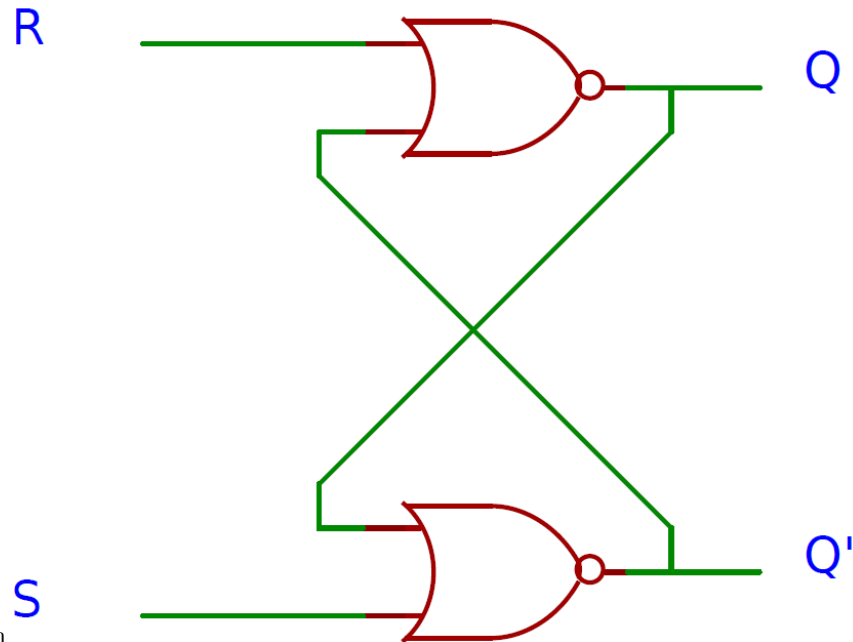


## Lecture 12

### Latches



- RS Latch

- A cross is used in 2 symmetric NOR switches such that the output of one NOR gate is used as the input of the other NOR gate, and the second input is either R or S.
- R stands for reset, and S stands for set. If we change the voltages (**in bold**),

R	S	Q	$\overline{Q}$
1	0	0	1
<b>0</b>	$0 \rightarrow 1$	$0 \rightarrow 1$	$1 \rightarrow 0$
0	<b>0</b>	1	0
<b>1</b>	0	0	1
1	<b>1</b>	0	0
<b>0</b>	<b>0</b>	oscillates	oscillates

- Gated RS Latch

- A clock is added to disable and enable the latch
- A clock is square wave generated by a crystal oscillator

Clock	S	R	Q(t+1)
0	Any	Any	Q(t)

Clock	S	R	Q(t+1)
1	0	0	Q(t)
1	0	1	0
1	1	0	1
1	1	1	not used

This circuit is built by replacing R and S with R' and S' respectively, where R' = clock AND R, and S' = clock AND S.

If we let R =  $\sim D$  and S = D, we have

Clock	D	Q(t+1)
0	Any	Q(t)
1	0	0
1	1	1

D is the data input, where when clock = 1, Q = D, but when clock = 0, Q stores the present value of D. Any circuit with this truth table is a gated D latch.

### Flip Flops

- Clock = 0: Qm=0, Q = stored value
- Clock = 1: Q = Qm = D (no longer tracks input changes)
- Summary: when clock changes from 0 to 1, the value of D **at that moment** is stored in FF