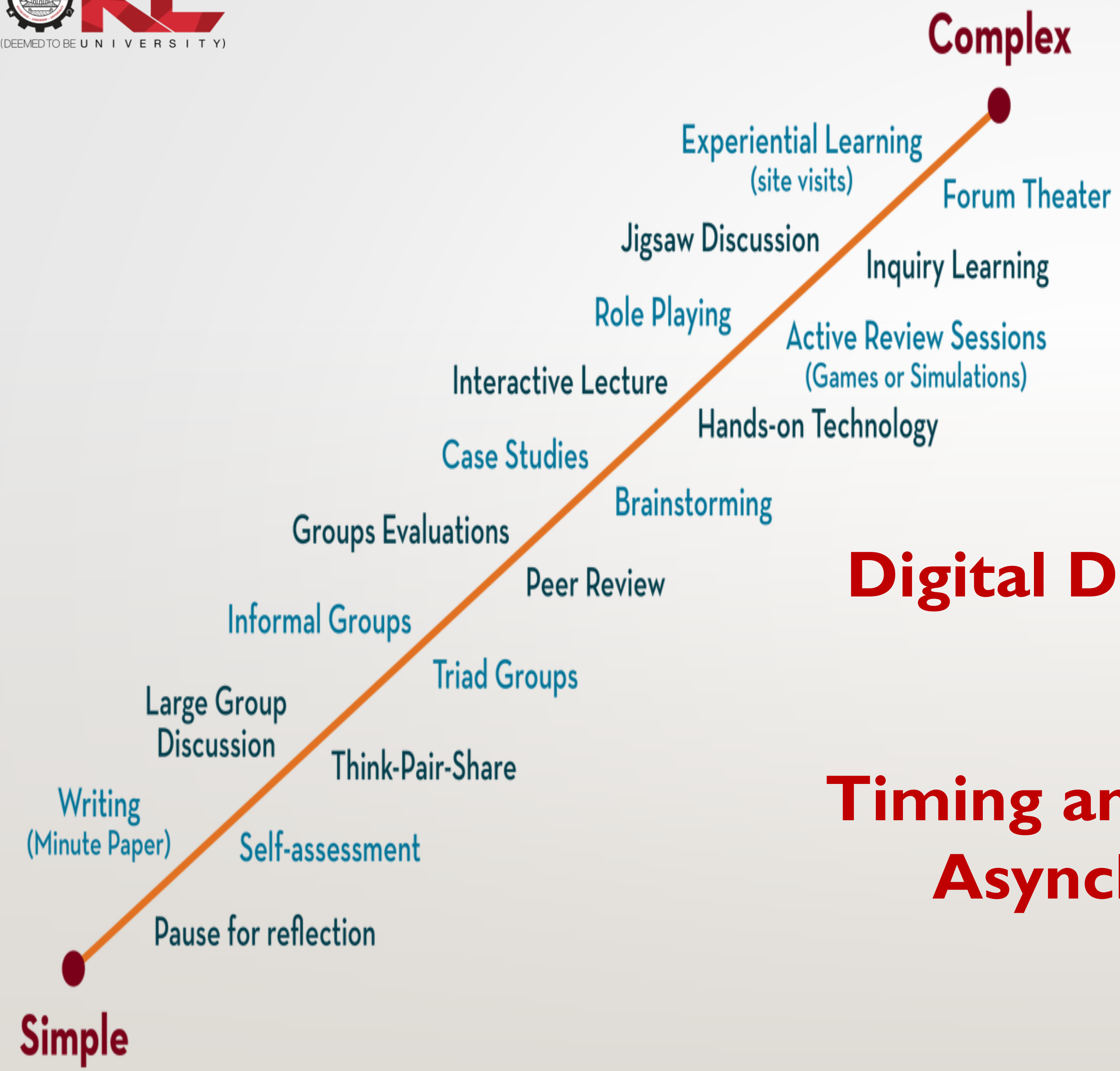


Department of BES-II

Digital Design and Computer Architecture
23EC1202

Topic:

Timing and sequence control modules using Asynchronous/Synchronous counters

Session No:16 & 17

AIM OF THE SESSION

To familiarize students with the basic concept of Synchronous and asynchronous counters.

