SIEMENS

SIMATIC

S7-1500

CPU 1512C-1 PN (6ES7512-1CK00-0AB0)

Manual

Edition 06/2015

Answers for industry.

SIEMENS

SIMATIC

S7-1500
CPU 1512C-1 PN
(6ES7512-1CK00-0AB0)

Manual

06/2015
A5E35306440-AA

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

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We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Preface

Purpose of the documentation

This manual supplements the system manual of the S7-1500 automation system / ET 200MP distributed I/O system as well as the function manuals. This manual contains a description of the module-specific information. The system-related functions are described in the system manual. Cross-system functions are described in the function manuals.

The information provided in this manual and the system manual enables you to commission the CPU 1512C-1 PN.

Conventions

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

Table of contents

Documentation guide

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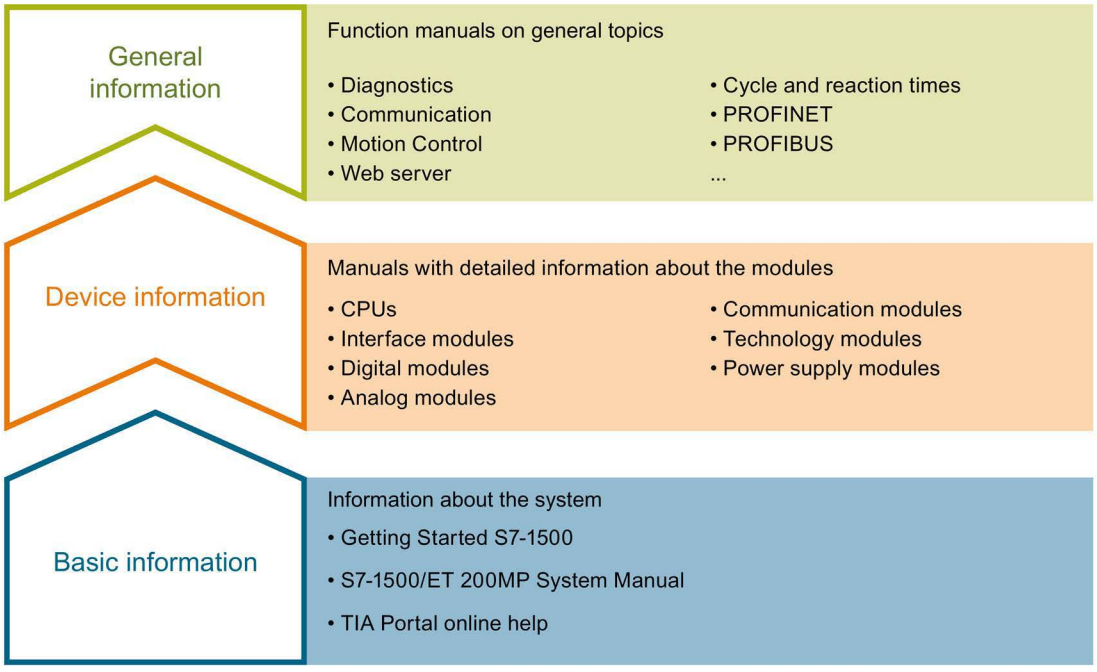
The documentation for the SIMATIC S7-1500 automation system and the SIMATIC ET 200MP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500 and ET 200MP systems. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC S7-1500 and ET 200MP systems, e.g. diagnostics, communication, Motion Control, Web server.

You can download the documentation free of charge from the Internet (http://www.automation.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-controllers/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/68052815).

Manual Collection S7-1500/ET 200MP

The Manual Collection contains the complete documentation on the SIMATIC S7-1500 automation system and the ET 200MP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/86140384).

"mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (https://support.industry.siemens.com/My/ww/en).

"mySupport" - Documentation

In the Documentation area in "mySupport" you can combine entire manuals or only parts of these to your own manual.
You can export the manual as PDF file or in a format that can be edited later.

You can find "mySupport" - Documentation on the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx data

In the CAx data area in "mySupport", you can access the current product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

Product overview

2

2.1 Applications of the S7-1500 CPUs

The CPUs of the SIMATIC S7-1500 controller family offer the best possible performance combined with excellent usability. The CPUs are suitable for many different applications in automation engineering. They feature:

- Integrated PROFINET/PROFIBUS interfaces
- Integrated Web server
- Integrated functionalities:
  - Trace
  - Motion
  - Closed-loop control functions

Performance segments of standard and fail-safe CPUs

The CPUs can be used for smaller and medium-sized applications, as well as for the high-end range of machine and plant automation.

Table 2- 1 Performance overview of standard and fail-safe CPUs

CPU	Performance segment	PROFIBUS interfaces	PROFINET IO RT/IRT interface	PROFINET standard interface	Work memory	Processing time for bit operations
Standard CPUs						
CPU 1511-1 PN	Standard CPU for smaller to medium-sized applications	--	1	--	1.15 MB	60 ns
CPU 1513-1 PN	Standard CPU for medium-sized applications	--	1	--	1.8 MB	40 ns
CPU 1515-2 PN	Standard CPU for medium-sized to large applications	--	1	1	3.5 MB	30 ns
CPU 1516-3 PN/DP	Standard CPU for demanding applications and communications tasks	1	1	1	6 MB	10 ns
CPU 1517-3 PN/DP	Standard CPU for demanding applications and communications tasks	1	1	1	10 MB	2 ns
CPU 1518-4 PN/DP	Standard CPU for high-performance applications, demanding communications tasks and very short reaction times	1	1	2	24 MB	1 ns

CPU	Performance segment	PROFIBUS interfaces	PROFINET IO RT/IRT interface	PROFINET standard interface	Work memory	Processing time for bit operations
Fail-safe CPUs						
CPU 1511F-1 PN	Fail-safe CPU for smaller to medium-sized applications	--	1	--	1.23 MB	60 ns
CPU 1513F-1 PN	Fail-safe CPU for medium-sized applications	--	1	--	1.95 MB	40 ns
CPU 1515F-2 PN	Fail-safe CPU for medium-sized to large applications	--	1	1	3.75 MB	30 ns
CPU 1516F-3 PN/DP	Fail-safe CPU for demanding applications and communications tasks	1	1	1	6.5 MB	10 ns
CPU 1517F-3 PN/DP	Fail-safe CPU for demanding applications and communications tasks	1	1	1	11 MB	2 ns
CPU 1518F-4 PN/DP	Fail-safe CPU for high-performance applications, demanding communications tasks and very short reaction times	1	1	2	26 MB	1 ns

Performance segments of compact CPUs

The compact CPUs can be used for smaller to medium-sized applications and have an integrated analog and digital on-board I/O as well as integrated technology functions. The following table shows the differences in performance between the two compact CPUs.

Table 2- 2 Performance overview of compact CPUs

	CPU 1511C-1 PN	CPU 1512C-1 PN
PROFIBUS interfaces	--	--
PROFINET interfaces	1	1
Work memory (for program)	175 KB	250 KB
Work memory (for data)	1 MB	1 MB
Processing time for bit operations	60 ns	48 ns
Integrated analog inputs/outputs	5 inputs/2 outputs	5 inputs/2 outputs
Integrated digital inputs/outputs	16 inputs/16 outputs	32 inputs/32 outputs
High-speed counters	6	6

Supported technology functions

The SIMATIC S7-1500 CPUs support motion control functions. STEP 7 offers PLCopen-standardized blocks for configuring and connecting a drive to the CPU. Motion control supports speed, positioning and synchronous axes, as well as external encoders.

For effective commissioning, diagnostics and fast optimization of drives and controls, the SIMATIC S7-1500 controller family offers extensive trace functions for all CPU tags.

In addition to drive integration, the SIMATIC S7-1500 has extensive closed-loop control functions, such as easy-to-configure blocks for automatic optimization of the controller parameters for optimized control quality.

Technology modules also implement functions such as high-speed counting, position detection and measuring functions. For compact CPUs CPU 1511C-1 PN and CPU 1512C-1 PN, these functions are already integrated and can be implemented without additional technology modules.

Due to the supported technology functions, the CPUs are suitable for controlling pumps, fans, mixers, conveyor belts, lifting platforms, gate control systems, building management systems, synchronized axes, etc.

Security Integrated

In conjunction with STEP 7, each CPU offers password-based know-how protection against unauthorized reading or modification of the program blocks.

The copy protection provides reliable protection against unauthorized reproduction of program blocks. The copy protection can be used to link individual blocks with the serial number of the compact CPU or SIMATIC memory card.

In addition, four different authorization levels in the CPUs can be used to assign different access rights to various user groups.

Improved manipulation protection allows the CPUs to detect changed or unauthorized transfers of the engineering data.

Safety Integrated

The fail-safe CPUs are intended for users who want to implement demanding standard and fail-safe applications both centrally and distributed.

These fail-safe CPUs allow the processing of standard and safety programs on a single CPU. This allows fail-safe data to be evaluated in the standard user program. The integration provides the system advantages and the extensive functionality of SIMATIC also for fail-safe applications.

The fail-safe CPUs are certified for use in safety mode up to:

- Safety class (Safety Integrity Level) SIL 3 according to IEC 61508:2010
- Performance Level (PL) e and Category 4 according to ISO 13849-1:2006 or according to EN ISO 13849-1:2008

Additional password protection for F-configuration and F-program is set up for IT security.

Note

Note that fail-safe CPUs are available only in the following variants: CPU 1511F-1 PN, CPU 1513F-1 PN, CPU 1515F-2 PN, CPU 1516F-3 PN/DP, CPU 1517F-3 PN/DP and CPU 1518F-4 PN/DP.

The compact CPUs CPU 1511C-1 PN and CPU 1512C-1 PN, on the other hand, are available only as standard CPUs and not as fail-safe CPUs.

Design and handling

The design and handling of the CPUs is very straightforward and provides the greatest possible user friendliness. All CPUs have a display. The display provides information on order numbers, firmware version and serial numbers of all connected modules. The IP address of the CPU and other network settings can be set directly on the device. The display shows occurring error messages directly as plain text multi-lingual messages and helps you to shorten downtimes.

System diagnostics

Integrated system diagnostics is enabled by default for the CPUs. The different types of diagnostics are configured instead of programmed. System diagnostics information is shown uniformly and in plain text on the display of the CPU, in STEP 7, on the HMI and on the Web server, even for alarms related to drives. This information is available in RUN mode, but also in STOP mode of the CPU. The diagnostics information is updated automatically when you configure new hardware components.

2.2 Properties

The hardware of the CPU 1512C-1 PN consists of a CPU part, an analog on-board I/O (X10) and a digital on-board I/O (X11 and X12). When configured in the TIA Portal, the compact CPU therefore occupies a single shared slot (slot 1).

The properties of the CPU part, the analog on-board I/O and the digital on-board I/O can be found in the subsections below.

Article number of the compact CPU

6ES7512-1CK00-0AB0

Accessories

The following accessories are included in the scope of delivery and can also be ordered separately as spare parts:

- 3 x front connector (push-in terminals) including cable ties
- 3 x shield clamp
- 3 x shield terminal
- 3 x infeed element (push-in terminals)
- 3 x labeling strip
- 3 x universal front cover

For more information on accessories, refer to the S7-1500, ET 200MP system manual (http://support.automation.siemens.com/WW/view/en/59191792).

2.2.1 Properties of the CPU part

View of the CPU

The figure below shows the CPU part of the CPU 1512C-1 PN.

Figure 2-1 CPU 1512C-1 PN

Note

Protective film

Note that a protective film is attached to the display of the CPU when shipped from the factory. Remove the protective film if necessary.

Properties

The CPU 1512C-1 PN has the following technical properties:

- Communication:
  - Interfaces

    The CPU 1512C-1 PN has a PROFINET interface (X1) with two ports (P1 R and P2 R). It supports not only PROFINET basic functionality but also PROFINET IO RT (real time) and IRT (isochronous real time), which means you can configure PROFINET IO communication or real-time settings on the interface. Port 1 and port 2 can also be used as ring ports for configuration of redundant ring structures in Ethernet (media redundancy).
    PROFINET basic functionality supports HMI communication, communication with the configuration system, communication with a higher-level network (backbone, router, Internet) and communication with another machine or automation cell.
    For more information on “PROFINET IO", refer to the online help of STEP 7 and the PROFINET (http://support.automation.siemens.com/WW/view/en/68039307) function manual.
- Integrated Web server:

  A Web server is integrated in the CPU. You can read the following information with the Web server:
  - Start page with general CPU information
  - Identification information
  - Contents of the diagnostics buffer
  - Status query of analog and digital on-board I/O and additional modules that are plugged in
  - Alarms (without acknowledgment option)
  - Information about communication
  - PROFINET topology
  - Tag status
  - Watch tables
  - Memory usage
  - User pages
  - Data logs (if used)

- Supported technology:
  - Counting, measuring, position detection

    The technology functions high-speed counting, measuring and position detection for motion control are integrated in the CPU.
    For more information on integrated technology functions, refer to the section Technology functions.
  - Motion Control

    The motion control functionality supports speed axes, positioning axes, synchronous axes and external encoders as well as PLCopen blocks for programming the motion functionality.
    For more information about motion control, refer to the section Technology functions.
    For a detailed description of the use of motion control and its configuration, refer to the S7-1500 Motion Control
    (http://support.automation.siemens.com/WW/view/en/59381279) function manual.
  - Integrated closed-loop control functionality

    - Universal PID controller

    - 3-point step controller/valve controller with integrated optimization

    - Integrated temperature controller
- Trace functionality:
  - The trace functionality supports troubleshooting and optimization of the user program, especially for motion control and closed-loop control applications.
    For more information on "Trace", refer to the Using the trace and logic analyzer functions (http://support.automation.siemens.com/WW/view/en/64897128) function manual.
- Integrated system diagnostics:
  - The alarms for the system diagnostics are automatically created by the system and displayed by a PG/PC, HMI device, Web server or the integrated display. System diagnostics is also available when the CPU is in STOP mode.

- Integrated security:
  - Copy protection

    Copy protection links user blocks to the serial number of the SIMATIC memory card or to the serial number of the CPU. User programs cannot run without the corresponding SIMATIC memory card or CPU.
  - Know-how protection

    The know-how protection protects user blocks against unauthorized access and modifications.
  - Access protection

    Extended access protection provides high-quality protection against unauthorized configuration changes. You can use authorization levels to assign separate rights to different user groups.
  - Integrity protection

    The system protects the data transferred to the CPU against manipulation. The CPU detects incorrect or manipulated engineering data.
- The CPU 1512C-1 PN supports the following functions:
  - CPU memory reset
    For information on "Memory reset", refer to the S7-1500, ET 200MP system manual (http://support.automation.siemens.com/WW/view/en/59191792).
  - Reset CPU to factory settings
    For information on "Reset CPU to factory settings", refer to the S7-1500, ET 200MP system manual (http://support.automation.siemens.com/WW/view/en/59191792).
  - Firmware update
    For information on "Firmware update", refer to the S7-1500, ET 200MP system manual (http://support.automation.siemens.com/WW/view/en/59191792).
  - Configuration control
    For information on "Configuration control", refer to the S7-1500, ET 200MP system manual (http://support.automation.siemens.com/WW/view/en/59191792) and the PROFINET (http://support.automation.siemens.com/WW/view/en/68039307) function manual.
  - PROFIenergy
    For information on "PROFIenergy", refer to the PROFINET (http://support.automation.siemens.com/WW/view/en/68039307) function manual and the PROFINET specification on the Internet (http://www.profibus.com).

2.2.2 Properties of the analog on-board I/O

View

The following figure shows the analog on-board I/O (X10) of the CPU 1512C-1 PN.

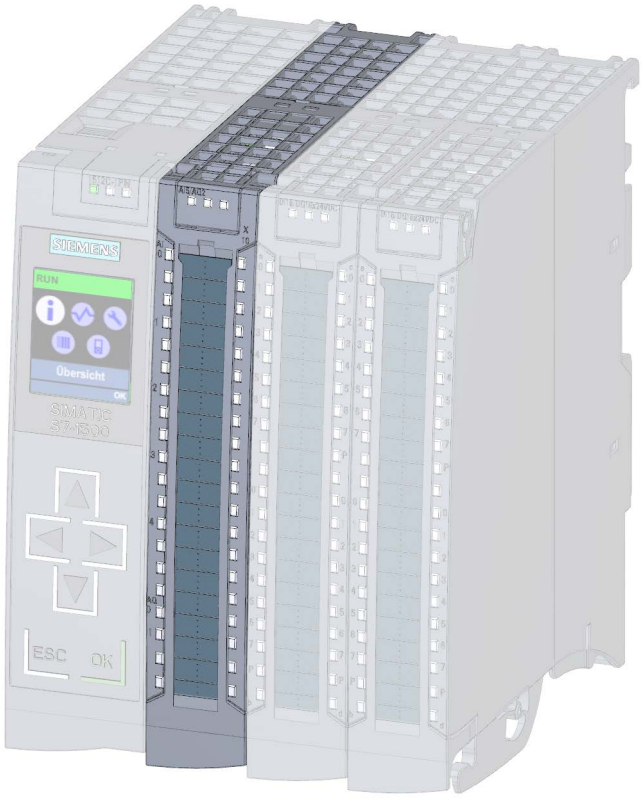


Figure 2-2 Analog on-board I/O

Properties

The analog on-board I/O has the following technical properties:

- Analog inputs
  - 5 analog inputs
  - Resolution 16 bits including sign
  - Voltage measurement type can be set individually for channel 0 to 3
  - Current measurement type can be set individually for channel 0 to 3
  - Resistor measurement type can be set for channel 4
  - Thermal resistor measurement type can be set for channel 4
  - Configurable diagnostics (per channel)
  - Hardware interrupt on limit violation can be set per channel (two low and two high limits in each case)
- Analog outputs
  - 2 analog outputs
  - Resolution: 16 bits incl. sign
  - Voltage output selectable by channel
  - Current output selectable by channel
  - Configurable diagnostics (per channel)

The analog on-board I/O supports the following functions:

- Reconfiguration in RUN
  (for more information, refer to the section Parameter assignment and structure of parameter data records of the analog on-board I/O (Page 110))

2.2.3 Properties of the digital on-board I/O

View

The following figure shows the digital on-board I/O (X11 and X12) of the CPU 1512C-1 PN.

Figure 2-3 Digital on-board I/O

Properties

The digital on-board I/O has the following technical properties:

- Digital inputs
  - 32 high-speed digital inputs for signals up to max. 100 kHz
    The inputs can be used as standard inputs and as inputs for technology functions.
  - Rated input voltage 24 V DC
  - Suitable for switches and 2-/3-/4-wire proximity switches
  - Configurable diagnostics
  - Hardware interrupt can be set (for each channel)
- Digital outputs
  - 32 digital outputs, 8 of which can be used as high-speed outputs for technology functions
    The outputs can be used as standard outputs and as outputs for technology functions.
  - Rated output voltage 24 V DC
  - Rated output current
    as output for standard mode: 0.5 A per channel
    as output for technology function 0.1 A per channel
  - Suitable for solenoid valves, DC contactors, and indicator lights
  - Configurable diagnostics

The digital on-board I/O supports the following functions:

- Reconfiguration in RUN
  (for more information, refer to the section Parameter assignment and structure of parameter data records of the digital on-board I/O (Page 118))

Simultaneous use of technology and standard functions

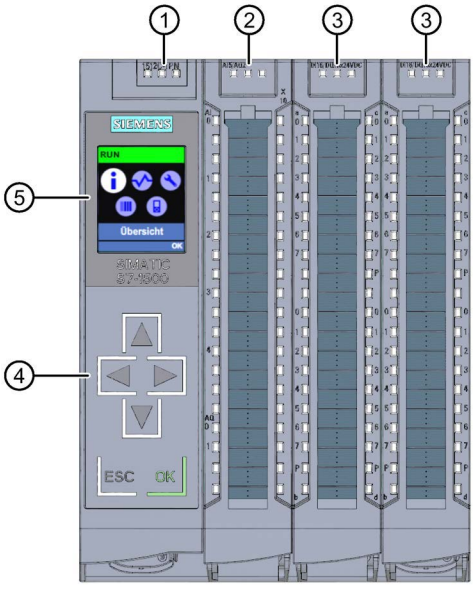
You can use technology and standard functions at the same time, provided the hardware allows this. For example, all the digital inputs not assigned to the counting, measuring or position detection technology functions can be used as standard DI.

Inputs to which technology functions are assigned can be read. Outputs to which technology functions are assigned cannot be written.

2.3 Operator controls and display elements

2.3.1 Front view with closed front panels

The following figure shows the front view of the CPU 1512C-1 PN.



① LEDs for the current operating mode and diagnostics status of the CPU
② Status and error displays RUN/ERROR of the analog on-board I/O
③ Status and error displays RUN/ERROR of the digital on-board I/O
④ Control keys
⑤ Display

Figure 2-4 View of the CPU 1512C-1 PN with closed front panels (front)

Note

Temperature range for display

To increase its service life, the display switches off at a temperature below the permitted operating temperature of the device. When the display cools down again, it automatically switches itself on again. When the display is switched off, the LEDs continue to show the status of the CPU.

For more information on the temperatures at which the display switches itself on and off, refer to the Technical specifications (Page 90).

Pulling and plugging the front panel with display

You can pull and plug the front panel with display during operation. The CPU retains its operating mode when the front panel is pulled and plugged.

⚠ WARNING

Personal injury and damage to property may occur

If you pull or plug the front panel of an S7-1500 automation system during operation, personal injury or damage to property can occur in zone 2 hazardous areas.

Before you pull or plug the front panel in hazardous area zone 2, always ensure that the S7-1500 automation system is de-energized.

Locking the front panel

You can lock the front panel to protect your CPU against unauthorized access.

You can attach a security seal or a padlock with a hoop diameter of 3 mm to the front panel.

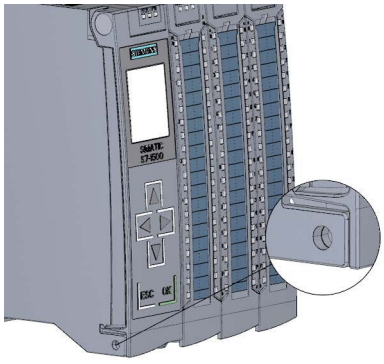


Figure 2-5 Locking latch on the CPU

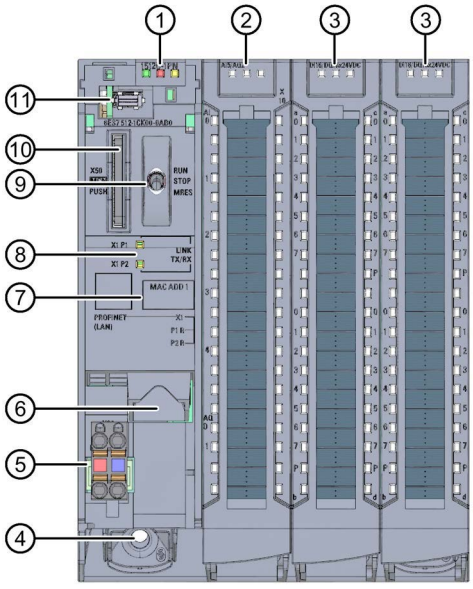
In addition to the mechanical lock, you can also block access to a password-protected CPU on the display (local lock) and assign a password for the display. For more information on the display, the configurable protection levels and the local lock, refer to the S7-1500, ET 200MP (http://support.automation.siemens.com/WW/view/en/59191792) system manual.

Reference

You will find detailed information on the individual display options, a training course and a simulation of the available menu commands in the SIMATIC S7-1500 Display Simulator (http://www.automation.siemens.com/salesmaterial-as/interactive-manuals/getting-started_simatic-s7-1500/disp_tool/start_en.html).

2.3.2 Front view without front panel on the CPU

The following figure shows the operator control and connection elements of the CPU 1512C-1 PN with the front cover of the CPU open.

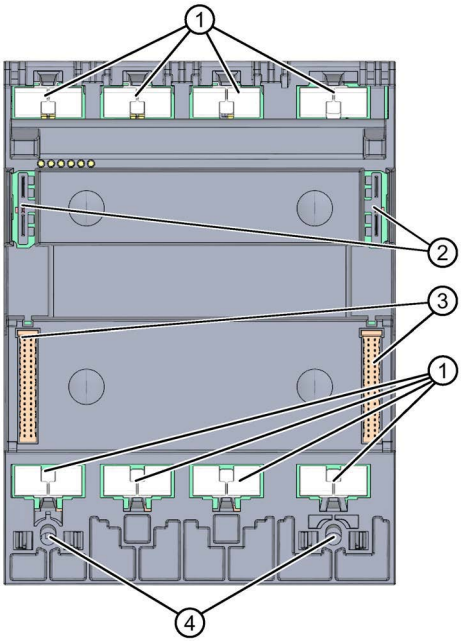


① LEDs for the current operating mode and diagnostics status of the CPU
② Status and error displays RUN/ERROR of the analog on-board I/O
③ Status and error displays RUN/ERROR of the digital on-board I/O
④ Fastening screw
⑤ Connection for supply voltage
⑥ PROFINET interface (X1) with 2 ports (X1 P1 and X1 P2)
⑦ MAC address
⑧ LEDs for the 2 ports (X1 P1 and X1 P2) of the PROFINET interface X1
⑨ Mode selector
⑩ Slot for the SIMATIC memory card
⑪ Display connection

Figure 2-6 View of the CPU 1512C-1 PN without front panel on the CPU (front)

2.3.3 Rear view

The following figure shows the connection elements on the rear of the CPU 1512C-1 PN.



① Shield contact surfaces
② Plug-in connection for power supply
③ Plug-in connection for backplane bus
④ Fastening screws

Figure 2-7 View of the CPU 1512C-1 PN - rear

2.4 Mode selector

You use the mode selector to set the operating mode of the CPU.

The following table shows the position of the selector and the corresponding meaning:

Position of the mode selector

Position	Meaning	Explanation
RUN	RUN mode	The CPU executes the user program.
STOP	STOP mode	The user program is not executed.
MRES	Memory reset	Position for CPU memory reset.

Technology functions 3

3.1 Properties

Properties

The technology functions of the compact CPU have the following technical properties:

- 32 high-speed digital inputs (up to 100 kHz), isolated
  - 6 high speed counters (High Speed Counter/HSC), which can all be used as A/B/N
- Interfaces
  - 24 V encoder signals of sourcing or push-pull encoders and sensors
  - 24 V encoder supply output, short-circuit-proof
  - Up to 2 additional digital inputs per high-speed counter for possible HSC DI functions (Sync, Capture, Gate)
  - 1 digital output per high-speed counter for fast reaction to the count
- Counting range: 32 bits
- Diagnostics and hardware interrupts can be configured
- Supported encoder/signal types
  - 24 V incremental encoder
    (with 2 tracks A and B, phase-shifted by 90°, up to 6 incremental encoders also with zero track N)
  - 24 V pulse encoder with direction signal
  - 24 V pulse encoder without direction signal
  - 24 V pulse encoder each for forward pulse & reverse pulse

The technology functions support reconfiguration in RUN. For more information, refer to the section Parameter data records of the technology functions (Page 122).

3.2 Functions

3.2.1 Counting

Counting refers to the detection and adding up of events. The counters acquire and evaluate encoder signals and pulses. The count direction can be specified using encoder or pulse signals or through the user program.
You can control counting processes using the digital inputs. You can switch the digital outputs exactly at defined count values, regardless of the user program.
You can configure the response of the counters using the functionalities described below.

Counting limits

The counting limits define the count value range used. The counting limits are selectable and can be modified during runtime by the user program.
The highest counting limit that can be set is 2147483647 (2^{31}–1). The lowest counting limit that can be set is –2147483648 (–2^{31}).
You can configure the response of the counter at the counting limits:

- Continue or stop counting (automatic gate stop) on violation of a counting limit
- Set count value to start value or to opposite counting limit on violation of a counting limit

Start value

You can configure a start value within the counting limits. The start value can be modified during runtime by the user program.
Depending on the parameter assignment, the compact CPU can set the current count value to the start value during synchronization, during the Capture function, on violation of a counting limit or when the gate is opened.

Gate control

Opening and closing the hardware gate and software gate defines the period of time during which the counting signals are acquired.
The hardware gate is controlled externally via the digital inputs of the digital on-board I/O. The software gate is controlled by the user program. The hardware gate can be enabled by assigning parameters. The software gate (bit in the control interface of the cyclic I/O data) cannot be disabled.

Capture

You can configure an external reference signal edge that triggers the saving of the current count value as a Capture value. The following external signals can trigger the Capture function:

- Rising or falling edge of a digital input
- Both edges of a digital input
- Rising edge of signal N at the encoder input

You can configure whether counting continues from the current count value or from the start value after the Capture function.

Hysteresis

You can specify hysteresis for the comparison values, within which a digital output is prevented from switching again. An encoder may stop at a certain position, and slight movements may make the count value fluctuate around this position. If a comparison value or a counting limit lies within this fluctuation range, the corresponding digital output will be switched on and off often if hysteresis is not used. The hysteresis prevents these unwanted switching operations.

Reference

For more information on the counter, refer to the S7-1500, ET 200MP, ET 200SP Counting, measurement and position detection function manual (http://support.automation.siemens.com/WW/view/en/59709820).

3.2.2 Measuring

Measuring functions

The following measuring functions are available:

Table 3- 1 Overview of available measuring functions

Measurement type	Description
Frequency measurement	Based on the time sequence of the count pulses, the average frequency within a measuring interval is calculated and returned as a floating-point number in units of hertz.
Period measurement	Based on the time sequence of the count pulses, the average period within a measuring interval is calculated and returned as a floating-point number in units of seconds.
Velocity measurement	Based on the time sequence of the count pulses and additional parameters, the average velocity within a measuring interval is calculated and returned in the configured unit.

The measured value and count value are both available in the feedback interface.

Update time

You can configure the interval at which the compact CPU updates the measured values cyclically as the update time. Setting longer update time intervals allows turbulent measured variables to be smoothed and increases measuring accuracy.

