ECE 504 - lecture 3

Note Title 8/29/2016

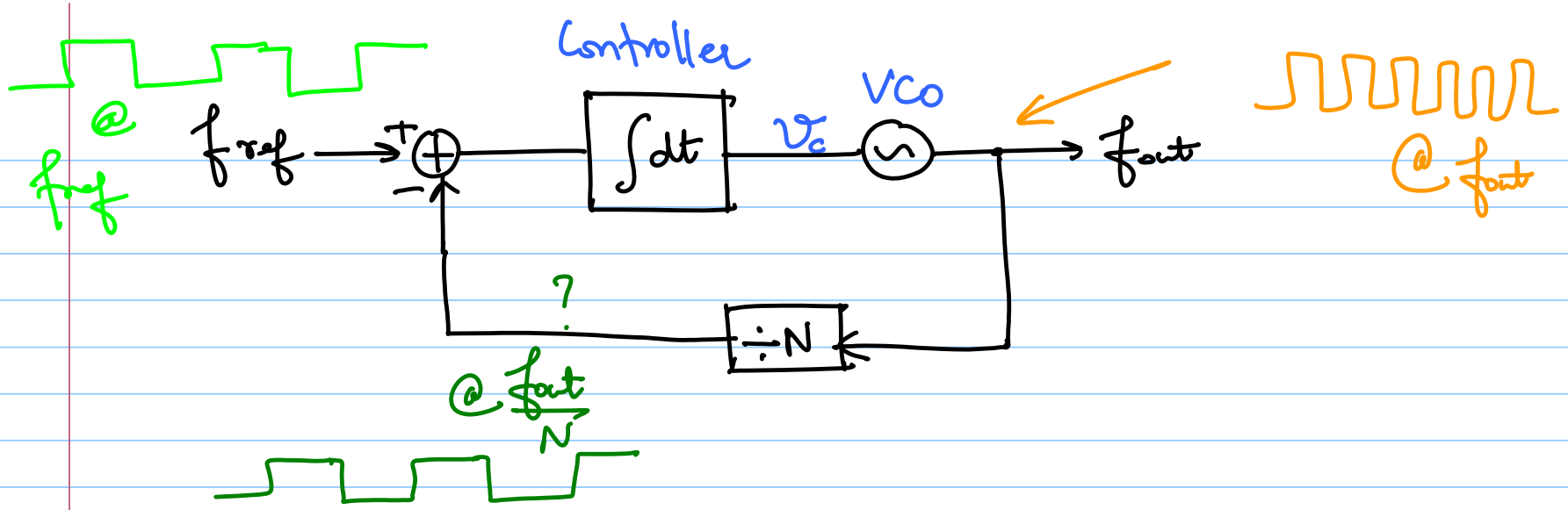
Matlab HW#1

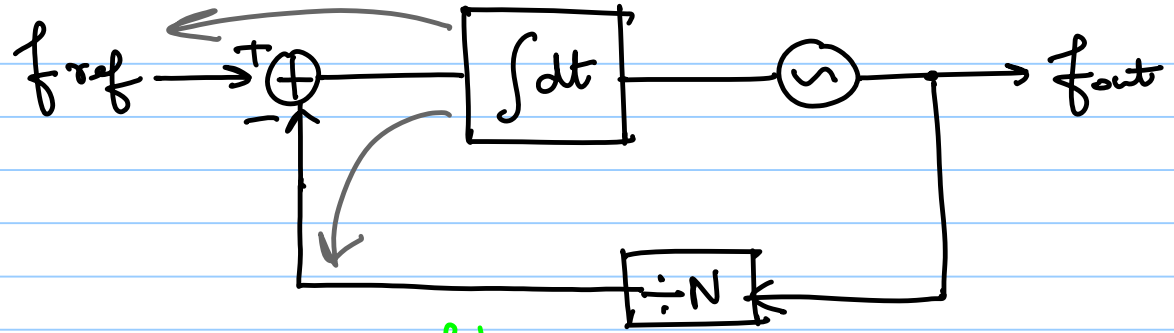
↳ VLab

Cadence

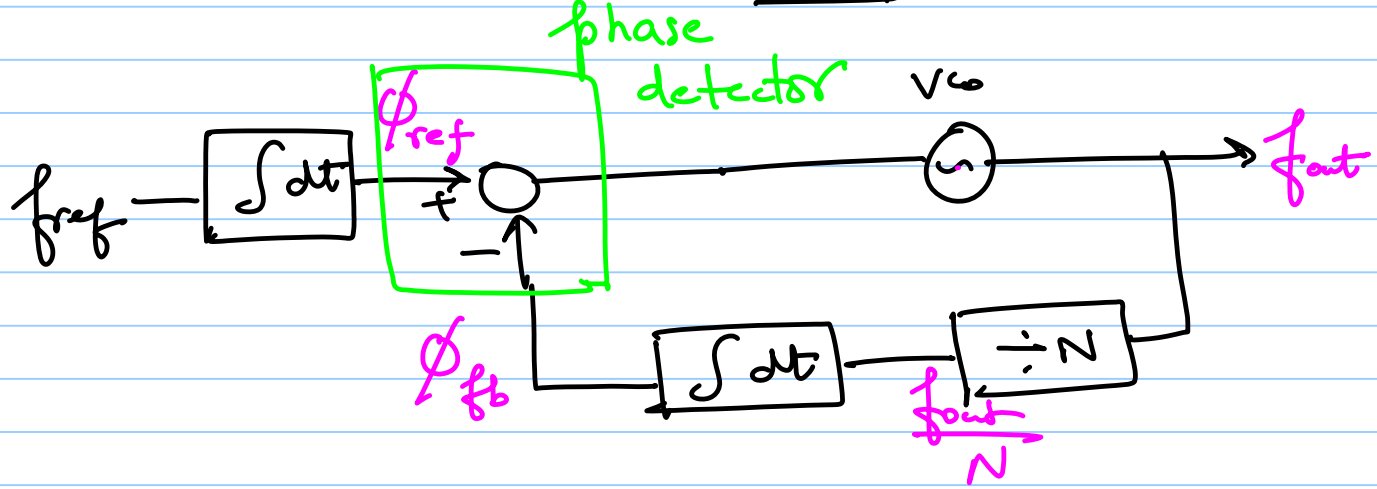
