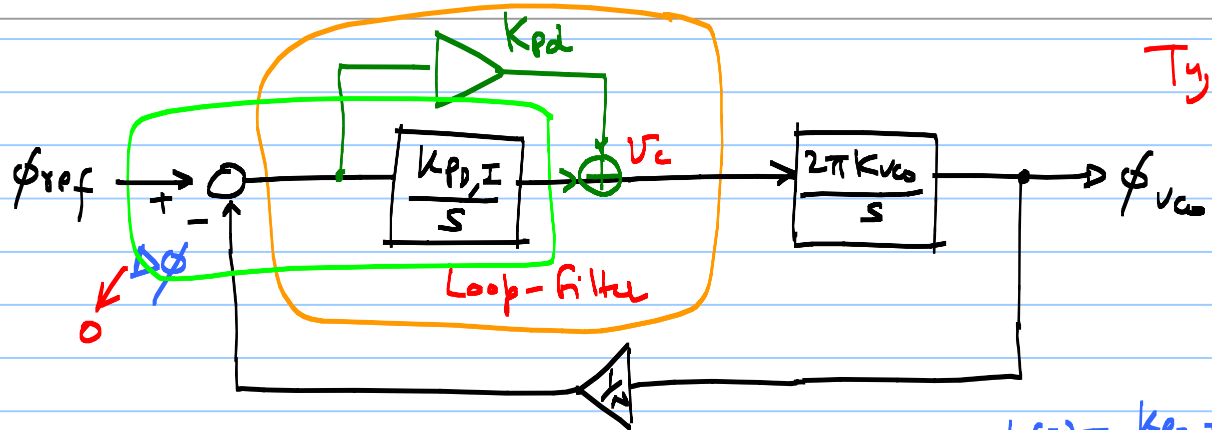
ECE 518 – Lecture 14

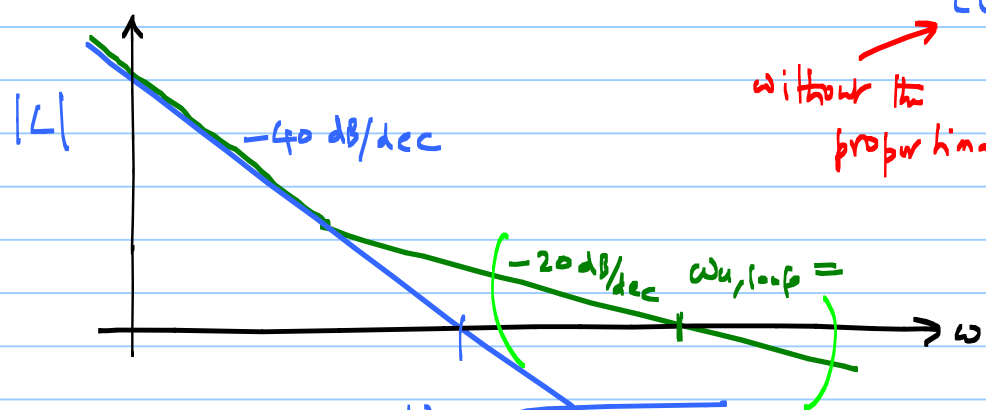
Note Title 3/7/2013



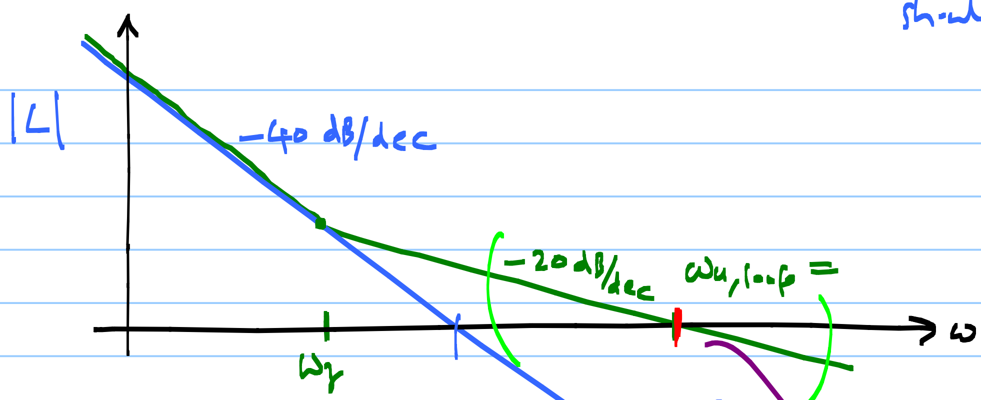
Type-II system

$$L(s) = \frac{2\pi K_{PD,I} \cdot K_{vco}}{s^2 N}$$

without the proportional path



$$\omega_u = \sqrt{\frac{2\pi K_{PD,I} K_{vco}}{N}}$$



$$\omega_u = \sqrt{\frac{2\pi K_{PD,I} K_{vco}}{N}}$$

$$\frac{2\pi K_{vco} \cdot K_{PD}}{N}$$

* around $\omega_{u,loop}$ the system should look like $-20\,dB/dec$

* 2 poles @ DC
* one zero earlier to $\omega_{u,loop}$

"Type-II system"

order ≠ Type

* with the proportional path

$$L(s) = \left[K_{PD} + \frac{K_{PD,I}}{s}\right] \cdot \frac{2\pi K_{vco}}{s} \cdot \frac{1}{N}$$

$$= \frac{2\pi K_{vco} K_{PD,I}}{N} \; \frac{\left(1 + \frac{s K_{PD}}{K_{PD,I}}\right)}{s^2}$$

$1 + \frac{s}{\omega_z}$

