AKTU

GATEWAY CLASSES

Digital System Design

B.Tech. 3rd Sem

EC & Allied



Exam/Result Oriented Content

- ✓ Recorded Video Lectures
- ✓ Pdf Notes
- ✓ PYQs

DIGITAL SYSTEM DESIGN

UNIT 3 : Sequential logic design

Lec 6

Today's Target

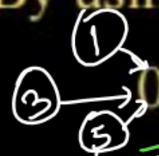
- Specific Sequence Counters
- Ring Counters
- Johnson Counter
- Advantages, Disadvantages & Applications of Johnson counter
- Flip Flop Conversion
- University Questions

UNIVERSITY QUESTIONS

YEAR	QUESTIONS	MARKS
20-21	Explain 4bit Johnson counter with circuit diagram and waveforms.	10 Marks
18-19	How many flip flops are required to design Mod-5 Ring counter and Mod-5 Johnson counter?	2 Marks

Specific Sequence Counters

By using suitable flip flop design a counter to go through the following states:

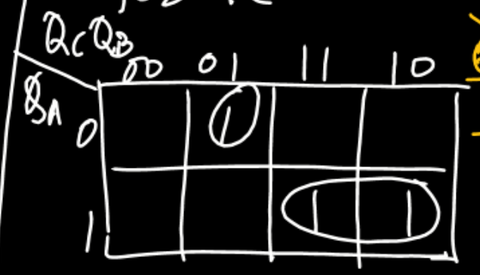


0 → 2 → 4 → 6 → 7 → 0 Avoid Lockout condition.

State Table

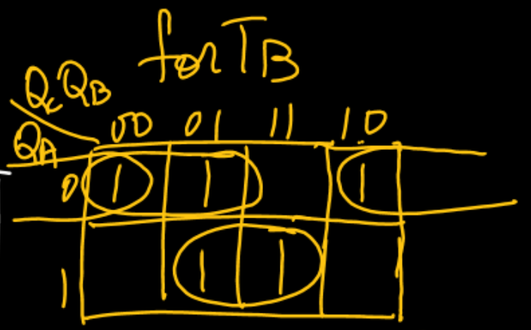
Present state			Next state			Excitation inputs		
Q_C	Q_B	Q_A	Q_{C+1}	Q_{B+1}	Q_{A+1}	T_C	T_B	T_A
0	0	0	0	1	0	0	1	0
0	0	1	0	0	0	0	0	1
0	1	0	1	0	0	1	1	0
0	1	1	0	0	0	0	1	1
1	0	0	1	1	0	0	1	0
1	0	1	0	0	0	1	0	1
1	1	0	0	0	0	1	0	1
1	1	1	0	0	0	1	0	1

for T_C



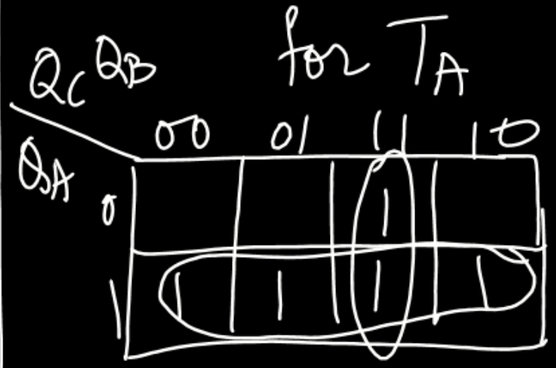
$T_C = Q_C Q_A + \bar{Q}_C Q_B \bar{Q}_A$