↳ Work in progress

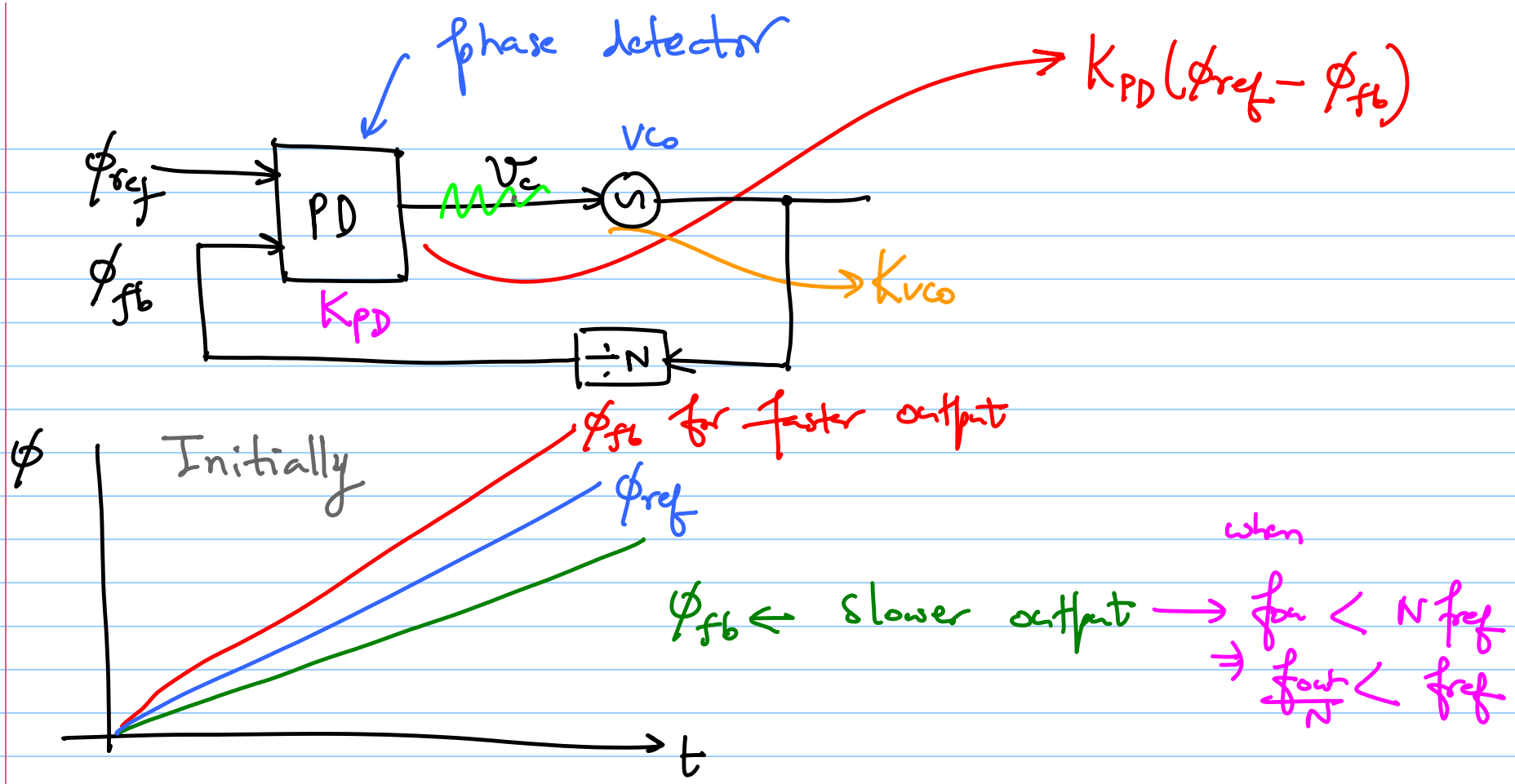
↳ Verilog-A


Controller
VCO
@
f_{ref}
f_{ref}
$\int dt$
v_c
f_{out}
@ f_{out}
?
$\div N$
@ $\frac{f_{out}}{N}$



"integral of frequency is phase"





