4.32.1. Shift Register Counters

It is defined as "shift registers with the serial outputs connected back to the serial inputs in order to produce a particular sequence."

These registers are classifed as counters because they exhibit a specified sequence of states.

They are of two types

(1) Ring counter

(2) Johnson counter

4.32.2. Ring Counter

Ring counter is an synchronous counter in which last output (*i.e.*, LSB) is feeded back to the input of the first flip-flop as shown in below diagram. As it is synchronous one, the clock pulse of all flip-flop is same.

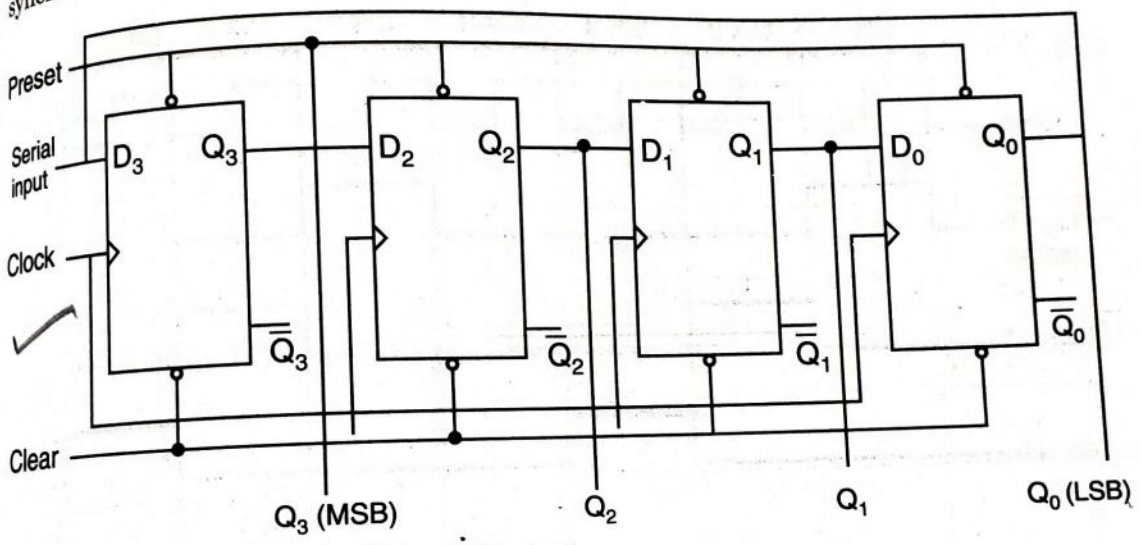

Fig. 4.154.

	Q_3 (MSB)	Q_2	Q_1	Q_0 (LSB)	Counts
On Reset (Initially)	0	0	0	0	0
1st clock pulse	1	0	0	0	1
2nd clock pulse	0	1	0	0	2
3rd clock pulse	0	0	1	0	3
4th clock pulse	0	0	0	1	4
5th clock pulse	①	0	0	0	Recycle or repetition

The output of FF-3 is set to one or arrival of 1st clock pulse with the help of preset input and on reset all flip-flop are cleared to '0' with clear input= '0'.

As the positive edge of clock is arrived flip-flop with shifts its output to the flip-flop 2 and similarly flip-flop 2 gives its output to the flip-flop 1 and so on.

The working can be easily understand by the help of state diagram and waveforms as shown below.