Gate control

Opening and closing the hardware gate and software gate defines the period of time during which the count signals are acquired. The update time is asynchronous to the opening of the gate, which means that the update time is not started when the gate is opened. After the gate is closed, the last measured value calculated is still returned.

Measuring ranges

The measuring functions have the following measuring range limits:

Table 3- 2 Overview of low and high measuring range limits

Measurement type	Low measuring range limit	High measuring range limit
Frequency measurement	0.04 Hz	400 kHz *
Period measurement	2.5 µs *	25 s
Velocity measurement	Depending on the configured number of "increments per unit" and the "timebase for velocity measurement"	

* Applies to 24 V incremental encoder and "quadruple" signal evaluation

All measured values are returned as signed values. The sign indicates whether the count value increased or decreased during the relevant time period. For example, a value of -80 Hz means that the count value decreases at 80 Hz.

Reference

For more information on measuring, refer to the S7-1500, ET 200MP, ET 200SP Counting, measurement and position detection function manual (http://support.automation.siemens.com/WW/view/en/59709820).

3.2.3 Position detection for motion control

You can use the digital on-board I/O, e.g. with an incremental encoder, for position detection with S7-1500 Motion Control. The position detection is based on the counting function, which evaluates the acquired encoder signals and provides them for S7-1500 Motion Control.
In the hardware configuration of the CPU 1512C-1 PN in STEP 7, select the "Position input for Motion Control" mode.

Reference

For a detailed description of the use of motion control and its configuration, refer to the S7-1500 Motion Control function manual (http://support.automation.siemens.com/WW/view/en/59381279). In the function module, the interface between the drives and encoders is referred to as a technology module (TM). In this context, a technology module (TM) also refers to the digital on-board I/O of the compact CPU described here.

3.2.4 Additional functions

Synchronization

You can configure an external reference signal edge to load the counter with the specified start value. The following external signals can trigger a synchronization:

- Rising or falling edge of a digital input
- Rising edge of signal N at the encoder input
- Rising edge of signal N at the encoder input depending on the level of the assigned digital input

Comparison values

The integrated counter supports 2 comparison values and digital output DQ1. This means that if the counter or measured value meets the set comparison condition, HSC DQ1 can be set in order to trigger direct control operations in the process.

Both comparison values can be set in the parameters and can be changed during runtime by the user program.

Hardware interrupts

If you have enabled a hardware interrupt in the hardware configuration, the counter can trigger a hardware interrupt in the CPU when a comparison event occurs, if there is overflow or underflow, at a zero crossing of the counter, and/or at a change of count direction (direction reversal). You can specify which events are to trigger a hardware interrupt during operation in the hardware configuration.

Diagnostics interrupts

If you have enabled a diagnostics interrupt in the hardware configuration, the counter can trigger a diagnostics interrupt if the supply voltage is missing, if there is an incorrect A/B count signal or lost hardware interrupt.

3.3 Configuring

3.3.1 General

You configure the high-speed counters (HSC) in STEP 7.

The functions are controlled by the user program.

Reference

A detailed description of configuring the counting and measuring functions can be found in:

- S7-1500, ET 200MP, ET 200SP Counting, measurement and position detection (http://support.automation.siemens.com/WW/view/en/59709820) function manual
- in the STEP 7 online help under "Using technology functions > Counting, measuring and position detection > Counting, measuring and position detection (S7-1500)"

A detailed description of configuring Motion Control be found in:

- S7-1500 Motion Control (http://support.automation.siemens.com/WW/view/en/59381279) function manual
- in the STEP 7 online help under "Using technology functions > Motion Control > Motion Control (S7-1500)"

3.3.2 Assignment of the control interface

The user program uses the control interface to influence the behavior of the high speed counter.

Note

Operation with High_Speed_Counter technology object

The High_Speed_Counter technology object is available for high-speed counting mode. We therefore recommend use of the High_Speed_Counter technology object instead of the control interface/feedback interface for controlling the high speed counter.

For information on configuring the technology object and programming the associated instruction, refer to the S7-1500, ET 200MP, ET 200SP Counting, measurement and position detection (http://support.automation.siemens.com/WW/view/en/59709820) function manual.

Control interface per channel

The following table shows the control interface assignment:

Table 3- 3 Assignment of the control interface

Offset from start address	Parameter	Meaning				
Bytes 0 to 3	Slot 0	Load value (meaning of the value is specified in LD_SLOT_0)				
Bytes 4 to 7	Slot 1	Load value (meaning of the value is specified in LD_SLOT_1)				
Byte 8	LD_SLOT_0*	Specifies the meaning of the value in Slot 0				
		Bit 3	**Bit 2**	**Bit 1**	**Bit 0**	
		0	0	0	0	No action, idle state
		0	0	0	1	Load counter
		0	0	1	0	Reserve
		0	0	1	1	Load start value
		0	1	0	0	Load comparison value 0
		0	1	0	1	Load comparison value 1
		0	1	1	0	Load low counting limit
		0	1	1	1	Load high counting limit
		1	0	0	0	Reserve
		to				
		1	1	1	1	
	LD_SLOT_1*	Specifies the meaning of the value in Slot 1				
		Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	
		0	0	0	0	No action, idle state
		0	0	0	1	Load counter
		0	0	1	0	Reserve
		0	0	1	1	Load start value
		0	1	0	0	Load comparison value 0

Offset from start address	Parameter	Meaning				
		0	1	0	1	Load comparison value 1
		0	1	1	0	Load low counting limit
		0	1	1	1	Load high counting limit
		1	0	0	0	Reserve
		to				
		1	1	1	1	
Byte 9	EN_CAPTURE	Bit 7: Enable capture function				
	EN_SYNC_DN	Bit 6: Enable downward synchronization				
	EN_SYNC_UP	Bit 5: Enable upward synchronization				
	SET_DQ1	Bit 4: Set DQ1				
	SET_DQ0	Bit 3: Set DQ0				
	TM_CTRL_DQ1	Bit 2: Enable technological function DQ1				
	TM_CTRL_DQ0	Bit 1: Enable technological function DQ0				
	SW_GATE	Bit 0: Software gate				
Byte 10	SET_DIR	Bit 7: Count direction (with encoder without direction signal)				
	–	Bits 2 to 6: Reserve; bits must be set to 0				
	RES_EVENT	Bit 1: Reset of saved events				
	RES_ERROR	Bit 0: Reset of saved error states				
Byte 11	–	Bits 0 to 7: Reserve; bits must be set to 0				

* If values are loaded simultaneously via LD_SLOT_0 and LD_SLOT_1, the value from Slot 0 is taken first internally and then the value from Slot 1 . This may lead to unexpected intermediate states.

3.3.3 Assignment of the feedback interface

The user program receives current values and status information from the high speed counter via the feedback interface.

Note

Operation with High_Speed_Counter technology object

The High_Speed_Counter technology object is available for high-speed counting mode. We therefore recommend use of the technology object High_Speed_Counter instead of the control interface/feedback interface for controlling the high speed counter.

For information on configuring the technology object and programming the associated instruction, refer to the S7-1500, ET 200MP, ET 200SP Counting, measurement and position detection (http://support.automation.siemens.com/WW/view/en/59709820) function manual.

Feedback interface per channel

The following table shows the feedback interface assignment:

Table 3- 4 Assignment of the feedback interface

Offset from start address	Parameter	Meaning
Bytes 0 to 3	COUNT VALUE	Current count value
Bytes 4 to 7	CAPTURED VALUE	Last Capture value acquired
Bytes 8 to 11	MEASURED VALUE	Current measured value
Byte 12	–	Bits 3 to 7: Reserve; set to 0
	LD_ERROR	Bit 2: Error when loading via control interface
	ENC_ERROR	Bit 1: Incorrect encoder signal
	POWER_ERROR	Bit 0: Incorrect supply voltage L+
Byte 13	–	Bits 6 to 7: Reserve; set to 0
	STS_SW_GATE	Bit 5: Software gate status
	STS_READY	Bit 4: Digital on-board I/O started up and parameters assigned
	LD_STS_SLOT_1	Bit 3: Load request for Slot 1 detected and executed (toggling)
	LD_STS_SLOT_0	Bit 2: Load request for Slot 0 detected and executed (toggling)
	RES_EVENT_ACK	Bit 1: Reset of event bits active
	–	Bit 0: Reserve; set to 0
Byte 14	STS_DI2	Bit 7: Reserve; set to 0
	STS_DI1	Bit 6: Status HSC DI1
	STS_DI0	Bit 5: Status HSC DI0
	STS_DQ1	Bit 4: Status HSC DQ1
	STS_DQ0	Bit 3: Status HSC DQ0
	STS_GATE	Bit 2: Internal gate status
	STS_CNT	Bit 1: Count pulse detected within last approx. 0.5 s
	STS_DIR	Bit 0: Direction of last count value change
Byte 15	STS_M_INTERVAL	Bit 7: Count pulse detected in previous measuring interval
	EVENT_CAP	Bit 6: Capture event has occurred
	EVENT_SYNC	Bit 5: Synchronization has occurred
	EVENT_CMP1	Bit 4: Comparison event for DQ1 has occurred
	EVENT_CMP0	Bit 3: Comparison event for DQ0 has occurred
	EVENT_OFLW	Bit 2: Overflow has occurred
	EVENT_UFLW	Bit 1: Underflow has occurred
	EVENT_ZERO	Bit 0: Zero crossing has occurred

Wiring

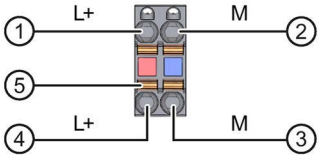
4

4.1 Supply voltage

24 V DC supply voltage (X80)

The connecting plug for the supply voltage is plugged in when the CPU ships from the factory.

The following table shows the terminal assignment for a 24 V DC power supply.



① +24 V DC of the supply voltage
② Ground of the supply voltage
③ Ground of the supply voltage for loop-through (maximum of 10 A permitted)
④ +24 V DC of the supply voltage for loop-through (maximum of 10 A permitted)
⑤ Spring-loaded NC contact (one spring-loaded NC contact per terminal)

Bridged internally:
① and ④
② and ③

Figure 4-1 Connection for supply voltage

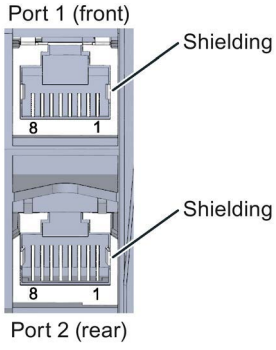
If the CPU is supplied by a system power supply, it is not necessary to connect the 24 V supply.

4.2 PROFINET interfaces

PROFINET interface X1 with 2-port switch (X1 P1 R and X1 P2 R)

The following table shows the terminal assignment for the PROFINET interface with 2-port switch. The assignment corresponds to the Ethernet standard for an RJ45 plug.

Table 4- 1 Terminal assignment of the PROFINET interface with 2-port switch

View	Signal name		Pin assignment
	1	TD	Transmit Data +
	2	TD_N	Transmit Data -
	3	RD	Receive Data +
	4	--	Unassigned
	5	--	Unassigned
	6	RD_N	Receive Data -
	7	--	Unassigned
	8	--	Unassigned

Reference

For more information on "Wiring the CPU" and "Accessories/spare parts", refer to the S7-1500, ET 200MP system manual (http://support.automation.siemens.com/WW/view/en/59191792).

Assignment of the MAC addresses

The CPU 1512C-1 PN has a PROFINET interface with two ports. The PROFINET interface itself has a MAC address, and each of the two PROFINET ports has its own MAC address. The CPU 1512C-1 PN therefore has three MAC addresses in total.

The MAC addresses of the PROFINET ports are needed for the LLDP protocol, for example for the neighborhood discovery function.

The number range of the MAC addresses is continuous. The first and last MAC address are lasered on the rating plate on the right side of each CPU 1512C-1 PN.

The table below shows how the MAC addresses are assigned.

Table 4- 2 Assignment of the MAC addresses

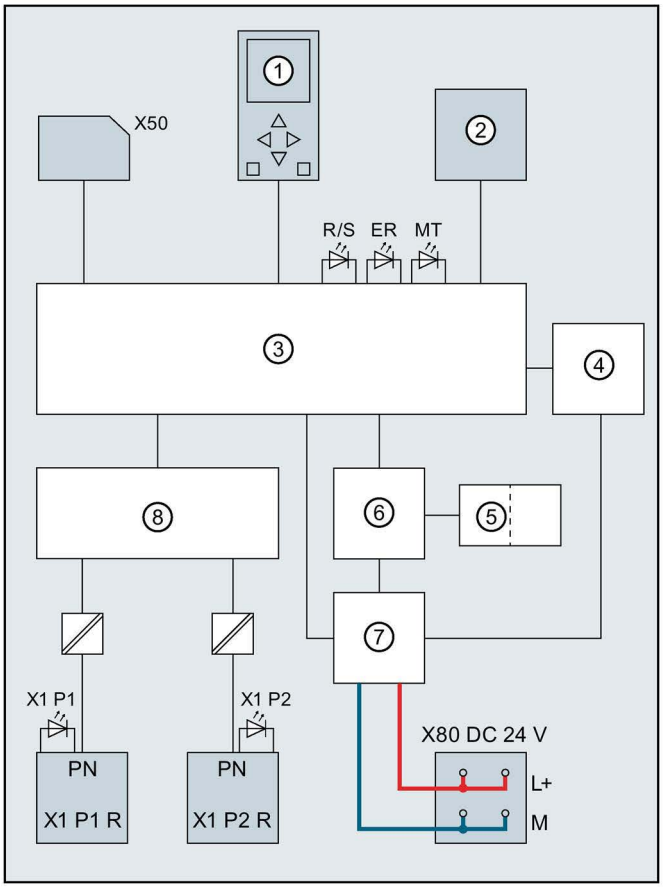
	Assignment	Labeling
MAC address 1	PROFINET interface X1 (visible in STEP 7 for accessible devices)	• Front, lasered • Right side, lasered (start of number range)
MAC address 2	Port X1 P1 R (required for LLDP, for example)	• Front and right side, not lasered
MAC address 3	Port X1 P2 R (required for LLDP, for example)	• Front, not lasered • Right side, lasered (end of number range)

4.3 Terminal and block diagrams

4.3.1 Block diagram of the CPU part

Block diagram

The following figure shows the block diagram of the CPU part.



①	Display	X80 24 V DC	Infeed of supply voltage
②	RUN/STOP/MRES mode selector	PN X1 P1 R	PROFINET interface X1 port 1
③	Electronics	PN X1 P2 R	PROFINET interface X1 port 2
④	Interface to on-board I/O	L+	24 V DC supply voltage
⑤	Interfaces to the backplane bus	M	Ground
⑥	Backplane bus interface	R/S	RUN/STOP LED (yellow/green)
⑦	Internal supply voltage	ER	ERROR LED (red)
⑧	PROFINET switch	MT	MAINT LED (yellow)
X50	SIMATIC Memory Card	X1 P1, X1 P2	Link TX/RX LED

Figure 4-2 Block diagram of the CPU part

4.3.2 Terminal and block diagram of the analog on-board I/O

This section contains the block diagram of the analog on-board I/O (X10) and various wiring options.

For information on wiring the front connector, establishing the cable shield, etc., refer to the S7-1500, ET 200MP (http://support.automation.siemens.com/WW/view/en/59191792) system manual.

Note

You can use and combine the different wiring options for all channels. Note, however, that unneeded terminals of an analog input channel must not be connected.

Definition

U_n+/U_n-	Voltage input channel n (voltage only)
M_n+/M_n-	Measuring input channel n
I_n+/I_n-	Current input channel n (current only)
$I_{c\,n}+/I_{c\,n}-$	Current output for RTD, channel n
QV_n	Voltage output channel
QI_n	Current output channel
M_{ANA}	Reference potential of the analog circuit
CHx	Channel or display of the channel status

Infeed element

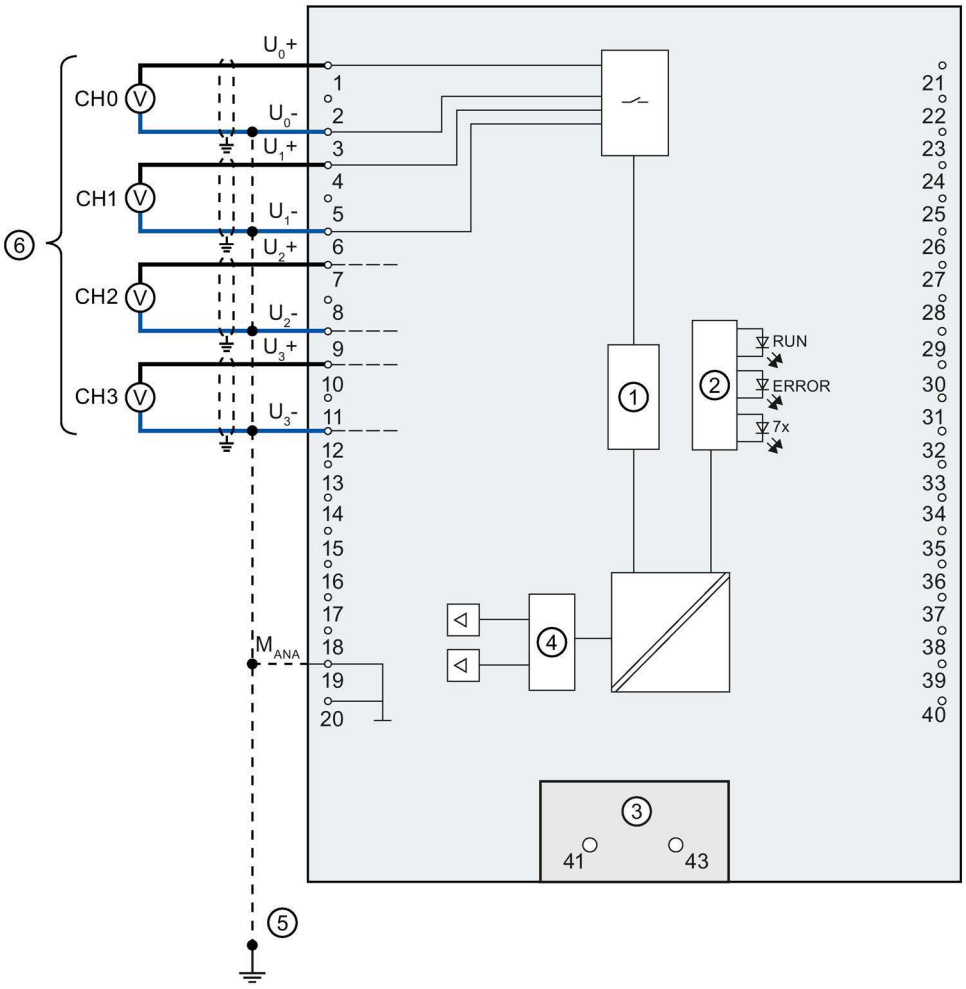
The infeed element is inserted on the front connector and serves to shield the analog on-board I/O.

Note

The analog on-board I/O does not require power to be supplied by the infeed element. The infeed element is, however, necessary for shielding.

Wiring: Voltage measurement

The following figure shows the terminal assignment for voltage measurement at the channels available for this measurement type (channels 0 to 3).

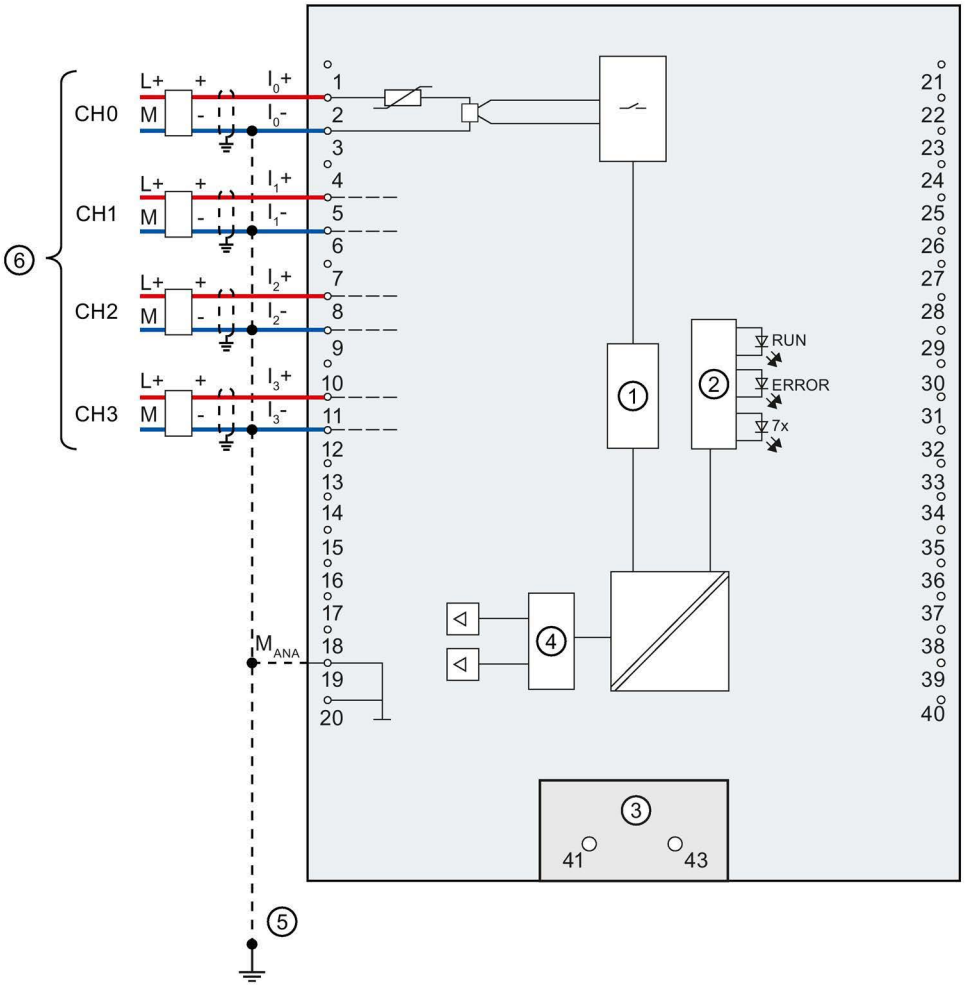


① Analog-to-digital converter (ADC)
② LED interface
③ Infeed element (for shielding only)
④ Digital-to-analog converter (DAC)
⑤ Equipotential bonding cable (optional)
⑥ Voltage measurement

Figure 4-3 Block diagram and terminal assignment for voltage measurement

Wiring: 4-wire measuring transducer for current measurement

The following figure shows the terminal assignment for current measurement with 4-wire measuring transducer at the channels available for this measurement type (channels 0 to 3).

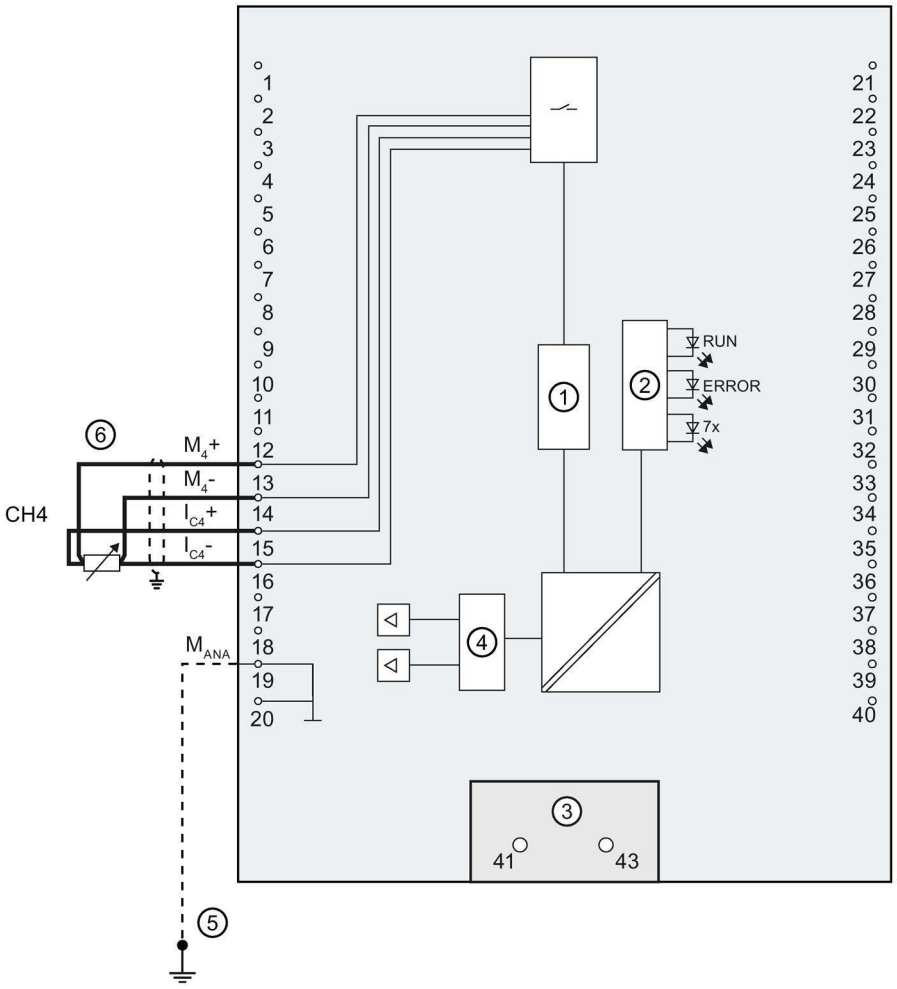


① Analog-to-digital converter (ADC)
② LED interface
③ Infeed element (for shielding only)
④ Digital-to-analog converter (DAC)
⑤ Equipotential bonding cable (optional)
⑥ Connector 4-wire measuring transducer

Figure 4-4 Block diagram and terminal assignment for current measurement with 4-wire measuring transducer

Wiring: 4-wire connection of resistance-type sensors or thermal resistors (RTD)

The following figure shows the terminal assignment for 4-wire connection of resistance-type sensors or thermal resistors at the channel available for this (channel 4).



① Analog-to-digital converter (ADC)
② LED interface
③ Infeed element (for shielding only)
④ Digital-to-analog converter (DAC)
⑤ Equipotential bonding cable (optional)
⑥ 4-wire connection

Figure 4-5 Block diagram and terminal assignment for 4-wire connection

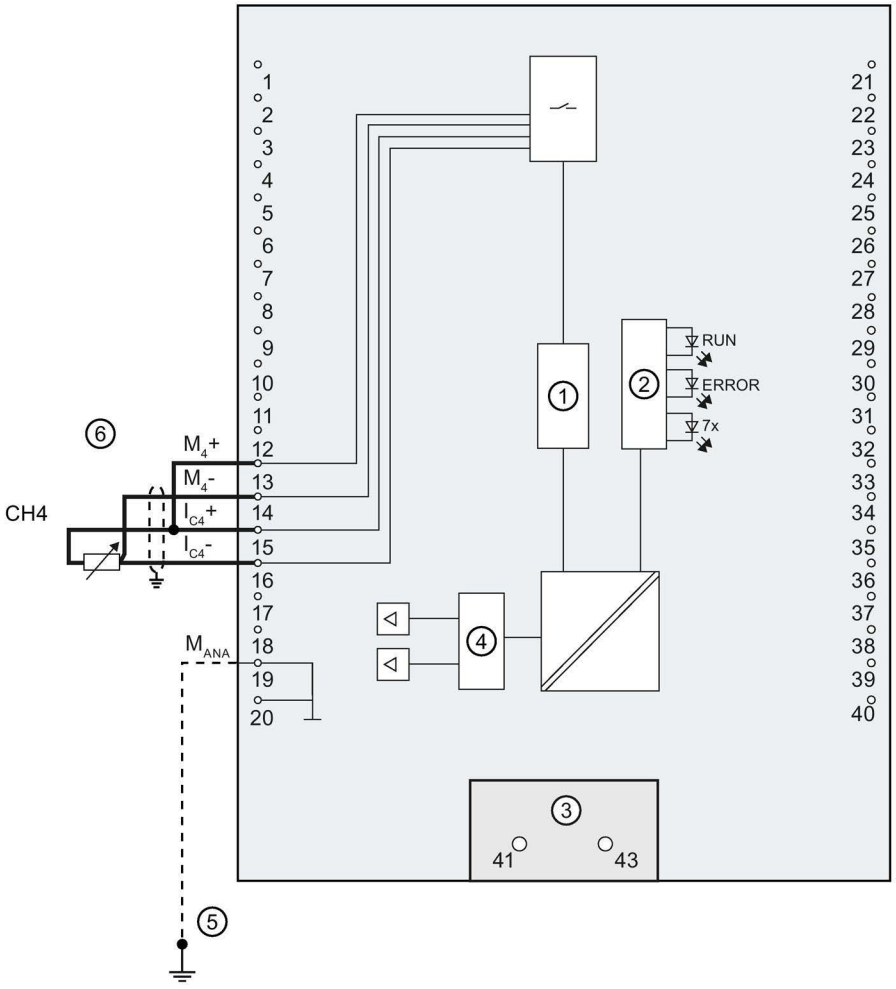
Wiring: 3-wire connection of resistance-type sensors or thermal resistors (RTD)

The following figure shows the terminal assignment for 3-wire connection of resistance-type sensors or thermal resistors at the channel available for this (channel 4).

Note

Parameter assignment of 3-wire connections

Note that line resistances are not compensated with a 3-wire connection.



