EE322 Second MidTerm Exam

Spring 2000

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Instructions: You are permitted to use a **self-prepared** study-guide limited to one ($8\frac{1}{2}$" × 11") page (both sides). The duration of this test is 75 minutes. Show all the intermediate steps for credits.

1. (10 pts.) Z-transform and FIR filter

   (a) The impulse response of a LTI system is given as follows.

   $$h(n) = \begin{matrix} \{ & 1 & 2 & -1 & 0 & -3\} \\ n = & -1 & 0 & 1 & 2 & 3 \end{matrix}$$

   Find its transfer function $H(z)$ and R.O.C.

   (b) Given the transfer function of a LTI system,

   $$H(z) = 2z^{-2} + 1 - 0.5z^{-4},$$

   find its impulse response.

2. (10 pts.) A LTI system is described by a transfer function

   $$H(z) = z^{-1} - 0.6z^{-2} + 1.2z^{-4}.$$

   (a) Find its difference equation representation of the system.

   (b) Draw the implementation diagram in direct form.

   (c) Draw the implementation diagram in transposed direct form.

3. (15 pts.) A LTI system is described by its impulse response

   $$h(n) = 2^n[u(n-1) - u(n-5)].$$

   For an input signal $x(n) = (-1)^n$ for $n = -2, -1, 0, 1, 2, 3$, use convolution sum to find the output signal $y(n)$.

   (a) Find start index, S_y, ending index, E_y and length, L_y of the output signal.

   (b) Show the convolution calculation and list the output signal $y(n)$ in a table with correct index.

4. (25 pts.) A LTI system has five zeros: $z_{1,2} = 0.9e^{\pm j\frac{\pi}{4}}$, $z_{3,4} = \pm j$ and $z_5 = -1$.

   (a) Plot the pole/zero diagram of the digital system.

   (b) Find transfer function $H(z)$.

   (c) sketch the magnitude frequency response of the digital system (with exact frequency and amplitude labels on some key frequency points).

(d) What kind of frequency selective filter is this system?

(e) Find the steady state response $y_{ss}(n)$ of the digital system to the input signal

$$x_a(t) = 2 + 2\sin(200\pi t + \frac{\pi}{4}) - 3\cos(400\pi t + 2)$$

sampled at $f_s = 800$ Hz.

5. (20 pts.) A moving average (running sum) filter is given as

$$H(z) = \frac{1}{N}\sum_{k=0}^{N-1} z^{-k}$$

where $N = 10$.

(a) Is it a linear phase filter? Reasons?

(b) What is the group delay of the system?

(c) Find all the zeros? Plot the pole/zero diagram.

(d) If this filter is used to process a signal sampled at $f_s = 10$ KHz, list all the nulling frequencies (eigenvalues equal to zero at those frequencies).

6. (20 pts.) An EKG medical signal $x_m(t)$ is acquired via a digital instrument. The bandwidth of the medical signal is 360Hz. The medical signal is also contaminated by the 60 Hz sinusoids and its harmonics. Design a comb (nulling) filter to remove all of the sinusoidal interferences less than the folding frequency.

7. (Optional 10 pts.) Following the problem 6,

(a) Subplot pole/zero diagram and frequency response of your designed system.

(b) Generate the measured signal using simulation,

$$x_a(t) = x_m(t) + \text{sinusoidal interferences}$$

for $0 \le t \le 1$ second where $x_m(t)$ is simulated by a chirp signal with Matlab^{TM} function chirp() as follows.

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T  = 1/fs; % using the fs in your design
t  = 0:T:1;
xm = chirp(t,20,1,360);
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It generates one second chirp signal from 20 Hz to 360 Hz at the sampling frequency that you selected. Subplot the simulated signal $x_a(t)$ and the desired signal $x_m(t)$ and their magnitude Fourier spactra. You can use the same "t" time vector to generate sinusoids.

(c) Filter the signal using the nulling filter that you designed. Subplot the output signal and its magnitude Fourier spectrum.

E-mail your Matlab m-file on May 12 (Friday) by 16:00. The m–file must be executable (total of 8 subplot(4,2,k) in one figure). The first line of you m–file must be %your name.

Please hand in your one-page study guide with the test book to avoid 20% off penalty.