Chapter 6

REGISTERS & COUNTERS

Design of Counters:

❑**Counter:**

A sequential circuit that goes through a prescribed sequence of states upon the application of input pulses is called a counter.

✓Counter circuits serve many purposes:

- Used for counting the number of occurrences of an event
- For generating timing sequences to control operations in a digital system
- Track elapsed time between events

✓A counter that follows the binary sequence is called a **binary counter.**

✓ An n-bit binary counter consists of n flip flops and can count in binary from **0 to 2^n-1**

Categories of counters

1. **Synchronous counters:**

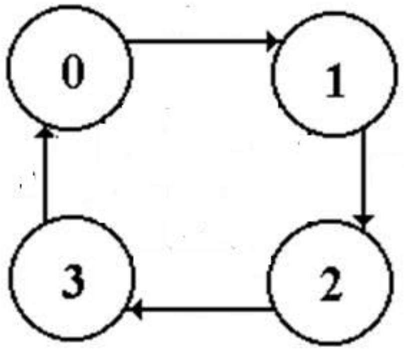
   - flip-flops receive the same common clock as *the* pulse

2. **Asynchronous counters (Ripple counters):**

   - The flip-flops within the counter do not change state at the same time. The flip-flop output transition serves as a source for triggering other flip-flop.

Example: Design a 2 bit synchronous binary counter.

- Solution:



State diagram

State Table

Present state		Next State	
Q2	Q1	Q2	Q1
0	0	0	1
0	1	1	0
1	0	1	1
1	1	0	0

Excitation Map

Present state		Next State		FF's input			
Q2	Q1	Q2	Q1	J2	K2	J1	K1
0	0	0	1	0	X	1	X
0	1	1	0	1	X	X	1
1	0	1	1	X	0	1	X
1	1	0	0	X	1	X	1

