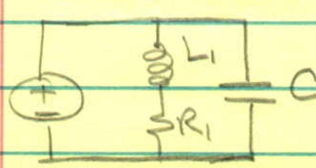
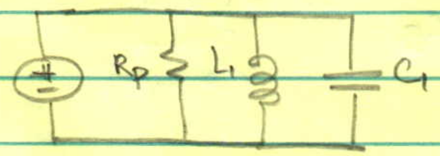
HW 6 Solutions

(1)





$$Z_1 = \frac{(R_1 + j\omega L_1)\cdot\frac{1}{j\omega C_1}}{R_1 + j\omega L_1 + \frac{1}{j\omega C_1}} \qquad Z_p = \frac{\frac{jR_p\omega L_1}{R_p + j\omega L_1}\cdot\frac{1}{j\omega C_1}}{\frac{jR_p\omega L_1}{R_p + j\omega L_1} + \frac{1}{j\omega C_1}}$$

$$Z_1 = \frac{R_1 + j\omega L_1}{(1-\omega^2 L_1 C_1) + j\omega C_1 R_1} \qquad Z_p = \frac{jR_p\omega L_1}{R_p(1-\omega^2 L_1 C_1) + j\omega L_1}$$

$$Z_1 = \frac{(R_1 + j\omega L_1)\left[(1-\omega^2 L_1 C_1) - j\omega R_1 C_1\right]}{(1-\omega^2 L_1 C_1)^2 + \omega^2 R_1^2 C_1^2} \qquad Z_p = \frac{\omega^2 L_1^2 R_p + jR_p^2\omega L_1(1-\omega^2 L_1 C_1)}{R_p^2(1-\omega^2 L_1 C_1)^2 + \omega^2 L_1^2}$$

$$\mathrm{Re}\{Z_1\} = \frac{R(1-\omega^2 L_1 C_1) + \omega^2 R_1 C_1 L_1}{(1-\omega^2 L_1 C_1)^2 + \omega^2 R_1^2 C_1^2} \qquad \mathrm{Re}\{Z_p\} = \frac{\omega^2 L_1^2 R_p}{R_p^2(1-\omega^2 L_1 C_1)^2 + \omega^2 L_1^2}$$

$$\mathrm{Im}\{Z_1\} = j\,\frac{\omega L_1(1-\omega^2 L_1 C_1) - \omega R_1^2 C_1}{(1-\omega^2 L_1 C_1)^2 + \omega^2 R_1^2 C_1^2} \qquad \mathrm{Im}\{Z_p\} = j\,\frac{R_p^2\omega L_1(1-\omega^2 L_1 C_1)}{R_p^2(1-\omega^2 L_1 C_1)^2 + \omega^2 L_1^2}$$

$\mathrm{Re}\{Z_1\} = \mathrm{Re}\{Z_p\}$

Assume $1 - \omega^2 L_1 C_1 \cong 0$

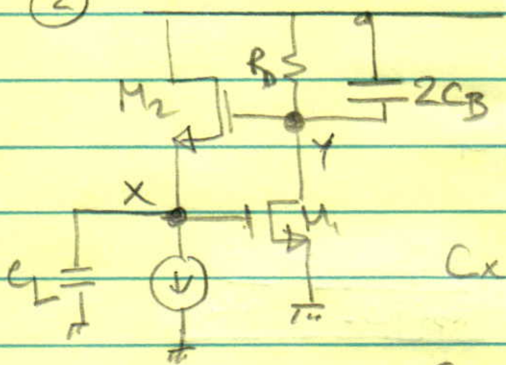
$$\frac{\cancel{\omega^2}\cancel{R_1}\cancel{C_1}L_1}{\cancel{\omega^2}R_1^{\cancel{2}}C_1^{\cancel{2}}} = \frac{\cancel{\omega^2}\cancel{L_1^2}R_p}{\cancel{\omega^2}\cancel{L_1^2}}$$

$$\Rightarrow \frac{L_1}{C_1} = R_p R_1 \quad \text{but} \quad \omega^2 = \frac{1}{L_1 C_1} \Rightarrow C_1 = \frac{1}{\omega^2 L_1}$$

$$\Rightarrow R_p R_1 = \omega^2 L_1^2$$

$$\Rightarrow \boxed{R_p = \frac{\omega^2 L_1^2}{R_1}}$$

(2)



(due to virtual ground concept)

