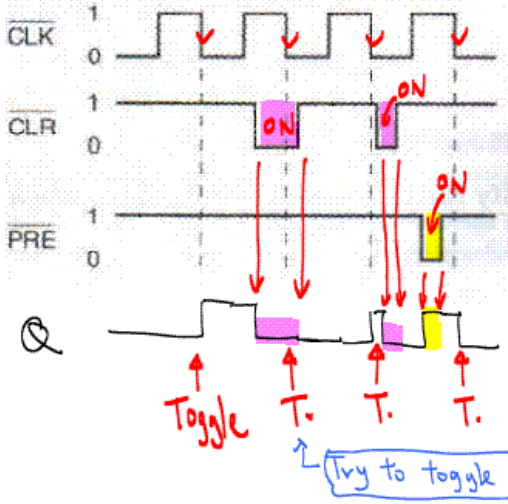
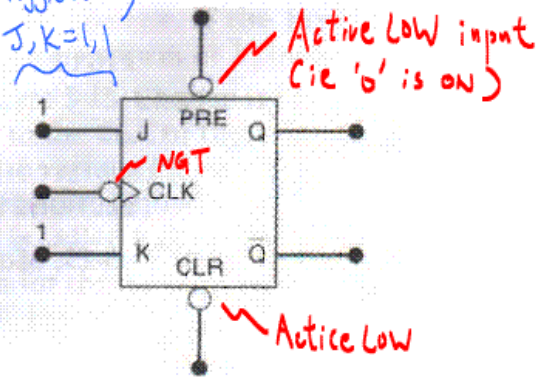
5-20. Determine the Q waveform for the FF in Figure 5-81 (below). Assume that $Q = 0$ initially, and remember that the asynchronous inputs override all other inputs.

ie PRE & CLR

Q can change only when either this is a NGT or the PRE/CLR is ON.



(Toggle mode) J, K = 1, 1



PRESET: immediately make Q = 1

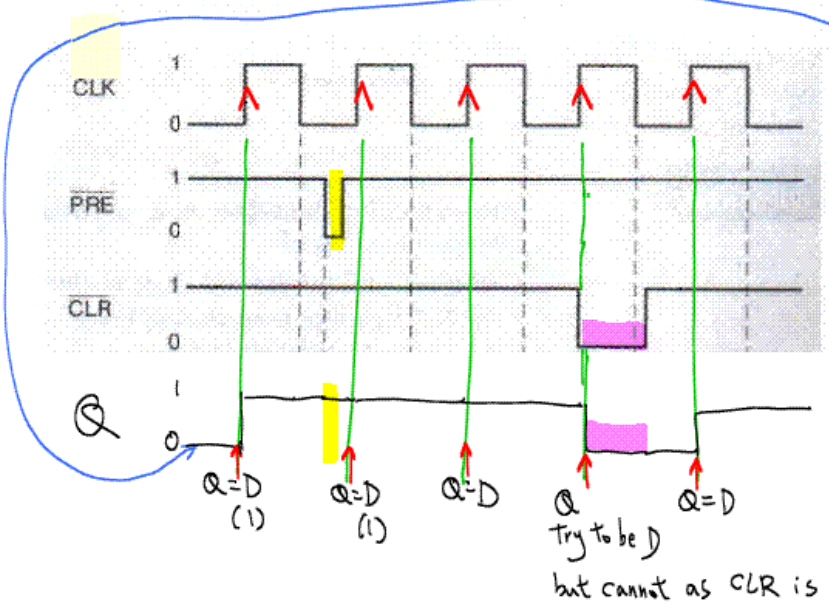
CLEAR: " " Q = 0

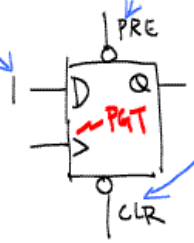
Try to toggle, but cannot as CLR is still ON.

