Reg. No.											

MANIPAL INSTITUTE OF TECHNOLOGY

(A constituent unit of MAHE, Manipal 576104)

I SEM M.Tech (BME) DEGREE END-SEMESTER EXAMINATIONS, NOV/DEC 2023

SUBJECT: APPLIED BIOMEDICAL SIGNAL PROCESSING (BME 5113)
(REVISED CREDIT SYSTEM)
Saturday, 02nd December, 2023, 9:30 AM to 12:30 PM

TIME: 3 HOURS **MAX. MARKS: 50**

Instructions to Candidates:

1. **Answer ALL questions.**
2. **Draw labeled diagram wherever necessary**

1. a) Identify the primary function and key ions responsible for the rapid depolarization phase of the action potential. (2M)

   b) Compare the characteristics of a normal sinus rhythm and a Sinus Tachycardia rhythm of an ECG signal. (3M)

   c) Analyze the different EEG frequency bands to understand the brain activity. (5M)

2. a) Explain how one may apply temporal (time) averaging procedure to process a given signal $x(n)$. Identify the application in ECG signal. (2M)

   b) A biomedical signal is bandpass filtered to the range $0-150\ Hz$ as shown in Figure 1. Assume the filter to be ideal. **(i)** Determine the minimum frequency at which the signal should be sampled to avoid aliasing error. **(ii)** A researcher samples the signal at 500 Hz. Draw a schematic representation of the spectrum of the sampled signal. **(iii)** Another researcher samples the signal at 200 Hz. Draw a schematic representation of the spectrum of the sampled signal. **(iv)** Explain the difference between cases (ii) and (iii). (3M)

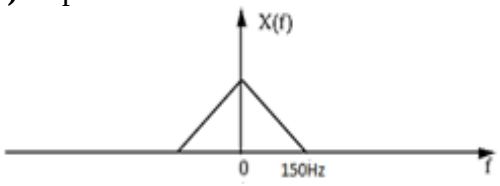

Figure 1

   c) Design an optimal filter to remove noise $\eta(n)$ from a signal $x(n) = d(n) + \eta(n)$, given that the desired signal $d(n)$ and noise processes $\eta(n)$are independent, stationary random processes. You may assume that the "desired" characteristics of the uncorrupted signal are known. The noise characteristics may also be assumed to be known. (5M)

3. a) Consider the IIR Low pass filter defined by the system function $H(z) = \frac{1-\alpha}{2}\frac{1+z^{-1}}{1-\alpha z^{-1}}$. Design the filter for the $\frac{\pi}{4}\ radians/sample$ cut off frequency. (2M)

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b) Design an IIR digital Low Pass filter for the specifications as shown in Figure 2 by transforming an analog Low Pass filter using Bilinear transformation. Consider analog Butterworth Low pass filter design for the given specifications. (4M)

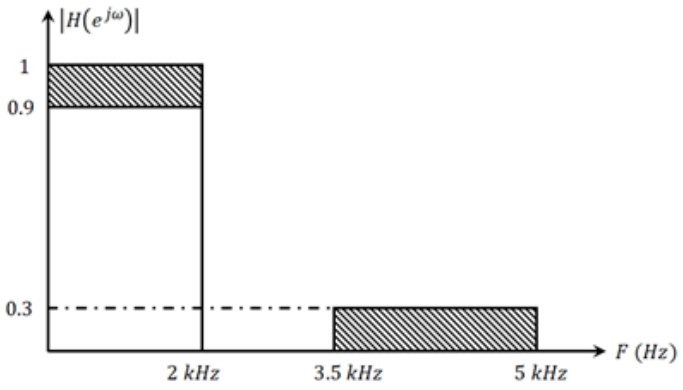

Figure 2

c) Propose a method to detect QRS complexes in ECG signals with a neat block diagram. Explain the purpose and nature of each step in the procedure, including the detection of the peaks in the output corresponding to the QRS complexes. (4M)

4. a) Propose an adaptive noise cancellation filter to remove the non-stationary interference present in the Biomedical signals. (3M)

b) Propose a homomorphic filter to separate two signals that have been combined through the modulation. (2M)

c) Given a single realization of a Biomedical signal generated from a random process. Explain step-by-step to obtain an averaged periodogram method to estimate the true Power Spectral Density. (5M)

5. a) The AR-model coefficients of a signal are $a_0 = 1,\ a_1 = 1,\ a_2 = 0.5$. Determine the transfer function of the model. (2M)

b) Formulate a mathematical model representing the generation of a train of SMUAPs and derive an expression for the PSD of the signal. (3M)

c) A model is described by the relationship $y(n) = x(n) + 0.5x(n-1) + 0.25y(n-2)$, where $x(n)$ is the input and $y(n)$ is the output. (5M)

(i) Identify the type of this system among Autoregressive (AR), Moving Average (MA), and ARMA systems. Justify.

(ii) Determine the order of the model?

(iii) Determine the system function?

(iv) Draw the pole-zero diagram of the system and comment on the stability of the system?