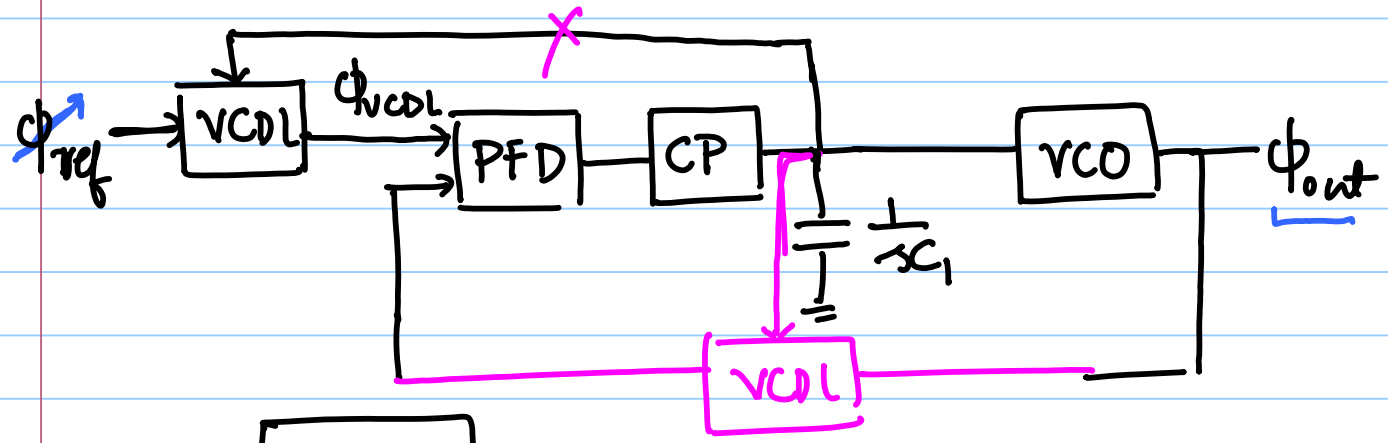
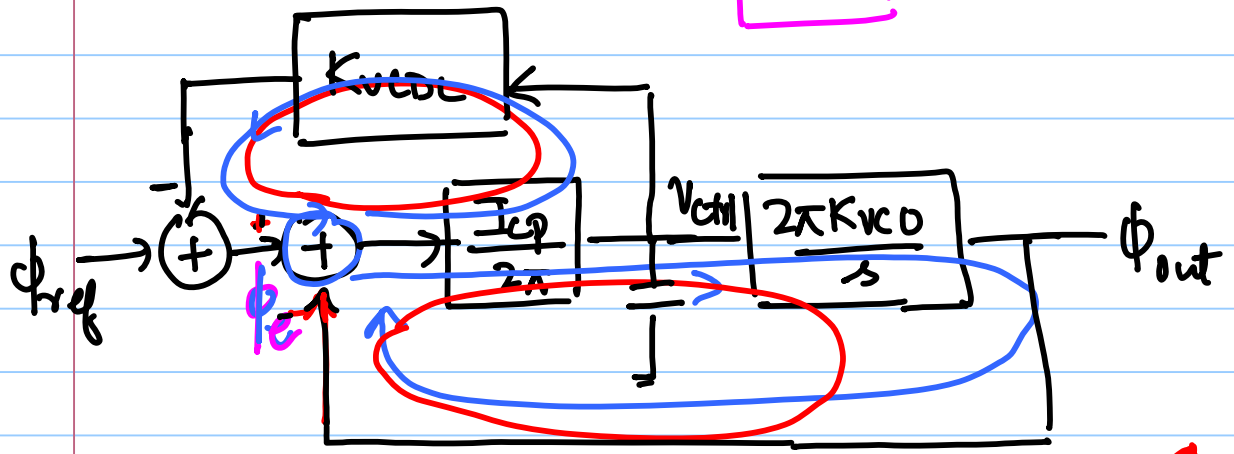
Note Title

