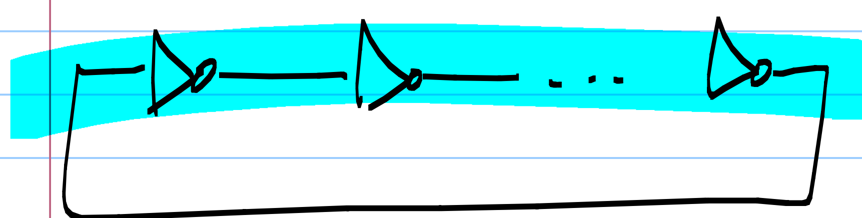
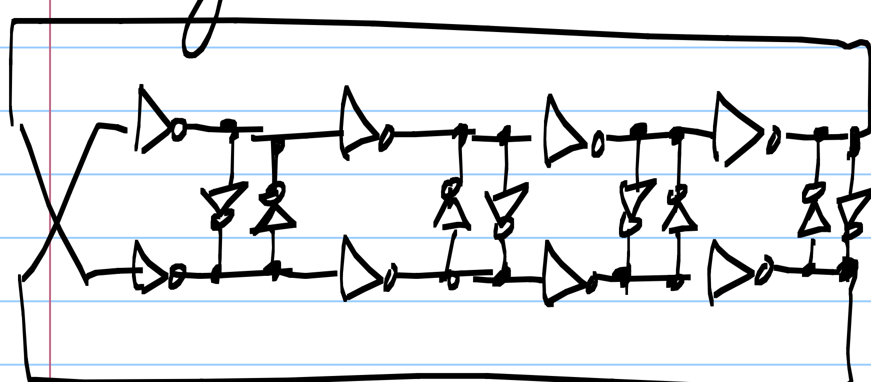
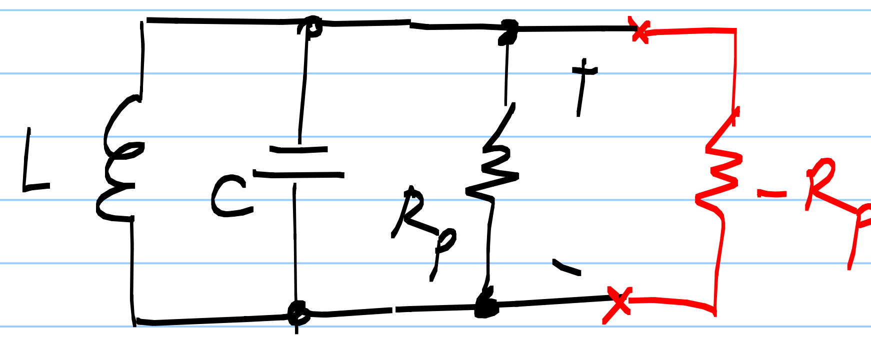
Lecture 19 — Jitter / phase noise in VCOs

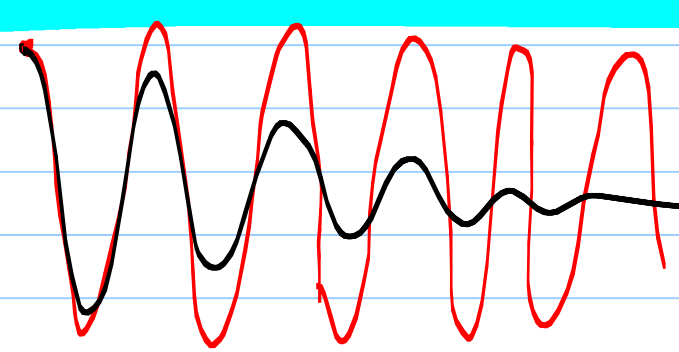
VCOs :



