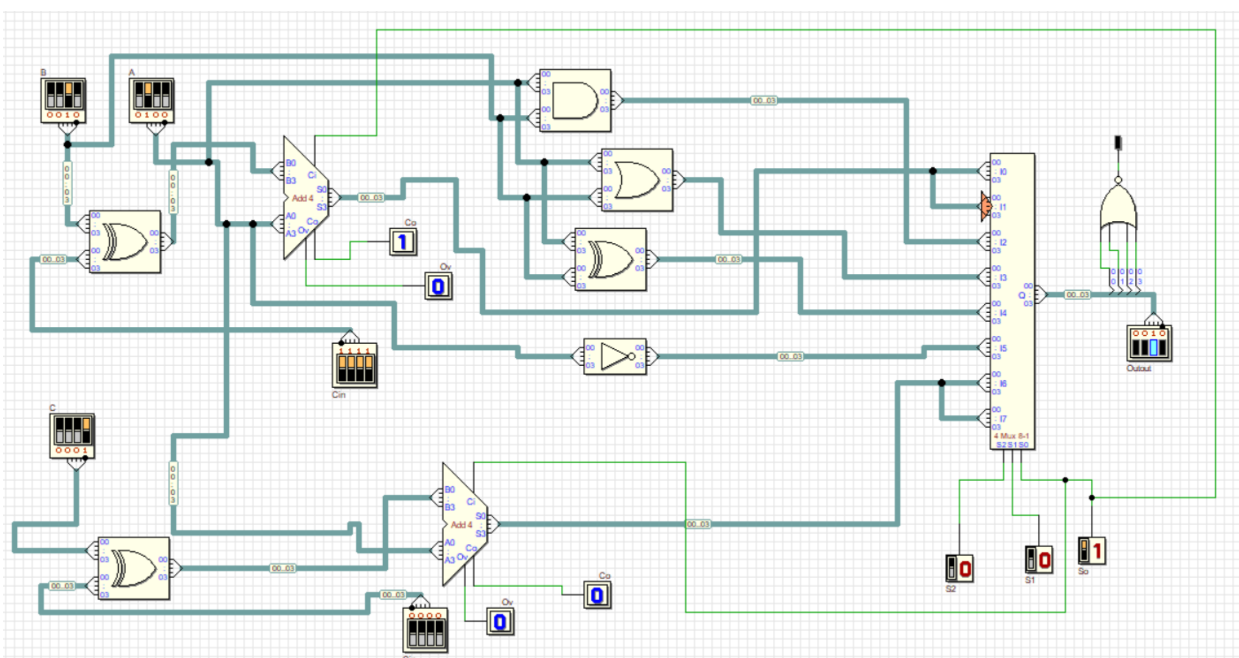
❖ Simulation results with screenshots and analysis:

- Addition (A+B):



