江西理工大学
Jiangxi University of Science and Technology
信息工程学院
School of information engineering

Dr Ata Jahangir Moshayedi

Digital System Design

Clip Lecture series

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Prof Associate , School of information engineering Jiangxi university of science and technology, China
EMAIL: ajm@jxust.edu.cn

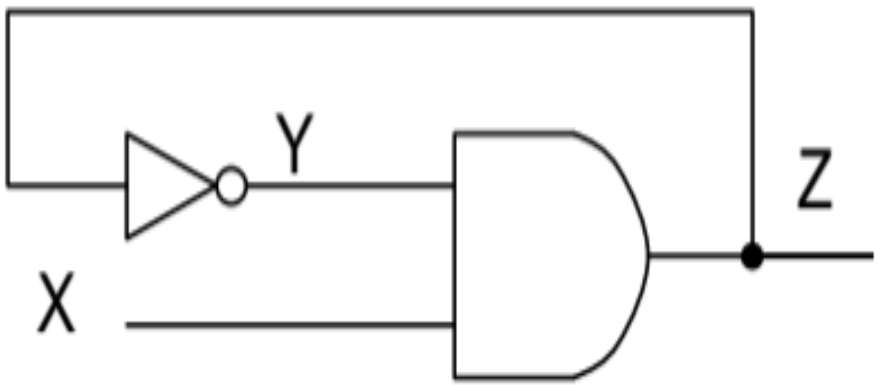
Jiangxi University of Science and Technology

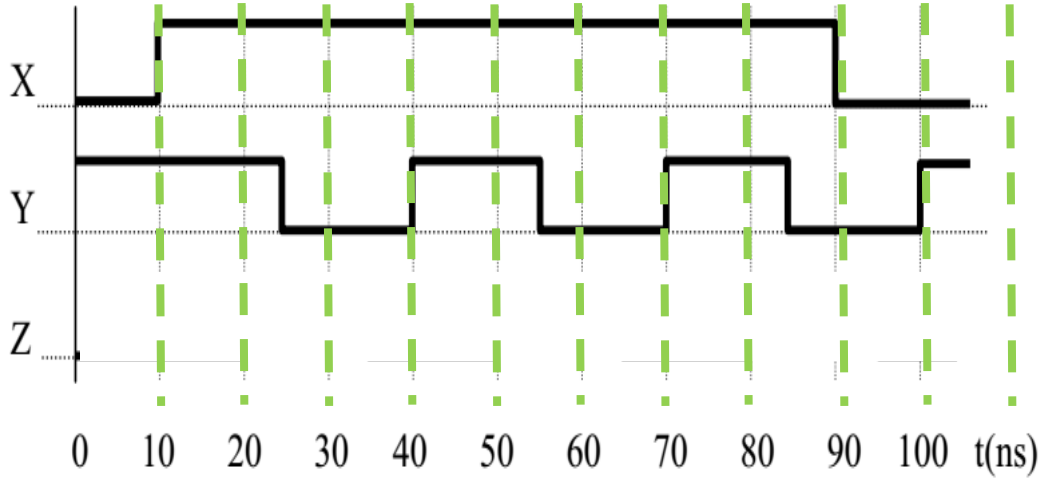
Sequential Circuits

9 Example and review: Flip-flop/Basic Flip-Flop

Example_1

Assume that the inverter in the network below has a propagation delay of 5 ns and the AND gate has a propagation delay of 10 ns. Draw a timing diagram for the network showing X, Y, and Z. Assume that X is initially 0, Y is initially 1, X becomes 1 for 80 ns, and then X is 0 again.

