North South University

Department of Electrical & Computer Engineering

LAB REPORT- 08

Course Code: CSE 231L

Course Title: Digital Logic Lab

Section: 08

Lab Number: 08

Experiment Name: Synchronous Sequential Circuits.

Synchronous Sequential Circuits

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Submitted by Group Number: 05

Group members:

Name	ID	Obtained Mark Simulation [5]	Obtained Mark Lab Report [15]
1. Md. Rafawat Islam	2122343642		
2. Syed Tashriful Alam	2212623042		
3. Joy Kumar Ghosh	2211424642		
4. Sazid Hasan	2211513642		
5. Md. Nifat Hossain	2212923042		

Course Instructor: Dr. Md. Abdur Razzak (Azz)

Submitted To: Pritthika Dhar

Experiments Name: Synchronous Sequential Circuit

Objective:

- Gain a practical understanding of state Diagrams and State Tables.
- Understand the concept of designing Sequential circuits using Flip-Flops.
- Design and implement a Synchronous Sequential Circuit given a State Diagram

Apparatus:

- 1 x IC 74107 JK Flip-Flop
- 1x IC 7408 2-input AND gates
- 1x IC 7404 Hex inverters (NOT gates)
- 1x IC 7432 2-input OR gates
- 1x IC 7474 Dual D Flip-Flops
- Trainer Board
- Wires

Theory:

A synchronous sequential circuit is a digital circuit composed of flip-flops and combinational logic, where the outputs depend not only on the present inputs but also on the circuit's state. The flip-flops serve as memory elements to store information.

In a synchronous sequential circuit, a clock signal synchronizes the operations. On each clock edge, the inputs are sampled, and the outputs are updated based on the current state and the combinational logic. The state transition is governed by a set of logical equations that define the next state in terms of the current state and inputs.

The circuit's behavior can be described

using a state diagram, which illustrates the various states and the transitions between them. The design process involves determining the required states, defining the state transition table and deriving the logic equations for each flip-flop and output.

Synchronous sequential circuits are widely used in digital systems, such as microprocessors, memory units and communication protocols. They offer predictable and reliable operation, allowing for precise control and synchronization in complex digital systems.

To analyze and design Synchronous Sequential circuits, we need to use State Tables and State Diagrams. The State

Table (or transition table) shows how the state and output of the sequential circuit changes with respect to the current state and input. State Diagrams are simply graphical forms of the State Tables. In this type of digram, a state is represented by a circle, and the (clock-triggered) transitions between states are indicated by directed lines connecting the circles. The binary number each circle identifies the state of the flip-flops. The directed lines are ~~tabled~~ lableled with two binary numbers separated by a slash. The input value during the present state is labeled first and the number after the slash gives the output during the present state with the given input.

Figure B3 shows the state Table and state Diagram for a sequential circuit.

Present state		Input	Next state		Output
A	B	x	A	B	y
0	0	0	0	0	0
0	0	1	0	1	0
0	1	0	0	0	1
0	1	1	1	1	0
1	0	0	0	0	1
1	0	1	1	0	0
1	1	0	0	0	1
1	1	1	1	0	0

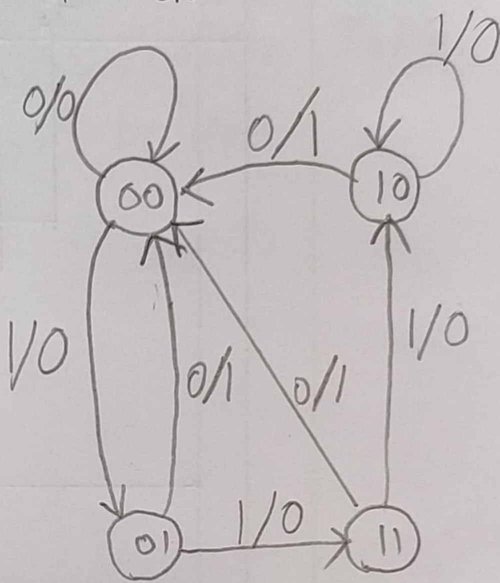


Figure B3: State Table and Diagram Table

Circuit Diagram:

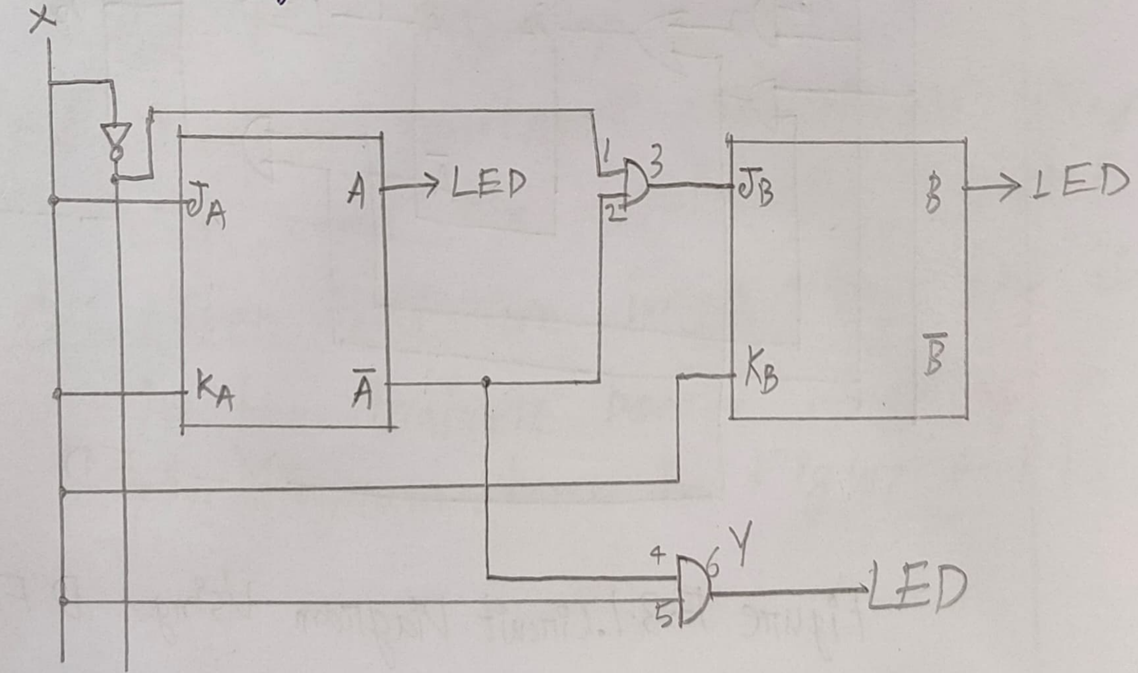


Figure1.1: Circuit Diagram Using J.K Flip-Flo

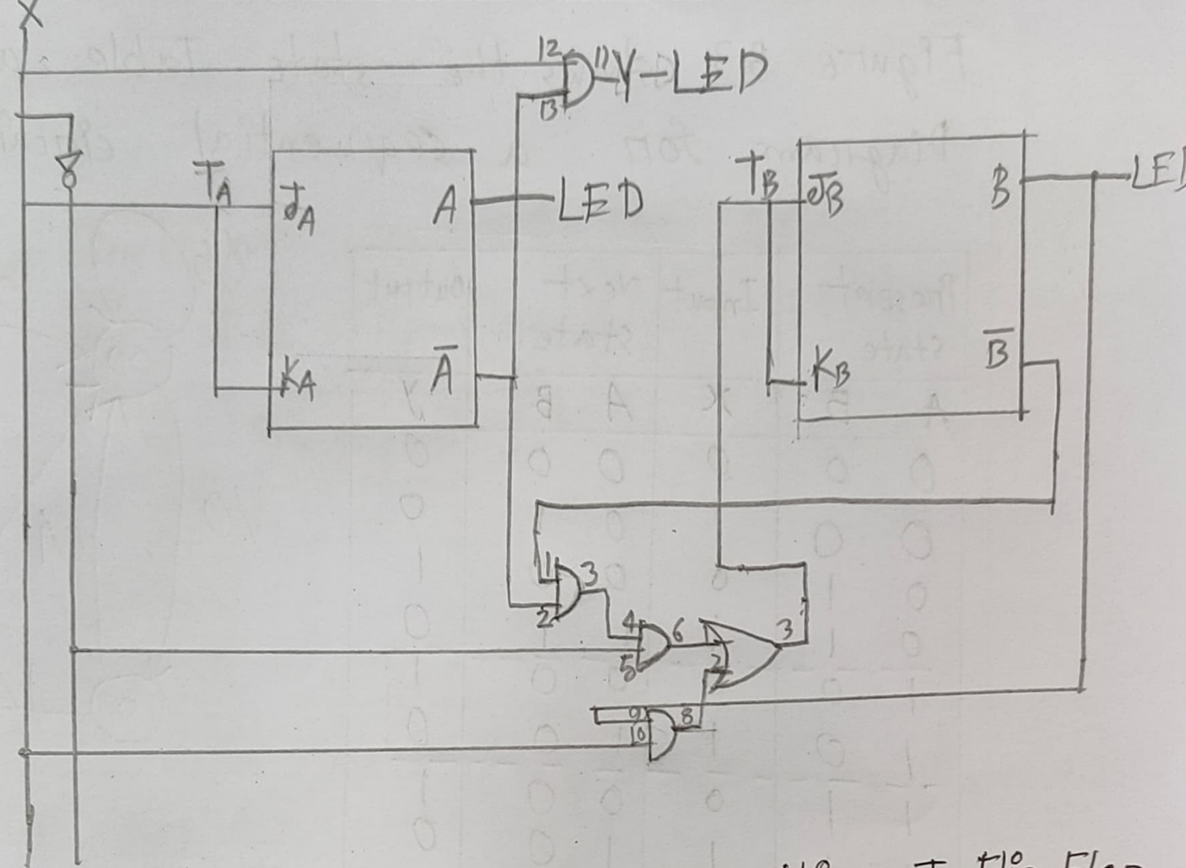


Figure F.2.1: Circuit Diagram Using T-Flip-Flop

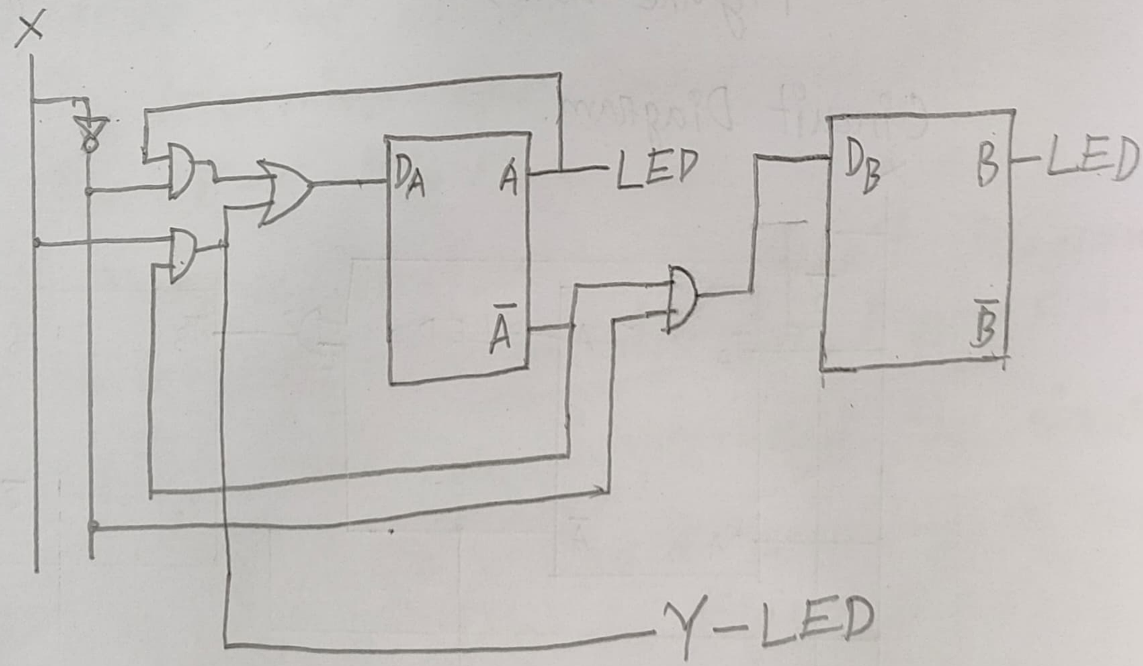


Figure F.3.1: Circuit Diagram Using D Flip-Flop

Experimental Procedure:

Experiment-1:

01. First, we construct the excitation Table for J-K Flip-Flop given bellow:

Q	Qnext	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

02. Using this excitation table, we complete the Experimental Data Table F.1.1.
03. After that, we use the K-map to determine the input equation for the J-K Flip-Flop.
04. Then, we construct the circuit Diagram with some pin details in Figure F.1.1.
05. After that we implement the circuit in the trainer board according to the pin diagram shown in Figure F.1.1.

Experiment-2:

01. First, we constructed the excitation table for T Flip-Flop given bellow:

Q	Q next	T
0	0	0
0	1	1
1	0	1
1	1	0

02. Using this excitation table, we complete the Experimental Data Table F.2.1.

03. Then, again we use the K-map to determine the input equation for T Flip-Flops.

