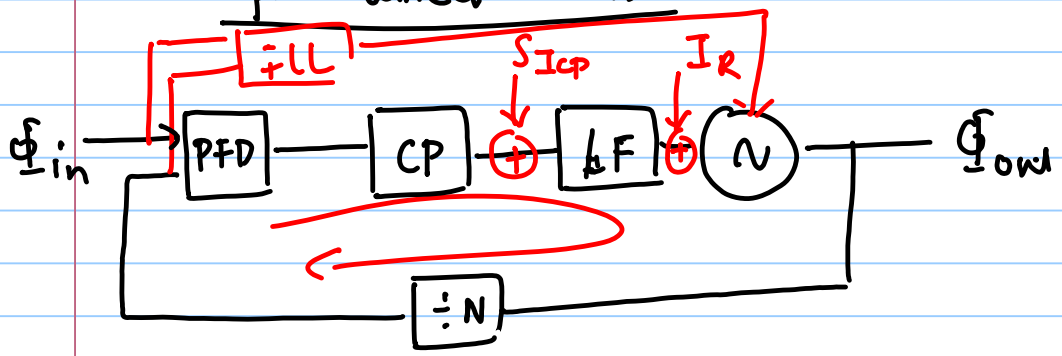
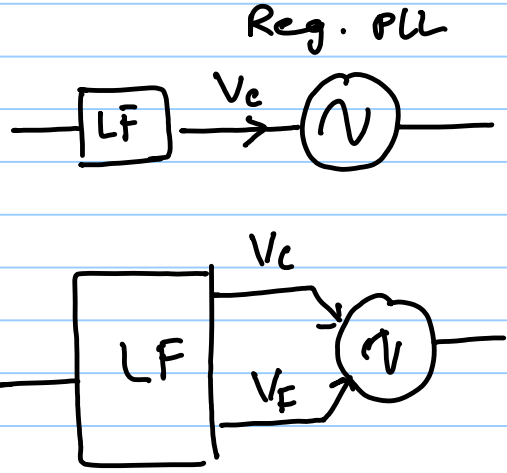
Note Title 29-10-2018

Lecture # 41

Split-tuned PLLs



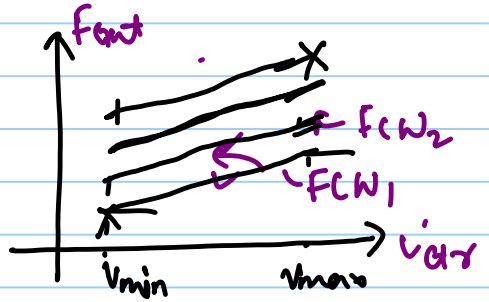


$$LG(s) = \frac{I_{cp}}{2\pi} F(s) \frac{K_{VCO}}{s}$$ ✓

Split-tuned PLL.

$$F(s) = \frac{1+sRC_1}{1+sRC_1\frac{C_2}{C_1+C_2}} \times \frac{1}{s(C_1+C_2)}$$

$$\frac{\Phi_{out}}{I_{cp,n}} = NTF = \frac{2\pi}{I_{cp}} \frac{M \cdot LG}{1+LG}$$



$$S_{Icp} \propto g_m \propto I_{cp}$$

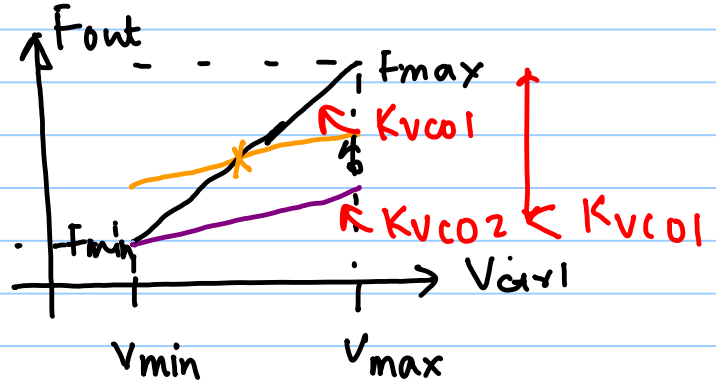
$$\Phi_{n,out} = |NTF|^2 S_{Icp} \propto \frac{1}{I_{cp}}$$

Large K_{VCO} → More R noise

→ low I_{CP} → CP noise

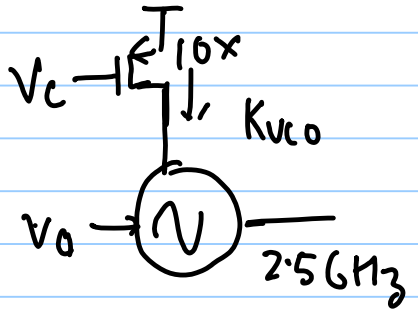
$$\Phi_{n,out,R} = |NTF|^2 S_R \propto K_{VCO}^2$$