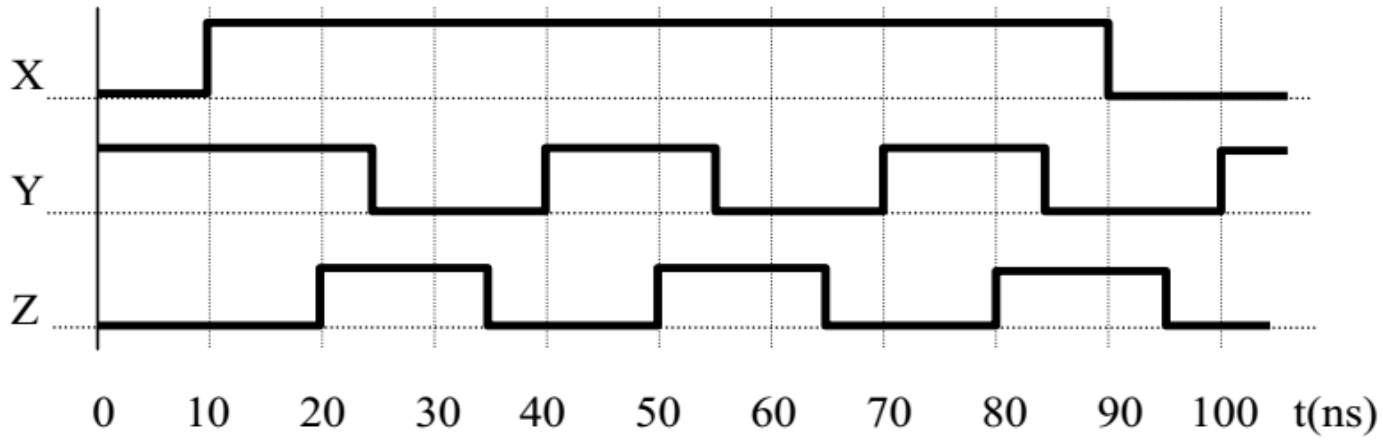


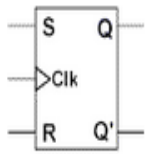
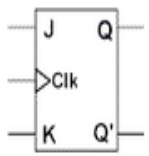
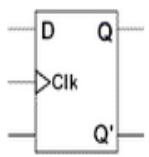
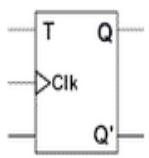


Example_1(solution)

Solution 1. You must remember to take into account delays. Steps for the solution:

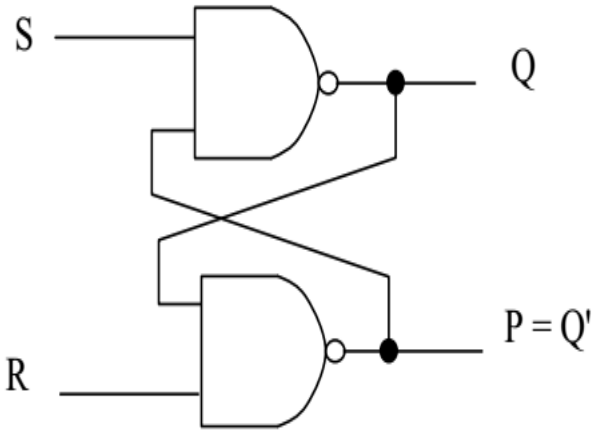
1. Draw an empty timing diagram
2. Write related characteristic equation: $Z = XY = XZ'$
3. Plot initial states for X and Y
4. Plot remaining diagram by considering appropriate delays