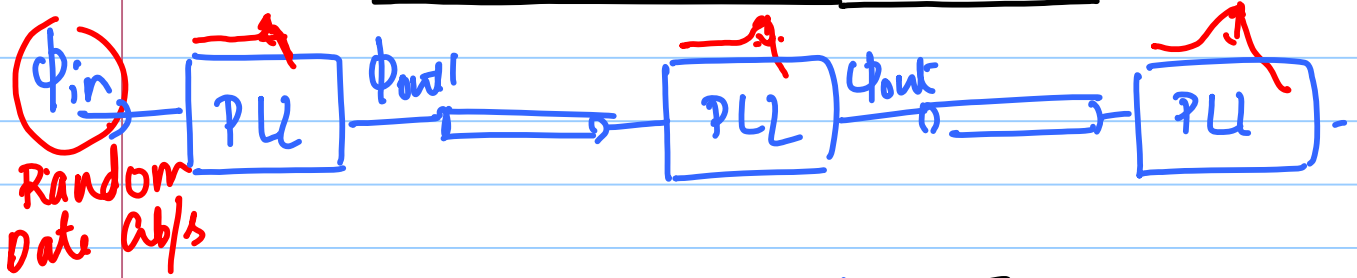
Lecture #34

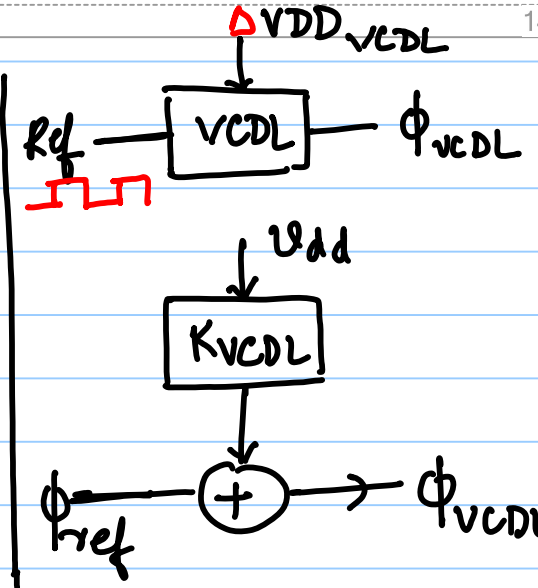
14-08-2020

$V_{out} = \cos(\omega_0 t + a_m \sin(\omega_m t))$

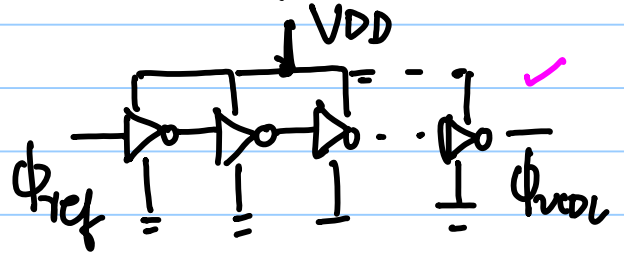








$\phi_{VCDL} = \phi_{ref} + K_{VCDL} \cdot V_{dd}$



$\frac{I_{cp}}{2\pi} \frac{2\pi K_{VCO}}{s} \times \frac{1}{sC_1}$

$+ \frac{I_{cp}}{2\pi} \frac{1}{sC_1} 2\pi K_{VCDL}$

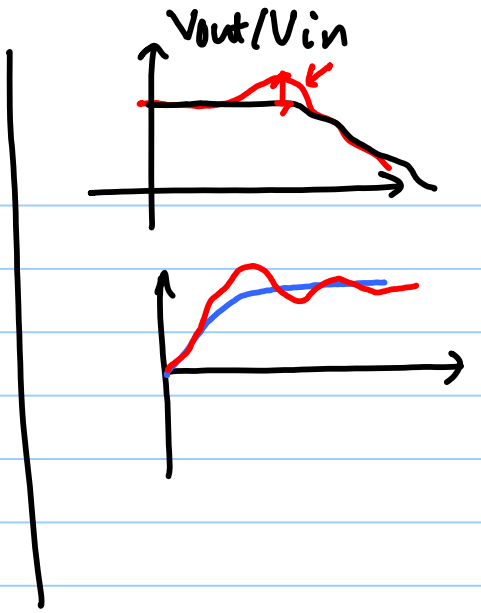
$$\left(\phi_{ref} - K_{VCDL} \cdot V_{ctrl} - \phi_{out}\right) \frac{I_{cp}}{2\pi} \times \frac{1}{sC_1} = V_{ctrl} \quad -(1)$$

$$V_{ctrl} \cdot \frac{2\pi K_{VCO}}{s} = \phi_{out} \quad -(2)$$

$$\Rightarrow \quad V_{ctrl} = \frac{s\phi_{out}}{2\pi K_{VCO}}$$

$$\left(\phi_{ref} - \phi_{out}\right) = \left(\frac{2\pi s C_1}{I_{cp}} + K_{VCOL}\right)\frac{s\phi_{out}}{2\pi K_{VCO}}$$