for T_B



$T_B = Q_B Q_C + \bar{Q}_C \bar{Q}_A + \bar{Q}_B \bar{Q}_A$

for T_A

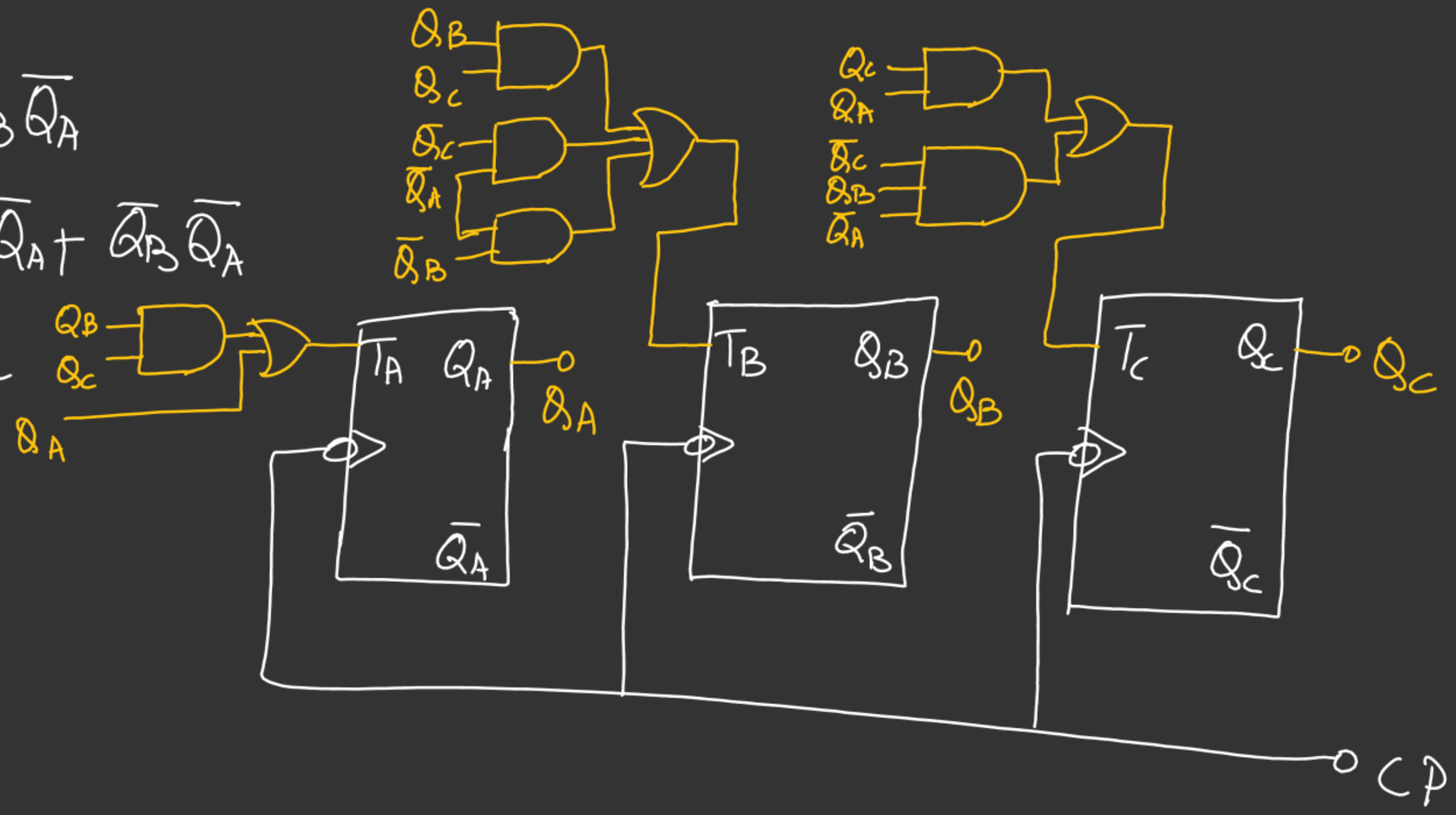


$T_A = Q_A + Q_C Q_B$

$$T_C = Q_C Q_A + \bar{Q}_C Q_B \bar{Q}_A$$

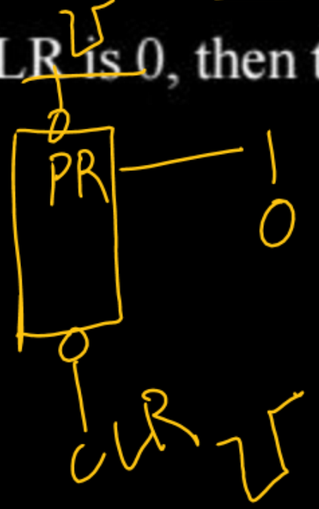
$$T_B = Q_B Q_C + \bar{Q}_C \bar{Q}_A + \bar{Q}_B \bar{Q}_A$$

