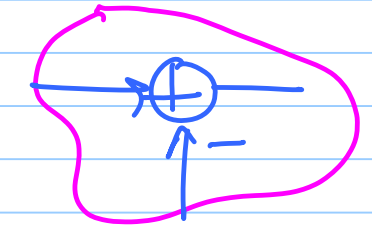
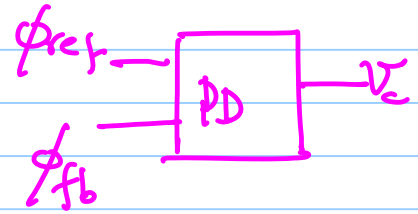
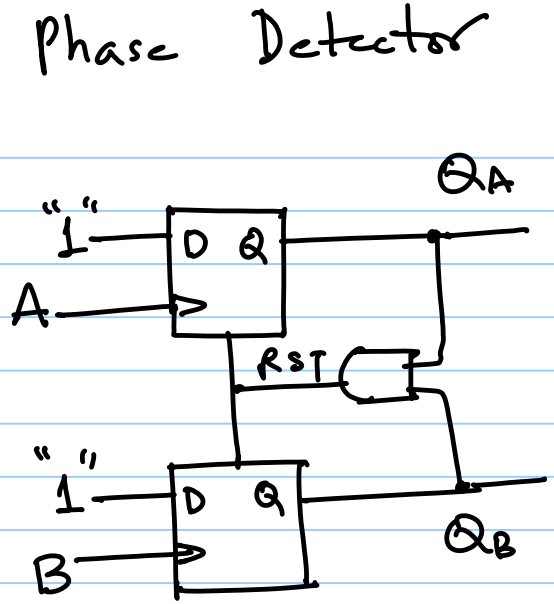
# ECE 504 - Lecture 4