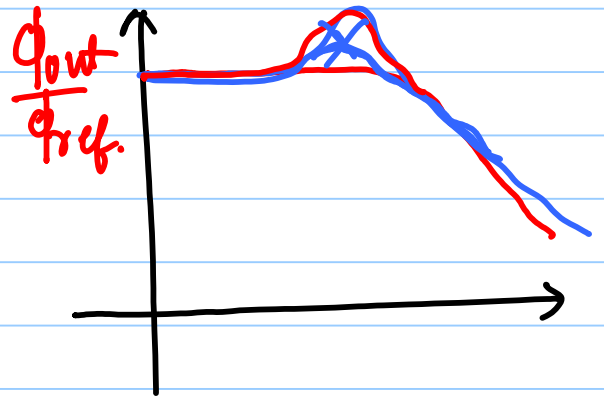
$$= \left(\frac{s^2 C_1}{I_{cp} \cdot K_{VCO}} + \frac{s K_{VCOL}}{2\pi K_{VCO}}\right)\phi_{out}$$



$$\frac{\phi_{out}}{\phi_{ref}} = \frac{1}{1 + s\left(\frac{K_{VCOL}}{2\pi K_{VCO}} + \frac{s^2 C_1}{I_{cp} K_{VCO}}\right)}$$

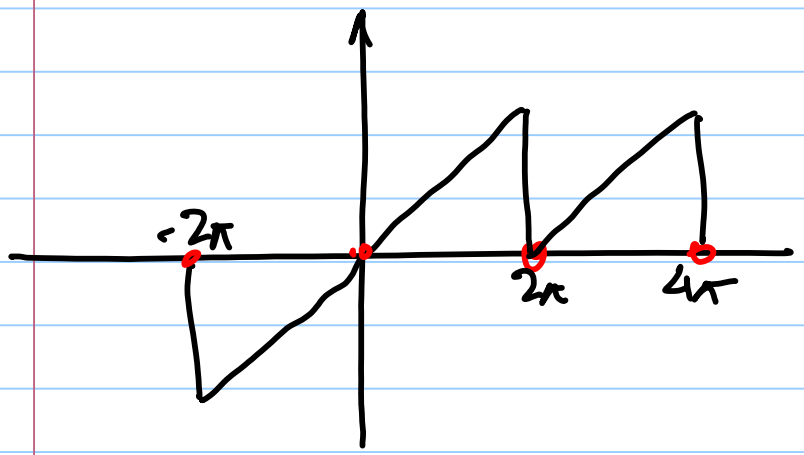
$$= \frac{1}{1 + s\left(\frac{K'_{VCOL}}{K_{VCO}} + \frac{s C_1}{I_{cp} K_{VCO}}\right)}$$

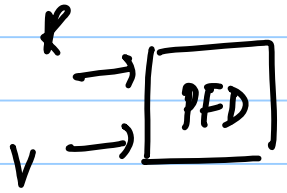
$$K'_{VCOL} = 2\pi K_{VCOL}$$



$$\omega_n = \frac{I_{cp}}{2\pi} \frac{2\pi K_{vco}}{s} \times \frac{1}{sC_1} + \frac{I_{cp}}{2\pi} \frac{1}{sC_1} 2\pi K'_{vcoL}$$

