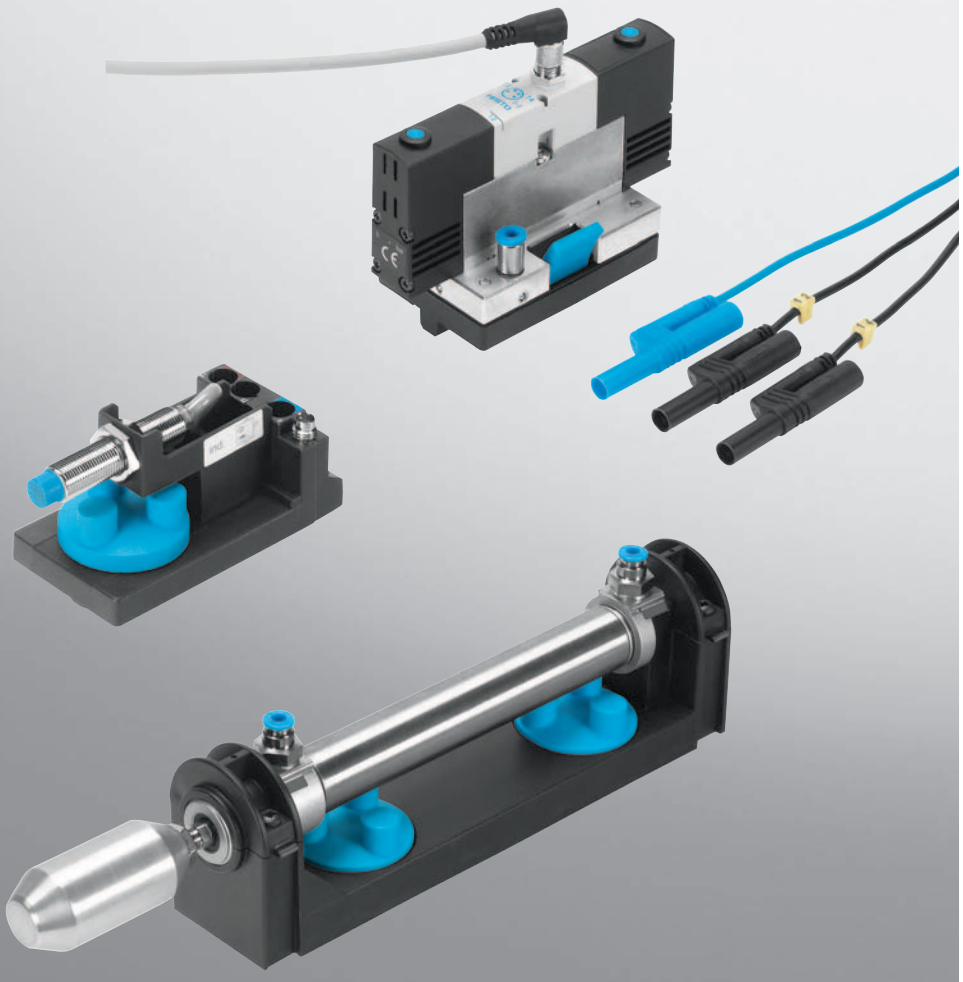
Programmable Logic Controllers
Basic Level

FESTO

Workbook TP 301



Festo Didactic
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Order No.: 093314
Edition: 08/2002
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Preface

The Festo Didactic Learning System for Automation and Technology is designed to meet a number of different training and vocational requirements, and the training packages are structured accordingly:

- Basic packages convey basic knowledge spanning a wide range of technologies
- Technology packages deal with important areas of open and closed-loop control technology
- Function packages explain the basic functions of automated systems
- Application packages provide basic and further training closely oriented to everyday industrial practice

The technology packages encompass pneumatics, electro-pneumatics, control pneumatics, programmable logic controllers, hydraulics, electro-hydraulics, proportional hydraulics and control hydraulics.

