Final Assessment Test – November 2019

VIT
Vellore Institute of Technology

Course: ECE4001 - Digital Communication Systems

Class NBR(s): 0993 / 0996 / 1000 / 1004 Slot: A1+TA1

Time: Three Hours Max. Marks: 100

KEEPING MOBILE PHONE/SMART WATCH, EVEN IN 'OFF' POSITION, IS EXAM MALPRACTICE

General Instructions :

1. **Students are permitted to use erf, erfc and Q tables.**
2. **Make necessary assumptions if any data is required.**

Answer ALL Questions

(100 Marks)

1. Consider an audio signal s(*t*), which is to be sampled, quantized, encoded and transmitted through the channel. [10]
   a) Calculate the Nyquist rate?
   b) Consider any arbitrary spectrum for s(*t*). Draw the spectrum of the sampled audio signal.
   c) If the signal is sampled below the Nyquist rate, what is the corresponding effect? Explain the effect using spectral analysis.
   d) Consider that a power line signal with a maximum frequency of 40 kHz is added to the audio signal. Assume that the resultant signal is sampled using critical sampling. Is there any possibility of aliasing effect? If yes, how can it be rectified?
   e) How the original audio signal can be reconstructed at the receiver? What type of filter you will prefer? Specify the ideal and practical bandwidths of the required filter.

2. a) A waveform, $x(t) = 10\cos(1000t+\pi/3) + 20\cos(2000t + \pi/6)$ is to be uniformly sampled for digital transmission. [5]
   i) What is the maximum allowable time interval between sample values that will ensure perfect signal reproduction?
   ii) If we want to reproduce 1 hour of this waveform, how many sample values need to be stored?

   b) Consider a low pass signal with a bandwidth of 3 kHz. A linear delta modulation system, with step size is 0.1V, is used to process this signal at a sampling rate ten times the Nyquist rate. Evaluate the maximum amplitude of a test sinusoidal signal of frequency 1 kHz, which can be processed by the system without slope overload distortion. [5]

3. a) A 40MB hard disk is used to store PCM data. The signal is sampled at 8 kHz and the encoded PCM is to have an average signal to noise ratio of at least 30 dB. For how many minutes the PCM data can be stored on the hard disk?. [5]

   b) A linear delta modulator is designed to operate on speech signal limited to 3 kHz. The specifications of the modulator are as follows. Sampling rate = $5f_{Nyquist}$, step size is 75 mV. The modulator is tested with 1.8 kHz sinusoidal signal. Determine the maximum amplitude of this test signal required to avoid slope overload and SNR. [10]

4. Consider the following binary sequences
   (a) An alternating sequence of 1's and 0's in a 10 bit sequence.
   (b) A sequence of five 1's followed by a single 0 and then a sequence of four 1's.
   Sketch the waveform for each of these sequences using the following line coding schemes:
   i) Pseudo-ternary Signaling,
   ii) biphase baseband signaling,
   iii) Polar quaternary format and
   iv) RZ bi-polar.
   Assume the voltage level for mapping to be 2 V. [10]

5. Consider the two signals $s_1(t)$ and $s_2(t)$ shown in Figure 1. Note that V and T_b are some positive constants.

(a) Find the energy in each signal.

(b) Using the Gram–Schmidt orthogonalization procedure, find a set of orthonormal basis function to represent the signals $s_1(t)$ and $s_2(t)$.

(c) Using part (b) express the signals $s_1(t)$ and $s_2(t)$ in terms of basis function.

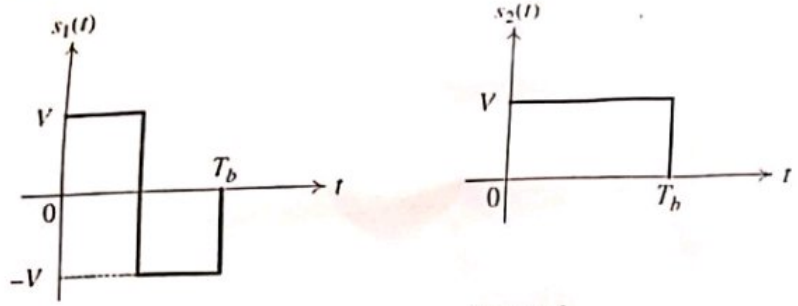

Figure 1

6. For a band-pass digital transmission system employing coherent dibit modulation scheme, determine the message points and the associated signal vectors. Use the results to draw the signal space diagram for the same. Derive the probability of symbol error assuming that the dibit 00 was transmitted. **[10]**

7.(a) Binary PSK is used for data transmission over an AWGN channel with power spectral density 10^{-10} W/Hz. **[10]**

(i) Determine the value of amplitude 'A' needed to achieve an error probability of 10^{-6}, if the data rate is 1 Mbps.

(ii) If the data rate given in (i) is increased twice, what is signal amplitude to achieve the same probability of error? Also compute the additional power required in dB compared to part (i).

OR

7.(b) I. In a binary ASK system, the channel is corrupted by AWGN with mean zero and power spectral density $\frac{N_0}{2}$. The symbols 1 and 0 occur with equal probability. The data rate is 10^6 bit per second. The average energy of the received sinusoidal signal is 0.36×10^{-18} Joules. Determine **[6]**

i) The amplitude of the received sinusoidal signal.

ii) The minimum amplitude of the received signal in the case of binary FSK and binary PSK systems, if the data rate and average probability of error are to be same as that of ASK system.

II. Binary data are transmitted at a rate of 10^6 bit per second over a microwave link. Assuming channel noise is AWGN with zero mean and power spectral density at the receiver input is 10^{-10} Watts per Hz, find the average carrier power required to maintain an average probability of error $P_e \leq 10^{-4}$ for coherent binary signaling scheme, where the two possible transmitted signals are orthogonal to each other. Determine the minimum channel bandwidth required. **[4]**

8. Consider the following binary sequence {1, 0, 0, 0, 0, 0, 1}. Explain the operation of MSK for the above mentioned sequence using Phase Trellis diagram by assuming $\theta(0)=0$ radians and $\theta(0)=\pi$. Derive the probability of error. **[10]**

9. Draw the block diagram of a matched filter and derive an expression for impulse response of the same. **[10]**

10.(a) Draw the block schematic and construct the PN sequence for the Feedback Taps [5, 2]. Verify Run and balance property. **[10]**

OR

10.(b) Illustrate the variation of the frequency of a Fast FH/MFSK signal with time for one complete period of the PN sequence. Input data sequence is 01111110001001111010. Generate PN sequence of length is 15. FH/MFSK signal has the following parameters. **[10]**

Number of bits per MFSK Symbol= 2

Number of MFSK tones = 4

Length of PN segment per hop = 3

Total number of frequency hops= 8

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