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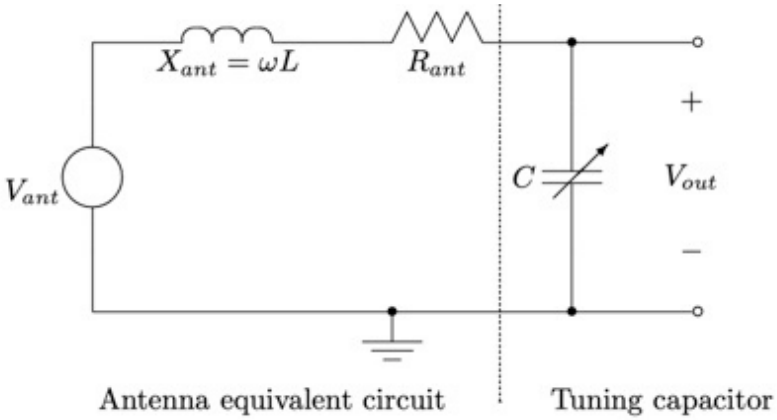
Prelab 2

3.1 (a)



$Z_L = j\omega L \quad Z_C = \frac{1}{j\omega C} \quad Z_R = R$.

$$H(j\omega) = \frac{V_{out}}{V_{ant}} = \frac{\frac{1}{j\omega C}}{j\omega L + R + \frac{1}{j\omega C}}$$

$$= \frac{1}{-LC\omega^2 + j\omega CR + 1}$$

$$\Rightarrow H(s) = \frac{1}{LCs^2 + CRs + 1}$$

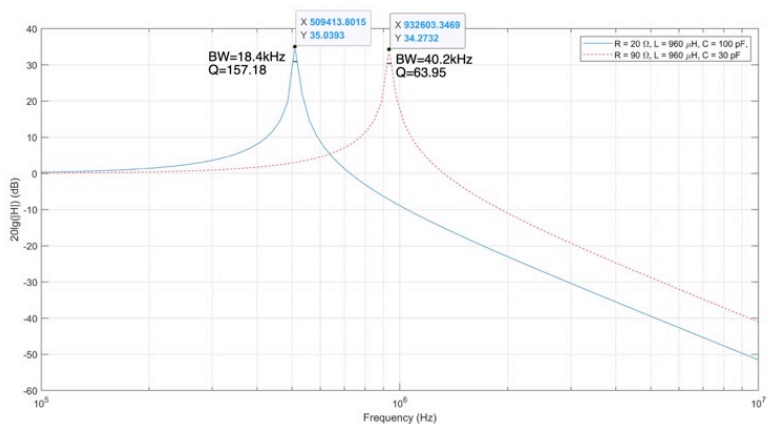
(b)

	Peak freq. (kHz)	3dB BW (kHz)	Quality Factor
C = 100 pF	514	3.32	155
C = 30 pF	938	14.9	62.9

Table from equation

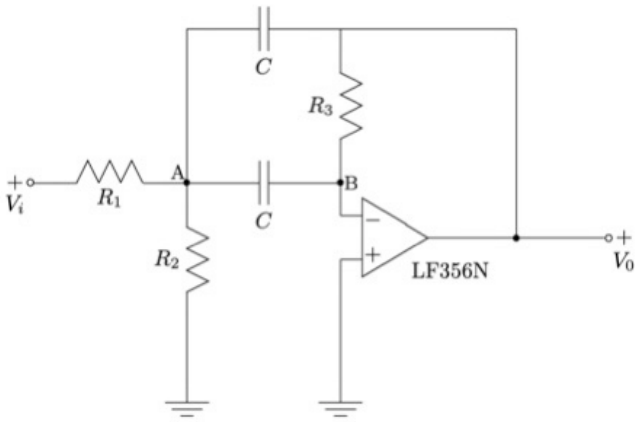
	Peak freq. (kHz)	3dB BW (kHz)	Quality Factor
C = 100 pF	521	18.4	157
C = 30 pF	954	40.2	64.0

