Birla Institute of Technology & Science, Pilani, Rajasthan
First Semester 2022-2023
Comprehensive Exam (Open Book)

EEE F311 Communication Systems

Date: 30-12-2022, Duration: 3 Hours, Maximum Marks: 60

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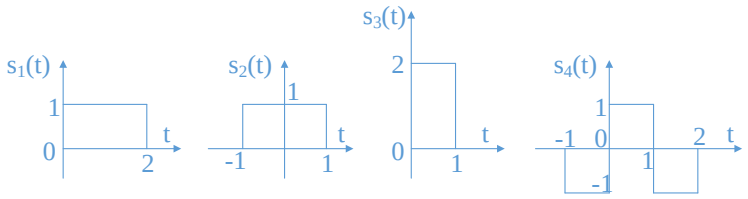
1. (a) Find the FM bandwidth (using Carson's rule) for a message signal $m(t) = 200sinc(200\pi t)$ with $k_f = 1$ vol/Hz. Take carrier signal as $10\cos(10000\pi t)$.

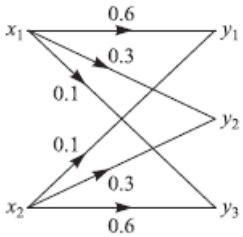
   (b) Find the modulation index for an amplitude modulated signal is given as $x(t) = \left(25 + \sum_{i=1}^{10} \cos 200i\pi t\right) \cos 200000\pi t$.

   (c) Draw minimum number of orthonormal basis signal for the signal set as given below:



   (d) For a WSS noise process x, the double-sided noise PSD is given as $S_x(f) = N_0/2$. Find the autocorrelation of the output process y as shown in the figure. Take $R = 10\Omega$ and $C = 1$F.

   (e) Find the channel capacity with transition probabilities as shown in the figure. Assume equally probable input i.e. $P(x_1) = P(x_2) = 1/2$.



   (f) Find mutual information of a continuous channel $y = x + n$ if the output signal y is uniformly distributed $y \sim U(-2, 2)$ and the additive noise n is exponentially distributed with PDF $f_n(x) = e^{-x}$, $x \geq 0$.

2. (a) There are two messages with probabilities 0.9 and 0.1. Find the coding efficiency (in % upto two decimal points without rounding off) with the third-order source extension using Huffman encoding. [**Marks: 6**]

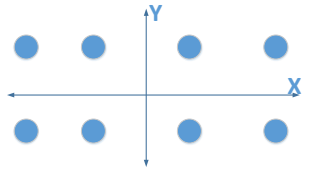
   (b) The generator matrix for the (7, 3) linear block code is given as $\begin{bmatrix} 1 & 0 & 0 & 1 & 0 & 1 & 1 \\ 0 & 1 & 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 1 & 0 & 1 & 1 & 1 \end{bmatrix}$. List all the code words and determine the error-detecting capability of the code. Also decode the data from the received codes 0101010, 1101011, and 1110111. [**Marks: 6**]

3. A signal $m(t) = 10sinc^2(10\pi t)$ is to be transmitted over an ideal channel with impulse response $h(t)$ using both analog and digital schemes.

   (a) For analog transmission, the transmitter uses DSB-SC at a carrier frequency of 500 KHz and the receiver uses synchronized detector. The receiver is impacted by AWGN with double-sided passband PSD $N_0/2 = 4$. Find the noise power and the SNR at the output of the synchronized detector. [**Marks: 6**]

   (b) For digital transmission, the transmitter uses baseband polar signaling and the receiver uses the matched filtering. The receiver is impacted by AWGN with double-sided PSD $N_0/2 = 4$. find the signal power at the output of the matched filter. [**Marks: 6**]

4. A transmitter uses 8-QAM constellation (as shown in the figure) for digital communications. The distance between adjacent symbols is 2 and the symbols are equi-probable. At the receiver, the symbols are disturbed by the AWGN modeled as $n_x \sim N(0, 1)$ and $n_y \sim N(0, 1)$.



   (a) Determine the SER in terms of Q function without any approximation. [**Marks: 6**]

   (b) If the noise component in the y-direction is ignored (i.e., $n_y = 0$), determine the SER in terms of Q function without any approximation. [**Marks: 6**]

5. A wireless communication link over free-space is to be established from your hostel room to a nearby base station situated at a distance of 95 m. The assigned carrier frequency is 100 MHz and the channel bandwidth is 1 MHz. The antenna gain for transmitter and receiver are equal at 0 dB, i.e. $G_t = G_r = 0$ dB. The information source is voice signal of a 3 minutes duration. The A/D uses 4-bit quantizer at the minimum sampling rate. You are given the task to design a digital transmitter to transmit the data in 1 second. The AWGN has a PSD $N_0 = -100$ dBm/Hz and the signal power $P_t = 30$ dBm.

   (a) Determine the source information in bits? [**Marks: 4**]

   (b) Determine is the channel capacity in bps? [**Marks: 4**]

   (c) Determine the maximum constellation size used. [**Marks: 4**]