$\Rightarrow \omega_z = \frac{K_{PD,I}}{K_{PD}}$

@ LHP

$$= \frac{2\pi K_{VCO} \cdot K_{PD,I}}{N} \cdot \frac{\left(1+\frac{s}{\omega_z}\right)}{s^2}$$

$$1+\frac{s}{\omega_z} \simeq \frac{s}{\omega_z}$$

$$\sqrt{1+\left|\frac{\omega}{\omega_z}\right|^2} \simeq \frac{\omega}{\omega_z}$$

around $\omega = \omega_{u,loop}$

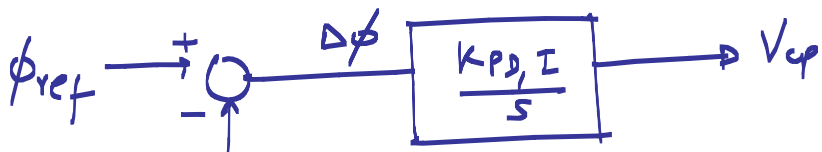
$$L(s) \simeq \frac{2\pi K_{VCO} K_{PD_I}}{N} \cdot \frac{\cancel{s}}{\left(\frac{K_{PD,I}}{K_{PD}}\right)} \cdot \frac{1}{s^{\cancel{2}}}$$

$$L(s) \simeq \frac{2\pi K_{VCO} \cdot K_{PD}}{N \quad \omega_z} \cdot \frac{1}{s}$$

$$\boxed{\omega_{u,loop} \simeq \frac{2\pi K_{VCO} \cdot K_{PD}}{N}}$$

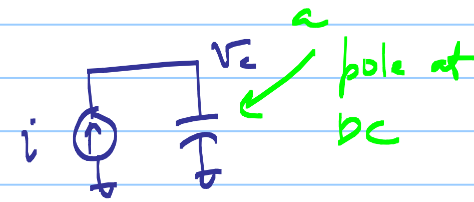
$$|L(s)| = \left| \frac{2\pi K_{VCO} K_{PD,I}}{N} \frac{\left(1 + \frac{s K_{PP}}{K_{PD,I}}\right)}{s^2} \right| = 1 \qquad s \to j\omega$$

