SIEMENS

SIMATIC

Automation System S7-400
Module Specifications

Reference Manual

This manual is part of the documentation package with the order number **6ES7498-8AA05-8BA0**

11/2006

A5E00850736-02

Safety Guidelines

This manual contains notices intended to ensure personal safety, as well as to protect the products and connected equipment against damage. These notices are highlighted by the symbols shown below and graded according to severity by the following texts:

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 can result if proper precautions are not taken.

Caution

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

Notice

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 description, 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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Siemens AG
Bereich Automation and Drives
Geschaeftsgebiet Industrial Automation Systems
Postfach 4848, D- 90327 Nuernberg

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.

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Technical data subject to change.

Siemens Aktiengesellschaft

A5E00850736-02

Preface

Purpose of the Manual

The manual contains reference information on operator actions, descriptions of functions and technical specifications of the central processing units, power supply modules and interface modules of the S7-400.

How to configure, assemble and wire these modules in an S7-400 system is described in the installation manuals for each system.

Required Basic Knowledge

You will need a general knowledge of automation to understand this manual.

In addition, you are required to know how to use computers or devices with similar functions (e. g. programming devices) under Windows 2000 / XP operating systems. Since S7-400 is configured with the STEP 7 basic software, you have to have a good working knowledge of the software. You can acquire this knowledge in the manual “Programming with STEP 7”. Read the notes on the safety of electronic controllers in the appendix of the Installation manual – especially when using a S7-400 in safety-relevant areas.

Target Group

This manual is aimed at people with the required qualifications to commission, operate and maintain the products described.

Where is this Manual valid?

The manual is valid for the S7-400 programmable controller.

Certification

You can find details on the certificates and approvals in the reference manual “General Technical Data”.

Place of this Documentation in the Information Environment

This manual forms part of the S7-400 documentation.

System	Documentation Package
S7-400	• *S7-400 Programmable Controllers; Hardware and Installation* • *S7-400 Programmable Controllers; Module Specifications* • *Automation System S7-400 CPU Data* • *S7-400 Instruction List*

Finding Your Way

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.
- 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 rapid access to the information you need.

Recycling and Disposal

The S7-400 is environmentally friendly and can thus recyclable. Consult a certified disposal agency for electronics junk to recycle and dispose of your old equipment in an environmentally friendly manner.

Further Support

If you have any technical questions, please get in touch with your Siemens representative or agent responsible.

`http://www.siemens.com/automation/partner`

A guide for the technical documentation for the various SIMATIC products and systems is found under:

`http://www.siemens.de/simatic–tech–doku–portal`

You find the online catalog and order system under:

`http://mall.automation.siemens.com/`

Training Centers

Siemens 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:

Telephone: +49 (911) 895-3200.

Internet: `http://www.sitrain.com`

Technical Support

You can reach the Technical Suport for all A&D products

- Via the Web formula for the Support Request
  `http://www.siemens.com/automation/support-request`
- Phone: + 49 180 5050 222
- Fax:+ 49 180 5050 223

Additional information about our Technical Support can be found on the Internet pages:
`http://www.siemens.com/automation/service`.

Service & Support on the Internet

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

`http://www.siemens.com/automation/service&support`

where you will find the following:

- The newsletter, which constantly provides you with up-to-date information on your products.
- The right documents via our Search function in Service & Support.
- A forum, where users and experts from all over the world exchange their experiences.
- Your local representative for Automation & Drives.
- Information on field service, repairs, spare parts and more under “Services”.

Contents

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1 General Technical Specifications

What are General Technical Specifications?

General technical specifications include the following:

- The standards and test specifications complied with and met by the modules of the S7-400 programmable controllers
- The test criteria against which the S7-400 modules were tested

Chapter Overview

1.1 Standards and Approvals

Warning

You will find the current approvals on the identification label of the respective products.

Warning

Open equipment

Risk of death, serious injury or substantial material damage.

S7–400 modules are open equipment. The S7 400 must be installed in a cabinet or cubicle.

Access to these cabinets or cubicles may only be possible using a key or tool, and is only permitted for instructed or authorized personnel.

IEC 61131-2

The S7-400 programmable controller satisfies the requirements and criteria of the IEC 61131-2 standard (programmable controllers, part 2 on equipment requirements and tests).

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 controllers:

- 73/23/EEC "Electrical Equipment Designed for Use between Certain Voltage Limits" (Low-Voltage Directive)
- 89/336/EEC "Electromagnetic Compatibility" (EMC Directive)
- 94/9/EG "Devices and protection systems to be used as prescribed in potentially explosive areas (Guidelines for Explosion Protection)"

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

Siemens Aktiengesellschaft
Bereich Automation and Drives
A&D AS RD ST
Postfach 1963
D-92209 Amberg

These files are also available for download on the Customer Support Internet pages, under "Declaration of Conformity".

EMC Directive

SIMATIC products are 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 61000-6-4 : 001	EN 61000-6-2 : 001

Low Voltage Directive

The products listed in the table below fulfill the requirements of EU low-voltage directive (73/23/EEC). Adherence to this EU directive was tested in accordance with IEC 61131-2.

Table 1-2 Products that Fulfill the Requirements of the Low-Voltage Directive

Name	Order number
Digital Input Module SM 421; DI 32 x 120 VUC	6ES7421-1EL00-0AA0
Digital Input Module SM 421; DI 16 x 120/230 VUC	6ES7421-1FH00-0AA0
Digital Output Module SM 422; DO 8 x 120/230 VAC/5 A	6ES7422-1FF00-0AA0
Digital Output Module SM 422; DO 16 x 120/230 VAC/2 A	6ES7422-1FH00-0AB0
Relay Output Module SM 422; DO 16 x 30/230 VUC/Rel5A	6ES7422-1HH00-0AA0
Digital input module SM 421; DI 16 x UC 120/230 V	6ES7421-1FH20-0AA0
The 120/230 VAC Fan Subassembly	6ES7408-1TB00-0XA0
PS 407 4A	6ES7407-0DA01-0AA0
PS 407 10A	6ES7407-0KA01-0AA0
PS 407 20A	6ES7 407-0RA01-0AA0
PS 407 10A R	6ES7407-0KR00-0AA0

Warning

In the new releases, some of the devices listed above fulfil the requirements of the explosion protection guidelines instead of that of the low-voltage directive. Please note the information on the identification label.

Explosion Protection Guidelines

According to EN 50021 (Electrical apparatus for potentially explosive atmospheres; Type of protection “n”)

II 3 G EEx nA II T3..T6

Mark for Australia and New Zealand

Our products satisfy the requirements of Standard AS/NZS CISPR 11 (Class A).

Warning

You will recognize the approval assigned to your product from the mark on the identification label. The opprovals are listed below UL/CSA or cULus.

UL Approval

UL recognition mark
Underwriters Laboratories (UL) to the UL 508 Standard:

- Report E 85972

CSA Approval

CSA certification mark
Canadian Standard Association (CSA) to Standard C 22.2 No. 142:

- Certification Record 212191-0-000

or

cULus Approval

Underwriters Laboratories Inc. nach

- UL 508 (Industrial Control Equipment)
- CSA C22.2 No. 142 (Pocess Control Equipment)

or

cULus Certification, Hazardous Location

HAZ. LOC.

CULUS Listed 7RA9 INT. CONT. EQ. FOR HAZ. LOC.

Underwriters Laboratories Inc. nach

- UL 508 (Industrial Control Equipment)
- CSA C22.2 No. 142 (Pocess Control Equipment)
- UL 1604 (Hazardous Location)
- CSA-213 (Hazardous Location)

APPROVED for Use in

- Cl. 1, Div. 2, GP. A, B, C, D T4A
- Cl. 1, Zone 2, GP. IIC T4

Please read the notes below.

or
cULus Certification, Hazardous Location for relay modules

CULUS Listed 7RA9 INT. CONT. EQ. FOR HAZ. LOC.

Underwriters Laboratories Inc. nach

- UL 508 (Industrial Control Equipment)
- CSA C22.2 No. 142 (Pocess Control Equipment)
- UL 1604 (Hazardous Location)
- CSA-213 (Hazardous Location)

APPROVED for Use in

- Cl. 1, Div. 2, GP. A, B, C, D T4A
- Cl. 1, Zone 2, AEx nC IIC T4
- Cl. 1, Zone 2, Ex nC IIC T4

Please read the notes below.

Warning

This plant has to be mounted according to the NEC (National Electric Code) stipulations.

When used in environments according to class I, division 2 (see above), S7-400 must be mounted in a housing that corresponds to at least IP54 according to EN 60529.

For information on the operation of an S7-400 in potentially explosive areas of Zone 2, refer to the separate document included in this documentation package.

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cuULu requirements on hazardous location on the battery power supply for CPUs

The power supply to the backup battery of a CPU must be via a non-incendive plug. The figure below portrays the concept of such connection.

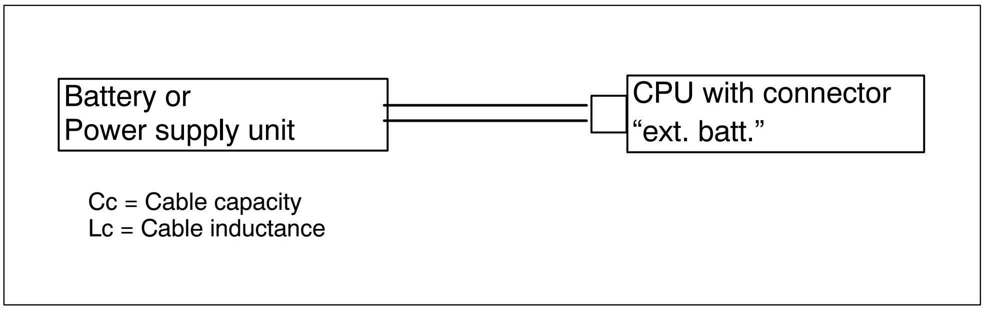


Figure 1-1 Power supply to the backup battery

The following conditions apply to the performance characteristics of this connection:

Voc (no load voltage) = 15V	Vmax = 15V
Isc (short–circuit current)= 50 mA	Imax = 50 mA
Ca = Battery capacity/ power supply	Ci = 25 nF maximum
La= Battery inductance/ power supply	Li = 2 mH maximum

The battery/power supply which supplies the non–ingnitable connection must have the following values:

Battery/Power supply		CPU iput “Ext. Batt.” incl. cabel
Voc	≤	Vmax (15V)
Isc	≤	Imax (50 mA)

Battery/Power supply		CPU iput “Ext. Batt.” incl. cable
Ca	≥	Ci + Cc (25nF + Cc)
La	≥	Li + Lc (2mH + Lc)

The batteries used must have the following properties:

- Battery technology: Li/SOCL2
- Model: AA
- Voltage: 3.6 V

The batteries stipulated by Siemens fulfil requirements that go beyond the ones mentioned above.

You may only use batteries approved by Siemens !

Warning

If you do not know the capacity and inductance of the cable, you can use the following values:

Cc = 197 pF/m (60 pF/ft.), Lc = 0.66 pF/m (0.2 mH/ft)

Example

The battery of type 4022 from Varta together with a 1.5 m long cable and a plug connection of type 02–02.1500 from Leonhardy meet these conditions.

FM Approval

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

Temperature class: T4 at 60 °C ambient temperature

Warning

Personal injury or property damage can result.

In hazardous areas, personal injury or property damage can result if you create or break an electrical circuit during operation of an S7-400 (for example, by means of plug-in connections, fuses, switches).

Do not create or break live electric circuits unless you are certain there is no danger of explosion.

If you use S7-400 under FM conditions, it has to be mounted in a housing, which at least corresponds to IP54 in accordance with EN 60529.

Marine approvals

Classification organizations:

- ABS (American Bureau of Shipping)
- BV (Bureau Veritas)
- DNV (Det Norske Veritas)
- GL (Germanischer Lloyd)
- LRS (Lloyds Register of Shipping)
- Class NK (Nippon Kaiji Kyokai)

Safety Requirements for Installation

The S7-400 programmable controllers are “open type” equipment to the IEC 61131-2 standard and therefore adhere to the EU directive 73/23/EEC “Low-Voltage Directive” and are UL/CSA certified as such.

To fulfill requirements for safe operation with regard to mechanical stability, flame retardance, stability, and shock-hazard protection, the following alternative types of installation are specified:

- Installation in a suitable cabinet
- Installation in a suitable housing
- Installation in a suitably equipped, enclosed operating area.

1.2 Electromagnetic Compatibility

Introduction

In this section you will find information on the noise immunity of S7-400 modules and on radio interference suppression.

All the components of S7-400 automation systems meet the requirements of the standards that apply in Europe provided they are installed in accordance with all the appropriate regulations (see *Installation Manual,* Chapters 2 and 4).

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.

Warning

Personal injury or property damage can result.

Installation of expansions that have not been approved for the S7-400 can result in violations of the requirements and regulations for safety and electromagnetic compatibility.

Use only expansions that have been approved for the system.

Pulse-Shaped Interference

The following table shows the electromagnetic compatibility of modules when there are pulse-shaped disturbance variables. A requirement for this is that the S7-400 system complies with the relevant requirements and guidelines on electric design.

Table 1-3 Pulse-Shaped Interference

Pulse-Shaped Interference	Test Voltage	Degree of Severity
Electrostatic discharge To IEC 61000-4-2	Discharge to air: ±8 kV Contact discharge: ±6 kV	3
Bursts (fast transient interference in accordance with IEC 61000-4-4)	2 kV (power supply line) 2 kV (signal line > 30 m) 1 kV (signal line < 30 m)	3
Energy-rich single impulse (surge) to IEC 61000-4-5		3
• Asymmetrical coupling	2 kV (supply line) DC voltage with protective elements 2 kV (signal line/data line > 30 m only), possibly with protective elements	
• Symmetrical coupling	1 kV (supply line) DC voltage with protective elements 1 kV (signal line > 30 m only), possibly with protective elements	

Sinusoidal Interference

The following table shows you the EMC behavior of the S7-400 modules when there is sinusoidal interference.

Table 1-4 Sinusoidal Interference

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

Table 1-5 Interference emission of electromagnet fields

Frequency Range	Limit Value
From 20 to 230 MHz	30 dB (μV/m)Q
From 230 to 1000 MHz	37 dB (μV/m)Q
Measured at a distance of 30 m (98.4 ft.)	

Emitted interference via the mains AC power supply in accordance with EN 55011: Limit value class A, group 1.

Table 1-6 Interference emission via the mains AC power supply

Frequency Range	Limit Value
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

System Perturbation

The S7-400 AC Power Supply Modules fulfill the requirements of the following standards for system perturbation:

Harmonic currents: EN 61000-3-2

Voltage fluctuations and flicker EN 61000-3-3

Additional Measures

If you want to connect an S7-400 system to the public power system, you must ensure compliance with **limit value class B in accordance with EN 55022**.

Suitable additional measures must be taken, if you need to enhance the noise immunity of the system as a result of high external noise levels.

1.3 Shipping and Storage Conditions for Modules and Backup Batteries

Shipping and Storage of Modules

S7-400 modules surpass the requirements of IEC 61131-2 in respect of shipping and storage requirements. The following details apply to modules shipped and/or stored in their original packing.

The climatic conditions conform to IEC 60721, Part 3-3, Class 3K7 for storage and IEC 60721, Part 3-2, Class 2K4 for transport.

The mechanical conditions conform to IEC 60721, Part 3-2, Class 2M2.

Table 1-7 Shipping and Storage Conditions for Modules

	Permitted Range
Free fall	≤ 1 m (up to 10 kg)
Temperature	–40 °C to +70 ° C
Atmospheric pressure	1080 to 660 hPa (corresponds to a height of -1000 to 3500 m)
Relative humidity (at +25 °C)	5 to 95 %, without condensation
Sinusoidal oscillations to IEC 60068-2-6	5 to 9 Hz: 3.5 mm 9 to 500 Hz: 9.8 m/s^2
Shock to IEC 60068-2-29	250 m/s^2, 6 ms, 1000 shocks

Shipping of Backup Batteries

Wherever possible, transport backup batteries in their original packing. No special measures are required for the transport of the backup batteries used in the S7-400 system. The lithium component of the backup battery is less than 0.5 g.

Storing Backup Batteries

Backup batteries must be stored in a cool, dry place. The maximum storage time is 10 years.

Warning

Risk of injury, material damage, release of hazardous substances.

Lithium batteries can explode if handled improperly. Their improper disposal may result in the release of hazardous substances. Strictly adhere to the following instructions:

- Do not throw a new or low battery into an open fire and do not perform any soldering work on the cell casing (max. temperature 100 °C). Do not recharge the battery – risk of explosion! Do not open a battery. Replace a faulty battery onoly with the same type. Replacement batteries can be ordered from SIEMENS (for order numbers, refer to the *"Module data" reference manual,* in appendix C). This will insure that your are installing a short circuit-proof type.
- Always try to return low batteries to the manufacturer or deliver these to a registered recycling company.

1.4 Mechanical and Ambient Climatic Conditions for Operating the S7-400

Operating Conditions

The S7-400 is designed for weather-protected use as a permanent installation. The S7-400 fulfills the requirements for use in accordance with IEC 60721-3-3:

- Class 3M3 (mechanical requirements)
- Class 3K3 (ambient climatic conditions)

Use with Additional Measures

The S7-400, 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 S7-400 in a cabinet or in a housing.

Ambient Mechanical Conditions

The ambient mechanical conditions for S7-400 modules are listed in the following table in the form of sinusoidal oscillations.

Table 1-8 Mechanical Conditions

Frequency Range in Hz	Test Values
$10 \leq f < 58$	0.075 mm amplitude
$58 \leq f < 500$	1 g constant acceleration

Reducing Vibrations

If the S7-400 is subject to high levels of shock or vibration, you must take suitable measures to reduce the acceleration or amplitude.

We recommend that you install the S7-400 on vibration-damping materials (for example, rubber-metal antivibration mountings).

Tests for Ambient Mechanical Conditions

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

Table 1-9 Ambient Mechanical Conditions Test

Test ...	Test Standard	Remarks
Vibrations	Vibration test in accordance with IEC 60068-2-6 (sinusoidal)	Type of oscillation: frequency sweeps with a rate of change of 1 octave/minute. 10 Hz ≤ f < 58 Hz, constant amplitude 0.075 mm 58 Hz ≤ f < 500 Hz, constant acceleration 1 g Duration of oscillation: 10 frequency sweeps per axis in each of three axes perpendicular to each other
Shock	Shock test in accordance with IEC 60068-2-29	Type of shock: half-sine Severity of shock: 10 g peak value, 6 ms duration Direction of shock: 100 shocks in each of the 3 axes arranged vertically to each other

Ambient Climatic Conditions

You can use the S7-400 under the following ambient climatic conditions:

Table 1-10 Ambient Climatic Conditions

Climatic Conditions	Permitted Range	Remark
Temperature	0 to +60 °C	
Temperature change	Max. 10 °C/h	
Relative humidity	Max. 95 % at +25 °C	No condensation, corresponds to RH stressing level 2 in accordance with IEC 61131-2
Atmospheric pressure	1080 to 795 hPa (corresponds to a height of -1000 to 2000 m)	
Concentration of contaminants	SO_2: < 0.5 ppm; RH < 60 %, no condensation H_2S: < 0.1 ppm; RH < 60 %, no condensation	Test: 10 ppm; 4 days Test: 1 ppm; 4 days

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

Test Voltages

Insulation resistance was demonstrated in routine testing with the following test voltages in accordance with IEC 61131-2:

Table 1-11 Test Voltages

Circuits with Rated Voltage U_e to Other Circuits or Ground	Test Voltage
0 V < U_e ≤ 50 V	350 V
50 V < U_e ≤ 100 V	700 V
100 V < U_e ≤ 150 V	1300 V
150 V < U_e ≤ 300 V	2200 V

Protection Class

Safety class I to IEC 60536 (VDE 0106, Part 1). In other words, a connection is required from the protective conductor to the power supply module.

Protection Against Ingress of Foreign Bodies and Water

Degree of protection IP 20 to IEC 60529. In other words, there is protection against contact with standard probes.

There is no special protection against the ingress of water.

Racks

2

Chapter Overview

2.1 Function and Structure of the Racks

Introduction

The racks in the S7-400 have the following tasks:

- They hold the modules
- They supply the modules with operating voltage
- They connect the individual modules to each other via the signal buses

Structure of the Racks

A rack consists of the following elements:

- Mounting rail with threaded bolts for fixing the modules and lateral cutouts for mounting the rack
- Plastic parts that function, among other things, as guides when swinging the modules into place.
- A backplane bus, an I/O bus and, if necessary, a communication bus with bus connector
- Connection for local ground

Figure 2-1 shows the mechanical configuration of a rack (UR1).

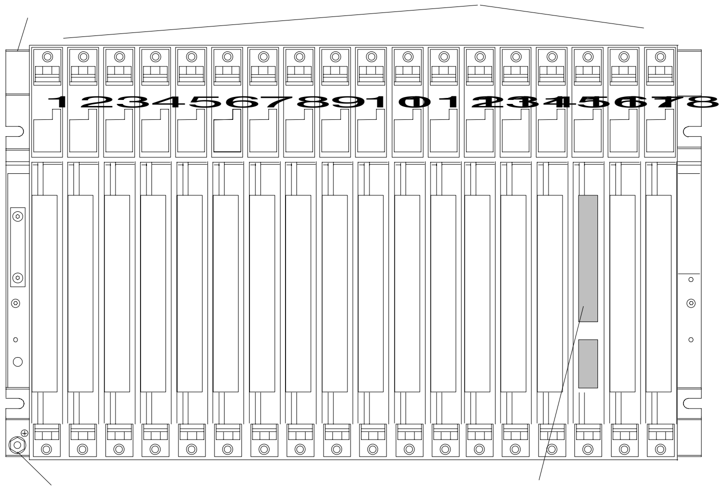


Figure 2-1 Structure of a Rack with 18 Slots

UL/CSA Note

Special requirements should be taken into consideration in the area of influence of the UL/CSA; these may be fulfilled by installing the system in a cabinet.

2.2 The Racks UR1; (6ES7400-1TA01-0AA0) and UR2; (6ES7400-1JA01-0AA0)

Introduction

The UR1 and UR2 racks are used for assembling central racks and expansion racks. The UR1 and UR2 racks have both an I/O bus and a communication bus.

Suitable Modules for UR1 and UR2

You can use the following modules in the UR1 and UR2 racks:

- When the UR1 or UR2 is used as a central rack:
  All S7-400 modules with the exception of receive IMs
- When the UR1 or UR2 is used as an expansion rack:
  All S7-400 modules with the exception of CPUs and send IMs

  Special case: Power supply modules cannot be used in conjunction with the IM 461-1 receive IM.

Structure of the UR1 and UR2

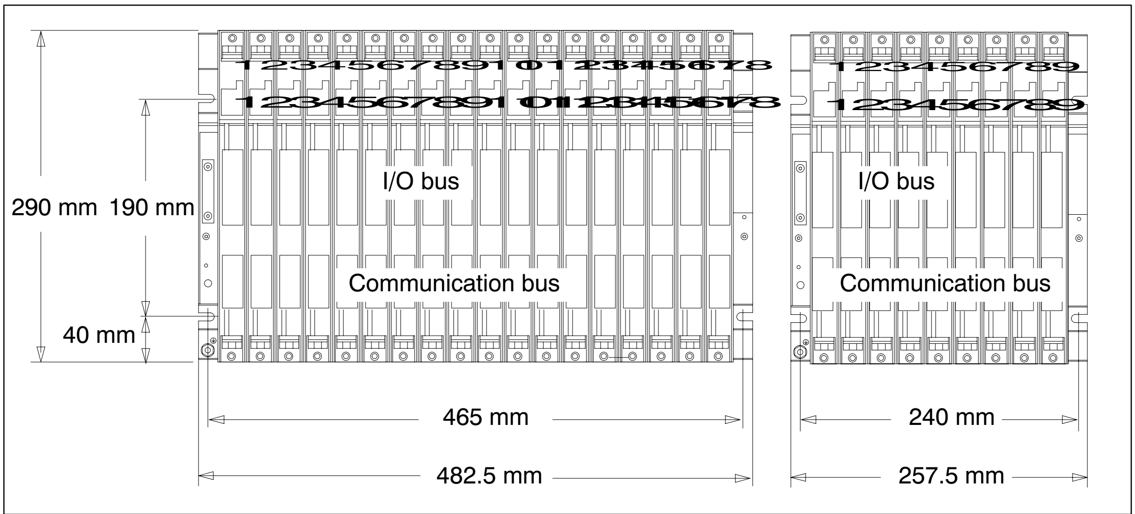


Figure 2-2 Dimensions of the UR1 18-Slot or UR2 9-Slot Rack

Technical Specifications of the UR1 and UR2 Racks

Rack	UR1	UR2
Number of single-width slots	18	9
Dimensions W x H x D (in mm)	482.5 x 290 x 27.5	257.5 x 290 x 27.5
Weight (in kg)	4.1	2.15
Buses	I/O bus and communication bus	

2.3 The Rack UR2-H; (6ES7400-2JA00-0AA0)

Introduction

The UR2-H rack is used for assembling two central racks or expansion racks in one rack. The UR2-H rack essentially represents two electrically isolated UR2 racks on the same rack profile. The main area of application of the UR2-H is in the compact structure of redundant S7-400H systems (two devices or systems in one rack).

Suitable Modules for the UR2-H

You can use the following modules in the UR2-H rack:

When the UR2-H is used as a central rack:

- All S7-400 modules with the exception of receive IMs

When the UR2-H is used as an expansion rack:

- All S7-400 modules apart from CPUs, send IMs, the IM 463-2, and the adapter module

  Special case: Power supply modules cannot be used in conjunction with the IM 461-1 receive IM.

Structure of the UR2-H

Figure 2-3 shows the structure of the UR2-H rack with 2 x 9 slots.

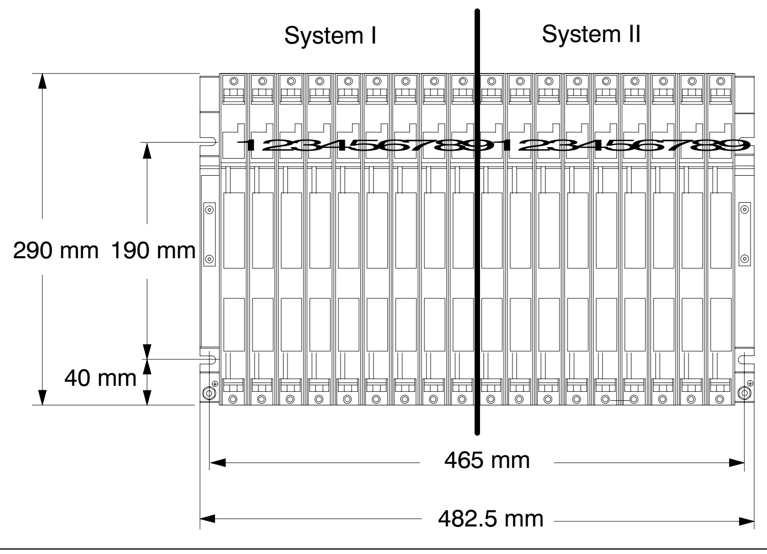


Figure 2-3 Rack Dimensions

Caution

Danger of damage to equipment.

If you insert a power supply module in a slot that is not permitted for power supply modules, the module may be damaged. Slots 1 to 4 are permitted, whereby power supply modules starting from slot 1 must be inserted without leaving gaps.

Make sure that power supply modules are only inserted in permitted slots. Take particular notice of the option of swapping modules in slot 1 on rack II and slot 9 on rack I.

Technical Specifications of the UR2-H Rack

Rack	UR2-H
Number of single-width slots	2 x 9
Dimensions W x H x D (in mm)	482.5 x 290 x 27.5
Weight (in kg)	4.1
Buses	Segmented I/O bus, segmented communication bus

2.4 The Rack CR2; (6ES7401-2TA01-0AA0)

Introduction

The CR2 rack is used for assembling segmented central racks. The CR2 has both an I/O bus and a communication bus. The I/O bus is split into two local bus segments with 10 or 8 slots.

Suitable Modules for the CR2

You can use the following modules in the CR2 rack:

- All S7-400 modules with the exception of receive IMs

Structure of the CR2

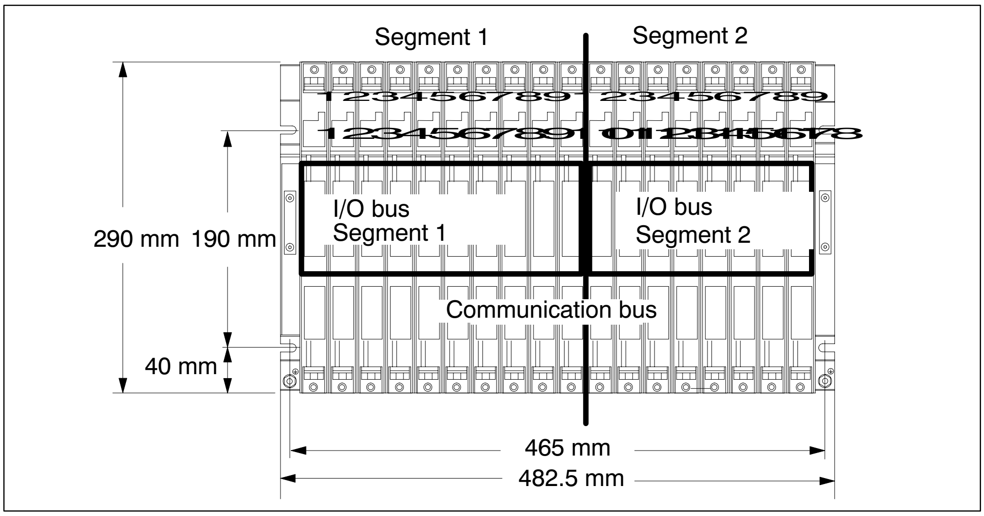


Figure 2-4 CR2 Rack

Technical Specifications of the CR2 Rack

Rack	CR2
Number of single-width slots	18
Dimensions W x H x D (in mm)	482.5 x 290 x 27.5
Weight (in kg)	4.1
Busses	Segmented I/O bus, continuous communication bus
Only one power supply module required	

2.5 The Rack CR3; (6ES7401-1DA01-0AA0)

Introduction

The CR3 rack is used for the assembly of CRs in standard systems (not in fault-tolerant systems). The CR3 has an I/O bus and a communication bus.

Suitable Modules for CR 3

You can use the following modules in CR3:

- All S7-400 modules with the exception of receive IMs
- You can only use the CPU 414-4H and CPU 417-4H in stand-alone operation.

Structure of the CR3

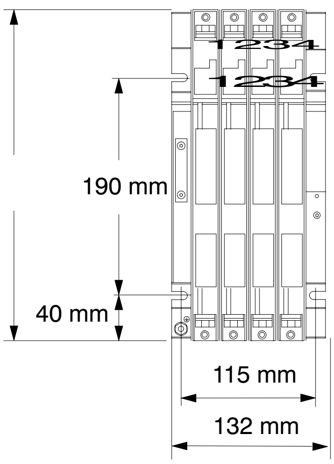


Figure 2-5 CR3 Rack

Technical Specifications of the CR3 Rack

Rack	CR3
Associated programming package	As of STEP 7 V 5.1; ServicePack 3
Number of single-width slots	4
Dimensions W x H x D (in mm)	122.5 x 290 x 27.5
Weight (in kg)	0.75
Buses	I/O bus and communication bus

2.6 The Racks ER1; (6ES7403-1TA01-0AA0) and ER2; (6ES7403-1JA01-0AA0)

Introduction

The ER1 and ER2 racks are used for assembling expansion racks.

The ER1 and ER2 racks have only one I/O bus with the following restrictions:

- Interrupts from modules in the ER1 or ER2 have no effect since there are no interrupt lines provided.
- Modules in the ER1 or ER2 are not supplied with 24 V. Modules requiring a 24 V supply are not provided for use in the ER1 or ER2.
- Modules in the ER1 or ER2 are not backed up either by the battery in the power supply module or by the voltage supplied externally to the CPU or the receive IM (EXT.-BATT. socket).

  There is therefore no advantage in using backup batteries in the power supply modules in ER1 and ER2.

  Battery faults and backup voltage faults are not reported to the CPU.
  The battery monitoring function of a power supply module installed in the ER1 or ER2 should therefore always be switched off.

Suitable Modules for ER1 and ER2

You can use the following modules in the ER1 and ER2 racks:

- All power supply modules
- Receive IMs
- All signal modules provided the above-mentioned restrictions are observed.

However: Power supply modules cannot be used in conjunction with the IM 461-1 receive IM.

Structure of ER1 and ER2

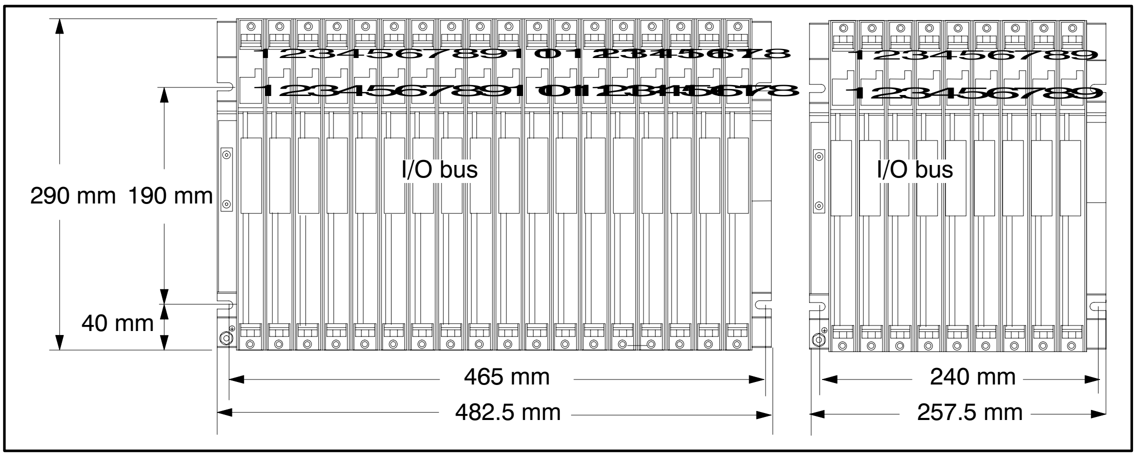


Figure 2-6 ER1 Rack with 18 Slots and ER2 Rack with 9 Slots

Technical Specifications of the ER1 and ER2 Racks

Rack	ER1	ER2
Number of single-width slots	18	9
Dimensions W x H x D (in mm)	482.5 x 290 x 27.5	257.5 x 290 x 27.5
Weight (in kg)	2.5 3.8 as of version 03	1.25 2.0 as of version 03
Busses	Restricted I/O bus	Restricted I/O bus

Power Supply Modules

3

Chapter Overview

3.1 Common Characteristics of the Power Supply Modules

Tasks of the Power Supply Modules

The power supply modules of the S7-400 supply the other modules in the rack with their operating voltages via the backplane bus. They do not provide load voltages for the signal modules.

Common Characteristics of the Power Supply Modules

The power supply modules share certain common characteristics in addition to their special technical specifications. The most important common characteristics are:

- Encapsulated design for use in mounting racks of the S7-400 system
- Cooling via natural convection
- Plug-in connection of the supply voltage with AC - DC coding
- Protection class I (with grounding conductor) to IEC 61140; VDE 0140, Part 1
- Limiting of the inrush current according to NAMUR recommendation NE 21
- Short circuit-proof outputs
- Monitoring of both output voltages. If one of these voltages fails, the power supply module signals a fault to the CPU.
- Both output voltages (5 VDC and 24 VDC) share a common ground.
- Primary clocked
- Battery backup as option. The parameters set and the memory contents (RAM) are backed up via the backplane bus in the CPUs and programmable modules. In addition, the backup battery enables you to carry out a restart of the CPU. Both the power supply module and the backed up modules monitor the battery voltage.
- Operating and fault/error LEDs on the front plate.

Warning

A mains disconnector must be provided when installing AC power supply modules.

Switching the Line Voltage Off/On

The power supply modules have a making-current limiter in accordance with NAMUR.

Power Supply Module in Invalid Slot

If you insert the power supply module of a rack in an invalid slot, it will not power up. In this case, proceed as follows to start up the power supply module correctly:

1. Disconnect the power supply module from the mains (not just the standby switch).
2. Remove the power supply module.
3. Install the power supply module in slot 1.
4. Wait at least 1 minute and then switch the line voltage on again.

Caution

Damage can result.

If you insert the power supply module in a slot that is not intended for power supply modules, the module may be damaged. Slots 1 to 4 are permissible as long as you start at slot 1 and leave no gaps.

Make sure that power supply modules are only inserted in permissible slots.

3.2 Redundant Power Supply Modules

Order Numbers and Function

Table 3-1 Redundant power supply modules

Type	Order Number	Input Voltage	Output Voltage	See Section
PS 407 10A R	6ES7407-0KR00-0AA0	85 VAC to 264 VAC or 88 VDC to 300 VDC	5 VDC/10 A and 24 VDC/1 A	3.8
PS 407 10A R	6ES7 407-0KR02-0AA0	85 to 264 VAC or 88 to 300 VDC	5 VDC/10 A and 24 VDC/1 A	
PS 405 10A R	6ES7405-0KR00-0AA0	19.2 VDC to 72 VDC	5 VDC/10 A and 24 VDC/1 A	3.14
PS 405 10A R	6ES7 405-0KR02-0AA0	19.2 to 72 VDC	5 VDC/10 A and 24 VDC/1 A	

Redundant Operation

If you use two power supply modules of type PS 407 10A R or PS 405 10A R, you can install a redundant power supply on a mounting rack. We recommend this if you want to increase the availability of your programmable controller, particularly if you are operating it on an unreliable power system.

Configuring a Redundant Power Supply

Redundant operation is possible with any of the S7 CPUs and racks described in this manual. STEP 7 as of V4.02 is also required.

To set up a redundant power supply, insert a power supply module in slots 1 and 3 of the rack. You can then insert as many modules as can be supplied by a single power supply module. In other words, in redundant operation all the modules can only draw a total of 10 A.

Characteristics

The redundant power supply of an S7-400 has the following characteristics:

- The power supply module delivers a making current in accordance with NAMUR.
- Each of the power supply modules can take over the supply of power to the whole rack if the other one fails. There is no loss of operation.
- Each of the power supply modules can be exchanged while the system is in operation. No loss of power and no peak stress occurs with the effective voltages when the modules are removed or inserted.
- Each of the power supply modules monitors its function and sends a message if it fails.
- Neither of the power supply modules can generate an error which affects the output voltage of the other power supply module.
- A redundant battery concept (backup concept) is only provided when two backup batteries are used in each of the power supply modules. If only one battery is used in each module, only non-redundant backup is possible, since both batteries are being used at the same time.
- The failure of a power supply module is registered via a plug and remove interrupt (default STOP). If used in the second segment of the CR 2 is no message sent if the power supply module fails.
- If two power supply modules are inserted but only one is switched on, there is a power-up delay of up to one minute when the line voltage is switched on.

Warning

The check box “Startup if preset configuration not equal to actual configuration” should be activated in the “Properties” dialog box of the CPU.

3.3 Backup Battery (Option)

Introduction

The power supply modules of the S7-400 have a battery compartment for one or two backup batteries. Use of these batteries is optional.

Function of the Backup Batteries

If backup batteries have been installed, the parameters set and the memory contents (RAM) will be backed up via the backplane bus in CPUs and programmable modules if the supply voltage fails. The battery voltage must be within the tolerance range.

In addition, the backup battery enables you to carry out a restart of the CPU after power-on.

Both the power supply module and the backed up modules monitor the battery voltage.

Attention

Insert the power supply module into the rack and switch it on before you insert a backup battery for the first time. This will extend the battery life.

Power Supply Modules With Two Backup Batteries:

Some power supply modules contain a battery compartment for two batteries. If you use two batteries and set the switch to 2BATT, the power supply module defines one of the two batteries as the backup battery. This assignment remains in force until the battery is empty. When the backup battery is completely discharged, the system switches to the reserve battery which is then in turn used as the backup battery for the duration of its life. The status “backup battery” is also stored in the event of a power failure.

Battery Type

Only batteries approved by Siemens must be used (see Appendix C: Spare Parts)

The batteries can form a passivation layer. Depassivation takes place when the batteries are inserted in the power supply module.

Technical Specifications of the Backup Battery

Backup Battery	
Order number	6ES7971-0BA00
Type	1 x lithium AA
Rated voltage	3.6 V
Rated capacity	2.3 Ah

Backup Times

The maximum backup time is based on the capacity of the backup batteries used and the backup current in the rack. The backup current is the sum of all individual currents of the inserted backed-up modules as well as the requirements of the power supply module when the power is switched off.

Example for the Calculation of Backup Times

The capacity of the batteries is listed in the technical specifications of the power supply. The typical and maximum backup current of the backed-up module is listed in the technical specifications of the module.

The typical backup current of a CPU is an empirically determined value. The maximum backup current is a worst-case value that is calculated based on the corresponding manufacturer specifications for the memory blocks.

The following technical specifications produce backup times for a CR with a PS 407 4A (6ES7407-0DA02-0AA0) and a CPU 417-4 (6ES7417-4XL04-0AB0) as the only backed-up module:

Capacity of the backup battery: 2.3 Ah

Maximum backup current (including own requirement at power off) of the power supply:100 µA

Typical backup current of the CPU 417-4: 600 µA

A rated capacity of less than 100% is to be assumed when calculating the backup time because the backup battery is also affected at power on by the regular depassivation.

A battery capacity of 63% of the rated capacity produces the following values:

Backup time = 2.3 Ah * 0.63 / (100 + 600) µA = (1.197 / 700) * 1 000 000 = 2070 h

This produces a maximum backup time of 86 days.

3.4 Controls and Indicators

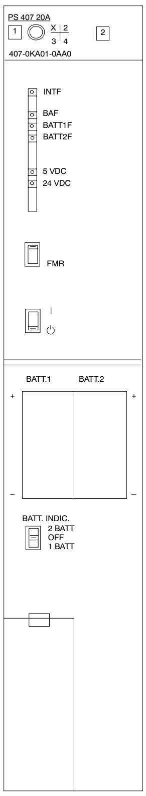
Introduction

The power supply modules of the S7-400 have essentially the same controls and indicators.The main differences are:

- Power supply modules with a backup battery have an LED (BATTF) that indicates an empty, defective, or missing backup battery.
- Power supply modules with two redundant backup batteries have two LEDs (BATT1F and BATT2F) to indicate empty, defective or missing backup batterie

Operator Controls and Indicators

Figure 3-1 shows you an example of a power supply module (PS 407 20A) with two (redundant) backup batteries. The LEDs are at the top left of the module front plate.



- Fixing screw
- LEDs INTF,
  BAF, BATT1F, BATT2F,
  5 VDC, 24 VDC
- FMR pushbutton (Failure Message Re-set)
- Standby switch (does not cut off mains)

Under cover

- Battery compartment
- Switches BATT. INDIC.
  2 BATT, OFF, 1 BATT
- 3-pin plug–in power connector
- Fixing screw

Figure 3-1 Controls and Indicators of the PS 407 20A

Meaning of the LEDs

The meaning of the LEDs on the power supply modules is described in the tables below. Section 3.5 contains a list of the faults indicated by these LEDs and notes on how to acknowledge the faults.

INTF, 5 VDC, 24 VDC

Table 3-2 INTF, DC 5V, DC 24 V LEDs

LED	Color	Meaning
INTF	red	Lights up in the event of an internal fault
5 VDC	green	Lights up as long as the 5 V voltage is within the tolerance limits
24 VDC	green	Lights up as long as the 24 V voltage is within the tolerance limits

BAF, BATTF

Power supply modules with a backup battery have the following indicators:

Table 3-3 BAF, BATTF LEDs

LED	Color	Meaning
BAF	Red	Lights up if the battery voltage on the backplane bus is too low and the BATT.INDIC. switch is at the BATT position
BATTF	Yellow	Lights up if the battery is empty, if the polarity is reversed, or if the battery is missing, and the BATT.INDIC. switch is at the BATT position

BAF, BATT1F, BATT2F

Power supply modules with two backup batteries have the following indicators:

Table 3-4 BAF, BATT1F, BATT2F LEDs

LED	Color	Meaning
BAF	Red	Lights up if the battery voltage on the backplane bus is too low and the BATT.INDIC. switch is at the 1 BATT or 2 BATT position
BATTF	Yellow	Lights up if battery 1 is empty or if the polarity is reversed or if the battery is missing, and the BATT.INDIC. switch is at the 1 BATT or 2 BATT position
BATTF	Yellow	Lights up if battery 2 is empty or if the polarity is reversed, or if the battery is missing, and the BATT.INDIC. switch is at the 2 BATT position

Battery Voltage on the Backplane Bus

The battery voltage is either supplied by the backup battery or externally into the CPU or receive IM. In its normal state, the level of the battery voltage is between 2.7 V and 3.6 V.

The battery voltage is monitored for the lower limit. Violation of the lower limit is indicated by the BAF LED and reported to the CPU.

BAF lights up if the battery voltage on the backplane bus is too low. Possible causes of this include:

- Battery (batteries) empty or battery polarity has been reversed.
- External supply via CPU or receive IM is defective or supply from secondary power supply module is defective or missing.
- Short circuit or overload on the battery voltage.

Warning

Due to internal capacities, if you remove the battery or switch off the external supply, some time may elapse before BAF, BATT1F, or BATT2F lights up.

Function of the Operator Controls

Table 3-5 Function of the operator controls of the power supply modules

FMR momentary-contact pushbutton	For acknowledging and resetting a fault indicator after correcting the fault
Standby switch	Switches the output voltages (5 VDC/24 VDC) to 0 V by intervening in the control loop (no mains disconnection). • ▮: Output voltages at rated value • ⏻ : Output voltages 0 V
BATT.INDIC. switch	Used for setting LEDs and battery monitoring Where one battery can be used (PS 407 4A, PS 405 4A): • OFF: LEDs and monitor signals inactive • BATT: BAF/BATTF LEDs and monitor signals active Where two batteries can be used (PS 407 10A, PS 407 20A, PS 405 10A, PS 405 20A): • OFF: LEDs and monitor signals inactive • 1 BATT: Only BAF/BATT1F LEDs (for battery 1) active. • 2 BATT: BAF/BATT1F/BATT2F LEDs (for batteries 1 and 2) active.
Battery compartment	For backup battery (batteries)
Power connection	3-pin connector for line voltage connection (do not plug in or remove when power is on).

Cover

The battery compartment, battery selector switch, voltage selector switch and power connection are housed under one cover. The cover must remain closed during operation in order to protect these operator controls and to prevent static electricity from affecting the battery connections.

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.

3.5 Fault/Error Messages via LEDs

Introduction

The power supply modules of the S7-400 indicate module faults and backup battery faults via LEDs on the front plate.

Overview of the Fault/Error Messages

Table 3-6 Error messages of the power supply modules

Type of Fault/Error	LEDs
Module fault	INTF 5 VDC 24 VDC
Backup battery fault	Power supplies with 1 backup battery: BAF BATTF
	Power supplies with 2 backup batteries: BAF BATT1F BATT2F

INTF, 5 VDC, 24 VDC

The following table shows the faults indicated by the INTF, 5 VDC, and 24 VDC LEDs and lists how to remedy the faults.

The status of the BAF, BATTF, BATT1F, and BATT2F LEDs is not relevant here.

Table 3-7 INTF, DC5V, DC24V LEDs

LED			Cause of Fault	Remedy
INTF	**DC5V**	**DC24V**		
D	D	D	Standby switch in ⏻ position	Set standby switch to the | position
			Line voltage missing	Check line voltage
			Internal fault, power supply module defective	Replace power supply module
			Cutoff after overvoltage on 5 V or illegal external supply	Disconnect from mains and reconnect after approximately 3 minutes; if necessary, remove external supply
			Power supply module operated in wrong slot	Install the power supply module in the correct slot (slot 1)
			Short circuit or overload on 5 V	Switch off the power supply module, remove the source of the short circuit; after approximately 3 seconds, the power supply module can be switched on with the standby switch or via the power system.*
D	L	D	Overvoltage on 24 V	Check if the supply is external; if not, replace power supply module
D	D*	D	Short circuit or overload on 5 V and 24 V and temperature overflow	Check load on the power supply module. Possibly remove modules Wait 5 minutes before you restart the power supply module
L	L	D	If the standby switch is at the ⏻ position, illegal external supply on 5 V	Remove all modules. Determine which module is faulty
			If the standby switch is at the position |, short-circuit or overload on 24 V	Check load on the power supply module. Possibly remove modules
D	F	L	Voltage restored after short circuit or overload on 5 V if faults occur in operation	Press FMR momentary-contact pushbutton: Flashing light changes to constant light
			Dynamic overload on 5 V	Check load on the power supply module. Possibly remove modules
D	L	F	Voltage restored after short-circuit or overload on 24 V if faults occur in operation	Press FMR momentary-contact pushbutton: Flashing light changes to constant light
			Dynamic overload on 24 V	Check load on the power supply module. Possibly remove modules

Table 3-7 INTF, DC5V, DC24V LEDs, continued

LED			Cause of Fault	Remedy
INTF	DC5V	DC24V		
D	F	F	Voltage restored after short circuit or overload on 5 V and 24 V if faults occur in operation	Press FMR momentary-contact pushbutton: Flashing light changes to constant light
D	F	F	Dynamic overload on 5 V and 24 V	Check load on the power supply module. Possibly remove modules

D = LED is dark; L = LED lights up; F = LED flashing;

* If the power supply module does not start up again after a few seconds once the overload has been removed, remove power to the module for 5 minutes and thenswitch it on again. If the module still does not start up, replace it. This applies to the following power supply modules:

- 6ES7 407-0KA01-0AA0, release 3
- 6ES7407-0KR00-0AA0, release ≤ 5
- 6ES7407-0KA01-0AA0, release ≥ 10
- 6ES7405-0DA02-0AA0, 6ES7407-0DA02-0AA0
- 6ES7405-0KA02-0AA0, 6ES7407-0KA02-0AA0
- 6ES7405-0KR02-0AA0, 6ES7407-0KR02-0AA0
- 6ES7405-0RA02-0AA0, 6ES7407-0RA02-0AA0

Tripping of the integrated overtemperature protection produces the same behavior.

If either the 5 VDC or 24 VDC LEDs remains dark after switching on, the system has not powered up.

If either of the 5 VDC or 24 VDC LEDs of the PS 407 10AR remains dark for longer than 1 or 2 seconds after it is switched on, the power supply module will not start up.

