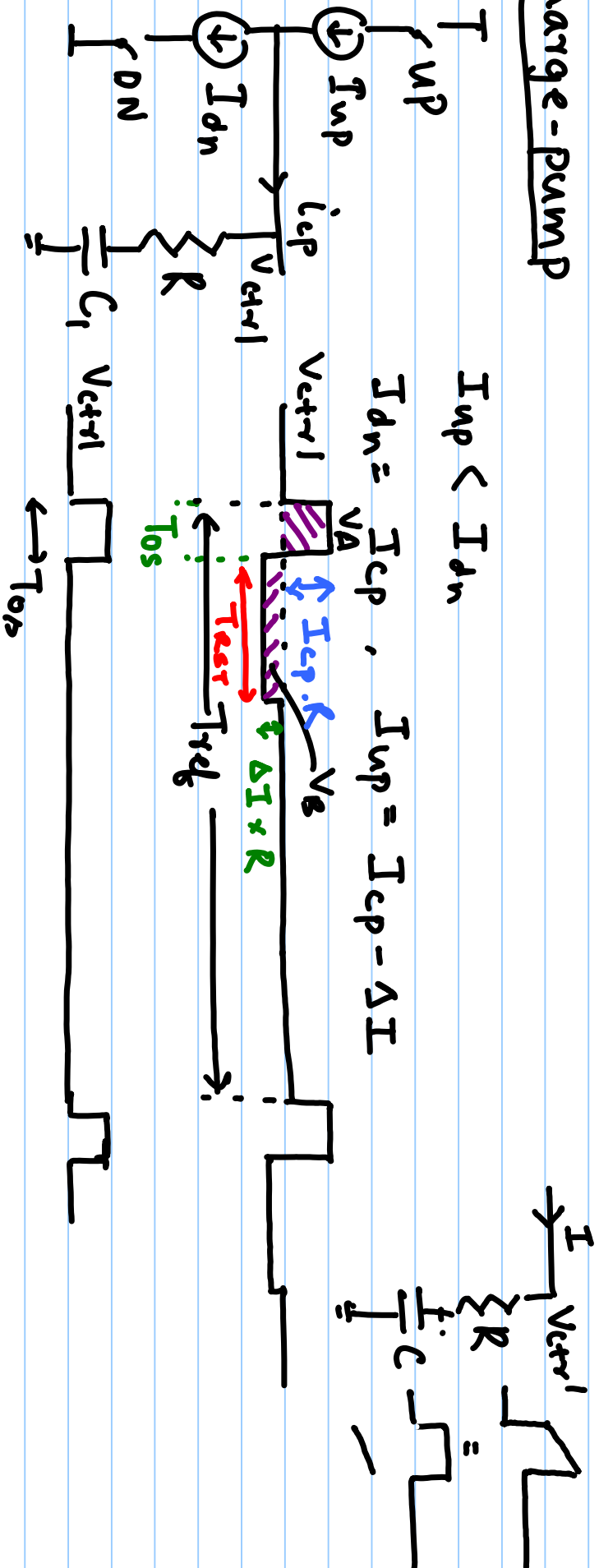


# Lecture # 26

## Charge-Pump



$$V_{cp1}(t) = a_0 + \sum a_n \sin(n\omega_r t) + b_n \cos(n\omega_r t)$$

$$b_n = \frac{I_{cp} \cdot R}{n\pi} \sin(n\omega_r T_{os})$$

$$a_n = \frac{I_{cp} R}{n\pi} (1 - \cos(n\omega_r T_{os}))$$

$$b_1 = \frac{I_{cpR}}{\kappa} \sin\left(2\pi \cdot \frac{T_{os}}{T_R}\right)$$

$$T_R = T_{rd.}$$

$$a_1 = \frac{I_{cpR}}{\kappa} \left(1 - \cos\left(2\pi \cdot \frac{T_{os}}{T_R}\right)\right)$$

$$V_{out} = \sin(\omega_{out}t + 2\pi K_{vco} \int v_{ctrl.} dt)$$

$$= \sin(\omega_{out}t) + \frac{\beta}{2} \left[ \sin(\overline{\omega_{out} + \omega_R}t) - \sin(\overline{\omega_{out} - \omega_R}t) \right]$$

$$\beta = \frac{2\pi K_{vco}}{\omega_R} \frac{I_{cpR}}{\kappa} \sin(\phi_{os}) \approx \frac{2I_{cpR} K_{vco}}{\omega_R} \phi_{os}$$

