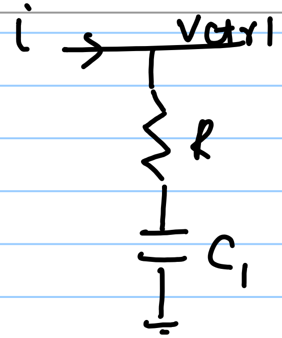
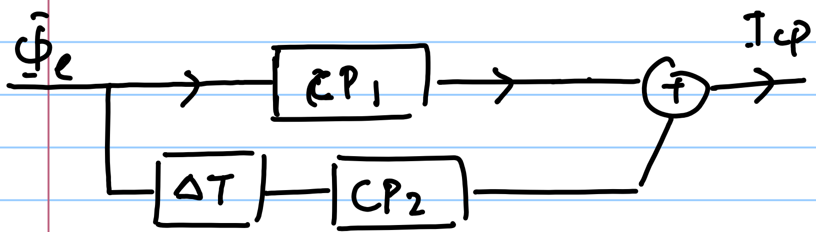
Lecture # 40



$$\frac{V_{ctrl}}{I} = \left(R + 1/sC_1\right)$$



$$\frac{I_{cp}}{\Phi_e} = I_{cp1} + I_{cp2}\, e^{-s.\Delta T}$$

$$= I_{cp1}\left(1 + \frac{I_{cp2}}{I_{cp1}}\, e^{-s\Delta T}\right)$$

$$e^{-s\Delta T} = 1 - s\Delta T + \frac{(s\Delta T)^2}{2!} + - \quad .$$

$$= I_{cp1}\left(1 + (-\alpha)(1 - s.\Delta T)\right)$$

$$|s\Delta T| \ll 1$$

$$|2\pi f_{ref} . \Delta T| \ll 1$$

$$= I_{cp1}\left((1+(\alpha)) + \alpha . s\, \Delta T\right)$$

$$\frac{I_{cp2}}{I_{cp1}} = -\alpha \qquad \Delta T \ll \frac{1}{2\pi f_{ref}} .$$

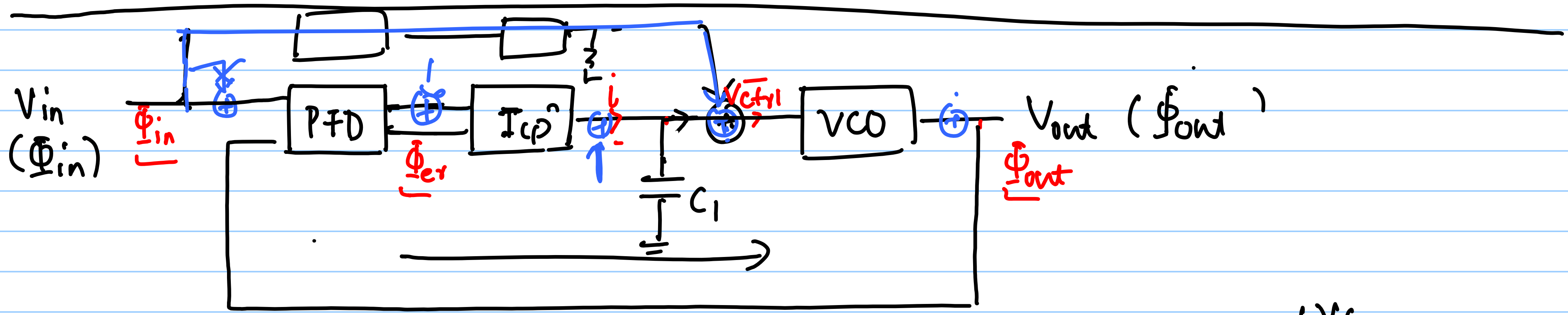
$$= I_{cp1}\left((1-\alpha) + \alpha . s\, \Delta T\right)$$