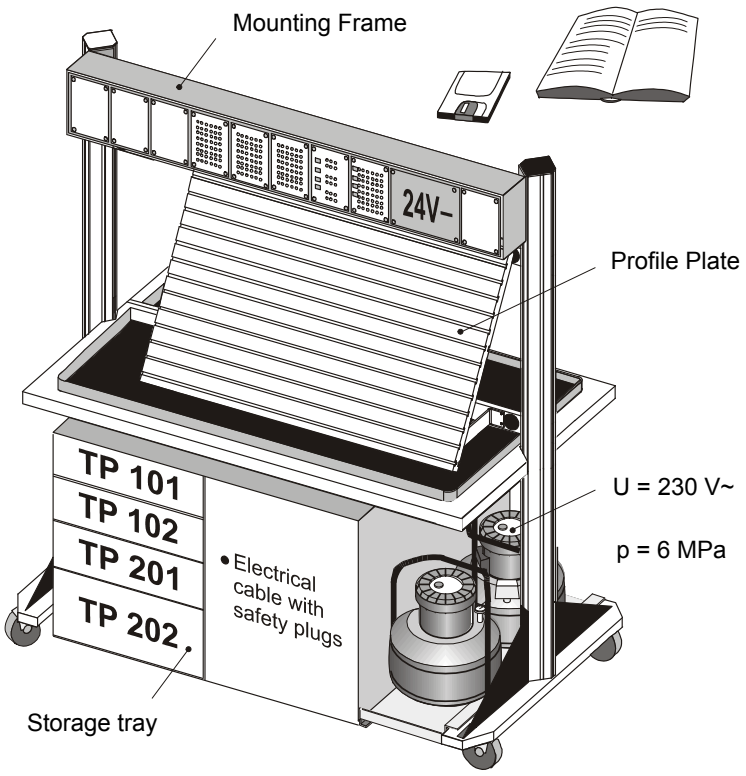


Fig. 1:
Pneumatik 2000 –
i.e. mobile workstation

The modular design of the learning system permits applications beyond the limits of the individual packages. PLC actuation, for example, is therefore possible of pneumatic, hydraulic and electrical actuators.

All learning packages have an identical structure:

- Hardware
- Teachware
- Software
- Courses

The hardware consists of industrial components and installations adapted for didactic purposes.

The courseware is matched methodologically and didactically to the training hardware. The courseware comprises:

- Textbooks (with exercises and examples)
- Workbooks (with practical exercises, worksheets, supplementary notes, solutions and data sheets)
- Overhead transparencies and videos (as a visual means of teaching support)

The teaching and learning media are available in several languages. They have been designed for use in classroom teaching, but can also be used for self-study purposes.

In the software field, computer-based training programs, computer simulating programs, CAD programs and programming software for programmable logic controllers are available.

Festo's Didactic range of products for basic and further training is completed by a comprehensive selection of courses matched to the contents of the technology packages.

Table of contents

Technology package TP301 13

Layout of this workbook 14

Component/exercise table 15

Equipment set TP301 16

Notes on safety 17

Operating notes 18

Section A – Course

Components of a programmable logic controller

Exercise 1: Design and commissioning of a programmable logic controller
Components of a PLC A-3

Programming to EN 61131 (IEC 61131)

Exercise 2: From problem to solution – taking into consideration EN 61131 (IEC 61131)
Practical steps for PLC programming A-11

Basic logic operations

Exercise 3: Lamp circuit
The assignment function A-19

Exercise 4: Burglar alarm
The NOT function A-29

Exercise 5: Press with protective guard
The AND function A-39

Exercise 6: Bell system
The OR function A-49

Logic control systems without latching properties

Exercise 7: Stamping device
Combination of AND/OR/NOT A-59

Exercise 8: Silo control system for two bulk materials
Combination circuit with branching A-69