① Analog-to-digital converter (ADC)
② LED interface
③ Infeed element (for shielding only)
④ Digital-to-analog converter (DAC)
⑤ Equipotential bonding cable (optional)
⑥ 3-wire connection

Figure 4-6 Block diagram and terminal assignment for 3-wire connection

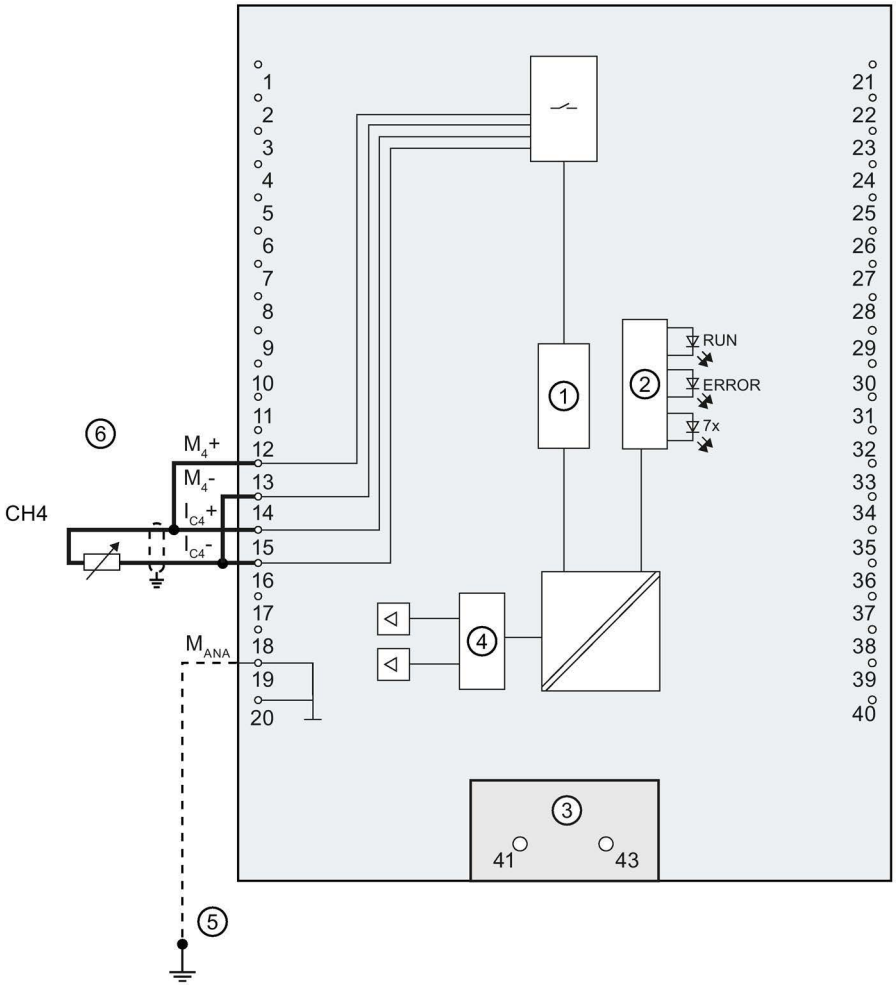
Wiring: 2-wire connection of resistance-type sensors or thermal resistors (RTD)

The following figure shows the terminal assignment for 2-wire connection of resistance-type sensors or thermal resistors at the channel available for this (channel 4).

Note

Parameter assignment of 2-wire connections

Note that line resistances are not compensated with a 2-wire connection.



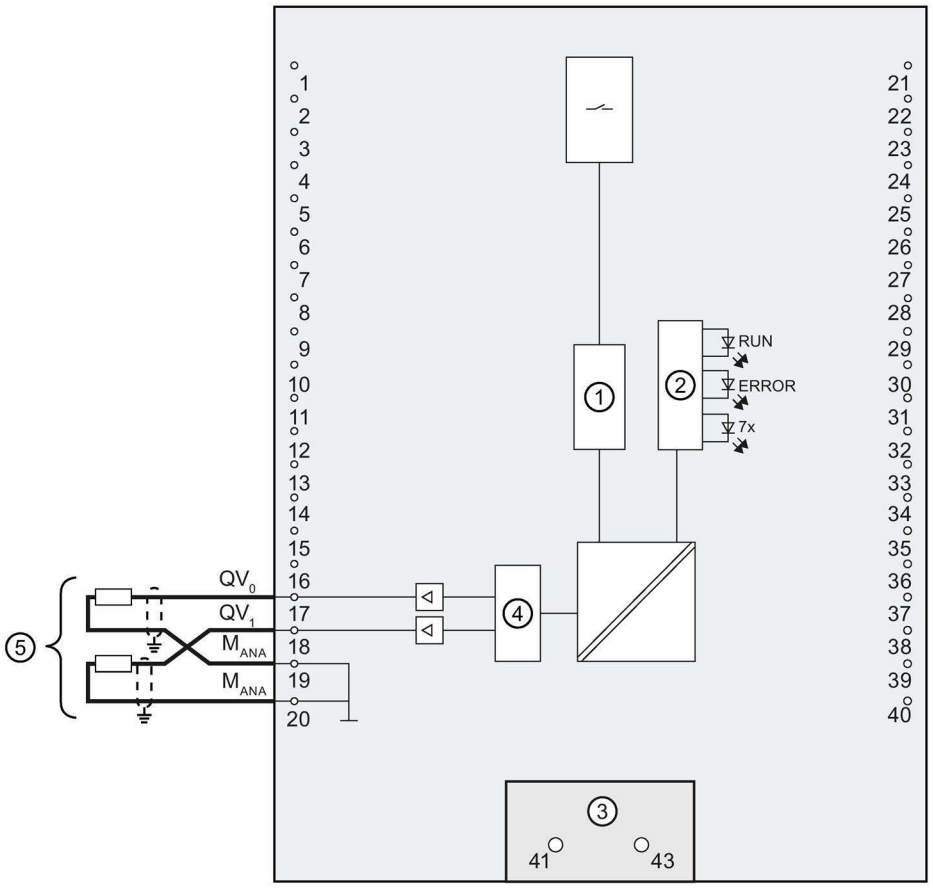
① Analog-to-digital converter (ADC)
② LED interface
③ Infeed element (for shielding only)
④ Digital-to-analog converter (DAC)
⑤ Equipotential bonding cable (optional)
⑥ 2-wire connection

Figure 4-7 Block diagram and terminal assignment for 2-wire connection

Wiring: Voltage output

The figure below shows the terminal assignment for the wiring of the voltage outputs with:

- 2-wire connection, no compensation for line resistances.

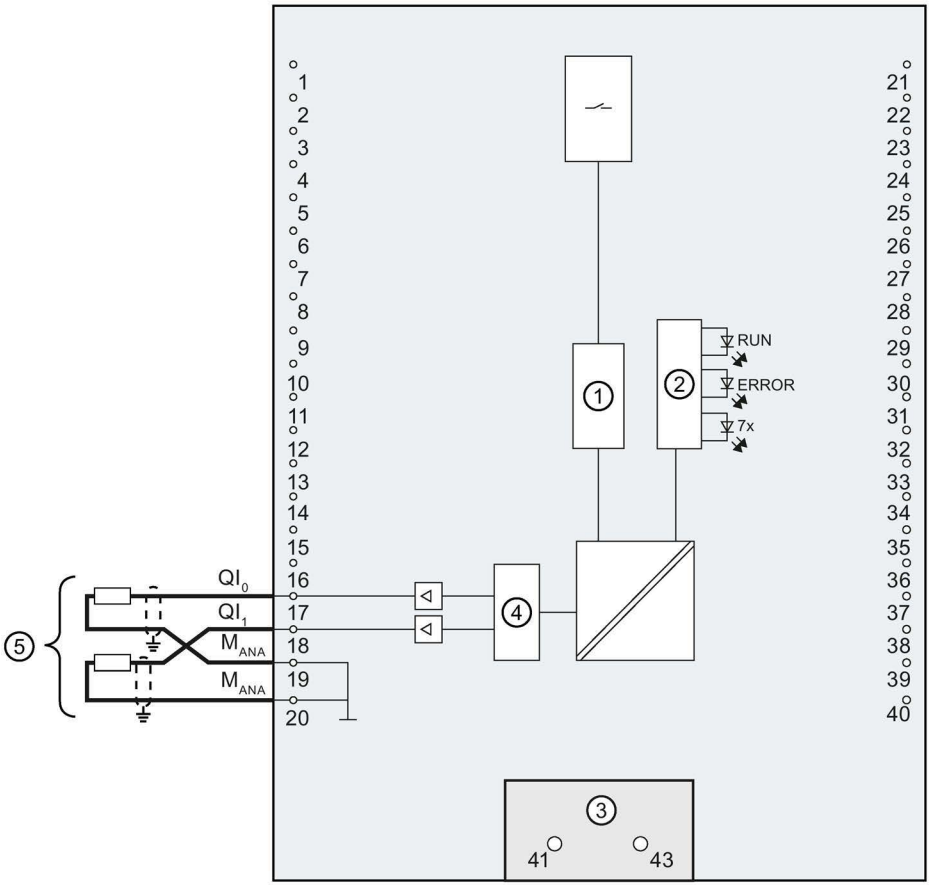


① Analog-to-digital converter (ADC)
② LED interface
③ Infeed element (for shielding only)
④ Digital-to-analog converter (DAC)
⑤ 2-wire connection CH0 and CH1

Figure 4-8 Block diagram and terminal assignment for voltage output

Wiring: Current output

The following figure shows an example of the terminal assignment for wiring current outputs.



① Analog-to-digital converter (ADC)
② LED interface
③ Infeed element (for shielding only)
④ Digital-to-analog converter (DAC)
⑤ Current output CH0 and CH1

Figure 4-9 Block diagram and terminal assignment for current output

4.3.3 Terminal and block diagram of the digital on-board I/O

This section contains the block diagram of the digital on-board I/O (X11 and X12) with standard inputs and outputs and the encoder supply, as well as the rules for the correct wiring of the ground connections.

For information on wiring the front connector, establishing the cable shield, etc., refer to the S7-1500, ET 200MP (http://support.automation.siemens.com/WW/view/en/59191792) system manual.

Infeed element

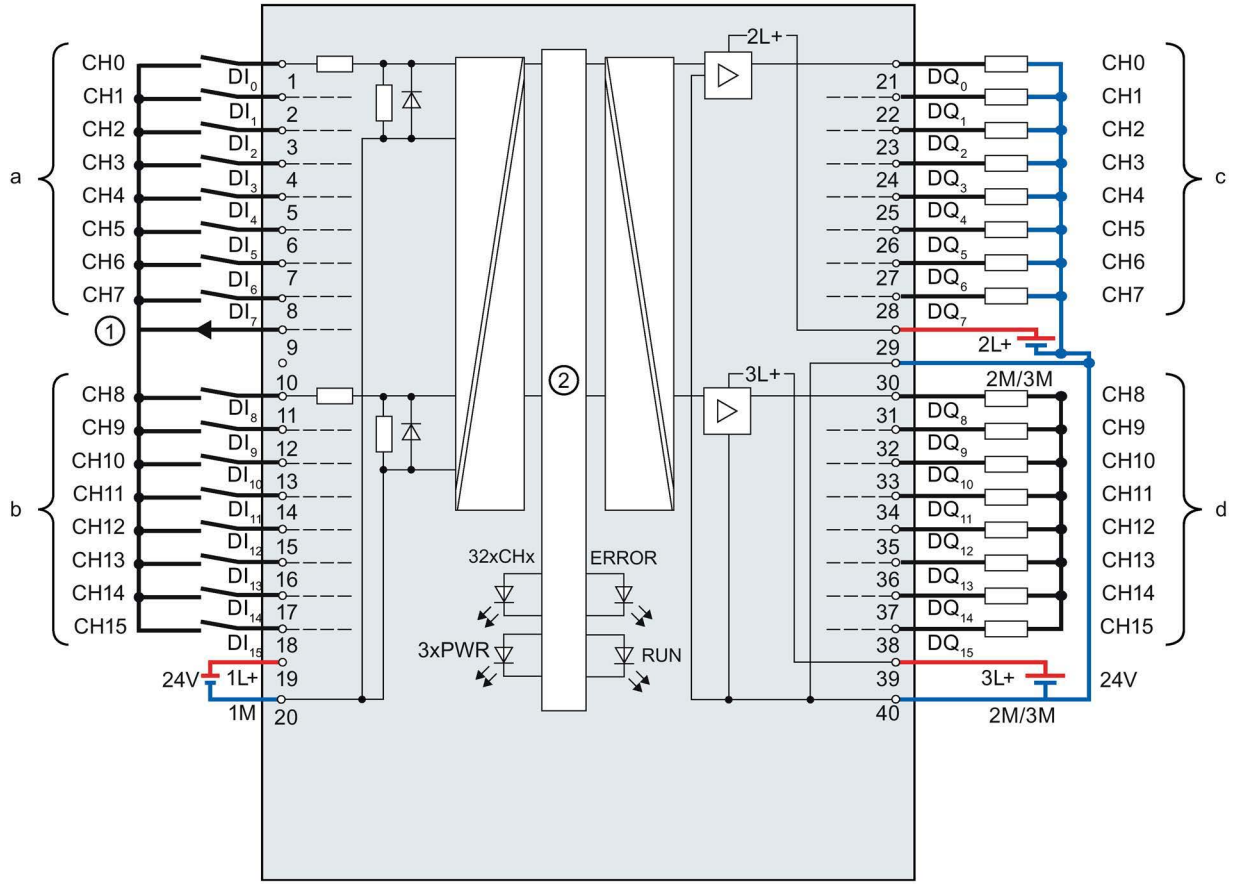
The infeed element is inserted on the front connector and serves to shield the digital on-board I/O.

Note

The digital on-board I/O is supplied via the front connector terminals and therefore does not require power to be supplied by the infeed element. The infeed element is, however, necessary for shielding.

Block diagram and terminal assignment X11

The figure below shows you how to connect the digital on-board I/O X11 and the assignment of the channels to the addresses (input byte a and b, output byte c and d).

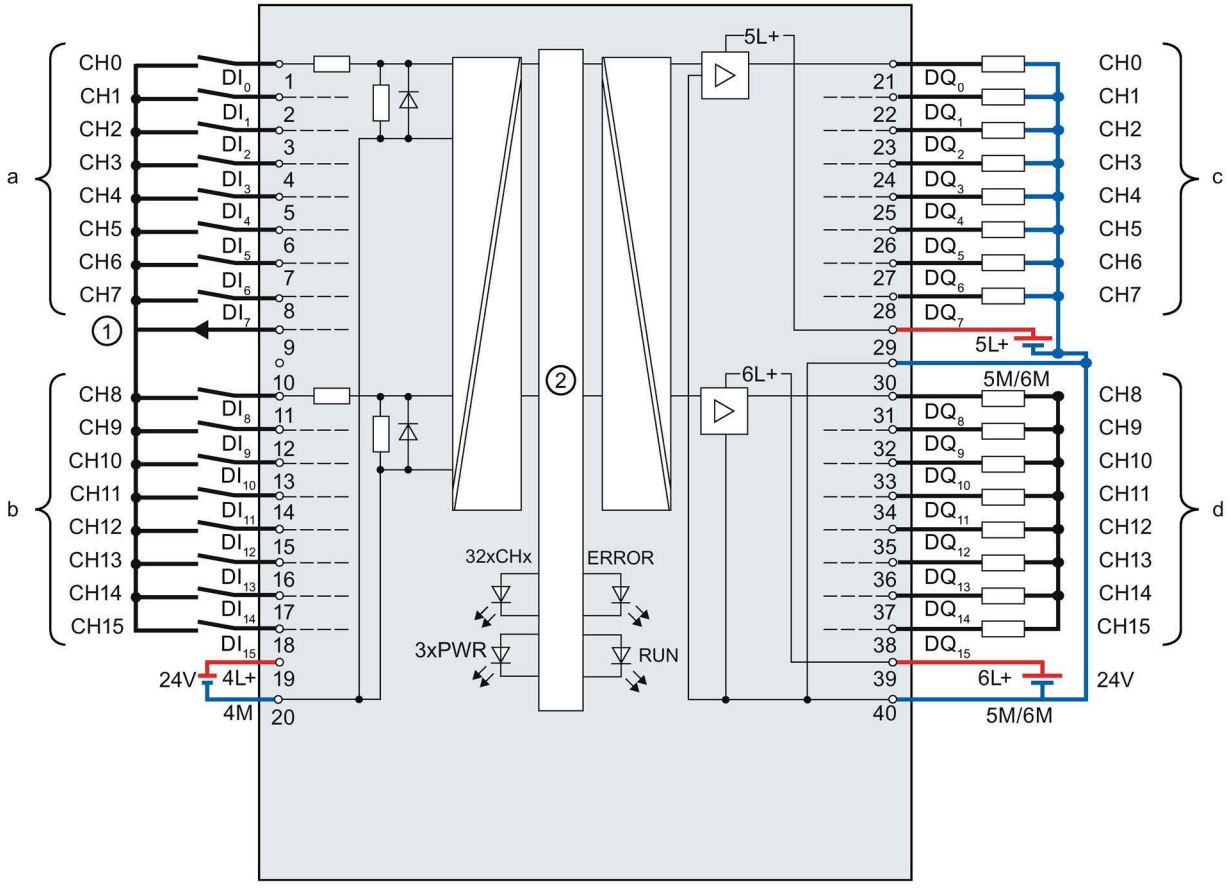


①	Encoder supply for the digital inputs
②	CPU interface
xL+	Connection for 24 V DC supply voltage
xM	Connection for ground
CHx	Channel or channel status LED (green)
RUN	Status display LED (green)
ERROR	Error display LED (red)
PWR	POWER supply voltage LED (green)

Figure 4-10 Block diagram and terminal assignment of the digital on-board I/O X11

Block diagram and terminal assignment X12

The figure below shows you how to connect the digital on-board I/O X12 and the assignment of the channels to the addresses (input byte a and b, output byte c and d).



①	Encoder supply for the digital inputs
②	CPU interface
xL+	Connection for 24 V DC supply voltage
xM	Connection for ground
CHx	Channel or channel status LED (green)
RUN	Status display LED (green)
ERROR	Error display LED (red)
PWR	POWER supply voltage LED (green)

Figure 4-11 Block diagram and terminal assignment of the digital on-board I/O X12

Supply voltage using the digital on-board I/O X11 as an example

The inputs and outputs of the digital on-board I/O are divided into two load groups, which are supplied with 24 V DC.

The digital inputs DI0 to DI15 form a load group and are supplied via the connections 1L+ (terminal 19) and 1M (terminal 20).

The digital outputs DQ0 to DQ7 are supplied via the connection 2L+ (terminal 29). The digital outputs DQ8 to DQ15 are supplied via the connection 3L+ (terminal 39). Please note that the digital outputs DQ0 to DQ15 only have a common ground. In each case, they are led through to the two terminals 30 and 40 (2M/3M) and bridged in the module. The digital outputs form a common load group.

Note

Polarity reversal of the supply voltage

An internal protective circuit protects the digital on-board I/O against destruction if the polarity of the supply voltage is reversed. In the case of polarity reversal of the supply voltage, however, unexpected states can occur at the digital outputs.

Response of the digital outputs to a wire break at ground connection of the outputs

Due to the characteristics of the output driver used in the module, approx. 25 mA supply current flows out through the outputs via a parasitic diode in the event of a ground wire break. This behavior can lead to non-set outputs also carrying high levels and emitting up to 25 mA output current. Depending on the type of load, 25 mA can be sufficient to control the load with high level. To prevent unintended switching of the digital outputs in the event of a ground wire break, follow these steps:

Wire to ground twice

Connect ground to terminal 30 and to terminal 40.

1. Route the first ground connection from terminal 30 to the central ground connection of the plant.

2. Route the second ground connection from terminal 40 to the central ground connection of the plant.

If terminal 30 or 40 are interrupted by a ground wire break, the outputs will continue to be supplied via the second, intact ground connection.

⚠ WARNING

Wire break at ground connection

Never bridge from terminal 30 to terminal 40 in the front connector and **never** lead only one wire to the central ground connection.

Connect terminal 30 and terminal 40 to a common ground point.

As a supplement to the block diagram and terminal assignment, the following figure shows the correct wiring of the outputs in order to prevent switching of the outputs in the event of a ground wire break.

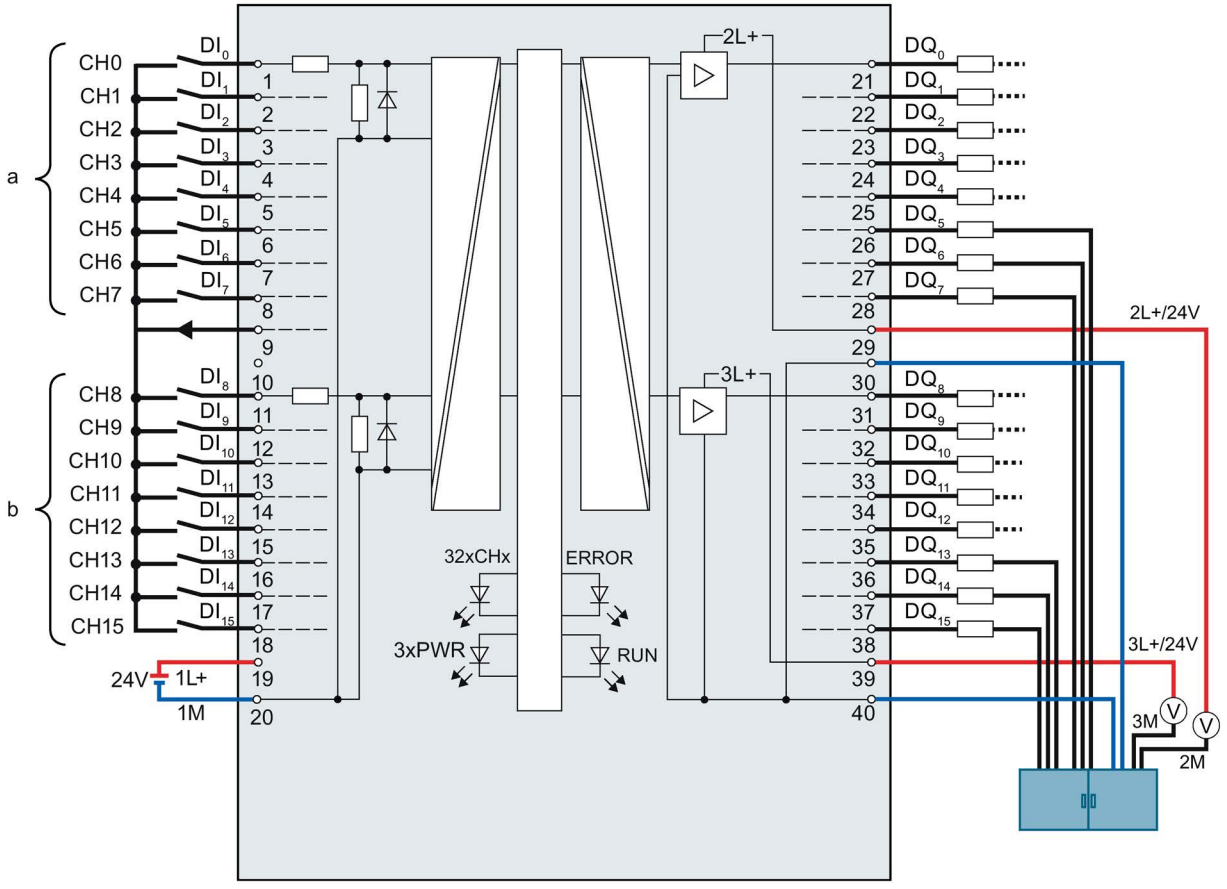


Figure 4-12 Correct wiring using the digital on-board I/O X11 as an example

The ground is supplied with a first cable from the central terminal block to terminal 30 of the module and additionally with a second cable also from the central terminal block to terminal 40 of the module.

At the digital outputs, each of the ground connections of the loads is connected with a separate cable for each load to the central terminal block.

The figure below shows the current flow with correct wiring.

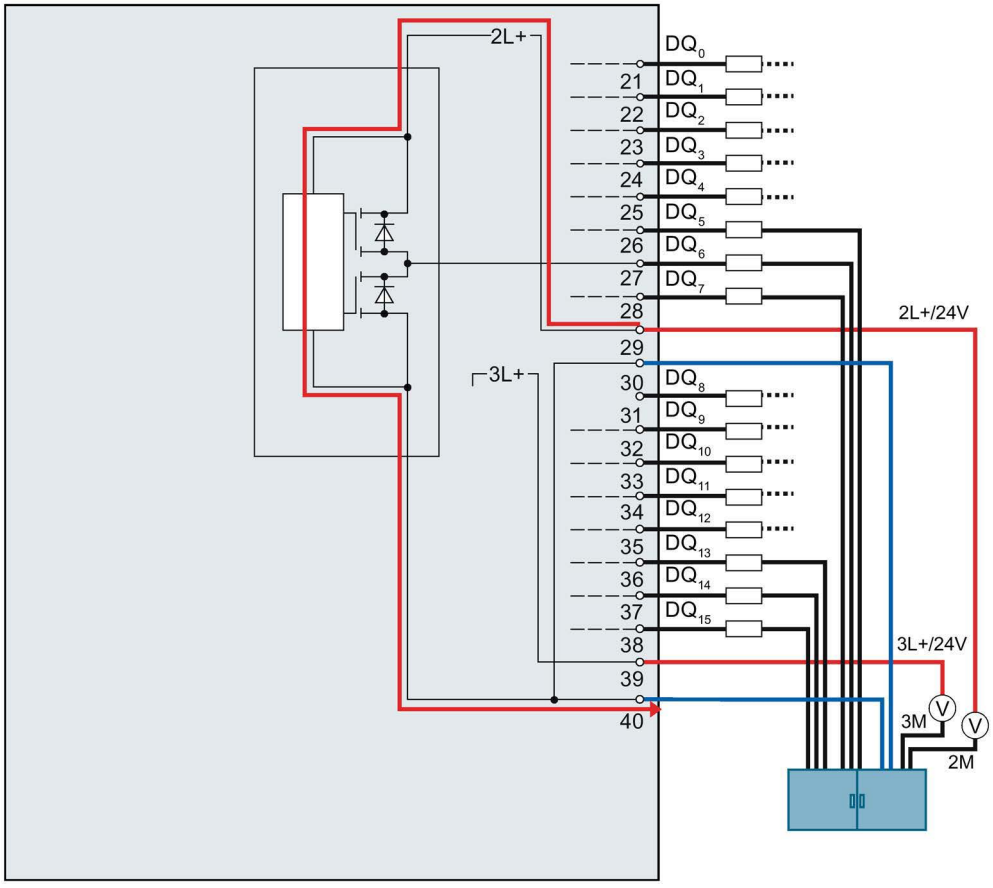


Figure 4-13 Current flow with correct wiring using the digital on-board I/O X11 as an example

With correct wiring, the supply current flows from the power supply 2L+ via terminal 29 to the module. In the module, the current flows via the output driver and exits the module via terminal 40.

The figure below shows the reaction to interruption of the first ground cable.

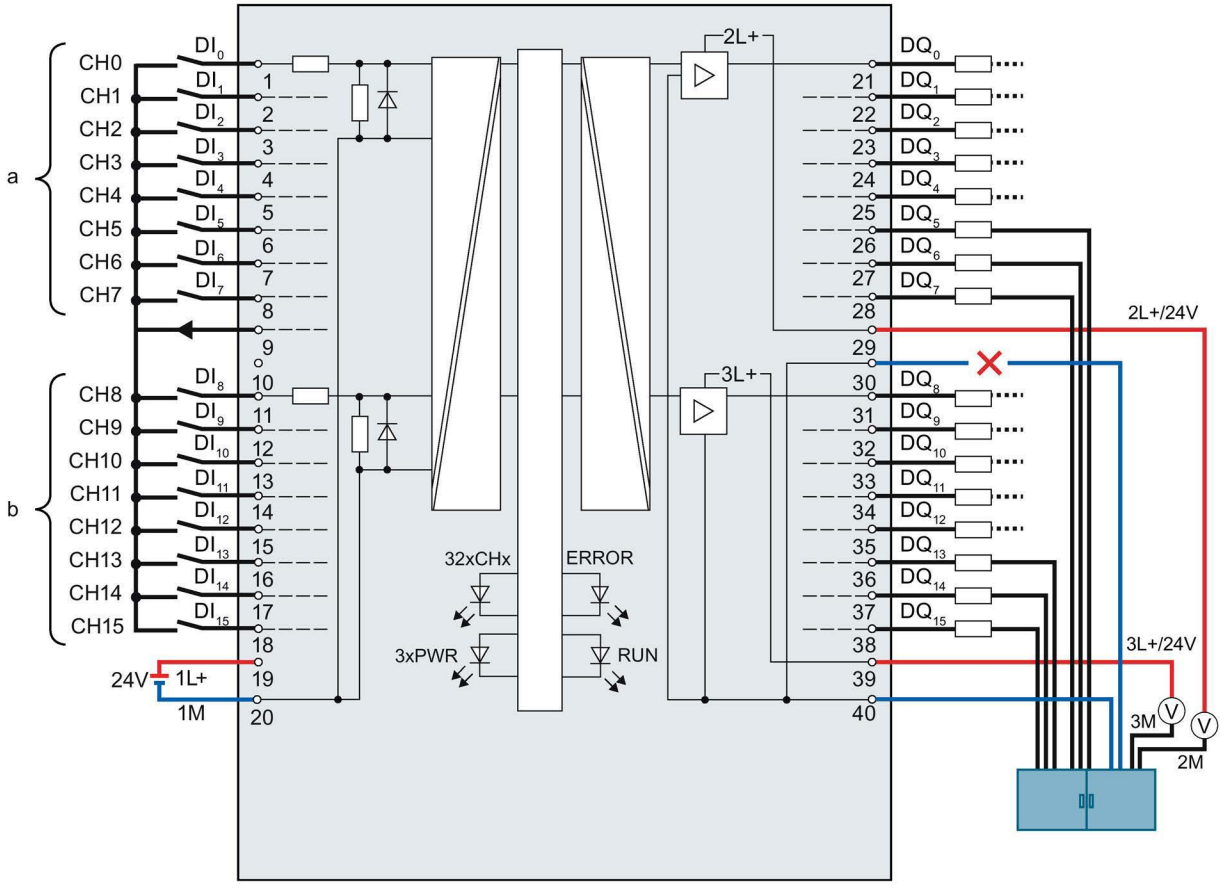


Figure 4-14 Interruption of the first ground cable using the digital on-board I/O X11 as an example

If a wire break occurs on the first ground cable from the central terminal block to terminal 30, the module can continue to operate without restrictions, as it is still connected to the ground via the second cable from the central terminal block to terminal 40.