$$= \frac{I_{cp}}{sC_1} \left(K_{vco} + sK'_{vcoL} \right)$$

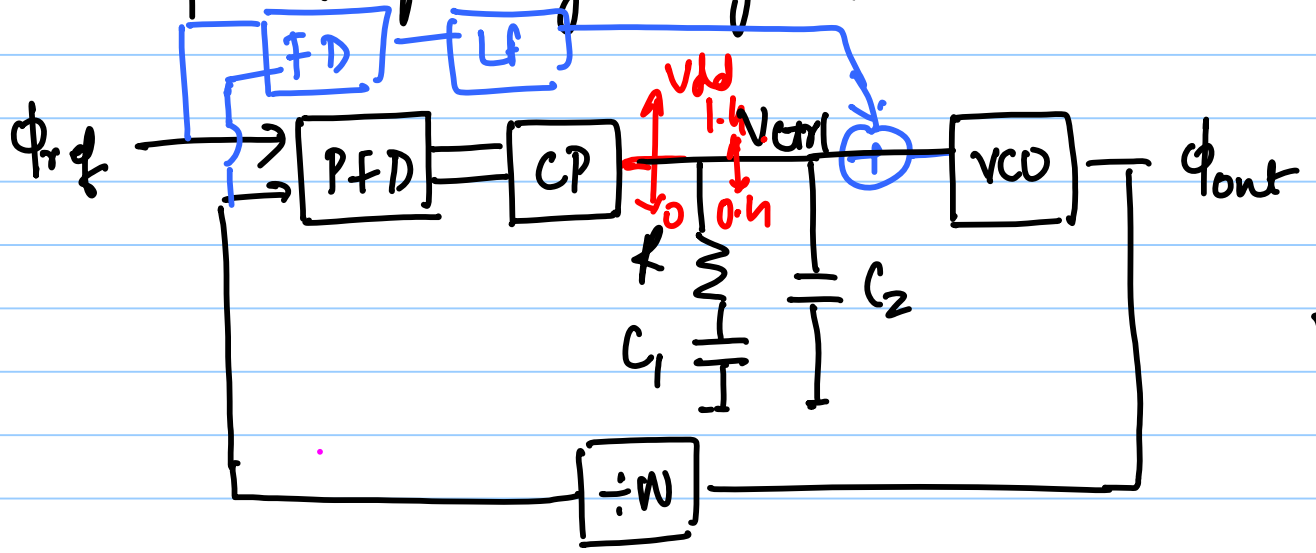


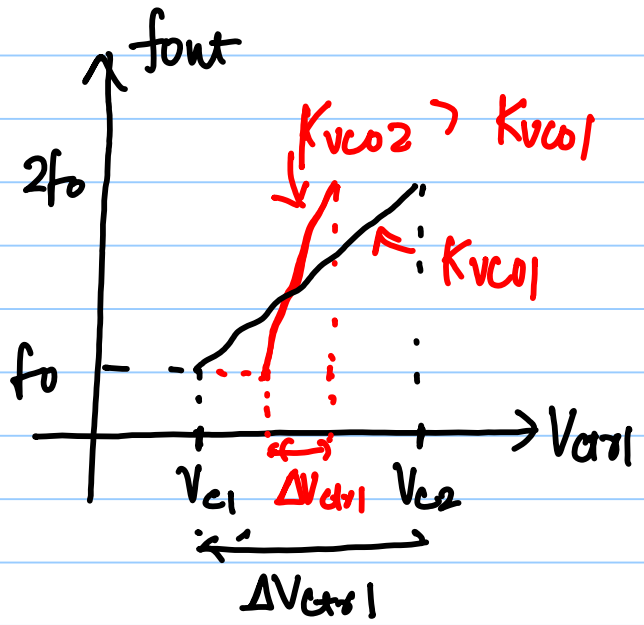


$-2\pi \leq K_{vcoL} \times v_{dd} \leq \underset{\sim}{2\pi}$ w.r.t T_{ref}.

Tunable delay, $\Delta t_d = \pm T_{ref}$.

Wide-output frequency range PLL



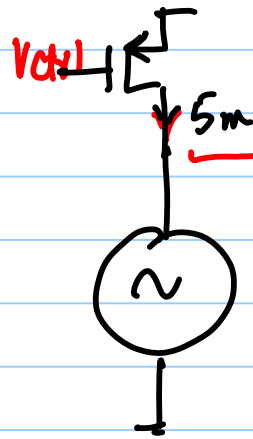


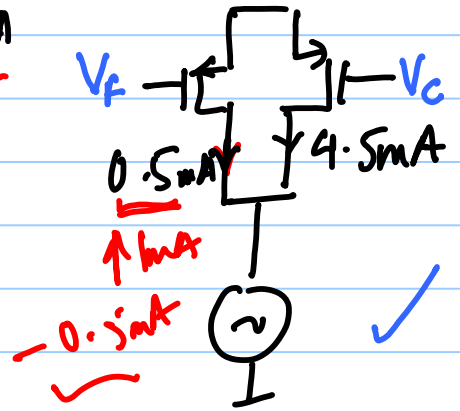
$$H_{ch} = \frac{I_{cp} K_{VCO}}{2\pi} \frac{s + \frac{1}{RC_1}}{s^2 C_2 \left(s + \frac{1}{RC_1 C_2 / (C_1 + C_2)} \right)} = \frac{I_{cp} K_{VCO}}{2\pi s^2 (C_1 + C_2)} \frac{(1 + sRC_1)}{\left(1 + sRC_1 C_2 / (C_1 + C_2)\right)}$$

