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JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY, WAKNAGHAT

TEST -2 EXAMINATION- April 2018

M.Tech 4th Semester

COURSE CODE: 12M1WEC432 MAX. MARKS: 25

COURSE NAME: Fundamentals of MIMO Systems

COURSE CREDITS: 03 MAX. TIME: 1Hr 30 min

Note: *All questions are compulsory. Carrying of mobile phone during examinations will be treated as case of unfair means.*

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1. [2 marks] In indoor channels $\sigma_{Tm} \approx 50$ ns whereas in outdoor microcells $\sigma_{Tm} \approx 30\,\mu$ sec. Find the maximum symbol rate $Rs = 1/Ts$ for these environments such that a linearly-modulated signal transmitted through these environments experiences negligible ISI. CO-2

2. [3 marks] Consider the following channel scattering function obtained by sending a 900 MHz sinusoidal input into the channel:

$$S(\tau,\rho) = \begin{cases} \alpha_1\delta(\tau) & \rho = 70\text{Hz}. \\ \alpha_2\delta(\tau - .022\mu\text{sec}) & \rho = 49.5\text{Hz}. \\ 0 & \text{else} \end{cases}$$

where $\alpha 1$ and $\alpha 2$ are determined by path loss, shadowing, and multipath fading. Clearly this scattering function corresponds to a 2-ray model. Assume the transmitter and receiver used to send and receive the sinusoid is located 8 meters above the ground.

(a) Find the distance and velocity between the transmitter and receiver.

(b) Does a 30 KHz voice signal transmitted over this channel experience flat or frequency-selective fading? CO-2

3. [5 marks] Consider an OFDM system operating in a channel with coherence bandwidth $B_c = 10$ KHz. CO-1

(a) Find a subchannel symbol time $T_N = 1/B_N = 10T_m$, assuming $T_m = 1/B_c$. This should insure flat-fading on the suchannels.

(b) Assume the system has $N = 128$ subchannels. If raised cosine pulses with $\beta = 1.5$ are used, and the required additional bandwidth due to time limiting to insure minimal power outside the signal bandwidth is $\varepsilon = .1$, what is the total bandwidth of the system?

(c) Find the total required bandwidth of the system using overlapping carriers separated by $1/T_N$, and compare with your answer in part (c).

4. [8 marks] For a Rayleigh fading channel with selection combining diversity CO-4
(a) Find the outage probability of QPSK modulation at $P_s = 10^{-3}$ for a Rayleigh fading channel with SC diversity for $M = 1$ (no diversity), $M = 2$, and $M = 3$. Assume branch SNRs $\gamma_1 = 10$ dB, $\gamma_2 = 15$ dB, and $\gamma_3 = 20$ dB. [Hint: for QPSK modulated signal with $\gamma_b = 10.8276$ has $P_b = 10^{-3}$].
(b) Consider a fading distribution $p(\gamma)$ where

$$\int_0^\infty p(\gamma)e^{-x\gamma}d\gamma = .01\overline{\gamma}/\sqrt{x}.$$

Find the average P_b for a BPSK modulated signal where the receiver has 2-branch diversity with MRC combining, and each branch has an average SNR of 10 dB and experiences independent fading with distribution $p(\gamma)$.

5. [7 marks] Answer in short the following questions for MIMO systems. CO-1
(a) Explain Multiplexing gain and Diversity gain, and find maximum value r of multiplexing gain and also find diversity gain for N_tXN_r MIMO systems if multiplexing gain is r.
(b) For three generalized fading distributions i.e., k-μ, α-μ and η-μ fading distributions, state the difference in conditions of applicability (scenario of multiple fading paths) and applications where to apply these models.

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