SIEMENS

SIMATIC

S7-300 and M7-300 Programmable Controllers Module Specifications

Reference Manual

This manual is part of the following documentation packages with the order numbers:
S7–300 Programmable Controller:
6ES7398-8FA10-8BA0
ET 200M Distributed I/O Device:
6ES7153-1AA00-8BA0

Edition 10/2001
A5E00105505-01

Safety Guidelines

This manual contains notices which you should observe to ensure your own personal safety, as well as to protect the product and connected equipment. These notices are highlighted in the manual by a warning triangle and are marked as follows according to the level of danger:

Danger

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

Warning

indicates that death, severe personal injury or substantial property damage **can** result if proper precautions are not taken.

Caution

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

Caution

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

Note

draws your attention to particularly important information on the product, handling the product, or to a particular part of the documentation.

Qualified Personnel

Only **qualified personnel** should be allowed to install and work on this equipment. Qualified persons are defined as persons who are authorized to commission, to ground, and to tag circuits, equipment, and systems in accordance with established safety practices and standards.

Correct Usage

Note the following:

Warning

This device and its components may only be used for the applications described in the catalog or the technical descriptions, and only in connection with devices or components from other manufacturers which have been approved or recommended by Siemens.

This product can only function correctly and safely if it is transported, stored, set up, and installed correctly, and operated and maintained as recommended.

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Bereich Automatisierungs- und Antriebstechnik
Geschaeftsgebiet Industrie-Automatisierungssysteme
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Disclaim of Liability

We have checked the contents of this manual for agreement with the hardware and software described. Since deviations cannot be precluded entirely, we cannot guarantee full agreement. However, the data in this manual are reviewed regularly and any necessary corrections included in subsequent editions. Suggestions for improvement are welcomed.

Technical data subject to change.

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Preface

Purpose of the Manual

The information contained in this manual will enable you to look up operator actions, function descriptions and the technical specifications of the signal modules, power supply modules and interface modules of the S7-300.

How to configure, assemble and wire these modules in an S7-300, M7-300 or ET 200M system is described in the installation manuals for each system.

Required Experience

To understand the manual, you should have general experience of automation engineering.

Audience

This reference manual describes the modules of the S7-300 which are used in the S7-300, M7-300 and ET 200M systems. It includes data sheets for the signal modules, power supply modules and interface modules of the S7-300.

Scope of the Manual

The present documentation package contains the descriptions for all modules available at the time of publication.

We reserve the right to separately include current product information on new modules and new releases of existing modules.

Changes Compared with the Previous Version

Compared to the previous version, of the ”Module Data” reference manual, the following chapters and appendices have been thoroughly revised and new modules added, as necessary:

- Chapter 3 “Digital Modules”,
- Chapter 4 “Analog Modules”
- Chapter 5 “Other Signal Modules”
- Chapter 8 “SIMATIC TOP connect und SIMATIC TOP connect TPA”
- Appendix A “Parameter Sets for Signal Modules”, Appendix B “Diagnostic Data of Signal Modules”, List of Abbreviations and Glossary

Note: The previous version of this ”Module Data” reference manual can be recognized by the number in the footer: EWA 4NEB 710 6067-0x-02.

The current number is: A5E00105505-01.

Standards and Approvals

The S7-300 meets the requirements and criteria of IEC 61131, Part 2. The S7-300 satisfies the requirements of the CE Mark. The approbations for CSA, UL and FM are available for the S7-300.

Details on the approbations and standards are given in Section 1.1.

How the Manual Fits in

S7-300, M7-300

Reference Manual "CPU Specifications" 📖 "CPU Specifications CPU 312 IFM to 318-2 DP" 📖 "CPU Specifications CPU 312C to 314C-2 PtP/DP"	Description of the operation, functions and technical CPU specifications.
Manual "Technological Functions" 📖 Manual Examples	Description of the individual technological functions: – Positioning – Counting – PtP Connection – Controlling The CD contains examples for the technological functions.
Installation Manual 📖 Manual	Description of the configuration, assembly, wiring, networking and commissioning of an S7-300.
Reference Manual "Module Specifications" →📖 Reference Manual You are reading this manual	Function description and technical specifications of the signal modules, power supply modules and interface modules.
Instruction List 📖 "CPUs 312 IFM, 314 IFM, 313, 315, 315-2 DP, 316-2 DP, 318-2 DP" 📖 "CPUs 312 C to 314 C-2 PtP/DP"	List of instructions for the CPUs and their execution times. List of blocks that can be executed (OBs/SFCs/SFBs) and their execution times.
Getting Started 📖 "CPU 31xC: Positioning with Analog Output" 📖 "CPU 31xC: Positioning with Digital Output" 📖 "CPU 31xC: Counting" 📖 "CPU 31xC: PtP Connection" 📖 "CPU 31xC: Controlling" 📖 "CPU 31xC" 📖 "S7-300"	A Getting Started leads you through an example from the first steps in commissioning to a functioning program.

ET 200M

Manual “ET 200M Distributed I/O Device” 📖 Manual	Description of the mechanical and electrical configuration, installation and wiring.
Reference Manual **“Signal Modules for Process Automation”** 📖 Reference Manual	Description of the overview of usage in process automation, the parameter assignment with SIMATIC PDM, the digital input and output modules.
Reference Manual “Module Specifications” →📖 Reference Manual You are reading this manual	Function description and technical specifications of the signal modules, power supply modules and interface modules.

Navigation

To help you find special information quickly, the manual contains the following access aids:

- At the start of the manual you will find a complete table of contents and a list of the diagrams and tables that appear in the manual.
- An overview of the contents of each section is provided in the left column on each page of each chapter.
- You will find a glossary in the appendix at the end of the manual. The glossary contains definitions of the main technical terms used in the manual.
- At the end of the manual you will find a comprehensive index which gives you fast access to the information you need.

Attributes of Technical Specifications

Several values of the technical data are specified with attributes in the module data sheets.

These attributes for the values in the technical data mean:

Attribute	Meaning
minimum/maximum	A minimum/maximum value represents a limit or operating value guaranteed by SIEMENS. The minimum or maximum of this value must not be exceeded within other operating limit values during operation. As a user, you must stay within the limits of this value.
typical	The typical value becomes settled under rated conditions and at an ambient temperature of 25° C. Values may fall below or exceed the typical value due to component tolerances.
approx.	The “approx.” value denotes a rounded value, for example the weight of a module.
without attributes	Values without attributes are rated values with no tolerances.

Further Support

Please contact your local Siemens representative if you have any queries about the products described in this manual.

http://www.ad.siemens.de/partner

Training Center

SSiemens offers a number of training courses to familiarize you with the SIMATIC S7 automation system. Please contact your regional training center or our central training center in D 90327 Nuremberg, Germany for details:
Telefon: +49 (911) 895-3200.

http://www.sitrain.com

SIMATIC Documentation on the Internet

You will find the documentation on the Internet at:

http://www.ad.siemens.de/support

Use the Knowledge Manager to find the documentation you need quickly. If you have any questions or suggestions concerning the documentation you can use the “Documentation” conference in the Internet forum.

Automation and Drives, Service & Support

Contact at any time of the day throughout the world:

SIMATIC Hotline

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The languages spoken on the SIMATIC Hotlines are normally English and German; on the Authorization Hotline, French, Italian and Spanish are also spoken.		

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In addition to our documentation, we offer our Know-how online on the Internet at:

http://www.ad.siemens.de/support

where you will find the following:

- Current Product Information leaflets, FAQs (Frequently Asked Questions), Downloads, Tips and Tricks.
- A newsletter giving you the most up-to-date information on our products.
- The Knowledge Manager helps you find the documents you need.
- Users and specialists from all over the world share information in the forum.
- Your local customer service representative for Automation & Drives in our customer service representative data bank.
- Information on field service, repairs, spare parts and more under “Services”.

Contents

Figures

Tables

General Technical Specifications

1

What are General Technical Specifications?

General technical specifications include the following:

- the standards and test values which the modules of the S7-300 programmable logic controller maintain and satisfy
- the test criteria to which the S7-300 modules were tested.

In this Chapter

1.1 Standards and Approvals

IEC 61131

The S7-300 programmable logic controller satisfies the requirements and criteria of Standard IEC 61131 Part 2.

CE Mark

Our products satisfy the requirements and protection objectives of the EC Directives listed below and comply with the harmonized European standards (EN) promulgated in the Official Journals of the European Community for programmable logic controllers:

- 89/336/EEC "Electromagnetic Compatibility" (EMC Directive)
- 73/23/EEC "Electrical Equipment Designed for Use between Certain Voltage Limits" (Low-Voltage Directive)

The declarations of conformity are held at the disposal of the competent authorities at the address below:

Siemens Aktiengesellschaft
Bereich Automatisierungstechnik
A&D AS E 42
Postfach 1963
D-92209 Amberg

Mark for Australia

Our products satisfy the requirements of Standard AS/NZS 2064 (Class A).

Use in Industrial Environment

SIMATIC products have been designed for use in industrial environments.

Table 1-1 Use in an Industrial Environment

EMC Directive	Requirements in Respect of:	
	Emitted Interference	Immunity
Industry	EN 50081-2 : 1993	EN 50082-2 : 1995

Use in Residential Areas

If you operate an S7-300 in a residential area, you must ensure Limit Value Class B in accordance with EN 55011 to guard against radio interference emissions.

Measures to achieve interference suppression according to Limit Value Class B:

- installation of the S7-300 in grounded cabinets and control boxes
- use of filters in supply lines

UL Approval

UL recognition mark
Underwriters Laboratories (UL) to
Standard UL 508, File No. 116536

CSA Approval

CSA certification mark
Canadian Standard Association (CSA) to
Standard C22.2 No. 142, File No. LR 48323

FM Approval

Factory Mutual Approval Standard Class Number 3611, Class I, Division 2, Group A, B, C, D.

Warning

Personal injury or property damage can result.

In areas subject to danger of explosion, personal injury or property damage can result if you withdraw connectors while an S7-300 is in operation.

Always isolate the S7-300 in areas subject to danger of explosion before withdrawing connectors.

1.2 Electromagnetic Compatibility

Introduction

In this section you will find details of the noise immunity of S7-300 modules and details of radio interference suppression.

The S7-300 modules satisfy, among other things, the requirements of the law applicable to EMC on the European domestic market.

Definition of "EMC"

Electromagnetic compatibility (EMC) is the ability of an electrical installation to function satisfactorily in its electromagnetic environment without interfering with that environment.

Pulse-Shaped Interference

The following table shows the electromagnetic compatibility of modules compared to pulse-shaped disturbance variables. A requirement for this is that the S7-300 system complies with the specifications and directives on electric design.

Table 1-2 Pulse-Shaped Interference

Pulse-Shaped Interference	Tested with	Satisfies Degree of Severity
Electrostatic discharge according to IEC 61000-4-2	8 kV 4 kV	3 (discharge in air) 2 (contact dis-charge)
Bursts (fast transient bursts) to IEC 61000-4-4	2 kV (supply cable) 2 kV (signal cable)	3
Energy-rich single impulse (surge) according to IEC 61000-4-5 External protective circuitry required (refer to the manual *S7-300 Programmable Controller, Hardware and Installation*, Chapter "Lightning Protection and Overvoltage Protection")		
• Asymmetrical coupling	2 kV (supply cable) 2 kV (signal/ data cable)	3
• Symmetrical coupling	1 kV (supply cable) 1 kV (signal/data data cable)	

Sinusoidal Interference

The table below shows the EMC behavior of the S7-300 modules with regard to sinusoidal disturbance variables.

Table 1-3 Sinusoidal Interference

Sinusoidal Interference	Test Values	Satisfies Degree of Severity
HF irradiation (electromagnetic fields) according to IEC 61000-4-3 according to IEC 61000-4-3	10 V/m with 80% amplitude modulation of 1 kHz over the range from 80 MHz to 1000 MHz 10 V/m with 50% pulse modulation at 900 MHz	3
HF conductance on cables and cable shields according to IEC 61000-4-6	Test voltage 10 V with 80% amplitude modulation of 1 kHz over the range from 9 MHz to 80 MHz	3

Emission of Radio Interference

Interference emission of electromagnetic fields in accordance with EN 55011: Limit value class A, Group 1.

From 30 to 230 MHz	< 40 dB (μV/m)Q
From 230 to 1000 MHz	< 47 dB (μV/m)Q
Measured at a distance of 10 m (98.4 ft.)	

Interference emission via the mains AC power supply in accordance with EN 55011: Limit value class A, Group 1.

From 0.15 to 0.5 MHz	< 79 dB (μV)Q < 66 dB (μV)M
From 0.5 to 5 MHz	< 73 dB (μV)Q < 60 dB (μV)M
From 5 to 30 MHz	< 73 dB (μV)Q < 60 dB (μV)M

1.3 Shipping and Storage Conditions for Modules and Backup Batteries

Shipping and Storage of Modules

S7-300 modules surpass the requirements of IEC 61131, Part 2, in respect of shipping and storage requirements. The following details apply to modules shipped and/or stored in their original packing.

Table 1-4 Shipping and Storage Conditions for Modules

Condition	Permitted Range
Free fall (in shipping packing)	$\leq$ 1m
Temperature	– 40 °C to + 70°C
Atmospheric pressure	1080 to 660 hPa (corresponding to an altitude of – 1000 to 3500 m)
Relative humidity	10 to 95 %, no condensation
Sinusoidal oscillations to IEC 60068-2-6	5 – 9 Hz: 3.5 mm 9 – 150 Hz: 9.8 m/s^2
Shock according to IEC 60068-2-29	250 m/s^2, 6 ms, 1000 shocks

Transporting Backup Batteries

Wherever possible, transport backup batteries in their original packing. Special approval does not have to be obtained for transporting backup batteries for S7-300 systems. The lithium content of the backup battery is approximately 0.25 g.

Storing Backup Batteries

Backup batteries must be stored in a cool and dry place. The maximum shelf life is 5 years.

Warning

Improper handling of backup batteries can result in injury and damage to property. If backup batteries are not treated properly, they can explode and cause severe burning.

Observe the following rules when handling backup batteries used in the S7-300 programmable logic controller:

- never charge them
- never heat them
- never throw them in the fire
- never damage them mechanically (drill, squeeze, etc.)

1.4 Mechanical and Climatic Environmental Conditions for Operating S7-300s

Operating Conditions

S7-300 systems are intended for stationary use in locations protected against the weather. The operating conditions surpass the requirements of IEC 61131, Part 2.

The S7-300 satisfies the operating conditions of Classes 3M3 and 3C3 to DIN EN 60721, Part 2.

Use with additional measures

The S7-300, for example, must **not** be used without taking additional measures:

- in locations exposed to a high degree of ionizing radiation
- in hostile environments caused, for instance, by
  - dust accumulation
  - corrosive vapors or gases
  - strong electric or magnetic fields
- in installations requiring special monitoring, for example
  - elevators
  - electrical installations in particularly hazardous areas

An additional measure might be, for instance, installation of the S7-300 in a cabinet or in a housing.

Ambient Mechanical Conditions

The ambient mechanical conditions for S7-300 modules are listed in the following table in the form of sinusoidal oscillations.

Table 1-5 Mechanical Conditions

Frequency Range in Hz	Continuous	Occasional
$10 \leq f \leq 58$	0.0375 mm amplitude	0.075 mm amplitude
$58 \leq f \leq 150$	0.5 g constant acceleration	1 g constant acceleration

Reducing Vibrations

If your S7-300 modules are exposed to severe shock and/or vibrations, you must take the appropriate measures to reduce the acceleration and/or amplitude, respectively.

We recommend that you install the S7-300 on vibration-damping materials (for example, rubber-metal antivibration mountings).

Ambient Mechanical Conditions Test

The following table contains important information on the type and scope of tests for ambient mechanical conditions.

Table 1-6 Ambient Mechanical Conditions Test

Test ...	Test Standard	Remarks
Vibrations	Vibration test according to IEC 60068 Part 2-6 (sinusoidal)	Type of oscillation: frequency sweeps with a rate of change of 1 octave/minute. 10 Hz $\leq$ f $\leq$ 58 Hz, constant amplitude of 0.075 mm 58 Hz $\leq$ f $\leq$ 150 Hz, constant acceleration of 1 g Duration of oscillation: 10 frequency sweeps per axis in each of three axes perpendicular to each other
Shock	Shock test to IEC 60068, Part 2-29	Type of shock: half-sine Severity of shock: 15 g peak value, 11 ms duration Direction of shock: 3 shocks each in the +/– direction in each of three axes perpendicular to each other

Climatic Conditions

You can use S7-300s under the following climatic conditions:

Table 1-7 Climatic Conditions

Climatic Conditions	Permitted Range	Remarks
Temperature: horizontal installation: vertical installation:	 0 to 60°C 0 to 40°C	–
Relative humidity	10 to 95 %	Non-condensing, corresponds to relative humidity (RH) Class 2 according to IEC 61131, Part 2
Atmospheric pressure	1080 to 795 hPa	Corresponding to an altitude of – 1000 to 2000 m
Concentration of contaminants	SO_2: < 0.5 ppm; RH < 60 %, non-condensing H_2S: < 0.1 ppm; RH < 60 %, non-condensing	Test: 10 ppm; 4 days Test: 1 ppm; 4 days

1.5 Information on Insulation Tests, Protection Class and Degree of Protection

Test Voltages

Dielectric strength was demonstrated in the routine test with the following test voltages:

Table 1-8 Test Voltages

Circuits with Rated Voltage U_e to Other Circuits or to Ground	Test Voltage
0 V < U_e ≤ 50 V	600 VDC, 1 s
100 V < U_e ≤ 300 V	(2 U_N + 1000) VAC

Protection Class

Protection Class I according to IEC 60536 – in other words, protective conductor connection to rail necessary

Protection against Ingress of Foreign Bodies and Water

Degree of protection IP 20 according to IEC 60529, that is, protection against contact with standard probes.

There is no special protection against the ingress of water.

1.6 Rated Voltages of the S7-300

Rated Operating Voltages

The modules of the S7-300 operate with different rated voltages. The following table contains the rated voltages and the corresponding tolerances.

Table 1-9 Rated Voltages

Rated Voltage	Tolerance Range
24 VDC	20.4 to 28.8 VDC
120 VAC	93 to 132 VAC
230 VAC	187 to 264 VAC

1.7 SIMATIC Outdoor Modules

Definition

SIMATIC Outdoor modules are modules that can be used under extended environmental conditions. Extended environmental conditions mean:

- operation possible at temperatures from – 25°C to + 60°C
- occasional, brief condensation permitted
- increased mechanical stress permissible

Comparison with “Standard” Modules

The functional scope and technical specifications for the SIMATIC Outdoor modules correspond to those of the “standard” modules.

The mechanical and climatic environmental conditions as well as their test method have changed.

The SIMATIC Outdoor modules have their own Order Numbers (refer to Table 1-10)

Configuring in *STEP 7*

If you have a *STEP 7* version in which the SIMATIC Outdoor modules are not contained in the hardware catalog, simply configure your system with the corresponding “standard” modules (refer to Table 1-10).

SIMATIC Outdoor Modules

The following table contains all SIMATIC Outdoor modules.

The Order Numbers of the corresponding ”standard” modules have been included as an aid to configuration. You can refer to the description and technical specifications in the special section on the “standard” module.

Table 1-10 “SIMATIC Outdoor Modules”

Module	SIMATIC Outdoor Module for Use under Extended Environmental Conditions	“Standard” Modules
	as of Order No.	
IM 153-1	6ES7 153-1AA**82**-0XB0	6ES7 153-1AA02-0XB0
CPU 315-2 DP CPU 312 IFM CPU 314 CPU 314 IFM	6ES7 315-2AF**82**-0AB0 6ES7 312-5AC**81**-0AB0 6ES7 314-1AE**83**-0AB0 6ES7 314-5AE**83**-0AB0	6ES7 315-2AF02-0AB0 6ES7 312-5AC01-0AB0 6ES7 314-1AE03-0AB0 6ES7 314-5AE03-0AB0
IM 365	6ES7 365-0BA**81**-0AA0	6ES7 365-0BA01-0AA0
Power supply module PS 305 PS 307	 6ES7 305-1BA**80**-0AA0 6ES7 307-1EA**80**-0AA0	 --- 6ES7 307-1EA00-0AA0
SM 321 digital input module; SM 321; DI 16 × 24 VDC SM 321; DI 32 × 24 VDC SM 321; DI 16 × 24 VDC SM 321; DI 16 × 24 V-125 VDC SM 321; DI 8 × 120/230 VAC	 6ES7 321-1BH**82**-0AA0 6ES7 321-1BL**80**-0AA0 6ES7 321-7BH**80**-0AB0 6ES7 321-1CH**80**-0AA0 6ES7 321-1FF**81**-0AA0	 6ES7 321-1BH02-0AA0 6ES7 321-1BL00-0AA0 6ES7 321-7BH00-0AB0 --- 6ES7 321-1FF01-0AB0
SM 322 digital output module; SM 322; DO 16 × 24 VDC/0.5 A SM 322; DO 8 × Rel. 230 VAC/5 A SM 322, DO 8 × 48-125 VDC/1.5 A SM 322; DO 8 × 120/230 VAC/2 A SM 322; DO 8 × 24 VDC/0.5 A	 6ES7 322-1BH**81**-0AA0 6ES7 322-1HF**80**-0AA0 6ES7 322-1CF**80**-0AA0 6ES7 322-1FF**81**-0AA0 6ES7 322-8BF**80**-0AB0	 6ES7 322-1BH01-0AA0 6ES7 322-1HF10-0AA0 --- 6ES7 322-1FF01-0AA0 6ES7 322-8BF00-0AB0
Digital input/output module SM 323; DI8/DO8 × 24 VDC/0.5 A	 6ES7 323-1BH**81**-0AA0	 6ES7 323-1BH01-0AA0
Analog input module SM 331 analog input module; AI 2 × 12 Bit	 6ES7 331-7KB**82**-0AB0	 6ES7 331-7KB02-0AB0
Analog output module SM 332 analog output module; AO 2 × 12 Bit	 6ES7 332-5HB**81**-0AB0	 6ES7 332-5HB01-0AB0
SM 334 analog I/O module; SM 334; AI4/AO 2 × 12 Bit	 6ES7 334-0KE**80**-0AB0	 6ES7 334-0KE00-0AB0

Table 1-10 "SIMATIC Outdoor Modules", continued

Module	SIMATIC Outdoor Module for Use under Extended Environmental Conditions	"Standard" Modules
	as of Order No.	
FEPROM 64 KByte memory card	6ES7 951-0KF**80**-0AA0	6ES7 951-0KF00-0AA0
FEPROM 32 kByte memory card	6ES7 951-0KE**80**-0AA0	6ES7 951-0KE00-0AA0
FEPROM 16 kByte memory card	6ES7 951-0KD**80**-0AA0	6ES7 951-0KD00-0AA0
Bus connector	6ES7 972-0BAx0-0XA0 6ES7 972-0BBx0-0XA0	

1.8 Mechanical and Climatic Environmental Conditions for Operating SIMATIC Outdoor Modules

Ambient Mechanical Conditions

Operating category: according to IEC 721 3-3, Class 3M4.

Ambient Mechanical Conditions Test

The following table provides information about the type and extent of tests for mechanical ambient conditions on SIMATIC Outdoor modules.

Table 1-11 Outdoor Modules Ambient Mechanical Conditions Test

Test ...	Test Standard	Remarks
Vibrations	Vibration test according to IEC 6008 Part 2-6 (sinusoidal)	Type of oscillation: frequency sweeps with a rate of change of 1 octave/minute. 5 Hz $\leq$ f $\leq$ 9 Hz, constant amplitude of 3.5 mm 9 Hz $\leq$ f $\leq$ 150 Hz, constant acceleration of 1 g Ocillation period: 10 frequency sweeps per axis in each of three axes perpendicular to each other
Shock	Shock test according to IEC 6008 Part 2-27	Type of shock: half-sine Severity of shock: 15 g peak value, 11 ms duration Direction of shock: 3 shocks each in the +/– direction in each of three axes perpendicular to each other

Climatic Conditions

The SIMATIC Outdoor modules can be used under the following climatic ambient conditions:

Operating category: according to IEC 721 3-3, Class 3K5.

Table 1-12 Outdoor Modules Climatic Conditions

Ambient Condition	Permitted Range	Remarks
Temperature: horizontal installation vertical installation	 –25°C to 60°C –25 °C to 40°C	–
Relative humidity	From 5 to 95 %	**Occasional, brief condensation**, corresponds to relative humidity (RH) Class 2 according to IEC 61131, Part 2
Atmospheric pressure	1080 to 795 hPa	Corresponds to a height of –1000 to 2000 m
Pollutant concentration (according to IEC 721 3-3; class 3C3)	 SO_2: < 0.5 ppm; Relative humidity < 60% H_2S: < 0.1 ppm; Relative humidity < 60%	Test: 10 ppm; 4 days 1 ppm; 4 days

Power Supply Modules 2

Introduction

Various power supply modules are available to supply your S7-300 programmable controller and the sensors/actuators with 24 VDC.

Power Supply Modules

This chapter describes the technical specifications of the power supply modules of the S7-300 programmable controller.

In addition to the technical specifications, this chapter describes the following:

- The characteristics
- Connection Diagram
- Block Diagram
- Line protection
- Reaction to atypical operating conditions

In this Chapter

2.1 Power Supply Module PS 305; 2 A; (6ES7 305-1BA80-0AA0)

Order Number “SIMATIC Outdoor Module”

6ES7 305-1BA80-0AA0

Characteristics

The PS 305 power supply module (2 A) has the following salient features:

- Output current 2 A
- Output voltage 24 VDC; proof against short-circuit and open circuit
- Connection to DC power supply
  (rated input voltage 24/48/72/96/110 VDC)
- Reliable isolation to EN 60 950
- Can be used as load power supply

Wiring Schematic of the PS 305; 2 A

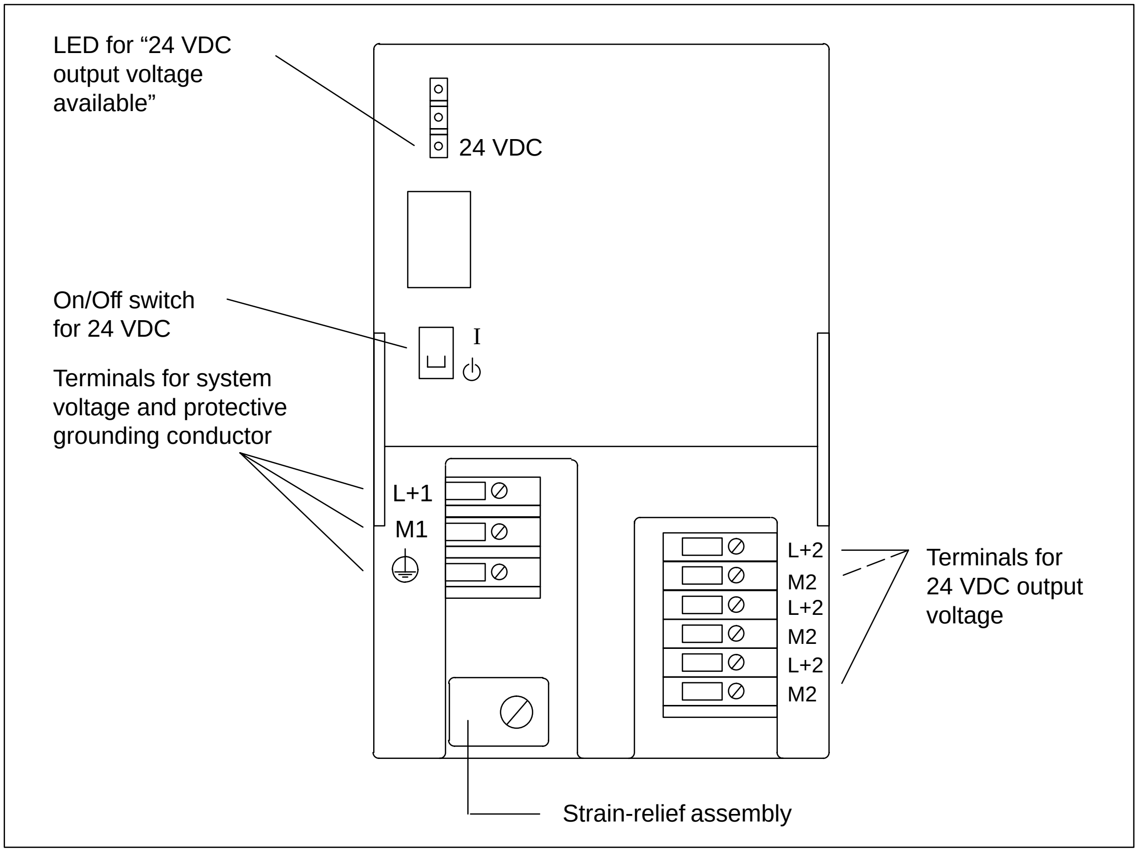


Figure 2-1 Wiring Schematic of the PS 305 Power Supply Module (2 A)

Technical Specifications of the PS 305; 2 A (6ES7 305-1BA80-0AA0)

Dimensions and Weight	
Dimensions W × H × D (in millimeters)	80 × 125 × 120
Weight	Approx. 740 g
Input Rating	
Input voltage	
• Rated value	24/48/72/96/110 VDC
• Voltage range	16.8 to 138 VDC
Rated input current	
• at 24 V	2.7 A
• at 48 V	1.3 A
• at 72 V	0.9 A
• at 96 V	0.65 A
• at 110 V	0.6 A
Inrush current (at 25 °C)	20 A
I^2t (at inrush current)	5 A^2s
Output Rating	
Output voltage	
• Rated value	24 VDC
• Permitted range	24 V ± 3%, stable at no load
• Ramp-up time	max. 3 s
Output current	
• Rated value	2 A; 1) Can be connected in parallel
Short-circuit protection	Electronic, nonlatching, from 1.65 to 1.95 × I_N
Residual ripple	max. 150 mV_{SS}

Other Parameters	
Protection class according to IEC 536 (DIN VDE 0106, Part 1)	I, with protective grounding conductor
Insulation	
• Isolation voltage rating (24 V to input)	150 VAC
• Tested with	2800 VDC
Reliable isolation	SELV circuit
Buffering of supply failures (at 24/48/72/96/110 V)	> 10 ms
• Repeat rate	min. 1 s
Efficiency	75%
Power input	64 W
Power loss	16 W
Diagnostics	
LED for output voltage available	Yes, green LED

1) With limited input voltage range > 24 V (24 to 138 VDC) the PS 305 can be loaded with 3 A.

Basic Circuit Diagram of the PS 305; 2 A

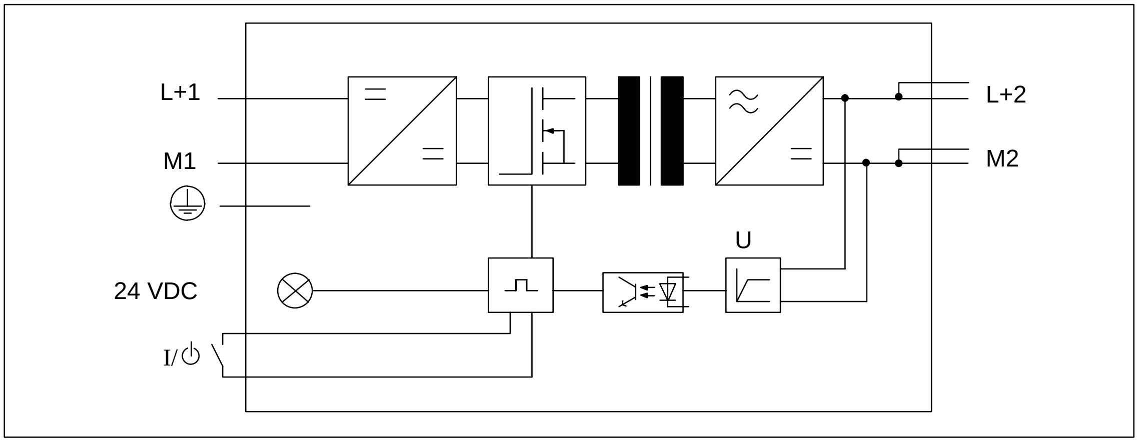


Figure 2-2 Basic Circuit Diagram of the PS 305 Power Supply Module (2 A)

Line Protection

We recommend that you install a miniature circuit-breaker (MCB) (for example Siemens 5SN1 series) with the following rating to protect the incoming supply cable of the PS 305 power supply module (2 A):

- Rated current at 110 VDC: 10 A
- Tripping characteristic (type): C.

Reaction to Atypical Operating Conditions

Table 2-1 Reaction of the PS 305 Power Supply Module (2 A) to Atypical Operating Conditions

If ...	... Then ...	24 VDC LED
... the output circuit is overloaded: • I > 3.9 A (dynamic) • 3 A < I ≤ 3.9 A (static)	 Voltage dip, autom. volt. recovery Voltage drop, shortening of service life	 Flashes
... the output is short-circuited	Output voltage 0 V; automatic voltage recovery after short circuit has been eliminated	Dark
an overvoltage occurs on the primary side	Possible destruction	-
there is an undervoltage on the primary side	Automatic disconnection; automatic voltage recovery	Dark

2.2 Power Supply Module PS 307; 2 A; (6ES7 307-1BA00-0AA0)

Order Number

6ES7 307-1BA00-0AA0

Characteristics

The PS 307 power supply module (2 A) has the following salient features:

- Output current 2 A
- Output voltage 24 VDC; proof against short-circuit and open circuit
- Connection to single-phase AC system

  (input voltage 120/230 VAC, 50/60 Hz)
- Reliable isolation to EN 60 950
- Can be used as load power supply

Wiring Schematic of the PS 307; 2 A

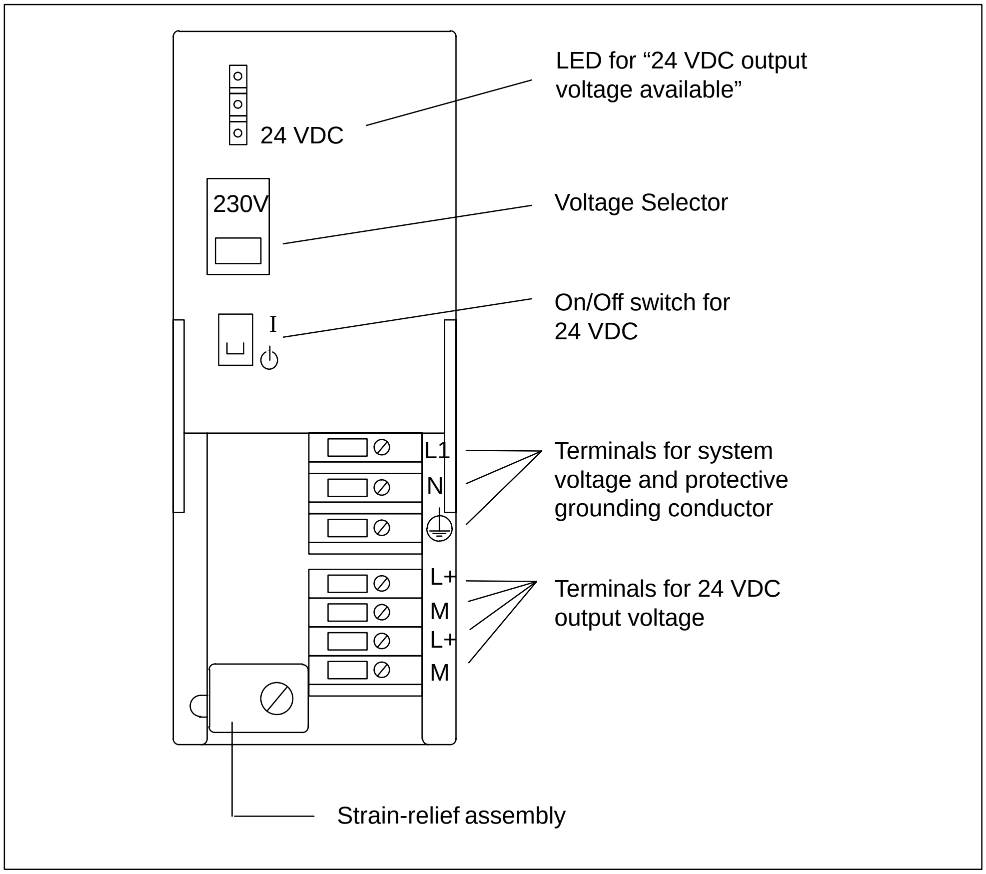


Figure 2-3 Wiring Schematic of the PS 307 Power Supply Module (2 A)

Basic Circuit Diagram of the PS 307; 2 A

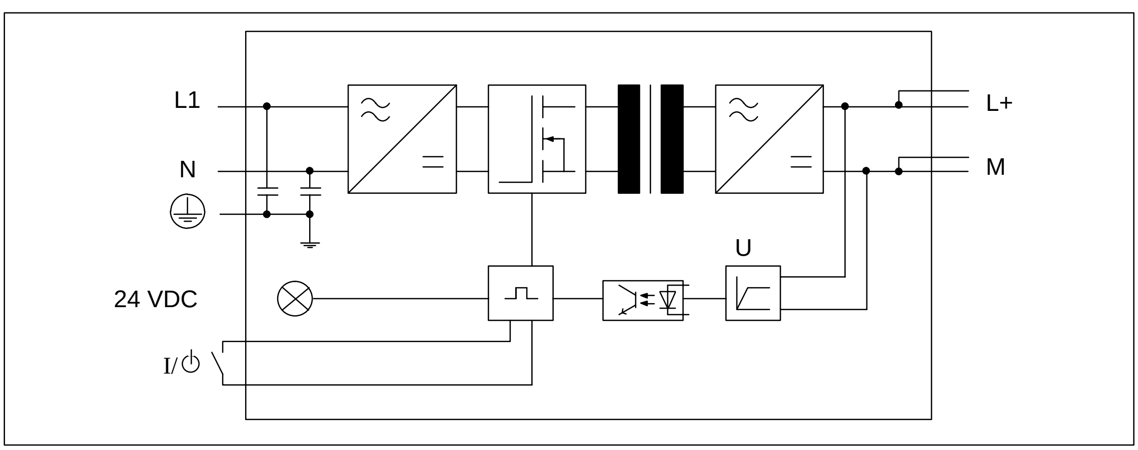


Figure 2-4 Basic Circuit Diagram of the PS 307 Power Supply Module (2 A)

Line Protection

We recommend that you install a miniature circuit-breaker (MCB) (for example Siemens 5SN1 series) with the following rating to protect the incoming supply cable of the PS 307 power supply module (2 A):

- Rated current at 230 VAC: 6 A
- Tripping characteristic (type): C.

Reaction to Atypical Operating Conditions

Table 2-2 Reaction of the PS 307 Power Supply Module (2 A) to Atypical Operating Conditions

If ...	... Then ...	24 VDC LED
... the output circuit is overloaded: • I > 2.6 A (dynamic) • 2 A < I ≤ 2.6 A (static)	 Voltage dip, autom. volt. recovery Voltage drop, shortening of service life	Flashes
... the output is short-circuited	Output voltage 0 V; automatic voltage recovery after short circuit has been eliminated	Dark
an overvoltage occurs on the primary side	Possible destruction	–
there is an undervoltage on the primary side	Automatic disconnection; automatic voltage recovery	Dark

Technical Specifications of the PS 307; 2 A (6ES7 307-1BA00-0AA0)

Dimensions and Weight	
Dimensions W × H × D (in millimeters)	50 × 125 × 120
Weight	Approx. 420 g
Input Rating	
Input voltage	
• Rated value	120 / 230 VAC
System frequency	
• Rated value	50 Hz or 60 Hz
• Permitted range	47 Hz to 63 Hz
Rated input current	
• at 230 V	0.5 A
• at 120 V	0.8 A
Inrush current (at 25°C)	20 A
I^2t (at inrush current)	1 A^2s
Output Rating	
Output voltage	
• Rated value	24 VDC
• Permitted range	24 V ± 5%, stable at no load
• Ramp-up time	max. 2.5 s
Output current	
• Rated value	2 A, cannot be connected in parallel
Short-circuit protection	Electronic, nonlatching, 1.1 to 1.3 × I_N
Residual ripple	max. 150 mV_{SS}

Other Parameters	
Protection class according to IEC 536 (DIN VDE 0106, Part 1)	I, with protective grounding conductor
Insulation	
• Rated insulation level (24 V to L1)	250 VAC
• Tested with	2800 VDC
Reliable isolation	SELV circuit
Bridging of power failures (at 93 and/or 187 V)	min. 20 ms
• Repeat rate	min 1 s
Efficiency	83 %
Power input	58 W
Power loss	typ. 10 W
Diagnostics	
LED for output voltage available	Yes, green LED

2.3 Power Supply Module PS 307; 5 A; (6ES7 307-1EAx0-0AA0)

Order Number: "Standard Module"

6ES7 307-1EA00-0AA0

Order Number "SIMATIC Outdoor Module"

6ES7 307-1EA80-0AA0

Characteristics

The PS 307 power supply module (5 A) has the following salient features:

- Output current 5 A
- Output voltage 24 VDC; proof against short-circuit and open circuit
- Connection to single-phase AC system
  (input voltage 120/230 VAC, 50/60 Hz)
- Reliable isolation to EN 60 950
- Can be used as load power supply

Wiring Schematic of the PS 307; 5 A

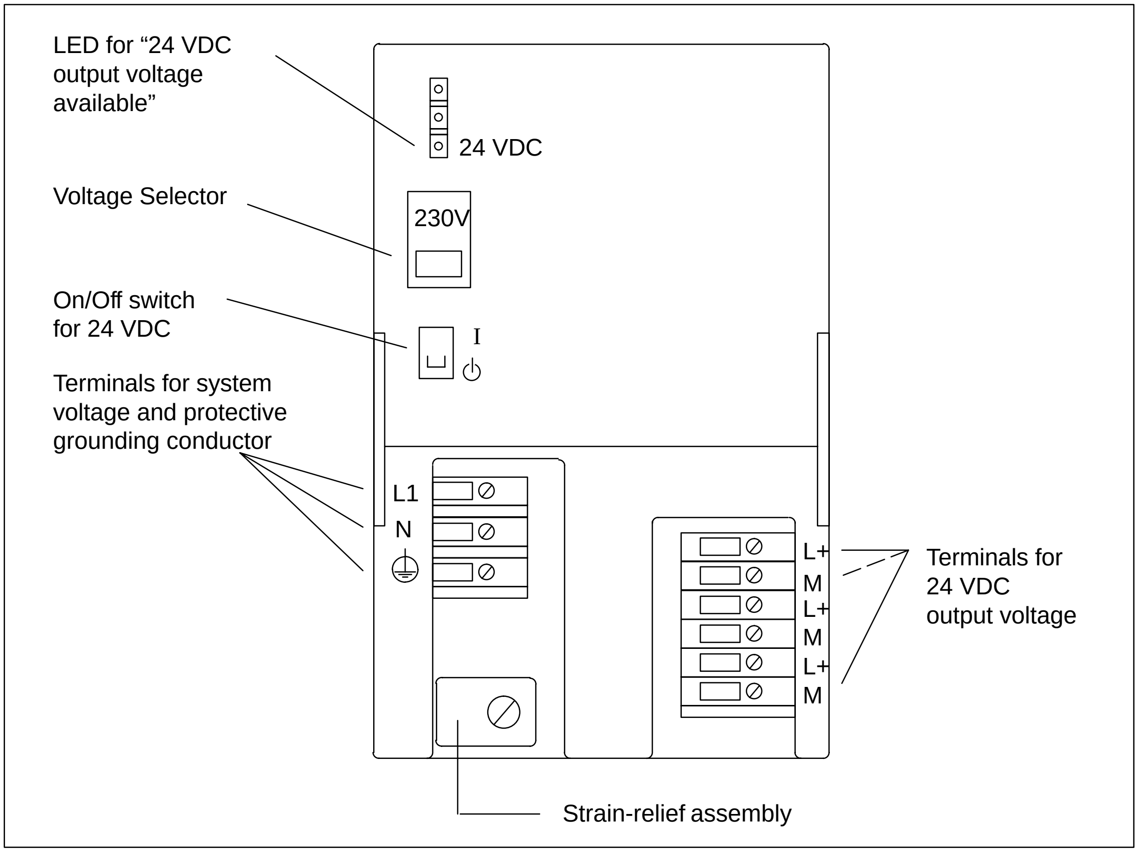


Figure 2-5 Wiring Schematic of the PS 307 Power Supply Module (5 A)

Basic Circuit Diagram of the PS 307; 5 A

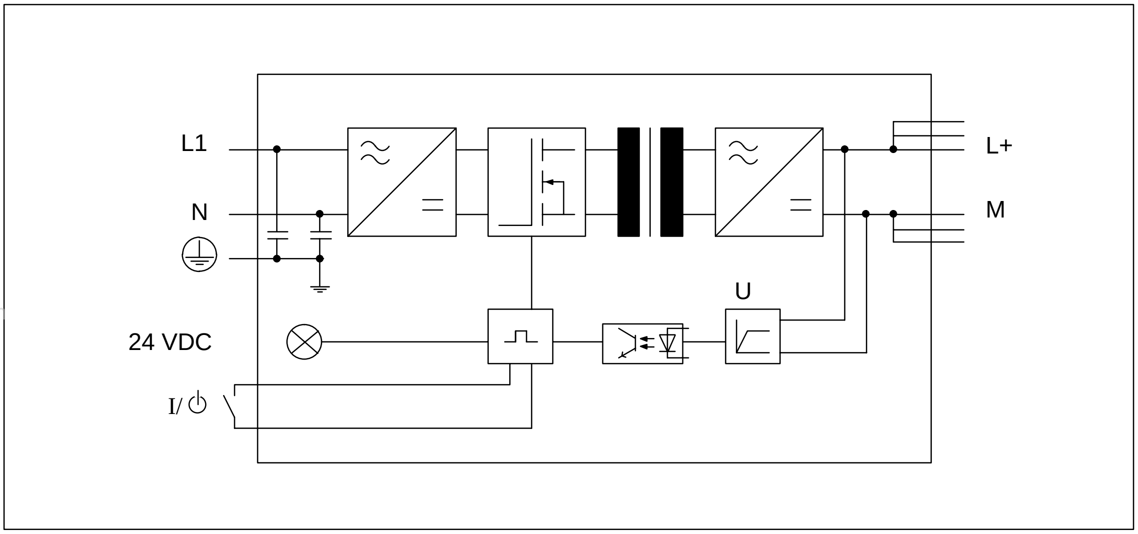


Figure 2-6 Basic Circuit Diagram of the PS 307 Power Supply Module (5 A)

Line Protection

We recommend that you install a miniature circuit-breaker (MCB) (for example Siemens 5SN1 series) with the following rating to protect the incoming supply cable of the PS 307 power supply module (5 A):

- Rated current at 230 VAC: 10 A
- Tripping characteristic (type): C.

Reaction to Atypical Operating Conditions

Table 2-3 Reaction of the PS 307 Power Supply Module (5 A) to Atypical Operating Conditions

If ...	... Then ...	24 VDC LED
... the output circuit is overloaded: • I > 6.5 A (dynamic) • 5 A < I ≤ 6.5 A (static)	 Voltage dip, autom. volt. recovery Voltage drop, shortening of service life	 Flashes
... the output is short-circuited	Output voltage 0 V; automatic voltage recovery after short circuit has been eliminated	Dark
an overvoltage occurs on the primary side	Possible destruction	–
there is an undervoltage on the primary side	Automatic disconnection; automatic voltage recovery	Dark

Technical Specifications of the PS 307; 5 A (6ES7 307-1EA00-0AA0)

Dimensions and Weight	
Dimensions W × H × D (in millimeters)	80 × 125 × 120
Weight	Approx. 740 g
Input Rating	
Input voltage	
• Rated value	120 / 230 VAC
System frequency	
• Rated value	50 Hz or 60 Hz
• Permitted range	47 Hz to 63 Hz
Rated input current	
• at 120 V	2 A
• at 230 V	1 A
Inrush current (at 25 °C)	45 A
I^2t (at inrush current)	1.2 A^2s
Output Rating	
Output voltage	
• Rated value	24 VDC
• Permitted range	24 V ± 5%, stable at no load
• Ramp-up time	max. 2.5 s
Output current	
• Rated value	5 A
	Cannot be connected in parallel
Short-circuit protection	Electronic, nonlatching, 1.1 to 1.3 × I_N
Residual ripple	max. 150 mV_{SS}

Other Parameters	
Protection class according to IEC 536 (DIN VDE 0106, Part 1)	I, with protective grounding conductor
Insulation	
• Rated insulation level (24 V to L1)	250 VAC
• Tested with	2800 VDC
Reliable isolation	SELV circuit
Bridging of power failures (at 93 and/or 187 V)	min. 20 ms
• Repeat rate	min 1 s
Efficiency	87 %
Power input	138 W
Power loss	typ. 18 W
Diagnostics	
LED for output voltage available	Yes, green LED

Technical Specifications of the PS 307; 5 A (6ES7 307-1EA80-0AA0)

Dimensions and Weight	
Dimensions W × H × D (in millimeters)	80 × 125 × 120
Weight	Approx. 570 g
Input Rating	
Input voltage	
• Rated value	120/230 VDC
System frequency	
• Rated value	50 Hz or 60 Hz
• Permitted range	47 Hz to 63 Hz
Rated input current	
• at 120 V	2.1 A
• at 230 V	1.2 A
Inrush current (at 25 °C)	45 A
I^2t (at inrush current)	1.8 A^2s
Output Rating	
Output voltage	
• Rated value	24 VDC
• Permitted range	24 V ± 3%
• Ramp-up time	max. 3 s
Output current	
• Rated value	5 A; cannot be connected in parallel
Short-circuit protection	Electronic, nonlatching, 1.1 to 1.3 × I_N
Residual ripple	max. 150 mV_{ss}

Other Parameters	
Protection class according to IEC 536 (DIN VDE 0106, Part 1)	I, with protective grounding conductor
Insulation	
• Rated insulation level (24 V to L1)	250 VAC
• Tested with	2800 VDC
Reliable isolation	SELV circuit
Bridging of power failures (at 93 and/or 187 V)	min. 20 ms
• Repeat rate	min. 1 s
Efficiency	84%
Power input	143 W
Power loss	23 W
Diagnostics	
LED for output voltage available	Yes, green LED

2.4 Power Supply Module PS 307; 10 A; (6ES7 307-1KA00-0AA0)

Order Number

6ES7 307-1KA00-0AA0

Characteristics

The PS 307 power supply module (10 A) has the following salient features:

- Output current 10 A
- Output voltage 24 VDC; proof against short-circuit and open circuit
- Connection to single-phase AC system
  (input voltage 120/230 VAC, 50/60 Hz)
- Reliable isolation to EN 60 950
- Can be used as load power supply

Wiring Schematic of the PS 307; 10 A

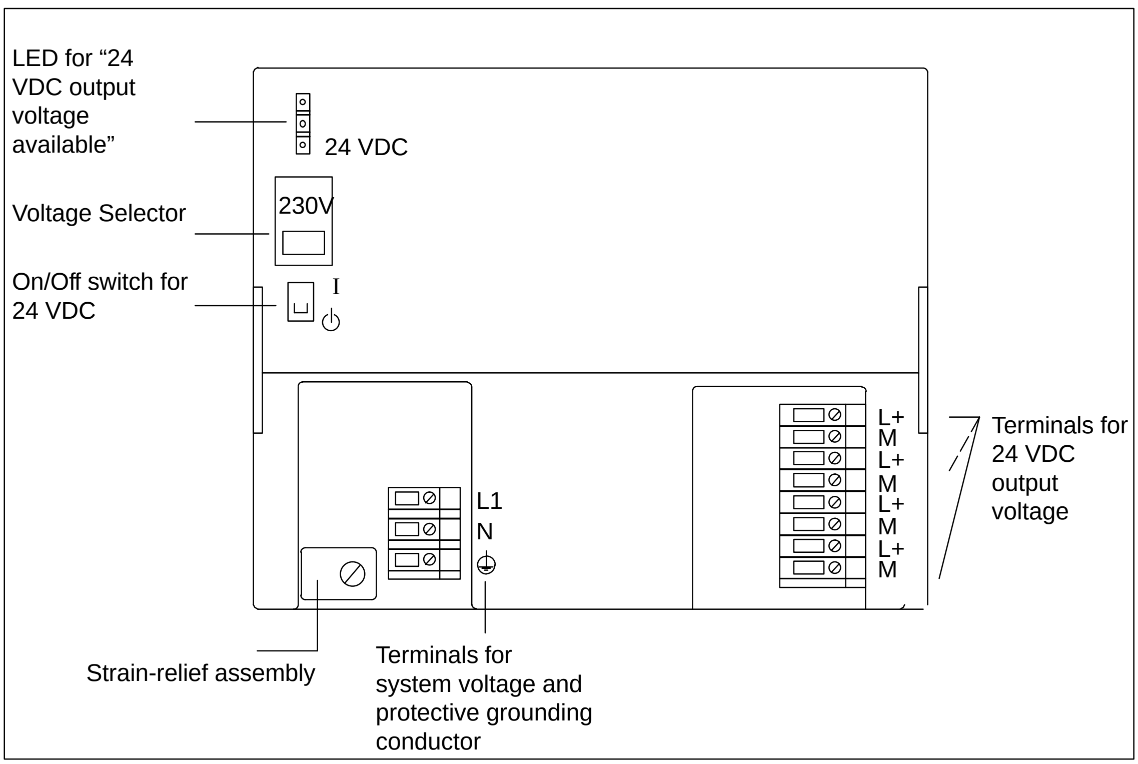


Figure 2-7 Wiring Schematic of the PS 307 Power Supply Module (10 A)

Basic Circuit Diagram of the PS 307; 10 A

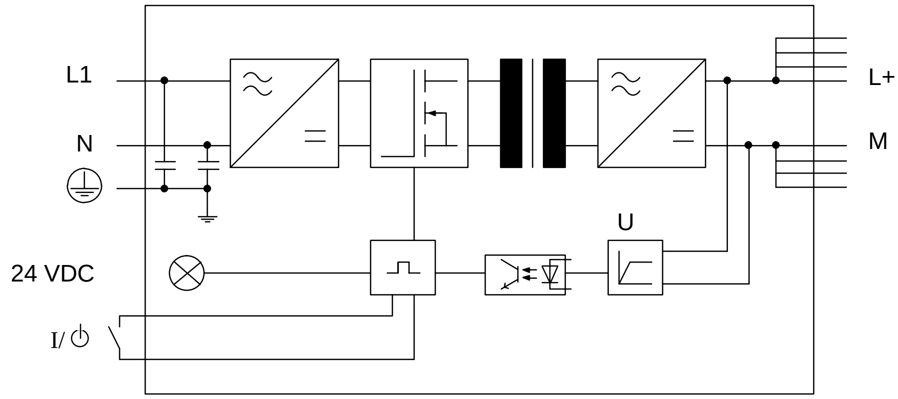


Figure 2-8 Basic Circuit Diagram of the PS 307 Power Supply Module (10 A)

Line Protection

We recommend that you install a miniature circuit-breaker (MCB) (for example, Siemens 5SN1 series) with the following rating to protect the incoming supply cable of the PS 307 power supply module (10 A):

- Rated current at 230 VAC: 16 A
- Tripping characteristic (type): C.

Reaction to Atypical Operating Conditions

Table 2-4 Reaction of the PS 307 Power Supply Module (10 A) to Atypical Operating Conditions

If ...	Reaction of the Module	24 VDC LED
... the output circuit is overloaded: • I > 13 A (dynamic) • 10 A < I ≤ 13 A (static)	Voltage dip, autom. volt. recovery Voltage drop, shortening of service life	Flashes
... the output is short-circuited	Output voltage 0 V; automatic voltage recovery after short circuit has been eliminated	Dark
an overvoltage occurs on the primary side	Possible destruction	–
there is an undervoltage on the primary side	Automatic disconnection; automatic voltage recovery	Dark

Technical Specifications of the PS 307; 10 A (6ES7 307-1KA00-0AA0)

Dimensions and Weight	
Dimensions W × H × D (in millimeters)	200 × 125 × 120
Weight	1.2 kg
Input Rating	
Input voltage	
• Rated value	120 / 230 VAC
System frequency	
• Rated value	50 Hz or 60 Hz
• Permitted range	47 Hz to 63 Hz
Rated input current	
• at 230 V	1.7 A
• at 120 V	3.5 A
Inrush current (at 25 °C)	55 A
I^2t (at inrush current)	9 A^2s
Output Rating	
Output voltage	
• Rated value	24 VDC
• Permitted range	24 V ± 5%, stable at no load
• Ramp-up time	max. 2.5 s
Output current	
• Rated value	10 A, cannot be connected in parallel
Short-circuit protection	Electronic, nonlatching, 1.1 to 1.3 × I_N
Residual ripple	max. 150 mV_{ss}

Other Parameters	
Protection class according to IEC 536 (DIN VDE 0106, Part 1)	I, with protective grounding conductor
Insulation	
• Rated insulation level (24 V to L1)	250 VAC
• Tested with	2800 VDC
Reliable isolation	SELV circuit
Bridging of power failures (at 93 and/or 187 V)	min. 20 ms
• Repeat rate	min 1 s
Efficiency	89 %
Power input	270 W
Power loss	typ. 30 W
Diagnostics	
LED for output voltage available	Yes, green LED

Digital Modules 3

Changes and Improvements since the Previous Version of the Reference Manual

This chapter describes all new digital modules. Furthermore, two new overview sections will make it easier for you to access the information:

- the “Module Overview” section shows you the modules that are available, together with their most important characteristics, and helps you quickly to find the module suitable for your task.
- the section entitled “Sequence of Steps from Choosing to Commissioning the Module” provides the answer to the question ”What must I do in succession to commission the module quickly and successfully?

Structure of the Chapter

The present chapter is broken down into the following subjects:

1. Overview containing the modules that are available here and a description
2. Information that is generally valid – in other words, relating to all digital modules (for example, parameter assignment and diagnostics)
3. Information that refers to specific modules (for example, characteristics, diagram of connections and block diagram, technical specifications and special characteristics of the module):
   a) for digital input modules
   b) for digital output modules
   c) for digital input/output modules

Additional Information

Appendix A describes the structure of the parameter sets (data records 0, 1 and 128) in the system data. You must be familiar with this configuration if you want to modify the parameters of the modules in the *STEP 7* user program.

Appendix B describes the structure of the diagnostic data (data records 0 and 1) in the system data. You must be familiar with this configuration if you want to evaluate the diagnostic data of the modules in the *STEP 7* user program.

In this Chapter

3.1 Module Overview

Introduction

The following tables summarize the most important characteristics of the digital modules. This overview is intended to make it easy to choose the suitable module for your task.

Table 3-1 Digital Input Modules: Characteristics at a Glance

Module / Characteristics	SM 321; DI 32 × 24 VDC (-1BLx0-)	SM 321; DI 16 × 24 VDC (-1BH02-)	SM 321; DI 16 × 24 VDC (-7BHx0-)	SM 321; DI 16 × 24 VDC; source input (-1BH50-)	SM 321; DI 16 × 48-125 VDC (-1CH80-)	SM 321; DI 16 × 120 VAC (-1EH01-)	SM 321; DI 8 × 120 /230 VAC (-1FFx1-)	SM 321; DI 32 × 120 VAC (-1EL00-)
Number of inputs	32 DI; isolated in groups of 16	16 DI; isolated in groups of 16	16 DI; isolated in groups of 16	16 DI; source input, isolated in groups of 16	16 DI; isolated in groups of 8	16 DI; isolated in groups of 4	8 DI, isolated in groups of 2	32 DI; isolated in groups of 8
Rated input voltage	24 VDC	24 VDC	24 VDC	24 VDC	48 to 125 VDC	120 VAC	120/ 230 VAC	120 VAC
Suitable for...	Switches; two, three, and four-wire proximity switches (BEROs)					Switches; two and three-wire AC proximity switches		
Programmable diagnostics	No	No	Yes	No	No	No	No	No
Diagnostic interrupt	No	No	Yes	No	No	No	No	No
Hardware interrupt upon edge change	No	No	Yes	No	No	No	No	No
Adjustable input delays	No	No	Yes	No	No	No	No	No
Special features	–	–	2 short-circuit-proof sensor supplies for 8 channels each External redundant power supply possible to supply sensors	–	–	–	–	–

Table 3-2 Digital Output Modules: Characteristics at a Glance

Module / Characteristics	SM 322; DO32 × 24 VDC/ 0.5 A (-1BL00-)	SM 322; DO16 × 24 VDC/ 0.5 A (-1BHx1-)	SM 322; DO 8 × 24 VDC/2 A (-1BF01-)	SM 322; DO 8 × 24 VDC/ 0.5 A (-8BFx1-)	SM 322; DO 8 × 48-125 VDC/ 1.5 A (-1CF80-)	SM 322; DO16 × 120 VAC/ 1 A (-1EH01-)	SM 322; DO 8 × 120/ 230 VAC/ 2A (-1FFx1-)	SM 322; DO 32 × 120 VAC/ 1.0 A (-1EL00-)
Number of outputs	32 DO; isolated in groups of 8	16 DO; isolated in groups of 8	8 DO; isolated in groups of 4	8 DO; isolated in groups of 8	8 DO; isolated and reverse polarity protection, in groups of 4	16 DO; isolated in groups of 8	8 DO, isolated in groups of 4	32 DO, isolated in groups of 8
Output current	0.5 A	0.5 A	2 A	0.5 A	1.5 A	1 A	2 A	1.0 A
Rated load voltage	24 VDC	24 VDC	24 VDC	24 VDC	48 to 125 VDC	120 VAC	120/ 230 VAC	120 VAC
Suitable for...	Solenoid valves, DC contactors and indicator lights					AC solenoid valves, contactors, motor starters, fractional h.p. motors and indicator lights.		
Programmable diagnostics	No	No	No	Yes	No	No	No	No
Diagnostic interrupt	No	No	No	Yes	No	No	No	No
Substitute value output	No	No	No	Yes	No	No	No	No
Special features				Redundant driving of a load possible	–	Fuse blown indicator. Replaceable fuse for each group		Blown fuse indicator for each group

Table 3-3 Relay Output Modules: Characteristics at a Glance

Module / Characteristics	SM 322; DO 16 × REL. 120 VAC (-1HH00-)	SM 322; DO 8 × REL. 230 VAC (-1HF01-)	SM 322; DO 8 × 230 VAC/5A REL. (-1HF10/-1HF80-)	SM 322; DO 8 × 230 VAC/5A REL. (-1HF20-)
Number of outputs	16 outputs, isolated in groups of 8	8 outputs, isolated in groups of 2	8 outputs, isolated in groups of 1	8 outputs, isolated in groups of 1
Rated load voltage	24 to 120 VDC, 48 to 120 VAC	24 to 120 VDC, 48 to 230 VAC	24 to 120 VDC, 48 to 230 VAC	24 to 120 VDC, 24 to 230 VAC
Suitable for...	AC/DC solenoid valves, contactors, motor starters, fractional horsepower motors and indicator lights			
Special features	–			

Table 3-4 Digital Input/Output Modules: Characteristics at a Glance

Module / Character-istics	SM 323; DI 16/DO 16 × 24 VDC/ 0.5 A (-1BL00-)	SM 323; DI 8/DO 8 × 24 VDC/0.5 A (-1BHx1-)
Number of inputs	16 inputs, isolated in groups of 16	8 inputs, isolated in groups of 8
Number of outputs	16 outputs, isolated in groups of 8	8 outputs, isolated in groups of 8
Rated input voltage	24 VDC	24 VDC
Output current	0,5 A	0,5 A
Rated load voltage	24 VDC	24 VDC
Inputs suitable for...	Switches and two, three and four-wire proximity switches (BEROs).	
Outputs suitable for...	Solenoid valves, DC contactors and indicator lights	
Programmable diagnostics	No	No
Diagnostic interrupt	No	No
Hardware interrupt upon edge change	No	No
Adjustable input delays	No	No
Substitute value output	No	No
Special features	–	

3.2 Sequence of Steps from Choosing to Commissioning the Digital Module

Introduction

The following table contains the tasks that you have to perform one after the other to commission digital modules successfully.

The sequence of steps is a suggestion, but you can perform individual steps either earlier or later (for example, assign parameters to the module) or install other modules or install, commission etc. other modules in between times.

Sequence of Steps

Table 3-5 Sequence of Steps from Choosing to Commissioning the Digital Module

Step	Procedure	Refer To...
1.	Select the module	Section 3.1 and specific module section from Section 3.5
2.	Install the module in the SIMATIC S7 network	"Installation" section in the manual for the programmable logic controller being used: • S7-300, M7-300, S7-400 or M7-400 Programmable Controllers, Hardware and Installation or • ET 200M Distributed I/O Device
3.	Assign parameters to module	Section 3.3
4.	Commission configuration	"Commissioning" section in the manual for the programmable logic controller being used: • S7-300, M7-300, S7-400 or M7-400 Programmable Controllers, Hardware and Installation or • ET 200M Distributed I/O Device
5.	If commissioning was not successful, diagnose configuration	Section 3.4

3.3 Digital Module Parameter Assignment

Introduction

Digital modules can have different characteristics. You can set the characteristics of dome modules by means of parameter assignment.

The information contained in this section refers only to the programmable digital modules:

- Digital Input Module SM 321; DI 16 × 24 VDC; (6ES7 321-7BHx0-0AB0)
- Digital Output Module SM 322; DO 8 ×24 VDC/0.5 A; (6ES7 322-8BFx0-0AB0)

Tools for Parameter Assignment

You assign parameters to digital modules in *STEP 7*. You must perform parameter assignment in STOP mode of the CPU.

When you have set all the parameters, download the parameters from the programming device to the CPU. On a transition from STOP to RUN mode, the CPU then transfers the parameters to the individual digital modules.

Static and Dynamic Parameters

The parameters are divided into static and dynamic parameters.

Set the static parameters in STOP mode of the CPU, as described above.

In addition, you can modify the dynamic parameters within the current user program of an S7 control by means of SFCs. Note, however, that after a change from RUN → STOP, STOP → RUN of the CPU, the parameters set in *STEP 7* apply again. You will find a description of the parameter assignment of modules in the user program in Appendix A.

Parameter	Settable with	CPU Operating State
Static	PG (STEP7 HWCONFIG)	STOP
Dynamic	PG (STEP7 HWCONFIG)	STOP
	SFC 55 in the user program	RUN

Parameters of the Digital Modules

You will find the parameters of the digital input or output module that you can set in the specific section for the module (Section 3.7 on page 3-16 or Section 3.16 on page 3-46).

3.4 Diagnostics of the Digital Modules

Introduction

The information contained in this section refers only to the digital modules with diagnostics capability. For the S7-300, these modules are as follows:

- Digital input module SM 321; DI 16 $\times$ 24 VDC; (6ES7 321-7BHx0-0AB0)
- Digital output module SM 322; DO 8 $\times$ 24 VDC/0.5 A; (6ES7 322-8BFx0-0AB0)

Programmable and Non-Programmable Diagnostic Messages

In diagnostics, we make a distinction between programmable and non-programmable diagnostic messages.

You obtain programmable diagnostic messages only if you have enabled diagnostics by parameter assignment. You perform parameter assignment in the ”Diagnostics” parameter field in *STEP 7*.

Non-programmable diagnostic messages are always made available by the digital module irrespective of diagnostics being enabled.

Actions Following Diagnostic Message in *STEP 7*

Each diagnostic message leads to the following actions:

- The diagnostic message is entered in the diagnosis of the digital module and forwarded to the CPU.
- The SF LED on the digital module lights.
- If you have programmed “Enable Diagnostic Interrupt” in STEP 7, a diagnostic interrupt is triggered and OB 82 is called.

Reading out Diagnostic Messages

You can read out detailed diagnostic messages by means of SFCs in the user program (refer to the Appendix “Diagnostic Data of Signal Modules”).

You can view the cause of the error in *STEP 7*, in the module diagnosis (refer to online Help for *STEP 7*).

Diagnostic Message by Means of SF LED

The digital modules with diagnostics capability indicate errors for you by means of their SF LED (group error LED). The SF LED lights as soon as a diagnostic message is triggered by the digital module. It goes out when all errors have been rectified.

The group fault (SF) LED also lights up in case of external errors (short circuit of sensor supply), independent of the operating status of the CPU (if power is on).

Diagnostic Messages Interrupt Processing by the Digital Modules

You will find the diagnostic messages of the digital input module and output module with their possible causes and remedial action, together with a description of possible interrupts in the specific section on the module (Section 3.7 on page 3-16 or Section 3.16 on page 3-46).

3.5 Digital Input Module SM 321; DI 32 × 24 VDC; (6ES7 321-1BLx0-0AA0)

Order Number: “Standard Module”

6ES7 321-1BL00-0AA0

Order Number: “SIMATIC Outdoor Module”

6ES7 321-1BL80-0AA0

Characteristics

The digital input module SM 321; DI 32 × 24 VDC has the following salient features:

- 32 inputs, isolated in groups of 16
- 24 VDC rated input voltage
- Suitable for switches and two/three/four-wire BEROs (proximity switches).

Terminal Assignment and Block Diagram of the SM 321; DI 32 × 24 VDC

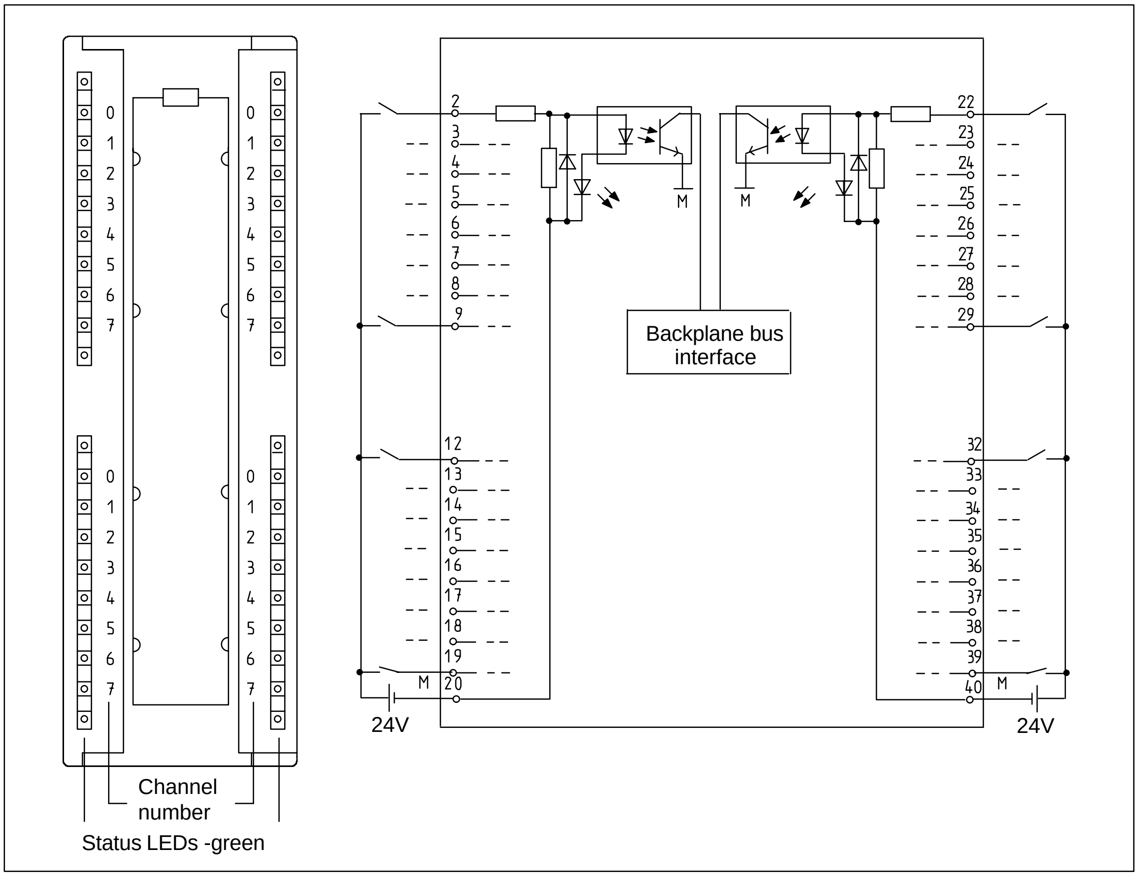


Figure 3-1 Module View and Block Diagram of the Digital Input Module SM 321; DI 32 × 24 VDC

Terminal Assignment of the SM 321; DI 32 × 24 VDC

The following figure shows the assignment of the channels to the addresses.

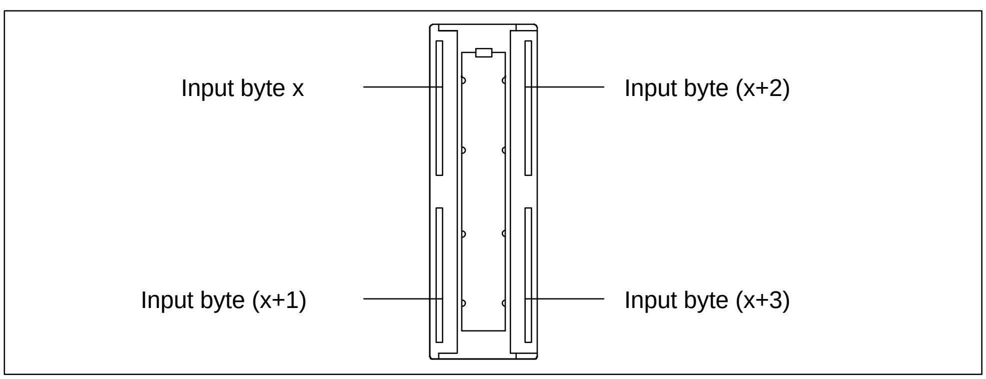


Figure 3-2 Terminal assignment of the SM 321; DI 32 × 24 VDC

Technical Specifications of the SM 321; DI 32 $\times$ 24 VDC

Dimensions and Weight	
Dimensions W $\times$ H $\times$ D (in millimeters)	40 $\times$ 125 $\times$ 120
Weight	Approx. 260 g
Data for Specific Module	
Number of inputs	32
Length of cable	
• Unshielded	max. 600 m
• Shielded	max. 1000 m
Voltage, Currents, Potentials	
Number of inputs that can be triggered simultaneously	
• Horizontal configuration	
Up to 40 °C	32
Up to 60 °C	16
• Vertical configuration	
Up to 40 °C	32
Isolation	
• Between channels and backplane bus	Yes
• Between the channels In groups of	Yes 16
Permitted potential difference	
• Between the different circuits	75 VDC / 60 VAC

Insulation tested with	500 VDC
Current consumption	
• From the backplane bus	max. 15 mA
Power dissipation of the module	typ. 6.5 W
Status, Interrupts, Diagnostics	
Status display	Green LEDs per channel
Interrupts	None
Diagnostic functions	None
Data for Selecting a Sensor	
Input voltage	
• Rated value	24 VDC
• For signal “1”	13 to 30 V
• For signal “0”	– 30 to + 5 V
Input current	
• At signal “1”	typ. 7 mA
Input delay	
• At “0” to “1”	1.2 to 4.8 ms
• At “1” to “0”	1.2 to 4.8 ms
Input characteristic curve	According to IEC 1131, Type 1
Connection of Two-Wire BEROs	Possible
• Permitted bias current	max. 1.5 mA

3.6 Digital Input Module SM 321; DI 16 $\times$ 24 VDC; (6ES7 321-1BHx2-0AA0)

Order Number: "Standard Module"

6ES7 321-1BH02-0AA0

Order Number: "SIMATIC Outdoor Module"

6ES7 321-1BH82-0AA0

Characteristics

The digital input module SM 321; DI 16 $\times$ 24 VDC has the following salient features:

- 16 inputs, isolated in groups of 16
- 24 VDC rated input voltage
- Suitable for switches and two/three/four-wire BEROs (proximity switches).

Terminal Assignment and Block Diagram of the SM 321; DI 16 × 24 VDC

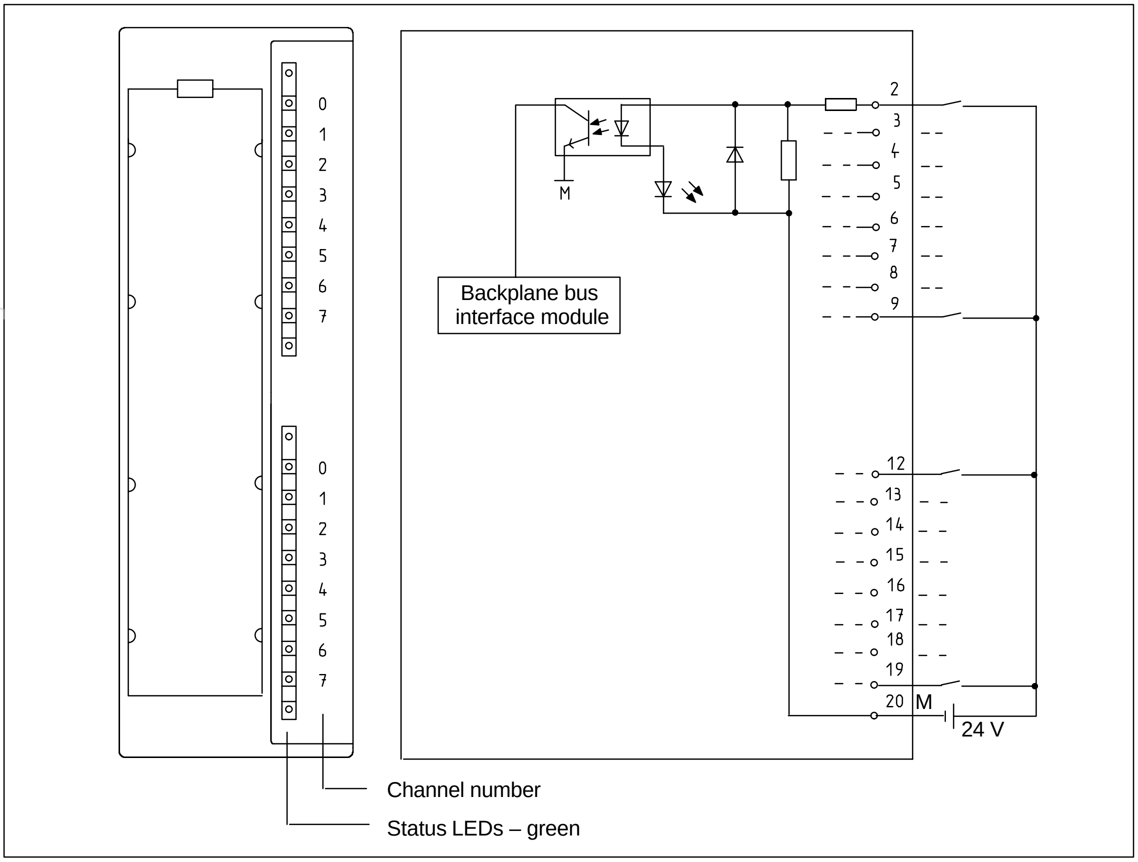


Figure 3-3 Module View and Block Diagram of Digital Input Module SM 321; DI 16 × 24 VDC

Technical Specifications of the SM 321; DI 16 × 24 VDC

Dimensions and Weight	
Dimensions W × H × D (in millimeters)	40 × 125 × 120
Weight	Approx. 200 g
Data for Specific Module	
Number of inputs	16
Length of cable	
• Unshielded	max. 600 m
• Shielded	max. 1000 m
Voltage, Currents, Potentials	
Number of inputs that can be triggered simultaneously	
• Horizontal configuration	
Up to 40 °C	16
• Vertical configuration	
Up to 60 °C	16
Isolation	
• Between channels and backplane bus	Yes
Permitted potential difference	
• Between the different circuits	75 VDC / 60 VAC
Insulation tested with	500 VDC
Current consumption	
• From the backplane bus	max. 10 mA
Power dissipation of the module	typ. 3.5 W
Status, Interrupts, Diagnostics	
Status display	Green LEDs per channel
Interrupts	None
Diagnostic functions	None

Data for Selecting a Sensor	
Input voltage	
• Rated value	24 VDC
• For signal “1”	13 to 30 V
• For signal “0”	–30 to + 5 V
Input current	
• At signal “1”	typ. 7 mA
Input delay	
• At “0” to “1”	1.2 to 4.8 ms
• At “1” to “0”	1.2 to 4.8 ms
Input characteristic curve	According to IEC 1131, Type 1
Connection of Two-Wire BEROs	Possible
• Permitted bias current	max. 1.5 mA

3.7 Digital Input Module SM 321; DI 16 × 24 VDC; with Hardware and Diagnostic Interrupts; (6ES7 321-7BHx0-0AB0)

Order Number: “Standard Module”

6ES7 321-7BH00-0AB0

Order Number: “SIMATIC Outdoor Module”

6ES7 321-7BH80-0AB0

Characteristics

The SM 321; DI 16 × 24 VDC; with hardware and diagnostic interrupts features the following characteristics:

- 16 inputs, isolated in groups of 16
- 24 VDC rated input voltage
- Input characteristic curve according to IEC 1131, Type 2
- Suitable for switches and two/three/four-wire BEROs (proximity switches).
- 2 short-circuit-proof sensor supplies for 8 channels each
- External redundant power supply possible to supply sensors
- “Sensor supply (Vs) O.K.” status LEDs
- Group error display
- Programmable diagnostics
- Programmable diagnostic interrupt
- Configurable hardware interrupt
- Programmable Input delays

Terminal Assignment of the SM 321; DI 16 × 24 VDC

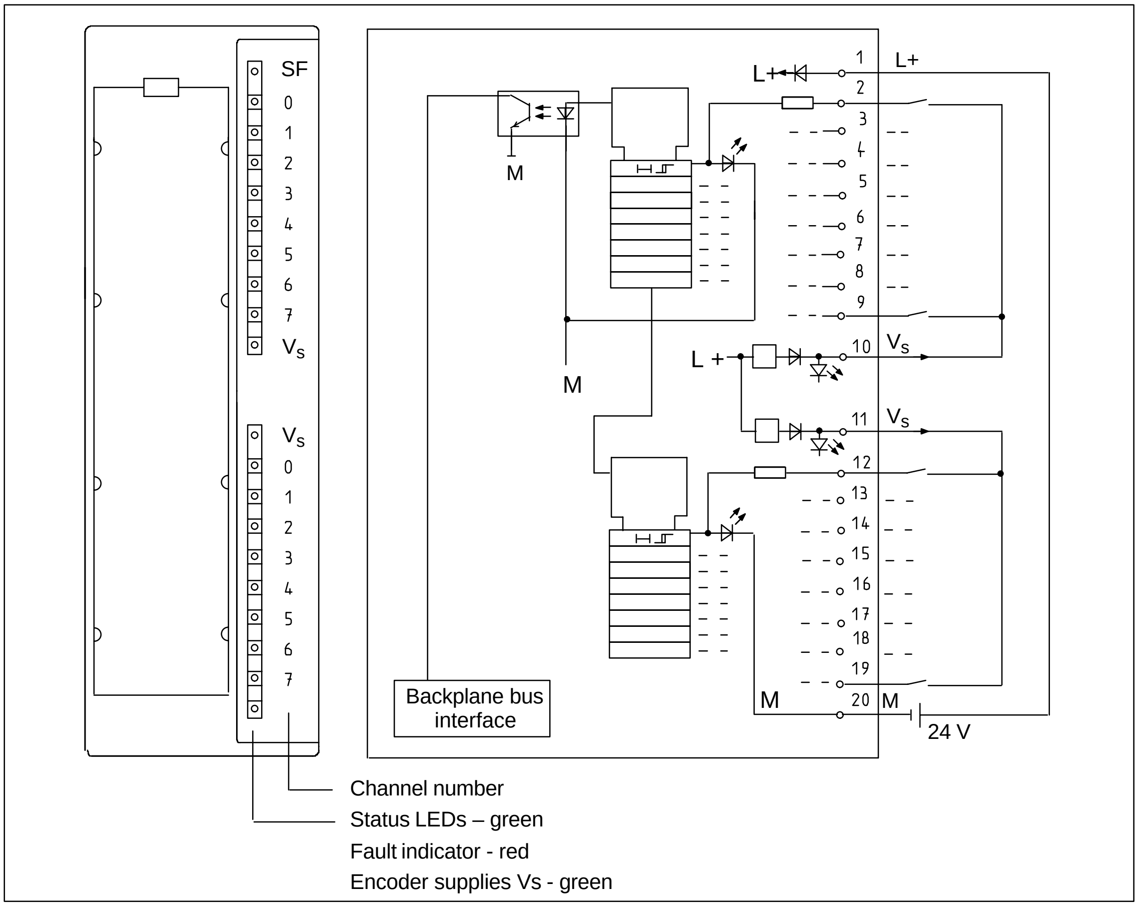


Figure 3-4 Module View and Block Diagram of the SM 321; DI 16 × 24 VDC (6ES7 321-7BHx0-0AB0)

Terminal Assignment for Redundant Supply of Encoders

The figure below shows how encoder can additionally be supplied by means of Vs with a redundant voltage source – for example, via another module.

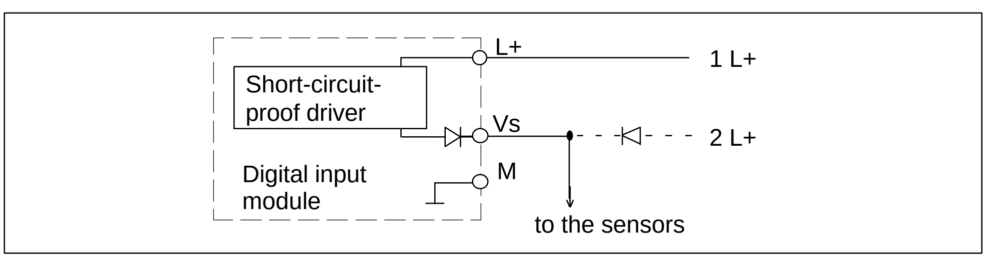


Figure 3-5 Terminal Assignment for the Redundant Supply of Encoders of the SM 321; DI 16 × 24 VDC (6ES7 321-7BHx0-0AB0)

Technical Specifications of the SM 321; DI 16 × 24 VDC

Dimensions and Weight	
Dimensions W × H × D (in millimeters)	40 × 125 × 120
Weight	Approx. 200 g
Data for Specific Module	
Number of inputs	16
Length of cable	
• Unshielded	max. 600 m
• Shielded	max. 1000 m
Voltage, Currents, Potentials	
Power rated voltage of the electronics and encoder L+	24 VDC
• Reverse polarity protection	Yes
Number of inputs that can be triggered simultaneously	
• Vertical configuration Up to 40 °C	16
• Vertical configuration Up to 60 °C	16
Isolation	
• Between channels and backplane bus	Yes
Permitted potential difference	
• Between the different circuits	75 VDC / 60 VAC
Insulation tested with	500 VDC
Current consumption	
• From the backplane bus	max. 55 mA
• From load voltage L + (without sensor supply V_S)	max. 40 mA
Power dissipation of the module	typ. 4 W
Status, Interrupts, Diagnostics	
Status display	
• Inputs	Green LEDs per channel
• Sensor power supplies (V_S)	Green LED per output
Interrupts	
• Hardware interrupt	Parameters can be assigned
• Diagnostic Interrupt	Parameters can be assigned
Diagnostic functions	Parameters can be assigned
• Group error display	Red LED (SF)
• Diagnostic information can be displayed	Possible
Sensor Power Supply Outputs	
Outputs	2
Output voltage	
• With load	min. L+ (– 2.5 V)
Output current	
• Rated value	120 mA
• Permitted range	0 to 150 mA
Additional (redundant) supply	Permitted
Short-circuit protection	Yes, electronic
Data for Selecting a Sensor	
Input voltage	
• Rated value	24 VDC
• For signal “1”	13 to 30 V
• For signal “0”	– 30 to + 5 V
Input current	
• At signal “1”	typ. 7 mA
Input characteristic curve	According to IEC 1131, Type 2
Connection of Two-Wire BEROs	Possible
• Permitted bias current	max. 2 mA
Time/Frequency	
Internal preparation time for	
• Only interrupt processing	max. 250 µs
• Interrupt and diagnostics processing	max. 250 µs
Input delay	
• Parameters can be assigned	Yes
• Rated value	typ. 0.1/0.5/3/15/20 ms

3.7.1 Assigning Parameters to the SM 321; DI 16 × 24 VDC

Parameterization

You will find a description of the general procedure for assigning parameters to digital modules in Section 3.3.

Parameters of the SM 321; DI 16 × 24 VDC

You will find an overview of the parameters that you can set and their default settings for the SM 321; DI 16 × 24 VDC in the table below.

The default settings apply if you have not performed parameter assignment in *STEP 7*.

Table 3-6 Parameters of the SM 321; DI 16 × 24 VDC (6ES7 321-7BHx0-0AB0)

Parameter	Value Range	Default Settings	Para-meter Type	Scope
Enable • Diagnostic interrupt • Hardware interrupt	 Yes/no Yes/no	 No No	 Dynamic	 Module
Input delay/voltage type	0.1 ms (DC) 0.5 ms (DC) 3 ms (DC) 15 ms (DC) 20 ms (DC/AC)	3 (DC)	Static	Module
Diagnostics • Sensor supply missing	 Yes/no	 No	 Static	 Channel group
Trigger for hardware interrupt • Rising edge • Falling edge	 Yes/no Yes/no	 No No	 Dynamic	 Channel group

Assignment of the Encoder Supplies to Channel Groups

The two encoder supplies of the module are used to supply two channel groups: inputs 0 to 7 and inputs 8 to 15. In these two channel groups, you parameterize the diagnostics for the encoder supply, too.

Assigning Interrupt Parameters to Channel Groups

The table below shows the channels that can be combined to form a channel group if you would like to parameterize interrupt processing.

You will need the channel group number to set the parameters in the user program with an SFC.

Table 3-7 Assigning the Interrupt Parameters to the Inputs of the SM 321; DI 16 × 24 VDC (6ES7 321-7BHx0-0AB0)

Parameter...	Can Be Set in Following Channel Groups	Channel Group Number
Hardware interrupt (for falling, rising or both types of pulse edges)	0 and 1 2 and 3 4 and 5 6 and 7 8 and 9 10 and 11 12 and 13 14 and 15	0 1 2 3 4 5 6 7
Diagnostic Interrupt (with missing encoder supply)	0 to 7 8 to 15	-

Tolerances of the Programmable Input Delays

Table 3-8 Tolerances of the Input Delays of SM 321; DI 16 × 24 VDC (6ES7 321-7BHx0-0AB0)

Programmed Input Delay	Tolerance
0.1 ms	87.5 to 112.5 µs
0.5 ms	0.43 to 0.57 ms
3 ms (preset)	2.62 to 3.38 ms
15 ms	13.1 to 16.9 ms
20 ms	20 to 25 ms

3.7.2 Behavior and Diagnostics of the SM 321; DI 16 × 24 VDC

Effect of Operating and Mode Supply Voltage on the Input Values

The input values of the SM 321; DI 16 × 24 VDC depend on the operating mode of the CPU and on the supply voltage of the module.

Table 3-9 Dependencies of Input Values on the Operating Mode of the CPU and Supply Voltage L+ of the SM 321; DI 16 × 24 VDC (6ES7 321-7BHx0-0AB0)

CPU Operating State		Power Supply L+ to Digital Module	Input Value of Digital Module
POWER ON	RUN	L+ exists	Process value
		L+ missing	0 signal
	STOP	L+ exists	Process value
		L+ missing	0 signal
POWER OFF	–	L+ exists	–
		L+ missing	–

Diagnostics Messages of the SM 321; DI 16 × 24 VDC

The table below presents an overview of the diagnostics messages for the SM 321; DI 16 × 24 VDC.

Table 3-10 Diagnostic Messages of the SM 321; DI 16 × 24 VDC (6ES7 321-7BHx0-0AB0)

Diagnostics Message	LED	Scope of the Diagnostics	Parameters can be assigned
Sensor supply missing	SF	Channel group	Yes
External auxiliary supply missing	SF	Module	No
Internal auxiliary power missing	SF	Module	
Fuse blown	SF	Module	
Incorrect parameter on module	SF	Module	
Watchdog timeout	SF	Module	
EPROM error	SF	Module	
RAM error	SF	Module	
Hardware interrupt lost	SF	Module	

Note

A prerequisite for detecting the errors indicated by programmable diagnostics messages is that you have assigned parameters to the digital module accordingly in *STEP 7*.

Behavior upon Failure of the Supply Voltage

A failure of the supply voltage of the SM 321; DI 16 × 24 VDC is always indicated by the SF LED on the module. In addition, this information is made available on the module (entry the “encoder supply missing” diagnosis).

The input value is initially held for 20 to 40 ms before the 0 signal is transferred to the CPU. Supply voltage dips < 20 ms do not modify the process value (refer to Table 3-9).

Triggering of the diagnostic interrupt depends on the parameter assignment (see Section 3.7.3).

Failure of the Supply Voltage with Redundant Encoder Incoming Supply

Note

If an external redundant source is applied simultaneously to the sensor supply (Vs), a failure in the internal sensor supply causes a failure of the internal and/or external sensor supply and/or a blown fuse to be indicated instead of a regular sensor supply failure.

Short-Circuit of Sensor Supply Vs

Irrespective of the parameter assignment, the corresponding Vs LED goes out if a short-circuit of the encoder supply Vs occurs.

Causes of Error and Remedial Measures

Table 3-11 Diagnostics Messages of the SM 321; DI 16 × 24 VDC (6ES7 321-7BHx0-0AB0), Causes of Error and Remedial Measures

Diagnostics Message	Possible Error Cause	Remedy
Lack of encoder supply	Overload of sensor supply	Eliminate overload
	Short circuit of sensor supply to M	Eliminate short circuit
External auxiliary voltage missing	Power supply L+ to module missing	Feed supply L+
Internal auxiliary voltage missing	Power supply L+ to module missing	Feed supply L+
	Fuse in module defective	Replace module
Fuse blown	Fuse in module defective	Replace module
Wrong parameters in the module	One parameter or the combination of parameters is not plausible	Reassign module parameter
Watchdog tripped	Temporary high electromagnetic interference	Eliminate interference
	Module defective	Replace module
EPROM error	Temporary high electromagnetic interference	Eliminate interference and switch on/off power supply of CPU
	Module defective	Replace module
RAM error	Temporary high electromagnetic interference	Eliminate interference and switch on/off power supply of CPU
	Module defective	Replace module
Hardware interrupt lost	The module cannot send an interrupt, since the previous interrupt was not acknowledged; configuration error possible	Change interrupt processing in CPU and reconfigure module parameters, if required The error continues until the module is configured with new parameters

3.7.3 Interrupts of the SM 321; DI 16 $\times$ 24 VDC

Introduction

This section describes the SM 321; DI 16 $\times$ 24 VDC with regard to its interrupt behavior. The following interrupts exist:

- Diagnostic Interrupt
- Hardware interrupt

The OBs and SFCs mentioned below can be found in the online Help for *STEP 7*, where they are described in greater detail.

Enabling Interrupts

The interrupts are not preset – in other words, they are inhibited without appropriate parameter assignment. Assign parameters to the Interrupt Enable in *STEP 7* (refer to Section 3.7.1).

Diagnostic Interrupt

If you have enabled diagnostic interrupts, then active error events (initial occurrence of the error) and departing error events (message after troubleshooting) are reported by means of an interrupt.

The CPU interrupts the execution of the user program and processes the diagnostics interrupt block (OB 82).

In the user program, you can call SFC 51 or SFC 59 in OB 82 to obtain more detailed diagnostic information from the module.

The diagnostic information is consistent until such time as OB 82 is exited. When OB 82 is exited, the diagnostic interrupt is acknowledged on the module.

Hardware Interrupt

The SM 321; DI 16 $\times$ 24 VDC can trigger a hardware interrupt for every channel group with a rising or falling edge, or both, of a signal status change.

Perform parameter assignment one channel group at a time. It can be modified at any time (in RUN mode using the user program).

Pending hardware interrupts trigger hardware interrupt processing in the CPU (OB 40). The CPU interrupts the execution of the user program or of the priority classes with low priority.

You can set in the user program of the hardware interrupt OB (OB 40) how the programmable logic controller has to react to an edge change. When the hardware interrupt OB is exited, the hardware interrupt is acknowledged on the module.

The module can buffer one interrupt per channel. If no higher priority run-time levels are waiting to be processed, the buffered interrupts (of all modules) are serviced one after the other by the CPU according to the order in which they occurred.

Hardware Interrupt Lost

In an interrupt has been buffered for a channel and another interrupt occurs on that channel before it has been processed by the CPU, a diagnostics interrupt “hardware interrupt lost” is triggered.

More interrupts on this channel are not acquired until processing of the interrupt buffered on this channel has been executed.

Interrupt-Triggering Channels

The interrupt-triggering channels are stored in the local data of the hardware interrupt OBs (in the OB start information). The start information is two words long (bits 0 to 31). The bit number is the channel number. Bits 16 to 31 are not assigned.

3.8 Digital Input Module SM 321; DI 16 × 24 VDC; Source Input; (6ES7 321-1BH50-0AA0)

Order Number

6ES7 321-1BH50-0AA0

Characteristics

The SM 321; DI 16 × 24 VDC (source input) has the following salient features:

- 16 inputs, source input, isolated in groups of 16
- 24 VDC rated input voltage
- Suitable for switches and two/three/four-wire BEROs (proximity switches).