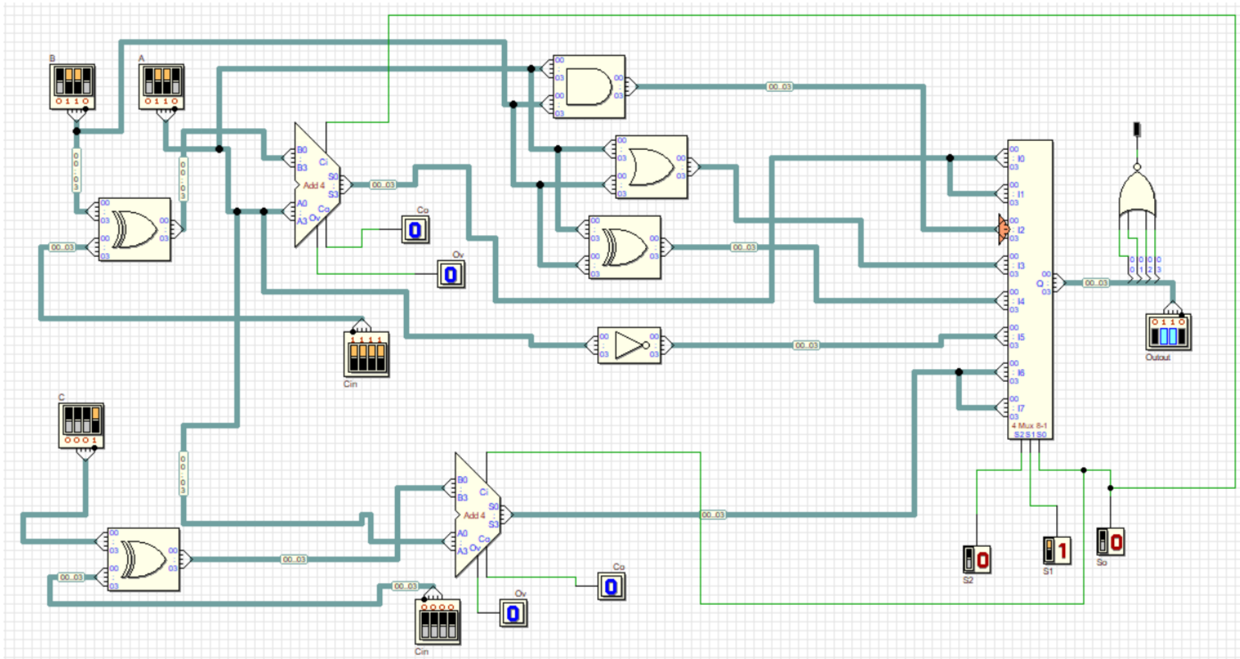
A=0010,B=0011   (A+B)=0101

- **Subtraction(A-B):**



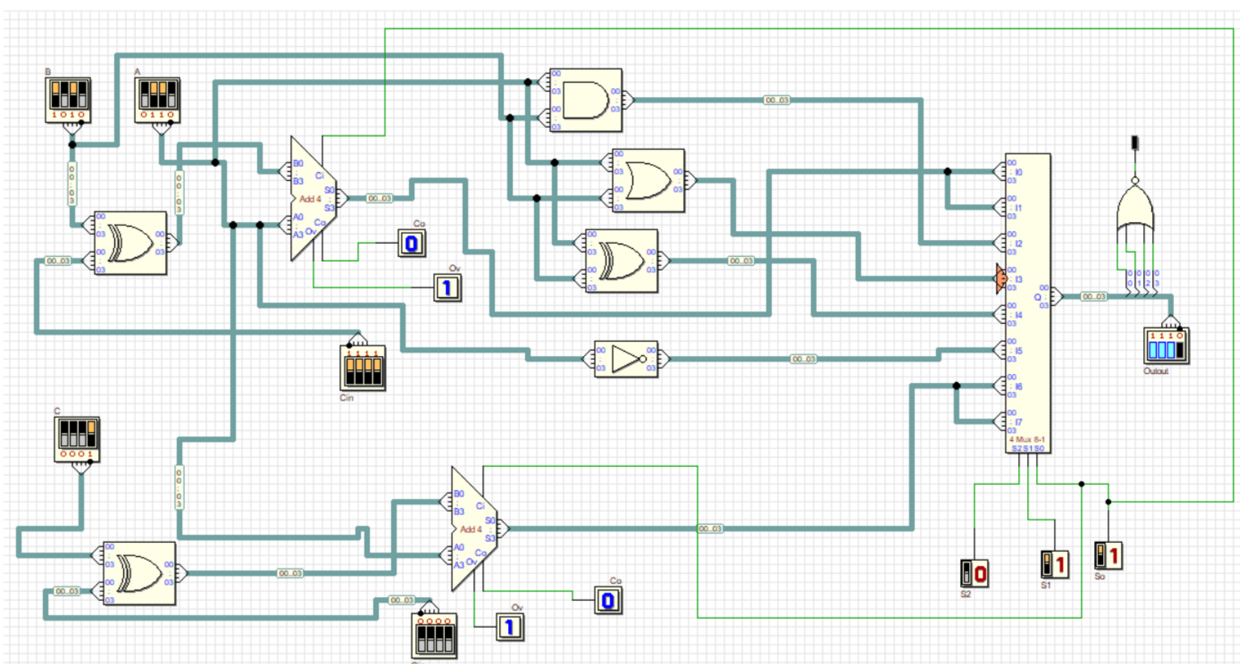
A=0100,B=0010 (A-B)=0010

- **And Operation(A And B):**



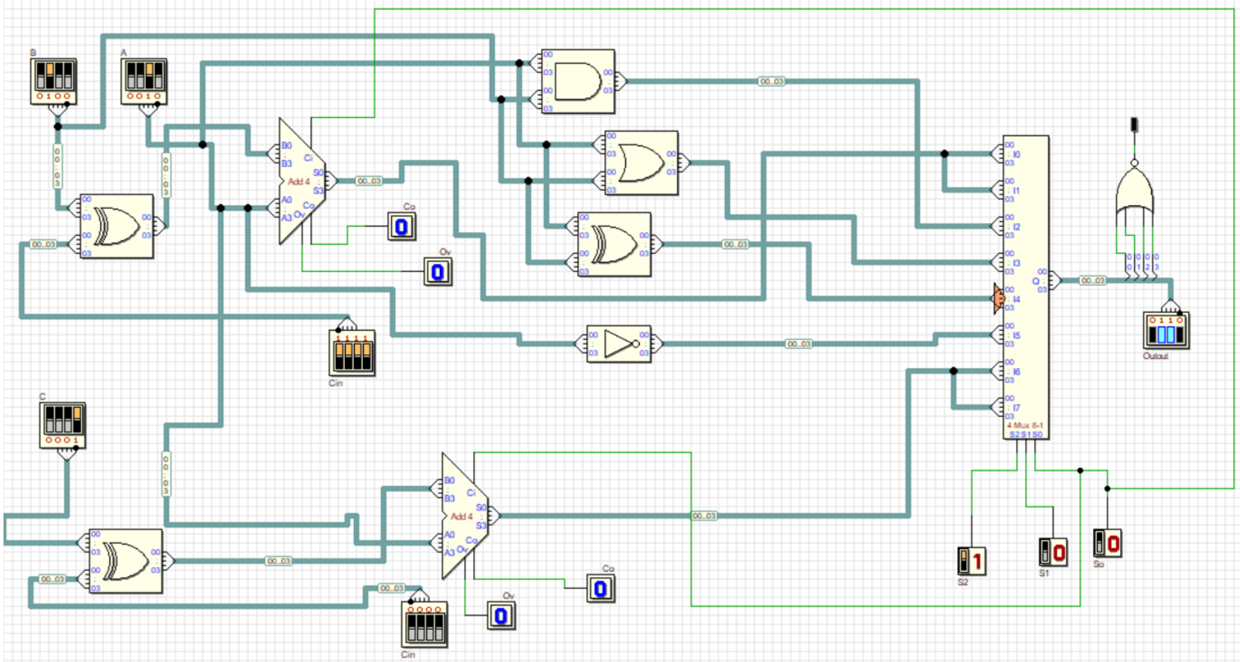
A=0110, B=0110 (A And B)=0110

- **Or Operation(A Or B):**



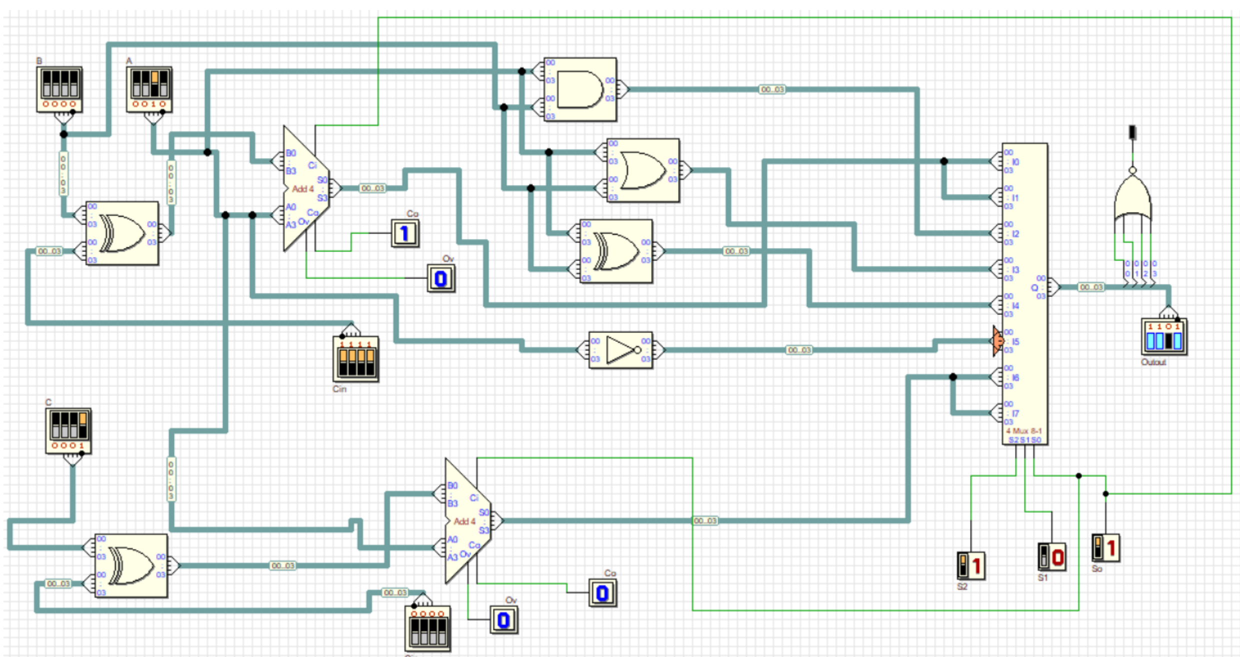
A=0110, B=1010 (A And B)=1110

- **A XOR B:**



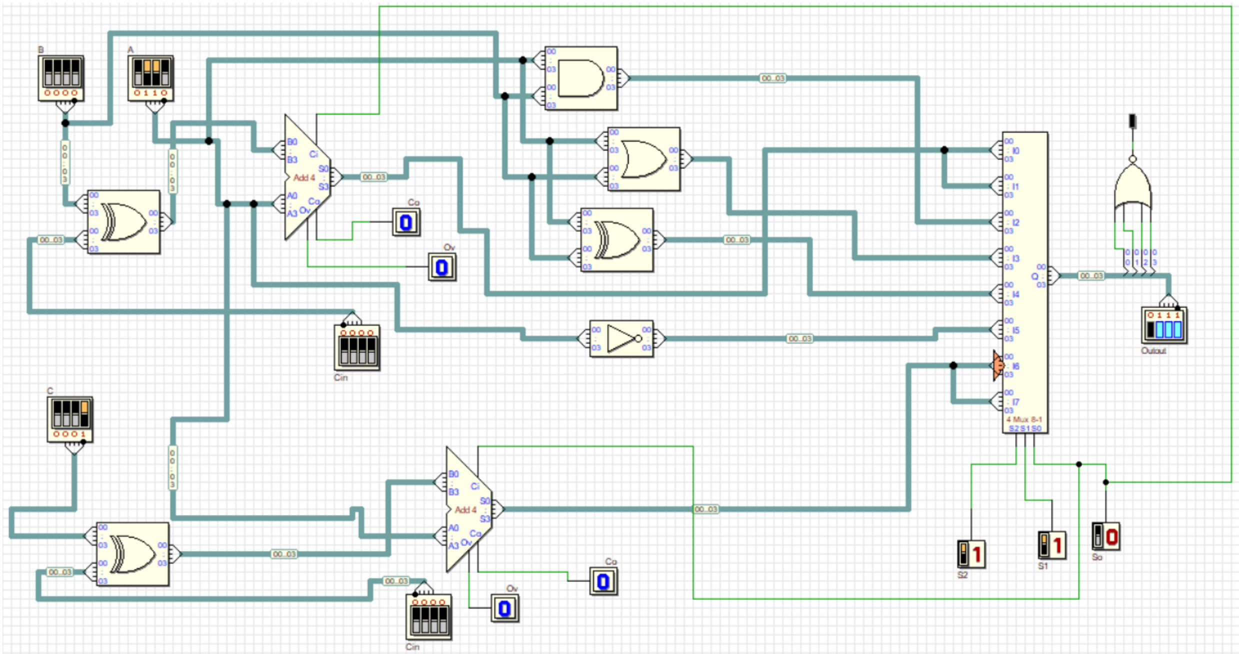
A=0010,B=0100 (A XOR B)=0110

- **NOT A:**



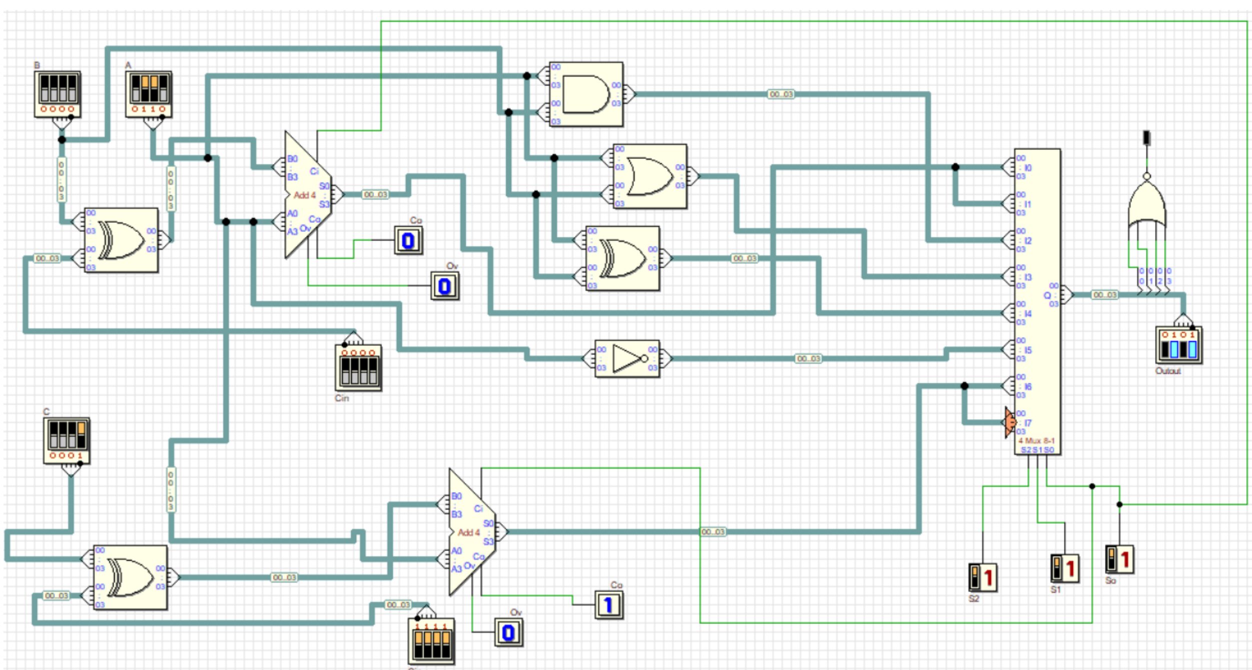
A=0010 (NOT A)=1100