$$\text{Spur Mag.} = \frac{\beta}{2} = \frac{K_{vco} \cdot I_{cpR}}{\omega_R} \phi_{os}$$

$$= \frac{N \omega_n}{\omega_R} \cdot \phi_{os}$$

$$L_{in} = \frac{1}{2k} \frac{I_{cp}}{sC_1} (1+sRC_1) \frac{2kK_{uc0}}{s \cdot N}$$

$$\omega_u \approx \frac{I_{cp} \cdot R K_{uc0}}{N}$$

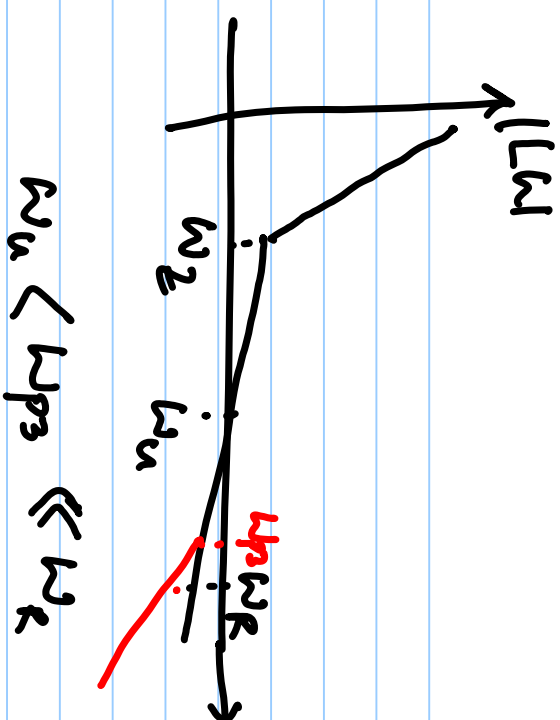
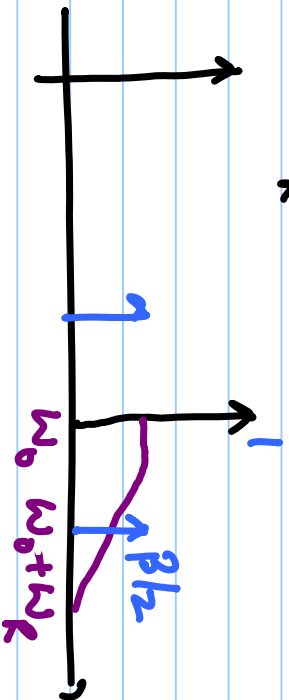
$$\boxed{\text{Spur Mag.} = N \frac{\omega_u}{\omega_R} \Phi_{os}}$$

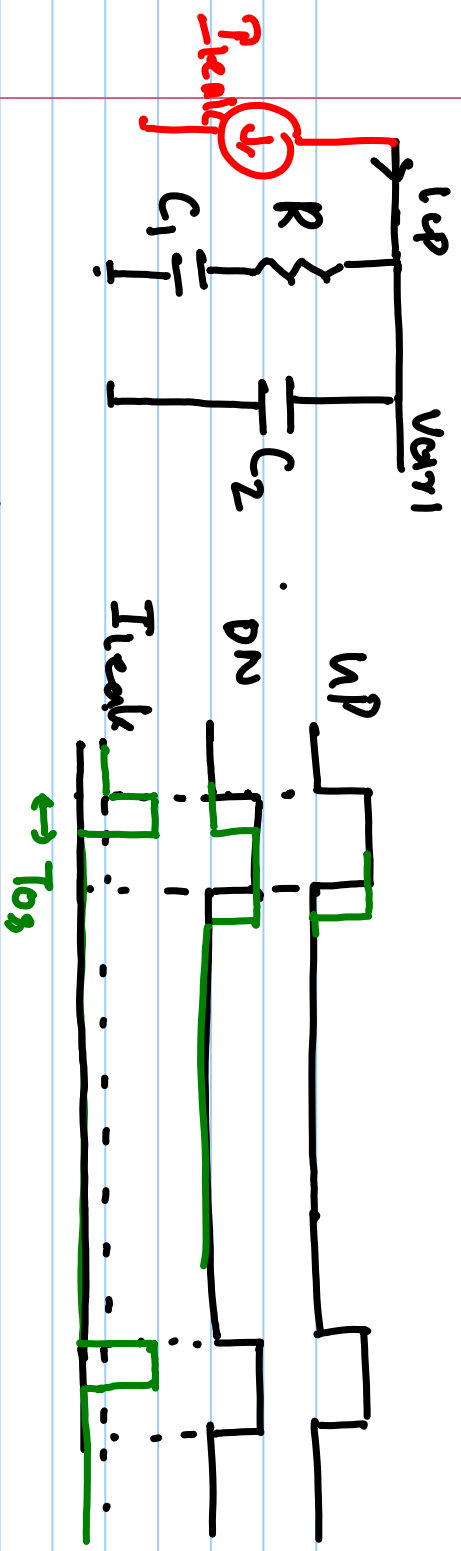
$\Delta I$  mismatch  $\rightarrow$   $\uparrow$  Spur mag.