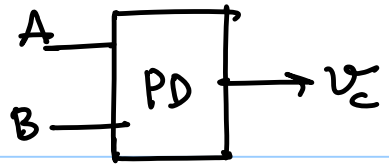
Note Title 8/31/2016





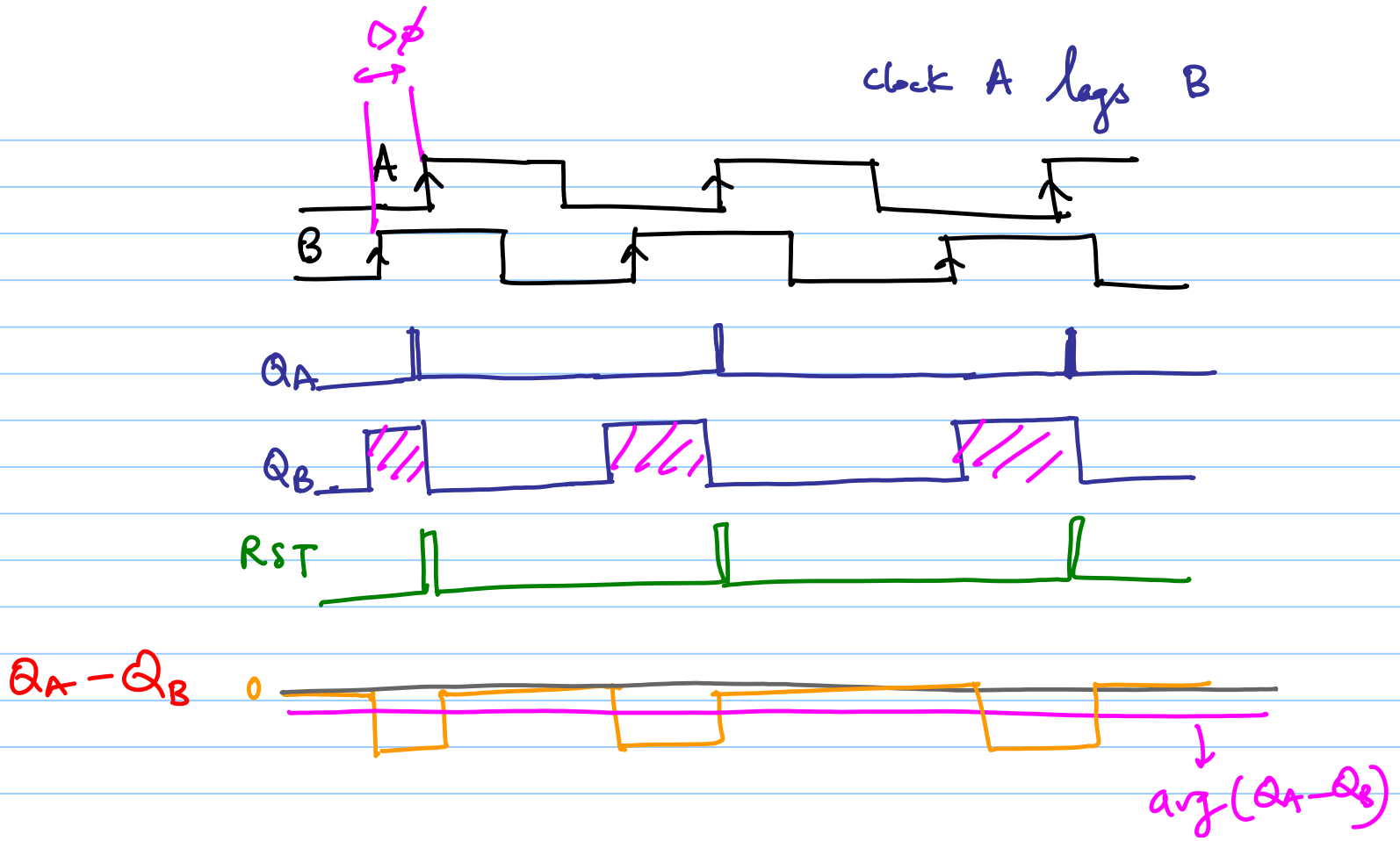
# Phase Detector

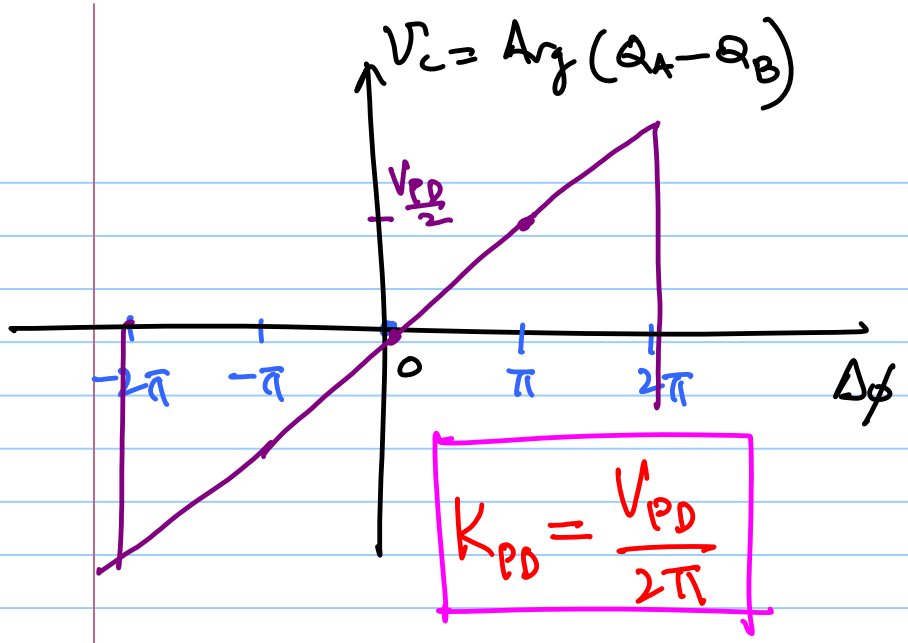



Clock A leads B


output is avg$(Q_A - Q_B)$

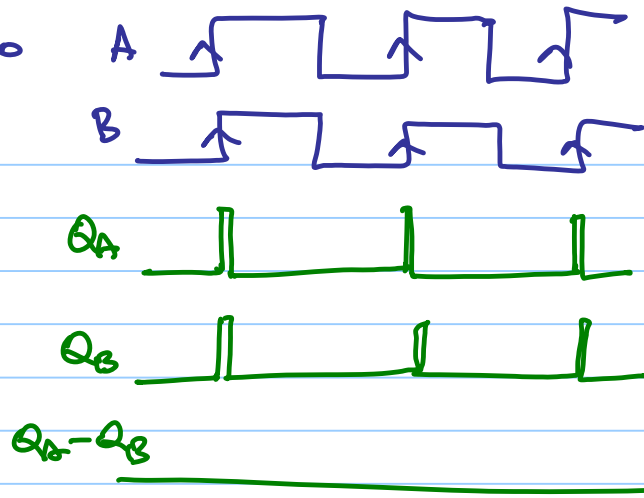

