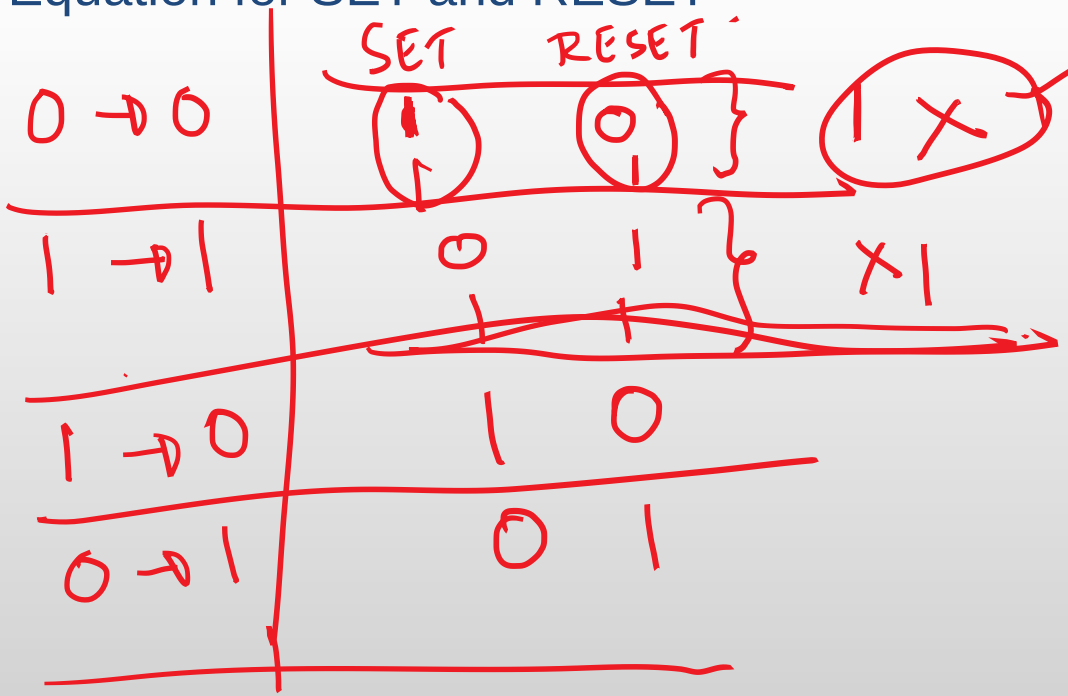
SEQUENTIAL CIRCUITS

- NAND Latch
- NOR Latch
- SR, D, JK, T flip flop

SR Flip Flop using NAND latch

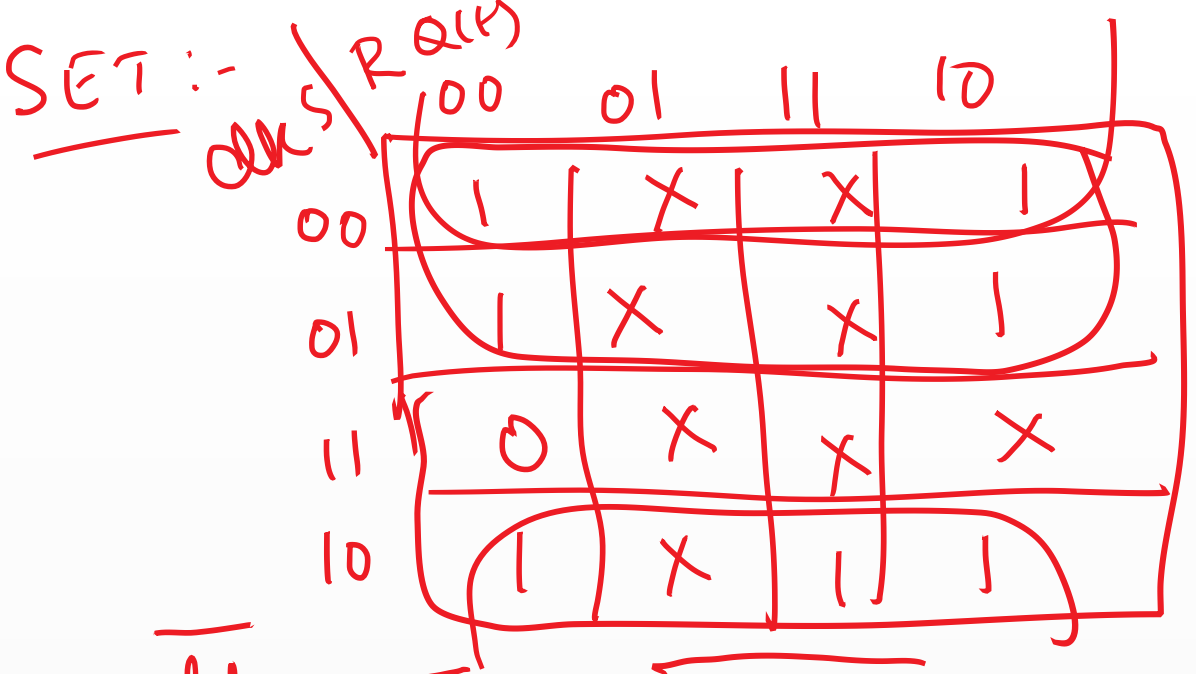
Function Table			
Clk	S	R	Output
0	X	X	No Change
1	0	0	No Change
1	0	1	Reset
1	1	0	Set
1	1	1	Indeterminate

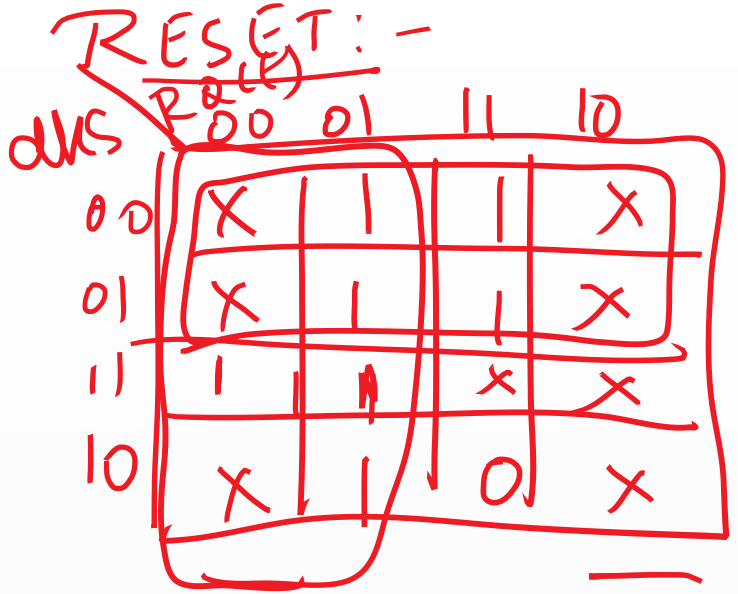
Equation for SET and RESET:



Excitation Table						
Clk	S	R	Q(t)	Q(t+1)	SET	RESET
0	0	0	0	0	1	X
0	0	0	1	1	X	1
0	0	1	0	0	1	X
0	0	1	1	1	X	1
0	1	0	0	0	1	X
0	1	0	1	1	X	1
0	1	1	0	0	1	X
0	1	1	1	1	X	1
1	0	0	0	0	1	X
1	0	0	1	1	X	1
1	0	1	0	0	1	X
1	0	1	1	0	1	0
1	1	0	0	0	0	1
1	1	0	1	1	X	1
1	1	1	0	X	X	X
1	1	1	1	X	X	X

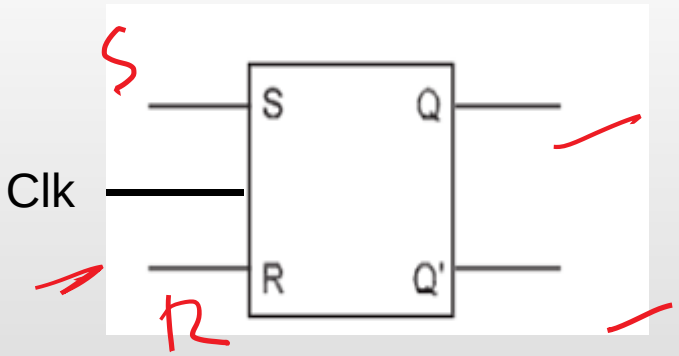
Circuit:

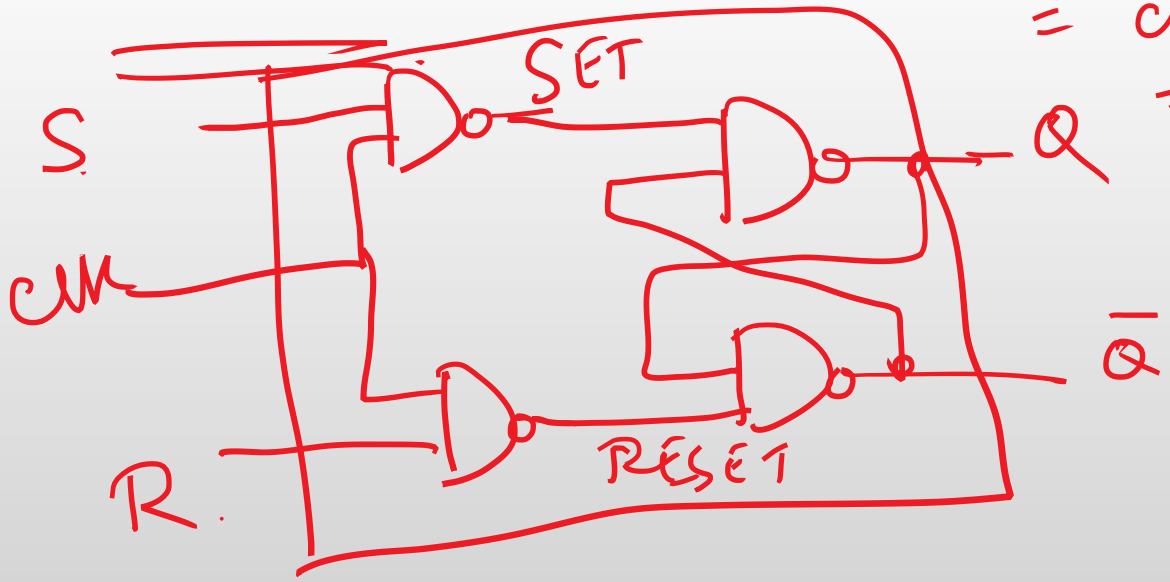




$$SET = \overline{clk} + \overline{S} = \overline{clk \cdot S}$$

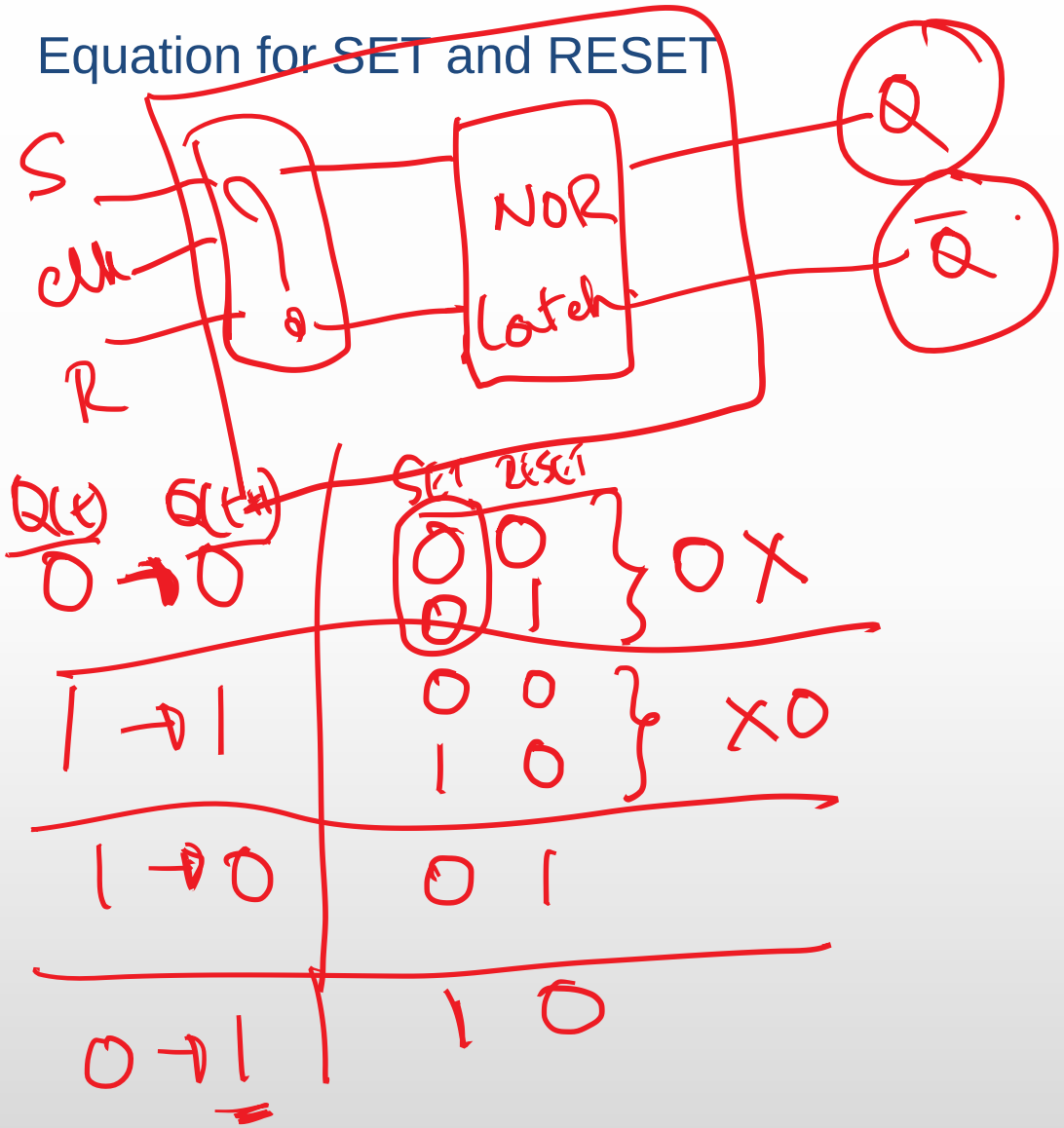
$$RESET = \overline{R + clk} = clk \cdot R$$





