Spring 2004; E4215: Analog Filter Synthesis and Design; Channel selection filter

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due on 5 May 2004

1 Description

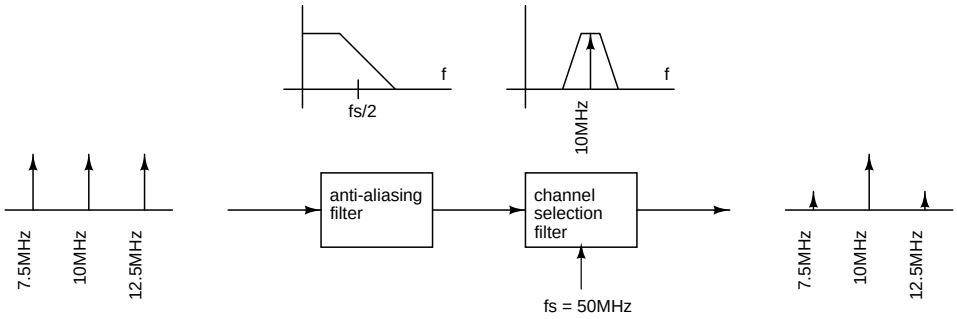

Figure 1: Filter, input and output spectra

2 Filter specifications

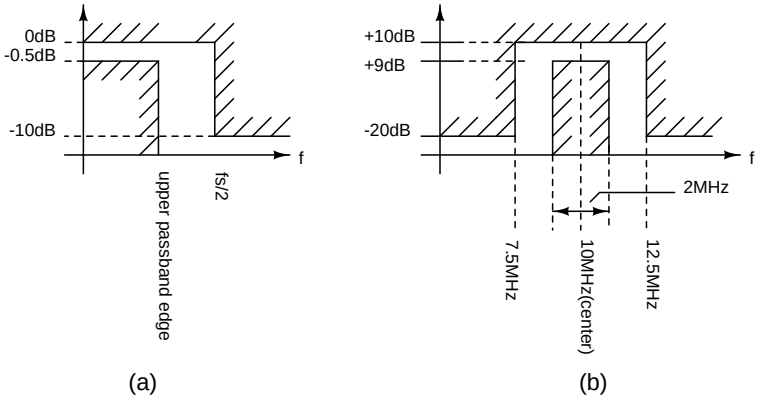

Figure 2: Magnitude response specifications for (a) antialiasing filter (Butterworth), (b) channel selection filter

Signals centered at multiple freuqencies (2.5MHz apart) are input to a filter which is required to pick out the channel around 10 MHz. Fig. 1 schematically shows the input and the output spectra. Your job is to design a switched capacitor channel selection bandpass filter (sampling rate = 50 MHz) and an antialiasing filter that precedes it. The channel selection filter and the antialiasing filters should satisfy the specifications in Fig. 2.

- You can use any of the magnitude response approximations for the channel selection filter. For the antialiasing filter, use Butterworth. You can use ladder/cascade, opamp-RC/g_m-C, bilinear/backward euler transformations for the two filters (as applicable).
- The transfer function from the input of each filter in Fig. 2 to each of the opamp/g_m outputs in that filter should have equal maxima.
- The total capacitance used in the channel selection filter must be 5$\times$(5.xx) pF and in the antialiasing filter should be 2.xx pF where xx are the last 2 digits of your CUID/social security number.

3 Project submission

1. Give a clear description of the following in your report.
   - Derivation of the prototype from the specs in Fig. 2. Transformation of the prototype to the desired filter poles-zeros/transfer function.
   - Detailed design of the antialiasing and channel selection filters with all the relevant component values (C, R, g_m).
   - Scaling the filters to have equal maxima in the ac response at all opamp/$g_m$outputs. Scaling the channel selection filter to use a total capacitance of 5.xx pF and the antialiasing filter to have a total capacitance of 2.xx pF.
   - A complete schematic with all the component values. Use a sensible hierarchy so that the design is understandable. Report the capacitor spread (ratio of the maximum to the minimum value) in the switched capacitor filter.
2. Before the due date (5 May 2004, 5pm) e-mail me your cadence library path that contains the project, and the name of the topmost cell in your hierarchy.
3. Submit the following simulation results.
   - Frequency response: magnitude response of the prototype lowpass filters; response of the designed channel-selection and antialiasing filters; What is the attenuation at 7.5 MHz and 12.5 MHz? Are they what you expect?

     Magnitude response from the input to each of the opamp outputs, for the two filters, overlaid on the same plot.

- Transient response: Simulate the channel selection filter with the three inputs provided. For each input, simulate the system with and without the antialiasing filter. Explain the results. Show the input and output plots in time and frequency domains.

4 Simulation/modeling

- You can generate a voltage source with an arbitrary waveform using the voltage source **vpwlf** in the library **analogLib**. You need to specify a file that has the voltage values at certain time points. The three input files are **nkrishna/courses/E4215/project/E4215proj_in1.dat**, **nkrishna/courses/E4215/project/E4215proj_in** and **nkrishna/courses/E4215/project/E4215proj_in3.dat**.
- Model the opamps using ideal voltage controlled voltage sources with gain=10k. Model the g_ms using ideal voltage controlled current sources.
- For simulating the frequency response of the switched capacitor filter, use the techniques discussed in the class and used in preivous homeworks.

5 Report

The report should be a single coherent document containing all the figures and text.

6 Timeline

There are 6 weeks to the project deadline. Budget 3 weeks for design and 3 weeks for simulation and writing the report. The design can be started with what you have learned in the class so far. For the prototype filter you can consult A. I. Zverev, *Handbook of Filter Synthesis*, Wiley, New York, 1967, which is a non circulating reference in the Engineering library; or use MATLAB. `butter, cheby1, cheby2, ellip, buttord, cheb1ord, cheb2ord, ellipord, freqz, freqs` are some relevant commands.