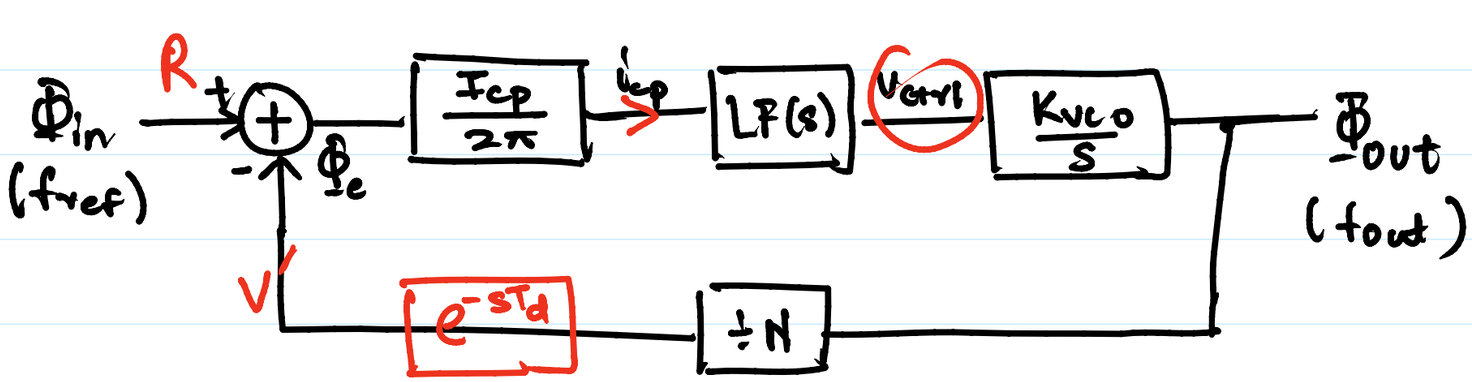
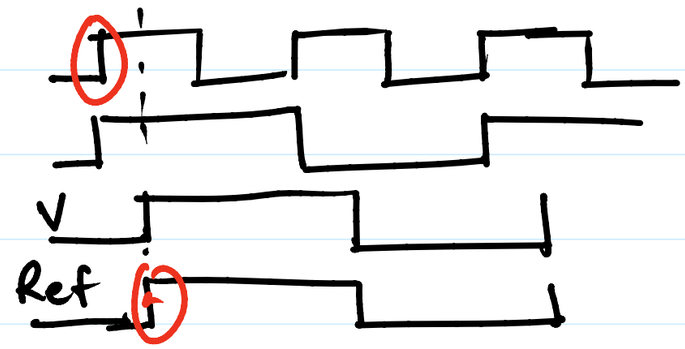
Lecture 11

Monday, February 6, 2017 9:39 AM

Charge-pump based clock multiplier (Type-II, order 3)

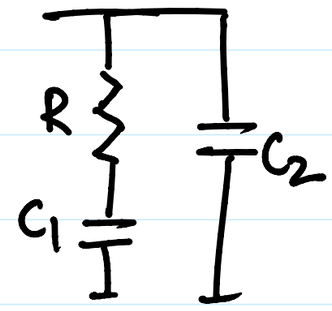




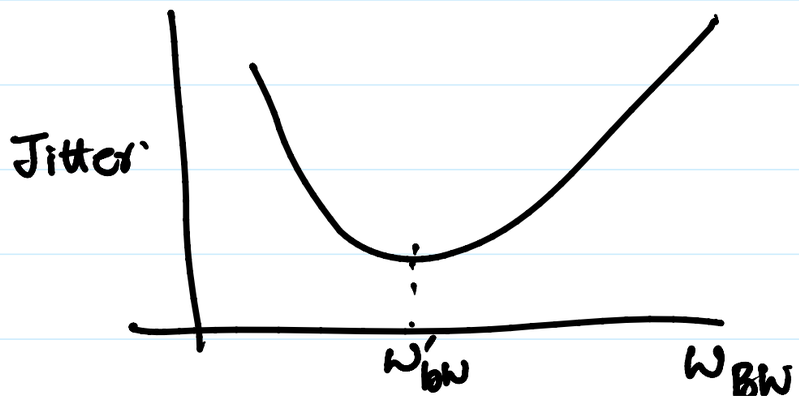
$f_{out} = N f_{ref}$.

