GLASGOW COLLEGE UESTC

Final Exam Paper

Mobile Communications (UESTC 4017)

Date: 8th Jan. 2021
Time: 14:00—16:00

Attempt all PARTS. Total 100 marks

Use one answer sheet for each of the questions in this exam.
Show all work on the answer sheet.

Make sure that your University of Glasgow and UESTC Student Identification Numbers are on all answer sheets.

An electronic calculator may be used provided that it does not allow text storage or display, or graphical display.

All graphs should be clearly labelled and sufficiently large so that all elements are easy to read.

The numbers in square brackets in the right-hand margin indicate the marks allotted to the part of the question against which the mark is shown. These marks are for guidance only.

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Q1 (a) Describe the conceptual difference between FDD/TDD and FDMA/TDMA. Name the link mode of downlink LTE-A (4G). [6]

(b) Describe the technical advantages and disadvantages of OFDM technique. [6]

(c) What is the channel code used for the public shared data channel in LTE-A (4G) and NR (5G), respectively? Assume the transmitting efficiency is according to the amount of source/information data to be transmitted within a certain time. Can the channel coding operation improve the transmitting efficiency? And can the source coding operation improve the transmitting efficiency? Explain the reasons of your answers. [4]

(d) Consider a (*n*, *k*, *m*) convolutional encoder with the state transition diagram of Fig. Q1.

(i) Find the value of *n*, *k* and *m*. [3]

(ii) Determine its coding rate. [2]

(iii) Determine the encoder output assuming the initial state of register as $S_0 = 0$ and message sequence is [1010]. [4]

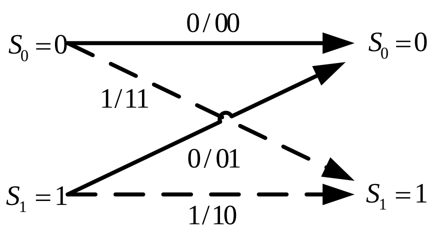

Figure Q1.

Q2 Consider a Hexagonal cellular network that the base station B-1 is broadcasting the control signal to the trains (T-1 and T-2) with a bandwidth of 10 kHz at a carrier frequency of 900MHz, and all the communication links around the base station B-1 are with the same propagation factor of $n = 4$.

(a) Assume the train T-1 is moving toward the base station B-1 at a speed of 360km/h and the angle between the signal radiation direction and the motion direction is 60 rad, determine the carrier frequency of the received signal of train T-1. [4]

(b) Calculate the maximum Doppler shift f_m, the coherence time T_c, and the symbol duration T_s of train T-1. Based on your calculations, is the Doppler dispersion

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(or Doppler spread) negligible at the receiver side? Explain the reason of your answers. [8]

(c) Assume that the train T-2 is 100m apart from the base station B-1, and it receives the control signal at an average power of 0.1 watts. If the train T-1 is 16.2 km apart from the base station B-1, what is the average power of the received signal at train T-1? [7]

(d) If train T-1 receives an interference signal from base station B-2 with the average power of -95dBm.

(i) Calculate the carrier to interference (C/I) power ratio of train T-1. [2]

(ii) Determine the optimal cluster size of the cellular network, if the C/I of all the trains should be no less than 20dB. [4]

Q3 Consider a phase-rotated QPSK modulator with the passband expression of the modulation signal as $x(t)=\sqrt{2}\cos\left(2\pi f_c t+\frac{2\pi(i-1)}{4}+\frac{\pi}{6}\right)$, $i=1,2,...,4$, and the bit-state mapping scheme given by Table.Q2. Note: the expansion sets are $\phi_1(t)=\cos(2\pi f_c t)$, $\phi_2(t)=\sin(2\pi f_c t)$.

Table Q2.

input bits	Modulation states S_i
00	S_1
10	S_2
11	S_3
01	S_4

(a) Plot the constellation diagram of the phase-rotated QPSK on Figure Q2-1, and illustrate both the amplitude and the phase of the constellation points. [8]

(b) Assume the input bit sequence of the modulator is [1011000110].

(i) Determine the output state sequence of modulator. [3]

(ii) Draw the state transition path on the constellation diagram on Fig. Q2-2. [3]

(iii) Find the maximum phase shifting of the output signal. [2]

(c) Calculate the average bit energy E_b, the minimum Euclidean distance $d_{\min}=\min\limits_{\substack{i=1,2,...M\\ j\neq i}}\{d_{ij}\}$ and the maximum Euclidean distance $d_{\max}=\max\limits_{\substack{i=1,2,...M\\ j\neq i}}\{d_{ij}\}$ of modulation symbols $\{S_i,\ i=1,2,...,4\}$, respectively. [6]

(d) If the bit rate of the input bit sequence is 1Mbps, calculate the symbol duration and the symbol rate of the transmission signal after modulation. [4]

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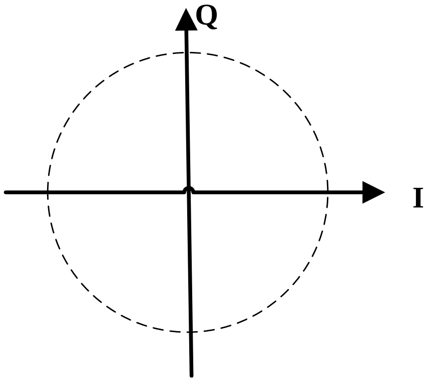

Figure Q2-1. Constellation diagram of phase-rotated QPSK

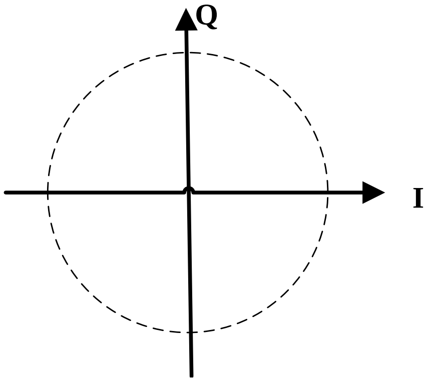

Figure Q2-2. State rout of the modulation signal

Q4 Assume a 1×3 single input multiple output (SIMO) system, where the transmitter sends binary phase shift key (BPSK) signal with a transmit power of $P_t = 1$ through single antennas, and the receiver adopts three antennas for spatial diversity. Assume the channel noise at all the receive antennas is standard AWGN noise (with zero mean and normalized variance of 1), and the fading channels of three antennas are statistically independent. Consider the instant fading coefficients of three diversity branch are $h_1 = 4,\ h_2 = 2e^{j\frac{\pi}{2}}$, and $h_3 = 1e^{-j\pi/3}$, respectively.

(a) If the transmit signal is defined as s, and the independent AWGN noise at three receiving antennas as n_1, n_2, n_3, respectively, derive the formula expressions of the received signal at three receiving antennas, i.e., r_1, r_2, r_3 . [6]

(b) If the receiver applies the selective combining (SC), equal gain combining (EGC) and maximum ratio combing (MRC) to three received signal, derive the

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formula expression of the combined signal under different combining criterion, respectively. [9]

(c) Determine the instant signal to noise ratio (SNR) of the combined signal using different combing criterion, respectively. [6]

(d) Consider the signal is transmitted over another communication environment where the fading channels of three antennas become fully correlated, i.e., $h_1 = h_2 = h_3$, will it achieve a better BER performance compared to the channel described in Q4(a-c)? Explain the reason for your answer. [4]

End of question paper