SIMATIC Technology

**For technological tasks –
counting/measuring, cam control, closed-loop control,
motion control**

Brochure · April 2011

SIMATIC Technology

Answers for industry.

SIEMENS

SIMATIC Technology
Equipped for all technological tasks

The perfect basis for all technological tasks – scalability made to order

With our detailed, sophisticated system solution you can simplify the handling of your machine or plant, benefit from user-friendly, uniform engineering and significantly shorten your commissioning times – seamlessly across systems. You achieve considerable cost savings during the engineering phase by utilizing existing know-how.

For counting and measuring, cam control, closed-loop control or motion control: With SIMATIC Technology you have all the technological tasks in any combination and with any degree of complexity under control. From CPU-integrated functions, through distributed ET 200S function modules or technology controllers, to freely configurable application modules and control systems – you have a free choice in the technical setup of your system.

Uniform and efficient with Totally Integrated Automation

In the spirit of Totally Integrated Automation, you benefit from a uniformity that is unique and products that are first class – for every application area in every sector. In production automation or process automation, or even solutions for infrastructure tasks: with Totally Integrated Automation and SIMATIC at its core, we will play an important part in enhancing your productivity.

Siemens – a partner that you can rely on

In addition, you can utilize the advantages of a proven partner for industrial automation and rely on our long-term experience and consistent innovative strength associated with it. We are always there for you: round the clock, worldwide – with a comprehensive range of services.

Integrated functions for S7 CPUs
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Loadable function blocks for software-based solutions
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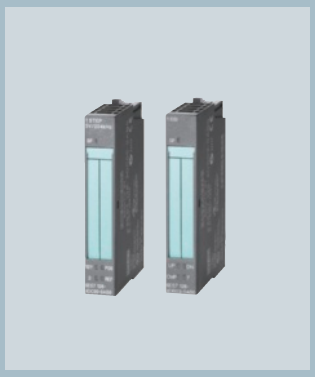
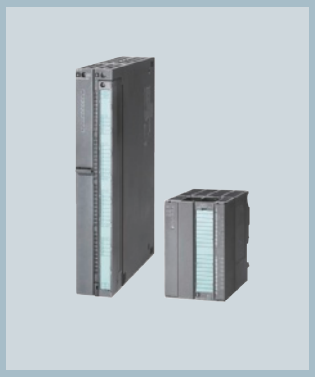
Intelligent ET 200S function modules for distributed solutions
from page 25

Parameterizable function blocks for S7-300/400
from page 28





Contents

Highlights

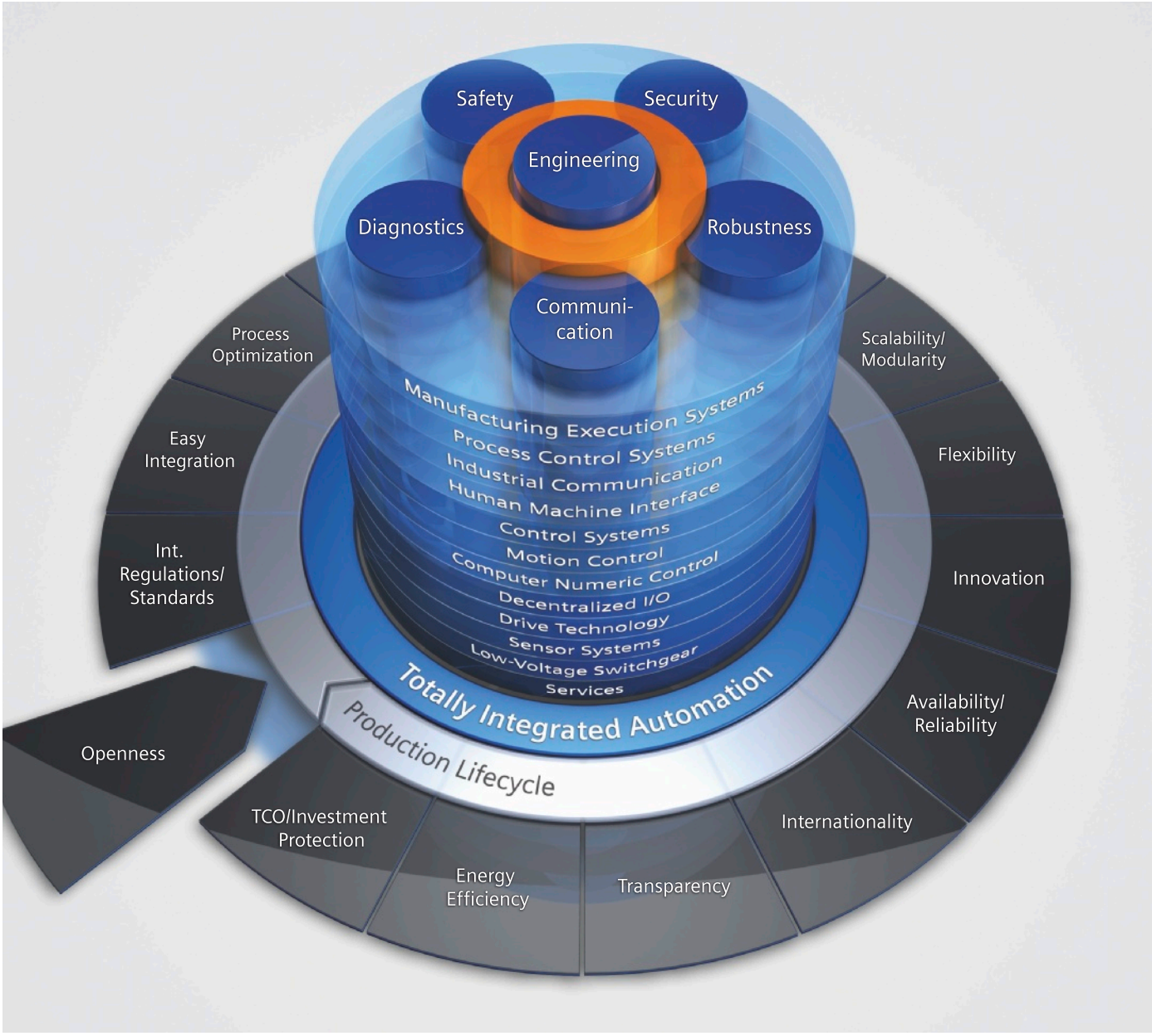
- Solution of technological tasks with the system integration of TIA
- Maximum scalability with selection of a software-based or hardware-based solution
- Parameter assignment and programming in the familiar STEP 7 environment
- Solutions with the isochronous PROFIBUS for maximum precision of fast processing operations.

Technology controllers for PLC, Motion Control and Safety Integrated from page 35

User-configurable application modules and control systems from page 40

Totally Integrated Automation

Rely on new productivity standards for sustained competitive advantages



To be able to respond to the increasing international competitive pressure, it is more important than ever to consistently make full use of the potential for optimization – over the complete lifecycle of a machine or plant.

Optimized processes reduce the total cost of ownership, shorten the time to market, and improve quality. This perfect balance between quality, time, and costs is now, more than ever, the decisive success factor in industry.

Totally Integrated Automation is optimally aligned to all requirements and open for international standards and third-party systems. With its six characteristic system features, Totally Integrated Automation supports the complete lifecycle of a machine or plant. The complete system architecture offers holistic solutions for every automation segment on the basis of a comprehensive range of products.

SIMATIC: more efficient and systematic automation

SIMATIC, a core component of Totally Integrated Automation, includes a variety of standardized, flexible, and scalable products – such as SIMATIC Technology for technological tasks presented in this brochure.

SIMATIC is currently considered to be the global number one in automation. One of the decisive reasons for this is that SIMATIC exhibits the six system features of Totally Integrated Automation:

- Engineering
- Communication
- Diagnostics
- Safety
- Security
- Robustness

In addition, SIMATIC features two additional system features:

- Technology
- High availability

You can find more about the system features and the resulting advantages in the following chapter “System features”.

System features

Engineering

Maximum engineering efficiency –
in all phases of the lifecycle of the machine and plant
With SIMATIC you rely on an integrated engineering environment. Efficient software supports you over the complete lifecycle of your machine or plant – from the planning and design stages through configuring and programming as far as commissioning, operation and upgrading. With its integration capability and harmonized interfaces, SIMATIC software supports a high degree of data consistency – throughout the entire engineering process.
Siemens has redefined engineering with its Totally Integrated Automation Portal (TIA Portal). The new TIA Portal engineering framework combines the SIMATIC STEP 7, SIMATIC WinCC and SINAMICS StartDrive automation software tools in a unique development environment.

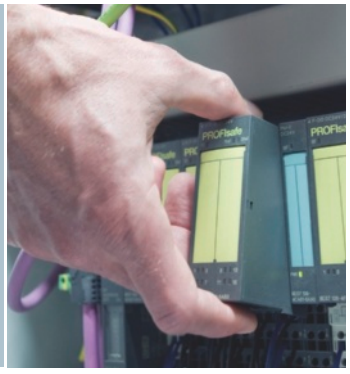
Communications

Maximum data transparency on all automation levels –
based on proven standards
SIMATIC creates the foundations for unlimited integration in communication – and thus for maximum transparency on all levels, from the field and control level to the operations management level all they way up to the corporate management level. SIMATIC relies on international, cross-vendor standards which can be combined flexibly: PROFINET, the leading Industrial Ethernet standard and PROFIBUS, the global No. 1 fieldbus.

Diagnostics

Minimization of downtimes –
through efficient diagnostic concepts
All SIMATIC products feature integrated diagnostic functions with which a fault can be identified and eliminated to provide increased system availability.
Even with larger plants, the Maintenance Station provides you with a uniform view of the maintenance-relevant information of all automation components.

Safety



Protection of personnel and machines –
within the framework of an integrated complete system
SIMATIC Safety Integrated offers TÜV-certified products, which facilitate compliance with relevant standards: IEC 62061 up to SIL 3, EN ISO 13849-1 up to PL e, as well as EN 954-1. Due to the integration of safety technology in standard technology, only one controller, one I/O, one engineering, and one bus system are required. Thus the system advantages and comprehensive functionality of SIMATIC are also available for fail-safe applications.

Data security in the networked world – through harmonized, scalable security systems
Due to the increased use of Ethernet connections penetrating the field level, security issues are gaining in importance in industry. For comprehensive protection of a plant, a variety of different measures must be implemented. These range from the company organization and its guidelines regarding protective measures for PC and control systems through to protection of automation cells by segmenting the network. Siemens follows the cell protection concept and, with the modules of the SCALANCE series and the Security modules, offers components for building up protected cells.

Security

Maximum industrial suitability – through increased robustness
Each standard product from the SIMATIC range is characterized by the highest quality and robustness and is perfect for use in industrial environments. Specific system tests ensure the planned and required quality. SIMATIC components meet all relevant international standards and are certified accordingly. Temperature and shock resistance are defined in the SIMATIC quality guidelines, as are vibration resistance or electromagnetic compatibility.
For demanding to extreme rated conditions, special versions such as SIPLUS extreme or special versions of SIMATIC ET200 are available. These include an increased degree of protection, extended temperature ranges, and exceptional environmental stress.

Robustness

More possibilities, less complexity – through integrated technology functionality
Counting and measuring, cam control, closed-loop control, or motion control: You can integrate technological tasks in many different combinations and with various degrees of complexity without a system changeover into the world of SIMATIC – easily, conveniently, consistently. Parameter assignment and programming are implemented in the familiar STEP 7 environment.

Technology

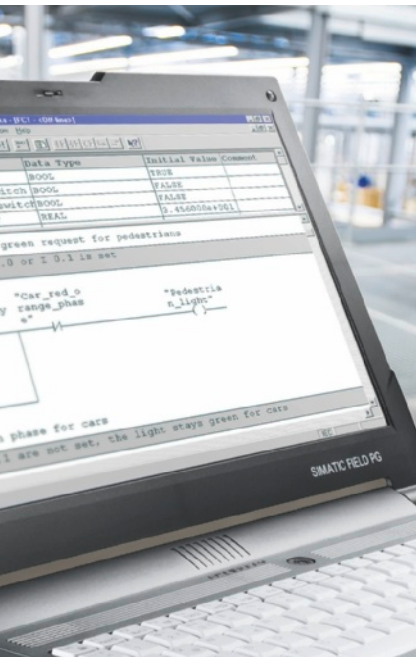
Maximum availability – with integrated high availability concepts
Siemens offers a comprehensive high availability concept to ensure high availability for the entire plant: from the field level to the control level all the way up to the management level. For example, field-tested controllers ensure high availability through bumpless switching with automatic event synchronization.

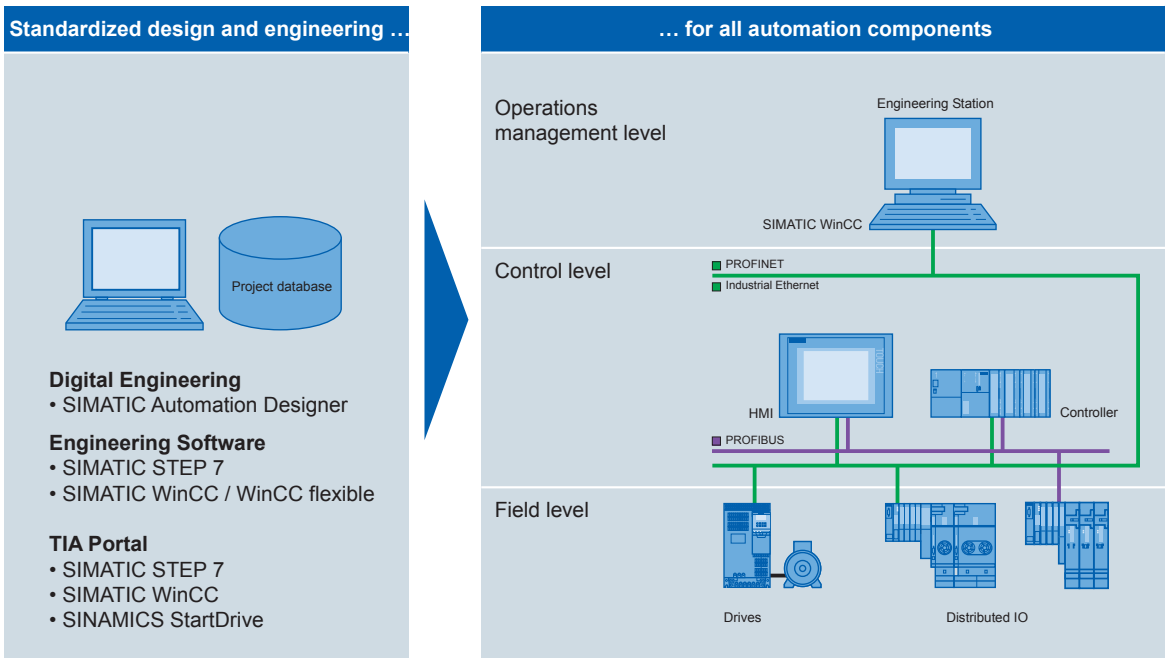
High availability

www.siemens.com/simatic-system-features

Engineering

Maximum engineering efficiency – in all phases of the lifecycle of the machine and plant





With SIMATIC you rely on an integrated engineering environment. Efficient software supports you over the complete lifecycle of your machine or plant – from the planning and design stages through configuring and programming as far as commissioning, operation and upgrading.
With its integration capability and harmonized interfaces, SIMATIC software permits a high degree of data consistency – throughout the entire engineering process.

Data consistency in the entire project
- Variables only have to be entered and configured in one editor
- Project-wide synchronization

Modularity through blocks
- Program sections and user interfaces can be created modularly as reusable blocks
- Program modules can be loaded into the automation system during operation
- In addition, expansions and changes to the hardware configuration are possible during operation

Shared configuration for the complete automation hardware
- Shared hardware configuration
- Shared network configuration

Open data interfaces
- Third-party components can be incorporated based on GSD/EDD
- Import/export interfaces permit data exchange with third-party software (MS Excel)

Data archiving
- All data, hardware configuration data, programs, user interfaces are saved and archived in one project

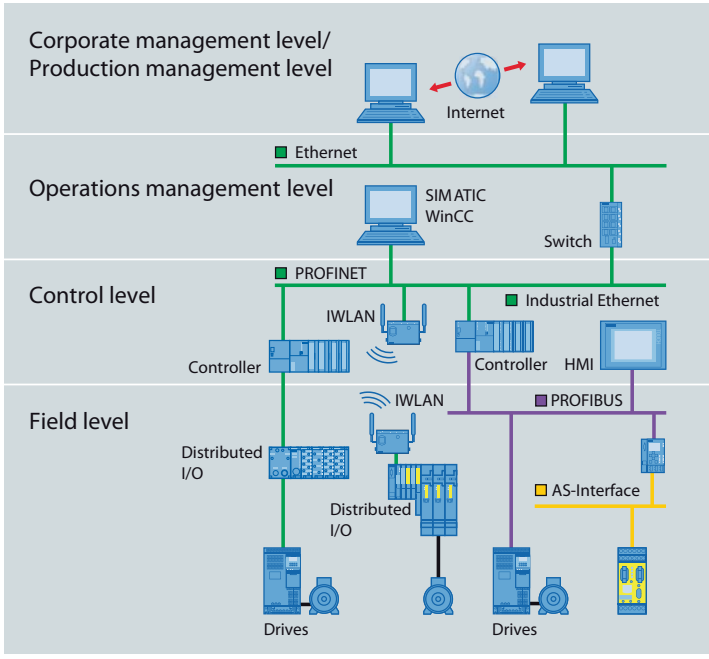
Multilingual/internationality
- The user interface of many software packages is available in six languages
- The interfaces of the HMI devices (operator panels) can be created in various languages, – as can the program comments within SIMATIC STEP 7

Standard programming languages
- PLCopen or IEC 61131-3-compliant programming languages
- PLCopen-certified motion control blocks

Siemens has redefined engineering with its Totally Integrated Automation Portal (TIA Portal). The new TIA Portal engineering framework combines the SIMATIC STEP 7, SIMATIC WinCC and SINAMICS StartDrive automation software tools in a unique development environment. With its intuitive user interface, effiient navigation and proven technology, the TIA Portal offers innovative highlights in many areas. It is a milestone in the software development of the future.

Communications

Maximum data transparency on all automation levels – based on proven standards



With SIMATIC you create the prerequisite for full integration of communication – and thus for maximum transparency from the field and control level via the operations management level all the way up to the corporate management level. SIMATIC relies on international, cross-vendor standards which can be combined flexibly: PROFIBUS, the global No. 1 fieldbus, and PROFINET, the leading Industrial Ethernet standard.
With SIMATIC, relevant information is thus available at any time throughout the plant. This enormously simplifies commissioning, diagnostics, and maintenance – even wirelessly or over the Internet. It is also possible to access the components from anywhere in order to intervene in the process if necessary.

Plant-wide or company-wide data access
- Integrated communications options via all automation levels
  - Management level
  - Operations management level
  - Control level
  - Field level

Flexibility and scalability
- Flexible combination options of the communication standard – without affecting the performance of a system (safety, diagnostics, etc.)
- Implementation of time-critical applications up to isochronous mode

Combinable bus systems
- Existing communications structures can be integrated and/or retained with the CP/Link communications processors (PROFINET, PROFIBUS, AS-Interface, etc.)

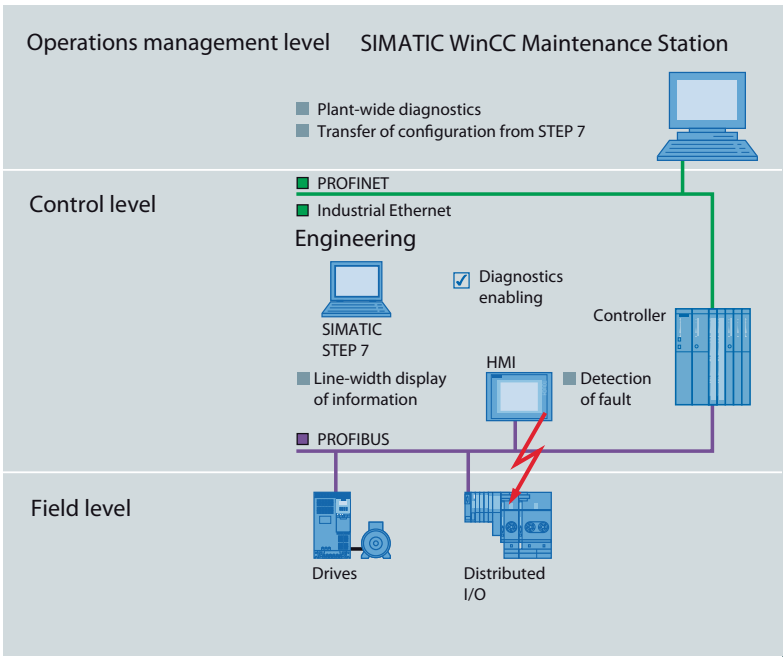
Wireless communication
- Support for wireless communication based on Industrial Wireless LAN – even safety functionality is implemented through IWLAN communication

Routing function
- System-wide access to all components – for facilitated commissioning, diagnostics, and remote maintenance

Integration in office applications
- OPC and OPC XML for the connection of office applications
- Web server functionality for access to device information (z. B. diagnostic buffer) from every Internet-ready PC

Diagnostics

Minimization of downtimes – through efficient diagnostic concepts



All SIMATIC products feature integrated diagnostic functions with which a fault can be detected and eliminated efficiently to provide increased system availability. Even with larger plants, the Maintenance Station provides you with a uniform view of the maintenance-relevant information of all automation components. This increases Overall Equipment Efficiency (OEE), minimizes downtimes, and saves costs.

