ELEC1200 - Final Exam Review Questions

Question 1

A text string is converted to a discrete time waveform according to the following steps:

1. Each character in the string is converted to an 8-bit ASCII codeword according to the table below, where the MSB is listed first.

0	0011 0000	O	0100 1111	m	0110 1101
1	0011 0001	P	0101 0000	n	0110 1110
2	0011 0010	Q	0101 0001	o	0110 1111
3	0011 0011	R	0101 0010	p	0111 0000
4	0011 0100	S	0101 0011	q	0111 0001
5	0011 0101	T	0101 0100	r	0111 0010
6	0011 0110	U	0101 0101	s	0111 0011
7	0011 0111	V	0101 0110	t	0111 0100
8	0011 1000	W	0101 0111	u	0111 0101
9	0011 1001	X	0101 1000	v	0111 0110
A	0100 0001	Y	0101 1001	w	0111 0111
B	0100 0010	Z	0101 1010	x	0111 1000
C	0100 0011	a	0110 0001	y	0111 1001
D	0100 0100	b	0110 0010	z	0111 1010
E	0100 0101	c	0110 0011	.	0010 1110
F	0100 0110	d	0110 0100	,	0010 0111
G	0100 0111	e	0110 0101	:	0011 1010
H	0100 1000	f	0110 0110	;	0011 1011
I	0100 1001	g	0110 0111	?	0011 1111
J	0100 1010	h	0110 1000	!	0010 0001
K	0100 1011	i	0110 1001	'	0010 1100
L	0100 1100	j	0110 1010	"	0010 0010
M	0100 1101	k	0110 1011	(	0010 1000
N	0100 1110	l	0110 1100	)	0010 1001
				space	0010 0000

2. Each codeword is arranged so that the MSB is transmitted first.

3. The resulting bit stream is divided into 16-bit blocks.

4. Each block is framed with a start bit of '1' and no stop bit.

5. Each bit is represented using two samples.

Suppose we obtain the following bit sequence:

110000111100000011000011110000000
110011001100000011000011000000000
1100001111110011000000110011000011

What was the original text string?

Answer: 10Q :)

Solution

You should reorganize the binary sequence as below:

11 0000111100000011 0000111100000000
11 0011001100000011 0000110000000000
11 0000111111001100 0000110011000011

The first two samples of each row correspond to the start bit and the following 32 samples to the 16 bits in the block (two characters). Removing the start bit and extracting the bits, we obtain

0011 0001→1
0011 0000→0
0101 0001→Q
0010 0000→space
0011 1010→:
0010 1001→)

<u>Question 2</u>

Given the following (15, 8, 4) parity block code encoding scheme:

Step 1: For N byte message

Step 2: Split message bit stream into N 8-bit blocks and add the necessary row/column/overall even parity bits to enable error correction. The 8 data bits (D1, D2, D3, D4 from row 1, and D5, D6, D7, D8 from row 2) are combined with the 7 even parity bits (R1, R2, C1, C2, C3, C4, and P) to form the 15-bit codeword. The order of bits in the codeword is shown below:

D1, D2, D3, D4, D5, D6, D7, D8, R1, R2, C1, C2, C3, C4, P

We want to communicate a text message encoded in ASCII so that we choose an 8-bit block.

Step 3: Interleave the bits from 3 codewords to handle burst errors.

Step 4: Bit-stuff each codeword block to make sure the sync sequence can be recognized.

Assume that 01111110 is used as the sync. After interleaving, we scan the whole bit sequence. When 5 consecutive bit “1” are observed in the data stream, a bit “0” is then added into the outgoing stream.

Step 5: Insert sync sequences at the beginning of the frame.

(a) Encode the following bit sequence.

“000010111010101000101111”

(b) Given the following received frame data:

“011111100001101010100011111001010110001001000110000111”

Decode the frame and find the corresponding ASCII characters. There might be errors in the received data. You are required to identify the error bits and correct the errors.