	Q1′	Q1
Q2′	0	1
Q2	X	X

J2= Q1

	Q1′	Q1
Q2′	X	X
Q2	0	1

K2= Q1

	Q1′	Q1
Q2′	1	X
Q2	1	X

J1=1

	Q1′	Q1
Q2′	X	1
Q2	X	1

K1= 1

FFs input equations

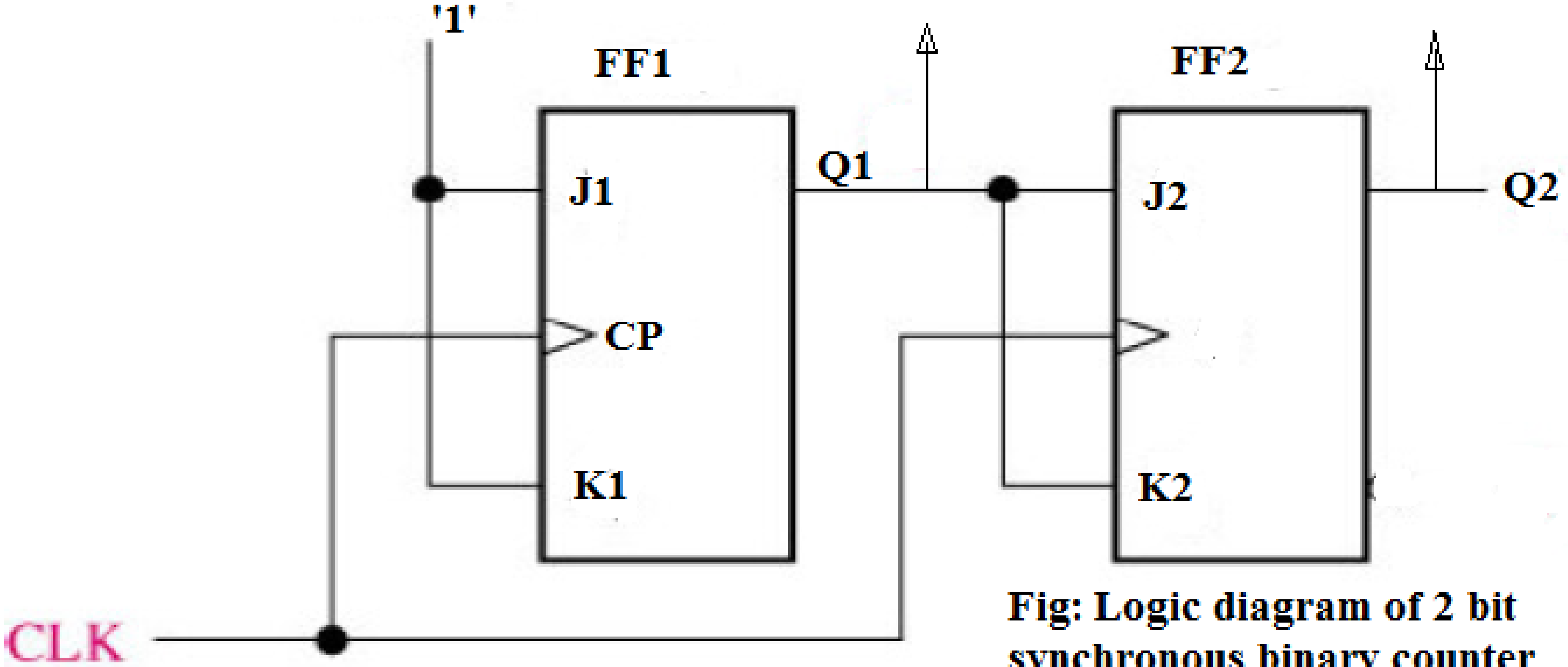


Fig: Logic diagram of 2 bit synchronous binary counter

Exercises

- Design a 3 bit synchronous binary counter using T flip flops.
- Design a 3 bit prime counter.
- Design a counter with the following repeated binary sequence: 0,1,2,4,6 using D flip flops.
- Design a counter with the following repeated binary sequence: 0,2,4,6,8 using D flip flops.

Ripple/Asynchronous counters

- In a ripple counter, the flip flop output transition serves as a source for triggering other flip flops. In other words, the clock pulse input of all flip flops (except the first) are triggered not by the incoming pulses but rather by the transition that occurs in other flip flops.
- Slower due to waiting for the ripple.
- Good for low power, low speed applications.

Binary Ripple Counter

- A binary ripple counter consists of a series connection of complementing flip flops, with the output of each flip flop connected to the clock pulse (CP) input of the next higher order flip flop. The flip flop holding the least significant bit receives the incoming count pulse.
- Example:

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

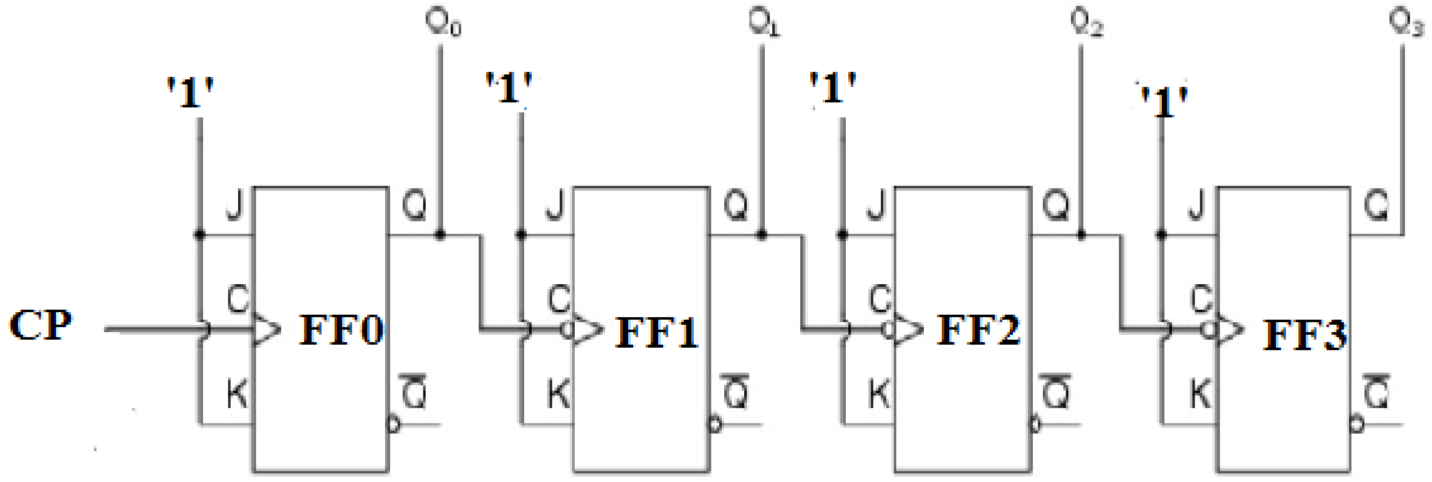
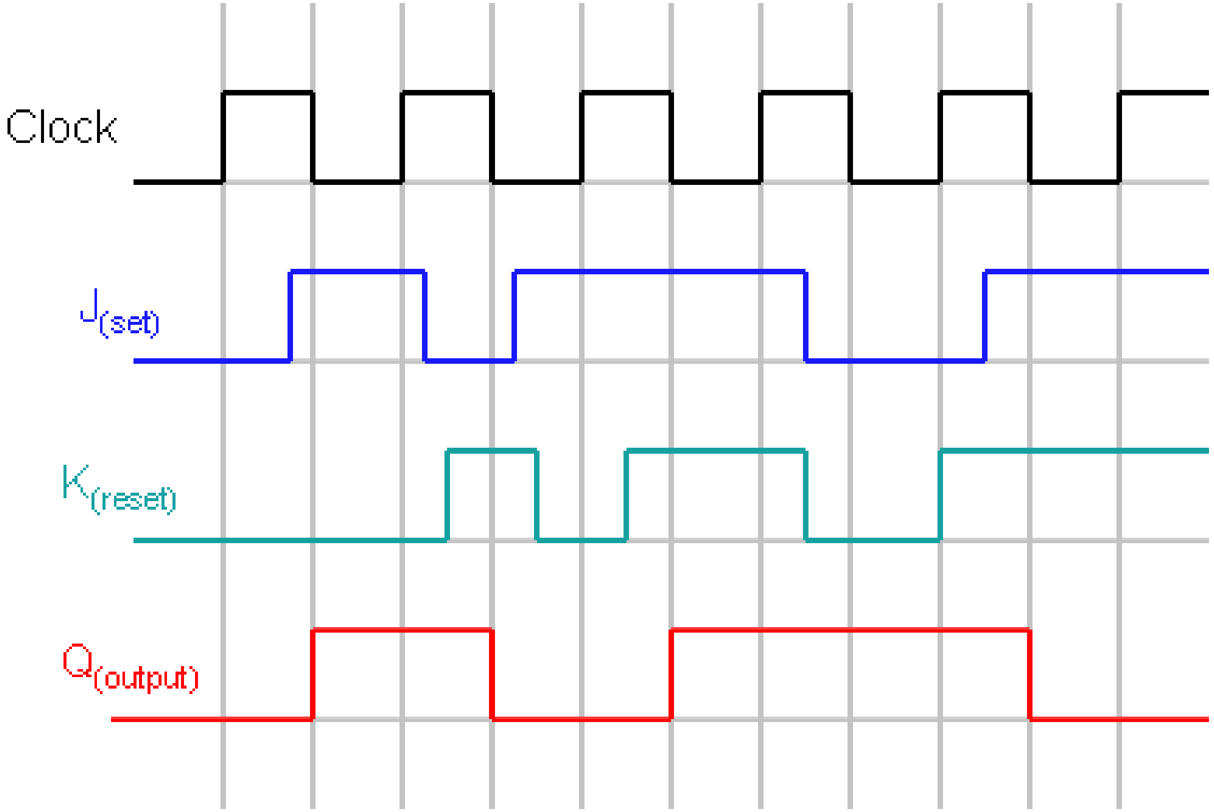


Fig: 4 bit binary ripple counter

Timing Diagram

- Determine the output wave form (Q) for the following J,K inputs of a negative edge triggered JK flip flop.

J	K	$Q_{(t+1)}$	
0	0	$Q_{(t)}$	*unchanged*
0	1	0	*reset*
1	0	1	*set*
1	1	$\overline{Q}_{(t)}$	*output inversion* *[Toggle]*



Timing diagram of 2 bit binary ripple counter