The following power supply modules will switch off in the event of a short circuit oroverload after 1 s to 3 s. The module will try to restart after no more than 3 s. If theerror has been eliminated by then, the module will start up. This applies to thefollowing modules:

PS 405 4A	(6ES7405-0DA01-0AA0)	PS 407 4A	(6ES7407-0DA01-0AA0)
PS 405 4A	(6ES7405-0DA02-0AA0)	PS 407 4A	(6ES7407-0DA02-0AA0)
PS 405 10A	(6ES7405-0KA01-0AA0)	PS 407 10A release ≥5	(6ES7407-0KA01-0AA0),
PS 405 10A	(6ES7405-0KA02-0AA0)	PS 407 10A	(6ES7407-0KA02-0AA0)
PS 405 10A R	(6ES7405-0KR00-0AA0)	PS 407 10A R release ≥7	(6ES7407-0KR00-0AA0),
PS 405 10A R	(6ES7405-0KR02-0AA0)	PS 407 10A R	(6ES7407-0KR02-0AA0)
PS 405 20A	(6ES7405-0RA01-0AA0)	PS 407 20A	(6ES7407-0RA01-0AA0)
		PS 407 20A	(6ES7407-0RA02-0AA0)

Overload at 24 V

In the event of overload at 24 V the output current is electronically limited to a value between 100% and 150% of the rated value. If the voltage then goes below the undervoltage threshold of 19.2 V (–0/+ 5% corresponds to 19.2 V to 20.16 V), the modules respond as follows:

- In the case of the power supply modules, the 24 V voltage is switched off and then switched on again at a repeat rate of approx. 0.5 to 1 s until anoutput voltage greater than the low–voltage threshold is built up.
- he voltage of 6ES7407-0KA01-0AA0, 6ES740x-0KR00-0AA0 and 6ES740x-0RA01-0AA0 power supply modules is automatically adjusted according to the load resistance, the modules operate within the characteristics curve.

After the overload has been eliminated, the voltage returns to the rated range and the green 24 V LED flashes. The CPU sets the EXTF LED (external fault) and saves the fault in the diagnostic buffer. You can trigger other responses, such as CPU STOP or a message to a control room, in OB 81 (power supply error). If OB 81 is not parameterized, the CPU continues as normal.

Overload at 5 V

In the event of an overload at 5V, the power supply modules with 10 A or 20 A output current can retain an output current of 16 A or 26 A for 300ms. The power supply modules with 4 A output current can retain an output current of 6 A for 300 ms. The CPU will then go to DEFECT afterwards. If the LED DC 5 V flashes on the power supply and is resettable with the FMR button, you will be able to perform a restart. The CPU will remain in STOP afterwards and will then require a memory reset.

BAF, BATTF

The following table applies to power supply modules with one battery if the BATT.INDIC. switch is in the BATT position. It shows the faults indicated and lists how to remedy the faults.

Table 3-8 BAF, BATTF; BATT.INDIC. LEDs on BATT

LED		Cause of Fault	Remedy
BAF	BATTF		
L	L	Battery empty or missing No backup voltage available	Insert new battery. Press FMR momentary-contact pushbutton
D	L	Battery empty or missing	Insert new battery. Press FMR momentary-contact pushbutton
		Battery has been stored for too long	Depassivate battery (see *Installation Manual*, Chapter 7)
L	D	Battery in order No backup voltage available (short circuit)	• Fault after plugging in a module: Plugged-in module defective • Fault after switching on: Remove all modules and plug in individually
D	D	Battery in order	–

D = LED is dark; L = LED lights up;

BAF, BATT1F, BATT2F

The following table applies to power supply modules with two batteries if the BATT.INDIC. switch is in the 1BATT position. It shows the faults indicated and lists how to remedy the faults.

Nothing is indicated about the condition of any second battery that may be in use.

Table 3-9 BAF, BATT1F, BATT2F; BATT.INDIC. LEDs on 1BATT

LED			Cause of Fault	Remedy
BAF	**BATT1F**	**BATT2F**		
L	L	D	Battery 1 empty or missing No backup voltage available	Insert new battery in compartment 1. Press FMR momentary-contact pushbutton
D	L	D	Battery 1 empty or missing	Insert new battery in compartment 1. Press FMR momentary-contact pushbutton
			Battery has been stored for too long	Depassivate battery (see *Installation Manual*, Chapter 6)
L	D	D	Battery 1 in order No backup voltage available (short circuit)	• Fault after plugging in a module: Plugged-in module defective • Fault after switching on: Remove all modules and plug in individually
D	D	D	Battery 1 in order	–

D = LED is dark; L = LED lights up;

The following table applies to power supply modules with two batteries if the BATT.INDIC. switch is in the 2BATT position. It shows the faults indicated and lists how to remedy the faults.

Table 3-10 BAF, BATT1F, BATT2F; BATT.INDIC. LEDs on 2BATT

<table>
<tr><th colspan="3">LED</th><th rowspan="2">Cause of Fault</th><th rowspan="2">Remedy</th></tr>
<tr><th>BAF</th><th>BATT1F</th><th>BATT2F</th></tr>
<tr><td>L</td><td>L</td><td>L</td><td>Both batteries are empty or missing.
No backup voltage available</td><td>Insert new batteries in compartments 1 and 2
Press FMR momentary-contact pushbutton</td></tr>
<tr><td>D</td><td>L</td><td>L</td><td>Both batteries empty or missing
Backup voltage available</td><td>Insert new batteries in compartments 1 and 2
Press FMR momentary-contact pushbutton</td></tr>
<tr><td>L</td><td>L</td><td>D</td><td>Battery 1 empty or missing
No backup voltage available
(short circuit or overload)</td><td>Insert new battery in compartment 1.
Press FMR momentary-contact pushbutton
• Fault after plugging in a module: Plugged-in module defective
• Fault after switching on: Remove all modules and plug in individually</td></tr>
<tr><td>D</td><td>L</td><td>D</td><td>Battery 1 empty or missing
Battery has been stored for too long
Backup voltage available</td><td>Insert new battery in compartment 1.
Press FMR momentary-contact pushbutton
Depassivate battery
(see Installation Manual, Chapter 6)</td></tr>
<tr><td>L</td><td>D</td><td>L</td><td>Battery 2 empty or missing

No backup voltage available
(short-circuit or overload)</td><td>Insert new battery in compartment 2.
Press FMR momentary-contact pushbutton
• Fault after plugging in a module: Plugged-in module defective
• Fault after switching on: Remove all modules and plug in individually</td></tr>
<tr><td>D</td><td>D</td><td>L</td><td>Battery 2 empty or missing
Battery has been stored for too long
Backup voltage available</td><td>Insert new battery in compartment 2.
Press FMR momentary-contact pushbutton
Depassivate battery
(see Installation Manual, Chapter 6)</td></tr>
<tr><td>L</td><td>D</td><td>D</td><td>Both batteries in order.
No backup voltage available
(short circuit)</td><td>• Fault after plugging in a module: Plugged-in module defective
• Fault after switching on: Remove all modules and plug in individually</td></tr>
<tr><td>D</td><td>D</td><td>D</td><td>Both batteries in order.
Backup voltage available</td><td>–</td></tr>
</table>

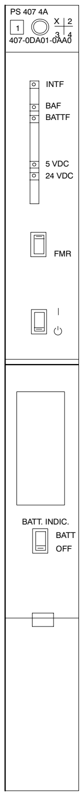
D = LED is dark; L = LED lights up;

3.6 Power Supply Module PS 407 4A; (6ES7407-0DA01-0AA0)

Function

The PS 407 4A power supply module is designed for connecting to either an AC line voltage of 85 to 264 V or a DC line voltage of 88 to 300 V and supplies 5 VDC/4 A and 24 VDC/0.5 A on the secondary side.

Controls and Indicators of the PS 407 4 A



- Fixing screw
- LEDs INTF, BAF, BATTF, DC 5 V, DC 24 V
- FMR pushbutton (Failure Message Reset)
- Standby switch (does not cut off mains)

Under cover

- Battery compartment
- Switches BATT. INDIC. BATT, OFF
- 3-pin plug-in power connector
- Fixing screw

Figure 3-2 Controls and Indicators of the PS 407 4 A

Power connection

An AC power connector is used for connecting the PS 407 4A to both an AC and DC supply.

Polarity Reversal of L+ and L–

Thepolarity reversal of L+ and L– at supply voltages of between 88 VDCand 300 VDC has no effect on the function of the power supply. The connectionshould be made as described in the instructions in the Installation Manual, Chapter 6.

Technical Specifications of the PS 407 4A

Dimensions, Weight and Cable Cross–Sections	
Dimensions WxHxD (mm)	25x290x217
Weight	0.76 kg
Cable cross–section	3x1.5 mm^2 (litz wire with wire end ferrule with insulating collar; use flexible sheath cable only)
Cable diameter	3 to 9 mm
Input Rating	
Input voltage	
• Rated value	120/230 VDC 120/230 VAC
• Permitted range	88 to 300 VDC 85 to 264 VAC (long–range input)
System frequency	
• Rated value	50/60 Hz
• Permitted range	47 to 63 Hz
Rated input current	
• At 120 VAC	0.42 A
• At 120 VDC	0.35 A
• At 230 VAC	0.22 A
• At 230 VDC	0.19 A
Inrush current	
• At 230 VAC	Peak value 8.5 A Half–value width 5 ms
• At 300 VDC	Peak value 8.5 A Half–value width 5 ms
Leakage current	< 3.5 mA

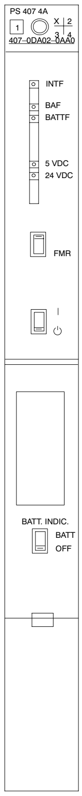
Output Rating	
Output voltages	
• Rated values	5.1/24 VDC
Output currents	
• Rated values	5 VDC: 4 A 24 VDC: 0.5 A
Other Parameters	
Protection class in accordance with IEC 61140	I, with protective grounding conductor
Overvoltage category	II
Pollution severity	2
Rated voltage U_e	Test voltage
$0 < U_e \leq 50$ V	700 VDC (secondary <–> PE)
150 V $< U_e \leq 300$ V	2300 VDC (primary <–> secondary/PE)
Buffering of power failures	> 20 ms Complies with the NE 21 NAMUR recommendation at a repeat rate of 1s
Power input 230 VAC	52 W
Power loss	20 W
Backup current	Max. 100 μA at power off
Backup battery (option)	1 x lithium AA, 3.6 V/2.3 Ah
Protective separation to IEC 61131-2	Yes

3.7 Power supply module PS 407 4A; (6ES7407-0DA02-0AA0)

Function

The PS 407 4A power supply module is designed for connecting to either an ACline voltage of 85 to 264 V or a DC line voltage of 88 to 300 V andsupplies 5 VDC/4 A and 24 VDC/0.5 A on the secondary side.

Controls and Indicators of the PS 407 4A



- Fixing screw
- LEDs INTF,
  BAF, BATTF,
  5 VDC, 24 VDC
- FMR pushbutton (Failure Message Reset)
- Standby switch (does not cut off mains)

Under cover

- Battery compartment
- Switches BATT. INDIC.
  BATT, OFF
- 3-pin plug–in power connector
- Fixing screw

Figure 3-3 Controls and Indicators of the PS 407 4A

Power Connection

An AC connector is used for connecting the PS 407 4A toboth an AC and a DC supply.

Polarity Reversal of L+ and L–

Thepolarity reversal of L+ and L– at supply voltages of between 88 VDCand 300 VDC has no effect on the function of the power supply. The connectionshould be made as described in the instructions in the Installation Manual, Chapter 6.

Technical Specifications of the PS 407 4A

Dimensions, Weight and Cable Cross–Sections	
Dimensions WxHxD (mm)	25x290x217
Weight	0.76 kg
Cable cross–section	3x1.5 mm^2 (litz wire with wire end ferrule with insulating collar; use flexible sheath cable only)
Cable diameter	3 to 9 mm
Input Rating	
Input voltage	
• Rated value	120/230 VDC 120/230 VAC
• Permitted range	88 to 300 VDC 85 to 264 VAC (long–range input)
System frequency	
• Rated value	50/60 Hz
• Permitted range	47 to 63 Hz
Rated input current	
• At 120 VAC	0.42 A
• At 120 VDC	0.35 A
• At 230 VAC	0.22 A
• At 230 VDC	0.19 A
Inrush current	
• At 230 VAC	Peak value 8.5 A Half–value width 5 ms
• At 300 VDC	Peak value 8.5 A Half–value width 5 ms
Leakage current	< 3.5 mA

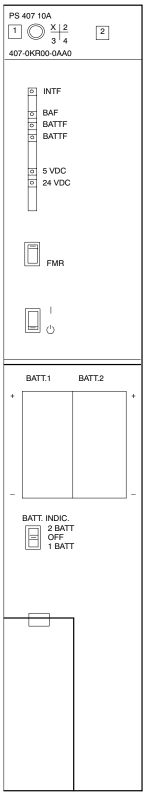
Output Rating	
Output voltages	
• Rated values	5.1/24 VDC
Output currents	
• Rated values	5 VDC: 4 A 24 VDC: 0.5 A
Other Parameters	
Protection class in accordance with IEC 61140	I, with protective grounding conductor
Overvoltage category	II
Pollution severity	2
Rated voltage U_e	Test voltage
$0 < U_e \leq 50$ V	700 VDC (secondary <–> PE)
$150 \text{ V} < U_e \leq 300$ V	2300 VDC (primary <–> secondary/PE)
Buffering of power failures	> 20 ms Complies with the NE 21 NAMUR recommendation at a repeat rate of 1s
Power input 230 VAC	52 W
Power loss	20 W
Backup current	Max. 100 µA at power off
Backup battery (option)	1 x lithium AA, 3.6 V/2.3 Ah
Protective separation to IEC 61131-2	Yes

3.8 Power Supply Modules PS 407 10A; (6ES7407-0KA01-0AA0) and PS 407 10A R; (6ES7407-0KR00-0AA0)

Function

The PS 407 10A (standard) and PS 407 10A R (redundant, see Chapter 3.2) power supply modules are designed for connecting to either an ACline voltage of 85 to 264 VAC or a DC line voltage of 88 to 300 VDC andsupply 5 VDC/10 A and 24 VDC/1 A on the secondary side.

Controls and Displays of the PS 407 10A and the PS 407 10A R



- Fixing screw
- LEDs INTF,
  BAF, BATT1F, BATT2F,
  5 VDC, 24 VDC
- FMR pushbutton (Failure Message Reset)
- Standby switch (does not cut off mains)

Under cover

- Battery compartment
- Switches BATT. INDIC.
  2 BATT, OFF, 1 BATT
- 3-pin plug-in power connector
- Fixing screw

Figure 3-4 Controls and Displays of the PS 407 10A and PS 407 10A R

Power Connection

An AC connector is used for connecting the PS 407 10A and the PS 407 10A R to both an AC and a DC supply.

Polarity Reversal of L+ and L-

The polarity reversal of L+ and L- with supply voltages of between 88 VDC and 300 VDC has no effect on the function of the power supply. The connection should be made as described in the instructions in the Installation Manual, Chapter 4.

Technical Specifications of the PS 407 10A and the PS 407 10A R

Dimensions, Weight, and Cable Cross-Sections	
Dimensions WxHxD (mm)	50x290x217
Weight	1.36 kg
Cable cross-section	1.2 kg, PS 407 as of version 10 3 x 1.5 mm^2 (litz wire with wire end ferrule with insulating collar; use only flexible sheath cable)
Cable diameter	3 to 9 mm
Input Rating	
Input voltage	
• Rated value	110/230 VDC 120/230 VAC
• Permitted range	88 to 300 VDC, 85 to 264 VAC (long-range input)
System frequency	
• Rated value	50 / 60 Hz
• Permitted range	47 to 63 Hz
Rated input current	
• At 120 VAC	0.9 A
• At 110 VDC	1.0 A
• At 230 VAC	0.5 A
• At 230 VDC	0.6 A (0.5 A*) 0.5 A
Inrush current	
• At 230 VAC	Peak value 230 A Half–value width 200 µs Peak value 63 A* Half–value width 1 ms*
• At 300 VDC	Peak value 230 A Half–value width 200 µs Peak value 58 A* Half–value width 1 ms*
Leakage current	< 3.5 mA

Output Variables	
Output voltages	
• Rated values	5.1 VDC /24 VDC
Output currents	
• Rated values	5 VDC: 10 A 24 VDC: 1.0 A
Other Parameters	
Protection class in accordance with IEC 61140	I, with protective grounding conductor
Overvoltage category	II
Pollution severity	2
Rated voltage U_e	Test Voltage
$0 < U_e \leq 50$ V	700 VDC (secondary <–> PE)
$150\ V < U_e \leq 300$ V	2300 VDC (primary <–> secondary/PE)
Buffering of power failures:	> 20 ms Complies with the NAMUR recommendation NE 21 at a repeat rate of 1 s
Power input	105 W, PS 407 10A as of version 5 105 W, PS 407 10A R as of version 7 95 W, PS 407 10A as of version 10
Power loss	29.7 W 20 W, PS 407 10A as of version 10
Backup current	Max. 100 µA at power off
Backup batteries (optional)	2 x Lithium AA, 3.6 V / 2.3 Ah
Protective separation to IEC 61131-2	Yes

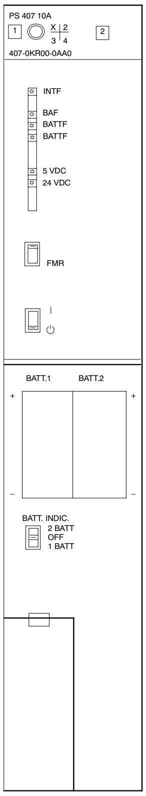
* PS 407 10A as of release 5,
* PS 407 10A R as of release 7

3.9 Power Supply Modules PS 407 10A; (6ES7407-0KA02-0AA0) and PS 407 10A R; (6ES7407-0KR02-0AA0)

Function

The PS 407 10A (standard) and PS 407 10A R (redundant, see Chapter 3.2) power supply modules are designed for connecting to either an ACline voltage of 85 to 264 VAC or a DC line voltage of 88 to 300 VDC andsupply 5 VDC/10 A and 24 VDC/1 A on the secondary side.

Controls and Displays of the PS 407 10A and the PS 407 10A R



- Fixing screw
- LEDs INTF,
  BAF, BATT1F, BATT2F,
  5 VDC, 24 VDC
- FMR pushbutton (Failure Message Reset)
- Standby switch (does not cut off mains)

Under cover

- Battery compartment
- Switches BATT. INDIC.
  2 BATT, OFF, 1 BATT
- 3-pin plug-in power connector
- Fixing screw

Figure 3-5 Controls and Displays of the PS 407 10A and PS 407 10A R

Power Connection

An AC connector is used for connecting the PS 407 10A and the PS 407 10A R to both an AC and a DC supply.

Polarity Reversal of L+ and L-

The polarity reversal of L+ and L- with supply voltages of between 88 VDC and 300 VDC has no effect on the function of the power supply. The connection should be made as described in the instructions in the Installation Manual, Chapter 4.

Technical Specifications of the PS 407 10A and the PS 407 10A R

Dimensions, Weight, and Cable Cross-Sections	
Dimensions WxHxD (mm)	50x290x217
Weight	1.2 kg
Cable cross-section	1.2 kg, PS 407 as of version 10 3 x 1.5 mm^2 (litz wire with wire end ferrule with insulating collar; use only flexible sheath cable)
Cable diameter	3 to 9 mm
Input Rating	
Input voltage	
• Rated value	110/230 VDC 120/230 VAC
• Permitted range	88 to 300 VDC, 85 to 264 VAC (long-range input)
System frequency	
• Rated value	50 / 60 Hz
• Permitted range	47 to 63 Hz
Rated input current	
• At 120 VAC	0.9 A
• At 110 VDC	1.0 A
• At 230 VAC	0.5 A
• At 230 VDC	0.5 A
Inrush current	
• At 230 VAC	Peak value 63 A Half–value width 1 ms
• At 300 VDC	Peak value 58 A Half–value width 1 ms
Leakage current	< 3.5 mA

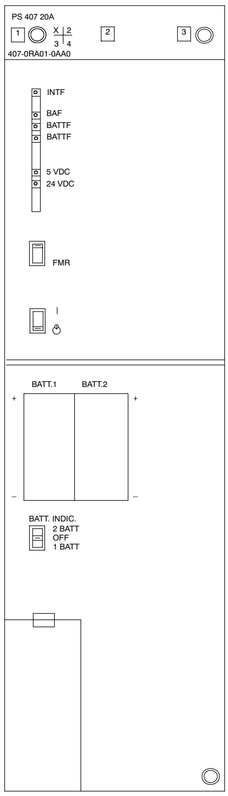
Output Variables	
Output voltages	
• Rated values	5.1 VDC /24 VDC
Output currents	
• Rated values	5 VDC: 10 A 24 VDC: 1.0 A
Other Parameters	
Protection class in accordance with IEC 61140	I, with protective grounding conductor
Overvoltage category	II
Pollution severity	2
Rated voltage U_e	Test Voltage
$0 < U_e \leq 50$ V	700 VDC (secondary <–> PE)
$150 \text{ V} < U_e \leq 300$ V	2300 VDC (primary <–> secondary/PE)
Buffering of power failures:	> 20 ms Complies with the NAMUR recommendation NE 21 at a repeat rate of 1 s
Power input	95 W
Power loss	20 W
Backup current	Max. 100 µA at power off
Backup batteries (optional)	2 x Lithium AA, 3.6 V / 2.3 Ah
Protective separation to IEC 61131-2	Yes

3.10 Power Supply Module PS 407 20A; (6ES7407-0RA01-0AA0)

Function

The PS 407 20 A power supply module is designed for connecting to either an AC line voltage of 85 to 264 VAC or a DC line voltage of 88 to 300 VDC and supplies 5 VDC/20 A and 24 VDC/1 A on the secondary side.

Controls and Indicators of the PS 407 20 A



- Fixing screws
- LEDs INTF,
  BAF, BATT1F, BATT2F, 5 VDC, 24 VDC
- FMR pushbutton (Failure Message Reset)
- Standby switch (does not cut off mains)

Under cover

- Battery compartment
- Switches BATT. INDIC.
  2 BATT, OFF, 1 BATT
- 3-pin plug-in power connector
- Fixing screw

Figure 3-6 Controls and Indicators of the PS 407 20 A

Power Connection

An AC power connector is used for connecting the PS 407 20A to both an AC and DC supply.

Polarity Reversal of L+ and L-

The polarity reversal of L+ and L- with supply voltages of between 88 VDC and 300 VDC has no effect on the function of the power supply. The connection should be made as described in the instructions in the Installation Manual, Chapter 6.

Technical Specifications of the PS 407 20 A

Dimensions, Weight, and Cable Cross-Sections	
Dimensions WxHxD (mm)	75x290x217
Weight	2.2 kg
Cable cross-section	3x1.5 mm ^{2} (litz wire with wire end ferrule with insulating collar; use only flexible sheath cable)
Cable diameter	3 to 9 mm
Input Rating	
Input voltage	
• Rated value	110/230 VDC 120/230 VAC
• Permitted range	88 to 300 VDC, 85 to 264 VAC (long-range input)
System frequency	
• Rated value	50 / 60 Hz
• Permitted range	47 to 63 Hz
Rated input current	
• At 120 VAC / 110 VDC	1.5 A
• At 230 VAC / 230 VDC	0.8 A
Starting current inrush	Peak value 88 A half-value width 1.1 ms
Leakage current	< 3.5 mA

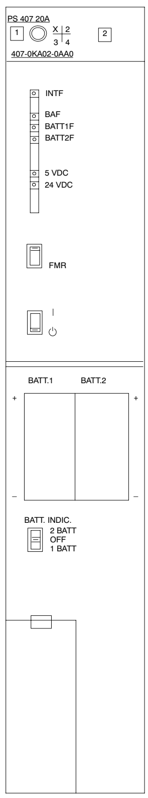
Output Rating	
Output voltages	
• Rated values	5.1 VDC /24 VDC
Output currents	
• Rated values	5 VDC: 20 A 24 VDC: 1.0 A
Other Parameters	
Protection class in accordance with IEC 61140	I, with protective grounding conductor
Overvoltage category	II
Pollution severity	2
Rated voltage U_e	Test Voltage
$0 < U_e \leq 50$ V	700 VDC (secondary <–> PE)
$150 \text{ V} < U_e \leq 300$ V	2300 VDC (primary <–> secondary/PE)
Buffering of power failures:	> 20 ms Complies with the NAMUR recommendation NE 21 at a repeat rate of 1 s
Power input	168 W
Power loss	44 W
Backup current	Max. 100 µA at power off
Backup batteries (optional)	2 x Lithium AA, 3.6 V / 2.3 Ah
Protective separation to IEC 61131-2	Yes

3.11 Power supply module PS 407 20A; (6ES7407-0RA02-0AA0)

Function

The PS 407 4A power supply module is designed for connecting to either an ACline voltage of 85 to 264 V or a DC line voltage of 88 to 300 V andsupplies 5 VDC/20 A and 24 VDC/1 A on the secondary side.

Controls and Indicators of the PS 407 20A



- Fixing screw
- LEDs INTF, BAF, BATT1F, BATT2F, 5 VDC, 24 VDC
- FMR pushbutton (Failure Message Reset)
- Standby switch (does not cut off mains)

Under cover

- Battery compartment
- Switches BATT. INDIC. 2 BATT, OFF, 1 BATT
- 3-pin plug–in power connector
- Fixing screw

Figure 3-7 Controls and Indicators of the PS 407 20A

Power Connection

An AC connector is used for connecting the PS 407 20A toboth an AC and a DC supply.

Polarity Reversal of L+ and L–

Thepolarity reversal of L+ and L– at supply voltages of between 88 VDCand 300 VDC has no effect on the function of the power supply. The connectionshould be made as described in the instructions in the Installation Manual, Chapter 6.

Technical Specifications of the PS 407 20A

Dimensions, Weight and Cable Cross–Sections	
Dimensions WxHxD (mm)	50x290x217
Weight	1.3 kg
Cable cross–section	3x1.5 mm^2 (litz wire with wire end ferrule with insulating collar; use flexible sheath cable only)
Cable diameter	3 to 9 mm
Input Rating	
Input voltage	
• Rated value	120/230 VDC 120/230 VAC
• Permitted range	88 to 300 VDC 85 to 264 VAC (long–range input)
System frequency	
• Rated value	50/60 Hz
• Permitted range	47 to 63 Hz
Rated input current	
• At 120 VAC/120 VDC	1.4 A
• At 230 VAC/230 VDC	0.7 A
Inrush current	Peak value 88 A Half–value width 1.1 ms
Leakage current	< 3.5 mA

Output Rating	
Output voltages	
• Rated values	5.1 to 24 VDC
Output currents	
• Rated values	5 VDC: 20 A 24 VDC: 1.0 A
Other Parameters	
Protection class in accordance with IEC 61140	I, with protective grounding conductor
Overvoltage category	II
Pollution severity	2
Rated voltage U_e	Test voltage
$0 < U_e \leq 50$ V	700 VDC (secondary <–> PE)
$150 \text{ V} < U_e \leq 300$ V	2300 VDC (primary <–> secondary/PE)
Buffering of power failures	> 20 ms Complies with the NE 21 NAMUR recommendation at a repeat rate of 1s
Power input	158 W
Power loss	35 W
Backup current	Max. 100 µA at power off
Backup batteries (option)	2 x lithium AA, 3.6 V/2.3 Ah
Protective separation to IEC 61131-2	Yes

3.12 Power Supply Module PS 405 4A; (6ES7405-0DA01-0AA0)

Function

The PS 405 4A power supply module is designed for connection to a DC line voltage of 19.2 to 72 VDC and supplies 5 VDC/4 A and 24 VDC/0.5 A on the secondary side.

Controls and Indicators of the PS 405 4 A

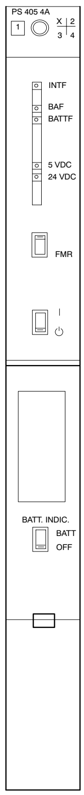


Figure 3-8 Controls and Indicators of the PS 405 4 A

Technical Specifications of the PS 405 4 A

Dimensions, Weight, and Cable Cross-Sections	
Dimensions WxHxD (mm)	25x290x217
Weight	0.76 kg
Cable cross-section	3 x 1.5 mm^2 (litz wire with wire end ferrule; use component conductor or flexible sheath cable)
Cable diameter	3 to 9 mm
Input Rating	
Input voltage	
• Rated value	24/48/60 VDC
• Permitted range	Static: 19.2 VDC to 72 VDC Dynamic: 18.5 VDC to 75.5 VDC
Rated input current	2 A/1 A/0.8 A

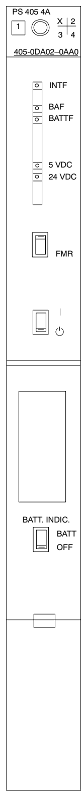
Output Rating	
Output voltages	
• Rated values	5.1 VDC /24 VDC
Output currents	
• Rated values	5 VDC: 4 A 24 VDC: 0.5 A
Other Parameters	
Protection class in accordance with IEC 61140	I, with protective grounding conductor
Overvoltage category	II
Pollution severity	2
Rated voltage U_e	Test Voltage
$0 < U_e \leq 50$ V	700 VDC (secondary <–> PE)
150 V $< U_e \leq 300$ V	2200 VDC (primary <–> secondary/PE)
Buffering of power failures:	> 20 ms Complies with the NAMUR recommendation NE 21 at a repeat rate of 1 s
Power consumption (24 VDC)	48 W
Power loss	16 W
Backup current	Max. 100 µA at power off
Backup battery (option)	1 x Lithium AA, 3.6 V / 2.3 Ah
Protective separation to IEC 61131-2	Yes

3.13 Power supply module PS 405 4A; (6ES7405-0DA02-0AA0)

Function

The PS 407 4A power supply module is designed for connecting to a DC line voltage of 19.2 to 72 VDC andsupplies 5 VDC/4 A and 24 VDC/0.5 A on the secondary side.

Controls and Indicators of the PS 405 4A



- Fixing screw
- LEDs INTF, BAF, BATTF, 5 VDC, 24 VDC
- FMR pushbutton (Failure Message Reset)
- Standby switch

Under cover

- Battery compartment
- Switches BATT. INDIC. BATT, OFF
- 3-pin plug–in power connector
- Fixing screw

Figure 3-9 Controls and Indicators of the PS 405 4A

Technical Specifications of the PS 405 4A

Dimensions, Weight and Cable Cross–Sections	
Dimensions WxHxD (mm)	25x290x217
Weight	0.76 kg
Cable cross–section	3x1.5 mm^2 (litz wire with wire end ferrule; use single conductor or flexible sheath cable)
Cable diameter	3 to 9 mm
Input Rating	
Input voltage	
• Rated value	24/48/60 VDC
• Permitted range	Static: 19.2 to 72 VDC Dynamic: 18.5 to 75,5 VDC
Rated input current	2 A/1 A/0.8 A
Inrush current	Peak value 18 A Half–value width 20 ms

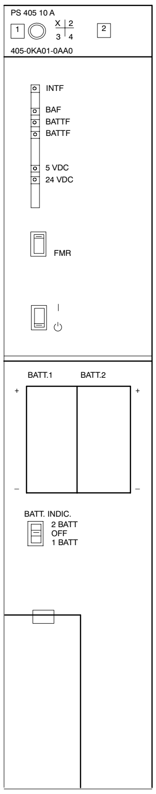
Output Rating	
Output voltages	
• Rated values	5.1/24 VDC
Output currents	
• Rated values	5 VDC: 4 A 24 VDC: 0.5 A
Other Parameters	
Protection class in accordance with IEC 61140	I, with protective grounding conductor
Overvoltage category	II
Pollution severity	2
Rated voltage U_e	Test voltage
$0 < U_e \leq 50$ V	700 VDC (secondary <–> PE)
$150 \text{ V} < U_e \leq 300$ V	2300 VDC (primary <–> secondary/PE)
Buffering of power failures	> 20 ms Complies with the NE 21 NAMUR recommendation at a repeat rate of 1s
Power input (24 VDC)	48 W
Power loss	16 W
Backup current	Max. 100 µA at power off
Backup battery (option)	1 x lithium AA, 3.6 V/2.3 Ah
Protective separation to IEC 61131-2	Yes

3.14 Power Supply Modules PS 405 10A; (6ES7405-0KA01-0AA0) and PS 405 10A R; (6ES7405-0KR00-0AA0)

Function

The power supply modules PS 405 10A (standard) and PS 405 10A R (redundancy-capable, see Section 3.2) are designed for connection to a DC line voltage of 19.2 VDC to 72 VDC and supply 5 VDC/10 A and 24 VDC/1 A on the secondary side.

Controls and Displays of the PS 405 10A and the PS 405 10A R



- Fixing screw
- LEDs INTF,
  BAF, BATT1F, BATT2F,
  5 VDC, 24 VDC
- FMR pushbutton (Failure Message Reset)
- Standby switch

Under cover

- Battery compartment
- Switches BATT. INDIC.
  2 BATT, OFF, 1 BATT
- 3-pin plug-in power connector
- Fixing screw

Figure 3-10 Controls and Displays of the PS 405 10A and PS 405 10A R

Technical Specifications of the PS 405 10A and the PS 405 10A R

Dimensions, Weight, and Cable Cross-Sections	
Dimensions WxHxD (mm)	50x290x217
Weight	1.4 kg
Cable cross-section	3 x 1.5 mm^2 (litz wire with wire end ferrule, use component conductor or flexible sheath cable)
Cable diameter	3 to 9 mm
Input Rating	
Input voltage	
• Rated value	24/48/60 VDC
• Permitted range	Static: 19.2 VDC to 72 VDC Dynamic: 18.5 VDC to 75.5 VDC
Rated input current	4.3 A/2.1 A/1.7 A
Starting current inrush	Peak value 18 A Half-value width 20 ms

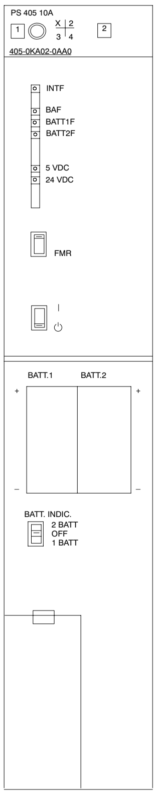
Output Rating	
Output voltages	
• Rated values	5.1 VDC/24 VDC
Output currents	
• Rated values	5 VDC: 10 A 24 VDC: 1.0 A
Other Parameters	
Protection class in accordance with IEC 61140	I, with protective grounding conductor
Overvoltage category	II
Pollution severity	2
Rated voltage U_e	Test Voltage
$0 < U_e \leq 50$ V	700 VDC (secondary <–> PE)
$150 < U_e \leq 300$ V	2300 VDC (primary <–> secondary/PE)
Buffering of power failures:	> 20 ms Complies with the NAMUR recommendation NE 21 at a repeat rate of 1 s
Power input	104 W
Power loss	29 W
Backup current	Max. 100 µA at power off
Backup batteries (optional)	2 x Lithium AA, 3.6 V / 2.3 Ah
Protective separation to IEC 61131-2	Yes

3.15 Power supply modules PS 405 10A; (6ES7405-0KA02-0AA0) and PS 405 10A R; (6ES7405-0KR02-0AA0)

Function

The PS 405 10A (standard) and PS 405 10A R (redundant, see Chapter 3.2) power supply modules are designed for connecting to a DC line voltage of 19.2 to 72 VDC andsupply 5 VDC/10 A and 24 VDC/1 A on the secondary side.

Controls and Indicators of the PS 405 10A and the PS 405 10A R



- Fixing screw
- LEDs INTF, BAF, BATT1F, BATT2F, 5 VDC, 24 VDC
- FMR pushbutton (Failure Message Reset)
- Standby switch

Under cover

- Battery compartment
- Switches BATT. INDIC. 2 BATT, OFF, 1 BATT
- 3-pin plug–in power connector
- Fixing screw

Figure 3-11 Controls and Indicators of the PS 405 10A and PS 405 10A R

Technical Specifications of the PS 405 10A

Dimensions, Weight, and Cable Cross-Sections	
Dimensions WxHxD (mm)	50x290x217
Weight	1.2 kg
Cable cross-section	3 x 1.5 mm^2 (litz wire with wire end ferrule, use component conductor or flexible sheath cable)
Cable diameter	3 to 9 mm
Input Rating	
Input voltage	
• Rated value	24/48/60 VDC
• Permitted range	Static: 19.2 VDC to 72 VDC Dynamic: 18.5 VDC to 75.5 VDC
Rated input current	4.0 A/2.0 A/1.6 A
Starting current inrush	Peak value 18 A Half-value width 20 ms

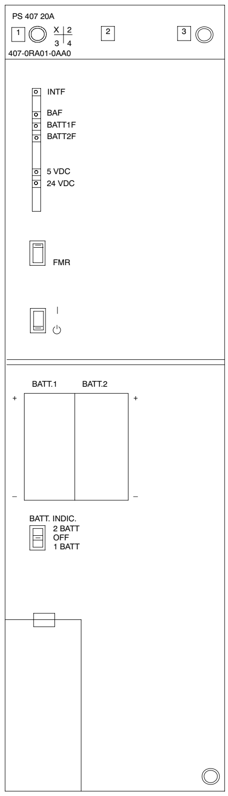
Output Rating	
Output voltages	
• Rated values	5.1 VDC/24 VDC
Output currents	
• Rated values	5 VDC: 10 A 24 VDC: 1.0 A
Other Parameters	
Protection class in accordance with IEC 61140	I, with protective grounding conductor
Overvoltage category	II
Pollution severity	2
Rated voltage U_e	Test Voltage
$0 < U_e \leq 50$ V	700 VDC (secondary <–> PE)
$150 < U_e \leq 300$ V	2300 VDC (primary <–> secondary/PE)
Buffering of power failures:	> 20 ms Complies with the NAMUR recommendation NE 21 at a repeat rate of 1 s
Power input	95 W
Power loss	20 W
Backup current	Max. 100 µA at power off
Backup batteries (optional)	2 x Lithium AA, 3.6 V / 1.9 Ah
Protective separation to IEC 61131-2	Yes
EN 50021 category 3, zone 2	Yes

3.16 Power Supply Module PS 405 20A; (6ES7405-0RA01-0AA0)

Function

The PS 405 20A power supply module is designed for connection to a DC line voltage of 19.2 VDC to 72 VDC and supplies 5 VDC/20 A and 24 VDC/1 A on the secondary side.

Controls and Indicators of the PS 405 20 A



- Fixing screws
- LEDs INTF, BAF, BATT1F, BATT2F, 5 VDC, 24 VDC
- FMR pushbutton (Failure Message Reset)
- Standby switch (does not cut off mains)

Under cover

- Battery compartment
- Switches BATT. INDIC. 2 BATT, OFF, 1 BATT
- 3-pin plug–in power connector
- Fixing screw

Figure 3-12 Controls and Indicators of the PS 405 20A

Technical Specifications of the PS 405 20 A

Dimensions, Weight, and Cable Cross-Sections	
Dimensions WxHxD (mm)	75x290x217
Weight	2.2 kg
Cable cross-section	3x1.5 mm^2 (litz wire with wire end ferrule; use component conductor or flexible sheath cable)
Cable diameter	3 to 9 mm
Input Rating	
Input voltage	
• Rated value	24/48/60 VDC
• Permitted range	Static: 19.2 VDC to 72 VDC Dynamic: 18.5 VDC to 75.5 VDC
Rated input current	7.3 A/3.45 A/2.75 A
Starting current inrush	Peak value 56 A half-value width 1.5 ms

Output Rating	
Output voltages	
• Rated values	5.1 VDC/24 VDC
Output currents	
• Rated values	5 VDC: 20 A 24 VDC: 1.0 A
Other Parameters	
Protection class in accordance with IEC 61140	I, with protective grounding conductor
Overvoltage category	II
Pollution severity	2
Rated voltage U_e	Test Voltage
$0 < U_e \leq 50$ V	700 VDC (secondary <–> PE)
$150 \text{ V} < U_e \leq 300$ V	2300 VDC (primary <–> secondary/PE)
Buffering of power failures:	> 20 ms Complies with the NAMUR recommendation NE 21 at a repeat rate of 1 s
Power input	175 W
Power loss	51 W
Backup current	Max. 100 μA at power off
Backup batteries (optional)	2 x Lithium AA, 3.6 V / 2.3 Ah
Protective separation to IEC 61131-2	Yes

4 Digital Modules

Structure of the Chapter

The present chapter is subdivided 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

Additional Information

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

Chapter Overview

4.1 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 4-1 Digital Input Modules: Characteristics at a Glance

Module / Characteristics	SM 421; DI 32 x 24 VDC (-1BL0x-)	SM 421; DI 16 x 24 VDC (-7BH00-)	SM 421; DI 16 x 120 VAC (-5EH00-)	SM 421; DI 16 x 24/60 VUC (-7DH00-)	SM 421; DI 16 x 120/230 VUC (-1FH00-)	SM 421; DI 16 x 120/230 VUC (-1FH20-)	SM 421; DI 32 x 120 VUC (-1EL00-)
Number of inputs	32 DI; isolated in groups of 32	16 DI; isolated in groups of 8	16 DI; isolated in groups of 1	16 DI; isolated in groups of 1	16 DI; isolated in groups of 4	16 DI; isolated in groups of 4	32 DI; isolated in groups of 8
Rated input voltage	24 VDC	24 VDC	120 VAC	24 VUC to 60 VUC	120 VAC/ 230 VDC	120/230 VUC	120 VAC/ VDC
Suitable for...	Switches Two-wire proximity switches (BEROs)						
Programmable diagnostics	No	Yes	No	Yes	No	No	No
Diagnostic Interrupt	No	Yes	No	Yes	No	No	No
Hardware interrupt upon edge change	No	Yes	No	Yes	No	No	No
Adjustable input delays	No	Yes	No	Yes	No	No	No
Substitute value output	–	Yes	–	–	–	–	–
Special Features	High packaging density	Quick and with interrupt capability	Channel-specific isolation	Interrupt capability with low, variable voltages	For high, variable voltages	For high, variable voltages Input characte-ristic curve to IEC 61131-2	High packaging density

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

Module / Characteristics	SM 422; DO 16 x 24 VDC/2 A (-1BH1x)	SM 422; DO 16 x 20-125 VDC/1.5 A (-5EH10)	SM 422; DO 32 x 24 VDC/ 0.5 A (-1BL00)	SM 422; DO 32 x 24 VDC/0.5 A (-7BL00)	SM 422; DO 8 x 120/230 VAC/5 A (-1FF00)	SM 422; DO 16 x 120/230 VAC/2 A (-1FH00)	SM 422; DO 16 x 20-120 VAC/2 A (-5EH00)
Number of outputs	16 DO; isolated in groups of 8	16 DO; isolated and reverse polarity protection in groups of 8	32 DO; isolated in groups of 32	32 DO; isolated in groups of 8	8 DO; isolated in groups of 1	16 DO; isolated in groups of 4	16 DO; isolated in groups of 1
Output current	2 A	1.5 A	0.5 A	0.5 A	5 A	2 A	2 A
Rated load voltage	24 VDC	20 to 125 VDC	24 VDC	24 VDC	120/ 230 VAC	120/ 230 VAC	20 to 120 VAC
Programmable diagnostics	No	Yes	No	Yes	No	No	Yes
Diagnostic Interrupt	No	Yes	No	Yes	No	No	Yes
Substitute value output	No	Yes	No	Yes	No	No	Yes
Special Features	For high currents	For variable voltages	High packaging density	Particularly quick and with interrupt capability	For high currents with channel-specific isolation	–	For variable currents with channel-specific isolation

Table 4-3 Relay Output Module: Characteristics at a Glance

Module / Characteristics	SM 422; DO 16 x 30/230 VUC/Rel. 5 A (-1HH00)
Number of Outputs	16 outputs, isolated in groups of 8
Load Voltage	125 VDC 230 VAC
Special Features	–

4.2 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 4-4 Sequence of Steps from Choosing to Commissioning the Digital Module

Step	Procedure	Refer To...
1.	Select the module	Section 4.1 and specific module section from Section 4.7
2.	Install the module in the SIMATIC S7 network	“Installation” section in the manual *S7-400 Programmable Controllers, Hardware and Installation*
3.	Assign parameters to module	Section 4.3 and, if necessary, the specific module section as of Section 4.7
4.	Commission configuration	Section on commissioning in the manual *S7-400 Programmable Controllers, Hardware and Installation*
5.	If commissioning was not successful, diagnose configuration	Section 4.4

4.3 Digital Module Parameter Assignment

Introduction

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

Tools for Parameter Assignment

You assign parameters to digital modules in *STEP 7*.

When you have set all the parameters, download the parameters from the programming device to the CPU. When there is a transition from STOP to RUN mode, the CPU 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 in the current user program in an S7 programmable controller 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.

Configuration in RUN (CiR)

The parameters are divided into static and dynamic parametersCiR (Configuration in RUN) is a method you can use to modify your system or edit the parameters of individual modules. These changes are made while your system is in operation, that is, your CPU will stay in RUN over a period of max. two seconds while these changes are applied.

For detailed information on this topic, refer to the “Configuration in RUN by means of CiR” manual. This manual is found, for example, as a file in PDF format on your included STEP 7 CD.

4.3.1 Parameters of the Digital Input Modules

The parameterized digital input modules use a subset of the parameters and ranges of values listed in the table below, depending on functionality. Refer to the section on a particular digital module, starting from Section 4.7, to find out which subset it is capable of using.

Don't forget that some digital modules have different time delays after parameter assignment.

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

Table 4-5 Parameters of the Digital Input Modules

Parameter	Value Range	Default[2]	Parameter Type	Scope
Enable • Diagnostic interrupt[1)] • Hardware interrupt[1)]	Yes/no Yes/no	No No	Dynamic	Module
• Destination CPU for interrupt	1 to 4	–	Static	Module
Diagnostics • Wire break • No load voltage L+/sensor supply	Yes/no Yes/no	No No	Static	Channel
Trigger for hardware interrupt • Rising (positive) edge • Falling (negative) edge	Yes/no Yes/no	No No	Dynamic	Channel
Input delay	0.1 ms (DC) 0.5 ms (DC) 3 ms (DC) 20 ms (DC/AC)	3 (DC)	Static	Channel
Reaction to error	Substitutea value (SV) Keep last value (KLV)	SV	Dynamic	Module
Substitute"1"	Yes/no	No	Dynamic	Channel [3)]

1) If you use the module in ER-1/ER-2, you must set this parameter to "No" because the interrupt lines are not available in ER-1/ER-2.

2) Only in the CC (central controller) is It possible to start up the digital modules with the default settings and without HWCONFIG support.

3) Channels not selected for substitution value "1" are set to substitution value "0".

4.3.2 Parameters of the Digital Output Modules

The parameterized digital 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 relevant digital module, starting from Section 4.16, to find out which subset it is capable of using.

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

Table 4-6 Parameters of the Digital Output Modules

Parameter	Value Range	Default[2]	Parameter Type	Scope
Enable • Diagnostic interrupt[1]	Yes/no	No	Dynamic	Module
• Destination CPU for interrupt	1 to 4	–	Static	Module
Reaction to CPU-STOP	Substitute a value (SV) Keep last value (KLV)	SV	Dynamic	Module
Diagnostics • Wire break • No load voltage L+ • Short circuit to M • Short circuit to L+ • Fuse blown	 Yes/no Yes/no Yes/no Yes/no Yes/no	 No No No No No	Static	Channel
Substitute “1”	Yes/no	No	Dynamic	Channel [3]

1) If you use the module in ER-1/ER-2, you must set this parameter to “No” because the interrupt lines are not available in ER-1/ ER-2.

2) Only in the CC (central controller) is it possible to start up the digital modules with the default settings and without support from HWCONFIG.

3) Channels not selected for substitution value “1” are set to substitution value “0”.

4.4 Diagnostics of the Digital 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 block in *STEP 7* (refer to Section 5.7).

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 diagnostics of the digital module, forwarded to the CPU and can be read out by the user program.
- The fault LED on the digital module lights up.
- If you have parameterized “Enable Diagnostic Interrupt” in STEP 7, a diagnostic interrupt is triggered and OB 82 is called (refer to Section 4.5).

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 the *STEP 7* online help system).

Diagnostics Using the INTF and EXTF LEDs

Some digital modules indicate faults by means of their two fault LEDs INTF (internal fault) and EXTF (external fault). The LEDs go out when all the internal and external faults have been eliminated.

Refer to the technical specifications of the modules, starting at Section 4.7, to find out which digital modules have these fault LEDs.

Diagnostic Messages of the Digital Modules

The table below gives an overview of the diagnostic messages for the digital modules with diagnostics capability.

You can find out which diagnostic message each module is capable of in the Appendix entitled "Diagnostic Data of the Signal Modules".