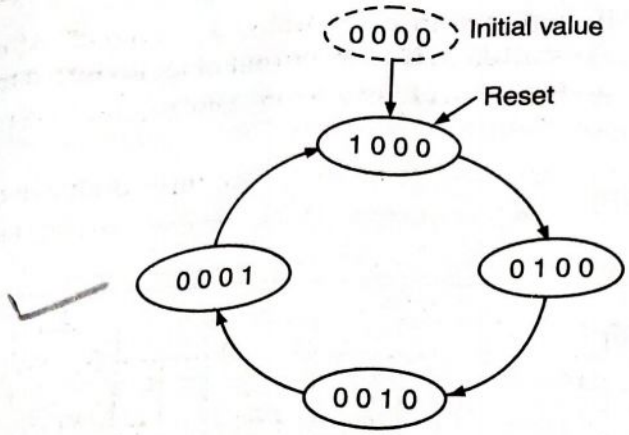

Fig. 4.155. State diagram of 4 bit ring counter

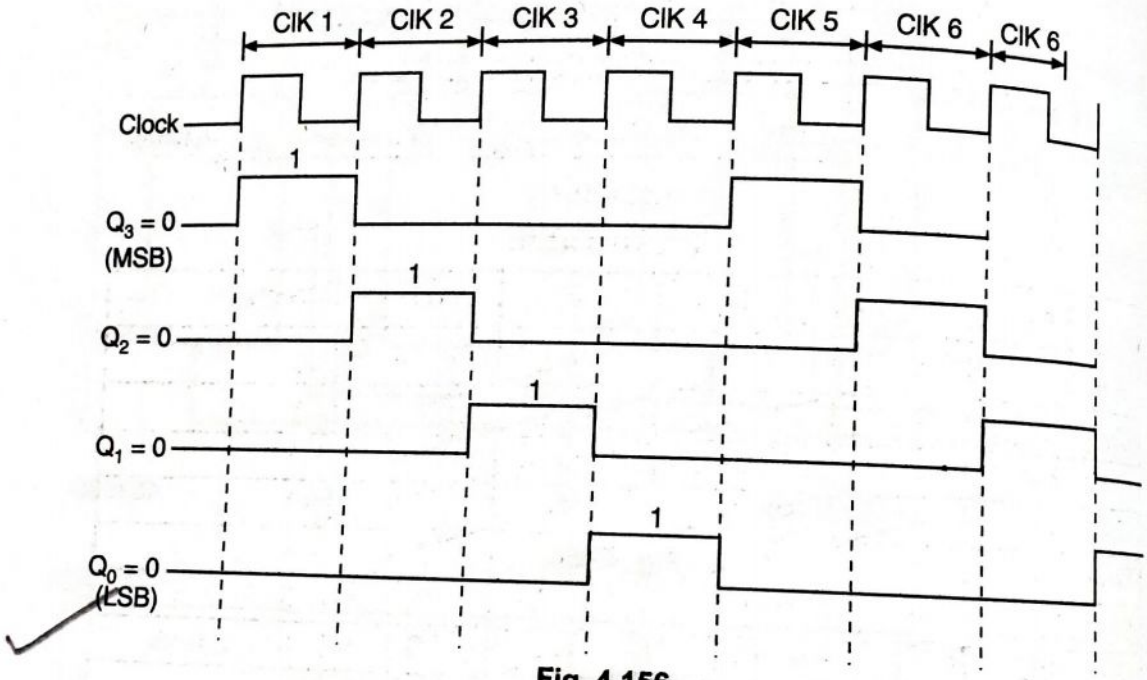

Fig. 4.156.

Note: If we use 4 flip-flop then number of states *i.e.*, modules is '4' (i.e., counts from 0, 1, 2, 3 and then repeats).

Advantages of Ring Counter

The major advantage of a ring counter over a binary counter is a self decoding counter. No extra decoding circuit is needed to determine what state the counter is in.

Disadvantage of Ring Counter

Ring counter is very inefficient in terms of state usage. Let us take an example—In MOD-4 counter, maximum states possible are 16 (as '4' flip flops are used so, 2^4 *i.e.*, 16 output/states are present) out of which only '4' states are used. So it is really inefficient in terms of states usage.

4.33 JOHNSON COUNTER (TWISTED RING COUNTER/MOEBIUS COUNTER)

This counter is similar to Ring Counter but only one difference is there that in it we feedback $\bar{Q}_0$ instead of Q_0 to the serial input (D_3).

Initially all the flip-flops are in reset state *i.e.*, "0 0 0 0". After each clock pulse, the output of Q_3 is shifted to Q_2, the output of Q_2 is shifted to Q_1, Q_1 to Q_0 and the output of $\bar{Q}_0$ is shifted to Q_3 and so on. This sequence is repeated after every eight clock pulses.

A positive edge triggered 4-bit twisted ring counter is shown below. It is an shift register (SIPO) in which last output ($\bar{Q}_0$) is feedback to the serial input (D_3).

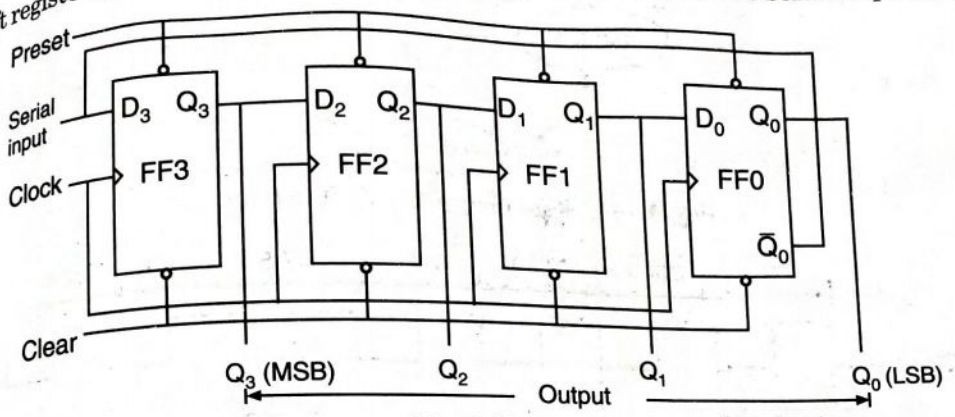

Fig. 4.157.

