Micro Application Example

applications
& TOOLS

Controlled Positioning with Standard Drives (Rotary Axis)

SIEMENS

Micro Automation Set 22

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Foreword

Micro Automation Sets are fully functional and tested automation configurations based on A&D standard products for simple, fast and inexpensive implementation of automation tasks for small-scale automation. Each of the available Micro Automatic Sets covers a frequently occurring subtask of a typical customer problem in the low-end performance level.

The sets help you obtain answers with regard to required products and the question how they function when combined.

However, depending on the system requirements, a variety of other components (e.g. other CPUs, power supplies, etc.) can be used to implement the functionality on which this set is based. Please refer to the respective SIEMENS A&D catalogs for these components.
The Micro Automation Sets are also available by clicking the following link:

http://www.siemens.de/microset

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1 Application Areas and Usage

Application Example

With regards to comprehensiveness, the controlled positioning of the Micro Automation Set is explained using the example of a shaping machine for socks.

The selected application example of the shaping machine for socks consists of a rotary and a linear axis. The sock hose is first pulled over the sock template (Figure 1-1). The sock hose is turned 180° by the rotary axis (Figure 1-2 and Figure 1-3). A steam blaster is switched on and via the linear axis moved along the sock hose so that the sock takes on the shape of the template. (Figure 1-4). Then the steam blaster is deactivated and via the linear axis moved to its original position (Figure 1-5). For further processing, it is then moved another 90° by the rotary axis (Figure 1-6).

Figure 1-1

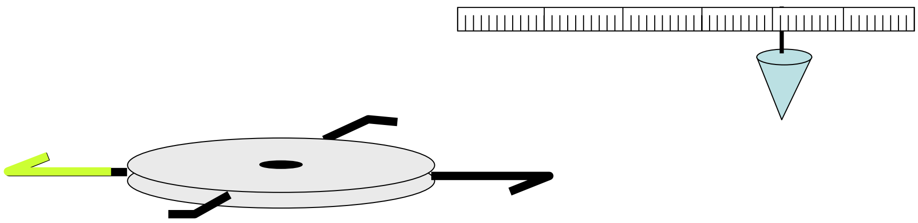


Figure 1-2

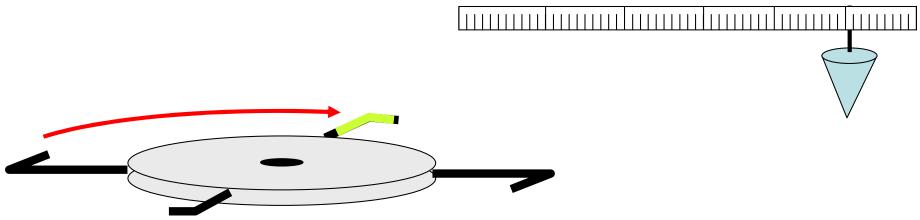


Figure 1-3

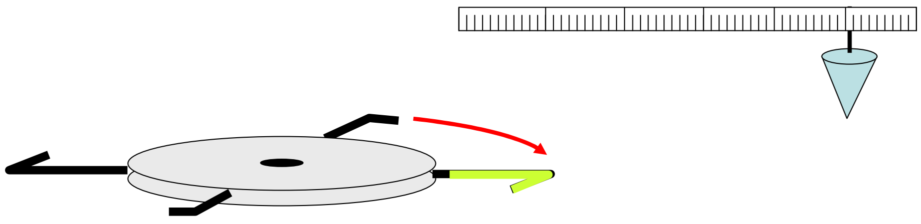


Figure 1-4

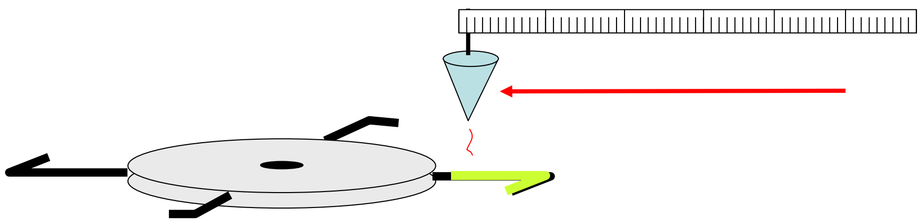


Figure 1-5

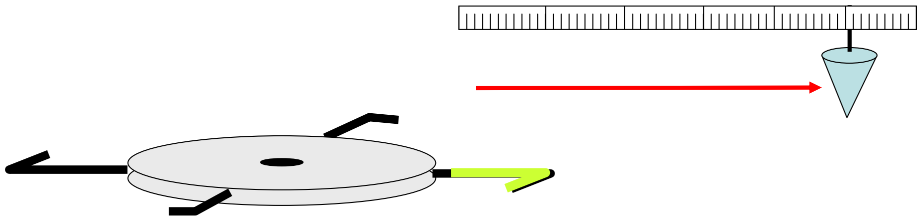
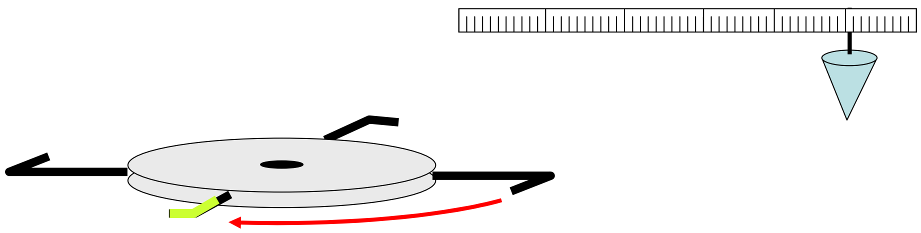


Figure 1-6



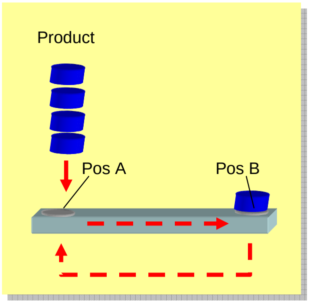
The following requirements are posed to the positioning:

- A positioning precision with two velocity stages is sufficient
- Configuring the plant in manual mode via local control
- Monitoring of positioning and shutdown in case of a failure
- Stop switch for stopping of all movements

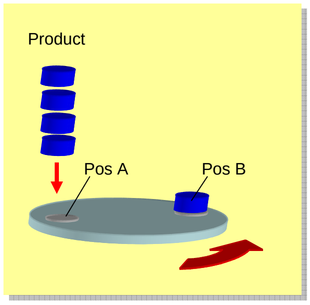
Automation solution – Set 22

The automation solution is divided into a linear and a rotary axis.

The linear and rotary axis should be viewed separately for better overview and the positioning process be reduced to 2 positions each.



Linear axis

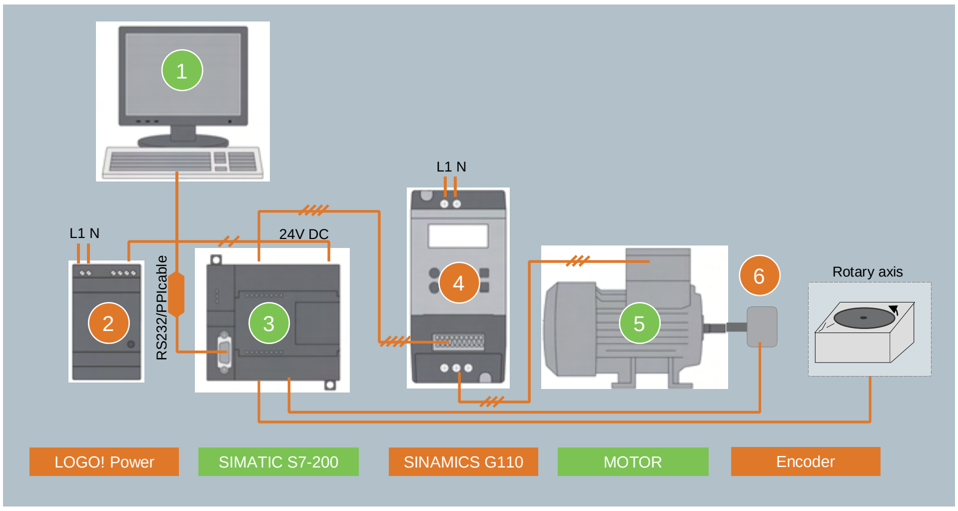


Rotary axis

Note In this document, the rotary axis is discussed.

A S7-200 controller is employed which controls the positioning process of the frequency converter SINAMIC G110 via digital outputs. This is a controlled positioning with rapid traverse and creep feed mode. The motor used is an asynchronous motor. Recording the actual position by means of an encoder enables moving variable distances as well as standstill monitoring. The plant is operated with a PC with WinCC flexible RT user interface.

Figure 1-7



Application Areas

- Gate controls
- Feed units
- Material transport equipment
- Advertising boards
- Conveyor technology

Benefit

- Cheap solution for simple positioning tasks
- Fast and simple commissioning, as no positioning control needs to be optimized.
- Robust due to low configuration expenses
- Controlling the positioning process in the controller without additional modules

2 Setup

Layout Diagram

Figure 2-1

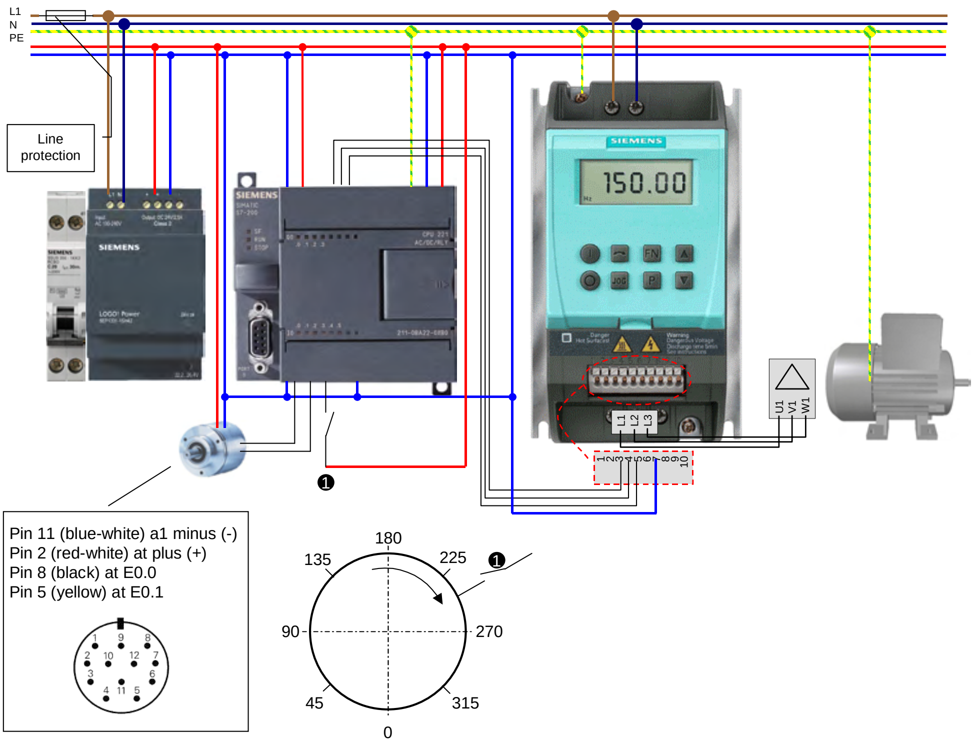


Table 2-1

No.	Inputs/outputs of the CPU	Assignment
1.	E 0.2	❶ (Reference point switch)
2.	A0.0	SYNAMICS G110, terminal 3
3.	A0.1	SYNAMICS G110, terminal 4
4.	A0.2	SYNAMICS G110, terminal 5

Attention

Depending on the selected type of the shaft angle encoder, there are different design versions of the connection cable.

