EIE 3333 Data and Computer Communications (2019/20)

Suggested Solutions to Tutorial 2

Unit 2: Physical Layer

Review Questions

6. What does the Nyquist theorem have to do with communications?

[Answer] The *Nyquist theorem* defines the maximum bit rate of a noiseless channel.

6. What does the Shannon Capacity have to do with communications?

[Answer] The *Shannon capacity* defines the theoretical highest data rate for a noisy channel.

8. Distinguish between baseband transmission and broadband transmission.

[Answer] *Baseband transmission* means sending a digital or an analog signal without modulation using a low-pass channel. *Broadband transmission* means to modulate signal using a band-pass channel.

10. Distinguish between a signal element and a data element.

[Answer]

A *data element* is the smallest entity that can represent a piece of information (a bit). A *signal element* is the shortest unit of a digital signal. Data elements are what we need to send; signal elements are what we can send. Data elements are being carried; signal elements are the carriers.

11. Distinguish between data rate (bit rate) and signal rate (baud rate).

[Answer]

The *data rate* defines the number of data elements (bits) sent in 1s. The unit is bits per second (bps). The *signal rate* is the number of signal elements sent in 1s. The unit is the baud.

12. Define a DC component and its effect on digital transmission.

[Answer]

When the voltage level in a digital signal is constant for a while, the spectrum creates very low frequencies, called *DC components*, that present problems for a system that cannot pass low frequencies.

Problems

1. *A device is sending out data at the rate of 1000 bits/s.*
   a. How long does it take to send out 10 bits?
   b. How long does it take to send out a single character (8 bits)?
   c. How long does it take to send out a file of 100,000 characters?

[Solution]

a. (10 / 1000) s = **0.01 s**
b. (8 / 1000) s = 0. 008 s = **8 ms**
c. ((100,000 × 8) / 1000) s = **800 s**

2. *If the peak voltage value of a signal is 20 times the peak voltage value of the noise, what is the SNR? What is the SNR_{dB}?*

[Solution]

We have
SNR= (signal power)/(noise power).

However, power is proportional to the square of voltage. This means we have
SNR = [(signal voltage)^2] / [(noise voltage)^2] =
[(signal voltage) / (noise voltage)]^2 = 20^2 = 400

We then have
SNR_{dB} = 10 $\log_{10}$ SNR ≈ **26.02**

3. *A line has a signal-to-noise ratio of 1000 and a bandwidth of 4000 Hz. What is the maximum data rate supported by this line?*

[Solution]

We have
4,000 log2 (1 + 1,000) ≈ 40 Kbps

4. *What is the theoretical capacity of a channel in each of the following cases:*

a. Bandwidth: 20 KHz $SNR_{dB} = 40$
b. Bandwidth: 200 KHz $SNR_{dB} = 4$
c. Bandwidth: 1 MHz $SNR_{dB} = 20$

[Solution]

Using the Shannon Equation, we have

a. C=265.8Kbps
b. C=362.5Kbps
c. C= 6.66 Mbps

5. *A computer monitor has a resolution of 1200 by 1000 pixels. If each pixel uses 1024 colors, how many bits are needed to send the complete contents of a screen?*

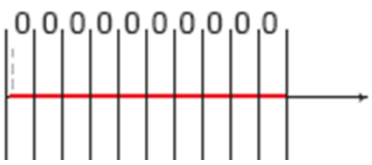
[Solution]

To represent 1024 colors, we need $\log_2 1024 = 10$ bits. The total number of bits are, therefore, **1200 × 1000 × 10 = 12,000,000 bits**

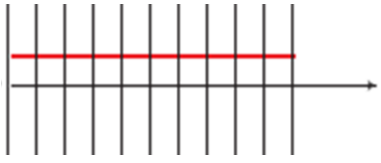
6. *Assume a data stream is made of ten 0s. Encode this stream, using the following encoding schemes.*
   a. *Unipolar*
   b. *NRZ-L*
   c. *NRZ-I*
   d. *Manchester*
   e. *Differential Manchester*
   f. *AMI*

[Solution]

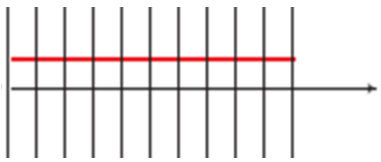
a. Unipolar



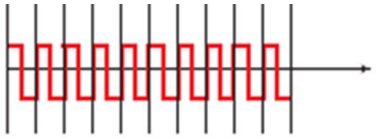
b. NRZ-L



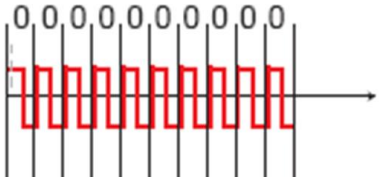
c. NRZ-I



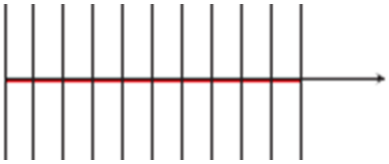
d. Manchester



e. Differential Manchester



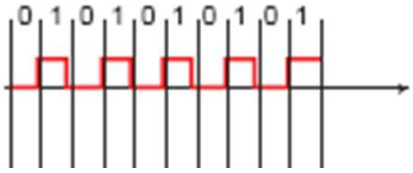
f. AMI



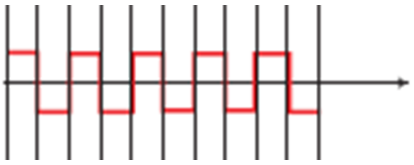
7. *Repeat Q6 for a data stream of 0101010101.*