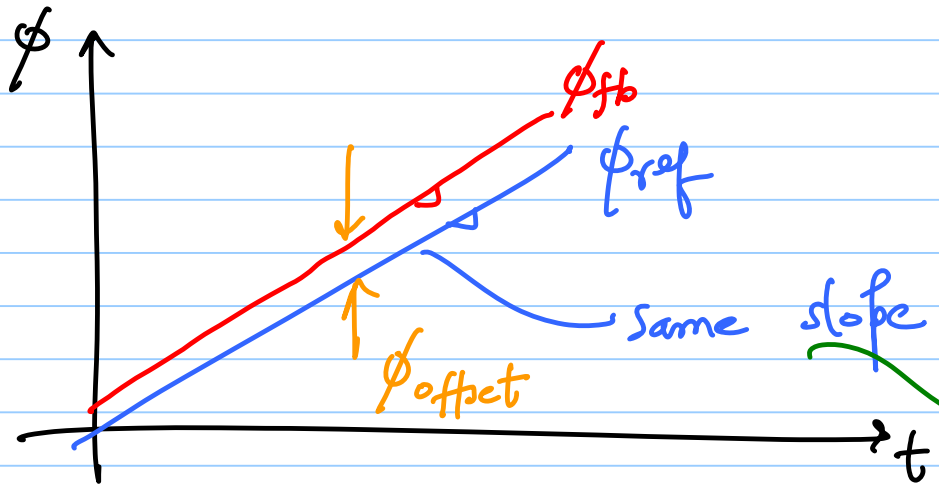
when

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

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

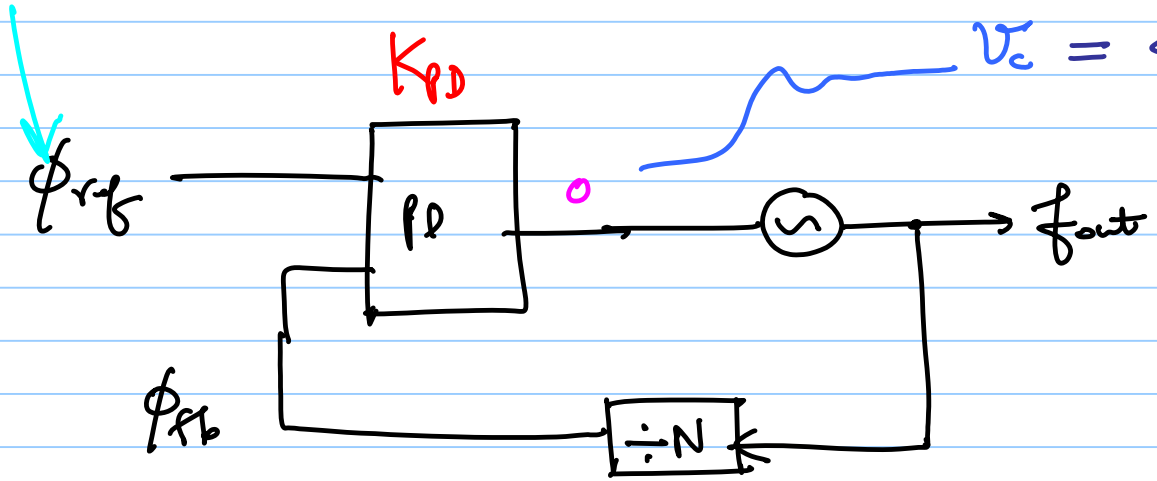
In steady-state
↳ V_c becomes constant
↳ both ϕ_{ref} & ϕ_{fb} have the same slope

In "steady-state"



