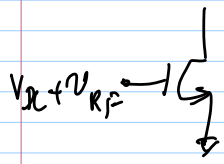
23-9-13

Lec 22

Linearity of Gilbert Mixer

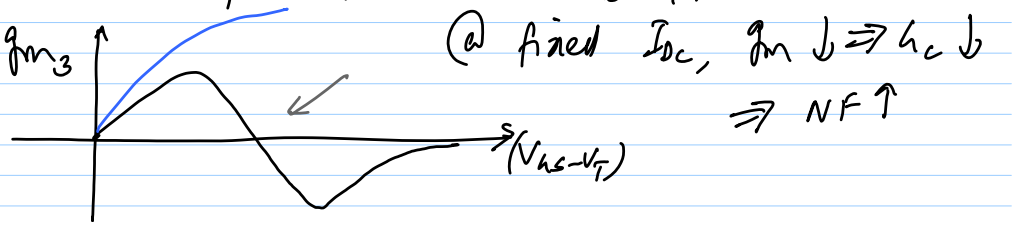
1) G_m - non linearity



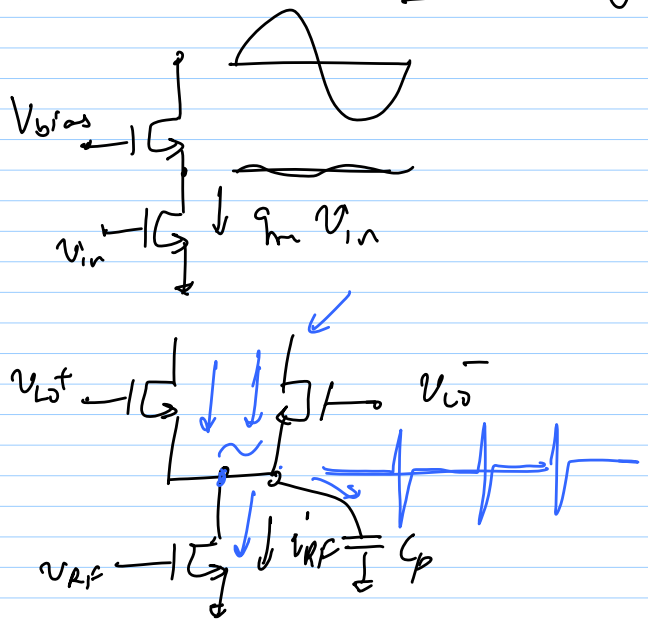
$$I_{out} = I_{DC} + g_{m_1} v_{RF} + g_{m_2} v_{RF}^2 + g_{m_3} v_{RF}^3 + \cdots$$

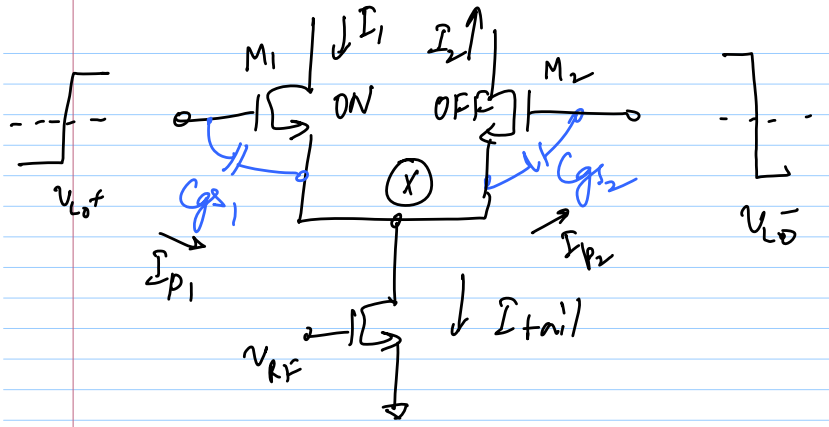
to improve IIP_3 $\rightarrow$ $\uparrow (V_{GS}-V_T)$

@ fixed I_{DC}, $g_m \downarrow \Rightarrow G_c \downarrow \Rightarrow NF \uparrow$



2) LO switch non linearity





$C_{gs_1} = \frac{2}{3} WL C_{ox}$; $C_{gs_2} = WL_D C_{ox}$ (overlap cap)

KCL @ node x

$$I_1 + I_{p_1} = I_2 + I_{p_2} + I_T$$

$$I_1 = I_T + (I_{p_2} - I_{p_1})$$

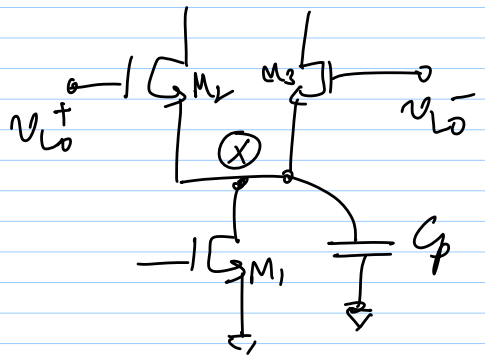
$$\approx I_T - I_{p_1} \quad (\because I_{p_1} \gg I_{p_2})$$

$$= I_T - C_{gs_1} \cdot \frac{d}{dt}(V_{LO} - V_x)$$

displacement current

* If I_1 becomes small enough, M_1 ($\&M_2$) may leave sat. region
* $\frac{dV_{LO}}{dt}$ is large (i.e. LO signal has

sharp edges) ⇒ more nonlinear



faster switching

lower V_{ov}

$\uparrow V_{ov}$ ⇒ $\downarrow I_{DC}$

$\downarrow$ ⇒ $C_p \uparrow$

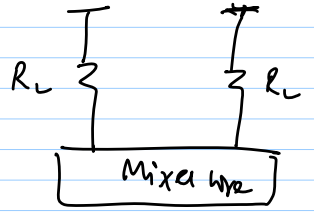
$\downarrow$ ⇒ $g_{m3} \downarrow$

Noise in Gilbert-cell Mixers

1) Load noise

a) R_L

* $\overline{v_{on}^2}_{R_L} = 8kTR_L$
* no flicker noise



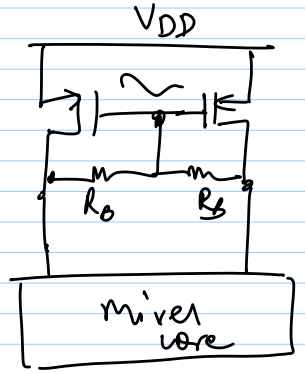
Issues

* voltage headroom

$V_{OCM} = V_{DD} - I_{DC}R_L$

* $G_C \propto R_L$

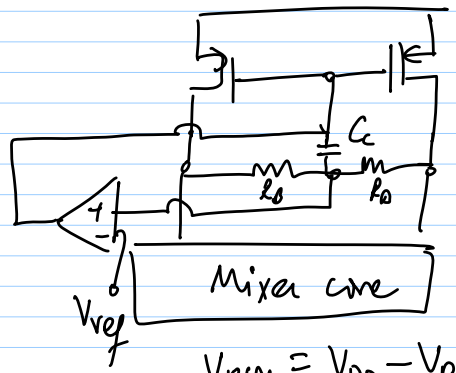
b) pMOS loads (active load)



$V_{OCM} = V_{DD} - V_{SG_p}$

$G_C \propto R_B, g_{m_p}$

CM fb.



$V_{OCM} = V_{DD} - V_{DSAT_p}$

C_c – miller comp cap

* Noise from pMOS dev is
→ $1/f$ noise & thermal noise

Use large pMOS