SR Flip Flop using NOR latch

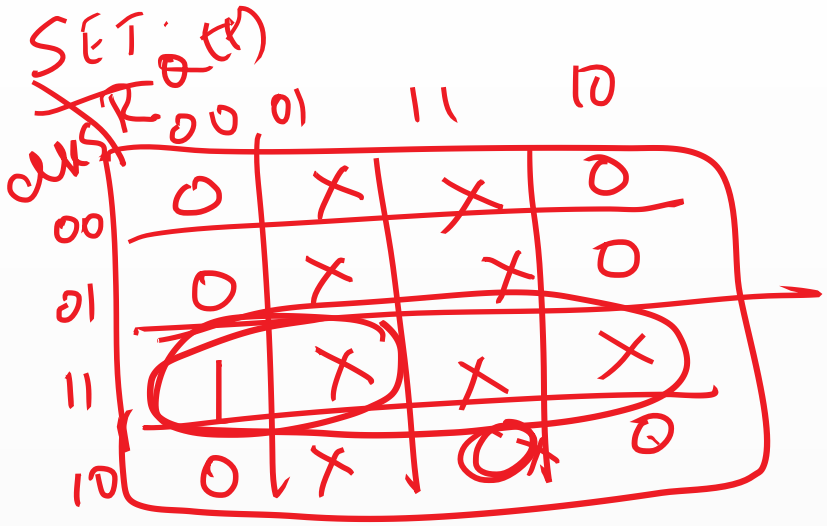
Equation for SET and RESET



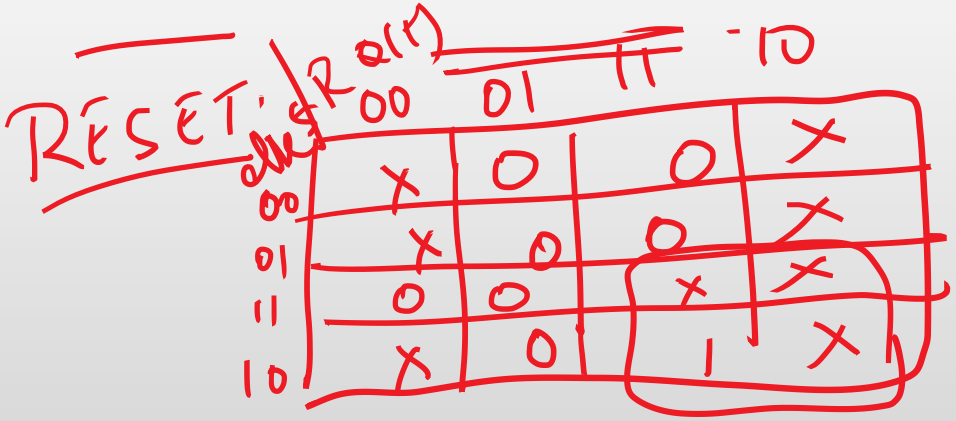
Excitation Table

Clk	S	R	Q(t)	Q(t+1)	SET	RESET
0	0	0	0	0	0	X
0	0	0	1	1	X	0
0	0	1	0	0	0	X
0	0	1	1	1	X	0
0	1	0	0	0	0	X
0	1	0	1	1	X	0
0	1	1	0	0	0	X
0	1	1	1	1	X	0
1	0	0	0	0	0	X
1	0	0	1	1	X	0
1	0	1	0	0	0	X
1	0	1	1	0	0	1
1	1	0	0	1	1	0
1	1	0	1	1	X	0
1	1	1	0	?	X	X
1	1	1	1	X	X	X

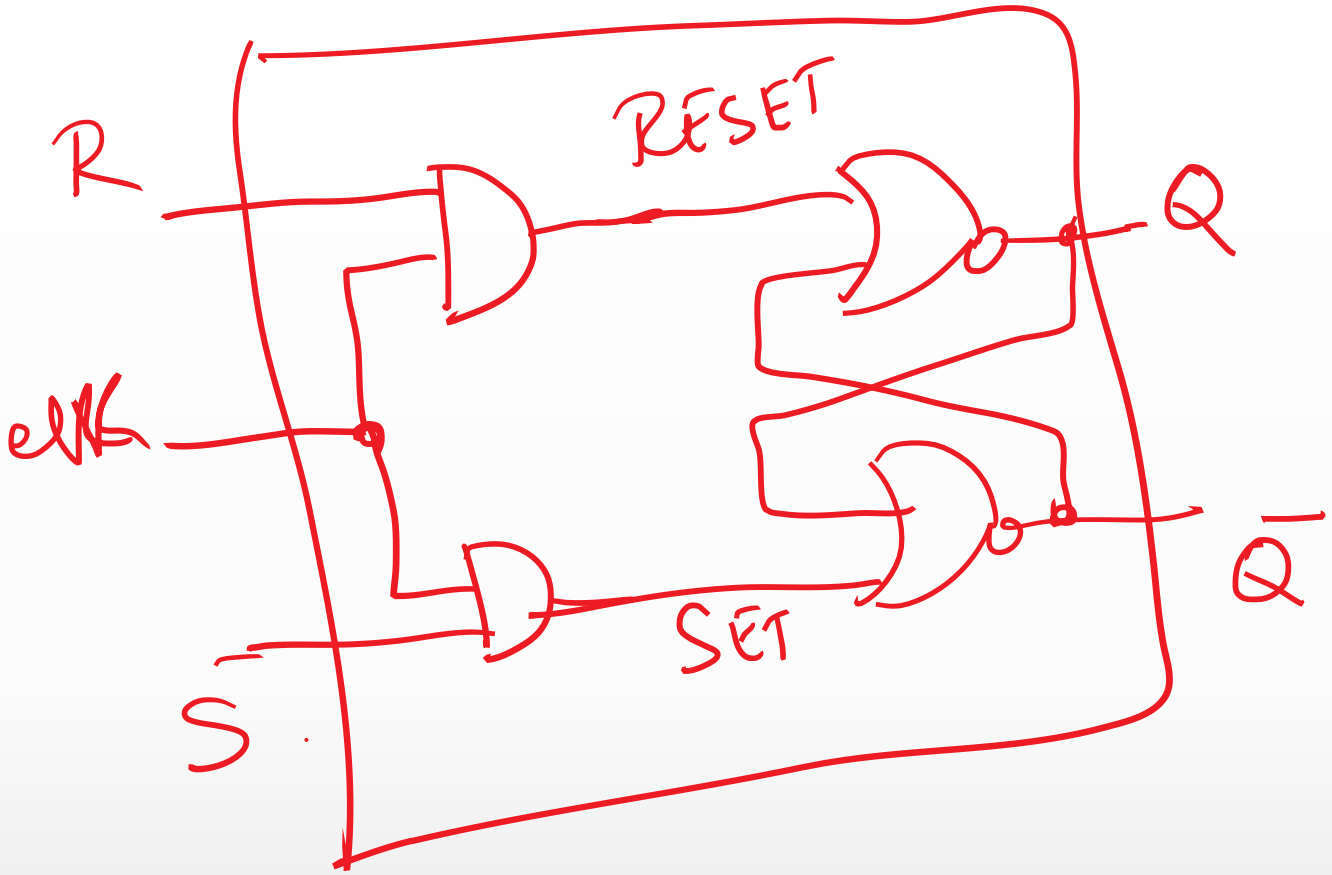
Circuit and Block Diagram



SET = clk S



RESET = clk R



SR - FF

Characteristic Table			
S	R	Q(t)	Q(t+1)
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	X
1	1	1	X

Characteristic equation:

Q(t+1)

S \ RQ(t)	00	01	11	10
0	0	1	0	0
1	1	1	X	X

$$Q(t+1) = S + \bar{R}Q(t)$$

; When S = R = 1 does not occur.

D Flip Flop using NAND latch

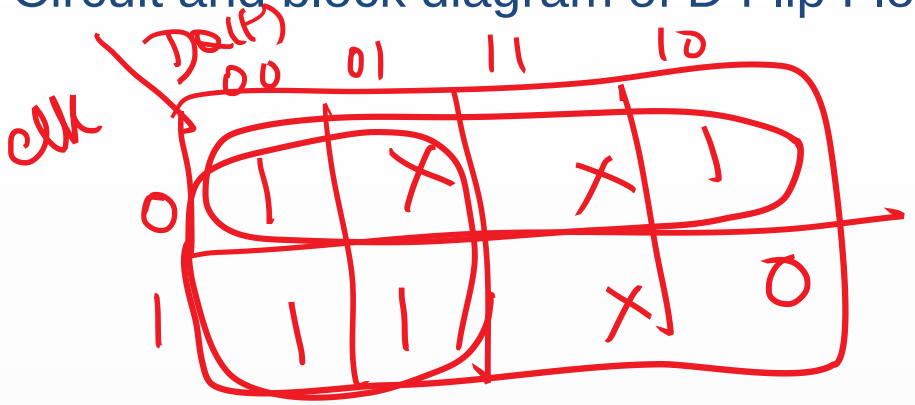
NAND Latch

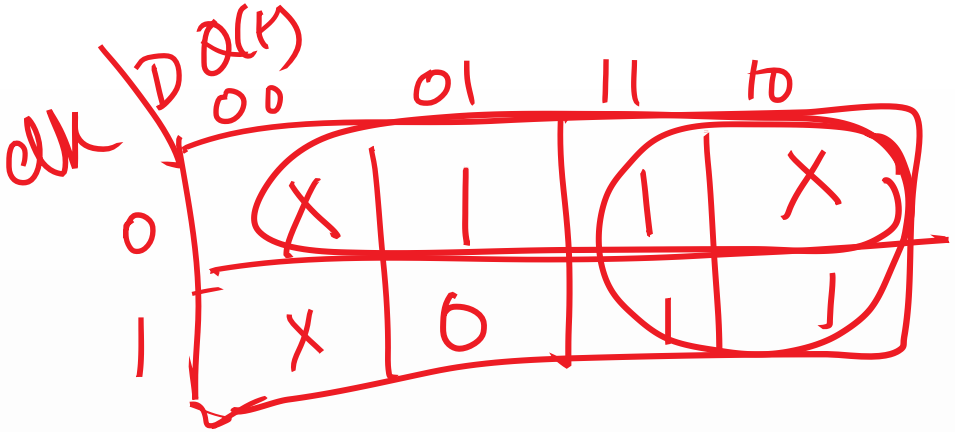
Function Table		
Clk	D	Output
0	X	No change
1	0	Reset 0
1	1	Set 1

