COMPREHENSIVE EXAMINATION

Instructors: B. Sainath, Asutosh Kar, Electrical and Electronics Eng. Dept., BITS Pilani.

Course Title: Advanced Digital Communication Course No.: ADC/EEE-G622

DATE: May 11th 2017 (AN) MAX. TIME: 3 hrs. MAX. SCORE: 40 Points

Notation: $\mathcal{CN}(\sigma^2)$ denotes Circularly Symmetric Complex Gaussian (CSCG) random variable with mean zero and variance σ^2.

Q. 1. a). Let $x[n]$ denote time-domain samples which can be computed from the following inverse DFT formula.

$$x[n] = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X[k] \exp\left(j2\pi k \frac{n}{N}\right), 0 \le n \le N-1,$$

where 'N' is the number of subcarriers, $j = \sqrt{-1}$. Suppose that $x[n] \sim \mathcal{CN}(0, {\sigma_x}^2), 0 \le n \le N-1$.

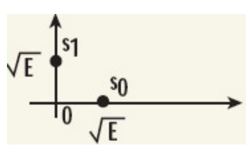
(a). Let τ denote the threshold. Derive an expression for $\mathcal{P}(\text{PAPR} > \tau)$. Compute the probability if the length of $x[n]$ is 4, ${\sigma_x}^2 = 1$, and $\tau = 3$ dB. [2 + 1 points]

(b). Derive an approximate expression for $\mathcal{P}(\text{PAPR} > \tau)$ when τ large and ${\sigma_x}^2 = 1$. [1 point]

(c). If $N_2 > N_1$, plot $\mathcal{P}(\text{PAPR} > \tau)$ as a function of τ. Assume ${\sigma_x}^2 = 1$. Comment on the impact of large N on PAPR. [2 points]

Q. 2. a). Consider coherent BPSK and Binary FSK modulation schemes (BFSK constellation is given below). Assuming AWGN channel model, which modulation scheme delivers better error performance for the same average bit energy? Justify your answer. [2 points]

Compute average symbol error probability of BPSK and BFSK when average symbol energy-to-noise ratio is 0 dB. [1 point]



b). Consider point-to-point half-duplex wireless communication link between a transmitter and a receiver, each having single antenna. Assuming coherent reception and frequency-flat Rayleigh fading ($h \sim \mathcal{CN}(1)$) plus AWGN channel, write-down single integral mathematical expressions for fading-averaged symbol error probability (SEP) of 8PSK and 16-QAM in terms of average symbol energy-to-noise ratio ($\overline{\Gamma}$). Simplify the expressions as much as possible (Note: You need not solve the integral.). Derive upper bounds and compare them. [2 + 4 points]

What are the values of upper bounds of 8-PSK and 16-QAM when $\overline{\Gamma}$ is equal to 0 dB? [2 points]

Q. 3. Consider GSM cellular system. It operates at 270.88 Kbps (utilizing capacity) and uses a bandwidth of 200 KHz. What is the theoretical SNR (in dB) that GSM phones need for operation? In reality, the phone uses a SNR of 10 dB. Using Shannon's capacity formula for AWGN channels, compute theoretical capacity and corresponding spectral efficiency assuming transmission rate equal to channel capacity. Compute $\%$ of utilization. [1+1+1+1 points]

Q. 4. Consider digital transmission via wireless fading channel. Suppose that a receiver implements microscopic diversity using two antennas. Let the envelope of the signals received by the two antennas at a given time instant be $\sqrt{P_1}$ and $\sqrt{P_2}$. Assume the noise at the antennas is uncorrelated and has the same power $N_0 B$, where B denotes the bandwidth. Compute the instantaneous SNR for this time instant at the output of the diversity combiner for selection diversity (SC) and maximum ratio combining (MRC), respectively for the following two cases. Assume that $u_b(t)$, the baseband equivalent transmitted signal, is one for the duration of transmission, that is, $P_t = 1$.

a). $\sqrt{P_1} = \sqrt{P_2} = \sqrt{P}$. b). $\sqrt{P_1} << \sqrt{P_2} = \sqrt{P}$.

Express your answer in terms of Γ, where $\Gamma_j \triangleq \frac{P_j}{N_0 B}$ for j = 1, 2. [3 points]

Q. 5. a). What is the significance of adaptive filter over a fixed time domain filter? Differentiate between convergence rate, steady state error and tracking with reference to adaptive Least Mean Square (LMS) algorithm in a liner adaptive filter. [2 + 2 points]

b). Explain the phenomenon of decision feedback channel equalization using Normalized LMS (NLMS) adaptive algorithm in wireless digital communication with the help of neat block diagram. Derive the expression for filter weight update and adaptation step-size in time domain for NLMS algorithm. How the step-size in NLMS is different from the adaptation step-size in LMS? [6 points]

Q. 6. Each question carries 1 point. Indicate 'TRUE' for true statement and 'FALSE' for false statement. Justify your answer in just ONE sentence. [6 points]

a). Gaussian minimum shift keying (GMSK) provides better spectral efficiency than staggered quadrature phase shift keying (QPSK).

b). In wideband multipath channels, the individual multipath components can be resolved by the receiver. If the components can be resolved then they can be combined for diversity gain.

c). Alamouti scheme offers transmit diversity. Alamouti code is a non-orthogonal space-time block code.

d). Wireless communication systems employing only OFDM offer better data transmission rates than the MIMO-OFDM based wireless systems.

e). The maximum diversity order (D.O) achievable by polarization diversity is two.

f). Minimum shift keying (MSK) is a special case of continuous phase frequency shift keying (CPFSK). □□