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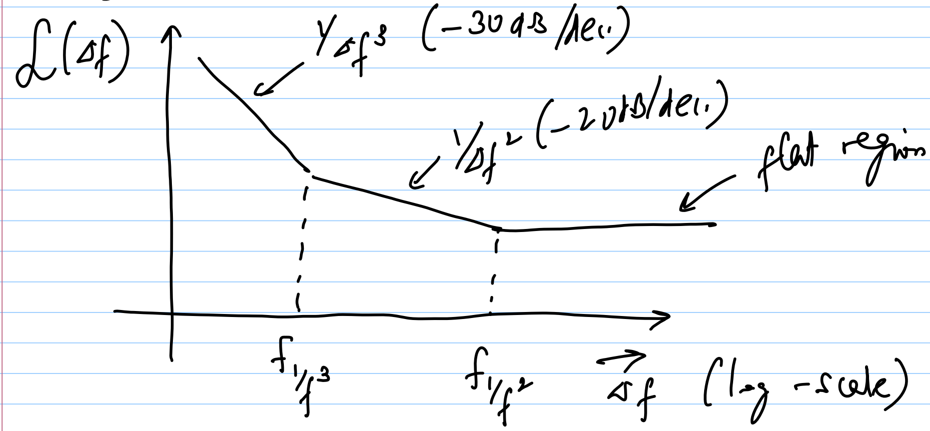
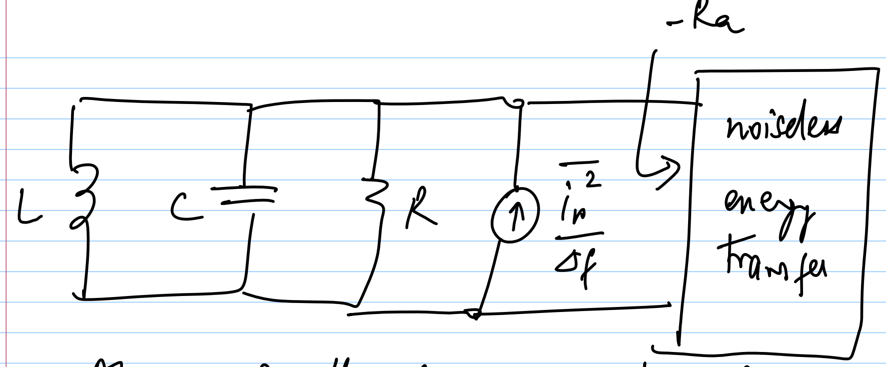
Lec 37

Phase Noise in VCOs





At a small freq. offset $\Delta\omega$, for LC tank:

$$Y(\omega_0+\Delta\omega) = G + j(\omega_0+\Delta\omega)\cdot C + \frac{1}{j(\omega_0+\Delta\omega)L}$$

$$= \frac{jG(\omega_0+\Delta\omega)L - (\omega_0+\Delta\omega)^2\cdot LC + 1}{j(\omega_0+\Delta\omega)L}$$

$$\approx G + j\frac{2\omega_0\Delta\omega}{(\omega_0+\Delta\omega)}\cdot C$$

$$Z(\omega_0+\Delta\omega) = \frac{1}{Y(\omega_0+\Delta\omega)}$$

$$= \frac{1}{G}\cdot\frac{1}{1+j\frac{2\omega_0\Delta\omega}{\omega_0+\Delta\omega}\cdot RC}$$

$Q = \omega_0 RC$

$$Z(\omega_0+\Delta\omega) = R\cdot\frac{1}{1+2Qj\cdot\frac{\Delta\omega}{\omega_0}}$$

$$|Z(\omega_0+\Delta\omega)| = \frac{R\omega_0}{2Q\Delta\omega}$$

$$\frac{\overline{v_n^2}}{\Delta f} = \frac{\overline{i_n^2}}{\Delta f}\cdot|Z|^2$$

$$= 4KT\cdot G\cdot R^2\cdot\frac{\omega_0^2}{(2Q\Delta\omega)^2}$$

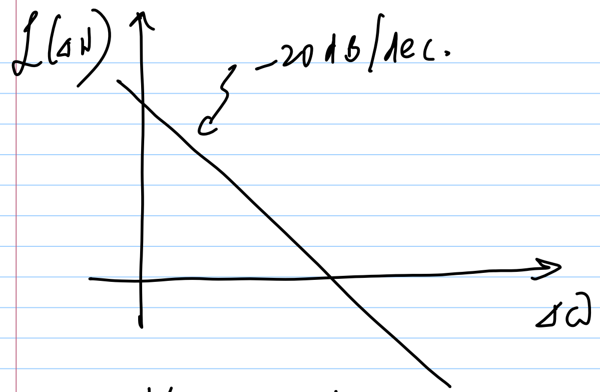
$$= 4KTR\cdot\left(\frac{\omega_0}{2Q\Delta\omega}\right)^2$$

→ ½ of this appears as phase noise

phase component = $2kTR\left(\frac{\omega_0}{2Q\Delta\omega}\right)^2$

$$\mathcal{L}(\Delta\omega) = 10\log_{10}\left[\frac{2kTR\left(\omega_0/2Q\Delta\omega\right)^2}{V_s^2}\right]$$

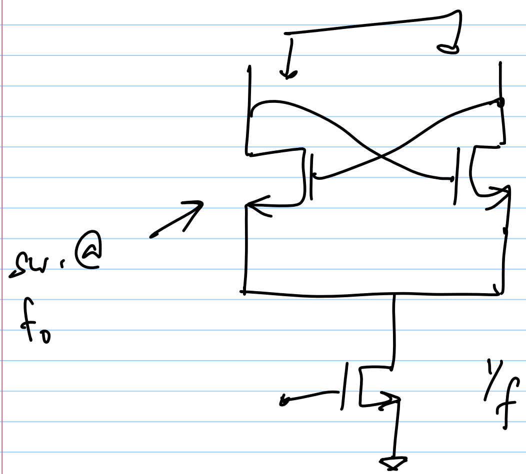
$$= 10\log_{10}\left[\frac{2kT}{P_{sig}}\left(\frac{\omega_0}{2Q\Delta\omega}\right)^2\right]$$

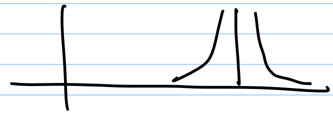


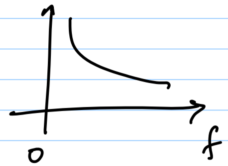
* $1/f^3$ region may come from $1/f$ noise filtered by tank
* Is $f_{1/f^3} = f_{1/f}$ of bias device?
* If not, is this only due to addl.

thermal noise from resistor?

* $1/f$ noise of C-C pair?







Leeson's Model

$$\mathcal{L}(\Delta\omega) = 10\log_{10}\left[\frac{2kTF}{P_{sig}}\left\{1+\left(\frac{\omega_0}{2Q_L\Delta\omega}\right)^2\right\}\left\{1+\frac{\Delta\omega_{1/f^3}}{|\Delta\omega|}\right\}\right]$$

* $1/f^3$ region exists
* $1/Q^2$ term exists
* ω_0 dependence exists

→ F – empirical factor