SNS COLLEGE OF TECHNOLOGY

Coimbatore-35
An Autonomous Institution

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Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

19ECB231 – DIGITAL ELECTRONICS

II YEAR/ III SEMESTER

1

UNIT 3 –SEQUENTIAL CIRCUITS

TOPIC 4. - Design of Synchronous Sequential circuits : Up/Down counter

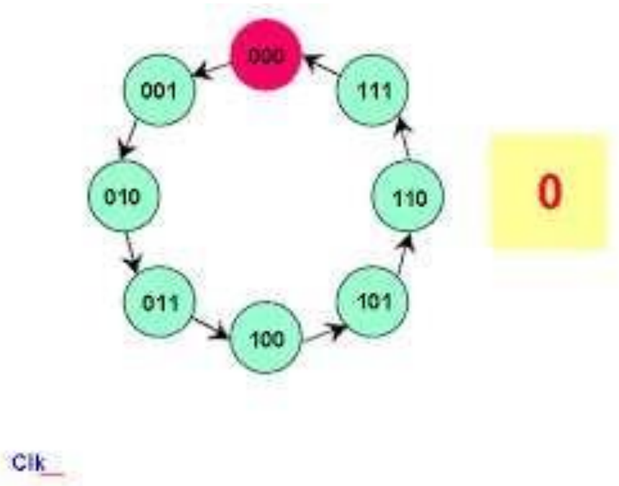
What is a Counter?

- A digital circuit which is used for a counting pulses is known as counter.
- Counter is the widest application of flip-flops.
- It is a group of flip-flops with a clock signal applied.

Types of counters

Two Types

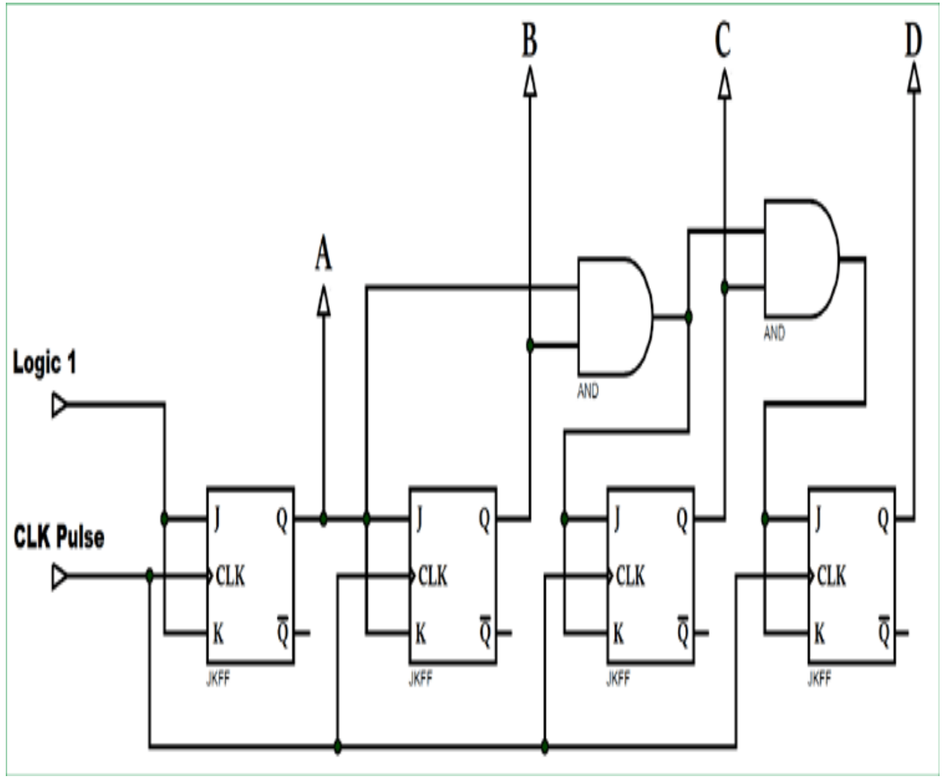
1. Asynchronous Counter or Ripple Counter.
2. Synchronous Counter



Synchronous Counter

➢**In synchronous counter**, the clock input across all the flip-flops use the same source and create the same clock signal at the same time.