Larger  $\omega_u$   $\rightarrow$  "

$\frac{\omega_u}{\omega_R} \downarrow \rightarrow \downarrow$  Spur mag.

$$\text{Spur Mag} = 20 \log \left( N \cdot \frac{\omega_u}{\omega_R} \Phi_{os} \right) - 20 \log \left( \frac{\omega_R}{\omega_{ps}} \right)$$

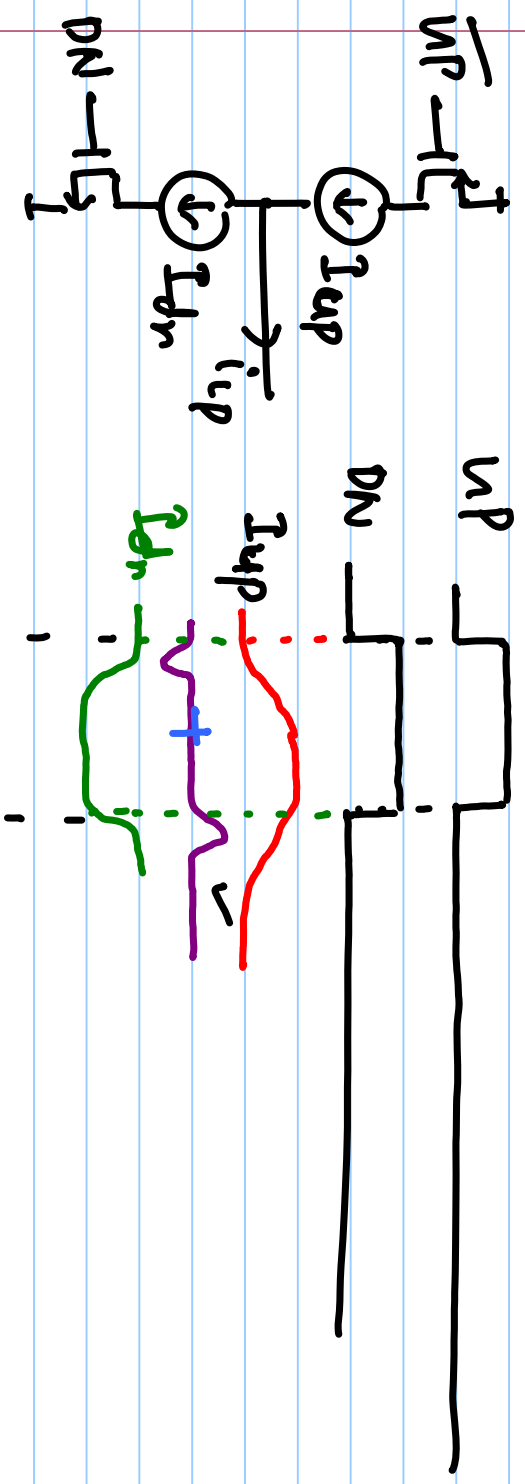