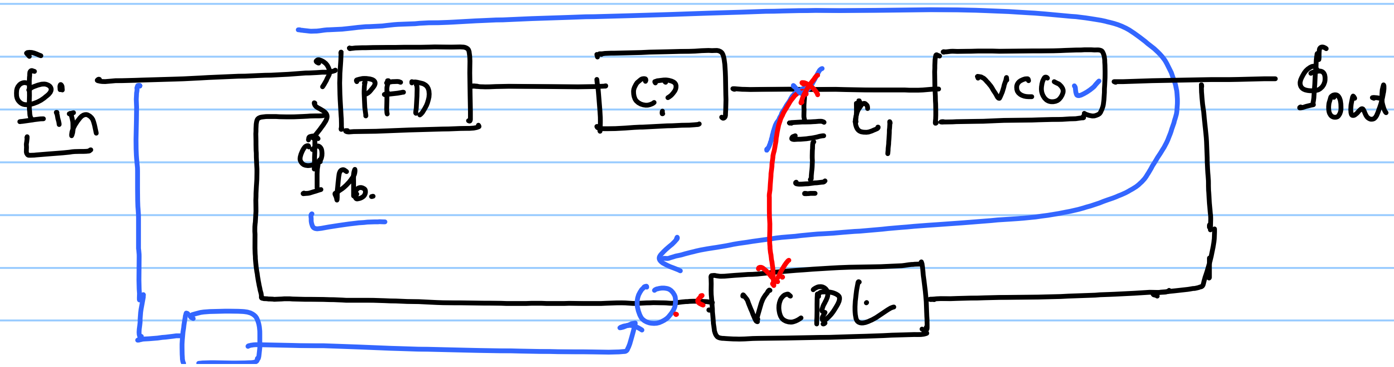
$$\frac{I_{cp}}{\Phi_e} = I_{cp1}(1-\alpha)\left(1 + s \cdot \frac{\alpha \cdot \Delta T}{1-\alpha}\right)$$

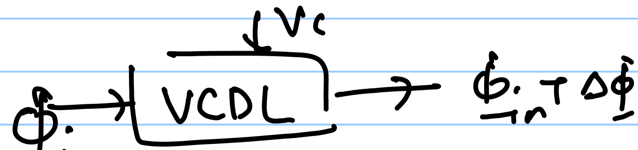
$$(1 + s/\omega_z$$

$$\omega_z = \frac{1-\alpha}{\alpha(\Delta T)} = 2\pi f_z$$

$f_{ref} = 40$ MHz, $bw = 4$ MHz, $f_z = 400$ kHz







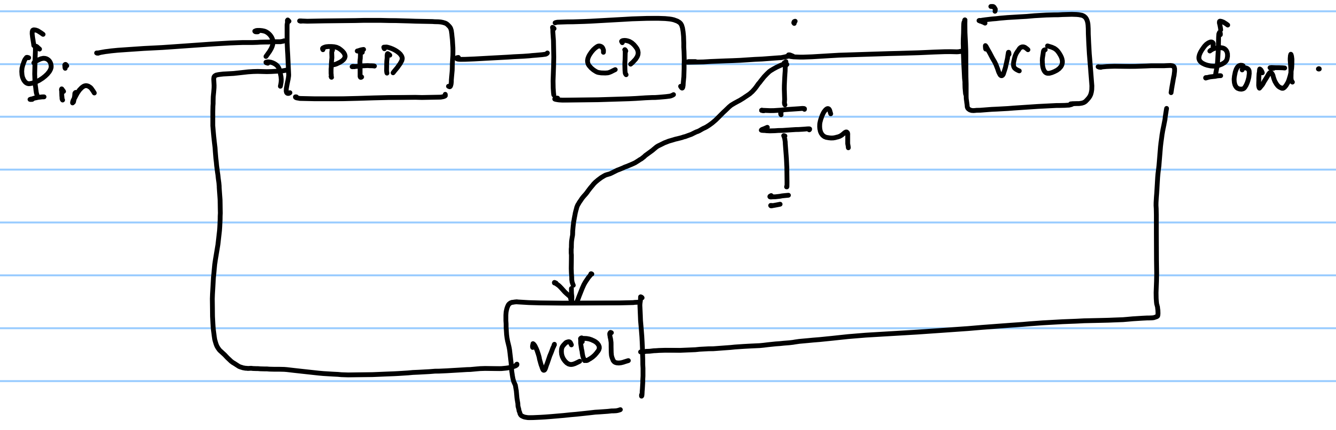
Voltage controlled Delay line.

