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Hyderabad Campus

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# CS/ECE/EEE/INSTR F215:Digital Design

## Lecture 20: *Latches*

*Thu, 14 Oct 2021*

**BITS Pilani**

Hyderabad Campus

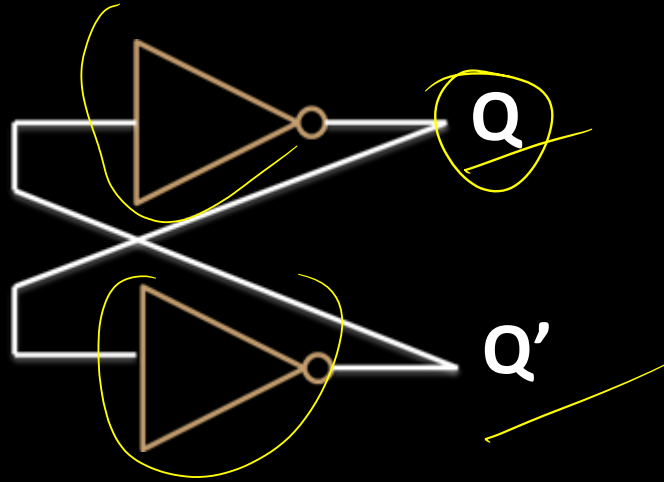
**Dr. R. N. Ponnalagu, EEE**

Challenges are what make  
life interesting.

Overcoming them is what make  
life meaningful.

- Joshua J. Marine

# One bit memory element



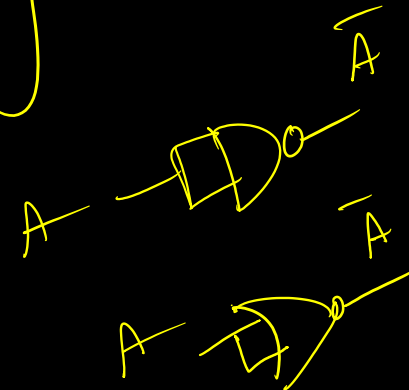
Cross coupling  
o/p of one gate  
given as i/p to  
another  
& vice versa

Is there any way to control the storage value ?

$Q=1 \Rightarrow$  Set State  
 $Q=0 \Rightarrow$  Reset State  
latch/ff  $\Rightarrow$  bistable element  
2 stable states

Set State  $Q=1$   
Reset State  $Q=0$

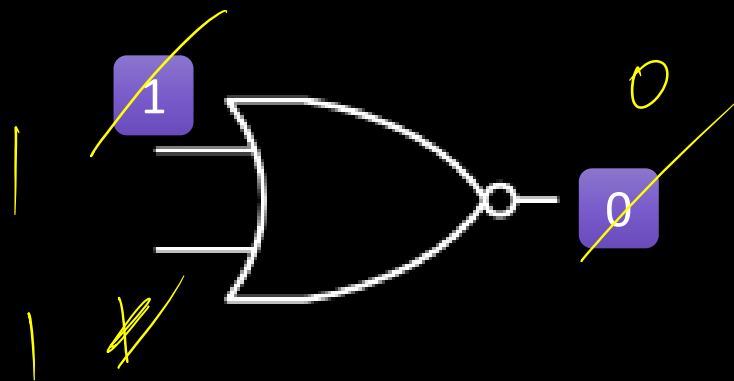
NAND gate }  $\Rightarrow$  Inverter  
NOR gate }



# NOR - NAND

Truth table NOR gate

A	B	O/P
0	0	1
0	1	0
1	0	0
1	1	0

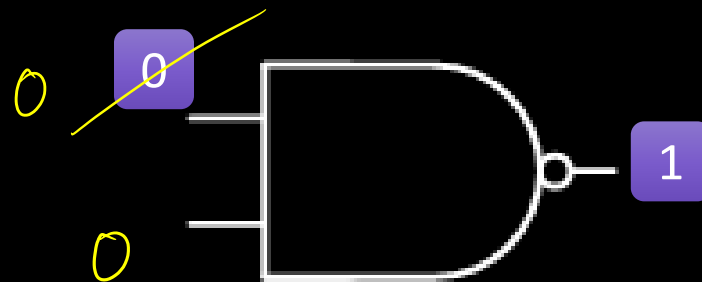


A '1' on any one or both  
i/p's of NOR gate forces  
output to '0'

