UNIVERSITY OF CALGARY
SCHULICH SCHOOL OF ENGINEERING
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
ENEL 563 BIOMEDICAL SIGNAL ANALYSIS
MIDTERM EXAM
Friday, November 3rd, 2006, ICT 114
3:00 p.m. − 4:00 p.m. (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:** A researcher is designing an experiment to record visual event-related potentials (ERPs). 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. (1 mark)

(b) Identify a potential source of structured noise. Propose a strategy or method to prevent or remove the artifact. (1 mark)

(c) Identify a potential source of physiological interference. Propose a strategy or method to prevent or remove the artifact. (2 marks)

No equations are required for your answers to this question.

**Question 2:** Explain the cardiac events that cause the second heart sound (S2). Identify the valves and their actions associated with S2. (2 marks)

Explain how the dicrotic notch in the carotid pulse is related to S2. (1 mark)

**Question 3:** Two linear, shift-invariant, discrete-time filters are specified in terms of their impulse responses as

$\delta(n) - \delta(n-1)$; and

$\delta(n) + 2\delta(n-1) + \delta(n-2)$.

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

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

(b) Derive the transfer function of the combined filter. (1 mark)

(c) Derive the impulse response of the combined filter. (1 mark)

(d) Does it matter which filter is placed first? Explain and justify your answer. (1 mark)

(e) Draw the signal-flow diagram of the combined filter. (2 marks)

(f) What is the gain of the combined filter at DC, $f_s/4$, and $f_s/2$, where $f_s$ is the sampling frequency? From these values, give an interpretation of the nature of the combined filter. (2 marks)

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