INSTRUCTIONAL OBJECTIVES

This Session is designed to:

1. Demonstrate about the digital counters
2. Describe the working of different counters with example
3. List out the different counters based the input we are giving
4. Compare synchronous and asynchronous counters in all aspects

LEARNING OUTCOMES

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

1. Define digital counter.
2. Describe working principle of counters.
3. Summarize different types and limitations of the counters.

Digital Counter

- A digital counter is a set of flip-flops whose states change in response to pulses applied at the input.
- Counters are commonly used to generate binary numbers in a systematic manner, either incrementing or decrementing based on the application's requirements, which can be used to count pulses.
- Counters play a crucial role in digital systems for tasks like frequency division, timekeeping, addressing memory locations, and controlling the sequencing of operations.

Modulus of the Counter

- The number of states through which the counter passes before returning to the starting state is called the modulus of the counter.
- Hence, the modulus of a counter is equal to the total number of distinct states including zero that a counter can store.
- A counter may have a shortened modulus. This type of counter does not utilize all the possible states.
- The condition to determine the number of flip-flops is $\mathrm{MOD\ number\ N} \leq 2^{n}$

Synchronous Vs Asynchronous Counters

Synchronous counter	Asynchronous counter
No connection between output of first flip-flop and clock input of next flip-flop.	Output of first flip-flop drives the clock for the next flip-flop.
All the flip-flops are clocked simultaneously.	All the flip-flops are not clocked simultaneously.
Design involves complex logic circuit as number of states increases.	Logic circuit is simple even for more number of states.
As the clock is simultaneously given to all flip-flops there is no problem of propagation delay.	Main drawback is their low speed as the clock is propagated through number of flip-flops before it reaches last flip-flop.

Mod 8 Ripple (Asynchronous) Counter

- In ripple counter, the flip-flops within the counter are not made to change the states at exactly the same time, i.e., they are not clocked simultaneously.

