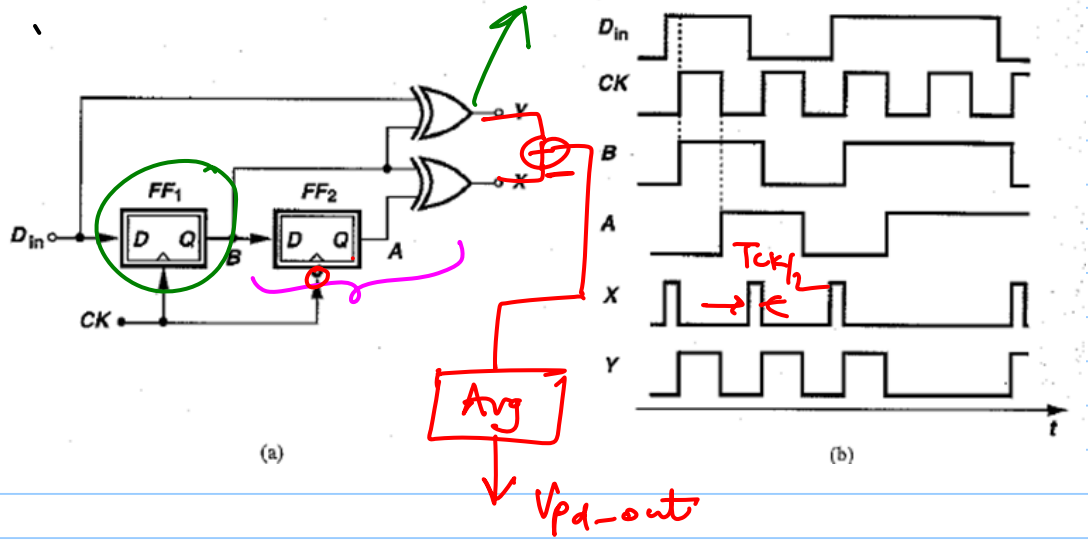
ECE 518 – Lecture 26

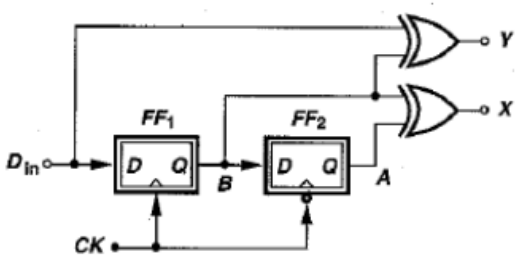
Note Title 4/23/2015

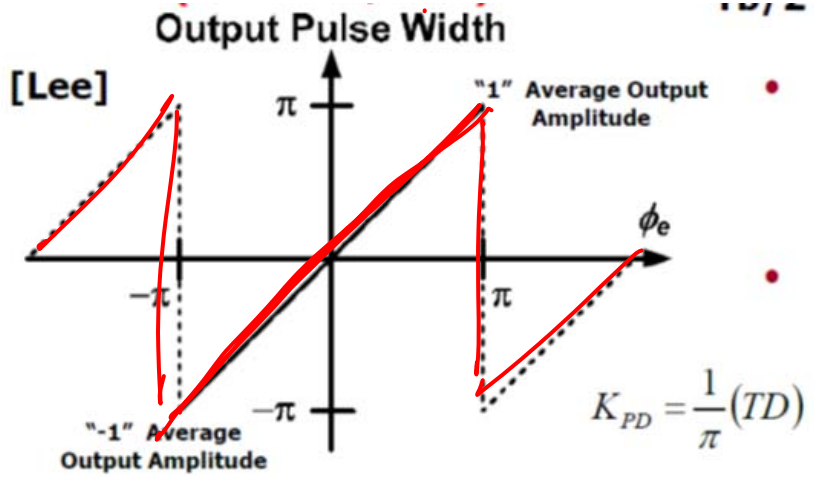
Hogge PD → Linear PD

edge detect + phase difference

