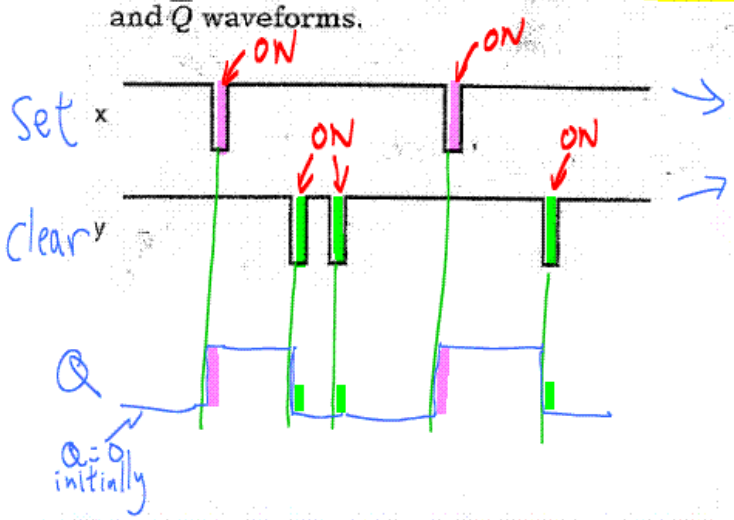
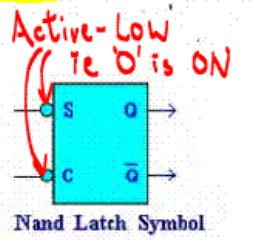
5-1. Assuming that $Q = 0$ initially, apply the x and y waveforms of Figure 5-73 to the SET and CLEAR inputs of a NAND latch, and determine the Q and $\bar{Q}$ waveforms.



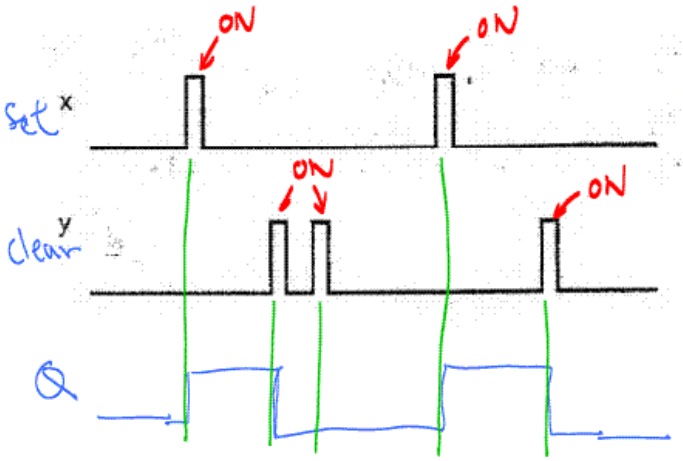


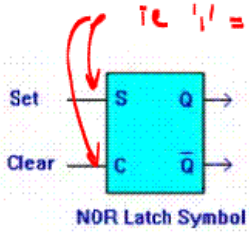
S	C	Q
0	0	Invalid ($Q = \bar{Q}$!)
0	1	1 (Set)
1	0	0 (Clear)
1	1	No Change

User should avoid !

5-2. Invert the x and y waveforms of Figure 5-73, apply them to the SET and CLEAR inputs of a NOR latch, and determine the Q and $\bar{Q}$ waveforms. Assume that $Q = 0$ initially.