'1'  $\rightarrow$  dominating i/p NOR gate

Truth table NAND gate

A	B	O/P
0	0	1
0	1	1
1	0	1
1	1	0



A '0' on any one or both the  
i/p's of NAND gate forces  
output to '1'

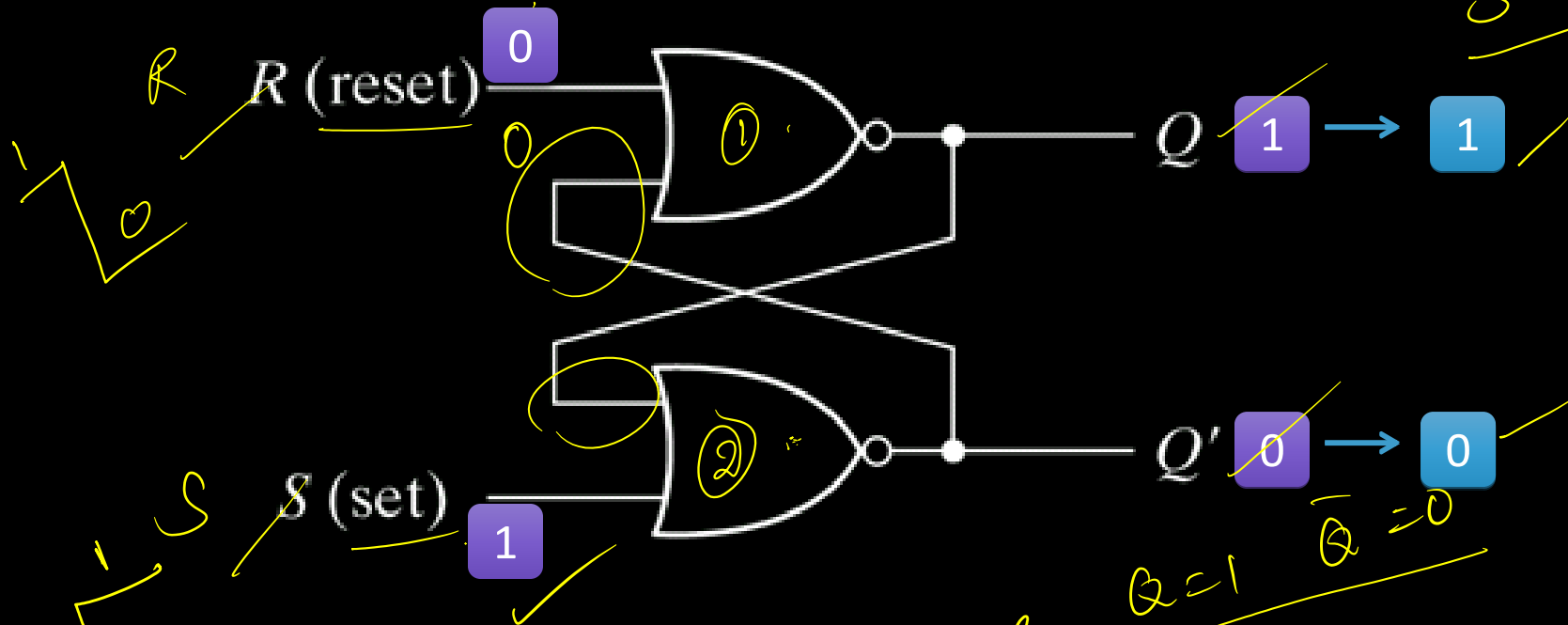
'0'  $\rightarrow$  dominating i/p

To Set the latch  $R=0, S=1$

Assume  
 $Q=0$   
 $\bar{Q}=1$   
 $S=1$   
 $R=0$

## SR Latch

Cross coupled NOR gates



S	R	Q	$\bar{Q}$
0	0	0	1

S	R	Q	$\bar{Q}$
1	0	1	0

NOR gate  
 A B o/p  
 0 0 1  
 0 1 0  
 1 0 0  
 1 1 0

Reset = 0, Set = 1

latch will be in set state

Assume  
 $Q=1$   
 $\bar{Q}=0$   
 $S=1$   
 $R=0$   
