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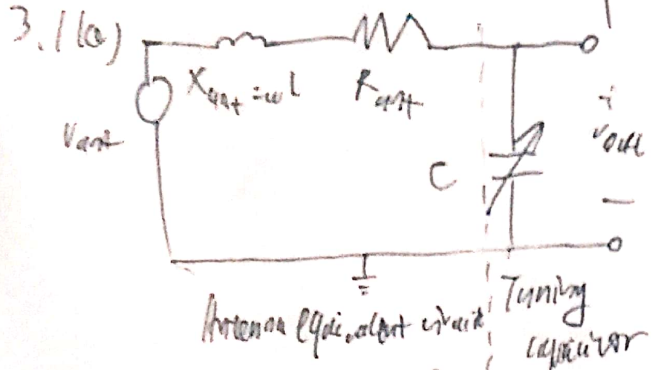
3.1(a)



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

The frequency response function

$$H(j\omega) = \frac{V_{out}(j\omega)}{V_{ant}(j\omega)} = \frac{\frac{1}{j\omega C}}{j\omega L + R + \frac{1}{j\omega C}} = \frac{1}{-\omega^2 LC + j\omega RC + 1}$$

$s = j\omega$

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

(b) Eq.(12.2.8) $f = \frac{1}{2\pi}\frac{1}{\sqrt{LC}}$ Hz or $\omega_{res} = \frac{1}{\sqrt{LC}}$ rad/s

Eq.(12.2.6) $BW_{3dB} = \frac{1}{2\pi}\frac{R}{L}$ Hz

Eq.(12.2.7) $Q = 2\pi f_{res}\frac{L}{R} = \frac{1}{\sqrt{LC}}\frac{L}{R} = \frac{1}{R}\sqrt{\frac{L}{C}} = \frac{f}{BW_{3dB}}$

Values read off from the plot:

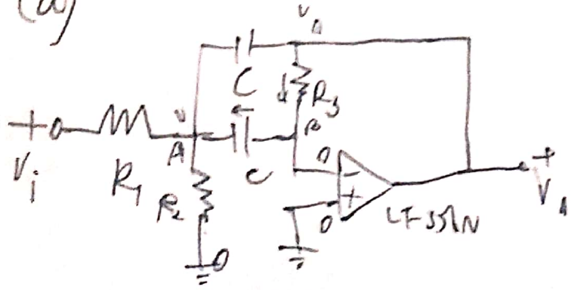
	Peak freq (kHz)	3dB BW (kHz)	Quality Factor
C=100pF	513.65	3.312	155.09
C=30pF	937.77	14.685	63.86

Values computed from the equations

	Peak freq (kHz)	3dB BW (kHz)	Quality Factor
C=100pF	513.67	3.316	154.92
C=30pF	937.83	14.921	62.85

Plot see attached pages

3.2 (a)



At node a

$$\begin{cases} \frac{V_i - V}{R_1} + \frac{V_o - V}{\frac{1}{j\omega C}} + \frac{V_o}{R_3} = \frac{V}{R_2} \\ V_o - V = \frac{V_o}{R_3}\left(R_3 + \frac{1}{j\omega C}\right) = V_o + \frac{V_o}{j\omega R_3 C} \end{cases}$$

$$V = -\frac{V_o}{j\omega R_3 C}$$

$$\frac{V_i}{R_1} + \frac{V_o}{j\omega R_1 R_3 C} + j\omega C V_o + \frac{2V_o}{R_3} = -\frac{V_o}{j\omega R_2 R_3 C}$$

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

$$H_{1c}(j\omega) = \frac{V_o}{V_i} = \frac{-1}{R_1} \Big/ \left(\frac{1}{j\omega R_2 R_3 C} + \frac{2}{R_3} + j\omega C + \frac{1}{j\omega R_1 R_3 C}\right)$$

$$= -\frac{1}{\frac{R_1}{j\omega R_2 R_3 C} + \frac{2R_1}{R_3} + j\omega R_1 C + \frac{1}{j\omega R_3 C}} = \frac{-j\omega R_2 R_3 C}{R_1 + 2j\omega R_1 R_2 C - \omega^2 R_1 R_2 R_3 C^2 + R_2}$$

$$= \frac{-j\omega R_2 R_3 C/(R_1+R_2)}{-\omega^2 \frac{R_1 R_2 R_3 C^2}{R_1+R_2} + 2j\omega \frac{R_1 R_2 C}{R_1+R_2} + 1} = \frac{-R_2 R_3 C/(R_1+R_2) \cdot s}{\frac{R_1 R_2 R_3 C^2}{R_1+R_2} s^2 + \frac{2R_1 R_2 C}{R_1+R_2} s + 1}$$

$$a_2 = \frac{R_1 R_2 R_3 C^2}{R_1+R_2} \quad a_3 = \frac{2R_1 R_2 C}{R_1+R_2} \quad H_{1c}(j\omega) = \frac{-\frac{R_2 R_3 C}{R_1+R_2} s}{\frac{R_1 R_2 R_3 C^2}{R_1+R_2} s^2 + \frac{2R_1 R_2 C}{R_1+R_2} s + 1}$$