No bubble → Active-HIGH
ie '1' = ON

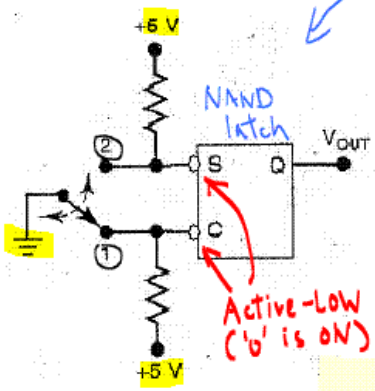


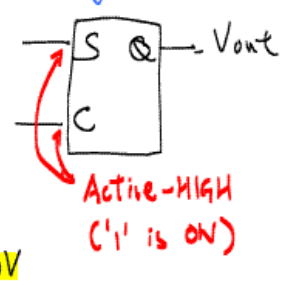


S	C	Q
0	0	No change
0	1	0 (Clear)
1	0	1 (Set)
1	1	Invalid

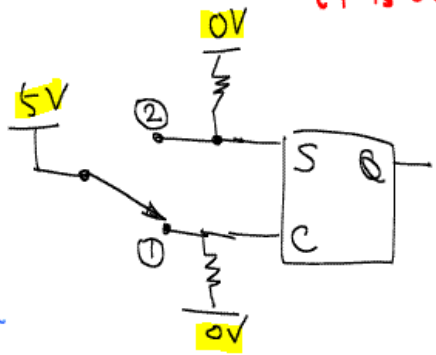
P·182 : Debounced switch using NAND latch

→ 5-4. Modify the circuit of Figure 5-9 to use a NOR gate latch.





Ans.

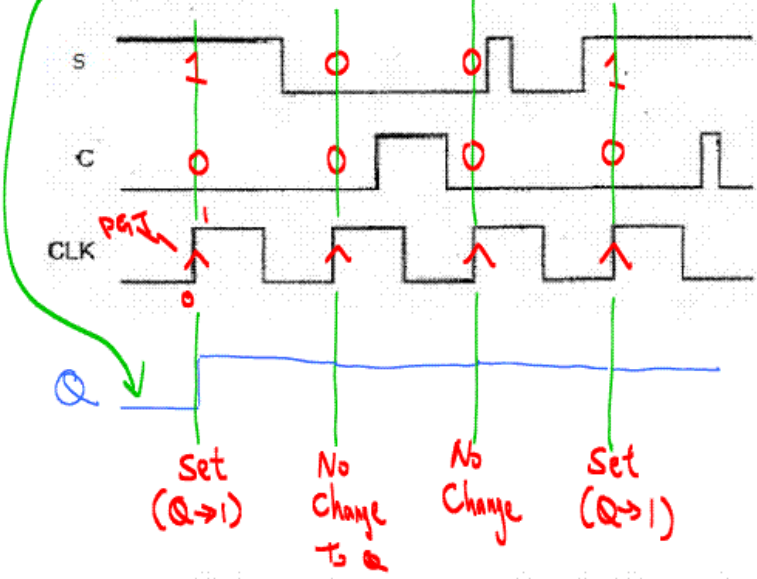


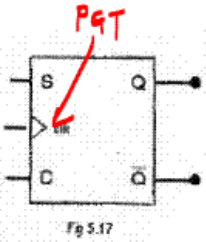
Comparison

	At ①	Between ① & ②	At ②
NAND latch (Active-LOW i/Ps ie '0' is ON)	S = 1 (5V) = OFF C = 0 (0V) = ON Hence Q → 0 (Cleared)	S = 1 (5V) = OFF C = 1 (5V) = OFF Hence Q → No Change	S = 0 (0V) = ON C = 1 (5V) = OFF Hence Q → 1 (Set)
NOR latch (Active-HIGH i/Ps ie '1' is ON)	S = 0 (0V) = OFF C = 1 (5V) = ON Hence Q → 0 (Cleared)	S = 0 (0V) = OFF C = 0 (0V) = OFF Hence Q → No Change	S = 1 (5V) = ON C = 0 (0V) = OFF Hence Q → 1 (Set)

5-9. Apply the waveforms of Figure 5-76 to the FF of Figure 5-17 and determine the waveform at Q. Assume $Q = 0$ initially.

