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Sixth Semester

Electronics and Communication Engineering

EC 8652 — WIRELESS COMMUNICATION

(Common to : Computer and Communication Engineering/Electronics and Telecommunication Engineering)

(Regulations 2017)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. What is Doppler shift? Derive the expression of Doppler shift.

2. (a) State the conditions for frequency selective fading channel.

   (b) If the rms delay spread is 2 μs, what could be the minimum signal period to avoid ISI.

3. Handoff threshold should neither be too large nor too small-justify.

4. Mention the drawbacks of cell splitting in cellular mobile communication.

5. What is inter-block interference? How can it be removed?

6. In Minimum Shift Keying, let δf be the change in carrier frequency from f_{c1} to f_{c2} due to the transition from 0 to 1 and T_b is the bit duration. Express δf in terms of T_b. If $f_c = \frac{f_{c1} + f_{c2}}{2}$, express f_{c1} and f_{c2} in terms of f_c and δf.

7. What is the function of an equalizer in a communication system? Write the major drawback of the zero-forcing equalizer?

8. How diversity techniques helps in combating fading? Write down the use of Microscopic and Macroscopic diversity techniques.

9. Explain how MRC diversity improves the capacity of a MIMO system.

10. What is the difference between frequency diversity and time diversity? Give one example for each type of diversity.

PART B — (5 × 13 = 65 marks)

11. (a) (i) What is coherence time? Define fast fading and slow fading.

(ii) (1) Calculate the mean excess delay and rms delay spread for the multipath profile given in figure 1.

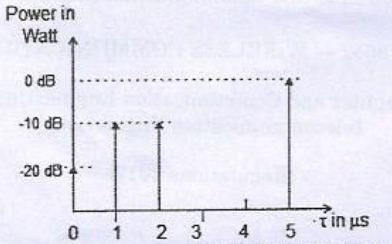

Figure 1: Power delay profile

(2) Find the type of fading if the modulated symbol duration is 10 μs.

(3) Estimate the coherence bandwith for 50% correlation of the channel. (3+5+3+2)

Or

(b) (i) How the received signal power in the case of Two-ray model is different from free-space propagation model.

(ii) A mobile phone that is 5 kilometres away from a base station receives cellular radio signals using a vertical monopole antenna with effective aperture 0.016 m². At a distance of 1 km from the transmitter, the E-field is measured to be 0.001 V/m. The carrier frequency is used in this system is 900 MHz. Find the received electric field and power at the mobile using the two-way ground reflection model assuming the height of the transmitting antenna is 50 m and the receiving antenna is 1.5 m above ground.

(iii) Estimate the median path loss using Okumura's model for d = 50 Km, h_{te} =100 m and h_{re} =10 m in an suburban environment, if the base station transmitter transmits with 2 kW at a carrier frequency of 900 MHz, find the received power at the receiver (transmitting antenna gain = 2, receiving antenna gain = 3).

G_{area} =9 dB; $A_{mu}(900\,MHZ, 50\,Km)$ = 43 dB. (3+6+4=13)

12. (a) (i) Why dynamic channel assignment strategy is better compared to the fixed channel assignment in cellular networks?

(ii) During the busy hour, 1000 calls were offered to a group of trunks and 10 calls were lost. The average call duration is 2 minutes. Estimate the traffic carried and GOS.

(iii) A cellular service provider decides to use a TDMA scheme that can tolerate SIR of 15 dB in worst case and n = 3. Find the cluster size in the case of

(1) Omni-directional antenna.

(2) 120° sectoring

(3) 60° sectoring

(4) Out of 120° sectoring and 60° sectoring, which one is better. (3+3+7=13)

Or

(b) (i) Explain the umbrella cell concept in connection with cellular communication.

(ii) How microcell zone concept helps is reducing hand-offs?

(iii) Consider a cluster of seven cells. There are a total of 105 channels. Each cell has a surface area of 5 square kilometers. The probability of a call being delayed is 0,05. Find the probability that a call will be delayed for more than 5 seconds if the traffic intensity and arrival rate per user is 0.029 Erlang and 1 call every hour. (3+6+4)

13. (a) (i) Explain the working principle of OFDM and mention its mathematical equation with proper diagram.

(ii) A 64 Kbps voice frame is to be modulated by OFDM scheme. The duration of OFDM symbol is 1000 μs. Total of 32 subcarriers are to be designed to this frame. Find

(1) The null-to-null sub-channel BW

(2) Total BW occupied, and

(3) The number of bits in OFDM frame. (7+6=13)

Or

(b) (i) Explain the working principle of MSK with proper block diagram.

(ii) Binary data is transmitted using MSK at a rate of 1 Mb/s over a RF link having bandwidth of 3 MHz. assume the noise power spectral density at the coherent receiver input to be 10^{-10} W/Hz, find the maximum signal power per bit required at the receiver input to maintain the probability of error less than or equal to 2×10^{-6}. Given $erfc^{-1}\left(2\times10^{-6}\right)=3.3$. (6+7=13)

14. (a) (i) What is selection combining technique? Describe the selection combining technique with proper diagram.