$$LF(s) = \frac{1}{sC_2} \frac{\left(s+\frac{1}{RC_1}\right)}{\left(s+\frac{1}{\frac{sC_1C_2}{C_1+C_2}}\right)}$$

$$LG(s) = \frac{I_{cp}}{2\pi} \times LF(s) \times \frac{K_{VCO}}{S} \times \frac{1}{N}$$



$$\frac{\Phi_{out}(s)}{\Phi_{in}(s)} = \frac{N \times LG(s)}{1 + LG(s)}$$

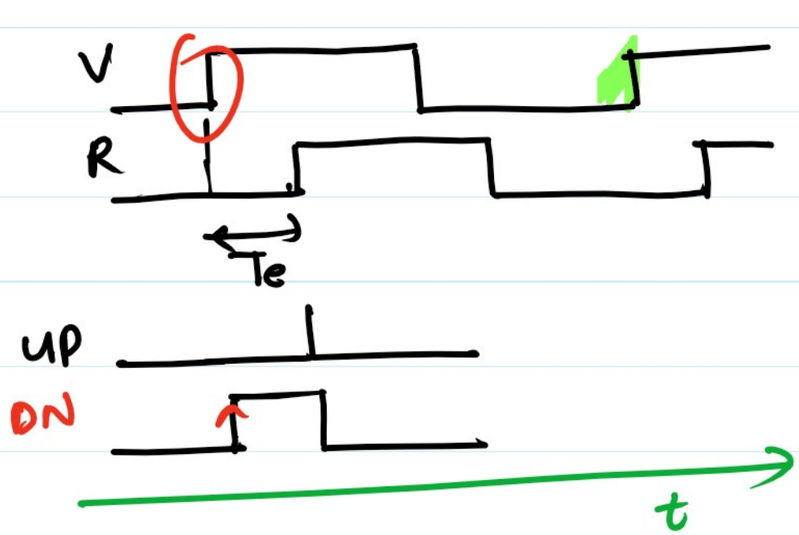


* PLL bandwidth $\leq \frac{f_{ref}}{10}$

Sources of non-linearity in CP-PLL

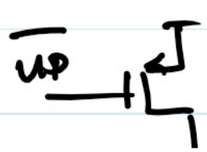
1.) Dead zone in PFD - Eliminated.

2) Inherent to PFD design

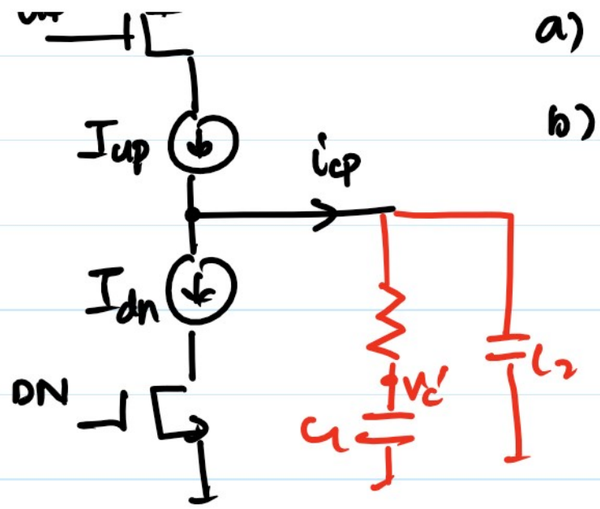


R- ref. signal, V- PLL o/p

3) charge-pump non-linearity.