Table 4-7 Diagnostic Messages of the Digital Modules

Diagnostic Message	LED	Scope of the Diagnosis	Parameters Can Be Assigned
Module problem	INTF/EXTF	Module	No
Internal malfunction	INTF	Module	No
External malfunction	EXTF	Module	No
Channel error present	INTF/EXTF	Module	No
External auxiliary supply missing	EXTF	Module	No
Front connector missing	EXTF	Module	No
Module not parameterized.	INTF	Module	No
Wrong parameters	INTF	Module	No
Channel information available	INTF/EXTF	Module	No
STOP mode	–	Module	No
Internal voltage failure	INTF	Module	No
EPROM error	INTF	Module	No
Hardware interrupt lost	INTF	Module	No
Parameter assignment error	INTF	Channel	No
Short-circuit to M	EXTF	Channel	Yes
Short-circuit to L+	EXTF	Channel	Yes
Wire break	EXTF	Channel	Yes
Fuse blown	INTF	Channel	Yes
Sensor supply missing	EXTF	Channel/channel group	Yes
No load voltage L+	EXTF	Channel/channel group	Yes

Warning

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 Errors and Remedial Measures for Digital Modules

Table 4-8 Diagnostic Messages of the Digital Modules, Causes of Errors and Remedial Measures

Diagnostic Message	Possible Error Cause	Remedy
Module malfunction	An error detected by the module has occurred	-
Internal malfunction	The module has detected an error within the programmable controller	-
External malfunction	The module has detected an error outside the programmable controller	-
There is a channel error	Indicates that only certain channels are faulty	-
No external auxiliary voltage	Voltage required to operate the module is missing (load voltage, sensor supply)	Supply missing voltage
No front connector	Jumper between connections 1 and 2 in the front connector missing	Install jumper
Parameters have not been assigned to the module	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 CPU 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 available	Channel error present; the module can supply additional channel information	-
Operating mode STOP	Module was not parameterized and the first module cycle has not been completed	If after rebooting the CPU all the input values are in the intermediate memory, this message is reset
Internal voltage failure	Module is defective	Replace module
EPROM error	Module is defective	Replace module
Hardware interrupt lost	The module cannot send an interrupt, since the previous interrupt was not acknowledged; configuration error possible	Change the interrupt handling in the CPU (change priority for interrupt OB; shorten interrupt program)
Parameter assignment error	Incorrect parameters transferred to the module (for example, impossible input delay); the corresponding channel is deactivated	Reassign module parameter
Short circuit to M	Overload of output	Eliminate overload
	Short-circuit of output to M	Check the wiring of the outputs
Short circuit to L+	Short circuit of output to L+	Check the wiring of the outputs
Wire break	Lines interrupted	Close circuit
	No external sensor supply	Wire sensors with 10 kΩ to 18 kΩ
	Channel not connected (open)	Disable the “Diagnostics – Wire Break” parameter for the channel in *STEP 7*
		Connect channel

Table 4-8 Diagnostic Messages of the Digital Modules, Causes of Errors and Remedial Measures, continued

Diagnostic Message	Possible Error Cause	Remedy
Fuse blown	One or more fuses on the module has blown and caused this fault.	Remove the overload and replace the fuse
No sensor supply	Overload of sensor supply	Eliminate overload
	Short circuit of sensor supply to M	Eliminate short circuit
No load voltage L+	Power supply L+ to module missing	Feed in supply voltage L+
	Fuse in module is defective	Replace module

4.5 Interrupts of the Digital Modules

Introduction

This section describes the interrupt behavior of the digital modules. The following interrupts exist:

- Diagnostic Interrupt
- Hardware interrupt

Note that not all digital 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 4.7, to find out which digital modules have interrupt capability.

The OBs and SFCs mentioned below can be found in the online help system 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. You enable the interrupts in *STEP 7* (refer to Section 4.3).

Special Feature: The Module is Inserted in ER-1/ER-2

Warning

If you use the digital module in ER-1/ER-2, you must set the parameters for enabling all the interrupts to “No” because the interrupt lines are not available in ER-1/ER-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 the 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.

Hardware Interrupt

A digital input module can trigger a hardware interrupt for each channel at a rising or falling edge, or both, of a signal status change.

You perform parameter assignment for each channel separately. 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 to OB 47). The CPU interrupts the execution of the user program or of the priority classes with low priority.

In the user program of the hardware interrupt OB (OB 40 to OB 47) you can specify how the programmable controller is to respond to an edge change. When the hardware interrupt OB is exited, the hardware interrupt is acknowledged on the module.

For each channel the digital input module can buffer an interrupt that has not been triggered. 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 diagnostic 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 start information of the corresponding OB). 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.

4.6 Input Characteristic Curve for Digital Inputs

IEC 61131–2, Type 1 and Type 2

The IEC 61131–2 standard requires the following for the input current:

- In the case of type 2, an input current of ≥ 2 mA already at + 5 V
- In the case of type 1, an input current of ≥ 0.5 mA already at + 5 V

EN 60947-5-2, Two-Wire BEROs

The standard for BEROs (EN 60947-5-2) specifies that there can be a current of ≤ 1.5 mA for BEROs in the "0" signal state.

The input current of the module in the "0" signal state is decisive for the operation of two-wire BEROs. This must be in accordance with BERO requirements.

Input Characteristic Curve for Digital Inputs

As long as the current flowing into the module remains ≤ 1.5 mA, the module recognizes this as a “0” signal.

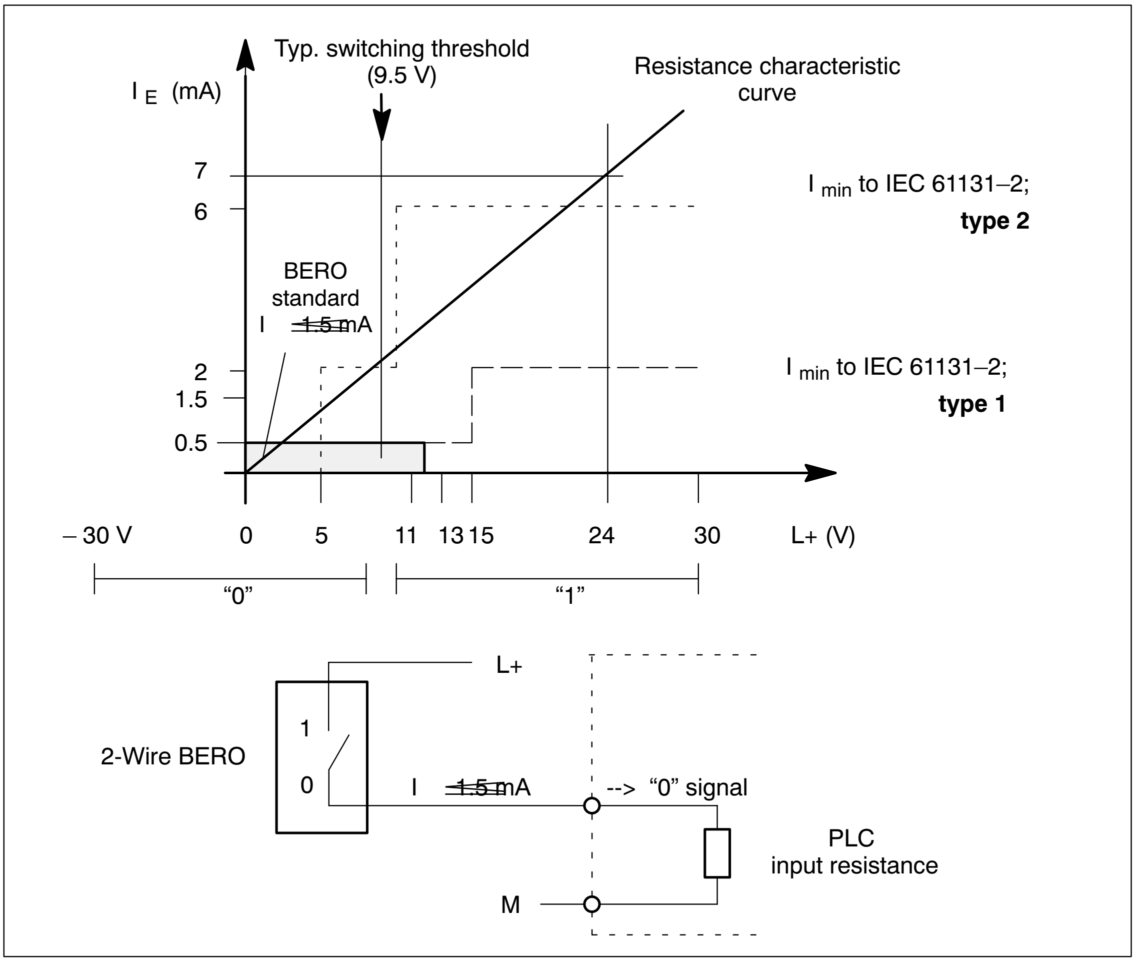


Figure 4-1 Input Characteristic Curve for Digital Inputs

4.7 Digital Input Module SM 421; DI 32 x 24 VDC; (6ES7421-1BL01-0AA0)

Characteristics

The digital input module SM 421; DI 32 x 24 VDC has the following features:

- 32 inputs, isolated in a group of 32
- 24 VDC rated input voltage
- Suitable for switches and two/three/four-wire proximity switches (BEROs, IEC 61131–2; type 1)

The status LEDs indicate the process status.

Terminal Assignment and Block Diagram of the SM 421; DI 32 x 24 VDC

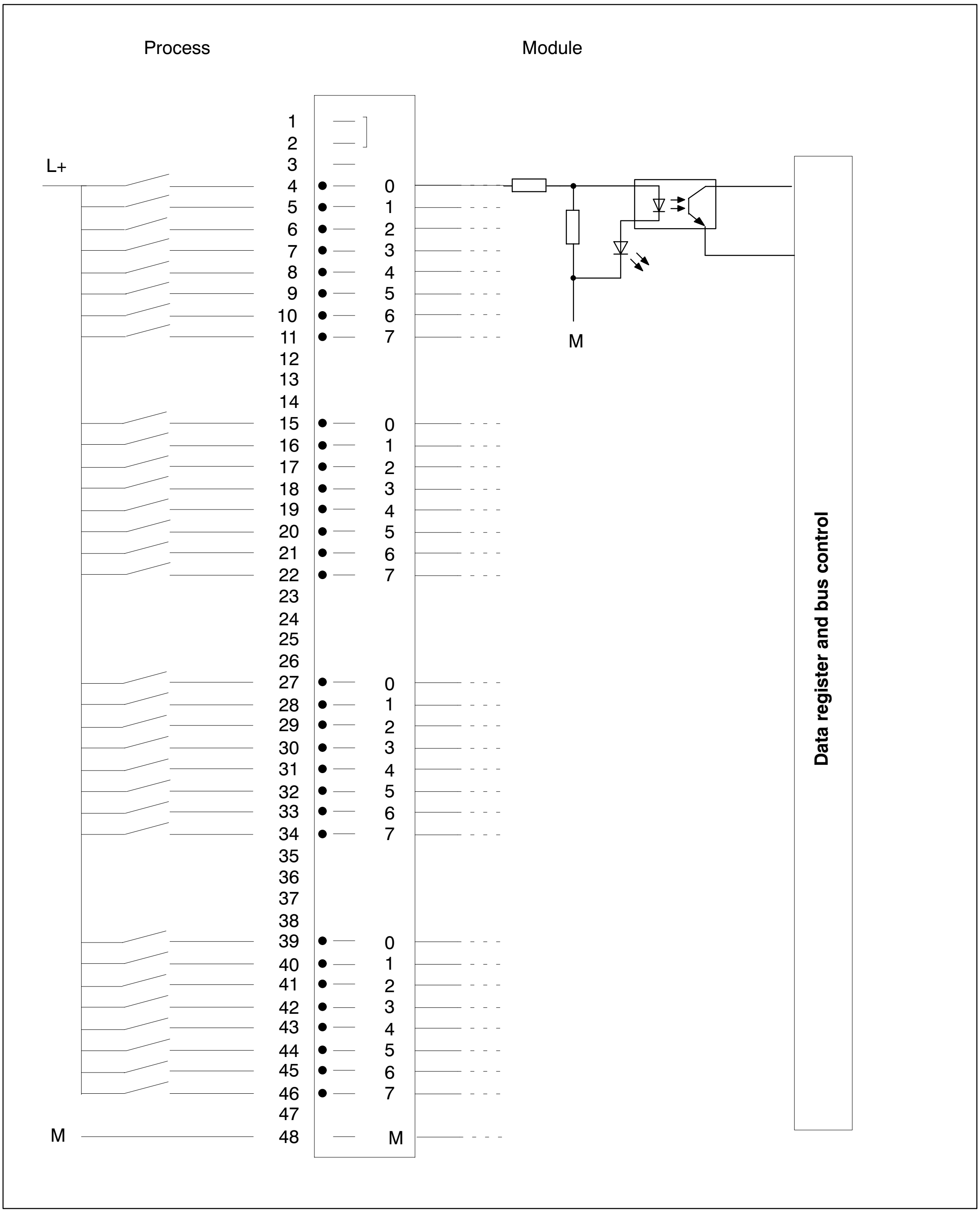


Figure 4-2 Terminal Assignment and Block Diagram of the SM 421; DI 32 x 24 VDC

Technical Specifications of the SM 421; DI 32 x 24 VDC

Dimensions and Weight	
Dimensions W x H x D (in millimeters)	25 x 290 x 210
Weight	Approx. 500 g
Data for Specific Module	
Number of inputs	32
Length of cable	
• Unshielded	Max. 600 m
• Shielded	Max. 1000 m
Voltages, Currents, Potentials	
Power rated voltage of the electronics L+	Not required
Number of inputs that can be triggered simultaneously	32
Isolation	
• Between channels and backplane bus	Yes
• Between the channels	No
Permitted potential difference	
• Between the different circuits	75 VDC / 60 VAC
Insulation tested with	
• Channels against backplane bus and load voltage L+	500 VDC
Current consumption	
• From the backplane bus	Max. 20 mA
Power dissipation of the module	Typ. 6 W

Status, Interrupts, Diagnostics	
Status display	Green LED per channel
Interrupts	None
Diagnostic functions	None
Substitute value can be applied	No
Data for Selecting a Sensor	
Input voltage	
• 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”	7 mA
Input delay	
• At “0” to “1”	1.2 ms to 4.8 ms
• At “1” to “0”	1.2 ms to 4.8 ms
Input characteristic curve	To IEC 61131–2; type 1
Connection of two-wire BEROs	Possible
• Permitted bias current	Max. 1.5 mA

4.8 Digital Input Module SM 421; DI 16 x 24 VDC; (6ES7421-7BH01-0AB0)

Characteristics

The digital input module SM 421; DI 16 x 24 VDC has the following features:

- 16 inputs, isolated in 2 groups of 8
- Very fast signal processing: input filter as of 50 μs
- 24 VDC rated input voltage
- Suitable for switches and two/three/four-wire proximity switches (BEROs, IEC 61131–2; type 2)
- 2 short-circuit-proof sensor supplies for 8 channels each
- External redundant power supply possible to supply sensors
- “Sensor supply (Vs) O.K.” status display
- Group error display for internal faults (INTF) and external faults (EXTF)
- Programmable diagnostics
- Programmable diagnostic interrupt
- Programmable hardware interrupt
- Programmable input delays
- Parameterizable substitute values in the input range

The status LEDs indicate the process status.

Warning

The spare parts of this module is compatible with SM 421; DI 16 x DC 24 V; (6ES7421-7BH00-0AB0).

To be able to use the new function “input delay 50 μs”, you require STEP 7 as of V 5.2.

Terminal Assignment and Block Diagram of the SM 421; DI 16 x 24 VDC

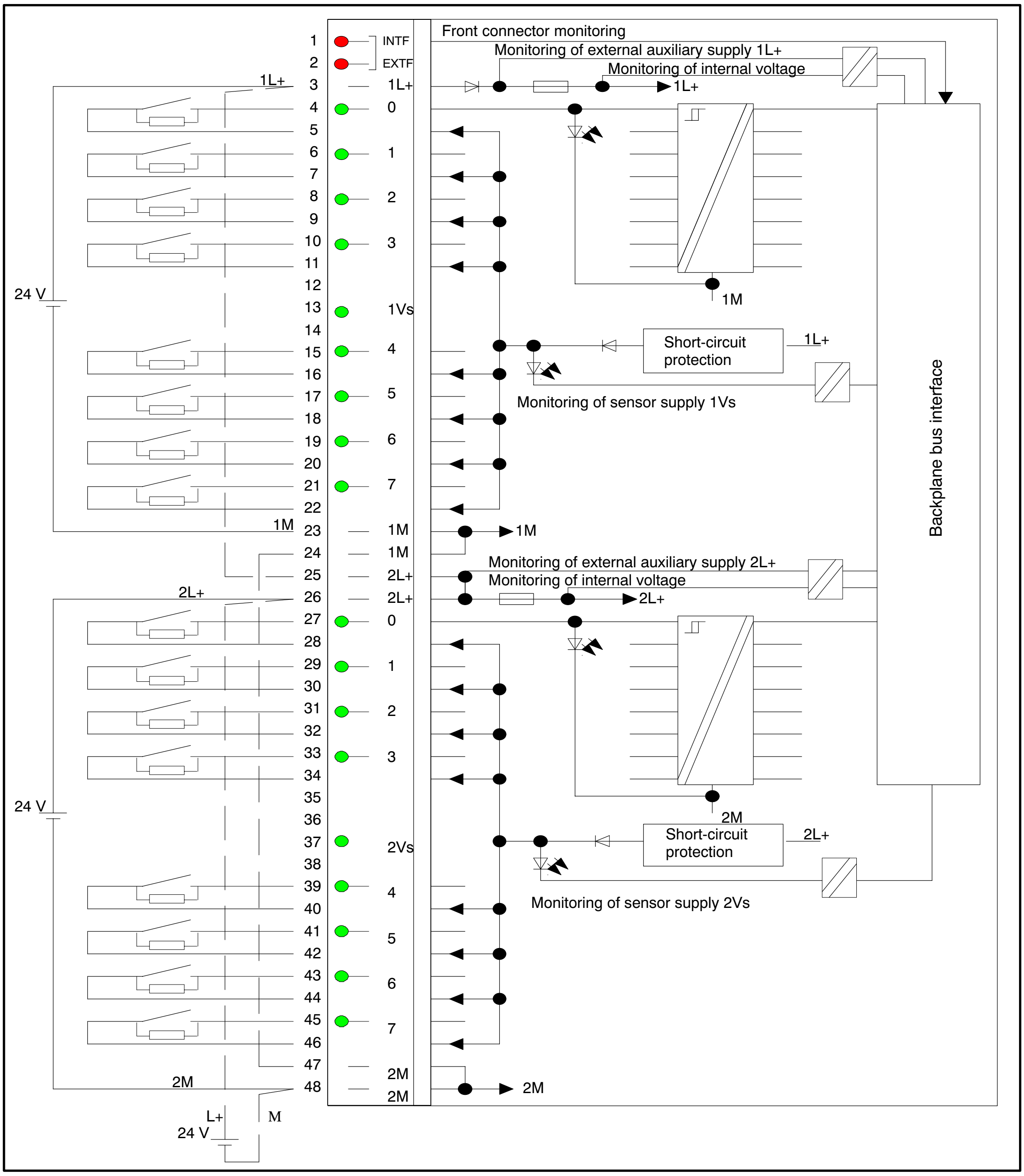


Figure 4-3 Terminal Assignment and Block Diagram of the SM 421; DI 16 x 24 VDC

Terminal Assignment Diagram for Redundant Supply of Sensors

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

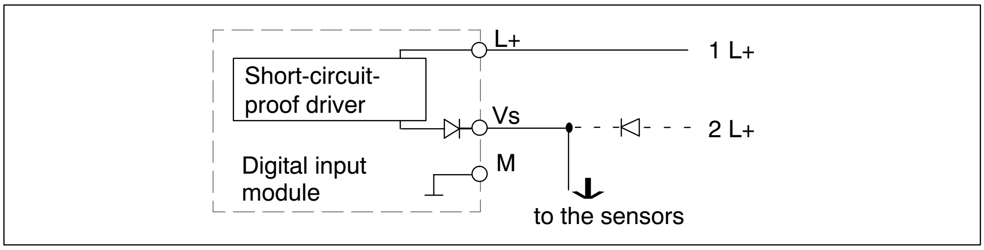


Figure 4-4 Terminal Assignment Diagram for the Redundant Supply of Sensors of the SM 421; DI 16 x 24 VDC

Technical Specifications of the SM 421; DI 16 x 24 VDC

Dimensions and Weight	
Dimensions W ~~H~~ ~~D~~ (in millimeters)	25 ~~290~~ ~~210~~
Weight	Approx. 600 g
Data for Specific Module	
Number of inputs	16
Length of cable	
• Unshielded input delay	
– 0.1 ms	Max. 20 m
– 0.5 ms	Max. 50 m
– 3 ms	Max. 600 m
• Shielded input delay	
– 0.1 ms	Max. 30 m
– 0.5 ms	Max. 70 m
– 3 ms	Max. 1000 m

Voltages, Currents, Potentials	
Rated supply voltage of the electronics and sensor L+	24 VDC
• Reverse polarity protection	Yes
Number of inputs that can be triggered simultaneously	16
Isolation	
• Between channels and backplane bus	Yes
• Between channels and power supply of the electronics	No
• Between the channels	Yes
– In groups of	2
Permitted potential difference	
• Between the different circuits	75 VDC, 60 VAC
Insulation tested with	
• Channels against backplane bus and load voltage L+	500 VDC
• Channel groups between themselves	500 VDC
Current consumption	
• From the backplane bus	Max. 130 mA
• From the power supply L+	Max. 120 mA
Power dissipation of the module	Typ. 5 W

Status, Interrupts, Diagnostics	
Status display	Green LED per channel
Interrupts	
• Hardware interrupt	Parameters can be assigned
• Diagnostic Interrupt	Parameters can be assigned
Diagnostic functions	
• Monitoring of the power supply voltage of the electronics	Yes
• Load voltage monitor	Green LED per group
• Group error display	
– For internal fault	Red LED (INTF)
– For external fault	Red LED (EXTF)
• Channel error display (F)	None
• Diagnostic information can be displayed	Yes
Monitoring for	
• Wire break	I < 1 mA
Substitute value can be applied	Yes
Sensor Power Supply Outputs	
Number of 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	Possible
Short-circuit protection	Yes, electronic
Data for Selecting a Sensor	
Input voltage	
• Rated value	24 VDC
• For signal “1”	11 V to 30 V
• For signal “0”	-30 V to 5 V
Input current	
• At signal “1”	6 mA to 12 mA
• At signal “0”	< 6 mA
Input characteristic curve	To IEC 61131–2; type 2
Connection of two-wire BEROs	Possible
• Permitted bias current	Max. 3 mA

Time, Frequency	
Internal preparation time [1] for	
• only status recognition	
– Input delay of the channel groups 0.05 ms/0.05 ms	max. 50 μs
– Input delay of the channel groups 0.05 ms/0.1 ms or 0.1 ms/0.1 ms	max. 70 μs
– Input delay of the channel groups >= 0.5 ms	max. 180 μs
• Status recognition and enable process interrupt	max. 60 μs
– Input delay of the channel groups 0.05 ms/0.05 ms [2]	
– Input delay for the channel groups 0.05 ms/0.1 ms or 0.1 ms/0.1 ms	max. 80 μs
– Input delay of the channel groups >= 0.5 ms	max. 190 μs
Internal preparation time for diagnostics/diagnostic interrupt	max. 5 ms
Input delay	
• Parameters can be assigned	Yes
• Rated value	0.1/0.5/3 ms
• Input frequency (with a time delay of 0.1 ms)	< 2 kHz
Values go into cycle and response times.	
Sensor Circuit	
Resistance circuit of the sensor for wire break monitoring	10 to 18 kΩ

[1] The filter times are added to the overall runtime of the selected input delay.

[2] Substitute functionality; diagnostics and diagnostic interrupt are not to be selected.

4.8.1 Assigning Parameters to the SM 421; DI 16 x 24 VDC

Parameter Assignment

You will find a description of the general procedure for assigning parameters to digital modules in Section 4.3.

Parameters of the SM 421; DI 16 x 24 VDC

You will find an overview of the parameters you can set and their default settings for the SM 421; DI 16 x 24 VDC in the table below.

Table 4-9 Parameters of the SM 421; DI 16 x 24 VDC

Parameter	Value Range	Default[2)]	Parameter Type	Scope
Enable • Diagnostic interrupt[1)] • Hardware interrupt[1)]	 Yes/no Yes/no	 No No	Dynamic	Module
• Destination CPU for interrupt	1 to 4	–	Static	Module
Diagnostics • Wire break • No load voltage L+/sensor supply	 Yes/no Yes/no	 No No	Static	Channel Channel group
Trigger for hardware interrupt • Rising edge • Falling edge	 Yes/no Yes/no	–	Dynamic	Channel
Input delay	0.05 ms 0.1 ms 0.5 ms 3 ms	3 ms	Static	Channel group
Reaction to Error	Substitute a Value (SV) Keep Last Value (KLV)	SV	Dynamic	Module
Enable substitute value “1”	Yes/no	No	Dynamic	Channel

1) If you use the module in ER-1/ER-2, you must set this parameter to “No” because the interrupt lines are not available in ER-1/ER-2.

2) Only in the CC (central controller) is it possible to start up the digital modules with the default settings.

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.

Ensuring a Wire Break Check Is Carried Out

To ensure that a wire break check is carried out, you require an external sensor circuit using a resistor of 10 kΩ to 18 kΩ. The resistor should be connected parallel to the contact and should be arranged as closely as possible to the sensor.

This additional resistor is not required in the following cases:

- If two-wire BEROs are used
- If you don't parameterize the "Wire Break" diagnosis

Setting the Input Delay for Channel Groups

You can only set the input delay for each group of channels. In other words, the setting for channel 0 applies to inputs 0 to 7 and the setting for channel 8 applies to inputs 8 to 15.

Warning

The parameters that are entered for the remaining channels (1 to 7 and 9 to 15) must be equal to the value 0 or 8, otherwise those channels will be reported as being incorrectly parameterized.

Any hardware interrupts that have occurred in the meantime will be reported after acknowledgement.

Optimum Signal Propagation Delay

You can achieve the fastest signal propagation delay with the following settings:

- Both channel groups are parameterized with an input delay of 50 μs
- All the diagnoses (load voltage error, wire break) are deactivated
- Diagnostic interrupt is not enabled

4.8.2 Behavior of the SM 421; DI 16 x 24 VDC

Effect of Operating Mode and Supply Voltage on the Input Values

The input values of the SM 421; DI 16 x 24 DC depend on the operating mode of the CPU and on the supply voltage of the module.

Table 4-10 How the Input Values Depend on the Operating Mode of the CPU and on the Supply Voltage L+ of the SM 421; DI 16 x 24 VDC

CPU Operating Mode		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	–

* Depends on the parameter assignment (see Table 4-9)

Behavior upon Failure of the Supply Voltage

Failure of the supply voltage of the SM 421; DI 16 x 24 DC is always indicated by the EXTF 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.

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.

Effect of Errors and Parameter Assignment on the Input Values

The input values of the SM 421; DI 16 x 24 DC are affected by certain errors and the parameter assignment of the module. The following table lists the effects on the input values.

You will find more diagnostic messages of the module in the Appendix entitled “Diagnostic Data of the Signal Modules”.

Table 4-11 How the Input Values Are Affected by Faults and by the Parameter Assignment of the SM 421; DI 16 x 24 VDC

Diagnostic Message	“Diagnostics” Parameter	“Reaction to Error” Parameter	Input Value of Digital Module
Module not parameterized	Cannot be disabled	Not relevant	0 signal (all channels)
No front connector		SV	Parameterized substitute value
		KLV	Last read, valid value
Incorrect parameters (module/channel)	Cannot be disabled	Not relevant	0 signal (module/all incorrectly parameterized channels)
STOP operating mode	Cannot be disabled	–	Process value (not updated)
Internal voltage failure	Cannot be disabled	SV	Parameterized substitute value
		KLV	Last read, valid value
Hardware interrupt lost	Cannot be disabled	Not relevant	Current process value
Wire break (for each channel)	Deactivated	–	0 signal
	Activated	SV	Parameterized substitute value
		KLV	Last read, valid value
Sensor supply missing (also activated via ”No Load Voltage L+”)	Deactivated	–	0 signal
	Activated	SV	Parameterized substitute value
		KLV	Last read, valid value
No load voltage L+ (for each channel group)	Deactivated	–	0 signal, if the contact is connected via the sensor supply; process value for the external sensor supply
	Activated	SV	Parameterized substitute value
		KLV	Last read, valid value

Behavior when the Input Delay Equals 0.1 ms and an Error Occurs

If you have parameterized the following:

- An input delay of 0.1 ms or 0.05 ms
- KLV or SV as the response to an error
- Substitute “1”

In the event of a fault on a channel that has a 1 signal, the following could occur:

- An 0 signal may be briefly output
- If parameterized, a hardware interrupt may be generated

This occurs before the last valid value or substitute value “1” is output.

4.9 Digital Input Module SM 421; DI 16 x 120 VAC; (6ES7421-5EH00-0AA0)

Characteristics

The SM 421; DI 16 x 120 VAC has the following features:

- 16 inputs, isolated
- 120 VAC rated input voltage
- Suitable for switches and two-wire proximity switches (BEROs, IEC 61131–2; type 2)

Terminal Assignment Diagram of the SM 421; DI 16 x 120 VAC

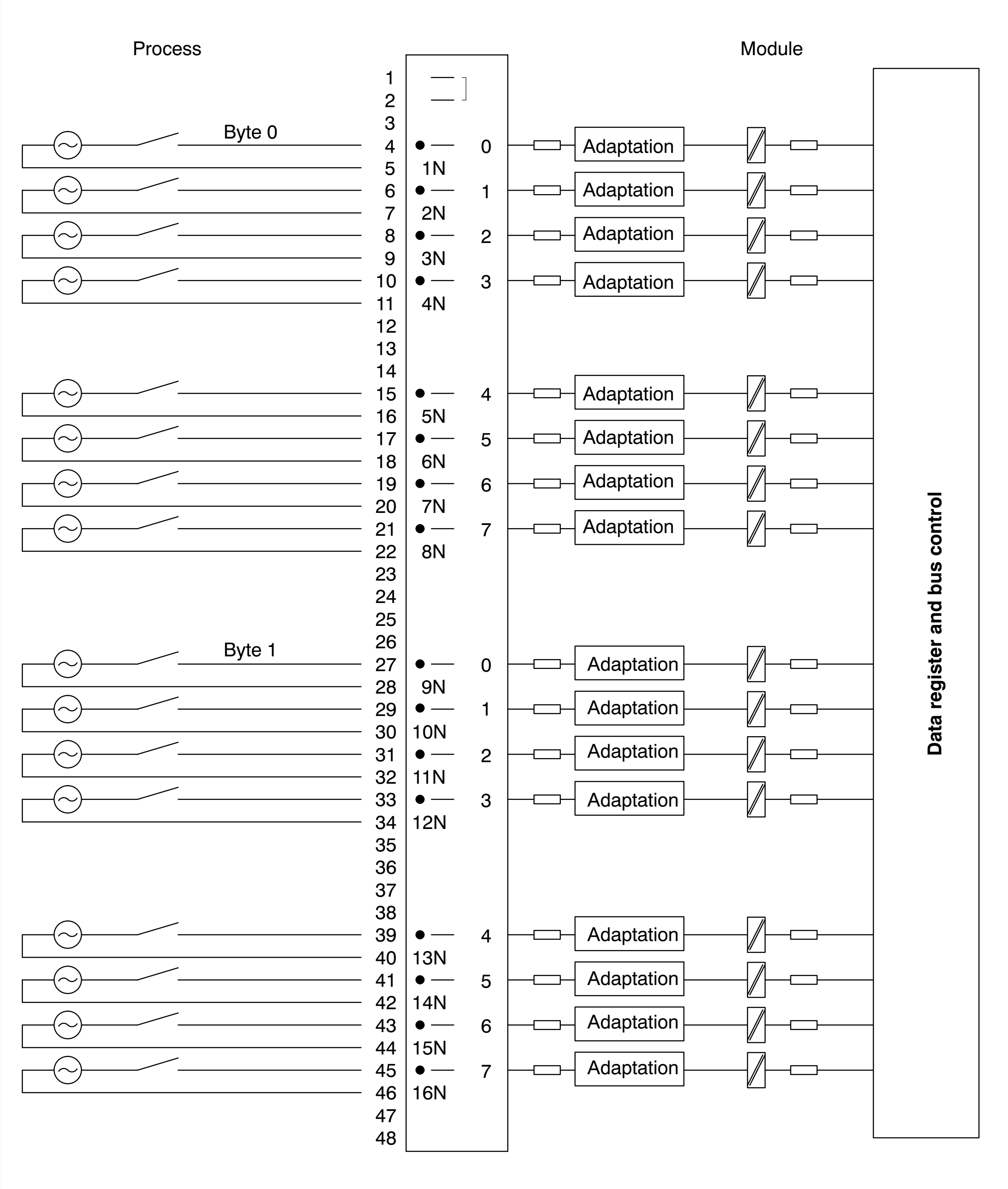


Figure 4-5 Terminal Assignment Diagram of the SM 421; DI 16 x 120 VDC

Technical Specifications of the SM 421; DI 16 x 120 VAC

Dimensions and Weight	
Dimensions W x H x D (in millimeters)	25 x 290 x 210
Weight	Approx. 650 g
Data for Specific Module	
Number of inputs	16
Length of cable	
• Unshielded	600 m
• Shielded	1000 m
Voltages, Currents, Potentials	
Number of inputs that can be triggered simultaneously	16
Isolation	
• Between channels and backplane bus	Yes
• Between the channels	Yes
– In groups of	1
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. 0.1 A
Power dissipation of the module	Typ. 3.0 W
Status, Interrupts, Diagnostics	
Status display	Green LED per channel
Interrupts	None
Diagnostic functions	None

Sensor Selection Data	
Input voltage	
• Rated value	120 V
• For signal “1”	72 to 132 VAC
• For signal “0”	0 to 20 V
• Frequency range	47 to 63 Hz
Input current	
• At signal “1”	6 to 20 mA
• At signal “0”	0 to 4 mA
Input delay	
• At “0” to “1”	2 to 15 ms
• At “1” to “0”	5 to 25 ms
Input characteristic curve	To IEC 61131–2; type 2
Connection of two-wire BEROs	Possible
• Permitted bias current	Max. 4 A

4.10 Digital Input Module SM 421; DI 16 x 24/60 VUC; (6ES7421-7DH00-0AB0)

Characteristics

The SM 421; DI 16 x 24/60 VUC is characterized by the following features:

- 16 inputs, individually isolated
- Rated input voltage 24 VUC to 60 VUC
- Suitable for switches and two-wire proximity switches (BEROs)
- Suitable as active high and active low input
- Group error display for internal faults (INTF) and external faults (EXTF)
- Programmable diagnostics
- Programmable diagnostic interrupt
- Programmable hardware interrupt
- Programmable input delays

The status LEDs indicate the process status.

Terminal Assignment and Block Diagram of the SM 421; DI 16 x 24/60 VUC

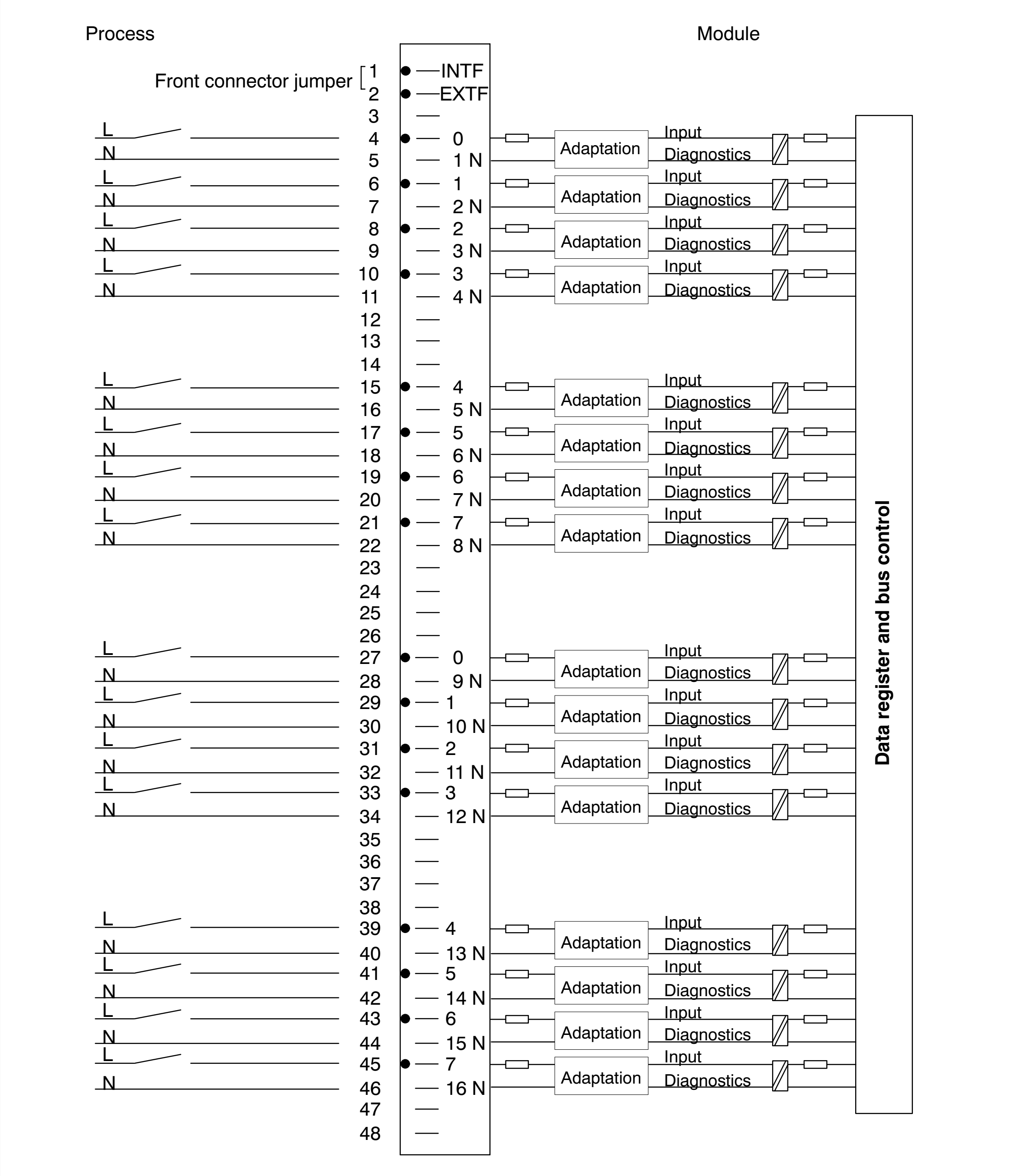


Figure 4-6 Terminal Assignment and Block Diagram of the SM 421; DI 16 x 24/60 VUC

Technical Specifications of the SM 421; DI 16 x 24/60 VUC

Dimensions and Weight	
Dimensions W x H x D (in millimeters)	25 x 290 x 210
Weight	Approx. 600 g
Data for Specific Module	
Number of inputs	16
Length of cable	
• Unshielded input delay	
– 0.5 ms	Max. 100 m
– 3 ms	Max. 600 m
– 10 / 20 ms	Max. 600 m
• Shielded line length	1000 m
Voltages, Currents, Potentials	
Number of inputs that can be triggered simultaneously	16
Isolation	
• Between channels and backplane bus	Yes
• Between the channels	Yes
– In groups of	1
Permitted potential difference	
• Between the different circuits	75 VDC, 60 VAC
Insulation tested with	
• Channels against backplane bus and load voltage L+	1500 VAC
• Channels among one another	1500 VAC
Current consumption	
• From the backplane bus	Max.150 mA
Power dissipation of the module	Typ. 8 W
Status, Interrupts, Diagnostics	
Status display	Green LED per channel
Interrupts	
• Hardware interrupt	Parameters can be assigned
• Diagnostic Interrupt	Parameters can be assigned
Diagnostic functions	Parameters can be assigned
• Group error display	
– For internal fault	Red LED (INTF)
– For external fault	Red LED (EXTF)
• Channel error display (F)	None
• Diagnostic information can be displayed	Possible
Monitoring for	
• Wire break	I > 0.7 mA
Substitute value can be applied	No
Sensor Selection Data	
Input voltage	
• Rated value	24 VUC to 60 VUC
• For signal “1”	15 to 72 VDC –15 VDC to -72 VDC 15 to 60 VAC
• For signal “0”	–6 VDC to +6 VDC 0 VAC to 5 VAC
Frequency range	47 DC/AC to 63 Hz
Input current	
• At signal “1”	Typ. 4 mA to 10 mA
Input characteristic curve	Similar to IEC 61131–2 [1)]
Connection of two-wire BEROs	Possible
• Permitted bias current	Max. 0.5 mA to 2 mA[2)]
Time, Frequency	
Internal preparation time for	
• Only hardware interrupt enable	Max. 450 µs
• Enable hardware and diagnostic interrupts	Max. 2 ms
Input delay	
• Parameters can be assigned	Yes
• Rated value	0.5/3/10/20 ms
Values go into cycle and response times.	
Sensor Circuit	
Resistance circuit of the sensor for wire break monitoring	
• Rated voltage 24 V (15 V to 35 V)	18 kΩ
• Rated voltage 48 V (30 V to 60 V)	39 kΩ
• Rated voltage 60 V (50 V to 72V)	56 kΩ

1) IEC 61131–2 does not specify any data for UC modules. The values have been adapted as much as possible to IEC 61131–2.

2) Minimum closed-circuit current is required for wire break monitoring.

4.10.1 Assigning Parameters to the SM 421; DI 16 x 24/60 VUC

Parameter Assignment

You will find a description of the general procedure for assigning parameters to digital modules in Section 4.3.

Parameters of the SM 421; DI 16 x 24/60 VUC

The following table contains an overview of the parameters you can set and their default settings for the SM 421; DI 16 x 24/60 VUC.

Table 4-12 Parameters of the SM 421; DI 16 x 24/60 VUC

Parameter	Value Range	Default[2)]	Parameter Type	Scope
Enable • Diagnostic interrupt[1)] • Hardware interrupt[1)]	 Yes/no Yes/no	 No No	 Dynamic	 Module
• Destination CPU for interrupt	1 to 4	–	Static	Module
Diagnostics • Wire break	 Yes/no	 No	 Static	 Channel
Trigger for hardware interrupt • Rising (positive) edge • Falling (negative) edge	 Yes/no Yes/no	 –	 Dynamic	 Channel
Input delay[3)]	0.5 ms (DC) 3 ms (DC) 20 ms (DC/AC)	3 ms (DC)	Static	Channel group

1) If you use the module in ER-1/ER-2, you must set this parameter to “No” because the interrupt lines are not available in ER-1/ER-2.
2) Only in the CC (central controller) is it possible to start up the digital modules with the default settings.
3) If you assign 0.5 ms , then you should not parameterize a diagnosis because the internal processing time for diagnostic functions can be > 0.5 ms.

Ensuring a Wire Break Check Is Carried Out

To ensure that a wire break check is carried out, you require an external sensor circuit using a resistor of 18 to 56 kΩ. The resistor should be connected parallel to the contact and should be arranged as closely as possible to the sensor.

This additional resistor is not required in the following cases:

- If two-wire BEROs are used
- If you don’t parameterize the “Wire Break” diagnosis

Setting the Input Delay for Channel Groups

You can only set the input delay for each group of channels. In other words, the setting for channel 0 applies to inputs 0 to 7 and the setting for channel 8 applies to inputs 8 to 15.

Warning

The parameters that are entered for the remaining channels (1 to 7 and 9 to 15) must be equal to the value 0 or 8, otherwise those channels will be reported as being incorrectly parameterized.

Any hardware interrupts that have occurred in the meantime will be reported after acknowledgement.

Optimum Signal Propagation Delays

You can achieve the fastest signal propagation delay with the following settings:

- Both channel groups are parameterized with an input delay of 0.5 ms
- The Diagnostics parameter is disabled
- The Diagnostic Interrupt parameter is disabled

Circuit as for active high or active low input

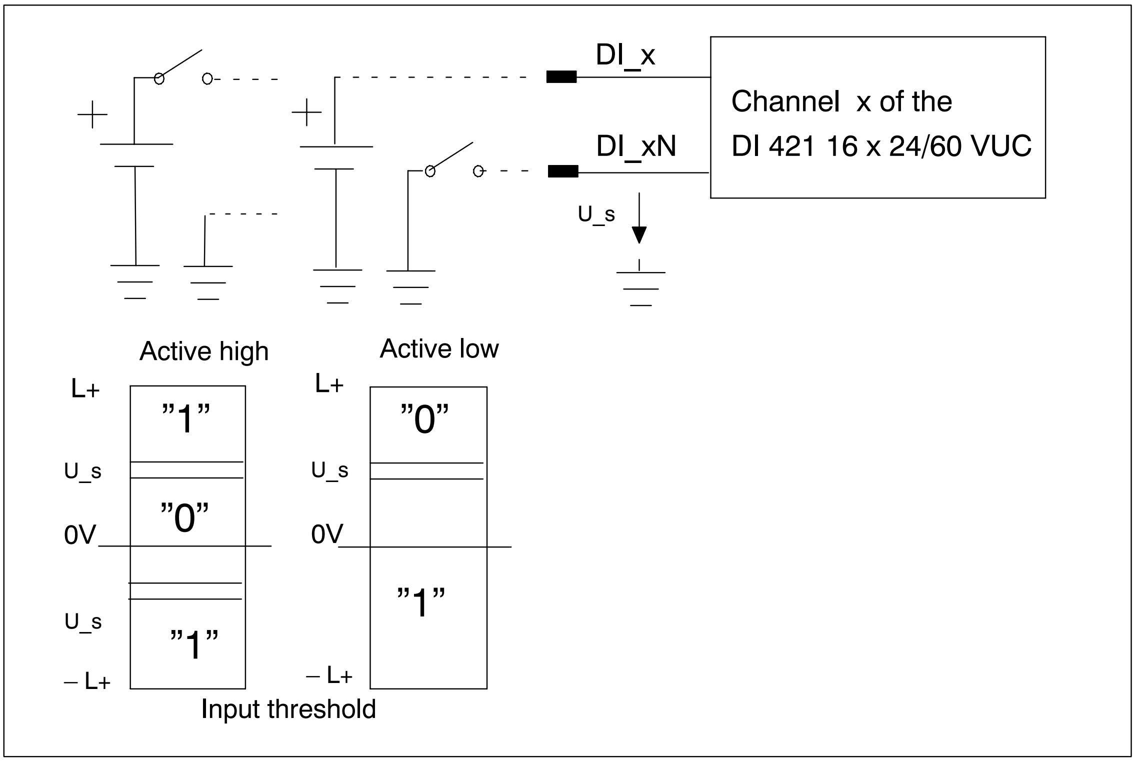


Figure 4-7 Circuit as for Active High or Active Low Input

4.11 Digital Input Module SM 421; DI 16 x 120/230 VUC; (6ES7 421-1FH00-0AA0)

Characteristics

The SM 421; DI 16 x 120/230 VUC is characterized by the following features:

- 16 inputs, isolated
- Rated input voltage 120/230 VUC
- Suitable for switches and two-wire proximity switches

Terminal Assignment and Block Diagram of the SM 421; DI 16 x 120/230 VUC

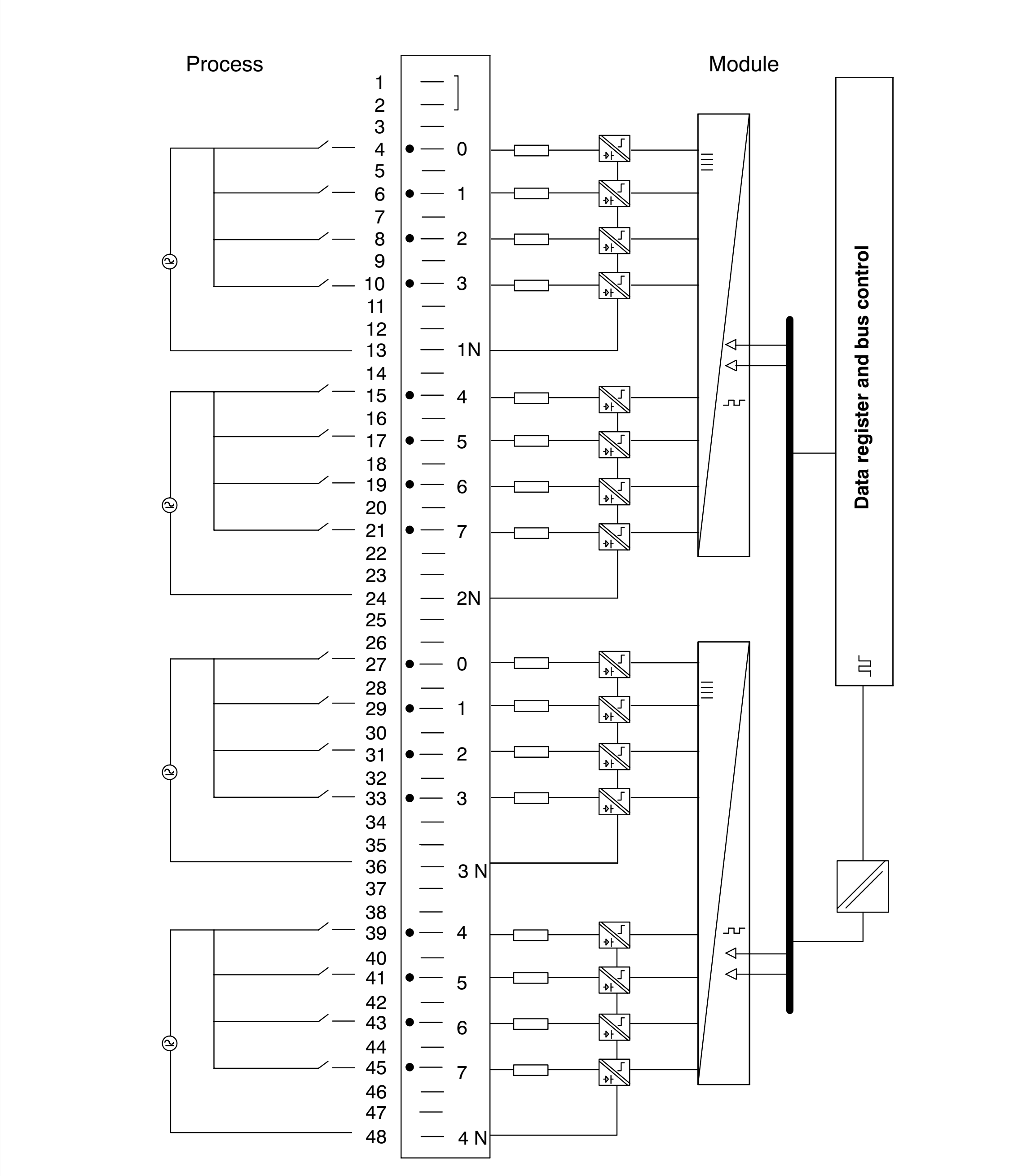


Figure 4-8 Terminal Assignment and Block Diagram of the SM 421; DI 16 x 120/230 VUC

Technical Specifications of the SM 421; DI 16 x 120/230 VUC

Dimensions and Weight	
Dimensions W x H x D (in millimeters)	25 x 290 x 210
Weight	Approx. 650 g
Data for Specific Module	
Number of inputs	16
Length of cable	
• Unshielded	600 m
• Shielded	1000 m
Voltages, Currents, Potentials	
Number of inputs that can be triggered simultaneously	16 at 120 V 8 at 240 V 16 with fan subassembly
Isolation	
• Between channels and backplane bus	Yes
• Between the channels	Yes
– In groups of	4
Permitted potential difference	
• Between $M_{internal}$ and the inputs	230 VAC
• Between the inputs of the different groups	500 VAC
Insulation resistance	4000 VAC
Current consumption	
• From the backplane bus	Max. 100 mA
Power dissipation of the module	Typ. 3.5 W

Status, Interrupts, Diagnostics	
Status display	Green LED per channel
Interrupts	None
Diagnostic functions	None
Data for Selecting a Sensor	
Input voltage	
• Rated value	120/230 VUC
• For signal “1”	79 to 264 VAC 80 to 264 VDC
• For signal “0”	0 VUC to 40 VUC
• Frequency range	47 to 63 Hz
Input current	
• At signal “1”	2 mA to 5 mA
• At signal “0”	0 to 1 mA
Input delay	
• At “0” to “1”	5 to 25 ms
• At “1” to “0”	5 to 25 ms
Input characteristic curve	To IEC 61131–2; type 1
Connection of two-wire BEROs	Possible
• Permitted bias current	Max. 1 mA

4.12 Digital Input Module SM 421; DI 16 x 120/230 VUC; (6ES7421-1FH20-0AA0)

Characteristics

The SM 421; DI 16 x 120/230 VUC is characterized by the following features:

- 16 inputs, isolated in groups of 4
- Rated input voltage 120/230 VUC
- Input characteristic curve to IEC 61131–2; type 2
- Suitable for switches and two-wire proximity switches (BEROs)

The status LEDs indicate the process status.

