Application on Drive Technology

Technology CPU Extension

Flying Shears Based on Gear Synchronism

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Foreword

The application described in this document deals with “flying shears”. It shows how an axis can be synchronized to another axis with the aid of the technology CPU so that processing on the fly (cutting, drilling, pressing, welding, ...) is enabled.

The core element is the “Flying Shears” technology template which implements the technological functions such as gear synchronism and positioning of an axis.
If you want to obtain further information on the technology template, a separate documentation is available from your Siemens contact person.
The reference data on this application are listed in 5.3 Related documentation in the appendix of this document.

Objective of the application example

This application shows the use of one of the technological functions or of a technology template in the technology CPU.
In order to provide a compact and practical description, a function frequently used in machines is used in a simple example with HMI connection. This ensures that the application can also be used as a demonstration model.
The application illustrates the following:

- The interaction of the components used
- Which technological functions are used
- The internal task sharing between the integrated technology and the control unit of the technology CPU
- The advantages of this solution
- How they are programmed and configured
- How it can be used as a demonstration system

Application structure

The application requires different standard components (hardware and software). They have to be provided by you (see figure below).
The application software delivered by us relieves you of complicated parameterizing and programming of the standard components and thus offers you a convenient option of quickly implementing the controlled positioning.
The application can be used as learning and demonstration system without real drives and motors or together with the SINAMICS S120 training case which includes all necessary standard drive components.

The application is delivered as STEP 7 archive with virtual axes. The optional connection of the SINAMICS S120 training case is explained in detail in the documentation and has to be performed by you using the instructions.

**Documentation structure**

The documentation of this application is divided into three documents:

- **Introduction**
- **Extension**
- **Demonstration**

In addition, the STEP7 code is available.

The first document, **Introduction**, is intended for persons who are interested in a quick overview.

<table>
<thead>
<tr>
<th>Document</th>
<th>Description</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>This document provides you with an overview. You are informed on the software and hardware components and on the function principle of the technical core functions of the solution.</td>
<td>This part enables you to transfer the technology also to other problems.</td>
</tr>
</tbody>
</table>
The second document, **Extension**, is intended for persons who want to study the subject in greater detail.

<table>
<thead>
<tr>
<th>Document</th>
<th>Description</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extension</td>
<td>This document provides you with information on the detailed functional sequences of the hardware and software components involved. It takes you step by step through the essential points of configuring and programming.</td>
<td>It is only required to read this part if you are interested in the detailed process and the interaction of the solution components.</td>
</tr>
</tbody>
</table>

The third document, **Demonstration**, is intended for persons who want to set up and test the application or who intend to demonstrate and present it.

<table>
<thead>
<tr>
<th>Document</th>
<th>Description</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demonstration</td>
<td>This document takes you step by step through configuration, startup, demonstration and use of the application.</td>
<td></td>
</tr>
</tbody>
</table>

An additional component available is the S7 program code.

<table>
<thead>
<tr>
<th>Document</th>
<th>Description</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>S7 program code</td>
<td>The S7 program code includes the code and a user interface which is also suitable as demonstration system.</td>
<td></td>
</tr>
</tbody>
</table>

**Previous knowledge**

Understanding this application example requires basic knowledge in the field of STEP 7 and motion control. You should e.g. be familiar with the meaning of the terms position, velocity, acceleration and jerk.
1 Introduction

This document contains additional information on the Flying Shears application example and is an extension of the document:

Technology CPU – Introduction
“Flying Shears Based on Gear Synchronism”

Introduction describes the basic application structure and should thus be read before reading this document, Extension.

Supplementary to Introduction, this document includes additional, in-depth information on the application.

This document does not replace the user manual.

Reference to Automation and Drives Service & Support

This entry is from the internet application portal of Automation and Drives Service & Support. The following link takes you directly to the download page of this document.

Function Mechanisms

2 Operating Principle of the Technology CPU

2.1 Structure

The technology CPU consists of two parts:

- The control unit which processes the control tasks and
- The integrated technology which processes the technological functions.

Both parts operate independently of one another to the greatest possible extent and have individual processors. This ensures that the technological functions are calculated in short, equidistant cycles without loading the cycle times of the control unit.

Both parts exchange data via technology data blocks and technology function blocks.

Figure 2-1 Detail of the technology CPU

The technological functions are functions which expand the SIMATIC CPU by MotionControl applications, i.e. drives can be controlled via PROFIBUS.

An equidistant PROFIBUS (PROFIBUS DP(Drive)) is used for the drives. This enables clock-synchronized operation of the integrated technology of the controller, PROFIBUS and all connected drives, i.e. the clock cycles of all devices connected to the bus start at the same time.

This clock synchronism enables to use centralized positioning control for the drives despite a distributed automation structure.

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1 Equidistant means that something is consistently repeated in a fixed and very exact time frame. This is e.g. required for control systems since it is otherwise not possible or difficult to optimize control loops due to the changing times. In SIMATIC e.g. OB35 is used for equidistant tasks.
2.1.1 **Control unit**

The control unit largely corresponds to the CPU 317-2 DP (without T) or to the CPU 315-2 DP (without T). Merely the second PROFIBUS interface (DP(Drive)) is provided for the equidistant operation with drives.

The data exchange between control unit and integrated technology is realized using technology data blocks and technology function blocks. In the control unit, e.g. a positioning job can be transmitted which is then executed by the integrated technology.

2.1.2 **Integrated technology**

The integrated technology is first configured. This includes the creation and configuration of technology objects, referred to as TOs.

The most important TO is the axis. An axis includes all information on inverter, motor, gear and encoder. If e.g. a positioning job is transferred to an axis, the inverter is controlled in such a way that the motor accelerates, runs and then decelerates so that it reaches the desired position when reaching the standstill.

The further TOs of the CPU are described in chapter 2.2 Technology objects of the technology CPU.

2.1.3 **Interaction between control unit and integrated technology**

![Diagram](image)

The technology function blocks and the technology data blocks form the interface between controller and integrated technology. These blocks are used to address (technology function block) and to monitor (technology data block) the desired technology objects.
A TO can be addressed by different technology FBs. For instance an axis can be enabled, positioned or synchronized. All of these functions are realized with different technology FBs.

Only a suitable chronological order of the technology FB calls in the control program ensures a technologically effective use of the TO. For this reason we recommend using a step sequence in the user program from which the PLCopen blocks are called.

The job status is updated with each call of the technology FB in the control unit.

**Technology data blocks**

After generating the technology objects in the S7T Config configuration tool, technology data blocks are automatically created. The TO status and further TO-typical information are entered at regular intervals asynchronously to the cyclic user program; for an axis e.g. the current position and velocity.

This information can be (read) accessed using normal data block commands from the user program.

The update cycle of the technology DBs can be set. The default setting is 18 ms.
The technology synchronous interrupt OB OB 65 is available for the consistent evaluation of the technology data blocks. OB 65 is called by the integrated technology after the update of the technology data blocks. This ensures that the content of the technology data blocks can be evaluated synchronously to the integrated technology and that changes in the technology data blocks can be reacted to timely.

The status of the actual integrated technology is also stored in a technology data block. The symbolic name of this technology DB is “MCDevice”.

**Technology function blocks**

To enable to address the TOs from the control unit, the S7-Tech library is provided for the technology CPU. It includes the function blocks according to the PLCopen standard of the PLCopen organization.

The technology function blocks form the interface between the control unit and the integrated technology. The functional sequences of the TOs are controlled by the consistent call of individual technology function blocks (mostly via step sequences). Different functions can be caused via the order of the calls.

In addition, the technology function blocks return the current function call status to the controller (not to be confused with the general status of the TO which is signaled via the technology data block).

During a positioning process, e.g. the signals **busy**, **done** and/or **error** are output at the technology FB so that the current status of the positioning job can be monitored or checked directly at the technology FB.

