Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

(Manipal University)
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SIXTH SEMESTER B.E. DEGREE END-SEMESTER EXAMINATIONS MAY 2008

SUBJECT: BIOMEDICAL DIGITAL SIGNAL PROCESSING (BME 308)

(REVISED CREDIT SYSTEM)

Friday, May 23, 2008 : 9.00 a.m..- 12.00 noon

TIME: 3 HOURS **MAX. MARKS: 100**

Instructions to Candidates:

1. **Answer any FIVE full questions.**
2. **Draw labeled diagram wherever necessary**

1. (A) If the Nyquist rate for $x_a(t)$ is Ω_s, what is the Nyquist rate for each of the following signals that are derived from $x_a(t)$? 06
   i) $dx_a(t)/dt$ ii) $x_a(2t)$ iii) $x_a^2(t)$ iv) $x_a(t)\,\mathrm{Cos}(\Omega_o t)$
   (B) Find the inverse of each of the following Z-transforms: 06
   i) $X(z) = \log\left(1-\frac{1}{2}z^{-1}\right)$; $|Z| > \frac{1}{2}$
   ii) $X(z) = e^{1/z}$, with x(n) a right sided sequence.
   (C) With an example explain the use of variable length coding in reducing the amount of ECG data. 08

2. (A) A linear shift invariant system has a unit sample response h(n) = u(-n-1). Find the output if the input is $x(n) = -n\,3^n u(-n)$. 06
   (B) A digital filter that is implemented on a DSP chip is described by the linear constant coefficient $y(n) = \frac{3}{4}y(n-1)-\frac{1}{8}y(n-2)+x(n)$. In evaluating the performance of the filter, the unit sample response is measured. The internal storage registers on the chip, however, are not set to zero prior to applying the input. Therefore, the output of the filter contains the effect of the initial conditions, which are y(-1) = -1 and y(-2) = 1. Determine the response of the filter for all $n \geq 0$ and compare it with the zero state response. 06
   (C) With block diagram and waveforms explain the Pan-Tompkins algorithm for detecting the QRS complex and to estimate the RR interval series. 08

3. (A) Suppose that we would like to design an analog Chebyshev low-pass filter so that $(1-\delta_p) \leq |H_a(j\Omega)| \leq 1$ for $|\Omega| \leq \Omega_p$ and $|H_a(j\Omega)| \leq \delta_s$ for $\Omega_s \leq |\Omega|$ Find an expression for the required filter order, N, as function of Ω_p, Ω_s, δ_p and δ_s. 06

(B) Let x(n) be a finite length sequence with X(k) = (0, 1+j, 1, 1-j). Using the properties of DFT, find DFT's of the following sequences: 06

i) $p(n) = e^{j(\pi/2)n}\, x(n)$

ii) $q(n) = \text{Cos}[(\pi/2)n]\, x(n)$

(C) i) Show that the bilinear transformation maps the jΩ-axis in the s-plane onto the unit circle, |Z| = 1, and maps the left-half s-plane , Re(s) < 0 inside the unit circle, |Z| < 1. 08

ii) Use the bilinear transformation to design a first order low-pass Butterworth filter that has a 3-dB cutoff frequency $w_c = 0.2\pi$.

4. (A) For the sequences $x_1(n) = \text{Cos}(\frac{2\pi n}{N})$, $x_2(n) = \text{Sin}(\frac{2\pi n}{N})$, $0 \le n \le N-1$ find the N-point circular convolution. 06

(B) Explain with a block schematic the steps involved in ECG interpretation. 06

(C) An analog signal contains frequencies up to 10KHz. This signal is sampled at 50KHz. Design an FIR filter having a linear phase characteristic and a transition band of 5KHz. The filter should provide minimum 50dB attenuation at the end of transition band. 08

5. (A) Implement the system $H(z) = \frac{4 + 2.25Z^{-1} - .25Z^{-2}}{1 + .25Z^{-1} - .122Z^{-2}}$ as a parallel network of first order direct form structures. 06

(B) Describe the following Template matching techniques to classify the patterns in the ECG Signal: i) Template cross-correlation ii) Template subtraction. 06

(C) Given the sequences $x_1(n) = \{2, 1, 1, 2\}$ and $x_2(n) = \{0, -1, -1, 1\}$ compute circular convolution using DIT-FFT algorithm. 08

6. (A) Explain the following: i) FIR filter properties ii) Portable Arrhythmia Monitor 06

(B) Given the list of raw ECG data : [0, 1, 1, 0, -1, 10, 20, 40, 50, 20, -1, -30, -20, -10, 0, 1, 0, 0, 1, -1] produce the data points that are stored using the turning point algorithm. 06

(C) Find the convolution of x(n) and h(n) using the 8-point DIF-FFT. 08

x(n) = { 1, 2, 1} & h(n) = { 1, 2, 3 }