Logic control systems with latching properties

Exercise 9: Fire alarm
Setting an output A-77

Exercise 10: Drill breakage monitoring
Setting and resetting an output A-85

Exercise 11: Activating a cylinder
Signal edges A-95

Logic control systems with time response

Exercise 12: Bonding of components
Pulse A-107

Exercise 13: Embossing device
Switch-on signal delay A-117

Exercise 14: Clamping device
Switch-off signal delay A-127

Sequence control systems

Exercise 15: Lifting device for packages
Linear sequence A-137

Exercise 16: Lifting and sorting device for packages
Alternative branching A-155

Exercise 17: Stamping device with counter
Counting cycles A-167

Section B – Fundamentals

Chapter 1	***Automating with a PLC***	***B-1***
1.1	Introduction	B-1
1.2	Areas of application of a PLC	B-2
1.3	Basic design of a PLC	B-5
1.4	The new PLC standard EN 61131 (IEC 61131)	B-8
Chapter 2	***Fundamentals***	***B-11***
2.1	The decimal number system	B-11
2.2	The binary number system	B-11
2.3	The BCD code	B-13
2.4	The hexadecimal number system	B-13
2.5	Signed binary numbers	B-14
2.6	Real numbers	B-14
2.7	Generation of binary and digital signals	B-15
Chapter 3	***Boolean operations***	***B-19***
3.1	Basic logic functions	B-19
3.2	Further logic operations	B-23
3.3	Establishing switching functions	B-25
3.4	Simplification of logic functions	B-28
3.5	Karnaugh-Veitch diagram	B-30

Chapter 4	***Design and mode of operation of a PLC***	***B-33***
4.1	Structure of a PLC	B-33
4.2	Central control unit of a PLC	B-35
4.3	Function mode of a PLC	B-37
4.4	Application program memory	B-39
4.5	Input module	B-41
4.6	Output module	B-43
4.7	Programming device/Personal computer	B-45
Chapter 5	***Programming of a PLC***	***B-47***
5.1	Systematic solution finding	B-47
5.2	EN 61131-3 (IEC 61131-3) structuring resources	B-50
5.3	Programming languages	B-54
Chapter 6	***Common elements of programming languages***	***B-57***
6.1	Resources of a PLC	B-57
6.2	Variables and data types	B-60
6.3	Program	B-70
Chapter 7	***Function block diagram***	***B-85***
7.1	Elements of function block diagram	B-85
7.2	Evaluation of networks	B-85
7.3	Loop structures	B-87
Chapter 8	***Ladder diagram***	***B-89***
8.1	Elements of ladder diagram	B-89
8.2	Functions and function blocks	B-92
8.3	Evaluation of current rungs	B-93

Chapter 9 Instruction list ***B-95***

9.1 Instructions B-95
9.2 Operators B-96
9.3 Functions and function blocks B-97

Chapter 10 Structured text ***B-99***

10.1 Expressions B-99
10.2 Statements B-101
10.3 Selection statements B-103
10.4 Iteration statements B-106

Chapter 11 Sequential function chart ***B-111***

11.1 Introduction B-111
11.2 Elements of sequential function chart B-111
11.3 Transitions B-120
11.4 Steps B-123
11.5 Example B-135

Chapter 12 Logic control systems ***B-139***

12.1 What is a logic control system B-139
12.2 Logic control systems without latching properties B-139
12.3 Logic control systems with memory function B-145
12.4 Edge evaluation B-148

Chapter 13 Timers ***B-153***

13.1 Introduction B-153
13.2 Pulse timer B-154
13.3 Switch-on signal delay B-156
13.4 Switch-off signal delay B-158

Chapter 14 Counter ***B-161***

14.1 Counter functions B-161
14.2 Incremental counter B-161
14.3 Decremental counter B-165
14.4 Incremental/decremental counter B-167