04. Then again draw a circuit diagram for T Flip-Flops.

05. After that, we simply follow the pin diagram already shown in the circuit diagram F.2.1. and implement the circuit diagram on the trainer board.

Experiment-3:

01. Like previous, again we constructed the excitation table for the D Flip-Flops given bellow:

Q	Qnext	D
0	0	0
0	1	1
1	0	0
1	1	1

02. Then, we complete the experimental data table F.3.1.

03. Then complete the K-Map to determine the input for the D Flip-Flops.

04. After that, we again construct a circuit diagram shown in Figure F.3.1. and implement the circuit on the trainer board according to the pin diagram shown in the Figure.

Simulation:

Attached.

Experimental Data Table:

F.1 Experimental Data: Constructing a Sequential Circuit using JK Flip-Flops

Present State		Input	Next State		Output	Flip-Flop input functions			
A	B	X	A	B	Y	J_A	$\bar{K}_A$	J_B	K_B
0	0	0	0	1	0	0	X	1	X
0	0	1	1	0	1	1	X	0	X
0	1	0	0	1	0	0	X	X	0
0	1	1	1	0	1	1	X	X	1
1	0	0	1	0	0	X	0	0	X
1	0	1	0	0	0	X	1	0	X
1	1	0	X	X	X	X	X	X	X
1	1	1	X	X	X	X	X	X	X

