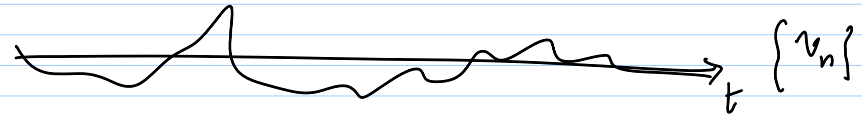
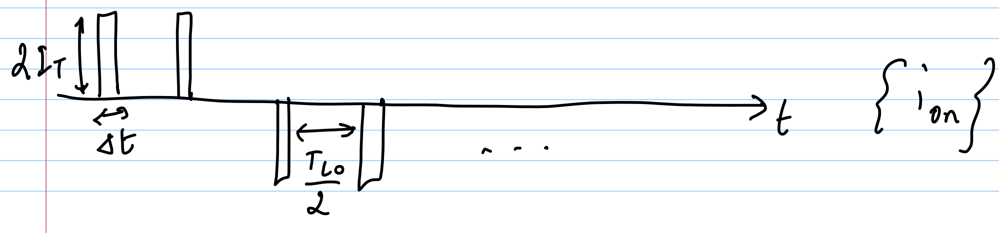
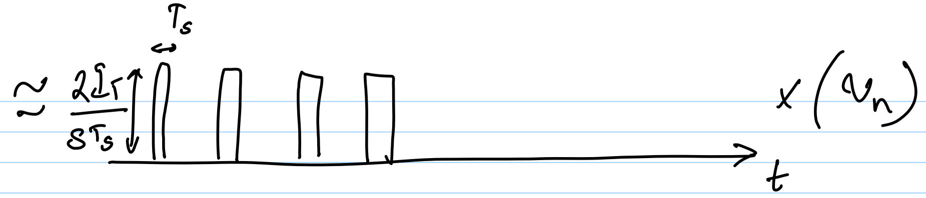
27/9/13

Lec 24

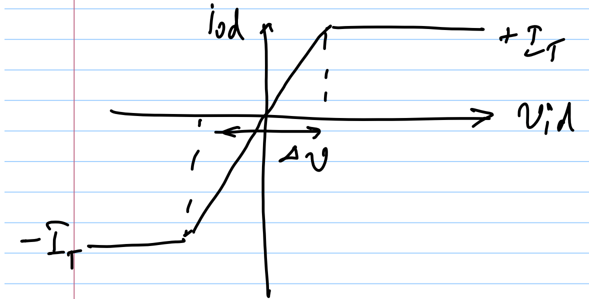
Ref: "Noise in RF CMOS Mixers: A simple Physical Model", IEEE JSSC, pp 15-25, Jan 2000





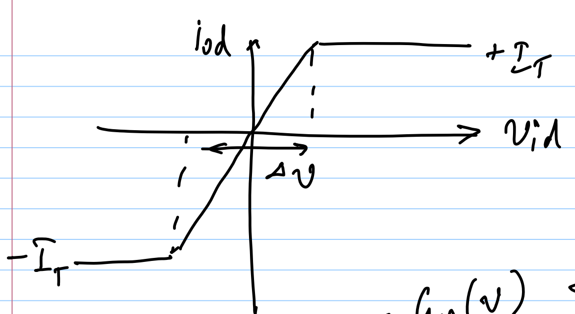


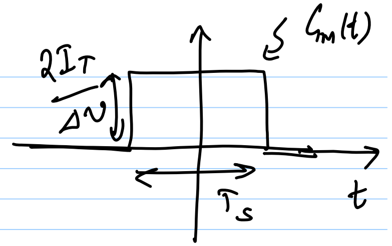
T_s = time during switching when both devices are turned on.
– calculated from I-V char.



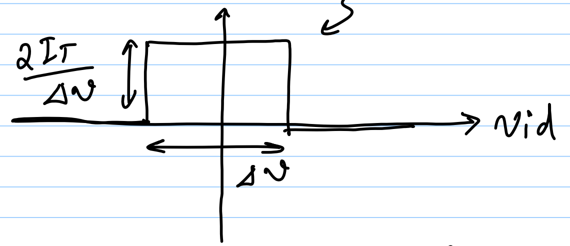
← piecewise linear approx.