Δφ
clock A lags B
A
B
$Q_A$
$Q_B$
RST
$Q_A - Q_B$
0
avg($Q_A - Q_B$)



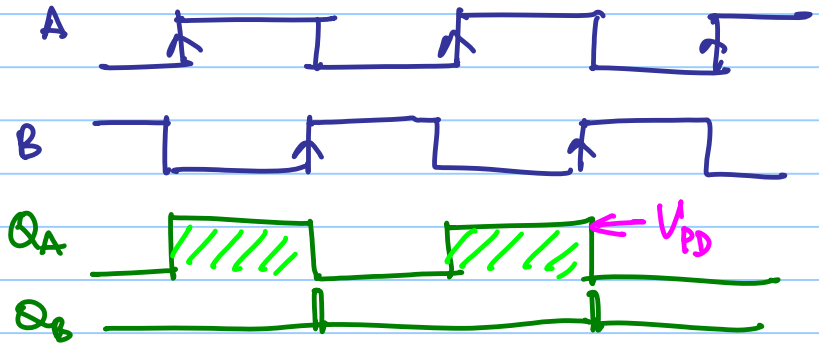

$$K_{PD} = \frac{V_{PD}}{2\pi}$$

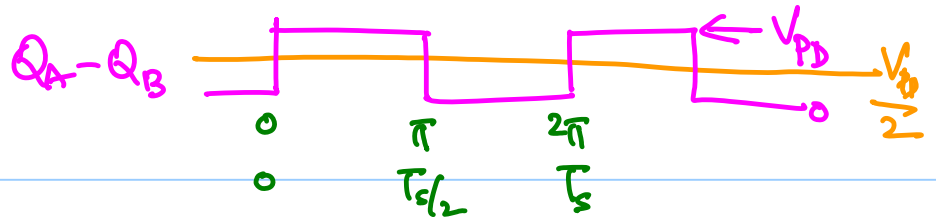
$V_{PD}$ ⇒ supply voltage or logic "1" for the FF