(ii) If the number of diversity branches is 3, the average SNR is 10 dB. Find the improvement in SNR achieved through diversity.

(iii) In a communication system, Selection Combining technique is employed at a receiver to detect the message signal where the links are Rayleigh faded

(1) Determine the order of diversity such that the instantaneous SNR doesn't drop below 10 dB to keep the outage probability less than or equal to 0.00086178. Consider the average link SNR is 20 dB,

(2) Find the improvement in SNR for the above scenario. (6+2+5=13)

Or

(b) (i) Write down the working principle of RAKE receiver. Write down the advantages of using Rake receiver.

(ii) Write down the working principle of LMS algorithm with necessary equation.

(iii) The received signal at a receiver is combined with Maximal Ratio Combining technique. There are four diversity branches and each one is Rayleigh faded.

(1) Determine probability of distribution of the modified instantaneous SNR γ_i if the average link SNR is 20 dB.

(2) Estimate the improved in link capacity for 10 KHz channel bandwidth and compare the same with and without diversity case. (4+4+5=13)

15. (a) (i) Write down the difference between transmitter diversity and receiver diversity. Why receiver diversity is better than transmit diversity.

(ii) In a 2 × 1 communication system, a transmitter transmits a message signal over a wireless medium. The received signal vectors at the receiver antennas are described as follows :

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} h_1 \\ h_2 \end{bmatrix} x + \begin{bmatrix} n_1 \\ n_2 \end{bmatrix}$$

where h_i is link coefficient, and n_i is the additive white Gaussian noise, $i = 1,2$. Find the beam forming vector for this given diversity.

(iii) In a MIMO system, let $\bar{x}$ be the transmit vector, $\bar{y}$ be the received vector and H be channel matrix. Show that the estimated signal for zero-forcing receiver is $\hat{x} = \left(H^T H\right)^{-1} H^T \bar{y}$. (4+3+6=13)

Or

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(b) (i) Design the received signal model for a 3 × 2 MIMO system.

(ii) What is spatial multiplexing? How it improves the system performance?

(iii) Consider a MIMO system with number of receiving antennas (r) = 3. Let the noise vector be $\overline{n}$ where $E\{|n_i|^2\}=1/2$ and $E\{n_i\ n_j\}=0$ while $i\neq j$. Show that the covariance matrix (R) is $R=\frac{1}{2}I_{3\times 3}$ where $\overline{n}=\begin{bmatrix} n_1 \\ n_2 \\ n_3 \end{bmatrix}$. (3+4+6=13)

PART C — (1 × 15 = 15 marks)

16. (a) Consider a 1 × 1 communication system where the channel coefficient between a transmitter and a receiver is $h=\frac{1}{\sqrt{2}}+j\frac{1}{\sqrt{2}}$. The transmitter transmits a message with the power of 0.1 W. Find the received SNR and channel capacity of the given system considering the channel bandwidth is 10 KHz, and noise variance (σ^2) is 1. Given $\log_{10}(1.1)=0.04139$. Now, the system is upgraded to a 2 × 1 communication system where the channel coefficients between a transmitter and a receiver are $h_1=\frac{1}{\sqrt{2}}+j\frac{1}{\sqrt{2}}$ and $h_2=\frac{1}{\sqrt{2}}-j\frac{1}{\sqrt{2}}$ respectively. For the same transmit power, channel bandwidth, and noise variance finds the impact on SNR and capacity. Given $\log_{10}(1.2)=0.07918$.

Or

(b) (i) In a typical communication system, OFDM scheme is used to modulate the frames. If the OFDM symbol duration is 1280 μs and it reaches the receiver after 450 ns, answer the following :

(1) What should be the minimum duration of cyclic prefix? What would be the OFDM duration after appending the cyclic prefix?

(2) If 64 point IFFT is used for frame modulation, how much spectrum is required for transmission?

(3) If one sample period is cyclically prefixed, would it be enough to avoid ISI? Justify your answer.

(ii) For a vehicle travelling 50 m/s using a 900 MHz carrier, find the coherence time of the channel. Given the duration of a frame is 20 ms, determine the number of fades the frame has to face while it is transmitted over the channel. If the frame has to avoid the impact of fading, what should be the frame duration?

(iii) The sum of squared errors between measured and estimated values of the received powers is given by 147 dB, It is assumed that the path loss for these measurements follows the model of Log Normal Shadowing, where the reference distance is $d_0 = 100\,m$, received power at reference distance is 0 dBm and $n = 3$.

(1) Calculate the standard deviation of shadowing about the mean value.

(2) Estimate the received power at $d = 2\,km$ using the Log-distance model. (6+4+5=15)