MSI EXAM - 1st Term 2023

Task 1 Signal Processing

    a) What should be the lowest sampling frequency to avoid aliasing when sampling following signal

    b) Which frequencies will appear in the spectrum when sampling frequency is set to 500 [Hz]

    c) What will be the resolution if signal is sampled with 1 kHz in a period of 10s.

Task 2 Filters

Moving average filter is defined with the following difference equation:

    a) Calculate the Z-transform, H(z) of this filter

    b) Analyse stability conditions of resulting filter

Task 3 Modal Analysis

    a) Define FRF. Calculate FRF for a single degree of freedom (SDOF) system with a structural damping.

    b) What modal parameters could be identified from FRF

    c) Give the modal superposition equation and briefly provide physical interpretation

Task 4 Nonlinear Systems

    a) How would you define what is linear and what is nonlinear in Nonlinear Dynamics.

    b) Define the coherence function. What is it used for?

    c) Define phase plot (in other words the phase portrait) used to analyse nonlinear systems calculate the Equlibrium position for the nonlinear system given by the equation $x + x - 4x^3 = 0$

1. Answer questions related to signal sampling and reconstruction.

   a) What should be the lowest sampling frequency to avoid aliasing the following signal

   $x(t) = \sin(2\pi 100t) + \sin(2\pi 400t)$? (1 mark)

   b) Which frequencies will appear in the spectrum when sampling freq to 500 Hz? (3 marks)

   c) What will be the frequency resolution if a signal is sampled with th = 1 kHz and recorded in the period of 10 s? (1 mark)

2. Moving average filter is defined with the following difference equation

$$y[n] = \frac{1}{8}\{x[n] + x[n-1] + x[n-2] + \cdots + x[n-7]\}$$

   a) Calculate the z-transform $H(z)$ of this filter. (3 marks)

   b) Analyse stability conditions of the resulting filter. (2 marks)

3. Modal Analysis is one of the major tools used for the identification structures.

   (a) Define the Frequency Response Function (FRF). Calculate the F Degree-of-Freedom (SDOF) system with structural damping. (3 ma

   (b) What modal parameters could be identified from the FRFs. (1 mark

   (c) Give the modal superposition equation and briefly provide physic (1 mark)

4. All engineering structures are nonlinear to some extent.   Identificati systems is a difficult problem and requires specific tools.

   (a) How would you define what is linear and what is nonlinea Dynamics? (1 mark)

   (b) Define the coherence function. What is it used for? (1 mark)

   (c) Define the phase plot (or in other words the phase portrait) used behaviour of nonlinear systems. Calculate the equilibrium pos . nonlinear system given by equation (3 marks)

$$\ddot{x} + x - 4x^3 = 0$$

(Please note: each question carries 5 marks)