EE 110, Winter 2016, Design Project: due March 09, 2016 in class

Goal: Your fancy audio system is powered by a so-called "switching mode power supply (SMPS)" that corrupts (adds) an undesired 10kHz signal to the audio signal (10Hz–50kHz) that you desire to amplify and eventually send to your speakers. Your goal is to design a circuit that removes the 10kHz signal from the corrupted signal.

Recommended Circuit: You will need a so-called notch or band-reject filter with a center frequency of ~~60Hz~~10kHz. Figure 1 shows an example circuit that you may want to consider.

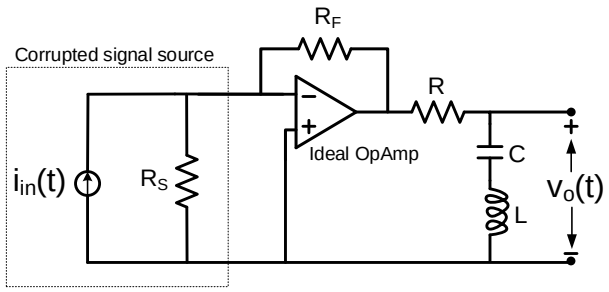

Figure 1

Specifications:

1. The corrupted signal is available as a current source with source impedance of 10 kOhms
2. The output of your circuit should be a voltage signal
3. Notch bandwidth should be ≤ 2kHz
4. For 10μA amplitude sinusoidal input in the passband, output sinusoidal voltage amplitude should be 100mV
5. For 10μA 10kHz sinusoidal input, the output sinusoidal amplitude should be ≤ 2mV

Constraints:

1. The only inductors available to you are L=100mH inductors with a series resistance of 10 Ohms (not shown in Figure 1)
2. Do not use resistors larger than 200kOhms; using multiple 200kOhm resistors in series to realize a larger resistor is also not allowed.

Assumptions:

1. Ideal operational amplifiers (infinite gain, infinite input impedance i.e. zero input current, zero output impedance) are available for your use.

Suggested Procedure:

1. Derive the transfer fuction of your circuit to cofirm that it is indeed a notch filter
2. Derive expressions for the notch frequency and the notch bandwidth (similar to the BPF case, as explained in class)
3. Derive an expression for the pass-band gain (far away from the desired notch frequency): this will tell you how large the sinusoidal output voltage amplitude would be for a given passband sinusoidal current input amplitude
4. Derive an expression for the the stop-band gain (i.e. at the notch frequency): this will tell

you how large the sinusoidal output voltage amplitude would be for a given sinusoidal current input amplitude at the notch frequency

5. Using the expressions derived above and the given specifications and constraints, choose component values

Deliverable Report:

1. Expressions for your design formulae (transfer function, notch frequency, notch band-width, pass-band gain, and stop-band gain). A schematic of your design clearly showing the component values
2. Clearly marked Bode plots of the magnitude and phase response of the filter circuit you have designed.
3. Expected steady state output voltage for $i_{in}(t) = 10\cos(2*pi*9x10^3t)$ uA.
4. An Appendix showing all derivations and calculations.

Extra Credit (25% extra):

1. Design to meet a revised, more stringent specification #5: the output sinusoidal voltage amplitude for 10μA 10kHz sinusoidal input should be ≤ 20μV

Notes:

1. The main report (excluding the amplitude) should be no more than 2 pages (single-sided).
2. The Appendix should be no more than 4 pages (single-sided). You will be graded based on your main report; the Appendix will be used mainly to prevent plagiarism.
3. You are not restricted to the recommended circuit shown in Figure 1. You are free to develop your own circuits. Transformers and dependent sources other than explicit OpAmps are not allowed.

Change Log:

Date	Changes
02/19/2016	Created original.
02/22/2016	Fixed a typo in the “Recommended Circuit” section
02/22/2016	Fixed a typo in the “Specifications” section
02/24/2016	Fixed the same (as above) in the “Extra Credit” section