Servo-Pneumatic Positioning
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Preface

The "Servo-Pneumatic Positioning" function package forms part of the learning system for Automation and Technology from Festo Didactic GmbH & Co.

Essentially, the equipment set comprises components compatible with those used for industrial applications. At the same time, the positioning axes are harmonised with the learning system for Automation and Technology.

Industrial application of pneumatic NC axes

The high flexibility, the relatively low-cost set-up and high motion dynamics ensure pneumatic NC axes a constantly increasing area of application.

- Pneumatic NC axes are used, for instance, in robotics or for palletisation tasks.
- One other area of application is software-controlled approach to stops. By comparison with conventional cylinder drives actuated with switching valves, these systems achieve far faster movements and shorter cycle times.

PneuPos 1 basic equipment set

The PneuPos1 basic equipment set consists of the following components:

- Linear drive (rodless cylinder) with guide and slide
- Festo MPYE-5-1/8 proportional valve
- Displacement measuring system (potentiometer)
- Festo SPC 200 axis controller for open and closed-loop control with related axis interface
- WinPISA PC software
- Electrical and pneumatic accessories
- Workbook with exercises and technical knowledge
- Manual for the WinPISA software

The WinPISA software can run on a personal computer (operating system: Windows or Windows NT).

PneuPos 1 course topics

The basic equipment set serves as an introduction to numerical control systems. The following course topics are taught:

- Setting up and commissioning a servo-pneumatic axis
- Programming numerically controlled axes to DIN 66025
- Examining and optimising the control response
- Self-adapting control algorithms
- EMERGENCY-STOP circuits
- Fault-finding
Another important course topic is using a PC as a programming and optimisation aid. The WinPISA software enables the NC axes to be operated very conveniently and allows graphic visualisation of the motion and control response of pneumatic servo drives.

**PneuPos 2 extension equipment set**

The PneuPos2 extension equipment set consists of the following components:

- Linear drive (rodless cylinder) with guide and slide and integrated displacement measuring system
- Festo MPYE-5-1/8 proportional valve
- Axis interface
- Columns for setting up a gantry system
- Electrical and pneumatic accessories

**PneuPos 2 course topics**

The PneuPos2 extension equipment set supports learning of the following course topics:

- Setting up and commissioning a gantry consisting of two pneumatic NC axes
- Programming the gantry to DIN 66025
- Examining and optimising the control response of a vertically mounted axis
- EMERGENCY-STOP: Pneumatic and electrical circuitry, system behaviour
- Fault-finding on multi-axis equipment

**Gripper extension equipment set**

The "gripper" extension equipment set contains:

- A pneumatically actuated gripper
- A switching valve for actuation
- An interface for connection to the NC control SPC 200
- Electrical and pneumatic accessories

**Gripper extension equipment set course topics**

The gripper extension equipment set supports the following course topics:

- Programming binary inputs and outputs with the NC axis control SPC200
- Implementing applications in which specific workpieces are moved
- EMERGENCY-STOP behaviour of gripping devices
The SPC 10 extension equipment set contains:
- The SPC controller (low-cost control for pneumatic high-speed drives)
- Electrical and pneumatic accessories.

The SPC 10 extension equipment supports the following course topics:
- Time-optimised positioning of pneumatic cylinders with proportional valve
- Setting up and programming the SPC 10

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This workbook forms part of the learning system for Automation and Technology from Festo Didactic GmbH & Co.

The workbook is subdivided into the following parts:
Part A: Course
Part B: Fundamentals
Part C: Solutions
Part D: Appendix

Part A, Course, explains how to commission and program servo-pneumatic axes on the basis of exercises which build on each other. The equipment sets required for performing the exercises are shown in the equipment/exercise table.

Part B, Fundamentals, contains generally valid technical knowledge as a supplement to the course topics of the exercises in Part A. It presents the theoretical interrelationships and clearly explains the required technical terms on the basis of examples.

Part C, Solutions, presents the results of the exercises and explains them briefly.

Part D, Appendix, serves as a reference work. It contains Standards and bibliography. The data sheets are enclosed with the equipment used.

The book is structured so that the technical content can be learned both by practical exercises, e.g. in seminars, and by self-study.
Part A

Exercises and worksheets

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Exercise 1
Setting up a servo-pneumatic axis

Training aim
- To be able to set up the system mechanically
- To be able to perform wiring and tubing connection
- To be able to prepare the system for commissioning

Technical knowledge

Modules of a servo-pneumatic axis
The following components are required for setting up a servo-pneumatic axis (Figure A1.1):
- A traversing slide; a guide for the slide; a double-acting cylinder drive for driving the slide (Item 6 in Figure A1.1)
- A measuring system which detects the position of the slide (Item 1 in Figure A1.1)
- An open-loop controller which monitors the process (Items 2 and 3 in Figure A1.1)
- A proportional valve which meters the flow rate (Item 4 in Figure A1.1)
- A service unit with fine filtration for protecting the proportional valve (Item 5 in Figure A1.1)

In addition, the following components are required:
- A safety device with which the automatic sequence can be interrupted in the event of an emergency
- Accessories for the mechanical set-up, for the tubing connection and for the wiring.
Figure A1.1: Modules of a servo-pneumatic linear axis

1  Measuring system
2  Axis interface, Type SPC-AIF
3  Smart Positioning Controller SPC200
4  Proportional Directional Control Valve, Type MPYE
5  Service unit with 5 \( \mu \text{m} \) filter
6  Cylinder
Pneumatic and mechanical components

Linear axes may be driven electrically, pneumatically or hydraulically. We use a pneumatic axis for this exercise.

A double-acting slotted cylinder is used as the drive. Slide, cylinder and guide are combined to form a linear unit in order to make this system as compact as possible. The stroke of the cylinder is 450 mm.