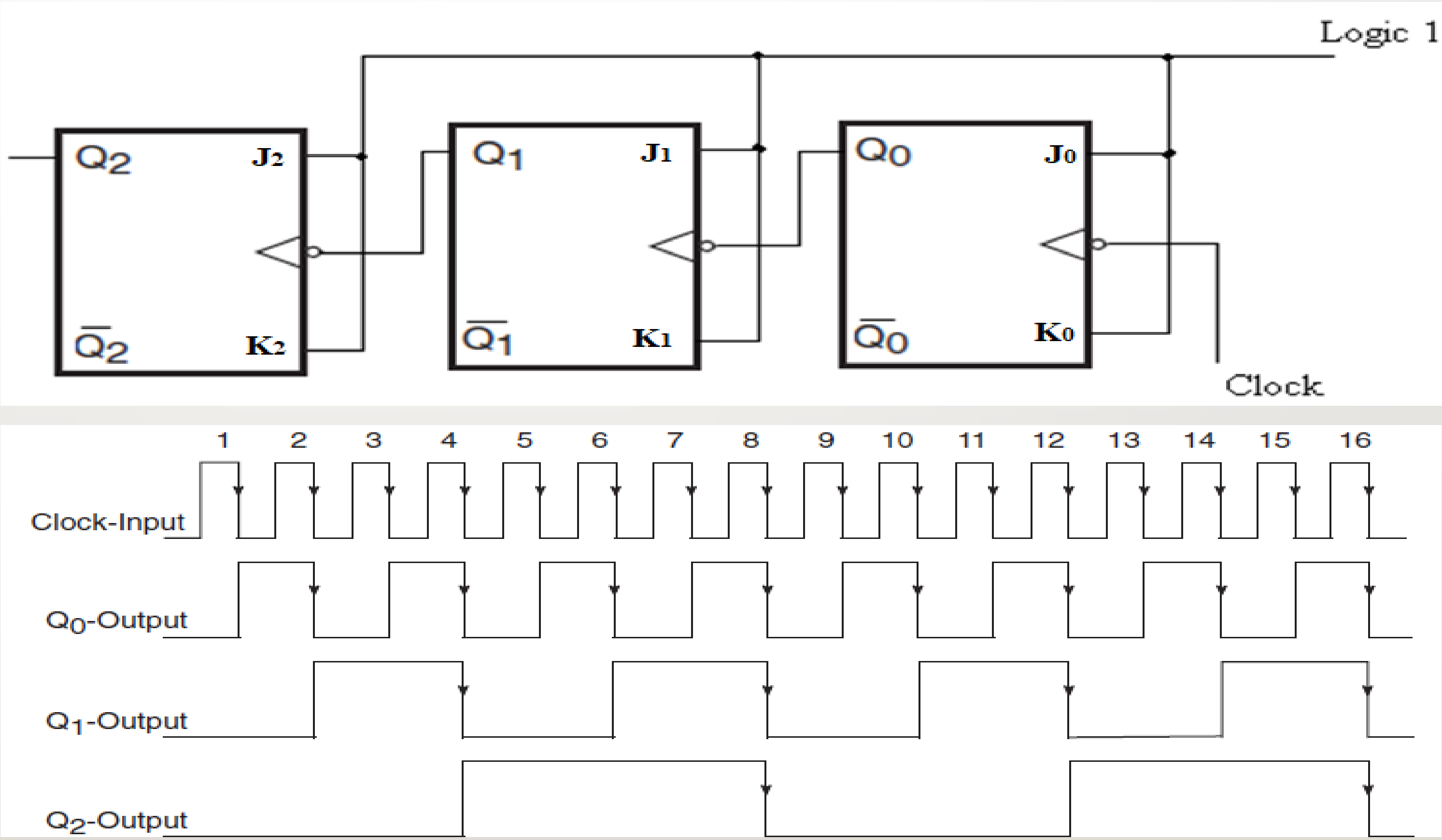
- In a ripple counter, also called an asynchronous counter or a serial counter, the clock input is applied only to the first flip-flop, also called the input flip-flop, in the cascaded arrangement.

- The clock input to any subsequent flip-flop comes from the output of its immediately preceding flip-flop.