Terminal Assignment and Block Diagram of the SM 421; DI 16 x 120/230 VUC

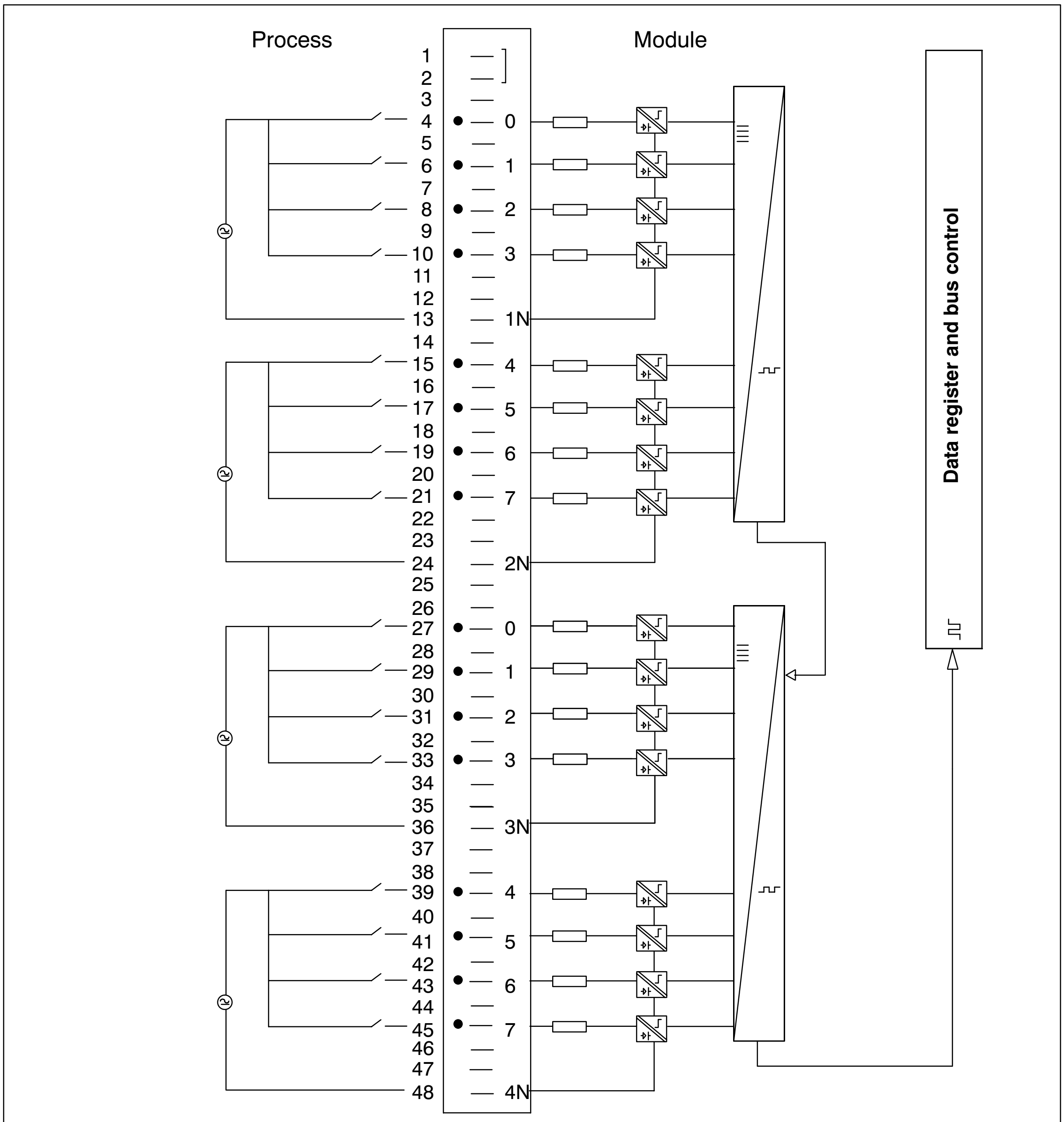


Figure 4-9 Terminal Assignment and Block Diagram of the SM 421; DI 16 x 120/230 VUC

Technical Specifications of the SM 421; DI 16 x 120/230 VUC

Dimensions and Weight	
Dimensions W x H x D (in millimeters)	25 x 290 x 210
Weight	Approx. 650 g
Data for Specific Module	
Number of inputs	16
Length of cable	
• Unshielded	600 m
• Shielded	1000 m
Voltages, Currents, Potentials	
Power rated voltage of the electronics L+	None
Number of inputs that can be triggered simultaneously	16
Isolation	
• Between channels and backplane bus	Yes
• Between the channels	Yes
– In groups of	4
Permitted potential difference	
• Between $M_{internal}$ and the inputs	250 VAC
• Between the inputs of the different groups	500 VAC
Insulation resistance	4000 VAC
Current consumption	
• From the backplane bus	Max. 80 mA
Power dissipation of the module	Typ. 12 W
Status, Interrupts, Diagnostics	
Status display	Green LED per channel
Interrupts	None
Diagnostic functions	None
Substitute value can be applied	No

Data for Selecting a Sensor	
Input voltage	
• Rated value	120/230 VUC
• For signal “1”	74 to 264 VAC 80 to 264 VDC –80 to –264 VDC
• For signal “0”	0 to 40 VAC –40 to +40 VDC
Frequency range	47 to 63 Hz
Input current	
• At signal ”1” (120 V)	Typ. 10 mA AC Typ. 1.8 mA DC
• At signal ”1” (230 V)	Typ. 14 mA AC Typ. 2 mA DC
• At signal “0”	0 to 6 mA AC 0 to 2 mA DC
Input delay	
• At “0” to “1”	Max. 20 ms AC Max. 15 ms DC
• At “1” to “0”	Max. 30 ms AC Max. 25 ms DC
Input characteristic curve	To IEC 61131–2; type 2
Connection of two-wire BEROs	Possible
• Permitted bias current	Max. 5 mA AC

4.13 Digital Input Module SM 421; DI 32 x 120 VUC; (6ES7421-1EL00-0AA0)

Characteristics

The SM 421; DI 32 x 120 VUC is characterized by the following features:

- 32 inputs, isolated
- Rated input voltage 120 VUC
- Suitable for switches and two-wire proximity switches

Terminal Assignment and Block Diagram of the SM 421; DI 32 x 120 VUC

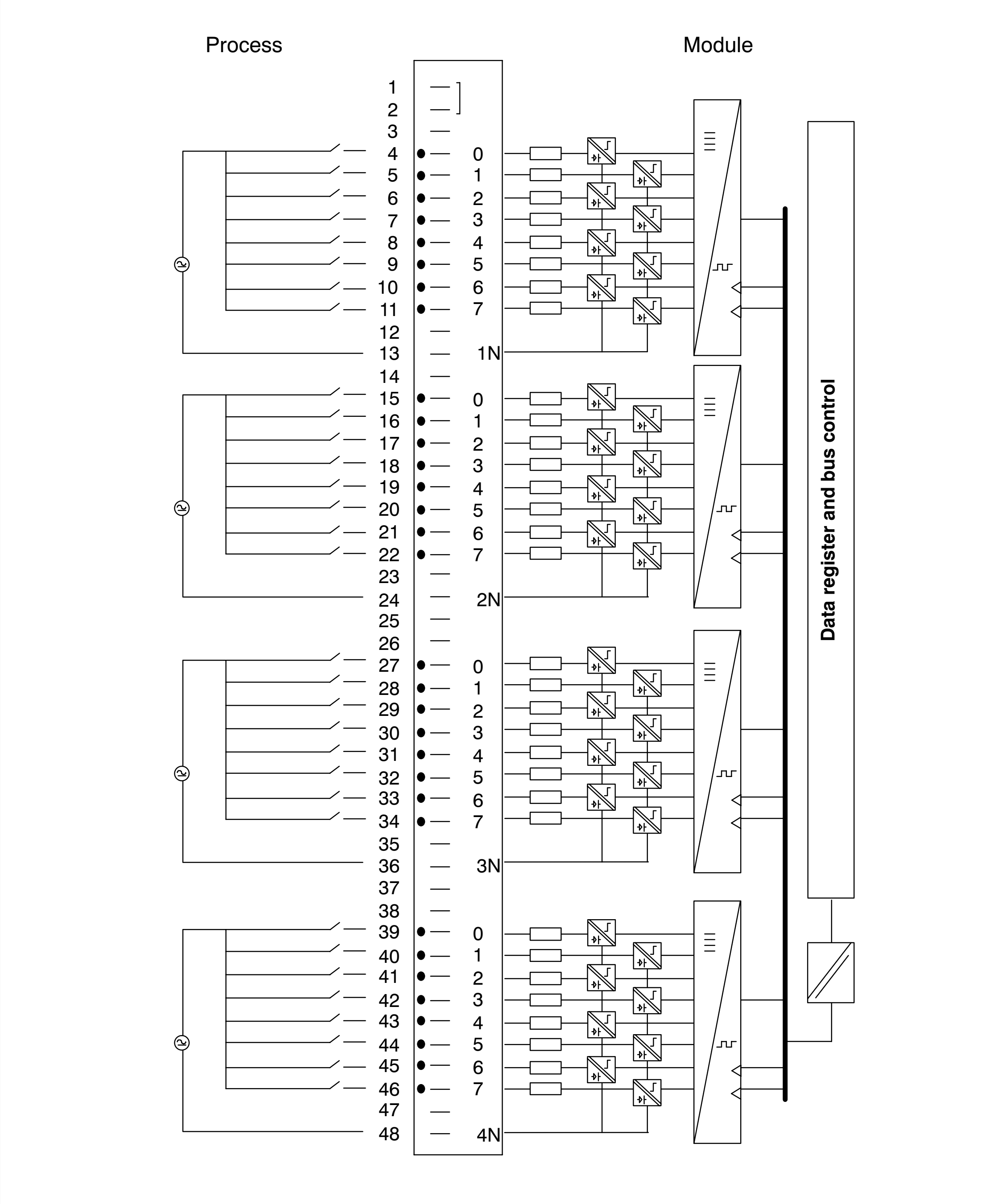


Figure 4-10 Terminal Assignment and Block Diagram of the SM 421; DI 32 x 120 VUC

Technical Specifications of the SM 421; DI 32 x 120 VUC

Dimensions and Weight	
Dimensions W x H x D (mm)	25 x 290 x 210
Weight	Approx. 600 g
Data for Specific Module	
Number of inputs	32
Length of cable	
• Unshielded	600 m
• Shielded	1000 m
Voltages, Currents, Potentials	
Rated load voltage L+	79 to 132 VAC 80 to 132 VDC
• Reverse polarity protection	Yes
Number of inputs that can be triggered simultaneously	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. 200 mA
Power dissipation of the module	Typ. 6.5 W

Status, Interrupts, Diagnostics	
Status display	Green LED per channel
Interrupts	None
Diagnostic functions	None
Data for Selecting a Sensor	
Input voltage	
• Rated value	120 VUC
• For signal “1”	79 to 132 VAC 80 VDC to 132 VDC
• For signal “0”	0 to 20 V
• Frequency range	47 to 63 Hz
Input current	
• At signal “1”	2 mA to 5 mA
• At signal “0”	0 to 1 mA
Input delay	
• At “0” to “1”	5 to 25 ms
• At “1” to “0”	5 to 25 ms
Input characteristic curve	To IEC 61131–2; type 1
Connection of two-wire BEROs	Possible
• Permitted bias current	Max.1 mA

4.14 Digital Output Module SM 422; DO 16 x 24 VDC/2 A; (6ES7422-1BH11-0AA0)

Characteristics

The digital output module SM 422; DO 16 x 24 VDC/2 A has the following features.

- 16 outputs, isolated in two groups of 8
- 2 A output current
- 24 VDC rated load voltage

The status LEDs also indicate the system status even when the front connector is not inserted.

A Note about Commissioning

The following technical feature applies to the digital output module SM 422; DO 16 x 24 VDC/2 A with the order number 6ES7422-1BH**11**-0AA0 but not to the digital output module SM 422; DO 16 x 24 VDC/2 A with the order number 6ES7422-1BH**10**-0AA0:

To commission the module, it is **no** longer necessary to apply load voltage (1L+ and 3L+, for example,) to each group of 8 outputs. The module is fully operative even if only one group is supplied with L+.

Warning

It is no longer possible to switch off all the outputs by disconnecting a single L+ supply as might have been the case with the previous module (6ES7422-1BH**10**-0AA0)L+.

Terminal Assignment and Block Diagram of the SM 422; DO 16 × 24 VDC/2 A

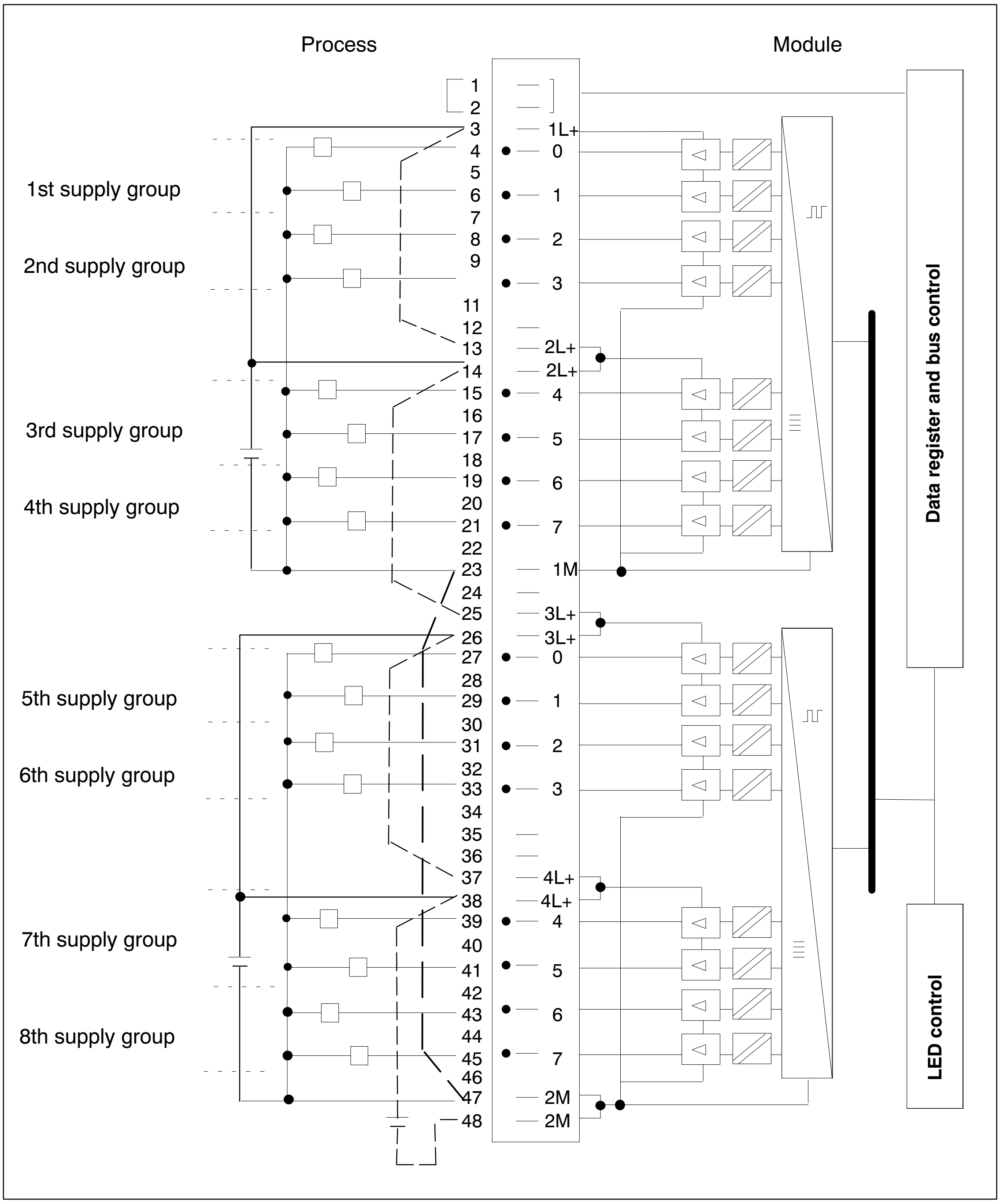


Figure 4-11 Terminal Assignment and Block Diagram of the SM 422; DO 16 × 24 VDC/2 A

Technical Specifications of the SM 422; DO 16 x 24 VDC/2 A

Dimensions and Weight	
Dimensions W x H x D (in millimeters)	25 x 290 x 210
Weight	Approx. 600 g
Data for Specific Module	
Number of outputs	16
Length of cable	
• Unshielded	600 m
• Shielded	1000 m
Voltages, Currents, Potentials	
Power rated voltage of the electronics L+	24 VDC
Rated load voltage L+	24 VDC
Aggregate current of the outputs (two outputs per supply group [1])	
Up to 40 °C	Max. 3 A
Up to 60 °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	
• Channels against backplane bus and load voltage L+	500 VDC
• Between the outputs of the different groups	500 VDC
Current consumption	
• From the backplane bus	Max. 160 mA
• Power supply and load voltage L+ (no load)	Max. 30 mA
Power dissipation of the module	Typ. 5 W
Status, Interrupts, Diagnostics	
Status display	Green LED per channel
Interrupts	None
Diagnostic functions	None

Data for Selecting an Actuator	
Output voltage	
• At signal “1”	Min. L+ (-0,5 V)
Output current	
• At signal “1”	
Rated value	2A
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. 1 ms
• At “1” to “0”	Max. 1 ms
Load resistor range	24 Ω to 4 kΩ
Lamp load	Max. 10 W
Parallel connection of 2 outputs	
• 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	100 Hz
• For inductive load to IEC 60947-5–1, DC 13	0.2 Hz at 1 A 0.1 Hz at 2A
• For lamp load	Max. 10 Hz
Limit (internal) of the inductive circuit interruption voltage up to	Max. -30 V
Short-circuit protection of output[1]	Electronically cyclic[2]
• Threshold on	2.8 A to 6 A

[1] A supply group always consists of two adjacent channels starting with channel 0. Channels 0 and 1, 2 and 3 and so on up to 14 and 15 therefore form one supply group.

[2] Following a short circuit, reclosing under a full load is not guaranteed. To prevent this, you can do one of the following things:

- Change the signal at the output
- Interrupt the load voltage of the module
- Briefly disconnect the load from the output

4.15 Digital Output Module SM 422; DO 16 x 20-125 VDC/1.5 A; (6ES7422-5EH10-0AB0)

Characteristics

The SM 422; DO 16 x 20-125 VDC/1.5 A has the following features:

- 16 outputs, each channel is fused; reverse polarity protection and isolated in groups of 8
- 1.5 A output current
- Rated load voltage 20 to 125 VDC
- Group error display for internal faults (INTF) and external faults (EXTF)
- Programmable diagnostics
- Programmable diagnostic interrupt
- Programmable substitute value output

Terminal Assignment Diagram of the SM 422; DO 16 x 20-125 VDC/1.5 A

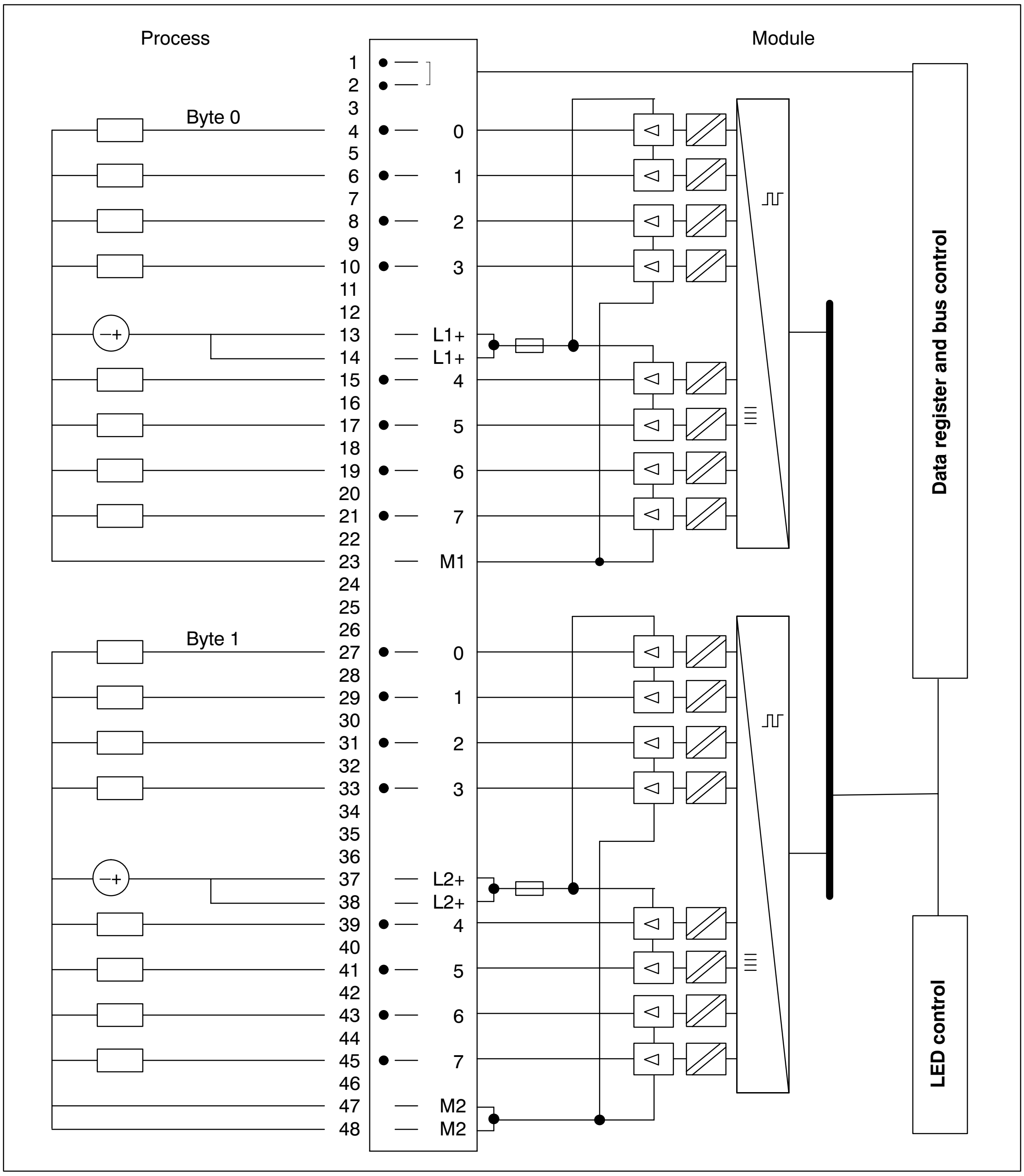


Figure 4-12 Terminal Assignment Diagram of the SM 422; DO 16 x 20-125 VDC/1.5 A

Technical Specifications of the SM 422; DO 16 x 20-125 VDC/1.5 A

Dimensions and Weight		
Dimensions W x H x D (in millimeters)	25 x 290 x 210	
Weight	Approx. 800 g	
Data for Specific Module		
Number of outputs	16	
Length of cable		
• Unshielded	Max. 600 m	
• Shielded	Max. 1000 m	
Voltages, Currents, Potentials		
Rated load voltage L1	20 VDC to 138 VDC	
• Reverse polarity protection	Yes, with fuse	
Total current of the outputs [1]		
		With fan sub assembly
Up to 40 °C	Max. 16 A	21 A
Up to 60 °C	Max. 8 A	14 A
Isolation		
• Between channels and backplane bus	Yes	
• Between the channels	Yes	
In groups of	8	
Permitted potential difference		
• Between the outputs of the different groups	250 VAC	
Insulation tested with	1500 VAC	
Current consumption		
• From the backplane bus	Max. 700 mA	
• From load voltage L + (without load)	Max. 2 mA	
Power dissipation of the module	Typ. 10 W	
Status, Interrupts, Diagnostics		
Status display	Green LED per channel	
Interrupts		
• Diagnostic Interrupt	Parameters can be assigned	
Diagnostic functions	Parameters can be assigned	
• Group error display		
– For internal fault	Red LED (INTF)	
– For external fault	Red LED (EXTF)	
• Diagnostic information readable	Yes	
Substitute value can be applied	Yes, programmable	

Data for Selecting an Actuator	
Output voltage	
• At signal “1”	Min. L+ (–1,0 V)
Output current	
• At signal “1”	
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. 13 ms
Parallel connection of 2 outputs	
• For redundant triggering of a load	Possible (only outputs of the same group)
• To increase performance	Possible (only outputs of the same group)
Triggering a digital input	Possible
Switch rate	
• For resistive load	Max. 10 Hz
• For inductive load to IEC 60947-5-1, DC 13	Max. 0.5 Hz
Short-circuit protection of output	Electronically protected[2]
• Threshold on	Typ. 04 A to 5 A
Replacement fuses	Fuse, 8 A/250 V, quick blow

1) To achieve maximum performance capability, distribute the high-current load between the two groups.

2) To reset a deactivated output, first set the output signal to 0 and then to 1.

If output signal 1 is written to a deactivated output and the short circuit remains, additional interrupts are generated (provided the diagnostic interrupt parameter was set).

Warning

If the power supply is switched on by means of a mechanical contact, a voltage pulse may occur at the outputs. The transient pulse lasts a maximum of 0.5 ms.

Changing Fuses

Warning

This can result in injury.

If you change a fuse without removing the front connector of the module, you could be injured by an electric shock.

Consequently, always remove the front connector before you change the fuse.

4.15.1 Assigning Parameters to the SM 422; DO 16 x 20-125 VDC/1.5 A

Parameter Assignment

You will find a description of the general procedure for assigning parameters to digital modules in Section 4.3.

Parameters of the SM 421; DO 16 x 20-125 VDC/1.5 A

You will find an overview of the parameters you can set and their default settings for the SM 422; DO 16 x 20-125 VDC/1.5 A in the following table.

Table 4-13 Parameters of the SM 422; DO 1 x 20-125 VDC/1.5 A

Parameter	Value Range	Default[2)]	Parameter Type	Scope
Enable • Diagnostic interrupt[1)]	Yes/no	No	Dynamic	Module
• Destination CPU for interrupt	1 to 4	–	Static	Module
Reaction to CPU-STOP	Substitute a value (SV) Keep last value (KLV)	SV	Dynamic	Module
Diagnostics • No load voltage L+ • Short circuit to M	Yes/no Yes/no	No No	Static	Channel group Channel
Enable substitute value “1”	Yes/no	No	Dynamic	Channel

1) If you use the module in ER-1/ER-2, you must set this parameter to “No” because the interrupt lines are not available in ER-1/ER-2.

2) Only in the CC (central controller) is it possible to start up the digital modules with the default settings.

Assigning the “No Load Voltage L+” Diagnosis to Channel Groups

You can only set the “No Load Voltage L+” diagnosis separately for each channel group. In other words, the setting for channel 0 applies to inputs 0 to 7, and the setting for channel 8 applies to inputs 8 to 15.

4.16 Digital Output Module SM 422; DO 32 x 24 VDC/0.5 A; (6ES7422-1BL00-0AA0)

Characteristics

The SM 422; DO 32 x 24 VDC/0.5 A has the following features:

- 32 outputs, isolated in a group of 32
- Power is supplied to 8 channels in groups.
- A supply group always consists of eight adjacent channels starting with channel 0. Channels 0 to 7, 8 to 15, 16 to 23 and 24 to 32 therefore form one supply group
- Each of these supply groups can be switched off separately by isolating L+, however you have to take note of the common ground connection.
- 0.5 A output current
- 24 VDC rated load voltage

The status LEDs also indicate the system status even when the front connector is not inserted.

Terminal Assignment and Block Diagram of the SM 422; DO 32 x 24 VDC/0.5 A

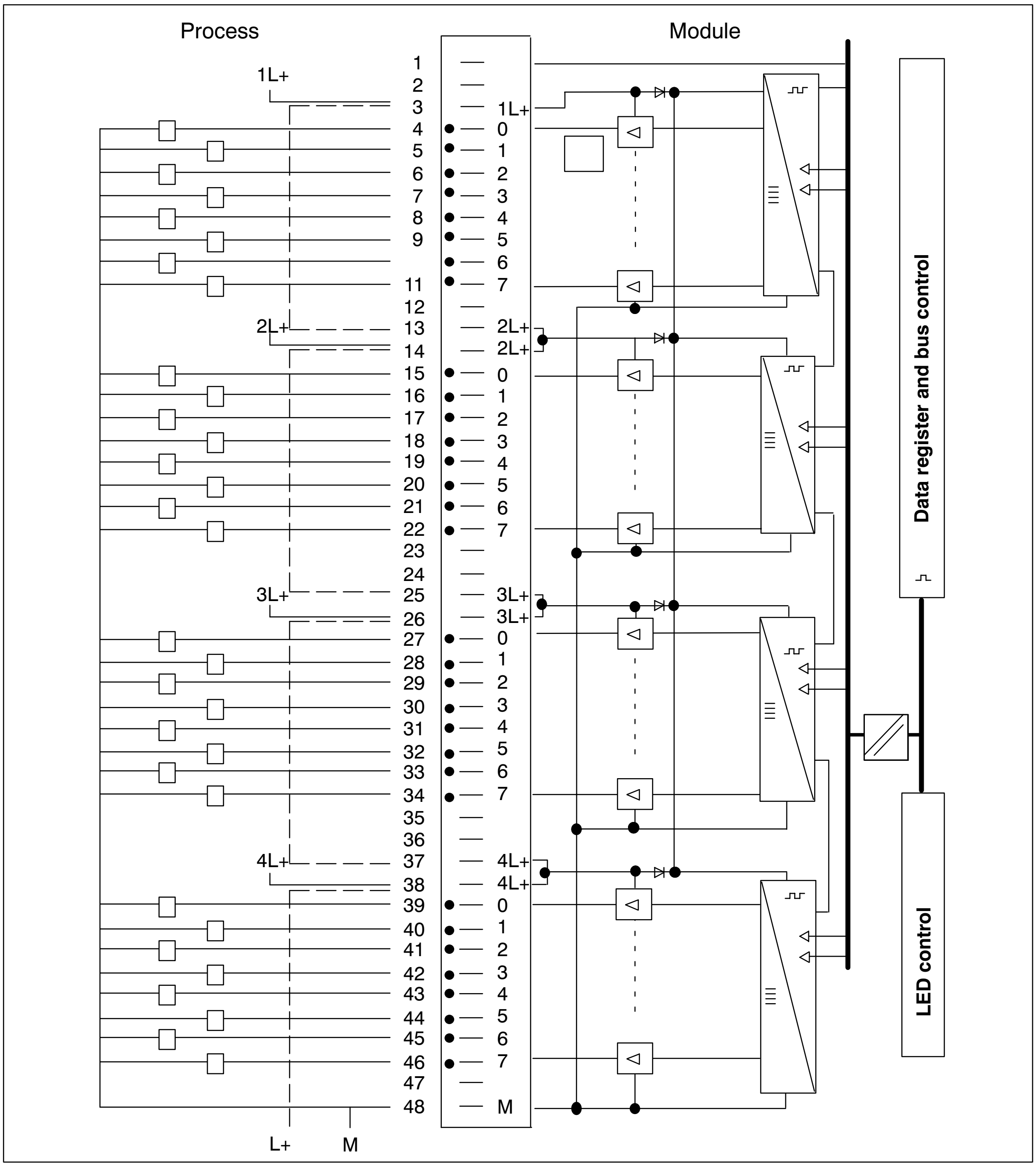


Figure 4-13 Terminal Assignment and Block Diagram of the SM 422; DO 32 x 24 VDC/0.5 A

Technical Specifications of the SM 422; DO 32 x 24 VDC/0.5 A

Dimensions and Weight	
Dimensions W x H x D (in millimeters)	25 x 290 x 210
Weight	Approx. 600 g
Data for Specific Module	
Number of outputs	32
Length of cable	
• Unshielded	600 m
• Shielded	1000 m
Voltages, Currents, Potentials	
Power rated voltage of the electronics L+	24 VDC
Rated load voltage L+	24 VDC
Aggregate current of the outputs (per supply group[1]) of 8 outputs)	
Up to 40 °C	Max. 4 A
Up to 60 °C	Max. 2 A
Isolation	
• Between channels and backplane bus	Yes
• Between the channels	No
Permitted potential difference	
• Between the different circuits	75 VDC / 60 VAC
Insulation tested with	
• Channels against backplane bus and load voltage L+	500 VDC
• Load voltage L+ against backplane bus	500 VDC
Current consumption	
• From the backplane bus	Max. 200 mA
• Power supply and load voltage L+ (no load)	Max. 30 mA
Power dissipation of the module	Typ. 4 W

Status, Interrupts, Diagnostics	
Status display	Green LED per channel
Interrupts	None
Diagnostic functions	None
Data for Selecting an Actuator	
Output voltage	
• At signal "1"	Min. L+ (-0,3 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. 0.3 mA
Output delay (for resistive load)	
• From " 0" to "1"	Max. 1 ms
• At "1" to "0"	Max. 1 ms
Load resistor range	48 Ω to 4 kΩ
Lamp load	Max. 5 W
Parallel connection of 2 outputs	
• For redundant triggering of a load	Possible (only outputs of the same group)
• To increase performance	Possible (only outputs of the same group)
Triggering a digital input	Possible
Switch rate	
• For resistive load	Max. 100 Hz
• For inductive load to IEC 60947-5-1, DC 13	Max. 2 Hz at 0.3 A Max. 0.5 Hz at 0.5 A
• For lamp load	Max. 10 Hz
Limit (internal) of the inductive circuit interruption voltage up to	Typ. – 27 V
Short-circuit protection of the output	Electronically cyclic
• Threshold on	Typ. 0.7 A to 1.5 A

[1]) A supply group always consists of eight adjacent channels starting with channel 0. Channels 0 to 7, 8 to 15, 16 to 23 and 24 to 32 therefore form one supply group.

4.17 Digital Output Module SM 422; DO 32 x 24 VDC/0.5 A; (6ES7422-7BL00-0AB0)

Characteristics

The digital output module SM 422; DO 32 x 24 VDC/0.5 A has the following features:

- 32 outputs, fused and isolated in groups of 8
- 0.5 A output current
- 24 VDC rated load voltage
- Group error display for internal faults (INTF) and external faults (EXTF)
- Programmable diagnostics
- Programmable diagnostic interrupt
- Programmable substitute value output

The status LEDs also indicate the system status even when the front connector is not inserted.

Terminal Assignment and Block Diagram of the SM 422; DO 32 x 24 VDC/0.5 A

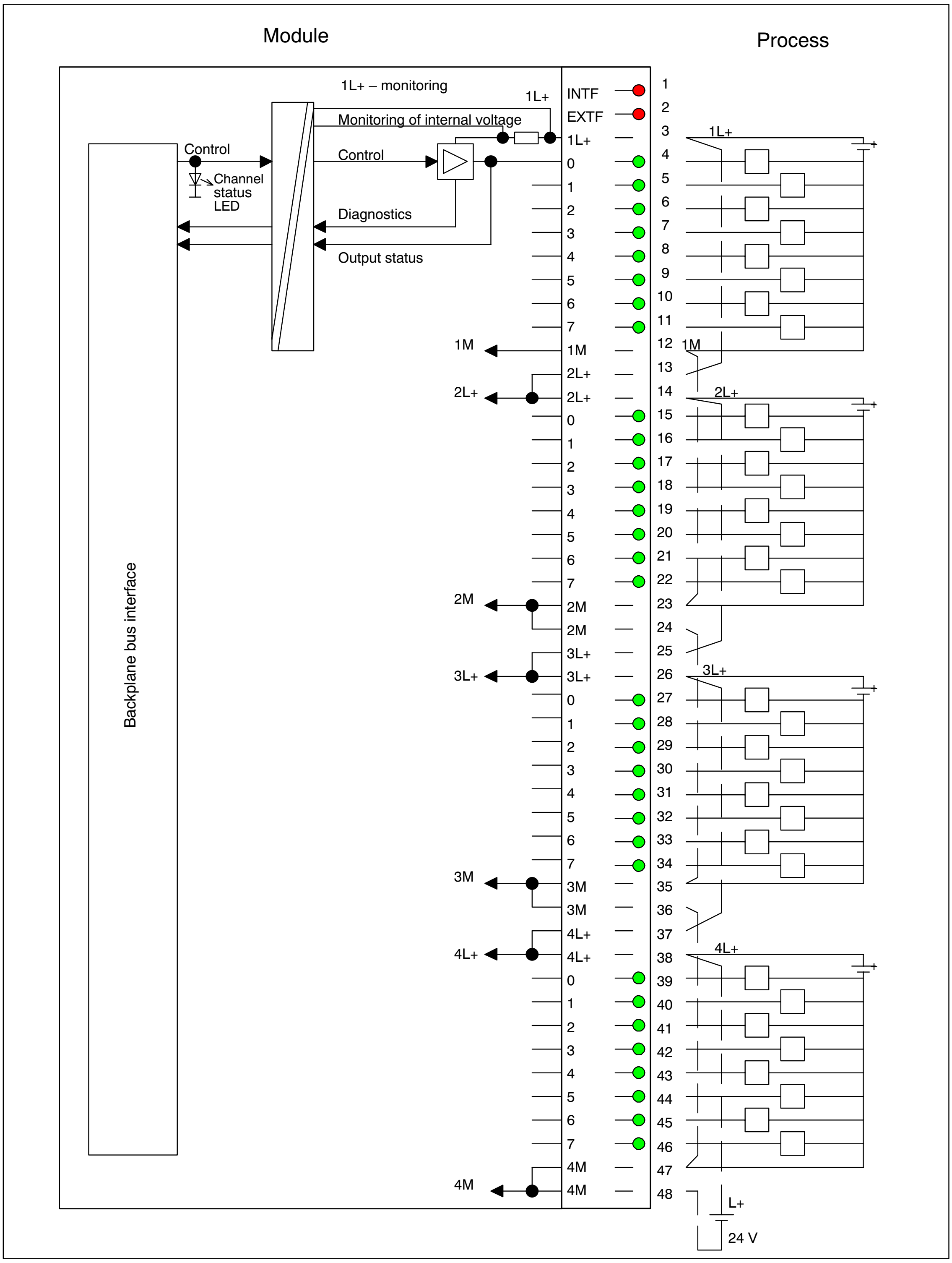


Figure 4-14 Terminal Assignment and Block Diagram of the SM 422; DO 32 x 24 VDC/0.5 A

Technical Specifications of the SM 422; DO 32 x 24 VDC/0.5 A

Dimensions and Weight	
Dimensions W x H x D (in millimeters)	25 x 290 x 210
Weight	Approx. 600 g
Data for Specific Module	
Number of outputs	32
Length of cable	
• Unshielded	600 m
• Shielded	1000 m
Voltages, Currents, Potentials	
Power rated voltage of the electronics L+	24 VDC
Rated load voltage L+	24 VDC
Total current of the outputs (per group)	
Up to 40 °C	Max. 4 A
Up to 60 °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	
• Channels against backplane bus and load voltage L+	500 VDC
• Between the outputs of the different groups	500 VDC
Current consumption	
• From the backplane bus	Max. 200 mA
• Power supply and load voltage L+ (no load)	Max. 120 mA
Power dissipation of the module	Typ. 8 W
Status, Interrupts, Diagnostics	
Status display	Green LED per channel
Interrupts	
• Diagnostic Interrupt	Parameters can be assigned
• Hardware interrupt	Parameters can be assigned
Diagnostic functions	
• Monitoring of the load voltage	Yes
• Group error display	
– For internal fault	Red LED (INTF)
– For external fault	Red LED (EXTF)
• Diagnostic information readable	Yes
Monitoring for	
• Short circuit	> 1 A (typ.)
• Wire break	< 0.15 mA
Substitute value can be applied	Yes
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
Load resistor range	48 Ω to 4 kΩ
Parallel connection of 2 outputs	
• For redundant triggering of a load	Possible (only outputs of the same group)
• To increase performance	Possible (only outputs of the same group)
Triggering a digital input	Possible
Switch rate	
• For resistive load	Max. 100 Hz
• For inductive load to IEC 60947-5-1, DC 13	Max. 2 Hz
• For lamp load	Max. 2 Hz
Limit (internal) of the inductive circuit interruption voltage up to	Typ. L + (– 45 V)
Short-circuit protection of the output	Electronically cyclic
• Threshold on	Typ. 0.75 A to 1.5 A

Time, Frequency	
Internal preparation time between backplane bus and input of the output driver[1]	
Up to hardware release 03	
• independent of enable diagnostics/diagnostic interrupt/ substitute value	max. 100 μs
Up to hardware release 04	
• without enable diagnostics/ diagnostic interrupt/ substitute value	max. 60 μs
• with enable diagnostics/ diagnostic interrupt/ substitute value	max. 100 μs
[1] The switching time of the output driver is added to the overall runtime on the module (< 100 μs for resistive load)	

4.17.1 Assigning Parameters to the SM 422; DO 32 x 24 VDC/0.5 A

Parameter Assignment

You will find a description of the general procedure for assigning parameters to digital modules in Section 4.3.

Parameters of the SM 422; DO 32 x 24 VDC/0.5 A

You will find an overview of the parameters that you can set and their default settings for the SM 422; DO 32 x 24 VDC/0.5 A in the table below.

Table 4-14 Parameters of the SM 422; DO 3 x 24 VDC/0.5 A (6ES7422-7BL00-0AB0)

Parameter	Value Range	Default[2]	Parameter Type	Scope
Enable • Diagnostic interrupt[1]	Yes/no	No	Dynamic	Module
• Destination CPU for interrupt	1 to 4	–	Static	Module
Reaction to CPU-STOP	Substitute a value (SV) Keep last value (KLV)	SV	Dynamic	Module
Diagnostics • Wire break • No load voltage L+/sensor supply • Short circuit to M • Short circuit to L+	Yes/no Yes/no Yes/no Yes/no	No no No No	Static	Channel Channel group Channel Channel
Substitute “1”	Yes/no	No	Dynamic	Channel

[1] If you use the module in ER-1/ER-2, you must set this parameter to “No” because the interrupt lines are not available in ER-1/ER-2.

[2] Only in the CC (central controller) is it possible to start up the digital modules with the default settings.

4.17.2 Behavior of the SM 422; DO 32 x 24 VDC/0.5 A

Effect of Operating Mode and Supply Voltage on the Output Values

The output values of the SM 422; DO 32 x 24 VDC/0.5 A depend on the operating mode of the CPU and on the supply voltage of the module.

Table 4-15 Dependence of the Output Values on the Operating Mode of the CPU and on the Supply Voltage L+ of the SM 422; DO 32 x 24 VDC/0.5 A

CPU Operating Mode		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 in the Event of Failure of the Supply Voltage

The failure of the supply voltage of the SM 422; DO 32 x 24VDC/0.5 A is always indicated by the EXTF 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 4.17.1).

4.18 Digital Output Module SM 422; DO 8 x 120/230 VAC/5 A; (6ES7422-1FF00-0AA0)

Characteristics

The SM 422; DO 8 x 120/230 VAC/5 A has the following features:

- 8 outputs, isolated in groups of 1
- Output current 5 A
- 120/230 VAC rated load voltage

The status LEDs also indicate the system status even when the front connector is not inserted.

Terminal Assignment and Block Diagram of the SM 422; DO 8 x 120/230 VAC/5 A

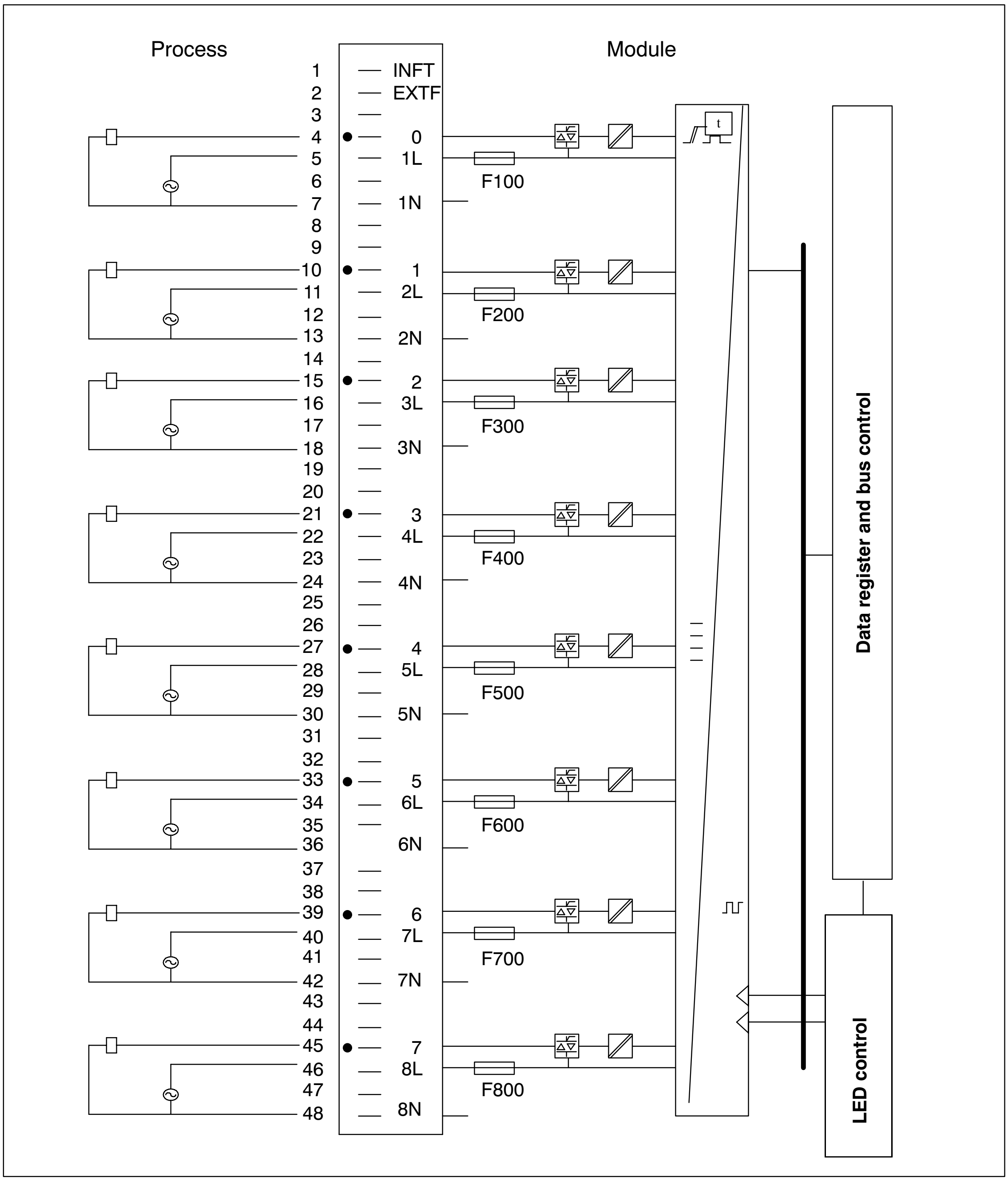


Figure 4-15 Terminal Assignment and Block Diagram of the SM 422; DO 8 x 120/230 VAC/5 A

Technical Specifications of the SM 422; DO 8 x 120/230 VAC/5 A

Dimensions and Weight		
Dimensions W x H x D (in millimeters)	25 x 290 x 210	
Weight	Approx. 800 g	
Data for Specific Module		
Number of outputs	8	
Length of cable		
• Unshielded	600 m	
• Shielded	1000 m	
Voltages, Currents, Potentials		
Rated load voltage L1	79 to 264 VAC	
Permitted frequency range	47 to 63 Hz	
Total current of the outputs		
		With fan sub-assembly
Up to 40 °C	Max. 16 A	24 A
Up to 60 °C	Max. 8 A	20 A
Isolation		
• Between channels and backplane bus	Yes	
• Between the channels	Yes	
In groups of	1	
Permitted potential difference		
• Between the outputs of the different groups	500 VAC	
Insulation resistance	4000 VAC	
Current consumption		
• From the backplane bus	Max. 250 mA	
• From load voltage L + (without load)	Max. 1.5 mA	
Power dissipation of the module	Typ. 16 W	
Status, Interrupts, Diagnostics		
Status display	Green LED per channel	
Interrupts	None	
Diagnostic functions	Parameters cannot be assigned	
• Group error display		
– For internal fault	Red LED (INTF) failed fuse	
– For external fault	Red LED (EXTF) failed load voltage	

Data for Selecting an Actuator	
Output voltage	
• At signal “1”	At maximum current min. L1 (–1.5 Vrms) At maximum current min. L1 (–10.7 Vrms)
Output current	
• At signal “1”	
Rated value	5 A
Permitted range	10 mA to 5 A
Permitted surge current (per group)	Max. 50 A per cycle
• At signal “0” (leakage current)	Max. 3.5 mA
Output delay (for resistive load)	
• From “ 0” to “1”	Not more than 1 AC scan cycle
• At “1” to “0”	Not more than 1 AC scan cycle
Minimum load current	10 mA
Zero cross inhibit voltage	Max. 55 V
Size of the motor starter	Max. size 5 to NEMA
Lamp load	Max. 100 W
Parallel connection of 2 outputs	
• For redundant triggering of a load	Possible (only outputs connected to the same load)
Triggering a digital input	Possible
Switch rate	
• For resistive load	Max. 10 Hz
• For inductive load to IEC 60947-5-1, DC 13	Max. 0.5 Hz
• For lamp load	1 Hz
Short-circuit protection of the output	Fuse, 8 A, 250 V (per output)
• Min. current required for fuse to blow	Min. 100 A
• Max. response time	Max. 100 ms
Replacement fuses	Fuse, 8 A, quick-acting
• Wickmann	194-1800-0
• Schurter	SP001.1013
• Littelfuse	217.008

Changing Fuses

Warning

This can result in injury.