Prior to connecting the shaft angle encoder you check the assignment of the connection cable.

3 Hardware and Software Components

Products

Table 3-1

Component	Qty.	MLFB / Order number	Note
LOGO! Power 24V 1.3A	1	6EP1331-1SH02	
S7-CPU 221	1	6ES7211-0AA23-0XB0	DC
SINAMICS G110	1	6SL3211-0AB11-2UA1	unfiltered
Asynchronous motor	1	1LA7060-4AB10	
Incremental encoder	1	6FX2001-4SA50	500 increments
Basic Operator Panel	1	6SL3255-0AA00-4BA0	
WinCC flexible PC-Runtime	1	6AV6613-1BA01-1CA0	

Accessories

Table 3-2

Component	Qty.	MLFB / Order number	Note
Hut rail, mounting kit for SINAMICS G110	1	6SL3261-1BA00-0AA0	
Network filter for low leakage currents	1	6SE6400-2FL01-0AB0	(e.g. for operation at earth leakage circuit breaker, FI)
Line protection switch	1	5SY6016-6KV	
PC/PPI cable	1	6ES7901-3CB30-0XA0	RS 232
Simulator	1	6ES7274-1XF00-0XA0	Optional

Configuration software/tools

Table 3-3

Component	Qty.	MLFB / Order number	Note
Step7 Micro/WIN V4.0	1	6ES7810-2CC03-0YX0	
WinCC flexible Advanced	1	6AV6613-0AA01-1CA5	

4 Function Principle

4.1 Introductory information on positioning

4.1.1 What is an axis?

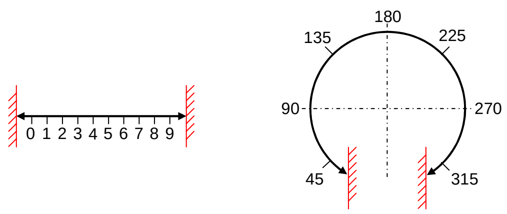
Moving an object on a defined line or performing a defined rotation is referred to as “moving an axis“. Basically, two different types of axes are distinguished:

- Linear axis
- Rotary axis

Linear axis

The travel range of the axis is defined by initial and end position. The currently recorded actual position is always within this area.

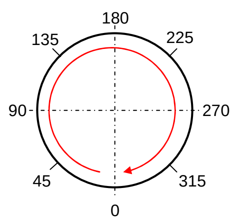
Figure 4-1, Example for linear axis



Rotary axis

After the cyclic 360° rotation of a rotary axis at this procedure is repeated cyclically (e.g. circular movement). The actual position starts again at 0° after a complete revolution. This is also referred to as a modulo axis.

Figure 4-2, Example for a modulo axis

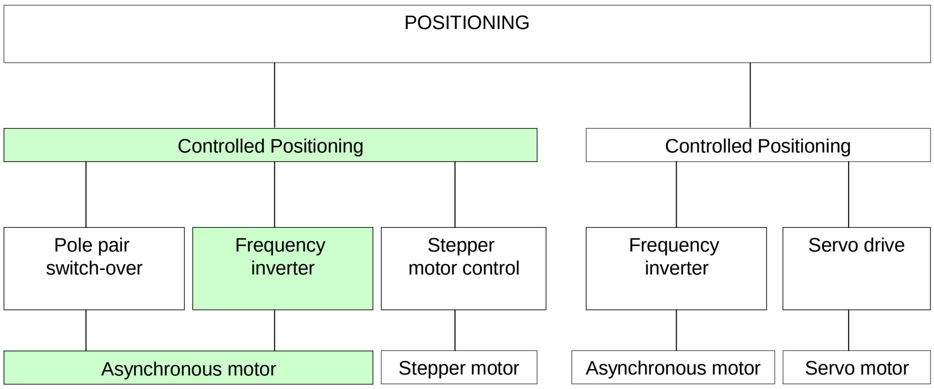


4.1.2 Properties of controlled and regulated positioning

Classification

The following figure gives a brief overview of the type of drive or motor depending on the selected positioning method. This Micro Automation Set focuses on the boxes shaded in green

Figure 4-3

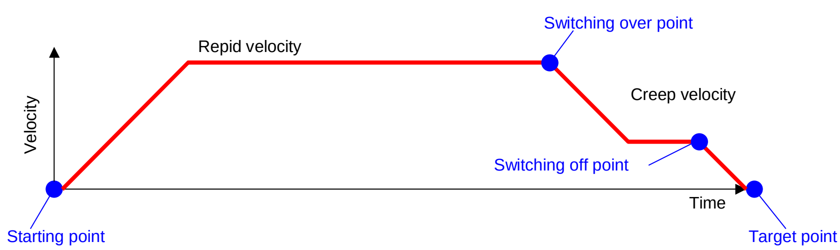


Controlled positioning with rapid traverse and creep feed mode

Controlled positioning in rapid traverse and creep feed mode starts at the starting point and accelerates to rapid velocity. Startup of the target position occurs by means of:

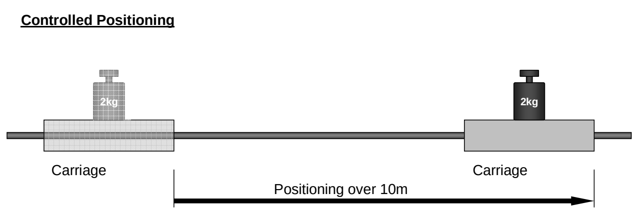
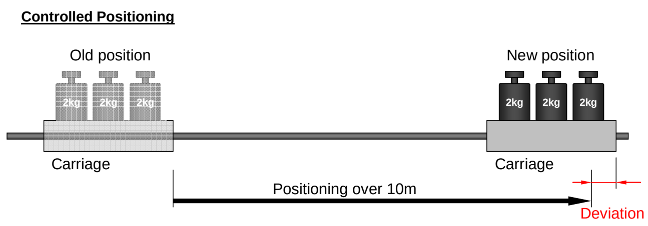
- Switching from rapid to creep velocity
- Decelerating the mass at the so-called “switching off point“

Figure 4-4



The following table shows the impact of a mass change on the positioning precision:

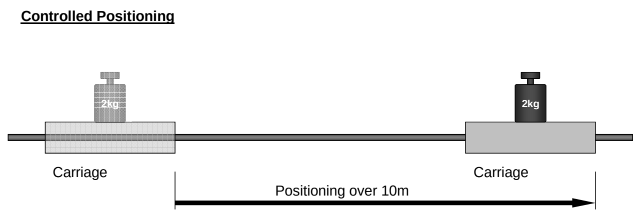
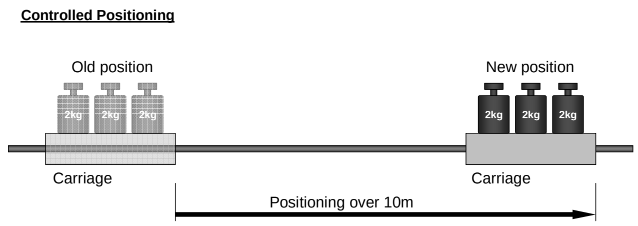
Table 4-1

<table>
<tr><td>
</td><td>The controlled positioning is exactly configured for a weight (e.g. 2kg). The deceleration process is started in such a way, that the carriage stops at a precisely defined location.</td></tr>
<tr><td>
</td><td>If the mass on the carrier is increased, the result is that upon starting the deceleration process the slow mass slides past the target position up to the previously defined location. This results in a deviation.</td></tr>
</table>

Controlled positioning

During controlled positioning, the continuous recording of the current setpoint and actual position, and the compensation of the difference of both position values with the position controller, provide for a continuous approaching of the target position. A temporary exceeding of the target position is corrected.

Table 4-2

<table>
<tr><td>
</td><td>During controlled positioning, the current position of the carrier is reported back to the controller and the control of the motor calculated accordingly. The motor speed can be respectively adjusted to the remaining travel of the carrier and the target position is reached precisely.</td></tr>
<tr><td>
</td><td>Increasing or reducing the mass change has no effect on the positioning precision and the target position continues to be reached precisely.</td></tr>
</table>

4.1.3 Task overview of controller and frequency inverter

Controller

From the pulses of the connected encoder, the S7-200 CPU calculates the current position (see chapter 4.3.3).

Depending on this position, the speed at which the motor is to move is signaled to the frequency inverter via 2 digital control outputs.

Frequency inverters

Depending on the status of the CPU control signals, the frequency inverter delays or accelerates the motor to the parameterized speeds. Acceleration or deceleration is here stored as a time value in form of a ramp.

The frequency of the phase rotation field of the motor is independent of the frequency of the power grid.

4.2 Determining the traversing parameters for controlled positioning

4.2.1 Determining the physical travel path

Switching the speed over / off using the rapid traverse and creep feed mode requires the ability to detect when the respective position has been reached. This can either occur via sensors or an encoder.

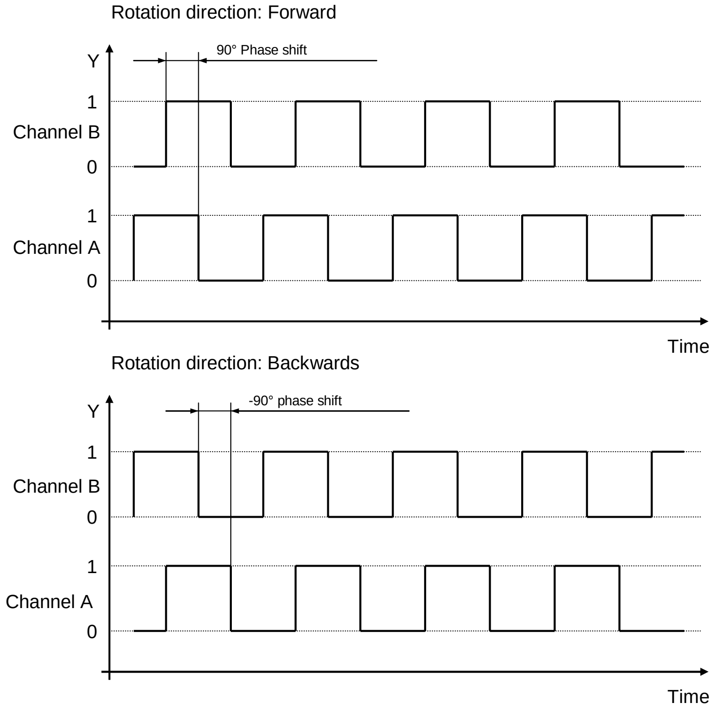
In the example on hand, an incremental encoder is used, which apart from recording the current position also enables standstill monitoring.