- **A+1:**



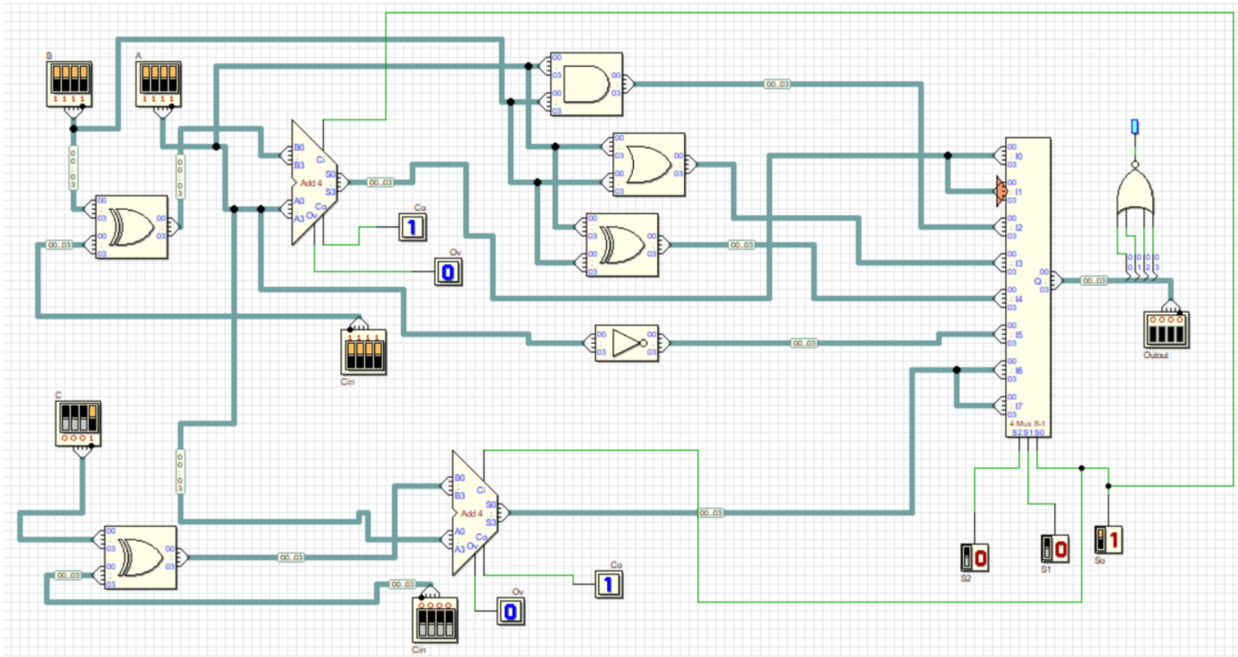
A=0110 (A+1)=0111

- **A-1:**



A=0110 (A-1)=0101

- **The zero flag (Z):**



When if the result of the operation is zero then the light turned on.

❖ Explanation of the control logic and how it selects the operations:

- ALU Control Logic and Operation Selection
- The Arithmetic Logic Unit (ALU) relies on a control logic mechanism to determine which operation it should perform based on instructions received from the CPU. This control logic is managed by a set of control signals that