$$T_A = Q_A + Q_B Q_C$$

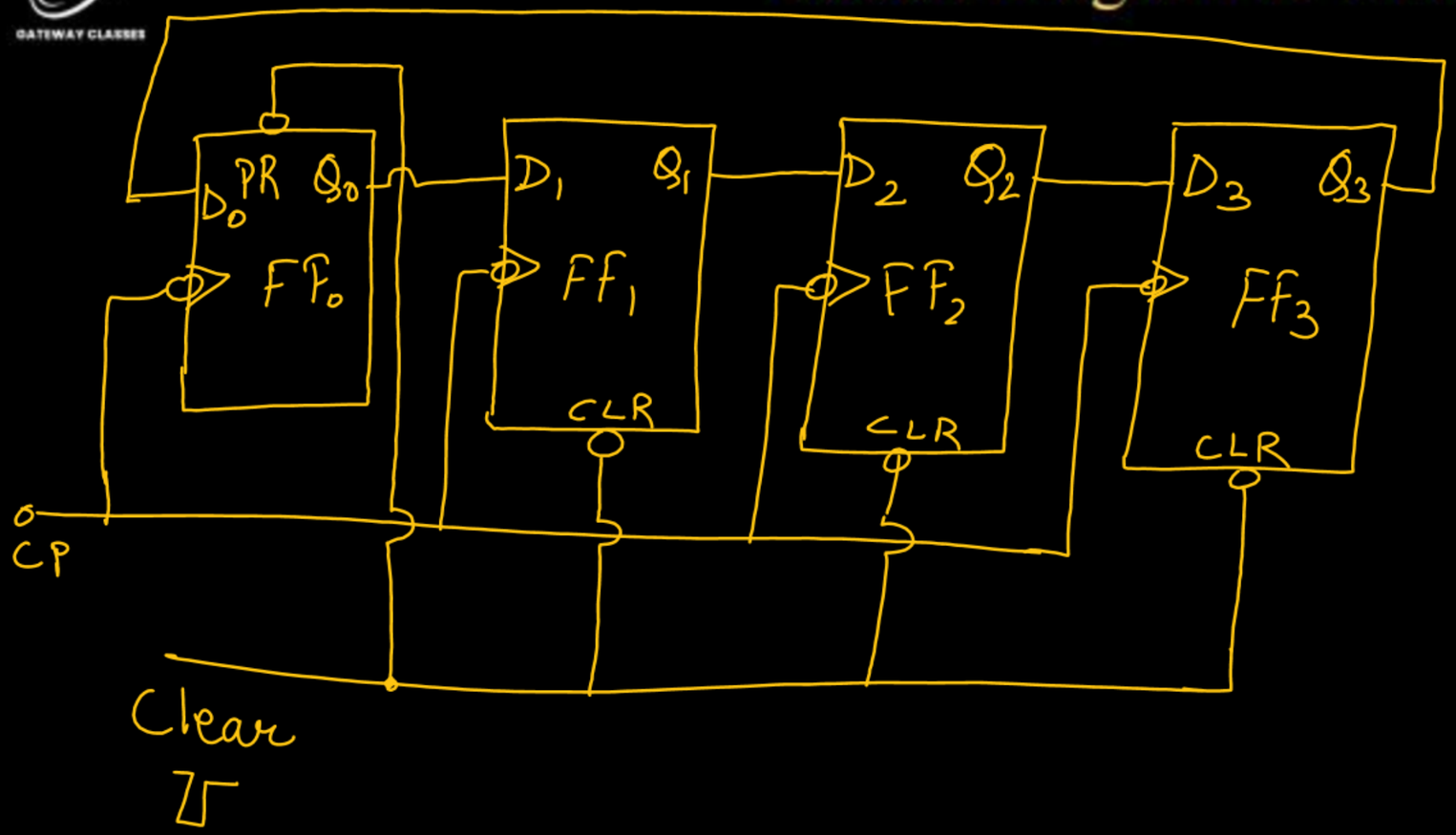


Ring Counters

- A ring counter is a typical application of the Shift register.
- The only change is that the output of the last flip-flop is connected to the input of the first flip-flop in the case of the ring counter but in the case of the shift register it is taken as output.
- No. of states in Ring counter = No. of flip-flop used. So, for designing a 4-bit Ring counter we need 4 flip-flops.
- The clock pulse (CLK) is applied to all the flip-flops simultaneously. Therefore, it is a Synchronous Counter.
- Here we use Overriding input (ORI) for each flip-flop, Preset (PR) and Clear (CLR)
- When PR is 0, then the output is 1. And when CLR is 0, then the output is 0.