Truth Table

Clock	Q_3	Q_2	Q_1	Q_0	Counts
Initially	0	0	0	0	0
Clock - 1st	1	0	0	0	1
Clock - 2nd	1	1	0	0	2
Clock - 3rd	1	1	1	0	3
Clock - 4th	1	1	1	1	4
Clock - 5th	0	1	1	1	5
Clock - 6th	0	0	1	1	6
Clock - 7th	0	0	0	1	7
Clock - 8th	0	0	0	0	0 → Repeats or Recycles

The state diagram is shown as follows:

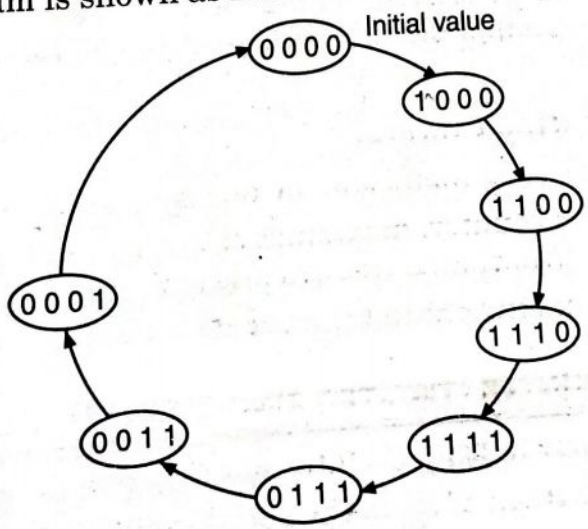

Fig. 4.158.

Note: As shown above, twisted ring counter is capable of counting 8 states (if 4 flip flops are used). Hence if 'N' flip-flop twisted ring counter is there, then it counts 2N states which is double of ring counter (If N flip-flop are there, then it counts 'N' states)

The waveform is shown as below:

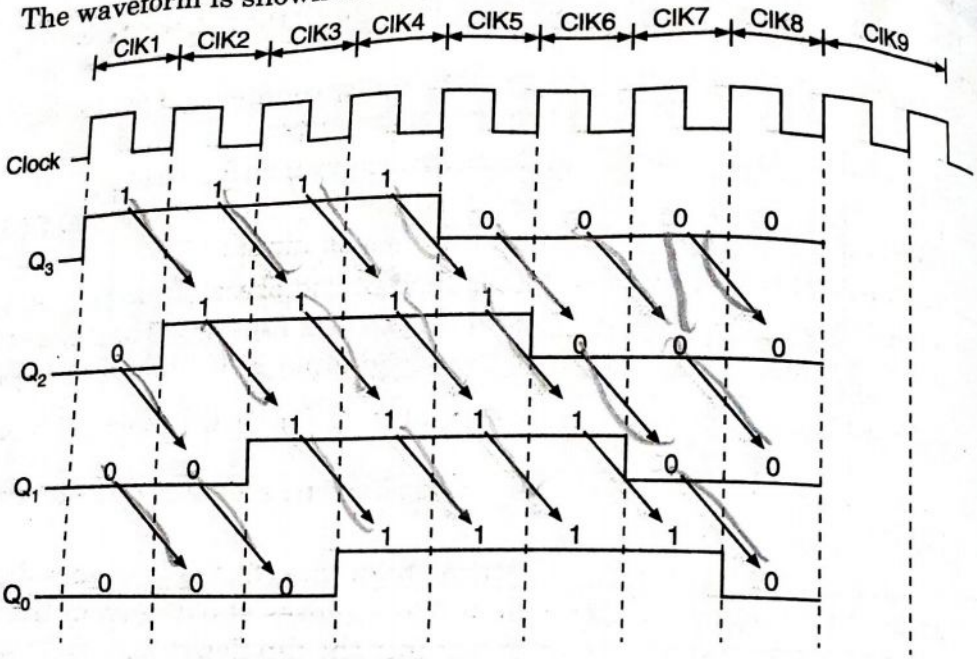

Fig. 4.159.

Disadvantage of Jonson counter

In Johnson counter maximum available states are not fully utilized. As in 4-bit twisted ring counter/Johnson counter only 8 of 16 states are being used.

4.34 COMPARISON BETWEEN RING COUNTER AND JOHNSON COUNTER

— A ring counter is a circular shift register with only one flip-flop being set any particular time, all others are cleared. The single bit is shifted from one flip flop to the other to produce the sequence of timing signals whereas Johnson ring counter is modified ring counter where the complement output of the last flip flop is connected to the input of the first flip flop.

— Ring counter is also known as conventional ring counter wheras Johnson ring counter is also known as twisted ring counter.

— In ring counter it requires at least one flip flop present to logic '1' and at least one flip flop reset to logic O whereas Johnson counter may start with all its flip flop in the reset condition.

— In ring counter the number of states is 'N' where 'N' is the number of flip flops whereas in case of Johnson counter the number of states is 2N.

— Ring counter is known as Divide by N counter whereas Johnson counter is known as Divide by 2N counter.

4.35 PRESETTABLE COUNTERS

Presettable counters are the type of counters that can count from any desired state.