Terminal Assignment and Block Diagram of the SM 321; DI 16 × 24 VDC

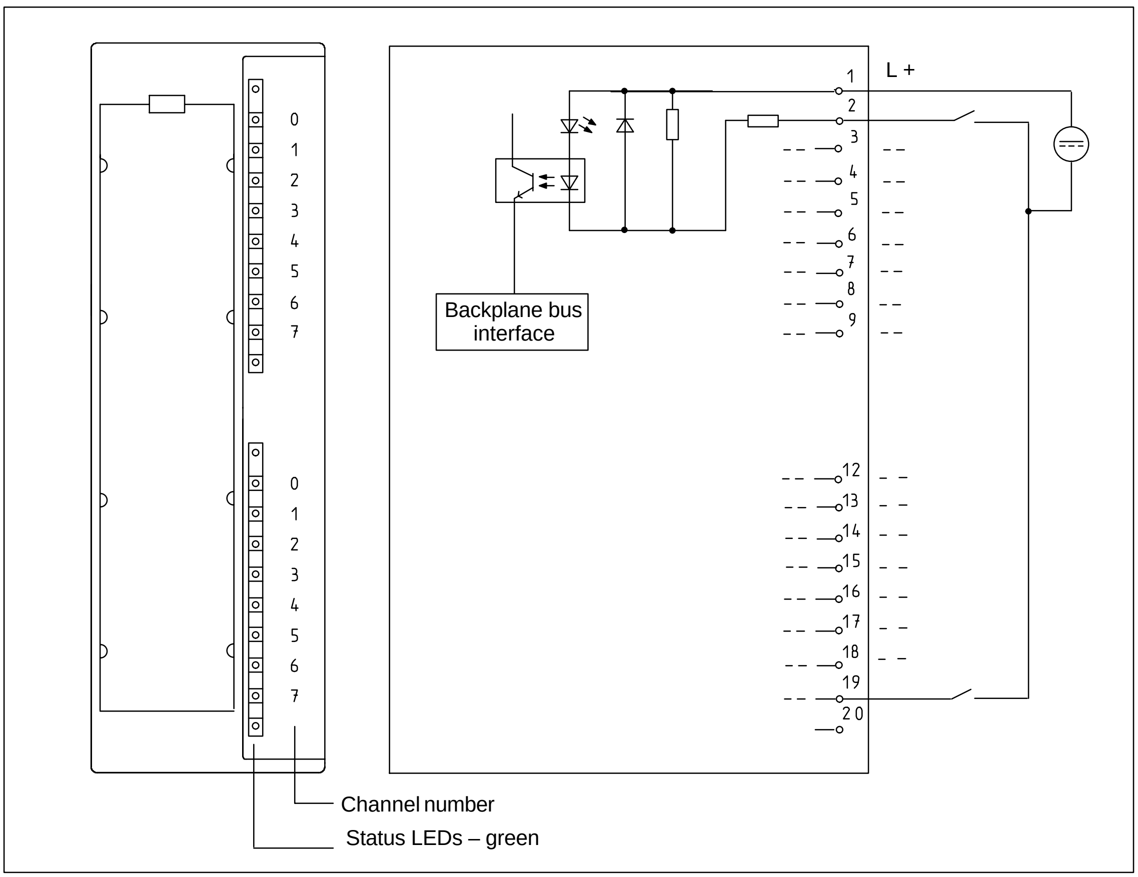


Figure 3-6 Module View and Block Diagram of Digital Input Module SM 321; DI 16 × 24 VDC (Source Input)

Technical Specifications of the SM 321; DI 16 $\times$ 24 VDC

Dimensions and Weight	
Dimensions W $\times$ H $\times$ D (in millimeters)	40 $\times$ 125 $\times$ 120
Weight	Approx. 200 g
Data for Specific Module	
Number of inputs	16
Length of cable	
• Unshielded	max. 600 m
• Shielded	max. 1000 m
Voltage, Currents, Potentials	
Number of inputs that can be triggered simultaneously	
• Vertical configuration Up to 40 °C	16
• Horizontal configuration Up to 60 °C	16
Isolation	
• Between channels and backplane bus	Yes
Permitted potential difference	
• Between the different circuits	75 VDC / 60 VAC
Insulation tested with	500 VDC
Current consumption	
• From the backplane bus	max. 10 mA
Power dissipation of the module	typ. 3.5 W
Status, Interrupts, Diagnostics	
Status display	Green LEDs per channel
Interrupts	None
Diagnostic functions	None

Data for Selecting a Sensor	
Input voltage (reference potential is L+)	
• Rated value	24 VDC
• For signal “1”	–13 V to –30 V
• For signal “0”	+30 V to –5 V
Input current	
• At signal “1”	typ. 7 mA
Input delay	
• At “0” to “1”	1.2 to 4.8 ms
• At “1” to “0”	1.2 to 4.8 ms
Input characteristic curve	According to IEC 1131, Type 1
Connection of Two-Wire BEROs	Possible
• Permitted bias current	max. 1.5 mA

3.9 Digital Input Module SM 321; DI 16 × 48-125 VDC; (6ES7 321-1CH80-0AA0)

Order Number: “SIMATIC Outdoor Module”

6ES7 321-1CH80-0AA0

Characteristics

The SM 321; DI 16 × 48-125 VDC features the following characteristics:

- 26 inputs, isolated in groups of 8
- Rated input voltage 48 to 125 VDC
- Suitable for switches and two/three/four-wire BEROs (proximity switches).

Terminal Assignment and Block Diagram of the SM 321; DI 16 × 48-125 VDC

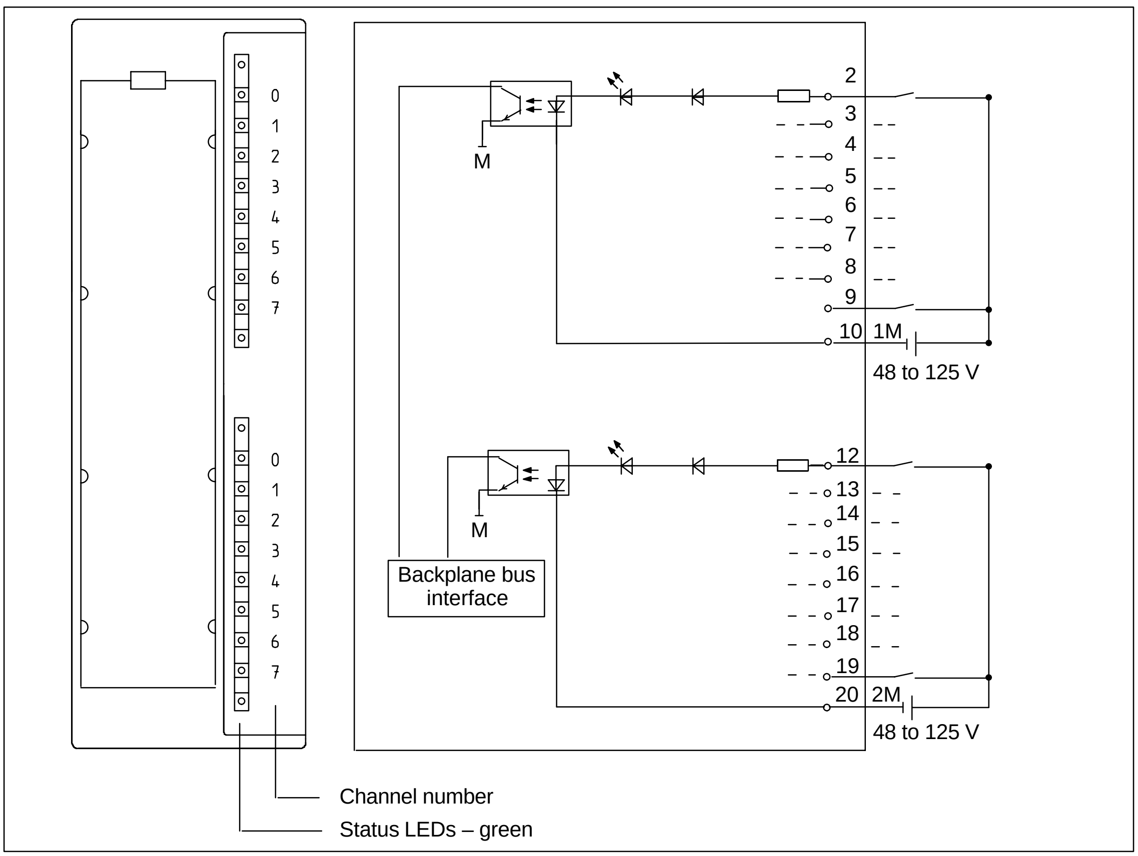


Figure 3-7 Module View and Block Diagram of SM 321; DI 16 × 48-125 VDC

Technical Specifications of the SM 321; DI 16 × 48-125 VDC

Dimensions and Weight		
Dimensions W × H × D (in millimeters)	40 × 125 × 120	
Weight	Approx. 200 g	
Data for Specific Module		
Number of inputs	16	
Length of cable		
• Unshielded	max. 600 m	
• Shielded	max. 1000 m	
Voltage, Currents, Potentials		
Number of inputs that can be triggered simultaneously at U_E	Up to 60 V	Up to 146 V
• Horizontal installation		
Up to 50 °C	8	8
Up to 60 °C	8	6
• Vertical configuration		
Up to 40 °C	8	8
Isolation		
• Between channels and backplane bus	Yes	
• Between the channels	Yes	
In groups of	8	
Permiss. potential differences		
• Between the different circuits	146 VDC / 132 VAC	
Insulation tested with	1500 VDC	
Current consumption		
• From the backplane bus	max. 40 mA	
Power dissipation of the module	typ. 4.3 W	

Status, Interrupts, Diagnostics	
Status display	Green LEDs per channel
Interrupts	None
Diagnostic functions	None
Sensor Selection Data	
Input voltage	
• Rated value	48 VDC to 125 VDC
• For signal “1”	30 V to 146 V
• For signal “0”	-146 V to 15 V
Input current	
• At signal “1”	typ. 3.5 mA
Input delay	
• From “ 0” to “1”	0.1 ms to 3.5 ms
• At “1” to “0”	0.7 ms to 3.0 ms
Input characteristic curve	According to IEC 1131, Type 1
Connection of Two-Wire BEROs	Possible
• Permitted bias current	max. 1 mA

3.10 Digital Input Module SM 321; DI 16 × 120 VAC; (6ES7 321-1EH01-0AA0)

Order Number

6ES7 321-1EH01-0AA0

Characteristics

The SM 321; DI 16 × 120 VAC features the following characteristics:

- 16 inputs, isolated in groups of 4
- 120 VAC rated input voltage
- Suitable for switches and two/three-wire AC proximity switches

Terminal Assignment and Block Diagram of the SM 321; DI 16 × AC 120 V

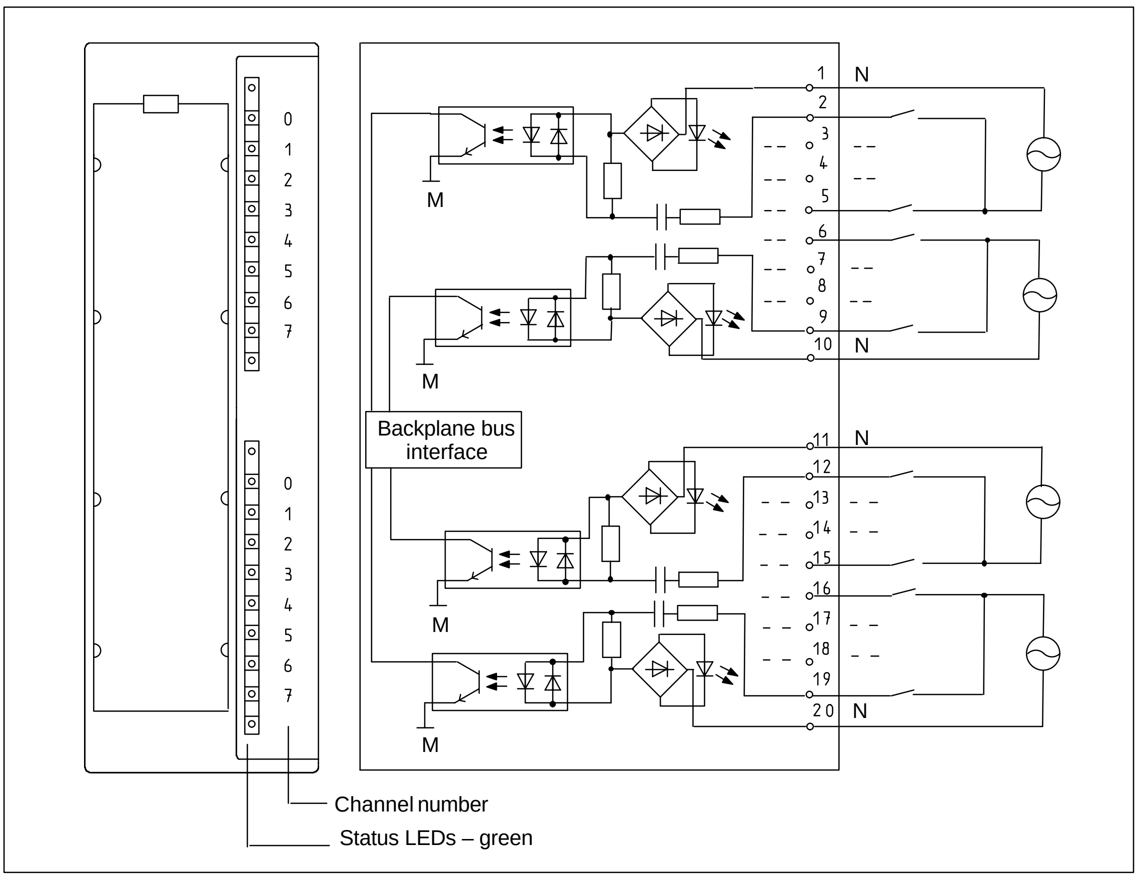


Figure 3-8 Module View and Block Diagram of Digital Input Module SM 321; DI 16 × 120 VAC

Technical Specifications of the SM 321; DI 16 × 120 VAC

Dimensions and Weight	
Dimensions W × H × D (in millimeters)	40 × 125 × 120
Weight	Approx. 225 g
Data for Specific Module	
Number of inputs	16
Length of cable	
• Unshielded	max. 600 m
• Shielded	max. 1000 m
Voltage, Currents, Potentials	
Number of inputs that can be triggered simultaneously	
• Horizontal configuration	16
Up to 60 °_C	
• Vertical configuration	16
Up to 40 °_C	
Isolation	
• Between channels and backplane bus	Yes
• Between the channels	Yes
In groups of	4
Permitted potential difference	
• Between $M_{internal}$ and the inputs	120 VAC
• Between the inputs of the different groups	250 VAC
Insulation tested with	1500 VAC
Current consumption	
• From the backplane bus	max. 16 mA
Power dissipation of the module	typ. 4.1 W
Status, Interrupts, Diagnostics	
Status display	Green LEDs per channel
Interrupts	None
Diagnostic functions	None

Data for Selecting a Sensor	
Input voltage	
• Rated value	120 VAC
• For signal “1”	79 to 132 V
• For signal “0”	0 to 20 V
• Frequency range	47 to 63 Hz
Input current	
• At signal “1”	typ. 6 mA
Input delay	
• At “0” to “1”	max. 25 ms
• At “1” to “0”	max. 25 ms
Input characteristic curve	According to IEC 1131, Type 1
Connection of Two-Wire BEROs	Possible
• Permitted bias current	max. 1 mA

3.11 Digital Input Module SM 321; DI 8 $\times$ 120/230 VAC; (6ES7 321-1FFx1-0AA0)

Order Number: “Standard Module”

6ES7 321-1FF01-0AA0

Order Number: “SIMATIC Outdoor Module”

6ES7 321-1FF81-0AA0

Characteristics

The SM 321; DI 8 $\times$ 120/230 VAC features the following characteristics:

- 8 inputs, isolated in groups of 2
- 120/230 VAC rated input voltage
- Suitable for switches and two/three-wire AC proximity switches

Terminal Assignment and Block Diagram of the SM 321; DI 8 × 120/230 VAC

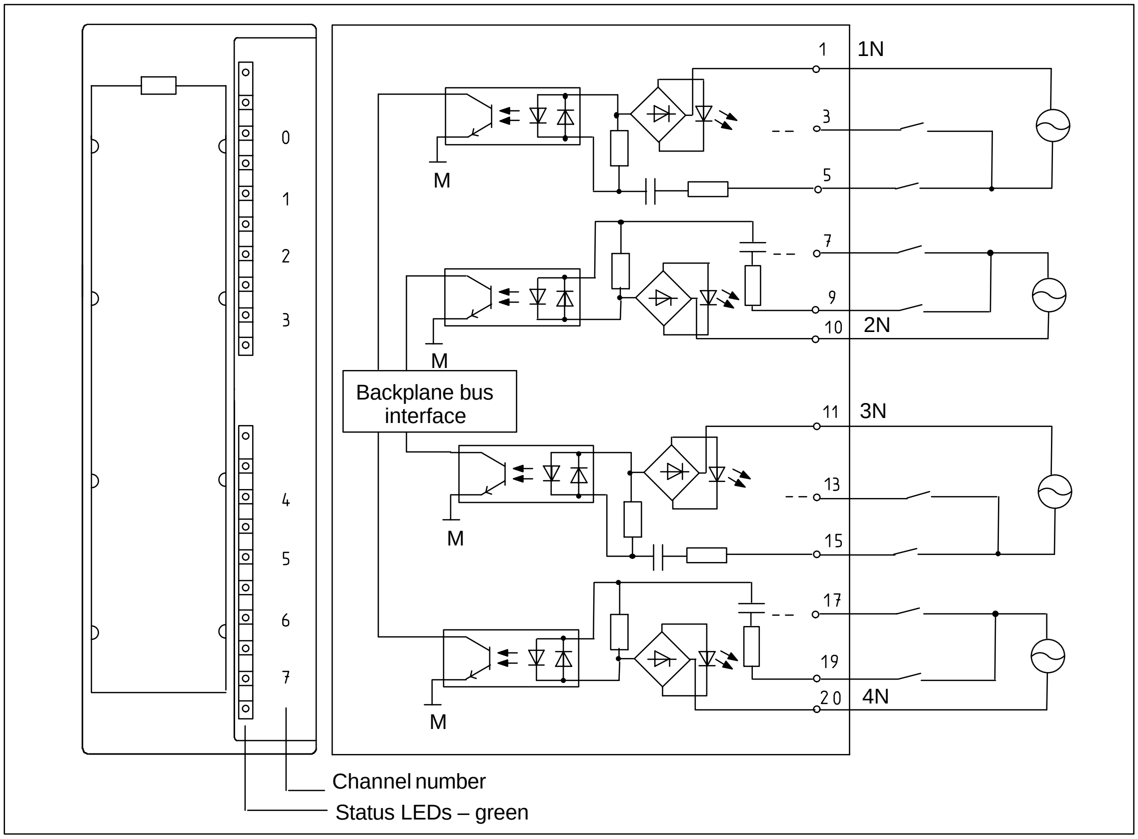


Figure 3-9 Module View and Block Diagram of the SM 321; DI 8 × 120/230 VAC

Technical Specifications of the SM 321; DI 8 × 120/230 VAC

Dimensions and Weight	
Dimensions W × H × D (in millimeters)	40 × 125 × 120
Weight	Approx. 240 g
Data for Specific Module	
Number of inputs	8
Length of cable	
• Unshielded	max. 600 m
• Shielded	max. 1000 m
Voltage, Currents, Potentials	
Number of inputs that can be triggered simultaneously	
• Horizontal configuration Up to 60 °C	8
• Vertical configuration Up to 40 °C	8
Isolation	
• Between channels and backplane bus	Yes
• Between the channels	Yes
In groups of	2
Permitted potential difference	
• Between $M_{internal}$ and the inputs	230 VAC
• Between the inputs of the different groups	500 VAC
Insulation tested with	1500 VAC
Current consumption	
• From the backplane bus	max. 29 mA
Power dissipation of the module	typ. 4.9 W
Status, Interrupts, Diagnostics	
Status display	Green LEDs per channel
Interrupts	None
Diagnostic functions	None

Data for Selecting a Sensor	
Input voltage	
• Rated value	120/230 VAC
• For signal “1”	79 to 264 V
• For signal “0”	0 to 40 V
• Frequency range	47 to 63 Hz
Input current	
• At signal “1”	
120 V, 60 Hz	typ. 6.5 mA
230 V, 50 Hz	typ. 11 mA
Input delay	
• At “0” to “1”	max. 25 ms
• At “1” to “0”	max. 25 ms
Input characteristic curve	According to IEC 1131, Type 1
Connection of Two-Wire BEROs	Possible
• Permitted bias current	max. 2 mA

3.12 Digital Input Module SM 321; DI 32 × 120 VAC; (6ES7 321-1EL00-0AA0)

Order Number

6ES7 321-1EL00-0AA0

Technical Specification

The SM 321; DI 32 × 120 VAC features the following characteristics:

- 32 inputs, isolated in groups of 8
- 120 V AC rated input voltage
- Suitable for switches and two/three-wire AC proximity switches

Terminal Assignment and Block Diagram of the SM 321; DI 32 × 120 VAC

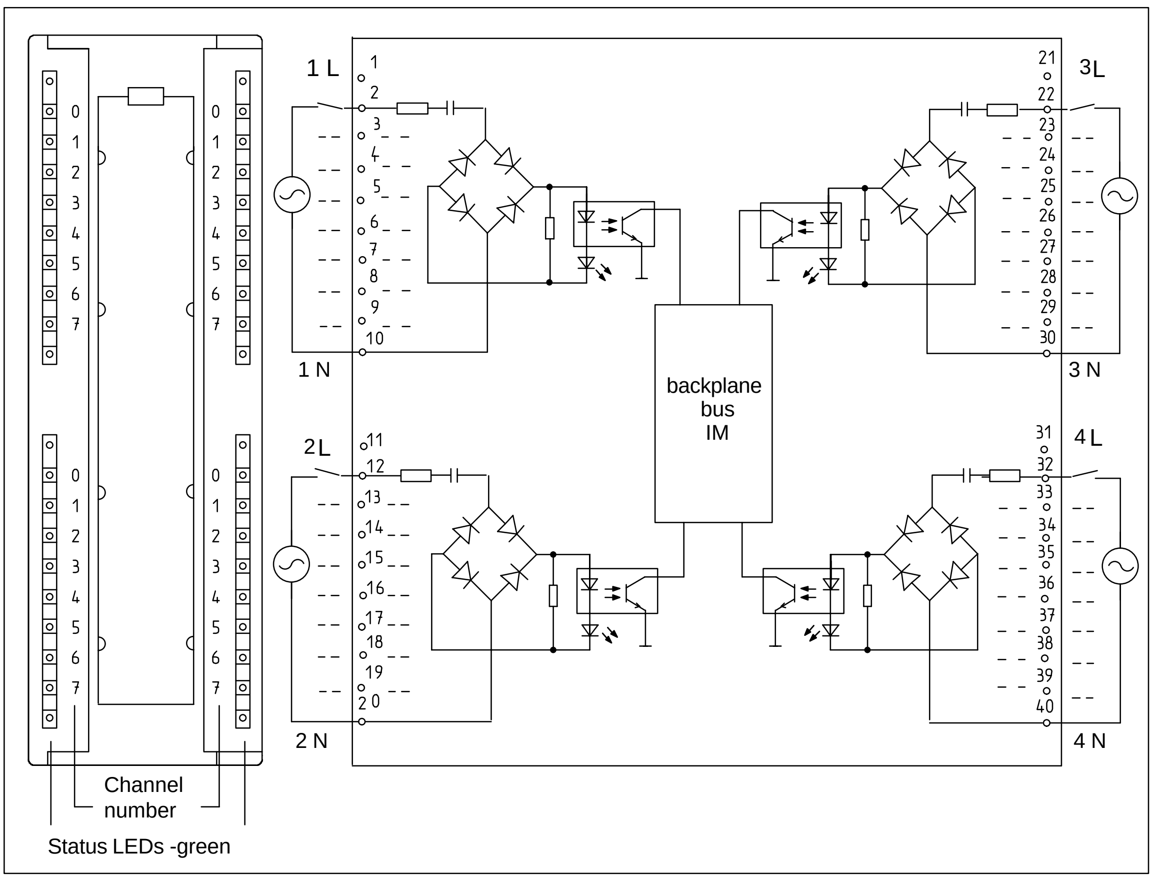


Figure 3-10 Module View and Block Diagram of Digital Input Module SM 321; DI 32 × 120 VAC

Technical Specifications of the SM 321; DI 32 × 120 VAC

Dimensions and Weight	
Dimensions W × H × D (in millimeters)	40 × 125 × 120
Weight	Approx. 300 g
Data for Specific Module	
Number of inputs	32
Length of cable	
• Unshielded	max. 600 m
• Shielded	max. 1000 m
Voltage, Currents, Potentials	
Number of inputs that can be triggered simultaneously	
• Horizontal configuration	
Up to 40 °C	32
Up to 60 °C	24
• Vertical configuration	
Up to 40 °C	32
Isolation	
• Between channels and backplane bus	Yes
• Between the channels	Yes
In groups of	8
Permitted potential difference	
• Between $M_{internal}$ and the inputs	120 VAC
• Between the inputs of the different groups	250 VAC
Insulation tested with	1500 VAC
Current consumption	
• From the backplane bus	max. 16 mA
Power dissipation of the module	typ. 4 W
Status, Interrupts, Diagnostics	
Status display	Green LEDs per channel
Interrupts	None
Diagnostic functions	None

Data for Selecting a Sensor	
Input voltage	
• Rated value	120 VAC
• for “1” signal	74 to 132 V
• for “0” signal	0 to 20 V
• Frequency range	47 to 63 Hz
Input current	
• at “1” signal	typ. 21 mA
Input delay	
• From “0” to “1”	max. 15 ms
• From “1” to “0”	max. 25 ms
Input characteristic curve	According to IEC 1131, Type 2
Connection of Two-Wire BEROs	Possible
• Permitted bias current	max. 4 A

3.13 Digital Output Module SM 322; DO 32 × 24 VDC/ 0.5 A; (6ES7 322-1BL00-0AA0)

Order Number

6ES7 322-1BL00-0AA0

Characteristics

The digital output module SM 322; DO 32 × 24 VDC/0.5 A has the following salient features:

- 32 outputs, isolated in groups of 8
- 0.5 A output current
- 24 VDC rated load voltage
- Suitable for solenoid valves, DC contactors and indicator lights

Using the Module with High-Speed Counters

Please take note of the following information on the use of the module in connection with high-speed counters:

Note

When connecting the 24 V power supply via a mechanical contact, the outputs of the SM 322; DO 32 × 24 VDC/0.5 A carry a ”1” signal for approximately 50 μs for reasons associated with the circuitry.

Module View and Block Diagram of the SM 322; DO 32 × 24 VDC/ 0.5 A

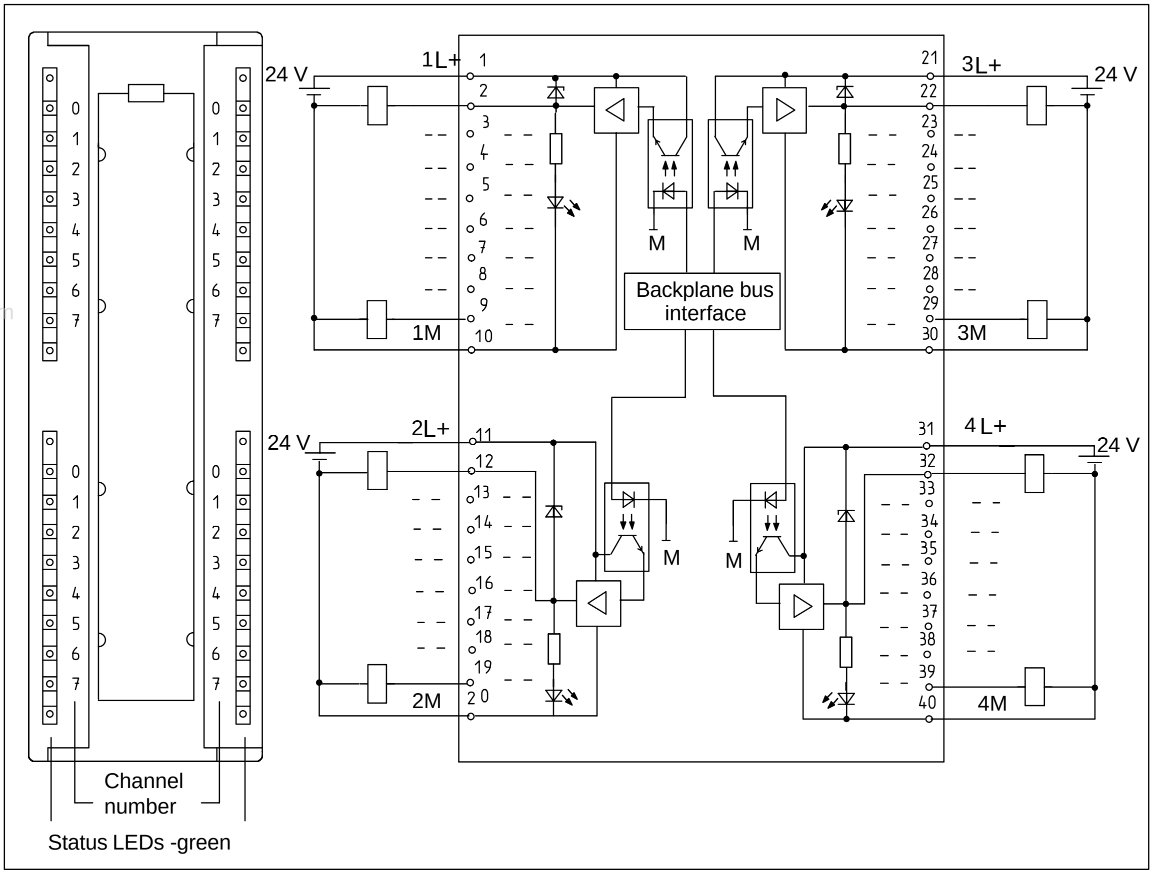


Figure 3-11 Module View and Block Diagram of Digital Output Module SM 322; DO 32 × 24 VDC/0.5 A

Terminal Assignment

The following figure shows the assignment of the channels to the addresses.

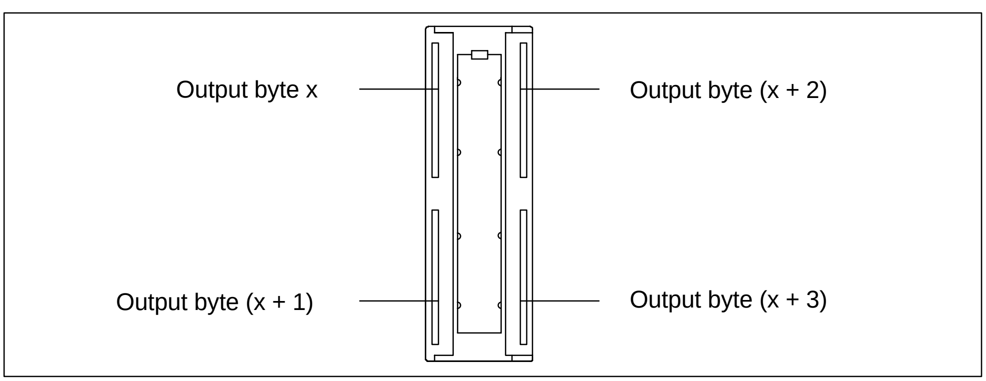


Figure 3-12 Terminal Assignment of the SM 322; DO 32 × 24 VDC

Technical Specifications of the SM 322; DO 32 × 24 VDC/ 0.5 A

Dimensions and Weight	
Dimensions W × H × D (in millimeters)	40 × 125 × 120
Weight	Approx. 260 g
Data for Specific Module	
Number of outputs	32
Length of cable	
• Unshielded	max. 600 m
• Shielded	max. 1000 m
Voltage, Currents, Potentials	
Rated load voltage L+	24 VDC
Total current of the outputs (per group)	
• Horizontal configuration	
Up to 40 °C	max. 4 A
Up to 60 °C	max. 3 A
• Vertical configuration Up to 40 °C	max. 2 A
Isolation	
• Between channels and backplane bus	Yes
• Between the channels	Yes
In groups of	8
Permitted potential difference	
• Between the different circuits	75 VDC 60 VAC
Insulation tested with	500 VDC
Current consumption	
• From the backplane bus	max. 110 mA
• From load voltage L + (without load)	max. 160 mA
Power dissipation of the module	typ. 6.6 W
Status, Interrupts, Diagnostics	
Status display	Green LEDs per channel
Interrupts	None
Diagnostic functions	None

Data for Selecting an Actuator	
Output voltage	
• At signal “1”	min. L + (– 0.8 V)
Output current	
• At signal “1”	
Rated value	0.5 A
Permitted range	5 mA to 0.6 A
• At signal “0” (leakage current)	max. 0.5 mA
Output delay (for resistive load)	
• From “ 0” to “1”	max. 100 µs
• At “1” to “0”	max. 500 µs
Load resistor range	48 Ω to 4 kΩ
Lamp load	max. 5 W
Connecting two outputs in parallel	
• For redundant triggering of a load	Possible (only outputs of the same group)
• To increase performance	Not possible
Triggering a digital input	Possible
Switch rate	
• For resistive load	max. 100 Hz
• For inductive load according to IEC 947-5-1, 13 DC	max. 0.5 Hz
• For lamp load	max. 10 Hz
Limit (internal) of the inductive circuit interruption voltage up	typ. L + (– 53 V)
Short-circuit protection of the output	Yes, electronic
• Threshold on	typ. 1 A

3.14 Digital Output Module SM 322; DO 16 × 24 VDC/ 0.5 A; (6ES7 322-1BHx1-0AA0)

Order Number: "Standard Module"

6ES7 322-1BH01-0AA0

Order Number: "SIMATIC Outdoor Module"

6ES7 322-1BH81-0AA0

Characteristics

The digital output module SM 322; DO 16 × 24 VDC/0.5 A has the following salient features:

- 16 outputs, isolated in groups of 8
- 0.5 A output current
- 24 VDC rated load voltage
- Suitable for solenoid valves, DC contactors and indicator lights

Using the Module with High-Speed Counters

Please take note of the following information on the use of the module in connection with high-speed counters:

Note

When connecting the 24 V power supply via a mechanical contact, the outputs of the SM 322; DO 16 × 24 VDC/0.5 A carry a "1" signal for approximately 50 μs for reasons associated with the circuitry.

Terminal Assignment and Block Diagram of the SM 322; DO 16 × 24 VDC/0.5 A

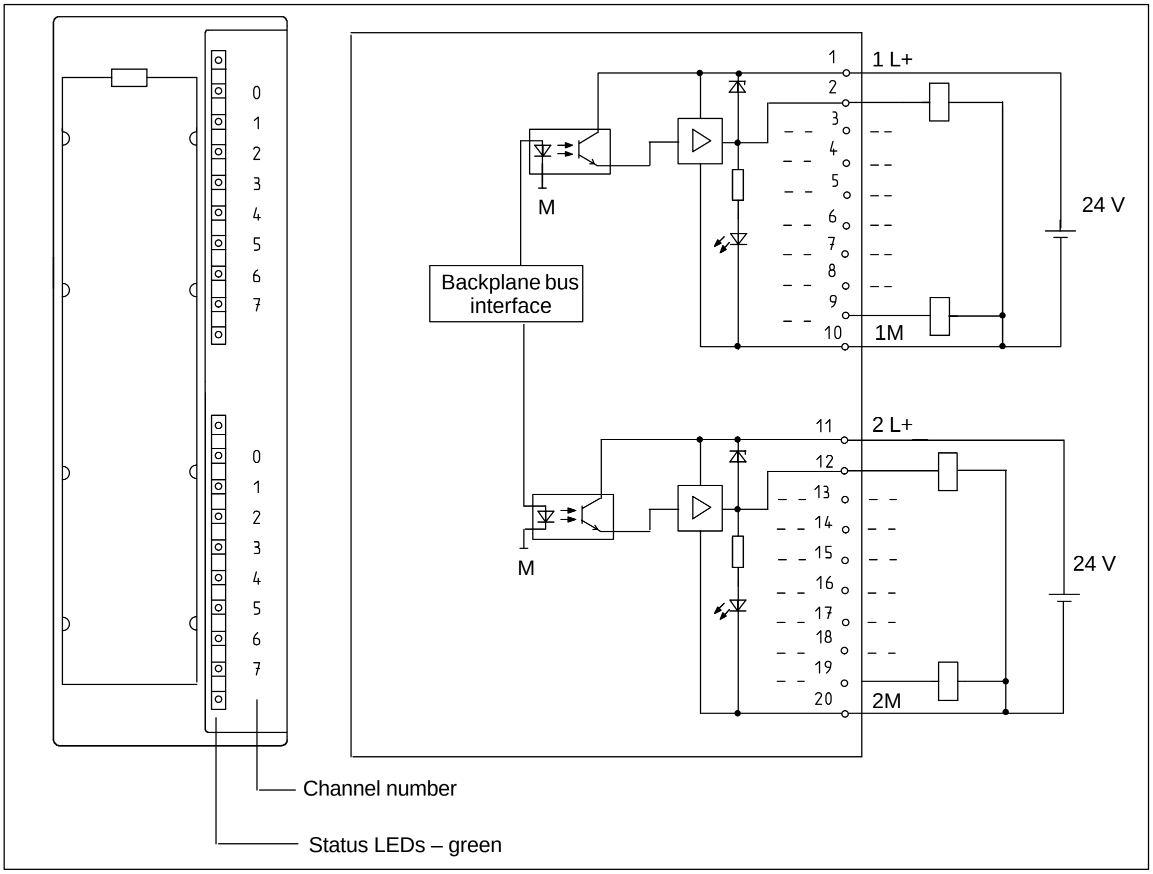


Figure 3-13 Module View and Block Diagram of the SM 322; DO 16 x 24 VDC/0.5 A

Technical Specifications of the SM 322; DO 16 × 24 VDC/0.5 A

Dimensions and Weight	
Dimensions W × H × D (in millimeters)	40 × 125 × 120
Weight	Approx. 190 g
Data for Specific Module	
Number of outputs	16
Length of cable	
• Unshielded	max. 600 m
• Shielded	max. 1000 m
Voltage, Currents, Potentials	
Rated load voltage L+	24 VDC
Total current of the outputs (per group)	
• Horizontal configuration	
Up to 40 °C	max. 4 A
Up to 60 °C	max. 3 A
• Vertical configuration Up to 40 °C	max. 2 A
Isolation	
• Between channels and backplane bus	Yes
• Between the channels	Yes
In groups of	8
Permitted potential difference	
• Between the different circuits	75 VDC / 60 VAC
Insulation tested with	500 VDC
Current consumption	
• From the backplane bus	max. 80 mA
• From load voltage L + (without load)	max. 80 mA
Power dissipation of the module	typ. 4.9 W
Status, Interrupts, Diagnostics	
Status display	Green LEDs per channel
Interrupts	None
Diagnostic functions	None

Data for Selecting an Actuator	
Output voltage	
• At signal “1”	min. L + (– 0.8 V)
Output current	
• At signal “1”	
Rated value	0.5 A
Permitted range	5 mA to 0.6 A
• At signal “0” (leakage current)	max. 0.5 mA
Output delay (for resistive load)	
• At “ 0” to “1”	max. 100 μs
• At “1” to “0”	max. 500 μs
Load resistor range	48 Ω to 4 kΩ
Lamp load	max. 5 W
Connecting two outputs in parallel	
• For redundant triggering of a load	Possible (only outputs of the same group)
• To increase performance	Not possible
Triggering a digital input	Possible
Switch rate	
• For resistive load	max. 100 Hz
• For inductive load according to IEC 947-5-1, 13 DC	max. 0.5 Hz
• For lamp load	max. 10 Hz
Limit (internal) of the inductive circuit interruption voltage up	typ. L + (– 53 V)
Short-circuit protection of the output	Yes, electronic
• Threshold on	typ. 1 A

3.15 Digital Output Module SM 322; DO 8 × 24 VDC/2 A; (6ES7 322-1BF01-0AA0)

Order Number

6ES7 322-1BF01-0AA0

Characteristics

The digital output module SM 322; DO 8 × 24 VDC/2 A has the following salient features.

- 8 outputs, isolated in groups of 4
- 2 A output current
- 24 VDC rated load voltage
- Suitable for solenoid valves, DC contactors and indicator lights

Using the Module with High-Speed Counters

Please take note of the following information on the use of the module in connection with high-speed counters:

Note

When connecting the 24 V power supply via a mechanical contact, the outputs of the SM 322; DO 8 × 24 VDC/2 A carry a ”1” signal for approximately 50 µs for reasons associated with the circuitry.

Module View and Block Diagram of the SM 322; DO 8 × 24 VDC/2 A

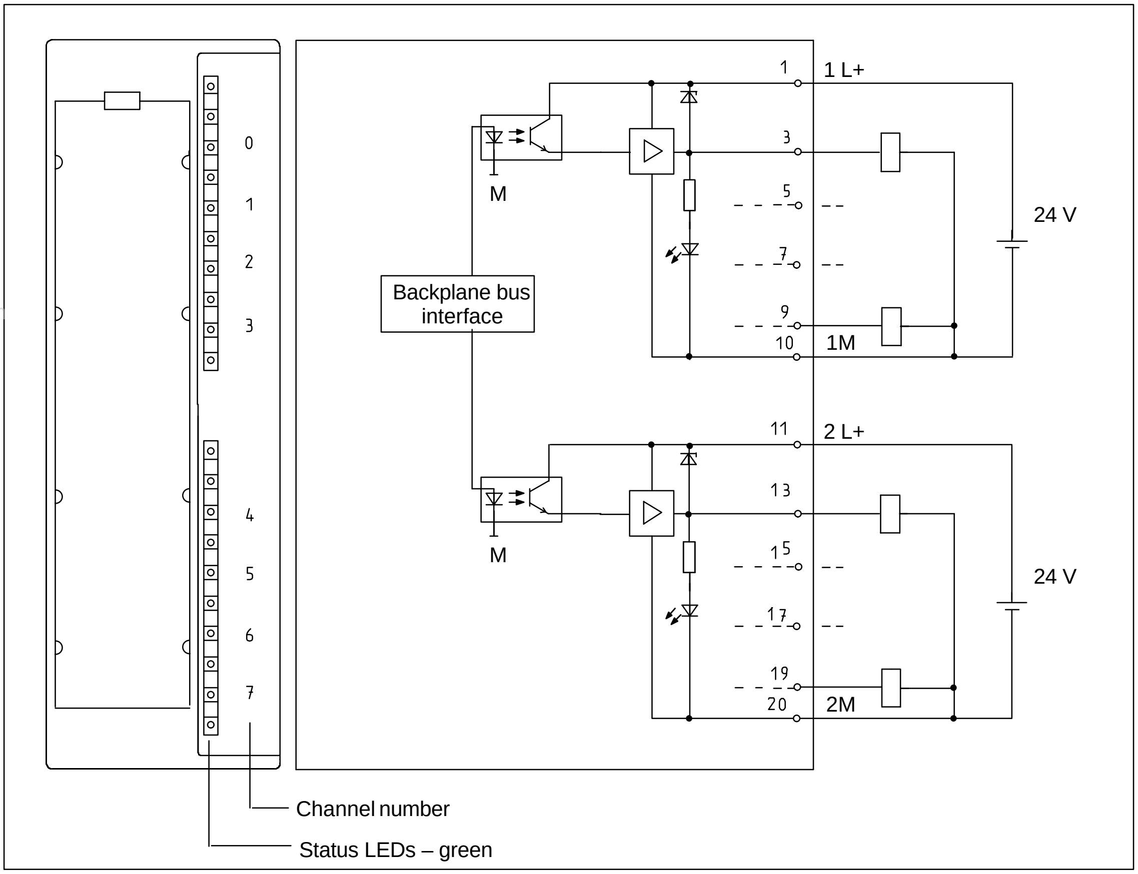


Figure 3-14 Module View and Block Diagram of Digital Output Module SM 322; DO 8 × 24 VDC/2 A

Technical Specifications of the SM 322; DO 8 × 24 VDC/2 A

Dimensions and Weight	
Dimensions W × H × D (in millimeters)	40 × 125 × 120
Weight	Approx. 190 g
Data for Specific Module	
Number of outputs	8
Length of cable	
• Unshielded	max. 600 m
• Shielded	max. 1000 m
Voltage, Currents, Potentials	
Rated load voltage L+	24 VDC
Total current of the outputs (per group)	
• Horizontal configuration	
Up to 60 °C	max. 4 A
• Vertical configuration	max. 4 A
Up to 40 °C	
Isolation	
• Between channels and backplane bus	Yes
• Between the channels	Yes
In groups of	4
Permitted potential difference	
• Between the different circuits	75 VDC / 60 VAC
Insulation tested with	500 VDC
Current consumption	
• From the backplane bus	max. 40 mA
• From the load voltage L+ (no load)	max. 60 mA
Power dissipation of the module	typ. 6.8 W
Status, Interrupts, Diagnostics	
Status display	Green LEDs per channel
Interrupts	None
Diagnostic functions	None

Data for Selecting an Actuator	
Output voltage	
• At signal “1”	min. L + (– 0.8 V)
Output current	
• At signal “1”	
Rated value	2 A
Permitted range	5 mA to 2.4 A
• At signal “0” (leakage current)	max. 0.5 mA
Output delay (for resistive load)	
• From “ 0” to “1”	max. 100 μs
• At “1” to “0”	max. 500 μs
Load resistor range	12 Ω to 4 kΩ
Lamp load	max. 10 W
Connecting two outputs in parallel	
• For redundant triggering of a load	Possible (only outputs of the same group)
To increase performance	Not possible
Triggering a digital input	Possible
Switch rate	
• For resistive load	max. 100 Hz
• For inductive load according to IEC 947-5-1, 13 DC	max. 0.5 Hz
• For lamp load	max. 10 Hz
Limit (internal) of the inductive circuit interruption voltage up	typ. L + (– 48 V)
Short-circuit protection of the output	Yes, electronic
• Threshold on	typ. 3 A

3.16 Digital Output Module SM 322; DO 8 × 24 VDC/ 0.5 A; with Diagnostic Interrupt; (6ES7 322-8BFx0-0AB0)

Order Number: “Standard Module”

6ES7 322-8BF00-0AB0

Order Number: “SIMATIC Outdoor Module”

6ES7 322-8BF80-0AB0

Characteristics

The digital output module SM 322; DO × 24 VDC/0.5 A has the following salient features:

- 8 outputs, isolated in groups of 8
- 0.5 A output current
- 24 VDC rated load voltage
- Suitable for solenoid valves, DC contactors and indicator lights
- 2 terminals per output
  - Output without series diode
  - Output with series diode (for redundant load control)
- Group error display
- Channel-specific status and error LEDs
- Programmable diagnostics
- Programmable diagnostic interrupt
- Programmable substitute value output

Module View of the SM 322; DO 8 × 24 VDC/0.5 A

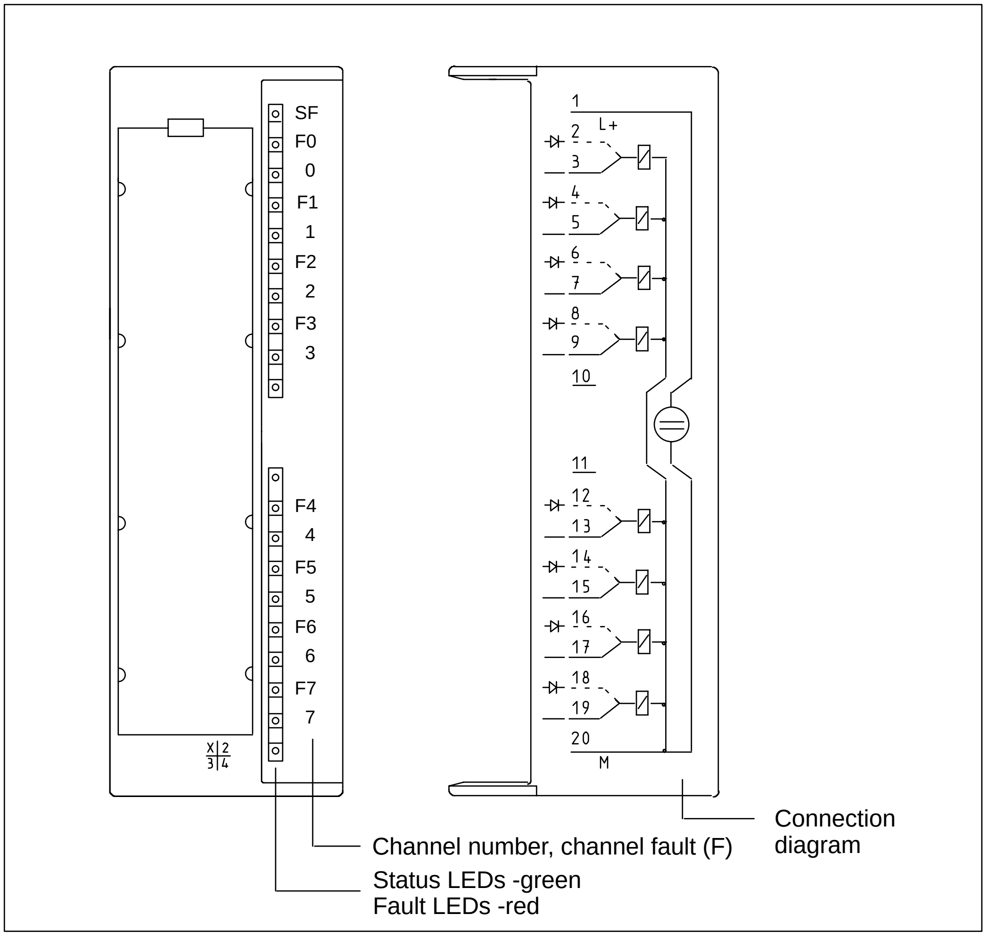


Figure 3-15 Terminal Assignment of the SM 322; DO 8 × 24 VDC/0.5 A

Block Diagram of the SM 322; DO 8 × 24 VDC/ 0.5 A

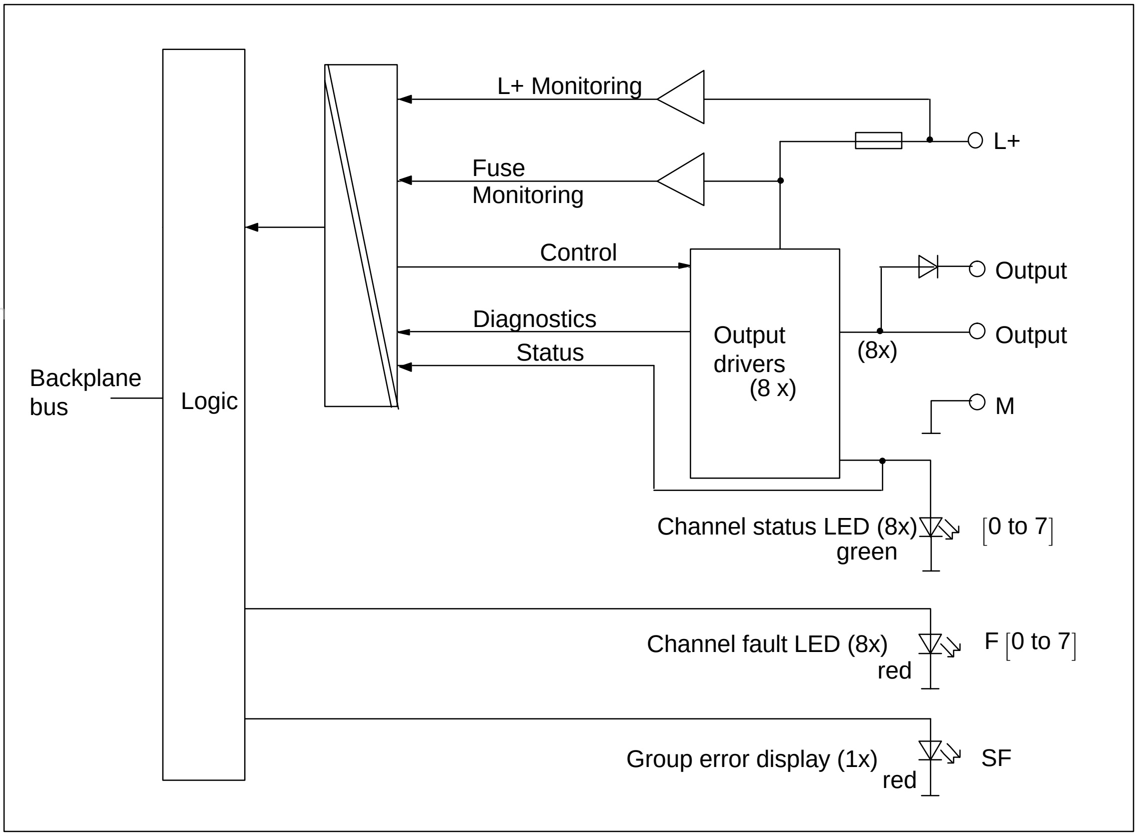


Figure 3-16 Block Diagram of the SM 322; DO 8 × 24 VDC/0.5 A

Redundant Control of a Load

The output with series diode can be used for redundant control of a load. Redundant control is possible from two different signal modules without external circuitry. Both modules must have the same reference potential, M.

Note

If the output with series diode is used, external short-circuits to L+ cannot be detected.

Technical Specifications of the SM 322; DO 8 × 24 VDC/0.5 A

Dimensions and Weight	
Dimensions W × H × D (in millimeters)	40 × 125 × 120
Weight	Approx. 210 g
Data for Specific Module	
Number of outputs	8
Length of cable	
• Unshielded	max. 600 m
• Shielded	max. 1000 m
Voltage, Currents, Potentials	
Rated load voltage L+	24 VDC
Total current of the outputs (per group) without series diode	
• Horizontal configuration	
Up to 40 °C	max. 4 A
Up to 60 °C	max. 3 A
• Vertical configuration	
Up to 40 °C	max. 4 A
Total current of the outputs (per group) with series diode	
• Horizontal configuration	
Up to 40 °C	max. 3 A
Up to 60 °C	max. 2 A
• Vertical configuration	max. 3 A
Up to 40 °C	
Isolation	
• Between channels and backplane bus	Yes
Permitted potential difference	
• Between the different circuits	75 VDC / 60 VAC
Insulation tested with	500 VDC
Current consumption	
• From the backplane bus	max. 70 mA
• From the load voltage L+ (no load)	max. 90 mA
Power dissipation of the module	typ. 5 W
Status, Interrupts, Diagnostics	
Status display	Green LEDs per channel
Interrupts	
• Diagnostic Interrupt	Parameters can be assigned

Diagnostic functions	Parameters can be assigned
• Group error display	Red LED (SF)
• Channel error display	Red LED (F) per channel
• Diagnostic information can be displayed	Possible
Data for Selecting an Actuator	
Output voltage	
• At signal “1”	
Without series diode	min. L + (– 0.8 V)
With series diode	min. L + (– 1.6 V)
Output current	
• At signal “1”	
Rated value	0.5 A
Permitted range	10 mA to 0.6 A[1)]
• At signal “0” (leakage current)	max. 0.5 mA
Output delay (for resistive load)	
• At “0” to “1”	max. 180 μs
• At “1” to “0”	max. 245 μs
Load resistor range	48 Ω to 3 kΩ
Lamp load	max. 5 W
Connecting two outputs in parallel	
• For redundant triggering of a load	Output with series diode only, must have the same reference potential
• To increase performance	Not possible
Triggering a digital input	Possible 1 binary input according to IEC 1131-2, Type 2; Type 1 with disabled open-circuit monitoring
Switch rate	
• For resistive load	max. 100 Hz
• Inductive load according to IEC 947-5-1, DC 13	max. 2 Hz
• For lamp load	max. 10 Hz
Limit (internal) of the inductive circuit interruption voltage up	typ. L + (– 45 V)
Short-circuit protection of the output	Yes, electronic
• Threshold on	typ. 0.75 to 1.5 A

1) 5 mA to 0.6 A with disabled open-circuit monitoring

3.16.1 Assigning Parameters to the SM 322; DO 8 × 24 VDC/0.5 A

Parameterization

You will find a description of the general procedure for assigning parameters to digital modules in Section 3.3.

Parameters of the SM 322; DO 8 × 24 VDC/0.5 A

You will find an overview of the parameters that you can set and their default settings for the SM 322; DO 8 × 24 VDC/0.5 A in the table below.

The default settings apply if you have not performed parameter assignment in *STEP 7*.

Table 3-12 Parameters of the SM 322; DO 8 × 24 VDC/0.5 A

Parameter	Value Range	Default Settings	Parameter Type	Scope
Enable • Diagnostic interrupt	 Yes/no	 No	Dynamic	Module
Behavior on CPU STOP	Apply substitute value (EWS) Hold last value (LWH)	EWS		
Diagnostics • Wire break • No load voltage L+ • Short-circuit to M • Short-circuit to L+	 Yes/no Yes/no Yes/no Yes/no	 No No No No	Static	Channel
Apply substitute value ”1”	Yes/no	No	Dynamic	Channel

3.16.2 Behavior and Diagnostics of the SM 322; DO 8 × 24 VDC/0.5 A

Effect of Operating and Mode Supply Voltage on the Output Values

The output values of the SM 322; DO 8 × 24 VDC/0.5 A depend on the operating mode of the CPU and on the supply voltage of the module.

Table 3-13 Dependence of the Output Values on the Operating Mode of the CPU and on the Supply Voltage L+ of the SM 322; DO 8 × 24 VDC/0.5 A.

CPU Operating State		Power Supply L+ to Digital Module	Output Value of Digital Module
POWER ON	RUN	L+ exists	CPU value
		L+ missing	0 signal
	STOP	L+ exists	Substitute value/last value (0 signal preset)
		L+ missing	0 signal
POWER OFF	–	L+ exists	0 signal
		L+ missing	0 signal

Behavior upon Failure of the Supply Voltage

Failure of the supply voltage of the SM 322; DO 8 × 24 VDC/0.5 A is always indicated by the SF LED on the module. Furthermore, this information is made available on the module (entry in diagnosis).

Triggering of the diagnostic interrupt depends on the parameter assignment (see Section 3.16.3).

Diagnostic Messages of the SM 322; DO 8 × 24 VDC/0.5 A

The following table provides an overview of the diagnostic messages of the SM 322; DO 8 × 24 VDC/0.5 A.

Table 3-14 Diagnostic Messages of the SM 322; DO 8 × 24 VDC/0.5 A

Diagnostics Message	LED	Scope of the Diagnostics	Parameters can be assigned
Wire break	SF	Channel	Yes
Load voltage missing	SF	Channel	Yes
Short-circuit to M	SF	Channel	Yes
Short-circuit to L+	SF	Channel	Yes
External auxiliary supply missing	SF	Module	No
Internal auxiliary power missing	SF	Module	No
Fuse blown	SF	Module	No
Watchdog timeout	SF	Module	No
EPROM error	SF	Module	No
RAM error	SF	Module	No

* Open-circuit detection is performed at a current < 1 mA.
When suitably parameterized, a wire break results only in the SF LED and the corresponding channel error LED lighting up.

Note

A prerequisite for detecting the errors indicated by programmable diagnostic messages is that you have assigned parameters to the digital module accordingly in *STEP 7*.

Causes of Error and Remedial Action

Table 3-15 Diagnostic Messages of the SM 322; DO 8 × 24 VDC/0.5 A, Causes of Error and Remedial Action

Diagnostics Message	Error Detection ...	Possible Error Cause	Remedy
Wire break	Only with output to "1"	Open circuit between module and actuator	Close circuit
		Channel not connected (open)	Disable the "Diagnose Wire Break" parameter for the channel in *STEP 7*
No load voltage	Only with output to "1"	Defective output	Replace module
Short-circuit to M	Only with output to "1"	Overload of output	Eliminate overload
		Short-circuit of output to M	Eliminate short circuit
Short-circuit to L+	Always	Short-circuit at output to L+ of module supply	Eliminate short circuit
No external auxiliary voltage	Always	Power supply L+ to module missing	Feed supply L+
No internal auxiliary voltage	Always	Power supply L+ to module missing	Feed supply L+
		Fuse in module defective	Replace module
Fuse blown	Always	Fuse in module defective	Replace module
Watchdog tripped	Always	Temporary high electromagnetic interference	Eliminate interference
		Module defective	Replace module
EPROM error	Always	Temporary high electromagnetic interference	Eliminate interference and switch on/off power supply of CPU
		Module defective	Replace module
RAM error	Always	Temporary high electromagnetic interference	Eliminate interference and switch on/off power supply of CPU
		Module defective	Replace module

3.16.3 Interrupts of the SM 322; DO 8 × 24 VDC/0.5 A

Introduction

The SM 322; DO 8 × 24 VDC/0.5 A can trigger diagnostic interrupts.

The OBs and SFCs mentioned below can be found in the online Help for *STEP 7*, where they are described in greater detail.

Enabling Interrupts

The interrupts are not preset – in other words, they are inhibited without appropriate parameter assignment. Assign parameters to the Interrupt Enable in *STEP 7* (refer to Section 3.16.1).

Diagnostic Interrupt

If you have enabled diagnostic interrupts, then active error events (initial occurrence of the error) and departing error events (message after troubleshooting) are reported by means of an interrupt.

The CPU interrupts the execution of the user program and processes the diagnostics interrupt block (OB 82).

In the user program, you can call SFC 51 or SFC 59 in OB 82 to obtain more detailed diagnostic information from the module.

The diagnostic information is consistent until such time as OB 82 is exited. When OB 82 is exited, the diagnostic interrupt is acknowledged on the module.

3.17 Digital Output Module SM 322; DO 8 $\times$ 48-125 VDC/1.5 A; (6ES7 322-1CF80-0AA0)

Order Number: “SIMATIC Outdoor Module”

6ES7 322-1CF80-0AA0

Characteristics

The SM 322; DO 8 $\times$ 48-125 VDC/1.5 A features the following characteristics:

- 8 outputs, reverse polarity protection and isolated in groups of 4
- 1.5 A output current
- Rated load voltage 48 to 125 VDC
- Suitable for solenoid valves, DC contactors and indicator lights
- Group error display

Using the Module with High-Speed Counters

Please take note of the following information on the use of the module in connection with high-speed counters:

Note

When connecting the power supply via a mechanical contact, the outputs of the SM 322; DO 8 $\times$ 48-125 VDC/1.5 A carry a ”1” signal for approximately 50 μs for reasons associated with the circuitry.

Terminal Assignment and Block Diagram of the SM 322; DO 8 × 48-125 VDC/1.5 A

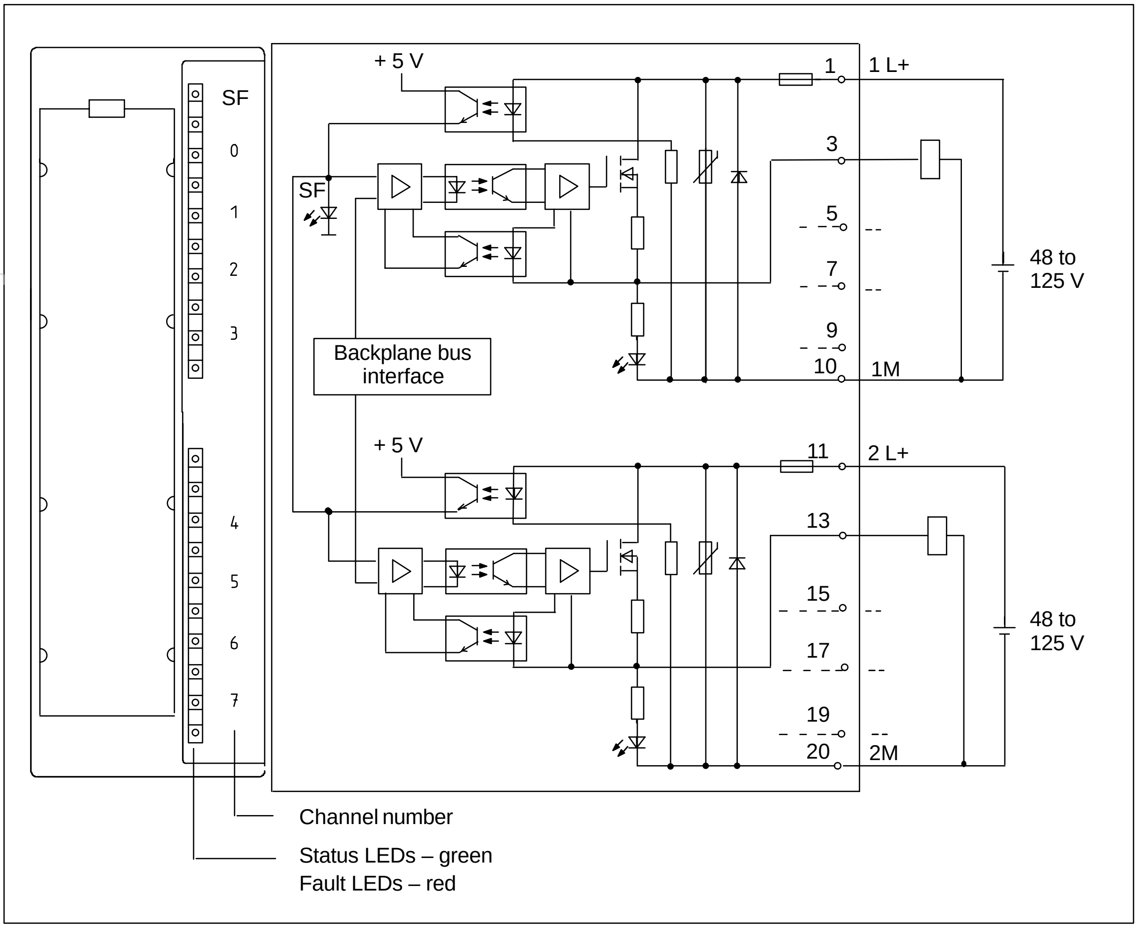


Figure 3-17 Module View and Block Diagram of the SM 322; DO 8 × 48-125 VDC/1.5 A

Technical Specifications of the SM 322; DO 8 × 48-125 VDC/1.5 A

Dimensions and Weight	
Dimensions W × H × D (in millimeters)	40 × 125 × 120
Weight	Approx. 250 g
Data for Specific Module	
Number of outputs	8
Length of cable	
• Unshielded	max. 600 m
• Shielded	max. 1000 m
Voltage, Currents, Potentials	
Rated load voltage L+	48 VDC to 125 VDC
• Reverse polarity protection	Yes, by means of fuse[1)]
Total current of the outputs (per group)	
• Horizontal configuration	
Up to 40 °C	max. 6 A
Up to 50 °C	max. 4 A
Up to 60 °C	max. 3 A
• Vertical configuration	
Up to 40°	max. 4 A
Isolation	
• Between channels and backplane bus	Yes
• Between the channels	Yes
In groups of	4
Permitted potential difference	
• Between the different circuits	146 VDC / 132 VAC
Insulation tested with	1500 VAC
Current consumption	
• From the backplane bus	max. 100 mA
• From load voltage L+ (no load)	max. 2 mA
Power dissipation of the module	typ. 7.2 W
Status, Interrupts, Diagnostics	
Status display	Green LEDs per channel
Interrupts	None
Diagnostic functions	None
• Group error display	Red LED (SF)[2)]

Data for Selecting an Actuator	
Output voltage	
• At “ 1” signal	min. L + (–1.,2 V)
Output current	
• At “ 1” signal	
Rated value	1.5 A
Permitted range	10 mA to 1.5 A
• Permitted surge current	max. 3 A for 10 ms
• At signal ”0” (leakage current)	max. 0.5 mA
Output delay (for resistive load)	
• From “ 0” to “1”	max. 2 ms
• At “1” to “0”	max. 15 ms
Lamp load	max. 15 W at 48 V max. 40 W at 125 V
Connecting two outputs in parallel	
• For redundant triggering of a load	Possible (only outputs of the same group)
• To increase performance	Not possible
Triggering a digital input	Possible
Switch rate	
• For resistive load	max. 25 Hz
• For inductive load	max. 0.5 Hz
• For lamp load	max. 10 Hz
Limit (internal) of the inductive circuit interruption voltage up	typ. M (–1V)
Short-circuit protection of the output	Yes, electronic[3)]
• Threshold on	typ. 4.4 A
Replacement fuses	Fuse 6.,3 A/250 V, quick blow, 5 x 20 mm
• Schurter	SP0001.1012
• Wickmann	194-1630-0
Fuse carrier	
• Schurter	FEK 0031.3562

1) The fuses on this module are merely supplementary fuses. External overcurrent protection (suitable for branch circuits conforming to the local regulations for electrical engineering) is required in the supply cables of the load circuit.

2) Potential errors are:
- No load voltage
- Fuse defective
- Output overloaded

3) If an overload condition is detected, the output is inhibited for approximately 2.4 s.

3.18 Digital Output Module SM 322; DO 16 × 120 VAC/1 A; (6ES7 322-1EH01-0AA0)

Order Number

6ES7 322-1EH01-0AA0

Characteristics

The SM 322; DO 16 × 120 VAC/1 A features the following characteristics:

- 16 outputs, fused and isolated in groups of 8
- 1 A output current
- 120 VAC rated load voltage
- Suitable for AC solenoid valves, contactors, motor starters, fractional h.p. motors and indicator lights.

Terminal Assignment and Block Diagram of the SM 322; DO 16 × 120 VAC/1 A

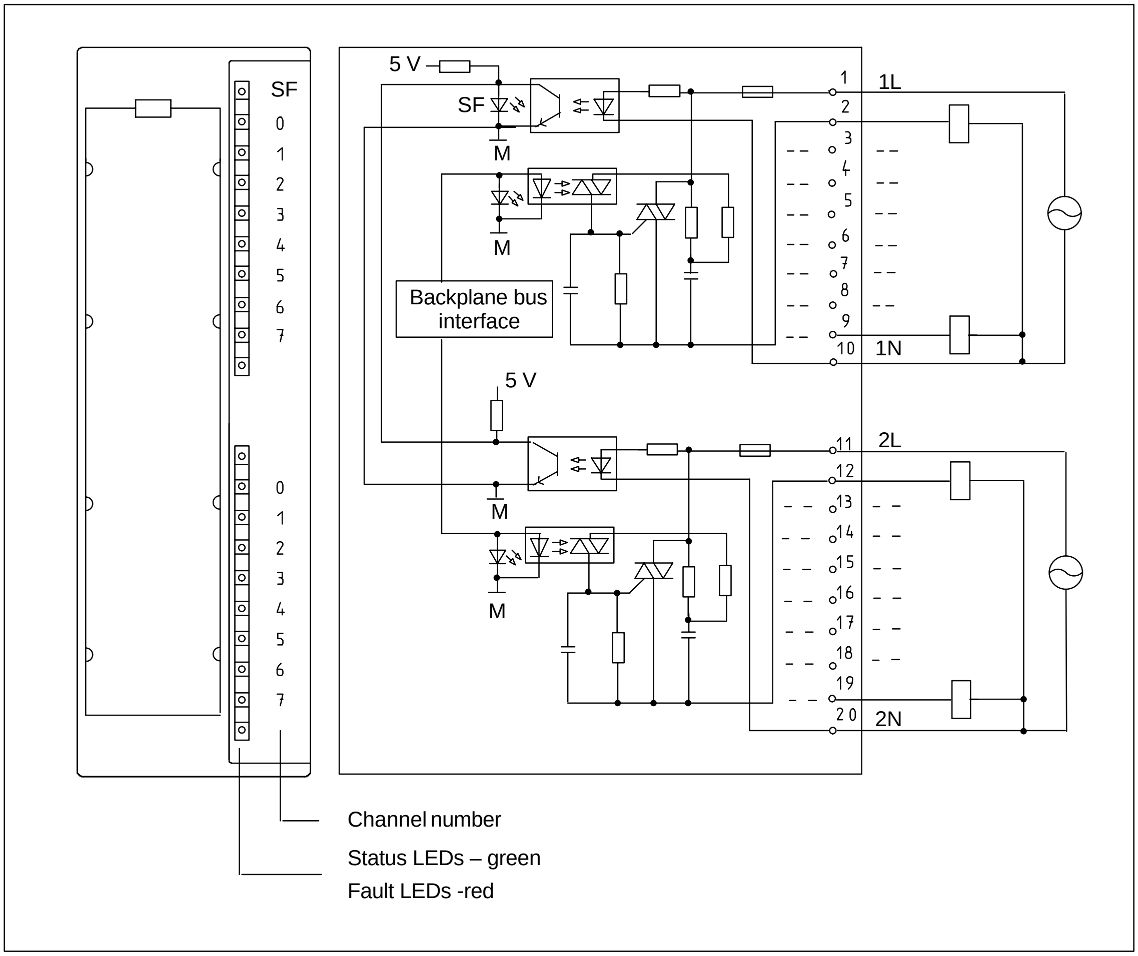


Figure 3-18 Module View and Block Diagram of Digital Output Module SM 322; DO 16 × 120 VAC/1 A

Technical Specifications of the SM 322; DO 16 × 120 VAC/1 A

Dimensions and Weight	
Dimensions W × H × D (in millimeters)	40 × 125 × 120
Weight	Approx. 300 g
Data for Specific Module	
Number of outputs	16
Length of cable	
• Unshielded	max. 600 m
• Shielded	max. 1000 m
Voltage, Currents, Potentials	
Rated load voltage L1	120 VAC
• Permitted frequency range	47 Hz to 63 Hz
Total current of the outputs (per group)	
• Horizontal configuration Up to 40 °C Up to 60 °C	 max. 4 A max. 2 A
• Vertical configuration Up to 40 °C	 max. 2 A
Isolation	
• Between channels and backplane bus	Yes
• Between the channels	Yes
In groups of	8
Permitted potential difference	
• Between $M_{internal}$ and the outputs	120 VAC
• Between the outputs of different groups	250 VAC
Insulation tested with	1500 VAC
Current consumption	
• From the backplane bus	max. 184 mA
• From load voltage L1 (without load)	max. 3 mA
Power dissipation of the module	typ. max. 9 W
Status, Interrupts, Diagnostics	
Status display	Green LEDs per channel
Interrupts	None
Diagnostic functions	Yes
• Group error display	Red LED (SF) [1)]

Data for Selecting an Actuator	
Output voltage	
• At signal “1”	
At maximum current	min. L1 (– 1.5 V)
At minimum current	min. L1 (– 8.5 V)
Output current	
• At signal “1”	
Rated value	1 A
Permitted range for 0 °C to 40 °C	10 mA to 1 A
Permitted range for 40 °C to 60 °C	10 mA to 0.5 A
Permitted surge current (per group)	max. 10 A (not more than 1 AC scan cycle)
• At signal “0” (leakage current)	max. 1 mA
Output delay (for resistive load)	
• From ”0” to “1”	1 ms
• From ”1” to “0”	Not more than 1 AC scan cycle
Minimum load current	10 mA
Zero cross inhibit voltage	Non-zero cross switch
Size of motor starter	max. size 3 according to NEMA
Lamp load	max. 25 W
Connecting two outputs in parallel	
• For redundant triggering of a load	Possible (only outputs of the same group)
• To increase performance	Not possible
Triggering a digital input	Possible
Switch rate	
• For resistive load	max. 10 Hz
• For inductive load according to IEC 947-5-1, 15 AC	max. 0.5 Hz
• For lamp load	max. 1 Hz

1) Possible errors:
- No load voltage
- Fuse defective

Short-circuit protection of the output	Fuse, 8 A/250 V; per group
• Current required for fuse to blow	min. 40 A
• Response time	max. 300 ms

Replacement fuses	8 A fuse/quick-acting
• Wickmann	194-1800-0
• Schurter	SP001.1013
• Littelfuse	217.008
Fuse carrier	
• Wickmann	653 07

3.19 Digital Output Module SM 322; DO 8 × 120/230 VAC/2 A; (6ES7 322-1FFx1-0AA0)

Order Number: “Standard Module”

6ES7 322-1FF01-0AA0

Order Number: “SIMATIC Outdoor Module”

6ES7 322-1FF81-0AA0

Characteristics

The SM 322; DO 8 × 120/230 VAC/2 A features the following characteristics:

- 8 outputs, fused and isolated in groups of 4
- 2 A output current
- 120/230 VAC rated load voltage
- Suitable for AC solenoid valves, contactors, motor starters, fractional h.p. motors and indicator lights
- Group error display

Terminal Assignment and Block Diagram of the SM 322; DO 8 × 120/230 VAC/2 A

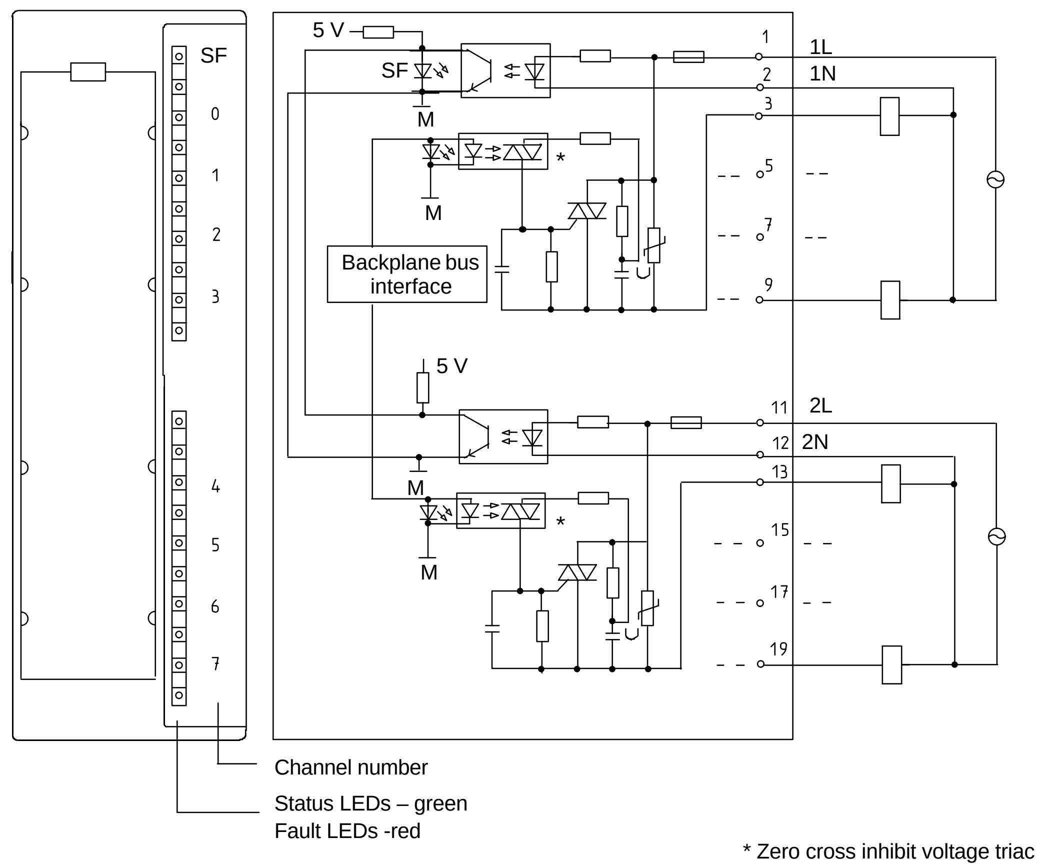


Figure 3-19 Module View and Block Diagram of the SM 322; DO 8 × 120/230 VAC/2 A

Technical Specifications of the SM 322; DO 8 × 120/230 VAC/2 A

Dimensions and Weight	
Dimensions W × H × D (in millimeters)	40 × 125 × 120
Weight	Approx. 275 g
Data for Specific Module	
Number of outputs	8
Length of cable	
• Unshielded	max. 600 m
• Shielded	max. 1000 m
Voltage, Currents, Potentials	
Rated load voltage L1	120/230 VAC
• Permitted frequency range	47 Hz to 63 Hz
Total current of the outputs (per group)	
• Horizontal configuration	
Up to 40 °C	max. 4 A
Up to 60 °C	max. 2 A
• Vertical configuration	
Up to 40 °C	max. 2 A
Isolation	
• Between channels and backplane bus	Yes
• Between the channels	Yes
In groups of	4
Permitted potential difference	
• Between $M_{internal}$ and the outputs	230 VAC
• Between the outputs of different groups	500 VAC
Insulation tested with	1500 VAC
Current consumption	
• From the backplane bus	max. 100 mA
• From load voltage L1 (without load)	max. 2 mA
Power dissipation of the module	typ. 8.6 W
Status, Interrupts, Diagnostics	
Status display	Green LEDs per channel
Interrupts	None
Diagnostic functions	Yes
• Group error display	Red LED [2]

Data for Selecting an Actuator	
Output voltage	
• At signal "1"	
– At maximum current	min. L1 (– 1.5 V)
– At minimum current	min. L1 (– 8.5 V)
Output current	
• At signal "1"	
Rated value	AC 2 A [1]
Permitted range for 0 °C to 40 °C	10 mA to 2 A
Permitted range for 40 °C to 60 °C	10 mA to 1 A
Permitted current surge (per group)	max. 20 A (not more than 1 AC scan cycle)
• At signal "0" (leakage current)	max. 2 mA
Output delay (for resistive load)	
• From "0" to "1"	Not more than 1 AC scan cycle
• From "1" to "0"	Not more than 1 AC scan cycle
Minimum load current	10 mA
Zero cross inhibit voltage	max. 60 V
Size of motor starter	max. size 5 according to NEMA
Lamp load	max. 50 W
Connecting two outputs in parallel	
• For redundant triggering of a load	Possible (only outputs of the same group)
• To increase performance	Not possible
Triggering a digital input	Possible
Switch rate	
• For resistive load	max. 10 Hz
• For inductive load according to IEC 947-5-1, 15 AC	max. 0.5 Hz
• For lamp load	1 Hz

1) The load current must not be half-wave
2) Possible errors:
- No load voltage
- Fuse defective

Short-circuit protection of the output	Fuse, 8 A/250 V; per group
• Current required for fuse to blow	min. 40 A
• Response time	max. 300 ms
Replacement fuses	8 A fuse/quick-acting
• Wickmann	194-1800-0
• Schurter	SP001.1013
• Littelfuse	217.008
Fuse carrier	
• Wickmann	653 07

3.20 Digital Output Module SM 322; DO 32 × 120 VAC/1.0 A; (6ES7 322-1EL00-0AA0)

Order Number

6ES7 322-1EL00-0AA0

Characteristics

The SM 322; DO 32 × 120 VAC/1.0 A features the following characteristics:

- 32 outputs, fused and isolated in groups of 8
- 1.0 A output current
- 120 VAC rated load voltage
- Blown fuse indicator for each group
- Suitable for AC solenoids, contactors, starters, fractional horsepower motors and indicator lights
- Group error display

Terminal Assignment and Block Diagram of the SM 322; DO 32 × 120 VAC/1.0 A

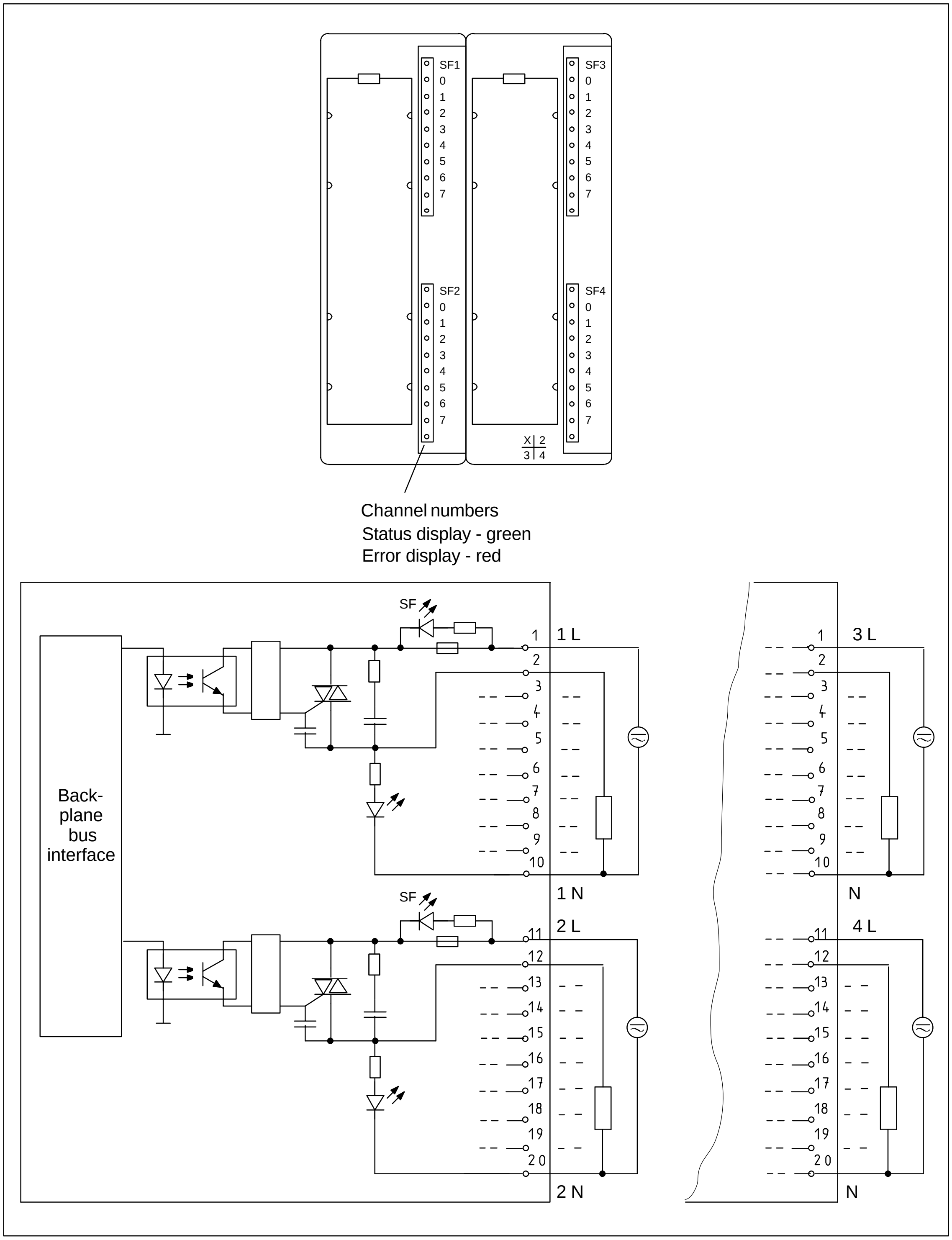


Figure 3-20 Module View and Block Diagram of the SM 322; D0 32 × 120 VAC/1.0 A

Terminal Assignment

The following figure shows the assignment of the channels to the addresses.

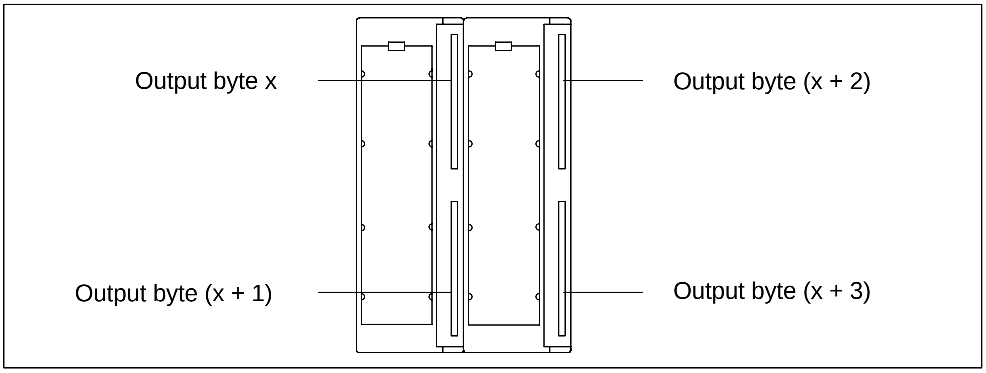


Figure 3-21 Terminal Assignment of the SM 322; DO 32 × 120 VAC/1.0 A

Technical Specifications of the SM 322; DO 32 × 120 VAC/1.0 A

Dimensions and Weight	
Dimensions W × H × D (in millimeters)	80 × 125 × 120
Weight	Approx. 500 g
Data for Specific Module	
Number of outputs	32
Length of cable	
• Unshielded	max. 600 m
• Shielded	max. 1000 m
Voltage, Currents, Potentials	
Rated load voltage L1	120 VAC
• Permitted frequency range	47 Hz to 63 Hz
Total current of the outputs (per group)	
• Horizontal configuration Up to 60 °C	max. 3 A
• Vertical configuration Up to 40 °C	max. 4 A
Isolation	
• Between channels and backplane bus	Yes
• Between the channels	Yes
In groups of	8
Permitted potential difference	
• Between $M_{internal}$ and the outputs	120 VAC
• Between the outputs of different groups	250 VAC
Insulation tested with	1500 VAC
Current consumption	
• From the backplane bus	max. 100 mA
• From load voltage L1 (without load)	max. 275 mA
Power dissipation of the module	typ. max. 25 W
Status, Interrupts, Diagnostics	
Status display	Green LEDs per channel
Interrupts	No
Diagnostic functions	Yes
• Group error display	Red LED (SF)

Data for Selecting an Actuator	
Output voltage	
• At signal “1”	min. L1 (– 1.5 V)
Output current	
• For signal “1”	
Rated value	1 A
• Permitted range	10 mA to 1 A
• Permitted current surge (per group)	10 A (for 2 AC scan cycles)
• At “0” signal leakage current	max. 3 mA
Output delay (for resistive load)	
• At “0” to “1”	3 ms
• At “1” to “0”	½ AC scan cycle
Zero cross inhibit voltage	Non-zero cross switch
Size of motor starter	max. size 4 according to NEMA
Lamp load	max. 25 W
Connecting two outputs in parallel	
• For redundant triggering of a load	Possible (only outputs of the same group)
• To increase performance	Not possible
Actuation of digital input	Possible
Switch rate	
• For resistive load	max. 10 Hz
• For inductive load according to IEC 947-5-1, 15 AC	max. 0.5 Hz
• For lamp load	1 Hz
Short-circuit protection of the output	No

3.21 Relay Output Module SM 322; DO 16 × Rel. 120 VAC; (6ES7 322-1HH00-0AA0)

Order Number

6ES7 322-1HH00-0AA0

Characteristics

The SM 322; DO 16 × REL. 120 VAC features the following characteristics:

- 16 outputs, isolated in groups of 8
- Load voltage 24 VDC to 120 VDC, 48 VAC to 120 VAC
- Suitable for AC/DC solenoid valves, contactors, motor starters, fractional h.p. motors and indicator lights.

Behavior upon Power down of the Supply Voltage

Note

When the power supply is switched off, the capacitor still stores energy for about 200 ms. The relay can therefore still be driven briefly within this time by the user program.

Terminal Assignment and Block Diagram of the SM 322; DO 16 × Rel. 120 VAC

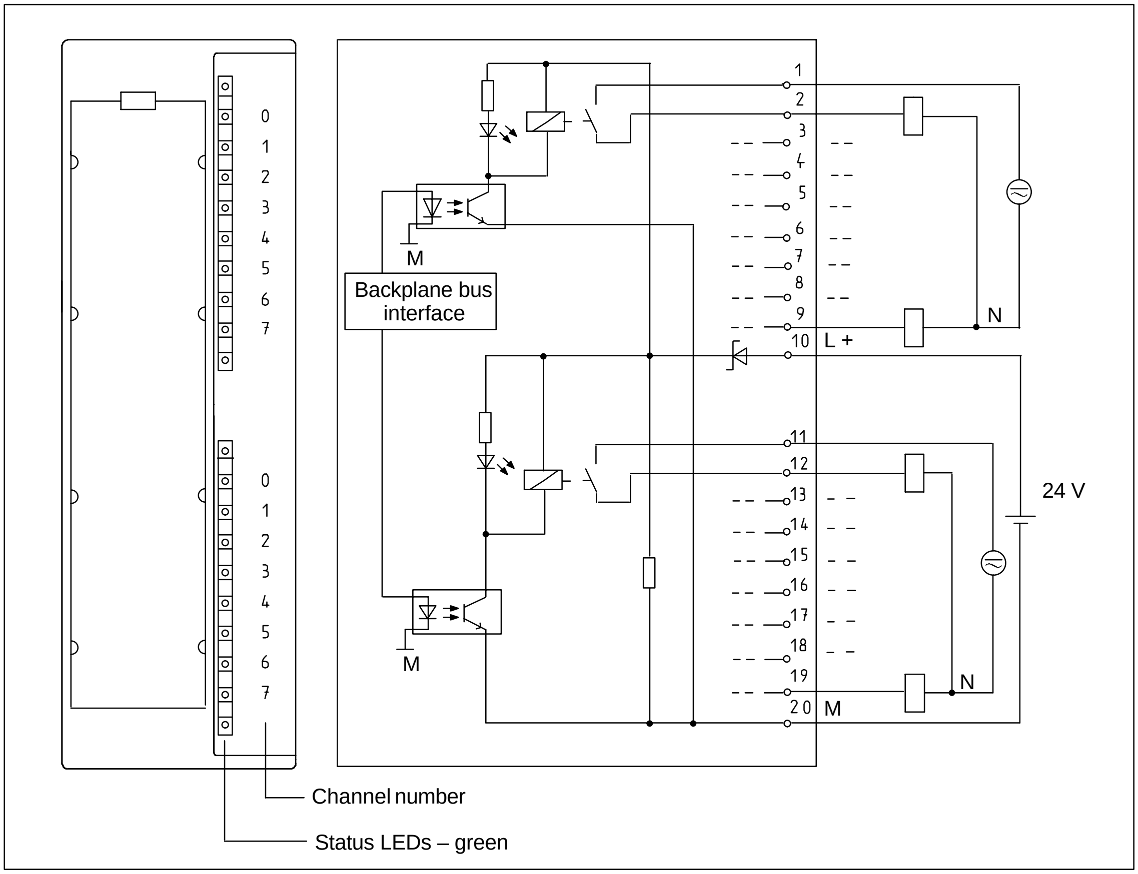


Figure 3-22 Module View and Block Diagram of SM 322; DO 16 × REL. 120 VAC

Technical Specifications of the SM 322; DO 16 × Rel. 120 VAC

Dimensions and Weight	
Dimensions W × H × D (in millimeters)	40 × 125 × 120
Weight	Approx. 250 g
Data for Specific Module	
Number of outputs	16
Length of cable	
• Unshielded	max. 600 m
• Shielded	max. 1000 m
Voltage, Currents, Potentials	
Power supply voltage of the relay L +	24 VDC
Total current of the outputs (per group)	max. 8 A
Isolation	
• Between channels and backplane bus	Yes
• Between the channels	Yes
In groups of	8
Permitted potential differences:	
• Between $M_{internal}$ and supply voltage of the relays	75 VDC 60 VAC
• Between $M_{internal}$ and supply voltage of the relays and the outputs	120 VAC
• Between the outputs of different groups	250 VAC
Insulation tested with	
• Between $M_{internal}$ and supply voltage of the relays	500 VDC
• Between $M_{internal}$ and supply voltage of the relays and the outputs	1500 VAC
• Between the outputs of different groups	1500 VAC
Current consumption	
• From the backplane bus	max. 100 mA
• From supply voltage L+	max. 250 mA
Power dissipation of the module	typ. 4.5 W

Status, Interrupts, Diagnostics	
Status display	Green LEDs per channel
Interrupts	None
Diagnostic functions	None
Data for Selecting an Actuator	
Continuous thermal current	max. 2 A
Minimum load current	10 mA

Switching capacity and lifetime of the contacts

- For resistive load

Voltage	Current	No. of switching cyc. (typ.)
24 VDC	2.0 A	0.1 mill
	1.0 A	0.2 mill
	0.5 A	1.0 mill
60 VDC	0.5 A	0.2 mill
120 VDC	0.2 A	0.6 mill
48 VAC	1.5 A	1.5 mill
60 VAC	1.5 A	1.5 mill
120 VAC	2.0 A	1.0 mill
	1.0 A	1.5 mill
	0.5 A	2.0 mill

- For inductive load according to IEC 947-5-1 13 DC/15 AC

Voltage	Current	No. of switching cyc. (typ.)
24 VDC	2.0 A	0.05 mill
	1.0 A	0.1 mill
	0.5 A	0.5 mill
60 VDC	0.5 A	0.1 mill
120 VDC	0.2 A	0.3 mill
48 VAC	1.5 A	1 mill
60 VAC	1.5 A	1 mill
120 VAC	2.0 A	0.7 mill
	1.0 A	1.0 mill
	0.5 A	1.5 mill

Size of the motor starter	max. size 5 according to NEMA
Lamp load	max. 50 W

You will achieve a longer service life of the contacts with an external suppressor circuit

Connecting two outputs in parallel	
• For redundant triggering of a load	Possible (only outputs of the same group)
• To increase performance	Not possible
Triggering a digital input	Possible

Switch rate	
• Mechanical	max. 10 Hz
• For resistive load	1 Hz
• For inductive load according to IEC 947-5-1, 13 DC/15 AC	max. 0.5 Hz
• For lamp load	1 Hz

3.22 Relay Output Module SM 322; DO 8 × Rel. 230 VAC; (6ES7 322-1HF01-0AA0)

Order Number

6ES7 322-1HF01-0AA0

Characteristics

The SM 322; DO 8 × REL. 230 VAC features the following characteristics:

- 8 outputs, isolated in groups of 2
- Rated load voltage 24 VDC to 120 VDC, 48 VAC to 230 VAC
- Suitable for AC/DC solenoid valves, contactors, motor starters, fractional h.p. motors and indicator lights.

Behavior upon Power down of the Supply Voltage

Note

Applicable only to the SM 322; DO 8 × REL. 230 VAC, product version 1:

When the power supply is switched off, the capacitor still stores energy for about 200 ms. The relay can therefore still be driven briefly within this time by the user program.

