North South University

Department of Electrical & Computer Engineering

LAB REPORT

Course Name:CSE231L

Section: 01

Experiment Number: 08

Experiment Name: Synchronous Sequential Circuit

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Remarks:	

Synchronous Sequential Circuit

Objective

- Understanding what a Sequential Circuit is.
- Gaining a practical understanding of State Diagrams and State Tables.
- Learning how to draw a State Table from a State Diagram.
- Understanding the concept of designing Sequential Circuits using Flip-Flops and the types of Sequential Circuits.
- Designing and implementing a Synchronous Sequential Circuit given a State Diagram.

Theory

Sequential Circuit

In a sequential logic circuit, the outputs depend not only on the present inputs but also on the past behavior of the circuit. Thus, a sequential logic circuit consists of a combinational circuit and memory elements that form a feedback system and is specified by a time sequence of inputs, outputs, and internal states.

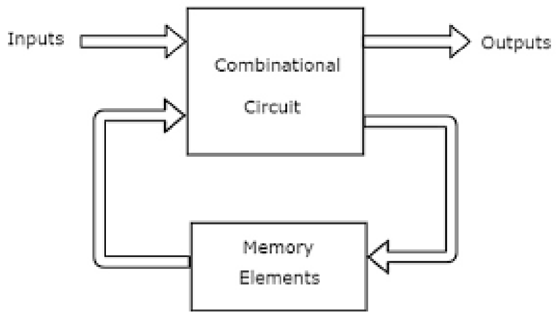

Figure B1: Sequential Circuit: Block Diagram

The memory elements are usually flip-flops which can store binary information’s.

State

Any binary information stored in memory elements (flip-flops) at a given time is called as the state of the sequential circuit at that time. It is represented as Q in the truth table.

Next State

When binary information is entered by the user as the external input to the sequential circuit, it together with the present state (Q) of the storage elements, determines the binary value of the outputs. The next state of the storage elements is therefore, a function of external inputs and the present state. It is represented as Qnext in the truth table.

Synchronous Sequential Circuit

It is one of the two main types of sequential circuit. Synchronous sequential circuits are digital sequential circuits in which the feedback to the input for next output generation is governed by clock signals. In Synchronous sequential circuits, the memory unit which is being used is clocked flip flop.

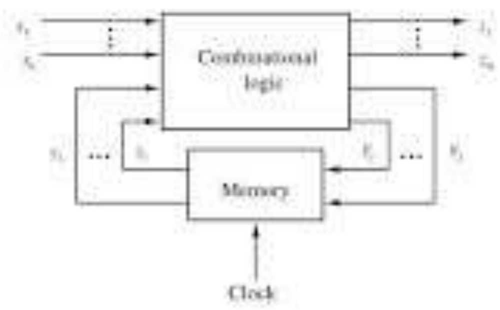

Figure: Synchronous Sequential Circuit

Asynchronous Sequential Circuit

Asynchronous sequential circuits are digital sequential circuits in which the feedback to the input for next output generation is not governed by clock signals.Unclocked flip flop or time delay is used as memory element.

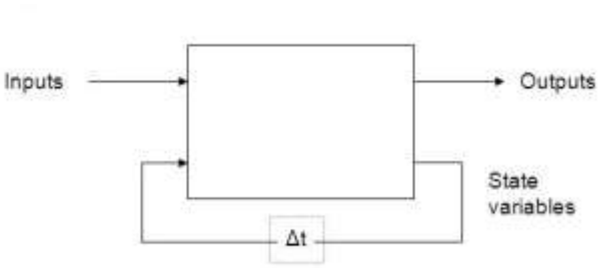

Figure: Asynchronous Sequential Circuit

State Table and State Diagram

A State Table also known as 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 diagram, 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 inside each circle identifies the state of the flip-flops. The directed lines are labeled 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.