same slope → can have different offsets

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



$$v_c = K_{PD}(\phi_{ref} - \phi_{fb})$$

$\Rightarrow$ offset

When doing phase detection

↳ it is implicit that we are integrating the frequencies before comparing phase

Aside

PVT - variations

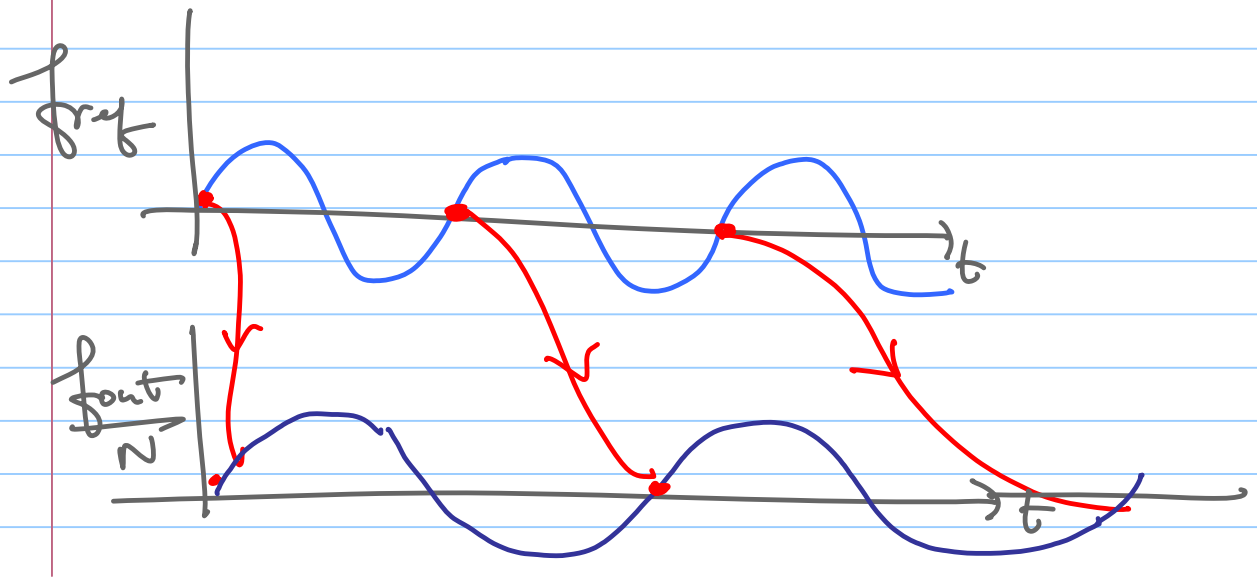
↳ process

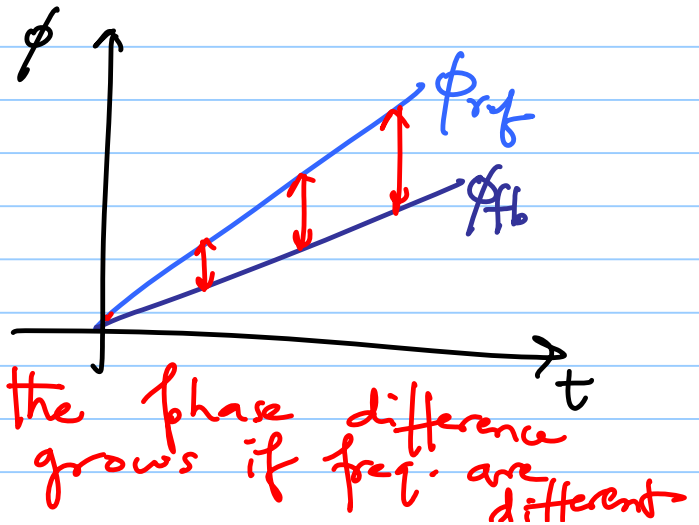
Voltage

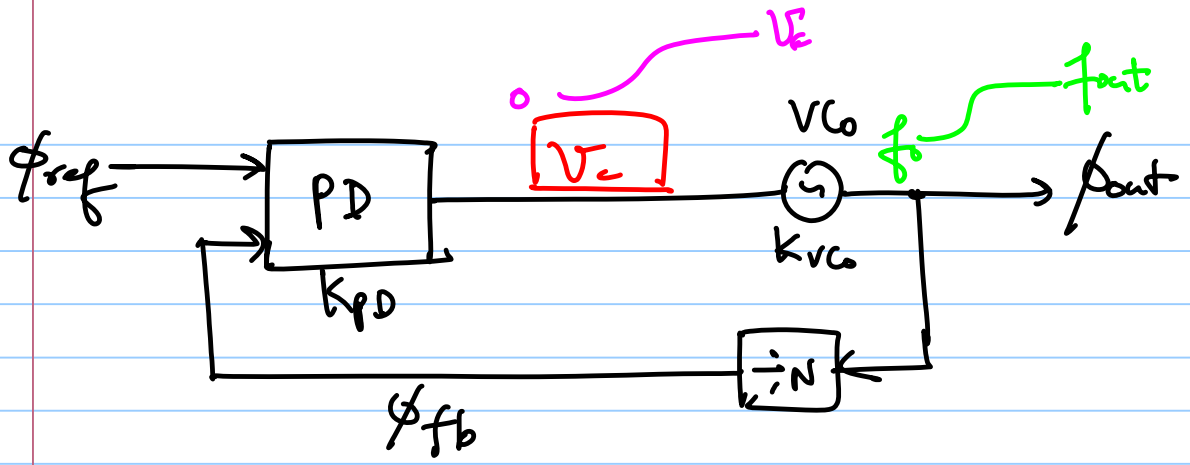
temperature

* Since we use the phase difference to control the frequency of the VCO

↳ phase locked loop (PLL)