Table F.1.1: State Table for circuit using JK Flip-Flops

A \ BX	00	01	11	10
0	0	1	1	0
1	X	X	X	X

$J_A = X$

A \ BX	00	01	11	10
0	X	X	X	X
1	0	1	X	X

$K_A = X$

A \ BX	00	01	11	10
0	1	0	X	X
1	0	0	X	X

$J_B = \bar{A}\bar{X}$

A \ BX	00	01	11	10
0	X	X	1	0
1	X	X	X	X

$K_B = X$

A \ BX	00	01	11	10
0	0	1	1	0
1	0	0	X	X

$Y = \bar{A}X$

F.2 Experimental Data: Constructing a sequential circuit using T Flip-Flops

Present State		Input	Next state		Output	Flip-Flop input functions	
A	B	X	A	B	Y	T_A	T_B
0	0	0	0	1	0	0	1
0	0	1	1	0	1	1	0
0	1	0	0	1	0	0	0
0	1	1	1	0	1	1	1
1	0	0	1	0	0	0	0
1	0	1	0	0	0	1	0
1	1	0	X	X	X	X	X
1	1	1	X	X	X	X	X

Tabe F.2.1: state Table for circuit using T Flip-Flops

A \ BX	00	01	11	10
0	0	1	1	0
1	0	1	X	X

$T_A = X$

A \ BX	00	01	11	10
0	1	0	1	0
1	0	0	X	X

$T_B = \bar{A}\bar{B}\bar{X} + BX$

A \ BX	00	01	11	10
0	0	1	1	0
1	0	0	X	X

$Y = \bar{A}X$

F.3 Experimental Data: Constructing a sequential circuit using D Flip-Flops

Present State		Input	Next State		Output	Flip-Flop input functions	
A	B	X	A	B	Y	D_A	D_B
0	0	0	0	1	0	0	1
0	0	1	1	0	1	1	0
0	1	0	0	1	0	0	1
0	1	1	1	0	1	1	0
1	0	0	1	0	0	1	0
1	0	1	0	0	0	0	0
1	1	0	X	X	X	X	X
1	1	1	X	X	X	X	X

Table F.3.1: State Table for circuit using D Flip-Flops

A \ BX	00	01	11	10
0	0	1	1	0
1	1	0	X	X

$D_A = \bar{A}X + A\bar{X}$

A \ BX	00	01	11	10
0	1	0	0	1
1	0	0	X	X

$D_B = \bar{A}\bar{X}$

A \ BX	00	01	11	10
0	0	1	1	0
1	0	0	X	X

$Y = \bar{A}X$

Results:

After completing the circuit, we test the circuit with our experimental data table. And the state of the circuit was changing according to the given sequence. Hence, we can say that we successfully implemented the circuit for a sequential state.

Questions and Answers (Q/A):

E.1:

simulation attached.

E.2:

Yes, equation is the same as J-K Flip-Flop. We know that in J-K Flip-Flop, if both inputs are same then the Flip-Flop works like a T Flip-Flop. Here, in the first experiment we gave the same input of X in 1st J-K Flip-Flop. In the second experiment, we also did the same. And in the experimental data table, output of Y are same for both experiments. That's why, output equation of Y is the same for both experiments.

E.3:

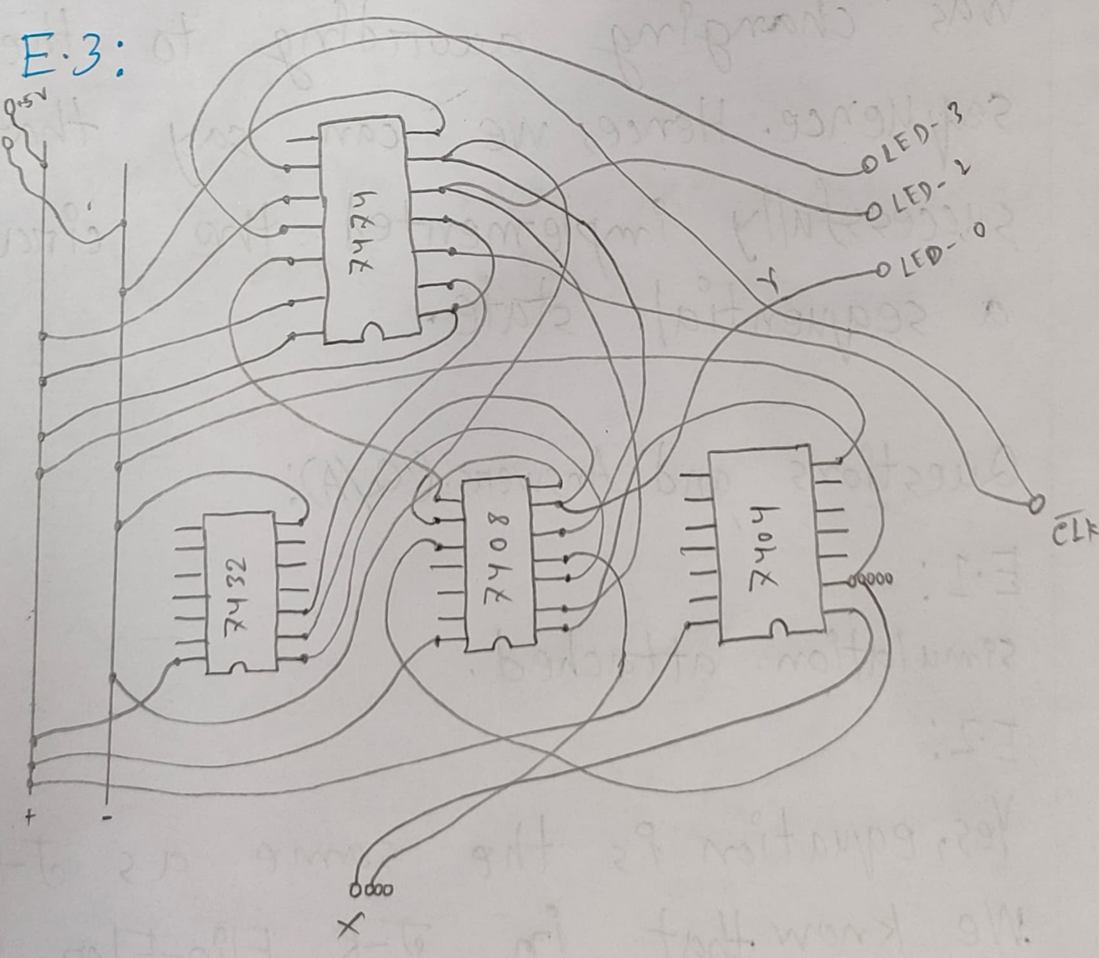
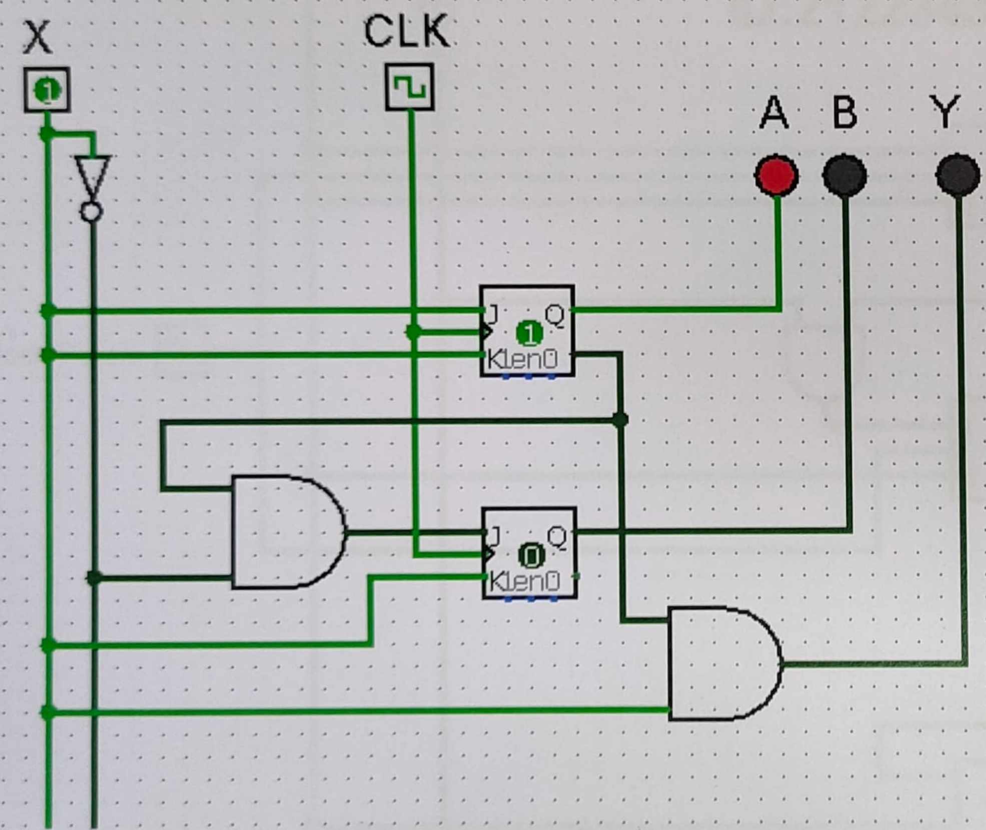


Figure: IC Diagram of D-Flip Flop

Discussion:

From this experiment, we learnt about the State Diagrams and state Tables. We also gain some practical understanding about that. In addition, we understand the concept of designing Sequential Circuits using Flip-Flops. We can now design and implement Synchronous Sequential Circuits for a given state Diagram. In this experiment we don't face any problems. We successfully completed the experiment within the given time.



