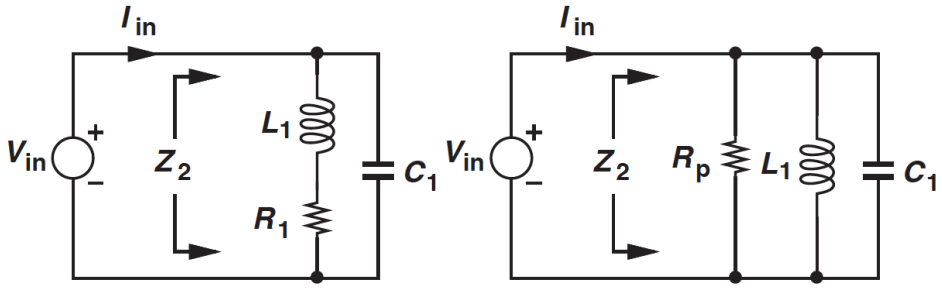
EHB 335E HW#7

Due: 17 January 2021 @22 o'clock – **No late homework will be accepted.**

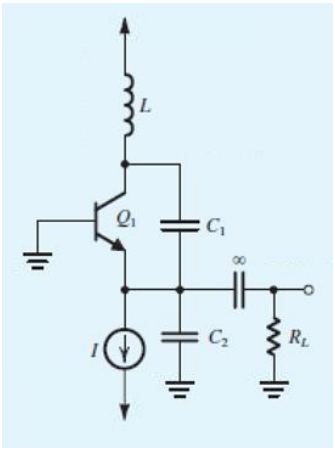
1) In this problem, you will analyze how the tank in Fig. 1(a) can be transformed to that in Fig. 1(b). Compute the impedance of each tank at a frequency $s = j\omega$ and equate the two impedances. Then, equate their real parts and do the same with their imaginary parts. Also, assume $j\omega L_1/R_1 \gg 1$, which means that the inductor has a high-quality factor $Q$.) Determine the value of $R_p$.

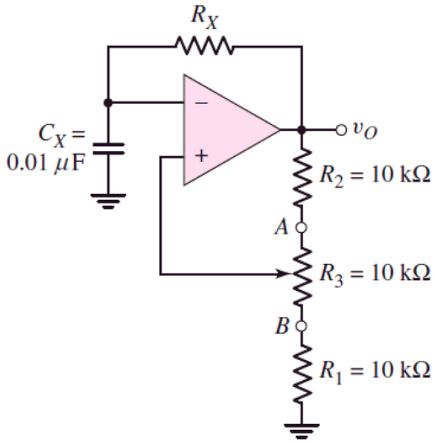



(a) (b)

Fig. 1: Circuit diagrams for question 1

2) For the Colpitts oscillator circuit shown in Fig. 2(a), derive an equation governing circuit operation and find the frequency of oscillation and the condition the gain $g_m R_L$ must satisfy to ensure that oscillations will start. Neglect $r_o$ of the BJT.
3) The saturated output voltages of the comparator in Fig. 2(b) are ±10 V. (a) Find Rx such that the frequency of oscillation is 500 Hz when the potentiometer is connected to point A. (b) Using the results of part (a), determine the oscillator frequency when the potentiometer is connected to point B.



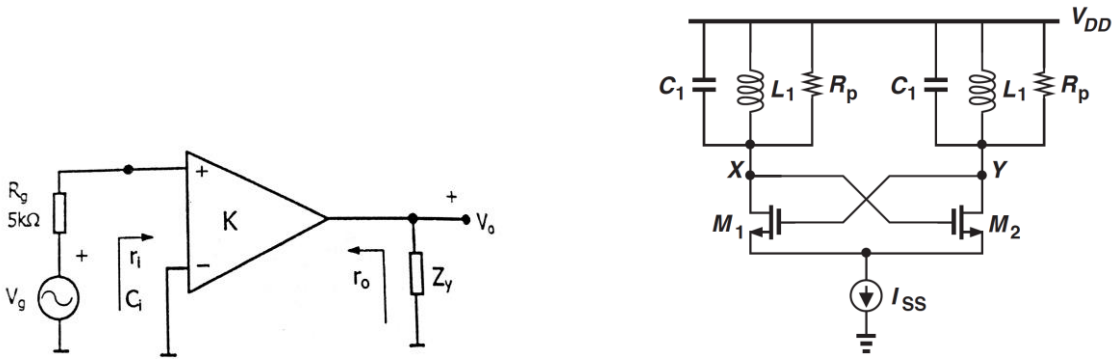




(a) (b)

Fig. 2: Circuit diagrams for questions 2 and 3

4) For the amplifier in Fig. 3(a), the unloaded voltage gain $A_{V,ul} = 100$, $r_i = 100k\Omega$, $C_i = 50pF$, and $r_o = 5k\Omega$. $C_o$ is negligible. The load impedance $Z_y$ is connected to the circuit, then the loaded voltage gain becomes $A_{V,l} = 70$, and the upper –3 dB cut-off frequency becomes 50 kHz. To increase the bandwidth of the circuit, how should an inductor $L$ be added to the circuit (series or parallel), and what would be the value of this inductor?

5) Simulate the cross-coupled oscillator of Fig. 3(b) with $W/L = 10/0.18\,\mu m$, $I_{ss} = 5$ mA, $L_1 = 10$ nH. Place a resistance of $R_s = 10\,\Omega$ in series with each inductor (and exclude $R_p$) and add enough capacitance from $X$ and $Y$ to the ground to obtain an oscillation frequency of 1 GHz. Plot the output voltages and the drain currents of $M_1$ and $M_2$ as a function of time. What is the minimum value of $I_{ss}$ to sustain oscillation? Take $V_{DD} = 1.8$ V.




(a) (b)

Fig. 3: Circuit diagrams for questions 4 and 5.