The figure below shows the reaction to interruption of the second ground cable.

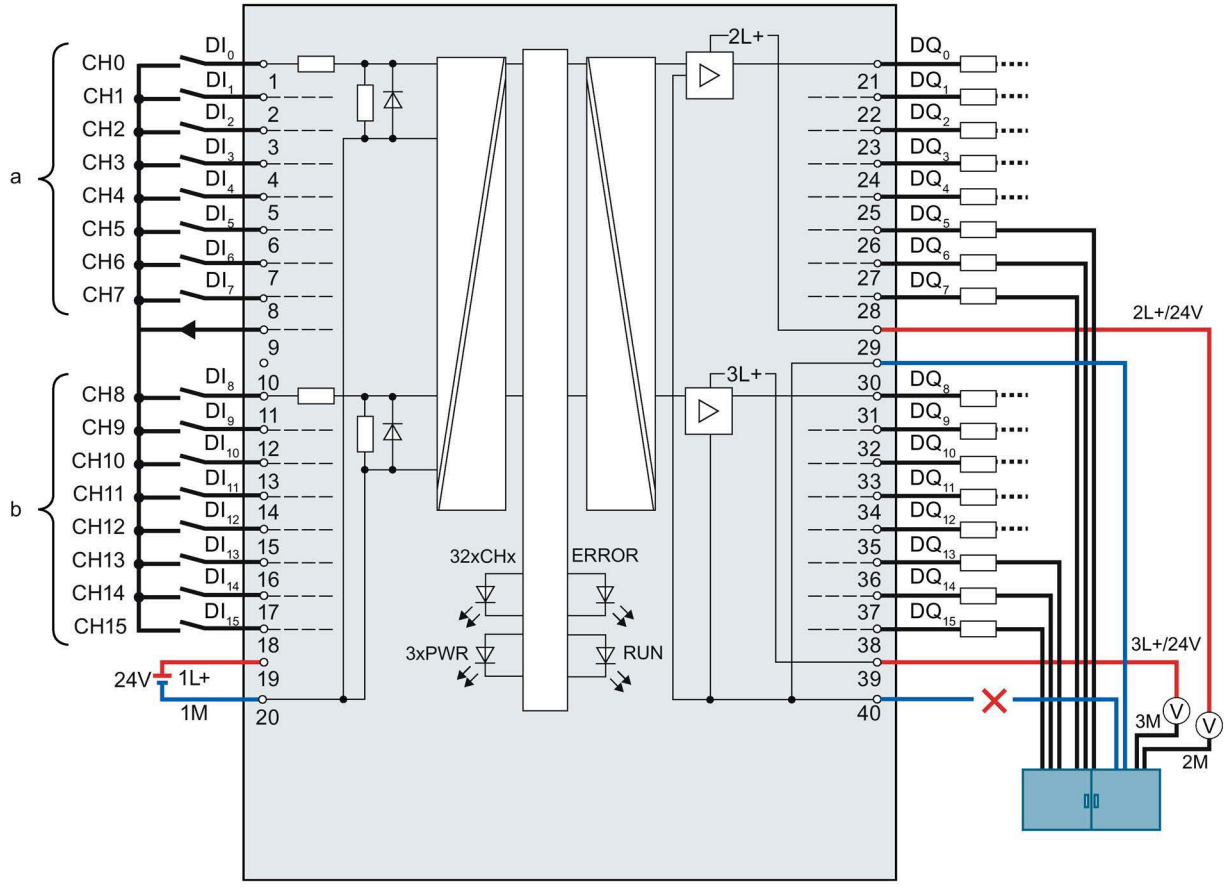


Figure 4-15 Interruption of the second ground cable using the digital on-board I/O X11 as an example

If a wire break occurs on the second ground cable from the central block terminal to terminal 40, the module can continue to operate without restrictions, as it is still connected to the ground via the first cable from the central terminal block to terminal 30.

The figure below shows the current flow upon interruption of both ground cables.

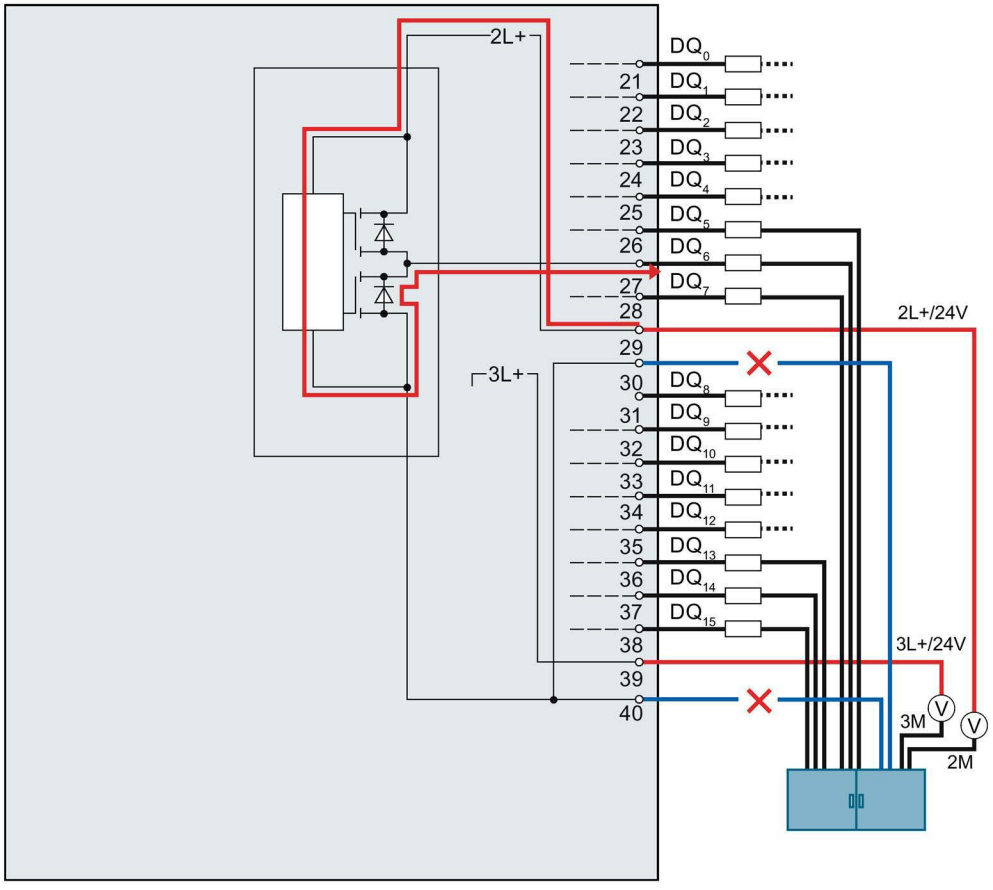


Figure 4-16 Current flow upon interruption of both ground cables using the digital on-board I/O X11 as an example

If a wire break occurs on the first and on the second ground cable from the central terminal block to the terminals 30 and 40 of the module, a malfunction occurs on the module. Both ground connections of the module are interrupted.

The supply current flows from the power supply 2L+ via terminal 29 to the module. In the module, the current flows via the output driver into the parasitic diode and exits the module via the output terminal, e.g. as shown in the figure via terminal 27. The supply current therefore flows via the connected load. The internal supply current is typically 25 mA.

WARNING

Interruption of both ground cables

If the ground terminals 30 and 40 are interrupted, the following incorrect response can occur:

The activated outputs, which are switched to high, start to switch continuously. If the load connected at the output is sufficiently small, the output is continuously activated.

Faulty wiring

The following figure shows faulty wiring, which has a bridge on the front connector.

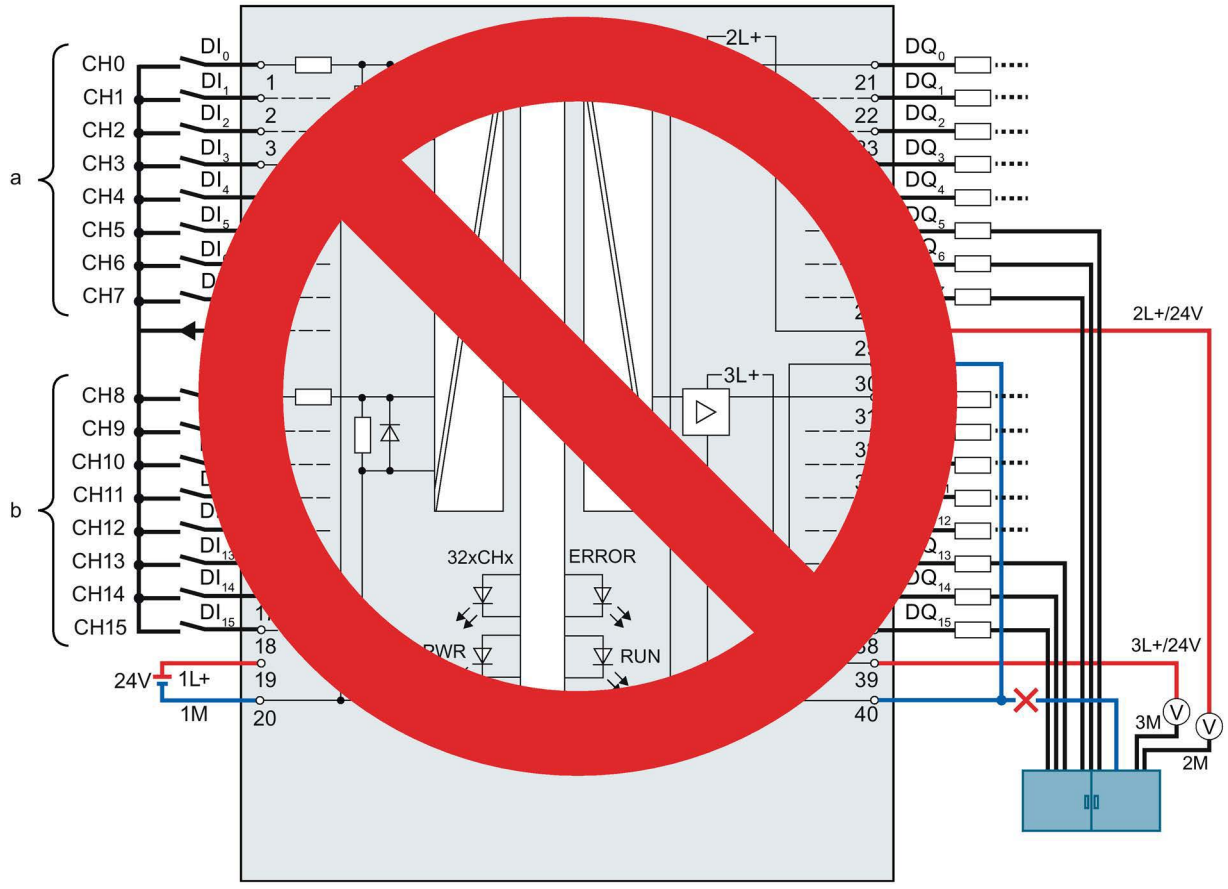
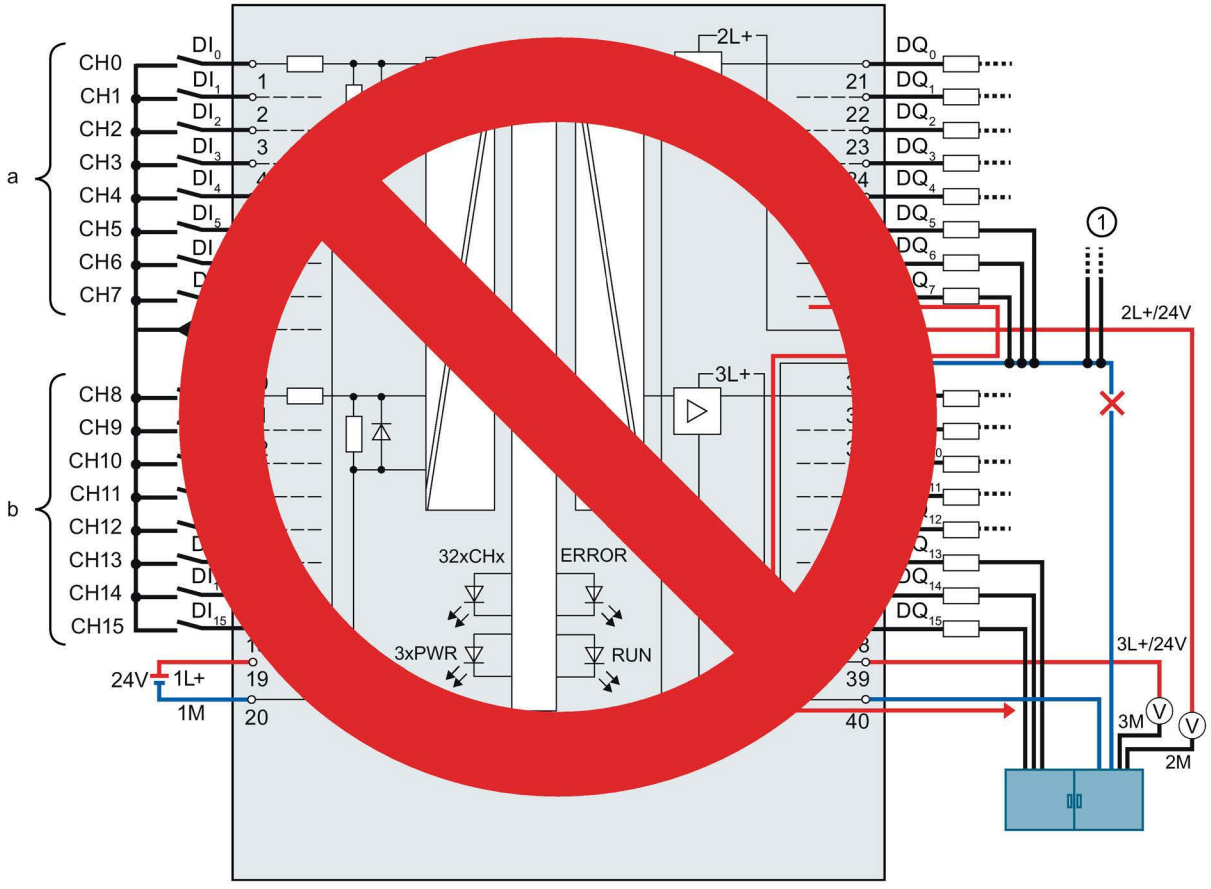


Figure 4-17 Faulty wiring using the digital on-board I/O X11 as an example: Bridge

The terminals 30 and 40 are connected in the front connector and only routed with one cable to the central terminal block. If this cable breaks, terminals 30 and 40 are no longer connected to the ground. The module's supply current flows out via the output terminal.

The figure below shows the current flow when the ground connections of the loads and the ground connection of terminal 30 are routed with a common cable to the central terminal block.



① Ground connections of other plant parts that can also carry large currents.

Figure 4-18 Faulty wiring using the digital on-board I/O X11 as an example: Common cable

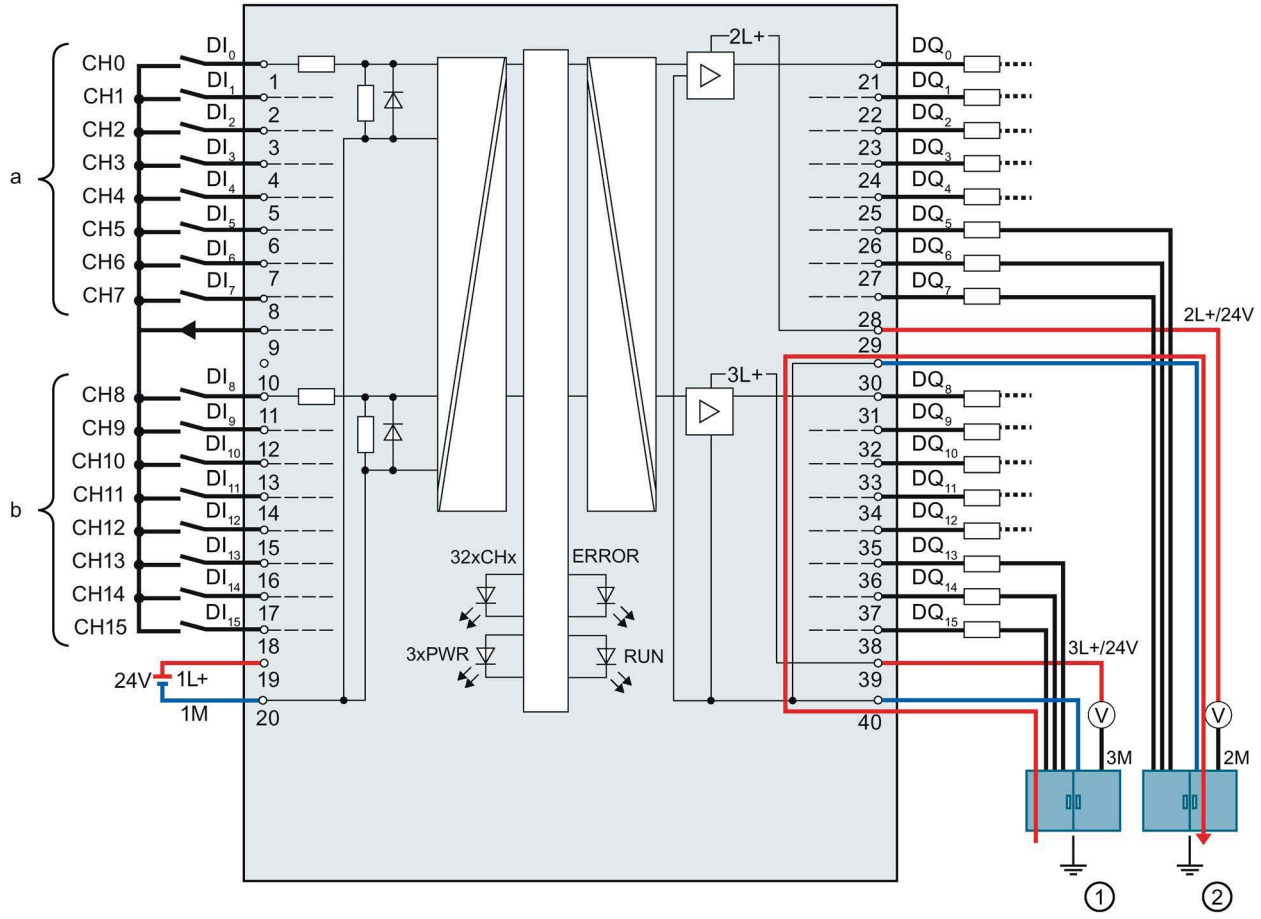
If a break occurs in the common cable, the current of the outputs flows via terminal 30 to the module and via terminal 40 to the central terminal block. The current flows via the module.

WARNING

Current flow with faulty wiring

If a break occurs in the common cable, the current can be very high, depending on the plant, and lead to the destruction of the module.

The figure below shows the current flow with correct wiring when a potential difference exits between the grounding points.



① Grounding point functional earth 1 (FE 1)
② Grounding point functional earth 2 (FE 2)

Figure 4-19 Potential difference using the digital on-board I/O X11 as an example

Potential equalization occurs via terminals 30 and 40. When a potential difference exists between the grounding points FE1 and FE2, the compensating current flows via terminals 30 and 40.

WARNING

Current flow with faulty wiring

In the event of a potential difference, the current can be very high, depending on the potential conditions, and lead to the destruction of the module.

Input filter for digital inputs

To suppress disruptions, you can configure an input delay for the digital inputs.

You can specify the following values for the input delay:

- None
- 0.05 ms
- 0.1 ms
- 0.4 ms
- 1.6 ms
- 3.2 ms (default setting)
- 12.8 ms
- 20 ms

Note

Shielding

If you use standard digital inputs with "None" set as the input delay, you must use shielded cables. Shielding and the infeed element are recommended for use of standard digital inputs starting from an input delay of 0.05 ms but are not absolutely necessary.

4.3.4 Addresses of the high-speed counters

You connect the encoder signals, the digital input and output signals and the encoder supplies to the two 40-pin front connectors of the digital on-board I/O. For information on wiring the front connectors, establishing the cable shields, etc., refer to the S7-1500, ET 200MP (http://support.automation.siemens.com/WW/view/en/59191792) system manual.

Encoder signals

The 24 V encoder signals are designated with letters A, B and N. You can connect the following encoder types:

- Incremental encoder with signal N:

  Signals A, B and N are connected using the correspondingly marked connections. Signals A and B are the two incremental signals, phase-shifted by 90°. N is the zero mark signal that supplies a pulse per revolution.

- Incremental encoder without signal N:

  Signals A and B are connected using the correspondingly marked connections. Signals A and B are the two incremental signals, phase-shifted by 90°.

- Pulse encoder without direction signal:

  The count signal is connected to the A connection.

- Pulse encoder with direction signal:

  The count signal is connected to the A connection. The direction signal is connected to the B connection.

- Pulse encoder with up/down count signal:

  The up count signal is connected to the A connection. The down count signal is connected to the B connection.

You can connect the following encoders or sensors to the A, B and N inputs:

- Sourcing:
  The encoder or sensor switches the A, B and N inputs to 24 V DC.
- Push-pull:
  The encoder or sensor switches the A, B and N inputs alternately to 24 V DC and to ground M.

Digital inputs HSC DI0 and HSC DI1

The digital inputs are logically assigned to the high-speed counters (HSC). For the possible assignment of the inputs of the on-board I/O to the high-speed counters, refer to the "HSC addresses of inputs" table. Up to two digital inputs are available for each high-speed counter. You can use the digital inputs for the gate control (Gate), synchronization (Sync) and Capture functions. Alternatively, you can use one or more digital inputs as standard digital inputs without the functions mentioned and read the signal state of the respective digital input using the feedback interface.

Digital inputs that you do not use for high-speed counting are available for use as standard DIs.

Input addresses of the high-speed counters

You set the digital input addresses used by the high-speed counters (HSC) and the assignment of A/B/N, DI0, DI1 and DQ1 signals in the hardware configuration in STEP 7. You can enable and configure each HSC when you configure the compact CPU.

The compact CPU assigns the input addresses for the A/B/N signals automatically according to the configuration.

You specify the input addresses for DI0 and DI1 according to the table "HSC addresses of inputs". The interconnection produces a direct connection of the HSC to an input of the on-board I/O. The high-speed counter then uses this input as HSC DI0 or HSC DI1 ([DI] symbol). The [DI] symbols in the table identify the input addresses for HSC DI0 and HSC DI1 that are offered for selection in the hardware configuration.

Assignment of HSC addresses of inputs

The "HSC addresses of inputs" table provides an overview of all possible interconnections of the inputs (DI0 to DI15) to the available high-speed counters (HSC1 to HSC6).

Table 4- 3 HSC addresses of inputs

HSC	DI0	DI1	DI2	DI3	DI4	DI5	DI6	DI7	DI8	DI9	DI10	DI11	DI12	DI13	DI14	DI15
HSC1	A	[B]	[N]													
									[DI]	[DI]	[DI]	[DI]	[DI]	[DI]	[DI]	[DI]
HSC2				A	[B]	[N]										
									[DI]	[DI]	[DI]	[DI]	[DI]	[DI]	[DI]	[DI]
HSC3							A	[B]	[N]							
									[DI]	[DI]	[DI]	[DI]	[DI]	[DI]	[DI]	[DI]

HSC	DI0	DI1	DI2	DI3	DI4	DI5	DI6	DI7	DI8	DI9	DI10	DI11	DI12	DI13	DI14	DI15
HSC4	A	[B]	[N]													
									[DI]	[DI]	[DI]	[DI]	[DI]	[DI]	[DI]	[DI]
HSC5				A	[B]	[N]										
									[DI]	[DI]	[DI]	[DI]	[DI]	[DI]	[DI]	[DI]
HSC6							A	[B]	[N]							
									[DI]	[DI]	[DI]	[DI]	[DI]	[DI]	[DI]	[DI]

The specified signal type is marked as optional by the square brackets [...]

[DI] stands for [HSC DI0/HSC DI1] = optional DI, B or N function: Technology or standard mode

The assignment to [B] or [N] takes precedence over the assignment to HSC DI0 or HSC DI1. This means that input addresses that are assigned to count signal [B] or [N] based on the selected signal type cannot be used for other signals such as HSC DI0 or HSC DI1.

The following table shows an example of the possible signal assignments of the inputs, broken down to signals A, B, N, HSC DI0 and HSC DI1 for the high-speed counter HSC1.

Table 4- 4 Signal assignment of the inputs of HSC1

HSC	Signal	DI0	DI1	DI2	DI3	DI4	DI5	DI6	DI7	DI8	DI9	DI10	DI11	DI12	DI13	DI14	DI15
HSC1	A	Yes															
	B		[Yes] 1)														
	N			[Yes] 1)													
	HSC DI0									[Yes] 2)	[Yes] 2)	[Yes] 2)	[Yes] 2)	[Yes] 2)	[Yes] 2)	[Yes] 2)	[Yes] 2)
	HSC DI1									[Yes] 2)	[Yes] 2)	[Yes] 2)	[Yes] 2)	[Yes] 2)	[Yes] 2)	[Yes] 2)	[Yes] 2)

The specified signal type is marked as optional by the square brackets [...]

Yes = The signal type specified in the "Signal" column can be assigned to the respective input

1) Depending on the selected signal type

2) Can be selected by the user

Note

HSC compatibility mode

The displayed interconnection options assume that the option "Front connector assignment like CPU 1511C" is deactivated. If the option is enabled, the input signals are interconnected the same way as for the CPU 1511C-1 PN. In this case, the interconnection options of the CPU 1511C-1 PN manual apply.

Digital outputs HSC-DQ0 and HSC-DQ1

Two digital outputs are available for each high-speed counter. Digital output HSC-DQ0 is a logical output that cannot be interconnected with a digital output of the on-board I/O. Digital output HSC-DQ0 can only be used by the user program. HSC-DQ1 is a physical output that can be interconnected with a digital output of the on-board I/O.

The digital outputs are 24 V sourcing output switches relative to M and can be loaded with a rated load current of 0.1 A. The outputs used as standard outputs have a rated load current of 0.5 A. The digital outputs are protected against overload and short-circuit.

Note

It is possible to directly connect relays and contactors without external wiring. For information on the maximum possible operating frequencies and the inductance values of the inductive loads at the digital outputs, refer to the Technical specifications section.

The following table shows which high-speed counters you can interconnect to which digital outputs. Digital outputs to which no high-speed counter is interconnected can be used as standard outputs. The maximum output delay of each digital output used as standard output is 500 µs.

Table 4- 5 Interconnection options of digital outputs to high-speed counters

Front connector	Channel		Use as HSC output	
			Can be used as HSC-DQ1	Max. output delay
X11	Channel 0	DQ0	No	--
	Channel 1	DQ1	Yes, for HSC1	5 µs
	Channel 2	DQ2	No	--
	Channel 3	DQ3	Yes, for HSC2	5 µs
	Channel 4	DQ4	Yes, for HSC3	
	Channel 5	DQ5	Yes, for HSC4	
	Channel 6	DQ6	Yes, for HSC6	
	Channel 7	DQ7	Yes, for HSC5	
	Channel 8	DQ8	No	--
	Channel 9	DQ9	Yes, for HSC1	500 µs
	Channel 10	DQ10	No	--
	Channel 11	DQ11	Yes, for HSC2	500 µs
	Channel 12	DQ12	Yes, for HSC3	
	Channel 13	DQ13	Yes, for HSC4	
	Channel 14	DQ14	Yes, for HSC6	
	Channel 15	DQ15	Yes, for HSC5	
X12	It is not possible to interconnect the digital outputs of the front connector X12 to high-speed counters. The digital outputs of the front connector X12 can only be used as standard outputs.			

Shielding

Note

When you use digital inputs/outputs with technology functions, i.e. interconnect high-speed counters with the inputs/outputs, you must use shielded cables and the infeed element for shielding.

Reference

For more information on configuring the inputs of the high-speed counters, refer to the S7-1500, ET 200MP, ET 200SP Counting, measurement and position detection (http://support.automation.siemens.com/WW/view/en/59709820) function manual and the STEP 7 online help.

Parameters/address space

5

5.1 Address space of the analog on-board I/O

Address space 1 x 7-channel analog on-board I/O

The addresses are assigned automatically by STEP 7. You can change the addresses in the hardware configuration of STEP 7, i.e. freely assign the start address. The addresses of the channels are based on the start address.

"IBx" represents the start address input byte x. "QBx" represents the start address output byte x.

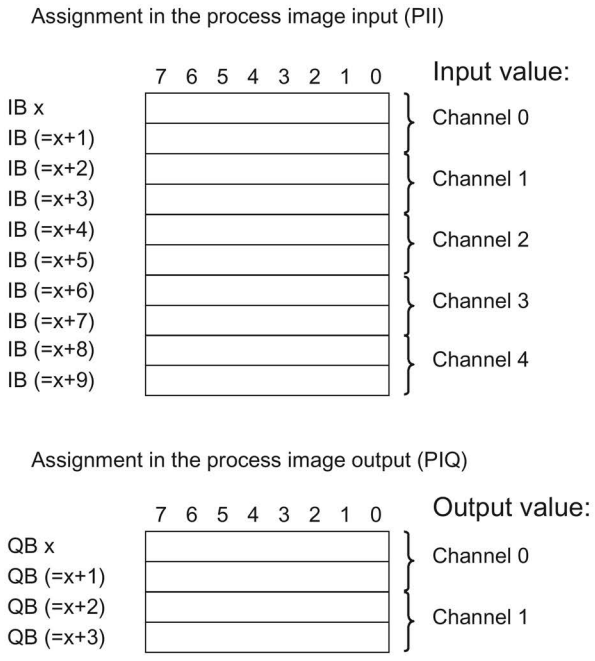


Figure 5-1 Address space 7-channel analog on-board I/O

5.2 Address space of the digital on-board I/O

Address space 2 x 32-channel digital on-board I/O

The addresses are assigned automatically by STEP 7. You can change the addresses in the hardware configuration of STEP 7, i.e. freely assign the start address. The addresses of the channels are based on the start address.