[Solution]

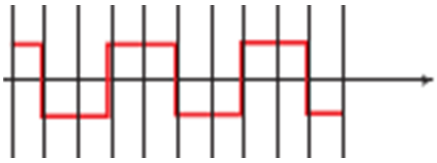
a. Unipolar



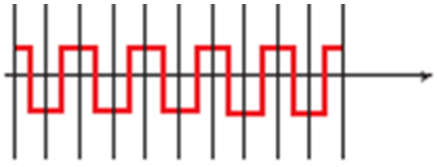
b. NRZ-L



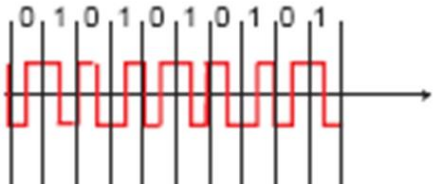
c. NRZ-I



d. Manchester



e. Differential Manchester

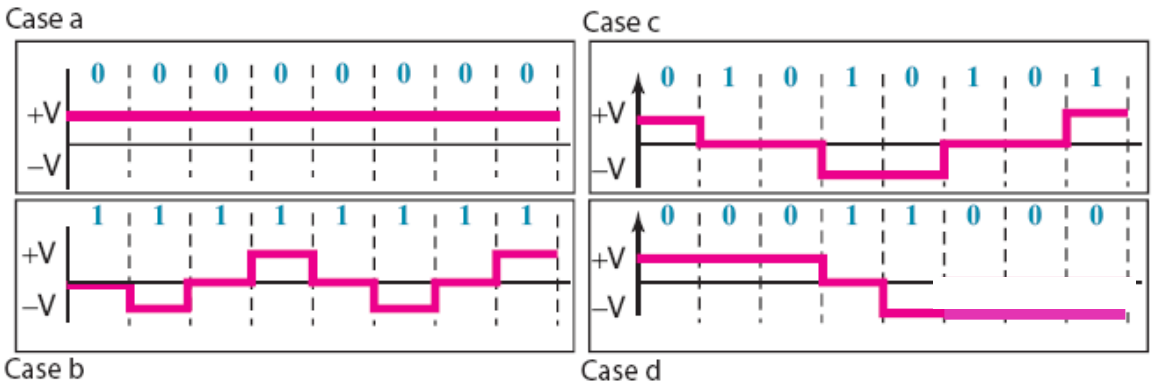


f. AMI

8. *Draw the graph of the MLT-3 scheme using the following data streams. Assume that the last signal level has been positive.*

a. 00000000
b. 11111111
c. 01010101
d. 00011000

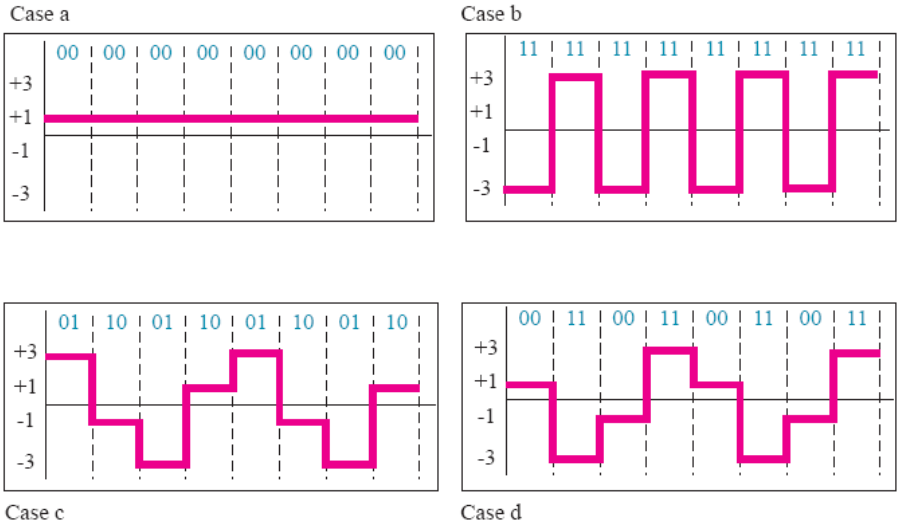
[Solution]



9. *Draw the graph of the 2B1Q scheme using the following data streams. Assume that the last signal level has been positive.*

a. 0000000000000000
b. 1111111111111111
c. 0110011001100110
d. 0011001100110011

[Solution]



10. What is the result of scrambling the sequence 11100000000000 using each of the following techniques? Assume that the last non-zero signal level has been positive.

a. B8ZS

b. HDB3

[Solution]