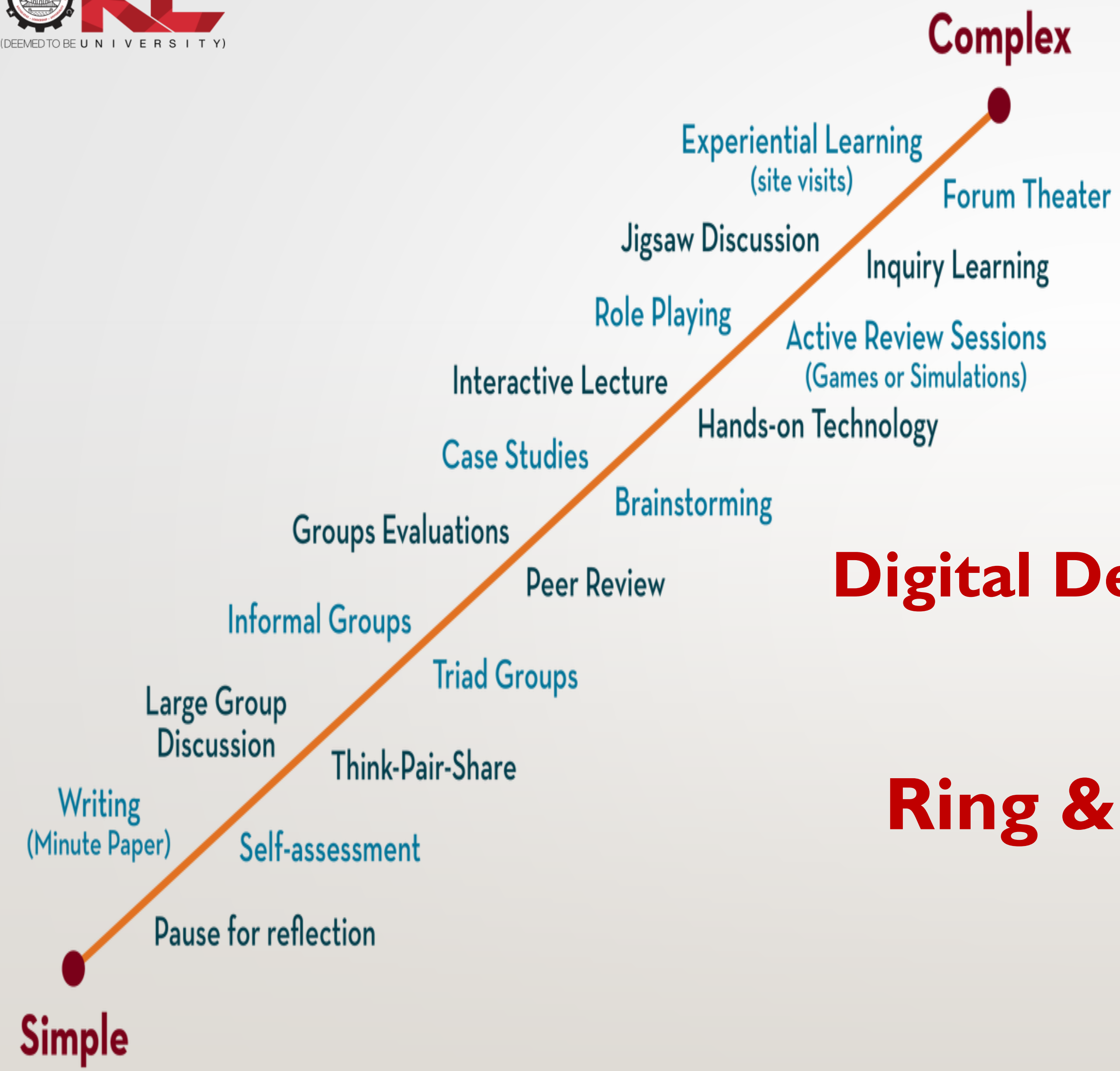


Department of BES-II

Digital Design and Computer Architecture

23EC1202

Topic:

Ring & Johnson Counter as Timing Control Units

Session No: 18 & 19

AIM OF THE SESSION

To familiarize students with the basic concept of Ring counter and Johnson counter

INSTRUCTIONAL OBJECTIVES

This Session is designed to:

1. Demonstrate role of clock pulses in advancing the state in a ring counter
2. Describe how a ring counter produces a binary sequence.
3. Explore the role of feedback in a Johnson counter circuit
4. Explore specific applications such as frequency dividers or LED displays where Johnson counters are beneficial

LEARNING OUTCOMES

At the end of this session, you should be able to:

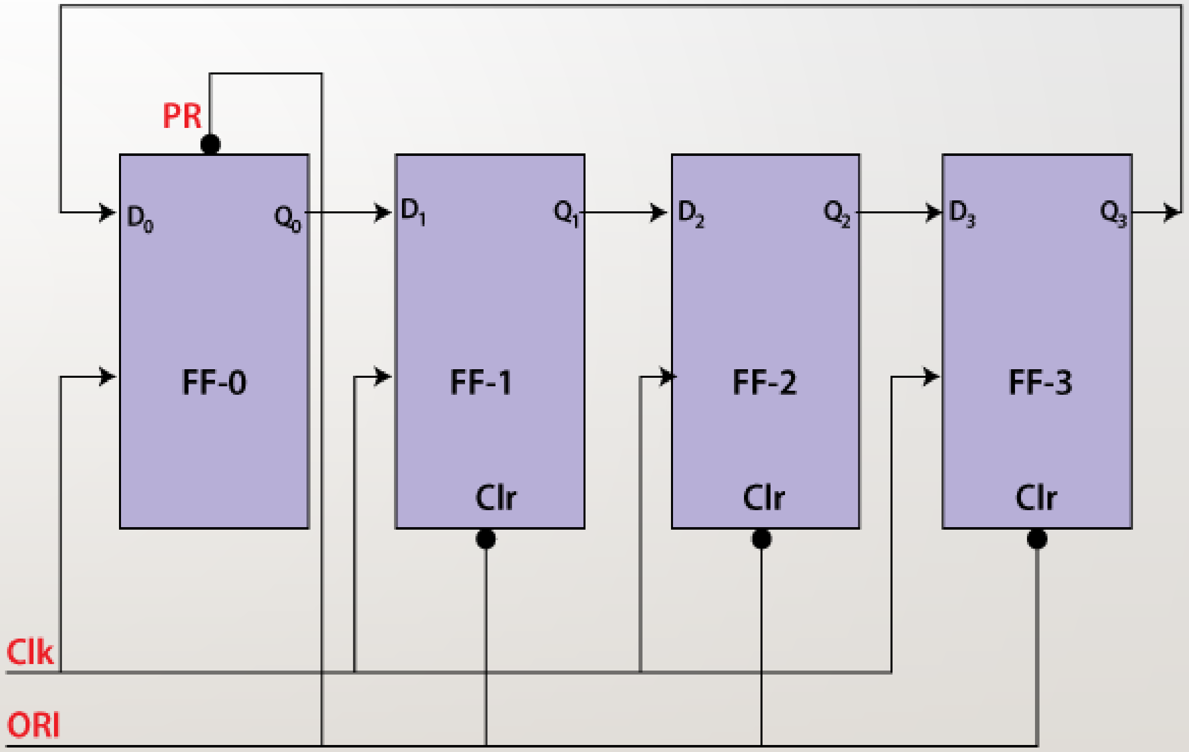
1. understand the concept of ring counter and its role in sequence generation.
2. compare and contrast the sequence generated by a Johnson counter with that of a traditional binary counter.