Chapter 15 Sequence control systems ***B-169***

15.1 What is a sequence control system B-169
15.2 Function chart to IEC 60848 B-169

Chapter 16 Commissioning and operational safety of a PLC ***B-175***

16.1 Commissioning B-175
16.2 Operational safety of a PLC B-177

Chapter 17 Communication ***B-183***

17.1 The need for communication B-183
17.2 Data transmission B-183
17.3 Interfaces B-184
17.4 Communication in the field area B-185

Appendix

A Bibliography of illustrations B-187
B Bibliography of literature B-189
C Guidelines and standards B-191
D Glossary B-193
E Index B-199

Section C – Solutions

Solution	1:	Design and commissioning of a programmable logic controller	C-3
Solution	2:	Practical steps for PLC programming	C-5
Solution	3:	Lamp circuit	C-7
Solution	4:	Burglar alarm	C-11
Solution	5:	Press with protective guard	C-15
Solution	6:	Bell system	C-21
Solution	7:	Stamping device	C-25
Solution	8:	Silo control system for two bulk materials	C-31
Solution	9:	Fire alarm	C-35
Solution	10:	Drill breakage monitoring	C-39
Solution	11:	Activating a cylinder	C-43
Solution	12:	Bonding of components	C-47
Solution	13:	Embossing device	C-53
Solution	14:	Clamping device	C-57
Solution	15:	Lifting device for packages	C-63
Solution	16:	Lifting and sorting device for packages	C-69
Solution	17:	Stamping device with counter	C-75

Section D – Data sheets

Technology package TP301

“ Programmable logic controllers“

The technology package TP301 "Programmable logic controllers" is a component part of the Festo Didactic Learning System for Automation and Technology and forms the basic level of TP300.

The training aims of TP301 are to learn how to program programmable logic controllers and to teach the fundamentals for creating programs in the programming languages ’ladder diagram’ (LD), ’function block diagram’ (FBD), ’instruction list’ (IL), ’structured text’ (ST) and ’sequential function chart’ (SFC). Programming is effected in accordance with EN 61131-3 (IEC 61131-3).

You have the option of using this workbook in conjunction with alternative programmable logic controllers by different manufacturers.

A basic knowledge of electro-pneumatics and sensor technology is recommended to work through technology package TP301.

The exercises in TP301 deal with the following main topics:

- Components of a programmable logic controller
- PLC programming to EN 61131 (IEC 61131)
- Basic logic operations
- Logic control systems
- Sequence control systems

The allocation of components and exercises can be seen from the component/exercise table.

Layout of this workbook

The workbook is structured as follows:

Section A – Course

Section B – Fundamentals

Section C – Solutions

Section D – Appendix

Section A – Course teaches the programming of programmable logic controllers with the help of a series of progressive exercises.

Any necessary technical knowledge required for the implementation of an exercise is provided at the beginning. Functions are limited to the most elementary requirements. More detailed knowledge may be gained in section B.

Section C – Solutions provides the solutions to the exercises with brief explanations.

Section B – Fundamentals contains generally applicable technical knowledge to supplement the training contents of the exercises in Section A. Theoretical links are established and the necessary technical terminology explained with the help of examples. An index provides an easy means of locating terminology.

Section D – Appendix which contains data sheets of the used components.

Allocation of component and exercise

Description	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*
Signal input, electrical			1	1	1	1		1	1	1	1	1	1	1		1	1
Signalling device and distributor, electrical			1	1		1			1	1							
Proximity sensor, optical							1			1					1	1	1
Proximity sensor, inductive					1		1				1		1				1
Proximity sensor, capacitive							1				1		1			1	1
Proximity sensor with cylinder mounting												1		4	4	4	4
5/2-way single solenoid valve					1		1	2			1	1	1	1	2	2	2
5/2-way double solenoid valve														1		1	1
Double-acting cylinder					1		1	2						1	2	2	2
Single-acting cylinder											1	1	1	1		1	1
On/off valve with filter regulator valve					1		1	1			1	1	1	1	1	1	1
Manifold					1		1	1			1	1	1	1	1	1	1

