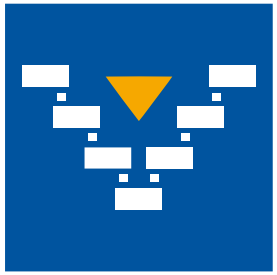

Introduction to
# Embedded Systems

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## Exercise 2 – Data Buses

# Overview

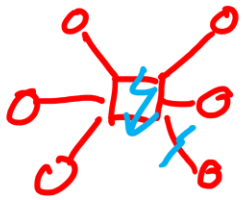
- Basics
- Hamming Code
- I²C
- Profibus

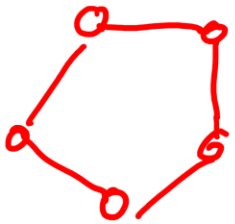
# Basics

Task 1: a) – c)

# Task 1: a)

a) Name two advantages that the **star topology** has over the **bus topology**.





**Adv.**

- no collision
- no implicit broadcast
- only one single point of failure
- multiple sender at the same time

**Disadv.**

- we have a single point of failure
- more wiring
- we need a central station

} overall more expensive

# Task 1: b)

=> avoid long sequences of 1s

b) Use the 4B/5B table to encode the message ***000000111111***.

0 | 3 | 15 = F

| Name | 4B | 5B | Name | 4B | 5B | Name | 5B | Desc |
|---|---|---|---|---|---|---|---|---|
| 0 | 0000 | 11110 | 8 | 1000 | 10010 | Q | 00000 | Quiet |
| 1 | 0001 | 01001 | 9 | 1001 | 10011 | I | 11111 | Idle |
| 2 | 0010 | 10100 | A | 1010 | 10110 | J | 11000 | Start #1 |
| 3 | 0011 | 10101 | B | 1011 | 10111 | K | 10001 | Start #2 |
| 4 | 0100 | 01010 | C | 1100 | 11010 | T | 01101 | End |
| 5 | 0101 | 01011 | D | 1101 | 11011 | R | 00111 | Reset |
| 6 | 0110 | 01110 | E | 1110 | 11100 | S | 11001 | Set |
| 7 | 0111 | 01111 | F | 1111 | 11101 | H | 00100 | Halt |

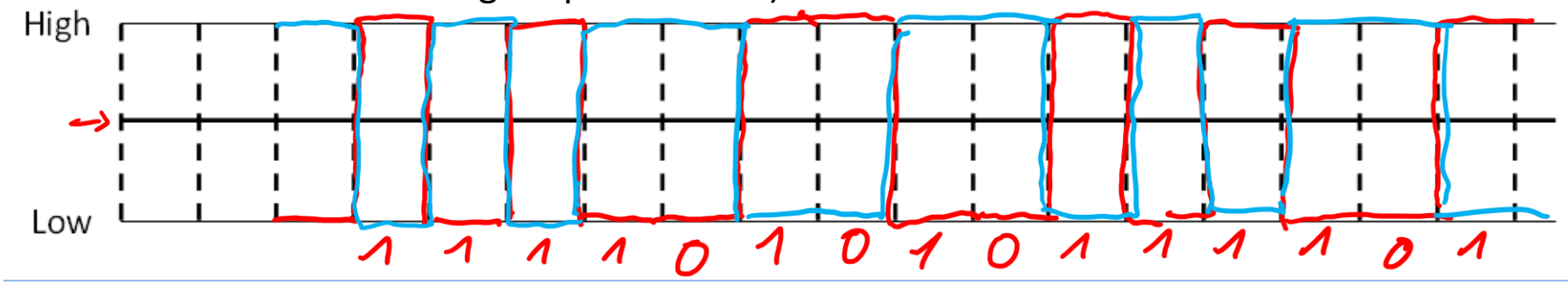
11110|10100|10101|10101

=> provided in the exam

4/5

=> 80% of data rate

Then draw the signal diagram using **Differential NRZI** (Differential NRZ with inverted semantics: a level change represents a 1).