'0' is ON ('1' is OFF)

PGT

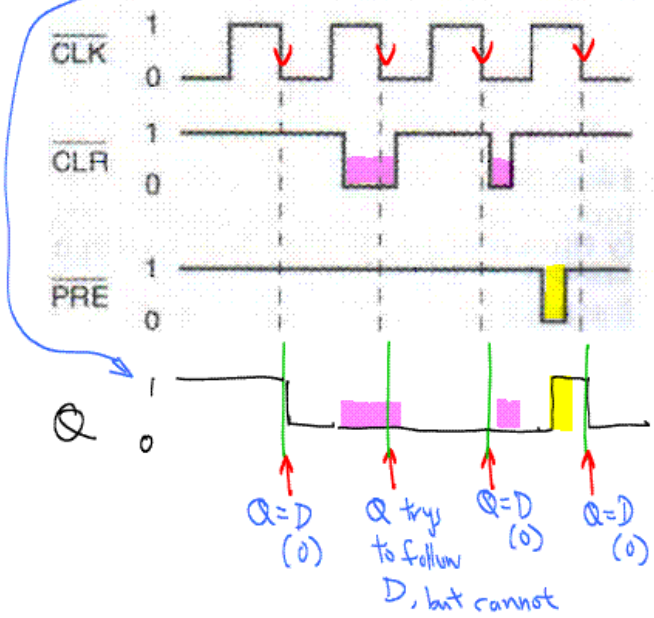
5-21. Apply the $\overline{CLK}$, $\overline{PRE}$, and $\overline{CLR}$ waveforms of Figure 5-30 to a positive-edge-triggered D flip-flop with active-LOW asynchronous inputs. Assume that D is kept HIGH and Q is initially LOW. Determine the Q waveform.

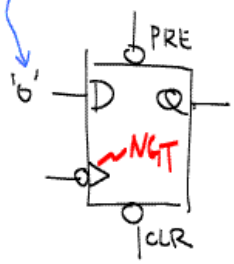




PRE & CLR have higher priority than the D and CLK i/Ps or J,K

5-22. Apply the waveforms of Figure 5-81 to a D flip-flop that triggers on NGTs and has active-LOW asynchronous inputs. Assume that D is kept LOW and that Q is initially HIGH. Draw the resulting Q waveform.





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5-23. Use Table 5-2 in Section 5-11 to determine the following.

(a) How long can it take for the *Q* output of a 74C74 to switch from 0 to 1 in response to an active *CLK* transition?

(b) Which FF in Table 5-2 requires its control inputs to remain stable for the longest time *after* the active *CLK* transition? *Before* the transition? ⇒ t_H ie PHT / NHT ⇒ t_S

(c) What is the narrowest pulse that can be applied to the $\overline{PRE}$ of a 7474 FF? ⇒ t_W

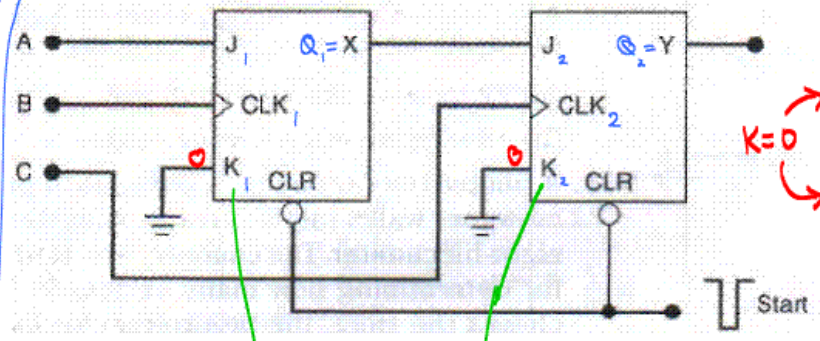
		TTL		CMOS	
		7474	74LS112	74C74	74HC112
t_S	(Setup time)	20	20	60	25
t_H	(Hold time)	5	0	0	0
t_{PHL}	from *CLK* to *Q*	40	24	200	31
t_{PLH}	from *CLK* to *Q*	25	16	200	31
t_{PHL}	from $\overline{CLR}$ to *Q*	40	24	225	41
t_{PLH}	from $\overline{PRE}$ to *Q*	25	16	225	41
$t_W(L)$	*CLK* LOW time	37	15	100	25
$t_W(H)$	*CLK* HIGH time	30	20	100	25
$t_W(L)$	at $\overline{PRE}$ or $\overline{CLR}$	30	15	60	25
f_{MAX}	in MHz	15	30	5	20

5-26. In the circuit of Figure 5-83, inputs *A*, *B*, and *C* are all initially LOW. Output Y is supposed to go HIGH only when *A*, *B*, and *C* go HIGH in a certain sequence.

(a) Determine the sequence that will make Y go HIGH.

(b) Explain why the START pulse is needed. – for clearing Q_1 & Q_2 (to 0)

(c) Modify this circuit to use D FFs.