Table from plot



3.2

(a)



$$\begin{cases} \frac{V_A}{R_2} + \frac{V_A - V_o}{\frac{1}{j\omega C}} + \frac{V_A}{\frac{1}{j\omega C}} = \frac{V_i - V_A}{R_1} \\ \frac{V_A}{\frac{1}{j\omega C}} = \frac{-V_o}{R_3} \end{cases}$$

$$\Rightarrow \frac{-V_o}{R_2 R_3}\left(\frac{1}{j\omega C}\right)^2 + \frac{-V_o}{R_3}\left(\frac{1}{j\omega C} - V_o\right) + \frac{-V_o}{R_3}\frac{1}{j\omega C} = \frac{1}{R_1} V_i \frac{1}{j\omega C} + \frac{V_o}{R_1 R_3}\left(\frac{1}{j\omega C}\right)^2$$

$$\Rightarrow V_o\left(-\frac{1}{R_1 R_3} - \frac{1}{R_2 R_3} - \frac{2}{R_3} j\omega C - (j\omega C)^2\right) = \frac{j\omega C}{R_1} V_i$$

$$\frac{V_o}{V_i} = \frac{-\frac{sC}{R_1}}{s^2C^2 + \frac{1}{R_1 R_3} + \frac{1}{R_2 R_3} + \frac{2sC}{R_3}} \Rightarrow$$

$$a_1 = -\frac{R_2 R_3 C}{R_1 + R_2} = -\frac{120 \times 10^3 \times 1.5 \times 10^{-9}}{10^3 + 120} = -1.61 \times 10^{-6}$$

$$a_2 = \frac{C^2 R_1 R_2 R_3}{R_1 + R_2} = \frac{(1.5 \times 10^{-9})^2 \cdot 10^3 \cdot 120 \cdot 10^3}{10^3 + 120} = 2.41 \times 10^{-12}$$

$$a_3 = \frac{2 R_1 R_2 C}{R_1 + R_2} = \frac{2 \cdot 10^3 \cdot 120 \cdot 1.5 \times 10^{-9}}{10^3 + 120} = 3.21 \times 10^{-7}$$

(b) $$H(s) = \frac{R_1 + R_2}{R_1 R_2 R_3 C^2} \cdot \frac{-R_2 R_3^2 C^2}{2(R_1 + R_2)} \cdot \frac{\frac{2}{R_3 C} s}{s^2 + \frac{2}{R_3 C} s + \frac{R_1 + R_2}{R_1 R_2 R_3 C^2}}$$

$$= \frac{-R_3}{2R_1} \cdot \frac{\frac{2s}{R_3 C}}{s^2 + \frac{2s}{R_3 C} + \frac{R_1 + R_2}{R_1 R_2 R_3 C^2}}$$

since $H(s) = H_0 \cdot \frac{\beta \cdot s}{s^2 + \beta s + \omega_0^2}$

$$|H_0| = \frac{R_3}{2R_1} = 5$$

$$BW_{3dB} \approx \beta = \frac{2}{C \cdot R_3} \cdot \frac{1}{2\pi} = 2.12 \times 10^4 \text{ Hz}$$

$$\omega_0^2 = \frac{R_1 + R_2}{R_1 R_2 R_3 C^2} \Rightarrow f_0 = \frac{\sqrt{\omega_0^2}}{2\pi} = 1.03 \times 10^5 \text{ Hz}$$

