Tutorial 2 - SS2017
Communication Systems and Protocols

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Task 1: Signal Classes

A) The signal in Figure 1.1 is given as the original analog signal. Transform this signal into a amplitude quantized signal. Use the diagram in Figure 1.1 with the given sampling points.

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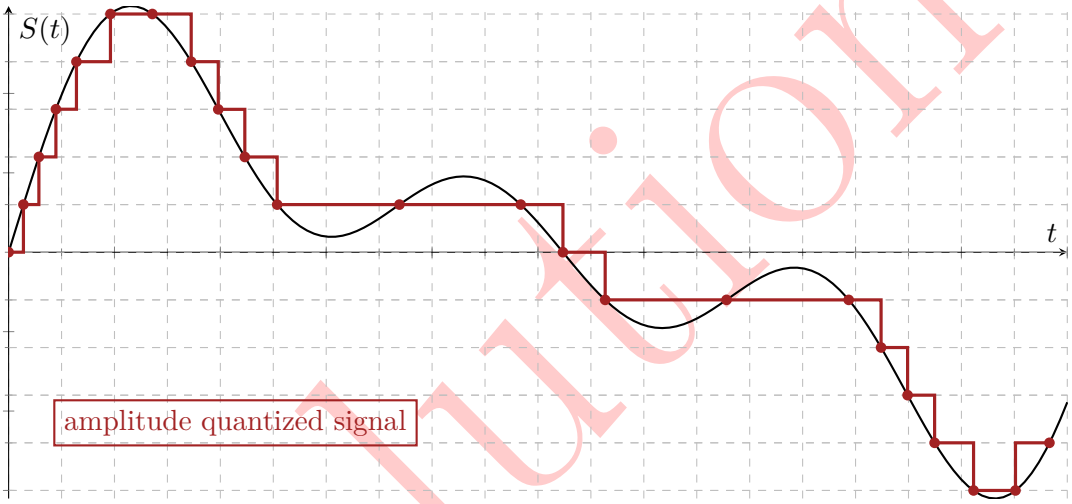

Figure 1.1: signal class:

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Task 2: Channel capacity and bandwidth

A digital transmission system with a bandwidth of $B = 1,5 * 10^6 Hz$ has a channel capacity of $C = 5Mbit/s$ (according to Shannon).

A) What is the minimum for the signal to noise ratio (SNR) in dB?

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$C = B * log_2(1 + S/N)$
$S/N = 2^{(C/B)} - 1 = 2^{(5Mbit/s/1,5*10^6 Hz)} - 1 = 9,079$
$SNR = 10 * lg(2^{(C/B)} - 1) = 9,58dB$

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Task 3: Line Codes

A) Draw the digital signals for the bit string 101 100 000 011 using each of the NRZ, Manchester, and differential Manchester digital encoding schemes. Use Figure 3.1. 3

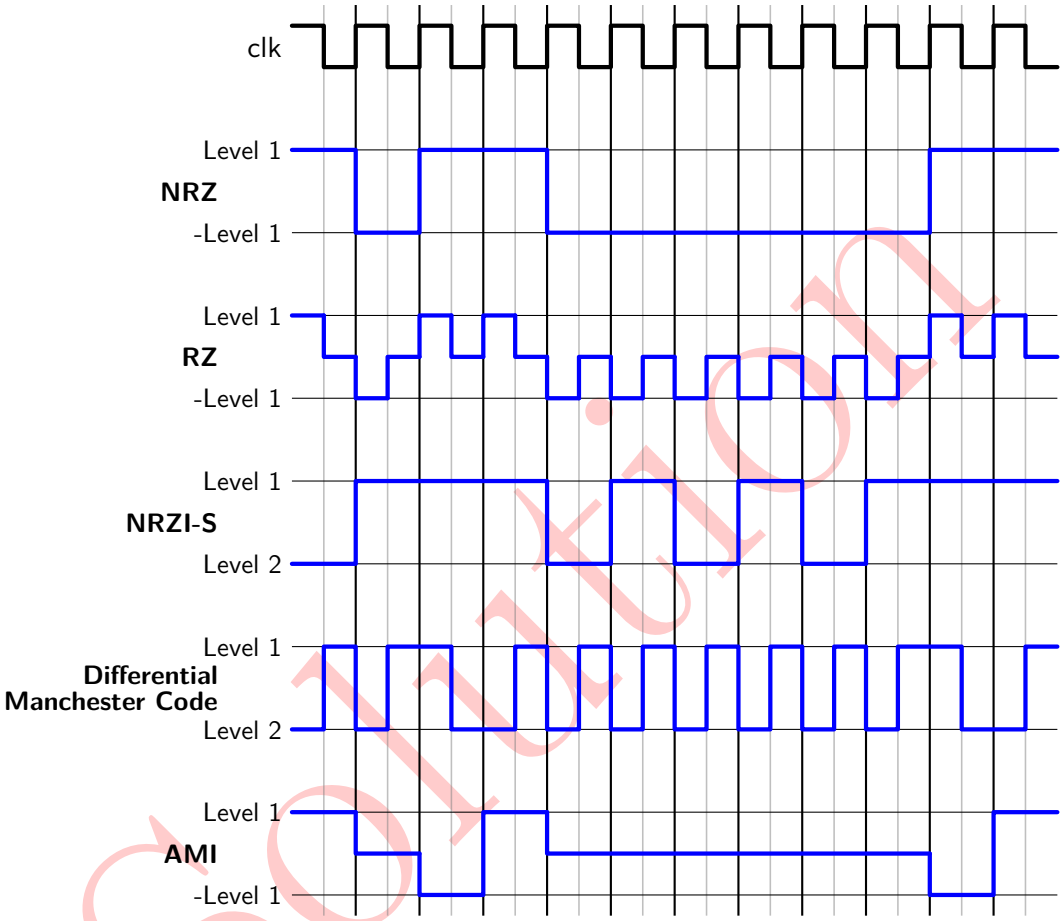

Figure 3.1: Line codes

B) Figure 3.2 shows the signal sequence for a Manchester coded signal. Determine the associated bit string. 1

