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Lab 7: Introduction to Flip-Flops and Shift Registers

A. Objectives

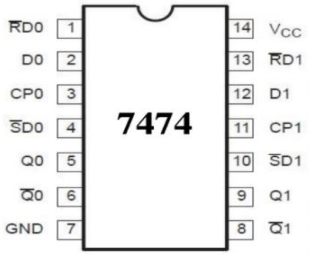
• Learn about the concept of states in digital logic and how Flip-Flop circuits can be used to store state information.
• Understand the internal logic of J-K Flip-Flops and implement one using basic logic gates.
• Understand the relationship between J-K, T and D Flip-Flops and observe the characteristics of all three.
• Implement a shift register using D Flip-Flops and analyze its operation.

B. Theory

Flip-Flops: Digital logic circuits can be divided into two types: combinational logic, whose output signals are dependent only on its present input signals, and sequential logic, whose outputs are a function of both the current inputs and the past history of inputs. In sequential logic, information from past inputs is stored in electronic memory elements, such as flip-flops and latches. The stored contents of these memory elements, at a given point in time, is collectively referred to as the circuit's "state" and contains all the information about the past to which the circuit has access.
A flip-flop is a binary storage device that has two stable states and is capable of storing one bit of information. In a stable state, the output of a flip-flop is either 0 or 1. The output can only change when a clock pulse is supplied to the flip-flop.

Registers: A register is a group of flip-flops. Each flip-flop is capable of storing one bit of information. An n-bit register contains a group of n flip-flops capable of storing n bits of binary information. In addition to flip- flops, a register may have combinational gates that perform certain data processing tasks. In the broadest definition, a register consists of a group of flip-flops and gates that effect their transition. The flip-flops hold binary information and the gates determine how the information is transferred into the registers. A register that is capable of shifting its binary information either to its right or its left is called a shift register.

New Apparatus:
IC 7474 (Dual D Flip-Flops):



PINS	DESCRIPTION
D0, D1	Data inputs
CP0, CP1	Clock inputs (active rising edge)
$\overline{S}D0$, $\overline{S}D1$	Set inputs (active low)
$\overline{R}D0$, $\overline{R}D1$	Reset inputs (active low)
Q0, Q1, $\overline{Q}0$, $\overline{Q}1$	Data outputs

Figure B1: Pinout of IC7474

The 7474 is a 14 pin IC which requires a Ground connection at pin 7 and VCC at pin 14. Pins 2 and 12 serve as the inputs for the two Flip-Flops and pins 5 and 9 act as the corresponding outputs. Pins 6 and 8 provide the inverse of the outputs. Pin 3 is the clock input for the first Flip-Flop and pin 11 is the clock input for the second Flip-Flop.

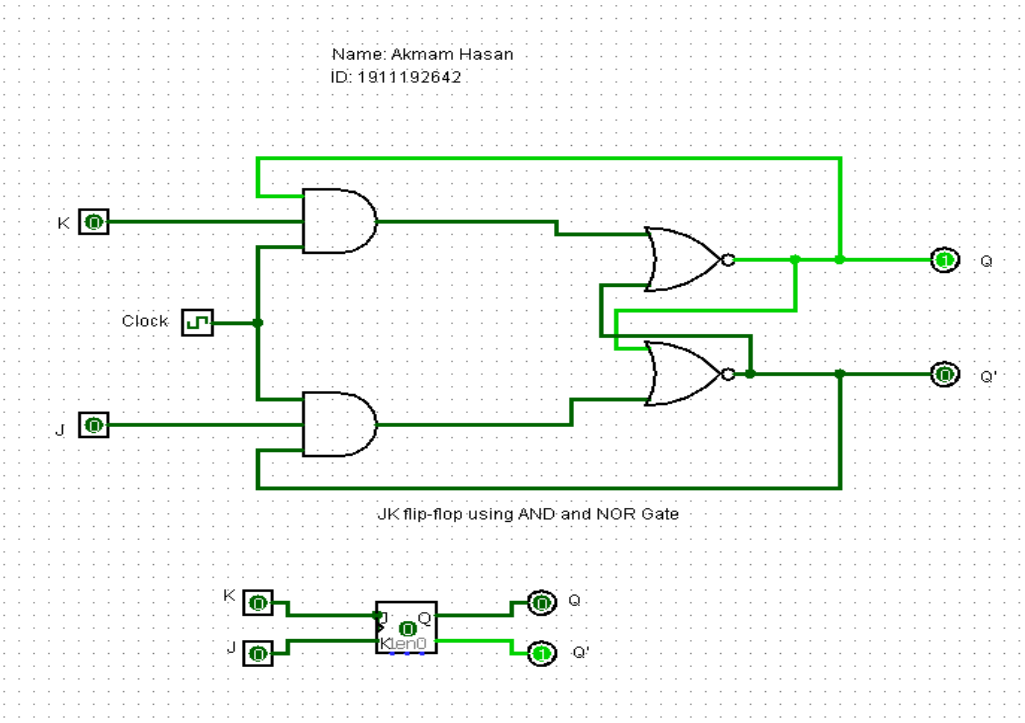
Experiment 1: Constructing a JK Flip-Flop using AND and NOR gates