Solution

00001011 10101010 00101111

(a)

00001011

0	0	0	0	0
1	0	1	1	1
1	0	1	1	1

➔000010110110111

10101010

1	0	1	0	0
1	0	1	0	0
0	0	0	0	0

➔101010100000000

00101111

0	0	1	0	1
1	1	1	1	0
1	1	0	1	1

➔001011111011011

000010110110111
101010100000000
001011111011011

The encoded bit sequence is

01111110 010 000 011 000 111 001 111 1001 001 100 101 001 100 101 101

Remark:

01111110 is the sync sequence

0 is added when you see 5 consecutive bit “1”

(b)
01111110
000
110
101
010
001
111
1001
010
110
001
001
000
110
000
111

01100110 1000101 ← 2^{nd} is the error bit
01010101 1000101 ← 3^{rd} is the error bit
00101110 0110001 ← 2^{nd} is the error bit

0	1	1	0	1
0	1	1	0	0
0	0	1	0	1

➔01000110 ➔F

0	1	0	1	1
0	1	0	1	0
0	0	1	0	1

➔01110101 ➔u

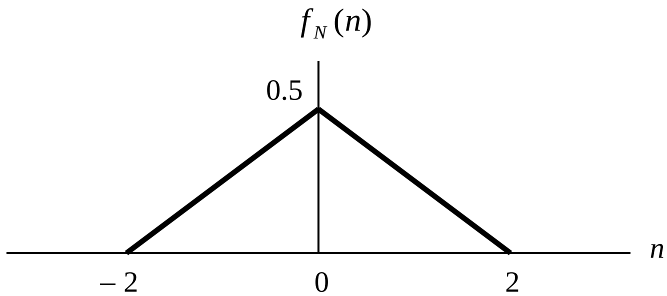
0	0	1	0	0
1	1	1	0	1
1	0	0	0	1

➔01101110➔n

The original message = Fun

Question 3

A binary communication channel has noise with the following PDF (probability density function).



The response to a bit is the sum of the response to the input and noise. Without noise, the responses to bit "0" and bit "1" are 0V and 2V, respectively. Decoding the channel output is done by comparing the channel output to a threshold value of T. The decoded bit is "1" if the channel voltage is greater than T and "0" otherwise.

(a) (2) Sketch the PDF of the received signal if the input bit is "0".

(b) (2) Sketch the PDF of the received signal if the input bit is "1".

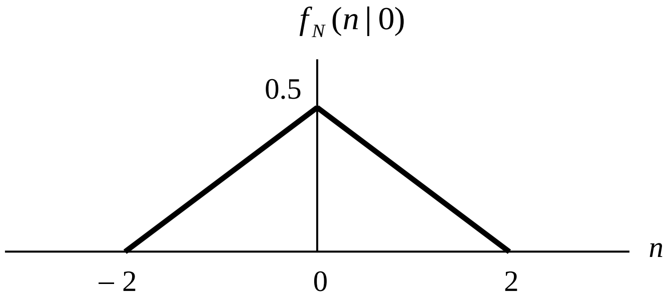
(c) (2) What is the optimal threshold if the inputs bits "0" and "1" are equally likely?

(d) (3) What is the BER (bit error rate) if we use the optimal threshold in (c)?

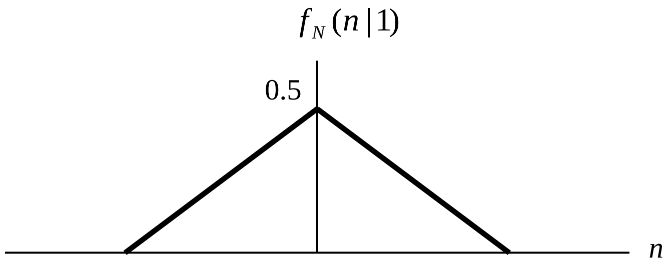
(e) (3) By how much does the BER change if the response to bit "1" without noise changes to 3 V while the response to bit "0" and the threshold value of T remain unchanged? Explain your answer.

Solution

(a)



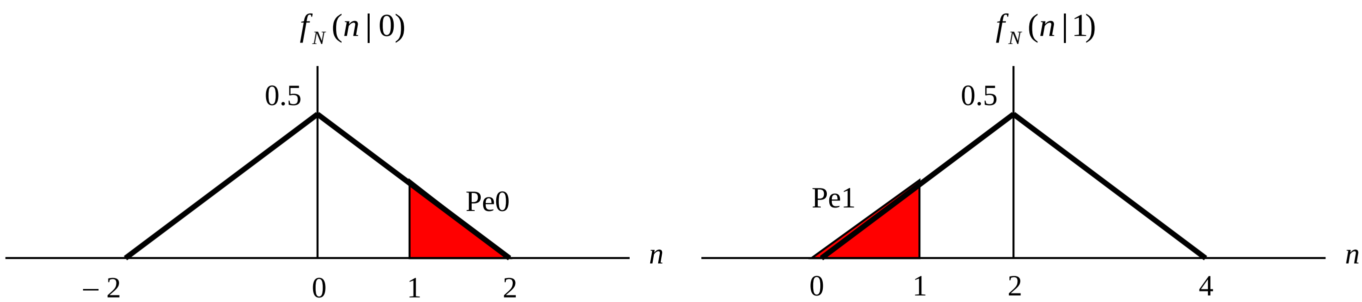
(b)