Mod 8 Ripple (Asynchronous) Counter

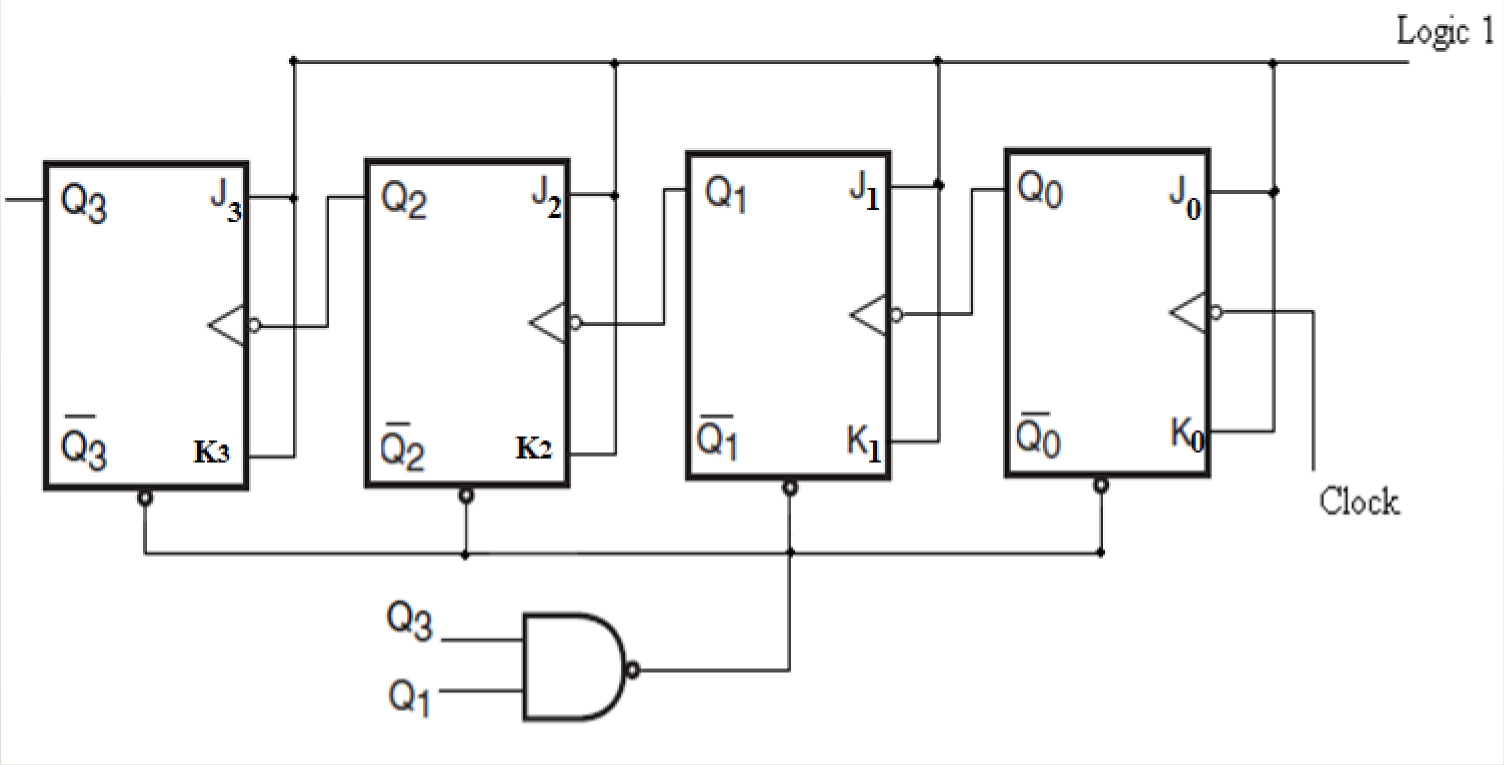
Since the modulus or mod

Q_2	Q_1	Q_0
0	0	0
0	0	1
0	1	0
0	1	1
1	0	0
1	0	1
1	1	0
1	1	1



Example

Design a BCD Ripple counter using JK flip-flops.



Q_3	Q_2	Q_1	Q_0
0	0	0	0
0	0	0	1
0	0	1	0
0	0	1	1
0	1	0	0
0	1	0	1
0	1	1	0
0	1	1	1
1	0	0	0
1	0	0	1

Synchronous Counter

- In a synchronous counter, also known as a parallel counter, all the flip-flops in the counter change state at the same time in synchronism with the input clock signal.