Integrated diagnostics
- Totally Integrated Automation offers products and modules with integrated diagnostic function
- Plant-wide system diagnostics for detection and automatic signaling of faults
- Additional messages for monitoring the application/process (process diagnostics) are easy to configure and can be generated automatically

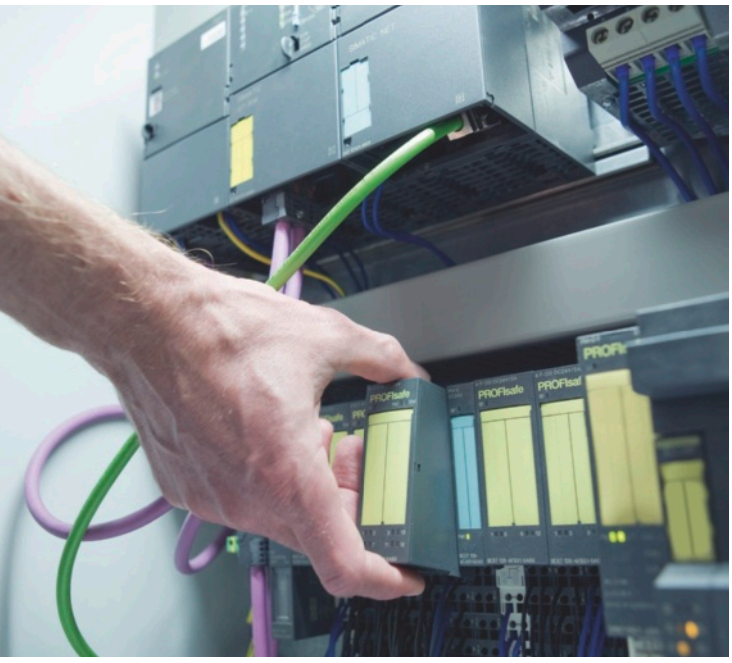
Diagnostics with display of relevant information
- Error text information
- Unique module identification (number)
- Address/slot information
- Chronological time stamp

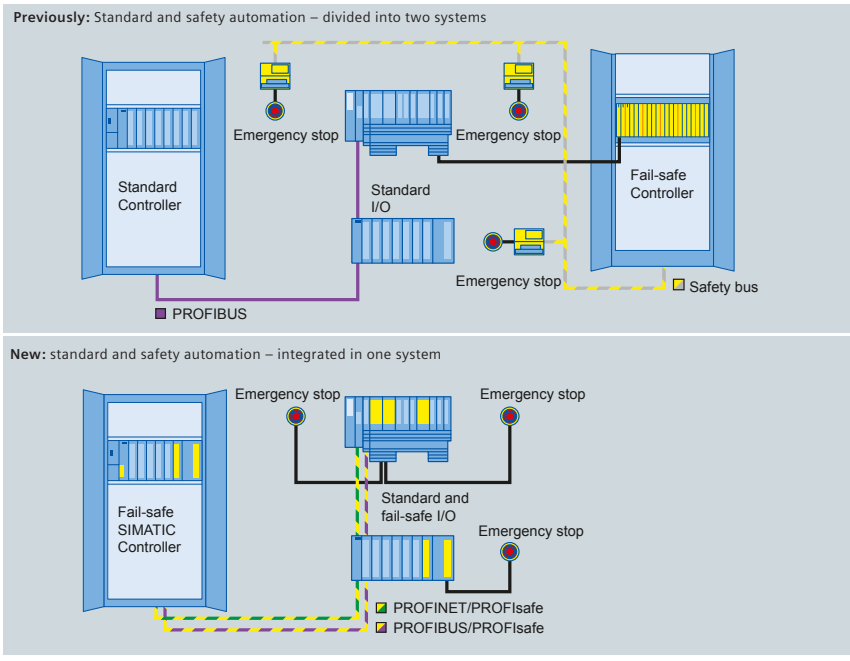
Diagnostics can be activated, no programming is required
- The diagnostic function of the modules is easily activated in SIMATIC STEP 7
- Message texts are available in five languages
- Predefined message windows/views for visualization on the HMI device

Consistent diagnostics from the field level to the management level
- System states (module and network status, system error messages) are available plant-wide with consistent display.
- Diagnostics displays with different degrees of detail (hierarchy) are automatically generated from configuration data (HW Config)

Safety

Protection of personnel and machines – within the framework of an integrated complete system





As a machine builder and plant constructor and operator, you are obliged by law to ensure the safety of personnel and the environment. With Safety Integrated, Siemens offers TÜV-certified products to meet these guidelines and that simplify compliance with relevant standards: IEC 62061 up to SIL 3, EN ISO 13849-1 up to PL e, as well as EN 954-1 up to Cat. 4.
In the spirit of Totally Integrated Automation, safety-related functions are integrated into standard automation with Safety Integrated. Thus Siemens offers a complete and integrated safety program – from detection to evaluation to reaction.
One of the cornerstones is SIMATIC Safety Integrated – the fail-safe control system. By integrating safety into standard technology, only one controller, one I/O, one engineering, and one bus system are required. Thus the system benefits and comprehensive functionality of SIMATIC are also available for fail-safe applications.

The result: A significant reduction in engineering overhead and the number of hardware components.

One controller for Standard and Safety
- Comprehensive self-tests and self-diagnostics of the fail-safe SIMATIC Controllers
- Simultaneous processing of the standard and safety program on one controller

Mixed configuration of I/O
- Space-saving setup thanks to the combination of fail-safe modules and standard modules in one station

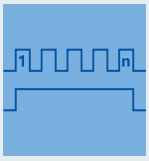
Uniform engineering
- All programming (standard and safety) is implemented in the proven STEP 7 environment
- Programming as needed with ready-made, TÜV-certified, or user-created blocks

Fail-safe communication
- Fail-safe communication over the global proven communication standards PROFINET or PROFIBUS, with the PROFIsafe profile
- Innovative approaches such as wireless fail-safe communication over IWLAN (Industrial Wireless LAN) and PROFINET – e.g. using the SIMATIC Mobile Panel 277F IWLAN with integrated safety function

Diagnostic function
- Identical system diagnostics of safety modules and standard components: Uniform function, display, parameterization as well as easy activation of the diagnostic function without programming

SIMATIC Technology

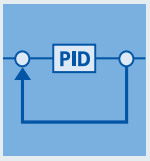
Equipped for all technological tasks



Counting and measuring

Counting and measuring (Page 54)

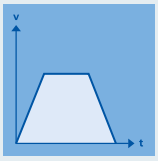
- Counting of pulses with frequencies of up to 650 kHz
- One-off, periodic or continuous counting
- High-speed, counter-dependent actions
- Measurement of path lengths, rotational speeds, frequencies, or period durations
- Position detection with incremental or SSI encoders
- Dosing
- Latch function



Closed-loop control

Closed-loop control (Page 56)

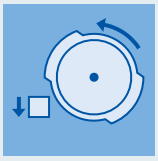
- Temperature/pressure/flow control
- Step/pulse/continuous controllers
- Fixed-setpoint control, follow-up control, cascade control, ratio control and hybrid control
- Ready-parameterized or flexibly programmable control structures
- Self-optimizing
- Output step controller/pulse width modulation



Positioning / Motion Control

Positioning / Motion Control (Page 58)

- Jogging
- Controlled positioning in rapid traverse/creep speed
- Controlled positioning
- Interpolation of several axes
- Gear and curve synchronization
- Asynchronous/stepper/servo motors
- Traversing range monitoring
- Latch function



Cam controls

Cam controls (Page 53)

- Position-dependent or time-dependent actions
- Direction-dependent
- Dynamic derivative action
- Hysteresis response
- Response times from 1 µs

Mastering high-speed processes through isochronous mode

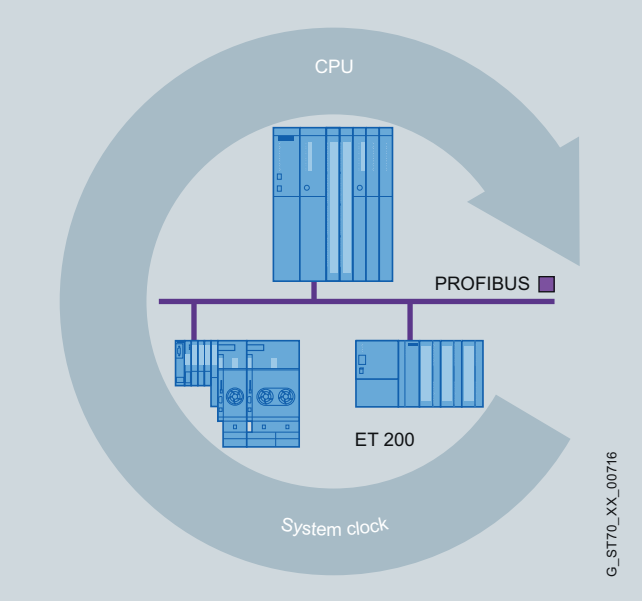
Distributed solutions with isochronous mode ensure extremely high accuracy as well as fast and reliable processing sequences. This is particularly important for controlling drives.

In order to control high-speed machines, production and machining processes, the processing cycles are synchronized. This means that the cycles of certain sequences are harmonized and embedded in a fixed time grid – the system clock. The processing sequences then exhibit continuity and can therefore be handled faster and more reliably.

This means that reproducible and defined process response times can be implemented. This is achieved in that I/O signals are read in, output and synchronized with the user program at equal time intervals.

For this reason, the time from acquisition of a signal by the distributed I/O through to the appropriate response of the actuator must be kept as short and as accurately reproducible as possible.

This requirement is solved by creating a direct link between the equidistant DP cycle, the I/O modules, and the user program.



The system clock applies throughout the complete automation structure

Maximum demand for clock accuracy: Weaving machines

The synchronous linking of a SIMATIC automation solution to the equidistant PROFIBUS is referred to as isochronous mode and offers the following advantages:

- High-speed, time-based procedures, in which reproducibility (deterministic features) plays a decisive role, can also be automated with distributed I/O.
- Isochronous mode opens up a wide range of possible applications that are not restricted to drive applications. Isochronous mode is suitable for applications whose sensors and actuators are distributed throughout the machine.

Product spectrum – Product lines and applications for SIMATIC Technology

SIMATIC Technology represents the greatest possible freedom in the choice of design and scalability of the hardware and software.

Integrated functions (from page 18)

Integrated technology functions are ideal for applications in compact machines with a small number of axes, counter channels and control channels.

The technology functions are an integral component of the operating system of the CPU or of STEP 7 and utilize the inputs/outputs that are directly integrated on the CPU or standard I/O.

Parameterization of the integrated functions, e.g. a control or positioning algorithm, is performed easily and conveniently using the screens embedded in STEP 7.

Your benefit:

- Low-cost solutions for low to medium requirements
- Simple handling: No additional hardware or runtime software
- No additional space requirements thanks to integrated functionality
- Integrated parameterization in STEP 7

Loadable function blocks (from page 21)

Software-based solutions are ideally suited to simple positioning and control tasks and represent a flexible and low-cost alternative to solving technology tasks with hardware.

The function blocks can be implemented universally on the SIMATIC S7-300, S7-400, ET 200S and WinAC hardware platforms. One runtime license is required per CPU. Engineering is carried out using STEP 7.

Function blocks are parameterized easily and efficiently with parameterization screens. They are supplied with the function blocks or as a separate package.

For connecting encoders and actuators, either

- standard SIMATIC modules are used, e.g. signal modules and counter modules, in a centralized or decentralized configuration
- or PROFIBUS with directly connected encoders and drives.

Your benefit:

- Low-cost solutions in the low-end performance range
- Flexible solution thanks to calling the respective blocks in the user program
- Performance/dynamic response is scalable according to the choice of hardware platform: SIMATIC S7-300, S7-400, ET 200S, WinAC

Distributed ET 200S function modules (from page 25)

ET 200S function modules are intelligent modules of the ET 200S distributed I/O system and are preferred for use in distributed applications. They execute technological tasks largely autonomously, i.e. independently of the CPU.

These modules bring all the advantages of the ET 200S system with them, such as the intelligent wiring concept, hot swapping of modules and bit-modular design.

The modules are parameterized using STEP 7.

Your benefit:

- Optimal performance with decentralized technology tasks
- Considerable savings in wiring costs
- Low space requirements and perfectly adapted hardware configurations thanks to compact, bit-modular design

Parameterizable functions (from page 28)

Function modules are always used when more stringent requirements on accuracy and dynamic response exist. They are intelligent modules of SIMATIC S7-300/400 which execute the technological tasks autonomously and therefore off-load the CPU.

Configuration tools based on STEP 7 are available for setting parameters. Parameterization and commissioning are performed via user-friendly screens.

The function modules of the S7-300 can also be used in a distributed configuration in the ET 200M I/O system – also with PC-based automation with WinAC.

Your benefit:

- Highly accurate, highly dynamic and short response time (deterministic time properties)
- Specialized or universal modules with a wide function range
- There is no additional loading on the CPU, because the functionality is stored in the firmware of each module

Technology controllers (from page 35)

Technology controllers are implemented for technology functions and are a low-cost solution for up to 32 axes.

The integrated motion controller provides additional computing power with which comprehensive motion control tasks can be solved with high performance.

Parameters are set with S7 Technology, an option package of STEP 7. A block library is available for programming that contains function blocks according to PLCopen.

Interfacing to the drives takes place over an additional integrated PROFIBUS interface DP(DRIVE).

This provides transparency from HMI through to the drive parameters.

Your benefit:

- High performance with motion control tasks
- Parameter assignment and programming in the familiar STEP 7 environment
- Efficient programming with ready-to-use function blocks according to the PLCopen standard

User-configurable application modules and control systems (from page 40)

Application modules expand the flexibility of the CPU with additional computing power and therefore offer maximum performance for open-loop control, closed-loop control and calculation in the SIMATIC.

The technological function is configured graphically depending on the module using the established tools of SIMATIC S7 (LAD/FBD, CFC/SFC or the C high-level language) and is individually adapted to the respective application.

The SIMATIC TDC control system also solves complex drive, control and communications tasks with maximum quantity structures and minimum cycle times.

Your benefit:

- Maximum machining speed and precision
- Highest possible flexibility for individual applications
- Can be used for all technologies

Selection guide

Specific characteristics of the components are listed from page 18 onwards, comparison tables for the technologies are listed from page 53 onwards.

Technological function	Page	Channels/ axes	Counting/measuring			Cam control	Closed-loop control				
									Actuating signal output		
			Counting	Measuring	Dosing	Position/time-based cam	Optimized for temperature controls	PID	PWM	Step	Continuous (analog)
Integrated functions											
CPU 1211C	18	3/2	●	●			●	●	●	●	●
CPU 1212C	18	4/2	●	●			●	●	●	●	●
CPU 1214C	18	6/2	●	●			●	●	●	●	●
CPU 312C	19	2	●	●							
CPU 313C	19	3	●	●			●	●	●	●	●
CPU 314C	19	4/1[4]	●	●			●	●	●	●	●
STEP 7 PID Control	20	Any						●	●	●	●
STEP 7 PID Temp. Control	20	Any					●	●	●	●	●
Loadable function blocks											
Standard PID Control	21	Any						●	●	●	●
Modular PID Control	23	Any						●	●	●	●
Easy Motion Control	24	Any									
Distributed ET 200S modules											
1 SSI	26	1									
2 PULSE	26	2							●	●	
1 STEP	27	1									
1 POS U	27	1									
1 COUNT 5/24V	27	1	●	●	●						
Parameterizable function modules											
FM 350-1/450	29	1/2	●	●	● / –						
FM 350-2	29	8	●	●	●						
FM 352/452	29	1/1				●					
FM 355C/455C	30	4/16						●			●
FM 355S/455S	30	4/16						●	●	●	
FM 355-2C	31	4					●				●
FM 355-2S	31	4					●		●	●	
FM 351/451	32	2/3									
SM 338	32	3									
IM 174	32	4									
FM 353	33	1									
FM 354	33	1									
FM 453	33	3									
FM 357-2	34	4									
Technology controllers											
CPU 315T/317T /317TF [1]	35	8/32/32				●					
User-configurable application modules and control systems											
FM 352-5	40	1	●	●	●	●					
FM 458-1 DP, EXM 4xx	43	Any	●	●	●	●		●	●	●	●
T400	46	2	●	●	●	●		●	●	●	●
SIMATIC TDC	50	Any	For all automation tasks in the top performance range								

	Closed-loop control		Motion control														
			Position feedback		Positioning (single or several axes)												
	Backup function	Integral online self-optimization	Incremental	Absolute	Rapid traverse/ creep speed	Position-controlled	Pulse interface	Jerk limitation	Electr. gear unit	Cam disk	Print mark synchronization	Hydraulic axes	Pressure control	Traversing programs	Interpolation	User-configurable
		●	●				●									
		●	●				●									
		●	●				●									
		● [3]														
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[1] In connection with S7 technology
[2] Incl. operation at CPU stop via OP
[3] In connection with PID Self-Tuner
[4] 4x counting, 1x positioning
[5] Through IM 174
[6] Actuating signal output

Integrated functions

Counting, positioning and closed-loop control with S7 CPUs

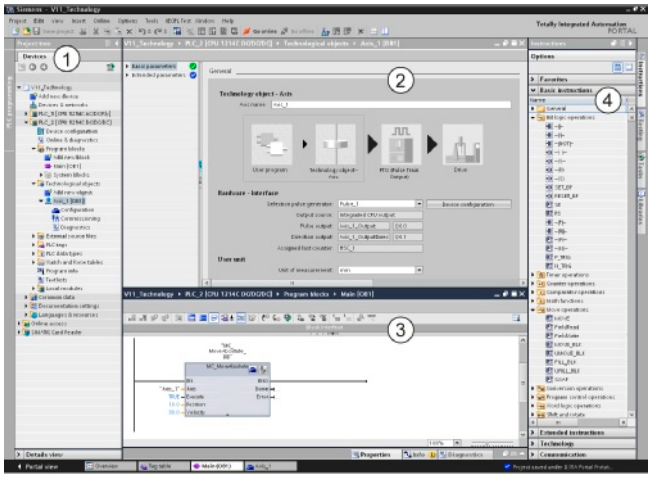
The S7 CPUs offer different integrated functions for implementing simple counting, positioning and closed-loop control tasks.

S7-1200

Depending on the CPU, up to six high-speed counters are integrated, three at 100 kHz and three at 30 kHz. Optionally, using Signal Boards, 200 kHz (24 V or 5 V version) is available. They are used for the precise monitoring of incremental encoders, frequency counting or high-speed counting of process events. Two high-speed outputs are integrated into the SIMATIC S7-1200 controller for use as pulse outputs. They can be used for the open-loop speed and position control of stepper motors and servo drives. They are easily configured using an axis technology object along with the internationally accepted PLCopen motion function blocks included within the SIMATIC STEP 7 Basic engineering system.

Intuitive and efficient engineering in the TIA Portal

The engineering of the S7-1200 offers a project view for all tasks, up-to-date user guidance for intuitive and graphical configuring with intelligent drag-and-drop technology, uniform data storage and integration of SIMATIC WinCC Basic.



TIA Portal - Engineering for the S7-1200

In the project view, the project tree (1) shows all the hardware components that are used and the associated program structure and data elements. This provides direct access to the appropriate devices, folders and special views that support the user with the automation tasks. Technology functions, such as closed-loop control or motion, are embedded in the engineering. This includes parameter assignment as well as commissioning functions.