Equation for SET and RESET

Excitation Table					
Clk	D	Q(t)	Q(t+1)	SET	RESET
0	0	0	0	1	X
0	0	1	1	X	1
0	1	0	0	1	X
0	1	1	1	X	1
1	0	0	0	1	X
1	0	1	0	1	0
1	1	0	1	0	1
1	1	1	1	X	1

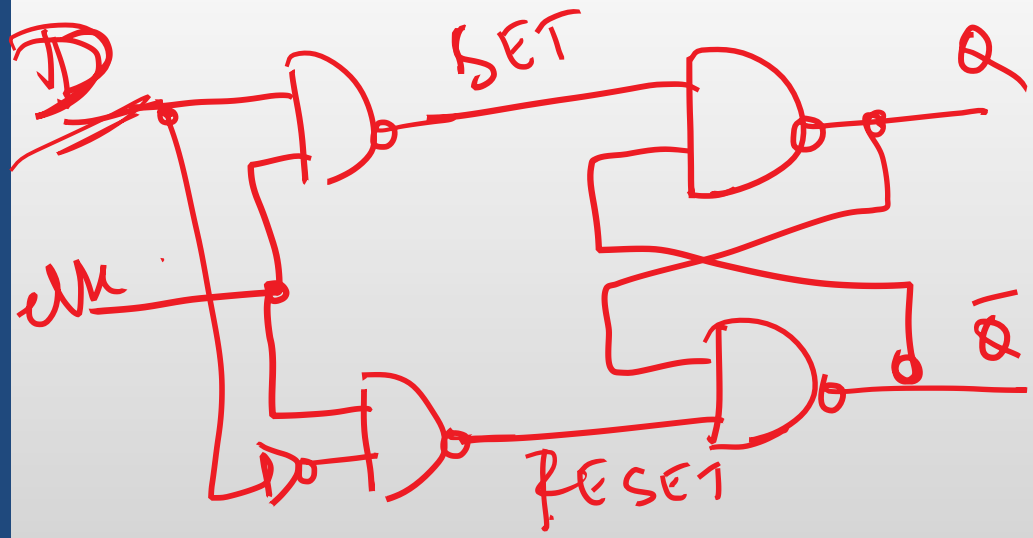
Circuit and block diagram of D Flip Flop

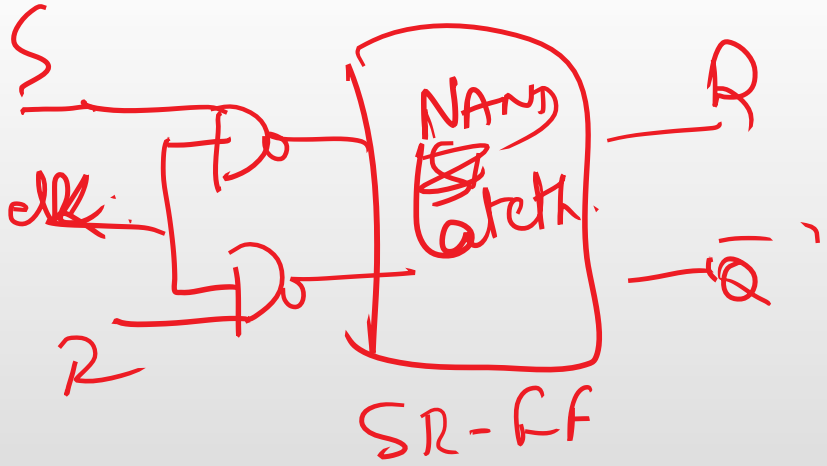




$SET = \overline{clk\ \bar{D}} = \overline{clk\ D}$

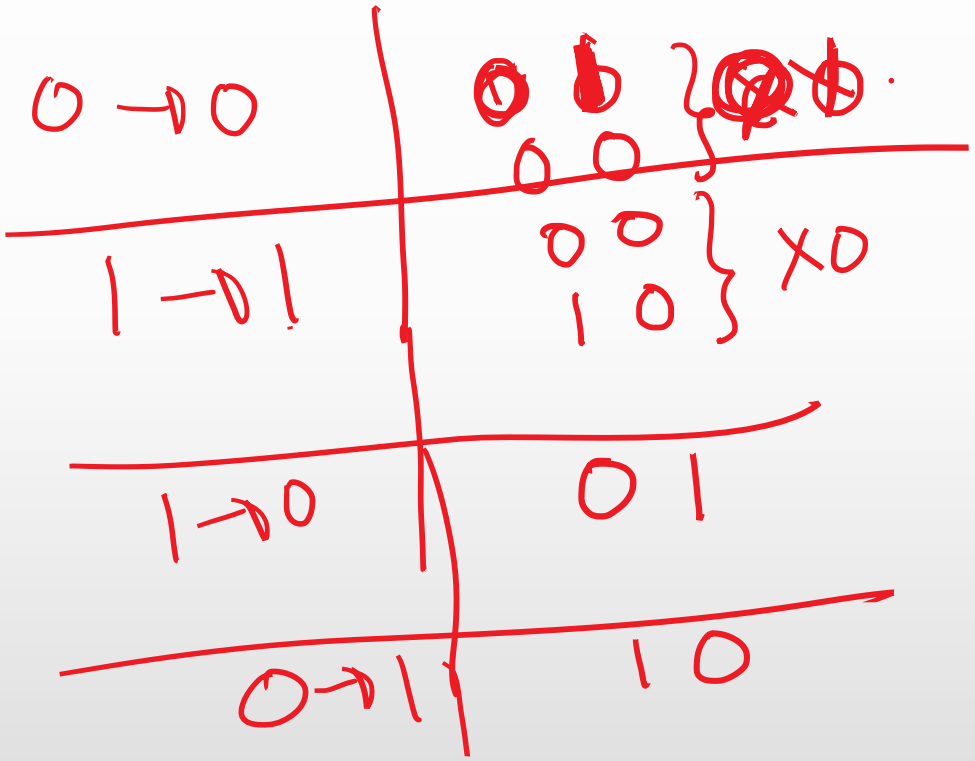
$RESET = \overline{clk \cdot D} = \overline{clk \cdot \bar{D}}$