**Sequence of a technology job using the example of a positioning**

To move an axis by a defined length, FB 411 “MC_MoveRelative” is used at the technology object Axis:
Figure 2-4 Interfaces of the technology object Axis

When FB 411 “MC_MoveRelative” is called, the following parameters have to be supplied with values:

- The axis input of the FB indicates the number of the axis to be positioned and the distance input of the FB specifies the distance to be traveled.
- A positive edge at the execute input starts the axis and the positioning.
- The busy output bit of the FB indicates that the positioning process is active.
- When the target has been reached, busy is cleared and done is set.
- If an error occurs, busy and done are cleared and error is set. The error is specified in greater detail via the ErrorID output.
Operating principle of the technology function blocks

Basically all PLCopen blocks are based on the following principle:

- A rising edge at the **Execute** input triggers the job (depending on the used PLCopen block).
- As long as the **Execute** input is set to 1, the job status is indicated at the status outputs of the FB (**busy**, **done**, **error**, **CommandAborted**, etc.).
- If the **Execute** input is set to 0, the status display stops and all status outputs of the FB (**busy**, **execute**, etc.) are set to 0; the actual job, however, is not aborted or terminated!
- A job is terminated if
  - it has been replaced by another job. If the **Execute** input is still set to 1, the **Command/Aborted** output is set.
  - an axis or job error occurs.
  - the target has been reached (e.g. positioning target or standstill reached or parameter value read) and the **Done** output has been set.
  
Some jobs run endlessly and consequently do not stop themselves. These jobs include e.g. synchronous operation commands or (endless) travel at constant velocity. For this reason the corresponding PLCopen blocks do not have a **Done** output but are instead equipped with e.g. **in_sync** or **in_velocity**.

Replacement of a job by another job

The following example shows how a job is replaced:

- An axis receives a job to move to position 500.0 mm. ("MC_MoveAbsolute")
- It accelerates as set and approaches the target position.
- It now receives the job to stop ("MC_Halt").
- The **busy** status bit at the original positioning FB is cleared and **commandAborted** is set. The Halt FB is set to **busy**.
- The axis decelerates according to the settings and comes to a standstill.
- The **busy** status bit at the Halt FB is cleared and **done** is set.
- The positioning job has now been replaced by the halt job and the halt job terminated itself when reaching the standstill.
### Function Mechanisms

**Operating Principle of the Technology CPU**

**Technology CPU**

**Flying Shears – Extension**

**ID Number:** 21063352

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**List of the PLCopen function blocks**

- The table below lists all technology function blocks:

  **Table 2-1 Technology objects and PLCopen function blocks**

<table>
<thead>
<tr>
<th>Technology object</th>
<th>Technology function block</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Axis</strong></td>
<td>FB 401 MC_Power</td>
<td>Enabling / disabling axis</td>
</tr>
<tr>
<td></td>
<td>FB 403 MC_Home</td>
<td>Homing / setting axis</td>
</tr>
<tr>
<td></td>
<td>FB 404 MC_Stop</td>
<td>Stopping axis and preventing new traversing tasks</td>
</tr>
<tr>
<td></td>
<td>FB 405 MC_Halt</td>
<td>Stopping axis (normal stop)</td>
</tr>
<tr>
<td></td>
<td>FB 409 MC_ChangeDataset</td>
<td>Changing data record</td>
</tr>
<tr>
<td></td>
<td>FB 410 MC_MoveAbsolute</td>
<td>Absolute positioning (e.g. moving axis to 10.0 mm)</td>
</tr>
<tr>
<td></td>
<td>FB 411 MC_MoveRelative</td>
<td>Relative positioning (e.g. moving axis by 10.0 mm)</td>
</tr>
<tr>
<td></td>
<td>FB 412 MC_MoveAdditive</td>
<td>Relative positioning to current target position</td>
</tr>
<tr>
<td></td>
<td>FB 413 MC_MoveSuperImposed</td>
<td>Superimposed positioning</td>
</tr>
<tr>
<td></td>
<td>FB 414 MC_MoveVelocity</td>
<td>Motion with speed specification</td>
</tr>
<tr>
<td></td>
<td>FB 415 MC_MoveToEndPos</td>
<td>Moving to mechanical endstop / clamping</td>
</tr>
<tr>
<td></td>
<td>FB 437 MC_SetTorqueLimit</td>
<td>Activating / deactivating torque limiting</td>
</tr>
<tr>
<td><strong>Synchronous Operation</strong></td>
<td>FB 420 MC_GearIn</td>
<td>Starting gear synchronism</td>
</tr>
<tr>
<td></td>
<td>FB 422 MC_GearOut</td>
<td>Terminating gear synchronism</td>
</tr>
<tr>
<td></td>
<td>FB 421 MC_CamIn</td>
<td>Starting cam synchronism</td>
</tr>
<tr>
<td></td>
<td>FB 423 MC_CamOut</td>
<td>Terminating cam synchronism</td>
</tr>
<tr>
<td></td>
<td>FB 424 MC_Phasing</td>
<td>Changing phase shift between master axis and slave axis</td>
</tr>
<tr>
<td></td>
<td>FB 441 MC_CamInSuperImposed</td>
<td>Starting superimposed cam synchronism</td>
</tr>
<tr>
<td></td>
<td>FB 443 MC_CamOutSuperImposed</td>
<td>Terminating superimposed cam synchronism</td>
</tr>
<tr>
<td></td>
<td>FB 440 MC_GearInSuperImposed</td>
<td>Starting superimposed gear synchronism</td>
</tr>
<tr>
<td></td>
<td>FB 442 MC_GearOutSuperImposed</td>
<td>Terminating superimposed gear synchronism</td>
</tr>
<tr>
<td></td>
<td>FB 444 MC_PhasingSuperImposed</td>
<td>Changing superimposed phase shift</td>
</tr>
<tr>
<td><strong>Cam Switches</strong></td>
<td>FB 430 MC_CamSwitch</td>
<td>Position-based cams / operating cams</td>
</tr>
<tr>
<td></td>
<td>FB 431 MC_CamSwitchTime</td>
<td>Time-based cams</td>
</tr>
<tr>
<td><strong>Ext. Encoder</strong></td>
<td>FB 432 MC_ExternalEncoder</td>
<td>External encoder</td>
</tr>
<tr>
<td>Technology object</td>
<td>Technology function block</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------</td>
<td>----------------------------</td>
<td>------------------------------------</td>
</tr>
<tr>
<td>Measuring Input</td>
<td>FB 433 MC_MeasuringInput</td>
<td>Measuring sensor</td>
</tr>
<tr>
<td>Cam Function</td>
<td>FB 434 MC_CamClear</td>
<td>Clearing cam</td>
</tr>
<tr>
<td></td>
<td>FB 435 MC_CamSectorAdd</td>
<td>Adding cam segment</td>
</tr>
<tr>
<td></td>
<td>FB 436 MC_CamInterpolate</td>
<td>Interpolating cam</td>
</tr>
<tr>
<td></td>
<td>FB 438 MC_GetCamPoint</td>
<td>Reading points from cam disc</td>
</tr>
<tr>
<td>Basic Function</td>
<td>FB 402 MC_Reset</td>
<td>Acknowledging errors / alarms</td>
</tr>
<tr>
<td></td>
<td>FB 406 MC_ReadSysParameter</td>
<td>Reading parameters</td>
</tr>
<tr>
<td></td>
<td>FB 407 MC_WriteParameter</td>
<td>Changing parameters</td>
</tr>
<tr>
<td></td>
<td>FB 450 MC_ReadPeriphery</td>
<td>Reading technology I/O</td>
</tr>
<tr>
<td></td>
<td>FB 451 MC_WritePeriphery</td>
<td>Writing technology I/O</td>
</tr>
<tr>
<td></td>
<td>FB 453 MC_ReadRecord</td>
<td>Reading data record</td>
</tr>
<tr>
<td></td>
<td>FB 454 MC_WriteRecord</td>
<td>Writing data record</td>
</tr>
<tr>
<td></td>
<td>FB 455 MC_ReadDriveParameter</td>
<td>Reading drive parameters</td>
</tr>
<tr>
<td></td>
<td>FB 456 MC_WriteDriveParameter</td>
<td>Writing drive parameters</td>
</tr>
</tbody>
</table>
2.2 **Technology objects of the technology CPU**

The individual technology objects (TOs) will be briefly explained in the following:

**Axis**

The most important TO is the axis. An axis includes all information on inverter, motor, gear and encoder. When parameterizing the axis, data such as speed and encoder pulses but also max. acceleration and (software) limit switches, etc. are indicated. Below only the axis is controlled. Which type of inverter, motor, gear or encoder is used is no longer relevant after the parameterization of the axis.

