RING COUNTER & JOHNSON COUNTER

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Shift Register Counters

- Shift registers can be arranged to form several types of counters. All shift register counters use feedback, whereby the output of the last flip-flop in the shift register is connected back to the first flip-flop.
- Based on the time of feedback connection the shift register counters are classified as:
  - ✓ **Ring Counter**
  - ✓ **Johnson Counter**

Ring Counter

- The ring counter is a cascaded connection of flip flops, in which the output of last flip flop is connected to input of first flip flop. In ring counter if the output of any stage is 1, then its reminder is 0. The Ring counters transfers the same output throughout the circuit.
- That means if the output of the first flip flop is 1, then this is transferred to its next stage i.e. 2nd flip flop. By transferring the output to its next stage, the output of first flip flop becomes 0. And this process continues for all the stages of a ring counter. If we use n flip flops in the ring counter, the '1' is circulated for every n clock cycles.

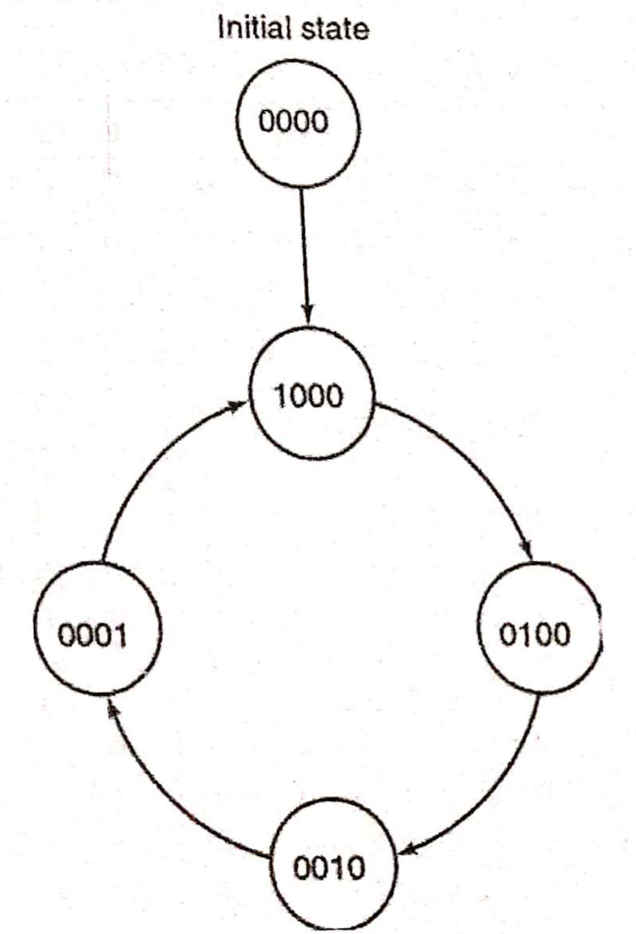
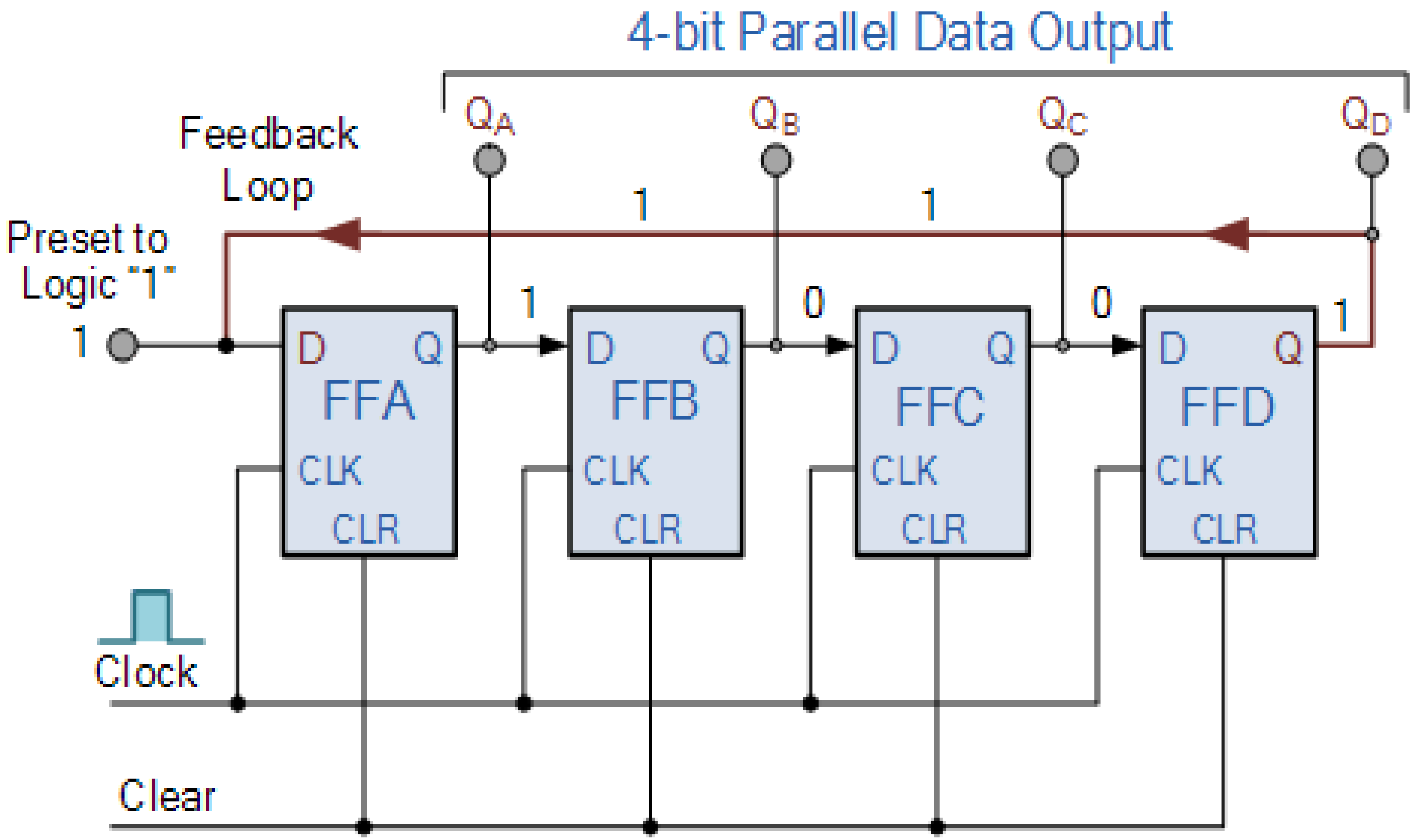


