Tutorial 1 - SS2016
Communication Systems and Protocols

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Task 1: Data transmission

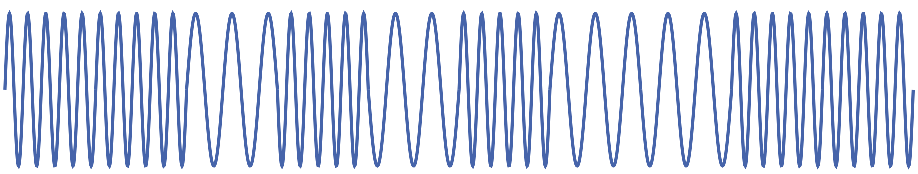
The Compact Muon Solenoid (CMS) experiment is one of two large general-purpose particle physics detectors built on the Large Hadron Collider (LHC) at CERN in Switzerland and France. On one single day the experiment produces about 20 TB (Terabyte = 1*1012 bytes) of interesting data. These data has to be transferred to GridKa (Karlsruhe, approx. 450 km distance). The following transport schemes are available:

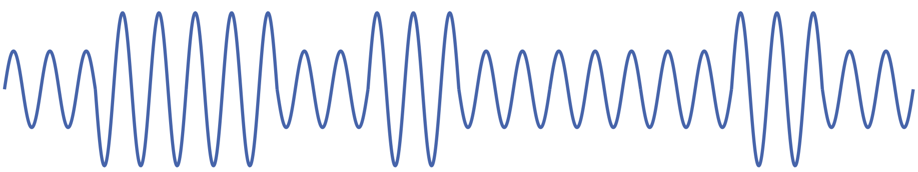
(i) Transmission over VDSL (50 Mbit/s)
(ii) Transmission over an optical fiber link (110Gbit/s)
(iii) Transport of the data using a hard disk and a car (95 km/h)

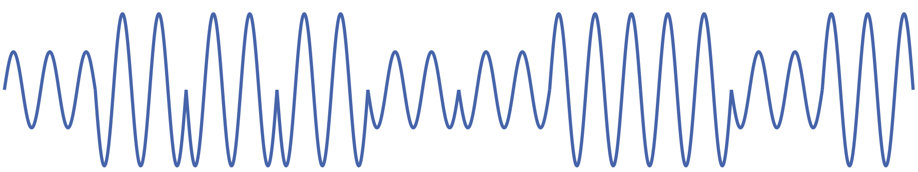
A) Calculate the time required to transfer the data using the different options. Hint: Use 1 Kbit = 1000 bit for the calculation.

Task 2: Modulation

Give the type of modulation used for the signals as shown in the diagram below. Give also the data that is being transmitted. Assume a constant bit length.


A)


B)


C)

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.

