City & Guilds

9210-119
Level 6 Graduate Diploma in Engineering
Wireless and mobile communications

Sample Paper

You should have the following for this examination
- one answer book
- non-programmable calculator
- pen, pencil, ruler

No additional data is attached

General instructions
- This examination paper is of **three** hours duration.
- This examination paper contains **nine** questions.
- Answer **any five** questions.
- All question carry equal marks. The maximum marks for each section within a question are given against that section.
- An electronic, non-programmable calculator may be used, but the candidate **must** show clearly the steps prior to obtaining final numerical values.
- Drawing should be clear, in good proportion and in pencil. Do **not** use red ink.

1 a) List **three** key disadvantages of wireless communications over wired communications. (3 marks)

b) Depending on the direction of the data flow, wireless communication systems can be divided into three major types. Briefly describe them with suitable examples. (6 marks)

c) Briefly explain **two** most important adverse effects of multipath propagation. (4 marks)

d) A base station transmitter operates at 900 MHz carrier frequency.

i) Calculate the received carrier frequency for a mobile moving at a speed of 60 km/h in a direction, which is 60° to the direction of arrival of the transmitted signal. (2 marks)

ii) Determine the maximum speed at which the mobile can move for a maximum Doppler frequency shift of 80 Hz. (2 marks)

iii) Suppose that the mobile is capable of receiving signals with Doppler frequencies ranging from 12 Hz to 48 Hz when moving at a uniform speed of 50 km/h. Calculate the beam width of the mobile antenna. (3 marks)

2 a) Briefly explain the following with respect to wireless communications.

i) Small-scale Fading. (2 marks)

ii) Multipath delay spread. (2 marks)

b) A transmitter produces 50 W of power. This power is applied to a unity gain antenna with a 900 MHz carrier frequency. The receiver antenna gain is 2. The receiver antenna has a purely real impedance of 50 Ω and is matched to the receiver.

i) Express the transmitted power in dBμ, dBm, dBW. (3 marks)

ii) Find the received power in dBm at a free space distance of 10 km from the antenna. Assume free space propagation. (3 marks)

iii) Find the magnitude of the E-field at the receiver antenna. (3 marks)

iv) Find the rms (root mean square) voltage applied to the receiver input. (3 marks)

v) If the receiver requires a minimum received power of –80 dBm, find the maximum coverage distance of the transmitter. (4 marks)

3 a) Why is the free space propagation model not usually applicable in mobile radio environments? (2 marks)

b) Briefly explain the difference between Rayleigh fading and Rician fading models. (3 marks)

c) The empirical Hata model is given below.

$L_{pH}(dB) = 68.75 + 26.16 \log f_c - 13.82 \log h_t + (44.9 - 6.55 \log h_t) \log$

where,

L_{pH} is the median value of the propagation path loss in dB,

f_c is the frequency of the transmission in MHz,

h_t is the effective cell-site antenna height in meters ranging from 30 m to 200 m,

r is the distance of the mobile form cell-site in km.

Using this model, determine the median propagation path loss for a radio signal at 900 MHz, with a transmitting antenna height of 40 m and a receiving antenna height of 3 m, over a distance of 10 km in a dense urban mobile environment. (4 marks)

d) Suppose that digitally modulated signals are transmitted through a channel with the power delay profile shown in the Figure Q3.d.

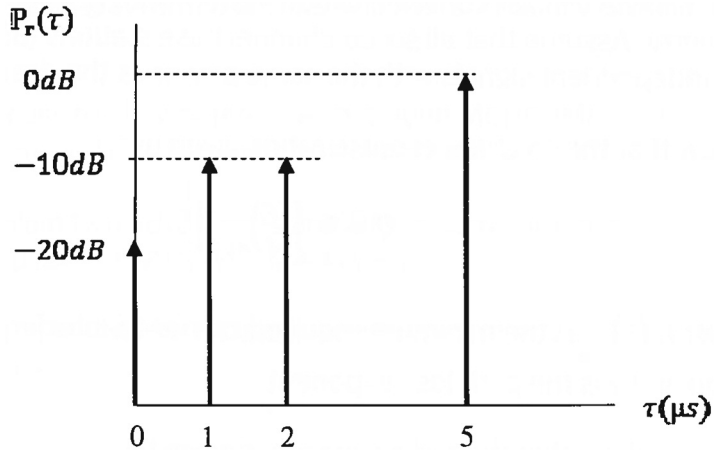

Figure Q3.d

i) Calculate the mean excess delay, rms delay spread and the maximum excess delay (10 dB). (4 marks)

ii) Estimate the 50 % coherence bandwidth of the channel. (2 marks)

iii) Would this channel be suitable for GSM communication without an equalizer? Justify your answer. (2 marks)

iv) Assume that QPSK (Quadrature Phase Shift Keying) modulation is used. What is the maximum bit rate that can be achieved through this channel without needing an equalizer? (3 marks)