① $\Delta\phi = 0$

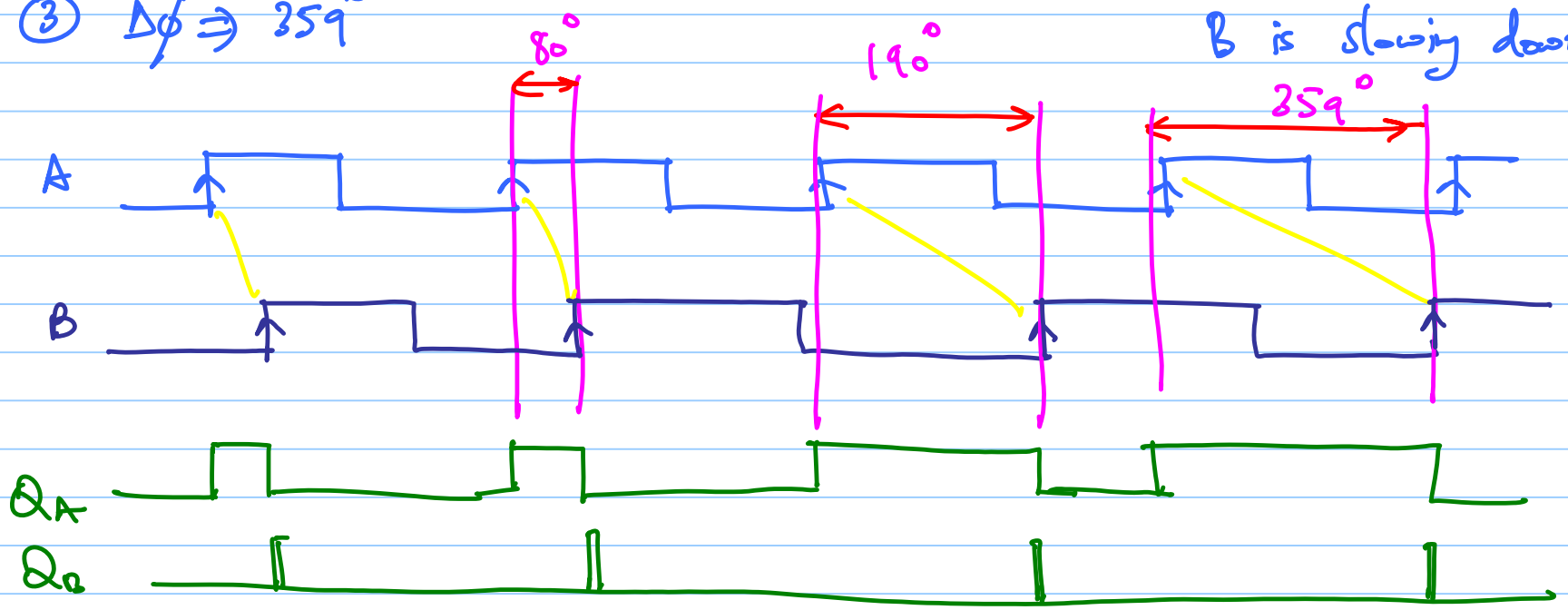


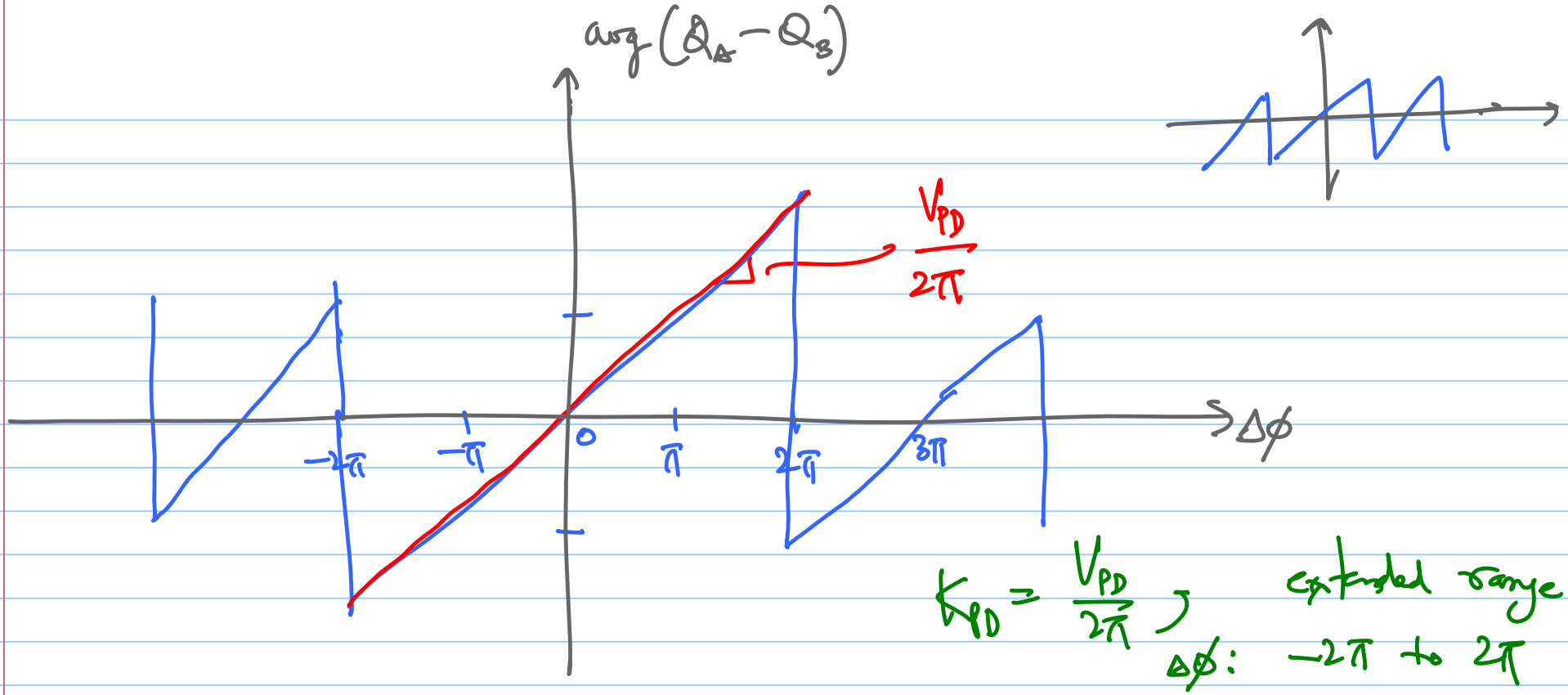

② $\Delta\phi = +\pi$





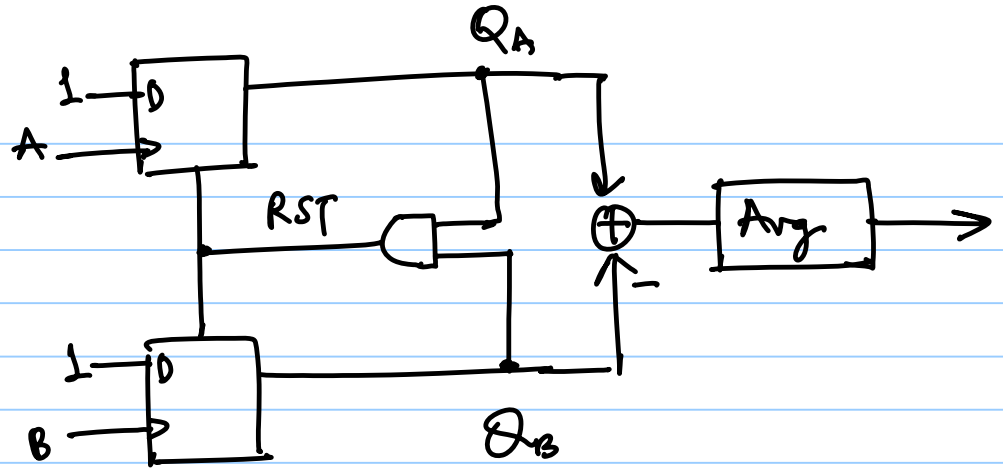

③ $\Delta\phi \Rightarrow 359^\circ$