Fig. 9.20 State diagram of 4-bit ring counter

State diagram of ring counter

4 bit Ring Counter



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

Ring Counter

- Ring counter's state needs to be set before the operation. Since ring counter circulates 1 through all stages, and there are no external inputs except the clock signal. So we need to set its state to initial state 1000 manually. We need to set the first stage flip-flop and clear the rest of the stages to obtain the state 1000.The preset input pin is designed to do this function.

- First, we need to set the initial state 1000 through preset input.

- Whenever the first clock edge hits the counter the outputs of each stage shifts to the next succeeding stage. And the output of the last will shift to the first stage making the state 0100.

- Upon next clock cycle, each stage will update its state according to its input. So the '1' will be shifted to the third stage making the state 0010. Upon another clock cycle, the '1' will reach the last stage making the 0001.

- Now upon next clock cycle, '1' from the last stage (flip-flop) will shift back to the first stage making the initial state 1000. And it starts again from the first state repeating itself considering the clock signal is provided. This is how the data inside the ring counter circulates in the ring.

Truth table of ring counter

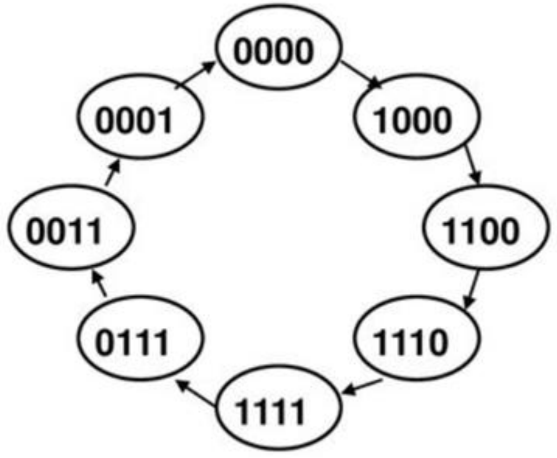
Q_0	Q_1	Q_2	Q_3
1	0	0	0
0	1	0	0
0	0	1	0
0	0	0	1

Johnson Counter

The ***shift or twisted ring counter*** is the such type of counter where the inverted output of the last flip flop is connected to the input of the first flip-flop. This counter is also known as ***Johnson Counter***. It is named for ***Robert Royce Johnson***.