ring oscillators

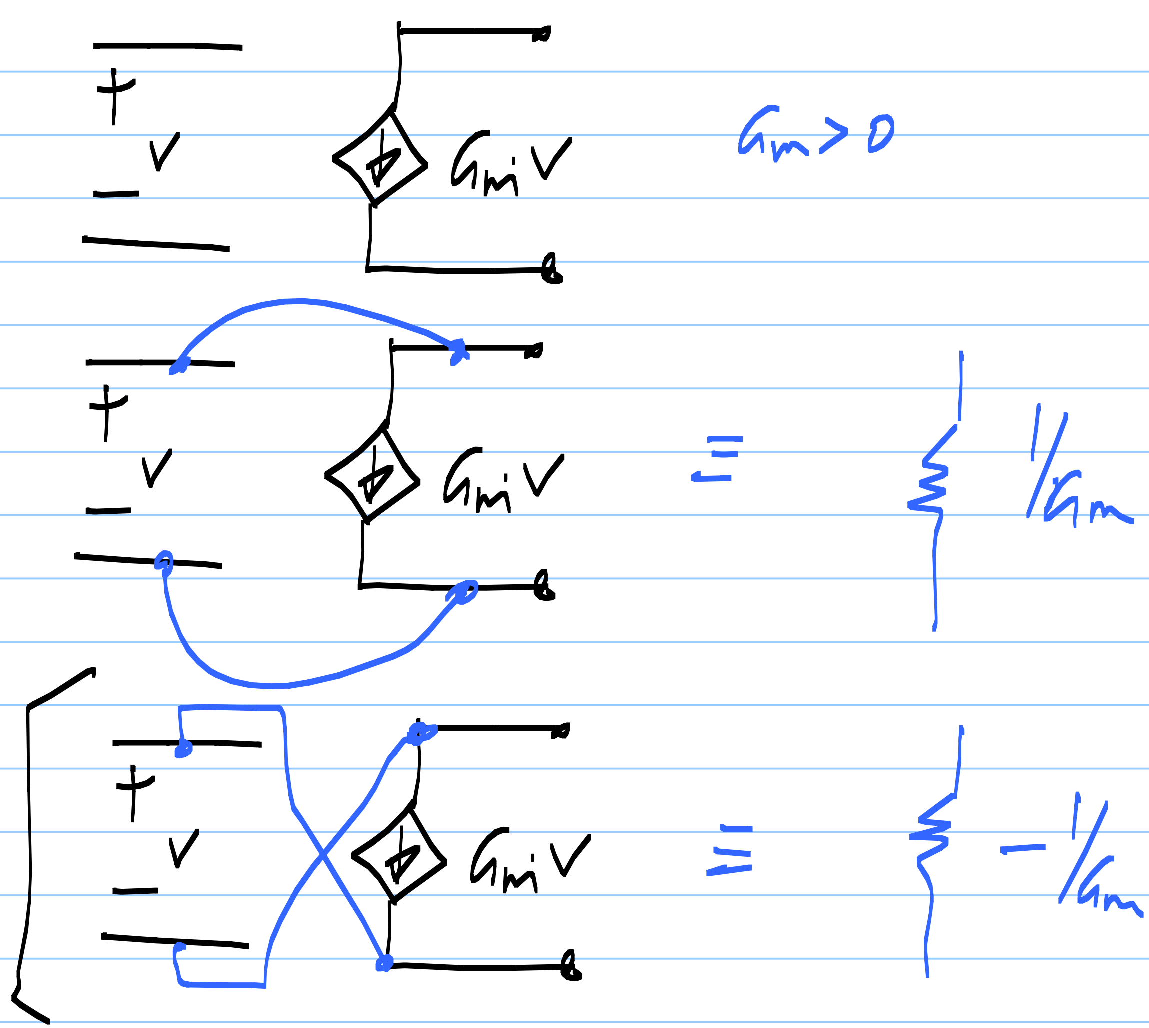


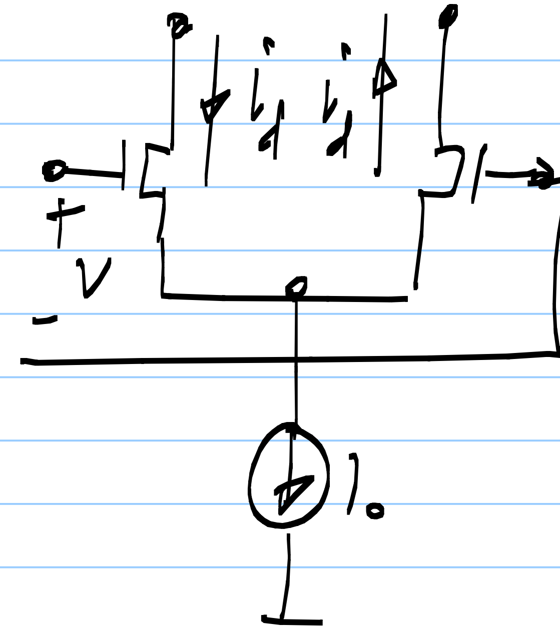


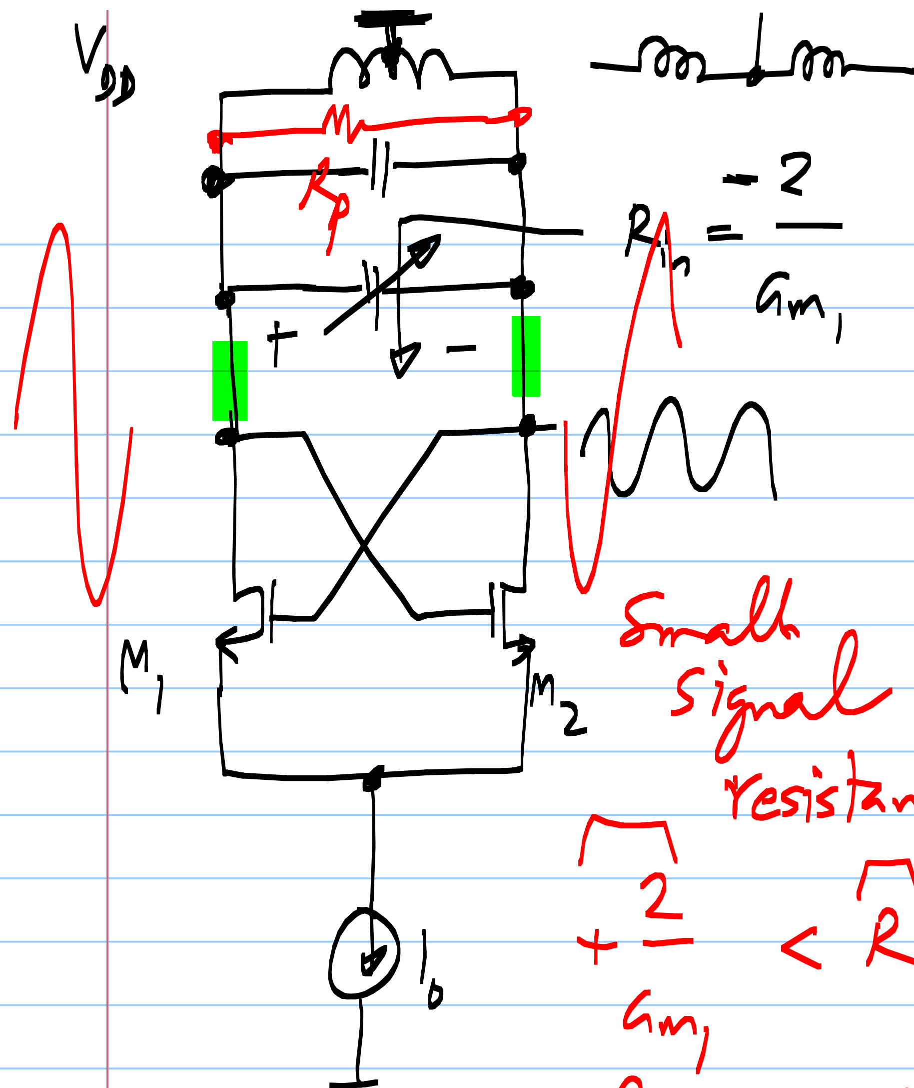


$$\frac{1}{2\pi\sqrt{LC}}$$

$G_m > 0$







$$R_{in} = \frac{-2}{g_{m_1}}$$

Transconductance of M_1 & M_2

