Department of Electrical Engineering and Computer Science

EECS 3213: Communication Networks (Fall 2015)

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Date: Oct 27, 2015

Midterm Examination

Instructions:

- Examination time: 75 min.
- Print your name and EECS student number in the space provided below.
- This examination is closed book and closed notes. Calculator and one-sided cheat-sheet containing formulas only are allowed.
- There are 6 questions. The points for each question are given in square brackets, next to the question title. The overall maximum score is 100.
- Answer each question in the space provided. If you need to continue an answer onto the last page, clearly indicate that and label the continuation with the question number.

FIRST NAME: _____

LAST NAME: _____

STUDENT #: _____

Question	Points
1	/ 30
2	/ 14
3	/ 8
4	/ 14
5	/ 16
6	/ 18
Total	/ 100

1. Multiple Choice [30 points]

Circle the letter beside the choice that is the best answer for each question. For each question choose only ONE answer.

(1.1) The TCP/IP _____ layer is equivalent to the combined session, presentation, and application layers of the OSI model.

(a) application
(b) transport
(c) network
(d) data-link

(1.2) Which of the following is NOT correct in TCP/IP architecture.

(a) A TCP packet is encapsulated in an IP packet.
(b) A UDP packet is encapsulated in a TCP packet.
(c) A UDP packet is encapsulated in an IP packet.
(d) An HTTP packet is encapsulated in an IP packet.

(1.3) The _____ layer is responsible for ensuring that the transmitting rate of the sending machine matches the current (operating) conditions of the receiving machine.

(a) transport
(b) network
(c) data-link
(d) physical

(1.4) What is the phase shift for a sine wave with the maximum amplitude at time zero?

(a) 90°
(b) 180°
(c) 270°
(d) none of the above

(1.5) Which signal has a wider bandwidth – a sine wave with a frequency 100 Hz or a sine wave with a frequency of 200 Hz?

(a) 100 Hz signal
(b) 200 Hz signal
(c) they have the same bandwidth
(d) none of the above

(1.6) A signal that is digital and periodic in time domain can be represented by _____ in frequency domain.

(a) one single spike

(b) a series of spikes
(c) a continuous function
(d) none of the above

(1.7) Baseband transmission of a digital signal is possible only if we have a _____ channel.
(a) band-pass
(b) low-pass
(c) high-rate
(d) low-rate

(1.8) _____ is generally considered to be the most challenging of the three known types of signal impairments.
(a) attenuation
(b) delay distortion
(c) noise
(d) neither of the above

(1.9) _____ is a type of transmission impairment in which a signal loses its form/shape due to the different propagation speeds of each frequency that makes up the given signal.
(a) attenuation
(b) delay distortion
(c) thermal noise
(d) cross talk

(1.10) Analog-to-analog conversion is typically needed if the available bandwidth is _____ .
(a) low-pass
(b) band-pass
(c) either (a) or (b)
(d) neither (a) nor (b)

(1.11) Assume a file is being transmitted between two computers over a single-hop link. The ***propagation delay*** component of the overall delay experienced during the transmission can be reduced by:
(a) compressing the file
(b) reducing the duration of each bit
(c) partitioning the file into packets
(d) none of the above

(1.12) In _____ , the change or lack of change in the level of the voltage determines the value of the bit.

(a) NRZ-L
(b) NRZ-I
(c) RZ
(d) none of the above

(1.13) The idea of RZ and the idea of NRZ-I are combined into the _____ scheme.

(a) Manchester
(b) Differential Manchester
(c) AMI
(d) neither (a) nor (b)

(1.14) If the frequency spectrum of an analog signal has a bandwidth of 200 kHz with the lowest frequency at 100 kHz, what should be the sampling rate (during a PCM process), according to the Nyquist theorem?

(a) 200,000 samples/sec
(b) 300,000 samples/sec
(c) 400,000 samples/sec
(d) 600,000 samples/sec

(1.15) The first step in PCM (analog-to-digital) conversion is

(a) sampling in amplitude
(b) sampling in time
(c) quantizing in amplitude
(d) quantizing in time

2. Potpourri [14 points]

2.1) Obtaining Physical (MAC) Address [4 points]

Assume you are interested in obtaining the physical address of the machine that you are currently using.

a) Which particular network utility/tool would you use for this purpose?
b) How long do you expect the obtained address to be (in bits/bytes)?