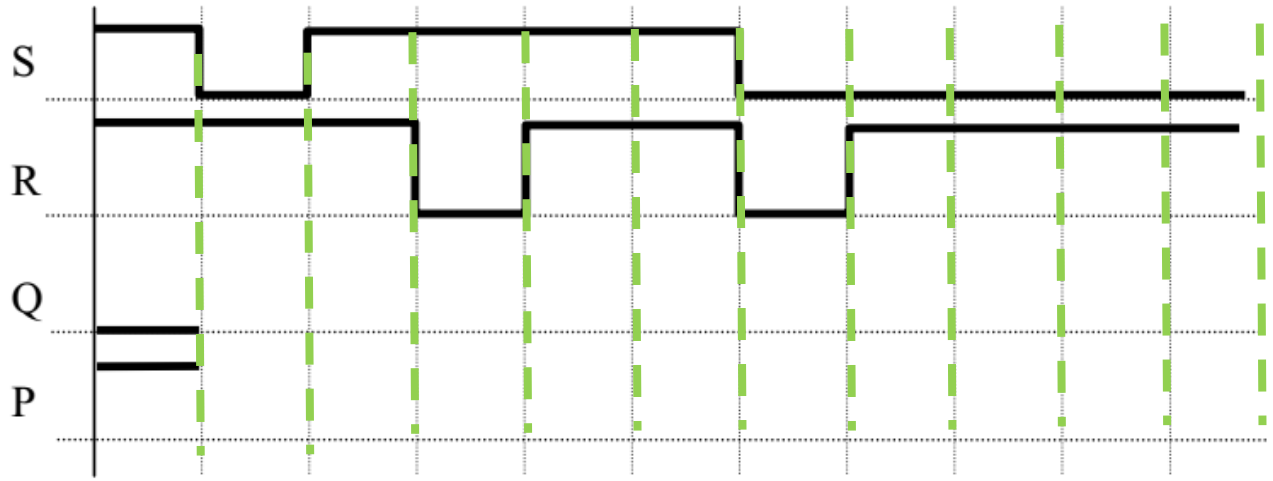
FLIP-FLOP NAME	FLIP-FLOP SYMBOL	CHARACTERISTIC TABLE	CHARACTERISTIC EQUATION	EXCITATION TABLE
SR		**S** | **R** | **$Q_{(next)}$** 0 | 0 | Q 0 | 1 | 0 1 | 0 | 1 1 | 1 | ?	$Q_{(next)} = S + R'Q$ $SR = 0$	**Q** | **$Q_{(next)}$** | **S** | **R** 0 | 0 | 0 | X 0 | 1 | 1 | 0 1 | 0 | 0 | 1 1 | 1 | X | 0
JK		**J** | **K** | **$Q_{(next)}$** 0 | 0 | Q 0 | 1 | 0 1 | 0 | 1 1 | 1 | Q'	$Q_{(next)} = JQ' + K'Q$	**Q** | **$Q_{(next)}$** | **J** | **K** 0 | 0 | 0 | X 0 | 1 | 1 | X 1 | 0 | X | 1 1 | 1 | X | 0
D		**D** | **$Q_{(next)}$** 0 | 0 1 | 1	$Q_{(next)} = D$	**Q** | **$Q_{(next)}$** | **D** 0 | 0 | 0 0 | 1 | 1 1 | 0 | 0 1 | 1 | 1
T		**T** | **$Q_{(next)}$** 0 | Q 1 | Q'	$Q_{(next)} = TQ' + T'Q$	**Q** | **$Q_{(next)}$** | **T** 0 | 0 | 0 0 | 1 | 1 1 | 0 | 1 1 | 1 | 0

Example_2

A flip-flop can be constructed from two NAND gates connected as follows:



(c) Complete the following timing diagram for the flip-flop.



Example_2(solution)

A δt time delay should be considered when constructing timing diagram. Although it is not required, drawing S', P', R', and Q' is helpful.