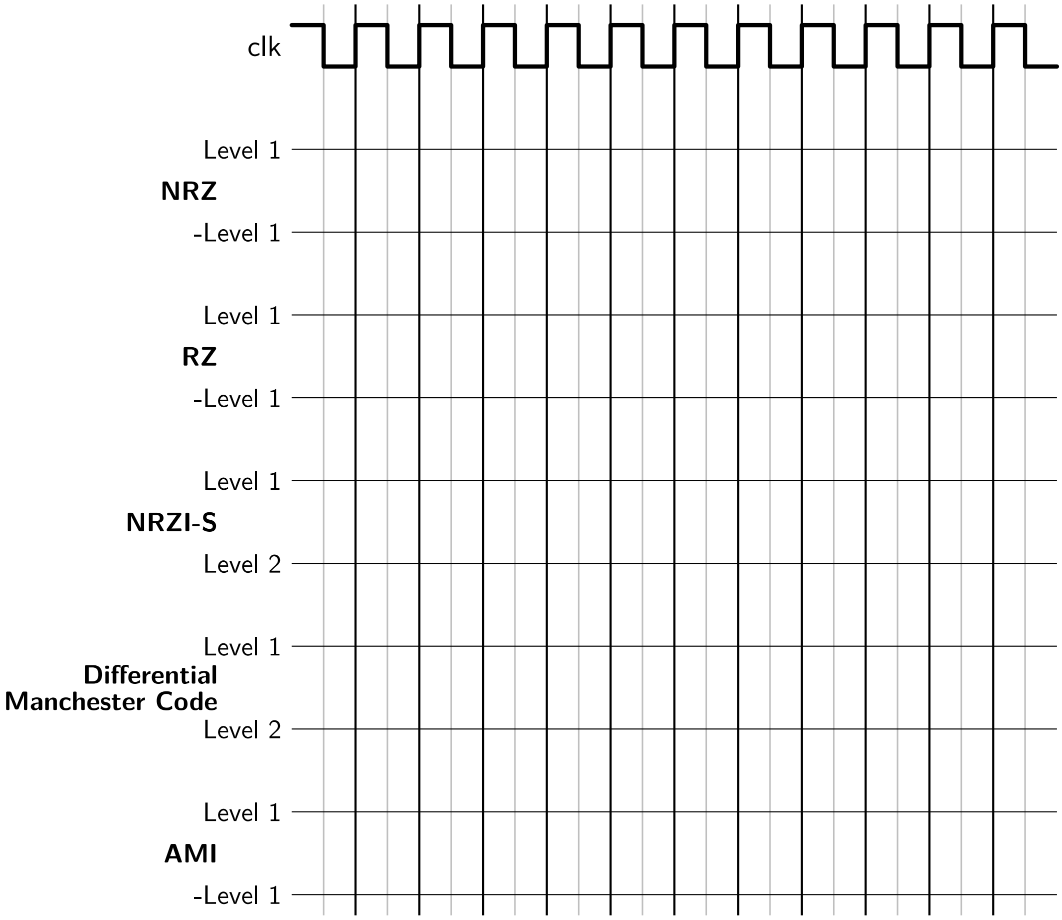


Figure 3.1: Line codes

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

101000001111111000010111

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

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

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

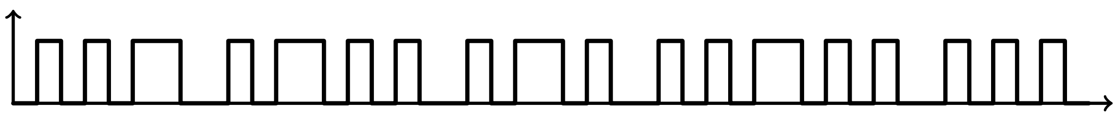


Figure 3.2: Manchester coded bit string

Task 4: Reflection on wires

A setup consisting of a voltage source with an internal resistance $R_I = 50\Omega$ as sender and a receiver with $R_T = 175\Omega$ is shown in Figure 4. The DC resistance of the line is zero, the characteristic impedance Z_0 is 75Ω.

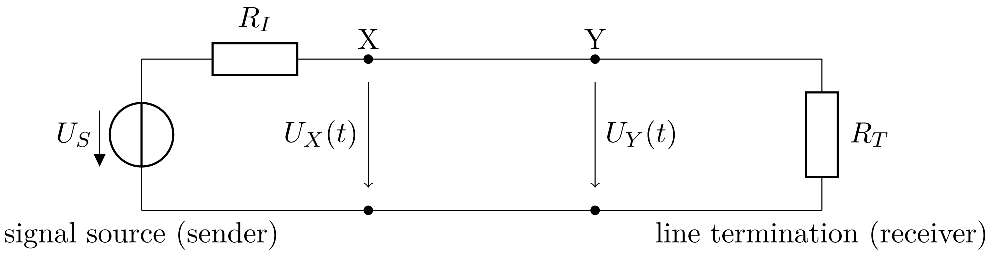


Figure 4.1: Test setup

At the time t= 0 the voltage U_s of the sender changes from $0V$ to $5V$ and is constant afterwards. The run time of a wave on the wire is t_d.

A) What is the value of the voltage at point X at the time $t = 0$?

B) Which voltage value appears at the points X and Y after an infinite amount of time?

C) Calculate the voltages at the points X and Y at the times $t = 0 \ldots 5t_d$. Neglect all transient events, use ideal rectangular impulses for calculation.

Task 5: Physical Basics

Task 5.1: TTL-Logic

A) Insert the logic level (HIGH, LOW) of the output and the state of the transistors (conducts, blocks) into the table 5.1 according to the input configuration x_1 and x_2 at the standard TTL output driver in figure 5.1.

x_1	x_2	T_1	T_2	T_3	T_4	y
0	0					
0	1					
1	0					
1	1					

Table 5.1: Logic Level

B) List two advantages when using TTL drivers.