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

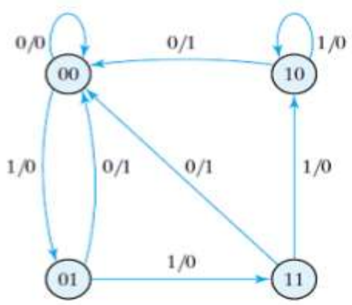

Figure: State Table and State Diagram

Circuit Diagram

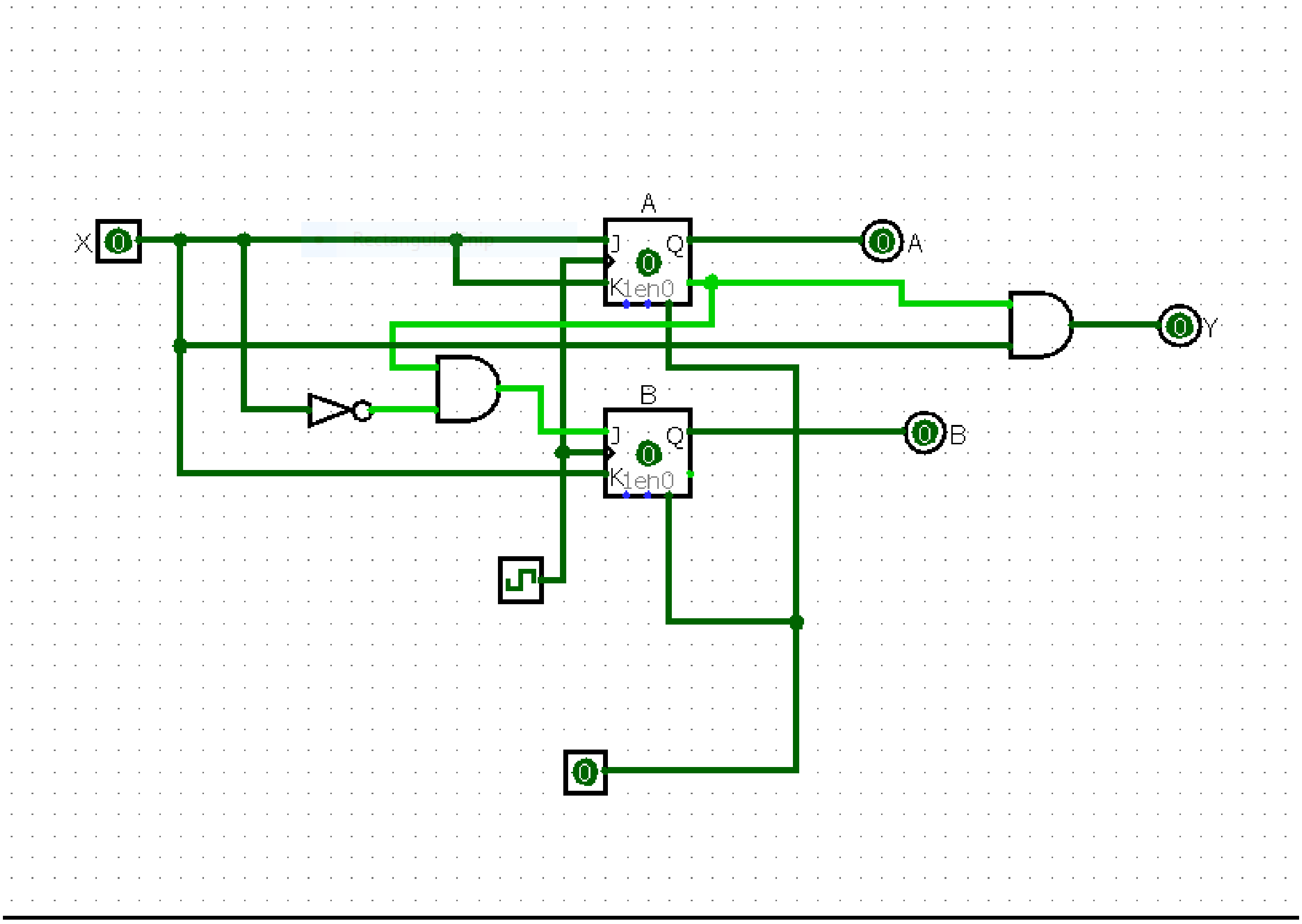