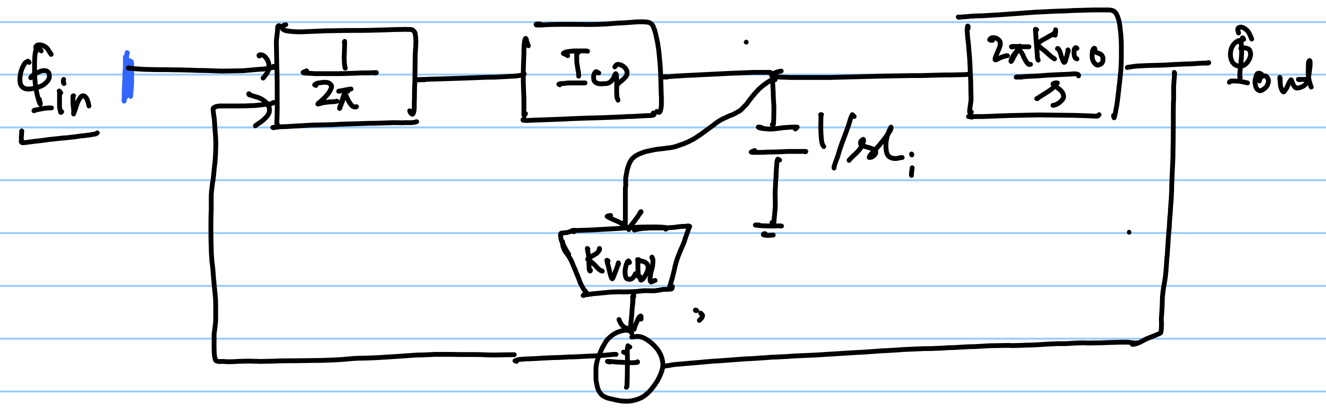
$$LG = \frac{I_{cp}}{2\pi}\left(R + \frac{1}{sC_1}\right)\frac{2\pi K_{VCO}}{s} = \frac{I_{cp}}{2\pi s C_1}(1 + sC_1R)\frac{2\pi K_{VCO}}{s}$$

$$= \frac{I_{cp}}{2\pi} \cdot \frac{1}{sC_1} \cdot \frac{2\pi K_{VCO}}{s} + \frac{\frac{I_{cp}}{2\pi} R \cdot \frac{2\pi K_{VCO}}{s}}{\quad}$$

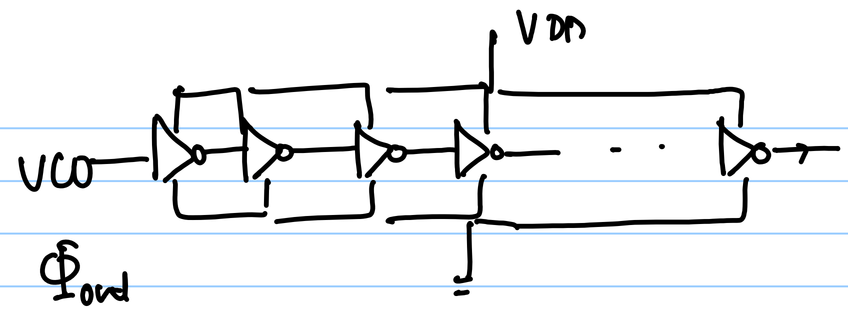
$$= \quad + \frac{1}{(1+s/\omega_p)}$$

$$\frac{\gamma}{s^2} + \frac{\beta}{s}$$





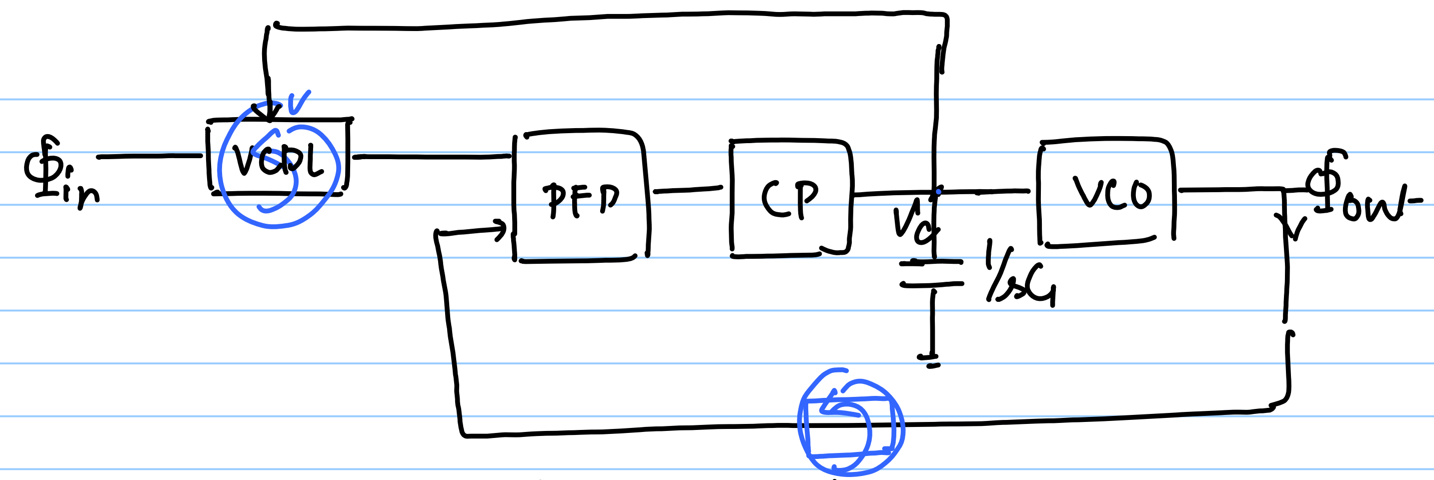
$$LG = \frac{1}{2\pi}\frac{I_{cp}}{sC_1}\left[\frac{2\pi K_{VCO}}{s} + K_{VCDL}\right] = \frac{I_{cp}}{s^2 C_1} K_{VCO}\left[1 + s\frac{K_{VCDL}}{2\pi K_{VCO}}\right]$$