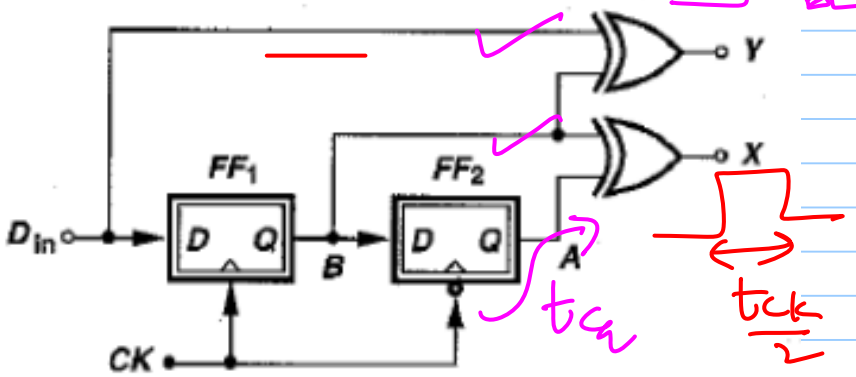
avg (Y-X) ∝ Δφ

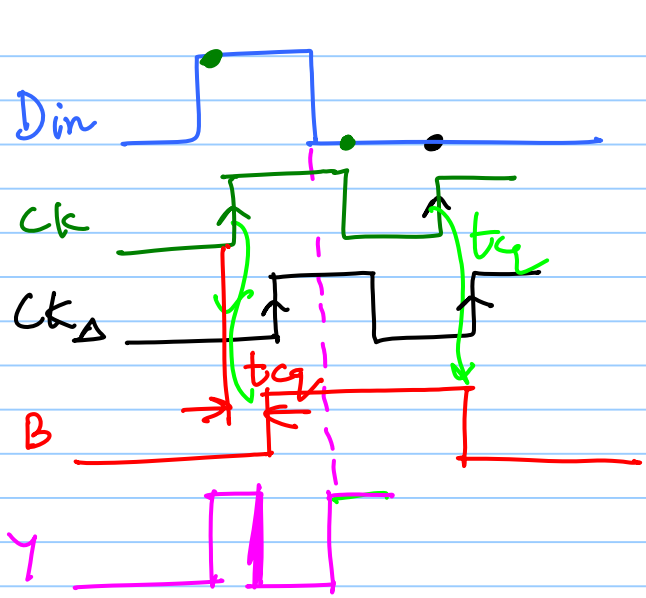



Y
X
FF1
FF2
D Q
D Q
Din
B
A
CK


Output Pulse Width
[Lee]
π
"1" Average Output Amplitude
ϕ_e
−π
π
−π
"-1" Average Output Amplitude
$K_{PD} = \frac{1}{\pi}(TD)$