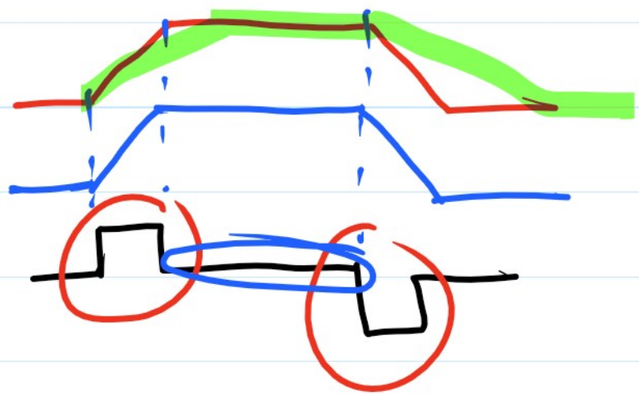
a) $I_{up} \neq I_{dn}$



a) $I_{up} \neq I_{dn}$

b) Channel length modulation
- Static
- Transient

c)



4) $LG_{new}(s) = e^{-sT_d} \; LG_{old}(s)$

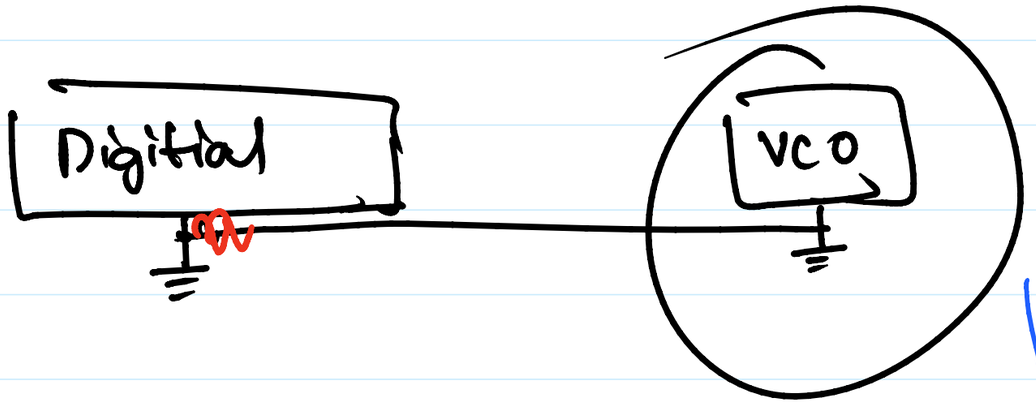
$= (1 - sT_d) \; LG_{old}(s)$

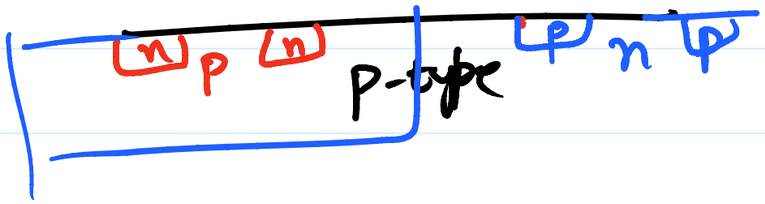
$\Phi_{m,new} = \Phi_{m,old} - \tan^{-1}(\omega_u T_d)$

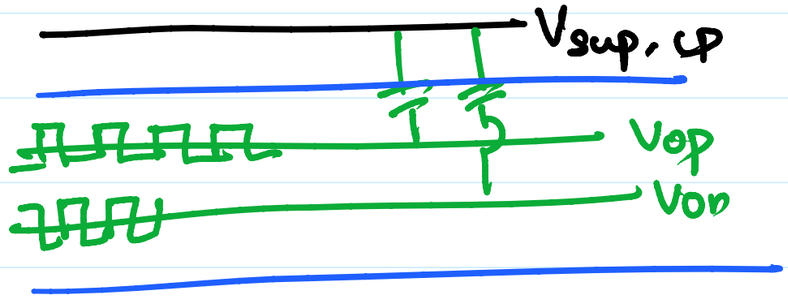
Noise Analysis of CP-PLL

1) Extrinsic noise sources:
- supply noise
- substrate noise

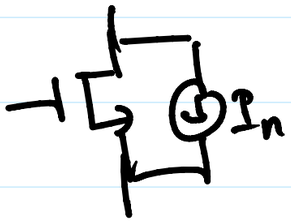
– coupling w/ external unwanted signals.



