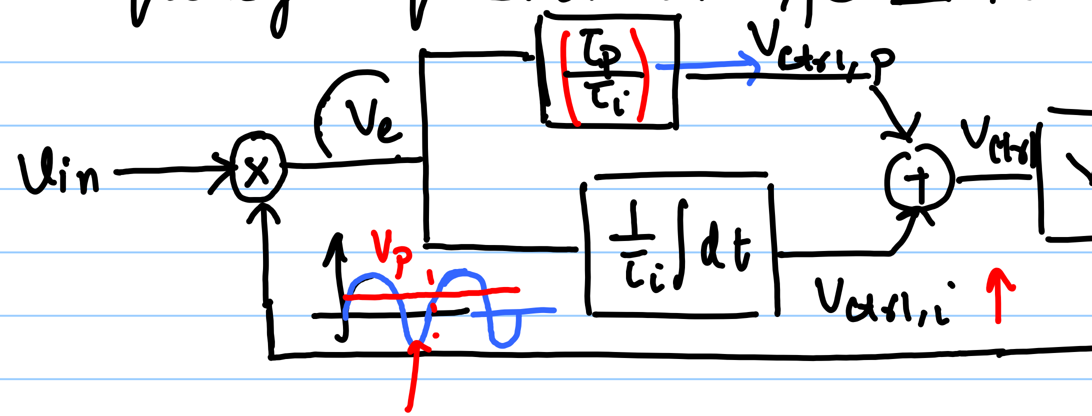
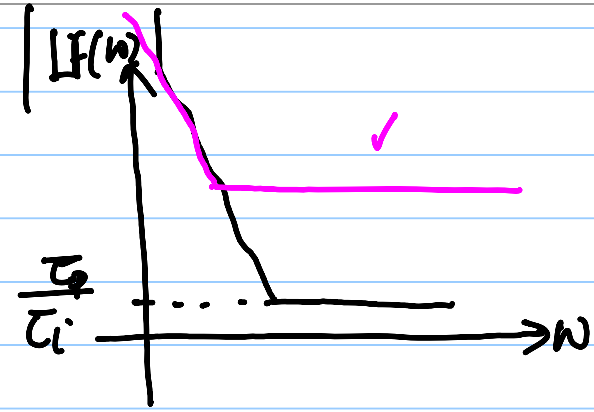
Lecture # 9

Frequency Acquistion in Type-II PLL

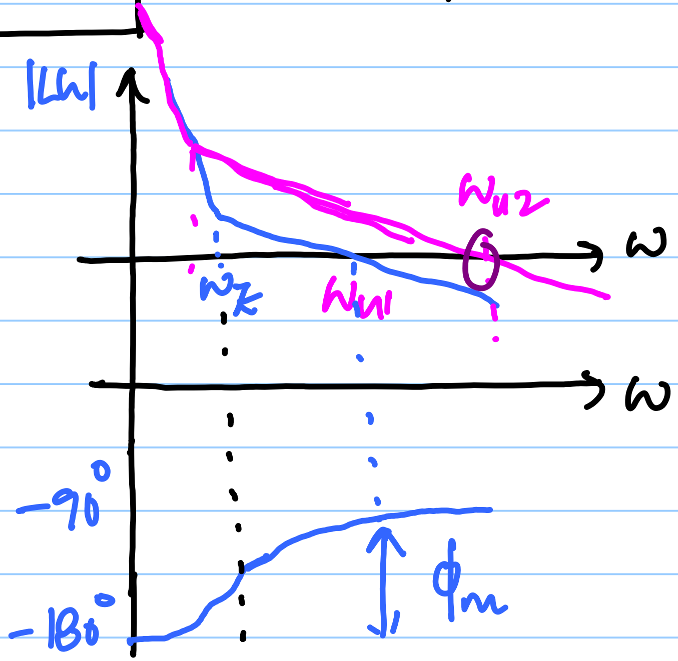




$$LF(s) = \frac{\tau_p}{\tau_i} + \frac{1}{\tau_i}\frac{1}{s} = \frac{1+s\tau_p}{s\tau_i}$$