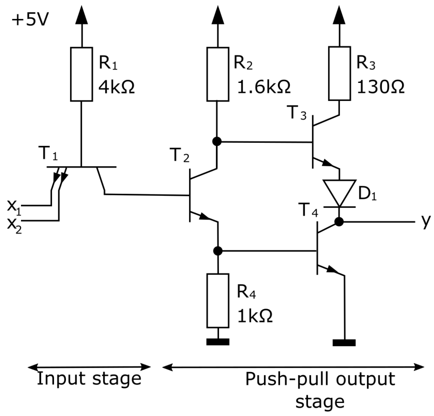


Figure 5.1: standard TTL output driver

C) How would it be possible to overcome the disadvantage of possible short circuits of a TTL driver? Which part of the TTL driver needs to be modified? Modify the Figure 5.2 to get the solution and describe the purpose of te adjustments made.

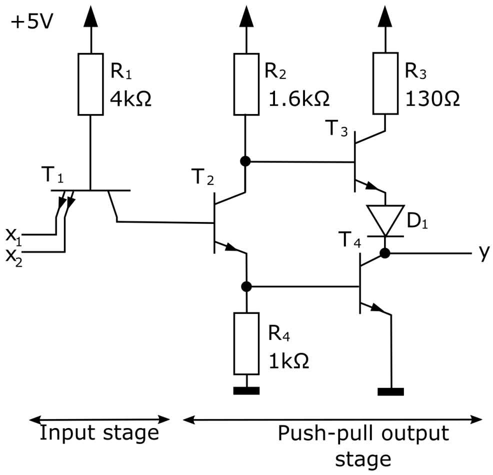


Figure 5.2: TTL driver

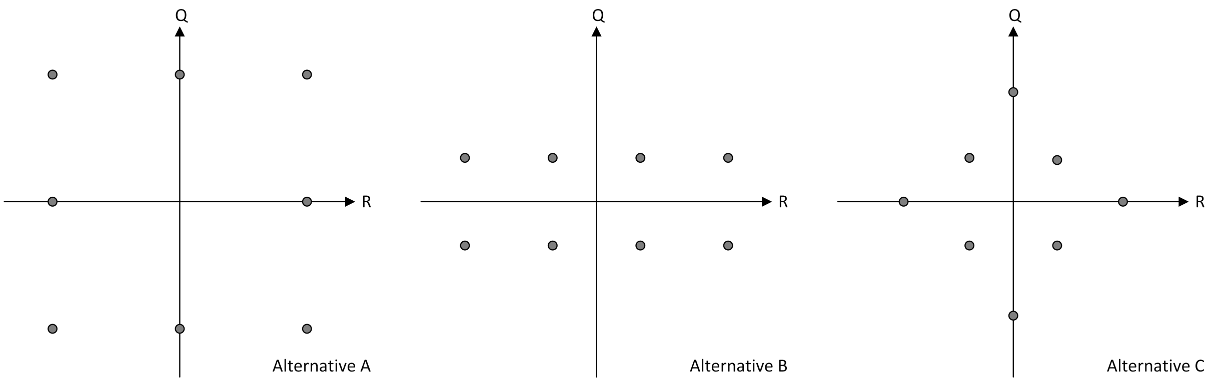
Task 5.2: Differential Signals

A) How could differential signal generation be realized?

B) What are the advantages for differential signal transmission? Name two.

Task 5.3: Modulation

Now consider the following constellation diagrams for 8-QAM. All diagrams are drawn with the same scaling of the axes.



A) If you had to realize a communication system using QAM modulation, which alternative would you choose? Give reasons for your decision

B) Briefly describe PSK modulation and give one advantage.

Task 5.4: Channel capacity, Bandwidth

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

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

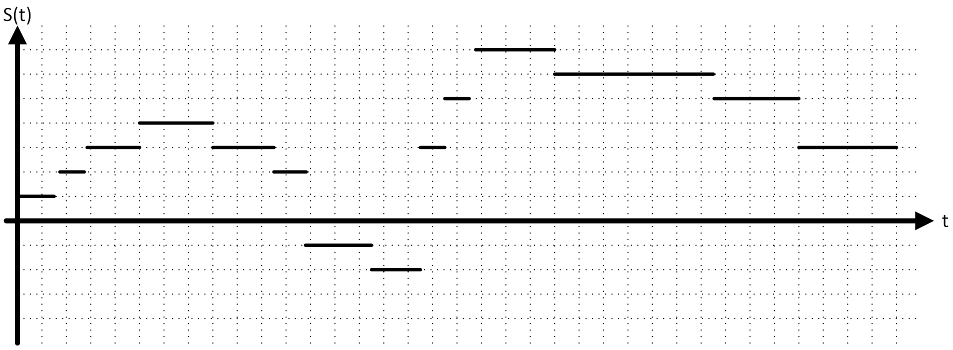
B) Give the definition for the Cut-Off-Frequency:

Task 5.5: Signal Conversion

A) When converting analog signals into digital signals, what has to be considered in order to be able to achieve an unambiguous reconstruction of the signal (name and formula)?

B) One can distinguish four different classes of signal. What are the parameters that are changed to form these classes? Give the combination of parameters that are characteristic for each class.

C) Which signal class does the following signal belong to? Briefly describe where this type of signal can be used.



Task 6: Wiring

Task 6.1: General Questions

A) What is a symmetric line? Name one disadvantage of symmetric signaling.

B) How does the wire length affect the characteristic impedance Z_W in a lossless case?

C) Name four causes for distortions of real data signals.

D) Name the four different possible cases of the reflection factor r and describe shortly their mechanical analogue.

Task 6.2: Reflection on wires

You have found a transmission link in the basement and want to find out the characteristic impedance. With the setup given in Figure 6.2 you make the measurements that can be seen in Figure 6.2. The signal source U_S is stuck at an unknown output voltage and has an internal resistance of 33Ω. The termination resistance is $R_T = 200\Omega$. You can assume that the DC resistance is zero. When using numbers from Figure 6.2, only use one decimal place and only use values where the voltage is mostly constant.

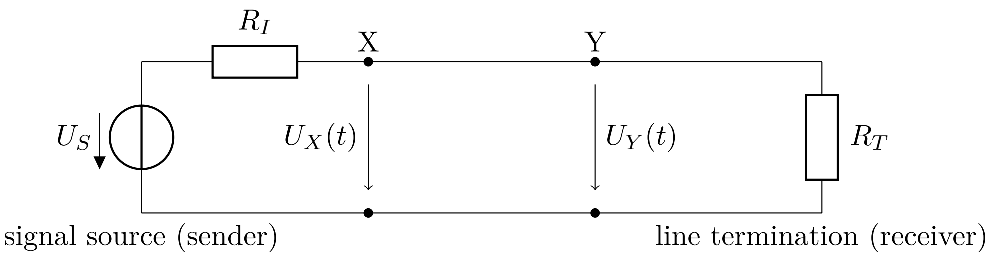


Figure 6.1: Test setup

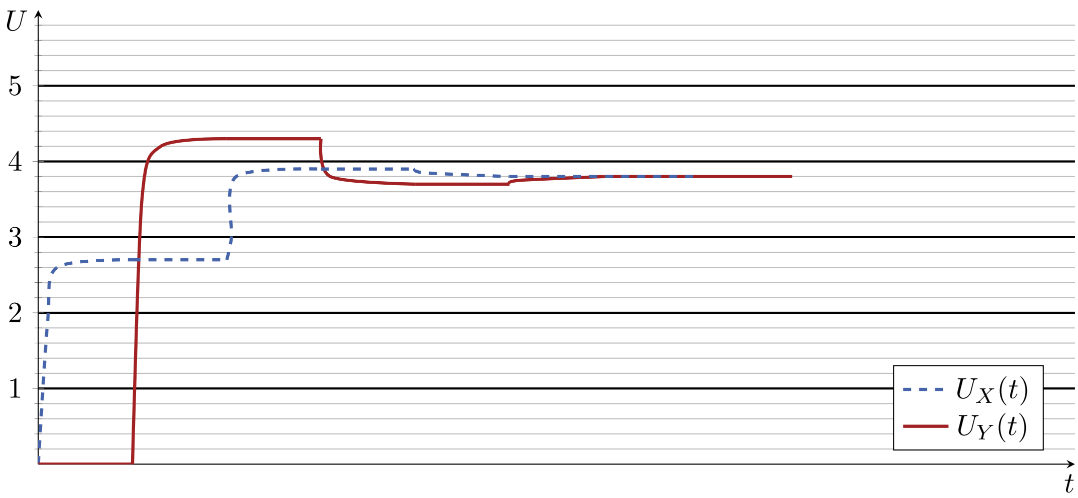


Figure 6.2: Measurement

A) How would you divide the timeline? Explain and mark at least four points on the timeline

B) Without calculation, make a quantitative statement about the reflection factors at the start and at the end.

C) Calculate the characteristic impedance Z_0 and the reflection factors at the start and at the end.

D) Calculate the internal sender voltage U_s