EE 115 Lab 3 Supplement

Like lowpass filters, bandpass filters are also important. A bandpass filter (BPF) is always needed in the implementation of mixer which turns a message signal $m(t)$ into a bandpass signal such as $x(t) = m(t)\cos(2\pi f_c t)$. In this lab, let us examine an analog bandpass filter consisting of a source resistor R_s and a load resistor R, the latter of which is in parallel with an inductor L and a capacitor C. The transfer function of the RLC circuit from its input voltage to its output voltage is

$$H(s) = \frac{Z}{R_s + Z} \tag{1}$$

with

$$Z = \frac{1}{\frac{1}{R} + \frac{1}{sL} + sC}. \tag{2}$$

The frequency response of the BPF is $H(j2\pi f)$. The peak of $|H(j2\pi f)|$ is known to be at $f = f_0 = \frac{1}{2\pi\sqrt{LC}}$. The bandwidth of the BPF is in the order of $\frac{1}{RC}$ or $\frac{1}{R_s C}$, depending on how the bandwidth is measured. Here $R_s \ll R$. The 3dB bandwidth of $|H(j2\pi f)|$ can be defined to be 2Δ with $20\log_{10}\frac{|H(j2\pi(f_0+\Delta)|}{|H(j2\pi f_0)|} = -3$. The 30dB bandwidth of $|H(j2\pi f)|$ can be defined to be 2Δ with $20\log_{10}\frac{|H(j2\pi(f_0+\Delta)|}{|H(j2\pi f_0)|} = -30$. Assume $R_s = 50\Omega$ and $R = 5000\Omega$. Then to meet requirements on f_0 and the bandwidth, we have to choose L and C properly.

Perform the following tasks:

1) Design the RLC based BPF (i.e., choose a pair of values for L and C) so that $f_0 = 100$KHz and the 3dB bandwidth is 15KHz.
2) Design the RLC based BPF (i.e., choose a pair of values for L and C) so that $f_0 = 100$KHz and the 30dB bandwidth is 15KHz.

Hint: Since f_0 is given, then L and C are one-to-one related. Since R_s and R are given, the bandwidth is now determined by C. You can choose a proper range of C. And for each value of C, check if $20\log_{10}\frac{|H(j2\pi(f_0+\Delta)|}{|H(j2\pi f_0)|}$ meets the requirement at least approximately. For each value of C, also plot $20\log_{10}\frac{|H(j2\pi f|}{|H(j2\pi f_0)|}$ versus f around $f = f_0$ to assist your design. Also note that L is in Henry, C is in Farad, R is in Ohm, and f is in Hertz. Also note that a design problem almost always involves some known principles as well as trials and errors.