Incremental encoder

In this application, an incremental (or shaft-angle) encoder is used. It generates a defined number of pulses per rotation.

The encoder has tow different count tracks which enable deducing the direction of the movement.

Figure 4-5



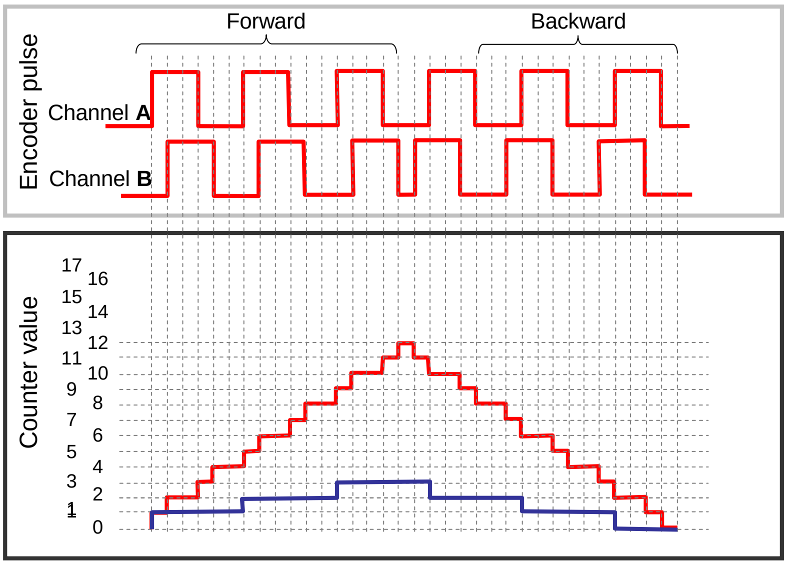
Evaluating the pulses

Using the integrated fast counter, the S7-200 CPU 221 counts the pulses of the incremental encoder. The integrated counter supports both count tracks of the incremental encoder and increases or reduces the counter value depending on the rotation direction (for example, see blue counter value in Figure 4-6). The counter value reflects the current position

Increasing the encoder precision

For increasing the precision, each edge change of channel A and B can alternatively be used for increasing or reducing the counter value, depending on the rotation direction (as an example see red counter value in Figure 4-6).

Figure 4-6



4.2.2 Determine acceleration and velocity

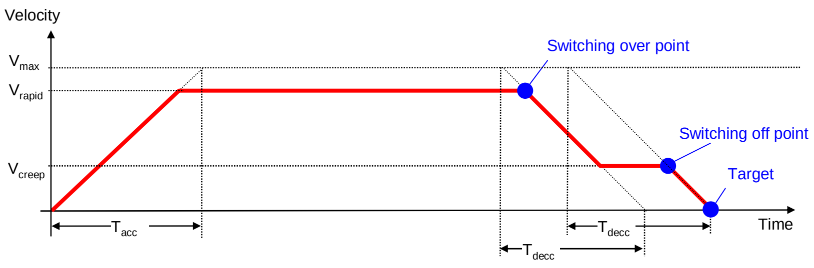
Rapid and creep velocity as well as acceleration and deceleration all affect speed and precision of the positioning.

The acceleration is established by input of a ramp up time T_{acc} in the frequency inverter. It describes the time interval in which the axis is accelerated from 0 to maximum velocity V_{max}.

The deceleration is established by input of a ramp down time T_{decc} in the frequency inverter. It describes the time interval in which the axis is accelerated from maximum velocity V_{max} to 0.

The increase of the ramp depends on the permissible mechanical system load and the maximum permissible torque of the frequency inverter as well as the inertia of the goods to be conveyed.

Figure 4-7



A short ramp down time means a short distance which the axis travels after switching off the frequency inverter.

The following configuration / design tools support you in determining the ramp up time (acceleration) or the ramp down time (deceleration)

- Sizer“.
  (**http://www.automation.siemens.com/ld/ac-umrichter-low/ld/html_00/sizer.html**)
- SGM-Designer
  (**http://ekat1.plan-software.de/easygui/easygui.php?EKSUBMITEVENT=START&APPNAME=SGM6&STARTLANGUAGE=DE**)

In this Micro Automation Set 22 a ramp up or down time of respectively one second related to a maximal speed of 1500 U/min was selected.

Rapid velocity V_{rapid}

The rapid velocity should ideally correspond to the setpoint speed of the motor. If the rapid velocity strongly deviates from the setpoint velocity, and the motor is moved with this speed over a longer period of time, the asynchronous motor might overheat due to insufficient cooling. If this is the case, the asynchronous motor must be separately cooled.

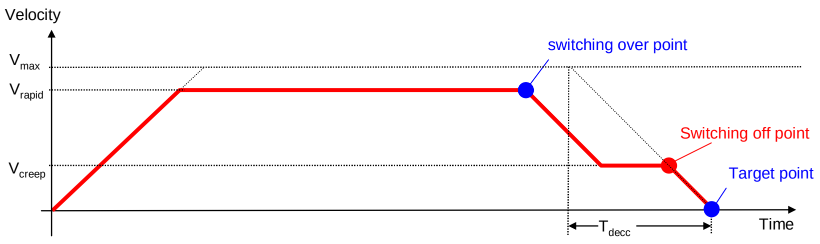
Creep velocity V_{creep}

A good positioning precision requires selecting the creep velocity to be considerably smaller than the rapid velocity.

4.2.3 Determining the switching over and switching off points

Calculating the switching off point

Figure 4-8



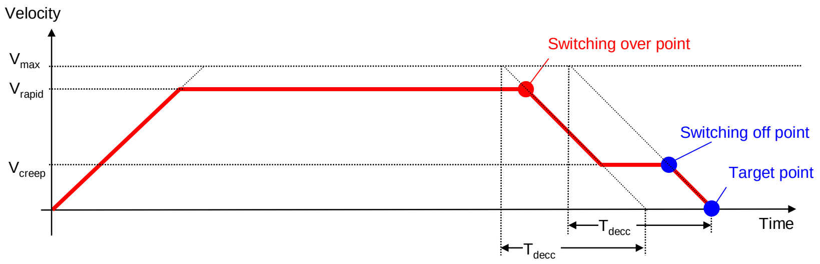
Section S_1 corresponds to the distance traveled by the axis from the switching off point to standstill. This distance can be approximated with the following equation:

$$S_1 = \frac{1}{2} * T_{decc} * \frac{(V_{creep})^2}{V_{\max}}$$

In practice, however, it is recommended to determine this distance by means of empirical measurements.

Calculating the switching over point

Figure 4-9



The travel section S_2 corresponds to the total of the following traveled distances

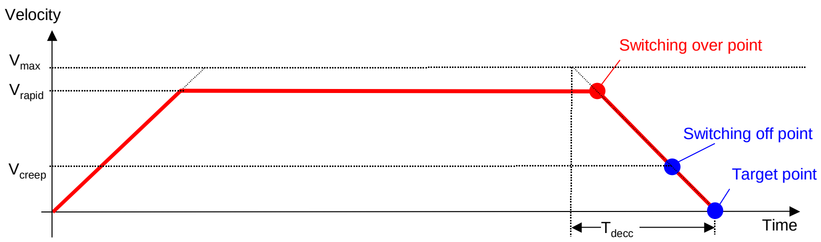
- The distance from switching over point to the starting of creep velocity
- The traveled distance in creep velocity
- The previously determined travel section S1
- Distance S_2 can be approximated with the following equation:

$$S_2 \rangle \frac{1}{2} * \frac{T_{decc}}{V_{\max}} * (V_{rapid}^2 - V_{creep}^2) + S_1$$

In practice, however, it is recommended to determine this distance by means of empirical measurements.

It must be noted here that the switching over point must be selected, so that the axis is still moved in creep velocity V_{creep} prior to reaching the switching off point. The following drawing shows the border case.

Figure 4-10



4.3 Application of controlled positioning

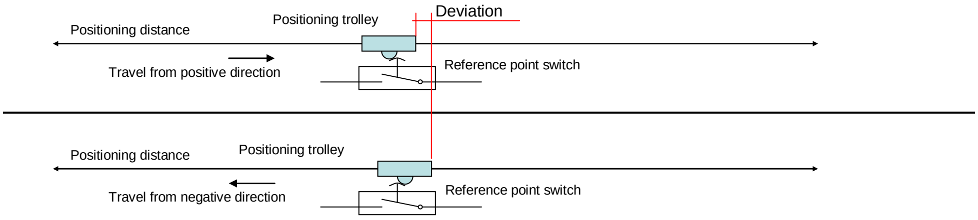
4.3.1 Referencing

After switching on the machine, the physical position of the axis as well as the logical position in the controller must be synchronized with each other. As the position of the axis may change in the switched off state, this process must be repeated after every switch on.

The prerequisite for synchronizing is a reference point switch whose position is known to the controller. This position is searched in the special “Referencing“ mode by moving the axis in slow speed.

In order to guarantee high precision the reference point switch is always only approached from one direction. Otherwise, this would result in the deviation displayed in the figure below.

Figure 4-11



4.3.2 Moving an axis in jog mode

Manual moving of the system enables “jog” mode even independently of a positioning or reference point search.

This enables moving the system with the following options by pressing a button:

- Moving slowly in positive direction
- Moving slowly in negative direction
- Moving fast in positive direction
- Moving fast in negative direction

4.3.3 Moving an axis to a defined position

In “absolute positioning“ mode, the axis is moved to this position by defining a target position (setpoint value). The prerequisite for absolute positioning is a successfully performed reference point search.

Calculating the current position

Converting the position counter into a metrical quantity requires the following information:

- How many pulses are generated per encoder revolution?
- How large is the metrical travel change of the axis for one encoder revolution?

