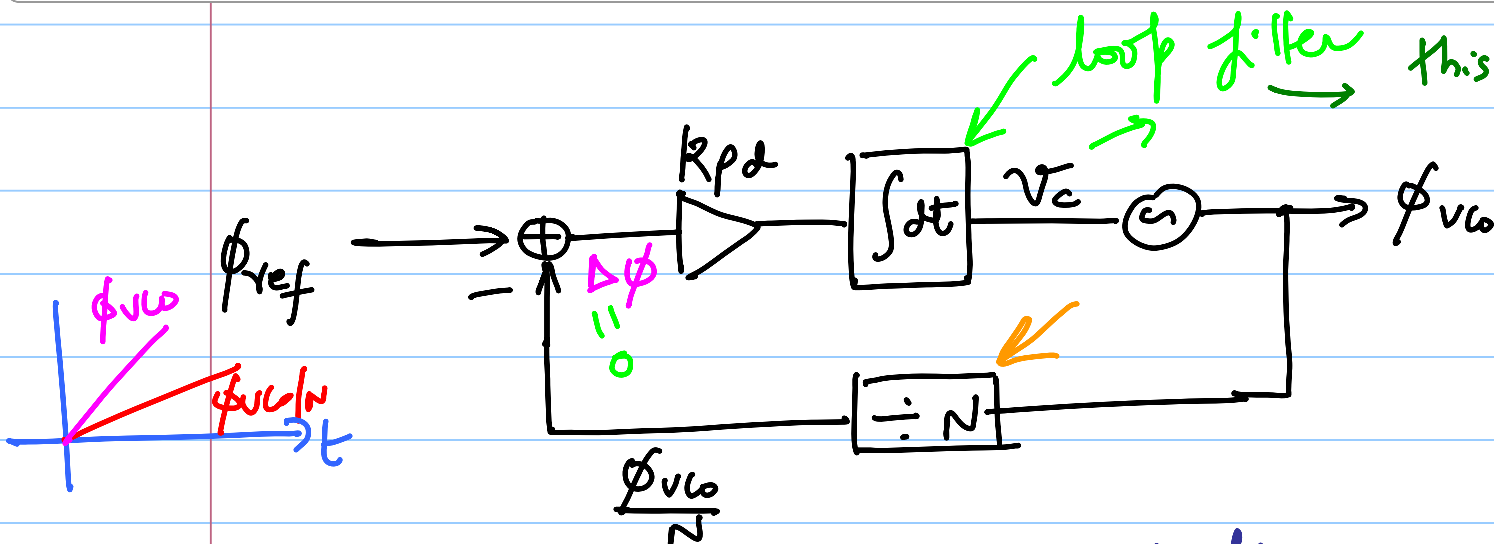
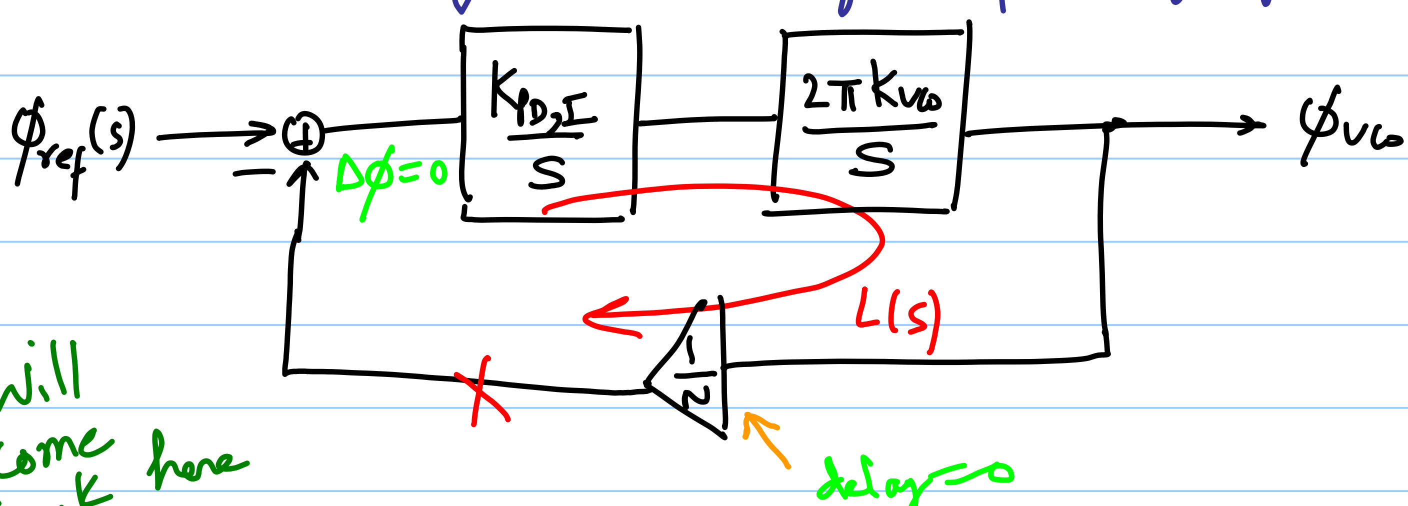
ECE 518 - Lecture 5