Figure 5-76

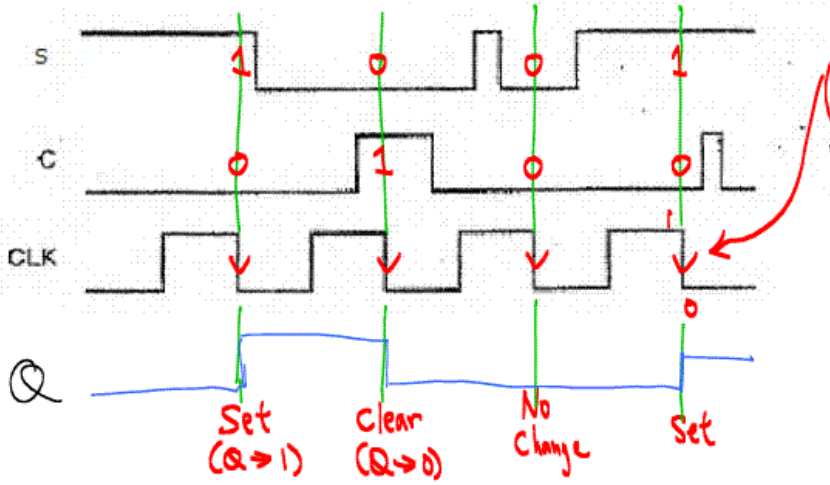


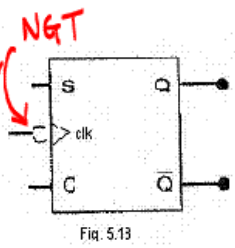


S-C ff.

S	C	CLK	Q
0	0	↑	No Change
0	1	↑	0 (Clear)
1	0	↑	1 (Set)
1	1	↑	Invalid

Repeat for the FF of Figure 5-18. Assume $Q = 0$ initially.

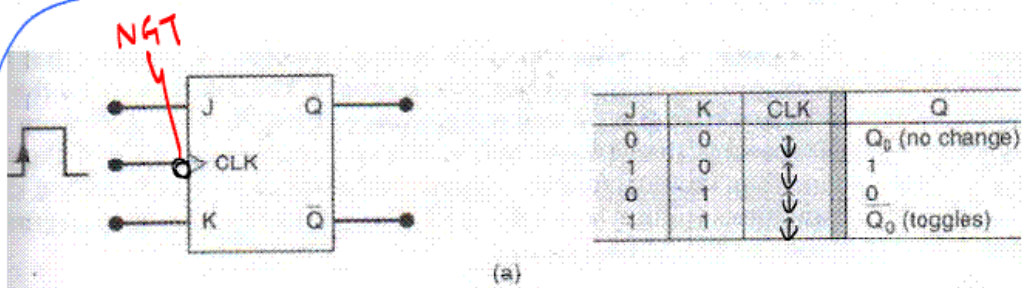




SECTION 5-6

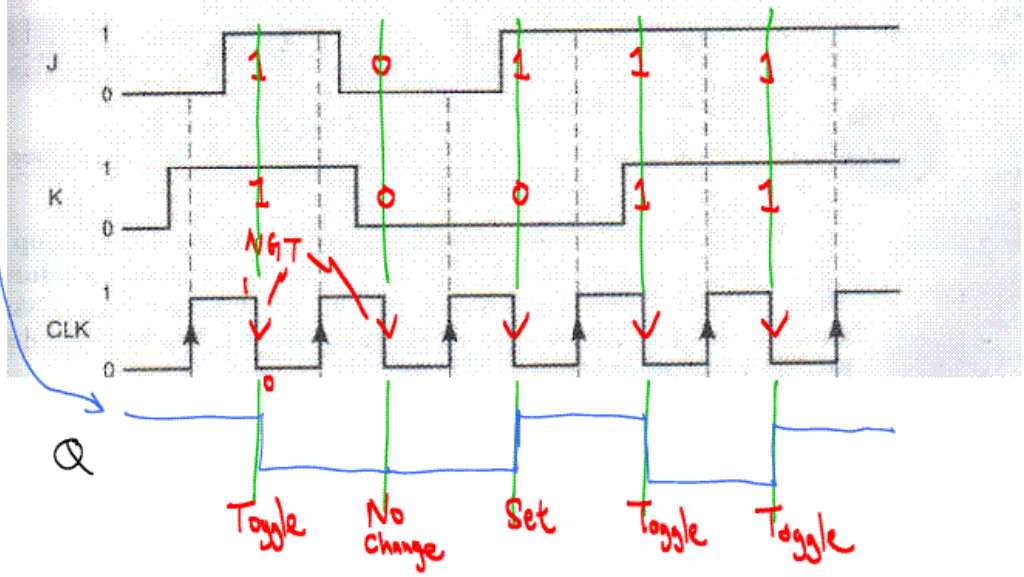
P.193 J-K (NGT) P.194

→5-10. Apply the *J*, *K*, and *CLK* waveforms of Figure 5-21 to the FF of Figure 5-22. Assume that $Q = 1$ initially, and determine the *Q* waveform.