Equipment set TP301

Equipment set TP301
Order No.:167101

Description	*Order No.*	*Quantity*
Plastic tubing	151496	
Manifold	152869	1
Single-acting cylinder	152887	1
Double-acting cylinder	152888	2
On/off valve with filter regulator valve	152894	1
Quick push-pull distributor	153128	1
Signal input, electrical	162242	1
Signalling device and distributor, electrical	162244	1
Proximity sensor with cylinder mounting	167060	4
5/2-way single solenoid valve	167074	2
5/2-way double solenoid valve	167076	1
Proximity sensor, inductive	178574	1
Proximity sensor, capacitive	178575	1
Proximity sensor, optical	178577	1

*optional, **not** included in scope of delivery of equipment set*	*Order No.*	*Quantity*
I/O data cable, digital	034031	
Plug-in adapter	035651	
Universal connection unit	162231	
Power supply unit	162416	
Set of cables	167091	

Notes on safety

The following notes should be followed in the interest of safety:

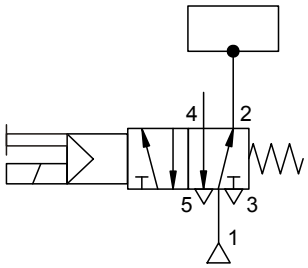
- Mount all components securely on the board.
- Do not switch on compressed air until all line connections have been established and secured.
- Proceed with care when switching on the compressed air. Cylinders may advance or retract as soon as the compressed air is switched on.
- Switch off air supply immediately if air lines become detached. This prevents accidents.
- Do not disconnect air lines under pressure.
- Do not exceed the permitted working pressure of 8 bar (800kPa).
- Observe general safety regulations in accordance with EN 60204-1 (IEC 60204-1).
- Use only extra-low voltages of up to 24 V DC.
- Observe the data sheets referring to the individual components, in particular all notes regarding safety.

Operating notes

The following rules should be observed when constructing a circuit:

- Block output 2 of the valve, if a single-acting cylinder is actuated by a 5/2-way single solenoid valve in a circuit.

Fig. 2:
Plug for output 2
of a 5/2-way valve



- Input signals, which would result from an actual production process sequence, are reproduced in part by signals via push buttons or switches.

Section A – Course

Components of a programmable logic controller

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Practical steps for PLC programming A-11

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Exercise 3: Lamp circuit
The assignment function A-19

Exercise 4: Burglar alarm
The NOT function A-29

Exercise 5: Press with protective guard
The AND function A-39

Exercise 6: Bell system
The OR function A-49

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Exercise 7: Stamping device
Combination of AND/OR/NOT A-59

Exercise 8: Silo control system for two bulk materials
Combination circuit with branching A-69

Logic control systems with latching properties

Exercise 9:	Fire alarm Setting an output	A-77
Exercise 10:	Drill breakage monitoring Setting and resetting an output	A-85
Exercise 11:	Activating a cylinder Signal edges	A-95

Logic control systems with time response

Exercise 12:	Bonding of components Pulse	A-107
Exercise 13:	Embossing device Switch-on signal delay	A-117
Exercise 14:	Clamping device Switch-off signal delay	A-127

Sequence control systems

Exercise 15:	Lifting device for packages Linear sequence	A-137
Exercise 16:	Lifting and sorting device for packages Alternative branching	A-155
Exercise 17:	Stamping device with counter Counting cycles	A-167

Programmable logic controllers — *Subject*

Design and commissioning of a programmable logic controller — *Title*

Components of a PLC

Training aim

- To be able to explain the basic design and mode of operation of a PLC
- To be able to configure and commission a PLC

Technical knowledge

Nowadays, programmable logic controllers form part of any automation process. Fig. A1.1 illustrates the typical configuration of an automation solution realised by means of a PLC. The control system shown represents the simpler, non-networked group of PLC applications.

