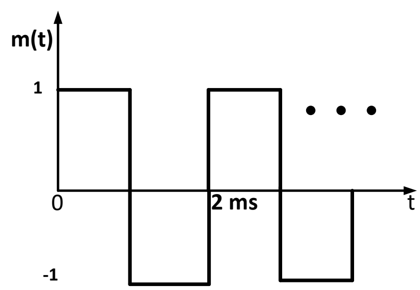
Birla Institute of Technology and Science, Pilani
ECE/EEE F311 Communication Systems
First Semester 2023-2024 (07-12-2023)
Comprehensive Exam (Open Book)

Maximum Marks: 105 **Duration: 180 minutes**

- **There are five questions. All questions are compulsory.**
- **Answer all the parts of a question at the same place.**
- **Write clearly your assumptions in a box, if taken to solve a problem.**

Q1. Message $m(t)$ is a periodic pulse with a period of 2 ms and amplitude ± 1 (see figure). A channel bandwidth of 5 KHz is available in the baseband from 0 to 5 KHz and in the passband from 97.5 KHz to 102.5 KHz for signal transmission. Draw transmitter blocks and specify relevant parameters to occupy the channel bandwidth for the following modulation schemes. [**21 Marks**]

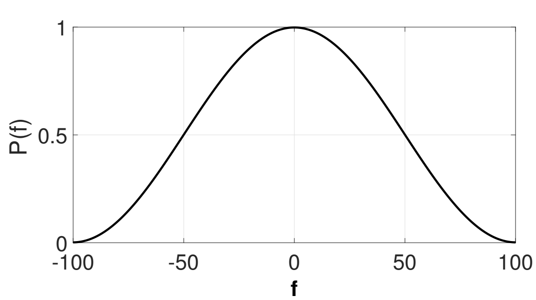


(a) Baseband binary PCM with SQNR = 0.048 and sampling at the Nyquist rate.

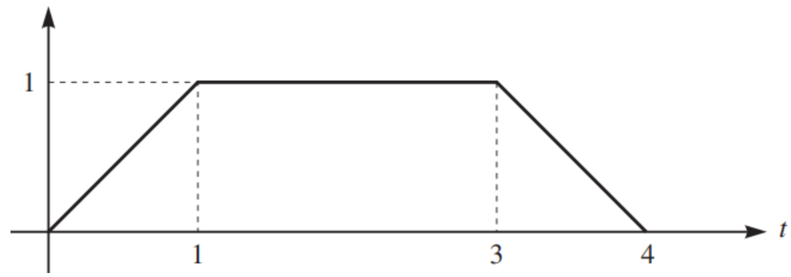
(b) Passband DSB-SC.

(c) Passband FM with $\beta = 4$. Use Carson's rule for FM bandwidth calculation.

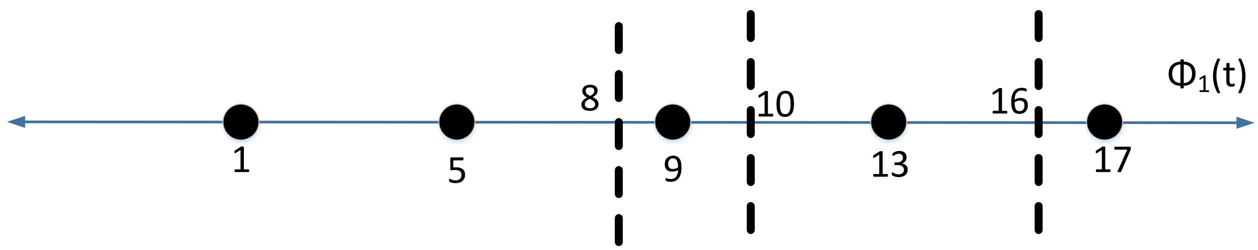
Q2. (a) Show that the frequency spectrum $P(f)$ of a raised cosine pulse (as shown in the figure) satisfies the Nyquist criterion for zero ISI. Also, find $p(t)$. [**2+5 Marks**]