An axis can be individually stopped, moved, positioned or moved in synchronism with other axes or external encoders. Changing between these modes is possible at any time.

It is also possible to create a virtual axis. A virtual axis does not have physical components such as motor or encoder. It only exists in the controller. Such a virtual axis can e.g. be used as master axis in a group of synchronized axes.

When creating the axis, one of the following axis types has to be selected:

- **Speed axis:** For axes which are only to be used in speed-controlled mode.
- **Positioning axis:** For axes which are to be used in speed-controlled and/or positioning mode. Axes of this type are suitable as master axis for synchronism applications.
- **Synchronization axis:** For axes which are to be used in speed-controlled mode or positioning mode and/or as slave axis in synchronous operation. Axes of this type are suitable as master axis for synchronism applications.

**Note**

Basically all axes can be created as synchronization axes. But since the computing time requirement of the technology part increases with an increasing functional scope, the axes should only be created with the type which corresponds to the required functional scope.
Cam Switch
A cam generates a digital signal depending on the axis position. A typical example is the camshaft in the internal combustion engine. The valves are opened and closed depending on the position of the pistons.

The technology CPU not only enables to use such position-based cams but also time-based and operating cams. Time-based cam signals remain set for a fixed period after overtravelling the activation position. An operating cam switches at the activation position and remains in the new status.

External Encoder
The TO External Encoder allows to read in an external encoder and to use the speed or position values of this encoder for further functions.

Synchronous Operation
Synchronous operation is the synchronous moving of a group of at least two axes. The TO Synchronous Operation is available only for synchronization axes.

The master value for a group of axes can be provided by an axis or an external encoder. All other axes of the group are slave axes.

The slave axes follow the positioning value (master value) of the master axis. The ratio between master value and position of the slave axis can be a constant (gear synchronism) or a mathematical function (cam disc synchronism). Individual slave axes can be included in or excluded from the group of axes by synchronization or desynchronization processes.

Cam Function
The cam function is an option to synchronize axes. However, no fixed, linear gear ratio between master and slave axis is used but a ratio e.g. input via interpolation points. This enables the realization of nonlinear ratios or ratios defined in segments between master axis and slave axis (axes).

The cam profile can be defined in different ways. Most frequently interpolation tables and functional equations are used to define the cam profile. The cam profile is partly also stored in segments and each segment is stored in the form which suits it best.

Cam discs can be recalculated during operation. After clearing the previous cam disc, the new cam data are read in. With the interpolation the actual cam disc is then calculated from the specifications. A large number of points of which the cam disc exists is calculated.
Measuring Input

The measuring input is used to store the position value of an axis when receiving a trigger signal (e.g. Bero or zero mark); this measured value is then used e.g. for positioning.
3 Operating Principle of the Flying Shears

What has already been generally described in the Introduction documentation will now be examined in detail from the technology CPU’s point of view.

3.1 Overview operating principle

This overview describes the structure of the solution approach into individual function modules and explains their interaction.

Solution structure

In this application, the “flying shears” functionality is to be realized via the “Flying Shears” technology template in the technology CPU which takes the control of the shears slide and the blades.

The task of the higher-level control program is to adequately control the technology template in order to achieve the desired functionality.
Objective of the application

With the aid of this solution approach the following functionalities of flying shears are illustrated:

- Simulation of the motion of a material line
- Synchronization of the shears slide to the cutting position
- Synchronous motion of the shears slide above the cutting position by means of angular synchronism for the duration of the cutting process of the shears
- Repositioning the shears slide to the initial position after performing the cut

Short description of the function modules

In Figure 3-2, the functional sequence of the flying shears is displayed as interaction of different function modules. The following modules determine the sequence:

- **Material axis (axis 2)**
  In this application, this module simulates the motion of a virtual material line at constant velocity via Move Velocity. In real applications this axis can also be replaced by an external encoder if the material line is controlled by a previous process.
• **Shears axis (axis 1)**
  This module moves the shears slide according to the input of the “Flying Shears” technology template. It is a synchronization axis which can be synchronized to the velocity of the material line.

• **“Flying Shears” technology template – template control**
  This module takes the complete sequential control and control for the realization of the “flying shears” functionality. Depending on the sequence phase, it controls the synchronization of the shears slide to the material line, the travel at constant speed or the repositioning of the shears slide to the initial position.

• **Shears simulation**
  The shears simulation determines the duration of the synchronous motion. A real cutting process is simulated by a timer which is started with the synchronous motion of material line and shears slide.

• **Resetting the material line position**
  For the next cut the resetting of the material line position is triggered via the “Flying Shears” technology template using the **Homing** function so the cut can respectively be performed at the same position of the material line from the point of view of the flying shears.

**Sequence**

The table below describes the sequence of the sequential process of the flying shears:

<table>
<thead>
<tr>
<th>No.</th>
<th>Event</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Start condition</td>
<td>The shears axis is in initial position. The material axis is in motion.</td>
</tr>
<tr>
<td>2</td>
<td>Start of the flying shears</td>
<td>The technology template takes the control of the shears axis and the sequence control.</td>
</tr>
<tr>
<td>3</td>
<td>Synchronizing</td>
<td>The shears axis is synchronized to the material axis via a gear synchronism.</td>
</tr>
<tr>
<td>4</td>
<td>Synchronous motion / cut</td>
<td>During the synchronous motion of both axes, the shears simulation is activated and the cut is performed.</td>
</tr>
<tr>
<td>5</td>
<td>Repositioning</td>
<td>At the end of the cut, the gear synchronism of the two axes is disabled and the shears axis is repositioned to the initial position at constant velocity. Subsequently the sequence restarts with step 3.</td>
</tr>
</tbody>
</table>
3.2 Detailed description of the function modules

This chapter provides detailed information on the individual function modules of the application. The following areas are explained in greater detail:

- Function of the module
- Components of the module
- Details on this module

The description refers to the control program and to the technology functions of the modules.

3.2.1 Material axis

Figure 3-3 Arrangement of the material axis in the solution concept

Function of this module

Via axis 2 the virtual material line is moved on which the material is fed to the flying shears.

Components of this module

The module consists of the following components:
Technology CPU
Flying Shears – Extension  ID Number: 21063352

- Technology object **axis material**
  The technology object establishes the connection between the technology CPU and the drive.

- Drive
- Motor with encoder system

The module includes all functions required for a motion of the axis e.g. the position control functionality. The position controller calculates the speed setpoint required for the drive; via this setpoint the motor is set to the desired condition of motion.

**Details on this module**

To enable to operate the material axis with variable speed, a speed setpoint is transferred from the controller to the drive via the technology function block **FB 414 “MC_MoveVelocity”**.

Via the technology function block **FB 403 “MC_Home”**, the current position value of the material axis can be influenced by the technology template. Before each cut, the position value of the material axis is set in such a way that the cut can respectively be performed at the same position of the material line.

Since the axis is additionally to be used as master axis for the axis of the shears slide, the technology object **axis material** must at least be created as positioning axis in the technology CPU to be able to provide the required position values for synchronizing the shears slide.
3.2.2 Shears axis

Function of this module
Via axis 1 the virtual axis of the shears slide is moved; the shears slide positions the shears above the material line.

Components of this module
The module consists of the following components:

- Technology object **axis shears**
  The technology object establishes the connection between the technology CPU and the drive.

- Drive

- Motor with encoder system

The module also includes all functions required for a motion of the axis e.g. the position control functionality. The position controller calculates the speed setpoint required for the drive; via this setpoint the motor is set to the desired condition of motion.
In addition, the axis is designed as synchronization axis. Via the technology object Synchronous Operation this axis can be connected to the master axis via the setpoint or actual value linkage and thus move synchronously to this master axis.

