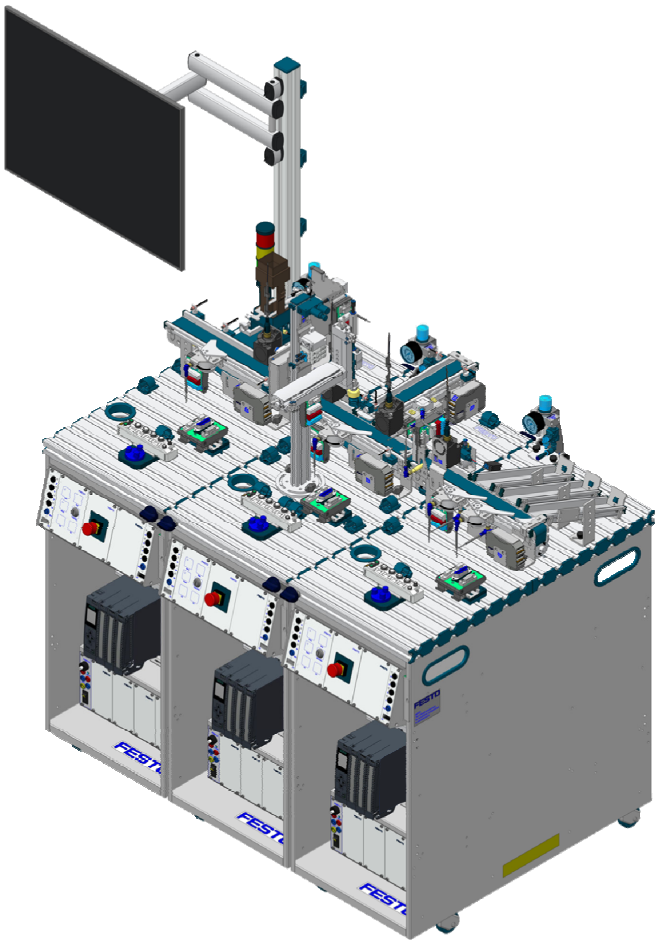
Getting started with Industry 4.0

MPS®
System 203 I4.0

Workbook



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Note

Wherever teachers, apprentices etc. are referred to in the masculine form in this manual, the feminine form is also implied. The use of a single gender is not intended as gender discrimination, but simply to aid readability and comprehension of the document and the formulations used.

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Use for intended purpose

The products included in the learning system for automation technology may only be used:

- For their intended use in teaching and training applications
- When their safety functions are in perfect condition

The products included in Festo Didactic's learning system for automation technology are designed in accordance with the latest technology and recognized safety rules. However, life and limb of the user or third parties may be endangered and the components may be impaired if they're used incorrectly.

The learning system from Festo Didactic has been developed and produced exclusively for basic and further training in the field of automation technology. The training company and/or trainers must ensure that all apprentices observe the safety precautions described in this workbook.

Festo Didactic hereby excludes any and all liability for damages suffered by apprentices, the training company and/or any third parties, which occur during use of the equipment sets in situations that serve any purpose other than training and/or vocational education, unless such damages have been caused by Festo Didactic due to malicious intent or gross negligence.

Preface

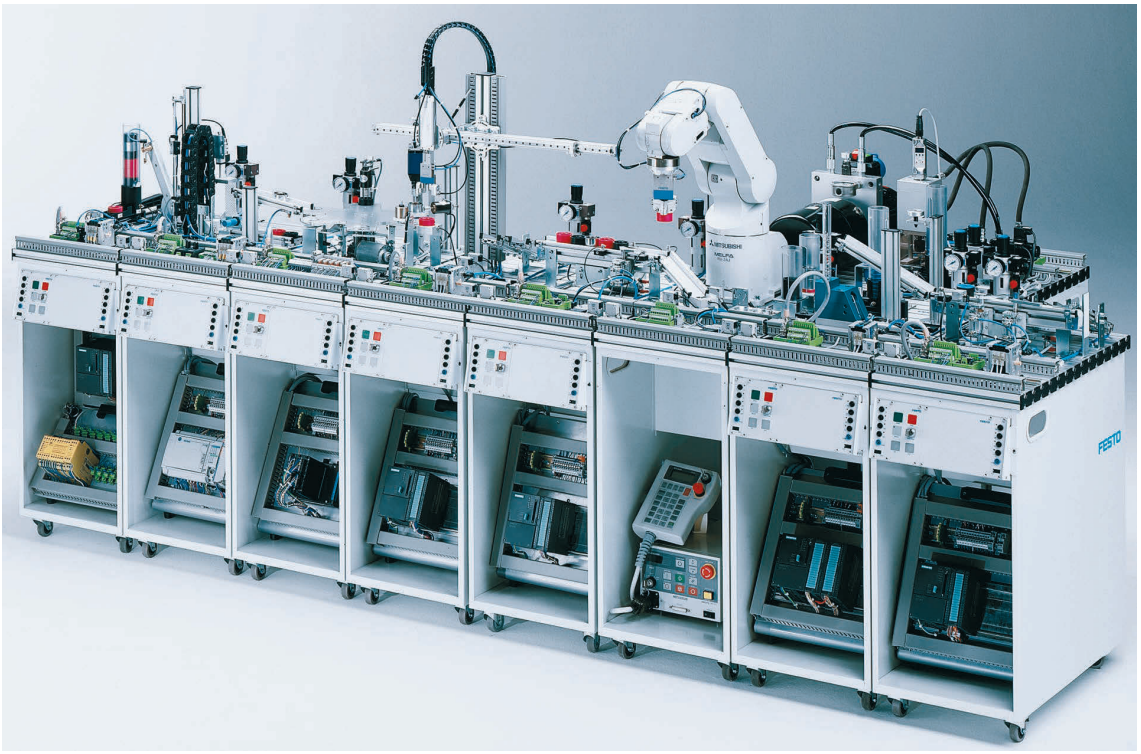
Festo Didactic's learning system for automation and technology is geared towards various educational backgrounds and vocational requirements. The training system is therefore broken down as follows:

- Technology-oriented training packages
- Mechatronics and factory automation
- Process automation and closed-loop control technology
- Mobile robotics
- Hybrid training factories

The training system for automation and technology is continuously updated and expanded in accordance with developments in the field of education, as well as actual professional practice.

Mechatronics is the synergistic combination of mechanical engineering, electrical engineering, electronics, information technology and thinking systems. This is used in the development of products and automation processes. Industrial automation deals primarily with the automation of manufacturing, quality control and materials handling processes.

The modular production system MPS® is the origin of, and basis for, almost all of Festo Didactic's mechatronic training systems.



The learning solutions also encompass a wide range of topics which are directly related to mechatronics and factory automation such as robotics, CAD/CAM and control technology. Instructors can easily expand the scope of learning by selecting other products and services from a broad spectrum of technologies.

All of the systems are 100% modular, thus permitting expansion and flexibility.

Hardware
The hardware included in the mechatronic systems is comprised of industrial components and systems that are specially designed for training purposes. The components of the mechatronic systems are specifically designed and matched to the projects in the accompanying media.

Media
The media provided for the individual topics consist of a mixture of courseware and software. The practically oriented courseware includes:

- Workbooks (practical exercises with supplementary instructions and sample solutions)
- Dictionaries, manuals and technical books (which provide technical information on groups of topics for further exploration)

Software is available for the following applications:

- Digital training programs (learning content specifically designed for virtual training)
- Simulation software
- Visualization software
- Software for acquiring measurement data
- Project engineering and design engineering software
- Programming software for programmable logic controllers

The teaching and learning media are available in several languages. They’re intended for use in classroom instruction, but are also suitable for self-study.

Workbook license types
We offer the following three license types for workbooks:

- **Home use license**
  For personal use. You order the workbook online as a PDF file. All of the workbook’s pages are watermarked. You can store the PDF file to your PC, print it out and edit it. The multimedia CD-ROM is not included.
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Note
The full rights of use are in compliance with the stipulations included in the legal notice of the purchased workbook.

Do you have tips or suggestions for improving this workbook?

If so, please inform us by e-mail at did@festo.com.
The authors and Festo Didactic look forward to your comments.

Work and safety instructions

General

- Apprentices should only work with the circuits under the supervision of an instructor.
- Observe the specifications included in the data sheets and operating instructions for the individual components and, in particular, all safety instructions!
- Faults which may impair safety should not be generated.
- Wear personal safety equipment (safety glasses, hearing protection, safety shoes) when working on circuits.
- Provide the trainer/instructor with confirmation that you have read and understood the safety instructions and warnings by affixing your signature. You are only authorized to participate in the laboratory event after appending your signature.

Mechanical safety

- **Switch off the power supply.**
  - Switch off working and control power before working on the circuit.
  - Only reach into the setup when it's at a complete standstill.
  - Be aware of potential overtravel times for the drives.
- Mount all of the components securely on the profile plate.
- Make sure that limit valves are not actuated from the front.
- Risk of injury during troubleshooting.
  Use a tool such as a screwdriver to actuate limit switches.
- Set all components up so that it's easy to activate the switches and interrupters.
- Follow the instructions about positioning the components.

Electrical safety

- **Disconnect from all sources of electrical power.**
  - Switch off the power supply before working on the circuit.
  - Please note that electrical energy may be stored in individual components.
    Further information on this issue is available in the data sheets and operating instructions included with the components.
- Use protective extra-low voltage only: max. 24 V dc.
- Establishing and disconnecting electrical connections
  - Electrical connections may only be established in the absence of voltage.
  - Electrical connections may only be disconnected in the absence of voltage.

- Use only connecting cables with safety plugs for electrical connections.
- When laying connecting cables, make sure they're not kinked or pinched.
- Do not lay cables over hot surfaces.
  - Hot surfaces are identified with a corresponding warning symbol.
- Make sure that connecting cables are not subjected to continuous tensile loads.
- Devices with an earth terminal must always be grounded.
  - If a ground connection (green-yellow laboratory socket) is available, it must always be connected to protective earth. Protective earth must always be connected first (before voltage), and must always be disconnected last (after voltage).
  - Some devices have high leakage current. These devices must be additionally grounded with a protective earth conductor.
- The device is not equipped with an integrated fuse unless specified otherwise in the technical data.
- Always pull on the plug when disconnecting connecting cables – never pull the cable.

Pneumatic safety

- **Depressurize the system.**
  - Switch off the compressed air supply before working on the circuit.
  - Check the system using pressure gauges to make sure that the entire circuit is fully depressurized.
  - Please note that energy may be stored in reservoirs.
    Further information on this issue is available in the data sheets and operating instructions included with the components.
- Do not exceed the maximum permissible pressure of 600 kPa (6 bar).
- Do not switch on compressed air until all tubing connections have been established and secured.
- Do not disconnect tubing while under pressure.
- Do not attempt to connect tubing or push-in connectors with your hands or fingers.
- Risk of injury when switching compressed air on.
  Cylinders may advance and retract automatically.
- Risk of accident due to advancing cylinders.
  - Always position pneumatic cylinders so that the piston rod's working space is unobstructed over the entire stroke range.
  - Make sure that the piston rod can't collide with any rigid components of the setup.
- Risk of accident due to tubing slipping off.
  - Use shortest possible tubing connections.
  - In the event that tubing slips off:
    Switch off the compressed air supply immediately.
- Pneumatic circuit setup:
  Connect the devices with plastic tubing with an outside diameter of 4 or 6 mm. Push the tubing into the push-in connector as far as it will go.

- Switch off the compressed air supply before dismantling the circuit.
- Dismantling the pneumatic circuit
  Press the blue release ring down so that the tubing can be pulled out.
- Noise due to escaping compressed air
  - Noise caused by escaping compressed air may damage your hearing. Reduce noise by using silencers, or wear hearing protection if noise can't be avoided.
  - All of the exhaust ports for the components included in the equipment set are equipped with silencers. Do not remove these silencers.

Information for trainers/instructors and apprentices/students

Workbook
Text passages which need to be completed are underscored with a dashed line or appear in table cells with a gray background.

Formulas which need to be completed or questions to be answered have a grey, checkerboard pattern in the background. Graphics which need to be completed are gray or have a checkerboard pattern in the background.

Solutions section
Solutions in text passages appear in red.
Solutions and supplements in graphics or diagrams have a red or gray background.
Additional information for the trainer is identified as “Information for the trainer/instructor”. This information is not included in the worksheets.

Structure of the training content
All technical training content is structured in individual chapters with the following layout:
- Learning objectives for the chapter
- Reference to work aids
- Information phase
- Work assignments and programming tasks

Structure of the exercises
All programming tasks have the same structure and are subdivided into:
- Description of the problem explored by the task
- Selection of a suitable module
- Definition of the module’s interface
- Development of a structured approach
- Programming the module
- Program test
- Program archiving

Prerequisites
Basic knowledge in the following areas is required in order to process the exercises in this workbook:
- Electropneumatics
- PLC programming
- Network technology
- Sensors

Required components

The components and software required for processing all of the work assignments are listed below:

Component	Description	Quantity
System 203 I4.0	The MPS® 203 I4.0 system is a small production line based on the slightly adapted standard versions of the Distributing/Conveyor, joining and Sorting stations. The entire system is networked and equipped with several RFID write/read heads. The system processes orders which are generated in the MES. In the first station, a workpiece is separated and then written to via an RFID sensor. The subsequent Joining station reads this RFID tag, decides what will happen with the workpiece based on the order and writes back a result. At the final Sorting station, the workpieces are distributed to the three chutes depending on the information which has been saved to the RFID tag.	1
C interface	The design of the C-Interface enables two modules to be easily connected to a PLC via SysLink.	3
SysLink data transmission line	Pre-assembled cable for connection between the C-Interface and the PLC	1
Digital simulation box	The simulation box is used to display the input and output signals of an MPS® station or PLC. Two types of use are possible: – Simulation of inputs for testing a PLC program Use the I/O data cable with order no. 034031 for this purpose. – Setting of outputs (with separate 24 V supply) in order to be able to operate an MPS® Station. The cable required for this purpose (2.5 m, order no. 167106) is included in the scope of delivery.	1
Workpiece set PA	The workpiece set consists of 6 black, 6 red, 6 transparent and 6 silver housings, as well as 24 black covers. The inserts with the RFID tags can be inserted into the housings. – Outside diameter: 40 mm – Inside diameter: 30 mm – Height: 25 mm	1

Component	Description	Quantity
RFID tag, 128 kb (10 pcs.) with insert	RFID tags with insert	1
MES software	In addition to the actual MiniMES software, the COMTool and the application for the web service are also included with the MES software. All of the programs have been preinstalled to the system's PC.	1
PLC programs	Each station is equipped with a controller to which the PLC program is preinstalled.	3
OPC server	The test version of the DeltaLogic OPC server has been preinstalled to the system's PC.	
TIA Portal	TIA Portal software is shipped loose with the individual stations.	

Note

The newest versions of the software, as well as detailed documentation concerning the modules and the stations, can be found on the **Festo Didactic Info Portal**.

Learning objectives

Exercise 1: Overview of the production system

After completing this exercise:

- You'll be able to commission a mechatronic system.
- You'll be familiar with the connection specifications for power supply.
- You'll be able to set up and test pneumatic and electrical power supply.
- You'll be able to describe a product manufacturing sequence.

Exercise 2: Familiarization with the overall system

After completing this exercise:

- You'll be familiar with the system's structural layout.
- You'll be able to describe the function of the components.
- You'll be able to test sensor signals on the basis of a variables list.
- You'll be able to operate a motor for the conveyor belt with pushbuttons and determine belt speed.

Exercise 3: Fundamentals of Ethernet and addressing

After completing this exercise:

- You'll be familiar with the layout of IP addresses and the meaning of the subnet mask.
- You'll be able to ascertain IP addresses.
- You'll be able to set IP addresses.
- You'll be able to check for the presence of individual components within the network.

Exercise 4: Familiarization with the software structure

After completing this exercise:

- You'll be familiar with the utilized software and its tasks.
- You'll understand interaction amongst the software.
- You'll be familiar with the difference between the software for process control and the communication software.

Exercise 5: Configuration of the OPC server

After completing this exercise:

- You'll be familiar with the task and the function of the OPC server.
- You'll be able to open and configure the OPC server.

Exercise 6: Fundamentals of RFID technology

After completing this exercise:

- You'll be familiar with the setup and the mode of operation of RFID technology.
- You'll be familiar with the characteristics of RFID.
- You'll be able to analyze an RFID string.

Exercise 7: Observing information in the TIA Portal

After completing this exercise:

- You'll be familiar with the principal of local control.
- You'll know why data are written to workpieces.
- You'll be able to observe workpiece information in the TIA Portal.

Exercise 8: Configuration of the MES and order entry

After completing this exercise:

- You'll be familiar with the layout of an MES.
- You'll be familiar with interaction amongst the involved software tools.
- You'll be able to enter an order to the MES.

Exercise 9: Control and status indication with mobile terminal devices

After completing this exercise:

- You'll be able to set up a WLAN and use it to connect the system.
- You'll be able to configure the parameters of an app for a tablet/iPad.
- You'll be able to use a tablet/iPad for control and data read-out.

Exercise 10: Push e-mail transmission

After completing this exercise:

- You'll be familiar with the data path of an e-mail.
- You'll be able to set up e-mail transmission.

Exercise 11: Web services

After completing this exercise:

- You'll be familiar with the basic layout of websites in HTML format.
- You'll be familiar with the communication principle used for web services.
- You'll be able to decipher information from the source code of a web service.

Exercise 12: Motor controller maintenance task

After completing this exercise:

- You'll be able to read the motor controller's wiring diagram.
- You'll be able to replace a function unit.
- You'll be able to set up the new motor controller.

Exercise 13: Inductive sensor maintenance task

After completing this exercise:

- You'll be familiar with the characteristics of an inductive sensor.
- You'll be able to determine the correct sensing distance.
- You'll be able to mount a sensor and adjust the distance.

Practical exercises

Exercise 1: Overview of the production system

Learning objectives

After completing this exercise:

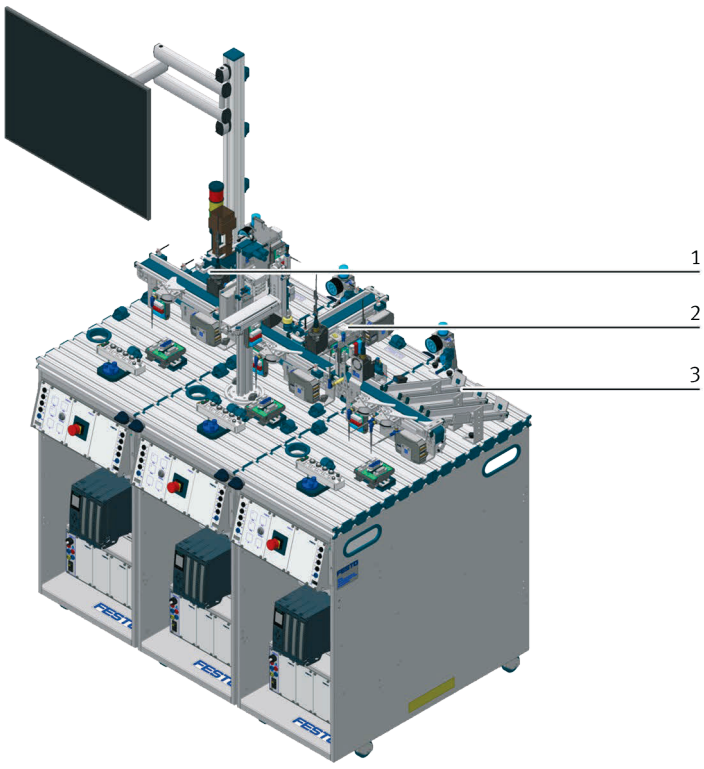
- You'll be able to commission a mechatronic system.
- You'll be familiar with the connection specifications for power supply.
- You'll be able to set up and test pneumatic and electrical power supply.
- You'll be able to describe a product manufacturing sequence.

Description of the problem

Machines are used for most operating sequences and production steps. Due to the fact that different tasks have to be completed, a separate piece of equipment is used for each of the various manufacturing steps. These are then combined into a complete system.

The layout and the task of the system need to be examined.

Layout



1 Distributing/Conveyor station with one RFID write/read head
2 Joining station with two RFID write/read heads
3 Sorting station with one RFID write/read head

MPS® System 203 Industry 4.0

Work assignments

1. Commission the system.
2. Observe and describe the operating sequences of all three stations.
3. Measure run-time at the individual stations.

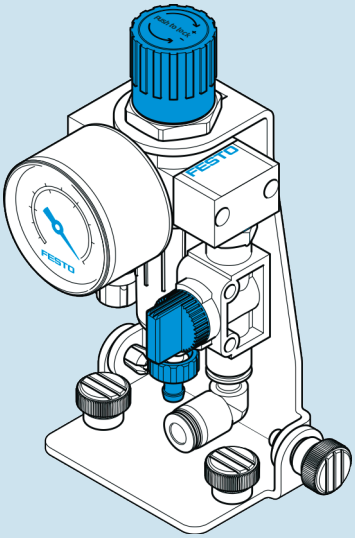
Work aids

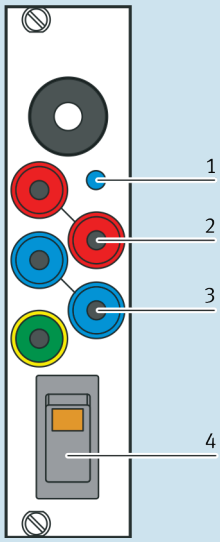
- Hardware
  - Stopwatch or smartphone with stopwatch function
  - Multimeter
  - Simulation box for performance test
- Media
  - Station handbooks for the individual system components and documents from the appendix
  - Documents in the Info Portal: circuit diagrams and pneumatic diagrams for the stations of the MPS® 203 I4.0 system

1. Commissioning the system

Information

Pneumatic components (cylinders, grippers) and electrical components (sensors, motors, and solenoids) are mounted to the system. The pneumatic components are supplied with compressed air. A pressure of 6 bar (0.6 MPa) has to be set at the service unit. The compressed air supply line must have an inside diameter of at least 4 mm and should only be as long as necessary.





1 LED for indicating the status of the power pack (on/off)
2 Red 4 mm socket for 24 V
3 Blue 4 mm socket for 24 V
4 On/Off switch

A power pack with 24 V dc and at least 4 A is required for electrical power supply. This is achieved with an appropriate power pack. No further fuse protection is required. The controllers, all components, and drives are supplied commonly with this current.

a) Set system pressure with the help of the pressure gauge.
How much pressure is indicated by the pressure gauge?

p = 6 bar

b) Switch on the power pack for all three controllers and document whether or not the LEDs light up blue.

☑ Yes
☐ No

c) How much voltage can you measure with the help of a multimeter? Make a note of the measured value.

Voltage U = 24 V

d) Fill out the following commissioning report.

Visual inspection

• Circuit documentation complete – Circuit diagrams and pneumatic diagrams for all modules	☑ OK	☐ Not OK
• Operating medium – Correct selection, no damage, equipment identification	☑ OK	☐ Not OK
• Cable connections – Insulation, stripping, attachment	☑ OK	☐ Not OK
• No detectible defects at the time of inspection	☑ OK	☐ Not OK

Pneumatic components

• Tubing checked according to circuit diagrams	☑ OK	☐ Not OK
• Pneumatic function test conducted for the individual functions	☑ OK	☐ Not OK

Electrical components

• Electrical wiring checked according to the circuit diagram	☑ OK	☐ Not OK
• I/O assignment checked against assignment table	☑ OK	☐ Not OK
• Electrical function test conducted	☑ OK	☐ Not OK

Commissioning completed

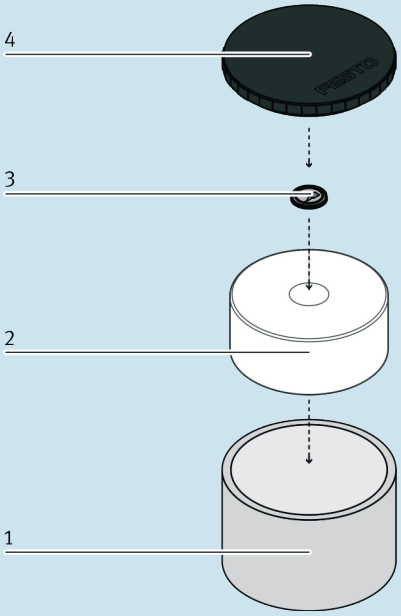
Name: _____ Date: _____

2. Observing and describing the operating sequence

Information

The following tasks are executed at the MPS® 203 I4.0 system:

1. An order is written from an MES to an RFID tag which is located in the workpiece. The tag accompanies the entire manufacturing process.
2. The tag is read at each station and new information is written to it depending on the process.
3. A cover (black) can be mounted to cans (black, red, silver).
4. Depending on the work order or correctness, the cans are sorted and transported to storage.
5. At the end of the process, the complete order history is on the tag in the form of an order string.



1 Workpiece can; 2 Tagp carrier: 3 RFID tag; 4 Workpiece cover

The system is set up and ready for operation. An authorized system operator explains the system briefly and demonstrates it. The system operator then issues the following order to the system: mount a cover to a black can and transport the workpiece to the 1st storage chute (national shipping).

– Describe the observed sequence in the form of a bullet list.

  – Station 1 places the can onto the conveyor belt.
  – The conveyor transports the can to station 2.
  – The can is stopped and the feed belt delivers the cover.
  – The cover is mounted to the can with the help of a cylinder.
  – Further transport is enabled and the can goes to the 3rd station.
  – The deflector at chute 1 is switched and the can is placed into chute 1.

3. Measuring run-times

a) The following times have to be measured during the sequence. Make a note of the measured time periods.

Station 1 process-start	Workpiece arrives at the end of the conveyor	Time 1 =	seconds
Station 2 Workpiece leaves the beginning of the conveyor	Workpiece arrives at the end of the conveyor	Time 2 =	seconds
Station 3 Workpiece leaves the beginning of the conveyor	Workpiece arrives at the chute	Time 3 =	seconds

Note
Production time required at the stations can be used later on, for example for condition monitoring.

b) Why are manufacturing processes frequently broken down into several independent individual stations (modules)?

Because the modules can be used in other systems. Identical modules can be manufactured more cost-effectively, and they reduce maintenance effort.

c) How does conveyor belt speed influence production time?

The higher the conveyor speed the shorter the production time.

Exercise 2: Familiarization with the overall system

Learning objectives

After completing this exercise:

- You'll be familiar with the system's structural layout.
- You'll be able to describe the function of the components.
- You'll be able to test sensor signals on the basis of a variables list.
- You'll be able to operate a motor for the conveyor belt with pushbuttons and determine belt speed.

Description of the problem

The system's individual components are connected and networked by means of cables. One way of becoming familiar with the system is to follow the electrical cables and check the various components for correct functioning.

The sensors must be checked for correct functioning when the system is set up and in the event that servicing becomes necessary. In this case, signals can be traced via status indicators (LED).

Work assignments

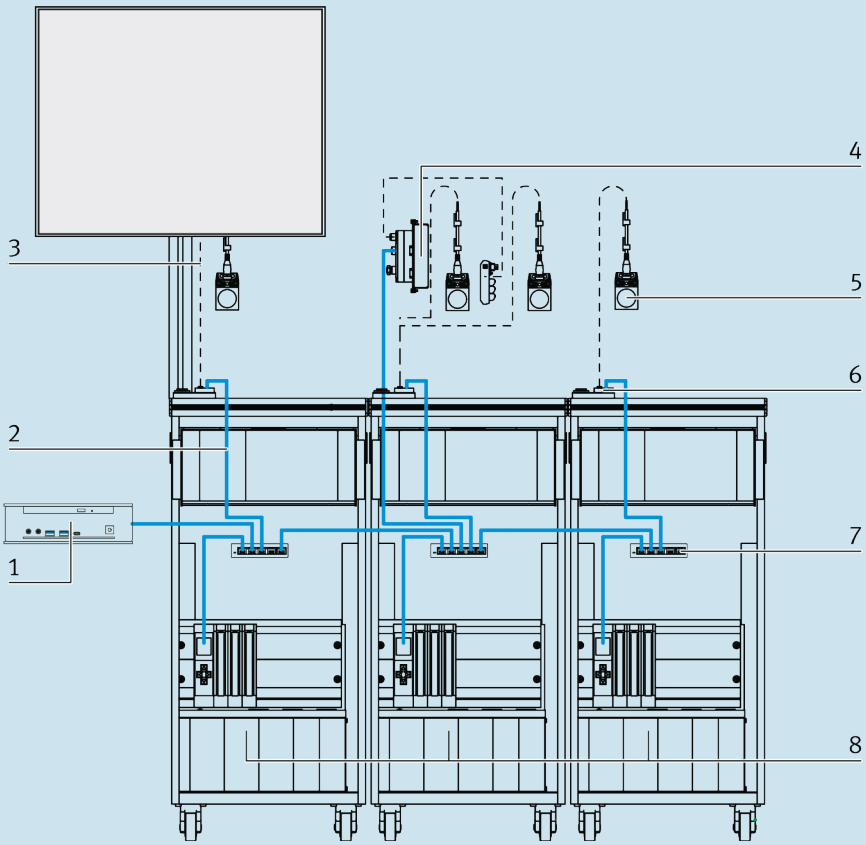
1. Follow the Ethernet cable to station 1.
2. Follow the Ethernet cable to station 2.
3. Test the sensor signals at station 3.
4. Test the enter keys at station 1 for correct functioning.
5. Operate the conveyor motor at station 1 with the pushbuttons and determine conveyor speed.

Work aids

- Hardware
  - Ruler
  - Marking pen
  - Stopwatch or smartphone
- Media
  - Data sheet for the motor controller with part no. 8064281
- Software
  - TIA Portal on the PC
  - PLC programs

Layout: network components

Information



The system is set up as follows (simplified representation):

- The three controllers (8) at the stations are connected to each other and to the control PC (1) via Ethernet (2) with the help of a switch (7). The MiniMES is running on the PC.
- Each station has one or more Turck RFID write/read heads (5) which are connected to the respective PLC by means of signal lines (3) via a gateway (6).
- The Joining station is also equipped with a fieldbus adapter with PROFINET module (4).

1. Following the Ethernet cable to the Distributing/Conveyor station

a) To which slot is the cable connected at the PLC? Make a note of the slot.

X1

b) To which slot is the cable connected at the switch? Make a note of the slot.