The letters "a" to "d" are lasered on the on-board I/O. "IB a" for example, stands for start address input byte a.

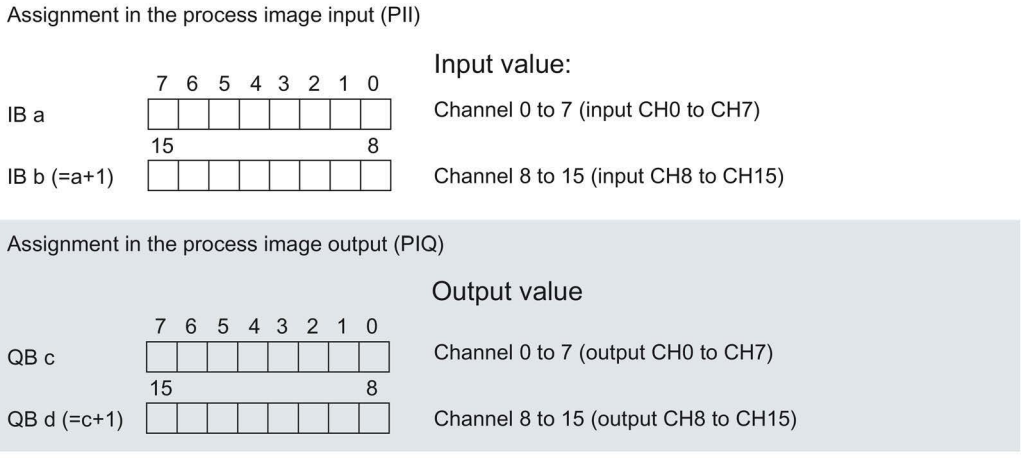


Figure 5-2 Address space of the first module of the 2 x 32-channel digital on-board I/O (16 digital inputs/16 digital outputs)

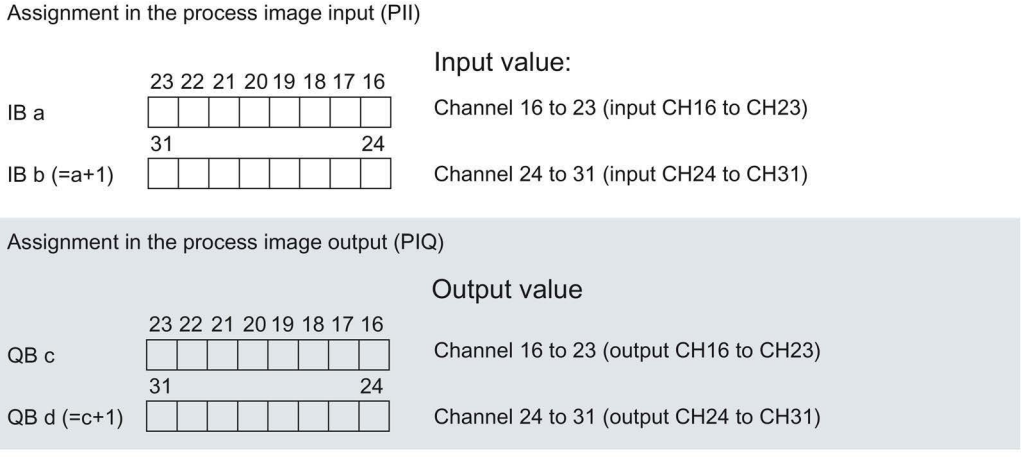


Figure 5-3 Address space of the second module of the 2 x 32-channel digital on-board I/O (16 digital inputs/16 digital outputs)

5.3 Address space of the technology functions

Address space

Table 5- 1 Size of the input and output addresses of the high-speed counters

	Inputs	Outputs
Size per high-speed counter (6x)	16 bytes	12 bytes

Table 5- 2 Size of the input and output addresses in operating mode "Position detection for Motion Control"

	Inputs	Outputs
Size per high-speed counter (6x)	16 bytes	4 bytes

Reference

For a description of the control interface, refer to the section Assignment of the control interface (Page 34). For a description of the feedback interface, refer to the section Assignment of the feedback interface (Page 35).

5.4 Measurement types and measuring ranges of the analog on-board I/O

Introduction

The analog on-board I/O is set to voltage measurement type and measuring range ±10 V by default for the inputs on channels 0 to 3. By default, channel 4 is set to resistance measuring type and measuring range 600 Ω. If you want to use another measurement type or measuring range, change the parameter settings of the analog on-board I/O with STEP 7.

Disable unused inputs to prevent disturbances that cause incorrect behavior (e.g. triggering of a hardware interrupt).

Measurement types and measuring ranges

The following table shows the measurement types, the measuring range and the possible channels.

Table 5- 3 Measurement types and measuring range

Measurement type	Measuring range	Channel
Voltage	0 to 10 V 1 to 5 V ±5 V ±10 V	0 to 3
Current 4WMT (4-wire measuring transducer)	0 to 20 mA 4 to 20 mA ±20 mA	0 to 3
Resistance	150 Ω 300 Ω 600 Ω	4
Thermal resistor RTD	Pt 100 Standard/Climate Ni 100 Standard/Climate	4
Disabled	-	-

The tables of the input ranges, overflow, underrange, etc. can be found in the appendix .

5.5 Output type and output ranges of the analog on-board I/O

Introduction

The analog on-board I/O is set to voltage output type and output output range ±10 V as default for the outputs. If you want to use another output range or output type, you need to change the parameter settings of the the analog on-board I/O in STEP 7.

Output types and output ranges

The following table shows the output type and the corresponding output ranges.

Table 5- 4 Output type and output ranges

Output type	Output range
Voltage	1 to 5 V 0 to 10 V ±10 V
Current	0 to 20 mA 4 to 20 mA ±20 mA
Disabled	-

5.6 Parameters of the analog on-board I/O

Parameters of the analog on-board I/O

You specify the properties of the analog on-board I/O during parameter assignment with STEP 7. The tables below list the parameters that can be set for inputs and outputs, respectively. The effective range of the parameters that can be set depends on the type of configuration.

In the case of parameter assignment in the user program, the parameters are transferred to the analog on-board I/O via data records with the WRREC instruction, see section Parameter data records of the analog on-board I/O (Page 110).

Configurable parameters and default settings for inputs

Table 5- 5 Configurable "Diagnostics" parameters

Parameter	Value range	Default	Reconfiguration in RUN	Effective range with STEP 7 (TIA Portal)	
Diagnostics					
• Overflow	Yes/No	No	Yes	Channel	Module [2]
• Underflow	Yes/No	No	Yes	Channel	Module [2]
• Wire break [1]	Yes/No	No	Yes	Channel	Module [2]
• Current limit for wire break diagnostics	1.185 mA or 3.6 mA	1.185 mA	Yes	Channel	--- [3]

[1] Only for the "Voltage" measurement type in the measuring range 1 to 5 V and for the "Current" measurement type in the measuring range 4 to 20 mA

[2] You can set the effective range of the diagnostics for each channel in the user program with data records 0 to 3.

[3] You can set the current limit for wire break diagnostics and the limits for hardware interrupts in the user program with data records 0 to 3.

Table 5- 6 Configurable "Measuring" parameters

Parameter	Value range	Default	Reconfiguration in RUN	Effective range with STEP 7 (TIA Portal)	
Measuring					
• Measurement type	See section Measurement types and measuring ranges (Page 70).	Voltage (channels 0 to 3) Resistance (channel 4)	Yes	Channel	Channel
• Measuring range		±10 V (channels 0 to 3) 600 Ω (channel 4)	Yes	Channel	Channel
• Temperature coefficient	Pt: 0.003851 Pt: 0.003916 Pt: 0.003902 Pt: 0.003920 Ni: 0.006180 Ni: 0.006720	0.003851	Yes	Channel	Channel
• Temperature unit	• Kelvin (K) [1] • Fahrenheit (°F) • Celsius (°C)	°C	Yes	Channel	Module
• Interference frequency suppression	400 Hz 60 Hz 50 Hz 10 Hz	50 Hz	Yes [2]	Channel	Module
• Smoothing	None/weak/medium/strong	None	Yes	Channel	Channel

[1] Kelvin (K) is only possible for the "Standard range" measuring range and not for the "Climatic range" measuring range

[2] The interference frequency suppression must have the same value for all active input channels. This value can only be changed through reconfiguration in RUN with single channel parameter assignment (data records 0 to 4) if all other input channels are disabled.

Table 5- 7 Configurable "Hardware interrupt" parameters

Parameter	Value range	Default	Reconfiguration in RUN	Effective range with STEP 7 (TIA Portal)	
Hardware interrupts					
• Hardware interrupt low limit 1	Yes/No	No	Yes	Channel	--- 1)
• Hardware interrupt high limit 1	Yes/No	No	Yes	Channel	--- 1)
• Hardware interrupt low limit 2	Yes/No	No	Yes	Channel	--- 1)
• Hardware interrupt high limit 2	Yes/No	No	Yes	Channel	--- 1)

1) You can set the current limit for wire break diagnostics and the limits for hardware interrupts in the user program with data records 0 to 3.

For an overview of the limits for the hardware interrupts, refer to the section Structure of a data record for input channels of the analog on-board I/O (Page 110).

Configurable parameters and default settings for outputs

Table 5- 8 Configurable "Diagnostics" parameters

Parameter	Value range	Default	Reconfiguration in RUN	Effective range with STEP 7 (TIA Portal)	
Diagnostics					
• Wire break 2)	Yes/No	No	Yes	Channel	Module 1)
• Short-circuit to ground 3)	Yes/No	No	Yes	Channel	Module 1)
• Overflow	Yes/No	No	Yes	Channel	Module 1)
• Underflow	Yes/No	No	Yes	Channel	Module 1)

1) You can set the effective range of the diagnostics for each channel in the user program with data records 0 to 3.

2) Only for the "Current" output type

3) Only for the "Voltage" output type

Table 5- 9 Configurable output parameters

Parameter	Value range	Default	Reconfiguration in RUN	Effective range with STEP 7 (TIA Portal)	
Output parameters					
• Output type	See section Output type and output ranges (Page 71)	Voltage	Yes	Channel	Channel
• Output range		±10 V	Yes	Channel	Channel
• Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value	Turn off	Yes	Channel	Channel
• Substitute value	Must be within the permitted voltage/current output range. See "Valid substitute value for the output range" table in the section Structure of a data record for output channels of the analog on-board I/O (Page 115).	0	Yes	Channel	Channel

Short-circuit detection

The diagnostics for short circuit to ground can be configured for the voltage output type. Short-circuit detection is not possible for low output values. The output voltages must therefore be under -0.1 V or over +0.1 V.

Wire break detection

The diagnostics for wire break can be configured for the current output type. Wire break detection is not possible for low output values; the output currents must therefore be below -0.2 mA or above +0.2 mA.

5.7 Parameters of the digital on-board I/O

Parameters of the digital on-board I/O in standard mode

You specify the properties of the digital on-board I/O during parameter assignment with STEP 7. The tables below list the parameters that can be set for inputs and outputs, respectively. The effective range of the parameters that can be set depends on the type of configuration.

In the case of parameter assignment in the user program, the parameters are transferred to the analog on-board I/O via data records with the WRREC instruction, see section Parameter data records of the digital on-board I/O (Page 118).

Configurable parameters and default settings for inputs

Table 5- 10 Configurable parameters for inputs

Parameter	Value range	Default	Reconfiguration in RUN	Effective range with STEP 7 (TIA Portal)	
Diagnostics					
• Missing supply voltage L+	Yes/No	No	Yes	Channel	Module
Input delay	None, 0.05 ms, 0.1 ms, 0.4 ms, 1.6 ms, 3.2 ms, 12.8 ms, 20 ms	3.2 ms	Yes	Channel	Module
Hardware interrupt					
• Rising edge	Yes/No	No	Yes	Channel	Module
• Falling edge	Yes/No	No	Yes	Channel	Module

Configurable parameters and default settings for outputs

Table 5- 11 Configurable parameters for outputs

Parameter	Value range	Default	Reconfiguration in RUN	Effective range with STEP 7 (TIA Portal)	
Diagnostics					
• Missing supply voltage L+	Yes/No	No	Yes	Channel	Module
Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value 1	Turn off	Yes	Channel	Module

Interrupts/diagnostics alarms

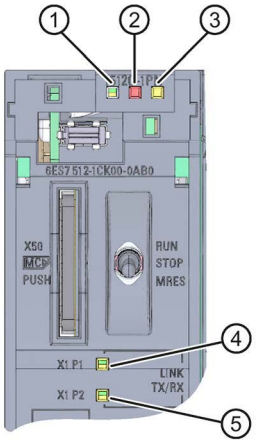
6

6.1 Status and error displays

6.1.1 Status and error displays of the CPU part

LED display

The figure below shows the LED displays of the CPU part.



① RUN/STOP LED (yellow/green LED)
② ERROR LED (red LED)
③ MAINT LED (yellow LED)
④ LINK RX/TX LED for port X1 P1 (yellow/green LED)
⑤ LINK RX/TX LED for port X1 P2 (yellow/green LED)

Figure 6-1 LED display of the CPU 1512C-1 PN (without front panel)

Meaning of the RUN/STOP, ERROR and MAINT LEDs

The CPU has three LEDs for displaying the current operating mode and diagnostics status. The following table shows the meaning of the various combinations of colors for the RUN/STOP, ERROR and MAINT LEDs.

Table 6- 1 Meaning of the LEDs

RUN/STOP LED	ERROR LED	MAINT LED	Meaning
LED off	LED off	LED off	Missing or insufficient supply voltage on the CPU.
LED off	LED flashes red	LED off	An error has occurred.
LED lit green	LED off	LED off	CPU is in RUN mode.
LED lit green	LED flashes red	LED off	A diagnostics event is pending.
LED lit green	LED off	LED lit yellow	Maintenance demanded for the plant. The affected hardware must be checked/replaced within a short period of time.
			Active Force job
			PROFIenergy pause
LED lit green	LED off	LED flashes yellow	Maintenance required for the plant. The affected hardware must be checked/replaced within a foreseeable period of time.
			Bad configuration
LED lit yellow	LED off	LED flashes yellow	Firmware update successfully completed.
LED lit yellow	LED off	LED off	CPU is in STOP mode.
LED lit yellow	LED flashes red	LED flashes yellow	The program on the SIMATIC memory card is causing an error.
			CPU defective
LED flashes yellow	LED off	LED off	CPU is performing internal activities during STOP, e.g. ramp-up after STOP.
			Download of the user program from the SIMATIC memory card
LED flashes yellow/green	LED off	LED off	Startup (transition from RUN → STOP)
LED flashes yellow/green	LED flashes red	LED flashes yellow	Startup (CPU booting)
			Test of LEDs during startup, inserting a module.
			LED flashing test

Meaning of LINK RX/TX LED

Each port has a LINK RX/TX LED. The table below shows the various "LED scenarios" of the CPU ports.

Table 6- 2 Meaning of the LED

LINK TX/RX LED	Meaning
LED off	There is no Ethernet connection between the PROFINET interface of the PROFINET device and the communication partner. No data is currently being sent/received via the PROFINET interface. There is no LINK connection.
LED flashes green	The "LED flashing test" is being performed.
LED lit green	There is an Ethernet connection between the PROFINET interface of your PROFINET device and a communication partner.
LED flickers yellow	Data is currently being received from or sent to a communications partner on Ethernet via the PROFINET interface of the PROFINET device.

6.1.2 Status and error displays of the analog on-board I/O

LED displays

The figure below shows the LED displays (status and error displays) of the analog on-board I/O.

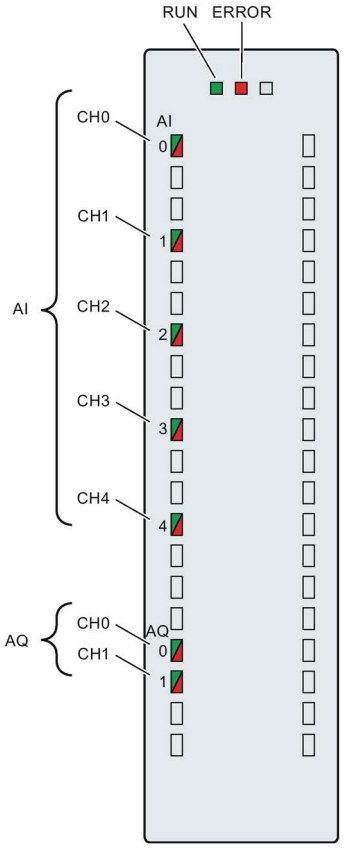


Figure 6-2 LED displays

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in the section Interrupts and diagnostics.

Table 6- 3 RUN/ERROR status and error displays

LEDs		Meaning	Remedy
RUN	ERROR		
Off	Off	No voltage or voltage too low	• Turn on the CPU and/or the system power supply modules.
Flashes	Off	Analog on-board I/O starts up and flashes until valid parameter assignment.	---
On	Off	Parameters have been set for the analog on-board I/O.	
On	Flashes	Indicates module errors (at least one error is present on one channel, e.g. wire break).	Evaluate the diagnostics and eliminate the error (e.g. wire break).
Flashes	Flashes	Hardware defective.	Replace the compact CPU.

CHx LED

Table 6- 4 CHx status display

CHx LED	Meaning	Remedy
Off	Channel disabled.	---
On	Channel parameters set and OK.	---
On	Channel parameters set, channel error present. Diagnostics alarm: e.g. wire break	Check the wiring. Disable diagnostics.

6.1.3 Status and error displays of the digital on-board I/O

LED displays

The figure below shows an example of the LED displays (status and error displays) of the first module of the digital on-board I/O. Corrective measures for diagnostics alarms can be found in the section Interrupts and diagnostics (Page 84).

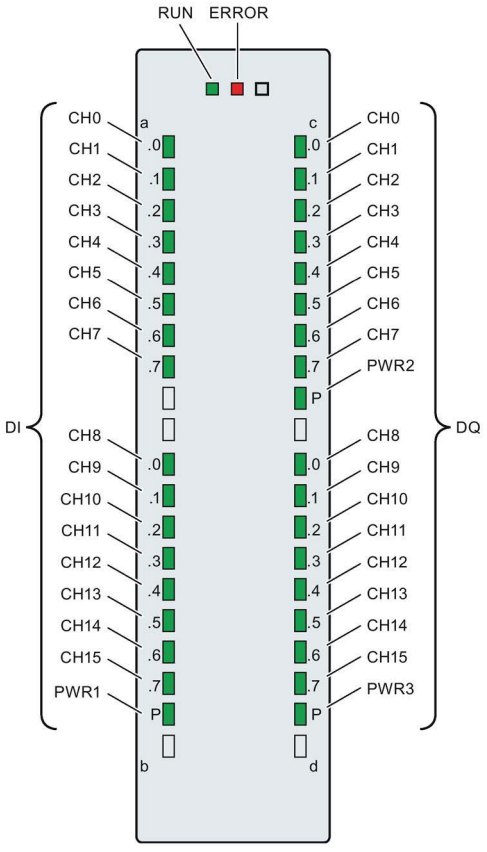


Figure 6-3 LED displays

Meaning of the LED displays

The following tables explain the meaning of the status and error displays.

RUN/ERROR LED

Table 6- 5 RUN/ERROR status and error displays

LED		Meaning	Remedy
RUN	ERROR		
Off	Off	No voltage or voltage too low	• Turn on the CPU. • Check whether too many modules are inserted.
Flashes	Off	Digital on-board I/O starts up.	---
On	Off	Digital on-board I/O is ready for operation.	
On	Flashes	A diagnostics interrupt is pending. Supply voltage missing.	Check supply voltage L+.
Flashes	Flashes	Hardware defective.	Replace the compact CPU.

PWRx LED

Table 6- 6 PWRx status display

PWRx LED	Meaning	Remedy
Off	Supply voltage L+ to module too low or missing	Check supply voltage L+.
On	Supply voltage L+ is present and OK.	---

CHx LED

Table 6- 7 CHx status display

CHx LED	Meaning	Remedy
Off	0 = Status of the input/output signal.	---
On	1 = Status of the input/output signal.	---

6.2 Interrupts and diagnostics

6.2.1 Interrupts and diagnostics of the CPU part

For information on "Interrupts", refer to the STEP 7 online help.

For information on "Diagnostics" and "System alarms", refer to the Diagnostics (http://support.automation.siemens.com/WW/view/en/59192926) function manual.

6.2.2 Interrupts and diagnostics of the analog on-board I/O

Diagnostics interrupt

The analog on-board I/O generates a diagnostics interrupt at the following events:

Table 6- 8 Diagnostics interrupt for inputs and outputs

Event	Diagnostics interrupt	
	Inputs	Outputs
Overflow	x	x
Underflow	x	x
Wire break	x [1]	x [2]
Short-circuit to ground	---	x [3]

[1] Possible for the voltage measuring range (1 to 5 V), current measuring range (4 to 20 mA)

[2] Possible for current output type

[3] Possible for voltage output type

Hardware interrupt for inputs

The compact CPU can generate a hardware interrupt for the following events:

- Below low limit 1
- Above high limit 1
- Below low limit 2
- Above high limit 2

You will find detailed information on the event in the hardware interrupt organization block with the "RALRM" (read additional interrupt information) instruction and in the STEP 7 online help.

The start information of the organization block includes information on which channel of the analog on-board I/O triggered the hardware interrupt. The figure below shows the assignment to the bits of double word 8 in local data.

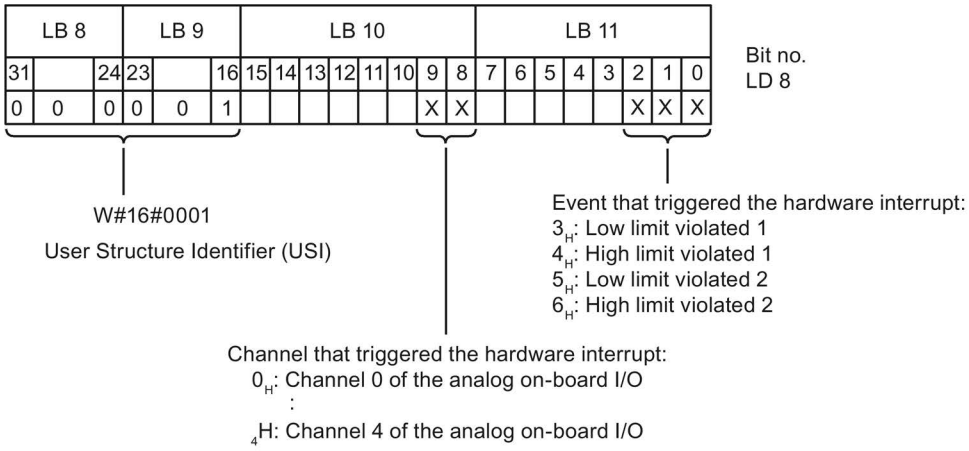


Figure 6-4 Start information of the organization block

Behavior when limits 1 and 2 are reached at the same time

If the two high limits 1 and 2 are reached at the same time, the analog on-board I/O always signals the hardware interrupt for high limit 1 first. The configured value for high limit 2 is irrelevant. After processing the hardware interrupt for high limit 1, the compact CPU triggers the hardware interrupt for high limit 2.

The analog on-board I/O behaves accordingly when the low limits are reached simultaneously. If the two low limits 1 and 2 are reached at the same time, the analog on-board I/O always signals the hardware interrupt for low limit 1 first. After processing the hardware interrupt for low limit 1, the analog on-board I/O triggers the hardware interrupt for low limit 2.

Structure of the additional interrupt information

Table 6- 9 Structure of USI = W#16#0001

Data block name		Contents	Comment	Bytes
USI (User Structure Identifier)		W#16#0001	Additional interrupt information of the analog on-board I/O	2
The channel that triggered the hardware interrupt follows.				
	Channel	B#16#00 to B#16#n	Number of the event-triggering channel (n = number of analog on-board I/O channels -1)	1
It is followed by the event that triggered the hardware interrupt.				
	Event	B#16#03	Below low limit 1	1
		B#16#04	Above high limit 1	
		B#16#05	Below low limit 2	
		B#16#06	Above high limit 2	

Diagnostics alarms

A diagnostics alarm is output for each diagnostics event and the ERROR LED flashes on the analog on-board I/O. The diagnostics alarms can, for example, be read out in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 6- 10 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Remedy
Wire break	6_H	Resistance of encoder circuit too high	Use a different encoder type or modify the wiring, for example, using cables with larger cross-section
		Interruption of the cable between the analog on-board I/O and sensor	Connect the cable
		Channel not connected (open)	• Disable diagnostics • Connect the channel
Overflow	7_H	Measuring range exceeded	Check the measuring range
		The output value set by the user program exceeds the valid rated range/overrange	Correct the output value
Underflow	8_H	Value below measuring range	Check the measuring range
		The output value set by the user program is below the valid rated range/underrange	Correct the output value
Short-circuit to ground	1_H	Overload at output	Eliminate overload
		Short-circuit of output Q_V to M_{ANA}	Eliminate the short-circuit

6.2.3 Interrupts and diagnostics of the digital on-board I/O

Diagnostics interrupt

A diagnostics alarm is output for each diagnostics event and the ERROR LED flashes on the digital on-board I/O. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 6- 11 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Corrective measures
Load voltage missing	11_H	No supply voltage L+	Feed supply voltage L+
Hardware interrupt lost	16_H	The digital on-board I/O cannot trigger an interrupt because the previous interrupt was not acknowledged; possibly a configuration error	• Change the interrupt processing in the CPU and reconfigure the digital on-board I/O. • The error persists until new parameters are set for the digital on-board I/O

Diagnostics interrupt when using the technology functions

Table 6- 12 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Corrective measures
Illegal A/B signal ratio	500_H	• Time sequence of the A and B signals of the incremental encoder do not meet certain requirements. • Possible causes: – Signal frequency too high – Encoder is defective – Process wiring is incorrect	• Correct the process wiring • Check the encoder/sensor • Check the parameter assignment.

Hardware interrupt

The compact CPU can generate a hardware interrupt for the following events:

- Rising edge
- Falling edge

You will find detailed information on the event in the hardware interrupt organization block with the "RALRM" (read additional interrupt information) instruction and in the STEP 7 online help.

The start information of the organization block includes information on which channel triggered the hardware interrupt. The figure below shows the assignment to the bits of double word 8 in local data.

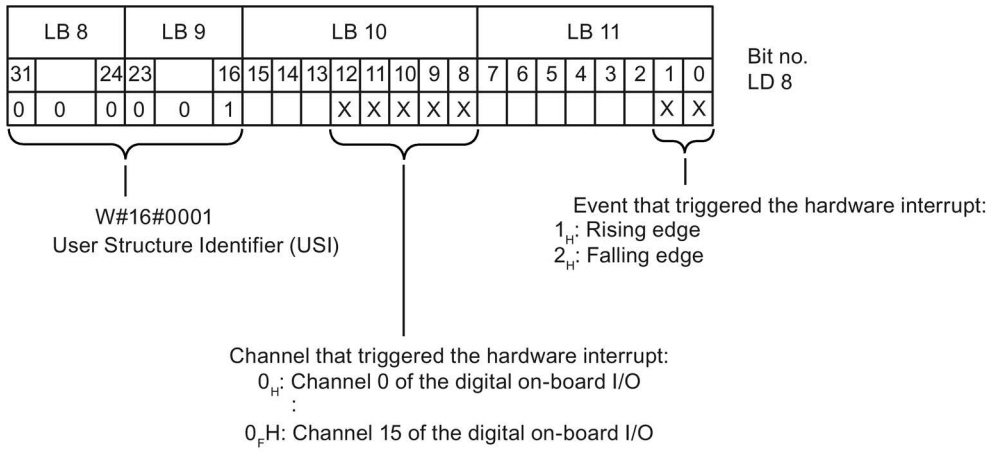


Figure 6-5 Start information of the organization block

Structure of the additional interrupt information

Table 6- 13 Structure of USI = W#16#0001

Data block name		Contents	Comment	Bytes
USI (User Structure Identifier)		W#16#0001	Additional interrupt information of the hardware interrupts of the digital on-board I/O	2
The channel that triggered the hardware interrupt follows.				
	Channel	B#16#00 to B#16#0F	Number of the event-triggering channel (channel 0 to channel 15)	1
The error event that triggered the hardware interrupt follows.				
	Event	B#16#01	Rising edge	1
		B#16#02	Falling edge	

Hardware interrupts when using the technology functions

Table 6- 14 Hardware interrupts and their meaning

Hardware interrupt	Event type number	Meaning
Opening of the internal gate (gate start)	1	When the internal gate is opened, the technology function triggers a hardware interrupt in the CPU.
Closing of the internal gate (gate stop)	2	When the internal gate is closed, the technology functions trigger a hardware interrupt in the CPU.
Overflow (high counting limit violated)	3	When the count value exceeds the high counting limit, the technology function triggers a hardware interrupt in the CPU.
Underflow (low counting limit violated)	4	When the count value falls below the low counting limit, the technology function triggers a hardware interrupt in the CPU.
Comparison event for DQ0 occurred	5	When a comparison event for DQ0 occurs due to the selected comparison condition, the technology function triggers a hardware interrupt in the CPU. When the change of the count value for an incremental or pulse encoder was not caused by a count pulse, the technology function does not trigger a hardware interrupt.
Comparison event for DQ1 occurred	6	When a comparison event for DQ1 occurs due to the selected comparison condition, the technology function triggers a hardware interrupt in the CPU. When the change of the count value for an incremental or pulse encoder was not caused by a count pulse, the technology function does not trigger a hardware interrupt.
Zero crossing	7	At a zero crossing of the counter or position value, the technology function triggers a hardware interrupt in the CPU.
New Capture value present[1)]	8	When the current counter or position value is saved as a Capture value, the technology function triggers a hardware interrupt in the CPU.
Synchronization of the counter by an external signal	9	At the synchronization of the counter by an N signal or edge at DI, the technology function triggers a hardware interrupt in the CPU.
Direction reversal[2)]	10	When the count value or position value changes direction, the technology function triggers a hardware interrupt in the CPU.

