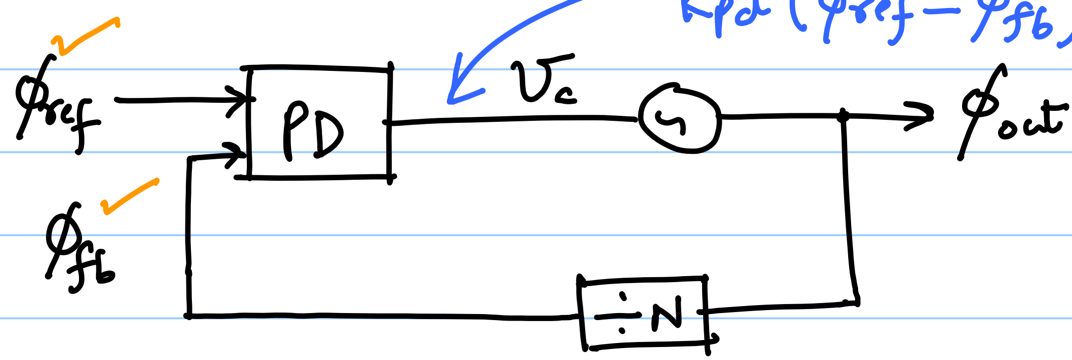
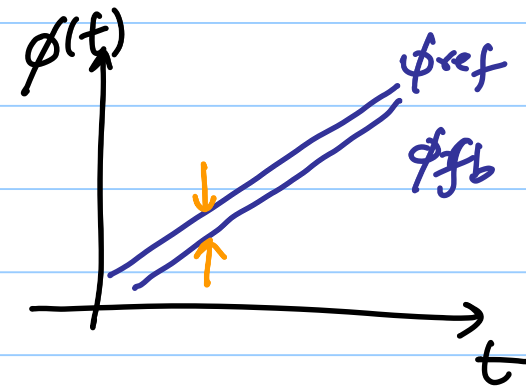
ECE 518 - Lecture 3

Note Title 1/20/2015





In steady state $\Rightarrow$ $V_c \rightarrow$ constant

$$f_{vco} = f_0 + K_{vco} \cdot V_c$$

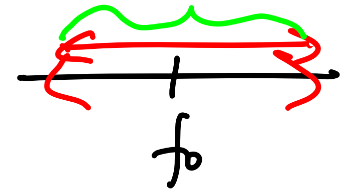
$$f_{vco} = N f_{ref}$$

$$V_c = \frac{f_{vco} - f_0}{K_{vco}}$$

In steady-state $\quad V_c = \dfrac{N f_{ref} - f_0}{K_{vco}} \longrightarrow (1)$

$$V_c = K_{pd}(\phi_{ref} - \phi_{fb}) \longrightarrow (2)$$

from ① & ②, we get



$$\boxed{\underbrace{\phi_{ref} - \phi_{fb}}_{\Delta\phi} = \frac{\overbrace{N f_{ref} - f_o}^{f_{vco}}}{K_{vco} \cdot K_{pd}}} \longrightarrow ②$$

phase offset

combined gain of PD & VCO

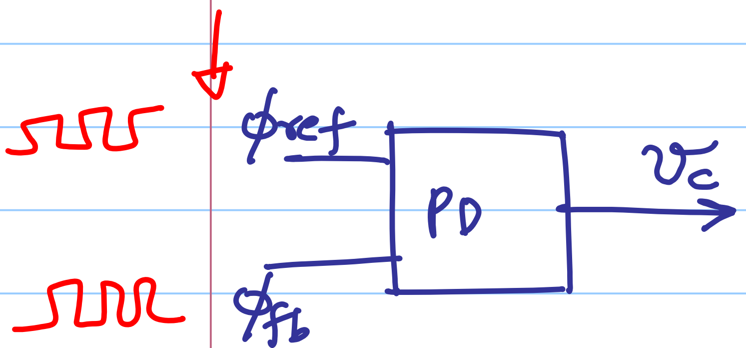
PD gain $\quad K_{pd} \Rightarrow \frac{V}{rad}$

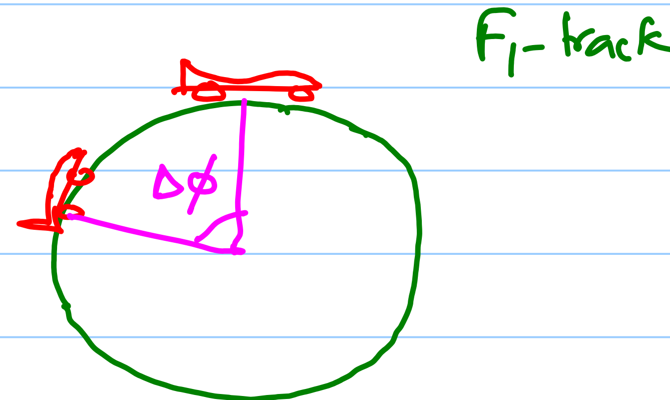
VCO gain $\quad K_{vco} \Rightarrow \frac{Hz}{V}$

units are important!

