جامعة المستقبل
نحو جامعة مستدامة

Al-Mustaqbal University - College of engineering
Department of computer engineering

Second stage

Lecture Week 3
“Flip-flops (Conversion between types & Applications)”

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Objectives Conversion between Flip-Flop Types

By the end of this lecture, students will be able to

- Understand the concept of flip-flop type conversion (e.g., D ↔ JK ↔ T).
- Analyze and derive excitation tables for different flip-flop conversions.
- Design circuits using conversion logic.
- Apply Karnaugh maps to simplify conversion equations.
- Implement converted flip-flops in sequential circuits.

Objectives Applications of Flip-Flops

By the end of this lecture, students will be able to

- Identify real-world applications of flip-flops (e.g., counters, shift registers, memory).
- Design binary and mod-N counters using flip-flops.
- Analyze and simulate sequential logic systems.
- Apply flip-flops in timing, control, and data storage circuits.
- Use flip-flops in denouncing, frequency division, and sequence detection.

(5 mins)

Group Activity
Brainstorming عصف ذهني

https://docs.google.com/forms/d/e/1FAIpQLSf8p2KWBtn8BIfVD3YYndnWpnnpkdXAh3zxAgFM_ZfudNF3XQ/viewform?usp=header

Try thinking about the appropriate way to apply the Flip Flop conversion!

Then Submit your answer using the QR code or the link above.

Conversion
Flip-Flops between types

Conversion for Flip-Flops

Excitation Table

Q_N	Q_{N+1}	S	R	J	K	D	T
0	0	0	X	0	X	0	0
0	1	1	0	1	X	1	1
1	0	0	1	X	1	0	1
1	1	X	0	X	0	1	0

Converting Flip-Flops

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Here we will discuss the steps that one must use to convert one given flip-flop to another one. Let us assume that we have the required flip-flops that are to be constructed using the sub-flip-flops:

Converting Flip-Flops

1. Drawing of the truth of the required flip-flop.

2. Writing of the corresponding outputs of those sub-flip-flops that are to be used from the given excitation table.

3. Drawing of the K-Maps using the required inputs of the flip-flops and then obtaining the excitation functions for the inputs of the sub-flip-flops.