C.1 Apparatus

• Trainer board
• 1 x IC 7402 2-input NOR gates
• 1 x IC 7411 3-input AND gates

J	K	Q	Q’
1	0	1	0
0	0	1	0
0	1	0	1
0	0	0	1
1	1	1	0
1	0	1	0
1	0	1	0
1	1	0	1

E.1 Report



Experiment 2: Using a JK Flip-Flop to construct T Flip-Flop and D Flip-Flop

C.2 Apparatus

• Trainer board
• 1 x IC 7402 2-input NOR gates
• 1 x IC 7411 3-input AND gates
• 1 x IC 7404 Hex Inverter (NOT gates)

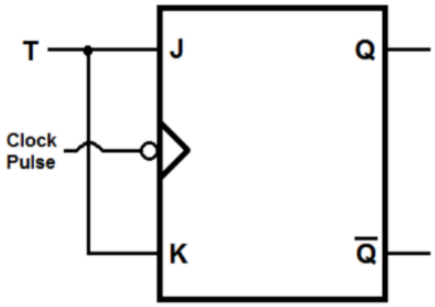


Figure D.2.1: T flip-flop constructed using JK flip-flop

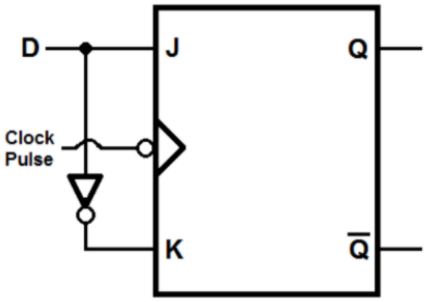


Figure D.2.2: D flip-flop constructed using JK flip-flop

T	Q
0	1
1	0

D	Q
0	0
1	1

E.2 Report

1. Briefly explain the difference between T and D Flip-Flops.

T flip-flop toggles its output every time it receives a signal. On the other hand, D flip-flop changes its output based on the data line when the clock pulse = 1. In a T flip-flop, when the input T is high, this flip-flop changes state (toggled). But in a D flip-flop, the value of the D input is only captured at a specific moment of the clock cycle like the rising edge of the clock.

So, the main difference between these two flip-flops is - In a D flip flop When the clock triggers, the value remembered by the flip-flop becomes the value of the D input (Data) at that instant. Bit in T flip-flop When the clock triggers, the value remembered by the flip-flop either toggles or remains the same depending on whether the T input (Toggle) is 1 or 0.

Experiment 3: Constructing a right shift register using D Flip-Flops

C.3 Apparatus

• Trainer board
• 2 x IC 7474 (D Flip-Flop)

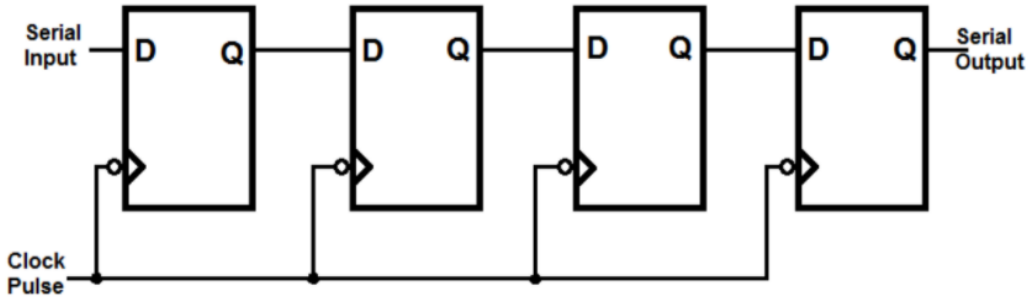


Figure D.3.1: Right Shift Register

States	Input	Output
Initial State	X	XXXX
T1	1	1XXX
T2	0	0100
T3	1	1010
T4	0	0101

E.3 Report

1. Why do we need shift registers?

In a shift register binary data can move from one flip-flop to another flip-flop within the register. So, shift registers are used as a data storage. It is also used for the movement of the data. It consists of a chain of flip-flop. It allows serial in – parallel out and parallel in – serial out which makes the data movement easier.

We need shift register to store data or movement of the data which is commonly used in calculators or computers and it convert the data from either parallel to serial or serial to parallel format. In a computer, all types of operations such as additions, subtractions, divisions, multiplications are performed by the registers.

2. What would happen if the output of the last D Flip-Flop in the register was connected to the input of the first D Flip-Flop?

If we connect output of the last D flip-flop to input of the first D flip-flop, then it will create a closed loop for the device. That means, output pulses at the last D flip-flop will have half the frequency of input clock frequency. Inside the loop, the values will repeat with each completion of clock cycles. As a result, the same value will keep repeating and act like a ring counter.

Discussion

Because of human errors we did not get our expected result in today's experiments. In this lab we learn about the concept of states in digital logic and how Flip-Flop circuits can be used to store state information. We also understand the internal logic of J-K Flip-Flops and implement one using basic logic gates. We understand the relationship between J-K, T and D Flip-Flops and observe the characteristics of all three. We finally implement a shift register using D Flip-Flops and analyze its operation.