Chapter 9
Flip-Flops

Introduction

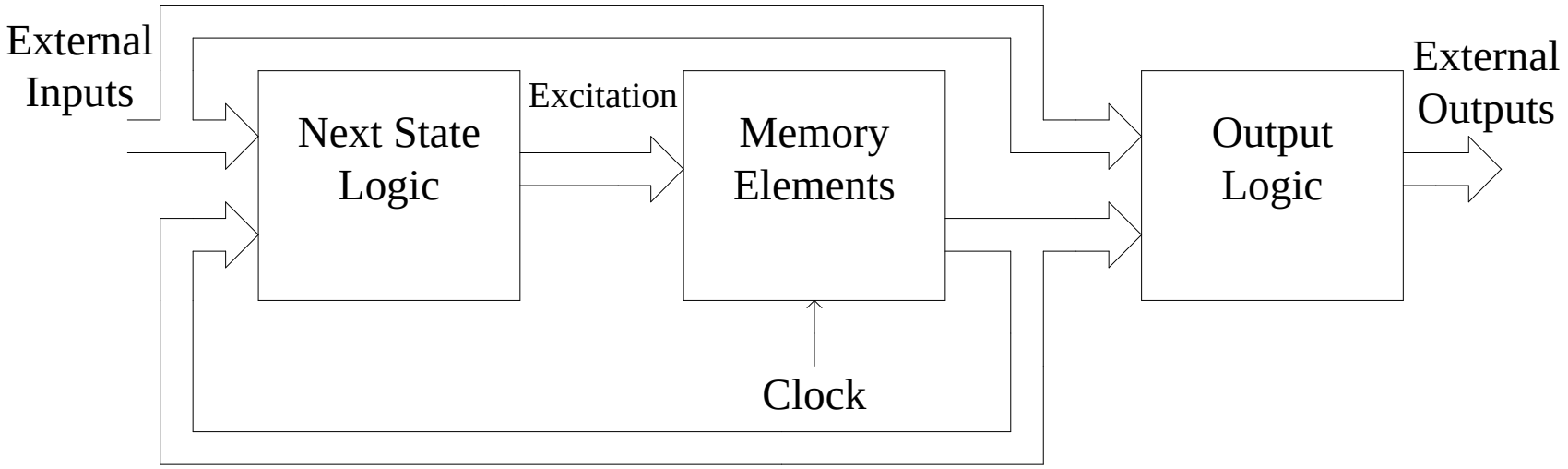


Figure Block Diagram of a sequential circuit

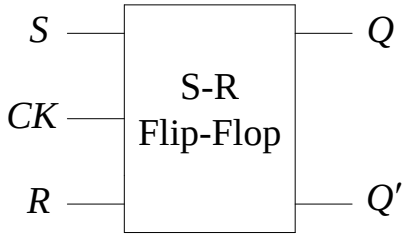
- Content of memory is called State.
- When clock is applied, then memory content is updated based on the excitation.
- When clock is low, then the memory content is not changed. This state is called Present State, Q_n
- External output is function of external input and present state.
- Excitation for next state, Q_{n+1}, is function of external input and present state.

Introduction (Contd.)

Types of Flip-Flops

1. S-R Flip-Flops
2. J-K Flip-Flops
3. D Flip-Flops
4. T Flip-Flops

S-R Flip-Flop



(a) Logic symbol

S_n	R_n	Q_n	Q_{n+1}
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	?
1	1	1	?

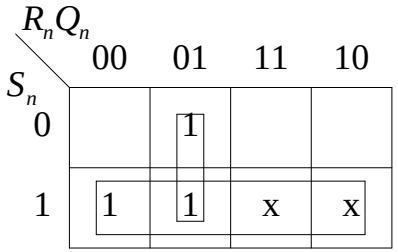
(b) Characteristic table

S_n	R_n	Q_{n+1}
0	0	Q_n
0	1	0
1	0	1
1	1	?