$$LG(s) = K_{PD}\left(\frac{1+s\tau_p}{s\tau_i}\right)\frac{K_{VCO}}{s}$$

$\frac{\tau_p}{\tau_i} \gg \frac{1}{\tau_i}$ | $\omega_z = \frac{1}{\tau_p}$



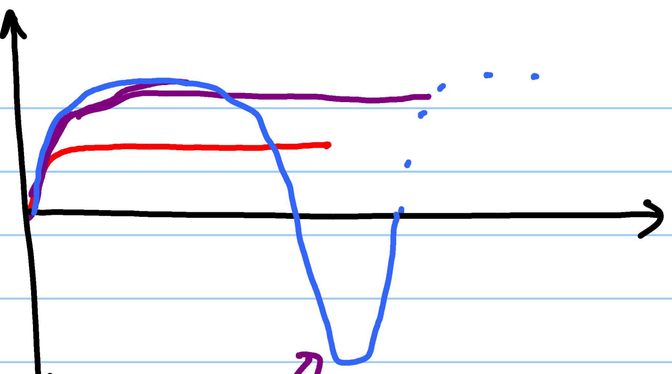
Lock-in range ($\Delta\omega_L$):

$$\frac{d\phi_{er}}{dt} = 0 \rightarrow \Delta\omega(0) - K_{PD}K_{VCO}\sin(\phi_e) = 0$$

$\times(\quad)$

$$|\Delta\omega_L| \leq K_{PD}K_{VCO}\frac{\tau_p}{\tau_i} \quad \text{or} \quad |\Delta\omega_L| \leq K_{PD}K_{VCO}\,LF(\infty)$$

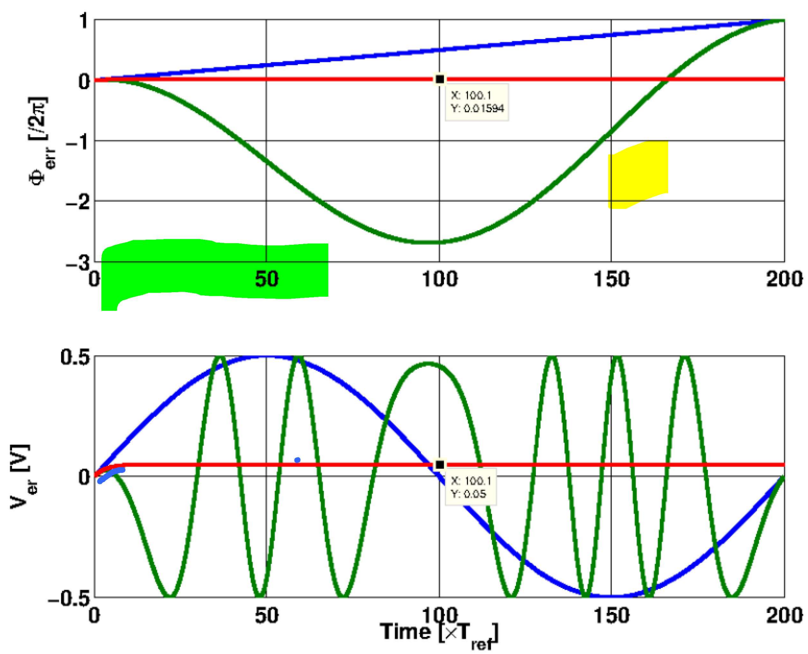
$$V_{ctrl} = \frac{\tau_p}{\tau_i} v_e + \frac{1}{\tau_i} \int v_e \, dt$$

