Dept. of E & E C E, IIT Kharagpur
Semester Examination, Spring 2009-10
Subject: *Digital Communications [EC31002]*
Date: 27.04.2010(A/N), Time: 03 Hrs; No. of Students: 83; Full Marks: 50

***Instructions**: Answer ANY FIVE questions. Answer of a question should be at one place. Make and state suitable assumptions wherever necessary. Use the following approximation if necessary: $erfc(u) = [1/(u.\sqrt{\pi})].exp(-u^2)$*

1. (a) Draw and neatly label the typical block diagrams of a narrowband digital communication transmitter, channel and receiver. Mention one important function of each block with reference to the nature and type of input and output signals / waveforms of the block. **4**

1. (b) Mathematically justify that equivalent baseband description and analysis of a narrowband digital transceiver and bandpass signals are sufficient for a linear time invariant channel. **2**

1. (c) Derive a desired condition for companding so that the SQNR of a PCM coded signal is independent of amplitude distribution of the input analog signal. **4**

2. (a) Let Z = a.X + b.Y, where a and b are arbitrary negative constants and X and Y are independent random variables. Determine variance of Z in terms of those of X and Y. **2**

2. (b) Let the input to an AWGN channel be a binary random variable X with P (X = -1.0 Volt) = P (X = +1.0 Volt) = 0.5. The output of the channel, Z is Z = X+Y, where Y is the noise component. Assuming that X and Y are independent and that Y is Gaussian with a mean of zero and variance of 1.0 $Volt^2$, determine and plot the pdf of Z. **2**

2. (c) Consider wireless digital transmission of a good quality music signal (from 80 Hz to 18 HKz). List the quantization and coding schemes that may be considered to ensure a desired SQNR of 50 dB. The signal is limited to ± 1.0 Volt and the normalized ACF for $\tau = 1\ T_s$ is 0.83. Determine the overall bit rates for the coding schemes and select one scheme as your choice. Draw a block diagram of the same and mention two limitations of the scheme. **6**

3. (a) State and justify the Gram Schmidt Orthogonalization procedure. **5**

3. (b) Consider 03 energy signals $s_1(t) = -4.0;\ 0 \le t \le 2.0$ sec, $s_2(t) = +2.0;\ 0 \le t \le 1.0$ sec and $s_3(t) = +3.0;\ 0 \le t \le 3.0$ sec. Find the orthonomal basis functions to represent these signals. **3**

3. (c) Suggest the basis functions and an information bit rate that can be supported in an AWGN channel following the principle of coherent demodulation for quaternary FSK (QFSK) if the modulated signal can occupy the frequency band from 400 MHz to 401 MHz. **2**

4. **(a)** Draw the block diagram of a correlation receiver structure and derive an expression for the likelihood function of the outputs of the correlator bank in presence of AWGN. **6**

4. **(b)** Let $\varphi(t) = -0.5$ for $0 \leq t \leq T/2$ and $\varphi(t) = +0.5$ for $T/2 < t \leq T$. Determine and plot the impulse response of a filter matched to this basis function. Plot the output of the filter when $\varphi(t)$ is given as input and determine the time instant when the output is maximum. **4**

5. **(a)** A BPSK signal is applied to a correlation receiver where the locally generated basis function is offset in phase from the basis function of the transmitter by θ radian. Determine an expression for the average probability of error for the receiver in AWGN. **4**

5. (b) Consider a BFSK system transmitting data @ 4.0 Mbps through an AWGN channel with noise psd (N_0) = 10^{-15} Watt/Hz. Determine the average BER if the peak amplitude of the received sinusoid waveforms for '0' and '1' is 1 micro volt in absence of noise. **3**

5. (c) Write a small C / MATLAB program with sufficient comments to generate Gaussian random variables. Write and sketch the expressions for the pdf and cdf with neat labels. **3**

6. (a) Write the general expression of a narrowband QPSK modulated signal s(t). Let the received signal in presence of AWGN be $r(t) = s(t) + n(t) = [s_I(t) + n_c(t)].\cos\omega_c t - [s_Q(t) + n_s(t)].\sin\omega_c t$. If $n_c(t)$ and $n_s(t)$ are i.i.d. zero-mean Gaussian processes with variance σ^2, write an expression for the envelope of r(t) and describe its statistical features. **4**

6. (b) Write short notes on **(any THREE):** (i) Lowpass equivalent of narrow bandpass signals and merits of such representation, (ii) Various 'channels' in the context of digital wireless communications, (iii) ADPCM and (iv) Nyquist pulse shaping for zero ISI. **2 x 3 = 6**

7. (a) Determine the maximum bit rate of a random binary sequence with bit energy E_b Joule for transmission using an 8-ary modulation through an AWGN channel with $N_0 = 0.02$ W/Hz. **3**

7. **(b)** Amplitude of an analog signal, varying between -200 mV and +600 mV, is uniformly distributed. Determine the ratio of SQNR-s if the coding format is changed from 4-bit PCM to 8-bit PCM. **2**

7. **(c)** Explain with a schematic diagram and mathematical expressions how the carrier of a BPSK modulated signal can be recovered in the receiver. **3**

7. **(d)** Write a note on differential encoding and decoding. **2**

--- X ---