(c) According to the equation: $f_0 = 1.03 \times 10^5$ Hz,

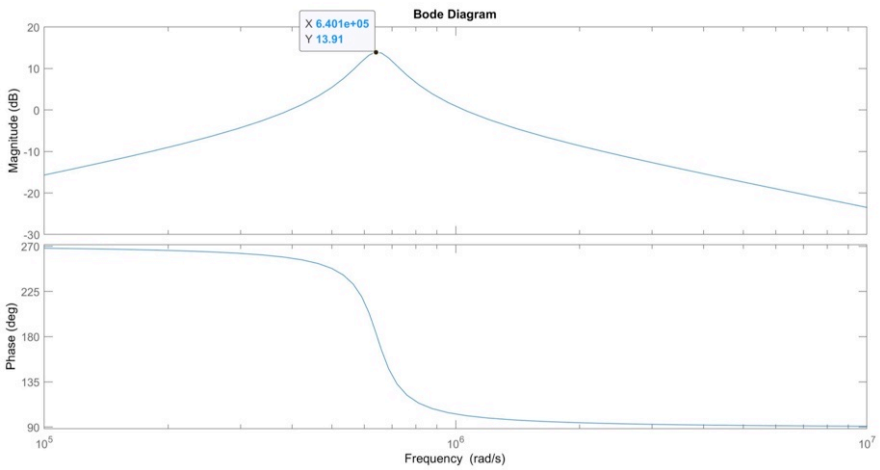
$BW_{3dB} = 2.12 \times 10^4$ Hz

$|H_0| = 5$

According to the plot : $f_0 = 1.02 \times 10^5$ Hz

$BW_{3dB} = 2.11 \times 10^4$ Hz

$|H_0| = 5$



3.3

(a) $f_{LO1} = f_C + f_{IF} = 1600 + 100 = 1700$ Hz

$f_{LO2} = f_C - f_{IF} = 1600 - 100 = 1500$ Hz

For f_{LO1} : $f_{imag1} = f_{IF} + f_{LO1} = 1800$ kHz

For f_{LO2} : $f_{imag2} = |f_{IF} - f_{LO}| = |100 - 1500| = 1400$ kHz

(b) $f_{LO1} = f_C + f_{IF} = 530 + 100 = 630$ kHz

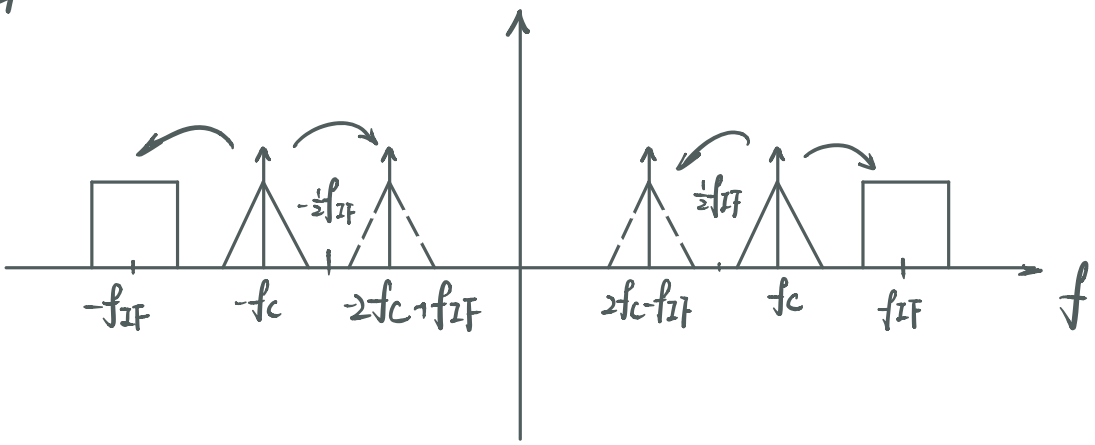
$f_{imag1} = f_{IF} + f_{LO1} = 100 + 630 = 730$ kHz

$f_{LO2} = f_C - f_{IF} = 530 - 100 = 430$ kHz

$f_{imag2} = |f_{IF} - f_{LO2}| = |100 - 430| = 330$ kHz

f_c (KHz)	f_{LO1} (KHz)	f_{LO2} (KHz)	f_{image1} (KHz)	f_{image2} (KHz)
1600	1700	1500	1800	1400
530	630	430	730	330

3.4



Using LO to Mix into IF Band when $f_{LO} = f_c - f_{IF}$, $f_c \in (\frac{1}{2}f_{IF}, f_{IF})$