Solution:

Tool to be used: ipconfig /all.
Note: without /all option, you will obtain only IP address!

Physical/MAC addresses are 48 bits long (i.e., 6 1-byte values typically presented as 6 groups of 2 hexadecimal digits).
(E.g., `01:23:45:67:89:ab.`)

2.2) PING Tool [4 points]

Suppose regularly spaced PING packets are sent to a remote host. What can you conclude from the following results:

(a) No replies arrive back. [2 points]

Solution:

Possibilities are: The remote host is down; the remote host or the host network is extremely congested.

(b) All replies arrive but with variable delay. [2 points]

Solution:

Possibilities are: The PING packets traverse network routes that have different path lengths (i.e., are composed of different routers) and/or experience different traffic loads.

2.3) Communication Delay [6 points]

Suppose a 128-kbps point-to-point link is set up between the Earth and a rover on Mars. The distance between the Earth to Mars (when they are closest to each other) is approximately 55 [Gm], and data travels over the link at the speed of light – $3 * 10^8$ [m/sec].

A camera on the rover takes pictures of its surrounding and sends these to Earth. How quickly after a picture is taken can a picture reach the Mission Control on Earth? Assume the average picture size is 5 MBytes.

Solution:

Delay = propagation delay + transmission delay

$= (55 * 10^9 / 3 * 10^8) + (5*10^6*8 / 128 * 10^3) =$

$= 183.3$ sec + 312.5 [sec] =

= 495.8 [seconds]

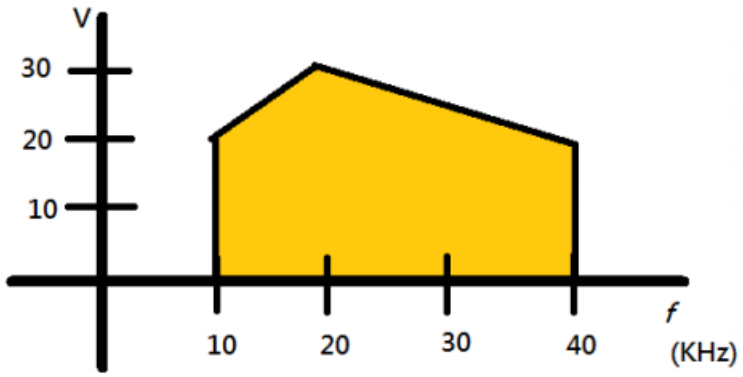
http://banyan.cm.nctu.edu.tw/cn2014/hw/Midterm1_sol.pdf

3. Frequency-Domain [8 points]

A non-periodic composite signal contains frequencies from 10 to 40 [KHz]. The peak amplitude is 20 [V] for the lowest and the highest frequency, and 30 [V] for the 20 [kHz]. Assuming that the value of peak amplitude changes linearly between 10 – 20 [kHz] and again between 20 – 40 [kHz], draw the frequency spectrum of the given signal.

Make sure to draw/discuss the actual character of the sketched frequency spectrum (under the curve), for full credit!

Solution:

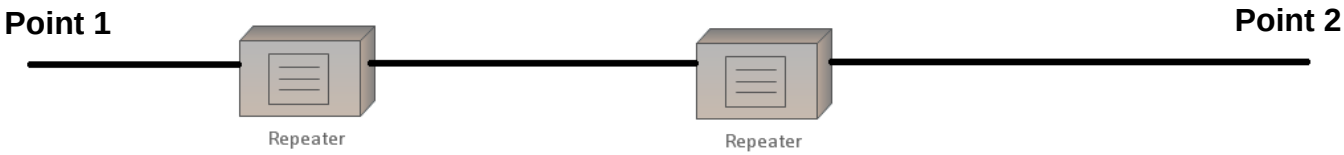


You will obtain the full mark only if you have indicated that the spectrum, under the indicated curve, is 'continuous' (i.e., all frequencies included).

http://banyan.cm.nctu.edu.tw/cn2014/hw/Midterm1_sol.pdf

4. Attenuation [14 points]

A 60km long fiber optical system consists of three segments, of lengths 10, 20 and 30 [km] respectively, joined by two repeaters (see below figure). Repeaters have 20 [dB] gain and cable has 1 [dB/km] attenuation.



a) [4 points] What is the overall attenuation/gain of the given system?