@ $I_0/2 = g_{m_1}$

LC oscillator

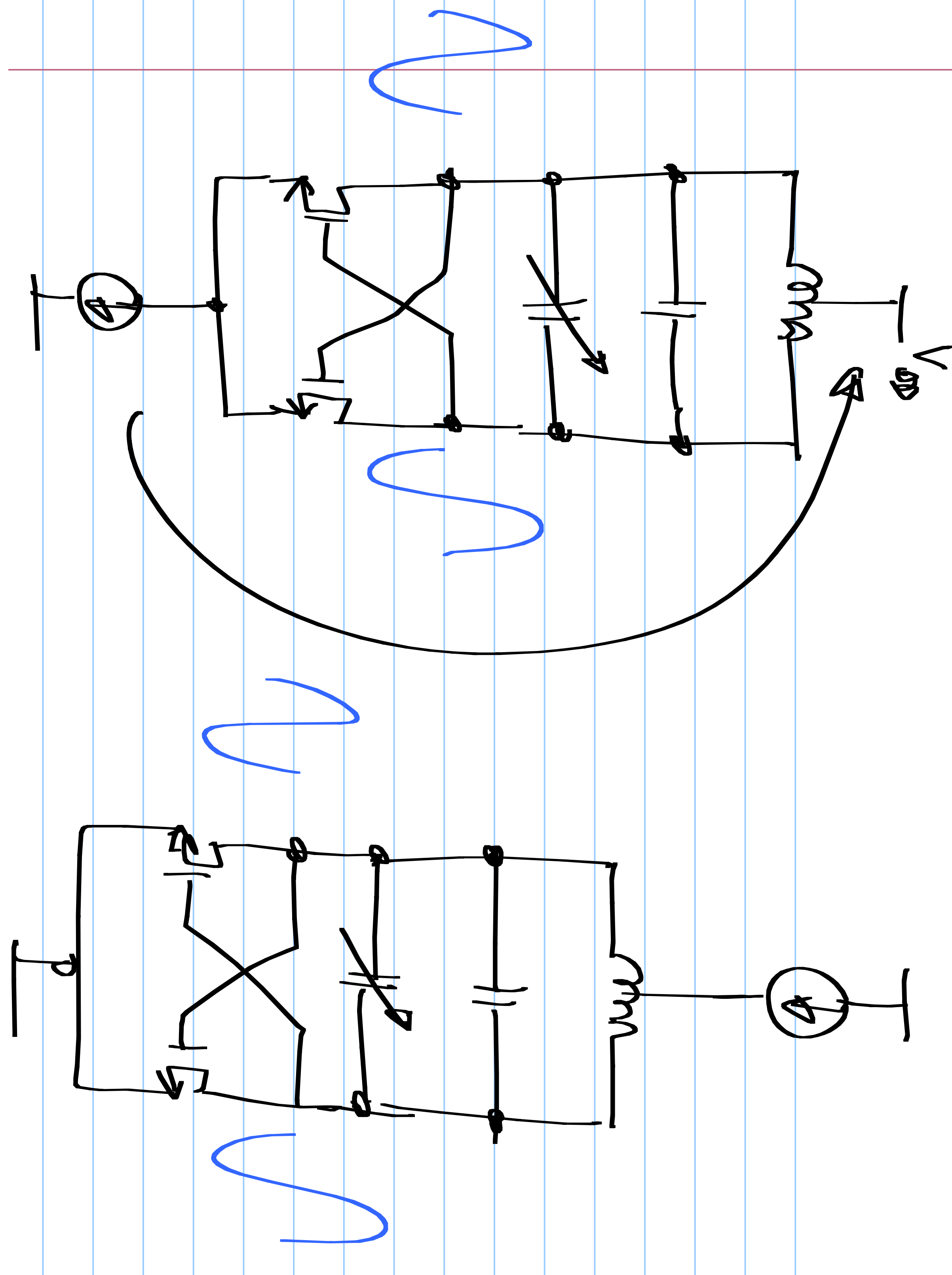
Small signal resistance

$$\overbrace{+\frac{2}{g_{m_1}}} < \overbrace{R_p}$$

for oscillation

$$Q = CV$$

$$Q = q(V)$$



* Ring oscillators : Active elements & C
  - High phase noise (MOS)
  - Very compact (small area)
* LC oscillators : L, C & active elements
  - Low phase noise
  - Large area

Phase noise / Jitter

Inherent noise of oscillators

Ideal periodic waveform : $\cos(2\pi f_0 t)$.

w/ phase disturbance : $\cos(2\pi f_0 t + \phi_n)$ (zero average)