Details on this module

In this application, the “Flying Shears” technology template completely takes the control of the shears axis.

3.2.3 “Flying Shears” technology template

Function of this module

The “Flying Shears” technology template takes the complete sequential control and provides the functionality of the flying shears. This module includes all functional sequences for the realization of flying shears.

Components of this module

The module consists of the following components:

- **Template Control**
  Template Control takes the *sequential control* of the technology template with different modes. It also provides the operator interface of the flying shears to the higher-level program.
- Synchronous operation start
  The technology function block FB 420 "MC_GearIn" is used to start the gear synchronism between material axis and shears axis. The shears axis synchronizes to the motion of the material axis until both axes are in velocity synchronism.

- Signal for the shears control
  If both axes are in velocity synchronism, the technology template sets a signal for the control of the shears. In synchronism both axes move at relative velocity 0 and the cutting process can be performed.

- Repositioning
  After completing the cutting process, the synchronism between material axis and shears axis is disabled and the shears slide is repositioned to initial position via the technology function FB 410 "MC_MoveAbsolute".

- Setting the position of the material line
  For the next cut the position of the material line is set via the technology function FB 403 "MC_Home" in such a way that the next cut can be performed at the position value.

Details on this module

For the realization of the functionality of flying shears, the “Flying Shears” technology template can take different modes which can be selected via the higher-level control program.

Figure 3-6  Modes of the “Flying Shears” technology template

- Manual (3) mode the shears axis can be controlled via technology functions outside the template.
In **Automatic (5)** mode the complete processing sequence of flying shears, i.e. synchronizing, synchronous motion and repositioning runs completely automatically.

Figure 3-7  Schematic representation of the flying shears structure

To enable a clear display of the synchronization process in the visualization, a large distance was deliberately selected between initial position and synchronization position.

In real applications we recommend selecting the synchronization distance as short as permitted by the dynamics of the shears slide. This ensures that the maximum distance for the synchronous motion is available.
4 Program Structure

This chapter describes the structure of the STEP 7 program.

4.1 List of the used blocks

This application example includes the following blocks:

Table 4-1 List of the used blocks

<table>
<thead>
<tr>
<th>Block</th>
<th>Symbolic name</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Blocks of the control program</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OB 1</td>
<td>CYCL_EXC</td>
<td>Cyclic call of the blocks of the application example.</td>
</tr>
<tr>
<td>OB 100</td>
<td>COMPLETE_RESTART</td>
<td>Initialization of the status of the application example and of various variables during the startup of the CPU.</td>
</tr>
<tr>
<td>FB 50</td>
<td>Control_General</td>
<td>Higher-level mode control of the application example for changing between manual and automatic mode.</td>
</tr>
<tr>
<td>FB 60</td>
<td>Control_axis_manual</td>
<td>Control of the manual mode of the axes of the application example.</td>
</tr>
<tr>
<td>FB 70</td>
<td>Control_axis_auto</td>
<td>Control of the automatic process execution of the application example. Control of the technology template for the realization of the technological execution of the flying shears.</td>
</tr>
<tr>
<td>FB 80</td>
<td>TemplateControl</td>
<td>Mode change of the technology template between manual and automatic mode.</td>
</tr>
<tr>
<td>FB 90</td>
<td>R/W_Parameter</td>
<td>Writing and reading technology parameters.</td>
</tr>
<tr>
<td>FB 100</td>
<td>AxisControl</td>
<td>Enabling the material axis and acknowledging error messages on all axes of the application example.</td>
</tr>
<tr>
<td><strong>Technology template</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FB 502</td>
<td>Shears</td>
<td>Technology template for the realization of the complete technological execution of the flying shears and control of the shears axis.</td>
</tr>
</tbody>
</table>
4.2 Overview of the program structure

The figure provides an overview of the call structure of the blocks of the overall control program of the application example.

The program is divided into three sections:

- **Operation / control:**
  The higher-level control of the application example is performed in this section. It is also possible to intervene in the functional sequence of the application using the HMI.

- **Axes:**
  This section takes the control of the axes of the application. The real axes, i.e. the inverters and motors, are connected to the control program via the technology object “Axis”.

- **Technological functionality:**
  The “Flying Shears” technology template is integrated into the program and takes the complete technological functionality of the application example.
  The technology template is parameterized and controlled via the “operation/control” section.

The individual sections will again be explained in greater detail in the following chapters. The technology function blocks used in this process will also be explained.
4.2.1 Section: Operation / control

In the “operation / control” section, the inputs are converted via the HMI and the sequential control of the application example is realized.

FB 90 “R/W_Parameter”

Accesses from the HMI to the technology parameters of the CPU are realized via this block. FB 406 “MC_ReadSysParameter” is used to read out the desired technology parameters and FB 407 “WriteParameter” is used to write the specified values.

FB 50 “Control General”

The higher-level mode control of the application example is realized in this block, the modes manual and automatic can be selected via FB 50 “Control General”.

Figure 4-2 Structure of FB 90 “R/W_Parameter”

Figure 4-1 Overview of the program structure
In manual mode block FB 60 “Control_axis_manual” is active and responsible for the control of one axis of the application example. The discrimination between the two axes is achieved by different instance data blocks DB 61 “idb_Control_axis_1” and DB 62 “idb_Control_axis_2”.

In this mode different functions are available for the axes for which the following technology function blocks are required:

- Homing axis:
  Via FB 403 “MC_Home” the axis can be homed or a position value can be set on the axis.

- Moving axis in JOG mode (jogging +/-):
  If a button is clicked to move an axis, the axis is set in motion via block FB 414 “MC_MoveVelocity”. If the button is released, the axis is stopped via block FB 405 “MC_Halt”.

- Positioning axis:
  Via block FB 410 “MC_MoveAbsolute” the axis can be moved to a specified position, the block taking control of the complete motional sequence.

In automatic mode block FB 70 “Control_axis_auto” is active via which the automatic mode of the flying shears is called via the “Flying Shears” technology template.

The control of the shears and the starting and stopping of the material line are also controlled in FB 70 “Control_axis_auto” via the technology function blocks FB 414 “MC_MoveVelocity” and FB 405 “MC_Halt”.

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The control of the shears and the starting and stopping of the material line are also controlled in FB 70 “Control_axis_auto” via the technology function blocks FB 414 “MC_MoveVelocity” and FB 405 “MC_Halt”.

---
4.2.2 Section: Axes

This “Axes” section takes the control of the axes of the application. The real axes, i.e. the inverters and motors, are connected to the control program via the technology objects “Axis” (DB 1 “Axis_1” and DB 2 “Axis_2”).

FB 100 “AxisControl”

In this section, the axes can be enabled via the technology function block FB 401 “MC_Power”; in the application example, the enable of the shears axis is taken by the “Flying Shears” technology template. For this reason, only the material axis is influenced via FB 401 “MC_Power” in this section.

Via FB 402 “MC_Reset” errors on the axes can be acknowledged and the axes can be reset. Reset jobs for both shears and material axis are processed in this section.

4.2.3 Section: Technological functionality

With the aid of the “Flying Shears” technology template, the “technological functionality” section controls the functional sequence of the application example.

In manual mode of the technology template, the shears axis can be manually moved. The shears axis is enabled by the technology template and can then be operated by the higher-level control program of the application in manual mode from FB 50 “Control_General”.

In automatic mode the motion process of the flying shears is fully automatic. In addition, different technology function blocks are used in the technology template which are responsible for the sections synchronizing, synchronous motion and shears slide. The correlation of these blocks with the motional sequence will be explained in greater detail in the following.

FB 80 “TemplateControl” and FB 502 “Shears”

Block FB 80 “TemplateControl” is used to change between the modes manual and automatic of the technology template and to comply with the mode sequences required for the change at the template block so that changing is possible from any mode of the technology template.
Correlation between processing sequence and technology FBs

Before a motion of the shears slide is possible, the axis has to be enabled via FB 401 “MC_Power”.