Note Title 1/29/2015



this integrator can support a non-zero VCO input while having $\Delta\phi = 0$

Incremental equivalent signal flow graph for the PLL



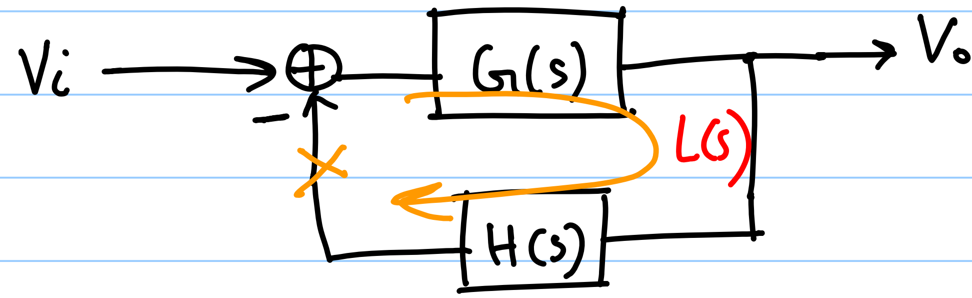
phase-domain SFG

will come back here

"open-loop" response:
$$L(s) = \frac{2\pi K_{PD,I} \cdot K_{vco}}{N \cdot s^2}$$

two poles at DC

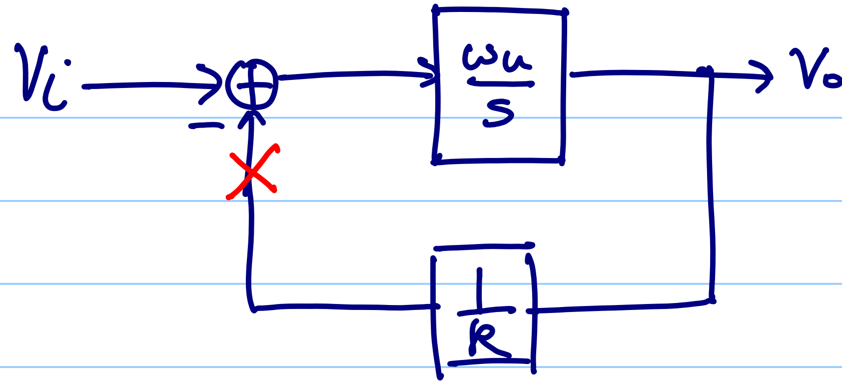
Feedback System Review

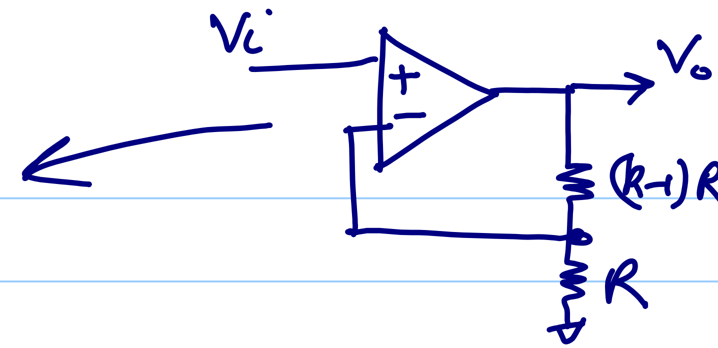


$$L(s) = G(s)H(s)$$

$$\frac{V_o}{V_i}(s) = \frac{G(s)}{1 + G(s)H(s)} = \frac{1}{H(s)} \cdot \frac{1}{1 + \frac{1}{G(s)H(s)}}$$

$$\simeq \begin{cases} \dfrac{1}{H(s)}, & |GH| \gg 1 \quad \text{for large } L(s) \\ G(s), & |GH| \ll 1 \quad \text{small } L(s) \end{cases}$$

