The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Electrical and Computer Engineering

Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Codes and Title	**: EEX6339 WIRELESS COMMUNICATION**
Academic Year	: 2021/22
Date	: 06th February 2023
Time	: 13:30-16:30hrs
Duration	: **03 hours**

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **six (06)** questions in **four (04)** pages.
3. Answer all the questions in Section I (60 marks).
4. Answer ONLY **two (02)** questions in Section II (40 marks). Each question in Section II is worth 20 marks.
5. Calculators are permitted to use.
6. Supplementary material is provided on page 04.
6. This is a Closed Book Test (CBT).
7. Do not use a red colour pen to write the answers.

SECTION I

Question 1

(20 marks)

Consider a transmitter transmitting at 1MHz with 50W power using an antenna with 1.5 gain. The terrain between the transmitter does not have any obstructions. Separation between the transmitter and the receiver is 500m. Both the transmitter and the receiver are at a height 0.25m from the ground. The receiving antenna has a gain of 2.

1) Describe the type of fading that occurs in this scenario.
2) State the suitable propagation model for this scenario. Clearly state any assumptions and support your answer with reasons.
3) Calculate the received power in dBm at a far-field distance of 10km. Assume the system loss of 1 in your calculations.
4) If there is a knife edge obstacle of height 5m is placed 200m from the transmitter, (i) draw the signal propagation paths, (ii) calculate the associated path length difference. Refer to Figure 1 for the calculations. Comment on the change in path length difference if the frequency is increased up to 1GHz.

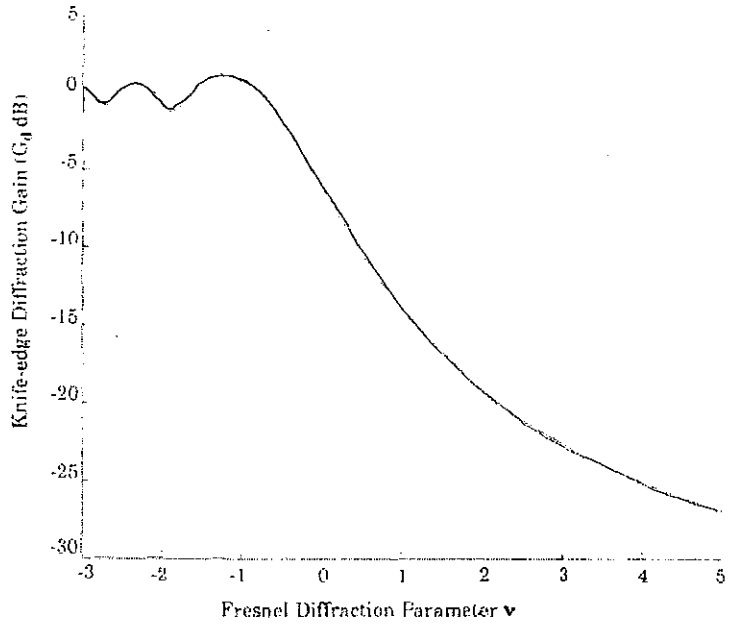

Figure 1

Question 2

(20 marks)

Consider a communication system operating in a large urban area where the signal transmits at 100MHz with the transmitter (T) and receiver (R) are separated by 200m. Heights of T and R are 30m and 1m respectively. It is also given that the gains of T and R antennas are 1.5 and 2 respectively.

1) Justify the statistical fading model that can be used for this scenario.
2) Calculate the median path loss in dB for the given signal transmission.
3) If the signal frequency is changed to 150MHz, determine whether the path loss will change. In your answer clearly show all the relevant calculations.
4) If the separation between T and R is reduced to 100m, determine the path loss for the signal transmission at 150MHz.