4. Construction of the logic diagram in accordance with the functions that we have obtained.

Conversion of SR to JK Flip-Flop

J	K	Q_N	Q_{N+1}	S	R
0	0	0	0	0	X
0	0	1	1	X	0
0	1	0	0	0	X
0	1	1	0	0	1
1	0	0	1	1	0
1	0	1	1	X	0
1	1	0	1	1	0
1	1	1	0	0	1

Excitation Functions SR to JK

$S = JQ_N'$

KQ_N

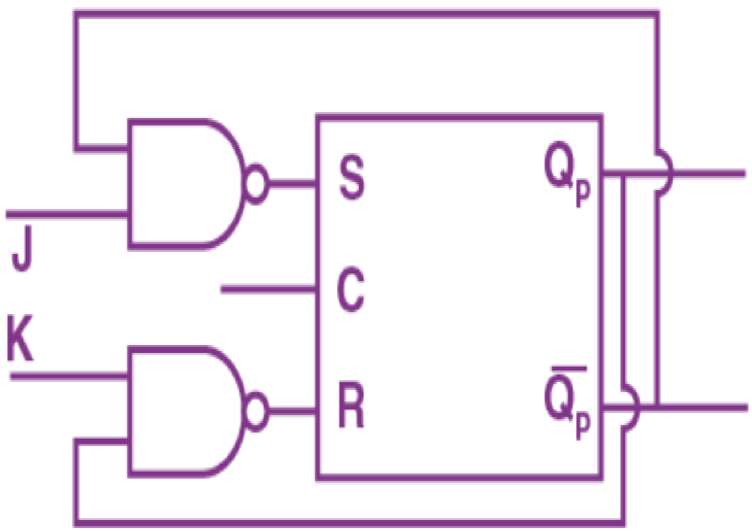
J

0	X	0	0
1	X	0	1

$R = KQ_N$

KQ_N

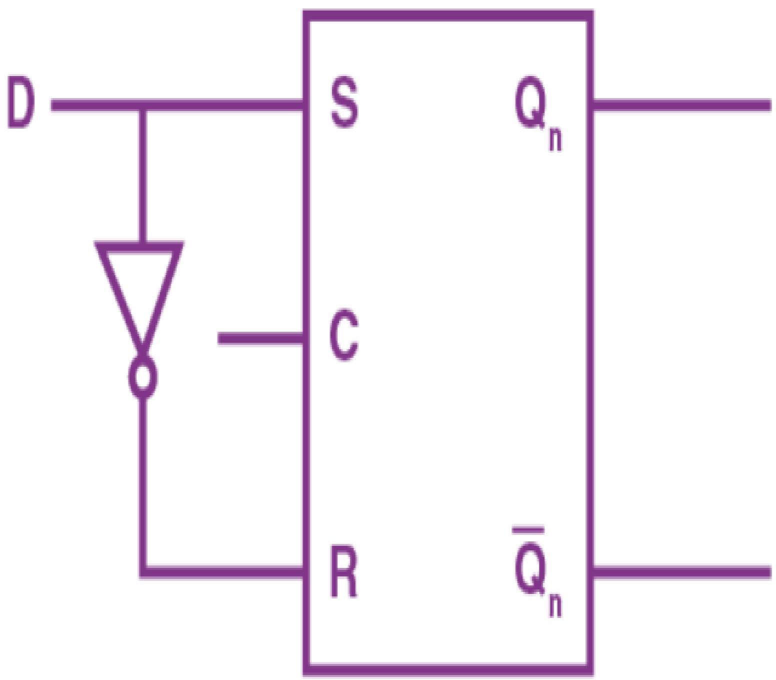
X	0	1	X
0	0	1	0



Conversion of SR to D FlipFlop

D	Q_N	Q_{N+1}	S	R
0	0	0	0	X
0	1	0	0	1
1	0	1	1	0
1	1	1	X	0

Excitation Functions SR to D



Logic Diagram

S:

D,Q_N		
	0	0
	1	X

R:

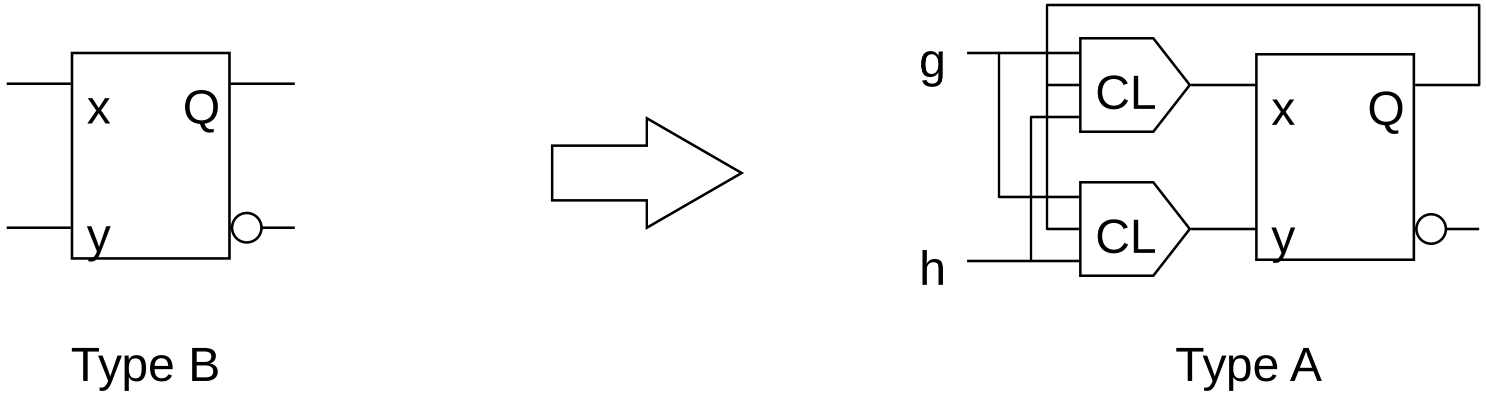
D,Q_N		
	X	1
	0	0

Conversion Between FlipFlop Types

Procedure uses excitation tables

Method: to realize a type A flipflop using a type B flipflop:

1. Start with the K-map or state-table for the A-flipflop.
2. Express B-flipflop inputs as a function of the inputs and present state of A-flipflop such that the required state transitions of A-flipflop are reallized



1. Find $Q^+ = f(g,h,Q)$ for type A (using type A state-table)

2. Compute $x = f1(g,h,Q)$ and $y=f2(g,h,Q)$ to realize Q^+.

Use JK-FF to realize D-FF

Example: Use JK-FF to realize D-FF

1) Start transition table for D-FF
2) Create K-maps to express J and K as functions of inputs (D, Q)
3) Fill in K-maps with appropriate values for J and K
   to cause the same state transition as in the D-FF transition table

D	Q	Q^+	J	K
0	0	0	0	X
0	1	0	X	1
1	0	1	1	X
1	1	1	X	0

State-Table

Q	Q^+	R	S	J	K	T	D
0	0	X	0	0	X	0	0
0	1	0	1	1	X	1	1
1	0	1	0	X	1	1	0
1	1	0	X	X	0	0	1

e.g.
when D=Q=0, then Q^+= 0
the same transition Q-->Q^+
is realize with J=0, K=X

Q \ D	0	1
0	0	1
1	X	X

J = D

Q \ D	0	1
0	X	X
1	1	0

$K = \overline{D}$

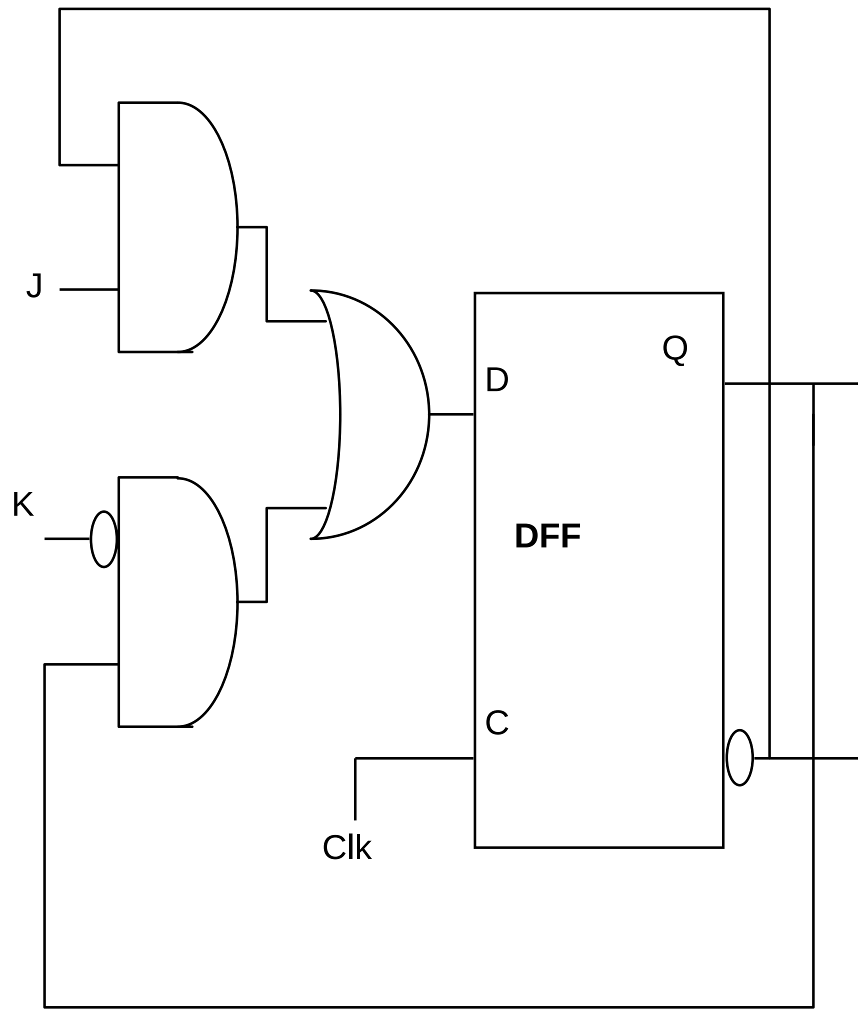
Implement JK-FF using a D-FF

J	K	Q	Q+	D	T
0	0	0	0	0	0
0	0	1	1	1	0
0	1	0	0	0	0
0	1	1	0	0	1
1	0	0	1	1	1
1	0	1	1	1	0
1	1	0	1	1	1
1	1	1	0	0	1

Q \ JK	00	01	11	10
0	0	0	1	1
1	1	0	0	1

J: columns 11, 10; K: columns 01, 11

d= jQ + Kq



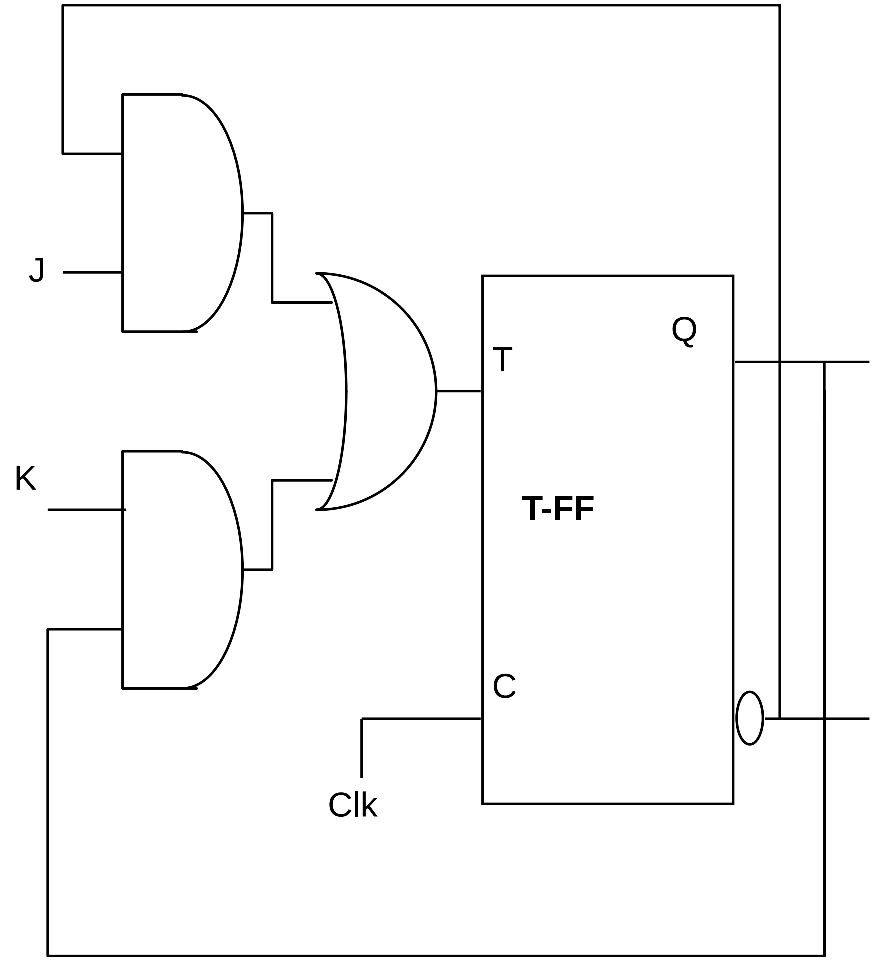
Implement JK-FF using a T-FF

J	K	Q	Q+	D	T
0	0	0	0	0	0
0	0	1	1	1	0
0	1	0	0	0	0
0	1	1	0	0	1
1	0	0	1	1	1
1	0	1	1	1	0
1	1	0	1	1	1
1	1	1	0	0	1

J

Q \ JK	00	01	11	10
0	0	0	1	1
1	0	1	1	0

K



t= jQ + kq

Part Two

Flip-Flops Applications

(6 Minutes)

Group Activity

