FLIPFLOPS

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Overview

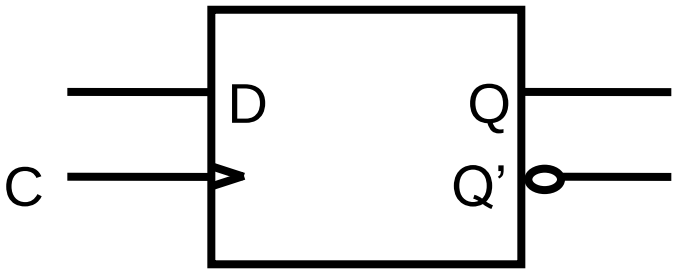
- Latches respond to trigger levels on control inputs
  - Example: If G = 1, input reflected at output
- Difficult to precisely time when to store data with latches
- Flip flips store data on a rising or falling trigger edge.
  - Example: control input transitions from 0 -> 1, data input appears at output
  - Data remains stable in the flip flop until until next rising edge.
- Different types of flip flops serve different functions
- Flip flops can be defined with characteristic functions

D Flip-Flop

- Stores a value on the positive edge of *C*
- Input changes at other times have no effect on output

D gets latched to Q on the rising edge of the clock.

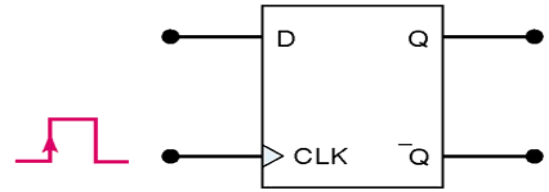
Positive edge triggered



D	C	Q	Q'
0	↑	0	1
1	↑	1	0
X	0	Q_0	Q_0'

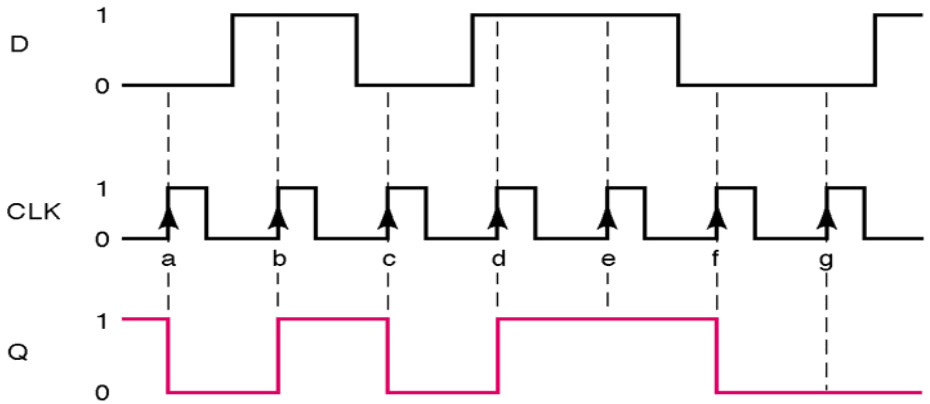
Clocked D Flip-Flop

- Stores a value on the positive edge of *C*
- Input changes at other times have no effect on output



D	CLK	Q
0	↑	0
1	↑	1

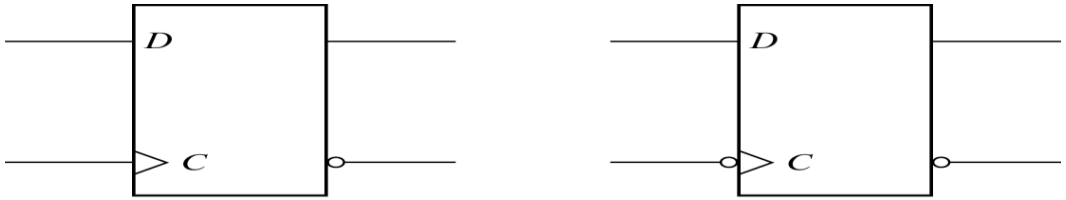
(a)



(b)

Positive and Negative Edge D Flip-Flop

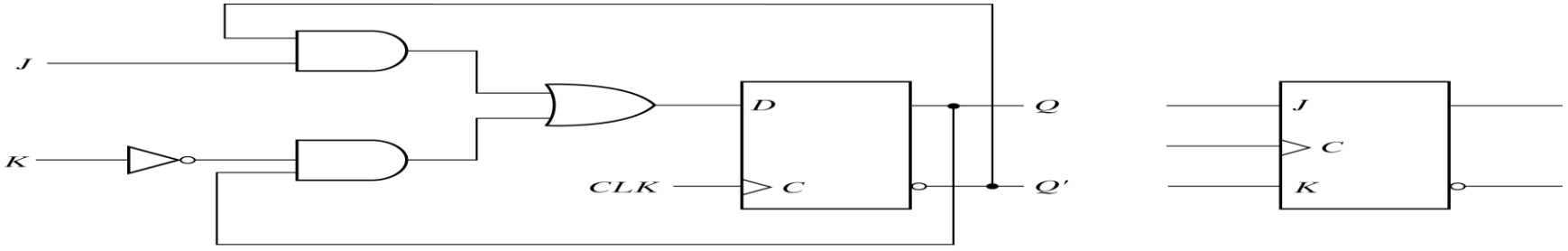
- D flops can be triggered on positive or negative edge
- Bubble before *Clock (C)* input indicates negative edge trigger