$\Delta v << V_{LO}$





$G_m(v)$ ← $G_m(t)$ during switching



$v_{id} = 2V_{LO}\cos\omega_{LO}t$

$$\left(T_s = \frac{\Delta v}{2V_{LO}\omega_{LO}} = \frac{\Delta v}{S}\right.$$

$$G_m = \frac{2I_T}{\Delta v} = \frac{2I_T}{ST_s}$$

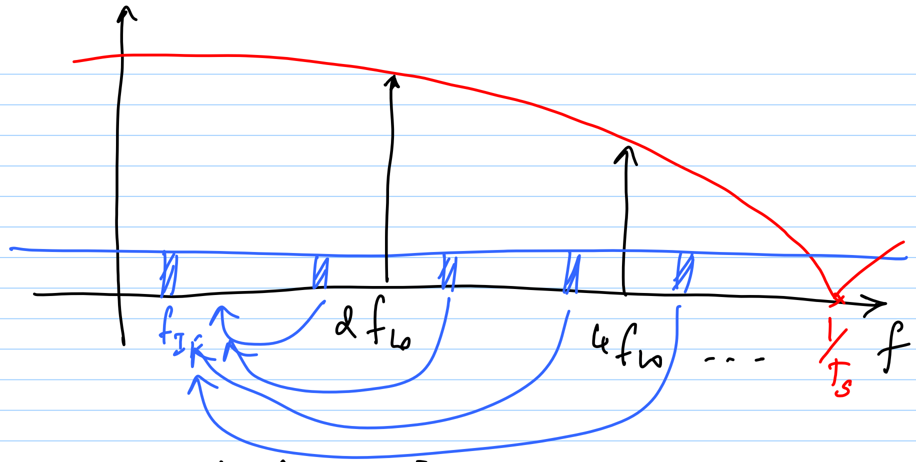
$$\frac{\hat{V}_n^2}{\Delta f} = \frac{4kT\gamma}{G_m}$$

It can be shown that:

$$\overline{i_{on,sw}^2} = \frac{2}{T_{LO}} \cdot \left(\frac{2I_T}{S}\right)^2 \cdot \frac{1}{T_s} \cdot \overline{V_n^2}$$

✓ $$\overline{i_{on,sw}^2} = 4kT\gamma \cdot \frac{I_T}{\pi V_{LO}} \quad \left\{ \begin{array}{l} \text{for sine} \\ \text{LO signal} \end{array} \right\}$$

* independent of LO size



Total Output Noise

$$\overline{v_{on}^2} = \overline{v_{on,R_L}^2} + \overline{v_{on,g_m}^2} + \overline{v_{on,sw}^2}$$

$$= 8kTR_L + 4kT\gamma g_m R_L^2 + 8kT\gamma R_L^2 \cdot \frac{I_T}{\pi V_{LO}}$$

$$= 8kTR_L\left\{1 + \frac{\gamma g_m R_L}{2} + \frac{\gamma R_L I_T}{\pi V_{LO}}\right\}$$

Optimisation

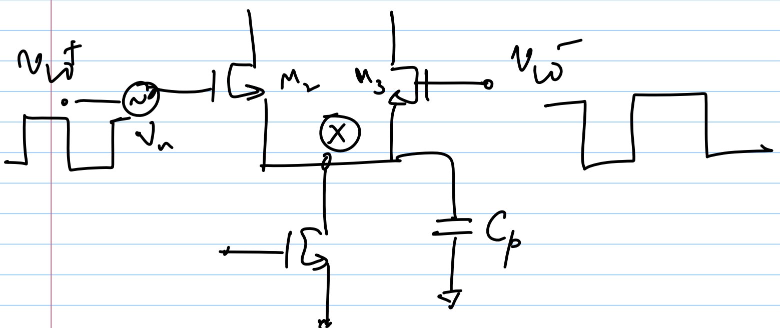
$$\overline{v_{on}^2} = 8kTR_L\left\{1 + \frac{\gamma R_L \cdot I_T}{2(V_{GS}-V_T)} + \frac{\gamma R_L I_T}{\pi V_{LO}}\right\}$$

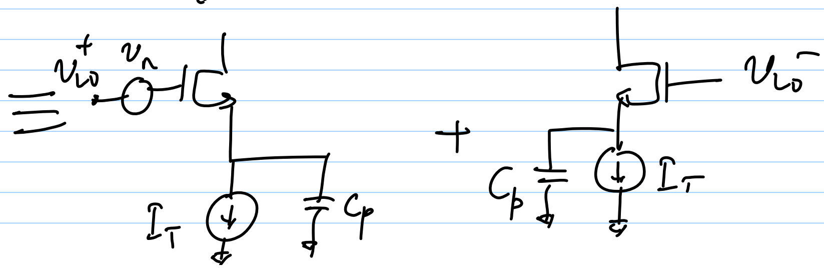
* sw & g_m relative contributions:

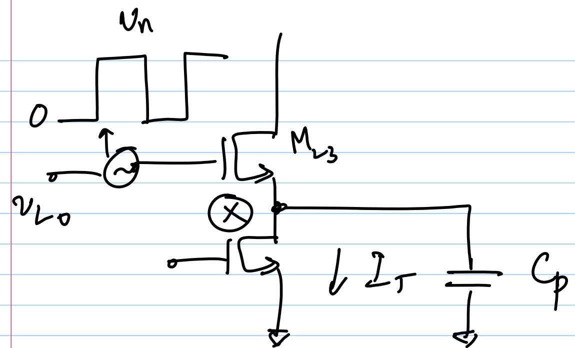
$$\frac{2(V_{GS}-V_T)}{\pi V_{LO}} \sim 1$$

optimum while keeping good linearity

b) indirect switch noise

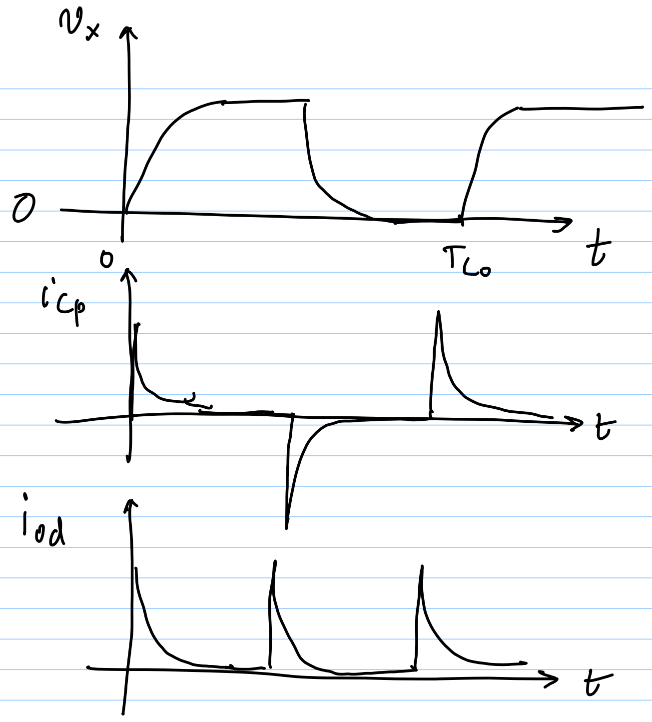






$v_n \ll V_{LO} \rightarrow$ linear

$$\tau_x \sim \frac{C_p}{g_{m_{2,3}}} \ll T_{LO}$$



freq. = f_{LO}

$i_{cp}(DC) = 0$

freq. = $2f_{LO}$,

finite DC

$$\overline{i_{on}} = \frac{2}{T_{LO}} \int_0^{T_{LO}/2} i_{cp}(t)\,dt$$

$$= \frac{2}{T_{LO}} \int_0^{T_{LO}/2} C_p \left[\frac{d V_x(t)}{dt}\right] . dt$$

$$= \frac{2}{T_{LO}} C_p \left[V_x(T_{LO}/2) - V_x(0) \right]$$

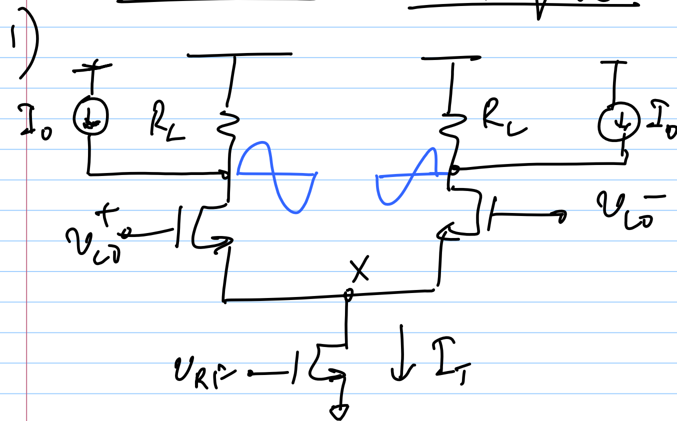
$$= \frac{2 C_p}{T_{LO}} . \overline{V_n}$$

$$G_c = \frac{2 C_p}{T_{LO}} = 2 f_{LO} C_p$$

→ ↑ with f_{LO}

Additional techniques

1)



$V_{R_L} = I_T R_L / 2$

* Linearity depends on $(V_{GS} - V_T)_{I_0}$ dev.

2)