Do you think traffic lights are a flip-flop application? Explain if so.

Submit your answer using the QR code or the link below:

https://docs.google.com/forms/d/e/1FAIpQLSdVNBy4EQSICezEvpOQHBX0sa1nsFP01Vzkaui_vda9OJCaYA/viewform?usp=header

Applications of Flip-Flops

- Frequency dividers
- Counters
- Storage registers
- Shift registers
- Data storage
- switch
- Latch
- Data transfer
- Memory
- Registers
- Bounce elimination

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Key Applications of Flip-Flops:

•**Data Storage:**

Flip-flops can store a single bit of information, making them essential for registers, which are used to hold data temporarily or for longer periods.

•**Frequency Division:**

Flip-flops can be configured to divide the frequency of a clock signal by a factor of 2, which is useful in applications like digital clocks and frequency synthesizers.

•**Counters:**

Flip-flops are the core components of counters, which are used to count events or pulses.

Key Applications of Flip-Flops:

- **Data Transfer:**
Flip-flops can be used to transfer data between different parts of a circuit or between different circuits.
- **Sequential Logic:**
They form the basis of sequential logic circuits, where the output depends not only on the current input but also on the past inputs.
- **Registers:**
Flip-flops are used to create registers, which are groups of flip-flops that can store multiple bits of data.

Key Applications of Flip-Flops:

- **Shift Registers:**

Shift registers, which are used to shift data bits along a series of flip-flops, are built using flip-flops.