Ring Counter

- A ring counter is a special type of application of the Serial IN Serial OUT Shift register.
- The only difference between the shift register and the ring counter is that the output of the last flip flop is taken as the output in the shift register.
- But in the ring counter, this outcome is passed to the first flip flop as an input.
- In the Ring counter,
- No. of states in Ring counter = No. of flip-flop used

Ring Counter

- The figure shows the block diagram of a 4-bit ring counter which uses 4 D-flip flops.
- The same clock pulse is applied to the clock input of all the flip flops as a synchronous counter.
- The Overriding Input (ORI) is used as clear and pre-set.
- It is often used during reset or initialization, useful for initializing or resetting the ring counter to a known state.



Ring Counter

- The output is 1 when the pre-set set to 0. The output is 0 when the clear set to 0.
- Both PR and CLR are always active low signals independent of input D and clock (CLK) signals.

PR = 0, Q = 1 ; CLR = 0, Q = 0

Operation of 4-bit ring counter:

- The ORI input is passed to the PR input of the first flip flop, i.e., FF-0, and to the clear input of the remaining three flip flops, i.e., FF-1, FF-2, and FF-3.
- The pre-set input set to 0 for the first flip flop. So, the output of the first flip flop is one, and the outputs of the remaining flip flops are 0. The output of the first flip flop is used to form the ring in the ring counter and referred to as Pre-set 1.

Ring Counter

Truth table:

In the above table, the highlighted 1's are pre-set 1.

The Pre-set 1 is generated when,

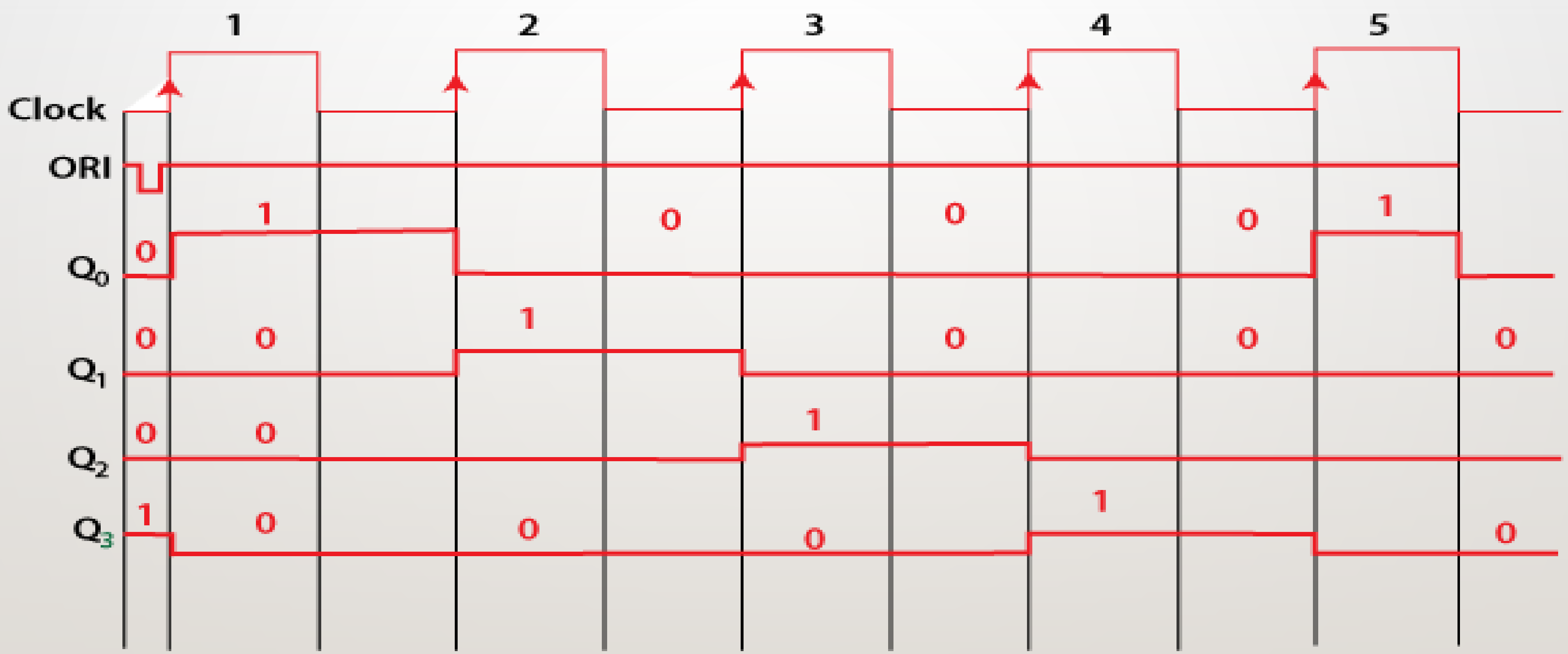
1)ORI input set to low, and that time the Clk is don't care.