$K_{PD} = \frac{V_{PD}}{2\pi}$ ; extended range

$\Delta\phi$: $-2\pi$ to $2\pi$




in radians

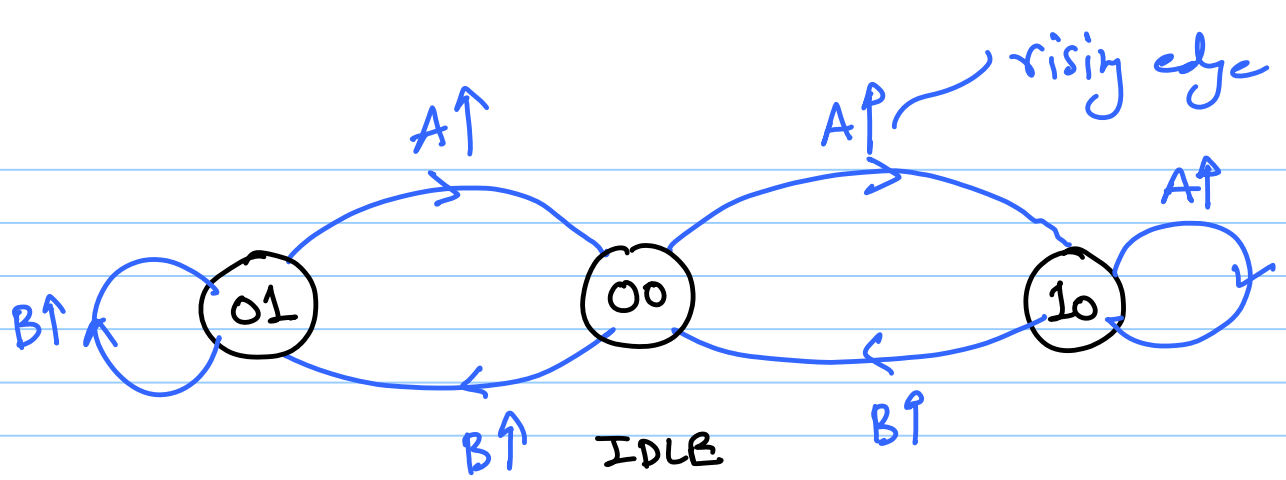
$$\frac{\Delta\phi}{2\pi} \cdot V_{PD}$$