PD characteristics

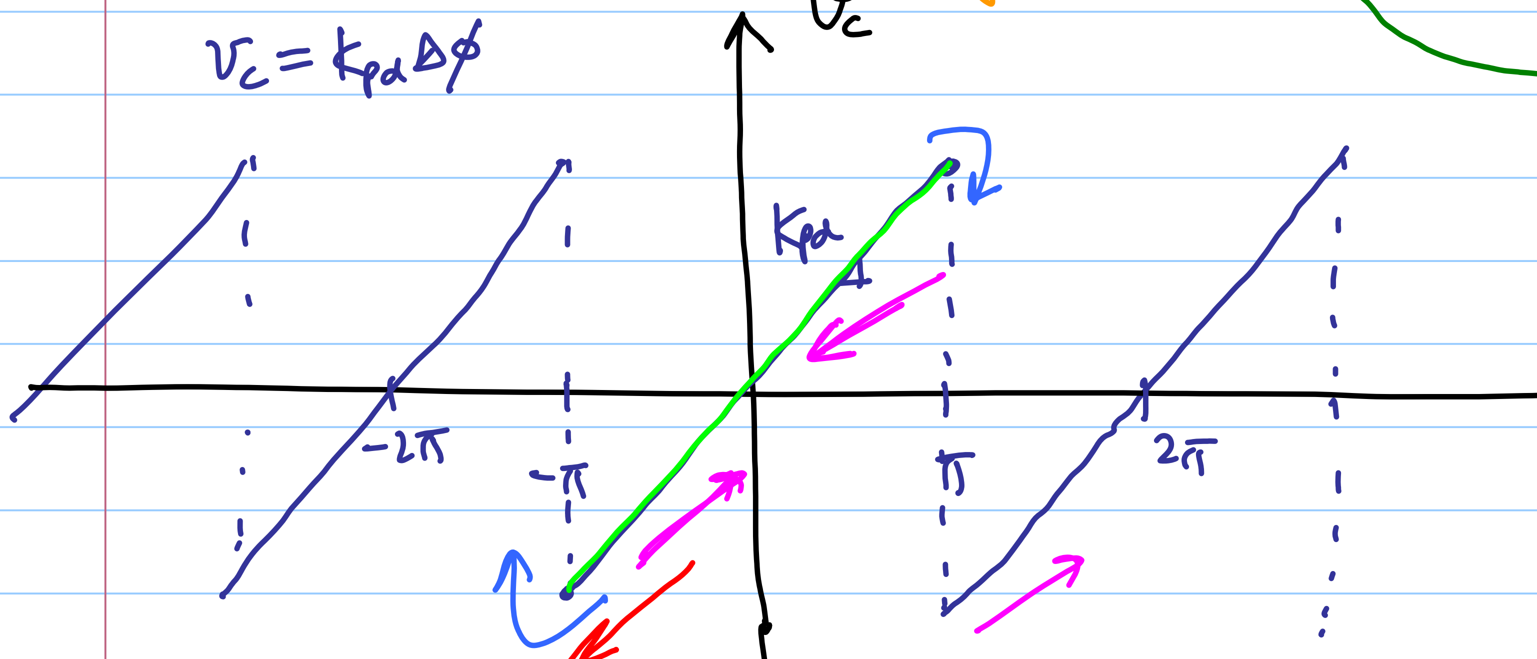
$$v_c \propto \Delta\phi = K_{pd}\Delta\phi$$

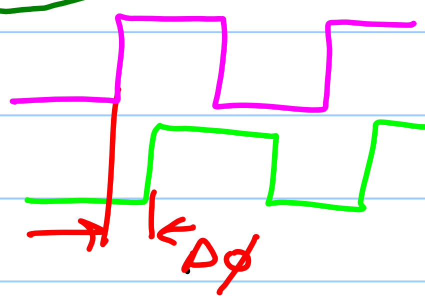




average PD output value

$v_c = K_{pd}\Delta\phi$





If you don't track the "lap difference"

↳ can only find $\{-\pi, \pi\}$ phase difference phase difference is inherently modulo 2π