Large K_{VCO}

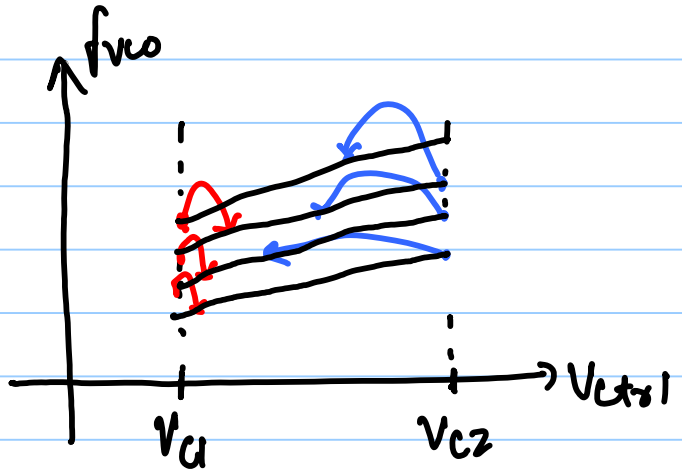
$K_{VCO} \uparrow \Rightarrow I_{cp} \downarrow \Rightarrow$ Increase Noise

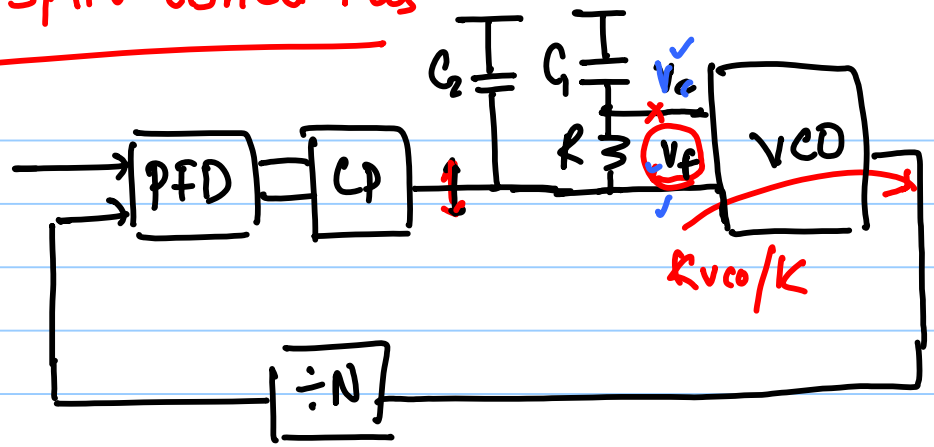
$K_{VCO} \uparrow \Rightarrow S^{V_2}_{\phi_{out}} \propto K_{VCO}^2$





Split-tuned PLLs





$$H(s) = \underbrace{\frac{I_{CP}}{2\pi} F(s) \frac{K_{VCO}/K}{s}}_{V_f \text{ control}} + \frac{I_{CP}}{2\pi} F(s) \frac{\left(\frac{K-1}{K}\right) K_{VCO}}{s} \times \frac{V/sC_1}{\frac{1}{sC_1} + R}$$

$$F(s) = \frac{s + 1/RC_1}{sC_2\left(s + \frac{1}{R\frac{C_1C_2}{C_1+C_2}}\right)}$$

$$H(s) = \frac{I_{CP}}{2\pi} F(s) \frac{K_{VCO}/K}{s} \left(1 + \frac{K-1}{1+sRC_1}\right)$$

$$= \frac{KI_{CP}}{2\pi} \frac{K_{VCO}}{s^2 K(C_1+C_2)} \frac{(1 + sRC_1/K)}{1 + sR\frac{C_1C_2}{C_1+C_2}}$$