J	K	CLK	Q
0	0	↓	Q_0 (no change)
1	0	↓	1
0	1	↓	0
1	1	↓	Q_0 (toggles)

(a)

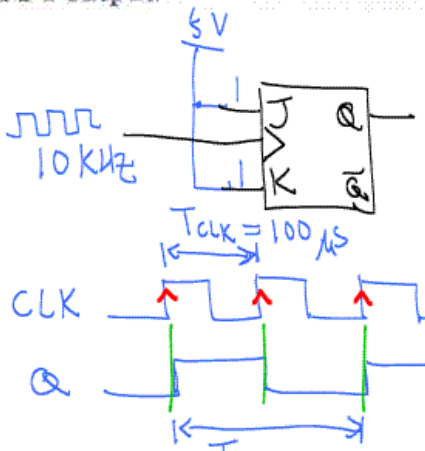


Assume PGT Toggle mode: J, K = 1, 1

5-11. (a) Show how a J-K flip-flop can operate as a *toggle* FF (changes state on each clock pulse). Then apply a 10-kHz clock signal to its *CLK* input and determine the waveform at *Q*.

(b) Connect *Q* from this FF to the *CLK* input of a second J-K FF that also has $J = K = 1$. Determine the frequency of the signal at this FF's output.

(a)



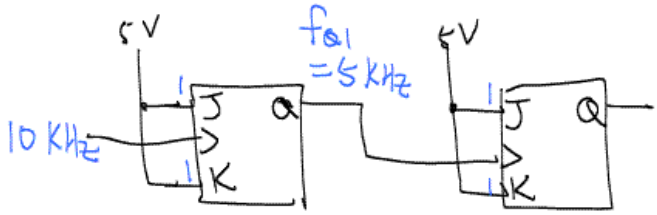
$f_{CLK} = 10\ kHz \Rightarrow T_{CLK} = \frac{1}{f_{CLK}} = \frac{1}{10 \times 10^3\ Hz} = 0.1 \times 10^{-3}\ s = 0.1\ ms = 100\ \mu s$

$T_Q = 200\ \mu s \rightarrow f_Q = \frac{1}{T_Q} = \frac{1}{200\ \mu s} = \frac{1}{200 \times 10^{-6}} = 5000\ Hz$

$f_Q = 5\ kHz$

$f_Q = \frac{1}{2} f_{CLK}$ — ie freq. has been divided by 2

(b)



$f_{Q1} = \frac{10\ kHz}{2} = 5\ kHz$

$f_{Q2} = \frac{5\ kHz}{2} = 2.5\ kHz$

5-13. A D FF is sometimes used to *delay* a binary waveform so that the bi-
nary information appears at the output a certain amount of time after
it appears at the *D* input.

(a) Determine the *Q* waveform in Figure 5-78, and compare it with the input waveform. Note that it is delayed from the input by one clock period. (T_{CLK})

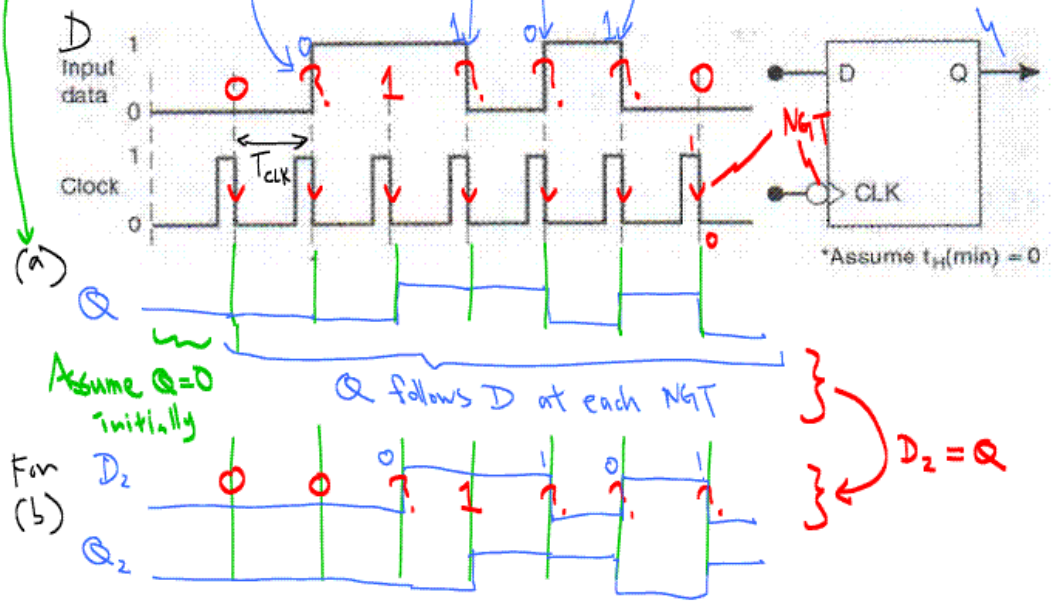
(b) How can a delay of two clock periods be obtained?

