ITS323 – Quiz 2 Answers

Name: ______________________________

ID: ______________________ Mark: __________ (out of 10)

Question 1 [4 marks]

Consider a network with two links:

Computer ---------------- Router ----------------- Server

link1 link2

- Link 1: full-duplex; 10/1Mb/s; 10/23μs propagation time
- Link 2: full-duplex; 1/100Mb/s; 13/6μs propagation time

On the Computer, you click on a link in a browser which triggers a 100 Byte message to be sent to the Server. The server processes the request and sends a 1000 Byte response. What is the response time, that is, the time from when you click on a link until the response is received? Assume all processing and queuing delays are 0, *except* a 10μs qls ueuing delay at the Router. You must show calculations.

Answer

Recall that transmission delay = message size / data rate

In the Computer to Server direction (message size is 100 Bytes):

Link 1 transmission delay = 100 Byte/10Mb/s = 80μs

Link 1 propagation delay = 10μs

Router queuing delay = 10μs

Link 2 transmission delay = 100 Byte/1Mb/s = 800μs

Link 2 propagation delay = 13μs

In the Server to Computer direction (message size is 1000 Bytes):

Link 1 transmission delay = 1000 Byte/10Mb/s = 800μs

Link 1 propagation delay = 10μs

Router queuing delay = 10μs

Link 2 transmission delay = 1000 Byte/1Mb/s = 8000μs

Link 2 propagation delay = 13μs

Total delay (response time) = 80 + 10 + 10 +800 + 13 + 800 + 10 +10 + 8000 +13 = 9746μs

The alternative data (link 1: 1Mb/s, 23μs; Link 2: 100Mb/s; 6μs): 8966μs

Question 1 [4 marks]

Consider a network with two links:

A ---------------------- B -------------------- C

link1 link2

- Link 1: 12/24km, 5/20Mb/s
- Link 2: 6/12km

If a message of 1000/2000 bits has to be sent from A to C with a maximum end-to-end delay of 295/430μs, then what is the minimum data rate required for link 2? You may assume no processing delays, and a queuing delay of 10μs at B. Also, the speed of light is $3x10^8$ m/s. You must show calculations.

Answer

Link 1 transmission delay = 1000bits / 5Mb/s = 200μs

Link 1 propagation delay = 12000m / $3x10^8$ m/s = 40μs

B queuing delay = 10μs

Link 2 propagation delay = 6000m / $3x10^8$ m/s = 20μs

Total delay = 270 + Link2Transmission < 295μs

Therefore Link 2 transmission delay = 25μs = 1000 bits / XMb/s

Therefore Link 2 data rate = 40Mb/s

The alternative data: 10Mb/s

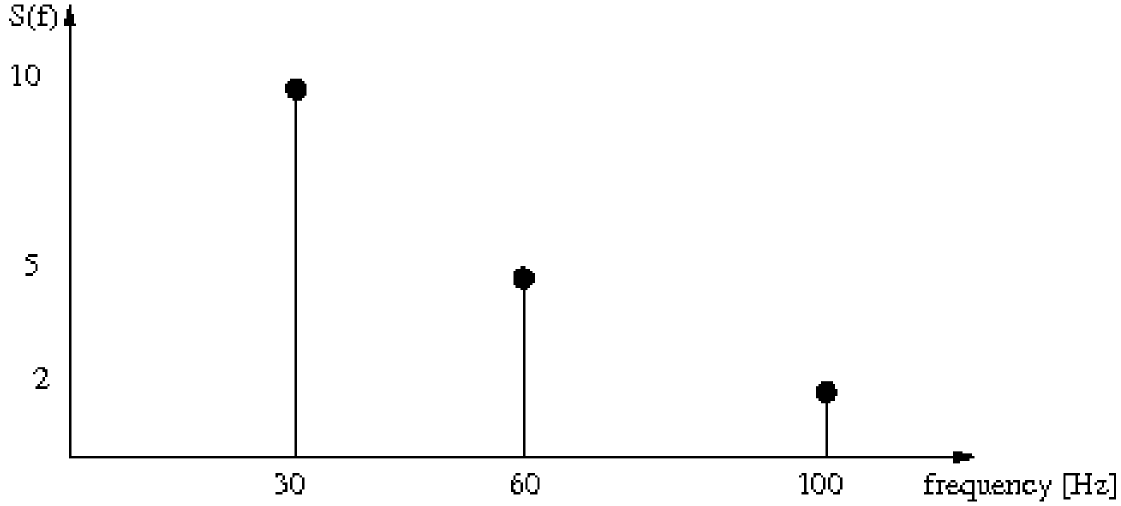
Question 2 [3 marks]