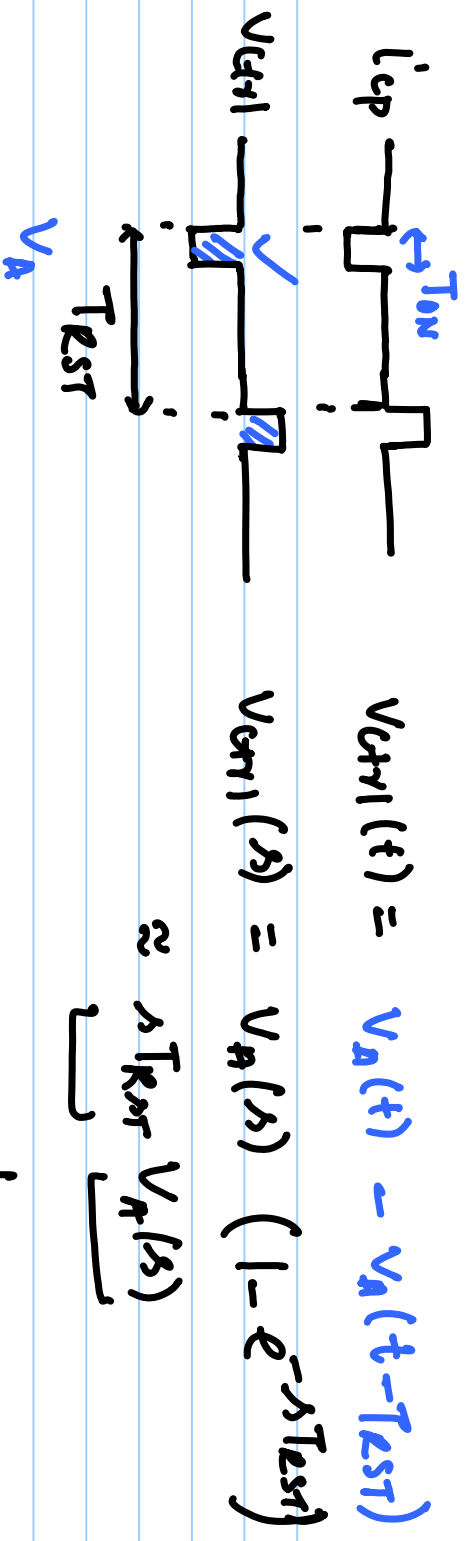


1.) Mismatch in  $I_{up}$ ,  $I_{dn}$

2) leakage current

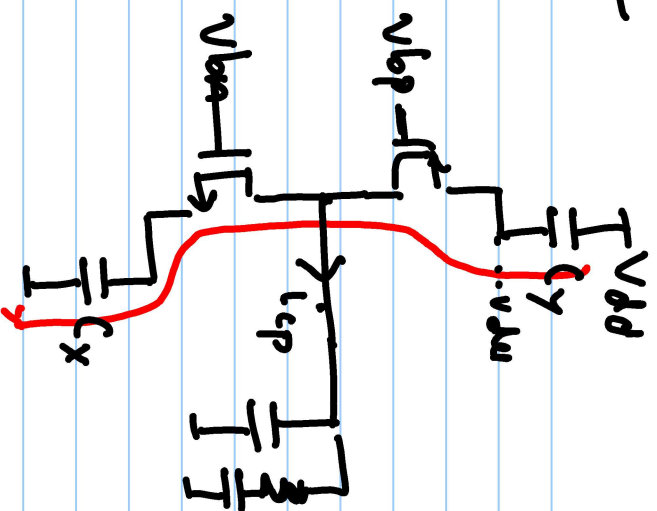
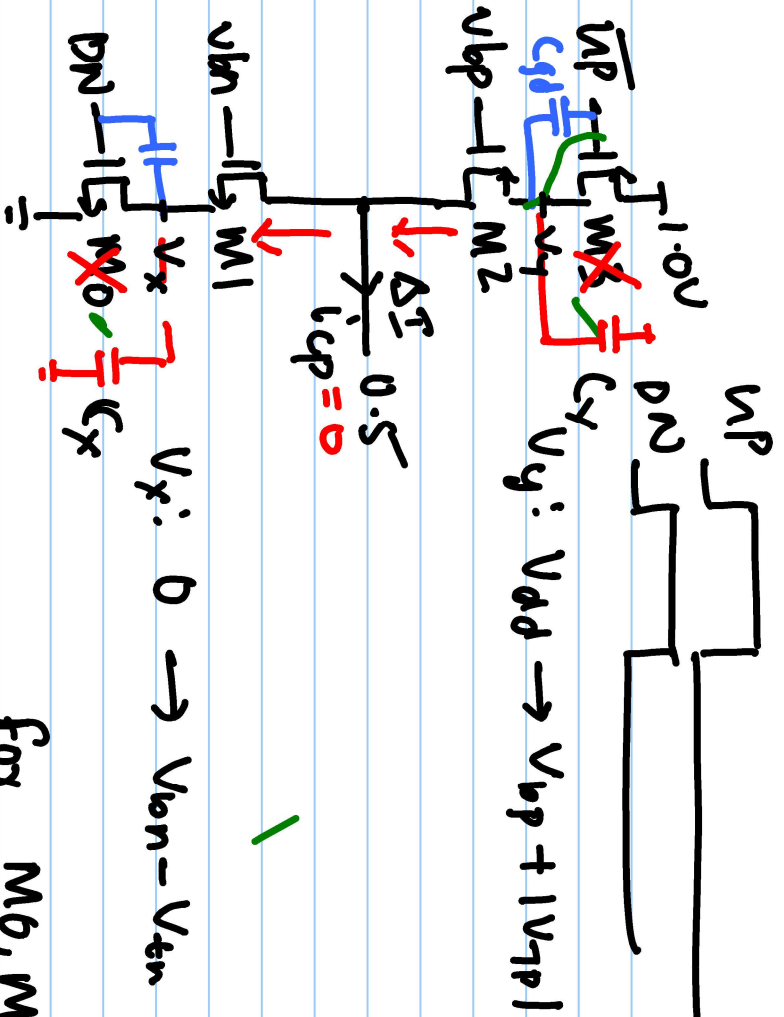
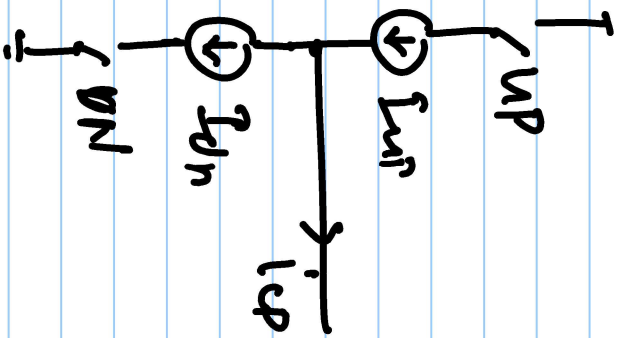
3) On-time mismatch for CP.