C) Encode the following bit string using the 4B/5B code: 1

101000001111111000010111

10110 11110 11101 11100 01001 01111

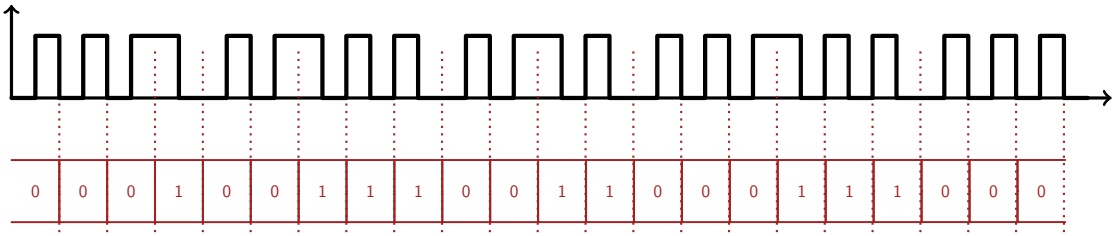

Figure 3.2: Manchester coded bit string

D) What is the longest sequence of "0" if the 4B/5B code is used? **1**

The longest sequence contains three "0". For example: 10100 01010

E) What is the longest sequence of "1" if the 4B/5B code is used? **1**

The longest sequence contains eight "1". For example: 01111 11110
On optical fiber, the 4B5B output is NRZI-encoded: A long sequence of "1" serves clock recovery

Task 4: Code Division Multiple Access (CDMA) **11**

A) The transmission scheme “Code Division Multiple Access” uses so called spreading codes to separate different transmissions. One group of functions that can be used for this purpose, are the Walsh functions. The CDMA scheme shall be used for simultaneous transmission of eight different messages. Derive the required Walsh functions and give them in binary notation. **2**

Function	Code							
0	0	0	0	0	0	0	0	0
1	0	1	0	1	0	1	0	1
2	0	0	1	1	0	0	1	1
3	0	1	1	0	0	1	1	0
4	0	0	0	0	1	1	1	1
5	0	1	0	1	1	0	1	0
6	0	0	1	1	1	1	0	0
7	0	1	1	0	1	0	0	1

B) The CDMA scheme shall be used for simultaneous transmission of eight different messages. Derive the required Walsh functions and give them in binary notation. **1**

For transmission replace “0” by signal value +1 and “1” by signal value -1.

C) For the simultaneous transmission of three messages, the Walsh function calculated in this task shall be used. The eight bit given in Table 4.1 shall be encoded each using one of the Walsh functions mentioned above. They are the transmitted simultaneously. The Walsh function is to be inverted when a ‘1’ is to be transmitted and remains unchanged for a ‘0’ to be send. Give the resulting signal on the media. Make use of the given scheme. **3**

The following Signal has been received from a transmission using the Walsh functions from this task.

+2.1 +1.9 +1.4 +2.0 -1.7 +5.3 -2.1 -1.9

Node	Data	Signal							
0	"0"	+1	+1	+1	+1	+1	+1	+1	+1
3	"1"	-1	+1	+1	-1	-1	+1	+1	-1
6	"0"	+1	+1	-1	-1	-1	-1	+1	+1
Signal on media		+1	+3	+1	-1	-1	+1	+3	+1

Table 4.1: transmission with CDMA

As corruptions might happen during transmission, the receiver has a tolerance band for the detection of "1" and "0". All values differing up to ±0.5 from the ideal value will still be accepted as "1" and "0".

D) Calculate the bit value that the receiver will detect for node 1 and node 5. **2**

Node 1

Received	+2.1	+1.9	+1.4	+2.0	-1.7	+5.3	-2.1	-1.9
Node 1	+1	-1	+1	-1	+1	-1	+1	-1
	+2.1	-1.9	+1.4	-2.0	-1.7	-5.3	-2.1	+1.9

-7.6 is in the tolerance band → a "1" has been detected.

Node 5

Received	+2.1	+1.9	+1.4	+2.0	-1.7	+5.3	-2.1	-1.9
Node 5	+1	-1	+1	-1	-1	+1	-1	+1
	+2.1	-1.9	+1.4	-2.0	+1.7	+5.3	+2.1	-1.9

6.8 is not in the tolerance band → error in transmission.

E) Is it possible to send only two different values (+1,-1) instead of the analog signal? **3**

Assume node five as a sender

Received	+1	+3	+1	-1	-1	+1	+3	+1
Node 5	+1	-1	+1	-1	-1	+1	-1	+1
	+1	-3	+1	+1	+1	+1	-3	+1

sum is zero ⇒ no data sended
send only two different values (+1,-1)

Received	+1	+1	+1	-1	-1	+1	+1	+1
Node 5	+1	-1	+1	-1	-1	+1	-1	+1
	+1	-1	+1	+1	+1	+1	-1	+1

sum is +4 ⇒ detect a sended "0"
It is not possibly to send only two different values, some information will get lost