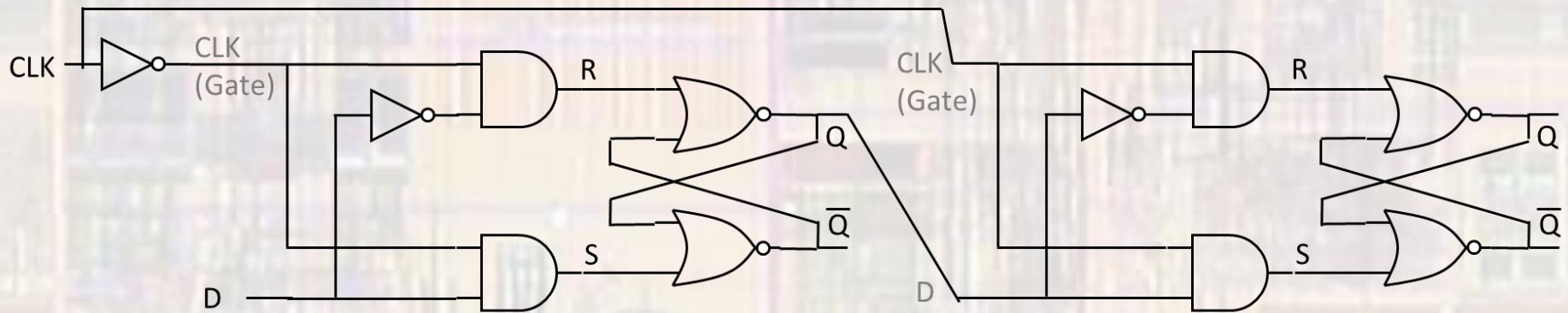
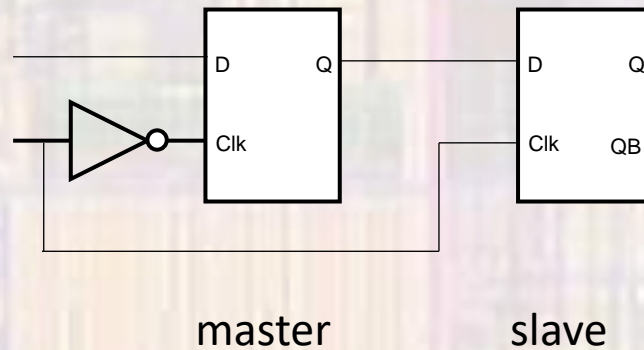


Flip-Flop Enhancements

Last updated 10/24/24

Flip-Flop Enhancements

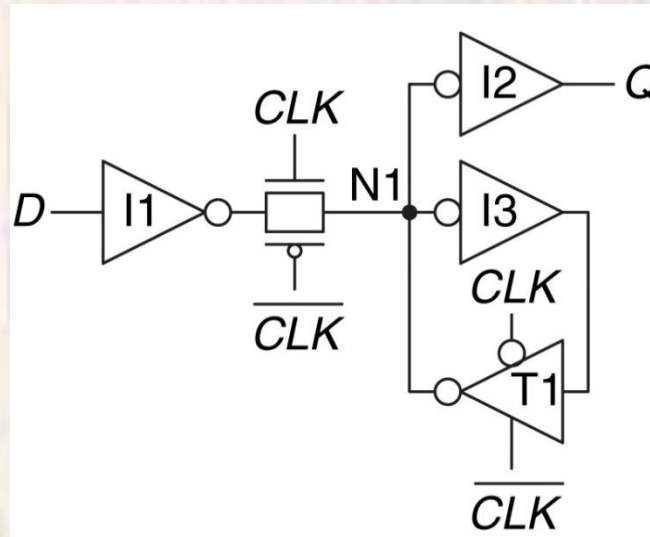
- D Flip-Flop – SR Latch based



How many Transistors ???