Terminal Assignment and Block Diagram of the SM 322; DO 8 × Rel. 230 VAC

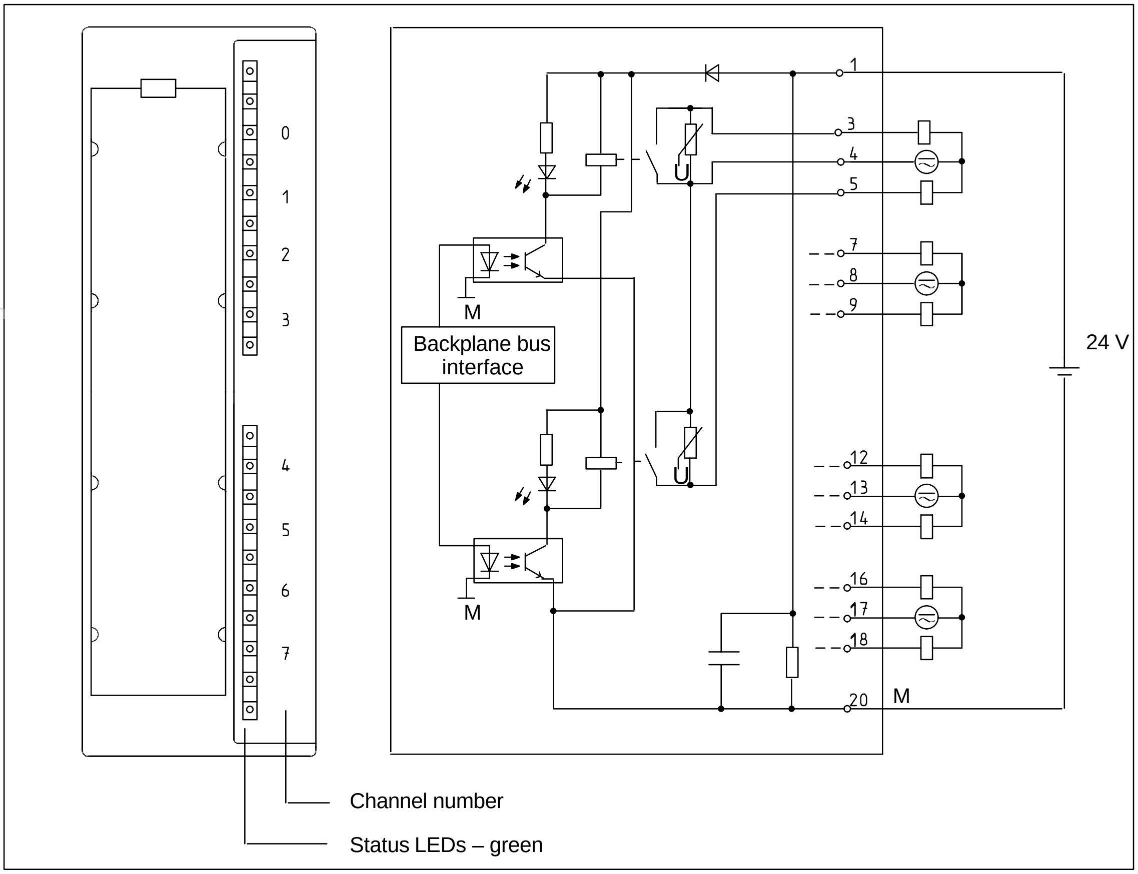


Figure 3-23 Module View and Block Diagram of the SM 322; DO 8 × REL. 230 VAC

Technical Specifications of the SM 322; DO 8 × Rel. 230 VAC

Dimensions and Weight	
Dimensions W × H × D (in millimeters)	40 × 125 × 120
Weight	Approx. 190
Data for Specific Module	
Number of outputs	8
Length of cable	
• Unshielded	max. 600 m
• Shielded	max. 1000 m
Voltage, Currents, Potentials	
Power supply voltage of the relay L +	24 VDC
Total current of the outputs (per group)	max. 4 A
Isolation	
• Between channels and backplane bus	Yes
• Between the channels	Yes
In groups of	2
Permitted potential differences:	
• Between $M_{internal}$ and supply voltage of the relays	75 VDC 60 VAC
• Between $M_{internal}$ and supply voltage of the relays and the outputs	230 VAC
• Between the outputs of different groups	400 VAC
Insulation tested with	
• Between $M_{internal}$ and supply voltage of the relays	500 VDC
• Between $M_{internal}$ and supply voltage of the relays and the outputs	1500 VAC
• Between the outputs of different groups	1500 VAC
Current consumption	
• From the backplane bus	max. 40 mA
• From supply voltage L+	max. 160 mA
Power dissipation of the module	typ. 3.5 W
Status, Interrupts, Diagnostics	
Status display	Green LEDs per channel
Interrupts	None
Diagnostic functions	None

Data for Selecting an Actuator			
Continuous thermal current	max. 3 A		
Minimum load current	5 mA		
Short-circuit proof according to IEC 947-5-1 2)	With circuit-breaker of characteristic B for: cos ϕ 1.0: 600 A cos ϕ 0.5 to 0.7: 900 A With Diazed 8 A fuse:1000 A		
Switching capacity and lifetime of the contacts			
• For resistive load			
	Voltage	Current	No. of switching cyc. (typ.)
	24 VDC	2.0 A	0.7 million
		1.0 A	1.6 million
		0.5 A	4 million
	60 VDC	0.5 A	1.6 million
	120 VDC	0.2 A	1.6 million
	48 VAC	2.0 A	1.6 million
	60 VAC	2.0 A	1.2 million
	120 VAC	2.0 A	0.5 million 2)
		1.0 A	0.7 million 2)
		0.5 A	1.5 million 2)
	230 VAC	2.0 A	0.5 million 2)
		1.0 A	0.7 million 2)
		0.5 A	1.5 million
• For inductive load according to IEC 947-5-1 13 DC/15 AC			
	Voltage	Current	No. of switching cyc. (typ.)
	24 VDC	2.0 A	0.3 million
		1.0 A	0.5 million
		0.5 A	1.0 million
	60 VDC	0.5 A	0.5 million
	120 VDC	0.2 A	0.3 million 2)
	48 VAC	1.5 A	1 million
	60 VAC	1.5 A	1 million
	120 VAC	2.0 A	0.2 million
		1.0 A	0.7 million
		0.7 A	1 million
		0.5 A	2.0 million
	230 VAC	2.0 A	0.3 million 2)
		1.0 A	0.7 million 2)
		0.5 A	2 million 2)
Contact protection (internal)	Varistor SIOV-CU4032 K275 G		
An external protection circuit will enhance the service life of the contacts.			

Data for Selecting an Actuator, continued		
Lamp load [1]	max. 50 W	
	Power	No. of switching cyc. (typ.)
Lamp load (230 VAC) [2]	1000 W 1500 W	25000 10000
Energy-saving lamps/fluorescent lamps with electronic ballast[2]	10 × 58W	25000
Fluorescent lamps, conventionally compensated [2]	1 × 58 W	25000
Fluorescent lamps, non-compensated [2]	10 × 58W	25000

Connecting two outputs in parallel	
• For redundant triggering of a load	Possible (only outputs of the same group)
• To increase performance	Not possible
Triggering a digital input	Possible
Switch rate	
• Mechanical	max. 10 Hz
• For resistive load	max. 2 Hz
• For inductive load according to IEC 947-5-1, 13 DC/15 AC	max. 0.5 Hz
• For lamp load	max. 2 Hz

1) Product status 1

2) Product status 2 or later

3.23 Relay Output Module SM 322; DO 8 × Rel. 230 VAC/5 A; (6ES7 322-1HF10/-1HF80-0AA0)

Order Number: "Standard Module"

6ES7 322-1HF10-0AA0

Order Number: "SIMATIC Outdoor Module"

6ES7 322-1HF80-0AA0

Characteristics

The SM 322; DO 8 × Rel. 230 VAC/5 A features the following characteristics:

- 8 outputs, isolated in groups of 1
- Rated load voltage 24 VDC to 120 VDC, 48 VAC to 230 VAC
- Suitable for AC/DC solenoid valves, contactors, motor starters, fractional h.p. motors and indicator lights.

Measures with Switching Currents > 3 A

Note

To keep the additional temperature rise of the module near the connectors as low as possible, you must select a cable cross-section of 1.5 mm^2 for connecting cables with switching currents > 3 A.

Terminal Assignment and Block Diagram of the SM 322; DO 8 × Rel. 230 VAC/5 A

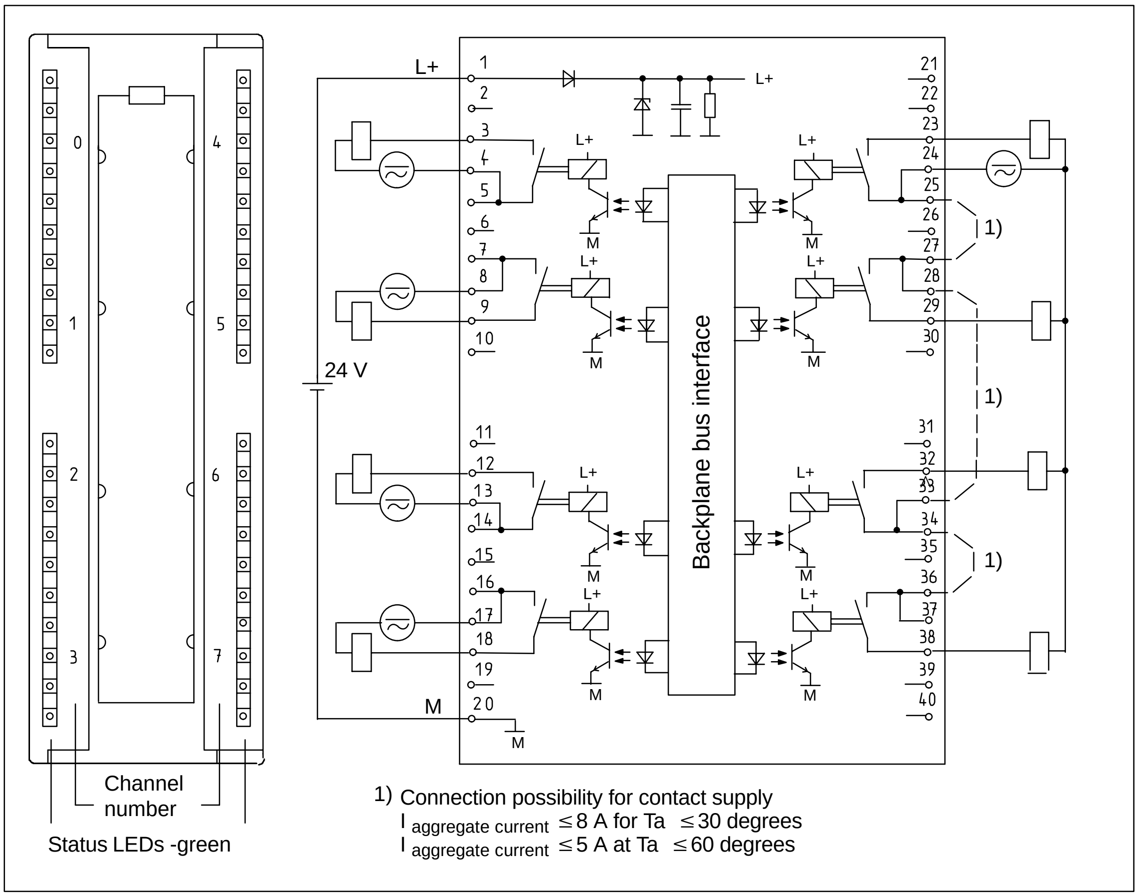


Figure 3-24 Module View and Block Diagram of the SM 322; DO 8 × Rel. 230 VAC/5 A

Operation with Safe Electrical Extra-Low Voltage

When using relay output module 322-1HF10 with safe and electrically isolated extra-low voltage, take the following special characteristic into account:

If a terminal is operated with a safe and electrically isolated extra-low voltage, the horizontally adjacent terminal must be operated at a rated voltage of not more than UC 120 V. With operation at voltages greater than UC 120 V, the creepages and clearances of the 40-pin front connector do not meet the SIMATIC requirements for safe electrical isolation.

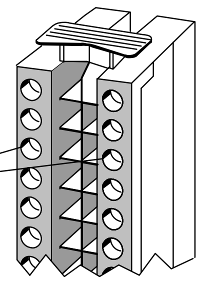


Figure 3-25 Special Characteristic for Operation with a Safe Electrical Extra-Low Voltage

Technical Specifications of the SM 322; DO 8 × Rel. 230 VAC/5 A

Dimensions and Weight	
Dimensions W × H × D (in millimeters)	40 × 125 × 120
Weight	Approx. 320 g
Data for Specific Module	
Number of outputs	8
Length of cable	
• Unshielded	max. 600 m
• Shielded	max. 1000 m
Voltage, Currents, Potentials	
Power supply voltage of the relay L +	24 VDC
Total current of the outputs (per group)	
• Horizontal configuration	
Up to 30 °C	max. 8 A
Up to 60 °C	max. 5 A
• Vertical configuration Up to 40 °C	max. 5 A

Isolation	
• Between channels and backplane bus	Yes
• Between the channels	Yes
In groups of	1
Permitted potential differences:	
• Between $M_{internal}$ and supply voltage of the relays	75 VDC / 60 VAC
• Between $M_{internal}$ and supply voltage of the relays and the outputs	250 VAC
• Between the outputs of different groups	500 VAC
Insulation tested with	
• Between $M_{internal}$ and supply voltage of the relays	500 VDC
• Between $M_{internal}$ and supply voltage of the relays and the outputs	1500 VAC
• Between the outputs of different groups	2000 VAC

Current consumption			
• From the backplane bus	max. 40 mA		
• From supply voltage L+	max. 125 mA		
Power dissipation of the module	typ. 4.2 W		
Status, Interrupts, Diagnostics			
Status display	Green LEDs per channel		
Interrupt	None		
Diagnostic functions	None		
Data for Selecting an Actuator			
Continuous thermal current	max. 8 A		
Minimum load current	5 mA		
Short-circuit current according to IEC 947-5-1	With circuit-breaker of characteristic B for: cos ϕ 1.0: 600 A cos ϕ 1.0: 900 A With Diazed 8 A fuse: 1000 A		
Switching capacity and lifetime of the contacts			
• For resistive load			
	Voltage	Current	No. of switching cyc. (typ.)
	24 VDC	8.0 A 4.0 A 2.0 A 0.5 A	0.1 million 0.3 million 0.7 million 4.0 million
	60 VDC	0.5 A	4 million
	120 VDC	0.2 A	1.6 mill.
	48 VAC	8.0 A 2.0 A	0.1 million 1.6 million
	60 VAC	8.0 A 2.0 A	0.1 million 1.2 million
	120 VAC	8.0 A 4.0 A 2.0 A 1.0 A 0.5 A	0.1 million 0.3 million 0.5 million 0.7 million 1.5 million
	230 VAC	8.0 A 4.0 A 2.0 A 1.0 A 0.5 A	0.1 million 0.3 million 0.5 million 0.7 million 1.5 million

Data for Selecting an Actuator, continued			
Switching capacity and lifetime of the contacts			
• For inductive load according to IEC 947-5-1 13 DC/15 AC			
	Voltage	Current	No. of switching cyc. (typ.)
	24 VDC	2.0 A 1.0 A 0.5 A	0.3 million 0.5 million 1 million
	60 VDC	0.5 A 0.3 A	0.5 million 1 million
	120 VDC	0.2 A	0.5 mill.
	48 VAC	3.0 A 1.5 A	0.5 million 1 million
	60 VAC	3.0 A 1.5 A	0.3 million 1 million
	120 VAC	3.0 A 2.0 A 1.0 A 0.5 A	0.2 million 0.3 million 0.7 million 2.0 million
	230 VAC	3.0 A 2.0 A 1.0 A 0.5 A	0.1 million 0.3 million 0.7 million 2.0 million
Aux. contactors Size 0 (3TH28)			30 mill.
An external protection circuit will enhance the service life of the contacts.			
		Power	No. of switching cyc. (typ.)
Lamp load (230 VAC)		1000 W 1500 W	25000 10000
Energy-saving lamps/fluorescent lamps with electronic ballast		10 × 58 W	25000
Fluorescent lamps, conventionally compensated		1 × 58 W	25000
Fluorescent lamps, non-compensated		10 × 58 W	25000

Data for Selecting an Actuator, continued	
Contact protection (internal)	none
Connecting two outputs in parallel	
• For redundant triggering of a load	Possible
• To increase performance	not possible
Triggering a digital input	Possible
Switch rate	
• Mechanical	max. 10 Hz
• For resistive load	max. 2 Hz
• For inductive load according to IEC 947-5-1, 13 DC/15 AC	max. 0.5 Hz
• For lamp load	max. 2 Hz

3.24 Relay Output Module SM 322; DO 8 × Rel. 230 VAC/5 A; (6ES7 322-1HF20-0AA0)

Order Number

6ES7 322-1HF20-0AA0

Characteristics

The SM 322; DO 8 × Rel. 230 VAC/5 A features the following characteristics:

- 8 outputs, isolated in groups of 1
- Rated load voltage 24 VDC to 120 VDC, 24 VAC to 230 VAC
- Suitable for AC/DC solenoid valves, contactors, motor starters, fractional h.p. motors and indicator lights.
- RC quenching element can be inserted for protection of the contacts by means of jumper SJ

Protection of Contacts against Overvoltages

You protect the contacts against overvoltages by inserting jumpers (SJ) on the module between terminals 3 and 4, 7 and 8, 12 and 13 etc. (refer to Figure 3-26).

Terminal Assignment and Block Diagram of the SM 322; DO 8 × Rel. 230 VAC/5 A

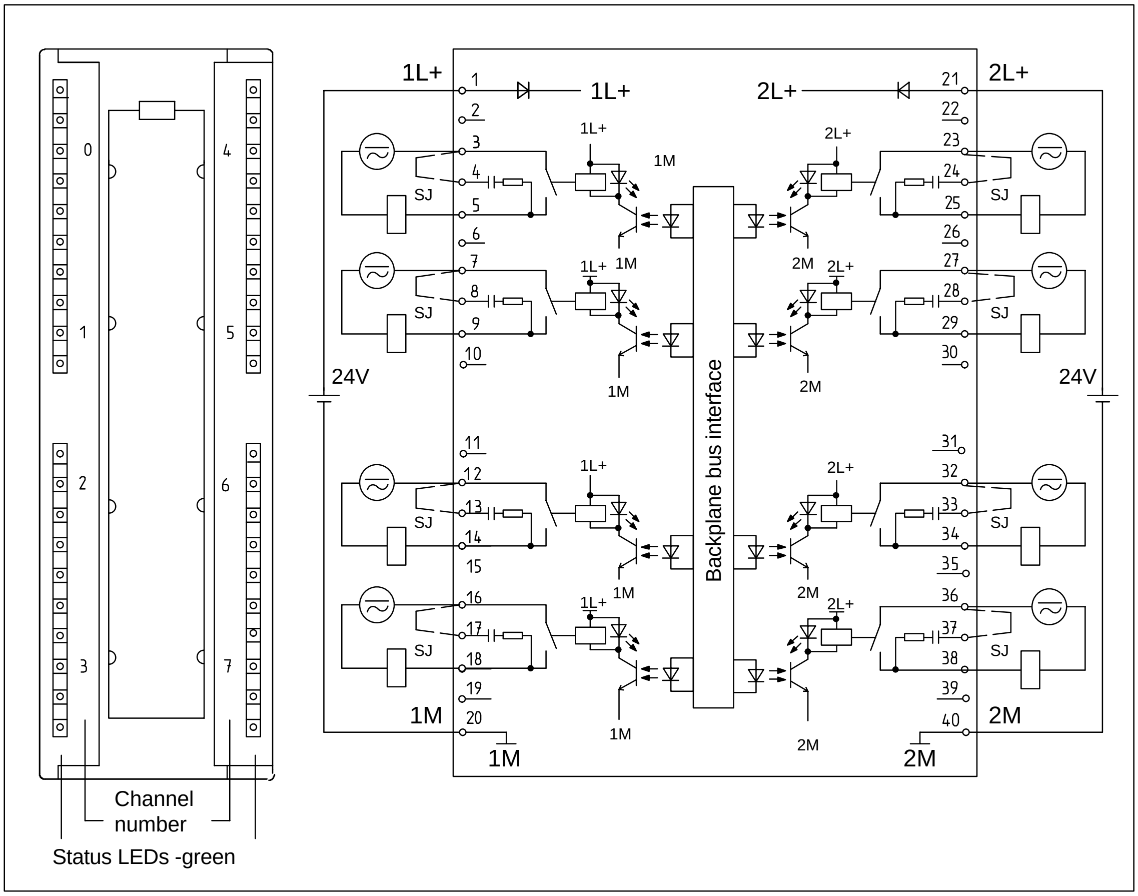


Figure 3-26 Module View and Block Diagram of the SM 322; DO 8 × Rel. 230 VAC/5 A

Operation with Safe Electrical Extra-Low Voltage

When using relay output module 322-1HF20 with safe and electrically isolated extra-low voltage, take the following special characteristic into account:

If a terminal is operated with a safe and electrically isolated extra-low voltage, the horizontally adjacent terminal must be operated at a rated voltage of not more than UC 120 V. With operation at voltages greater than UC 120 V, the creepages and clearances of the 40-pin front connector do not meet the SIMATIC requirements for safe electrical isolation.

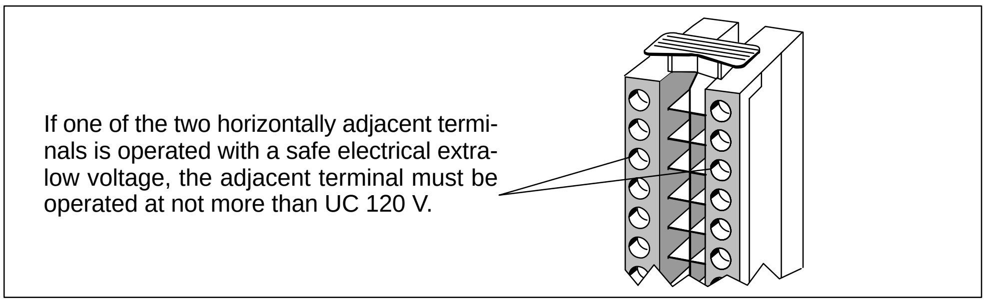


Figure 3-27 Special Characteristic for Operation with a Safe Electrical Extra-Low Voltage

Technical Specifications of the SM 322; DO 8 × Rel. 230 VAC/5 A

Dimensions and Weight	
Dimensions W × H × D (in millimeters)	40 × 125 × 120
Weight	Approx. 320 g
Data for Specific Module	
Number of outputs	8
Length of cable	
• Unshielded	max. 600 m
• Shielded	max. 1000 m
Voltage, Currents, Potentials	
Power supply voltage of the relay L +	24 VDC
• Reverse polarity protection	Yes
Total current of the outputs (per group)	
• Horizontal configuration	
Up to 60 °C	max. 5 A
• Vertical configuration	
Up to 40 °C	max. 5 A

Isolation	
• Between channels and backplane bus	Yes
• Between channels and power supply of the relays	Yes
• Between the channels	Yes
In groups of	1
Permitted potential differences:	
• Between $M_{internal}$ and supply voltage of the relays	75 VDC / 60 VAC
• Between $M_{internal}$ and supply voltage of the relays and the outputs	250 VAC
• Between the outputs of different groups	500 VAC

Insulation tested with	
• Between $M_{internal}$ and supply voltage of the relays	500 VDC
• Between $M_{internal}$ and supply voltage of the relays and the outputs	1500 VAC
• Between the outputs of different groups	1500 VAC
Current consumption	
• From the backplane bus	max. 45 mA
• From supply voltage L+	max. 160 mA
Power dissipation of the module	typ. 3.2 W
Status, Interrupts, Diagnostics	
Status display	Green LEDs per channel
Interrupt	None
Diagnostic functions	None
Data for Selecting an Actuator	
Continuous thermal current	max. 5 A
Minimum load current	10 mA[1)]
Leakage current	11.5 mA[2)]
Switching capacity and lifetime of the contacts	
• For resistive load	

Voltage	Current	No. of switching cyc. (typ.)
24 VDC	5.0 A 2.5 A 1 A	0.2 million 0.4 million 0.9 million
230 VAC	5.0 A 2.5 A 1 A	0.2 million 0.4 million 0.9 million

• For inductive load

Voltage	Current	No. of switching cyc. (typ.)
24 VDC	5.0 A 2.5 A 1 A	0.1 million 0.25 million 0.5 million
230 VAC	5.0 A 2.5 A 1 A	0.1 million 0.25 million 0.5 million

You can attain greater service life by connecting an RC quenching element (by inserting an SJ jumper) or with external protective circuitry

Size of motor starter	max. size 5 according to NEMA
Lamp load	max. 50 W
Contact protection (internal)	RC quenching element 330 Ω, 0.1 μF
Connecting two outputs in parallel	
• For redundant triggering of a load	Possible (only outputs with identical load voltage)
• To increase performance	Not possible
Triggering a digital input	Possible
Switch rate	
• Mechanical	max. 10 Hz
• For resistive load	max. 2 Hz
• For inductive load	max. 0.5 Hz
• For lamp load	max. 2 Hz

1) Without inserted “SJ” jumper.

2) For AC load voltage and inserted “SJ” jumper. (Without “SJ” jumper inserted there is a leakage current)

Note

Due to the leakage current of the RC quenching element, wrong signal states might occur when an IEC Type 1 input is connected (remove SJ jumper)

3.25 Digital Input/Output Module SM 323; DI 16/DO 16 × 24 VDC/0.5 A; (6ES7 323-1BL00-0AA0)

Order Number

6ES7 323-1BL00-0AA0

Characteristics

The SM 323; DI 16/DO 16 × 24 VDC/0.5 A features the following characteristics:

- 16 inputs, isolated in groups of 16
- 16 outputs, isolated in groups of 8
- 24 VDC rated input voltage
- 24 VDC rated load voltage
- Inputs suitable for switches and two/three/four-wire BEROs (proximity switches).
- Outputs suitable for solenoid valves, DC contactors and indicator lights

Using the Module with High-Speed Counters

Please take note of the following information on the use of the module in connection with high-speed counters:

Note

When connecting the 24 V power supply via a mechanical contact, the outputs of the SM 323; DI 16/DO 16 × 24 VDC/0.5 A carry a ”1” signal for approximately 50 µs ”1” signal for reasons associated with the circuitry.

Terminal Assignment and Block Diagram of the SM 323; DI 16/DO 16 × 24 VDC/0,5 A

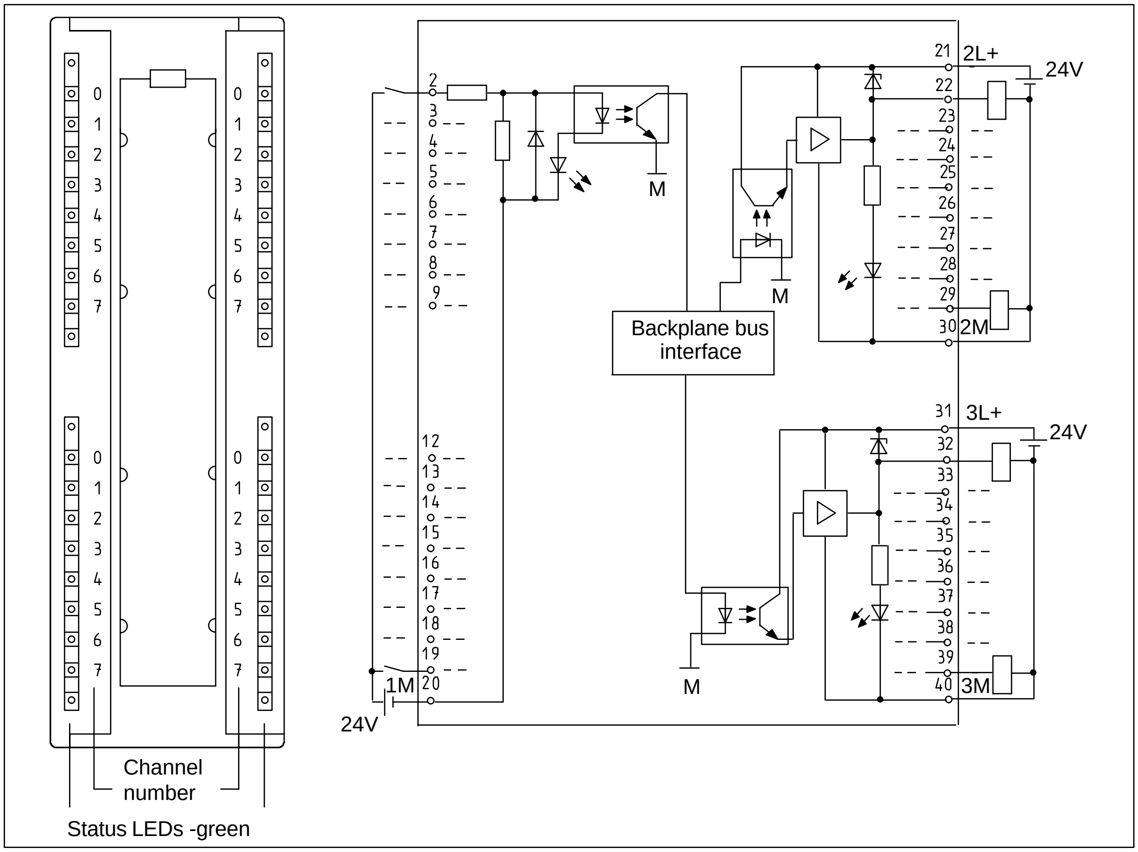


Figure 3-28 Module View and Block Diagram of the SM 323; DI 16/DO 16 × 24 VDC/0.5 A

Terminal Assignment

The figure below shows the assignment of the channels to the input and output addresses.

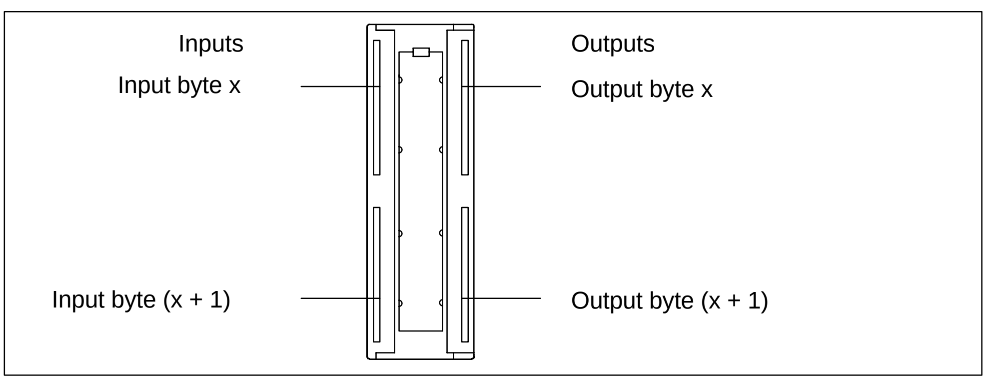


Figure 3-29 Terminal assignment of the SM 323; DI 16/DO 16 × 24 VDC/0.5 A

Technical Specifications of the SM 323; DI 16/DO 16 $\times$ DC 24 V/0.5 A

Dimensions and Weight	
Dimensions W $\times$ H $\times$ D (in millimeters)	40 $\times$ 125 $\times$ 120
Weight	Approx. 260 g
Data for Specific Module	
Number of inputs	16
Number of outputs	16
Length of cable	
• Unshielded	max. 600 m
• Shielded	max. 1000 m
Voltage, Currents, Potentials	
Rated load voltage L+	24 VDC
Number of inputs that can be triggered simultaneously	
• Horizontal configuration	
Up to 40 °C	16
Up to 60 °C	8
• Vertical configuration	
Up to 40 °C	16
Total current of the outputs (per group)	
• Horizontal configuration	
Up to 40 °C	max. 4 A
Up to 60 °C	max. 3 A
• Vertical configuration	
Up to 40 °C	max. 2 A
Isolation	
• Between channels and backplane bus	Yes
• Between the channels	Yes
Inputs in groups of	16
Outputs in groups of	8
Permitted potential difference	
• Between the different circuits	75 VDC / 60 VAC
Insulation tested with	500 VDC
Current consumption	
• From the backplane bus	max. 80 mA
• From the load voltage L+ (no load)	max. 80 mA
Power dissipation of the module	typ. 6.5 W

Status, Interrupts, Diagnostics	
Status display	Green LEDs per channel
Interrupts	None
Diagnostic functions	None
Data for Selecting a Sensor	
Input voltage	
• Rated value	24 VDC
• For signal “1”	13 to 30 V
• For signal “0”	– 30 to + 5 V
Input current	
• At signal “1”	typ. 7 mA
Input delay	
• At “0” to “1”	1.2 to 4.8 ms
• At “1” to “0”	1.2 to 4.8 ms
Input characteristic curve	According to IEC 1131, Type 1
Connection of Two-Wire BEROs	Possible
• Permitted bias current	max. 1.5 mA

Data for Selecting an Actuator	
Output voltage	
• At signal "1"	min. L + (– 0.8 V)
Output current	
• At signal "1"	
Rated value	0.5 A
Permitted range	5 mA to 0.6 A
• At signal "0" (leakage current)	max. 0.5 mA
Output delay (for resistive load)	
• At "0" to "1"	max. 100 µs
• At "1" to "0"	max. 500 µs
Load resistor range	48 Ω to 4 kΩ
Lamp load	max. 5 W

Connecting two outputs in parallel	
• For redundant triggering of a load	Possible (only outputs of the same group)
• To increase performance	Not possible
Triggering a digital input	Possible
Switch rate	
• For resistive load	max. 100 Hz
• For inductive load according to IEC 947-5-1, 13 DC	max. 0.5 Hz
• For lamp load	max. 10 Hz
Limit (internal) of the inductive circuit interruption voltage up	typ. L + (– 53 V)
Short-circuit protection of the output	Yes, electronic
• Threshold on	typ. 1 A

3.26 Digital Input/Output Module SM 323; DI 8/DO 8 × 24 VDC/0.5 A; (6ES7 323-1BHx1-0AA0)

Order Number: “Standard Module”

6ES7 323-1BH01-0AA0

Order Number: “SIMATIC Outdoor Module”

6ES7 323-8BH81-0AA0

Characteristics

The SM 323; DI 8/DO 8 × 24 VDC/0.5 A features the following characteristics:

- 8 inputs, isolated in groups of 8
- 8 outputs, isolated in groups of 8
- 24 VDC rated input voltage
- 24 VDC rated load voltage
- Inputs suitable for switches and two/three/four-wire BEROs (proximity switches).
- Outputs suitable for solenoid valves, DC contactors and indicator lights

Using the Module with High-Speed Counters

Please take note of the following information on the use of the module in connection with high-speed counters:

Note

When connecting the 24 V power supply via a mechanical contact, the outputs of the SM 323; DI 8/DO 8 × 24 VDC/0.5 A carry a ”1” signal for approximately 50 µs for reasons associated with the circuitry.

Terminal Assignment and Block Diagram of the SM 323; DI 8/DO 8 × 24 VDC/0.5 A

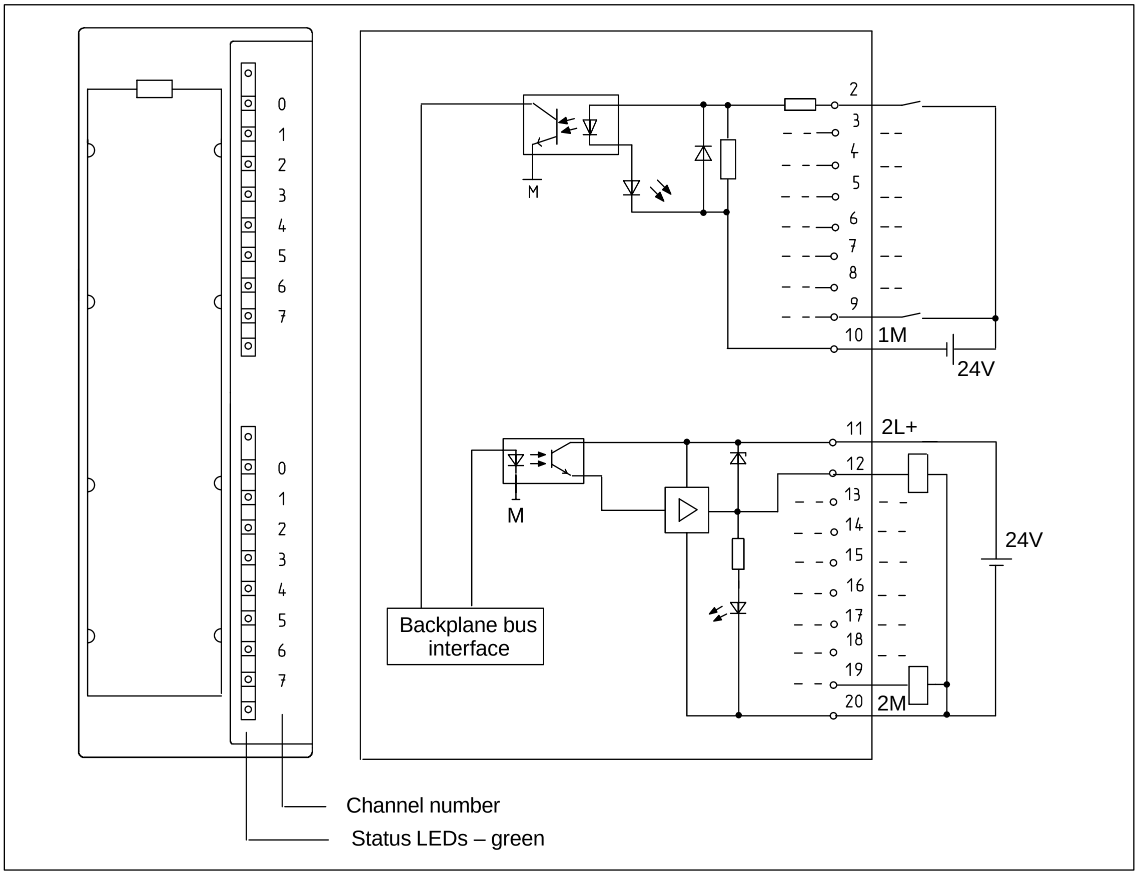


Figure 3-30 Module View and Block Diagram of Digital Input/Output Module SM 323; DI 8/DO 8 × 24 VDC/0.5 A

Technical Specifications of the SM 323; DI 8/DO 8 × 24 VDC/0.5 A

Dimensions and Weight	
Dimensions W × H × D (in millimeters)	40 × 125 × 120
Weight	Approx. 200 g
Data for Specific Module	
Number of inputs	8
Number of outputs	8
Length of cable	
• Unshielded	max. 600 m
• Shielded	max. 1000 m
Voltage, Currents, Potentials	
Rated load voltage L+	24 VDC
Number of inputs that can be triggered simultaneously	
• Horizontal configuration	
Up to 40 °C	8
• Vertical configuration	
Up to 60 °C	8
Total current of the outputs (per group)	
• Horizontal configuration	
Up to 40 °C	max. 4 A
• Vertical configuration	
Up to 60 °C	max. 4 A
Isolation	
• Between channels and backplane bus	Yes
• Between the channels	Yes
Inputs in groups of	8
Outputs in groups of	8
Permitted potential difference	
• Between the different circuits	75 VDC / 60 VAC
Insulation tested with	500 VDC
Current consumption	
• From the backplane bus	max. 40 mA
• From the load voltage L+ (no load)	max. 40 mA
Power dissipation of the module	typ. 3.5 W
Status, Interrupts, Diagnostics	
Status display	Green LEDs per channel
Interrupts	None
Diagnostic functions	None

Data for Selecting a Sensor	
Input voltage	
• Rated value	24 VDC
• For signal “1”	13 to 30 V
• For signal “0”	– 30 to 5 V
Input current	
• At signal “1”	typ. 7 mA
Input delay	
• At “0” to “1”	1.2 to 4.8 ms
• At “1” to “0”	1.2 to 4.8 ms
Input characteristic curve	According to IEC 1131, Type 1
Connection of Two-Wire BEROs	Possible
• Permitted bias current	max. 1.5 mA
Data for Selecting an Actuator	
Output voltage	
• At signal “1”	min. L + (– 0.8 V)
Output current	
• At signal “1”	
Rated value	0.5 A
Permitted range	5 mA to 0.6 A
• At signal “0” (leakage current)	max. 0.5 mA
Output delay (for resistive load)	
• At “0” to “1”	max. 100 µs
• At “1” to “0”	max. 500 µs
Load resistor range	48 Ω to 4 kΩ
Lamp load	max. 5 W
Connecting two outputs in parallel	
• For redundant triggering of a load	Possible (only outputs of the same group)
• To increase performance	Not possible
Triggering a digital input	Possible
Switch rate	
• For resistive load	max. 100 Hz
• For inductive load according to IEC 947-5-1, 13 DC	max. 0.5 Hz
• For lamp load	max. 10 Hz
Limit (internal) of the inductive circuit interruption voltage up	typ. L + (– 53 V)
Short-circuit protection of the output	Yes, electronic
• Threshold on	typ. 1 A

Analog Modules 4

Changes and improvements since the previous version of the reference manual

This chapter describes all new analog modules. Furthermore, two new overview sections will make it easier for you to access the information:

- the “Module Overview” section shows you the modules that are available, together with their most important characteristics, and helps you quickly to find the module suitable for your task.
- the section entitled “Sequence of Steps from Choosing to Commissioning the Module” provides the answer to the question ”What must I do in succession to commission the module quickly and successfully?

Structure of the chapter

The present chapter is broken down into the following subjects:

1. Overview containing the modules that are available here and a description
2. Information that is generally available – in other words, affects all analog modules (such as parameter assignment and diagnostics)
3. Information specific to the different modules (for example, characteristics, diagram of connections and block diagram, technical specifications and special features of the module):

   a) for analog input modules

   b) for analog output modules

   c) for analog input/output modules

STEP 7 blocks for analog functions

You can use the blocks FC 105 “SCALE” (Scale Values) and FC 106 “UNSCALE” (Unscale Values) for reading and outputting analog values in *STEP 7*. You will find the FCs in the standard library of *STEP 7* in the subdirectory called “TI-S7-Converting Blocks” (for a description refer to the *STEP 7* online Help for the FCs).

Additional information

Appendix A describes the structure of the parameter sets (data records 0,1 and 128) in the system data. You must be familiar with this configuration if you want to modify the parameters of the modules in the *STEP 7* user program.

Appendix B describes the structure of the diagnostic data (data records 0 and 1) in the system data. You must be familiar with this configuration if you want to evaluate the diagnostic data of the modules in the *STEP 7* user program.

In this chapter

4.1 Module Overview

Introduction

The following tables summarize the most important characteristics of the analog modules. This overview is intended to make it easy to choose the suitable module for your task.

Table 4-1 Analog Input Modules: Characteristics at a Glance

Module / Character-istics	SM 331; AI 8 × 12 Bit (-7KF02-)	SM 331; AI 8 × 16 Bit (-7NF00-)	SM 331; AI 2 × 12 Bit (-7KBx2-)	SM 331; AI 8 × RTD (-7PF00-)	SM 331; AI 8 × TC (-7PF10-)
Number of inputs	8 inputs in 4 channel groups	8 inputs in 4 channel groups	2 inputs in 1 channel group	8 inputs in 4 channel groups	8 inputs in 4 channel groups
Resolution	adjustable for each channel group: • 9 bits + sign • 12 bits + sign • 14 bits + sign	adjustable for each channel group: • 15 bits + sign	adjustable for each channel group: • 9 bits + sign • 12 bits + sign • 14 bits + sign	adjustable for each channel group: • 15 bits + sign	adjustable for each channel group: • 15 bits + sign
Measuring Method	adjustable for each channel group: • Voltage • Current • Resistors • Tempera-ture	adjustable for each channel group: • Voltage • Current	adjustable for each channel group: • Voltage • Current • Resistors • Tempera-ture	adjustable for each channel group: • Resistors • Tempera-ture	adjustable for each channel group: • Tempera-ture
Selection of measuring range	Arbitrary, per channel group	Arbitrary, per channel group	Arbitrary, per channel group	Arbitrary, per channel group	Arbitrary, per channel group
Programmable diagnostics	Yes	Yes	Yes	Yes	Yes
Diagnostic Interrupt	Adjustable	Adjustable	Adjustable	Adjustable	Adjustable
Limit value monitoring	Adjustable for 2 channels	Adjustable for 2 channels	Adjustable for 1 channel	Adjustable for 8 channels	Adjustable for 8 channels
Hardware interrupt upon limit violation	Adjustable	Adjustable	Adjustable	Adjustable	Adjustable
Hardware interrupt at end of cycle	No	No	No	Adjustable	Adjustable

Table 4-1 Analog Input Modules: Characteristics at a Glance, continued

Module / Characteristics	SM 331; AI 8 × 12 Bit (-7KF02-)	SM 331; AI 8 × 16 Bit (-7NF00-)	SM 331; AI 2 × 12 Bit (-7KBx2-)	SM 331; AI 8 × RTD (-7PF00-)	SM 331; AI 8 × TC (-7PF10-)
Potential relationships	Galvanic isolation to: • CPU • Load voltage (**not** for 2-DMU)	Galvanic isolation to: • CPU	Galvanic isolation to: • CPU • Load voltage (**not** for 2-DMU)	Galvanic isolation to: • CPU	Galvanic isolation to: • CPU
Permitted potential difference between the inputs (E_{CM})	2.5 VDC	50 VDC	2.5 VDC	120 VAC	120 VAC
Special Features	–	–	–	–	

2-DMU Two-wire transmitter

Table 4-2 Analog Output Modules: Characteristics at a Glance

Module / Characteristics	SM 332; AO 4 × 12 Bit (-5HD01-)	SM 332; AO 2 × 12 Bit (-5HB01-)	SM 332; AO 4 × 16 Bit (-7ND00-)
Number of outputs	4 outputs in 4 channel groups	2 output in 2 channels groups	4 outputs in 4 channel groups
Resolution	12 bits	12 bits	16 bits
Output type	Channel by channel: • Voltage • Current	Channel by channel: • Voltage • Current	Channel by channel: • Voltage • Current
Programmable diagnostics	Yes	Yes	Yes
Diagnostic Interrupt	Adjustable	Adjustable	Adjustable
Substitute value output	Adjustable	Adjustable	Adjustable
Potential relationships	Galvanic isolation to: • CPU • of the load voltage	Galvanic isolation to: • CPU • of the load voltage	Galvanic isolation between: • CPU and channel • the channels • output and L+, M • CPU and L+, M
Special features	–	–	–

Table 4-3 Analog Input/Output Modules: Characteristics at a Glance

Module / Characteristics	SM 334; AI 4/AO 2 × 8/8 Bit (-0CE01-)	SM 334; AI 4/AO 2 × 12 Bit (-0KE00-)
Number of inputs	4 inputs in 1 channel group	4 inputs in 2 channel groups
Number of outputs	2 outputs in 1 channel group	2 outputs in 1 channel group
Resolution	8 bits	12 bits + sign
Measuring method	Adjustable per channel group: • Voltage • Current	Adjustable per channel group: • Voltage • Resistors • Temperature
Output type	Per channel: • Voltage • Current	Per channel: • Voltage
Programmable diagnostics	No	No
Diagnostic interrupt	No	No
Limit value monitoring	No	No
Hardware interrupt upon limit violation	No	No
Hardware interrupt at end of cycle	No	No
Substitute value output	No	No
Potential relationships	• Non-isolated to CPU • Galvanic isolation to load voltage	Galvanic isolation to: • CPU • of the load voltage
Special features	Not parameterizable, setting of measurement and output type by means of wiring	–

4.2 Sequence of Steps from Choosing to Commissioning the Module

Introduction

The following table contains the tasks that you have to perform one after the other to commission analog modules successfully.

The sequence of steps is a suggestion but you can perform individual steps sooner or later (for example, assign parameters to the module) or install, commission etc. other modules in between times.

Sequence of steps

Table 4-4 Sequence of Steps from Choosing to Commissioning the Analog Module

Step	Procedure	Refer To...
1.	Select the module	Section 4.1 and specific module section from Section 4.18
2.	With some analog input modules: set the measuring method and measuring range by means of the measuring range module	Section 4.4
3.	Install the module in the SIMATIC S7 network	“Installation” section in the manual for the programmable logic controller being used: • S7-300, M7-300, S7-400 or M7-400 Programmable Controller, Hardware and Installation or • ET 200M Distributed I/O Device
4.	Assign parameters to module	Section 4.7
5.	Connect measuring sensor or loads to module	Sections 4.8 to 4.15
6.	Commission configuration	“Commissioning” section in the manual for the programmable logic controller being used: • S7-300, M7-300, S7-400 or M7-400 Programmable Controller, Hardware and Installation or • ET 200M Distributed I/O Device
7.	If commissioning was not successful, diagnose configuration	Section 4.16

4.3 Analog Value Representation

Introduction

This section describes the analog values for all the measuring ranges and output ranges which you can use with the analog modules.

Converting analog values

The CPU processes the analog values in binary form only.

Analog input modules convert the analog process signal into digital form.

Analog output modules convert the digital output value into an analog signal.

Analog value representation with 16-bit resolution

The digitized analog value is the same for both input and output values having the same nominal range. The analog values are represented as a fixed-point number in two's complement. The resulting assignment is as follows:

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Value of bits	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}

Sign

The sign of the analog value is always contained in bit number 15:

- "0" → +
- "1" → –

Resolution less than 16 bits

If the resolution of an analog module has fewer than 16 bits, the analog value is stored left-justified on the module. The lower-order bit positions not used are padded with zeros ("0").

Example

In the following example you can see how the positions not padded with "0" are written for low resolution.

Table 4-5 Example: Bit Pattern of a 16-Bit and a 13-Bit Analog Value

Resolution	Analog Value															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
16-bit analog value	0	1	0	0	0	1	1	0	0	1	1	1	0	0	1	1
13-bit analog value	0	1	0	0	0	1	1	0	0	1	1	1	0	**0**	**0**	**0**

4.3.1 Analog Value Representation for Analog Input Channels

Introduction

The tables in this chapter contain the measured value representations for the various measuring ranges of the analog input modules. The values in the tables apply to all modules with the corresponding measuring ranges.

Notes for readers of the tables

Tables 4-7 to 4-8 contain the binary representation of the measured values.

Since the binary representation of the measured values is always the same, starting at 4-9 these tables only contain the measured values and the units.

Measured value resolution

The resolution of the analog values can vary depending upon the analog module and its parameterization. With resolutions < 15 bit all bits identified with ”x” will be set to ”0”.

Note: This resolution does not apply to temperature values. The transformed temperature values are the result of a conversion within the analog module (see tables 4-15 through 4-29).

Table 4-6   Possible Resolutions of the Analog Values

Resolution in bits (+sign)	Units		Analog value	
	decimal	hexadecimal	High Byte	Low Byte
8	128	80_H	VZ 0 0 0 0 0 0 0	1 x x x x x x x
9	64	40_H	VZ 0 0 0 0 0 0 0	0 1 x x x x x x
10	32	20_H	VZ 0 0 0 0 0 0 0	0 0 1 x x x x x
11	16	10_H	VZ 0 0 0 0 0 0 0	0 0 0 1 x x x x
12	8	8_H	VZ 0 0 0 0 0 0 0	0 0 0 0 1 x x x
13	4	4_H	VZ 0 0 0 0 0 0 0	0 0 0 0 0 1 x x
14	2	2_H	VZ 0 0 0 0 0 0 0	0 0 0 0 0 0 1 x
15	1	1_H	VZ 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

Binary representation of the input ranges

The input ranges shown in Tables 4-7 to 4-8 are defined in two's complement representation:

Table 4-7 Bipolar Input Ranges

Units	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	> 118.515	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	
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	Rated range
– 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	Under-range
– 32512	– 117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
– 32768	≤ – 117.596	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

Table 4-8 Unipolar Input Ranges

Units	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	≥ 118.515	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	Over-range
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	Rated 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	Under-range
– 4864	– 17.593	1	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	
– 32768	≤ – 17.596	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

Analog value representation in voltage measuring ranges

Table 4-9 Analog Value Representation in Voltage Measuring Ranges ± 10 V to ± 1 V

System			Voltage Measuring Range				
	Dec.	**Hex.**	**± 10 V**	**± 5 V**	**± 2.5 V**	**± 1 V**	
118.515 %	32767	7FFF	11.851 V	5.926 V	2.963 V	1.185 V	Overflow
117.593 %	32512	7F00					
117.589 %	32511	7EFF	11.759 V	5.879 V	2.940 V	1.176 V	Overrange
	27649	6C01					
100.000 %	27648	6C00	10 V	5 V	2.5 V	1 V	Rated range
75.000 %	20736	5100	7.5 V	3.75 V	1.875 V	0.75 V	
0.003617 %	1	1	361.7 μV	180.8 μV	90.4 μV	36.17 μV	
0 %	0	0	0 V	0 V	0 V	0 V	
	– 1	FFFF					
– 75.000 %	– 20736	AF00	– 7.5 V	– 3.75 V	– 1.875 V	– 0.75 V	
– 100.000 %	– 27648	9400	– 10 V	– 5 V	– 2.5 V	– 1 V	
	– 27649	93FF					Underrange
– 117.593 %	– 32512	8100	– 11.759 V	– 5.879 V	– 2.940 V	– 1.176 V	
– 117.596 %	– 32513	80FF					Underflow
– 118.519 %	– 32768	8000	– 11.851 V	– 5.926 V	– 2.963 V	– 1.185 V	

Table 4-10 Analog Value Representation in Voltage Measuring Ranges ± 500 mV to ± 80 mV

System			Voltage Measuring Range			
	Dec.	Hex.	± 500 mV	± 250 mV	± 80 mV	
118.515 %	32767	7FFF	592.6 mV	296.3 mV	94.8 mV	Overflow
117.593 %	32512	7F00				
117.589 %	32511	7EFF	587.9 mV	294.0 mV	94.1 mV	Overrange
	27649	6C01				
100.000 %	27648	6C00	500 mV	250 mV	80 mV	Rated range
75.00 %	20763	5100	375 mV	187.5 mV	60 mV	
0.003617 %	1	1	18.08 μV	9.04 μV	2.89 μV	
0 %	0	0	0 mV	0 mV	0 mV	
	– 1	FFFF				
– 75.00 %	– 20763	AF00	– 375 mV	– 187.5 mV	– 60 mV	
– 100.000 %	– 27648	9400	– 500 mV	– 250 mV	– 80 mV	
	– 27649	93FF				Underrange
– 117.593 %	– 32512	8100	– 587.9 mV	– 294.0 mV	– 94.1 mV	
– 117.596 %	– 32513	80FF				Underflow
– 118.519 %	– 32768	8000	– 592.6 mV	– 296.3 mV	– 94.8 mV	

Table 4-11 Analog Value Representation in Voltage Measuring Ranges 1 to 5 V and 0 to 10 V

System			Voltage Measuring Range		
	Dec.	Hex.	1 to 5 V	0 to 10 V	
118.515 %	32767	7FFF	5.741 V	11.852 V	Overflow
117.593 %	32512	7F00			
117.589 %	32511	7EFF	5.704 V	11.759 V	Overrange
	27649	6C01			
100.000 %	27648	6C00	5 V	10 V	Rated range
75 %	20736	5100	3.75 V	7.5 V	
0.003617 %	1	1	1 V + 144.7 μV	0 V + 361.7 μV	
0 %	0	0	1 V	0 V	
	– 1	FFFF		No negative values possible	Underrange
– 17.593 %	– 4864	ED00	0.296 V		
	– 4865	ECFF			Underflow
≤–17.596 %	– 32768	8000			

Analog value representation in current measuring ranges

Table 4-12 Analog Value Representation in Current Measuring Ranges ± 20 mA to ± 3.2 mA

System			Current Measuring Range			
	Dec.	**Hex.**	**± 20 mA**	**± 10 mA**	**± 3.2 mA**	
118.515 %	32767	7FFF	23.70 mA	11.85 mA	3.79 mA	Overflow
117.593 %	32512	7F00				
117.589 %	32511	7EFF	23.52 mA	11.76 mA	3.76 mA	Overrange
	27649	6C01				
100.000 %	27648	6C00	20 mA	10 mA	3.2 mA	Rated range
75 %	20736	5100	15 mA	7.5 mA	2.4 mA	
0.003617 %	1	1	723.4 nA	361.7 nA	115.7 nA	
0 %	0	0	0 mA	0 mA	0 mA	
	– 1	FFFF				
– 75 %	–5100	AF00	– 15 mA	– 7.5 mA	– 2.4 mA	
– 100.000 %	– 27648	9400	–20 mA	–10 mA	–3.2 mA	
	– 27649	93FF				Underrange
– 117.593 %	– 32512	8100	–23.52 mA	–11.76 mA	–3.76 mA	
– 117.596 %	– 32513	80FF				Underflow
– 118.519 %	– 32768	8000	–23.70 mA	–11.85 mA	–3.79 mA	

Table 4-13 Analog Value Representation in Current Measuring Ranges 0 to 20 mA and 4 to 20 mA

System			Current Measuring Range		
	Dec.	**Hex.**	**0 to 20 mA**	**4 to 20 mA**	
118.515 %	32767	7FFF	23.70 mA	22.96 mA	Overflow
117.593 %	32512	7F00			
117.589 %	32511	7EFF	23.52 mA	22.81 mA	Overrange
	27649	6C01			
100.000 %	27648	6C00	20 mA	20 mA	
75 %	20736	5100	15 mA	15 mA	Rated range
0.003617 %	1	1	723.4 nA	4 mA + 578.7 nA	
0 %	0	0	0 mA	4 mA	
	– 1	FFFF			Underrange
– 17.593 %	– 4864	ED00	– 3.52 mA	1.185 mA	
	– 4865	ECFF			Underflow
≤ –17.596 %	– 32768	8000			

Analog value representation for resistance-type transmitters

Table 4-14 Analog Value Representation for Resistance-Type Transmitters 10 kΩ and from 150 to 600 Ω

System			Resistance-Type Transmitter Range				
	Dec.	**Hex.**	**10 kΩ**	**150 Ω**	**300 Ω**	**600 Ω**	
118.515 %	32767	7FFF	11.852 kΩ	177.77Ω	355.54 Ω	711.09 Ω	Overflow
117.593 %	32512	7F00					
117.589 %	32511	7EFF	11.759 kΩ	176.38 Ω	352.77 Ω	705.53 Ω	Overrange
	27649	6C01					
100.000 %	27648	6C00	10 kΩ	150 Ω	300 Ω	600 Ω	Rated range
75 %	20736	5100	7.5 kΩ	112.5 Ω	225 Ω	450 Ω	
0.003617 %	1	1	361.7 mΩ	5.43 mΩ	10.85 mΩ	21.70 mΩ	
0 %	0	0	0 Ω	0 Ω	0 Ω	0 Ω	
			(negative values physically not possible)				Underrange

Analog value representation for RTD resistance temperature detectors Pt x00 standard

Table 4-15 Analog Value Representation for RTD Resistance Temperature Detectors PT 100, 200, 500,1000

Pt x00 standard in °C (1 digit = 0.1°C)	Units		Pt x00 standard in °F (1 digit = 0.1 °F)	Units		Pt x00 standard in K (1 digit = 0.1 K)	Units		Range
	dec.	hex.		dec.	hex.		dec.	hex.	
> 1000.0	32767	$7FFF_H$	> 1832.0	32767	$7FFF_H$	> 1273.2	32767	$7FFF_H$	Overflow
1000.0 : 850.1	10000 : 8501	2710_H : 2135_H	1832.0 : 1562.1	18320 : 15621	4790_H : $3D05_H$	1273.2 : 1123.3	12732 : 11233	$31BC_H$: $2BE1_H$	Overrange
850.0 : –200.0	8500 : –2000	2134_H : $F830_H$	1562.0 : –328.0	15620 : –3280	$3D04_H$: $F330_H$	1123.2 : 73.2	11232 : 732	$2BE0_H$: $2DC_H$	Rated range
–200.1 : –243.0	–2001 : –2430	$F82F_H$: $F682_H$	–328.1 : –405.4	–3281 : –4054	$F32F_H$: $F02A_H$	73.1 : 30.2	731 : 302	$2DB_H$: $12E_H$	Underrange
< – 243.0	–32768	8000_H	< – 405.4	–32768	8000_H	< 30.2	32768	8000_H	Underflow

Analog value representation for RTD resistance temperature detectors Pt x00 climate

Table 4-16 Analog Value Representation for RTD Resistance Temperature Detectors Pt 100. 200, 500,1000

Pt x00 climate in °C (1 digit = 0.01°C)	Units		Pt x00 Klima in °F (1 digit = 0.01 °F)	Units		Range
	dec.	hex.		dec.	hex.	
> 155.00	32767	$7FFF_H$	> 311.00	32767	$7FFF_H$	Overflow
155.00 : 130.01	15500 : 13001	$3C8C_H$: $32C9_H$	311.00 : 266.01	31100 : 26601	$797C_H$: $67E9_H$	Overrange
130.00 : –120.00	13000 : –12000	$32C8_H$: $D120_H$	266.00 : –184.00	26600 : –18400	$67E8_H$: $B820_H$	Rated range
–120.01 : –145.00	–12001 : –14500	$D11F_H$: $C75C_H$	–184.01 : –229.00	–18401 : –22900	$B81F_H$: $A68C_H$	Underrange
< – 145.00	–32768	8000_H	< – 229.00	–32768	8000_H	Underflow

Analog value representation for RTD resistance temperature detectors Ni x00 standard

Table 4-17 Analog Value Representation for RTD Resistance Temperature Detectors Ni100, 120, 200, 500, 1000

Ni x00 standard in °C (1 digit = 0.1°C)	Units		Ni x00 standard in °F (1 digit = 0.1 °F)	Units		Ni x00 standard in K (1 digit = 0.1 K)	Units		Range
	dec.	hex.		dec.	hex.		dec.	hex.	
> 295.0	32767	$7FFF_H$	> 563.0	32767	$7FFF_H$	> 568.2	32767	$7FFF_H$	Overflow
295.0 : 250.1	2950 : 2501	$B86_H$: $9C5_H$	563.0 : 482.1	5630 : 4821	$15FE_H$: $12D5_H$	568.2 : 523.3	5682 : 5233	1632_H : 1471_H	Overrange
250.0 : –60.0	2500 : –600	$9C4_H$: $FDA8_H$	482.0 : –76.0	4820 : –760	$12D4_H$: $FD08_H$	523.2 : 213.2	5232 : 2132	1470_H : 854_H	Rated range
–60.1 : –105.0	–601 : –1050	$FDA7_H$: $FBE6_H$	–76.1 : –157.0	–761 : –1570	$FD07_H$: $F9DE_H$	213.1 : 168.2	2131 : 1682	853_H : 692_H	Underrange
< –105.0	–32768	8000_H	< –157.0	–32768	8000_H	< 168.2	32768	8000_H	Underflow

Analog value representation for RTD resistance temperature detectors Ni x00 climate

Table 4-18 Analog Value Representation for RTD Resistance Temperature Detectors Ni 100, 120, 200, 500, 1000

Ni x00 climate in °C (1 digit = 0.01°C)	Units		Ni x00 climate in °F (1 digit = 0.01 °F)	Units		Range
	dec.	hex.		dec.	hex.	
> 295.00	32767	7FFF$_H$	> 325.11	32767	7FFF$_H$	Overflow
295.00 : 250.01	29500 : 25001	733C$_H$: 61A9$_H$	327.66 : 280.01	32766 : 28001	7FFE$_H$: 6D61$_H$	Overrange
250.00 : –60.00	25000 : –6000	61A8$_H$: E890$_H$	280.00 : –76.00	28000 : –7600	6D60$_H$: E250$_H$	Rated range
–60.01 : –105.00	–6001 : –10500	E88F$_H$: D6FC$_H$	–76.01 : –157.00	–7601 : –15700	E24F$_H$: C2AC$_H$	Underrange
< – 105.00	–32768	8000$_H$	< – 157.00	–32768	8000$_H$	Underflow

Analog value representation for RTD resistance temperature detectors Cu 10 standard

Table 4-19 Analog Value Representation for RTD Resistance Temperature Detectors Cu 10

Cu 10 standard in °C (1 digit = 0.01°C)	Units		Cu 10 standard in °F (1 digit = 0.01 °F)	Units		Cu 10 standard in K (1 digit = 0.01 K)	Units		Range
	dec.	hex.		dec.	hex.		dec.	hex.	
> 312.0	32767	7FFF$_H$	> 593.6	32767	7FFF$_H$	> 585.2	32767	7FFF$_H$	Overflow
312.0 : 260.1	3120 : 2601	C30$_H$: A29$_H$	593.6 : 500.1	5936 : 5001	1730$_H$: 12D5$_H$	585.2 : 533.3	5852 : 5333	16DC$_H$: 14D5$_H$	Overrange
260.0 : –200.0	2600 : –2000	A28$_H$: F830$_H$	500.0 : –328.0	5000 : –3280	1389$_H$: F330$_H$	533.2 : 73.2	5332 : 732	14D4$_H$: 2DC$_H$	Rated range
–200.1 : –240.0	–2001 : –2400	F82F$_H$: F6A0$_H$	–328.1 : –400.0	–3281 : –4000	F32F$_H$: F060$_H$	73.1 : 33.2	731 : 332	2DB$_H$: 14C$_H$	Underrange
< – 240.0	–32768	8000$_H$	< – 400.0	–32768	8000$_H$	< 33.2	32768	8000$_H$	Underflow

Analog value representation for RTD resistance temperature detectors Cu 10 climate

Table 4-20 Analog Value Representation for RTD Resistance Temperature Detectors Cu 10

Cu 10 climate in °C (1 digit = 0.01°C)	Units		Cu 10 climate in °F (1 digit = 0.01 °F)	Units		Range
	dec.	hex.		dec.	hex.	
> 180.00	32767	7FFF$_H$	> 325.11	32767	7FFF$_H$	Overflow
180.00	18000	4650$_H$	327.66	32766	7FFE$_H$	
:	:	:	:	:	:	Overrange
150.01	15001	3A99$_H$	280.01	28001	6D61A$_H$	
150.00	15000	3A98$_H$	280.00	280.00	6D60$_H$	
:	:	:	:	:	:	Rated range
–50.00	–5000	EC78$_H$	–58.00	–5800	E958$_H$	
–50.01	–5001	EC77$_H$	–58.01	–5801	E957$_H$	
:	:	:	:	:	:	Underrange
–60.00	–6000	E890$_H$	–76.00	–7600	E250$_H$	
< – 60.00	–32768	8000$_H$	< – 76.00	–32768	8000$_H$	Underflow

Analog value representation for Thermocouple temperature detectors type B

Table 4-21 Analog Value Representation for Thermocouple Temperature Detectors Type B

Type B in °C	Units		Type B in °F	Units		Type B in K	Units		Range
	dec.	hex.		dec.	hex.		dec.	hex.	
> 2070.0	32767	7FFF$_H$	> 3276.6	32767	7FFF$_H$	> 2343.2	32767	7FFF$_H$	Overflow
2070.0	20700	50DC$_H$	3276.6	32766	7FFE$_H$	2343.2	23432	5B88$_H$	
:	:	:	:	:	:	:	:	:	Overrange
1821.0	18210	4722$_H$	2786.6	27866	6CDA$_H$	2094.2	20942	51CE$_H$	
1820.0	18200	4718$_H$	2786.5	27865	6CD9$_H$	2093.2	20932	51C4$_H$	
:	:	:	:	:	:	:	:	:	Rated range
0.0	0	0000$_H$	–32.0	–320	FEC0$_H$	273.2	2732	0AAC$_H$	
:	:	:	:	:	:	:	:	:	Underrange
–120.0	–1200	FB50$_H$	–184.0	–1840	F8D0$_H$	153.2	1532	05FC$_H$	
< –120.0	–32768	8000$_H$	< –184.0	–32768	8000$_H$	< 153.2	32768	8000$_H$	Underflow

Analog value representation for Thermocouple temperature detectors type E

Table 4-22 Analog Value Representation for Thermocouple Temperature Detectors Type E

Type E in °C	Units		Type E in °F	Units		Type E in K	Units		Range
	dec.	hex.		dec.	hex.		dec.	hex.	
> 1200.0	32767	$7FFF_H$	> 2192.0	32767	$7FFF_H$	> 1473.2	32767	$7FFF_H$	Overflow
1200.0 : 1000.1	12000 : 10001	$2EE0_H$: 2711_H	2192.0 : 1833.8	21920 : 18338	$55A0_H$: $47A2_H$	1473.2 : 1274.2	14732 : 12742	$398C_H$: $31C6_H$	Overrange
1000.0 : –270.0	10000 : –2700	2710_H : $F574_H$	1832.0 : –454.0	18320 : –4540	4790_H : $EE44_H$	1273.2 : 0	12732 : 0	$31BC_H$: 0000_H	Rated range
< –270.0	< –2700	< $F574_H$	< –454.0	< –4540	<$EE44_H$	< 0	<0	<0000_H	Underflow
In the case of incorrect wiring (e.g. polarity reversal or open inputs) or of a sensor error in the negative range (e.g. incorrect thermocouple type), the analog input module signals underflow below ...									
... $F0C4_H$ and outputs 8000_H.			... $FB70_H$ and outputs 8000_H.			... $E5D4_H$ and outputs 8000_H.			

Analog value representation for Thermocouple temperature detectors type J

Table 4-23 Analog Value Representation for Thermocouple Temperature Detectors Type J

Type J in °C	Units		Type J in °F	Units		Type J in K	Units		Range
	dec.	hex.		dec.	hex.		dec.	hex.	
> 1450.0	32767	$7FFF_H$	> 2642.0	32767	$7FFF_H$	> 1723.2	32767	$7FFF_H$	Overflow
1450.0 : 1201.0	14500 : 12010	$38A4_H$: $2EEA_H$	2642.0 : 2193.8	26420 : 21938	6734_H : $55B2_H$	1723.2 : 1474.2	17232 : 14742	4350_H : 3996_H	Overrange
1200.0 : –210.0	12000 : –2100	$2EE0_H$: $F7CC_H$	2192.0 : –346.0	21920 : –3460	$55A0_H$: $F27C_H$	1473.2 : 63.2	14732 : 632	$398C_H$: 0278_H	Rated range
< –210.0	< –2100	<$F7CC_H$	< –346.0	< –3460	<$F27C_H$	< 63.2	< 632	< 0278_H	Underflow
In the case of incorrect wiring (e.g. polarity reversal or open inputs) or of a sensor error in the negative range (e.g. incorrect thermocouple type), the analog input module signals underflow below ...									
... $F31C_H$ and outputs 8000_H.			... $EA0C_H$ and outputs 8000_H.			... $FDC8_H$ and outputs 8000_H.			

Analog value representation for Thermocouple temperature detectors type K

Table 4-24 Analog Value Representation for Thermocouple Temperature Detectors Type K

Type K in °C	Units		Type K in °F	Units		Type K in K	Units		Range
	dec.	hex.		dec.	hex.		dec.	hex.	
> 1622.0	32767	$7FFF_H$	> 2951.6	32767	$7FFF_H$	> 1895.2	32767	$7FFF_H$	Overflow
1622.0 : 1373.0	16220 : 13730	$3F5C_H$: $35A2_H$	2951.6 : 2503.4	29516 : 25034	$734C_H$: $61CA_H$	1895.2 : 1646.2	18952 : 16462	$4A08_H$: $404E_H$	Overrange
1372.0 : –270.0	13720 : –2700	3598_H : $F574_H$	2501.6 : –454.0	25061 : –4540	$61B8_H$: $EE44_H$	1645.2 : 0	16452 : 0	4044_H : 0000_H	Rated range
< –270.0	< –2700	< $F574_H$	< –454.0	< –4540	<$EE44_H$	< 0	< 0	< 0000_H	Underflow
In the case of incorrect wiring (e.g. polarity reversal or open inputs) or of a sensor error in the negative range (e.g. incorrect thermocouple type), the analog input module signals underflow below ...									
... $F0C4_H$ and outputs 8000_H.			... $E5D4_H$ and outputs 8000_H.			... $FB70_H$ and outputs 8000_H.			

Analog value representation for Thermocouple temperature detectors type L

Table 4-25 Analog Value Representation for Thermocouple Temperature Detectors Type L

Type L in °C	Units		Type L in °F	Units		Type L in K	Units		Range
	dec.	hex.		dec.	hex.		dec.	hex.	
> 1150.0	32767	$7FFF_H$	> 2102.0	32767	$7FFF_H$	> 1423.2	32767	$7FFF_H$	Overflow
1150.0 : 901.0	11500 : 9010	$2CEC_H$: 2332_H	2102.0 : 1653.8	21020 : 16538	$521C_H$: $409A_H$	1423.2 : 1174.2	14232 : 11742	3798_H : $2DDE_H$	Overrange
900.0 : –200.0	9000 : –2000	2328_H : $F830_H$	1652.0 : –328.0	16520 : –3280	4088_H : $F330_H$	1173.2 : 73.2	11732 : 732	$2DD4_H$: $02DC_H$	Rated range
< –200.0	< –2000	< $F830_H$	< –328.0	< –3280	<$F330_H$	< 73.2	< 732	<$02DC_H$	Underflow
In the case of incorrect wiring (e.g. polarity reversal or open inputs) or of a sensor error in the negative range (e.g. incorrect thermocouple type), the analog input module signals underflow below ...									
... $F380_H$ and outputs 8000_H.			... $EAC0_H$ and outputs 8000_H.			... $FE2C_H$ and outputs 8000_H.			

Analog value representation for Thermocouple temperature detectors type N

Table 4-26 Analog Value Representation for Thermocouple Temperature Detectors Type N

Type N in °C	Units		Type N in °F	Units		Type N in K	Units		Range
	dec.	hex.		dec.	hex.		dec.	hex.	
> 1550.0	32767	7FFF$_H$	> 2822.0	32767	7FFF$_H$	> 1823.2	32767	7FFF$_H$	Overflow
1550.0 : 1300.1	15500 : 13001	3C8C$_H$: 32C9$_H$	2822.0 : 2373.8	28220 : 23738	6E3C$_H$: 5CBA$_H$	1823.2 : 1574.2	18232 : 15742	4738$_H$: 3D7E$_H$	Overrange
1300.0 : –270.0	13000 : –2700	32C8$_H$: F574$_H$	2372.0 : –454.0	23720 : –4540	5CA8$_H$: EE44$_H$	1573.2 : 0	15732 : 0	3D74$_H$: 0000$_H$	Rated range
< –270.0	< –2700	< F574$_H$	< –454.0	< –4540	<EE44$_H$	< 0	< 0	< 0000$_H$	Underflow
In the case of incorrect wiring (e.g. polarity reversal or open inputs) or of a sensor error in the negative range (e.g. incorrect thermocouple type), the analog input module signals underflow below ...									
... F0C4$_H$ and outputs 8000$_H$.			... E5D4$_H$ and outputs 8000$_H$.			... FB70$_H$ and outputs 8000$_H$.			

Analog value representation for Thermocouple temperature detectors type R, S

Table 4-27 Analog Value Representation for Thermocouple Temperature Detectors Type R, S

Type R, S in °C	Units		Type R, S in °F	Units		Type R, S in K	Units		Range
	dec.	hex.		dec.	hex.		dec.	hex.	
> 2019.0	32767	7FFF$_H$	> 3276.6	32767	7FFF$_H$	> 2292.2	32767	7FFF$_H$	Overflow
2019.0 : 1770.0	20190 : 17770	4EDE$_H$: 4524$_H$	3276.6 : 3218.0	32766 : 32180	7FFE$_H$: 7DB4$_H$	2292.2 : 2043.2	22922 : 20432	598A$_H$: 4FD0$_H$	Overrange
1769.0 : –50.0	17690 : –500	451A$_H$: FE0C$_H$	3216.2 : –58.0	32162 : –580	7DA2$_H$: FDBC$_H$	2042.2 : 223.2	20422 : 2232	4FC6$_H$: 08B8$_H$	Rated range
–51.0 : –170.0	–510 : –1700	FE02$_H$: F95C$_H$	–59.8 : –274.0	–598 : –2740	FDAA$_H$: F54C$_H$	222.2 : 103.2	2222 : 1032	08AE$_H$: 0408$_H$	Underrange
< –170.0	–32768	8000$_H$	< –274.0	–32768	8000$_H$	< 103-2	< 1032	8000$_H$	Underflow

Analog value representation for Thermocouple temperature detectors type T

Table 4-28 Analog Value Representation for Thermocouple Temperature Detectors Type T

Type T in °C	Units		Type T in °F	Units		Type T in K	Units		Range
	dec.	hex.		dec.	hex.		dec.	hex.	
> 540.0	32767	$7FFF_H$	> 1004.0	32767	$7FFF_H$	> 813.2	32767	$7FFF_H$	Overflow
540.0 : 401.0	5400 : 4010	1518_H : $0FAA_H$	1004.0	10040	2738_H	813.2	8132	$1FC4_H$	Overrange
400.0 : –270.0	4000 : –2700	$0FA0_H$: $F574_H$	752.0 : –454.0	7520 : –4540	$1D60_H$: $EE44_H$	673.2 : 3.2	6732 : 32	$1AAC_H$: 0020_H	Rated range
< –270.0	< –2700	<$F574_H$	< –454.0	< –4540	<$EE44_H$	< 3.2	< 32	< 0020_H	Underflow
In the case of incorrect wiring (e.g. polarity reversal or open inputs) or of a sensor error in the negative range (e.g. incorrect thermocouple type), the analog input module signals underflow below ...									
... $F0C4_H$ and outputs 8000_H.			... $E5D4_H$ and outputs 8000_H.			... $FB70_H$ and outputs 8000_H.			

Analog value representation for Thermocouple temperature detectors type U

Table 4-29 Analog Value Representation for Thermocouple Temperature Detectors Type U

Type U in °C	Units		Type U in °F	Units		Type U in K	Units		Range
	dec.	hex.		dec.	hex.		dec.	hex.	
> 850.0	32767	$7FFF_H$	> 1562.0	32767	$7FFF_H$	> 1123.2	32767	$7FFF_H$	Overflow
850.0 : 601.0	8500 : 6010	2134_H : $177A_H$	1562.0 : 1113.8	15620 : 11138	2738.0_H : $2B82_H$	1123.2 : 874.2	11232 : 8742	$2BE0_H$: 2226_H	Overrange
600.0 : –200.0	6000 : –2000	1770_H : $F830_H$	1112.0 : –328.0	11120 : –3280	$2B70_H$: $F330_H$	873.2 : 73.2	8732 : 732	$221C_H$: $02DC_H$	Rated range
< –200.0	< –2000	<$F830_H$	< –328.0	< –3280	<$F330_H$	< 73.2	< 732	<$02DC_H$	Underflow
In the case of incorrect wiring (e.g. polarity reversal or open inputs) or of a sensor error in the negative range (e.g. incorrect thermocouple type), the analog input module signals underflow below ...									
... $F380_H$ and outputs 8000_H.			... $EAC0_H$ and outputs 8000_H.			... $FE2C_H$ and outputs 8000_H.			

4.3.2 Analog Value Representation for Analog Output Channels

Introduction

The tables in this chapter contain the analog value representation for output channels of the analog output modules. The values in the tables apply to all modules with the corresponding output ranges.

Notes for readers of the tables

Tables 4-30 to 4-31 contain the binary representation of the output values.

Since the binary representation of the output values is always the same, starting at 4-32 these tables only contain the output ranges and the units.

Output ranges for the SM 334; AI 4/AO 2 × 8/8 Bit

The analog input/output module SM 334; AI 4/AO 2 × 8/8 Bit has output ranges from 0 to 10 V and from 0 to 20 mA. Unlike the other analog modules, the SM 334 has a lower resolution, however. Please note that the SM 334; AI 4/AO 2 × 8/8 Bit with product status 1 does not have overranges.

Binary representation of the output ranges

The output ranges shown in Tables 4-30 to 4-31 are defined in two's complement representation:

Table 4-30 Bipolar Output Ranges

Units	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	
≥ 32512	0 %	0	1	1	1	1	1	1	1	x	x	x	x	x	x	x	x	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Over-range
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	
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	Rated range
– 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	Under-range
– 32512	– 117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
≤ 32513	0 %	1	0	0	0	0	0	0	0	x	x	x	x	x	x	x	x	Under-flow

Table 4-31 Unipolar Output Ranges

Units	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	
≥ 32512	0 %	0	1	1	1	1	1	1	1	x	x	x	x	x	x	x	x	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	
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	Rated range
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
– 1	0.000	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Limited to rated range lower limit 0 V and 0 mA
– 32512		1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
≤ 32513	0 %	1	0	0	0	0	0	0	0	x	x	x	x	x	x	x	x	Underflow

Analog value representation in voltage output ranges

Table 4-32 Analog Value Representation in Output Range ± 10 V

System			Voltage Output Range	
	Dec.	**Hex.**	**± 10 V**	
118.5149 %	32767	7FFF	0.00 V	Overflow, off circuit and de-energized
	32512	7F00		
117.589 %	32511	7EFF	11.76 V	Overrange
	27649	6C01		
100 %	27648	6C00	10 V	Rated 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	
	– 32513	80FF		Underflow, off circuit and de-energized
– 118.519 %	– 32768	8000	0.00 V	

Table 4-33 Analog Value Representation in Output Ranges 0 to 10 V and 1 to 5 V

System			Voltage Output Range		
	Dec.	**Hex.**	**0 to 10 V**	**1 to 5 V**	
118.5149 %	32767	7FFF	0.00 V	0.00 V	Overflow, off circuit and de-energized
	32512	7F00			
117.589 %	32511	7EFF	11.76 V	5.70 V	Overrange
	27649	6C01			
100 %	27648	6C00	10 V	5 V	
75 %	20736	5100	7.5 V	3.75 V	Rated range
0.003617 %	1	1	361.7µV	1V+144.7µV	
0 %	0	0	0 V	1 V	
	– 1	FFFF			Underrange
– 25 %	– 6912	E500		0 V	
	– 6913	E4FF			Not possible. The output value is limited to 0 V.
– 117.593 %	– 32512	8100			
	– 32513	80FF			Underflow, off circuit and de-energized
– 118.519 %	– 32768	8000	0.00 V	0.00 V	

Analog value representation in current output ranges

Table 4-34 Analog Value Representation in Output Range ± 20 mA

System			Current Output Range	
	Dec.	**Hex.**	**± 20 mA**	
118.5149 %	32767	7FFF	0.00 mA	Overflow, off circuit and de-energized
	32512	7F00		
117.589 %	32511	7EFF	23.52 mA	Overrange
	27649	6C01		
100 %	27648	6C00	20 mA	Rated 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	
	– 32513	80FF		Underflow, off circuit and de-energized
– 118.519 %	– 32768	8000	0.00 mA	

Table 4-35 Analog Value Representation in Output Ranges 0 and 20 mA and 4 to 20 mA

System			Current Output Range		
	Dec.	**Hex.**	**0 to 20 mA**	**4 to 20 mA:**	
118.5149 %	32767	7FFF	0.00 mA	0.00 mA	Overflow, off circuit and de-energized
	32512	7F00			
117.589 %	32511	7EFF	23.52 mA	22.81 mA	Overrange
	27649	6C01			
100 %	27648	6C00	20 mA	20 mA	Rated range
75 %	20736	5100	15 mA	15 mA	
0.003617 %	1	1	723.4 nA	4mA+578.7 nA	
0 %	0	0	0 mA	4 mA	
	– 1	FFFF			Underrange
– 25 %	– 6912	E500		0 mA	
	– 6913	E4FF			Not possible. The output value is limited to 0 mA.
– 117.593 %	– 32512	8100			
	– 32513	80FF			Underflow, off circuit and de-energized
– 118.519 %	– 32768	8000	0.00 mA	0.00 mA	

4.4 Setting the Measuring Method and Measuring Ranges of Analog Input Channels

Two procedures

There are two procedures for setting the measuring method and the measuring ranges of the analog input channels of the analog modules:

- With measuring range module and *STEP 7*
- By means of wiring the analog input channel and *STEP 7*

Which of these two methods is used for the individual analog modules depends on the module and is described in detail in the specific module sections.

The procedure for setting the measuring method and measuring range of the module in *STEP 7* is described in Section 4.7.

The following section describes how you set the measuring method and the measuring range by means of measuring range modules.

Setting the measuring method and the measuring ranges with measuring range modules

If the analog modules haves measuring range modules, they are supplied with the measuring range modules plugged in.

If necessary, the measuring range modules must be replugged to change the measuring method and the measuring range.

Note

Make sure that the measuring range modules are on the side of the analog input module.

Before installing the analog input module, therefore, check whether the measuring range modules have to be set to another measuring method and another measuring range.

Possible settings for the measuring range modules

The measuring range modules can be set to the following positions: “A”, “B”, “C” and “D”.

Which measuring range module positions you must select for the individual measuring methods and measuring ranges is described in detail in the specific module section.

The settings for the various types of measurement and measuring ranges are also printed on the analog module.

Replugging measuring range modules

If you want to replug a measuring range module, perform the following steps:

1. Use a screwdriver to ease the measuring range module out of the analog input module.

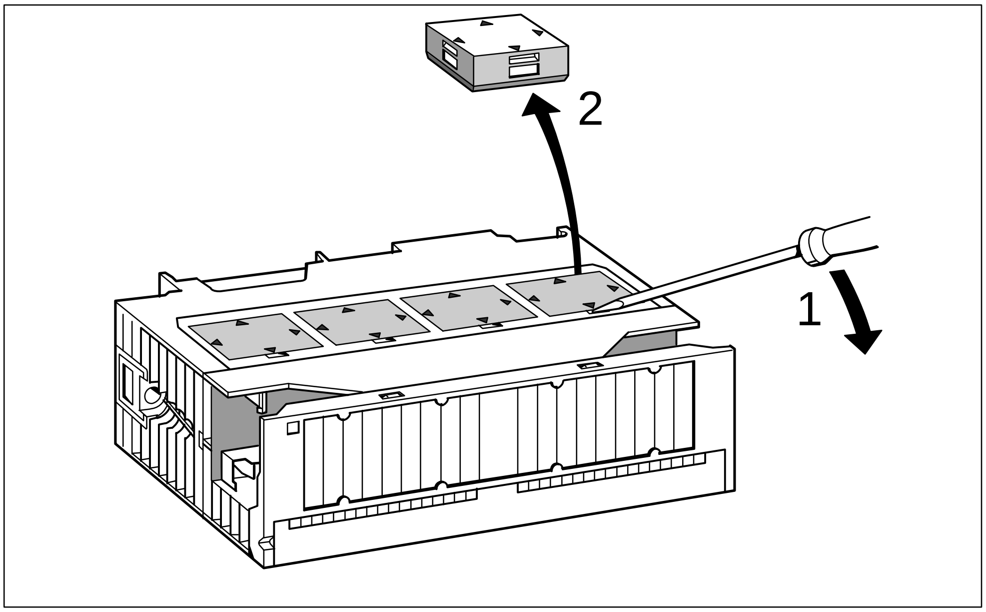


Figure 4-1 Easing Measuring Range Modules from the Analog Input Module

2. Insert the measuring range module (correctly positioned (1)) into the analog input module.

   The measuring range selected is the one that points to the marker point on module (2).

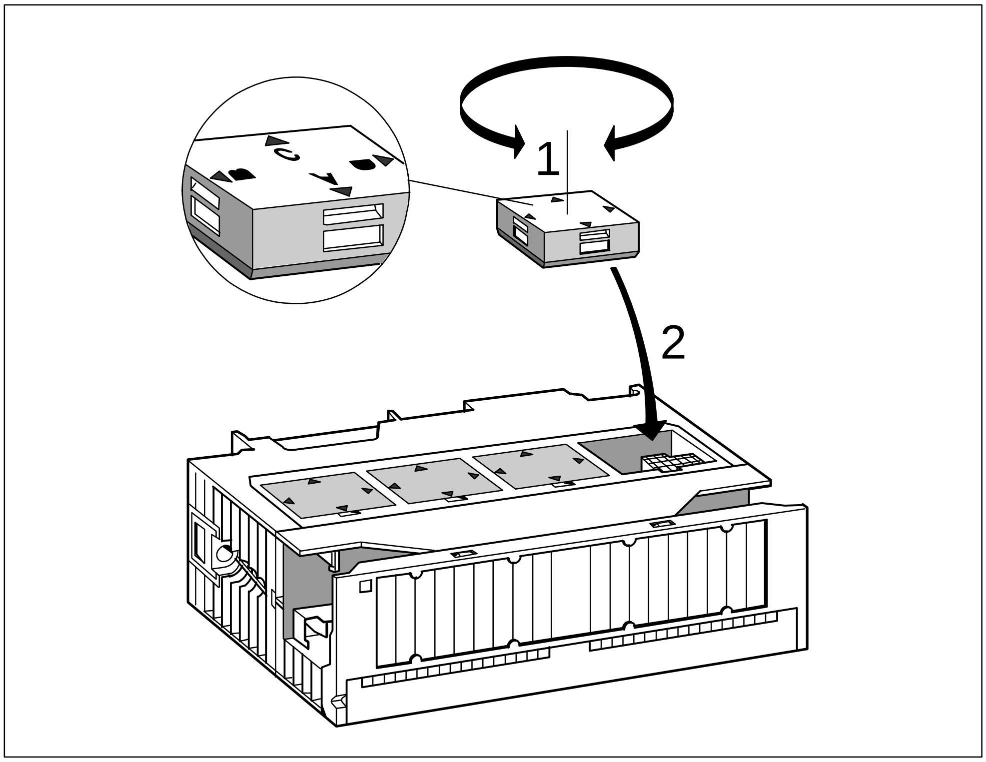


Figure 4-2 Inserting Measuring Range Modules into the Analog Input Module

Perform the same steps for all other measuring range modules.

The next step is to install the module.

Caution

If you have not set the measuring range modules correctly, the module may be destroyed.

Make sure that the measuring range module is in the correct position before connecting a sensor to the module.

4.5 Behavior of the Analog Modules

Introduction

In this section, you will find information on:

- How the analog input and output values depend on the operating states of the CPU and the supply voltage of the analog module
- The behavior of the analog modules depending on where the analog values lie within the value range
- The effect of the operational limit of the analog module on the analog input and output value, as illustrated by an example

4.5.1 Effect of Supply Voltage and Operating Mode

Effect of supply voltage and operating mode on the modules

The input and output values of the analog modules depend on the operating state of the CPU and on the supply voltage of the module.

Table 4-36 Dependencies of the Analog Input/Output Values on the Operating State of the CPU and the Supply Voltage L+

CPU Operating State		Supply Voltage L+ at Analog Module	Input Value of the Analog Input Module	Output Value of the Analog Output Module
POWER ON	RUN	L+ present	Measured value	CPU values
			$7FFF_H$ until first conversion following power–up or after parameter assignment of the module has been completed	Until the first conversion... • **after power–up** has been completed, a signal of 0 mA or 0 V is output. • **after parameter assignment** has been completed, the previous value is output.
		L+ missing	Overflow value	0 mA/0 V
POWER ON	STOP	L+ present	Measured value	Substitute value/last value (default values: 0 mA/0 V)
			$7FFF_H$ until first conversion following power–up or after parameter assignment of the module has been completed	
		L+ missing	Overflow value	0 mA/0 V
POWER OFF	–	L+ present	–	0 mA/0 V
		L+ missing	–	0 mA/0 V

Behavior on failure of the supply voltage

Failure of the supply voltage of the analog modules is always indicated by the SF LED on the module. Furthermore, this information is made available on the module (entry in diagnostic buffer).

Triggering of the diagnostic interrupt depends on the parameter assignment (see Section 4.7).

4.5.2 Effect of Range of Values of the Analog Values

Effect of errors on analog modules with diagnostics capability

Any errors that occur can lead to a diagnostics entry and a diagnostic interrupt with analog modules with diagnostics capability and corresponding parameter assignment. You will find the errors that might be involved in Section 4.16.

Effect of range of values on the analog input module

The behavior of the analog modules depends on where the input values lie within the range of values.

Table 4-37 Behavior of the Analog Input Modules as a Function of the Position of the Analog Value within the Range of Values

Measured Value Within	Input Value	SF LED	Diagnostics	Interrupt
Rated range	Measured value	–	–	–
Overrange/ underrange	Measured value	–	–	–
Overflow	$7FFF_H$	Flashes[1]	Entered[1]	Diagnostic interrupt[1]
Underflow	8000_H	Flashes[1]	Entered[1]	Diagnostic interrupt[1]
Beyond the programmed limit	Measured value	–	–	Process interrupt[1]

1 Only for modules with diagnostics capability and depending on parameter assignment

Effect of range of values on the analog output module

The behavior of the analog modules depends on where the output values lie within the value range.

Table 4-38 Behavior of the Analog Output Modules as a Function of the Position of the Analog Value within the Range of Values

Process Value Lies Within	Output Value	SF LED	Diagnostics	Interrupt
Rated range	CPU value	–	–	–
Overrange/ underrange	CPU value	–	–	–
Overflow	0 signal	–	–	–
Underflow	0 signal	–	–	–

4.5.3 Effect of Operational Limit and Basic Error Limit

Operational limit

The operational limit is the measuring error or output error of the analog module over the entire temperature range authorized for the module, referred to the rated range of the module.

Basic error limit

The basic error limit is the operational limit at 25 °C, referred to the rated range of the module.

Note

The percentage details of operational and basic error limits in the technical specifications of the module always refer to the **highest possible** input and output value in the rated range of the module.

Example of determination of the output error of a module

An analog output module SM 332; AO 4 $\times$ 12 Bit is being used for voltage output. The output range from “0 to 10 V” is being used. The module is operating at an ambient temperature of 30 °C. Thus the operational limit applies. The technical specifications of the module state:

- Operational limit for voltage output: $\pm$0.5 %

An output error, therefore, of $\pm$0.05 V ($\pm$0.5 % of 10 V) over the whole rated range of the module must be expected.

This means that with an actual voltage of, say, 1 V, a value in the range from 0.95 V to 1.05 V is output by the module. The relative error is $\pm$5 % in this case.

The figure below shows for the example how the relative error becomes increasingly less the more the output value approximates to the end of the rated range of 10 V.

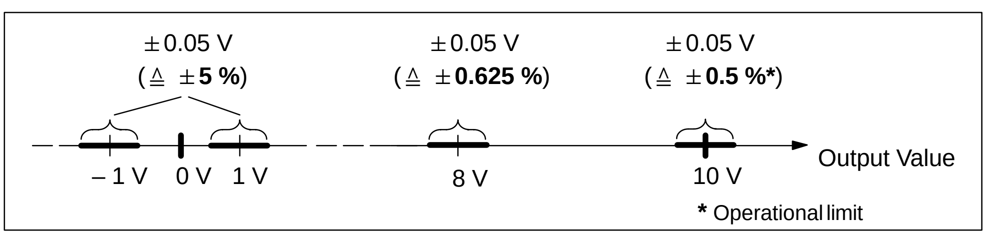


Figure 4-3 Example of the Relative Error of an Analog Output Module

4.6 Conversion, Cycle, Setting and Response Time of Analog Modules

Conversion time of analog input channels

The conversion time consists of a basic conversion time and additional processing times of the module for:

- Resistance test
- Wire-break monitoring

The basic conversion time depends directly on the conversion method of the analog input channel (integrating method, instantaneous value conversion).

In the case of integrating conversion methods, the integration time has a direct influence on the conversion time. The integration time depends on the interference frequency suppression that you set in *STEP 7* (refer to Section 4.7.1).

For the basic conversion times and additional processing times of the different analog modules refer to the technical specifications of the module concerned, starting at Section 4.18.

Scan time of analog input channels

Analog-to-digital conversion and the transfer of the digitized measured values to the memory and/or to the bus backplane are performed sequentially – in other words, the analog input channels are converted one after the other. The scan time – in other words, the time elapsing until an analog input value is again converted, is the sum of the conversion times of all activated analog input channels of the analog input module.

The following figure illustrates the components of the scan time for an n-channel analog module.

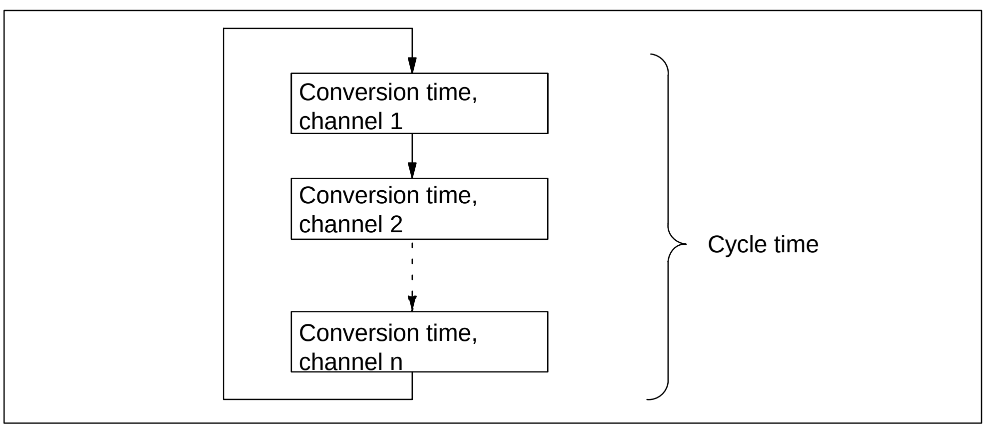


Figure 4-4 Scan Time of an Analog Input or Output Module

Conversion and scan times for analog input channels in channel groups

When the analog input channels are grouped in channel groups, you must take into account the conversion time channel group by channel group.

Example

Two analog input channels channels of the analog input module SM 331; AI 2×12 Bit are combined to form a channel group. You must therefore grade the cycle time in steps of 2.

Setting smoothing of analog values

You can set the smoothing of the analog values in *STEP 7* for some analog input modules.

Using smoothing

Smoothing of analog values ensures a stable analog signal for further processing.

It makes sense to smooth the analog values with slow variations of measured values – for example, with temperature measurements.

Smoothing principle

The measured values are smoothed by digital filtering. Smoothing is accomplished by the module calculating average values from a defined number of converted (digitized) analog values.

The user assigns parameters to smoothing at not more than four levels (none, low, average, high). The level determines the number of analog signals used for averaging.

The higher the smoothing level chosen, the more stable is the smoothed analog value and the longer it takes until the smoothed analog signal is applied after a step response (refer to the following example) Example.

Example

The following figure shows the number of module cycles for a step response after which the smoothed analog value is approximately 100 % applied, as a function of the smoothing that has been set. The figure applies to every change of signal at the analog input.

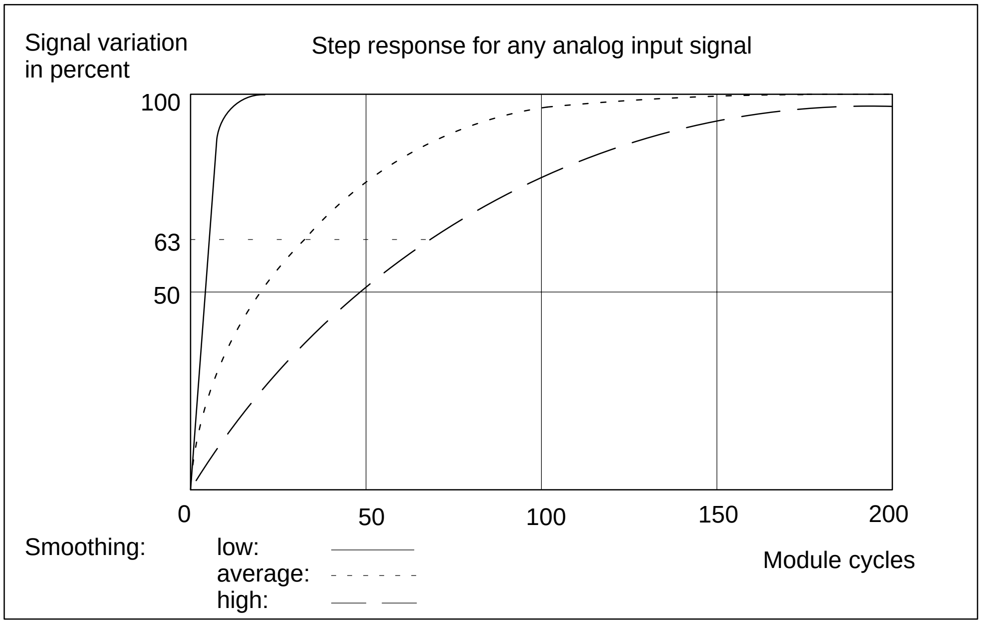


Figure 4-5 Example of the Influence of Smoothing on the Step Response

Additional information on smoothing

Refer to the specific section on the analog input module (from Section 4.18) to determine whether smoothing can be set for the specific module and for any special features that have to be taken into account.