dictate whether the ALU executes arithmetic operations (e.g., addition, subtraction) or logical operations (e.g., AND, OR, XOR).
- ALU Control Logic Components
- The control logic of an ALU typically consists of:
- Opcode (Operation Code) – Comes from the instruction decoder in the CPU and specifies the operation.
- Control Unit – Interprets the opcode and generates corresponding control signals.
- Multiplexer (MUX) – Selects the appropriate ALU function based on control signals.
- Function Unit (Arithmetic & Logic Modules) – Executes the selected operation.
- How the ALU Selects Operations
- Step 1: Receiving the Control Signal
- The CPU sends an Opcode that defines the required operation.

- The Control Unit deciphers the opcode and generates specific ALU control signals.
- Step 2: Decoding the Control Signals
- A multiplexer (MUX) is used to select between arithmetic or logic operations based on control bits.
- The control signals determine the active circuit within the ALU (addition circuit, AND gate, etc.).
- Step 3: Executing the Operation
- The ALU processes input operands based on the selected operation.
- The result is stored in a register or sent back to memory.

- **Conclusion:** Though the design has become too much complicated it should be little simpler to execute.But by this circuit we can perform different operations. The ALU’s control logic is crucial for selecting and executing the correct operations in a digital system. It ensures that arithmetic and logical computations are performed efficiently based on CPU instructions, enabling proper data processing in modern computers.