X1

2. Following the Ethernet cable to the Joining station

a) To which slot is the cable connected at the PLC? Make a note of the slot.

X1

b) To which slot is the cable connected at the switch? Make a note of the slot.

X1

c) To which slot is the cable connected at the PROFINET bus node? Make a note of the slot.

X3

d) Where does the cable connected to slot X2 end? Make a note of where the cable ends.

It goes to the switch at station 1, slot X5.

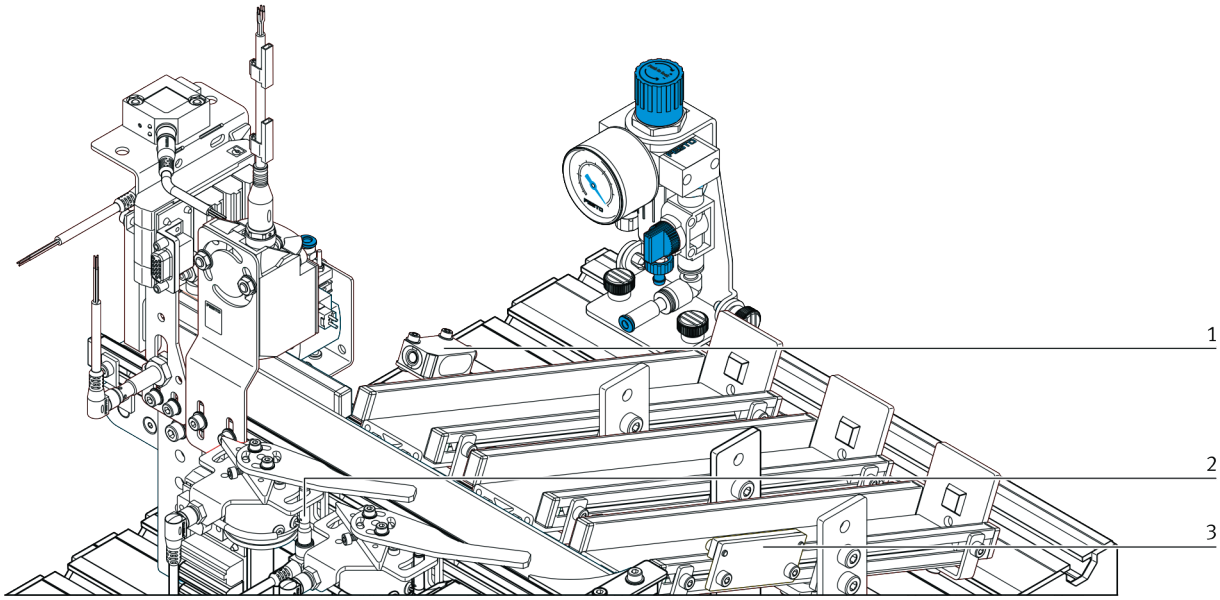
e) What can you say about networking of the system's devices?

All of the system's devices are networked with each other.

3. Testing the sensor signals at the Sorting station

Information

There are two solenoid-actuated deflectors at the Sorting station. There's a sensor at each deflector which detects the actuation status (position) in binary format. An opto-electrical sensor is mounted to the right of the chute. It generates a logic one signal when the chute is full. The variables are stored to the PLC program. The status of the variables can be read out in the observation table in the TIA Portal.



1 Opto-electrical sensor (emitter/receiver); 2 Inductive sensor; 3 Reflector for opto-electrical sensor

Sorting station excerpt

37		G1BG1	Bool	%E10.0	Werkstück bei Bandanfang / workpiece AT conveyor start
38		G1BG2	Bool	%E10.1	Weiche 1 ausgefahren / Seperator 1 Extracted
39		G1BG4	Bool	%E10.3	Weiche 2 ausgefahren / Seperator 2 Extracted
40		G1KF1_A1	Bool	%A4.0	Bandmotor vorwärts / Conveyor motor forward
41		G1MB1	Bool	%A4.1	Weiche 1 ausfahren / Extend Seperator 1
42		G1MB2	Bool	%A4.2	Weiche 2 ausfahren / Extend Seperator 2
43		iResultValue	Int	%MW302	Ergebnis von Erkennen(0 = Rot, 1 = Silber, 2 = Schwarz, 3 = Transparent)
44		G1BG3	Bool	%E10.2	Sensor Rutschen / Sensor Slides
45		G1MB3	Bool	%A4.3	Stopper einfahren / Retract Gate

Excerpt from the variables table for the Sorting station

a) Which is the associated input bit of the sensor at deflector 1? Make a note of the value.

Input bit: E10.1

b) What's the sensor's signal status in the initial position? Mark the correct answer.

- ☐ True
- ☑ False

c) What's the sensor's signal status in the case of manual reversing? Mark the correct answer.

- ☑ True
- ☐ False

d) Which is the associated input bit of the sensor which indicates whether or not the chute is full? Make a note of the value.

Input bit: E10.2

e) What's the sensor's signal status when the chute is empty? Mark the correct answer.

- ☐ True
- ☑ False

f) What's the sensor's signal status when the chute is full? Mark the correct answer.

- ☑ True
- ☐ False

g) Test the following inputs and outputs with the help of the simulation box and the variables table. Specify the designation of the switch.

Inputs/outputs	Switch
Deflector 1 advanced	I1
Deflector 2 advanced	I3
Conveyor motor on	Q0
Advance deflector 1	Q1
Advance deflector 2	Q2

4. Testing the “Start” and “Stop” enter buttons at station 1 for correct functioning

Information
The control panel is located at the front of station 1. The statuses of the inputs and outputs are indicated at the PLC with the help of LEDs. The status of the variables can be read out in the observation table in the TIA Portal.

a) What is the start button’s input address or input bit? Make a note of the value.

Input bit: E11.0

b) What is the start button’s status in the initial position? Mark the correct answer.

☐ True
☑ False

c) What is the stop button’s input address? Make a note of the value.

Input bit: E11.1

d) What is the stop button’s status in the initial position? Mark the correct answer.

☑ True
☐ False

e) What is the stop button's status in the depressed position? Mark the correct answer.

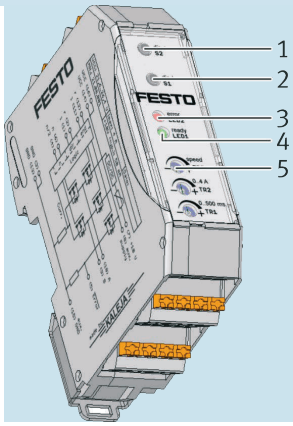
☐ True
☑ False

f) Why does it make good sense to lay out the stop button as a normally closed contact (NC)?

Due to the fact that an action or a sequence must be stopped through the use of stop buttons or emergency off switches in the event of a fault, they're laid out in a failsafe manner, i.e. in the event of a wire break the pushbutton or switch has the same logic status as it does when it's activated by the system operator.

5. Operating the conveyor motor at station 3 with pushbuttons and setting conveyor speed

Information
The conveyor motor is controlled by a Festo motor controller. In addition to external motor control, the controller also makes it possible to control the motor with pushbuttons (clockwise and counterclockwise operation). Speed can be controlled with a potentiometer (at the bottom of the controller).



1 Pushbutton S2, manual activation
2 Pushbutton S1, manual activation
3 Error LED
4 Ready LED
5 Potentiometer for setting speed

a) Which pushbutton causes the belt to move towards station 2? Mark the correct answer.

☑ The top pushbutton (S2)
☐ The bottom pushbutton (S1)

b) Set conveyor belt speed.

Note – suggested procedure
Mark the conveyor path (e.g. 30 cm). A workpiece is placed onto the conveyor belt and set into motion with the pushbutton. Time required for transport over the 30 cm path is measured.
The overall length of the conveyor belt is roughly 80 cm.

Time = 2.5 s

Speed = 0.12 m/s

Exercise 3: Fundamentals of Ethernet and addressing

Learning objectives

After completing this exercise:

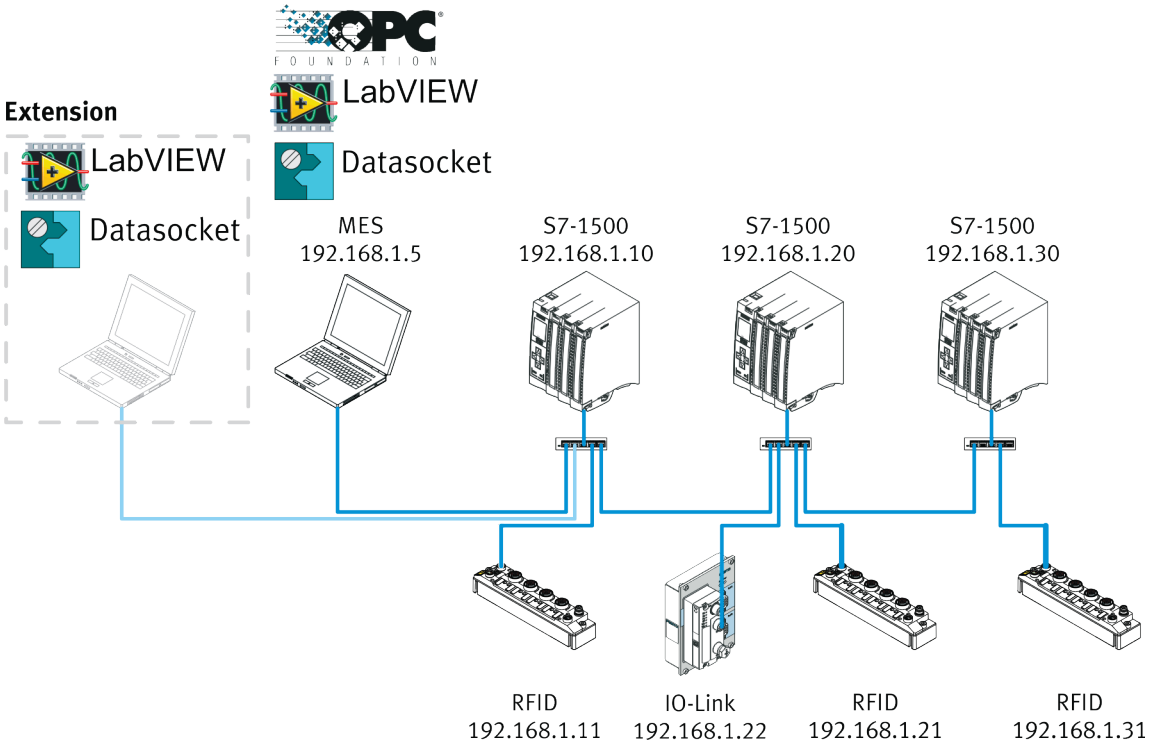
- You'll be familiar with the layout of IP addresses and the meaning of the subnet mask.
- You'll be able to ascertain IP addresses.
- You'll be able to set IP addresses.
- You'll be able to check for the presence of individual components within the network.

Description of the problem

In industry and in the field of automation technology, a system's individual devices must be located within a common network as a rule, in order to be able to communicate.

Your supervisor has asked you to check on this.

Layout



Work assignments

1. Familiarize yourself with the fundamentals of network technology.
2. Derive further network information on the basis of the IP address and the subnet mask.
3. Determine the IP address and the subnet mask of the PC in the MPS® 203 I4.0 system.
4. Change the IP address of the PC in the MPS® 203 I4.0 system.
5. Determine whether or not two devices can communicate via the network.

Work aids

- Hardware
  - Pocket calculator
- Media
  - Technical literature, e.g. “TCP/IP-Ethernet bis Web-I/O”, Wiesemann und Theis GmbH
  - Internet

1. The fundamentals of network technology have to be mastered.

a) What’s the significance of the term “10BaseT”?

Each participant is connected to a star connector (hub or switch) via its own twisted-pair cable, which forwards all data packets in the same way.

b) Why is a switch used and what’s the difference between a switch and a hub?

Unlike hubs, switches don’t forward all data traffic to all network participants. They simply make those data available at a port, which are of significance for the network participants connected to that port.

2. Deriving information about the network with the help of the IP address and the subnet mask

Information

Each device within the network has its own IP address. None of the addresses can be used more than once. The address consists of a 32-bit word. In order to make it easier to read, it's broken down into four groups of 8 bits each. Example of an address: 192.168.0.1
Up through 1993, these were assigned to various classes.

Class	Addresses	Subnet mask	Subnet mask (binary)	Host addresses
W	0.xxx.xxx.xxx- 127.xxx.xxx.xxx	255.0.0.0 ...	1111 1111.0000 0000.0000 0000.0000 0000	2^{24}-2 = approx. 16 million
B	128.0.xxx.xxx – 191.255.0.0	255.255.0.0...	1111 1111.1111 1111.0000 0000.0000 0000	2^{16}-2 = 65,534
C	192.0.0.xxx – 223.255.255.xxx	255.255.255.0...	1111 1111.1111 1111.1111 1111.0000 0000	2^{8}-2 = 254

The subnet mask is used in addition to the IP address and is also a 32-bit word. Together with the IP address, it determines the address and the number of participants (host addresses) within the network. Example: 255.255.255.0, participants from 192.168.0.1 to 192.168.0.254 are accordingly possible.

In the case if IP addresses, it must be remembered that there are two special addresses. 127.0.0.1 is the local host address and always specifies one's own PC. There's also a broadcast address which is used to address all PCs which are logged on within the network. This is the address which is obtained when all of the host portions of the IP address are set to 1. In the example shown above this would be 192.168.0.255.

The classes were abandoned after 1993 and CIDR notation was introduced. With the help of a postfix, this indicates how many bits of the IP address belong to the network portion and how many to the host portion. And thus, so to speak, it contains the subnet mask.

CIDR bits	Subnet mask	Subnet mask (binary)	Host addresses
/8	255.0.0.0	1111 1111.0000 0000.0000 0000.0000 0000	2^{24}-2 = approx. 16 million
/12	255.240.0.0	1111 1111.1111 0000.0000 0000.0000 0000	2^{20}-2 = 1,048,574
/24	255.255.255.0	1111 1111.1111 1111.1111 1111.0000 0000	2^{8}-2 = 254

The address from the example could thus also be written as follows: 192.168.0.1/24.

Before working on the IP address exercises, a simple task is worked through and explained as a helpful example. But conversion between number systems needs to be explained first.

Given: IP address (dec): 200.241.5.10/14

It makes good sense to convert the IP address to binary notation when processing the exercises. This is accomplished by breaking down the individual 8-bit blocks. 8 bits are capable of representing numbers within a range of 0 to 255. As an example, the fist bit block – namely 200 (dec) – will be converted. Always start with the highest place.

Bit	**2^7**	**2^6**	**2^5**	**2^4**	**2^3**	**2^2**	**2^1**	**2^0**
Value (dec)	128	64	32	16	8	4	2	1
Value to be converted	200	72	8	8	8	0	0	0
Value included, yes/no	Yes	Yes	No	No	Yes	No	No	No
Binary result	**1**	**1**	**0**	**0**	**1**	**0**	**0**	**0**
New value to be converted	200 – 128 = 72	72 – 64 = 8	8	8	8 – 8 = 0	0	0	0

As demonstrated by the example, the decimal number 200 is represented as follows in binary code: **1100 1000**

Accordingly, the complete IP address is:
1100 1000. 1111 0001.0000 0101.0000 1010.

This notation makes it possible to get information about the network and the host. The IP address is broken down into its network and host portions to this end with the help of the subnet mask. The CIDR code indicates that the first 14 bits belong to the network portion and the rest to the host portion. The following network and host numbers are thus obtained in decimal notation:

Network: 200.240.0.0 and Host: 0.1.5.10

The following network configurations are given:

1. IP: 20.2.3.4/16
2. IP: 192.168.1.5 SN:255.255.252.0
3. IP: 140.200.1.4/10

a) Enter the IP address in binary format and separate the network and host portions.

1. 0001 0100.0000 0010|0000 0011.0000 0100
2. 1100 0000.1010 1000.0000 000|1.0000 0101
3. 1000 1100.11|00 1000.0000 0001.0000 0100

b) Write down the networks.

1. 20.2.0.0
2. 192.168.0.0
3. 140.192.0.0

c) Write down the host numbers.

1. 0.0.3.4
2. 0.0.1.5
3. 0.8.1.4

d) How many host addresses would be possible?

1. 2^{16}-2 = 65,534
2. 2^{10}-2 = 1022
3. 2^{22}-2 = 4,194,302

3. Ascertaining the IP address and the subnet mask of the PC in MPS® 203 I4.0 system

Information
The IP settings of your own PC and the network cards can be read out by entering the “ipconfig” console command.

The console can be found by entering “cmd” to the Windows search.

a) What’s the PC’s IP address?

192.168.1.5

b) What’s the PC’s subnet mask?

255.255.255.0

c) How many bits belong to the network portion and how many to the host portion?

Network: 24
Host: 8

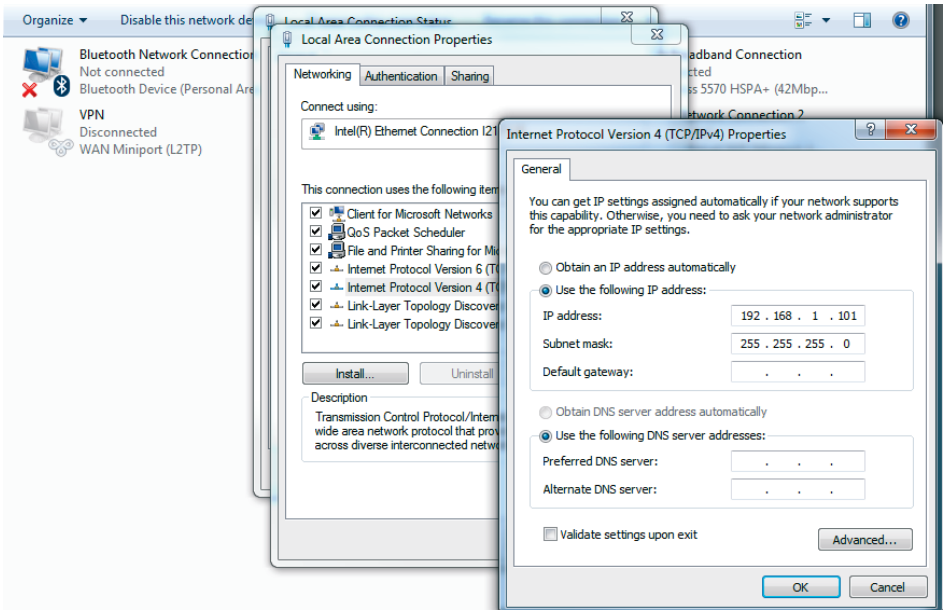
d) How many PCs would it be possible to have in the network?

$2^8 - 2 = 254$

4. Changing the IP address of the PC in the MPS® 203 I4.0 system

Information

The window for setting the IP address can be accessed via:
“Network and Sharing Center” -› “Change Network Adapter Settings” -› right click “Local Area Connection” -› “Internet Protocol Version 4 (TCP/IPv4)” -› “Properties”



a) Change the PC’s address to 192.168.1.6. The subnet mask must be retained.

b) Determine whether or not setting has been successful with the “ipconfig” command.

Training notes

Before instruction begins, the IP address has to be changed back to 192.168.1.5.

5. Testing communication between two devices via the network

Information

There are two ways to determine whether or not two devices within the same network can communicate with each other.

Practical method: The ping xxx.xxx.xxx.xxx console command can be used to determine whether or not devices are in the same network and if they respond.

Theoretical method: With the help of the devices' subnet masks and IP addresses, it can be theoretically determined whether or not communication is possible.

Example

Subnet mask:	255.255.255.0	1111 1111.1111 1111.1111 1111|0000 0000
IP address, device 1:	192.168.1.5	1100 0000.1010 1000.0000 0000|0000 0101
IP address, device 2:	192.168.1.10	1100 0000.1010 1000.0000 0000|0000 1010

Communication is possible due to the fact that both devices have the same bit pattern in the network portion.

a) Use the "ping" command to determine whether or not all of the system's controllers and other devices are within the network in accordance with the layout.

192.168.1.10	☑ Within the network	☐ Not within the network
192.168.1.11	☑ Within the network	☐ Not within the network
192.168.1.20	☑ Within the network	☐ Not within the network
192.168.1.21	☑ Within the network	☐ Not within the network
192.168.1.22	☑ Within the network	☐ Not within the network
192.168.1.30	☑ Within the network	☐ Not within the network
192.168.1.31	☑ Within the network	☐ Not within the network

b) Determine whether or not two devices with the specified addresses can communicate with each other. Write down the subnet mask and the addresses, one above the other, to this end.

Subnet mask:	255.240.0.0	1111 1111.1111|0000.0000 0000.0000 0000
IP-adress, device 1:	10.128.15.1	0000 1010.1000|0000.0000 1111.0000 0001
IP-adresse, device 2:	10.140.70.5	0000 1010.1000|1100.0100 0110.0000 0101

Communication is possible!

Exercise 4: Familiarization with the software structure

Learning objectives

After completing this exercise:

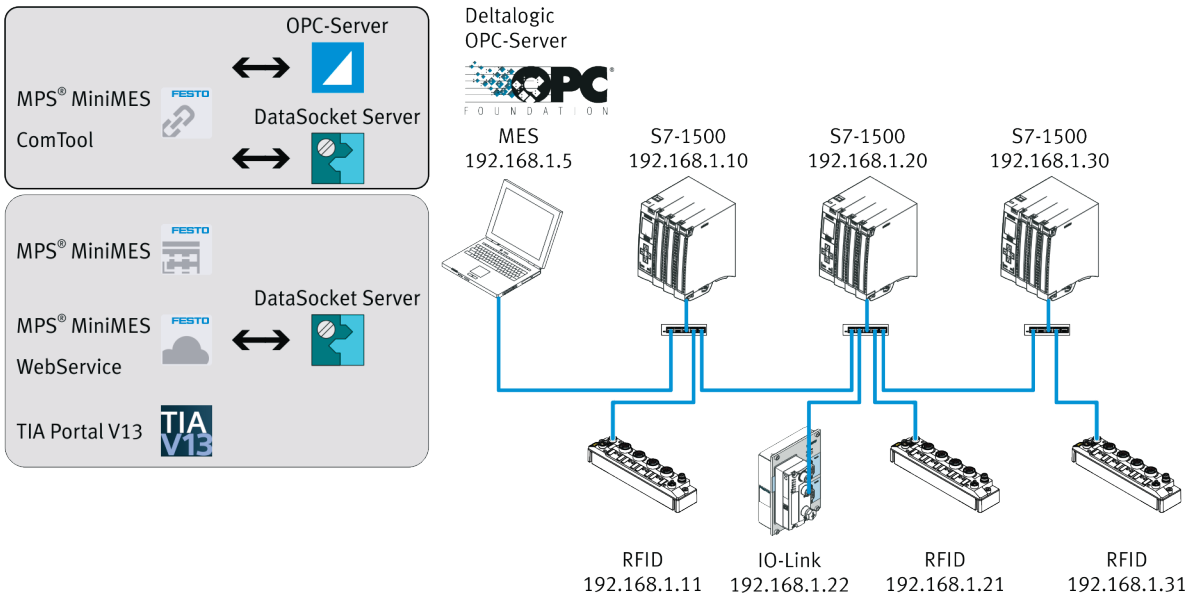
- You'll be familiar with the utilized software and its tasks.
- You'll understand interaction amongst the software.
- You'll be familiar with the difference between the software for process control and the communication software.

Description of the problem

The process is executed by the software in the respective controller. The provision of parameters and observation of the process take place via the communication interface of another software program.

Your task is to ascertain the functions of the individual software tools.

Layout – overview



Information

The respective software created with the TIA Portal runs on the controllers. COMTool software runs on the PC. COMTool reads the PLC data via the OPC server and forwards them to the DataSocket server. The server is installed within the application layer of the OSI layer model. Data coming from the MiniMES software are written to the DataSocket server and read by COMTool.

COMTool then transmits the data to the respective PLC via die the OPC server. This structure makes it possible for the MiniMES software to remain unchanged at all times, even if a PLC from a manufacturer other than Siemens is used because only COMTool has to be adjusted. Furthermore, for example, the MiniMES software can run on another PC within the network and the PC at the station only takes on the task of communicating with the PLC.

Work assignments

1. Start and stop the OPC server.
2. Open the DataSocket server.
3. Start COMTool and connect it to the controllers.
4. Answer the questions on software structure.

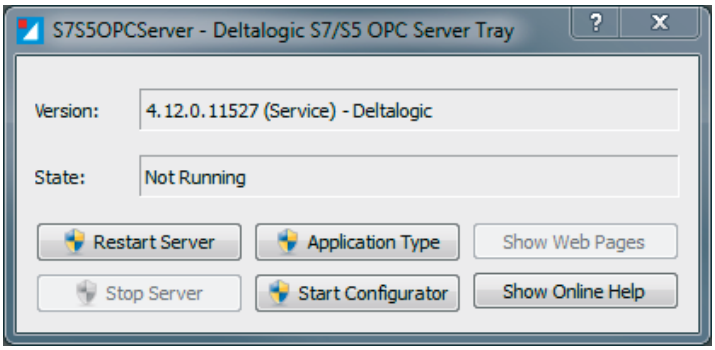
1. Opening, starting/stopping the OPC server

Information

The OPC server is installed to the PC. Deltalogic's OPC server is used. A demo version is provided with the system. This is fully functional software, but it has to be restarted every two hours.

The software is in the "Programs (x86)" directory. When COMTool is started later, the OPC server is automatically started as well because "Application" was selected as the run mode.

a) Start the OPC server program. Click the arrow at the bottom right in the taskbar next to the date to this end.



b) Click the "Restart server" button. What do you notice?

The following message is displayed: "OPC server started".

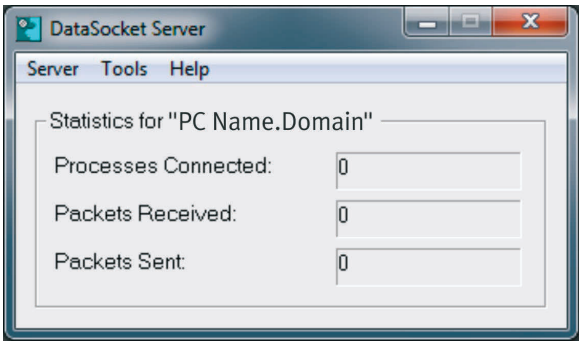
c) Stop the OPC server.

2. Opening the DataSocket server

Information
The DataSocket server is installed to the PC. It is located in the “National Instruments” directory. When COMTool is started, the DataSocket server is started automatically as well. When data are exchanged amongst the individual programs, this is indicated at the display.

The DataSocket server can also be opened while the software is running in order to see how many processes are connected (up to three via MES, COMTool and web service).

– Start the DataSocket server program.

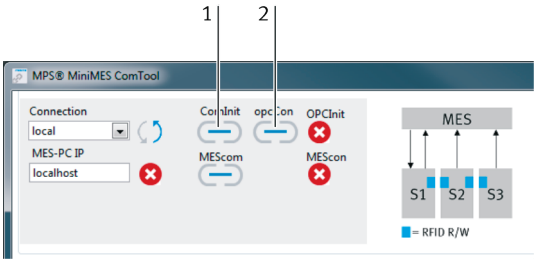


3. Opening COMTool and establishing connection with the controllers

Information
COMTool takes over the task of communication between the PLC (OPC server) and MiniMES software at the PC. The OPC server (which must be started) and the DataSocket server are required to this end.

Note
Before the OPC server is started, the number of controllers and their IP addresses have to be set.

– Acknowledge by clicking the “ComInit” button (1) and then the “opcCon” button (2). What do you observe?



OPCInit indicates correct execution by means of a checkmark. The following message appears at the bottom right-hand side of the of the monitor screen: “OPC server started”.

4. Questions concerning software structure

1. How do you recognize the fact that data is being transferred via the DataSocket server?

   The number of data packets (received files) increases continuously.

2. How does the OPC server’s icon indicate that the server has been started?

   There’s a green field at the OPC server icon in the upper left-hand corner. When the server has been stopped, this field is red.

3. In your opinion, which parts of the program are for communication and which are for process control?

Communication	Process control
COMTool	MES software
DataSocket server	PLC programs
OPC server	

Exercise 5: Configuration of the OPC server

Learning objectives

After completing this exercise:

- You'll be familiar with the task and the function of the OPC server.
- You'll be able to open and configure the OPC server.