$$V_c = K_{PD}(\phi_{ref} - \phi_{fb})$$

In steady-state: $f_{out} = N f_{ref}$ → ①

$$f_{out} = f_{VCO} = f_0 + K_{VCO} \cdot V_c \rightarrow ②$$

f_0: free running frequency of the VCO

from ②

$$v_c = \left(\frac{N f_{ref} - f_0}{K_{VCO}} \right)$$

f_{out}

$\because v_c = K_{PD}(\phi_{ref} - \phi_{fb})$

$\Rightarrow$

$$\phi_{ref} - \phi_{fb} = \frac{v_c}{K_{PD}} = \boxed{\frac{N f_{ref} - f_0}{K_{VCO} \cdot K_{PD}} = \Delta\phi}$$

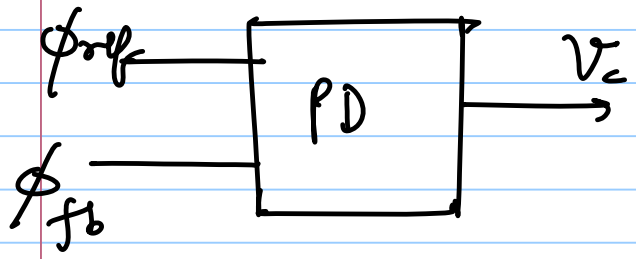
$\Delta\phi$ → phase-offset in the steady-state