$-\pi < \Delta\phi < \pi$: linear characteristic

$$-\pi < \frac{N f_{ref} - f_o}{K_{vco} \cdot K_{PD}} < \pi$$

$\Rightarrow$

$$-\pi K_{pd} K_{vco} < N f_{ref} - f_o < \pi \cdot K_{pd} \cdot K_{vco}$$

$$\Rightarrow \boxed{|N f_{ref} - f_o| < \pi K_{pd} \cdot K_{vco}}$$

with a finite $\Delta\phi$

for a wide range of output frequency

$K_{pd} \cdot K_{vco}$ should be large

$\hookrightarrow$ forward path gain

very large frequency range $\Rightarrow$ large gain

Any problems due to this?

"Later"

* If the reference frequency is lowered, such that $\Delta\phi < -\pi$, the PLL will not remain locked

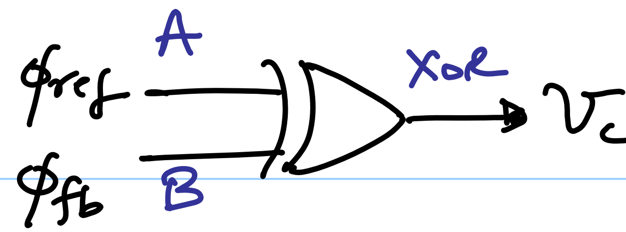
If this frequency range is outside $\pi K_{pd} K_{vco}$ value, the PLL will not lock.

Also if $f_{ref} \neq \frac{f_{vco}}{N} \Rightarrow \Delta\phi$ will be time varying