(KC_1)

$$\omega_z = \frac{1}{RC_1/K}, \quad \omega_{p1} = \omega_{p2} = 0, \quad \omega_{p3} = \frac{1}{RC_1C_2/(C_1+C_2)}$$

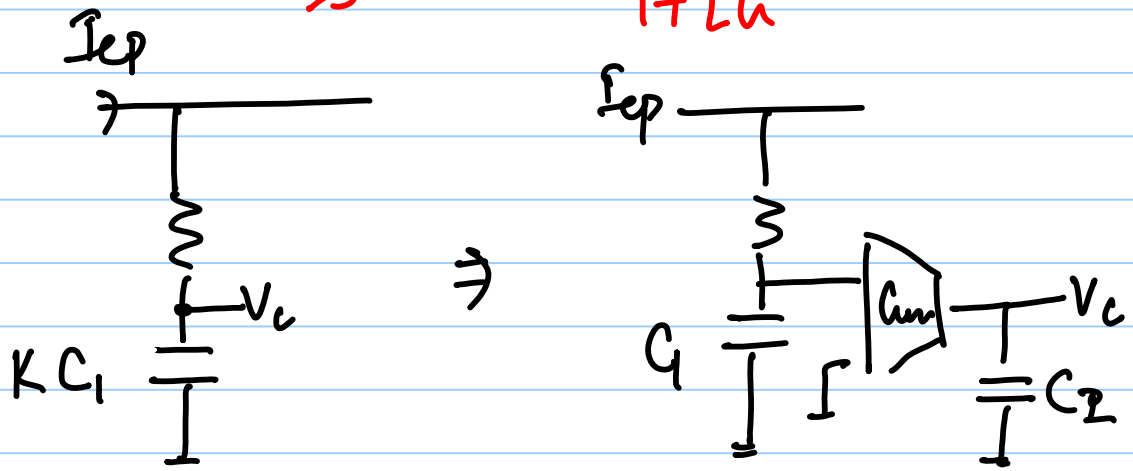
$$LG = \frac{I_{cp}}{2\pi} \frac{K_{VCO}}{s^2(C_1+C_2)} \frac{(1+sRC_1)}{\left(1+sR\frac{KC_1C_2}{KC_1+C_2}\right)}$$

V_c, V_f :

