Communication Theory

EC5.203 - Spring 2024

Exam: End Sem
Total Marks: 80

Date: 27 April 2023
Time: 3:00 pm to 6:00 pm

Instructions:

- Answer all the questions.
- Use of the calculator is allowed.
- Clearly state your assumptions (*if any*) that are not specified in the question.

---

1. Answer true of flase. [1×10]

   (a) $\text{sinc}(2\pi Bt - \pi)$ and $\text{sinc}(2\pi Bt - 2\pi)$ are orthogonal pulses.

   (b) Non-uniform quantization apply smaller step size to small amplitudes and larger step size for large amplitudes of the signal.

   (c) Nyquist's pulse decays sharply in time with the increase of roll-off factor.

   (d) ON-off line coding scheme requires twice as much power as the polar line coding scheme.

   (e) DPCM requires smaller transmission bandwidth as compared to PCM.

   (f) For M-ary PAM, the transmission power increases quadratically in M, however for M-ary FSK, it does not depend on M.

   (g) For M-ary FSK with BER efficient frequency spacing, the subcarriers are not necessarily orthogonal to each other.

   (h) Match filter $h(t) = p(T_o - t)$ is optimal receiver only for AWGN noise.

   (i) Variance of AWGN noise components is equal to $\mathcal{N}$ when double sided noise PSD is $\frac{\mathcal{N}}{2}$.

   (j) MAP detector is optimal only when the message symbols have equal priors.

2. Answer the following questions in short. [2×10]

   (a) Provide the relationship between auto-correlation functions of the input and output of a LTI systems.

   (b) State the reason for sampling the output of Matched filter $h(t) = p(T_o - t)$ at $t = T_o$ when T_o is the duration of pulse $p(t)$.

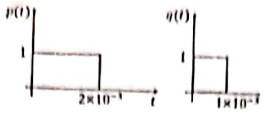
   (c) State the minimum spacing between subcarriers of M-ary FSK and mention the reason behind this choice of spacing.

   (d) Show that the matched filter can be implemented using correlator.

   (e) Sketch the block diagram of M-ary QAM demodulation.

   (f) A signal $m(t)$ band-limited to 3KHz is sampled at a rate $33\frac{1}{3}\%$ higher than the Nyquist rate. The maximum acceptable error in sample amplitude is 0.5% of the peak amplitude m_p. Find the minimum bandwidth of the channel required to transmit the encoded binary signal.

   (g) Determine BER of a binary scheme with transmission pluses shown in the following figure when the channel noise is AWGN with PSD equal to 10^{-6}.



(b) For a polar signaling scheme, we are required to transmit 2.08×10^6 binary digits per second with $P_b \leq 10^{-6}$. Assume the double sided noise PSD is equal to 10^{-8}. Determine the signal power at the receiver. [Note: $Q(4.7535) = 10^{-6}$]

(i) A telephone line of bandwidth 3KHz is used to transmit binary data. Calculate the data rate that can be transmitted if we use:

- Polar signal with rectangular half-width pulses
- Polar signal with rectangular full-width pulses
- Polar signal with Nyquist pulse of $r = 0.25$

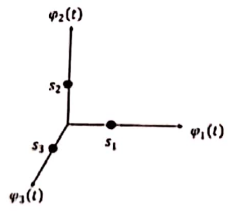
(j) If AWGN noise with PSD 10^{-6} is given as the input to an ideal LPF of bandwidth 30KHz, find power of output noise.

3. Answer the following questions. [6×5]

1. A signal of bandwidth 10KHz is sampled at a rate 24KHz, quantized into 256 levels and coded by means of M-ary PAM pulses satisfying Nyquist criteria for zero ISI with a roll-off factor 0.2. Determine the best value M if the available channel bandwidth is 30KHz. Suggest alternate scheme that is power efficient and provide the corresponding value of M. Also, compute the symbol error rate for these two schemes for $\frac{E_b}{N} = 3$ dB.
2. Explain AWGN noise process $n_w(t)$ in detail and determine the joint density function of random variables $n_w(t_1), n_w(t_2), \ldots, n_w(t_N)$.
3. Explain differential PCM modulation and demodulation in detail.
4. Derive the optimal filter and comparison threshold for decoding a general binary signalling scheme where "1" and "0" are represented using pulses $p(t)$ and $q(t)$.
5. Derive the BER for binary PSK, ASK and FSK under AWGN noise and compare the results in terms of the transmission power.

4. Answer any two of the following questions in detailed. [10×2]

1. Consider a polar line coded signal, where bits "1" and "0" are equiprobable and are represented using pulses $p(t) = \Pi(t/T_b)$ and $-p(t)$, respectively, is transmitted through a AWGN channel. Find the PSD of the signal at the output of channel.
2. Explain the vector representation of the received signal and utilize it to describe the MAP detector.
3. Provide the block diagram of MAP detector for M-ary FSK. Derive its error probability for $M = 3$ with following symbol constellation.



ALL THE BEST!