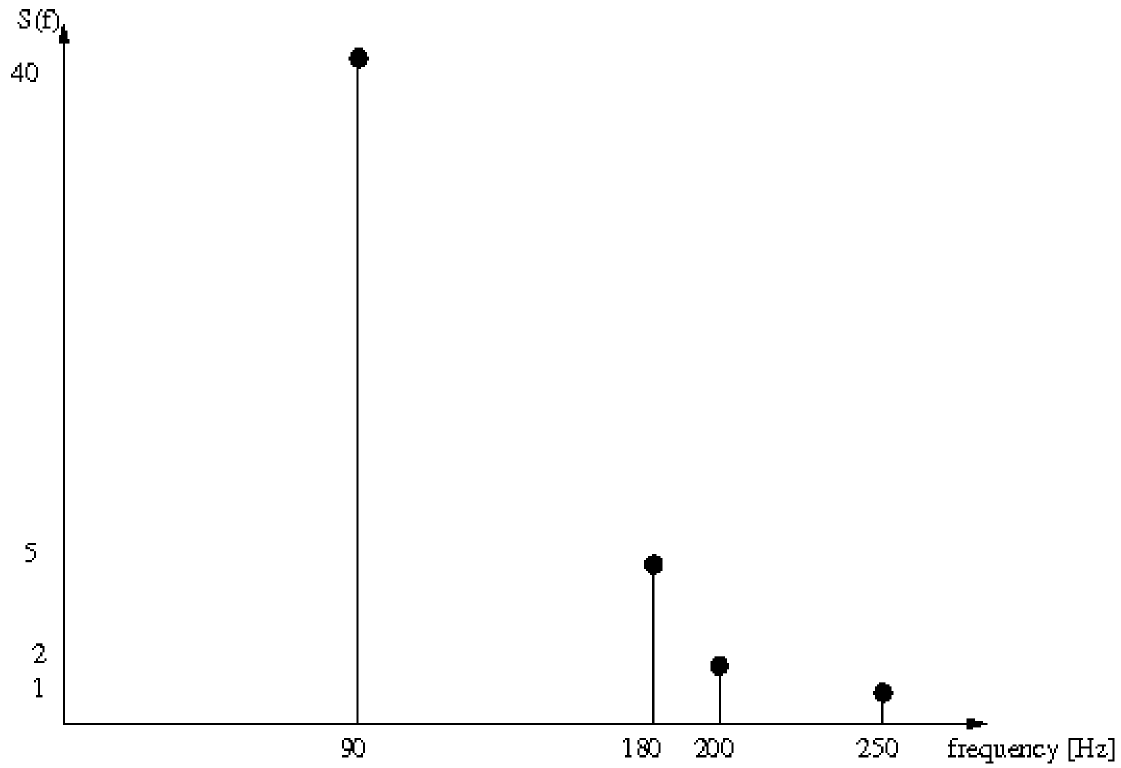
a) Draw a plot of the following signal in the frequency domain. [2 marks]

$$s(t)=10\sin(60\pi t)+5\sin(120\pi t)+2\sin(200\pi t)$$

$$s(t)=40\sin(180\pi t)+5\sin(360\pi t)+2\sin(400\pi t)+\sin(500\pi t)$$

Answer





b) What is the absolute bandwidth of the above signal? [1 mark]

Answer

70 Hz

160 Hz

Question 2 [2 marks]

Consider the signal *s(t)*:

$$s(t)=15\sin(10\text{x}10^6\pi t)+5\sin(30\text{x}10^6\pi t)+3\sin(50\text{x}10^6\pi t)$$

$$s(t)=105\sin(3\text{x}10^4\pi t)+35\sin(9\text{x}10^4\pi t)+21\sin(1.5\text{x}10^5\pi t)+15\sin(2.1\text{x}10^5\pi t)$$

a) What is the period of the *s(t)*? [1 mark]

