VIT®
Vellore Institute of Technology
(Deemed to be University under section 3 of the UGC Act, 1956)

Reg. No. : 21BC1[illegible]

Final Assessment Test (FAT) - May 2024

Programme	B.Tech.	Semester	WINTER SEMESTER 2023 - 24
Course Title	WIRELESS AND MOBILE COMMUNICATIONS	Course Code	BECE307L
Faculty Name	Prof. Hemanth C	Slot	A1
		Class Nbr	CH2023240500936
Time	3 Hours	Max. Marks	100

General Instructions:

- Write only Register Number in the Question Paper where space is provided (right-side at the top) & do not write any other details.

Section - I
Answer all questions (3 X 5 Marks = 15 Marks)

01. The Doppler spectrum of a wireless system deployed for indoor radio application operating at 1.9 GHz has an uniform distribution with a maximum Doppler shift of 10 Hz. The threshold for fading is chosen to be 10 dB below the average rms value of the signal. Determine [5]
    (i) the average number of fades per second [3 Marks]
    (ii) the average fade duration [2 Marks]

02. Draw the control-plane and data-plane protocol stack of UE & eNodeB of 4G(LTE) with its functionalities. [5]

03. In light of the guest lecture, describe five features of 5G. [5]

Section - II
Answer all questions (4 X 10 Marks = 40 Marks)

04. A power delay profile of a certain channel has the following specifications. The sum of power levels of all multipath components is − 45 dB. At a time delay of 2 μs, the power received is 15 dB lower than the power received at the first multipath component. At a time delay of 4 μs, the power received is 10 dB more than that received at 2 μs. At a time delay of 6 μs, the power received is 25 dB less than the power received at the first multipath component. [10]
    (i) Sketch the power delay profile [2 marks]
    (ii) Verify whether two different frequencies which are 1 MHz apart experience correlated fading in this channel? [5 Marks]
    (iii) Determine the maximum symbol rate that can be supported without an equalizer [3 Marks]

05. (a) In a rural area, with very low density of users, a tower communicates with a receiver at a user's home which is located close to it. The system uses MIMO at both the tower and at the user's home. What sort of receiver would best suit for this situation? Provide a convincing justification. [4 Marks] [10]

(b) For your choice from part (a), compute the receiver matrix and compute $\hat{x}$ for the given system if the MIMO channel matrix H is given by [6 Marks]

$$H = \begin{bmatrix} 1 & 1 \\ 2 & 1 \\ 3 & 4 \end{bmatrix}$$

06. (a) Whether 2G GSM follows TDM or FDM? Justify [2 Marks] [10]
(b) Explain the architecture of GPRS with a neat sketch indicating both voice call and data paths [8 Marks]

07. Summarize any two D2D current development in 4G LTE. Also discuss the challenges to be addressed in the 5G D2D. [10]

Section - III

Answer all questions (3 X 15 Marks = 45 Marks)

08. (a) An urban area has a population of two million residents. Two competing mobile networks (systems A and B) provide cellular service in this area. System A has 394 cells with 19 channels each and system B has 98 cells with 57 channels each. If each user averages two calls/ hour at an average call duration of 3 minutes, find the number of users that can be supported at 2% blocking probability. Traffic intensity for system A and system B is 12 Erlangs and 45 Erlangs respectively. If both the systems operate at maximum capacity, compute the market penetration of each cellular provider. [8 Marks] [15]
(b) Consider the downlink of a GSM system with the carrier frequency of 950MHz and receiver sensitivity (according to GSM specifications) of −102 dBm. The output power of the transmitting amplifier is 30 W. The antenna gain of the transmit antenna is 10 dB and the aggregate attenuation of connectors, combiners, etc. is 5 dB. The fading margin is 12 dB and the break point is at a distance of 100 m. Determine the distance covered when the path loss exponent is 3.5. [7 Marks]

09. (a) Consider an OFDM system with total passband bandwidth B = 5 MHz with N = 512 subcarriers. The channel has a maximum delay spread of $T_d = 4$ μs. Answer the following: : [15]
(i) What is the symbol time of a corresponding single-carrier system? [2 Marks]
(ii) What is the sample time of the OFDM system and the raw symbol time without cyclic prefix? [2 Marks]
(iii) What is the minimum number of samples required in the cyclic prefix? [2 Marks]
(iv) At a carrier frequency of $f_c = 2.4$ GHz, what is the maximum possible velocity of a mobile for the system to be able to function? [3 Marks]
(b) Explain how pilot symbols help in an OFDM system. With an example, discuss how interleaving helps in the process of Forward Error Correction (FEC)? [2 Marks+4 Marks]

10. (a) Consider a multiple receive antenna wireless system with three receive antennas and a single transmit antenna. The wireless channel has the following complex fading channel coefficients $h_1 = 2 - j$, $h_2 = 1 + 2j$ and $h_3 = 1 + j$ [15]
(i) Describe the system model for this multi-antenna channel [3 Marks]
(ii) Determinethe signal to noise ratio at the output of the beamformer with Maximal Ratio Combining [4 Marks]
(b) (i) Derive the diversity order for a single-antenna Rayleigh fading wireless channel at a high SNR value [4 Marks]

(ii) What is the value of the diversity order at high SNR for 'L' receive antenna wireless system? [4 Marks]

Few Formulas:

$$\overline{P_b} = \left(\frac{1-\lambda}{2}\right)^L \sum_{l=0}^{L-1} \binom{L-1+l}{l} \left(\frac{1+\lambda}{2}\right)^l \quad \text{where } \lambda = \sqrt{\frac{SNR}{2+SNR}}$$

$$\overline{P_b} = 0.5\left[1 - \sqrt{1 - \left(\frac{1}{1+SNR}\right)^2}\right]$$

$$N_R = \sqrt{2\pi} f_m \rho e^{-\rho^2}$$

$$\tilde{\tau} = \frac{e^{\rho^2} - 1}{\rho f_m \sqrt{2\pi}}$$

$$d = -\lim_{SNR \to \infty} \left(\frac{\log(P_e(SNR))}{\log(SNR)}\right)$$

$$P_e = \binom{2L-1}{L} \left(\frac{1}{2}\right)^L \left(\frac{1}{SNR}\right)^L$$

$$C = \sum_{i=1}^{t} \log_2 \left(1 + \frac{P_i \sigma_i^2}{\sigma_n^2}\right)$$

$$\sum_{i=1}^{t} \left(\frac{1}{\lambda} - \frac{\sigma_n^2}{\sigma_i^2}\right)^+ = P$$

$$P_i = \left(\frac{1}{\lambda} - \frac{\sigma_n^2}{\sigma_i^2}\right)$$

$$P_r = \frac{P_t G_t G_r \lambda^2}{(4\pi d)^2}$$

$$P_r(d)dBm = P_r(d_0)dBm + 20\log\left(\frac{d_0}{d}\right), d \geq d_0 \geq d_f$$

⇔⇔⇔