**FB 402 “MC_Reset”** is used to acknowledge pending errors and technology parameters for the flying shears, e.g. software limit switches, can be set by the template block in the CPU via **FB 407 “MC_WriteParameter”**.

All further technology function blocks are used for the realization of the processing sequence.

Figure 4-6  Processing sequence of the flying shears
FB 403 „MC_Home“ is used to assign the position value 0.0 to the material line at the cutting position. FB 420 “GearIn” generates a synchronization between shears slide and material line at the cutting position; the shears slide is brought to the velocity of the material line during synchronizing and the two axes are thus moved synchronously during the synchronous motion in gear synchronism. At the end of the cutting process, FB 410 “MC_MoveAbsolute” is used to disable the gear synchronism between shears slide and material line and the shears slide is repositioned to initial position.

FB 404 “MC_Stop” is used to set the shears axis to a defined status during the start of the processing sequence by the technology template and to release possibly existing synchronizations with other master axes.

FB 432 “MC_ExternalEncoder” is only used when an external encoder for the supply of the master values for the gear synchronism synchronization of the two axes is used instead of an axis. It is then required that the cutting position 0.0 is transferred to the external encoder via this technology function.

**Note**

A separate documentation is available for the “Flying Shears” technology template in which the functional sequence within the template is explained in detail.

The reference data on this documentation is available in the appendix in Related documentation.
4.3 Sequential control of the automatic process

The sequential control of the automatic process is completely realized via the "Flying Shears" technology template. To control the FB 502 "Shears" technology template in an appropriate way, the blocks FB 70 "Control_axis_auto" and FB 80 "TemplateControl" are used.

Figure 4-7 Sequential control of the automatic process

4.3.1 Operation and control of the automatic process

Block FB 70 "Control_axis_auto" is the central block of the application. All processes and parameterizations required for the automatic process are operated and monitored via this block.

With this block the material line of the application example can be started and stopped and the "Flying Shears" technology template can be set to the suitable mode to execute the automatic process.

The functions of the individual networks of the block are described in the following table:
Table 4-2  Function description FB 70

<table>
<thead>
<tr>
<th>Network</th>
<th>Function</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Providing the signals TRUE and FALSE for the use of these signals in the further program.</td>
<td>The signals are defined via the flags M0.0 and M0.1 so that the desired mode can be applied to the corresponding input directly via the symbols.</td>
</tr>
<tr>
<td>2 – 3</td>
<td>Selecting the mode automatic or manual of the “Flying Shears” technology template depending on the operation of the application via the HMI.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Error control. If an error occurs, the flying shears are stopped.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Signal to other blocks of the program that both material line and flying shears have been stopped.</td>
<td>Change to manual mode is now possible.</td>
</tr>
<tr>
<td>6 – 7</td>
<td>Setting the velocity of the material line.</td>
<td>Setting the minimum velocity and the velocity preset by the HMI.</td>
</tr>
<tr>
<td>8 – 9</td>
<td>Starting and stopping the material line.</td>
<td></td>
</tr>
<tr>
<td>10 – 14</td>
<td>Shears simulation.</td>
<td>Opening and closing the shears on the HMI and simulation of the cutting time.</td>
</tr>
<tr>
<td>15 – 17</td>
<td>Marking the cuts on the material line on the HMI.</td>
<td>After the cut, the material line is cut on the HMI.</td>
</tr>
<tr>
<td>18 – 21</td>
<td>Transfer of the axis position from the controller to the HMI.</td>
<td>Conversion from REAL to INT.</td>
</tr>
<tr>
<td>22 – 29</td>
<td>Adaptation of the parameters set at the technology template for display on the HMI.</td>
<td>Conversion from REAL to INT.</td>
</tr>
<tr>
<td>30 – 33</td>
<td>Calculation of the starting point of the synchronization length for display on the HMI.</td>
<td></td>
</tr>
<tr>
<td>34 – 35</td>
<td>Calculation of the values during setting the material line velocity, synchronization length and cutting length which depend on one another.</td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>Setting the default values for synchronization length and cutting length when the expert mode is deactivated.</td>
<td>Default values: Cutting length = 650 Sync. length = 200</td>
</tr>
<tr>
<td>37 – 38</td>
<td>Transferring the set cutting length to the controller and stopping the shears if the cutting length has been changed.</td>
<td>After changing the cutting length, the shears have to be restarted.</td>
</tr>
<tr>
<td>39 – 40</td>
<td>Adaptation of the current position for display on the HMI.</td>
<td>Conversion from REAL to INT.</td>
</tr>
</tbody>
</table>
41 – 42 Generation of the rectangular signal for marking the synchronous motion for the oscilloscope function in technology display 2 of the HMI.

43 – 44 Calculation of the position of the cut marks on the material line before and after the cut.

45 Animation of the shears in technology display 2 of the HMI during the cut. The animation is performed via clock flags.

4.3.2 Realization of the technological functionality

The processes parameterized via block FB 70 “Control_axis_auto” are then executed via the “Flying Shears” technology template. This technology template is realized in block FB 502 “Shears” of the user program of the application example.

Note A separate documentation is available for the “Flying Shears” technology template in which the functional sequence within the template is explained in detail.

Interface of block FB 502 “Shears”

For the operation and parameterization of the “Flying Shears” functionality, the following signals are available at block FB 502 “Shears” of the technology template.

Figure 4-8 Interface of FB 502 “Shears”
Table 4-3 Interfaces of FB 502 “Shears”

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Data type</th>
<th>Initial value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input parameter</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mode</td>
<td>INT</td>
<td>0</td>
<td>Via <strong>Mode</strong>, the mode is preselected which is activated with the next positive edge at the <strong>Execute</strong> input.</td>
</tr>
<tr>
<td>Execute</td>
<td>BOOL</td>
<td>False</td>
<td>A pending mode change is activated via this input.</td>
</tr>
<tr>
<td>Cutting_Finished</td>
<td>BOOL</td>
<td>False</td>
<td>Signal communicating to FB Shears that the cut is finished and that it can return the shears axis to the initial position. Level evaluation!</td>
</tr>
<tr>
<td>PM_Enable</td>
<td>BOOL</td>
<td>False</td>
<td>Switching to print-mark detection</td>
</tr>
<tr>
<td>Cut_Length</td>
<td>REAL</td>
<td>1000.0</td>
<td>Cut_Length is the piece length of the cut material in mm. Irrelevant for print-mark detection</td>
</tr>
<tr>
<td>Return_Speed</td>
<td>REAL</td>
<td>-1.0</td>
<td>Velocity in mm/s with which the initial position is approached.</td>
</tr>
<tr>
<td>PM_Position</td>
<td>REAL</td>
<td>0.0</td>
<td>Position of the print-mark detection in mm (usually a negative value)</td>
</tr>
<tr>
<td>Output parameter</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Done</td>
<td>BOOL</td>
<td>False</td>
<td>The mode selected via <strong>Mode</strong> is activated.</td>
</tr>
<tr>
<td>Busy</td>
<td>BOOL</td>
<td>False</td>
<td>Mode switching is active.</td>
</tr>
<tr>
<td>Error</td>
<td>BOOL</td>
<td>False</td>
<td>Displays errors in the FB and on the shears axis.</td>
</tr>
<tr>
<td>Cut</td>
<td>BOOL</td>
<td>False</td>
<td>Signals that the blade is synchronized to the material line and that cutting can be performed.</td>
</tr>
<tr>
<td>ErrorID</td>
<td>WORD</td>
<td>0</td>
<td>Warning or error code</td>
</tr>
<tr>
<td>State</td>
<td>INT</td>
<td>0</td>
<td>Current mode</td>
</tr>
</tbody>
</table>

**Possible modes of the “Flying Shears” technology template**

Via the **Mode** input of block FB 502 “Shears”, the following modes or statuses of the block can be selected, the change is activated via the **Execute** input. The currently active status of the block can be read via the **State** output of the block.
The different modes are listed in the following:

- **Initialisation (0)**
  The flying shears check the parameterization.

- **Error (1)**
  The flying shears have detected an error and the shears axis is disabled. The error is output at the error output of the technology template and can be evaluated by the user.