Question 3 **(20 marks)**

1) Briefly describe the two terms (i) microdiversity and (ii) macrodiversity. (02 marks)
2) Briefly describe the following diversity mechanisms and their limitations. (10 marks)
    a) Space diversity
    b) Polarization diversity
    c) Directional diversity
    d) Frequency diversity
    e) Time diversity

3) In an alphabet of 10 characters, the frequency of occurrences of each character is shown in Table 01. You are asked to design a Huffman encoding tree to compute the code words to encode each character. (08 marks)

Table 01: Frequency of occurrences of characters

Character	Frequency of occurrence
A	10
B	24
C	12
D	27
E	22
F	05

SECTION II

Question 4 **(20 marks)**

1) Uplink of a GSM cellular communication system requires a signal-to-noise ratio of 10dB. Assume a maximum mobile transmit power of 30 dBm, 0dB antenna gain at the mobile, and 12dB gain at the base station. Assume path loss is given by the urban area Hata model, with fc = 850MHz. Consider the base station antenna height of 30m, mobile height of 1m. Assume that the other losses are insignificant. calculate the maximum range of the link. (10 marks)

2) Selection combining method is one of the techniques that can be used to combine the signals received from diversity branches in a wireless communication system. (10 marks)
    a) Describe the principle used for selection combining.
    b) Calculate the required fade margin considering the number of branches (M=2) are statistically independent channels undergoing Rayleigh fading and are required to be above the prescribed threshold with 0.99 probability.

Question 5 **(20 marks)**

1) Describe the following multiple access methods using appropriate diagrams to support you answer: (06 marks)
   a) Frequency division multiple access
   b) Time division multiple access
   c) Code division multiple access

2) Briefly explain the near-far problem in CDMA uplink and a potential solution to overcome this issue in a mobile communication system. (04 marks)

3) Maximal length sequences are generated using linear shift registers connected with tap points and modulo-2 addition. (10 marks)
   a) Write the recursive relations for outputs at S1, S2, S3, S4, and S5.
   b) Compute the first five outputs of the linear feedback shift register shown in Figure 2, if the initial state is 00101.

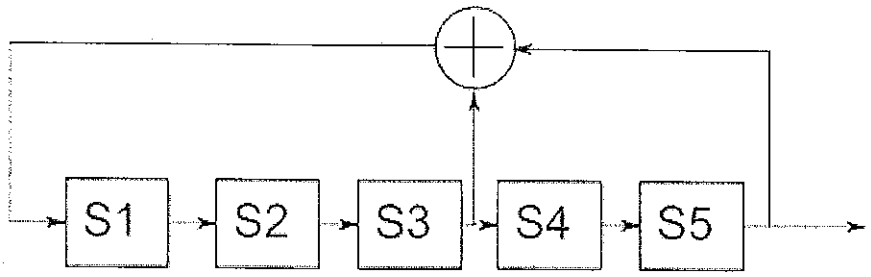

Figure 2

Question 6 **(20 marks)**

1) Explain the terms (i) bandwidth efficiency and (ii) power efficiency considerations of a digital modulation scheme when considering a digital communication system. (04 marks)

2) Calculate and compare the theoretical maximum data rate that can be supported in a 200kHz channel for SNR values 10dB and 30dB. Discuss the significance of the variation observed in the answers that you have computed. (06 marks)

3) Draw the modulation outputs for the (i) binary amplitude shift keying, (ii) binary frequency shift keying and (iii) binary phase shift keying for an input bit stream 101101. (03 marks)

4) Derive the expression for average bit energy of binary amplitude shift keying (BASK) modulation technique and draw the constellation diagram. $s1(t)$ and $s2(t)$ represent the signals corresponding to bit '0' and bit'1' transmissions given as follows: (11 marks)

$$s1(t) = A_1 \cos cos \left(2\pi f_c t + \theta\right)$$

$$s2(t) = A_2 \cos cos \left(2\pi f_c t + \theta\right)$$

Supplementary material

Free space model

$$PL\,(dB) = 10\log_{10}\frac{P_t}{P_r} = 10\ \log_{10}\left(\frac{G_t G_r \lambda^2}{16\pi^2 d^2}\right)$$

Okumura model

$$L_{50}(dB) = L_f + A_{m,u}(f,d) - G_{h_{re}} - G_{h_{te}} - G_{AREA}$$

$$G_{h_{te}} = 20\log\left(\frac{h_{te}}{200}\right)\ (dB)$$

$$G_{h_{re}} = 10\log\left(\frac{h_{re}}{3}\right)\ (dB)$$

Hata model

$$L_{50}(dB) = 69.55 + 26.16\log(f_c) - 13.82\log(h_{te}) - a(h_{re}) + (44.9 - 6.55\log(h_{re}))\log(d)$$

$$a(h_{re}) = 8.29(\log 1.54h_{re})^2 - 1.1\ (dB)$$