$$\Rightarrow \quad \omega_{u,loop} = \frac{2\pi K_{VCO} \cdot K_{PD}}{N}$$



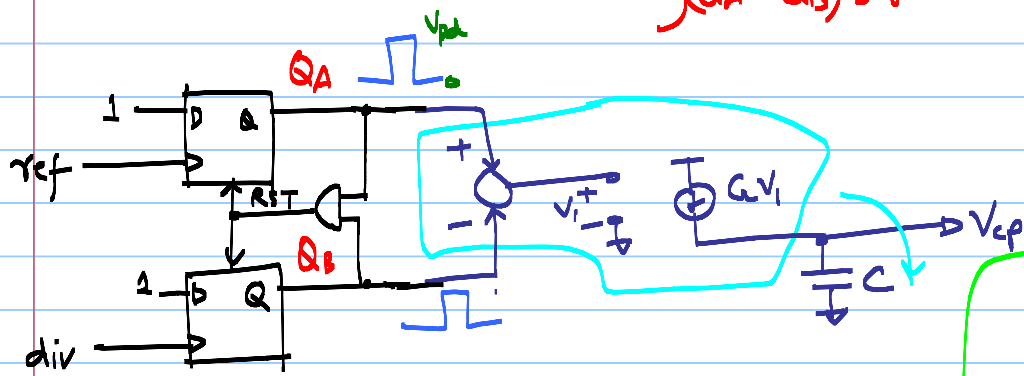
$$\phi_{fb} = \frac{\phi_{vco}}{N}$$

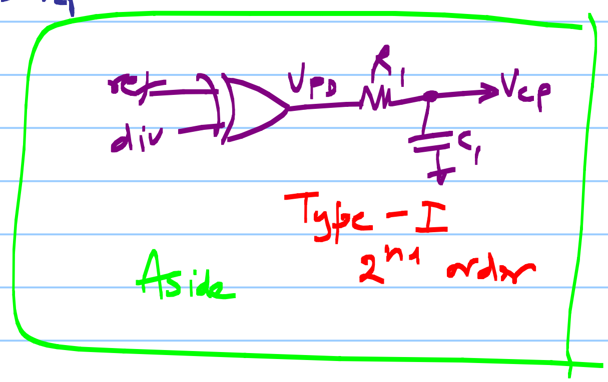
$$\int (Q_A - Q_B)\, dt$$

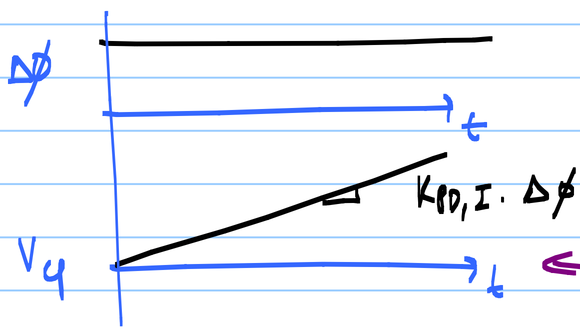


$$V_c = \frac{1}{C}\int i(t) \cdot dt$$

$$V_c(s) = \frac{1}{sC} I(s)$$

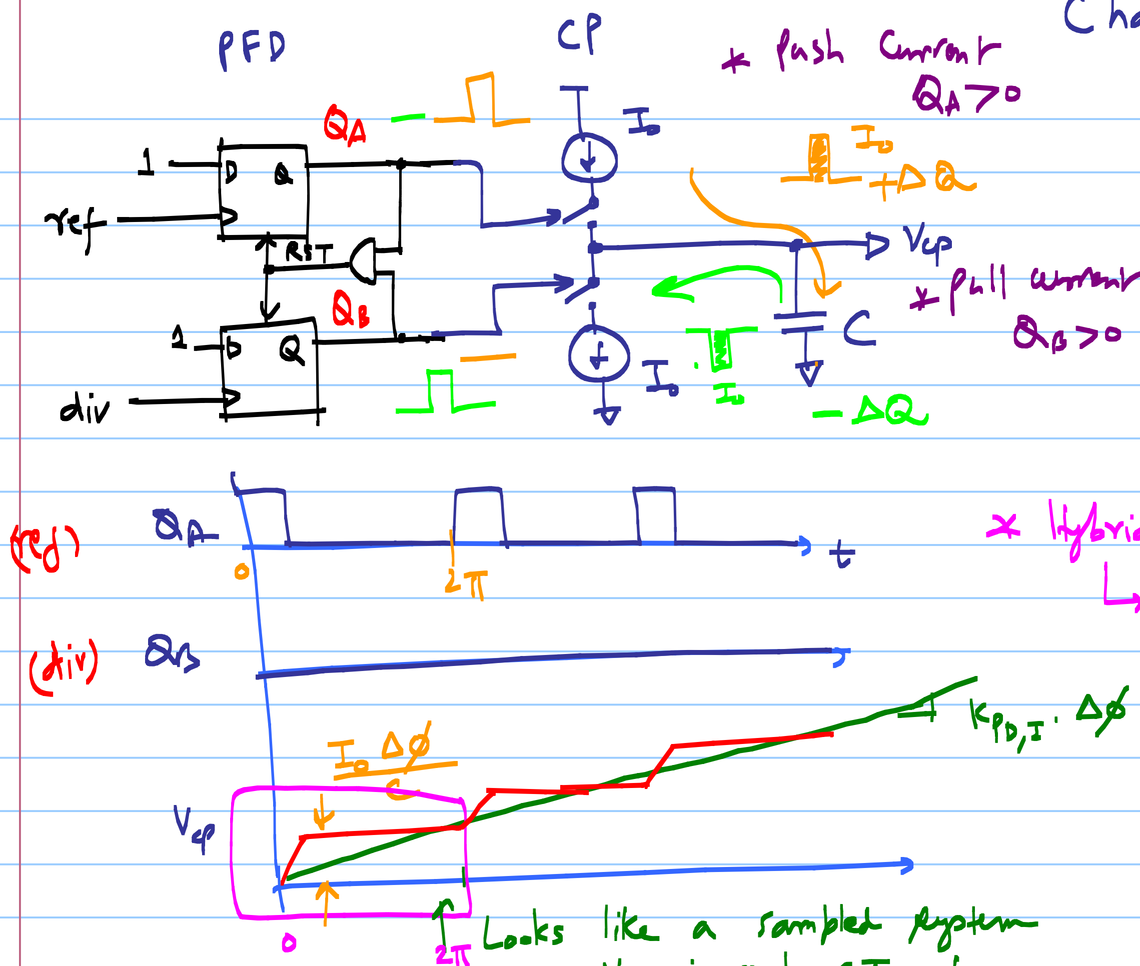






⟸ integration is CT

Charge Pump topology



* push current $Q_A > 0$

* pull current $Q_B > 0$

* Hybrid CT-DT system
  ↳ precise analysis is challenging

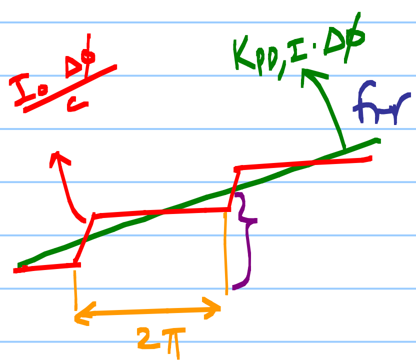
Looks like a sampled system
V_{cp} is not CT change

* We can approximate this system as a CT system for analysis as long as $\omega_{u,loop} \ll \omega_{ref}$