Figure F.1.1: Sequential Circuit using JK Flip-flop

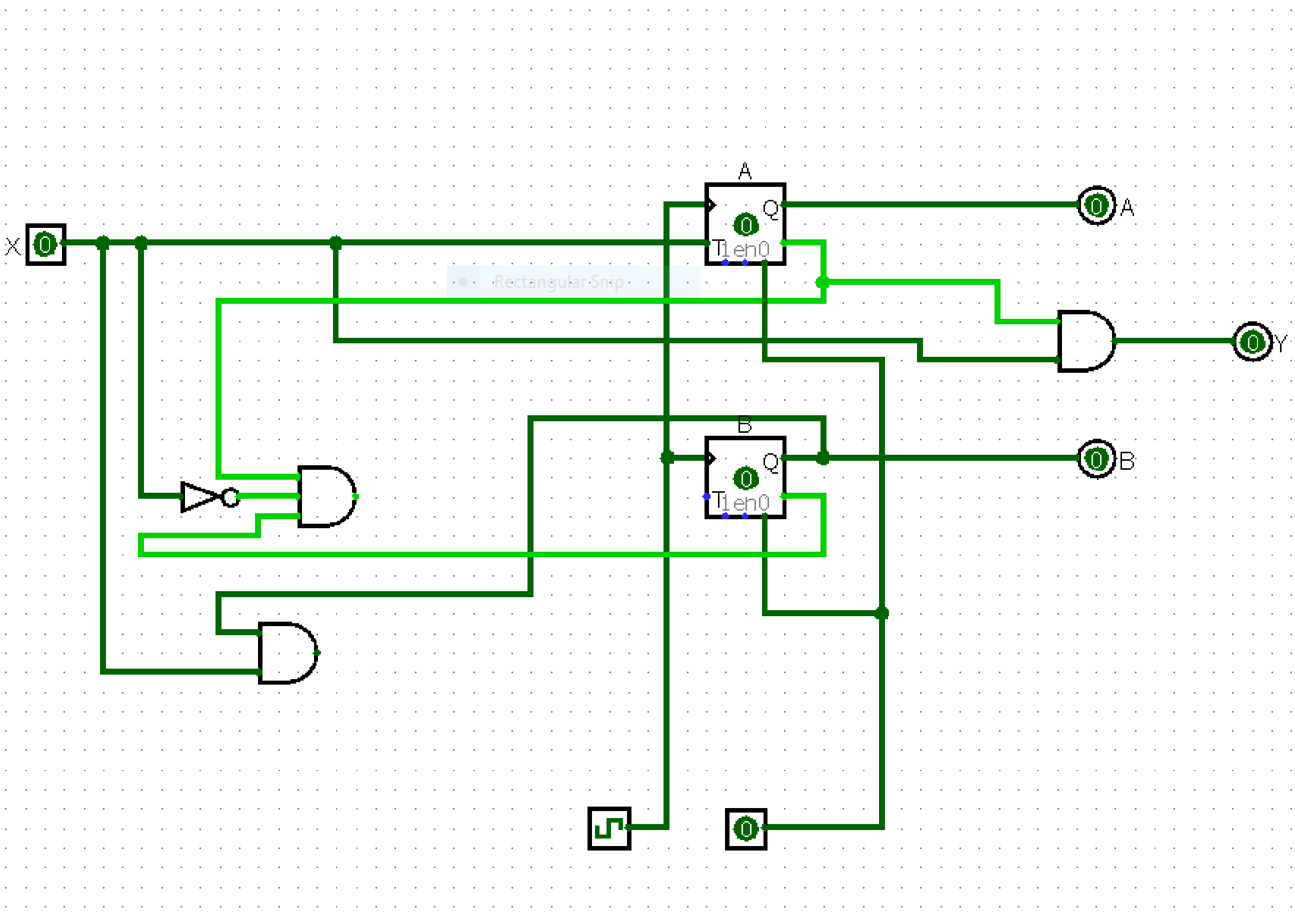

Figure F.2.1: Sequential Circuit using T Flip-flop

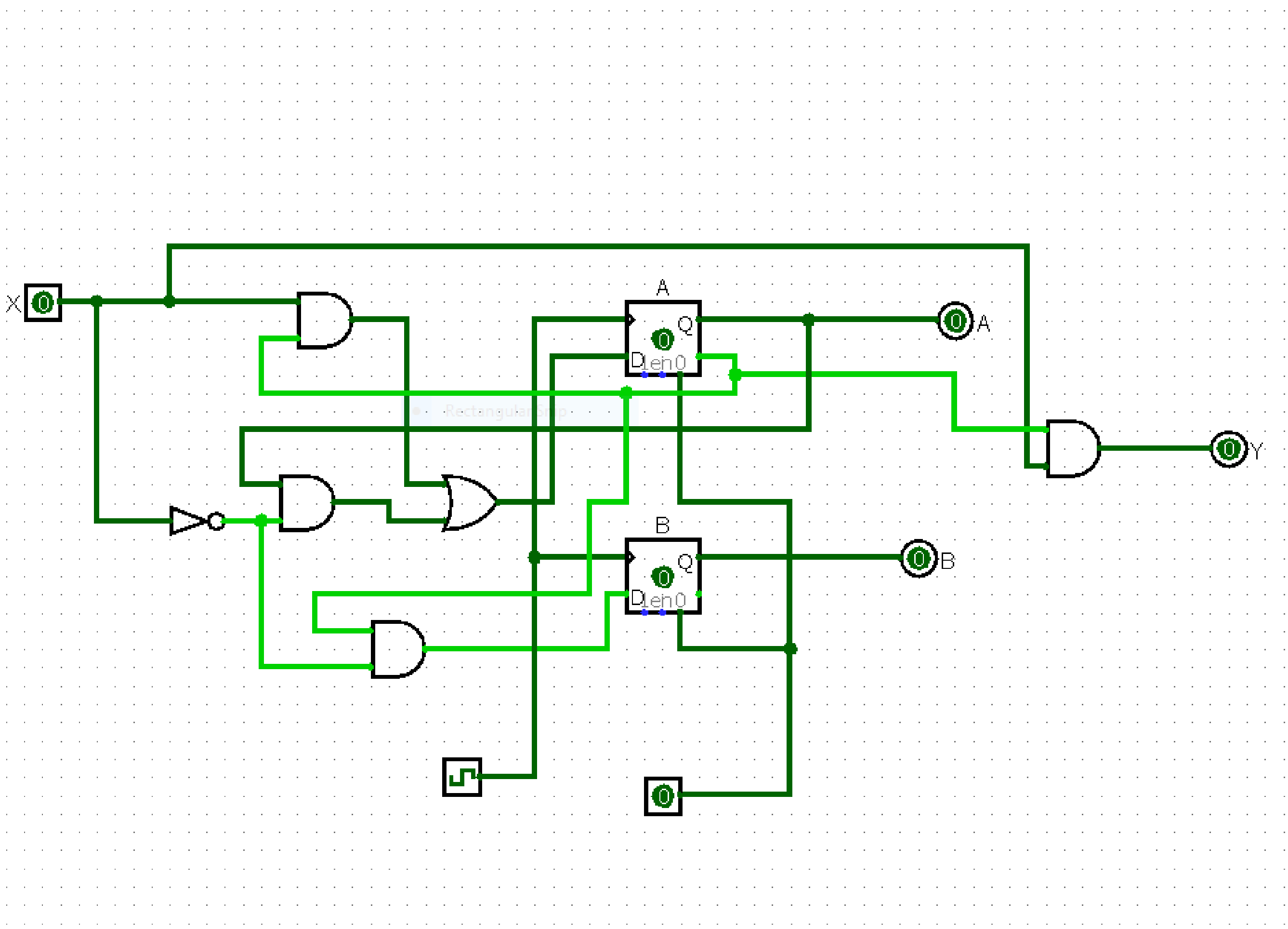

Figure F.3.1: Sequential Circuit using D Flip-flop

Truth 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	Ja	Ka	Jb	Kb
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