- **Disable (2)**
  The flying shears have acknowledged possibly present errors and are ready for use. But they are still disabled.

- **Manual (3)**
  The flying shears are enabled and in manual mode. The user can manually move the axis by calling the corresponding technology FBs outside FB 502 “Shears”.

- **StartPosition (4)**
  The flying shears axis is enabled and moves to or is located at the starting position and ready for synchronization to the material line.
• **Automatic (5)**
  The shears axis is enabled and cuts the material according to settings.

**Note**
When changing between the individual modes of the block, please observe the “changing paths” shown in the graphic representation, i.e. the permissible mode transitions.

**Guided mode change of the technology template**

For the application example the operation of the “Flying Shears” technology template is only required in the modes **manual** and **automatic**.

With the aid of block **FB 80 “TemplateControl”** it is achieved that the “Flying Shears” technology template can be set to **Manual** or **Automatic** mode from any desired mode. The value True is applied at the respective input of the block and the block then independently performs the consistent change of the individual modes of the **FB 502 “Shears”** technology template.

![Figure 4-10 Interface of FB 80 “TemplateControl”](image)

The order of the mode changes performed by **FB 80 “TemplateControl”** is displayed in the graphic below; each target mode can be reached on two possible paths depending on the starting status.
Table 4-4  Guided change of the mode at FB 502 “Shears”

<table>
<thead>
<tr>
<th>Change to 3: MANUAL</th>
<th>Change to 5: AUTOMATIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restart</td>
<td>Restart</td>
</tr>
<tr>
<td>0: Initialization</td>
<td>0: Initialization</td>
</tr>
<tr>
<td>1: Error</td>
<td>1: Error</td>
</tr>
<tr>
<td>2: Disable</td>
<td>2: Disable</td>
</tr>
<tr>
<td>4: Start-position</td>
<td>4: Start-position</td>
</tr>
<tr>
<td>Automatic</td>
<td>Automatic</td>
</tr>
</tbody>
</table>

When realizing FB 80 “TemplateControl”, the following characteristic features were considered:

- If the technology template is in Error mode, Disable has to be called first to acknowledge possibly pending errors before a change to further modes is possible.

- Before the technology template can be set to Automatic mode, it is required to change to StartPosition mode in which the shears axis is moved to the starting position. It is only then that the automatic process can be started in Automatic mode.
Configuration of the Technology CPU

5 Basic Configuration

5.1 Overview

To enable the use of the technology CPU in a plant, several basic configurations are necessary which are already included in this application example.

To familiarize you with the required configuration steps, the necessary configuration sequences for using the technology CPU will be briefly explained specifically for this application example:

- Configuration of the technology CPU in HW Config to enable the integration of the CPU as S7-300 station into a project.
- Configuration of the technology objects of the technology CPU in S7T Config and generation of the technology data blocks as interface to the technology objects in the STEP 7 program to make available axes, encoders, cam discs, cams, etc. in the CPU.
- Integration of the PLCopen blocks from the S7-Technology block library to enable the control of the configured technology objects via the STEP 7 program.

5.2 Configuring the technology CPU in HW Config

The technology CPU is integrated into a new or already existing STEP 7 project as S7-300 station exactly like any other SIMATIC CPU of the 300 series.

After creating the S7-300 station, the hardware of this station can be configured via HW Config and the technology CPU can be integrated.

Open HW Config and in the hardware catalog, open the SIMATIC Technology-CPU profile to display the components available for use with the technology CPU in the hardware catalog.
5.2.1 Integration of the technology CPU

In the station window of HW Config, position a Rack-300 and equip it with a PS-300. Select the desired technology CPU from the hardware catalog and use drag & drop to move it to the rack. Make sure to select the correct firmware revision level for the CPU used by you.

Note

If a technology CPU is already configured in HW Config, the CPU can be replaced by the version with the correct firmware using drag & drop.

Adapting the interface speed

When inserting the technology CPU in the hardware configuration of HW Config, a dialog box informs you to set the interface speed to a value $\geq 1.5$ Mbaud.
Figure 5-2  Message box on increasing the transmission rate

Setting a high transmission rate is necessary since the execution code of the integrated technology is also transferred to the CPU when downloading the configuration to the technology CPU. If the interface speed is set too low, the download of this large data volume may take a lot of time.

5.2.2 Parameterization of PROFIBUS DP(Drive)

When integrating the technology CPU into the configuration, the screen form for setting the PROFIBUS DP(Drive) parameters opens.

In this screen form, you can make the interface settings for the drives and I/O devices connected to the technology CPU.

Perform the following actions:

- Use the **New**… button to create a new PROFIBUS connection.
- In **Properties**, set the interface speed of this PROFIBUS connection to 12 Mbps.
In **Options**, also select the equidistance of this PROFIBUS connection as shown in the figure below.

Drives such as SINAMICS S120 can now be connected to the equidistant PROFIBUS generated as shown above for the control via technology CPU.

**Connecting a SINAMICS S120 to the technology CPU**

Specially for connecting the SINAMICS S120 drive system, an FAQ is available on the internet at the following link:


**5.2.3 Parameterization of the MPI**

When integrating the technology CPU into the configuration, a message box has already informed you on the setting of the MPI to a data transmission rate of $\geq 1.5$ Mbaud.
Warning

Before changing the interface speed, check which maximum speed is supported by your CP or interface adapter.

If the value set for the transmission rate in HW Config is too high and if you load this configuration to the CPU, you can no longer access the CPU!

To set the MPI, proceed as follows:

- In HW Config, double-click the X1 (MPI/DP) interface of the configured technology CPU.
- Select Properties.
- Set the desired address, e.g. address 2.
- Select the MPI bus to which the controller is to be connected, e.g. MPI(1)
- Select Properties and Network Settings.
- Set the desired interface speed, e.g. 12 Mbit /s
- Close all dialog boxes by clicking OK
- Save and compile everything and download the configuration to the CPU.

Note

Make sure that the correct station address is set for the MPI connection at the CPU.

For connection establishment from the PG/PC to the CPU please observe the following:

- In the SIMATIC Manager in Options / Set PG/PC Interface, set the interface of your PG/PC to CPxxxx_(Auto) to ensure that it is automatically set to the baud rate of the MPI bus and that it can communicate with the controller.
- Do not use the standard MPI cable for a transmission rate of 12 Mbit/s but a PROFIBUS cable to avoid failures on the bus connection.
5.2.4 Generation of the technology system data

To enable to use the technology part of the technology CPU, it is required to generate the system data of the technology firmware during saving and compiling the hardware configuration.

To achieve this, proceed as follows:

- In HW Config, double-click **Technology** of the configured technology CPU
- Activate the Generate technology system data setting
- Click **OK** to close the dialog box

Figure 5-5 Generating technology system data

5.2.5 Completion of the configuration of the technology CPU

If all configuration steps have been successfully performed in HW Config and if the settings of the parameters have been completed, **Save and Compile** this configuration and use **PLC / Download...** to download it to the technology CPU.
5.3 Configuration of the technology objects

5.3.1 Configuration tools for the technology objects

The following two tools are available for the configuration of the technology objects in the technology CPU:

- **S7T Config**
  For creating and parameterizing the desired technology objects such as axes, cam discs, cams, etc.

- **Technology Objects Management (TOM)**
  For generating the technology data blocks to provide the technology objects generated with the aid of S7T Config in the STEP 7 program.

In the SIMATIC-Manager, the S7 program of the technology CPU includes a Technology folder in addition to the folders Sources and Blocks.

Via the Technological Objects entry in this folder, the configuration tools for the technology objects can be called.

**S7T Config**

S7T Config is called via the Configure Technology context menu of Technological Objects.

Figure 5-6 Call of S7T Config
Technology Objects Management (TOM)

To call the Technology Objects Management (TOM), double-click **Technological Objects** or click the **Open Object** entry of the context menu of **Technological Objects**.

Figure 5-7  Call of the Technology Objects Management (TOM)

Note

If no technology objects have been configured yet, S7T Config is opened in addition to the Technology Objects Management (TOM) to enable to create and parameterize technology objects.