➢A counter which is using the same clock signal from the same source at the same time is called **Synchronous counter**.

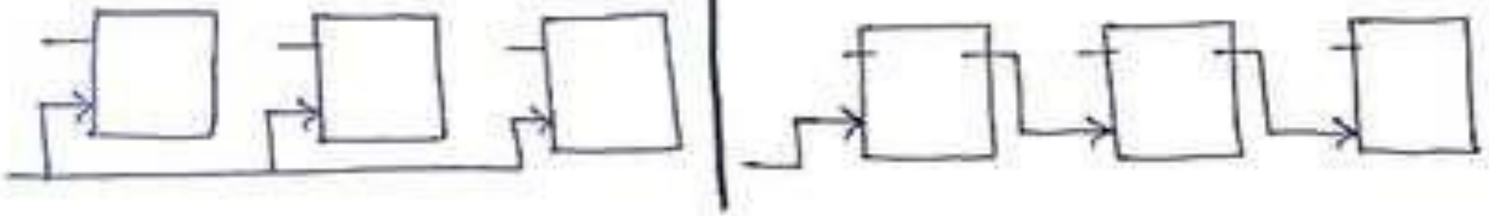


Asynchronous Counter

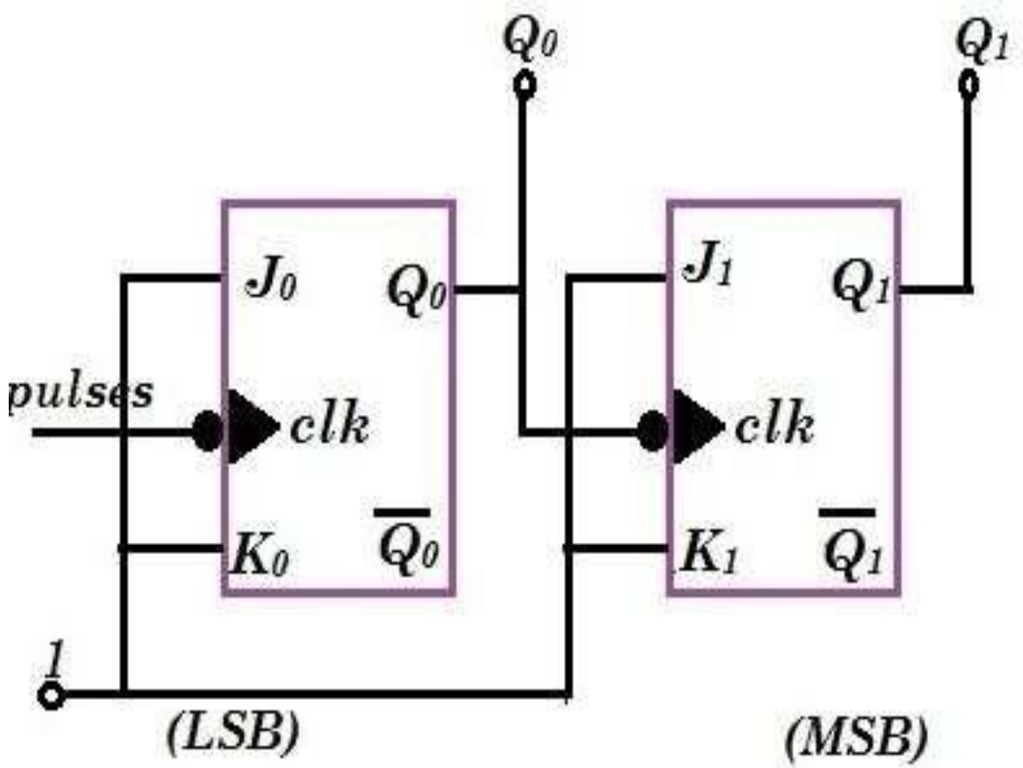
- Depending upon the manner in which the flip-flop are triggered, counters can be divided into two major categories.
  1) Asynchronous counter (Ripple/series counter).
  ii) Synchronous counter (parallel counter).