1) Can only be set in counting mode

2) Feedback bit STS_DIR is preset to "0". When the first count value or position value change occurs in the reverse direction directly after switching on the digital on-board I/O, a hardware interrupt is not triggered.

Technical specifications

7

Technical specifications of the CPU 1512C-1 PN

	6ES7512-1CK00-0AB0
Product type designation	CPU 1512C-1 PN
General information	
Hardware functional status	FS01
Firmware version	V1.8
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 SP1 Update 4
Display	
Screen diagonal (cm)	3.45 cm
Operator controls	
Number of keys	6
Mode selector	1
Supply voltage	
Type of supply voltage	24 V DC
Valid range, low limit (DC)	19.2 V; 20.4 V DC for supply of digital inputs/outputs
Valid range, high limit (DC)	28.8 V
Reverse polarity protection	Yes
Power and voltage failure backup	
Power/voltage failure backup time	5 ms; only affects CPU part
Input current	
Current consumption (rated value)	0.8 A; digital on-board I/O is supplied separately
Inrush current, max.	1.9 A; rated value
I^2t	0.34 A^2s
Digital inputs	
From the load voltage L+ (no load), max.	20 mA; per group
Digital outputs	
From the load voltage L+, max.	30 mA; per group, without load
Output voltage	
Rated value (DC)	24 V
Encoder supply	
Number of outputs	2; a common 24 V encoder supply for each of 16 digital inputs

	6ES7512-1CK00-0AB0
24 V encoder supply	
24 V	Yes; L+ (-0.8 V)
Short-circuit protection	Yes
Output current, max.	1 A
Power	
Power consumption from the backplane bus (balanced)	9 W
Incoming power to the backplane bus	10 W
Memory	
SIMATIC Memory Card required	Yes
Work memory	
integrated (for program)	250 KB
integrated (for data)	1 MB
Load memory	
Plug-in (SIMATIC Memory Card), max.	32 GB
Buffering	
maintenance-free	Yes
CPU processing times	
for bit operations, typ.	48 ns
for word operations, typ.	58 ns
for fixed point arithmetic, typ.	77 ns
for floating point arithmetic, typ.	307 ns
CPU blocks	
Number of elements (total)	2000; elements can be taken to mean blocks such as DBs, FBs and FCs, as well as UDTs, global constants, etc.
DB	
Number range	1 ... 60 999; divided into: Number range available for the user: 1 ... 59 999 and number range for DBs generated by SFC 86: 60 000 ... 60 999
Size, max.	1 MB; the maximum size of the DB is 64 KB with non-optimized block access
FB	
Number range	0 ... 65 535
Size, max.	250 KB
FC	
Number range	0 ... 65 535
Size, max.	250 KB
OB	
Size, max.	250 KB
Number of free cycle OBs	100
Number of time-of-day interrupt OBs	20
Number of time-delay interrupt OBs	20
Number of cyclic interrupt OBs	20

	6ES7512-1CK00-0AB0
Number of hardware interrupt OBs	50
Number of DPV1 interrupt OBs	3
Number of isochronous mode OBs	1
Number of technology synchronization interrupt OBs	2
Number of startup OBs	100
Number of asynchronous error OBs	4
Number of synchronous error OBs	2
Number of diagnostics interrupt OBs	1
Nesting depth	
per priority class	24
Counters, timers and their retentivity	
S7 counters	
Number	2048
Retentivity	
• can be set	Yes
IEC counters	
Number	Any (only limited by the work memory)
Retentivity	
• can be set	Yes
S7 timers	
Number	2048
Retentivity	
• can be set	Yes
IEC timers	
Number	Any (only limited by the work memory)
Retentivity	
• can be set	Yes
Data areas and their retentivity	
Retentive data area in total (incl. timers, counters, bit memory), max.	128 KB; in total; for bit memory, timers, counters, DBs and technological data (axes), usable retentive memory: 88 KB
Bit memory	
Number, max.	16 KB
Number of clock memory bits	8; there are 8 clock memory bits, grouped in one clock memory byte
Data blocks	
Retentivity can be set	Yes
Retentivity preset	No
Local data	
per priority class, max.	64 KB; max. 16 KB per block
Address area	
Number of IO modules	2048; max. number of modules/submodules

	6ES7512-1CK00-0AB0
I/O address area	
Inputs	32 KB; all inputs are within the process image
Outputs	32 KB; all outputs are within the process image
per integrated IO subsystem	
• Inputs (volume)	8 KB
• Outputs (volume)	8 KB
per CM/CP	
• Inputs (volume)	8 KB
• Outputs (volume)	8 KB
Process image partitions	
Number of process image partitions, max.	32
Hardware configuration	
Number of hierarchical IO systems	20
Number of DP masters	
via CM	6; a total of up to 6 CMs/CPs (PROFIBUS, PROFINET, Ethernet) can be inserted
Number of IO controllers	
integrated	1
via CM	6; a total of up to 6 CMs/CPs (PROFIBUS, PROFINET, Ethernet) can be inserted
Rack	
Modules per rack, max.	32; CPU + 31 modules
Rack, number of rows, max.	1
PtP CM	
Number of PtP CMs	The number of connectable PtP CMs is only limited by the number of available slots
Time	
Clock	
Type	Hardware clock
Deviation per day, max.	10 s; typ.: 2 s
Buffered period	6 wk; at 40 °C ambient temperature, typ.
Operating hours counter	
Number	16
Time of day synchronization	
supported	Yes
in AS, master	Yes
in AS, slave	Yes
on Ethernet via NTP	Yes

	6ES7512-1CK00-0AB0
Digital inputs	
integrated channels (DI)	32
Digital inputs, configurable	Yes
Sourcing/sinking input	Sinking input
Input characteristic curve acc. to IEC 61131, type 3	Yes
Digital input functions, configurable	
Gate start/stop	Yes; when technological function is activated
Capture	Yes; when technological function is activated
Synchronization	Yes; when technological function is activated
Input voltage	
Type of input voltage	DC
Rated value (DC)	24 V
for signal "0"	-3 ... +5 V
for signal "1"	+11 ... +30 V
Input current	
for signal "1", typ.	2.5 mA
Input delay (for rated value of input voltage)	
For standard inputs	
• Configurable	Yes; none / 0.05 / 0.1 / 0.4 / 1.6 / 3.2 / 12.8 / 20 ms
• at "0" to "1", min.	6 µs; with parameter assignment "none"
• at "0" to "1", max.	20 ms
• at "1" to "0", min.	6 µs; with parameter assignment "none"
• at "1" to "0", max.	20 ms
for interrupt inputs	
• Configurable	Yes; same as for standard inputs
for counters/technological functions	
• Configurable	Yes; same as for standard inputs
• at "0" to "1", min.	6 µs; with parameter assignment "none"
• at "0" to "1", max.	20 ms
• at "1" to "0", min.	6 µs; with parameter assignment "none"
• at "1" to "0", max.	20 ms
Cable length	
shielded, max.	1000 m; 600 m for technological functions; dependent on input frequency, encoder and cable quality; max. 50 m at 100 kHz
unshielded, max.	600 m; For technological functions: No

	6ES7512-1CK00-0AB0
Digital outputs	
Type of digital output	Transistor
integrated channels (DO)	32
Sourcing output	Push-pull output
Short-circuit protection	Yes; electronic / thermal
• Response threshold, typ.	1.6 A with standard output; 0.5 A with high speed output
Limitation of inductive shutdown voltage to	-0.8 V
Activation of a digital input	Yes
Digital output functions, configurable	
Switch at comparison values	Yes; for use as HSC output
Switching capacity of outputs	
with resistive load, max.	0.5 A; 0.1 A with High Speed output
with lamp load, max.	5 W; 1 W with High Speed output
Load resistance range	
Low limit	48 Ω; 240 ohm with High Speed output
High limit	12 kΩ
Output voltage	
Type of output voltage	DC
for signal "0", max.	1 V; for High Speed output
for signal "1", min.	L+ (-0.8 V)
Output current	
for signal "1" rated value	0.5 A; 0.1 A with High Speed output, note derating
for signal "1" permissible range, min.	2 mA
for signal "1" permissible range, max.	0.6 A; 0.12 A with High Speed output, note derating
for signal "0" residual current, max.	0.5 mA
Output delay with resistive load	
"0" to "1", max.	100 µs
"1" to "0", max.	500 µs; load-dependent
for technological functions	
• "0" to "1", max.	5 µs; dependent on output used, see additional description in the manual
• "1" to "0", max.	5 µs; dependent on output used, see additional description in the manual
Wiring 2 outputs in parallel	
For logic operations	Yes; For technological functions: No
For performance increase	No; For technological functions: No
For redundant activation of a load	Yes; For technological functions: No
Switching frequency	
with resistive load, max.	100 Hz
with inductive load, max.	0.5 Hz; acc. to IEC 947-5-1, DC13; note derating curve
with lamp load, max.	10 Hz

	6ES7512-1CK00-0AB0
Total current of the outputs	
Current per channel, max.	0.5 A; see additional description in the manual
Current per group, max.	8 A; see additional description in the manual
Current per power supply, max.	4 A; two power supplies per group, current per power supply max. 4 A, see additional description in the manual
for technological functions	
• Current per channel, max.	0.1 A; see additional description in the manual
Cable length	
shielded, max.	1000 m; 600 m for technological functions; dependent on output frequency, load and cable quality
unshielded, max.	600 m; For technological functions: No
Analog inputs	
Number of analog inputs	5; 4x for U/I, 1x for R/RTD
• for current measurement	4; max.
• for voltage measurement	4; max.
• for resistance/resistance-type thermometer measurement	1
permissible input voltage for voltage input (destruction limit), max.	28.8 V
permissible input current for current input (destruction limit), max.	40 mA
Cycle time (all channels), min.	1 ms; dependent on the configured interference frequency suppression, for details see Conversion method in the manual
Technical unit for temperature measurement, can be set	Yes
Input ranges (rated values), voltages	
0 to +10 V	Yes; Physical measuring range is +/-10V
Input resistance (0 to 10 V)	100 kΩ
1 V to 5 V	Yes; Physical measuring range is +/-10V
Input resistance (1 V to 5 V)	100 kΩ
-10 V to +10 V	Yes
Input resistance (-10 V to +10 V)	100 kΩ
-5 to +5 V	Yes; Physical measuring range is +/-10V
Input resistance (-5 to +5 V)	100 kΩ
Input ranges (rated values), currents	
0 to 20 mA	Yes; Physical measuring range is +/-20 mA
Input resistance (0 to 20 mA)	50 Ω; plus approx. 55 ohm for overvoltage protection by PTC
-20 mA to +20 mA	Yes
Input resistance (-20 mA to +20 mA)	50 Ω; plus approx. 55 ohm for overvoltage protection by PTC
4 mA to 20 mA	Yes; Physical measuring range is +/-20 mA

	6ES7512-1CK00-0AB0
Input resistance (4 mA to 20 mA)	50 Ω; plus approx. 55 ohm for overvoltage protection by PTC
Input ranges (rated values), resistance-type thermometer	
Ni 100	Yes; standard/climate
Input resistance (Ni 100)	10 MΩ
Pt 100	Yes; standard/climate
Input resistance (Pt 100)	10 MΩ
Input ranges (rated values), resistances	
0 to 150 ohms	Yes; Physical measuring range is 0 ... 600 ohm
Input resistance (0 to 150 ohms)	10 MΩ
0 to 300 ohms	Yes; Physical measuring range is 0 ... 600 ohm
Input resistance (0 to 300 ohms)	10 MΩ
0 to 600 ohms	Yes
Input resistance (0 to 600 ohms)	10 MΩ
Resistance-type thermometer (RTD)	
Technical unit of temperature measurement	°C / °F / K
Cable length	
shielded, max.	800 m; with U/I, 200 m with R/RTD
Analog outputs	
Integrated channels (AO)	2
Voltage output, short-circuit protection	Yes
Cycle time (all channels), min.	1 ms; dependent on the configured interference frequency suppression, for details see Conversion method in the manual
Output ranges, voltage	
0 to 10 V	Yes
1 V to 5 V	Yes
-10 V to +10 V	Yes
Output ranges, current	
0 to 20 mA	Yes
-20 mA to +20 mA	Yes
4 mA to 20 mA	Yes
Load resistance (in nominal range of the output)	
For voltage outputs, min.	1 kΩ
For voltage outputs, capacitive load, max.	100 nF
For current outputs, max.	500 Ω
For current outputs, inductive load, max.	1 mH
Cable length	
shielded, max.	200 m

	6ES7512-1CK00-0AB0
Analog value generation for the inputs	
Integration and conversion time/resolution per channel	
Resolution with overrange (bit including sign), max.	16 bits
Integration time configurable	Yes; 2.5 / 16.67 / 20 / 100 ms, acts on all channels
Interference voltage suppression for interference frequency f1 in Hz	400 / 60 / 50 / 10
Measured value smoothing	
Configurable	Yes
Setting: None	Yes
Setting: Weak	Yes
Setting: Medium	Yes
Setting: Strong	Yes
Analog value generation for the outputs	
Integration and conversion time/resolution per channel	
Resolution with overrange (bit including sign), max.	16 bits
Settling time	
For resistive load	1.5 ms
For capacitive load	2.5 ms
For inductive load	2.5 ms
Encoders	
Connection of the signal transmitters	
For voltage measurement	Yes
For current measurement as 4-wire transducer	Yes
For resistance measurement with two-wire connection	Yes
For resistance measurement with three-wire connection	Yes
For resistance measurement with four-wire connection	Yes
Connectable encoders	
2-wire sensor	Yes
• Permissible quiescent current (2-wire sensor), max.	1.5 mA

	6ES7512-1CK00-0AB0
Encoder signals, incremental encoder (asymmetric)	
Input voltage	24 V
Input frequency, max.	100 kHz:
Counting frequency, max.	400 kHz; with quadruple evaluation
Signal filter, configurable	Yes
Incremental encoder with A/B tracks, 90° phased-shifted	Yes
Incremental encoder with A/B tracks, 90° phased-shifted and zero track	Yes
Pulse encoder	Yes
Pulse encoder with direction	Yes
Pulse encoder with one pulse signal per count direction	Yes
Errors/accuracies	
Linearity error (relative to input range), (+/-)	0.1%
Temperature error (relative to input range), (+/-)	0.005%/K
Crosstalk between the inputs, max.	-60 dB
Reproducibility in steady state condition at 25 °C (relative to input range), (+/-)	0.05%
Output ripple (relative to output range, bandwidth 0 to 50 kHz), (+/-)	0.02%
Linearity error (relative to output range), (+/-)	0.15%
Temperature error (relative to output range), (+/-)	0.005%/K
Crosstalk between outputs, max.	-80 dB
Reproducibility in steady state condition at 25 °C (relative to output range), (+/-)	0.05%
Operational limit across the entire temperature range	
Voltage, relative to input range, (+/-)	0.3%
Current, relative to input range, (+/-)	0.3%
Resistance, relative to input range, (+/-)	0.3%
Resistance-type thermometer, relative to input range, (+/-)	Pt100 Standard: ±2 K, Pt100 Climatic: ±1 K, Ni100 Standard: ±1.2 K, Ni100 Climatic: ±1 K
Voltage, relative to output range, (+/-)	0.3%
Current, relative to output range, (+/-)	0.3%
Basic error limit (operational limit at 25 °C)	
Voltage, relative to input range, (+/-)	0.2%
Current, relative to input range, (+/-)	0.2%
Resistance, relative to input range, (+/-)	0.2%
Resistance-type thermometer, relative to input range, (+/-)	Pt100 Standard: ±1 K, Pt100 Climatic: ±0.5 K, Ni100 Standard: ±0.6 K, Ni100 Climatic: ±0.5 K
Voltage, relative to output range, (+/-)	0.2%
Current, relative to output range, (+/-)	0.2%

	6ES7512-1CK00-0AB0
Interference voltage suppression for f = n x (f1 +/- 1%), f1 = interference frequency	
Series-mode interference (peak of the interference < rated value of the input range), min.	30 dB
Common mode voltage, max.	10 V
Common mode interference, min.	60 dB
Interfaces	
Number of PROFINET interfaces	1
1st interface	
Interface hardware	
• Number of ports	2
• Integrated switch	Yes
• RJ45 (Ethernet)	Yes; X1
Protocols	
• PROFINET IO controller	Yes
• PROFINET IO device	Yes
• SIMATIC communication	Yes
• Open IE communication	Yes
• Web server	Yes
• Media redundancy	Yes
Interface hardware	
RJ45 (Ethernet)	
100 Mbps	Yes
Autonegotiation	Yes
Autocrossing	Yes
Industrial Ethernet status LED	Yes
Protocols	
Number of connections	
Number of connections, max.	128; via integrated interfaces of the CPU and connected CPs/CMs
Number of connections reserved for ES/HMI/Web	10
Number of connections via integrated interfaces	88
Number of S7 routing connections	16
PROFINET IO controller	
Services	
• PG/OP communication	Yes
• S7 routing	Yes
• Isochronous mode	Yes
• Open IE communication	Yes
• IRT	Yes

	6ES7512-1CK00-0AB0
• MRP	Yes; as MRP redundancy manager and/or MRP client; max. number of devices in the ring: 50
• PROFIenergy	Yes
• Prioritized startup	Yes; max. 32 PROFINET devices
• Number of connectable IO devices, max.	128; a total of up to 256 distributed I/O devices can be connected via PROFIBUS or PROFINET
• of these IO devices with IRT and the "high performance" option, max.	64
• Number of connectable IO devices for RT, max.	128
• of these in a line, max.	128
• Number of IO devices that can be enabled/disabled simultaneously, max.	8
• Number of IO devices per tool, max.	8
• Update times	Minimum value of update time also depends on the communication allocation setting for PROFINET IO, the number of IO devices and the amount of configured user data.
with RT	
• with send clock of 250 µs	250 µs to 128 ms
• with send clock of 500 µs	500 µs to 256 ms
• with send clock of 1 ms	1 ms to 512 ms
• with send clock of 2 ms	2 ms to 512 ms
• with send clock of 4 ms	4 ms to 512 ms
with IRT with the "high performance" option	
• with send clock of 250 µs	250 µs to 4 ms
• with send clock of 500 µs	500 µs to 8 ms
• with send clock of 1 ms	1 ms to 16 ms
• with send clock of 2 ms	2 ms to 32 ms
• with send clock of 4 ms	4 ms to 64 ms
• with IRT with the "high performance" option and parameter assignment of so-called "odd" send clocks	Update time = set "odd" send clock (any multiple of 125 µs: 375 µs, 625 µs ... 3 875 µs)
PROFINET IO device	
Services	
• PG/OP communication	Yes
• S7 routing	Yes
• Isochronous mode	No
• Open IE communication	Yes

	6ES7512-1CK00-0AB0
• IRT	Yes
• MRP	Yes
• PROFIenergy	Yes
• Shared device	Yes
• Number of IO controllers with shared device, max.	4
SIMATIC communication	
S7 communication, as server	Yes
S7 communication, as client	Yes
User data per job, max.	See online help (S7 communication, user data size)
Open IE communication	
TCP/IP	Yes
• Data length, max.	64 KB
• Multiple passive connections per port, supported	Yes
ISO-on-TCP (RFC1006)	Yes
• Data length, max.	64 KB
UDP	Yes
• Data length, max.	1472 bytes
DHCP	No
SNMP	Yes
DCP	Yes
LLDP	Yes
Web server	
HTTP	Yes; standard and user-defined pages
HTTPS	Yes; standard and user-defined pages
Additional protocols	
MODBUS	Yes; MODBUS TCP
Media redundancy	
Failover time in the case of cable break, typ.	200 ms
Number of devices in the ring, max.	50
Isochronous mode	
Isochronous operation (application synchronized up to terminal)	Yes; with minimum OB 6x cycle of 625 µs
Constant bus cycle	Yes
S7 alarm functions	
Number of stations that can log in for alarm functions, max.	32
Block-related alarms	Yes
Number of configurable interrupts, max.	5000

	6ES7512-1CK00-0AB0
Number of simultaneously active interrupts in interrupt pool	
• Number of reserved user interrupts	300
• Number of reserved interrupts for system diagnostics	100
• Number of reserved interrupts for motion technology objects	80
Test - commissioning functions	
Joint commissioning (team engineering)	Yes; parallel online access possible for up to 5 engineering systems
Status block	Yes; up to 8 simultaneously (in total over all ES clients)
Single step	No
Status/modify	
Status/modify tag	Yes
Tags	Inputs/outputs, bit memory, DB, peripheral inputs/outputs, timers, counters
Number of tags, max.	
• of which status tags, max.	200; per job
• of which modify tags, max.	200; per job
Force	
Forcing, tags	Peripheral inputs/outputs
Number of tags, max.	200
Diagnostics buffer	
available	Yes
Number of entries, max.	1000
• of these protected against power failure	500
Traces	
Number of configurable traces	4; up to 512 KB data possible per trace
Interrupts/diagnostics/status information	
Interrupts	
Diagnostics interrupt	Yes
Hardware interrupt	Yes
Diagnostics alarms	
Monitoring of the supply voltage	Yes
Wire break	Yes; for analog inputs/outputs, see description in manual
Short-circuit	Yes; for analog outputs, see description in manual
A/B transition error with incremental encoder	Yes
Diagnostics display LED	
RUN/STOP LED	Yes
ERROR LED	Yes

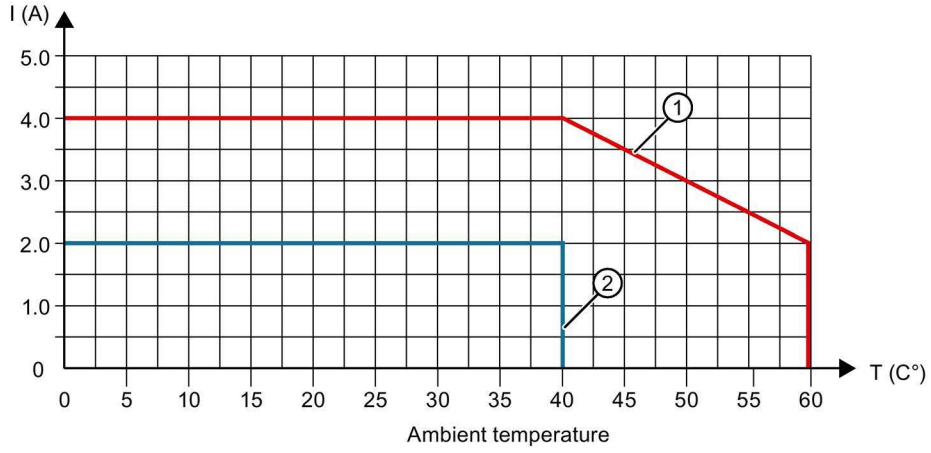
	6ES7512-1CK00-0AB0
MAINT LED	Yes
Monitoring of supply voltage (PWR LED)	Yes
Channel status display	Yes
For channel diagnostics	Yes; for analog inputs/outputs
Connection display LINK TX/RX	Yes
Supported technology objects	
Motion	
• Speed-controlled axis	
– Number of speed-controlled axes, max.	6; Requirement: no other motion technology objects have been created
• Positioning axis	
– Number of positioning axes, max.	6; Requirement: no other motion technology objects have been created
• Synchronous axes (relative gear synchronization)	
– Number of axes, max.	3; Requirement: no other motion technology objects have been created
• External encoders	
– Number of external encoders, max.	6; Requirement: no other motion technology objects have been created
Controllers	
• PID_Compact	Yes; universal PID controller with integrated optimization
• PID_3Step	Yes; PID controller with integrated optimization for valves
• PID temp	Yes; PID controller with integrated optimization for temperature
Counting and measuring	
• High-speed counter	Yes
Integrated functions	
Number of counters	6
Counting frequency (counter), max.	400 kHz; with quadruple evaluation
Counting functions	
Count continuously	Yes
Configurable counting behavior	Yes
Hardware gate via digital input	Yes
Software gate	Yes
Event-controlled stop	Yes
Synchronization via digital input	Yes
Counting range, configurable	Yes
Comparator	
• Number of comparators	2; per counter channel
• Direction dependence	Yes

	6ES7512-1CK00-0AB0
• Modifiable from user program	Yes
Position detection	
Incremental detection	Yes
Suitable for S7-1500 Motion Control	Yes
Measuring functions	
Measurement time, configurable	Yes
Dynamic measurement time configuration	Yes
Number of thresholds, configurable	2
Measuring range	
• Frequency measurement, min.	0.04 Hz
• Frequency measurement, max.	400 kHz
• Period measurement, min.	2.5 µs
• Period measurement, max.	25 s
Accuracy	
• Frequency measurement	100 ppm; dependent on measurement interval and signal evaluation
• Period measurement	100 ppm; dependent on measurement interval and signal evaluation
• Velocity measurement	100 ppm; dependent on measurement interval and signal evaluation
Electrical isolation	
Electrical isolation of digital inputs	
Between channels	No
Between channels, in groups of	16
Electrical isolation of digital outputs	
Between channels	No
Between channels, in groups of	16
Electrical isolation of channels	
Between the channels and the backplane bus	Yes
Between the channels and the load voltage L+	No
Permitted potential difference	
Between different circuits	75 V DC / 60 V AC (basic insulation)
Ambient conditions	
Ambient temperature in operation	
Horizontal installation, min.	0 °C
Horizontal installation, max.	60 °C; Note derating information for on-board I/O in the manual; Display: 50 °C, at an operating temperature of typically 50 °C, the display is switched off
Vertical installation, min.	0 °C
Vertical installation, max.	40 °C; Note derating information for on-board I/O in the manual; Display: 40 °C, at an operating temperature of typically 40 °C, the display is switched off

	6ES7512-1CK00-0AB0
Configuring	
Programming	
Programming language	
• LAD	Yes
• FBD	Yes
• STL	Yes
• SCL	Yes
• GRAPH	Yes
Know-how protection	
User program protection	Yes
Copy protection	Yes
Block protection	Yes
Access protection	
Protection level: Write protection	Yes
Protection level: Write/read protection	Yes
Protection level: Complete protection	Yes
Cycle time monitoring	
Low limit	Configurable minimum cycle time
High limit	Configurable maximum cycle time
Dimensions	
Width	110 mm
Height	147 mm
Depth	129 mm
Weights	
Weight, approx.	1360 g

Power reduction (derating) to total current of digital outputs (per power supply)

The following graphs show the loading capacity of the digital outputs in relation to the mounting position and the ambient temperature.



① Horizontal mounting position
② Vertical mounting position

Figure 7-1 Loading capacity of the digital outputs per mounting position

General technical specifications

For information on the general technical specifications, such as standards and approvals, electromagnetic compatibility, protection class, etc., refer to the S7-1500, ET 200MP system manual (http://support.automation.siemens.com/WW/view/en/59191792).

Dimension drawings

A

A.1 Dimension drawings

This appendix contains the dimension drawings of the compact CPU installed on a mounting rail. You must take the dimensions into consideration for installation in cabinets, control rooms, etc.