Circuit Diagram & Truth Table

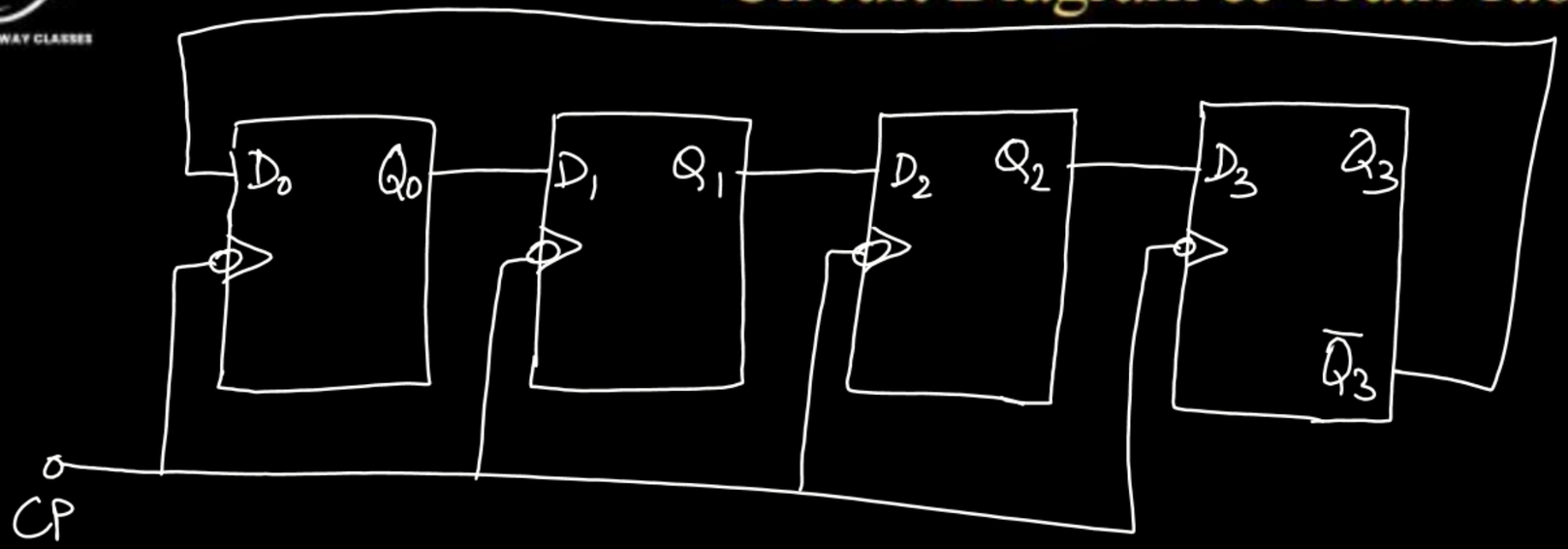


ORI	CLK	Q0	Q1	Q2	Q3
0	X	1	0	0	0
1	↓	0	1	0	0
1	↓	0	0	1	0
1	↓	0	0	0	1
1	↓	1	0	0	0
1					
1					
1					

Johnson Counter

- Johnson counter also known as creeping counter
- It is an example of synchronous counter.
- In Johnson counter, the complemented output of last flip flop is connected to input of first flip flop
- To implement n-bit Johnson counter we require n flip-flop.
- Another name of Johnson counter are:creeping counter, twisted ring counter, walking counter, mobile counter and switch tail counter.
- Total number of used and unused states in n-bit Johnson counter:
  number of used states=2n
  number of unused states=2n – 2*n

Circuit Diagram & Truth Table



	CLK	Q0	Q1	Q2	Q3
1		0	0	0	0
2	↓	1	0	0	0
3	↓	1	1	0	0
4	↓	1	1	1	0
5	↓	1	1	1	1
6	↓	0	1	1	1
7	↓	0	0	1	1
8	↓	0	0	0	1
	↓	0	0	0	0

Advantages, Disadvantages & Applications of Johnson counter:

Advantages of Johnson counter:

The Johnson counter has same number of flip flop but it can count twice the number of states the ring counter can count.