Solution:

Overall Gain = -10 dB + 20 dB - 20 dB + 20 dB - 30 dB = **- 20 dB**

Which, in fact, implies that there was an overall attenuation of 20 dB.

http://www2.cmpe.boun.edu.tr/courses/cmpe475/fall2002/MT1_solutions.pdf

b) [4 points] What is the SNR of the outgoing signal (at point 2) when a signal characterized with 40 [dB] SNR is injected at the input of the given system (at point 1), and assuming the system itself is perfect and does not add any additional noise? (Hint: The channel attenuates equally all initially injected signal components.)

Solution:

System will impose the same attenuation/gain on both the useful signal and the noise. Hence, in this case, the SNR remains unchanged **– 40 dB.**

c) [6 points] What is the SNR of the outgoing signal (at point 2) when a signal characterized with 40 [dB] SNR is injected at the input of the given system (at point 1), and this time the system is not perfect (i.e., its elements introduce additional noise). In particular, the noise injected by each repeater (when observed at point 2) totals 3 [dB], while the noise injected by the cables (when observed at point 2) totals 0.1 [dB/km]?

Solution:

In this case, the initially observed/injected signal and noise again experience the same attenuation and gain. However, the difference is in the increased levels of noise, which at point 2 amount to:

Additional N = 2 * 3 dB + (10+20+30) km * 0.1 dB/km = 6 dB + 6 dB = 12 dB

$SNR_2 = S_2$ [dB] – N_2 [dB] =
= (S_1 attenuated) – (N_1 attenuated + additional N) =
= (S_1 attenuated – N_1 attenuated) + additional N =
= SNR_1 – additional N =
= 40 – 12 dB =
= 28 dB

5. Channel Capacity [16 points]

You are entrusted with the design of a network to interconnect a set of geographically distributed hosts within your corporation. After some research, you narrow the options to two choices: a fiber-based token ring, or a copper-based switched network. The pertinent statistics appear in the table below.

type	fiber-based network	copper-based network
supported signal bandwidth	10 MHz	1 MHz
SNR at transmitter	20 dB	20 dB
attenuation rate	1 dB/km	2 dB/km

(You can assume the noise levels to be constant throughout both cables – fiber and copper.)

The longest link in the network, in either case is 10 km.

What maximum link bandwidth is possible for:

a) the fiber-based network,
b) the copper-based network?

Solution:

a) Fiber-Based Network

We need to use Shannon's formula, at the receiver!!!, to calculate the theoretically maximum bandwidth:

$$C_{fiber} = B * \log_2 (1 + SNR_r) \quad (1)$$

While B in the above formula is known, SNR_r (i.e., SNR at the receiver) is not directly given, so we need to derive it …

Now,

$$SNR_t = S_t\,[dB] - N\,[dB] = 20\,[dB] \text{ (at the transmitter)} \quad (2)$$

and

$$SNR_r = S_r\,[dB] - N\,[dB] = ??? \text{ (at the receiver)} \quad (3)$$

(Note, the noise is the same in both expressions.)

With the attenuation rate of 1 dB/km, we can write

$$S_r\,[dB] = S_t\,[dB] - 10 * 1\,[dB] = S_t - 10\,[dB] \quad (4)$$

By substituting (4) in (3), we obtain

$$SNR_r = S_t\,[dB] - 10\,[dB] - N\,[dB] = 20\,[dB] - 10\,[dB] = 10\,[dB] \quad (5)$$

which implies that $SNR_r = 10$ (6)

And, from there

$$\mathbf{C_{fiber} = 10\ MHz * \log_2 (1 + 10) = 10 * 3.45\ [Mbps] = 34.5\ [Mbps]}$$

b) Copper-Based Network

By following the procedure from a), in this case we obtain:

$$S_r\ [dB] = S_t\ [dB] - 10 * 2\ [dB] = S_t - 20\ [dB] \quad (7)$$

$$SNR_r = S_t\ [dB] - 20\ [dB] - N\ [dB] = 20\ [dB] - 20\ [dB] = 0\ [dB] \quad (8)$$

which implies that $SNR_r = 1$ (6)

And, from there

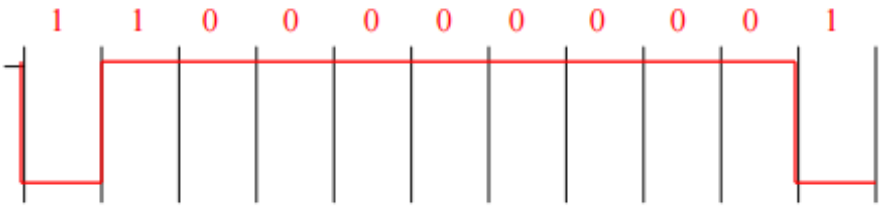
$$\mathbf{C_{fiber} = 1\ MHz * \log_2 (1 + 1) = 1 * 1\ [Mbps] = 1\ [Mbps]}$$

6. Line Coding [18 points]

6.1) [8 points] For the bit stream 1 1 0 0 0 0 0 0 0 0 1, sketch the respective waveforms for each of the following line codes.