If you change a fuse without removing the front connector of the module, you could be injured by an electric shock.

Consequently, always remove the front connector before you change the fuse.

4.19 Digital Output Module SM 422; DO 16 x 120/230 VAC/2 A; (6ES7422-1FH00-0AA0)

Characteristics

The SM 422; DO 1 x 120/230 VAC/2 A has the following features:

- 16 outputs, isolated in groups of 4
- 2 A output current
- 120/230 VAC rated load voltage

The status LEDs also indicate the system status even when the front connector is not inserted.

Terminal Assignment and Block Diagram of the SM 422; DO 16 x 120/230 VAC/2 A

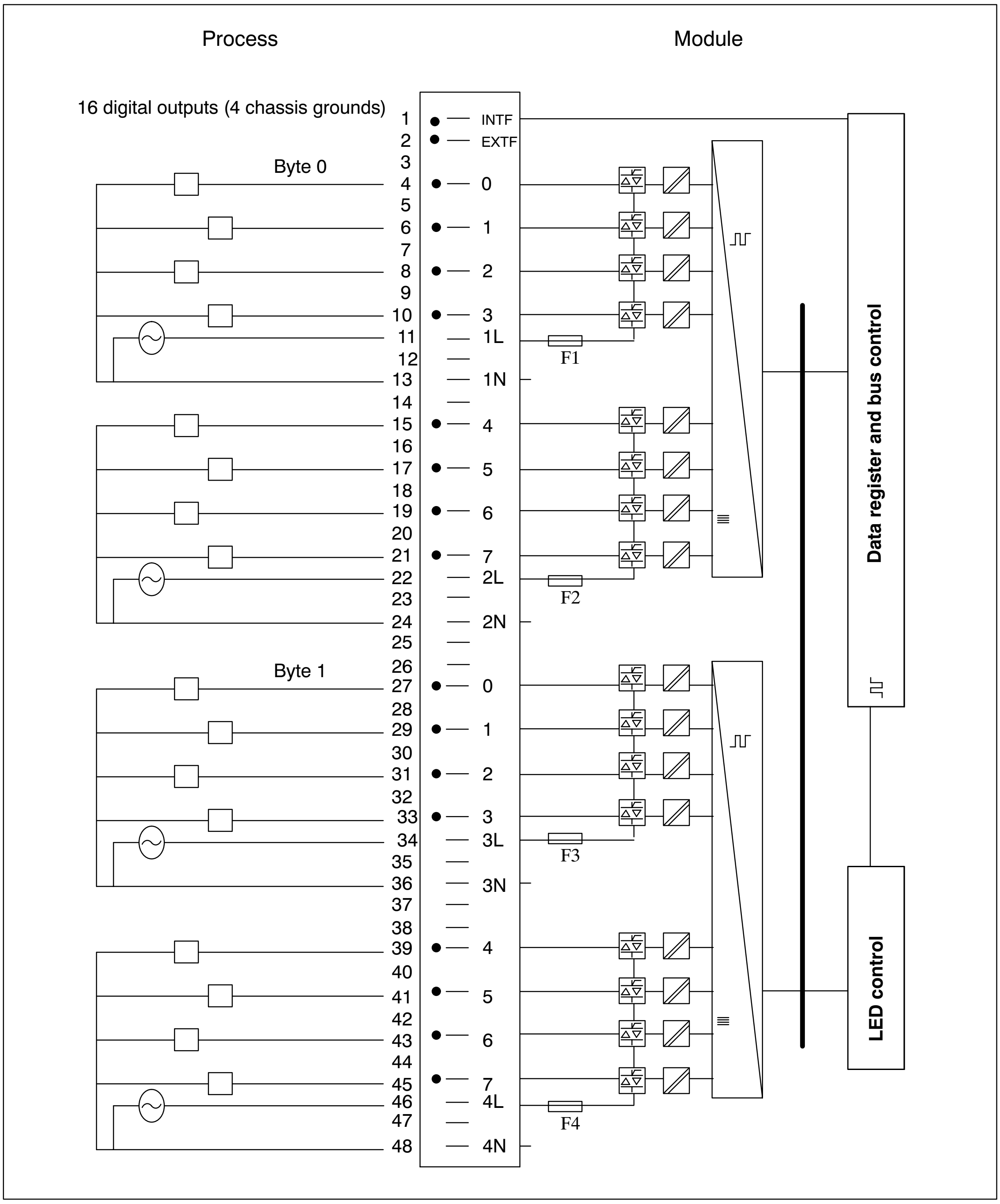


Figure 4-16 Terminal Assignment and Block Diagram of the SM 422; DO 16 x 120/230 VAC/2 A

Technical Specifications of the SM 422; DO 16 x 120/230 VAC/2 A

Dimensions and Weight		
DimensionsW x H x D (in millimeters)	25 x 290 x 210	
Weight	Approx. 800 g	
Data for Specific Module		
Number of outputs	16	
Length of cable		
• Unshielded	600 m	
• Shielded	1000 m	
Voltages, Currents, Potentials		
Rated load voltage L1	79 to 264 VAC	
Permitted frequency range	47 to 63 Hz	
Total current of the outputs (per group)		
		With fan sub–assembly
Up to 40 °C	Max. 4 A	6 A
Up to 60 °C	Max. 2 A	5 A
Isolation		
• Between channels and backplane bus	Yes	
• Between the channels	Yes	
In groups of	4	
Permitted potential difference		
• Between the outputs of the different groups	500 VAC	
Insulation resistance	4000 VAC	
Current consumption		
• From the backplane bus	Max. 400 mA	
• From load voltage L + (without load)	1.5 mA	
Power dissipation of the module	Typ. 16 W	
Status, Interrupts, Diagnostics		
Status display	Green LED per channel	
Interrupts	None	
Diagnostic functions	Parameters cannot be assigned	
• Group error display		
– For internal fault	Red LED (INTF) failed fuse	
– For external fault	Red LED (EXTF) failed load voltage	

Data for Selecting an Actuator	
Output voltage	
• At signal “1”	At maximum current min. L1 (–1.3 Vrms)
	At minimum current min. L1 (–18.1 Vrms)
Output current	
• At signal “1”	
Rated value	2 A
Permitted range	10 mA to 2 A
Permitted surge current (per group)	Max. 50 A per cycle
• At signal “0” (leakage current)	Max. 2.6 mA
Output delay (for resistive load)	
• From “ 0” to “1”	Max. 1 ms
• At “1” to “0”	Not more than 1 AC scan cycle
Minimum load current	10 mA
Zero cross inhibit voltage	Non-zero cross outputs
Size of the motor starter	Max. size 5 to NEMA
Lamp load	Max. 50 W
Parallel connection of 2 outputs	
• For redundant triggering of a load	Possible (only outputs connected to the same load)
Triggering a digital input	Possible
Switch rate	
• For resistive load	Max. 10 Hz
• For inductive load, to IEC 60947-5-1, AC 15	Max. 0.5 Hz
• For lamp load	1 Hz
Short-circuit protection of the output	Fuse, 8 A, 250 V (per group)
• Min. current required for fuse to blow	Min. 100 A
• Max. response time	Max. 100 ms
Replacement fuses	Fuse, 8 A, quick-acting
• Wickmann	194-1800-0
• Schurter	SP001.1013
• Littelfuse	217.008

Changing Fuses

Warning

This can result in injury.

If you change a fuse without removing the front connector of the module, you could be injured by an electric shock.

Consequently, always remove the front connector before you change the fuse.

4.20 Digital Output Module SM 422; DO 16 x 20-120 VAC/2 A; (6ES7422-5EH00-0AB0)

Characteristics

The SM 422; DO 16 x 20-120 VAC/2 A has the following features:

- 16 outputs, isolated in groups of 1
- 2 A output current
- Rated load voltage 20 VAC to 120 VAC
- Group error display for internal faults (INTF) and external faults (EXTF)
- Programmable diagnostics
- Programmable diagnostic interrupt
- Programmable substitute value output

Terminal Assignment Diagram of the SM 422; DO 16 x 20-120 VAC/2 A

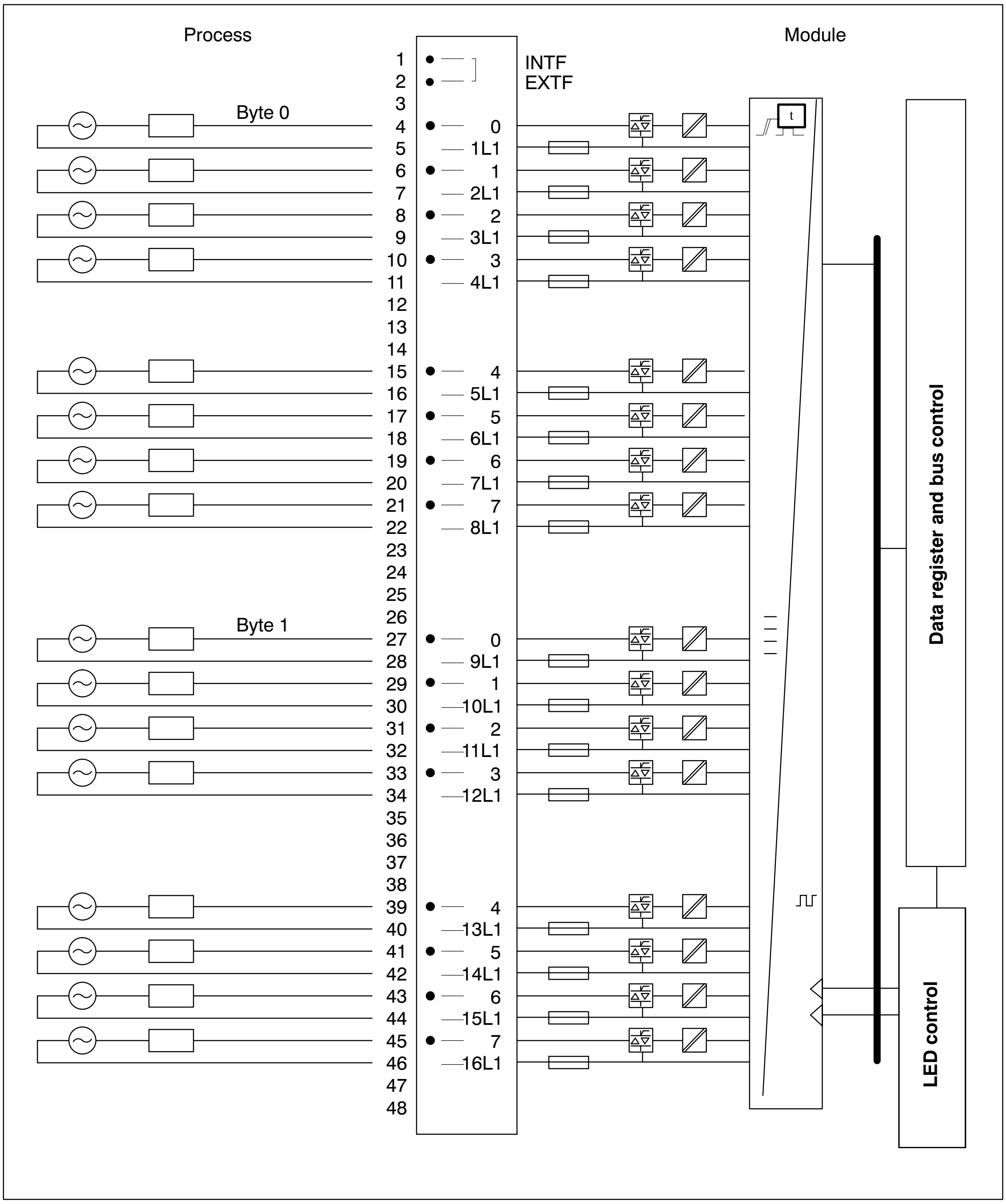


Figure 4-17 Terminal Assignment Diagram of the SM 422; DO 16 x 20-120 VAC/2 A

Technical Specifications of the SM 422; DO 16 x 20-120 VAC/2 A

Dimensions and Weight		
Dimensions W x H x D (in millimeters)	25 x 290 x 210	
Weight	Approx. 800 g	
Data for Specific Module		
Number of outputs	16	
Length of cable		
• Unshielded	Max. 600 m	
• Shielded	Max. 1000 m	
Voltages, Currents, Potentials		
Rated load voltage L+	20 to 132 VAC	
• Permitted frequency range	47 Hz to 63 Hz	
Total current of the outputs		With fan sub–assembly
Up to 40 °C	Max. 16 A	24 A
Up to 60 °C	Max. 7 A	16 A
Isolation		
• Between channels and backplane bus	Yes	
• Between the channels	Yes	
In groups of	1	
Permitted potential difference		
• Between $M_{internal}$ and the outputs	120 VAC	
• Between the outputs of the different groups	250 VAC	
Insulation tested with	1500 VDC	
Current consumption		
• From the backplane bus	Max. 600 mA	
• From load voltage L + (without load)	Max. 0 mA	
Power dissipation of the module	Typ. 20 W	
Status, Interrupts, Diagnostics		
Status display	Green LED per channel	
Interrupts		
• Diagnostic Interrupt	Parameters can be assigned	
Diagnostic functions	Parameters can be assigned	
• Group error display		
– For internal fault	Red LED (INTF)	
– For external fault	Red LED (EXTF)	

• Diagnostic information readable	Possible
Substitute value can be applied	Yes, programmable
Data for Selecting an Actuator	
Output voltage	
• At signal “1”	L1 (–1.5 Vrms)
Output current	
• At signal “1”	
Rated value	2 A
Permitted range	100 mA to 2 A
Permitted surge current (per group)	Max. 20 A/2 cycles
• At signal “0” (leakage current)	Max. 2.5 mA at 30 V Max. 4.5 mA at 132 V
Output delay (for resistive load)	
• From “ 0” to “1”	1 ms
• At “1” to “0”	1 AC cycle
Zero cross inhibit voltage	Non-zero cross outputs
Size of the motor starter	Max. size 5 to NEMA
Lamp load	Max. 50 W
Parallel connection of 2 outputs	
• 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 to IEC 60947-5-1, DC 13	Max. 0.5 Hz
• For lamp load	1 Hz
Short-circuit protection of the output	Fuse 8A/125 V 2AG (per output)
• Min. current required for fuse to blow	Min. 40 A
• Max. response time	Typ. 33 ms
Replacement fuses	Fuse, 8 A, quick-acting
• Littelfuse	225.008

Changing Fuses

Warning

This can result in injury.

If you change a fuse without removing the front connector of the module, you could be injured by an electric shock.

Consequently, always remove the front connector before you change the fuse.

4.20.1 Assigning Parameters to the SM 422; DO 16 x 20-120 VAC/2 A

Parameter Assignment

You will find a description of the general procedure for assigning parameters to digital modules in Section 4.3.

Parameters of the SM 422; DO 16 x 20-120 VAC/2 A

You will find an overview of the parameters you can set and their default settings for the SM 422; DO 16 x 20-120 VAC/2 A in the following table.

Table 4-16 Parameters of the SM 422; DO 16 x 20-120 VAC/2 A

Parameter	Value Range	Default[2]	Parameter Type	Scope
Enable • Diagnostic interrupt[1]	Yes/no	No	Dynamic	Module
• Destination CPU for interrupt	1 to 4	–	Static	Module
Reaction to CPU STOP	Substitute a value (SV) Keep last value (KLV)	SV	Dynamic	Module
Diagnostics • Fuse blown	Yes/no	No	Static	Channel
Enable substitute value “1”	Yes/no	No	Dynamic	Channel

[1] If you use the module in ER-1/ER-2, you must set this parameter to “No” because the interrupt lines are not available in ER-1/ER-2.

[2] Only in the CC (central controller) is it possible to start up the digital modules with the default settings.

4.21 Relay Output Module SM 422; DO 16 x 30/230 VUC/Rel. 5 A; (6ES7422-1HH00-0AA0)

Characteristics

The SM 422; DO 16 x 30/230 VUC/Rel. 5 A has the following features:

- 16 outputs, isolated in 8 groups of 2
- Output current 5 A
- Rated load voltage 230 VAC/ 125 VDC

The status LEDs also indicate the system status even when the front connector is not inserted.

Terminal Assignment and Block Diagram of the SM 422; DO 16 x 30/230 VUC/Rel. 5 A

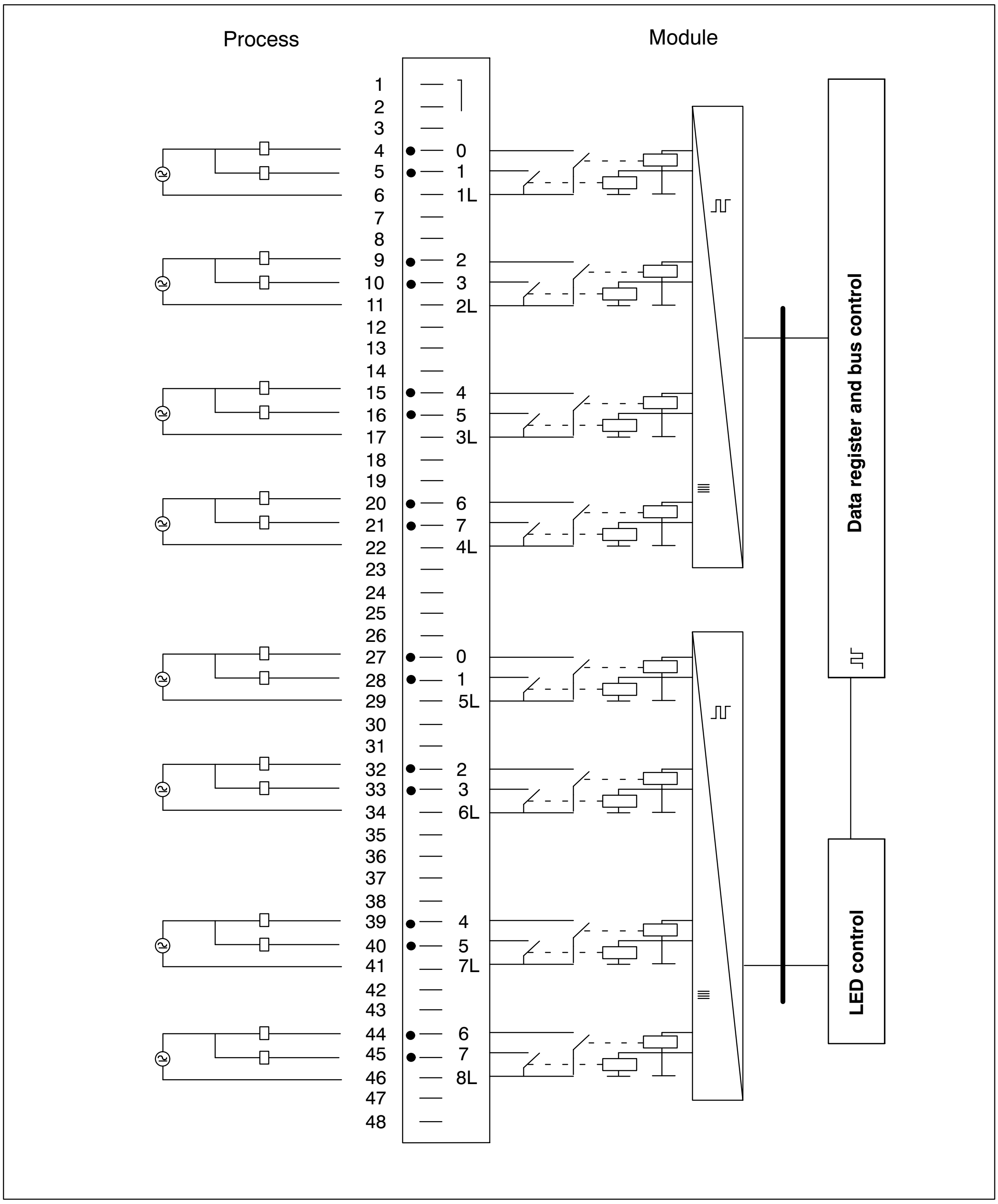


Figure 4-18 Terminal Assignment and Block Diagram of the SM 422; DO 16 x 30/230 VUC/Rel. 5 A

Technical Specifications of the SM 422; DO 16 x 30/230 VUC/Rel. 5 A

Dimensions and Weight		
Dimensions W x H x D (in millimeters)	25 x 290 x 210	
Weight	Approx. 700 g	
Data for Specific Module		
Number of outputs	16	
Length of cable		
• Unshielded	Max. 600 m	
• Shielded	Max. 1000 m	
Voltages, Currents, Potentials		
Total current of the outputs (per group)		
		With fan sub–assembly
Up to 40 °C	Max. 10 A	10 A
Up to 60 °C	Max. 5 A	10 A
Isolation		
• Between channels and backplane bus	Yes	
• Between the channels	Yes	
In groups of	2	
Permitted potential differences:		
• Between the outputs of the different groups	500 VAC	
Insulation resistance	4000 VAC	
Current consumption		
• From the backplane bus	Max. 1 A	
Power dissipation of the module	Typ. 4.5 W	
Status, Interrupts, Diagnostics		
Status display	Green LED per channel	
Interrupt	None	
Diagnostic functions	None	
Relay Features		
Relay response times		
• Power up	Max. 10 ms	
	Typ. 5.5 ms	
• Power down	Max. 5 ms	
	Typ. 3 ms	
Debouncing time	Typ. 0.5 ms	

Data for Selecting an Actuator			
Continuous thermal current	Max. 5 A		
Minimum load current	10 mA		
External fuse for relay outputs	Fuse, 6 A, quick-acting		
Switching capacity and lifetime of the contacts			
• For resistive load			
	Voltage	Current	No. of switching cyc. (typ.)
	30 VDC	5.0 A	0.18 mill
	60 VDC	1.2 A	0.1 mill
	125 VDC	0.2 A	0.1 mill
	230 VAC	5.0 A	0.18 mill
• For inductive load to IEC 60947-5-1 13 DC/15 AC			
	Voltage	Current	No. of switching cyc. (typ.)
	30 VDC (☛7 ms max.)	5.0 A	0.1 mill
	230 VAC (pf=0.4)	5.0 A	0.1 mill
Size of the motor starter	Max. size 5 to NEMA		
Lamp load	Max. 60 W		
Contact protection (internal)	None		
Connecting two outputs in parallel			
• For redundant actuation of a load	Possible (only outputs with identical load voltage)		
• To increase performance	Not possible		
Triggering a digital input	Possible		
Switch rate			
• Mechanical	Max. 20 Hz		
• For resistive load	Max. 10 Hz		
• For inductive load to IEC 60947-5-1, 13 DC/15 AC	1 Hz		
• For lamp load	1 Hz		

Warning

Use a suppressor circuit in environments with high humidity and where sparks might occur at the relay contacts. This will increase the life of the relay contacts.

To do this, connect an RC element or a varistor parallel to the relay contacts or to the load. The dimensions depend on the size of the load (see Chapter 4 of the installation manual).

Analog Modules

5

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 that refers to specific modules (for example, characteristics, diagram of connections and block diagram, technical specifications and special characteristics of the module):
   a) For analog input modules
   b) For analog output modules

STEP 7 Blocks for Analog Functions

You can use blocks FC 105 and FC 106 to read and output analog values in *STEP 7*. You will find the FCs in the standard library of *STEP 7* in the subdirectory called “S5-S7 Converting Blocks” (for a description refer to the *STEP 7* online help system for the FCs).

Additional Information

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

Chapter Overview

5.1 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 5-1 Analog Input Modules: Characteristics at a Glance

Module / Characteristics	SM 431; AI 8 x 13 Bit (-1KF00-)	SM 431; AI 8 x 14 Bit (-1KF10-)	SM 431; AI 8 x 14 Bit (-1KF20-)	SM 431; AI 13 x 16 Bit (-0HH0-)	SM 431; AI 16 x 16 Bit (-7QH00-)	SM 431; AI 8 x RTD 16 Bit (-7KF10-)	SM 431; AI 8 x 16 Bit (-7KF00-)
Number of Inputs	8 AI U-/I measurement 4 AI for resistance measurement	8 AI for U/I measurement 4 AI for resistance/ temperature measurement	8 AI for U/I measurement 4 AI for resistance measurement	16 inputs	16 AI for U/ I/temperature measurement 8 AI for resistance measurement	8 inputs	8 inputs
Resolution	13 bits	14 bits	14 bits	13 bits	16 bits	16 bits	16 bits
Measuring Method	Voltage Current Resistors	Voltage Current Resistors Temperature	Voltage Current Resistors	Voltage Current	Voltage Current Resistors Temperature	Resistors	Voltage Current Temperature
Measuring Principle	Integrating	Integrating	Instantaneous value encoding	Integrating	Integrating	Integrating	Integrating
Programmable Diagnostics	No	No	No	No	Yes	Yes	Yes
Diagnostic Interrupt	No	No	No	No	Adjustable	Yes	Yes
Limit value Monitoring	No	No	No	No	Adjustable	Adjustable	Adjustable
Hardware Interrupt upon Limit Violation	No	No	No	No	Adjustable	Adjustable	Adjustable
Hardware Interrupt at End of Cycle	No	No	No	No	Adjustable	No	No
Potential Relationships	Analog section isolated from CPU			Non-isolated	Analog section isolated from CPU		
Max. Permissible Common Mode Voltage	Between the channels or between the reference potential of the connected sensors and M_{ANA}: 30 VAC	Between the channels or between the channel and central ground point: 120 VAC	Between the channels or between the reference potential of the connected sensors and M_{ANA}: 8 VAC	Between the channels or between the reference potential of the connected sensor and central ground point: 2 VDC/AC	Between the channels or between the channel and central ground point: 120 VAC	Between channel and central ground point: 120 VAC	Between the channels or between the channel and central ground point: 120 VAC

Table 5-1 Analog Input Modules: Characteristics at a Glance, continued

Characteristics / Module	SM 431; AI 8 x 13 Bit (-1KF00-)	SM 431; AI 8 x 14 Bit (-1KF10-)	SM 431; AI 8 x 14 Bit (-1KF20-)	SM 431; AI 13 x 16 Bit (-0HH0-)	SM 431; AI 16 x 16 Bit (-7QH00-)	SM 431; AI 8 x RTD 16 Bit (-7KF10-)	SM 431; AI 8 x 16 Bit (-7KF00-)
Ext. Power Supply Necessary	No	24 VDC (only with current, 2-DMU)	24 VDC (only with current, 2-DMU)	24 VDC (only with current, 2-DMU)	24 VDC (only with current, 2-DMU)	No	No
Special Features	–	Suitable for temperature measurement Temperature sensor types can be configured Linearization of the sensor characteristic curves Smoothing of the measured values	Rapid A/D change, suitable for highly dynamic processes Smoothing of the measured values	–	Suitable for temperature measurement Temperature sensor types can be configured Linearization of the sensor characteristic curves Smoothing of the measured values	Resistance thermometer can be configured Linearization of the sensor characteristic curves Smoothing of the measured values	Internal measuring resistor Field connection with internal reference temperature (included with the module) Smoothing of the measured values

2-DMU Two-wire transmitter

Table 5-2 Analog Output Modules: Characteristics at a Glance

Characteristics / Module	SM 432; AO 8 x 13 Bit (-1HF00-)
Number of outputs	8 outputs
Resolution	13 bits
Output type	Channel by channel: • Voltage • Current
Programmable diagnostics	No
Diagnostic Interrupt	No
Substitute value output	No
Potential relationships	Analog section isolated from: • CPU • The load voltage
Max. permissible common mode voltage	Between the channels and the channels against M_{ANA} 3 VDC
Special Features	–

5.2 Sequence of Steps from Choosing to Commissioning the Analog Modules

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

Step	Procedure	Refer To...
1.	Select the module	Section 5.1 and specific module section from Section 5.18
2.	With some analog input modules: set the measuring method and measuring range by means of the measuring range module	Section 5.4
3.	Install the module in the SIMATIC S7 network	“Installation” section in the manual *S7-400 Programmable Controllers, Hardware and Installation*
4.	Assign parameters to module	Section 5.7
5.	Connect measuring sensor or loads to module	Sections 5.8 to 5.15
6.	Commission configuration	“Commissioning” section in the manual *S7-400 Programmable Controllers, Hardware and Installation*
7.	If commissioning was not successful, diagnose configuration	Section 5.16

5.3 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

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}

Bit 15 Can Be Interpreted as a Sign

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

- “0” $\longrightarrow$ +
- “1” $\longrightarrow$ –

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 5-4 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**

5.3.1 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 5-6 to 5-8 contain the binary representation of the measured values.

Since the binary representation of the measured values is always the same, starting at 5-9 these tables only contain the measured values and the units.

Measured-Value Resolution

The resolution of the analog values can differ depending on the analog module and its parameter assignment. With resolutions < 16 bit, the bits marked with “x” are set to “0”.

Note: This resolution doesn’t apply to temperature values. The changed temperature values are the result of recalculation in the analog module (see Tables 5-16 to 5-30).

Table 5-5 Possible Resolutions of the Analog Values

Resolution in Bits	Units		Analog Value	
	Decimal	Hexadecimal	High-Order Byte	Low-Order Byte
9	128	80_H	0 0 0 0 0 0 0 0	1 x x x x x x x
10	64	40_H	0 0 0 0 0 0 0 0	0 1 x x x x x x
11	32	20_H	0 0 0 0 0 0 0 0	0 0 1 x x x x x
12	16	10_H	0 0 0 0 0 0 0 0	0 0 0 1 x x x x
13	8	8_H	0 0 0 0 0 0 0 0	0 0 0 0 1 x x x
14	4	4_H	0 0 0 0 0 0 0 0	0 0 0 0 0 1 x x
15	2	2_H	0 0 0 0 0 0 0 0	0 0 0 0 0 0 1 x
16	1	1_H	0 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 5-6 to 5-8 are defined in two's complement representation:

Table 5-6 Bipolar Input Ranges

Units	Measured Value in %	Data Word 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}	Range
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	
–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 5-7 Unipolar Input Ranges

Units	Measured Value in %	Data Word 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}	Range
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	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	Underrange
–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

Table 5-8 Life-Zero Input Ranges

Units	Measured Value in %	Data Word 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}	Range
32767	118.515	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Over-flow
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	
In the event of wire break, the module reports $7FFF_H$																		

Analog Value Representation in Voltage Measuring Ranges

Table 5-9 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					
–75.00%	–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 5-10 Analog Value Representation in the Voltage Measuring Ranges ± 500 mV to ± 25 mV

System			Voltage Measuring Range					
	Dec.	**Hex.**	**± 500 mV**	**± 250 mV**	**± 80 mV**	**± 50 mV**	**± 25 mV**	
118.515%	32767	7FFF	592.6 mV	296.3 mV	94.8 mV	59.3 mV	29.6 mV	Overflow
117.593%	32512	7F00						
117.589%	32511	7EFF	587.9 mV	294.0 mV	94.1 mV	58.8 mV	29.4 mV	Overrange
	27649	6C01						
100.000%	27648	6C00	500 mV	250 mV	80 mV	50 mV	25 mV	Rated range
75%	20736	5100	375 mV	187.54 mV	60 mV	37.5 mV	18.75 mV	
0.003617%	1	1	18.08 µV	9.04 µV	2.89 µV	1.81 µV	904.2 nV	
0%	0	0	0 mV	0 mV	0 mV	0 mV	0 mV	
	–1	FFFF						
–75.00%	–20736	AF00	–375 mV	–187.54 mV	–60 mV	–37.5 mV	–18.75 mV	
–100.000%	–27648	9400	–500 mV	–250 mV	–80 mV	–50 mV	–25 mV	
	–27649	93FF						Underrange
–117.593%	–32512	8100	–587.9 mV	–294.0 mV	–94.1 mV	–58.8 mV	–29.4 mV	
–117.596%	–32513	80FF						Underflow
–118.519%	–32768	8000	–592.6 mV	–296.3 mV	–94.8 mV	–59.3 mV	–29.6 mV	

Table 5-11 Analog Value Representation in the 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		Negative values not possible	Underrange
–17.593%	–4864	ED00	0.296 V		
	–4865	ECFF			Underflow
~~–17.5~~96%	–32768	8000			

Analog Value Representation in Current Measuring Ranges

Table 5-12 Analog Value Representation in the Current Measuring Ranges ± 20 mA to ± 3.2 mA

System			Current Measuring Range				
	Dec.	**Hex.**	**± 20 mA**	**± 10 mA**	**± 5 mA**	**± 3.2 mA**	
118.515%	32767	7FFF	23.70 mA	11.85 mA	5.93 mA	3.79 mA	Overflow
117.593%	32512	7F00					
117.589%	32511	7EFF	23.52 mA	11.76 mA	5.88 mA	3.76 mA	Overrange
	27649	6C01					
100.000%	27648	6C00	20 mA	10 mA	5 mA	3.2 mA	Rated range
75%	20736	5100	15 mA	7.5 mA	3.75 mA	2.4 mA	
0.003617%	1	1	723.4 nA	361.7 nA	180.8 nA	115.7 nA	
0%	0	0	0 mA	0 mA	0 mA	0 mA	
	–1	FFFF					
–75%	–20736	AF00	–15 mA	–7.5 mA	–3.75 mA	–2.4 mA	
–100.000%	–27648	9400	–20 mA	–10 mA	–5 mA	–3.2 mA	
	–27649	93FF					Underrange
–117.593%	–32512	8100	–23.52mA	–11.76mA	–5.88 mA	–3.76 mA	
–117.596%	–32513	80FF					Underflow
–118.519%	–32768	8000	–23.70 mA	–11.85 mA	–5.93 mA	–3.79 mA	

Table 5-13 Analog Value Representation in Current Measuring Ranges 0 to 20 mA

System			Current Measuring Range	
	Dec.	**Hex.**	**0 to 20 mA**	
118.515%	32767	7FFF	23.70 mA	Overflow
117.593%	32512	7F00		
117.589%	32511	7EFF	23.52 mA	Overrange
	27649	6C01		
100.000%	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		Underrange
–17.593%	–4864	ED00	–3.52 mA	
	–4865	ECFF		Underflow
~~–17.~~596%	–32768	8000		

Table 5-14 Analog Value Representation in Current Measuring Ranges 4 to 20 mA

System			Current Measuring Range	
	Dec.	Hex.	4 to 20 mA	
118.515%	32767	7FFF	22.96 mA	Overflow
117.593%	32512	7F00		
117.589%	32511	7EFF	22.81 mA	Overrange
	27649	6C01		
100.000%	27648	6C00	20 mA	Rated range
75%	20736	5100	16 mA	
0.003617%	1	1	4 mA + 578.7 nA	
0%	0	0	4 mA	
	–1	FFFF		Underrange
–17.593%	–4864	ED00	1.185 mA	
				Underflow
≤–17.596%	–32767	7FFF		

Analog Value Representation for Resistance-Type Sensors

Table 5-15 Analog Value Representation for Resistance-Type Sensors from 48 Ω to 6 kΩ

System			Resistance-Type Sensor Range					
	Dec.	Hex.	48 Ω	150 Ω	300 Ω	600 Ω	6 kΩ	
118.515%	32767	7FFF	56.89 Ω	177.77 Ω	355.54 Ω	711.09 Ω	7.11 kΩ	Overflow
117.593%	32512	7F00						
117.589%	32511	7EFF	56.44 Ω	176.38 Ω	352.77 Ω	705.53 Ω	7.06 kΩ	Overrange
	27649	6C01						
100.000%	27648	6C00	48 Ω	150 Ω	300 Ω	600 Ω	6 kΩ	Rated range
75%	20736	5100	36 Ω	112.5 Ω	225 Ω	450 Ω	4.5 kΩ	
0.003617%	1	1	1.74m Ω	5.43m Ω	10.85m Ω	21.70m Ω	217.0m Ω	
0%	0	0	0 Ω	0 Ω	0 Ω	0 Ω	0 Ω	
			(negative values physically not possible)					Underrange

Analog Value Representation for Resistance Thermometers Pt x00 Standard

Table 5-16 Analog Value Representation for Resistance Thermometers 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
	Deci-mal	Hexa-deci-mal		Deci-mal	Hexa-deci-mal		Deci-mal	Hexa-deci-mal	
> 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 Resistance Thermometers Pt x00 Climatic

Table 5-17 Analog Value Representation for Resistance Thermometers Pt 100, 200, 500,1000

Pt x00 Climatic in °C (1 Digit = 0.01 °C)	Units		Pt x00 Climatic in °F (1 Digit = 0.01 °F)	Units		Range
	Decimal	Hexadecimal		Decimal	Hexadecimal	
> 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 Resistance Thermometers Ni x00 Standard

Table 5-18 Analog Value Representation for Resistance Thermometers 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
	Deci-mal	**Hexa-deci-mal**		**Deci-mal**	**Hexa-deci-mal**		**Deci-mal**	**Hexa-deci-mal**	
> 295.0	32767	7FFFH	> 563.0	32767	7FFFH	> 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 Resistance Thermometers Ni x00 Climatic

Table 5-19 Analog Value Representation for Resistance Thermometers Ni 100, 120, 200, 500, 1000

Ni x00 Climatic in °C (1 Digit = 0.01 °C)	Units		Ni x00 Climatic in °F (1 Digit = 0.01 °F)	Units		Range
	Decimal	**Hexadecimal**		**Decimal**	**Hexadecimal**	
> 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 Resistance Thermometers Cu 10 Standard

Table 5-20 Analog Value Representation for Resistance Thermometers 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
	Decimal	Hexadecimal		Decimal	Hexadecimal		Decimal	Hexadecimal	
> 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 Resistance Thermometers Cu 10 Climatic

Table 5-21 Analog Value Representation for Resistance Thermometers Cu 10

Cu 10 Climatic in °C (1 Digit = 0.01 °C)	Units		Cu 10 Climatic in °F (1 Digit = 0.01 °F)	Units		Range
	Decimal	Hexadecimal		Decimal	Hexadecimal	
> 180.00	32767	7FFF$_H$	> 325.11	32767	7FFF$_H$	Overflow
180.00 : 150.01	18000 : 15001	4650$_H$: 3A99$_H$	327.66 : 280.01	32766 : 28001	7FFE$_H$: 6D61$_H$	Overrange
150.00 : –50.00	15000 : –5000	3A98$_H$: EC78$_H$	280.00 : –58.00	28000 : –5800	6D60$_H$: E958$_H$	Rated range
–50.01 : –60.00	–5001 : –6000	EC77$_H$: E890$_H$	–58.01 : –76.00	–5801 : –7600	E957$_H$: E250$_H$	Underrange
< – 60.00	–32768	8000$_H$	< – 76.00	–32768	8000$_H$	Underflow

Analog Value Representation for Thermocouple Type B

Table 5-22 Analog Value Representation for Thermocouple Type B

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

Analog Value Representation for Thermocouple Type E

Table 5-23 Analog Value Representation for Thermocouple Type E

Type E in °C	Units		Type E in °F	Units		Type E in K	Units		Range
	Decimal	Hexadecimal		Decimal	Hexadecimal		Decimal	Hexadecimal	
> 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 (for example, polarity reversal or open inputs) or of a sensor error in the negative range (for example, incorrect thermocouple type), the analog input module reports an underflow...									
...if F0C4$_H$ is violated and outputs 8000$_H$			...if FB70$_H$ is violated and outputs 8000$_H$			...if E5D4$_H$ is violated and outputs 8000$_H$			

Analog Value Representation for Thermocouple Type J

Table 5-24 Analog Value Representation for Thermocouple Type J

Type J in °C	Units		Type J in °F	Units		Type J in K	Units		Range
	Decimal	Hexade-cimal		Decimal	Hexa-decimal		Deci-mal	Hexade-cimal	
> 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 (for example, polarity reversal or open inputs) or of a sensor error in the negative range (for example incorrect thermocouple type), the analog input module reports an underflow...									
...if F31C$_H$ is violated and outputs 8000$_H$			...if EA0C$_H$ is violated and outputs 8000$_H$			...if FDC8$_H$ is violated and outputs 8000$_H$			

Analog Value Representation for Thermocouple Type K

Table 5-25 Analog Value Representation for Thermocouple Type K

Type K in °C	Units		Type K in °F	Units		Type K in K	Units		Range
	Decimal	Hexade-cimal		Decimal	Hexa-decimal		Deci-mal	Hexade-cimal	
> 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 (for example, polarity reversal or open inputs) or of a sensor error in the negative range (for example, incorrect thermocouple type), the analog input module reports an underflow...									
...if F0C4$_H$ is violated and outputs 8000$_H$			...if E5D4$_H$ is violated and outputs 8000$_H$			...if FB70$_H$ is violated and outputs 8000$_H$			

Analog Value Representation for Thermocouple Type L

Table 5-26 Analog Value Representation for Thermocouple Type L

Type L in °C	Units		Type L in °F	Units		Type L in K	Units		Range
	Decimal	Hexa-decimal		Decimal	Hexa-deci-mal		Deci-mal	Hexa-decimal	
> 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 (for example, polarity reversal or open inputs) or of a sensor error in the negative range (for example, incorrect thermocouple type), the analog input module reports an underflow...									
...if F380$_H$ is violated and outputs 8000$_H$			...if EAC0$_H$ is violated and outputs 8000$_H$			...if FE2C$_H$ is violated and outputs 8000$_H$			

Analog Value Representation for Thermocouple Type N

Table 5-27 Analog Value Representation for Thermocouple Type N

Type N in °C	Units		Type N in °F	Units		Type N in K	Units		Range
	Decimal	Hexade-cimal		Decimal	Hexade-cimal		Deci-mal	Hexade-cimal	
> 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$_H$	Overrang e
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 (for example, polarity reversal or open inputs) or of a sensor error in the negative range (for example, incorrect thermocouple type), the analog input module reports an underflow...									
...if F0C4$_H$ is violated and outputs 8000$_H$			...if E5D4$_H$ is violated and outputs 8000$_H$			...if FB70$_H$ is violated and outputs 8000$_H$			

Analog Value Representation for Thermocouple Types R, S

Table 5-28 Analog Value Representation for Thermocouple Types R, S

Types R, S in °C	Units		Types R, S in °F	Units		Types R, S in K	Units		Range
	Decimal	Hexadecimal		Decimal	Hexadecimal		Decimal	Hexadecimal	
> 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 Type T

Table 5-29 Analog Value Representation for Thermocouple Type T

Type T in °C	Units		Type T in °F	Units		Type T in K	Units		Range
	Decimal	Hexadecimal		Decimal	Hexadecimal		Decimal	Hexadecimal	
> 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	H	< –454.0	< –4540	<EE44$_H$	< 3.2	< 32	< 0020$_H$	Underflow
In the case of incorrect wiring (for example, polarity reversal or open inputs) or of a sensor error in the negative range (for example, incorrect thermocouple type), the analog input module reports an underflow...									
...if F0C4$_H$ is violated and outputs 8000$_H$			...if E5D4$_H$ is violated and outputs 8000$_H$			...if FB70$_H$ is violated and outputs 8000$_H$			

Analog Value Representation for Thermocouple Type U

Table 5-30 Analog Value Representation for Thermocouple Type U

Type U in °C	Units		Type U in °F	Units		Type U in K	Units		Range
	Decimal	Hexa-decimal		Decimal	Hexa-decimal		Deci-mal	Hexa-decimal	
> 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	D04$_H$: 2B82$_H$	1123.2 : 874.2	11232 : 8742	2BE0$_H$: 2226$_H$	Overrange
600.0 : –200.0	6000 W : –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	H	< –328.0	< –3280	H	< 73.2	< 732	<02DC$_H$	Underflow
In the case of incorrect wiring (for example, polarity reversal or open inputs) or of a sensor error in the negative range (for example, incorrect thermocouple type), the analog input module reports an underflow...									
...if F380$_H$ is violated and outputs 8000$_H$			...if EAC0$_H$ is violated and outputs 8000$_H$			...if FE2C$_H$ is violated and outputs 8000$_H$			

5.3.2 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 on How to Read the Tables

Tables 5-31 to 5-33 contain the binary representation of the output values.

Since the binary representation of the output values is always the same, starting at 5-34 these tables only contain the output ranges and the units.

Binary Representation of the Output Ranges

The output ranges shown in Tables 5-31 to 5-33 are defined in two's complement representation:

Table 5-31 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}	
~~3251~~2	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	~~100.0~~04	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	
–27648	–100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
–27649	~~100.0~~04	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	
~~3251~~3	0%	1	0	0	0	0	0	0	0	x	x	x	x	x	x	x	x	Under-flow

Table 5-32 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	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	0.000	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Limited to rated range lower limit of 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	Under-flow

Table 5-33 Life-Zero 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	Over-flow
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
–6912	–25.000	1	1	1	0	0	1	0	1	0	0	0	0	0	0	0	0	
–6913	–25.000	1	1	1	0	0	1	0	0	1	1	1	1	1	1	1	1	Limited to over-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	–25%	1	0	0	0	0	0	0	0	x	x	x	x	x	x	x	x	Under-flow

Analog Value Representation in Voltage Output Ranges

Table 5-34 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 deenergized
	32512	7F00		
117.589%	32511	7EFF	11.76 V	Overrange
	27649	6C01		
100%	27648	6C00	10 V	
75%	20736	5100	7.5 V	Rated range
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 deenergized
–118.519%	–32768	8000	0.00 V	

Table 5-35 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 deenergized
	32512	7F00			
117.589%	32511	7EFF	11.76 V	5.70 V	Overrange
	27649	6C01			
100%	27648	6C00	10 V	5 V	Rated range
75%	20736	5100	7.5 V	3.75 V	
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 deenergized
–118.519%	–32768	8000	0.00 V	0.00 V	

Analog Value Representation in Current Output Ranges

Table 5-36 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 deenergized
	32512	7F00		
117.589%	32511	7EFF	23.52 mA	Overrange
	27649	6C01		
100%	27648	6C00	20 mA	
75%	20736	5100	15 mA	Rated range
0.003617%	1	1	723.4 nA	
0%	0	0	0 mA	
	–1	FFFF	–723.4 mA	
–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 deenergized
–118.519%	–32768	8000	0.00 mA	

Table 5-37 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 deenergized
	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 deenergized
–118.519%	–32768	8000	0.00 mA	0.00 mA	

5.4 Setting the Measuring Method and Measuring Ranges of the 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 a measuring range module and *STEP 7*
- By 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 5.7.

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 have 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.

Attention

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.

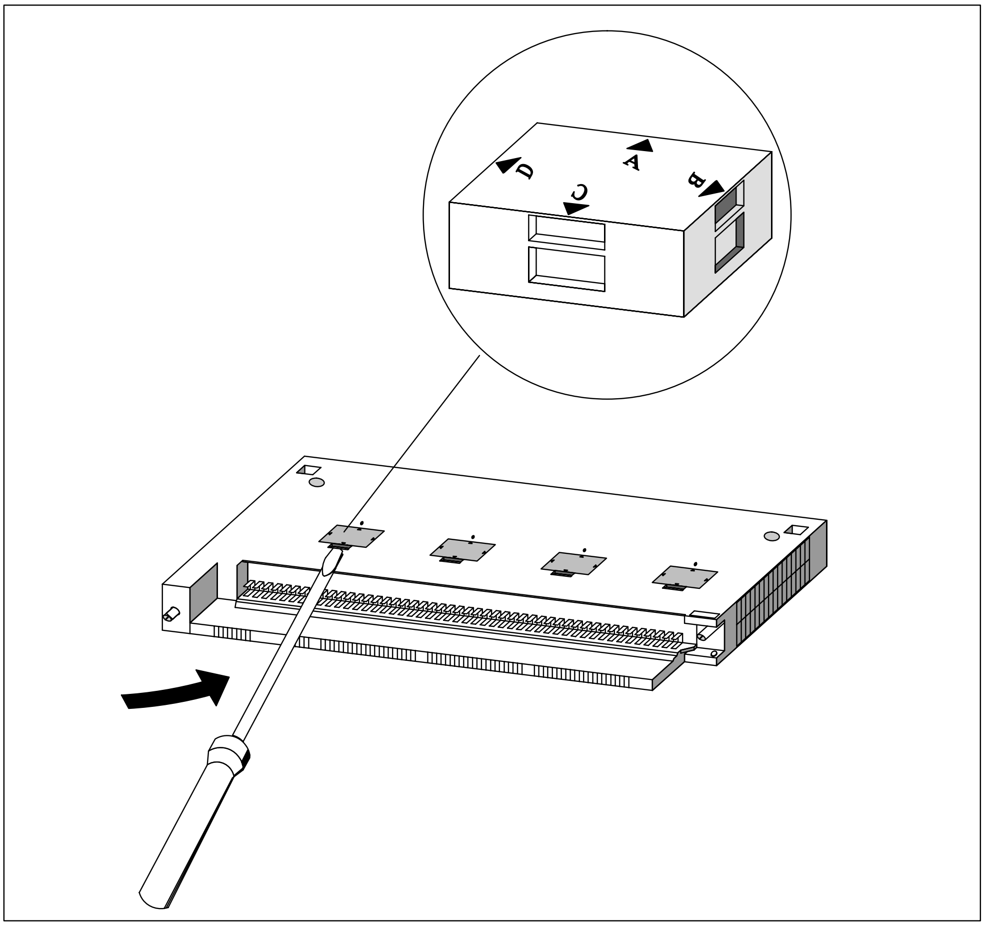


Figure 5-1 Levering the Measuring Range Module out of the Analog Input Module

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

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

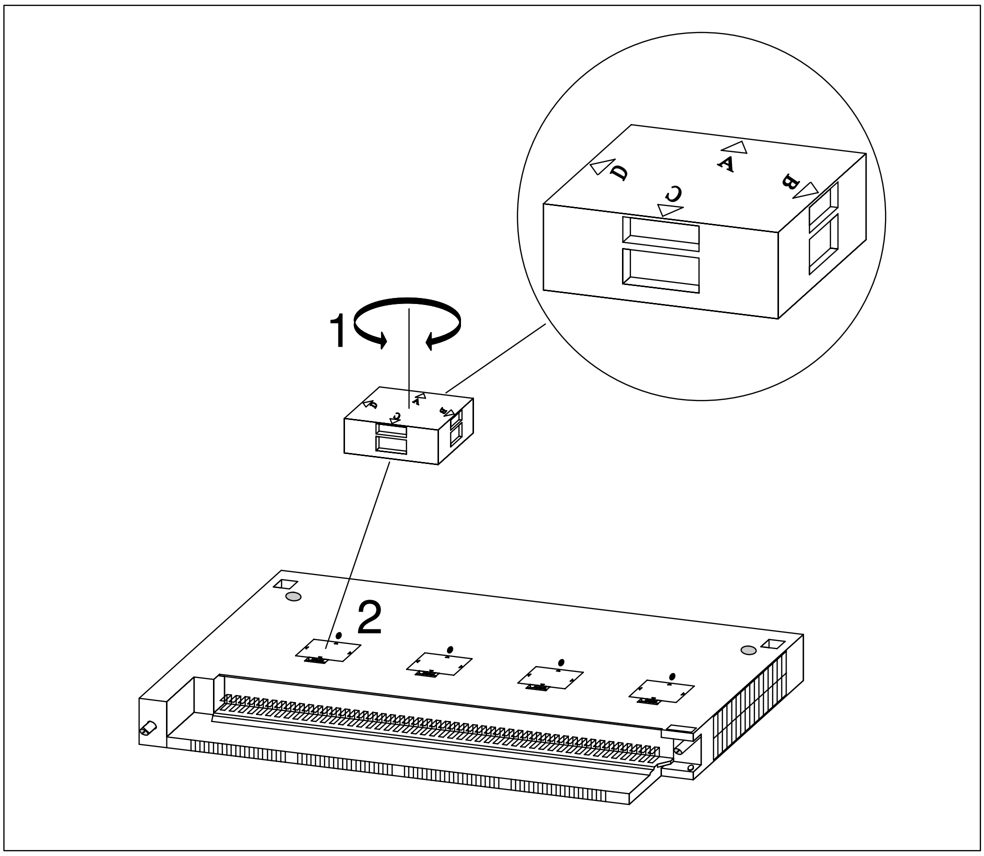


Figure 5-2 Inserting the Measuring Range Module into the Analog Input Module

Perform the same steps for all other measuring range modules.

