Project 04: Handling system with Profibus

1. Informing

Project definition

A conveyor belt successively transports two parts of one component, which belong together, but are to be machined at different positions. After machining the parts are to be placed down in the same order for removal.
In the event of an electricity failure, the X-axis is to stop immediately, the Y- and Z-axis are to retract to their end positions, and the gripper is to maintain its position.
Together with the handling system, the valves are to form a decentralized unit, which is to be controlled by a central PLC L20.
The installation of the complete system is to be designed so that further decentralized units can be added without any difficulties.

Preconditions

To be able to solve this task, you must have a knowledge of pneumatic and electro-pneumatic controls, basic knowledge of the operating principle of a PLC, understand bus systems and apply the findings from Project 03..

Learning objectives

- Working out a sequence control for handling systems.
- Use of valve clusters.
- Use of PLCs for electrical controlling.
- Establishment of pneumatic and electrical connections.
- Profibus-DP installation.

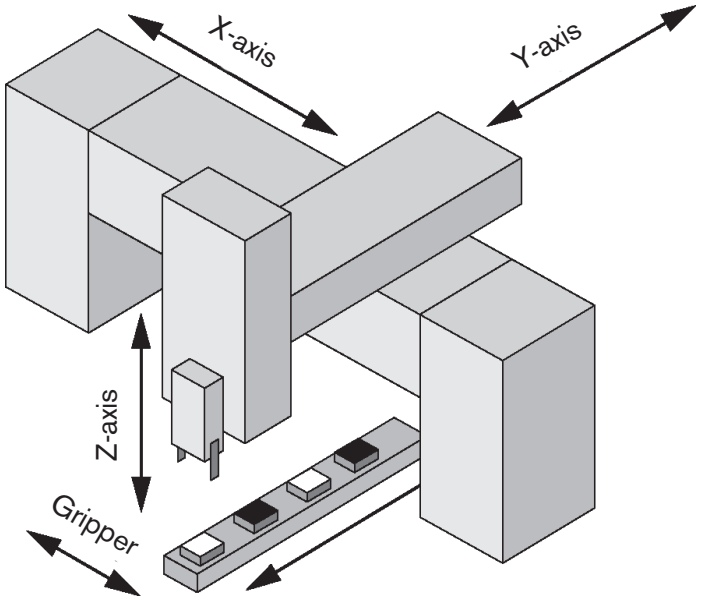


Fig. 04-1: Structure of the handling system

2. Planning

- Select the components.
- Determine the axes of the area gantry as well as the starting position.
- Assign cylinders to the axes.
- Work out and optimize the sequence in tabular form.
- Supplement the pneumatic circuit diagram.
- Create assignment tables for inputs and outputs of the PLC.
- Represent the sequence of the GRAFCET diagrams.
- Install Profibus-DP.
- Set up and test circuit.

3. Decision-making

Task 1:

n view of the tasks, the following components should be used, among others:

- Handling system with 3 axes and gripper
- Valve carrier system with central plug-in connector
- For the X-axis a 5/3 directional solenoid valve, blocked in the rest position
- For the Y-axis a 5/2 directional solenoid valve with spring return
- For the Z-axis a 5/2 directional solenoid valve with spring return
- For the gripper a 5/2 directional solenoid impulse valve

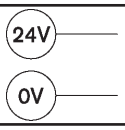
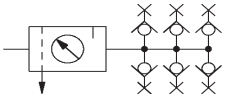
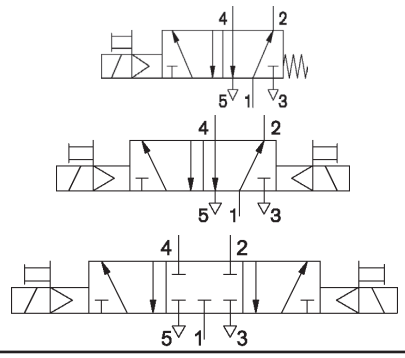
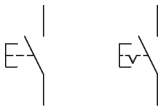
Item	Quantity	Designation	Symbol
1	1	Handling system with 3 axes and gripper	
2	1	PLC L20 with Profibus-DP master	
3	1	Power supply, 24 V	
4	1	Maintenance unit	
5	1 2 1 1	Valve carrier system with central plug-in connector and	
6	1	Distributor for power supply	
7	1	Switch/push-button box	
8	1	OUT-Box	
		PROFIBUS slave (RF-FLS PB M12 DIO 8 M12)	8 inputs / 8 outputs
9		Hoses	
10		Connection cable	

Fig. 04-2: Overview of components

Task 2:

FDetermination of the positions to be approached according to Fig. 04-3 as well as of the start-up conditions..

- Position for the provision of parts = parts pick-up from the conveyor belt or starting position.
- Machining position 1 = machining of part 1.
- Machining position 2 = machining of part 2.
- Place position for removal of parts.
- At the starting position, all cylinders are _____ (X0, Y0, Z0)

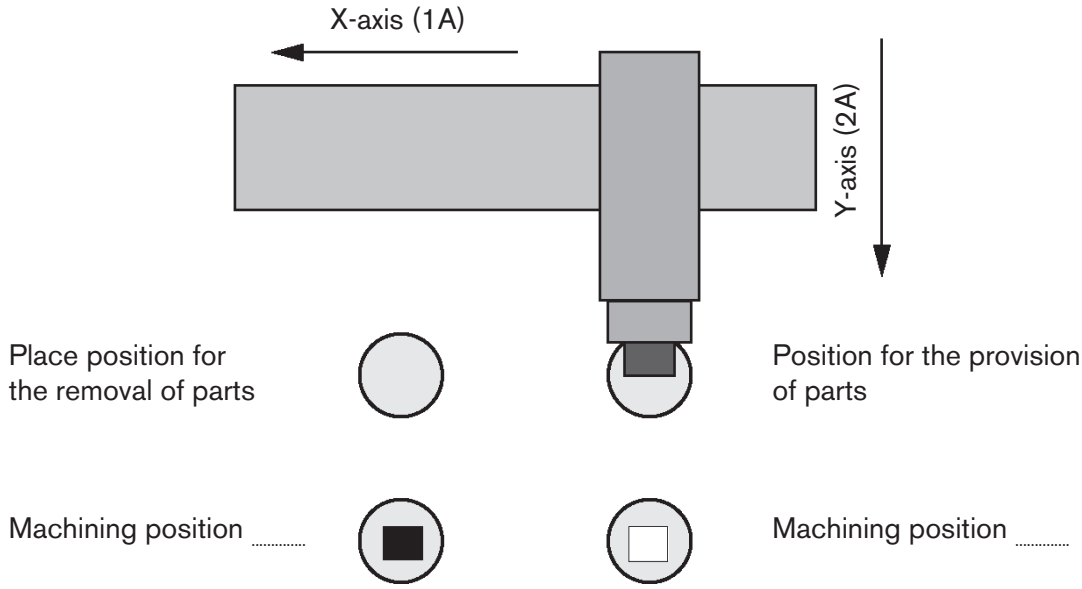


Fig. 04-3: Location of the individual positions

Task 3:

Assignment of cylinders to the axes according to Fig. 04-3 and 04-6

- X-axis = cylinder ____, Y-axis = cylinder ____, Z-axis = cylinder ____, gripper = cylinder ____.

Task 4:

Enter sequence 1-4 for approaching each position in the table taking account of the following conditions.

- Parts are in machining position 1 and 2, machining is completed.
- Every sequence starts and ends in the starting position (all cylinders are retracted).
- Only one axis movement is performed per step.
- The short code is to be used for the pneumatic cylinders, e.g. “1A+“ for the extension of the X-axis.

Step	Sequence 1: Transport from machining position 1 to the place position	Sequence 2: Transport from the feed position to machining position 1	Sequence 3: Transport from machining position 2 to the place position	Sequence 4: Transport from the feed position to machining position 2
01	2A +			
02	3A +			
03	4A +			
04	3A -			
05				
06				
07				
08				
09				
10				

Fig. 04-4 Sequence (long, 38 steps)

Task 5:

Optimize sequence 1-4 from the table (Fig. 04-4) taking account of the following positions.

- Parts are in machining positions 1 and 2, machining is completed.
- The first sequence starts in the starting position (all cylinders are retracted).
- The last sequence ends in the starting position.
- One or two axes may be moved per step.
- The short code is to be used for the pneumatic cylinders, e.g. “1A+“ for the extension of the X-axis.

Step	Sequence 1: Transport from machining position 1 to the place position	Sequence 2: Transport from the feed position to machining position 1	Sequence 3: Transport from machining position 2 to the place position	Sequence 4: Transport from the machining position to machining position 2
01	2A +			
02	3A +			
03	4A +			
04	3A -			
05	2A - / 1A +			
06				
07				
08				
09				
10				

Fig. 04-5 Sequence (optimized, 33 steps)

Task 6:

Supplement pneumatic circuit diagram

- Add designations of solenoid coils.
- Add designations of cylinder switches..

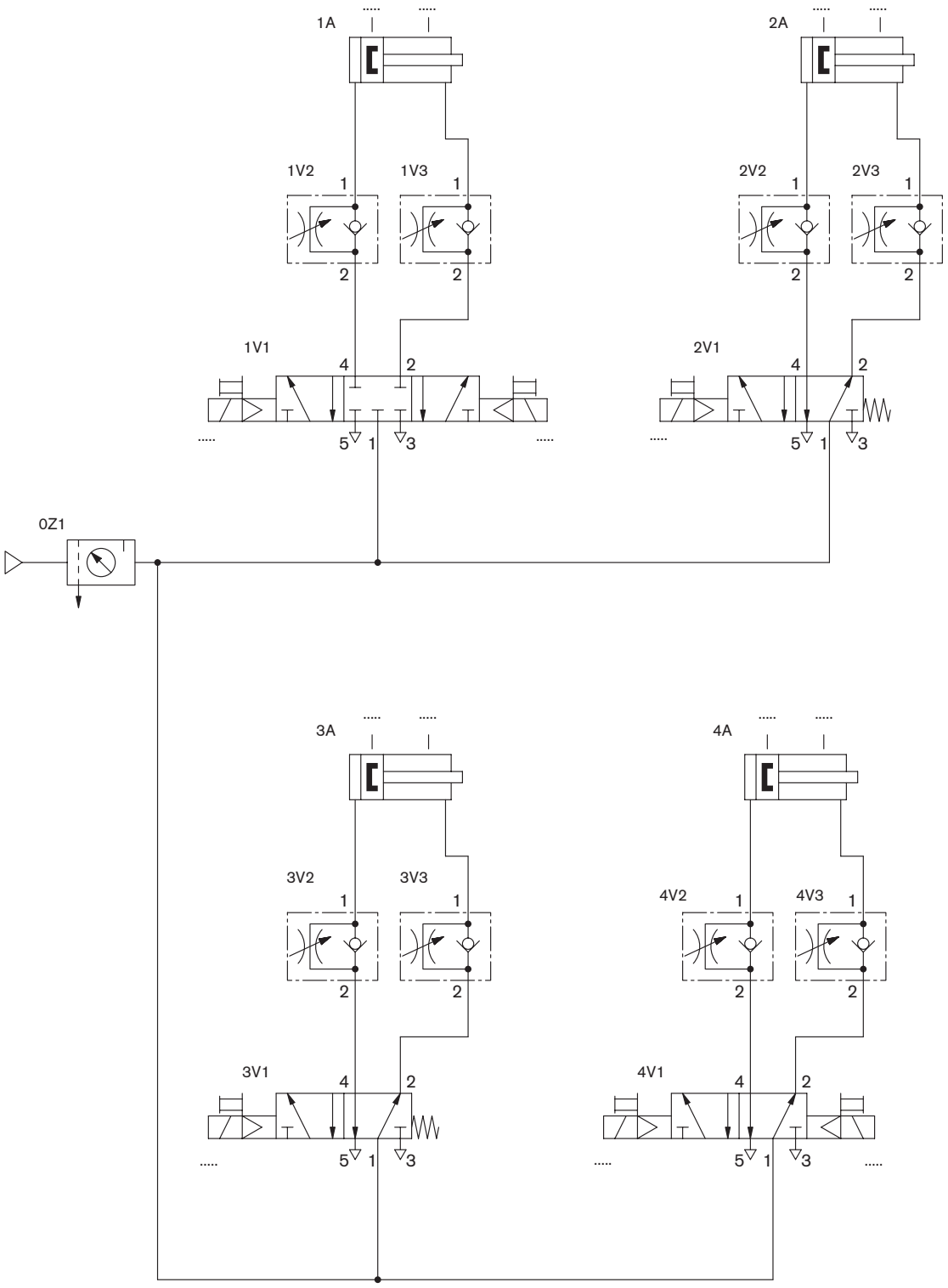


Fig 04-6: Pneumatic circuit diagram

Task 7:

Supplement the assignment table for the inputs used of the PLC taking account of the information from Fig. 04-6.

Input	Designation	Cable #	Description
IX1.0	S1		Push-button “Start“
IX1.1	S2		Push-button “Reset“
IX1.3	+24 V		Program selection for Profibus
IX6.0	B1	1 + 2	X-axis retracted
IX6.1		1 + 2	X-axis extended
IX6.2		3 + 4	Y-axis retracted
IX6.3		3 + 4	Y-axis extended
IX6.4		5 + 6	Z-axis retracted
IX6.5		5 + 6	Z-axis extended
IX6.6		7 + 8	Gripper open
IX6.7		7 + 8	Gripper closed

Fig. 04-7: PLC inputs

Task 8:

Supplement assignment table for the outputs used of the PLC taking account of the information from Fig. 04-6 and Fig. 04-8.

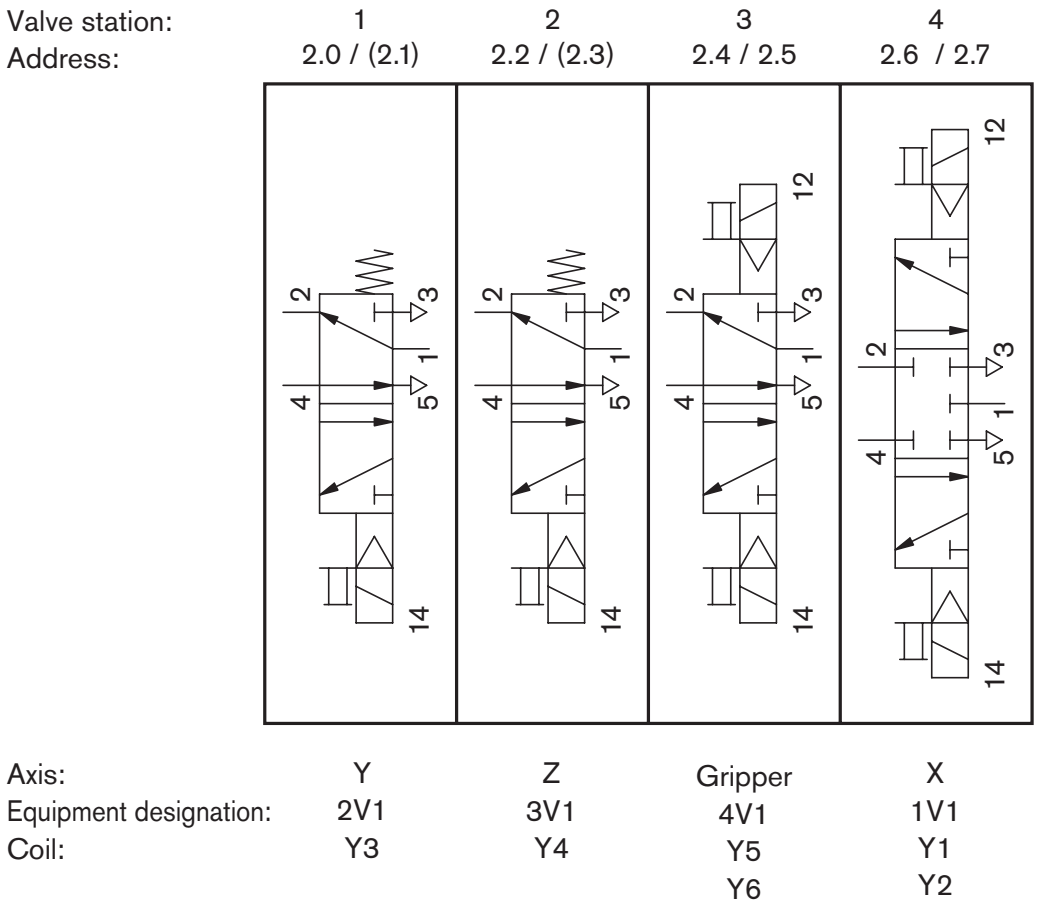


Fig. 04-8: Arrangement of the valves on the valve carrier system

Valve designation	Output	Designation	Cable #	Description
	QX 6.0	Y3	3 + 4	Y-axis, coil 14
	QX 6.1		3 + 4	Z-axis, coil 14
	QX 6.2		5 + 6	Gripper, coil 14
	QX 6.3		5 + 6	Gripper, coil 12
	QX 6.4		1 + 2	X-axis, coil 14
	QX 6.5		1 + 2	X-axis, coil 12

Fig. 04-9: PLC outputs

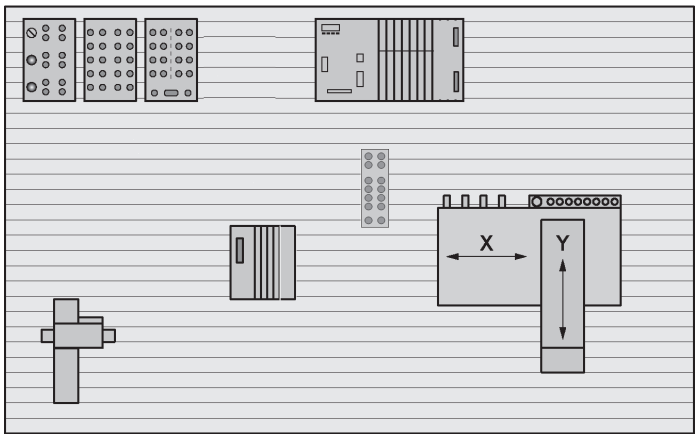


Fig. 04-10: Arrangement of the components

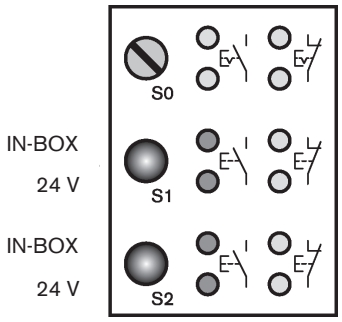
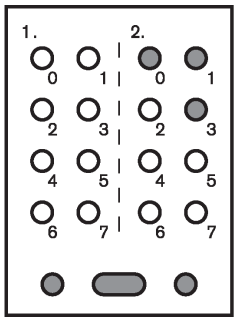


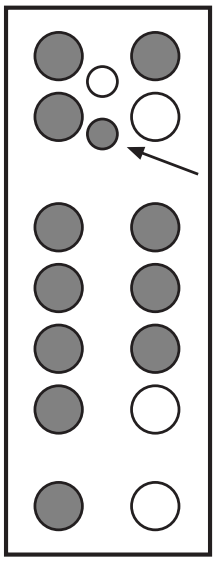
Fig. 04-11: Switch/push-button box



S1 S2

Program selection Profibus

Fig. 04-12: Connections of the IN-Box



BUS IN von PLC

Voltage supply for BUS

B1 + B2

B5 + B6

Y3 + Y4

Y1 + Y2

Voltage supply for solenoid coils

BUS-Abschlusswiderstand

Rotary switch for PROFIBUS address

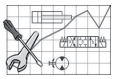
B3 + B4

B7 + B8

Y5 + Y6

Fig. 04-13: Connections of the PROFIBUS slave module

4. Execution



To ensure operability and to be able to recognize possible risks, safety regulations must be observed before and during the project exercise.

Warning

Work carried out improperly on electro-pneumatic components and systems involves a risk of injury and represents a safety risk during operation of the system, including danger to life.

Attention

Before starting to set up the experiment, make sure that the electric and pneumatic supply is switched off.
Pneumatic systems can store a residual amount of energy after having been disconnected from any source of energy, This energy must be discharged without any risks before the system is disassembled.

Experiment

1. Arrange the components as shown on Fig. 04-10.
2. Set up pneumatic circuit according to Fig. 04-6.
3. Cut in compressed air (power supply remains OFF!)
4. Use the manual override on the valves to check that the assignment of valves and the relevant connections 2 and 4 correspond to the circuit diagram.
5. Switch off the compressed air supply.
6. Connect Sub-D connection on input/output box to Sub-D connection “Input“ on the PLC training system. (→ “IN-Box“)
7. Connect normally-open contact of push-button S1 (Start) to input 2.0 on the IN-Box according to Fig. 04-12.
8. Connect normally-open contact of push-button S2 (Reset) to input 2.1 on the IN-Box according to Fig. 04-12.
9. Install PROFIBUS slave module (Fig. 04-13):
   – Set address “6” on the PROFIBUS slave module by means of rotary switch.
10. Connect PROFIBUS slave module according to Fig. 04-13
    – Establish connection B1 - B8 using the cylinder switch (plug-in connector on e2c).
    – Establish connection with solenoid coils Y1 - Y6 (on plug-in connector VTS) .
    – Provide voltage supply for BUS.
    – Provide voltage supply for solenoid coils.
    – Plug in and tighten terminal resistor.
    – Establish connection with PLC (via PROFIBUS cable).
11. The PLC program is pre-installed on the Flash card. It consists of two sub-programs. To activate the sub-program for Project 04, connection 2.3 on the IN-Box must be connected to 24V. (If the program is not installed, install it from the CD-ROM according to the Annex “Instructions for PLC commissioning“ or “IndraWorks/IndraLogic instructions“ .)
12. Establish the required 24V and 0V connections.
13. Cut in compressed air, switch on voltage supply.
14. Wait until PLC signals “RUN“ and the green LED on the PROFIBUS slave module is on (If PLC does not signal “RUN“ proceed as described in “Instructions PLC-IB“.
15. Make sure that all cylinders are retracted and the LEDs are ON. (If required, move X-axis and gripper to the relevant positions by manual operation.)

16. Operate push-button S1 (Start) and let the sequence run completely.
17. Switch PLC to stop “STOP“ on the operator panel.
18. Move X-axis away from the end position by means of the manual override until the LED goes out.
19. Switch PLC to “RUN“ on the operator panel.
20. Operate push-button S1. (→ The axes do not move.)
21. Operate push-button S2 (Reset) .
22. After having reached the starting position, operate push-button S1 and observe sequence..

5. Checking

Intermediate results

Understanding of the operating principle of a PLC.
Understanding of the general function of bus systems.

Result / customer requirement

The required sequence is executed.

6. Evaluating

Self-assessment

Does the PLC signal a Profibus fault?	☐ yes	☐ no
Do the valve carrier system and bus nodes signal faults?	☐ yes	☐ no
Corresponds the sequence to the set tasks?	☐ yes	☐ no

External assessment

Was the PLC correctly connected?	☐ yes	☐ no
Has the general structure of a bus system been understood?	☐ yes	☐ no

Instructions for commissioning the PLC

The electrical control unit used for project exercises 02 and 03 with the training system “electro-pneumatic handling technology“ is a PLC. The PLC program for “Rexroth IndraLogic L20“ is installed on the supplied Flash card and is automatically activated upon the “Program Start“.

In the case of loss of data, the PLC program can be installed from the CD-ROM, which is included in the scope of supply. In this context, please follow the steps below.

To upload the programs to the L20, an Ethernet connection must be established between the L20 and the programming device. The communication between the two devices is handled by means of the software “IndraWorks“.

Use of the PLC for controlling the handling system

The following steps must be executed to integrate the PLC as control unit:

1. Commission the PLC training system
2. Copy the PLC project (zip-file) from the CD-ROM, which is included in the scope of supply, to the hard disk and “restore“ it in the IndraWorks section. (See instructions “e2c-Handling_IWorks_ILogic_de_170308“)
3. Start the PLC program

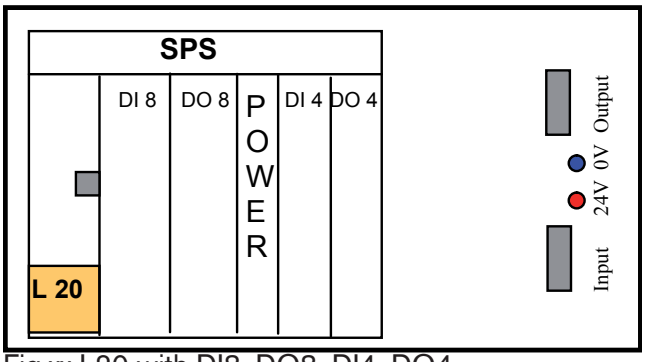


Fig.xx L20 with DI8, DO8, DI4, DO4

Commissioning of the PLC training system

- Mount the PLC training system to a suitable component carrier
- Carefully insert the firmware (Compact-Flash card) in the rack provided for this purpose on the IndraControl L20 (see Engineering IndraControl L20)
- Connect the 4mm laboratory sockets (24VDC red, 0VDC blue) on the PLC training system to a suitable voltage supply.

Ethernet settings of the PLC

To enable the communication between the PLC IndraControl L20 and the PLC programming device, the IP addresses, the sub-network and, if applicable, the gateway, must be properly set. To this end, you must know and, if required, change the current Ethernet settings of the PLC.

The Ethernet settings can also be displayed/changed when there is no connection to the PLC programming device.

Attention

Arbitrary settings may lead to network malfunction!

→ IP addresses in the Ethernet network must be clear. Double assignments are not permitted.

For this reason, ask your network administrator, which settings are to be used! Observe the instructions of your network administrator, if the devices are to be hooked up to a higher-order network!

Displaying Ethernet settings of the PLC

- Press the <Esc> key on the PLC repeatedly until you are at the highest menu level or until the display does not longer change.
- Press the <Enter> key.
- Press the <down> key (arrow down) repeatedly until “Ethernet“ appears on the display.
- Press the <Enter> key.
- The current IP address of the PLC (e.g. “192.168.0.1“) is displayed in a ticker. Note the IP address.
- Press the <down> key.
- The sub-network of the PLC is displayed as a ticker (e.g. “255.255.255.0“). Note the figures.
- Press the <down> key.
- The IP address of the gateway is displayed in a ticker (e.g. “192.168.0.254“). Note the figures.
- Press the <down> key.
- The MAC address (which cannot be changed) is displayed in a ticker. Note the figures.
- Unless the settings are to be changed, press the <Esc> key 2x to return to the “standard screen“.

Changing the Ethernet settings of the PLC

- Press the <down> key repeatedly until the setting to be changed (IP address, sub-network, gateway) appears in a ticker on the display of the PLC.
- Press the <Enter> key. The letter string “AAA:“ appears on the display to identify the first address byte, followed by its current decimal value.
- Set the desired value by means of the <Up>- and <Down> keys.
- Acknowledge the setting by pressing <Enter>.
- The letter string “BBB:“ appears on the display to identify the second address byte, followed by its current decimal value.
- Set the remaining address bytes (BBB, CCC, DDD) as described before.
- After the last setting was acknowledged, the system prompts you to confirm the new address value by displaying “OK ?“.
- When you confirm by pressing the <Enter> key, the new address value is displayed, written to the Compact-Flash card and used after a restart of the PLC. If you wish not to take the changes over, you can undo them by pressing <Esc>. In this case, the old address value will remain effective.
- In both cases, the PLC then shows the current setting in a ticker on the display.
- Press <Esc> 2x on the PLC to return to the “standard screen“.

- If you changed any settings, restart the PLC.
- The new Ethernet settings will then be active in the PLC.

Changing the PLC over to “RUN“

- Press the <Esc> key on the PLC repeatedly until you are at the highest menu level and the display does no longer change.
- Press the <Down> key (arrow down) until “PLC: RUN“ is displayed.
- Press the <Enter> key.
- Press the <Esc> key 2x on the PLC to return to the “standard screen“.

Hardware requirements (programming device)

- Performance class of a modern standard PC
- Min. 512 MB RAM
- Min. 2 GB free hard disk space
- Ethernet connection with RJ45 socket

Software requirements (programming device)

- • Microsoft operating system Windows 2000 Professional or higher
- • Internet protocol (TCP/IP) installed on the operating system (TCP/IP)

Installation of IndraWorks on the programming device

The installation program is available on the CD-ROM. When IndraWorks is installed, the required target system information of IndraLogic L20 is transferred to the target computer.

After having started the installation, follow the instructions on the screen.

Configuring Ethernet settings of the programming device

The Ethernet settings of the programming device are to be made as described in the following:

<Settings> → <Network and data transmission connection> → <Local area connection> → <Properties> → <Internet protocol (TCP/IP)> → <Properties> → <Use the following IP address> → <IP address: 192.168.0.11> → <Sub-network: 255.255.255.0> → <Gateway: 192.168.0.254> → <OK>

You can also use other settings for the IP, sub-network or gateway address.

Notes

Notes