(below)

Assume 0 hold-time requirement

Take the value of D just before the NGT

Q follows D at each NGT



(a)

Assume Q=0 initially

Q follows D at each NGT

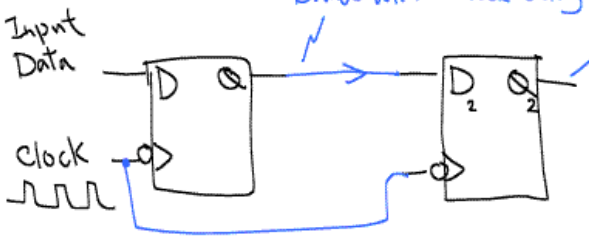
$D_2 = Q$

For (b)

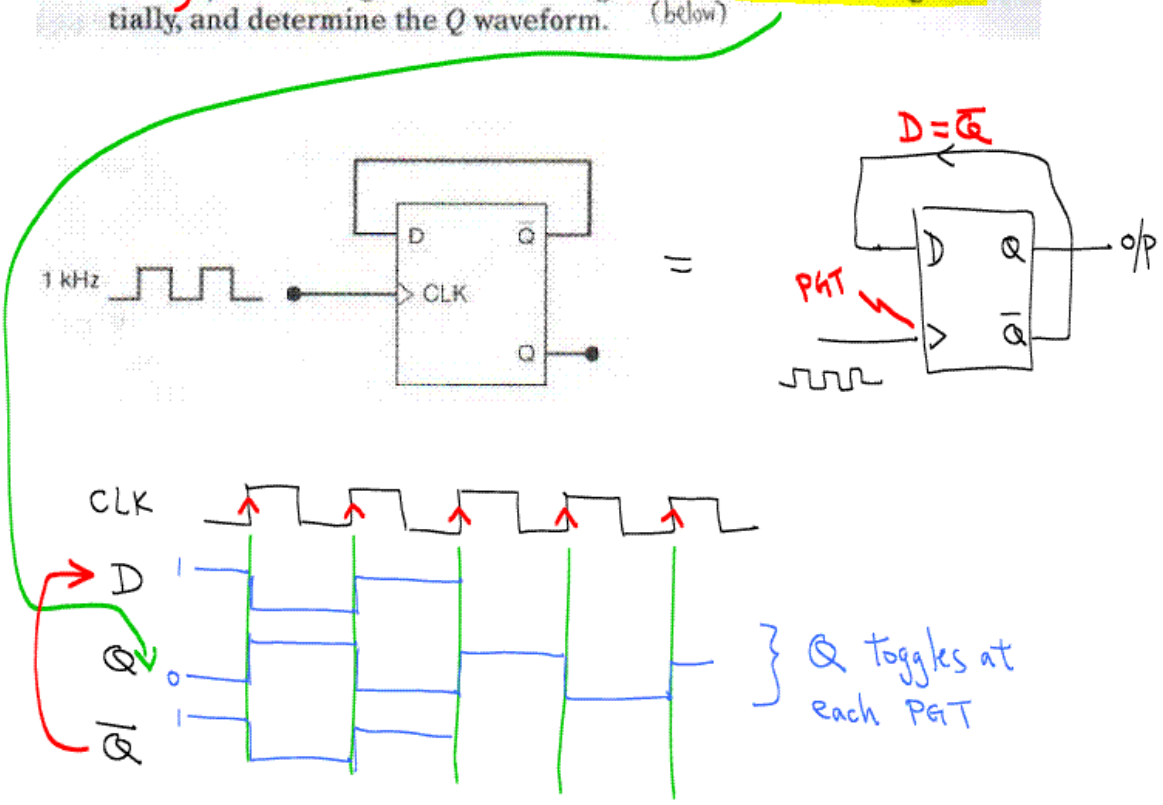
(b)

