Course Name:	**Digital Design Laboratory**	Semester:	**III**
Date of Performance:	**28/ 08 /2023**	Batch No:	**C2**
Faculty Name:		Roll No:	**16010122267**
Faculty Sign & Date:		Grade/Marks:	**___/25**

Experiment No: 5
Title: Flip Flops

Aim and Objective of the Experiment:

To Verify truth table of JK Flip flop using IC 7476 and study conversion of JK FF to D FF and T FF
_____

COs to be achieved:

CO3: Design synchronous and asynchronous sequential circuits.

Tools used:

Trainer kits

Theory:

Flip-flop is the common name given to two-state devices which offer basic memory for sequential logic operations. Flip-flops are heavily used for digital data storage and transfer and are commonly used in banks called "registers" for the storage of binary numerical data.

JK-flip flop: has two inputs, traditionally labeled J and K. IC 7476 is a dual JK master slave flip flop with preset and clear inputs. If J and K are different then the output Q takes the value of J at the next clock edge. If J and K are both low then no change occurs. If J and K are both high at the clock edge, then the output will toggle from one state to the other. It can perform the functions of the set/reset flip-flop and has the advantage that there are no ambiguous states.

D Flip Flop: tracks the input, making transitions with match those of the input D. The D stands for "data"; this flip-flop stores the value that is on the data line. It can be thought of as a basic memory cell. D flip-flop can be made from J-K flip-flop by connecting both inputs through a not gate.

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T Flip Flop: T or "toggle" flip-flop changes its output on each clock edge, giving an output which is half the frequency of the signal to the T input. It is useful for constructing binary counters, frequency dividers, and general binary addition devices. It can be made from a J-K flip-flop by tying both of its inputs high.
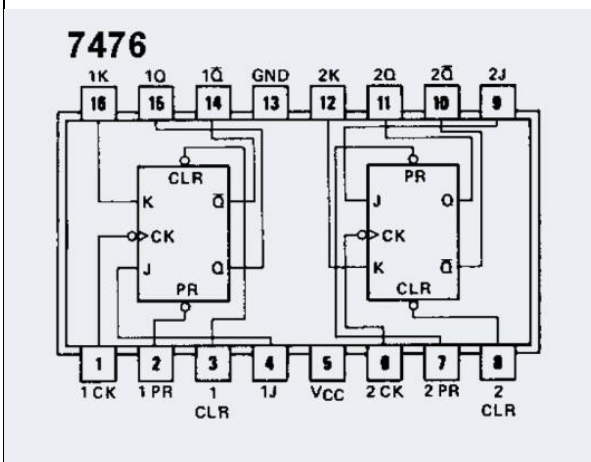
Implementation Details:
Procedure
1) Locate IC 7476 on Digital trainer kit
2) Apply various inputs to J & K pins by means of the output on logic output indicator.
3) Connect a pulsar switch to the clock input.
4) Connect the J&K as D and T flip flop as shown in diagrams and verify the respective   truth tables.
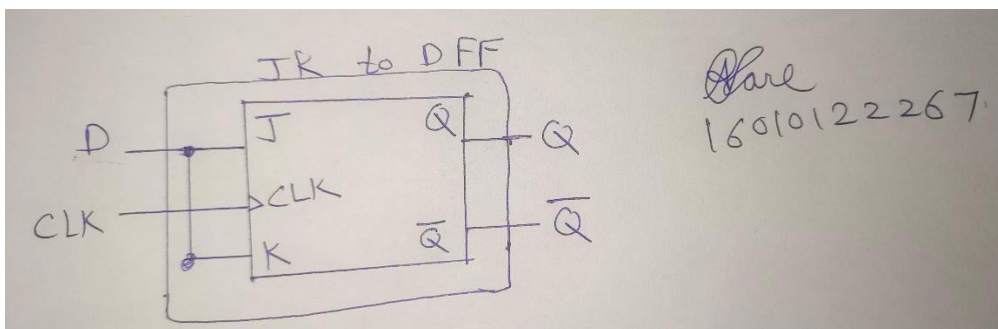
Logic Symbol

