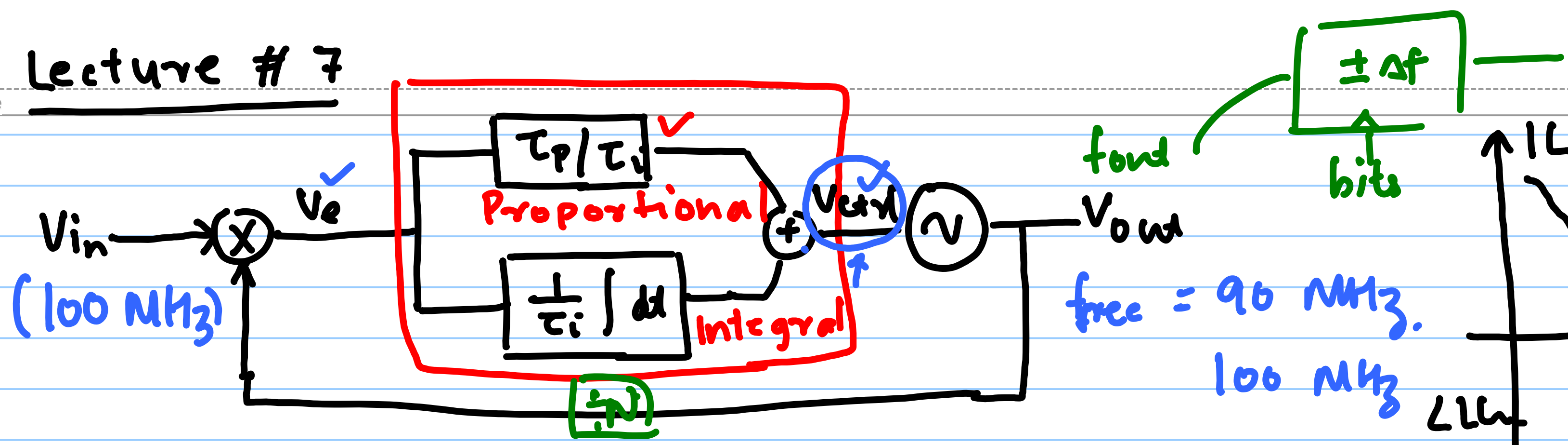
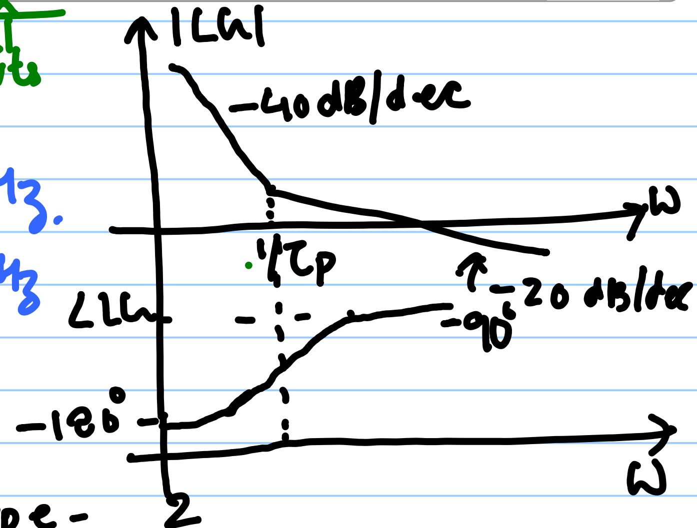
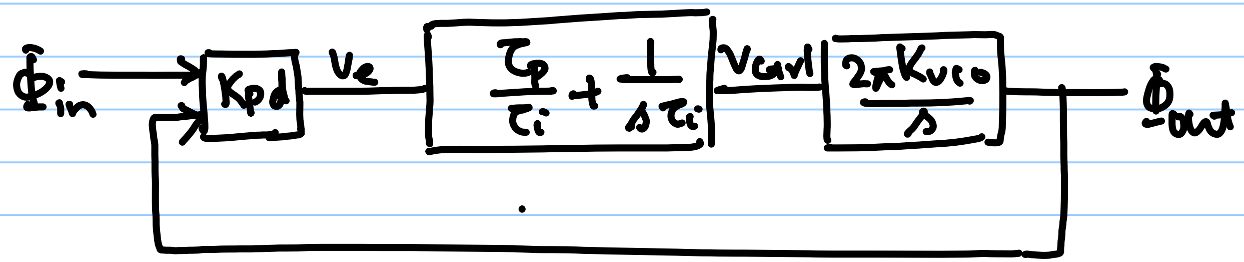
Lecture # 7