Like Set Clear

J	K	CLK	Q
0	0	↑	No change
0	1	↑	0 Clear
1	0	↑	1 Set
1	1	↑	Toggle

K=0

(a)

$Y = Q_2 \to 1$ when $J_2, K_2 = 1, 0$ while CLK_2 goes 1 (PGT at CLK_2)

X — when will it go 1? C

$X = Q_1 \to 1$ when $J_1, K_1 = 1, 0$ while CLK_1 goes 1 (PGT at CLK_1)

A B

Hence the seq. is:

1. A (J_1) goes 1 first (before the PGT at CLK_1)
2. B (CLK_1) then goes 1 (to give the PGT at CLK_1, hence $Q_1 \to 1$)
3. C (CLK_2) then goes 1 (∵ ∵ ∵ ∵ ∵ CLK_2, ∵ $Q_2 \to 1$)

(c) Compare the truth-table between J-K ff. vs D f.f:

J	K	CLK	Q
0	0	↑	No change
0	1	↑	0
1	0	↑	1
1	1	↑	Toggle

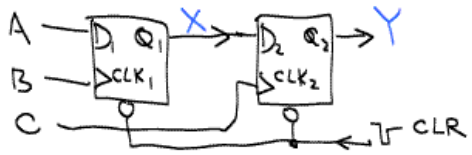
K=0

D	CLK	Q
0	↑	0
1	↑	1

Any similarity?

Seq.:

1. A (D_1) goes 1 first
2. B (CLK_1) then goes 1
3. C (CLK_2) ∵ ∵ 1



5-35. A photodetector circuit is being used to generate a pulse each time a customer walks into a certain establishment. The pulses are fed to an eight-bit counter. The counter is used to count these pulses as a means for determining how many customers have entered the store. After closing the store, the proprietor checks the counter and finds that it shows a count of $00001001_2 = 9_{10}$. He knows that this is incorrect because there were many more than nine people in his store. Assuming that the counter circuit is working properly, what could be the reason for the discrepancy?

8-bit → 2^8 = 256 nos (0 to 255)

ie 8 ff.s

If there were 255 people → count 255

" " " 256 " → " 0

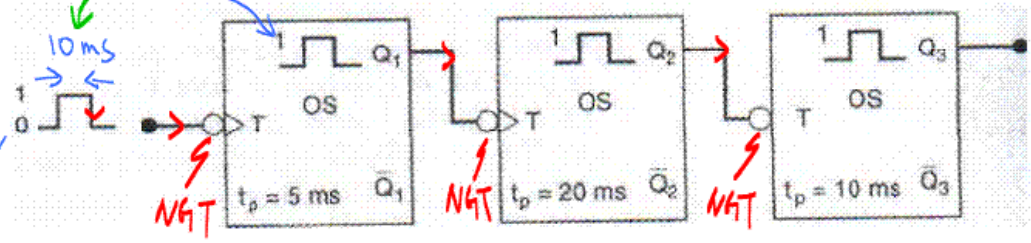
" " " 256+9 " → " 9

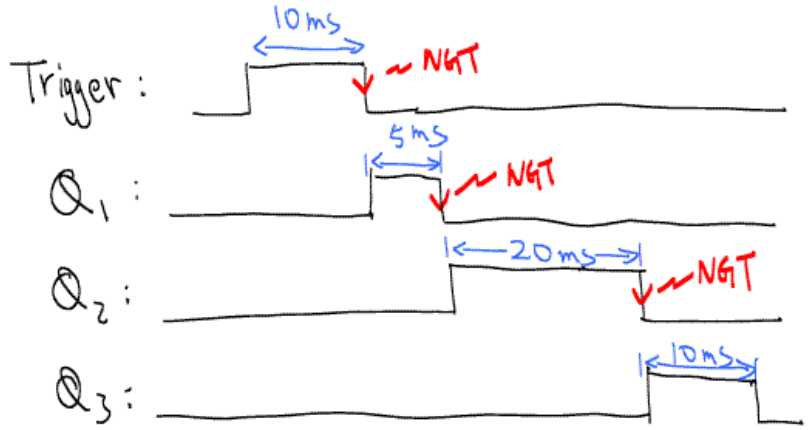
" " " (2×256)+9 " → " 9

" " " (N×256)+9 " → " 9

(ie will ignore any NGT while Q is still 1)

5-40. Figure 5-84 shows three nonretriggerable one-shots connected in a timing chain that produces three sequential output pulses. Note the "1" in front of the pulse on each OS symbol to indicate nonretriggerable operation. Draw a timing diagram showing the relationship between the input pulse and the three OS outputs. Assume an input pulse duration of 10 ms.





