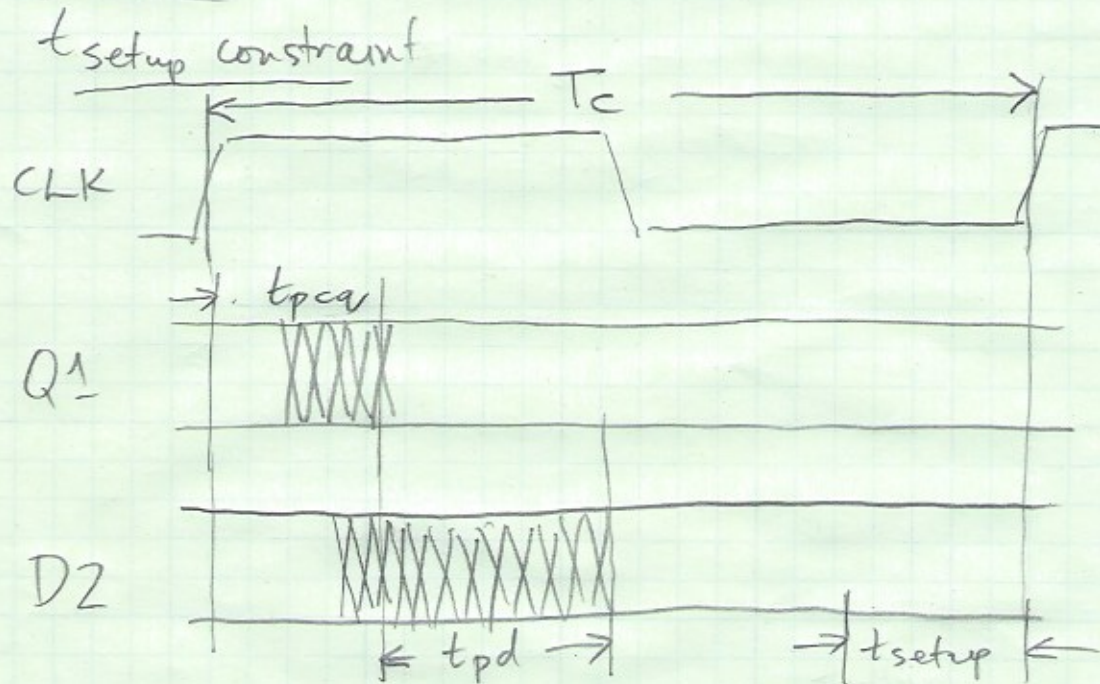


Tue Dec 3 2019

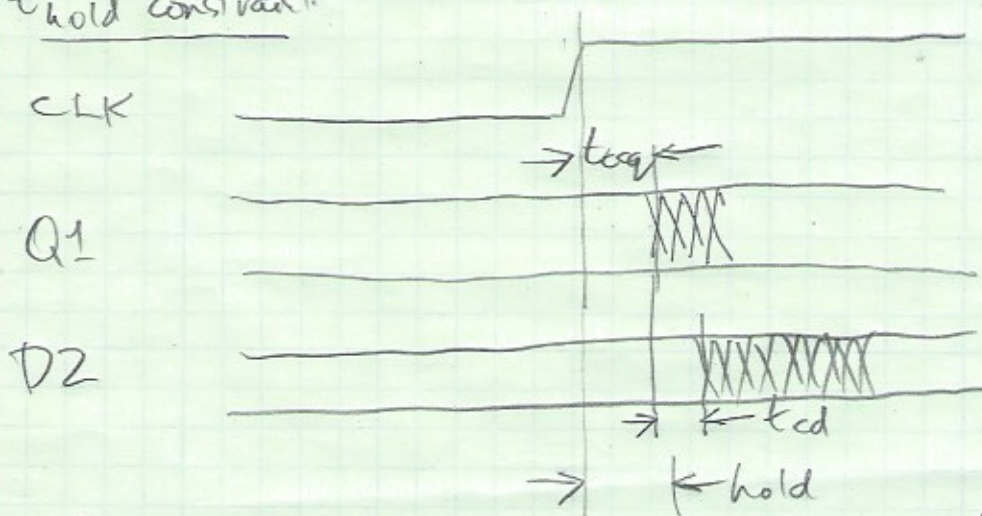
Quiz 4 - TAs have not finished marking
 - I hope to return papers in lecture tomorrow.