Data with 1 T_{CLK} delay

Data with 2 T_{CLK} delay



5-15. An edge-triggered D flip-flop can be made to operate in the toggle mode by connecting it as shown in Figure 5-79. Assume that $Q = 0$ initially, and determine the Q waveform. (below)

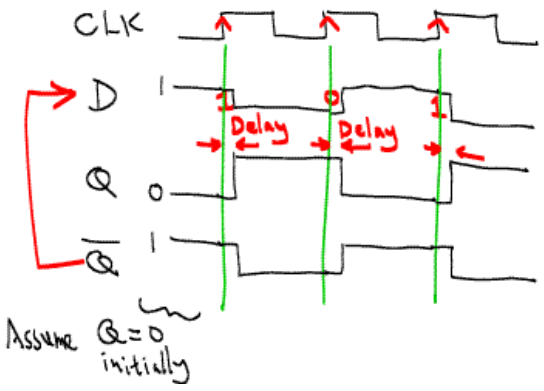


Initially $Q=0 \rightarrow \bar{Q}=1 = D$

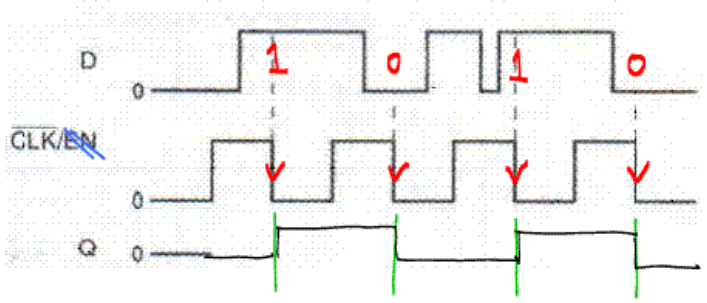
At the 1st PGT, Q follows D → Q=1 (After PGT) (Hence $\bar{Q} \rightarrow 0$, $\bar{D} \rightarrow 0$)

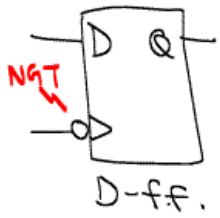
At the 2nd PGT, Q " D → Q=0 (" $\bar{Q} \rightarrow 1$, $\bar{D} \rightarrow 1$)

Alternative explanation — using propagation delay:

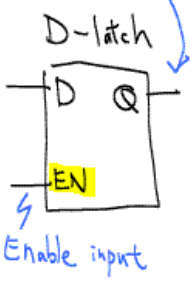


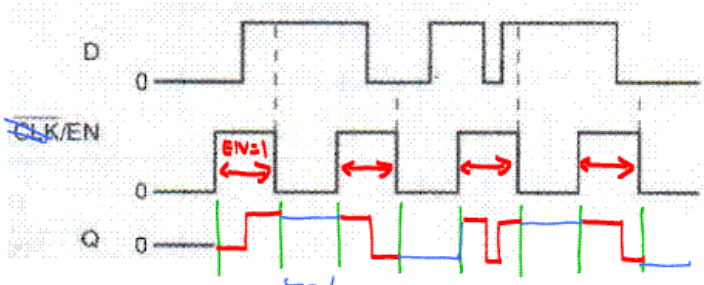
5-18. Compare the operation of the *D* latch with a negative-edge-triggered D flip-flop by applying the waveforms of Figure 5-80 to each and determining the *Q* waveforms. (below)





Q=D when EN=1
Q has no change when EN=0





Q has no change (when EN=0)

Q=D (when EN=1)