The control panel included with the SIMATIC STEP 7 Basic engineering system simplifies the commissioning of stepper drives and servo drives with a pulse/direction interface. It provides both automatic and manual control of individual single motion axes as well as online diagnostics information.

Below the axis parameterization (2), the user program (3) is displayed. This program editor supports efficient programming in LAD and FBD using statements and libraries (4).

Symbolic program elements can be directly assigned between the PLC and HMI editors using intelligent drag-and-drop functions. HMI editors as well as PLC editors can be efficiently used together in the engineering environment.

Devices and networks are easily configured using graphical editors, thanks to the structured interface.

S7-300
Depending on the type of S7-300 compact CPU, various high-speed counters are available up to 60 kHz. They are used for counting and frequency measurement with incremental encoders.

The compact CPUs also offer pulse outputs for pulse width modulation for direct activation of valves, final controlling elements and switching devices. CPU 313C and CPU 314C are also equipped with integrated control blocks that do not reserve any space in user memory. They can be combined with onboard I/Os for simple closed-loop control tasks.

S7-300 compact CPUs

Simple positioning tasks can be solved conveniently in the CPU with the compact CPU 314C. The positioning algorithm for traversing an axis relatively or absolutely according to the rapid traverse/creep speed principle is integrated into the operating system of the CPU.

A 24 V incremental encoder can be connected as the position measuring system. Setpoints can either be output over 4 digital outputs or one analog output ± 10 V.

When positioning, the module first starts the drive (for example, a frequency converter with standard asynchronous motor) by setting an output in rapid traverse. Just before the destination is reached (changeover difference), the module switches the drive to creep feed mode. The drive is shutdown completely when the target position is reached or shortly before this, depending on the parameterization.

PID Control

PID Control with S7-1200

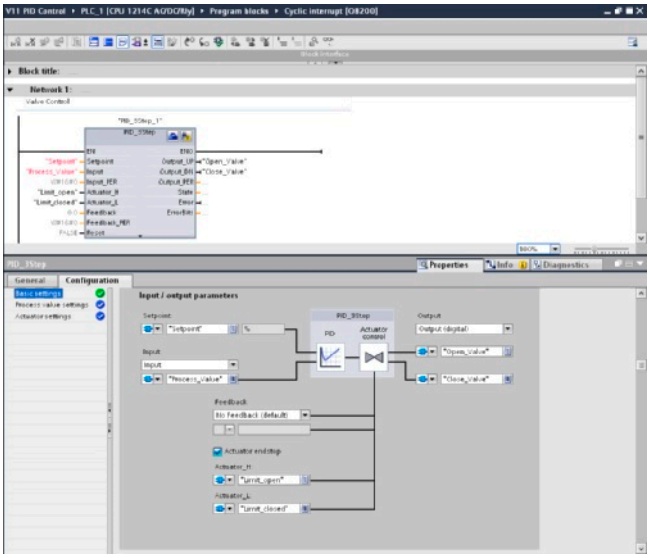
In the S7-1200, two different PID control algorithms are available:

- PID Compact for continuous control and pulse control (pulse width modulation)
- PID 3-Step for step control of valves and flaps

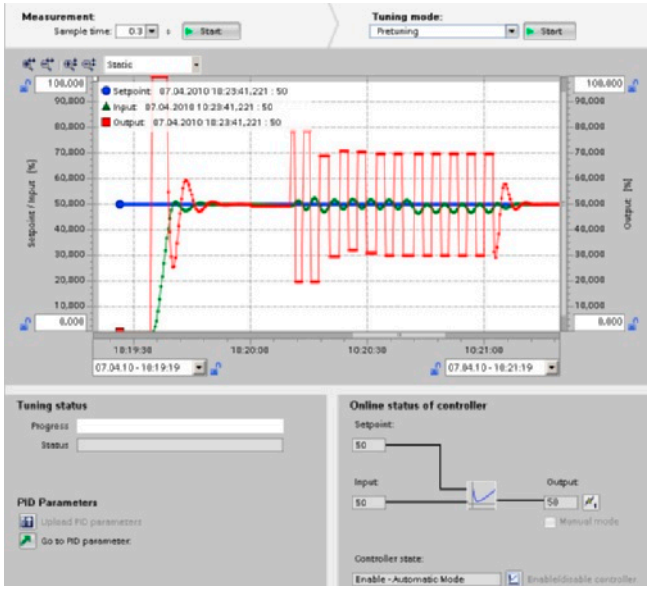
Closed-loop control tasks are easily implemented with the supporting editors in the SIMATIC STEP 7 engineering system and the universally implemented controller blocks.

After placing the controller block in the user program, the setpoint, process value and manipulated variable can be interconnected. Commissioning is performed with two-stage autotuning, i.e. optimum parameters for gain, integration time and differentiation time are automatically calculated at the initial optimization stage and fine-tuning stage. With this combination, even difficult controlled systems can be easily mastered. The control panel integrated into SIMATIC STEP 7 supports, alongside monitoring of the control loop in a graphics view in real-time, also activation of autotuning and manual control of the controller (bumpless manual/automatic changeover, and activation and deactivation of the controller).

PID control with the S7-1200 supports easy configuration and successful commissioning.



PID 3-Step in the program editor with S7-1200



Control panel for PID optimization with S7-1200

PID Control with S7-300/400:

The standard function blocks for the different controller functions are provided in the libraries of STEP 7 and CFC and are loaded into the CPUs. In the compact CPU 313C and 314C, these controllers are already available as SFBs (System Function Blocks) in the operating system and do not occupy any user memory.

The controllers are parameterized in STEP 7 using a table. The number of controllers that can be implemented results from the available memory space and the resulting overall runtime.

PID Temperature Control

In addition to the universal PID Control function blocks, STEP 7 offers two control blocks that are specifically for the closed-loop control of simple temperature loops (e.g. heater or cooler controls). This includes parameterization software, a sample project and an electronic manual.

The parameterization software provides a wizard for self-optimization as well as a special commissioning screen, and can be directly started from the SIMATIC Manager.

- Apart from the functions described for PID Control, the function block for temperature control features integrated online self-optimization, which is possible without a PG/PC.
- A pulse shaper is also integrated for implementing pulse controllers. In contrast to the solution using PID Control, there is no need to connect control blocks – it is parameterized rather than programmed.
- An additional function block is used to implement step controllers.

Loadable function blocks

Standard PID Control

Standard PID Control is a preconfigured controller structure that is easily adapted by connecting or disconnecting functions to and from the control process. The controller structure is implemented in a function block to be loaded into the CPU. This is graphically configured with the appropriate parameterization software. Standard PID Control is implemented wherever small or medium-scale closed-loop control tasks arise: in temperature control, pressure control, flow control as well as fill-level control. Standard PID Control is particularly suited to applications that have been automated with compact controllers until now.

Standard PID Control contains the following pre-configured examples:

- Step controllers with line simulation
- Continuous-action controller with path simulation
- Multi-loop ratio controller
- Blending control
- Cascade control

Pulse controllers

The pulse controller is combined with the continuous-action controller in the same block, including conversion to a pulse/pause signal (pulse shaper). This simplifies parameterization and commissioning of the pulse controller.

It is also possible to adjust the sampling time of the controller and the period duration of the pulse shaper independently. The period duration can therefore be set longer than the sampling time.

- The advantage of a shorter sampling time lies in the rapid response of the controller to faults and operating commands.
- The longer period duration, however, protects the final controlling element due to the lower switching frequency. The oscillation of actual values is suppressed because the effective cycle duration is automatically shortened.
- A further advantage is the reduced loading on the CPU because the pulse shaper can be called at less frequent intervals.
- The example provided for a pulse controller with a 3-point output "HEATING - OFF - COOLING" simplifies commissioning of the temperature control.

Step controllers

An adjustment algorithm ensures that for the same control accuracy, step controllers can have up to 50% fewer switching actions as conventional step controllers. This protects the connected actuators and increases their service life considerably.

Extended manual/automatic changeover

The following functions can be selected for manual/automatic changeover by setting parameters:

- Bumpless manual/automatic changeover
- Bumpless manual/automatic changeover with a corresponding step change in controller output for faster compensation of the system deviation
- Manual value follow-up in automatic mode

User-friendly parameterization

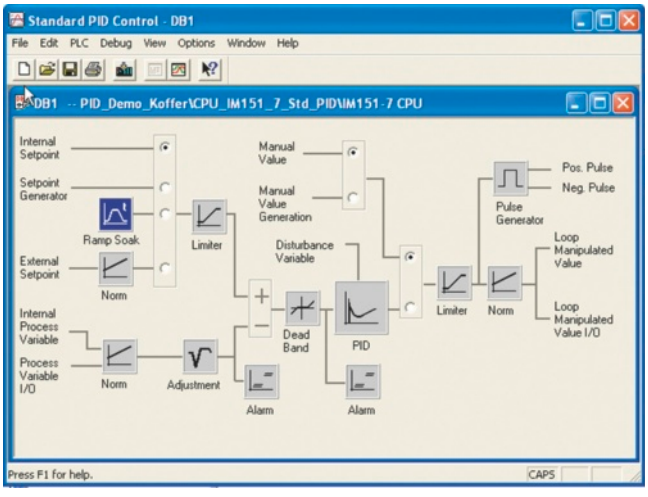
Parameterization is graphically supported by means of a controller structure display, loop display, graphic plotter and controller optimization function. The clearly comprehensible controller structure makes it easy to connect and disconnect functions using software switches.

Parameter changes can be performed in the RUN state of the CPU or when the graphic plotter or loop display are active.

Debugging functions

Comprehensive test functions aid commissioning and diagnostics. As in the case of the FM 355/455 control modules and Modular PID Control, a control loop display is available with a bar chart and a graphic plotter for recording the signal charts. The controller structure, the entered parameters and their effect on the result can be displayed at the same time.

The curves plotted with the graphic plotter can be archived in files and subsequently processed, for example, with a spreadsheet program.



The clear controller structure of Standard PID Control

PID Self-Tuner

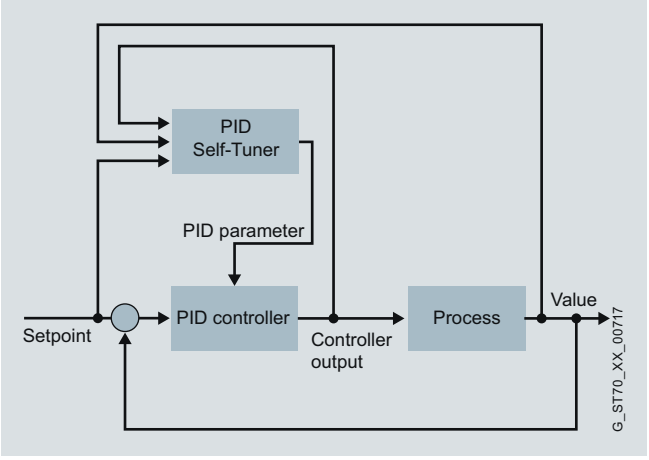
Controller optimization

The parameterization software contains a self-tuning function that can be used to adjust this controller extremely quickly without the need for exact knowledge of the controlled system. For this purpose, the process is activated with a step change in controller output or a setpoint change. During the settling period, the process values are automatically acquired and displayed. The program calculates a mathematical model of the controlled system from the values and determines the most favorable controller parameters for PI and PID controllers according to the optimum value.

There is a choice of two different transient responses for controller self-optimization:

- Response of the control loop with overshoot of up to 10%
- Transient response without overshoot

For online self-optimization, the PID Self-Tuner is recommended.



PID Self-Tuner optimizes a PID controller

The PID Self-Tuner option package expands the PID controller with additional function blocks to form a self-tuning PI or PID controller:

- Continuous-action PID controllers
- Step controller with or without position feedback

Easily understandable functions and systematically structured examples enable the controller to be adjusted online and adapted to the process.

PID Self-Tuner can be flexibly combined with the controller products PID Control (integrated into STEP 7), Standard and Modular PID Control as well as FM 355 and FM 455. It can be used on the hardware platforms SIMATIC S7-300/400 and WinAC and is ideally suitable for optimizing temperature, fill-level and flow controls.

Process requirements

- Stable asymptotic transient response
- Delay times that are not too long
  (delay time < 0.3 * build-up time)
- Sufficient linearity in the selected operating range
- Sufficient quality of measurement signals
- Processes are not intensified too much

Functions

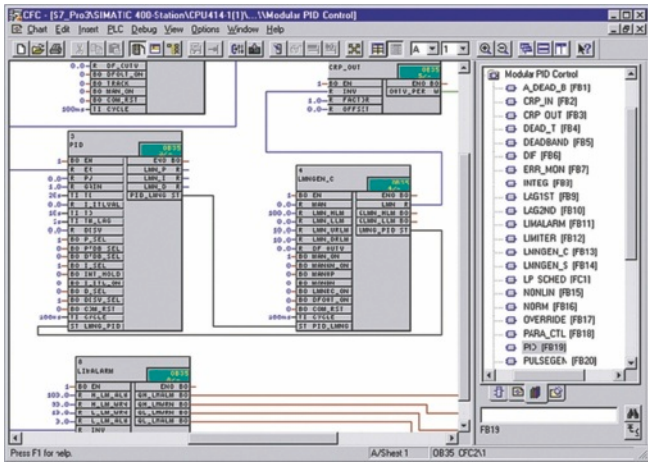
- Online initial adjustment of PID controllers
- Online adaptation of the PID controller for reoptimizing at the operating point
- Optimization of processes with heating and active cooling
- Manual mode
- Optimization with control zone response
- Debugging functions

Modular PID Control

Modular PID Control is a library of standard function blocks that are optimally tuned to each other.

They can be used to implement any type of controller structure for SIMATIC S7-300/400 and WinAC in process engineering applications. In combination with the SM 334 analog module, sampling times of up to 5 ms are possible.

The function blocks can be interconnected in STEP 7, SCL and extremely easily using graphical techniques in CFC. This means that complex control structures can be generated clearly and flexibly and tested.



Modular PID Control with the graphical function diagram editor CFC

The associated parameterization software contains a control loop display with bar charts and a graphic plotter for indicating the signal charts. This makes commissioning much easier.

Modular PID Control is used on the one hand for applications in which extremely complex control structures have to be constructed. On the other hand, it is also suitable for applications in which memory space has to be saved and single controllers from the building block set meet the requirements exactly. Modular PID Control is also recommended when analog calculation blocks such as dead zone, polygon, standardization or time scheduler are used.

The following controller types exist:
- Continuous PID controller
- Pulse controllers
- Step controllers

Prepared examples

- Fixed value controller with different outputs
- Single-loop ratio controller
- Multi-loop ratio controller
- Mixture controller
- Cascade controller
- Controller with precontrol
- Controller with feed-forward control
- Range selection controller
- Alternating controller
- Multi-variable controllers

Functions according to Standard PID Control

- Debugging functions
- Controller optimization
- Transient response without overshoot
- Control algorithm for step controller

For online self-optimization of temperature control loops, the combination with the PID Self-Tuner is recommended.

Easy Motion Control

Easy Motion Control is the flexible and low-cost software-based solution for position-controlled tasks with the SIMATIC S7-300/400 and WinAC. Easy Motion Control comprises function blocks for the CPU and parameterization software.

Applications include approaching absolute positions or relative traversing, as well as simple gearbox synchronism both with linear and rotary axes. The application areas are positioning axes and operating axes, as well as feed and transport axes. On-the-fly transition to a new motion is possible.

Easy Motion Control is the obvious choice when 1 to 5 axes per machine are to be traversed. Memory requirements are between 10 and 20 KB for the first axis. Each subsequent axis requires only 1 KB.

Benefits

- Free choice of drives (except stepper motors)
- Standard interface in accordance with PLCopen Motion Control
- Can be flexibly integrated into the STEP 7 program
- Support of isochronous mode

Operating principle

The positioning operation is carried out using the function blocks loaded into the CPU. The standardized interface in accordance with PLCopen Motion Control enables simple and seamless integration into the user program.

The positioning task can be parameterized and started up comfortably with STEP 7 and the supplied parameterization software; that is, no special motion control language is required.

Different interface modules can be used for encoder acquisition and setpoint output, depending on the application.

Input and output drivers are available for the most frequent interface modules. In addition, universal drivers enable the connection of any actual value and setpoint interfaces.

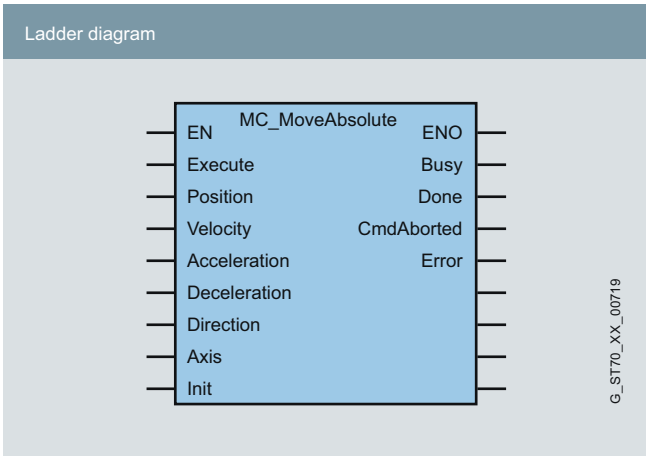
Input drivers for position feedback

- CPU 314C
- SM 338
- FM 350-1, FM 450-1
- ET 200S 1 SSI
- ET 200S 1 COUNT
- PROFIBUS DP absolute encoder
- Universal drivers for any interface modules

Output drivers for controlling the drive for

- CPU 314C
- SM 332, SM 432
- ET 200S 2 AO U
- MICROMASTER 4 over PROFIBUS DP
- Universal driver

Input and output drivers for SINAMICS and IM174 are available on the Internet for download
http://support.automation.siemens.com/WW/view/en/40787611



PLCopen block in STEP 7

Distributed ET 200S modules

Bit-modular ET 200S station

A range of ET 200S modules are available for the distributed execution of preprocessing functions. With the IM 151 head modules, networking via PROFIBUS DP or PROFINET is possible. In this case, S7 masters or standard masters can be used.

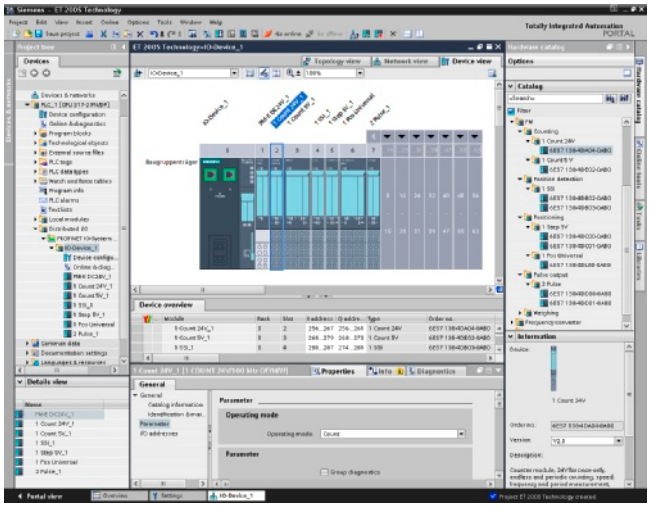
Parameterization is performed with STEP 7 of with standardized GSD files in the open automation environment. Standard function blocks are not required.

Engineering in the TIA Portal

For the engineering, the new TIA Portal offers up-to-date software technology that, through the intuitive user interface, enables every configuration task to be implemented easily and efficiently with a minimum of learning.

On starting the project, it is possible to choose between the task-oriented portal view with simplified user guidance or the project view - all the relevant tools for configuring the technology modules are already integrated.

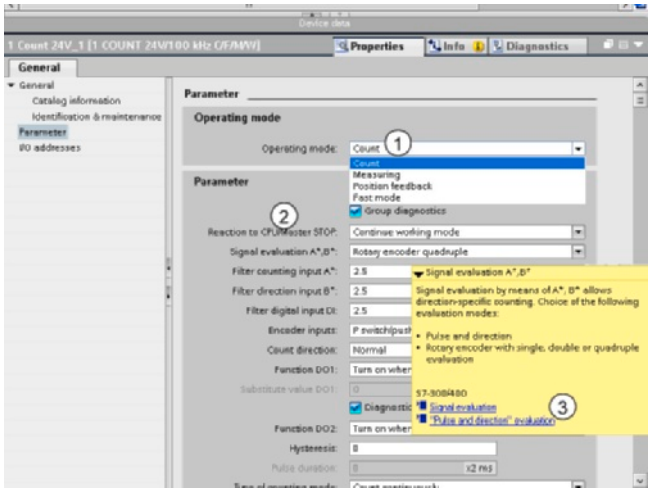
The portal view guides the user through every engineering step intuitively. Whether a controller has to be programmed, an HMI screen has to be designed or network connections have to be configured - the TIA Portal helps new and experienced users to work as productively as possible.



