

EE 302 PS 05 - SOLUTIONS

Problems: 1, 2, 3, 4, 5

Problem 1

A band-reject filter.

Problem 2

$$f_{co} = \frac{R}{2\pi L} \rightarrow R = 2\pi f_{co}L = 1256.7 \Omega$$

Problem 3

3.a. Filtering at $f_r = 104.1$ MHz:

$$Q = \frac{f_r}{BW} = \frac{104.1 \text{ MHz}}{200 \text{ kHz}} = 520.5$$

3.b. Filtering at $f_r = 10.7$ MHz:

$$Q = \frac{f_r}{BW} = \frac{10.7 \text{ MHz}}{200 \text{ kHz}} = 53.5$$

Problem 4

4.a. Highpass filter.

4.b.

$$f_{co} = \frac{1}{2\pi RC} = \frac{1}{2\pi(2.2 \Omega)(9.0 \times 10^{-6} \text{ F})} = 8.038 \text{ kHz}$$

4.c. See Figure 1 for the schematic.

$$L = \frac{R}{2\pi f_{co}} = \frac{2.2 \Omega}{2\pi(8.038 \text{ kHz})} = 43.6 \mu\text{H}$$

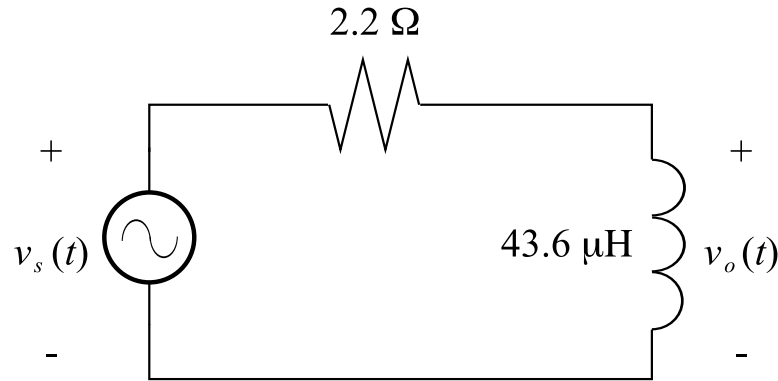


FIGURE 1. RL highpass figure for Problem 4.c.

Problem 5

5.a.

$$f_r = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{(6.366 \times 10^{-3} \text{ H})(15.92 \times 10^{-6} \text{ F})}} = 499.94 \text{ Hz}$$

$$Q = \frac{2\pi f_r L}{R} = \frac{2\pi(499.94 \text{ Hz})(6.366 \times 10^{-3} \text{ H})}{1 \Omega} = 19.997$$

$$BW = \frac{f_r}{Q} = \frac{499.94 \text{ Hz}}{19.997} = 25.00 \text{ Hz}$$

5.b. By the voltage divider rule, we can determine that the output voltage is:

$$\mathbf{V}_o = \mathbf{V}_s \frac{\mathbf{Z}_R}{\mathbf{Z}_{ser}}$$

where $\mathbf{Z}_R = R$ and \mathbf{Z}_{ser} is the total impedance of the series-RLC circuit ($\mathbf{Z}_{ser} = R + jX_L - jX_C$). At resonance, $X_L = X_C$ so that \mathbf{Z}_{ser} reduces to $\mathbf{Z}_{ser} = R$. Therefore,

$$\mathbf{V}_o = \mathbf{V}_s \frac{\mathbf{Z}_R}{\mathbf{Z}_{ser}} = \mathbf{V}_s \frac{R}{R} = \mathbf{V}_s$$

$$P_R = \frac{V_R^2}{R} = \frac{V_o^2}{R} = \frac{V_s^2}{R} = \frac{(2.0 \text{ V}_{\text{rms}})^2}{1 \Omega} = 4 \text{ W}$$

5.c. The hint clues us in to the fact that 512.5 Hz is the upper cutoff frequency. First, we recognize that this is a high-Q circuit since $Q \geq 10$. This enables us to assume that the peak's bandwidth is symmetric about f_r and thus $f_1 = f_r - BW/2$

and $f_2 = f_r + BW/2$. A mental calculation of the upper cutoff frequency yields $f_2 \approx 512.5$ Hz. We know that cutoff frequencies are defined as the frequencies at which power P_R dissipated in the resistor drops to one half of its peak (resonant) value. We calculated the peak value to be 4 W, so P_R at the cutoff frequency $f = 512.5$ Hz is 2 W.