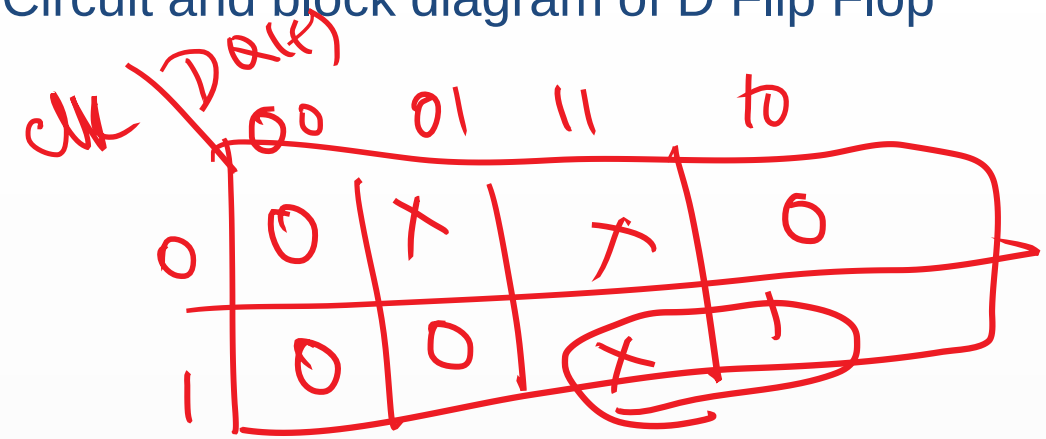
D Flip Flop using NOR Latch

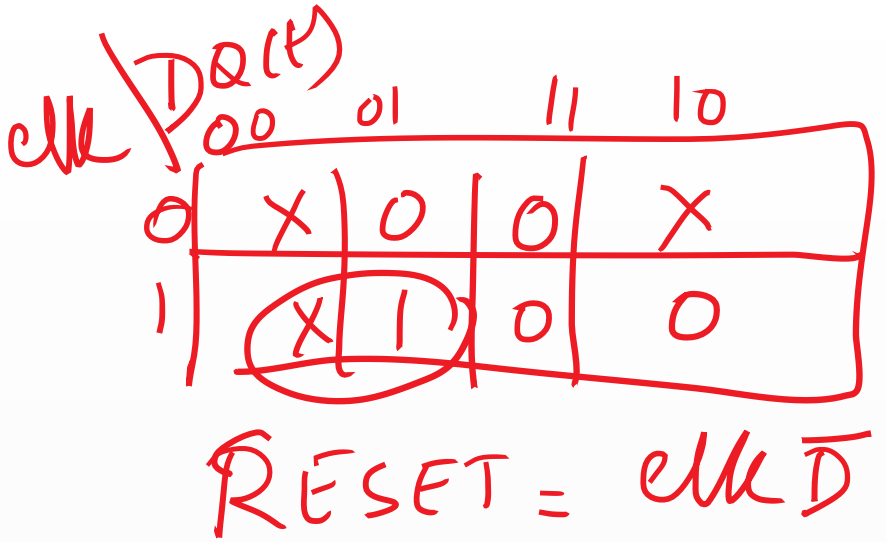
Equation for SET and RESET



Excitation Table					
Clk	D	Q(t)	Q(t+1)	SET	RESET
0	0	0	0	0	X
0	0	1	1	X	0
0	1	0	0	0	X
0	1	1	1	X	0
1	0	0	0	0	X
1	0	1	0	0	1
1	1	0	1	1	0
1	1	1	1	X	0

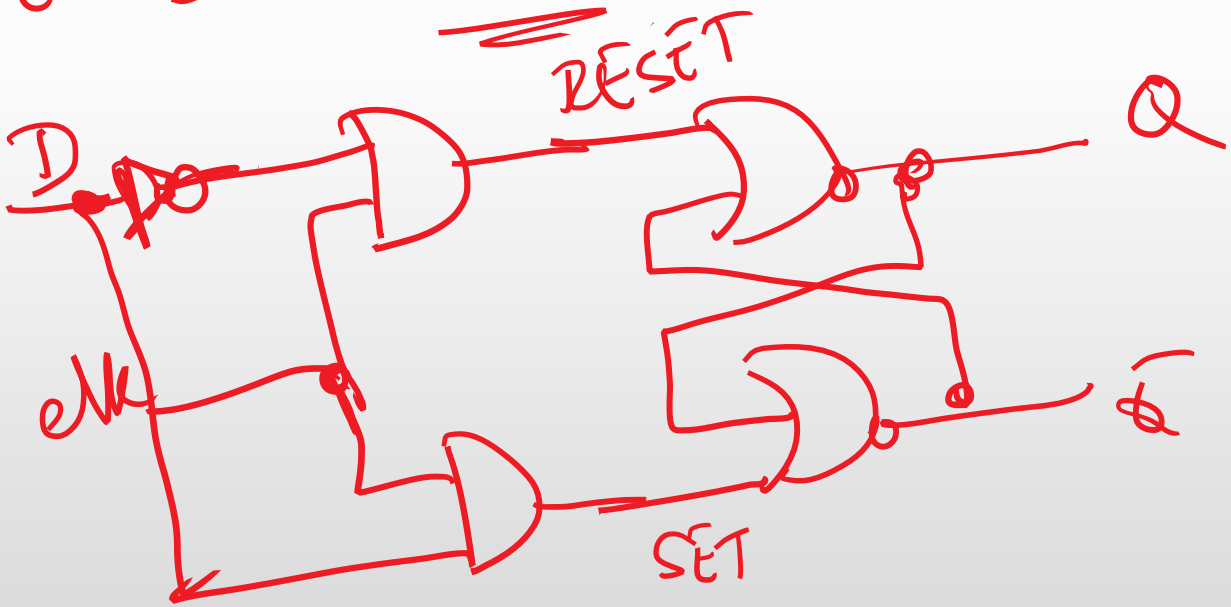
Circuit and block diagram of D Flip Flop



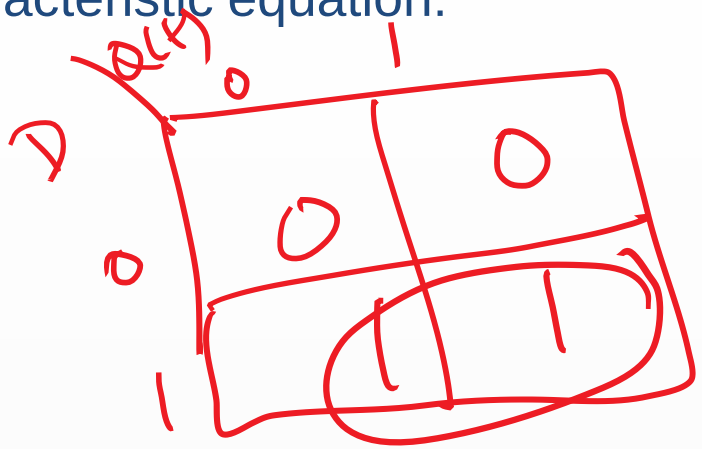


SET = clk D.

RESET = clk $\bar{D}$

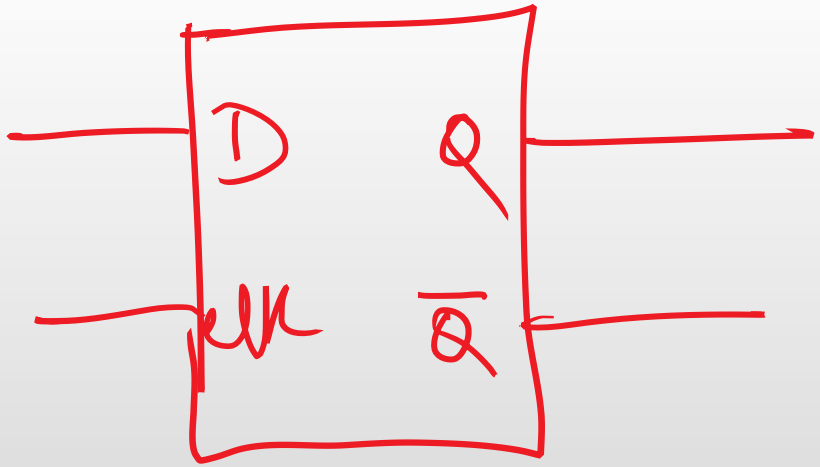


Characteristic equation:



Characteristic Table		
D	Q(t)	Q(t+1)
0	0	0
0	1	0
1	0	1
1	1	1

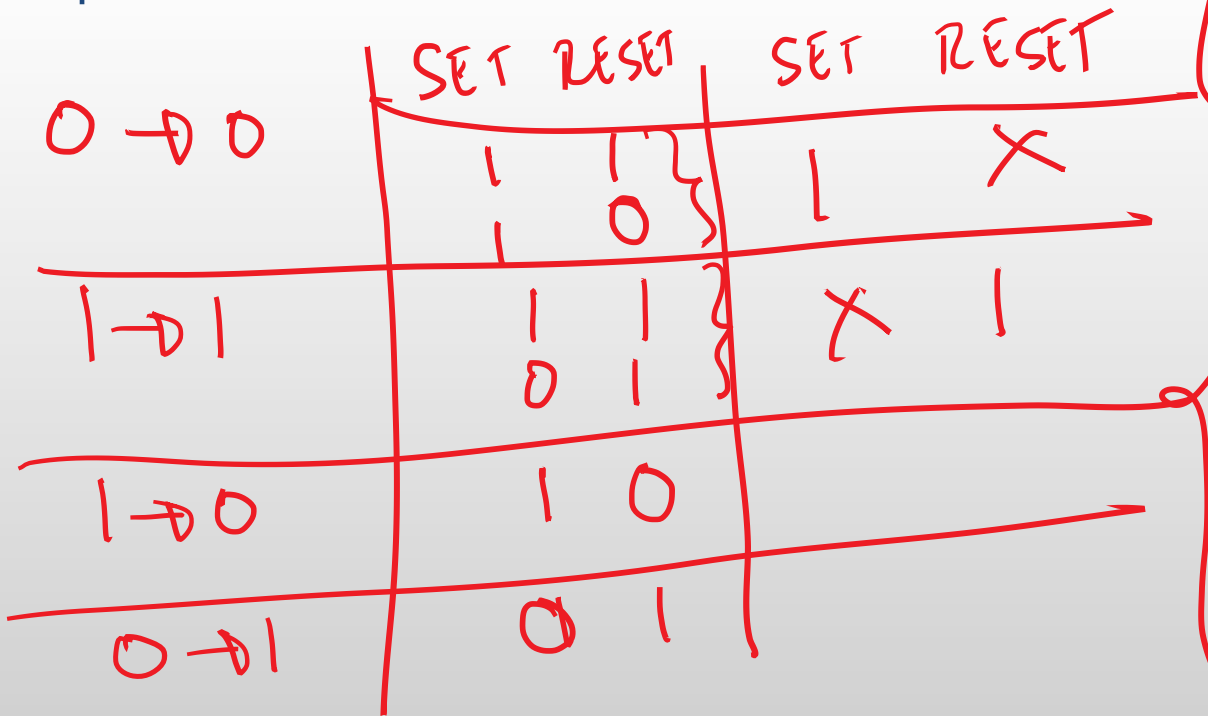
$Q(t+1) = D$



JK Flip Flop using NAND latch

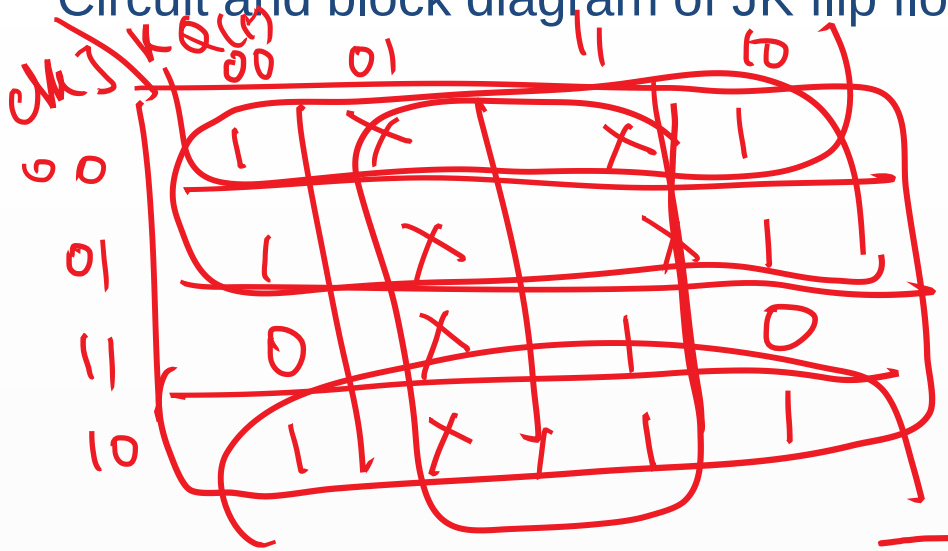
Function Table			
Clk	J	K	Output
0	X	X	No Change
1	0	0	No Change
1	0	1	Reset
1	1	0	Set
1	1	1	Toggle

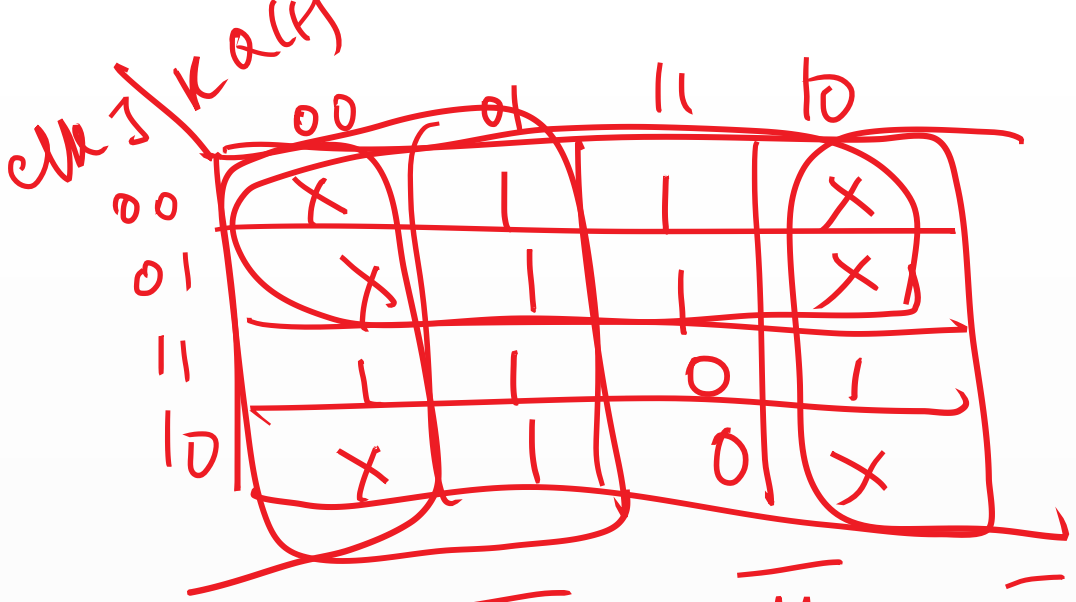
Equation for SET and RESET



Excitation Table						
Clk	J	K	Q(t)	Q(t+1)	SET	RESET
0	0	0	0	0	1	X
0	0	0	1	1	X	1
0	0	1	0	0	1	X
0	0	1	1	1	X	1
0	1	0	0	0	1	X
0	1	0	1	1	X	1
0	1	1	0	0	1	X
0	1	1	1	1	X	1
1	0	0	0	0	1	X
1	0	0	1	1	X	1
1	0	1	0	0	1	X
1	0	1	1	0	1	0
1	1	0	0	1	0	1
1	1	0	1	1	X	1
1	1	1	0	1	0	1
1	1	1	1	0	1	0

Circuit and block diagram of JK flip flop:



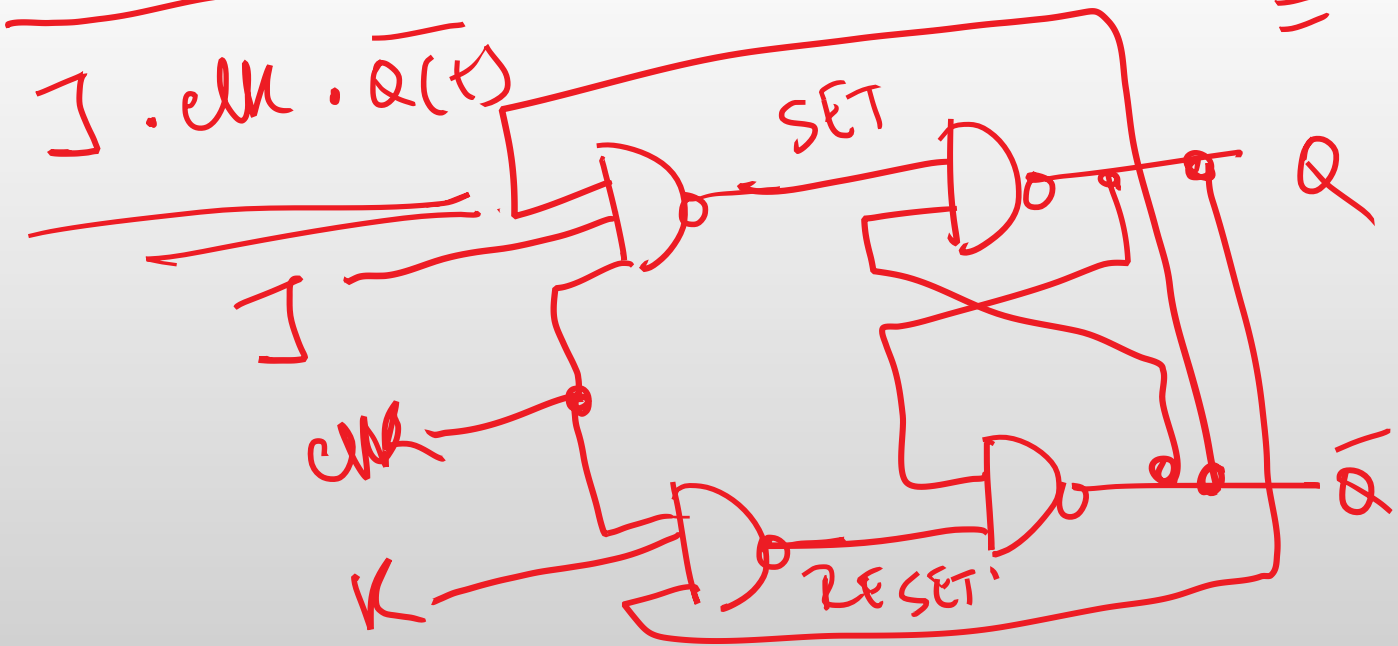


$$SET = \overline{J} + Q(t) + \overline{CLK}$$

$$= J \cdot CLK \cdot \overline{Q(t)}$$

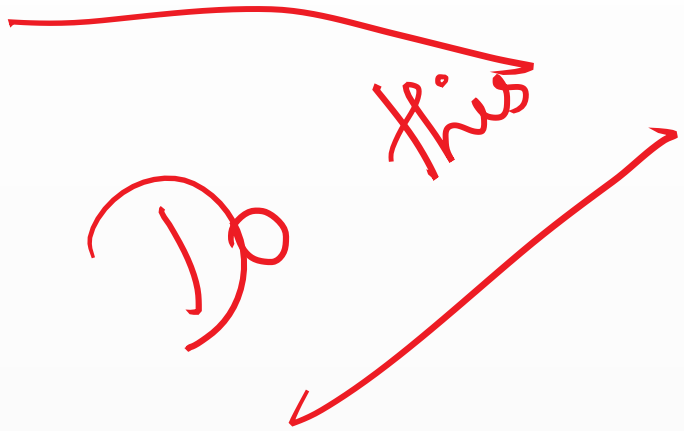
$$RESET = \overline{Q(t)} + \overline{CLK} + \overline{K}$$

$$= K \cdot CLK \cdot Q(t)$$



JK Flip Flop using NOR latch

Equation for SET and RESET

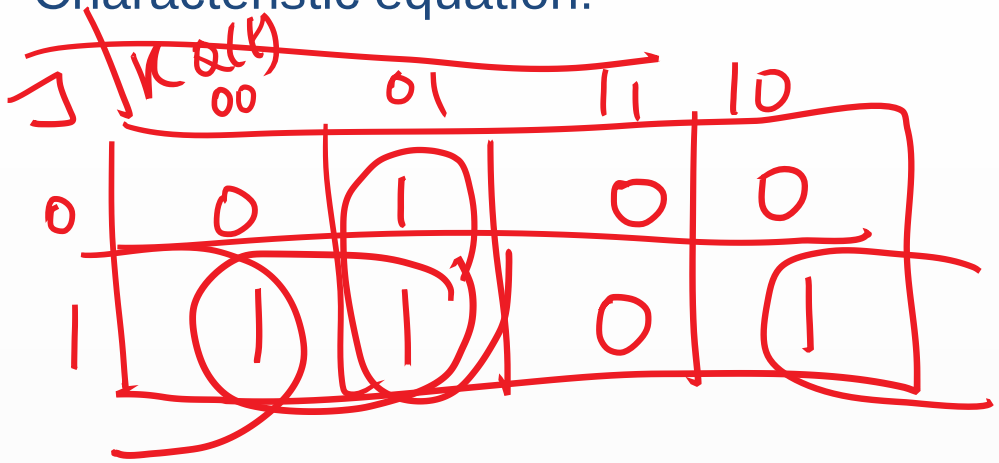


Excitation Table						
Clk	J	K	Q(t)	Q(t+1)	SET	RESET
0	0	0	0			
0	0	0	1			
0	0	1	0			
0	0	1	1			
0	1	0	0			
0	1	0	1			
0	1	1	0			
0	1	1	1			
1	0	0	0			
1	0	0	1			
1	0	1	0			
1	0	1	1			
1	1	0	0			
1	1	0	1			
1	1	1	0			
1	1	1	1			

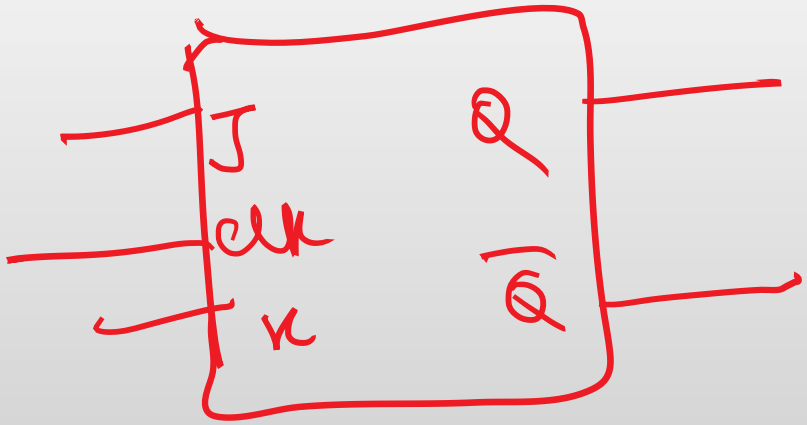
Circuit and Block Diagram

Characteristic Table			
J	K	Q(t)	Q(t+1)
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

Characteristic equation:



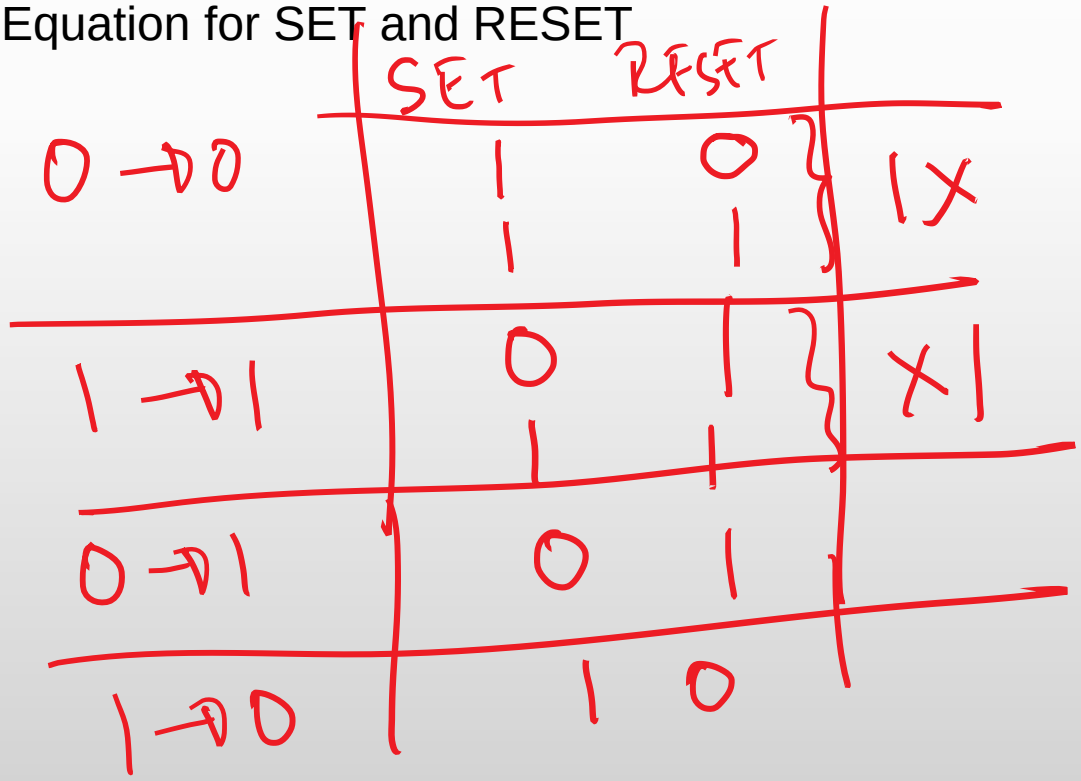
$$Q(t+1) = J\bar{K} + \bar{K}Q(t) + J\bar{Q}(t)$$