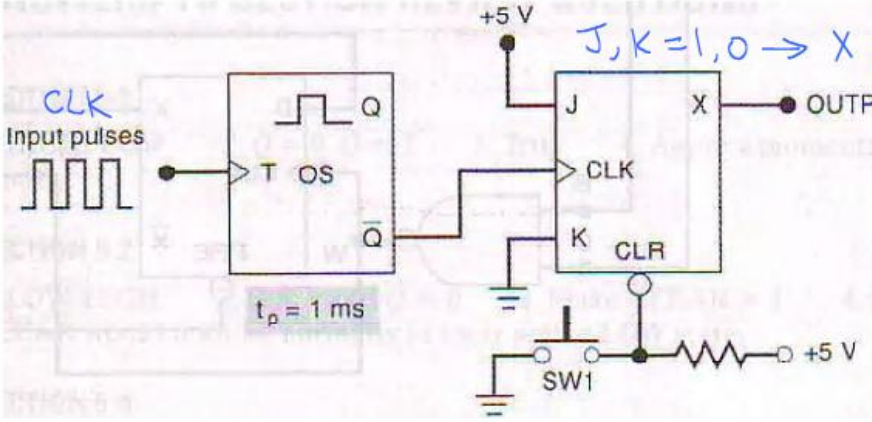
(ie while Q = 1, any PGT will re-trigger the timing and hence extends the pulse)

5-41. A *retriggerable* OS can be used as a pulse-frequency detector that detects when the frequency of a pulse input is below a predetermined value. A simple example of this application is shown in Figure 5-85. The operation begins by momentarily closing switch SW1.

(a) Describe how the circuit responds to input frequencies above 1 kHz.

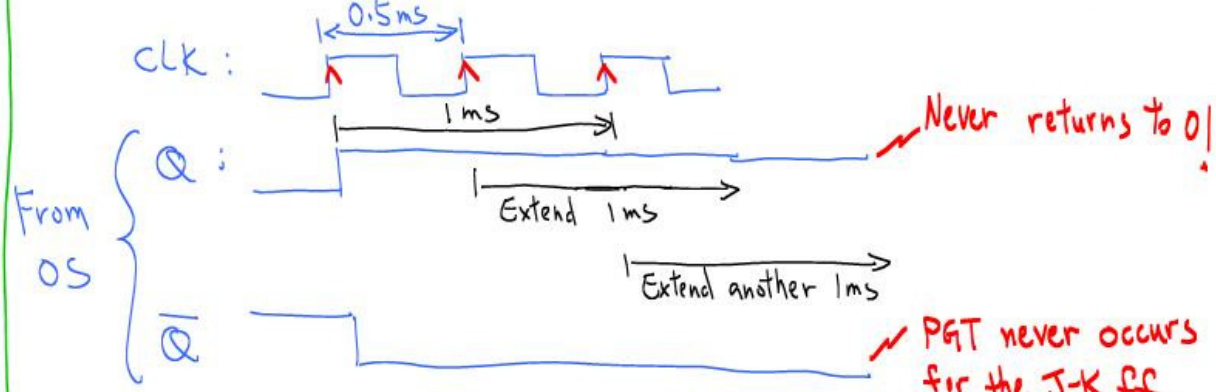
(b) Describe how the circuit responds to input frequencies below 1 kHz.

(c) How would you modify the circuit to detect when the input frequency drops below 50 kHz?



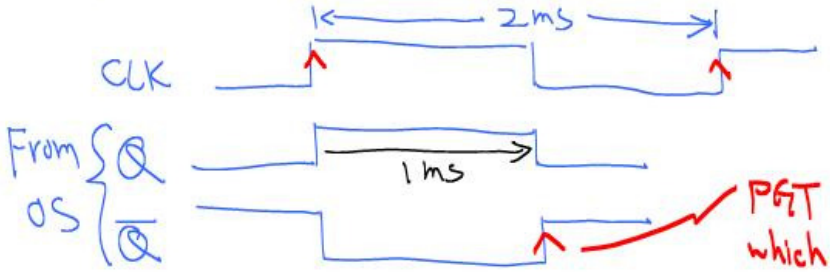
J, K = 1, 0 → X goes 1 when there is PGT at its CLK.

