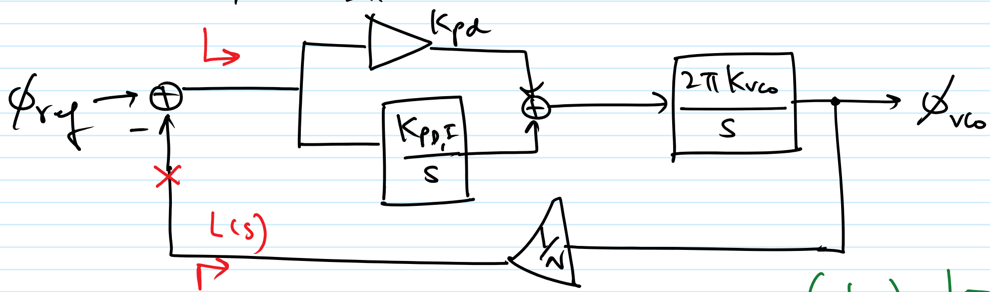
ECE 504 Lecture 8

Monday, September 19, 2016 3:29 PM

ECE 504 – Lecture 8

$$K_{PD,I} = \frac{I_0}{2\pi C} \qquad K_{PD} = \frac{I_0 R}{2\pi}$$



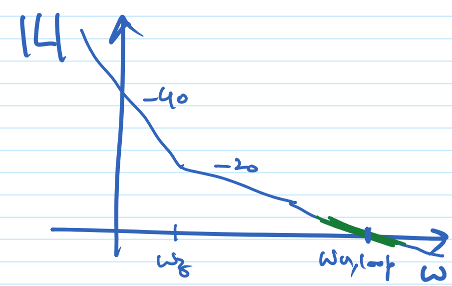
(open) loop gain

$$L(s) = \left(K_{pd} + \frac{K_{PD,I}}{s}\right)\frac{2\pi K_{vco}}{s \cdot N}$$

$$= \left(\frac{I_0 R}{\cancel{2\pi}} + \frac{I_0}{\cancel{2\pi} C \cdot s}\right)\frac{\cancel{2\pi} K_{vco}}{s \cdot N} = \frac{(1+sRC) K_{vco} I_0 R}{N \cdot s^2 \cdot RC}$$

$$L(s) = \frac{(1+sRC) K_{vco} I_0 \cancel{R}}{N s^2 \cancel{R} C}$$

$$= \frac{(1+s/\omega_z)}{s^2} \cdot \frac{K_{vco} I_0}{NC}$$



$$\omega_z = \frac{1}{RC}$$

@ $\omega = \omega_{u,loop}$, $|L(j\omega)| = 1$

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around unity-gain crossing

$$1 + sRC \simeq sRC \qquad \frac{\omega}{\omega_z} \gg 1$$

$$L(s) \simeq \frac{\cancel{sRC} \cdot K_{vco} I_0 R}{s^{\cancel{2}} \cancel{RC} \cdot N} = \frac{K_{vco} I_0 R}{s \cdot N} = \frac{\alpha}{s}$$

where $\alpha = \frac{K_{vco} I_0 R}{N}$

$|L(j\omega)| = 1$, $\omega = \alpha$

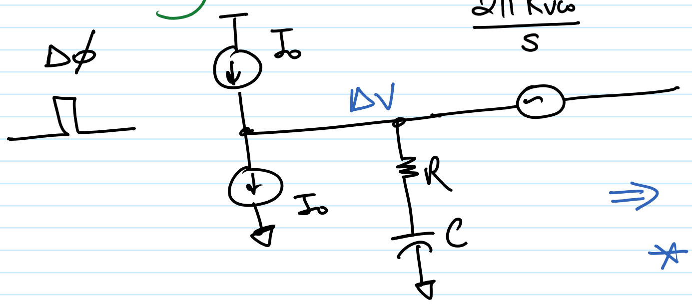
$$\boxed{\omega_{u,loop} \simeq \frac{K_{vco} I_0 R}{N}}, \qquad \omega_{u,loop} \gg \omega_z$$

$\omega_{u,loop} \gg \omega_z$

$$\omega_{u,loop} = \alpha\sqrt{\tfrac{1}{2} \times \left(1 + \sqrt{1 + 4/\tau^2\alpha^2}\right)}, \qquad \tau = RC = \frac{1}{\omega_z}$$

* Understanding $\omega_{u,loop} = \frac{I_0 R K_{vco}/N}{2\pi K_{vco}}$

* Understanding $\omega_{u,loop} = I_0 R K_{VCO}/N$



$$\Rightarrow \Delta\omega = \frac{I_0}{\cancel{2\pi}} R \times \cancel{2\pi} K_{VCO} \times \Delta\phi$$

$$= I_0 R K_{VCO} \cdot \Delta\phi$$

$\Rightarrow$

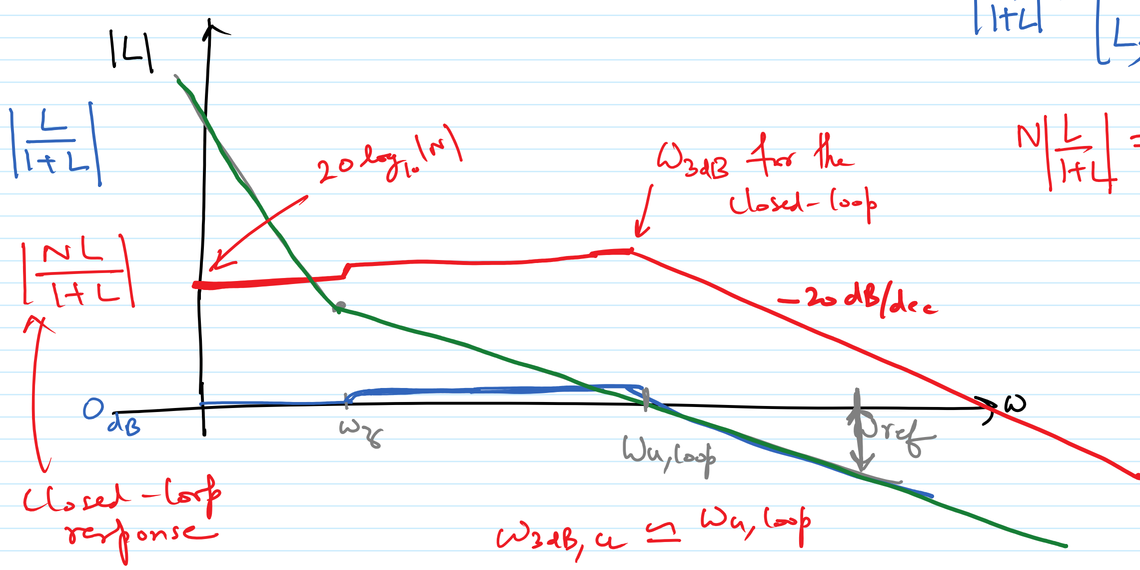
* current pulse I_0 is applied for $\Delta\phi$ time

$\Rightarrow$ voltage increment in one cycle $= \frac{I_0 R}{2\pi} \cdot \Delta\phi$

$\Rightarrow$ frequency increment $\Rightarrow I_0 R K_{VCO} \cdot \Delta\phi$

$$\left|\frac{L}{1+L}\right| \simeq \begin{cases} 1, & |L| \gg 1 \\ L, & |L| \ll 1 \end{cases}$$

$$N\left|\frac{L}{1+L}\right| = \frac{G}{1+L}$$

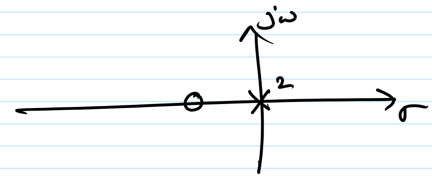


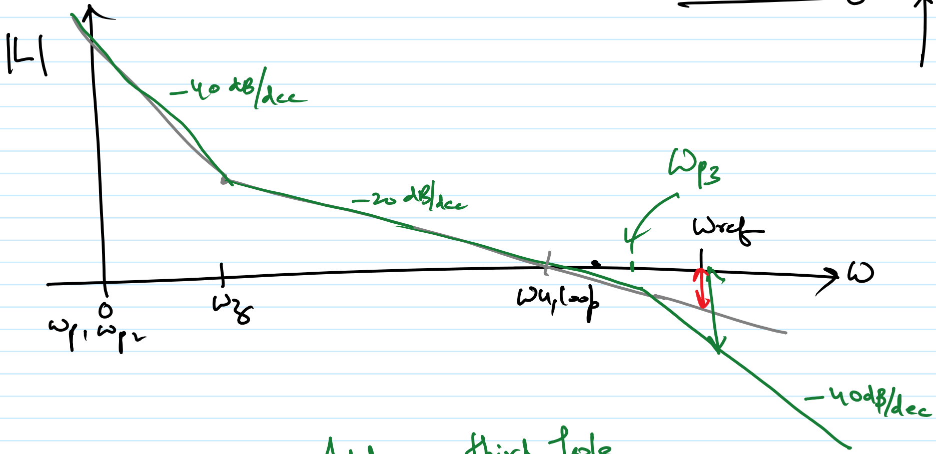
$\omega_{ref} \gg \omega_{u,loop}$ to minimize "reference feedthrough" at ω_{ref}

$\omega_{ref} > 10\, \omega_{u,loop}$

loop-bandwidth, $\omega_{3dB} \simeq \omega_{u,loop} = \frac{K_{VCO} I_0 R}{N}$

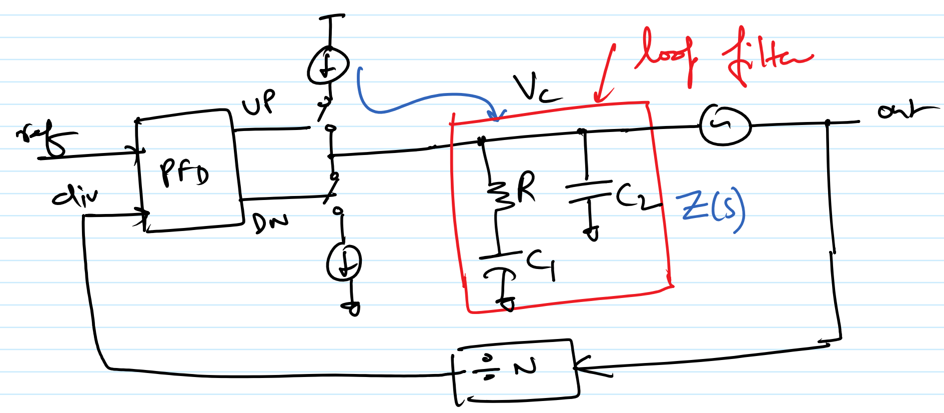
* A higher $\omega_{u,loop} \Rightarrow$ PLL settles faster

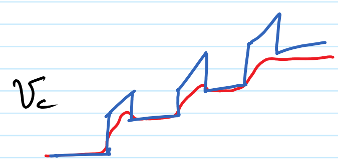




Add a third pole ⟹ higher reference feedthru suppression

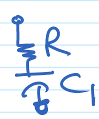
↳ can reduce phase margin and affect stability.





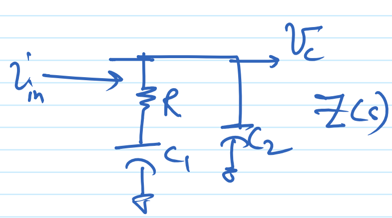
$$L(s) = \frac{I_o}{\cancel{2\pi}} \cdot Z(s) \cdot \frac{\cancel{2\pi} K_{vco}}{s \cdot N} = \frac{K_{vco} \cdot I_o}{s \cdot N} \cdot Z(s)$$ ⟸ loop-filter impedance

Before $Z(s) = R + \frac{1}{sC_1}$



Now with the addition of C_2

$$Z(s) = \left(R + \frac{1}{sC_1}\right) \| \frac{1}{sC_2}$$



$$= \frac{\left(R + \frac{1}{sC_1}\right) \cdot \frac{1}{sC_2}}{R + \frac{1}{sC_1} + \frac{1}{sC_2}} = \frac{(1 + sRC_1)}{s\,(C_1 + C_2)\left(1 + sR\,\frac{C_1C_2}{C_1+C_2}\right)}$$

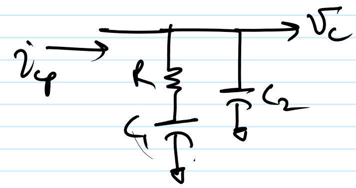
$$Z(s) = \frac{(1 + sRC_1)}{s\,(C_1 + C_2)\,(1 + sR \cdot C_1 \| C_2)}$$

where $a \| b = \frac{ab}{a+b}$

$$\omega_{p3} = \frac{1}{R(C_1 \| C_2)}$$

$$L(s) = \frac{K_{VCO} I_o}{s \cdot N} \cdot Z(s)$$

$$= \frac{K_{VCO} I_o}{s^2 (C_1 + C_2) N} \cdot \frac{(1 + sRC_1)}{(1 + sR \cdot C_1 \| C_2)} = \frac{K_{VCO} I_o \,(1 + s/\omega_z)}{(C_1 + C_2) N \cdot s^2 (1 + s/\omega_{p3})}$$



Type-II

3rd-order PLL