2)ORI input set to high Clk signal is applied.

A ring forms when the pre-set 1 is shifted to the next flip-flop at each clock pulse.

ORI	Clk	Q_0	Q_1	Q_2	Q_3
low	X	1	0	0	0
high	high	0	1	0	0
high	high	0	0	1	0
high	high	0	0	0	1
high	high	1	0	0	0

Timing diagram – Ring Counter



Advantages of Ring counter

- Ring counters have a straightforward structure, typically consisting of a circular arrangement of flip-flops.
- It generates a unique pattern of bit states as it cycles through its sequence.
- Ring counters require fewer components compared to other types of counters with similar state counts.

Disadvantages of Ring Counter

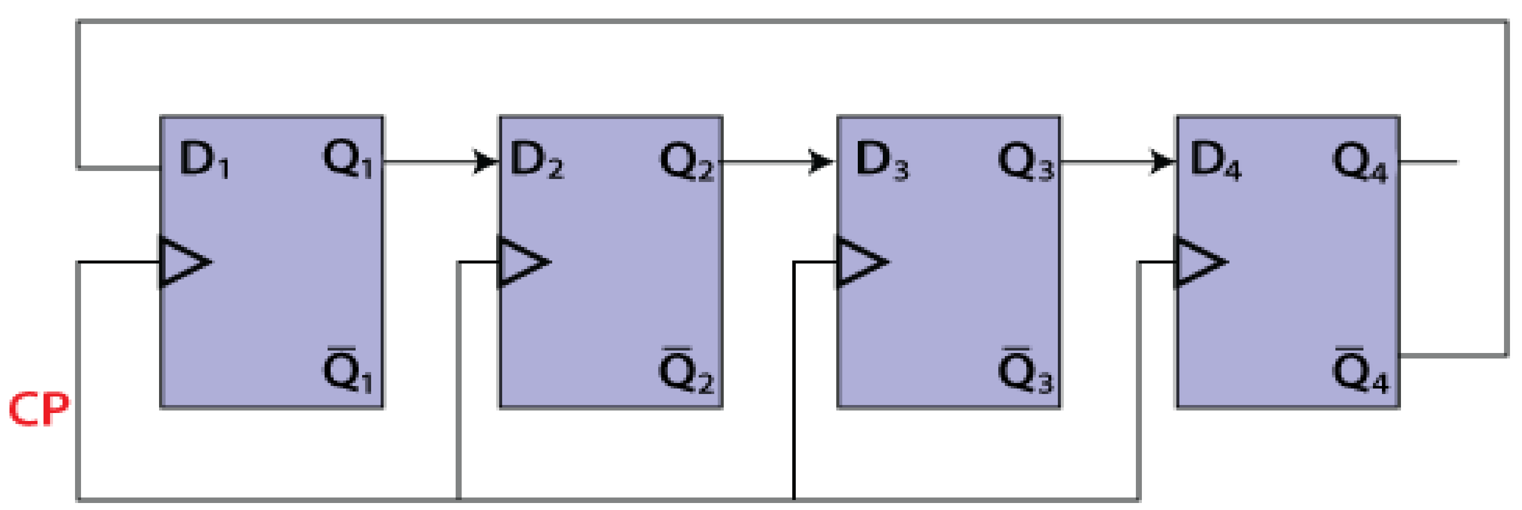
- Ring counters have a limited number of states equal to the number of flip-flops in the ring.
- Propagation delays through each flip-flop in the ring can cause variations in the arrival time of the output signals.
- The output sequence of a ring counter is fixed and may not be easily programmable.
- Building large ring counters with a high number of bits can lead to increased complexity.