Type - 2

Order - 2

$$LG(s) = K_{pd}\left(\frac{\tau_p}{\tau_i} + \frac{1}{s\tau_i}\right)\frac{2\pi K_{vco}}{s} = \frac{\overbrace{2\pi K_{pd} K_{vco}}^{K}}{\tau_i\, s^2}\,(1 + s\tau_p)$$

$$\frac{\Phi_{out}(s)}{\Phi_{in}(s)} = \frac{LG}{1+LG} \; ; \quad \frac{\Phi_{err}}{\Phi_{in}} = \frac{\Phi_{in} - \Phi_{out}}{\Phi_{in}} = \frac{1}{1+LG}$$

$$\frac{\Phi_{err}}{\Phi_{in}} = \frac{1}{1+LG} = \frac{1}{1+\frac{K}{\tau_i \cancel{s}}\,s^2\left(\frac{1}{s}+\tau_p\right)} \qquad \frac{K}{\tau_i}\left(1+s\tau_p\right)$$

$$1 \qquad s\tau_p$$

at $t=0$; $\quad \Phi_{in} = \Delta\Phi_{in}(0)\,u(t)$

$$\lim_{t\to 0} \Phi_{err}(t) = \lim_{s\to 0} s \cdot \frac{1}{s} \times \Delta\Phi_{in}(0) \times \frac{1}{1+LG} = 0$$

at $t=0$; $\quad f_{in} = \Delta f_{in}(0)\,u(t) \Rightarrow \Phi_{in} = \Delta f_{in}(0) \times t\, u(t)$

$$\lim_{t\to 0} \Phi_{err}(t) = \lim_{s\to 0} \cancel{s} \cdot \frac{1}{s^{\cancel{2}}} \Delta f_{in}(0) \times \frac{1}{1+LG} = 0$$

at $t=0$, $\quad f_{in} = \Delta f_{in}'(0) \cdot t\, u(t) \Rightarrow \Phi_{in} = \frac{\Delta f_{in}(0)}{2} t^2 u(t)$

$$\lim_{t\to 0} \Phi_{err}(t) = \lim_{S\to 0} \cancel{s} \cdot \frac{1}{s^{\cancel{3}\,2}} \frac{\Delta f_{in}(0)}{2} \frac{1}{1+LG} = \frac{\Delta f_{in}(0)}{2} \frac{1}{K/\tau_i}$$

1) Hold in range ($\Delta\omega_H$): Range of frequencies the PLL can hold the lock.

2) Lock-in range ($\Delta\omega_L$): Range of frequencies the PLL can acquire lock without cycle slipping (w/o Φ_e exceeding 2π)

3) Pull-in range ($\Delta\omega_p$): Range of frequencies the PLL can acquire lock w/ or w/o cycle slipping.

Type II, Order 2

$$\boxed{\Delta\omega_H \geqslant \Delta\omega_p \geqslant \Delta\omega_L}$$

at $t=0$: $f_{in} = 100\,MHz$, $f_{out} = 90\,MHz$, $V_e = 0$, $V_{ctrl,prop} = 0$

$V_{ctrl,int} = 0$

if $\lim_{t\to\infty} V_{ctrl,int}(t) = \dfrac{10\,MHz}{K_{vco}}$ $\Delta\omega_p$, $\Delta\omega_L$

if $V_{ctrl,int}(0) = \dfrac{10\,MHz}{K_{vco}}$ $\Delta\omega_H$

$$\Phi_{in} = (\omega_{in} - \omega_{out})\,t = \Delta\omega \cdot t$$

Type. I, Order-II

$$\Delta\omega_H = K$$

$$\Delta\omega_p = K$$

$$\Delta\omega_L = K$$

$$\frac{\Delta\omega}{\underbrace{2\pi K_{vco}\cdot K_{pd}}_{K}} = \sin(\Phi_e) \leq 1$$

Type-II, Order-II

$$V_{out} = A\cos\left[\omega_{free}t + 2\pi K_{vco}\cdot\left(\int\left\{\underline{\frac{\tau_p}{\tau_i}}V_e + \underline{\int_0^t\frac{1}{\tau_i}V_e\,dx}\right\}dt\right)\right]$$

$$V_{in} = A\sin(\omega_{in}t)$$

$$\Phi_{err} = \omega_{in}t - \omega_{out}t$$

$$= \Delta\omega.t - \frac{2\pi K_{vco}}{\tau_i}\left[\int\left(\tau_p V_e + \int_0^t V_e\,dx\right)dt\right]$$

$$\frac{d\dot{\Phi}_{err}}{dt} = 0$$

$$\frac{d\dot{\Phi}_{err}}{dt} = \Delta\omega - \frac{2\pi K_{vco}}{\tau_i} \times \left[\tau_p v_e + \int_0^t v_e \, dx \right]$$

$$= \Delta\omega - \frac{2\pi K_{vco} K_{pd}}{\tau_i} \left[\tau_p \sin(\Phi_e) + \underbrace{\int_0^t \sin(\Phi_e) \, dx} \right]$$

$$= \Delta\omega - \frac{2\pi K_{vco} K_{pd} \tau_p}{\tau_i} \sin(\Phi_e)$$

$$\Delta\omega_L \leq \frac{2\pi K_{vco} K_{pd} \tau_p}{\tau_i}$$