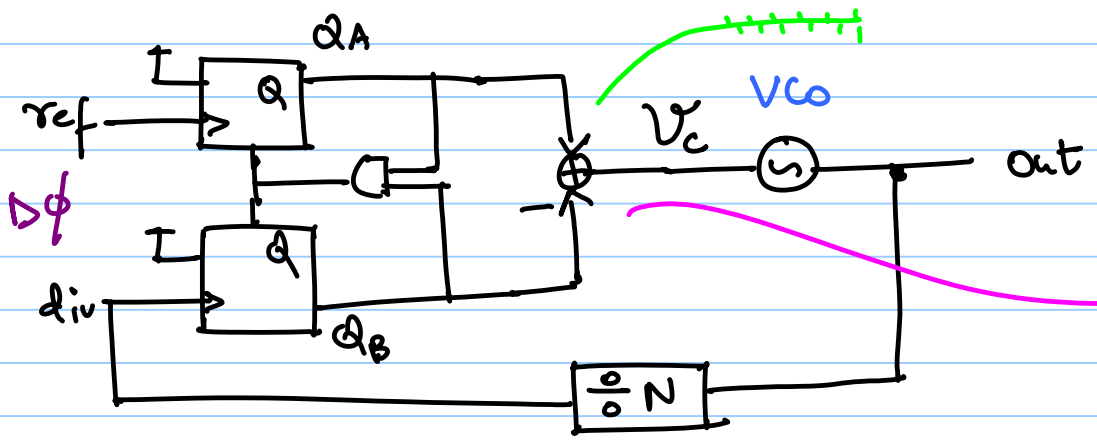
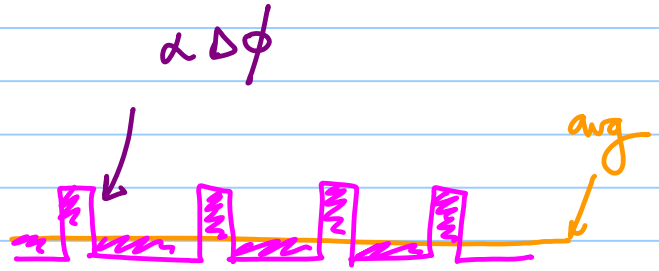
ECE 504 - Lecture 6

Note Title 9/12/2016



PLL



↓ periodic content with fundamental at f_{ref} (ω_{ref})

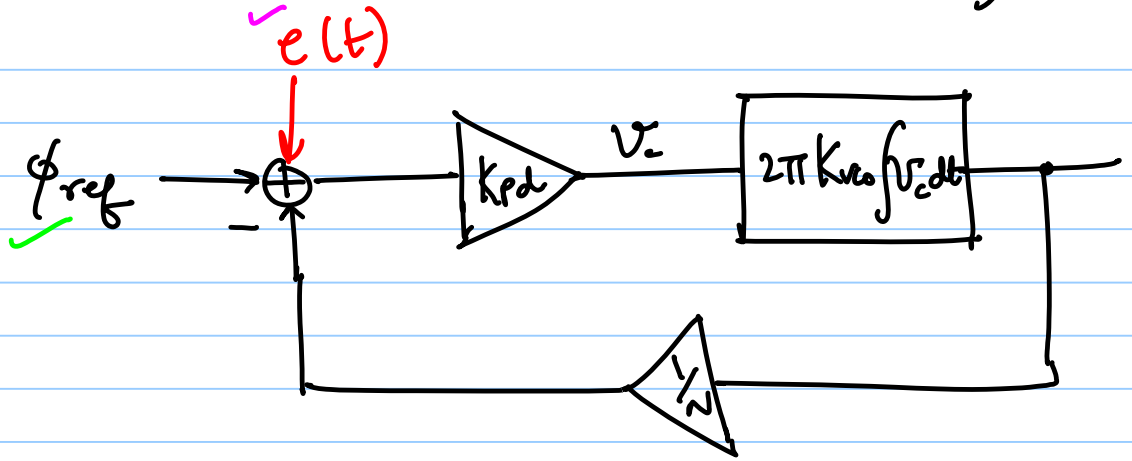
Type-I PLL

reference spurs

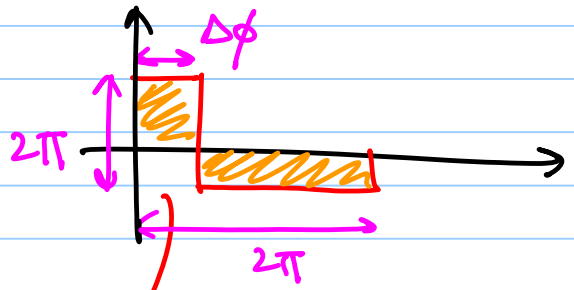
↓

"spurious tones"

Incremental model (phase domain)

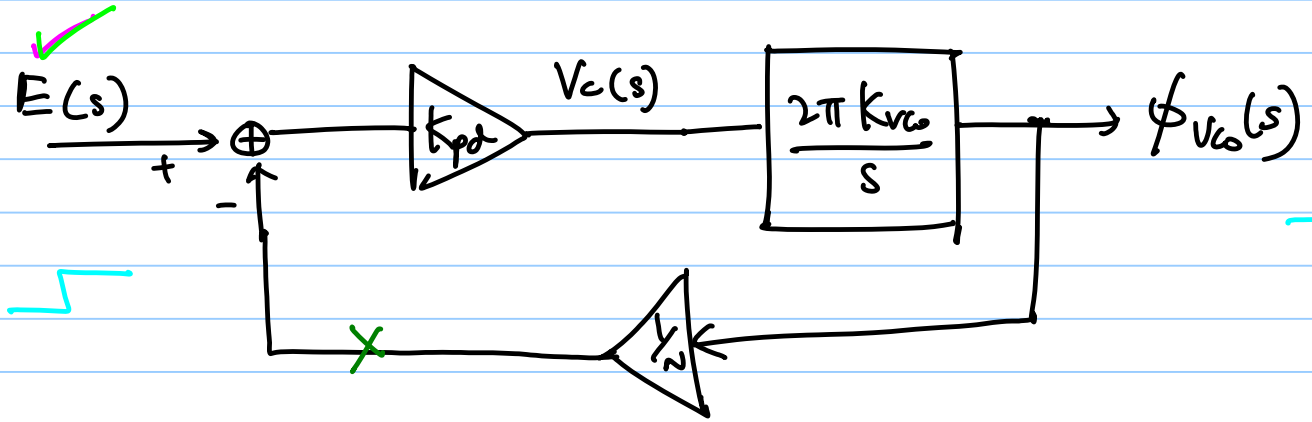


periodic disturbance reflected at the input



frequency content of this error ⇒ freq and its harmonics

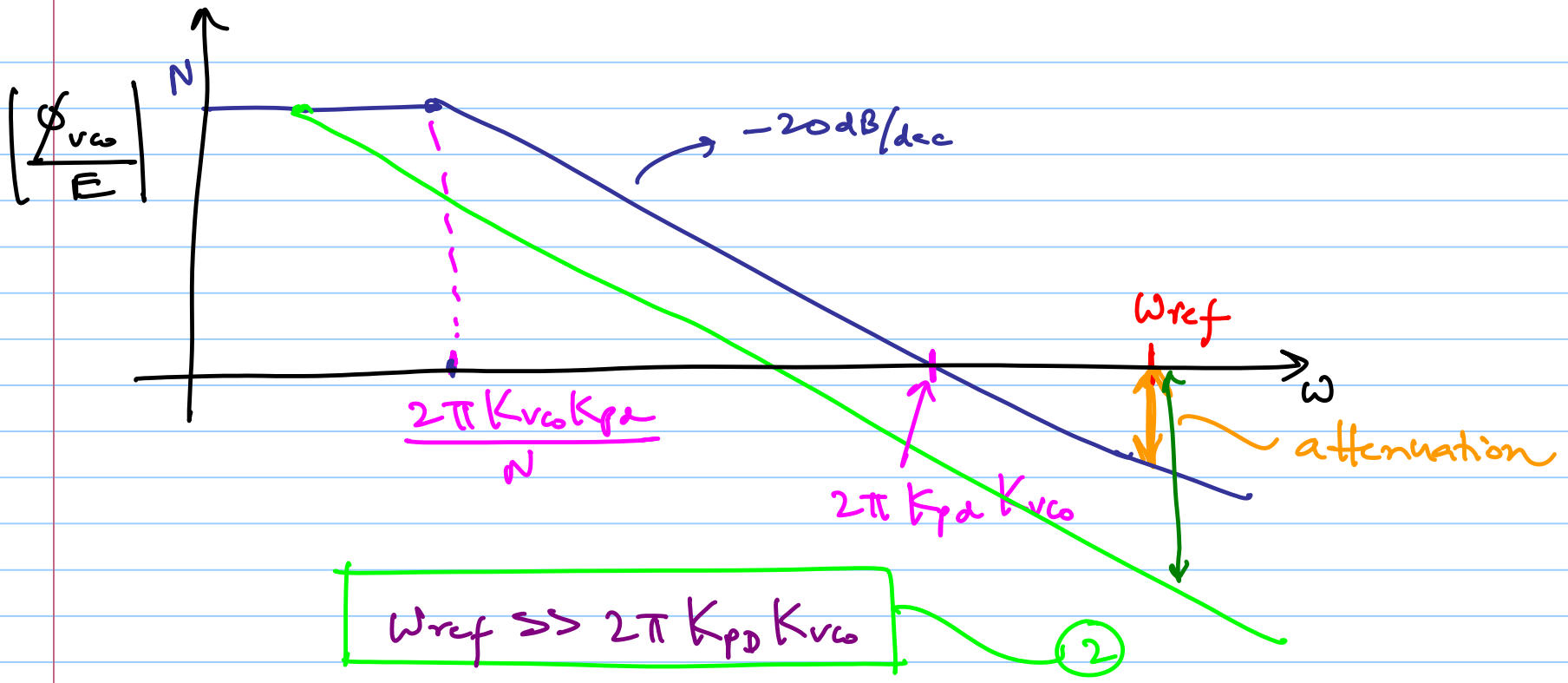
Laplace Model:



$$L(s) = \frac{2\pi K_{pd} V_{co}}{s \cdot N}$$

$$H_{closed-loop}(s) = \frac{\phi_{Vco}(s)}{E(s)} = \frac{K_{pd} \cdot \frac{2\pi K_{vco}}{s}}{1 + L(s)} = \frac{N}{1 + \frac{s \cdot N}{2\pi K_{vco} \cdot K_{pd}}}$$

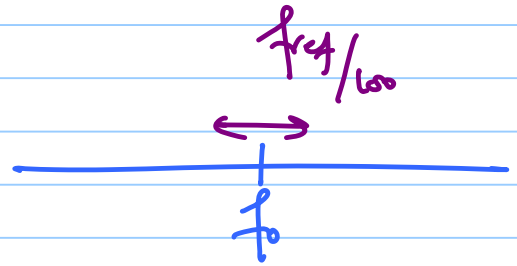
$$\frac{N}{1 + \frac{s}{\omega_{3dB}}}$$



$$\omega_{ref} >> 2\pi K_{PD} K_{vco}$$ (2)

Constraint on the range

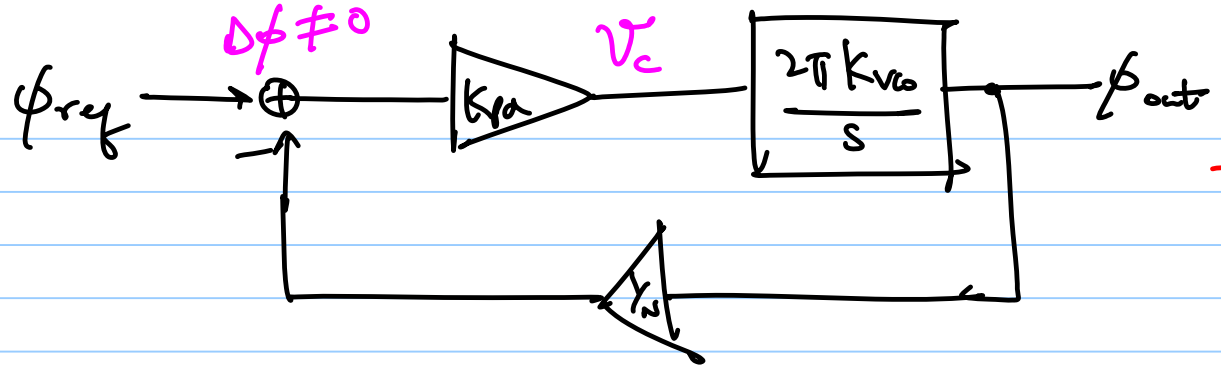
$$|N f_{ref} - f_0| < 2\pi K_{PD} K_{VCO}$$ (1)



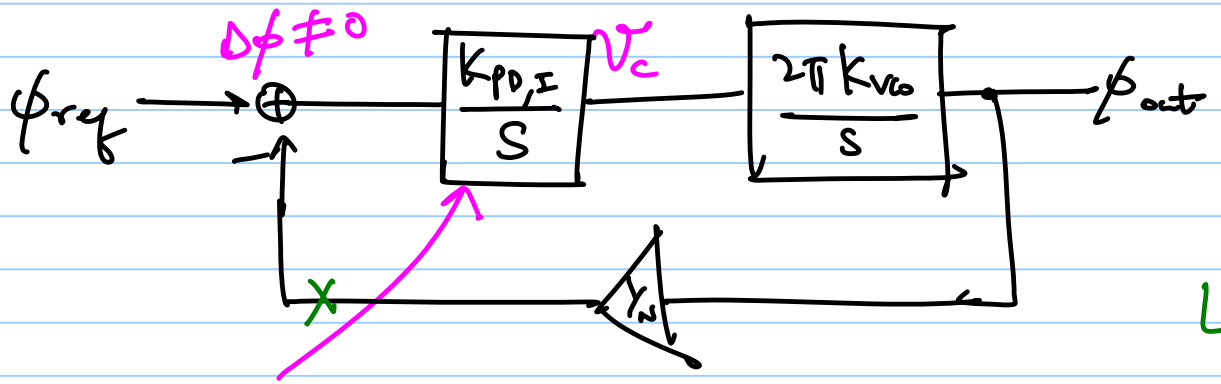
$$|N f_{ref} - f_0| < 2\pi K_{PD} K_{VCO} \ll 2\pi f_{ref}$$

$$\Rightarrow \quad |N f_{ref} - f_0| \ll 2\pi f_{ref} \simeq 2\pi \frac{f_{ref}}{100}$$

↳ very limited tuning range



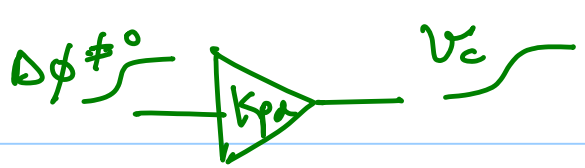
Type-I PLL

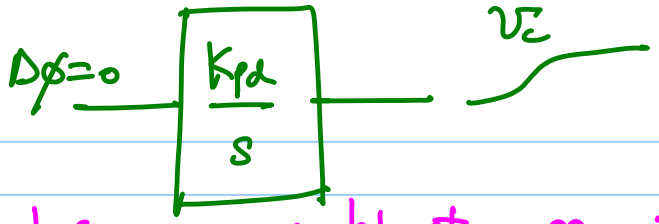


PD now is an integrator

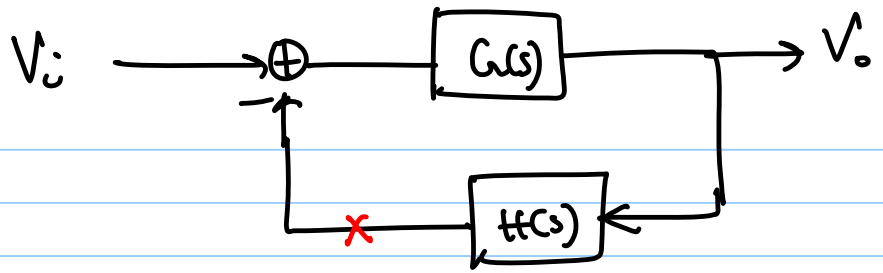
Type-II PLL

$$L(s) = \frac{2\pi K_{PD,I} K_{VCO}}{s^2 \cdot N}$$





The integrator can support non-zero Vc inputs while having $\Delta\phi = 0$.



$$L(s) = G(s)H(s)$$

$$H_{CL}(s) = \frac{V_o}{V_i}(s) = \frac{G(s)}{1 + G(s)H(s)} = \frac{\text{FWD PATH GAIN}}{1 + \text{LOOP-GAIN}}$$

$$= \frac{1}{H} \cdot \frac{1}{1 + \frac{1}{GH}} = \begin{cases} \simeq \frac{1}{H}, & |GH| \gg 1 \\ \simeq G_{OL}, & |GH| \ll 1 \end{cases}$$

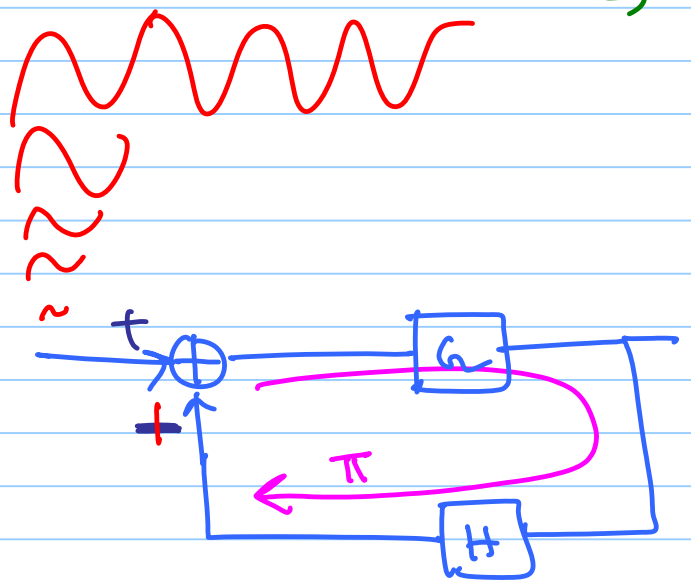
Instability when $GH = -1$

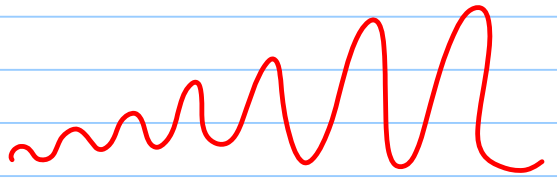
Instability when $L = -1$

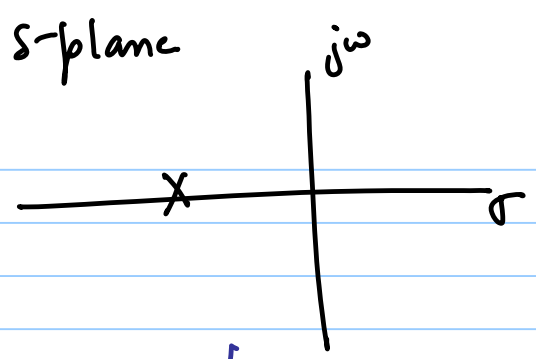
Barkhausen Criterion

$\Rightarrow$ $|L| = 1$ & $\angle L = \pi$ or $180°$

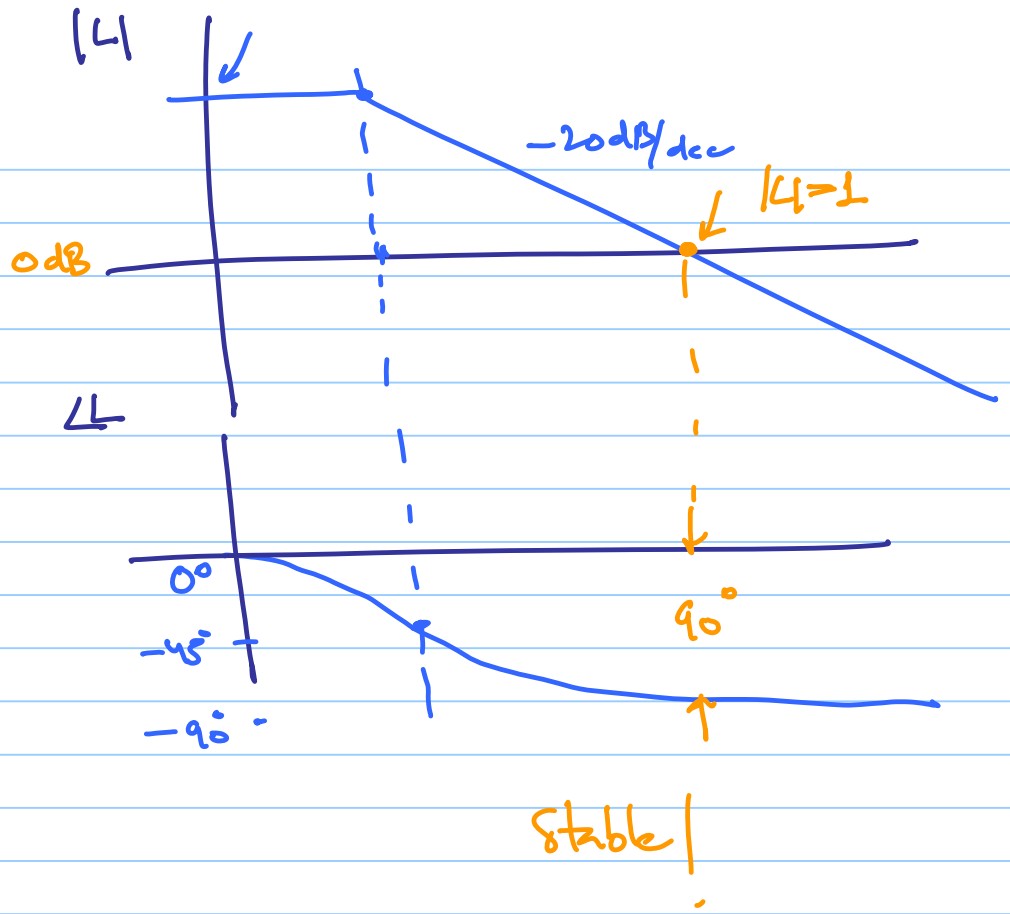
or $0\,dB$

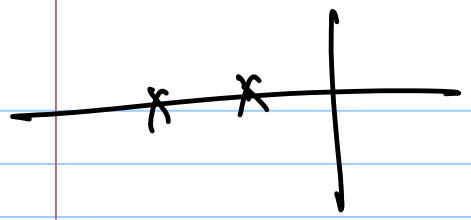




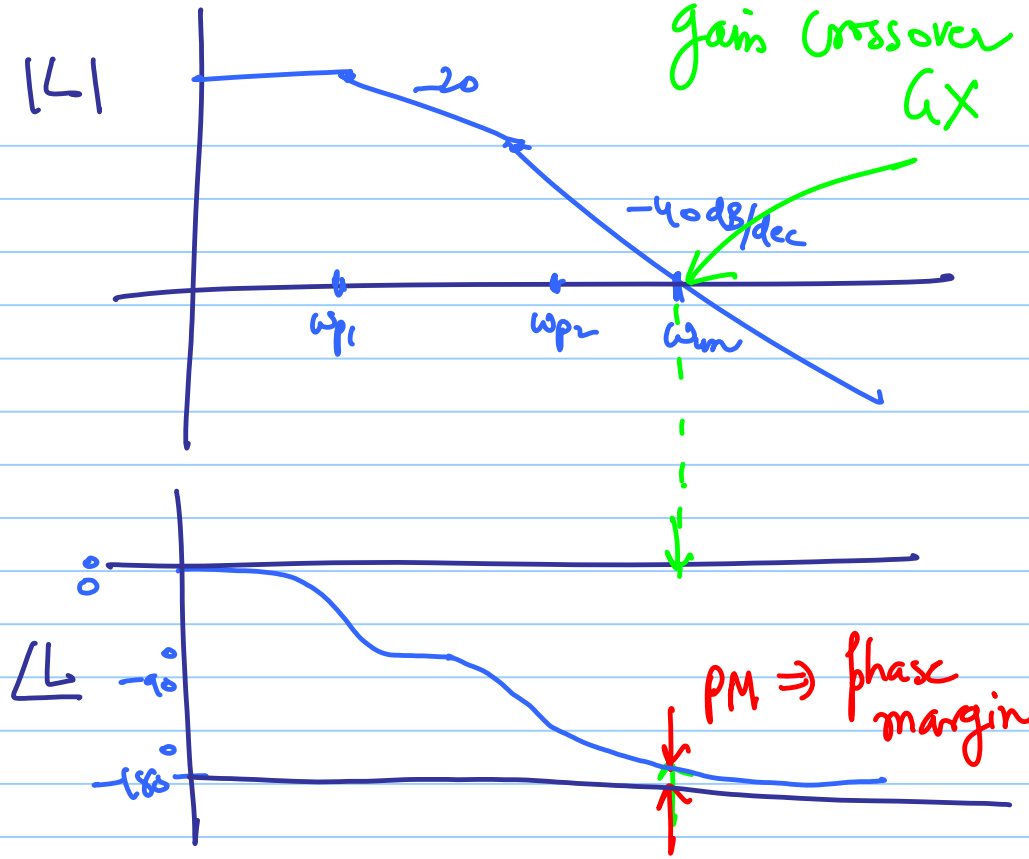


$$L(s) = \frac{N}{1 + s/\omega_0}$$

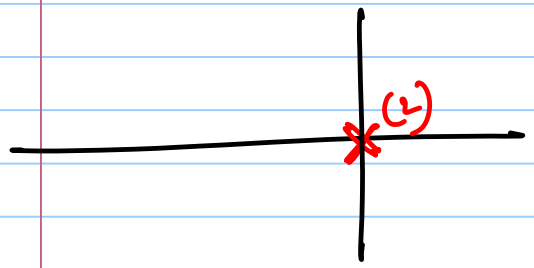


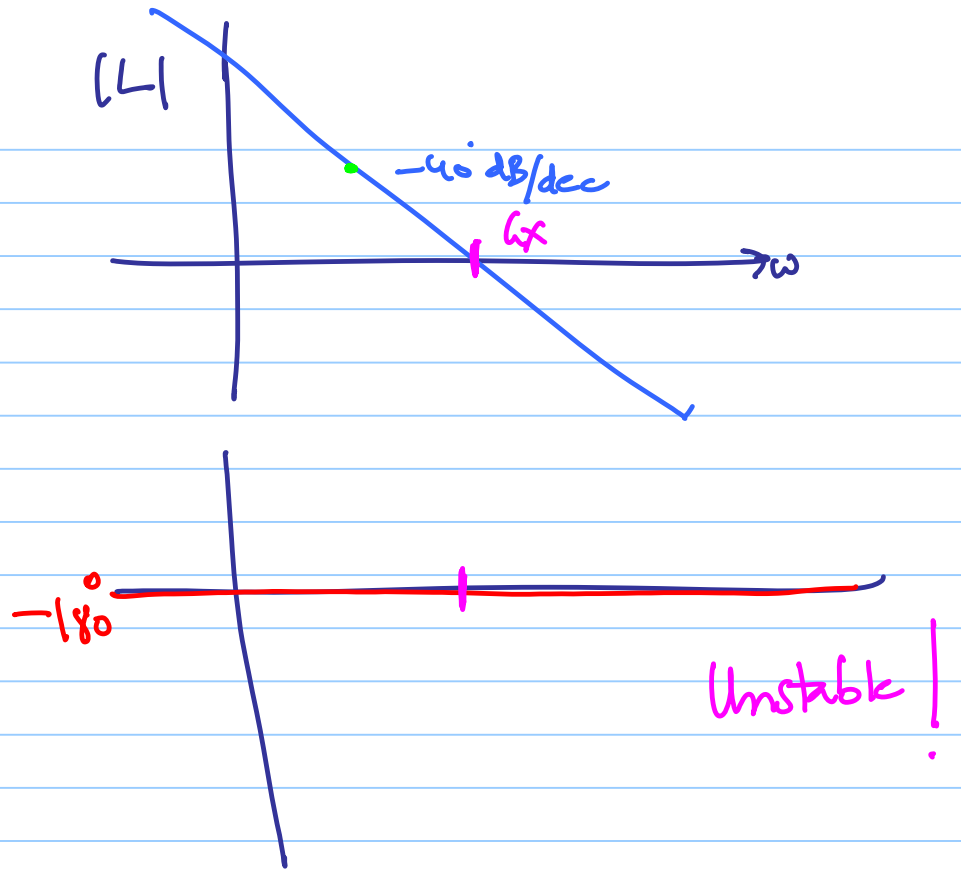


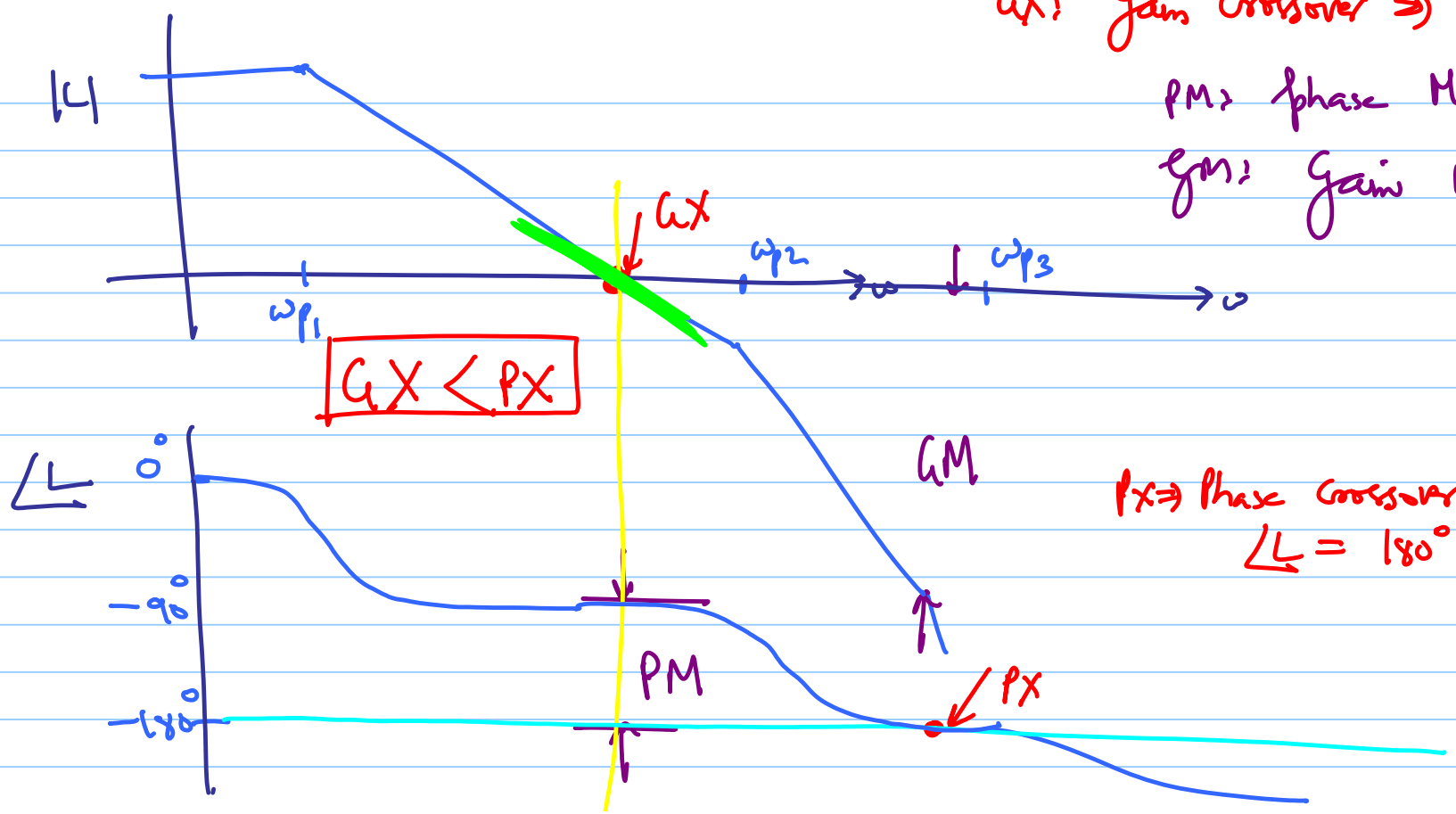
$$L(s) = \frac{A_0}{\left(1+\frac{s}{\omega_{p1}}\right)\left(1+\frac{s}{\omega_{p2}}\right)}$$



$$L(s) = \frac{2\pi K_{PD,I} K_{VCO}}{N \cdot s^2}$$







ωX: Gain Crossover ⇒ |L| = 0dB

PM: Phase Margin

GM: Gain Margin

PX ⇒ Phase Crossover

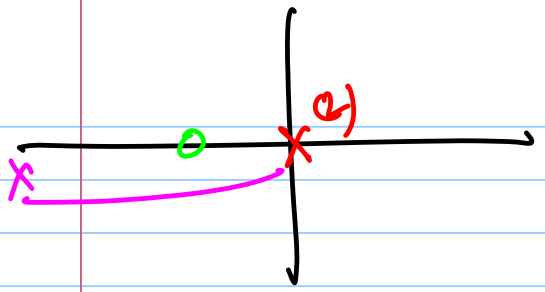
∠L = 180°

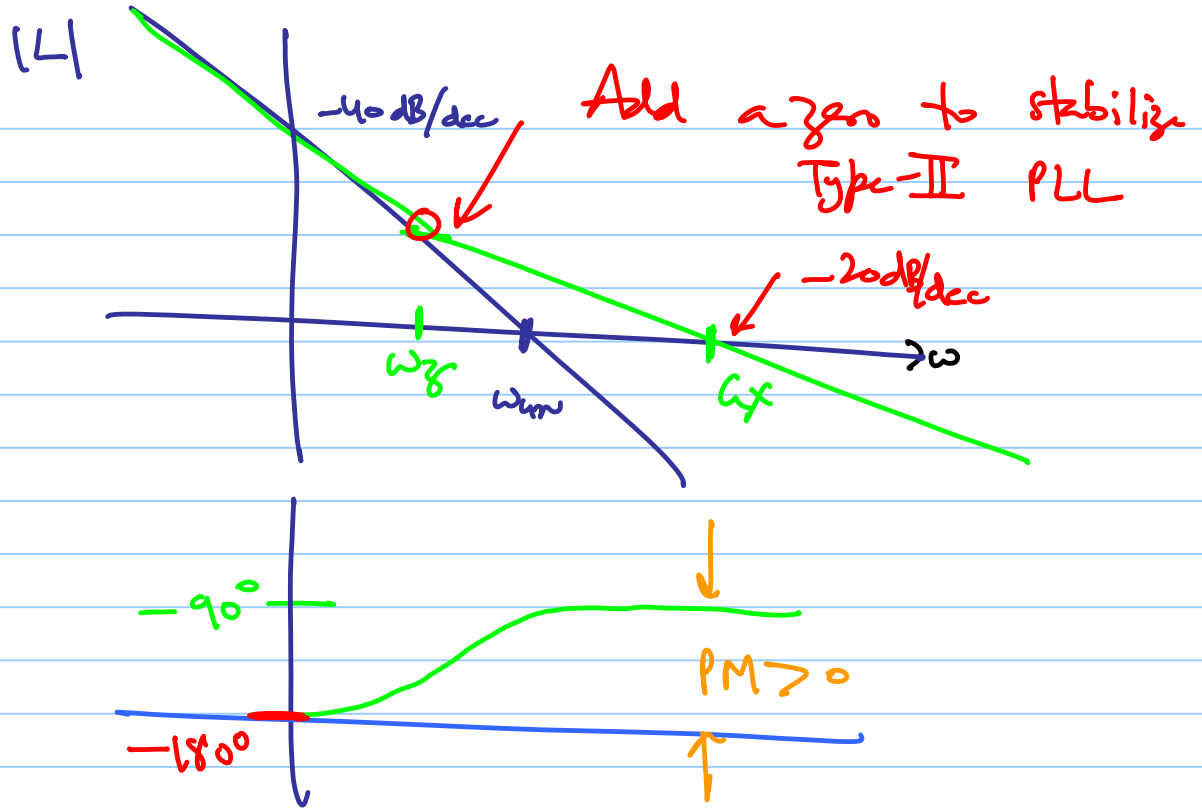
for stability $\omega_x < \omega_{PX} \Rightarrow PM > 0$

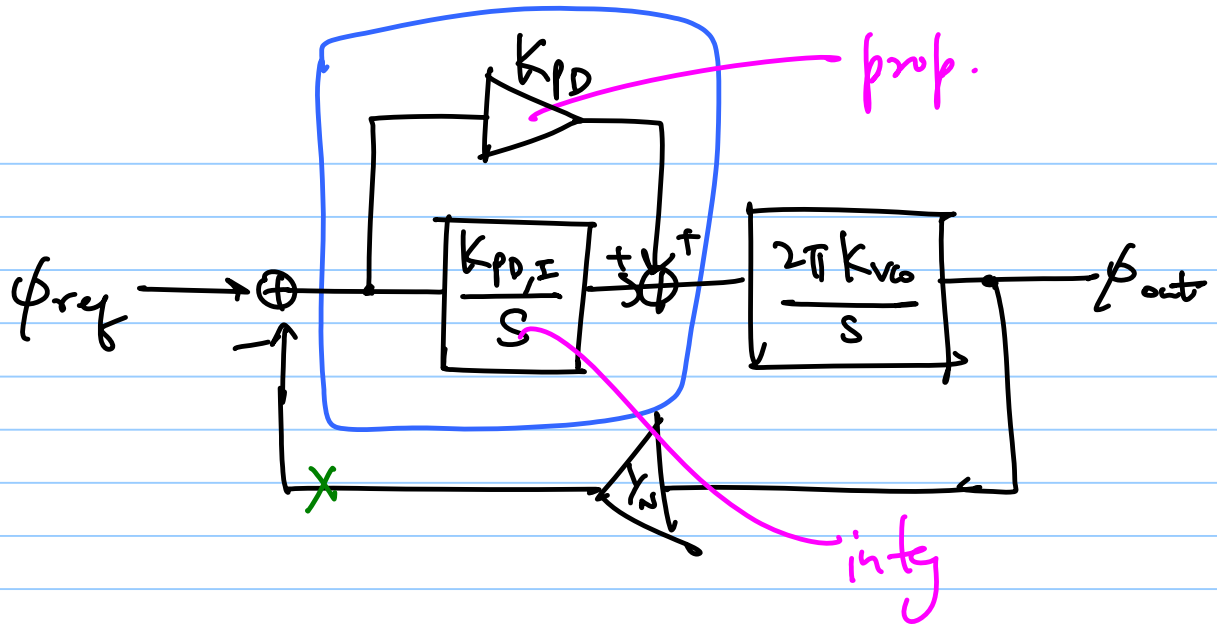
* The system should look like a single-pole (1^{st} order) system around the gain crossover frequency.
  - $\hookrightarrow$ -20 dB/dec slope at ω_{cm}

* PM $\Rightarrow$ phase Margin is a metric of stability

$PM > \underline{\underline{32^\circ}}$ subjective number


O
X
X


|L|
-40 dB/dec
Add a zero to stabilize
Type-II PLL
-20dB/dec
ω
ωz
ωm
ωx
-90°
-180°
PM>0


K_{PD}
prop.
ϕ_{ref}
$\frac{K_{PD,I}}{S}$
$\frac{2\pi K_{VCO}}{S}$
ϕ_{out}
K_N
X
integ