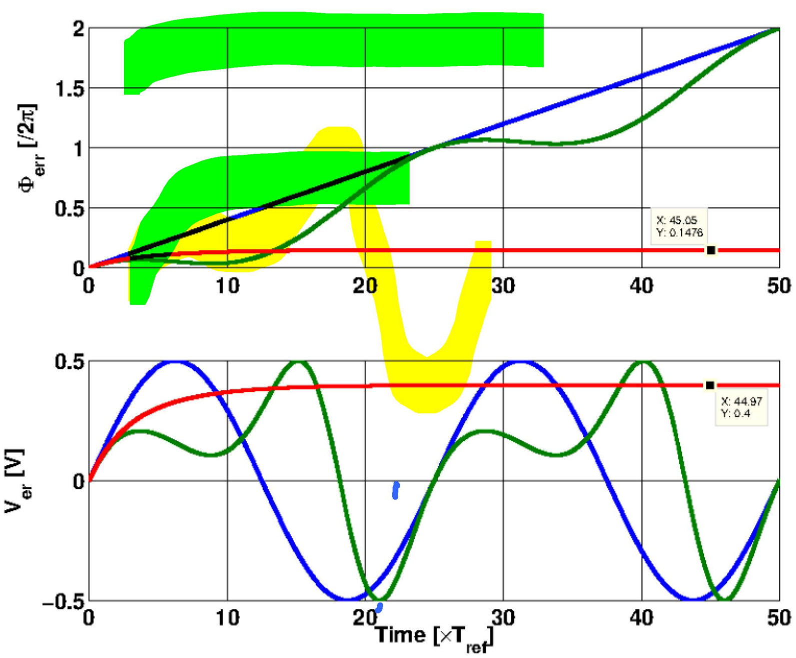


$$v_e = K_{PD} \sin(\phi_e)$$

$$\phi_{er} = \omega_{in} t - \omega_{free} \cdot t - K_{VCO} \int \left(\frac{\tau_p}{\tau_i} v_e + \left(\frac{1}{\tau_i} \int v_e \, dt \right) \right) . dt$$

$$\frac{d\phi_{er}}{dt} = (\omega_{in} - \omega_{free}) - K_{VCO} \frac{\tau_p}{\tau_i} v_e - \frac{K_{VCO}}{\tau_i} \int v_e \, dt = 0$$





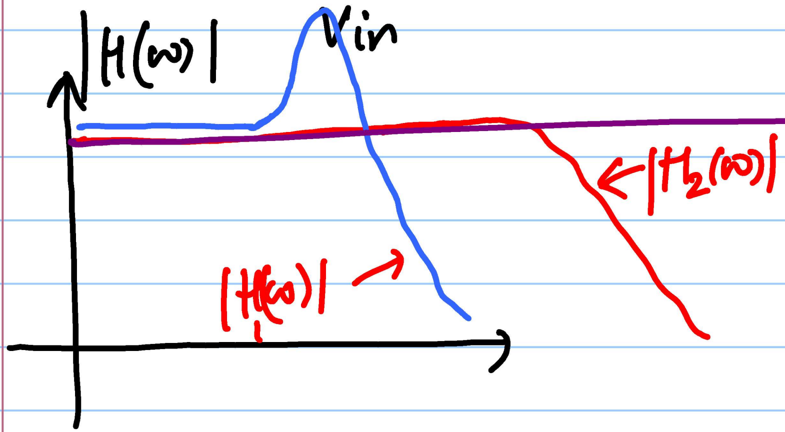
$$\frac{d\phi_{er}}{dt} = \Delta\omega(0) - \underbrace{\frac{\tau_p}{\tau_i} K_{PD} K_{VCO} \sin(\phi_{er})}_{} - \underbrace{\frac{1}{\tau_i} K_{PD} K_{VCO} \int \sin(\phi_{er}) \cdot dt}_{=0}$$