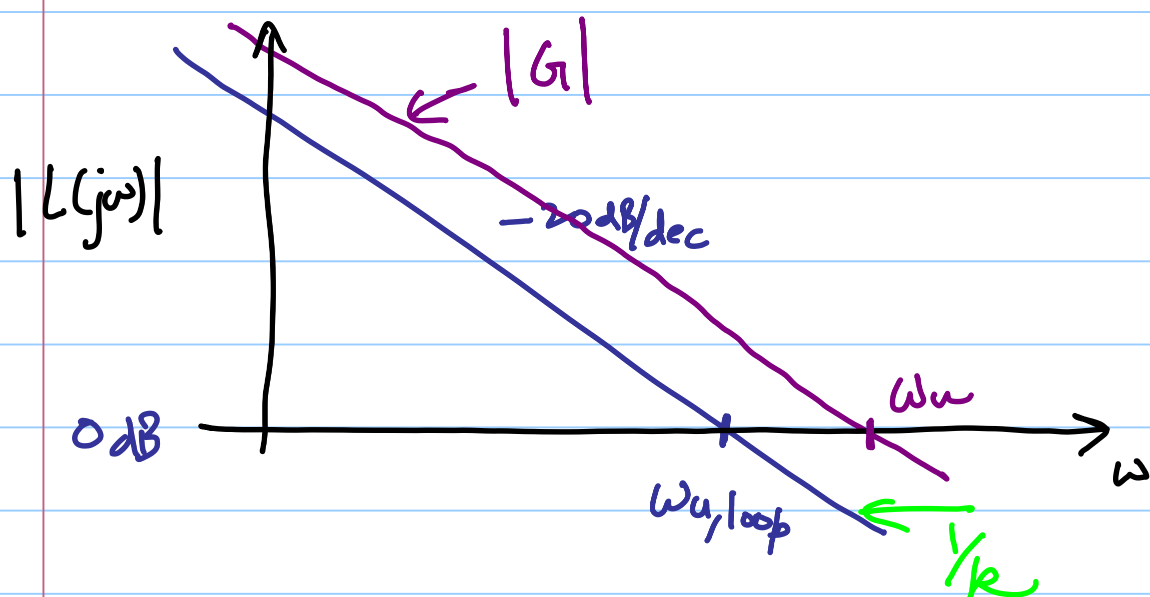


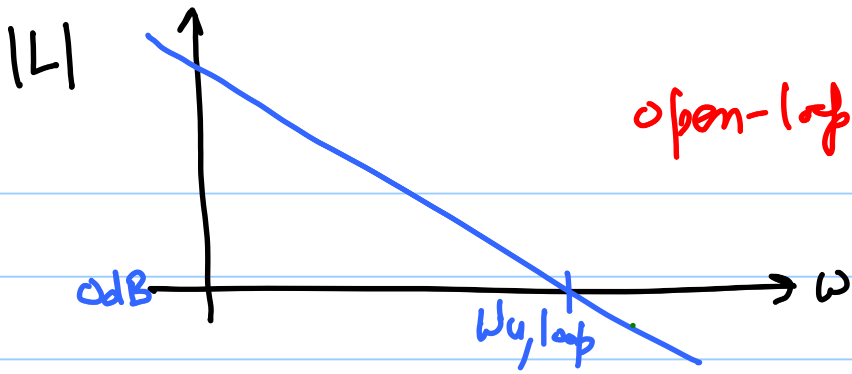


$$L(s) = \frac{\omega_u}{k \cdot s}$$ loop-gain

$$G(s) = \frac{\omega_u}{s}$$

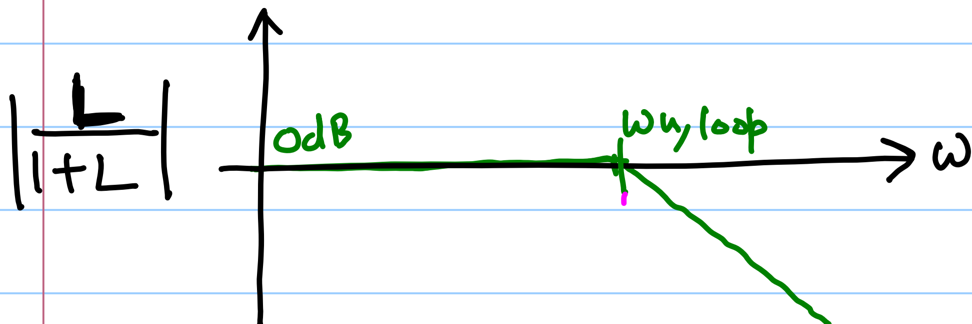
$$\omega_{u,loop} = \frac{\omega_u}{k}$$





open-loop response

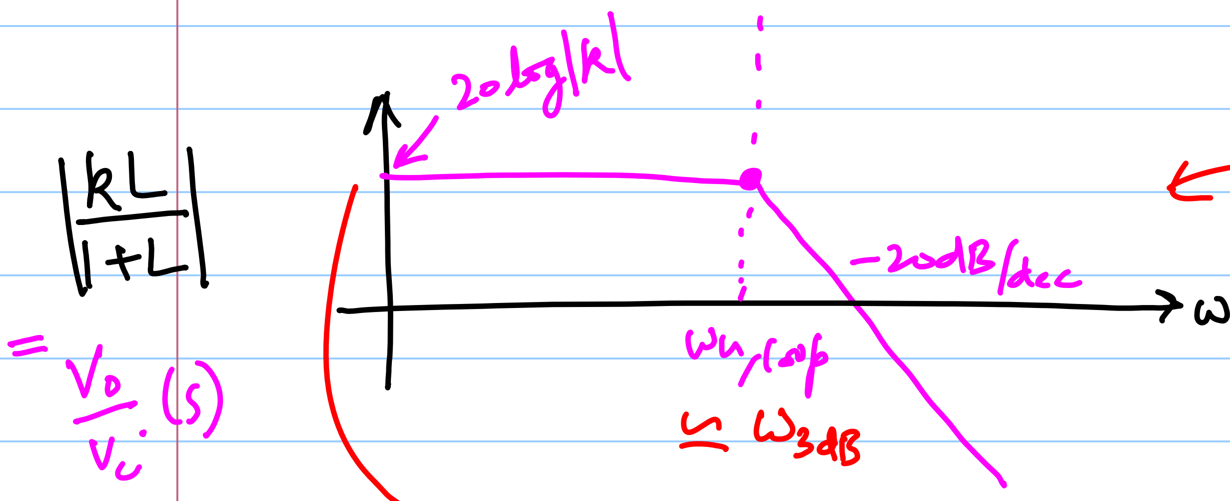
$|L| >> 1 \rightarrow 1 \sim 0dB$



unity-gain response

$\left|\frac{G}{1+GH}\right|$

closed-loop response



DC gain $\frac{1}{\beta} = \frac{y}{y_R} = k$

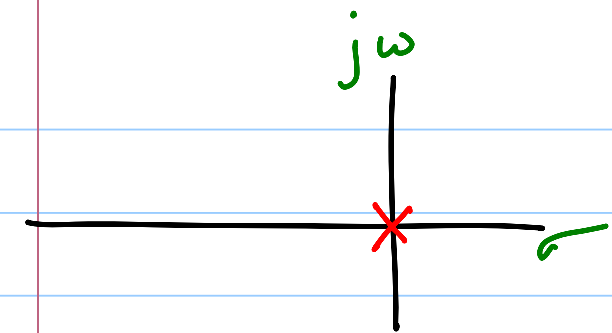
unity loop-gain frequency, $\omega_{u,loop} = \frac{\omega_u}{k}$