Pulse per encoder revolution

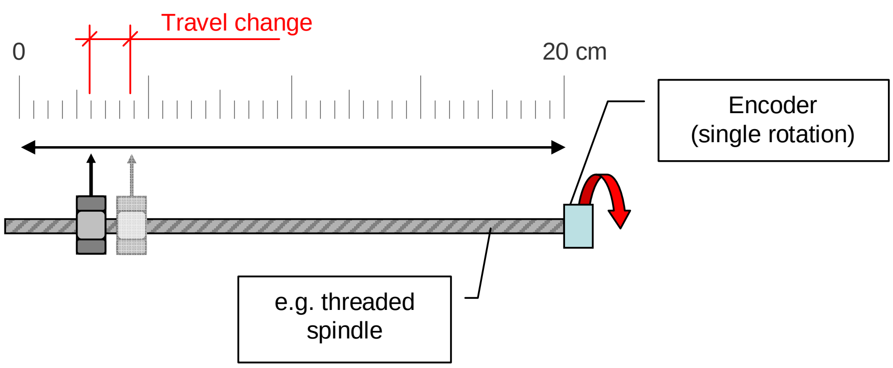
This is a fixed technical value of the employed encoder. It is affected by an activating or deactivating of the increased encoder precision (pulse quadruplication).

- With pulse quadruplication: $Position\_counter = 4 * \frac{Encoder\_pulses}{Revolution}$
- Without pulse quadruplication: $Position\_counter = \frac{Encoder\_pulses}{Revolution}$

Metric travel change per encoder revolution

The “travel change“ defines by which distance the axis moves (in the following figure at the example of a threaded spindle) after one revolution made by the encoder.

Figure 4-12



Converting the position counter into a metrical travel

Using the following formula, the control program calculates the current position from the current position counter status:

$$\text{Position} = \text{Position counter} * \frac{\text{Travel change}}{\text{Encoder pulse/Revolution}}$$

4.4 Details of the control functions for the S7-200 CPU 221

4.4.1 Process inputs

Table 4-3:

Process input	Description / Function
Sensor	The S7-200 records the counter pulses via the fastest counter input and calculates the current position from it.
Reference point switch	Using the reference point switch, the position counter is synchronized with the axis position. The S7-200 uses a standard digital input.
HMI system	Setpoint values and limit values for positioning.

4.4.2 Process outputs

Table 4-4:

Process output	Description / Function
Creep velocity (fixed frequency f_1)	This output signal signals the frequency inverter to move in creep velocity. The fixed frequency 0 is hereby used in the frequency inverter. The S7-200 uses a standard digital output.
Rapid velocity (fixed frequency “f_1+f_2”)	This output signal signals the frequency inverter to move in rapid velocity. In the frequency inverter, the fixed frequency 0+1 is used. The S7-200 uses one standard digital output for each frequency.
Reversing (change of direction)	The frequency inverter is reversed with this output signal. The S7-200 uses a standard digital output.
HMI system	Status information, current position.

4.4.3 Alternative process output with USS protocol

Alternatively, the frequency inverters MICROMASTER 4XX and SINAMICS G110 from the S7-200 can be controlled via a drive bus (USS protocol).

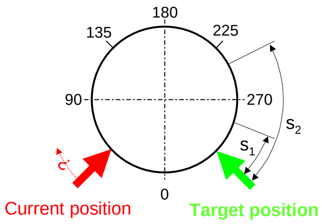
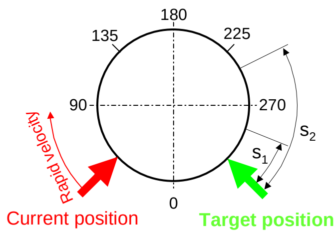
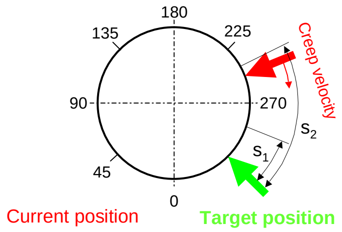
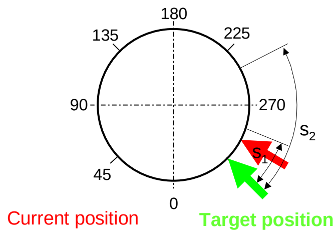
This requires the optimal USS interface for the frequency inverter and the USS library for the STEP -Micro/WIN.

Note When using this application example, the additional storage demand of the USS communication library requires using at least an S7-200 CPU 224.

4.4.4 Control program

This section describes the operation principle of the positioning.

Table 4-5:

No.	Process inputs/outputs	Control program
1.	User input: • Target position • Start	Check whether the switching over/off point has been reached. 
2.	Process output: • Creep velocity • Input • Reversing	Start in rapid velocity, check whether the switch over/off point has been reached. 
3.	Process output: • Creep velocity • Reversing	Check whether switching off point has been reached. 
4.	Process output: • Creep velocity • Reversing	Terminating the movement. The frequency inverter stops the motor with the configured delay. 
5.	After standstill of the axis, the positioning process is terminated.	

4.5 Details of the frequency inverter

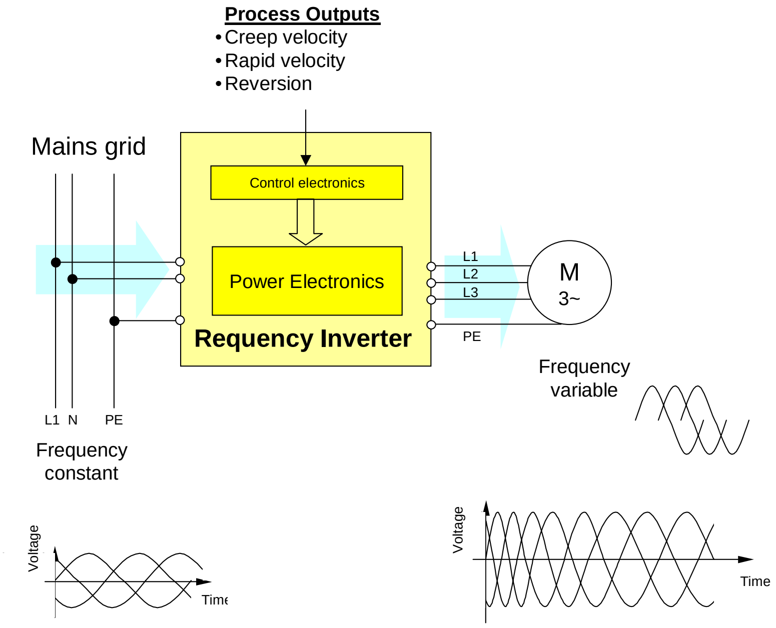
4.5.1 Why is a frequency inverter used?

The speed of an asynchronous motor depends on the make of the motor and of the network frequency of the power grid. For fixed network frequency, a constant motor speed results depending on the load torque. When using rapid traverse and creep feed mode, the frequency inverter causes a motor control with 2 different speeds.

4.5.2 Function of the frequency inverter

From the current network with a constant frequency, the frequency inverter generates a three-phase current with a variable frequency (see graphic below), which then enables using it for positioning tasks as well.

Figure 4-13



4.5.3 Additional requirements to the motor due to the dynamics of the moving process and decelerating the load.

Motor operation with speeds smaller than the setpoint speed

Motors can be operated at the frequency inverter with speeds smaller than the setpoint speed.
The following limitations have to be noted here:

- The torque for speeds < setpoint speed is smaller than the given setpoint torque. The motor has generally less power at lower speeds.
- Motor cooling is not optimal during speeds < setpoint speed due to reduced internal ventilation. The motor may heat up very strongly.

To prevent the motor from overheating, it must either be cooled externally, or pauses for cooling the motor be considered in the movement process.

Acceleration and deceleration capability

Standard asynchronous motors are designed for applications with classic permanent operation (approximately constant speeds over a longer period of time).

Acceleration and deceleration phases often occur during positioning processes. This means, the asynchronous motor heats up in addition.

The motor must be designed for these higher performance requirements.

Dissipating deceleration energy during deceleration

For positioning tasks whose loads must be actively decelerated, application of a MICROMASTER 440 instead of the SINAMICS G110 must be recommended. MICROMASTER 440 enables connecting the breaking resistance via which surplus deceleration energy can be dissipated.

4.5.4 Avoiding electromagnetic disturbances

Notes on operation of frequency inverters

- Make sure a good conductive connection between the frequency inverter and the (grounded) metal mounting plate is provided.
- Ensure all devices in the cabinet are earthed using short earthing lines with a large diameter and are connected to a common earthing point or earthing bar.

- Ensure that each control device connected at the frequency inverter (e.g. a PLC) has a short line with large cross-section connected at the same earthing as the frequency inverter.
- Connect the protective conductor of the motor to the earth connection (PE) of the respective frequency inverter.
- Flat earthing conductors are preferred as their impedance is lower at higher frequencies.
- The line ends should be properly terminated and unshielded lines kept as short as possible.
- Control lines must be installed separately from power cables in separate installation channels, if possible. Crossings between power and control lines should be at 90° angle.
- If possible you use shielded control lines.
- Check that the contactors in the cabinet are suppressed. This is either achieved by means of RC interference suppressors for AC conductors or with “bypass“ diodes for DC contactors,. The suppressor devices must be attached at the coils. Varistor voltage surge suppressors are also effective.
- Please use shielded or armoured lines for motor connections. Earth the shielding with cable clamps at the frequency inverter as well as the motor.

Accessories on the network side

The following table describes the network side accessories for the SINAMICS G110.

Table 4-6:

Accessories	Description of the accessories
EMV filter[1] class B with low leakage currents	This filter reduces leakage currents into the mains supply to less than 3.5 mA. (e.g. for operation at the FI protective switch)
Additional EMV filter of class B	Extension for the frequency inverter with integrated class B filter. Using this additional filter increases the maximum length when using shielded connection cables from 5m to 25m.
Mains choke[2]	Please refer to the manual of the SINAMICS G110,

[1] EMV filter: is an additional device, which reduces negative feedbacks into the mains power supply. Classification of EMV capability is regulated in the standard EN 55011 and divided into class A and B, whereby class A fulfills lower requirements than class B. (Filter standard of class A is supported by SIMANICS without filter.)

Accessories	Description of the accessories
	whether it is necessary to employ a mains choke. (Link: http://support.automation.siemens.com/WW/view/en/22102965, chapter 9)

[2] Mains choke: is an additional device used to smoothen voltage peaks or to bridge commutating dips.

5 Configuring the Startup Software

5.1 Preliminary remark

For the startup, we offer you software examples with the Startup Code as a download. The software example supports you during the first steps and tests with this Micro Automation Set. It enables quick testing of hardware and software interfaces between the products described in the Micro Automation Sets.

The software example is always assigned to the components used in the set and show their principal interaction. However, it is not a real application in the sense of technological problem solving with definable properties.

5.2 Download of the startup code

The software example is available on the HTML page from which you downloaded this document.