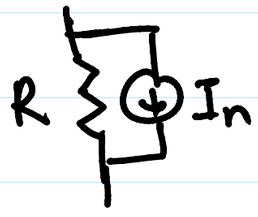




2) Intrinsic noise sources:

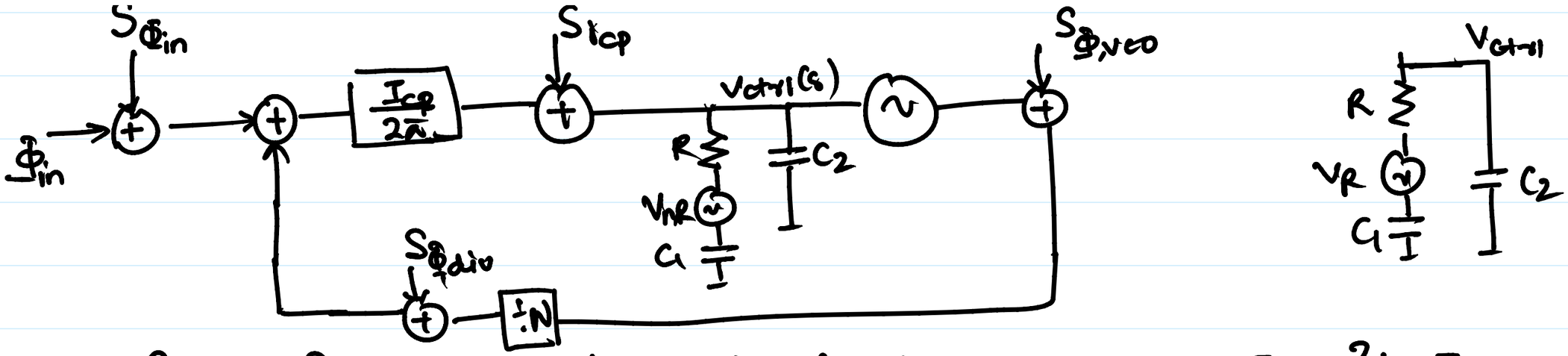


$$S_{I_m} = \frac{8KT}{3} g_m$$



$$S_{I_R} = \frac{4KT}{R}$$

$S_{\Phi_{in}}$ $S_{I_{CP}}$ $S_{\Phi,VCO}$ V_{Ctrl}



$S_{\Phi in}$: Power spectral density of reference noise [rad^2/Hz]

S_{Icp} : " charge pump noise

S_R : " resistor noise

$S_{\Phi VCO}$: " VCO

$S_{\Phi div}$: " divider

Noise contribution to $\Phi_{n,out}$

Noise transfer function (NTF)

$$NTF_{in} = \frac{N \times LG(s)}{1 + LG(s)}$$

$$NTF_{cp} = \frac{2\pi}{I_{cp}} \frac{N \times LG(s)}{1 + LG(s)} = \frac{2\pi}{I_{cp}} NTF_{in}$$

$$NTF_{cp} = \frac{2\pi}{I_{cp}} \frac{N \times LG(s)}{1 + LG(s)} = \frac{2\pi}{I_{cp}} NTF_{in}$$

$$= \frac{2\pi}{I_{cp}} \frac{LF(s) \times \underbrace{\frac{K_{vco}}{s}}_{} \times \frac{I_{cp}}{2\pi}}{1 + LG(s)} =$$

$$NTF_R = \frac{V_{ctrl}(s)}{V_R} \frac{\frac{K_{vco}}{s}}{1 + LG}$$

$$NTF_{vco} = \frac{1}{1 + LG}$$

$$NTF_{div} = \frac{N \times LG}{1 + LG}$$

$$S_{total,out} = S_{\Phi in} \times |NTF_{in}|^2 + S_{Icp} \times |NTF_{cp}|^2$$
$$+ S_R \times |NTF_R|^2 + S_{vco} \times |NTF_{vco}|^2$$
$$+ S_{\Phi div} \times |NTF_{div}|^2$$