Applications of Ring counter

- Frequency prescalers, counters, and dividers for various instruments and systems.
- Accumulator counter elements for decimal arithmetic in computers.
- Finite-state machines that control sequential logic circuits.
- Circular buffers or queues in memory devices.

Johnson Counter

- It is similar to the **Ring counter**.
- The difference is that the inverted outcome Q' of the last flip flop is passed as an input.
- No. of states in Johnson counter = No. of flip-flop used
- Number of used states = $2\,n$; Number of unused states = $2^{n}\ - 2\,n$



Johnson Counter

Truth table:

CP	Q1	Q2	Q3	Q4
0	0	0	0	0
1	1	0	0	0
2	1	1	0	0
3	1	1	1	0
4	1	1	1	1
5	0	1	1	1
6	0	0	1	1
7	0	0	0	1
8	0	0	0	0

Advantages of Johnson counter

- The number of flip flops in the Johnson counter is equal to the number of flip flops in the ring counter, and the Johnson counter counts twice the number of states the ring counter can count.
- The Johnson counter can also be designed by using D or JK flip flop.
- The data is count in a continuous loop in the Johnson ring counter.
- The circuit of the Johnson counter is self-decoding.

Disadvantages of Johnson counter

- The Johnson counter is not able to count the states in a binary sequence.
- In the Johnson counter, the unutilized states are greater than the states being utilized.
- The number of flip flops is equal to one half of the number of timing signals.
- It is possible to design the Johnson counter for any number of timing sequences.

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.

SUMMARY

- The ring counters and Johnson counters are digital circuits that generate sequences of states.
- But, they differ in the nature of the sequence they produce and the feedback mechanisms involved in their operation.
- Ring counters produce a straightforward binary sequence, while Johnson counters generate a more controlled Gray code sequence.

SELF-ASSESSMENT QUESTIONS

1. How many flip-flops are required for an n-bit Ring Counter?

(a) n
(b) n-1
(c) 2n
(d) 2n-1

2. How many distinct states are possible in a 4-bit Ring Counter?

(a) 4
(b) 8
(c) 16
(d) 32

SELF-ASSESSMENT QUESTIONS

3. How many flip-flops are required for an n-bit johnson Counter?

(a) n
(b) n-1
(c) 2n
(d) 2n-1

4. What is the characteristic feature of a Johnson counter?

(a) Bidirectional shift
(b) Counting in binary
(c) Decrementing sequence
(d) Parallel loading

TERMINAL QUESTIONS

Short answer questions:

1. List out the applications of Johnson counter.
2. Specify the advantages of Johnson & Ring counter.

Long answer questions:

1. Design a 4-bit Ring Counter using D-flip flops and describe it's working.
2. Design 4-Johnson counter using D-flip-flops and describe it's working.
3. Model the functioning of a 4-bit Johnson counter using D Flip-flops using truth table.

REFERENCES FOR FURTHER LEARNING OF THE SESSION

Reference Books:

1. Computer System Architecture by M. Moris Mano
2. Fundamentals of Digital Logic with Verilog HDL by Stephen Brown and ZvonkoVranesic

Sites and Web links:

1. https://www.javatpoint.com/johnson-counter-in-digital-electronics
2. https://www.geeksforgeeks.org/ring-counter-in-digital-logic/

THANK YOU

(DEEMED TO BE UNIVERSITY)

Team – Digital Design & Computer Architecture