Flip-Flop Enhancements

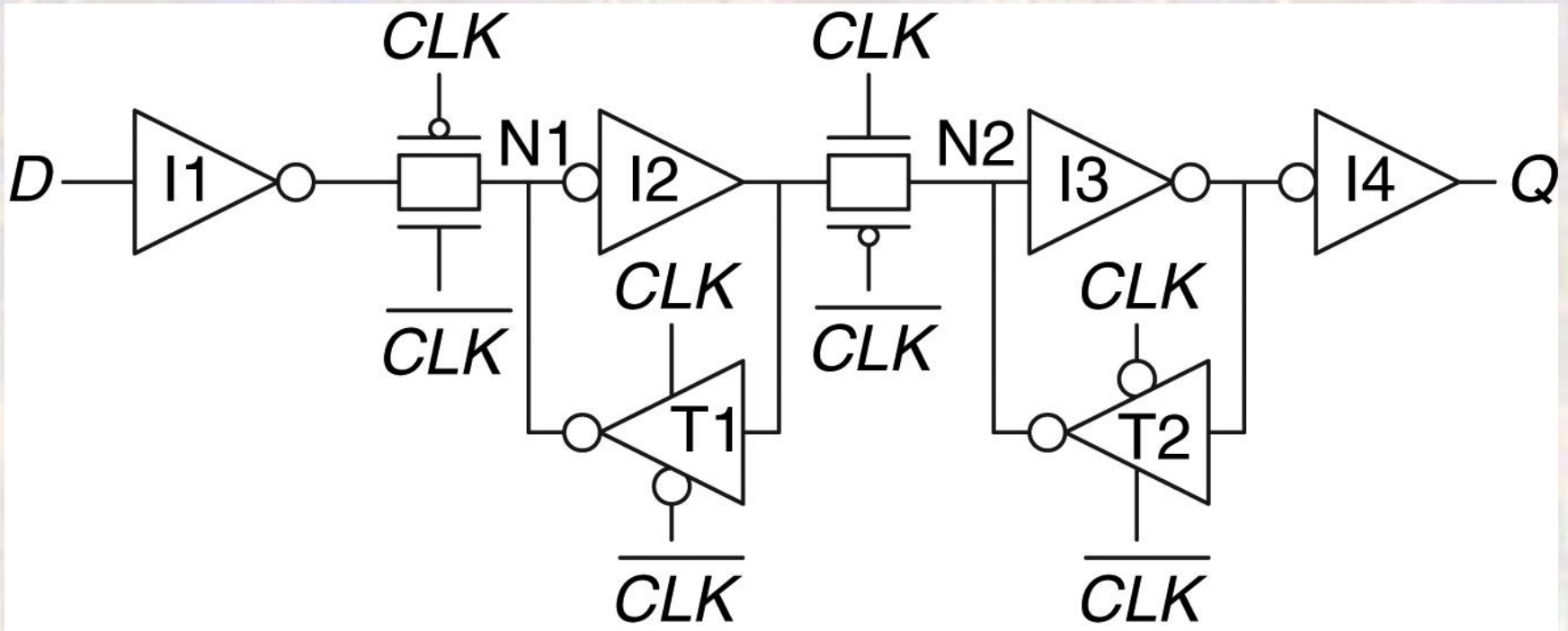
- D Flip-Flop – Pass Gate based
- D latch



src: Harris & Harris

Flip-Flop Enhancements

- D Flip-Flop – Pass Gate Based



picture src: Harris & Harris

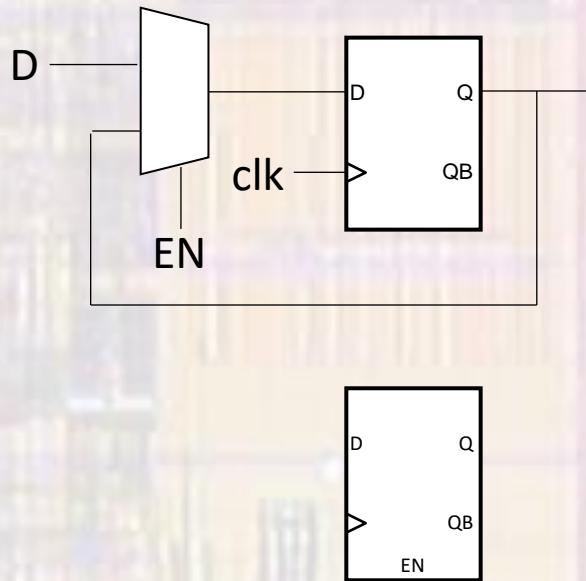
How many transistors ???