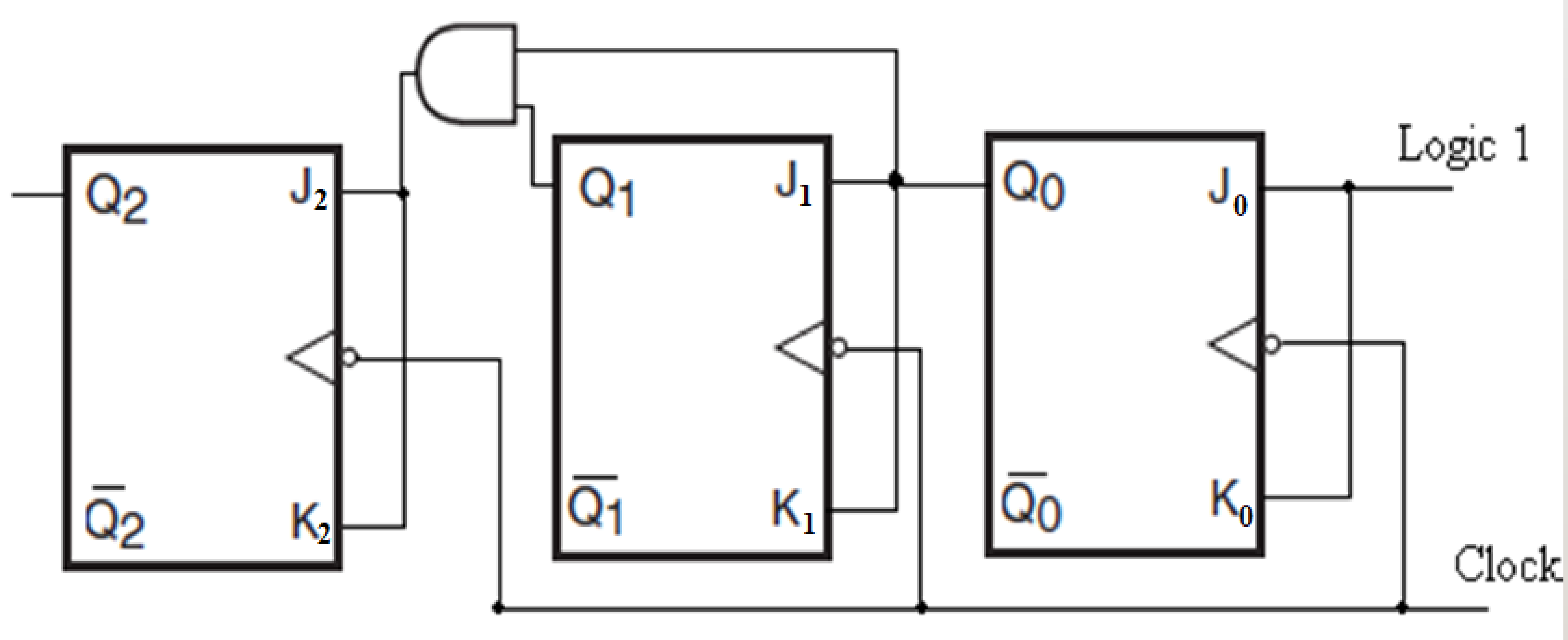
- The clock signal in this case is simultaneously applied to the clock inputs of all the flip-flops.

- The delay involved in this case is equal to the propagation delay of one flip-flop only, irrespective of the number of flip-flops used to construct the counter.

