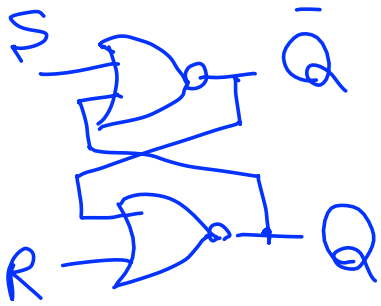
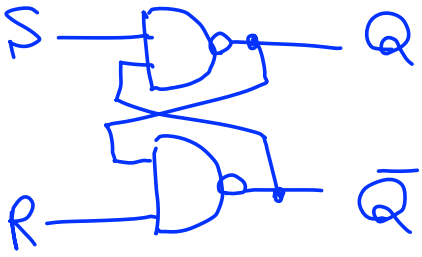


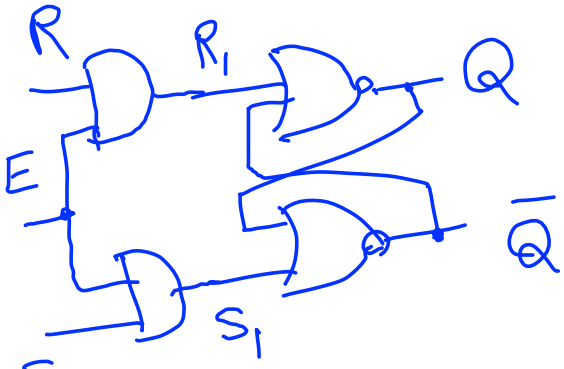

| S | R | $Q^+$ | $\bar{Q}^+$ | |
|---|---|---|---|---|
| 0 | 0 | Q | $\bar{Q}$ | (memory) |
| 0 | 1 | 0 | 1 | (reset) |
| 1 | 0 | 1 | 0 | (set) |
| 1 | 1 | (غیرمجاز) | | |

active-high inputs




| S | R | $Q^+$ | $\bar{Q}^+$ | |
|---|---|---|---|---|
| 0 | 0 | (غیرمجاز) | | |
| 0 | 1 | 1 | 0 | (set) |
| 1 | 0 | 0 | 1 | (reset) |
| 1 | 1 | Q | $\bar{Q}$ | (memory) |

active-Low inputs




gated SR Latch

L

Clocked SR Latch

$E=0 \Rightarrow S_1=R_1=0 \Rightarrow$ (memory)

$Q^+=Q$

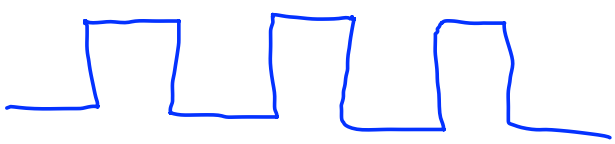
Enable

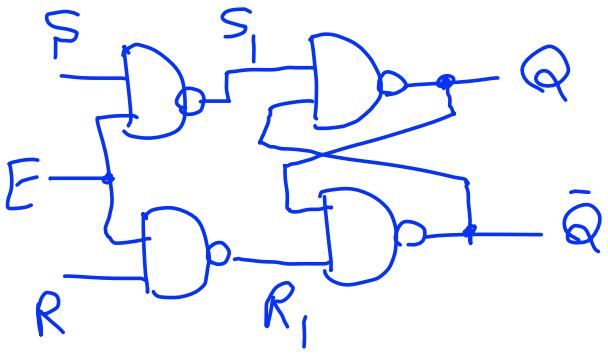
$E=1 \Rightarrow \begin{cases} R_1=R \\ S_1=S \end{cases} \rightarrow$ عملکرد عادی

E

↘

CLOCK





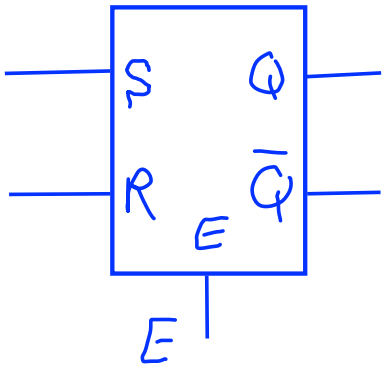

$E=0 \Rightarrow S_1=R_1=1 \Rightarrow$ memory

$Q^{n+1}=Q^n$

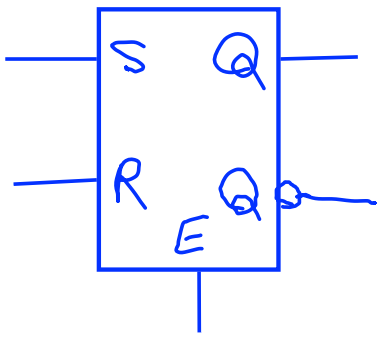
$E=1 \Rightarrow \begin{cases} S_1=\bar{S} \\ R_1=\bar{R} \end{cases} \Rightarrow$ عملکرد عادی

ورودیهای S و R، active high هستند.

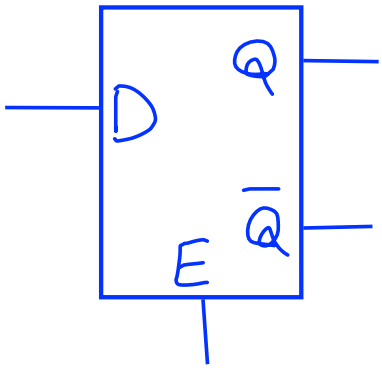
clocked SR latch = gated = } active-high

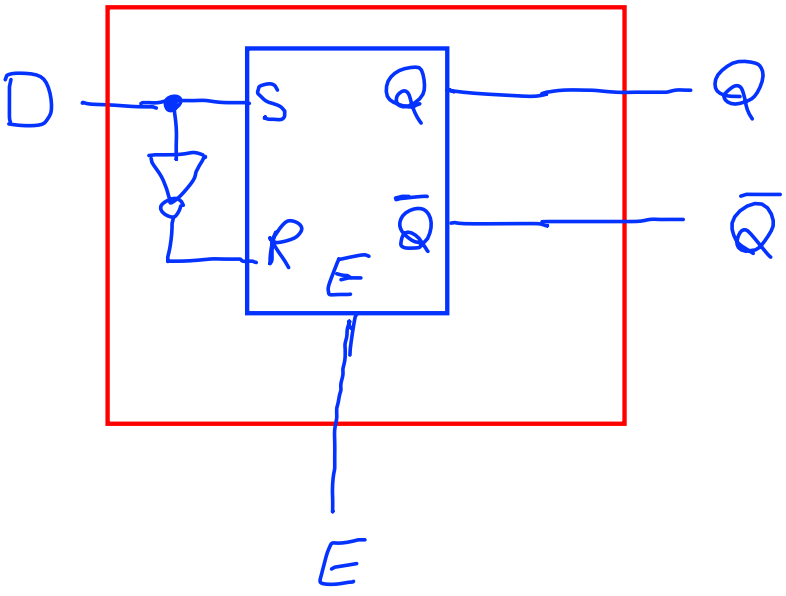



| S | R | $Q^{n+1}$ | $\overline{Q^{n+1}}$ |
|---|---|---|---|
| 0 | 0 | $Q^n$ | $\overline{Q^n}$ |
| 0 | 1 | 0 | 1 |
| 1 | 0 | 1 | 0 |
| 1 | 1 | غیرمجاز | |



# D Latch (Data Latch)




E=1

| S | R | $Q^{n+1}$ |
|---|---|---|
| 0 | 0 | $Q^n$ |
| 0 | 1 | 0 |
| 1 | 0 | 1 |
| 1 | 1 | ~~is~~ |

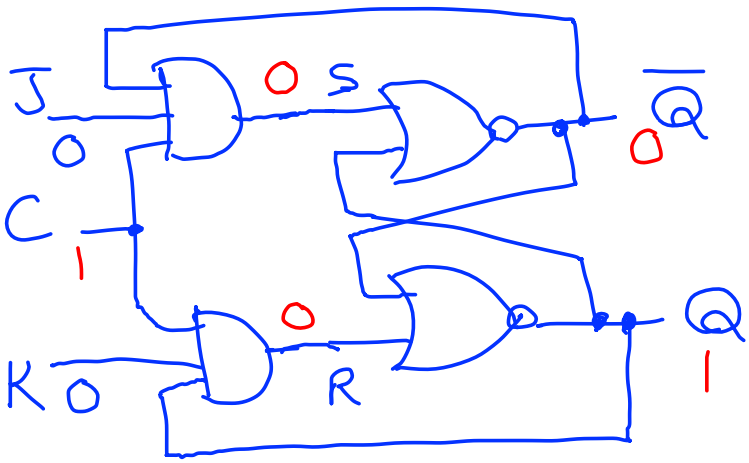
⇒

| D | $Q^{n+1}$ |
|---|---|
| 0 | 0 |
| 1 | 1 |

$E=0 \Rightarrow Q^{n+1}=Q^n$ (memory)

# J-K Latch

C = clock = CLK = ck

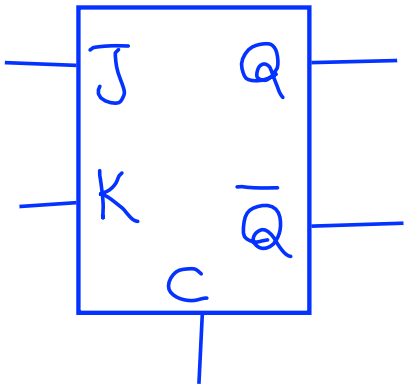



| J | K | Q | $Q^+$ | |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | memory |
| 0 | 0 | 1 | 1 | memory |
| 0 | 1 | 0 | 0 | reset (Kill) |
| 0 | 1 | 1 | 0 | reset (Kill) |
| 1 | 0 | 0 | 1 | set (Jump) |
| 1 | 0 | 1 | 1 | set (Jump) |
| 1 | 1 | 0 | 1 | (toggle) |
| 1 | 1 | 1 | 0 | (toggle) |

$Q^+ = \bar{Q}$

$C=0 \Rightarrow Q^+ = Q$

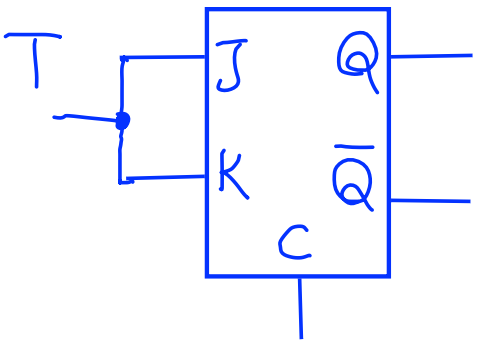
$C=1$




| J | K | $Q^{n+1}$ | |
|---|---|---|---|
| 0 | 0 | $Q^n$ | (memory) |
| 0 | 1 | 0 | (reset) |
| 1 | 0 | 1 | (set) |
| 1 | 1 | $\bar{Q}^n$ | (toggle-complement) |

C=1 في حالة

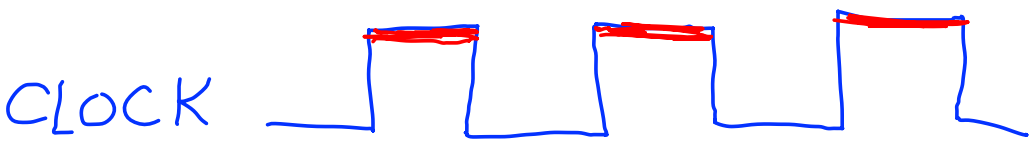
# T-Latch



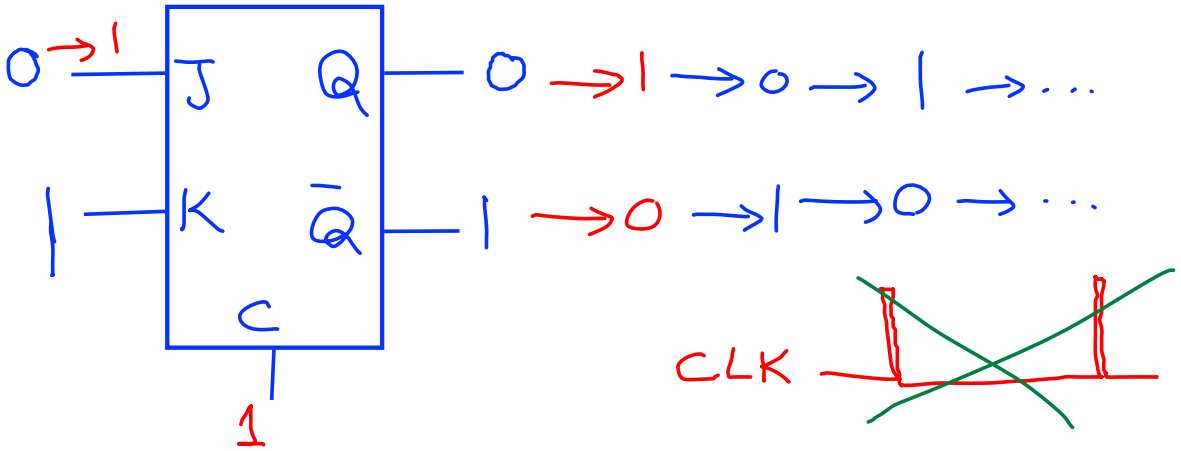

| T | $Q^{n+1}$ | |
|---|---|---|
| 0 | $Q^n$ | (memory) |
| 1 | $\bar{Q}^n$ | (toggle) |

$C=0 \Rightarrow Q^{n+1}=Q^n$

C=1

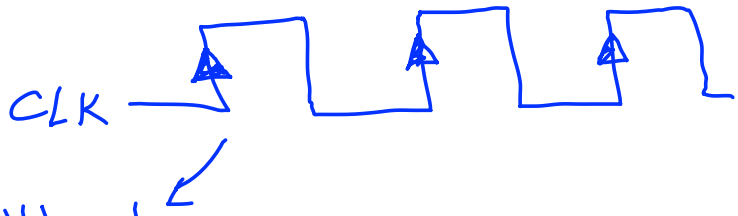



Level sensitive Latch



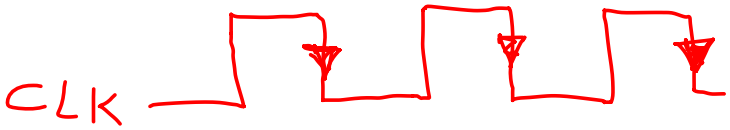
# Flip-Flop (FF)

edge-sensitive




لبه بالارونده rising edge

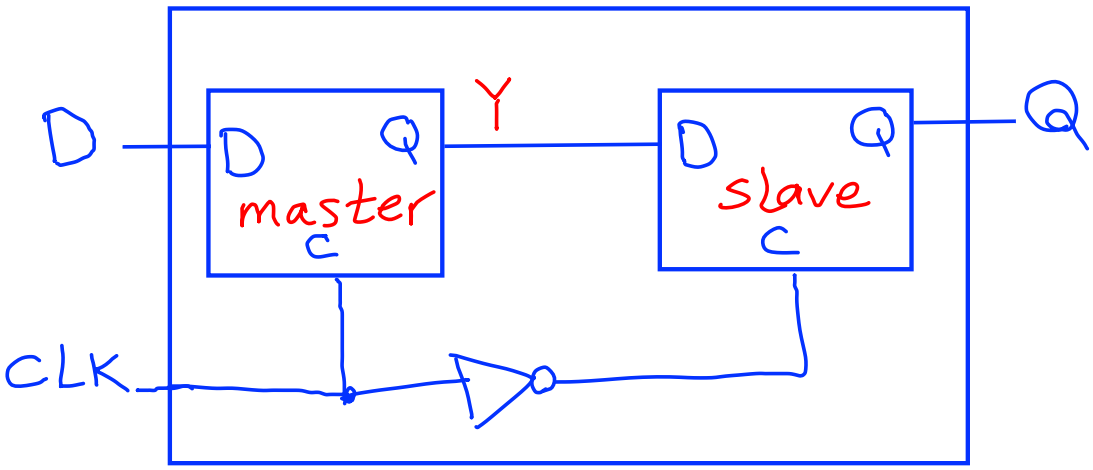
لبه مثبت positive edge




لبه پایین رونده falling edge

لبه منفی negative edge

راه اندازی : trigger




master-slave D Flip-Flop

CLK=0 → تغییری نداریم $\Rightarrow Q^+ = Q$

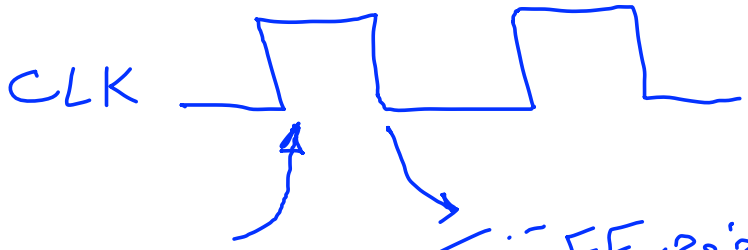
CLK=1 $\Rightarrow$ master: enable(فعال) → $Y = D$

slave: disable(غیرفعال)

داده در master ذخیره می‌شود (ولی خروجی نهایی تغییر نمی‌کند)

$CLK=0 \Rightarrow \begin{cases} master: disable \rightarrow \text{تغییر ورودی بی اثر است} \\ slave: enable \rightarrow Q^+ = Y = D \end{cases}$

خروجی FF مساوی با D ذخیره شده می شود.




ورودی داخل master خروجی FF تغییری کند

## FF

۱- خروجی در هر CLK فقط یک بار تغییری کند. نوشته می شود.

۲- تغییر خروجی با لبه ی پائین ساعت ترتیکی می شود.