J-K Type

$$S = J\bar{Q} \text{ and } R = KQ$$

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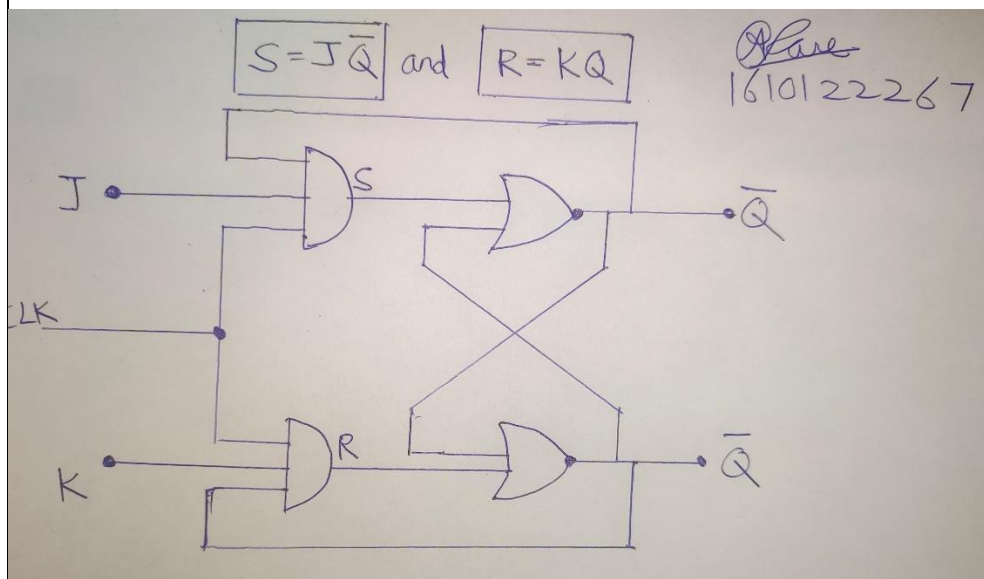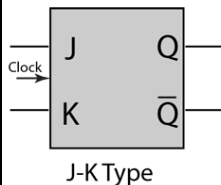
Pin Diagram of IC 7476

Truth Table of JK FF

	CLK	J	K	Q	$\overline{Q}$	Description
Same as for SR Latch	X	0	0	1	0	Memory no change
	X	0	0	0	1	
	⁻↓	0	1	1	0	Reset Q >> 0
	X	0	1	0	1	
	⁻↓	1	0	0	1	Set Q >> 1
	X	1	0	1	0	
Toggle action	⁻↓	1	1	0	1	Toggle
	⁻↓	1	1	1	0	

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Conversion of FFs

1) **JK to D FF**

   Conversion Diagram

   Truth Table of D FF

CLK	D	Q	$\overline{Q}$	Description
↓ » 0	X	Q	$\overline{Q}$	Memory no change
↑ » 1	0	0	1	Reset Q >> 0
↑ » 1	1	1	0	Set Q >> 1

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T R U S T

2) JK to T FF

Conversion Diagram
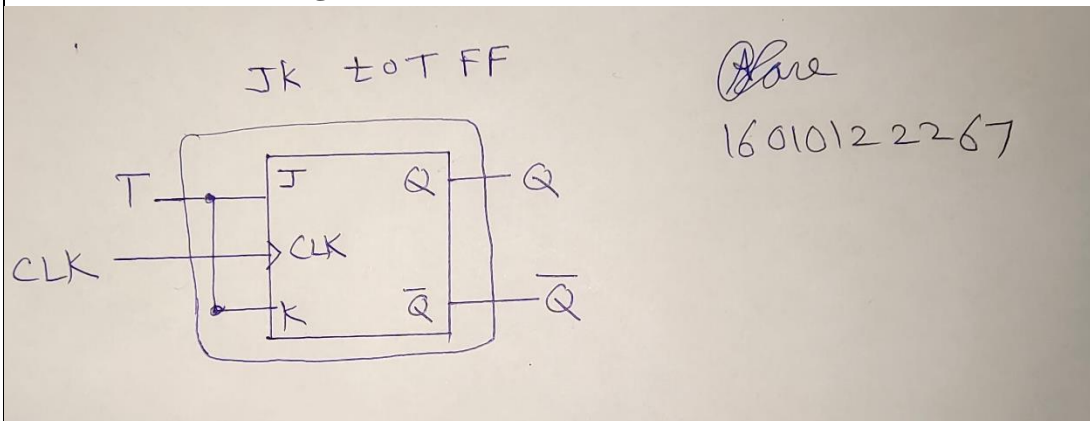
Truth Table of T FF

	Previous		Next	
T	**Q**	$\overline{Q}$	**Q**	$\overline{Q}$
0	**0**	**1**	**0**	**1**
0	**1**	**0**	**1**	**0**
1	**0**	**1**	**1**	**0**
1	**1**	**0**	**0**	**1**

Implementation Details

Procedure:

1) Locate the IC 7476 and place the IC on trainer kit.
2) Connect VCC and ground to respective pins of IC trainer kit.
3) Implement the circuit as shown in the circuit diagram.
4) Connect the inputs to the input switches provided in the trainer kit.
5) Connect the outputs to the switches of O/P LEDs
6) Apply various combinations of inputs according to the truth table and observe the condition of LEDs.
7) Note down the corresponding output readings for various combinations of inputs.