- It can be implemented using D and JK flip flop.
- Johnson ring counter is used to count the data in a continuous loop.
- Johnson counter is a self-decoding circuit.

Disadvantages of Johnson counter:

Johnson counter doesn't count in a binary sequence.

- In Johnson counter more number of states remain unutilized than the number of states being utilized.
- The number of flip flops needed is one half the number of timing signals.
- It can be constructed for any number of timing sequence.

Applications of Johnson counter:

Johnson counter is used as a synchronous decade counter or divider circuit.

- It is used in hardware logic design to create complicated Finite states machine. ex: ASIC and FPGA design.
- The 3 stage Johnson counter is used as a 3 phase square wave generator which produces 1200 phase shift.
- It is used to divide the frequency of the clock signal by varying their feedback.

Flip Flop Conversion

- The main purpose of the flip flop conversion is to convert type- A flip flop into a desired type-B flip flop using some conversion logic.
- The flip flop conversions are classified into different types that are

SR-FF to JK-FF Conversion

JK-FF to SR-FF Conversion

SR-FF to D-FF Conversion

D-FF to SR-FF Conversion

JK-FF to T-FF Conversion

JK-FF to D-FF Conversion

D-FF to JK-FF Conversion

SR-Flip Flop to JK-Flip Flop Conversion

J	K	Qn	Qn+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

for S

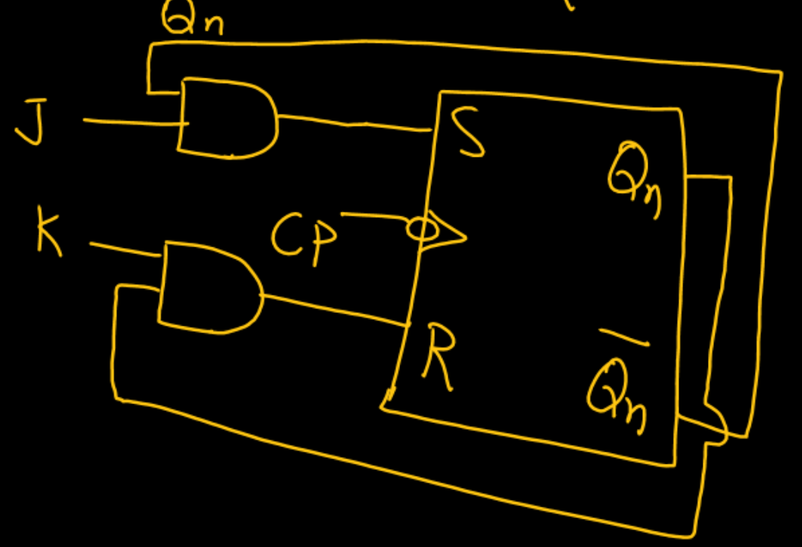
Qn \ JK	00	01	11	10
0			1	1
1	X			X

$S = J\bar{Q}_n$

for R

Qn \ JK	00	01	11	10
0	X	X		
1		1	1	

$R = KQ_n$



D FF using JK FF

D	Q_n	Q_{n+1}	J	K
0	0	0	0	X
0	1	0	X	1
1	0	1	1	X
1	1	1	X	0

for J

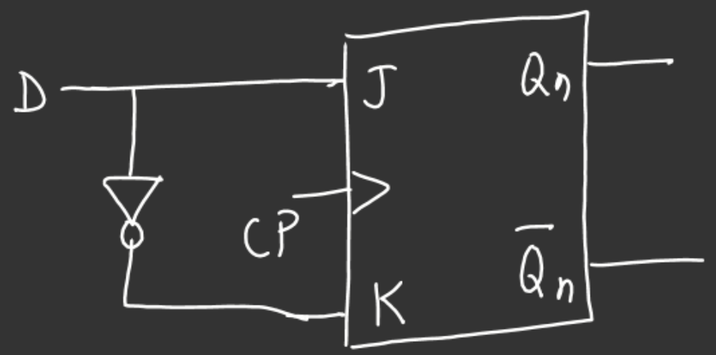


$J = D$

for K



$K = \overline{D}$



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Thank You