2) Under the bias condition determined in 1), calculate phase noise contributions from parasitic resistance from inductor at 10 MHz offset frequency (10 pt).

differential & no-correlation

$$\left(\overline{\phi_n^2}\right)_{\text{due to } R_{ind}} = \left(\frac{1}{2Q\frac{\Delta\omega}{\omega_0}}\right)^2 \times \frac{4KTR_{ind}\times 2}{\frac{1}{2}V_p^2 \times 4}$$

differential & correlation

$$= \left(\frac{1}{2\times 7.5}\frac{2G}{10M}\right)^2 \times \frac{4\times 1.38\times 10^{-23}\times 300\times 596.6\times 2}{\frac{1}{2}\cdot(1.538)^2\times 4}$$

$$= 742.52\times 10^{-18}\ \text{rad}^2/\text{Hz}$$

$$= -151.29\ \text{dBc/Hz @ 10MHz offset}$$

3) Under the bias condition determined in 1), calculate phase noise contributions from M1 at 10 MHz offset frequency (10 pt)

(Note: You don't need to calculate phase noise contribution due to flicker noise of M1, since at 10MHz offset dominant noise source will be thermal noise of M1.)

$$\left(\overline{\phi_n^2}\right)_{\text{due to } M1} = \left(\frac{1}{2Q\frac{\Delta\omega}{\omega_0}}\right)^2 \times \frac{4KT\frac{\Gamma}{\alpha}g_{m1}\cdot R_{ind}^2}{\frac{1}{2}V_p^2\times 4}$$

$$= \left(\frac{1}{2\times 7.5}\cdot\frac{2G}{10M}\right)^2 \times \frac{4\times 1.38\times 10^{-23}\times 300\times \frac{1.5}{0.9}\times 54m\times 596.59^2}{\frac{1}{2}(1.538)^2\times 4}$$

$$= 19.934\times 10^{-15}\ \text{rad}^2/\text{Hz}$$

$$= -137.\ \text{dBc/Hz @ 10MHz offset}$$

4) Under the bias condition determined in 1), calculate total phase noise at 10 MHz offset frequency (5 pt).

$$\left(\overline{\phi_n^2}\right)_{\text{total}} = 742.52\times 10^{-18} + 19.934\times 10^{-15}$$

$$\approx 19.934\times 10^{-15}\ \text{rad}^2/\text{Hz}$$

$$= -137\ \text{dBc/Hz @ 10MHz offset}$$

$$= -117\ \text{dBc/Hz @ 1MHz offset}$$

⇒ This is a typical number for NMOS VCO at MHz range.