Number:	3. Assignment
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General information about the exercises

Accompanying the lecture, we will hand out some assignments. These exercises should be solved but you do not have to submit your solutions. The solutions will be presented in the tutorial sessions. We expect each student to have solved the exercises.

Exercise 1, Signal to Noise Ratio:

A binary signal is sent via a 3 kHz wide channel with a signal to noise ratio of 20 dB. Calculate the maximum data rate.

Exercise 2, Maximum Data Rate:

A quaternary signal is sent via a 20 MHz wide channel. The medium experiences interference. We measure a signal to noise ratio of 30 dB. Calculate the maximum data rate that can be achieved over this channel.

Exercise 3, Noiseless channel:

Specify the maximum data rate that can be achieved over a noiseless 4 kHz wide channel.

Exercise 4, (Differential) Manchester:

Consider you have measured the following signal.

The vertical lines represent the end of a bit. Specify the bit sequence that is encoded in the signal considering that it was encoded with:

1. Manchester baseband encoding (also called biphase-level)

2. Differential Manchester

Can the bit sequences be specified unambiguously?

Exercise 5, Data Encoding:

The following bit sequence shall be encoded: `0101110010`
Represent the sequence in a time-voltage-diagram using the following encoding schemes:

1. Non-Return-to-Zero (NRZ)

2. Return-to-Zero (RZ)

3. Differential-Non-Return-to-Zero

4. Manchester

5. Differential-Manchester

Exercise 6, Manchester Encoding & Bandwidth:

Explain the disadvantage of the Manchester encoding scheme. Propose an improvement!

Exercise 7, Analog to Digital:

Consider a scenario where an analog voice sample has to be transmitted via a digital network.

1. Explain how this can be achieved and which steps are necessary.

2. Discuss the errors that can occur.

3. Discuss the sampling theorem in this context.

Exercise 8, Base- and Broadband:

Explain the term baseband and broadband. Why do we need broadband communication? Explain how broadband communication of baseband signals is achieved. Give example application scenarios.

Exercise 9, Modulation:

1. Consider a sender transmits the bit sequence 000110010011. A combination of amplitude shift keying (ASK) and differential phase shift keying (Differential PSK) is applied[a]. The base frequency is f and, for simplicity, each symbol is sent for $\frac{1}{2}T$. The following modulation table is used:

Symbol	Amplitude	Phase Shift
00	1	0
01	2	0
10	1	π
11	2	π

In the following diagram, a sine wave carrier $s(t) = \sin(2\pi f t)$ is depicted for $\frac{1}{f}$ seconds. Modulate the bit sequence on the carrier.
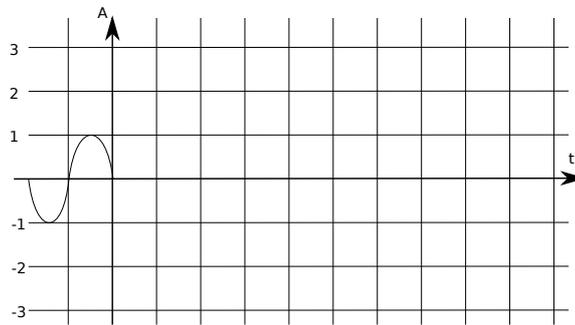
2. A receiver has sampled the amplitudes 0, 1, 0, 0, -1, 1, 0, 0, 2 at the times depicted in the following diagram.
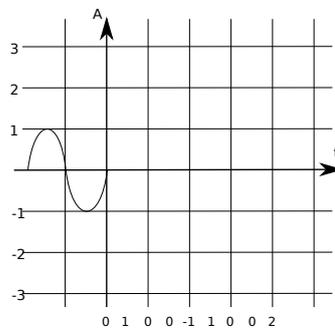
Consider every 3-tupel of bits was encoded as follows:

Symbol	Amplitude	Phase Shift
000	1	0
001	2	0
010	1	$\frac{\pi}{2}$
011	2	$\frac{\pi}{2}$
100	1	π
101	2	π
110	1	$\frac{3\pi}{2}$
111	2	$\frac{3\pi}{2}$

Sketch the wave carrier based on the sampled values. Specify the bit sequence that was transmitted.

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[a]Differential phase shift keying means that the signal is shifted by the given phase relative to the current value.

Exercise 10, Modulation 2:

Consider the following modulation diagram.
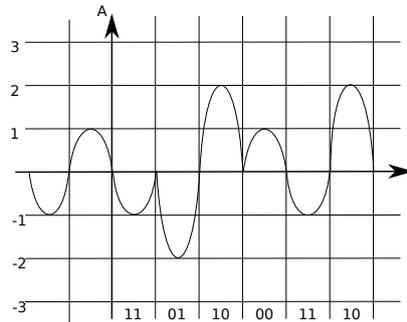
The signal has already been sampled and demodulated. The symbols are depicted in the modulation diagram. Specify the (de-)modulation table for the applied (de-)modulation scheme. Sketch the corresponding constellation diagram.

Exercise 11, Modulation 3:

Modulate the bit sequence 100101111001 using a combination of amplitude and frequency shift keying. Each symbol shall be modulated for $\frac{1}{2}T$ time units on the sine carrier wave. Use the following modulation table:

Symbol	Frequency	Amplitude
00	f	1
01	f	2
10	2f	1
11	2f	2
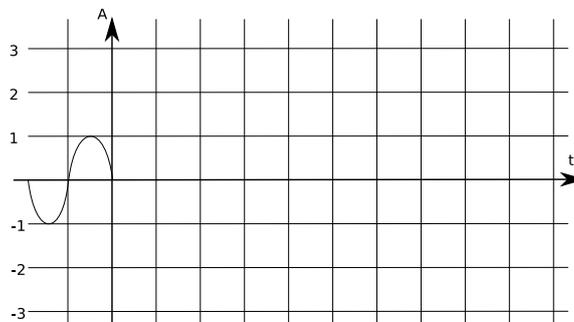
Exercise 12, The Big Picture:

1. Why do we need modulation and encoding? Which problems do they solve?

2. Which layers are responsible for these two tasks?

3. Which operations are necessary to transmit some data from A to B using modulation and encoding and in which order?

4. Is modulation always used together with encoding?

4