Table 5-1:

No.	Object	File name	Contents
1.	S7-221 Code rotary axis	Set22_S7-200_Rotary_v1d0.mwp	STEP7 Micro/WIN program for S7-200 CPU 221 for moving a rotary axis
2.	HMI rotary axis	Set22_PC.Bediengeraet_1.hmi	WinCC flexible 2005 SP1 for operating the moving process, configuration file
3.	Library rotary axis	Set22_MicroWin_Library_Rotary_V1d4.mwl	STEP7 Micro/WIN library

5.3 Configuring Components

Note

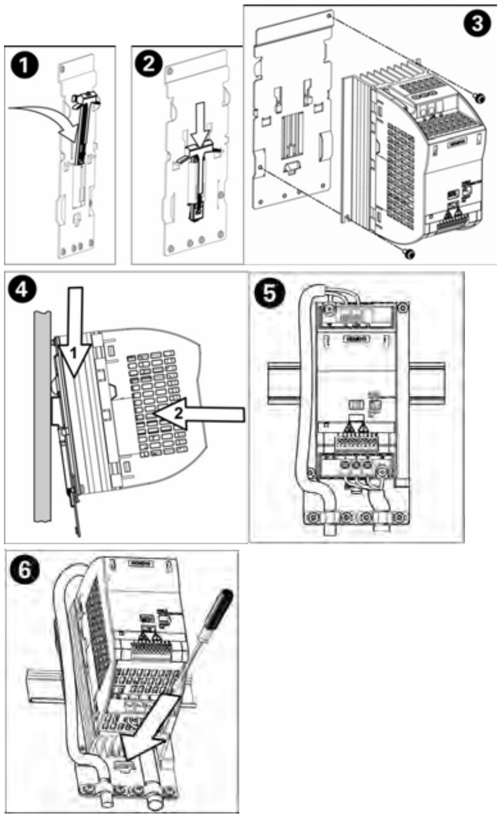
Here it is assumed, that the required software

- STEP7 Micro/WIN V4.0 SP4
- WinCC flexible 2005 SP1 PC-Runtime

has been installed on your computer and you are familiar with the principal operation of this software.

5.3.1 Installing and wiring the hardware

Table 5-2:

No.	Action	Comment
1.	Mount the line protection on the top-hat rail.	
2.	Mount the LOGO! Power 24V, 1.3A power supply on the top-hat rail.	
3.	Mount the S7-200 CPU 221 on the top-hat rail.	Open the DIN snap-on hook (on the bottom side of the modules) and place the back side of the module on the top-hat rail. Turn the module downwards to the standard top-hat rail and close the snap-on hook. Make sure that the hook is properly engaged and that the device is properly fixed on the rail. To avoid damage to the module, please press on the drilling and not directly on the front of the module.
4.	Mount the SINAMICS G110 to the top-hat rail mounting kit.	

No.	Action	Comment
5.	At the front of the SINAMICS G110 you switch the DIP switch to the mains supply used here.	
6.	Snatch the operator panel open (BOP)	
7.	Mount the motor to your mechanic.	
8.	Mount the encoder to your mechanic.	
9.	Wire all components to Figure 2-1.	See chapter 2.

5.3.2 Parameterize the frequency inverter

General

The frequency inverter requires important settings for operation, such as motor voltage, current and acceleration times.

These must be parameterized in the frequency inverter prior to the first usage!

Which parameter is required by the frequency inverter?

The frequency inverter requires the following parameter:

- Electrical parameters, such as current, voltage and frequency (of motor and mains supply)
- Mechanical parameters of the motor, such as speed
- Mechanical parameter of the overall configuration, such as maximum possible speed, maximum possible acceleration and delay
- Control interface

Determining the parameters of the frequency inverter

- The electrical and mechanical parameters of the motor are available on the rating plate
- The mechanical parameter of the overall configuration must be determined/calculated by you.
  The configuration tool “Size“r or “SGM-Designer“ can help you with this (see 4.2.2).

Configure the SINAMICS G110 frequency inverter

Warning

Please carefully read all safety and warning notices given in the operating instructions on the SINAMICS G110 and all warning labels attached to the device before performing any installation and commissioning procedures. Please maintain warning labels in a legible condition and do not remove them from the device.

Please enter the following parameter using Operator Panel:

Table 5-3:

No.	Parameter	Description
1.	P0010 = 1	Start quick startup
2.	P0100 = 0	Set country settings to Europe. **ATTENTION this parameter must correspond with the settings of the DIP switch at the front of the SINAMICS G110.**
3.	P0304 = 230	Set rated motor voltage to 230V.
4.	P0305 = 0,73	Set rated motor voltage to 0.73A.
5.	P0307 = 0,12	Set rated motor voltage to 0.12kW
6.	P0310 = 50	Set rated motor voltage to 50Hz.
7.	P0311 = 1395	Set rated speed to 1395min-1
8.	P0700 = 2	Select the command source of the SINAMICS G110 as the command source
9.	P1000 = 3	Select the fixed frequencies (digital inputs) as source of the frequency setpoint value for the SINAMICS G110
10.	P1080 = 0	Set the minimum frequency to 0Hz
11.	P1082 = 50	Set the maximum frequency to 50Hz
12.	P1120 = *	Set the startup time from minimal to maximal speed. (At the used demo system, the time is 1 second.)
13.	P1121 = *	Set the ramp-down time from maximal to minimal. (At the used demo system, the time is 1 second.)
14.	P3900 = 1	Terminate fast commissioning
15.	P0003 = 3	Enable further parameters

No.	Parameter	Description
16.	P0701 = 16	Fixed frequency 1 and command ON
17.	P0702 = 16	Fixed frequency 2 and command ON
18.	P0703 = 12	Reversing
19.	- P1001 = *	- Selecting the frequency for frequency 1. (at the used demo-system the frequency is 10 hertz.)
20.	- P1002 = *	- Selecting the frequency for frequency 2. (at the used demo-system the frequency is 20 hertz.)
21.	- P0971 = 1	- Secure all values in EEPROM

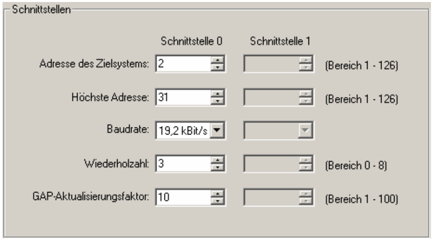
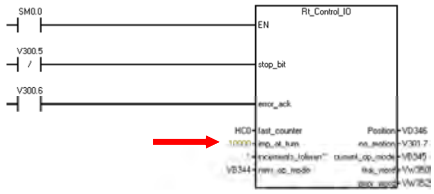
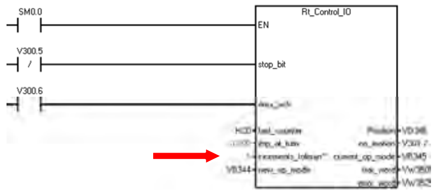
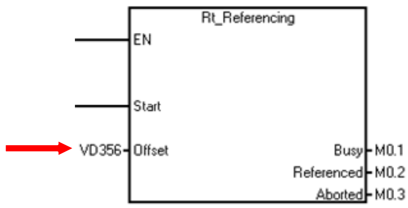
Attention

In the course of quick startup, the electrical values of the motors mentioned in chapter 3 “Hardware and Software Components” are listed in the table above.

Please use the electrical values of your motor!

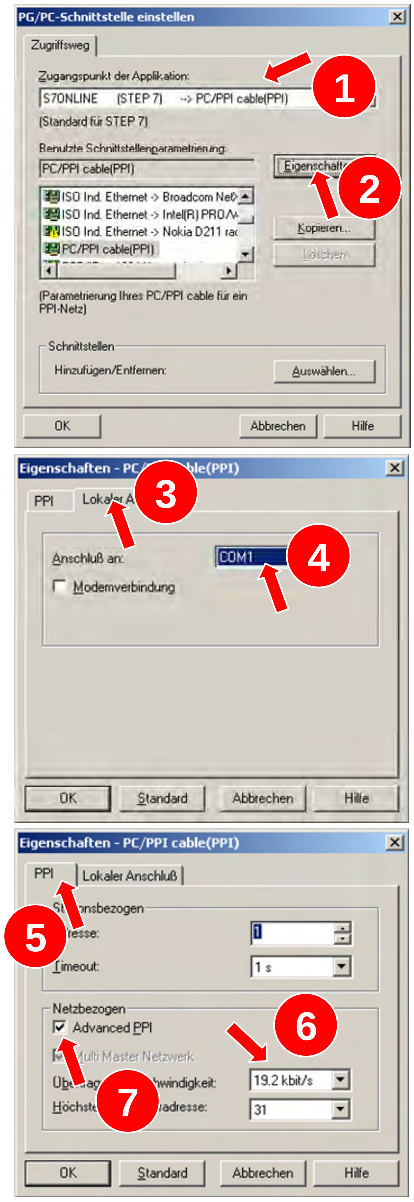
5.3.3 Configuring the startup code

Table 5-4:

No.	Action	Note / Picture
1.	Open the S7-200 project.	
2.	Please ensure that the following values have been entered in the system block of the CPU.	
3.	In “Libary“ you navigate to the interrupt program ”Rt_Control_INT“. Check the correct settings of your encoder. Enter the numberof encoder pulses per drive rotation.	
4.	Adjust the value for standstill monitoring. This value specifies which maximum change of increments can still be interpreted as standstill.	
5.	In the main program “Program_Block“ you navigate to the call of subprogram “Rt_Referencing“. Adjust the value for the reference point shift. (In this example, the variable VD356 in the data block has the value -3.5 assigned to it)	
6.	Load the project into the controller.	Connect the CPU using the RS232/PPI cable with the serial interface of your PC. (Set all DIP switches of the cable to zero).
7.	Set the controller into “RUN” mode.	

5.3.4 Configuring WinCC flexible RT

Table 5-5:

No.	Action	Note / Picture
1.	Connect the RS232/PPI cable with CPU and the serial interface of your PC. (Set all DIP switches of the cable to zero). Switch 3 is enabled.	
2.	For the access point “S7-Online“ you make the following settings. (System controller: Set PG/PC Interface)	
3.	Then start the WinCC flexible Runtime.	

6 Live Demo

Overview of features

The following features of this Micro Automation Set can be demonstrated:

- Setting up the positioning (finding the switch-off points)
- Manual/jog mode
- Reference point search
- Manual positioning
- Automatic positioning
- Limit value monitoring of the travel range

6.1 Navigation

Overview

The user interface of the Micro Automation Sets 22 consists of the operator images:

- Commissioning
- Manual
- Automatic

Navigation menu

All operator screens have the following navigation menu on the left side.

Figure 6-1

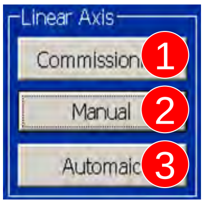


Table 6-1:

No.	Description
1.	Changes to the “Commissioning“ operator screen
2.	Changes to the “Manual“ operator screen
3.	Changes to the “Automatic“ operator screen

6.2 HMI screen

Attention

In each screen, any control of the frequency converter can be cancelled by pressing the "Stop" button!