Flip-Flop Enhancements

- Enhanced D Flip-Flops
 - Enable – limit when the FF responds to the clk
 - Set – force the FF into the $Q=1$ state, independent of D
 - Reset – force the FF into the $Q=0$ state, independent of D
 - Set/Reset can be asynchronous or synchronous
 - Enable/Set/Reset – can be active high or active low

Flip-Flop Enhancements

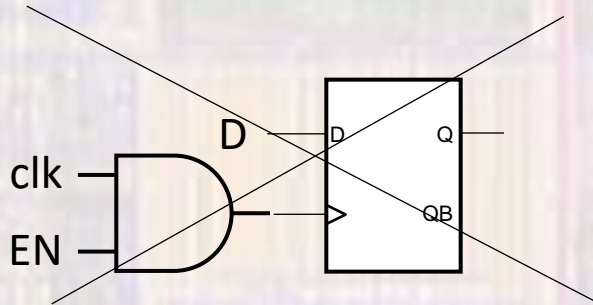
- Enhanced D Flip-Flops
 - Synchronous Enable - mux



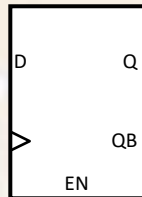
D	Clk	EN	Q
x	x	0	Q_{old}
x	0	1	Q_{old}
x	1	1	Q_{old}
x	↓	1	Q_{old}
D	↑	1	D

Flip-Flop Enhancements

- Enhanced D Flip-Flops
 - Synchronous Enable – gated clock



Requires EN only changes when clk is low



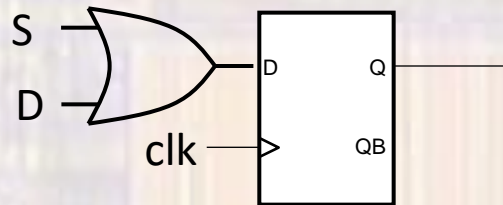
D	Clk	EN	Q
x	x	0	Q_{old}
x	0	1	Q_{old}
x	1	1	Q_{old}
x	↓	1	Q_{old}
D	↑	1	D

Normally clock gating is considered bad practice at the system level

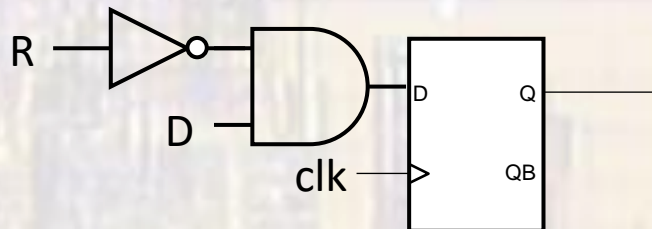
Flip-Flop Enhancements

- Enhanced D Flip-Flops

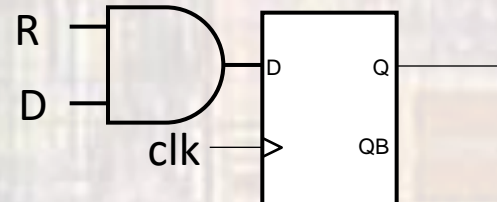
- Synchronous Set



- Synchronous: Reset - RST



- Reset_bar – RSTB

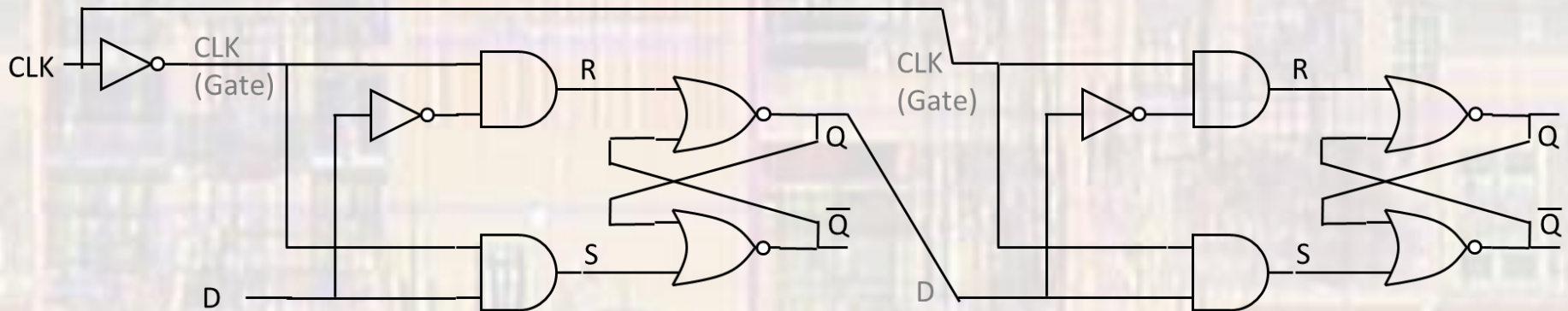


Flip-Flop Enhancements

- Enhanced D Flip-Flops

- Asynchronous** Set/Reset/Reset_bar (rstb)