Engineering from SIMATIC technology modules to ET 200S distributed I/O

STEP 7 supports clear and uniform configuring of the technology modules. The product catalog presents all the available modules filtered context-sensitively and clearly structured according to function. The main technical features are presented as early as this selection stage. If several versions exist, the right one can be selected easily. The presentation in the hardware catalog and in the finished configuration in photographic quality prevents errors and provides an attractive picture of the configuration being built up.

After the ET 200S station has been selected for the project, it is depicted in the structured project tree - complete with the associated device configuration and online diagnostics. All the technology modules that can be configured and programmed in the TIA Portal are shown in the diagram. The procedure is intuitive: The modules are arranged in the hardware catalog on the right according to topics, and can be selected by order number and directly "placed" in the rack shown in photographic quality by means of drag-and-drop.



User-friendly parameter assignment at a glance

By selecting the required operating mode (1), the conditions for selecting the possible parameters and the required address space are defined. The appropriate parameters are displayed (2). Context-sensitive selection lists offer exactly the right choice of settings. As required, cascading tool tips provide detailed information about the respective settings and even a direct link to the comprehensive online help system (3). In the background, the appropriate addresses are automatically assigned correctly and, if required, adapted to the requirements of the system.

Position decoder module 1 SSI

The single-channel 1 SSI signal module enables SSI encoders to be connected to ET 200S and allows simple positioning tasks to be implemented. The actual positioning algorithm is processed in the CPU, e.g. with Easy Motion Control.

- The 1 SSI module acquires the actual values of the SSI encoder (13 to 25 bits) and makes them available to the higher-level master (e.g. the CPU).
- The actual value can also be compared with two values specified by the master.
- 1 SSI supports a cycle time of 250 µs in isochronous mode. A slower encoder can also be operated in synchronization with down-scaling.
- For transmission security, a parity bit can be evaluated.

Pulse generator module 2 PULSE

The dual-channel technology module 2 PULSE is used to activate final controlling elements and valves. In combination with the SIMATIC software control packages, e.g. Standard PID Control, it can output pulse-width-modulated manipulated variables and therefore off-load the CPU. It can be used for example for controlling semiconductor contactors or for switching heating elements.

The 2 PULSE module operates in the following modes:

- Pulse output: On the 24 V digital output, a single pulse is output for the specified duration.
- Pulse train: On the 24 V digital output, a number of pulses specified by the user is output at the predefined frequency.
- PWM (pulse width modulation):
  A pulse-width-modulated signal sequence is output on the 24 V digital output.
- On/Off delay:
  A signal that is active on a 24 V digital input is output on the 24 V digital output with an ON delay or OFF delay.
- Frequency output: A preset frequency of up to 5 kHz is output at the 24 V output.

In the PWM and pulse string operating modes, the 2 PULSE can measure the current output in each case and report it to the CPU. The measured value is averaged over the period. This enables simple proportional valves to be directly connected and precisely regulated. Isochronous mode improves the precision of the closed-loop control even further.
To increase performance, the two channels of the module can be switched in parallel, enabling them to provide a current of up to 4 A. The extended user data interface offers greater user-friendliness when controlling the module.

Stepper motor module 1 STEP

The single-channel stepper motor module 1 STEP performs positioning tasks in combination with stepper motors.
It is suitable, for example, for feed equipment in assembly lines, transfer lines, printing machinery, paper and textile machinery.

The following traversing tasks are available:

- Relative positioning: The axis is moved along the specified route
- Absolute positioning: The axis is moved to the specified position
- Reference point travel: The axis is moved in order to find the reference point and to initialize the measuring system
- Speed operation: The frequency specified by the controller is sent to the output, taking into account the acceleration/delay ramp. This operating mode is also suitable for using the 1 STEP on a higher-level position controller as an output for stepper motors, if necessary also in isochronous mode.

For flexible use, the current speed, the current position, or the distance still to be traveled are available as a checkback value.

The 1 STEP has two digital inputs with configurable functionality as:

- Reference point switches for supporting the reference point approach
- Upper or lower limit switches in order to restrict the range of travel
- External stop in order to stop the axis with an external signal
- External pulse enable in order to enable operation by means of an external signal

Simultaneous use as a reference point switch and limit switch is possible.

Positioning module 1 POS U

Positioning module 1 POS U

The single-channel positioning module 1 POS U is suitable for positioning positioning axes and operating axes - for both linear and rotary axes.
It is used, for example, in paper and cardboard processing machines, in the food processing industry and in conveyor systems.

- Pulse generator modules, incremental encoders (with 5 V difference signals or 24 V signals) or absolute position encoders with SSI interface can be used for position detection.
- Controlled positioning is performed in accordance with the rapid traverse/creep feed principle with three digital outputs that control the drive. The axis can be traversed to an absolute position or by a relative path.
- In the jog function, the control signals are specified by the user program and connected through by the module.
- Three 24 V digital inputs are used for reference-point approach and as a hardware limit switch.
- Parameterization during normal operation (for switchover/switch-off difference) is possible.
- Apart from the actual value, the residual distance can be read back.
- With a 2-position valve, 1 POS U also supports proportioning operation; in this case only one channel of the incremental encoder is evaluated.

Counter modules 1 COUNT 5V/24V

The single-channel counter modules 1 COUNT 5 V/24 V are ideally suited to distributed counting and measuring applications.
The modules supply the 24 V to the connected encoders.

- 1 COUNT acquires the encoder pulses in accordance with gate signals (e.g. light barriers connected to an integrated digital input).
- The direction of the signals is evaluated, the counter value/measured value is compared with a pre-specified value and, if necessary, a response is output over an integrated digital output.

The counter modules support the following functions:

- One-off, periodic, continuous counting
- Length, frequency, speed and period duration measurements
- Position detection with incremental encoder *)

*) Particularly fast isochronous mode applications up to 500 µs are possible in fast mode.

1 COUNT 5 V/500 kHz counter module

Parameterizable function modules

A range of parameterizable function modules (FM) are available for technology tasks:

- In S7-300 design for S7-300, ET 200M and WinAC
- In S7-400 design

The associated parameterization software allows the FM to be easily parameterized in screens, e.g.

- Selection the desired encoder type
- Selection of the appropriate operating mode
- Input of the machine data
- Presetting of the traversing paths

A Getting Started Guide guides the user to an executable configuration in easy steps.

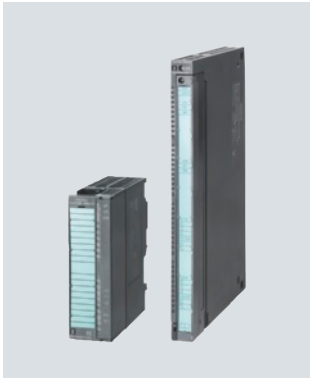
The FMs are equipped with special onboard inputs and outputs to which sensors (e.g. position encoders) and actuators (e.g. drives) can be directly connected.

The electronic rating plate contains the identification data stored in a module, e.g. Order No., product version, installation date, higher level designation. These uniquely identify the module and are available online, for example, for easier fault rectification.

Function modules of the S7-400 and S7-300 systems

Counter modules

Counter modules
FM 350-1/450



Counter modules FM 350-1 (left) and FM 450 (right)

The intelligent counter modules FM 350-1 (single-channel) and FM 450-1 (2-channel) are ideal for implementation in many different high-frequency counting tasks and precise measuring tasks (up to 500 kHz).

- They directly acquire the pulses from incremental encoders on the basis of gate signals (e.g. light barriers). Gate control is implemented by level, pulse or user program.
- They evaluate the direction of the pulses in incremental encoders and compare the counter value with two comparison values that can be specified.
- When a limit value or comparison value is reached, a parameter setting determines whether a response should be output on digital outputs or a process interrupt in the CPU.

The counter modules support the following functions:

- One-off, periodic, continuous counting
- Length, frequency, speed and period duration measurements *)
- Position measuring with incremental encoder

Counter module FM 350-2

The FM 350-2 is a double-width counter module with 8 independent channels for a broad spectrum of universal counting and measuring tasks up to 20 kHz.

In interaction with multi-position valves, the FM 350-2 also handles the dosing function. In this case, 4 counter channels are combined to form one dosing channel. After a gate enabling signal, a single dosing procedure is performed until the lower or upper limit value is reached.

*) only with FM 350-1

Cam controllers

Cam controllers
FM 352/452

Cam controllers FM 452 (left) and FM 352 (right)

Cam controllers are implemented to activate position-dependent or time-dependent functions. They are far superior to mechanical cam controllers, due in particular to their high flexibility, e.g. changes can be implemented by means of software during normal operation.

FM 352/FM 452 modules are single-channel cam controllers and take the load off the CPU thanks to autonomous setting and resetting of electronic cams. They have 32 cam channels that can be read by the CPU. Apart from this, many of these cam channels can be directly output on onboard digital outputs to ensure extremely short response times.

The cams can be freely assigned and can be implemented as position or time-based cams:

- Path-dependent cam control:
  A position encoder detects the position of an axis – the cams can be activated and deactivated correspondingly.
- Time-dependent cam control:
  The cams are set depending on the position and reset depending on the time as supplied by an integrated clock.
- Maximum accuracy is assured by a reproducibility of up to 20 µs.

Additional functions of FM 352/452:

- Dynamic dead time compensation (velocity-dependent derivative action before the switching position)
- Parameterizable counter cam channel
- Parameterizable brake cam channel (the press always stops in the open position)

Control modules

Control modules FM 355/455

Control modules FM 455 (left) and FM 355 (right)

The FM 355 (4 channels) and FM 455 (16 channels) are universal control modules that are available in two different versions:

- FM 355C/FM 455C as continuous-action controller for activating analog final controlling elements, e.g. valves
- FM 355S/FM 455S as step controller or pulse controller for digitally activated actuators (e.g. motorized, electrical heating elements, integrating actuators)

Applications

The control modules are universally implementable, e.g. for temperature, pressure, flow and fill-level control in the many different sectors of mechanical and plant engineering. Through the backup function in particular, the modules are ideally suited to process control applications in the chemicals, glass and ceramic industrial sectors. Continuous processes and batch processes can be controlled.

Parameterization

Parameterization software is available for the control module complete with comprehensive online help, manual and Getting Started Guide as well as function blocks for communication with the FM and CPU. Comprehensive test functions as well as simulation functions make start-up easy.

Closed-loop control structures

The control modules contain several largely ready-to-use closed-loop control structures:

- Fixed setpoint control
- Cascade control
- Ratio control
- 3-component control

Up to 4 controllers can be connected to create a closed-loop control structure.

Controller optimization

- The PID controller can be optimized using the parameterization software (a PG/PC is required).
- For closed-loop control and optimization of many temperature control loops, separate blocks are available for FM 455 (with the exception of step controllers). They are used for closed-loop control of a large number of individual heating or heating/cooling zones, as in the case of an extruder.

Backup operation

This function ensures that the control module continues to operate when the CPU fails or switches to Stop. For back-up operation, it is possible to set a safety setpoint. A safety setpoint can be parameterized for use in the event of a measuring transducer fault.

Operating modes

Apart from automatic mode and back-up mode, the modules also operate in the following modes:

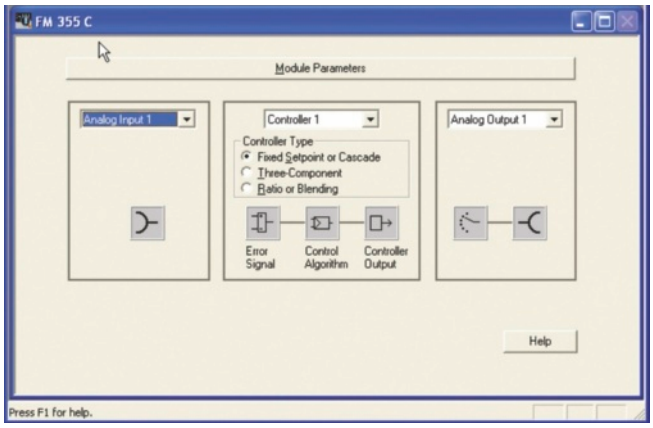
- Manual mode
- Follow-up mode
- Safety mode

Firmware update

For quick and easy updating, the latest firmware version can be loaded from the Internet free of charge. With the help of the parameterization software, the new firmware is transferred to the module.

Inputs

The analog inputs can be used for analog value acquisition or for feed-forward control. An additional input is used for temperature compensation with thermocouples. For connectable encoders, the associated characteristics are saved on the module and are activated by means of parameter settings. If a characteristic is not configured for an encoder, the required characteristic can be entered by specifying interpolation points.



Graphical parameterization interface for FM 355C

Controller optimization with the FM 355-2 temperature control module

Temperature control module FM 355-2

The 4-channel temperature control module FM 355-2 is available in two versions:

- FM 355-2C with analog outputs as continuous-action controller
- FM 355-2S with digital outputs as pulse/step controller

FM 355-2 control module

The module is designed for closed-loop temperature control, whereby controllers with heaters and/or active coolers can be implemented and optimized. Other controlled systems with similar requirements can generally also be controlled. In contrast to FM 355, the analog outputs of FM 355-2 are more accurate, which is an advantage especially when using thermocouples.

The module operates with a PID algorithm. The sampling time is 100 ms per analog input used. For easy operation of the most important closed-loop control functions, an OP27 project example is provided with the module.

Backup operation

This function ensures that the control module continues to operate when the CPU fails or switches to Stop. For back-up operation, it is possible to set a safety setpoint. A safety setpoint can be parameterized for use in the event of a measuring transducer fault.

Controller optimization

FM 355-2 features integrated online self-optimization that can also be performed without a PG/PC.

Self-optimization can be activated based on the ambient temperature by means of a setpoint jump (initial optimization) or based on the operating point of the controller (subsequent optimization).

A quasi steady state is required for starting the optimization, i.e. drifting of the actual value is tolerated. As soon as the changeover point of the step response is reached, the control parameters are available. A steady final state is not necessary; this significantly reduces the commissioning time.

The controller uses a closed-loop control zone for fast approach of the operating point. An adjustable weakening of the P component for setpoint changes allows the control response of the controller to be modified to prevent overshoot. The control output limits can be changed online.

Positioning modules

Positioning modules FM 351/451

Positioning modules FM 451/351

The FM 351 (2-channel) and FM 451 (3-channel) are positioning modules for displacing and positioning mechanical axes in accordance with the rapid traverse/creep speed principle. Rotary and linear axes can be traversed absolutely or relatively.

FM 351/451 modules support relatively high positioning accuracy even when using simple drives and therefore support low-cost solutions. Typical applications for FM 351/451 are, for example, positioning axes in the transport and logistics sector.

The target positions can be specified by the CPU and modified during operation. However, they can also be permanently stored in a table on the positioning module. If desired, the target position is always approached from the same direction regardless of the current position. Standstill of the axis can be optionally monitored until the start of a new position approach.

Position decoder module SM 338

Position decoder module SM 338

The position decoder module SM 338 supports the connection of up to 3 SSI encoders to S7-300 and ET 200M. The isochronous response and latch functions over digital inputs also support time-critical applications in the field of position sensing.

SM 338 provides encoder values for further processing in the STEP 7 program. Further processing is performed in the CPU, e.g. with Easy Motion Control. Parameterization is performed with STEP 7 without the need for additional configuration software.

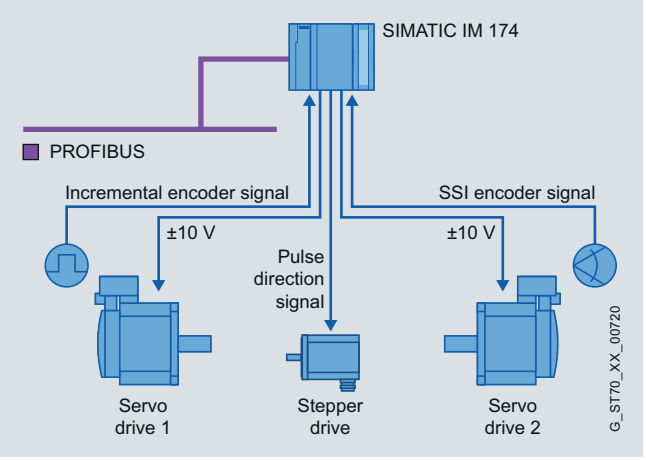
The SM 338 handles SSI frames with 13 to 25 bits which are protected by a parity bit.

PROFIBUS module IM 174

The new isochronous PROFIBUS module IM 174

The IM 174 is an isochronous PROFIBUS module of S7-300 design for operating up to four drives over PROFIBUS DP on a motion control controller. These can be electric or hydraulic drives with analog setpoint interface (+/- 10 V) or stepper drives with pulse direction interface. The isochronous SIMATIC S7-300, S7 400, Technology CPUs and SIMOTION C/P/D can be used as the controller.

The actual values (encoder values) are transferred from the IM 174 to the motion control controller over PROFIBUS DP. 5 V or 24 V incremental encoders or SSI absolute encoders can be used as encoders. The position controller of the control unit calculates the speed setpoint. This value is transferred to the IM 174 via PROFIBUS DP and then output.



Connecting drives to the PROFIBUS module IM 174

Positioning modules for stepper and servo motors

Positioning modules for stepper and servo motors			
Module	**FM 353**	**FM 354**	**FM 453**
Design	S7-300	S7-300	S7-400
Motor	Stepper motor	Servo motor	Stepper and servo motor
Position measurement system	Not required	5 V incremental, SSI	5 V incremental, SSI
Number of axes	1	1	3

These modules are used for controlling stepper motors or for position control with servo motors. They can be used for simple point-to-point positioning tasks as well as for complex traverse profiles with the highest demands for dynamic response, accuracy, and velocity through to multi-axis applications. Rotary and linear axes can be traversed absolutely or relatively. Application examples include positioning infeed axes, positioning axes, setup axes, operating axes, production axes, and transport axes.

Autonomous positioning of the stepper and servo motors takes the load off the CPU of the automation system.
In automatic mode, complex positioning profiles (traversing programs) are traversed continuously or step-by-step.
The traverse programs can be loaded during operation.
For coupling with the machine, there are freely configurable inputs (for high-speed measuring, for example) and outputs ('position reached', for example).

Stepper motors

Stepper motors are used when positioning must be performed at minimal load and when no large load variations occur. It is then possible to achieve accuracies (µm range) of a similarly high level to those achieved with servo motors. Contributions are also made by the equalization of tool wear and the compensation of gearless motors. They permit relatively low-cost solutions because a measuring system is not required.

Over their pulse/direction interface, the FMs 353/453 transmit pulses to the power section of the stepper motor. The total number of pulses determines the length of the traverse path, and the pulse frequency influences the traversing speed.

Positioning module for FM 354 stepper motors

Servo motors

Servo motors create torques between 0.1 Nm and several hundred Nm and are suitable, for example, for precise positioning actions with load variations or high dynamics.

FMs 354/453 control the drive over the analog drive interface. Position encoders report the current axis position. Comparison of the actual position with the specified setpoint enables continuous optimization of position, speed and acceleration. The absolute encoder adjustment function enables fast re-adjustment of the system following replacement of a defective absolute encoder. This means low-cost, non-programmable encoders can also be used.

Complete system from a single source

The drives SIMODRIVE 611 Universal or MASTERDRIVES MC/VC as well as SINAMICS S120 (TM 41 required) with 1FT6/1FT7/1FK7 servo motors are the ideal supplement for servo motor axes. Incremental and absolute encoders of the SIMODRIVE Sensor range and prefabricated MOTION-CONNECT cables are available to complete the drive solution.

Path control and positioning module FM 357-2

Applications

The FM 357-2 is a path control and positioning module for controlling up to four rotary or linear axes. Stepper and servo motors with ± 10 V interface or PROFIBUS DP interface can be connected. The actual position can be monitored using either RS 422 incremental encoders or SSI absolute encoders.

The FM 357-2 offers the performance power of a CNC for general mechanical equipment manufacture. Integrated into the SIMATIC, the module offers the full level of user friendliness of STEP 7.

FM 357-2 path control and positioning module

It covers just about all areas of automated motion control from simple positioning right up to interpolating path control. It works autonomously and thus offloads the CPU of the automation system.

