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7/12/2022

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**National Institute of Technology Hamirpur (HP)**

**Electronics & Communication Engineering Department**

End Semester Examination, December 2022

B.Tech./Dual Degree (ECE) – 3rd Semester

Communication Theory (EC-213)

**Time: 3 Hrs.** **Max. Marks: 50**

Note: The symbols and variables used have their usual meaning. All questions carry equal marks.

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Q1. (a) If $x(t) = e^{j(2t+\pi/4)}$, then determine the normalized energy and normalized average power of $x(t)$. Hence, classify it as a power or an energy signal.

(b) Find the Fourier transform of the following signals

(i) $x_1(t) = \cos(\omega_0 t)$ (ii) $x_2(t) = \frac{1}{1+jt}$

Q2. (a) A continuous random variable has a probability density function given by $f_X(x) = kx^2$, for $0 \le x \le 1$ and zero elsewhere. Find values of the constants $\mathbf{k}$ and $\mathbf{a}$ such that $P(X \le \mathbf{a}) = P(X > \mathbf{a})$.

(b) Find the expected values $E(X)$ and $E(X^2)$ of a random variable X whose probability density function is given by $f_X(x) = (1-x)^2$, for $0 \le x \le 1$ and zero elsewhere.

Q3. (a) Consider a wide-sense stationary (WSS) random process $X(t)$ being applied to the input of an LTI system whose impulse response is $h(t) = 3e^{-2t}u(t)$. Find the mean value of the output random process $Y(t)$ of the system if $E[X(t)] = 2$.

(b) A WSS random process $X(t)$ with autocorrelation $R_{XX}(\tau) = e^{-2|\tau|}$ is applied to the input of an LTI system with impulse response $h(t) = e^{-2t}u(t)$. Find the power spectral density of the output random process $Y(t)$ of the system.

Q4. (a) Discuss the following types of noise in communication systems

(i) Shot noise (ii) Thermal noise

(b) An amplifier has a bandwidth of 500 kHz, and an input resistance of 50 Ω. When a 0.5 μV input signal level is applied to the amplifier input under matched conditions, the output signal-to-noise ratio (SNR) = 0 dB. Determine the noise figure of the amplifier. Assume room temperature of 290 K.

Q5. (a) Discuss the following discrete memoryless channels in terms of their channel matrix

(i) Lossless channel (ii) Deterministic channel

(iii) Noiseless channel (iv) Binary symmetric channel

(b) Show that for a binary symmetric channel (BSC), the mutual information is given by

$$I(X;Y) = H(Y) + p\log_2 p + (1-p)\log_2(1-p),$$

where X is the channel input alphabet, Y is the channel output alphabet, and p is the channel transition probability.

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