

EECS 361
Homework #16

1. Section 6.22 Participation Activities

- 6.22.1: Data window properties.
- 6.22.2: Data window equations.
- 6.22.4: Cosine signal spectra with rectangular and Hamming data windows.
- 6.22.5: Rectangular and Hamming data windows reveal presence of cosine signal components.
- 6.22.6: Rectangular and Hamming data windows with a small-magnitude cosine signal.

2. (Concept: Properties of data windows)

Use the **Discrete Fourier Transform of a Two-Tone Signal** to answer the following questions. Set the noise amplitude to 0.1 for this problem. Note the frequency of the fix tone is 770 Hz and the sample rate is 8000 samples/sec. Use the dBV scale.

- a. For $N = 512$ what is the record length and Δf .
- b. Set the sine frequency = 910 Hz and the sine amplitude = 0.5.

Describe and explain the change as N changes from 512 to 1024 to 4096.

- c. Set the sine frequency = 900 Hz and the sine amplitude = 0.5 and $N=512$. Describe and explain the change as the window is changed from rect to Hanning to Blackman.

3. Section 6.24 Participation Activities

- 6.24.1: Discrete filter terminology.
- 6.24.2: Lowpass filter designed by windowing.

4. Section 6.26 Participation Activities

- 6.26.1: Resonant IIR filter designed using impulse invariance.

5. (Concept: IIR filter design)

A system uses a sampling frequency of 1000 samples/sec. Design a first order IIR LPF with a 3dB bandwidth=100 Hz and DC response = 1. Provide the transfer function and implementation, difference equation. Verify your design. Hint: Use **Design a first order LPF with specified 3dB bandwidth.**

6. (Concept: Given an IIR filter design, applying the frequency sampling approach to designing an approximate FIR filter)

A system uses a sampling frequency of 1000 samples/sec. Design an 7-tap FIR LPF using the IIR Transfer Function from problem 5 and the IDFT. The specified 3dB bandwidth= 100 Hz and DC response = 1. Provide the transfer function and implementation and difference equation. Validate your design, i.e., report the $20 \text{ Log}(\text{Abs}(H(e^{j\Omega_{3dB}})))$. Compare the magnitude of the transfer functions from problems 5 and 6.

Remember that $H(z)$ sampled on the unit circle is the DFT of $h[n] = \{h[0], h[1], \dots, h[N]\}$. Sample $H(z)$ of the IIR filter on the unit circle take the IDFT of the 8 samples find to $h[n] = \{h[0], h[1], \dots, h[7]\}$. Verify your design. Does the 7-tap FIR have linear phase.

Hint: Use **Comparison of FIR and IIR filter designs**

7. (Concept: FIR filter design by frequency sampling and solution to a system of linear equations)

A system uses a sampling frequency of 1,000 samples/sec. Design an 5-point linear phase FIR LPF. The specified 3dB bandwidth= 100 Hz and DC response = 1. Use the FIR filter design by **frequency sampling**, i.e., specify $M[e^{j\Omega_i}]$ for Ω_i for several values of i and solve for the filter coefficient values. This will require solving a set of three linear equations in three unknowns. You can use an on-line solver, e.g., **3 Equation System Solver**. Consider a causal implementation of the filter and validate that your selection meets the design specification. Provide the transfer function and implementation, i.e., the difference equation for a causal implementation of the filter.

Hint: See: **Linear phase FIR 5 tap LP filter with a 3dB bandwidth of 400 Hz with a same rate of 2000 samples/sec**

8. (Concept: Comparison of digital filter design methodologies)

Compare the designs in problems 5, 6, and 7 in terms of how well each design meets the design specification and computational requirements. Try to put the frequency response (in dB) of each filter on the same plot.

See **Comparison of FIR and IIR filter designs**

9. (Concept: Comparison of digital filter design methodologies)

The BPF specified in Homework 14 Problem 12 has 2-zeros at zero and poles at $0.9 e^{-j\frac{\pi}{8}}$ and $0.9 e^{+j\frac{\pi}{8}}$.

An approximate FIR filter is designed using frequency sampling.

Use **FIR design by frequency sampling for first and second order filters** to find the number of taps needed such that the FIR magnitude response approximately matches the IIR filter. Provide a screen shot of your answer. Comment on the difference in computational requirements.