$$K_{PD} = \frac{V_{PD}}{2\pi}$$

Two ff's
2-bit State Machine
↳ only 3 valid states

$[Q_A\ Q_B]$ state

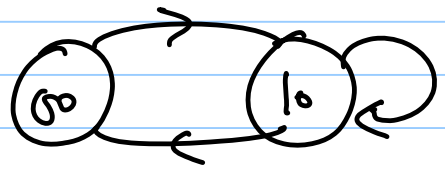
| $Q_A$ | $Q_B$ | |
|---|---|---|
| 0 | 0 | ✓ |
| 0 | 1 | ✓ |
| 1 | 0 | ✓ |
| 1 | 1 | X |




$Q_A$-$Q_B$

Tri-state Phase-frequency detector (PFD)

let $f_A > f_B \Rightarrow$ more $A\uparrow$ than $B\uparrow$ transitions




$\Rightarrow \arg(\theta_A - \theta_B) > 0$

$\Rightarrow V_c > 0 \Rightarrow$ VCO will speed up & B will catch up

for $f_A < f_B \Rightarrow$ opposite will happen

↳ always moves in the right direction to catch up with the reference frequency

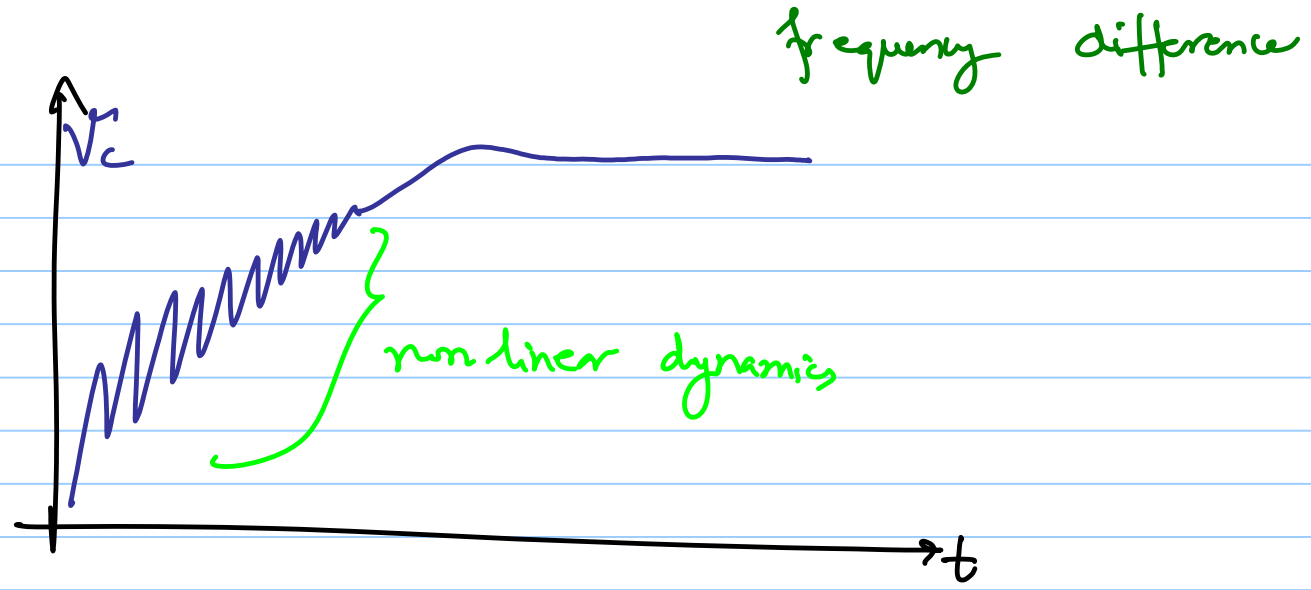
↳ This PFD also provides frequency difference detection.