5.3.2 Calling S7T Config

For the “Flying Shears” application example the following technology objects have to be created in the technology part of the technology CPU:

- Axis 1 – shears axis
- Axis 2 – axis of the material line

Call the S7T Config configuration tool and create the two axes for the application example as explained in detail in the following.

The user interface of S7T Config

The user interface of S7T Config is divided into three sections:
5.3.3 Creating the material axis (axis 2)

The configuration of the material axis (axis 2) is shown first, which is created as positioning axis and which is then to be used as master axis for the shears axis (axis 1).
### Table 5-1  Configuration of the material axis

<table>
<thead>
<tr>
<th>No.</th>
<th>Instruction</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Start the configuration of the axis by double-clicking <strong>Insert axis</strong> in the Navigator of S7T Config.</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Assign the name <strong>Axis_2</strong> to the material axis.</td>
<td>For a positioning axis activate the checkboxes of the technologies <strong>Speed Control</strong> and <strong>Positioning</strong>.</td>
</tr>
<tr>
<td>3.</td>
<td>For the <strong>Axis type</strong> of the axis select <strong>Linear</strong> and <strong>Electrical</strong>. The configured axis can thus be connected to a real axis of a drive.</td>
<td><strong>Note:</strong> If there is no drive, select the <strong>Virtual</strong> setting. In this case, it is not required to perform all configuration steps for this axis described in this table.</td>
</tr>
<tr>
<td>4.</td>
<td>Check the set <strong>units</strong>.</td>
<td></td>
</tr>
</tbody>
</table>
5. Since the material axis is a continuously moving linear axis, confirm the settings window for a modulo axis without changes.

6. Since no drive was configured in HW Config, no real axis is provided for selection in this dialog box and only a virtual axis can be created.

**Note:**
The connection to a real axis of a drive will be explained in greater detail in the following section.

7. Click the Finish button to complete the configuration of the material axis.

Since the motion of the material axis is independent of the motion of the shears axis, a configuration of this axis as positioning axis is sufficient. This restriction ensures that computing time can be saved in the technology part of the technology CPU and that the technology can be operated with shorter cycle times if required.

**Connecting the technology object Axis to a real axis of a drive**

If a real drive with real axes has been configured in the hardware configuration of the application example, the technology object Axis can also be connected to this drive. When configuring the corresponding technology object, this requires additional inputs which will be explained in greater detail in the following.
A connection of the technology object to a real drive, e.g. to a SINAMICS S120, is only possible if the drive has already been completely commissioned and if it is functional.

The additional inputs follow after step 6 of the configuration of the material axis shown above. If necessary, repeat the configuration of the axis without inputs to step 6 and continue with the inputs shown here.

Table 5-2  Additional inputs for connecting the axis to a drive

<table>
<thead>
<tr>
<th>No.</th>
<th>Instruction</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>If a drive unit is not yet offered for selection in the screen form, click the <strong>Align Sinamics devices...</strong> button to perform an alignment with the configured drives.</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Select the desired drive for the <strong>alignment</strong> from the displayed list.</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>You can now select the <strong>drive unit</strong> you want to connect to the technology object Axis from the drop-down list.</td>
<td></td>
</tr>
</tbody>
</table>
4. Select the corresponding drive of the device, define the telegram for the PROFIBUS communication and set the maximum speed of the connected motor. For optimum dynamics also activate Dynamic Servo Control (DSC).

5. Set Encoder type, Encoder mode and Measuring system type at the selected drive.

6. Set the Encoder pulses per revolution and the Multiplication factor of the cyclic actual value of the encoder.

7. Click the Finish button to complete the configuration of the material axis.

Note: If Dynamic Servo Control (DSC) is activated at the drive, at least PROFIBUS telegram 105 has to be set for the communication between technology CPU and drive.
Settings for the SINAMICS S120 training case

If you use the SINAMICS S120 training case as drive system, the screen shots below show all necessary settings for the material axis:

Figure 5-9  SINAMICS S120 training case – drive assignment

- Selection of the drive
- Activation of the Dynamic Servo Control
- Setting of the PROFIBUS telegram 105
- Setting of the maximum motor speed

Figure 5-10  SINAMICS S120 training case – encoder assignment

- The encoder is connected directly to the drive
- Setting of the measuring system type
- Setting of the encoder mode
- Setting of the encoder type
5.3.4 Parameterizing an axis

After the axis has been successfully created, further screen forms are available in S7T Config via which different preassignments and settings can be made on the axis.

Mechanics

In the Mechanics section, the axis created in the controller can be adapted to the real conditions at the machine. The direction of rotation of the measuring system can be changed, settings for load and measuring gearbox can be made and the traveled distance per motor revolution can be entered.

In addition, a backlash compensation can be performed via which the mechanical backlash of the drive spindle can be compensated in case of a reversal of the axis.
Preassignment

In the Preassignment section, the standard values of the axis are defined which can be used when controlling the axis via the STEP 7 program. A velocity profile for the axis motion with values for jerk and acceleration can be defined.
Limitations

In the Limitations section, the maximum values for the motion of the corresponding axis can be defined.

The Position and Velocity section includes boxes for the definition of the hardware and software limit switches of the axis and for the definition of the maximum axis velocity.

The Dynamic Response section includes boxes for the definition of the maximum acceleration of the axis and the maximum jerk. It is possible to differentiate between the mechanical limitations of the hardware and the limits set in the software. Different values can be entered for both cases.

In the software limits, an additional differentiation between acceleration and deceleration of the axis is possible.
Homing

In the Homing section, it can be set whether the corresponding axis has to be homed or not.

Figure 5-15 Parameterization – Limitations (dynamic response)

Figure 5-16 Parameterization – Homing (active homing)
In active homing, homing is performed according to the set mode via a motion initiated by the homing command in the STEP 7 program. Different modes can be defined for the homing process and different velocities can be preset for the reference cam approach, the motion into the reference point and the deactivation at the reference point. The position of the reference point and an additional offset which is assigned to the axis position in the reference point can also be defined here.

In passive homing, homing is performed according to the set mode via a motion which is not initiated by the homing command in the STEP 7 program. Homing is virtually performed “on the fly” during a currently active motion as soon as the reference mark is detected or passed.

Monitorings

In the Monitoring section, different monitoring values can be defined for the corresponding axis which control the execution of the axis motion and possibly output an error message at the technology data block if the axis leaves the defined tolerance range.

In the Positioning and Standstill Monitoring section, tolerance ranges can be defined for the compliance with the defined axis position and the monitoring of the axis standstill. This enables to monitor the execution of a positioning command if disturbance variables occur which externally affect the axis.
In the Following Error Monitoring section, the inertia of the axis can be monitored. The following error is the difference between the setpoint position specified by the controller and the actual position of the axis during the motion.
In the Standstill Signal section, a velocity threshold can be defined under which the “Standstill drive” signal is set in the technology data block of the axis. In the STEP 7 program, this signal can be used to check the axis standstill.

Figure 5-20 Parameterization – Monitoring (standstill signal)

Control

In the Control section, the parameters of the position controller in the technology part of the technology CPU can be influenced.

The signs for actual value and setpoint value can be inverted and consequently the control loop can be adapted to the hardware conditions of the machine.

The servo gain factor displays the gain of the position control loop via which the response of the control to deviations between setpoint and actual value can be influenced. If the servo gain factor is set too low, the actual value follows the setpoint value only very slowly. If, however, the servo gain factor is set too high, an overshoot of the controller may occur.

Via the drift compensation, the integration component of the position controller can be activated; this enables to compensate steady-state deviations during positioning.

The use of Dynamic Servo Control (DSC) enables to set a larger servo gain factor for the position control loop. This increases the dynamics for the reference variable sequence and disturbance variable control in highly dynamic drives.
Note

If Dynamic Servo Control (DSC) is activated, at least PROFIBUS telegram 105 has to be set for the communication between technology CPU and drive.