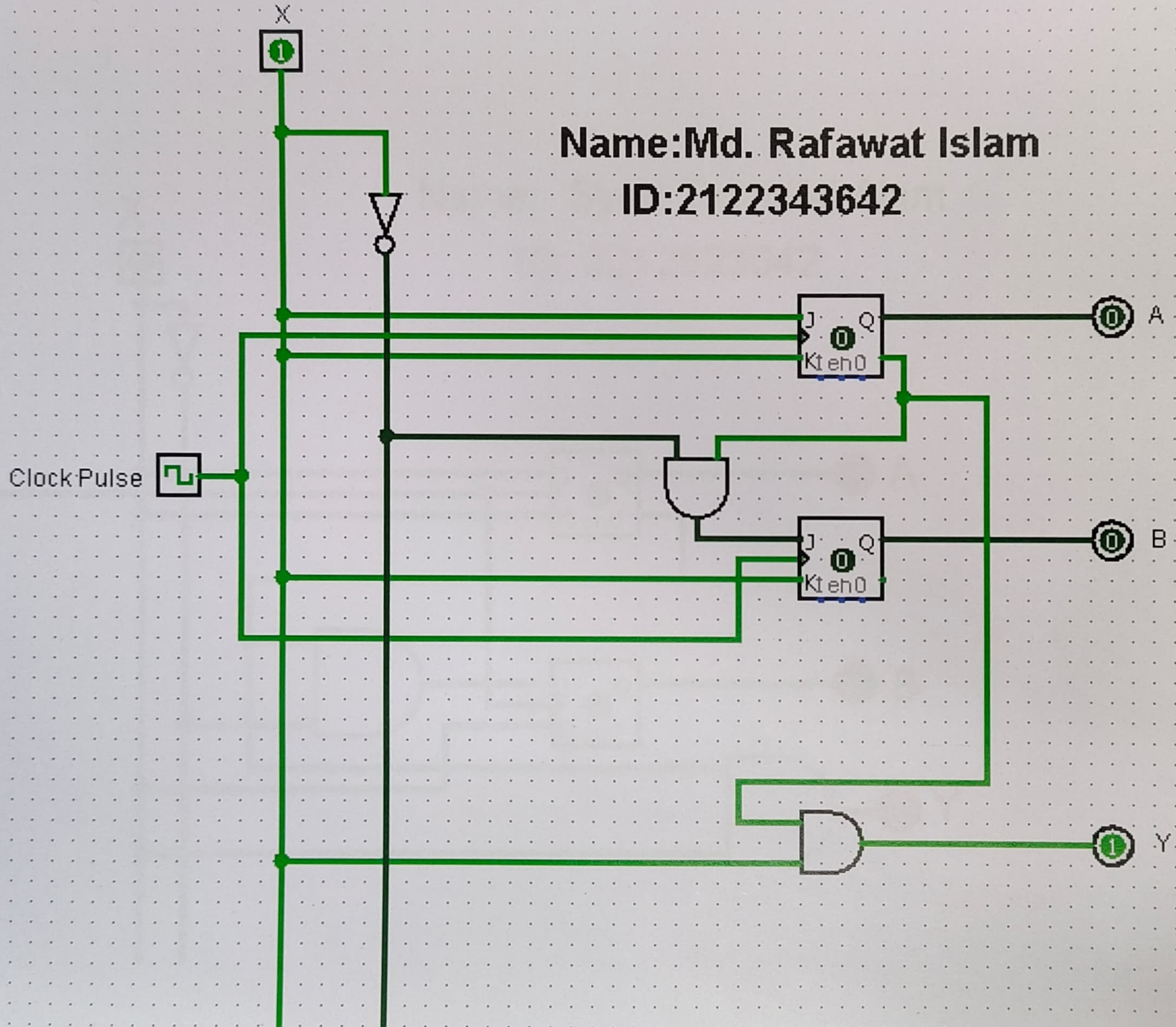
Joy Kumar Ghosh

ID: 2211424642

Group: 05

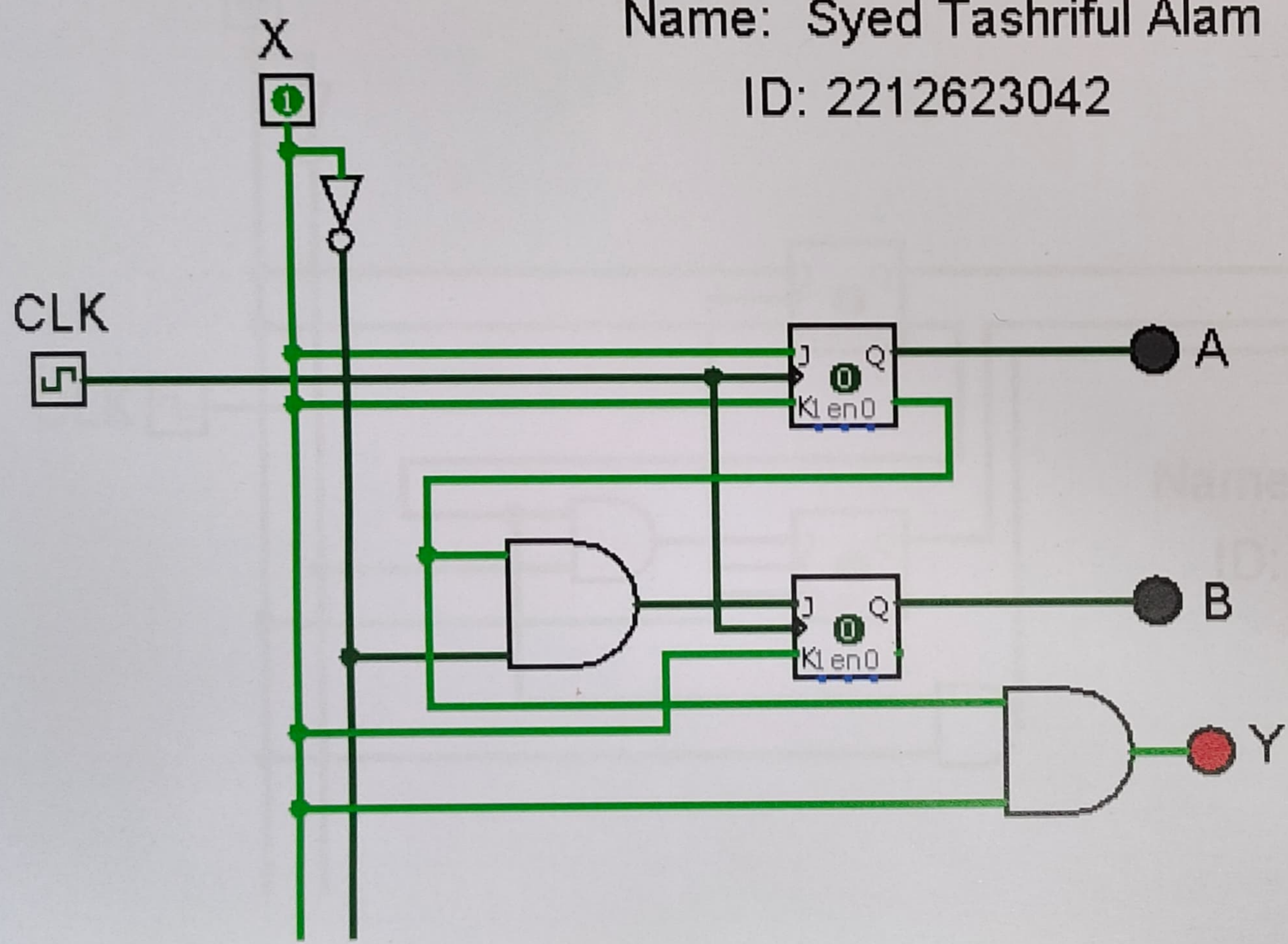