The next step is to install the module.

Caution

This can result in damage.

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.

5.5 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 modes 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 errors on analog modules with diagnostics capability
- The effect of the operational limit of the analog module on the analog input and output value, as illustrated by an example

5.5.1 Effect of Supply Voltage and Operating Mode

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

Table 5-38 Dependencies of the Analog Input/Output Values on the Operating Mode of the CPU and the Supply Voltage L+

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

* L+ only required with 2-wire transmitters

Behavior on Failure of the Supply Voltage

Failure of the load power supply L+ of the diagnostics-capable analog module is indicated in the case of configured two-wire transmitters by the EXTF LED on the module. Furthermore, this information is made available on the module (entry in diagnostic buffer).

Triggering of a diagnostic interrupt depends on the parameter assignment (see Section 5.7).

5.5.2 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 5.16.

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 5-39 Behavior of the Analog Input Modules as a Function of the Position of the Analog Value Within the Range of Values

Measured Value In	Input Value	LED (EXTF)	Diagnostics	Interrupt
Rated range	Measured value	–	–	–
Overrange/ underrange	Measured value	–	–	–
Overflow	7FFFH	Flashes[1)]	Entered[1)]	Diagnostic interrupt[1)]
Underflow	8000H	Flashes[1)]	Entered[1)]	Diagnostic interrupt[1)]
Beyond the programmed limit	Measured value	–	–	Hardware 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 5-40 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	LED (EXTF)	Diagnostics	Interrupt
Rated range	CPU value	–	–	–
Overrange/underrange	CPU value	–	–	–
Overflow	0 signal	–	–	–
Underflow	0 signal	–	–	–

5.5.3 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.

Warning

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. In the measurement range ±10 V this would be the 10 V

Example of Determination of the Output Error of a Module

An analog output module SM 432; AO 8 x13 Bit is being used for voltage output. The output range "±10 V" is used. The module is operating at an ambient temperature of 30°C. The operational limit thus applies. The technical specifications of the module state:

- Operational limit for voltage output: ±0.5%

An output error, therefore, of ±0.05 V (±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 ±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.

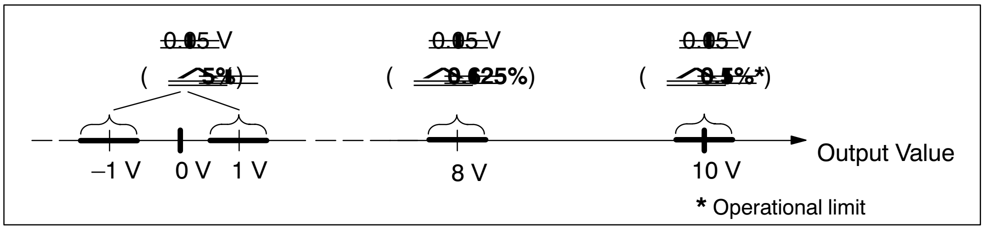


Figure 5-3 Example of the Relative Error of an Analog Output Module

5.6 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 5.7).

To find out 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 5.18.

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.

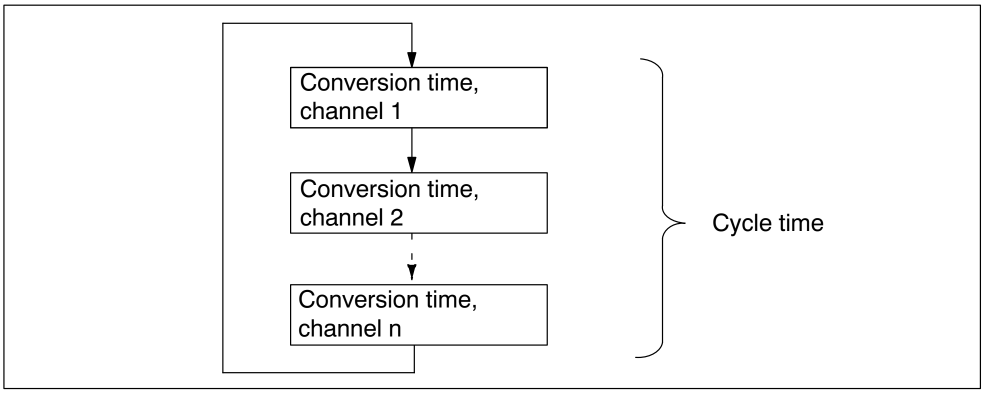


Figure 5-4 Scan Time of an Analog Input or Output Module

Basic Execution Time of the Analog Input Channels

The basic execution time corresponds to the cycle time for all the enabled channels.

Setting the 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

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.

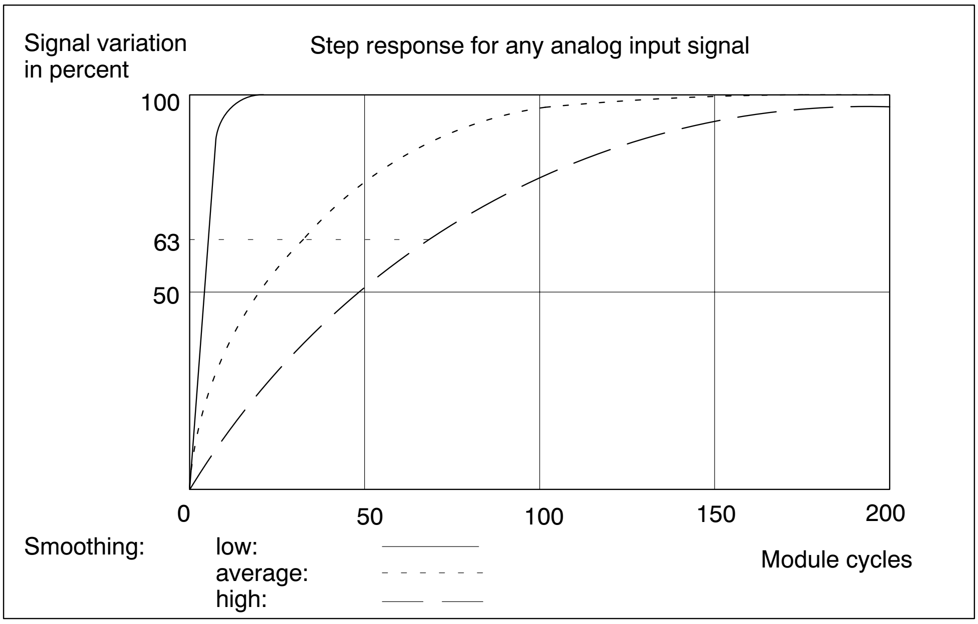


Figure 5-5 Example of the Influence of Smoothing on the Step Response

Additional Information on Smoothing

Refer to the specific section on the analog input module (from Section 5.18) 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 5-4).

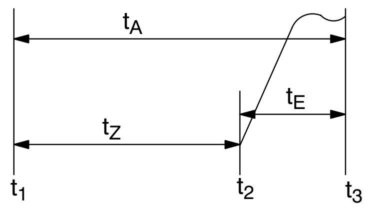
Basic Execution Time of the Analog Output Channels

The basic execution time corresponds to the cycle time for all the enabled channels.

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 conversion time (n = activated channels)

t_E = settling time

t_1 = new output value is present

t_2 = output value transferred and converted

t_3 = specified output value reached

Figure 5-6 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 5.18.

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).

5.7 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*.

When you have set all the parameters, download the parameters from the programming device to the CPU. When there is a transition from STOP to RUN mode, the CPU 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 5.4).

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.

Configuration in RUN (CiR)

You can use this method to modify the system or the configuraion of specific modules while the system is in RUN. That is, the CPU stays in RUN upt o a maximum period of 2.5 seconds.

For further information on this topic, refer to the *”Configuration in RUN by means of CiR” manual.* This manual is included in PDF format on the STEP 7 CD.

5.7.1 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 5.18, to find out which subset the module is capable of using.

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

Table 5-41 Parameters of the Analog Input Modules

Parameter	Value Range	Default[2)]	Parameter Type	Scope
Enable • Diagnostic interrupt[1)] • Hardware interrupt[1)]	Yes/no Yes/no	No No	Dynamic	Module
• Destination CPU for interrupt	1 to 4	–	Static	Module
Trigger for hardware interrupt • End of scan cycle reached at input	Yes/no	No	Static	Channel
• High limit • Low limit	Constraint possible due to measuring range 32511 to –32512 –32512 to 32511	–	Dynamic	Channel
Diagnostics • Wire break • Reference channel error • Underflow • Overflow • Short circuit to M	Yes/no Yes/no Yes/no Yes/no Yes/no	No No No No No	Static	Channel

Table 5-41 Parameters of the Analog Input Modules, continued

Parameter	Value Range	Default2)	Parameter Type	Scope
Measurement • Measuring type	Disabled U Voltage 4DMU Current (four-wire transmitter) 2DMU Current (two-wire transmitter) R-4L Resistance (four-conductor connection) R-3L Resistance three-conductor connection RTD-4L Thermal resistor (linear, four-conductor connection) RTD-3L Thermal resistor (linear, three-conductor connection) TC-L Thermocouple (linear)	U	Static	Channel
• Measuring range	For the settable measuring ranges of the input channels, please refer to the individual module description.	±10 V		
• Reference temperature	–273.15 to 327.67 °C	0 °C	Dynamic	Module
• Temperature unit	Degrees Celsius; degrees Fahrenheit; Kelvins	Degrees Celsius	Static	Module
• Temperature coefficient for temperature measurement with thermal resistor (RTD)	Platinum (Pt) 0.00385 Ω/Ω/°C 0.003916 Ω/Ω/°C 0.003902 Ω/Ω/°C 0.003920 Ω/Ω/°C Nickel (Ni) 0.00618 Ω/Ω/°C 0.00672 Ω/Ω/°C	0.00385	Static	Channel
• Interference frequency suppression	400 Hz; 60 Hz; 50 Hz; 10 Hz; none	50 or 60 Hz		
• Smoothing	None Low Average High	None		
• Reference junction	None Internal RTD on channel 0 Reference temperature value dynamic	None		

1) If you use the module in ER-1/ER-2, you must set this parameter to “No” because the interrupt lines are not available in ER-1/ER-2.

2) Only in the CC (central controller) is it possible to start up the analog modules with the default settings.

5.7.2 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 5.18, to find out which subset the module is capable of using.

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

Table 5-42 Parameters of the Analog Output Modules

Parameter	Value Range	Default[1)]	Parameter Type	Scope
Output • Type of output	Disabled Voltage Current	U	Static	Channel
• Output range	For the settable measuring ranges of the output channels, please refer to the individual module description.	±10 V		

[1)] Only in the CC (central controller) is it possible to start up the analog modules with the default settings.

5.8 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.

Non-Isolated Analog Input Modules

In the case of the non-isolated analog input modules there is an electrical connection between the reference point of the measuring circuit M_{ANA} and chassis ground.

You use non-isolated analog modules if there are few or no potential differences between the measuring sensors and chassis ground.

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 chassis ground.

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

Limited Potential Difference U_{CM}

Only a limited potential difference U_{CM} (common mode voltage) may occur amongst the M– measuring lines of the input channels and between the leads 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 line (positive)

M –: Measuring line (negative)

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

U_{CM}: Potential difference between inputs and reference potential of the M_{ANA} measuring circuit

U_{ISO}: Potential difference between M_{ANA} and chassis ground

Connection of Isolated Measuring 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.

To ensure that the permissible value for U_{CM} is not exceeded during use in heavily EMC-affected environments, connect M– to M_{ANA} in modules with an M_{ANA} connection.

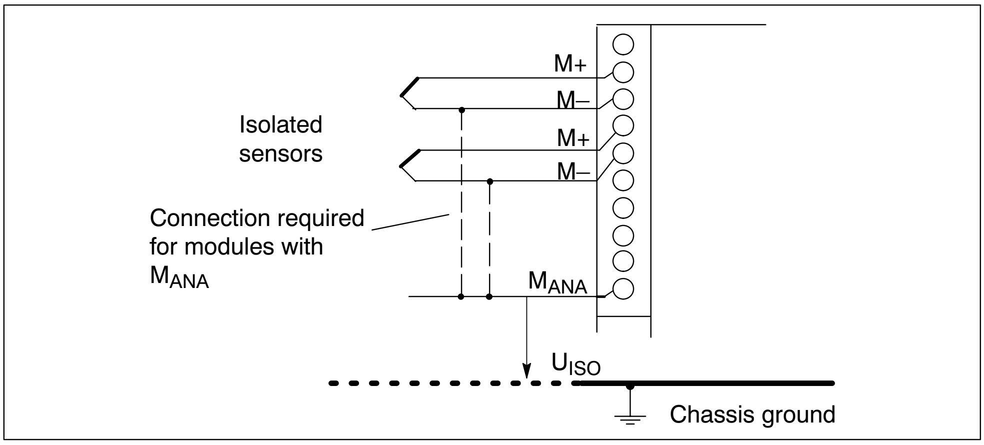


Figure 5-7 Connecting Isolated Sensors to an Isolated AI

Warning

Do not connect M– to M_{ANA} when connecting two-wire transmitters for current measurement and when connecting 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 chassis ground.

Connecting Non-Isolated Sensors

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

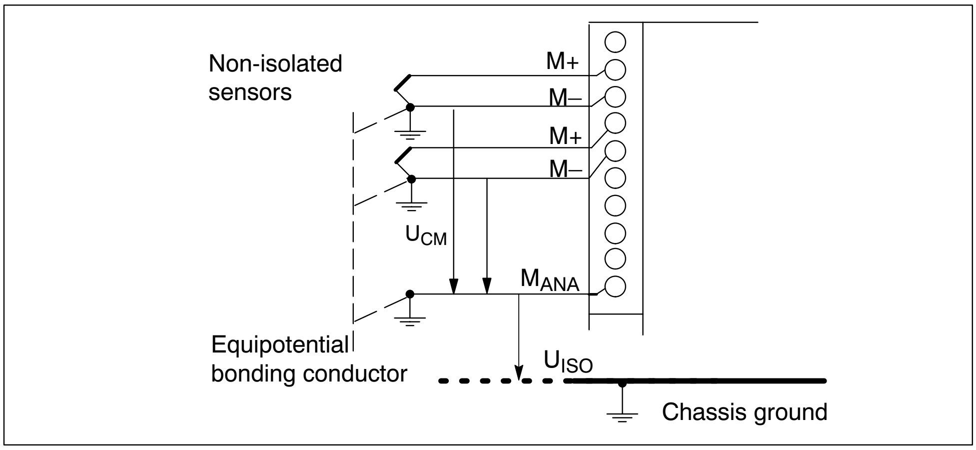


Figure 5-8 Connecting Non-Isolated Sensors to an Isolated AI

Warning

Do not use non-isolated two-wire transmitters and non-isolated resistance sensors!

5.9 Connecting Voltage Sensors

Warning

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.

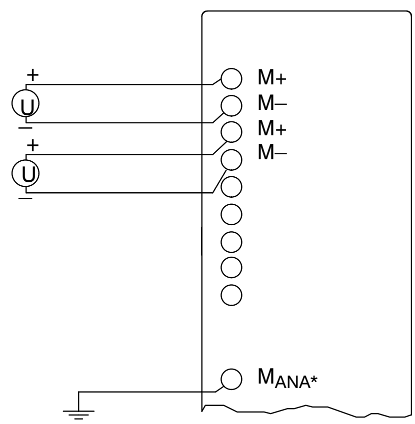
In other words, you must continue to take note of and implement Section 5.8 with its generally applicable information on connecting sensors.

Abbreviations and Mnemonics Used in the Figure Below

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

- M +: Measuring line (positive)
- M – : Measuring line (negative)
- M_{ANA}: Reference potential of the analog measuring circuit

Connection of Voltage Sensors



* Connection required in the case of modules with M_{ANA}

Figure 5-9 Connecting Voltage Sensors to an AI

5.10 Connecting Current Sensors

Warning

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 5.8 with its generally applicable 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 line (positive)
M –:	Measuring line (negative)
M_{ANA}:	Reference potential of the analog measuring circuit
M :	Ground terminal
L +:	Terminal for 24 VDC supply voltage
U_H:	Auxiliary supply
M_{I+}:	Current measuring line (positive)
M_{V+}:	Voltage measuring line (positive)

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.
Because the two-wire transmitter is supplied by the module, you must **not** ground the M– cables.

Four-wire transmitters require a separate supply voltage U_H (auxiliary supply).

Connecting Two-Wire Transmitters

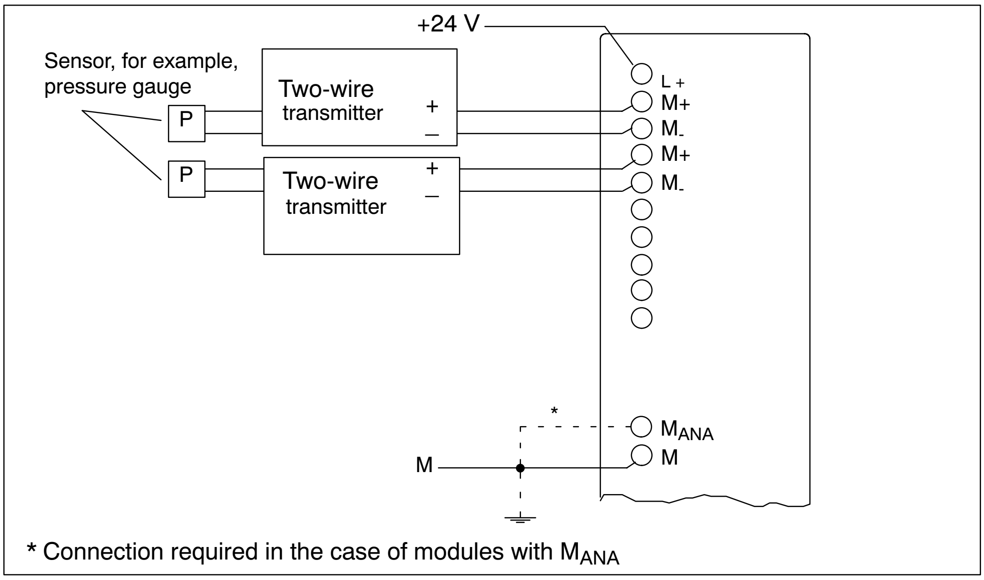


Figure 5-10 Connecting Two-Wire Transmitters to an Isolated AI

SM 431; 8 x 13 Bit: Connecting Two-Wire Transmitters

Because the supply voltage for the two-wire transmitters is not fed by the SM 431; 8 x 13 Bit, you must supply the sensors separately with 24 V.

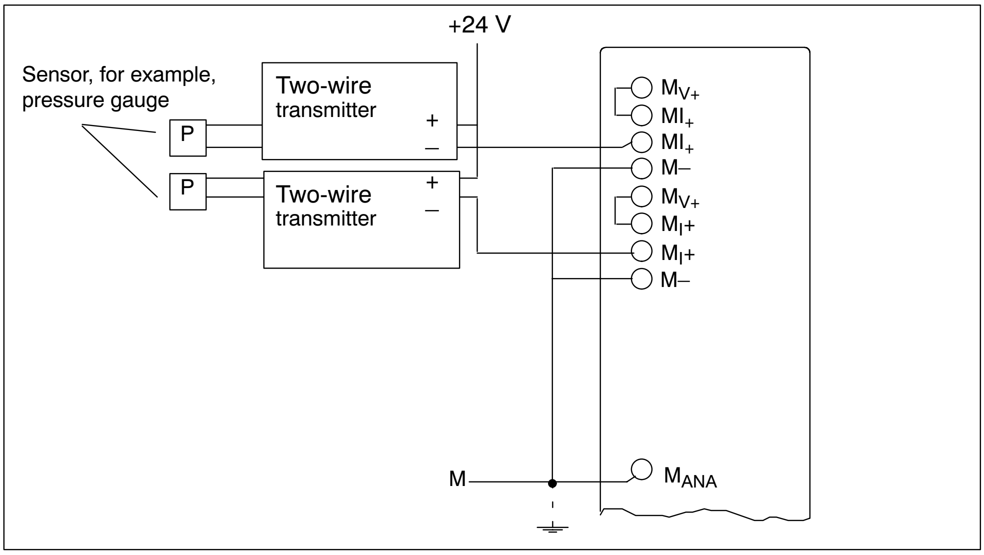
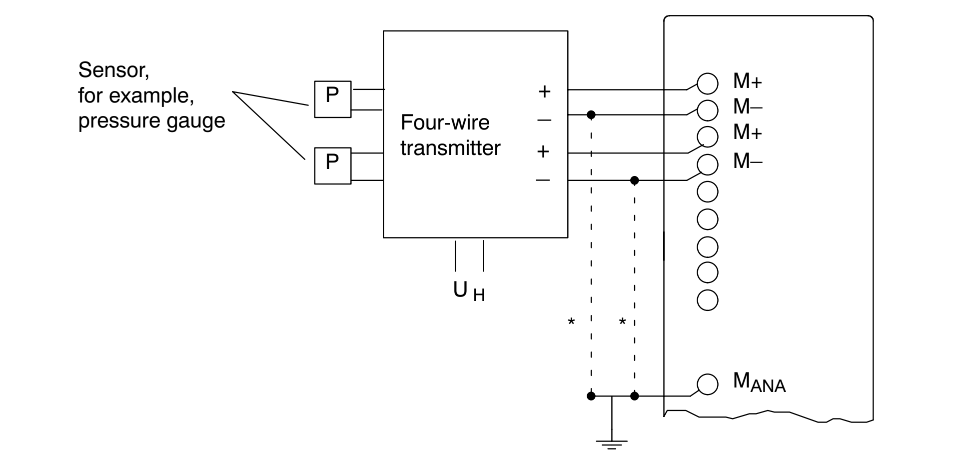


Figure 5-11 Connecting Two-Wire Transmitters to an SM 431; 8 x 13 Bit

Connecting Four-Wire Transmitters



* Connection required in the case of modules with M_{ANA}

Figure 5-12 Connecting Four-Wire Transmitters to an AI

SM 431; 8 x 13 Bit: Connecting Four-Wire Transmitters

To ensure that the permissible value for U_{CM} is not exceeded, you must connect the M– cables to M_{ANA}.

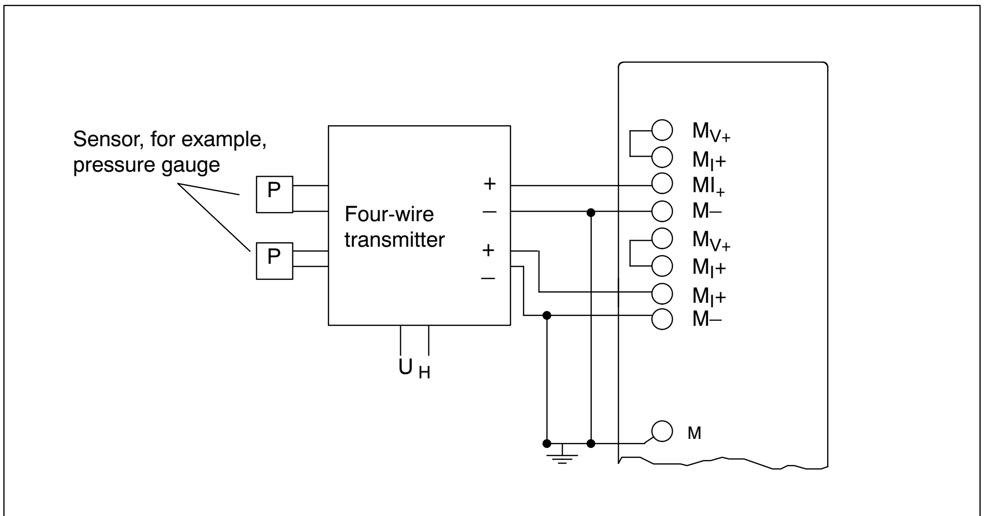


Figure 5-13 Connecting Four-Wire Transmitters to an SM 431; 8 x 13 Bit

5.11 Connecting Resistance Thermometers and Resistors

Warning

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 5.8 with its generally applicable 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 line (positive)
M– :	Measuring line (negative)

Connecting Resistance Thermometers and Resistors

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

With four-conductor and three-conductor connections, 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-conductor or three-conductor connections supply a more precise measuring result due to compensation than measurements with a two-conductor connection.

Four-Conductor Connection of a Resistance Thermometer

The voltage generated at the resistance 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).

Make sure that the connected cables **I_C + and M+** and **SO and SE+** and cables **I_C – and M–** and **AGND and SE–** are connected directly on the resistance thermometer.

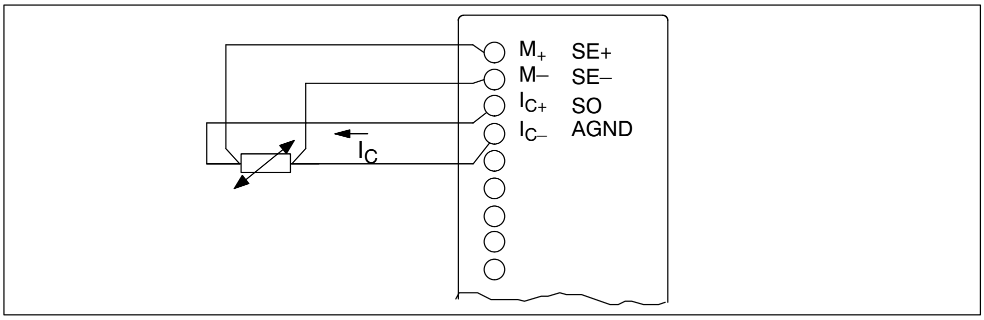


Figure 5-14 Four-Conductor Connection of Resistance Thermometers on an AI

Three-Conductor Connection of a Resistance Thermometer

During three-conductor connection to modules with 4 terminals per resistance thermometer, you must set up a **jumper between M– and I_C–** and **SE– and AGND** (see Figure 5-15).

The module compensates in this circuit for the effect of the line resistance between the module and the resistance thermometer/resistor.

Make sure that the connected cables **I_C + and M+** and the cables **SO and SE+** are directly connected to the resistance thermometer.

To get an accurate measurement, make sure that the connected cables **M+, I_C + and I_C–** and the cables **SE+, SO and AGND** are the same length and have the same cross-section.

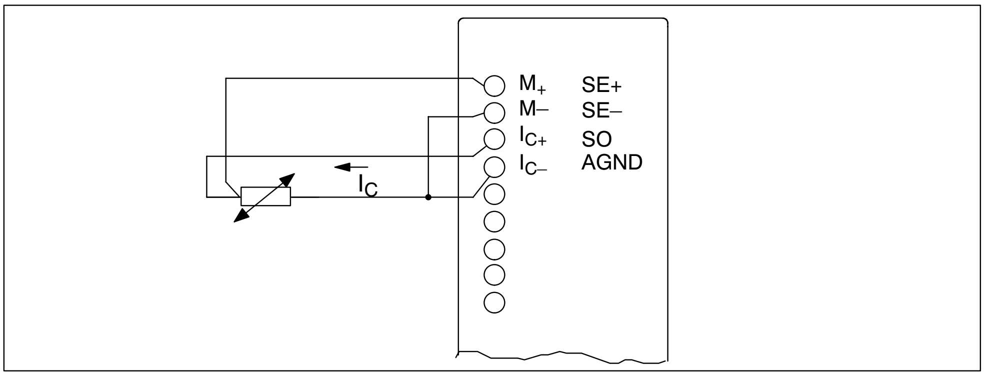


Figure 5-15 Three-Wire Connection of Resistance Thermometers to an AI

Two-Conductor Connection of a Resistance Thermometer

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

Note: Cable resistance is also measured.

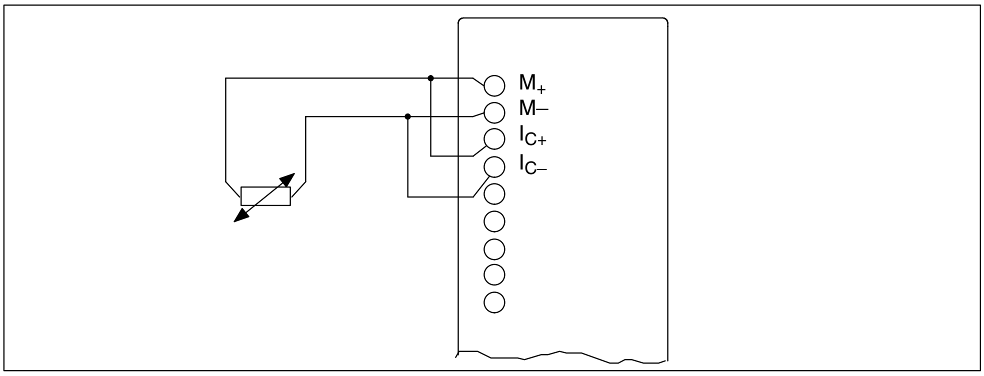


Figure 5-16 Two-Wire Connection of Resistance Thermometers to an AI

5.12 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.

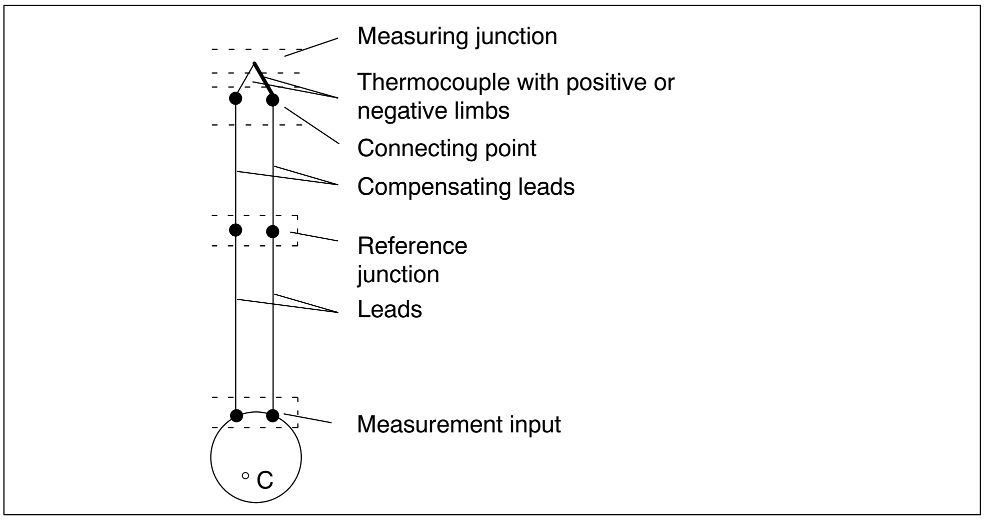


Figure 5-17 Design of Thermocouples

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 emf, 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

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.

The last column of the following table lists the feature you must set for the “Reference Junction” parameter in *STEP 7*. The reference temperature value is a separate parameter in *STEP 7*.

Table 5-43 Options for Compensation of the Reference Junction Temperature

Option	Explanation	Ref. Junction
No compensation (refer to Figure 5-18 for connection)	When you want to acquire only the difference in temperature between the measuring point and the reference junction	None
Internal compensation (refer to Figure 5-18 for connection)	If you employ internal compensation, the internal temperature of the module is used for comparison purposes.	Internal
External compensation with a compensating box in leads of an individual thermocouple (see Figure 5-19 for connection)	You have already acquired and compensated the reference junction temperature using a compensating box, which you have looped into an individual thermocouple. No further processing is necessary owing to the module.	None
External compensation with a resistance thermometer to obtain the reference junction temperature **(recommended method)** (see Figure 5-20 for connection)	You can acquire the reference temperature by means of a resistance thermometer (pt 100) and have it calculated by the module for any thermocouple.	RTD on Channel 0
External compensation with a resistance thermometer when thermocouples with the same reference junction are divided amongst several modules (see Figure 5-20 for connection)	Use a resistance thermometer on a module that measures the reference junction temperature. Read in the climatic temperature value to the CPU and transfer the value to the other modules using SFC55.	RTD on Channel 0
Constant reference junction temperature (thermometer, ice bath; see Figure 5-18 for connection)	If the reference junction temperature is constant and known, you can specify this value in parameter assignment in *STEP 7*.	Reference temperature value

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 line (positive)
M_-:	Measuring line (negative)
I_{C+}:	Constant-current lead (positive)
I_{C-}:	Constant-current lead (negative)

Warning

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 5.8 with its generally applicable information for connecting sensors.

Connection of Thermocouples without Compensation or Using the Reference Temperature Value

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

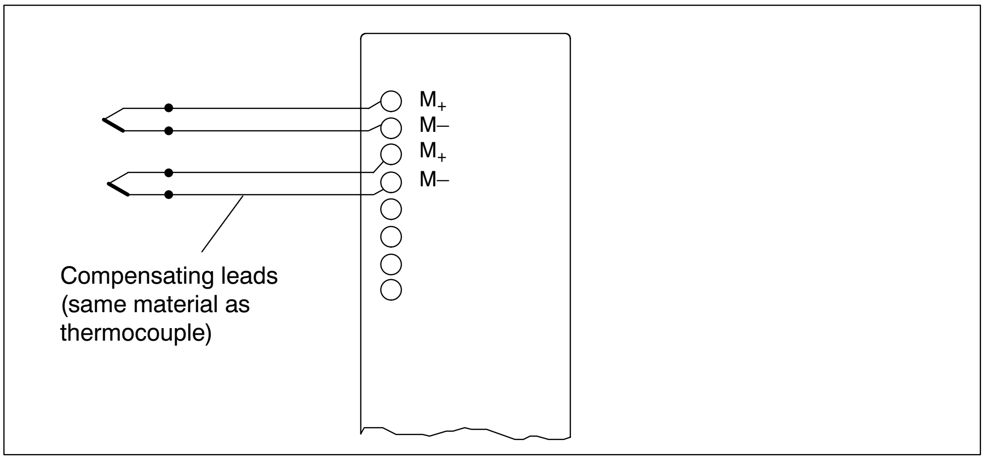


Figure 5-18 Connection of Thermocouples without Compensation or Using the Reference Temperature Value to an Isolated AI

Connecting the Compensating Box

The compensating box is looped in in the leads of each thermocouple. The compensating box must have an isolated supply. The power supply must have adequate filtering, for example by means of a grounded shielding winding.

Each channel can use a thermocouple type supported by the analog module independently of the other channels. Each channel requires its own compensating box.

Warning

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

Recommended Compensating Box

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

Table 5-44 Ordering Data of the Comparison Point

Recommended Compensating Box			Order Number
Reference junction with integrated power supply unit, for rail mounting			M72166-□□□□□
Auxiliary power	230 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
Reference temperature	0 °C		00

Connecting to the Comparison Point (Order No. M72166-xxx00)

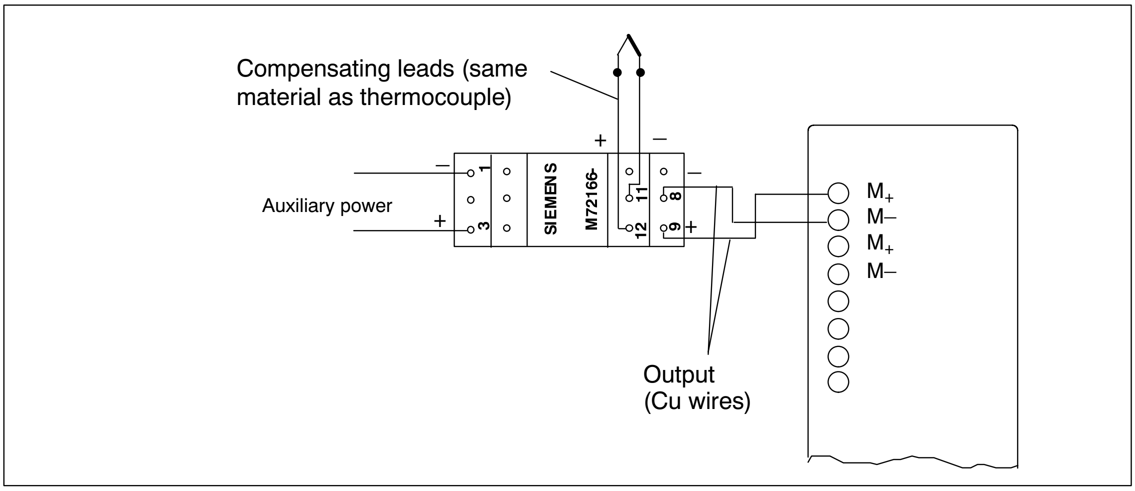


Figure 5-19 Connection of a Thermocouple with Reference Junction (Order No. M72166-xxx00) to an Isolated AI

Connecting Thermocouples and Resistance Thermometers

Connect the resistance thermometer to channel 0 of the module. Make sure that you parameterize the “RTD on Channel 0“ reference junction in *STEP 7* for each channel that has a thermocouple connected to it.

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

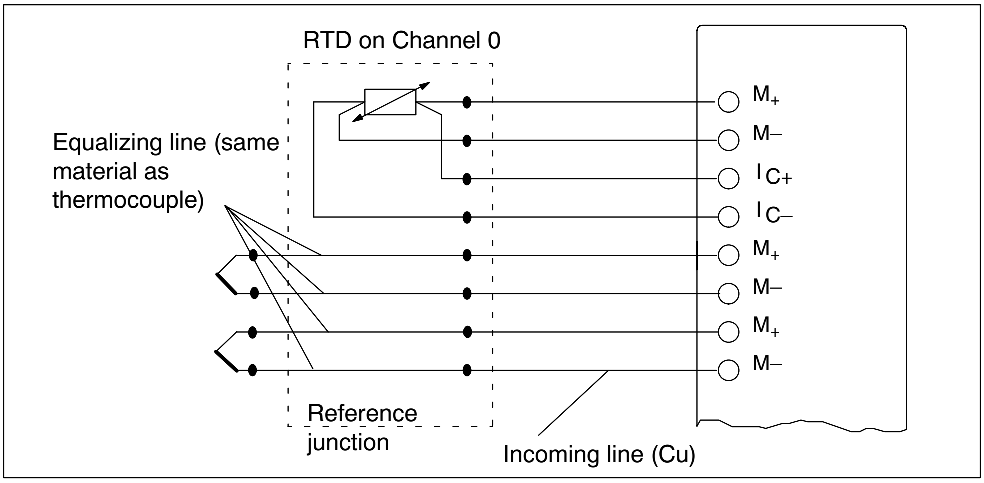


Figure 5-20 Connection of Thermocouples of the Same Type with External Compensation by Means of a Resistance Thermometer, Connected to Channel 0

5.13 Connecting Loads/Actuators to Analog Outputs

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 chassis ground.

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

5.14 Connecting Loads/Actuators to Voltage Outputs

Connecting Loads to a Voltage Output

Connecting loads to a voltage output is possible both in a four-conductor and a two-conductor connection.

Warning

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 5.13 with its generally applicable 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
U_{ISO}:	Potential difference between M_{ANA} and chassis ground

Four-Conductor Connection of Loads to a Voltage Output

A high accuracy at the load can be achieved through the four-conductor connection. 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.

Problems or a voltage drop can result in a potential difference between the sensor lead S– and the reference circuit of the analog circuit MANA. This potential difference (U_{CM}) must not exceed the permissible value. If the permissible potential difference is exceeded, the accuracy of the analog signal is impaired.

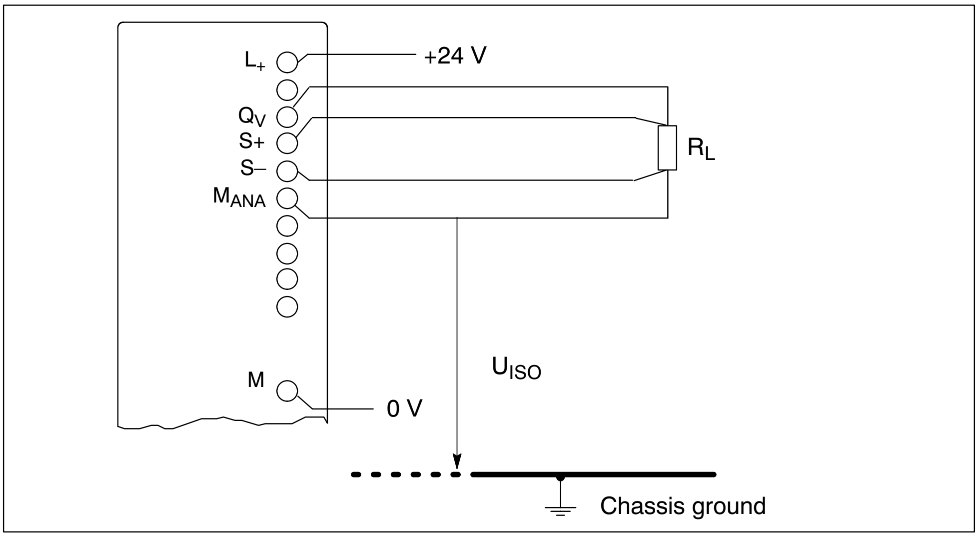


Figure 5-21 Connecting Loads to a Voltage Output of an Isolated AO over a Four-Conductor Connection

Two-Conductor Connection of Loads to a Voltage Output

In the case of a two-conductor connection, connect Q_V to S+ and M_{ANA} to S– on the front connector. However, this will not produce the accuracy of a four-conductor connection.

Connect the load to terminals Q_V and to the reference point of the measuring circuit M_{ANA} of the module.

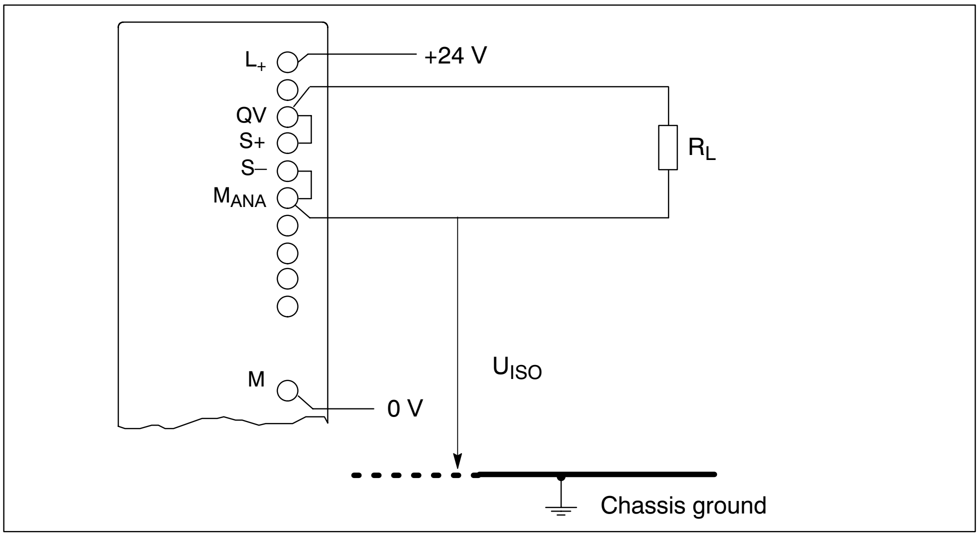


Figure 5-22 Two-Conductor Connection of Loads to a Voltage Output of an Isolated AO

5.15 Connecting Loads/Actuators to Current Outputs

Warning

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 5.13 with its generally applicable information for connecting loads/actuators.

Abbreviations and Mnemonics Used in the Figure Below

The abbreviations and mnemonics used in the figure 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
U_{ISO}:	Potential difference between M_{ANA} and chassis ground

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.

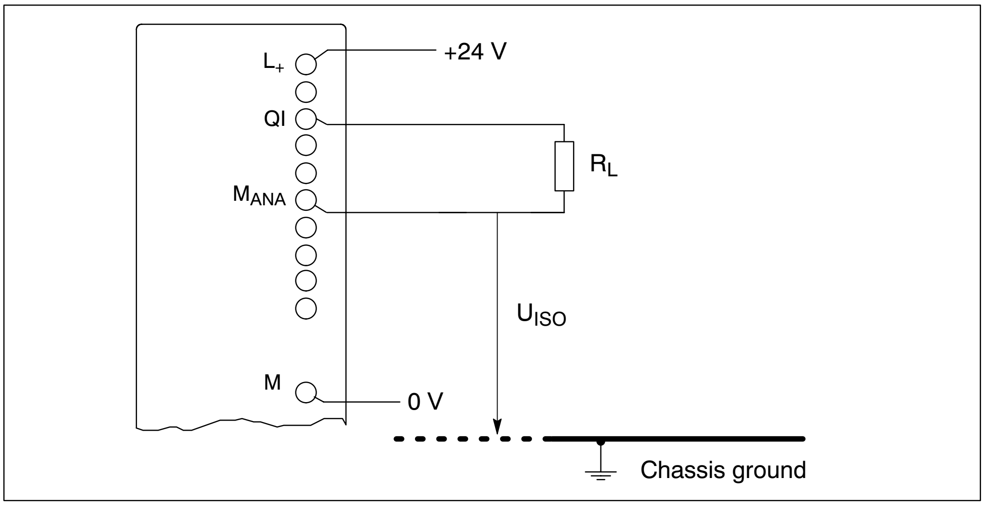


Figure 5-23 Connecting Loads to a Current Output of an Isolated AO

5.16 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 block in *STEP 7* (refer to Section 5.7).

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

Actions Following Diagnostic Messages in *STEP 7*

Each diagnostic message leads to the following actions:

- The diagnostic message is entered in the diagnosis of the analog module, forwarded to the CPU and can be read out by the user program.
- The error LED on the analog module lights.
- If you have enabled diagnostic interrupts in STEP 7, a diagnostic interrupt is triggered and OB 82 is called (refer to Section 4.5).

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 the *STEP 7* online help system).

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 via the INTF and EXTF LEDs

Some analog input modules indicate faults by means of their two fault LEDs INTF (internal fault) and EXTF (external fault). The LEDs go out when all the internal and external faults have been eliminated.

Refer to the technical specifications of the modules, starting at Section 5.18, to find out which analog input modules have these fault LEDs.

Diagnostic Messages of the Analog Input Modules

The table below gives an overview of the diagnostic messages for the analog input modules with diagnostics capability.

You can find out which diagnostic messages are possible with which modules in the Appendix entitled “Diagnostic Data of the Signal Modules”.

Table 5-45 Diagnostic Messages of the Analog Input Modules

Diagnostic Message	LED	Diagnostics Effective for	Parameters Can Be Assigned
Module problem	INTF/EXTF	Module	No
Internal malfunction	INTF	Module	No
External malfunction	EXTF	Module	No
Channel error present	INTF/EXTF	Module	No
External auxiliary supply missing	EXTF	Module	No
Front connector missing	EXTF	Module	No
Module not configured.	INTF	Module	No
Wrong parameters	INTF	Module	No
Channel information available	INTF/EXTF	Module	No
Coding key incorrect or missing	INTF	Module	No
Thermocouple connection fault	EXTF	Module	No
STOP operating mode	–	Module	No
EPROM error	INTF	Module	No
RAM error	INTF	Module	No
ADC/DAC error	INTF	Module	No
Hardware interrupt lost	INTF	Module	No
Configuring/parameter assignment error	INTF	Channel	No
Short-circuit to M	EXTF	Channel	Yes
Wire break	EXTF	Channel	Yes
Reference channel error	EXTF	Channel	Yes
Underflow	EXTF	Channel	Yes
Overflow	EXTF	Channel	Yes
User connection not wired	EXTF	Channel	No
Open conductor in + direction	EXTF	Channel	No
Open conductor in – direction	EXTF	Channel	No
Run time calibration error	EXTF	Channel	No
Underrange or overrange	EXTF	Channel	No
Open conductor in the current source	EXTF	Channel	No
User calibration doesn’t correspond to the parameter assignment	EXTF	Channel	No

Warning

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

Causes of Errors and Remedial Measures for Analog Input Modules

Table 5-46 Diagnostics Messages of the Analog Input Modules, Causes of Errors and Remedial Measures

Diagnostics Message	Possible Error Cause	Remedy
Module malfunction	An error detected by the module has occurred	–
Internal malfunction	The module has detected an error within the programmable controller	–
External malfunction	The module has detected an error outside the programmable controller	–
There is a channel error	Indicates that only certain channels are faulty	–
No external auxiliary voltage	Load voltage to supply the 2-wire transmitter is missing on terminals L+ and M	Feed supply L+
No front connector	Jumper between connections 1 and 2 in the front connector missing	Install jumper
Parameters have not been assigned to the module	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 CPU has been completed; parameterize the module, as required
Wrong parameters	A parameter or combination of parameters is incorrect; impermissible measurement range, for example	Reassign module parameter
Channel information available	Channel error present; the module can supply additional channel information	–
Measuring range module incorrect/missing	One or more measuring range modules is missing or incorrectly inserted	Insert the measuring range modules on the module according to the parameter assignment of the type of measurement and the measurement range
STOP operating mode	Module not configured and the first module cycle not completed	If a reboot of the CPU all the digitized analog values are in the intermediate memory, this message is reset
EPROM error	The module is defective	Replace module
RAM error		
ADC/DAC error		

Table 5-46 Diagnostics Messages of the Analog Input Modules, Causes of Errors and Remedial Measures, continued

Diagnostics Message	Possible Error Cause	Remedy
Hardware interrupt lost	The module cannot send an interrupt, since the previous interrupt was not acknowledged; configuration error possible	Change interrupt handling in the CPU (change priority for interrupt OB; shorten interrupt program)
Configuring/parameter assignment error	Illegal parameters transferred to module	Check measuring range module
		Reassign module parameter
Short circuit to M	A short circuit to the M potential has occurred on the sensor supply of two-wire transmitters	Eliminate short circuit
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 ("Measuring Type" parameter)
		Connect channel
Reference channel error	The reference junction connected at channel 0 is faulty due to a wire break, for example	Check terminals
	The reference temperature value transferred is not within the value range	Reparameterize the reference temperature
Underflow	Input value violates 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
Run time calibration error	A wiring fault has occurred on a channel during the calibration cycle	Eliminate the wiring fault (fault remains until the next calibration; in other words, a maximum 6 minutes or until there is a STOP-RUN transition of the CPU)

5.17 Analog Module Interrupts

Introduction

In this Section, the interrupt behavior of the analog modules is described. The following interrupts exist:

- Diagnostic Interrupt
- Hardware 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 5.18, to find out which analog modules have interrupt capability.