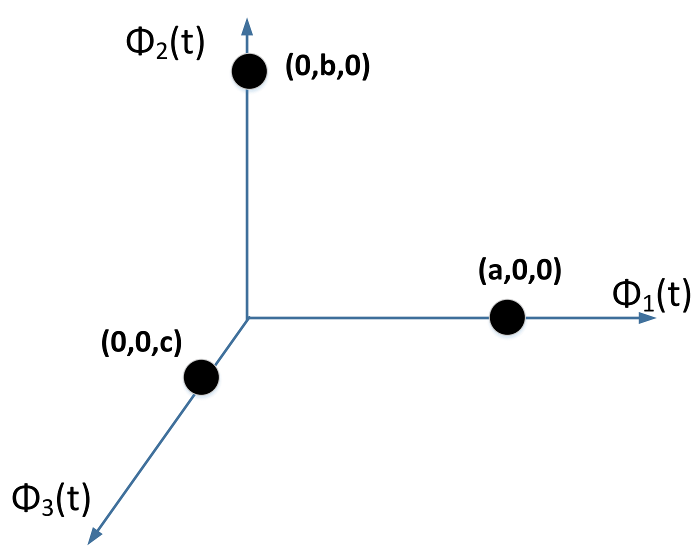
(b) A polar signaling system uses the following pulse for transmission with equal probability. It passes through a channel $h(t) = \delta(t)$. Take the noise PSD at the input of the matched filter as $N_0/2$. Find signal power, noise power, and BER at the output of the matched filter. [**5+5+4 Marks**]



Q3. (a) Five symbols located at 1, 5, 9, 13, and 17 have probabilities P_1, P_2, P_3, P_4, and P_5, respectively. The decision boundaries (depicted by dotted lines at 8, 10, and 16) between 5 and 9, 9 and 13, and 13 and 17 are also shown in the figure. Find the optimum average SER over AWGN channel $n_1 \sim N(0, 1)$. [**14 Marks**]



(b) Draw a transceiver using basis signals at the transmitter and matched filter implementation at the receiver under AWGN. [**7 Marks**]

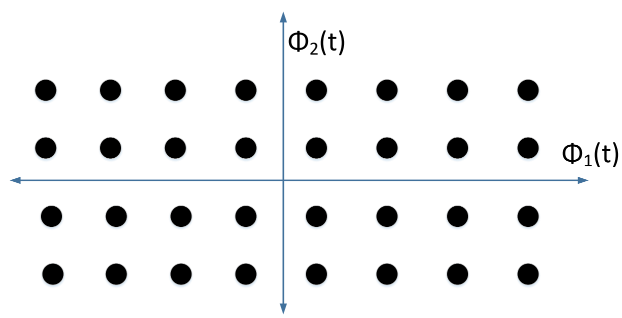


Q4. A two-dimensional constellation is shown in the figure. All symbols are equi-probable and the distance between each adjacent symbol is 2.

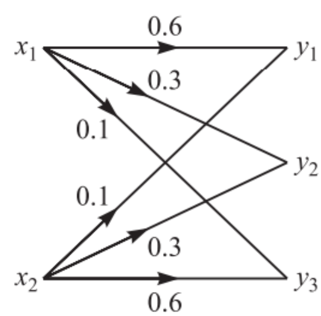
(a) Find the probability of correctness for a symbol from the third quadrant having the largest symbol energy. Take in-phase noise $n_1 \sim N(0, 4)$ and quadrature-phase noise $n_2 \sim N(0, 16)$. [**5 Marks**]

(b) Find the probability of correctness for a symbol from the second quadrant having the smallest symbol energy. Take in-phase noise $n_1 \sim N(0, 4)$ and quadrature-phase noise $n_2 \sim N(0, 16)$. [**5 Marks**]

(c) Find average SER assuming that in-phase noise is zero and quadrature-phase noise PDF is $f_{n_2}(x) = \frac{1}{2}e^{-|x|}$. [**11 Marks**]



Q5. (a) Find the channel capacity for the following channel (as shown in figure) assuming $P(x_1) = P(x_2) = \frac{1}{2}$. [**7 Marks**]



(b) An additive communication channel is represented by $y = x + v$. The choice for y and v can be from Gaussian distributions $N(0, 1)$ and $N(1, 2)$, and uniform distribution $U(-1, 1)$. Find the maximum and minimum channel (bits/symbol) capacity by appropriately choosing distribution functions for y and v. [**4+3 Marks**]

(c) The generator matrix $\mathbf{G}$ for a $(7, 4)$ block code is given by

$$\mathbf{G} = \begin{bmatrix} 1 & 1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 & 1 & 0 & 1 \end{bmatrix}$$

Find all code words and error-detection capability of the code. [**7 Marks**]