# Task 1: b)

b) Use the 4B/5B table to encode the message ***000000111111***.

| Name | 4B | 5B | Name | 4B | 5B | Name | 5B | Desc |
|---|---|---|---|---|---|---|---|---|
| 0 | 0000 | 11110 | 8 | 1000 | 10010 | Q | 00000 | Quiet |
| 1 | 0001 | 01001 | 9 | 1001 | 10011 | I | 11111 | Idle |
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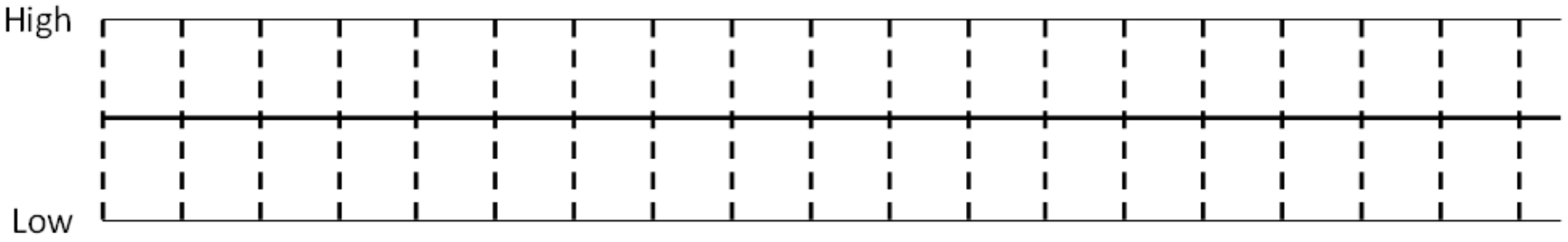
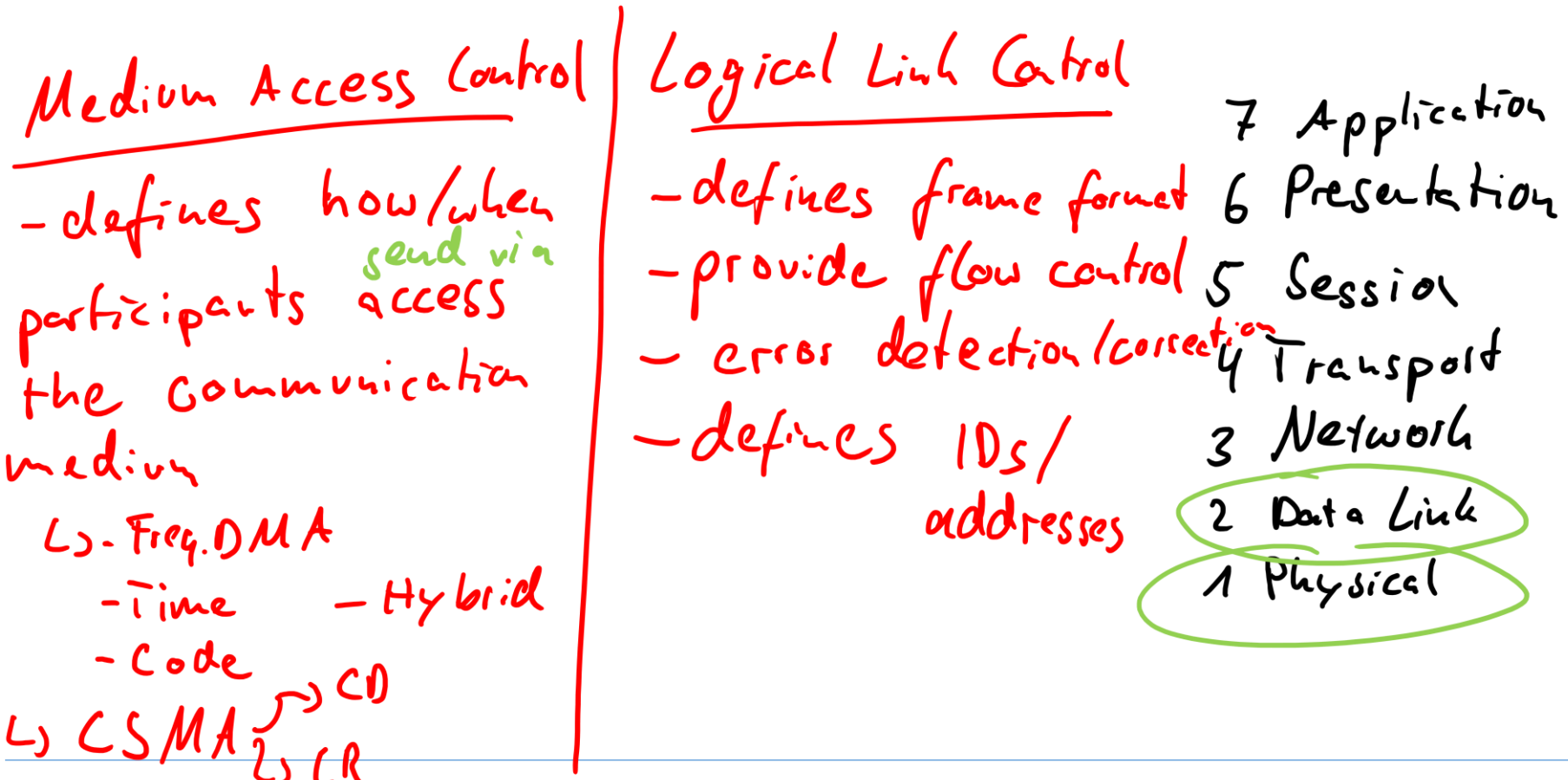
| 7 | 0111 | 01111 | F | 1111 | 11101 | H | 00100 | Halt |

Then draw the signal diagram using **Differential NRZI** (Differential NRZ with inverted semantics: a level change represents a 1).



# Task 1: c)

c) What are the names of the two sublayers of **Layer 2** (OSI-Model)? What are their tasks?



# Hamming-Code

Task 2: a) – b)

# Task 2: a)

a) Calculate the even parity Hamming code of the following bit sequence: 11001110

| Bit # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Value | ? | ? | 1 | ? | 1 | 0 | 0 | ? | 1 | 1 | 1 | 0 | | |
| $p_1$ | 0 | | 1 | | 1 | | 0 | | 1 | | 1 | | | |
| $p_2$ | | 1 | 1 | | | 0 | 0 | | | 1 | 1 | | | |
| $p_4$ | | | | 1 | 1 | 0 | 0 | | | 1 | | 0 | | |
| $p_8$ | | | | | | | | 1 | 1 | 1 | 1 | 0 | | |
| | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | | |

# Task 2: b)

b) Correct and extract the 11 bit data sequence from this Hamming code protected sequence (even parity): 10010010100011

| Bit # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Value | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 01 | 1 | 1 |
| $p_1$ | 1 | | 0 | | 0 | | 1 | | 1 | | 0 | | 01 | | 1 |
| $p_2$ | | 0 | 0 | | | 0 | 1 | | | 1 | 0 | | | 1 | 1 |
| $p_4$ | | | | 1 | 0 | 0 | 1 | | | | | 0 | 01 | 1 | 1 |
| $p_8$ | | | | | | | | 0 | 1 | 1 | 0 | 0 | 01 | 1 | 1 |
| | | | | | | | | | | | | | | | |

⇒ 00011100011

- One error correction
- two error detection

1+4+8 = 13

# Inter-Integrated Circuit

Task 3: a) - e)

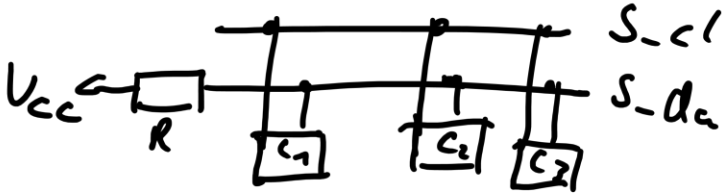
$I^2C$

# Task 3: a) – c)

a) What topology does I²C use?

Bus-Topologie

b) What does Wired-AND mean?




a zero is dominant on the bus

c) What is the basic MAC concept? Why are there no collisions when multiple senders start at the same time?

- Master/Slave

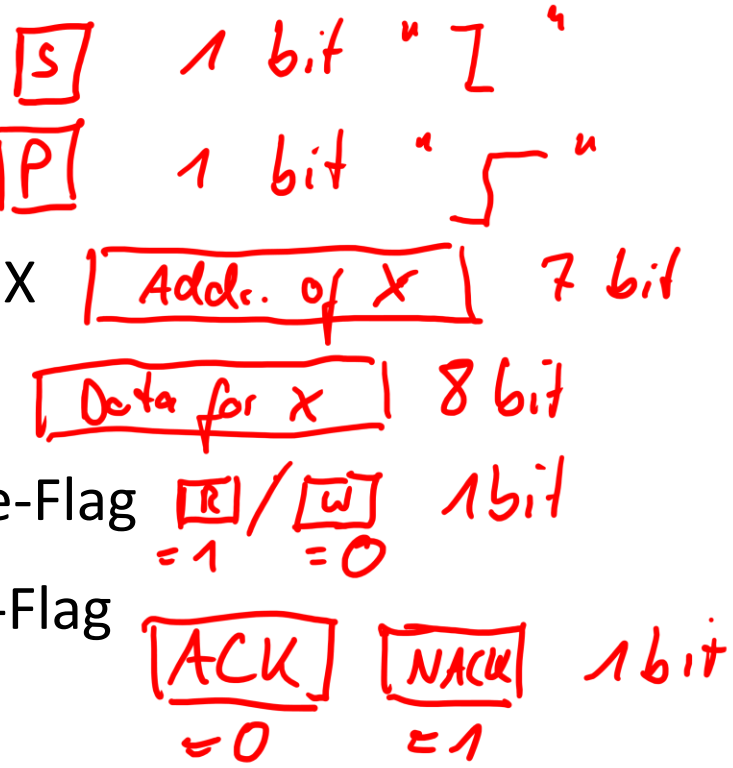
- Multiple Master

↳ CSMA/CR with Wired-AND

# Task 3: d)

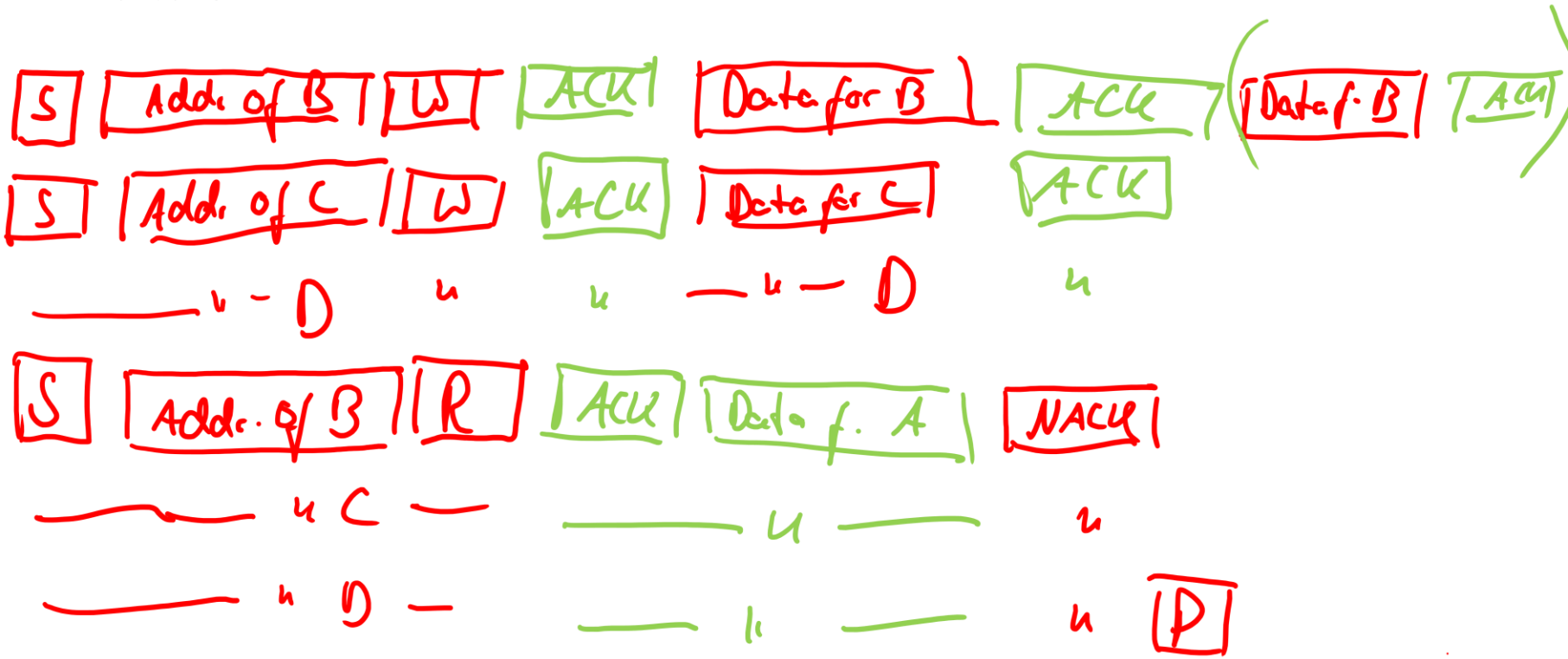
d) Use a block scheme to depict the following communication: ***A*** **sends** three participants ***B***, ***C*** and ***D*** a data byte each. After ***A*** sent the third data byte, it starts **querying** ***B***, ***C*** and ***D*** for a one byte response. Indicate who controls the data line for each block.

- Start-Flag
- Stop-Flag
- Address of X
- Data for X
- Read/Write-Flag
- ACK/NACK-Flag



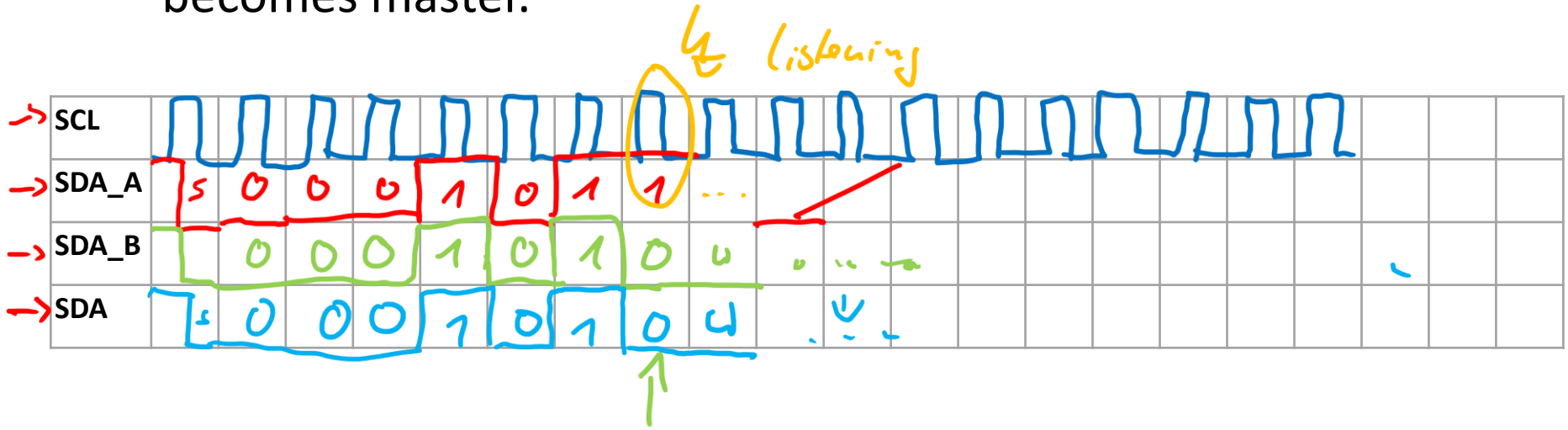
# Task 3: d)

- ***A* sends** data bytes to ***B***, ***C*** and ***D***.
- ***A* reads** data bytes from ***B***, ***C*** and ***D***.
- **Indicate** who controls the data line for each block.



# Task 3: e)

- **A** *(address = **0x0a**)* and **B** *(address = **0x0b**)* want to **send** messages to each other at the same time. **A**‘s message is ***0xaa*** while **B**‘s message is ***0xbb***. Assume their clocks are perfectly synchronous, there is no transmission delay and they start at the exact same time. Draw SCL, SDA_A, SDA_B and SDA until the first transmission is complete. **Mark** the bit that decides who becomes master.



# Profibus

Task 4

# Task 4

a) What is the topology of Profibus and how is medium access controlled?

- Bus topology
- Master / Slave
- Multiple Masters: Tokenbus