(a) Positive-edge (a) Negative-edge

Fig. 5-11 Graphic Symbol for Edge-Triggered *D* Flip-Flop

Positive Edge-Triggered J-K Flip-Flop



(a) Circuit diagram (b) Graphic symbol

Fig. 5-12 *JK* Flip-Flop

Created from D flop

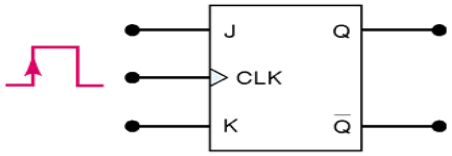
J sets

K resets

J=K=1 -> invert output

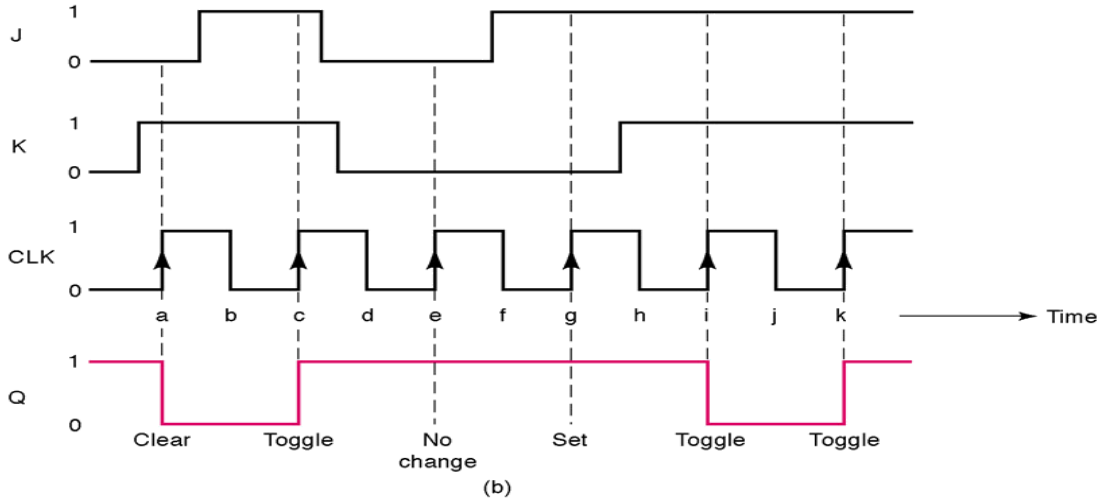
Clocked J-K Flip Flop

- Two data inputs, J and K
- J -> set, K -> reset, if J=K=1 then toggle output



J	K	CLK	Q
0	0	↑	Q_0 (no change)
1	0	↑	1
0	1	↑	0
1	1	↑	$\overline{Q}_0$ (toggles)

(a)

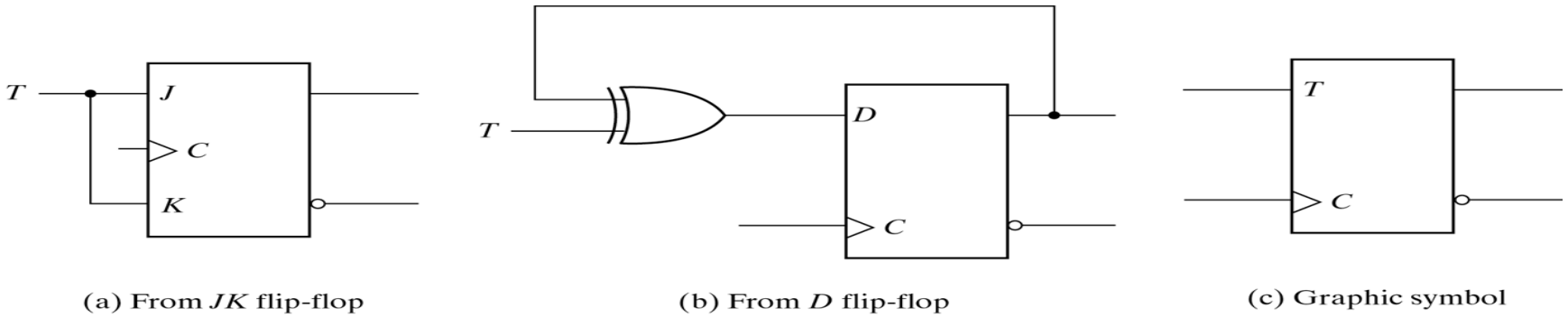


(b)

JK FLIPFLOP OUTOUT

CLK	J	K	Q_n	Q_{n+1}	Q_{n+1}
0	X	X	0/1	0/1	Q_n
↑	0 0	0 0	0 1	0 1	Q_n
↑	0 0	1 1	0 1	0 0	0
↑	1 1	0 0	0 1	1 1	1
↑	1 1	1 1	0 1	1 0	Q_n'

Positive Edge-Triggered T Flip-Flop



(a) From *JK* flip-flop (b) From *D* flip-flop (c) Graphic symbol

Fig. 5-13 T Flip-Flop

Created from D flop

T=0 -> keep current

K resets

T=1 -> invert current

Q_t	Q(t+1)	T
0	0	0
1	0	1
0	1	1
1	1	0

Summary

- Flip flops are powerful storage elements
  - They can be constructed from gates and latches!
- D flip flop is simplest and most widely used
- Asynchronous inputs allow for clearing and presetting the flip flop output
- Multiple flops allow for data storage
  - The basis of computer memory!
- Combine storage and logic to make a computation circuit.