JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY, WAKNAGHAT

TEST -1 EXAMINATION- Feb 2018

M.Tech 4th Semester

COURSE CODE: 12M1WEC432 MAX. MARKS: 15

COURSE NAME: Fundamentals of MIMO Systems

COURSE CREDITS: 03 MAX. TIME: 1Hr

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] Consider a voice system with acceptable BER when the received signal power is at or above half its average value. If the BER is below its acceptable level for more than 120 ms, users will turn off their phone. Find the range of Doppler values in a Rayleigh fading channel such that the average time duration when users have unacceptable voice quality is less than t = 60 ms. CO-1

2. [2 marks] For a channel with Doppler spread B_d = 80 Hz, what time separation is required in samples of the received signal such that the samples are approximately independent. CO-1

3. [6 marks] Answer the following for multi-carrier and OFDM systems CO-4
   a. Draw multicarrier transmitter and receiver block diagrams.
   b. Draw OFDM transmitter and receiver block diagrams.
   c. Compare the two systems drawn in a. and b. parts.
   d. What are the two important purposes of cyclic prefix in OFDM systems?

4. [5 marks] In order to improve the performance of cellular systems, multiple base stations can receive the signal transmitted from a given mobile unit and combine these multiple signals either by selecting the strongest one or summing the signals together, perhaps with some optimized weights. This typically increases SNR and reduces the effects of shadowing. Combining of signals received from multiple base stations is called macrodiversity, and in this problem we explore the benefits of this technique. Consider a mobile at the midpoint between two base stations in a cellular network. The received signals (in dBW) from the base stations are given by CO-2

$$P_{r,1} = W + Z_1.$$

$$P_{r,2} = W + Z_2.$$

where $Z_{1,2}$ are $\mathcal{N}(0, \sigma^2)$ random variables. We define outage with macrodiversity to be the event that both $P_{r,1}$ and $P_{r,2}$ fall below a threshould T.

(a) Interpret the terms W, Z_1, Z_2 in $P_{r,1}$ and $P_{r,2}$.

(b) If Z_1 and Z_2 are independent, show that the outage probability is given by

$$P_{out} = [Q(\Delta/\sigma)]^2,$$

where $\Delta = W - T$ is the fade margin at the mobile's location.

(c) Now suppose Z_1 and Z_2 are correlated in the following way:

$$Z_1 = a\,Y_1 + b\,Y.$$

$$Z_2 = a\,Y_2 + b\,Y,$$

where Y, Y_1, Y_2 are independent $\mathcal{N}(0, \sigma^2)$ random variables, and a, b are such that $a^2 + b^2 = 1$. Show that

$$P_{out} = \int_{-\infty}^{+\infty} \frac{1}{\sqrt{2\pi}} \left[Q\left(\frac{\Delta + by\sigma}{|a|\sigma} \right) \right]^2 e^{-y^2/2} dy.$$

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