(c) Reduced characteristic table

CK=0, Q unchanged
CK=1, Q is determined by S & R

Characteristic Equation:



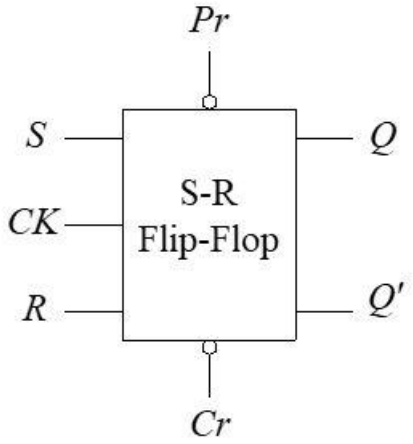
$$Q_{n+1} = S_n + R'_n Q_n$$

$$S_n R_n = 0$$

Excitation Table:

Q_n	Q_{n+1}	S_n	R_n
0	0	0	X
0	1	1	0
1	0	0	1
1	1	X	0

S-R Flip-Flop with Preset and Clear Inputs

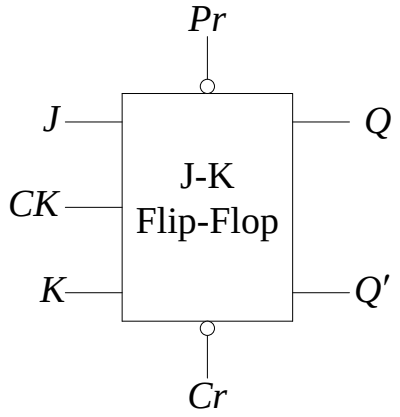


(a) Logic symbol

P_r and C_r active when $CK = 0$
For synchronous operation, $P_r = C_r = 1$

P_rC_r	Q_n
00	Unused
01	1 (Preset)
10	0 (Clear)
11	Unchanged

J-K Flip-Flop



(a) Logic symbol

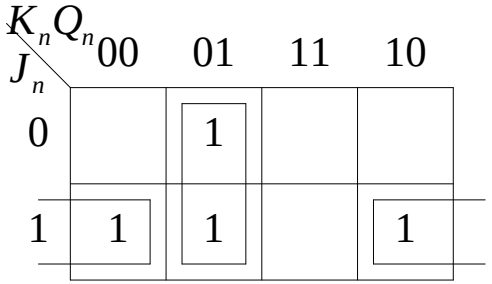
J_n	K_n	Q_n	Q_{n+1}
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	0

(b) Characteristic table

J_n	K_n	Q_{n+1}
0	0	Q_n
0	1	0
1	0	1
1	1	Q'_n

(c) Reduced characteristic table

Characteristic Equation:

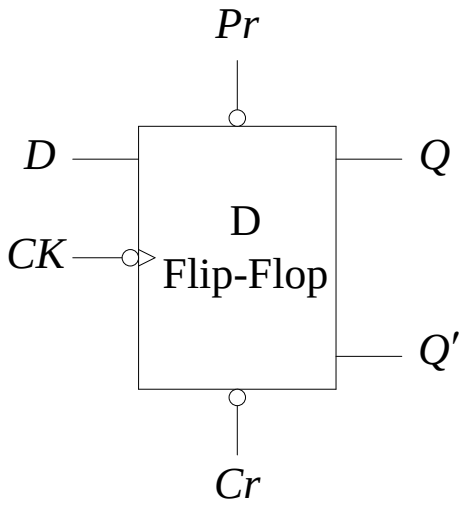


$$Q_{n+1} = J_nQ'_n + K'_nQ_n$$

Excitation Table:

Q_n	Q_{n+1}	J_n	K_n
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

D Flip-Flop



(a) Logic symbol

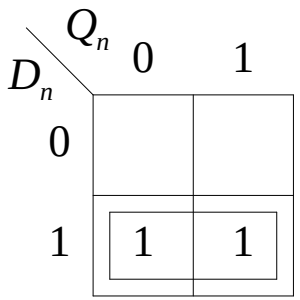
D_n	Q_n	Q_{n+1}
0	0	0
0	1	0
1	0	1
1	1	1

(b) Characteristic table

D_n	Q_{n+1}
0	0
1	1

(c) Reduced characteristic table

Characteristic Equation:

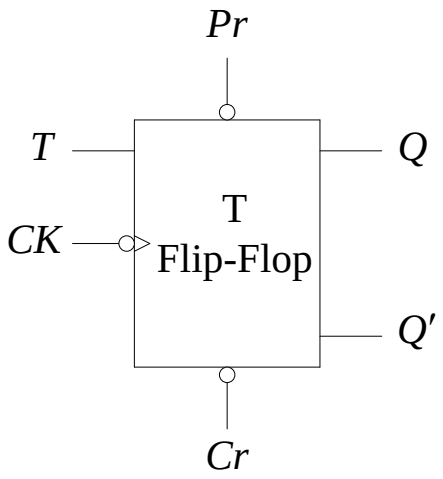


$Q_{n+1} = D_n$

Excitation Table:

Q_n	Q_{n+1}	D_n
0	0	0
0	1	1
1	0	0
1	1	1

T Flip-Flop



(a) Logic symbol

T_n	Q_n	Q_{n+1}
0	0	0
0	1	1
1	0	1
1	1	0

(b) Characteristic table

T_n	Q_{n+1}
0	Q_n
1	Q'_n

(c) Reduced characteristic table

Characteristic Equation:

T_n \ Q_n	0	1
0		1
1	1	

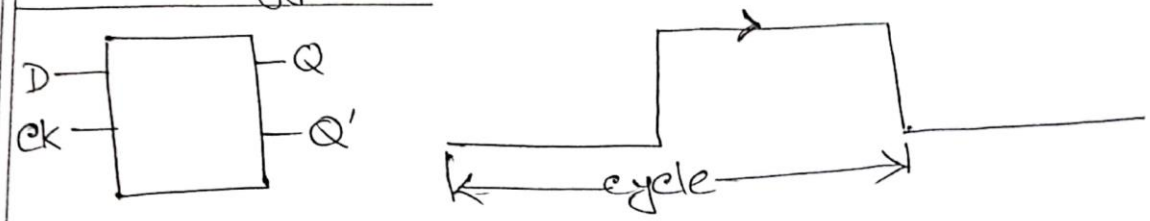
$$Q_{n+1} = T'_n Q_n + T_n Q'_n$$

Excitation Table:

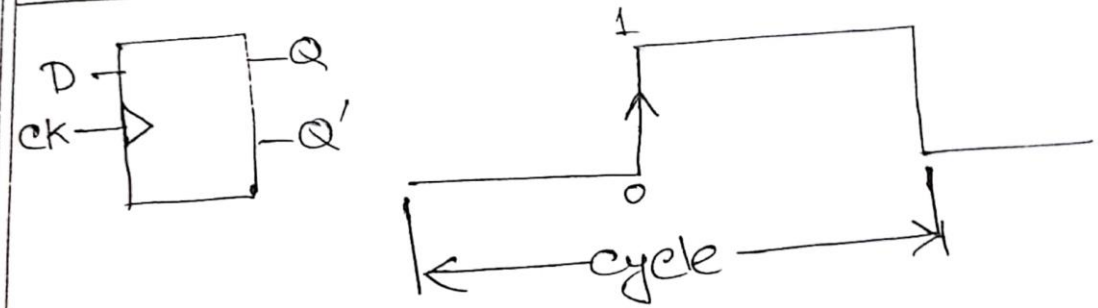
Q_n	Q_{n+1}	T_n
0	0	0
0	1	1
1	0	1
1	1	0

Triggering of Flip-Flops

Level - Triggered:



Positive-edge Triggered/Rising-edge Triggered:



Negative-edge Triggered/ Falling-edge Triggered: