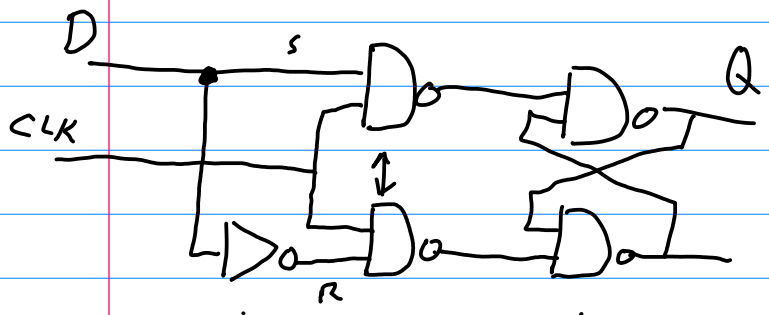
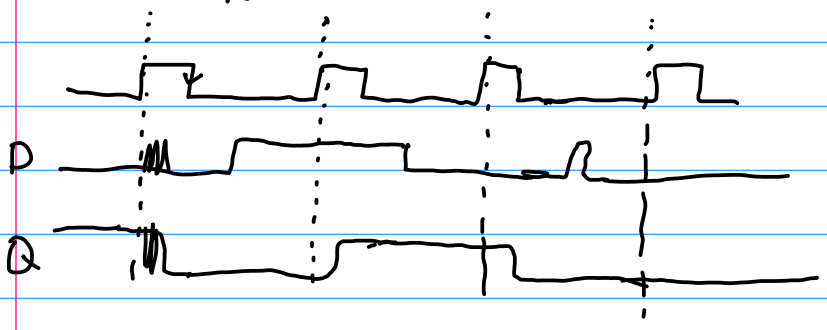
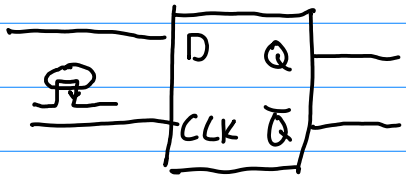
Gated D-latch

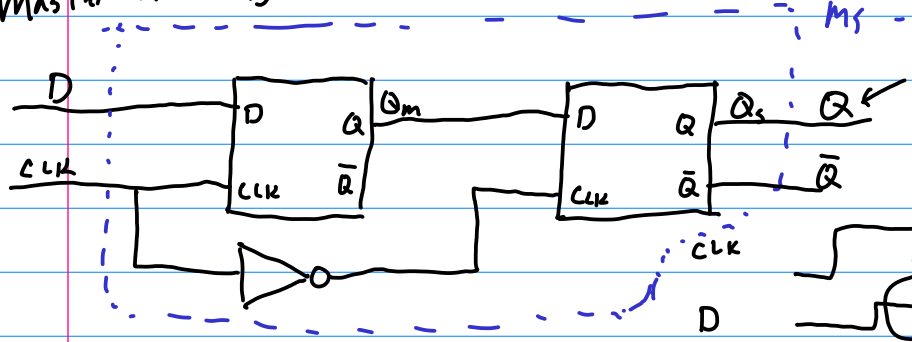


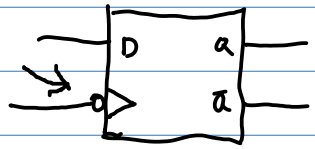
CLK	D	Q	
0	X	Q	hold
1	0	0	
1	1	1	

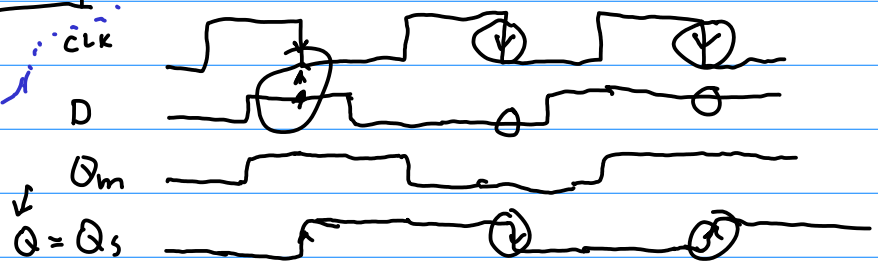




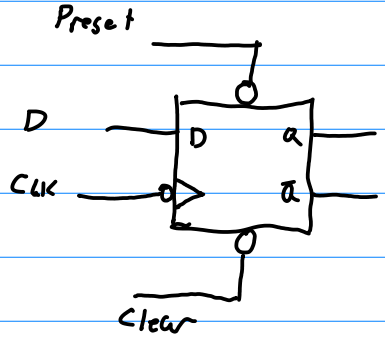
Master-Slave D







Edge-Triggered D-ff



D	Q+ next state
0	0
1	1

Characteristic Equation

$Q^+ = D$

FF goes to 1 on Preset
0 on clear ← has precedence

Asynchronous - happens now

Synchronous - happens on clock edge

T-ff

T	Q^+
0	Q (hold)
1	$\bar{Q}$ (toggle)

Next state (after)

Present state (before)

J	K	Q^+
0	0	Q
0	1	0
1	0	1
1	1	$\bar{Q}$

T \ Q	0	1
0	0	1
1	1	0

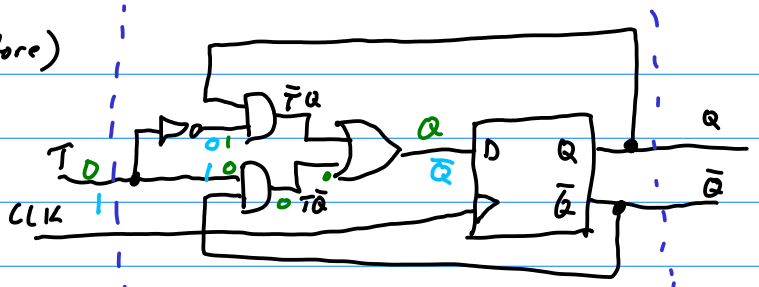
Q^+

Characteristic Equation

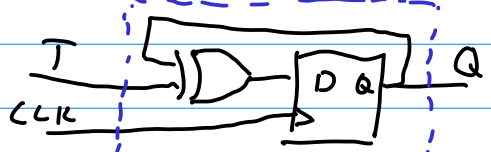
$Q^+ = \bar{T}Q + T\bar{Q}$

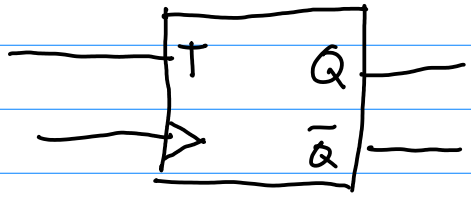
D

T-f



same





Jk-ff

S R

$Q(t+1)$

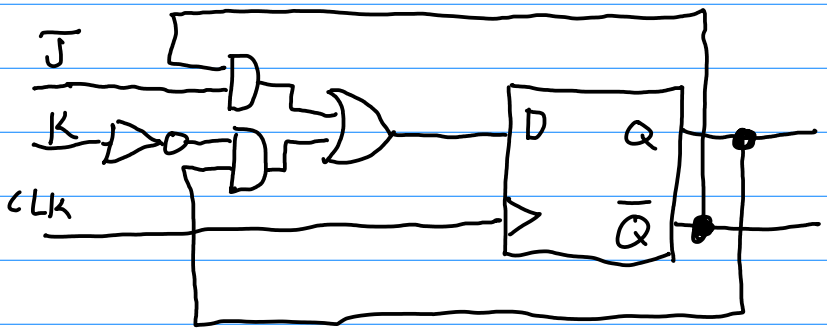
J	K	Q^+	
0	0	Q	(hold)
0	1	0	(Reset)
1	0	1	(Set)
1	1	$\bar{Q}$	(Toggle)