4 a) Describe **three** disadvantages of FDMA (Frequency Division Multiple Access) as a multiple access scheme for cellular communication systems. (6 marks)

b) Briefly explain the nonlinear effects in FDMA systems. (4 marks)

c) With the use of suitable diagrams, briefly explain the near-far problem in CDMA (Code Division Multiple Access) systems. (4 marks)

d) i) Briefly explain what Timing Advance (TA) is, while highlighting its necessity in GSM systems. (3 marks)

ii) Consider a GSM system, which uses TDMA with Frequency Division Duplexing (FDD). Each GSM time slot consists of 8 trailing bits, 8.25 guard bits, 24 training bits, and 2 traffic bursts of 56 bits of data. Find the frame efficiency. (3 marks)

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5 a) Briefly explain **two** drawbacks of spread spectrum technology. (4 marks)

b) Draw the block diagrams of the transmitter and receiver of a typical FH-SS (Frequency Hopping Spread Spectrum) system. (6 marks)

c) Briefly explain **two** techniques that can be used to enhance the capacity of a WCDMA (Wideband Code Division Multiple Access) system. (4 marks)

d) Consider a FDMA cellular communication system with hexagonal cell geometry. Assume that all six co-channel base stations (BSs) transmit independent signals with the same power as the desired BS.

i) Show that the co channel reuse ratios given by

$$Q = 6\left[\left(\frac{C}{I}\right)_{min}\right]^{\frac{2}{\gamma}},$$

where, $\left(\frac{C}{I}\right)_{min}$ is the minimum required carrier-to-interference ratio and γ is the path loss exponent. (3 marks)

ii) Hence, show that the radio capacity is given by

$$m = \frac{B_t}{B_c\left[\frac{6}{3^{\gamma/2}}\left(\frac{C}{I}\right)_{min}\right]^{2/\gamma 1}}$$

where B_c is the channel bandwidth and B_t is the total allocated spectrum for the system. (3 marks)

6 a) Briefly explain **three** key features of a CDMA cellular system. (6 marks)

b) Briefly explain the self-jamming problem in CDMA systems. (2 marks)

c) Two transmitters A and B of a CDMA system need to transmit bit $A_d = 1$ and $B_d = 0$, respectively. The spreading sequences allocated for transmitter A and transmitter B are [1 –1 1 –1] and [1 –1 –1 1], respectively. Assume that BPSK modulation is used and binary 0 is represented as –1 and binary 1 is represented as +1.

i) What is the processing gain of the system? (1 mark)

ii) Determine the transmitted chip sequences for A and B. (2 marks)

iii) Assume that the signals are transmitted from transmitters A and B at the same time using the same frequency. The interference from other transmitters and noise can be neglected, and the received signals have the same strength at the receiver. Find the received (composite) chip sequence at the receiver. (1 mark)

iv) Detect the transmitted bits A_d and B_d from the received (composite) chip sequence. All the intermediate steps should clearly be shown. (4 marks)

v) Now suppose that a random noise/interference sequence [–2 1 –0.5 1] is added to the received (combined) chip sequence. Detect the transmitted bits from the noise-added received sequence. Comment on the detected bits. (4 marks)

7 a) Draw the block diagram of a RAKE receiver and briefly explain its operation. (6 marks)

b) Briefly discuss the key differences between MCHO (Mobile Control Handoff) and NCHO (Network Control Handoff) algorithms. (4 marks)

c) Briefly explain two advantages and **one** disadvantage of soft handover used in UMTS WCDMA systems. (6 marks)

d) Explain **two** reasons for intracell interference in orthogonal CDMA cellular systems. (4 marks)

8 a) Describe the frame structure of GSM systems using a suitable diagram. (4 marks)

b) Explain the purpose of the random access channel (RACH) used in the uplink of GSM systems. (2 marks)

c) Briefly describe the **three** main steps of the cell search procedure of UMTS WCDMA systems. (6 marks)

d) A GSM system uses a periodic pattern of 26 slots with a traffic channel (TCH). For data transmission, 20 out of 26 physical slots are used. Each normal burst used for data transmission carries up to 120 bits of user data. It is repeated every 4.15 ms. Compute the maximum data rate for user traffic supported by a TCH. (5 marks)

e) Briefly explain how the control and data channels are multiplexed in the downlink of UMTS WCDMA systems with a suitable diagram. (3 marks)

9 a) Briefly explain the operation of the **two** main components of a Radio Network Subsystem (RNS) in UMTS. (6 marks)

b) A Tower Mounted Amplifier (TMA) is commonly used in base transceiver stations. State **two** benefits and **two** drawbacks of using TMAs. (4 marks)

c) Explain **three** key similarities between CDMA2000 and UMTS-WCDMA systems. (6 marks)

d) Explain the purpose of channelization codes and scrambling codes in UMTS WCDMA systems. (4 marks)