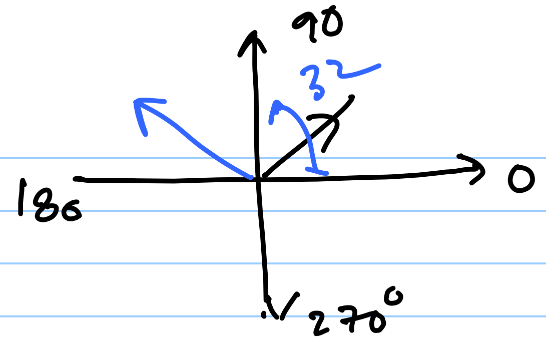


$\Phi_{vco} + \Phi_{offset} + K_{VCDL} \times V_{DD}$

Earlier $\dfrac{\Phi_{out}}{\Phi_{in}} = \dfrac{LG}{1+LG}$ ✓

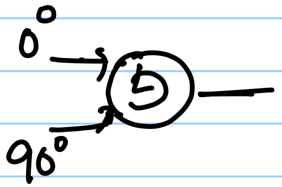
$$\frac{\Phi_{out}}{\Phi_{in}} = \frac{\dfrac{I_{cp}}{2\pi s C_1} \times \dfrac{2\pi K_{VCO}}{s}}{1 + LG} = \frac{\dfrac{I_{cp} K_{VCO}}{s^2 C_1}}{1 + \dfrac{I_{cp} K_{VCO}}{s^2 C_1}\left(1 + \dfrac{s K_{VCDL}}{2\pi K_{VCO}}\right)}$$



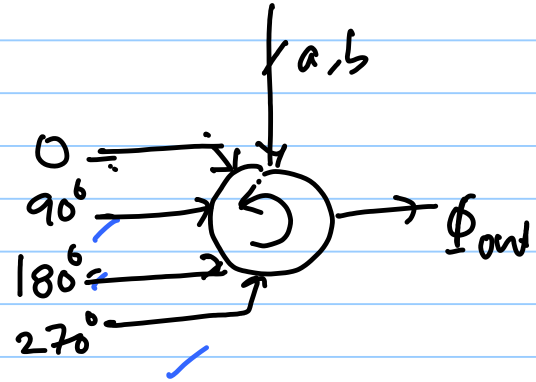


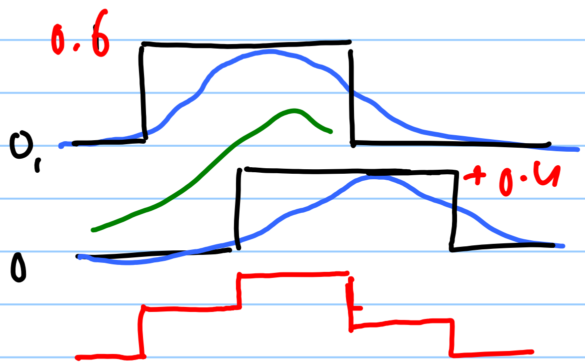
VCDL : Voltage Controlled Delay Line

PI : Phase interpolator.



$0 < \Phi < 90°$





$\Phi_0 = \tan^{-1}\left(\frac{b}{a}\right)$

$$\cdot\ y(t) = a\sin(\omega t) + b\cos(\omega t)$$

$$= \sqrt{a^2+b^2}\left(\frac{a}{\sqrt{a^2+b^2}}\sin(\omega t) + \frac{b}{\sqrt{b^2+a^2}}\right)$$

$$= \sqrt{a^2+b^2}\ \sin(\omega t + \Phi_0)$$