	B'X'	B'X	BX	BX'
A'	0	1	1	0
A	x	x	x	x

Ja=X

	B'X'	B'X	BX	BX'
A'	x	x	x	x
A	0	1	x	x

Ka=X

	B'X'	B'X	BX	BX'
A'	1	0	x	x
A	0	0	x	x

Jb=A'X'

	B'X'	B'X	BX	BX'
A'	x	x	1	0
A	x	x	x	x

Kb=X

	B'X'	B'X	BX	BX'
A'	0	1	1	0
A	0	0	x	x

Y=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	Ta	Tb
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

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

	B'X'	B'X	BX	BX'
A'	0	1	1	0
A	0	1	x	x

Ta=X

	B'X'	B'X	BX	BX'
A'	1	0	1	0
A	0	0	x	x

Tb=A'B'X'+BX

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	Da	Db
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 T Flip-Flops

	B'X'	B'X	BX	BX'
A'	0	1	1	0
A	1	0	x	X

Da=A'X+AX'

	B'X'	B'X	BX	BX'
A'	1	0	0	1
A	0	0	x	x

Db=A'X

Discussion

In Lab-8, we first learnt about sequential circuits and studied the block diagram of a sequential circuit. We learned how the memory elements in a sequential circuit stores binary information and uses them for the next input. Then we were told what are present state and next state. After that we studied the two types of sequential circuit: Synchronous and Asynchronous and each of their properties and how they differ from each other. For the synchronous circuit it has a clock pulse whereas the asynchronous does not have any. Secondly, we were taught how to study a state diagram and what state tables are and how to read from it.

In a state table we learnt the relation between present state(A and B), Input (x),Next Input (A and B) and output (y). Then using all these knowledge we completed Experiment-1, which required constructing a sequential circuit using JK flip-flops. Firstly, we drew the state table of the Figure D.1.1 given in the manual, which had Present State, Input, Next State and Output and is a state table for the sequential circuit .Then we used the excitation table of JK Flip-flop provided in the manual to determine the inputs for the two flip-flops (Ja, Jb and Ka, Kb) for each state transition. Following that we completed Table F.1.1.Then we preceded to step-3 where we drew K-Maps for each flip-flop input and used them to minimize the functions for each Flip-Flop input (Ja, Ka, Jb and Kb) as well as the combinational circuit for the output (Y).Lastly, we used the minimized equations derived from K-Maps and drew the Synchronous Sequential Circuit using Jk Flip-flops of Figure F.1.1 and verified the circuit using the state transitions and outputs of the completed circuit to see if they match those in the State Table F.1.1.After that we did Experiment-2,where we had to construct a synchronous sequential circuit using T Flip-flops.Firstly,we completed Table F.2.1 where the state table up to sequential circuit output was the same for all flip-flops and the Flip-flop input functions were (Ta and Tb).Secondly, we drew the K-Maps for Ta, Tb and Y and derived the minimized equations. Lastly, using those equations we drew the synchronous sequential circuit using T Flip-flops of Figure F.2.1. The last experiment was Experiment-3, where we constructed a synchronous sequential circuit using D Flip-flops. At first, we completed Table F.3.1 which is a state table for D Flip-flop with flip-flop input functions (Da and Db).Then we drew the respective K-Maps and derived the minimized equations for each of them. Lastly; we drew the circuit using the equations and completed Figure F.3.1.