 $Q=1$   
 $\bar{Q}=0$

To reset the latch  $R=1$   $S=0$

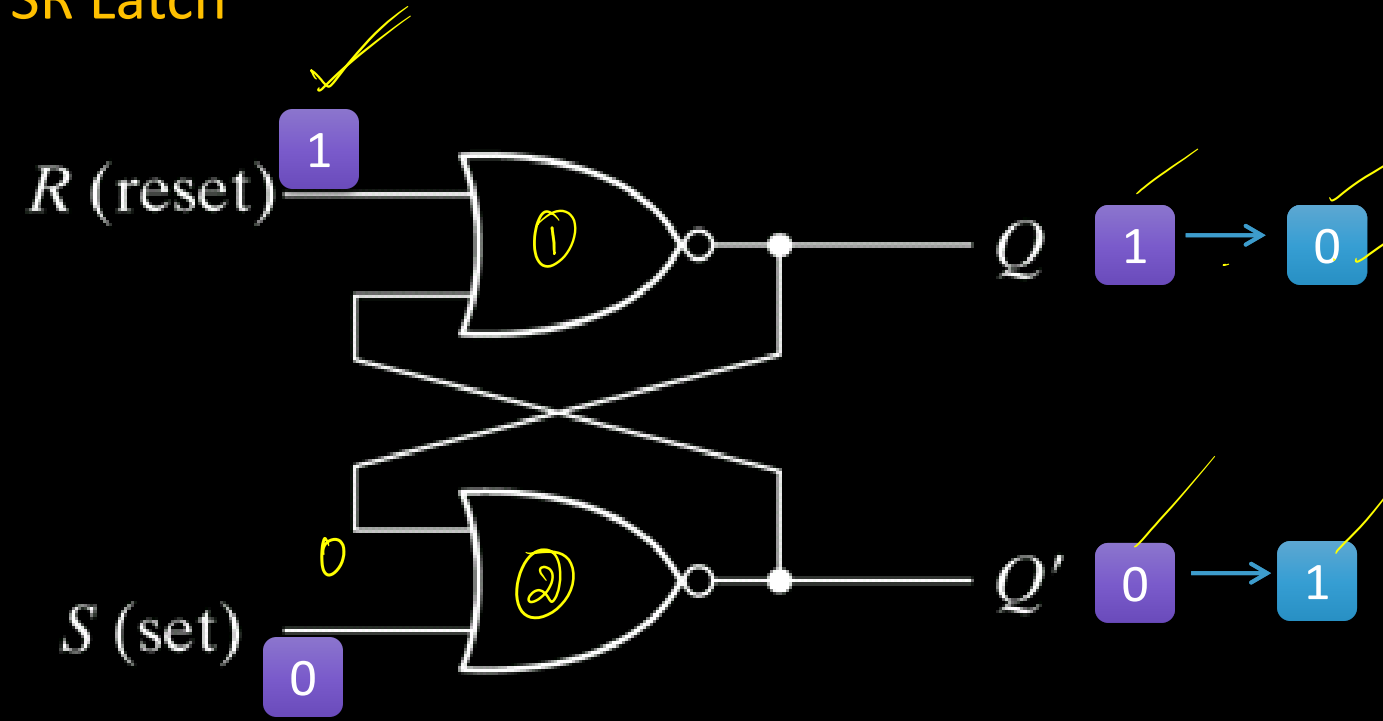
Assume  
 $Q=1$   
 $\bar{Q}=0$

$R=1$   
 $S=0$

$Q=0$   
 $\bar{Q}=1$

Reset = 1, Set = 0

SR Latch



Assume  
 $Q=0$   $\bar{Q}=1$   
 $R=1$   $S=0$   
 $Q=0$   $\bar{Q}=1$

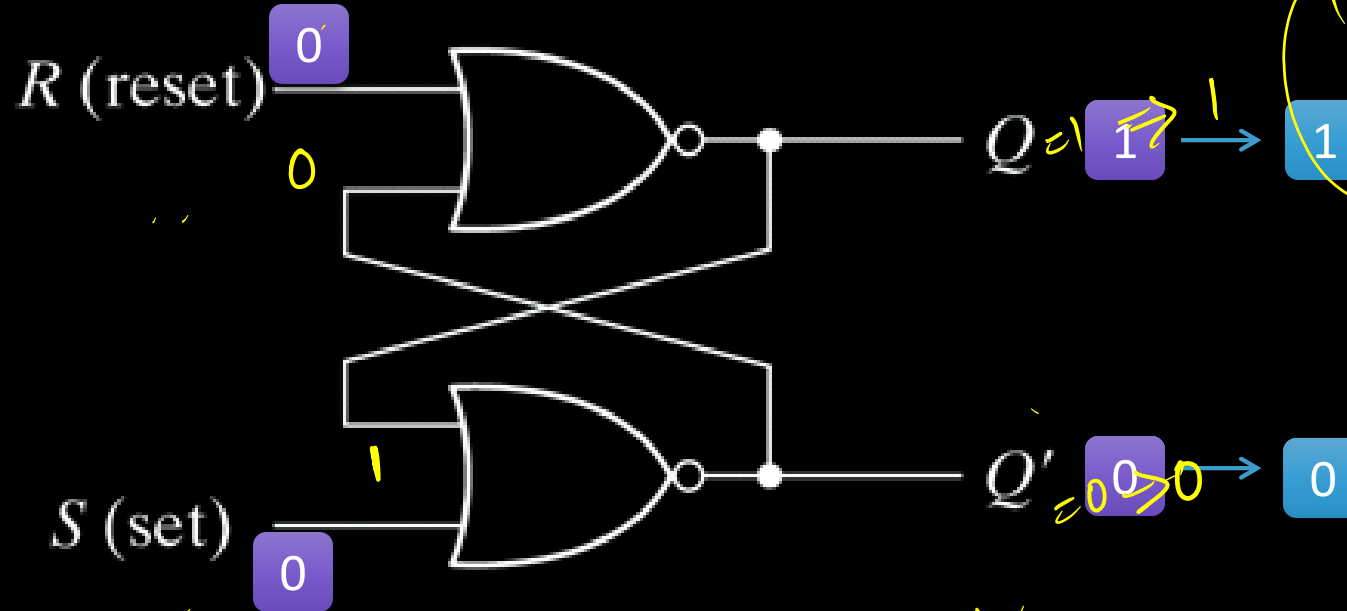
$Q=0$   
 reset state

reset state

S  
 0  
 0  
 0  
 1

R  
 1  
 0  
 0  
 1

# SR Latch



i) Assume  
 $Q = 0$   $\bar{Q} = 1$   
 $R = 0$   $S = 0$   
 $Q = 0$   $\bar{Q} = 1$

ii) Assume  
 $Q = 1$   $\bar{Q} = 0$   
 $R = 0$   $S = 0$   
 $Q = 1$   $\bar{Q} = 0$