* finite delay in FF → t_{cq}

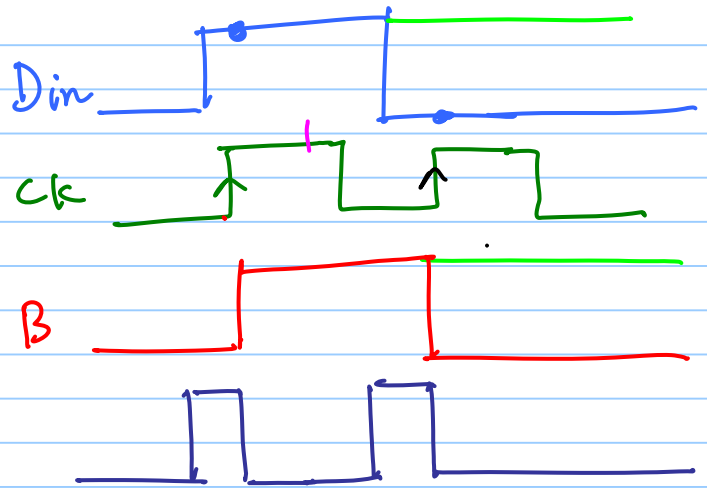




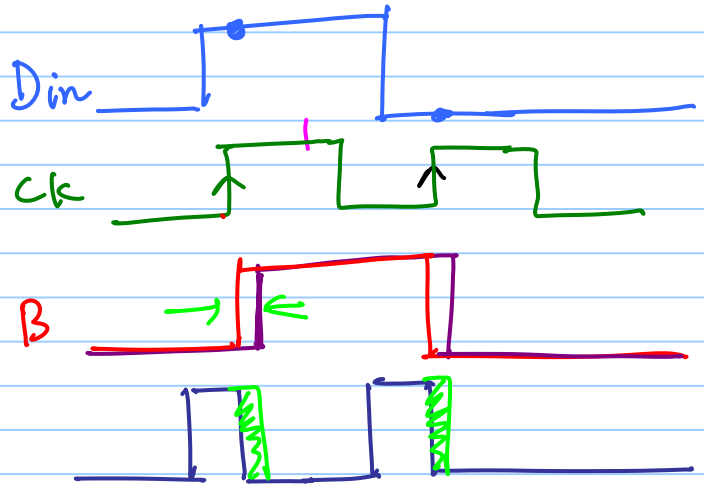
t_{cq} of FF_1 ⇒ B changes t_{cq} after the clock rises

↳ pulse at Y is t_{cq} seconds wider than the actual phase difference b/w Din & CK

Ideal



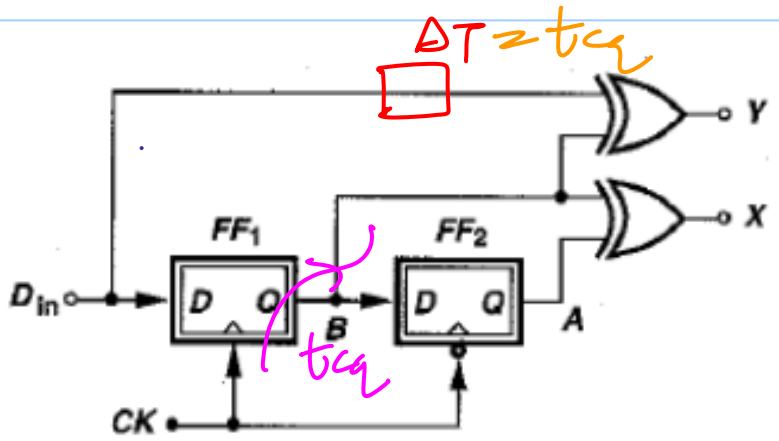
Delay in FF_1



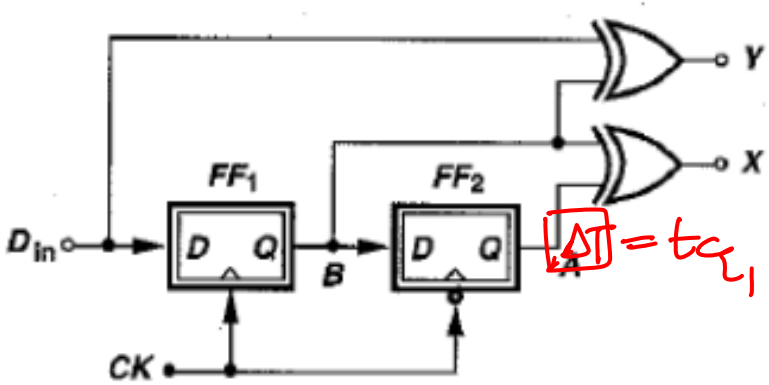
* t_{CQ} of FF_2 shifts the pulse at A by ΔT
  ↳ but still produces PW equal to $\frac{T_{clk}}{2}$

* At high speeds ΔT can be significant fraction of the clock period
  → Systematic offset when the loop is locked

