

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

Enel 563 Biomedical Signal Analysis
Midterm Exam

Wednesday, 22 October 2008, ENC 123
11:00 a.m. – noon (60 minutes)
Total Marks: 15

Instructions:

1. This is a closed-book, closed-notes 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.
5. In case of problems requiring descriptive answers, provide clear statements in point form; long essays are not required.
6. In case of problems requiring algorithms, provide the reason or logic for each step.
7. Specify units or dimensions when appropriate.
8. In drawing plots of signals, spectra, etc., label the axes clearly.

Question 1: Draw Einthoven's triangle and indicate the axes representing the six leads of the electrocardiogram (ECG) obtained using the four limb leads. Mark the positions of the four limb leads in your diagram. (4 marks)

Question 2: A signal of interest $x(t)$ is affected by additive noise $\eta(t)$ and is observed as $y(t) = x(t) + \eta(t)$. It is assumed that the processes are random, and that the noise process is statistically independent of the signal process. It is also assumed that the mean of η is zero.

Write the basic definition of the expected value (mean) of the random process x based upon its probability density function.

Derive the relationship between the mean of y and the statistics of x and η .

Derive the relationship between the variance of y and the statistics of x and η .

Interpret and explain your results. (4 marks)

Question 3: A researcher obtains a set of event-related potential (ERP) signals $x_k(n)$, $k = 1, 2, \dots, M$, and $n = 1, 2, \dots, N$, where $x_k(n)$ is the k th signal, M is the number of signals recorded, and N is the number of samples in each signal. Help the researcher with the following:

Give a step-by-step procedure (algorithm) to obtain the synchronized average of the ERPs.

State the conditions and requirements for synchronized averaging to be applicable and yield good results.

Give an equation to define the synchronized or ensemble average of the ERPs.

Give an equation to define the temporal average of one of the ERPs over a specified window of time.

Give an equation to obtain the average Euclidean distance between the result of synchronized averaging and the M ERPs available. Explain the meaning of the Euclidean distance in this context. (7 marks)