The module is particularly suitable for motion control of systems that work multi-dimensionally such as metalworking machines, robots, manipulators and bending and folding machines.
It is also ideal for controlling machines with coordinated motion control, e.g. packaging, paper, and printing and textile machinery.

Layout

The basic FM 357-2 can be turned into the versions FM 357-2L, FM 357-2LX or FM 357-2H depending on the system firmware. Variable interfaces allow the connection of different drive systems (also in mixed operation):

- Analog/PROFIBUS DP interface for motion control applications or servo axes with encoder as well as three-phase asynchronous motors
- Stepper motor interface for stepper motor axes

Operating principle

Depending on the axis type used, the stepper or servo motor axes are moved as with the FM 353/FM 354 modules.
On the FM 357-2, however, the axes can also be moved with interpolation.

Functions of the FM 357-2L

- Internal interpolation and coordination of one to four axes: Linear interpolation, circular interpolation and complex interpolation; path control; synchronized axes; table interpolation; intelligent cam disk.
- Monitoring functions: broken cable, zero mark, zero speed, target approach, software limit switch.
- Special functions: length measurement, start/stop via high-speed input, jerk limitation, on-the-fly actual value setting.
- Multi-channel capability: up to 4 channels definable in any combination (on FM 357-2H: 1 channel).

Functions of the FM 357-2LX

As for FM 357-2L, plus the following additional functions:

- High-performance spline interpolation,
- Gantry axis control for gantries,
- Travel to fixed stop (e.g. for clamping tools),
- 3D protection areas.

Functions of the FM 357-2H

As FM 357-2LX, plus the following functions:

- Coordinate transformation for articulated arm robot, scara systems and gantry systems with up to four axes;
- Teach-in function with HT 6 handheld terminal.

Parameterization

The FM 357-2 is programmed in accordance with DIN 66025 using a programming editor integrated into STEP 7.
The FM 357-2 contains powerful high-level-language commands that go beyond the language scope of the standard.
Commissioning is supported by a commissioning wizard offering user-friendly functions:

- Traverse and test axes online from the programming device/PC,
- MDI, JOG, automatic mode,
- Diagnostics and error messages,
- Oscilloscope function.

Technology controllers

A combination of PLC and motion control functionalities

Technology CPUs of the S7-300

Mechanical and plant engineers are increasingly facing the challenge to offer more flexible and more productive machines despite high price pressures. There is a significant increase in cost-effective mechatronic solutions[1)] in new designs.

To facilitate mechatronic solutions, technology functions focusing on motion control are being implemented to a much greater extent in automation systems and drive systems. For this purpose, Siemens offers the SIMATIC S7-300 Technology CPUs for open-loop control and motion control in one CPU.

The technology CPUs combine
- the powerful standard CPUs 315-2 DP, 317-2 DP and
- PLCopen-compatible motion control functions.

The technology CPUs have a compact design with high-speed distributed I/Os (4 digital inputs, 8 digital outputs) and two PROFIBUS DP interfaces:
- Isochronous PROFIBUS DP(DRIVE) interface for the dynamic motion control of several coupled or single axes.
- MPI/DP interface for connecting other SIMATIC components, e.g. PG, OP, S7 controllers and distributed I/O. During operation as a DP interface, extensive networks can be built up.

Applications

In combination with the PLCopen-compatible Motion Control blocks, the technology controllers are particularly suitable for coupled motion sequences of multiple axes.

Along with position-controlled single axis positioning, primarily complex, synchronized motion sequences are possible, e.g. geared synchronous motion, curve synchronization and printmark correction. The synchronous axes can be coupled to a virtual master or a real master.

For path interpolations, powerful PLCopen-compatible functions are available that support various standard kinematics (SCARA, roll picker, articulated arm robot, delta-picker 2D/3D).

The isochronous PROFIBUS permits control of the axes over a digital bus system. The second PROFIBUS DP interface can be used for user-friendly parameter assignment and commissioning of the drives from a PC/programming device.

As a result, the technology controllers can be used for a host of new applications, e.g.:
- Processing/assembly lines
- Throughput machines
- Handling systems
- Cross-arms
- Gantries
- Filling
- Wrapping
- Roll feeds
- Flying shears
- Carton erectors
- Labeling machines
- Cross cutters
- Hydraulic presses
- Palletizers

[1)] Mechatronics: substitution of mechanical components such as gearboxes with a pure software solution "Electronic gearbox"

SIMATIC CPU 317TF-2 DP – Safety and motion control in one controller

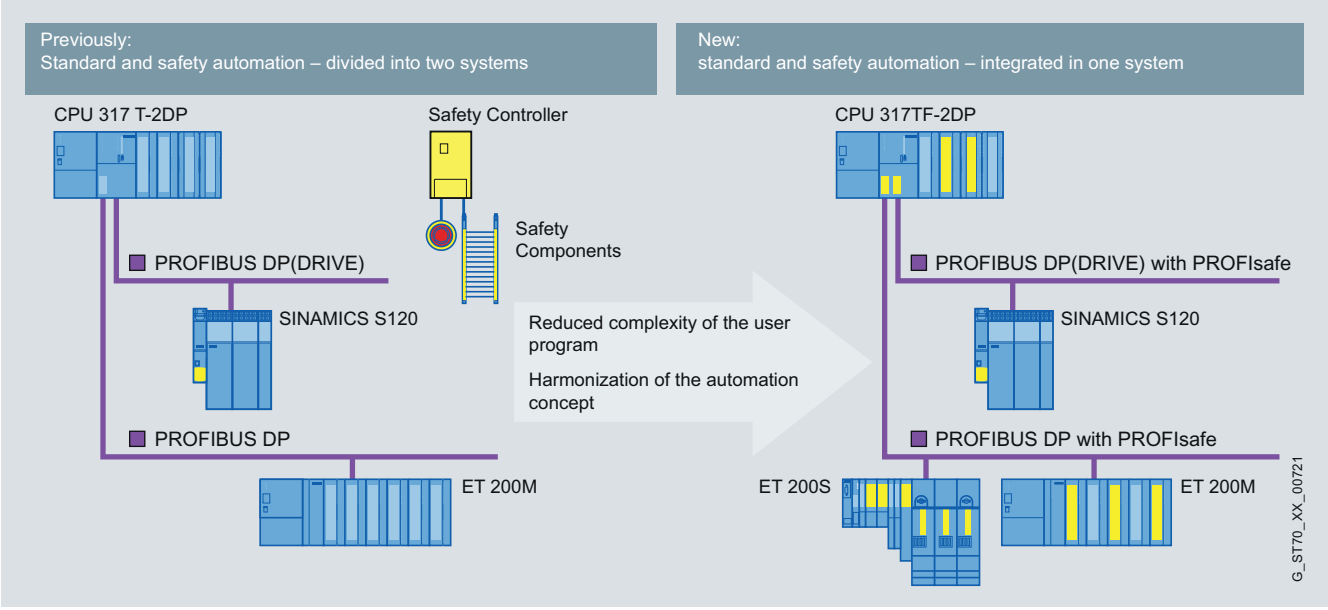
With the new SIMATIC CPU 317TF-2 DP it is now possible to perform motion control, safety and standard tasks in one controller.

You profit from all the advantages of the CPU 317T-2 DP and receive prepared TÜV-certified library modules for fail-safe applications with the optional package STEP 7 Distributed Safety that contains the following main functions: Emergency stop, two-hand control, muting, door monitoring.

For failsafe communication, the controller uses PROFIBUS DP with the PROFIsafe protocol. Fail-safe functions from the drives can be used directly.

The controller complies with the toughest safety requirements, making it easier to adhere to the relevant standards: EN 954-1 up to Cat. 4, IEC 62061 up to SIL 3, and EN ISO 13849-1 up to PL e.

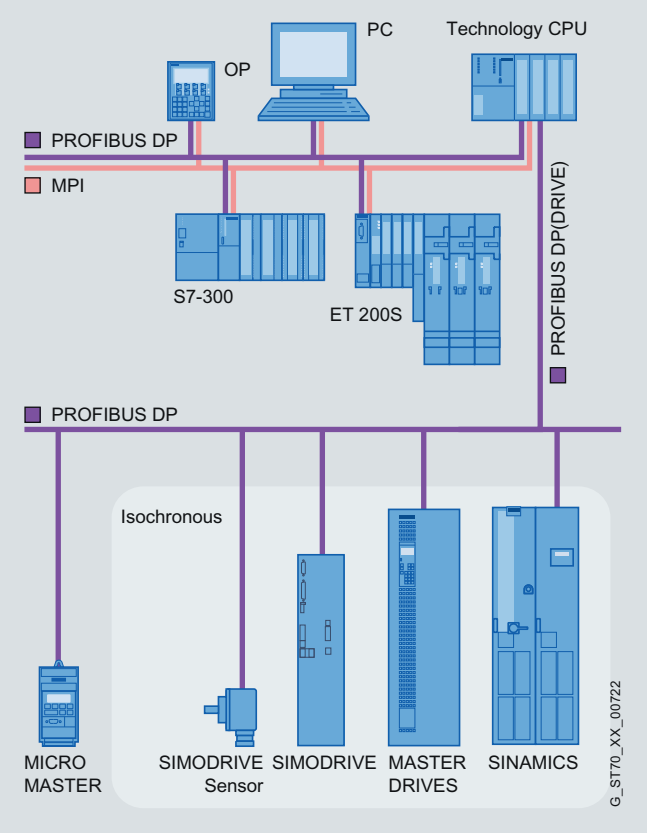
The benefit: You have one uniform engineering for all functions and save considerable time and money on programming, commissioning, and maintenance. It is no longer necessary to use external safety hardware or complicated wiring, so that significantly less space is required in the control cabinet.



Standard and safety automation in one system

Connection of drive components

The technology controllers have an isochronous DP(DRIVE) interface for connecting the drive components. This is optimized for connection of drives over PROFIBUS – all Siemens drives are supported.



Connection of the components to the technology CPU via DP(MPI) and PROFIBUS DP(DRIVE)

Supported components on PROFIBUS DP(DRIVE)	
Speed-controlled axes	MICROMASTER 420/430/440
	COMBIMASTER 411
	SIMOVERT MASTERDRIVES VC
	SINAMICS G 120
Positioning/synchronized axes	SIMODRIVE 611 universal HR
	SIMOVERT MASTERDRIVES MC
	SIMODRIVE POSMO CD/SI/CA
	SINAMICS S 120
Other PROFIBUS nodes	SIMODRIVE sensor isochronous
	ADI 4 analog drive interface module
	IM 174
	ET 200M with IM 153-2 High Feature
	ET 200S with IM 151-1 High Feature

Configuration with STEP 7 and S7-Technology option package

The S7-Technology option package, which is based on STEP 7, is required for parameterizing and programming the technology:

- S7-Technology contains a library with PLCopen-compatible function blocks for programming and configuring the motion control tasks as well as the software components for integration and commissioning of the drive.
- It is used to parameterize the technology objects, e.g. axis, path object, cam disk, output cam, probe. No special Motion Control language is required for this.
- It offers a control panel and a real-time trace in addition to the SIMATIC diagnostic functions. Consequently the time required for commissioning and optimization is reduced.
- S7-Technology stores the user-specific data for the technology objects in data blocks. These can be scanned in the S7 user program.
- S7-Technology uses the STEP 7 languages LAD, FBD and STL as well as all engineering tools, e.g. S7-SCL and S7-GRAPH.
- S7-Technology supports position-controlled and pressure-controlled hydraulic axes.
- For path interpolations, powerful PLCopen-compatible functions are available that support various standard kinematics (SCARA, roll picker, articulated arm robot, delta-picker 2D/3D).

Motion control functions

The technology controllers offer the following motion control functions, among others:

- Virtual master / real master
- Angular synchronization
- Geared synchronous motion
- Camming
- Path interpolation
- Engaging and disengaging
- Insert/eject function
- Offset angle (absolute/relative)
- Print mark correction
- Cams and cam tracks
- Travel to fixed stop
- Position-controlled positioning for electric, virtual and hydraulic axes

PLCopen motion control

Technical data: Technology CPUs

Technology CPU	CPU 315T-2 DP	CPU 317T-2 DP	CPU 317TF-2 DP
Dimensions	160 x 125 x 130	160 x 125 x 130	
Required front connector	1 x 40-pin	1 x 40-pin	
Order no. group:			
- CPU 6ES7	315-6TH.	317-6TK.	317-6TF.
- S7-Technology 6ES7	864-1CC.	864-1CC.	
Memory			
RAM	256 KB	1 MB	1.5 MB
Instructions	84 K	333 K	400 K
Execution times			
Bit operation	0.1 µs	0.05 µs	
Word operation	0.2 µs	0.2 µs	
Fixed-point operation	2 µs	0.2 µs	
Floating-point operation	3 µs	1 µs	
Bit memories/timers/counters			
Bit memories	4 096 bytes	4 096 bytes	
S7 timers/S7 counters	256 / 256	512 / 512	
IEC timers/IEC counters	● *)	● *)	
Address ranges			
I/O address range	2 048 / 2 048 bytes	8 192 / 8 192 bytes	
Process image I/O	2 048 / 2 048 bytes	2 048 / 2 048 bytes	
Digital channels (central)	512	512	
Analog channels (central)	64	64	
DP interfaces			
DP master systems, internal/CP 342-5	● / ●	● / ●	
DP slave	●	●	
Integrated I/Os			
Digital inputs	4 x 24 V DC; e.g. for BERO evaluation		
Digital outputs	8 x 24 V DC; 0.5 A; for high-speed cam switching functions		
Integrated functions	Gear and curve synchronization Travel to fixed stop Print mark correction via probes Position or time-based cam switching Position-controlled positioning		
Fail-safety			●
Maximum quantitative framework for technology			
Axes	8	32	
Cam disks	16	32	
Output cams	16	32	
Probes	8	16	
External encoders	8	16	
Can be used simultaneously	32	64	

*) through SFB, number unlimited or limited by work memory

Application examples

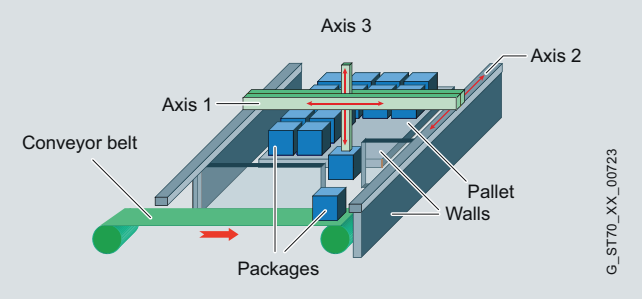
Palletizer with simple interpolating axes based on cam disks

Task

The technological task is based on a palletizer with 3 axes. The central unit is a conveyor unit tasked with arranging 16 crates on a pallet. Axis 1 moves the conveyor unit in direction X, axis 2 is responsible for movement in the direction Y, and axis 3 moves in direction Z. The process of positioning the crates is hampered by the fact that the crates have to be moved past two walls to their target position after transfer from the conveyor belt.

Solution

The task was implemented using a series of ready-to-use functions from the S7-Technology library. Using the traversing function "MC_MovePath", the path axes are moved in accordance with the specified palletizing positions. The function "MC_PathSelect" calculates the path as well as the required 3D interpolation. With the function "MC_GroupInterrupt", the axes are brought to a halt correctly synchronized on the specified path without leaving it. The function "MC_GroupContinue" is used to resume the path from the halted position.



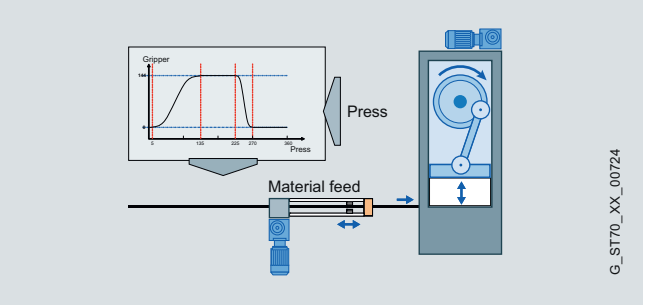
Gripper feeder for a press based on static cam disks

Task

The technological task is based on a press with connected feeder for stock feed. The rotary axis of the press is used as the leading axis for controlling stock feed via a static cam disk. The cam disk is developed and arranged in such a way here as to create a precisely defined sequence between the continuously moving leading axis of the press and the following axis of the stock feed. In addition, a control signal for the gripper of the feeder is generated via an electronic cam on the leading axis of the press.

Solution

The central task of this application for a Technology CPU is the application-oriented development of a suitable cam disk for coupling the feeder with the continuously moving rotary axis of the press. This results in a simple cam disk that is accom panied by further optimized versions.



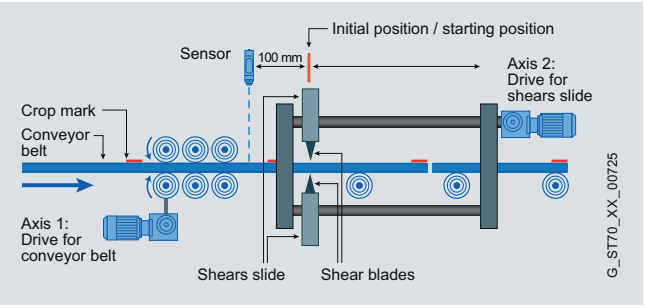
Flying shears with print-mark synchronization based on geared synchronous motion

Task

The technological task is based on flying shears with 2 axes. Axis 1 transports a material web with print marks via a conveyor belt. On detection of the print mark, the speed of the shears connected with axis 2 is to be synchronized with the speed of the shears of axis 1. When both axes are synchronous, the material is to be cut, and axis 2 returned to its initial position.

Solution

The task was implemented by synchronizing the shears slide axis to the material web axis in geared synchronism. Synchronous operation is retained as long as required for the machining process (here, cutting). Following this, the synchronous operation is deactivated and the shears slide axis returns to its initial position. Detection of the next print mark reactivates synchronous operation.



The download files with the documentation and project data are available on the Internet at:
www.siemens.com/t-cpu
in the section "More about SIMATIC Technology"

User-configurable application modules and control systems

Solution for highly flexible and dynamic applications

Demanding mechatronic tasks can be solved using the user-configurable application modules that combine a high degree of flexibility, functionality and performance:

- FM 352-5 for extremely high-speed bit logic operations with S7-300
- FM 458-1 DP for fast and precise calculation and control with S7-400
- T400 technology module for demanding drive controls
- SIMATIC TDC for solutions in the plant sector

Systems and function modules for demanding closed-loop control tasks

High-speed Boolean processor FM 352-5

High-speed Boolean processor FM 352-5

The FM 352-5 application module supports extremely high-speed bit combinations in machines with maximum clock-pulse rates. It is suitable for counting and measuring applications with very short response times, e.g. for quality assurance. Onboard digital I/O (12 DI, 8 DO) and the position encoder input (incremental or SSI) permit extremely short response times. As a result of the specific hardware configuration, a fixed program cycle time of 1 µs is set.

The FM 352-5 can be used centrally in the S7-300, decentralized on PROFIBUS or as a stand-alone controller. The digital inputs/outputs can be freely combined in the user program or switched in accordance with the displacement.

A subset of the S7-300 instruction set is available for programming, e.g. binary logic operations, arithmetic operations, comparisons, counter/timer functions, shift registers, frequency and period measurement (e.g. pulse generators). Programs are created using the standard LAD/FBD editor of STEP 7. The created program can be tested in an S7 CPU before downloading into the module.

The provided configuring software for the FM 352-5 is used for generating the destination code. The destination code is transferred to the FM 352-5 using a memory card or by downloading.

Common features of FM 458-1 DP, T400, SIMATIC TDC

The FM 458-1 DP application modules, T400 and the SIMATIC TDC control system are freely configurable with STEP 7 and the engineering tools CFC and SFC. Configuring requires the function block library of the D7-SYS add-on package.

Comparison of modules and systems

Technology module T400

Integrated into drives

- MASTERDRIVES
- DC master
- In own rack (stand alone)

Application module FM 458-1 DP

High-speed calculation and control

- In S7-400 system
- Rapid I/O access by using expansion modules
- Isochronous mode with onboard PROFIBUS DP

High-performance SIMATIC TDC automation system

Synchronized multicomputing

- Up to 20 CPUs per rack
- Up to 44 racks
- For large plants, iron and steel works, rolling mills, and power transmission

Block library

The wide range of drive-specific functions used in modern machines are implemented with ready-to-use CFC function blocks. These are included in the library of the D7 SYS option package.

D7 SYS contains a number of function blocks that can be combined as required, ranging from simple mathematical or logic operations to complex functions for complete motion control of linear or rotary axes.