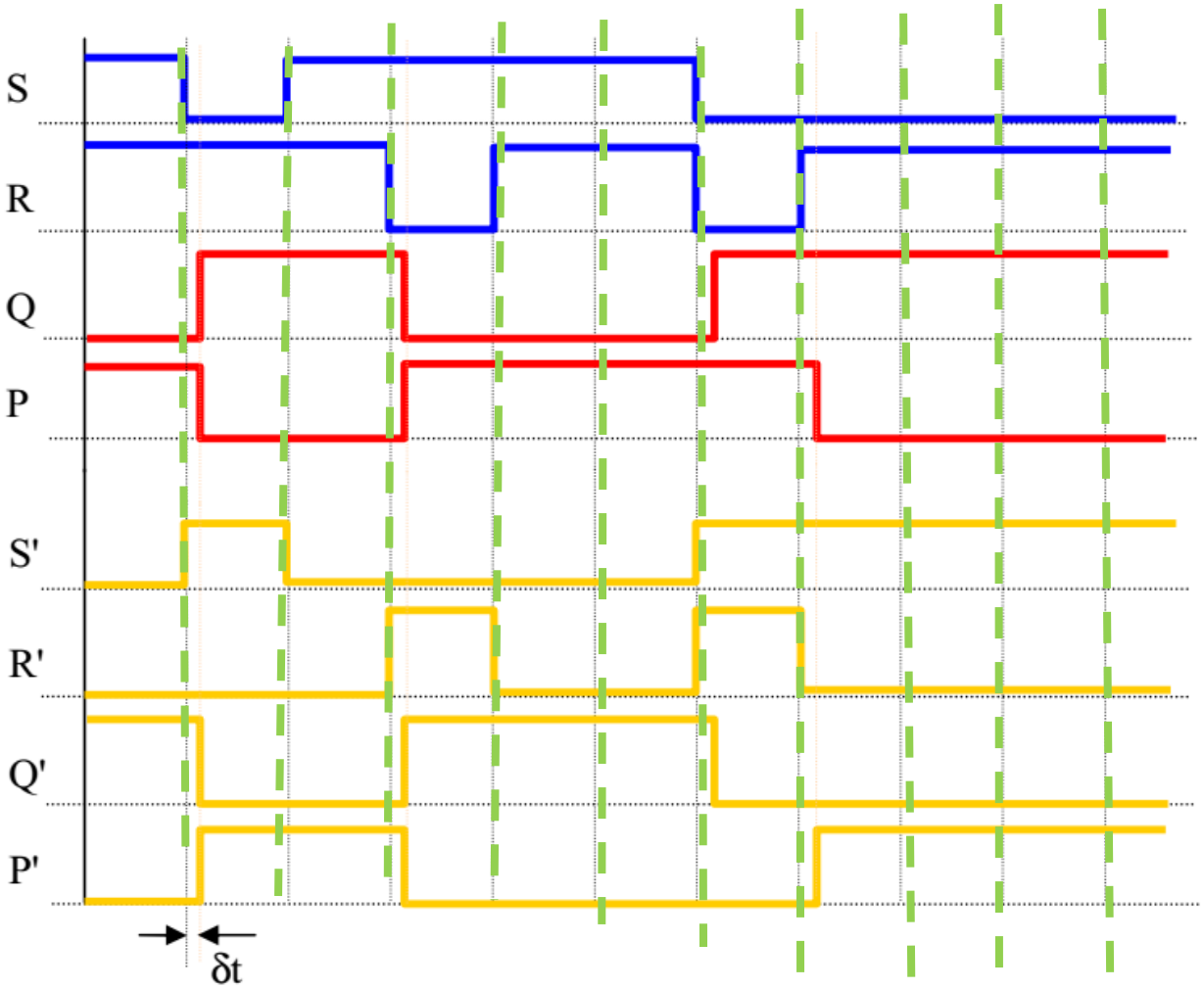
$Q = S'+P'$ $P = R'+Q'$

$Q_+ = S' + RQ$

CHARACTERISTIC TABLE		
S	R	$Q_{(next)}$
0	0	Q
0	1	0
1	0	1
1	1	?

