

Sequential Circuit (Shift Register Counters)

Shift Register Counters

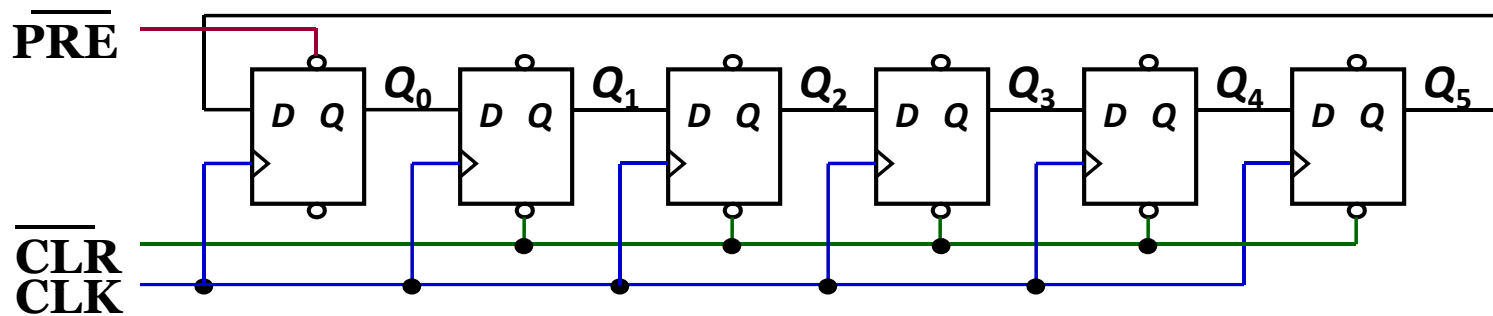
- **Shift register counter**: a shift register with the serial output connected back to the serial input.
- They are classified as counters because they give a specified sequence of states.
- Two common types: the *Johnson counter* and the *Ring counter*.

Ring Counters

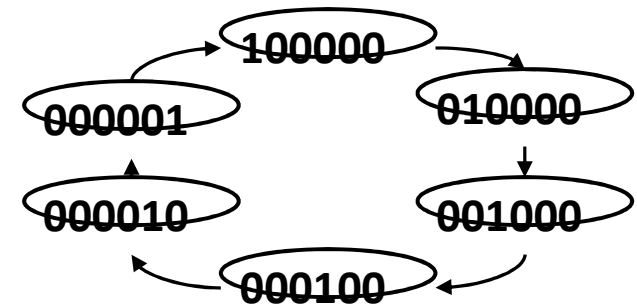
- One flip-flop (stage) for each state in the sequence.
- The output of the last stage is connected to the D input of the first stage.
- An n -bit ring counter cycles through n states.
- No decoding gates are required, as there is an output that corresponds to every state the counter is in.

Ring Counters

- Example: A 6-bit (MOD-6) ring counter.



Clock	Q ₀	Q ₁	Q ₂	Q ₃	Q ₄	Q ₅
0	1	0	0	0	0	0
1	0	1	0	0	0	0
2	0	0	1	0	0	0
3	0	0	0	1	0	0
4	0	0	0	0	1	0
5	0	0	0	0	0	1

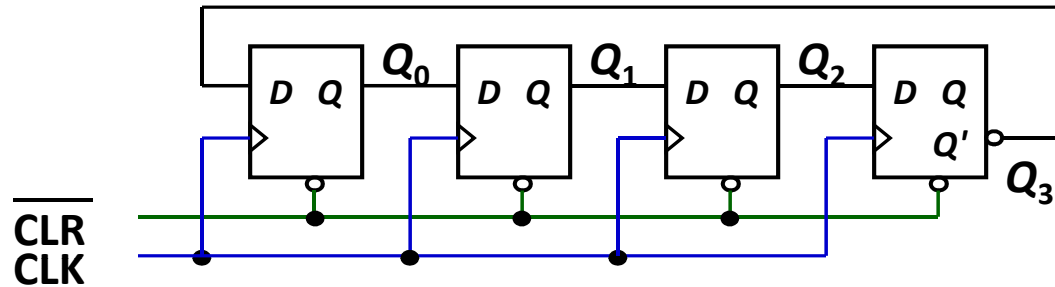


Johnson Counters

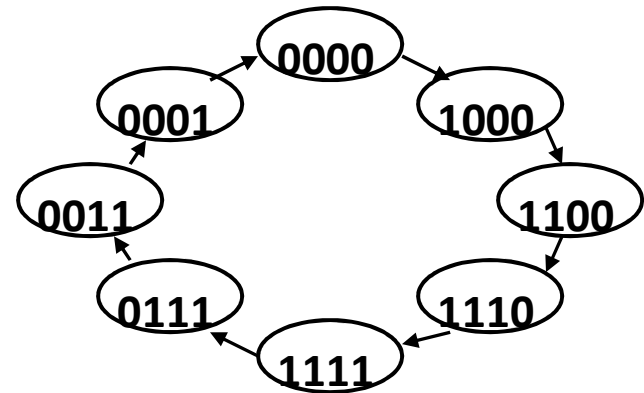
- The complement of the output of the last stage is connected back to the D input of the first stage.
- Also called the *twisted-ring counter*.
- Require fewer flip-flops than ring counters but more flip-flops than binary counters.
- An n -bit Johnson counter cycles through $2n$ states.
- Require more decoding circuitry than ring counter but less than binary counters.

Cont...

- Example: A 4-bit (MOD-8) 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



Cont...

- Decoding logic for a 4-bit Johnson counter.

Clock	A	B	C	D	Decoding
0	0	0	0	0	$A'.D'$
1	1	0	0	0	$A.B'$
2	1	1	0	0	$B.C'$
3	1	1	1	0	$C.D'$
4	1	1	1	1	$A.D$
5	0	1	1	1	$A'.B$
6	0	0	1	1	$B'.C$
7	0	0	0	1	$C'.D$