A powerful code generator is also included that translates the completed function diagrams into high-speed machine code.

D7-SYS contains the following function block groups:

- Control loop blocks
- Arithmetic blocks
- Input/output blocks
- Communication/operation/signaling blocks
- Conversion blocks
- Logic modules
- Service and diagnostic blocks
- SFC blocks
- Motion control blocks

Configuration and start-up

Control functions are configured easily and efficiently with CFC (Continuous Function Chart). This is performed by selecting the technology function blocks from the D7-SYS function block library and connecting their inputs and outputs. The function block diagrams automatically provide detailed documentation for the created program.

Downloading, commissioning and servicing are implemented by means of the online functions available from STEP 7 and CFC/D7-SYS via the central MPI/DP interface.

Sequential Function Chart (SFC) is used when CFC programs are combined with sequence controls.

Using the FB-GEN options package for special applications, customer-specific function blocks can be programmed in C and integrated smoothly into the application. Runtime licenses are not required for this purpose.

Function blocks for motion control

The following blocks are examples of a wide variety of function blocks from the library.

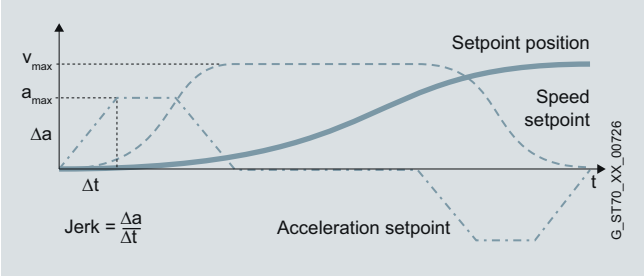
Positioning

In addition to the setpoint for the selected position, the positioning block simultaneously provides the associated feed-forward variables such as speed and acceleration. This provides a high dynamic performance.

The positioning procedure can be optimally adapted to the application requirements. The following are adjustable:

- Maximum speed
- Maximum acceleration
- Maximum jerk

The target position can be reached in the shortest possible time or without overshoots. In addition to absolute positioning, relative positioning is also possible for linked movements.



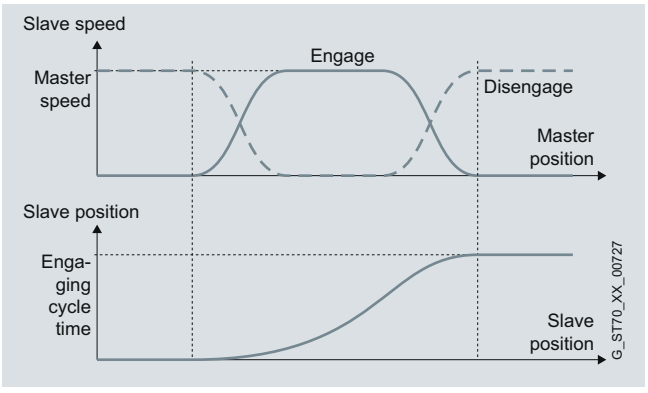
Adjustable parameters for positioning

Engaging/disengaging function

The engaging function drives the axis from standstill by the defined engaging length.

The disengaging function brakes a drive down to standstill, and accelerates it again to the master speed when the disengaging length has been reached.

Engaging and disengaging lengths are adjustable and can be increased on-the-fly. Rounding can also be defined for the movements.



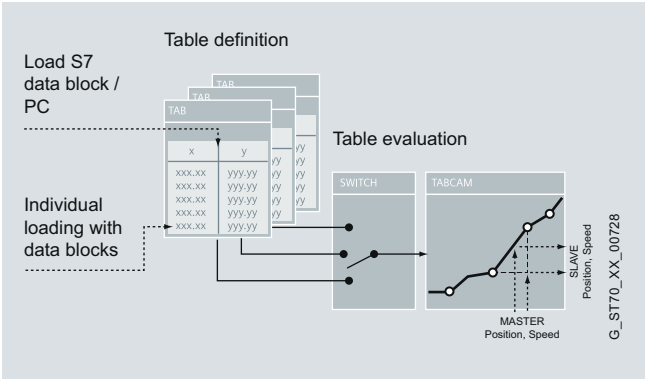
Engaging and disengaging functions

Electronic cam

Cams are saved in the TAB block as tables containing approximately 16 000 to 250 000 interpolation points.

The tables are evaluated by the TABCAM block. Using the table, this determines the slave position to be driven to for a certain master position, as well as the speed. Linear interpolation is carried out between two points.

A multiplexer block can be used to switch between several tables during operation.



Loading and evaluation of tables

Application module FM 458-1 DP

The FM 458-1 DP application module integrates fast, accurate calculation and control into S7-400.

With the function block library, FM 458-1 DP has all the necessary mechatronic functions for solving open-loop control, closed-loop control, motion control and technological tasks.

Equidistant sampling times **of 100 µs and more** support dynamic control tasks, e.g. for increasing accuracy or speeding up the machine cycle.

With firmware version V2, the FM 458-1 DP offers even more performance at the same price.

Technological blocks created by users themselves can be protected by a dongle.

Possible application areas include the speed-synchronized and position-synchronized operation of linear and rotary axes, engaging and disengaging of other axes, winders and hydraulic controls.

Communication

Communication with peers takes place over the PROFIBUS DP interface on the FM 458-1 DP. This offers the following characteristics:

- Constant bus cycle time, i.e. the PROFIBUS DP cycle is always precisely the same length.
- Isochronous, i.e. the CPU, I/O and user program are synchronized with the PROFIBUS cycle.
- Slave-to-slave communication, i.e. the configured slaves can exchange data with each other directly without the need for any additional configuring work on the FM 458-1 DP.
- Routing capability, i.e. all nodes are accessed over one interface, e.g. MPI or PROFIBUS DP and optionally also Industrial Ethernet.

Approx. 100 drives of the SIMOVERT Masterdrives series or SIMOREG series can be connected per ring over the high-speed, fiber-optic SIMOLINK connection.

Benefits

- High processing speed, computing performance, positioning accuracy and large number of axes
- More advanced closed-loop control at higher clock rates (100 µs)
- Motion control with high dynamic response
- Universally implementable for all technology applications used in mechanical and plant engineering
- Extensive function block library
- Highest possible flexibility for individual applications
- Freely configurable graphically with the SIMATIC tools STEP 7 and CFC, optionally SFC as well as C programs

Computing and control with the FM 458

Task	Features
Counting / Measuring	Suitable for a wide range of different counting and measuring tasks with incremental or absolute value encoders up to a maximum of 2.5 MHz.
Cam control	16 digital outputs as cam tracks (displacement or time cams). Each track can be individually adapted to the task with a derivative action or overrun. Dynamic derivative action, dynamic hysteresis
Closed-loop control	Controller structures/types are freely programmable, e.g. fixed value control, follow-on control, cascading control, ratio and mixer controls, continuous and override control, pressure, level and temperature control, hydraulic control, drive control
Motion Control	Open/closed-loop controlled positioning of individual axes as well as multi-axis applications over PROFIBUS DP or SIMOLINK

Scalable hardware for wide range of applications

FM 458-1 DP is of a modular design and comprises a basic module and two different expansion modules that can be combined. This permits that only the components are used that are actually required in the respective application. For each S7-400, several FM 458-1 DP combinations can be integrated. The maximum number is limited solely by the output of the power supply used.

FM 458-1 DP basic module with two expansion modules

FM 458 module range		
FM 458-1 DP basic module	**EXM 438-1 I/O module**	**EXM 448 communication modules**
64-bit floating-point RISC processor for extremely high computing performance ■ Constant bus cycle times from 100 µs ■ Fast setpoint calculation, e.g. for drives, electrical shafts with flying master and virtual shafts ■ Fast, strictly cyclic coordination of non-linear drive movements ■ 8 digital inputs with interrupt capability	Expansion module for very fast, synchronizable speed and absolute value encoding as well as digital and analog inputs and outputs.	Expansion modules for high-speed communication: ■ EXM 448: - PROFIBUS DP or SIMOLINK - Spare slot for a MASTERDRIVES option module ■ EXM 448-2: - Up to 2 SIMOLINK interfaces with complete functionality (master, slave, dispatcher, etc.) - For coupling several FM 458-1 DP application modules with synchronized scanning times

Connection of drives

Replaceable serial and analog interfaces support the connection of many different axis types:

- Integrated, isochronous PROFIBUS DP interface with constant bus cycle time, ideal for distributed motion control applications
- Extremely fast SIMOLINK fiber-optic ring, e.g. for connecting SIMOVERT MASTERDRIVES frequency converters
- Analog interfaces for connecting drives without PROFIBUS or SIMOLINK interface

Implementation of the FM 458-1 DP starts typically with applications from 6 axes upwards. For multi-axis applications, up to 127 drives are specified over PROFIBUS DP and up to 200 slaves over SIMOLINK. Consequently, in many cases, a single FM 458-1 DP is sufficient.

Connection through serial interfaces

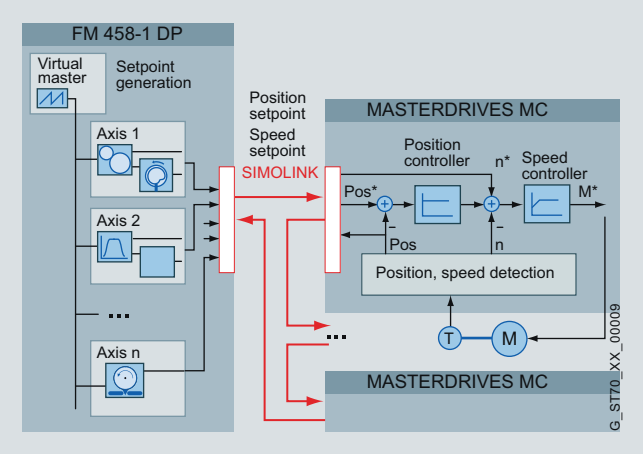
Drives are connected to FM 458-1 DP over a digital bus system. Data transfer is performed either by the isochronous PROFIBUS or the extremely high-speed SIMOLINK fiber-optic ring (with MASTERDRIVES).

In MASTERDRIVES MC, the position control with position sensing is used to determine a speed setpoint.

FM 458-1 DP also provides a speed precontrol value that can be used to achieve an enhanced dynamic response and stability.

The standardized DSC interface can be used in combination with SIMODRIVE and SINAMICS. Using SINAMICS configurations, 60 drives can be calculated in 4 ms.

A significant advantage in applications requiring high production speed and accuracy, 12 SINAMICS S120 can be operated with a position control cycle time of 1 ms.

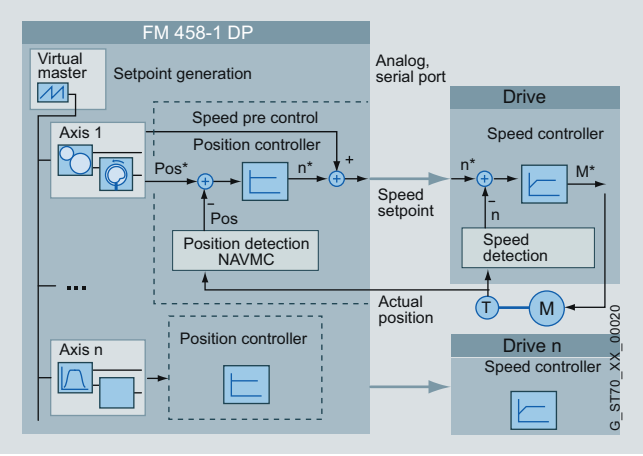


Control structure of an FM 458-1 DP axis control for MASTERDRIVES MC

Connection through analog interfaces

Drives without a SIMOLINK or PROFIBUS DP connection can be connected through analog interfaces. In this case, in addition to generating setpoints, FM 458-1 DP also performs the function of the position control for the drives.

Speed setpoints are maintained for the drives. Actual values for speed and position are acquired by a block on the FM 458-1 DP.



Control structure of an FM 458-1 DP axis control for other drives

Technology module T400

The graphically configurable T400 technology module allows drives to be expanded cost-effectively with sophisticated closed-loop control, open-loop control and positioning functions. The powerful 32-bit RISC processor supports constant bus cycle times of 100 µs and above to increase the precision of the movements or to speed up the machine cycle.

SRT400 is a compact rack – comparable to the electronic box of SIMOVERT MASTERDRIVES – and is used to control two to four drives.

Either two T400 technology modules or one T400 and a MASTERDRIVES communication module can be plugged into the SRT400. This means, for example, that low-cost functional expansion and modernization of existing plants is possible.

T400 features integrated digital and analog I/O, serial interfaces and supports the connection of position encoders (incremental, absolute).

Use		
In the electronic box of AC converters SIMOVERT MASTERDRIVES 6SE70	In the electronics box of SIMOREG DC Master 6RA70 DC devices	Stand-alone in the SRT400 technology box for other drives
		

Configuring the T400

Depending on the application of the T400, there are several possibilities for configuring:

Configuration			
Using the T400	**User-configurable**	**Standard configuration on the module**	**Standard configuration in source code**
User-configurable	STEP 7, CFC and D7-SYS required		
Axial winder		The associated, executable code is already loaded onto the T400 and the module is ready to use. [1]	The associated source code is available on CD ROM. [2]
Angular synchronization			
Shear control			

Benefits

- High processing speed, computing performance, positioning accuracy and large number of axes
- More advanced closed-loop control at higher clock rates (100 µs)
- Motion control with high dynamic response
- Universally implementable for all technology applications used in mechanical and plant engineering
- Extensive function block library
- Highest possible flexibility for individual applications
- Freely configurable graphically with the SIMATIC tools STEP 7 and CFC, optionally SFC as well as C programs

[1] Control is performed in a higher-level automation system that is connected with the T400 over PROFIBUS.

It is only necessary to set a few parameters application-specifically during commissioning. Various aids are available for this, ranging from a simple operator panel up to the PC software (Drive ES); STEP 7 and CFC are not required for this purpose.

When parameter assignment has been completed, the settings can be duplicated on other systems.

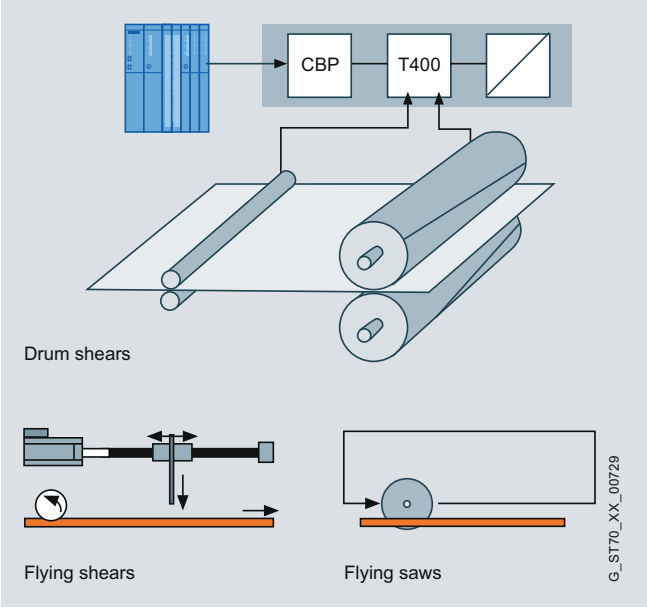
[2] Extensive application-specific modifications are possible with STEP 7 and CFC.

Shear control

In many production plants, it is necessary to cut a continuously moving material into separate parts. Elements must often be cut to a precisely specified length. In the case of printed materials, the cuts must often be located with reference to marks on the material. Depending on the material characteristics and cutting method, drum shears (rotating arrangement of shears), flying shears and flying saws are used.

Typical applications include:
- Panel cuts in the metalworking and paper industries
- Creation of smooth cut ends at the start and end of the conveyor
- Cutting pipes and sections in the metalworking and plastics industries
- Flying saws in pressboard production
- Mark-synchronized hole punches

Accurate cutting of a fast-moving material demands precise coordination of the cutting tool with the motion of the material. A control system with a highly dynamic response is required for controlling the motion sequences, especially when the quality of the cut is required to be maintained at different material speeds and for different shapes of cut.



Shear control

Operating modes and functions

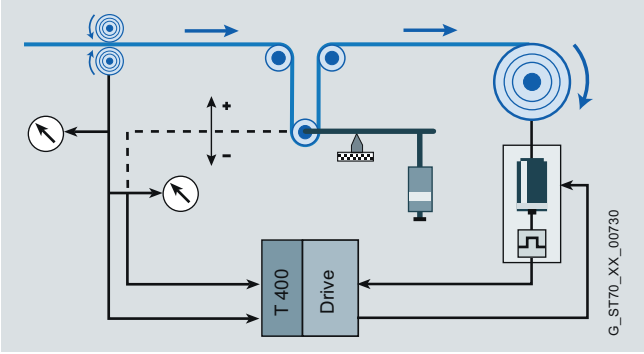
The following operating modes and functions are available:
- Continuous cutting
- Cut program (number of cuts)
- Test cut (one panel)
- Single cut (separating cut)
- Final cut
- Homing
- Jog mode
- Approach starting position
- Approach blade replacement position
- Automatic adaptation of the motion sequences to the current material speed
- The type of cut can be changed from one cut to the next
- Synchronization with marks on the material
- Selection of the ideal velocity profile for accuracy of the cut and for motor design
- Velocity overshoot during cutting
- Characteristic for individual specification of the velocity during the cutting procedure
- Format control for optimizing the cutting accuracy
- Application of cutting torques
- Compensation for friction and position-dependent moments of inertia
- Adaptation of controller amplification in accordance with the dynamic response
- Fault monitoring

Axial winder

Winding processes are one of the most frequently used applications of electrical drive systems in mechanical engineering. High-performance, software-based winders can be implemented with electrical closed-loop control technology. Until now, generating programs has involved a considerable amount of work. Ready-to-use standard configurations have minimized this overhead.

High-performance, high-precision winders and unwinders can be implemented, for example, with SPW420 for the following applications:

- Film take-off units
- Textile machines
- Printing machines
- Coating systems
- Paper finishing machines
- Winders in wire-drawing machines
- Coilers in metalworking



Axial winder

Functions

Winding and measuring techniques must be used in accordance with the type of material used; the following functions are available:

- Indirect tension control
- Direct tension control
  - Speed controller, override (controller acts on the motor torque)
  - Speed correction procedure (tension controller acts on the speed setpoint)
  - Constant speed control
- Adaptation of tension controller and speed controller amplification in accordance with the diameter to provide low-vibration, more stable and faster closed-loop control over the complete winding process
- Winding tightness control can be parameterized diam eter-related over a polygon function to improve the winding quality
- Precontrol is included:
  - Speed-dependent friction compensation can be parameterized using a polygon function
  - Acceleration precontrol depending on the diameter as well as the width, gear stage and material thickness
  - Tension precontrol depending on the diameter and tension setpoint for minimizing response times
- Diameter calculation with control function, alternatively with or without velocity signals "Set diameter" and "Maintain diameter"
- Path length calculation
- Switching between two gear stages on command
- For the first time, software function blocks that can be wired up as required for application-specific requirements
- Largely freely-selectable wiring of the process data to functions of the parameter system (Bico system)

Operating modes

The following operating modes are available:

- Suitable for winders with/without roller changeover on the fly with revolving mechanism
- On-site operation, e.g. jog, positioning and creep modes
- Stopping without overshoot with a braking characteristic for quick stop

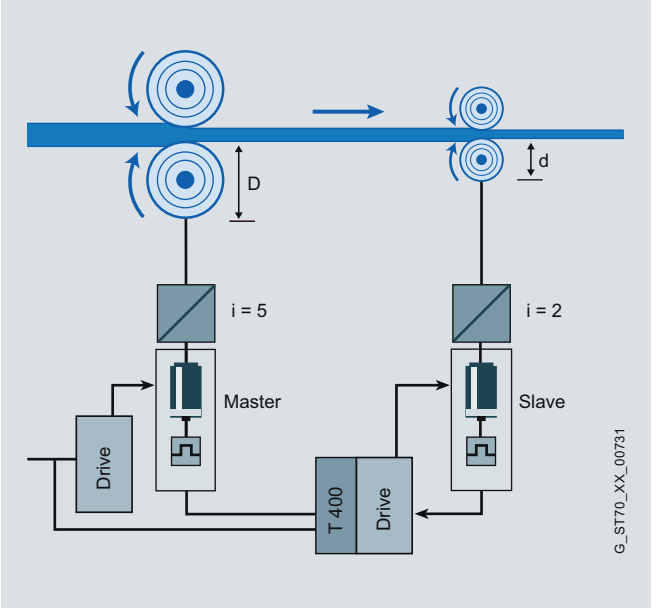
The following can be connected for measured value acquisition:

- Tension measuring device or dancer roll
- Two pulse encoders for measuring the motor speed and path velocity

Angular synchronization

Angular synchronization is one of the most demanding positioning tasks in multi-axis applications. Applications include, for example:

- Substitutes for mechanical shafts, e.g. in gantry drive units, insertion and removal machines at ovens or weaving looms.
- Substitutes for gear units with fixed or variable transmission ratios, e.g. change wheel gears implemented at the transfer point of conveyor belts or at the point of handover from one machine section to another, such as on packaging machines, book spine gluing machines.
- Operation in perfect synchronism, also applied when two machine parts interlock, e.g. for roughing the surface of fabrics. Can also be used for printing or folding the edges of bags, round materials, etc.