$Q_{(next)} = S + R'Q$

$SR = 0$



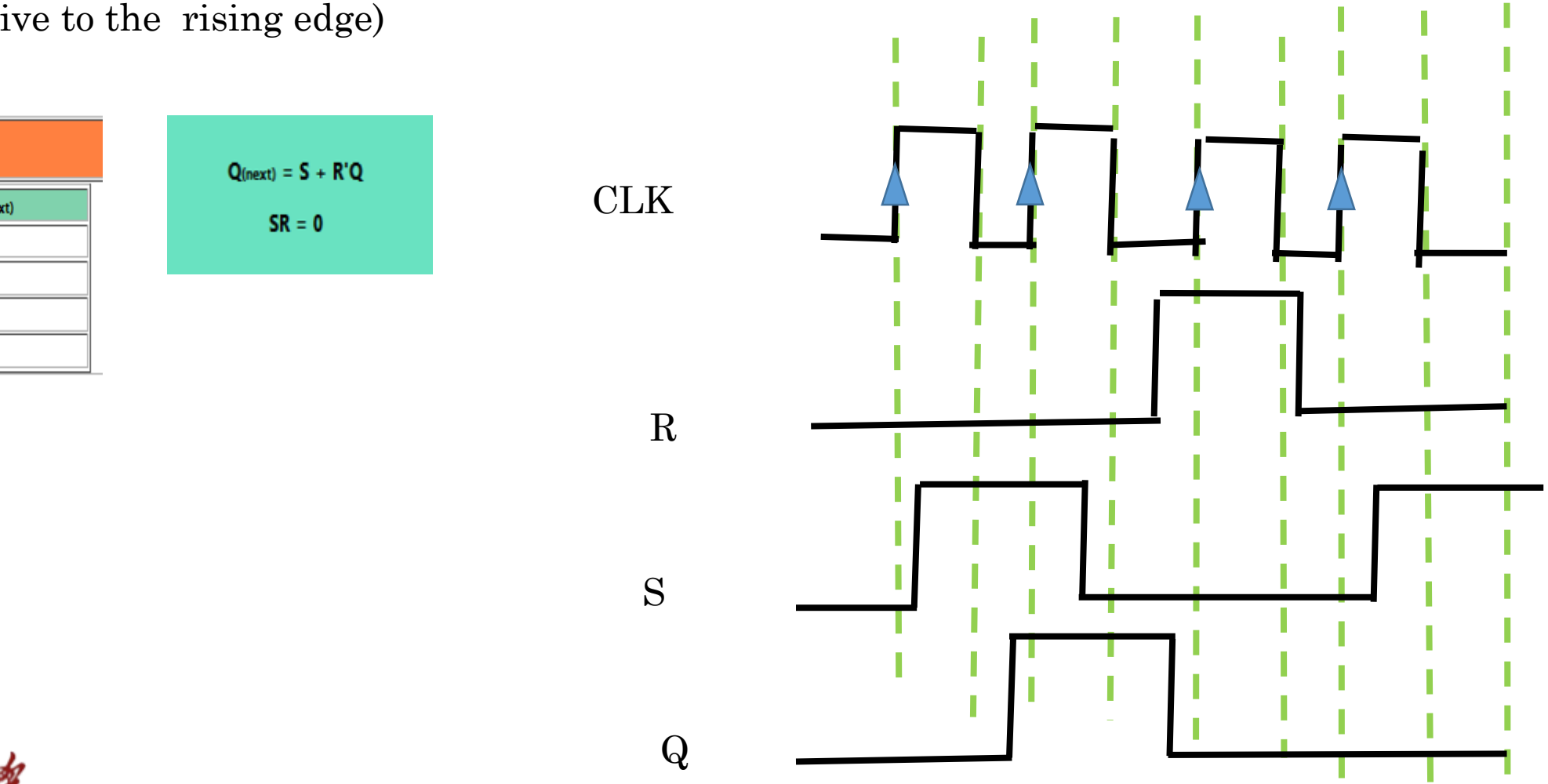
Example_3(solution)

Considering the RS _FF
Draw the Output Diagram if the initial value of is zero
(Q=0 and its sensitive to the rising edge)

CHARACTERISTIC TABLE		
S	R	$Q_{(next)}$
0	0	Q
0	1	0
1	0	1
1	1	?

$Q_{(next)} = S + R'Q$

$SR = 0$



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Make FF from each others

Example_7: Making the Flip flops

- WITH THE HELP OF D ff MAKE THE T TYPE

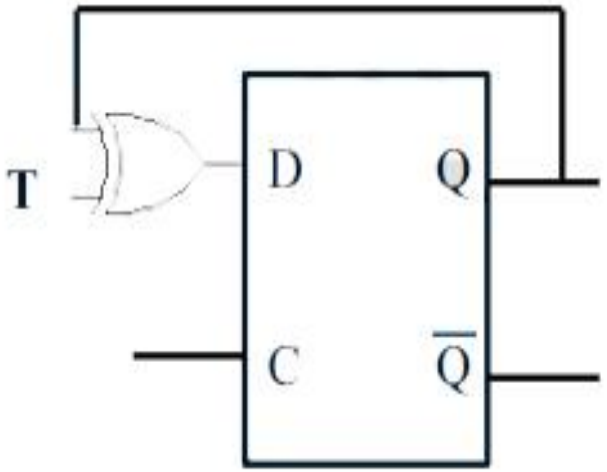
$$Q_{(next)} = D$$

D-FF equation : $Q^* = D$

T-FF equation : $Q^* = T \oplus Q$

$$D = T \oplus Q$$

$$Q_{(next)} = TQ' + T'Q$$



Example_8: Making the Flip flops

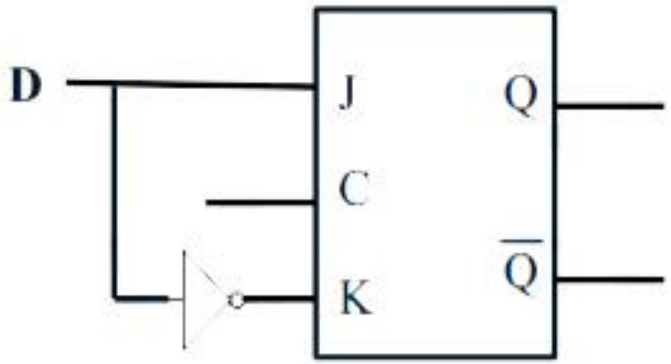
- WITH THE HELP OF JK ff MAKE THE D TYPE

