Exercise (SS 2022)

Comunication Systems and Protocols

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Task 1: Line Codes 7

1.1 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 1.1. 3

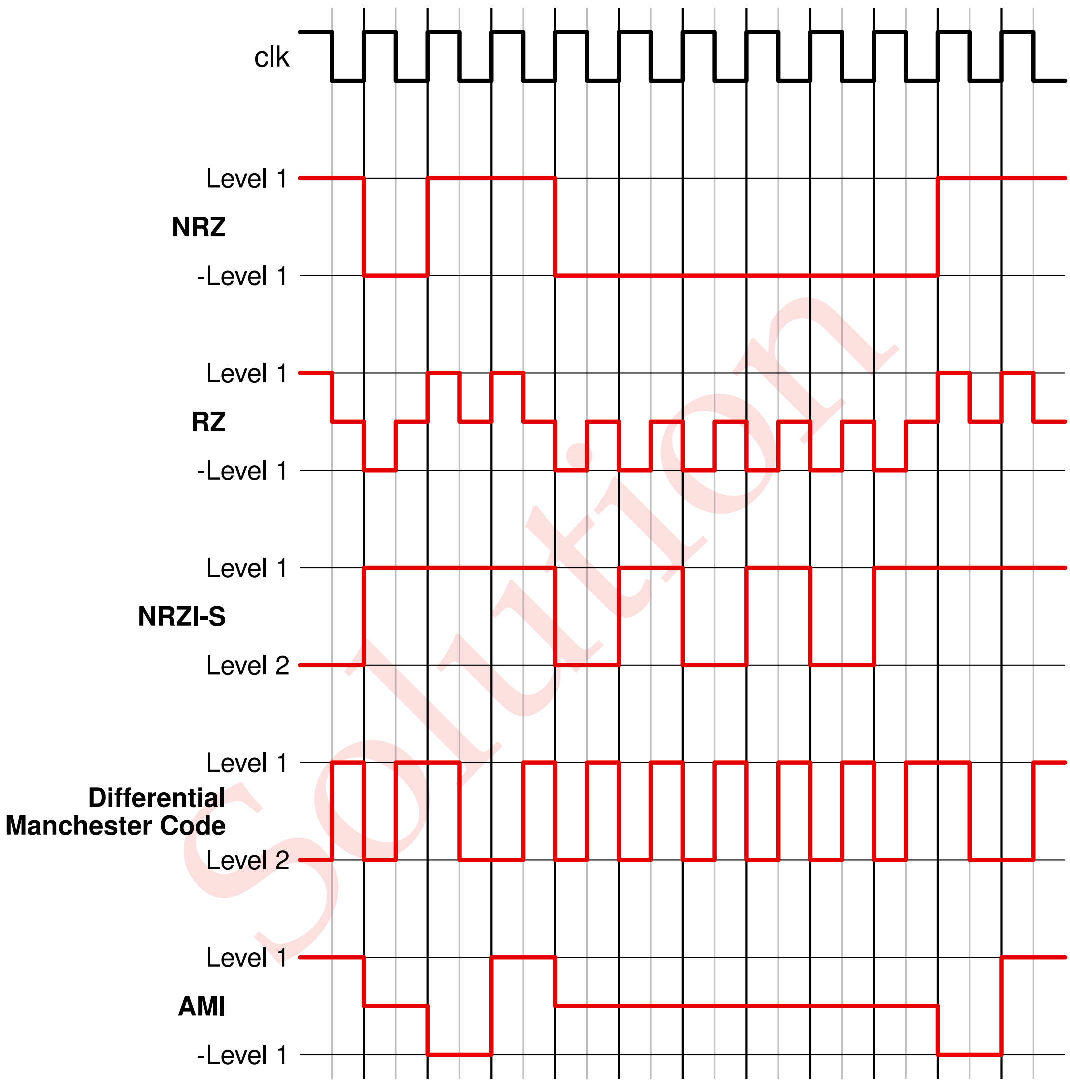

Figure 1.1: Line codes

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

101000001111111000010111

10110 11110 11101 11100 01001 01111

1.3 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

1.4 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

1.5 Figure 1.2 shows the signal sequence for a Manchester II coded signal. Determine the associated bit string. 1

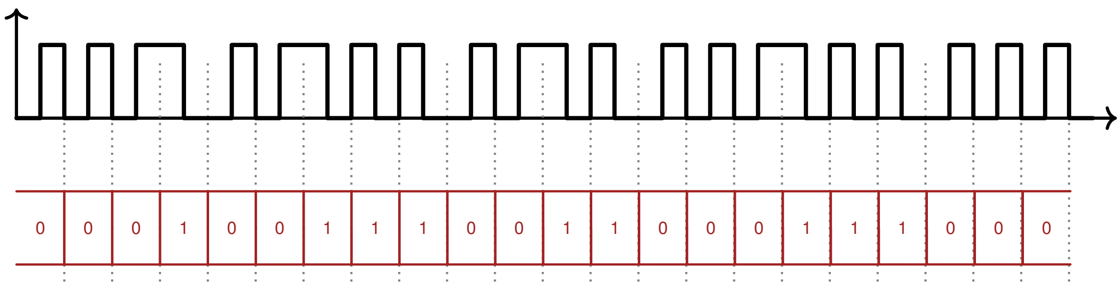

Figure 1.2: Manchester coded bit string

Task 2: Sampling

4

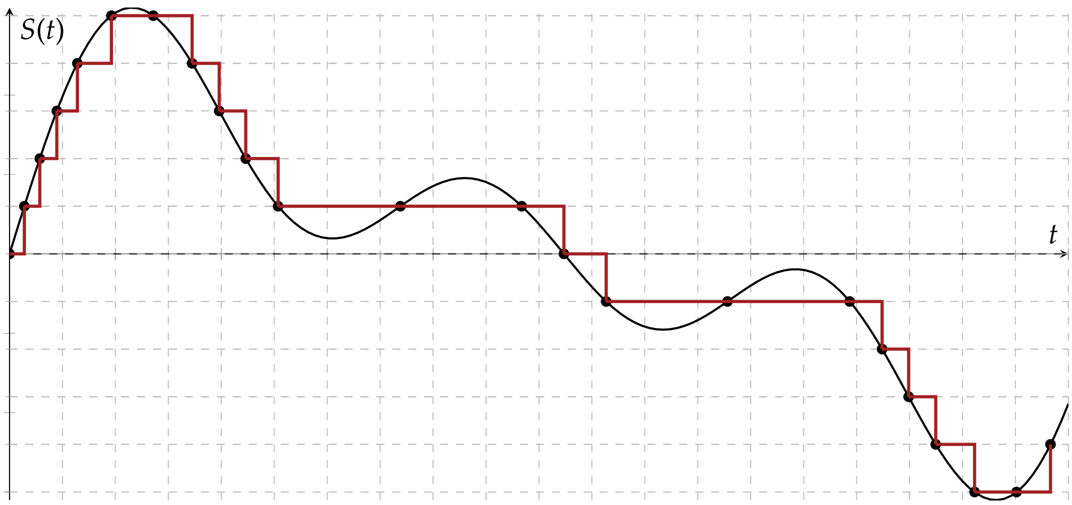

Figure 2.1: signal class: amplitude quantized signal

2.1 The signal in Figure 2.1 is given as the original analog signal. Transform this signal into a amplitude quantized signal. Use the diagram in Figure 2.1 with the given sampling points. 4

Task 3: Channel Capacity

3

3.1 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). What is the minimum for the signal to noise ratio (SNR) in dB? 3

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

Task 4: Code Division Multiple Access (CDMA) 11

4.1 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. 2

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

4.2 Consider now that there are 100 messages to be sent. Here again CDMA scheme shall be used and Walsh table will be used to obtain the spreading codes. What is the number of elements in the spreading code? 1

We need 100 spreading codes.

In general, the number of Walsh Functions generated is $2^{(n)}$. If n is 7 then the number of Walsh functions generated is 128. We can use 100 of them as spreading codes.
The number of elements in the spreading code is 128.

4.3 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 in Task 4A. They are the transmitted simultaneously. The Walsh function is to be inverted when a '0' is to be transmitted and remains unchanged for a '1' to be send. Give the resulting signal on the media. Make use of the given scheme. 3

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

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

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".

4.4 Calculate the bit value based on what the receiver listening to node 1 and 5 detects on the channel. **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 "0" 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.

4.5 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 sent
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 sent "1"
It is not possible to send only two different values, some information will get lost