5/11/13

Lec 39

LTV Model

$$\varphi(t) = \frac{1}{q_{max}} \left[\frac{c_0}{2} \int_{-\infty}^{t} i(\tau) d\tau + \sum_{n=1}^{\infty} c_n \int_{-\infty}^{t} i(\tau) \cos(n\omega_0 \tau) d\tau \right]$$

$$i(t) = I_m \cos((m\omega_0 + \Delta\omega)t)$$ noise current @ $(m\omega_0 + \Delta\omega)$

$$\varphi(t) \approx \frac{I_m C_m \sin \Delta\omega t}{2 q_{max} \cdot \Delta\omega}$$

$$v_0(t) = A \cos(\omega_0 t + \varphi(t))$$ phase to voltage conversion

disturbance $\varphi(t) = v_m \cos \omega_m t$

$$v_0(t) = A \cos \omega_0 t + \frac{A v_m K_{vco}}{2\omega_m} \left[\cos\{(\omega_0 \pm \omega_m)t\} \right]$$

$$P_{SB}(\Delta\omega) \approx 10 \log \left[\frac{(\overline{i_n^2}/\Delta f) \cdot \sum_{m=0}^{\infty} C_m^2}{4 q^2 \Delta\omega^2} \right]$$

when noise is white

$$\sum C_m^2 = 2 \Gamma_{rms}^2$$

$$L(\Delta\omega) = 10 \log \left[\frac{(\overline{i_n^2}/\Delta f) \cdot \Gamma_{rms}^2}{2 q_{max}^2 \cdot \Delta\omega^2} \right]$$

Flicker Noise

$$\overline{i_{n,1/f}^2} = \overline{i_n^2} \cdot \frac{\omega_{1/f}}{\Delta\omega}$$ in 1/f noise region

$$L(\Delta\omega) = 10 \log \left[\frac{(\overline{i_n^2}/\Delta f) \cdot C_0^2}{8 q_{max}^2 \Delta\omega^2} \cdot \frac{\omega_{1/f}}{\Delta\omega} \right]$$

$$\Delta\omega_{1/f^3} = \omega_{1/f} \cdot \frac{C_0^2}{4 \Gamma_{rms}^2} = \omega_{1/f} \left(\frac{\Gamma_{dc}}{\Gamma_{rms}} \right)^2$$

$1/f^3$ noise can be reduced by reducing Γ_{dc}

* Flat noise region due to noise of buffers & measurement NF

VCO Design

1) ~~$f_0 = \frac{1}{2\pi\sqrt{LC}}$~~

2) R_p of tank – decides amplitude

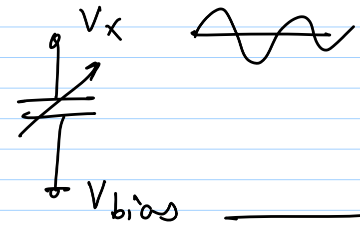
R_p : assume due to L alone

$R_p = Q \cdot \omega_0 L$

* To a first order $R_p \propto L$

* to get max amplitude (given I_T), we need to maximise R_p
  $\Rightarrow$ maximise L
  $\Rightarrow$ C is minimum (low tuning range)

* Design CC pair, say startup gain = 3
* Replace C with varactors



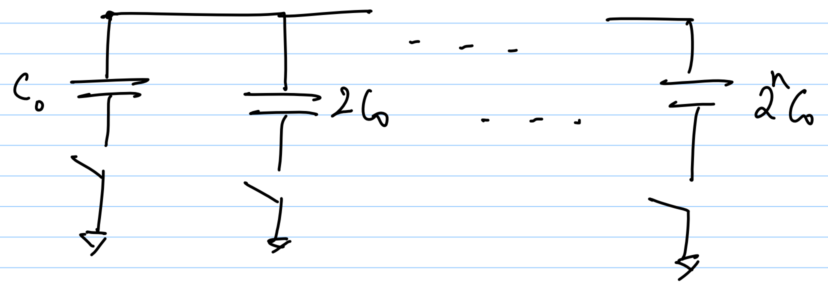
AM $\rightarrow$ PM conversion

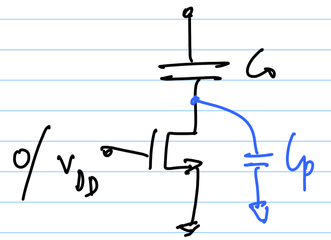
large K_{vco} $\Rightarrow$ wrse phase noise

$C = C_{var} + C_{sw}$

$K_{vco} \approx 50 - 500$ MHz/V

"0" – C_{max}





$C_{min.} = \frac{C_0 C_p}{C_0 + C_p}$

$C_{max} = C_0$

trade-off between Q & $\frac{C_{max}}{C_{min}}$