Angular synchronous control

Functions

The ready-to-use standard configuration of angular synchronous control offers the following functions:

- Angular synchronization with a transformation ratio that can be set within a wide range
- Offset angle adjustment between the drives in accordance with course and fine pulse markers for angle sensing (synchronization)
- Synchronization signals can originate from proximity switches (e.g. BERO) or from pulse encoders (zero pulse)
- Angle setting can be altered by means of a setpoint
- Rollback lock
- Overspeed and blocking protection
- Jog mode:
  For each direction of rotation, different offset angles can be specified (automatic changeover on change of rotation). This is required for synchronization when the switching positions of the fine pulse mark differ for clockwise and anticlockwise rotation of the drive (or the machine part to which it should be synchronized) and must be compensated. Another example would be a crane path in which the fine pulse mark is two-dimensional.
- Adaptation of the angular controller to the transmission ratio
- The speed setpoint can also be set using a pulse encoder, for example, if no speed setpoint is provided via a terminal or interface.

Control system SIMATIC TDC

SIMATIC TDC – Unlimited open-loop and closed-loop control

SIMATIC TDC is a multi-processor automation system that is particularly used in large plants for process, energy and drive engineering.

SIMATIC TDC also solves complex drive, control and technology tasks with maximum quantity frameworks and minimum cycle times on a single platform, and is therefore an ideal supplement to SIMATIC S7 in the top performance range.
SIMATIC TDC is the technology and drive automation system integrated into the SIMATIC, with which the configuration and programming is performed using the proven SIMATIC Tools – and thus part of Totally Integrated Automation.

SIMATIC TDC is consistent with standards, making it easy to work with, e.g. in communication and HMI:
- PROFIBUS DP and Industrial Ethernet
- SIMATIC WinCC and SIMATIC Operator Panels

SIMATIC TDC consists of one or more module racks where the required modules are inserted. The multi-processor operation enables the performance to be expanded almost without limit.

Highlights

- Modular system design with scalable hardware
- Sampling intervals as low as 100 µs for dynamic control tasks
- Maximum performance thanks to the 64-bit architecture of the central processing unit
- Synchronizable multi-processing with up to 20 CPUs per rack
- Extremely high communications performance between the CPUs due to the VME bus system
- Synchronous coupling of up to 44 racks
- Graphical configuration using the STEP 7 engineering tools: continuous function chart (CFC) and sequential function chart (SFC)
- Proprietary blocks in C

Benefits

- Increased productivity and competitiveness thanks to maximum computing power
- Reduction in purchasing costs thanks to reduced component diversity and simpler stocking of spare parts
- Reduction in engineering costs thanks to the use of commonly used standard tools and the reuse of existing software
- Use of worldwide standards

SIMATIC TDC – Unlimited open-loop and closed-loop control

Automation solutions for large-scale plants

Potential users of SIMATIC TDC are not only the plant engineers, but also engineering offices which develop automation solutions for the plant operators.

SIMATIC TDC can be used, for example,
- for the closed-loop control of drives (torque, rpm, position, angle/angular difference, speed), in particular if several drives are to be coordinated or complex relationships exist between drives
- for regulating several/different physical variables (e.g. tension, pressure)
- for calculating a number of process/plant variables (e.g. temperature)

SIMATIC TDC facilitates short computing cycles (100 µs), has functional reserves and offers outstanding flexibility.

Application examples

Application examples of SIMATIC TDC include:
- Metal production, metal processing and metal machining: Wire-drawing plants, stretcher levelers, bending and straightening machines, presses, circular arc type plants, rolling mills, upsetting devices, shearing and winding machines.
- High-voltage DC transmission stations for transmitting power over large distances, e.g. also marine cables.
- Reactive power compensation systems for stabilizing the power transmission, e.g. capacitor units, capacitor banks.

Modular system

SIMATIC TDC is a modular multi-processor system comprising one or more racks. The racks are equipped with CPUs, I/O modules and communication modules.

Components of TDC		
Rack UR5213		The electromagnetically shielded 19" rack UR5213 allows scalable expansion of hardware with large reserves of power. It is suitable for wall and cubicle mounting and has an integral power supply with active cooling and internal monitoring. The performance can be increased by plugging in up to 20 CPUs or by connecting up to 44 racks together.
Central processing unit CPU551		The central processing unit CPU551 is suitable for open and closed-loop control tasks with very high computing requirements. The CPU ensures strictly cyclic processing with adjustable scanning intervals.
I/O module SM500		The SM500 I/O module offers numerous options for connecting the digital and analog I/O. In addition, incremental position encoders and absolute encoders can be connected.
Communication modules CP50M1, CP51M1		The communications modules CP50M1 and CP51M1 provide high-performance communication for ■ Commissioning ■ Process control ■ Operator control and monitoring They handle the powerful protocols ■ MPI ■ PROFIBUS DP ■ Fast Ethernet with TCP/IP and/or UDP
Global Data Memory GDM		By means of a Global Data Memory (GDM), a number of racks with CP52x0 can communicate with one another for an almost unlimited expansion of the computing power. Up to 44 racks can be networked by means of fiber optic cables and a shared memory. Apart from the communication between several racks, the GDM also allows synchronization (scanning time, clock time) and alarm functions. The update time is set at < 1 ms.
Frame connection module CP53M0		The CP53M0 frame connection module provides the following functionality: ■ Coupling of a SIMATIC TDC system to a SIMADYN D system ■ Coupling of a SIMATIC TDC systems to two additional SIMATIC TDC racks ■ Communications buffer for the exchange of data between the CPU modules and rack

SIMATIC Technology

Notes

Comparison tables

Cam control

Feature	FM 352	FM 452	FM 352-5	CPU 315T	CPU 317T	T400	FM 458 EXM 438
Order No. group	6ES7 352-1A.	6ES7 452-1A.	6ES7 352-5A.	6ES7 315-6TG.	6ES7 317-6TJ.	6DD1 606-	6DD1 607-
Characteristics							
Number of encoder channels	1	1	1	8	32	1	EXM 438: 2 x 12; PROFIBUS DP: 127 SIMOLINK: 2 x 200
Linear/ rotary axis	●	●	▲	●	●	●	●
Cam functions							
Number of cam track	32	32	▲	8	16	▼	▼
Position-based / time-based cams	128	128	▲	8	16	▼	▼
Brake cams	1	1				▼	▼
Counter cams	3	3	▲			▼	▼
Dyn. dead time compensation	●	●	▲	●	●	▼	▼
Connection system / onboard I/O							
Incremental encoder with 5 V difference ignal	●	●	●	Through IM174, ADI4	Through IM174, ADI4	●	8 (incl. 15 V encoder)
Incremental encoder with 15/24 V signal	●	●	Through 3 DI	ADI4	ADI4	●	8 (incl. 5 V encoder)
SSI encoder	●	●	●	Through IM174, ADI4	Through IM174, ADI4	●	4
Encoder monitoring	●	●	●	●	●	●	●
Digital inputs (24 V)	4	11	12	4	4	8 + 4 bidirectional	16 (200 µs); 8 (20 µs)
Functions Digital inputs	1 enable input	8 enable inputs	User-program-mable	Latch	Latch	▼	▼
	Brake enable, length measure-ment, set actual value on the fly, reference point switch						
Digital outputs (24 V)	13	16	8 (current sourc-ing/sinking)	8	8	2 + 4 bidirectional	8
System environment							
Centralized application	S7-300	S7-400	S7-300, stand-alone	S7-300	S7-300	SRT 400	S7-400
Distributed application	ET 200M		ET 200M			MASTERDRIVES, DC master	
PC-based Control	●		●				
Configuring software	Configuring package includ-ed in scope of supply	Configuring package includ-ed in scope of supply	Configuring package includ-ed in scope of supply	S7-Technology [1)]	S7-Technology [1)]	D7-SYS[1)]	D7-SYS[1)]
Programming software STEP7 V11	P	P					
Module replacement without PG/PC	●	●	●	●	●		●

● available ▲ programmable ▼ configurable P Professional B Basic [1)] order separately

Counting/measuring

Feature	CPU 1211C CPU 1212C CPU 1214C	CPU 31xC	1 COUNT 5/24 V	FM 352-5	FM 350-1	FM 350-2	FM 450	T400	FM 458 EXM 438
Order no. group:	6ES7 21.	6ES7 31.	6ES7 138-4DE./-4DA.	6ES7 352-5.	6ES7 350-1A.	6ES7 350-2A.	6ES7 450-1A.	6DD1 606-	6DD1 607-
Characteristics									
Number of channels (CC = counter chan., DC = dosing chan.)	CPUs 1211C: 3 1212C: 4 1214C: 6	CPUs 312C: 2; 313C: 3; 314C: 4	1	1-12 depending on encoder type and application	1	8 CC or 2 DC or 4 CC and 1 DC	2	2	8 per EXM
Counter frequency in kHz, max.	100, 200 [1]	CPUs 312C: 10; 313C: 30; 314C: 60	24 V: 100; 5 V: 650	5 V: 1 000; 24 V: 200	5 V: 500; 24 V: 200	Incremental encoders: 10; initiators/ direction encoder: 20	5 V: 500; 24 V: 200	5 V: 1 500; 15 V: 400	5 V: 2 500; 15 V: 1 000
Maximum counting width	64 bits	32 bits	32 bits	32 bits	32 bits	32 bits	32 bits	32 bits	32 bits
Counting direction	Up/ down	Up/ down	Up/ down	Up/ down	Up/ down	Up/ down	Up/ down	Up/ down	Up/ down
4 times evaluation	●	●	●	●	●	●	●	●	●
Encoder power supply	24 V		24 V	24 V, 5 V	24 V, 5 V	For NAMUR encoder	24 V, 5 V		
Encoder monitoring			With 1 COUNT 5 V	With 5 V incr. encoder	With 5 V incr. encoder	For NAMUR encoder	With 5 V incr. encoder	●	●
Counter functions									
One-off/ continuous counting	▲	●	●	▲	●	●	●	▼	▼
Periodic counting		●	●	▲	●	●	●	▼	▼
Frequency measurement		●	●	▲	●	●		▼	▼
Speed measurement			●	▲	●	●		▼	▼
Period duration measurement			●	▲	●	●		▼	▼
Length measurement	▲	Through gate function	Through gate/ latch function	▲	Through gate/ latch function	Through gate function	Through gate/ latch function	▼	▼
Dosing			1-stage	▲	1-stage	4-stage	1-stage	▼	▼
HW gate		Start/stop	Start/stop	Start/stop	Start/stop	Start/stop	Start/stop		
Software gate		Start/stop	Start/stop	Start/stop	Start/stop	Start/stop	Start/stop	▼	▼
Direction-dependent comparators per counter channel		1	2	▲	2	1	2	▼	▼
Latch function		●	●	▲	●		●	Per HW interrupt	Per HW interrupt
Synchronization with zero signal			●	▲	●	●	●	▼	▼
Process interrupt	●	●		▲	●	●	●	▼	▼

● available ▲ programmable ▼ configurable P Professional B Basic [1] with High-Speed Digital Signal Board

Feature	CPU 1211C CPU 1212C CPU 1214C	CPU 31xC	1 COUNT 5/24 V	FM 352-5	FM 350-1	FM 350-2	FM 450	T400	FM 458 EXM 438
Connectable encoders/onboard I/O									
Incremental encoder with 5 V difference signal	with Signal Board		1 COUNT 5 V	●	●		●	●	●
Incremental encoder with 15/24 V signal	●	●	1 COUNT 24 V	●	●	●	●	15 V HTL	15 V HTL
Direction encoder 24 V	●	●	1 COUNT 24 V	●	●	●	●		
Initiators 24 V	●	●	1 COUNT 24 V	●	●	●	●		
NAMUR sensor						●			
SSI encoder				●				●	●
DI for HW gate per counter input	▲	●	1 DI vacant, configurable function	▲	2	1	2		
Set DI for counter value per counter input	▲	●	1 DI vacant, configurable function	▲	1	1	1	▼ Up to 6	▼ Up to 8
DOs per counter channel		1 per comparator	1 (2.0 A) with 24 V; 2 (2.0 A) with 5 V	Up to 8 (0.5 A)	2 (0.5 A)	1 per counter channel, 4 per dosing channel	2 (0.5 A)	▼	▼
Connectors	Standard front connector	Standard front connector (40-pole)	TM-E	Standard front connector (40-pole)	Standard front connector (20-pole)	Standard front connector (40-pole)	Standard front connector	Standard	Standard
System environment									
Centralized application	S7-1200	S7-300 with CPU 31xC		S7-300	S7-300	S7-300	S7-300	SRT 400	S7-400
Distributed application	PN basic services	CPU 314C	ET 200S on S7 master and PROFIBUS standard master	ET 200M on S7 master and PROFIBUS standard master	ET 200M on S7 master	ET 200M on S7 master		MASTER-DRIVES, DC master	
PC-based Control			●	●	●	●			
Parameterization software	Component of STEP 7 Basic	Component of STEP 7	Component of STEP 7	Configuring package included in scope of supply	Configuring package included in scope of supply	Configuring package included in scope of supply	Configuring package included in scope of supply	D7-SYS[1)]	D7-SYS[1)]
Programming software STEP7 V11	B/P	P	B/P		P	P	P		
Types of access	Through user program	Through SFB	Through user data interface	Through FB or user data interface	Through FB or user data interface	Through FB or user data interface	Through FB or user data interface	Through FB	Through FB
Supports isochronous mode			●		●			With SRT 400 and CBP 2 (slave only)	●
Hot swapping in RUN mode			●		Only with active backplane bus	Only with active backplane bus	●		
Module replacement without PG/PC	●	●	●	●	●	●	●		●

● available ▲ programmable ▼ configurable P Professional B Basic [1)] order separately

Closed-loop control

Feature	CPU 1211C CPU 1212C CPU 1214C	PID Control in STEP 7, CFC	PID Temp. Control	CPU 313C CPU 314C	Standard PID Control	Modular PID Control	FM 355C FM 355S	FM 355-2C FM 355-2S	FM 455C FM 455S	T400	FM 458 EXM 438
Order no. group:	6ES7 21.	6ES7 810-4.	6ES7 810-4.	6ES7 31.	6ES7830-2. [1] 6ES7860-2. [2]	6ES7830-1. [1] 6ES7860-1. [2]	6ES7 355-.	6ES7 355-2.	6ES7 455-.	6DD1 606-	6DD1 607-
Characteristics											
Number of channels	16	Determined by CPU and I/O			Determined by CPU and I/O		4	4	16	Limited by memory and connected I/O	
Backup capability							●	●	●		
Self-optimization of the controller during start-up with PG/PC											
Temp. processes and similar	●		●		● [1] [3]	● [1] [3]	With configuration package (CP)				
Gen. processes	●						With CP		With CP		
Self-optimization of the controller during normal operation											
Temp. processes and similar	●	With PID Self-Tuner [3]	●	With PID Self-Tuner [3]	With PID Self-Tuner [3]	With PID Self-Tuner [3]	With PID Self-Tuner [3]	●	With PID Self-Tuner [3]		
Gen. processes	●										
Elementary closed-loop control functions											
PID algorithm	●	●	●	●	●	●	●	●	●	▼	
Output of continuous-action PID controller	●	●	●	●	●	●	FM 355C	FM 355-2C	FM 455C		
Step controller output	●	●	●	●	●	●	FM 355S	FM 355-2S	FM 455S		
PWM output	●	●	●	●	●	●					
Additional functions											
Setpoint generator					●	●	●	●	●	▼	
Non-linear static characteristic						●	●	●	●		
Split range						●	●	●	●		
Position feedback					●	●	FM 355S	FM 355-2S	FM 455S		
Setpoint branch											
Delimiter	●				●	●	●	●	●	▼	
Limiting of rate of change					●	●					
Actual-value branch											
Format conversion	●	●	●	●	●	●				▼	
Scaling	●	●	●	●	●	●	●	●	●		
Smoothing					●	●	●	●	●		
Root function					●		●	●	●		
Monitoring of rate of change					●	●					
Limit monitor					●	●	●	●	●		
Connectable encoders											
Thermocouple elements	● [5]						Type B, J, K, R, S	Type B, E, J, K, R, S	Type B, J, K, R, S		
Resistance thermometers	● [5]			Pt100			Pt100	Pt100	Pt100		
Voltage	●			+/- 10 V			0 ... 10 V	0 ... 10 V	0 ... 10 V	+/- 10 V	+/- 10 V
Current	● [6]			0/4 ... 20 A			0 ... 20 mA, 4 ... 20 mA				
Integrated I/Os											
Analog inputs	2			4 [4]			1 per control-ler chan-nel	1 per controller channel	1 per control-ler chan-nel	2	5 per EXM 438

[1] Parameterization software [2] Runtime software (FBs) [3] Order separately [4] Depending on CPU type [5] With Signal Module [6] With Signal Board or Signal Module

Feature	CPU 1211C CPU 1212C CPU 1214C	PID Control in STEP 7, CFC	PID Temp. Control	CPU 313C CPU 314C	Standard PID Control	Modular PID Control	FM 355C FM 355S	FM 355-2C FM 355-2S	FM 455C FM 455S	T400	FM 458 EXM 438
Digital inputs	● [4]			16/24 [4]			2 per controller channel	2 per controller channel	1 per controller channel	8 + 4 bidirectional	16 per EXM 438
Analog outputs				2 [4]			1 per controller channel (FM 355C only)	1 per controller channel (FM 355-2C only)	1 per controller channel (FM 455C only)	2	8 per EXM 438
Digital outputs	● [4]			16 [4]			2 per controller channel (FM 355S only)	2 per controller channel (FM 355-2S only)	2 per controller channel (FM 455S only)	2 + 4 bidirectional	8 per EXM 438
Connection system	Standard front conn.			Standard front conn.			Standard front connector			Terminals	Interface module
Manipulated variable branch											
Manual/auto sw.	●	●	●	●	●	●	●	●	●	▼	
Delimiter	●	●	●	●	●	●	●	●	●		
Limitation of the rate of change					●	●					
Closed-loop control structures											
Fixed setp. control	●	●	●	●	●	●	●	●	●	▼	
Follow-up control	▲				●	▲	●	●	●		
Cascade control		▲			●	●	●	●	●		
Ratio control	▲				●	●	●	●	●		
Blending control	▲				▲	●	●	●	●		
3-comp. control		▲			▲	▲	●	●	●		
System environment											
Central application	S7-1200	S7-300, S7-400, WinAC	S7-300, S7-400, WinAC	S7-300 (CPU 313C/ 314C)	S7-300, S7-400, WinAC	S7-300 (CPU 313 and higher), S7-400, WinAC	S7-300	S7-300	S7-400	With SRT 400	S7-400
Distr. application	PN Basic Services						ET 200M on S7 master	ET 200M on S7 master		MASTER-DRIVES, DC master	
PC-based Control		●	●	●	●	●	●	●			
Parameterization software	Component of STEP 7 Basic	Component of STEP 7	Component of STEP 7	Component of STEP 7	● [3]	● [3]	Configuring package included in scope of supply			D7-SYS[3]	
Programming software STEP7 V11	B/P	P	P	P							
Authorization					For param. SW					For D7-SYS	
Runtime license for FB/FC/C library					Required per CPU						
Types of access	Through user program	Through FB	Through FB	Through SFB	Through FB/FC	Through FB/FC	Through FB	Through FB	Through FB	Through FB	Through FB
Hot swapping of modules							Only with active backplane bus				
Module replacement without PG/PC	●	Through memory card	Through memory card	Through memory card	Through memory card	Through memory card	●	●	●		Through memory card

