ECE486 Test 2, In Class Portion
April 16, 2008
Closed Book, Closed Notes, No Calculators or Computers

When you are finished with this portion of the exam, turn it in and go to work on the computer portion. After you turn this exam in, you may not return to this part of the test.

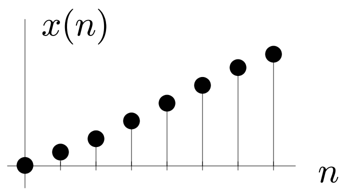
1. Let $h(n)$ and $x(n)$ be

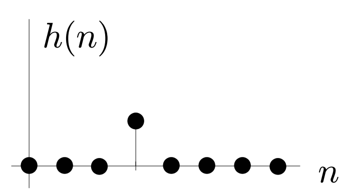
$$x(n) = \begin{cases} n, & n = 0, 1, 2, \ldots, 7 \\ 0 & \text{Elsewhere.} \end{cases} \qquad h(n) = \delta(n-3),$$

and define $X(k)$ and $H(k)$ as the 8-point DFTs of $x(n)$ and $h(n)$.

(a) Find and sketch the inverse-DFT of the product $X(k)H(k)$.

(b) Find and sketch the inverse-DTFT of the product $X(f)H(f)$.





2. Determine which of the following length-9 sequences defined for $0 \le n \le 8$ has a real-valued 9-point DFT, and which has an purely imaginary-valued 9-point DFT.

   (a) $x_1(n) = \begin{bmatrix} 4 & 3 & -5 & 1 & -2 & -2 & 1 & -5 & 3 \end{bmatrix}$

   (b) $x_2(n) = \begin{bmatrix} 0 & 5 & 1 & 4 & -3 & 3 & -4 & -1 & -5 \end{bmatrix}$

   (c) $x_3(n) = \begin{bmatrix} 0 & -5 & 2 & 4 & -3 & 3 & -4 & -1 & -5 \end{bmatrix}$

   (d) $x_4(n) = \begin{bmatrix} -5 & 5 & -2 & 2 & 4 & 4 & 2 & -2 & 5 \end{bmatrix}$

3. Consider a length-10 sequence defined for $0 \le n \le 9$ given by

$$x_1(n) = \begin{bmatrix} 1 & -1 & 0 & 2 & 4 & -3 & -3 & 5 & -1 \end{bmatrix}$$

   A 10-point DFT is given by $X(k),\ k = 0, \ldots, 9$. Determine numerical values for

   (a) $X(0)$

   (b) $X(5)$

   (c) $\displaystyle\sum_{k=0}^{9} X(k)$

4. Give an example of a Linear phase filter with

   (a) DC gain of 5.
   (b) $h(2) = 1$.
   (c) $h(0) \neq 0$.
   (d) 2-sample delay

   Provide and sketch the impulse response of your filter, and give the frequency response of your filter as a function of ω. Clearly indicate the real-valued transfer function.

ECE486 Test 2, Computer Portion

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Open Book, Open Notes
Calculators and Computers allowed

You may use your own printed or written reference material. Communication with other people is not allowed. Web browsers should be closed. Use of chat rooms, bulletin boards, firstclass etc. is not allowed.

Results submitted after the end of the test will not be accepted or graded.

Do not send output to the printer. Printed output will not be accepted or graded.

All submitted filter designs should have real coefficients. All FIR filter designs should be linear phase filters. In all filter designs, try to minimize the number of filter coefficients.

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1. In MATLAB, type the command:

   ```
   xdata = ece486_load('data.txt');
   ```

   This should load a vector (named "`xdata`") which contains 1024 samples of a signal which has been captured using a sampling frequency of 100 Msps. You may assume that the samples are in units of volts, and that the original signal was band-limited to 50 MHz, so that aliasing is not an issue. The (noisy) signal includes two sinusoids at closely spaced frequencies between 9 and 13 MHz. The signals have dramatically different amplitudes.

   Determine (as accurately as possible) the amplitude and frequency of both of the sinusoids. Give your results, and describe how you determined your answers in the space below.

2. Design a minimum-order IIR "Band-stop" filter filter based on a sampling frequency of $F_s = 44.1$ ksps. The filter should have 6 ± 0.2 dB gain in the passbands; $F < 1$ kHz and $F > 2$ kHz. The filter should attenuate signals in the stopband 1.3 kHz $< F <$ 1.6kHz by at least 60 dB. Submit your design for grading using

```
ece486_submit('lastname_test2_2',b,a);
```

In the space below, give the filter order for your design, and specify the number of multiplications per second which would be required to implement your filter in real time.

3. *Use the window-method FIR filter design technique* to design a linear-phase FIR filter which meets the same specifications as that given in problem 1. Submit your design for grading using

```
ece486_submit('lastname_test2_3',b);
```

In the space below, give the filter order and the number of filter coefficients. Indicate the delay associated with the filter.

4. Design a linear phase FIR filter (any technique) which meets the following specification.

Passband:	$0 < \|f\| < 0.05$
Passband Gain:	15 dB $\pm$ 0.3 dB
Two Stopbands:	$0.2 < \|f\| < 0.3$
	$0.45 < \|f\| < 0.5$
Stopband Attenuation:	≥ 60 dB

Submit your design for grading using

```
ece486_submit('lastname_test2_4',b);
```

In the space below, give the filter order and the number of filter coefficients. Indicate the delay associated with the filter.