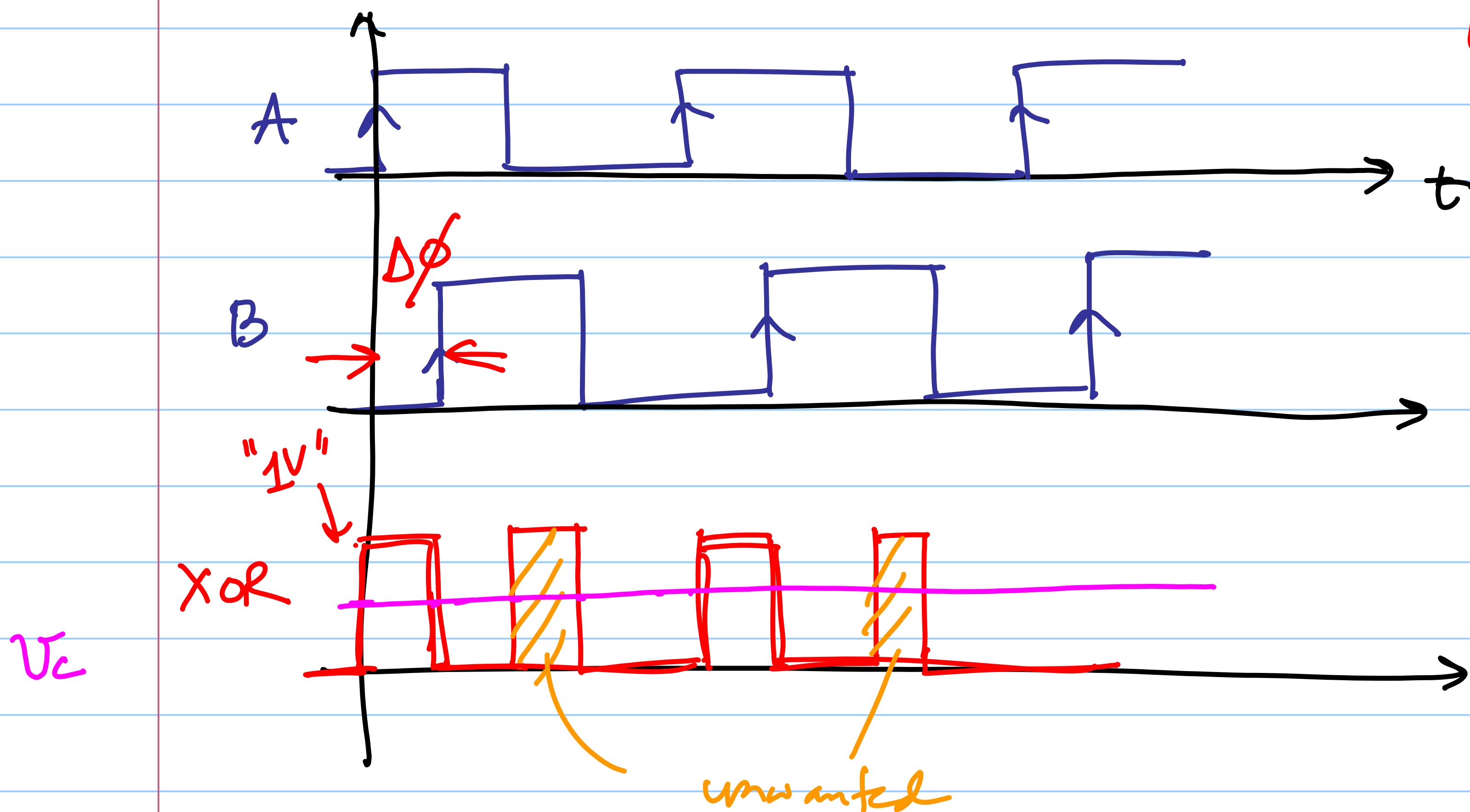
$\Rightarrow v_c$ will be time varying

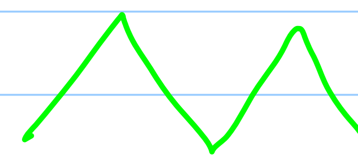
$\Rightarrow$ the output will not be a ~~fixed~~ varying frequency.

XOR PD:



Level sensitive





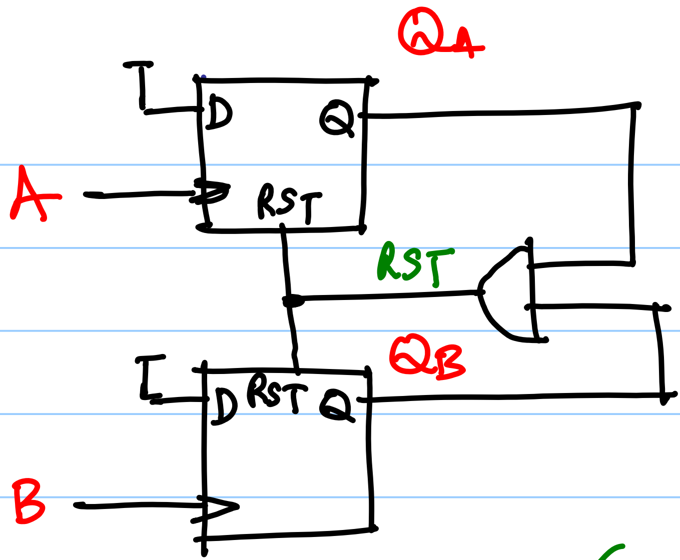
XOR is duty cycle sensitive

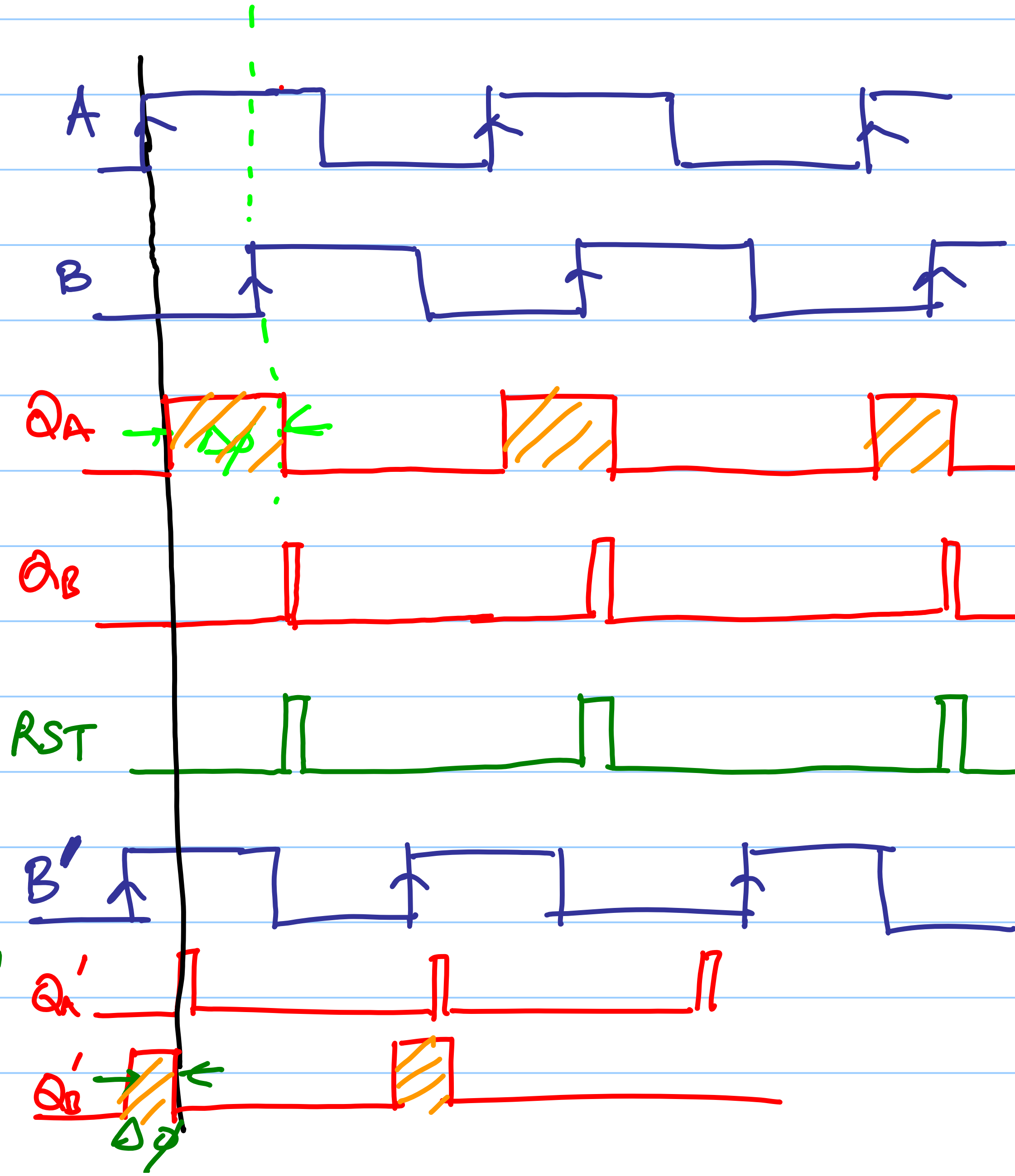
↳ sensitive to logic levels, not edges.

We want a PD output

$$\begin{cases} +\text{ve} & \text{when } A \text{ rises earlier than } B \\ -\text{ve} & \text{when } A \text{ rises later than } B \end{cases}$$

Rising edge of A $\Rightarrow Q_A = 1$



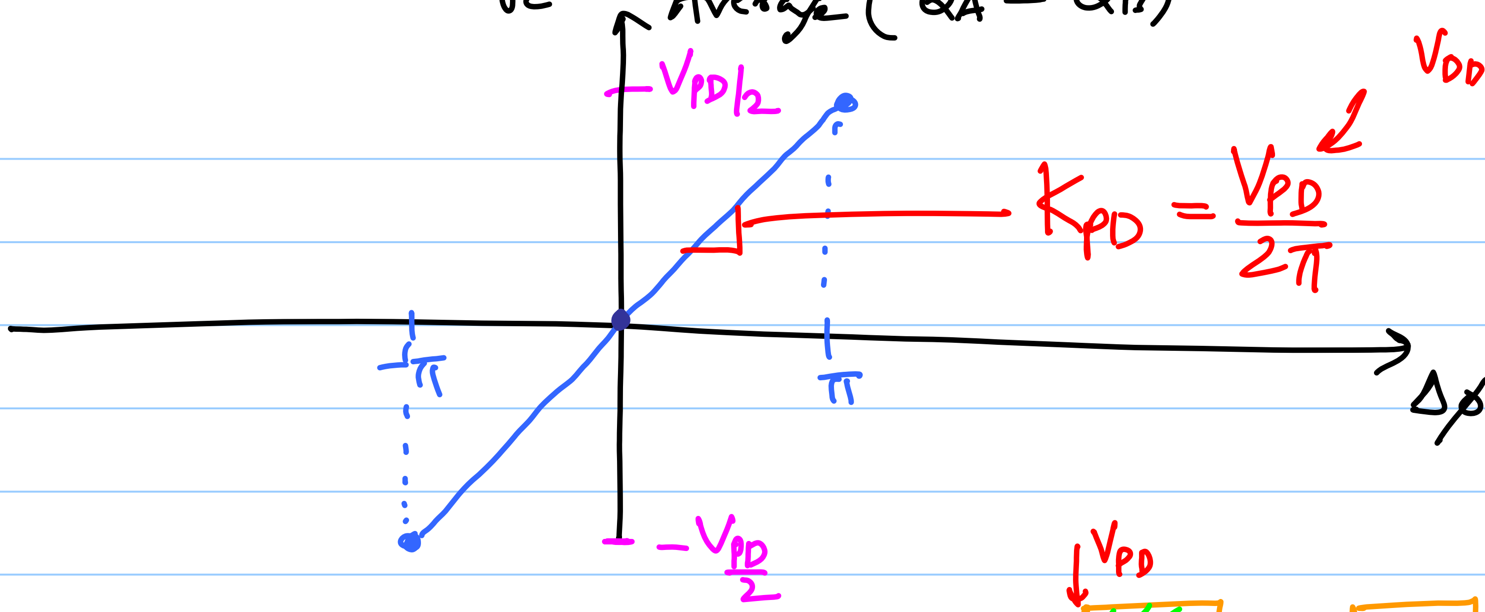


A is leading B

A is lagging B

Let $v_c = \underbrace{Q_A - Q_B}_{\text{Analog difference}}$

$V_c = \text{Average}\left(Q_A - Q_B\right)$

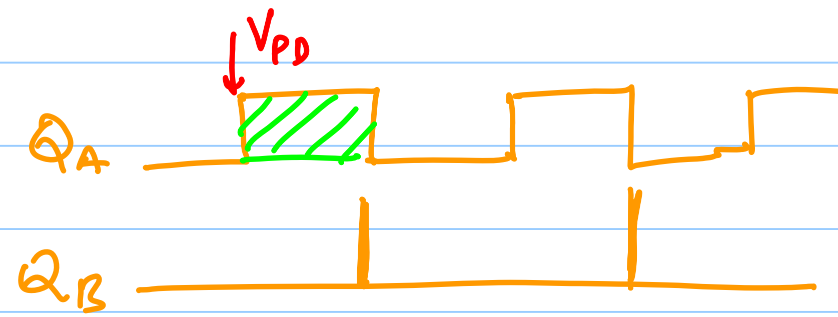


$K_{PD} = \frac{V_{PD}}{2\pi}$

V_{DD} of the FF

① $\Delta\phi = 0 \Rightarrow 0$

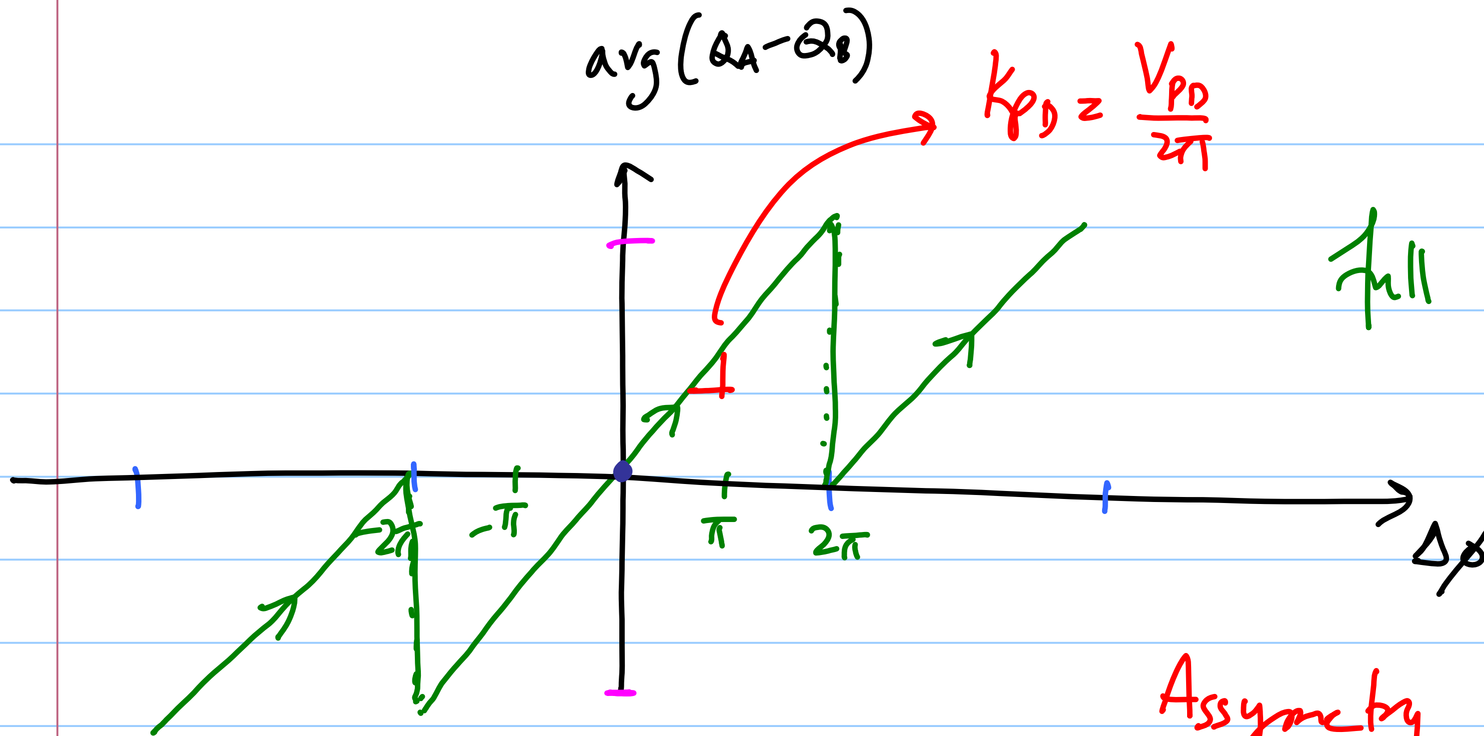
② $\Delta\phi = \pi$



$\text{avg}\left(Q_A - Q_B\right) = \frac{V_{PD}}{2}$

③ $\Delta\phi = -\pi$

$\text{avg}\left(Q_A - Q_B\right) \Rightarrow -\frac{V_{PD}}{2}$

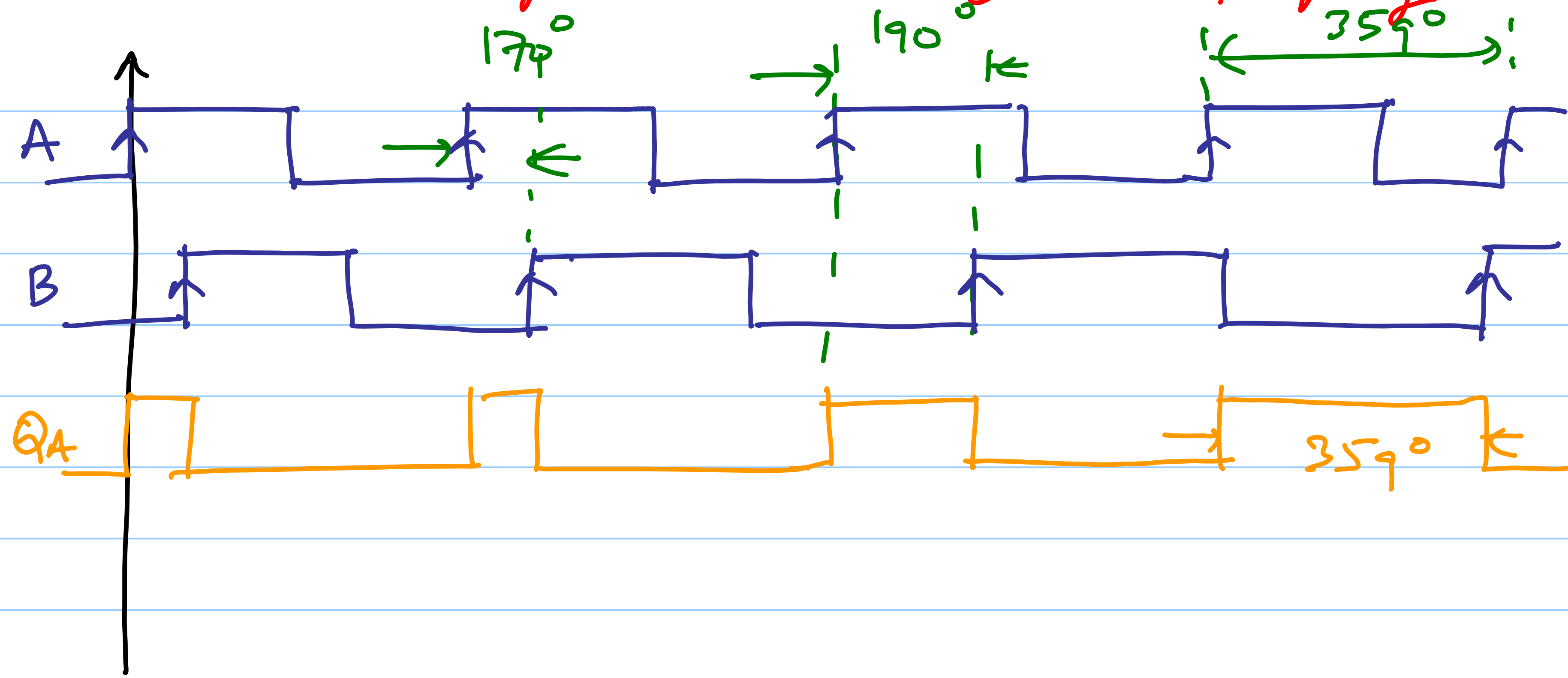


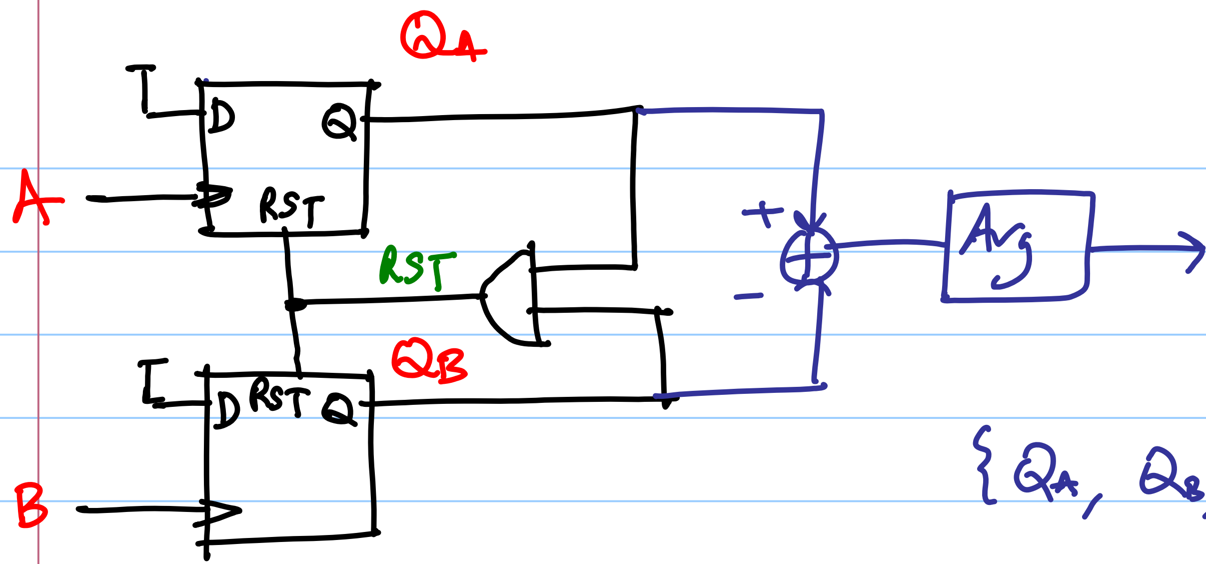
$K_{PD} = \frac{V_{PD}}{2\pi}$

full $\pm 2\pi$ range

Assymetry about y-axis
$\Rightarrow$ hysteresis

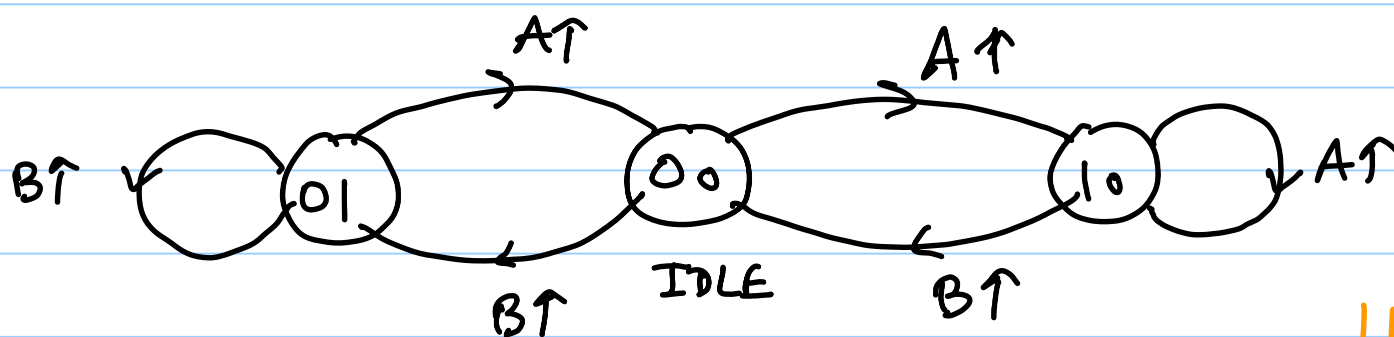
Let's say B is slowing its frequency





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

$\{Q_A, Q_B\}$



11 is not a valid state

3-State Phase Frequency detector