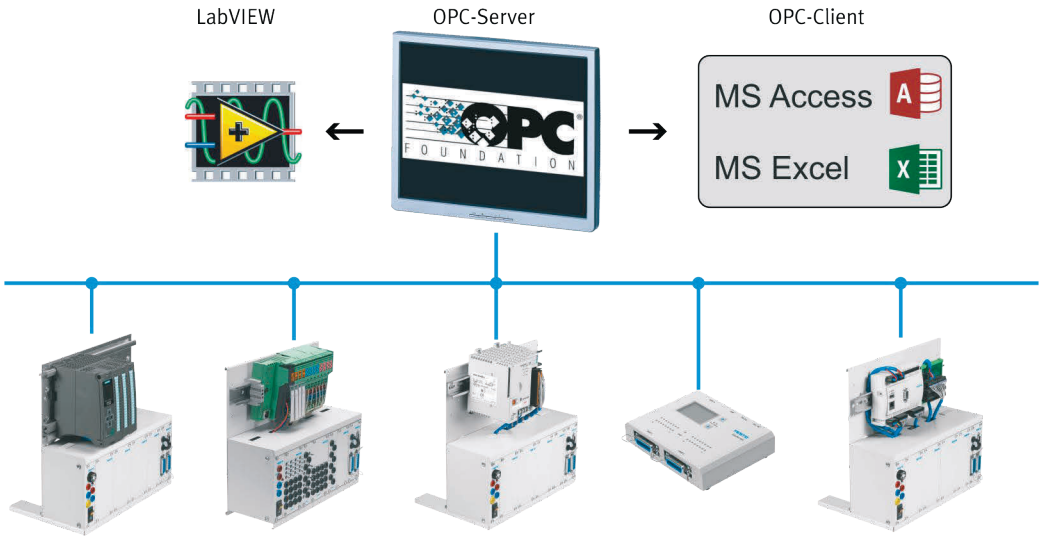
Description of the problem

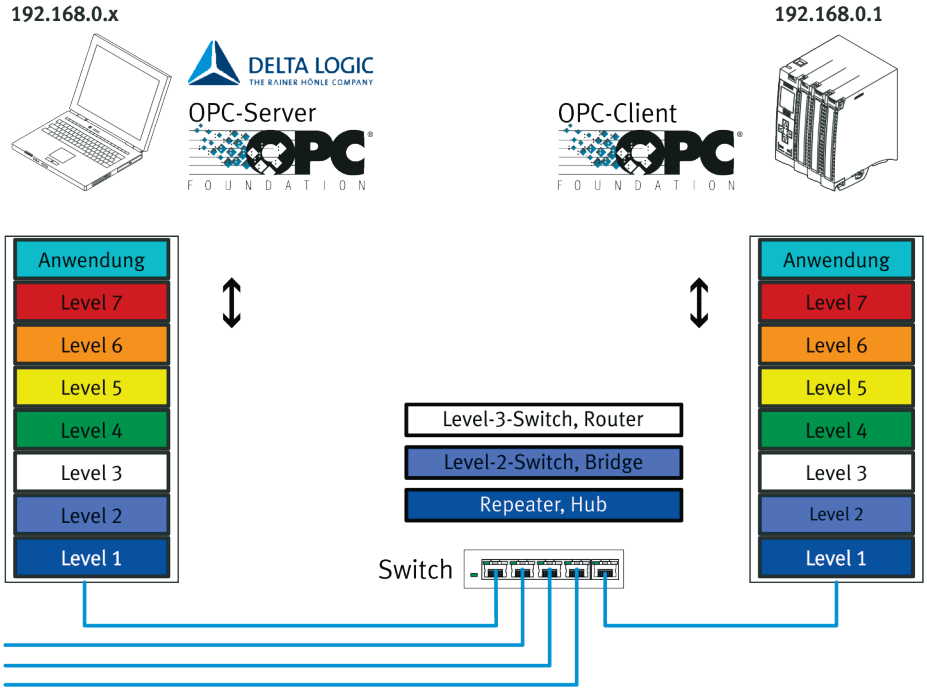
In the field of automation technology, data have to be exchanged amongst the individual automation devices and the utilized PCs. The manufacturers of these devices have created a common standard to this end. The OPC server has to be configured in order to assure that it works with a Siemens S7-1500 controller and the PC.

Information

OLE for Process Control (OPC) is the name for standardized software interfaces which permit an exchange of data amongst applications from a great variety of manufacturers in the field of automation technology. COM/DCOM technology (component object model / distributed component object model) is used for OPC-DA. Member companies of the OPC Foundation™ have specified how data from an OPC server can be read or written by an OPC client. This makes it possible to record manufacturing data (e.g. quantities, measured values, operating hours etc.) and incorporate them, for example, into Microsoft Office applications or other OPC client applications.

Layout





Note

If the free demo version of the Delta Logic OPC server is used, it must be restarted every two hours. Otherwise there aren't any restrictions where function is concerned.

The OPC server runs on the PC. It's connected in the top OSI layer (application layer).

Use of an OPC server must be explicitly enabled for Siemens controllers.

Work assignments

1. Set up the OPC server for a Siemens S7-1500 controller.
2. Enable use of the OPC server in the S7-1500 controller.
3. Enable the data modules for use of the OPC server.
4. Answer the questions concerning the OPC server.

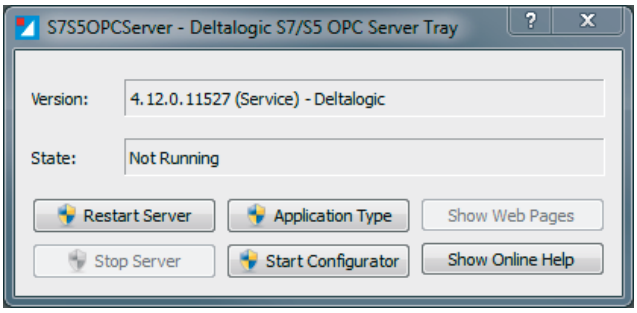
1. Setting up the OPC server for a Siemens S7 1500 controller

Training notes

Before instruction begins, delete all OPC server settings. The ready-made configuration files for the OPC server can be found in the following directory as a standard feature:
Program Files (x86)\Didactic\MPS MiniMES\OPC Config

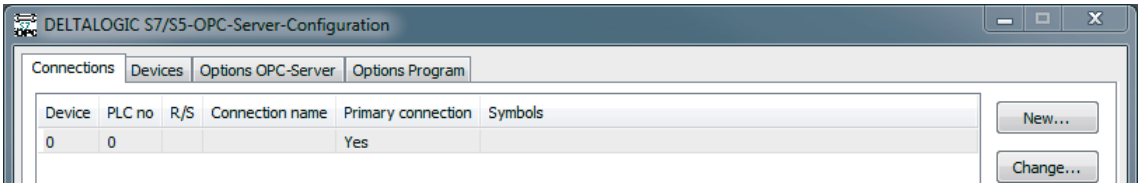
These have to be copied to the settings data directory (last tab of the OPC configuration). This is only necessary if something doesn't work during manual setup by the apprentices

a) Step 1: Open the OPC server. Click the arrow at the bottom right in the taskbar next to the date.

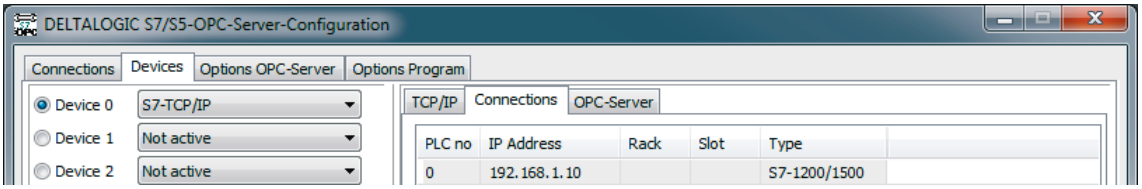


b) Step 2: Activate the "Start configurator" button and select "New ..."

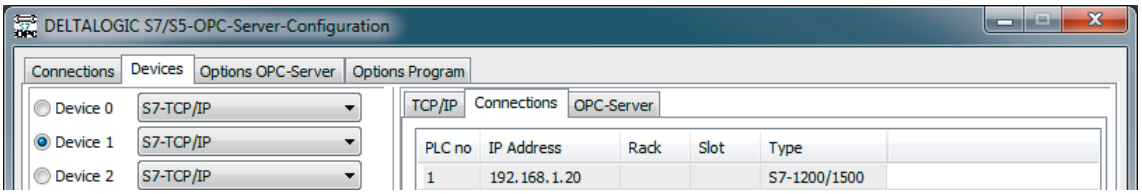
c) Create a device with the number 0 and the AG number 0. Set up a primary connection for the PLC at the first station. Primary connection must not be selected for the other stations.



d) Step 4: Enter the connection address and the PLC type.
Select the devices tab in the top bar and then the connection tab.



e) Repeat steps b) through d) and set up connection to the controllers at stations 2 and 3.



Double checking

1. Is the OPC server set up in accordance with the specification?

2. Has the OPC server been started (status = started)?

Note
PLC number assignment can be started with 0, as with the system. Assignment is started with number 2 as a standard feature.

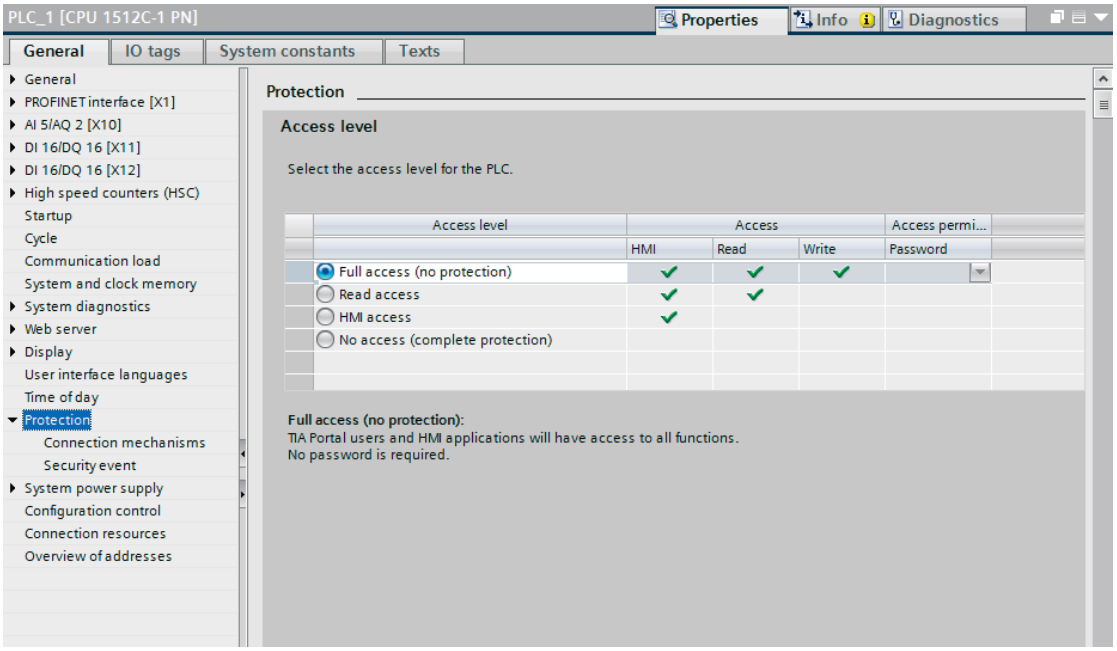
The IP addresses of the controllers can be found in exercise 3.

2. Enabling use of the OPC server in the S7-1500 controller

Information
Use of the OPC server with S7-1500 controllers is disabled for safety reasons. Enabling takes place in the TIA Portal.

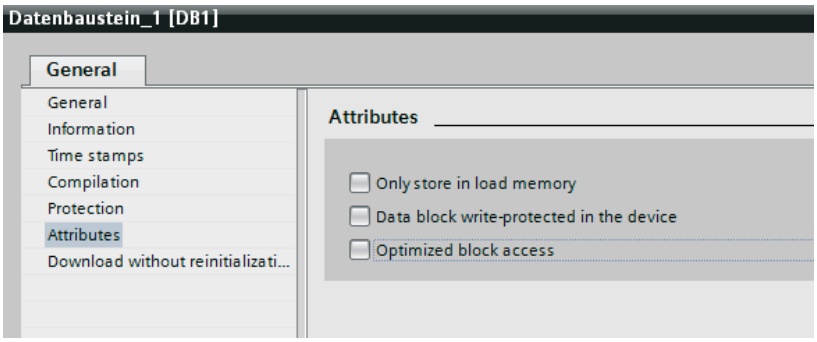
a) Open the menu as follows: “Properties” --› tab: “General” --› “Protection”.

b) Enable access via PUT/GET under “Connection mechanisms”.



3. Enabling the data modules for use of the OPC server

– Select the data module in the PLC program. Then select “Attributes”. Delete the checkmark next to “Optimized module access”.



Note
After making changes, the software and the hardware configuration have to be transferred again to the PLC.

4. Questions concerning the OPC server

1. What’s the task of the OPC server?

   It makes it possible for programs to communicate with automation devices.

2. Why does the OPC server have to be enabled at the PLC?

   This is required for safety reasons, so that unauthorized modules don’t communicate with the PLC.

Additional information on the OPC server
Thus far the DA OPC server has been used. It is based on the Windows DCOM interface. The server is comprised of software which runs on the connected PC. OPC-DA is suitable for use in our case, because we’re using the Windows operating system.

This standard is currently being supplemented with OPC-UA. OPC-UA is on the respective controller or on the device. Due to the fact that it’s connected to the respective device, it is independent of the operating system. Furthermore, OPC-UA offers the option of setting up safety mechanisms, in order to prevent unauthorized access.

Exercise 6: Fundamentals of RFID technology

Learning objectives

After completing this exercise:

- You'll be familiar with the setup and the mode of operation of RFID technology.
- You'll be familiar with the characteristics of RFID.
- You'll be able to analyze an RFID string.

Description of the problem

Workpieces are furnished with information in production and sales.

The RFID system makes it possible to write data to a transponder (RFID tag), and to read it from the tag again later. In the system utilized here, work order data are written to the transponder and are worked through during the process. The data of the workpieces used in the system are analyzed as an example.

Information

RFID is used in production wherever data have to be written, stored, and read. RFID is the abbreviation for radio frequency identification. As opposed to many other identification processes, RFID is entirely contact-free, i.e. there's no visual or physical contact at all.

In Europe, RFID works in the ultra-high, high, low, and super-high frequency ranges. The Turck RFID system works in the high-frequency range. The system consists of a transponder, a write/read device, and an IT system (gateway). The transponder is located, for example, on a workpiece, a pallet or the like, and consists of an antenna and a transponder as a data storage medium. It's counterpart is the read/write device.

A classic application for RFID technology is access control for buildings. Access authorization is stored to a card (transponder) and is checked by a reader.

In our system, the production data are written to the transponder as a string. This string is saved to memory as an array of bytes. The data are stored in ASCII code or as a decimal number. The RFID string is up to 110 bytes long.

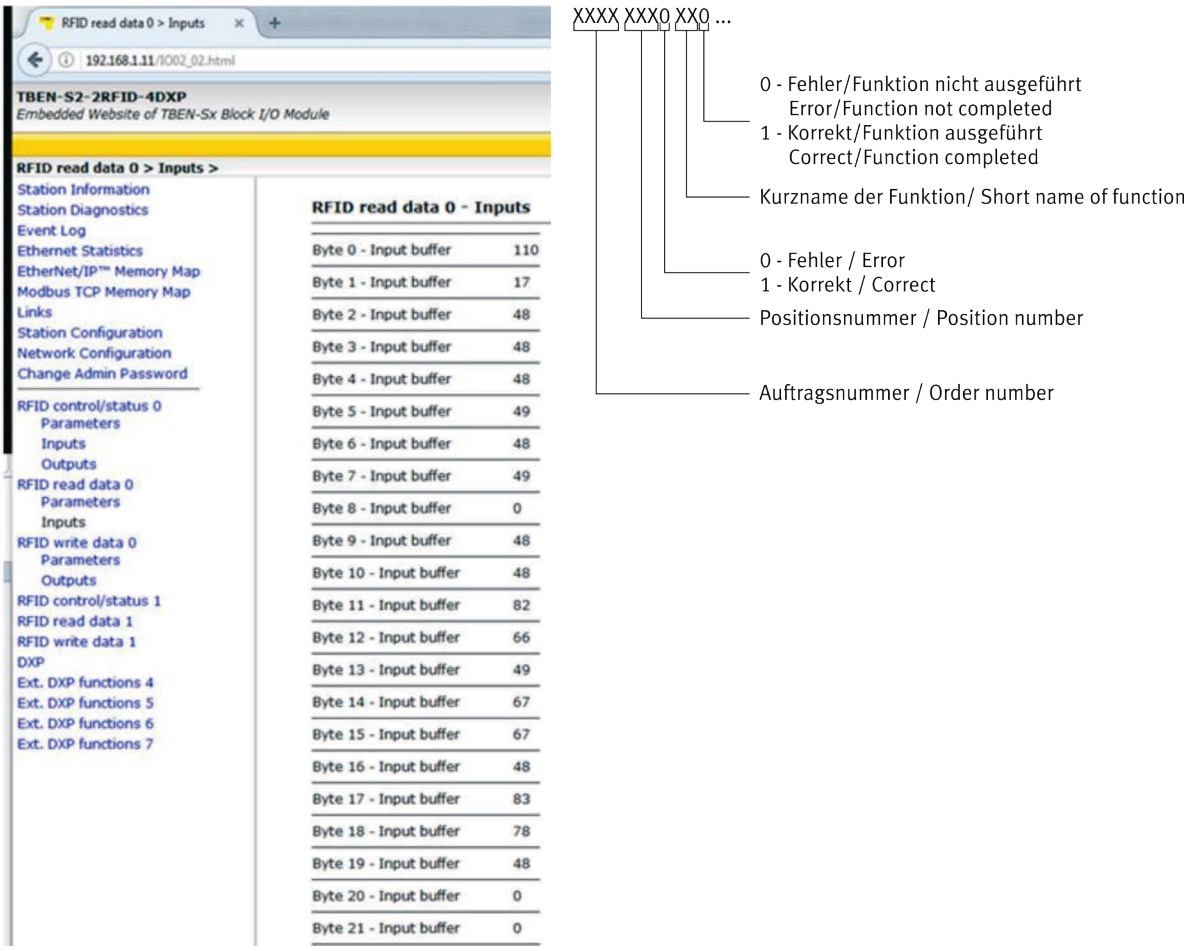
Work assignments

1. Translate a data string from the table above into ASCII characters (char).
2. Analyze a pending work order.
3. Read out a data string from a transponder with the help of an app on the smartphone.
4. Answer the questions concerning RFID systems.

Work aids

- Hardware
  - Smartphone with Near Field Communication (NFC) and an app for reading RFID data
- Media
  - ASCII table from appendix
  - Data sheets for the Turck RFID system (if applicable from the Info Portal, the Internet or, the documentation)

1. Translating a data string into ASCII characters (char)



RFID string read out with Turck's web service / layout of the data string in the MPS 203 I 4.0 system.

Information

The RFID string is laid out as shown above. In our example, only one function is included in the string, i.e. a work step. However, in most cases a product consists of several steps, and three new characters are added to the string for each step.

The individual ID codes of the functions are explained in the following table.

A **0** in the string after the function may indicate an error. However, it can also mean that the function hasn't yet been executed. A **1** means that the function has been correctly executed. String sections **RB0** and **CC1** can be described as examples as follows with the table below.

RB0: A black workpiece needs to be ejected. Not yet completed.
CC1: A quality test needs to be conducted. The quality test has been successfully completed.

Text on the transponder	Explanation	Process step	Station for the function
RS	Release silver workpiece	Color of the required workpiece	1
RR	Release red workpiece		1
RB	Release black workpiece		1
MC	Mount cap	Joining operation	2
CC	Check color	Quality inspection	3
SN	Sort national (chute 1)	Shipping mode	3
SI	Sort international (chute 2)		3

a) Translate the data string from the Turck web service view (figure above) with the help of an ASCII table.

Note
You can start translating as of byte 2.

Byte 0 only specifies the total number of bytes and byte 1 the number of bytes, which are not 0 (dec) or null (ASCII).

Byte	2	3	4	5	6	7	8	9	10
Dec	48	48	48	49	48	49	48	48	82
Hex	30	30	30	31	30	31	30	30	52
ASCII	0	0	0	1	0	1	0	0	R

Byte	11	12	13	14	15	16	17	18
Dec	66	49	67	67	48	83	78	48
Hex	42	31	43	43	30	53	4E	30
ASCII	B	1	C	C	0	S	N	0

b) What's the meaning of the following parts of the string in which status do they have?

- RB1 — A black workpiece needs to be ejected. This process has already been completed.
- CC0 — A quality test needs to be conducted. Not yet completed.
- SN0 — The workpiece should be directed to chute 1. Not yet completed.

2. Analyze a pending work order

The following string is on the transponder:

00040100RS0CC0SN0

– Which data does the string contain?

0004 --› Work order number: 4
010 --› Position number 10
0 --› Work order not yet completed.
RS0 --› A silver workpiece needs to be issued. Not yet completed.
CC0 --› The color needs to be checked. Not yet completed.
SN0 --› The workpiece should be directed to chute 1.

3. Reading a data string out of a transponder using a smartphone with the help of an app

Information
The data on the transponder (RFID tag) can be read with the help of an app such as NXP TagInfo on the smartphone.

a) Install the app to and NFC-compatible smartphone.

b) Start the app and read a transponder to which a string has been previously written.

Example

4. Review questions concerning RFID systems

a) What's special about an RFID system as opposed to other communication systems?

The special feature of this technology is contactless communication between the transponder and the write/read device. There's no visual or physical contact between the transmitter and the receiver.

b) Which components does an RFID system consist of?

- Transponder
- Read/write device
- IT system

c) Which working frequencies do RFID systems use in Europe?

1. Low frequency (LF)
2. High frequency (HF)
3. Ultra-high Frequency (UHF)
4. Super-high frequency (SHF)

d) What's the working frequency of the Turck RFID system?

13.56 MHz

Exercise 7: Observing information in the TIA Portal

Learning objectives

After completing this exercise:

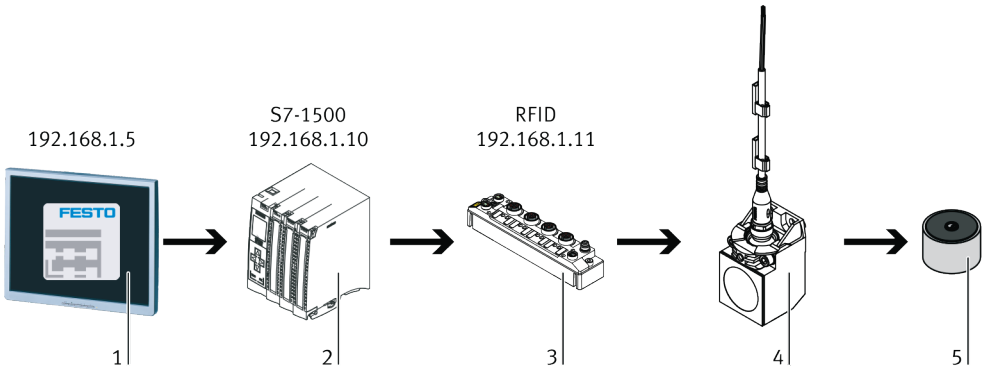
- You'll be familiar with the principal of local control.
- You'll know why data are written to workpieces.
- You'll be able to observe workpiece information in the TIA Portal.

Description of the problem

When workpieces run through several processing stations, control is made possible with the help of the RFID tag. In this way, several different variants can be produced in a "workpiece-controlled" fashion.

Your task is to read out the current status of the manufacturing process from the PLC.

Layout



1 PC; 2 PLC; 3 Gateway; 4 RFID read/write device; 5 Workpiece with RFID-Tag

Work assignments

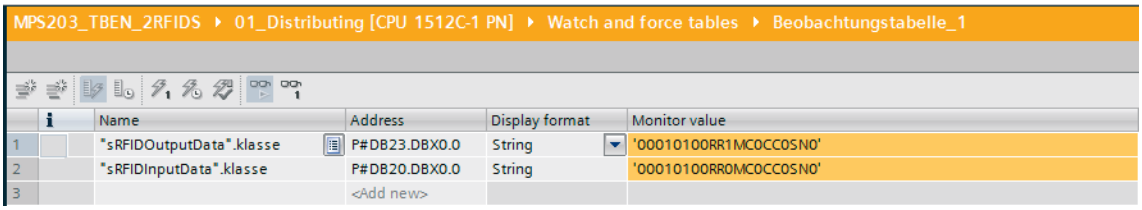
1. Start the TIA Portal and open the data string.
2. Analyze the data string at the beginning of the process.
3. Analyze the data string at the end of the process.
4. Answer the questions concerning the RFID system.

1. Starting the TI -Portal and opening the data string

Information

The data on the workpiece (RFID tag) control the production process. The data are stored in a data module as a string (array of bytes) on the PLC.

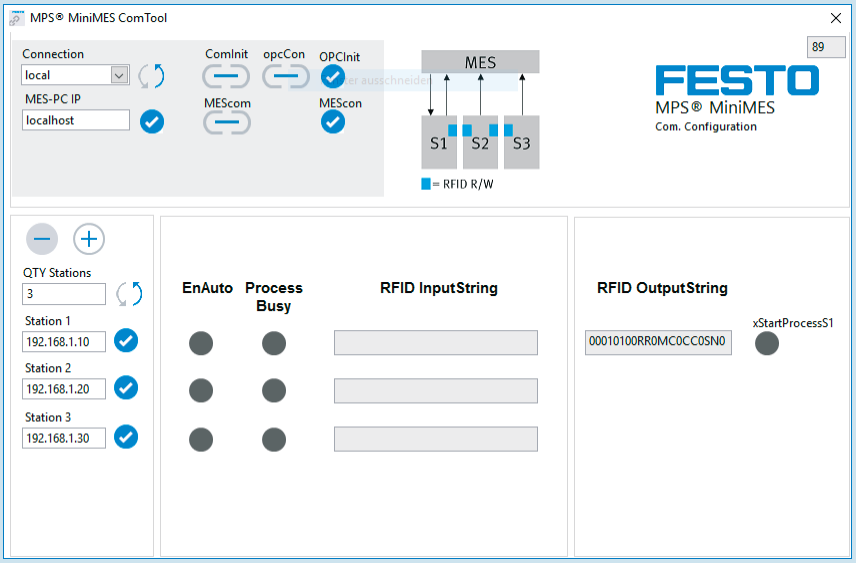
– Create an observation table for station 1 and enter both variables as shown below.



2. Analyzing the data string at the beginning of the process

Information

The output string from station 1 already has a 1 at the place where checking is conducted to determine whether or not a workpiece has been issued. The original output string from the MES can be best viewed when an order has been set up and before “Start” is pressed at the first station. This string can also be observed in COMTool.



a) Which data string is written to station 1?

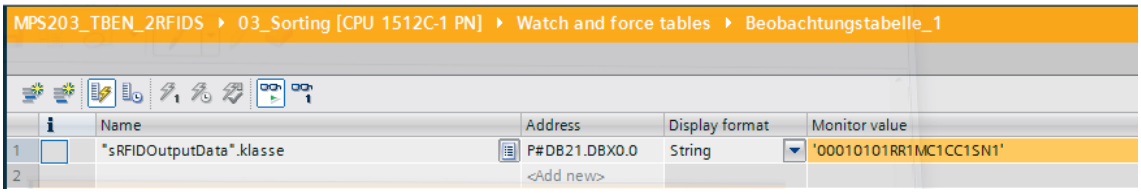
00080100RR1MC0SI0 (example, depending on order)

b) Which information does the string provide you with?

Order number	8
Position number	10
Workpiece color	Red
Mount cover	Yes
Discharge to which chute	International shipping, chute 2

3. Analyzing the data string at the end of the process

a) Create an observation table to this end for station 3 and enter the variables as shown below.



In order to display the string for a longer period of time, the workpiece at station 3 must be removed before it passes the sensor at the chute. When removing the workpiece during the process, be careful not to injure yourself on any moving parts. After removing the workpiece, the conveyor belt will continue until a part passes the sensor at the chute.

b) Which data string was written to the RFID tag at the third station?

00080101RR1MC1SI1 (example, depending on order)

c) Which change has taken place in comparison with task 2?

The work order has been executed. A cover has been mounted to the red workpiece and the workpiece has been placed into chute 2.

4. Review questions concerning RFID systems

1. Why is an RFID system used to control manufacturing?

The RFID system makes it possible to link the work order directly to the workpiece. Thus several products can be produced with a single system without having to access each controller externally.

2. Which type of data is used here on the RFID tag?

In the RFID tag itself, the data are represented as an array of bytes. Encoding is based on the ASCII code, which composition is represented as a string.

3. Why does each workstation have to have at least one RFID write/read head?

The order has to be read at each station in order to decide whether or not and which type of processing is required. The conclusion of the manufacturing step has to be written to the RFID tag as well.

Exercise 8: Configuration of the MES and order entry

Learning objectives

After completing this exercise:

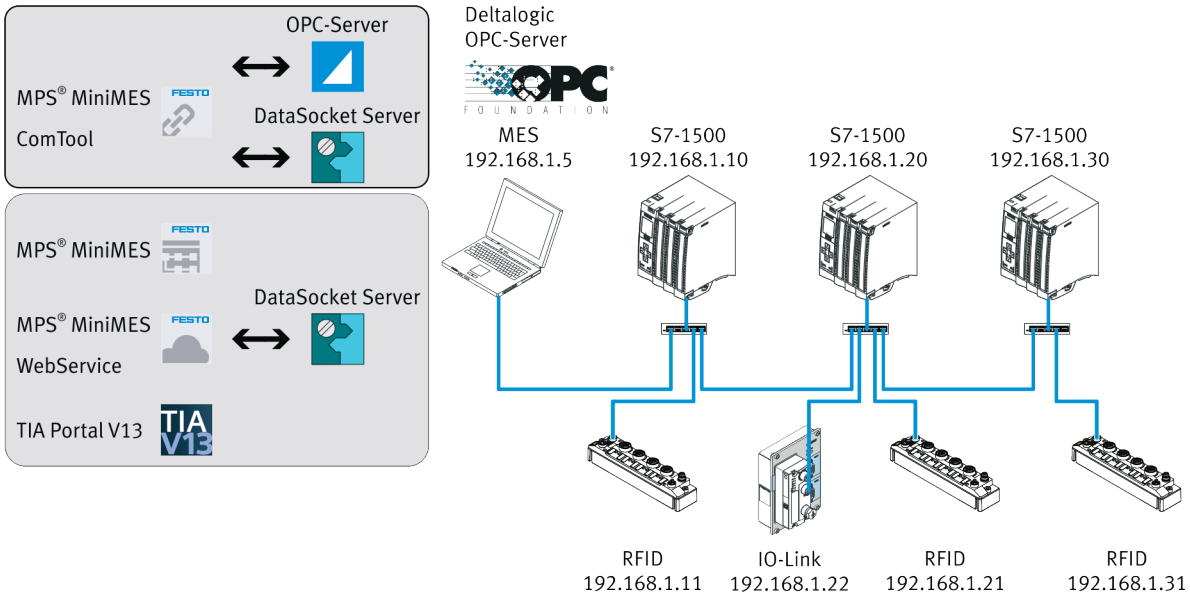
- You'll be familiar with the layout of an MES.
- You'll be familiar with interaction amongst the involved software tools.
- You'll be able to enter an order to the MES.

Description of the problem

In order to make dynamic production of workpieces and their variants possible, an MES is used at a higher level above the controllers. The MES controls the manufacturing process.

A system with an MES needs to be commissioned and a part has to be produced.

System layout



Work assignments

1. Gather information about the term MES.
2. Commission COMTool.
3. Start MiniMES software and configure the system.
4. Configure a product.
5. Enter a work order.
6. Answer the questions concerning the MES.

Work aids

- Media
  - Operating instructions for MiniMES software (installed to the PC)
  - Internet
- Software
  - MiniMES software

1. Meaning of the term MES

– What does the acronym MES stand for and what is the task of an MES?

MES stands for manufacturing execution system. It's used for production planning. It is connected directly to the automation system.

Amongst other things, an MES provides the user with:
- A production plan for each product
- A manufacturing sequence
- Acquisition of production and product data

Thus the MES is used to implement an existing plan and provide feedback from the process.

2. Starting and commissioning COMTool

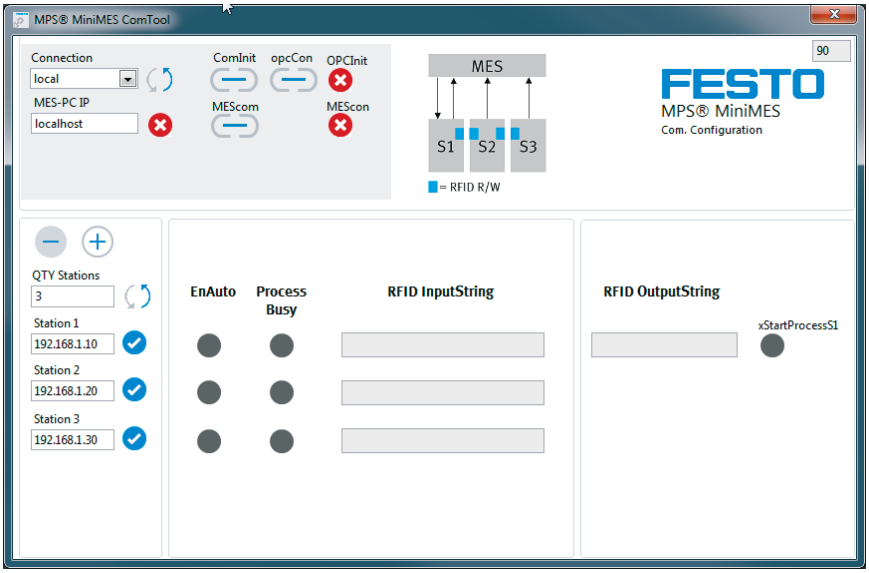
Information

The system has to be in its initial position. There must be adequate space on the chutes (station 3). Compressed air must be available. The software must be loaded to the controllers and the controllers must be in the “RUN” mode.

COMTool establishes connection from the controllers to MiniMES software.

a) Start COMTool software.

b) Set the number of stations using the ⊕ button and enter the IP addresses of the controllers.



Note

After the controllers and their IP addresses have been entered, their configuration can be checked by clicking the double arrow button. Afterwards, the symbols next to the controllers have to change to the OK status (as shown in the figure).

If this is not the case, the IP address may be faulty or the controller might not be in the network.

c) Check the connection with the MES PC by clicking the double arrow button next to the **Connection** field.

Note
If MiniMES software is running on another PC within the network, connection to the respective PC can be checked here by entering the PC's IP address. MiniMES software is normally on the same PC (local host).

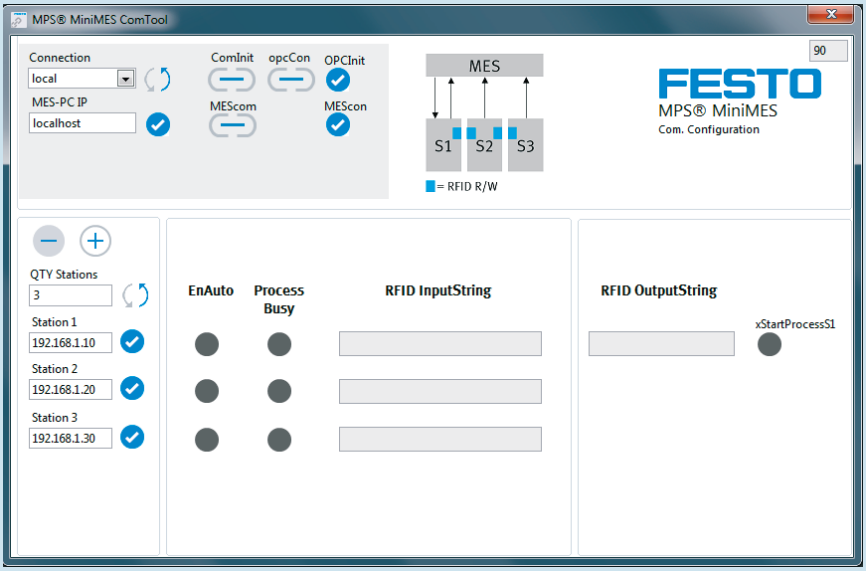
d) Click the **ComInit** and **opcCon** buttons.

– Is the OPC server started?

☑ Yes
☐ No

e) Connect the MES by clicking the **MEScom** button.

Information
If everything functions, which means that communication and the network have been set up correctly, the panel looks like this:



3. Starting MiniMES software and configuring the system

a) Start MiniMES software.

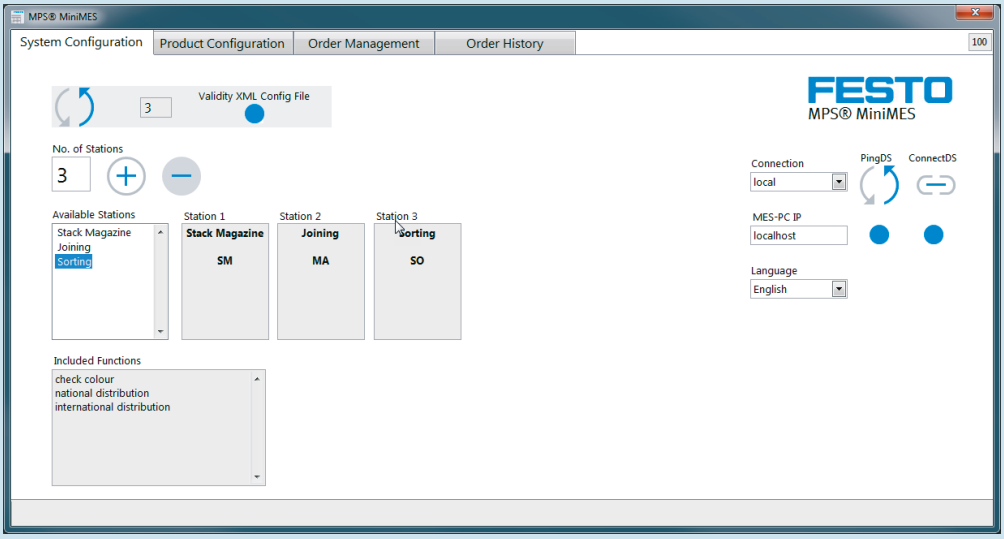
b) Select the **system configuratio**n tab and click the two buttons at the right-hand side to connect the MES to COMTool.

c) Configure the system by specifying the number and order of the included stations.

Note

The stations can be moved into the empty fields by means of drag & drop. In the case of the MPS® 203 I4.0 system, the order is always: **stack magazine – joining – sorting.**

After configuration has been completed, the user interface looks like this.



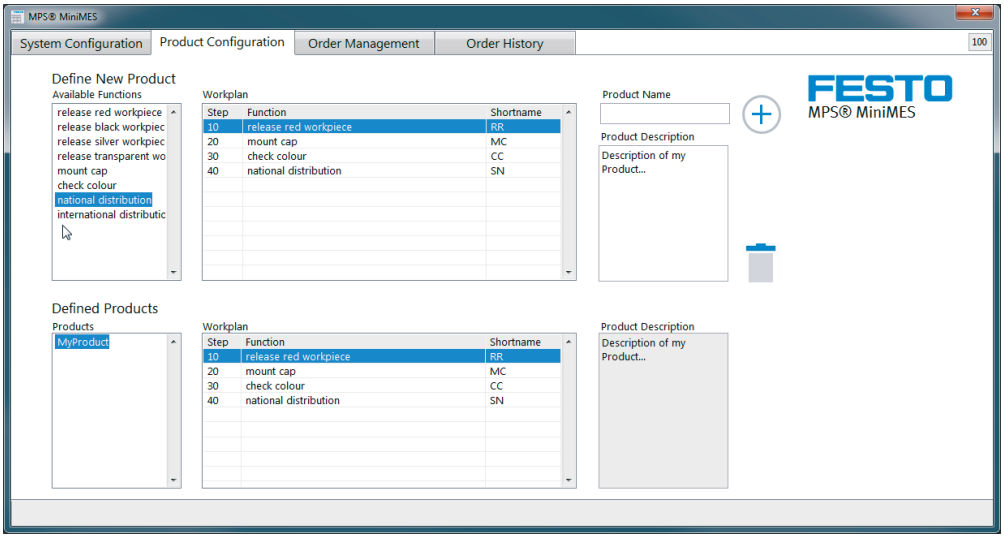
4. Configuring a product

a) Select the **Product configuration** tab.

b) Drag and drop the desired functions to the work plan. The order should be as follows:
- Which color is the can (red, black, silver)?
- Does a cover need to be mounted to the can?
- Does quality inspection need to be conducted?
- Where should the part be placed into storage?

c) Assign a product name and a product description.
Add the part by clicking ⊕.

Sample results: mount red cover, with quality inspection, chute 1



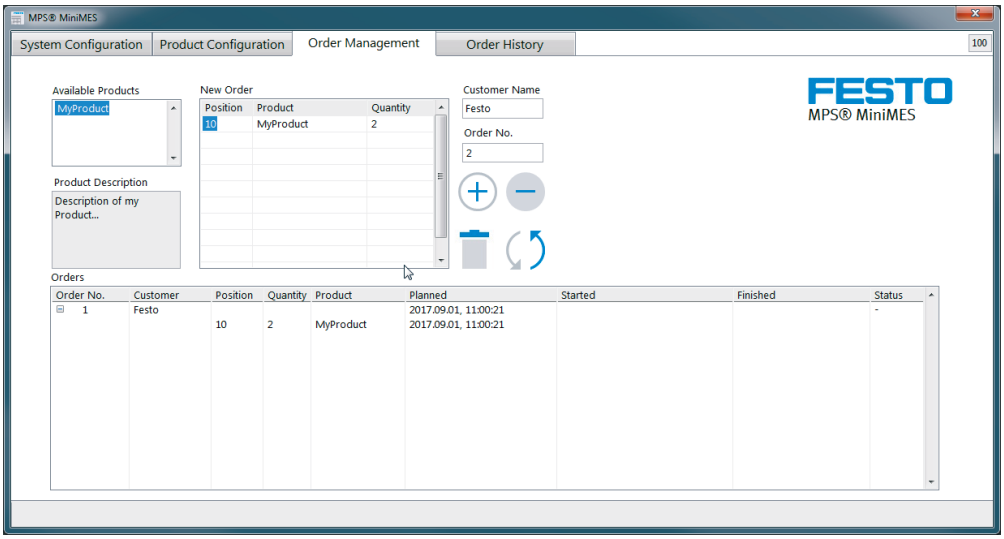
5. Entering a work order

a) Select the **order management** tab.

b) Drag and drop available products to the work order.

c) Assign a work order number and a customer name and add the work order by clicking  .

d) Finished work orders can be moved into history by clicking the arrow icon  and thus permanently saved as an *.xml file.



Training notes

If the same number is assigned to several work orders, they also have the same number in the XML file. When searching for an order , for example using the web service, the order which is found first is always read out.

The XML file can simply be deleted in order to clear the history.

6. Review questions concerning the MES

– Which of the classic features worked out in subtask 1 is also included in the MES, and in which subprogram are they found?

Feature	Subprogram
Production plan for each product	Product configuration
Production sequence	RFID tag
Acquisition of production and product data	Order management and product history

Exercise 9: Control and status indication with mobile terminal devices

Learning objectives

After completing this exercise:

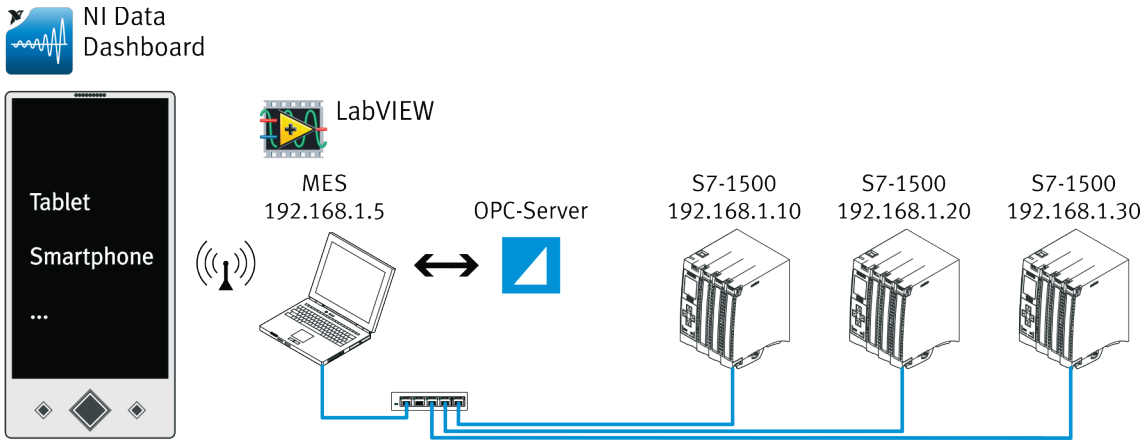
- You'll be able to set up a WLAN and use it to connect the system.
- You'll be able to configure the parameters of an app for a tablet/iPad.
- You'll be able to use a tablet/iPad for control and data read-out.

Description of the problem

Mobile terminal devices are being used to an ever greater extent in the field of automation technology. Above all they're used to display process quantities and sensor values. During commissioning, it may also be advisable to control actuators with mobile terminal devices as well.

Due to the fact the controllers often don't have direct WLAN access to the variables, this task is taken over by an external communication program. A corresponding app needs to be installed to a tablet and configured. The sensors then need to be read out and the deflectors and a conveyor motor have to be controlled.

Layout



Network layout for the MPS® 203 I4.0 system

Information

An access point is incorporated into the Ethernet network. The OPC server and **OPC_WLAN.exe** communication software has to be started at the PC. This software loads PLC's inputs via the OPC server and transmits the signals to the PLC's outputs.

Furthermore, the inputs/outputs are forwarded to the access point as an environment variable. With the help of the free “NI Data Dashboard” app from National Instruments, the outputs can be operated and the inputs can be displayed on a tablet (Android) or an iPad (iOS). Currently, only inputs can be observed at the smartphone.

The additional OPC_WLAN.exe program and the latest LabView Runtime can be found on the Festo Didactic Info Portal at **ip.festo-didactic.com** in the MPS® software area.

Work assignments

1. Set up an access point and connect it to the system.
2. Start the OPC server and OPC_WLAN.exe software.
3. Set up the app for tablet/IPad, read out the sensor signals, and control the outputs.
4. Set up the app for smartphone (Android).

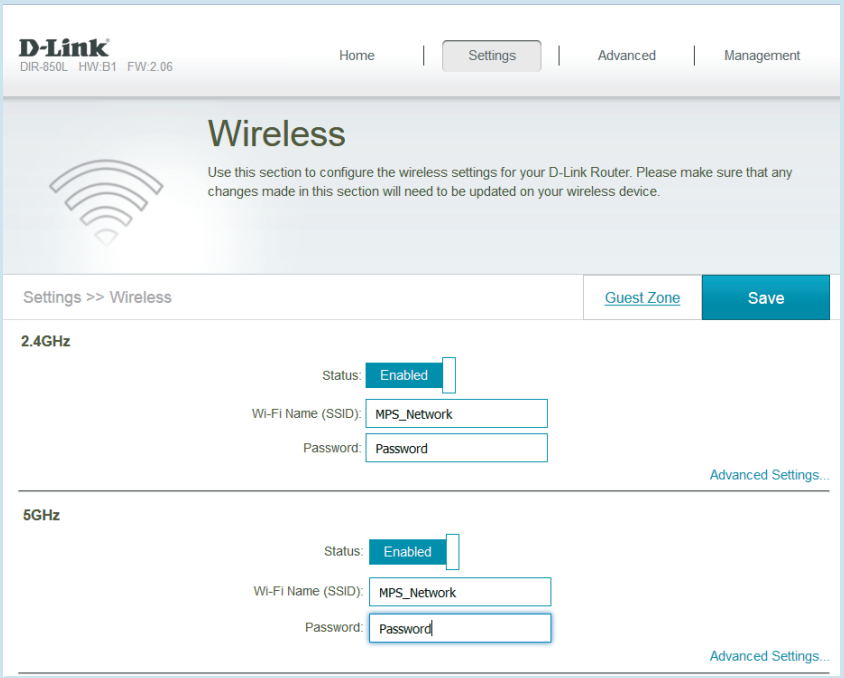
Work aids

- Hardware
  - Tablet (Android)/iPad
  - Smartphone (Android)
  - WLAN access point
- Software
  - OPC_WLAN.exe
  - NI Data Dashboard app

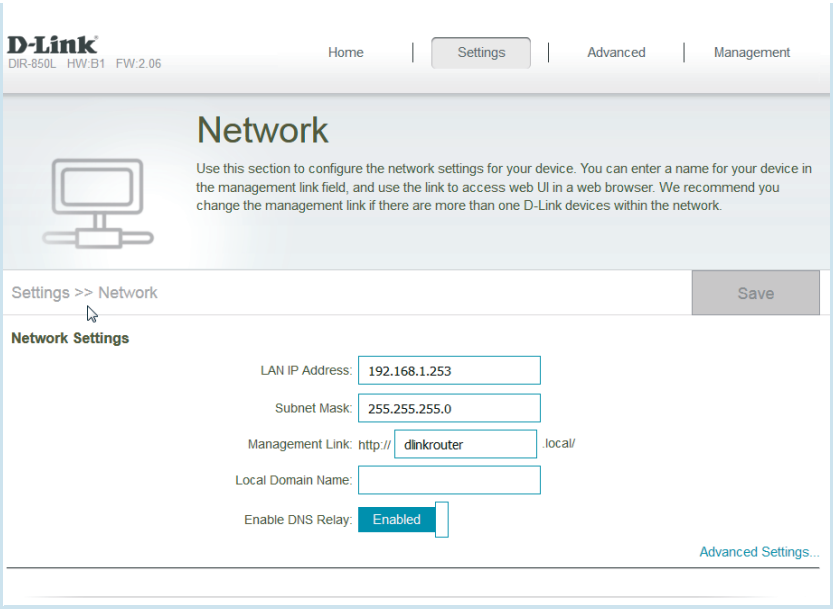
1. Setting up the WLAN

a) Configure the access point and connect the system and the PC to the WLAN. Access point configuration is explained based on an example. The MES PC has to be connected to the network wirelessly.

There's a label on the access point with the standard network name (SSID), the standard password, and the access point's preset IP address. Connect your PC to this network and access the IP address using the browser. The access point's web service appears, in which the access point can be configured.



You can select a new network name (SSID) and a new password. Settings can be entered for the 2.4 GHz and the 5 GHz network, in so far as these are supported by the access point.



As a second step, a new IP address and a new subnet mask can be assigned to the access point. When doing so, observe the system's preset address space. It is also important to ensure that DNS is activated, because IP addresses are assigned automatically to new devices.

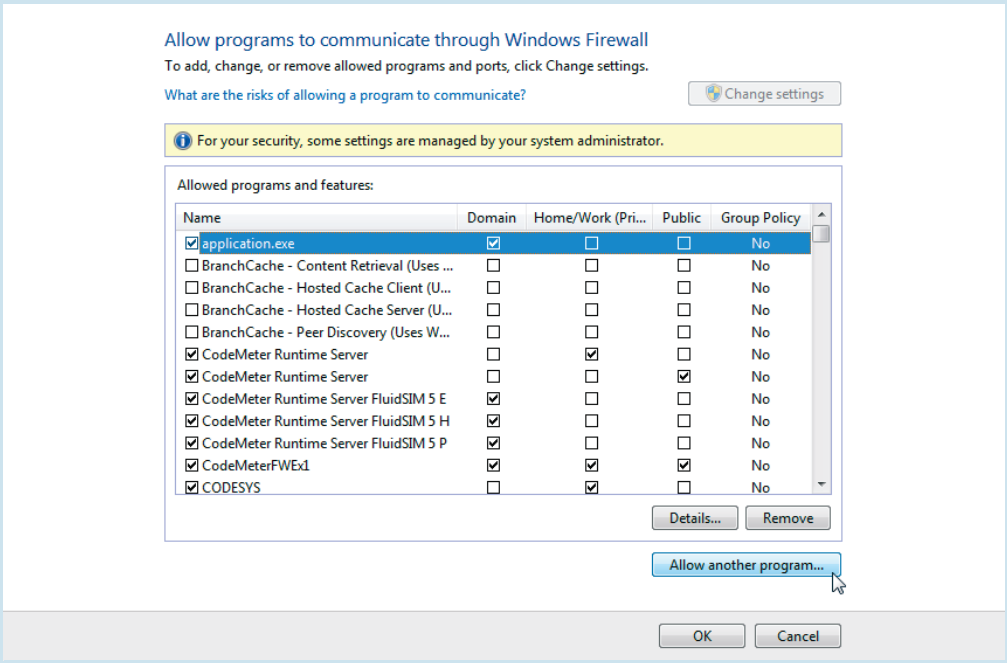
b) Configure the firewall in order to be able to access measurement data via the Ni Data Dashboard.

It is usually impossible to entirely deactivate a PC's Windows firewall. An explanation is provided here, indicating which system programs have to be enabled and how this is done.

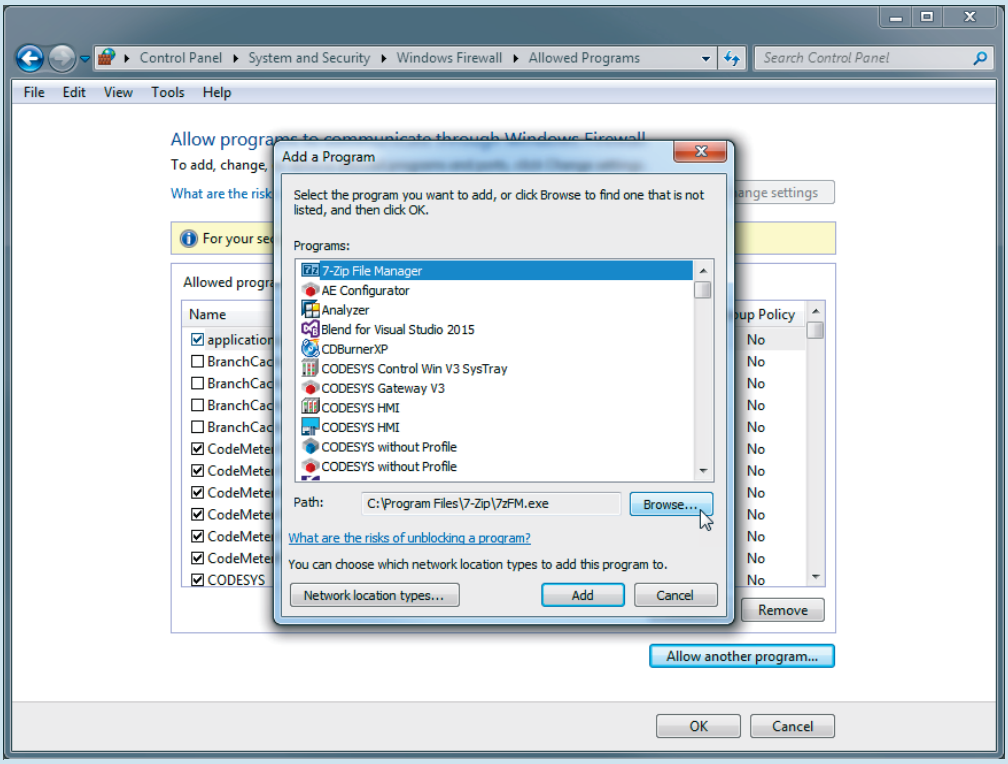
Two programs have to be enabled which can be found at the following storage locations.
...\Programs(86)\National Instruments\Shared\Tagger\tagsrv.exe
...\Windows\SysWOW64\lkads.exe

In order to enable a new program, open the Windows firewall and select **Allow a program or feature through Windows Firewall**.

Select **Change settings** and then **Allow another program**.



Select the program's directory path as shown in the next figure, and add it. Then enter checkmarks for all domains (home/work and public). Repeat this procedure for both programs.

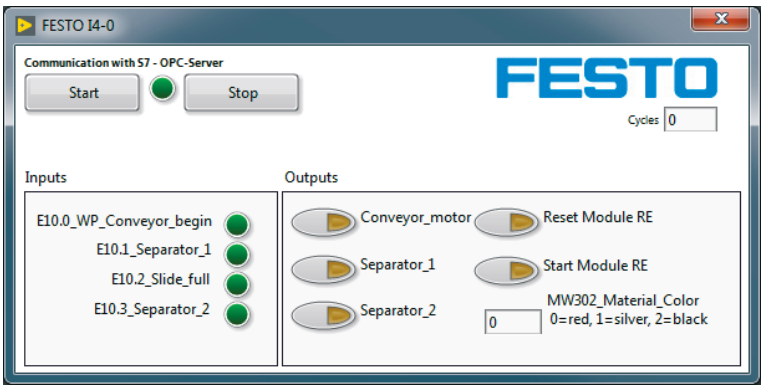


c) Read out the PC's WLAN IP address with the help of ipconfig and make a note of it.

For example: 192.168.1.140

2. Starting the OPC server and OPC_WLAN.exe software

a) Start OPC_WLAN.exe software. The OPC server should start as soon as start is clicked in the application, because it is in **Application** mode.



45		G1BG1	Bool	%E10.0	Werkstück bei Bandanfang / workpiece AT conveyor start
46		G1BG2	Bool	%E10.1	Weiche 1 ausgefahren / Seperator 1 Extracted
47		G1BG4	Bool	%E10.3	Weiche 2 ausgefahren / Seperator 2 Extracted
48		G1KF1_A1	Bool	%A4.0	Bandmotor vorwärts / Conveyor motor forward
49		G1MB1	Bool	%A4.1	Weiche 1 ausfahren / Extend Seperator 1
50		G1MB2	Bool	%A4.2	Weiche 2 ausfahren / Extend Seperator 2
51		iResultValue	Int	%MW302	Ergebnis von Erkennen(0 = Rot, 1 = Silber, 2 = Schwarz, 3
52		G1BG3	Bool	%E10.2	Sensor Rutschen / Sensor Slides
53		G1MB3	Bool	%A4.3	Stopper einfahren / Retract Gate

b) Activate deflector 1 with the software. What do you notice?

Deflector 1 is advanced and sensor 10.1 lights up.

c) Set a black workpiece onto the beginning of the conveyor. Then start the detection module (recognition) and advance the workpiece through the system with the help of the software. Describe your observations.

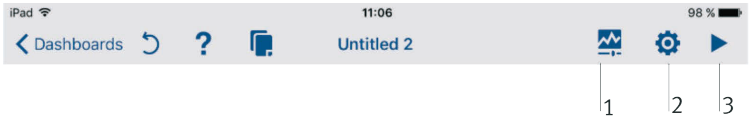
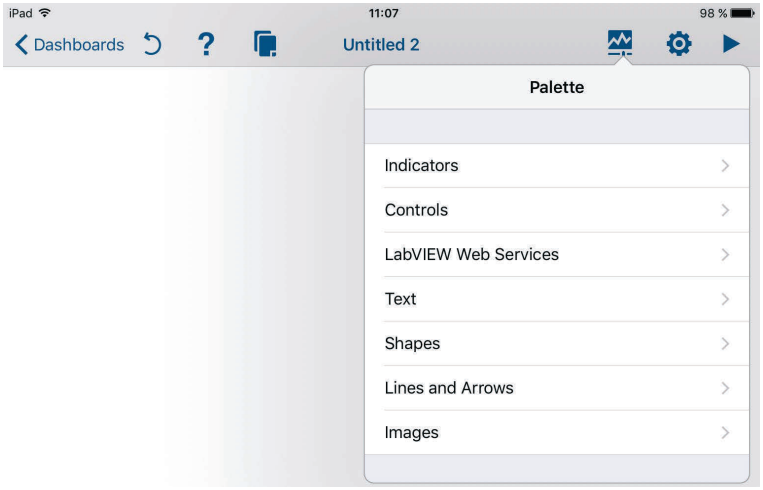
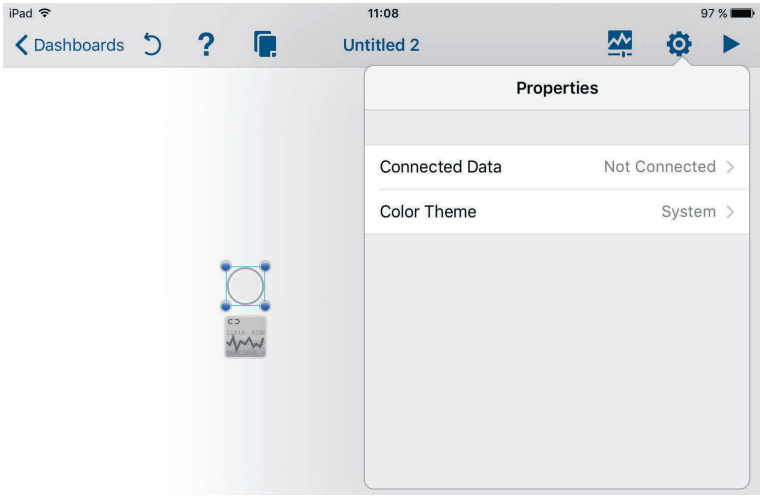
Sensor E10.0 lights up when the workpiece is placed onto the conveyor belt. After the workpiece has passed through the detection module, the color of the material is identified as 2 = black.

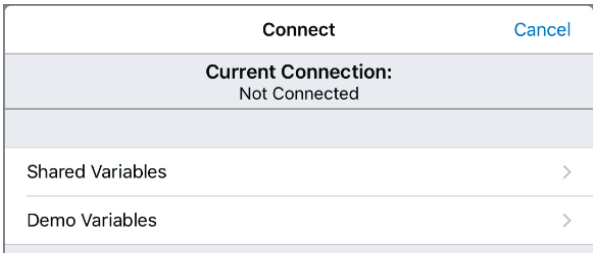
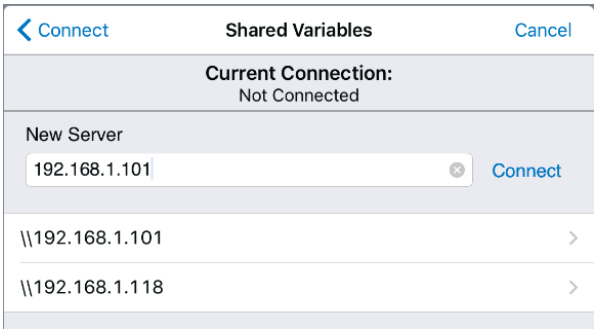
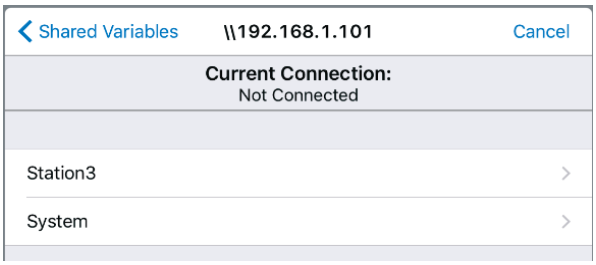
d) Stop the detection module and reset it.

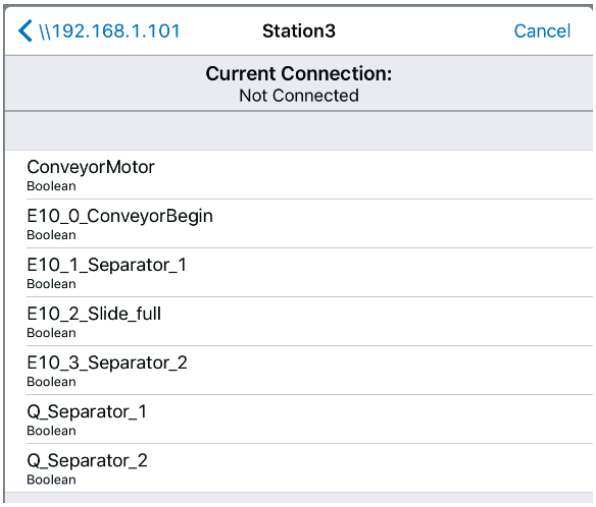
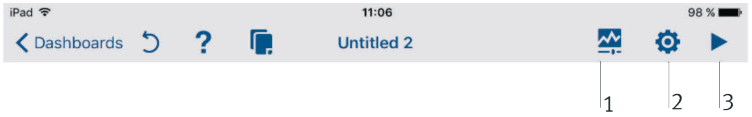
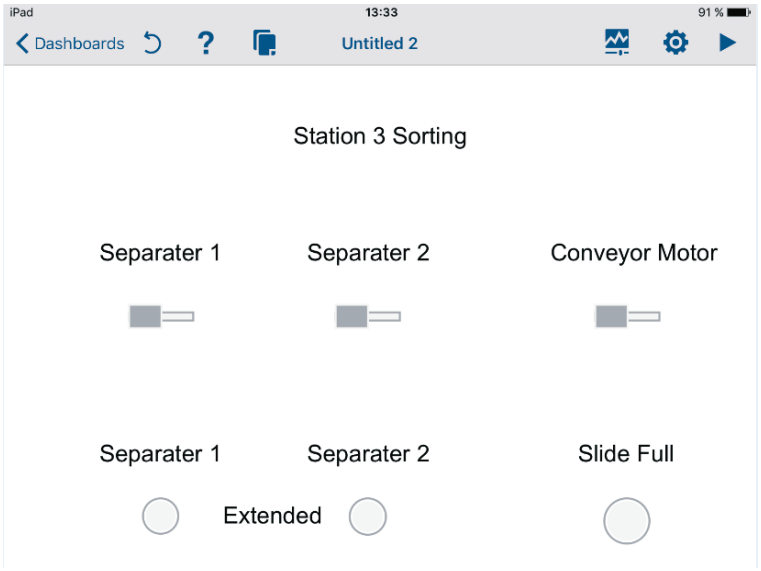
3. Setting up the app, reading out sensor signals, and controlling the outputs

a) Install the NI Data Dashboard app to your tablet and connect it to the WLAN.

b) Configure the app. Configuration is shown below for an input LED as an example.

Work step	Screenshot
Familiarization with the user interface 1 Selection of an element. 2 Configuration of an element. 3 Starting the measurement.	
Selection of an indicator element (display) with the button (1). The “Controls” pallet has to be selected in order to add control components later on.	
The element is configured with the button (2). Select “Connected Data” to this end and “Connect to New Data” in the next step.	

Work step	Screenshot
Select “Share Variables” in the next window.	
In the next window, select the WLAN address of the PC at which OPC_WLAN.exe and the OPC server are run. You selected this address previously during step 1b).	
Select station 3.	

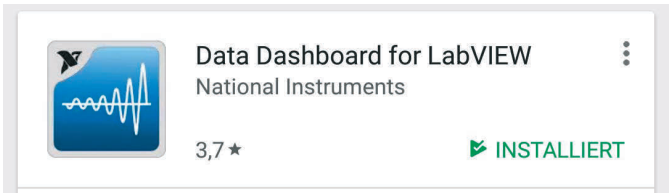
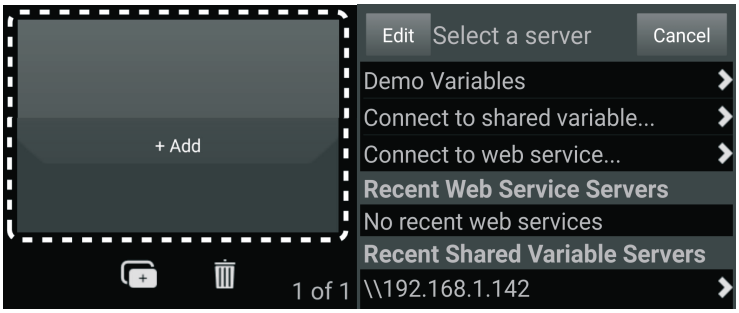
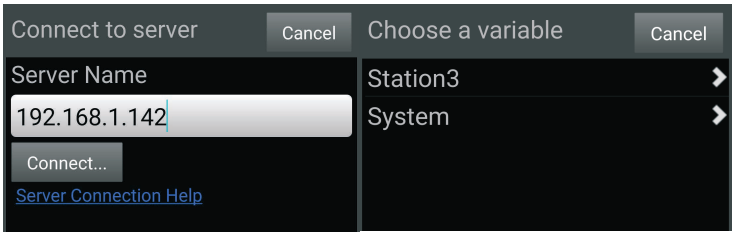
Work step	Screenshot
Select a sensor you'd like to display.	
Test the combination by connecting the dashboard via the "Play" button (3) at the top right.	
Configure the rest of the display and operating components by repeating these steps.	

c) Test overall communication and make a note of your observations.

The outputs are set when the switch is activated. The inputs are read out correctly.

4. Setting up the app for smartphone (Android)

– Set up the NI Data Dashboard app at your Android smartphone.

Work step	Screenshot
Install the app. Then, connect your smartphone to the system's WLAN.	
Start the app and establish connection to the PC at which OPC_WLAN.exe is run. Select "Connect to shared variable".	
Enter the previously determined IP address to this end and select station 3.	
Select an input or an output and specify appearance depending on type.	

Exercise 10: Push e-mail transmission

Learning objectives

After completing this exercise:

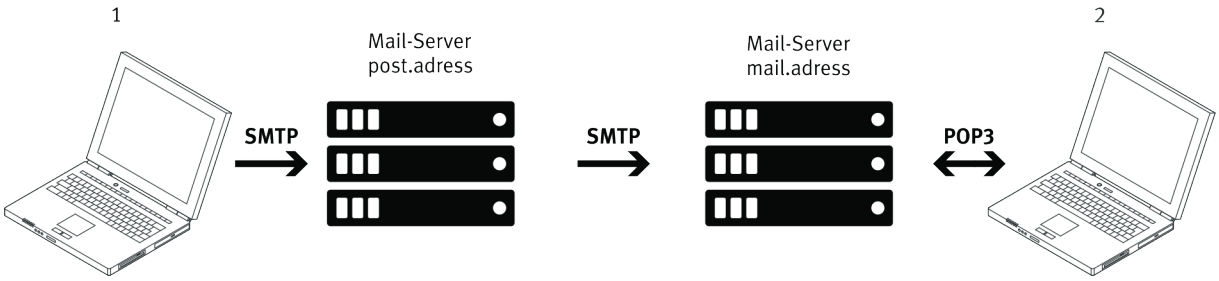
- You'll be familiar with the data path of an e-mail.
- You'll be able to set up e-mail transmission.

Description of the problem

It's important for the system to automatically generate a message, for example in the event of a malfunction, in order to monitor the automated manufacturing process. One possibility is automatic transmission of e-mails.

Your task is to adapt the system's e-mail protocol.

Layout



Information

The transmission of e-mail is a service for which no direct connection is established between the sender and the recipient. This is necessary because the sender and the recipient are not normally logged onto the network at the same time. And thus the recipient has a mailbox to which incoming messages are initially saved. The e-mail address is the designation of the recipient's mailbox. Transmission is completed by means of two sub-steps:

1. From the sender's PC to the recipient's mailbox – the SMTP protocol is used in this case (simple mail transfer protocol).
2. From the recipient's mailbox to the recipient's PC – the POP3 protocol is used in this case (post office protocol 3).

Automatic e-mail transmission
Automatic email transmission is triggered in the MPS® 203 I4.0 system when an emergency-off pushbutton is pressed. The program automatically enters the station number (X) to the e-mail ("Station X"). Text before and after this message can be freely configured in HTML format.

The name/address of the technician who should receive the e-mail is entered to the web service.

Work assignments

1. Start the web service and enter the address of the maintenance technician.
2. Configure the sender's information in the Mail.xml file.

Work aids

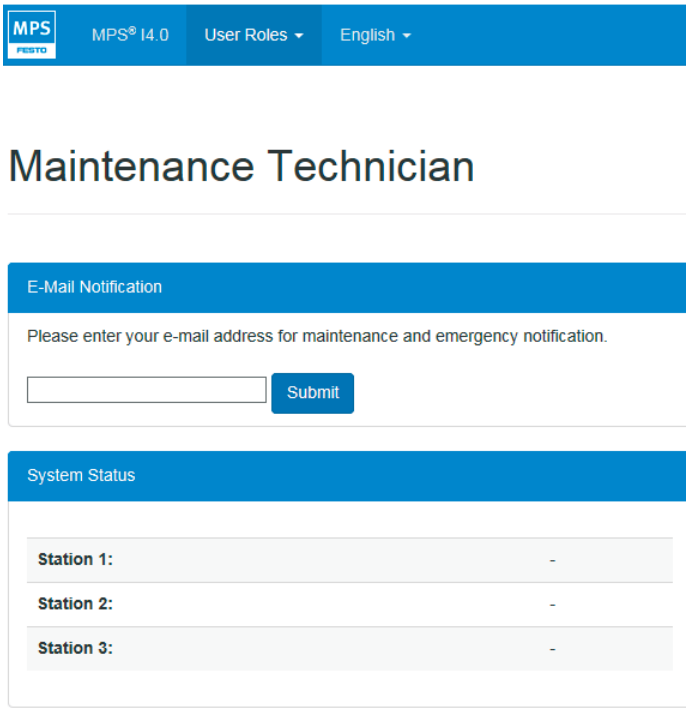
- Media
  - Internet for the mail provider's data
- Software
  - The system's web service

1. Starting the web server and entering the e-mail recipient's data

Training notes
Please note that the system has to be connected to the Internet for automatic e-mail transmission. When entering a sender's address, it must be assured that external access to the mailbox via e-mail programs such as Outlook, Thunderbird or the web service is expressly enabled.

As described in the manual, the web service can be reached at:
http://*PC's IP address*:80/WebService1/index.html

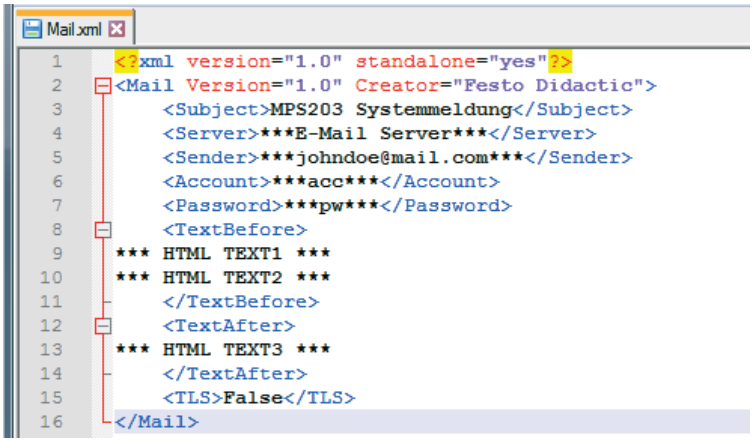
– Start the web service and enter one or more recipient addresses. Be sure to use correct notation for all of the addresses.



2. Entering the sender's information to the mail.xml file

Information
The email program uses the data which are included in the mail.xml file. The file is located in the following folder: c:/...../Dokumente/MES_MiniMES/Settings/Mail.xml.

a) Open the **Mail.xml** file in a text editor such as the Windows Notepad++.



b) Ascertain your e-mail provider's e-mail transmission settings. If you don't yet have an e-mail address, set one up now. Be certain to enable external access to the mailbox.

SMTP server: e.g. mail.gmx.net

Port no.: e.g. 587

Note
In the case of a German GMX address for example, the server "mail.gmx.net" and port "587" would have to be selected. "mail.gmx.net:587" would have to be entered to the e-mail server placeholder in the XML file.

Most e-mail providers use TLS in order to encrypt e-mails. And thus TLS must be set to "True" at the bottom of the XML file.

c) Enter the rest of the information including sender, account and password.

d) Configure a system e-mail with just a few HTML commands. The placeholders HTML Text1, HTML Text 2 and HTML Text 3 are replaced to this end in the XML file. Don't forget that the station number is sent along with the e-mail automatically in the form of "Station X", where X is the station number.

Information

As with information in XML files, HTML commands are started and ended with start tags and end tags. The following information and commands are required for the exercise:

1 Paragraph: ‹br›‹/br›
2 List: ‹ol›‹/ol›
3 List constituent: ‹li›‹/li›
4 Representation of German vowel mutations:
   – ä = &auml
   – ö = &ouml
   – ü = &uuml

e) The message should be laid out as follows:

Dear Service Technician,

There was an emergency event at Station 1.
Please follow these steps to get the system running again:

1. Release the emergency button.
2. Turn the key switch clockwise (Manual Mode).
3. Press the Reset Button.
4. Turn the key switch counter-clockwise (Automatic Mode).
5. Press the Start Button.

This is an automatic mail generated by the MPS 203 I4.0 plant.

1. First of all process the text before the station number by entering the following text between the tags ‹TextBefore› and ‹/TextBefore› in the XML file.

```
‹TextBefore›
        Dear service technician,‹/br›‹/br›
        There was an emergency event at
‹/TextBefore›
```

This results in the following message:
Dear service technician,

There was an emergency event at station 1. .....

2. Process the text between the tags ‹TextAfter› and ‹/TextAfter› in the XML file in order to generate the rest of the e-mail.

```
‹TextAfter›
Please follow these steps to get the system running again:‹/br›‹/br›
    ‹ol›
    ‹li›Release the emergency button.‹/li›
    ‹li›Turn the key switch clockwise (manual mode).‹/li›
    ‹li›Press the reset button.‹/li›
    ‹li›Turn the key switch counterclockwise (automatic mode).‹/li›
    ‹li›Press the start button.‹/li›
    ‹/ol›
This is an automatic mail generated by the MPS 203 I4.0 system.‹/br›‹/br›
‹/TextAfter›
```

f) Press the emergency off button and test e-mail transmission.

Exercise 11: Web services

Learning objectives

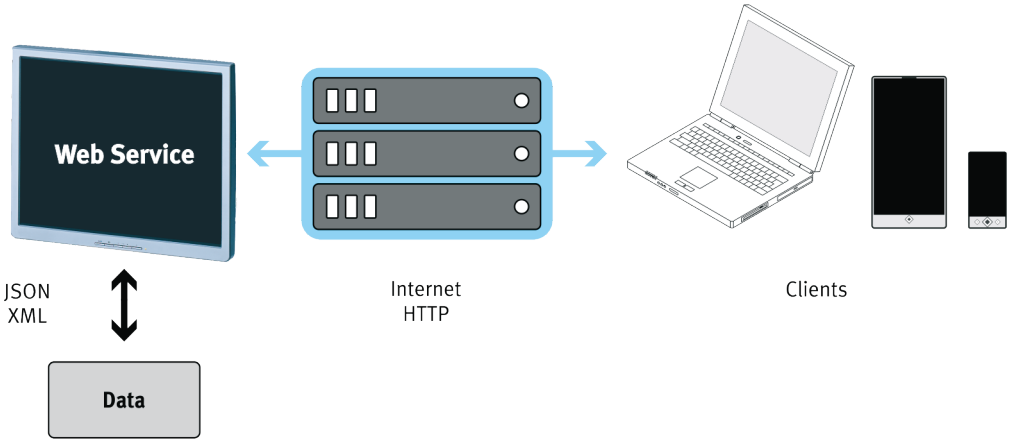
After completing this exercise:

- You'll be familiar with the basic layout of websites in HTML format.
- You'll be familiar with the communication principle used for web services.
- You'll be able to read out information from the source code of a web service.

Description of the problem

You've been assigned the task of familiarizing yourself with basic web technologies. The web service included with the MPS® 203 I4.0 system is available to you as an example to this end.

Layout



Information

A web service permits machine-to-machine communication on the basis of HTTP or HTTPS requests via computer networks. Data are exchanged and functions are accessed at remote computers.

Every web service has a URI (uniform resource identifier) and interface description in machine-readable format such as XML, or as in this case JavaScript object notation (JSON), which defines how interaction with the web service takes place.

Work assignments

1. Set up a simple HTML page.
2. Start and analyze the web service of the MPS® 203 I4.0 system.
3. Answer the questions.

Work aids

- Software
  - The system's web service
  - Web browser

1. Laying out an HTML page

Note
HTML code is used to create the basic content of websites. The function is implemented in JavaScript code. In order to make websites more optically pleasing, cascading style sheets (CSS, language for the creation of digital documents) is used for the layout.

During the course of this exercise, step-by-step, you'll create a simple HTML page and a JavaScript which simply adds two numbers.

a) Create a file folder and two new documents with the extensions shown below.

b) Open both of the files in an editor such as the Windows Notepad++.

c) Enter the following text to the HTML document.

```
<!doctype html>
<html>
    <head>
        <meta charset="UTF-8">
        <title>My First HTML-Page</title>
        <script src="Calculation.js"></script>
    </head>
    <body>
        <h1>This is a addition of two numbers..</h1>
            <p>First Number:</p>
            <input id="FirstNumber" type="text"><br>
            <p>Second Number:</p>
            <input id="SecondNumber" type="text"><br></br>

            <button  id="Button" onclick="getResult()">Calculate</button>

            <p id="Result" ></p>
    </body>
</html>
```

Information

As you can see, the first line specifies the type of document involved. This is followed by the main constituents of the HTML document, namely the header and the body. In order to check appearance only, the HTML document can be opened with a double-click in the web browser.

The header contains the document's basic data, for example the title (mandatory) which appears in the web browser's tab. Data is also included such as the utilized character set and integrated scripts. Scripts are not restricted to the header only, and can also be incorporated into the body. As you can see, the JavaScript file you created earlier is already integrated here. As a result, the page is already familiar with the JavaScript functions later on.

The visible elements of the document are included in the body. These are listed individually in the following table.

1. ‹h1›...‹/h1›: Document heading
2. ‹p›...‹/p› Simple paragraph
3. ‹input› Input field
4. ‹button› Switch element

An ID which is written directly into the start tag must be assigned to all elements which will be addressed, described or read by the JavaScript later on. The function which should be started when the button is clicked is also included next to the button (getResult()). This function is now implemented in JavaScript.

d) Enter the following code to the JavaScript document.

```
function getResult(){
    var number1;
    var number2;

        number1 = document.getElementById("FirstNumber").value;
        number2 = document.getElementById("SecondNumber").value;

        document.getElementById("Result").innerHTML= Number(number1) + Number(number2);
    }
```

1 2 3 4

Information

The function header (1) and the associated curly brackets limit the beginning and the end of the function. For the purpose of clarity, two local variables (2) are declared at the beginning. These are described with the values of the two input elements (3).

As you can see, the HTML elements are addressed with the help of their IDs. Finally, the result is entered to the paragraph with the ID “Result” (4). In order for addition to be executed correctly, both variables have to be converted to numbers with the Number() function.

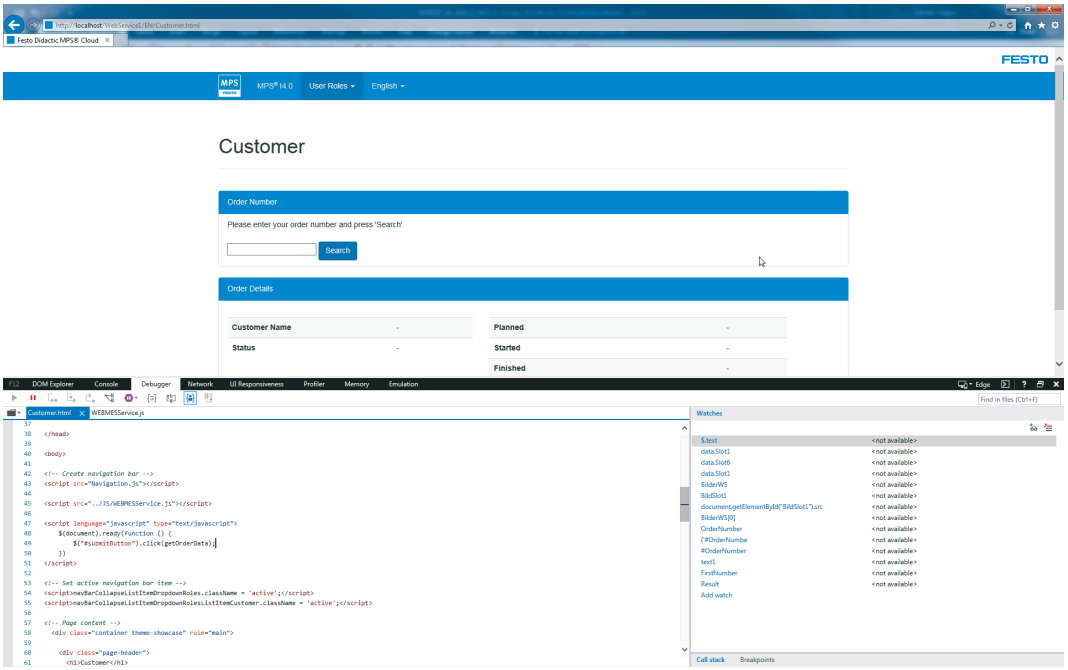
e) Remove type conversion of the two variables and try executing addition of 1 + 2. Which result do you obtain and how do you explain it?

1 + 2 = 12. The numbers are interpreted as strings which are lined up one after the other.

2. Analyzing the web service

a) Start the web service and go to the customer view. Then open the debugger by pressing F12 (in our case based on the example of IE 11).

> **Note**
> As described in the manual, the web service can be reached at:
> **http://*PC's IP address*:80/WebService1/index.html**



b) As of and up to which line do the header area and the body area of the document extend?

Header: Lines 3 through 39
Body: Lines 41 through 141

c) In which line is the button included, what is its ID and which function does it access?

Line 73, ID: "submitButton", function: getOrderData()

d) The JavaScript file required for the function is: **WEBMESService.js**. Open this file via the file folder icon on the left-hand side.

> **Note**
> The WEBMESService.js file contains all JavaScript functions for the entire web service. One of the few functions that is accessed by clicking a button is the prompting of customer data, along with the entry of the email address. All other functions are invoked cyclically in order to always provide the most current data

e) In which line does the getOrderData ()function appear?

Line 276.

f) Take a closer look at this function.

> **Note**
> It can be seen how a JSON string which contains the data is read in in response to an HTTP request via a URL. These data can now be displayed and processed.

3. Review questions

1. How frequently is the “getMaintenanceData()” function invoked on the maintenance technician’s page.

   Every 500 ms

2. Find the function in the JavaScript. To which HTML element is the “text1” string assigned?

   The element with the following ID: “Error1”.

Exercise 12: Motor controller maintenance task

Learning objectives

After completing this exercise:

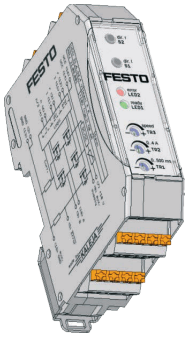
- You'll be able to read the motor controller's wiring diagram.
- You'll be able to replace a function unit.
- You'll be able to set up the new motor controller.

Description of the problem

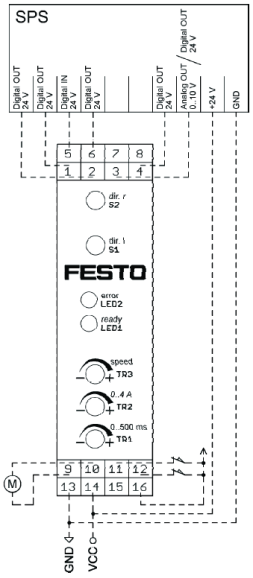
During assembly of a technical system and when maintenance is required, modules are dismantled, mounted, connected, and often configured as well.

During operation it has been determined that the drive unit for the conveyor belt at station 3 is defective. Although the PLC signal arrives, the motor doesn't run. The red LED at the motor controller lights up. The controller has to be replaced.

Controller layout and circuit diagram



Terminal	Function
1	Digital input, "counterclockwise rotation" (switching to P potential)
2	Digital input, "clockwise rotation" (switching to P potential)
3	GND for external potentiometer, max. 0.5 A
4	Digital input, "creep speed" (switching to P potential)
5	Digital output, "ready for operation", high active
6	Analog input, 0 ... 12 V, the speed specified by the internal potentiometer applies at > 11 V.
7	Auxiliary voltage output, +10 V / approx. 50 mA (PTC fuse)
8	Auxiliary voltage output, +24 V, max. 0.5 A
9	Motor connection -
10	Motor connection +
11	Digital input "enable counterclockwise/acknowledge" (switching to P potential)
12	Digital input "enable clockwise/acknowledge" (switching to P potential)
13	GND
14	+24 V DC (±10 %) in
15	GND
16	+24 V out



Information
The conveyor motor is controlled with the help of the motor controller. The conveyor motor can be controlled directly via the S1 and S2 pushbuttons. Motor speed, i.e. conveyor belt speed, is adjusted with the potentiometers. The controller is activated by output A4.0 at the PLC.

Only one output is required because the conveyor belt in this station only needs to run in one direction.

Work assignments

1. Remove the defective controller.
2. Install the new controller.
3. Test the new controller and adjust conveyor belt speed.
4. Document the completed repair.

Work aids

- Hardware
  - Slotted-head screwdriver
  - Ruler
  - Stopwatch or smartphone
- Media
  - Circuit diagram of the conveyor module in the appendix

1. Removing the defective controller

a) Switch off supply power to station 3.

b) Label each connecting cable with the exact terminal designation.

c) Disconnect and remove the motor controller.

2. Installing the new controller

a) Install the new controller and connect it.

b) With the help of the motor controller's connection diagram and the layout, explain the function of utilized jumpers.

1. Jumper 8 – 6: The 24 V signal applied to analog terminal 6 specifies that speed is determined by the internal potentiometer and not the PLC.

2. Jumper 16 – 11 – 12: The 24 V signal from output 16 enables counterclockwise (terminal 11) or clockwise motion (terminal 12).

3. Testing the new controller and adjusting conveyor belt speed

a) Switch electrical power back on again and test the following functions. Make a note of your functions.

1. LED 1 (ready) lights up? — LED lights up green
2. Followed by pushbutton S1: — Conveyor runs clockwise
3. Followed by pushbutton S2: — Conveyor runs counterclockwise

b) Adjust conveyor belt speed to about 4.2 meters per minute.

Sample calculation for a conveyor length of 30 cm:

$$4{,}2\ \frac{\text{m}}{\text{min}} = \frac{0{,}3\ \text{m}}{t\ \text{min}}$$

$$\rightarrow\ t = \frac{0{,}3\ \text{m}}{4{,}2\ \frac{\text{m}}{\text{min}}} = 0{,}07\ \text{min} = 4{,}3\ \text{s}$$

4. Documentation of the completed repair

– Enter the completed repair to the machine logbook.

Number	Date	Time	Component	Problem/activity	Employee/signature
1	31 August 2017	14:40	Suction cup. Front handling axis.	Parts were not correctly gripped. The specified vacuum value was not achieved. As a result there was no sensor signal. The suction cup was replaced due to wear.	John Doe
2					

Example of a machine logbook

Exercise 13: Inductive sensor maintenance task

Learning objectives

After completing this exercise:

- You'll be familiar with the characteristics of an inductive sensor.
- You'll be able to determine the correct sensing distance.
- You'll be able to mount a sensor and adjust the distance.

Description of the problem

Components can fail, or can become loose and incorrectly adjusted, due to vibration in automation systems In the case of inductive sensors, this is made apparent by the fact that they no longer read out a signal. The deflector is switched by the controller at station 3. However, the sensor doesn't inform the controller that switching has taken place. This problem needs to be examined and the sensor may have to be replaced or readjusted.

Work assignments

1. Test the sensor for correct functioning.
2. Determine the correct sensing distance under the prevailing conditions.
3. Replace or adjust the sensor.
4. Document the repair work.

Work aids

- Hardware
  - Wrench for removing and mounting the sensor
  - Feeler gauge for adjusting sensing distance

Training notes

Before instruction starts, incorrectly adjust the sensor such that it no longer switches when it's approached by the deflector.

1. Testing the sensor for correct functioning

a) What's the status of the sensor's LED in the initial position?

The LED is not lit up.

b) What's the status of the LED when the deflector is switched manually?

In this case as well, the LED does not light up.

c) Hold a piece of metal close to the sensor. Does the sensor switch now?

Yes, the sensor switches.

d) In order to rule out the possibility of a wire break at the signal line, observe the PLC's input bit as well. Does the signal arrive at the PLC?

Yes, the signal arrives. There's no wire break.

e) Does the sensor need to be replaced or adjusted?

Due to the fact that the sensor is switched, it is not defective and should only require adjustment.

2. Determining the sensing distance

Information

Sensing distance depends on sensor type and design, as well as reduction factor. This depends on the material to be detected. The table shows an excerpt from the sensor's data sheet.

Output, general											
Installation		flush							Non-flush			
Size		4 mm	M5	6,5 mm	M8	M12	M18	M30	M8	M12	M18	M30
Repetition accuracy	[mm]	0,04	0,04	0,07	0,07	0,1	0,25	0,5	0,12	0,2	0,4	0,75
Rated sensing distance	[mm]	0,8	0,8	1,5	1,5	2	5	10	2,5	4	8	15
Assured sensing distance	[mm]	0,64	0,64	1,21	1,21	1,62	4,05	8,1	2,03	3,24	6,48	12,15
Reduction factors												
Aluminum		0,4	0,4	0,25	0,25	0,4	0,4	0,45	0,25	0,5	0,5	0,5
Stainless steel 18/8		0,7	0,7	0,7	0,7	0,6	0,8	0,8	0,7	0,9	0,8	0,85
Copper		0,3	0,3	0,2	0,2	0,3	0,4	0,4	0,2	0,5	0,4	0,43
Brass		0,4	0,4	0,35	0,35	0,5	0,5	0,55	0,35	0,6	0,5	0,53
Stainless steel 37		1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0

a) Determine the current distance from the sensor to the workpiece.

Approximately 0.5 mm (depending on adjustment)

b) According to the data sheet, which distance is required for the sensor in order to assure that it switches reliably when the material to be detected is aluminum?

Sensing distance = 0.64 mm * 0.4 = 0.256 mm

3. Adjusting and testing sensing distance

– Set sensing distance to the calculated value shown under 2b) above and test for correct functioning. What do you notice?

The sensor switches.

4. Documenting the repair

– Document the successful repair procedure in the machine logbook.

Number	Date	Time	Component	Problem/activity	Employee/signature
1	31 August 2017	14:40	Suction cup. Front handling axis.	Parts were not correctly gripped. The specified vacuum value was not achieved. As a result there was no sensor signal. The suction cup was replaced due to wear.	John Doe
2					

Example of a machine logbook

Appendix

ASCII table

Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char
0	0	Null	**32**	20	Space	**64**	40	@	**96**	60	`
1	1	SOH	**33**	21	!	**65**	41	W	**97**	61	a
2	2	STX	**34**	22	"	**66**	42	B	**98**	62	b
3	3	ETX	**35**	23	#	**67**	43	C	**99**	63	c
4	4	EOT	**36**	24	$	**68**	44	D	**100**	64	d
5	5	ENQ	**37**	25	%	**69**	45	E	**101**	65	e
6	6	ACK	**38**	26	&	**70**	46	F	**102**	66	f
7	7	BEL	**39**	27	‘	**71**	47	G	**103**	67	g
8	8	BS	**40**	28	(	**72**	48	H	**104**	68	h
9	9	HT	**41**	29	)	**73**	49	I	**105**	69	i
10	0 A	LF	**42**	2 A	*	**74**	4 A	J	**106**	6 A	j
11	0B	VT	**43**	2B	+	**75**	4B	K	**107**	6B	k
12	0C	FF	**44**	2C	,	**76**	4C	L	**108**	6C	l
13	0D	CR	**45**	2D	-	**77**	4D	M	**109**	6D	m
14	0E	SO	**46**	2E	.	**78**	4E	N	**110**	6E	n
15	0F	SI	**47**	2F	/	**79**	4F	O	**111**	6F	o
16	10	DLE	**48**	30	0	**80**	50	P	**112**	70	p
17	11	DC1	**49**	31	1	**81**	51	Q	**113**	71	q
18	12	DC2	**50**	32	2	**82**	52	R	**114**	72	r
19	13	DC3	**51**	33	3	**83**	53	S	**115**	73	s
20	14	DC4	**52**	34	4	**84**	54	T	**116**	74	t
21	15	NAK	**53**	35	5	**85**	55	U	**117**	75	u
22	16	SYN	**54**	36	6	**86**	56	V	**118**	76	v
23	17	ETB	**55**	37	7	**87**	57	W	**119**	77	w
24	18	CAN	**56**	38	8	**88**	58	X	**120**	78	x
25	19	EM	**57**	39	9	**89**	59	Y	**121**	79	y
26	1 A	SUB	**58**	3 A	:	**90**	5 A	Z	**122**	7 A	z
27	1B	ESC	**59**	3B	;	**91**	5B	[	**123**	7B	{
28	1C	FS	**60**	3C	‹	**92**	5C	\	**124**	7C	|
29	1D	GS	**61**	3D	=	**93**	5D	]	**125**	7D	}
30	1E	RS	**62**	3E	›	**94**	5E	^	**126**	7E	~
31	1F	US	**63**	3F	?	**95**	5F	_	**127**	7F	DEL

Terminal assignment table, Distributing/Conveyor station with signal column at the control panel

Digital (station -XG1)

Function	SysLink	Color	Designation
I0	13	Gray-pink	Workpiece at beginning of conveyor
I1	14	Red-blue	Workpiece at intermediate conveyor position
I2	15	White-green	No workpiece at end of conveyor
I3	16	Brown-green	
I4	17	White-yellow	Slide retracted
I5	18	Brown-yellow	Slide advanced
I6	19	White-gray	Magazine empty
I7	20	Gray-brown	
Q0	1	White	Conveyor belt forward
Q1	2	Brown	Conveyor belt in reverse
Q2	3	Green	Advance feed separator
Q3	4	Yellow	
Q4	5	Gray	Advance slide
Q5	6	Pink	
Q6	7	Blue	
Q7	8	Red	
24 V A	9+10	Black	24 V power supply for outputs
24 V B	21+22	White-pink	24 V power supply for inputs
GND A	11	Brown-pink	0 V power supply for outputs
GND A	12	Purple	0 V power supply for outputs
GND B	23+24	White-blue	0 V power supply for inputs

Digital signal column (control panel -XG2)

Function	SysLink	Color	Designation
Q5	6	Pink	Light is red
Q6	7	Blue	Light is yellow
Q7	8	Red	Light is green
GND A	11	Brown-pink	0 V power supply for outputs

Note

Cable jumpers are connected from emergency off to bit 1.5 for all standard PLC versions.

Terminal assignment table, Joining station

Digital (station -XG1)

Function	SysLink	Color	Designation
I0	13	Gray-pink	Workpiece at beginning of conveyor (1)
I1	14	Red-blue	Workpiece at intermediate conveyor position (1)
I2	15	White-green	No workpiece at end of conveyor (1)
I3	16	Brown-green	Digital distance sensor
I4	17	White-yellow	Workpiece at beginning of conveyor (2)
I5	18	Brown-yellow	
I6	19	White-gray	No workpiece at end of conveyor (2)
I7	20	Gray-brown	
Q0	1	White	Conveyor belt (1) forward
Q1	2	Brown	Conveyor (1) belt reverse
Q2	3	Green	Advance feed separator
Q3	4	Yellow	Retract stopper
Q4	5	Gray	Conveyor belt (2) forward
Q5	6	Pink	Conveyor belt (2) reverse
Q6	7	Blue	
Q7	8	Red	
24 V A	9+10	Black	24 V power supply for outputs
24 V B	21+22	White-pink	24 V power supply for inputs
GND A	11	Brown-pink	0 V power supply for outputs
GND A	12	Purple	0 V power supply for outputs
GND B	23+24	White-blue	0 V power supply for inputs

Analog

Function	D-SUB-15	Color	Designation
AI0	8		Analog distance sensor

Note

Cable jumpers are connected from emergency off to bit 1.5 for all standard PLC versions.

Digital (station -XG2)

Function	SysLink	Color	Designation
I0	13	Gray-pink	Slide retracted
I1	14	Red-blue	Slide advanced
I2	15	White-green	Suction cup up
I3	16	Brown-green	Workpiece suction-gripped
I4	17	White-yellow	
I5	18	Brown-yellow	
I6	19	White-gray	
I7	20	Gray-brown	
Q0	1	White	Retract slide
Q1	2	Brown	Advance slide
Q2	3	Green	Suction cups facing down
Q3	4	Yellow	Vacuum on
Q4	5	Gray	
Q5	6	Pink	
Q6	7	Blue	
Q7	8	Red	
24 V A	9+10	Black	24 V power supply for outputs
24 V B	21+22	White-pink	24 V power supply for inputs
GND A	11	Brown-pink	0 V power supply for outputs
GND A	12	Purple	0 V power supply for outputs
GND B	23+24	White-blue	0 V power supply for inputs

Note

Cable jumpers are connected from emergency off to bit 1.5 for all standard PLC versions.

In the case of -XG2, all signals are transmitted via a bus node which addresses the signals with different protocols depending on the controller.

- For Siemens PLCs: ProfiNet,
- For Allen Bradley PLCs: Ethernet IP

Terminal assignment table, Sorting station

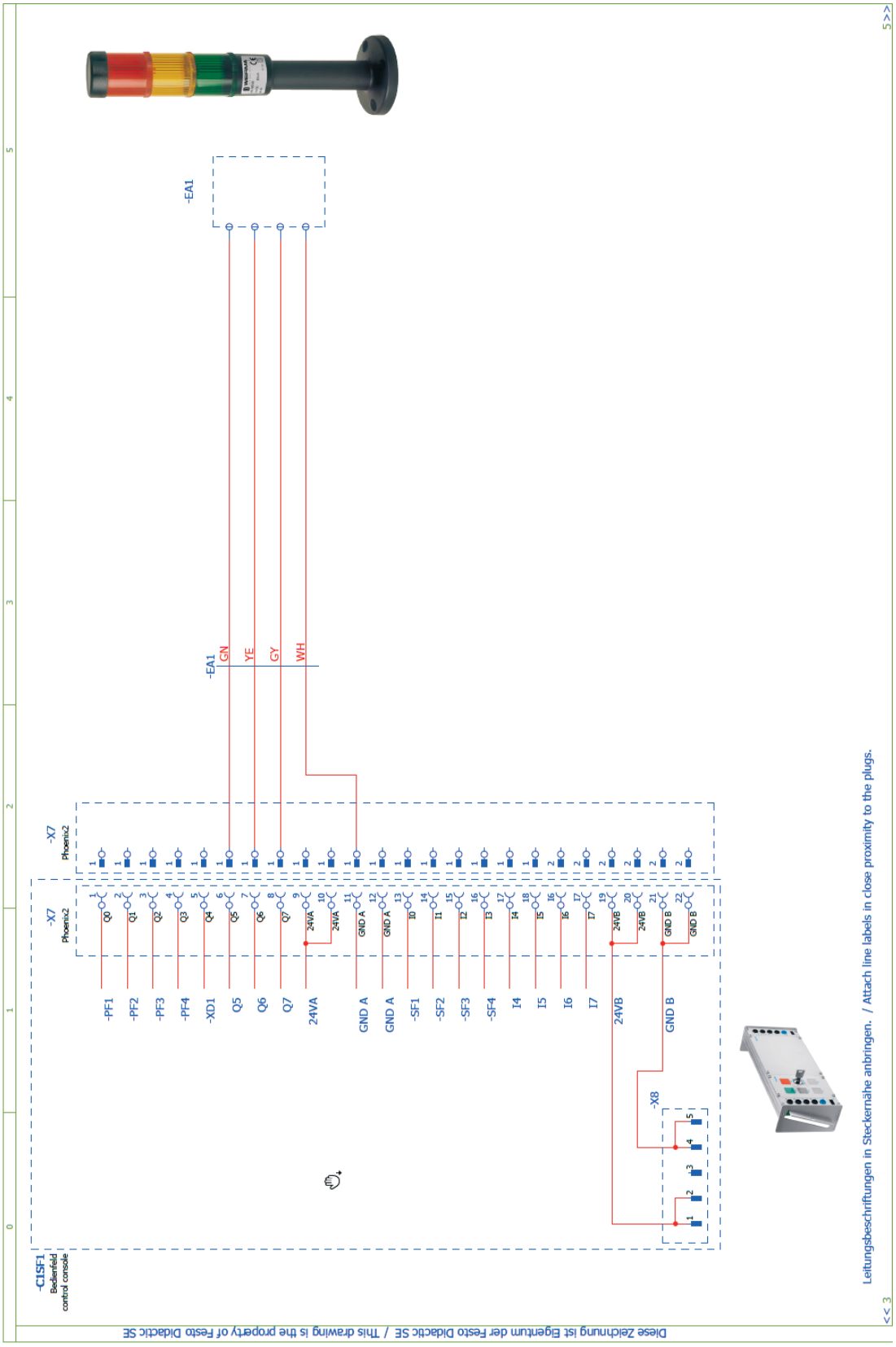
Digital (station -XG1)

Function	SysLink	Color	Designation
I0	13	Gray-pink	Workpiece at beginning of conveyor
I1	14	Red-blue	Deflector 1 advanced
I2	15	White-green	Chute full
I3	16	Brown-green	Deflector 2 advanced
I4	17	White-yellow	Workpiece detected
I5	18	Brown-yellow	Workpiece not black
I6	19	White-gray	Workpiece metallic
I7	20	Gray-brown	
Q0	1	White	Conveyor belt forward
Q1	2	Brown	Advance deflector 1
Q2	3	Green	Advance deflector 2
Q3	4	Yellow	Retract stopper
Q4	5	Gray	
Q5	6	Pink	
Q6	7	Blue	
Q7	8	Red	
24 V A	9+10	Black	24 V power supply for outputs
24 V B	21+22	White-pink	24 V power supply for inputs
GND A	11	Brown-pink	0 V power supply for outputs
GND A	12	Purple	0 V power supply for outputs
GND B	23+24	White-blue	0 V power supply for inputs

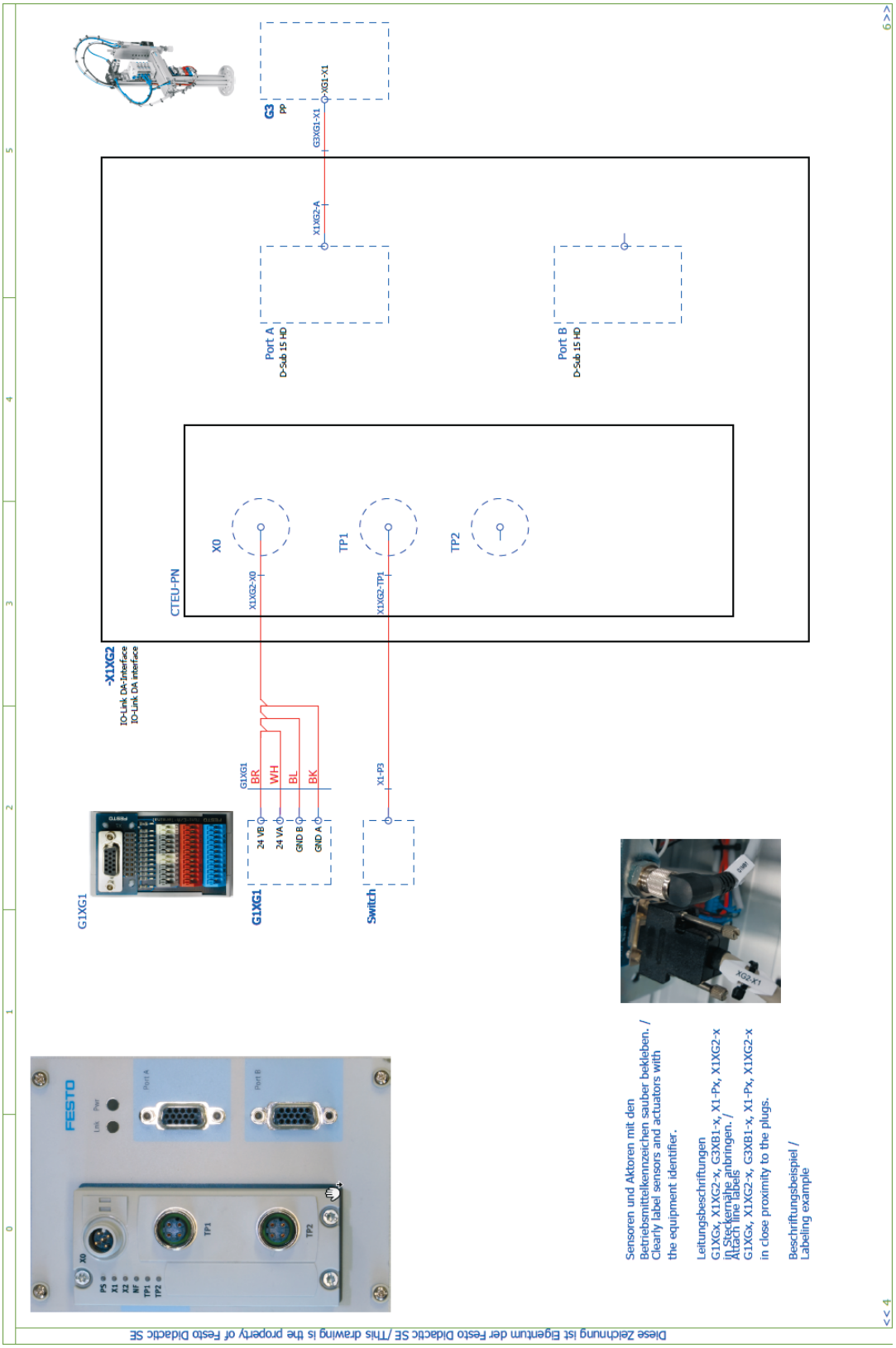
Note

Cable jumpers are connected from emergency off to bit 1.5 for all standard PLC versions.

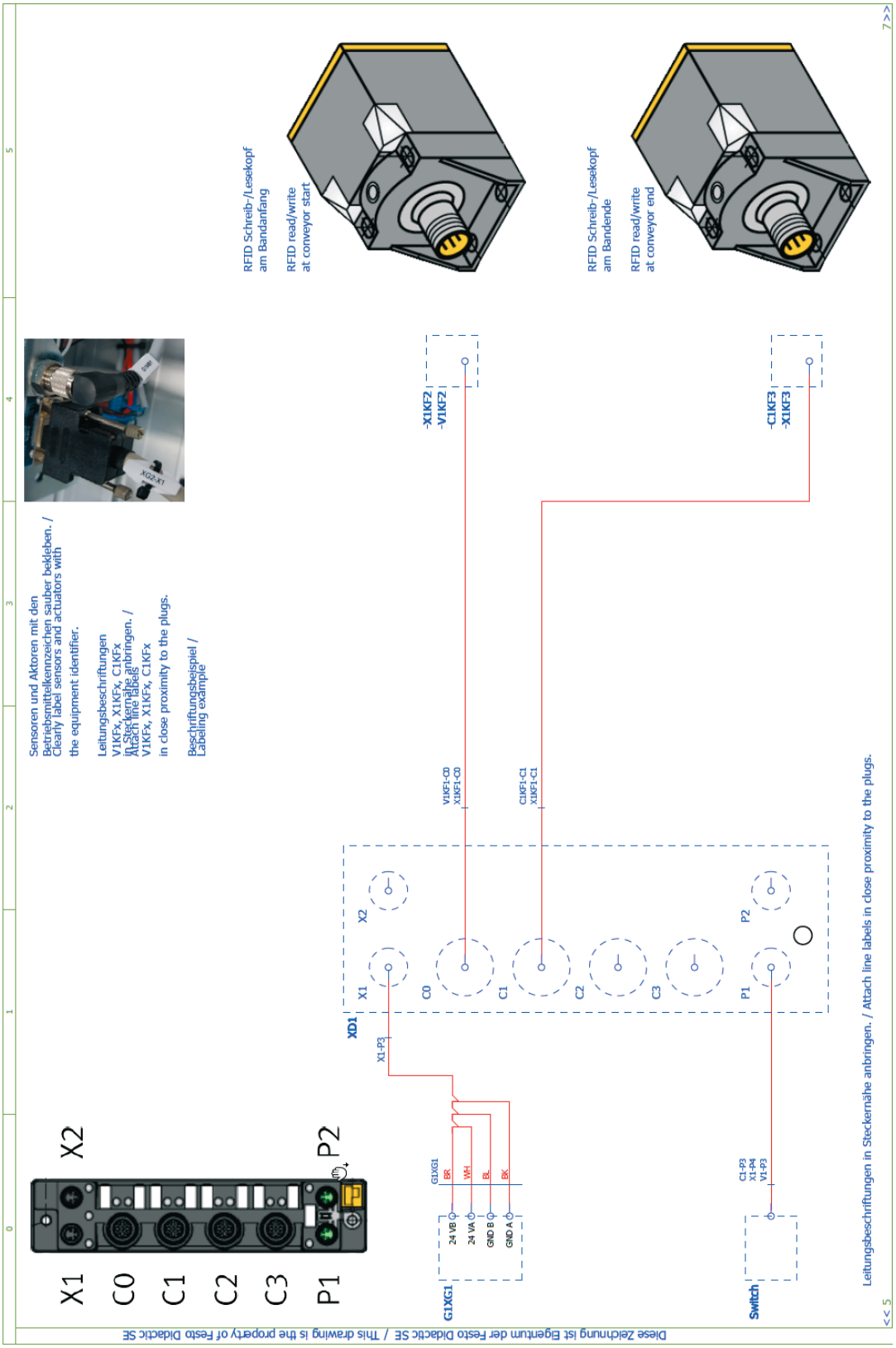
Circuit diagram System 203 I4.0: Signal column



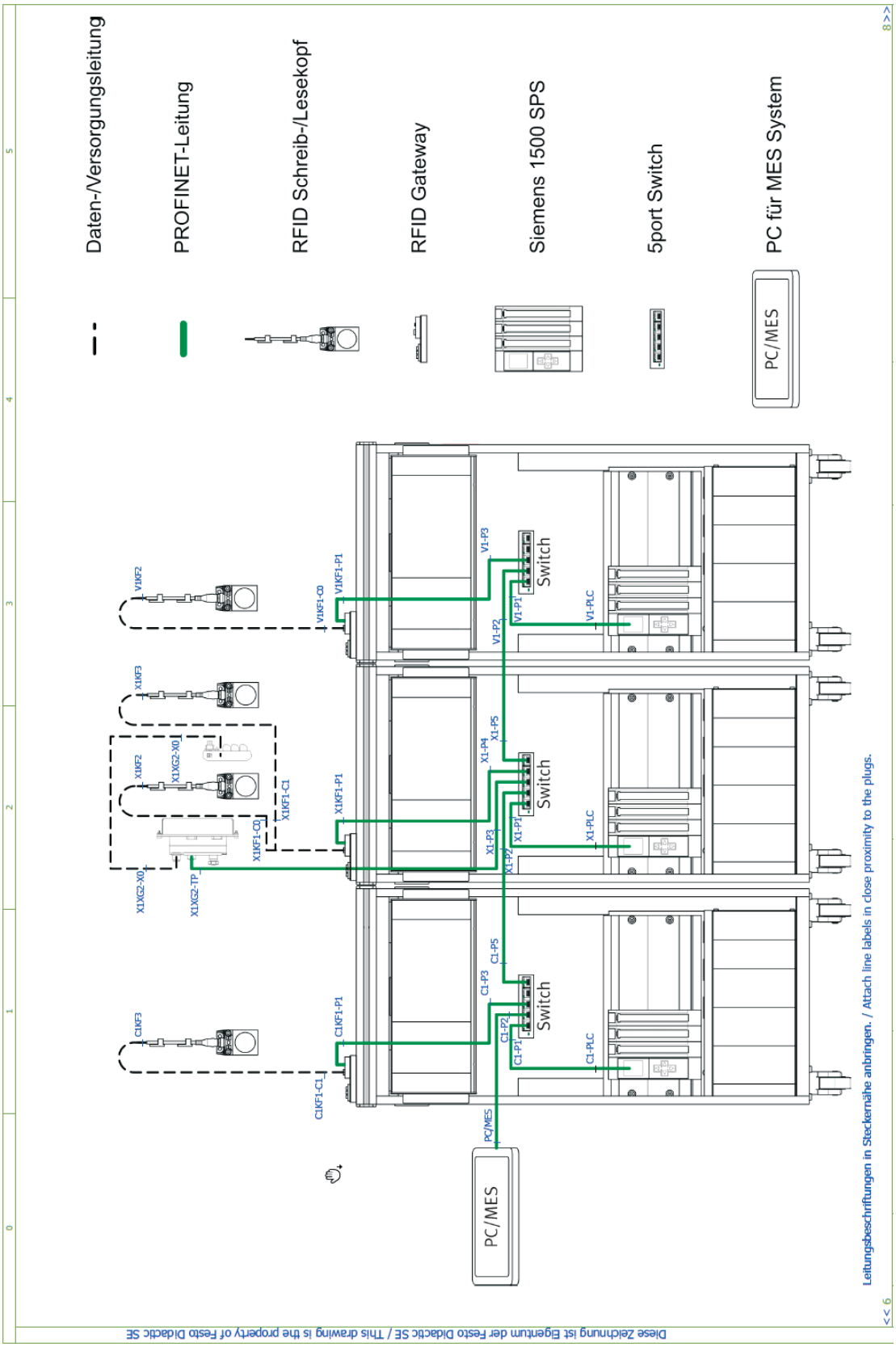
Circuit diagram System 203 I4.0: Joining station -X1XG2



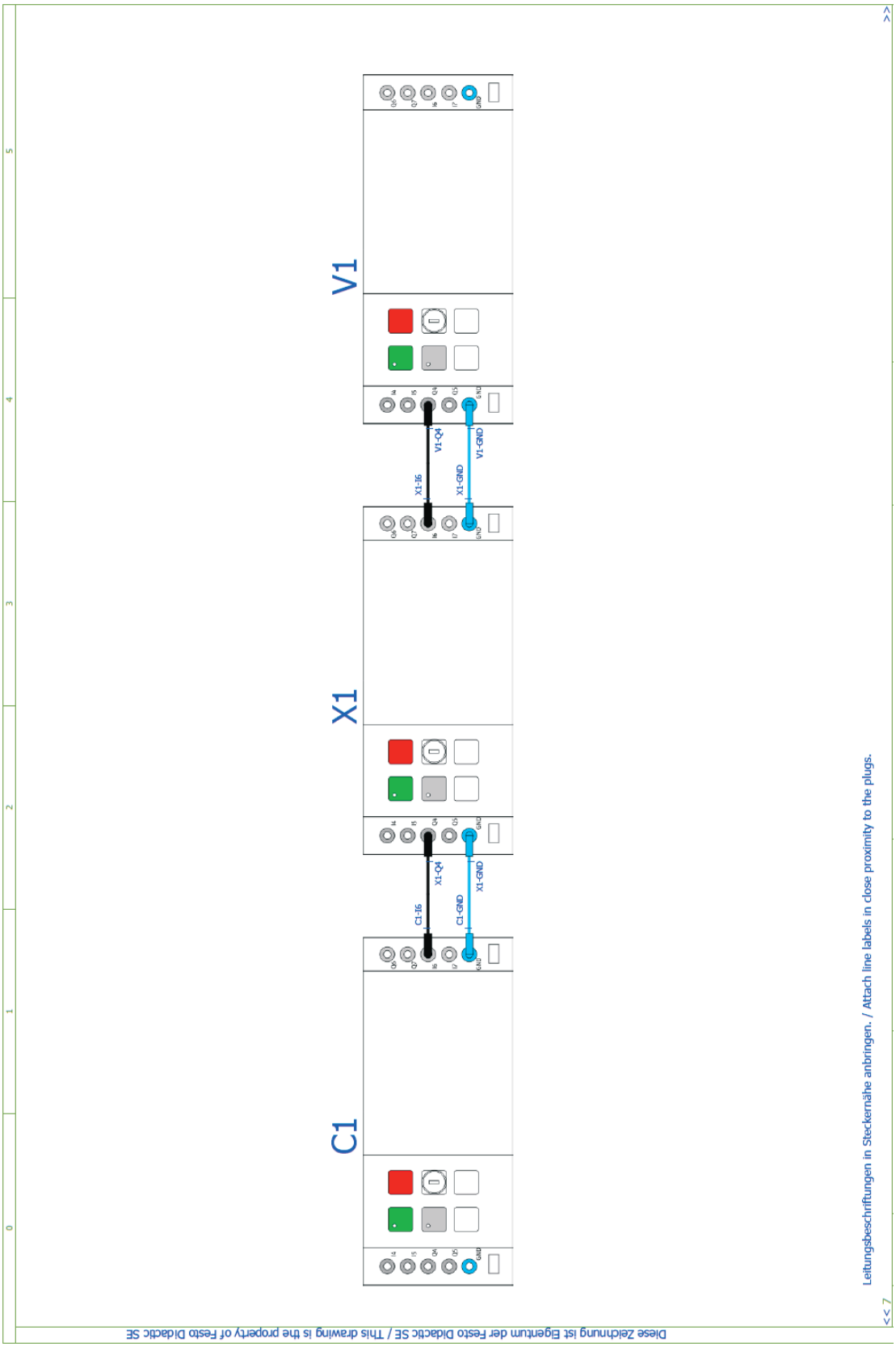
Circuit diagram System 203 I4.0: RFID



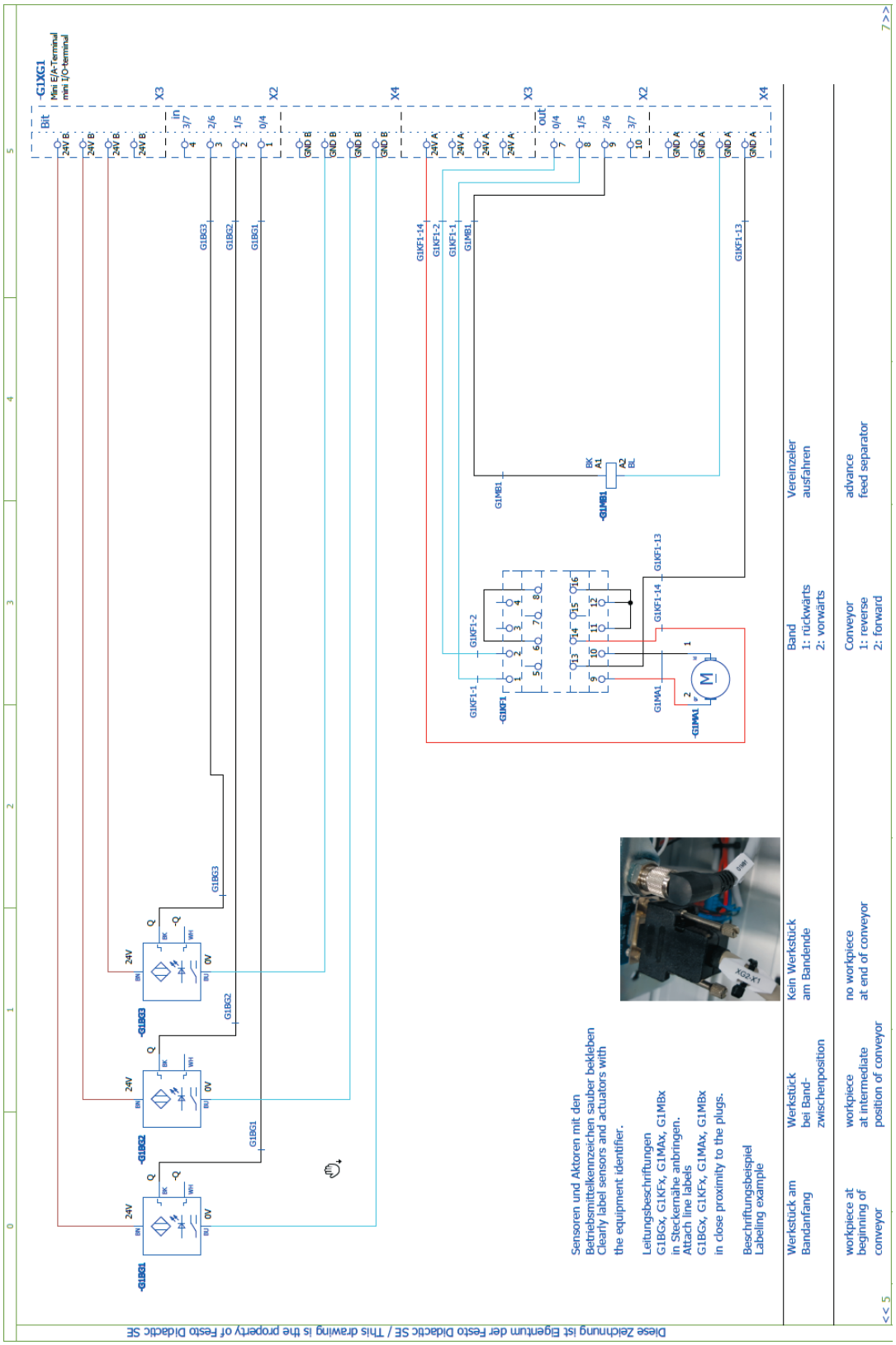
Circuit diagram System 203 I4.0: Siemens network



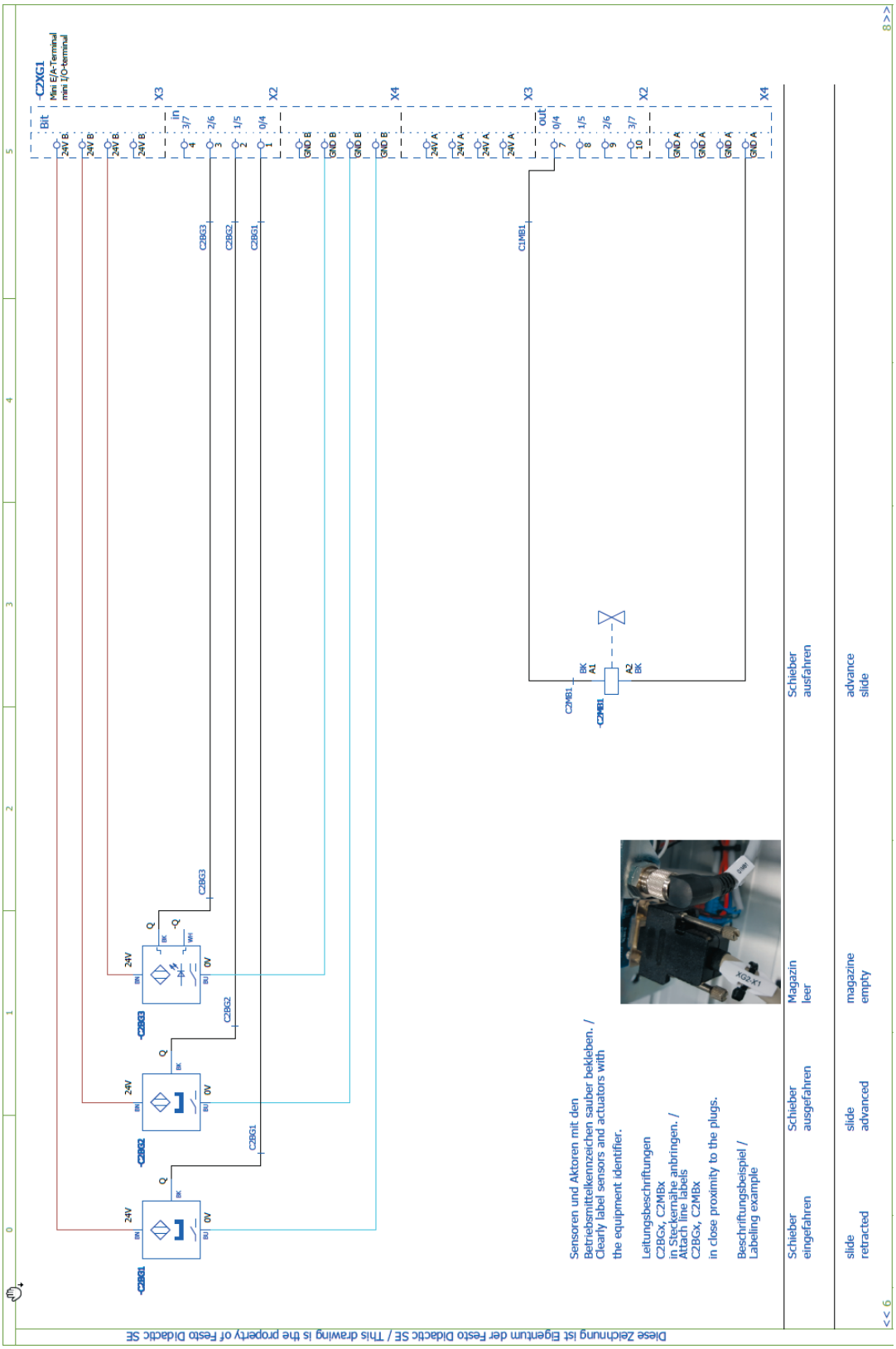
Circuit diagram System 203 I4.0: Siemens 1-bit communication



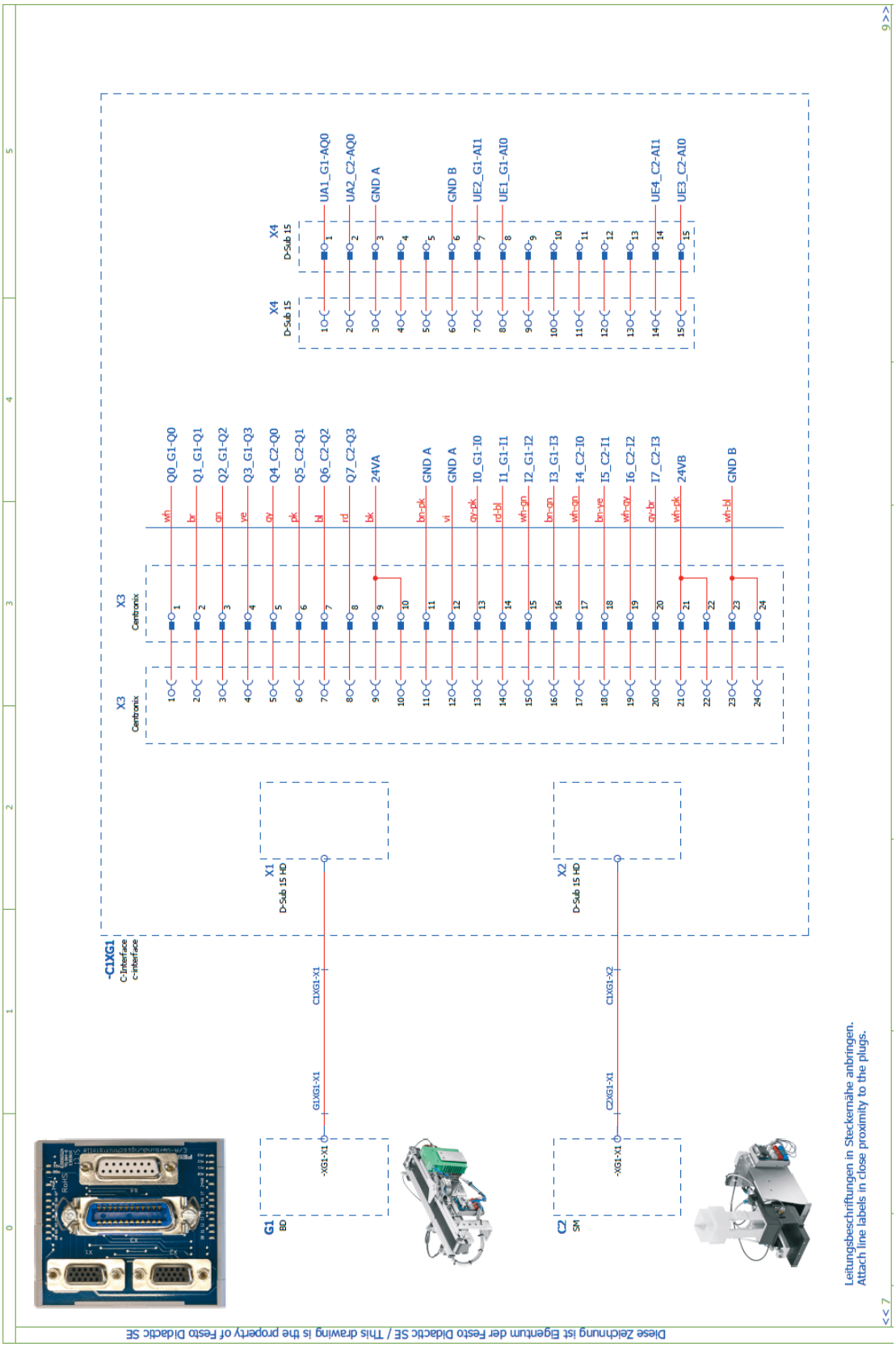
Circuit Diagram, Distributing/Conveyor Station: Conveyor Module



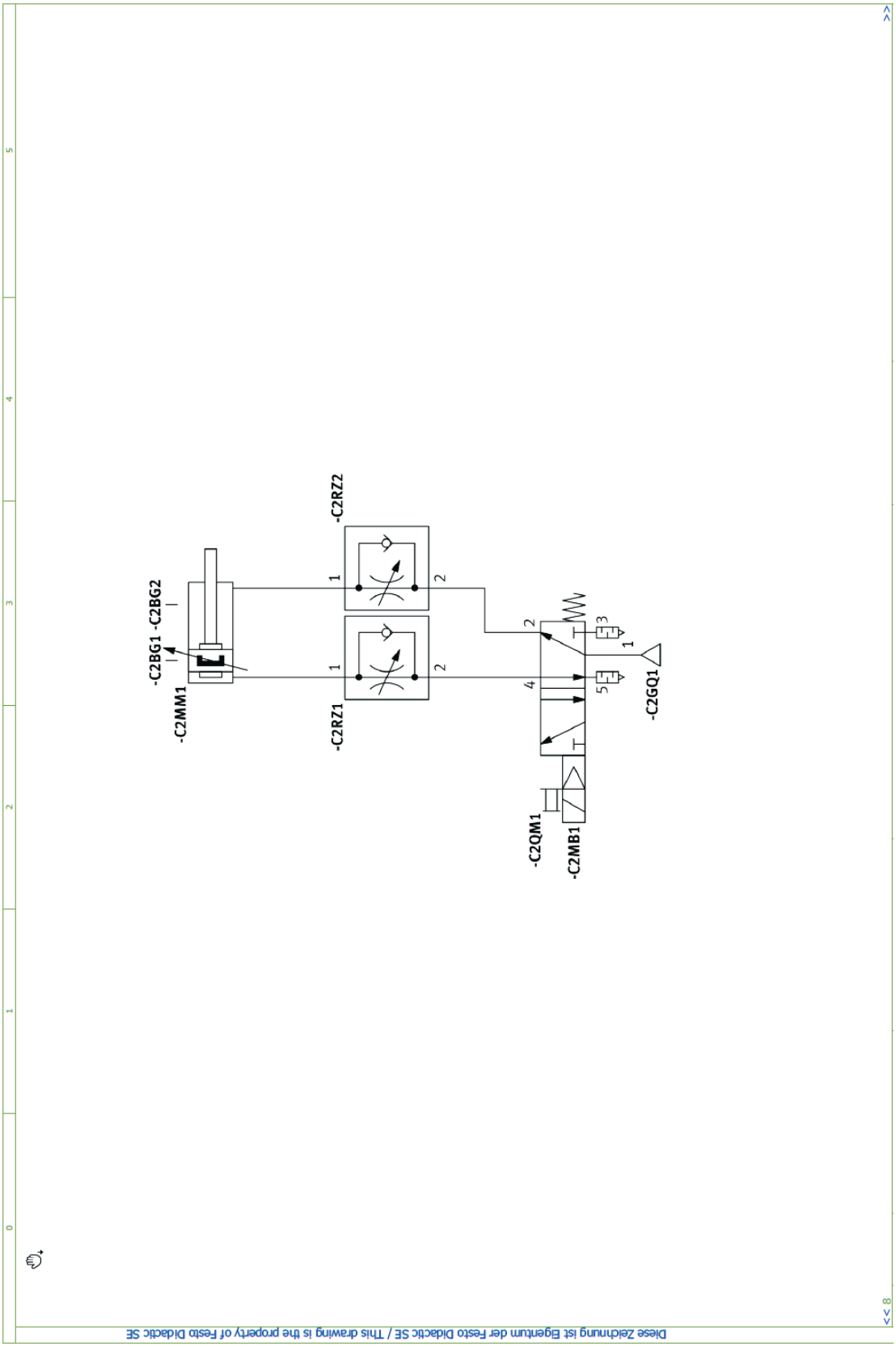
Circuit Diagram, Distributing/Conveyor Station: Stacking Magazine Module



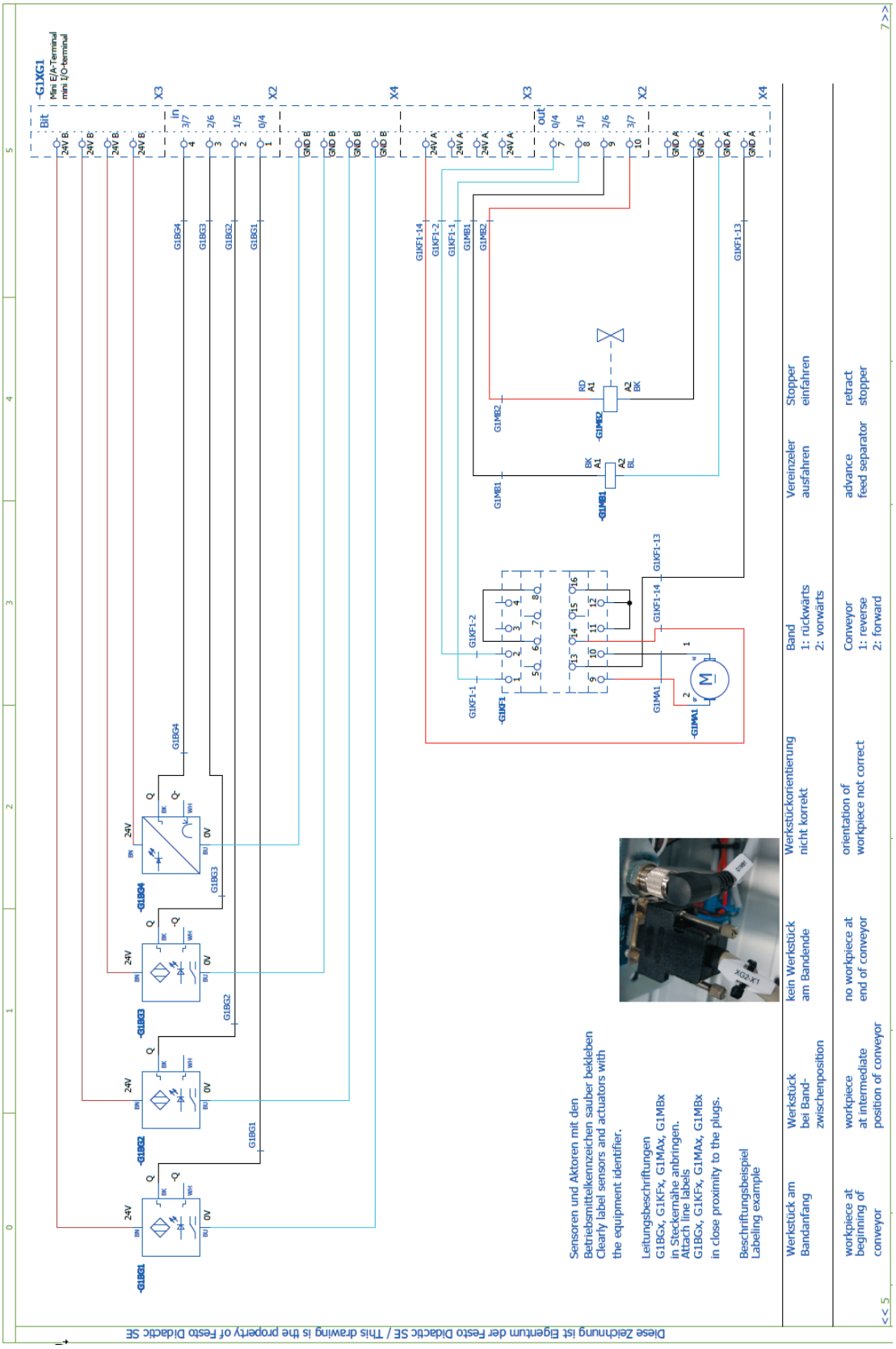
Circuit Diagram, Distributing/Conveyor Station: C-Interface



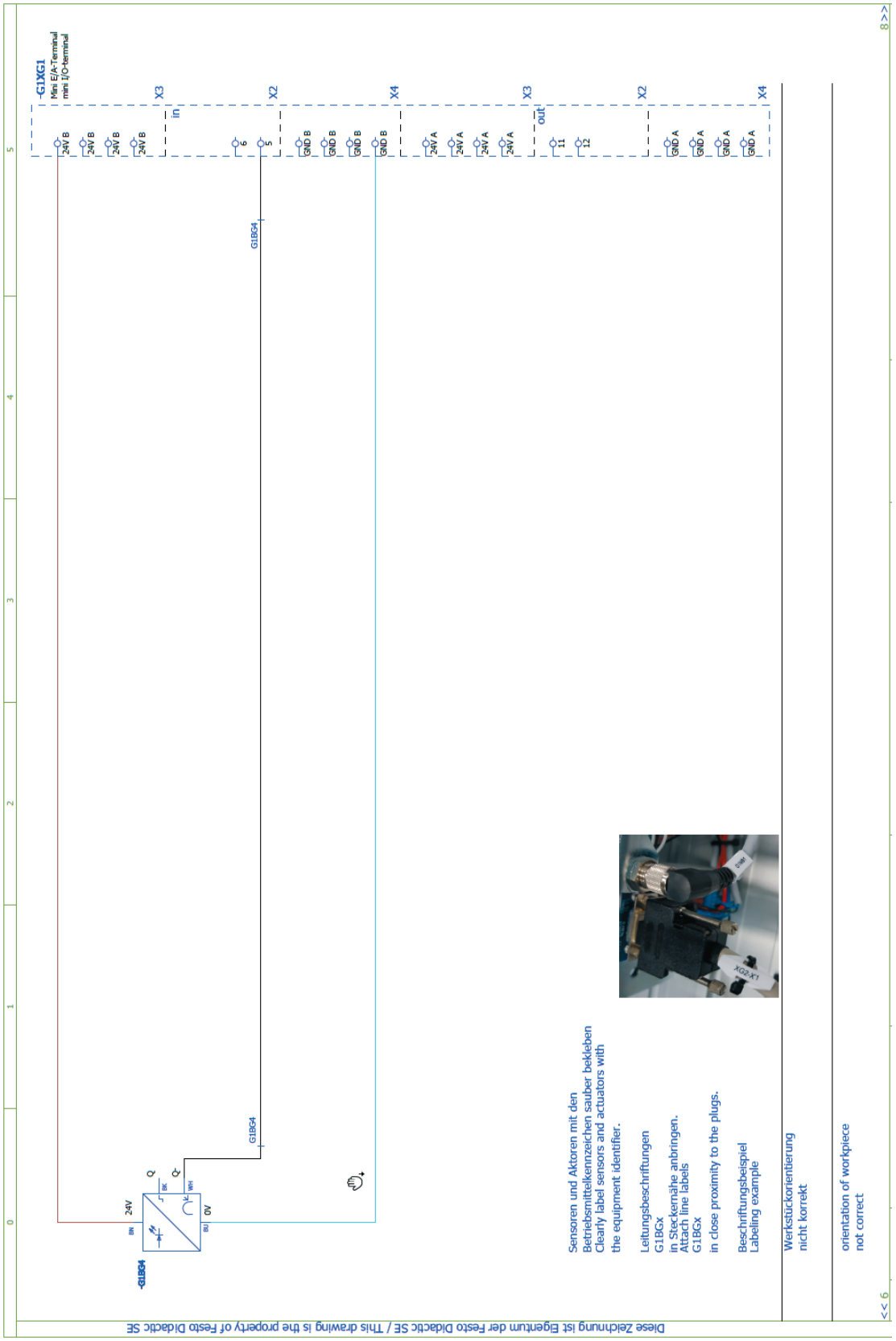
Pneumatic Circuit Diagram, Distributing/Conveyor Station: Stacking Magazine Module



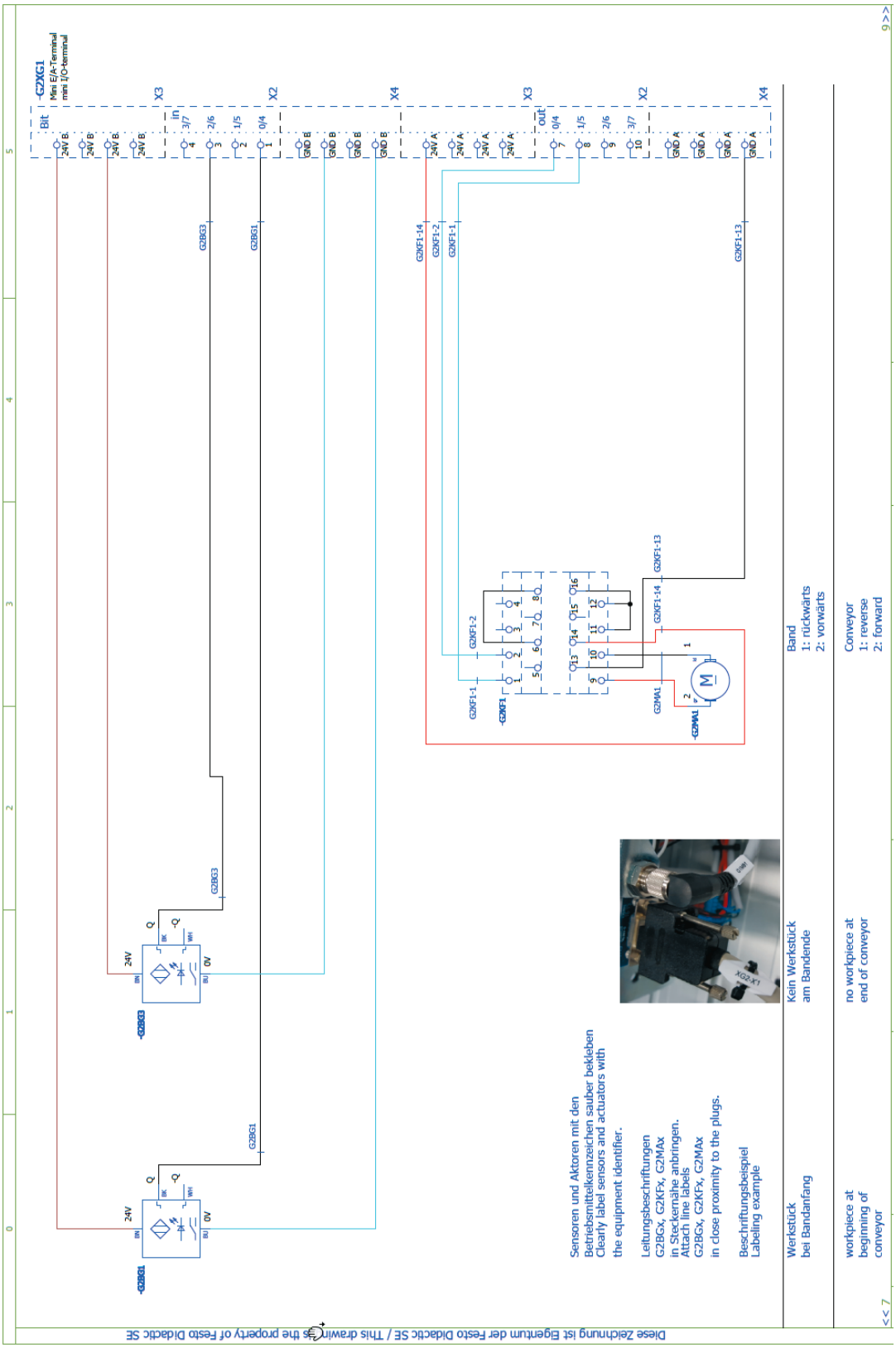
Circuit Diagram, Joining Station: Conveyor Module 1, digital



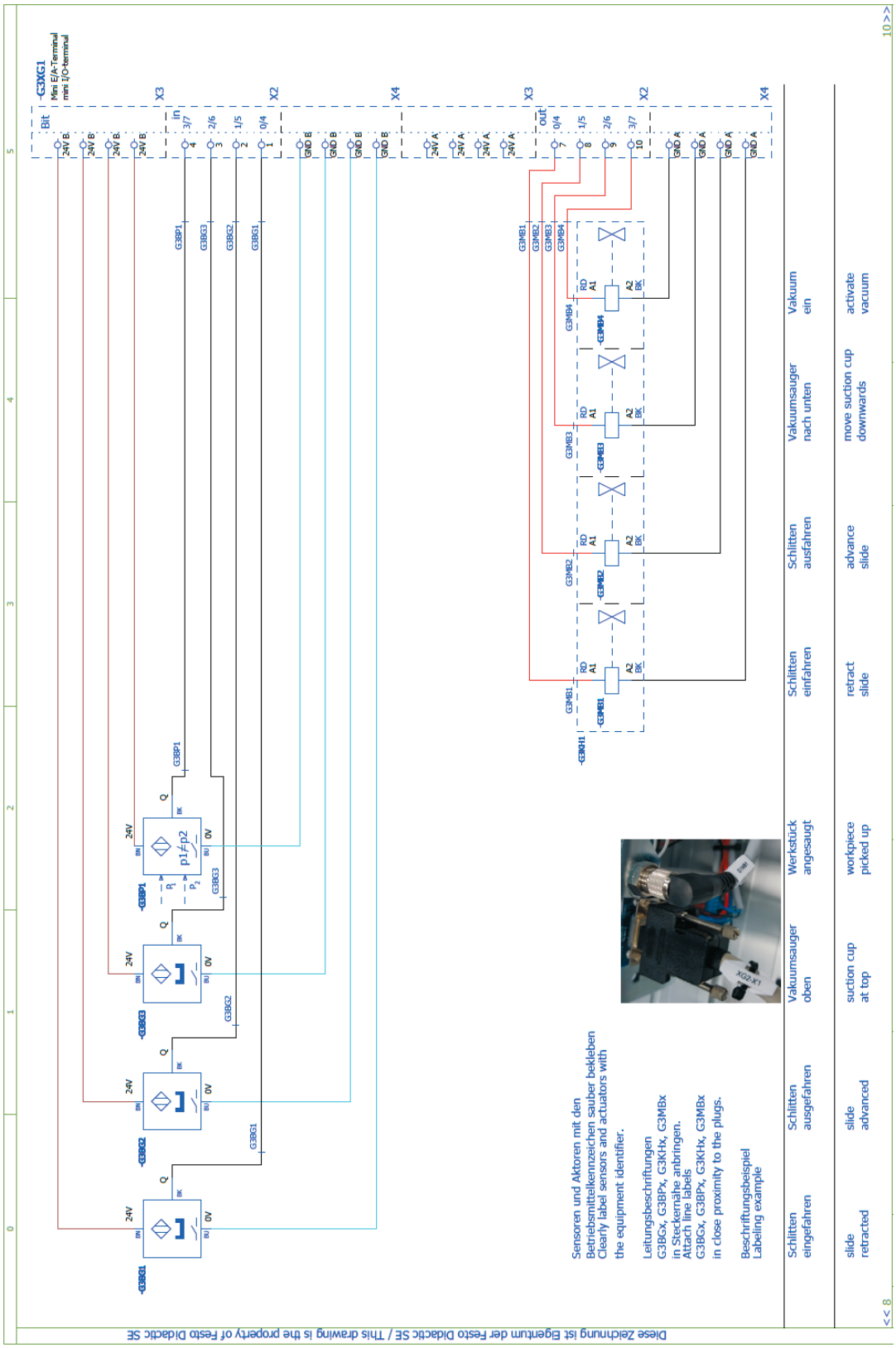
Circuit Diagram, Joining Station: Conveyor Module 1, analog



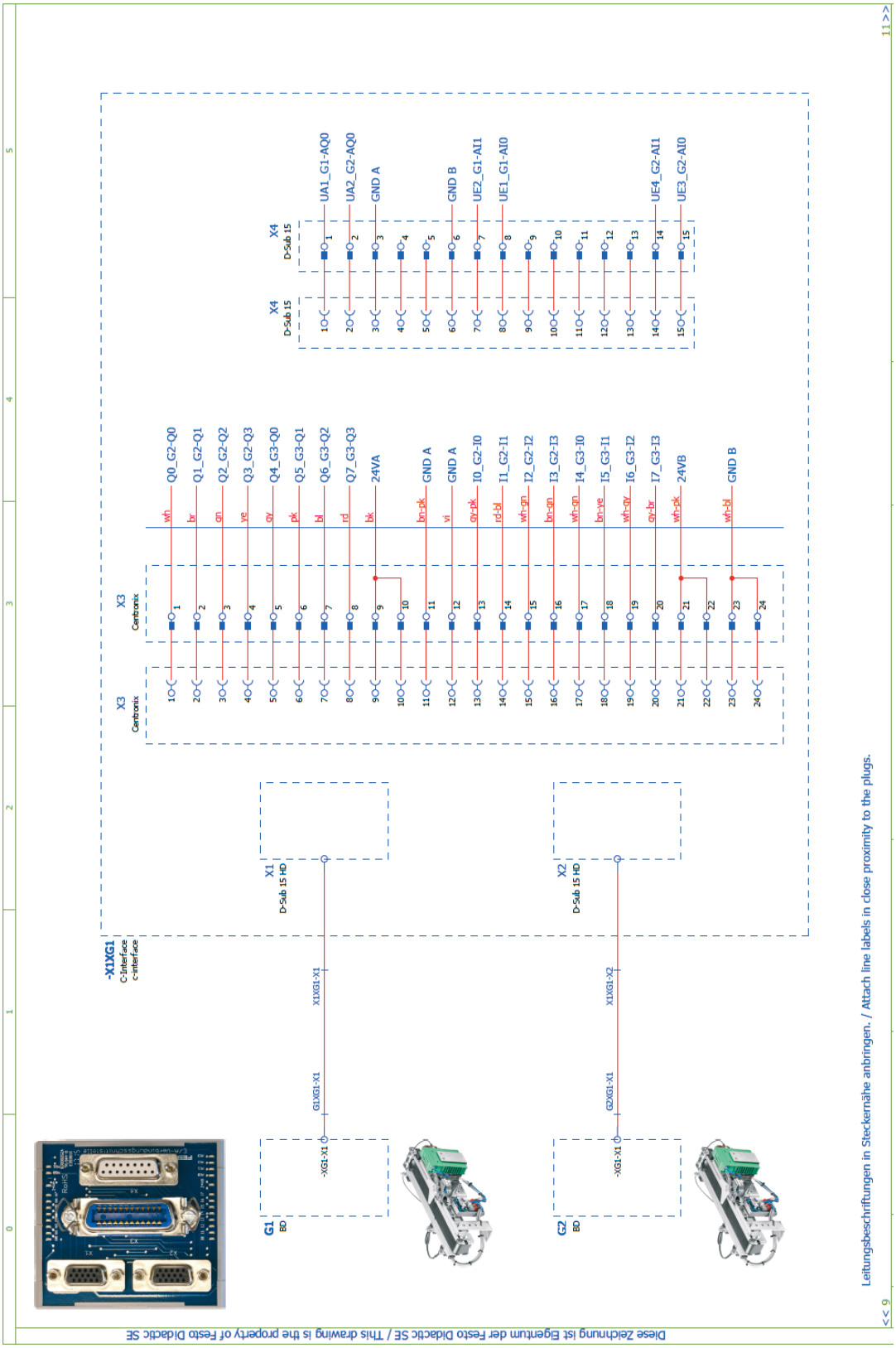
Circuit Diagram, Joining Station: Conveyor Module 2, digital



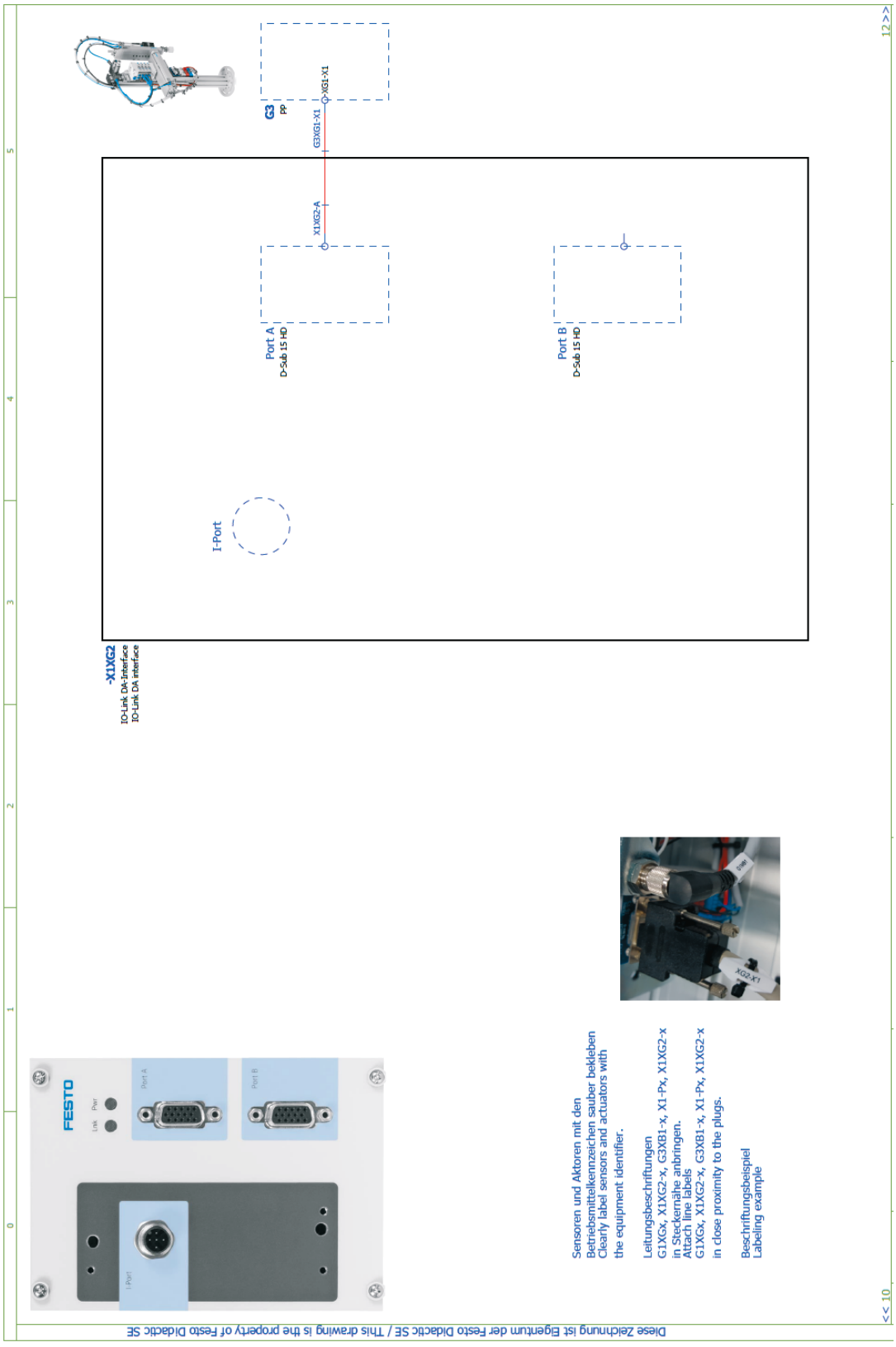
Circuit Diagram, Joining Station: Pick&Place Module



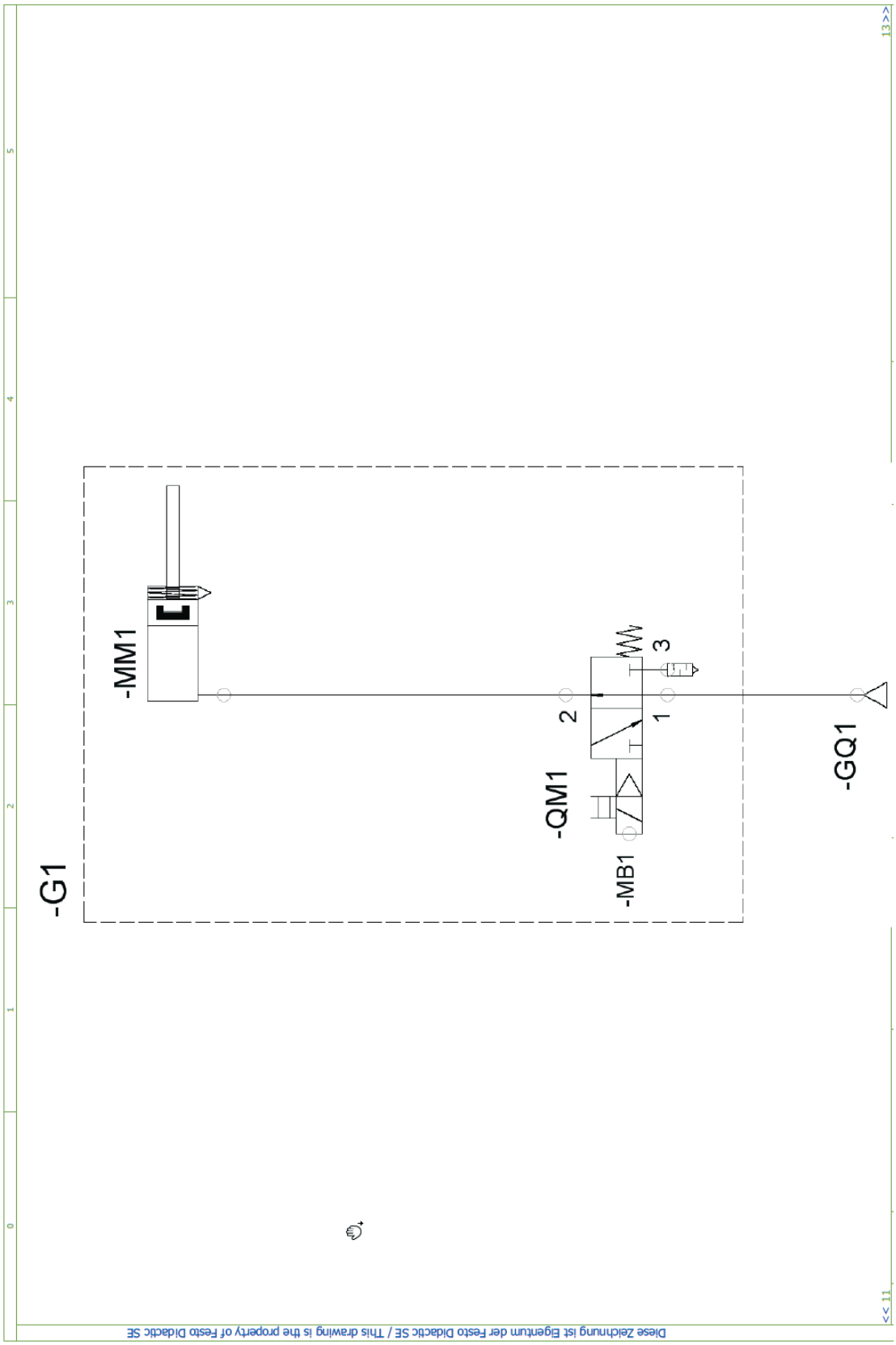
Circuit Diagram, Joining Station: C-Interface



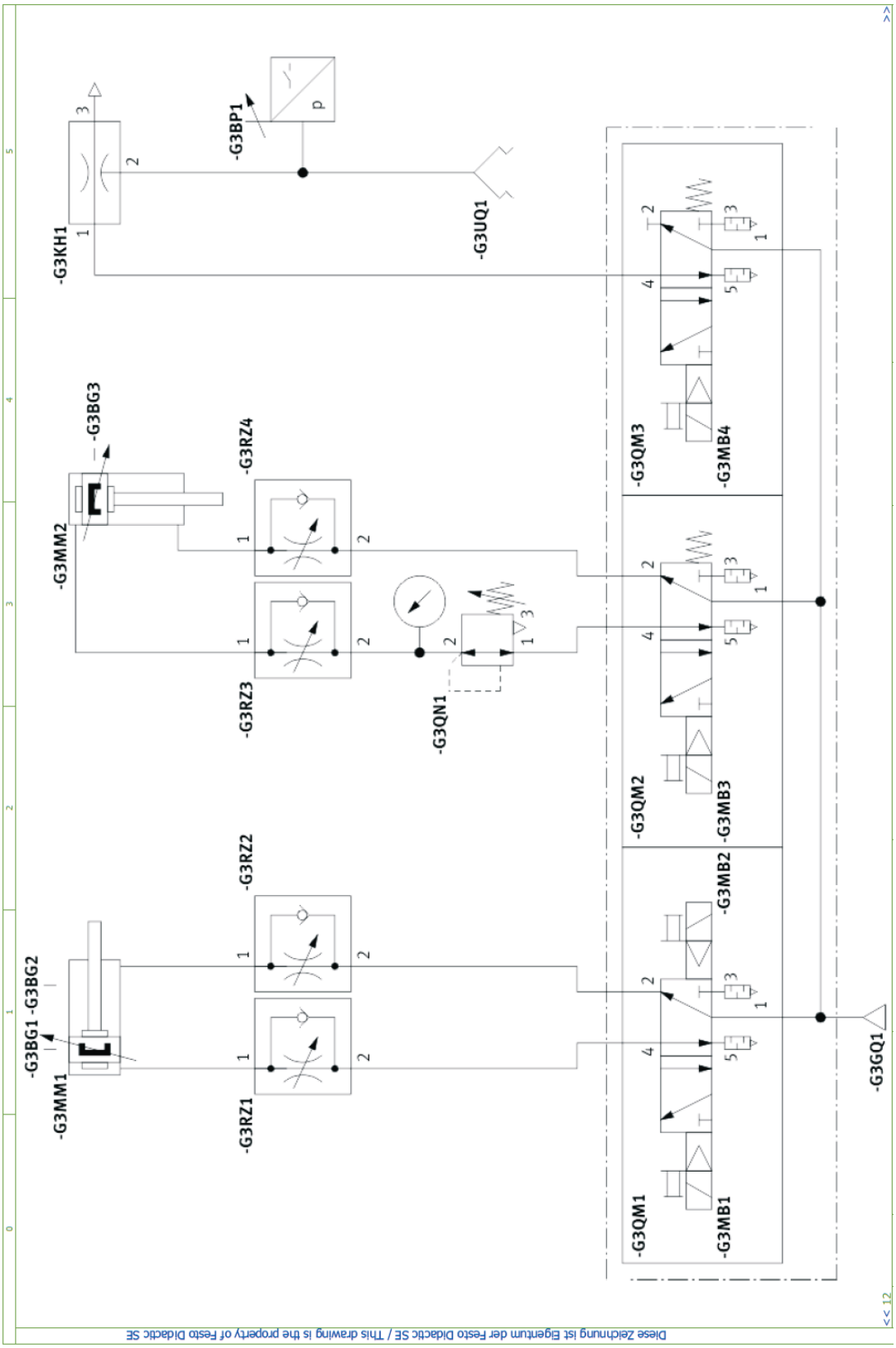
Circuit Diagram, Joining Station: IO-Link Interface



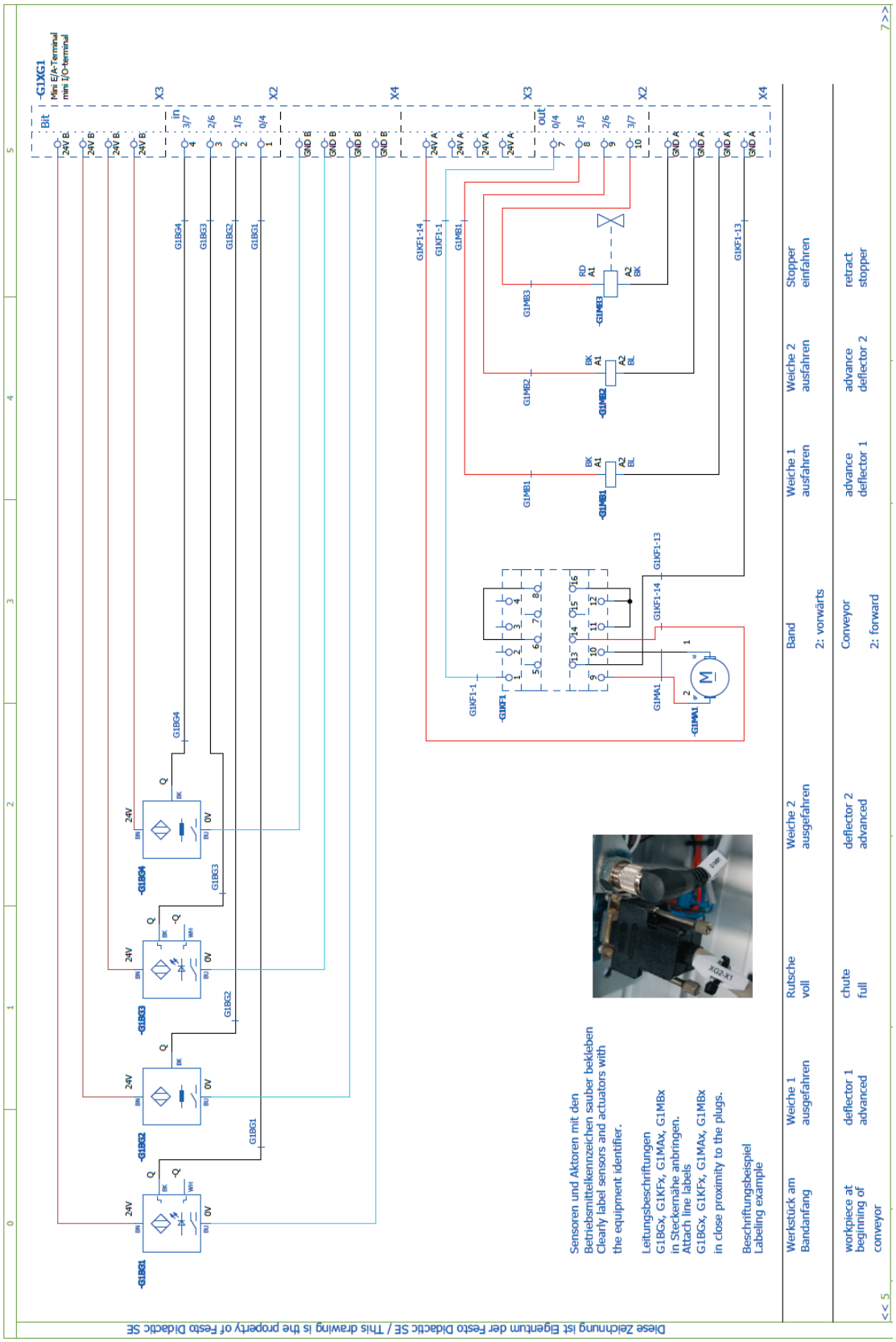
Pneumatic Circuit Diagram, Joining Station: Conveyor Module 1



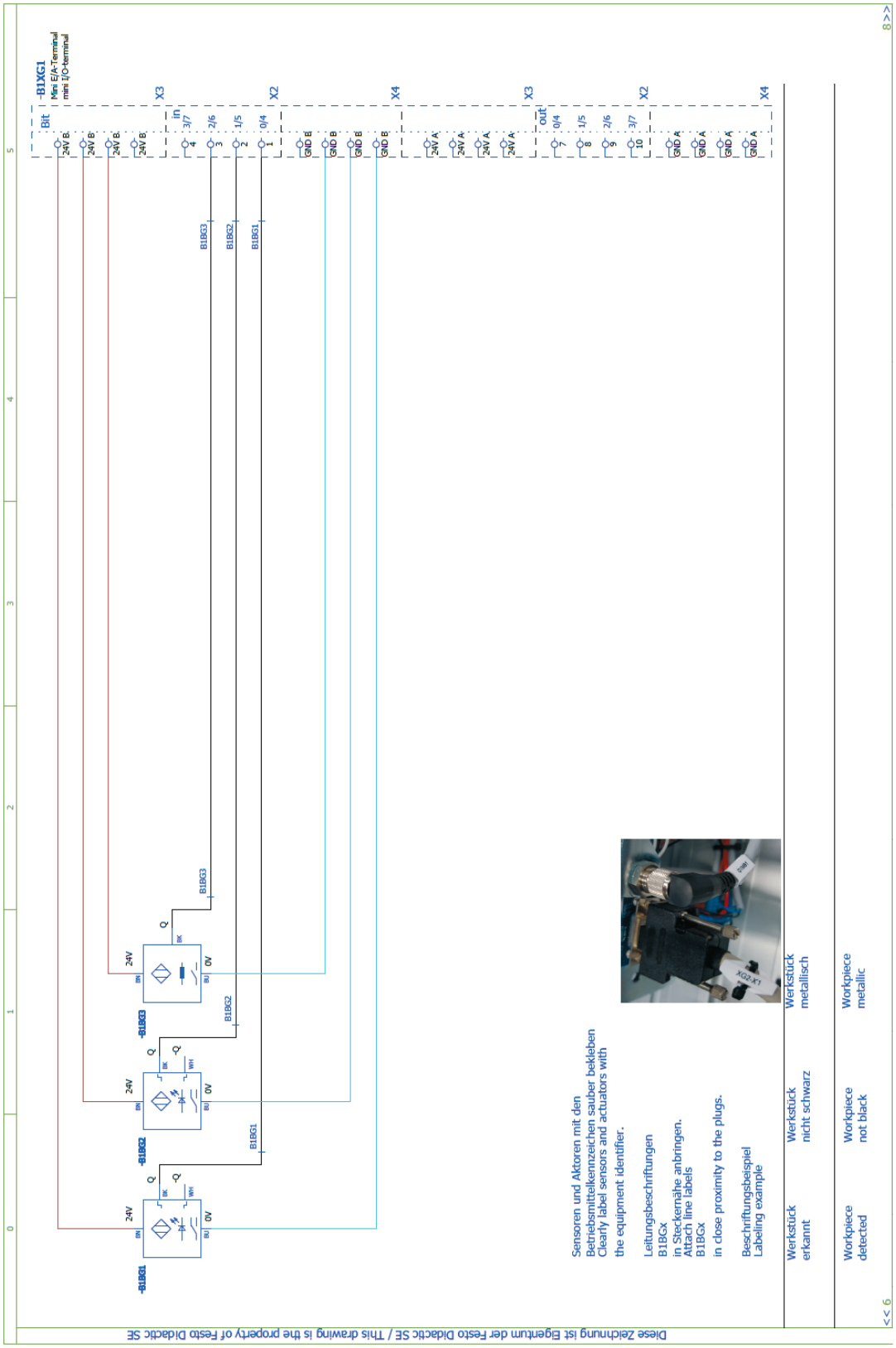
Pneumatic Circuit Diagram, Joining Station: Pick&Place Module



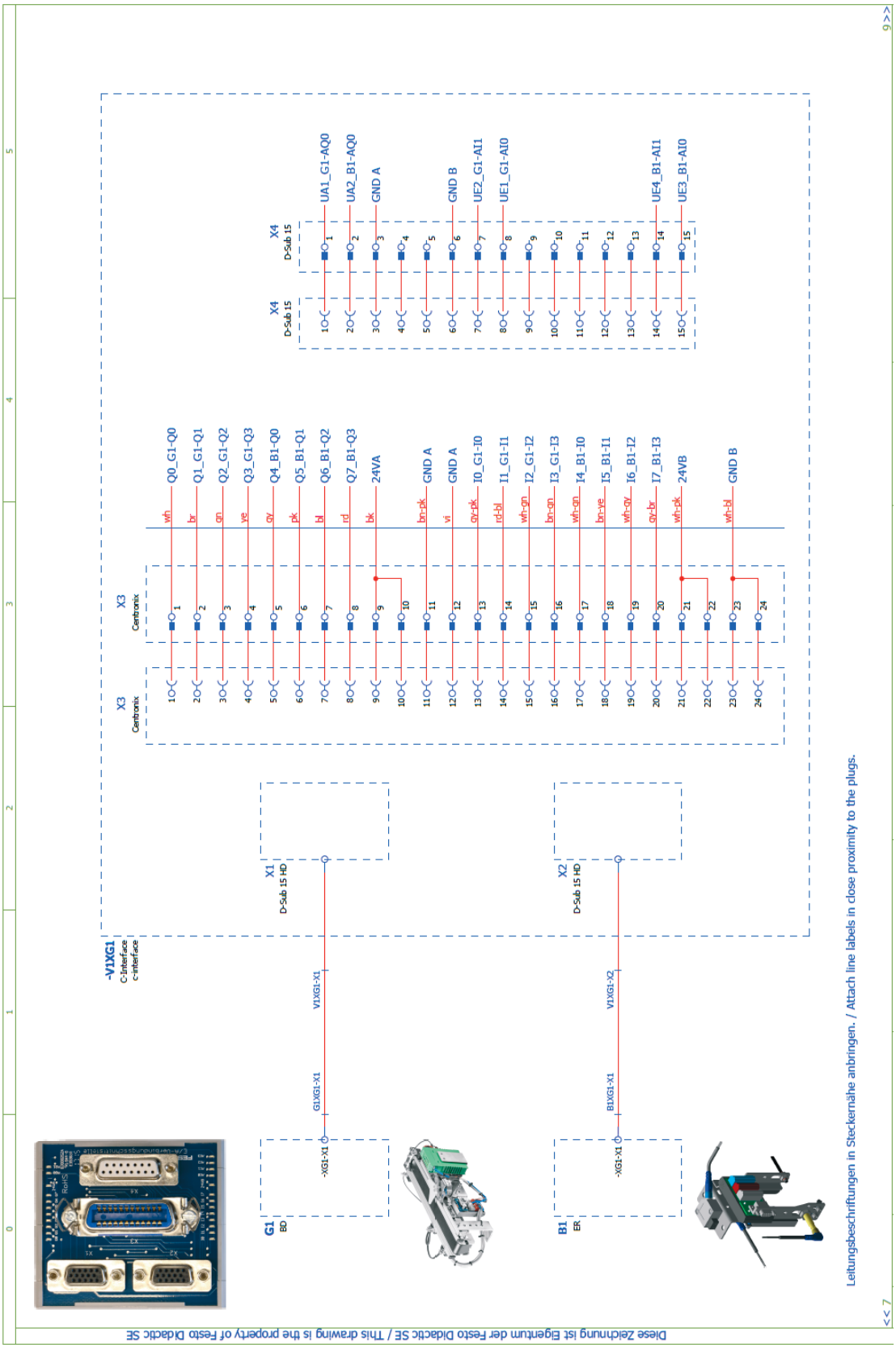
Circuit Diagram, Sorting Station: Conveyor Module



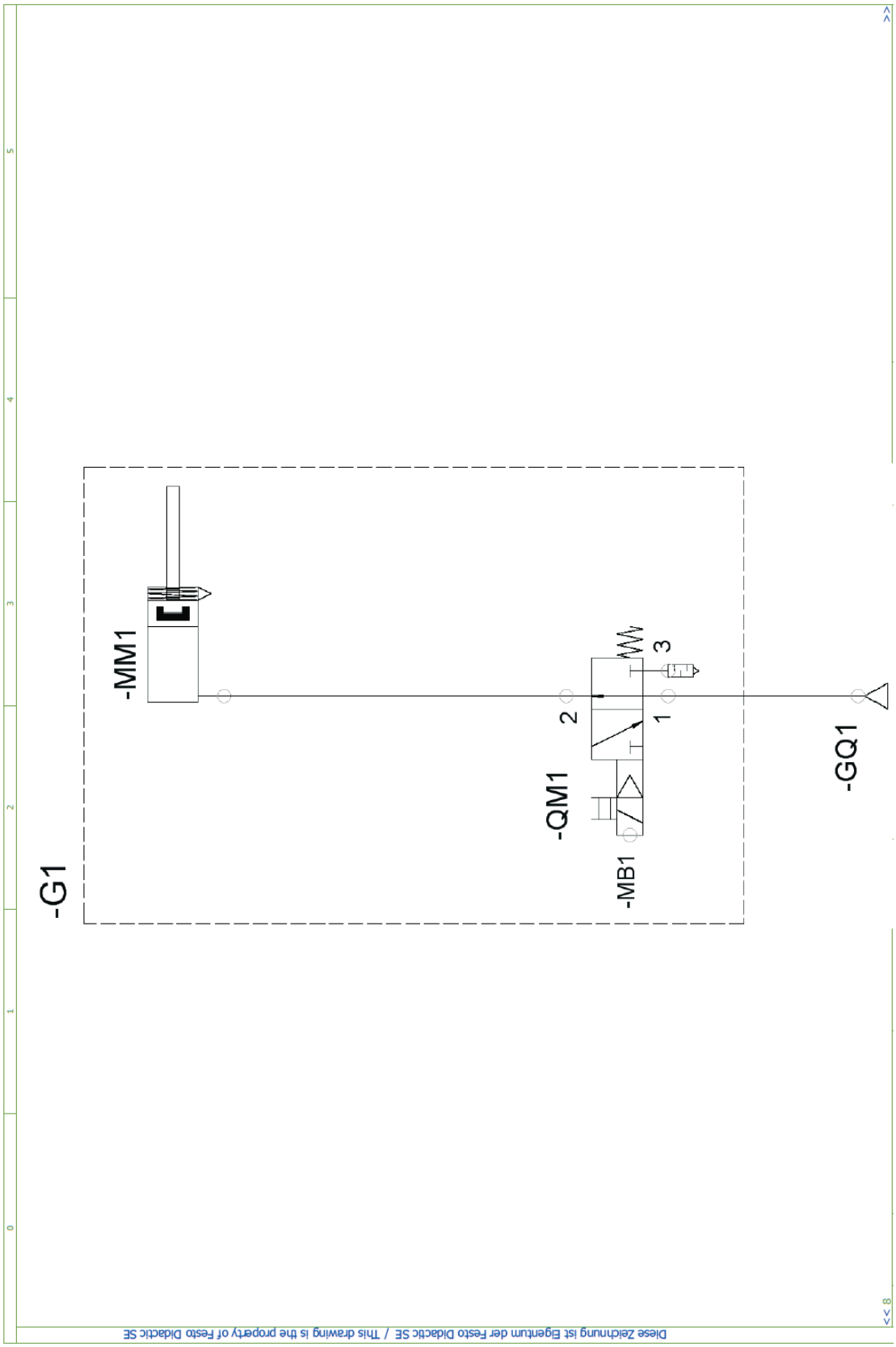
Circuit Diagram, Sorting Station: Detection Module



Circuit Diagram, Sorting Station: C-Interface



Pneumatic Circuit Diagram, Sorting Station: Conveyor Module 1



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