Structure of the "Commissioning" operator screen

Figure 6-2

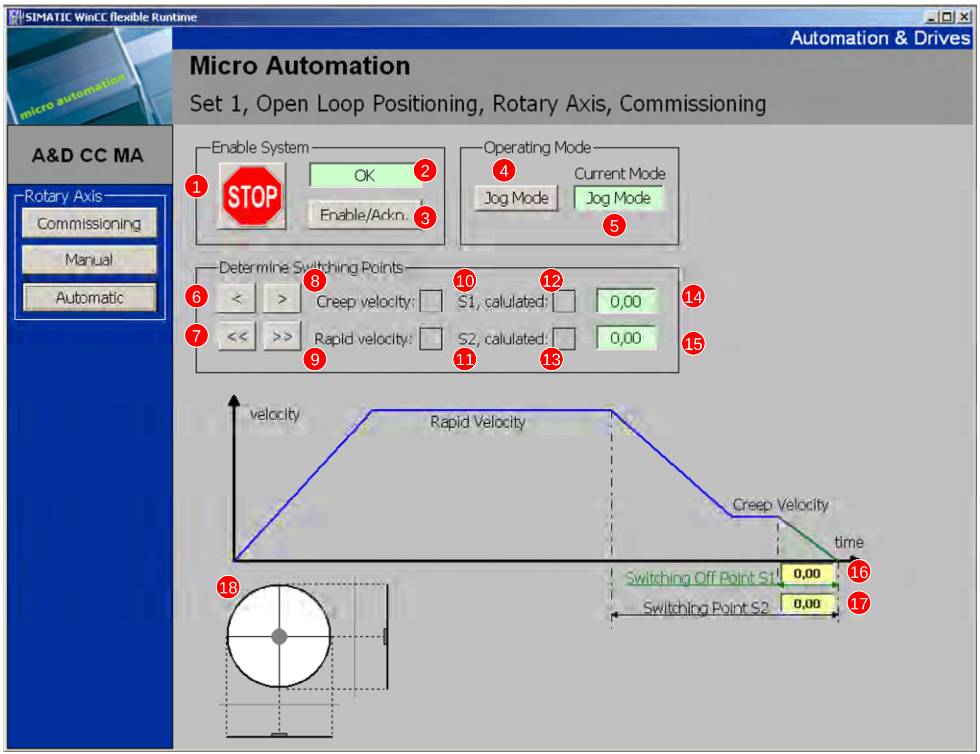


Table 6-2:

No.	Name	Description
1.	Stop	Pressing the button interrupts the control of the frequency inverter. The system goes into standstill.
2.	Status: system activated/deactivated	Here the current status of the system is displayed: • "Wait for ackn.": The system is deactivated. • "OK": The system is active.

No.	Name	Description
3.	Enable/ackn. system	Pressing this button activates/enables the system
4.	Switching over into jog mode	Pressing this button switches into jog mode. (Switching only becomes effective during standstill of the system)
5.	Display of the operating mode	Here, the currently selected operating mode is displayed • Jog Mode • Referencing • Positioning
6.	Slow jog, negative	Moves the system in manual mode with creep velocity in negative direction
7.	Fast jog, negative	Moves the system in manual mode with rapid velocity in negative direction
8.	Slow jog, positive	Moves the system in manual mode with creep velocity in positive direction
9.	Fast jog, positive	Moves the system in manual mode with rapid velocity in positive direction.
10.	Creep velocity	This display lights green, as soon as the creep velocity has been reached. This display lighting up is the prerequisite for correct calculation of value s_1.
11.	Rapid speed	This display lights green, as soon as the rapid velocity has been reached. This display lighting up is the prerequisite for the correct calculation of value s_2.
12.	Switching off point s_1, calculated	This display lights green as soon as a new (correct) value was calculated for s_1.
13.	Switching over point s_2, calculated	This display lights green as soon as a new (correct) value was calculated for s2.
14.	Calculated value s_1	Here the newly calculated value for s_1 is displayed.
15.	Calculated value s_2	Here the newly calculated value for s_2 is displayed.
16.	Value for s_1	Displays the currently used value for the switching off point s_1. (On the right side of this value a button appears for acknowledging newly calculated values)
17.	Value for s_2	Displays the currently used value for the switching off point s_2. (On the right side of this value a button appears for acknowledging newly calculated values)
18.	Position	Displays the current position on a round scale.

Structure of the “Manual“ operator screen

Figure 6-3

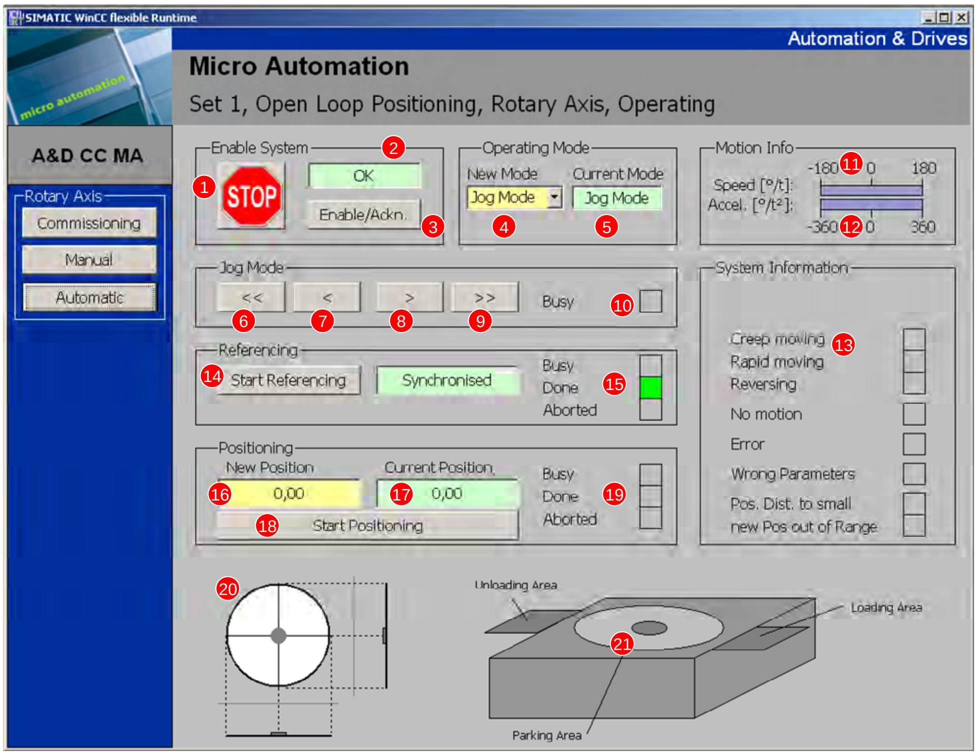


Table 6-3

No.	Name	Description
1.	Stop	As operator screen “Commissioning“, see Figure 6-2.
2.	Status: system activated/deactivated	As operator screen “Commissioning“, see Figure 6-2.
3.	Enable/ackn. system	As operator screen “Commissioning“, see Figure 6-2.
4.	Switching the operating mode	Pressing this button switches into jog mode. (Switching only becomes effective during standstill of the system)
5.	Display of the operating mode	As operator screen “Commissioning“, see Figure 6-2.
6.	Fast jog, negative	Moves the system in manual mode with rapid velocity in negative direction
7.	Slow jog, negative	Moves the system in manual mode with creep velocity in negative direction
8.	Slow jog, positive	Moves the system in manual mode with creep velocity in positive direction

No.	Name	Description
9.	Fast jog, positive	Moves the system in manual mode with rapid velocity in positive direction.
10.	Jog busy	Indicates (green) when the system is moved in jog mode.
11.	Velocity	Graphically displays the calculated velocity
12.	Acceleration	Graphically displays the calculated acceleration
13.	System information / Error information	Indicates that status / error information of the system
14.	Start referencing	Starts the reference point search. (operating mode “referencing“ must be activated)
15.	Busy, Done and Aborted of the referencing block.	Indicates the status of the referencing block
16.	New target position	Here you enter the new target position.
17.	Current position	Indicates the current position of the axis.
18.	Start positioning to the target position	Starts the positioning to the target position.
19.	Busy, Done and Aborted of the positioning block.	Indicates the status of the positioning block
20.	Position	Displays the current position in a round scale.
21.	Position	Displays the position on a positioning table.

Description of the operator screen “Automatic“

Figure 6-4

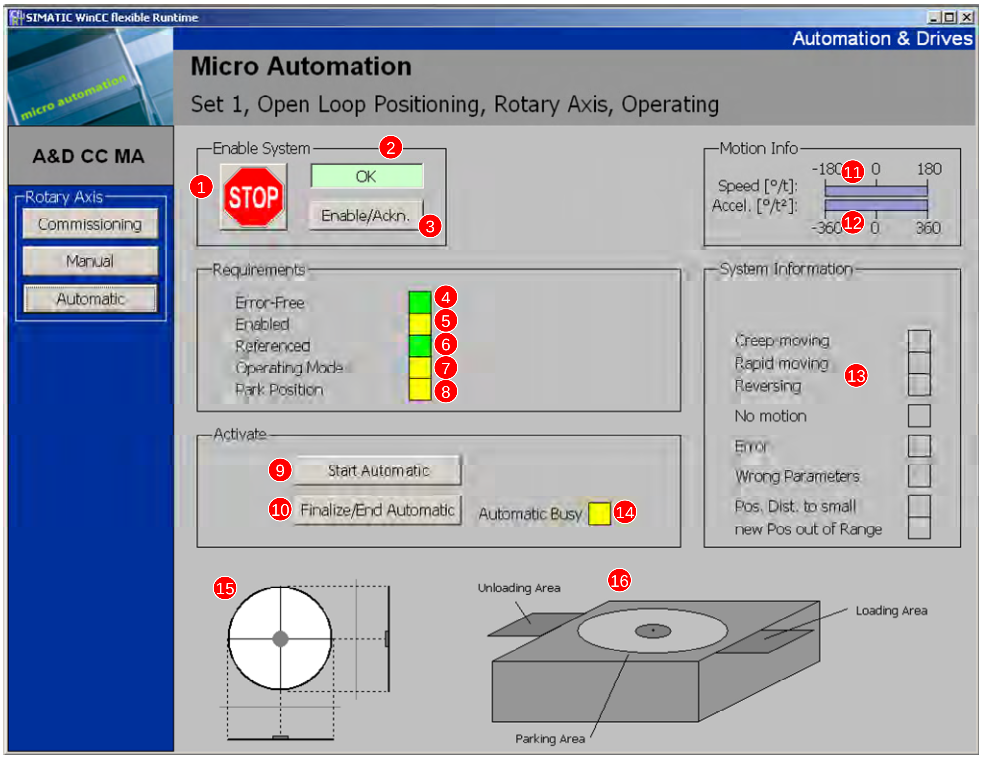


Table 6-4:

No.	Name	Description
1.	Stop	As operator screen “Commissioning“, see Figure 6-2.
2.	Status: system activated/deactivated	As operator screen “Commissioning“, see Figure 6-2.
3.	Enable/ackn. system	As operator screen “Commissioning“, see Figure 6-2.
4.	Automatic condition: no error	Start conditions (4-8) must be active (green), so that the automatic mode can be started.
5.	Automatic condition: system activated	
6.	Automatic condition: system referenced	
7.	Automatic condition: positioning mode selected	
8.	Automatic condition: system in parking position	The park position (8) is specified in network 6 of the main program “Program_block” At a position between 250°…290° the device is in parking position.