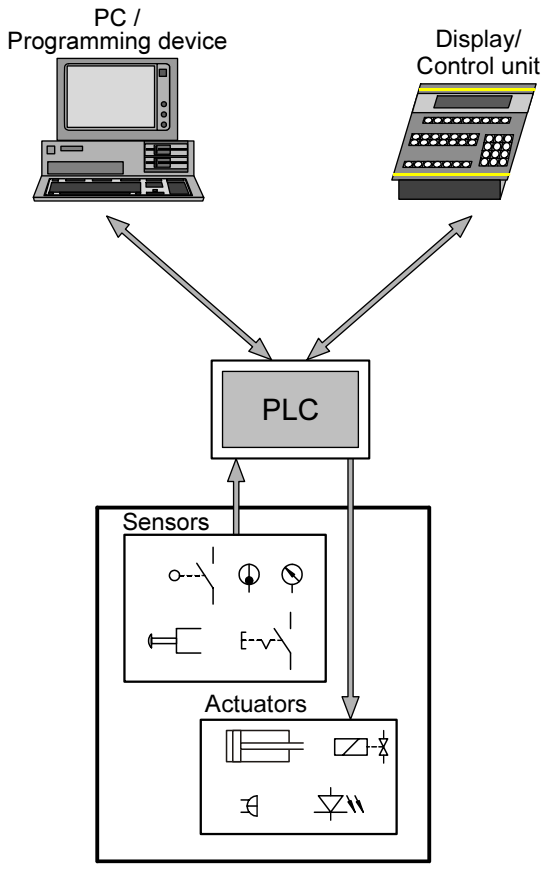


Fig. A1.1: Automation via PLC

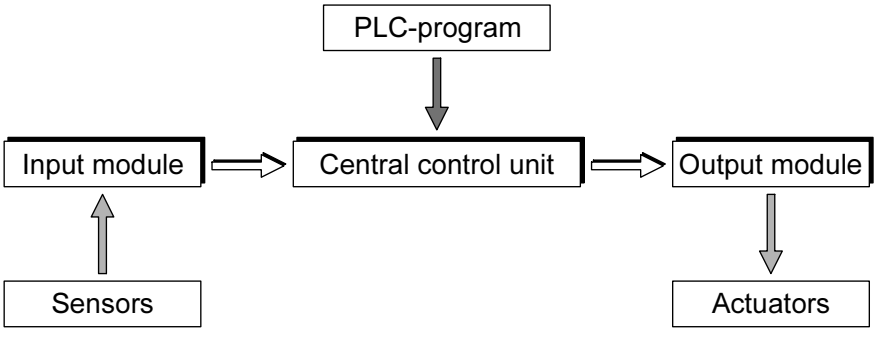
The basic components of the control system are:

- Programmable logic controller (PLC)
  By this, we understand the electronic modules through which all of the system or machine functions to be controlled are addressed and activated in a logic sequence.
- Sensors
  These components are located directly on the system or machinery be controlled, through to which the PLC is communicated actual statuses.
- Actuators
  These components are located directly on the system or machinery to be controlled, through which the PLC is able to change or influence statuses and as such the technical process.
- PC or programming device
  This is used to create the program containing the logic of the system or machinery to be controlled and to transfer this to the memory of the PLC. At the same time, these programming tools also provide supporting functions for the testing of the PLC program and commissioning of the controller.
- Display and control units
  These enables you to monitor and influence the operation of the system or machinery.

Programmable logic controller

The most important component of a control system is the PLC and its program. Fig. A1.2 illustrates the system components of a PLC.

Fig. A1.2: System components of a PLC



A PLC is connected to the system to be controlled via input and output modules. The system to be controlled supplies input signals (mostly binary) via sensors to the input modules. These signals are processed within the main processing unit, the main component of the PLC. Prior .to formulation of IEC standards, known as "central control unit" (CCU). The "specification" for the processing of signals is defined in the PLC program. The result of the processing is output to the actuators of the system to be controlled via the output module. Thus, the design of a PLC corresponds to that of a computer.