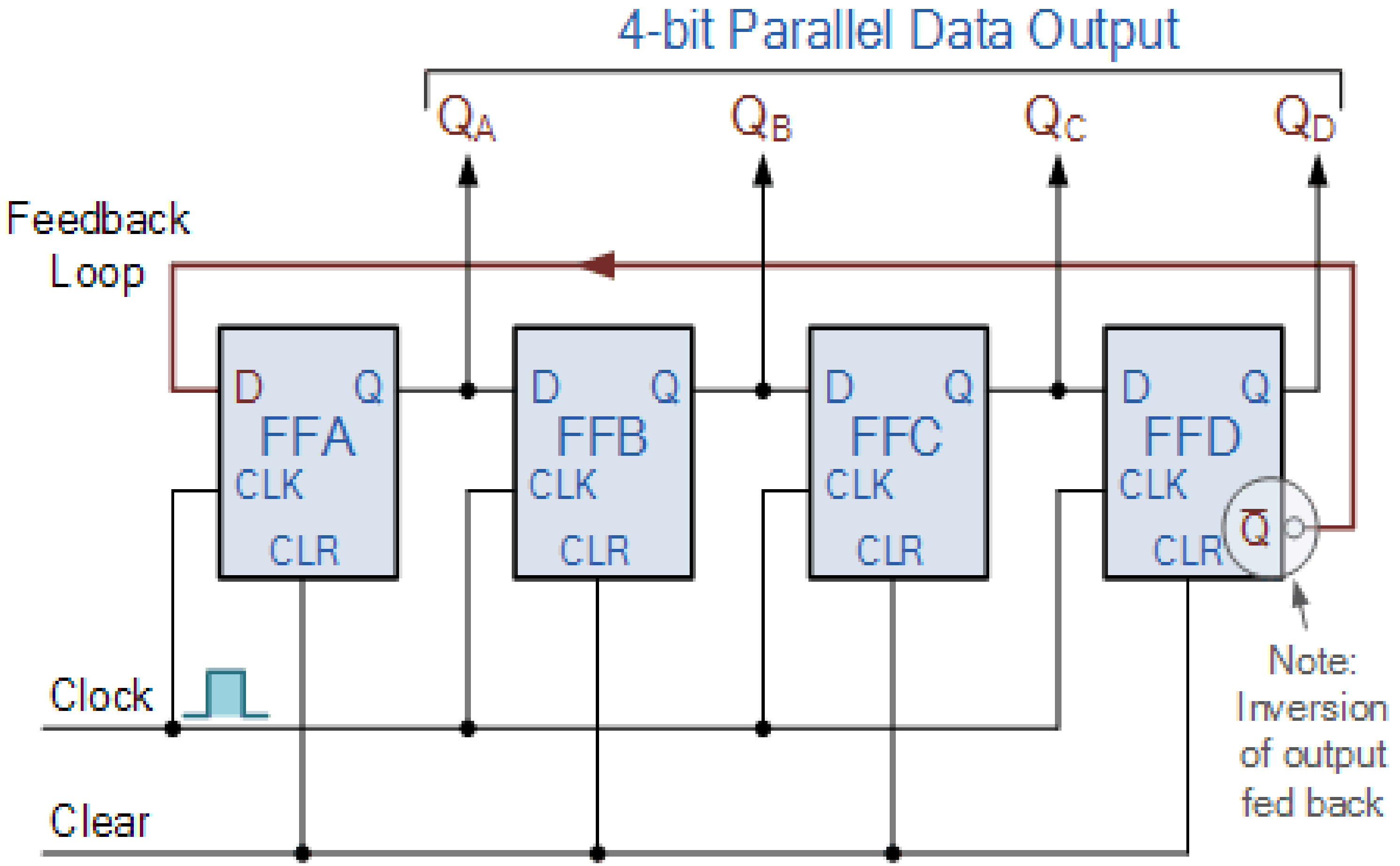
Operations:-

- The default state of Johnson counter is 0000 thus before starting the clock input we need to clear the counter using clear input.
- Whenever a clock edge hits the counter the output of each flip-flop will transfer to the next stage (flip-flop) but the inverted output of the last flip-flop will shift to the first stage making the state 1000.
- Upon next clock cycle, another '1' will stack in from the left side as the inverted output of the last stage will be shifted to the first stage.
- On next clock cycle, another '1' will add in from left until the state becomes 1111.
- Now that the last flip-flop's output is '1', the next clock cycle will shift the invert of the last flip-flop which is '0' into the first flip-flop. It will result in stacking '0' from the left side. This stacking of the first 0 will make the state 1111 into 0111.
- The next coming clock cycles will stack in 0's from the left making the states 0011, 0001 & 0000 with each clock cycle. Eventually, it reaches its default state and it starts from the beginning again.



State diagram of Johnson counter

Johnson Counter



Clock	Q_0	Q_1	Q_2	Q_3
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