(c) Optimal threshold = (0 + 2) / 2 = 1 V

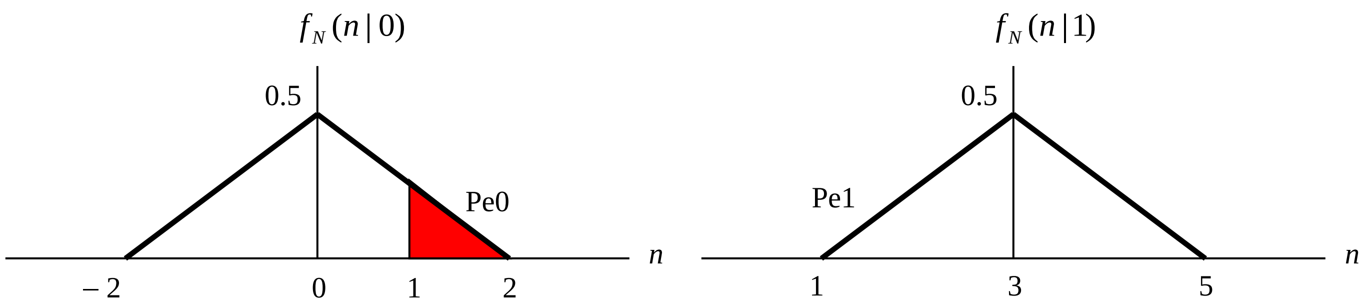
(d) P1 = P0 = 0.5 Pe1 = (0.25) (1) / 2 = 0.125 Pe0 = Pe1

BER = P0 (Pe0) + P1 (Pe1) = 0.125



(e) BER = P0 (Pe0) + P1 (Pe1) = 0.0625

BER is reduced by 50%.



Question 4

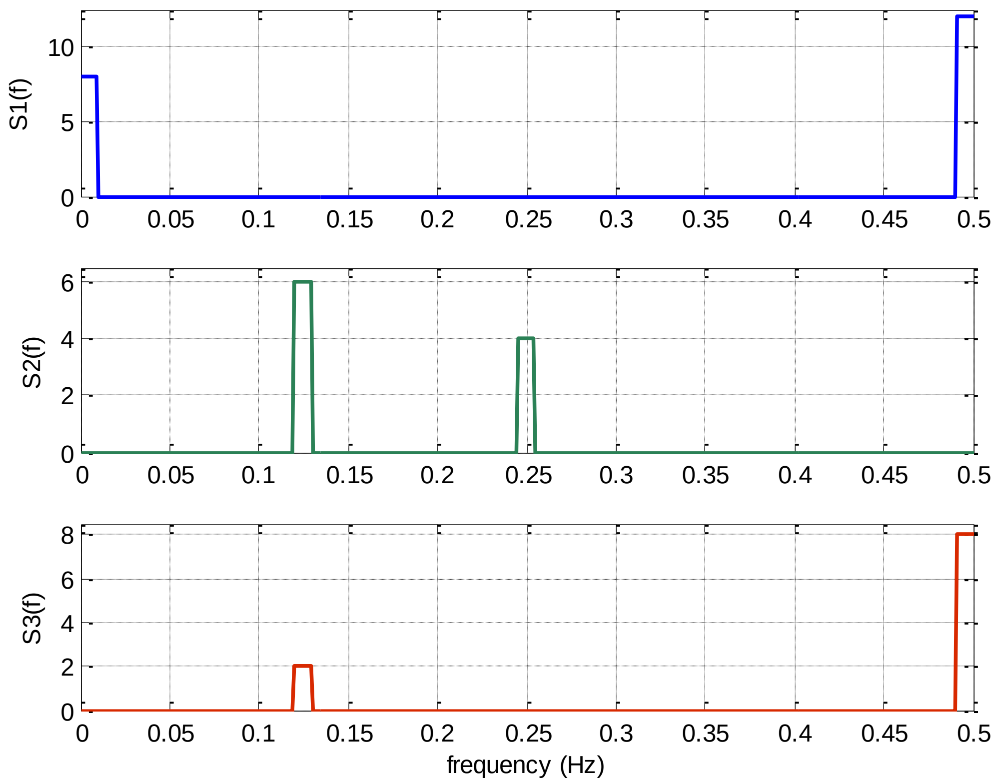
Suppose the input to a linear time invariant system is a 256 points waveform

$$x(n) = 2 + \cos\left(2\pi\frac{32}{256}n\right) + \cos\left(2\pi\frac{96}{256}n\right) + 3\cos\left(2\pi\frac{128}{256}n\right) \qquad \text{where n = 0, 1, …, 255.}$$