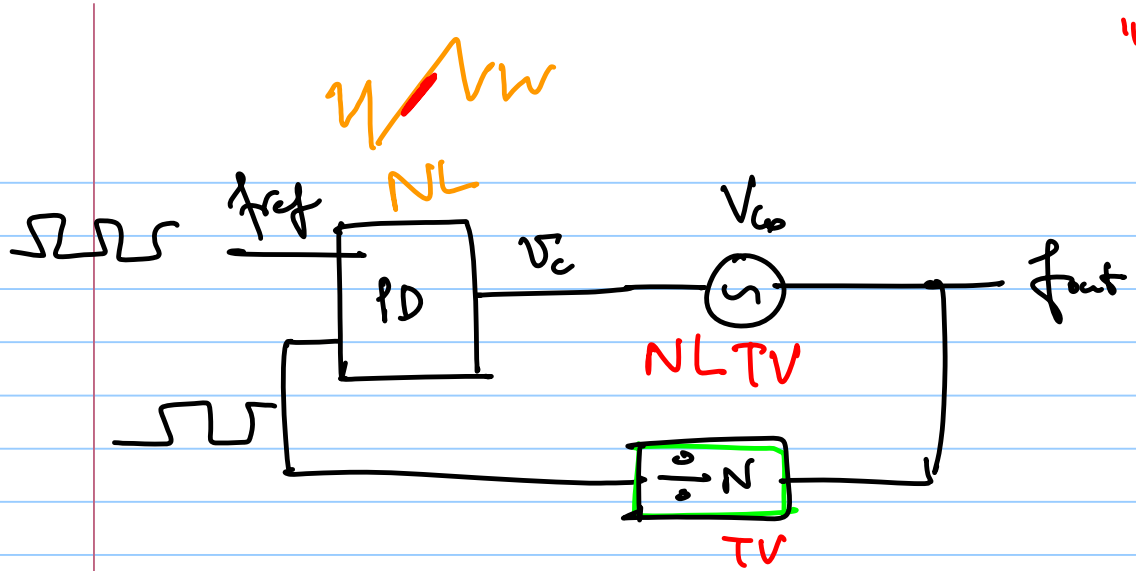
"Locking" → for what frequency range the PLL remains locked