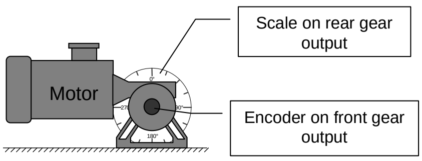
No.	Name	Description
9.	Start Automatic	This button starts the automatic mode. The button is only visible if conditions ❹…❽ have been fulfilled.
10.	Terminate automatic	This button terminates the automatic mode.
11.	Velocity	As operator screen “Manual Operating“, see Figure 6-3.
12.	Acceleration	As operator screen “Manual Operating“, see Figure 6-3..
13.	System information / Error information	As operator screen “Manual Operating“, see Figure 6-3..
14.	Atuomatic active	Indicates (yellow) whether the automatic has been activated
15.	Position	Displays the current position in a round scale.
16.	Position	Displays the position on a positioning table.

6.3 Overview of live demo

Drive model of the live demo

For the description of the live demo, a geared motor with two shaft ends is used. It is sketched out in the following figure.

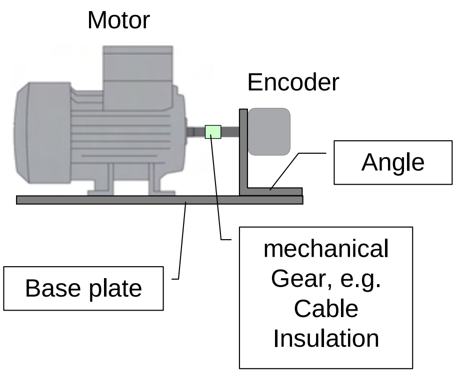
Figure 6-5



Simulated model

To be able to use the live demo without larger expenditure, it is briefly sketched out here, how you can set up a demo model with the least amount of work.

Figure 6-6



Connect a simulator (SIM 274, 6ES7274-1XF00-0XA0) to the inputs of the S7-200 CPU 221. This enables simulating the process inputs of the positioning.

Content of the live demo

In the following chapters the processes of the live demo are displayed:

- Checking the count direction of the encoder
- Determining the positioning parameter
- System referencing
- Manual positioning for the target position to be entered
- Automatic positioning
- Provoking errors
  - Position change falls short of the minimum travel

6.3.1 Checking the count direction of the encoder

Precondition

Steps in chapter 5 were performed successfully.

Checking the count direction

The objective of this scenario is determining whether the encoder connected to the S7-200 CPU 221 has the correct count direction. Depending on the installation position of the encoder (attached at the left or right spindle end, belt, gear) and the wiring (exchanging the wires for count channels) has the phase shift of both count channels has different signs (plus or minus). From the phase shift, the S7-200 CPU determines the wrong count direction if necessary.

Figure 6-7, Example for different rotation directions

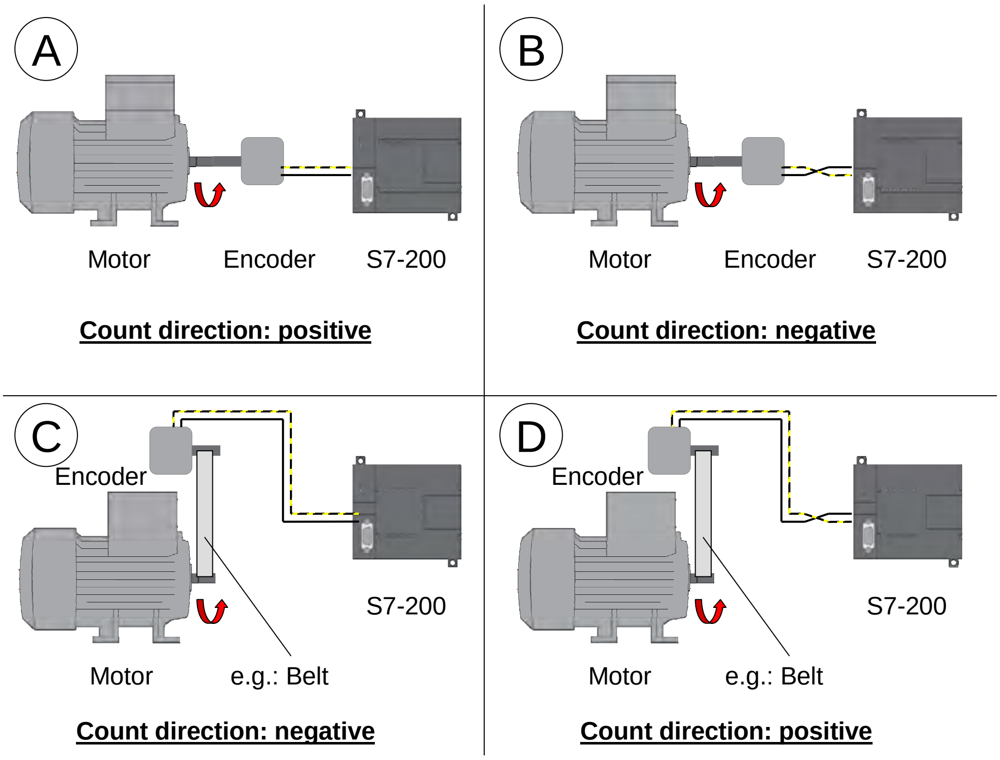
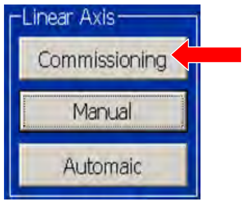
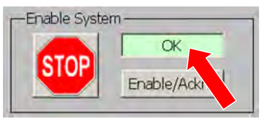
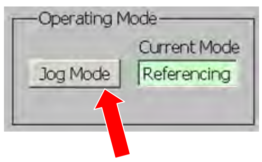
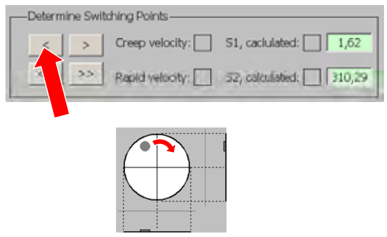


Table 6-5

No.	Description	Comment
1.	Change to the “Commissioning“ operator screen	
2.	Check whether the system is activated	
3.	Switch the system to jog mode. (Note that the operating mode is only acknowledged if the system is in standstill).	
4.	**Please ensure in the following steps, that your system always moves in the permissible travel range!**	

No.	Description	Comment
5.	Move in negative direction in creep velocity and observe whether the visualization of the rotary axis behaves as in the graphic in the right hand pane. If this is the case, the count direction is correct. If the position on the scale moves into the opposite direction, the count direction is reversed. Please note the following:	

Note If the count direction is wrong, please change the wiring at inputs E0.0 and E0.1!

6.3.2 Scenario Determining the switching off/over distance

Precondition

Steps in chapter 5 were performed successfully.

Determining the switching off/over distance

The objective of this scenario is determining the switching off and over distance (s_1, s_2) of the positioning.

Figure 6-8 Switching off point

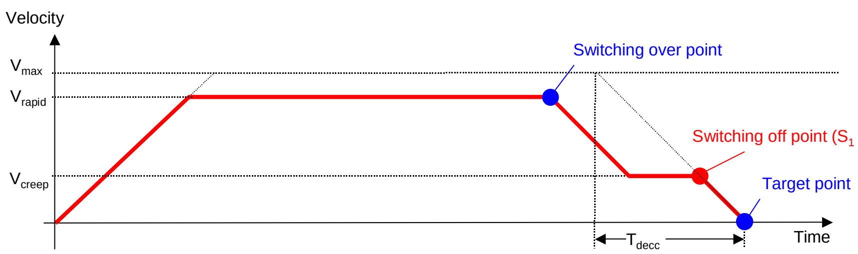


Figure 6-9 Switching over point

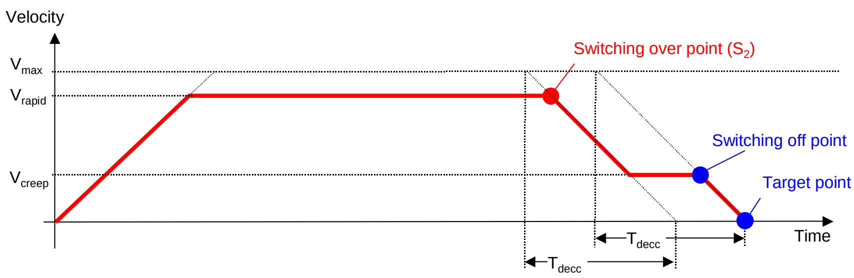
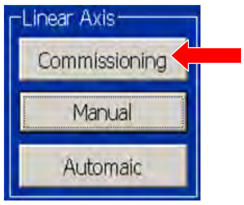
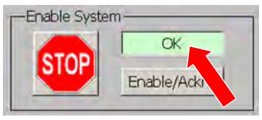
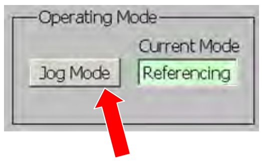
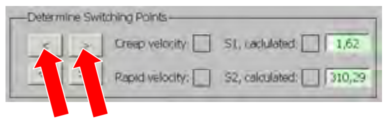
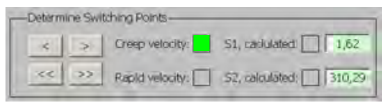
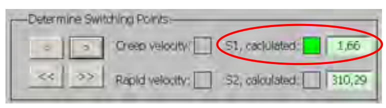
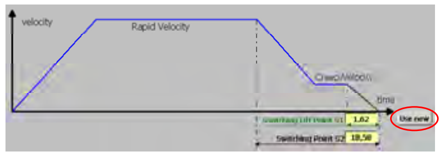
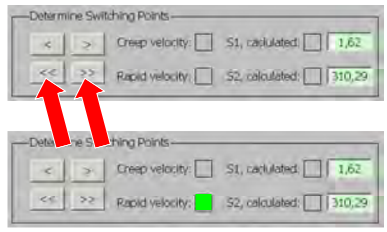
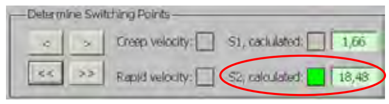


Table 6-6:

No.	Description	Comment
1.	Change to the “Commissioning“ operator screen	
2.	Check whether the system is activated	
3.	Switch the system to jog mode. (Note that the operating mode is only acknowledged if the system is in standstill).	
4.	**Please ensure in the following steps, that your system always moves in the permissible travel range!**	
5.	Move in positive or negative direction in creep speed, until the “Creep velocity“ display lights up green. (You have now reached creep velocity. This is a prerequisite for a successful caclulation of the switchoff point)	 
6.	Stop moving the axis in creep velocity. As a result, the display “s_1, calculated“ lights up green. The value for s_1 was calculated successfully.	