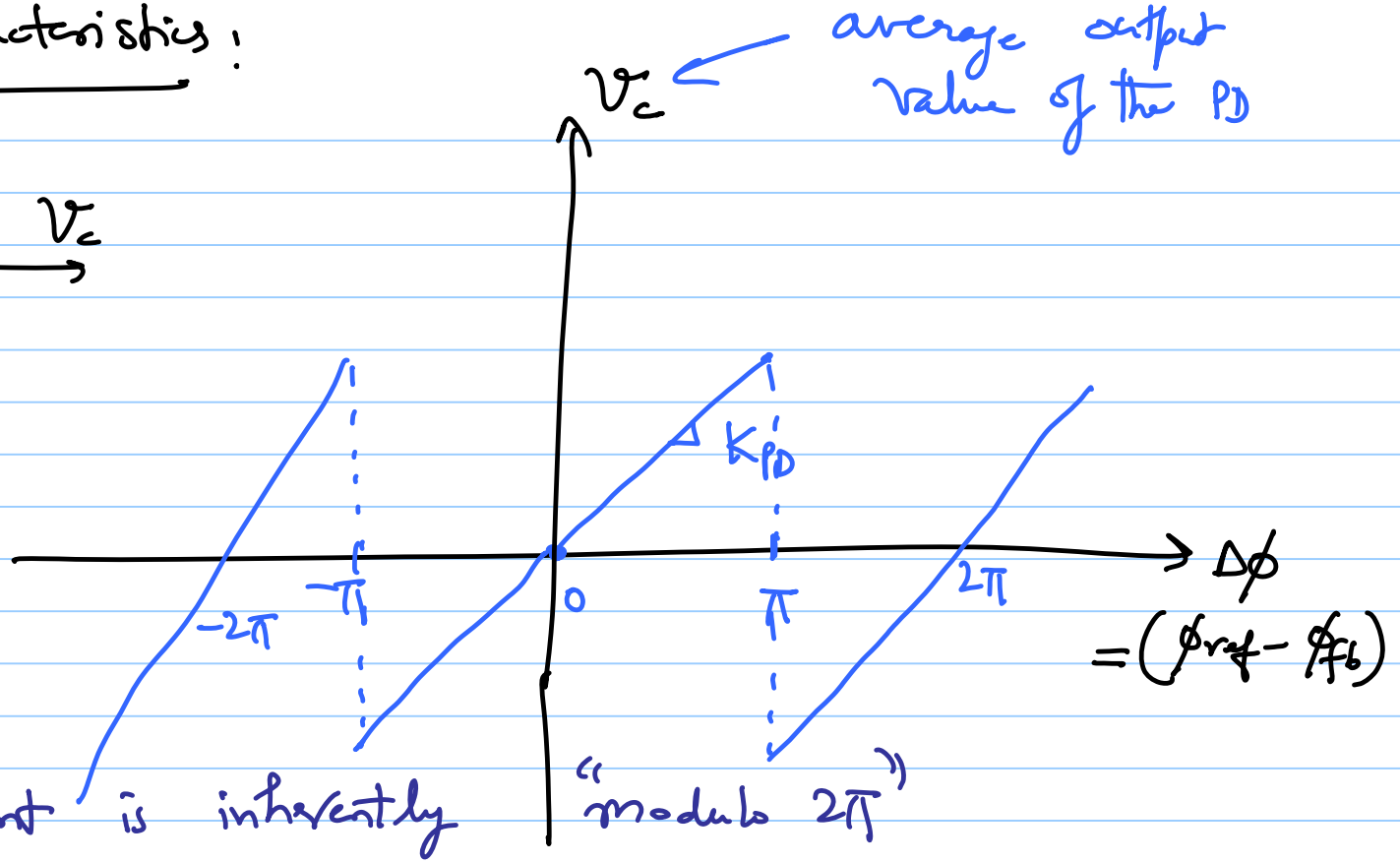
$K_{PD} \Rightarrow \frac{V}{rad}$

$K_{VCO} \Rightarrow \frac{Hz}{V}$

} Units are important

PD characteristics:





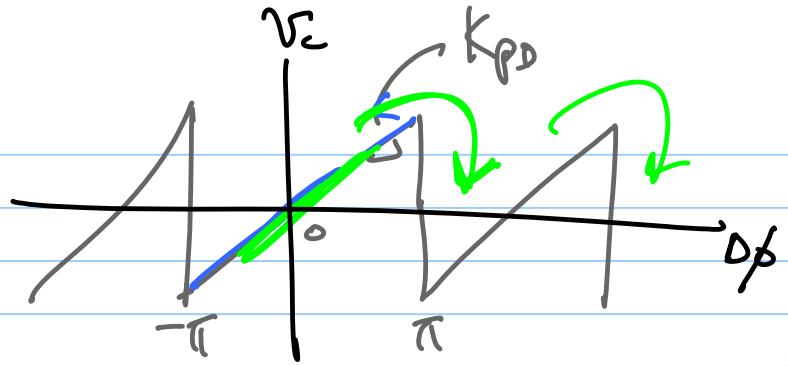
PD measurement is inherently "modulo 2π"

$$-\pi \leq \Delta\phi \leq \pi$$

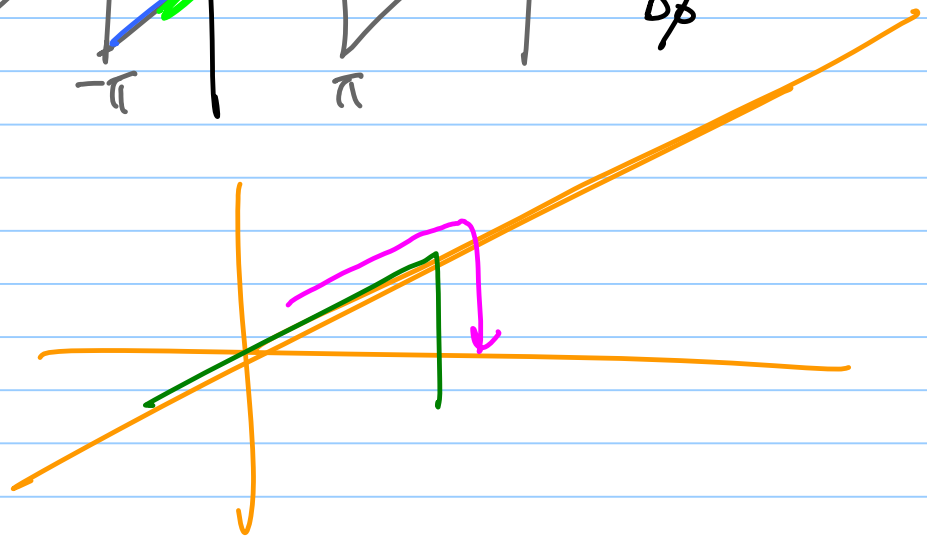
$$-\pi K_{PD} \cdot K_{VCO} \leq N f_{ref} - f_0 \leq \pi \cdot K_{PD} \cdot K_{VCO}$$

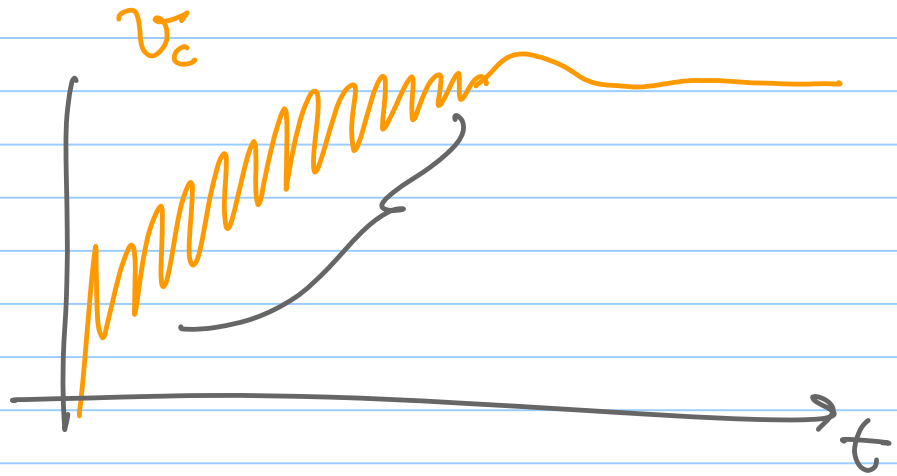
$$\Rightarrow \quad |N f_{ref} - f_0| \leq \pi \cdot K_{PD} \cdot K_{VCO} \quad \leftarrow \text{will revisit the limitations due to this constraint}$$