Conversion time of the analog output channels

The conversion time of the analog output channels comprises the transfer of the digitized output values from the internal memory and the digital-to-analog conversion.

Scan time of analog output channels

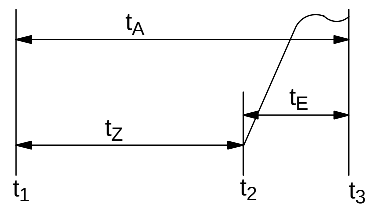
The analog output channels are converted sequentially – in other words, the analog output channels are converted one after the other.

The scan time – in other words, the time elapsing until an analog output value is again converted, is the sum of the conversion times of all activated analog output channels (refer to 4-4).

Tip

You should disable any analog channels that are not being used to reduce the scan time in *STEP 7*.

Overview of the settling time and response time of the analog output modules



t_A = Response time

t_Z = Cycle time corresponds to n $\times$ conversion time (n = activated channels)

t_E = Settling time

t_1 = New digitized output value is present

t_2 = Output value transferred and converted

t_3 = Specified output value reached

Figure 4-6 Settling and Response times of the Analog Output Channels

Settling time

The settling time (t_2 to t_3) – in other words, the time elapsing from application the converted value until the specified value is reached at the analog output – is load-dependent. A distinction is made between resistive, capacitive and inductive loads.

For the settling times of the different analog output modules as a function of load refer to the technical specifications of the module concerned, starting at Section 4.23.

Response time

The response time (t_1 to t_3) – in other words, the time elapsing from application of the digital output values in the internal memory until the specified value is reached at the analog output – in a worst case scenario is the sum of the scan time and the settling time.

You have a worst case situation, if, shortly prior to the transfer of a new output value, the analog channel has been converted and is not converted again until all other channels are converted (cycle time).

4.7 Analog Module Parameter Assignment

Introduction

Analog modules can have different characteristics. You can set the characteristics of the modules by means of parameter assignment.

Tools for parameter assignment

You assign parameters to analog modules with *STEP 7*. You must perform parameter assignment in STOP mode of the CPU.

When you have set all the parameters, download the parameters from the programming device to the CPU. On a transition from STOP to RUN mode, the CPU then transfers the parameters to the individual analog modules.

In addition, if necessary you must place the measuring range modules of the module in the necessary position (refer to Section 4.4).

Static and dynamic parameters

The parameters are divided into static and dynamic parameters.

Set the static parameters in STOP mode of the CPU, as described above.

You can similarly modify the dynamic parameters in the current user program by means of SFCs. Note, however, that after a change from RUN → STOP, STOP → RUN of the CPU, the parameters set in *STEP 7* apply again. You will find a description of the parameter assignment of modules in the user program in Appendix A.

Parameter	Settable with	CPU Operating State
Static	Programming device	STOP
Dynamic	Programming device	STOP
	SFC 55 in the user program	RUN

4.7.1 Parameters of the Analog Input Modules

The analog input modules use a subset of the parameters and ranges of values listed in the table below, depending on the functionality. Refer to the section on the module concerned, starting from Section 4.18, for the subset ”mastered” by the specific analog modules.

The default settings apply if you have not performed parameter assignment in *STEP 7*.

Table 4-39 Parameters of the Analog Input Modules

Parameter	Value Range	Default Settings	Para-meter Type	Scope
Enable • Diagnostics interrupt • Hardware interrupt upon limit violation • Hardware interrupt at end of cycle	 Yes/no Yes/no Yes/no	 No No No	Dynamic	Module
Trigger for hardware interrupt • Upper limit value • Lower limit value	Constraint possible due to measuring range 32511 to – 32512 – 32512 to 32511	–	Dynamic	Channel or Channel group
Diagnostics • Group diagnostics • With wire-break check	 Yes/no Yes/no	 No No	Static	Channel or Channel group

Table 4-39 Parameters of the Analog Input Modules, continued

Parameter	Value Range	Default Settings	Para-meter Type	Scope
Measurement • Measuring method	deactivated U Voltage 4DMU Current (four-wire transmitter) 2DMU Current (two-wire transmitter) R-4L Resistance (four-wire connection) R-3L Resistance, (three-wire connection) RTD-4L Bulb resistor (linear, four-conductor terminal) RTD-3L Bulb resistor (linear, three-conductor terminal) TC-I[1)] Thermocouple (internal comparison) TC-E[1)] Thermocouple (external comparison) TC-IL[2)] Thermocouple (linear, internal comparison) TC-EL[2)] Thermocouple (linear, external comparison) TC-L00C[2)] Thermocouple (linear, reference temp.0°C) TC-L50C[2)] Thermocouple (linear, reference temp.50°C)	U	Dynamic	Channel or Channel group
• Measuring range	For the settable measuring ranges of the input channels, please refer to the individual module description.	± 10 V		
• Reaction with open thermocouple	Overflow; underflow	Overflow		
• Temperature unit[3]	Degrees Celsius; degrees Fahrenheit; Kelvin	Degrees Celsius	Dynamic	Module
• Module filtering mode	8 channels, hardware filter 8 channels, software filter 4 channels, hardware filter	8 chan-nels, hardware filter	Dynamic	Module
• Temperature coefficient for temperature measurement with bulb resistor (RTD)	Platinum (Pt) 0.00385 Ω/Ω/°C 0.003916 Ω/Ω/°C 0.003902 Ω/Ω/°C 0.003920 Ω/Ω/°C 0.003851 Ω/Ω/°C Nickel (Ni) 0.00618 Ω/Ω/°C 0.00672 Ω/Ω/°C Copper (Cu) 0.00472 Ω/Ω/°C	0.00385	Dynamic	Channel or Channel group

Table 4-39 Parameters of the Analog Input Modules, continued

Parameter	Value Range	Default Settings	Para-meter Type	Scope
• Interference frequency suppression	400/60/50 Hz; 400 Hz; 60 Hz; 50 Hz; 10 Hz	50 Hz	Dynamic	Channel or Channel group
• Smoothing	None Low Average High	None	Dynamic	Channel or Channel group

1) The module supplies a decimal value of the measured thermal voltage to the CPU – for example, 27648 at 80 mV (refer to Table 4-10)
2) The module supplies a temperature value to the CPU – for example, 120°C (refer to Table 4-16)
3) 1 digit = 0.1°C; 1 digit = 0.1°F

4.7.2 Parameters of the Analog Output Modules

The analog output modules use a subset of the parameters and ranges of values listed in the table below, depending on the functionality. Refer to the section on the module concerned, starting from Section 4.23, for the subset ”mastered” by the specific analog modules.

The default settings apply if you have not performed parameter assignment in *STEP 7*.

Table 4-40 Parameters of the Analog Output Modules

Parameter	Value Range	Default Settings	Para-meter Type	Scope
Enable • Diagnostics interrupt	Yes/no	No	Dynamic	Module
Diagnostics • Group diagnostics	Yes/no	No	Static	Channel
Output • Output type	deactivated Voltage Current	U	Dynamic	Channel
• Output range	For the settable measuring ranges of the output channels, please refer to the individual module description.	±10 V		
Response with CPU-STOP	ASS Outputs de-energized LWH Hold last value EWS Apply substitute value	ASS	Dynamic	Channel

4.7.3 Parameters of the Analog Input/Output Modules

The analog input/output modules make available the parameters contained in the following table. The default settings apply if you have not performed parameter assignment in *STEP 7*.

Table 4-41 SM 334; AI 4/AO 2 x 12 Bit: Parameters

Parameter	Value Range	Default Setting	Para-meter Type	Scope
Input Measurement • Measuring method	deactivated U Voltage R-4L Resistance (four-conductor terminal) RTD-4L Bulb resistor (linear, four-conductor terminal)	RTD-4L	Dynamic	Channel
• Measuring range	0 to 10 V 10000 Ω Pt 100 climate	Pt 100 climate		
• Integration time	20 ms; 16.6 ms	20 ms		
Output • Output type	deactivated Voltage	U	Dynamic	Channel
• Output range	0 to 10 V	0 to 10 V		

4.8 Connecting Sensors to Analog Inputs

Introduction

You can connect different sensors to the analog input modules depending on the measuring method; voltage and current sensors, and resistors.

This section contains general information that is generally applicable to all the connection options for sensors described in the sections that follow.

Cables for analog signals

To reduce electrical interference, you should use twisted-pair shielded cables for the analog signals. The shield of the analog signal cables should be grounded at both cable ends.

If there are potential differences between the cable ends, an equipotential bonding current can flow over the shield, which leads to an interference of the analog signals. In such a case, you should ground the shield at one end of the cable only.

Isolated analog input modules

With the isolated analog input modules there is no electrical connection between the reference point of the measuring circuit M_{ANA} and the M terminal of the CPU.

You must use isolated analog input modules if a potential difference E_{ISO} can occur between the reference point of the measuring circuit M_{ANA} and the M terminal of the CPU. By means of a equipotential bonding conductor between the M_{ANA} terminal and the M terminal of the CPU, make sure that E_{ISO} does not exceed the permitted value.

Non-isolated analog input modules

With the non-isolated analog input modules, you must establish a connection between the reference point of the measuring circuit M_{ANA} and the M terminal of the CPU. Establish IM 153. For this purpose, connect the M_{ANA} terminal with the M terminal of the CPU and IM 153. A potential difference between M_{ANA} and the M terminal of the CPU and the IM 153 can result in corruption of the analog signal.

Limited potential difference E_{CM}

Only a limited potential difference E_{CM} (common mode voltage) may occur between the measuring lines M– of the input channels and the reference point of the measuring circuit M_{ANA}. In order to prevent the permissible value from being exceeded, you must take different actions, described below, depending on the potential connection of the sensors.

Abbreviations and mnemonics used in the figures below

The abbreviations and mnemonics used in the figures below have the following meanings:

M +:	Measuring lead (positive)
M –:	Measuring lead (negative)
M_{ANA}:	Reference potential of the analog measuring circuit
M:	Ground terminal
L +:	Terminal for 24 VDC supply voltage
E_{CM}:	Potential difference between inputs and reference potential of the M_{ANA} measuring circuit
E_{ISO}:	Potential difference between M_{ANA} and M terminal of CPU

Connecting isolated sensors

The isolated sensors are not connected with the local ground potential (local ground). They can be operated free of potential.

With isolated sensors, potential differences might arise between the different sensors. These potential differences can arise as a result of interference or the local distribution of the sensors.

In order to prevent the permissible value for E_{CM} from being exceeded when operating in areas with heavy EMC interference, we recommend you to connect M– with M_{ANA}.

You can operate the CPU in Grounded mode (refer to the figure below) or Ungrounded mode.

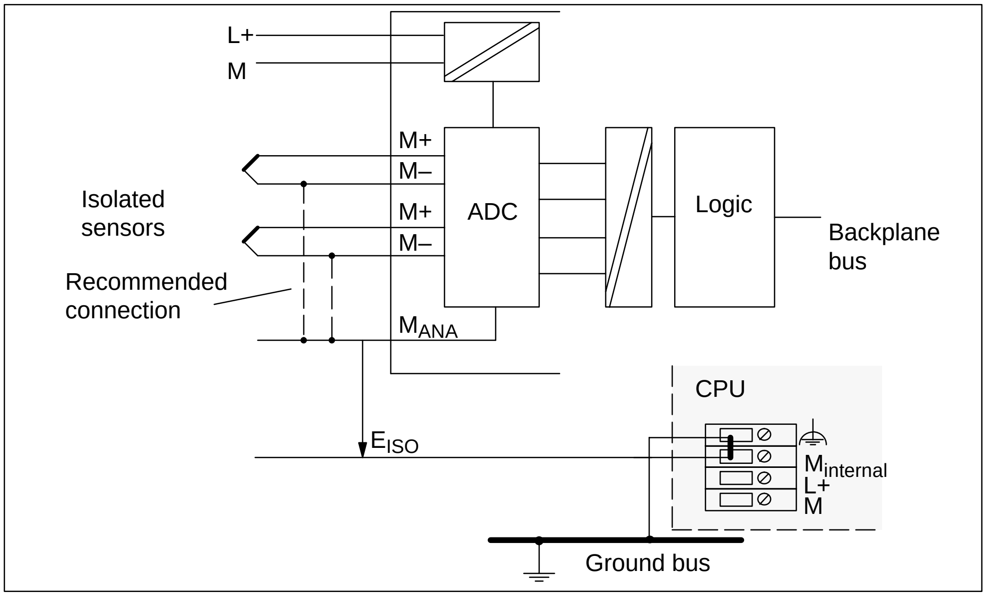


Figure 4-7 Connecting Isolated Sensors to an Isolated AI

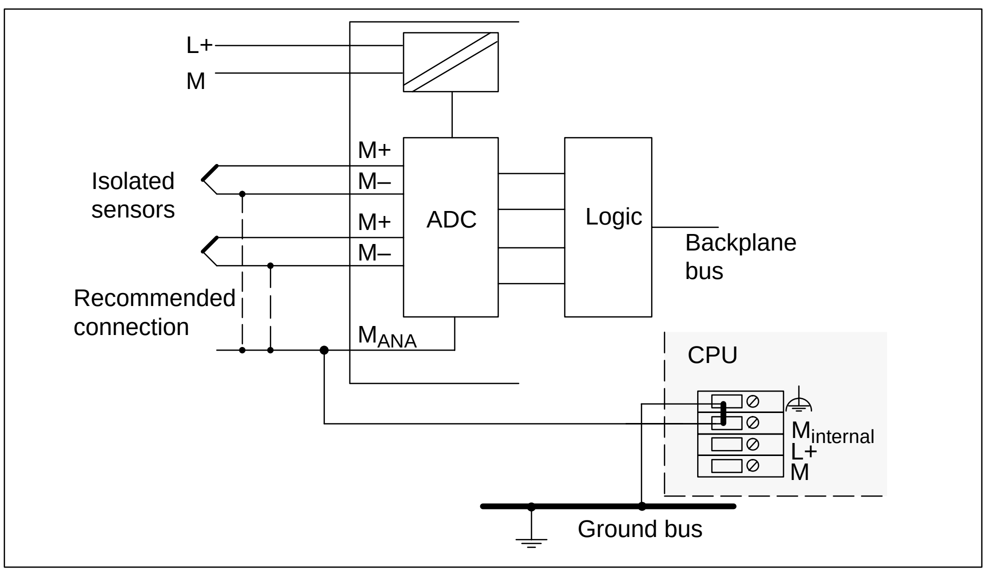


Figure 4-8 Connecting Isolated Sensors to a Non-Isolated AI

Note

Do not connect M– to M_{ANA} when connecting two-wire transmitters for current measurement and resistance-type sensors. This also applies to inputs which are not used.

Non-isolated sensors

The non-isolated sensors are connected with the local ground potential (local ground). When using non-isolated sensors, you must connect M_{ANA} to the local ground.

Connecting non-isolated sensors

Caused by local conditions or interferences potential differences E_{CM} (static or dynamic) can occur between the locally distributed individual measuring points. If the potential difference E_{CM} exceeds the permissible value, you must provide equipotential bonding conductors between the measuring points.

When connecting non-isolated sensors to optically isolated modules, you can operate the CPU in Grounded mode (refer to the figure below) or Ungrounded mode.

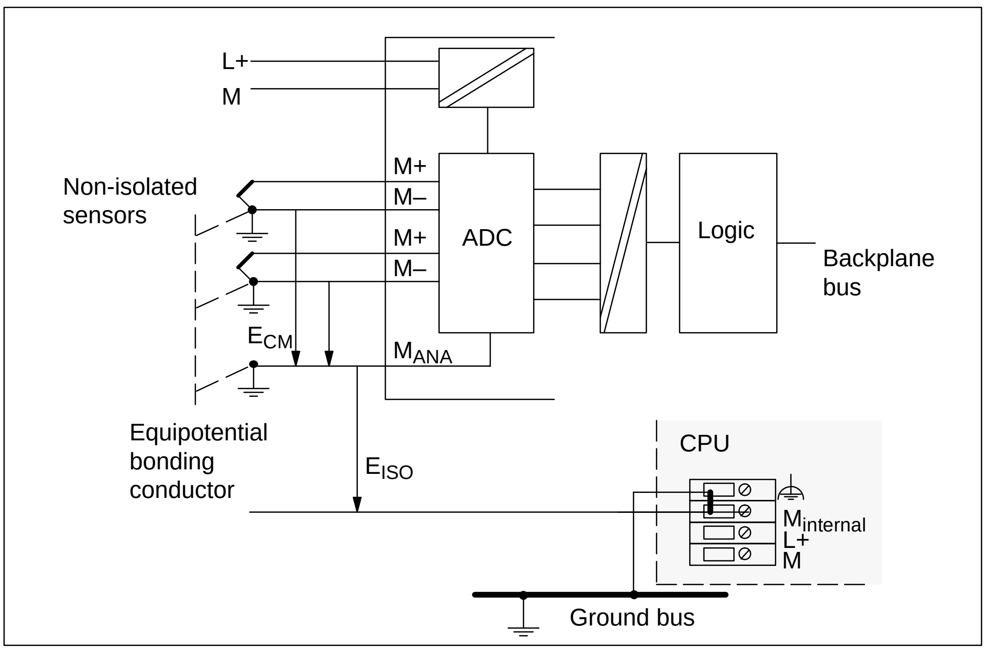


Figure 4-9   Connecting Non-Isolated Sensors to an Isolated AI

When connecting non-isolated sensors to non-isolated modules, you can operate the CPU only in Grounded mode.

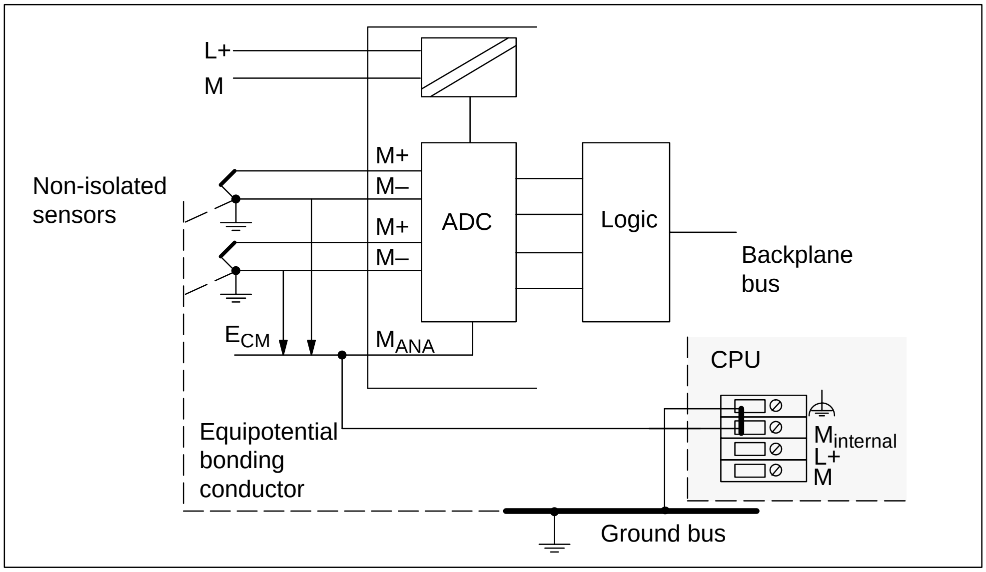


Figure 4-10 Connecting Non-Isolated Sensors to a Non-Isolated AI

Note

Non-isolated 2-wire transmitters and non-isolated resistance-type sensors may not be used with non-isolated AI!

4.9 Connecting Voltage Sensors

Note

The necessary connecting cables, which result from the potential connection of the analog input module and the sensors, are not drawn in the figures shown below.

In other words, you must continue to take note of and implement Section 4.8 with its generally valid information for connecting sensors.

Abbreviations and mnemonics used in the figure below

The abbreviations and mnemonics used in the figure below have the following meanings:

M +: Measuring lead (positive)

M –: Measuring lead (negative)

M_{ANA}: Reference potential of the analog measuring circuit

M : Ground terminal

L +: Terminal for 24 VDC supply voltage

Connection of voltage sensors

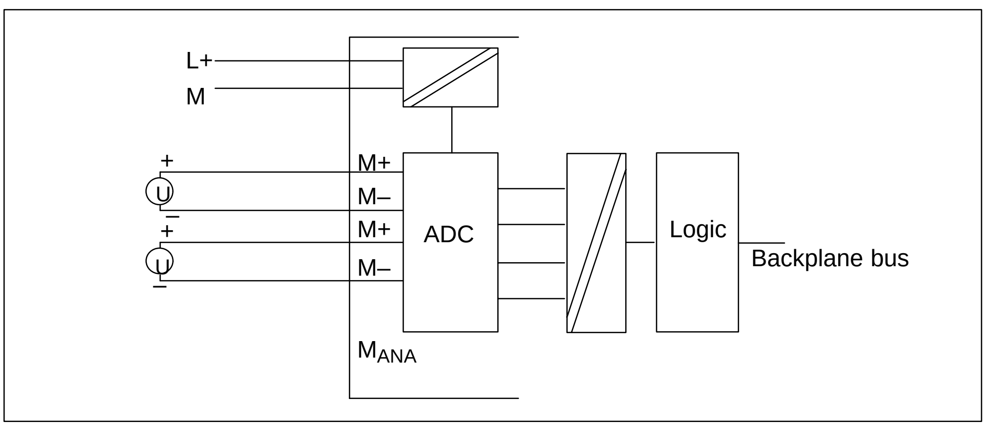


Figure 4-11 Connecting Voltage Sensors to an Isolated AI

4.10 Connecting Current Sensors

Note

The necessary connecting cables, which result from the potential connection of the analog input module and the sensors, are not drawn in the figures shown below.

In other words, you must continue to take note of and implement Section 4.8 with its generally valid information for connecting sensors.

Abbreviations and mnemonics used in the figures below

The abbreviations and mnemonics used in the figures below have the following meanings:

M +:	Measuring lead (positive)
M –:	Measuring lead (negative)
M_{ANA}:	Reference potential of the analog measuring circuit
M :	Ground terminal
L +:	Terminal for 24 VDC supply voltage

Supply voltage of the sensors

The two-wire transmitter receives its short-circuit-proof power supply via the terminals of the analog input module.
This transmitter then converts the measured variable into a current. Two-wire transmitters must be isolated sensors.

Four-wire transmitters have separate power supplies.

Connecting two-wire transmitters

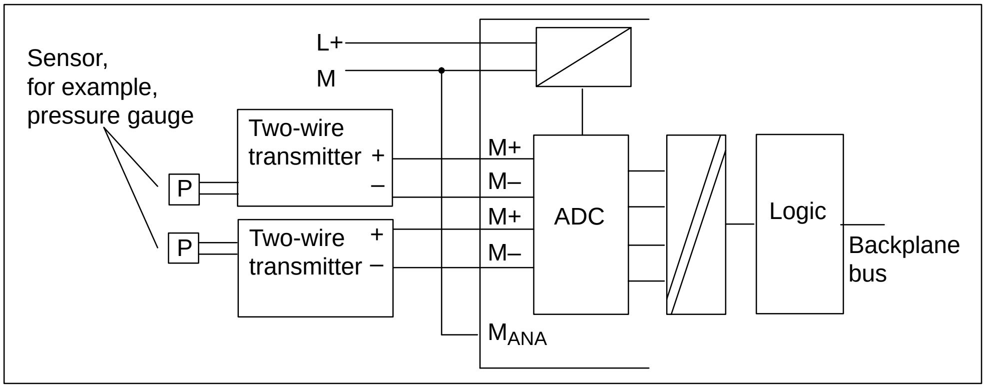


Figure 4-12 Connecting Two-Wire Transmitters to an Isolated AI

When the supply voltage L+ is fed from the module, you must assign parameters to the two-wire transmitter as a four-wire transmitter in *STEP 7*.

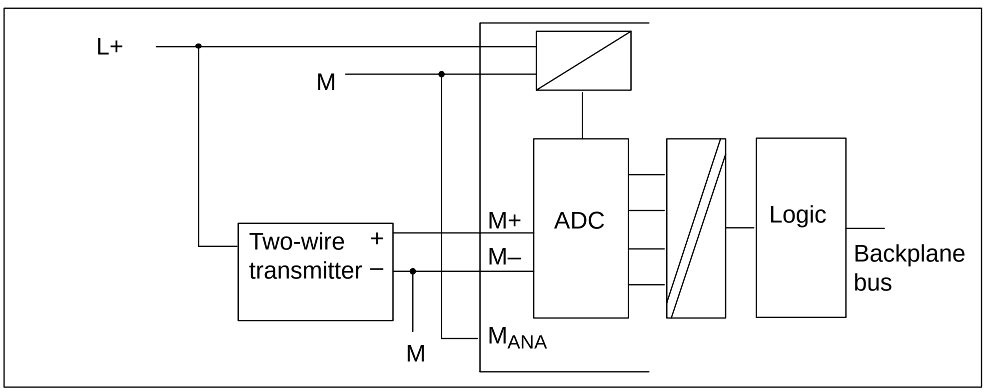


Figure 4-13 Connecting Two-Wire Transmitters Supplied from L+ to an Isolated AI

Connecting four-wire transmitters

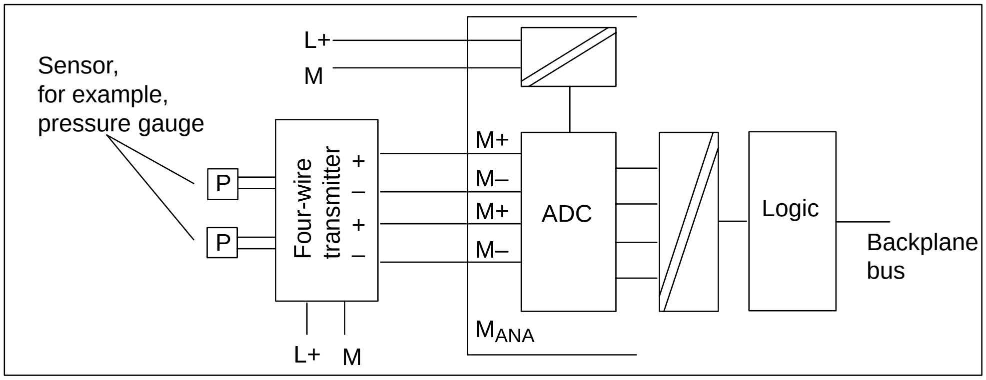


Figure 4-14 Connecting Four-Wire Transmitters to an Isolated AI

4.11 Connecting Resistance Thermometers and Resistors

Note

The necessary connecting cables, which result from the potential connection of the analog input module and the sensors, are not drawn in the figures shown below.

In other words, you must continue to take note of and implement Section 4.8 with its generally valid information for connecting sensors.

Abbreviations and mnemonics used in the figures below

The abbreviations and mnemonics used in the figures below have the following meanings:

- I_{C+}: Constant-current lead (positive)
- I_{C-}: Constant-current lead (negative)
- M_{+}: Measuring lead (positive)
- M_{-}: Measuring lead (negative)
- M_{ANA}: Reference potential of the analog measuring circuit
- M: Ground terminal
- L_{+}: Terminal for 24 VDC supply voltage

Connecting resistance thermometers and resistors

The resistance thermometers/resistors are wired in a four-wire, three-wire or two-conductor terminal.

With four-wire and four-conductor terminals, the module supplies a constant current via terminals I_{C+} and I_{C-} so that the potential drop occurring on the measuring cables is compensated. It is important that the connected constant current cables are directly connected to the resistance thermometer/resistor.

Measurements with four-wire or three-conductor terminals supply a more precise measuring result due to compensation than measurements with a two-conductor terminal.

Four-conductor connection of a resistance thermometer

The voltage generated at the resistance-type thermometer is measured via the M_+ and M_- terminals. When you connect, watch out for the polarity of the connected cable (connect I_{C+} and M+ as well as I_{C-} and M– to the resistance thermometer).

When connecting, make sure that the connected cables **I_C + and M+** and the cables **I_C – and M–** are connected directly to the resistance thermometer.

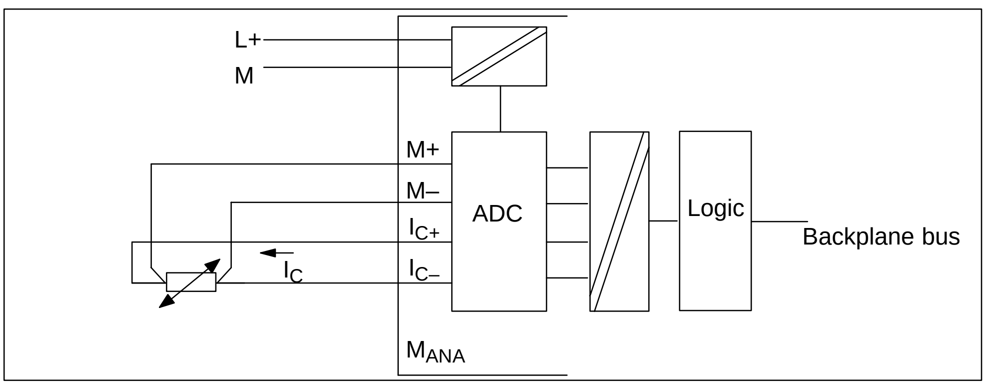


Figure 4-15 Four-Wire Connection of Resistance Thermometers to an Isolated AI

Three-conductor connection of a resistance thermometer

With a three-conductor terminal on modules with four terminals, you must normally insert a **jumper between M_{-} and I_{C-}** (refer to Figure 4-16). Take note of the exception for the SM 331; AI 8 × RTD (refer to Figure 4-17).

When connecting, make sure that the connected cables **I_C + and M+** are connected directly to the resistance thermometer.

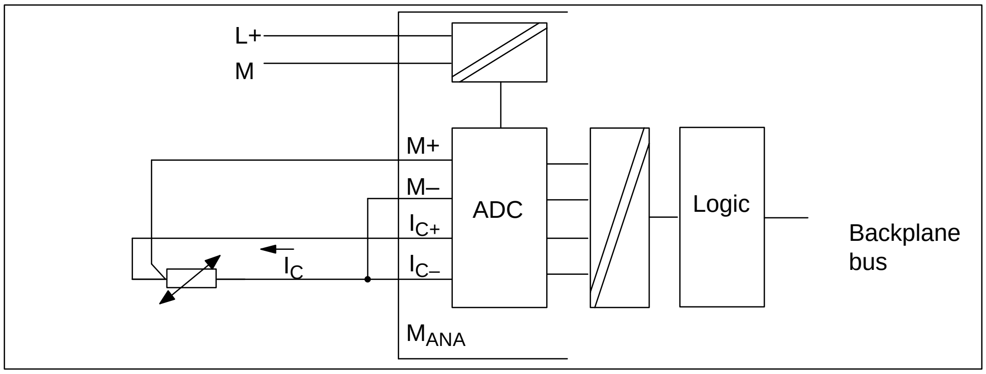


Figure 4-16 Three-Wire Connection of Resistance Thermometers to an Isolated AI

Three-conductor connection to the SM 331; AI 8 × RTD

With a three-conductor terminal to the SM 331; AI 8 × RTD, you must insert a **jumper between M_{+} and I_{C+}** (refer to Figure 4-17).

When connecting, make sure that the connected cables **I_C – and M–** are connected directly to the resistance thermometer.

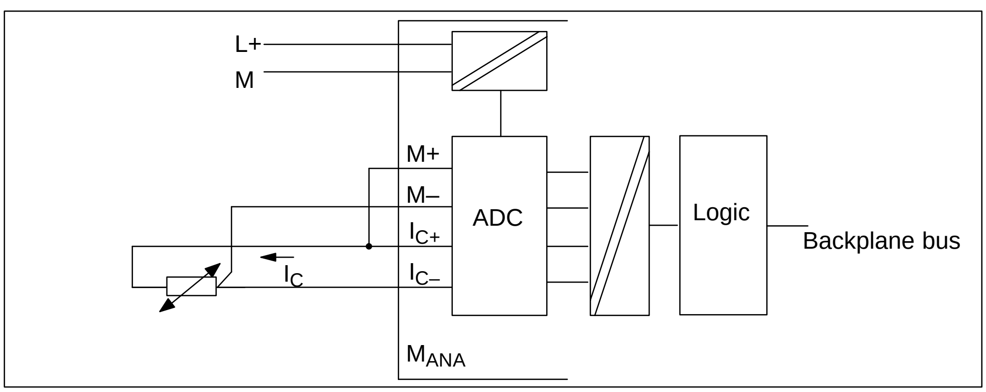


Figure 4-17 Three-Wire Connection of Resistance Thermometers to the SM 331; AI 8 × RTD

Caution

Incorrect wiring of the three-conductor terminal can lead to unforeseen operation of the module and dangerous conditions in the system.

Two-conductor connection of a resistance thermometer

With a two-conductor terminal, you must insert jumpers on the module between M_+ and I_{C+} and between M_- and I_{C-}.

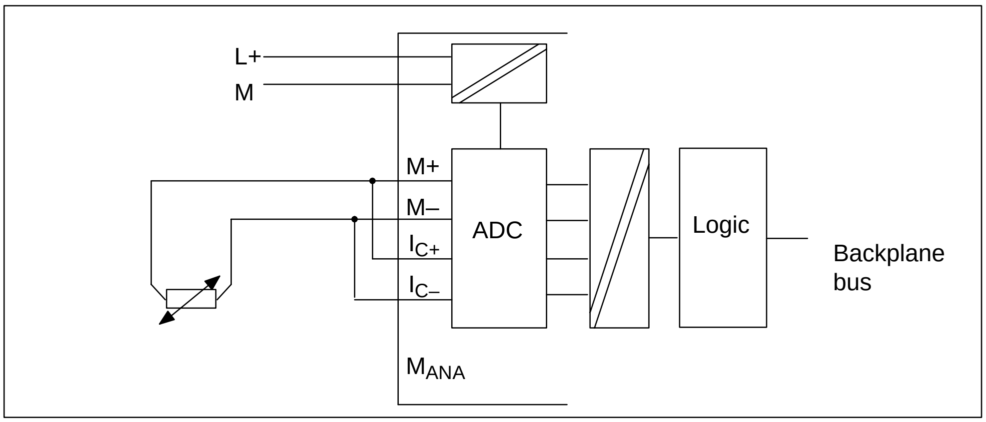


Figure 4-18   Two-Wire Connection of Resistance Thermometers to an Isolated AI

4.12 Connecting Thermocouples

Design of thermocouples

A thermocouple consists of a pair of sensors and the necessary installation and connecting parts. The thermocouple consists of two wires of dissimilar metals or metal alloys soldered or welded together at the ends.

There are different types of thermocouple, depending on the composition of the material used – for example, K, J, N thermocouples. The measuring principle of all thermocouples is the same, irrespective of their type.

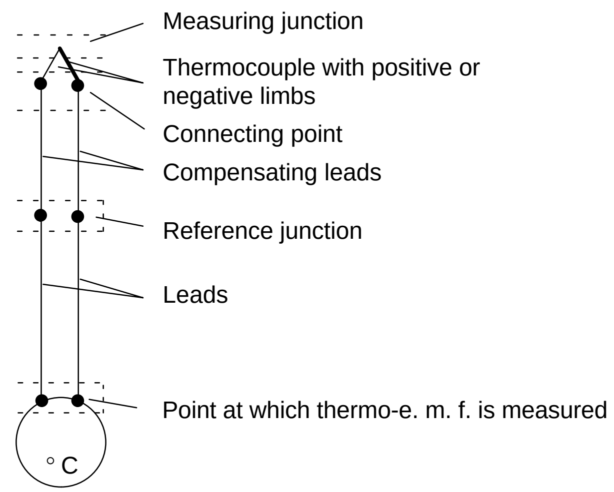


Figure 4-19 Design of Thermocouples

Principle of operation of thermocouples

If the measuring point is subjected to a temperature different from that of the free ends of the thermocouple (point of connection), a voltage, the thermo-e.m.f., occurs at the free ends. The magnitude of the thermo-e.m.f. generated depends on the difference between the temperature at the measuring junction and the temperature at the free ends, as well as on the material combination used for the thermocouple.

Since a thermocouple always measures a temperature difference, the free ends must be kept at a known temperature at a reference junction in order to determine the temperature of the measuring junction.

The thermocouples can be extended from their point of connection to the reference junction by means of compensating wires. These compensating wires consist of the same material as the thermocouple wires. The supply leads are copper wire. **Note:** Make sure these wires are connected with the correct polarity, otherwise there will be considerable measuring errors.

Compensation of the reference junction temperature

You can compensate for the effects of temperature fluctuations at the reference junction by means of compensating leads.

There are several options for you to choose from for acquiring the reference junction temperature in order to obtain an absolute temperature value from the difference in temperature between the reference junction and measuring point.

You can use internal or external compensation, depending on where you want the reference junction to be.

Table 4-42 Options for Compensation of the Reference Junction Temperature

Option	Explanation
No compensation	When you want to acquire only the difference in temperature between the measuring point and the reference junction
Internal compensation (refer to Figure 4-20 for connection)	If you employ internal compensation, the internal temperature (thermocouple internal comparison) of the module is used for comparison purposes.
External compensation with compensating box in the leads of an individual thermocouple (refer to Figures 4-21 and 4-22 for its connection)	You have already acquired and compensated the reference junction temperature (thermocouple external comparison) using a compensating box, which you have looped into an individual thermocouple. No further processing is necessary owing to the module.
Only for SM 331; AI 8 × TC: External compensation with resistance thermometer for acquisition of the reference junction temperature (refer to Figure 4-23 for connection)	You can acquire the reference temperature by means of a resistance thermometer (platinum or nickel) and have it calculated by the module for any thermocouple.

Theory of operation of internal compensation

With internal compensation, you can establish the reference point across the terminals of the analog input modules. In this case, you must run the compensating lines right up to the analog module. The internal temperature sensor acquires the temperature of the module and supplies a compensation voltage.

Note that internal compensation is not as accurate as external compensation.

Theory of operation of external compensation with compensating box

If you employ external compensation, the temperature of the reference junction of the thermocouples is taken into account via a compensating box, for example.

The compensating box contains a bridge circuit calibrated for a definite reference junction temperature. The reference junction is formed by the connections for the ends of the thermocouple's compensating leads.

If the actual temperature deviates from the compensating temperature, the temperature-sensitive bridge resistance changes. This results in a positive or negative compensating voltage, which is added to the thermo-e.m.f.

Abbreviations and mnemonics used in the figures below

The abbreviations and mnemonics used in the figures below have the following meanings:

M +: Measuring lead (positive)

M –: Measuring lead (negative)

$COMP_+$: Compensating terminal (positive)

$COMP_-$: Compensating terminal (negative)

M_{ANA}: Reference potential of the analog measuring circuit

M : Ground terminal

L +: Terminal for 24 VDC supply voltage

Note

The necessary connecting cables, which result from the potential connection of the analog input module and the sensors, are not drawn in the figures shown below.

In other words, you must continue to take note of and implement Section 4.8 with its generally valid information for connecting sensors.

Connection of thermocouples with internal compensation

Connect the thermocouples to the inputs of the module, either directly or by means of compensating lines. Each channel group can use a thermocouple type supported by the analog module independently of the other channel groups.

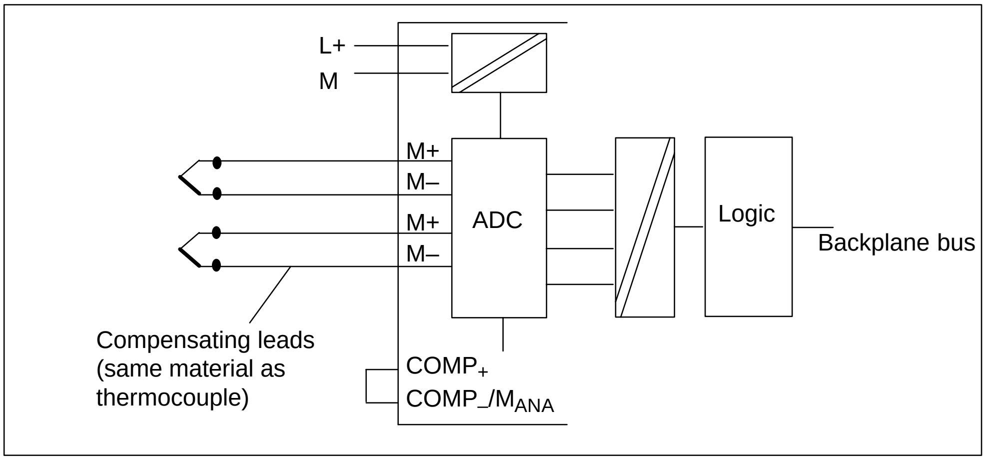


Figure 4-20 Connection of Thermocouples with Internal Compensation to an Isolated AI

Connecting the compensating box

Connect the compensating box to the COMP terminals of the module, locating the compensating box at the reference junction of the thermocouples. The compensating box must have an isolated supply. The power supply must have adequate filtering, for example by means of a grounded shielding winding.

The terminals for connecting the thermocouple to the compensating box are not required and must therefore be shorted (refer to Figure 4-22 for an example).

The following constraints apply:

- The parameters of a channel group are general valid for all channels of that group (for example, input voltage, integrating time etc.)
- External compensation with connection of the compensating box to the COMP terminals of the module can be performed only for one thermocouple type. In other words, all channels operating with external compensation must use the same type.

Connecting thermocouples with compensating box

If all thermocouples connected to the inputs of the module have the same reference junction, you compensate as follows:

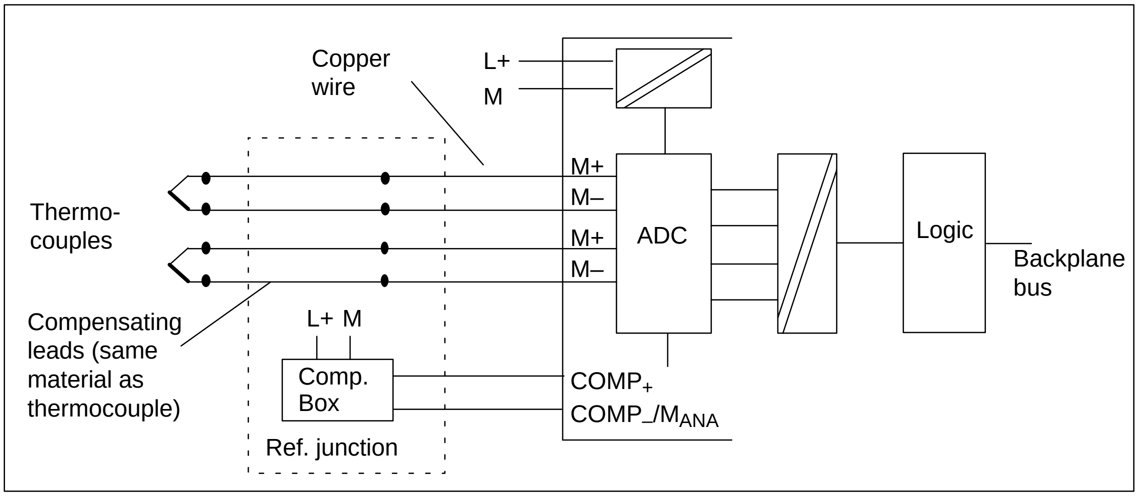


Figure 4-21 Connection of Thermocouples with Compensation Box to an Isolated AI

Note

Use compensating boxes with a **reference junction temperature of 0°C** for analog input modules.

Recommended compensating box

We recommend that you use a reference junction (with integrated power supply unit) from Siemens as a compensating box. You will find the necessary ordering data in the table below.

Table 4-43 Ordering Data of the Comparison Point

Recommended Compensating Box			Order Number
Reference junction with integrated power supply unit, for rail mounting			M72166-□□□□□
Auxiliary power	220 VAC		B1
	110 VAC		B2
	24 VAC		B3
	24 VDC		B4
Connection to thermocouple	Fe-CuNi	Type L	1
	Fe/Cu Ni	Type J	2
	Ni Cr/Ni	Type K	3
	Pt 10 % Rh/Pt	Type S	4
	Pt 13 % Rh/Pt	Type R	5
	Cu-CuNi	Type U	6
	Cu/Cu Ni	Type T	7
			00
Reference temperature	0°C		

Connecting to the reference junction (Order No. M72166-xxx00)

If all thermocouples connected to the inputs of the module have the same reference junction, you compensate as follows:

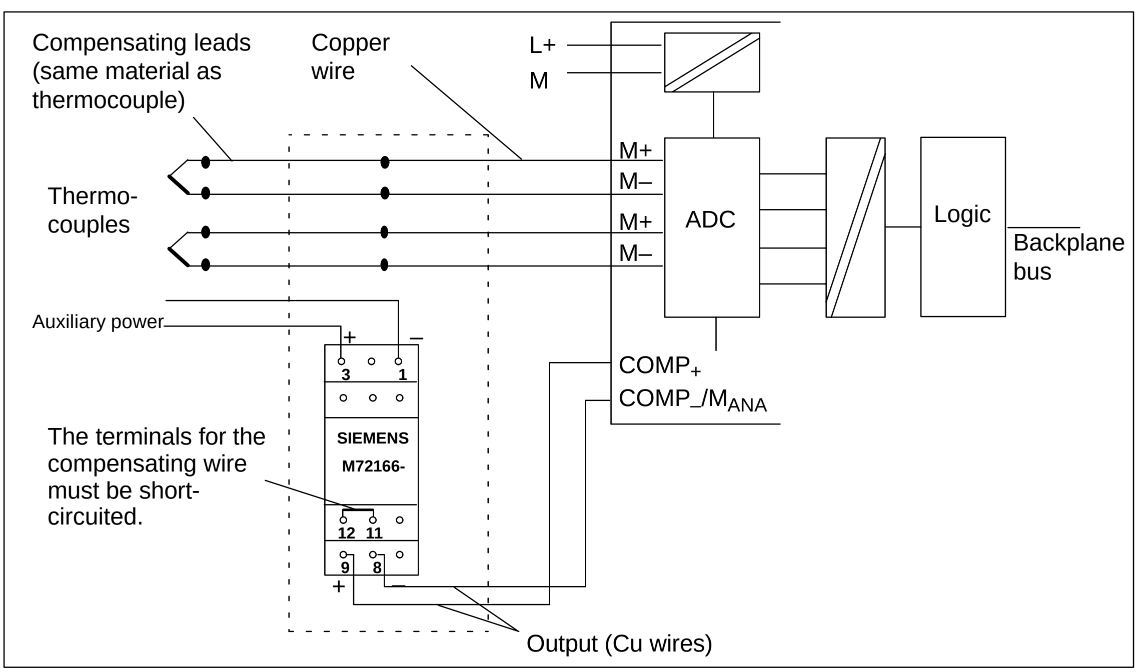
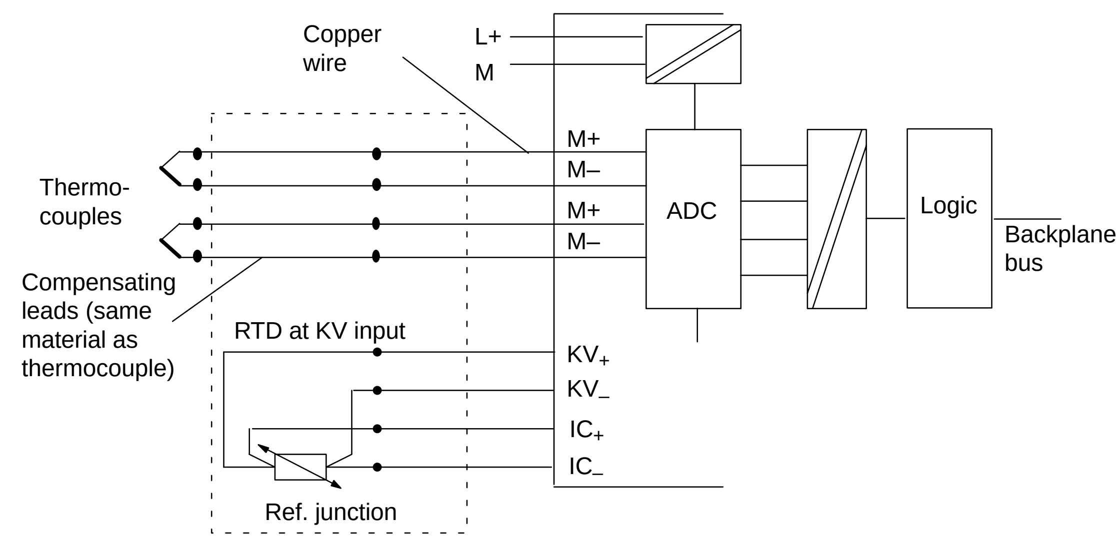


Figure 4-22 Connection of Thermocouples with Comparison Point (Order No. M72166-xxx00) to an Isolated AI

Connecting thermocouples with resistance thermometer to the SM 331; AI 8 × TC × 24 Bit

Connect the resistance thermometer to the special KV input of the SM 331; AI 8 × TC × 24 Bit. If all thermocouples connected to the inputs of the module have the same reference junction, you compensate as follows:



KV_+: Cold junction (positive)
KV_-: Cold junction (negative)
IC_+: Constant-current lead (positive)
IC_-: Constant-current lead (negative)

Figure 4-23 SM 331; AI 8 × TC × 24 Bit: Connection of Thermocouples of the Same Type with External Compensation by Means of a Resistance Thermometer

4.13 Connecting Loads/Actuators to Analog Output

Introduction

You can use the analog output modules to supply loads and actuators with current and voltage.

This section contains general information that is generally applicable to all the connection options for loads and actuators described in the sections that follow.

Cables for analog signals

For the analog signals, you should use shielded and twisted pair cables. The cables Q_V and S+ and M and S–, respectively, are to be twisted together. This reduces the interference. Ground the screen of the analog cables at both ends of the cables.

If there are potential differences between the cable ends, an equipotential bonding current, which can flow over the shield, can cause interference of the analog signals. In such a case, you should ground the shield at one end of the cable only.

Isolated analog output modules

With the isolated analog output modules there is no electrical connection between the reference point of the measuring circuit M_{ANA} and the M terminal of the CPU.

You must use isolated analog output modules if a potential difference E_{ISO} can occur between the reference point of the measuring circuit M_{ANA} and the M terminal of the CPU. By means of a equipotential bonding conductor between the M_{ANA} terminal and the M terminal of the CPU, make sure that E_{ISO} does not exceed the permitted value.

Non-Isolated analog output modules

With the non-isolated analog output modules, you must establish a connection between the reference point of the measuring circuit M_{ANA} and the M terminal of the CPU. Therefore, connect the M_{ANA} terminal with the M terminal of the CPU. A potential difference between M_{ANA} and the M terminal of the CPU can lead to a corruption of the analog signal.

4.14 Connecting Loads and Actuators to Voltage Outputs

Connecting loads to a voltage output

Connecting loads to a voltage output is possible both in a four-wire and a two-wire circuit. However, not all analog output modules allow both types of connection.

Note

The necessary connecting cables, which result from the potential connection of the analog output module, are not drawn in the figures shown below.

In other words, you must continue to take note of and implement Section 4.13 with its generally valid information for connecting loads and actuators.

Abbreviations and mnemonics used in the figures below

The abbreviations and mnemonics used in the figures below have the following meanings:

Q_V:	Analog output voltage
S +:	Detector lead (positive)
S –:	Detector lead (negative)
M_{ANA}:	Reference potential of analog circuit
R_L:	Load impedance
L +:	Terminal for 24 VDC supply voltage
M :	Ground terminal
E_{ISO}:	Potential difference between M_{ANA} and M terminal of CPU.

Connecting loads to a voltage output of an isolated module over a four-wire circuit

A high accuracy at the load can be achieved through the four-wire circuit. You must therefore connect the sensor leads (S– and S+) directly to the load. The voltage is thus measured and corrected directly at the load.

Interferences or a voltage drop can result in a potential difference between the sensor lead S– and the reference circuit of the analog circuit M_{ANA}. This potential difference must not exceed the permissible value. If the permissible potential difference is exceeded, the accuracy of the analog signal is impaired.

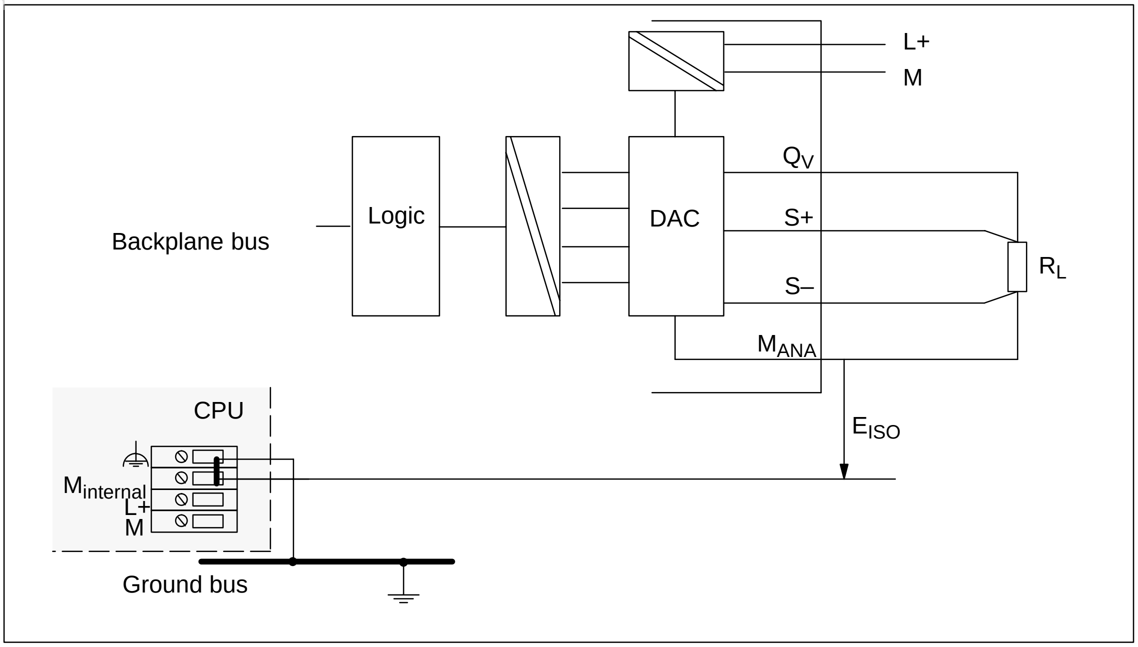


Figure 4-24 Connecting Loads to a Voltage Output of an Isolated AO over a Four-Wire Circuit

Connecting loads to a voltage output of a non-isolated module over a two-wire circuit

With a two-wire circuit, the S+ and S– terminals can be left open. However, you will not achieve the accuracy of a four-wire circuit.

Connect the load to terminals Q_V and the reference point of the measuring circuit, M_{ANA}.

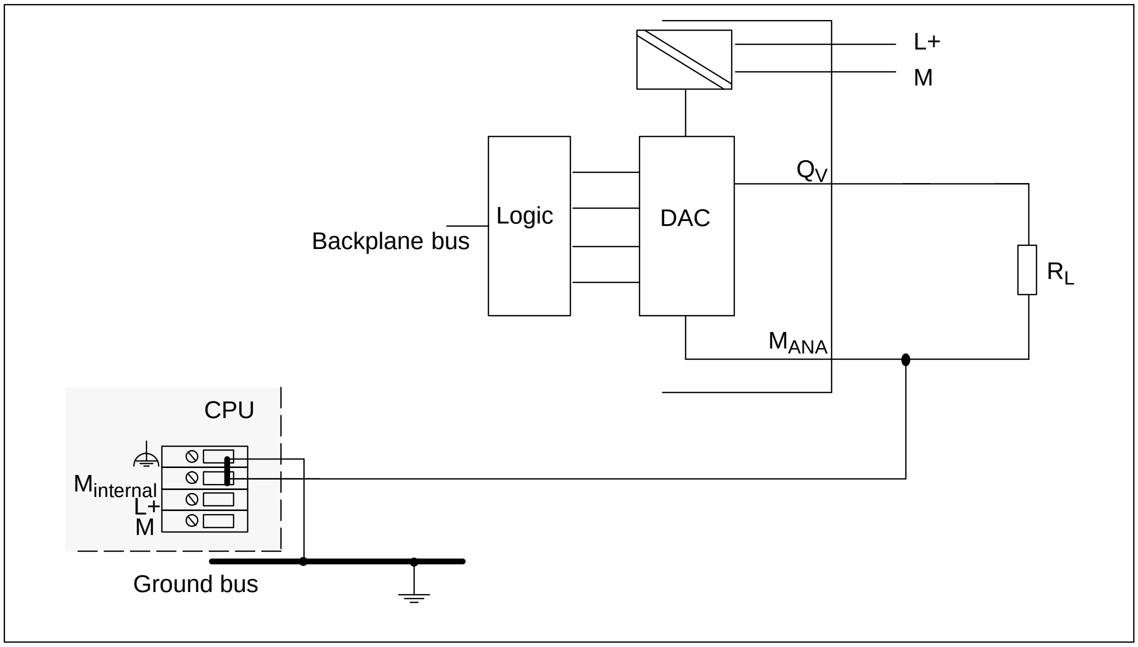


Figure 4-25 Connecting Loads to a Voltage Output of a Non-Isolated AO over a Two-Wire Circuit

4.15 Connecting Loads and Actuators to Current Outputs

Note

The necessary connecting cables, which result from the potential connection of the analog output module, are not drawn in the figures shown below.

In other words, you must continue to take note of and implement Section 4.13 with its generally valid information for connecting loads and actuators.

Abbreviations and mnemonics used in the figures below

The abbreviations and mnemonics used in the figures below have the following meanings:

- Q_I: Analog output current
- M_{ANA}: Reference potential of analog circuit
- R_L: Load impedance
- L +: Terminal for 24 VDC supply voltage
- M : Ground terminal
- E_{ISO}: Potential difference between M_{ANA} and M terminal of CPU.

Connecting loads to a current output

You must connect loads to Q_I and the reference point of the analog circuit M_{ANA} of a current output.

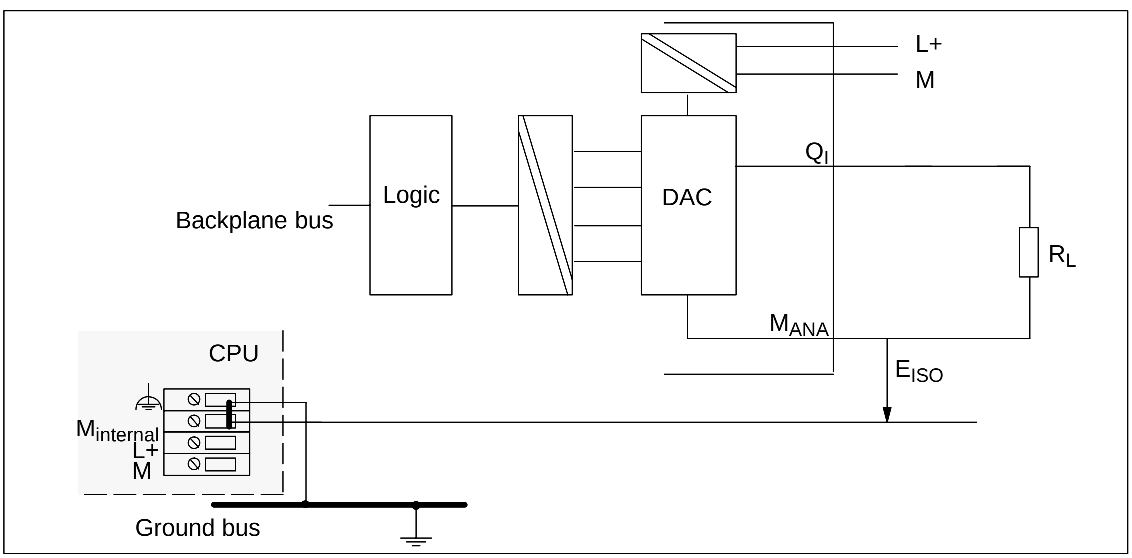


Figure 4-26 Connecting Loads to a Current Output of an Isolated AO

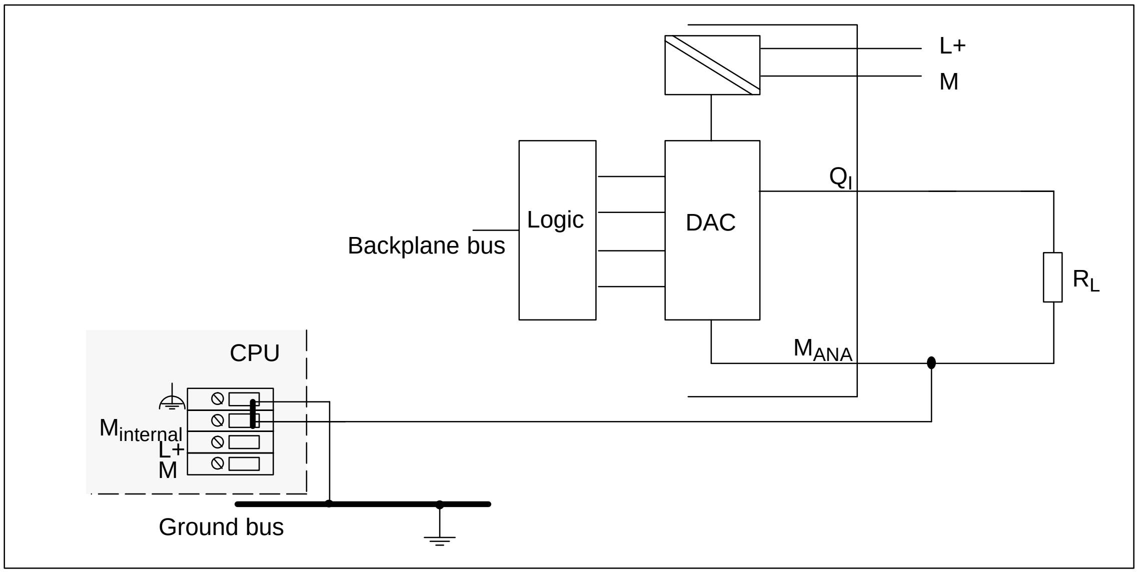


Figure 4-27 Connecting Loads to a Current Output of a Non-Isolated AO

4.16 Diagnostics of the Analog Modules

Programmable and non-programmable diagnostic messages

In diagnostics, we make a distinction between programmable and non-programmable diagnostic messages.

You obtain programmable diagnostic messages only if you have enabled diagnostics by parameter assignment. You perform parameter assignment in the ”Diagnostics” parameter field in *STEP 7* (refer to Section 4.7).

Non-programmable diagnostic messages are always made available by the analog module irrespective of diagnostics being enabled.

Actions following diagnostic message in *STEP 7*

Each diagnostic message leads to the following actions:

- The diagnostic message is entered in the diagnosis of the analog module and forwarded to the CPU.
- The error LED on the analog module lights.
- If you have programmed “Enable Diagnostic Interrupt” with STEP 7, a diagnostic interrupt is triggered and OB 82 is called (refer to Section 4.17).

Reading out diagnostic messages

You can read out detailed diagnostic messages by means of SFCs in the user program (refer to the Appendix “Diagnostic Data of Signal Modules”).

You can view the cause of the error in *STEP 7*, in the module diagnosis (refer to online Help for *STEP 7*).

Diagnostic message in the measured value of analog input modules

Every analog input module supplies the measured value $7FFF_H$ irrespective of the parameter assignment when an error is detected. This measured value means either Overflow, Malfunction or a channel is disabled.

Diagnostic message by means of SF LED

Every analog module indicates errors for you by means of your SF LED (group error LED). The SF LED lights as soon as a diagnostic message is triggered by the analog module. It goes out when all errors have been rectified.

Diagnostic messages of the analog input modules

The table below gives an overview of the diagnostic messages for the analog input modules.

Table 4-44 Diagnostic Messages of the Analog Input Modules

Diagnostics Message	LED	Diagnostics Effective for	Parameterizable
External auxiliary supply missing	SF	Module	No
Configuring/parameter assignment error	SF	Channel	Yes
Common-mode error	SF	Channel	Yes
Wire break	SF	Channel	Yes
Underflow	SF	Channel	Yes
Overflow	SF	Channel	Yes

Diagnostic messages of the analog output modules

The table below gives an overview of the diagnostic messages for the analog output modules.

Table 4-45 Diagnostics Messages of the Analog Output Modules

Diagnostics Message	LED	Diagnostics Effective for	Parameterizable
External auxiliary supply missing	SF	Module	No
Configuring/parameter assignment error	SF	Channel	Yes
Short-circuit to M	SF	Channel	Yes
Wire break	SF	Channel	Yes

Note

A prerequisite for detecting the errors indicated by programmable diagnostic messages is that you have assigned parameters to the analog module accordingly in *STEP 7*.

Causes of errors and remedial measures for analog input modules

Table 4-46 Diagnostics Messages of the Analog Input Modules, Causes of Errors and Remedial Measures

Diagnostics Message	Possible Error Cause	Remedy
External load voltage missing	Load voltage L+ of module missing	Feed supply L+
Configuring/parameter assignment error	Illegal parameters transferred to module	Check measuring range module
		Reassign module parameter
Common-mode error	Potential difference E_{CM} between the inputs (M–) and reference potential of measuring circuit (M_{ANA}) too high	Connect M– with M_{ANA}
Wire break	Resistance too high in the sensor connection	Use different type of sensor or connection, e.g. use conductors with a larger cross-sectional core area
	Open circuit between module and sensor	Close circuit
	Channel not connected (open)	Disable channel group (“measuring procedure” parameter)
		Connect channel
Underflow	Input value underflows underrange, error may be caused: Wrong measuring range selected	Configure other measuring range
	With the measuring ranges 4 to 20 mA and 1 to 5 V, if necessary by polarity reversal of sensor connection	Check terminals
Overflow	Input value overflows overrange	Configure other measuring range

Causes of errors and remedial measures for analog output modules

Table 4-47 Diagnostics Messages of the Analog Output Modules, Causes of Errors and Remedial Measures

Diagnostics Message	Possible Error Cause	Remedy
External load voltage missing	Load voltage L+ of module missing	Feed supply L+
Configuring/parameter assignment error	Illegal parameters transferred to module	Reassign module parameter
Short-circuit after M	Overload of output	Eliminate overload
	Short-circuit of output Q_V after M_{ANA}	Eliminate short circuit
Wire break	Actuator resistance too high	Use different type of actuator or connection, e.g. use conductors with a larger cross-sectional core area
	Open circuit between module and actuator	Close circuit
	Channel not used (open)	Disable channel group (“output type” parameter)

4.17 Interrupts of the Analog Modules

Introduction

In this Section, the interrupt behavior of the analog modules is described. The following interrupts exist:

- Diagnostic Interrupt
- Process interrupt

Note that not all analog modules have interrupt capability or they are only capable of a subset of the interrupts described here Refer to the technical specifications of the modules, starting at Section 4.18, to determine which analog modules have interrupt capability.

The OBs and SFCs mentioned below can be found in the online Help for *STEP 7*, where they are described in greater detail.

Enabling interrupts

The interrupts are not preset – in other words, they are inhibited without appropriate parameter assignment. Assign parameters to the Interrupt Enable in *STEP 7* (refer to Section 4.7).

Diagnostic interrupt

If you have enabled diagnostic interrupts, then active error events (initial occurrence of the error) and departing error events (message after troubleshooting) are reported by means of an interrupt.

The CPU interrupts execution of the user program and processes the diagnostics alarm block (OB 82).

In the user program, you can call SFC 51 or SFC 59 in OB 82 to obtain more detailed diagnostic information from the module.

The diagnostic information is consistent until such time as OB 82 is exited. When OB 82 is exited, the diagnostic interrupt is acknowledged on the module.

Hardware interrupt with trigger “Upper or lower limit exceeded”

Define a working range by setting parameters for an upper and lower limit value. If the process signal (for example, the temperature) leaves this working range, the module triggers a process interrupt, provided the interrupt is enabled.

The CPU interrupts execution of the user program and processes the hardware interrupt block (OB 40).

In the user program of OB 40, you can set how the programmable logic controller is required to react to a limit value being surpassed or not being reached.

When OB 40 is exited, the hardware interrupt is acknowledged on the module.

Note

Note that a hardware interrupt is not triggered if you have set the upper limit above the overrange or the lower limit below the underrange.

Structure of the start information tag OB40_POINT_ADDR of OB 40

The limit values exceeded by the different channels are entered in the start information of OB 40 in the tag OB40_POINT_ADDR. The following figure shows the assignment to the bits of local data double word 8.

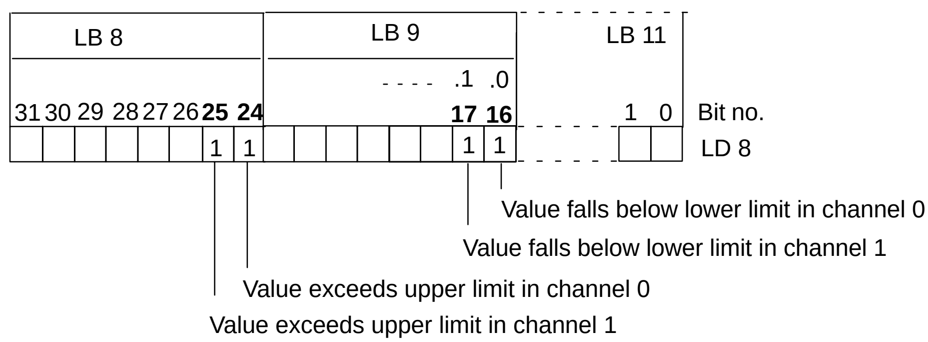


Figure 4-28 Start Information of OB 40: Which Event Has Triggered the Hardware Interrupt at the Limit Value

Hardware interrupt upon trigger “Reached end of scan cycle”

By parameterizing the hardware interrupt a the end of the scan cycle, you have the option of synchronizing a process with the scan cycle of the analog input module.

A scan cycle includes the conversion of the measured values of all enabled channels of the analog input module. The module processes the channels one after the other. After all the measured values have been converted, the module of the CPU reports by means of an interrupt that there are new measured values on all channels.

You can use the interrupt to load the currently converted analog values.

4.18 Analog Input Module SM 331; AI 8 $\times$ 12 Bit; (6ES7 331-7KF02-0AB0)

Order number

6ES7 331-7KF02-0AB0

Characteristics

The analog input module SM 331; AI 8 $\times$ 12 Bit has the following characteristic features:

- 8 inputs in 4 channel groups
- Measured-value resolution; settable per group (depending on the integration time set)
  - 9 bits + sign
  - 12 Bit + sign
  - 14 Bit + sign
- Measuring method selectable per channel group:
  - Voltage
  - Current
  - Resistors
  - Temperature
- Arbitrary measuring range selection per channel group
- Programmable diagnostics
- Programmable diagnostic interrupt
- Two channels with limit monitoring
- Programmable limit interrupt
- Galvanic isolation to the backplane bus interface
- Galvanic isolation to load voltage (**not** for two-wire transmitter)

Resolution

The resolution of the measured value is a direct function of the integration time selected. In other words the longer the integration time for an analog input channel, the more accurate the resolution of the measured value will be (see Technical Specifications of the module and Table 4-5 on page 4-9).

Terminal connection diagram and block diagram of the SM 331; AI 8 × 12 Bit

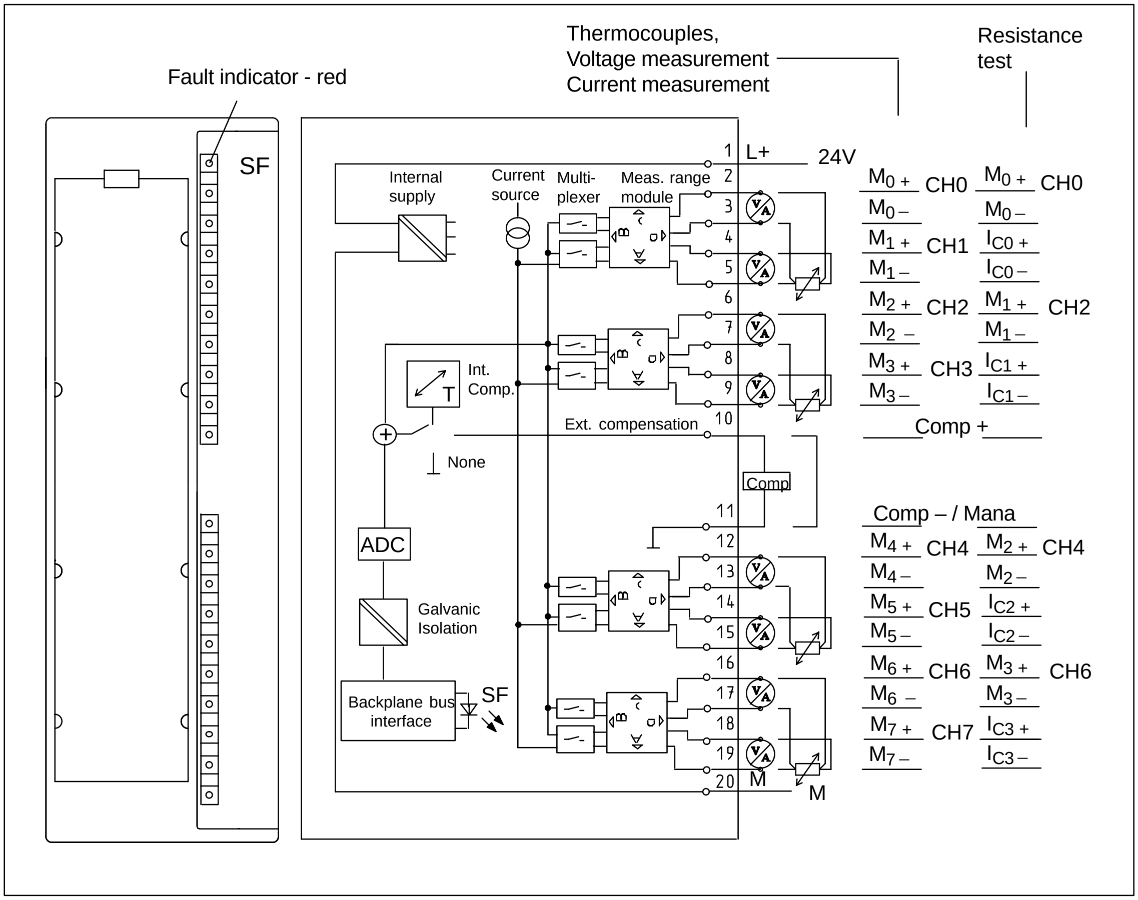


Figure 4-29 Module View and Block Diagram of the Analog Input Module SM 331; AI 8 × 12 Bit

The input resistances depend on the measuring range selected (see Technical Specifications).

Technical specifications of the SM 331; AI 8 × 12 Bit

Dimensions and Weight	
Dimensions W × H × D (in millimeters)	40 × 125 × 120
Weight	Approx. 250 g
Module-Specific Data	
Number of inputs	8
• For resistance-type sensor	4
Lenght of cable	max. 200 m
• Shielded	max. 50 m at 80 mV and thermocouples
Voltage, Currents, Potentials	
Power rated voltage of the electronics L +	24 VDC
• Reverse polarity protection	Yes
Power supply of the transmitters	
• Supply current	max. 60 mA (per channel)
• Short-circuit-proof	Yes
Constant measured current for resistance-type sensor	typ. 1.67 mA
Isolation	
• Between channels and backplane bus	Yes
• Between channels and power supply of the electronics	Yes
Permitted potential difference	
• Between inputs and M_{ANA} (E_{CM}) – At signal = 0 V – Not for two-wire transmitter	2.5 VDC
• Between the inputs (E_{CM})	2.5 VDC
• Between M_{ANA} and $M_{internal}$ (E_{ISO})	75 VDC / 60 VAC
Insulation tested with	500 VDC
Current consumption	
• From the backplane bus	max. 50 mA
• From the load voltage L +	max. 30 mA (without two-wire transmitter)

Power dissipation of the module	typ. 1 W			
Analog Value Generation				
Measuring principle	Integrating			
Integration time/conversion time/resolution (per channel)				
• Parameters can be assigned	Yes			
• Integration time in ms	2.5	$16^2/_3$	20	100
• Basic conversion time including Integration time in ms	3	17	22	102
Additional conversion time for measuring resistance, in ms or	1	1	1	1
Additional conversion time for open-circuit monitoring, in ms or	10	10	10	10
Additional conversion time for measuring resistance **and** open-circuit monitoring, in ms	16	16	16	16
• Resolution in bits including sign	9 bits	12 bits	12 bits	14 bits
• Suppression of interference voltage for interference frequency f1 in Hertz	400	60	50	10
• Basic response time of module, in ms (all channels enabled)	24	136	176	816
Smoothing of the measured values	None			

Suppression of interference, Limits of Error		
Suppression of interference for f = nx (f1 ± 1 %), (f1 = interference frequency)		
• Common-mode interference (E_{CM} < 2.5 V)	> 70 dB	
• Series-mode interference (peak value of the interference < rated value of the input range)	> 40 dB	
Crosstalk between the inputs	> 50 dB	
Operational limit (in the entire temperature range, with reference to the input range)		
• Voltage input	80 mV	± 1 %
	250 to 1000 mV	± 0.6 %
	2.5 to 10 V	± 0.8 %
• Current input	3.2 to 20 mA	± 0.7 %
• Resistor	150Ω; 300Ω; 600 Ω	± 0.7 %
• Thermocouple	Type E, N, J, K, L	± 1, 1 %
• Resistance thermometer	Pt 100/ Ni 100	± 0.7 %
	Pt 100 climate	± 0.8 %
Basic error (operational limit at 25 °C with reference to the input range)		
• Voltage input	80 mV	± 0.7 %
	250 to 1000 mV	± 0.4 %
	2.5 to 10 V	± 0.6 %
• Current input	3.2 to 20 mA	± 0.5 %
• Resistor	150Ω; 300Ω; 600 Ω	± 0.5 %
• Thermocouple	Type E, N, J, K, L	± 0.7 %
• Resistance thermometer	Pt 100/ Ni 100	± 0.5 %
	Pt 100 climate	± 0.6 %
Temperature error (with reference to the input range)	± 0.005 %/K	
Linearity error (with reference to the input range)	± 0.05 %	

Repeatability (in steady state at 25 °C with reference to the input range)	± 0.05 %	
Temperature error of the internal compensation	± 1 %	
Status, Interrupts, Diagnostics		
Interrupts		
• Hardware interrupt when limit has been exceeded	Parameters can be assigned Channels 0 and 2	
• Diagnostic Interrupt	Parameters can be assigned	
Diagnostic functions	Parameters can be assigned	
• Group error display	Red LED (SF)	
• Diagnostic information can be displayed	Possible	
Data for Selecting a Sensor		
Input range (rated values)/ Input resistance		
• Voltage	± 80 mV	/10 MΩ
	± 250 mV	/10 MΩ
	± 500 mV	/10 MΩ
	±1000 mV	/10 MΩ
	± 2.5 V;	/100kΩ
	± 5 V;	/100kΩ
	1 to 5 V;	/100kΩ
	± 10 V;	/100kΩ
• Current	± 3.2 mA	/25 Ω
	± 10 mA	/25 Ω
	± 20 mA	/25 Ω
	0 to 20 mA;	/25 Ω
	4 to 20 mA:	/25 Ω
• Resistor	150 Ω	/10 MΩ
	300 Ω	/10 MΩ
	600 Ω	/10 MΩ
• Thermocouple	Type E, N, J, K, L	/10 MΩ
• Resistance thermometer	Pt 100, Ni 100	/10 MΩ
Maximum input voltage for voltage input (destruction limit)	20 V continuous; 75 V for max. 1 s (pulse duty factor 1:20)	
Maximum input current for current input (destruction limit)	40 mA	

Connection of the sensor	
• For measuring voltage	Possible
• For measuring current	
As two-wire transmitter	Possible
As four-wire transmitter	Possible
• For measuring resistance	
With two-conductor terminal	Possible
With three-conductor terminal	Possible
With four-conductor terminal	Possible
• Load of the two-wire transmitter	max. 820 Ω

Characteristic linearization	Parameters can be assigned
• For thermocouples	Type E, N, J, K, L
• For RTD Resistance Temperarture Detector	Pt 100 (standard, climate range) Ni 100 (standard, climate range)
Temperature compensation	Parameters can be assigned
• Internal temperature compensation	Possible
• External temperature compensation with compensating box	Possible
• Compensation for 0 °C reference junction temperature	Possible
• Technical unit for measuring temperature	Degrees Celsius

4.18.1 Commissioning the SM 331; AI 8 × 12 Bit

You set the mode of operation of the SM 331; AI 8 × 12 Bit by means of measuring range modules on the module and in *STEP 7*.

Meas. range module

If necessary, the measuring range modules must be replugged to change the measuring method and the measuring range. The steps you have to perform to do this are described in detail in Section 4.4.

The corresponding table in Section 4.18.2 tells you which assignment you have to select for which measuring method and measuring range. In addition, the necessary settings are embossed on the module.

Default settings for measuring range module

The measuring range modules are preset to ”B” (voltage; ± 10 V) when the module is supplied.

To use the following preset measuring methods and measuring ranges, you only have to change the measuring range module to the corresponding setting. Parameter assignment in *STEP 7* is not necessary.

Table 4-48 Default Settings of the SM 331; AI 8 × 12 Bit Using Measuring Range Modules

Measuring Range Module Setting	Measuring Method	Measuring Range
A	Voltage	± 1000 mV
B	Voltage	± 10 V
C	Current, four-wire transmitter	4 to 20 mA
D	Current, two-wire transmitter	4 to 20 mA

Parameter

You will find a description of the general procedure for assigning parameters to analog modules in Section 4.7.

An overview of the parameters that you can set and their default settings are shown in the table below.

Table 4-49 Parameters of the SM 331; AI 8 $\times$ 12 Bit

Parameter	Value Range	Default Settings	Parameter Type	Scope
Enable • Diagnostic interrupt • Hardware interrupt upon limit violation	 Yes/no Yes/no	 No No	 Dynamic	 Module
Trigger for hardware interrupt • Upper limit value • Lower limit value	Constraint possible due to measuring range. 32511 to – 32512 – 32512 to 32511	–	Dynamic	Channel
Diagnostics • Group diagnostics • With wire-break check	 Yes/no Yes/no	 No No	Static	Channel group
Measurement • Measuring Method	 Deactivated U Voltage 4DMU Current (four-wire transmitter) 2DMU Current (two-wire transmitter) R-4L Resistance (four-conductor terminal) RTD-4L Bulb resistor (linear, four-conductor terminal) TC-I Thermocouple (internal comparison) TC-E Thermocouple (external comparison) TC-IL Thermocouple (linear, internal comparison) TC-EL Thermocouple (linear, external comparison)	 U	Dynamic	Channel or Channel group
• Measuring Range	Refer to Section 4.18.2 for the measuring ranges of the input channels that you can set.	$\pm$10 V		
• Interference Suppression	400 Hz; 60 Hz; 50 Hz; 10 Hz	50 Hz		

Channel groups

The channels of the SM 331; AI 8 × 12 Bit are arranged in four groups of two. You can only ever assign parameters to one channel group.

The analog input module SM 331; AI 8 × 12 Bit has a measuring range module for each channel group.

The table below shows which channels are parameterized as a channel group in each case. You will need the channel group number to set the parameters in the user program with an SFC.

Table 4-50 Assignment of Channels of the SM 331; AI 8 × 12 Bit to Channel Groups

Channels ...	... form one Channel Group each
Channel 0	Channel group 0
Channel 1	
Channel 2	Channel group 1
Channel 3	
Channel 4	Channel group 2
Channel 5	
Channel 6	Channel group 3
Channel 7	

Special characteristic of channel groups with resistance measurement

If you use the resistance measurement method, there is only one channel per channel group. The “2nd” channel of each group is used for current injection (I_C).

The measured value is obtained by accessing the “1st” channel of the group. The “2nd” channel of the group has the default carry value “$7FFF_H$”.

Special characteristic of channel groups for hardware interrupts

You can set hardware interrupts in *STEP 7* for the channel groups 0 and 1. Note, however, that a hardware interrupt is set only for the first channel in the channel group in each case – in other words, for channel 0 or channel 2

Diagnostics

You will find the diagnostic messages that are grouped under the “group diagnosis” parameter in Table 4-44, on page 4-69.

4.18.2 Measuring Methods and Measuring Ranges of the SM 331; AI 8 × 12 Bit

Measuring methods

You can set the following measuring methods for the input channels:

- Voltage measurement
- Current measurement
- Resistance test
- Temperature measurement

You perform the setting by means of the measuring range modules on the module and with the “measuring method” parameter in *STEP 7*.

Unused channels

You must short-circuit unused channels and connect them to M_{ANA}. In this way, you obtain an optimum interference immunity for the analog input module. Set the ”measuring method” parameter for unused channels to “disabled”. In this way you shorten the scan time of the module.

If you do not use the COMP input, you must short-circuit it also.

Special characteristics of unused channels for some measuring ranges

Since configured inputs can remain unused because of the channel group generation, you must take note of the following special characteristics of these inputs to enable the diagnostic functions on the used channels.

- **Measuring range 1 to 5 V:** Connect the unused input in parallel with a used input of the same channel group.
- **Current measurement, two-wire transmitter:** There are two ways to use the channels:
  a) Leave the unused input open and do not enable diagnostics for this channel group. With enabled diagnostics, the analog module will otherwise trigger a diagnostic interrupt once and the group error LED on the analog module lights up.
  b) Connect a 1.5 to 3.3 kΩ resistor to the unused input. You may then enable diagnostics for this channel group.
- **Current measurement 4 to 20 mA, four-wire transmitter:** Connect the unused input in series with an input of the same channel group.

Special characteristic when all channels are disabled

If you disable **all** input channels of the module and enable diagnostics when parameterizing the analog input module SM 331; AI 8 × 12 Bit, the module does **not** indicate that the “external auxiliary voltage” is missing.

Measuring ranges

You perform the setting of the measuring ranges by means of the measuring range modules on the module and with the “measuring method” parameter in *STEP 7*.

Table 4-51 Measuring Ranges of the SM 331; AI 8 × 12 Bit

Method Selected	Measuring Range (Type of Sensor)	Measuring Range Module Setting	Description
U: voltage	± 80 mV ± 250 mV ± 500 mV ± 1000 mV	A	You will find the digitized analog values in Section 4.3.1 in the voltage measuring range
	± 2.5 V ± 5 V 1 to 5 V ± 10 V	B	
TC-I:thermocouple (internal compensation) (thermovoltage measurement)	Type N [NiCrSi-NiSi] Type E [NiCr-CuNi] Type J [Fe-CuNi] Type K [NiCr-Ni] Type L [Fe-CuNi]	A	You will find the digitized analog values in Section 4.3.1 in ± 80 mV the voltage measuring range
TC-E:thermocouple (external compensation) (thermovoltage measurement)			
2DMU: current (two-wire transmitter)	4 to 20 mA	D	You will find the digitized analog values in Section 4.3.1 in the current measuring range
4DMU: current (four-wire transmitter)	± 3.2 mA ± 10 mA 0 to 20 mA 4 to 20 mA ± 20 mA	C	
R-4L: resistor (four-wire circuit)	150 Ω 300 Ω 600 Ω	A	You will find the digitized analog values in Section 4.3.1 in the resistance measuring range

Table 4-51 Measuring Ranges of the SM 331; AI 8 × 12 Bit, continued

Method Selected	Measuring Range (Type of Sensor)	Measuring Range Module Setting	Description
TC-IL: thermocouple (linear, internal compensation) (temperature measurement)	Type N [NiCrSi-NiSi] Type E [NiCr-CuNi] Type J [Fe-CuNi] Type K [NiCr-Ni] Type L [Fe-CuNi]	A	You will find the digitized analog values in Section 4.3.1 in the temperature range The characteristics are linearized: • Pt 100 to DIN IEC 751 • Ni 100 according to IEC DIN 43760 • Thermocouple to DIN 584, type L to DIN 43710.
TC-EL: thermocouple (linear, external compensation) (temperature measurement)			
RTD-4L: bulb resistor linear, four-conductor terminal (temperature measurement)	Pt 100 climate Ni 100 climate Pt 100 standard Ni 100 standard	A	

Default settings

The default settings of the module in *STEP 7* are the ”voltage” measuring method und the ”± 10 V” measuring range. You can use this combination of measuring method and measuring range without parameterizing the SM 331; AI 8 × 12 Bit in *STEP 7*.

Wire-break check

The wire-break check is intended primarily for temperature measurements (thermocouples and bulb Resistors).

Special characteristics of the wire-break check for the 4 to 20 mA measuring range

With a parameterized measuring range of 4 to 20 mA and **enabled wire-break check**, the analog input module enters wire break in the diagnosis when a current falls below 3.6 mA.

If you have enabled diagnostics interrupt during configuration, the module additionally triggers a diagnostic interrupt.

If no diagnostics interrupt has been enabled, the illuminated SF LED is the only indication of the wire break and you must evaluate the diagnostic bytes in the user program.

With a parameterized measuring range of 4 to 20 mA and **disabled wire-break check** and enabled diagnostic interrupt, the module triggers a diagnostic interrupt when the underflow is reached.

4.19 Analog Input Module SM 331; AI 8 $\times$ 16 Bit; (6ES7 331-7NF00-0AB0)

Order Number

6ES7 331-7NF00-0AB0

Characteristics

The analog input module SM 331; AI 8 $\times$ 16 Bit has the following characteristic features:

- 8 inputs in 4 channel groups
- Measured-value resolution 15 Bit + sign (independent of integration time)
- Measurement mode selectable per channel group:
  - Voltage
  - Current
- Arbitrary measuring range and filter/update rate selection per channel group
- Programmable diagnostics
- Programmable diagnostic interrupt
- Two channels with limit monitoring
- Programmable limit interrupt
- Galvanic isolation to the backplane bus interface
- Permissible common mode voltage between channels of 50 VDC maximum

Terminal connection diagram and block diagram of the SM 331; AI 8 × 16 Bit

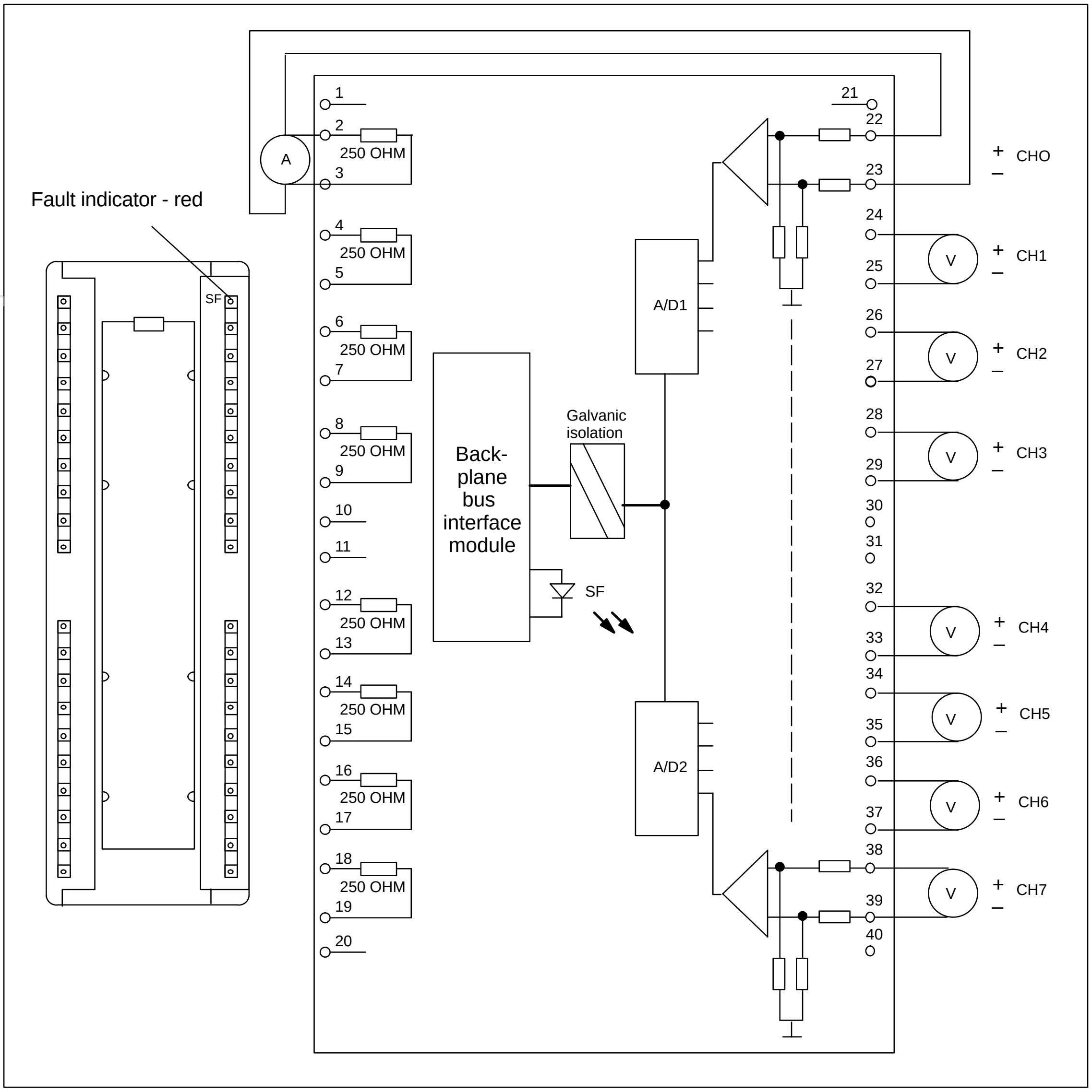


Figure 4-30 Module View and Block Diagram of the Analog Input Module SM 331; AI 8 × 16 Bit

Note that Channel 0 is configured for current and Channel 7 is configured for voltage.

Note

An external protective network is required in the signal leads conforming according to IEC 61000-4-5 (150 V/14 mm MOV across each + and – input to chassis ground)

Wiring of the module for measuring current

Current measurements are made by paralleling a channel's voltage input terminals with its respective current sense resistor. This is accomplished by jumpering the channels input terminals to the adjacent terminals on the field connector.

For example, to configure channel 0 for current mode, you must jumper terminal 22 to 2 and terminal 23 to 3.

The channel being configured for current measurements must be paired with the sense resistor connected to the channel's adjacent terminals in order to achieve the specified accuracy.

Technical specifications of the SM 331; AI 8 × 16 Bit

Dimensions and Weight	
Dimensions W × H × D (in millimeters)	40 × 125 × 120
Weight	Approx. 272 g
Module-Specific Data	
Number of inputs	8
Lenght of cable	
• Shielded	max. 200 m
Voltage, Currents, Potentials	
Isolation	
• Between channels and backplane bus	Yes
Permitted potential difference	
• Between the inputs (E_{CM})	50 VDC, 35 VAC
• Between M_{ANA} and $M_{internal}$ (E_{ISO})	50 VDC / 35 VAC
Insulation tested with	500 VDC
Current consumption	
• From the backplane bus	max. 130 mA
Power dissipation of the module	typ. 0.6 W

Analog Value Generation				
Measuring principle	Integrating			
Integration time/conversion time/resolution (per channel)				
• Parameters can be assigned	Yes			
• Integration time in ms	10	16.7	20	100
• Basic conversion time per channel group when more than one channel group is active	35	55	65	305
• Channel conversion time per channel group if only channel group 0 or 1 is enabled	10	16.7	20	100
Channel integration time (1/f1) in ms	10	16.7	20	100
• Resolution including sign	15 bits + sign			
• Suppression of interference voltage for interference f1 in Hertz	100	60	50	10
Basic response time of module, in ms (all channels enabled)	140	220	260	1220

Suppression of interference, Limits of Error	
Suppression of interference for f = nx (f1 ± 1 %), (f1 = interference frequency); n = 1, 2, etc.	
• Common-mode interference (U_{cm} < 50 V)	> 100 dB
• Series-mode interference (peak value of the interference < rated value of the input range)	> 90 dB
Crosstalk between the inputs	> 100 dB
Operational limit (in the entire temperature range, with reference to the input range)	E_{CM} = 0 / E_{CM} = ± 50 V
• Voltage input	± 0.1 % / ± 0.7 %
• Current input	± 0.3 % / ± 0.9 %
Basic error (operational limit at 25° C with reference to the input range)	
• Voltage input	± 0.05 %
• Current input	± 0.05 %
Temperature error (with reference to the input range)	± 0.005 %/K
Linearity error (with reference to the input range)	± 0.03 %
Repeatability (in steady state at 25 °C, with reference to the input range)	± 0.025 %

Status, Interrupts, Diagnostics		
Interrupts		
• Hardware interrupt when limit has been exceeded	Parameters can be assigned, channels 0 and 2	
• Diagnostic interrupt	Parameters can be assigned	
Diagnostic functions	Parameters can be assigned	
• Group error display	Red LED (SF)	
• Diagnostic information can be displayed	Possible	
Data for Selecting a Sensor		
Input range (rated values)/ Input resistance		
• Voltage	± 5 V	/ 2 MΩ
	1 to 5 V	/ 2 MΩ
	± 10 V	/ 2 MΩ
• Current	0 to 20 mA	/ 250 Ω
	± 20 mA	/ 250 Ω
	4 to 20 mA	/ 250 Ω
Maximum input voltage for voltage input (destruction limit)	max. 50 V continuous	
Connection of the sensors		
• For voltage measurement	Possible	
• For current measurement		
As a two-wire transmitter	Possible	
As a four-wire transmitter	Possible	
• Load of the two-wire transmitter	max. 820 Ω	

4.19.1 Commissioning the SM 331; AI 8 × 16 Bit

You set the mode of operation of the SM 331; AI 8 × 16 Bit in *STEP 7*.

Parameter

You will find a description of the general procedure for assigning parameters to analog modules in Section 4.7.

An overview of the parameters that you can set and their default settings are shown in the table below.

