Exercise (SS 2022)
Comunication Systems and Protocols

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Task 1: ITIV-Protocol 18

The ITIV want to transmit data bidirectional from campus south to campus north with multiple clients. Therefore a customized protocol is build by the ITIV for transmission of information with id, data and a check sum. The bus should use Manchester coding to transmit the raw data. Use the Manchester code where data bit '1' is represented by signal transition from low level to high level. The voltage level on the bus is induced by an open-collector that is connected to the output stage of the microcontroller (see Figure 1.1). The transmission is initialized by a start-bit (low) and finished with a stop-bit (high).

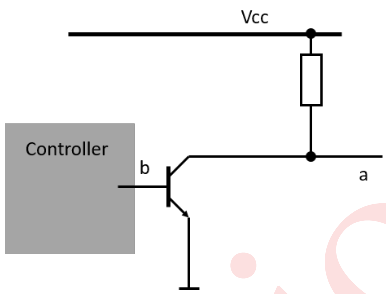

Figure 1.1: Open collector schematics

1.1 How can data integrity be checked on physical layer without changing the protocol? number of point **2**

Check for start-bit and stop-bit or
Macnchester needs to change at least once every clock cycle

Correction hints: *1pt each*

1.2 The transmitted data-field will have variable length. Name two ways of determining the data-field length within a transmission. **4**

Length specification in length field of frame
Use of delimiter for data field

Correction hints: *2pt each*

1.3 Can the clock be recovered within this system? Justify your answer. If clock recovery is not working give a possible solution. **2**

Yes. Manchester-II is used, therefor a change of level for every bit.

Correction hints: *2Pt for yes with reason,*
0Pt if wrong or no reason

1.4 Draw the Manchester coded and raw data (8-bit of information) transmitted over the channel in the following graphic. The signal names correspont to the names from Figure 1.1. Please write down the transmitted data. **6**

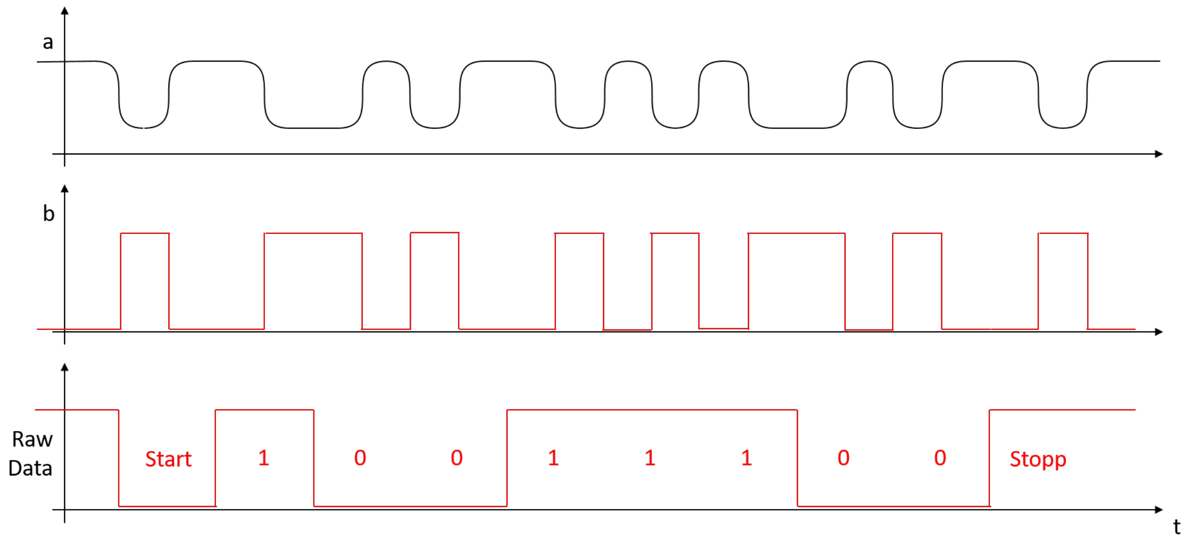

Figure 1.2: Transmitted data over the channel

1.5 Because of license reasons the Manchester coding cannot be used. Why can't differential Manchester be used for the system? Please name the Problem and a possible solution. Hint: What happens to the bus line after transmission. 4

Differential Manchester is alternating, therefor last level depends on number of '0's and '1's. This means the stop bit ends not always at recessive level.
For odd parity a second stop-bit or parity-bit has to be added.