The OBs and SFCs mentioned below can be found in the online help system 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. You enable interrupts in *STEP 7* (refer to Section 5.7).

Special Feature: The Module is Inserted in ER-1/ER-2

Warning

If you use the analog module in ER-1/ER-2, you must set the parameters for the input of all the interrupts to “No” because the interrupt lines are not available in ER-1/ER-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 the 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.

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 hardware 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 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.

Warning

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.

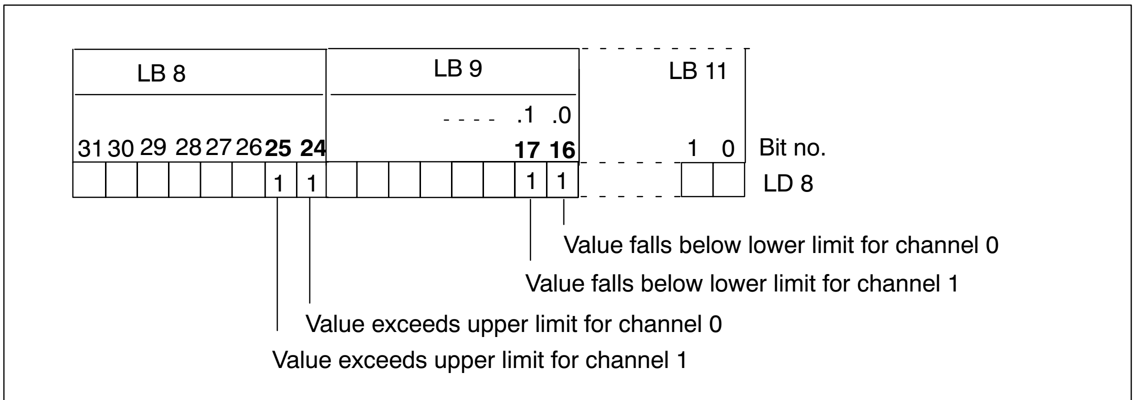


Figure 5-24 Start Information of OB 40: Which Event Triggered the Hardware Interrupt at the Limit Value

Hardware Interrupt on 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.

5.18 Analog Input Module SM 431; AI 8 x 13 Bit; (6ES7431-1KF00-0AB0)

Characteristics

The analog input module SM 431; AI 8 x 13 Bit has the following features:

- 8 inputs for voltage/current measurement
- 4 inputs for resistance measurement
- Various measurement ranges, can be adjusted in parallel
- 13-bit resolution
- Analog section isolated from CPU
- The maximum permissible common mode voltage between the channels and between the reference potential of the connected sensors and M_{ANA} is 30 VAC

Block Diagram of the SM 431; AI 8 x 13 Bit

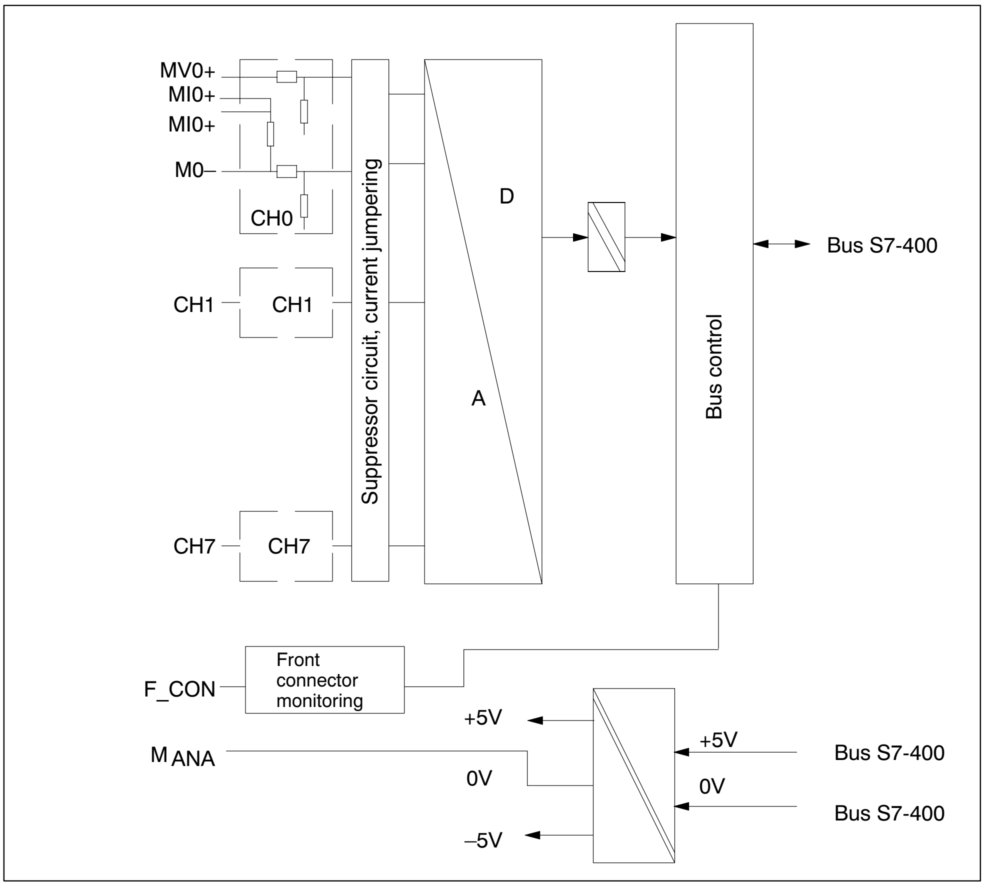


Figure 5-25 Block Diagram of the SM 431; AI 8 x 13 Bit

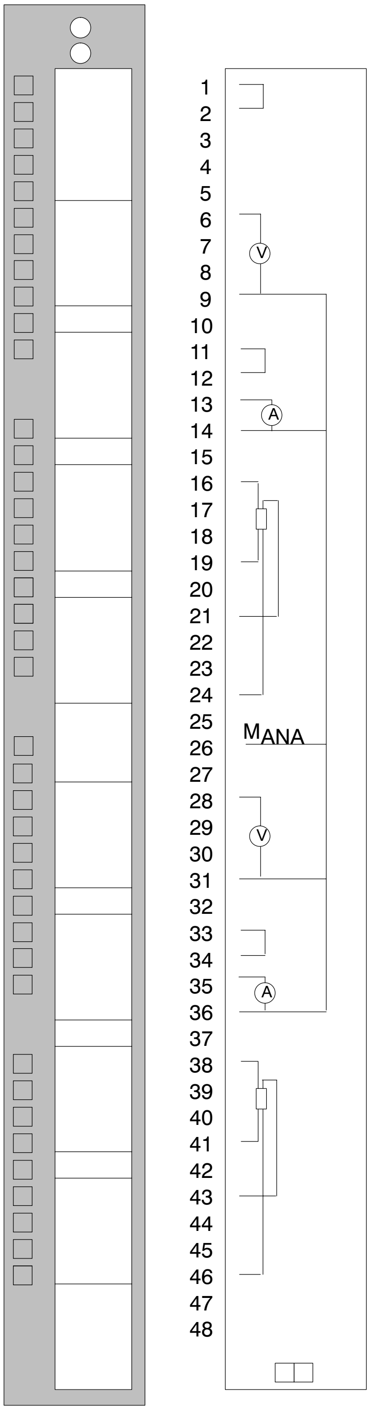
Warning

The module can be damaged.

The shunt of an input channel can be destroyed if you inadvertently connect a voltage sensor to the M– /MI+ terminals of a channel.

Make sure that the front connector wiring corresponds to the following terminal assignment diagram.

Terminal Assignment Diagram of the SM 431; AI 8 x 13 Bit



Terminal	Voltage measurement			Current measurement		Resistance measurement		
1								
2								
3								
4								
5								
6	MV0+			MV0+		M0+		
7		CH0	**Word 0**	MI0+	CH0			
8				MI0+				
9	M0–			M0–		M0–		
10							CH0	**Word 0**
11	MV1+			MV1+		IC0+		
12		CH1	**Word 2**	MI1+	CH1			
13				MI1+				
14	M1–			M1–		IC0–		
15								
16	MV2+			MV2+		M1+		
17		CH2	**Word 4**	MI2+	CH2			
18				MI2+				
19	M2–			M2–		M1–		
20							CH2	**Word 4**
21	MV3+			MV3+		IC1+		
22		CH3	**Word 6**	MI3+	CH3			
23				MI3+				
24	M3–			M3–		IC1–		
25								
26	M_{ANA}							
27								
28	MV4+			MV4+		M2+		
29		CH4	**Word 8**	MI4+	CH4			
30				MI4+				
31	M4–			M4–		M2–		
32							CH4	**Word 8**
33	MV5+			MV5+		IC2+		
34		CH5	**Word 10**	MI5+	CH5			
35				MI5+				
36	M5–			M5–		IC2–		
37								
38	MV6+			MV6+		M3+		
39		CH6	**Word 12**	MI6+	CH6			
40				MI6+				
41	M6–			M6–		M3–		
42							CH6	**Word 12**
43	MV7+			MV7+		IC3+		
44		CH7	**Word 14**	MI7+	CH7			
45				MI7+				
46	M7–			M7–		IC3–		
47								
48								

Figure 5-26 Terminal Assignment Diagram of the SM 431; AI 8 x 13 Bit

Technical Specifications of the SM 431; AI 8 x 13 Bit

Dimensions and Weight	
Dimensions W x H x D (in millimeters)	25 x 290 x 210
Weight	Approx. 500 g
Data for Specific Module	
Number of inputs	8
• For resistance-type sensor	4
Length of cable	
• Shielded	max. 200 m
Voltages, Currents, Potentials	
Rated load voltage L+	Not required
Constant measured current for resistance-type sensor	Typ. 1.67 mA
Isolation	
• Between channels and backplane bus	Yes
• Between the channels	No
Permitted potential difference	
• Between inputs and M_{ANA} (U_{CM})	30 VAC
• Between the inputs (E_{CM})	30 VAC
• Between M_{ANA} and $M_{internal}$ (U_{ISO})	75 VDC / 60 VAC
Insulation tested with	
• Between bus and analog section	2120 VDC
• Between bus and chassis ground	500 VDC
• Between analog section and chassis ground	2120 VDC
Current consumption	
• From the backplane bus	Max. 350 mA
Power dissipation of the module	Typ. 1.8 W
Analog Value Generation	
Measuring principle	Integrative
Integration time/conversion time/resolution (per channel)	(Does not go into the response time)
• Parameters can be assigned	Yes
• Interference voltage suppression f1 in Hz	60/50
• Integration time in milliseconds	16.7/20
• Basic conversion time in ms	23/25
• Resolution including sign	13/13 Bit
Smoothing of the measured values	Not possible
Basic execution time of the module, in ms (all channels enabled)	184/200

Suppression of Interference, Limits of Error	
Interference voltage suppression for f = nx (f1 ±1%), (f1 = interference frequency) n = 1, 2, ...	
• Common-mode interference (U_{CM} < 30 V)	> 100 dB
• Series-mode interference (peak value of interference < rated value of 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	
– ±1 V	±1.0%
– ±10 V	±0.6%
– 1 V to 5 V	±0.7%
• Current input	
– ±20 mA	±1.0%
– 4 mA to 20 mA	±1.0%
• Resistance measurement 0 to 500 Ω; four-conductor measurement (in the range of 600 Ω)	±1.25%
Basic error (operational limit at 25 °5C, referred to input range)	
• Voltage input	
– ±1 V	±0.7%
– ±10 V	±0.4%
– 1 V to 5 V	±0.5%
• Current input	
– ±20 mA	±0.7%
– 4 mA to 20 mA	±0.7%
• Resistance measurement 0 to 500 Ω; four-conductor measurement (in the range of 600 Ω)	±0.8%
Temperature error with reference to the input range	
• In the resistance measurement range	±0.02% K
• In all the other measurement ranges	±0.007% K
Linearity error (with reference to the input range)	±0.05% K
Repeat accuracy (in the steady state at 25 °C, referred to the input range)	±0.1%

Status, Interrupts, Diagnostics	
Interrupts	None
Diagnostic functions	None
Substitute value can be applied	No
Data for Selecting a Sensor	
Input range (rated values)/input resistance	
• Voltage	±1 V/200 kΩ
	±10 V/200 kΩ
	1 V to 5 V/200 kΩ
• Current	±20 mA/80 Ω
	4 mA to 20 mA/80 Ω
• Resistors	0 to 600 Ω, of use up to 500 Ω
Maximum allowable input voltage for voltage input (destruction limit)	Max. 50 V continuous 75 V for max. 1 ms (clock ratio 1 : 20)
Maximum input current for current input (destruction limit)	40 mA continuous

Connection of the signal sensors	
• For measuring voltage	Possible
• For measuring current	
– As two-wire transmitter	Possible; with external transmitter supply
– As four-wire transmitter	Possible
• For measuring resistance	
– With two-conductor terminal	Possible; cable resistance is also measured
– With three-conductor terminal	
– With four-conductor terminal	Possible

5.18.1 Commissioning the SM 431; AI 8 x 13 Bit

You set the mode of operation of the SM 431; AI 8 x 13 Bit in *STEP 7*.

Parameters

You will find a description of the general procedure for assigning parameters to analog modules in Section 5.7.

An overview of the parameters that you can set and their default settings are shown in the table below.

Table 5-47 Parameters of the SM 431; AI 8 × 13 Bit

Parameter	Value Range	Default[1]	Parameter Type	Scope
Measurement • Measuring method	Disabled U Voltage 4DMU Current (4-wire transmitter) 2DMU Current (2-wire transmitter) R-4L Resistance (four-conductor connection)	U	Static	Channel
• Measuring range	Refer to Section 5.18.2 for the measuring ranges of the input channels that you can set.	±10 V		
• Interference suppression	60 Hz; 50 Hz	50 Hz		

[1] Only in the CC (central controller) is it possible to start up the analog modules with the default settings.

5.18.2 Measuring Methods and Measuring Ranges of the SM 431; AI 8 x 13 Bit

Measuring Methods

You can set the following measuring methods for the input channels:

- Voltage measurement
- Current measurement
- Resistance test

You perform the setting with the “Measuring Type” parameter in *STEP 7*.

Wiring for Resistance Measurement

The following conditions apply when measuring the resistance with the SM 431; AI 8 x 13 Bit:

Table 5-48 Channels for Resistance Measurement of the SM 431; AI 8 x 13 Bit

Measuring Type Parameter	Permissible for Channel n	Condition
Resistance (four-conductor connection)	0, 2, 4 or 6	You must disable the “Measuring Type” parameter for channels n+1 (1, 3, 5, 7). The reason: The connections of channel n+1 are used to supply the resistance that is connected to channel n.

Unused Channels

Unused channels can be left open. You can improve the noise immunity of the module in a measuring environment with serious interference by short-circuiting the channels and connecting to M_{ANA}. Disable the “Measuring Type” parameter for unused channels. In this way you shorten the scan time of the module.

Measuring Ranges

You set the measuring ranges by means of the “Measuring Range” parameter in *STEP 7*.

Table 5-49 Measuring Ranges of the SM 431; AI 8 x 13 Bit

Method Selected	Measuring Range	Description
U: Voltage	± 1 V 1 to 5 V ± 10 V	You will find the digitized analog values in Section 5.3.1 in the voltage measuring range
2DMU: Current (two-wire transmitter)	4 to 20 mA	You will find the digitized analog values in Section 5.3.1 in the current measuring range
4DMU: Current (four-wire transmitter)	4 to 20 mA ± 20 mA	You will find the digitized analog values in Section 5.3.1 in the current measuring range
R-4L: Resistance (four-conductor connection)	600 Ω	You will find the digitized analog values in Section 5.3.1 in the resistance measuring range

Default Settings

The default measuring method of the module is “Voltage”, at a range of “ ± 10 V”. You can use this combination of measuring method and measuring range without parameterizing the SM 431; AI 8 x 13 bit in *STEP 7*.

5.19 Analog Input Module SM 431; AI 8 x 14 Bit; (6ES7431-1KF10-0AB0)

Characteristics

The analog input module SM 431; AI 8 x 14 Bit has the following features:

- 8 inputs for voltage/current measurement
- 4 inputs for resistance and temperature measurement
- Various measuring ranges, adjustable in parallel
- 14-bit resolution
- Particularly suitable for measuring temperatures
- Parameter can be assigned to temperature sensor types
- Linearization of the sensor characteristic curves
- Supply voltage 24 VDC required only for the connection of 2-wire transmitters
- Analog section isolated from CPU
- The maximum permissible common mode voltage between the channels and between the channel and the central ground point is120 VAC

Block Diagram of the SM 431; AI 8 x 14 Bit

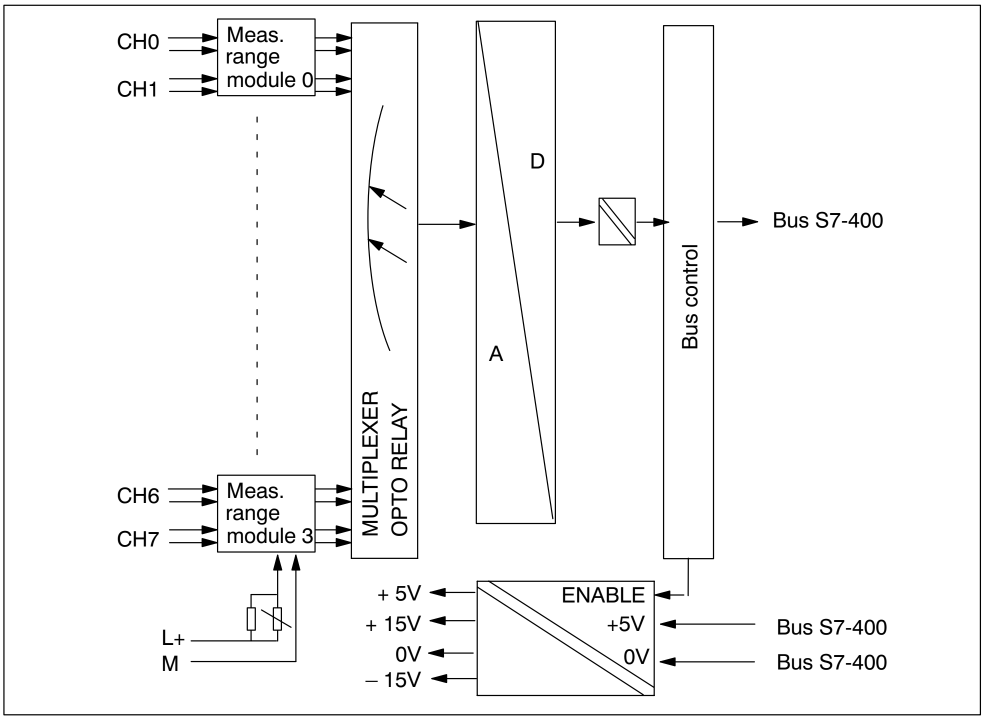


Figure 5-27 Block Diagram of the SM 431; AI 8 x 14 Bit

Terminal Assignment Diagram of the SM 431; AI 8 x 14 Bit

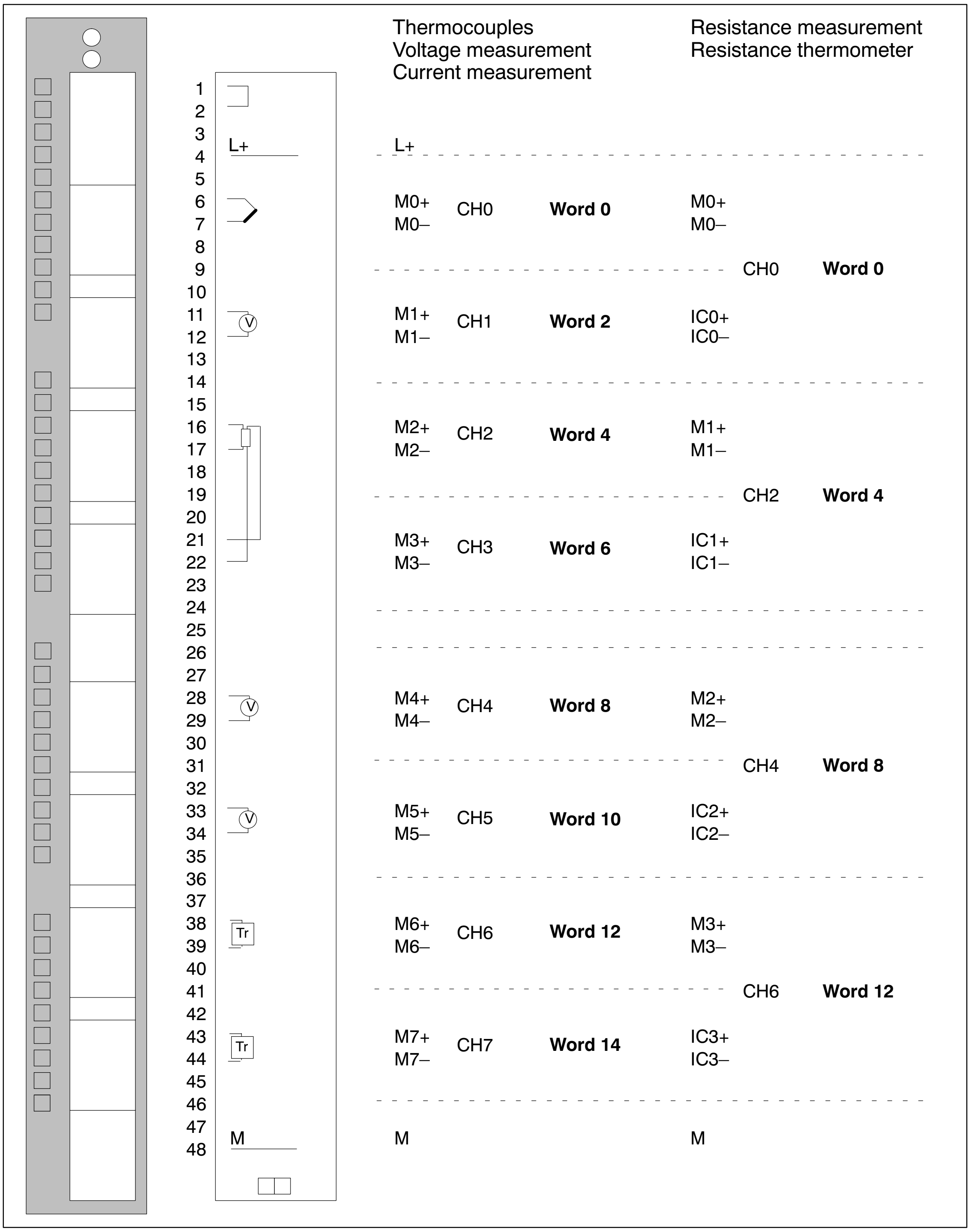


Figure 5-28 Terminal Assignment Diagram of the SM 431; AI 8 x 14 Bit

Technical Specifications of the SM 431; AI 8 x 14 Bit

Dimensions and Weight	
Dimensions W x H x D (in millimeters)	25 x 290 x 210
Weight	Approx. 500 g
Data for Specific Module	
Number of inputs	8
• For resistance-type sensor	4
Length of cable	
• Shielded in the 80 mV input range and with thermocouples	Max. 200 m Max. 50 m
Voltages, Currents, Potentials	
Rated load voltage L+	24 VDC (required only for the supply of two-wire transmitters)
• Reverse polarity protection	Yes
Power supply of the transmitters	
• Supply current	max. 50 mA
• Short-circuit proof	Yes
Constant measured current for resistance-type sensor	Typ. 1.67 mA
Isolation	
• Between channels and backplane bus	Yes
• Between the channels	No
• Between channels and load voltage L+	Yes
Permitted potential difference	
• Between inputs and M_{ANA} (U_{CM})	120 VAC
• Between the inputs (E_{CM})	120 VAC
• Between M_{ANA} and $M_{internal}$ (U_{ISO})	75 VDC / 60 VAC
Insulation tested with	
• Between bus and L+/M	2120 VDC
• Between bus and analog section	2120 VDC
• Between bus and chassis ground	500 VDC
• Between analog section and L+/M	707 VDC
• Between analog section and chassis ground	2120 VDC
• Between L+/M and chassis ground	2120 VDC

Current consumption	
• From the backplane bus	Max. 600 mA
• From the backplane bus L+	Max. 200 mA (with 8 connected, fully controlled two-wire transmitters)
Power dissipation of the module	Typ. 3.5 W
Analog Value Generation	
Measuring principle	Integrative
Integration time/conversion time/resolution (per channel)	(Does not go into the response time)
• Parameters can be assigned	Yes
• Interference voltage suppression f1 in Hz	60/50
• Integration time in milliseconds	16.7/20
• Basic conversion time in ms	20.1/23.5
• Additional conversion time for measuring resistance in ms	40.2/47
• Additional conversion time for open-circuit monitoring in ms	4.3/4.3
• Additional conversion time for measuring resistance in ms	5.5/5.5
• Resolution including sign	14/14 bit
– Smoothing activated	16/16 bit
Smoothing of the measured values	Parameters can be assigned in 4 stages
Basic execution time of the module, in ms (all channels enabled)	161/188

Suppression of Interference, Limits of Error	
Interference voltage suppression for f = nx (f1 ±1%), (f1 = interference frequency) n = 1, 2, ...	
• Common-mode interference (U_{CM} < 120 V_{ss})	> 100 dB
• Series-mode interference (peak value of interference < rated value of input range)	> 40 dB
Crosstalk between the inputs	>70 dB
Operational limit (in the entire temperature range, with reference to the input range)	
• Voltage input	
– ±80 mV	±0.38%
– ±250 mV	±0.35%
– ±500 mV	±0.35%
– ±1 V	±0.35%
– ±2.5 V	±0.35%
– ±5 V	±0.35%
– 1 V to 5 V	±0.35%
– ±10 V	±0.35%
• Current input	
– 0 ... 20 mA	±0.35%
– ±20 mA	±0.35%
– 4 mA to 20 mA	±0.35%
• Resistance test	
– 0 to 48 Ω four-conductor measurement	±0.35%
– 0 to 150 Ω four-conductor measurement	±0.35%
– 0 to 300 Ω, four-conductor measurement	±0.35%
– 0 to 600 Ω four-conductor measurement	±0.35%
– 0 to 5000 Ω four-conductor measurement (in the range of 6000 Ω)	±0.35%
– 0 to 300 Ω three-conductor measurement	±0.6%
– 0 to 600 Ω three-conductor measurement	±0.6%
– 0 to 5000 Ω; three-conductor measurement (in the range of 6000 Ω)	±0.6%

• Thermocouples	
– TC type B	±14.8 K
– TC type R	±9.4 K
– TC type S	±10.6 K
– TC type T	±2.2 K
– TC type E	±4.0 K
– TC type J	±5.2 K
– TC type K	±7.6 K
– TC type U	±3.6 K
– TC type L	±5.1 K
– TC type N	±5.6 K
• Resistance thermocouples, four-conductor standard measuring range	
– Pt 100	±4.6 K
– Pt 200	±5.7 K
– Pt 500	±4.6 K
– Pt 1000	±3.7 K
– Ni 100	±0.9 K
– Ni 1000	±0.9 K
Climatic measuring range	
– Pt 100	±0.6 K
– Pt 200	±0.6 K
– Pt 500	±0.6 K
– Pt 1000	±0.6 K
– Ni 100	±0.9 K
– Ni 1000	±0.9 K
• Resistance thermocouples, three-conductor standard measuring range	
– Pt 100	±5.2 K
– Pt 200	±8.2 K
– Pt 500	±6.6 K
– Pt 1000	±5.2 K
– Ni 100	±1.3 K
– Ni 1000	±1.3 K
Climatic measuring range	
– Pt 100	±0.7 K
– Pt 200	±0.7 K
– Pt 500	±0.7 K
– Pt 1000	±0.7 K
– Ni 100	±1.3 K
– Ni 1000	±1.3 K

Basic error (operational limit at 25 °C, referred to input range)	
• Voltage input	
– ± 80 mV	± 0.17%
– ± 250 mV	± 0.15%
– ± 500 mV	± 0.15%
– ± 1 V	± 0.15%
– ± 2.5 V	± 0.15%
– ± 5 V	± 0.15%
– 1 V to 5 V	± 0.15%
– ± 10 V	± 0.15%
• Current input	
– 0 mA to 20 mA	± 0.15%
– ± 20 mA	± 0.15%
– 4 ... 20 mA	± 0.15%
• Resistance test	
– 0 to 48 Ω; four-conductor measurement	± 0.15%
– 0 to 150 Ω; four-conductor measurement	± 0.15%
– 0 to 300 Ω; four-conductor measurement	± 0.15%
– 0 to 600 Ω; four-conductor measurement	± 0.15%
– 0 to 5000 Ω; four-conductor measurement (in the range of 6000 Ω)	± 0.15%
– 0 to 300 Ω; three-conductor measurement	± 0.3%
– 0 to 600 Ω; three-conductor measurement	± 0.3%
– 0 to 5000 Ω; three-conductor measurement (in the range of 6000 Ω)	± 0.3%
• Thermocouples	
– TC type B	± 8.2 K
– TC type R	± 5.2 K
– TC type S	± 5.9 K
– TC type T	± 1.2 K
– TC type E	± 1.8 K
– TC type J	± 2.3 K
– TC type K	± 3.4 K
– TC type U	± 1.8 K
– TC type L	± 2.3 K
– TC type N	± 2.9 K

• Resistance thermocouples, four-conductor standard measuring range	
– Pt 100	± 2.0 K
– Pt 200	± 2.5 K
– Pt 500	± 2.0 K
– Pt 1000	± 1.6 K
– Ni 100	± 0.4 K
– Ni 1000	± 0.4 K
Climatic measuring range	
– Pt 100	± 0.2 K
– Pt 200	± 0.2 K
– Pt 500	± 0.2 K
– Pt 1000	± 0.2 K
– Ni 100	± 0.4 K
– Ni 1000	± 0.4 K
• Resistance thermocouples, three-conductor standard measuring range	
– Pt 100	± 3.1 K
– Pt 200	± 4.9 K
– Pt 500	± 3.9 K
– Pt 1000	± 3.1 K
– Ni 100	± 0.8 K
– Ni 1000	± 0.8 K
Climatic measuring range	
– Pt 100	± 0.4 K
– Pt 200	± 0.4 K
– Pt 500	± 0.4 K
– Pt 1000	± 0.4 K
– Ni 100	± 0.8 K
– Ni 1000	± 0.8 K
Temperature error (with reference to the input range)	± 0.004% K
Linearity error (with reference to the input range)	± 0.01% K
Repeat accuracy (in the steady state at 25 °C, referred to the input range)	± 0.1%

Status, Interrupts, Diagnostics	
Interrupts	None
Diagnostic functions	None
Substitute value can be applied	No
Data for Selecting a Sensor	
Input range (rated values)/Input resistance	
• Voltage	±80 mV/1 MΩ ±250 mV/1 MΩ ±500 mV/1 MΩ ±1 V/1 MΩ ±2.5 V/1 MΩ ±5 V/1 MΩ 1 to 5 V/1 MΩ ±10 V/1 MΩ
• Current	0 to 20 mA/50 Ω ±20 mA/50 Ω 4 to 20 mA/50 Ω
• Resistors	0 to 48 Ω/1 MΩ 0 to 150 Ω/1 MΩ 0 to 300 Ω/1 MΩ 0 to 600 Ω/1 MΩ 0 to 6000 Ω/1 MΩ (can be used up to 5000 Ω)
• Thermocouples	TC type B/1 MΩ TC type R/1 MΩ TC type S/1 MΩ TC type T/1 MΩ TC type E/1 MΩ TC type J/1 MΩ TC type K/1 MΩ TC type U/1 MΩ TC type L/1 MΩ TC type N/1 MΩ
• Resistance thermometer	Pt 100/1 MΩ Pt 200/1 MΩ Pt 500/1 MΩ Pt 1000/1 MΩ Ni 100/1 MΩ Ni 1000/1 MΩ
Maximum input voltage for voltage input (destruction limit)	Max. 18 V continuous 75 V for 1 ms (cycle factor 1 : 20)
Maximum input current for current input (destruction limit)	40 mA continuous

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; cable resistance is also measured
– With three-conductor terminal	Possible
– With four-conductor terminal	Possible
• Load of the two-wire transmitter	Max. 750 Ω
Characteristic linearization	Parameters can be assigned
• For thermocouples	Types B, R, S, T, E, J, K, U, L, N
• For resistance thermometers	Pt 100, Pt 200, Pt 500, Pt 1000, Ni 100, Ni 1000
Temperature compensation	Yes, programmable
• Internal temperature compensation	No
• External temperature compensation with compensating box	Possible
• External temperature compensation with Pt 100	Possible
• Compensation for definable reference junction temperature	Possible
Unit for temperature measurement	Degrees Celsius

5.19.1 Commissioning the SM 431; AI 8 x 14 Bit

You set the mode of operation of the SM 431; AI 8 x 14 Bit by means of measuring range modules on the module and in *STEP 7*.

Measuring Range Module

A measuring range module of the module matches two channels and one resistance channel to each type of sensor. 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 5.4.

The corresponding table in Section 5.19.2 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.

Parameter

You will find a description of the general procedure for assigning parameters to analog modules in Section 5.7.

An overview of the parameters that you can set and their default settings are shown in the table below.

Table 5-50 Parameters of the SM 431; AI 8 x 14 Bit

Parameter	Value Range	Default[1)]	Parameter Type	Scope
Diagnostics • Wire break	Yes/no	No	Static	Channel
Measurement • Measuring type	Disabled U Voltage 4DMU Current (four-wire transmitter) 2DMU Current (two-wire transmitter) R-4L Resistance (four-conductor terminal) R-3L Resistance (three-conductor terminal) RTD-4L Thermal resistor (linear, four-conductor terminal) RTD-3L Thermal resistor (linear, three-conductor terminal) TC-L Thermocouple (linear)	U	Static	Channel
• Measuring range	Refer to Section 5.19.2 for the measuring ranges of the input channels that you can set.	±10 V		
• Reference Temperature	–273.15 to 327.67 °C	0,00 °C	Dynamic	Module
• Interference suppression	60 Hz; 50 Hz	50 Hz	Static	Channel

Table 5-50 Parameters of the SM 431; AI 8 x 14 Bit, continued

Parameter	Value Range	Default[1)]	Parameter Type	Scope
• Smoothing	None Low Average High	None	Static	Channel
• Ref. junction	None RTD on Channel 0 Reference temperature value dynamic	None		

1) Only in the CC (central controller) is it possible to start up the analog modules with the default settings.

Smoothing of the Measured Values

You fill find information that is generally applicable to the smoothing of analog values in Section 5.6.

The following figure indicates for the module in the case of a step response the number of module cycles after which the smoothed analog value applies at almost 100%, depending on the smoothing setting. The figure applies to every change of signal at an analog input.

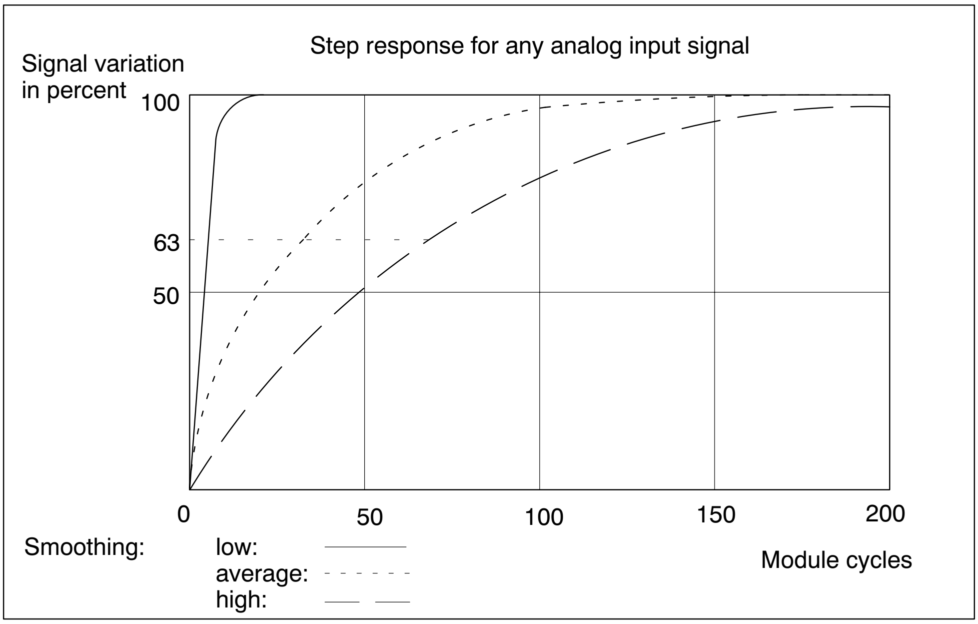


Figure 5-29 Step Response of the SM 431; AI 8 x 14 Bit

5.19.2 Measuring Methods and Measuring Ranges of the SM 431; AI 8 x 14 Bit

Measuring Methods

You can set the following measuring methods for the input channels:

- Voltage measurement
- Current measurement
- Resistance test
- Temperature measurement

You specify the setting by means of the measuring range modules on the module and by means of the “Measuring Type” parameter in *STEP 7*.

Circuit Variants for the Channels

Two channels are set with each measuring range module. There are therefore restrictions as regards the measuring method for the adjacent channels 0/1, 2/3, 4/5 and 6/7, as shown in the following table:

Table 5-51 Selection of the Measuring Method for Channel n and Channel n+1 of the SM 431; AI 8 x 14 Bit

Meas. Method Chan. n+1 / Meas. Method Channel n	Disa-bled	Voltage	Current 4-DMU	Current 2-DMU	R-4L	R-3L	RTD-4L	RTD-3L	TC-L
Disabled	x	x	x	x					x
Voltage	x	x							x
Current four-wire transmitter	x		x						
Current two-wire transmitter	x			x					
Resistor four-conductor	x								
Resistor three-conductor	x								
Thermal resistor four-conductor	x								
Thermal resistor three-conductor	x								
Thermocouples	x	x							x

Example

If you select “current (two-wire transmitter)” for channel 6, you can then only deactivate the measuring method or set “current (two-wire transmitter)” for channel 7.

Wiring for Resistance and Temperature Measurement

The following conditions apply when measuring the resistance and temperature with the SM 431; AI 8 x 14 Bit:

Table 5-52 Channels for Resistance and Temperature Measurement with the SM 431; AI 8 x 14 Bit

Measuring Type Parameter	Permissible for Channel n	Condition
Resistor (four-conductor terminal)	0, 2, 4 or 6	You must disable the “Measuring Type” parameter for channels n+1 (1, 3, 5, 7). The reason The connections of channel n+1 are used to supply the resistance that is connected to channel n.
Resistor (three-conductor terminal)	0, 2, 4 or 6	
Thermal resistor (linear, four-conductor terminal)	0, 2, 4 or 6	
Thermal resistor (linear, four-conductor terminal)	0, 2, 4 or 6	

Wiring for Junction Compensation for Thermocouples

If you select “RTD on Channel 0” as a reference junction for reference junction compensation for thermocouples, the following applies:

Table 5-53 Thermocouple with Reference Junction Compensation via RTD on Channel 0

Reference Junction Parameter	Permissible for Channel n	Condition
RTD on Channel 0	2 to 7	You must connect and parameterize on channel 0 a resistance thermometer with linearization, a 3– or 4-conductor connection in the **climatic range** (channels 0 and 1 are thus assigned). The reason: If channel 0 is to be used as the reference junction, a resistance-type sensor must be connected there to record absolute temperatures in the climatic range.

Unused Channels

Unused channels can be left open. Set the measuring range module to position “A”. You can improve the noise immunity of the module in a measuring environment with serious interference by short-circuiting the channels.

Disable the “Measuring Type” parameter for unused channels. In this way you shorten the scan time of the module.

Measuring Ranges

You set the measuring ranges by means of the measuring range modules on the module and the "Measuring Type" parameter in *STEP 7*.

Table 5-54 Measuring Ranges of the SM 431; AI 8 x 14 Bit

Method Selected	Measuring Range (Type of Sensor)	Measuring Range Module Setting	Description
U: Voltage	± 80 mV ± 250 mV ± 500 mV ± 1 V ± 2.5 V ± 5 V 1 to 5 V ± 10 V	A	You will find the digitized analog values in Section 5.3.1 in the voltage measuring range
2DMU: Current (two-wire transmitter)	4 to 20 mA	D	To supply these transmitters with current you must connect 24 V to the L+ and M front connector terminals. You will find the digitized analog values in Section 5.3.1 in the current measuring range
4DMU: Current (four-wire transmitter)	0 to 20 mA 4 to 20 mA ± 20 mA	C	You will find the digitized analog values in Section 5.3.1 in the current measuring range
R-4L: Resistors (four-conductor connection)	48 Ω 150 Ω 300 Ω 600 Ω 6000 Ω	A	You will find the digitized analog values in Section 5.3.1 in the resistance measuring range
R-3L: Resistors (three-conductor connection)	300 Ω 600 Ω 6000 Ω		

Table 5-54 Measuring Ranges of the SM 431; AI 8 x 14 Bit, continued

Method Selected	Measuring Range (Type of Sensor)	Measuring Range Module Setting	Description
TC-L: Thermocouple (linear) (temperature measurement)	Type B Type N Type E Type R Type S Type J Type L Type T Type K Type U	A	You will find the digitized analog values in Section 5.3.1 in the temperature range
RTD-4L: thermal resistor (linear, four-conductor connection) (temperature measurement)	Pt 100 climatic Pt 200 climatic Pt 500 climatic Pt 1000 climatic Ni 100 climatic Ni 1000 climatic	A	
RTD-3L: thermal resistor (linear, three-conductor connection) (temperature measurement)	Pt 100 standard Pt 200 standard Pt 500 standard Pt 1000 standard Ni 100 standard Ni 1000 standard		

Default Settings

The module has the following default settings in *STEP 7*:

- Channels 0 to 7: “Voltage” for the measuring method ; “±10 V” for the measuring range

You can use these measuring methods and measuring ranges without parameterizing the SM 431; AI 8 x 14 Bit in *STEP 7*.

Wire Break Check for Temperature or Resistance Measurement

The wire break check is intended primarily for temperature measurements (TC, RTD) or resistance measurements. Always parameterize the wire break check in these cases as this ensures that, in the event of a wire break, the measured value provided by the module accepts the data for overrun 7FFFH.

Special Characteristics of the Wire Break Check for the Voltage Measurement Methods

In some transmitters, incorrect measured values may be obtained due to the fact that the wire break check is enabled. If so, disable the wire break check.

The reason Some transmitters try to correct the test current and in doing so corrupt the setpoint value provided.

5.20 Analog Input Module SM 431; AI 8 x 14 Bit; (6ES7431-1KF20-0AB0)

Characteristics

The analog input module SM 431; AI 8 x 14 Bit has the following features:

- Rapid A/D changeover, therefore particularly suitable for highly dynamic processes
- 8 inputs for voltage/current measurement
- 4 inputs for resistance measurement
- Various measuring ranges, adjustable in parallel
- 14-bit resolution
- Supply voltage: 24 VDC required only for the connection of 2-wire transmitters
- Analog section isolated from CPU
- The maximum permissible common mode voltage between the channels and between the reference potential of the connected sensors and M_{ANA} is 8 VAC

Block Diagram of the SM 431; AI 8 x 14 bits

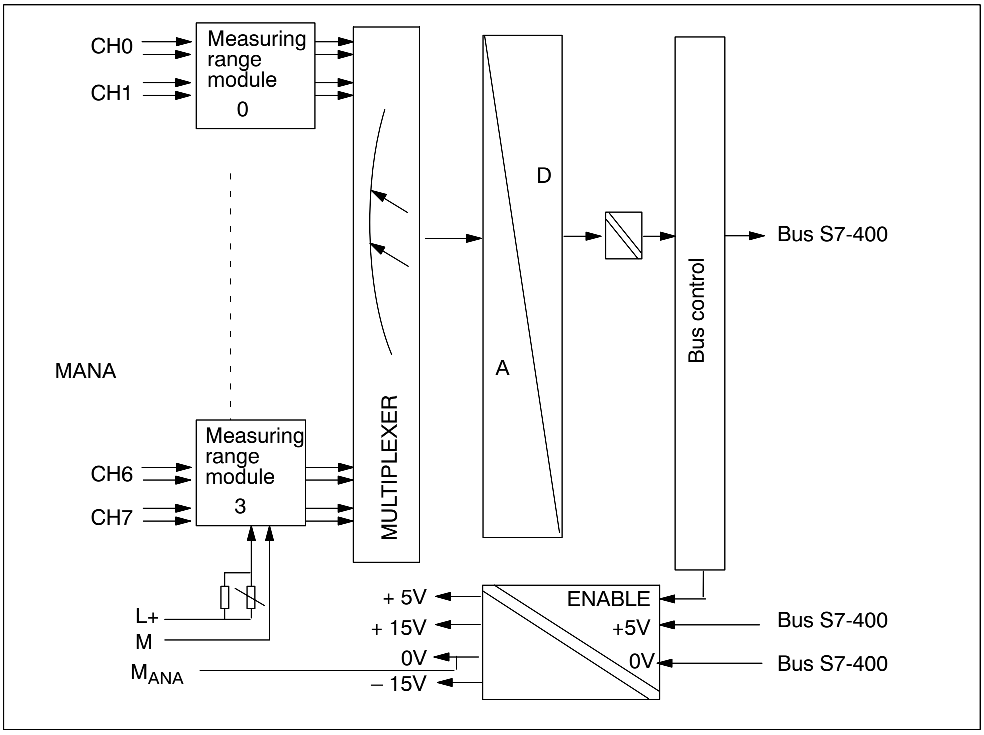


Figure 5-30 Block Diagram of the SM 431; AI 8 x 14 Bit

Terminal Assignment Diagram of the SM 431; AI 8 x 14 Bit

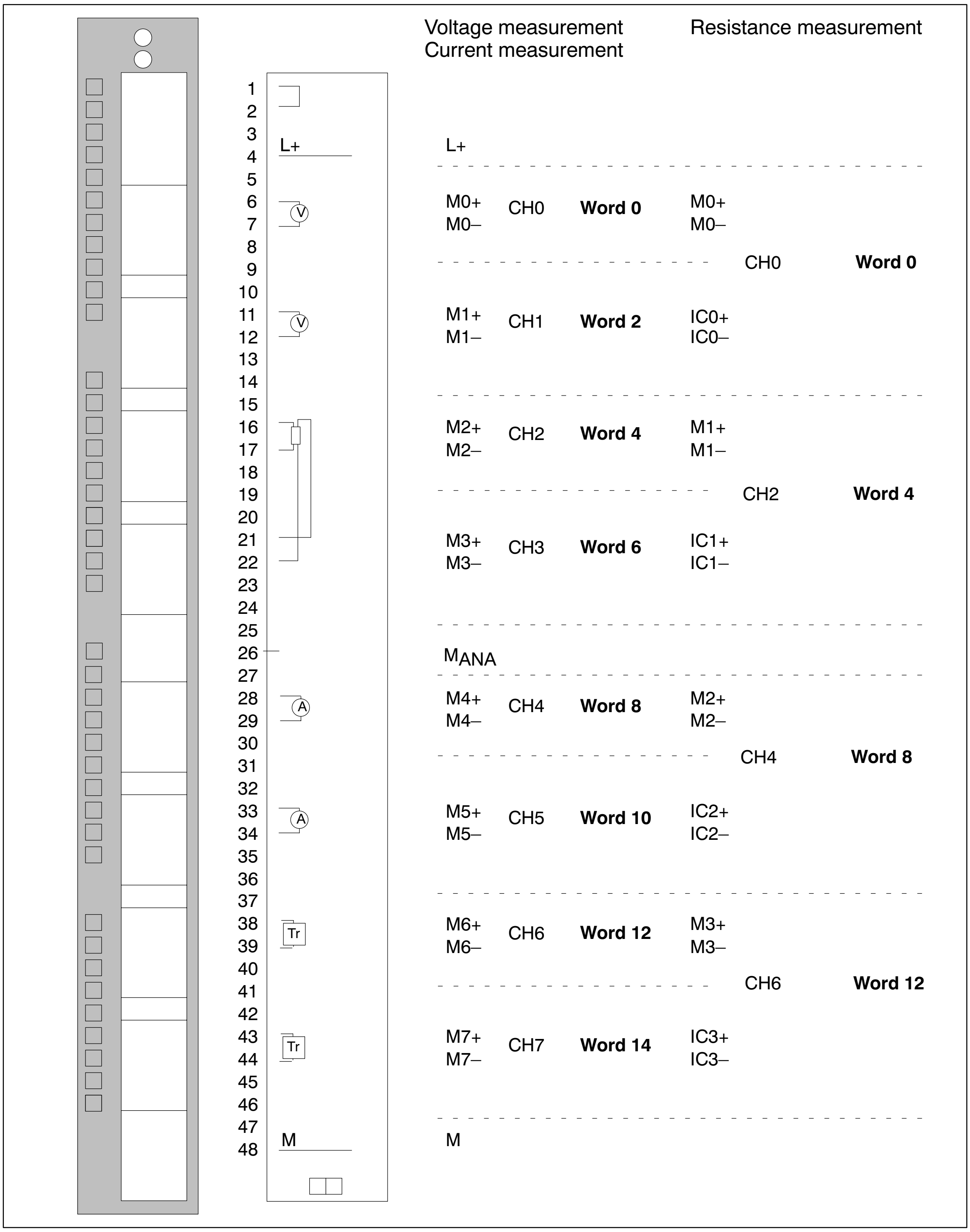


Figure 5-31 Terminal Assignment Diagram of the SM 431; AI 8 x 14 Bit

Technical Specifications of the SM 431; AI 8 x 14 Bit

Dimensions and Weight	
Dimensions W x H x D (in millimeters)	25 x 290 x 210
Weight	Approx. 500 g
Data for Specific Module	
Number of inputs	8
• For resistance-type sensor	4
Length of cable	
• Shielded	Max. 200 m
Voltages, Currents, Potentials	
Rated load voltage L+	24 VDC (required only for the supply of 2-wire transmitters)
• Reverse polarity protection	Yes
Power supply of the transmitters	
• Supply current	Max. 50 mA
• Short-circuit proof	Yes
Constant measured current for resistance-type sensor	Typ. 1.67 mA
Isolation	
• Between channels and backplane bus	Yes
• Between the channels	No
• Between channels and load voltage L+	Yes
Permitted potential difference	
• Between inputs and M_{ANA} (U_{CM})	8 VAC
• Between the inputs (E_{CM})	8 VAC
• Between M_{ANA} and $M_{internal}$ (U_{ISO})	75 VDC/60 VAC
Insulation tested	
• Between bus and analog section	2120 VDC
• Between bus and chassis ground	500 VDC
• Between analog section and L+/M	707 VDC
• Between analog section and chassis ground	2120 VDC
• Between L+/M and chassis ground	2120 VDC

Current consumption	
• From the backplane bus	Max. 1000 mA
• From the backplane bus L+	Max. 200 mA (with 8 connected, fully controlled 2-wire transmitters)
Power dissipation of the module	Typ. 4.9 W
Analog Value Generation	
Measuring principle	Actual-value conversion
Integration time/conversion time/resolution (per channel)	(Does not go into the response time)
• Parameters can be assigned	Yes
• Interference voltage suppression f1 in Hz	None/400/60/50
• Basic conversion time	52 μs
• Resolution (incl. overrange)	14/14/14
Smoothing of the measured values	Can be configured “none – a lot”
Time constant of the input filter	15 μs
Basic execution time of the module, in ms (all channels enabled)	0.420

Suppression of interference, Limits of Error	
Interference voltage suppression configured for f = nx (f1 ±1%), (f1 = interference frequency) n = 1, 2 , ... filter 400/60/50 Hz	
• Common-mode interference (U_{CM} < 11 V_{ss})	> 80 db
• Series-mode interference (peak value of interference < rated value of input range)	> 40 dB
Crosstalk between the inputs	> 70 dB
Operational limit (in the entire temperature range, with reference to the input range)	
• Voltage input	
– ±1 V	±0.17 %
– ±10 V	±0.19 %
– 1 V to 5 V	±0.19 %
• Current input	
– ±20 mA	±0.18%
– 4 mA to 20 mA	±0.18%
• Resistance test	
– 0...600 Ω	±1.0%
Basic error (operational limit at 25°C, referred to input range)	
• Voltage input	
– ±1 V	±0.16%
– ±10 V	±0.175%
– 1 ... 5 V	±0.175%
• Current input	
– ±20 mA	±0.17%
– 4 mA to 20 mA	±0.17%
• Resistance test	
– 0 to 600 Ω	±0.17%
Temperature error (with reference to the input range)	±0.003% K
Linearity error (with reference to the input range)	±0.005% K
Repeat accuracy (in the steady state at 25 °C, referred to the input range)	±0.2%

Status, Interrupts, Diagnostics	
Interrupts	None
Diagnostic functions	None
Substitute value can be applied	No
Data for Selecting a Sensor	
Input range (rated values)/Input resistance	
• Voltage	±1 V/10 MΩ ±10 V/10 MΩ 1 V to 5 V/10 MΩ
• Current	±20 mA/50 Ω 4 mA to 20 mA/50 Ω
• Resistors	0 to 600 Ω/10 MΩ
Maximum input voltage for voltage input (destruction limit)	Max. 18 V continuous; 75 V for 1 ms (cycle factor 1 : 20)
Maximum input current for current input (destruction limit)	40 mA continuous
Connection of the signal 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 – With three-conductor terminal	Possible; cable resistance is also measured
– With four-conductor terminal	Possible
• Load of the two-wire transmitter	Max. 750 Ω

5.20.1 Commissioning the SM 431; AI 8 x 14 Bit

You set the mode of operation of the SM 431; AI 8 x 14 Bit by means of measuring range modules on the module and in *STEP 7*.