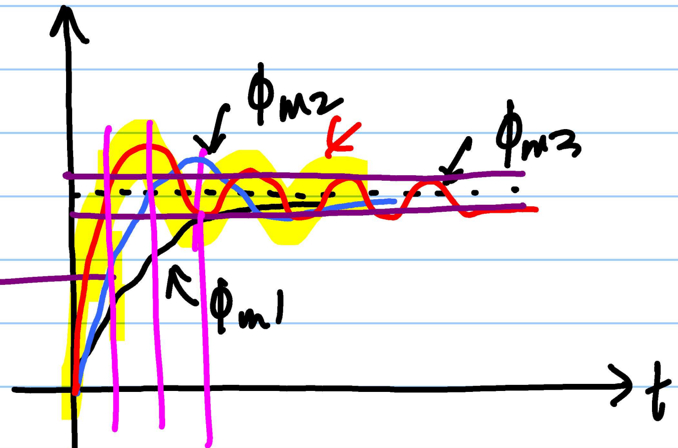
$=0$

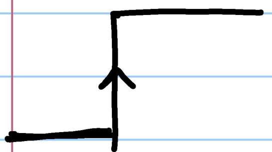
$$\frac{d\phi_{er}}{dt} = 0$$

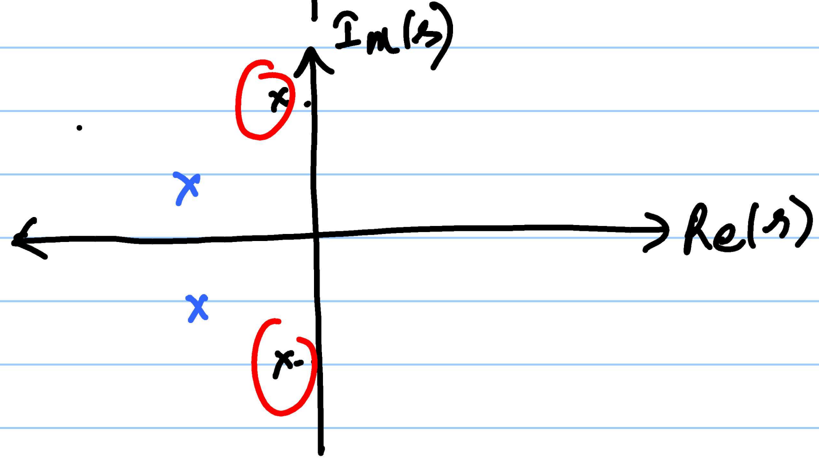
$\phi_{m1} > \phi_{m2} > \phi_{m3}.$

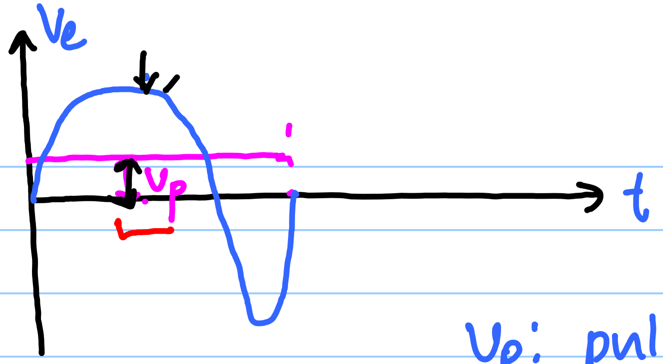
$$H(s) = \frac{V_{out}}{V_{in}}$$

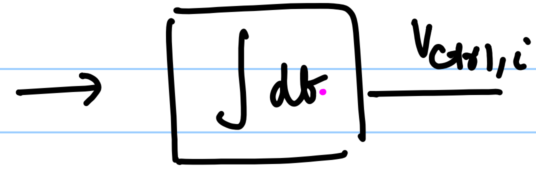


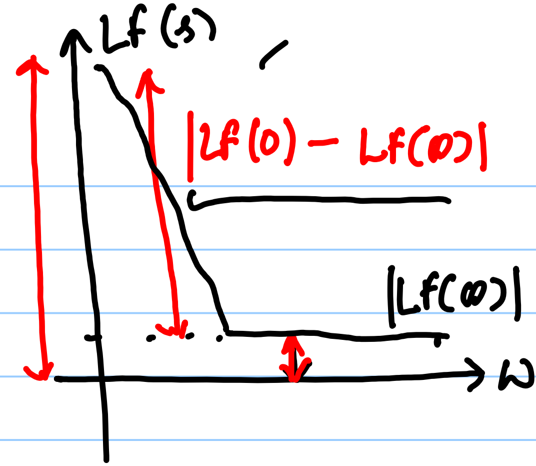












V_p: pull in voltage.

✓ $\Omega_{out} = \omega_{free} + K_{vco} \cdot V_{ctrl,i}$

$\Delta\Omega = \omega_{in} - \Omega_{out}$

$= \Delta\omega(0) - K_{vco} V_{ctrl,i}$

$= \Delta\omega(0) - K_{vco} \cdot (Lf(0) - Lf(\infty))\, V_p$

$$\tilde{\Delta\Omega} = \Delta\omega(0) - [K_{dc} - K]\left[\frac{\Delta\Omega}{K} - \sqrt{\left(\frac{\Delta\Omega}{K}\right)^2 - 1}\right]$$

$$V_p = K_{PD}\left[\frac{\Delta\Omega}{K} - \sqrt{\left(\frac{\Delta\Omega}{K}\right)^2 - 1}\right]$$

$K = K_{vco} K_{PD} Lf(\infty)$ ✓

$K_{dc} = K_{vco} \cdot K_{pd}\, Lf(0)$

if $\Delta\Omega$ real value:

$\Delta\Omega$ complex:

for complex roots: $\underline{\Delta\omega(0)} < K \sqrt{\left(\frac{2K_{dc}}{K} - 1\right)}$

Pull-in range $\Delta\omega_p < K \sqrt{\frac{2K_{DC}}{K} - 1} \approx \sqrt{2K_{DC} \cdot K} = \sqrt{2LF(0)\,LF(\infty)}$

$\times\ K_{PD} K_{VCO}$