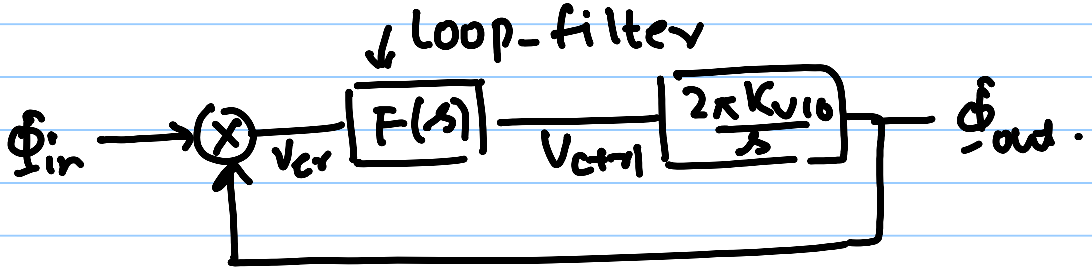
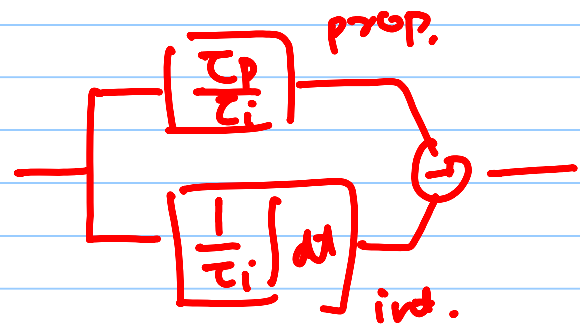
Note Title 17-08-2017

Lecture #11

Frequency acq. in Type-II PLL



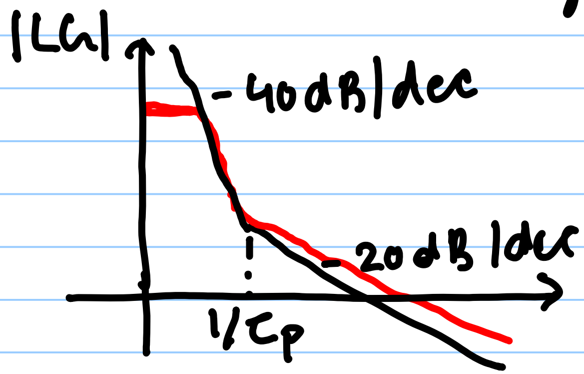


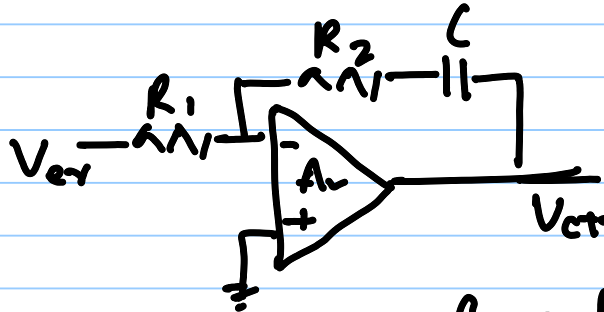
Type-II Order-2.

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

$F(0) = \infty$, $F(\infty) = \frac{\tau_p}{\tau_i}$

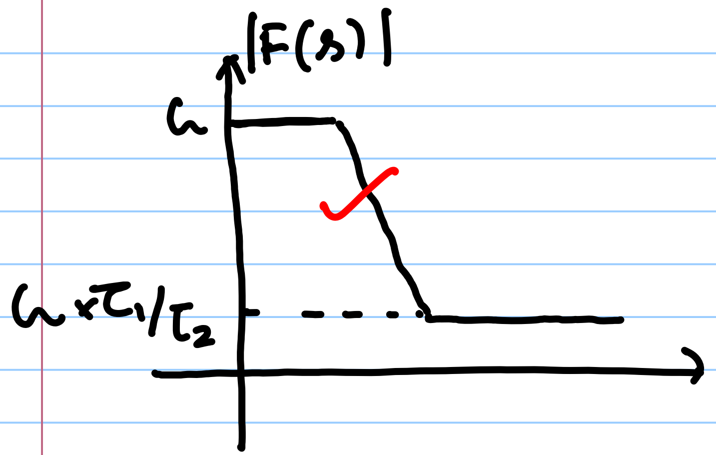
* Hold-in range $\Delta\omega_H = \infty$
* Pull-in range $\Delta\omega_p = \infty$
* Lock-in range $\Delta\omega_L = 2\pi K_{vco} \cdot K_{pd} \frac{\tau_p}{\tau_i}$