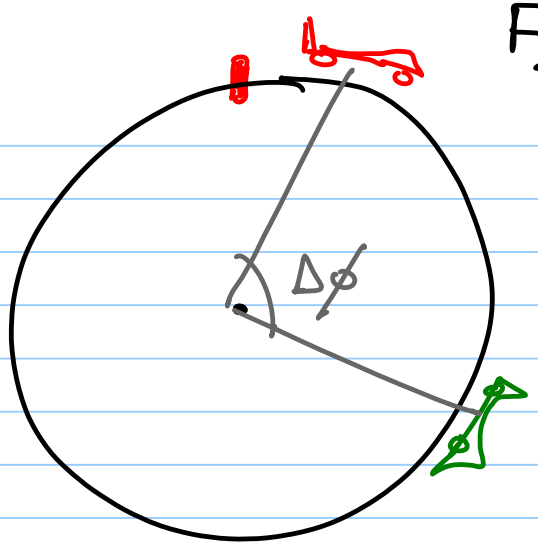
$|N f_{ref} - f_0|$: PLL o/p frequency range



Non-linear behaviour outside $|\Delta\phi| > \pi$





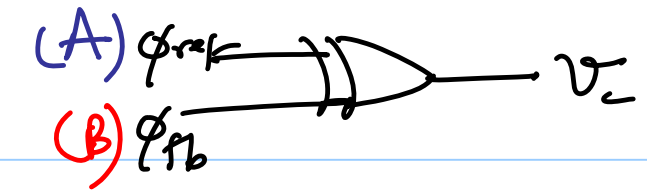


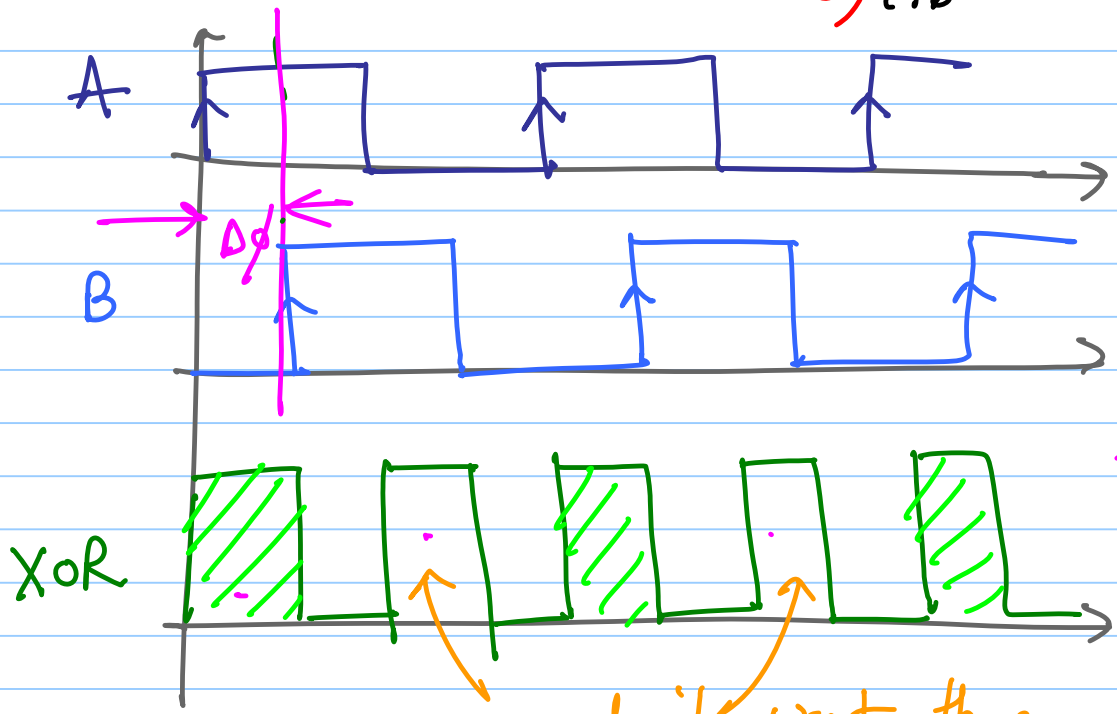
F1-race analogy

Need to keep track of the lap difference between the two

↳ Else can only track 2π phase difference

XOR PD:





"level sensitive"

avg → V_c

don't want these

(Duty cycle dependent)

We want an output

$$= \begin{cases} +ve & \text{when } A \text{ leads } B \\ -ve & \text{when } A \text{ lags } B \end{cases}$$

Phase detector