GLASGOW COLLEGE UESTC

Exam paper

Advanced Digital Communication (UESTC4028)

Date: 2nd Jan. 2020
Time: 14:30-16:30pm

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 16QAM modulation, labelling the constellation points in binary. [5]

(b) Calculate how many times faster 16QAM modulation can transmit than BPSK modulation in terms bits per symbol. [5]

(c) Consider a BPSK system with a bit rate of 1 Mbit/s. The received waveform $s_1(t) = Acos(w_o t)$ and $s_2(t) = -Acos(w_o t)$, are coherently detected with a matched filter. The value of A is 10 mA, and you may assume that the single-side noise power spectrum density is $N_o = 10^{-11}$ W/Hz and the signal power and energy per bit are normalized relative to a 1 Ω load.

(i) Calculate the noise power. [5]

(ii) Find the energy per bit E_b. [5]

(iii) Find the bit error probability P_b using the following reference equation $Q(x) = \frac{1}{x\sqrt{2\pi}} \exp\left(-\frac{x^2}{2}\right)$. [5]

Q2 (a) Explain the advantages and disadvantages of zero-forcing (ZF) equalization, comparing it with the minimum mean square error (MMSE) equalization. [5]

(b) Design a 3-tap ZF equalizer for input x(n) = {0, 0.1, −0.15, −0.87, −0.12, 0.2, 0} in which x(0) = -0.87. [10]

(c) Describe the impulse response of a matched filter for detecting the discrete signal shown in Figure Q2. [5]

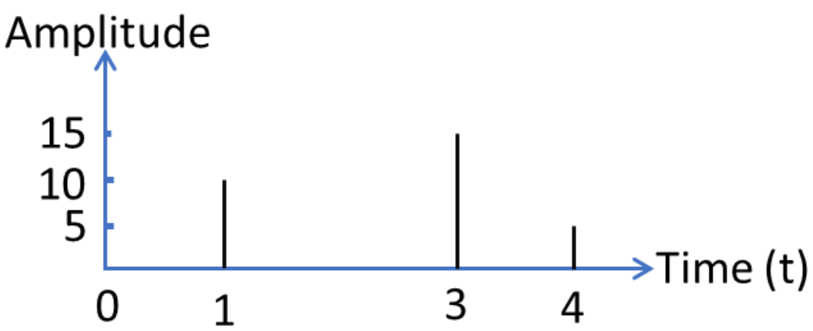

Figure Q2

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(d) With the signal of part (c) in Figure Q2 at the input to the filter, show the output as a function of time. [5]

Q3 (a) Consider wireless communication systems,

(i) Explain why channel coding is important. [3]

(ii) Explain the cost of using channel coding. [3]

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

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

Assuming a received codeword $\boldsymbol{r}$ = [1 0 0 1 0 0 1], calculate the syndrome vector $\boldsymbol{s}$. [7]

(c) Given the look up table of Table Q3, decode the transmitted codeword. [12]

Table Q3

Syndrome	Error Pattern
100	1000000
010	0100000
001	0010000
110	0001000
011	0000100
111	0000010
101	0000001

Q4 Considering a communication system with bandwidth of 45 kHz. The (time domain) channel impulse response $\boldsymbol{h}[n] = [1, 0.5]$. The transmitted signal vector in an OFDM symbol is $\boldsymbol{x}[n] = [1, -1, -1]$. Assume we design an inter-symbol-interference (ISI) free cyclic prefix based orthogonal frequency division multiplexing (CP-OFDM) system with subcarrier spacing 15 kHz to

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transmit the signal $\boldsymbol{x}[n]$ over the multi-path channel $\boldsymbol{h}[n]$, by using the OFDM system sketched in Figure Q4.

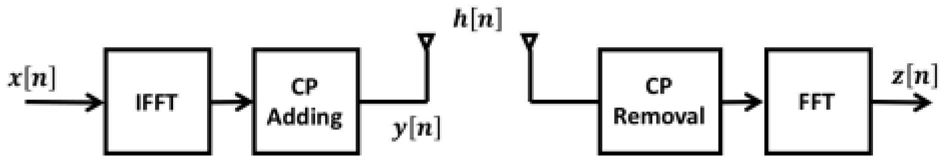

Figure Q4

(a) Explain the role of CP in an OFDM system. [5]

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

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

(d) Calculate the channel frequency response $\boldsymbol{H}$ corresponding to the modulated signals at the receiver side after FFT. [5]

(e) Assume the system is noise free (i.e., no noise in the system), calculate the received signal $\boldsymbol{z}[n]$ at the receive side. [5]

End of question paper