$$Q_{(next)} = JQ' + K'Q$$

$D = 0 \rightarrow J = 0, K = 1 \rightarrow Q^* = 0$

$D = 1 \rightarrow J = 1, K = 0 \rightarrow Q^* = 1$

$$Q_{(next)} = D$$



Example_9: Making the Flip flops

- WITH THE HELP OF T FF make the JK ff

T-FF equation $Q^* = T \oplus Q$

$T = Q^* \oplus Q$

JK-FF equation $Q^* = J.\overline{Q} + \overline{K}.Q$

$T = (J.\overline{Q} + \overline{K}.Q) \oplus Q$

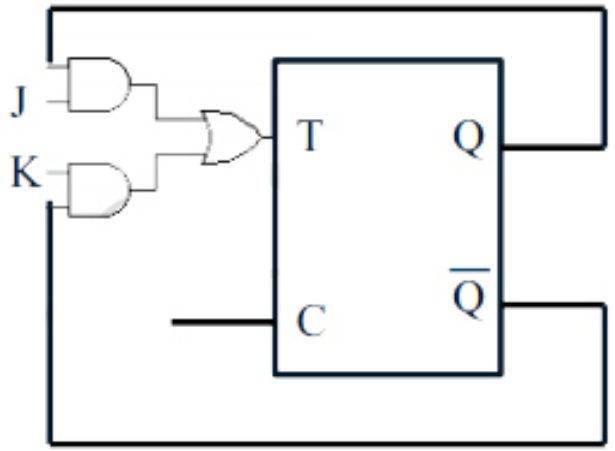
$Q_{(next)} = JQ' + K'Q$

$T = \overline{(J.\overline{Q} + \overline{K}.Q) .Q + (J.\overline{Q} + \overline{K}.Q).\overline{Q}}$

