Assignment #4

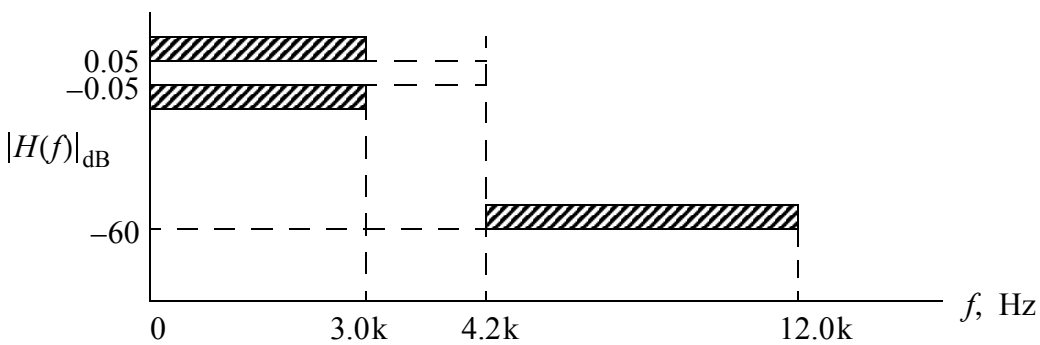
Due April 9, 2013

Make Note of the Following:

- This assignment will also be written up more like a lab report
- Include the observations made from the scope etc., also include a block diagram of how the test equipment is configured around the OMAP-L138 and AIC3106, etc.

Problems: Real-Time FIR Digital Filters

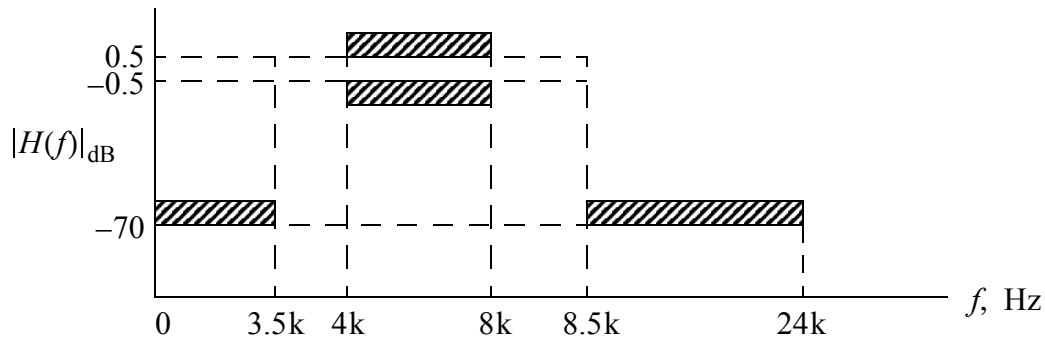
1. Direct Form FIR for Even Symmetric Fixed-point Coefficients:
   a.) Develop and write a filtering algorithm similar to `fir_short_aic3106.c` and `fir_float_aic3106.c`, that implements the modified (*folded*) direct form FIR structure depicted on page 7–6 of the notes. Assume that the filter has $M + 1$ coefficients, and M is even. Implement your design using Q15 arithmetic in C. Try to use the intrinsic functions. Note you will get a chance to test your algorithm in part (d).
   b.) Using a 24 kHz sampling rate on the AIC3106, design a lowpass filter using `fdatool` and an equiripple FIR response, that satisfies the amplitude response specifications shown below.



   Provide MATLAB design information, including magnitude and phase response plots. Your plots should use a digital frequency axis scaled to the actual sampling frequency.
   c.) Verify the filter real-time frequency response by placing the coefficients in the folded FIR direct form filtering program of part (a). For verification all you need to obtain is the frequency response magnitude in dB. The best approach is probably to use the vector network analyzer, but optionally you may drive the filter routine with the noise generator code used in Homework 3, and collect output signal samples using Goldwave and the PC audio input.
   d.) Profile your new folded FIR filter algorithm under `-o3` optimization and compare it with the simple FIR direct form algorithm in `fir_short_`

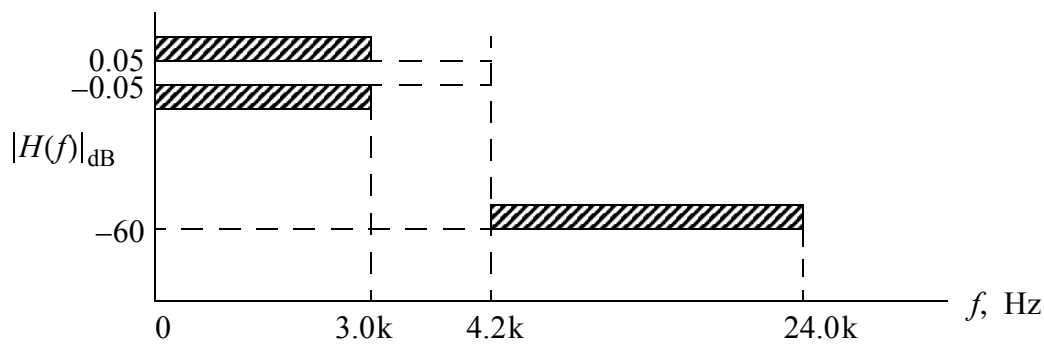
`aic3106.c` and also using the C-based circular buffer FIR filter program discussed in the notes. For each algorithm determine without any further optimization, what the maximum sampling rate could be without loss of real-time performance. The GPIO signals should be useful here. Direct profiling should also be checked for consistency.

2. The goal objective is to have the experience of working with a large filter order and be challenged with finding a workable solution. As a filter design create an equiripple FIR bandpass filter in fixed-point to meet the following response requirements:



The filter order should be $M = 217$, which means the number of taps is 218. The closest power of two is 256. Can this filter be implemented using `fir_short_ aic3106.c`? Does the use of a circular buffer help? How about C optimization?

3. Implement the lowpass filter design similar to Problem 1 on the VC5505/C5515 eZdsp using `Int16` coefficients. Use the AIC3204 code developed in Set #3 or an improved interrupt driven version, if one is available. Notice that the sampling rate is increased to 48 ksps, but the filter critical frequencies and amplitude response characteristics remain the same as for the 24 ksps design in Problem 1. Can the same coefficients be used? Provide MATLAB design infor-



mation, including magnitude and phase response plots. Your plots should use a digital frequency axis scaled to the actual sampling frequency. Implement a standard direct-form filtering algorithm in C. For verification you need to obtain a plot of the frequency response magnitude in dB.