$R_1 = 10^3\ \Omega \quad R_2 = 10^4\ \Omega \quad R_3 = 120\ \Omega \quad C = 1.5\times 10^{-9}\ F$

$$\boxed{\begin{aligned} a_1 &= -1.607\times 10^{-6} \\ a_2 &= 2.411\times 10^{-13} \\ a_3 &= 3.214\times 10^{-6} \end{aligned}}$$

(b) $H(s) = H_o \frac{\beta s}{s^2 + \beta s + \omega_n^2}$ $\quad H(j\omega) = H_o \frac{1}{\frac{\omega}{\omega_o} + j\frac{(\omega^2-\omega_o^2)}{\beta\omega_o/(\omega_o t \omega)}} \approx H_o \frac{1}{1 + j\frac{(\omega-\omega_o)}{\beta/2}}$, $BW_{3dB} \approx \beta$ when $\beta \ll \omega_o$

Formulas:

The peak value of the frequency response function H_o, the 3-dB bandwidth β

$$H_{1c}(s) = \frac{-\frac{1}{R_1 C} s}{s^2 + \frac{2}{R_3 C} s + \frac{R_1+R_2}{R_1 R_2 R_3 C^2}} = -\frac{R_3}{2R_1} \frac{\frac{2}{R_3 C} s}{s^2 + \frac{2}{R_3 C} s + \frac{R_1+R_2}{R_1 R_2 R_3 C^2}}$$

$\boxed{H_o = -\frac{R_3}{2R_1}}$ $\boxed{\beta = \frac{2}{R_3 C}}$, $\omega_o = \sqrt{\frac{R_1+R_2}{R_1 R_2 R_3 C^2}}$

Using eq. (2.5.2) through (2.5.5) that $\beta \ll \omega_o$ so we can use $BW_{3dB} \approx \beta$

The center of the passband in frequency

$$f = \frac{\omega_o}{2\pi} = \boxed{\frac{1}{2\pi}\sqrt{\frac{R_1+R_2}{R_1 R_2 R_3 C^2}}}$$

Eq. (2.5.4) shows $H(j\omega)$ achieves a maximum value of H_o at ω_o i.e. the peak value of the frequency response function

Numerical values: Substituting given values in formulas above

$\boxed{H_0 = -5}$ peak value of $H_{IF}(j\omega)$

$\boxed{B = 1.33 \times 10^5 Hz}$ 3dB bandwidth of IF

$\boxed{f = 1.025 \times 10^5 Hz}$ center of the passband

(c) The graph see attached pages

3.3 a) Carrier frequency $f_c = 1600 kHz$

IF filter centered at $f_{IF} = 100 kHz$ $f_c > f_{IF}$

LO frequency $f_{LO} = f_c - f_{IF} = 1500 kHz$

$f_{LO} = f_c + f_{IF} = 1700 kHz$

For $f_{LO} = 1500 kHz$ The frequency band centered at f_{imag} known as image band

$$f_{imag} = f_c + 2f_{IF} = 1800 kHz$$

For $f_{LO} = 1700 kHz$. $f_{imag} = |f_{IF} - f_{LO}| = |2f_{IF} - f_c| = 1400 kHz$

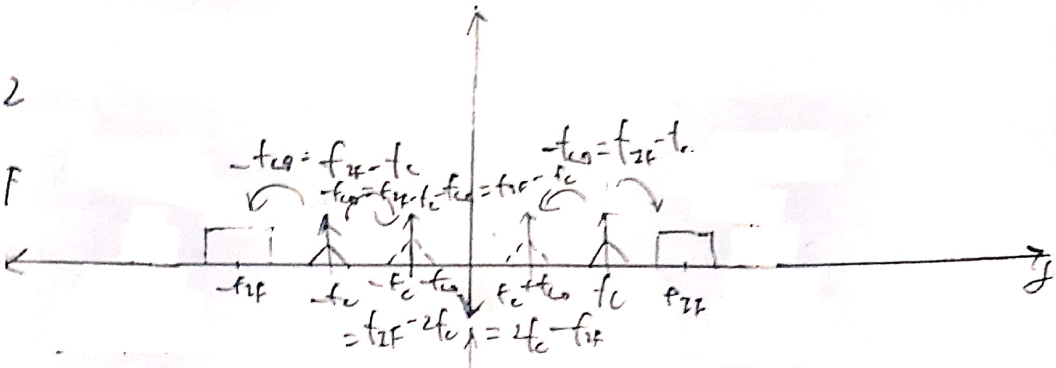
b) $f_c = 530 kHz$ $f_{IF} = 100 kHz$

LO frequency $f_{LO} = f_c - f_{IF} = 430 kHz$, image band center $f_{imag} = |2f_{IF} - f_c| = 330 kHz$

$f_{LO} = f_c + f_{IF} = 630 kHz$, image band center $f_{imag} = f_c + 2f_{IF} = 730 kHz$

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

3.4 Equivalents of Figs 2.4.2
that $\frac{1}{2}f_{IF} < f_c < f_{IF}$
$f_{LO} = f_c - f_{IF}$



Equivalents of Figs 2.4.3
that $\frac{1}{2}f_{IF} < f_c < f_{IF}$
$f_{LO} = f_c + f_{IF}$