Exercise series no. 2

Exercise 01

1. A digital signal has 8 levels. How many bits are needed per level?
2. A digital signal has 10 levels. How many bits are needed per level?
3. Calculate the bit length in a channel with propagation speed of 2×10^8 m/s if the channel bandwidth is 100 Mbps.
4. What is the maximum binary data rate of a noise-free transmission channel with a bandwidth of 3 KHz?

Exercise 02

1. If a binary signal is sent over a 3 KHz channel whose signal-to-noise ratio is 20 dB, what is the maximum achievable data rate?
2. Given a channel with an intended capacity of 20 Mbps. The bandwidth of channel is 3 MHz. What signal-to-noise ratio is required in order to achieve this capacity?
3. A digital signaling system is required to operate at 9600 bps. If a signal element encodes a 4-bit word, what is the minimum required bandwidth of the channel?

Exercise 03

1. A digitized TV image must be transmitted from a source that uses a display matrix of 450 × 500 pixels, where each pixel can take 32 different intensity values. It is assumed that 30 images are sent per second. What is the data rate (D) of the source?
2. The TV image is transmitted over a 4.5 MHz bandwidth channel with a signal-to-noise ratio of 35 dB.
    a) Determine the channel capacity.
    b) Can the video signal be transmitted over this channel?

Exercise 04

1. Encode the following bit sequences using NRZ-L, NRZ-I, Manchester, Differential Manchester and draw the signal waveforms.
    - 0011101011011001
    - 1110001010110011

    Attention: Assume that the initial signal level of NRZ-I and Differential Manchester encoding is signal level 1 (low signal).
2. Encode the following bit sequences using RZ, AMI (Bipolar Encoding) and draw the signal waveforms.
    - 1100110010101101
    - 0101011001100010

Exercise 05

1. A binary data sequence 101101 is transmitted using Binary ASK (BASK). Draw the ASK waveform for the given binary sequence (use 5V as the amplitude for bit 1 and 0V for bit 0).
2. A 4-FSK (Frequency Shift Keying) system is used for digital communication, where four different frequencies represent 00, 01, 10, and 11.
    a) How many bits are transmitted per symbol?
    b) Convert the binary sequence 110101100011 into 4-FSK symbols.
    c) Assign frequencies f0, f1, f2, and f3 to the symbols and sketch the waveform.
3. A BPSK (Binary Phase Shift Keying) system transmits the binary sequence 101110. Sketch the BPSK waveform, assuming bit 1 corresponds to 0° phase and bit 0 corresponds to 180° phase shift.

Exercise 06

A radio broadcasting company wants to multiplex 20 FM radio stations using FDM.

- Each FM channel requires 200 KHz.
- There must be a guard band of 10 KHz between each adjacent stations.

1. Compute the total bandwidth required for this system.
2. If the available spectrum is 5 MHz, how many stations can be accommodated?

Exercise 07

A TDM system is designed to multiplex 5 sources, each generating 64 Kbps of data.

- Each frame contains 1 byte per source.
- An additional sync byte is added to each frame.

1. Calculate the frame size in bits.
2. What is the frame rate?
3. What is the output data rate?

Exercise 08

Consider an analog telephone line with a bandwidth of 300 - 3400 Hz. The modulation rate is 1200 baud, and the signals are 16-level.

1. What is the binary data rate of the line?
2. Assuming the line has a signal-to-noise ratio (S/N) of 34 dB, what is the theoretical capacity of this line?
3. We want to digitize voice using the PCM (Pulse Code Modulation) method.
    a) What are the different steps involved in digitization.
    b) Calculate the data rate for voice digitization, given that sampling occurs every 125 microseconds and encoding is done using 8 bits per sample.
    c) What can be done to reduce the data rate?