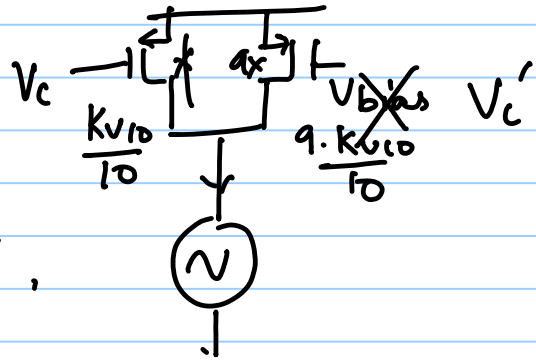
$$= \frac{(K_{VCO}/s)^2}{|1+LG|^2} \cdot S_R$$

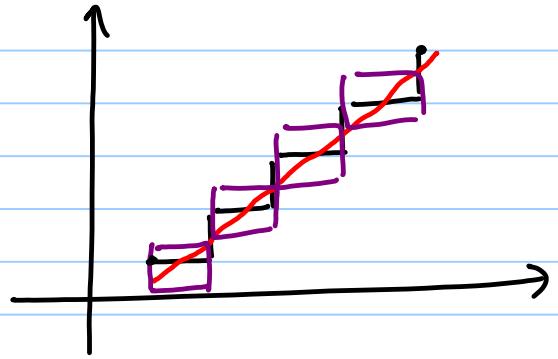


$$LG = \frac{I_{CP}}{2\pi} \frac{K_{VCO}}{s^2(C_1+C_2)} \frac{(1+sRC_1)}{\left(1+sR\frac{C_1C_2}{C_1+C_2}\right)}$$

Large K_{VCO} —×K→ $K \times K_{VCO}$ ⟨ I_{CP}/K → CP Noise↑ ; R noise increase.







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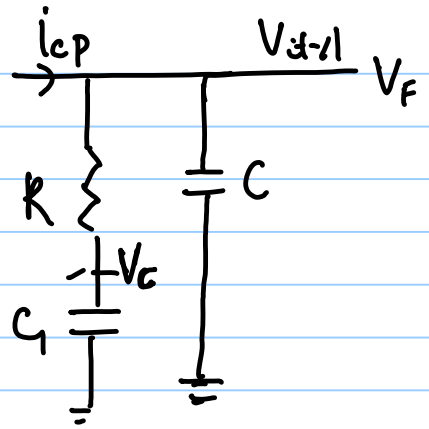
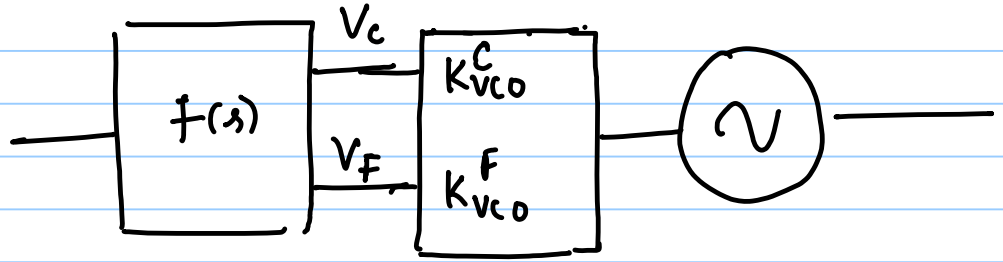


$$\frac{V_{ctrl}}{I_{CP}} = \frac{1}{s(C_1+C_2)} \cdot \frac{1+sRC_1}{1+sR\frac{C_1C_2}{C_1+C_2}} = \frac{V_F}{I_{CP}}$$

$$\frac{V_C}{I_{CP}} = \frac{1/sC_1}{\frac{1}{sC_1}+R}$$

$$= \frac{1}{1+sRC_1} \quad F(s)$$



$$L(s) = \frac{I_{CP}}{2\pi}\left[F(s)\,\frac{K_{VCO}^{F}}{s} + \frac{F(s)}{1+sRC_1}\,\frac{K_{VCO}^{C}}{s}\right]$$

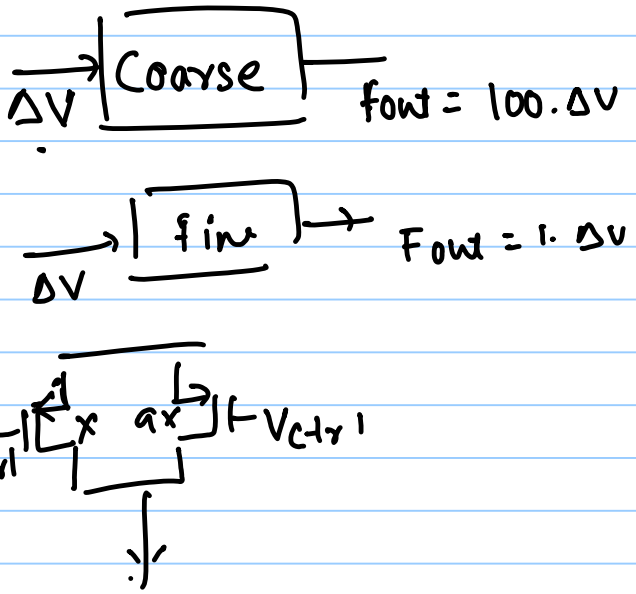
$$= \frac{I_{cp}}{2\pi} \frac{F(s)}{s} \left[\underbrace{\frac{K_{VCO}}{K}}_{\text{Fine}} + \underbrace{\frac{1}{1+sRC_1} \frac{(K-1)K_{VCO}}{K}}_{\checkmark\ \text{Coarse}} \right]$$