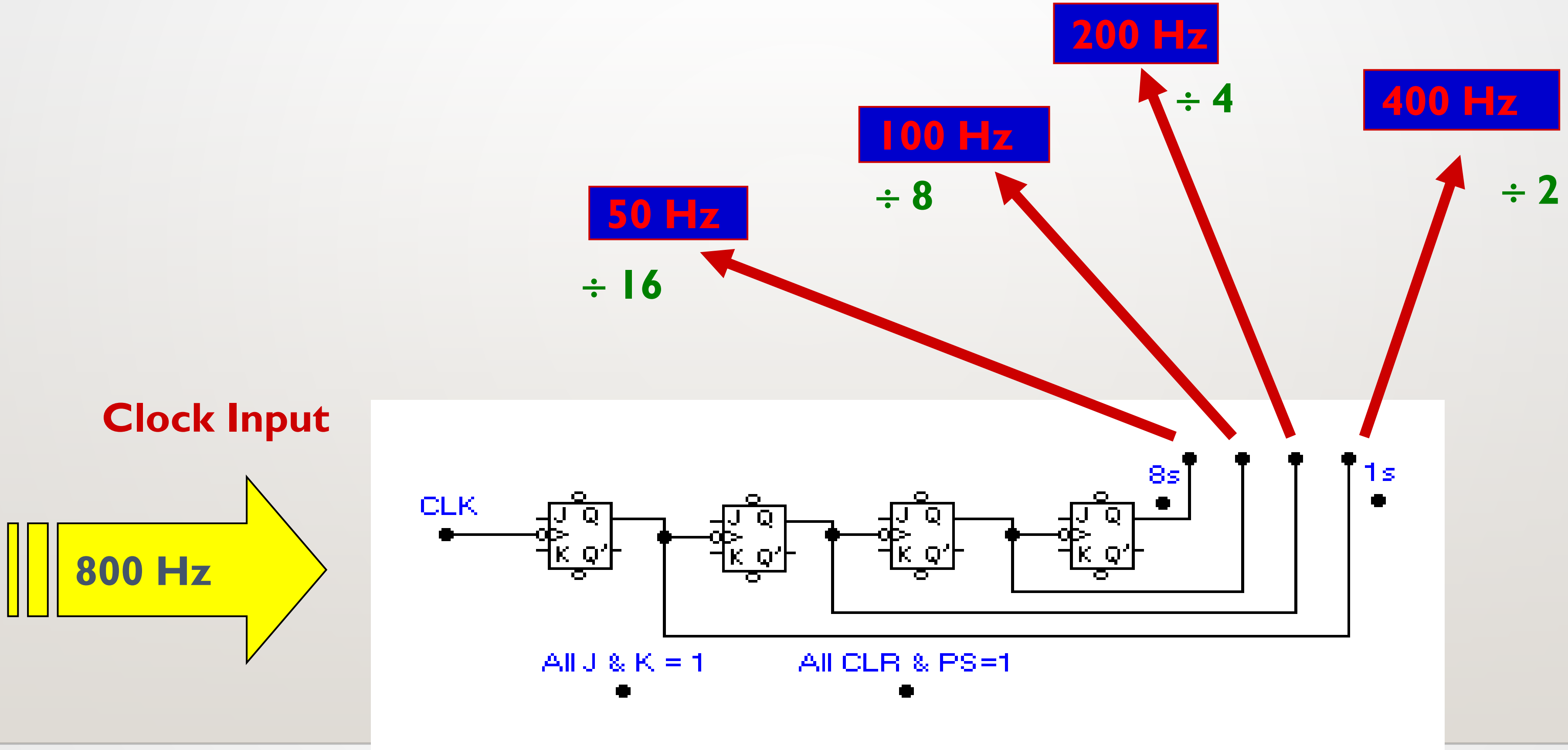
3-bit Synchronous counter or MOD 8 Counter