T Flip Flop using NAND latch

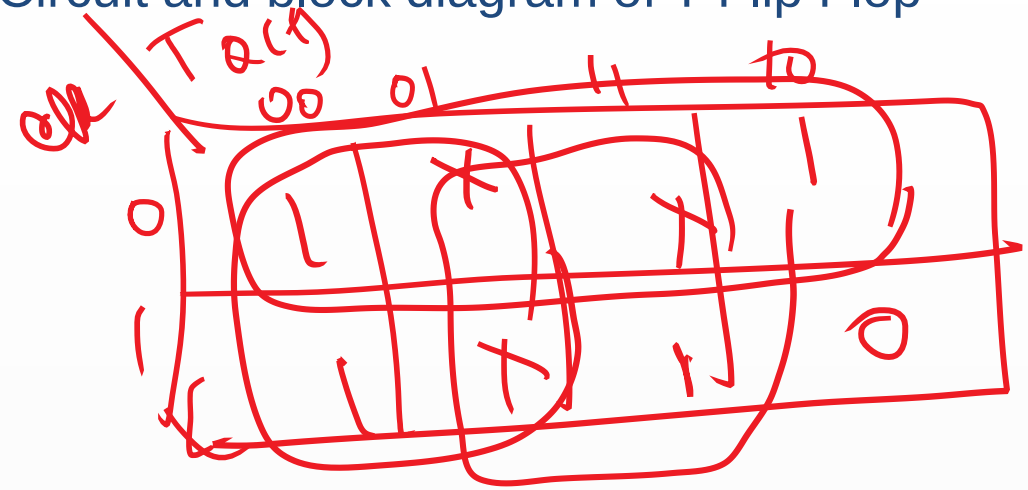
Function Table		
Clk	T	Output
0	X	No change
1	0	No Change
1	1	Toggle

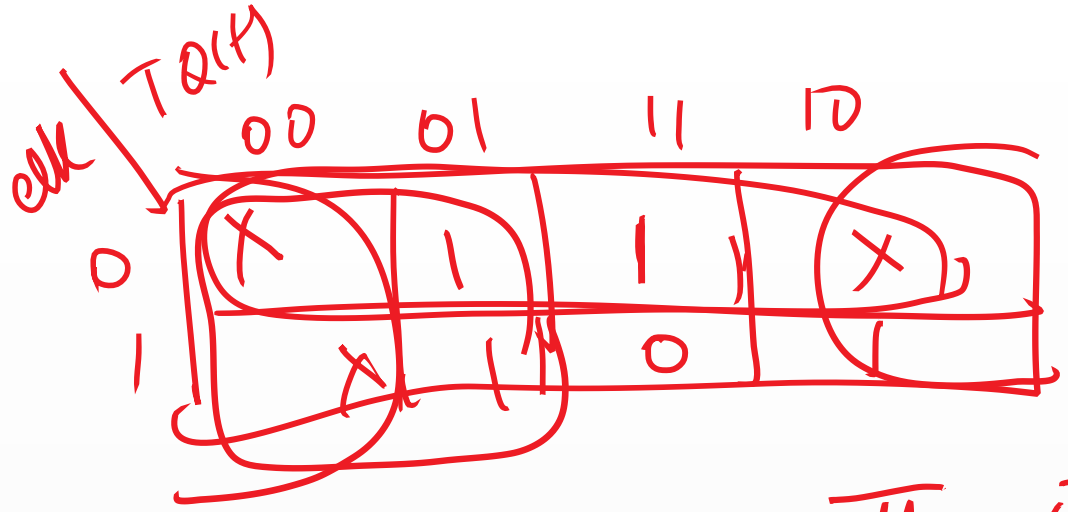
Equation for SET and RESET



Excitation Table					
Clk	T	Q(t)	Q(t+1)	SET	RESET
0	0	0	0	1	X
0	0	1	1	X	1
0	1	0	0	1	X
0	1	1	1	X	1
1	0	0	0	1	X
1	0	1	1	X	1
1	1	0	1	0	1
1	1	1	0	1	0

Circuit and block diagram of T Flip Flop



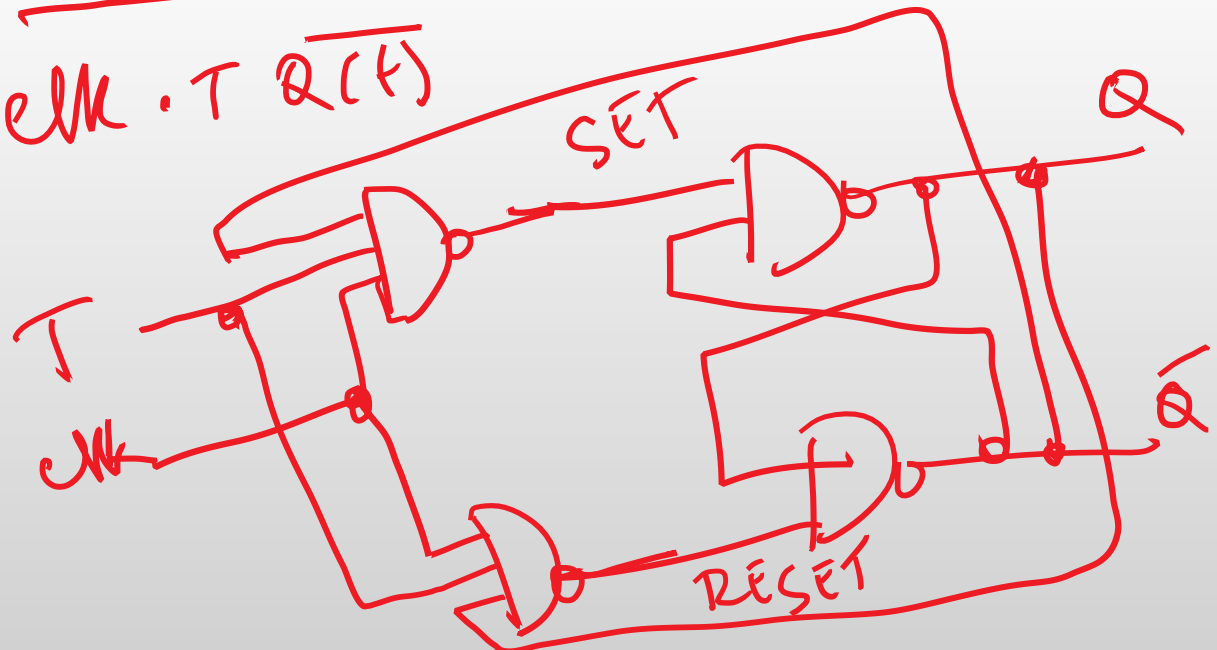


$$SET = \overline{cM + \bar{T} + Q(t)}$$

$$= cM \cdot T\,\overline{Q(t)}$$

$$RESET = \overline{\bar{T} + \overline{cM + Q(t)}}$$

$$= T \cdot cM \cdot Q(t)$$



T Flip Flop using NOR Latch

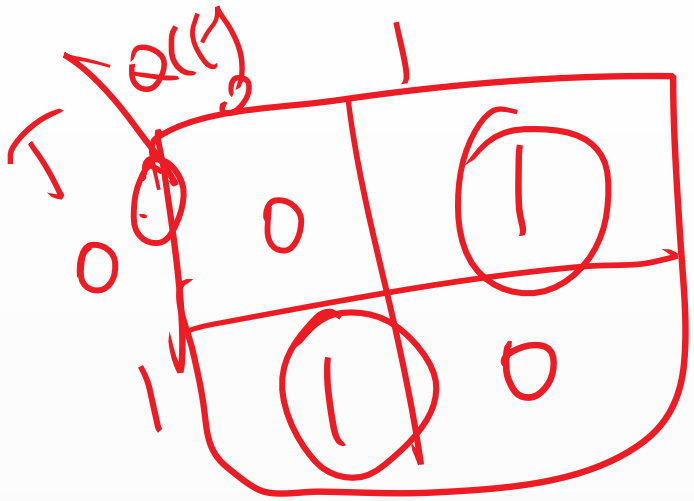
Equation for SET and RESET

Do this

Excitation Table					
Clk	T	Q(t)	Q(t+1)	SET	RESET
0	0	0			
0	0	1			
0	1	0			
0	1	1			
1	0	0			
1	0	1			
1	1	0			
1	1	1			

Circuit and block diagram of T Flip Flop

Characteristic equation:



Characteristic Table		
T	Q(t)	Q(t+1)
0	0	0
0	1	1
1	0	1
1	1	0

$$Q(t+1) = T\overline{Q(t)} + \overline{T}Q(t)$$

$$= T \oplus Q(t)$$