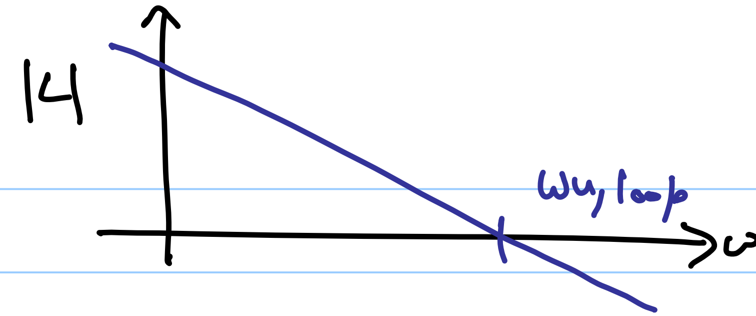
↳ $\omega_{u,loop}$ is not always ω_u divided by closed loop-gain 'k'

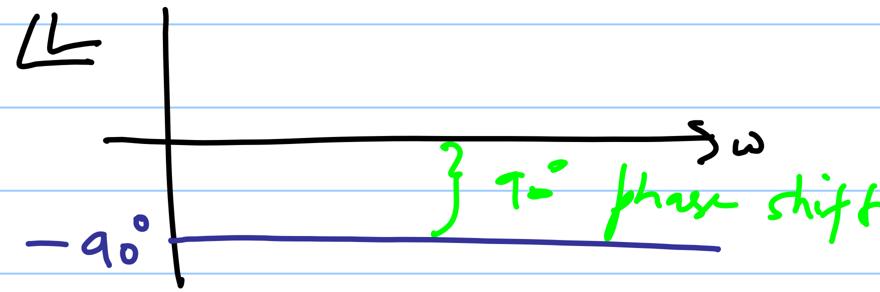
↳ 1st order system

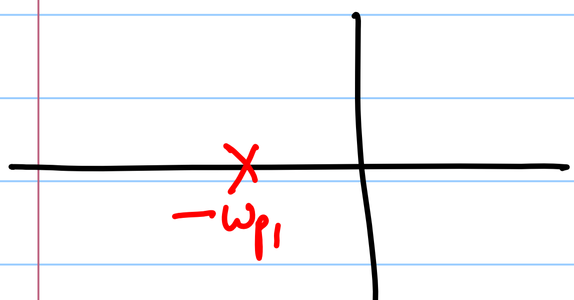
↳ $\omega_{u,loop}$ is the unity gain frequency of $L(s) = G(s) \cdot H(s)$ not just $G(s)$

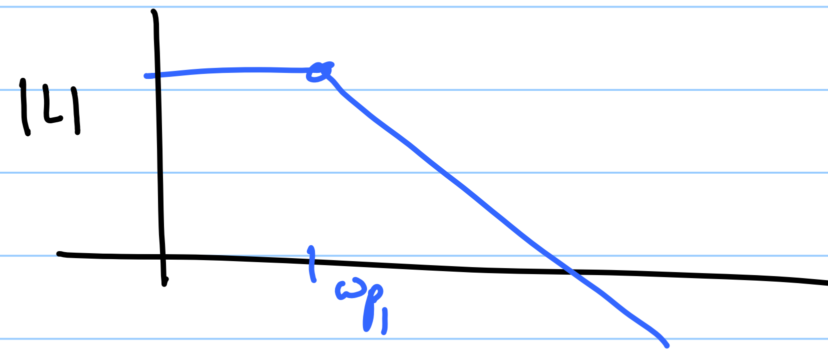
1st-order system

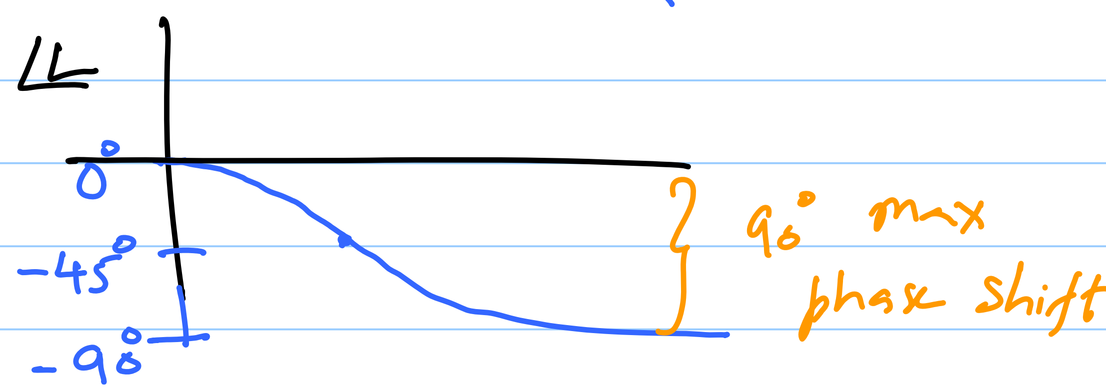










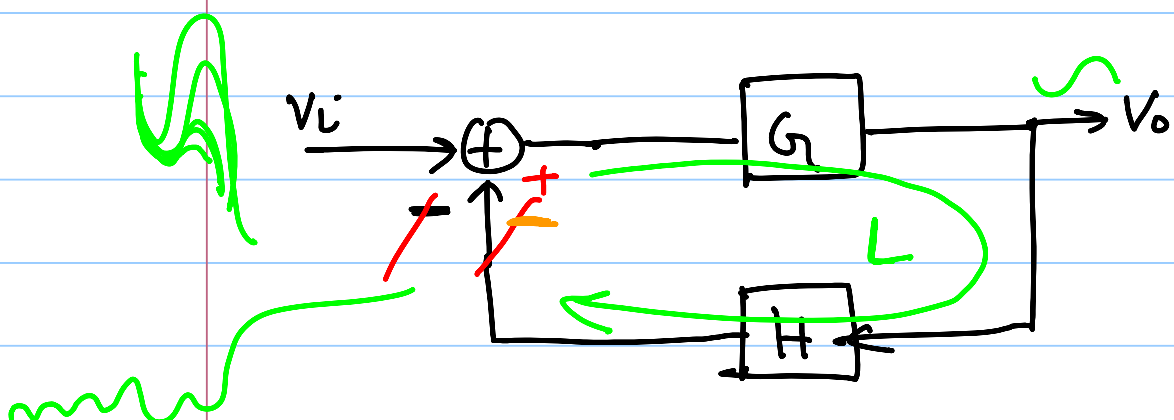


closed-loop response $\quad \dfrac{V_o}{V_i}(s) = \dfrac{G(s)}{1+L(s)}$

Instability if the loop gain $L = GH = -1$ at any frequency

$L = -1$

at any frequency: $|L| = 1$ and $\angle L = 180^\circ$ "Barkhausen's criterion"



if at any frequency $|L| \geq 1$ & $\angle L = 180^\circ$

−ve feedback becomes +ve feedback as the total phase around the loop is 360° ⇒ unstable for stability;

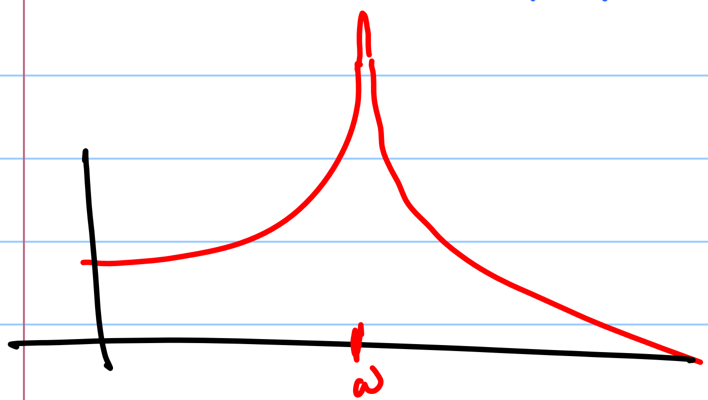
① for all frequencies where $|L| \geq 1$

$\angle L < 180°$

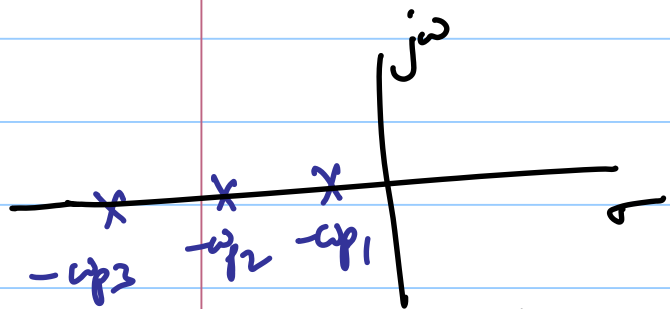
② for all frequencies where $\angle L \geq 180°$

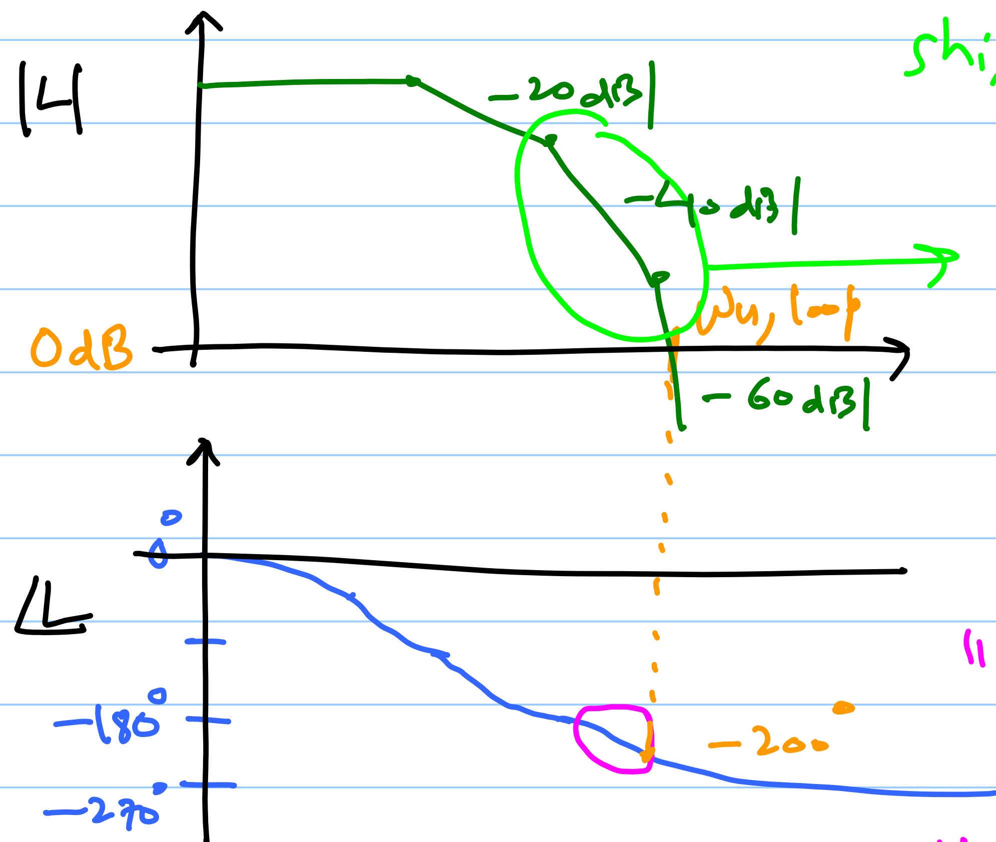
$|L| < 1$

$\left|\frac{KL}{1+L}\right|$



Multiple poles:



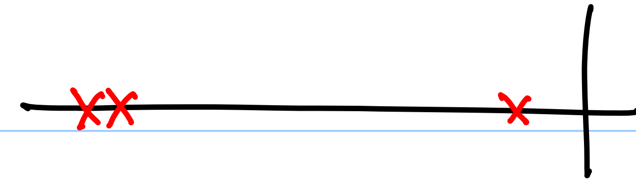


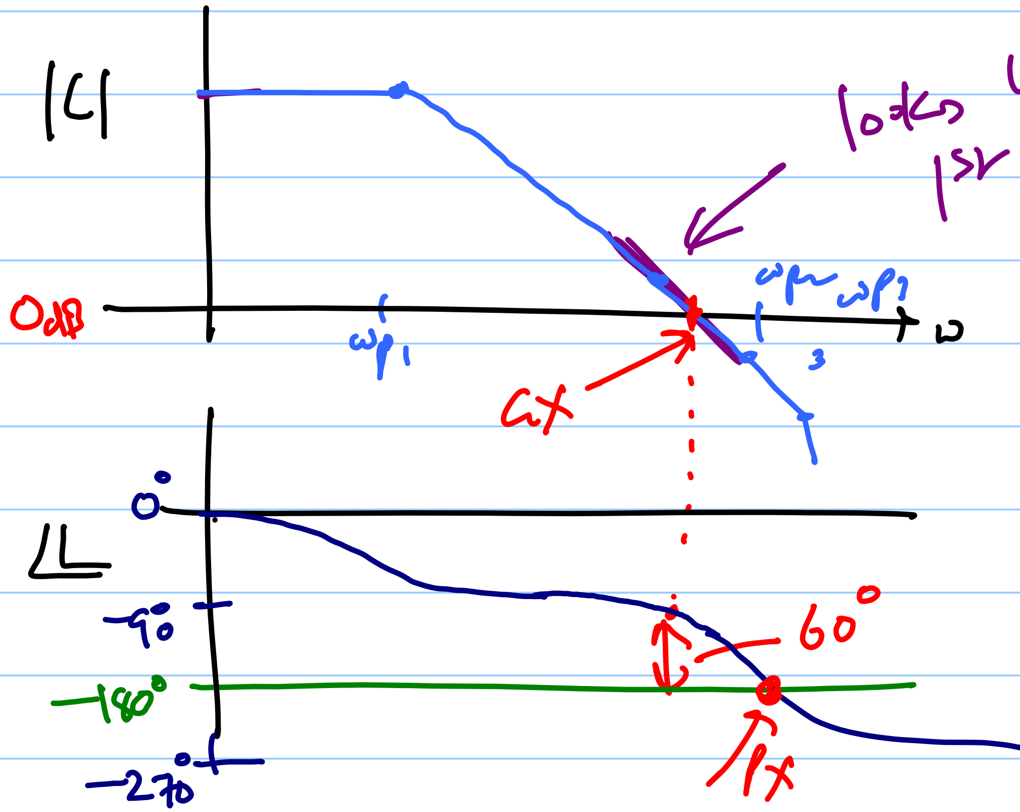
shift the higher poles beyond ωu, loop

"unstable"

phase margin = -20°

poles far from each other





looks like 1st order response at the unity-gain crossover frequency

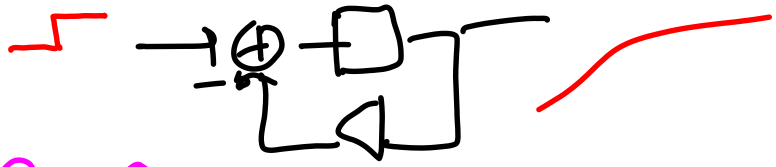
phase margin = 60°

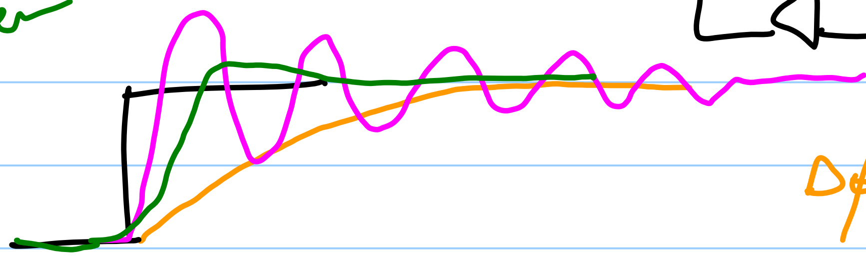
GX < PX for stability

GX → gain crossover frequency

PX → phase " "

2nd order system

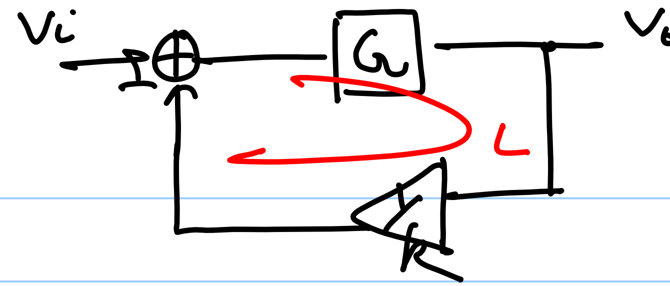


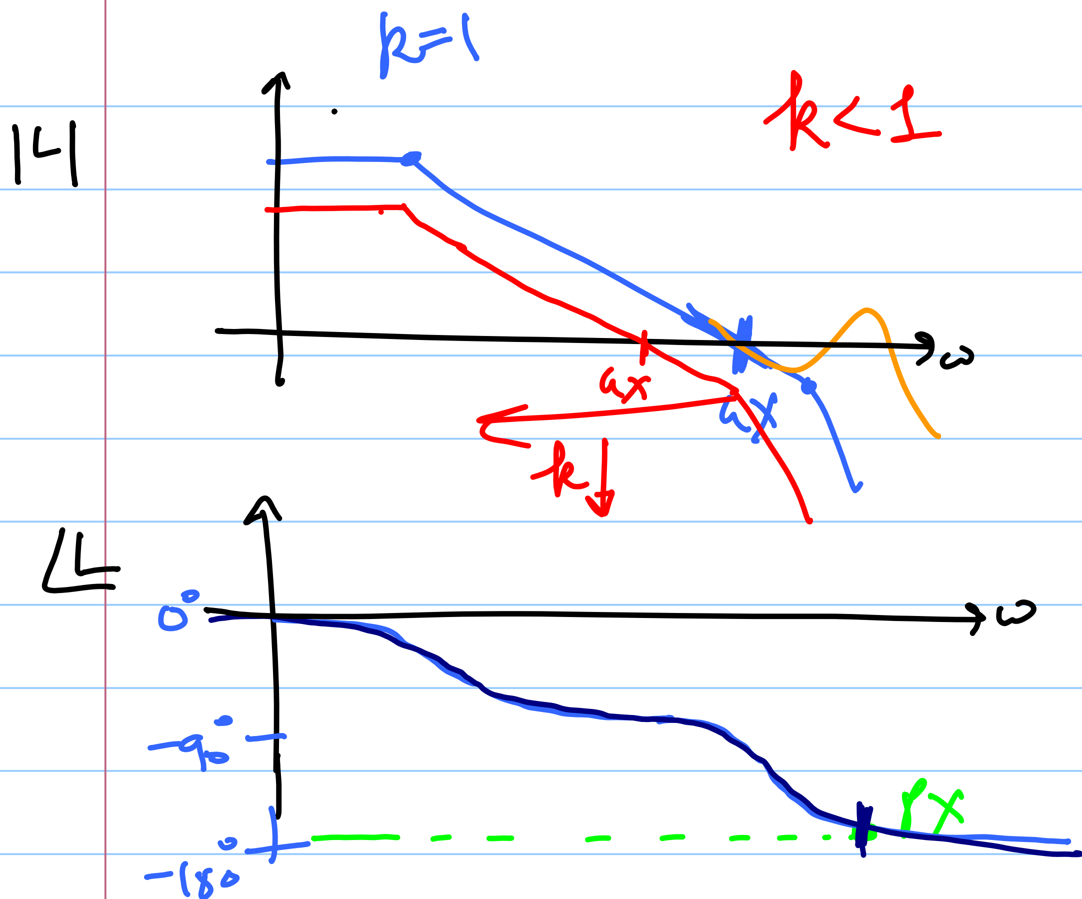


$\Delta\phi = 90^\circ$

$\Delta\phi \simeq 60^\circ$ critically damped

$\Delta\phi = 20^\circ$



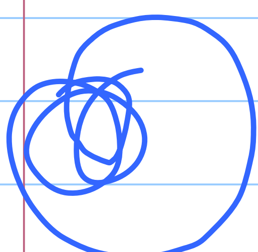


worst-case stability condition for $k=1$

if stable for $k=1$ $\Rightarrow$ stable for all $k<1$

↳ there should only be one GX

if this happens then need to use Nyquist stability



In Summary:

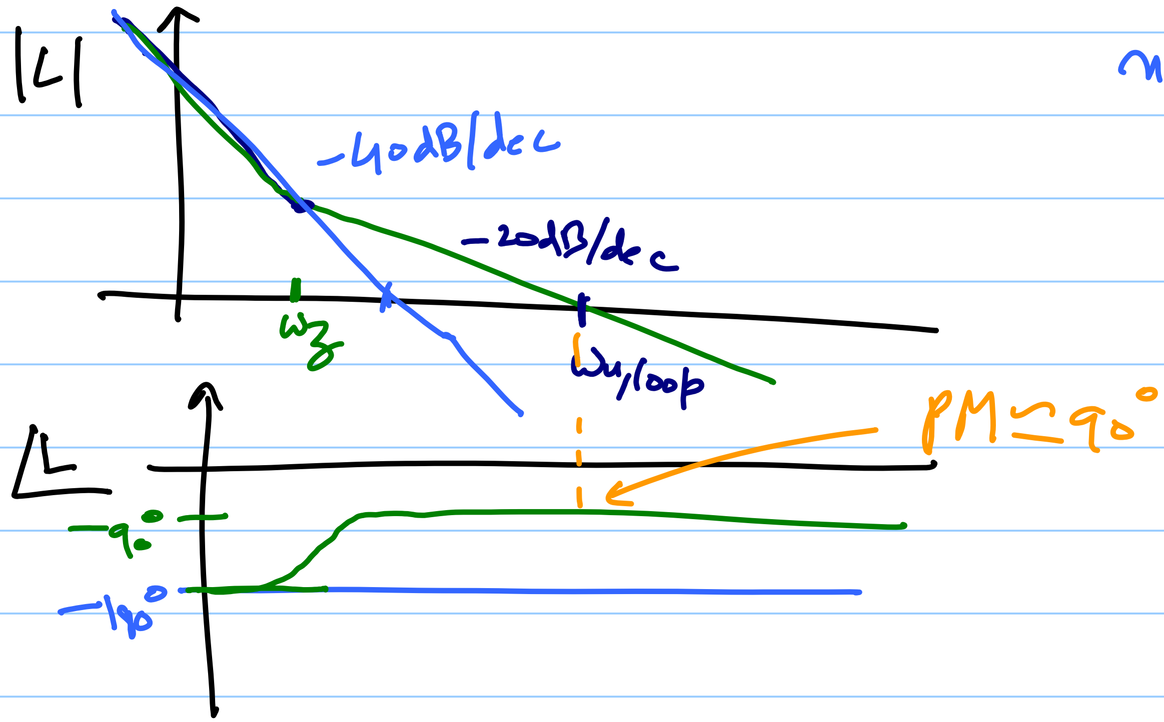
* for stability, the mag plot must have a slope of −20dB/dec around the unity gain frequency

* There can be any number of poles to the right as long as they are sufficiently far away from the ω_c.

* To stabilize a higher order system, it must be made to "look-like" a first-order system at and around the ω_u, loop.

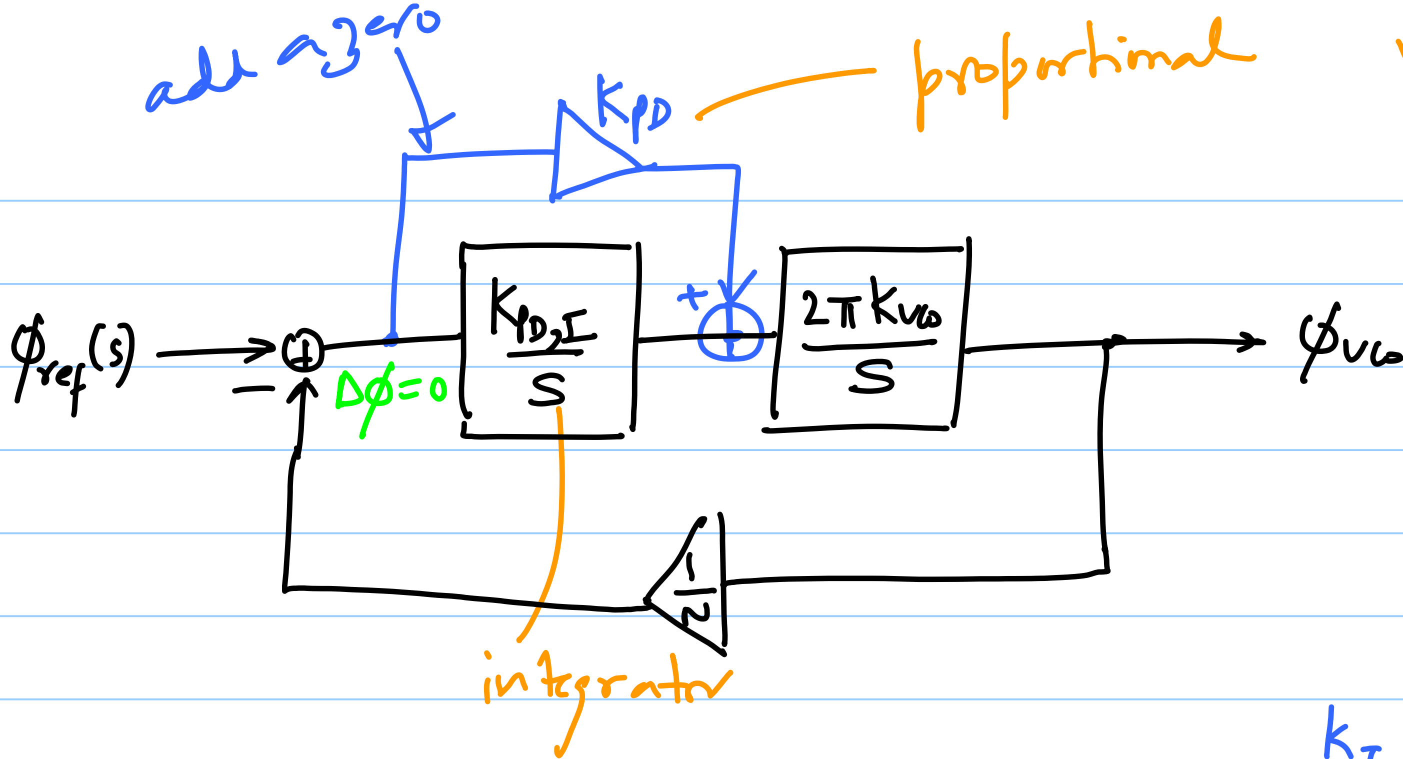
$$L(s) = \frac{2\pi K_{PD,I} \cdot K_{VCO}}{N \cdot s^2}$$

not stable



Add a zero

*



"PI-controller"

Type-II system

↳ # of poles at DC

$$\frac{k_I}{s} + k_p$$

$$= \frac{(k_I + s k_p)}{s}$$

zero

$$= \alpha \frac{(1 + s/\omega_z)}{s}$$