(a) Is this sequence periodic? In other words, does it repeat after a number of samples N so that x(n + N) = x(n)? What is this value of N?

(b) What is the smallest positive value of n for which x(n) achieves its maximum value? What is this maximum value of x(n)?

Suppose that x(n) is input to three different linear time invariant systems whose frequency responses $S_1(f)$, $S_2(f)$ and $S_3(f)$ are plotted below as a function of k, where $f = \frac{k}{256}$.



(c) Which system generates the output $y(n) = 16 + 36\cos(\pi n)$ to this input?

Solution

(a) The sequence is periodic. N = 8

$$x(n) = 2 + \cos\left(\frac{2\pi n}{8}\right) + \cos\left(\frac{6\pi n}{8}\right) + 3\cos\left(\frac{8\pi n}{8}\right)$$

(b) The smallest positive value of n = 8

$$x(8) = 2 + \cos\left(\frac{2\pi 8}{8}\right) + \cos\left(\frac{6\pi 8}{8}\right) + 3\cos\left(\frac{8\pi 8}{8}\right) = 2 + \cos(2\pi) + \cos(6\pi) + 3\cos(8\pi) = 7$$

(c) System S1

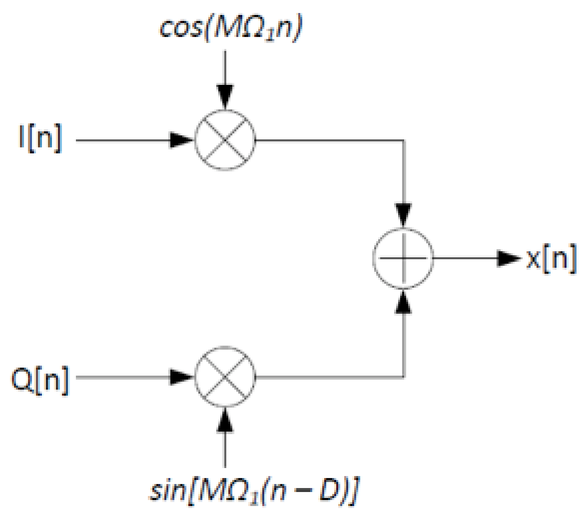
The dc term (i.e. constant value of 2) is amplified by a factor of 8.

The frequency component of $3\cos\left(2\pi\frac{128n}{256}\right)$ is amplified by a factor of 12.

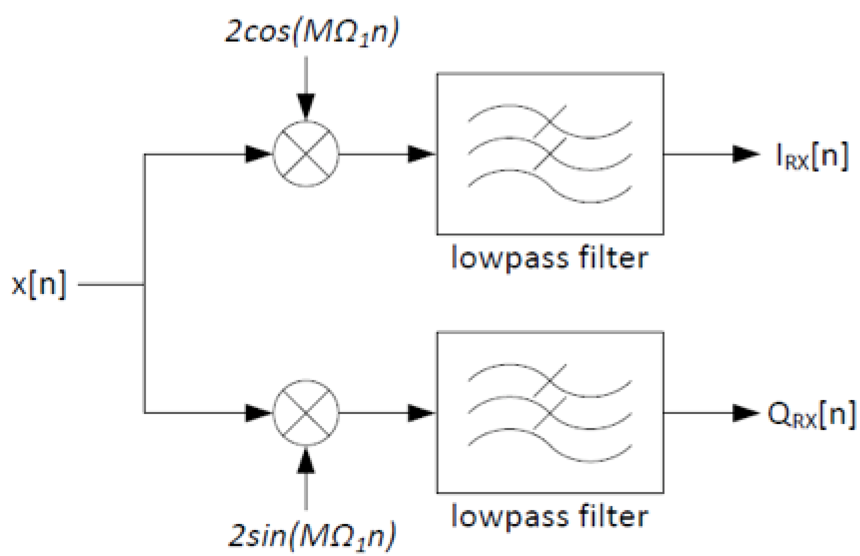
Other frequency components are blocked by the system.

