UNIVERSITY OF CALGARY

DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING

BIOMEDICAL SIGNAL ANALYSIS

ENEL 563

MIDTERM EXAM

Friday, November 5th, 2004
3:00 p.m. – 4:00 p.m.
ICT 116

Total: 20 Marks

NOTE:

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

Marks		
3	1.	Describe two cardiac abnormalities that cause changes in the shape of the QRS complex. Draw the ECG waveforms for the two cases and compare their features with those of a normal ECG waveform.
	2.	A biomedical signal sampled at 500 Hz contains power-line interference at 60 Hz.
3		(a) Design a notch filter to remove the artifact.
2		(b) Derive the input-output difference equation of the filter.
1		(c) What is the effect of the filter if a signal sampled at 200 Hz is applied as the input?

Marks

3. A researcher uses a combination of the following two digital filters in cascade (series):

Filter 1: The output is the first derivative or difference of the input.

Filter 2: The output is the average of the current input sample and the preceding input sample.

1 (a) Give the input-output relationship in the time domain (difference equation) for each filter.

1 (b) Derive the transfer function H(z) for each filter.

1 (c) Derive the impulse response of the complete system.

1 (d) Derive the transfer function H(z) of the complete system.

1 (e) Does it matter which filter is placed first? Explain.

2 (f) Compute the gain of the complete system at 0, $f_s/4$, and $f_s/2$, where f_s is the sampling frequency.

4 4. A noisy signal **x** (n) is expressed in vector notation as

x (n) = **d** (n) + **η** (n)

where **d** (n) is the original (ideal) signal and **η** (n) is random noise that is statistically independent of the signal. All signals are assumed to be second-order stationary.

Derive an expression for the autocorrelation function (ACF) matrix of **x** in terms of the ACF matrices of **d** and **η**. Explain each step of your derivation.

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