- **Bounce Elimination:**

Flip-flops can be used to eliminate bounce (unwanted electrical noise) from mechanical switches.

- **Latching:**

They can be used as latches, which hold a piece of data until a new input changes its value.

Conversion Flip-Flops between types

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Summary

From \ To

	SR Flip-Flop	**JK Flip-Flop**	**D Flip-Flop**	**T Flip-Flop**
SR	—	$J = S$ $K = R$	$D=S$	$T=S\oplus R$
JK	$S=J$ $R=K$	—	$D=J\cdot\overline{Q} + \overline{K}\cdot Q$	$T=J\cdot\overline{K} + \overline{J}\cdot K$
D	$S=D$ $R=\overline{D}$	$J= D\cdot\overline{Q}$ $K =\overline{D}\cdot Q$	—	$T=D\oplus Q$
T	$S=T\cdot\overline{Q}$ $R=T\cdot Q$	$J=T\cdot\overline{Q}$ $K=T\cdot Q$	$D=T\oplus Q$	—

Notes:
- $\oplus$ = XOR (Exclusive OR)
- Q = Current output
- $\overline{Q}$ = Complement of output

Summary

- Essential for Data Storage: Flip-flops are the fundamental units for storing binary data in digital systems, forming the basis of memory and registers.
- Core of Sequential Logic: They enable circuits to remember past states, making them crucial for designing counters, shift registers, and state machines.
- Foundation of Digital Systems: Flip-flops are vital for building reliable and synchronized digital systems like processors, communication devices, and embedded systems.

شكراً لحسن
إصغائكم

THANK YOU ☺

UOMU022021 Digital Systems

Department of Computer Engineering

END LESSON 3: FLIP-FLOPS (CONVERSION BETWEEN TYPES & APPLICATIONS)