Correction hints: *2pt: for Problem*
2pt: for possible Solution

Task 2: I²C Communication

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In this task we want to investigate the data transmission on the I²C-Bus. The simplified frame format is given in Figure 2.1. Three master nodes are simultaneously trying to transmit or read one byte of data to or from different slaves over the I²C-Bus.

S	ADDR	$R/\bar{W}$	A	DATA	A	DATA	$A/\bar{A}$	P

data transfered (n bytes + acknowledge)

term	description
S	start condition
ADDR	7-bit slave address
$R/\bar{W}$	read/write: read 1, write 0
A	acknowledge ('0')
$\bar{A}$	not acknowledge ('1')
DATA	8-bit data
P	stop Condition

Figure 2.1: I²C-Bus frame format

2.1 Is I²C a synchronous or asynchronous protocol? Justify your answer. 2

It is a Synchronous Protocol because it sends the transmitter's clock through SCL.

Correction hints: *2p for SCL/presence of clock line*

2.2 Consider the following cases where two masters try to access the same slave.
Case 1: Two masters try to perform a read operation at the exact same time.
Case 2: Two masters try to perform a write operation at the exact same time.
Case 3: One master tries to read and the other master tries to write at the exact same time.
What happens in each case ? Is the write or read operation successful in each case? Explain if any collisions could be detected and how they are detected. Justify your answer for each of the cases. 6

If both Masters try to read, they both receive the same data from the Slave and no collision is detected.
If both try to write, the Master who writes the smallest value (first to write a ’0’) gets priority and completes the operation, a collision is detected during the writing of the data.
If they ask for different operations, the write operation has priority as it correspond to a ’0’ bit, and a collision is detected before the data is sent.

Correction hints: *2p for each case with explanation.*

2.3 The diagram in Figure 2.2 corresponds to a I^2C Multimaster configuration. The system is composed of 3 Slave and 3 Master nodes. Complete the diagram with the signals generated by each node for the simultaneous transactions presented in Table 2.1 and for the resulting SDA line of this bus. The table shows for each master, the address of the slave it is accessing, the communication mode (R/W) and the data to be sent or read. 8

Correction hints: *2p for correct SDA line.*
1p for correct address and R/W request for each Master (3p total for all 3).
1p for correct assignment of all A/not A by Slaves.
1p for correct assignment of Stop Condition.
1p for correct data of Slaves

node	slave address	$R/\overline{W}$	data
Master 1	1011101	0	01111001
Master 2	1010101	1	01011010
Master 3	1010111	0	01000011

Table 2.1: I^2C Communication Parameters

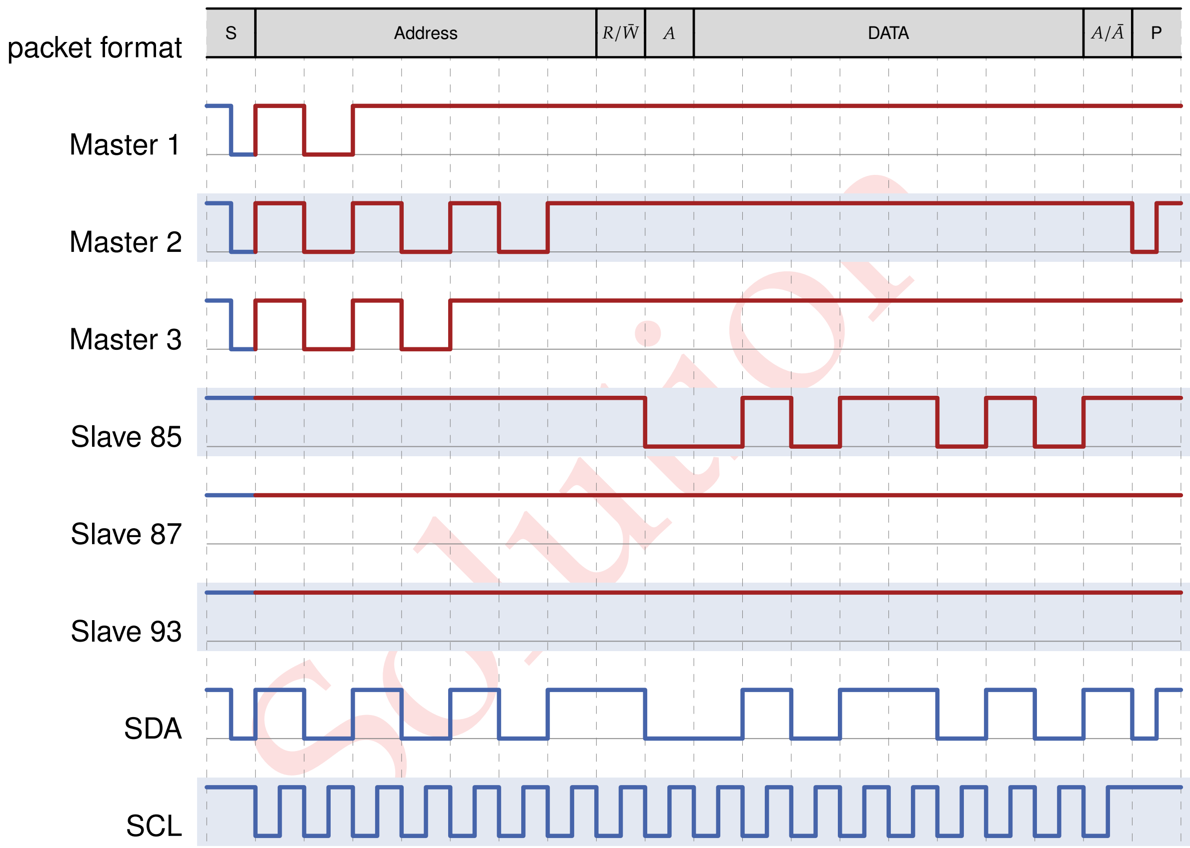

Figure 2.2: I²C Signal sequence

Task 3: Reflection on wires

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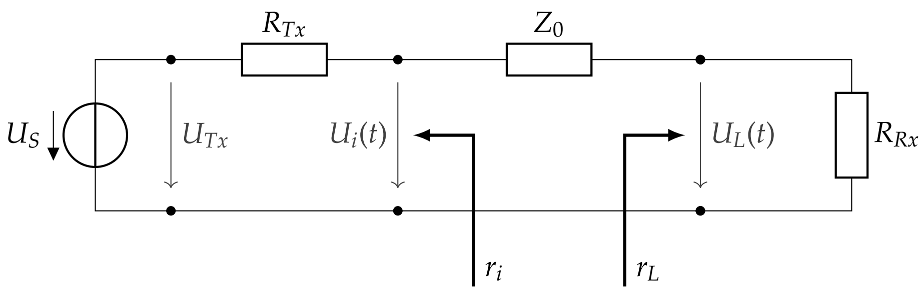

Figure 3.1: Test setup

Figure 3.1 shows the equivalent circuit diagram of an ideal (lossless) transmission line: A transmitter having output impedance R_{Tx} is connected to a receiver with the input impedance R_{Rx} using a long cable.
$R_{Tx} = 60\,\Omega$ and $R_{Rx} = 180\,\Omega$. The signal line is characterized by $Z_0 = 60\,\Omega$.

3.1 Give the generic formula to calculate the reflection factor and give the reflection factors r_i and r_L. 3

$r = (R_T - Z_0)/(R_T + Z_0)$
$r_i = (R_{Tx} - Z_0)/(R_{Tx} + Z_0) = 0$
$r_L = (R_{Rx} - Z_0)/(R_{Rx} + Z_0) = 0.5$

Correction hints: *1pt per correct r_i and r_L value*
1pt for generic formula (or at least one specific form).

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

3.2 Calculate the value of the voltage $U_i(t)$ at the time $t = 0$. 3

At the time $t = 0$ the wave only „sees“ a series connection of the internal resistance R_{Tx} and the wave impedance Z_0.

$$U_i(0) = U_S \cdot \frac{Z_0}{R_{Tx}+Z_0} = 5\,\text{V} \cdot \frac{60\,\Omega}{60\,\Omega+60\,\Omega} = 2.5\,\text{V}$$

Correction hints: *2pt for correct apoproach and formula*
1pt for correct value

3.3 Calculate the voltage $U_m(t)$ in the middle of the line at the times $t \in \{0, t_d, 2t_d, 3t_d\}$. Neglect all transient events, use ideal rectangular impulses for calculation. 6

$U_m(0t_d) = 0\,\text{V}$ (since the wave has not reached this point yet).

$U_m(1t_d) = 2.5\,\text{V}$ (see previous task).

$U_m(2t_d) = U_m(1t_d) + r_L \cdot [U_m(1t_d) - U_{cable,m}(0t_d)] = 3.75\,\text{V}$

$U_m(3t_d) = U_m(2t_d) + r_i \cdot [U_m(2t_d) - U_m(1t_d)] = 3.75\,\text{V}$

In general:

$U_m(t) = U_{cable,m}(t - 1t_d) + r_{i/L} \cdot [U_{cable,m}(t - 1t_d) - U_{cable,m}(t - 2t_d)]$

Correction hints: *For $U_m(0t_d)$ and $U_m(1t_d)$: 1pt per correct value.*
For $U_m(2t_d)$ and $U_m(3t_d)$: 2pt if value is correct, 1pt if value is wrong/missing but formula makes sense.

In case that the idea of monitoring the voltage in the middle of the line was not considered (e.g. $U_m(0) = 2.5\,\text{V}$): No points for $U_m(0)$. Subsequent lines are then graded as described above considering consequential errors.

Task 4: Protocols

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FireWire Arbitration

The result of the self-identify process for a FireWire network is shown in Figure 4.1. The number shown in the center of each node represents its physical ID given by the self-identify process.

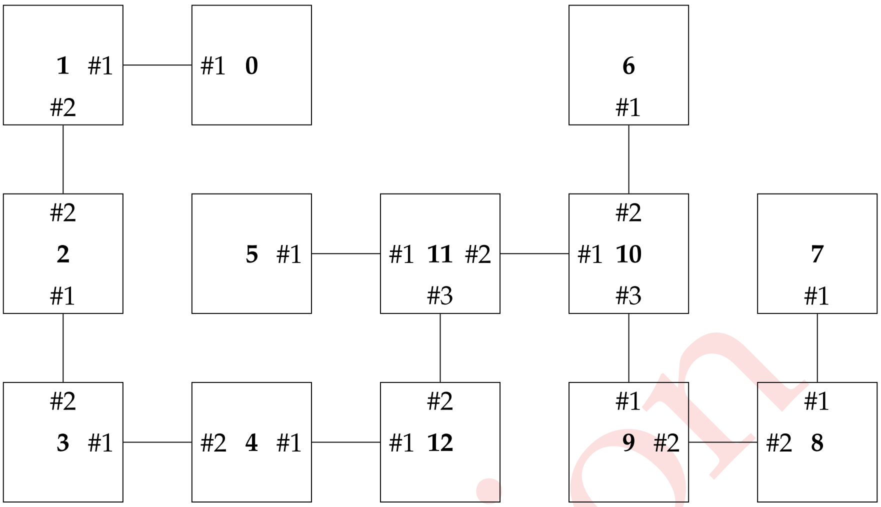


Figure 4.1: FireWire network

4.1 The nodes in Figure 4.1 having address **2**, **5**, **7**, **10** would like to transmit data and start requesting at the same time. Describe in which order are the nodes granted request. 4

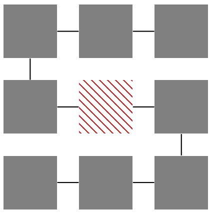
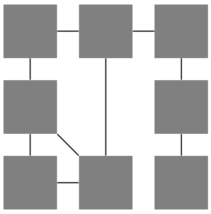
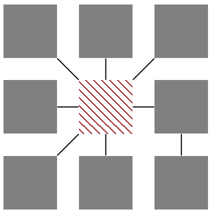
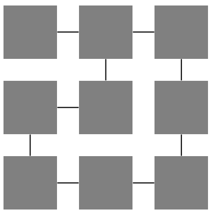
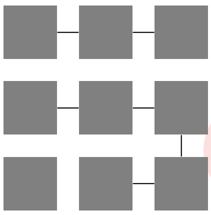
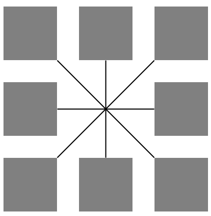
- Assume that every node needs one time unit for processing and forwarding of its request signal.
- If a node receives multiple bus requests, it will always forward the request that it receives from the port with the lowest number.

Granted request order: 5, 10, 2, 7.

Correction hints: *+4 pts. for correct order.*

FireWire Structures

4.2 Different FireWire structures were built, but not all of them are working correctly. State for each row if the nodes shown are building *one connected* FireWire system that is working correctly. If a system is correct, mark its root node. If it is not correct, give a reason for this. 6

	Correct	Wrong	Reason
	x		
		x	Closed loops are unsupported.
	x		
		x	Closed loops are unsupported.
		x	All nodes of one systems have to be connected. Alternate solution: the system is correct, there are three different FireWire systems with the roots marked as being the node at the center of each network
		x	One output cannot have multiple connections.

Correction hints: *+1 pts. per system with reason for wrong cases. Third structure can have two possible roots. The center node or the node to the right of it.*

FireWire Architecture

4.3 Name the three stacked protocol layers of FireWire presented in the lecture. 3

- Transaction layer
- Link layer
- Physical layer

Correction hints: *+1 pts. per layer.*