Z/K/TX

Reg. No: 21BEC0328

VIT
Vellore Institute of Technology

Final Assessment Test – November 2024

Course: BECE307L - Wireless and Mobile Communications

Class NBR(s): 2748 / 2752 / 2756 / 2759 / 2761 / 2764 / 2766 / 2768 / 2771 / 2773

Slot: A2

Time: Three Hours

Max. Marks: 100

- KEEPING MOBILE PHONE/ANY ELECTRONIC GADGETS, EVEN IN 'OFF' POSITION IS TREATED AS EXAM MALPRACTICE
- DON'T WRITE ANYTHING ON THE QUESTION PAPER

General Instructions : Duly signed Erlang Chart is permitted

Answer ALL Questions

(10 X 10 = 100 Marks)

1. a) Consider a regular hexagonal geometry pattern, where each cell contains 12 channels, and the shift parameters are i = 2 and j = 4. Find the number of cells in a cluster, the total number of channels in a cluster, and the system capacity when the cluster is reused 30 times within the system. Comment on the result. **[5]**

   b) i) Explain the practical handoff approach that efficiently handles both high-speed and low- speed users in an urban environment. **[3]**

   ii) Cell dragging is a pertaining problem in cellular deployment strategy – justify your answer with suitable illustration. Device some strategy the combat the same. **[2]**

2.(a) A communication link operates at a frequency of 2.4 GHz between a base station and a mobile receiver. The base station antenna is mounted at a height of 50 meters, while the receiver is positioned 1.8 meters above the ground. The distance between the transmitter and the receiver is 2 kms. Using the Two-Ray Reflection Model, calculate the path loss. Extend your calculation to compare the path loss occurring when a Free Space Path Loss (FSPL) model is used. Assume that the ground is a perfect reflector and neglect atmospheric effects. **[5+5]**

OR

2.(b) A cellular system using a four cell reuse pattern has hexagonal cells, each having a radius of 1.387 km. A total number of 60 channels are used within the entire system. If the average traffic load / user is 0.029 Erlangs and λ = 1 call / hour, compute the following for the trunking system that has a 2 % blocking probability of a delayed call.

   a) How many users per square kilometre will this system support? **[5]**

   b) What is the probability that delayed call will have to wait for more than 20 s? **[3]**

   c) What is the probability that a call will be delayed for more than 20 s? **[2]**

3. A high-speed train is traveling at 90 km/h and communicates at a frequency of 3.5 GHz. [10]

a) Calculate the Doppler spread B_D for the channel.

b) Determine the spatial sampling interval required to ensure consecutive samples are highly correlated.

c) If the train covers a distance of 20 meters, how many samples are needed?

d) What is the time required to cover this 20-meter distance?

4. a) Explain the fundamental structure of an AMPS system, including its approach to frequency allocation, method of signal modulation, and techniques for managing system capacity. [5]

b) Looking at the HLR/VLR database approach used in GSM—how does this architecture limit the scalability in terms of users, especially moving users [5]

5.(a) Consider an OFDM system with a transmission bandwidth of 1 MHz and a subcarrier bandwidth of 10 kHz. The channel has strong multipaths and a delay spread of 10 μs. Determine the following [10]

i) Number of subcarriers

ii) Symbol time without cyclic prefix (CP)

iii) Minimum CP duration required to overcome inter symbol interference

iv) The loss in spectral efficiency.

OR

5.(b) The IEEE 802.11b standard operates in the range of 2.412 GHz to 2.484 GHz has a total 14 available channels. To implement OFDM in IEEE 802.11b, N = 52 subcarriers are generated. In the system if the carrier frequency oscillator is accurate to 0.1 parts per million (ppm). Calculate the value of normalized frequency offset ε. [10]

6. A transmitter of a SISO communication system transmits a BPSK modulated information with 0.01 mW power to a receiver. The received signal is corrupted by an additive white Gaussian noise with variance 0.001 mW. Find the following: [10]

(i) What is the bit error rate (BER) if the channel between the transmitter and receiver is wired?

(ii) If there is a Rayleigh fade in the channel between the transmitter and the receiver, what is the BER? Is there an improvement in BER performance over the wired scenario? Explain your response.

(iii) Find the probability of deep fading? How it can be reduced?

7. Consider a wireless communication scenario with receiver diversity employed to overcome the adverse impact of fading. If Equal Gain Combining (EGC) is utilized with $L = 3$ and complex fading channel coefficients given as $h_1 = \frac{1}{2} + j\frac{1}{2}, h_2 = 1 - j$, and $h_3 = -\frac{1}{2} + j\,1$. The transmitted signal $x(t)$ is BPSK modulated such that for bit '0', $x(t) = -0.5$ volt and for bit '1', $x(t) = 0.5$ volt. The received signal at different antennas are $y_1(t), y_2(t)$, and $y_3(t)$, corrupted by independent Gaussian noise with a variance $\sigma_n^2 = 1$. **[10]**

   a) Calculate the signal power $E\{|x(t)|^2\}$

   b) Obtain the SNR at the output of the EGC combiner.

   c) Calculate the BER at the output of the EGC combiner

8. Compute SVD for the 2X2 MIMO channel matrix **H** given below **[10]**

$$H = \begin{bmatrix} 3 & 0 \\ 4 & 5 \end{bmatrix}$$

9. What are the key benefits of using Reconfigurable Intelligent Surfaces (RIS) to improve coverage and reliability in wireless communications, and how could this technology impact future network design? **[10]**

10. a) Explain the concept of spatial modulation and describe its operation in a system with 4 antennas. **[5]**

    b) What are the defined performance requirements for 5G technology in terms of key metrics such as peak data rate, user experience data rate, spectral efficiency, energy efficiency, latency, connection density, and reliability? **[5]**

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