UNIVERSITY OF CALGARY

DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING

BIOMEDICAL SIGNAL ANALYSIS

ENEL 563

MIDTERM EXAM
Friday, November 4th, 2005
3:00 p.m. – 4:00 p.m.
ICT 114
60 minutes

Total: 15 Marks

NOTE:
1. *This is a closed-book exam.*
2. *Calculators with text/program storage capabilities are not allowed.*
3. *Answer all questions.*
4. *In case of problems requiring numerical or algebraic manipulation, show all steps clearly.*
   In case of problems requiring descriptive answers, provide clear statements in point form; long essays are not required.
   In case of problems requiring algorithms, provide the reason/logic for each step.
5. *Specify units or dimensions when appropriate.*
6. *In drawing plots of signals, spectra, etc. label the axes clearly.*

Marks

1 1. (a) Draw the waveform of a typical, normal ECG over one cardiac cycle. Label the names of the component waves and give their typical durations and intervals.

1 (b) Draw a version of the ECG waveform as above including power-line artifact at 60 Hz. Describe a potential cause of the artifact and a method to prevent or remove the artifact.

1 (c) Draw a version of the ECG waveform as above including high-frequency noise. Describe a potential cause of the artifact and a method to prevent or remove the artifact.

Marks

2. The transfer function of a digital filter is specified as

$$H(z) = \frac{1}{3}\left[1 + z^{-1} + z^{-2}\right]$$

1 (a) Derive and plot the impulse response of the filter.

1 (b) What is the gain of the filter at DC and $f_S/2$, where f_S is the sampling frequency?

1 (c) Draw the signal-flow diagram of the filter.

1 (d) A signal with the samples {3,1,2} is applied as the input to the filter. Compute the output of the filter.

Show all steps in your solutions.

Marks

3. For a signal sampled at f_S= 200 Hz, design a notch filter to reject power-line artifact at 50 Hz. Use only one pair of zeros. Give the following in your solution:

2 (a) The pole-zero plot of the filter. Show the frequencies DC, 50 Hz, and 100 Hz on the plot.

2 (b) The transfer function and impulse response of the filter.

Marks

4. Two filters connected in series (cascade) are specified in terms of their difference equations

$$y_1(n) = x(n) - x(n-1)$$

and

$$y_2(n) = \frac{1}{2}\left[y_1(n) + y_1(n-1) \right],$$

where x(n) is the input to the first filter, $y_1(n)$ is the output of the first filter that is provided as the input to the second filter, and $y_2(n)$ is the output of the second filter.

1 (a) Derive the transfer function of each filter.

1 (b) Derive the transfer function of the combined system.

1 (c) Derive the impulse response of the combined system.

1 (d) Plot the pole-zero diagram of the combined system.

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