$Q_{(next)} = TQ' + T'Q$

$T = (\overline{J}+Q).(K+\overline{Q}).Q + J.\overline{Q}$

$T = K.Q + J.\overline{Q}$

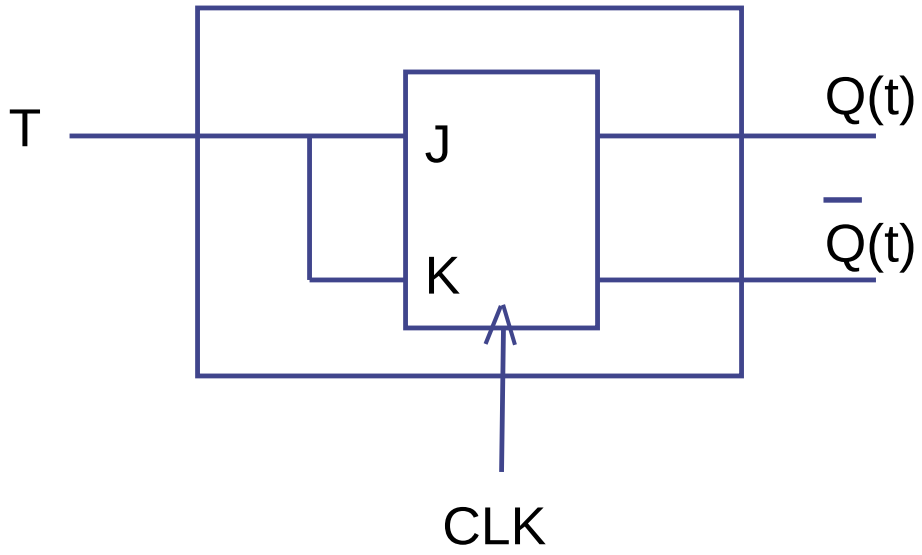


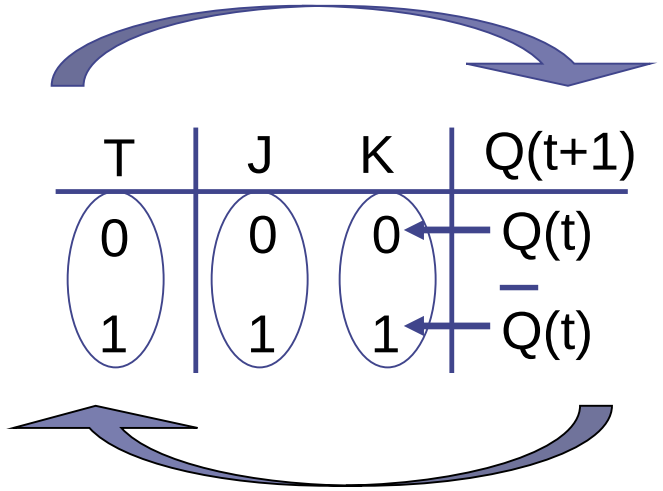
Example_4:

$$Q_{(next)} = JQ' + K'Q$$

$$Q_{(next)} = TQ' + T'Q$$

Make the T flip flop from JK FF



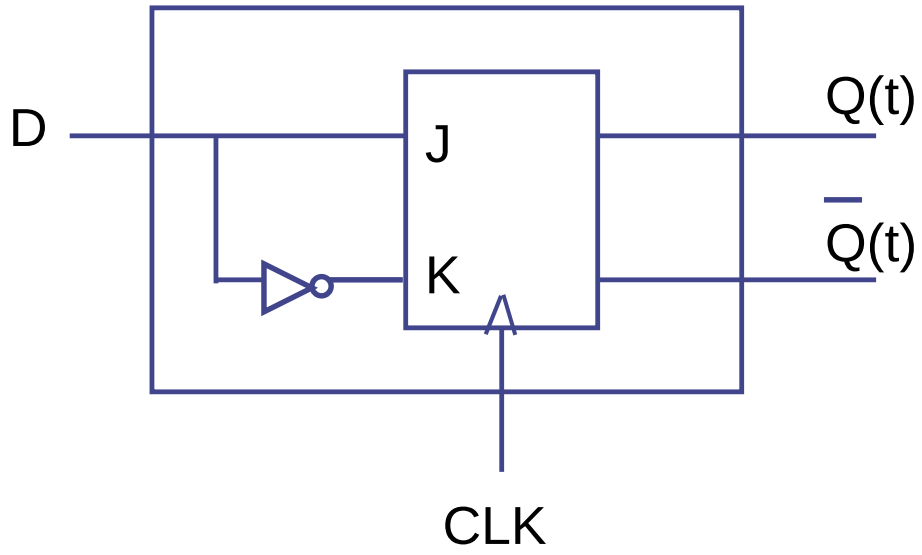


Example_5:

$Q_{(next)} = D$

$Q_{(next)} = JQ' + K'Q$

Make the D type flip flop From JK FF



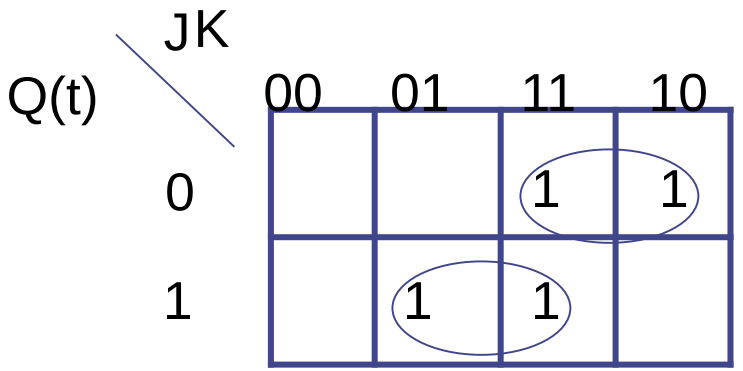
D	J	K	Q(t+1)
0	0	1	Q(t)
1	1	0	$\overline{Q(t)}$

not

Example_6:

Make the JK FF from T type flip flop

Q(t)	J	K	T	Q(t+1)
0	0	0	0	0
0	0	1	0	0
0	1	0	1	1
0	1	1	1	1
1	0	0	0	1
1	0	1	1	0
1	1	0	0	1
1	1	1	1	0



$T = J\overline{Q}(t) + K\,Q(t)$