Telematics

Winter Semester 2008/09

Number:	2. Assignment
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General information about the exercises
Accompanying the lecture, we will give out some assignments. You shall do the exercises on your own 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 and might ask anyone to present these.

Exercise 1, Channel Bandwidth:

Consider a channel to have a bandwidth of 4 MHz. How many bit per second can be sent if digital signals with 8 levels are used? The channel shall be noiseless.

Exercise 2, Noiseless channel:

A noiseless 4 kHz channel is to be sampled every millisecond. Calculate the maximum data rate.

Exercise 3, 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.

Exercises unrelated to Telematics. Solve these brainteasers if you like.

Exercise 4, Brainteaser: Digital Clock:

How many times a day will a digital clock show three of the same digits in a row, for example 02:22 ? Please note that the clock uses the US time format with an 12-hour scale.

Exercise 5, Brainteaser: Cats & Mice:

Five cats can catch five mice in five minutes. How many cats does it take to catch 100 mice in 100 minutes?

Exercise 6, Modulation:

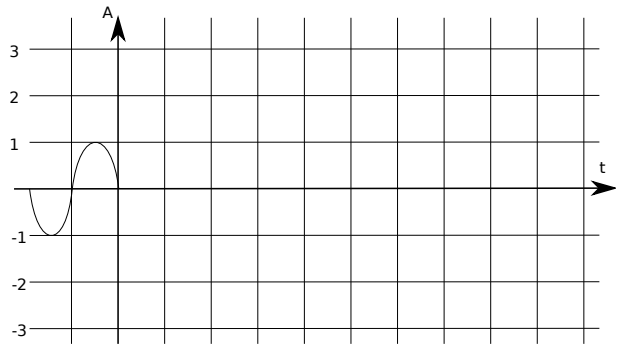
A sender transmits the bit sequence `000110010011`. A combination of amplitude shift keying (ASK) and differential phase shift keying (Differential PSK) is to be used. The base frequency is `f`. Differential phase shift keying means that the signal is shifted by the given phase relative to the current value. The following coding table is to be used:

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

For simplicity each symbol is sent for $\frac{1}{2}f$ seconds.

1. What does modulation mean? Explain the term.

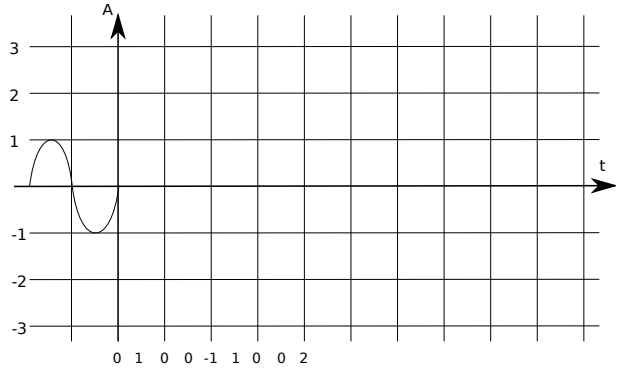
2. In the following diagram the base signal $s(t) = \sin(2\pi ft)$ for $\frac{1}{f}$ seconds is shown. Continue the signal waveform based on the given bit sequence. Which values are measured by the receiver when the signal is sampled every $\frac{1}{2}f$ seconds? (At a phase shift the signal is scanned directly before the shift.)



3. The receiver has scanned the values 0, 1, 0, 0, -1, 1, 0, 0, 2 at the times depicted in the following diagram. For higher efficiency, consider every 3-tupel of bits encoded as follows:

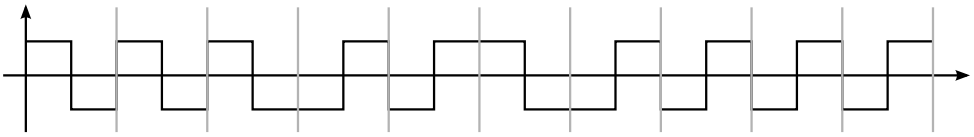
Symbol	Amplitude	Phase
000	1	0
001	2	0
010	1	$\frac{\pi}{2}$
011	2	$\frac{\pi}{2}$
100	1	π
101	2	π
110	1	$\frac{3\pi}{2}$
111	2	$\frac{3\pi}{2}$

Modulate the transferred bit sequence and sketch the signal waveform.



Exercise 7, (Differential) Manchester:

Consider to have measured the following signal.



The vertical lines represent the end of a bit. Specify the original bit sequence that was sent and encoded with...

1. Manchester baseband encoding (also called biphase-level) and
2. Differential Manchester.
3. Are the sequences unambiguous?

Exercise 8, Data Encoding:

The following bit sequence has to be sent: `0101110010`
Represent the sequence in a time-voltage-diagram using...

1. Non Return to Zero (NRZ),
2. Return to Zero (RZ),
3. Manchester,
4. and Differential Manchester encoding.

Exercise 9, Hamming-Code:

Two communication partners have agreed to the following coding scheme for transmitting characters:

Character	Code Word
A	10000
B	01000
C	11000
D	00100
...	...
Z	01011

1. How many check bits are needed to correct all 1-bit errors in messages of length m bits?
2. To protect the transmission a Hamming Code with 4 check bits shall be used. Give the bit sequence which represents the word HAMMING.
3. One communication partner has received the following bit sequence:
   010101000 111001000 010101001 001011000 111111100 001001100
   Decode this sequence and mark the blocks detected to be damaged. Which blocks are corrected wrongly and which blocks are detected to be correct mistakenly? How many bit errors have happened in those cases?