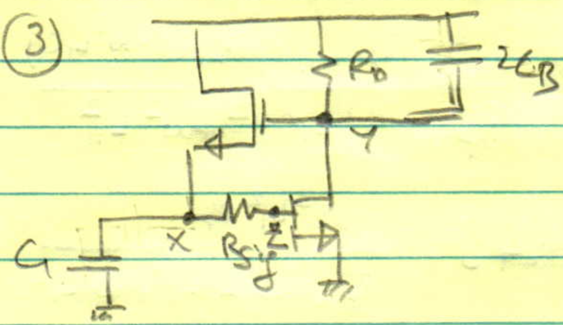
There are two poles associated with the nodes X & Y

$$C_X = C_L + C_{gs1} + C_{gd1X} + C_{gs2X} + C_{sb2} \Rightarrow \tau_X = \left(\frac{1}{g_{m2}} \| r_{o2}\right) C_X$$

$$C_Y = 2C_B + C_{gd1Y} + C_{gd2} + C_{db1} + C_{gs2Y} = \tau_Y = R_D C_Y$$

Having 2 poles, the circuit would have oscillated at $\omega = \infty$ but there is zero gain at $\omega = \infty$ So, this circuit would not oscillate

(3)



$$C_X = C_L + C_{gs2X} + C_{sb2} \Rightarrow \tau$$

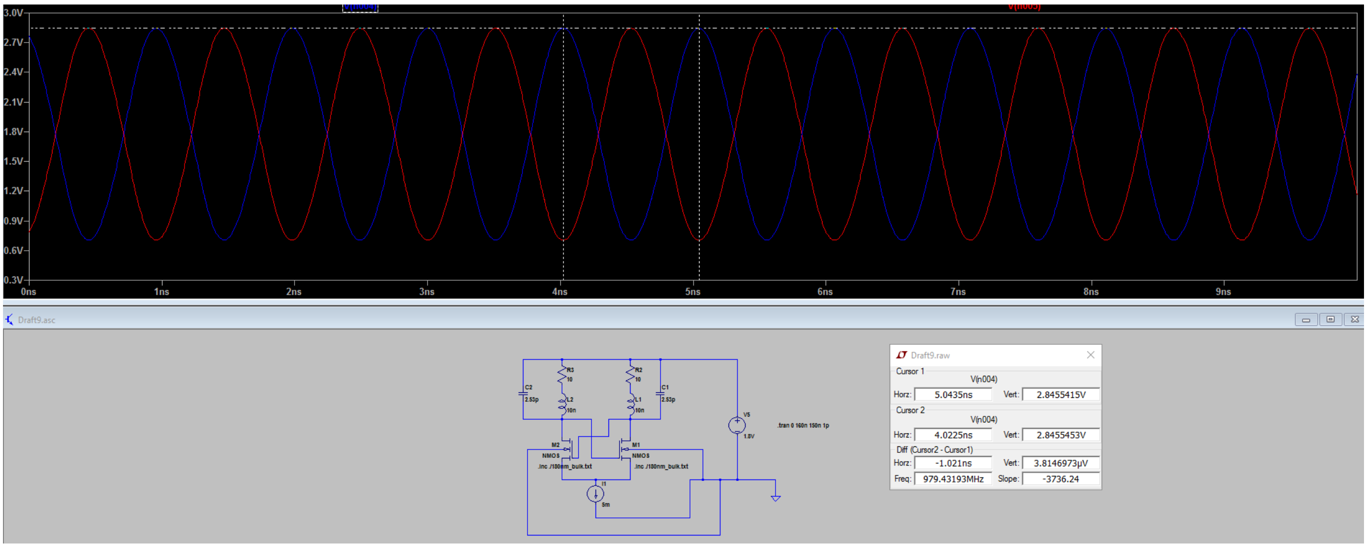
$$C_Y = 2C_B + C_{gd1Y} + C_{gd2} + C_{db1} + C_{gs2Y}$$

$$C_Z = C_{gs1} + C_{gd1X}$$

$\tau_X = \left(\frac{1}{g_{m2}} \| r_{o2}\right) C_X$ $\quad \tau_Y = R_D C_Y$ $\quad \tau_Z = \left[R_{sig} + \left(\frac{1}{g_{m2}} \| r_{o2}\right)\right] C_Z$

This time, we have three poles, bringing the total phase shift to 270°, thus this circuit can oscillate

Solution of 4) C value can be computed from $C = 1/(\omega^2 L) = 2.53\ \mathrm{pF}$.



At $I_{SS} = 2.12\ \mathrm{mA}$, the oscillation ceases.