(a) f > 1 kHz (e.g. 2 kHz → $T = \frac{1}{2}$ ms = 0.5 ms)



PGT never occurs for the J-K ff. (Hence X never goes 1)

(b) f < 1 kHz (e.g. 0.5 kHz → T = 2 ms)



PGT for the J-K ff. which causes X → 1.

Q41 (c)

$t_p = 1\,ms \rightarrow$ detects $f = \frac{1}{1\,ms} = 1\,KHz$

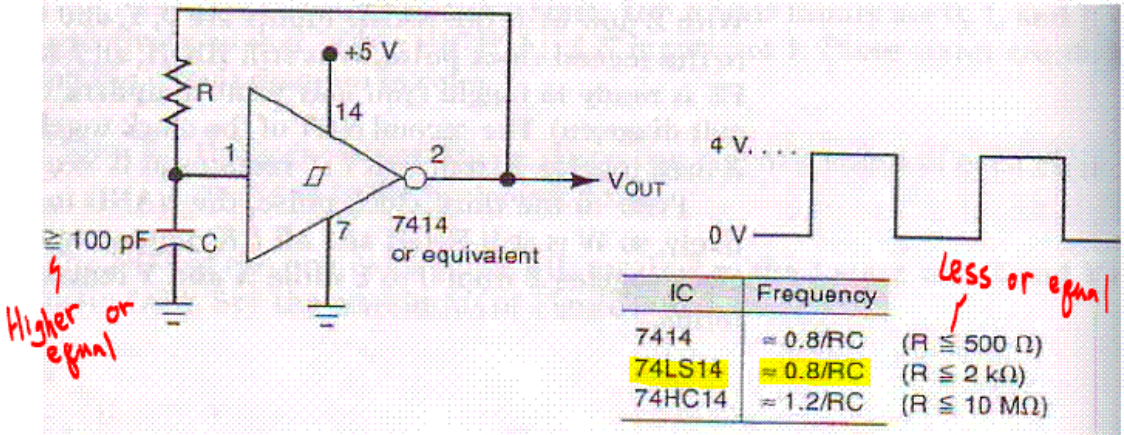
t_p of the OS

For $f = 50\,KHz \rightarrow t_p = \frac{1}{50\,KHz}$

$= 0.02\,ms$

$t_p = \underline{20\,\mu s}$

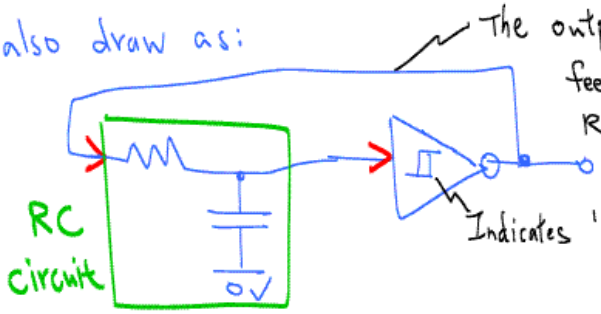
→ 5-45. Show how to use a 74LS14 Schmitt-trigger INVERTER to produce a approximate square wave with a frequency of 10 kHz.



IC	Frequency	
7414	≈ 0.8/RC	(R ≦ 500 Ω)
74LS14	≈ 0.8/RC	(R ≦ 2 kΩ)
74HC14	≈ 1.2/RC	(R ≦ 10 MΩ)

FIGURE 5-54 Schmitt-trigger oscillator using a 7414 INVERTER. A 7413 Schmitt-trigger NAND may also be used.

Can also draw as:



The output of the Schmitt Trigger inverter feeds back to its input via the RC circuit

Indicates 'Schmitt Trigger' type

$$f = \frac{0.8}{RC}$$

For example, let us choose $C = 1\ nF\ (10^{-9})$

$$10 \times 10^3 = \frac{0.8}{R \times (1 \times 10^{-9})}\ Hz \Rightarrow R = 0.8 \times 10^5\ \Omega$$

$$= 800\ k\Omega$$

Too big: must ≦ 2kΩ

Now try $C = 1\ \mu F\ (10^{-6})$

$$10 \times 10^3 = \frac{0.8}{R \times (1 \times 10^{-6})}\ Hz \Rightarrow R = 0.8 \times 10^2\ \Omega$$

$$= 800\Omega$$ — OK ✓