- Due to the latching behavior of the DFF – require internal circuit changes

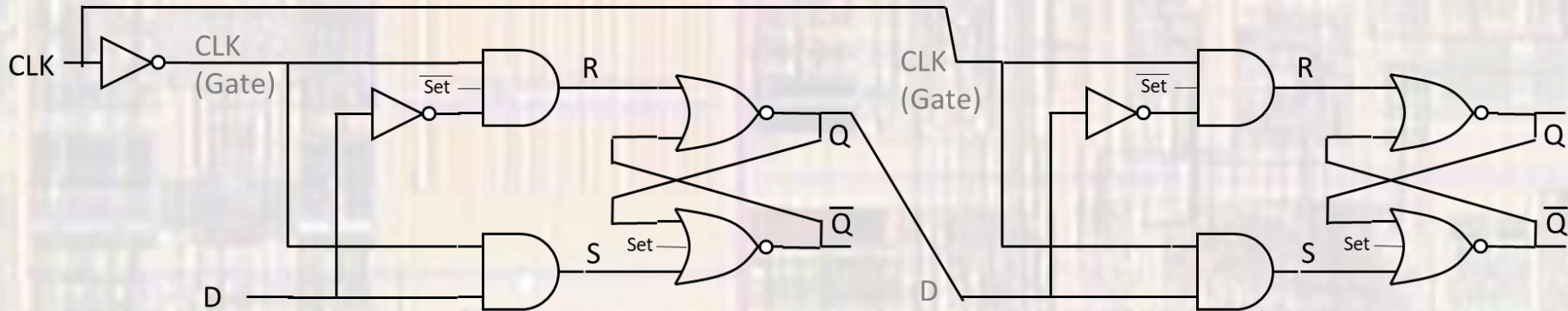


Flip-Flop Enhancements

- Enhanced D Flip-Flops

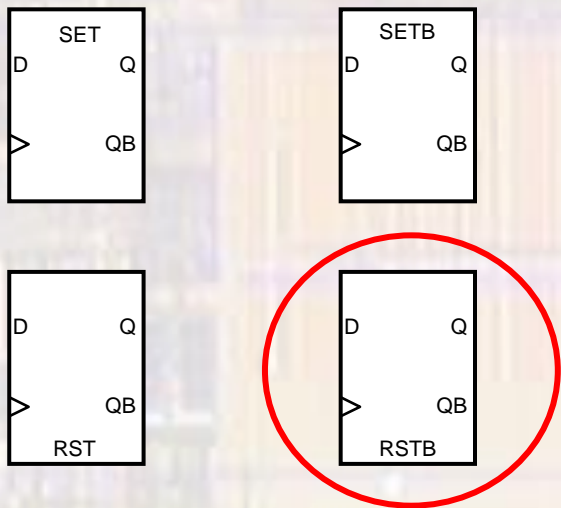
- Asynchronous Set

- Due to the latching behavior of the DFF – require internal circuit changes



Flip-Flop Enhancements

- Enhanced D Flip-Flops
 - Asynchronous Set/Reset/Reset_bar (rstb)



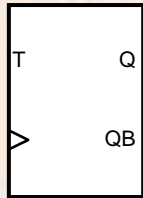
most common

D	Clk	SET	RST	Q
x	0	0	0	Q_{old}
x	1	0	0	Q_{old}
x	↓	0	0	Q_{old}
D	↑	0	0	D
x	x	1	-	1
x	x	-	1	0

SETB / RSTB operate in active low mode

Flip-Flop Enhancements

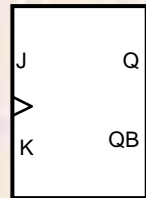
- Additional Flip-Flops
 - T – Flip-Flop (Toggle)



T	Clk	Q
x	0	Q_{old}
x	1	Q_{old}
x	↓	Q_{old}
0	↑	Q_{old}
1	↑	$\overline{Q_{old}}$

Flip-Flop Enhancements

- Additional Flip-Flops
 - JK – Flip-Flop



J	K	clk	Q
x	x	0	Q_{old}
x	x	1	Q_{old}
x	x	↓	Q_{old}
0	0	↑	Q_{old}
0	1	↑	0
1	0	↑	1
1	1	↑	$\overline{Q_{old}}$

} Matches the J input