Axis test via control panel

If an axis has been successfully created and parameterized in the technology of the controller, it can be moved in test mode via the control panel of the technology from S7T Config.
5.3.5 Creating the shears axis (axis 1)

Now the shears axis (axis 1) is to be created, which is to be configured as synchronization axis to the material line.

As synchronization axis, the shears axis can be synchronized with the material axis so that the position of the shears axis dynamically follows the position of the material axis.

Table 5-3 Configuration of the shears axis

<table>
<thead>
<tr>
<th>No.</th>
<th>Instruction</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Double-click <strong>Insert axis</strong> in the Navigator of S7T Config to create an additional axis.</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Assign the name <strong>Axis_1</strong> to the shears axis. For a synchronization axis activate the checkboxes of the technologies <strong>Drive axis</strong>, <strong>Positioning axis</strong> and <strong>Following axis</strong>.</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>For the <strong>Axis type</strong> of the axis select <strong>Linear</strong> and <strong>Electrical</strong>. The configured axis can thus be connected to a real axis of a drive. <strong>Note:</strong> If there is no drive, select the <strong>Virtual</strong> setting. In this case, it is not required to perform all configuration steps for this axis described in this table.</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Check the set <strong>units</strong>.</td>
<td></td>
</tr>
</tbody>
</table>
5. Since the shears axis is also a continuously moving **linear axis**, confirm the settings window for a modulo axis without changes.

![Configuration window](image1)

6. Select the corresponding drive of the drive unit, define the **telegram** for the PROFIBUS communication and set the **maximum speed** of the connected motor. For optimum dynamics also activate **Dynamic Servo Control (DSC)**.

![Configuration window](image2)

7. Set **Encoder type**, **Encoder mode** and **Measuring system type** at the selected drive.

![Configuration window](image3)

8. Set the **Encoder pulses per revolution**, the **Number of Data Bits** and the **Multiplication factor of the cyclic actual value** of the encoder.

![Configuration window](image4)
9. Click the **Finish** button to complete the configuration of the material axis.

Settings for the SINAMICS S120 training case

If you use the SINAMICS S120 training case as drive system, the screen shots below show all necessary settings for the material axis:

Figure 5-23  SINAMICS S120 training case – Drive assignment

- **Selection of the drive**
- **Activation of the Dynamic Servo Control**
- **Selection of the PROFIBUS telegram 105**
- **Setting of the maximum motor speed**

**Note**

If Dynamic Servo Control (DSC) is activated at the drive, at least PROFIBUS telegram 105 has to be set for the communication between technology CPU and drive.
For setting the encoder assignment and the encoder data, a list with the required data is available on the internet.
5.3.6 Parameterizing the synchronism relations between the axes

After the axis has been successfully created, further screen forms are available in S7T Config for this axis via which different preassignments and settings can be made on the axis. These screen forms are explained in greater detail in chapter 5.3.4 Parameterizing an axis.

In addition, further screen forms are available for a synchronization axis for the parameterization of the synchronism relation between a master and a slave axis. They can be called under the synchronization axis via SYNCHRONOUS_OPERATION in the Navigator of S7T Config.

Configuration

In the synchronism relation, the synchronization axis operates as slave axis which is synchronized to the positioning values of a master axis.
Via the configuration of the synchronism relation, a master axis can be assigned to this slave axis which provides the positioning values for the synchronization. In the “Flying Shears” application example, the material axis (axis 2) is assigned to the shears axis as master axis. Setpoint coupling is selected as coupling type so that the setpoint of the shears axis can be synchronized to the setpoint of the material axis.

Figure 5-27 Configuration of the synchronism relation

Preassignment

In the “Flying Shears” application example, gear synchronism is selected for the synchronism link of the two axes, i.e. the two axes are synchronized via a linear relationship, the gear ratio.

For this reason only the screen forms Gear synchronization and Dynamic response are relevant for the preassignment for the parameterization of the synchronism relation.
In the Gear Synchronization section, the **Synchronization position specification of leading axis** setting is used for the synchronization of the two axes. This ensures that the synchronization of the two axes is performed related to the position of the master axis. From the position defined via the **SyncPos master setpoint** parameter, the two axes move in synchronism. The position reference **Synchronize before synchronization position** additionally defines that the synchronization process starts before the position **SyncPos master setpoint** so that the two axes can be in synchronism at this position.

During desynchronization, i.e. during disabling the synchronism, the **Effective immediately** setting ensures that the synchronism relation of the two axes is disabled directly after calling the function for disabling the synchronism in the STEP 7 program.

All further parameters in this screen form are ineffective when the settings described here are used.

---

![Figure 5-28 Preassignment – Gear synchronization](image-url)
In the Dynamics section, the input boxes for **Synchronization length** and **Desynchronization length** are activated by selecting the **master axis-related synchronization profile** so that the section for synchronizing can be defined within which the synchronization process starts before **SyncPos. master setpoint**.

The information in the **Desynchronization length** parameter for the desynchronization range is insignificant since the **Effective immediately** setting was selected for the desynchronization.

All further parameters in this screen form are ineffective when the settings described here are used.

---

**Figure 5-29 Preassignment – Dynamics**

![Diagram showing settings for synchronization and desynchronization parameters.](image-url)
Example for the synchronization process

With the above settings, the synchronization is performed as follows:

In the graphic, the time of the motion is plotted on the X axis and the position of the axes is plotted on the Y axis.

The shears axis is at rest at the position 0mm. The synchronization point is at the position 200mm and the synchronization length is also 200mm so that the synchronization process can start before the synchronization point from the position 0mm.

As soon as the material axes passes the position 0mm, the synchronization process starts. The shears axis accelerates and synchronizes to the material line. In the synchronization point, both axes have the same position and are synchronized via the gear synchronism with the gear ratio 1:1. Both axes move synchronously.

Generation of the technology data blocks

After completing the configuration and parameterization of the technology objects material axis and shears axis, it is now required to generate the technology data blocks of these technology objects via the Technology Objects Management (TOM). These data blocks enable to check or monitor the status of the technology objects in the STEP 7 program.

Call the Technology Objects Management (TOM) as described in chapter 5.3.1 Configuration tools for the technology objects, define the desired numbers of the data blocks, select all lines and then generate the data blocks of the technology objects.
Figure 5-31  Technology Objects Management (TOM)

Define DB number.

Select all lines.

Click this button to generate all selected data blocks.
5.4 Integration of the PLCopen blocks

Different function blocks according to the PLCopen standard are available for the control of the configured technology objects by the STEP 7 program. These blocks are combined in the S7-Tech block library. From there they can be integrated into the user program and called.

Figure 5-32 S7-Tech block library in FBD Editor

Note

We recommend integrating the technology function blocks as multi-instance into the block in which they are called to contain the number of instance data blocks of the STEP 7 project. Otherwise it is required to create an individual instance data block for each technology function block.
# Appendix and Bibliographic References

## 6 Bibliographic References

### 6.1 Bibliographic references

This list is by no means complete and only provides a selection of appropriate sources.

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<thead>
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<th>Table 6-1</th>
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</thead>
<tbody>
<tr>
<td><strong>Topic</strong></td>
</tr>
<tr>
<td>/1/</td>
</tr>
</tbody>
</table>
6.2 Internet links

This list is by no means complete and only provides a selection of appropriate sources.

Table 6-2

<table>
<thead>
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<th>Topic</th>
<th>Title</th>
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</thead>
<tbody>
<tr>
<td>1\1</td>
<td>Reference to the entry</td>
</tr>
<tr>
<td>1\2</td>
<td>Siemens A&amp;D Customer Support</td>
</tr>
<tr>
<td>1\3</td>
<td>Siemens A&amp;D Applications &amp; Tools</td>
</tr>
</tbody>
</table>
6.3 Related documentation

This list includes a summary of related documentations which you can obtain from Siemens Customer Support or your Siemens contact person.

Table 6-3

<table>
<thead>
<tr>
<th>Topic</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>/A/ Technology template</td>
<td>“Flying Shears” Technology Template Technology CPU – Documentation Entry ID: 21062270</td>
</tr>
</tbody>
</table>