Name:Md. Rafawat Islam

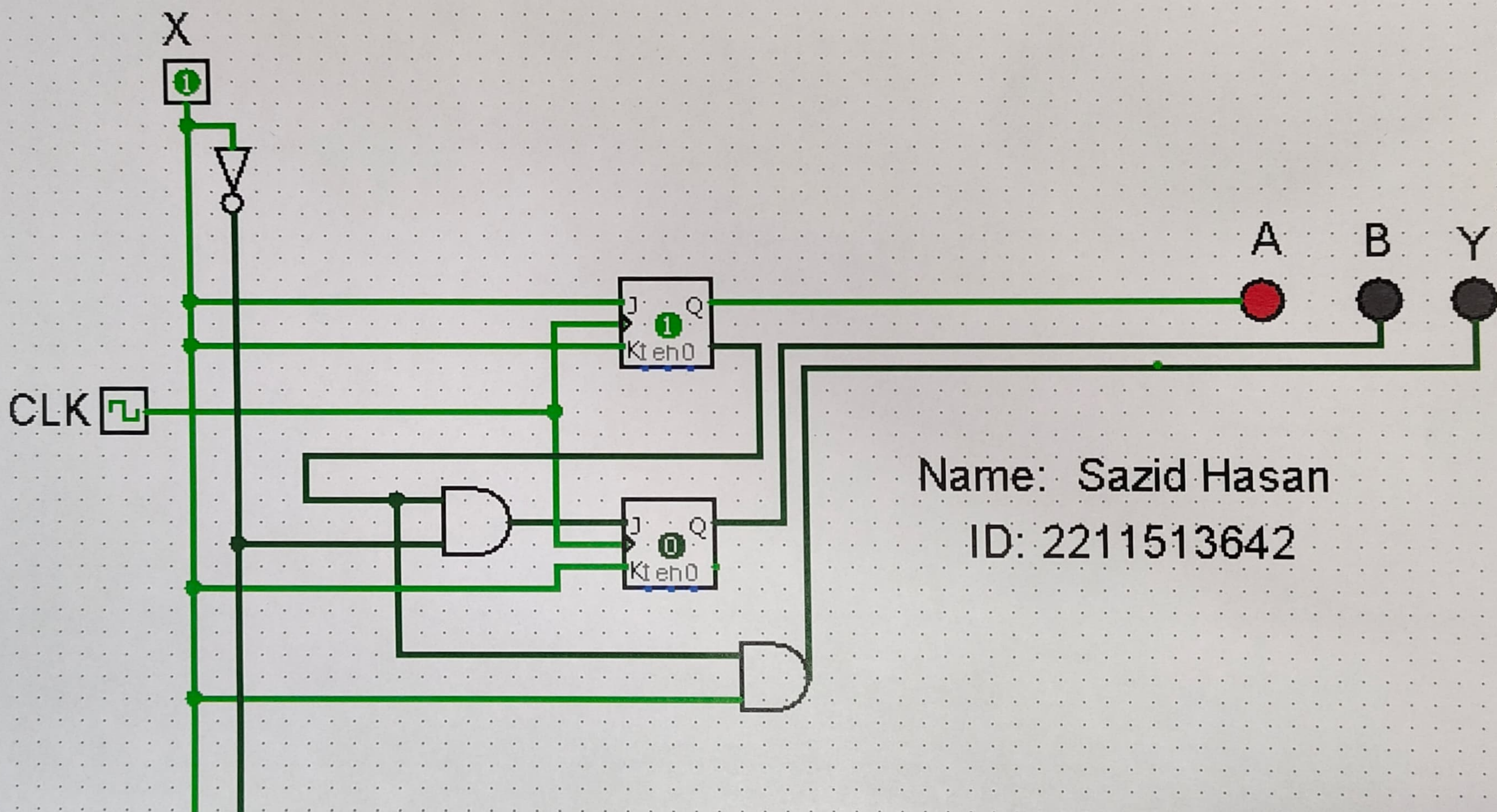
ID:2122343642



Name: Syed Tashriful Alam