$\phi_n \ll 1$ rad

$$\cos(2\pi f_0 t)\cdot\underbrace{\cancel{\cos(\phi_n)}}_{1} - \sin(2\pi f_0 t)\cdot\underbrace{\sin(\phi_n)}_{\simeq\,\phi_n}$$

$$\cos(2\pi f_0 t) - \underbrace{\phi_n \sin(2\pi f_0 t)}_{\sin(2\pi f_0 t)\text{ modulated by }\phi_n}$$

$$\phi_n = a \cdot \cos(2\pi f_m t)$$

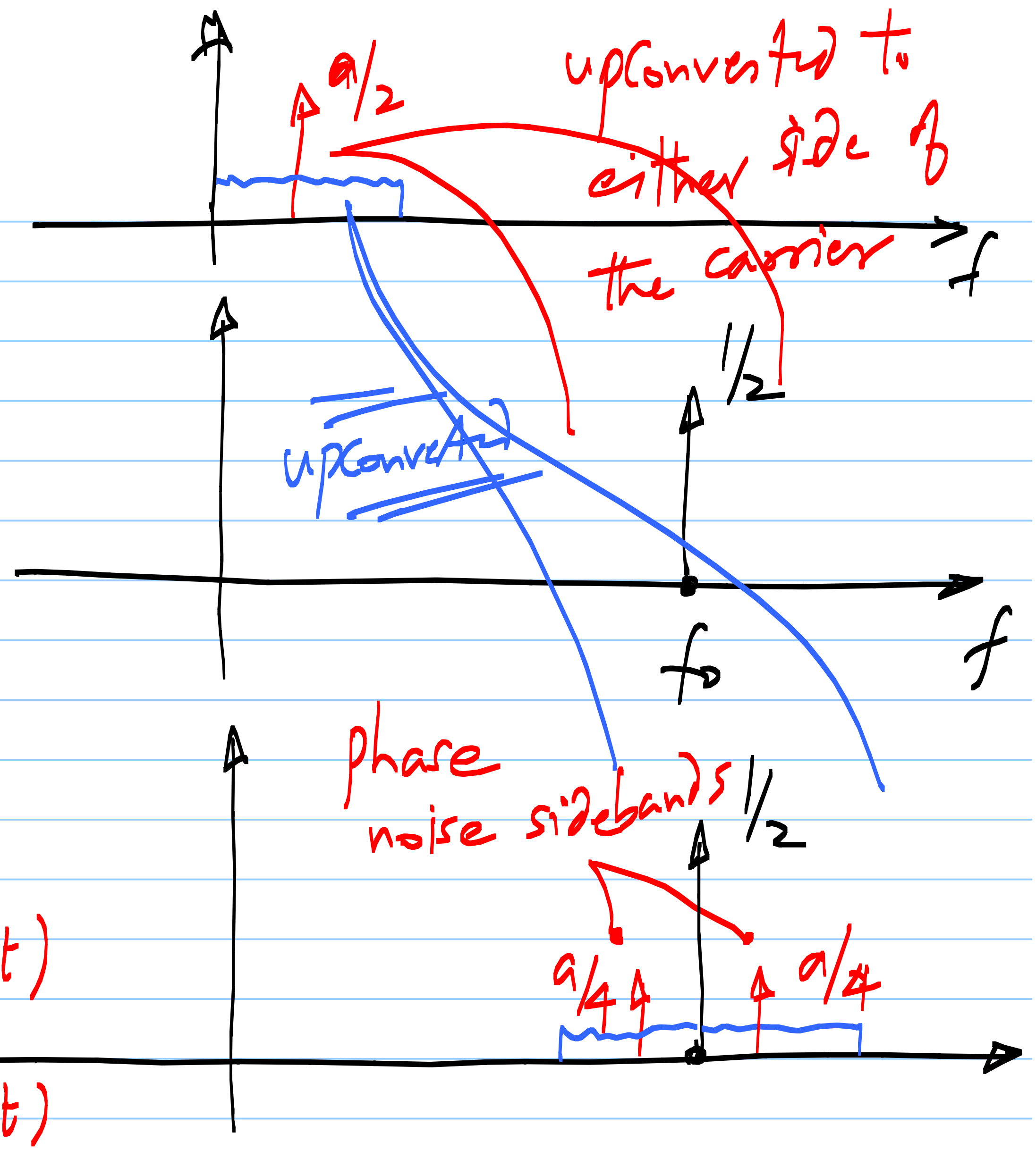
Ideal : $\cos(2\pi f_0 t)$

$\cos(2\pi f_0 t)$

w/ phase disturbance ϕ_n : $- \underbrace{\phi_n \sin(2\pi f_0 t)}$

$$\frac{a}{2} \sin(2\pi \overline{f_0 + f_m} \cdot t)$$

$$+ \frac{a}{2} \sin(2\pi f_0 - f_m \cdot t)$$



Real oscillators: Amplitude limited

(Steady state solution has a particular amplitude)