

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

ENEL 563 Biomedical Signal Analysis  
Midterm Exam

Wednesday, 4 March 2015, SA 235

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 Einthoven's triangle for lead I, II, and III of the ECG signal. On the same triangle, show how the four limbs of the subject are connected to obtain the three ECG signals. Label the positive and negative connections for each lead.

Draw a vectorial representation of the three ECG leads and give the vectorial relationship between them.

(4 marks)

**Question 2:** Draw a schematic representation of a normal ECG signal and label the important waves in the signal. Identify the baseline of the signal.

Explain why the PQ and ST segments are normally isoelectric.

(3 marks)

**Question 3:** A filter is specified as having three zeros in the  $z$ -plane at  $z = j1$ ,  $z = -j1$ , and  $z = -1$ . Draw the pole-zero plot of the filter.

Derive the transfer function, difference equation, impulse response, and frequency response (magnitude and phase) of the filter.

Sketch a plot of the impulse response.

Draw a signal-flow diagram of the filter.

(6 marks)

**Question 4:** A system is specified as having a zero at  $z = 1$  and a pole at  $z = 0.9$ .  
Derive the transfer function and difference equation of the filter.  
Draw a signal-flow diagram of the filter using only one delay element.  
(3 marks)

**Question 5:** Two filters with the transfer functions

$$H_1(z) = \frac{1}{2} [1 + z^{-1}] \quad (1)$$

and

$$H_2(z) = 1 - z^{-1} \quad (2)$$

are connected in series (cascade).

Derive the transfer function, difference equation, and impulse response of the combined filter.

Draw a plot of the impulse response.

(4 marks)

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