Post Lab Subjective/Objective type Questions:

1. How does a JK flip-flop differ from an SR flip-flop in its basic operation?

Ans:

JK flip-flops and SR flip-flops are both types of sequential logic circuits used in digital electronics for storing and manipulating binary information. However, they have distinct characteristics:

1. **Inputs**:
   - **JK Flip-Flop**: A JK flip-flop has two inputs, J (set) and K (reset), which allow for controlling and toggling the flip-flop's state.
   - **SR Flip-Flop**: An SR flip-flop has two inputs, S (set) and R (reset), used to set, reset, or maintain the current state.

2. **Operation**:
   - **JK Flip-Flop**: JK flip-flops offer greater versatility as they can act as toggle flip-flops. They can change their output state to the opposite of the current state when given specific inputs. The possible input combinations for a JK flip-flop are: J=0, K=0 (No Change), J=0, K=1 (Reset), J=1, K=0 (Set), and J=1, K=1 (Toggle).
   - **SR Flip-Flop**: SR flip-flops have a simpler operation. They can be set (S=1, R=0), reset (S=0, R=1), or maintain their current state (S=0, R=0) based on input values. However, setting both S and R to 1 (S=1, R=1) should be avoided, as it leads to unpredictable behavior.

3. **State Transition**:
   - **JK Flip-Flop**: A JK flip-flop can directly toggle its output state when provided with the J=1, K=1 input condition. This means it can switch between '0' and '1' states.
   - **SR Flip-Flop**: An SR flip-flop cannot directly toggle its output state and relies on setting or resetting. To achieve toggling with an SR flip-flop, additional logic gates are required.

4. **Use Cases**:
   - **JK Flip-Flop**: JK flip-flops are preferred when a flip-flop with toggling capability is needed, such as in frequency division circuits and sequential logic designs where alternating between two states is required.
   - **SR Flip-Flop**: SR flip-flops are used in applications where a simple set or reset operation suffices, such as memory storage elements in digital systems.

In summary, JK flip-flops provide more flexibility with the ability to toggle their output state, while SR flip-flops are simpler and can only set or reset their state based on the inputs.

2. What is the use of characteristic and excitation table?

Ans:

Characteristic tables and excitation tables are valuable tools in the design and analysis of digital sequential circuits, including flip-flops and state machines. Here's a detailed explanation of their purpose and usage:

1. **Characteristic Table**:
   - **Purpose**: A characteristic table, also known as a characteristic equation table, serves to provide a clear representation of how a sequential circuit element (typically a flip-flop or state machine) behaves concerning its inputs and outputs. It summarizes the

relationship between inputs, the current state, and the next state or output.
- **Usage**:
    - **State Machine Design**: When designing state machines, characteristic tables help define the next state based on the current state and input conditions. They list all possible combinations of inputs and states, specifying the desired output or next state for each combination.
    - **Flip-Flop Analysis**: In the case of flip-flops, characteristic tables illustrate the connection between input conditions (e.g., J and K for JK flip-flops) and the resulting changes in the flip-flop's state (set, reset, toggle, or no change).
- **Representation**: A characteristic table typically includes columns for inputs, the current state, and the next state or output. It enumerates all potential input and state combinations, along with the corresponding desired output or next state values.

2. **Excitation Table**:
    - **Purpose**: An excitation table, also known as an excitation equation table, is used to define the necessary input conditions to achieve a specific change in state or output within a sequential circuit. It details how the flip-flop inputs should be configured to attain the desired state transition.
    - **Usage**:
        - **Flip-Flop Design**: Excitation tables are frequently employed during flip-flop design to determine the input conditions (e.g., J and K values for JK flip-flops) required to set, reset, toggle, or maintain the flip-flop's state.
        - **State Machine Optimization**: In state machine design, excitation tables are valuable for optimizing the circuit by identifying the minimal input changes needed to transition efficiently between states.
    - **Representation**: An excitation table typically consists of columns for the current state, the desired next state, and the required input conditions (e.g., J and K values) necessary to achieve the desired transition.

In summary, characteristic tables aid in defining the behavior of digital circuits with respect to inputs and outputs, while excitation tables are crucial for determining the input conditions required to achieve specific state changes in flip-flops or state transitions in state machines. Both tables play vital roles in digital circuit design and analysis, contributing to the development of efficient and reliable sequential circuits.

3. How many flip flops do you require storing the data 1101?

Ans:

To store the binary data '1101', you would need 4 flip-flops. Each flip-flop can store one bit of data, and since you have four bits in the binary sequence '1101', you would require four flip-flops to store each of these bits individually.

Conclusion:

From this experiment, we learnt about flip-flops and how they work. We also learnt to use JK, D and

T flip-flops. Finally, we learnt to convert JK flip-flops into D and T flip-flops.

Signature of faculty in-charge with Date: