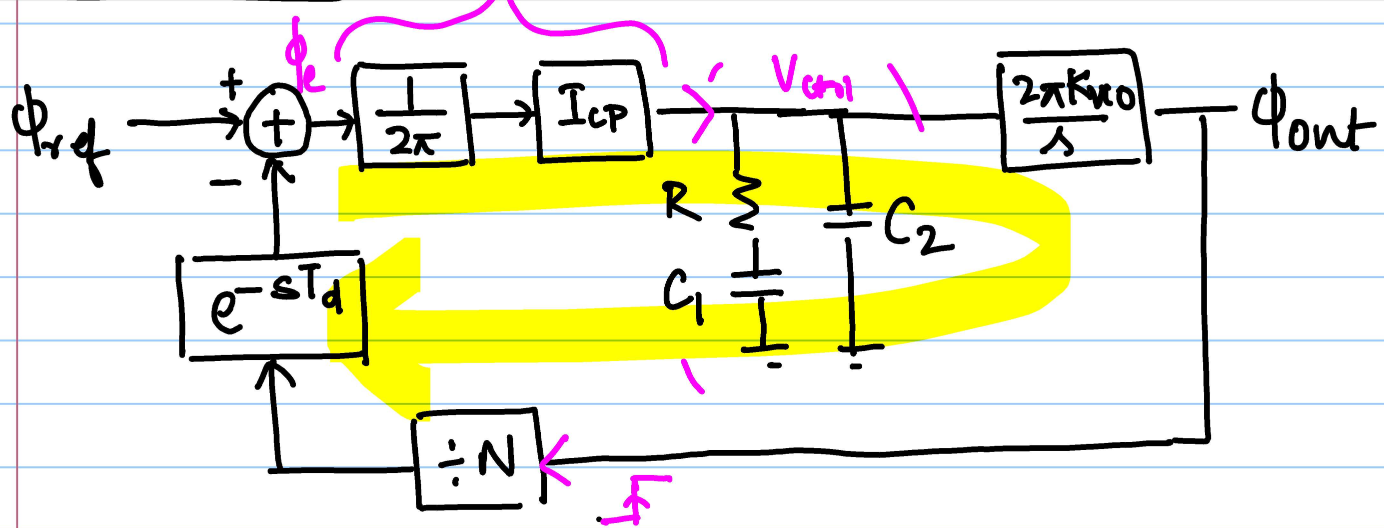
Note Title 15-10-2020

Lecture # 19



$x(t) \to \boxed{\ } \to y(t)$

$y(t) = x(t - t_d)$

$Y(s) = X(s) \cdot e^{-st_d}$

$$LG = \frac{1}{2\pi} I_{cp} \frac{(1+sRC_1)}{\left(1+s\frac{RC_1C_2}{C_1+C_2}\right)} \frac{1}{s(C_1+C_2)} \frac{2\pi K_{vco}}{s} \frac{1}{N} = \frac{I_{cp}K_{vco}(1+s/\omega_z)}{s^2 N(C_1+C_2)(1+s/\omega_{p3})} \times e^{-st_d}$$

$$\measuredangle LG = -180^\circ + \tan^{-1}\left(\frac{\omega}{\omega_z}\right) - \tan^{-1}\left(\frac{\omega}{\omega_{p3}}\right) - \tan^{-1}(\omega t_d)$$

$$\phi_m \downarrow = \measuredangle LG - (-180^\circ) = \tan^{-1}\left(\frac{\omega_u \downarrow}{\omega_z \downarrow}\right) - \tan^{-1}\left(\frac{\downarrow\omega_u}{\omega_{p3}\downarrow}\right) - \tan^{-1}(\omega_u t_d) \Rightarrow \omega_u^2 = \omega_z \cdot \omega_{p3}$$

$|LG(\omega_u)| = 1$; ω_u is unity gain frequency.

$$\Downarrow$$

$$\uparrow K_c = \frac{C_1}{C_2} = 2\left(\tan^2\phi_m + \tan\phi_m\sqrt{1+\tan^2\phi_m}\right)$$

$\underline{\omega_n, \phi_m}$ $\xrightarrow{\left.\frac{d\phi_m}{d\omega}\right|_{\omega_n} = 0}$ $\boxed{\frac{C_1}{C_2} = f(\phi_m)}$

$$\omega_n^2 = \omega_z \cdot \frac{1}{RC_1 \frac{C_2}{C_1+C_2}}$$

$$\omega_n^2 = \omega_z^2 \left(1 + \frac{C_1}{C_2}\right)$$

$$\omega_z \downarrow = \frac{\omega_n^2}{\omega_{p3}} = \frac{\omega_n}{\sqrt{1+\frac{C_1}{C_2}\uparrow}}$$

ω_{p3} :

Choose R for $\underline{\text{low noise}}$:

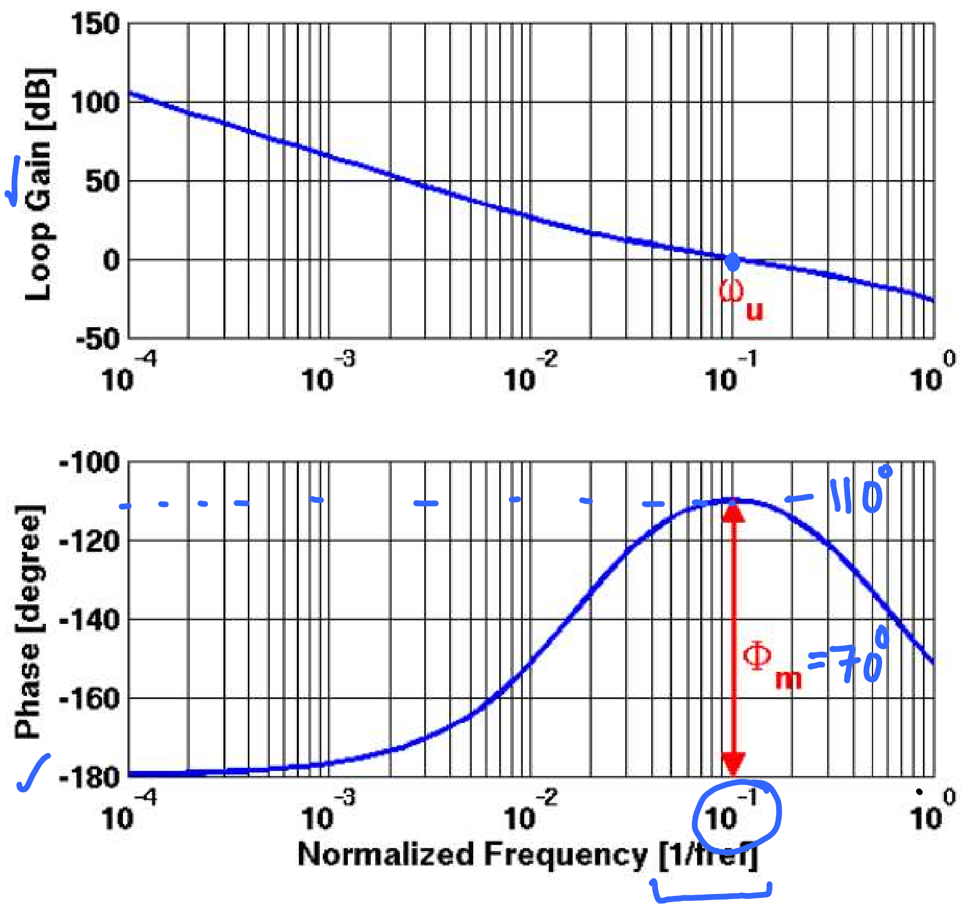
$$C_1 \uparrow = \frac{1}{\downarrow \omega_z \cdot R} \xrightarrow{\frac{C_1}{C_2} = K_c} C_2 = \frac{C_1}{K_c}$$

$$\frac{\overline{v_{n,R}^2}}{\Delta f} = 4kTR \quad \frac{V^2}{Hz}$$

I_{cp}, $\underbrace{K_{vco}}$.

$$|H(\omega_n)| = 1$$

$$I_{cp} = \frac{2\pi C_2}{K_{vco}} \cdot \omega_n^2 \sqrt{\frac{\omega_{p3}^2 + \omega_n^2}{\omega_z^2 + \omega_n^2}}$$



Closed loop gain, $\frac{\phi_{out}(s)}{\phi_{ref}(s)} = \frac{N\,LG(s)}{1+LG(s)}$

$$\frac{\phi_{out}(s)}{\phi_{ref}(s)} = \frac{N}{1+\frac{1}{LG}}$$

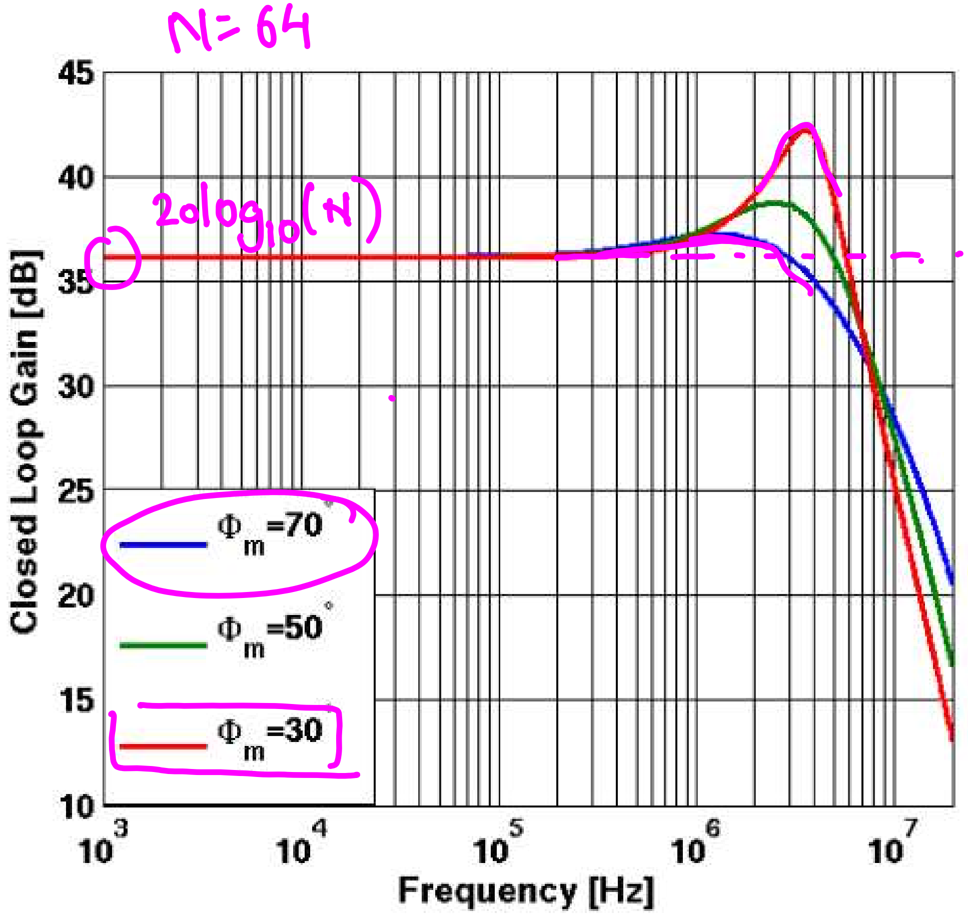
$$= \frac{N}{1+\frac{s^2 N (C_1+C_2)(1+s/\omega_{p3})}{I_{cp}K_{vco}\,(1+s/\omega_z)}}$$

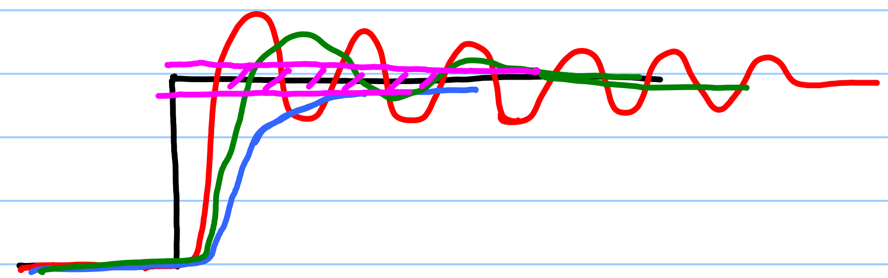
$$= \frac{N I_{cp}K_{vco}(1+s/\omega_z)}{\frac{s^3 N(C_1+C_2)}{\omega_{p3}} + s^2 N(C_1+C_2) + \frac{I_{cp}K_{vco}\,s}{\omega_z} + I_{cp}K_{vco}}$$

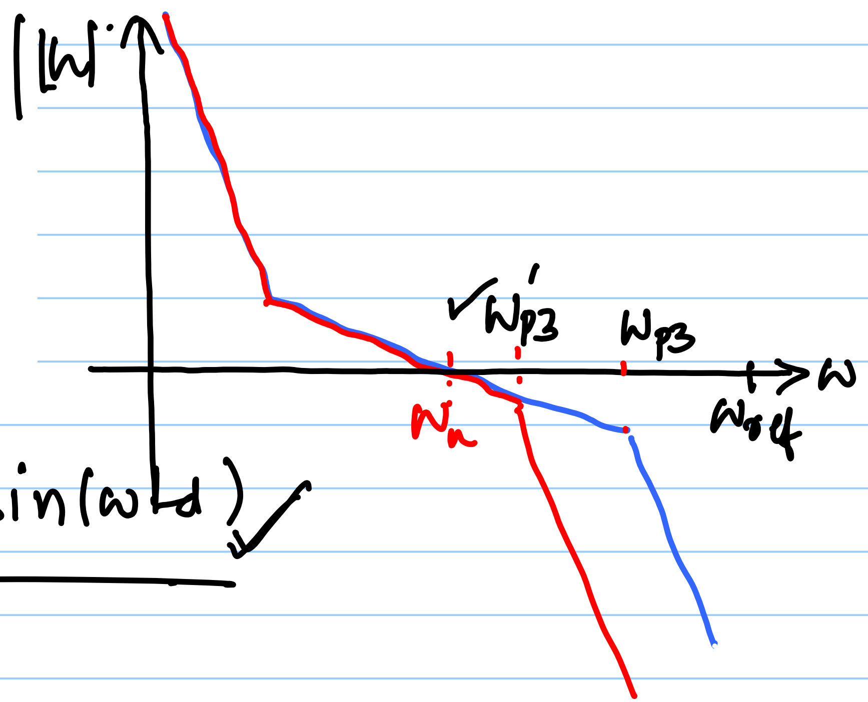
$$H(s) = \frac{\phi_{out}}{\phi_{ref}} = \frac{N(1+s/\omega_z)}{\frac{s^3 N(C_1+C_2)}{\omega_{p3} I_{cp}K_{vco}} + \frac{s^2 N(C_1+C_2)}{I_{cp}K_{vco}} + \frac{s}{\omega_z} + 1}$$ ✓

Zero: $\omega = \omega_z$

Poles: $\omega_{p1}', \omega_{p2}', \omega_{p3}'$







$$e^{-st_d} = e^{-j\omega t_d} = \underbrace{\cos(\omega t_d) - j\sin(\omega t_d)}$$

$$\approx \underbrace{(1 - j\omega t_d)}.$$

$$\underbrace{\tan^{-1}(\omega t_d)}$$

$$e^{-st_d} = \frac{e^{-st_d/2}}{e^{+st_d/2}} \approx \frac{1 - st_d/2}{1 + st_d/2} = \left(\underbrace{\frac{1 - j\omega t_d/2}{1 + j\omega t_d/2}} \right)$$

$$|\quad| = 1$$

$$\measuredangle(\quad) = -2\tan^{-1}\left(\frac{\omega t_d}{2}\right)$$