Table 4-52 Parameters of the SM 331; AI 8 × 16 Bit

Parameter	Value Range	Default Settings	Parameter Type	Scope
Enable • Diagnostic interrupt • Hardware interrupt upon limit violation	 Yes/no Yes/no	 No No	Dynamic	Module
Trigger for hardware interrupt • Upper limit value • Lower limit value	Constraint possible due to measuring range. 32511 to – 32512 – 32512 to 32511	–	Dynamic	Channel
Diagnostics • Group diagnostics • With wire-break check	 Yes/no Yes/no	 No No	Static	Channel group
Measurement • Measuring method • Measuring range • Interference suppression	deactivated U Voltage 4DMU Current (four-wire transmitter) Refer to Section 4.19.2 for the measuring ranges of the input channels that you can set. 400 Hz; 60 Hz; 50 Hz; 10 Hz	U ±10 V 50 Hz	Dynamic	Channel group

Channel groups

The channels of the SM 331; AI 8 $\times$ 16 Bit are arranged in four groups of two. You can only ever assign parameters to one channel group.

The table below shows which channels are parameterized as a channel group in each case. You will need the channel group number to set the parameters in the user program with an SFC.

Table 4-53 Assignment of Channels of the SM 331; AI 8 $\times$ 16 Bit to Channel Groups

Channels ...	... form one Channel Group each
Channel 0	Channel group 0
Channel 1	
Channel 2	Channel group 1
Channel 3	
Channel 4	Channel group 2
Channel 5	
Channel 6	Channel group 3
Channel 7	

High speed update mode

In the high speed update mode, updates for the two channels in the group occur three times faster than with multiple channel groups enabled.

For example, if channels 0 and 1 are enabled with 2.5 ms filtering, data updates for both channels will be available to the PLC every 10 msec. (For other filter settings, the filter setting equals the update rate.)

The high speed update mode is only available when both channels are enabled on channel group 0 or 1, in other words, the “measuring method” parameter is set. However, only channel group 0 or only channel 1 (in other words, not both together) must be enabled.

Special characteristic of channel groups for hardware interrupts

You can set hardware interrupts in *STEP 7* for the channel groups 0 and 1. Note, however, that a hardware interrupt is set only for the first channel in the channel group in each case – in other words, for channel 0 or channel 2

Diagnostics

You will find the diagnostic messages that are grouped under the “group diagnosis” parameter in Table 4-44, on page 4-69.

4.19.2 Measuring Methods and Measuring Ranges of the SM 331; AI 8 × 16 Bit

Measuring methods

You can set the following measuring methods for the input channels:

- Voltage measurement
- Current measurement

You perform the setting with the “measuring method” parameter in *STEP 7*.

Unused channels

Set the ”measuring method” parameter for unused channels to “disabled”. In this way you shorten the scan time of the module.

Since configured inputs can remain unused because of the channel group generation, you must take note of the following special characteristics of these inputs to enable the diagnostic functions on the used channels.

- **Measuring range 1 to 5 V:** Connect the unused input in parallel with a used input of the same channel group.
- **Current measurement 4 to 20 mA:** Connect the unused input in series to an input of the same channel group. Ensure that a current sense resistor is connected for each active and unused channel.
- **Other ranges:** Short the positive to the negative input of the channel.

Measuring ranges

You perform setting of the measuring ranges with the “measuring range” parameter in *STEP 7*.

Table 4-54 Measuring Ranges of the SM 331; AI 8 × 16 Bit

Method Selected	Measuring Range	Description
U: voltage	± 5 V 1 to 5 V ± 10 V	You will find the digitized analog values in Section 4.3.1 in the voltage measuring range
4DMU: current (four-wire transmitter)	0 to 20 mA ± 20 mA 4 to 20 mA	You will find the digitized analog values in Section 4.3.1 in the current measuring range

Default settings

The default settings of the module are ”voltage” for the measuring method ”$\pm$ 10 V” for the measuring range. You can use this combination of measuring method and measuring range without parameterizing the SM 331; AI 8 $\times$ 16 Bit in *STEP 7*.

Measuring errors with common-mode voltages

The SM 331; AI 8 x 16 Bit can make measurements in the presence of AC or DC common mode voltage.

For **AC common mode voltages** at multiples of the filter frequency setting, the rejection is accomplished by the integration period of the A/D converter and by the common mode rejection of the input amplifiers. For AC common mode voltages < 35 V_{RMS}, the rejection ratio of > 100 dB results in negligible measurement error.

For **DC common mode voltages**, only the rejection of the input amplifier stage is available to minimize the effect of the common mode voltage. Therefore, some accuracy degradation occurs in proportion to the common mode voltage. The worst case error occurs with 50 VDC between one channel and the other seven channels. The calculated worst case error is 0.7 % from 0 to 60 degrees C, and measured error is typically 3 0.1 % @ 25 degrees C.

Special characteristic of parameter assignment to upper and lower limit values

The parameterizable limit values (triggers for hardware interrupt) differ for the SM 331; AI 8 x 16 Bit from the range of values contained in Table 4-52.

The reason for this is that numerical methods in the module software for evaluating the process variables prevent values up to 32511 from being reported in some cases. The process input value at which a hardware interrupt for an underflow or overflow occurs depends on the calibration factors for an individual channel and can vary between the lower limits shown in the Table below and 32511 ($7EFF_H$).

Limit values should not be set at values higher than the minimum potential limit values shown in the table below.

Table 4-55 Minimum Possible Upper and Lower Limit Values of SM 331; AI 8 $\times$ 16 Bit

Measuring Range	Minimum Possible Upper Limit Value	Minimum Possible Lower Limit Value
$\pm$ 10 V	11.368 V 31430 $7AC6_H$	– 11.369 V – 31433 8537_H
$\pm$ 5 V	5.684 V 31430 $7AC6_H$	– 5.684 V – 31430 $853A_H$

Table 4-55 Minimum Possible Upper and Lower Limit Values of SM 331; AI 8 × 16 Bit, continued

Measuring Range	Minimum Possible Upper Limit Value	Minimum Possible Lower Limit Value
1 to 5 V	5.84 V 32376 $7E78_H$	0.96 V – 4864 $ED00_H$
0 to 20 mA	22.37 mA 31432 $7AC8_H$	– 3.19 mA – 4864 $ED00_H$
4 to 20 mA	22.37 mA 32378 $7E7A_H$	1.185 mA – 4864 $ED00_H$
± 20 mA	22.737 mA 31432 $7AC8_H$	– 22.737 mA – 31432 8538_H

Wire-break check

The wire-break check is available for the 1 to 5 V voltage range and the 4 to 20 mA current range.

The following applies to both measuring ranges:

Enabled wire-break check, the analog input module enters a wire break in the diagnosis if a current falls below 3.6 mA (0.9 V).

If you have enabled diagnostics interrupt during configuration, the module additionally triggers a diagnostic interrupt.

If no diagnostics interrupt has been enabled, the illuminated SF LED is the only indication of the wire break and you must evaluate the diagnostic bytes in the user program.

With a **disabled** wire-break check and enabled diagnostic interrupt, the module triggers a diagnostic interrupt when the underflow is reached.

4.20 Analog Input Module SM 331; AI 2 × 12 Bit; (6ES7 331-7KBx2-0AB0)

Order number: “Standard module”

6ES7 331-7KB02-0AB0

Order number: “SIMATIC Outdoor module”

6ES7 331-7KB82-0AB0

Characteristics

The analog input module SM 331; AI 2 × 12 Bit has the following characteristic features:

- Two inputs in one channel group
- Measured-value resolution (depending on the integration time set)
  - 9 bits + sign
  - 12 bits + sign
  - 14 bits + sign
- Measuring method selectable per channel group:
  - Voltage
  - Current
  - Resistor
  - Temperature
- Arbitrary measuring range selection per channel group
- Programmable diagnostics
- Programmable diagnostic interrupt
- One channel with limit monitoring
- Programmable limit interrupt
- Galvanic isolation to the backplane bus interface
- Galvanic isolation to load voltage (**not** for two-wire transmitter)

Resolution

The resolution of the measured value is a direct function of the integration time selected. In other words the longer the integration time for an analog input channel, the more accurate the resolution of the measured value will be (see Technical Specifications of the module and Table 4-5 on page 4-9).

Terminal connection diagram and block diagram of the SM 331; AI 2 × 12 Bit

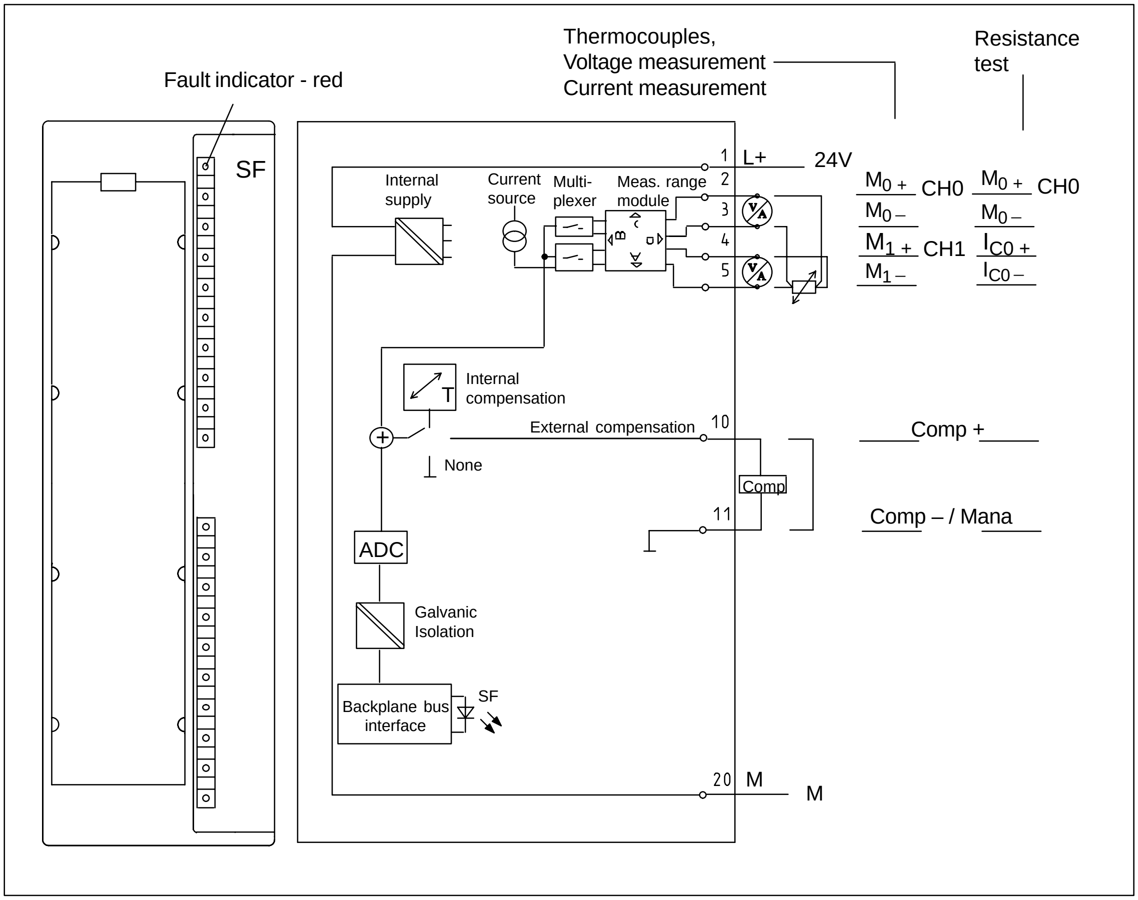


Figure 4-31 Module View and Block Diagram of the Analog Input Module SM 331; AI 2 × 12 Bit

The input resistances depend on the measuring range selected (refer to the technical specifications for the module).

Technical specifications of the SM 331; AI 2 × 12 Bit

Dimensions and Weight	
Dimensions W × H × D (in millimeters)	40 × 125 × 120
Weight	Approx. 250 g
Module-Specific Data	
Number of inputs	2
• For resistance-type sensor	1
Lenght of cable	max. 200 m
• Shielded	max. 50 m at 80 mV and thermocouples
Voltage, Currents, Potentials	
Power rated voltage of the electronics L +	24 VDC
• Reverse polarity protection	Yes
Power supply of the transmitters	
• Supply current	max. 60 mA (per channel)
• Short-circuit-proof	Yes
Constant measured current for resistance-type sensor	typ. 1.67 mA
Isolation	
• Between channels and backplane bus	Yes
• Between channels and power supply of the electronics	Yes
Permitted potential difference	
• Between inputs and M_{ANA} (E_{CM})	2.5 VDC
– At signal = 0 V	
– Not for two-wire transmitter	
• Between M_{ANA} and $M_{internal}$ (E_{ISO})	75 VDC / 60 VAC
Insulation tested with	500 VDC
Current consumption	
• From the backplane bus	max. 50 mA
• From the load voltage L +	max. 30 mA (without two-wire transmitter)
Power dissipation of the module	typ. 1.3 W

Analog Value Generation				
Measuring principle	Integrating			
Integration time/conversion time/resolution (per channel)				
• Parameters can be assigned	Yes			
• Integration time in ms	2.5	$16^2/_3$	20	100
• Basic conversion time including integration time in ms	3	17	22	102
Additional conversion time for measuring resistance, in ms or	1	1	1	1
Additional conversion time for open-circuit monitoring, in ms or	10	10	10	10
Additional conversion time for measuring resistance **and** open-circuit monitoring, in ms	16	16	16	16
• Resolution in bits (incl.) overrange)	9 bits	12 bits	12 bits	14 bits
• Suppression of interference voltage for interference frequency f1 in Hertz	400	60	50	10
• Basic response time of module, in ms (all channels enabled)	24	136	176	816
Smoothing of the measured values	None			

Suppression of interference, Limits of Error		
Suppression of interference for f = nx (f1 ± 1 %), (f1 = interference frequency)		
• Common-mode interference (E_{CM} < 2.5 V)	> 70 dB	
• Series-mode interference (peak value of the interference < rated value of the input range)	> 40 dB	
Crosstalk between the inputs	> 50 dB	
Operational limit (in the entire temperature range, with reference to the input range)		
• Voltage input	80 mV	± 1 %
	250 to 1000 mV	± 0.6 %
	2.5 to 10 V	± 0.8 %
• Current input	3.2 to 20 mA	± 0.7 %
• Resistor	150Ω; 300Ω; 600 Ω	± 0.7 %
• Thermocouple	Type E, N, J, K, L	± 1, 1 %
• Resistance thermometer	Pt 100/ Ni 100	± 0.7 %
	Pt 100 climate	± 0.8 %
Basic error (operational limit at 25 °C with reference to the input range)		
• Voltage input	80 mV	± 0.6 %
	250 to 1000 mV	± 0.4 %
	2.5 to 10 V	± 0.6 %
• Current input	3.2 to 20 mA	± 0.5 %
• Resistor	150Ω; 300Ω; 600 Ω	± 0.5 %
• Thermocouple	Type E, N, J, K, L	± 0.7 %
• Resistance thermometer	Pt 100/ Ni 100	± 0.5 %
	Pt 100 climate	± 0.6 %
Temperature error (with reference to the input range)	± 0.005 %/K	
Linearity error (with reference to the input range)	± 0.05 %	

Repeatability (in steady state at 25 °C with reference to the input range)	± 0.05 %	
Temperature error of the internal compensation	± 1 %	
Status, Interrupts, Diagnostics		
Interrupts		
• Hardware interrupt when limit has been exceeded	Parameters can be assigned Channel 0	
• Diagnostic interrupt	Parameters can be assigned	
Diagnostic functions	Parameters can be assigned	
• Group error display	Red LED (SF)	
• Diagnostic information can be displayed	Possible	
Data for Selecting a Sensor		
Input range (rated values)/ Input resistance		
• Voltage	± 80 mV	/10 MΩ
	± 250 mV	/10 MΩ
	± 500 mV	/10 MΩ
	±1000 mV	/10 MΩ
	± 2.5 V	/100kΩ
	± 5 V	/100kΩ
	1 to 5 V	/100kΩ
	± 10 V	/100kΩ
• Current	± 3.2 mA	/25 Ω
	± 10 mA	/25 Ω
	± 20 mA	/25 Ω
	0 to 20 mA	/25 Ω
	4 to 20 mA	/25 Ω
• Resistor	150 Ω	/10 MΩ
	300 Ω	/10 MΩ
	600 Ω	/10 MΩ
• Thermocouple	Type E, N, J, K, L	/10 MΩ
• Resistance thermometer	Pt 100, Ni 100	/10 MΩ
Maximum input voltage for voltage input (destruction limit)	20 V continuous; 75 V for max. 1 s (pulse duty factor 1:20)	
Maximum input current for current input (destruction limit)	40 mA	

Connection of the sensor	
• For measuring voltage	Possible
• For measuring current	
As two-wire transmitter	Possible
As four-wire transmitter	Possible
• For measuring resistance	
With two-conductor terminal	Possible
With three-conductor terminal	Possible
With four-conductor terminal	Possible
• Load of the two-wire transmitter	max. 820 Ω

Characteristic linearization	Parameters can be assigned
• For thermocouples	Type E, N, J, K, L
• For RTD Resistance Temperature Detector	Pt 100 (standard, climate range) Ni 100 (standard, climate range)
Temperature compensation	Parameters can be assigned
• Internal temperature compensation	Possible
• External temperature compensation with compensating box	Possible
• Compensation for 0 °C reference junction temperature	Possible
• Technical unit for measuring temperature	Degrees Celsius

4.20.1 Commissioning the SM 331; AI 2 × 12 Bit

You set the mode of operation of the SM 331; AI 2 × 12 Bit by means of a measuring range module on the module and in *STEP 7*.

Measuring range module

If necessary, the measuring range module must be replugged to change the measuring method and the measuring range. The steps you have to perform to do this are described in detail in Section 4.4.

The corresponding table in Section 4.20.2 tells you which assignment you have to select for which measuring method and measuring range. In addition, the necessary settings are embossed on the module.

Default settings for measuring range module

The measuring range module is preset to ”B” (voltage; ± 10 V) when the module is supplied.

To use the following preset measuring methods and measuring ranges, you only have to change the measuring range module to the corresponding setting. Parameter assignment in *STEP 7* is not necessary.

Table 4-56 Default Settings of the SM 331; AI 2 × 12 Bit Using Measuring Range Module

Measuring Range Module Setting	Measuring Method	Measuring Range
A	Voltage	± 1000 mV
B	Voltage	± 10 V
C	Current, four-wire transmitter	4 to 20 mA
D	Current, two-wire transmitter	4 to 20 mA

Parameter

You will find a description of the general procedure for assigning parameters to analog modules in Section 4.7.

An overview of the parameters that you can set and their default settings are shown in the table below.

Table 4-57 Parameters of the SM 331; AI 2 × 12 Bit

Parameter	Value Range	Default Settings	Parameter Type	Scope
Enable • Diagnostic interrupt • Hardware interrupt upon limit violation	 Yes/no Yes/no	 No No	Dynamic	Module
Trigger for hardware interrupt • Upper limit value • Lower limit value	 32511 to – 32512 – 32512 to 32511	–	Dynamic	Channel
Diagnostics • Group diagnostics • With wire-break check	 Yes/no Yes/no	 No No	Static	Channel group
Measurement • Measuring Method	 Deactivated U Voltage 4DMU Current (four-wire transmitter) 2DMU Current (two-wire transmitter) R-4L Resistance (four-wire connection) RTD-4L Bulb resistor (linear, four-conductor terminal) TC-I Thermocouple (internal comparison) TC-E Thermocouple (external comparison) TC-IL Thermocouple (linear, internal comparison) TC-EL Thermocouple (linear, external comparison)	 U	Dynamic	Channel or Channel group
• Measuring Range	Refer to Section 4.20.2 for the measuring ranges of the input channels that you can set.	±10 V		
• Interference Suppression	400 Hz; 60 Hz; 50 Hz; 10 Hz	50 Hz		

Channel groups

The two channels of the analog input module SM 331; AI 2 × 12 Bit are combined to a channel group. You can only ever assign parameters to the channel group.

The SM 331; AI 2 × 12 Bit has a measuring range module for this channel group.

Special characteristic of channel groups with resistance measurement

If you use the resistance measurement method, the analog input module has only one channel. The “2nd” channel is used for current injection (I_C).

The measured value is obtained by accessing the “1st” channel. The “2nd” channel has the default carry value “$7FFF_H$”.

Special characteristic of channel groups for hardware interrupts

You can set a process interrupt in *STEP 7* for the channel group. Note, however, that a hardware interrupt is set only for the first channel in the channel group in each case – in other words, for channel 0.

Diagnostics

You will find the diagnostic messages that are grouped under the “group diagnosis” parameter in Table 4-44, on page 4-69.

4.20.2 Measuring Methods and Measuring Ranges of the SM 331; AI 2 × 12 Bit

Measuring methods

You can set the following measuring methods for the input channels:

- Voltage measurement
- Current measurement
- Resistance test
- Temperature measurement

You perform the setting by means of the measuring range module on the module and with the “measuring method” parameter in *STEP 7*.

Unused channels

You must short-circuit unused channels and connect them to M_{ANA}. In this way, you obtain an optimum interference immunity for the analog input module. Set the ”measuring method” parameter for unused channels to “disabled”. In this way you shorten the scan time of the module.

If you do not use the COMP input, you must short-circuit it also.

Special characteristics of unused channels for some measuring ranges

Since configured inputs can remain unused because of the channel group generation, you must take note of the following special characteristics of these inputs to enable the diagnostic functions on the used channels.

- **Measuring range 1 to 5 V:** Connect the unused input in parallel with a used input of the same channel group.
- **Current measurement, two-wire transmitter:**
  There are two ways to use the channels:
  a) Leave the unused input open and do not enable diagnostics for this channel group. With enabled diagnostics, the analog module will otherwise trigger a diagnostic interrupt once and the group error LED on the analog module lights up.
  b) Connect a 1.5 to 3.3 kΩ resistor to the unused input. You may then enable diagnostics for this channel group.
- **Current measurement 4 to 20 mA, four-wire transmitter:** Connect the unused input in series with an input of the same channel group.

Measuring ranges

You perform the setting of the measuring ranges by means of the measuring range module on the module and with the “measuring method” parameter in *STEP 7*.

Table 4-58 Measuring Ranges of the SM 331; AI 2 × 12 Bit

Method Selected	Measuring Range (Type of Sensor)	Measuring Range Module Setting	Description
U: voltage	± 80 mV ± 250 mV ± 500 mV ± 1000 mV	A	You will find the digitized analog values in Section 4.3.1 in the voltage measuring range
	± 2.5 V ± 5 V 1 to 5 V ± 10 V	B	
TC-I: thermocouple (internal compensation) (thermovoltage measurement)	Type N [NiCrSi-NiSi] Type E [NiCr-CuNi] Type J [Fe-CuNi] Type K [NiCr-Ni] Type L [Fe-CuNi]	A	You will find the digitized analog values in Section 4.3.1 in ± 80 mV the voltage measuring range
TC-E: thermocouples (external compensation) (thermovoltage measurement)			
2DMU: current (two-wire transmitter)	4 to 20 mA	D	You will find the digitized analog values in Section 4.3.1 in the current measuring range
4DMU: current (four-wire transmitter)	± 3.2 mA ± 10 mA 0 to 20 mA 4 to 20 mA ± 20 mA	C	
R-4L: resistor (four-wire circuit)	150 Ω 300 Ω 600 Ω	A	You will find the digitized analog values in Section 4.3.1 in the resistance measuring range

Table 4-58 Measuring Ranges of the SM 331; AI 2 × 12 Bit, continued

Method Selected	Measuring Range (Type of Sensor)	Measuring Range Module Setting	Description
TC-IL: thermocouples (linear, internal compensation) (temperature measurement)	Type N [NiCrSi-NiSi] Type E [NiCr-CuNi] Type J [Fe-CuNi] Type K [NiCr-Ni] Type L [Fe-CuNi]	A	You will find the digitized analog values in Section 4.3.1 in the temperature range The characteristics are linearized: • Pt 100 to DIN IEC 751 • Ni 100 according to IEC DIN 43760 • Thermocouple to DIN 584, type L to DIN 43710.
TC-EL: thermocouples (linear, external compensation) (temperature measurement)	Type N [NiCrSi-NiSi] Type E [NiCr-CuNi] Type J [Fe-CuNi] Type K [NiCr-Ni] Type L [Fe-CuNi]	A	
RTD-4L: bulb resistor linear, four-conductor terminal (temperature measurement)	Pt 100 climate Ni 100 climate Pt 100 standard Ni 100 standard	A	

Default settings

The default settings of the module in *STEP 7* are the ”voltage” measuring method und the ”± 10 V” measuring range. You can use this combination of measuring method and measuring range without parameterizing the SM 331; AI 8 × 12 Bit in *STEP 7*.

Wire-break check

The wire-break check is intended primarily for temperature measurements (thermocouples and bulb resistors).

Special characteristics of the wire-break check for the 4 to 20 mA measuring range

With a parameterized measuring range of 4 to 20 mA and **enabled wire-break check**, the analog input module enters wire break in the diagnosis when a current falls below 3.6 mA.

If you have enabled diagnostics interrupt during configuration, the module additionally triggers a diagnostic interrupt.

If no diagnostics interrupt has been enabled, the illuminated SF LED is the only indication of the wire break and you must evaluate the diagnostic bytes in the user program.

With a parameterized measuring range of 4 to 20 mA and **disabled wire-break check** and enabled diagnostic interrupt, the module triggers a diagnostic interrupt when the underflow is reached.

4.21 Analog Input Module SM 331; AI 8 × RTD (6ES7 331-7PF00-0AB0)

Order Number

6ES7 331-7PF00-0AB0

Characteristics

The SM 331; AI 8 × RTD, 16 Bit (internal 24 bits by the sigma delta method) features the following characteristics:

- 8 differential inputs for RTD resistance temperature detector in 4 channel groups
- Optional setting of the resistance thermometer type per channel group
- Rapid measured value updating for up to 4 channels
- Measured-value resolution 23 Bit + sign (independent of integration time)
- Programmable diagnostics
- Programmable diagnostic interrupt
- 8 channels with limit monitoring
- Programmable limit interrupt
- Programmable end-of-scan-cycle interrupt
- Galvanic isolation to the backplane bus interface

Terminal connection diagram and block diagram of the SM 331; AI 8 × RTD

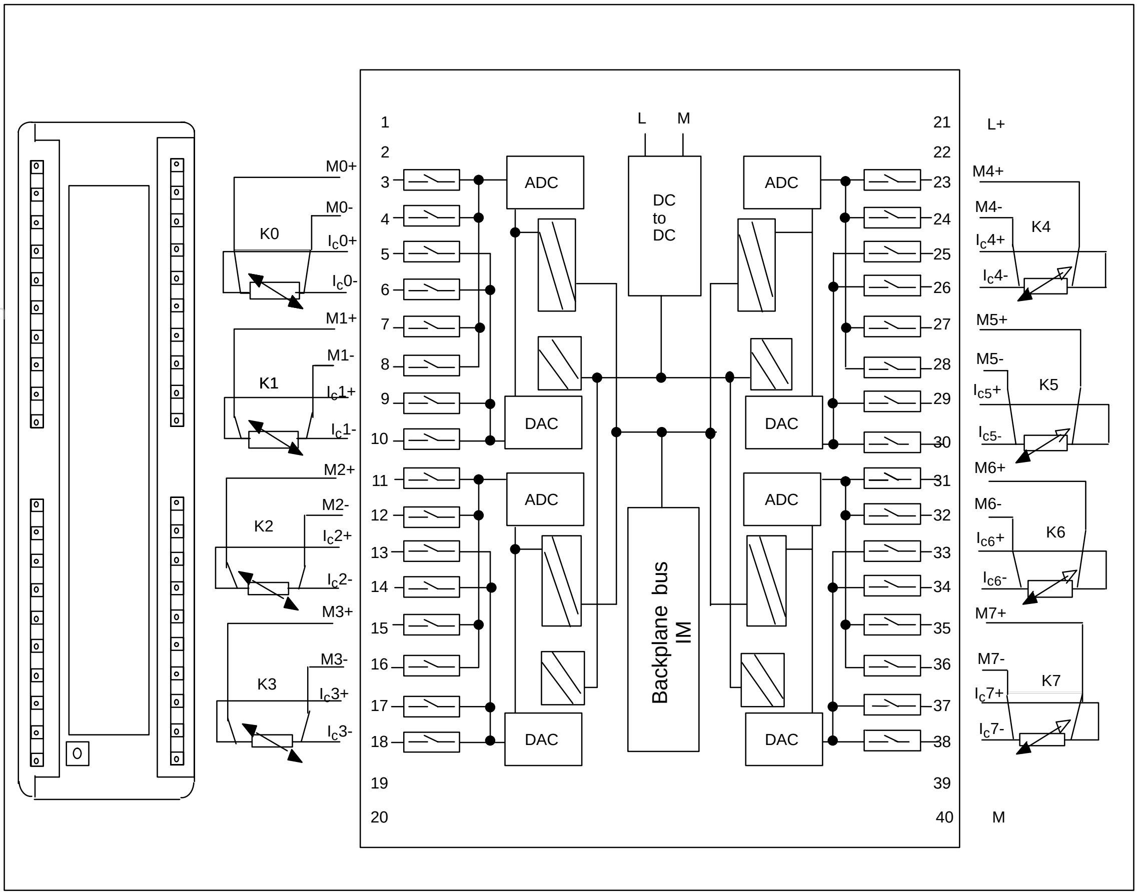


Figure 4-32 Module View and Block Diagram of the SM 331; AI 8 × RTD

Technical specifications of the SM 331; AI 8 × RTD

Dimensions and Weight	
Dimensions W × H × D (in millimeters)	40 × 125 × 120
Weight	Approx. 272 g
Module-Specific Data	
Number of inputs	8
Lenght of cable	
• Shielded	max. 200 m
Voltage, Currents, Potentials	
Power rated voltage of the electronics L+	24 VDC
• Reverse polarity protection	Yes
Constant measured current for resistance-type sensor	max. 5 mA
Isolation	
• Between channels and backplane bus	Yes
• Between channels and power supply of the electronics	Yes
• Between the channels	Yes
In groups of	2
Permitted potential difference	
• Between the inputs (E_{CM})	60 VAC/75 VDC
• Between M_{ANA} and $M_{internal}$ (E_{ISO})	60 VAC/75 VDC
Insulation tested with	500 VAC
Curr ent consumption	
• From the backplane bus	max. 100 mA
• From the load voltage L+	max. 240 mA
Power dissipation of the module	typ. 4.6 W

Analog Value Generation	
Measuring principle	Integrating
Operating mode	**8 channels, Hardware**
Integration time/conversion time/ resolution (per channel)	
• Parameters can be assigned	Yes
• Basic conversion time in ms	80
• Additional conversion time for measuring resistance, in ms	185*
• Additional conversion time for open-circuit monitoring, in ms	100
• Resolution (including overrange)	24 bits
• Suppression of interference voltage for interference interference frequency f1 in Hz	400 / 60 / 50
Smoothing of the measured values	None / low/ average/ high
Basic response time of module (all channels enabled)	200 ms
Operating mode	**8 channels, Software**
Integration time/conversion time/ resolution (per channel)	
• Parameters can be assigned	Yes
• Basic conversion time in ms	8 / 25 / 30
• Additional conversion time for measuring resistance, in ms	45 / 79 / 89*
• Additional conversion time for open-circuit monitoring, in ms	20 / 37 / 42
• Resolution (including overrange)	24 bits
• Suppression of interference voltage for interference interference frequency f1 in Hz	400 / 60 / 50
Smoothing of the measured values	None / low/ average/ high

Basic response time of module (all channels enabled)	40 / 79 / 84 ms
Operating mode	**4 channels, Hardware**
Integration time/conversion time/ resolution (per channel)	
• Parameters can be assigned	Yes
• Basic conversion time in ms	3.3
• Additional conversion time for measuring resistance, in ms	185*
• Additional conversion time for open-circuit monitoring, in ms	85**
• Resolution (including overrange)	24 bits
• Suppression of interference voltage for interference interference frequency f1 in Hz	400 / 60 / 50
Smoothing of the measured values	None / low/ average/ high
Basic response time of module (all channels enabled)	10 ms
Suppression of interference, Limits of Error	
Suppression of interference for f = nx (f1 ± 1 %), (f1 = interference frequency) n = 1,2 , etc.	
• Common-mode interference (E_{CM} < 60 VAC/75 VDC)	> 100 dB
• Series-mode interference (peak value of the interference < rated value of the input range)	> 90 dB
Crosstalk between the inputs	> 100 dB
Operational limit (in the entire temperature range, with reference to 0 to 60 °C input range)	
• Resistance thermometer	± 1.0°C
• Resistance input	± 0.1 %
Basic error (operational limit at 25 °C, with reference to the input range)	
• Resistance thermometer	± 0.5°C
• Resistance input	± 0.05 %
Temperature error (with reference to the input range)	± 0.005 %/K

Linearity error (with reference to the input range)	± 0.02 %
Repeatability (in steady state at 25 °C, with reference to the input range)	± 0.01 %
Status, Interrupts, Diagnostics	
Interrupts	
• Hardware interrupt	Parameters can be assigned
• Diagnostic Interrupt	Parameters can be assigned
Diagnostic functions	Parameters can be assigned
• Group error display	Red LED (SF)
• Diagnostic information can be displayed	Possible
Data for Selecting a Sensor	
Input range (rated values) input resistance	
• Resistance-type thermometer	Pt 100, Pt 200, Pt 500, Pt 1000, Ni 100, Ni 120, Ni 200, Ni 500, Ni 1000, Cu 10
• Resistor	150, 300, 600 Ω
Maximum input voltage for voltage input (destruction limit)	35 VDC continuous 75 VDC for no more than 1 s (pulse duty factor 1 : 20)
Connection of the sensor	
• For measuring resistance	
With two-conductor terminal	Possible (without resistance correction)
With three-conductor terminal	Possible
With four-conductor terminal	Possible
Characteristic linearization	
• Resistance thermometer	Pt 100, Pt 200, Pt 500, Pt 1000, Ni 100, Ni 120, Ni 200, Ni 500, Ni 1000, Cu 10 (standard and climatic range)
• Technical unit for measuring temperature	Degrees C; degrees Fahrenheit

* The resistance measurement for a three-conductor terminal is performed every 5 minutes.

** Open-circuit monitoring in operating mode 4 Channels, Hardware is performed every 3 seconds.

4.21.1 Commissioning the SM 331; AI 8 × RTD

You set the mode of operation of the SM 331; AI 8 × RTD in *STEP 7*.

Parameter

You will find a description of the general procedure for assigning parameters to analog modules in Section 4.7.

An overview of the parameters that you can set and their default settings are shown in the table below.

Table 4-59 Parameters of the SM 331; AI 8 × RTD

Parameter	Value Range	Default Settings	Parameter Type	Scope
Enable • Diagnostic interrupt • Hardware interrupt upon limit violation • Hardware interrupt at end of cycle	 Yes/no Yes/no Yes/no	 No No No	Dynamic	Module
Trigger for hardware interrupt • Upper limit value • Lower limit value	 32511 to – 32512 – 32512 to 32511	–	Dynamic	Channel
Diagnostics • Group diagnostics • With wire-break check	 Yes/no Yes/no	 No No	Static	Channel group
Measurement • Measuring method	deactivated R-4L Resistance (four-conductor terminal) R-3L Resistance, (three-conductor terminal) RTD-4L Bulb resistor (linear, four-conductor terminal) RTD-3L Bulb resistor (linear, three-conductor terminal)	RTD-4L	Dynamic	Channel group
• Measuring range	Refer to Section 4.21.2 for the measuring ranges of the input channels that you can set.	Pt 100 climate		
• Temperature unit	Degrees Celsius; degrees Fahrenheit	Degrees Celsius	Dynamic	Module
• Operating mode	8 channels, hardware filter 8 channels, software filter 4 channels, hardware filter	8 channels, hardware filter	Dynamic	Module

Table 4-59 Parameters of the SM 331; AI 8 × RTD, continued

Parameter	Value Range	Default Settings	Parameter Type	Scope
• Temperature coefficient for temperature measurement with bulb resistor (RTD)	Platinum (Pt) 0.00385 Ω/Ω/°C 0.003916 Ω/Ω/°C 0.003902 Ω/Ω/°C 0.003920 Ω/Ω/°C 0.003851 Ω/Ω/°C Nickel (Ni) 0.00618 Ω/Ω/°C 0.00672 Ω/Ω/°C Copper (Cu) 0.00472 Ω/Ω/°C	0.00385	Dynamic	Channel group
• Interference suppression*	50/60/400 Hz; 400 Hz; 60 Hz; 50 Hz	50/60/400 Hz	Dynamic	Channel group
• Smoothing	None Low Average High	None	Dynamic	Channel group

* 50/60/400 Hz programmable only for modes 8 or 4-Channel Hardware Filter Modes;
50 Hz, 60 Hz or 400 Hz programmable only for mode 8-Channel Hardware Filter Mode

Channel groups

The channels of the SM 331; AI 8 × RTD are arranged in four groups of two. You can only ever assign parameters to one channel group.

The table below shows which channels are parameterized as a channel group in each case. You will need the channel group number to set the parameters in the user program with an SFC.

Table 4-60 Assignment of Channels of the SM 331; AI 8 × RTD to Channel Groups

Channels ...	... form one Channel Group each
Channel 0	Channel group 0
Channel 1	
Channel 2	Channel group 1
Channel 3	
Channel 4	Channel group 2
Channel 5	
Channel 6	Channel group 3
Channel 7	

Special characteristic of channel groups for hardware interrupts upon limit violation

You can set the upper and lower limits for each channel with hardware interrupts in *STEP 7*.

Operating mode

The SM 331; AI 8 × RTD operates in one of the following modes:

- "Hardware Filter, 8 Channels"
- "Software Filter, 8 Channels"
- "Hardware Filter, 4 Channels"

The operating mode affects the scan time of the module.

High speed update mode

With high speed updating, updating of not more than 4 channels is performed in only 10 ms.

High speed updating is possible only in "Hardware Filter, 4 Channels" mode. In this mode, the module does not switch between the channels of the different groups. You must only use the channels with even numbers (0, 2, 4, 6) on the module.

Scan time in "Hardware Filter, 8 Channels" mode

In "Hardware Filter, 8 Channels" mode, the module always converts the analog values simultaneously, first for the channels with even numbers, followed the channels with odd numbers.

The scan time for the module results in:

Scan time = $(t_K + t_U) \times 2$

Scan time = $(85\text{ ms} + 12\text{ ms}) \times 2$

Scan time = <u>194 ms</u>

t_K: channel conversion time for one channel
t_U: time for switching to the other channel in the channel group

Scan time in “Software Filter, 8 Channels” mode

In “Software Filter, 8 Channels” mode, analog-to-digital conversion is performed in exactly the same manner as in “Hardware Filter, 8 Channels” mode. In other words, the analog values are always converted simultaneously, first for the channels with even numbers and then for the channels with odd numbers.

The channel conversion time depends, however, on the programmed interference frequency suppression. This relationship is shown in the table that follows.

Table 4-61 Scan Times in “Software Filter, 8 Channels” Mode

Programmed Interference Frequency Suppression	Channel Scan Time*	Module Scan Time (All Channels)
50 Hz	42 ms	**84 ms**
60 Hz	37 ms	**74 ms**
400 Hz	20 ms	**40 ms**

* Channel scan time = channel conversion time + 12 ms switching time to the other channel in the channel group

Scan time in “Hardware Filter, 4 Channels” mode

In this mode, the module does not switch between the channels of the different groups. The module converts the channels with even numbers simultaneously.

This results for the scan time in:

Channel conversion time = channel scan time = module scan time = **10 ms**

Prolongation of the scan time with a wire-break check

The wire-break check is a software function of the module that is available in all operating modes.

In the 8-Channel Hardware and Software Filter operating modes, the scan time of the module is doubled, irrespective of the number of channels for which Wire Break has been enabled.

In the 4-Channel Hardware Filter operating mode, the module interrupts processing of the input data 170 ms and performs a wire-break check. In other words, each wire-break check prolongs the scan time of the module by 170 ms.

Smoothing of the measured values

You fill find information that is generally applicable to the smoothing of analog values in Section 4.6.

Special characteristic with short-circuit to M or L

If you short an input channel to M or L, the module does not suffer any damage. The channel continues to issue valid data; neither is a diagnosis reported.

Diagnostics

You will find the diagnostic messages that are grouped under the "group diagnosis" parameter in Table 4-44, on page 4-69.

4.21.2 Measuring Methods and Measuring Ranges of the SM 331; AI 8 × RTD

Measuring methods

You can set the following measuring methods for the input channels:

- Resistance test
- Temperature measurement

You perform the setting with the "measuring method" parameter in *STEP 7*.

Unused channels

Set the "measuring method" parameter for unused channels to "disabled". In this way you shorten the scan time of the module.

You must terminate an unused channel of an enabled channel group with a nominal resistance in order to avoid diagnostic errors for the unused channel (refer to the block diagram, Figure 4-32, for the connection).

In the "4-Channel Hardware Filter" operating mode, termination is not necessary provided that you have disabled the unused channel groups. Channels 1, 3, 5 and 7 are not monitored in this mode.

Measuring ranges

You perform setting of the measuring ranges with the "measuring range" parameter in *STEP 7*.

Table 4-62 Measuring Ranges of the SM 331; AI 8 × RTD

Method Selected	Measuring Range	Description
R-3L: resistor (three-conductor terminal)	150 Ω 300 Ω 600 Ω	You will find the digitized analog values in Section 4.3.1 in the resistance measuring range
R-4L: resistor (four-conductor terminal)		

Table 4-62 Measuring Ranges of the SM 331; AI 8 × RTD, continued

Method Selected	Measuring Range	Description
RTD-3L: bulb resistor linear, three-conductor terminal (temperature measurement)	Pt 100 climate Pt 200 climate Pt 500 climate Pt 1000 climate Ni 100 climate Ni 120 climate Ni 200 climate Ni 500 climate Ni 1000 climate Cu 10 climate	You will find the digitized analog values in Section 4.3.1 in the temperature range
RTD-4L: bulb resistor linear, four-conductor terminal (temperature measurement)	Pt 100 standard Pt 200 standard Pt 500 standard Pt 1000 standard Ni 100 standard Ni 120 standard Ni 200 standard Ni 500 standard Ni 1000 standard Cu 10 standard	

Default settings

The default settings of the module are the ”Bulb resistor (linear, four-conductor terminal)” measuring method and the ”Pt 100 climate” measuring range. You can use this combination of measuring method and measuring range without parameterizing the SM 331; AI 8 × RTD in *STEP 7*.

Measuring errors with common-mode voltages

The SM 331; AI 8 × RTD can perform measurements even when there are AC or DC common-mode voltages.

For AC and DC common-mode voltages, common-mode rejection is performed by the input amplifiers. For common mode voltages < 120 $V_{r.m.s}$ and 120 VDC, the rejection ratio of > 100 dB results in negligible measurement error.

Special characteristic of parameter assignment to upper and lower limit values

The parameterizable limit values (triggers for hardware interrupt) differ for the AI 8 × RTD from the range of values shown in Table 4-59.

The reason for this is that numerical methods in the module software for evaluating the process variables prevent values up to 32511 from being reported in some cases. The process input value at which a hardware interrupt for an underflow or Overflow occurs depends on the calibration factors for an individual channel and can vary between the lower limits shown in the Table below and 32511 ($7EFF_H$).

Limit values should not be set at values higher than the minimum potential limit values shown in the table below.

Table 4-63 Minimum Possible Upper and Lower Limit Values of SM 331; AI 8 × RTD

Measuring Range	Minimum Possible Upper Limit Value	Minimum Possible Lower Limit Value
150 Ω 300 Ω 600 Ω	176.384 Ω 352.768 Ω 705.535 Ω	– – –
Pt 100 climate Pt 200 climate Pt 500 climate Pt 1000 climate	155.01 °C	– 145.01 °C
Ni 100 climate Ni 120 climate Ni 200 climate Ni 500 climate Ni 1000 climate	295.01 °C	– 105.01 °C
Cu 10 climate	180.01 °C	– 60.01 °C
Pt 100 standard Pt 200 standard Pt 500 standard Pt 1000 standard	1000.1 °C	– 243.1 °C
Ni 100 standard Ni 120 standard Ni 200 standard Ni 500 standard Ni 1000 standard	295.1 °C	– 105.1 °C
Cu 10 standard	312.1 °C	– 240.1 °C

4.22 Analog Input Module SM 331; AI 8 × TC (6ES7 331-7PF10-0AB0)

Order number

6ES7 331-7PF10-0AB0

Characteristics

The SM 331; AI 8 × TC, 16 Bit (internal 24 bits by the sigma delta method) features the following characteristics:

- 8 differential inputs for thermocouples (TC) in 4 channel groups
- Optional setting of the thermocouple type per channel group
- Rapid measured value updating for up to 4 channels
- Measured-value resolution 23 Bit + sign (independent of integration time)
- Programmable diagnostics
- Programmable diagnostic interrupt
- 8 channels with limit monitoring
- Programmable limit interrupt
- Programmable end-of-scan-cycle interrupt
- Programmable reaction to open thermocouple
- Galvanic isolation to the backplane bus interface

Terminal connection diagram and block diagram of the SM 331; AI 8 × TC

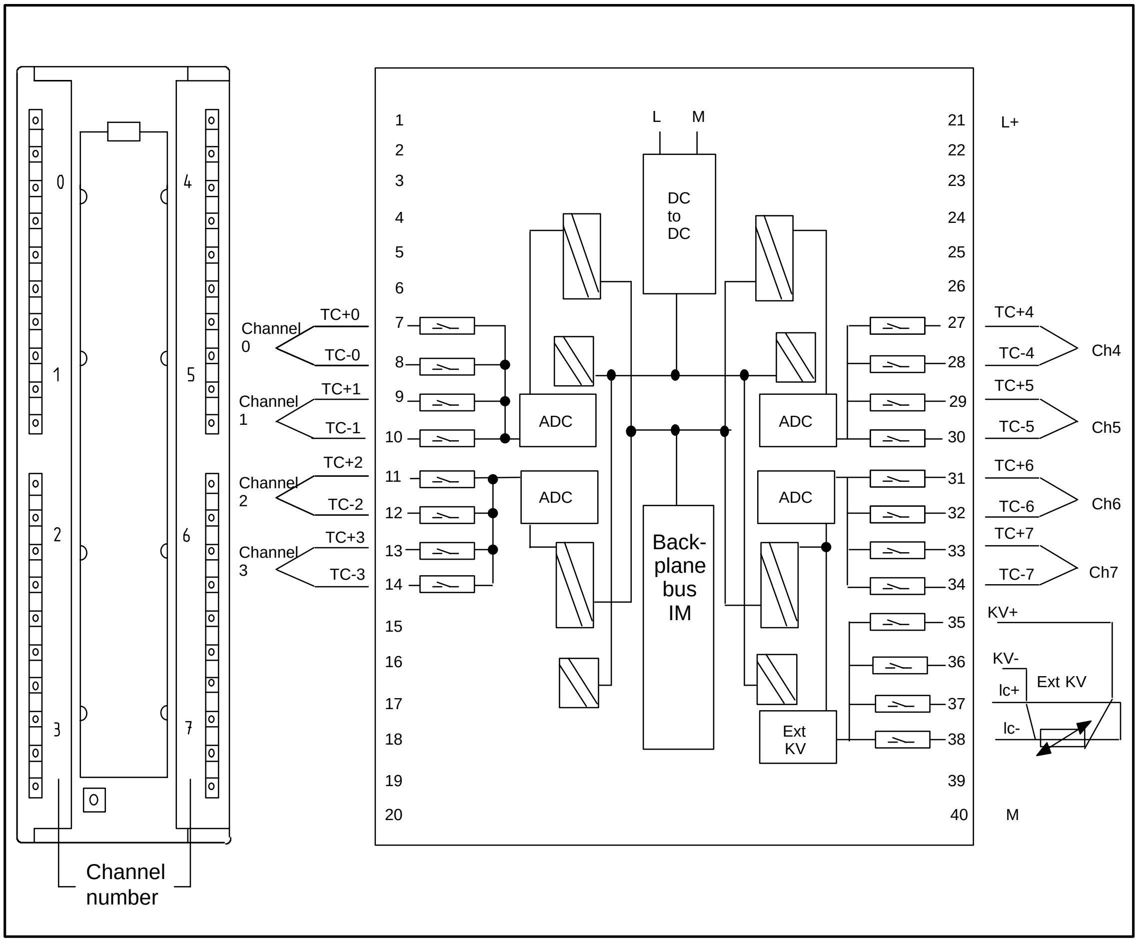


Figure 4-33 Module View and Block Diagram of the SM 331; AI 8 × TC

Technical specifications of the SM 331; AI 8 × TC

Dimensions and Weight	
Dimensions W × H × D (in millimeters)	40×125×120
Weight	Approx. 270 g
Module-Specific Data	
Number of inputs	8
Lenght of cable	
• Shielded	max. 100 m
Voltage, Currents, Potentials	
Power rated voltage of the electronics L+	24 VDC
• Reverse polarity protection	Yes
Constant measured current for resistance-type sensor	typ. 0.7 mA
Isolation	
• Between channels and backplane bus	Yes
• Between channels and power supply of the electronics	Yes
• Between the channels	Yes
In groups of	2
Permitted potential difference	
• Between the inputs (E_{CM})	60 VAC/75 VDC
• Between M_{ANA} and $M_{internal}$ (E_{ISO})	60 VAC/75 VDC
Insulation tested with	500 VAC
Current consumption	
• From the backplane bus	max. 100 mA
• From the load voltage L+	max. 240 mA
Power dissipation of the module	typ. 3.0 W

Analog Value Generation	
Measuring principle	Integrating
Operating mode	**8 channels, Hardware**
Integration time/conversion time/resolution (per channel)	
• Parameters can be assigned	Yes
• Basic conversion time in ms	95
• Additional conversion time for open-circuit monitoring, in ms	4
• Resolution including sign	24 bits
• Noise suppression for interference frequency f1 in Hz	400/60/50
Smoothing of the measured values	None / low/ average/ high
Basic response time of module (all channels enabled)	190 ms
Operating mode	**8 channels, Software**
Integration time/conversion time/resolution (per channel)	
• Parameters can be assigned	Yes
• Basic conversion time in ms	23/72/83
• Additional conversion time for open-circuit monitoring, in ms	4
• Resolution including sign	24 bits
• Suppression of interference voltage for interference frequency f1 in Hertz	400/60/50
Smoothing of the measured values	None / low/ average/ high
Basic response time of module (all channels enabled)	46/144/166 ms

Analog Value Generation (Cont'd)	
Measuring principle	Integrating
Operating mode	**4 channels, Hardware**
Integration time/conversion time/resolution (per channel)	
• Parameters can be assigned	Yes
• Basic conversion time in ms	3.30
• Additional conversion time for open-circuit monitoring, in ms	93 [1])
• Resolution including sign	24 bits
• Suppression of interference voltage for interference interference frequency f1 in Hertz	400/60/50
Smoothing of the measured values	None / low / average / high
Basic response time of module (all channels enabled)	10 ms

Suppression of interference, Limits of Error	
Suppression of interference for f = nx (f1 ± 1 %), (f1 = interference frequency) n = 1,2 , etc.	
• Common-mode interference (U_{cm} < 60 VAC/75 VDC)	> 100 dB
• Series-mode interference (peak value of the interference < rated value of the input range)	> 90 dB [2)]
Crosstalk between the inputs	> 100 dB
Operational limit (in the entire temperature range, with reference to the input range) (0 to 60°C)	
• Thermocouple	± 1.0 °C [3)]
Basic error (operational limit at 25 °C, with reference to the input range)	
• Thermocouple	± 0.05 % [4), 5)]
Temperature error (with reference to the input range)	±0.005 %/K
Linearity error (with reference to the input range)	± 0.02 %
Repeatability (in steady state at 25 °C, with reference to the input range)	±0.01 %

Status, Interrupts, Diagnostics	
Interrupts	
• Hardware interrupt	Parameters can be assigned
• Diagnostic Interrupt	Parameters can be assigned
Diagnostic functions	Parameters can be assigned
• Group error display	Red LED (SF)
• Diagnostic information can be displayed	Possible

Data for Selecting a Sensor	
Input range (rated values)/ Input resistance	
• Thermocouples	Types B, N, E, R, S, J, L, T, K, U
Maximum input voltage for voltage input (destruction limit)	20 V continuous; 75 VDC for max. 1 s (pulse duty factor 1:20)
• Characteristic linearization	Parameters can be assigned
• Temperature compensation	Parameters can be assigned
• Internal temperature compensation	Possible
• External temperature compensation with Pt 100	Possible
• Compensation for temperature of 0 °C at reference junction	Possible
• Compensation for temperature of 50 °C at reference junction	Possible
• Technical unit for measuring temperature	Degrees C/ degrees F

Footnotes to technical specifications

1 Open-circuit monitoring in 4 Channels, Hardware operating mode is performed every 3 seconds.

2 Series-mode rejection in 8 Channels, Software mode is reduced as follows:

50 Hz	> 70 db
60 Hz	> 70 db
400 Hz	> 80 db

3 The operating limit with internal compensation is derived from:

Basic error of the analog input for the type of thermocouple used
Accuracy of the temperature of the internal reference junction ± 1.5 °C
Temperature error in module temperature, T_A

The operating limit with external compensation is derived from:

Basic error of the analog input for the type of thermocouple used
Accuracy of the external PT 100 bulb resistor used
Temperature error in module temperature, T_A

The operating limit with compensation of the external reference junction of 0 °C/50 °C is derived from:

Basic error of the analog input for the type of thermocouple used
Accuracy of the reference junction temperature
Temperature error in module temperature, T_A

4 The basic error includes the linearization error of the conversion from voltage into temperature and the basic error of the analog-to-digital conversion at T_A=25 °C.

Type T	– 200 °C	to +400 °C	± 0.2 °C
	– 270 °C	to – 200 °C	± 0.5 °C
Type U	– 150 °C	to +400 °C	± 0.2 °C
	– 200 °C	to – 150 °C	± 0.5 °C
Type E	– 200 °C	to +1000 °C	± 0.2 °C
	– 270 °C	to – 200 °C	± 0.5 °C
Type J	– 150 °C	to +1200 °C	± 0.2 °C
	– 210°C	to – 150 °C	± 0.5 °C
Type L	– 150 °C	to +900 °C	± 0.2 °C
	– 200 °C	to – 150 °C	± 0.5 °C
Type K	– 200 °C	to +1372 °C	± 0.2 °C
	– 270 °C	to – 200 °C	± 1.0 °C
Type N	– 200 °C	to 1300 °C	± 0.2 °C
	– 270 °C	to – 200 °C	± 1.0 °C
Type R	+100 °C	to 1768 °C	± 0.2 °C
	– 50 °C	to +100 °C	± 0.5 °C
Type S	+100 °C	to 1768 °C	± 0.2 °C
	– 50 °C	to +100 °C	± 0.5 °C
Type B	+200 °C	to +1802 °C	± 0.3 °C
	+45 °C	to +200 °C	± 0.5 °C

5 Owing to the slight rise over the range of approximately 0 °C to 85 °C, the lack of compensation of the reference junction temperature has only a negligible effect on a type B thermocouple. If there is no compensation and the measuring method “Compensation to 0 °C” is set, the deviation for a type B thermocouple during temperature measurement is

200 °C   to 1802 °C   <0.5 °C

4.22.1 Commissioning the SM 331; AI 8 × TC

You set the mode of operation of the SM 331; AI 8 ×TC Bit in *STEP 7*.

Parameter

You will find a description of the general procedure for assigning parameters to analog modules in Section 4.7.

An overview of the parameters that you can set and their default settings are shown in the table below.

Table 4-64 Parameters of the SM 331; AI 8 × TC

Parameter	Value Range	Default Settings	Parameter Type	Scope
Enable • Diagnostic interrupt • Hardware interrupt upon limit violation • Hardware interrupt at end of cycle	 Yes/no Yes/no Yes/no	 No No No	Dynamic	Module
Trigger for hardware interrupt • Upper limit value • Lower limit value	 32511 to – 32512 – 32512 to 32511	–	Dynamic	Channel
Diagnostics • Group diagnostics • With wire-break check	 Yes/no Yes/no	 No No	Static	Channel group
Measurement • Measuring method	deactivated TC-IL Thermocouple (linear, internal comparison) TC-EL Thermocouple (linear, external comparison) TC-L00C thermocouple (linear, ref. temperature 0°C) TC-L50C thermocouple (linear, ref. temperature 50°C)	TC-IL	Dynamic	Channel group
• Measuring range	For the settable measuring ranges of the input channels, please refer to the individual module description.	Type K		
• Reaction to open thermocouple	Overflow; underflow	Overflow		
• Temperature unit	Degrees Celsius; degrees Fahrenheit	Degrees Celsius	Dynamic	Module

Table 4-64 Parameters of the SM 331; AI 8 × TC, continued

Parameter	Value Range	Default Settings	Parameter Type	Scope
• Operating mode	8 channels. hardware filter 8 channels. software filter 4 channels. hardware filter	8 channels, hardware filter	Dynamic	Module
• Interference suppression*	50/60/400 Hz; 400 Hz; 60 Hz; 50 Hz; 10 Hz	50/60/400 Hz	Dynamic	Channel group
• Smoothing	None Low Average High	None	Dynamic	Channel group

* 50/60/400 Hz programmable only for modes 8 or 4-Channel Hardware Filter Modes; 50 Hz, 60 Hz or 400 Hz programmable only for mode 8-Channel Hardware Filter Mode

Channel groups

The channels of the SM 331; AI 8 × TC are arranged in four groups of two. You can only ever assign parameters to one channel group.

The table below shows which channels are parameterized as a channel group in each case. You will need the channel group number to set the parameters in the user program with an SFC.

Table 4-65 Assignment of Channels of the SM 331; AI 8 × TC to Channel Groups

Channels ...	... form one Channel Group each
Channel 0	Channel group 0
Channel 1	
Channel 2	Channel group 1
Channel 3	
Channel 4	Channel group 2
Channel 5	
Channel 6	Channel group 3
Channel 7	

Special characteristic of channel groups for hardware interrupts upon limit violation

You can set the upper and lower limits for each channel with hardware interrupts in *STEP 7*.

Reaction to open thermocouple

You can assign parameters to ”Overflow” or ”Underflow” as a function of the process you want to control.

You should program ”Overflow” for heat-producing processes. When a thermocouple opens, $7FFF_H$ is the value supplied by the module. The control loop then shuts down the production of heat automatically.

You should program ”Underflow” for refrigeration processes. When a thermocouple opens, 8000_H is the value supplied by the module. The control loop then shuts down the refrigeration automatically.

Operating mode

The SM 331; AI 8 × TC operates in one of the following modes:

- “Hardware Filter, 8 Channels”
- “Software Filter, 8 Channels”
- “Hardware Filter, 4 Channels”

The operating mode affects the scan time of the module.

High speed update mode

With high speed updating, updating of not more than 4 channels is performed in only 10 ms.

High speed updating is possible only in “Hardware Filter, 4 Channels” mode. In this mode, the module does not switch between the channels of the different groups. You must only use the channels with even numbers (0, 2, 4, 6) on the module.

Scan time in “Hardware Filter, 8 Channels” mode

In “Hardware Filter, 8 Channels” mode, the module always converts the analog values simultaneously, first for the channels with even numbers, followed the channels with odd numbers.

The scan time for the module results in:

Scan time = $(t_K + t_U) \times 2$

Scan time = $(91\ \text{ms} + 7\ \text{ms}) \times 2$

Scan time = <u>196 ms</u>

t_K: channel conversion time for one channel
t_U: time for switching to the other channel in the channel group

Scan time in “Software Filter, 8 Channels” mode

In “Software Filter, 8 Channels” mode, analog-to-digital conversion is performed in exactly the same manner as in “Hardware Filter, 8 Channels” mode. In other words, the analog values are always converted simultaneously, first for the channels with even numbers and then for the channels with odd numbers.

The channel conversion time depends, however, on the programmed interference frequency suppression. This relationship is shown in the table that follows.

Table 4-66 Scan Times in “Software Filter, 8 Channels” Mode

Programmed Interference Frequency Suppression	Channel Scan Time*	Module Scan Time (All Channels)
50 Hz	83 ms	**166 ms**
60 Hz	72 ms	**144 ms**
400 Hz	23 ms	**46 ms**

* Channel scan time = channel conversion time + 7 ms switching time to the other channel in the channel group

Scan time in “Hardware Filter, 4 Channels” mode

In this mode, the module does not switch between the channels of the different groups. The module converts the channels with even numbers simultaneously.

This results for the scan time in:

Channel conversion time = channel scan time = module scan time = **<u>10 ms</u>**

Prolongation of the scan time with a wire-break check

The wire-break check is a software function of the module that is available in all operating modes.

The 8-Channel Hardware and Software Filter operating modes prolong the scan time of the module by 4 ms, irrespective of the number of channels for which Wire Break has been enabled.

In the 4-Channel Hardware Filter operating mode, the module interrupts processing of the input data 170 ms and performs a wire-break check. In other words, each wire-break check prolongs the scan time of the module by 93 ms.

Smoothing of the measured values

You fill find information that is generally applicable to the smoothing of analog values in Section 4.6.

Special characteristic with short-circuit to M or L

If you short an input channel to M or L, the module does not suffer any damage. The channel continues to issue valid data; neither is a diagnosis reported.

Diagnostics

You will find the diagnostic messages that are grouped under the “group diagnosis” parameter in Table 4-44, on page 4-69.

4.22.2 Measuring Methods and Measuring Ranges of the SM 331; AI 8 × TC

Measuring methods

As the measuring method for the input channels, you can set the temperature measurement with different thermocouples.

You perform the setting with the “measuring method” parameter in *STEP 7*.

Unused channels

Set the ”measuring method” parameter for unused channels to “disabled”. In this way you shorten the scan time of the module.

You must terminate an unused channel in an enabled channel group to avoid diagnostic errors for the unused channel. To do this, short the Plus input and Minus input of the channel.

In the “4-Channel Hardware Filter” operating mode, termination is not necessary provided that you have disabled the unused channel groups. Channels 1, 3, 5 and 7 are not monitored in this mode.

Measuring ranges

You perform setting of the measuring ranges with the “measuring range” parameter in *STEP 7*.

Table 4-67 Measuring Ranges of the SM 331; AI 8 × TC

Method Selected	Measuring Range	Description
TC-L00C: (thermocouple, linear, reference temperature 0 °C) TC-L50C: (thermocouple, linear, reference temperature 50 °C) TC-IL: (thermocouple, linear, internal compensation) TC-EL: (thermocouple, linear, external compensation)	Type B Type E Type J Type K Type L Type N Type R Type S Type T Type U	You will find the digitized analog values in Section 4.3.1 in the temperature range

Default settings

The default settings of the module are the ”Thermocouple (linear, internal compensation)” measuring method and the ”Type K” measuring range. You can use this combination of measuring method and measuring range without parameterizing the SM 331; AI 8 × TC × 24 Bit in *STEP 7*.

Measuring errors with common-mode voltages

The SM 331; AI 8 × TC can perform measurements even when there are AC or DC common-mode voltages.

For AC and DC common-mode voltages, common-mode rejection is performed by the input amplifiers. For common mode voltages < 120 $V_{r.m.s}$ and 120 VDC, the rejection ratio of > 100 dB results in negligible measurement error.

Special characteristic of parameter assignment to upper and lower limit values

The parameterizable limit values (triggers for hardware interrupt) differ for the AI 8 × TC from the range of values shown in Table 4-64.

The reason for this is that numerical methods in the module software for evaluating the process variables prevent values up to 32511 from being reported in some cases. The process input value at which a hardware interrupt for an underflow or Overflow occurs depends on the calibration factors for an individual channel and can vary between the lower limits shown in the Table below and 32511 ($7EFF_H$).

Limit values should not be set at values higher than the minimum potential limit values shown in the table below.

Table 4-68 Minimum Possible Upper and Lower Limit Values of SM 331; AI 8 × TC

Measuring Range	Minimum Possible Upper Limit Value	Minimum Possible Lower Limit Value
Type B	1802.1 °C	45.1 °C
Type E	1000.1 °C	– 270.1 °C
Type J	1200.1 °C	– 210.1 °C
Type K	1372.1 °C	– 270.1 °C
Type L	900.1 °C	– 200.1 °C
Type N	1300.1 °C	– 270.1 °C
Type R	1768.1 °C	– 50.1 °C
Type S	1768.1 °C	– 50.1 °C
Type T	400.1 °C	– 270.1 °C
Type U	600.1 °C	– 200.1 °C

4.23 Analog Output Module SM 332; AO 4 × 12 Bit; (6ES7 332-5HD01-0AB0)

Order number

6ES7 332-5HD01-0AB0

Characteristics

The analog output module SM 332; AO 4 × 12 Bit has the following characteristic features:

- 4 outputs in 4 channel groups
- The individual output channels can be programmed as
  - voltage outputs
  - current outputs
- Resolution 12 bits
- Programmable diagnostics
- Programmable diagnostic interrupt
- Programmable substitute value output
- Isolated to backplane bus interface and load voltage

Terminal connection and block diagram of analog output module SM 332; AO 4 × 12 Bit

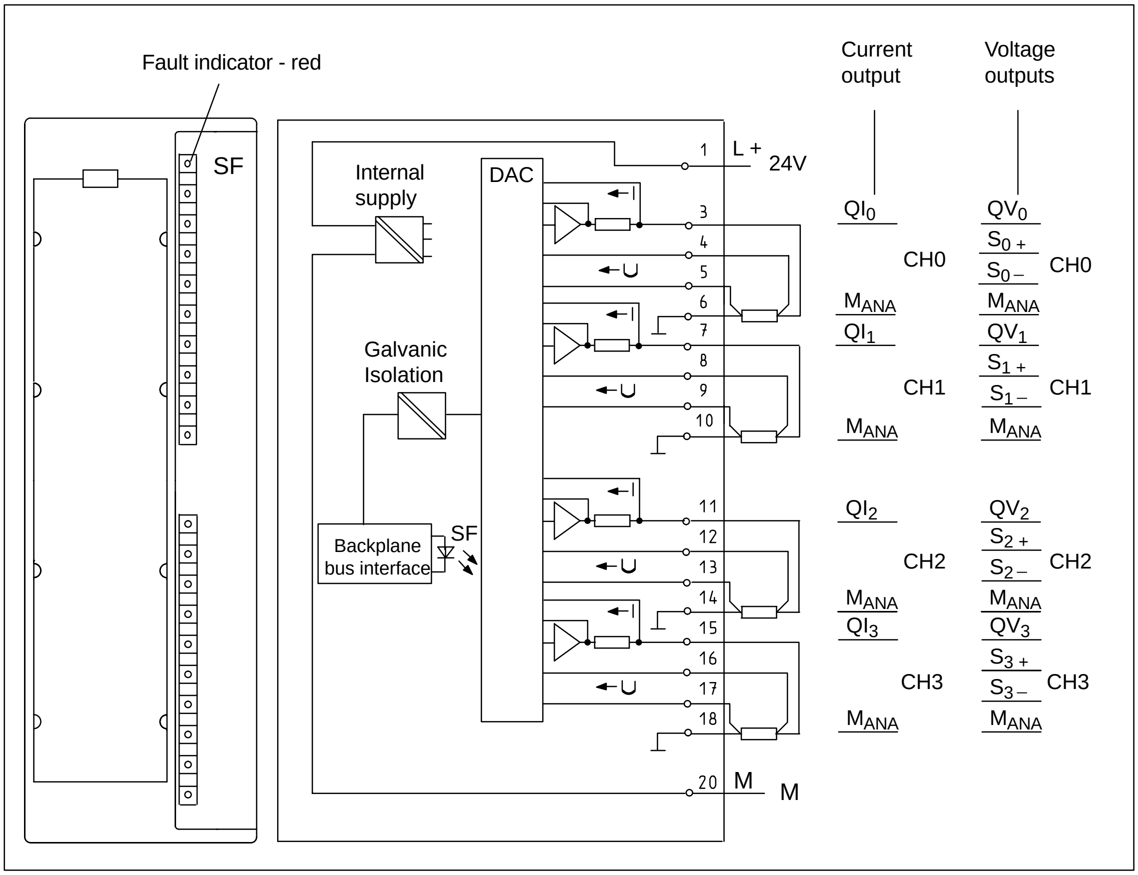


Figure 4-34 Module View and Block Diagram of the Analog Output Module SM 332; AO 4 × 12 Bit

Technical specifications of the SM 332; AO 4 × 12 Bit

Dimensions and Weight	
Dimensions W × H × D (in millimeters)	40 × 125 × 120
Weight	Approx. 220 g
Module-Specific Data	
Number of outputs	4
Lenght of cable	
• Shielded	max. 200 m
Voltage, Currents, Potentials	
Rated load voltage L +	24 VDC
• Reverse polarity protection	Yes
Isolation	
• Between channels and backplane bus	Yes
• Between channels and power supply of the electronics	Yes
• Between the channels	No
• Between channels and load voltage L+	Yes
Permitted potential difference	
• Between outputs and M_{ANA} (E_{CM})	3 VDC
• Between S– and M_{ANA} (E_{CM})	3 VDC
• Between M_{ANA} and $M_{internal}$ (E_{ISO})	75 VDC / 60 VAC
Insulation tested with	600 VDC
Current consumption	
• From the backplane bus	max. 60 mA
• From the load voltage L+ (without load)	max. 240 mA
Power dissipation of the module	typ. 3 W

Analog Value Generation	
Resolution including sign	
• ± 10 V; ± 20 mA; 4 to 20 mA; 1 to 5 V	11 bits + sign
• 0 to 10 V; 0 to 20 mA	12 bits
Conversion time (per channel)	max. 0.8 ms
Settling time	
• For resistive load	0.1 ms
• For capacitive load	3.3 ms
• For inductive load	0.5 ms
Suppression of interference, Limits of Error	
Crosstalk between the outputs	> 40 dB
Operational limit (in the entire temperature range, with reference to the output range)	
• Voltage outputs	± 0.5 %
• Current outputs	± 0.6 %
Basic error (operational limit at 25 °C, with reference to the output range)	
• Voltage outputs	± 0.2 %
• Current outputs	± 0.3 %
Temperature error (with reference to the output range)	± 0.02 %/K
Linearity error (with reference to the output range)	± 0.05 %
Repeatability (in steady state at 25 °C, with reference to the output range)	± 0.05 %
Output ripple; band width 0 to 50 kHz (with reference to the output range)	± 0.05 %
Status, Interrupts, Diagnostics	
Interrupts	
• Diagnostic Interrupt	Parameters can be assigned
Diagnostic functions	Parameters can be assigned
• Group error display	Red LED (SF)
• Diagnostic information can be displayed	Possible
Substitute value can be applied	Parameters can be assigned

Data for Selecting an Actuator	
Output ranges (nominal values)	
• Voltage	± 10 V 0 to 10 V 1 to 5 V
• Current	± 20 mA 0 to 20 mA 4 to 20 mA
Load resistance (in the nominal range of the output)	
• For voltage outputs	min. 1 kΩ
– Capacitive load	max. 1 µF
• For current outputs	max. 500 Ω
– At E_{CM} < 1V	max. 600 Ω
– Inductive load	max. 10 mH
Voltage outputs	
• Short-circuit protection	Yes
• Short-circuit current	max. 25 mA
Current outputs	
• No-load voltage	max. 18 V

Destruction limit against voltages/currents applied from outside	
• Voltage to the outputs against M_{ANA}	max 18 V continuous; 75 V for max. 1 s (pulse duty factor 1:20)
• Current	max. DC 50 mA
Connection of actuators	
• For voltage output	
– Four-conductor connection (measuring circuit)	Possible
• For current output	
– Two-conductor connection	Possible

4.23.1 Commissioning the SM 332; AO 4 × 12 Bit

Note

When switching on and off the rated load voltage (L+), wrong intermediate values can occur across the output for approximately 10 ms.

Parameter

You will find a description of the general procedure for assigning parameters to analog modules in Section 4.7.

You will find an overview of the programmable parameters and their default values in Table 4-40, on page 4-41.

Assigning parameters to channels

You can configure each output channel of the SM 332; AO 4 × 12 Bit individually. You can thus assign separate parameters for each output channel.

When you set the parameters with SFCs in the user program, the parameters are assigned to channel groups. Every output channel of the SM 332; AO 4 × 12 Bit is assigned to a channel group in this instance – in other words, for example output channel 0 = channel group 0.

Note

If you modify output ranges when the analog output module SM 332; AO 4 × 12 Bit is in operation, incorrect intermediate values may arise across the output.

Diagnostics

You will find the diagnostic messages that are grouped under the "group diagnosis" parameter in Table 4-45, on page 4-69.

4.23.2 Output Ranges of the Analog Output Module SM 332; AO 4 × 12 Bit

Connecting the analog outputs

You can connect the outputs as voltage or current outputs, or disable them. You perform connection of the outputs with the "output type" parameter in *STEP 7*.

Unused channels

So that unused output channels of the SM 332; AO 4 × 12 Bit remain de-energized, you must set the "output type" parameter to "disabled" and leave the terminal open.

Output ranges

You program the output ranges for voltage and current outputs in *STEP 7*.

Table 4-69 Output Ranges of the Analog Output Module SM 332; AO 4 × 12 Bit

Selected Type of Output	Output Range	Description
Voltage	1 to 5 V 0 to 10 V ± 10 V	You will find the digital analog values in Section 4.3.2 in the voltage and current output ranges
Current	0 to 20 mA 4 to 20 mA ± 20 mA	

Default settings

The default settings of the module are ”Voltage” for the output type and ”± 10 V” for the output range. You can use this combination of output type and output range without parameterizing the SM 332; AO 4 × 12 Bit in *STEP 7*.

Wire-break check

The analog output module SM 332; AO 4 × 12 Bit carries out a wire-break check only for current outputs.

Short-circuit test

The analog output module SM 332; AO 4 × 12 Bit carries out a short-circuit test only for voltage outputs.

Substitute values

You can configure the SM 332; AO 4 × 12 Bit for the CPU operating mode STOP as follows: Outputs De-energized, Hold Last Value or Inject Substitute Values. If you inject substitute values, they must be within the output range.

Special characteristic of substitute values for output ranges 1 to 5 V and 4 to 20 mA

The following special characteristic applies to output ranges 1 to 5 V and 4 to 20 mA:

You have to set the substitute value $E500_H$ for the output to become de-energized (refer to Tables 4-33 and 4-35 on pages 4-25 and 4-26).

4.24 Analog Output Module SM 332; AO 2 × 12 Bit; (6ES7 332-5HB01-0AB0)

Order number

6ES7 332-5HB01-0AB0

Characteristics

The analog output module SM 332; AO 2 × 12 Bit has the following characteristic features:

- 2 outputs in 2 channel groups
- The individual output channels can be programmed as
  - voltage outputs
  - current outputs
- Resolution 12 bits
- Programmable diagnostics
- Programmable diagnostic interrupt
- Programmable substitute value output
- Isolated to backplane bus interface and load voltage

Terminal connection diagram and block diagram of the SM 332; AO 2 × 12 Bit

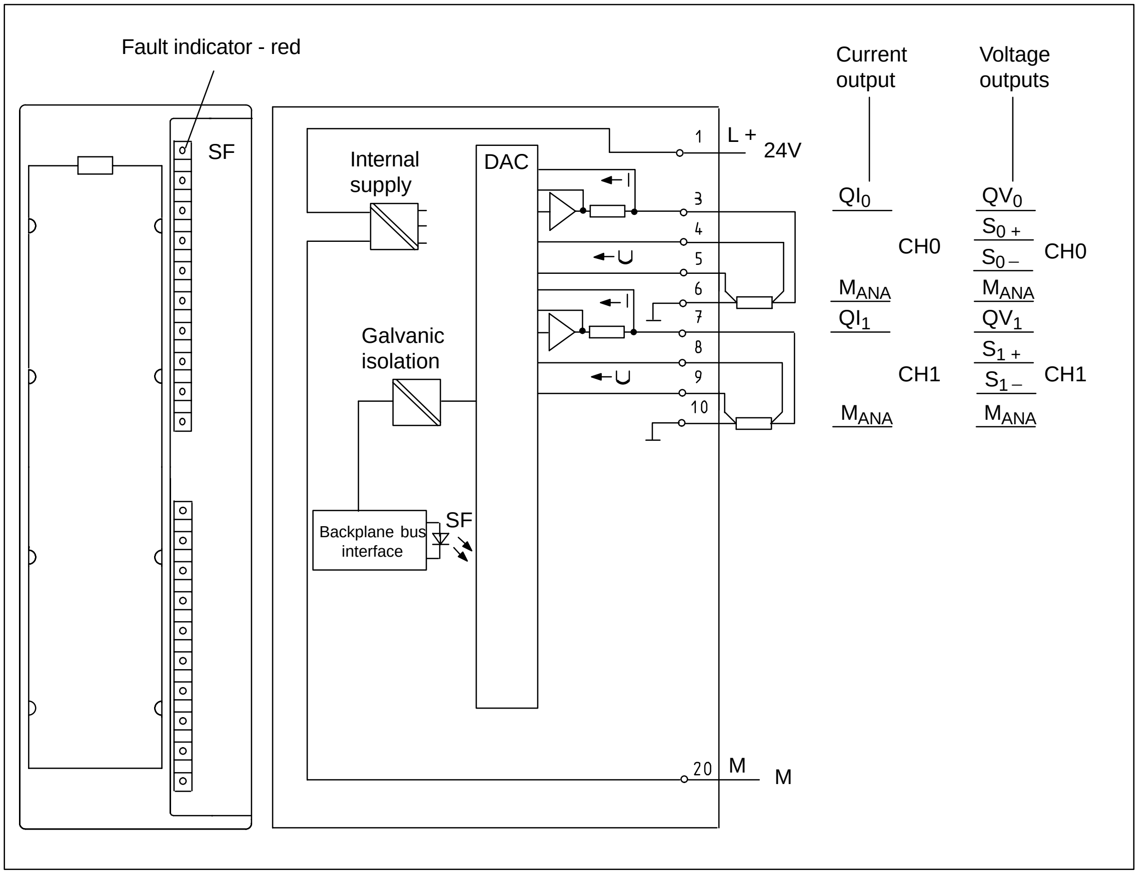


Figure 4-35 Module View and Block Diagram of the Analog Output Module SM 332; AO 2 × 12 Bit

Technical specifications of the SM 332; AO 2 × 12 Bit

Dimensions and Weight	
Dimensions W × H × D	40 × 125 × 120
Weight	Approx. 220 g
Module-Specific Data	
Number of outputs	2
Lenght of cable	
• Shielded	max. 200 m
Voltage, Currents, Potentials	
Rated load voltage L +	24 VDC
• Reverse polarity protection	Yes
Isolation	
• Between channels and backplane bus	Yes
• Between channels and power supply of the electronics	Yes
• Between the channels	No
• Between channels and load voltage L+	Yes
Permitted potential difference	
• Between outputs and M_{ANA} (E_{CM})	3 VDC
• Between S– and M_{ANA} (E_{CM})	3 VDC
• Between M_{ANA} and $M_{internal}$ (E_{ISO})	75 VDC / 60 VAC
Insulation tested with	600 VDC
Current consumption	
• From the backplane bus	max. 60 mA
• From the load voltage L+ (without load)	max. 135 mA
Power dissipation of the module	typ. 3 W

Analog Value Generation	
Resolution including sign	
• ± 10 V; ± 20 mA; 4 to 20 mA; 1 to 5 V	11 bits + sign
• 0 to 10 V; 0 to 20 mA	12 bits
Conversion time (per channel)	max. 0.8 ms
Settling time	
• For resistive load	0.1 ms
• For capacitive load	3.3 ms
• For inductive load	0.5 ms
Suppression of interference, Limits of Error	
Crosstalk between the outputs	> 40 dB
Operational limit (in the entire temperature range, with reference to the output range)	
• Voltage outputs	± 0.5 %
• Current outputs	± 0.6 %
Basic error (operational limit at 25 °C, with reference to the output range)	
• Voltage outputs	± 0.2 %
• Current outputs	± 0.3 %
Temperature error (with reference to the output range)	± 0.02 %/K
Linearity error (with reference to the output range)	± 0.05 %
Repeatability (in steady state at 25 °C, with reference to the output range)	± 0.05 %
Output ripple; band width 0 to 50 kHz (with reference to the output range)	± 0.05 %
Status, Interrupts, Diagnostics	
Interrupts	
• Diagnostic interrupt	Parameters can be assigned
Diagnostic functions	Parameters can be assigned
• Group error display	Red LED (SF)
• Diagnostic information can be displayed	Possible
Substitute value can be applied	Parameters can be assigned

Data for Selecting an Actuator	
Output ranges (nominal values)	
• Voltage	± 10 V 0 to 10 V 1 to 5 V
• Current	± 20 mA 0 to 20 mA 4 to 20 mA
Load resistance (in the nominal range of the output)	
• For voltage outputs	min. 1 kΩ
– capacitive load	max. 1 µF
• For current outputs	max. 500 Ω
– At E_{CM} < 1V	max. 600 Ω
– Inductive load	max. 10 mH
Voltage outputs	
• Short-circuit protection	Yes
• Short-circuit current	max. 25 mA
Current outputs	
• No-load voltage	max. 18 V

Destruction limit against voltages/currents applied from outside	
• Voltage to the outputs against M_{ANA}	max 18 V continuous; 75 V for max. 1 s (pulse duty factor 1:20)
• Current	max. DC 50 mA
Connection of actuators	
• For voltage output	
– Two-wire circuit	Possible
– Four-conductor connection (measuring circuit)	Possible
• For current output	
– Two-conductor circuit	Possible

4.24.1 Commissioning the SM 332; AO 2 × 12 Bit

Note

When switching on and off the rated load voltage (L+), wrong intermediate values can occur across the output for approximately 10 ms.

Parameter

You will find a description of the general procedure for assigning parameters to analog modules in Section 4.7.

You will find an overview of the programmable parameters and their default values in Table 4-40, on page 4-41.

Assigning parameters to channels

You can configure each output channel of the SM 332; AO 2 × 12 Bit individually. You can thus assign separate parameters for each output channel.

When you set the parameters with SFCs in the user program, the parameters are assigned to channel groups. Every output channel of the SM 332; AO 2 × 12 Bit is assigned to a channel group in this instance – in other words, for example output channel 0 = channel group 0.

Note

If you modify output ranges when the analog output module SM 332; AO 2 × 12 Bit is in operation, incorrect intermediate values can arise across the output.

Diagnostics

You will find the diagnostic messages that are grouped under the “group diagnosis” parameter in Table 4-45, on page 4-69.

4.24.2 Output Ranges of the Analog Output Module SM 332; AO 2 × 12 Bit

Connecting the analog outputs

You can connect the outputs as voltage or current outputs, or disable them. You perform connection of the outputs with the “output type” parameter in *STEP 7*.

Unused channels

So that unused output channels of the SM 332; AO 2 × 12 Bit remain de-energized, you must set the “output type” parameter to “disabled” and leave the terminal open.

Output ranges

You program the output ranges for voltage and current outputs in *STEP 7*.

Table 4-70 Output Ranges of the Analog Output Module SM 332; AO 2 × 12 Bit

Selected Type of Output	Output Range	Description
Voltage	1 to 5 V 0 to 10 V ± 10 V	You will find the digital analog values in Section 4.3.2 in the voltage and Current Output Range
Current	0 to 20 mA 4 to 20 mA ± 20 mA	

Default settings

The default settings of the module are "Voltage" for the output type and "± 10 V" for the output range. You can use this combination of output type and output range without parameterizing the SM 332; AO 2 × 12 Bit in *STEP 7*.

Wire-break check

The analog output module SM 332; AO 2 × 12 Bit carries out a wire-break check only for current outputs.

Short-circuit test

The analog output module SM 332; AO 2 × 12 Bit carries out a short-circuit check only for voltage outputs.

Substitute values

You can configure the SM 332; AO 2 × 12 Bit for the CPU operating mode STOP as follows: Outputs De-energized, Hold Last Value or Inject Substitute Values. If you inject substitute values, they must be within the output range.

Special characteristic of substitute values for output ranges 1 to 5 V and 4 to 20 mA

The following special characteristic applies to output ranges 1 to 5 V and 4 to 20 mA:

You have to set the substitute value $E500_H$ for the output to remain de-energized (refer to Tables 4-33 and 4-35 on pages 4-25 and 4-26).

4.25 Analog Output Module SM 332; AO 4 × 16 Bit; (6ES7 332-7ND00-0AB0)

Order number

6ES7 332-7ND00-0AB0

Characteristics

The analog output module SM 332; AO 4 × 16 Bit has the following characteristic features:

- 4 outputs in 4 channel groups
- The individual output channels can be programmed as
  - voltage outputs
  - current outputs
- Resolution of 16 bits
- Programmable diagnostics
- Programmable diagnostic interrupt
- Programmable substitute value output
- Galvanic isolation between:
  - backplane bus interface and analog output channel
  - the different analog output channels
  - analog output and L+, M
  - backplane bus interface and L+, M

Terminal connection and block diagram of analog output module SM 332; AO 4 × 16 Bit

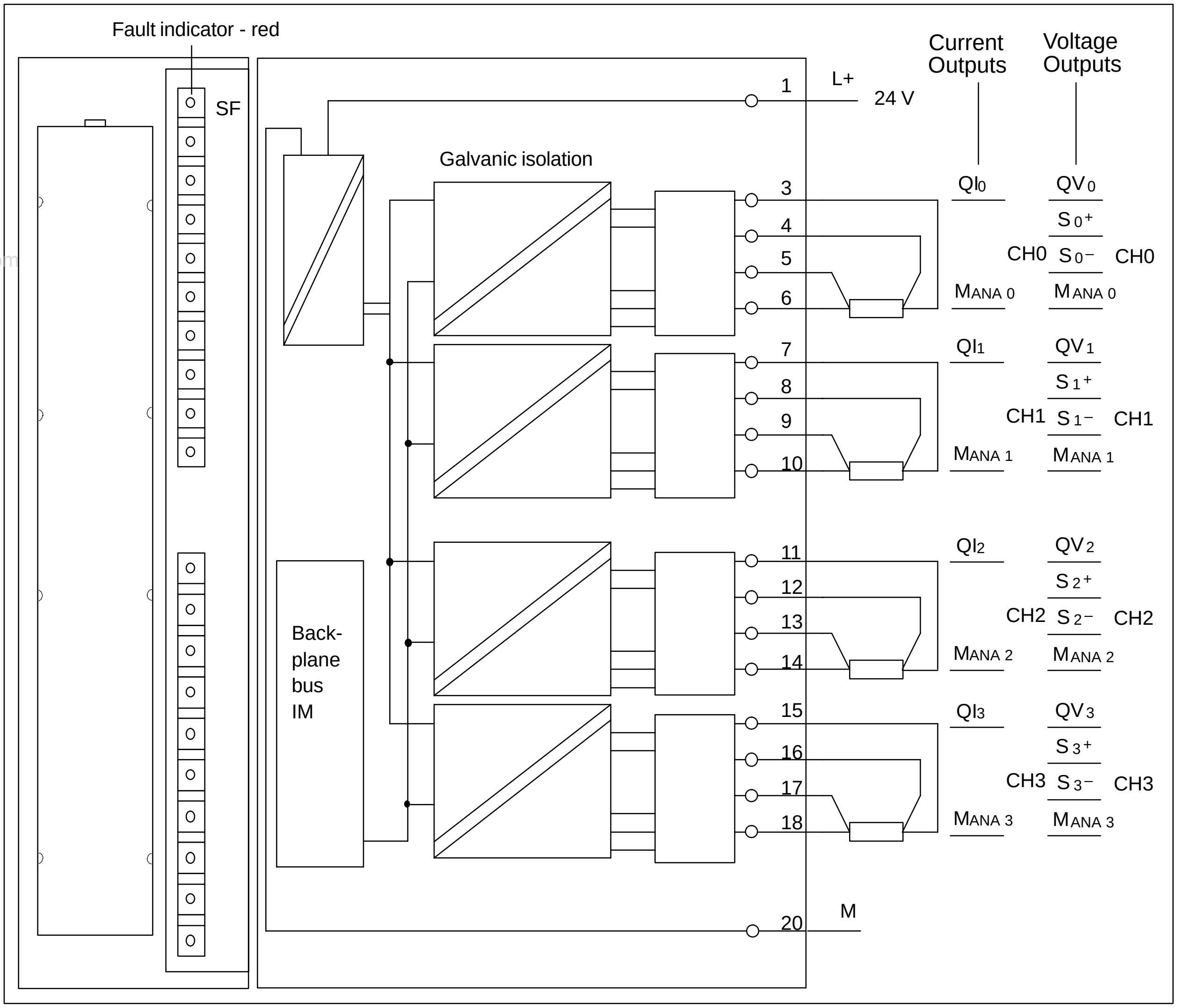


Figure 4-36 Module View and Block Diagram of the SM 332; AO 4 × 16 Bit

Technical specifications of the SM 332; AO 4 × 16 Bit

Dimensions and Weight	
Dimensions W × H × D (in millimeters)	40 × 125 × 120
Weight	Approx. 220 g
Module-Specific Data	
Number of outputs	4
Lenght of cable	
• Shielded	max. 200 m
Voltages, Currents, and Potentials	
Rated load voltage L+	24 VDC
• Reverse polarity protection	Yes
Isolation	
• Between channels and backplane bus	Yes
• Between channels and power supply of the electronics	Yes
• Between the channels	Yes
• Between channels and load voltage L+	Yes
Permitted potential difference	
• Between the outputs (E_{CM})	200 VDC / 120 VAC
• Between M_{ANA} and $M_{internal}$ (E_{ISO})	200 VDC / 120 VAC
Insulation tested with	1500 VAC
Current consumption	
• From the backplane bus	max. 60 mA
• From the load voltage L+ (without load)	max. 240 mA
Power dissipation of the module	typ. 3 W

Analog Value Generation	
Resolution including sign	15 bits + sign
• 1 to 5 V	13 bits
• 4 to 20 mA	14 bits
Conversion time (per channel)	max. 1.5 ms
Settling time	
• For resistive load	0.2 ms
• For capacitive load	1.0 ms
• For inductive load	0.2 ms
Suppression of Interference, Limits of Error	
Crosstalk between outputs	> 100 dB
Operational limit (in the entire temperature range, with reference to the output range)	
• Voltage outputs	± 0.12 %
• Current outputs	± 0.18 %
Basic error (operational limit at 25 °C, with reference to the output range)	
• Voltage outputs	± 0.01 %
• Current outputs	± 0.01 %
Temperature errror (with reference to the output range)	± 0.001 %
Linearity error (with reference to the output range)	± 0.004 %
Repeatability (in steady state at 25 °C, with reference to the output range)	± 0.002 %
Output ripple; bandwidth 0 to 50 kHz (with reference to the output range)	± 0.05 %
Status, Interrupts, Diagnostics	
Interrupts	
• Diagnostic interrupt	Parameters can be assigned
Diagnostic functions	Parameters can be assigned
• Group error display	Red LED (SF)
• Diagnostic information can be displayed	Possible
Substitute value can be applied	Parameters can be assigned

Data for Selecting an Actuator	
Output ranges (nominal values)	
• Voltage	± 10 V 0 to 10 V 1 to 5 V
• Current	± 20 mA 0 to 20 mA 4 to 20 mA
Load resistance (in the nominal range of the output)	
• For voltage outputs	min. 1 kΩ
– capacitive load	max. 1 μF
• For current outputs	max. 500 Ω
– inductive load	max. 1 mH
Voltage outputs	
• Short-circuit protection	Yes
• Short-circuit current	max. 40 mA
Current outputs	
• No-load voltage	max. 18 V
Destruction limit against voltages/currents applied from outside	
• Voltage to the outputs against M_{ANA}	max. 15 V continuous 75 VDC for no more than 0.1 s (pulse duty factor 1 : 20)
• Current	max. DC 50 mA
Connection of actuators	
• For voltage output	
– Four-conductor connection (measuring circuit)	Possible
• For current output	
– Four-conductor connection	Possible

4.25.1 Commissioning the SM 332; AO 4 × 16 Bit

Parameter

You will find a description of the general procedure for assigning parameters to analog modules in Section 4.7.

You will find an overview of the programmable parameters and their default values in Table 4-40, on page 4-41.

Assigning parameters to channels

You can configure each output channel of the SM 332; AO 4 × 16 Bit individually. You can thus assign separate parameters for each output channel.

When you set the parameters with SFCs in the user program, the parameters are assigned to channel groups. Every output channel of the SM 332; AO 4 × 16 Bit is assigned to a channel group in this instance – in other words, for example output channel 0 = channel group 0.

Note

If you modify output ranges when the analog output module SM 332; AO 4 × 16 Bit is in operation, incorrect intermediate values may arise across the output.

Diagnostics

You will find the diagnostic messages that are grouped under the “group diagnosis” parameter in Table 4-45, on page 4-69.

4.25.2 Output Ranges of the Analog Output Module SM 332; AO 4 × 16 Bit

Connecting the analog outputs

You can connect the outputs as voltage or current outputs, or disable them. You perform connection of the outputs with the “output type” parameter in *STEP 7*.

Unused channels

So that unused output channels of the SM 332; AO 4 × 16 Bit remain de-energized, you must set the “output type” parameter to “disabled” and leave the terminal open.

Output ranges

You program the output ranges for voltage and current outputs in *STEP 7*.

Table 4-71 Output Ranges of the Analog Output Module SM 332; AO 4 × 16 Bit

Selected Type of Output	Output Range	Description
Voltage	1 to 5 V 0 to 10 V ± 10 V	You will find the digital analog values in Section 4.3.2 in the voltage and Current Output Range
Current	0 to 20 mA 4 to 20 mA ± 20 mA	

Default settings

The default settings of the module are ”Voltage” for the output type and ”± 10 V” for the output range. You can use this combination of output type and output range without parameterizing the SM 332; AO 4 × 16 Bit in *STEP 7*.

Substitute values

You can configure the SM 332; AO 4 × 16 Bit for the CPU operating mode STOP as follows: Outputs De-energized, Hold Last Value or Inject Substitute Values. If you inject substitute values, they must be within the output range.

4.26 Analog Input/Output Module SM334; AI 4/AO 2 × 8/8 Bit; (6ES7 334-0CE01-0AA0)

Order number

6ES7 334-0CE01-0AA0

Characteristics

The analog input/output module SM 334: AI 4/AO 2 × 8/8 Bit has the following characteristic features:

- Four input and two output channels
- Resolution 8 bits
- Not parameterizable, setting of measurement and output type by means of wiring
- Measuring range of 0 to 10 V or 0 to 20 mA
- Output range of 0 to 10 V or 0 to 20 mA
- Both voltage and current output options
- Isolated from the backplane bus interface
- Non-isolated to load voltage

Module View and Block Diagram of the SM 334; AI 4/AO 2 × 8/8 Bit

Select the measuring method of the input channels and the output type of the output channels via the wiring.

