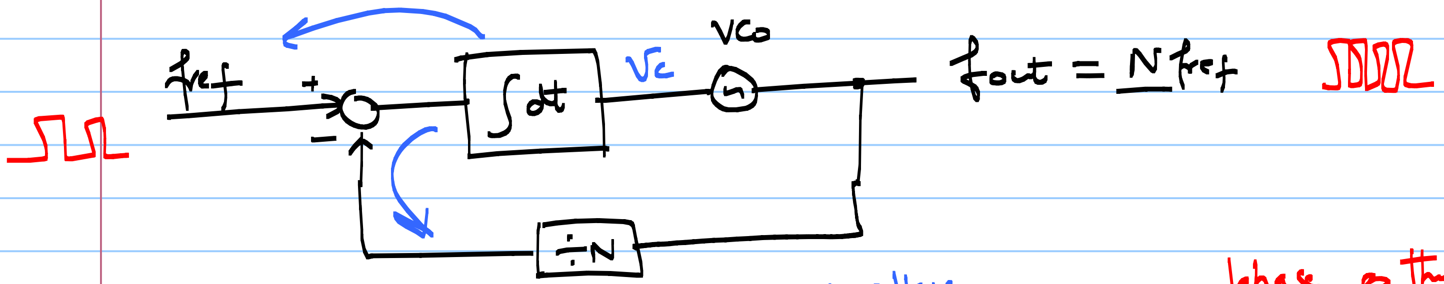
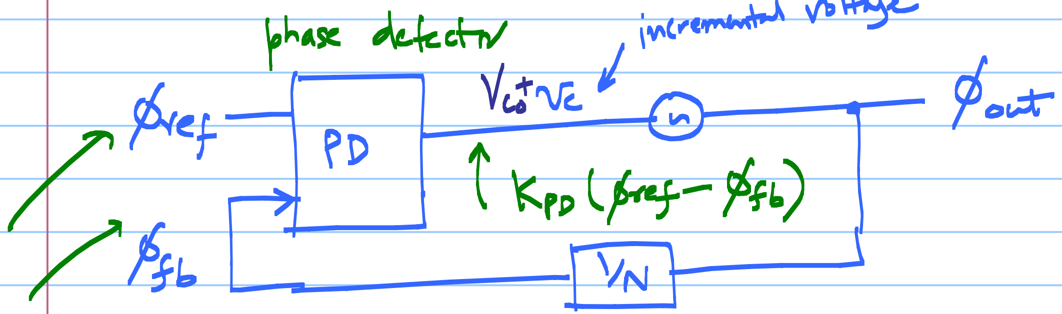
ECE 518- Lecture 10

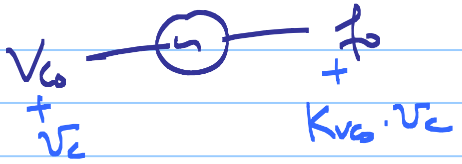
Note Title

2/21/2013



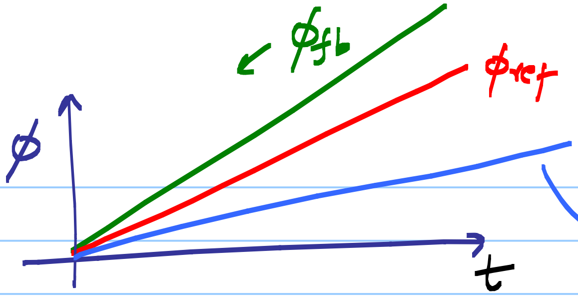


phase as the primary Variable



implicit that the frequency is integrated to get the phase

* initially



$\phi_{ref} \leftarrow \int f_{ref} \cdot dt$

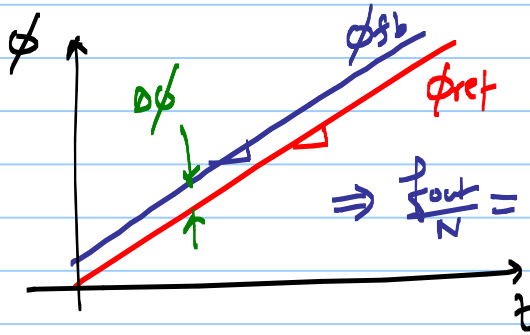
$\frac{f_{out}}{N} > f_{ref}$

$\frac{f_{out}}{N} < f_{ref}$

In steady-state,

$V_c \rightarrow$ becomes constant

when both ϕ_{ref} & ϕ_{fb} have the same slope



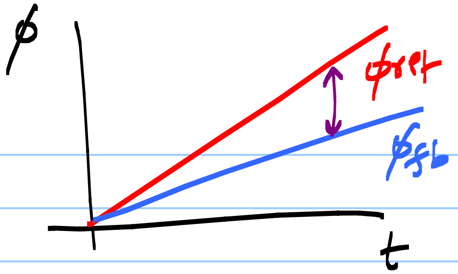
$\Rightarrow \frac{f_{out}}{N} = f_{ref}$

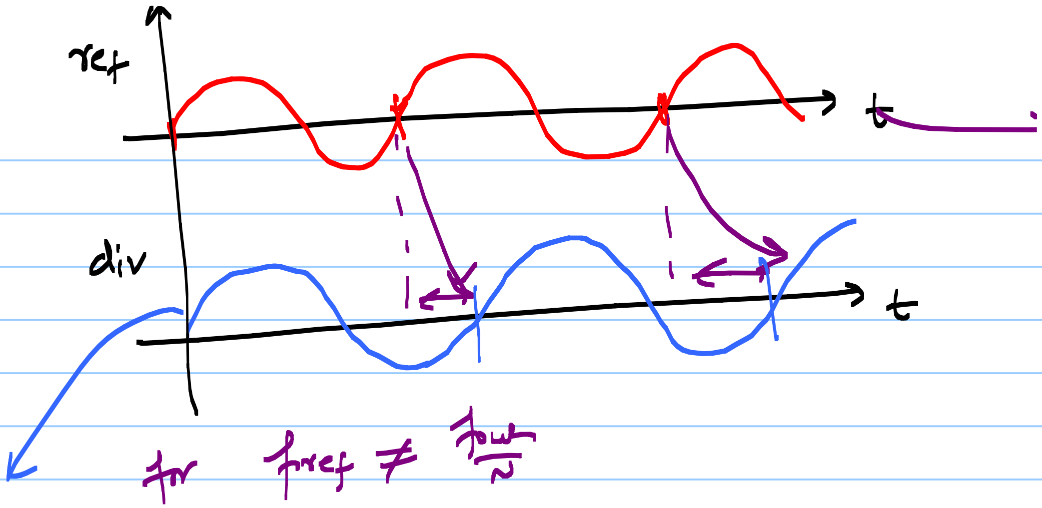
↳ they can have a constant offset

↳ But the $\Delta f = 0$

both the f_{ref} & feedback frequencies are same

$\Rightarrow f_{ref} = \frac{f_{out}}{N} \Rightarrow f_{out} = N f_{ref}$



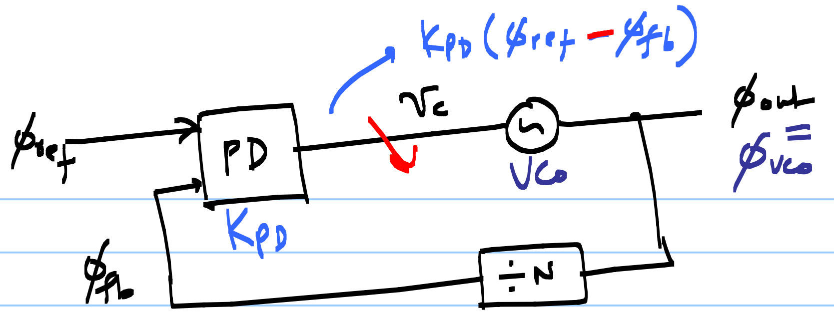


the cycles are longer

for $f_{ref} \neq \frac{f_{out}}{N}$

the phase difference will grow.

"Phase locked Loop"



$N f_{ref} > f_o$

$v_c > 0$

$$f_{VCO} = \underset{\text{free running frequency}}{f_o} + K_{VCO} \cdot \underline{\underline{v_c}}$$

In steady-state:

$$v_c = \frac{\overset{f_{out}}{N f_{ref}} - \overset{\text{free running}}{f_o}}{K_{vo}} \longrightarrow ①$$

* Back-calculate the phase difference $(\Delta\phi = \phi_{ref} - \phi_{fb})$

$$\phi_{ref} - \phi_{fb} = \boxed{\Delta\phi = \frac{N f_{ref} - f_o}{K_{VCO} \cdot K_{PD}}} \longrightarrow ②$$

Phase Detector : gain

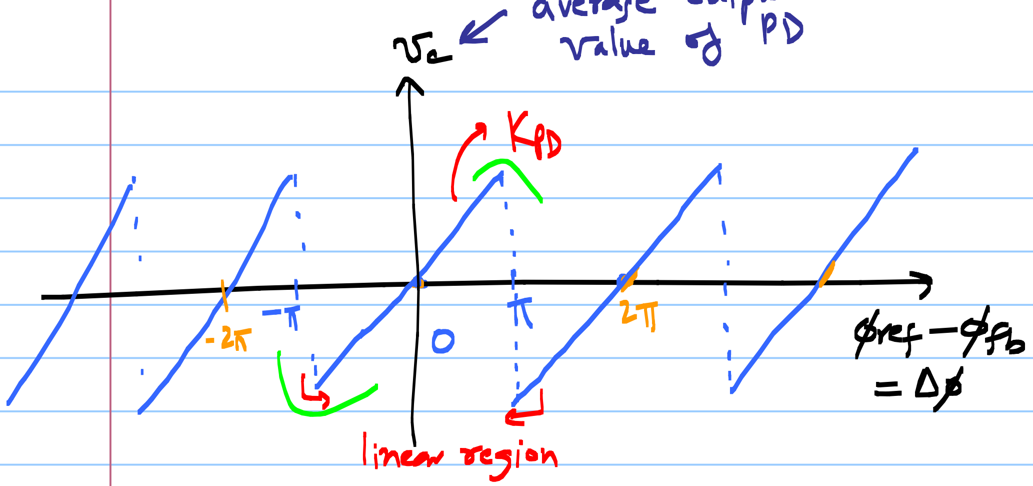
VCO gain

$$\boxed{\begin{array}{l} K_{PD} \Rightarrow \dfrac{V}{rad} \\[1em] K_{VCO} \Rightarrow \dfrac{Hz}{V} \end{array}}$$

Units are important

"2π factor"

Phase Detector



average output value of PD

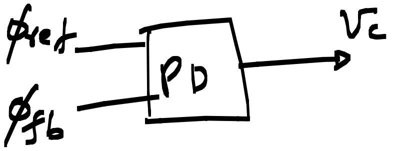
linear region

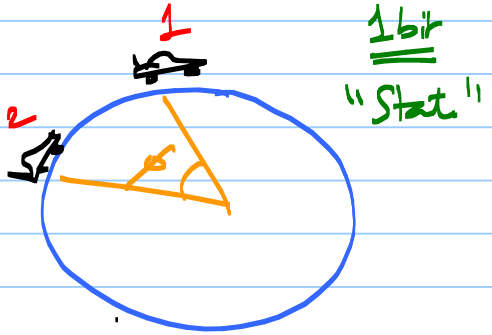
phase difference is inherently modulo 2π

$$\Delta\phi \leftarrow \{-\pi, \pi\}$$

* In the steady-state, we want to operate in the linear region

$\Rightarrow \quad -\pi < \Delta\phi < \pi$ → ③





⇒ If we don't keep track of the "laps" "cycles"

↳ can only detect 2π phase difference from ② & ③

$$-\pi < \overbrace{\frac{N f_{ref} - f_0}{K_{VCO} \cdot K_{PD}}}^{\Delta\phi} < \pi$$

$$\Rightarrow \quad \boxed{-\pi K_{VCO} \cdot K_{PD} < N f_{ref} - f_0 < \pi K_{VCO} \cdot K_{PD}} \longrightarrow ④$$

$$|\underbrace{N f_{ref}}_{f_{out}} - \underbrace{f_0}_{\text{free running}}| < \pi \underbrace{K_{VCO} \cdot K_{PD}}$$

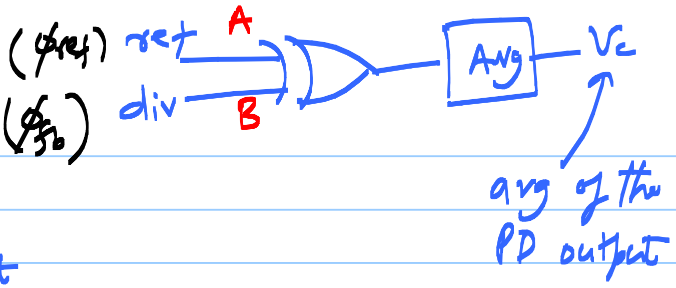
output frequency range

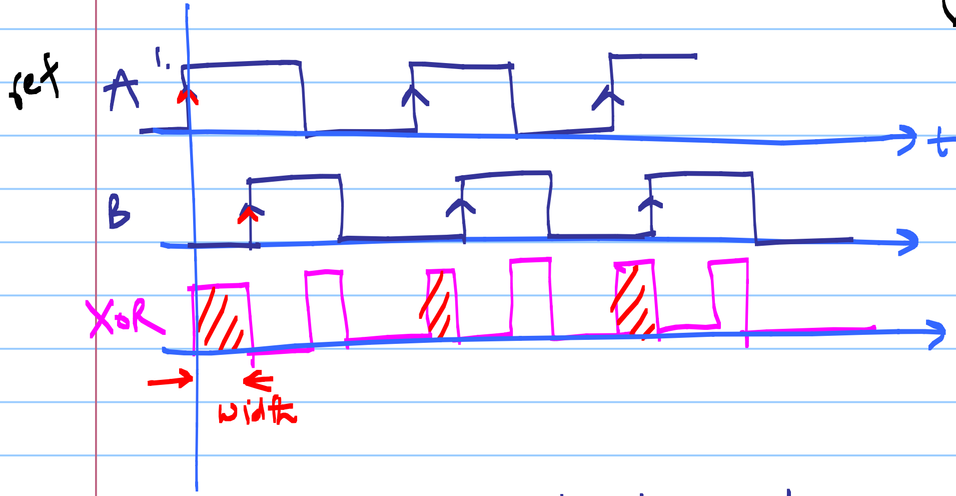
related to the loop-gain

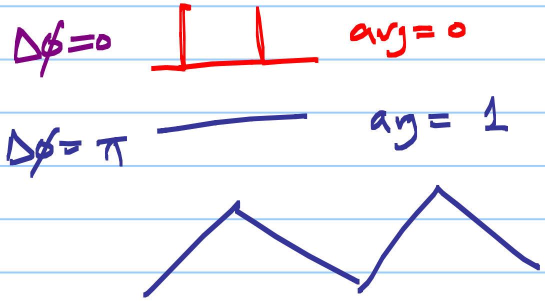
↳ problems?

"Later"

XOR PD



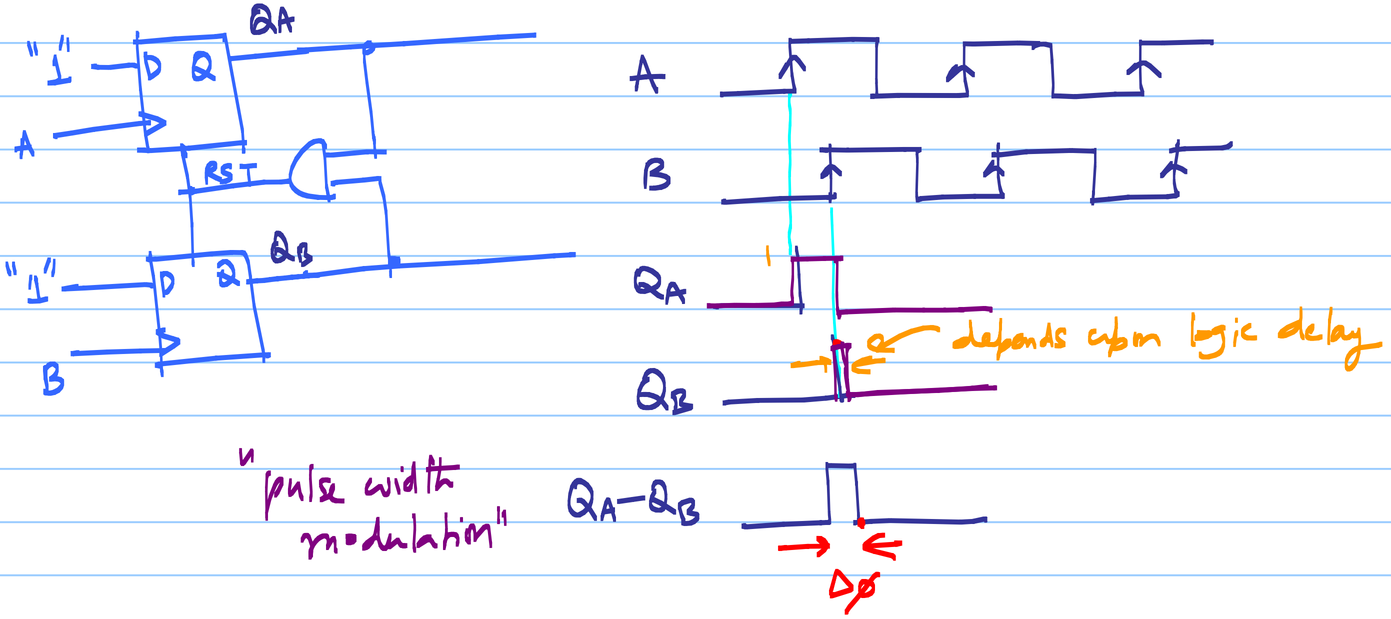




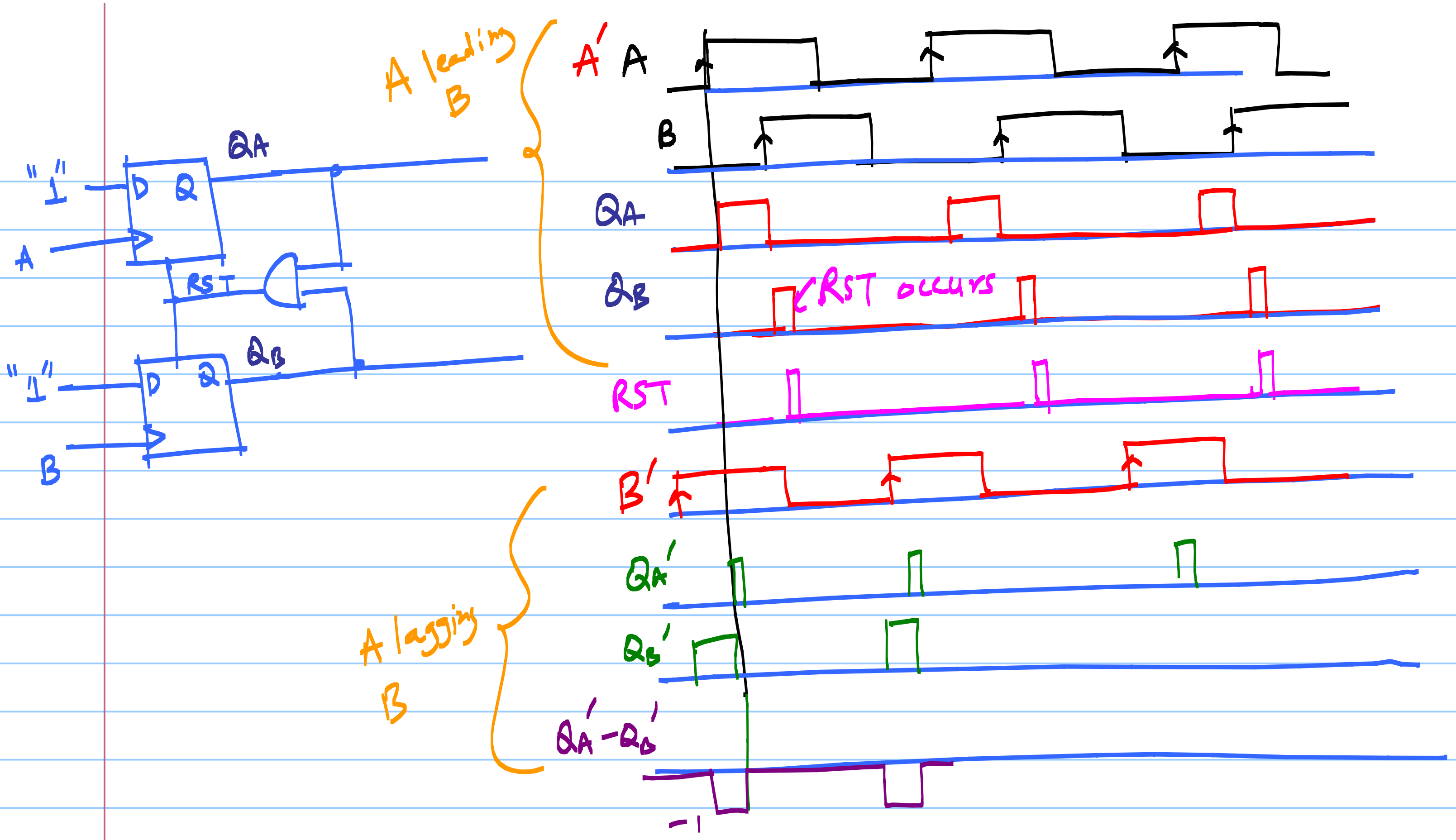
✗ Level sensitive

⇒ PD should be sensitive only to the rising edges

$$\text{We desire a PD} = \begin{cases} +\text{ve avg output when A rises earlier than B} \\ -\text{ve output when A rises later than B} \end{cases}$$



"pulse width modulation"



"1"
D
Q
A
QA
RST
"1"
D
Q
B
QB
A leading B
A lagging B
A'
A
B
QA
QB
RST occurs
RST
B'
QA'
QB'
QA'-QB'
-1