Reset = 0, Set = 0

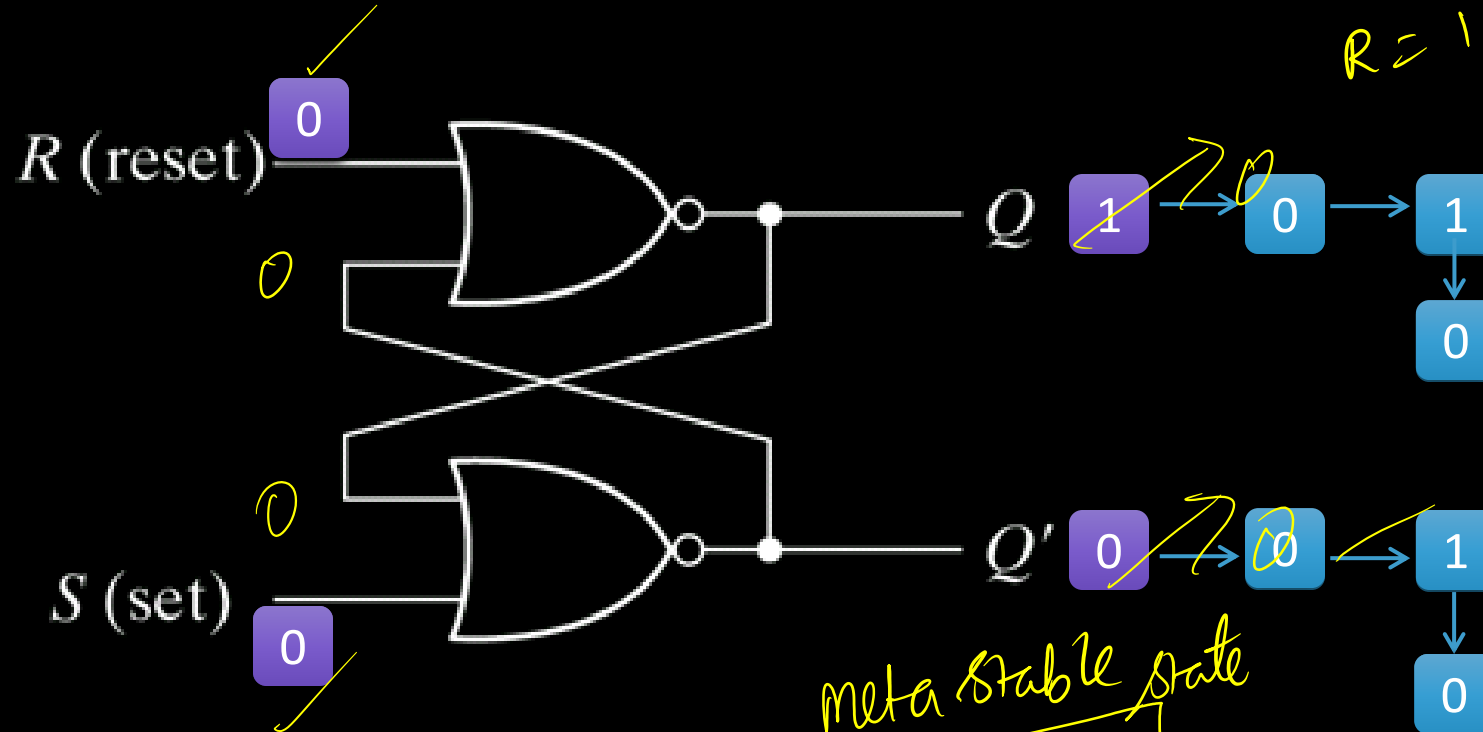
Next Previous  
 New state = Old state

No change

# SR Latch

$\bar{Q}$  &  $Q$  are complementary

Assume  
 $Q=1$   $\bar{Q}=0$   
 $R=1$   $S=1$



Reset = 1, Set = 1       $Q = 0$  and  $Q' = 0$       Not possible

Cant predict output -> metastable state

meta stable state  
 $R=1$   $S=1$

Not recommended  
 forbidden  
 not defined



# SR Latch

2 i/p's      ✓ 2 o/p's

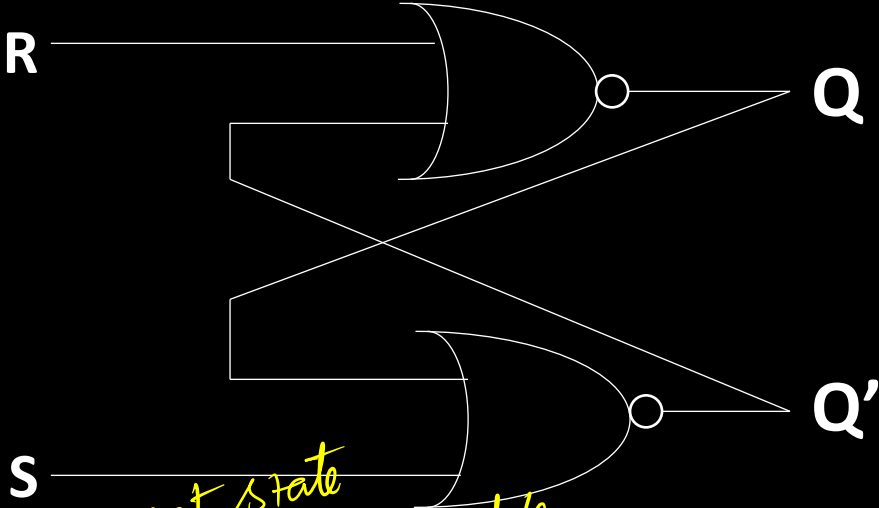
S	R	Q	Q'
0	0	Q	Q'
0	1	0	1
1	0	1	0
1	1	Forbidden	

No change

Reset

set

Not recommended



Characteristic table

R → reset i/p  
S → set i/p

→ present state      → next state

S	R	Q <sub>t</sub>	Q <sub>t+1</sub>
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	0
1	1	1	1

no change      reset      set

$Q_{t+1} \Rightarrow 3 \text{ var.}$

	$\bar{R}Q_t$	$RQ_t$	$\bar{R}Q_t$	$RQ_t$	$\bar{R}Q_t$	$RQ_t$
$S$	0	1	0	0	0	0
$\bar{S}$	1	1	1	*	*	*

don't care

Next state of RS latch

$$Q_{t+1} = S + \bar{R}Q_t$$

provided

RS latch

$$SR = 0$$

characteristic equation

$\bar{S}R + \bar{R}Q_t$  Characteristic table

I/PS		P.S	N.S
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

No change

reset

set

Indeterminate  
undefined

both S & R should not be '1' at the same time