NAME: ______________ **McGill ID:** _______________

Make-up MIDTERM EXAMINATION

ECSE 436: Signal Processing Hardware

Time: 14:15 – 15:45

Instructions:

1. This is an open notes, closed book exam.
2. Only faculty calculators are allowed for the in-class part.
3. Attempt all **four (4) problems, write the answers on the exam paper.**
4. Each part of a problem, e.g. (a), (b) or (c), carries the same weight.
5. Prove each answer or give reference to a fact covered in class/lab/book.

GOOD LUCK!

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PROBLEM 1: IDs

Using your words, system diagrams and/or equations, answer the following questions in the context of this course:

(a) What is **aliasing** when sampling a band-limited speech signals *s(t)* ?

Why is aliasing important?

How can aliasing be prevented?

(b) What is the **Fast Fourier Transform**? (as opposed to Discrete Fourier and Discrete-Time Fourier Transforms.)

How is Fast-Fourier Transform important in the context of this course?

Why is it used in practice?

PROBLEM 2: Error-Correcting Codes

Consider parity check equations of the Hamming *(8,4,4)* code, discussed extensively this term. Design a new code by removing/not transmitting the last parity check symbol of each codeword, thus getting a (7,4,3) code.

(a) What is the rate this new code? Write down the generator matrix ***G*** of the new code.

Can the new code always correct 2 erasures in a codeword?

(b) Show that d_{min} is 3 for the new (7,4,3) code.

(c) Can the original (8,4,4) Hamming code always correct 1 error and 1 erasure that occur in a given codeword? If YES, explain why yes and how you would accomplish it. If NOT, justify your answer.

PROBLEM 3: Filtering and Inverse System Design

Consider a digital recording system described by its transfer function $H(z) = (1 - 1/z)$

(a) Determine the impulse response $h[n]$ *and* frequency response H of the above system.

(b) Design an inverse filter system that will undo the recording echo from signal $y[n]$ above. Draw a schematic block diagram of your inverse system implementation.

(c) Using $\delta[n]$ as your inverse system input, determine the impulse response $h_{inv}[n]$ of the inverse system from part (b). Determine also if your inverse LTI system is BIBO stable. Fully justify your answers.

Problem 4: Material from Lab Component of the Course

(a) Write a short Matlab script that will reconstruct a greyscale intensity image (e.g., Lena or Baboon we used in the lab) in the following 2 cases:

- Using only phase of its 2-dimenstional FFT. (All magnitude values will be set to 1.)
- Using magnitude only of its 2-dimensional FFT. (All phase values are set to 0.)

(b) Briefly describe appearance of two reconstructed images in part **(a),** based on what you previously implemented/saw in the Lab in November. Also, explain the reason for difference in the two reconstructed images.

Fourier Series and Transform

Determine the maximum frequency

Describe the cond

ransforms and their Properties

(c) In your own words using drawings, sketches and block diagrams, explain how the compact disk (CD) system works. In particular, explain how the following works:

- Waveform recording through sampling
- Reconstruction of the signal from stored samples
- Prevention of aliasing

NOTE: Do not prove anything in this part, just state the used results.

PROBLEM 2: Systems and their Properties

(a) Consider an LTI system that has an impulse response $h(t) = \begin{cases} 1 & \text{for } -1<t<2 \\ 0 & \text{otherwise} \end{cases}$.

Show that for this LTI system, the output signal y(t) depends on FUTURE values of input x(t).

(b) A key property of LTI systems derived in this class is that they do not generate new frequencies at their output. Using *this property*, show that the following systems are not LTI:

- AM modulator $y(t) = x(t)\cos(\omega_c t)$**,** where ω_c is a fixed carrier frequency.
- An optical crystal onto which you shine red light and out comes blue light.

Please fully justify your reasoning.

(c) Consider a feedback system shown below. Derive its transfer function $H_{FB}(s) = \dfrac{Y(s)}{X(s)}$

(d) Determine all values of real parameter a for which this feedback system is BIBO stable