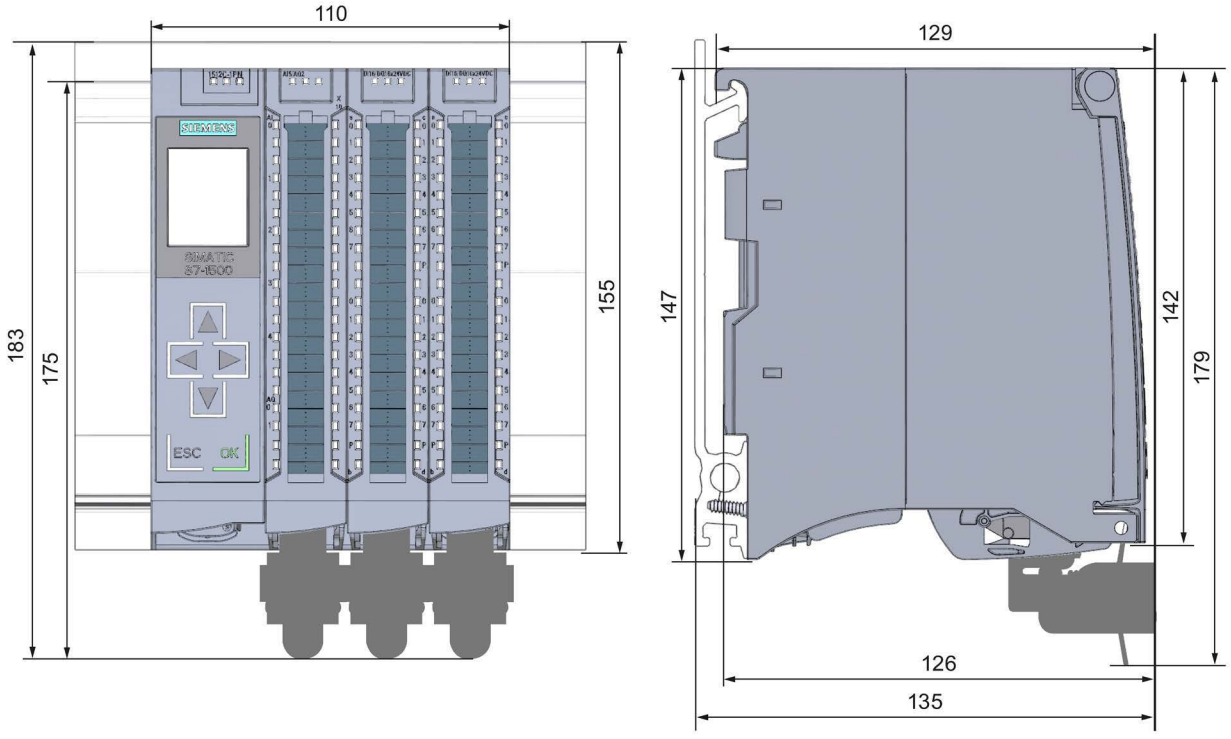


Figure A-1 Dimension drawing of CPU 1512C-1 PN – front and side views

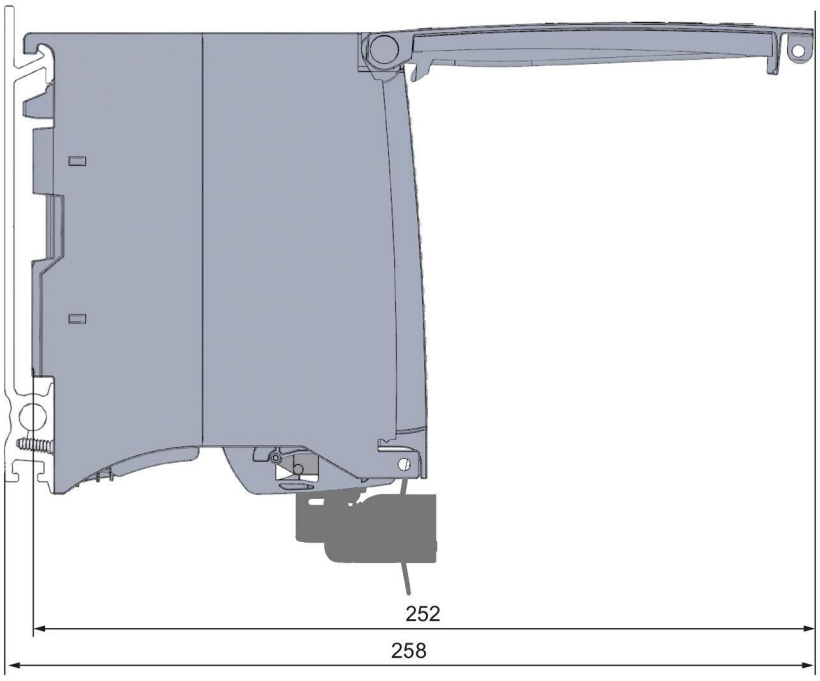


Figure A-2 Dimension drawing of CPU 1512C-1 PN – side view with front panel open

Parameter data records

B

B.1 Parameter assignment and structure of the parameter data records of the analog on-board I/O

Parameter assignment in the user program

You have the option of reassigning parameters for the analog on-board I/O in RUN (for example, measuring ranges of individual channels can be modified in RUN without affecting the other channels).

Changing parameters in RUN

The parameters are transferred to the analog on-board I/O via data records with the WRREC instruction. The parameters set with STEP 7 are not changed in the CPU, which means the parameters set in STEP 7 will be valid after a restart.

The parameters are checked for plausibility by the analog on-board I/O only after the transfer.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the analog on-board I/O continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.

You will find a description of the WRREC instruction and the error codes in the STEP 7 online help.

B.2 Structure of a data record for input channels of the analog on-board I/O

Assignment of data record and channel

The parameters for the 5 analog input channels are located in data records 0 to 4 and are assigned as follows:

- Data record 0 for channel 0
- Data record 1 for channel 1
- Data record 2 for channel 2
- Data record 3 for channel 3
- Data record 4 for channel 4

Data record structure

The example in the figure below shows the structure of data record 0 for channel 0. The structure is identical for channels 1 to 4. The values in byte 0 and byte 1 are fixed and must not be changed.

You enable a parameter by setting the corresponding bit to "1".

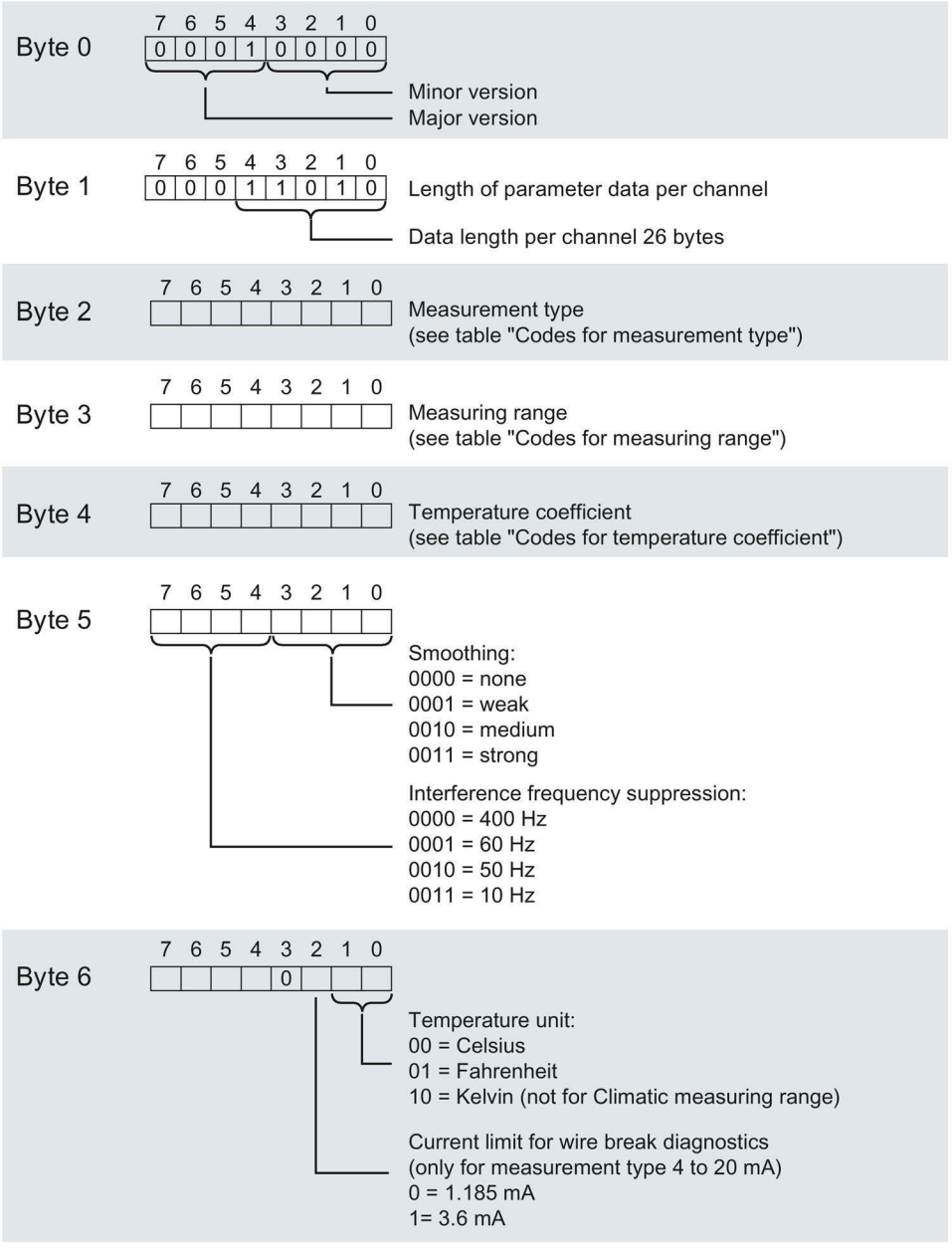
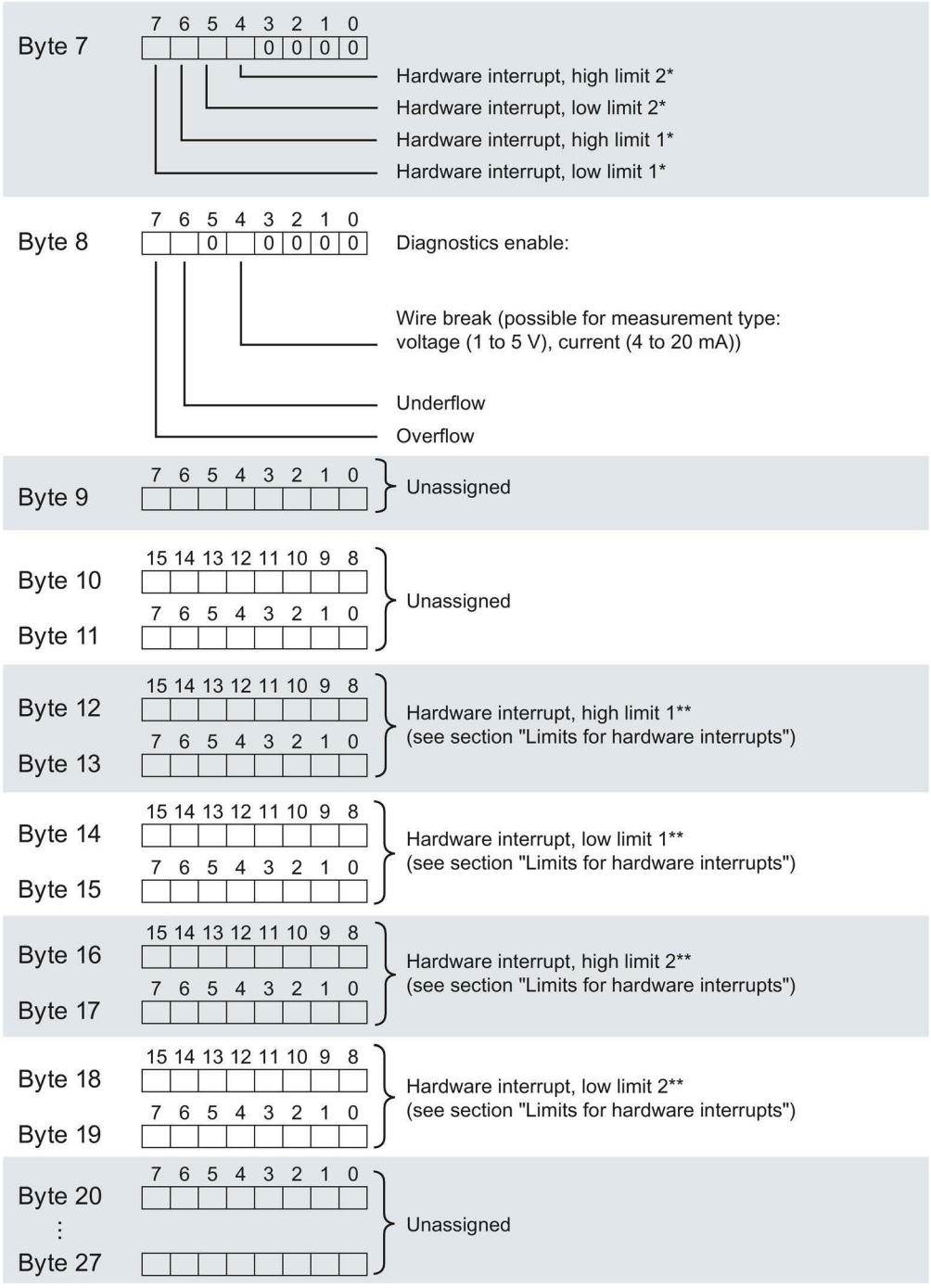


Figure B-1 Structure of data record 0: Bytes 0 to 6



* Hardware interrupts may only be enabled via a data record if a hardware interrupt OB is assigned to the channel in STEP 7

** High limit must be greater than low limit

Figure B-2 Structure of data record 0: Bytes 7 to 27

Codes for measurement types

The following table contains all measurement types of the inputs of the analog on-board I/O with the corresponding codes. You must enter these codes in byte 2 of the data record for the corresponding channel (refer to the figure Structure of data record 0: Bytes 0 to 6).

Table B- 1 Codes for measurement type

Measurement type	Code
Deactivated	0000 0000
Voltage (valid for channels 0 to 3)	0000 0001
Current, 4-wire measuring transducer (valid for channels 0 to 3)	0000 0010
Resistance (valid for channel 4)	0000 0100
Thermal resistor linear (valid for channel 4)	0000 0111

Codes for measuring ranges

The following table contains all measuring ranges of the inputs of the analog on-board I/O with the corresponding codes. You must enter these codes in each case in byte 3 of the data record for the corresponding channel (refer to the figure Structure of data record 0: Bytes 0 to 6).

Table B- 2 Codes for measuring range

Measuring range	Code
Voltage	
±5 V	0000 1000
±10 V	0000 1001
1 to 5 V	0000 1010
0 to 10 V	0000 1011
Current, 4-wire measuring transducer	
0 to 20 mA	0000 0010
4 to 20 mA	0000 0011
±20 mA	0000 0100
Resistance	
150 Ω	0000 0001
300 Ω	0000 0010
600 Ω	0000 0011
Thermal resistor	
Pt 100 Climate	0000 0000
Ni 100 Climate	0000 0001
Pt 100 Standard	0000 0010
Ni 100 Standard	0000 0011

Codes for temperature coefficient

The following table lists all temperature coefficients for temperature measurement of the thermal resistors along with their codes. You must enter these codes in each case in byte 4 of the data record for the corresponding channel (refer to the figure Structure of data record 0: Bytes 0 to 6)

Table B- 3 Codes for temperature coefficient

Temperature coefficient	Code
Pt xxx	
0.003851	0000 0000
0.003916	0000 0001
0.003902	0000 0010
0.003920	0000 0011
Ni xxx	
0.006180	0000 1000
0.006720	0000 1001

Hardware interrupt limits

The values that can be set for hardware interrupts (high/low limit) must be within the nominal range and overrange/underrange of the relevant measuring range.

The following tables list the permitted hardware interrupt limits. The limits depend on the selected measurement type and measuring range.

Table B- 4 Voltage limits

Voltage		
±5 V, ±10 V	1 to 5 V, 0 to 10 V	
32510	32510	High limit
-32511	-4863	Low limit

Table B- 5 Current and resistance limits

Current		Resistance	
±20 mA	4 to 20 mA / 0 to 20 mA	(all configurable measuring ranges)	
32510	32510	32510	High limit
-32511	-4863	1	Low limit

Table B- 6 Limits for thermal resistor Pt 100 Standard and Pt 100 Climate

Thermal resistor						
Pt 100 Standard			Pt 100 Climate			
°C	°F	K	°C	°F	K	
9999	18319	12731	15499	31099	---	High limit
-2429	-4053	303	-14499	-22899	---	Low limit

Table B- 7 Limits for thermal resistor Ni 100 Standard and Ni 100 Climate

Thermal resistor						
Ni 100 Standard			Ni 100 Climate			
°C	°F	K	°C	°F	K	
2949	5629	5681	15499	31099	---	High limit
-1049	-1569	1683	-10499	-15699	---	Low limit

B.3 Structure of a data record for output channels of the analog on-board I/O

Assignment of data record and channel

The parameters for the 2 analog output channels are located in data records 64 and 65 and are assigned as follows:

- Data record 64 for channel 0
- Data record 65 for channel 1

Data record structure

The figure below shows the structure of data record 64 for channel 0 as an example. The structure is identical for channel 1. The values in byte 0 and byte 1 are fixed and must not be changed.

You enable a parameter by setting the corresponding bit to "1".

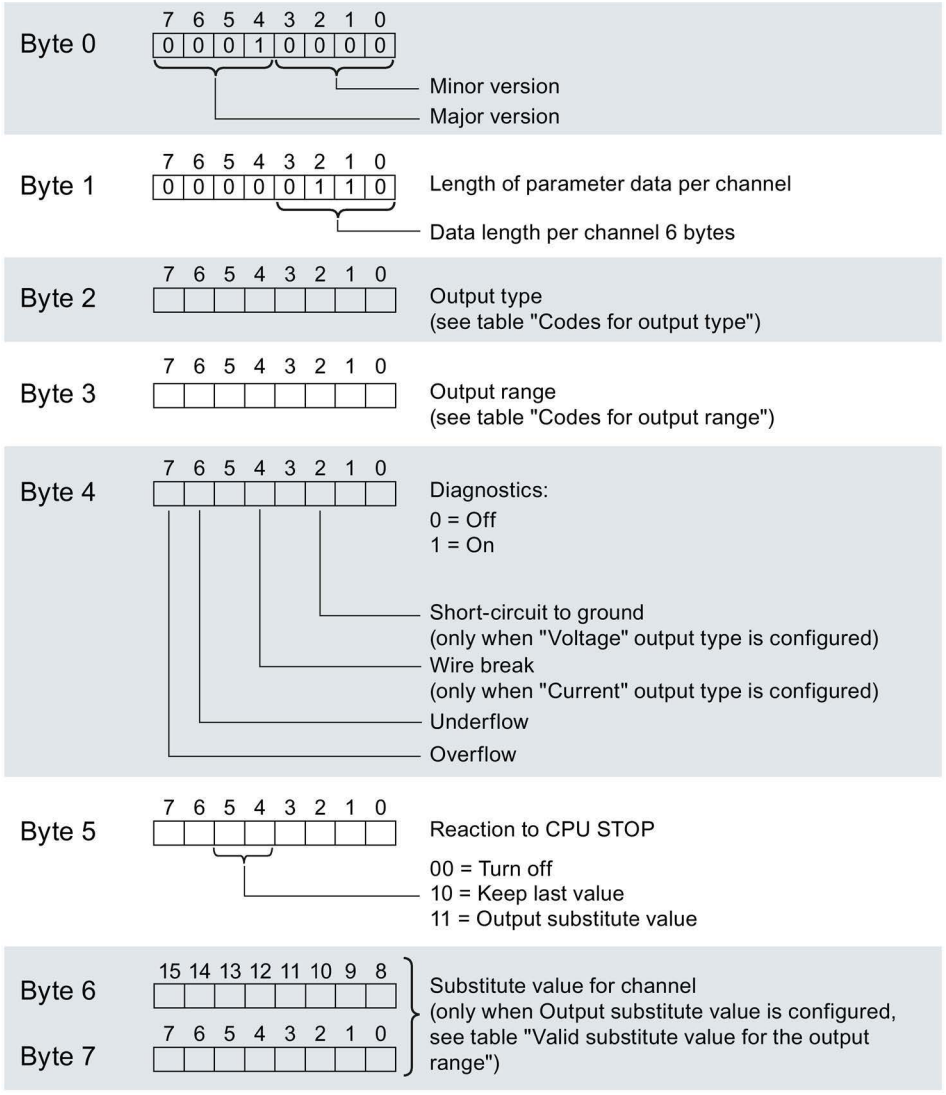


Figure B-3 Structure of data record 64: Bytes 0 to 7

Codes for output type

The following table contains all output types of the outputs of the analog on-board I/O with the corresponding codes. You must enter these codes in each case in byte 2 of the data record for the corresponding channel (see the previous figure).

Table B- 8 Codes for the output type

Output type	Code
Disabled	0000 0000
Voltage	0000 0001
Current	0000 0010

Codes for output ranges

The following table contains all output ranges for voltage and current of the outputs of the analog on-board I/O with the corresponding codes. You must enter these codes in each case in byte 3 of the corresponding data record (see previous figure).

Table B- 9 Codes for output range

Output range for voltage	Code
1 to 5 V	0000 0011
0 to 10 V	0000 0010
±10 V	0000 0000
Output range for current	**Code**
0 to 20 mA	0000 0001
4 to 20 mA	0000 0010
±20 mA	0000 0000

Permitted substitute values

The following table lists all output ranges for the permitted substitute values. You must enter these substitute values in each case in bytes 6 and 7 of the data record for the corresponding channel (see the previous figure). You will find the binary representation of the output ranges in the section Representation of output ranges (Page 141).

Table B- 10 Permitted substitute value for the output range

Output range	Permitted substitute value
±10 V	-32512 ... +32511
1 to 5 V	-6912 ... +32511
0 to 10 V	0 ... +32511
±20 mA	-32512 ... +32511
4 to 20 mA	-6912 ... +32511
0 to 20 mA	0 ... +32511

B.4 Parameter assignment and structure of the parameter data records of the digital on-board I/O

Parameter assignment in the user program

You have the option of reassigning parameters for the digital on-board I/O in RUN (for example, values for input delay of individual channels can be modified in RUN without affecting the other channels).

Changing parameters in RUN

The parameters are transferred to the digital on-board I/O via data records 0 to 15 with the WRREC instruction. The parameters set with STEP 7 are not changed in the CPU, which means the parameters set in STEP 7 will be valid again after a restart.

The parameters are only checked for plausibility after the transfer.

Output parameter STATUS

If errors occur when transferring parameters with the WRREC instruction, the digital on-board I/O continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.

You will find a description of the WRREC instruction and the error codes in the STEP 7 online help.

B.5 Structure of a data record for input channels of the digital on-board I/O

Assignment of data record and channel

The parameters per submodule for the 32 digital input channels are located in data records 0 to 15 and are assigned as follows:

First submodule:

- Data record 0 for channel 0
- Data record 1 for channel 1
- …
- Data record 14 for channel 14
- Data record 15 for channel 15

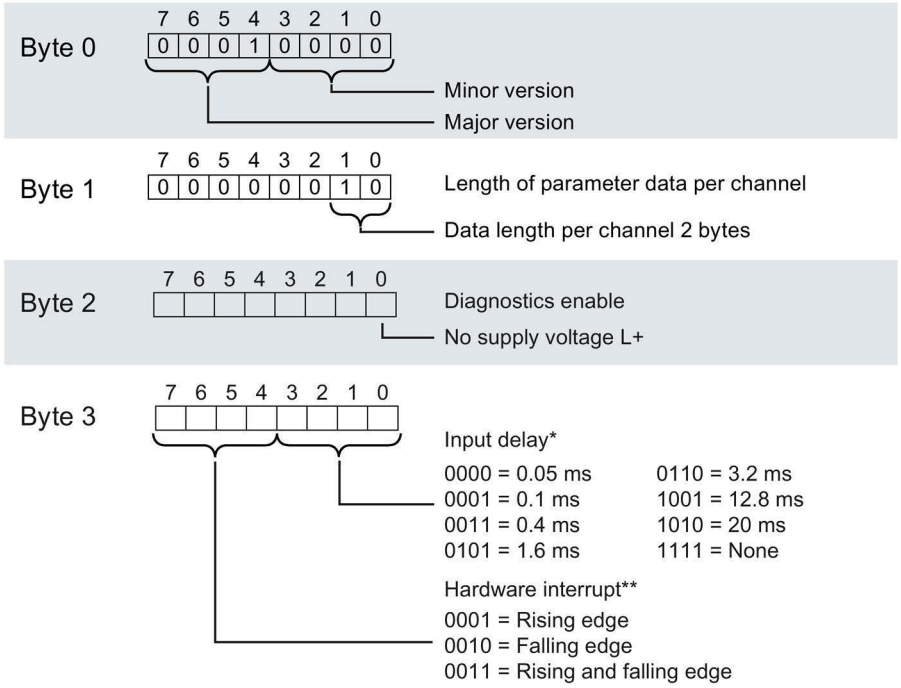
Second submodule:

- Data record 0 for channel 0
- Data record 1 for channel 1
- …
- Data record 14 for channel 14
- Data record 15 for channel 15

Data record structure

The example in the figure below shows the structure of data record 0 for channel 0. The structure is identical for channels 1 to 31. The values in byte 0 and byte 1 are fixed and must not be changed.

You enable a parameter by setting the corresponding bit to "1".



* 0.05 ms in isochronous mode (cannot be changed)

** Hardware interrupts can only be enabled via a data record if a hardware interrupt OB is assigned to the channel in STEP 7

Figure B-4 Structure of data record 0: Bytes 0 to 3

B.6 Structure of a data record for output channels of the digital on-board I/O

Assignment of data record and channel

The parameters per submodule for the 32 digital output channels are located in data records 64 to 79 and are assigned as follows:

First submodule:

- Data record 64 for channel 0
- Data record 65 for channel 1
- …
- Data record 78 for channel 14
- Data record 79 for channel 15

Second submodule:

- Data record 64 for channel 0
- Data record 65 for channel 1
- …
- Data record 78 for channel 14
- Data record 79 for channel 15

Data record structure

The example in the figure below shows the structure of data record 64 for channel 0. The structure is identical for channels 1 to 31. The values in byte 0 and byte 1 are fixed and must not be changed.

You enable a parameter by setting the corresponding bit to "1".

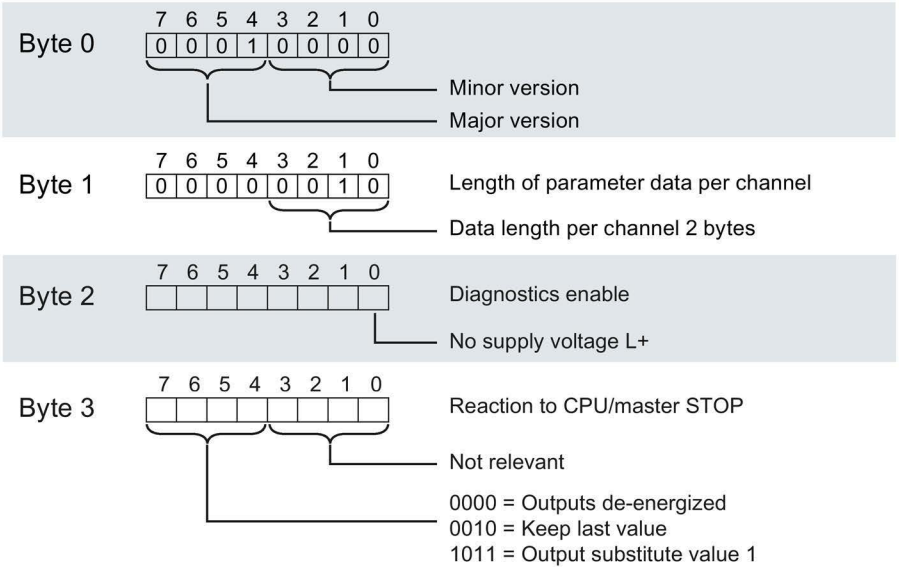


Figure B-5 Structure of data record 64: Bytes 0 to 3

B.7 Parameter data records of the technology functions

You can change the parameters of the High Speed Counter in RUN mode. The WRREC instruction is used to transfer the parameters to the High Speed Counter using data record 128.

If errors occur when transferring or validating parameters with the WRREC instruction, the High Speed Counter continues operation with the previous parameter assignment. The STATUS output parameter then contains a corresponding error code. If no error has occurred, the length of the data actually transferred is entered in the STATUS output parameter.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 (TIA Portal) online help.

Data record structure

The following table shows you the structure of data record 128 with the counter channel. The values in byte 0 to byte 3 are fixed and must not be changed. The value in byte 4 may only be changed by parameter reassignment and not in RUN mode.