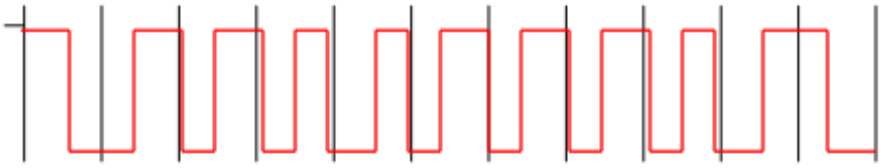
Solution:
http://www.cse.fau.edu/~sam/course/intro_dc/test/mid10fSol.pdf

a. NRZ-I

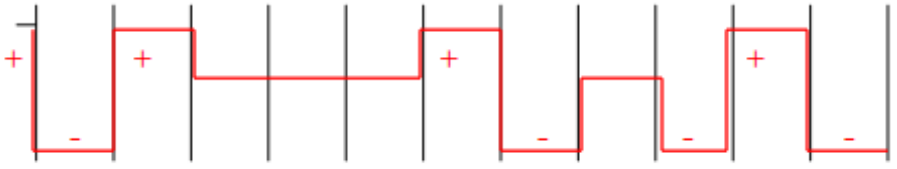


b. Bipolar AMI

c. Differential Manchester



d. B8ZS



6.2) [7 points] In the Fibre Distributed Data Interface (FDDI) protocol, every 4-bit of data is encoded using a 5-bit code sequence – often referred to as 4B/5B code. The resulting 5-big codewords are then transmitted using NRZ-I encoding.

The 4B/5B code table is shown below.

4-bit data	*5-bit codeword*
0000	11110
0001	01001
0010	10100
0011	10101
0100	01010
0101	01011
0110	01110
0111	01111
1000	10010
1001	10011
1010	10110
1011	10111
1100	11010
1101	11011
1110	11100
1111	11101

The following data bit sequence is to be transmitted over an FDDI network:
0 0 1 0 0 1 1 1 1 0 0 0 0 1 0 0

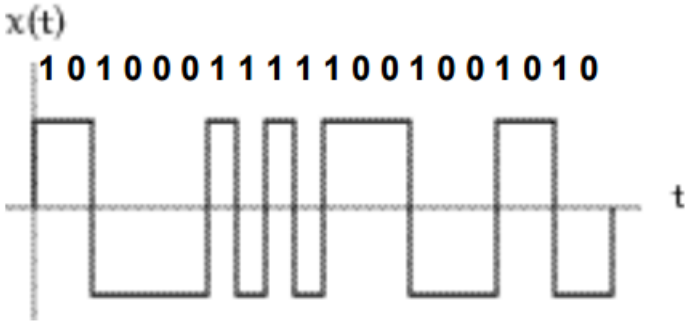
Sketch the transmitted FDDI waveform. (Clearly annotate the respective bit values, for full credit.)

Solution:

Breaking up the data sequence into four bit blocks, the corresponding coded sequence can be written down directly by inspection from the 4B/5B code table. Spaces have been introduced for reading clarity.

Data sequence: 0010 0111 1000 0100
Coded sequence: 10100 01111 10010 01010

The corresponding NRZ-I waveform is shown below.



6.3) [3 points] Do long strings of 1-s in the data stream cause synchronization problems for FDDI? How about long strings of 0-s in the data stream?

Solution:

Long strings of 1s do not pose a synchronisation or DC problem in FDDI which inherits its immunity from the differential encoding NRZ-I. In addition, unlike plain NRZ-I, FDDI also enjoys immunity from synchronisation or DC problems caused by long strings of 0s by virtue of the 4B/5B encoding—observe that the encoding guarantees that there will be no more than 3 contiguous 0s in the coded sequence. Thus, neither long strings of 1s nor long strings of 0s cause synchronisation or DC difficulties in FDDI.