GLASGOW COLLEGE UESTC

Exam paper

Advanced Digital Communication (UESTC4028)

Date: 29th Dec. 2020
Time: 09:30am - 11:30am

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) Draw a constellation diagram of 8-Phase Shift Keying (PSK) modulation and label the constellation points in binary. [5]

(b) Explain the following channel impairments:

(i) Attenuation [2]

(ii) Distortion [2]

(c) Consider a wireless link transmitting on a carrier frequency of 2.4 GHz with 5 km between the transmitter and receiver. Assume the transmission power is 23 dBm, and the antenna gain at the transmitter and receiver sides are 9 dBi and 10 dBi, respectively. The receive sensitivity is -89 dBm.

(i) Calculate the received signal power. [6]

(ii) The receiver receives a 7 dBm interference. Explain whether the receiver can detect the received signal. [5]

(d) Explain why modulation is important in communication systems. [5]

Q2 (a) Explain the concepts of Automatic Repeat ReQuest (ARQ). [5]

(b) In block codes, the encoder transforms each 3-bit data block into a larger block of 6-bits called code bits. What is the redundancy of code of the system? [4]

(c) Considering a (7,4) coding whose parity check matrix **H** is

$$\mathbf{H} = \begin{bmatrix} 1 & 0 & 0 & 1 & 0 & 1 & 1 \\ 0 & 1 & 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 1 & 0 & 1 & 1 & 1 \end{bmatrix}$$

Calculate the syndrome vector ($\boldsymbol{s}$) for the received codeword $\boldsymbol{r} = [1\ 0\ 1\ 1\ 0\ 1\ 0]$. [6]

(d) Given the look up table of Table Q2, find the transmitted codeword. [6]

Table Q2

Syndrome	Error Pattern
100	1000000
010	0100000
001	0010000

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110	0001000
011	0000100
111	0000010
101	0000001

(e) Explain why duplexers are needed in Frequency Division Duplexing (FDD). [4]

Q3 (a) What is the role of matched filter in communication systems? [5]

(b) Assume T is the symbol-period of the communications system, draw figures to show the raised cosine filter in both time and frequency domain respectively, with roll-off factor $\beta = 0, 0.25, 0.5, 1$. [8]

(c) Consider communication system with noise power spectrum density $N_o = 10^{-11}$ W/Hz and the symbol energy $E_s = 10^{-10}$ J.

(i) Find the energy per bit E_b for BPSK and QPSK modulation respectively. [6]

(ii) Find the bit error probability P_b for BPSK and QPSK modulation using the following reference equation $Q(x) = \frac{1}{x\sqrt{2\pi}} \exp\left(-\frac{x^2}{2}\right)$. [6]

Q4 Considering an inter-symbol-interference (ISI) free cyclic prefix based orthogonal frequency division multiplexing (CP-OFDM) system. The communication system bandwidth is 30 kHz and subcarrier spacing is 10 kHz. The signal $\boldsymbol{x}[n]$ is transmitted over multi-path channel $\boldsymbol{h}[n]$, by using the OFDM system sketched in Figure Q4. The time domain channel response $\boldsymbol{h}[n] = [1, 0.2]$. Assume there is no noise in the system, the received signal vector in an OFDM symbol is $\boldsymbol{z}[n] = [-1.2,\ 0.9 - 0.1732\mathrm{i},\ 0.9 + 0.1732\mathrm{i}]$.

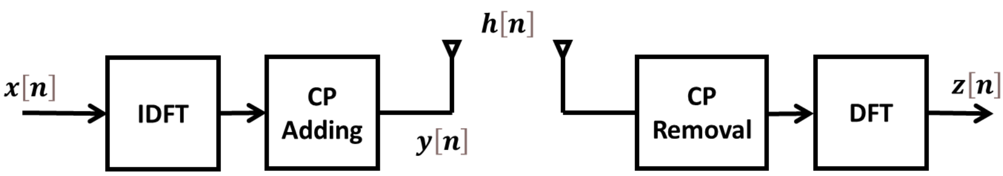

Figure Q4

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(a) What is the common purpose of using CP and zero-padding (ZP) in OFDM system, and what is the advantage of CP compared to ZP? [5]

(b) Write done the DFT matrix for this OFDM system, and calculate the frequency domain channel. [5]

(c) Design the minimum length of CP in samples and second, respectively. [5]

(d) Calculate the transmitted signal $\boldsymbol{x}[n]$ at the transmitter side. [5]

(e) Write down the transmitted signal $\boldsymbol{y}[n]$ with a CP. [5]

End of question paper