Table B- 11 HSC parameter header

Bit → / Byte	7	6	5	4	3	2	1	0
0	Major Version = 1				Minor Version = 0			
1	Length of parameter data of the channel = 48							
2	Reserved[2]							
3								

Table B- 12 Parameter data record 128

Bit → / Byte	7	6	5	4	3	2	1	0
	Operating mode							
0	Reserved[2]				Operating mode:			
					0000_B: Disabled			
					0001_B: Counting			
					0010_B: Measuring			
					0011 to 1111_B: Reserved			
	Basic parameters							
1	Reserved[2]					Enable additional diagnostics interrupts[1]	Reaction to CPU STOP:	
							00_B: Output substitute value	
							01_B: Keep last value	
							10_B: Continue operation	
							11_B: Reserved	
	Counter inputs							
2	Reserved[2]		Signal evaluation:		Signal type:			
			00_B: Single		0000_B: Pulse (A)			
			01_B: Double		0001_B: Pulse (A) and direction (B)			
			10_B: Quadruple		0010_B: Count up (A), count down (B)			
			11_B: Reserved		0011_B: Incremental encoder (A, B phase-shifted)			
					0100_B: Incremental encoder (A, B, N)			
					0101 to 1111_B: Reserved			

Bit → / Byte	7	6	5	4	3	2	1	0
3	Response to signal N:		Invert direction[1]	Reserved[2]	Filter frequency			
	00_B: No reaction to signal N				0000_B: 100 Hz			
					0001_B: 200 Hz			
	01_B: Synchronization at signal N				0010_B: 500 Hz			
					0011_B: 1 kHz			
	10_B: Capture at signal N				0100_B: 2 kHz			
	11_B: Reserved				0101_B: 5 kHz			
					0110_B: 10 kHz			
					0111_B: 20 kHz			
					1000_B: 50 kHz			
					1001_B: 100 kHz			
					1010_B: Reserved			
					1011 to 1111_B: Reserved			
	Hardware interrupts[1]							
4	Reserved[1]	Reserved[1]	Reserved[1]	Direction reversal	Underflow (low counting limit violated)	Overflow (high counting limit violated)	Gate stop	Gate start
5	Synchronization of the counter by an external signal	New capture value available	Reserved[1]	Zero crossing	Reserved[1]	Comparison event for DQ1 occurred	Reserved[1]	Comparison event for DQ0 occurred
	Behavior of DQ0/1							
6	Set output (DQ1):				Set output (DQ0):			
	0000_B: Use by user program				0000_B: Use by user program			
	0001_B: Counting: Between comparison value 1 and high counting limit; Measuring: Measured value >= Comparison value 1				0001_B: Counting: Between comparison value 0 and high counting limit; Measuring: Measured value >= Comparison value 0			
	0010_B: Counting: Between comparison value 1 and low counting limit; Measuring: Measured value <= Comparison value 1				0010_B: Counting: Between comparison value 0 and low counting limit; Measuring: Measured value <= Comparison value 0			
	0011_B: Counting: At comparison value 1 for one pulse duration; Measuring: Reserved				0011_B: Counting: At comparison value 0 for one pulse duration; Measuring: Reserved			
	0100_B: Between comparison value 0 and 1				0100_B: Reserved			
	0101_B: Counting: After set command from CPU until comparison value 1; Measuring: Reserved				0101_B: Counting: After set command from CPU until comparison value 0; Measuring: Reserved			
	0110_B: Counting: Reserved Measuring: Not between comparison value 0 and 1				0110 to 1111_B: Reserved			
	0111 to 1111_B: Reserved							

Bit → / Byte	7	6	5	4	3	2	1	0
7	Count direction (DQ1): 00_B: Reserved 01_B: Up 10_B: Down 11_B: In both directions		Count direction (DQ0): 00_B: Reserved 01_B: Up 10_B: Down 11_B: In both directions		Reserved[2)]		Substitute value for DQ1	Substitute value for DQ0
8 9	Pulse duration (DQ0): WORD: Value range in ms/10: 0 to 65535_D							
10 11	Pulse duration (DQ1): WORD: Value range in ms/10: 0 to 65535_D							
	Behavior of DI0							
12	Behavior of count value after Capture (DI0): 0_B: Continue counting 1_B: Set to start value and continue counting	Edge selection (DI0): 00_B: Reserved 01_B: On a rising edge 10_B: On a falling edge 11_B: On rising and falling edge	Level selection (DI0): 0_B: Active at high level 1_B: Active at low level	Reserved[2)]	Set function of the DI (DI0): 000_B: Gate start/stop (level-controlled) 001_B: Gate start (edge-controlled) 010_B: Gate stop (edge-controlled) 011_B: Synchronization 100_B: Enable synchronization at signal N 101_B: Capture 110_B: Digital input without function 111_B: Reserved			
13	**Behavior of DI1**: See byte 16							
14	Reserved[2)]							
15	Sync option 0_B: Once 1_B: Periodically	Reserved[2)]			Reserved[2)]			
	Values							
16-19	High counting limit: DWORD: Value range: –2147483648 to 2147483647_D or 80000000 to $7FFFFFFF_H$							
20-23	Comparison value 0: Counting mode: DWORD Value range: –2147483648 to 2147483647_D or 80000000 to $7FFFFFFF_H$; Measuring mode: REAL Floating-point number in the set unit of the measured variable							
24-27	Comparison value 1: Counting mode: DWORD Value range: –2147483648 to 2147483647_D: or 80000000 to $7FFFFFFF_H$; Measuring mode: REAL Floating-point number in the set unit of the measured variable							
28-31	Start value: DWORD: Value range: –2147483648 to 2147483647_D or 80000000 to $7FFFFFFF_H$							
32-35	Low counting limit: DWORD: Value range: –2147483648 to 2147483647_D or 80000000 to $7FFFFFFF_H$							
36-39	Update time: DWORD: Value range in µs: 0 to 25000000_D							

Bit →								
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
	Counter behavior at limits and at gate start							
40	Response to gate start:		Response to counting limit violation:			Reset at counting limit violation:		
	00_B: Set to start value		000_B: Stop counting			000_B: To other counting limit		
	01_B: Continue with current value		001_B: Continue counting			001_B: To start value		
	10 to 11_B: Reserved		010 to 111_B: Reserved			010 to 111_B: Reserved		
	Specify measured value							
41	Reserved2)			Time base for velocity measurement:			Measured variable:	
				000_B: 1 ms			00_B: Frequency	
				001_B: 10 ms			01_B: Period duration	
				010_B: 100 ms			10_B: Velocity	
				011_B: 1 s			11_B: Reserved	
				100_B: 60 s/1 min				
				101 to 111_B: Reserved				
42	Increments per unit:							
43	WORD: Value range: 1 to 65535_D							
44	Set hysteresis range: Value range: 0 to 255_D							
45	Use of DI0	Reserved2)	Selection HSC DI0					
46	Use of DI1	Reserved2)	Selection HSC DI1					
47	Use of DQ1	Reserved2)	Selection HSC DQ1					

1) Reserved bits must be set to 0

Analog value processing

C

C.1 Conversion method

Conversion

So that the compact CPU can process the analog signal read in by an analog channel, an analog-to-digital converter integrated in the analog on-board I/O converts it to a digital signal. Once the CPU has processed the digital signal, a digital-to-analog converter integrated in the analog on-board I/O converts the output signal to an analog current or voltage value.

Interference frequency suppression

The interference frequency suppression of the analog inputs suppresses the interference caused by the frequency of the AC voltage network used. The frequency of the AC voltage network may interfere with measured values, particularly for measurements within narrow voltage ranges.

You set the line frequency that the plant operates with (400, 60, 50 or 10 Hz) using the "Interference frequency suppression" parameter in STEP 7. The interference frequency suppression filters out the set interference frequency (400/60/50/10 Hz) as well as multiples of it. The selected interference frequency suppression also defines the integration time. The conversion time changes depending on the set interference frequency suppression.

For example, an interference frequency suppression of 50 Hz corresponds to an integration time of 20 ms. The analog on-board I/O supplies one measured value to the CPU every millisecond over a period of 20 ms. This measured value corresponds to the floating mean value of the last 20 measurements.

The following figure shows how this works using a 400 Hz interference frequency suppression as an example. A 400 Hz interference frequency suppression corresponds to an integration time of 2.5 ms. The analog on-board I/O supplies a measured value to the CPU every 1.25 milliseconds within the integration time.

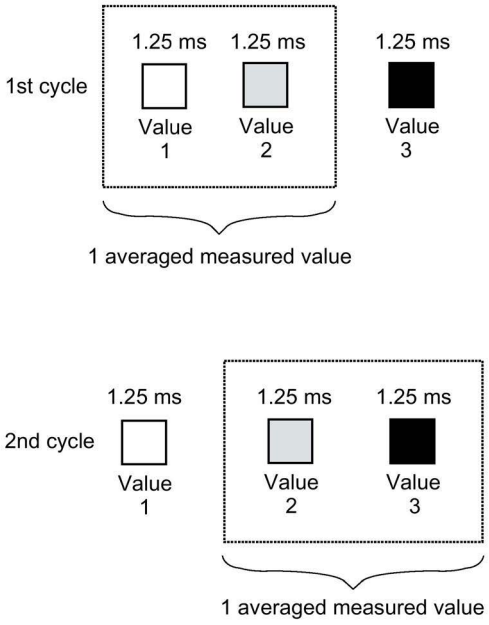


Figure C-1 Interference frequency suppression 400 Hz

The following figure shows how this works using a 60 Hz interference frequency suppression as an example. A 60 Hz interference frequency suppression corresponds to an integration time of 16.6 ms. The analog on-board I/O supplies a measured value to the CPU every 1.04 milliseconds within the integration time.

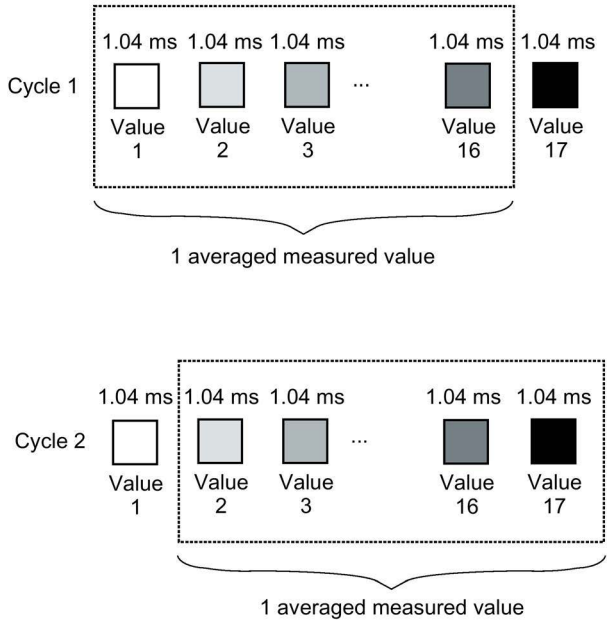


Figure C-2 Interference frequency suppression 60 Hz

The following figure shows how this works using a 50 Hz interference frequency suppression as an example. A 50 Hz interference frequency suppression corresponds to an integration time of 20 ms. The analog on-board I/O supplies a measured value to the CPU every millisecond within the integration time.

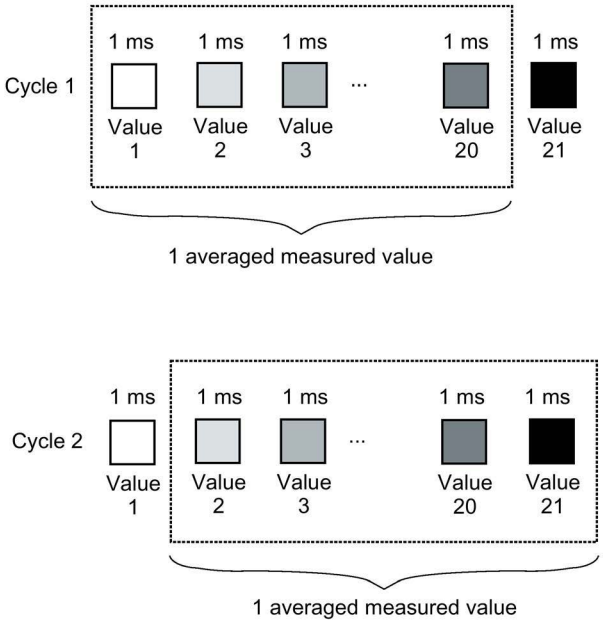


Figure C-3 Interference frequency suppression 50 Hz

The following figure shows how this works using a 10 Hz interference frequency suppression as an example. A 10 Hz interference frequency suppression corresponds to an integration time of 100 ms. The analog on-board I/O supplies a measured value to the CPU every millisecond within the integration time.

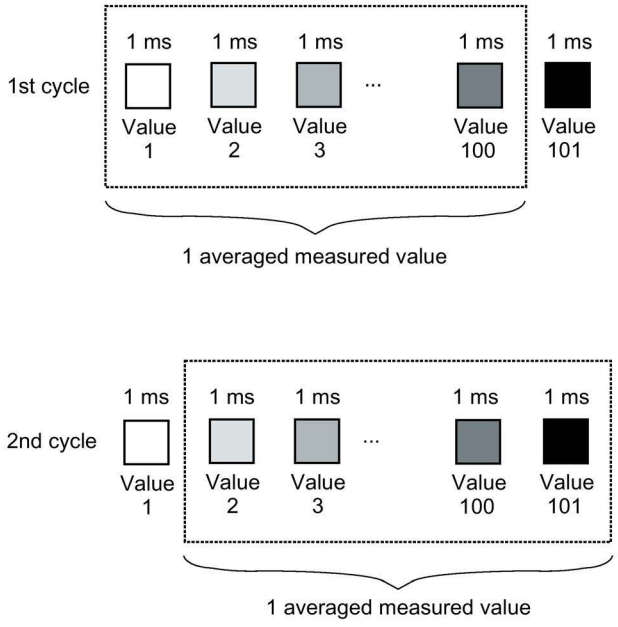


Figure C-4 Interference frequency suppression 10 Hz

The following table provides an overview of the configurable line frequencies, the integration time and the intervals within which measured values are supplied to the CPU.

Table C- 1 Overview of the configurable line frequencies

Interference frequency suppression	Integration time	Interval
400 Hz	2.5 ms	2 x 1.25 ms
60 Hz	16.6 ms	16 x 1.04 ms
50 Hz	20 ms	20 x 1 ms
10 Hz	100 ms	100 x 1 ms

Note

Basic error with an integration time of 2.5 ms.

With an integration time of 2.5 ms, the measured value is changed by the following values based on the additionally obtained basic error and noise:

- with "voltage", "current" and "resistance" by ±0.1 %
- with "Thermal resistor Pt 100 Standard" by ±0.4 K
- with "Thermal resistor Pt 100 Climatic" by ±0.3 K
- with "Thermal resistor Ni 100 Standard" by ±0.2 K
- with "Thermal resistor Ni 100 Climatic" by ±0.1 K

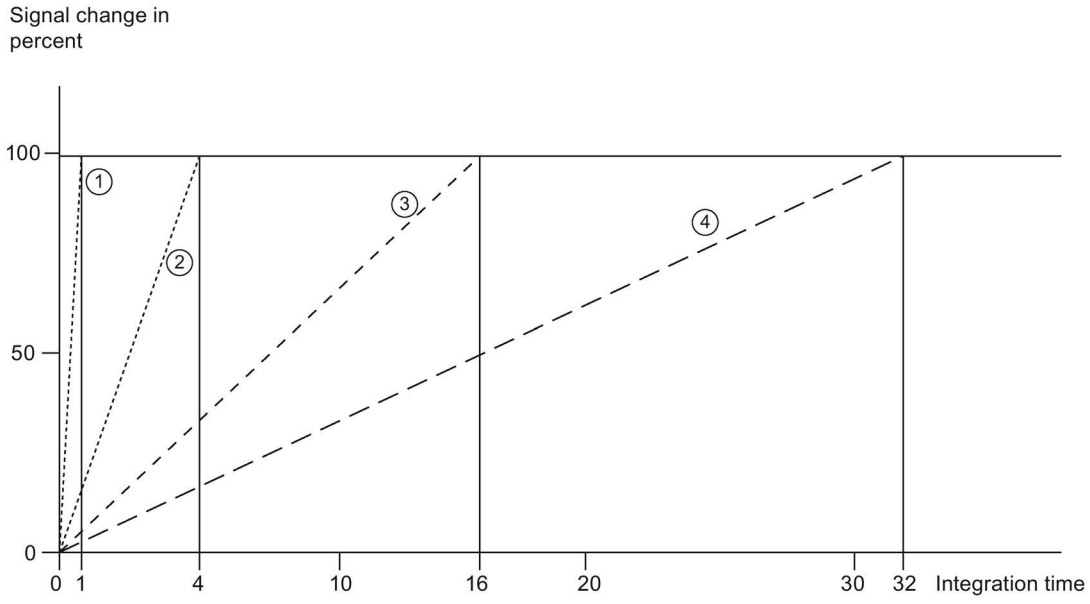
A detailed description of the basic and operating error is available in the function manual Analog value processing (http://support.automation.siemens.com/WW/view/en/67989094).

Smoothing

The individual measured values are smoothed by filtering. The smoothing can be set in 4 levels.

Smoothing time = Smoothing (k) x configured integration time

The following figure shows the time it takes for the smoothed analog value to reach approximately 100 % depending on the set smoothing. This is valid for all signal changes at the analog input.



① None (smoothing = 1 x integration time)
② Weak (smoothing = 4 x integration time) *
③ Medium (smoothing = 16 x integration time) *
④ Strong (smoothing = 32 x integration time) *

* The smoothing time can increase by 1 x integration time.

Figure C-5 Smoothing time depending on the set smoothing level

The following table shows the time it takes for the smoothed analog value to reach approximately 100 % depending on the set smoothing and the set interference frequency suppression.

Table C- 2 Smoothing time depending on the set smoothing level and interference frequency suppression

Selection of the smoothing (mean value generation from scan values)	Interference frequency suppression/smoothing time			
	400 Hz	60 Hz	50 Hz	10 Hz
None	2.5 ms	16.6 ms	20 ms	100 ms
Weak	10 ms	66.4 ms	80 ms	400 ms
Medium	40 ms	265.6 ms	320 ms	1600 ms
Strong	80 ms	531.2 ms	640 ms	3200 ms

Cycle time

The cycle times (1 ms, 1.04 ms and 1.25 ms) result from the configured interference frequency suppression. The cycle time is independent of the number of configured analog channels. The values for the analog input channels are detected sequentially in each cycle.

Reference

For more information on conversion time, cycle time and conversion method, refer to the Analog value processing (http://support.automation.siemens.com/WW/view/en/67989094) function manual.

C.2 Representation of analog values

Introduction

The analog values for all measuring ranges that you can use with the analog on-board I/O are represented in this appendix.

For cross-product information on "analog value processing", refer to the Analog value processing (http://support.automation.siemens.com/WW/view/en/67989094) function manual.

Measured value resolution

Each analog value is entered left aligned into the tags. The bits marked with "x" are set to "0".

Note

This resolution does not apply to temperature values. The digitalized temperature values are the result of a conversion in the analog on-board I/O.

Table C- 3 Resolution of the analog values

Resolution in bits including sign	Values		Analog value	
	Decimal	Hexadecimal	High byte	Low byte
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

C.3 Representation of input ranges

C.3.1 Representation of input ranges

The tables below set out the digitized representation of the input ranges separately for bipolar and unipolar input ranges. The resolution is 16 bits.

Table C- 4 Bipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
-27649	-100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Underrange
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
-32768	<-117.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

Table C- 5 Unipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Underrange
-4864	-17.593	1	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	
-32768	<-17.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

C.3.2 Representation of analog values in voltage measuring ranges

The following tables list the decimal and hexadecimal values (codes) of the possible voltage measuring ranges.

Table C- 6 Voltage measuring ranges ±10 V, ±5 V

Values		Voltage measuring range		Range
dec.	hex.	±10 V	±5 V	
32767	7FFF	>11.759 V	>5.879 V	Overflow
32511	7EFF	11.759 V	5.879 V	Overrange
27649	6C01			
27648	6C00	10 V	5 V	Nominal range
20736	5100	7.5 V	3.75 V	
1	1	361.7 µV	180.8 µV	
0	0	0 V	0 V	
-1	FFFF			
-20736	AF00	-7.5 V	-3.75 V	
-27648	9400	-10 V	-5 V	
-27649	93FF			Underrange
-32512	8100	-11.759 V	-5.879 V	
-32768	8000	<-11.759 V	<-5.879 V	Underflow

Table C- 7 Voltage measuring range 1 to 5 V, 0 to 10 V

Values		Voltage measuring range		Range
dec.	hex.	1 to 5 V	0 to 10 V	
32767	7FFF	>5.704 V	11.852 V	Overflow
32511	7EFF	5.704 V	11.759 V	Overrange
27649	6C01			
27648	6C00	5 V	10.0 V	Nominal range
20736	5100	4 V	7.5 V	
1	1	1 V + 144.7 µV	361.7 µV	
0	0	1 V	0 V	
-1	FFFF			Underrange
-4864	ED00	0.296 V	-1.759 V	
-32768	8000	< 0.296 V	< -1.759 V	Underflow

C.3.3 Representation of analog values in current measuring ranges

The following tables list the decimal and hexadecimal values (codes) of the possible current measuring ranges.

Table C- 8 Current measuring range ±20 mA

Values		Current measuring range	
dec.	**hex.**	**±20 mA**	
32767	7FFF	>23.52 mA	Overflow
32511	7EFF	23.52 mA	Overrange
27649	6C01		
27648	6C00	20 mA	Nominal range
20736	5100	15 mA	
1	1	723.4 nA	
0	0	0 mA	
-1	FFFF		
-20736	AF00	-15 mA	
-27648	9400	-20 mA	
-27649	93FF		Underrange
-32512	8100	-23.52 mA	
-32768	8000	<-23.52 mA	Underflow

Table C- 9 Current measuring ranges 0 to 20 mA and 4 to 20 mA

Values		Current measuring range		
dec.	**hex.**	**0 to 20 mA**	**4 to 20 mA**	
32767	7FFF	>23.52 mA	>22.81 mA	Overflow
32511	7EFF	23.52 mA	22.81 mA	Overrange
27649	6C01			
27648	6C00	20 mA	20 mA	Nominal range
20736	5100	15 mA	16 mA	
1	1	723.4 nA	4 mA + 578.7 nA	
0	0	0 mA	4 mA	
-1	FFFF			Underrange
-4864	ED00	-3.52 mA	1.185 mA	
-32768	8000	<-3.52 mA	<1.185 mA	Underflow

C.3.4 Representation of the analog values of resistance-type sensors/resistance-type thermometers

The following tables list the decimal and hexadecimal values (codes) of the possible resistance-type sensor ranges.

Table C- 10 Resistance-type sensors of 150 Ω, 300 Ω and 600 Ω

Values		Resistance-type sensor range			
dec.	hex.	150 Ω	300 Ω	600 Ω	
32767	7FFF	>176.38 Ω	>352.77 Ω	>705.53 Ω	Overflow
32511	7EFF	176.38 Ω	352.77 Ω	705.53 Ω	Overrange
27649	6C01				
27648	6C00	150 Ω	300 Ω	600 Ω	Nominal range
20736	5100	112.5 Ω	225 Ω	450 Ω	
1	1	5.43 mΩ	10.85 mΩ	21.70 mΩ	
0	0	0 Ω	0 Ω	0 Ω	

Table C- 11 Resistance-type thermometer Pt 100 Standard

Pt 100 Standard in °C (1 digit = 0.1°C)	Values		Pt 100 Standard in °F (1 digit = 0.1 °F)	Values		Pt 100 Standard in K (1 digit = 0.1 K)	Values		Range
	dec.	hex.		dec.	hex.		dec.	hex.	
> 1000.0	32767	7FFF	> 1832.0	32767	7FFF	> 1273.2	32767	7FFF	Overflow
1000.0 : 850.1	10000 : 8501	2710 : 2135	1832.0 : 1562.1	18320 : 15621	4790 : 3D05	1273.2 : 1123.3	12732 : 11233	31BC : 2BE1	Overrange
850.0 : -200.0	8500 : -2000	2134 : F830	1562.0 : -328.0	15620 : -3280	3D04 : F330	1123.2 : 73.2	11232 : 732	2BE0 : 2DC	Nominal range
-200.1 : -243.0	-2001 : -2430	F82F : F682	-328.1 : -405.4	-3281 : -4054	F32F : F02A	73.1 : 30.2	731 : 302	2DB : 12E	Underrange
< -243.0	-32768	8000	< -405.4	-32768	8000	< 30.2	32768	8000	Underflow

Table C- 12 Resistance-type thermometer Pt 100 Climate

Pt 100 Climate/ in °C (1 digit = 0.01 °C)	Values		Pt 100 Climate/ in °F (1 digit = 0.01 °F)	Values		Range
	dec.	hex.		dec.	hex.	
> 155.00	32767	7FFF	> 311.00	32767	7FFF	Overflow
155.00 : 130.01	15500 : 13001	3C8C : 32C9	311.00 : 266.01	31100 : 26601	797C : 67E9	Overrange
130.00 : -120.00	13000 : -12000	32C8 : D120	266.00 : -184.00	26600 : -18400	67E8 : B820	Nominal range
-120.01 : -145.00	-12001 : -14500	D11F : C75C	-184.01 : -229.00	-18401 : -22900	B81F : A68C	Underrange
< -145.00	-32768	8000	< -229.00	-32768	8000	Underflow

Table C- 13 Resistance-type thermometer Ni 100 standard

Ni 100 Standard in °C (1 digit = 0.1 °C)	Values		Ni 100 Standard in °F (1 digit = 0.1 °F)	Values		Ni 100 Standard in K (1 digit = 0.1 K)	Values		Range
	dec.	hex.		dec.	hex.		dec.	hex.	
> 295.0	32767	7FFF	> 563.0	32767	7FFF	> 568.2	32767	7FFF	Overflow
295.0 : 250.1	2950 : 2501	B86 : 9C5	563.0 : 482.1	5630 : 4821	15FE : 12D5	568.2 : 523.3	5682 : 5233	1632 : 1471	Overrange
250.0 : -60.0	2500 : -600	9C4 : FDA8	482.0 : -76.0	4820 : -760	12D4 : FD08	523.2 : 213.2	5232 : 2132	1470 : 854	Nominal range
-60.1 : -105.0	-601 : -1050	FDA7 : FBE6	-76.1 : -157.0	-761 : -1570	FD07 : F9DE	213.1 : 168.2	2131 : 1682	853 : 692	Underrange
< -105.0	-32768	8000	< -157.0	-32768	8000	< 168.2	32768	8000	Underflow

Table C- 14 Resistance-type thermometer Ni 100 Climate

Ni 100 Climate in °C (1 digit = 0.01 °C)	Values		Ni 100 Climate in °F (1 digit = 0.01 °F)	Values		Range
	dec.	hex.		dec.	hex.	
> 155.00	32767	7FFF	> 311.00	32767	7FFF	Overflow
155.00 : 130.01	15500 : 13001	3C8C : 32C9	311.00 : 266.01	31100 : 26601	797C : 67E9	Overrange

Ni 100 Climate in °C (1 digit = 0.01 °C)	Values		Ni 100 Climate in °F (1 digit = 0.01 °F)	Values		Range
	dec.	hex.		dec.	hex.	
130.00 : -60.00	13000 : -6000	32C8 : E890	266.00 : -76.00	26600 : -7600	67E8 : E250	Nominal range
-60.01 : -105.00	-6001 : -10500	E88F : D6FC	-76.01 : -157.00	-7601 : -15700	E24F : C2AC	Underrange
< - 105.00	-32768	8000	< - 157.00	-32768	8000	Underflow

C.3.5 Measured values for wire break diagnostics

Measured values for "Wire break" diagnostics as a function of diagnostics enables

With suitable parameter assignment, events that occur trigger a diagnostics entry and a diagnostics interrupt.

Table C- 15 Measured values for wire break diagnostics

Format	Parameter assignment	Measured values		Explanation
S7	• "Wire break" diagnostics enabled • "Overflow/Underflow" diagnostics enabled or disabled ("Wire break" diagnostics has a higher priority than "Overflow/Underflow" diagnostics)	32767	$7FFF_H$	"Wire break" or "Cable break" diagnostics alarm
	• "Wire break" diagnostics disabled • "Overflow/Underflow" diagnostics enabled	-32767	8000_H	• Measured value after leaving the underrange • Diagnostics alarm "Low limit" violated
	• "Wire break" diagnostics disabled • "Overflow/Underflow" diagnostics disabled	-32767	8000_H	Measured value after leaving the underrange

C.4 Representation of output ranges

C.4.1 Representation of output ranges

The tables below set out the digitalized representation of the output ranges separately for bipolar and unipolar ranges. The resolution is 16 bits.

Table C- 16 Bipolar output ranges

Dec. value	Output value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Maximum output value*
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
-27649	-100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Underrange
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	Minimum output value**

* When values > 32511 are specified, the output value is limited to 117.589%.

** When values < -32512 are specified, the output value is limited to -117.593%.

Table C- 17 Unipolar output ranges

Dec. value	Output value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32511	117.589	0	1	1	1	1	1	1	1	x	x	x	x	x	x	x	x	Maximum output value*
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Minimum output value**

* When values > 32511 are specified, the output value is limited to 117.589%.

** When values < 0 are specified, the output value is limited to 0%.

C.4.2 Representation of analog values in the voltage output ranges

The tables below list the decimal and hexadecimal values (codes) of the possible voltage output ranges.

Table C- 18 Voltage output range ±10 V

Values			Voltage output range	Range
	dec.	hex.	±10 V	
>117.589%	>32511	>7EFF	11.76 V	Maximum output value
117.589%	32511	7EFF	11.76 V	Overrange
	27649	6C01		
100%	27648	6C00	10 V	Nominal range
75%	20736	5100	7.5 V	
0.003617%	1	1	361.7 µV	
0%	0	0	0 V	
	-1	FFFF	-361.7 µV	
-75%	-20736	AF00	-7.5 V	
-100%	-27648	9400	-10 V	
	-27649	93FF		Underrange
-117.593%	-32512	8100	-11.76 V	
<-117.593%	<-32512	< 8100	-11.76 V	Minimum output value

Table C- 19 Voltage output range 0 V to 10 V

Values			Voltage output range	Range
	dec.	hex.	0 to 10 V	
>117.589%	>32511	>7EFF	11.76 V	Maximum output value
117.589%	32511	7EFF	11.76 V	Overrange
	27649	6C01		
100%	27648	6C00	10 V	Nominal range
75%	20736	5100	7.5 V	
0.003617%	1	1	361.7 µV	
0%	0	0	0 V	
<0%	<0	<0	0 V	Minimum output value

Table C- 20 Voltage output range 1 V to 5 V

Values			Voltage output range	Range
	dec.	hex.	1 to 5 V	
>117.589%	>32511	>7EFF	5.70 V	Maximum output value
117.589%	32511	7EFF	5.70 V	Overrange
	27649	6C01		
100%	27648	6C00	5 V	Nominal range
75%	20736	5100	4 V	
0.003617%	1	1	1 V +144.7 µV	
0%	0	0	1 V	
	-1	FFFF	1 V -144.7 µV	Underrange
-25%	-6912	E500	0 V	
<-25%	<-6912	<E500	0 V	Minimum output value

C.4.3 Representation of analog values in the current output ranges

The tables below list the decimal and hexadecimal values (codes) of the possible current output ranges.

Table C- 21 Current output range ±20 mA

Values			Current output range	Range
	dec.	hex.	±20 mA	
>117.589%	>32511	>7EFF	23.52 mA	Maximum output value
117.589%	32511	7EFF	23.52 mA	Overrange
	27649	6C01		
100%	27648	6C00	20 mA	Nominal range
75%	20736	5100	15 mA	
0.003617%	1	1	723.4 nA	
0%	0	0	0 mA	
	-1	FFFF	-723.4 nA	
-75%	-20736	AF00	-15 mA	
-100%	-27648	9400	-20 mA	
	-27649	93FF		Underrange
-117.593%	-32512	8100	-23.52 mA	
<-117.593%	<-32512	<8100	-23.52 mA	Minimum output value

Table C- 22 Current output range 0 to 20 mA

Values			Current output range	Range
	dec.	hex.	0 to 20 mA	
>117.589%	>32511	>7EFF	23.52 mA	Maximum output value
117.589%	32511	7EFF	23.52 mA	Overrange
	27649	6C01		
100%	27648	6C00	20 mA	Nominal range
75%	20736	5100	15 mA	
0.003617%	1	1	723.4 nA	
0%	0	0	0 mA	
<0%	<0	<0	0 mA	Minimum output value

Table C- 23 Current output range 4 to 20 mA

Values			Current output range	Range
	dec.	hex.	4 to 20 mA	
>117.589%	>32511	>7EFF	22.81 mA	Maximum output value
117.589%	32511	7EFF	22.81 mA	Overrange
	27649	6C01		
100%	27648	6C00	20 mA	Nominal range
75%	20736	5100	16 mA	
0.003617%	1	1	4 mA	
0%	0	0	4 mA	
	-1	FFFF		Underrange
-25%	-6912	E500	0 mA	
<-25%	<-6912	<E500	0 mA	Minimum output value