$$F(s) = \frac{V_{ctrl}}{V_{er}} = \frac{(1+s\tau_1)}{(1+s\tau_2)} \times G$$

$G = f(A)$



$$F(s) = G\,\frac{(1+s\tau_1)}{(1+s\tau_2)}$$

$$LG(s) = K_{pd}\,\frac{G(1+s\tau_1)}{(1+s\tau_2)}\,\frac{2\pi K_{vco}}{s}$$

$$F(\infty) = G \times \frac{\tau_1}{\tau_2}$$ (Proportional path gain)

$F(0)$ = prop. path gain at DC + int. path gain at DC.

Integral path gain at DC $\approx F(0) - F(\infty)$

Hold-in range for above PLL, $\Delta\omega_H =$

$$\Delta\omega_H = 2\pi K_{vco}.V_{ctrl} = 2\pi K_{vco} F(0).V_{er}$$
$$= 2\pi K_{vco}.F(0)\,K_{pd}\sin(\phi_e)$$

$$\boxed{\frac{\Delta\omega_H}{2\pi K_{vco} \cdot K_{pd}\, F(0)} \leq 1}$$

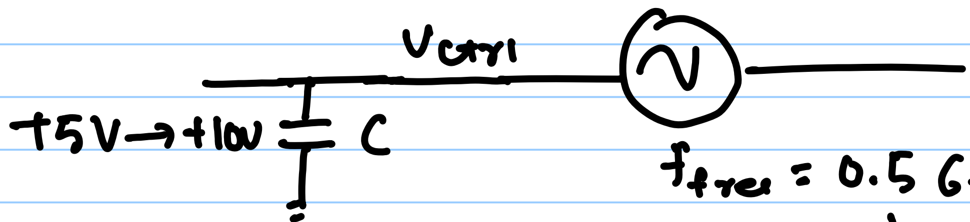
$f_c = 1.6\,GHz$

Ex. $\omega_{in} = 1\,GHz$. $\omega_{free} = 0.5 \rightarrow 1.5\,GHz$.

$K_{vco} = 100\,MHz/V$, $V_{ctrl} = -5 \rightarrow +5V$.