No.	Description	Comment
7.	Accept the calculated value into the positioning program with the “Use new“ button.	
8.	Move in positive or negative direction in rapid speed, until the “Rapid velocity“ display lights up green. (You now have reached the velocity, this is the prerequisite for a successful calculation of the switching off point)	
9.	Stop moving in creep velocity, the display “s_2, calculated“ then lights up green. The value for s_1 was calculated successfully.	
10.	Accept the calculated value into the positioning program with the “Use new“ button.	

The calculated values apply equally for any target point to be defined.

6.3.3 Scenario reference point search

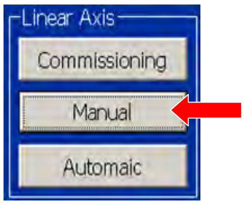
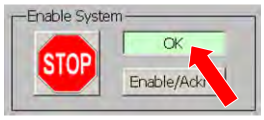
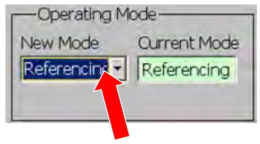
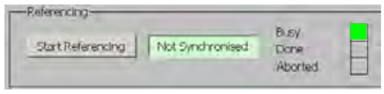
Precondition

Steps in chapter 5 were performed successfully.

Reference point search

The objective of this scenario is to reference the system. This adjusts the position calculated by the S7-200 CPU 221 to the actual position.

Table 6-7:

No.	Description	Comment
1.	Change to the “Manual“ operator screen	
2.	Check whether the system is activated	
3.	Switch the system to “Referencing” mode. (Note that the operating mode is only acknowledged if the system is in standstill).	
4.	Then in the Referencing field you click the ”Start Referencing“ button.	
5.	Then the field “Busy“ lights up and signals that the reference point is searched.	
6.	The system moves in creep velocity and searches the reference point switch in positive direction.	
7.	After a successful search, the “Done“ status and the “Synchronised“ in the output box symbolizes that the search has been completed successfully.	

Note After a stop of the positioning device via the stop button, new referencing is necessary as the drive is not shut down via a defined ramp and therefore, the shutdown time is not defined in this case.

6.3.4 Scenarios for positioning

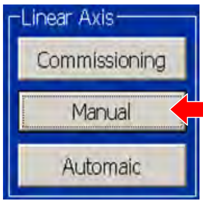
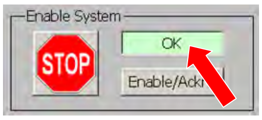
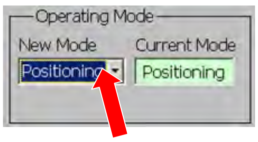
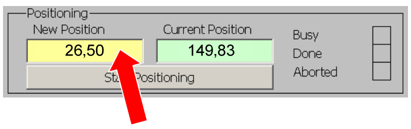
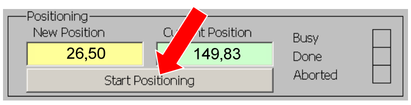
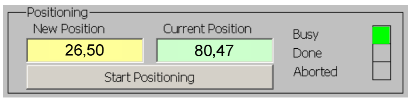
Precondition

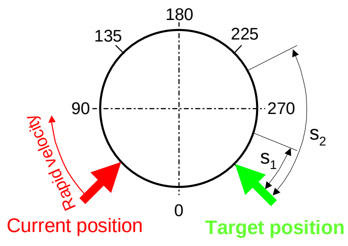
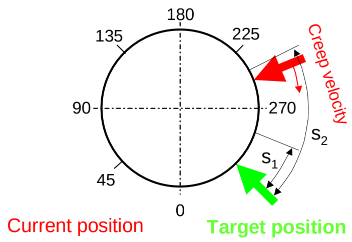
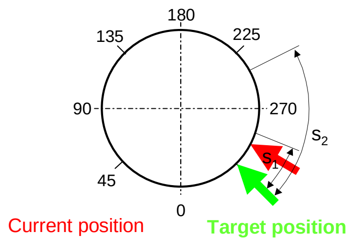
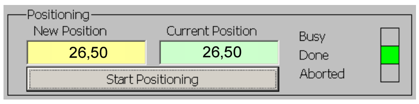
- Steps in chapter 5 were performed successfully.
- Switching over and switching off distances are configured
- The reference point search has been completed successfully

Manual positioning

The objective of this scenario is to move to a manually defined position.

Table 6-8:

No.	Description	Comment
1.	Change to the “Manual“ operator screen	
2.	Check whether the system is activated	
3.	Switch the system to “Positioning” mode. (Note that the operating mode is only acknowledged if the system is in standstill).	
4.	In the positioning field you enter a new position as target and close the input with the enter button.	
5.	Then you click on the “Start Positioning“ button.	
6.	Then the “Busy“ indication lights up and signals that positioning is in progress.	

No.	Description	Comment
7.	Positioning always starts in positive with rapid velocity. At the turning point it is switched to creep velocity. At slow speed it is moved to the switching off point and the drive is switched off there. The axis stops with the configured deceleration ramp.	  
8.	After completed positioning the “Done“ indication lights up green.	

6.3.5 Scenario for automatic movement

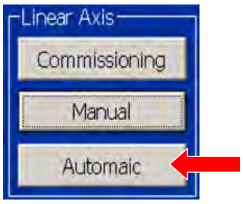
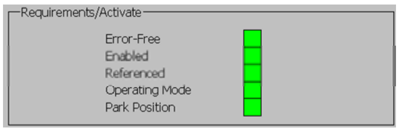
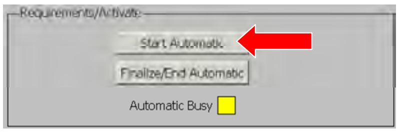
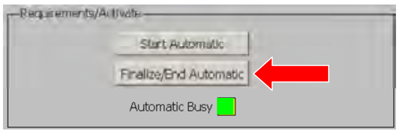
Precondition

- Steps in chapter 5 were performed successfully.
- Switching over and switching off points are configured
- The system has no errors.
- The system is enabled/activated.
- The system is referenced.
- The positioning device is in parking position (250°…290°)
- The operating mode is set to “Positioning“

Automatic positioning

The objective of this scenario is to perform an automatically controlled positioning, comparable with the application example from this document (see chapter. 1 “Application Areas and Usage”). Here the positioning device swings endlessly back and forth between both target points.

Table 6-9:

No.	Description	Comment
1.	Change to the “Automatic“ operator screen.	
2.	Check the conditions for automatic positioning.	
3.	Now you click on the “Start Automatic“. The button is only visible if all conditions in step 2 have been fulfilled	
4.	If the automatic movement has been activated, this will be indicated with “Automatic Busy” lighting up. Clicking the “Finalize/End Automatic“ terminates the automatic movement. The positioning device stops when reaching the next target position.	

6.3.6 Scenario error provoking: Position change falls short of the minimum travel

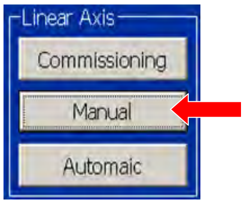
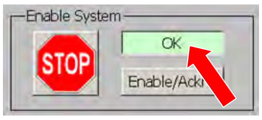
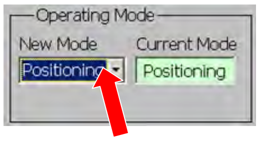
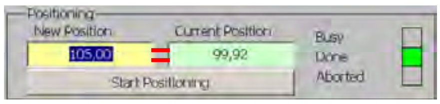
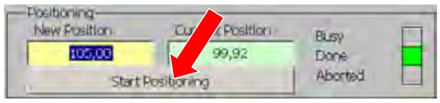
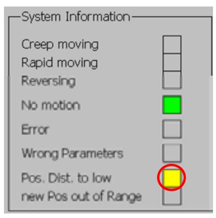
Precondition

- Steps in chapter 5 were performed successfully.
- Switching over and switching off point configured, and reference point search must be completed
- Ramp up and ramp down time in the frequency inverter (P1120, P1121) are set identical to 1 second

Position change falls short of the minimum travel

The objective of this scenario is to verify the system reactions to a positioning travel which falls short.

Table 6-10:

No.	Description	Comment
1.	Change to the "Manual" operator screen	
2.	Check whether the system is activated	
3.	Switch the system to "Positioning" mode. (Note that the operating mode is only acknowledged if the system is in standstill).	
4.	In the positioning field you enter a new target position which is closer than $2s_1$ at the start position.	
5.	Then you click on the "Start Positioning" button.	
6.	Then the started positioning process is aborted and in the "System Information" field the error "Positioning Distance too low" is displayed. Positioning travels shorter than $2s_1$ cannot be performed.	

7 Technical Data

LOGO!Power 24 V/1.3 A

Table 7-1:

Criterion	Technical data	Additional note
Supply voltage	85 to 264 V AC	
Output voltage	DC 24 V (setting range DC 22.2 to 26.4 V)	
Output current	1.3 A	
Dimensions (W x H x D) in mm	54 x 90 x 55	

S7-200 CPU 221 (DC)

Table 7-2:

Criterion	Technical data	Additional note
Input voltage	24 V DC	
Current consumption	900 mA	
Output current	180 mA	
Interfaces	1x RS 485 interface	
Inputs/outputs	5DE/4DA	
EPROM user data	2KB	Program 4kB
Dimensions (W x H x D) in mm	90 x 80 x 62 mm (w x h x d)	

Incremental encoder

Table 7-3:

Criterion	Technical data	Additional note
Input voltage	10 ... 30V DC	
Current consumption	150mA	
Maximum resolution	500 pulses/revolution	

SINAMICS G110

Table 7-4:

Criterion	Technical data	Additional note
Mains voltage	AC 200 to 240 V ±10%	
Network frequency	47 to 63 Hz	
Rated current	2.30 A	

Criterion	Technical data	Additional note
Rated output	0.37 kW	

Low-voltage motor

Table 7-5:

Criterion	Technical data	Additional note
Rated output	0.12 kW	
Rated speed	1350 1/min	
Rated current at 230V	0.42 A	
Rated torque	0,85	

WinCC flexible RT

Table 7-6:

Criterion	Technical data	Additional note
Operating system	MS Windows 2000 / XP Professional	
Variables	Depending on order, maximum of 2000 variables with external connection to the controller, internal values unlimited	
Number of connectable partners, max.	Depending on scale of configuration (communication), up to 8 connections possible with WinCC flexible Runtime	
Online languages, max.	16	Offline languages, max. 32