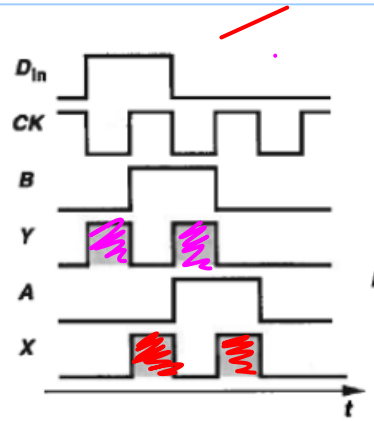
① Restore the proportional pulse at Y

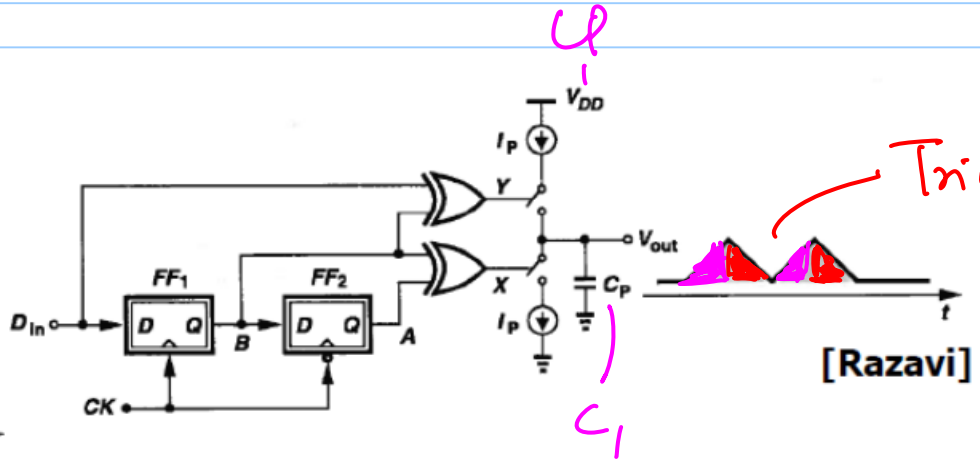


② widen the reference pulse by ΔT



$B \oplus A_\Delta \Rightarrow$ pulsewidth of $\frac{T_{ck}}{2} + \Delta T$





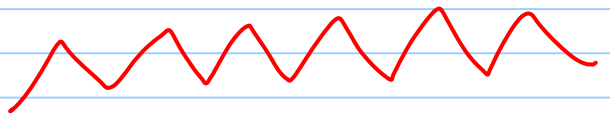
[Razavi]

