ECE 3304 Discrete Time Signals and Systems Final Exam – Take Home Portion

Name:

I hereby declare that I have worked on my own on the problems in this take-home portion of the final exam. I have not asked any human being for help nor have I used results given to me from classmates or any student previously enrolled in this course (including possibly myself). I have listed all resources I used to solve the problems (website, textbooks, youTube videos, etc.) at the end of each question.

I understand that providing incorrect information is considered academic dishonesty and will be filed as such with the TTU office of student conduct.

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Signature Date

Problem 1: Signal Analysis, IIR Filter Design, and Filter Implementation

The .wav-file *noisy_chirp.wav* contains 4 seconds of a linear chirp signal contaminated by noise.

1. The squared magnitude spectrum $|X(e^{j\Omega})|^2$ provides the power spectral density of the signal. In MATLAB, use the Fast Fourier Transform command to calculate $|X[k]|^2$ and graph it over the normalized frequency Ω. What is the relationship between k and Ω and the physical frequency in hertz?
2. Determine the range of frequencies (in Hertz) that are part of the chirp signal and the frequency band in which the noise is present. Explain how you proceeded.
3. Using MATLAB's filterDesigner, design an IIR filter of max. order of 10 that removes the noise from the signal. Explain how you chose your design parameters. Export your IIR filter using File > Generate MATLAB Code > Filter Design Function. Graph the filter magnitude and phase frequency responses and the pole-zero plot. Is your filter stable? Justify your answer!
4. What filter order would be required for an FIR filter with the same design parameters? Export your IIR filter using File > Generate MATLAB Code > Filter Design Function. Graph the filter magnitude and phase frequency responses and the pole-zero plot. Which filter do you prefer?
5. MATLAB implements IIR filters as a cascade of order 2 filters (second order sections, SOS). Convert the filter structure to a single IIR filter of order N (Nmax=10). Graph the magnitude and phase frequency response and the pole-zero plot of the filter you obtained and compare it to the original design. Are there any differences? If yes, why? Which implementation do you prefer?
6. Filter the noisy signal and record your result. During what time duration is the chirp signal unrecoverable? Why? Were you successful in removing the noise for the remaining time of the signal?
7. While the signal properties change with time (increasing pitch) the statistical properties of the noise remain the same. For a duration of 1 second of the signal, separate the noise from the chirp signal by filtering the noisy signal with an appropriate filter. What time period did you choose and how did you design your filter? Export your filter using File > Generate MATLAB Code > Filter Design Function. Graph the filter magnitude and phase frequency responses and the pole-zero plot. Is your filter stable? Justify your answer!