$\uparrow$ effective rate of DT sampling

$$\boxed{\omega_{u,loop} \leqslant \frac{\omega_{ref}}{10}}$$

$\Rightarrow$ the PLL response is much slower than the frequency of phase detection (sampling)

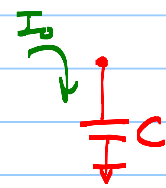


for $\omega_{u,loop} < \frac{\omega_{ref}}{10}$

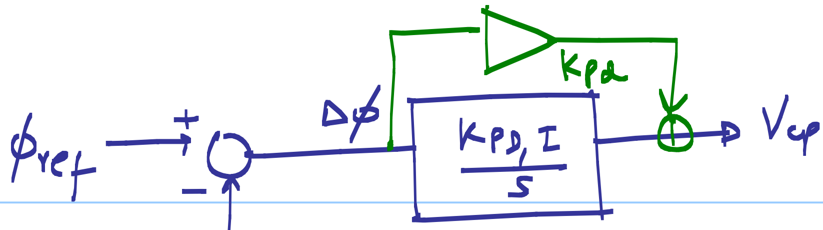
$$K_{PD,I} \cdot \cancel{\Delta\phi} \cdot 2\pi = \frac{I_o \cancel{\Delta\phi}}{c} \Leftarrow \text{step height}$$

V_{cp} step height

$$\boxed{K_{PD,I} = \frac{I_o}{2\pi C}}$$

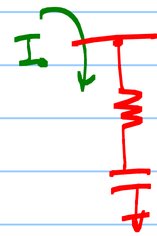


$\swarrow$ Loop filter



$$\phi_{fb} = \frac{\phi_{vco}}{N}$$

Loop-filter



R $\pm$ I_oR $\pm$ proportional

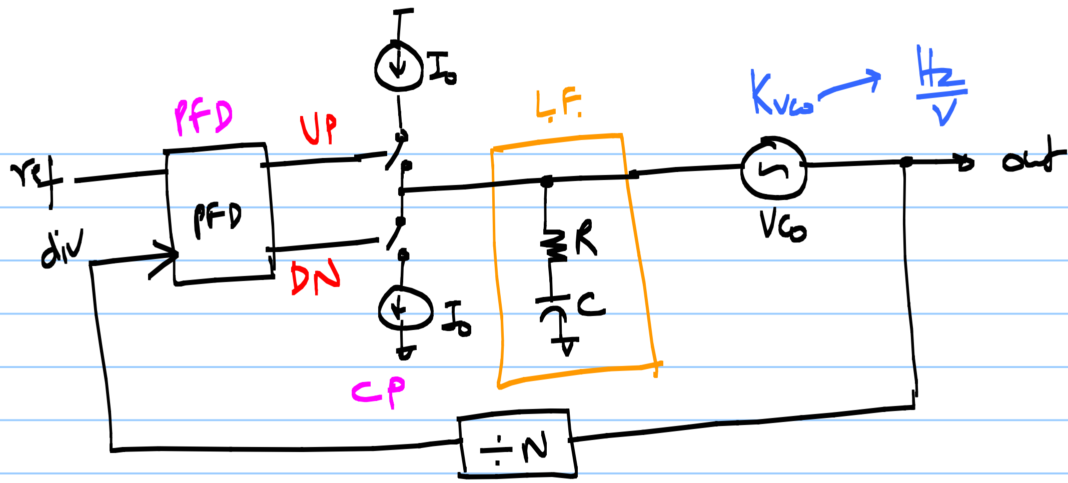
C $\pm$ $\frac{1}{C}\int I\,dt$ $\pm$ integrator

$$\boxed{K_{PD} = \frac{I_oR}{2\pi}}$$

same explanation as

$$K_{PD,I} = \frac{I_o}{2\pi C}$$

Charge Pump PLL



UP ⇒ increase Vco frequency

DN ⇒ decrement Vco frequency