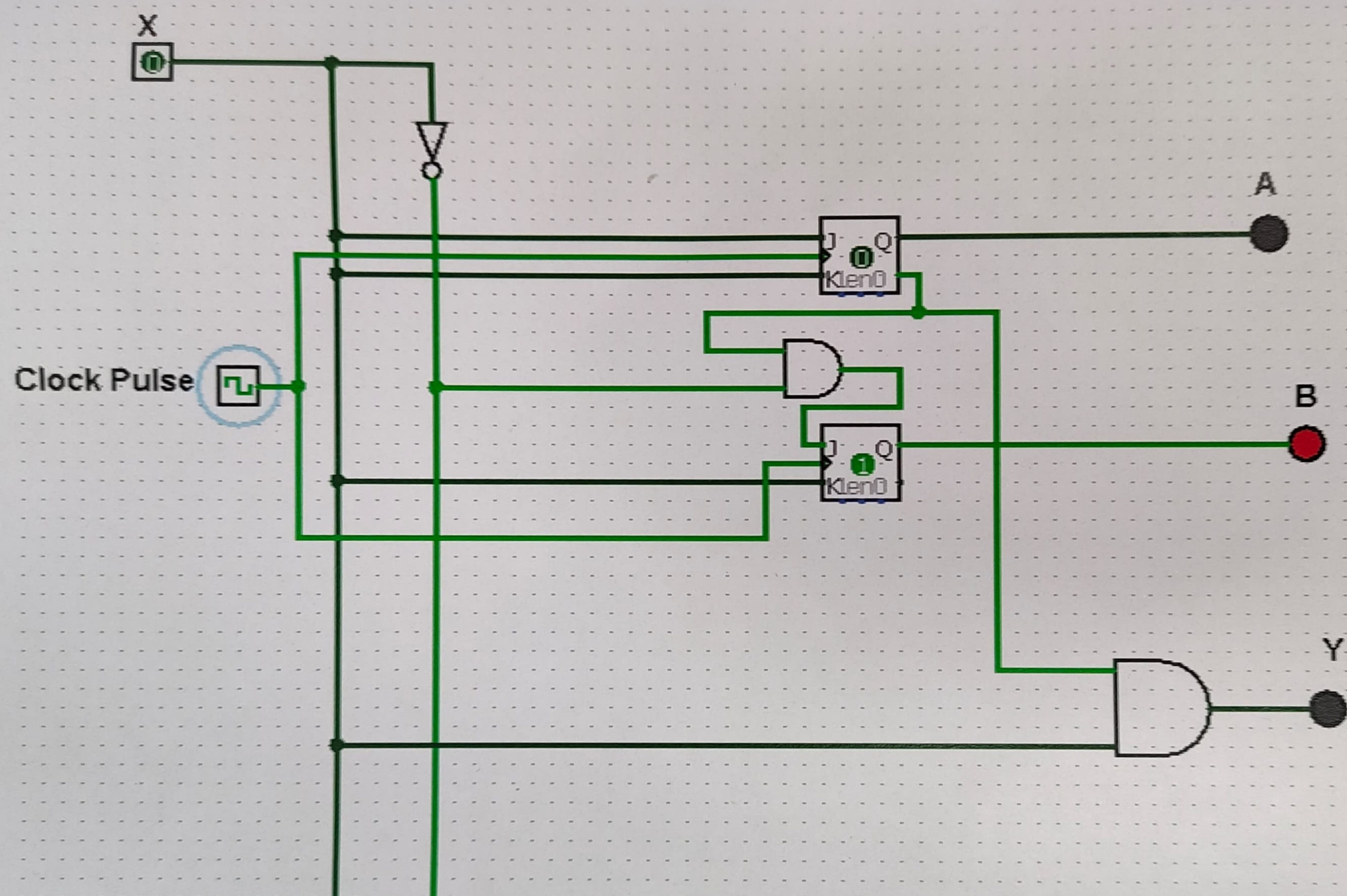
ID: 2212623042





Name: Sazid Hasan

ID: 2211513642



Md. NIFAT HOSSAIN

Id: 2212923042

Group: 05