$+10V$

$\omega_{in} = 2GHz$, $\omega_{free} = 0.5\,GHz$



$f_{free} = 0.5\,GHz \xrightarrow{\text{Using loop}} f_{max} = 1.5\,GHz$

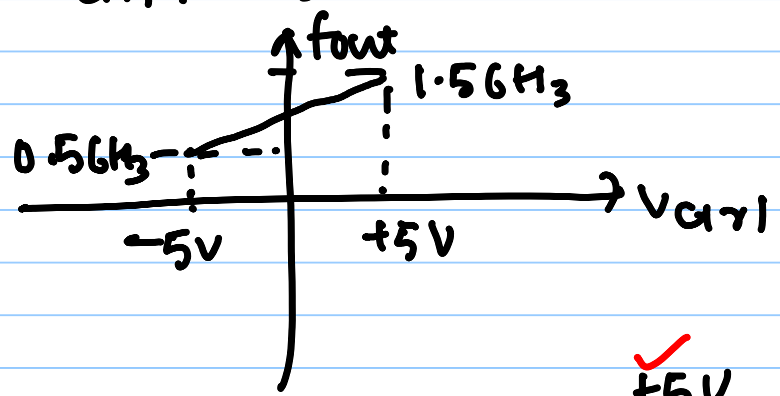
$\downarrow$

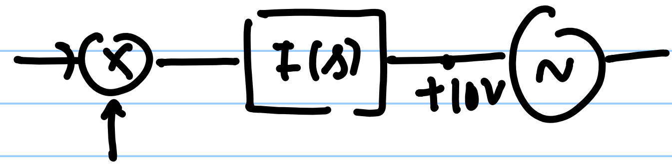
$2.0\,GHz$

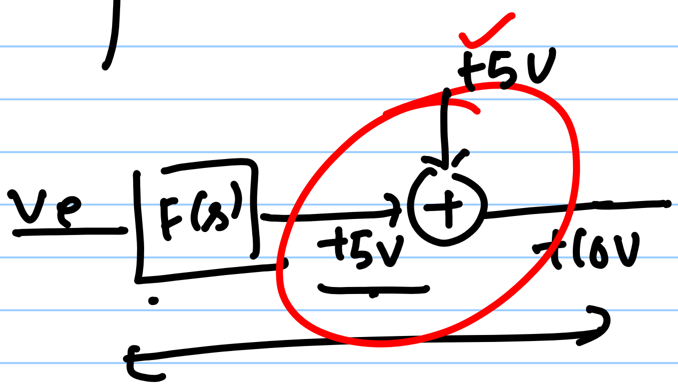
$f_{osc} = 1.0\,GHz + 100\,MHz \cdot V_{ctrl}$.

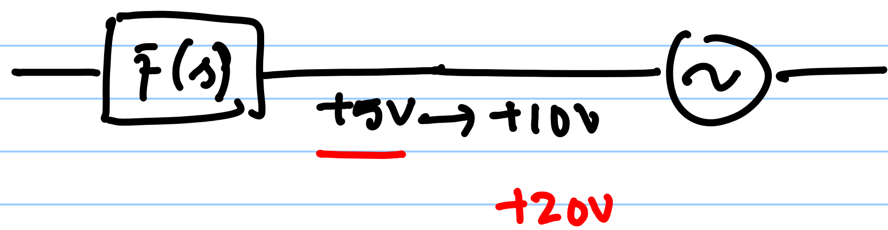
f_{out} : $0.5\,GHz$ — $1.5\,GHz$.
V_{ctrl} : $-5V$ — $+5V$

$$\left.\begin{array}{l} f_{out}: 0.5\,GHz - 1.5\,GHz \\ V_{ctrl}: -5V - +5V \end{array}\right\} \quad K_{VCO} = \frac{1.0\,GHz}{10\,V} = 100\,MHz/V.$$









Pull-in range of PLL

$$\omega_{out} = \omega_{free} + 2\pi K_{vco} V_{ctrl}$$

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

$$= \underbrace{\Delta\omega}_{\text{freq. error at } t=0} - 2\pi K_{vco} \cdot V_{ctrl} \checkmark$$

in steady state,

$$\Delta\Omega = \Delta\omega - 2\pi K_{vco} \cdot (\underbrace{F(0) - F(\infty)}_{\text{int. path gain}}) V_{er}$$

$$= \Delta\omega - 2\pi K_{vco} (F(0) - F(\infty)) K_{pd} \left(\frac{\Delta\Omega}{K} - \underbrace{\sqrt{\left(\frac{\Delta\Omega}{K}\right)^2 - 1}}\right)$$

In steady state, $\overline{V_{er}} = K_{pd} \underline{\left(\frac{\Delta\Omega}{K} - \sqrt{\left(\frac{\Delta\Omega}{K}\right)^2 - 1}\right)}$,

$\Delta\Omega$: freq. err

$K = 2\pi K_{vco} \cdot K_{pd} F(\infty)$ ✓

$\Delta\Omega > K$

$$\underline{\Delta\Omega} = \Delta\omega - \underbrace{2\pi K_{vco} \cdot K_{pd}}\left(\underset{\sim}{F(0)} - F(\infty)\right)\left(\frac{\Delta\Omega}{K} - \sqrt{\left(\frac{\Delta\Omega}{K}\right)^2 - 1}\right)$$

$$= \Delta\omega - \left(K_{DC} - K\right)\left(\frac{\Delta\Omega}{K} - \sqrt{\left(\frac{\Delta\Omega}{K}\right)^2 - 1}\right)$$

$\Delta\omega \geq K\sqrt{\frac{2K_{DC}}{K} - 1} \Rightarrow \Delta\Omega$ have real roots.

$\Delta\omega < K\sqrt{\frac{2K_{DC}}{K} - 1} \Rightarrow \Delta\Omega$ complex roots.

Pull-in range $\Delta\omega_{pull\text{-}in} \leq K\sqrt{\frac{2K_{DC}}{K} - 1} \approx \sqrt{2K_{DC}K}$.

$$\Delta\omega_{pull\text{-}in} = 2\pi K_{pd} K_{vco} \sqrt{2F(0)F(\infty)}$$

$$\Delta\omega_H = 2\pi K_{pd} K_{vco} \cdot F(0)$$