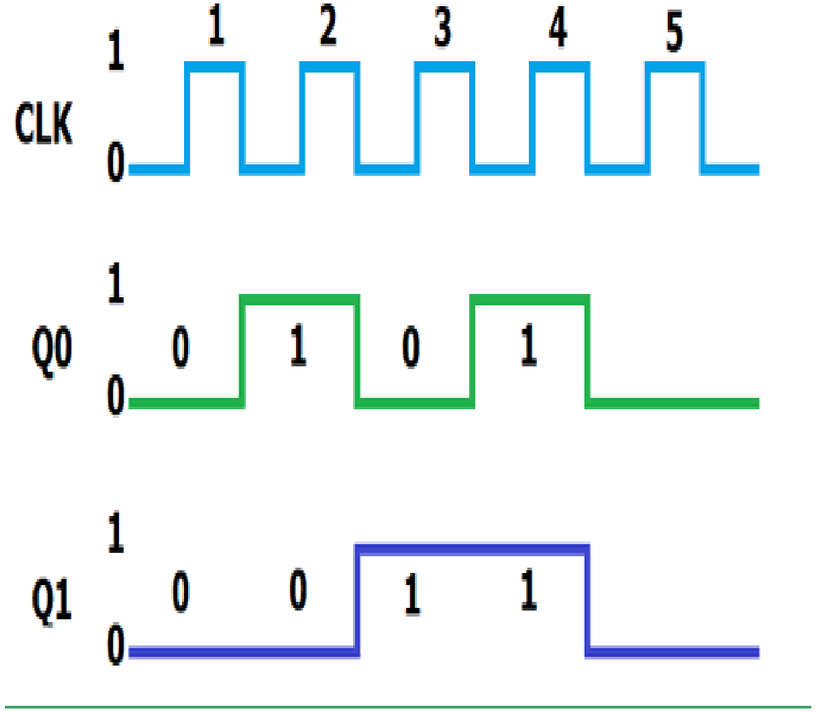
The comparison between synchronous and Asynchronous counter.

Synchronous	Asynchronous
→ use system clock to trigger all f-f.	→ output of one used as a clock in the next F-F.