Answer

Fundamental frequency is 5Mhz, therefore period is 0.2µs

(Alternative: frequency is 15000Hz, period is 66µs)

b) What is the absolute bandwidth of *s(t)*? [1 mark]

Answer

Minimum frequency component at 5Mhz and maximum at 25Mhz: BW = 20MHz

(Alternative: 90kHz)

Question 3 [3 marks]

A receiver receives a 4MHz/200kHz signal with power 150mW/310µW.

a) If the channel also contains noise of 10mW/10µW, what is the theoretical data rate possible? [2 marks]

Answer

Using Shannon capacity equation, Data rate = B $\log_2$(1+SNR)

B = 4MHz, Signal = 150mW, Noise = 10mW, SNR = 15, Data rate = 16Mb/s

B = 200kHz, Signal = 310µW, Noise = 10µW, SNR = 31, Data rate = 1Mb/s

b) Assuming the noise cannot be controlled, explain how can the data rate be increased, without increasing the bandwidth. [1 mark]

Answer

Increase the transmit power, thereby increasing receive power and SNR.

Question 3 [3 marks]

An encoding scheme maps 3/4 bits of digital data into one signal element.

a) In a noise-free channel with a bandwidth of 200KHz/10MHz, what is the maximum theoretical data rate possible? [2 marks]

Answer

If there are *n* bits of data mapped to a signal element, then 2^n different signal elements are needed to represent any combination of bits. That is, there are $M = 2^n$ possible signal levels.

Using Nyquist capacity equation, Data rate = $2B\log_2(M)$

n = 3, M = 8, BW = 200KHz, Data rate = 1200Kb/s

n = 4, M = 16, BW = 10MHz, Data rate = 80Mb/s

b) Explain how can the data rate be increased, without increasing the bandwidth. [1 mark]

Answer

Increase the number of levels, e.g. more bits per signal element.

c) What is a disadvantage of increasing the data rate with the approach you suggest in part (b)? [1 mark]

Answer

Increase the number of errors.

Extra Question for Quizzes f, g and h

Question 4 [4 marks]

A terrestrial microwave communications system is created to deliver 1/2/2KB emergency warning messages from a transmission tower in town A to a receiver tower in town B. Because of the large distance between A and B, 5/4/3 *repeater* towers are needed between the two towns. Each tower uses the same equipment (for transmitter and receiver) with specifications as follows:

Transmit power: 10W Antenna Gain: 25dBi Receive sensitivity: -31/-37.5/-35dBm

Data rate: 10Mb/s Frequency: 30MHz

The time to deliver a warning message from A to B is 5.4/9/7ms.

What is the distance between town A and B?

Answer

Consider the total delay to deliver the message, D. If we assume there is no (or very little) processing and queuing delays, then the total delay should be the sum of the transmission and propagation delay for each link. There are R+1 transmissions, where R is the number of repeaters. So the total delay is:

D = Distance / $(3\text{x}10^8)$ + (R+1) * MessageSize / DataRate

As we know the message size, data rate, number of repeaters (R) and total delay (D), we can determine the distance between A and B.

Case 1:

5.4ms = Distance / $(3\text{x}10^8)$ + 6 * (8*1000) / $10\text{x}10^6$; therefore distance = 180,000m = 180km

Case 2:

9ms = Distance / ($3x10^8$) + 5 * (8*2000) / $10x10^6$; therefore distance = 300,000m = 300km

Case 3:

7ms = Distance / ($3x10^8$) + 4 * (8*2000) / $10x10^6$; therefore distance = 180,000m = 180km

Another approach is to consider the path loss, and assuming free space path loss, determine the distance between transmitter and receiver. However we do not know the *Received Power* at each receiver. We only know the *Receiver Sensitivity*, which is the minimum Receive Power that the receiver can understand. It does not mean that the receive *has to* receive at this power level; it is likely (and true in this question) that the receiver receives at a power much greater than the receiver sensitivity. Therefore we do not have enough information to use the free-space path loss model.