"Capture" → apply some frequency and see if the PLL can lock

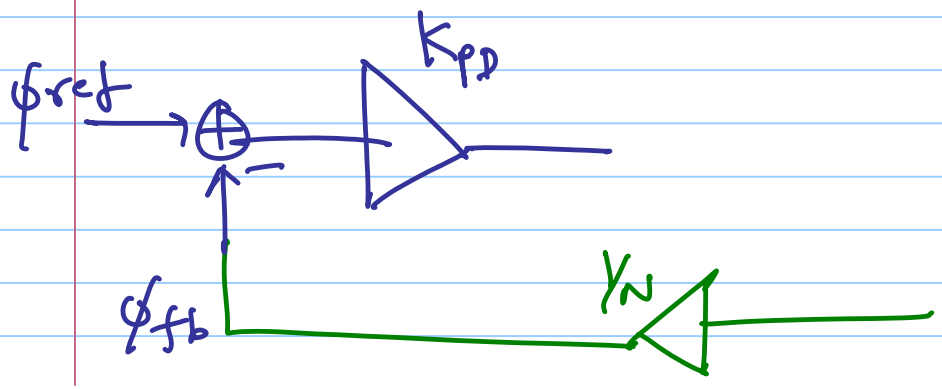
* PFD facilitates a faster capture

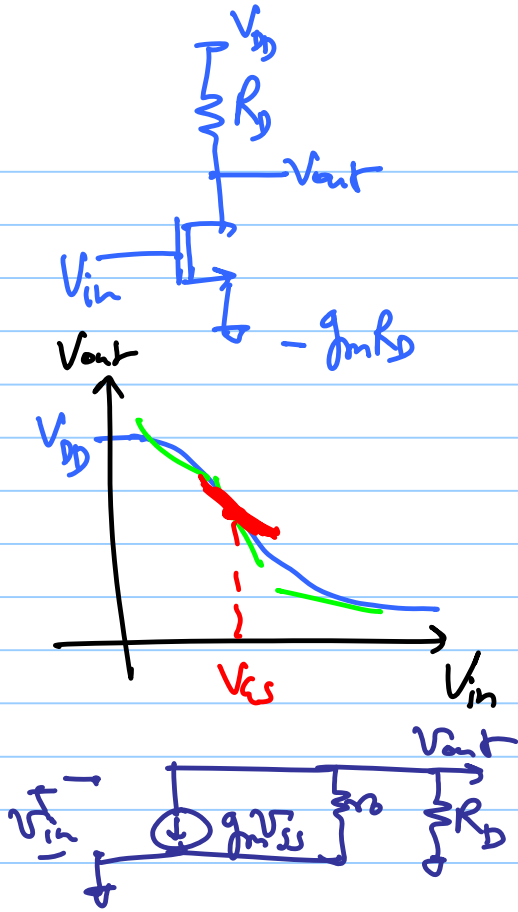
XOR PD ⇒ the output avg is zero ⇒ takes time to lock when starting with large

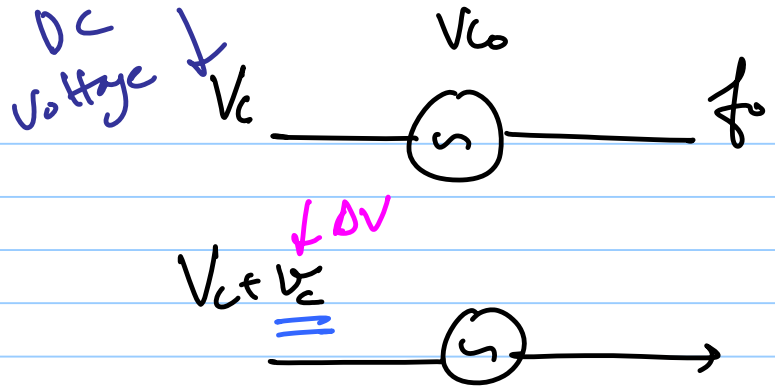

frequency difference
$V_c$
non linear dynamics
t


NL
$f_{ref}$
PD
$V_c$
$V_{co}$
NLTV
$f_{out}$
÷N
TV

"LTI"

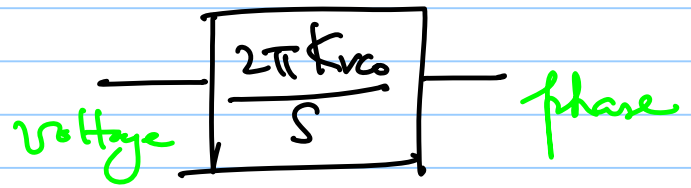

$\phi_{ref}$
$K_{PD}$
$\phi_{fb}$
$Y_N$


$V_{DD}$
$R_D$
$V_{out}$
$V_{in}$
$-g_mR_D$
$V_{out}$
$V_{DD}$
$V_{GS}$
$V_{in}$
$V_{out}$
$v_{in}$
$g_mv_{gs}$
$r_o$
$R_D$




$$\cos\left(2\pi f_o t + 2\pi K_{vco}\int V_c\,dt\right)$$

$$\cos\left(2\pi f_o t + 2\pi K_{vco}\int V_c\,dt + \underbrace{2\pi K_{vco}\int v_c\,dt}_{\Delta\phi}\right)$$

incremental phase-domain equivalent model