The Open University of Sri Lanka
Department of Electrical and Computer Engineering
Bachelor of Technology Honours in Engineering
ECX6239 – Wireless Communications
Final Examination – 2016/2017

Date: 2017-12-06 Time: 0930-1230

Answer **any five questions.** Assume any missing parameter with suitable values.

Gaussian distribution: $N(\mu,\sigma)\sim\frac{1}{\sqrt{2\pi\sigma^2}}e^{\frac{-(x-\mu)^2}{2\sigma^2}}$ Q-function: $Q(x)=\frac{1}{\sqrt{2\pi}}\int_x^\infty e^{-\frac{u^2}{2}}du$

Q1.

(a) Using clear diagrams and necessary formulas briefly explain the different causes of fading. [5]

(b) How diversity is used to mitigate fading? [3]

(c) A mobile receiver is moving at a speed v and is receiving signals arriving along two reflected paths which make angles θ_1 and θ_2 with the direction of motion. The transmitted signal is a sinusoid at frequency f. Is above information enough for estimating (i) the coherence time T_c (ii) the coherence band width W_c? If so express them in terms of the given parameters. If not specify what additional information would be needed. [12]

Q2.

(a) What are the differences between Rician fading and Rayleigh fading? [4]

(b) The probability density function for a Rayleigh continuous random variable is given in

$$p(r_0)=\begin{cases}\frac{r_0}{\sigma^2}\exp\left[-\frac{r_0^2}{2\sigma^2}\right] & for\ r_0\geq 0\\ 0 & otherwise\end{cases}$$

i. Find an expression for the received signal amplitude distribution function. [8]

ii. For a signal transmitted over a mobile wireless channel experiencing Rayleigh fading, use the distribution function to estimate the percentage of time that the signal level is 15 dB below the rms value. [6]

iii. Repeat part (ii) for a signal level that is 5 dB below the rms value. [2]

Q3.

(a) Explain the different demodulation schemes for linear modulated digital signals. Compare and contrast them. [5]

(b) The $\pi/4$-QPSK modulation may be considered as two QPSK systems offset by $\pi/4$ radians.

i. Sketch the signal space diagram for $\pi/4$-QPSK signal. [5]

ii. Using Gray encoding label the signal points with the corresponding data bits. [4]

iii. Determine the sequence of symbols transmitted via $\pi/4$-QPSK for the bit sequence 0100100111100101. [6]

Q4.

(a) Using the constellation diagrams explain how QAM modulation provides a better bandwidth efficiency-error tradeoff compared to PAM and PSK modulation schemes. [6]

(b) Consider a certain transmission system which has the binary PAM modulation mapping {1,0}→{1,-1}. What is the minimum bandwidth required to transmit an input data stream with a rate 14kbps? [6]

(c) This same input data stream is to be now transmitted by a 16-ary PAM based system maintaining the same noise immunity as in the binary system. If each of the 16-ary symbols is equally probable, calculate the required transmit power. [8]

Q5.

(a) What is the requirement for channel coding? [3]

(b) Compare and contrast the linear block codes and convolutional codes. [3]

(c) Consider Generator matrix $\boldsymbol{G}$,

$$\boldsymbol{G} = \begin{pmatrix} 0 & 1 & 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 0 & 1 & 0 \\ 1 & 1 & 0 & 0 & 0 & 1 \end{pmatrix}$$

(i) Construct the complete codeword set [6]

(ii) Show that d_{min} the minimum distance between codewords is 3. [4]

(iii) Show that this code can correct at least one error. [4]

Q6.

(a) What is OFDM? Explain how OFDM achieves higher spectral efficiencies in cellular communication. [6]

(b) A certain cellular system has hexagonal cells and system deploys clustering to avoid co-channel interference. Let the distance to a mobile from the serving base station be d_S and the distance from closest other base station using the same channel be d_I.

a. Assuming a free space path loss model with a path loss exponent 2 , show that signal to interference ratio $\left(\frac{S}{I}\right) = 20\log\left(\frac{d_I}{6d_S}\right)\ dB.$ [6]

b. Thus, determine a suitable reuse factor for a threshold $\frac{S}{I} = -4dB.$ [4]

c. If the cellular system uses a total bandwidth of $50MHz$ and a subscriber requires $50kHz$ (simplex), calculate the system capacity for 100 base stations. [4]

Q7.

(a) Compare different generations of cellular communication systems focusing on the multiple access technique, capacity and the efficiency. [4]

(b) "CDMA is an interference limited system". Discuss. [4]

(c) Consider a CDMA system occupying a 10MHz spectrum. Assume an interference limited system with a spreading gain of G and code correlation ξ.

i. Find a formula for the signal to interference ratio (SIR) of the received signal for a K number of subscribers. Assume that all subscribers transmit at the same power and the power control mechanism ensures that all subscribers have the same received power. [8]

ii. Hence find the maximum number of simultaneous users which can be supported if threshold SIR is 7dB, $G = 100$ and $\xi = 0.67$. [4]

Q8.

(a)

i. How does MIMO technology improves wireless communication? [4]

ii. Using the relevant formulas formulate the parallel decomposition in MIMO. [6]

(b)

i. Why is dynamic resource allocation beneficial in cellular systems? What resources can be dynamically allocated? [5]

ii. Cognitive radio supports dynamic resource allocation. Explain the concept of cognitive radio. [5]