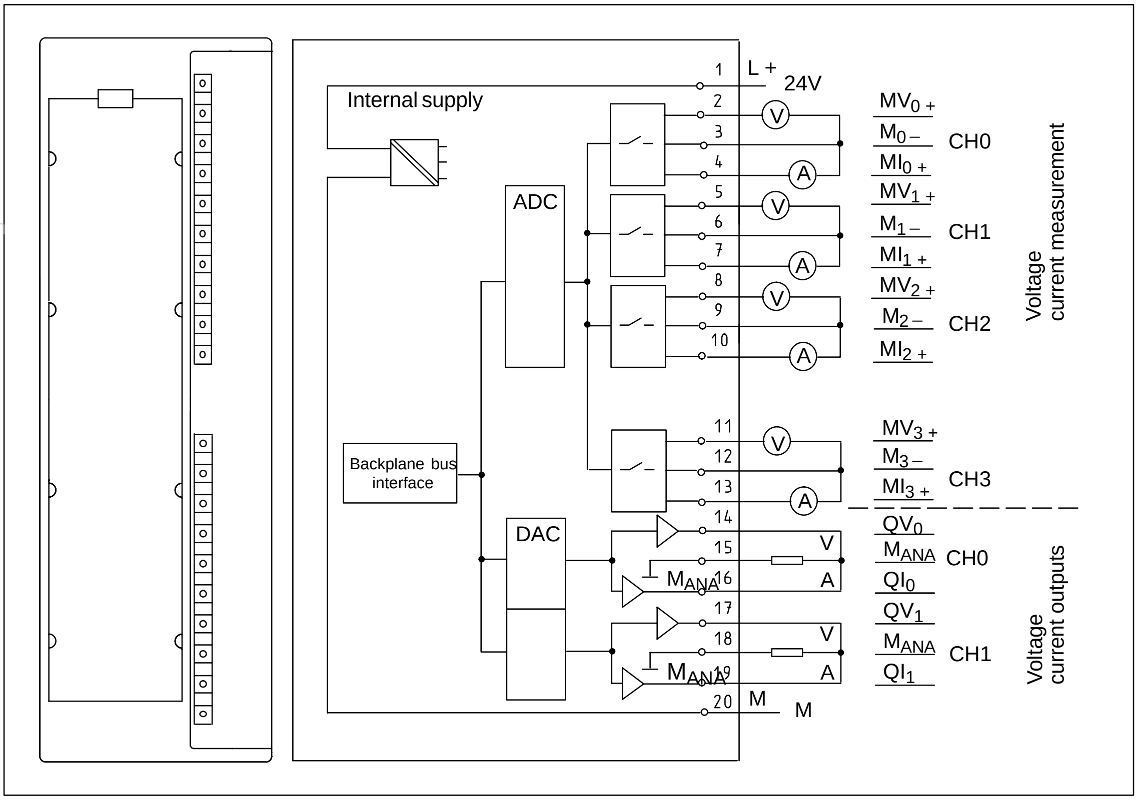


Figure 4-37 Module View and Block Diagram of the Analog Input/Output Module SM 334; AI 4/AO 2 × 8/8 Bit

Technical specifications of the SM 334; AI 4/AO 2 × 8/8 Bit

Dimensions and Weight	
Dimensions W × H × D (in millimeters)	40 × 125 × 120
Weight	Approx. 285 g
Module-Specific Data	
Number of inputs	4
Number of outputs	2
Lenght of cable	
• Shielded	max. 200 m
Voltage, Currents, Potentials	
Rated load voltage L +	24 VDC
Power rated voltage of the rated electronics voltage and rated load voltage L+	24 VDC
Isolation	
• Between channels and backplane bus	No
• Between channels and power supply of the electronics	Yes
Between the channels	No
Permitted potential difference	
• Between inputs and M_{ANA} (E_{CM})	1 VDC
• Between the inputs (E_{CM})	1 VDC
Insulation tested with	500 VDC
Current consumption	
• From the backplane bus	max. 55 mA
• From power supply and load voltage L+ (no load)	max. 110 mA
Power dissipation of the module	typ. 3 W
Analog Value Generation for the Inputs	
Measuring principle	Instantaneous value conversion
Integration time/conversion time (per channel)	
• Parameters can be assigned	No
• Integration time in milliseconds	500
• Basic conversion time including Integration time in µs	100
• Resolution including sign	8 bits

Time constant of the input filter	max. 0.8 ms
Basic response time of module (all channels enabled)	max. 5 ms
Analog Value Generation for the Outputs	
Resolution including sign	8 bits
Conversion time (per channel)	max. 500 µs
Settling time	
• For resistive load	0.3 ms
• For capacitive load	3.0 ms
• For inductive load	0.3 ms
Suppression of interference, Limits of Error	
Suppression of interference for f = nx (f1 ± 1 %) (f1 = interference frequency)	
• Common mode interference (U_{pp} < 1 V)	> 60 dB
Crosstalk between the outputs	> 50 dB
Operational limit (in the entire temperature range, with reference to the input range)	
• Voltage input	± 0.9 %
• Current input	± 0.8 %
Basic error (operational limit at 25 °C , with reference to the input range)	
• Voltage input	± 0.7 %
• Current input	± 0.6 %
Temperature error (with reference to the input range)	± 0.005 %/K
Linearity error (with reference to the input range)	± 0.05 %
Repeatability (in steady state at 25 °C with reference to the input range)	± 0.05 %
Output ripple; band width 0 to 50 kHz (with reference to the output range)	± 0.05 %

Interference Suppression, Error Limits for the Outputs	
Crosstalk between the outputs	> 40 dB
Operational limit (in the entire temperature range, with reference to the output range)	
• Voltage outputs	±0.6 %
• Current outputs	±1.0 %
Basic error (operational limit at 25 °C with reference to the output range)	
• Voltage outputs	±0.5 %
• Current outputs	±0.5 %
Temperature error (with reference to the output range)	±0.02 %/K
Linearity error (with reference to the output range)	± 0.05 %
Repeatability (in steady state at 25 °C with reference to the output range)	± 0.05 %
Output ripple (bandwidth with reference to the output range)	± 0.05 %
Status, Interrupts, Diagnostics	
Interrupts	None
Diagnostic functions	None
Data for Selecting a Sensor	
Input range (rated values)/ Input resistance	
• Voltage	0 to 10 V/100 k Ω
• Current	0 to 20 mA/50 Ω
Maximum input voltage for voltage input (destruction limit)	20 V continuous; 75 V for max. 1 s (pulse duty factor 1:20)
Maximum input current for current input (destruction limit)	40 mA
Connection of the sensor	
• For measuring voltage	Possible
• For measuring current	
As two-wire transmitter	Not possible
As four-wire transmitter	Possible

Data for Selecting an Actuator	
Output ranges (nominal values)	
• Voltage	0 to 10 V
• Current	0 to 20 mA
Load resistance (in the nominal range of the output)	
• For voltage outputs	min. 5 kΩ
– capacitive load	max. 1 μF
• For current outputs	max. 300 Ω
– inductive load	max. 1 mH
Voltage outputs	
• Short-circuit protection	Yes
• Short-circuit current	max. 11 mA
Current outputs	
• No-load voltage	max. 15 V
Destruction limit against voltages/currents applied from outside	
• Voltage to the outputs against M_{ANA}	max. 15 V continuous;
• Current	max. 50 mA DC
Connection of actuators	
• For voltage output	
Two-conductor connection	Possible
Four-conductor connection (measuring circuit)	Not possible
Connection of the sensor	
• For measuring current	
Two-conductor connection	Possible

4.26.1 Commissioning the SM 334; AI 4/AO 2 × 8/8 Bit

The analog/output module SM 334; AI 4/AO 2 x 8/8 Bit is a non-isolated module. You cannot program the SM 334; AI 4/AO 2 × 8/8 Bit.

Important information on connecting the module

Note

Note when connecting the SM 334 that:

- the **analog chassis ground M_{ANA} (terminal 15 or 18) is connected to the chassis ground M of the CPU and/or the interface module (IM)**. Use a wire with a minimum cross-section of 1 mm^2 for this.

  If there is no ground connection between M_{ANA} and M, the module switches off. Inputs are read with $7FFF_H$; outputs return a value of 0. If the module is run without a ground connection for some time, it may be destroyed.
- the **supply voltage for the CPU and/or the interface module (IM) must not be connected with reversed polarity**. Reverse polarity causes the destruction of the module because M_{ANA} is subjected to an unauthorized high potential (+24 V).

Addressing

The inputs and outputs of the module are addressed as of the initial module address.

The address of a channel is obtained from the module start address and an address offset.

Input addresses

The following addresses apply to the inputs:

Chan-nel	Address
0	Initial module address
1	Module start address + 2 bytes address offset
2	Module start address + 4 bytes address offset
3	Module start address + 6 bytes address offset

Output addresses

The following channel addresses apply to the module outputs:

Channel	Address
0	Initial module address
1	Module start address + 2 bytes address offset

4.26.2 Measuring/Output Method and Measuring/Output Range of the SM 334; AI 4/AO 2 × 8/8 Bit

You cannot program the SM 334; AI 4/AO 2 × 8/8 Bit.

Selecting the measurement method and the type of output

Select the measuring method of an input channel (voltage, current) by wiring the input channel appropriately.

Select the type of output of an output channel (voltage, current) by wiring the output channel appropriately.

Unused channels

You must short-circuit unused input channels and you should connect them to M_{ANA}. In this way, you obtain an optimum noise immunity for the analog module.

Unused output channels must be left open.

Measuring ranges

The SM 334; AI 4/AO 2×8/8 Bit has the measuring ranges 0 to 10 V and 0 to 20 mA.

Unlike the other analog modules, the SM 334 has a lower resolution and no negative measuring ranges. Take this into account when you read measured value tables 4-11 and 4-13 on pages 4-13 and 4-14.

Output ranges

The SM 334; AI 4/AO 2×8/8 Bit has the output ranges 0 to 10 V and 0 to 20 mA.

Unlike the other analog modules, the SM 334 has a lower resolution the analog outputs do not have underranges. Take this into account when you read tables 4-33 and 4-35 on pages 4-25 and 4-26.

4.27 Analog Input/Output Module SM 334; AI 4/AO 2 × 12 Bit; (6ES7 334-0KE00-0AB0)

Order number

6ES7 334-0KE00-0AB0

Characteristics

The SM 334 has the following characteristic features:

- 4 inputs in two groups
- 2 outputs (voltage outputs)
- Resolution of 12 bits + sign
- Measuring method selectable
  - Voltage
  - Resistors
  - Temperature
- Isolated to the backplane bus interface
- Isolated to load voltage

Terminal connection and block diagram of the SM334; AI 4/AO 2 × 12 Bit

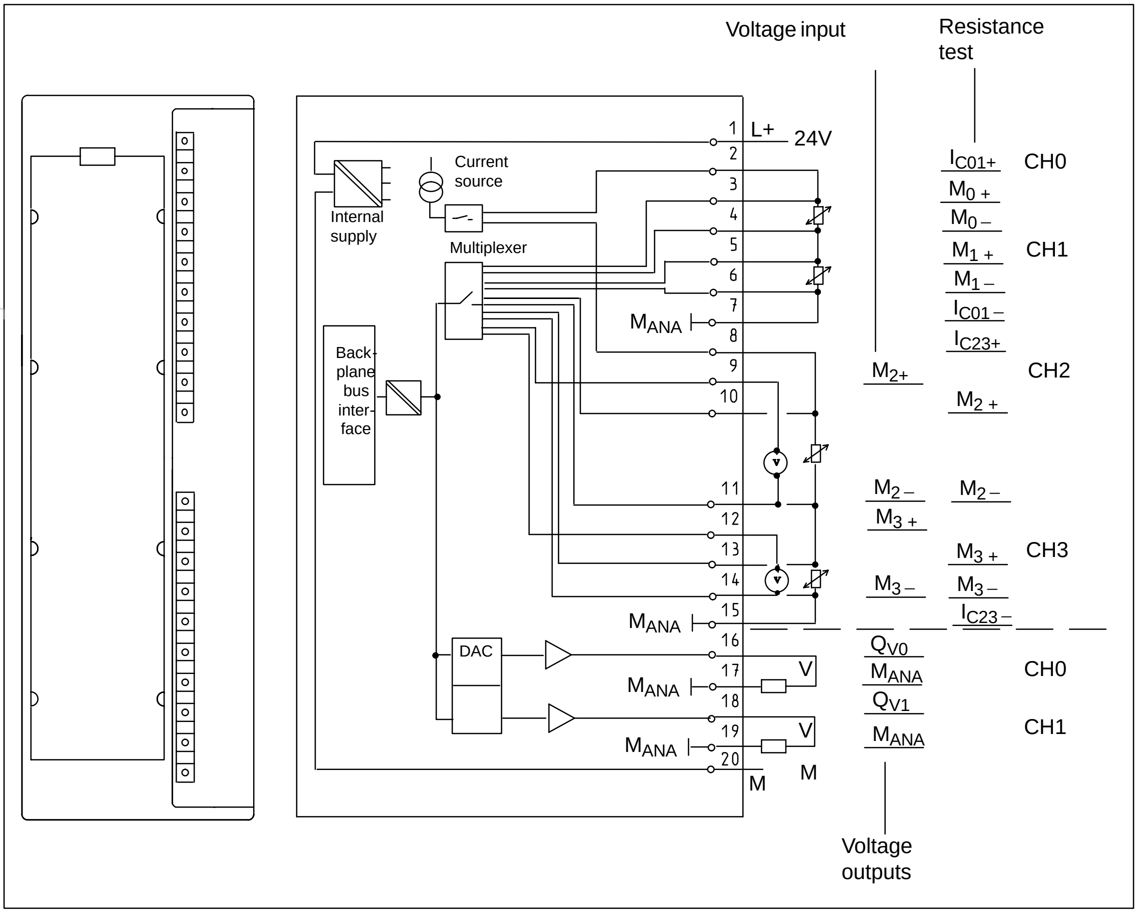


Figure 4-38 Module View and Block Diagram of the SM 334; AI 4/AO 2 × 12 Bit

Technical specifications of the SM334; AI 4/AO 2 × 12 Bit

Dimensions and Weight	
Dimensions W × H × D (in millimeters)	40 × 125 × 120 mm
Weight	Approx. 200 g
Module-Specific Data	
Number of inputs	4
• For resistance-type sensor	4
Number of outputs	2
Shielded line length	max. 100 m
Voltage, Currents, Potentials	
Rated load voltage L +	24 VDC
• Reverse polarity protection	Yes
Supply voltage of the rated electronics voltage and rated load voltage L+	24 VDC
Power supply of the transmitters	
• Short-circuit-proof	Yes
Constant measured current for resistance-type sensor	
• For PT 100	typ. 490 μA
• At 10 kΩ	typ. 105 μA
Isolation	
• Between channels and backplane bus	Yes
• Between channels and power supply of the electronics	Yes
Between the channels	No
Permitted potential difference	
• Between inputs and M_{ANA} (E_{CM})	1 V
• Between the inputs (E_{CM})	1 V
• Between M_{ANA} and $M_{internal}$-(E_{ISO})	75 VDC / 60 VAC
Insulation tested with	500 VDC
Current consumption	
• From the backplane bus	max. 60 mA
• From power supply and load voltage L+ (no load)	max. 80 mA
Power dissipation of the module	typ. 2 W

Analog Value Generation for the Inputs		
Measuring principle	Integrating	
Integration time/conversion time (per channel)		
• Parameters can be assigned	Yes	
• Integration time in ms	$16^2/_3$	20
• Basic conversion time including Integration time in ms	72	85
• Additional conversion time for measuring resistance, in ms	72	85
• Resolution in bits including sign	12 bits	12 bits
• Suppression of interference voltage for interference frequency f1 in Hertz	60	50
Smoothing of the measured values	Parameters can be assigned in 2 stages	
Time constant of the input filter	0.9 ms	
Basic response time of module (all channels enabled)	350 ms	
Analog Value Generation for the Outputs		
Resolution including sign	12 bits	
Conversion time (per channel)	500 μs	
Settling time		
• For resistive load	max. 0.8 ms	
• For capacitive load	max. 0.8 ms	

Interference Suppression, Error Limits for Inputs		
Suppression of interference for f = nx (f1 ± 1 %) (f1 = interference frequency)		
• Common-mode interference (U_{pp} < 1 V)	> 38 dB	
• Series-mode interference (peak value of the interference < rated value of the input range)	> 36 dB	
Crosstalk between the inputs	> 88 dB	
Operational limit (in the entire temperature range, with reference to the input range)		
• Voltage input	0 to 10 V	±0.7 %
• Resistor input	10 k Ω	± 3.5 %
• Temperature input	Pt 100	± 1 %
Basic error limit (operational limit at 25 °C, with reference to the input range)		
• Voltage input	0 to 10 V	±0.5 %
• Resistor input	10 k Ω	±2.8 %
• Temperature input	Pt 100	±0.8 %
Temperature error (with reference to the input range)	±0.01 %/K	
Linearity error (with reference to the input range)	± 0.05 %	
Repeatability (in steady state at 25 °C with reference to the input range)	± 0.05 %	

Interference Suppression, Error Limits for Outputs	
Crosstalk between the outputs	> 88 dB
Operational limit (in the entire temperature range, with reference to the output range)	
• Voltage outputs	±1.0 %
Basic error limit (operational error limit at 25 °C, with reference to the output range)	
• Voltage outputs	±0.85 %
Temperature error (with reference to the output range)	±0.01 %/K
Linearity error (with reference to the output range)	± 0.01 %
Repeatability (in steady state at 25 °C, with reference to the output range)	± 0.01 %
Output ripple; bandwidth 0 to 50 kHz (with reference to the output range)	± 0.1 %

Status, Interrupts, Diagnostics		
Interrupts	None	
Diagnostic functions	None	
Data for Selecting a Sensor		
Input range (rated values)/ Input resistance		
• Voltage	0 to 10 V	100 kΩ
• Resistor	10 kΩ	10 mΩ
• Temperature	PT 100	10 mΩ
Maximum input voltage for voltage input (destruction limit)	20 V continuous; 75 V for max. 1 s (pulse duty factor 1:20)	
Connection of the sensor		
• For measuring voltage	Possible	
• For measuring resistance		
With two-conductor terminal	Possible	
With three-conductor terminal	Possible	
With four-conductor terminal	Possible	
Characteristic linearization	Parameters can be assigned	
• For RTD Resistance Temperature Detector	PT 100 (climate range)	
User data in engineering format	Degrees Celsius	
Data for Selecting an Actuator		
Output range (rated value)		
• Voltage	0 to 10 V	
Load resistance (in the nominal range of the output)		
• For voltage outputs	min. 2.5 kΩ	
• Capacitive load	max. 1.0 μF	
Voltage outputs		
• Short-circuit protection	Yes	
• Short-circuit current	max. 10 mA	
Destruction limit against voltages/ currents applied from outside		
• Voltage to the outputs against M_{ANA}	max. 15 V continuous	
Connection of actuators		
• For voltage output		
Two-conductor connection	Possible	
Four-conductor connection (measuring circuit)	Not possible	

4.27.1 Commissioning the SM 334; AI 4/AO 2 × 12 Bit

Note

Below the rated load voltage range, incorrect intermediate values occur at the output when the rated load voltage supply (L+) is switched on/off.

Tool for parameter assignment *STEP 7* V 4.0

The SM 334; AI 4/AO 2 × 12 Bit is contained in the module catalog in *STEP 7* V.4.0 or higher.

Parameters

You will find a description of the general procedure for assigning parameters to analog modules in Section 4.7.

You will find an overview of the programmable parameters and their default values in Table 4-41, on page 4-42.

4.27.2 Measuring/output method and measuring/output range of the SM 334; AI 4/AO 2 × 12 Bit

Connecting the inputs and outputs

You can connect the inputs as voltage, resistance or temperature measurement inputs, or deactivate them.

You can connect the outputs as voltage, or disable them.

Perform connection of the inputs and outputs with the parameters “measuring method” and “output method” in *STEP 7*.

Connection options for the input channels

You can connect the SM 334; AI 4/AO 2 × 12 Bit in the following combinations:

Channel	Wiring Versions
Channels 0 and 1	• 2 x temperature or • 2 x resistance
Channels 2 and 3	• 2 x voltage, • 2 x resistance, • 2 x temperature, • 1 x temperature and 1 x voltage, or • 1 x resistance and 1 x voltage

Note

Simultaneous connection of a temperature sensor and a resistor to channels 0 and 1 and 2 and 3 is not allowed.

Reason: common current source for both channels.

Unused channels

Set the ”measuring method” parameter for unused input channels to “disabled”. In this way you shorten the scan time of the module.

You must short-circuit unused input channels and you should connect them to M_{ANA}. In this way, you obtain an optimum interference immunity for the analog input module.

So that unused output channels of the SM 334; AI 4/AO 2 × 12 Bit remain de-energized, you must set the “output type” parameter to “disabled” and leave the terminal open.

Measuring ranges

Use *STEP 7* for programming the measuring ranges.

Table 4-72 Measuring Ranges of the SM 334; AI 4/AO 2 × 12 Bit

Method Selected	Measuring Range	Description
U: voltage	0 to 10 V	You will find the digital analog values in Section 4.3.1
R-4L: resistor (four-conductor terminal)	10 kΩ	
RTD-4L: bulb resistor (linear, four-conductor terminal) (temperature measurement)	Pt 100 climate	

Default settings of inputs

The default settings of the module are the ”Bulb resistor (linear, four-conductor terminal)” measuring method and the ”Pt 100 climate” measuring range. You can use this combination of measuring method and measuring range without parameterizing the SM 334; AI 4/AO 2 × 12 Bit in *STEP 7*.

Output ranges

Use *STEP 7* for programming the output ranges.

Table 4-73 Output Ranges of the SM SM 334; AI 4/AO 2 × 12 Bit

Selected Type of Output	Output Range	Description
Voltage	0 to 10 V	You will find the digital analog values in Section 4.3.2 in the voltage output range

Default settings of outputs

The default settings of the module are ”Voltage” for the output type and ”0 to 10 V” for the output range. You can use this combination of measuring method and measuring range without parameterizing the SM 334; AI4/AO 2 × 2 Bit in *STEP 7*.

Other Signal Modules

5

Changes and improvements since the previous version of the reference manual

A new overview section will make it easier for you to access the information:

- The “Module Overview”section shows you the modules that are available, together with their most important characteristics, and helps you quickly to find the module suitable for your task.

In this Chapter

5.1 Module Overview

Introduction

The following table summarizes the most important characteristics of the signal modules described in this chapter. This overview is intended to make it easy to choose the suitable module for your task.

Table 5-1 Other Signal Modules Characteristics at a Glance

Module / Characteristics	Simulator Module SM 374; IN/OUT 16	Dummy Module DM 370	Position Detection Module SM 338; POS-INPUT
Number of inputs/outputs	• Up to 16 inputs or outputs	Reserves one slot for one non-programmed module	• 3 inputs for connection of encoders absolute (SSI) • 2 digital inputs for freezing encoder values
Suitable for...	Simulation of: • 16 inputs or • 16 outputs or • 8 input and 8 outputs	Dummy for: • Interface Modules • Non-programmed signal modules • Modules occupying two slots	Position detection with up to 3 encoders absolute (SSI) Encoder types: Encoder absolute (SSI) with 13 bit, 21 bit or 25 bit message frame length Data formats: Gray code or binary code
Programmable diagnostics	No	No	No
Diagnostic Interrupt	No	No	Adjustable
Special Features	The function can be set using screwdriver	When replacing the DM 370 with anther module, the mechanical configuration and the address assignment of the overall configuration remain unchanged	Encoders absolute with a monoflop time of more than 64 µs must not be used on the SM 338

5.2 Simulator Module SM 374; IN/OUT 16; (6ES7 374-2XH01-0AA0)

Order number

6ES7 374-2XH01-0AA0

Characteristics

The simulator module SM 374; IN/OUT 16 has the following salient features:

- Simulation of:
  - 16 inputs or
  - 16 outputs or
  - 8 inputs and 8 outputs (with the same start addresses each!)
- Status displays for simulation of inputs and outputs
- The function can be set using screwdriver

Note

Do not actuate the switch for setting the mode when the CPU is in the RUN mode!

Configuration with *STEP 7*

Simulator module SM 374; IN/OUT 16 is not included in the module catalog of *STEP 7*. In other words, the Order Number of SM 374 is not detected by *STEP 7*. You must therefore ”simulate” the desired function of the simulator module for configuration in the following manner:

- If you want to use the SM 374 **with 16 inputs**, enter the Order Number of a digital input module with 16 inputs in *STEP 7*;

  Example: 6ES7 321-1BH02-0AA0
- If you want to use the SM 374 **with 16 outputs**, enter the Order Number of a digital input module with 16 outputs in *STEP 7*;

  Example: 6ES7 322-1BH01-0AA0
- If you want to use SM 374 **with 8 inputs and 8 outputs**, enter the Order Number of a digital input/output module with 8 inputs and 8 outputs in *STEP 7*;

  Example: 6ES7 323-1BH00-0AA0

Module view (without front door)

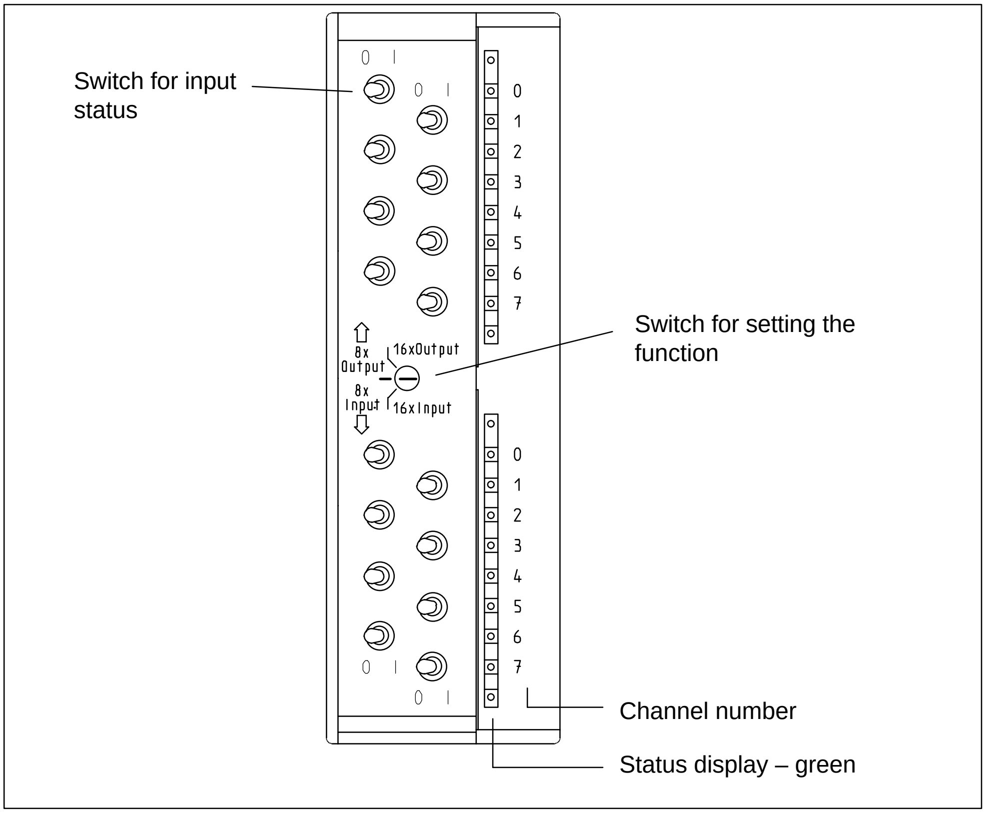


Figure 5-1 Module View of Simulator Module SM 374; IN/OUT 16

Technical specifications of the SM 374; IN/OUT 16

Dimensions and Weight	
Dimensions W × H × D (in millimeters)	40 × 125 × 110
Weight	Approx. 190 g
Data for Specific Module	
Simulation either of	16 inputs 16 outputs 8 input and outputs

Voltages, Currents, Potentials	
Current consumption from the backplane bus	max. 80 mA
Power dissipation of the module	typ. 0.35 W
Status, Interrupts, Diagnostics	
Status display	Yes, green LED per channel
Interrupts	No
Diagnostic functions	No

5.3 Dummy Module DM 370; (6ES7 370-0AA01-0AA0)

Order number

6ES7 370-0AA01-0AA0

Characteristics

Dummy module DM 370 reserves a slot for an unprogrammed module. It can be a dummy for:

- Interface modules (without reserving address space)
- Unprogrammed signal modules (with reservation address area)
- Modules occupying 2 slots (with reservation of address area)

When replacing the dummy module with another module from the S7-300, the mechanical configuration and the address assignment remain unchanged.

Configuration with *STEP 7*

Use *STEP 7* to configure the dummy module only if you are using the module to reserve the slot for a parameterized signal module. If the module is reserving the slot for an interface module, there is no need to configure with *STEP 7*.

Modules occupying two slots

For modules that occupy two slots, you must plug in two dummy modules. In doing so, you reserve the address area only with the dummy module at slot ”x” (not with the dummy module at ”x + 1”; for the steps you need to perform refer to Table 5-2).

Not more than 8 modules must be inserted in a mounting rack (SM/FM/CP). If, for example, you reserve one slot for an 80 mm module with two dummy modules, you may only insert seven more modules (SM/FM/CP) since the dummy module only occupies the address area for one module.

Module view

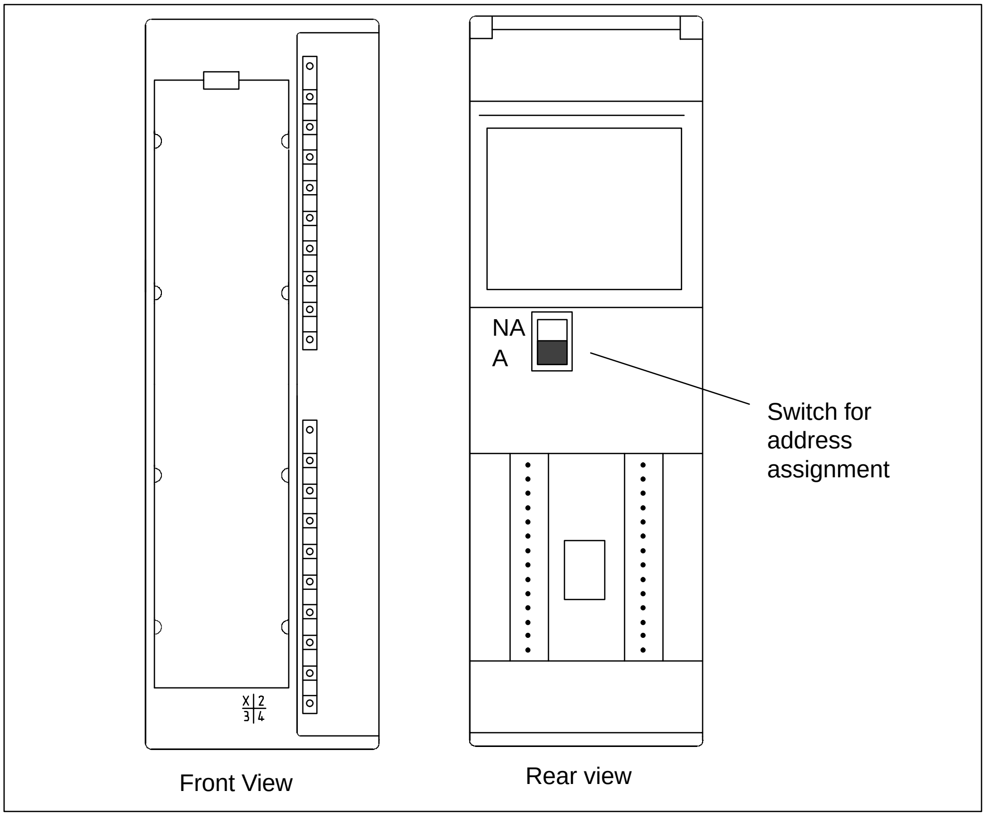
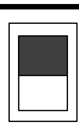
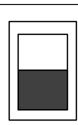


Figure 5-2 Module View of Dummy Module DM 370

Switch settings for address assignment

The table below shows how you have to set the switch on the back of the module to match the module type.

Table 5-2 Meaning of the Switch Positions of the Dummy Module DM 370

Switch Position	Meaning	Use in an ET 200M configuration with active bus modules (Insert and Remove)
NA A 	Dummy module reserves the slot for an interface module (NA = No Address, that is no address space reserved)	No
NA A 	Dummy module reserves the slot for a signal module (A = Address, that is address space reserved)	Dummy module reserves the slot for a signal module. If you use the dummy module for an “empty slot”, you must configure the “empty slot” with 0 bytes input/output addresses.

Technical specifications of the DM 370

Dimensions and Weight	
Dimensions W × H × D (in millimeters)	40 × 125 × 120
Weight	Approx. 180 g

Voltages, Currents, Potentials	
Current consumption from the backplane bus	Approx. 5 mA
Power loss	typ. 0.03 W

5.4 Position Detection Module SM 338; POS-INPUT; (6ES7 338-4BC00-0AB0)

Order Number

6ES7 338-4BC00-0AB0

Characteristics

Position detection module SM 338; POS-INPUT features the following characteristics:

- 3 inputs for the connection of up to three encoders absolute (SSI) and 2 digital inputs for freezing encoder values
- Direct reaction to encoder values in moving systems possible
- Processing of the encoder values acquired by the SM 338 in the user program
- 24 VDC rated input voltage
- Isolated from CPU

Supported encoder types

The following encoder types are supported by the SM 338; POS-INPUT :

- The encoder absolute (SSI) with 13 bit message frame length
- The encoder absolute (SSI) with 21 bit message frame length
- The encoder absolute (SSI) with 25 bit message frame length

Supported data formats

The SM 338; POS-INPUT supports the gray code and binary code data formats.

Terminal connection diagram and block diagram

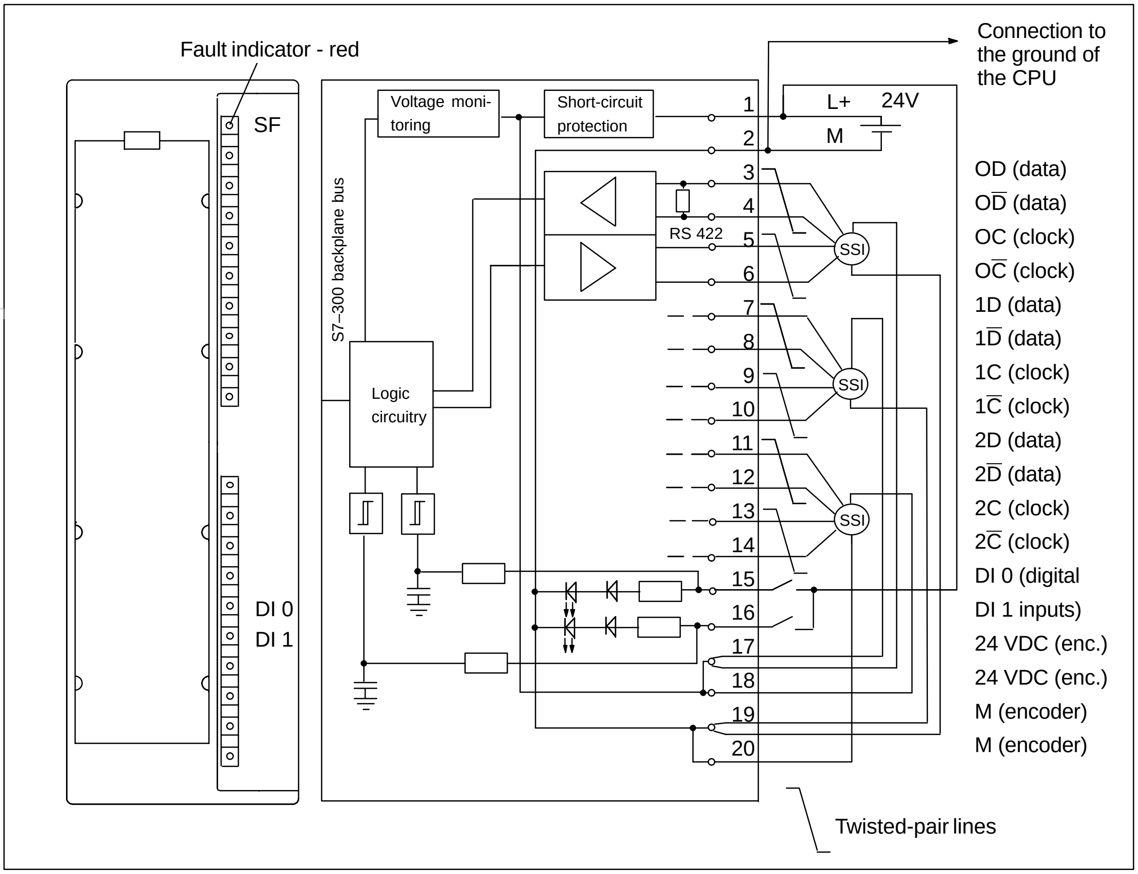


Figure 5-3 Module View and Block Diagram of the SM 338; POS-INPUT

Wiring Rules

Be sure to observe the following important rules when wiring the module:

- The ground of the encoder supply is non-isolated to the ground of the CPU. Therefore connect pin 2 of the SM 338 (M) to the ground of the CPU with low impedance.
- The encoder lines (pins 3 to 14) must be shielded, twisted-pair cables. Support the shield on either side.
  To support the shield on the SM 338, use the shield supporting element (Order number: 6ES7 390-5AA00-0AA0).
- If you exceed the maximum output current (900 mA) of the encoder supply, you must connect an external power supply.

Technical specifications of the SM 338; POS-INPUT

Dimensions and Weight	
Dimensions W x H x D (mm)	$40 \times 125 \times 120$
Weight	Approx. 240 g
Voltages, Currents, Potentials	
Rated load voltage L+	24 VDC
• Range	20.4 to 28.8 V
• Reverse polarity protection	No
Isolation	No, only from shield
Permitted potential difference	
• Between input (M connection) and central grounding point of CPU	1 VDC
Encoder supply	
• Output voltage	L+ –0,8V
• Output current	max. 900 mA short circuit-proof
Current consumption	
• From the backplane bus	max. 160 mA
• From the load voltage L+ (no load)	max. 10 mA
Power dissipation of the module	typ. 3W
Encoder Inputs POS-INPUT 0 to 2	
Position detection	Absolute
Data transmission rate and line length with absolute encoders (shielded)	• 125 kHz max. 320 m • 250 kHz max. 160 m • 500 kHz max. 60 m • 1 MHz max. 20 m
Digital inputs DI 0, DI 1	
Isolation	No, only from shield
Input voltage	0 signal: –3 V to 5 V 1 signal: 11 V to 30.2 V
Input current	0 signal: $\leq$2 mA (closed-circuit current) 1 signal: 9 mA (typically)
Input delay	0 > 1: max. 300 µs 1 > 0: max. 300 µs
Maximum repetition frequency	1 kHz
Connection of a two-wire BERO type 2	Possible
Shielded line length	600 m
Unshielded line length	32 m
Status, Interrupts, Diagnostics	
Interrupts	
• Diagnostic Interrupt	Parameters can be assigned
Status display for digital inputs	LED (green)
Group error/fault	LED (red)

Unsharpness of the Measured Value			
Minimum unsharpness[1]	Frame time + 130 µs		
Maximum unsharpness[1]	($2 \times$ frame time) + monoflop time + 600 µs		
Frame time of the encoders	13-bit	21-bit	25-bit
• 125 kHz	112 µs	176 µs	208 µs
• 250 kHz	56 µs	88 µs	104 µs
• 500 kHz	28 µs	44 µs	52 µs
• 1 MHz	14 µs	22 µs	26 µs
Monoflop time[2]	16 µs, 32 µs, 48 µs, 64 µs		
Update rate	Evaluation of the frame every 450 µs		

1 Age of the encoder values determined by the method of transmission and the processing

2 Encoders with a monoflop time of more than 64 µs cannot be used on the SM 338 You have to add the time $2 \times$(1/transmission rate) to the specified values.

5.4.1 Operating Principle of the SM 338; POS-INPUT

The SM 338 periodically acquires the signals from up to three connected encoders absolute (SSI).

Example of the operating principle of the SM 338 at an encoder input

The following figure illustrates the basic operating principle by means of an encoder input. A 25-bit encoder may be connected to the input, for example.

You will find a detailed description of the parameters and addressing in the sections that follow.

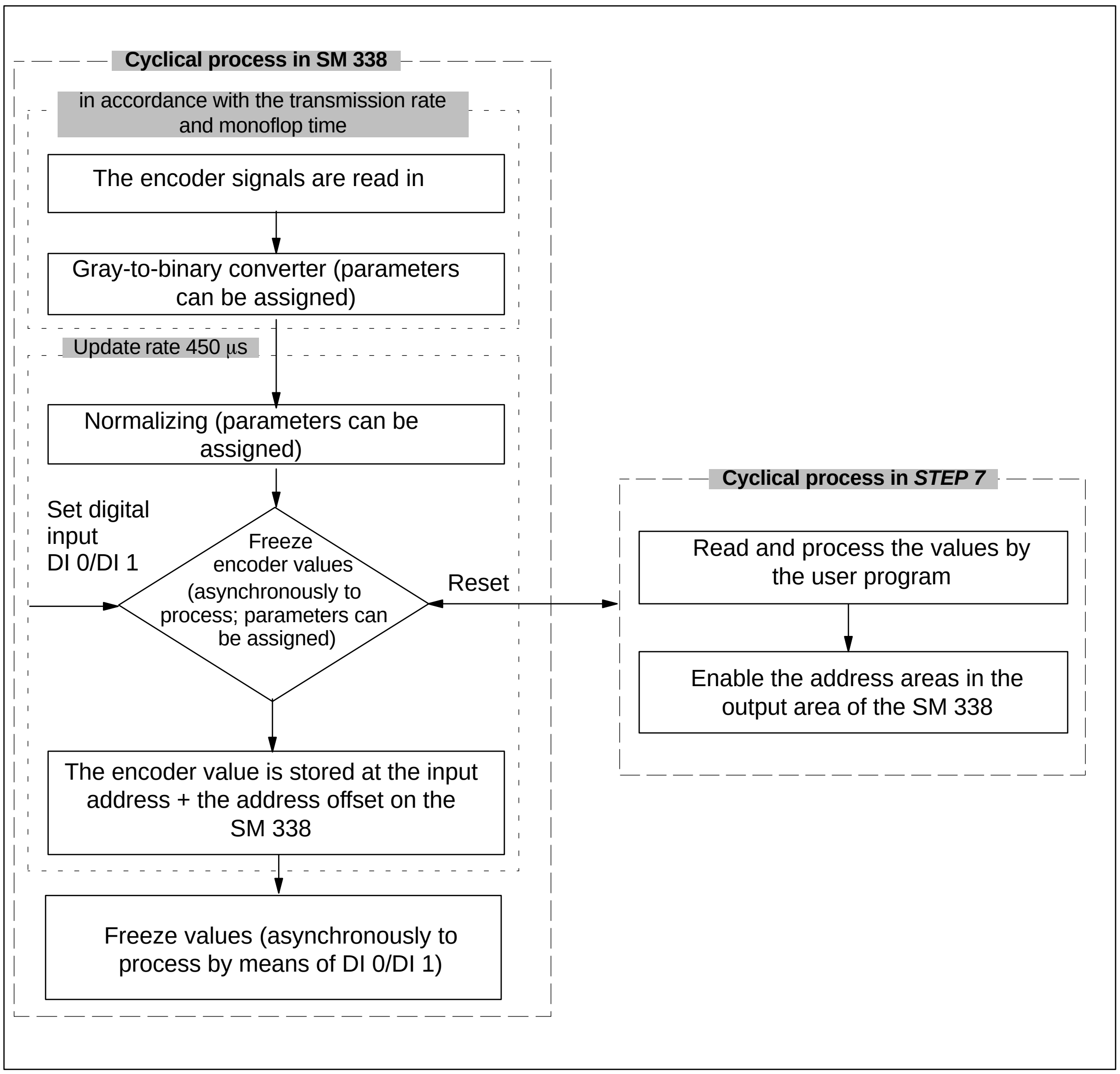


Figure 5-4 Operating Principle of the SM 338; POS-INPUT

5.4.2 Assigning Parameters to the SM 338; POS-INPUT

Tools for parameter assignment

You assign parameters to the SM 338; POS-INPUT in *STEP 7*. You must perform parameter assignment in STOP mode of the CPU.

When you have set all the parameters, download the parameters from the programming device to the CPU. On a transition from STOP to RUN mode, the CPU transfers the parameters to the SM 338.

Parameter assignment is not possible in the user program

All parameters of the SM 338; POS-INPUT are static parameters. In other words, you can assign parameters to the module only as described above with the CPU in STOP mode, and not in the user program.

Parameters of the SM 338; POS-INPUT

You will find an overview of the programmable parameters and their default values for the SM 338 in the table below.

The default settings apply if you have not performed parameter assignment in *STEP 7*.

Table 5-3 Parameters of the SM 338; POS-INPUT

Parameter	Value Range	Default values	Parameter Type	Scope
Enable • Diagnostic interrupt	Yes/no	No	Static	Module
Encoder absolute (SSI) Code type Transmission rate Monoflop time	None; 13-bit; 21-bit; 25-bit Gray; Binary 125 kHz; 250 kHz; 500 kHz; 1 MHz 16 µs; 32 µs; 48 µs; 64 µs	13 bits Gray 125 kHz 64 µs	Static	Channel
Normalizing • Positions • Steps/revolution	0 to 12 2 to 8192*	0 8192	Static	Channel
Enable Freeze	Off; 0; 1	Dark	Static	Channel

* To the power of 2

Transmission rate parameter

Parameterize the transmission rate of the encoders absolute as specified by the encoder manufacturer and in accordance with the length of cable between the encoder and the module:

Table 5-4 SM 338; POS-INPUT: Interrelationship between Length of Cable and Transmission Rate

Maximum length of cable (shielded cable)	Baud Rate
320 m	125 kHz
160 m	250 kHz
60 m	500 kHz
20 m	1 MHz

Note

The transmission rate affects the message frame time of the encoders absolute (SSI).

Monoflop time parameter

The monoflop time is the interval between two SSI message frames.

Rule: The programmed monoflop time must be greater than the monoflop time of the encoder absolute (refer to the technical specifications of the encoder manufacturer).

Note

Encoders absolute with a monoflop time of more than 64 μs cannot be used on the SM 338

Note that the transmission rate and the monoflop time affect the accuracy and topicality of the encoder values (refer to the technical specifications of the encoder manufacturer).

Normalizing of encoder values

On account of normalizing, the encoder is right-justified in the address area; irrelevant places are discarded. You parameterize normalizing in *STEP 7*.

Note

When you use an encoder absolute which transfers additional information in the subsequent bits (refer to the manufacturer specifications) and you would like to evaluate this information, you must take this into account in normalizing by specifying the places.

Steps/revolution parameter

The number of irrelevant bit places by which the encoder value must be moved to the right for it to be right-justified is automatically calculated from the number of steps per revolution of the encoder and the sensor type (for example, 13-bit).

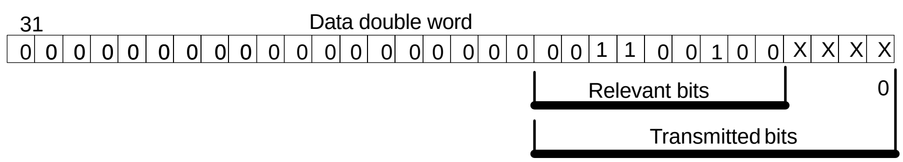
Example of encoder value normalizing

You use a single turn encoder with 2^9 steps = 512 steps/revolution (resolution/360°).

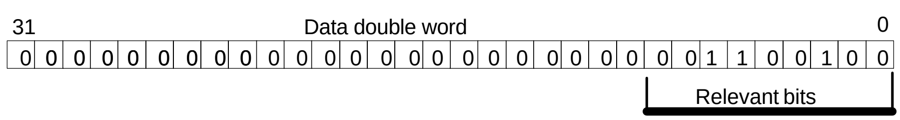
You have parameterized the following in *STEP 7*:

- Encoder absolute: 13-bit
- Normalizing: 4 places
- Steps/revolution: 512

Prior to normalizing: periodically acquired encoder value 100



After normalizing: encoder value 100



Result: Bits 0 to 3 (4 places, identified by “x”) have been excluded.

Enable FREEZE function

With the FREEZE function, you “freeze” the current encoder values of the SM 338. The FREEZE function is connected to digital inputs DI 0 and DI 1 of the SM 338.

Freezing is triggered by transitional edges (rising pulse edge) across DI 0 or DI 1. A frozen encoder value is identified by the set bit 31 (output address). With one digital input you can freeze one, two or three encoder values.

You have to enable the FREEZE function – in other words parameterize accordingly in *STEP 7*.

The encoder values are retained until the end of the FREEZE function and can thus be evaluated as a function of the result.

Terminating the FREEZE function

You have to terminate the FREEZE function for each encoder input. You acknowledge the function in the user program by resetting bit 31 in the output address with the *STEP 7* operation T PAB “xyz” (for an example program refer to Section 5.4.3).

The encoder values are updated again following acknowledgement. The encoder values can be frozen again.

5.4.3 Addressing SM 338; POS-INPUT

Data areas for the encoder values

The inputs and outputs of the SM 338 are addressed as of the initial module address. You determine the input and output addresses during configuration of the SM 338 in *STEP 7*.

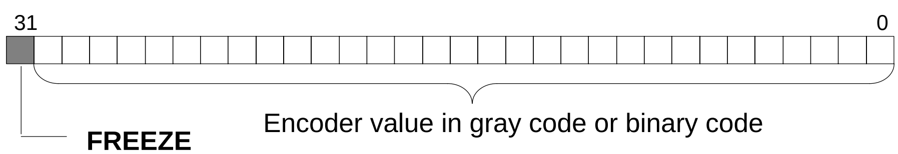
Input addresses

Table 5-5 SM 338; POS-INPUT: Input Addresses

Encoder Input	Input Address (from Configuration) + Address Offset
0	“Initial module address”
1	“Initial module address” + 4 bytes address offset
2	“Initial module address” + 8 bytes address offset

Structure of the data double word

The data double word is structured as follows at each encoder input:

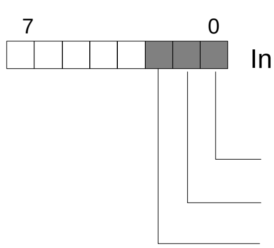


FREEZE

0 = encoder value is not frozen. The value is continuously updated.

1 = encoder value is frozen. The value remains the same until acknowledgment.

Output address



Initial module address

Acknowledgement of the FREEZE function:

Bit 0 = encoder input 0

Bit 1 = encoder input 1

Bit 2 = encoder input 2

Reading out data areas

You can read out the data area in your user program with the *STEP 7* operation L PED “xyz”.

Example of access to encoder values and use of the FREEZE function

You want to read out and evaluate the value of the encoder at the encoder inputs. The initial module address is 256.

STL			Explanation
L	PED	256	The encoder value in the address area for encoder input 0 is read.
T	MD	100	The encoder value is stored in the memory double word.
U	M	100.7	Determine and store FREEZE status for
=	M	99.0	acknowledgement later
L	PED	260	The encoder value in the address area for encoder input 1 is read.
T	MD	104	The encoder value is stored in the memory double word.
U	M	104.7	Determine and store FREEZE status for
=	M	99.1	acknowledgement later
L	PED	264	The encoder value in the address area for encoder input 2 is read.
T	MD	108	The encoder value is stored in the memory double word.
U	M	108.7	Determine and store FREEZE status for
=	M	99.2	acknowledgement later
L	MB	99	Load the FREEZE status and
T	PAB	256	acknowledge (SM 338: output address 256)

Afterwards you can further process the encoder values from the bit memory address area MD 100, MD 104 and MD 108. The encoder value is in bits 0 to 30 of the memory double word.

5.4.4 Diagnostics of the SM 338; POS-INPUT

Programmable and non-programmable diagnostic messages

In diagnostics, we make a distinction between programmable and non-programmable diagnostic messages.

The SM 338 makes non-programmable diagnostic messages available. In other words, all diagnostic messages are provided by the SM 338 without your having to do anything.

Actions following diagnostic message in *STEP 7*

Each diagnostic message leads to the following actions:

- The diagnostic message is entered in the diagnosis of the module and forwarded to the CPU.
- The SF LED on the module lights.
- If you have programmed “Enable Diagnostic Interrupt” in *STEP 7*, a diagnostic interrupt is triggered and OB 82 is called.

Reading out diagnostic messages

You can read out detailed diagnostic messages by means of SFCs in the user program (refer to the Appendix “Diagnostic Data of Signal Modules”).

You can view the cause of the error in *STEP 7*, in the module diagnosis (refer to online Help for *STEP 7*).

Diagnostic message by means of SF LED

The SM 338 indicates errors by means of its SF-LED (group error LED). The SF LED lights as soon as a diagnostic message is triggered by the SM 338. It goes out when all errors have been rectified.

The group fault (SF) LED also lights up in case of external errors (short circuit of sensor supply), independent of the operating status of the CPU (if power is on).

The SF LED lights briefly during startup, during the SM 338 self-test.

Diagnostic messages of the SM 338; POS-INPUT

The table below gives an overview of the diagnostic messages for the SM 338; POS-INPUT.

Table 5-6 Diagnostic Messages of the SM 338; POS-INPUT

Diagnostics Message	LED	Scope of the Diagnostics	Parameters can be assigned
Module problem	SF	Module	No
Internal malfunction	SF	Module	No
External malfunction	SF	Module	No
Channel error present	SF	Module	No
External auxiliary supply missing	SF	Module	No
Module not parameterized.	SF	Module	No
Wrong parameters	SF	Module	No
Channel information available	SF	Module	No
Time monitoring triggered	SF	Module	No
Channel error present	SF	Channel (encoder input)	No
Configuring/parameter assignment error	SF	Channel (encoder input)	No
External channel error (encoder error)	SF	Channel (encoder input)	No

Causes of errors and troubleshooting

Table 5-7 Diagnostic Messages of the SM 338, Causes of Errors and Troubleshooting

Diagnostics Message	Possible Error Cause	Remedy
Module malfunction	An error detected by the module has occurred	
Internal error	The module has detected an error within the programmable logic controller	
External error	The module has detected an error outside the programmable logic controller	
Channel error present	Indicates that only certain channels are faulty	
External auxiliary voltage missing	Power supply L+ to module missing	Feed supply L+
Module not parameterized	The module requires the information as to whether it should work with system default parameters or with your parameters	Message queued after power-on until parameter transmission by the COU has been completed; parameterize the module, as required
Wrong parameters	One parameter or the combination of parameters is not plausible	Reassign module parameter
Channel information present	Channel error present; the module can supply additional channel information	
Watchdog tripped	Temporary high electromagnetic interference	Eliminate interference
Channel error present	An error detected by the module has occurred at the encoder input	
Configuration/parameterization error	Illegal parameters transferred to module	Reassign module parameter
External channel error (encoder error)	Wire break of encoder cable, encoder cable not connected or encoder defective	Check connected encoder

5.4.5 Interrupts of the SM 338; POS-INPUT

Introduction

This section describes the interrupt behavior of the SM 338; POS-INPUT. The SM 338 can trigger diagnostic interrupts.

The OBs and SFCs mentioned below can be found in the online Help for *STEP 7*, where they are described in greater detail.

Enabling interrupts

The interrupts are not preset – in other words, they are inhibited without appropriate parameter assignment. Assign parameters to the Interrupt Enable in *STEP 7* (refer to Section 5.4.2).

Diagnostic interrupt

If you have enabled diagnostic interrupts, then active error events (initial occurrence of the error) and departing error events (message after troubleshooting) are reported by means of an interrupt.

The CPU interrupts execution of the user program and processes the diagnostic interrupt block (OB 82).

In the user program, you can call SFC 51 or SFC 59 in OB 82 to obtain more detailed diagnostic information from the module.

The diagnostic information is consistent until such time as OB 82 is exited. When OB 82 is exited, the diagnostic interrupt is acknowledged on the module.

Interface Modules

6

Interface modules

In this chapter you will find the technical specifications and characteristic features of the interface modules for the S7-300.

Contents

The following interface modules are described in this chapter:

6.1 Module Overview

Introduction

The following table summarizes the most important characteristics of the interface modules described in this chapter. This overview is intended to make it easy to choose the suitable module for your task.

Table 6-1 Interface Modules: Characteristics at a Glance

Module / Characteristics	Interface Module IM 360	Interface Module IM 361	Interface Module IM 365
Suitable for plugging into S7-300 mounting racks	• 0	• 0 and 1	• 0 and 1
Data transmission	• From IM 360 to IM 361 over the connecting cable 386	• From the IM 360 to the IM 361 or from the IM 361 to the IM 361 via connecting cable 386	• From IM 365 to IM 365 via connecting cable 386
Distance between...	• max. 10 m	• max. 10 m	• 1 m, permanently connected
Special Features	---	---	• Preassembled module pair • Install only signal modules in rack 1 • IM 365 does not route the communication bus to subrack 1

6.2 Interface Module IM 360; (6ES7 360-3AA01-0AA0)

Order number

6ES7 360-3AA01-0AA0

Characteristics

The interface module IM 360 has the following characteristic features:

- Interface for rack 0 of the S7-300
- Data transfer from IM 360 to IM 361 over the connecting cable 368
- Maximum distance between IM 360 and IM 361 is 10 m (32.8 ft.)

Status and fault LEDs

The interface module IM 360 has the following status and fault LEDs.

LED	Meaning	Explanation
SF	Group error/fault	The LED lights up if • the connecting cable is missing. • IM 361 is switched off.

Front view

Figure 6-1 shows the front view of the interface module IM 360.

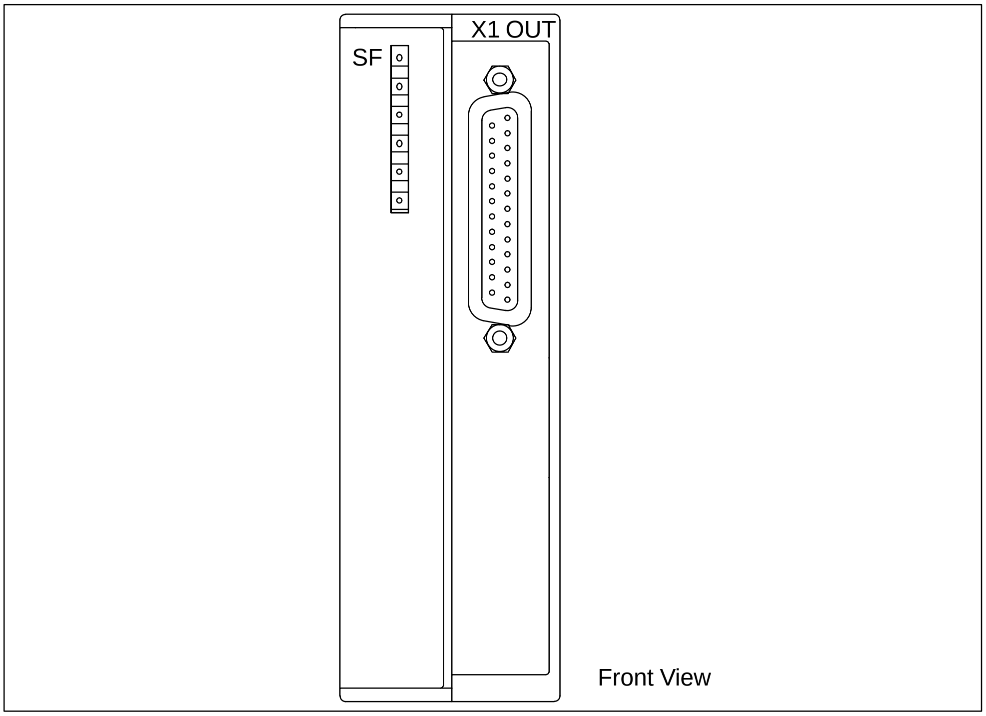


Figure 6-1 Front View of the Interface Module IM 360

Technical specification

The following overview lists the technical specifications for the interface module IM 360.

Dimensions and Weight	
Dimensions W × H × D (in millimeters)	40 × 125 × 120
Weight	Approx. 250 g
Data for Specific Module	
Length of cable	
• Maximum length to next IM	10 m
Current consumption	
• From the backplane bus	350 mA
Power loss	typ. 2 W
Status and Fault LEDs	Yes

6.3 Interface Module IM 361; (6ES7 361 3CA01-0AA0)

Order number

6ES7 361 3CA01-0AA0

Characteristics

The interface module IM 361 has the following characteristic features:

- 24 VDC power supply
- Interface for racks 1 to 3 of the S7-300
- Current output via the S7-300 backplane bus max. 0.8 A
- Data transfer from the IM 360 to the IM 361 or from the IM 361 to the IM 361 via connecting cable 368
- Maximum distance between IM 360 and IM 361 is 10 m
- Maximum distance between IM 361 and IM 361 is 10 m

Status and fault LEDs

The interface module IM 361 has the following status and fault LEDs.

LED	Meaning	Explanation
SF	Group error/fault	The LED lights up if • the connecting cable is missing • the series-connected IM 361 is switched off • the CPU is in the POWER OFF state
5 VDC	5 VDC supply for the S7-300 backplane bus	–

Front view

Figure 6-2 shows the front view of the interface module IM 361.

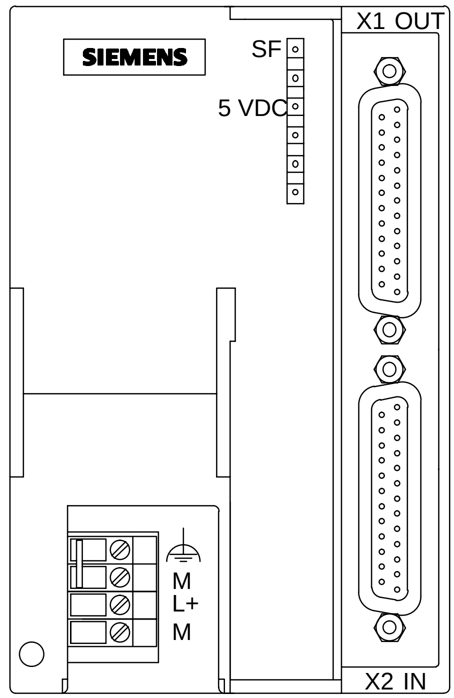


Figure 6-2 Front View of the Interface Module IM 361

Technical specification

The following overview lists the technical specifications for the interface module IM 361.

Dimensions and Weight	
Dimensions W × H × D (in millimeters)	80 × 125 × 120
Weight	505 g
Data for Specific Module	
Length of cable	
Maximum length to next IM	10 m
Current consumption	
From 24 VDC	0.5 A
Power loss	typ. 5 W
Current output	
To backplane bus	0.8 A
Status and fault LEDs	Yes

6.4 Interface Module IM 365; (6ES7 365-0BA01-0AA0)

Order number

6ES7 365-0BA01-0AA0

Characteristics

The interface module IM 365 has the following characteristic features:

- Pre-assembled pair of modules for rack 0 and rack 1
- Total power supply of 1.2 A, of which up to 0.8 A can be used per rack.
- Connecting cable with a length of 1 m already permanently connected
- Install only signal modules in rack 1
- IM 365 does **not** route the communication bus to subrack 1

Front view

Figure 6-3 shows the front view of the interface module IM 365.

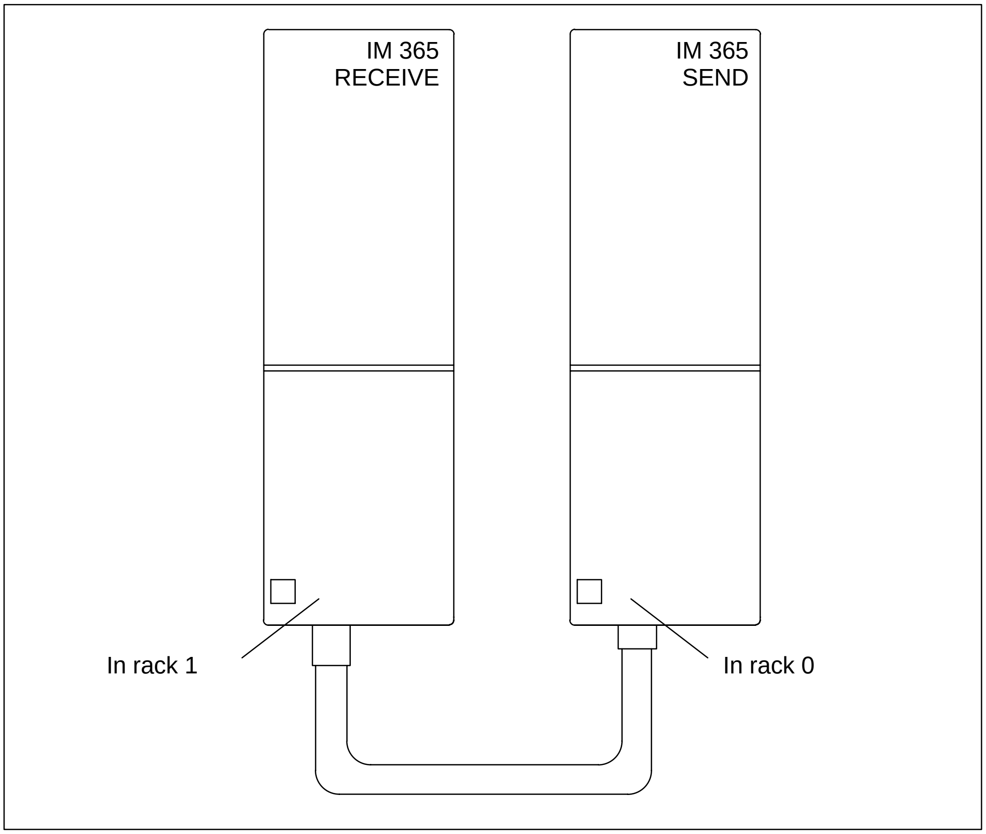


Figure 6-3 Front View of the Interface Module IM 365

Technical specification

The following overview lists the technical specifications for the interface module IM 365.

Dimensions and Weight	
Dimensions W × H × D per rack (in millimeters)	40 × 125 × 120
Total weight	580 g

Data for Specific Module	
Length of cable	
Maximum length to next IM	1 m
Current consumption	
From the backplane bus	100 mA
Power loss	typ. 0.5 W
Current output	max. 1.2 A
Per rack	0.8 A
Status and fault LEDs	No

RS 485 Repeater

7

In this chapter

In this chapter, you will find a detailed description of the RS 485 repeater.

Included in the description are:

- The purpose of the RS 485 repeater
- The maximum cable lengths possible between two RS 485 repeaters
- The functions of the individual operating elements and terminals
- Information about grounded and non-grounded operation
- Technical specifications and the block diagram

Further information

You will find further information on the RS 485 repeater in the manuals *Hardware and Installation* in the Chapter “Configuring of an MPI or PROFIBUS-DP network”.

In this chapter

7.1 Application and Characteristics; (6ES7 972-0AA01-0XA0)

Order number

6ES7 972-0AA01-0XA0

What is an RS 485 repeater?

The RS 485 repeater amplifies data signals on bus lines and interconnects bus segments.

Application of the RS 485 repeater

You need an RS 485 repeater if:

- more than 32 nodes are connected to the bus
- bus segments are to be operated non-grounded on the bus, or
- the maximum cable length of a segment is exceeded. (See table 7-1).

Table 7-1 Maximum Cable Length of a Segment

Baud Rate	Max. Cable Length of a Segment (in m)
9.6 to 187.5 kbd	1000
500 kbaud	400
1.5 Mbaud	200
3 to 12 Mbaud	100

Rules

If you configure the bus with RS 485 repeaters:

- Up to 9 RS 485 repeaters can be connected in series.
- The maximum cable length between two nodes must not exceed the values in Table 7-2.

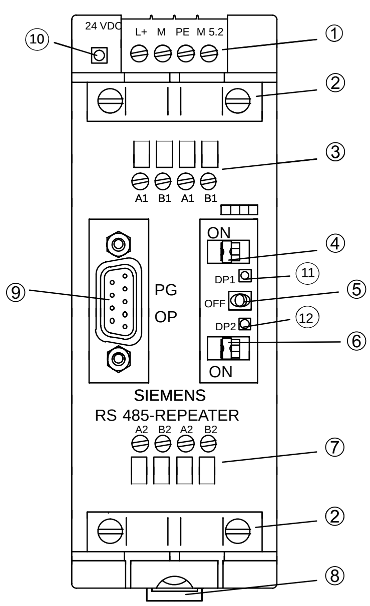
Table 7-2 Maximum Cable Length between Two RS 485 Repeaters

Baud Rate	Maximum Length of Cable between 2 Nodes (in m) with RS 485 Repeater (6ES7 972-0AA01-0XA0)
9.6 to 187.5 kbaud	10000
500 kbaud	4000
1.5 Mbaud	2000
3 to 12 Mbaud	1000

7.2 Appearance of the RS 485 Repeater; (6ES7 972-0AA01-0XA0)

The table below shows the appearance of the RS 485 repeater and lists its functions.

Table 7-3 Description and Functions of the RS 485 Repeater



Repeater Design	No.	Function
	①	Connection for the RS 485 repeater power supply (pin “M5.2” is the ground reference, if you want to measure the voltage difference between terminals “A2” and “B2”).
	②	Shield clamp for the strain relief and grounding of the bus cable of bus segment 1 or bus segment 2
	③	Terminals for the bus cable of bus segment 1
	④	Terminating resistance for bus segment 1
	⑤	Switch for OFF operating mode (= isolate bus segments from each other – for example, for startup
	⑥	Terminating resistance for bus segment 2
	⑦	Terminals for the bus cable of bus segment 2
	⑧	Slide for mounting and removing the RS 485 repeater on the standard rail
	⑨	Interface for programming device/OP in bus segment 1
	⑩	LED 24 V supply voltage
	⑪	LED for bus segment 1
	⑫	LED for bus segment 2

7.3 RS 485 Repeater in Ungrounded and Grounded Operation

Grounded or ungrounded

The RS 485 repeater is ...

- grounded, if all other nodes in the segment are also operated with a grounded potential

- ungrounded, if all other nodes in the segment are operated with an ungrounded potential

---

Note

The bus segment 1 is grounded if you connect a programming device to the PG/OP socket of the RS 485 repeater. Ground connection is effected since the MPI in the programming device is grounded and the PG/OP socket is connected internally with bus segment 1 in the RS 485 repeater.

Grounded operation of the RS 485 repeater

For grounded operation of the RS 485 repeater, you must jump terminals “M” and “PE” on the top of the RS 485 repeater.

Ungrounded operation of the RS 485 repeater

For ungrounded operation of the RS 485 repeater, “M” and “PE” on the top of the RS 485 repeater must not be interconnected. In addition, the supply voltage of the RS 485 repeater must be ungrounded.

Terminal connection diagram

In the case of a repeater configuration with ungrounded reference potential (ungrounded operation), any interference currents and static charges are discharged by means of an RC network integrated in the repeater (refer to Figure 7-1) to the protective conductor.

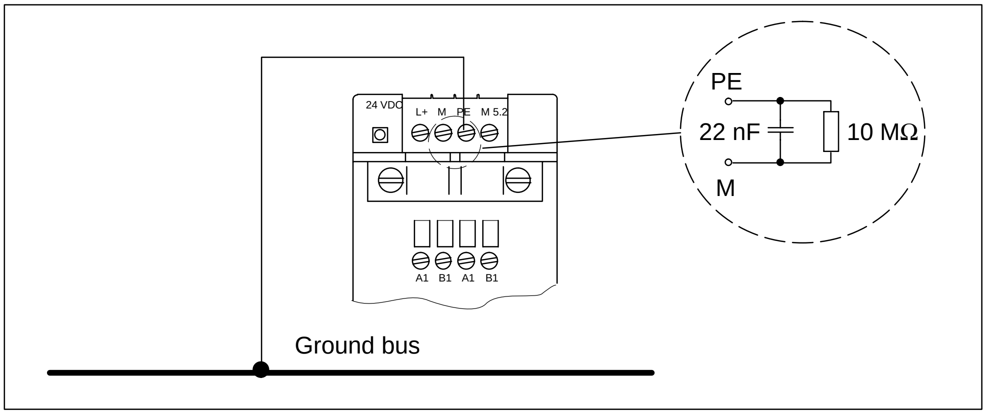


Figure 7-1 RC Network with 10 MΩohm for Configuration with Ungrounded Reference Potential

Isolation between bus segments

Bus segment 1 and bus segment 2 are galvanically isolated from each other. The PG/OP interface is connected internally to the port for bus segment 1. Figure 7-2 shows the front panel of the RS 485 repeater.

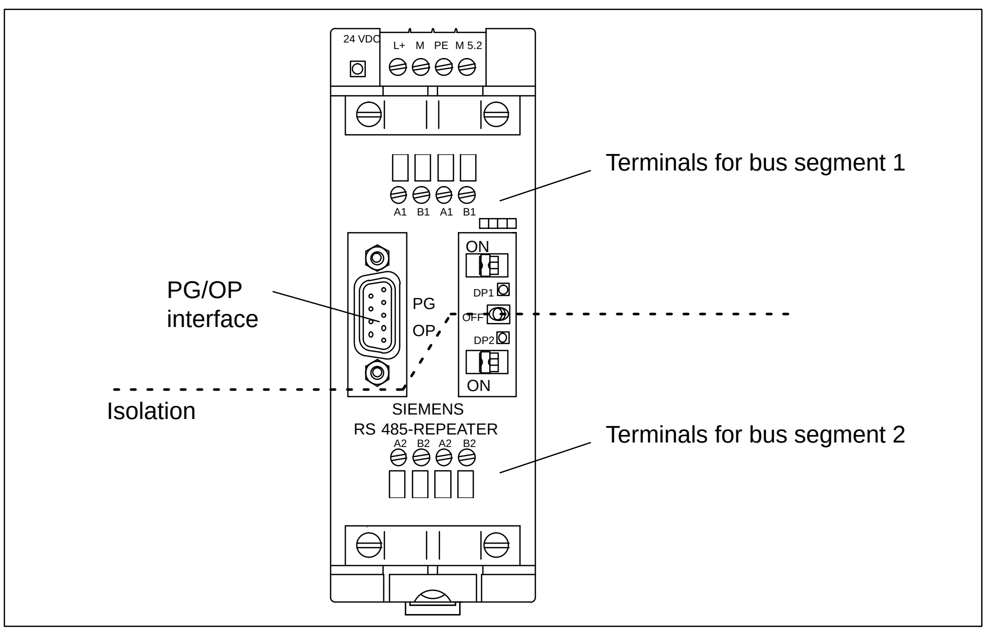


Figure 7-2 Isolation between the Bus Segments

Amplification of the bus signals

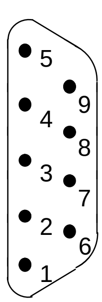
The amplification of the bus signals takes place between the port for bus segment 1 or the PG/OP interface and the port for bus segment 2.

7.4 Technical Specifications

Technical specifications of the RS 485 repeater

Technical Specification	
Power supply • Rated voltage • Ripple	 24 VDC 20.4 to 28.8 VDC
Current consumption at rated voltage • without node at PG/OP socket • Node at PG/OP socket (5 V/90 mA) • Node at PG/OP socket (24 V/100 mA)	 200 mA 230 mA 200 mA
Isolation	Yes, 500 VAC
Connection of fiber optic cables	Yes, via repeater adapters
Redundancy operation	No
Transmission rate (automatically detected by the repeater)	9.6 kbaud, 19.2 kbaud, 45.45 kbaud, 93.75 kbaud, 187.5 kbaud, 500 kbaud. 1,5 Mbaud. 3 Mbaud, 6 Mbaud, 12 Mbaud
Degree of protection	IP 20
Dimensions W × H × D (in millimeters)	45 × 128 × 67 mm
Weight (incl. packaging)	350 g

Pin assignment of the sub-D connector (PG/OP socket)

View	Pin No.	Signal Name	Designation
	1	–	–
	2	M24V	Ground 24 V
	3	RxD/TxD-P	Data line B
	4	RTS	Request To Send
	5	M5V2	Data reference potential (from station)
	6	P5V2	Supply plus (from station)
	7	P24V	24 V
	8	RxD/TxD-N	Data line A
	9	–	–

Block diagram of the RS 485 repeater

- Bus segment 1 and bus segment 2 are galvanically isolated from each other.
- Bus segment 2 and the PG/OP socket are galvanically isolated from each other.
- Signals are amplified
  - between bus segment 1 and bus segment 2
  - between PG/OP socket and bus segment 2

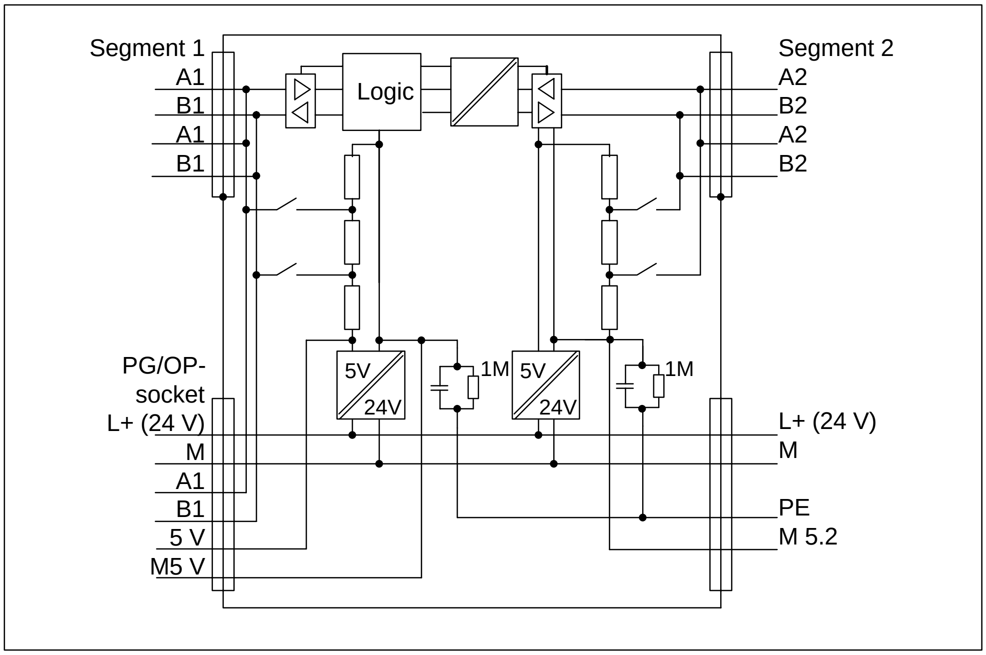


Figure 7-3 Block Diagram of the RS 485 Repeater

SIMATIC TOP connect and SIMATIC TOP connect TPA

8

Changes and modifications compared with the previous version of the reference manual

The descriptions of SIMATIC TOP connect and SIMATIC TOP connect TPA are summarized in this chapter. In this way it was possible to extract and give precedence to generally valid information.

A new overview section will make it easier for you to access the information.

The section entitled “Module Overview” shows the basic configuration of SIMATIC TOP connect and SIMATIC TOP connect TPA. In addition, you will also find out which modules in the S7-300 family can be used with SIMATIC TOP connect/... TPA.

In this chapter

Structure of the chapter

Sections 8.1 and 8.2 apply to SIMATIC TOP connect and SIMATIC TOP connect TPA.

Section 8.3 contains specific information on SIMATIC TOP connect and thus supplements the preceding sections.

Section 8.4 contains specific information on SIMATIC TOP connect TPA and thus supplements Sections 8.1 and 8.2.

8.1 Module Overview

Introduction

“SIMATIC TOP connect” denotes components for wiring digital modules.

“SIMATIC TOP connect TPA” denotes components for wiring analog modules.

Wiring

Wiring with SIMATIC TOP connect/... TPA is an elegant alternative to conventional wiring of the actuators and sensors directly at the front connector of the module. When using these components, you wire actuators and sensors ”in situ” on one more terminal blocks. You establish the connection to the module by means of a connecting cable (round-sheath ribbon cable).

Configuration of SIMATIC TOP connect with a S7-300

A SIMATIC TOP connect and a SIMATIC TOP connect TPA always consist of:

- a front connector module with flat ribbon connection ①,
- one or more terminal blocks ③ and
- one or more connecting cables with plug-and-socket connectors at ends ②

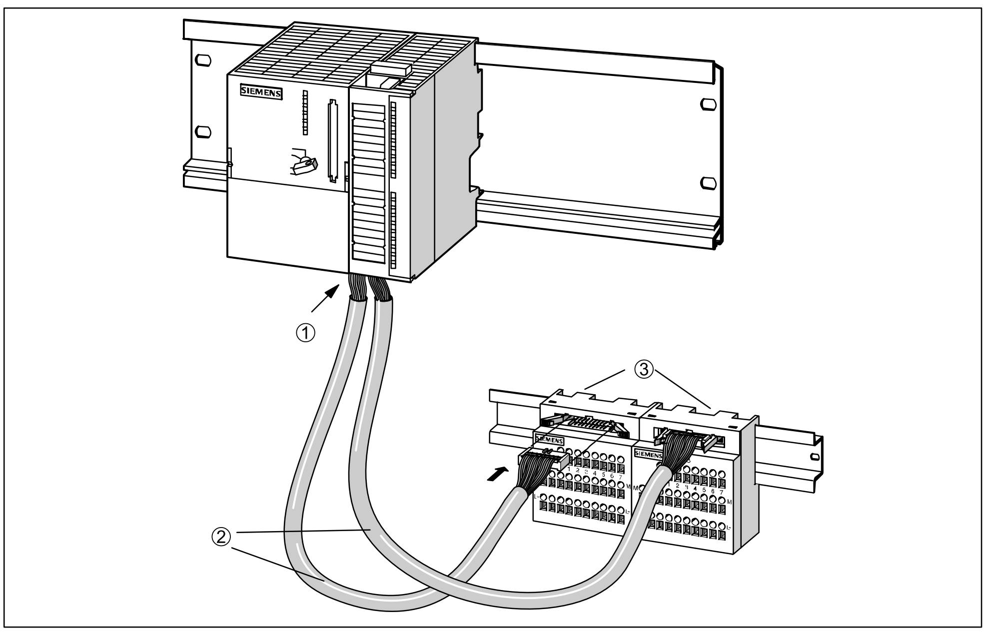


Figure 8-1 SIMATIC TOP connect on a S7-300

Advantages

Use of SIMATIC TOP connect/... TPA features the following advantages:

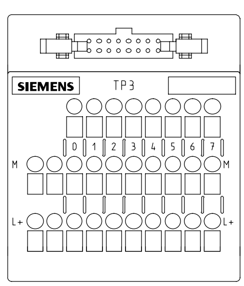
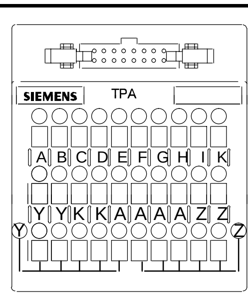
- Fast, low-cost wiring (the use of central terminal blocks is no longer necessary)
- Simple mounting of the components (front connector module, connecting cable, terminal block)
- Each component can be replaced separately
- Connecting cable configurable without waste
- Wiring errors are drastically reduced
- Neat and tidy cabinet wiring
- The supply voltage for the module can be connected to components of SIMATIC TOP connect/... TPA
- Simplification of the terminals for M- and L+ connection

Range of modules

The table below lists all the modules which you can wire with SIMATIC TOP connect and SIMATIC TOP connect TPA.

You will find a detailed list of the components of SIMATIC TOP connect/... TPA with their order numbers in Table 8-5 on page 8-12 and Table 8-13 on page 8-20.

Table 8-1 SIMATIC TOP connect/... TPA: Connectable Modules

Component	Front view of terminal block	Wiring possible with module...
SIMATIC TOP connect		SM 321; DI 32 × 24 VDC SM 321; DI 16 × 24 VDC SM 321; DI 16 × 24 VDC; source input
		SM 322; DO 32 × 24 VDC/0.5 A SM 322; DO 16 × 24 VDC/0.5 A SM 322; DO 8 × 24 VDC/0.5 A; with diagnostic interrupt SM 322; DO 8 × 24 VDC/2 A
		SM 323; DI 16/DO 16 × 24 VDC/0.5 A SM 323; DI 8/DO 8 × 24 VDC/0.5 A
SIMATIC TOP connect TPA		SM 331; AI 2 × 12 Bit SM 331; AI 8 × 12 Bit SM 332; AO 4 × 12 Bit SM 332; AO 2 × 12 Bit SM 332; AO 4 × 16 Bit SM 334; AI 4/AO 2 × 8/8 Bit SM 334; AI 4/AO 2 × 12 Bit SM 335; AI 4/AO 4 × 14 Bit;

8.2 Wiring Components

Introduction

The following table contains the tasks that you have to perform one after the other to commission SIMATIC TOP connect/... TPA successfully.

The sequence of steps is a suggestion but you can perform individual steps sooner or later.

Sequence of steps for wiring

Table 8-2 Sequence of Steps for Wiring SIMATIC TOP connect/... TPA

Step	Procedure	Refer to Section...
1.	Cut connecting cable to length and terminate	8.2.1
2.	Wire the front connector module	8.2.2 and 8.3 or 8.4
3.	Connect the connecting cable to the terminal block	8.2.3 and 8.3 or 8.4
4.	Wire actuators/sensors to the terminal block	8.2.4

8.2.1 Cut the Connecting Cable to Length and Terminate

Maximum length of cable

The length of the connecting cable (round-sheath ribbon cable) between the SIMATIC S7 and the terminal blocks must not be more than 30 m.

Using the connectors

You must attach connectors to either end of the round-sheath ribbon cable, for connection to the front connector module and the terminal block.

Connect the round-sheath ribbon cable to connector

1. Cut the round-sheath ribbon cable to the length required and remove part of the cable sheath at both ends.

   You will find the length of the cable sheath that has to be removed in the following table:

Cable End to ...		**cable sheath to be removed**		**outer ribbon cable**	**inner ribbon cabel**	**outer ribbon cable**	**inner ribbon cable**
		20-pin front connec-tor	**40-pin front connec-tor**	**20-pin front connector**		**40-pin front connector**	
... top connector of front connector module	1 x 16 cores shielded/uns hielded	110 mm	115 mm				
... bottom connector of front connector module		70 mm	75 mm				
... top connector of front connector module	2 x 16 cores unshielded	95 mm	115 mm	95 mm		115 mm	
... bottom connector of front connector module					40 mm		75 mm
... socket of terminal block		40 mm		100 mm			

2. Thread the cable into the 16-pin connector.

   It is important that you note the position of the details marked in the following figure.

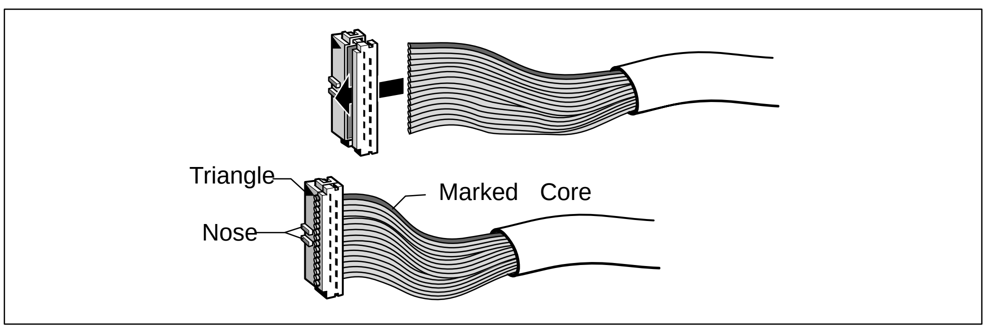


Figure 8-2 Threading the Round-Sheath Ribbon Cable into the Connector

3. Clamp the end of the cable into the connector with the crimping tool.
4. Attach the strain relief device to the connector of the terminal block as follows:
   – Fold back the cable over the connector
   – Push the enclosed strain relief device over the cable
   – Snap the strain relief device into place on the connector

8.2.2 Wiring the Front Connector Module

Introduction

This chapter describes the principle of wiring the front connector modules. Note also the special sections for SIMATIC TOP connect and SIMATIC TOP connect TPA (Section 8.3 and 8.4, respectively). In those sections, you will find, among other things, selection criteria for the front connector modules and specific connection examples.

Using the front connector module

You require the front connector module to connect the connecting cable to the module. In addition, you can connect the supply voltage of the module to the front connector module.

Wiring rules for connecting the supply voltage

The following table shows you what you have to consider when connecting the module supply voltage to the terminal block or front connector module.

The terminals for the supply voltage are screws or spring-loaded terminals (refer to Section 8.2.4 for handling spring-loaded terminals).

Table 8-3 Wiring Rules for Connecting the Supply Voltage

Rules for ...	Terminal block		Front connector	
	Spring-loaded connection	Screw-type connection	Up to 4 Terminals	Up to 8 Terminals
Conductor cross-sections suitable for connection:				
Solid conductors	No		No	No
Stranded conductors				
• without end ferrules	0.25 to 1.5 mm^2		0.25 to 1.5 mm^2	0.25 to 0.75 mm^2
• with end ferrules	0.25 to 1.5 mm^2		0.25 to 1.5 mm^2	0.25 to 0.75 mm^2
No of conductors per terminal	1 or combination of 2 conductors up to 1.5 mm^2 (sum) in a common end ferrule			
Max. diameter of conductor insulation	∅ 3.1 mm		∅ 3.1 mm	∅ 2.0 mm
Length of conductor insulation to be stripped				
• without insulation collar	11 mm		6 mm	
• with insulation collar	11 mm		–	
End ferrules to DIN 46228				
• without insulation collar	Model A; up to 12 mm long	Model A; up to 12 mm long	Model A; 5 to 7 mm long	
• with insulation collar			–	
– 0.25 to 1.0 mm^2	Model E; up to 12 mm long	Model E; up to 12 mm long		
– 1.5 mm^2	Model E; 12 mm long	Model E; 18 mm long		

Connect the connecting cable and the supply voltage to the front connector module

1. Open the front door of the module.
2. Bring the front connector into the wiring position.
3. If necessary, connect the cables for the incoming supply of the module supply voltage.
4. Insert the connecting cable into the front connector module as shown in the following figure:

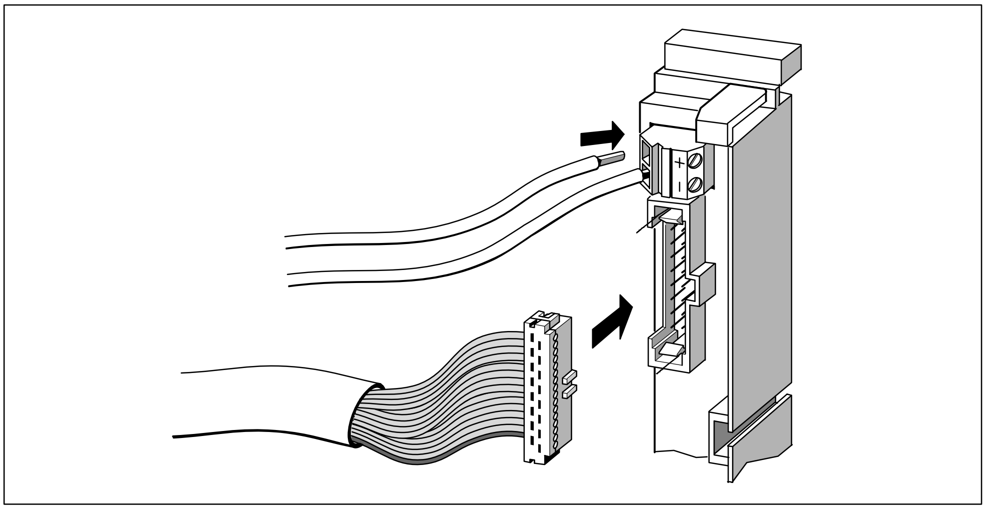


Figure 8-3 Inserting the Connecting Cable into the Front Connector Module

5. Twist every connecting cable 90 ° downwards and turn through one whole turn to the extent possible.

Additional steps for wiring for 32-channel digital modules

Note

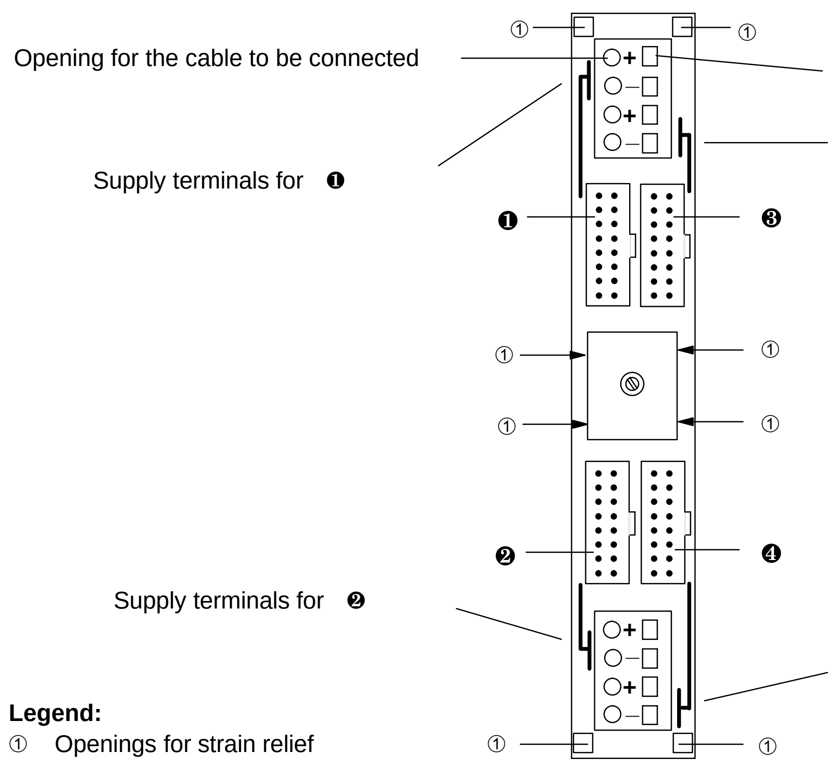
When using 32-channel digital modules, you must observe the assignment of the supply connections to the connecting cable terminals and the assignment of the connecting cable terminals to the address bytes of the module (refer to Figure 8-4 and Table 8-4).

---

6. Thread a strain relief assembly into the middle of the front connector. This strain relief assembly is used to fix the connecting cables in the narrow cable stowage area of the module.
7. Thread the strain relief assembly into the front connector.

Front connector module for 32-channel digital modules

The following figure shows the front view of the front connector module for 32-channel digital modules.



Legend:
① Openings for strain relief
❶ to ❹: Terminals for connecting cable; refer to Table 8-4 for the address assignment

Figure 8-4 Front Connector Module for 32-Channel Digital Modules

Assignment of connecting cable terminals to address bytes of 32-channel digital modules

Table 8-4 Assignment of Connecting Cable Terminals to Address Bytes of 32-Channel Digital Modules

Refer to Figure 8-4: Connecting Cable Terminal	Address Assignment for		
	Digital Input Module	Digital Output Module	Digital Input/Output Module
❶	IB x	QB x	IB x
❷	IB (x+1)	QB (x+1)	IB (x+1)
❸	IB (x+2)	QB (x+2)	QB x
❹	IB (x+3)	QB (x+3)	QB (x+1)

8.2.3 Connecting the Connecting Cable to the Terminal Block

Introduction

A description of how to mount the terminal blocks is presented in the following. Note also the special sections for SIMATIC TOP connect and SIMATIC TOP connect TPA (Section 8.3 and 8.4, respectively). In those sections, you will find, among other things, selection criteria for the different terminal blocks and specific connection examples.

Mounting the terminal block and connecting cable

1. Attach the terminal block to a 35 mm standard rail in accordance with EN 50 022.
2. Insert the connecting cable into the terminal block as shown in the following figure:

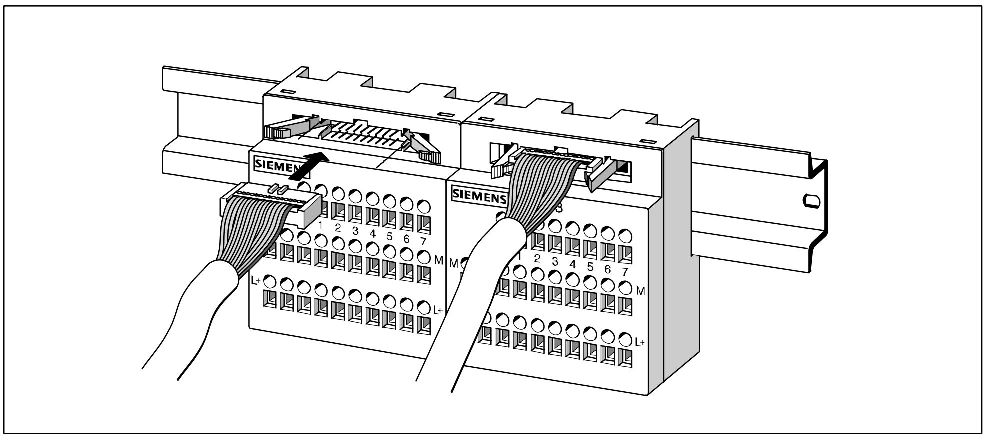


Figure 8-5 Insert the Connecting Cable into the Terminal Block

8.2.4 Wiring Actuators/Sensors to the Terminal Block

Screw-type or spring-loaded terminals

To mount the signal leads of the actuators/sensors to the terminal block and the supply lines to the terminal block and front connector module, you can choose between screw-type and spring-loaded components.

The principle of spring-loaded components is dealt with in greater detail in the following, since it allows fast and simple connection of the signal lines and supply cables.

Spring-loaded terminal block

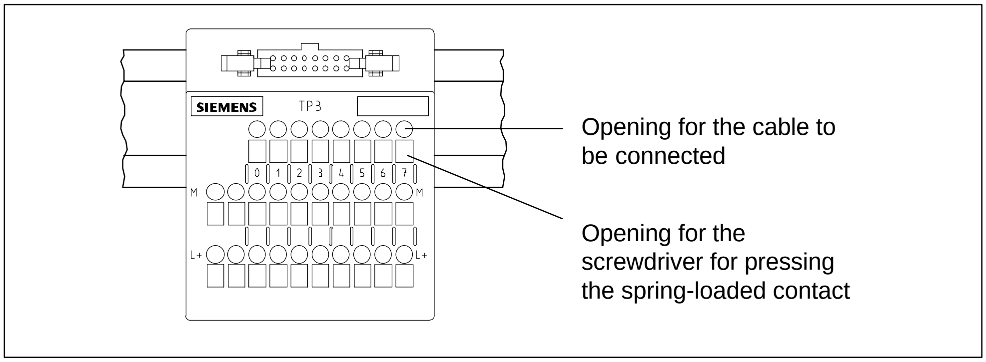


Figure 8-6 Spring-Loaded Terminal Block

Caution

The spring-loaded contact will be damaged, if you insert the screwdriver into the opening for the cable.

Make sure that you insert the screwdriver only into the rectangular opening of the terminal block.

Attaching the cable to the spring-loaded contact

Attach the cables to the spring-loaded contacts as follows:

1. Use a screwdriver ① to press down the spring-loaded terminal in the rectangular opening and to hold it down.
2. Insert the cable ② into the round opening of the corresponding spring-loaded terminal as far as it will go.
3. Remove the screwdriver ③ from the spring-loaded terminal. The cable is held by the spring-loaded contact.

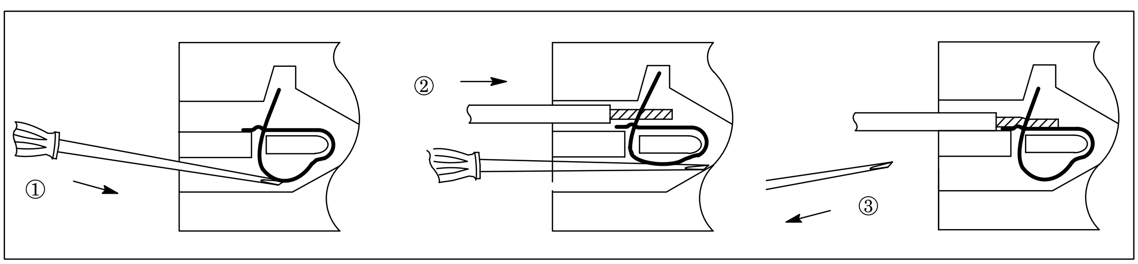


Figure 8-7 Principle of Spring-Loaded Connections

8.3 Wiring SIMATIC TOP connect with Digital Modules

Introduction

For wiring the module with actuators/sensors using SIMATIC TOP connect, you must first select the components as a function of the module and method of connection (screw-type or spring-loaded terminal, one-conductor, three-conductor or 2A connection; relay).

8.3.1 SIMATIC TOP connect Components and Selection Aid

Components

The following table contains all the component of SIMATIC TOP connect.