S R

Q \ J	00	01	11	10
0	0	0	1	1
1	1	0	0	1

K

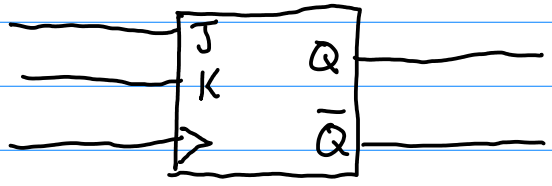
Q^+



Characteristic Equation

$Q^+ = \bar{K}Q + J\bar{Q}$

D =



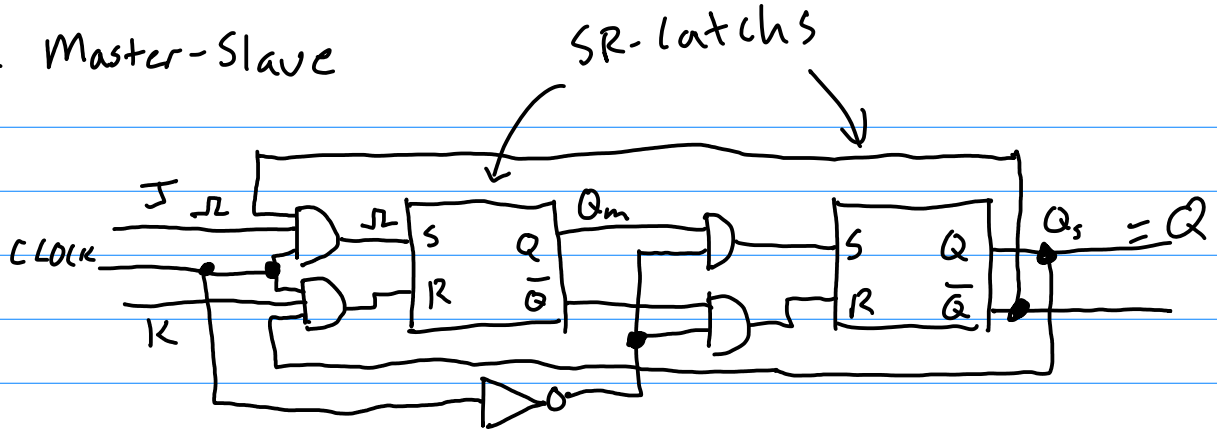
JK excitation table

J K	Q^+
0 0	Q
0 1	0
1 0	1
1 1	$\bar{Q}$

J K Q	Q^+
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

Q Q^+	J K
0 0	0 X
0 1	1 X
1 0	X 1
1 1	X 0

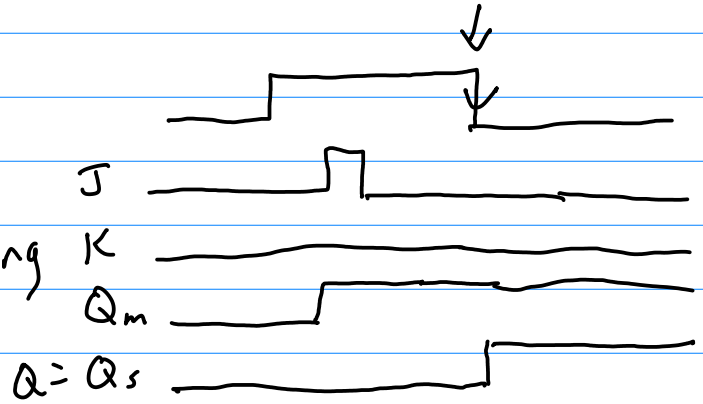
JK Master-Slave



Effecively samples on the falling edge of the clock

Ones Catching:

It is not "true" edge-triggering



JK from a T - homework

T from a JK

J	K	Q^+
0	0	Q
0	1	0
1	0	1
1	1	$\bar{Q}$

→

J	K	Q	Q^+	T
0	0	0	0	0
0	0	1	1	0
0	1	0	0	0
0	1	1	0	1
1	0	0	1	1
1	0	1	1	0
1	1	0	1	1
1	1	1	0	1

Excitation table

Q	Q^+	T
0	0	0
0	1	1
1	0	1
1	1	0

Q \ J,K	00	01	11	10
0	0	1	1	0
1	0	1	1	0

$T = KQ + J\bar{Q}$