● available ▲ programmable ▼ configurable P Professional B Basic

Positioning / motion control

Feature	CPU 1211C CPU 1212C CPU 1214C	CPU 314C	SM 338	Easy Motion Control	1 SSI	1 STEP	1 POS U	
Order no. group:	6ES7 21.	6ES7 314-6.	6ES7 338-4BC.	6ES7 864-0A.	6ES7 138-4DB.	6ES7 138-4DC.	6ES7 138-4DL.	
Characteristics								
Number of axes/channels	2	1	3	Dependent on the CPU	1	1	1	
Linear axis	●	●		●		●	●	
Rotary axis	●	●		●		●	●	
Position measuring system (refer also to **www.siemens.com/encodertypes**)								
Incremental encoder with 5 V difference signal	● [1)]			Through module			●	
Incremental encoder with 24 V signal	●	●		Through module			●	
SSI encoder			●	Through module	●		●	
PROFIBUS DP absolute encoder				●				
Encoder supply	24 V		24 V		24 V		24 V	
Drive interface								
Digital outputs for speed and direction	▼	4					3	
Pulse/direction interface (5 V difference signals)	▼ [1)]					Max. 500 kHz		
± 10 V analog interface		●		Through AO				
PROFIBUS DP with PROFIdrive				●				
Typical drives/motors								
Standard induction motor, contactor-controlled		●					●	
Standard induction motor on frequency converter (e.g. SINAMICS G120)	through USS protocol	●		Through AO			●	
Induction motors		●		Through AO			●	
DC drives		●		Through AO				
Servo or stepper motors on power unit with pulse interface	●					●		
Servo motors on power unit with analog interface				Through AO				
Servo motors on power unit with PROFIBUS DP/PROFIdrive (e.g. SIMODRIVE, SINAMICS or MASTERDRIVES MC)				Through unassigned message				
Functions								
Jogging	I	●		●		●	●	
Rapid traverse/creep speed		●					●	
Point-to-point positioning	●	●		●		Relative	●	
Traversing profiles/programs	▲			▲				
Jerk limitation								
Synchronous operation/electronic gear/ master value coupling				●				
Travel to fixed stop (e.g. for clamping workpieces)								
Interpolation/transformation								

● available ▲ programmable ▼ configurable P Professional B Basic [1)] with High-Speed Digital Signal Board

	FM 351	FM 451	FM 353	FM 354	FM 357-2	FM 453	IM 174	CPU 315T CPU 317T	T400	FM 458 EXM 438
	6ES7 351-1.	6ES7 451-1.	6ES7 353-1AH.	6ES7 354-1AH	6ES7 357-4AH.	6ES7 453-3.	6ES7 174-0.	6ES7 315-6TG. 6ES7 317-6TJ.	6DD1 606-	6DD1 607-
	2	3	1	1	4 [2]	3	4	315T: 8; 317T: 32	2	Up to approx. 100
	●	●	●	●	●	●		●	●	●
	●	●	●	●	●	●		●	●	●
	●	●		●	●	●	●	● [3]	●	●
	●	●					●	● [3]	15 V HTL	15 V HTL
	●	●		●	●	●	●	● [3]	●	●
								●		●
	24 V / 5 V	24 V / 5 V		24 V / 5 V	24 V / 5 V	24 V / 5 V	●	● [3]		
	4 per axis	4 per axis							▼	▼
			Max. 200 kHz		Max. 750 kHz	Max. 1 MHz	Max. 750 kHz			
				●	●	●	●	● [3]	●	●
					●			●		●
	●	●								
	●	●						● [4]	●	●
	●	●		●	●	●		● [4]	●	●
				●	●	●		● [4]	●	●
			●		●	●	●	● [3]		
				●	●	●	●	● [3]	●	●
					●			●		●
	●	●	●	●	●	●		▲	▼	▼
	●	●							▼	▼
	●	●	●	●	●	●		●	●	●
			●	●	●	●		▲	▼	▼
			●	●	●	●		●	●	●
					●			●	●	●
					● [5]			●	●	●
					●					

[2] FM357-2H and single-channel [3] Through ADI4, IM174 [4] Through DP or ADI4, IM174 [5] Except for FM357-2L

Positioning / motion control

Feature	CPU 1211C CPU 1212C CPU 1214C	CPU 314C	SM 338	Easy Motion Control	1 SSI	1 STEP	1 POS U	
Setting a digital output on reaching of target position	●			Through DO				
Starting of positioning through digital input	●			Through DI				
Monitoring functions								
Limit switches for monitoring the traversing range	●	Software		Software			Hardware	
Standstill monitoring		●		●				
Following error monitoring				●				
Encoder monitoring		●	●	Depending on module	●		●	
Integrated inputs/outputs								
Digital inputs	●	5	2		1	2	3	
Latch function			●		●		●	
Length measurement		●			●			
Reference point approach	●	●				●	●	
External stop	●					●		
Hardware limit switches	●						●	
Reversing switch	▲							
Flying actual-value setting	●	●						
External start	●							
External block change								
Digital outputs	2	4					3	
Functions		Drive interface					Drive interface	
System environment								
Centralized application	S7-1200	S7-300	S7-300	S7-300 (CPU 314C and higher) [1], S7-400				
Distributed application	PN Basic Services	●	ET 200M		ET 200S	ET 200S	ET 200S	
PC-based Control		●	●	●	●	●	●	
Parameterization software	Component of STEP 7 Basic	Component of STEP 7	Component of STEP 7	Included in scope of supply	Component of STEP 7	Component of STEP 7	Component of STEP 7	
Programming software STEP7 V11	B/P	P	P		B/P	B/P	B/P	
Support of isochronous mode			●	●	●			
Hot swapping in RUN mode			Only with active backplane bus		●	●	●	
Module replacement without PG/PC	●	●	●		●	●	●	

● available ▲ programmable ▼ configurable P Professional B Basic [1] used exclusively by the technology

	FM 351	FM 451	FM 353	FM 354	FM 357-2	FM 453	IM 174	CPU 315T CPU 317T	T400	FM 458 EXM 438
			●	●	●	●		●	▼	▼
	●	●	●	●	●	●		●	▼	▼
	Software	Software	Software	Software	Software	Software		●	▼	▼
	●	●		●	●	●		●	▼	▼
				●	●	●		●	●	●
	●	●		●	●	●	●	●	●	●
	4 per axis	4 per axis	4	4	12	4 per axis, freely configurable	10 [1]	4	8 + 4 bidirectional	16 per EXM 438
	●	●				●			Per HW interrupt	Per HW interrupt
			●	●	●	●			▼	▼
	●	●	●	●	●	●		●	●	●
									▼	▼
								●	▼	▼
	●	●	●	●		●			▼	▼
	●	●	●	●		●	●		●	●
	●	●	●	●	● [2]	●			▼	▼
			●	●		●			▼	▼
	4 per axis	4 per axis	4	4	8	4 per axis	10	8	2 + 4 bidirectional	8 per EXM 438
	Drive interface	Drive interface	▼	▼	Cam controller	▼	[1]	Cam controller	▼	▼
	S7-300 (CPU 314 and higher)	S7-400	S7-300 (CPU 314 and higher)	S7-300 (CPU 314 and higher)	S7-300 (CPU 314 and higher)	S7-400		S7-300	SRT 400	S7-400
	ET 200M		ET 200M (with IM 153-2)	ET 200M (with IM 153-2)			● [3]	●	MASTER-DRIVES, DC master	
	●		●	●						
	Configuring package included in scope of supply	Configuring package included in scope of supply	Configuring package included in scope of supply	Configuring package included in scope of supply	Configuring package included in scope of supply [5]	Configuring package included in scope of supply	Component of STEP7	S7-Technology [4]	D7-SYS [4]	D7-SYS [4]
	P	P								
					●		●	●	With SRT 400 and CBP 2 (slave only)	●
	Only with active backplane bus									
	●	●	●	●	●	●	●	●		●

[2] through synchronized actions [3] with CPU 31xT [4] order separately [5] of the firmware

Glossary

Term	Explanation
Absolute traversing	Traversing to an absolute target position.
Angular synchronization	The slave axes move at a defined position offset to a master axis; they run with angular synchronism. Any following error is compensated.
Automatic mode	Continuous or step-by-step execution of complex positioning profiles (traverse programs).
Cam control	Cams are digital signals used to control connected I/Os. The position-dependent switching signals output to the master can be delayed or leading. They can be used to compensate the clearing times of connected final controlling elements.
Camming	The cam disc is a variable gearing, in which any relationship between the motion of the master and slave is defined using a table.
Compact CPU	CPU with integrated technology functions and integrated I/Os.
Continuous counting	After the gate has been enabled, counting is performed continuously (beginning with the starting value) between the upper and lower limit.
Counter-dependent setting and resetting of the digital output	Depending on 2 comparison values, a digital output is set when comparison value 1 is set and is reset when comparison value 2 is reached.
Count once	After the gate has been enabled, counting is performed once (beginning at the starting value) to the upper or lower limit.
Dosing	Setting or resetting of one or more digital outputs for closing one or more valves at certain counter values.
Dynamic dead time compensation	Velocity-dependent derivative action before the switching position.
Engaging and disengaging	Engaging and/or disengaging an axis in/from the synchronized system.
Frequency measurement	After the gate has been enabled, all the pulses received within a parameterizable time frame are counted and the frequency is determined from this.
Geared synchronous motion	The synchronization function is expanded with the ability to adjust the transmission ratio. The velocity of a slave drive is controlled with a selectable transmission ratio dependent on a master drive.
HMI	Human Machine Interface (operator control and monitoring)
Hydraulic axes	Position-controlled positioning of a hydraulic cylinder with consideration of the valve characteristic.
Insert/eject function	For inserting or ejecting a product into or out of the product sequence.
Jerk limitation	Limits the change in acceleration; enables a soft start-up of the axis protecting the mechanical system.
Jog mode (set up)	Traversing the axis at the press of a button with constant speed or frequency.

Term	Explanation
Latch Function	Through the integrated latch function, it is possible to store the current value accurate to the pulse and subsequently supply it to a higher-level controller.
MDI/MDI on-the-fly	Point-to-point positioning with any specifiable positions, paths, or velocities.
Offset angle (absolute/relative)	Adjustment of the position reference in angular synchronization.
Override	Reduction in the programmed velocity.
Period duration measurement	After the gate has been enabled, all the pulses received within a parameterizable time frame are counted and the period is determined from this.
Periodic counting	After the gate has been enabled, counting is performed periodically (beginning at the starting value) within the parameterized counting range.
PLCopen	Organization that promotes standardization in automation. For further details, visit **www.plcopen.org**
Position control	Driving to a position at which the actual value exactly reaches the setpoint.
Position detection	Acquisition of actual values scaled to units of length.
Position/time-based cam	A position-based cam is active during a defined displacement regardless of the velocity. A time-based cam is active during a defined time period, starting from a defined position.
Pressure control	Control of a defined pressure setpoint in a hydraulic cylinder for generating the desired force.
Print mark correction	Offset compensation for angular synchronization axes. Any following error is compensated.
Pulse width modulation	Output of pulses of different lengths at a defined frequency.
Rapid traverse/creep feed principle	The drive is started in rapid traverse mode. Just before the destination is reached (changeover difference), the drive is switched to creep feed mode. The drive is shutdown completely when the target position is reached or shortly before this, depending on the parameterization.
Relative traverse	Traversing of a specified distance.
Simulation operation	Operation of the position control without a physical axis connected.
Speed measurement	After the gate has been enabled, all the pulses received within a parameterizable time frame are counted and the speed is determined from this.
Synchronization	By evaluating a digital input and/or the zero mark signal, synchronization is possible. The actual value is loaded with an initial value.
Virtual master / real master	The virtual master generates the master setpoint for the slave drives based on the required machine velocity. The real master operates like the virtual master, whereby the position of the real axis is detected by an encoder system.

References

Mepac Produktions-GmbH – Manufacturer of packaging machines, Germany

Requirements

Mepac Produktions-GmbH was planning to restart production of servo driven tubular bag machines. The company decided to draw on the integrated controller and drives technology from Siemens. A programmable logic controller with integral technology functionality and a custom-made application template was a decisive factor for the company based in the state of Hesse, Germany. In addition, Mepac benefits from a high degree of investment protection and future orientation due to the long-term and world-wide availability of Siemens components.

Solution

The perfect solution to these requirements was swiftly found – with the technology CPU SIMATIC S7-315T-2 DP. This combines conventional PLC functionality with extensive motion control and technology functions in the familiar design technology of the SIMATIC product line. In addition, the controller is configured, programmed, diagnosed, and maintained like a conventional SIMATIC PLC. The STEP 7 option package S7 Technology contains a library with PLCopen-compatible function blocks for programming and configuring the motion control tasks as well as the software components for integration and commissioning of the drive.

Benefits

The technology CPU SIMATIC S7-315T-2 DP impressed Mepac all round as a future-oriented automation concept for its servo-driven tubular bag machines: The response at trade fairs and the feedback from the first users has been consistently positive – the machines run quickly, smoothly, and reliably even under the toughest conditions in practice. That is why the people at Mepac have now elevated the new control and drive concept to a permanent standard for all servo machines.

Alukon – Manufacturer of roller shutters and roller shutter doors, Germany

Requirements

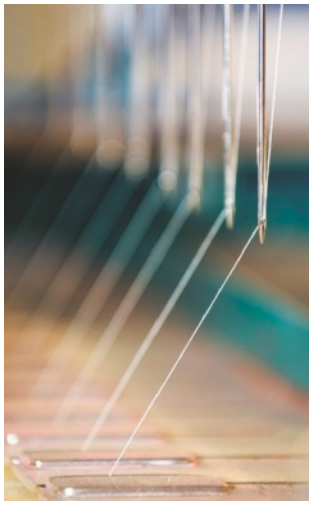
In order to meet the rising demand in future with maximum reliability and flexibility, the Alukon company planned to update the control technology of its plants for the manufacture of roller shutter slats. The setting up and adaptation of the systems was to be made easier and more convenient by combining all processes in one controller. In short: All technologies involved in the continuous manufacturing process were to be automated, operated, and monitored with just a single controller. In doing so, the company wanted to modernize existing plants rather than build new ones in order to cap its expenditure.

Solution

A technology CPU interacting with SINAMICS drives implements not only PLC tasks, but also motion control and technology tasks in one device. Thanks to the PLCopen-compliant function blocks integrated in the STEP 7 option package S7 Technology, motion control tasks could be implemented easily and consistently. The integration of logic and motion control in one device renders external function modules superfluous.

Benefits

With the new automation technology, the plants now operate more productively and reliably again: The roller shutter manufacturer is now ideally equipped to meet new challenges in the future. At the same time, energy consumption has been reduced by 40 percent. Since only one controller is required, not only the level of user friendliness was raised, but it was also possible to save space as well as hardware and coordination expenses by doing without a second control cabinet.



Konrad Sondermaschinenbau – mechanical equipment manufacture, Germany

Requirements

Konrad Sondermaschinenbau's customers include leading global players from the most varied sectors. The company's constructions are used mainly for manufacturing end products that have to be sewn together in one way or another. The latest example: a fully automatic system for sewing conical filter bags for air conditioning systems in buildings. The Swedish customer Camfil Farr provided clear requirements: the highest levels of reliability and productivity.

Solution

A technology CPU 315T-2 DP from the SIMATIC S7-300 family is the central automation component of the industrial plant and the clock pulse generator for six servo axes. In addition to the actual control functions, this also supports diverse technology and motion control functions – and all in one compact device. The following are connected via the isochronous and equidistant PROFIBUS: three Double Motor Modules of the SINAMICS drives family and three-phase servo motors type 1FK7.

Benefits

Konrad's solution is the first of its kind in the world: The technology CPU ensures fast and harmonious movements because they are electronically coordinated – and it significantly reduces the number of additional hardware function modules as well as bringing down interface costs. The now patented system operates approximately twice as fast as familiar solutions and considerably exceeds the required output.

Danfoss A/S – refrigeration and air conditioning industry, Denmark

Requirements

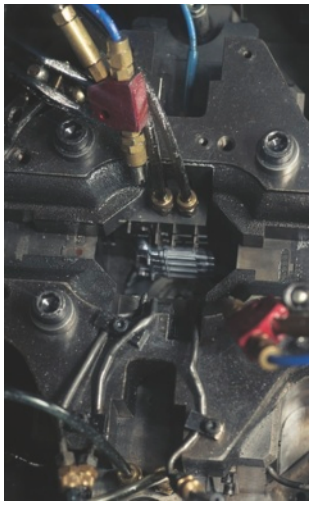
Danfoss A/S, a global leader in the manufacture of compressors and components for the refrigeration and air conditioning industry, purchases its technical equipment from the German company Bremer Werk für Montagesysteme (bwm). The Danish company commissioned bwm to implement several cells for pre-assembly and final assembly of thermostatic expansion valves. The requirements were for ultra-high-precision laser welding on a circular path and different linear variations of precise motion control – and all at low cost.

Solution

For the more complex motion control requirements, a separate solution based on the PROFIBUS-enabled CPU 317T-2 DP was implemented. This CPU integrates functions for motion control and technology tasks in addition to the usual controller functions. The expanded functionality is provided by the SIMATIC S7 Technology option package, an extensive library of PLCopen-compliant function blocks – specially developed for motion control.

Benefits

The assembly system convinces Danfoss A/S with regard to output and quality. Users do not have to learn any special motion control language in order to configure and program the control and drive section of the technology CPU. The PLC technology used also opens up diverse diagnositcs possibilities that have been expanded with the S7 Technology option package. This shortens startup and optimization times and increases availability.



Dynacast – Die casting machines, Germany

Requirements

As the technology leader in the die casting of metals, Dynacast Deutschland stands for first-class solutions in this area. The company wanted to fundamentally innovate the automation system of its servohydraulic die casting machine KH2 SIS. For the new solution, only standard components were to be used that are available worldwide at all times and can be configured simply and system-wide without special software know-how.

Solution

At the core of the new automation solution is a standard SIMATIC S7-400 PLC with high-dynamic FM 458-1 DP function module for the closed-loop control of hydraulic (and electronic) axes. This combination enables extremely high-speed control of up to five hydraulic axes with a high level of repetition accuracy. Also used are coordinated EXM 438-1 expansion modules for incremental and SSI encoders as well as analog or digital inputs and outputs.

Benefits

As demanded, the new solution is based on standardized automation technology. With response times < 0.5 ms, it is more than twice as fast as the previous multiprocessor system. Thanks to integrated configuring and programming under SIMATIC Manager, it has been possible to almost halve the engineering costs. Despite its increased functionality, the Continuous Function Chart (CFC) graphical configuring tool used is clearly structured and easy to read – and thus also ideal for non-specialists.

MMK Magnitogorsk Iron & Steel Works – Steel industry, Russia

Requirements

MMK Magnitorsk Iron & Steel Works, one of the leading steel producers in Russia, planned a new cold rolling mill for the manufacture of high-grade steel. The company hoped for the highest possible productivity levels from the new plant. With an annual capacity of 800 000 tons, the intention was to cover the continuously rising domestic and international demand. At the same time, of course, every colled-rolled steel strip that leaves the plant must meet the very highest quality requirements.

Solution

The plant's outstanding performance is thanks in part to the use of powerful closed-loop control systems of the SIMATIC family. The SIMATIC TDC closed-loop control system, for example, handles the drive tasks and the higher-level control of the entire rolling mill - in addition to the automation tasks. Lower-level tasks are handled by SIMATIC S7 controllers. The Global Data Memory (GDM) integrated into the SIMATIC TDC enables high-speed data exchange between all connected components – thus providing the basis for smooth synchronous automation. This, in turn, is essential to ensuring mass production at the quality levels demanded.

Benefits

The new plant convinced MMK Magnitorsk right from the start. The performance levels promised in the contract have been far exceeded. The same applies to the quality of the steel strip produced - with regard to its strength and length. The first steel coil to leave the plant was already of such outstanding quality that it could be sold straight away. SIMATIC TDC provides centralized data management – as well as high-resolution data acquisition and classification. The customer is thus best equipped to respond quickly and flexibly to future market requirements. In addition, powerful diagnostics functions enable a significant increase in plant availability – and thus productivity.

Step into the world of SIMATIC

This brochure has given you an initial overview of the extensive SIMATIC portfolio for factory automation – and of the advantages for you as a machine builder and plant operator. Further information on the individual families of systems can be found in the Internet sites listed below.

S I M A T I C

SIMATIC is a principal component of Totally Integrated Automation, the comprehensive and integrated range of products and systems for automation:
www.siemens.com/tia

SIMATIC – the leading automation system for industry:
www.siemens.com/simatic

Get to know the SIMATIC consistency through its system features:
www.siemens.com/simatic-system-features

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