2-bit Asynchronous Counter



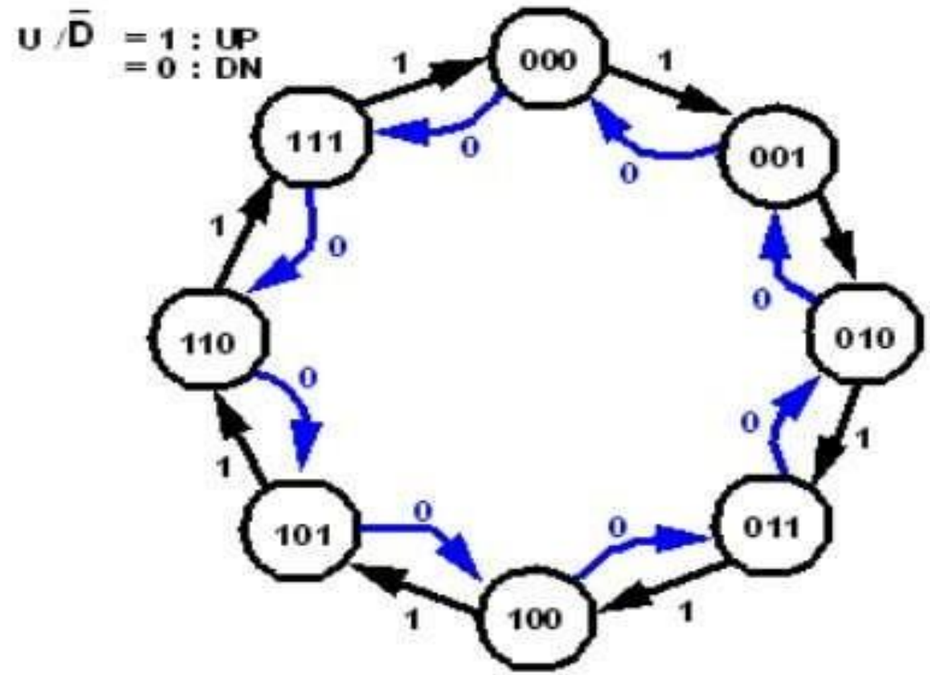


Synchronous Counter	Asynchronous Counter
All flip flops are triggered with same clock.	Different clock is applied to different flip flops.
It is faster.	It is lower
Design is complex.	I Design is relatively easy.
Decoding errors not present.	Decoding errors present.
Any required sequence can be designed	Only fixed sequence can be designed.

3-bit Synchronous Up/Down Counter

Up/Down Counters

- A 3-bit binary up/down counter (State diagram)



26

3-bit Synchronous Down Counter

State Table

CP	UP	Q_C	Q_B	Q_A	DOWN
0		0	0	0	
1		0	0	1	
2		0	1	0	
3		0	1	1	
4		1	0	0	
5		1	0	1	
6		1	1	0	
7		1	1	1	

3-bit Synchronous Down Counter

Excitation table

Input	Present State			Next State			Flip-flop Inputs		
UP/DOWN (UD)	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	1	1	1	1	1
0	0	0	1	0	0	0	0	0	1
0	0	1	0	0	0	1	0	1	1
0	0	1	1	0	1	0	0	0	1
0	1	0	0	0	1	1	1	1	1
0	1	0	1	1	0	0	0	0	1
0	1	1	0	1	0	1	0	1	1
0	1	1	1	1	1	0	0	0	1
1	0	0	0	0	0	1	0	0	1
1	0	0	1	0	1	0	0	1	1
1	0	1	0	0	1	1	0	0	1
1	0	1	1	1	0	0	1	1	1
1	1	0	0	1	0	1	0	0	1
1	1	0	1	1	1	0	0	1	1
1	1	1	0	1	1	1	0	0	1
1	1	1	1	0	0	0	1	1	1