Exercise 1



For reliable operation: $t_{pcq} + t_{pd} \leq T_c - t_{setup}$

t_{hold} constraint



For reliable operation $t_{coq} + t_{cd} \geq t_{hold}$

Exercise 2

We need to look at all paths from a register to a register through Φ only.

path from R1 to R1
250ps

path from R1 to R2
 $t_{pd} = \underbrace{60ps}_{\text{Bar}} + \underbrace{180ps}_{\text{Zork}} = 240ps$
(slower than Quux)

Only need to worry about slowest path

$$T_c \geq t_{pcq} + \underbrace{t_{pd}}_{\text{slowest}} + t_{\text{setup}}$$

$$T_c \geq 33 + 250 + 75 = 358 \text{ ps}$$

ENEL 353
tutorial
Dec 3 2019
2 of 4

Exercise 3

hold time $t_{\text{hold}} \leq t_{\text{ccq}} + t_{\text{cd}}$

If $t_{\text{cd}} = 0$, then we need $t_{\text{hold}} \leq t_{\text{ccq}}$.

That's true here, so a hold-time violation is impossible.

Setup time

$$\begin{aligned} t_{pd} &\leq T_c - (t_{pcq} + t_{\text{setup}}) \\ &\leq 500 - (50 + 25) = 425 \text{ ps} \end{aligned}$$

t_{pd} for Φ must be $\leq 425 \text{ ps}$
for reliable operation.

Exercise 4 As t_{skew} gets larger, both the setup and hold problems get tougher for designers hold constraint.

We need to look at the faster path, the one from $Q1_{2:0}$ to $D2_{2:0}$.

$$t_{ccq} + t_{cd} \geq t_{hold} + t_{skew}$$

$$t_{skew} \leq t_{ccq} + t_{cd}^0 - t_{hold}$$

$$\leq 30ps - 10ps$$

$$\boxed{t_{skew} \leq 20ps}$$

Setup constraint

We need to look at the slower path, the one from $Q1_{7:3}$ to $D2_{7:3}$.

$$t_{pd} \leq T_c - (t_{pcq} + t_{setup}) - t_{skew}$$

$$t_{skew} \leq T_c - t_{pcq} - t_{setup} - t_{pd}$$

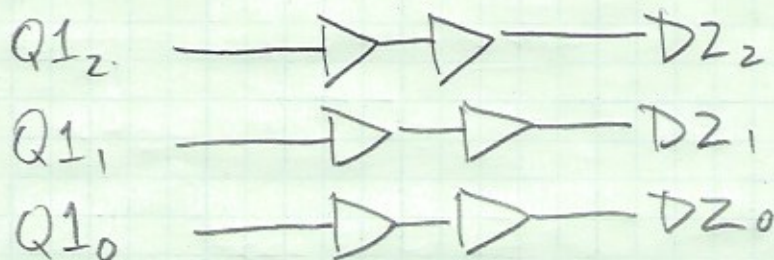
$$\leq 500 - 50 - 25 - 350$$

$$\boxed{t_{skew} \leq 75ps}$$

Overall result: $\boxed{t_{skew} \leq 20ps}$

ENEZ 353
tutorial
Dec 3 2019
3 of 4

For tolerance of $t_{skew} = 70\text{ps}$, we must add at least 50ps of t_{cd} to the path between $Q1_{2:0}$ and $D2_{2:0}$ ---



ENEL 353
tutorial
Dec 3 2019
4 of 4.

New hold constraint $t_{skew} \leq 90\text{ps}$

Old setup constraint $t_{skew} \leq 75\text{ps}$

Now we can tolerate $t_{skew} = 70\text{ps}$

Exercise 5 (to be continued Wed Dec 4)

state transition diagram

