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

ENEL 563 Biomedical Signal Analysis
Midterm Exam

Monday, 3 March 2014, SA 109
2:00 – 2:50 p.m. (50 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 the action potential of a ventricular muscle cell. Label the various phases of the signal and indicate its typical amplitude and duration.
(4 marks)

Question 2: A researcher is designing an experiment to record electrocardiograms (ECGs). Provide advice to the researcher on the following:
(a) Indicate where electrodes should be placed to obtain lead II ECG.
(b) Identify a potential source of artifact in the form of random noise. Propose a strategy to prevent the artifact.
(c) Identify a potential source of structured noise. Suggest a method to remove the artifact.
(d) Identify a potential source of physiological interference. Propose a strategy to prevent the artifact.
No equations are required for your answers to this question.
(4 marks)

Question 3: You are given an ensemble of M signals with N samples each, $x_k(n)$, $n = 0, 1, 2, \ldots, N-1$, and $k = 0, 1, 2, \ldots, M-1$. Give equations to compute

(a) the ensemble average mean at an instant of time $\mu_x(n_1)$;

(b) the ensemble average autocorrelation function $\phi_{xx}(n_1, n_1 + n_d)$;

(c) the ensemble average of all signals or prototype $\bar{x}(n)$;

(d) the root-mean-squared value of one of the signals.

(4 marks)

Question 4: A filter is specified with the transfer function

$$H(z) = \frac{1}{4}\left[1 + z^{-1} + z^{-2} + z^{-3}\right]. \tag{1}$$

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

(b) Rewrite the difference equation in the form of a recursive relationship.

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

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

Show all steps of your calculations.

(4 marks)

Question 5: A researcher acquiring electroencephalographic (EEG) signals observes the ECG signal appearing as an artifact.

(a) Advise the researcher on prevention of the artifact.

(b) Assuming that the artifact persists, provide advice on the set up of an adaptive filter to cancel the artifact. Draw a schematic diagram of the adaptive filter and indicate how the inputs required should be obtained. No equations are required for your answers to this question.

(4 marks)

******