A 5/3-way proportional valve is used to control the cylinder (Figure A1.2). This valve has the following features:

- Flow is blocked in the centre position so that the piston can be stopped at any position between the stops.
- The required direction of movement of the piston is preset by controlling the valve accordingly.
- The valve is constantly adjustable (= proportional valve) in order to be able to regulate the flow rate and, thus, the speed of movement of the piston.
- The valve is directly actuated and electrically controlled.

Figure A1.2: Pneumatic circuit diagram of a servo-pneumatic linear axis
**Measuring system**

The measuring system is a sensor which converts the position of the slide into an electrical signal.

On the pneumatic NC axis, a linear potentiometer serves as the measuring system. It is mounted at the side on the linear unit. The potentiometer’s slide is connected to the slide of the linear axis by means of a driver.

**Open-loop and closed-loop control**

The open-loop control presets the positions which the slide is to approach. The actual position of the slide is signalled to the open-loop controller via the measuring system. The closed-loop controller forms an appropriate positioning signal for the valve from both variables.

On the NC axis, the SPC200 controller contains the electrical open-loop control and closed-loop control (Figure A1.3). The controller is of modular design and features several devices. Various stages are required depending on application. The following components are required for open-loop and closed-loop control of a linear axis:

- SPC200 controller
- Control panel
- Axis interface
### Modules of the controller

<table>
<thead>
<tr>
<th>Components</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPC200, Type SPC200-……-……</td>
<td>The SPC200 is accommodated in a rack. You may install the appropriate modules in the rack depending on the requirements of the positioning task.</td>
</tr>
<tr>
<td>Control panel, Type SPC200-MMI-1</td>
<td>The control panel can be plugged on to the SPC200. It is operated via 6 keys with which all functions can be called with menu prompting.</td>
</tr>
<tr>
<td>Axis interface, Type SPC-AIF</td>
<td>The axis interface establishes the connection between the components on the axis and the SPC200. It receives the values supplied via the measuring system, forwards them to the SPC200 and supplies the positioning signal for the proportional directional control valve.</td>
</tr>
</tbody>
</table>

Figure A1.3: Modules of the controller for a linear axis

### Safety devices

Shock absorbers and EMERGENCY-STOP button are required as safety devices.

- The shock absorbers absorb positioning movements which extend beyond the permitted range. They must be fitted in such a manner that they do not unnecessarily restrict the slide's range of movement.
- The EMERGENCY-STOP button serves to stop the system in the event of danger. It must be attached at an easily accessible position (electrical interconnection: see Figure A1.4).
Connections diagram, electrical

Figure A1.4: Electrical interconnection of controller, axis interface, valves and EMERGENCY-STOP

**Accessories**
The accessories required for setting up the system are enclosed with the equipment set. Use of the parts is either described in the assembly instructions or it can be seen from the set-up of the electrical and pneumatic circuit.

**Safety measures**
Keep well away from the traversing area of the slide whilst the system is operating. Risk of injury!
A servo-pneumatic axis is to be set up. The equipment has been delivered. A location has been prepared for installation. It is now the task of the fitter to set up the system professionally at the required location.

Figure A1.5: Delivered components of a servo-pneumatic axis

- Assembling the equipment
- Setting up the pneumatic circuit
- Setting up the electrical circuit
- Checking the overall set-up
Exercise 1

1. **Assembling the measuring system**
   The measuring system must be mounted on the linear unit. Slide the slide by hand once from one end to the other in order to align the measuring system with the working stroke. If both end positions of the cylinder can be reached without the measuring system reaching its stops, the measuring system is correctly positioned and can be definitively secured.

2. **Assembling the shock absorbers**
   Attach the shock absorbers to the linear unit. Please note the following requirements:
   - The shock absorbers must be fitted as far out as possible in order not to unnecessarily restrict the range of movement of the slide.
   - The shock absorbers must be attached so that they are depressed before the slide reaches the stop of the cylinder resp. of the linear guide.

3. **Drawing a positional sketch**
   Please note the following points when drawing the positional sketch showing the arrangement of the equipment in the slotted assembly board:
   - The control panel of the controller must be attached at an easily accessible point. The display must be easy to read off.
   - You must be able to operate the EMERGENCY-STOP button easily.
   - You must be able to observe the axis and valves.
   - You must be able to easily monitor the mains voltage and supply pressure.
   - Keep well away from the traversing area of the linear unit (risk of injury).

4. **Mechanical construction**
   Set up the system mechanically in accordance with the positional sketch using the existing accessories.

5. **Set-up of the pneumatic circuit**
   The tubing connections must be made in accordance with the pneumatic circuit diagram.

**Caution**
When laying the tubing, please ensure that none projects into the traversing area of the slide.
Exercise 1

6. Set-up of the electrical circuit
The electrical interconnection is made in accordance with the block circuit diagram (Figure A1.4). Plug on the controller control panel. Use the Festo Didactic 24 V power pack as the power supply.

Caution
No cables may be routed in the traversing area of the slide!

7. Checking the set-up
- Does the layout correspond to the positional sketch?
- Are all screws firmly tightened?
- Can the slide be slid by hand between both stops preset by the shock absorbers?
- Is all tubing firmly attached?
- Are all plugs firmly attached?
- Ensure that there are no wires or tubing running crosswise over the linear unit (risk of shearing off!)
- Do the circuits correspond to the circuit diagrams?
- Is the controller with control panel easily accessible?
- Can you easily monitor supply pressure and supply voltage?

Caution
The system is not switched on until the next exercise!

Note
The slide will be traversed with high power and at high speed in the exercises which follow. Consequently, the slotted assembly board must be firmly clamped or bolted to a sturdy base!
Exercise 1