Table 8-5 Components of SIMATIC TOP connect

Components of SIMATIC TOP connect			Order number
Terminal block	... for one-conductor connection	Spring-loaded screw-type	6ES7 924-0AA00-0AB0 6ES7 924-0AA00-0AA0
	... for one-conductor connection (10 items)	Spring-loaded screw-type	6ES7 924-0AA00-1AB0 6ES7 924-0AA00-1AA0
	... for three-conductor connection	Spring-loaded screw-type	6ES7 924-0CA00-0AB0 6ES7 924-0CA00-0AA0
	... for three-conductor connection (10 items)	Spring-loaded screw-type	6ES7 924-0CA00-1AB0 6ES7 924-0CA00-1AA0
	... for 2A modules	Spring-loaded screw-type	6ES7 924-0BB00-0AB0 6ES7 924-0BB00-0AA0
	... for 2A modules (10 items)	Spring-loaded screw-type	6ES7 924-0BB00-1AB0 6ES7 924-0BB00-1AA0
	... for relay	Spring-loaded screw-type	6ES7 924-0CD00-0AB0 6ES7 924-0CD00-0AA0
Front connector	for 32-channel modules (refer to Figure 8-4)	Voltage supply via: Spring-loaded terminals	6ES7 921 3AA20-0AA0
	for 16-channel modules	Voltage supply via: spring-loaded screw-type	6ES7 921-3AA00-0AA0 6ES7 921-3AB00-0AA0
	for 16-channel 2A modules	Voltage supply via: spring-loaded screw-type	6ES7 921-3AC00-0AA0 6ES7 921-3AD00-0AA0
Connectors (plug-in connectors), set of 8 (insulation displacement connectors)			6ES7 921-3BE10-0AA0

Table 8-5 Components of SIMATIC TOP connect, continued

Components of SIMATIC TOP connect			Order number
Round-sheath ribbon cable 1x 16	Unshielded	30 m 60 m	6ES7 923-0CD00-0AA0 6ES7 923-0CG00-0AA0
	Shielded	30 m 60 m	6ES7 923-0CD00-0BA0 6ES7 923-0CG00-0BA0
Round-sheath ribbon cable 2 x 16	Unshielded	30 m 60 m	6ES7 923-2CD00-0AA0 6ES7 923-2CG00-0AA0
Crimping tool for 16-pin connector			6ES7 928-0AA00-0AA0

Selection aid

In the following table you will find the components of SIMATIC TOP connect with which you can wire the digital modules.

Table 8-6 Selection Table for SIMATIC TOP connect Components

Digital Modules	Terminal block for...				Front connector module for...	
	One-conductor connection	Three-conductor connection	2A modules	Relay	SM; 16 or 32 channels	2A modules
SM 321; DI 32 × 24 VDC	×	×	–	–	×	–
SM 321; DI 16 × 24 VDC	×	×	–	–	×	–
SM 321; DI 16 × 24 VDC; source input	×	×	–	–	×	–
SM 322; DO 32 × 24 VDC/0.5 V	×	×	–	×	×	–
SM 322; DO 16 × 24 VDC/0.5 V	×	×	–	×	×	–
SM 322; DO 8 × 24 VDC/0.5 V; with diagnostic interrupt	×	×	–	–	×	–
SM 322; DO 8 × 24 VDC/2 A	–	–	×	–	–	×
SM 323; DI 16 / DO 16 × 24 VDC/ 0.5 A	×	×	–	–	×	–
SM323; DI 8/DO 8 × 24 VDC/0.5 A	×	×	–	–	×	–

One-conductor or three-conductor connection

With the three-conductor connection, you can optionally apply the supply voltage for the module to the front connector module or to the terminal block. With the one-conductor connection, this can only be done to the front connector module.

2A module connection

You require the following information on wiring 2A modules only when you want to use the SM 322; 8 × DO 24 VDC/2 A with SIMATIC TOP connect.

8.3.2 Wiring the Module with Terminal Block for One-Conductor Connection

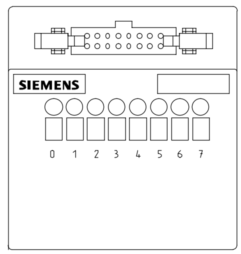
Connection Notes

Table 8-7 Connection Notes for SIMATIC TOP connect with One-Conductor Connection

Digital Modules	Connection Notes				
	Supply Voltage Feed-In			Additional jumper required at power supply	Description on terminal block not in line with description on SM
	at front connector only	add. ground conn. at terminal block	at front connector or terminal block		
SM 321; DI 32 × 24 VDC	×	–	–	–	–
SM 321; DI 16 × 24 VDC	×	–	–	–	–
SM 321; DI 16 × 24 VDC; source input	×	–	–	–	–
SM 322; DO 32 × 24 VDC/0.5 A	×	–	–	–	–
SM 322; DO 16 × 24 VDC/0.5 A	×	–	–	–	–
SM 322; DO 8 × 24 VDC/0.5 A; with diagnostic interrupt	×	–	–	–	×
SM 323; DI 16/DO 16 × 24 VDC/0.5 A	×	–	–	–	–
SM 323; DI 8/DO 8 × 24 VDC/ 0.5 A	×	–	–	–	–

Assignments of the terminal block for one-conductor connection

Table 8-8 Terminal Assignments of the Terminal Block for One-Conductor Connection

Front view of terminal block	Assignments of the Terminals
	Top row: Terminals 0 to 7: inputs/outputs x.0 to x.7

Connecting the power supply

Always connect the supply voltage to the front connector module Observe the wiring rules in Table 8-3 on page 8-7.

In the following example, you must connect L+ to Plus of the **upper** terminal and M to Minus of the **lower** terminal.

Connecting the terminal block for one-conductor connection

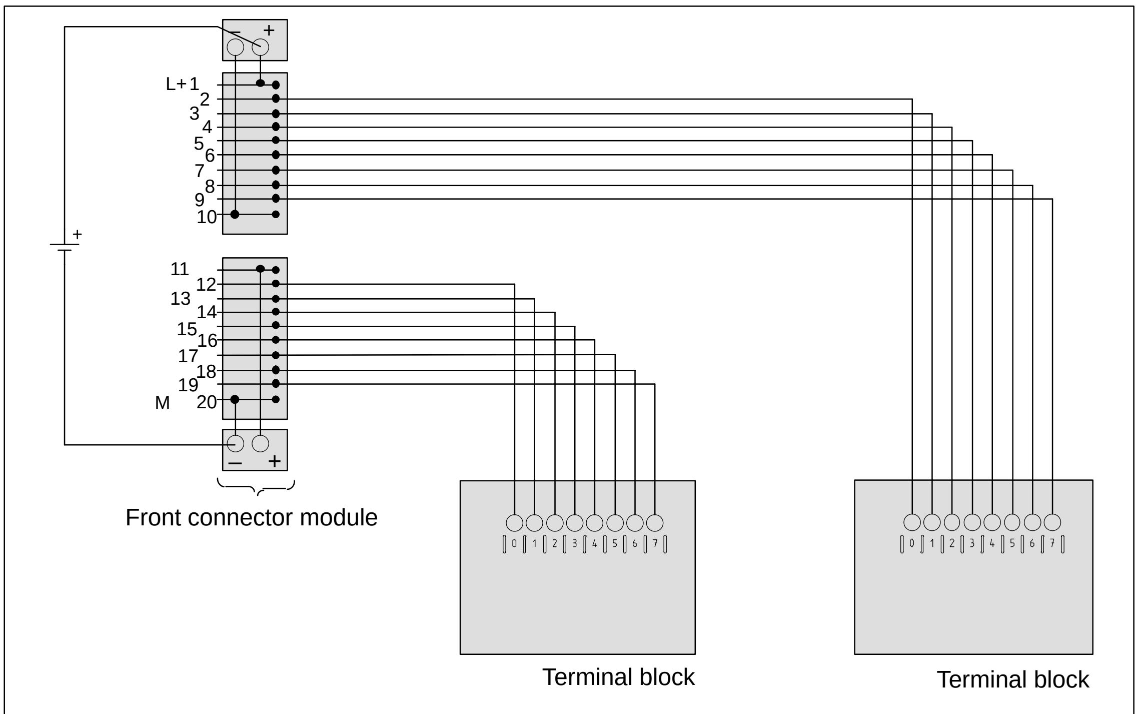


Figure 8-8 Wiring a Digital Module with Terminal Block for a One-Conductor Connection

8.3.3 Wiring the Module with Terminal Block for Three-Conductor Connection

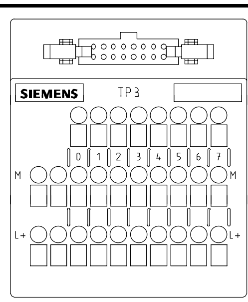
Connection Notes

Table 8-9 Connection Notes for SIMATIC TOP connect with Three-Conductor Connection

Digital Modules	Connection Notes				
	Supply Voltage Feed-In			Additional jumper required at power supply	Descrip-tion on ter-minal block not in line with description on SM
	at front connector only	add. ground conn. at terminal block	at front connector or terminal block		
SM 321; DI 32 × 24 VDC	–	–	×	×	–
SM 321; DI 16 × 24 VDC	–	–	×	×	–
SM 321; DI 16 × 24 VDC; source input	–	–	×	×	–
SM 322; DO 32 × 24 VDC/0.5 A	–	–	×	–	–
SM 322; DO 16 × 24 VDC/0.5 A	–	–	×	–	–
SM 322; DO 8 × 24 VDC/0.5 A with diagnostic interrupt	–	–	×	×	×
SM 323; DI 16/DO 16 × 24 VDC/0.5 A	–	–	×	–	–
SM 323; DI 8/DO 8 × 24 VDC/ 0.5 A	–	–	×	–	–

Assignment of the terminal block for three-conductor connection

Table 8-10 Terminal Assignments of the Terminal Block for Three-Conductor Connection

Front view of terminal block	Assignments of the Terminals
	Top row: Terminals 0to 7:inputs/outputs x.0 to x.7
	Center row: All terminals: M potential
	Bottom row: All terminals: L + potential

Connecting the power supply

Observe the wiring rules in Table 8-3 on page 8-7.

With some digital modules, two jumpers are generally required for connecting the supply voltage (refer to Table 8-9 on page 8-16).

You can wire the jumpers either in the front connector or in the terminal block. Irrespective of this, you must interconnect the two Plus terminals and the two Minus terminals.

Connecting the terminal block for three-conductor connection

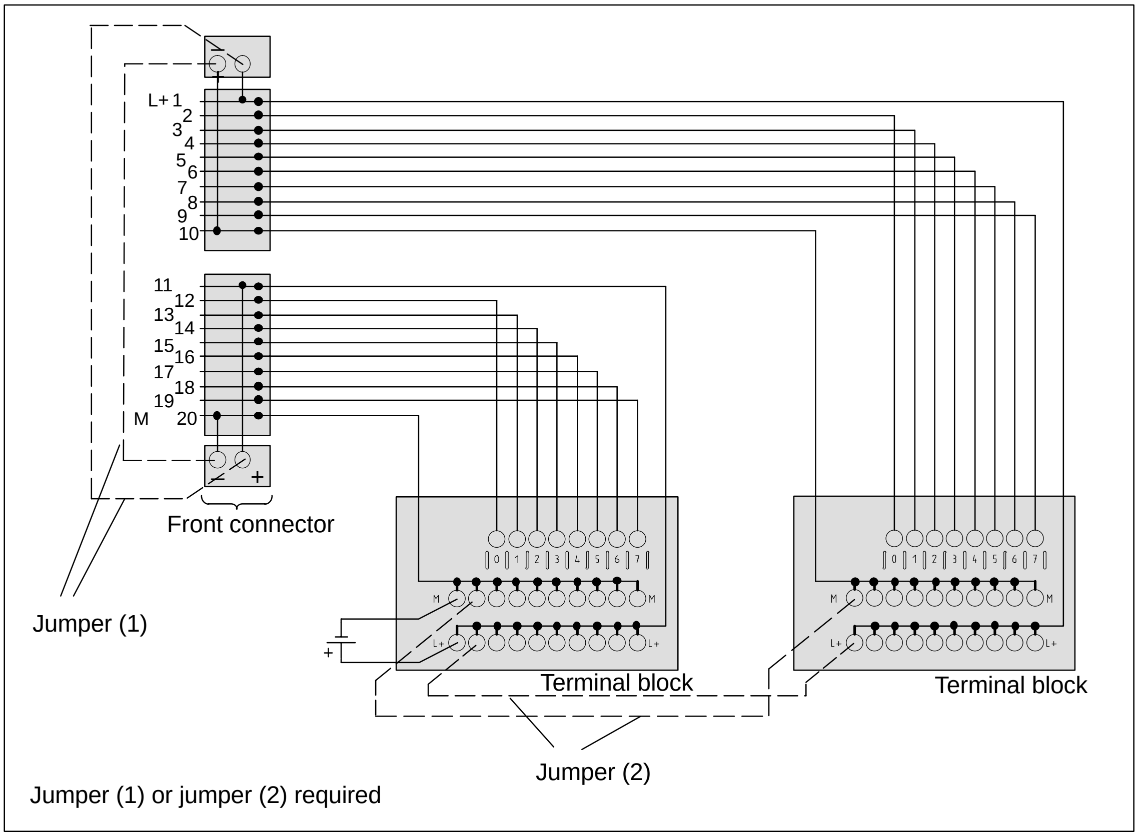


Figure 8-9 Wiring a Digital Module with Terminal Block for a Three-Conductor Connection

8.3.4 Wiring the Module with Terminal Block for 2A Modules

You can use the terminal block for 2A modules to wire the SM 322; 8 × DO 24 VDC/2A.

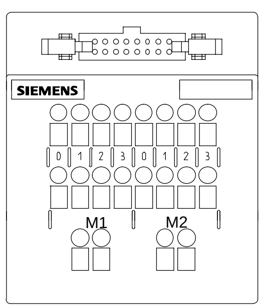
Connection Notes

Table 8-11 Connection Notes for SIMATIC TOP connect with 2A Module Connection

Digital Modules	Connection Notes				
	Supply Voltage Feed-In			add. jumper required for power supply	Descr. on terminal block not in line with descr. on SM
	at front connector only	add. ground conn. at terminal block	at front connector or terminal block		
SM 322; DO 16 × 24 VDC/2 A	×	×	–	–	–

Assignment of the Terminal Block for Connection of 2A Modules

Table 8-12 Terminal Assignments of the Terminal Block for 2A Modules

Front view of terminal block	Assignments of the Terminals (left)	Assignments of the Terminals (right)
	Top row: Terminals 0 to 3: outputs x.0 to x.3	Top row, on right: Terminals 0 to 3: outputs x.4 to x.7
	Center row: Terminals 0 to 3: potential M1 for x.0 to x.3	Center row, on right: Terminals 0 to 3: potential M2 for x.4 to x.7
	Bottom row: two-terminal connection for M1	Bottom row: two-terminal connection for M2

Connecting the power supply

Please observe the following when connecting the power supply:

- Apply the wiring rules in Table 8-3 on page 8-7.
- Connect the supply voltage at the front connector module to the potential terminals using separate cables.
- You must equip each terminal block with a cable for M1 or M2, in addition to the connecting cable.
- Connect M1 or M2 via a separate line with the front connector and the terminal block. You may jumper the potential of M1 and M2.

Connection to terminal block for 2A modules

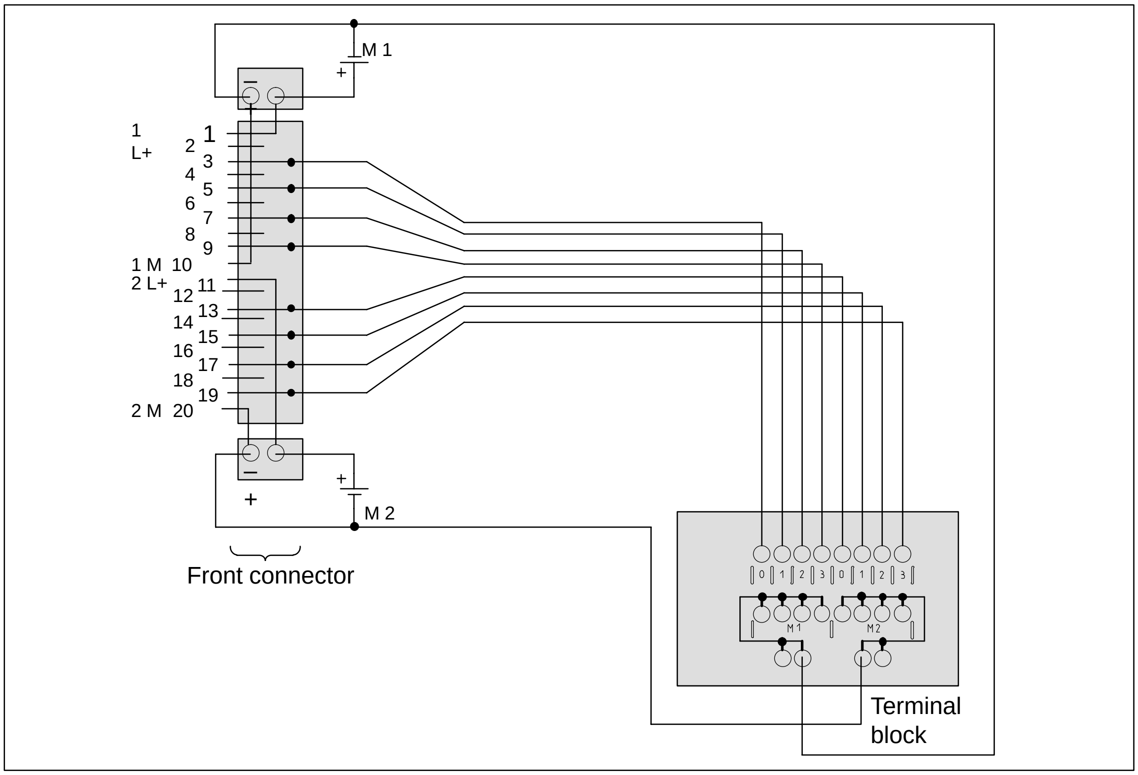


Figure 8-10 Wiring with Terminal Block for 2A Module

8.4 Wiring SIMATIC TOP connect TPA with Analog Modules

Introduction

For wiring the module with actuators/sensors using SIMATIC TOP connect TPA, you must first select the components as a function of the method of connection (screw-type or spring-loaded terminal).

8.4.1 SIMATIC TOP connect TPA Components and Selection Aid

Components

The following table contains all the component of SIMATIC TOP connect TPA.

Table 8-13 Components for SIMATIC TOP connect TPA

Components of SIMATIC TOP connect TPA			Order number
Terminal block	Quantity: 1	Spring-loaded terminals Screw-type terminals	6ES7 924-0CC00-0AB0 6ES7 924-0CC00-0AA0
	Quantity: 10	Spring-loaded terminals Screw-type terminals	6ES7 924-0CC00-1AB0 6ES7 924-0CC00-1AA0
Front connector		Voltage supply via: Spring-loaded terminals Screw-type terminals	 6ES7 921-3AF00-0AA0 6ES7 921-3AG00-0AA0
Connectors (plug-in connectors), set of 8 (insulation displacement connectors)			6ES7 921-3BE10-0AA0
Shielding plate for terminal block, set of 4			6ES7 928-1BA00-0AA0
Terminal element for: 2 cables, each with a shield diameter of 2 to 6 mm 1 cable with a shield diameter of 3 to 8 mm 1 cable with a shield diameter of 4 to 13 mm			 6ES7 390-5AB00-0AA0 6ES7 390-5BA00-0AA0 6ES7 390-5CA00-0AA0
Round-sheath ribbon cable, shielded ∅ 8 mm		30 m 60 m	6ES7 923-0CD00-0BA0 6ES7 923-0CG00-0BA0
Crimping tool for 16-pin connector			6ES7 928-0AA00-0AA0

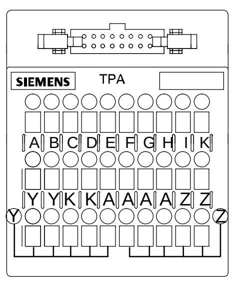
8.4.2 SIMATIC TOP connect TPA Terminal Assignment and Terminal Allocation

Terminal marking

On the TPA terminal block, the terminals are identified by letters. This simplifies the allocation of the terminals on the analog module to the terminals on the terminal block.

Terminal block assignment

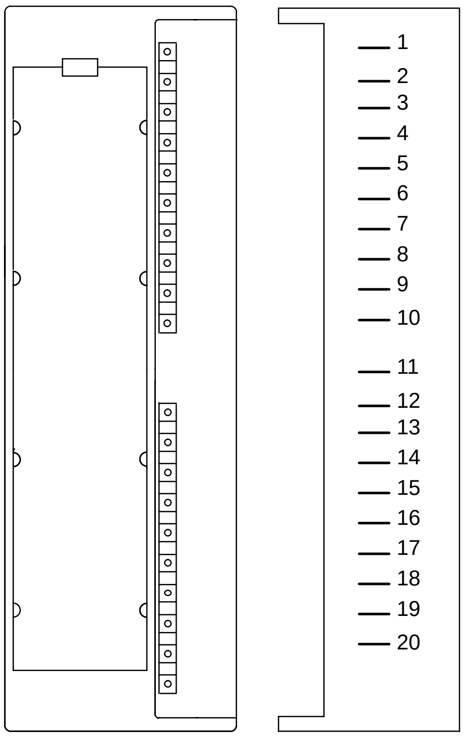
Table 8-14 Terminal Assignment of the Terminal Block of SIMATIC TOP connect TPA

Front view of terminal block	Assignments of the Terminals
	Terminals Z and Y can be used for multiplying arbitrary potentials and signals.
	The terminals having identical letters are electrically interconnected, **with the exception** of terminals Z and Z, and also Y and Y.

Multiplier terminal

The lower tier of terminals on the terminal block is designed as 2 × 5 multiplier terminals.

Terminal allocation of an analog module to SIMATIC TOP connect TPA



Terminal number on module	Terminal assignment on terminal block TPA	
	Terminal block 1	Terminal block 2
1	Y	Y
2	B	
3	C	
4	D	
5	E	
6	F	
7	G	
8	H	
9	I	
10	K	K
11	A	A
12		B
13		C
14		D
15		E
16		F
17		G
18		H
19		I
20	Z	Z

Figure 8-11 Terminal Assignment of Analog Module to SIMATIC TOP connect TPA

8.4.3 Connecting the Signal-Line Shield

Two options for connecting the shield

You can connect the signal line shield to ground as follows:

- on the analog module by means of a shield-support element

  (refer to the manual *Hardware and Installation for the S7-300* or the manual *Distributed I/O device ET 200M* in the section on wiring)

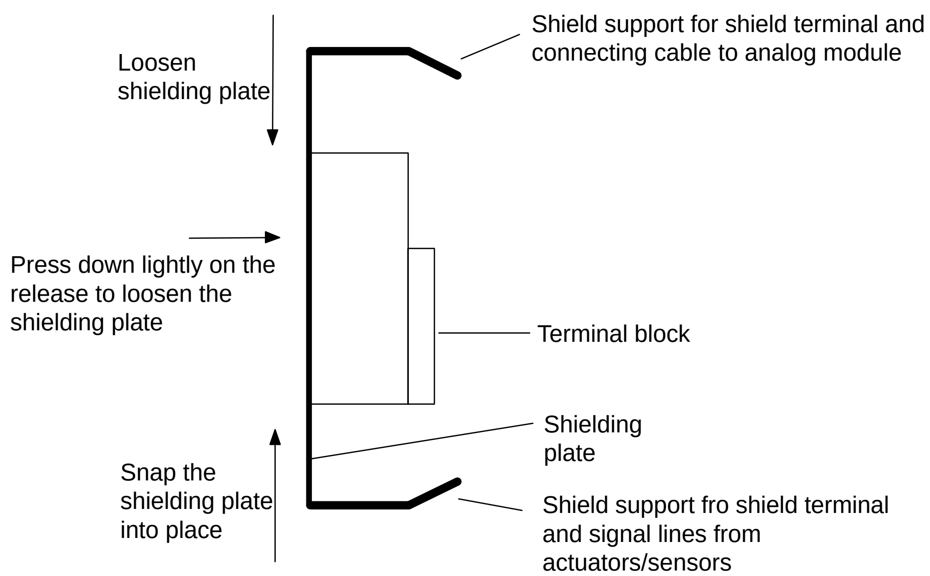
- directly to the terminal block by means of a shielding plate

Connecting the shield to the terminal block using a shielding plate

1. Before mounting, attach a shielding plate to the terminal block.
2. Mount the terminal block on the DIN rail.

   (In the figure below, you can see that the shielding plate is applied to the rear of the terminal block and thus there is a connection to the grounded rail.)

3. Place the signal-line shield with the shield terminals on the shielding plate.



Snap the shielding plate into place at the rear of the terminal block.

Figure 8-12 SIMATIC TOP connect TPA Terminal Block with Shielding Plate

8.4.4 Connection Example

Connecting the load voltage supply

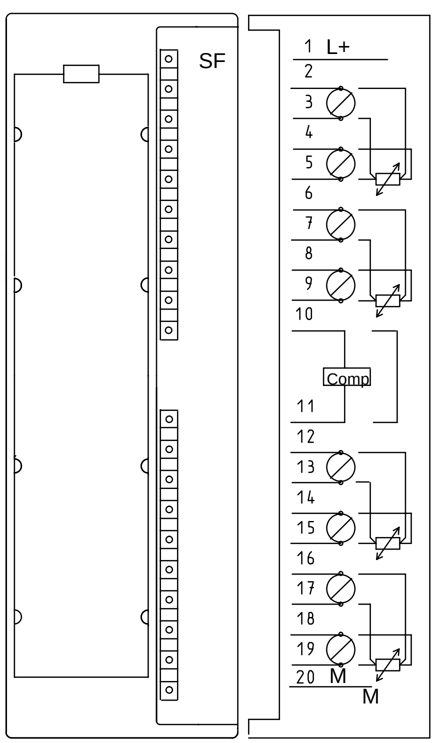
You can connect the load voltage supply of the analog module to the front connector module. Their are separate terminals on the front connector module for the load voltage L+ und M. Observe the wiring rules in Table 8-3 on page 8-7.

Allocation of front connector to terminal block

The **upper socket** of the front connector module is the connection for **terminal block 1** and the **lower socket** of the front connector module is the connection for **terminal block 2**.

Connection example

The illustration below shows an example of connecting the analog input module SM 321; AI 8 × 12 Bit in ”Resistance Test” mode.



Resistance test	Terminal number on module	Terminal assignment on terminal block TPA: Terminal block 1	Terminal block 2
L+	1	Y	Y
M_{0+} CH0	2	B	
M_{0-}	3	C	
I_{C0+}	4	D	
I_{C0-}	5	E	
M_{1+} CH2	6	F	
M_{1-}	7	G	
I_{C1+}	8	H	
I_{C1-}	9	I	
Comp +	10	K	K
Comp – / Mana	11	A	A
M_{2+} CH4	12		B
M_{2-}	13		C
I_{C2+}	14		D
I_{C2-}	15		E
M_{3+} CH6	16		F
M_{3-}	17		G
I_{C3+}	18		H
I_{C3-}	19		I
M	20	Z	Z

Figure 8-13 Example of Connecting SIMATIC TOP connect TPA to SM 321; AI 8 × 12 Bit

Parameter Sets for Signal Modules

A

In this chapter

A.1 How to Assign the Parameters for Signal Modules in the User Program

Parameter assignment in the user program

You have already assigned parameters to the modules in *STEP 7*.

In the user program, you can use a SFC:

- to reassign parameters to the module and
- and transfer the parameters from the CPU to the addressed signal module

On M7-300

On M7-300 programmable logic controllers you can likewise assign with the *M7-API* software to the signal modules in the user program (refer to *System Software Manuals for M7-300/400*).

Parameters stored in data records

The parameters of the signal modules are located in data records 0 and 1; for some other analog input modules, in data record 128 as well.

Modifiable parameters

You can change the parameters of record 1 and pass them to the signal module using SFC 55. The parameters set on the CPU are not changed when you do this!

You cannot modify the parameters of data record 0 in the user program.

SFCs for parameter assignment

The following SFCs are available for assigning parameters to the signal modules in the user program:

Table A-1 SFCs for Assigning Parameters to Signal Modules

SFC No.	Identifier	Application
55	WR_PARM	Transfer modifiable parameters (data record 1 and 28) to the addressed signal module.
56	WR_DPARM	Transfer parameters (data record 0, 1 **or** 128) from the CPU to the addressed signal module.
57	PARM_MOD	Transfer all parameters (data record 0, 1 **and** 128) from the CPU to the addressed signal module.

Description of the parameters

The following sections contain **all** the modifiable parameters for the various module classes. The parameters of the signal modules are described:

- in the on-line help of *STEP 7*
- in this reference manual

  You will find the parameters that can be adjusted for the signal module concerned in the specific sections for the different signal modules.

Further references

An in-depth description of the principle of assigning parameters to signal modules in the user program and a description of the SFCs that can be used for that purpose will be found in the *STEP 7* manuals.

A.2 Parameters of the Digital Input Modules

Parameters

The table below contains all the parameters you can set for digital input modules.

You will see which parameters you can modify from the list:

- in *STEP 7*
- with SFC 55 ”WR_PARM”

The parameters set with *STEP 7* can also be transferred with SFCs 56 and 57 to the module (refer to the *STEP 7* manuals).

Table A-2 Parameters of the Digital Input Modules

Parameter	Data Record No.	Parameters can be assigned with ...	
		... SFC 55	... Programming Device
Input delay	0	No	Yes
Diagnostics		No	Yes
Hardware interrupt enable	1	**Yes**	Yes
Diagnostics interrupt enable		**Yes**	Yes
Hardware interrupt with rising edge		**Yes**	Yes
Hardware interrupt with falling edge		**Yes**	Yes

Note

If you want to enable the diagnostic interrupt in the user program in data record 1, you must enable the diagnosis in data record 0 beforehand using *STEP 7*.

Data record 1 structure

The figure below shows the structure of data record 1 for the parameters of the digital input modules.

You activate a parameter by setting the corresponding bit to “1”.

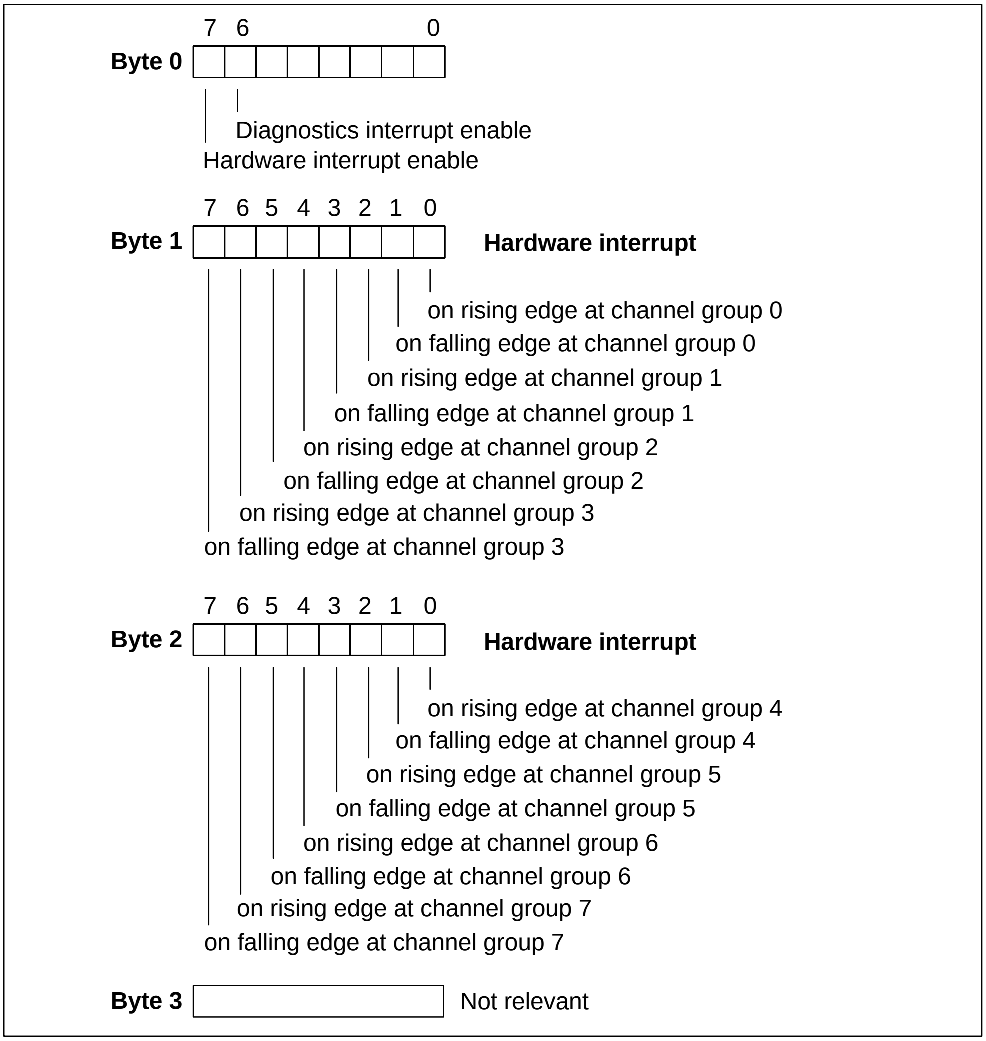


Figure A-1 Data Record 1 for Parameters of the Digital Input Modules

A.3 Parameters of the Digital Output Modules

Parameters

The table below contains all the parameters you can set for digital output modules.

You will see which parameters you can modify from the list:

- in *STEP 7*
- with SFC 55 ”WR_PARM”

The parameters set with *STEP 7* can also be transferred with SFCs 56 and 57 to the module (refer to the *STEP 7* manuals).

Table A-3 Parameters of the Digital Output Modules

Parameter	Data Record No.	Parameters can be assigned with ...	
		... SFC 55	... Programming Device
Diagnostics	0	No	Yes
Diagnostics interrupt enable	1	**Yes**	Yes
Behavior on CPU STOP		**Yes**	Yes
Enable substitute value “1”		**Yes**	Yes

Note

If you want to enable the diagnostic interrupt in the user program in data record 1, you must enable the diagnosis in data record 0 beforehand using *STEP 7*.

Data record 1 structure

The figure below shows the structure of data record 1 for the parameters of the digital output modules.

You activate a parameter by setting the corresponding bit in byte 0 to “1”.

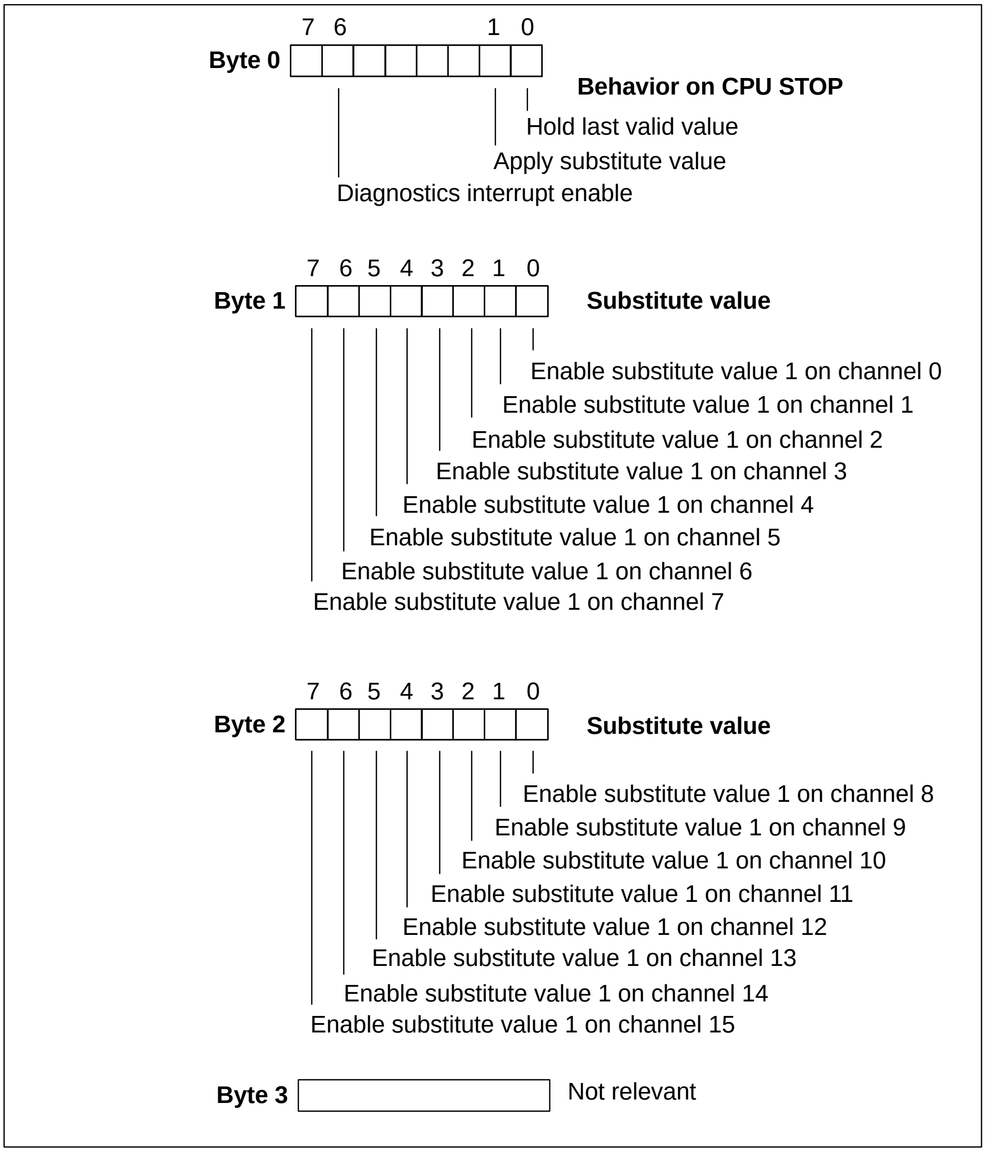


Figure A-2 Data Record 1 for Parameters of the Digital Output Modules

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Note

You should only enable the parameters in byte 0, ”Hold last valid value” and ”Enable substitute value” as an alternative.

A.4 Parameters of the Analog Input Modules

Parameters

The table below contains all the parameters you can set for analog input modules.

You will see which parameters you can modify from the list:

- in *STEP 7*
- with SFC 55 "WR_PARM"

The parameters set with *STEP 7* can also be transferred with SFCs 56 and 57 to the module (refer to the *STEP 7* manuals).

Table A-4 Parameters of the Analog Input Modules

Parameter	Data Record No.	Parameters can be assigned with ...	
		... SFC 55	... Programming Device
Diagnostics: Group diagnostics	0	No	Yes
Diagnostics: With wire-break check		No	Yes
Temperature unit		No	Yes
Temperature coefficient		No	Yes
Smoothing		No	Yes
Diagnostics interrupt enable	1	**Yes**	Yes
Limit value interrupt enable		**Yes**	Yes
Cycle end interrupt enable		**Yes**	Yes
Interference Suppression		**Yes**	Yes
Measuring Method		**Yes**	Yes
Measuring Range		**Yes**	Yes
Upper limit value		**Yes**	Yes
Lower limit value		**Yes**	Yes

Note

If you want to enable the diagnostic interrupt in the user program in data record 1, you must enable the diagnosis in data record 0 beforehand using *STEP 7*.

Data record 1 structure

The figure below shows the structure of data record 1 for the parameters of the analog input modules.

You activate a parameter by setting the corresponding bit in byte 0 to “1”.

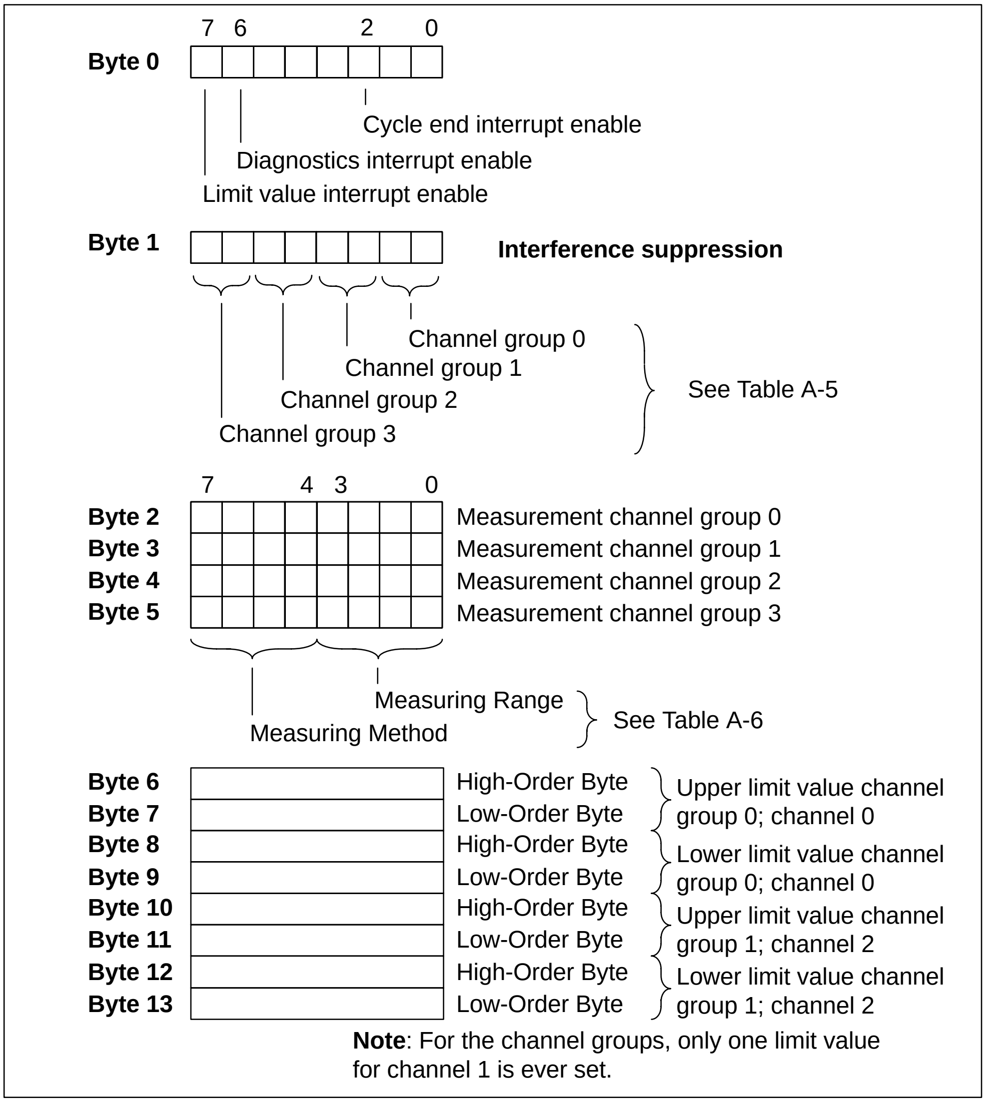

Figure A-3 Data Record 1 for Parameters of the Analog Input Modules

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Note

The representation of the limit values matches the analog value representation (see Chapter 4). Please observe the range limits when setting the limit values.

Interference frequency suppression

The table below contains the codes for the different frequencies, which you enter in byte 1 of data record 1 (refer to Figure A-3). You must count the resulting integration time separately for each channel!

Table A-5 Codes for Interference Suppression of the Analog Input Modules

Interference Suppression	Integration Time	Code
400 Hz	2.5 ms	2#00
60 Hz	16.7 ms	2#01
50 Hz	20 ms	2#10
10 Hz	100 ms	2#11

Measuring methods and measuring ranges

The table below contains all the measuring methods and measuring ranges of the analog input modules and their codes. You must enter these codes in bytes 2 to 5 of data record 1 (refer to Figure A-3).

Note

Please note that a measuring range module may need to be reconnected, depending on the measuring range (see Chapter 4)!

Table A-6 Codes for the Measuring Ranges of the Analog Input Modules

Measuring Method	Code	Measuring Range	Code
deactivated	2#0000	deactivated	2#0000
Voltage	2#0001	± 80 mV ± 250 mV ± 500 mV ± 1 V ± 2.5 V ± 5 V 1 to 5 V 0 to 10 V ± 10 V ± 25 mV ± 50 mV	2#0001 2#0010 2#0011 2#0100 2#0101 2#0110 2#0111 2#1000 2#1001 2#1010 2#1011

Table A-6 Codes for the Measuring Ranges of the Analog Input Modules, continued

Measuring Method	Code	Measuring Range	Code
Four-wire transducer	2#0010	± 3.2 mA ± 10 mA 0 to 20 mA 4 to 20 mA ± 20 mA ± 5 mA	2#0000 2#0001 2#0010 2#0011 2#0100 2#0101
Two-wire transducer	2#0011	4 to 20 mA	2#0011
Resistance, four-conductor connection	2#0100	150 Ω 300 Ω 600 Ω 10 kΩ	2#0010 2#0100 2#0110 2#1001
Resistor four-conductor connection; 100 Ω compensation	2#0110	52 to 148 Ω 250 Ω 400 Ω 700 Ω	2#0001 2#0011 2#0101 2#0111
Thermal resistance + linearization four-conductor connection	2#1000	Pt 100 climate Ni 100 climate Pt 100 standard range Pt 200 standard range Pt 500 standard range Pt 1000 standard range Ni 1000 standard range Pt 200 climate Pt 500 climate Pt 1000 climate Ni 1000 climate Ni 100 standard range	2#0000 2#0001 2#0010 2#0011 2#0100 2#0101 2#0110 2#0111 2#1000 2#1001 2#1001 2#1011
Thermocouples internal comparison	2#1010	Type B [PtRh – PtRh] Type N [NiCrSi – NiSi] Type E [NiCr – CuNi] Type R [PtRh –Pt] Type S [PtRh –Pt] Type J [Fe – CuNi IEC] Type L [Fe – CuNi] Type T [Cu – CuNi] Type K [NiCr – Ni] Type U [Cu –Cu Ni]	2#0000 2#0001 2#0010 2#0011 2#0100 2#0101 2#0110 2#0111 2#1000 2#1001
Thermocouples external comparison	2#1011		
Thermocouples + linearization internal comparison	2#1101		
Thermocouples + linearization external comparison	2#1110		

A.5 Parameters of the SM 331; AI 8 × RTD

Parameters

The table below contains all the parameters which you can set for analog input module SM 331; AI 8 × RTD.

You will see which parameters you can modify from the list:

- in *STEP 7*
- with SFC 55 ”WR_PARM”

The parameters set with *STEP 7* can also be transferred with SFCs 56 and 57 to the module (refer to the *STEP 7* manuals).

Table A-7 Parameters of the SM 331; AI 8 × RTD

Parameter	Data Record No.	Parameters can be assigned with ...	
		... SFC 55	... Programming Device
Diagnostics: Group diagnostics	0	No	Yes
Diagnostics: With wire-break check		No	Yes
Diagnostics interrupt enable	1	**Yes**	Yes
Limit value interrupt enable		**Yes**	Yes
Cycle end interrupt enable		**Yes**	Yes
Temperature unit		**Yes**	Yes
Measuring Method	128	**Yes**	Yes
Measuring Range		**Yes**	Yes
Module filtering mode		**Yes**	Yes
Temperature coefficient		**Yes**	Yes
Interference Suppression		**Yes**	Yes
Smoothing		**Yes**	Yes
Upper limit value		**Yes**	Yes
Lower limit value		**Yes**	Yes

Note

If you want to enable the diagnostic interrupt in the user program in data record 1, you must enable the diagnosis in data record 0 beforehand using *STEP 7*.

Structure of data record 1

The figure below shows the structure of data record 1 for SM 331; AI 8 × RTD. You activate a parameter by setting the corresponding bit to “1”.

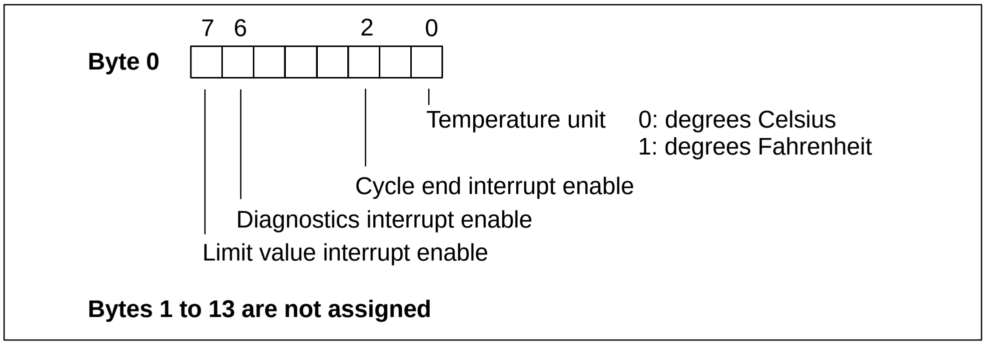


Figure A-4 Data Record 1 of the Parameters for SM 331; AI 8 × RTD

Structure of data record 128

The figure below shows the structure of data record 128 for SM 331; AI 8 × RTD.

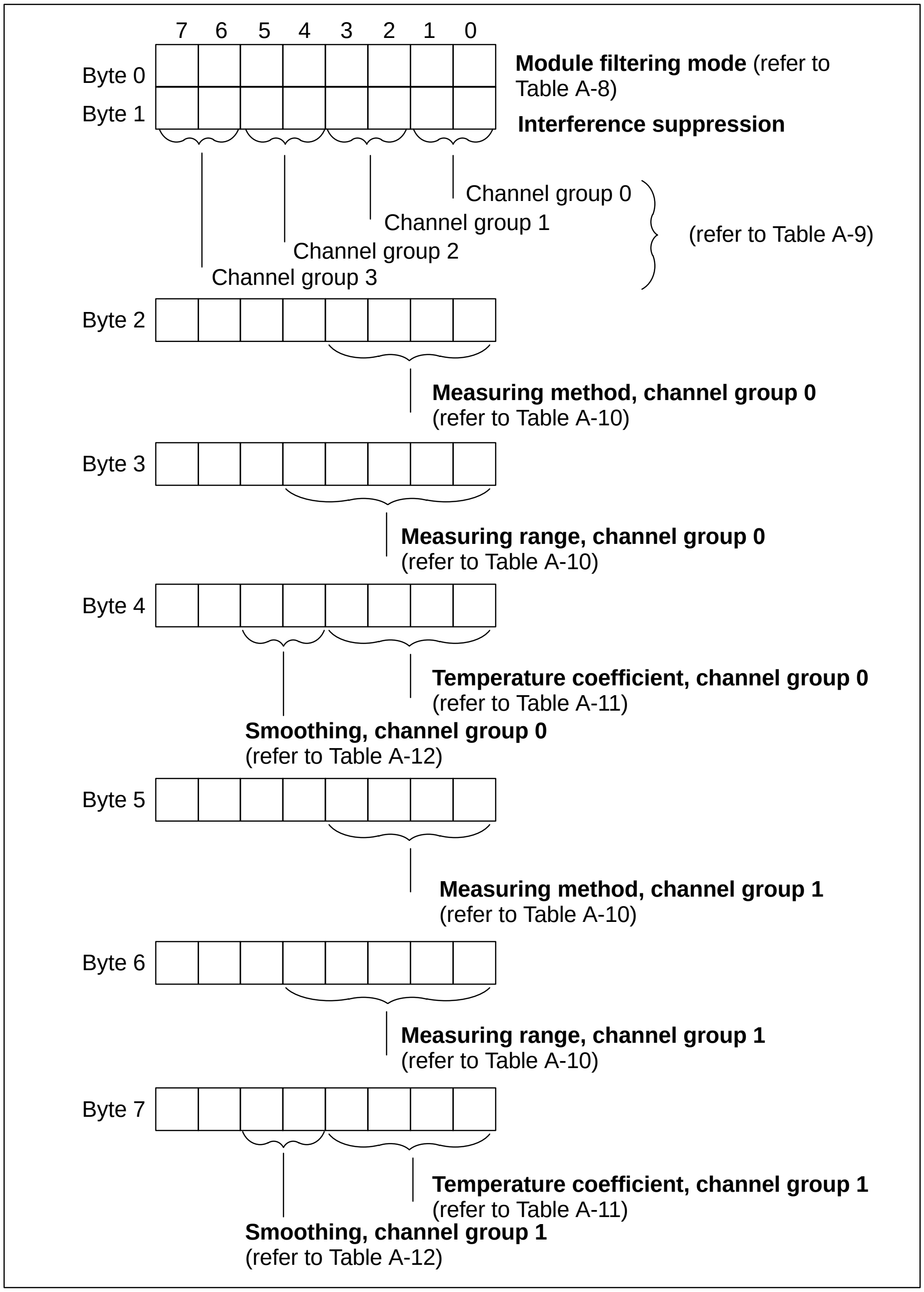


Figure A-5 Data Record 128 of the Parameters for SM 331; AI 8 × RTD

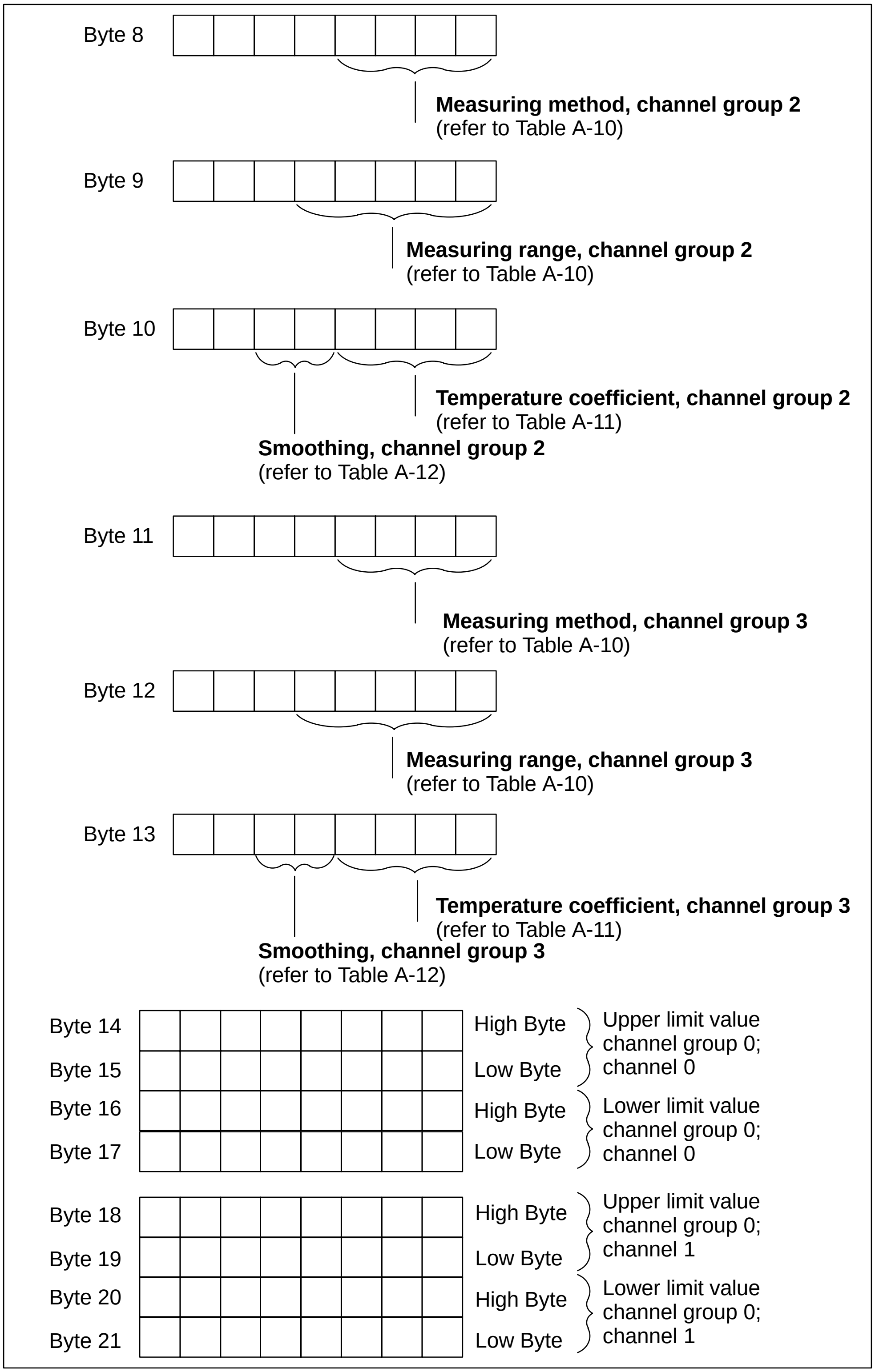


Figure A-6 Data Record 128 of the SM 331; AI 8 × RTD (Continued)

Byte 22	High Byte	Upper limit value channel group 1; channel 2
Byte 23	Low Byte	
Byte 24	High Byte	Lower limit value channel group 1; channel 2
Byte 25	Low Byte	
Byte 26	High Byte	Upper limit value channel group 1; channel 3
Byte 27	Low Byte	
Byte 28	High Byte	Lower limit value channel group 1; channel 3
Byte 29	Low Byte	
Byte 30	High Byte	Upper limit value channel group 2; channel 4
Byte 31	Low Byte	
Byte 32	High Byte	Lower limit value channel group 2; channel 4
Byte 33	Low Byte	
Byte 34	High Byte	Upper limit value channel group 2 channel 5
Byte 35	Low Byte	
Byte 36	High Byte	Lower limit value channel group 2; channel 5
Byte 37	Low Byte	
Byte 38	High Byte	Upper limit value channel group 3; channel 6
Byte 39	Low Byte	
Byte 40	High Byte	Lower limit value channel group 3; channel 6
Byte 41	Low Byte	
Byte 42	High Byte	Upper limit value channel group 3; channel 7
Byte 43	Low Byte	
Byte 44	High Byte	Lower limit value channel group 3; channel 7
Byte 45	Low Byte	

Figure A-7 Data Record 128 of the SM 331; AI 8 × RTD (Continued)

Note

The representation of the limit values matches the analog value representation (see Chapter 4). Please observe the range limits when setting the limit values.

Operating modes of the SM 331; AI 8 × RTD

The table below contains the codes for the different operating modes, which you enter in byte 0 of data record 128 (refer to Figure A-5).

Table A-8 Codes of Operating Modes of the SM 331; AI 8 × RTD

Module filtering mode	Code
8 channels hardware filter	2#00000000
8 channels software filter	2#00000001
4 channels hardware filter	2#00000010

Interference frequency suppression of the SM 331; AI 8 × RTD

The table below contains the codes for the different frequencies, which you enter in byte 1 of data record 128 (refer to Figure A-3).

Table A-9 Interference Frequency Suppression Codes for SM 331; AI 8 × RTD

Interference Suppression	Code
400 Hz	2#00
60 Hz	2#01
50 Hz	2#10
50/60/400 Hz	2#11

Measuring methods and measuring ranges of the SM 331; AI 8 × RTD

The table below contains all the measuring methods and measuring ranges of the module and its codes. You must enter these codes in the corresponding bytes of data record 128 (refer to Figure A-3).

Table A-10 Codes for the Measuring Ranges of the SM 331; AI 8 × RTD

Measuring Method	Code	Measuring Range	Code
deactivated	2#0000	deactivated	2#0000
Resistance, four-conductor connection	2#0100	150 Ω 300 Ω 600 Ω	2#0010 2#0100 2#0110
Resistance, three-conductor connection	2#0101	150 Ω 300 Ω 600 Ω	2#0010 2#0100 2#0110

Table A-10 Codes for the Measuring Ranges of the SM 331; AI 8 × RTD, continued

Measuring Method	Code	Measuring Range	Code
Thermal resistance + linearization four-conductor connection	2#1000	Pt 100 climate Ni 100 climate Pt 100 standard Ni 100 standard Pt 500 standard Pt 1000 standard Ni 1000 standard Pt 200 climate Pt 500 climate Pt 1000 climate Ni 1000 climate Pt 200 standard Ni 120 standard Ni 120 climate Cu 10 climate Cu 10 standard Ni 200 standard Ni 200 climate Ni 500 standard Ni 500 climate	2#00000000 2#00000001 2#00000010 2#00000011 2#00000100 2#00000101 2#00000110 2#00000111 2#00001000 2#00001001 2#00001010 2#00001011 2#00001100 2#00001101 2#00001110 2#00001111 2#00010000 2#00010001 2#00010010 2#00010011
Thermal resistance + linearization three-conductor connection	2#1001	Pt 100 climate Ni 100 climate Pt 100 standard Ni 100 standard Pt 500 standard Pt 1000 standard Ni 1000 standard Pt 200 climate Pt 500 climate Pt 1000 climate Ni 1000 climate Pt 200 standard Ni 120 standard Ni 120 climate Cu 10 climate Cu 10 standard Ni 200 standard Ni 200 climate Ni 500 standard Ni 500 climate	2#00000000 2#00000001 2#00000010 2#00000011 2#00000100 2#00000101 2#00000110 2#00000111 2#00001000 2#00001001 2#00001010 2#00001011 2#00001100 2#00001101 2#00001110 2#00001111 2#00010000 2#00010001 2#00010010 2#00010011

Bulb resistor temperature coefficient of the SM 331; AI 8 × RTD

The table below contains the codes for all temperature coefficients for the measuring range RTD-4L and RTD-3L, which you enter in the corresponding byte of data record 128 (refer to Figure A-5).

Table A-11 Codes of Temperature Coefficients of the SM 331; AI 8 × RTD

Temperature coefficient	Code
Pt 0.003850Ω/Ω/°C	2#0000
Pt 0.003916Ω/Ω/°C	2#0001
Pt 0.003902Ω/Ω/°C	2#0010
Pt 0.003920Ω/Ω/°C	2#0011
Pt 0.003851Ω/Ω/°C	2#0100
Ni 0.00618Ω/Ω/°C	2#1000
Ni 0.00672Ω/Ω/°C	2#1001
Cu 0.00472Ω/Ω/°C	2#1100

Smoothing of the SM 331; AI 8 × RTD

The table below contains the codes for all smoothing modes, which you enter in the corresponding byte of data record 128 (refer to Figure A-5).

Table A-12 Codes Smoothing of the SM 331; AI 8 × × × RTD

Smoothing	Code
None	2#00
Low	2#01
Average	2#10
High	2#11

A.6 Parameters der SM 331; AI 8 × TC

Parameters

The table below contains all the parameters which you can set for analog input module SM 331; AI 8 ×TC.

You will see which parameters you can modify from the list:

- in *STEP 7*

- with SFC 55 ”WR_PARM”

The parameters set with *STEP 7* can also be transferred with SFCs 56 and 57 to the module (refer to the *STEP 7* manuals).

Table A-13 Parameters of the SM 331; AI 8 × TC

Parameter	Data Record No.	Parameters can be assigned with ...	
		... SFC 55	**... Programming Device**
Diagnostics: Group diagnostics	0	No	Yes
Diagnostics: With wire-break check		No	Yes
Diagnostics interrupt enable	1	**Yes**	Yes
Limit value interrupt enable		**Yes**	Yes
Cycle end interrupt enable		**Yes**	Yes
Temperature unit		**Yes**	Yes
Measuring method	128	**Yes**	Yes
Measuring range		**Yes**	Yes
Module filtering mode		**Yes**	Yes
Reaction to open thermocouple		**Yes**	Yes
Interference suppression		**Yes**	Yes
Smoothing		**Yes**	Yes
Upper limit value		**Yes**	Yes
Lower limit value		**Yes**	Yes

Note

If you want to enable the diagnostic interrupt in the user program in data record 1, you must enable the diagnosis in data record 0 beforehand using *STEP 7*.

Structure of data record 1

The figure below shows the structure of data record 1 of the SM 331; AI 8 × TC. You activate a parameter by setting the corresponding bit to “1”.

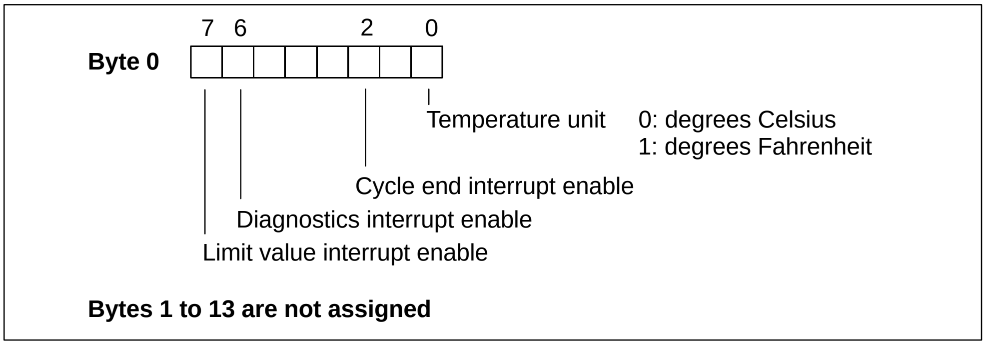


Figure A-8 Data Record 1 of the Parameters for SM 331; AI 8 × TC

Structure of data record 128

The figure below shows the structure of data record 128 for SM 331; AI 8 × TC.

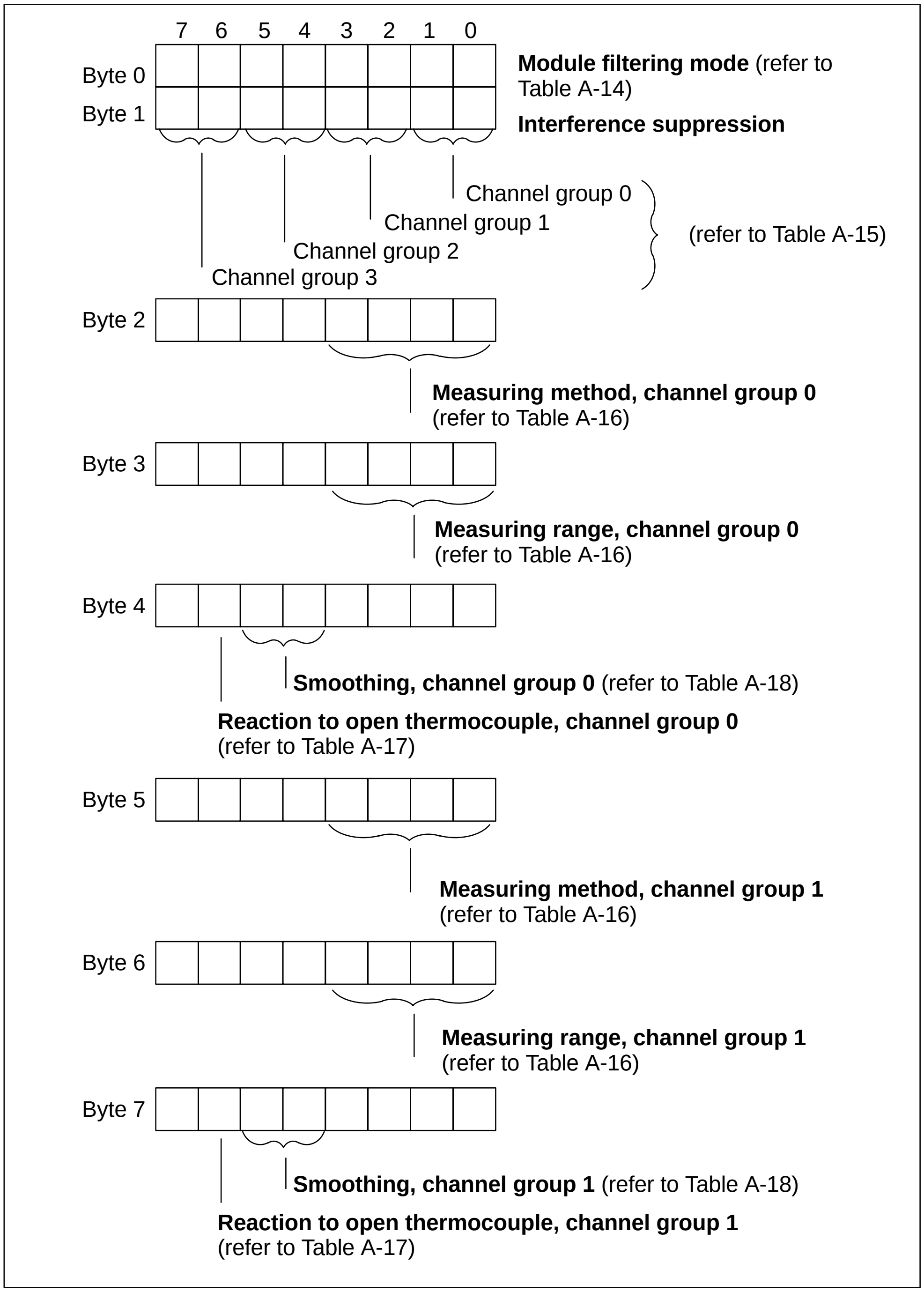


Figure A-9 Data Record 128 of the SM 331; AI 8 × TC

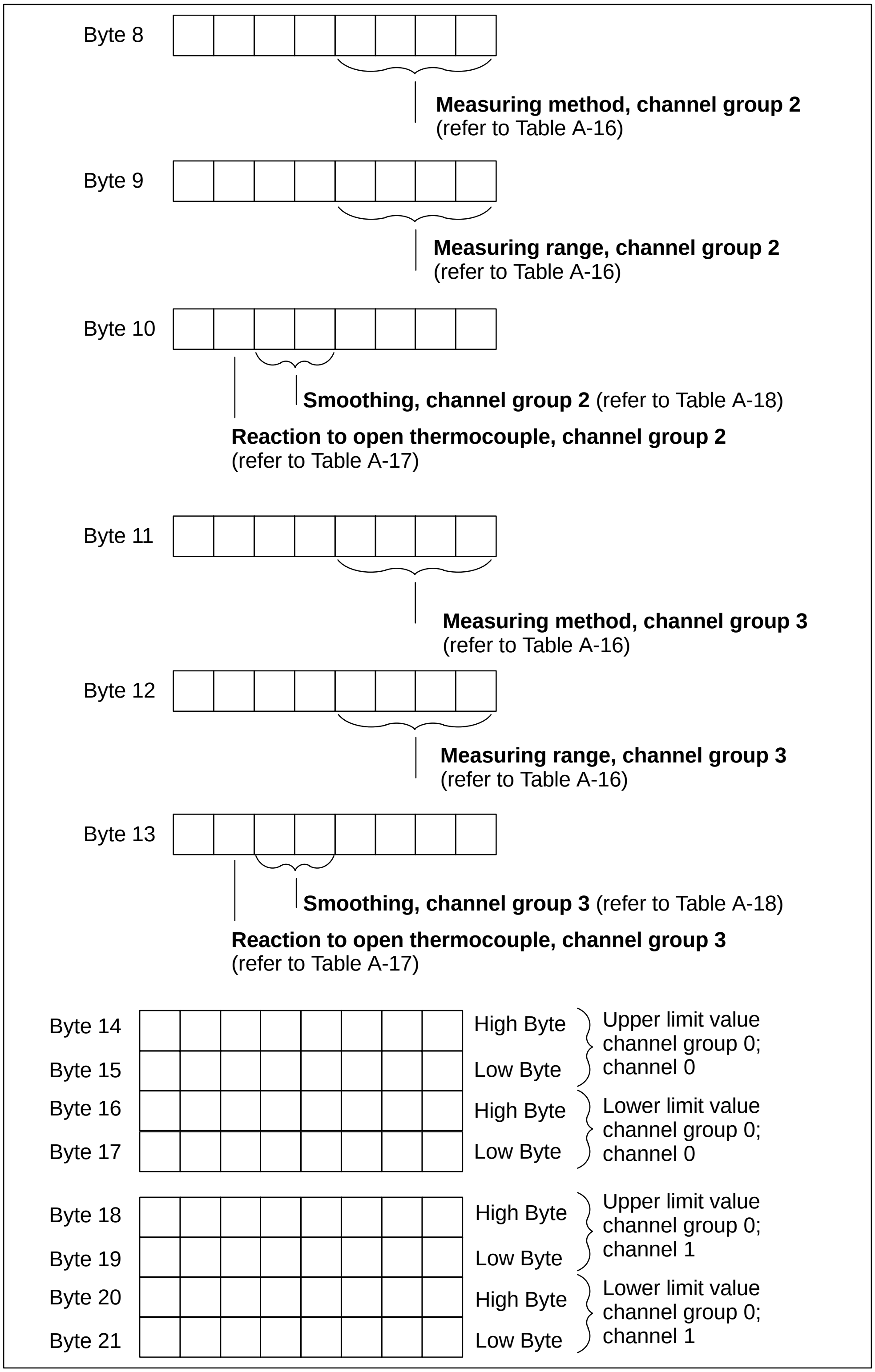


Figure A-10 Data Record 128 of the SM 331; AI 8 × TC (Continued)

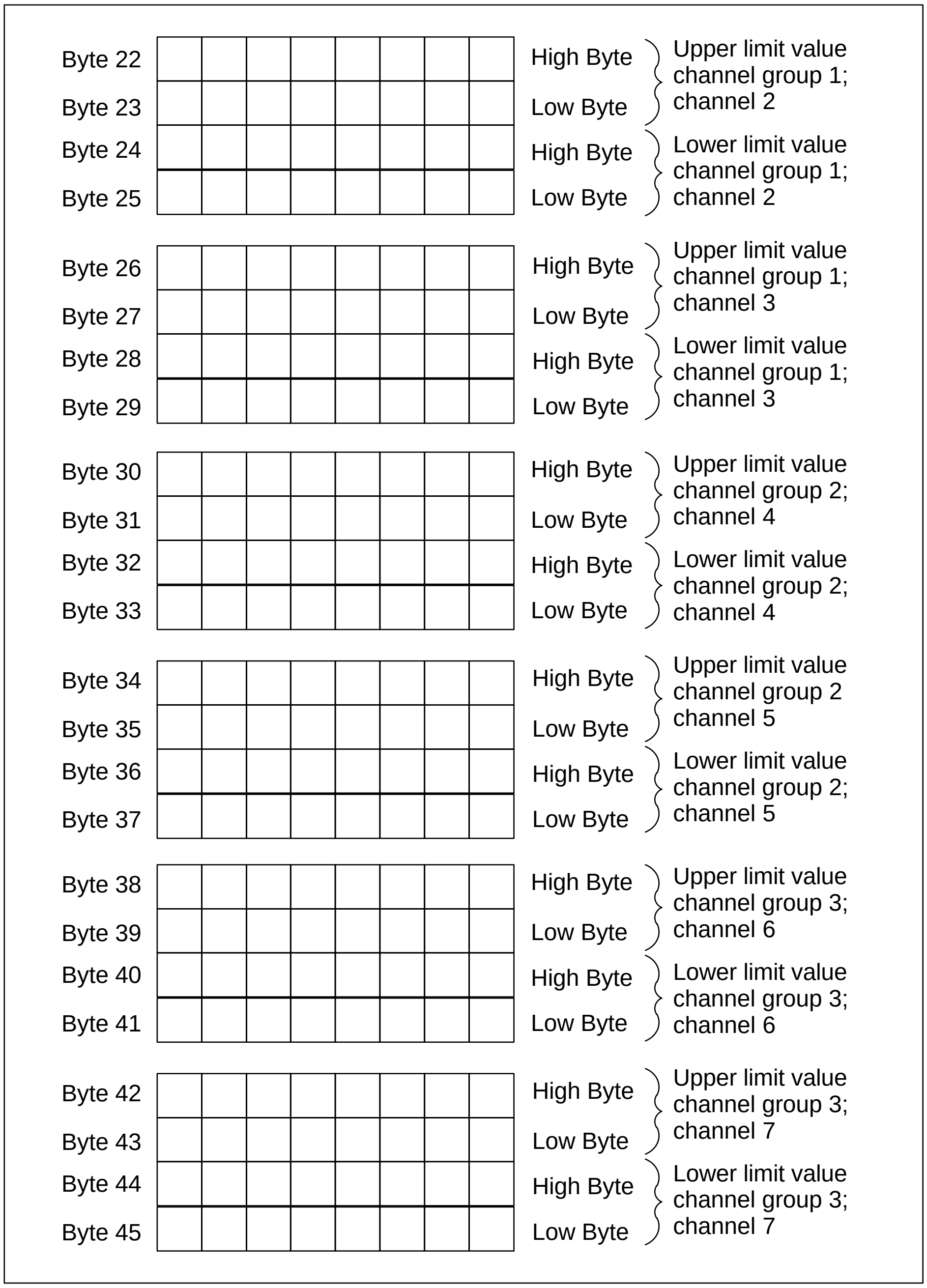


Figure A-11 Data Record 128 of the SM 331; AI 8 × TC (Continued)

Note

The representation of the limit values matches the analog value representation (see Chapter 4). Please observe the range limits when setting the limit values.

Operating modes of the SM 331; AI 8 × TC

The table below contains the codes for the different operating modes, which you enter in byte 0 of data record 128 (refer to Figure A-5).

Table A-14 Codes of Operating Modes of the SM 331; AI 8 × TC

Module filtering mode	Code
8 channels hardware filter	2#00000000
8 channels software filter	2#00000001
4 channels hardware filter	2#00000010

Interference frequency suppression of the SM 331; AI 8 × TC

The table below contains the codes for the different frequencies, which you enter in byte 1 of data record 128 (refer to Figure A-3).

Table A-15 Interference Frequency Suppression Codes for SM 331; AI 8 × TC

Interference Suppression	Code
400 Hz	2#00
60 Hz	2#01
50 Hz	2#10
50/60/400 Hz	2#11

Measuring methods and measuring ranges of the SM 331; AI 8 × TC

The table below contains all the measuring methods and measuring ranges of the module and its codes. You must enter these codes in the corresponding bytes of data record 128 (refer to Figure A-3).

Table A-16 Codes for the Measuring Ranges of the SM 331; AI 8 × TC

Measuring Method	Code	Measuring Range	Code
deactivated	2#0000	deactivated	2#0000
TC-L00C: (thermocouple, linear, reference temperature 0 °C)	2#1010	B N E R S J L T K U	2#0000 2#0001 2#0010 2#0011 2#0100 2#0101 2#0110 2#0111 2#1000 2#1001
TC-L50C: (thermocouple, linear, reference temperature 50 °C)	2#1011	B N E R S J L T K U	2#0000 2#0001 2#0010 2#0011 2#0100 2#0101 2#0110 2#0111 2#1000 2#1001
TC-IL (thermocouple, linear, internal compensation)	2#1101	B N E R S J L T K U	2#0000 2#0001 2#0010 2#0011 2#0100 2#0101 2#0110 2#0111 2#1000 2#1001
TC-EL (thermocouple, linear, external compensation)	2#1110	B N E R S J L T K U	2#0000 2#0001 2#0010 2#0011 2#0100 2#0101 2#0110 2#0111 2#1000 2#1001

Reaction to open thermocouple of the SM 331; AI 8 × TC

The table below contains the codes for the reactions to an open thermocouple, which you enter in the corresponding byte of data record 128 (refer to Figure A-5).

Table A-17 Codes of Reaction to Open Thermocouple of the SM 331; AI 8 × TC

Reaction to open thermocouple	Code
Overflow	2#0
Underflow	2#1

Smoothing of the SM 331; AI 8 × TC

The table below contains the codes for all smoothing modes, which you enter in the corresponding byte of data record 128 (refer to Figure A-5).

Table A-18 Codes Smoothing of the SM 331; AI 8 × TC

Smoothing	Code
None	2#00
Low	2#01
Average	2#10
High	2#11

A.7 Parameters of the Analog Output Modules

Parameters

Table A-19 contains all the parameters you can set for analog output modules.. The comparison shows:

- which parameters you can change with *STEP 7* and
- which parameters you can change with SFC 55 “WR_PARM”.

The parameters which you set with *STEP 7* can also be transferred to the module with SFCs 56 and 57.

Table A-19 Parameters of the Analog Output Modules

Parameter	Data Record No.	Parameters can be assigned with ...	
		... SFC 55	**... Programming Device**
Diagnostics: Group diagnostics	0	No	Yes
Diagnostics interrupt enable	1	**Yes**	Yes
Behavior on CPU STOP		**Yes**	Yes
Output type		**Yes**	Yes
Output Range		**Yes**	Yes
Substitute value		**Yes**	Yes

Note

If you want to enable the diagnostic interrupt in the user program in data record 1, you must enable the diagnosis in data record 0 beforehand using *STEP 7*.

Data record 1 structure

The figure below shows the structure of data record 1 for the parameters of the analog output modules.

You activate the diagnostics interrupt enable by setting the corresponding bit in byte 0 to “1”.

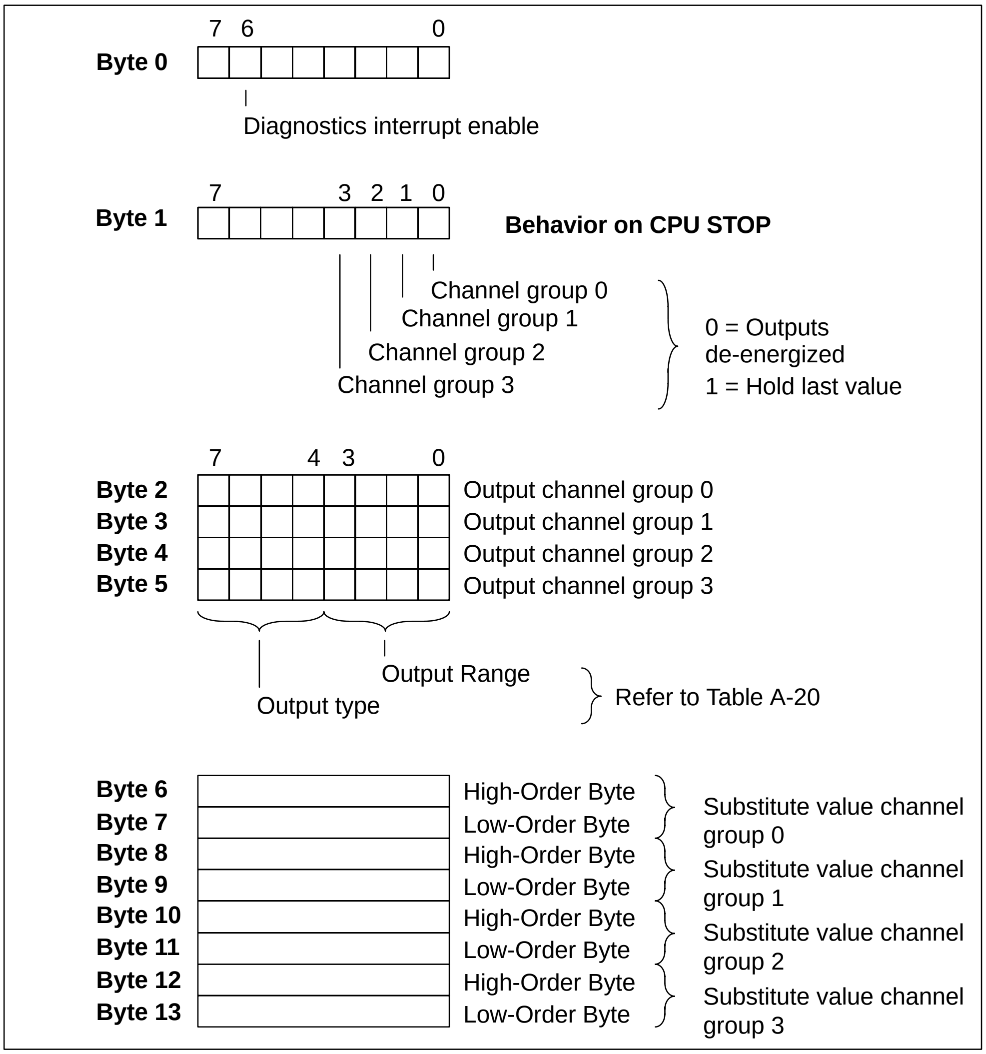


Figure A-12 Data Record 1 for Parameters of the Analog Output Modules

Setting substitute values

Note

For output ranges 4 to 20 mA and 1 to 5 V you must set the substitute value $E500_H$ so that the output remains de-energized (refer to Tables 4-33 and 4-35 on pages 4-25 and 4-26).

The representation of the substitute values corresponds to the analog value representation. You should observe the relevant range limits when setting the substitute values.

Output methods and output ranges

The table below contains all the output methods and output ranges of the analog output modules and their codes. You must enter these codes in bytes 2 to 5 of data record 1 (refer to Figure A-12).

Table A-20 Codes for the Output Ranges of the Analog Output Modules

Output type	Code	Output Range	Code
deactivated	2#0000	deactivated	2#0000
Voltage	2#0001	1 to 5 V 0 to 10 V ± 10 V	2#0111 2#1000 2#1001
Current	2#0010	0 to 20 mA 4 to 20 mA ± 20 mA	2#0010 2#0011 2#0100

A.8 Parameters of the Analog Input/Output Modules

Parameters

The table below contains all the parameters you can set for analog input/output modules.

You will see which parameters you can modify from the list:

- in *STEP 7*
- with SFC 55 ”WR_PARM”

The parameters set with *STEP 7* can also be transferred with SFCs 56 and 57 to the module (refer to the *STEP 7* manuals).

Table A-21 Parameters of the Analog Input/Output Modules

Parameter	Data Record No.	Parameters can be assigned with ...	
		... SFC 55	**... Programming Device**
Measuring Method	1	**Yes**	Yes
Measuring Range		**Yes**	Yes
Integration Time		**Yes**	Yes
Output type		**Yes**	Yes
Output Range		**Yes**	Yes

Structure of data record 1

The figure below shows the structure of data record 1 for the parameters of the analog input/output modules.

You activate a parameter by setting the corresponding bit in byte 0 to “1”.

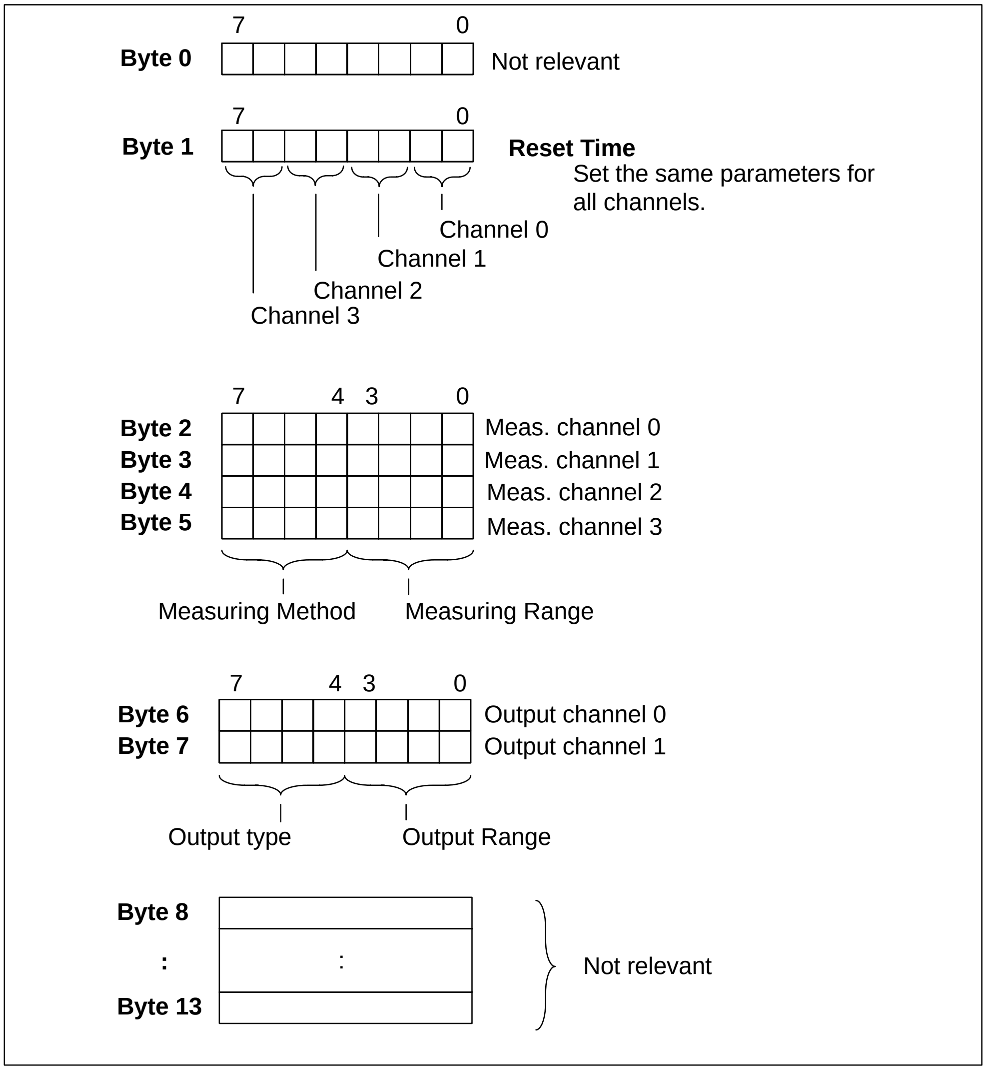


Figure A-13 Data Record 1 for Parameters of the Analog Input/Output Modules

Measuring methods and measuring ranges

The table below contains all the measuring methods and measuring ranges of the analog input/output modules and their codes. You must enter these codes in bytes 2 to 5 of data record 1 (refer to Figure A-13).

Table A-22 Codes for the Measuring Ranges of the Analog Input/Output Modules

Measuring Method	Code	Measuring Range	Code
deactivated	2#0000	deactivated	2#0000
Voltage	2#0001	0 to 10 V	2#1000
Resistance, four-conductor connection	2#0100	10 kΩ	2#1001
Thermal resistance + linearization four-conductor connection	2#1000	Pt 100 climate	2#0000

Output methods and output ranges

The table below contains all the output methods and output ranges of the analog input/output modules and their codes. You must enter these codes in bytes 6 and 7 of data record 1 (refer to Figure A-13).

Table A-23 Codes for the Output Ranges of the Analog Input/Output Modules

Output type	Code	Output Range	Code
deactivated	2#0000	deactivated	2#0000
Voltage	2#0001	0 to 10 V	2#1000

Diagnostics Data of Signal Modules

B

In this Appendix

B.1 Evaluating Diagnostic Data of the Signal Modules in the User Program

In this Appendix

This Appendix describes the structure of the diagnostic data in the system data. You must be familiar with this configuration if you want to evaluate the diagnostics data of the signal module in the *STEP 7* user program.

Diagnostic data are contained in data records

The diagnostic data of a module can be up to 16 bytes long and are contained in data records 0 and 1:

- Data record 0 contains 4 bytes of diagnostic data that describe the current status of a programmable logic controller.
- Data record 1 contains the four bytes of diagnostic data that are also contained in data record 0 **and** as many as 12 bytes of module specific diagnostic data.

Further references

An in-depth description of the principle of evaluating the diagnostic data of signal modules in the user program and a description of the SFCs that can be used for that purpose will be found in the *STEP 7* manuals.

B.2 Structure and Content of Diagnostic Data Bytes 0 to 7

The structure and contents of the different bytes of the diagnostic data are described below. The following general rule applies: When an error occurs, the bit concerned is set to ”1”.

Bytes 0 and 1

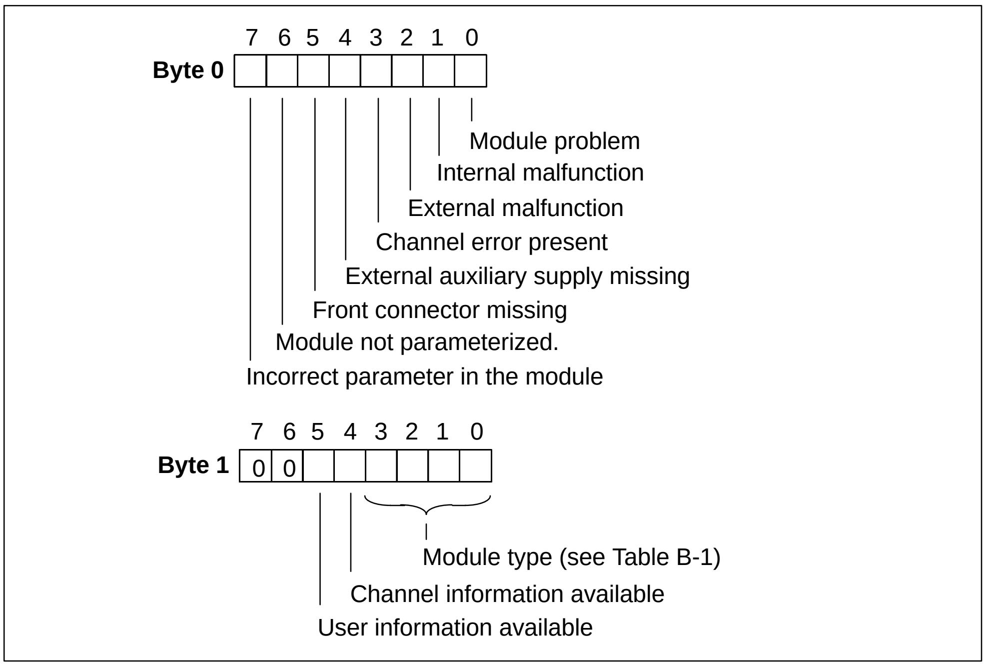


Figure B-1 Bytes 0 and 1 of the Diagnostic Data

Module types

The following table contains the IDs of the module classes (bits 0 to 3 in byte 1).

Table B-1 Codes of the Module Types

Code	Module Type
0101	Analog module
0110	CPU
1000	Function module
1100	CP
1111	Digital module

Bytes 2 and 3

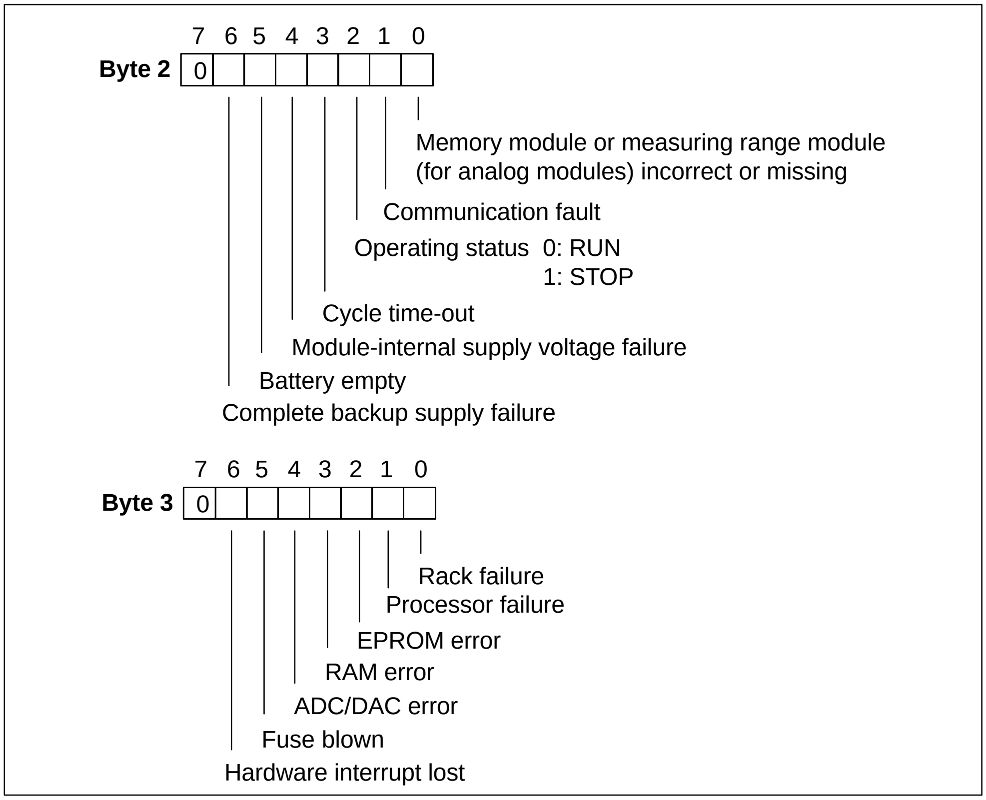


Figure B-2 Bytes 2 and 3 of the Diagnostics Data

Bytes 4 to 7

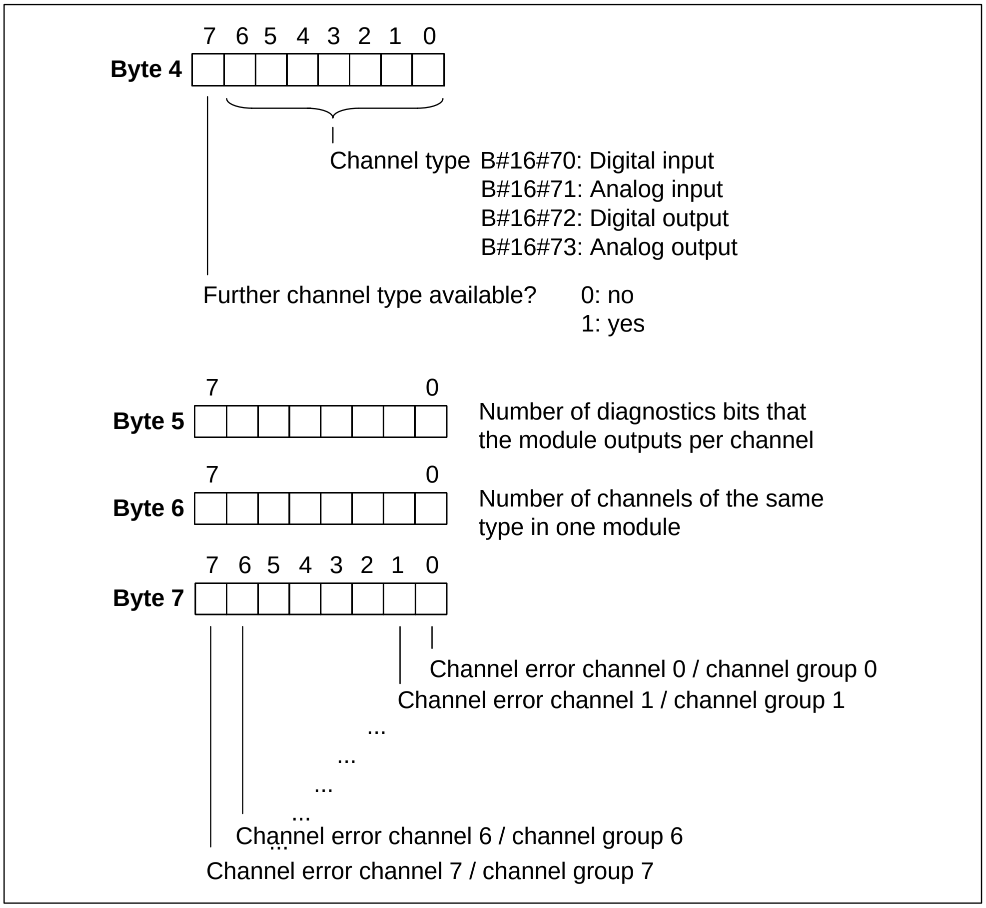


Figure B-3 Bytes 4 to 7 of the Diagnostics Data

B.3 Channel-Specific Diagnostic Data from Byte 8

From byte 8 up to byte 15, data record 1 contains the channel-specific diagnostic data. The figures below show the assignment of the diagnostic byte for a channel or a channel group of the specific module. The following general rule applies: When an error occurs, the bit concerned is set to ”1”.

You will find a description of possible error causes and appropriate remedies in the section called “Diagnostics of the Modules”.