PLC program

PLC programs consist of a logic sequence of instructions. The control program is stored in a special, electronic readable memory, the so-called program memory of the PLC. Special RAMs with back-up battery are used during the program development, since its contents can always be changed again very quickly.

After commissioning and error-free function of the controller it is a good idea to transfer the PLC program unerasably to a read-only memory, e.g. an EPROM. If the program is executed, it will be processed in continuous cycles.

Signals

Input signals reach the PLC via sensors. These signals contain information about the status of the system to be controlled. It is possible to input binary, digital and analogue signals.

A PLC can only recognise and output electrical signals. For this reason, non-electrical signals are converted into electrical signals by the sensors. Sensor examples are:

- Push buttons, switches, limit switches, proximity sensors

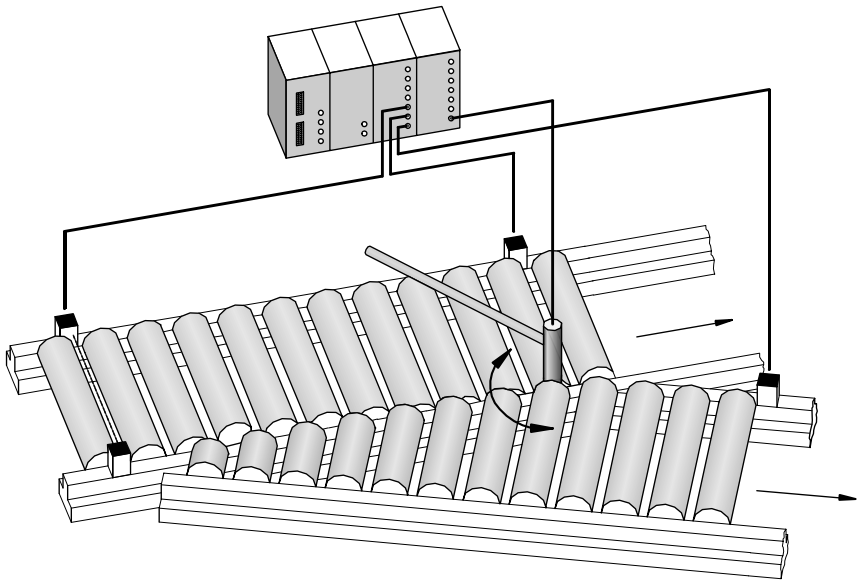
Output signals influence the system to be controlled. The signals can be output in the form of binary, digital or analogue signals. Output signals are amplified into switching signals via the actuators or converted into signals of other energy forms. Actuators examples are:

- Lamps, buzzers, bells, contactors, cylinders with solenoid valves, stepper motors

Problem description

A control task is to be solved via a programmable logic controller (PLC). Familiarise yourself with the basic design of a PLC.

Positional sketch



Exercise definition

1. Components of a PLC
2. Design and commissioning of the PLC you have selected

Implementation

To carry out the exercise using the worksheets, refer to Section B of the workbook and your PLC data sheet or manual.

WORKSHEET

1.1 Components of a PLC

Question 1:
What are the basic components of a programmable logic controller?

Question 2:
What are the basic modules making up the central control unit of a programmable logic controller?

Question 3:
How is electrical isolation achieved between sensor/actuator signals and the PLC?

WORKSHEET

1.2 Design and commissioning of the PLC you have selected

Enter the technical data of the selected programmable logic controller in the table below.

Criteria	*Technical data*	*Technical data*
Operating voltage		
Nominal voltage		
Permissible voltage range		
Current consumption		
Inputs		
Number		
Input current		
Input level		
Outputs		
Number		
Switching logic		
Output voltage		
Output current		

Configure the PLC in accordance with the notes in the relevant data sheet or manual.