$$= \frac{I_{cp}}{2\pi} \frac{F(s)}{s} \frac{K_{VCO}}{K} \left[1 + \frac{K-1}{1+sRC_1} \right]$$

$$= \frac{I_{cp}}{2\pi} \frac{K_{VCO}}{K} \frac{K(1+sRC_1/K)}{1+sRC_1} \frac{F(s)}{s}$$

$$LG = \frac{KI_{cp}}{2\pi} \frac{K_{VCO}\ (1+sRC_1/K)}{s^2(KC_1+C_2)\left(1+\frac{sRKC_1C_2}{KC_1+C_2}\right)}$$

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



Fine VCO gain = K_{VCO}/K

Coarse " = $(K-1)K_{VCO}/K$

Cap. size = KC_1

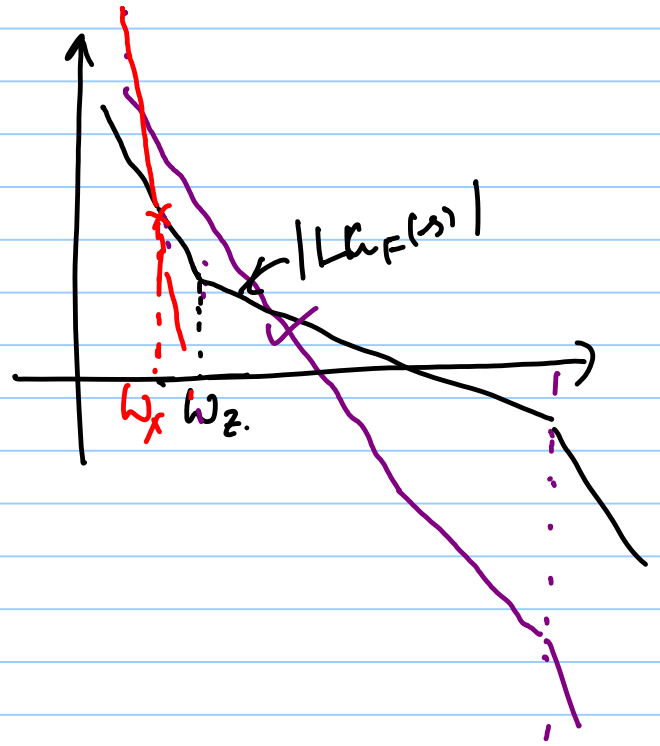
I_{cp} = $K.I_{cp}$.

LG constant

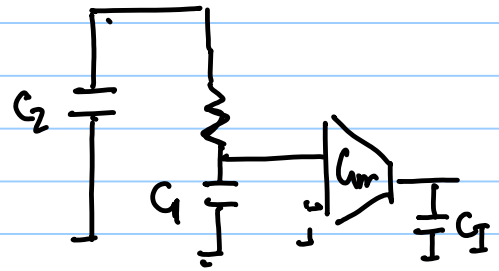
$$L(s) = \frac{K I_{cp}}{2\pi} F(s) \left[\frac{K_{VCO}}{K \cdot s} + \frac{(K-1)}{K} \frac{K_{VCO}}{s} \frac{1}{1+sRKC_1} \right] \frac{G_m}{sC_I}$$

$$F(s) = \frac{1+sRKC_1}{s(KC_1+C_2)\left(1+sR\frac{KC_1 \cdot C_2}{KC_1+C_2}\right)}$$

$$L_F(s) = \frac{K I_{cp}}{2\pi} \frac{1+sRKC_1}{s(KC_1+C_2)(1+s/\omega_{p3})} \frac{K_{VCO}}{K \cdot s}$$



$$L_c(s) =$$



$$LG = \frac{I_{cp}}{2\pi}\left[F(s)\frac{K_{VCO}}{K}\frac{1}{s} + F(s)\left(\frac{K-1}{K}\right)\frac{K_{VCO}}{s} \times \frac{1}{1+sRC_1} \times \frac{G_m}{sC_I}\right]$$

$$= \frac{I_{cp}}{2\pi} F(s) \frac{K_{VCO}}{K.s}\left[1 + \frac{(K-1)}{1+sRC_1}\frac{G_m}{sC_I}\right]$$

$$= \frac{I_{cp}}{2\pi} F(s) \frac{K_{VCO}}{K.s}\left[\frac{sC_I(1+sRC_1)+(K-1)G_m}{sC_I(1+sRC_1)}\right]$$