$C_1 \to KC_1$

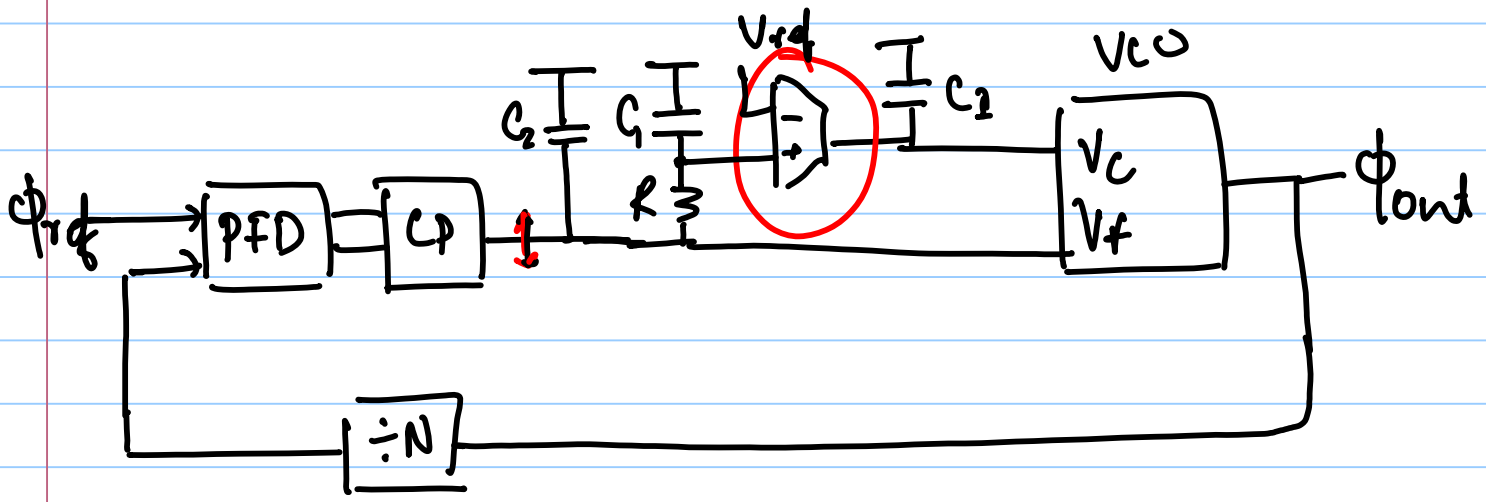
$I_{cp} \to KI_{cp}$

$$NTF_R = \frac{(K_{VCO}/K)}{s} \frac{1}{1+LG} \times$$



$$V_c = \frac{I_{cp}}{s(KC_1)}$$

$$V_c = \frac{I_{cp}}{sC_1} \times C_{un} \times \frac{1}{sC_2} = \frac{I_{cp}}{s^2 C_1\left(\frac{C_2}{C_{un}}\right)}$$



$$LG_F = \frac{I_{ep}}{2\pi N} \frac{K^F_{VCO}}{s^2(C_1+C_2)} \frac{1+sRC_1}{1+sRC_1C_2/C_1+C_2}$$

$$LG_C = \frac{I_{ep}}{2\pi N} \frac{K^C_{VCO}}{s^2(C_1+C_2)} \frac{1}{1+sRC_1C_2/C_1+C_2} \times \frac{G_m}{sC_I}$$

$$LG = LG_C + LG_F = \frac{I_{ep}}{2\pi N} \frac{1}{s^2(C_1+C_2)} \underbrace{\frac{1}{1+\frac{sRC_1C_2}{C_1+C_2}}} \left[K^F_{VCO}(1+sRC_1) + K^C_{VCO} \frac{G_m}{sC_2} \right]$$

$$\frac{K_{VCO}^{F}(1+sRC_1) + K_{VCO}^{C}\frac{G_m}{sC_I}}{sK_{VCO}^{F}C_I + s^2RC_1C_IK_{VCO}^{F} + K_{VCO}^{C}G_m}$$

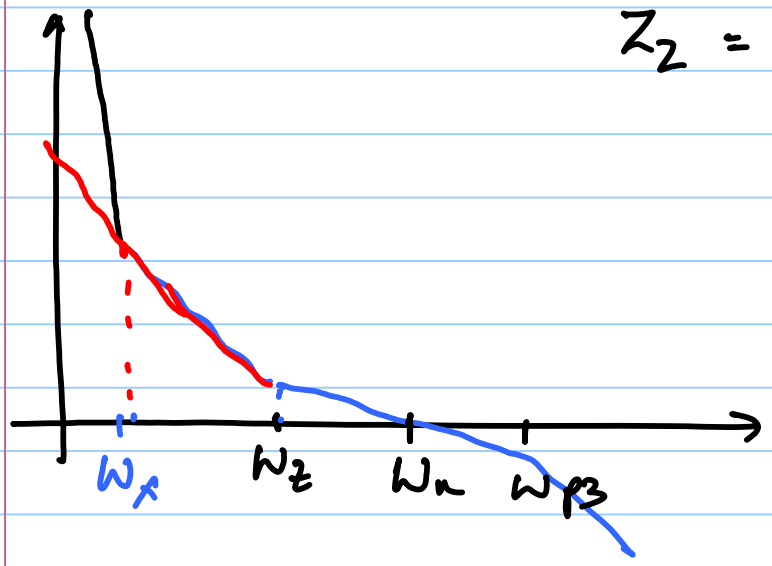
$$sC_I$$

$$K_{VCO}^{F}RC_1C_Is^2 + K_{VCO}^{F}C_Is + K_{VCO}^{C}G_m$$

$$z_1 = -\frac{K_{VCO}^{F}C_I}{K_{VCO}^{F}RC_1C_I} = -\frac{1}{RC_1} \checkmark \checkmark$$

$$z_2 = -\frac{K_{VCO}^{C}G_m}{K_{VCO}^{F}RC_1C_I} \times RC_1 = -\frac{K_{VCO}^{C}}{K_{VCO}^{F}}\frac{G_m}{C_I} \checkmark$$

ω_x



$$\omega_x \ll \omega_z$$

$$\frac{K_{VCO}^{C}}{K_{VCO}^{F}}\frac{G_m}{C_I} \ll \frac{1}{RC_1}$$