E4215: Analog Filter Synthesis and Design: HW5

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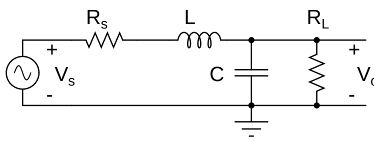

Figure 1:

1. (2 pts.) Determine $V_o(s)/V_i(s)$ for the filter in Fig. 1. For a given R_s, determine R_L such that Q is maximum. What is the maximum Q? What is ω_p under this condition?

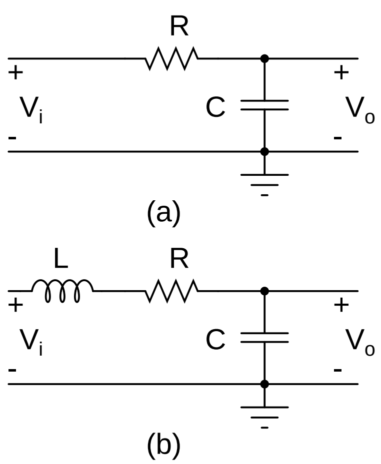

Figure 2:

2. (2 pts.) What is the bandwidth of the circuit in Fig. 2(a)? If you were allowed to place a series inductor L as in Fig. 2(b), what value would you choose for it to maximize the bandwidth without introducing peaking in the magnitude response? What is the resulting bandwidth? Sketch the frequency responses of the two circuits.

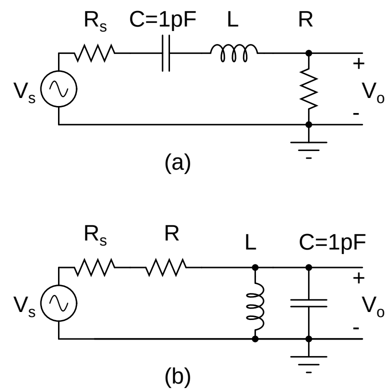

Figure 3:

3. (4 pts.) For each of Fig. 3(a) and Fig. 3(b), (a) Assuming $R_s = 0$ determine L and R so that a bandpass filter with $\omega_p/2\pi = 5\,\text{GHz}$[1] and a -3dB bandwidth of 1 GHz is realized. (b) If $v_s(t)$ is a 1V sinusoid at $5\,\text{GHz}$, what is the current flowing through the input source? (c) What is the value of R_s, the source resistance, that results in a 10% deviation in Q?

4. (5 pts.) In Fig. 4 consider two cases $R_1 = R_2 = R$ and $R_1 = 2R, R_2 = R/2$.

   For each of these, (a) Find $V_1(s)/V_i(s)$ Is there a difference? (b) Evaluate $V_k(s)/V_i(s)$, $k = \{2, 3\}$ Is there a difference? What is the maximum of $|V_k(j\omega)/V_i(j\omega)|$? (c) The input is a sinusoid $v_i(t) = V_{ip}\cos(\omega t)$ where ω can be

[1] This means that $\omega_p = 2\pi \times 5\,\text{Grad/s}$

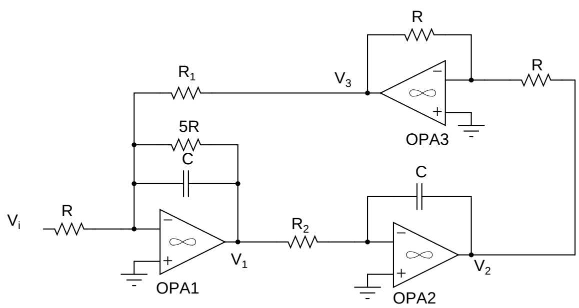

Figure 4:

anything. If the opamps have a swing limit of 1V, what is the largest V_{ip} that can be applied while maintaining all the opamps in the linear region?

5. (3 pts.) (a) Design a second order g_m-C Butterworth filter with dc gain=1 and -3dB bandwidth=1 MHz. Assume that the smallest g_m is 10 μS. Give the transfer function and all the component values in the g_m-C filter schematic.

   (4 pts.) (b) Using the above filter as the basis, design a lowpass notch filter with dc gain=10 and a notch at $\sqrt{10}$ MHz. Use the voltage summing technique. Give the transfer function and all the component values in the g_m-C filter schematic. What is the high frequency gain of this filter? What is the attenuation of the filter at 1 MHz w.r.t. dc? Has the -3dB bandwidth increased or decreased compared to the filter in (a)?