Spur Mag. =  $N_1 \frac{\omega_n}{\omega_r} \Phi_{0s} \times 2\pi \cdot \frac{T_{test}}{T_{ref}}$  |  $\Phi_{0s} = 2\pi \cdot \frac{T_{on}}{T_{ref}}$   
 $= N_1 \omega_n \cdot T_{test} \cdot \Phi_{0s}$

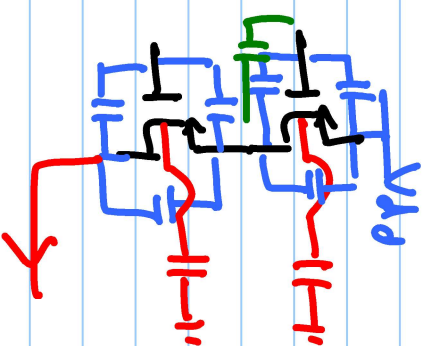
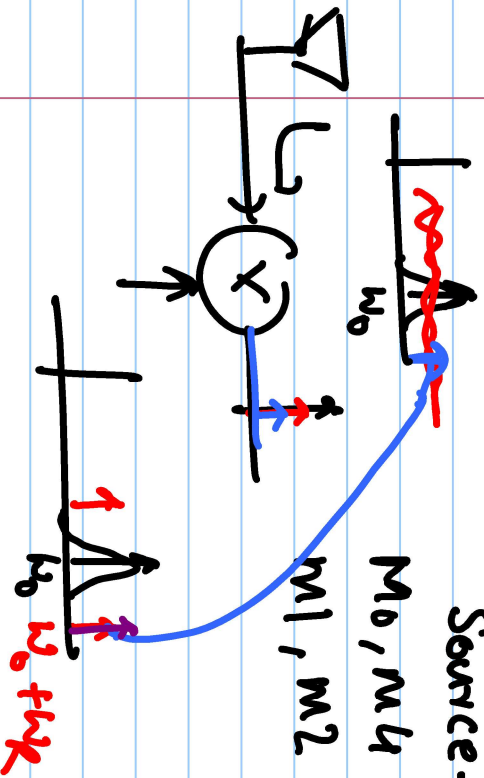
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Source-switched CP

$M_0, M_4$  switches

$M_1, M_2$  current sources.



for  $M_0, M_3$   $V_{ds} \approx 0 \rightarrow$  large  $S_{gs}$

$\uparrow C_{gd}$