Question 5

The diagram for a broken IQ transmitter is shown below. Assume N = 1024, M = 64 and $\Omega_1 = 2\pi/N$.



The IQ receiver was designed assuming the transmitter was working correctly.



(a) The broken transmitter sent the symbols I = 1 and Q = 1. However, the receiver received the symbols $I_{RX} = 0.617$ and $Q_{RX} = 0.924$. What is the value of D?

(b) The broken transmitter sent the symbols I = 1 and Q = 1. However, the receiver received the symbols $I_{RX} = 0$ and $Q_{RX} = 0$. What is the value of D?

**Hint: use the formula sin(a-b)=sin(a)cos(b)-cos(a)sin(b)

Solution

(a) $x[n] = I[n]\cos(M\Omega_1 n) + Q[n]\sin(M\Omega_1 n - M\Omega_1 D)$

Recall the identity : $\sin(a - b) = \sin(a)\cos(b) - \cos(a)\sin(b)$

$x[n] = I[n]\cos(M\Omega_1 n) + Q[n] * [\sin(M\Omega_1 n) \cos(M\Omega_1 D) - \cos(M\Omega_1 n)\sin(M\Omega_1 D)]$
$x[n] = [I[n] - Q[n]\sin(M\Omega_1 D)] * \cos(M\Omega_1 n) + Q[n]\cos(M\Omega_1 D) \sin(M\Omega_1 n)$

The receiver demodulates x[n] back to baseband, so that

$I_{RX}[n] = I[n] - Q[n]\sin(M\Omega_1 D)$ eq.(1)
$Q_{RX}[n] = Q[n]\cos(M\Omega_1 D)$ eq.(2)

Solve one of the above equations (1) or (2) to give D = 1.

(b) Solve one of the above equations (1) or (2) to give D = 4.

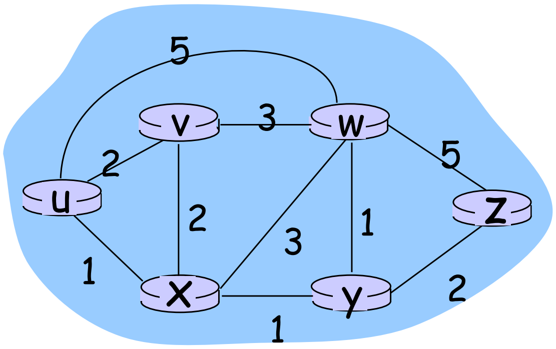
Question 6

a) Explain two key functions of the Network layer (Routing and Forwarding).
b) List the names of the five layers in a computer network. Briefly explain the function of each layer. Why do communication systems use layering?
c) Multiple Access protocols are fundamental in sharing a channel. Explain briefly how channel partitioning protocols such as FDMA and TDMA operate.
d) List two advantages and two disadvantages of the random multiple access protocol Slotted Aloha compared to channel partitioning protocols such as FDMA and TDMA.

Solution: Referring to the Lecture Notes.

Question 7

Consider the following network topology

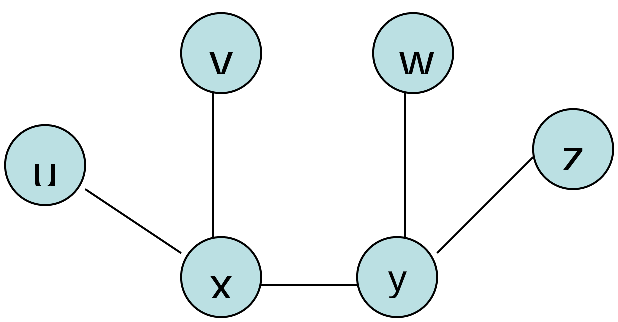


Construct the forward table and shortest path tree in **z (source)** using the Dijkstra's Algorithm.

Solution

Step	N	D(x), P(x)	D(u), P(u)	D(v), P(v)	D(w), P(w)	D(y), P(y)
0	z	∞	∞	∞	5, z	2, z
1	z, y	3, y	∞	∞	3, y	
2	z, y, x		4, x	5, x	3, y	
3	z, y, x, w		4, x	5, x		
4	z, y, x, w, u			5, x		
5	z, y, x, w, u, v					

Shortest path trees



Forward tables

Destination	Link
x	(z, y)
u	(z, y)
v	(z, y)
w	(z, y)
y	(z, y)