Digital input channel of the SM 321; DI 16 × 24 VDC; with hardware and diagnostic interrupts

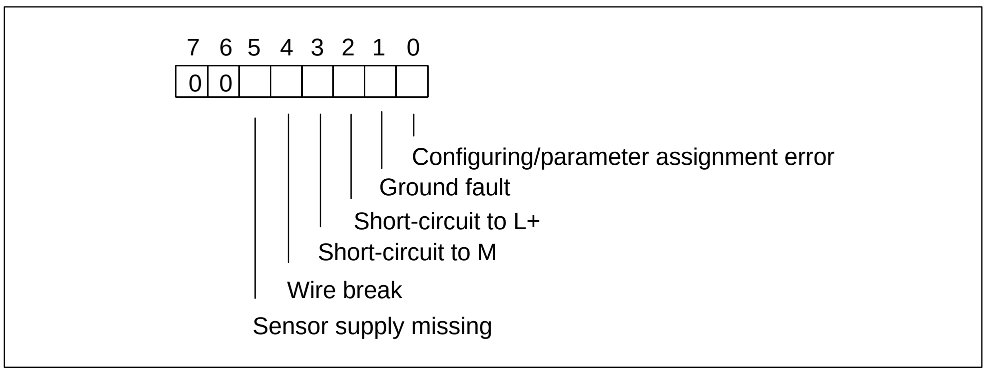


Figure B-4 Diagnostic Byte for a Digital Input Channel of the SM 321; DI 16 × 24 VDC

Digital output channel of the SM 322; DO 8 × 24 VDC/0.5 A; with diagnostic interrupt

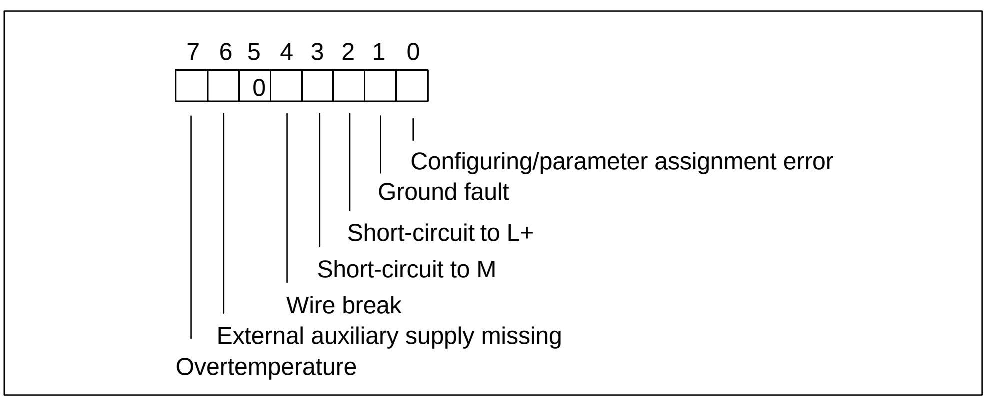


Figure B-5 Diagnostic Byte for a Digital Output Channel of the SM 322; DO 8 × 24 VDC/0.5 A

Analog input channel of the SM 331 modules with diagnostics capability

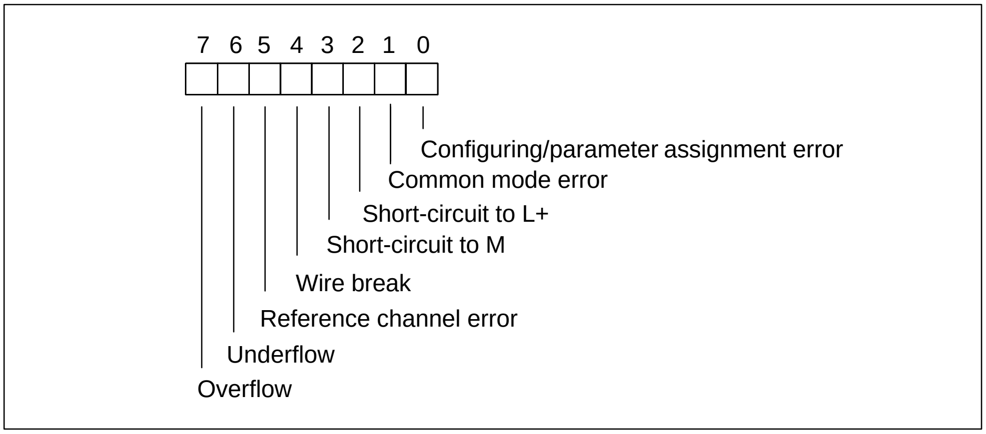


Figure B-6 Diagnostic Byte for an Analog Input Channel of a SM 331 with Diagnostics Capability

Analog output channel of the SM 332 modules with diagnostics capability

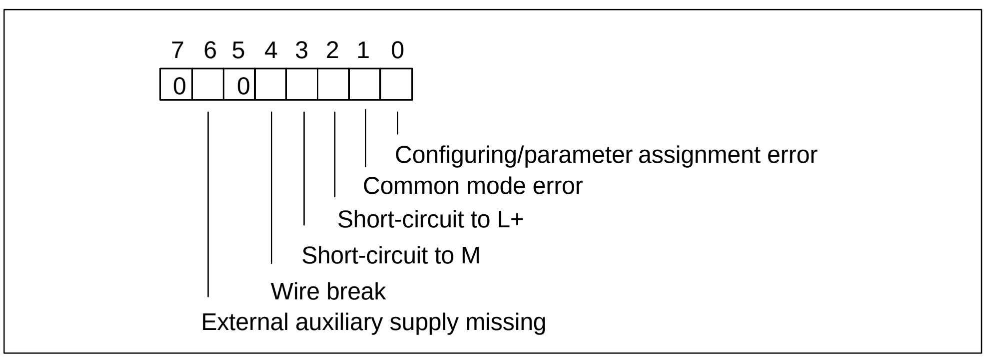


Figure B-7 Diagnostic Byte for an Analog Output Channel of a SM 332 with Diagnostics Capability

B.4 Diagnostic Data of the SM 338; POS-INPUT

The structure and contents of the different bytes of the diagnostic data for position detection module SM 338; POS-INPUT are described below. The following general rule applies: When an error occurs, the bit concerned is set to ”1”.

Section 5.4 includes a description of possible error causes and appropriate remedies.

Bytes 0 and 1

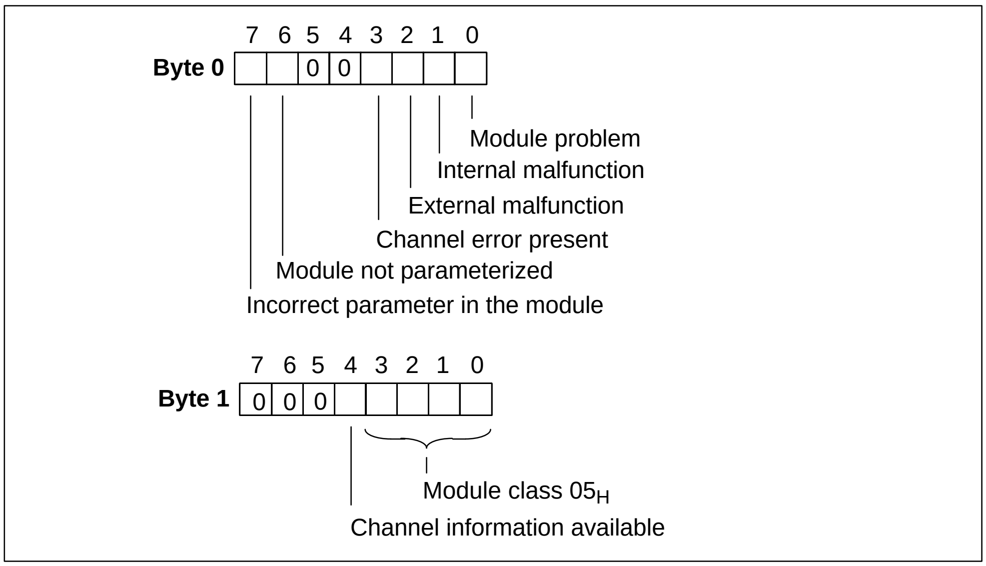


Figure B-8 Bytes 0 and 1 of the Diagnostic Data for the SM 338; POS-INPUT

Bytes 2 to 7

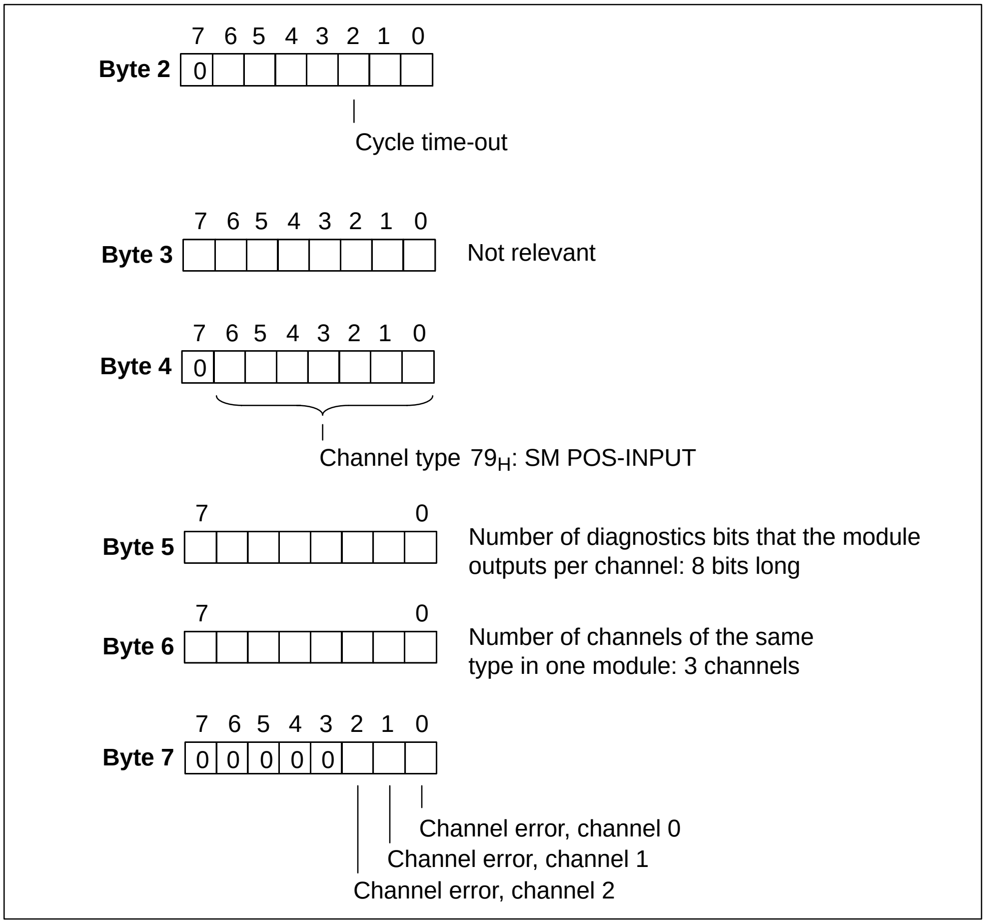


Figure B-9 Bytes 2 and 7 of the Diagnostic Data for the SM 338; POS-INPUT

Bytes 8 to 10

From byte 8 up to byte 10, data record 1 contains the channel-specific diagnostic data. The figure below shows the assignment of the diagnostic byte for a channel of the SM 338; POS-INPUT.

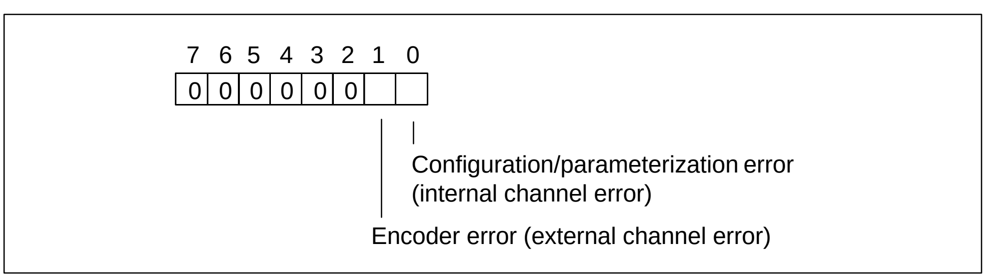


Figure B-10 Diagnostic Byte for a Channel of the SM 338; POS-INPUT

Dimension Drawings

C

Introduction

In this appendix, you will find the dimension drawings for the most important components of an S7-300. The specifications in these dimension drawings are required for dimensioning the S7-300 configuration. The dimensions of an S7-300 configuration must be taken into account when installing an S7-300 in cabinets, switchgear rooms, etc. This appendix does not contain any dimension drawings of the CPUs of the S7-300 or M7-300 or of the IM 153-1. These dimension drawings are contained in the relevant manuals.

Contents

In this appendix, you will find the dimension drawings of the following S7-300 components.

C.1 Dimension Drawings of the Rails

483 mm standard rail

Figure C-1 shows the dimension drawing of the 483 mm standard rail.

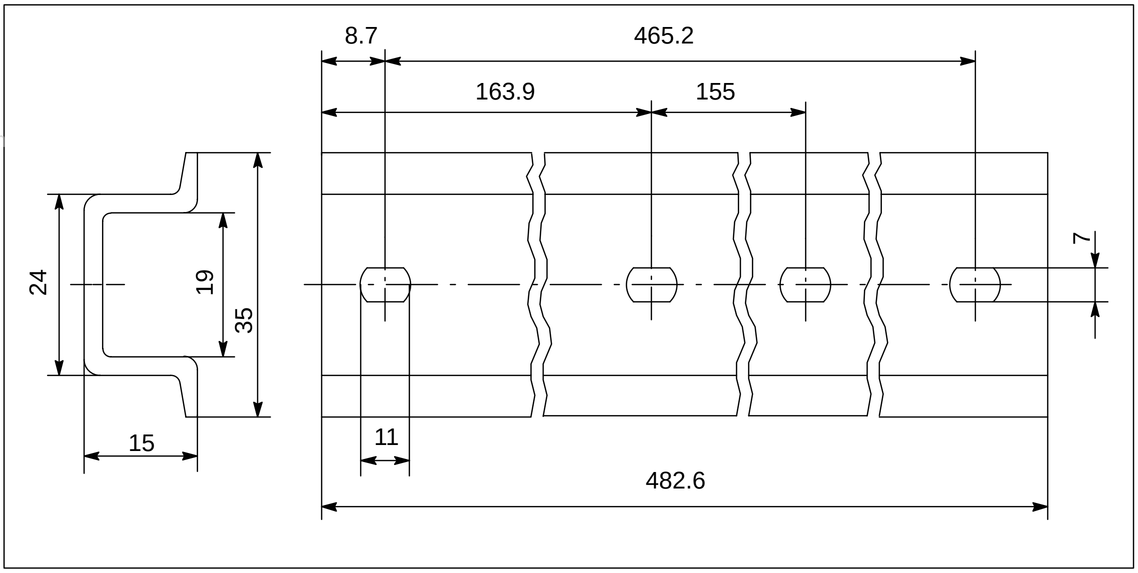


Figure C-1 Dimension Drawing of the 483 mm Standard Rail

530 mm standard rail

Figure C-2 shows the dimension drawing of the 530 mm standard rail.

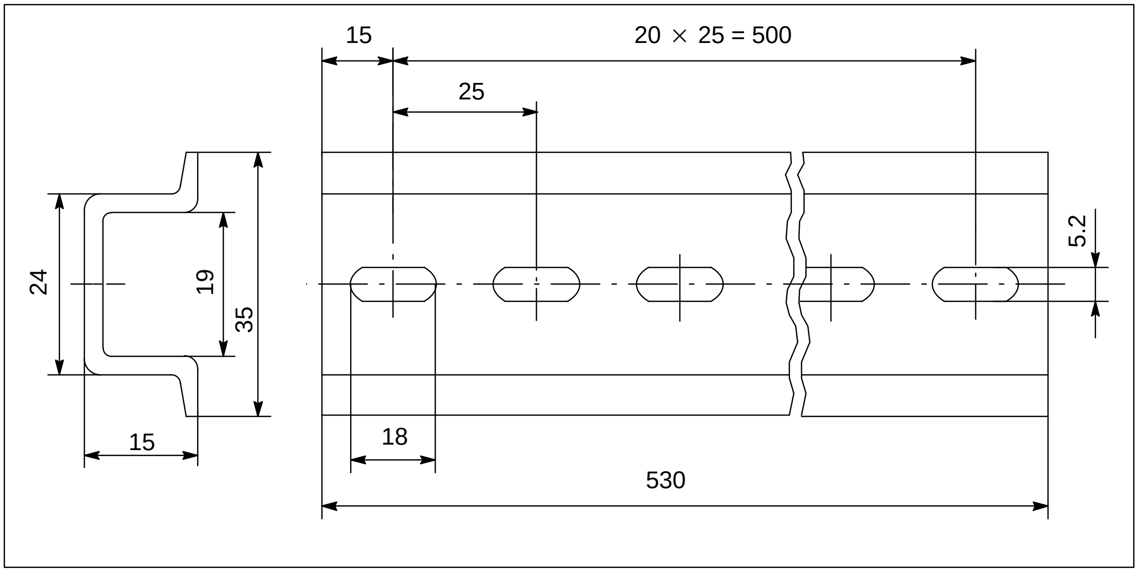


Figure C-2 Dimension Drawing of the 530 mm Standard Rail

830 mm standard rail

Figure C-3 shows the dimension drawing of the 830 mm standard rail.

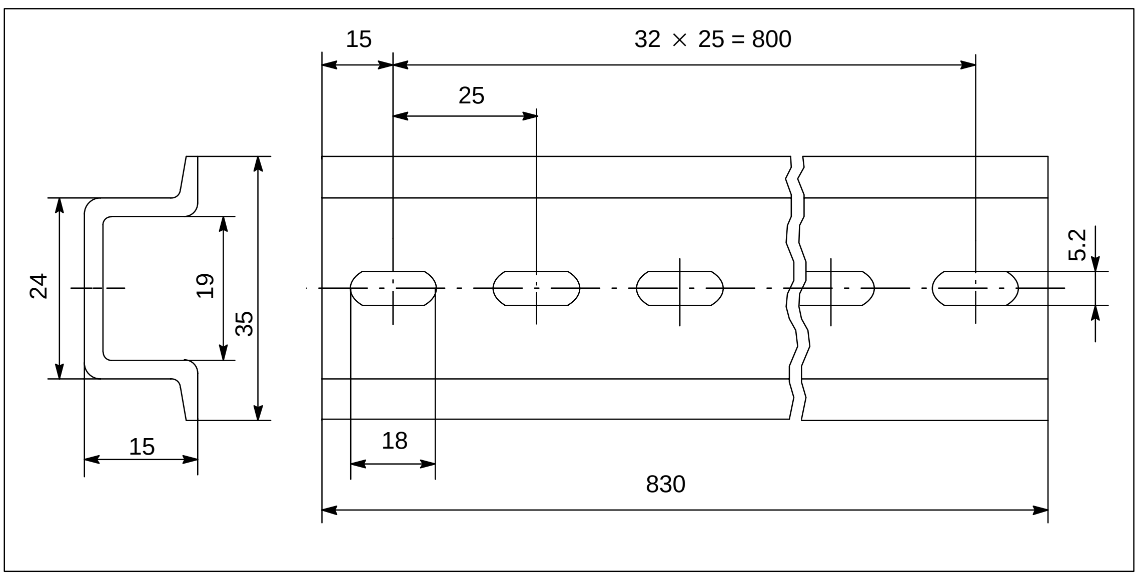


Figure C-3 Dimension Drawing of the 830 mm Standard Rail

2000 mm standard rail

Figure C-4 shows the dimension drawing of the 2000 mm standard rail.

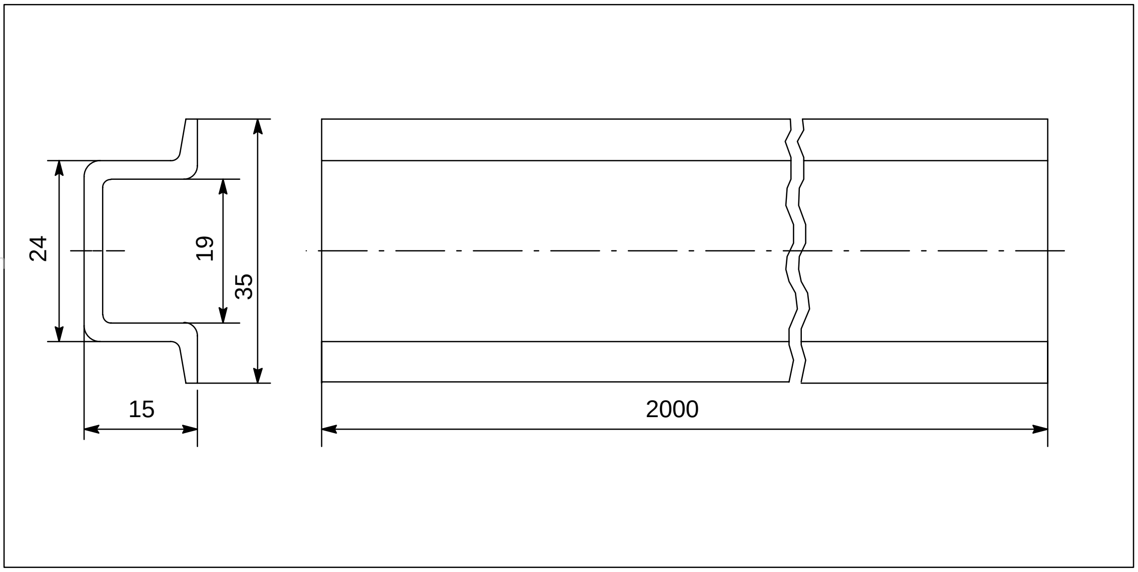


Figure C-4 Dimension Drawing of the 2000 mm Standard Rail

160 mm rail

Figure C-5 shows the dimension drawing of the 160 mm rail.

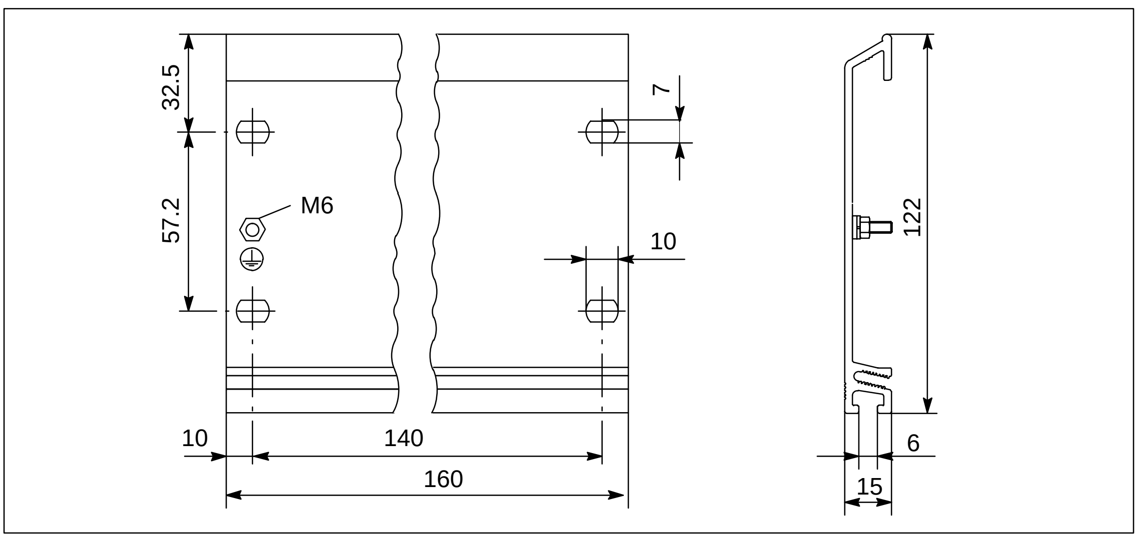


Figure C-5 Dimension Drawing of the Rail with 160 mm Standard Width

482.6 mm rail

Figure C-6 shows the dimension drawing of the 482.6 mm rail.

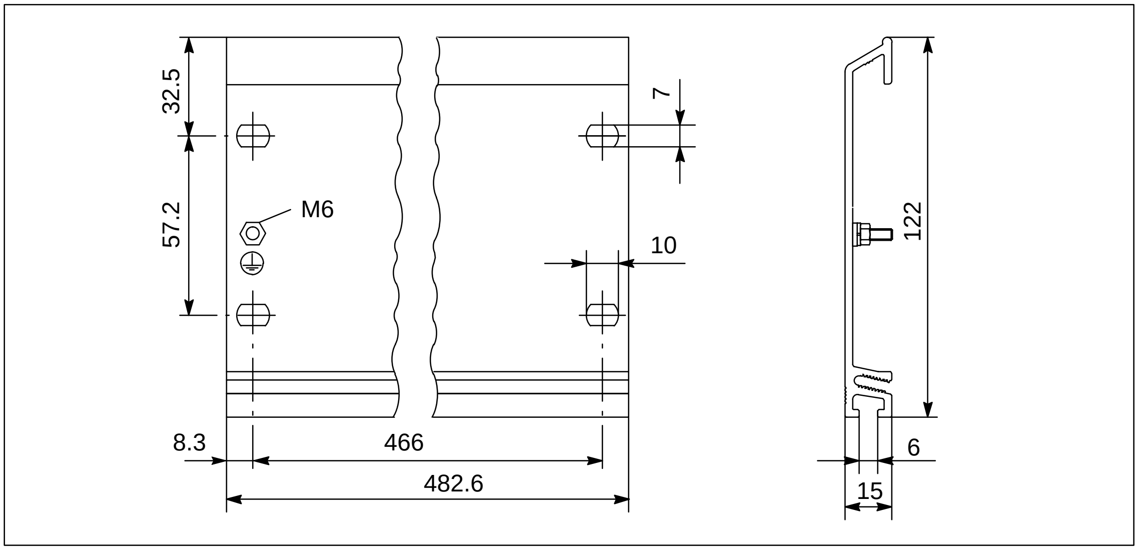


Figure C-6 Dimension Drawing of the Rail with 482.6 mm Standard Width

530 mm rail

Figure C-7 shows the dimension drawing of the 530 mm rail.

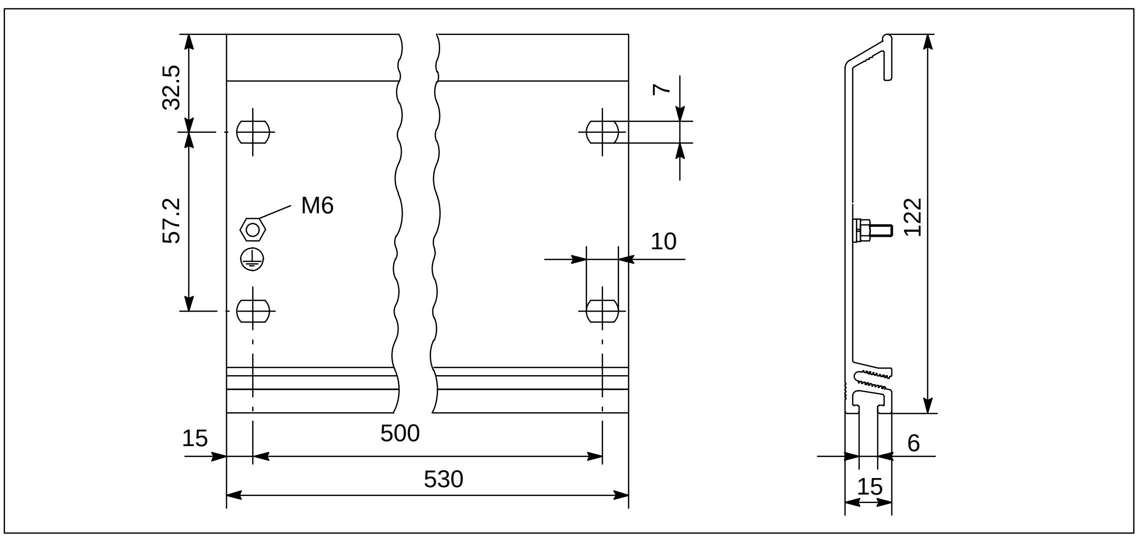


Figure C-7 Dimension Drawing of the Rail with 530 mm Standard Width

830 mm rail

Figure C-8 shows the dimension drawing of the 830 mm rail.

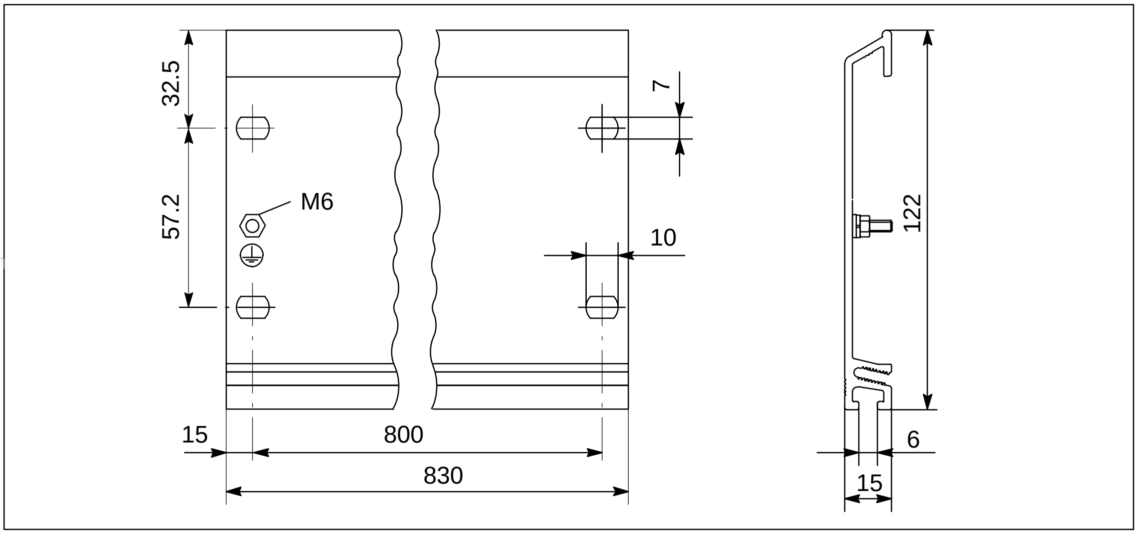


Figure C-8 Dimension Drawing of the Rail with 830 mm Standard Width

2000 mm rail

Figure C-9 shows the dimension drawing of the 2000 mm rail.

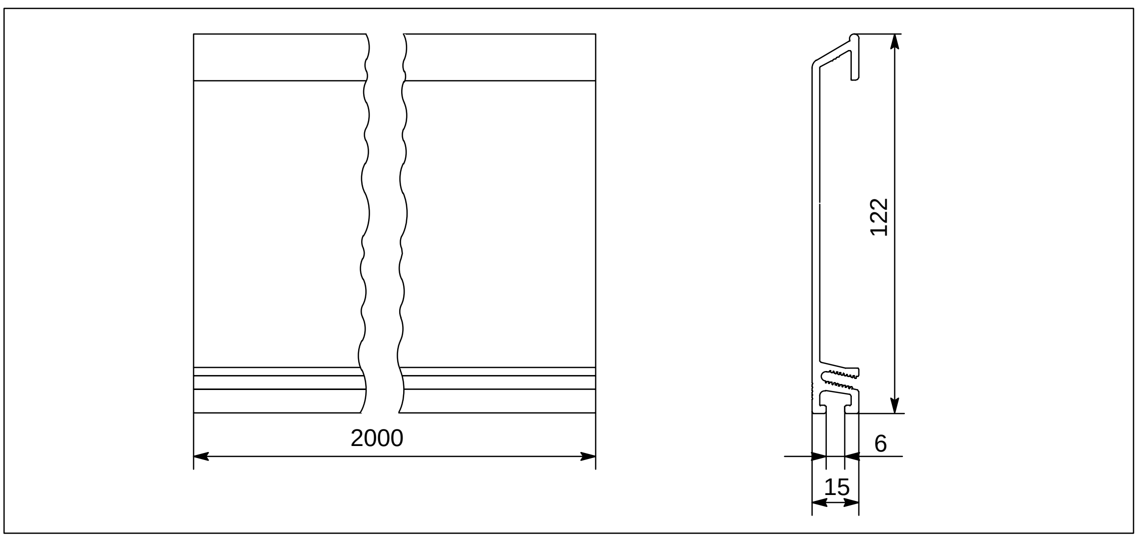


Figure C-9 Dimension Drawing of the 2000 mm Rail

Rail for “Insert and Remove” function

Figure C-10 shows the dimension drawing of the rail for the “Insert and Remove” function with active bus module, S7-300 module and explosion-proof partition. The rail is 482.6 mm or 530 mm long.

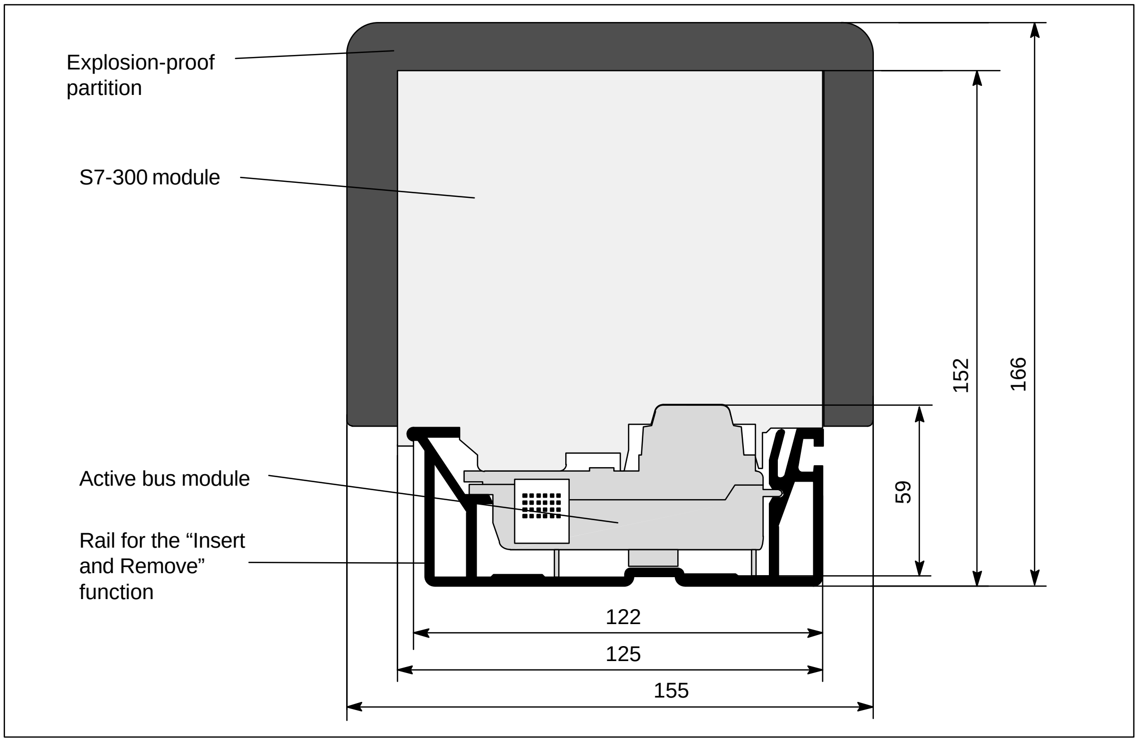
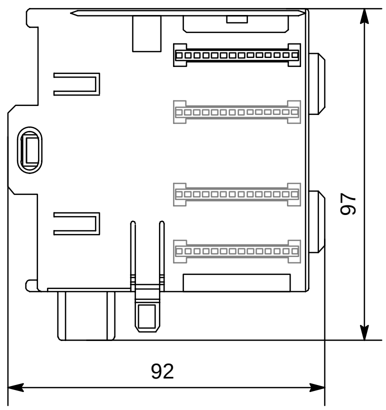


Figure C-10 Complete Dimension Drawing of a Rail for “Insert and Remove” Function with Active Bus Module, S7-300 Module and Explosion-Proof Partition

Bus modules (Expansion buses)

Figure C-11 shows the dimension drawing of the active bus module for the “Insert and Remove” function.



Bus modules
BM PS/IM (...7HA)
BM IM/IM (...7HD)
BM 2 × 40 (...7HB)
BM 1 × 80 (...7HC)

Figure C-11 Dimension Drawing of the Active Bus Modules

C.2 Dimension Drawings of the Power Supply Modules

PS 307; 2 A

Figure C-12 shows the dimension drawing of the PS 307; 2 A power supply module.

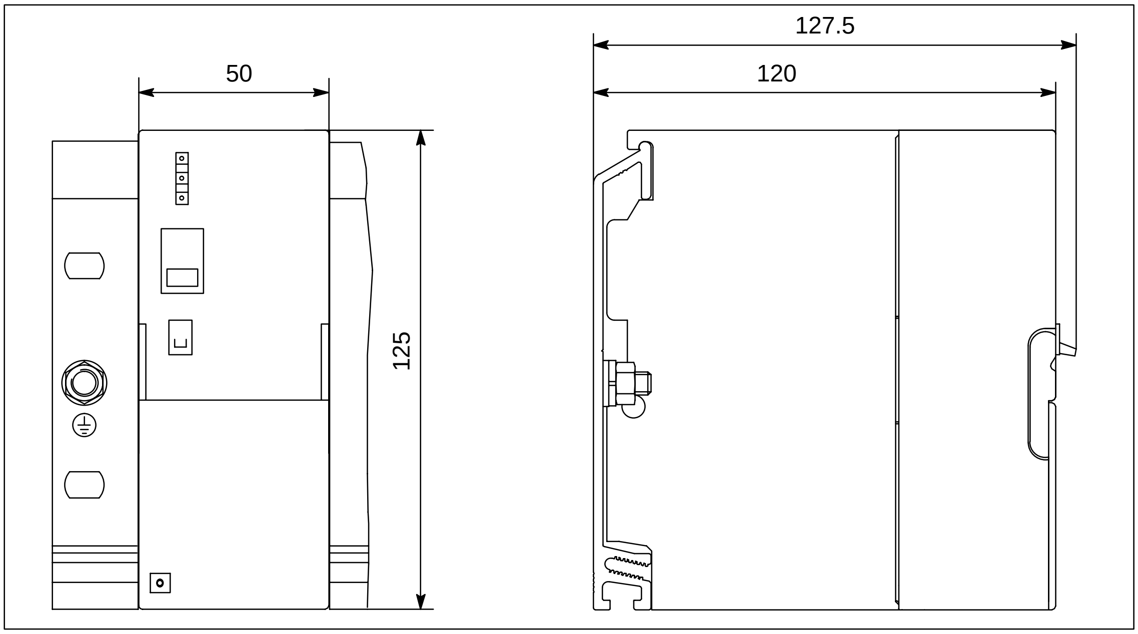


Figure C-12 Power Supply Module PS 307; 2 A

PS 307; 5A

Figure C-13 shows the dimension drawing of the PS 307; 5 A power supply module.

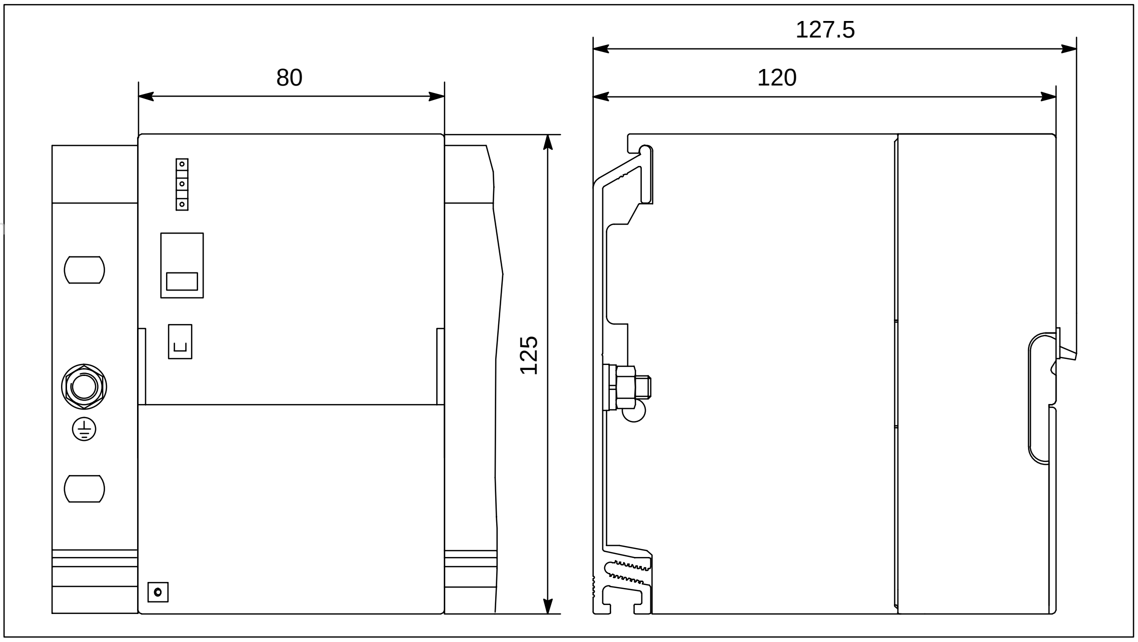


Figure C-13 Power Supply Module PS 307; 5 A

PS 307; 10 A

Figure C-14 shows the dimension drawing of the PS 307; 10 A power supply module.

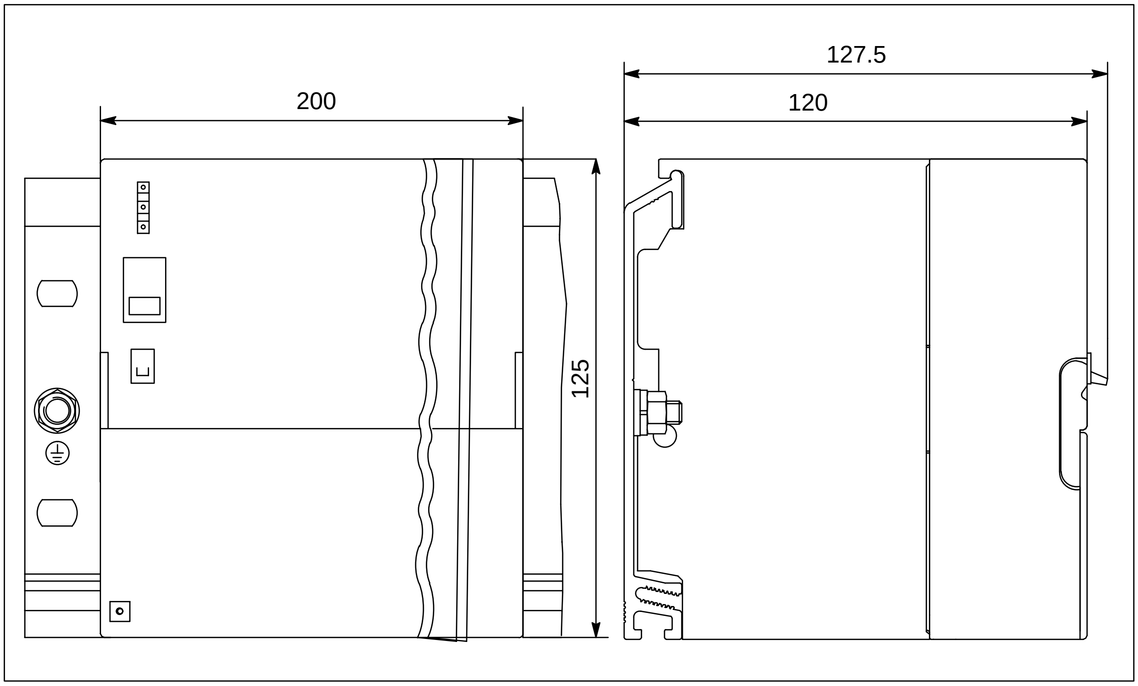


Figure C-14 Power Supply Module PS 307; 10 A

PS 307; 5 A with CPUs 313/314/315/315-2 DP

Figures C-15 and C-16 show the dimension drawings of the configuration of a power supply module PS 307; 5 A with the CPUs 313/314/315/315-2 DP. Observe the dimensions that result from the use of the power connector for wiring the PS 307; 5 A with the CPU.

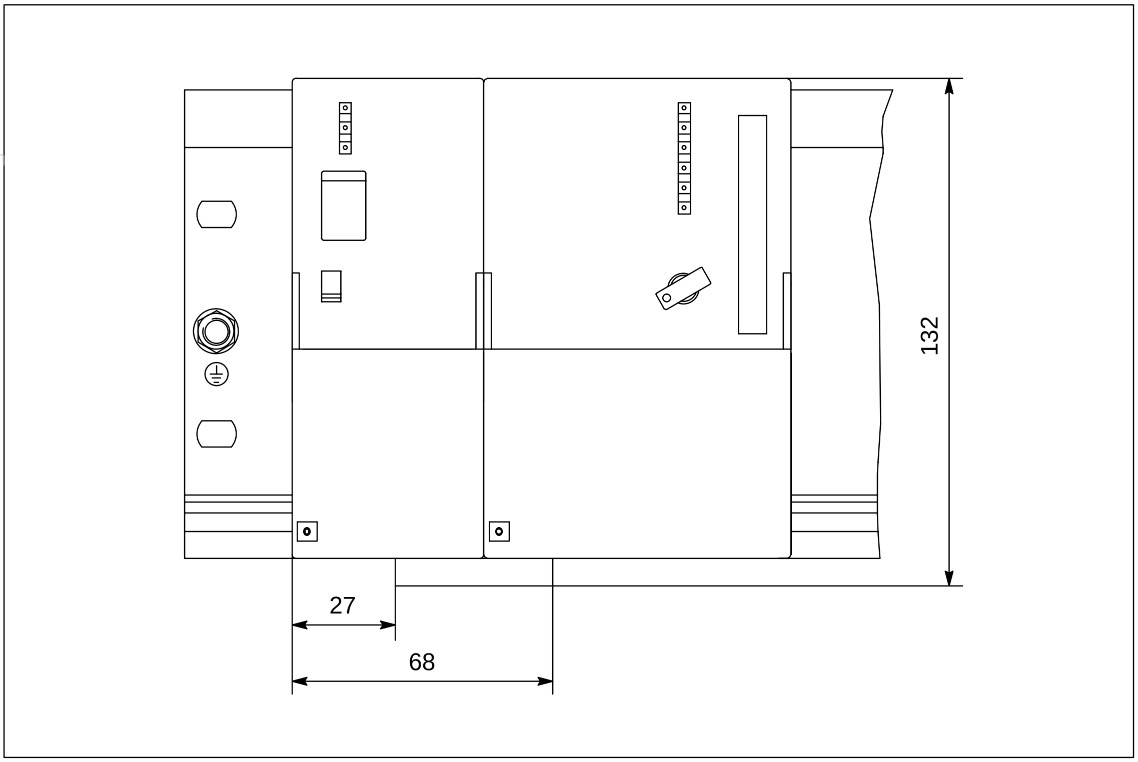


Figure C-15 Dimension Drawing of the Power Supply Module PS 307; 5 A with CPUs 313/314/315/315-2 DP. Front View

PS 307; 5 A with CPUs 313/314/315/315-2 DP

Figure C-16 shows the dimension drawing of the power supply module PS 307; 5 A with the CPUs 313/314/315/315-2 DP in the side view.

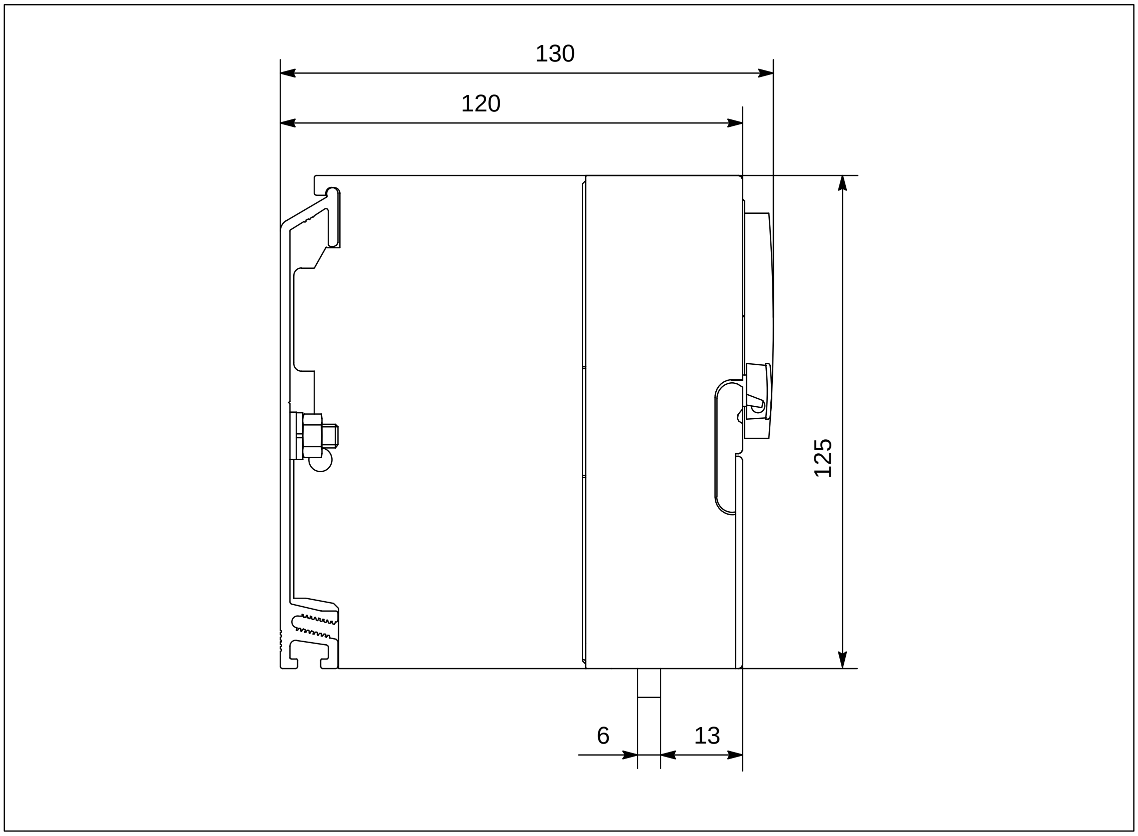


Figure C-16 Dimension Drawing of the Power Supply Module PS 307; 5 A with CPUs 313/314/315/315-2 DP. Side View

C.3 Dimension Drawings of the Interface Modules

IM 360

Figure C-17 shows the dimension drawing of the interface module IM 360.

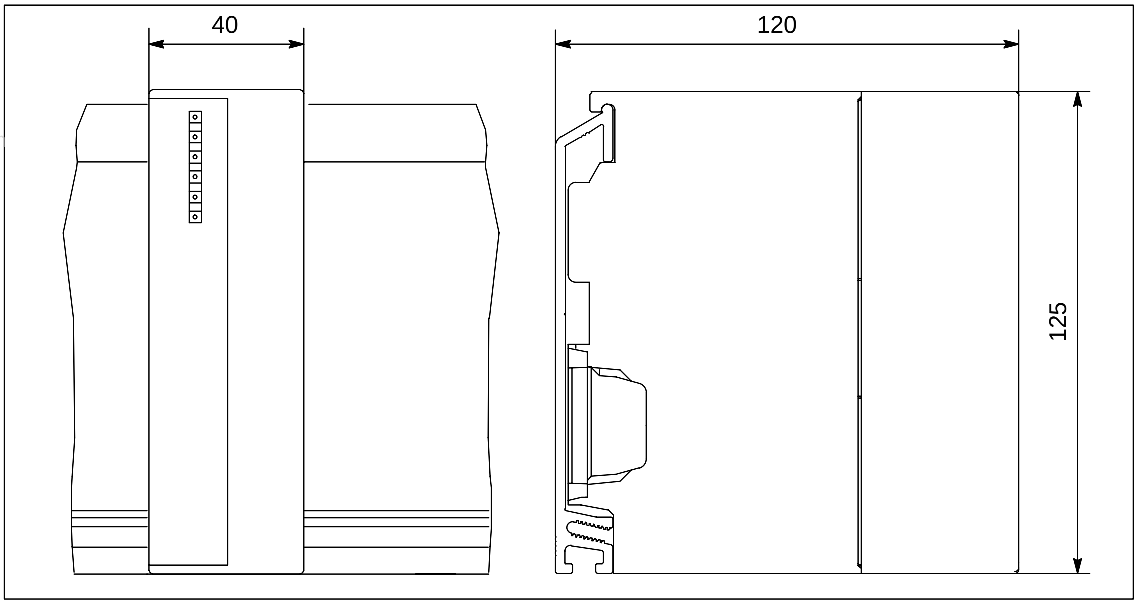


Figure C-17 Interface Module IM 360

IM 361

Figure C-18 shows the dimension drawing of the interface module IM 361.

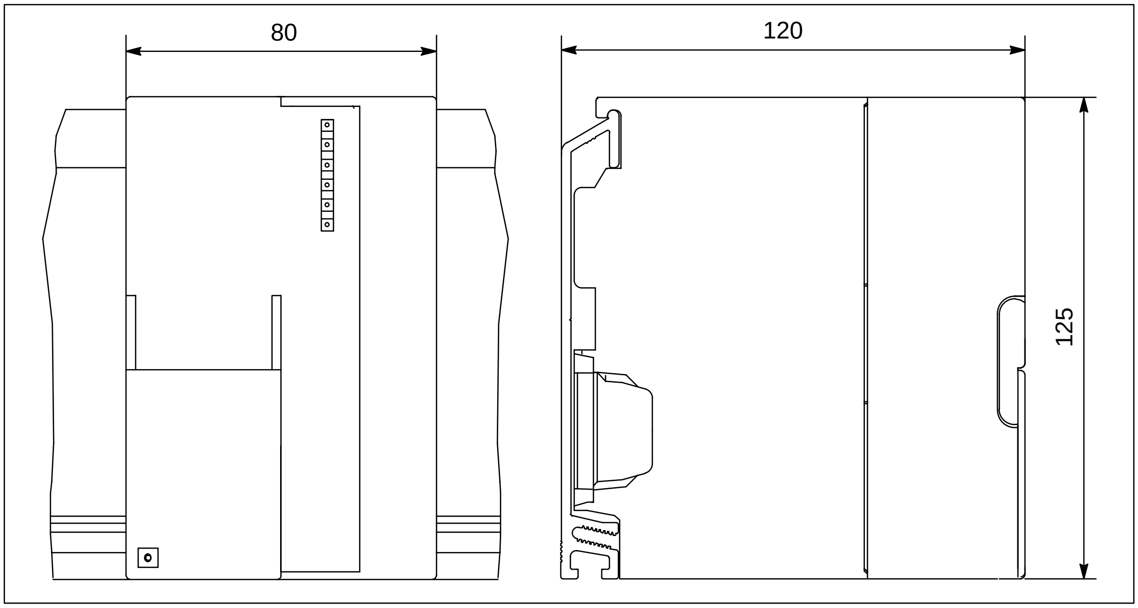


Figure C-18 Interface Module IM 361

IM 365

Figure C-19 shows the dimension drawing of interface module IM 365.

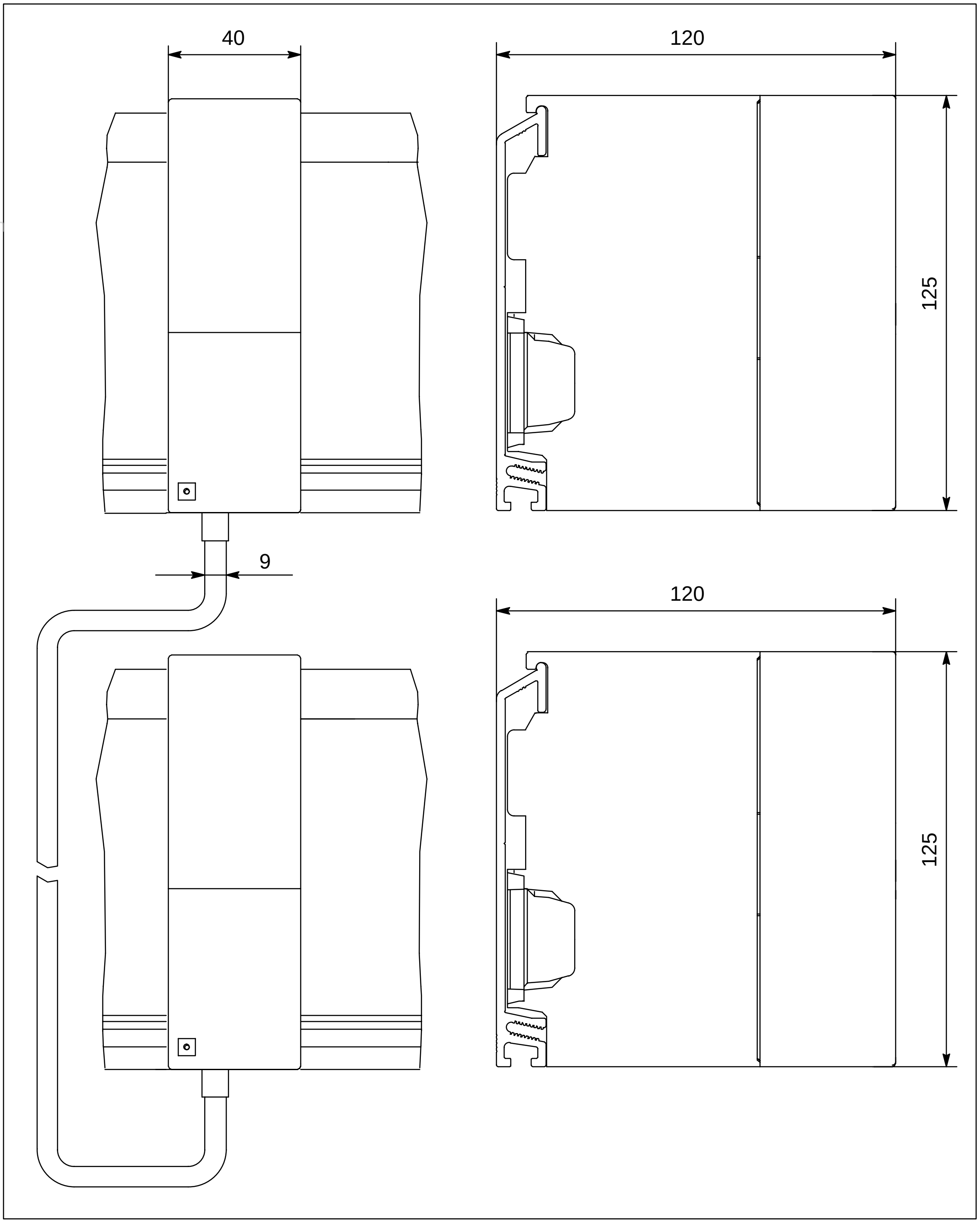


Figure C-19 Interface Module IM 365

C.4 Dimension Drawings of the Signal Modules

Signal Module

Figure C-20 shows the dimension drawing of the signal module. A signal module might look slightly different than the example below. The dimensions however are always the same.

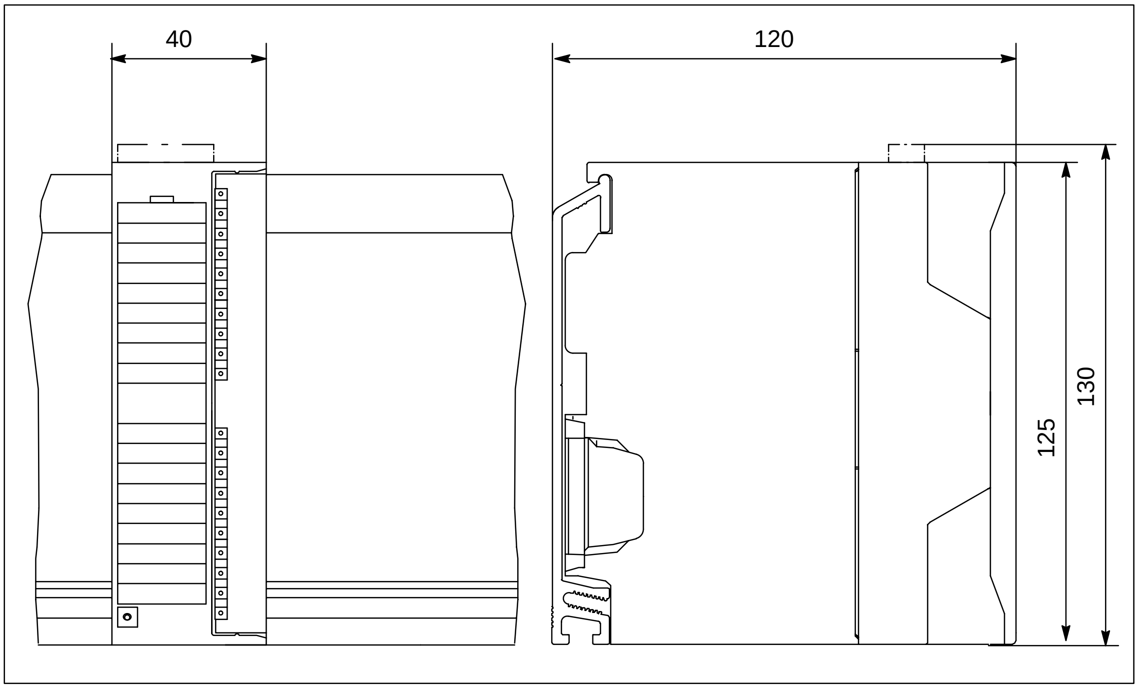


Figure C-20 Signal Module

C.5 Dimension Drawings for Accessories

Shield connecting element

Figure C-21 shows the dimension drawing of the shield connecting element in connection with two signal modules.

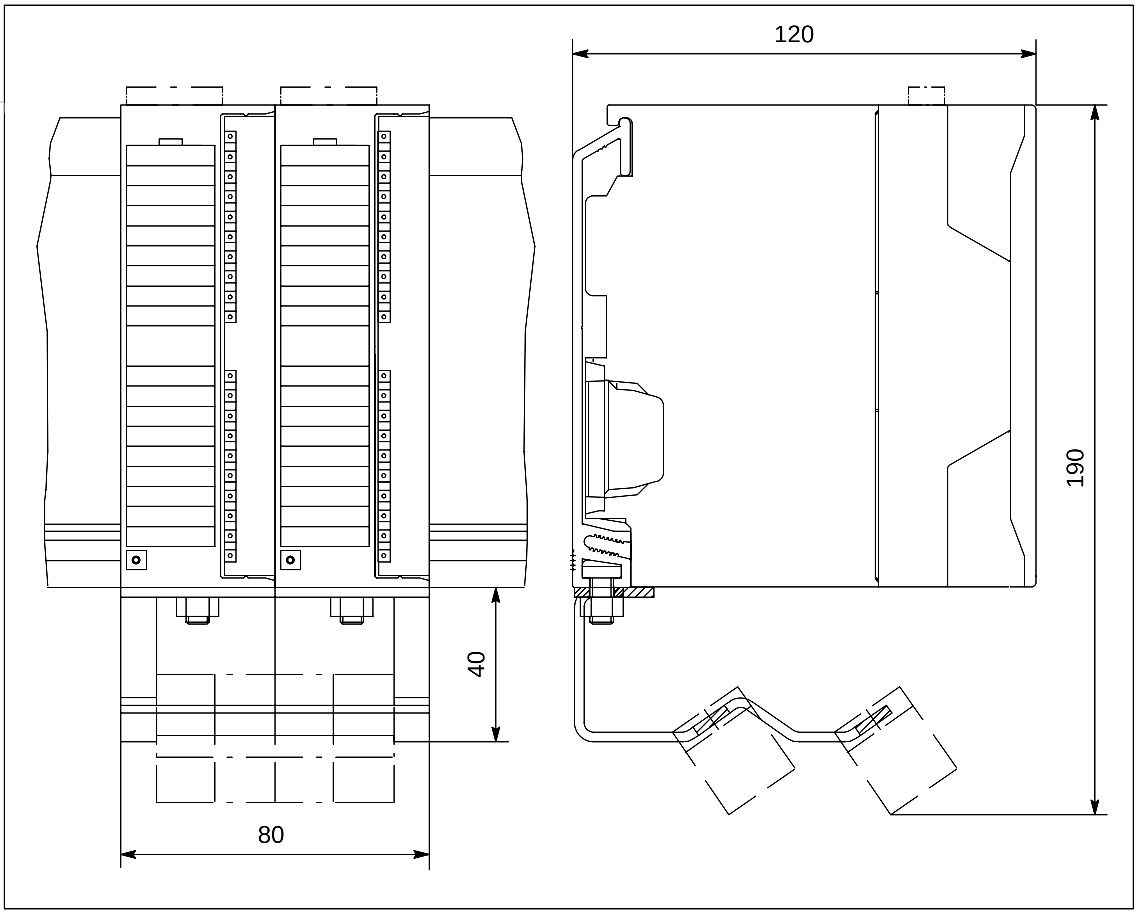


Figure C-21 2 Signal Modules with Shield Connecting Element

SIMATIC TOP connect, 3-tier

Figure C-22 shows the dimension drawing of the 3-tier SIMATIC TOP connect.

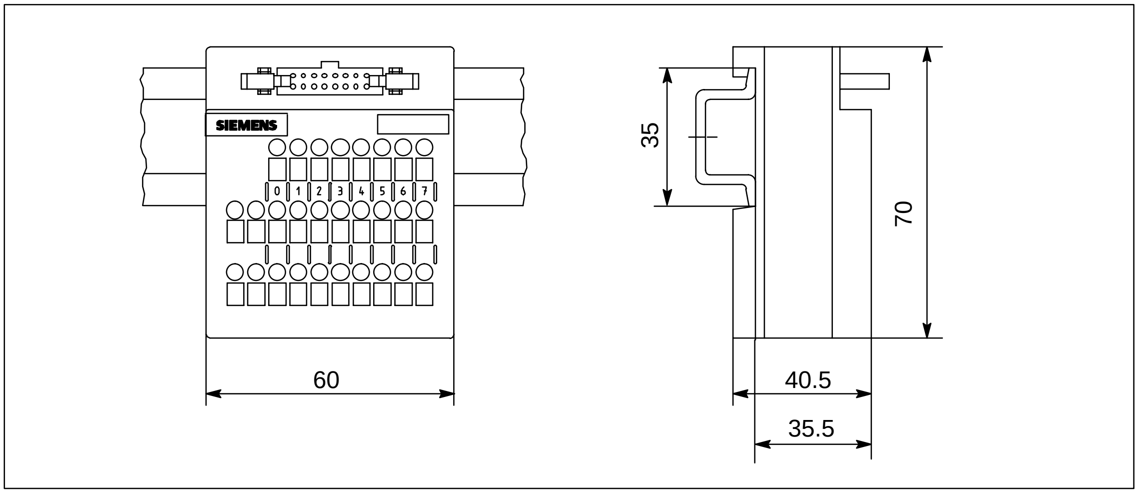


Figure C-22 SIMATIC TOP connect, 3-Tier

SIMATIC TOP connect, 2-tier

Figure C-23 shows the dimension drawing of the 2-tier SIMATIC TOP connect.

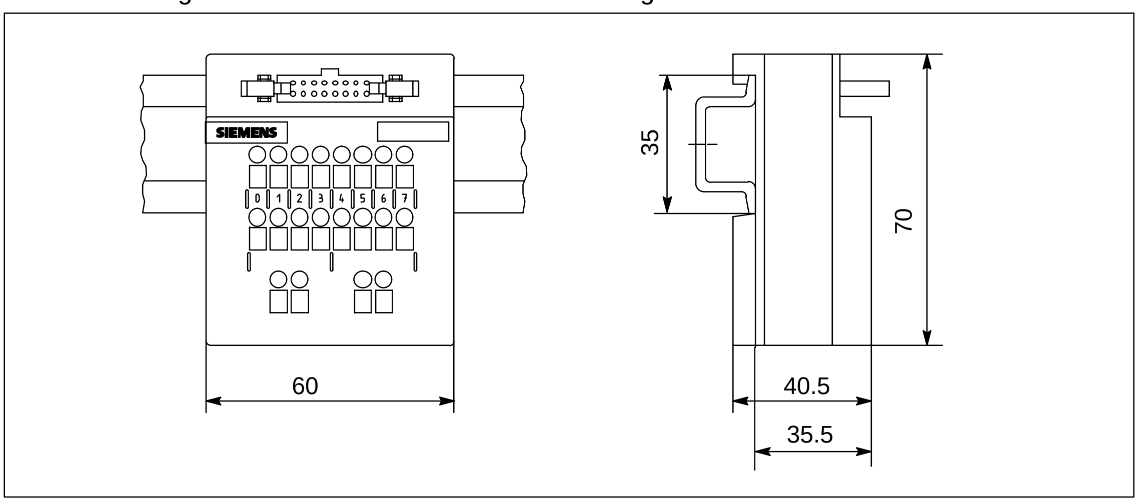


Figure C-23 SIMATIC TOP connect, 2-Tier

SIMATIC TOP connect, 1-tier

Figure C-24 shows the dimension drawing of the 1-tier SIMATIC TOP connect.

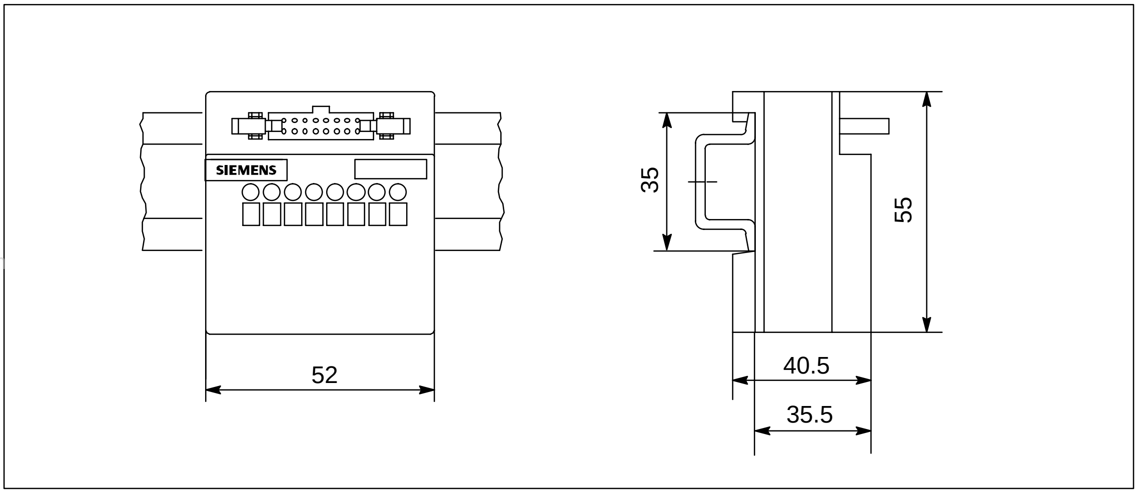


Figure C-24 SIMATIC TOP connect, 1-Tier

RS 485 repeater on standard rail

Figure C-25 shows the dimension drawing of the RS 485 repeater on the standard rail.

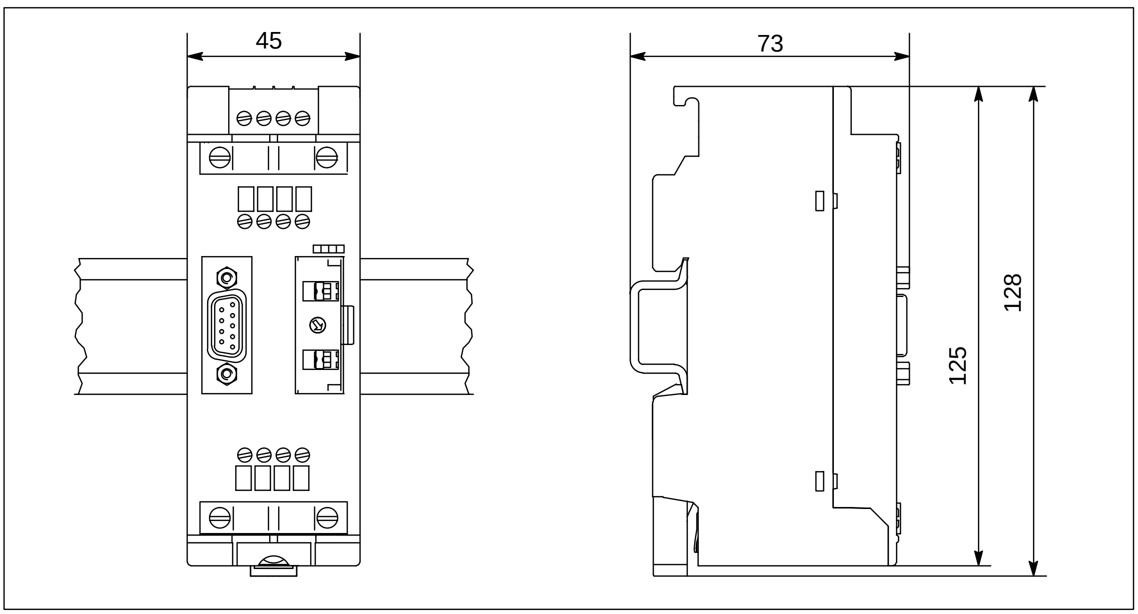


Figure C-25 RS 485 Repeater on Standard Rail

RS 485 repeater on S7-300 Rail

Figure C-26 shows the dimension drawing of the RS 485 repeater on the S7-300 rail.

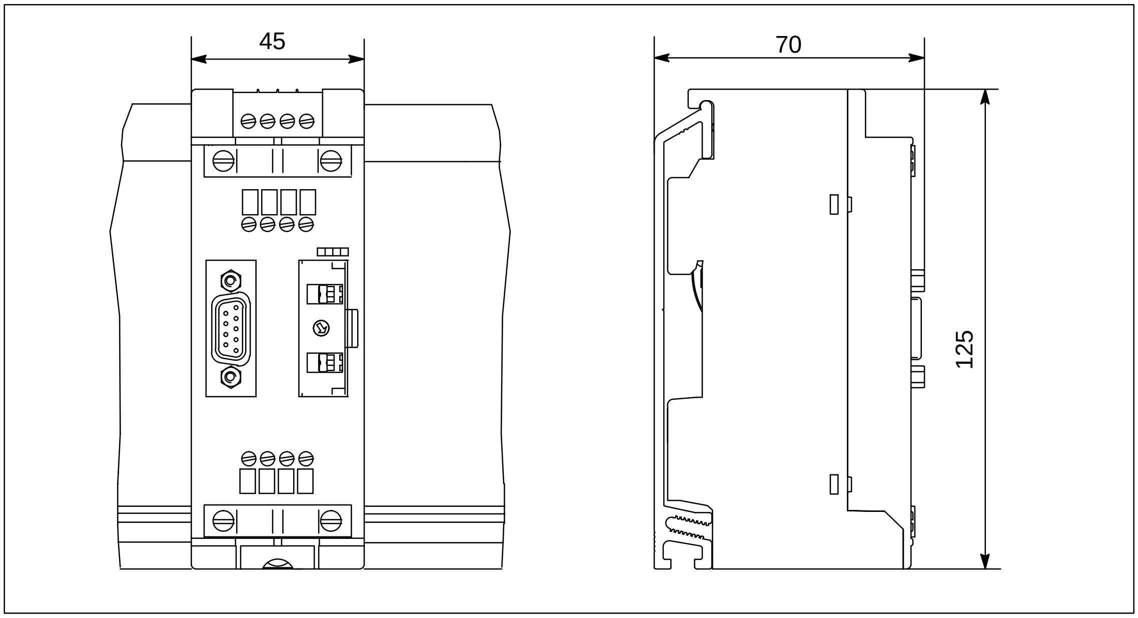


Figure C-26 RS 485 Repeater on S7-300 Rail

Spare Parts and Accessories for S7-300 Modules

D

Spare parts

Table D-1 lists all the parts you can order separately or later for S7-300 programmable controllers.

Table D-1 Accessories and Spare Parts

S7-300 Parts	Order Number
Bus connector	6ES7 390-0AA00-0AA0
Power connector between power supply unit and CPU	6ES7 390-7BA00-0AA0
Labeling strip (Qty 10) • for 8/16-channel modules • for 32-channel modules	 6ES7 392-2XX00-0AA0 6ES7 392-2XX10-0AA0
Slot numbering label	6ES7 912-0AA00-0AA0
Front connector 20-pin • Screw-type Connection • Spring-loaded Connection	 6ES7 392-1AJ00-0AA0 6ES7 392-1BJ00-0AA0
Front connector 40-pin • Screw-typeConnection	 6ES7 392-1AM00-0AA0
Front connector for 2 flat ribbon terminals • Screw-type Connection • Spring-loaded Connection	 6ES7 921-3AB00-0AA0 6ES7 921-3AA00-0AA0
Front connector for 4 flat ribbon terminals • Spring-loaded Connection	 6ES7 921-3AA20-0AA0
SIMATIC TOP connect, 1-tier, with • Screw-type Connection • Spring-loaded Connection	 6ES7 924-0AA00-0AA0 6ES7 924-0AA00-0AB0
SIMATIC TOP connect, 2-tier, with • Screw-type Connection • Spring-loaded Connection	 6ES7 924-0BB00-0AA0 6ES7 924-0BB00-0AB0

Table D-1 Accessories and Spare Parts, continued

S7-300 Parts	Order Number
SIMATIC TOP connect, 3-tier, with • Screw-type Connection • Spring-loaded Connection	 6ES7 924-0CA00-0AA0 6ES7 924-0CA00-0AB0
Round-sheath ribbon cable (16-pin) • Unshielded 30 m • Unshielded 60 m • Shielded 30 m • Shielded 60 m	 6ES7 923-0CD00-0AA0 6ES7 923-0CG00-0AA0 6ES7 923-0CD00-0BA0 6ES7 923-0CG00-0BA0
Plug-in connectors, 16-pin, set of 8 (insulation displacement connectors)	6ES7 921-3BE10-0AA0
Shield connecting element	6ES7 390-5AA00-0AA0
Shield connection terminals for • 2 cables, each with a shield diameter of 2 to 6 mm • 1 cable with a shield diameter of 3 to 8 mm • 1 cable with a shield diameter of 4 to 13 mm	 6ES7 390-5AB00-0AA0 6ES7 390-5BA00-0AA0 6ES7 390-5CA00-0AA0
Measuring range module for analog modules	6ES7 974-0AA00-0AA0
Fuse set for 120/230 VAC digital output modules (contains 10 fuses and 2 fuse carriers)	6ES7 973-1HD00-0AA0
Connecting cable between IM 360 and IM 361 or alternatively IM 361 and IM 361 • 1 m • 2.5m • 5 m • 10 m	 6ES7 368-3BB01-0AA0 6ES7 368-3BC51-0AA0 6ES7 368-3BF01-0AA0 6ES7 368-3CB01-0AA0

Guidelines for Handling Electrostatic Sensitive Devices (ESD)

E

Introduction

In this appendix, we explain

- what is meant by “electrostatic sensitive devices”
- the precautions you must observe when handling and working with electrostatic sensitive devices.

Contents

This chapter contains the following sections on electrostatic sensitive devices:

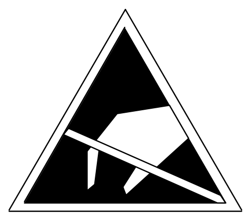
E.1 What is ESD?

Definition

All electronic modules are equipped with large-scale integrated ICs or components. Due to their design, these electronic elements are very sensitive to overvoltages and thus to any electrostatic discharge.

These **E**lectrostatic **S**ensitive **D**evices are commonly referred to by the abbreviation **ESD**.

Electrostatic sensitive devices are labelled with the following symbol:



Caution

Electrostatic sensitive devices are subject to voltages that are far below the voltage values that can still be perceived by human beings. These voltages are present if you touch a component or the electrical connections of a module without previously being electrostatically discharged. In most cases, the damage caused by an overvoltage is not immediately noticeable and results in total damage only after a prolonged period of operation.

E.2 Electrostatic Charging of Persons

Charging

Every person with a non-conductive connection to the electrical potential of its surroundings can be charged electrostatically.

Figure E-1 shows you the maximum values for electrostatic voltages which can build up on a person coming into contact with the materials indicated in the figure. These values are in conformity with the specifications of IEC 801-2.

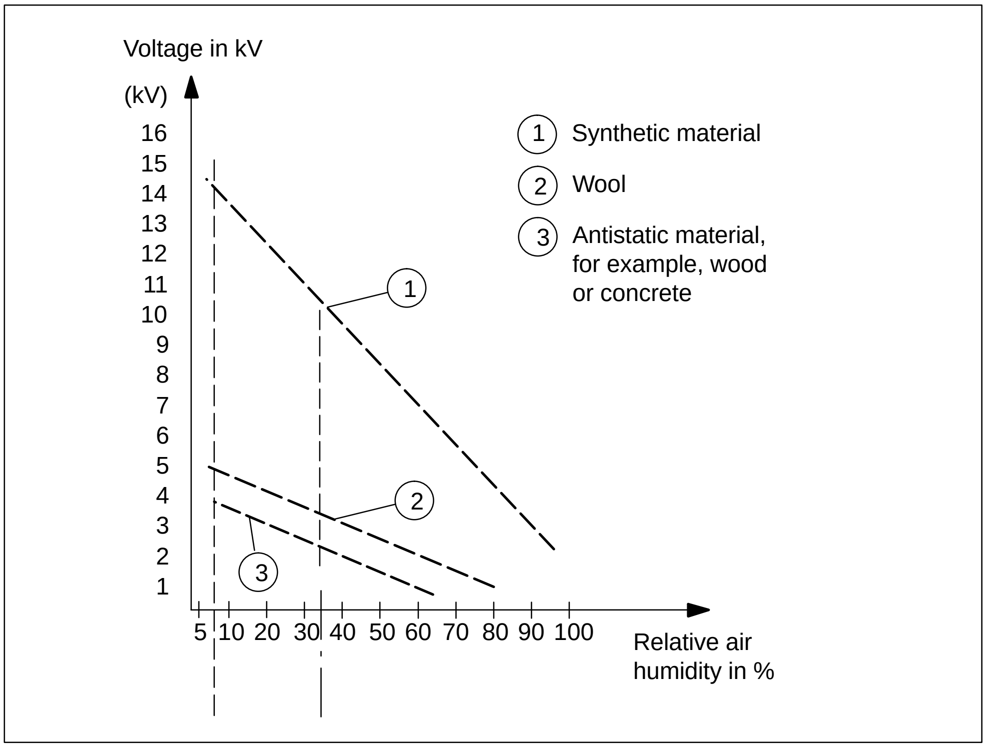


Figure E-1 Electrostatic Voltages which Can Build up on a Person

E.3 General Protective Measures Against Electrostatic Discharge Damage

Ensure sufficient grounding

Make sure that the personnel, working surfaces and packaging are sufficiently grounded when handling electrostatic sensitive devices. You thus avoid electrostatic charging.

Avoid direct contact

You should touch electrostatic sensitive devices only if it is unavoidable (for example, during maintenance work). Hold modules without touching the pins of components or printed conductors. In this way, the discharged energy cannot affect the sensitive devices.

If you have to carry out measurements on a module, you must discharge your body before you start the measurement by touching grounded metallic parts. Use grounded measuring devices only.

List of Abbreviations

F

Abbreviation	Explanation
AC	Alternating current
ADC	Analog-to digital converter
AI	Aanalog input
AO	Analog output
Comp	Compensating terminal
CP	Communications processor
CPU	Central processing unit of a PLC
DAC	Digital-to-analog converter
DB	Data block
DC	Direct current
DI	Digital input
DO	Digital output
EMC	Electromagnetic compatibility
EPROM	Erasable programmable read-only memory
ES	Encoder supply
ESD	Electrostatic sensitive devices
EWS	Apply substitute value
FB	Function block
FC	Function
FEPROM	Flash erasable programmable read only memory
FOC	Fiber-optic cable
I_C	Constant-current lead
L+	Terminal for 24 VDC supply voltage
LWH	Hold last valid value
M	Ground terminal
M+	Measuring lead (positive)
M–	Measuring lead (negative)
M_{ANA}	Reference potential of the analog measuring circuit
MPI	Multipoint interface

OB	Organization block
OP	Operator panel
OS	Operator system
PIQ	Process-image output table
PII	Process-image input table
PLC	Programmable logic controller
Programming device	Programming device
PS	Power supply
Q_I	Analog output current
Q_V	Analog output voltage
RAM	Random access memory
R_L	Load impedance
S +	Detector lead (positive)
S –	Detector lead (negative)
SF	“Group error” error LED
SFB	System function block
SFC	System function
SM	Signal module
SSI	Synchronous serial interface
TD	Text display
U_{CM}	Common mode voltage
U_{iso}	Potential difference between M_{ANA} and local ground
VZ	Sign

Glossary

Address

An address denotes a specific operand or address area; examples of this are: input I 12.1; memory word MW 25; data block DB 3.

Aggregate current

Sum of the currents of all output channels on a digital output module.

Backplane bus

The backplane bus is a serial data bus that is used by the modules to communicate with each other and to supply them with the voltage they require. The interconnection of the modules is established by the bus connector.

Backup battery

The backup battery ensures that the → User program is stored in a powerfail-proof manner in the → CPU and defined data areas and memory markers, timers and counters are kept → Retentive.

Binary code

Data format of → encoders absolute

Bus

A bus is a transmission medium that interconnects several nodes. Data transmission can be serial or parallel, and be performed over electric conductors or fiber-optic cables.

Bus segment

A bus segment is a self-contained section of a serial bus system. Bus segments are interconnected by means of → repeaters.

Central processing unit

→ CPU

Common mode voltage

A voltage that is common to all inputs/outputs of a group and is measured between this group and any reference point (usually to ground).

Communication processor

Programmable module for communication tasks, such as networking, point-to-point connection.

Comparison point

When using thermocouples on analog input modules: point of known temperature (for example, → compensating box).

Compensating box

Compensating boxes can be used for measuring temperatures with thermocouples on analog input modules. The compensating box is a compensation circuit for compensating temperature fluctuations at the → Comparison point.

Complete restart

When a CPU starts up (say, when the mode selector switch is moved from STOP to RUN or when the mains supply is turned on), OB 100 (Restart) is processed before cyclic programming processing (OB 1).
With a complete restart, the → Process input image is read in and the *STEP 7* user program is processed, starting with the first instruction in OB1.

Configure

Select and put together different components on a programmable logic controller and install the requisite software (for example, operating system on M7 automation computer) and adapt to the specific use (for example, by assigning parameters to the modules).

CP

→ communications processor

CPU

The CPU (central processing unit) is a CPU module of the → programmable logic controller that stores and runs the user program. It contains the operating system, memory, processing unit and communication interface.

Default setting

The default setting is a sensible basic setting that is used whenever no other value is used.

Diagnostics

Generic term for → System diagnostics, process error diagnosis and user-defined diagnostics.

Diagnostic buffer

The diagnostic buffer is a buffered memory area in the CPU which stores the diagnostics events in the order in which they occurred.
For troubleshooting, the user can read out the exact error cause in *STEP 7* (PLC -> Module State) from the diagnostic buffer.

Diagnostic data

All the diagnostics events that occurred are collected in the CPU and entered in the → Diagnostic buffer. If there is an error OB, it is started.

Diagnostic Interrupt

Modules with diagnostics capability report system errors by means of diagnostic interrupts to the → CPU. The operating system of the CPU calls OB 82 in the course of a diagnostic interrupt.

Direct access

A direct access is the direct accessing of the CPU by means of the → Backplane bus to modules while avoiding the → Process image.

Edge, falling

Signal status change from 1 to 0

Edge, rising

Signal status change from 0 to 1

Encoder absolute

An encoder absolute determines the path traveled during position detection by reading a numerical value. In the case of encoders absolute with a serial interface (SSI), path information is transferred synchronously and serially according to the SSI protocol (synchronous serial interface).

EPROM

Erasable programmable read-only memory

Equipotential bonding

Electrical connection (equipotential bonding conductor), which brings the bodies of electrical resources and foreign conductive bodies to an identical or approximately identical potential in order to avoid interfering or hazardous voltages between these bodies.

External load memory

→ Memory card

FEPROM

In their ability to retain data in the event of a power failure (even without a backup battery), FEPROMs (flash erasable programmable read only memories) are the equivalent of the electrically erasable → EEPROMS, but can be erased considerably more quickly.

FREEZE

Parameter in *STEP 7* for position detection module SM 338; POS-INPUT. The FREEZE function is a control command for freezing current encoder values of the SM 338 to the instantaneous value.

Gray code

Data format of → Encoders absolute

Ground

The conductive ground whose electric potential can be set equal to zero at every point.
In the proximity of grounding electrodes, the ground can have a potential differing from zero. The term "reference ground" is frequently used to describe such circumstances.

Ground

The ground is the total number of all interconnected inactive parts of an item which cannot assume a hazardous voltage in the event of a fault.

Ground, to

To ground means connect an electrically conductive part by means of a grounding system to the grounding electrode (one or more conductive parts having a very good contact to ground).

Hardware interrupt

A hardware interrupt is triggered by interrupt-triggering modules as a result of a certain event in the process (overshooting or undershooting of a limit value; a module has completed the cyclic conversion of its channels).
The hardware interrupt is reported to the CPU. In accordance with the priority of this interrupt, the → Organization block assigned to it is scanned.

Hold last value (LWH)

The module retains the last value read out before STOP mode.

Input delay

Parameter in *STEP 7* for digital input modules. The input delay is used to suppress injected interference. Interfering pulses from 0 ms to the set input delay are suppressed.
The set input delay is subject to a tolerance, which can be taken from the technical specifications of the module. A high input delay suppresses long interfering pulses, whereas a low input delay suppresses short ones.
The permissible input delay depends on the length of the cable between the encoder and the module. For example, a high input delay has to be set for long unshielded supply conductors to the encoder (longer than 100m).

Integration time

Parameter in *STEP 7* for analog input modules. The integration time is the inverse value of the → Interference frequency suppression in ms.

Interface, multipoint

→ MPI

Interference frequency suppression

Parameter in *STEP 7* for analog input modules. The frequency of the AC network can interfere with the measured value, especially with measurements in low voltage ranges and with thermocouples. This parameter is used by the user to specify the prevailing line frequency on his system.

Interrupt

The SIMATIC S7 is familiar with 28 different run-time level, which govern running of the user program. These run-time levels include interrupts such as hardware interrupts, among other things. When an interrupt occurs, the operating system automatically calls an assigned organization block in which the user can program the reaction he wants (for example, in an FB).

Interrupt, diagnostic

→ Diagnostic Interrupt

Interrupt, end-of-scan-cycle interrupt

→ Hardware interrupt

Interrupt, hardware

→ Hardware interrupt

Logic block

In a SIMATIC S7 context, a logic block is a block that contains a part of the *STEP 7* user program. By contrast, a data block only contains data. There are the following logic blocks: organization blocks (OBs), function blocks (FBs), functions (FCs), system function block (SFBs), system functions (SFCs).

M7

Owing to its standardized AT computer architecture, automation computers M7-300 and M7-400 represent a freely programmable expansion of the SIMATIC automation platform. The hardware configuration is similar to that of a S7-300 or S7-400. The user programs for the SIMATIC M7 can also be programmed in a high-level language, such as C, or graphically.

Measuring range module

Measuring range modules are plugged into the analog input modules for adaptation to different measuring ranges.

Memory card

Pluggable load memory. Memory cards are credit-card size storage media for CPUs and CPs. They are implemented as → RAM or → FEPROMs.

Monoflop time

Parameter in *STEP 7* for position detection module SM 338; POS-INPUT. The monoflop time is the time interval between 2 SSI message frames (→ Encoder absolute).

MPI

The multipoint interface (MPI) is the programmer port of the SIMATIC S7. It is used to access programmable modules ((CPUs, CPs), text displays and operator panel from a central point. The nodes on the MPI can communicate with each other.

Module filtering mode

By operating mode we mean:
1. The selection of an operating mode of the CPU using the mode switch or the PG
2. The type of program execution in the CPU
3. A parameter in *STEP 7* for analog input modules

Non-isolated

In the case of non-isolated input/output modules, the reference potentials of the control and load circuit are electrically connected.

Normalizing

Parameter in *STEP 7* for position detection module SM 338; POS-INPUT. Normalizing right justifies the encoder value of the → encoder absolute; non-relevant places are discarded.

OB

→ Organization block

Operating system

The operating system of the CPU organizes all functions and processes of the CPU that are not tied to a specific control task.

Optically isolated

With optically isolated input/output modules, the reference potentials of the control and load circuit are galvanically isolated; for example, by an optocoupler, contact assembly or repeater. Input/output circuits can be connected to common potential.

Organization block

Organization blocks (OBs) form the interface between the operating system of the CPU and the user program. The order in which the user program is processed is defined in the organization blocks.

Parameters

1. Tag of a → Logic block
2. Tag for setting the characteristics of a module (one or more per module). When delivered to the customer, each module has a practical basic setting for its parameters, which the user can modify in *STEP 7*.

PLC

→ Programmable logic control

Process image

The signal states of the digital input and output modules are stored in the CPU in process image.
A distinction is made between the process-image of inputs and of outputs. The process input image (PII) is read by the input modules before the operating system scans the user program. The process output image (PIQ) is transferred to the output modules at the end of program scanning.

Product status

Products having an identical Order Number are distinguished by their product status. The product status is incremented for upwards compatible extensions, modifications due to production reasons (use of new component parts and components) and troubleshooting.

PROFIBUS-DP

Digital, analog and intelligent I/O modules and a wide range of field devices to EN 50170, Part 3, such as drives or valve terminals, are repositioned by the automation system to the process, on site, over a distance of as many as 23 km. The modules and field devices are connected to the programmable logic controller by means of the PROFIBUS-DP fieldbus and addressed in the same way as central I/O.

Programmable logic control

Programmable logic controls (PLCs) are electronic controls whose function is stored as a program on the control device. The design and wiring of the device do not therefore depend on the function of the control.
The architecture of a programmable logic control is similar to that of a computer; it consists of a → CPU (central processing unit) with memory, input/output modules and an internal bus system. The I/O and the programming language are designed to meet the requirements of open-loop control.

Programmable logic controller

A programmable logic controller is a → programmable logic control consisting of a → central device, a CPU and diverse input/output modules.

Programming device

A programming device (PG) is a personal computer in a specific industry-standard and compact design. A PG is completely equipped for programming SIMATIC programmable logic controllers.

RAM

A RAM (random access memory) is a semiconductor memory with random access.

Reaction to open thermocouple

Parameter in *STEP 7* for analog input modules when using Thermocouples. This parameter defines whether ”Overflow” ($7FFF_H$) or “Underflow” (8000_H) is output by the module in the event of an open thermocouple.

Repeater

Equipment for the amplification of bus signals and connection of → bus segments over long distances.

Reference ground

→ Ground

Reference potential

Potential from the point of view of which the voltages of the involved circuits are analyzed and measured.

Resolution

With analog modules, the number of bits which represent the digitized analog value in binary. Resolution depends on the module and with analog input modules on the → integration time. The precision of the resolution of a measured value increases with the length of the integration time. The resolution can be as many as 16 bits, including sign.

Retentivity

Data areas in data blocks, and also timers, counters and memory markers are retentive when their contents are not lost upon a complete restart or POWER DOWN.

Scan time

The scan time is the time required by the → CPU to scan the → user program once.

SDB

→ System data block

Segment

→ Bus segment

SFC

→ System function

Signal module

Signal modules (SM) form the interface between the process and the programmable logic controller. There are input modules, output modules, input/output modules (both digital and analog).

Short-circuit

Connection with negligibly low impedance between operationally opposed live conductors. The current is a multiple of the operating current; this can result in thermal overloading (rated short-time current) or mechanical overloading (rated peak withstand current) of the switchgear and system components.

Smoothing

Parameter in *STEP 7* for analog input modules. The measured values are smoothed by digital filtering. For specific modules it is possible to choose between no, low, medium and high smoothing. The higher the smoothing, the greater is the time constant of the digital filter.

STARTUP

The STARTUP mode is transversed during the transition from STOP mode to RUN mode. STARTUP can be triggered by the → Mode switch or following power-on or by means of an operator input on the programming device. With the S7-300 and M7-300, a → Complete restart is performed.

Status mode

The SIMATIC S7 programmable logic controllers are familiar with the following of status modes: STOP, → STARTUP, RUN and STOP.

STEP 7

Parameter assignment and programming software for assigning parameters to and the creation of user programs for SIMATIC S7 controllers.

Substitute value

Substitute values are values that can be output to the process when signal output modules have failed or be used in the user program instead of a process value when signal input modules have failed.
The substitute values can be assigned parameters by the user in *STEP 7* (old value retained, substitute value 0 or 1). They are values which the output(s) have to output in the event of a CPU STOP.

System data block

SDBs (system data blocks) are data areas on the central processing unit which contain system settings and module parameters. The system data blocks are created and modified in *STEP 7*.

System diagnostics

System diagnostics is the detection, analysis and reporting of errors that occur within the programmable logic controller. Examples of such errors are: program errors or failures on modules. System errors can be indicated with LED displays or in *STEP 7*.

System function

A system function (SFC) is a function that is integrated in the operating system of the CPU a function that can be triggered in the *STEP 7* user program, if necessary.

Temperature coefficient

Parameter in *STEP 7* for analog input modules when measuring temperatures with a resistance thermometer (RTD). The temperature coefficient you select depends on the resistance thermometer being used (to DIN standard).

Transmission rate

Parameter in *STEP 7* for position detection module SM 338; POS-INPUT: Rate of data transmission (bit/s)

Two-conductor/three-conductor/four-conductor connection

Method of connection to the module – for example, of resistance thermometers/resistors to the front connector of the analog input module or of loads at the voltage output of an analog output module.

Two-wire transmitter/four-wire transmitter

Kind of transmitter (two-wire transmitter: supply (via terminals of the analog input module; four-wire transmitter: supply via separate terminals of the transmitter)

 Ungrounded

Without galvanic connection to ground

User program

The user program contains all the statements, tags and data for signal processing used to control a system or a process. It is assigned to a programmable module (CPU, FM, for example) and can be structured in smaller units (blocks).

Varistor

Voltage-dependent resistor

Wire break

Parameter in *STEP 7*. A wire break test is used for monitoring the connection from the input to the encoder and from the output to the actuator. With wire break, the module detects a flow of current at the appropriately parameterized input/output.

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