University of Calgary
Schulich School of Engineering
Department of Electrical and Computer Engineering

ENEL 563 Biomedical Signal Analysis
Midterm Exam

Tuesday, 26 February 2013, ENC 033
$9:30 - 10:45$ a.m. (75 minutes)
Total Marks: 20

Instructions:

1. This is a closed-book, closed-notes exam.
2. Calculators and electronic devices of any kind are not allowed.
3. Answer all (five) questions.
4. In case of problems requiring numerical or algebraic manipulation, show all steps clearly.
5. In case of problems requiring algorithms, provide the reason or logic for each step.
6. Specify units or dimensions when appropriate.
7. In drawing plots of signals, spectra, etc., label the axes clearly.

Question 1: Draw a schematic representation of an electrocardiographic (ECG) signal over one cardiac cycle.

Label intervals related to atrial contraction and ventricular contraction.

Overlay the ECG signal with schematic representations of the action potentials of atrial and ventricular myocytes.

Explain the relationships between the various parts of the action potentials and the ECG signal.

(4 marks)

Question 2: A researcher is designing an experiment to record electroneurograms (ENGs). Provide advice to the researcher on the following:

(a) Identify a potential source of artifact in the form of random noise. Propose a strategy or method to prevent or remove the artifact.

(b) Identify a potential source of structured noise. Propose a strategy or method to prevent or remove the artifact.

(c) Identify a potential source of physiological interference. Propose a strategy or method to prevent or remove the artifact.

No equations are required for your answers to this question.

(3 marks)

Question 3: You are given two signals, $x(n)$ and $y(n)$, each with N samples, $n = 0, 1, 2, \ldots, N-1$. No information is available regarding the probability density functions (PDFs) of the related processes.

Give an equation to compute the normalized correlation coefficient between the two signals. Explain the meaning and purpose of each part of your equation.

(4 marks)

Question 4: A filter is specified with the transfer function

$$H(z) = \frac{1}{T} \left[\frac{1 - z^{-1}}{1 - 0.95\ z^{-1}} \right]. \tag{1}$$

(a) Derive an expression for the input–output relationship of the filter in the time domain.

(b) Draw a signal-flow diagram of the filter using only one delay element.

(c) Draw the pole–zero plot of the system.

(d) What is the gain of the system at zero frequency and at one-half of the sampling frequency?

(4 marks)

Question 5: Two linear, shift-invariant, discrete-time filters are specified in terms of their impulse responses as

$\delta(n) - \delta(n-2)$; and

$\frac{1}{3}\{\delta(n) + \delta(n-1) + \delta(n-2)\}$.

A researcher prepares a new filter by connecting the two filters described above in series.

(a) Derive the transfer function $[H(z)]$ of each filter.

(b) Derive the transfer function of the combined filter.

(c) Derive the impulse response of the combined filter.

(d) Draw the signal-flow diagram of the combined filter.

(5 marks)

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