Q_2	Q_1	Q_0
0	0	0
0	0	1
0	1	0
0	1	1
1	0	0
1	0	1
1	1	0
1	1	1

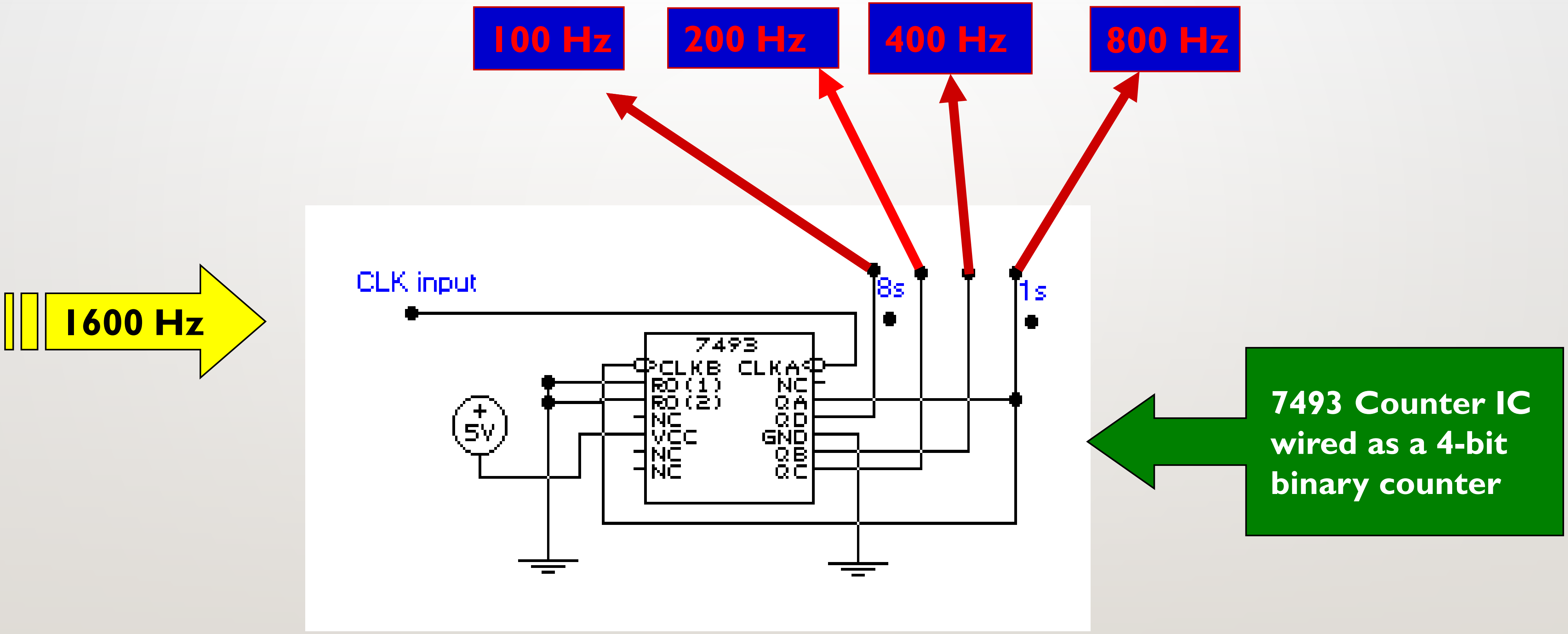
FLIP-FLOP INPUTS: $J_2 = K_2 = Q_1.Q_0$ $J_1 = K_1 = Q_0$ $J_0 = K_0 = 1$



APPLICATION: COUNTER USED FOR FREQUENCY DIVISION



APPLICATION: IC7493 as 4-bit binary counter



Advantages of Synchronous counters

- Synchronous counters are easier to design.
- With all clock inputs wired together there is no inherent propagation delay.
- Overall faster operation may be achieved compared to Asynchronous counters.

SUMMARY

- Synchronous Counters can be made from Toggle or D-type flip-flops.
- They are called synchronous counters because the clock input of the flip-flops are clocked with the same clock signal.
- Due to the same clock pulse all outputs change simultaneously.
- Synchronous counters are also called parallel counters as the clock is fed in parallel to all flip-flops.
- Synchronous binary counters use both sequential and combinational logic elements.
- The memory section keeps track of the present state.
- The sequence of the count is controlled by combinational logic.

SELF-ASSESSMENT QUESTIONS

1. In which flipflop the output serves as a source for triggering other flipflops

(a) shift register
(b) Ripple counter
(c) Ring counter
(d) Serial adder

2. In which one of the following counters, the flip flops are not clocked simultaneously?

(a) Synchronous counter
(b) Asynchronous counter
(c) Shift register
(d) none

TERMINAL QUESTIONS

Short answer questions:

1. Specify the importance of modulus of a counter in digital circuits using an equation.
2. Analyze the differences between synchronous and asynchronous counters.

Long answer questions:

1. Interpret the functioning of a BCD ripple counter using JK Flip-flops using truth table.
2. Design a MOD-8 ripple counter using JK Flip-flops and describe its functionality.
3. Develop 3-bit synchronous counter using JK Flip-flops with 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.geeksforgeeks.org/differences-between-synchronous-and-asynchronous-counter/
2. https://www.tutorialspoint.com/difference-between-synchronous-and-asynchronous-counter

THANK YOU

(DEEMED TO BE UNIVERSITY)

Team – Digital Design & Computer Architecture