3-bit Synchronous Down Counter

K-map simplification

For T_C

UD Q_C \ Q_BQ_A	00	01	11	10
00	1	0	0	0
01	1	0	0	0
11	0	0	1	0
10	0	0	1	0

$T_C = \overline{UD}\ \overline{Q}_B\ \overline{Q}_A + UD\ Q_B\ Q_A$

For T_B

UD Q_C \ Q_BQ_A	00	01	11	10
00	1	0	0	1
01	1	0	0	1
11	0	1	1	0
10	0	1	1	0

$T_B = \overline{UD}\ \overline{Q}_A + UD\ Q_A$

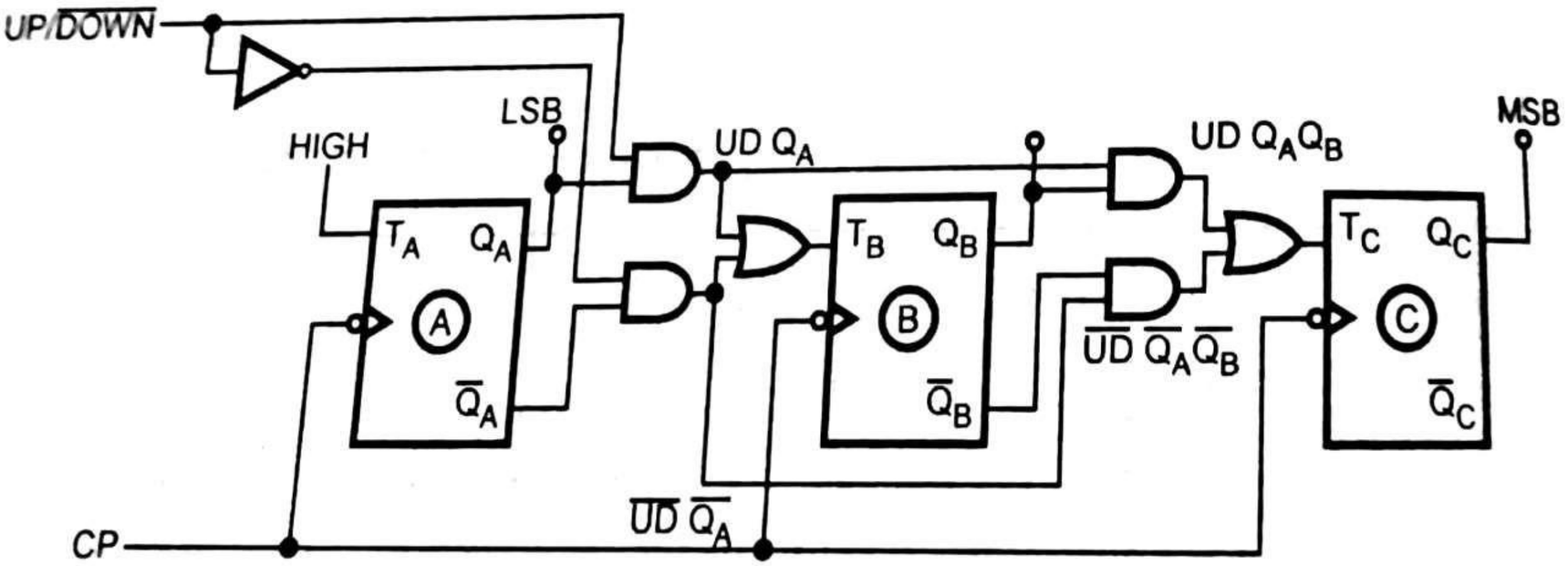
For T_A

UD Q_C \ Q_BQ_A	00	01	11	10
00	1	1	1	1
01	1	1	1	1
11	1	1	1	1
10	1	1	1	1

$T_A = 1$

3-bit Synchronous Down Counter

Logic Diagram

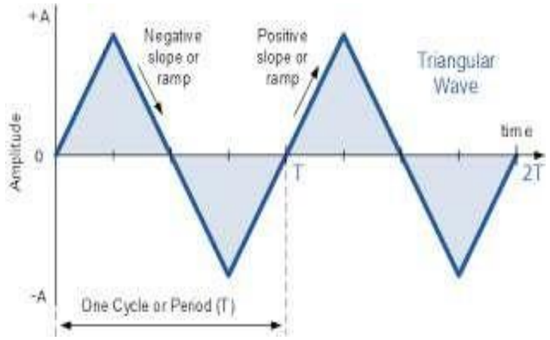


Applications of Counters

Frequency counters

Digital clocks

Digital triangular wave generator



Application for counter

- Frequency counters
- Digital clock
- Time measurement
- A to D converter
- Frequency divider circuits

13

ASSESSMENTS

1. How many natural states will there be in a 4-bit ripple counter?
   a) 4
   b) 8
   c) 16
   d) 32
2. A ripple counter's speed is limited by the propagation delay of _____
   a) Each flip-flop
   b) All flip-flops and gates
   c) The flip-flops only with gates
   d) Only circuit gates.
3. Internal propagation delay of asynchronous counter is removed by _____
   a) Ripple counter
   b) Ring counter
   c) Modulus counter
   d) Synchronous counter

ASSESSMENTS

4. An asynchronous 4-bit binary down counter changes from count 2 to count 3. How many transitional states are required?

a) 1

b) 2

c) 8

d) 15

5. A ripple counter's speed is limited by the propagation delay of

_____

a) Each flip-flop

b) All flip-flops and gates

c) The flip-flops only with gates

d) Only circuit gates

THANK YOU