Triwave

C_1

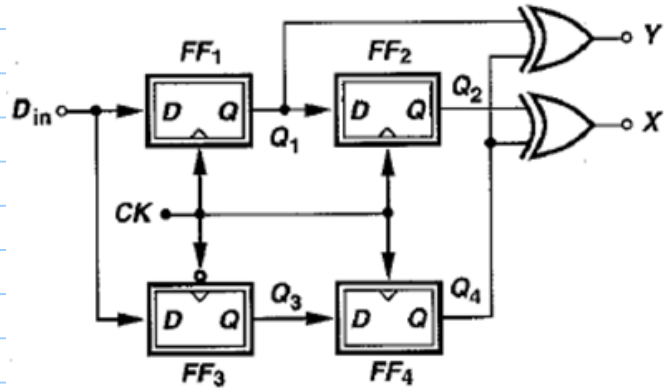
non-zero area

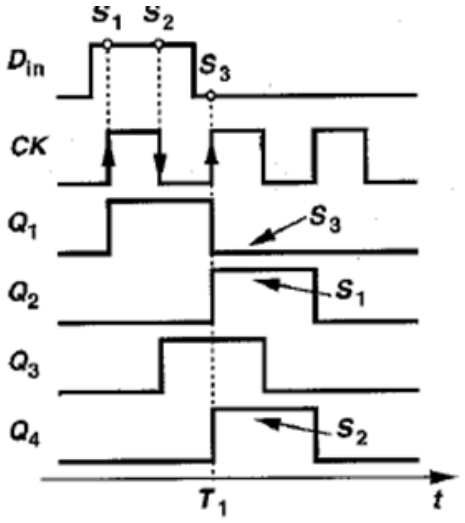
↳ severely distorts V_{out}



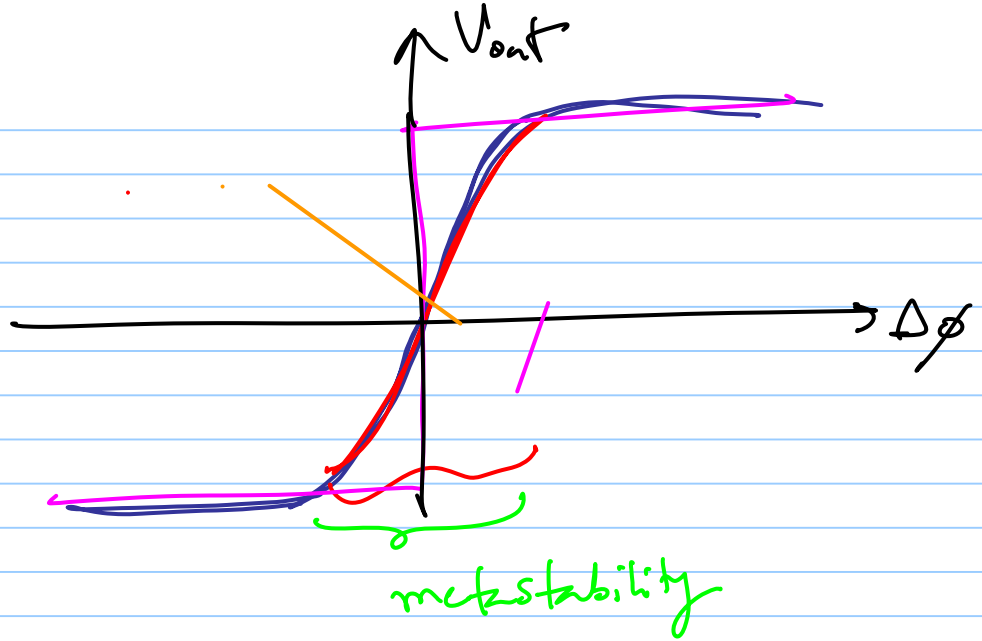
Non-linear (Binary)

Alexander Phase detector

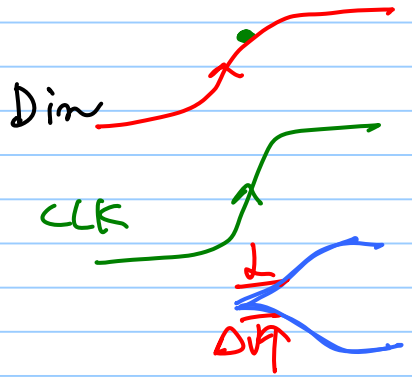





Din
CLK
CLK is late
CLK is early
Vout
Δϕ



metastability in the FF:

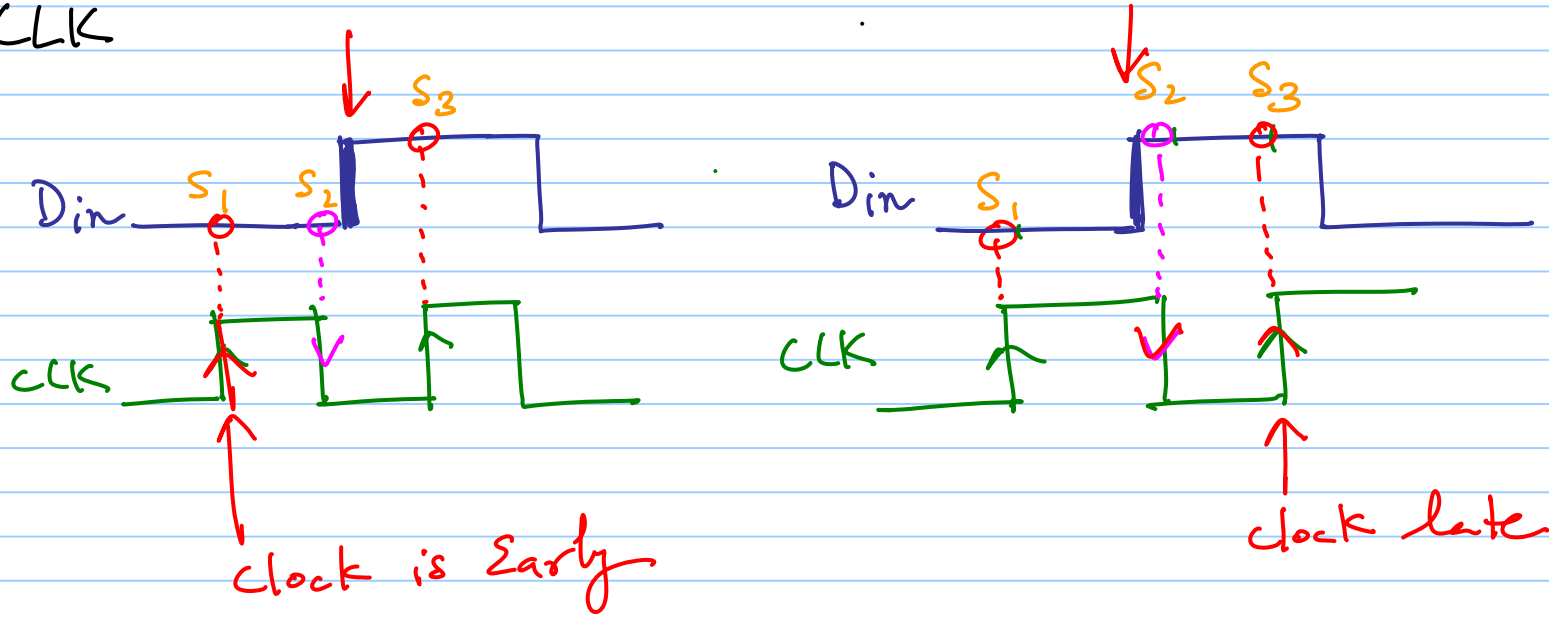


$$\frac{V_{out}}{\Delta\phi} = V_p e^{T_b/\tau_R}$$

↳ Can approximate as linear PLL

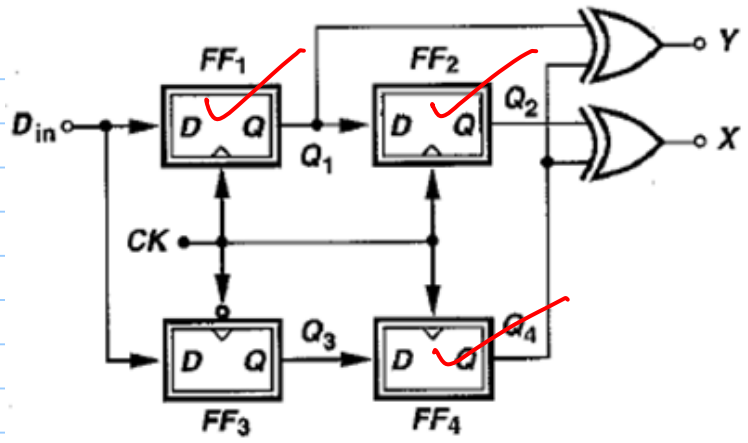
Din

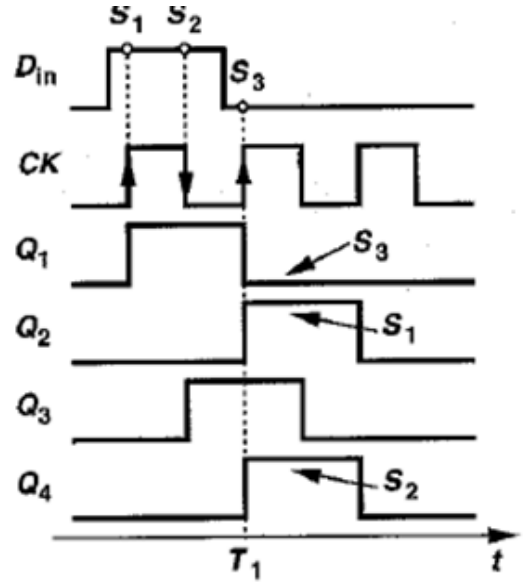
CLK



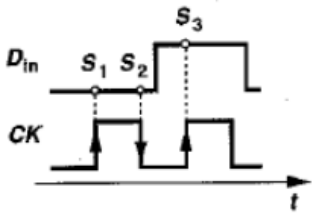
Take 3-samples $S_1 \rightarrow S_3$ by three consecutive clock edges

↳ The PD detects whether a transition occurred and whether the clock leads or lags the data





Clock Early



Clock Late