Measuring Range Modules

A measuring range module of the module matches two channels and one resistance channel to each type of sensor. 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 5.4.

The corresponding table in Section 5.20.2 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.

Parameters

You will find a description of the general procedure for assigning parameters to analog modules in Section 5.7.

An overview of the parameters that you can set and their default settings are shown in the table below.

Table 5-55 Parameters of the SM 431; AI 8 x 14 Bit (6ES7431-1KF20-0AB0)

Parameter	Value Range	Default[1]	Parameter Type	Scope
Measurement • Measuring type	Disabled U Voltage 4DMU Current (four-wire transmitter) 2DMU Current (two-wire transmitter) R-4L Resistance (four-conductor terminal)	U	Static	Channel
• Measuring range	Refer to Section 5.20.2 for the measuring ranges of the input channels that you can set.	±10 V		
• Interference suppression	400 Hz; 60 Hz; 50 Hz; none	50 Hz		
• Smoothing	None High	None		

[1] Only in the CC (central controller) is it possible to start up the analog modules with the default settings.

Smoothing of the Measured Values

You will find information that is generally applicable to the smoothing of analog values in Section 5.6. You can only set strong smoothing for the SM 431; AI 8 x 14 Bit.

The module cycle time is a constant, irrespective of how many channels are enabled. It therefore has no effect on the filter settling time, which is defined by the parameter assignment of interference frequency suppression and smoothing.

Warning

It is only advisable to parameterize smoothing if you also parameterize interference frequency suppression; otherwise, the measured value resolution will be reduced to 9 bits (analog value representation is right aligned in this case).

Filter Settling Time with Strong Smoothing

Table 5-56 Interference Frequency Suppression and Filter Settling Time with Smoothing of the SM 431; AI 8 x 14 Bit (6ES7431-1KF20-0AB0)

Interference Suppression	Smoothing	Filter settling time in ms
None	High	–
50 Hz	High	100
60 Hz	High	83.333
400 Hz	High	12.5

Step Response with Strong Smoothing

The following figure illustrates the contents of Table 5-56. It shows the filter settling time after which, in the case of a step response, the smoothed analog value is applied to almost 100%, depending on the interference frequency suppression that has been set. The figure applies to every change of signal at an analog input.

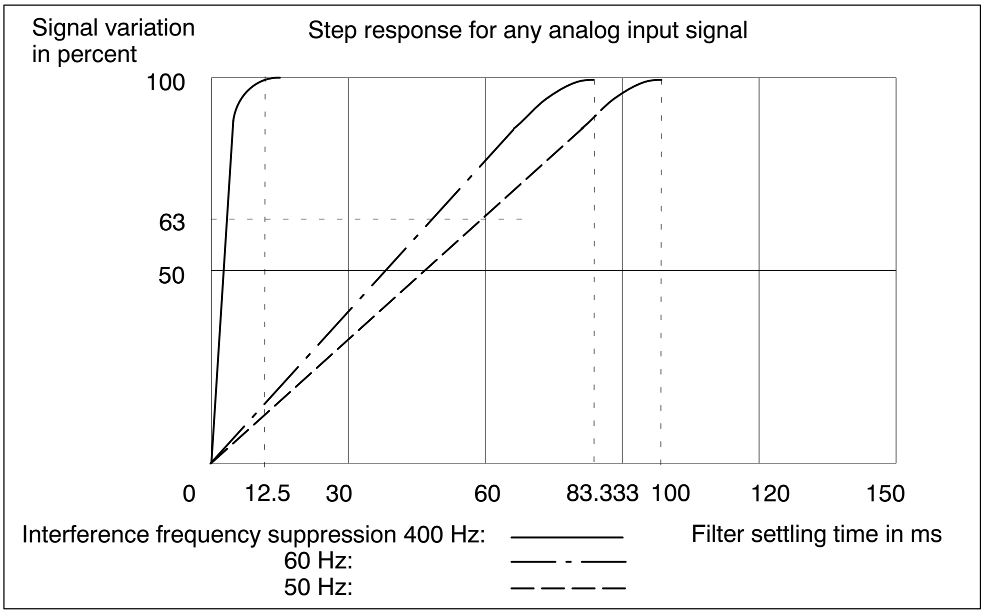


Figure 5-32 Step Response of the SM 431; AI 8 x 14 Bit (6ES7 431-1KF20-0AB0)

5.20.2 Measuring Methods and Measuring Ranges of the SM 431; AI 8 x 14 Bit

Measuring Methods

You can set the following measuring methods for the input channels:

- Voltage measurement
- Current measurement
- Resistance test

You specify the setting by means of the measuring range modules on the module and the “Measuring Type” parameter in *STEP 7*.

Circuit Variants of the Channels

Two channels are set in each case with the measuring range module. There are therefore restrictions as regards the measuring method for the adjacent channels 0/1, 2/3, 4/5 and 6/7, as shown in the following table:

Table 5-57 Selection of the Measuring Method for Channel n and Channel n+1 of the SM 431; AI 8 x 14 Bit (6ES7431-1KF20-0AB0)

Meas. Type Channel n+1 / Meas. Type Channel n	Disabled	Voltage ±1 V	Voltage 1 to 5 V	Voltage ±10 V	Current 4-DMU	Current 2-DMU	R-4L
Disabled	x	x	x	x	x	x	
Voltage ±1 V	x	x					
Voltage 1 to 5 V	x		x	x			
Voltage ±10 V	x		x	x			
Current four-wire transmitter	x				x		
Current two-wire transmitter	x					x	
Resistance four-conductor	x						

Example

If you select “current (two-wire transmitter)” for channel 6, you can only disable the measuring method or set “current (two-wire transmitter)” for channel 7.

Circuit for Resistance Measurement

The following conditions apply when measuring the resistance with the SM 431; AI 8 x 14 Bit:

Table 5-58 Channels for Resistance Measurement of the SM 431; AI 8 x 14 Bit (6ES7431-1KF20-0AB0)

Measuring Type Parameter	Permissible for Channel n	Condition
Resistor (four-conductor terminal)	0, 2, 4 or 6	You must disable the “Measuring Type” parameter for channels n+1 (1, 3, 5, 7). The reason The connections of channel n+1 are used to supply the resistance that is connected to channel n.

Unused Channels

Unused channels can be left open. Set the correspondingmeasuring range modules in position “B”. You can improve the noise immunity of the module in a measuring environment with serious interference by connecting M– and M_{ANA}.

Measuring Ranges

You set the measuring ranges by means of the measuring range modules on the module and the “Measuring Type” parameter in *STEP 7*.

Table 5-59 Measuring Ranges of the SM 431; AI 8 x 14 Bit (6ES7431-1KF20-0AB0)

Method Selected	Measuring Range (Type of Sensor)	Measuring Range Module Setting	Description
U: Voltage	±1 V	A	You will find the digitized analog values in Section 5.3.1 in the voltage measuring range
	1 to 5 V ±10 V	B	
2DMU: Current (two-wire transmitter)	4 to 20 mA	D	To supply these transmitters with current you must connect 24 V to the L+ and M front connector terminals. You will find the digitized analog values in Section 5.3.1 in the current measuring range
4DMU: Current (four-wire transmitter)	4 to 20 mA ±20 mA	C	You will find the digitized analog values in Section 5.3.1 in the current measuring range
R-4L: Resistor (four-conductor terminal)	600 Ω	A	You will find the digitized analog values in Section 5.3.1 in the resistance measuring range

Default Settings

The module has the following default settings in *STEP 7*:

- Channels 0 to 7: “Voltage” for the measuring method ; “±10 V” for the measuring range

You can use these measuring methods and measuring ranges without parameterizing the SM 431; AI 8 x 14 Bit in *STEP 7*.

5.21 Analog Input Module SM 431; AI 16 x 13 Bit; (6ES7431-0HH00-0AB0)

Characteristics

The analog input module SM 431; AI 13 x 16 Bit has the following features:

- 16 inputs for voltage/current measurement
- Various measuring ranges, adjustable in parallel
- 13-bit resolution
- Non-isolated between the analog section and bus
- The maximum permissible common mode voltage between the channels and the reference potentials of the connected sensors and central ground point is 2 VDC/VAC

Block Diagram of the SM 431; AI 16 x 13 Bit

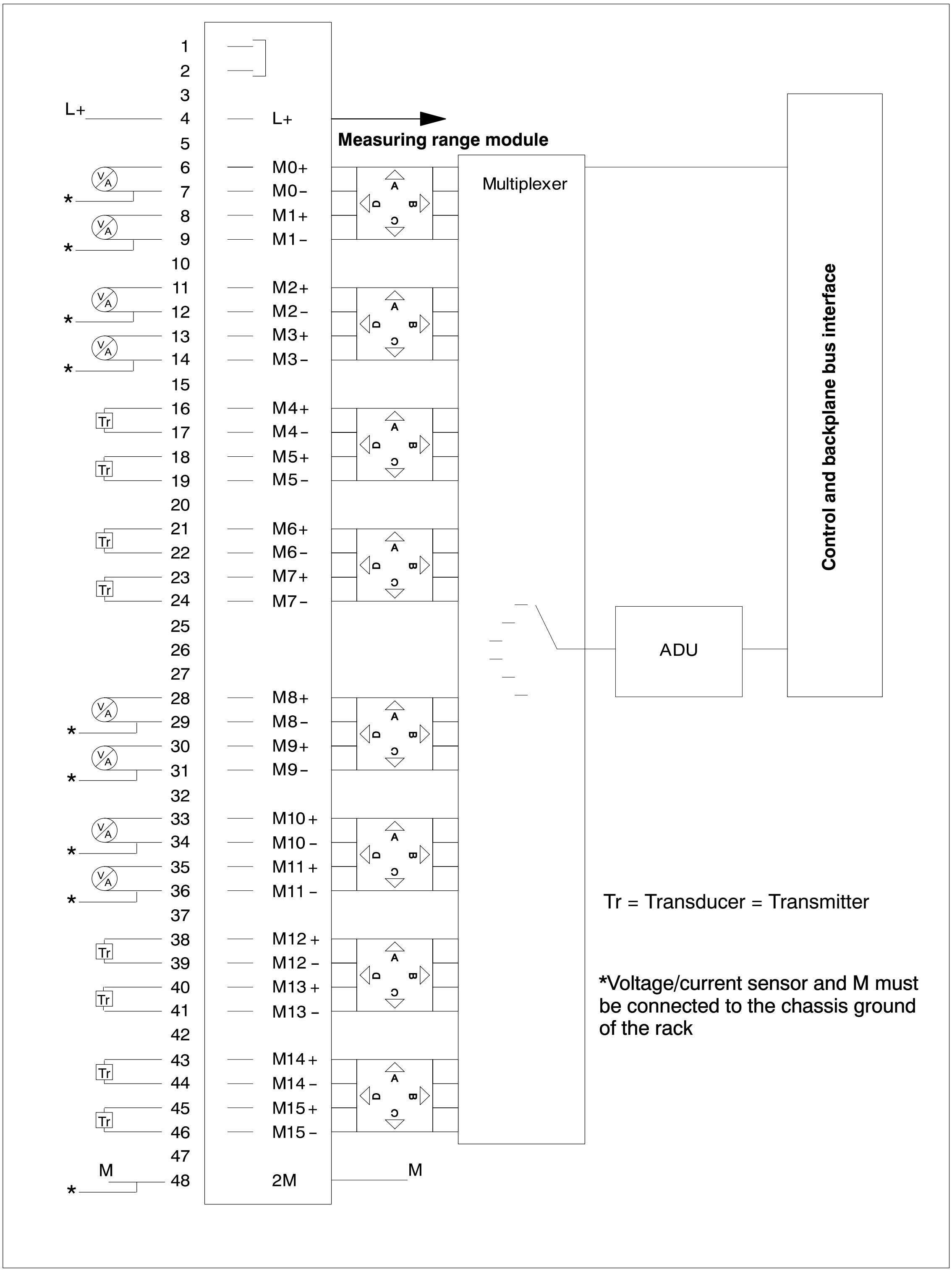


Figure 5-33 Block Diagram of the SM 431; AI 16 x 13 Bit

Terminal Assignment Diagram of the SM 431; AI 16 x 13 Bit

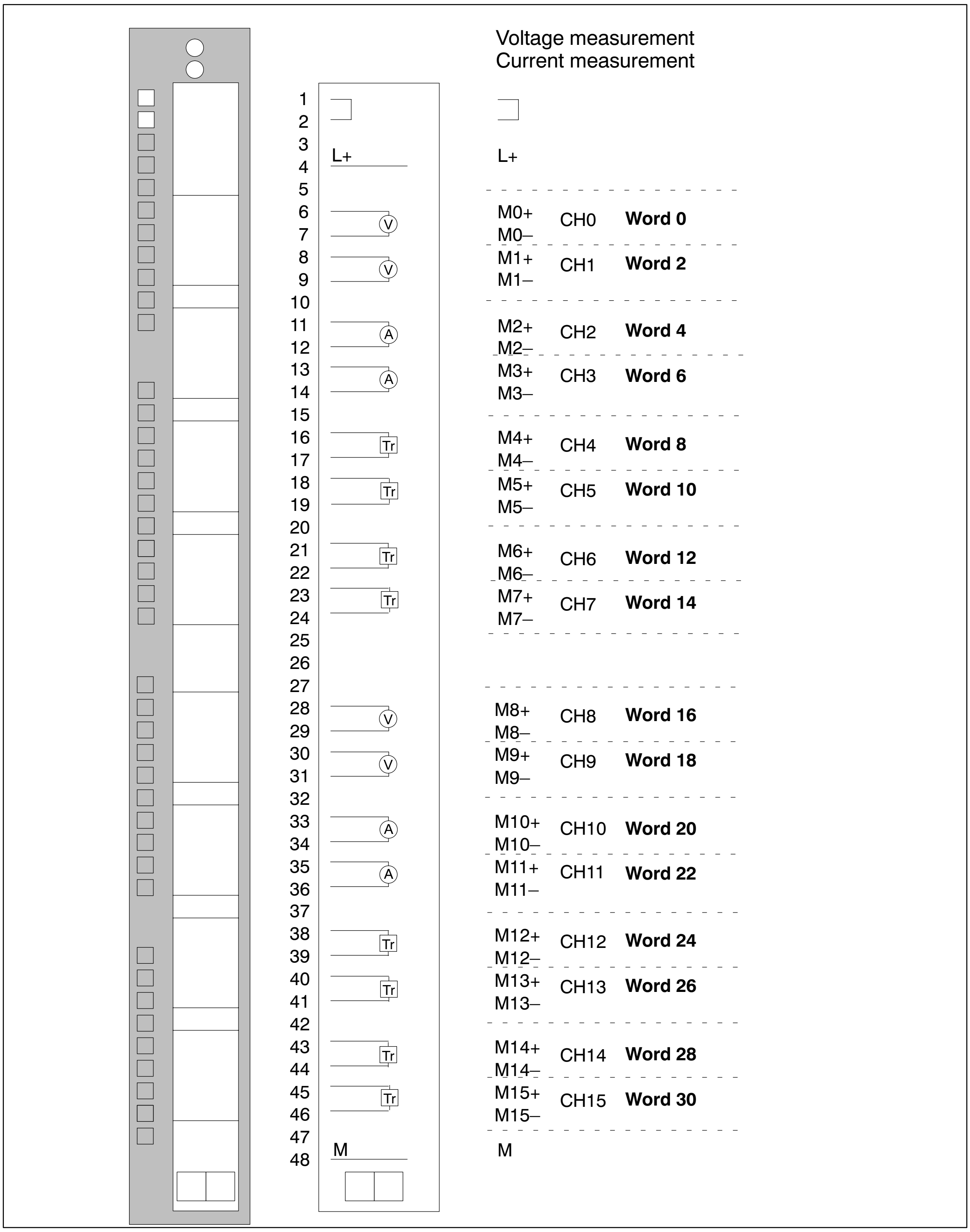


Figure 5-34 Terminal Assignment Diagram of the SM 431; AI 16 x 13 Bit

Technical Specifications of the SM 431; AI 16 x 13 Bit

Dimensions and Weight	
Dimensions L x H x D (in millimeters)	25 x 290 x 210
Weight	Approx. 500 g
Data for Specific Module	
Number of inputs	16
• Shielded	Max. 200 m
Voltages, Currents, Potentials	
Rated load voltage L+	24 VDC (only required for the supply of 2-wire transmitters)
• Reverse polarity protection	Yes
Power supply of the transmitters	
• Supply current	Max. 50 mA
• Short-circuit proof	Yes
Constant measured current for resistance-type sensor	Typ. 1.67 mA
Isolation	
• Between channels and backplane bus	No
• Between the channels	No
• Between channels and load voltage L+	No
Permitted potential difference	
• Between inputs and M_{ANA} (U_{CM})	2 VDC/2 VAC_{SS}
• Between the inputs (E_{CM})	2 VDC/2 VAC_{SS}
Insulation tested with	
• Between bus and chassis ground	500 VDC
Current consumption	
• From the backplane bus	Max. 100 mA
• From load voltage L+ (with 16 connected, fully controlled two-wire transmitters)	Max. 400 mA
Power dissipation of the module	Typ. 2 W
Analog Value Generation	
Measuring principle	Integrative
Integration time/conversion time/resolution (per channel)	(Does not go into the response time)
• Parameters can be assigned	Yes
• Interference voltage suppression f1 in Hz	60/50
• Integration time in milliseconds	50/60
• Basic conversion time in ms	55/65
• Resolution including sign	13 bits
Smoothing of the measured values	Not possible

Basic execution time of the module, in ms (all channels enabled)	880/1040
Suppression of Interference, Limits of Error	
Interference voltage suppression for f = nx (f1 ± 1%), (f1 = interference frequency) n = 1, 2, ...	
• Common-mode interference (U_{CM} < 2 V)	> 86 dB
• Series-mode interference (peak value of interference < rated value of input range)	> 60 dB
Crosstalk between the inputs	> 50 dB
Operational limit (in the entire temperature range, with reference to the input range)	
• Voltage input	
– ± 1 V	± 0.65%
– ± 10 V	± 0.65%
– 1 V to 5 V	± 1%
• Current input	
– ± 20 mA	± 0.65%
– 4 mA to 20 mA	± 0.65%
Basic error (operational limit at 25 °C, referred to input range)	
• Voltage input	
– ± 1 V	± 0.25%
– ± 10 V	± 0.25%
– 1 V to 5 V	± 0.5%
• Current input	
– ± 20 mA	± 0.25%
– 4 mA to 20 mA	± 0.25%
Temperature error (with reference to the input range)	± 0.01%
Linearity error (with reference to the input range)	± 0.05%
Repeat accuracy (in the steady state at 25 °C, referred to the input range)	± 0.01%
Status, Interrupts, Diagnostics	
Interrupts	None
Diagnostic functions	None
Substitute value can be applied	No

Data for Selecting a Sensor	
Input range (rated values)/Input resistance	
• Voltage	± 1 V/10 MΩ ± 10 V/100 MΩ 1 V to 5 V/100 MΩ
• Current	± 20 mA/50 Ω 4 mA to 20 mA/50 Ω
Maximum input voltage for voltage input (destruction limit)	20 V continuous; 75 V for 1 ms (cycle factor 1 : 20)
Maximum input current for current input (destruction limit)	40 mA

Connection of the signal sensor	
• For measuring voltage	Possible
• For measuring current	
– As two-wire transmitter	Possible
– As four-wire transmitter	Possible
• Load of the two-wire transmitter	Max. 750 Ω

5.21.1 Commissioning the SM 431; AI 16 x 13 Bit

You set the mode of operation of the SM 431; AI 16 x 13 Bit by means of measuring range modules on the module and in *STEP 7*.

Measurement Range Modules

A measuring range module of the module matches two consecutive channels to each type of sensor. 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 5.4.

The corresponding table in Section 5.21.2 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.

Parameters

You will find a description of the procedure of assigning parameters to analog modules in Section 5.7.

An overview of the parameters that you can set and their default settings are shown in the table below.

Table 5-60 Parameters of the SM 431; AI 16 x 13 Bit

Parameter	Value Range	Default[1)]	Parameter Type	Scope
Measurement • Measuring type	Disabled U Voltage 4DMU Current (four-wire transmitter) 2DMU Current (two-wire transmitter)	U	Static	Channel
• Measuring range	Refer to Section 5.21.2 for the measuring ranges of the input channels that you can set.	10 V		
• Interference suppression	60 Hz; 50 Hz	50 Hz		

1) Only in the CC (central controller) is it possible to start up the analog modules with the default settings.

5.21.2 Measuring Methods and Measuring Ranges of the SM 431; AI 16 x 13 Bit

Measuring Methods

You can set the following measuring methods for the input channels:

- Voltage measurement
- Current measurement

You specify the setting by means of the measuring range modules on the module and the “Measuring Type” parameter in *STEP 7*.

Circuit Variants of the Channels

Two channels are set in each case with the measuring range module. There are therefore restrictions as regards the measuring method for the adjacent channels 0/1, 2/3, 4/5, 6/7, 8/9, 10/11, 12/13 and 14/15, as shown in the following table:

Table 5-61 Selection of the Measuring Method for Channel n and Channel n+1 of the SM 431; AI 16 x 13 Bit

Meas. Type Channel n+1 / **Meas. Type Channel n**	Disabled	Voltage ± 1 V	Voltage 1 to 5 V	Voltage ± 10 V	Current 4-DMU	Current 2-DMU
Disabled	x	x	x	x	x	x
Voltage ± 1 V	x	x				
Voltage 1 to 5 V	x		x	x		
Voltage ± 10 V	x		x	x		
Current four-wire transmitter	x				x	
Current two-wire transmitter	x					x

Example

If you select “current (two-wire transmitter)” for channel 6, you can only disable the measuring method or set “current (two-wire transmitter)” for channel 7.

Unused Channels

Unused channels can be left open. Put the measuring range modules in position “B”. You can improve the noise immunity of the module in a measuring environment with serious interference by interconnecting M– and Mana.

Disable the “Measuring Type” parameter for unused channels to reduce the scan cycle time of the module.

Measuring Ranges

You set the measuring ranges by means of the measuring range modules on the module and the “Measuring Type” parameter in *STEP 7*.

Table 5-62 Measuring Ranges of the SM 431; AI 16 x 13 Bit

Method Selected	Measuring Range (Type of Sensor)	Measuring Range Module Setting	Description
U: Voltage	± 1 V	A	You will find the digitized analog values in Section 5.3.1 in the voltage measuring range
	1 to 5 V ± 10 V	B	
2DMU: Current (two-wire transmitter)	4 to 20 mA	D	To supply these transmitters with current you must connect 24 V to the L+ and M front connector terminals. You will find the digitized analog values in Section 5.3.1 in the current measuring range
4DMU: Current (four-wire transmitter)	4 to 20 mA ± 20 mA	C	You will find the digitized analog values in Section 5.3.1 in the current measuring range

Default Settings

The module has the following default settings in *STEP 7*:

- Measuring method “voltage”
- Measuring range “+/–10 V”.

You can use this combination of measuring method and measuring range without parameterizing the SM 431; AI 16 x 13 Bit in *STEP 7*

5.22 Analog Input Module SM 431; AI 16 x 16 Bit; (6ES7431-7QH00-0AB0)

Characteristics

The analog input module SM 431; AI 16 x 16 Bit has the following features:

- 16 inputs for voltage/current and temperature measurement with thermocouple (TC)
- 8 inputs for resistance and temperature measurement with thermocouple (TC)
- Various measuring ranges, adjustable in parallel
- 16-bit resolution
- Programmable diagnostics
- Programmable diagnostic interrupt
- Programmable hardware interrupt when limit has been exceeded
- Programmable end-of-scan-cycle interrupt
- Analog section isolated from CPU
- The maximum permissible common mode voltage between the channels and between the channel and central ground is 120 VAC

Block Diagram of the SM 431; AI 16 x 16 Bit

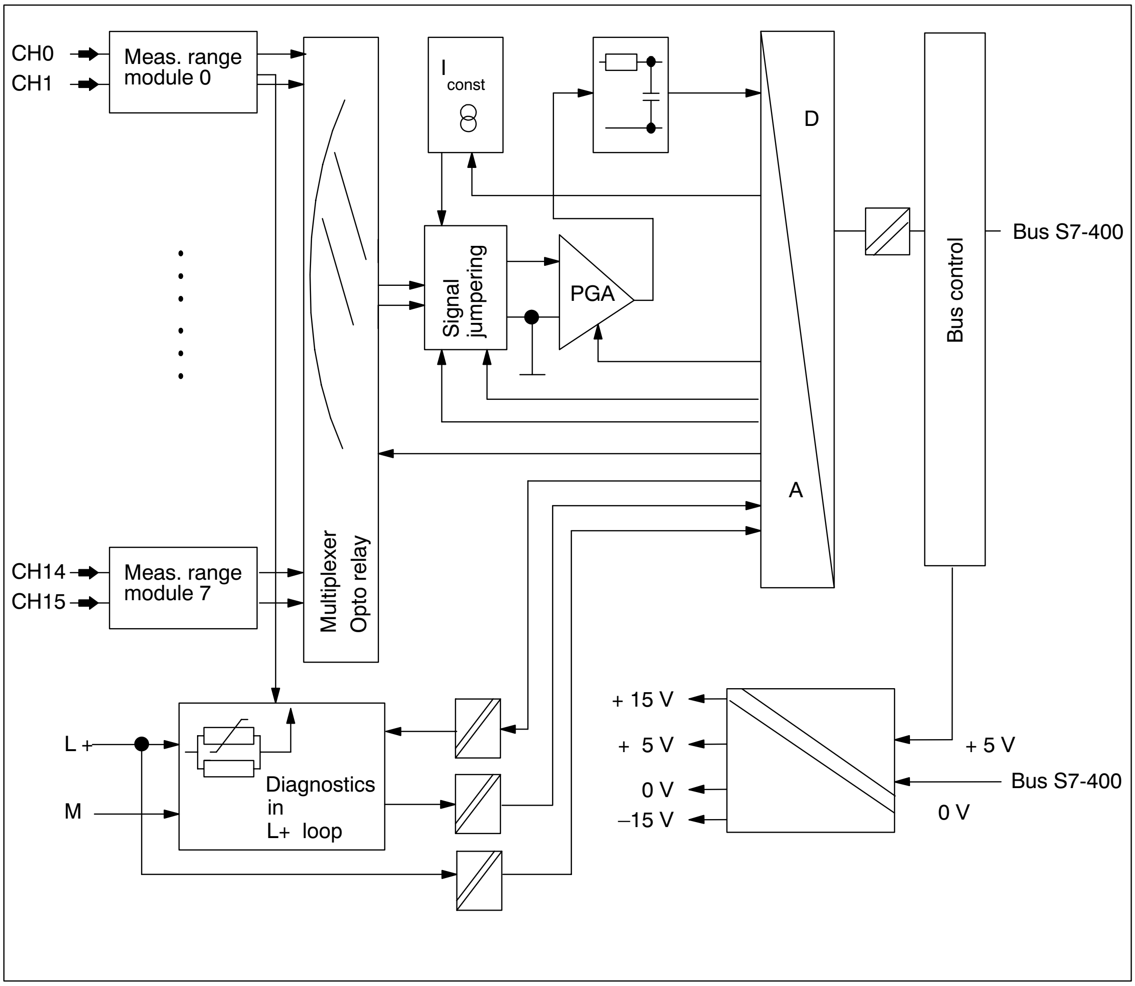


Figure 5-35 Block Diagram of the SM 431; AI 16 x 16 Bit

Terminal Assignment Diagram of the SM 431; AI 16 x 16 Bit

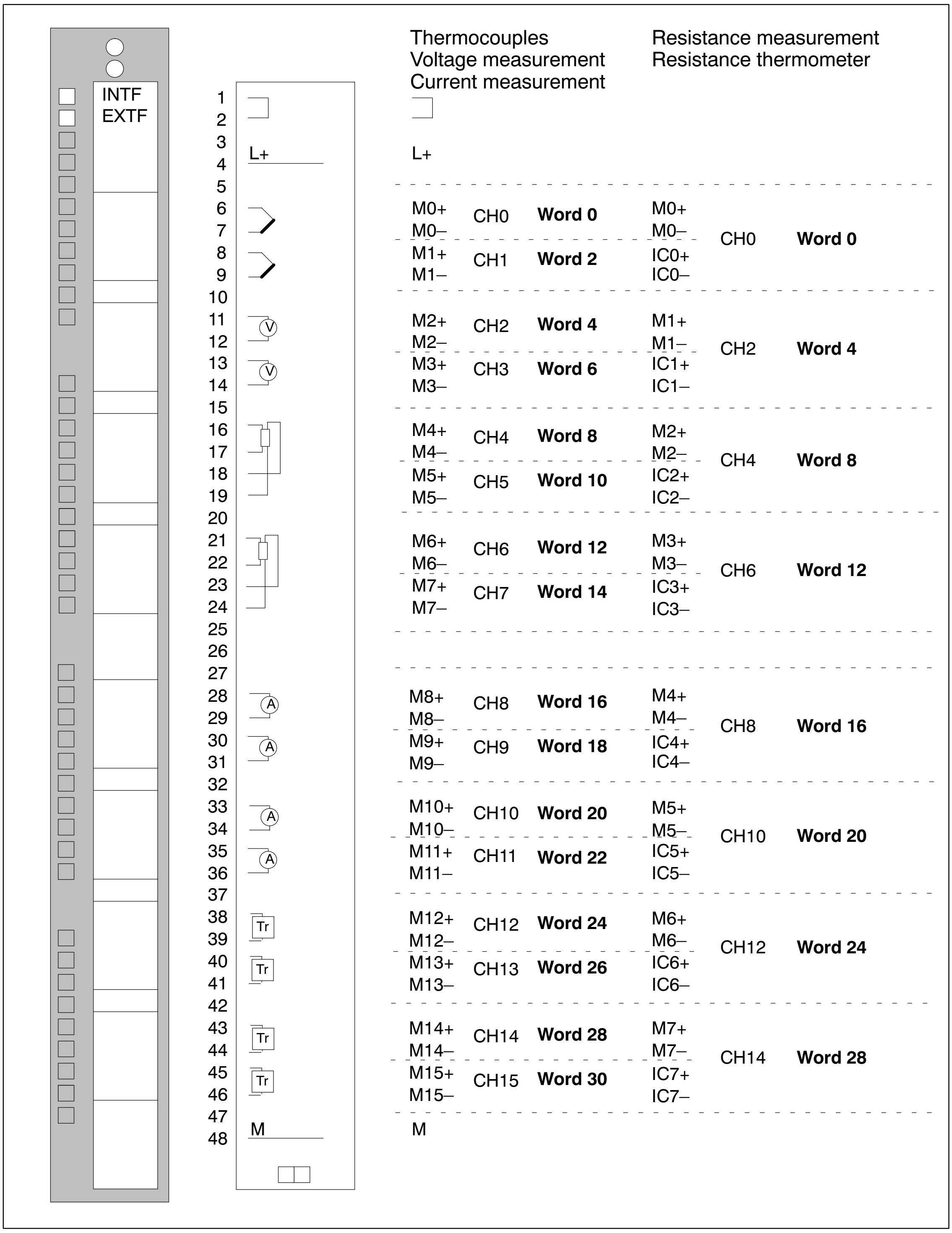


Figure 5-36 Terminal Assignment Diagram of the SM 431; AI 16 x 16 Bit

Technical Specifications of the SM 431; AI 16 x 16 Bit

Dimensions and Weight	
Dimensions W x H x D (in millimeters)	25 x 290 x 210
Weight	Approx. 500 g
Data for Specific Module	
Number of inputs	16
• For resistance-type sensor	8
Length of cable	
• Shielded	Max. 200 m
in the input ranges ≤ 80 mV and with thermocouples	Max. 50 m
Voltages, Currents, Potentials	
Rated load voltage L+	24 VDC (only required for the supply of two-wire transmitters)
• Reverse polarity protection	Yes
Power supply of the transmitters	
• Supply current	Max. 50 mA
• Short-circuit proof	Yes
Constant measured current for resistance-type sensor	Typ. 1.67 mA
Isolation	
• Between channels and backplane bus	Yes
• Between the channels	No
• Between channels and load voltage L+	Yes
Permitted potential difference	
• Between inputs and M_{ANA} (U_{CM})	120 VAC
• Between the inputs (E_{CM})	120 VAC
• Between M_{ANA} and $M_{internal}$ (U_{ISO})	75 VDC/60 VAC

Insulation tested with	
• Between bus and L+/M	2120 VDC
• Between bus and analog section	2120 VDC
• Between bus and chassis ground	500 VDC
• Between analog section and L+/M	707 VDC
• Between analog section and chassis ground	2120 VDC
• Between L+/M and chassis ground	2120 VDC
Current consumption	
• From the backplane bus (5 V)	Max. 700 mA
• From load voltage L+ (with 16 connected, fully controlled two-wire transmitters)	Max. 400 mA
Power dissipation of the module	Typ. 4.5 W
Analog Value Generation	
Measuring principle	Integrative
Integration time/conversion time/resolution (per channel)	(Does not go into the response time)
• Parameters can be assigned	Yes
• Interference voltage suppression f1 in Hz	400/60/50
• Integration time in ms	2.5/16.7/20
• Basic conversion time in ms	6/20.1/23.5
• Additional conversion time for measuring resistance with 3-conductor terminal, in ms	12/40.2/47
• Additional conversion time for open-circuit monitoring, in ms	4.3/4.3/4.3
• Additional conversion time for measuring resistance in ms	5.5/5.5/5.5
• Resolution including sign	16/16/16 bit
Smoothing of the measured values	Parameters can be assigned in 4 stages
Basic execution time of the module, in ms (all channels enabled)	96/322/376

Suppression of Interference, Limits of Error

Interference voltage suppression for f = nx (f1 ± 1%), (f1 = interference frequency) n = 1, 2, ...

- Common-mode interference (U_{CM} < 120 V_{SS}) — > 100 dB
- Series-mode interference (peak value of interference < rated value of input range) — > 40 dB

Crosstalk between the inputs — > 70 dB

Operational limit (in the entire temperature range, with reference to the input range)

- Voltage input
  - ± 25 mV — ± 0.35 %
  - ± 50 mV — ± 0.32%
  - ± 80 mV — ± 0.31%
  - ± 250 mV — ± 0.3%
  - ± 500 mV — ± 0.3%
  - ± 1 V — ± 0.3%
  - ± 2.5 V — ± 0.3%
  - ± 5 V — ± 0.3%
  - 1 V to 5 V — ± 0.3%
  - ± 10 V — ± 0.3%
- Current input
  - 0 mA to 20 mA — ± 0.3%
  - ± 5 mA — ± 0.3%
  - ± 10 mA — ± 0.3%
  - ± 20 mA — ± 0.3%
  - 4 mA to 20 mA — ± 0.3%
- Resistance test
  - 0 to 48 Ω; four-conductor measurement — ± 0.3%
  - 0 to 150 Ω; four-conductor measurement — ± 0.3%
  - 0 to 300 Ω; four-conductor measurement — ± 0.3%
  - 0 to 600 Ω; four-conductor measurement — ± 0.3%
  - 0 to 5000 Ω; four-conductor measurement (in the range of 6000 Ω) — ± 0.3%
  - 0 to 300 Ω; three-conductor measurement — ± 0.4%
  - 0 to 600 Ω; three-conductor measurement — ± 0.4%
  - 0 to 5000 Ω; three-conductor measurement (in the range of 6000 Ω) — ± 0.4%
- Thermocouples
  - TC type B — ± 11.5 K
  - TC type R — ± 7.3 K
  - TC type S — ± 8.3 K
  - TC type T — ± 1.7 K
  - TC type E — ± 3.2 K
  - TC type J — ± 4.3 K
  - TC type K — ± 6.2 K
  - TC type U — ± 2.8 K
  - TC type L — ± 4.2 K
  - TC type N — ± 4.4 K
- Resistance thermocouples, four-conductor standard measuring range
  - Pt 100 — ± 3.1 K
  - Pt 200 — ± 4.0 K
  - Pt 500 — ± 3.0 K
  - Pt 1000 — ± 3.1 K
  - Ni 100 — ± 0.8 K
  - Ni 1000 — ± 0.8 K

  Climatic measuring range
  - Pt 100 — ± 0.4 K
  - Pt 200 — ± 0.4 K
  - Pt 500 — ± 0.4 K
  - Pt 1000 — ± 0.4 K
  - Ni 100 — ± 0.8 K
  - Ni 1000 — ± 0.8 K
- Resistance thermocouples, three-conductor standard measuring range
  - Pt 100 — ± 4.2 K
  - Pt 200 — ± 6.5 K
  - Pt 500 — ± 5.2 K
  - Pt 1000 — ± 4.2 K
  - Ni 100 — ± 1.0 K
  - Ni 1000 — ± 1.0 K

  Climatic measuring range
  - Pt 100 — ± 0.5 K
  - Pt 200 — ± 0.5 K
  - Pt 500 — ± 0.5 K
  - Pt 1000 — ± 0.5 K
  - Ni 100 — ± 1.0 K
  - Ni 1000 — ± 1.0 K

Basic error (operational limit at 25 °C, referred to input range)

- Voltage input

– ± 25 mV	± 0.23%
– ± 50 mV	± 0.19%
– ± 80 mV	± 0.17%
– ± 250 mV	± 0.15%
– ± 500 mV	± 0.15%
– ± 1 V	± 0.15%
– ± 2.5 V	± 0.15%
– ± 5 V	± 0.15%
– 1 V to 5 V	± 0.15%
– ± 10 V	± 0.15%

- Current input

– 0 mA to 20 mA	± 0.15%
– ± 5 mA	± 0.15%
– ± 10 mA	± 0.15%
– ± 20 mA	± 0.15%
– 4 mA to 20 mA	± 0.15%

- Resistance test

– 0 to 48 Ω four-conductor measurement	± 0.15%
– 0 to 150 Ω four-conductor measurement	± 0.15%
– 0 to 300 Ω, four-conductor measurement	± 0.15%
– 0 to 600 Ω four-conductor measurement	± 0.15%
– 0 to 5000 Ω four-conductor measurement (in the range of 6000 Ω)	± 0.15%
– 0 to 300 Ω three-conductor measurement	± 0.3%
– 0 to 600 Ω three-conductor measurement	± 0.3%
– 0 to 5000 Ω; three-conductor measurement (in the range of 6000 Ω)	± 0.3%

- Thermocouples

– TC type B	± 7.6 K
– TC type R	± 4.8 K
– TC type S	± 5.4 K
– TC type T	± 1.1 K
– TC type E	± 1.8 K
– TC type J	± 2.3 K
– TC type K	± 3.4 K
– TC type U	± 1.7 K
– TC type L	± 2.3 K
– TC type N	± 2.6 K

- Resistance thermocouples, four-conductor standard measuring range

– Pt 100	± 1.6 K
– Pt 200	± 2.5 K
– Pt 500	± 2.0 K
– Pt 1000	± 1.6 K
– Ni 100	± 0.4 K
– Ni 1000	± 0.4 K

Climatic measuring range

– Pt 100	± 0.2 K
– Pt 200	± 0.2 K
– Pt 500	± 0.2 K
– Pt 1000	± 0.2 K
– Ni 100	± 0.4 K
– Ni 1000	± 0.4 K

- Resistance thermocouples, three-conductor standard measuring range

– Pt 100	± 3.1 K
– Pt 200	± 4.0 K
– Pt 500	± 3.0 K
– Pt 1000	± 3.1 K
– Ni 100	± 0.8 K
– Ni 1000	± 0.8 K

Climatic measuring range

– Pt 100	± 0.4 K
– Pt 200	± 0.4 K
– Pt 500	± 0.4 K
– Pt 1000	± 0.4 K
– Ni 100	± 0.8 K
– Ni 1000	± 0.8 K

Temperature error (with reference to the input range)	± 0.004% K
Linearity error (with reference to the input range)	± 0.01% K
Repeat accuracy (in the steady state at 25 °C, referred to the input range)	± 0.1%

Status, Interrupts, Diagnostics	
Interrupts	
• Hardware interrupt	Parameters can be assigned
• Hardware interrupt when limit has been exceeded	Parameters can be assigned
• Diagnostic Interrupt	Parameters can be assigned
Diagnostic functions	
• Group error display	
– For internal fault	Red LED (INTF)
– For external fault	Red LED (EXTF)
• Diagnostic information readable	Yes
Substitute value can be applied	No
Data for Selecting a Sensor	
Input range (rated values)/Input resistance	
• Voltage	± 25 mV/1 MΩ ± 50 mV/1 MΩ ± 80 mV/1 MΩ ± 250 mV/1 MΩ ± 500 mV/1 MΩ ± 1 V/1 MΩ ± 2.5 V/1 MΩ ± 5 V/1 MΩ 1 V to 5 V/1 MΩ ± 10 V/1 MΩ
• Current	0 mA to 20 mA/50 Ω ± 5 mA/50 Ω ± 10 mA/50 Ω ± 20 mA/50 Ω 4 mA to 20 mA/50 Ω
• Resistors	0 to 48 Ω/1 MΩ 0 to 150 Ω/1 MΩ 0 to 300 Ω/1 MΩ 0 to 600 Ω/1 MΩ 0 to 6000 Ω/1 MΩ (can be used up to 5000 Ω)
• Thermocouples	TC type B/1 MΩ TC type R/1 MΩ TC type S/1 MΩ TC type T/1 MΩ TC type E/1 MΩ TC type J/1 MΩ TC type K/1 MΩ TC type U/1 MΩ TC type L/1 MΩ TC type N/1 MΩ

• Resistance thermometer	Pt 100/1 MΩ Pt 200/1 MΩ Pt 500/1 MΩ Pt 1000/1 MΩ Ni 100/1 MΩ Ni 1000/1 MΩ
Maximum input voltage for voltage input (destruction limit)	Max. 18 V continuous; 75 V for 1 ms (cycle factor 1 : 20)
Maximum input current for current input (destruction limit)	40 mA
Connection of the signal 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; cable resistance is also measured
– With three-conductor terminal	Possible
– With four-conductor terminal	Possible
• Load of the two-wire transmitter	Max. 750 Ω
Characteristic linearization	Parameters can be assigned
• For thermocouples	Types B, R, S, T, E, J, K, U, L, N
• For resistance thermometer	Pt 100, Pt 200, Pt 500, Pt 1000, Ni 100, Ni 1000
Temperature compensation	Yes, programmable
• Internal temperature compensation	No
• External temperature compensation with compensating box	Possible
• External temperature compensation with Pt 100	Possible
• Compensation for definable reference junction temperature	Possible
Unit for temperature measurement	Degrees Celsius

5.22.1 Commissioning the SM 431; AI 16 x 16 Bit

You set the mode of operation of the SM 431; AI 16 x 16 Bit by means of measuring range modules on the module and in *STEP 7*.

Measuring Range Module

A measuring range module of the module matches two channels and one resistance channel to each type of sensor. 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 5.4.

The corresponding table in Section 5.22.2 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.

Parameters

You will find a description of the procedure for assigning parameters to analog modules in Section 5.7.

An overview of the parameters that you can set and their default settings are shown in the table below.

Table 5-63 Parameters of the SM 431; AI 16 x 16 Bit

Parameter	Value Range	Default2)	Parameter Type	Scope
Enable • Diagnostic interrupt1) • Hardware interrupt1)	 Yes/no Yes/no	 No No	Dynamic	Module
• Destination CPU for interrupt	1 to 4	–	Static	Module
Trigger for hardware interrupt • End of scan cycle reached at input	Yes/no	No	Static	Channel
• High limit • Low limit	32511 to –32512 –32512 to 32511	–	Dynamic	Channel
Diagnostics • Wire break • Reference channel error • Underflow • Overflow • Short circuit to M	 Yes/no Yes/no Yes/no Yes/no Yes/no	 No No No No No	Static	Channel

Table 5-63 Parameters of the SM 431; AI 16 x 16 Bit, continued

Parameter	Value Range	Default[2)]	Parameter Type	Scope
Measurement • Measuring type	Disabled U Voltage 4DMU Current (4-wire transmitter) 2DMU Current (two-wire transmitter) R-4L Resistor (four-conductor terminal) R-3L Resistor (three-conductor terminal) RTD-4L Thermal resistor (linear, four-conductor terminal) RTD-3L Thermal resistor (linear, three-conductor terminal) TC-L Thermocouple (linear)	U	Static	Channel
• Measuring range	Refer to Section 5.22.2 for the measuring ranges of the input channels that you can set.	±10 V		
• teference Temperature	–273.15 to 327.67 °C	0.00 °C	Dynamic	Module
• Interference suppression	400 Hz; 60 Hz; 50 Hz	50 Hz		
• Smoothing	None Low Average High	None		
• Ref. junction	None RTD on Channel 0 Reference temperature value	None		

1) If you use the module in ER-1/ER-2, you must set this parameter to “No” because the interrupt lines are not available in ER-1/ER-2.
2) Only in the CC (central controller) is it possible to start up the analog modules with the default settings.

A Point to Note About Channels for Hardware Interrupts with the End of Scan Cycle Trigger

You can parameterize hardware interrupts for the end of scan cycle **for one** of the 16 channels because the module can only trigger these interrupts on one channel.

Smoothing of the Measured Values

You fill find information that is generally applicable to the smoothing of analog values in Section 5.6.

The following figure indicates for the module the number of module cycles after which, in the case of a step response, the smoothed analog value is applied at almost 100%, depending on the smoothing setting. The figure applies to every change of signal at an analog input.

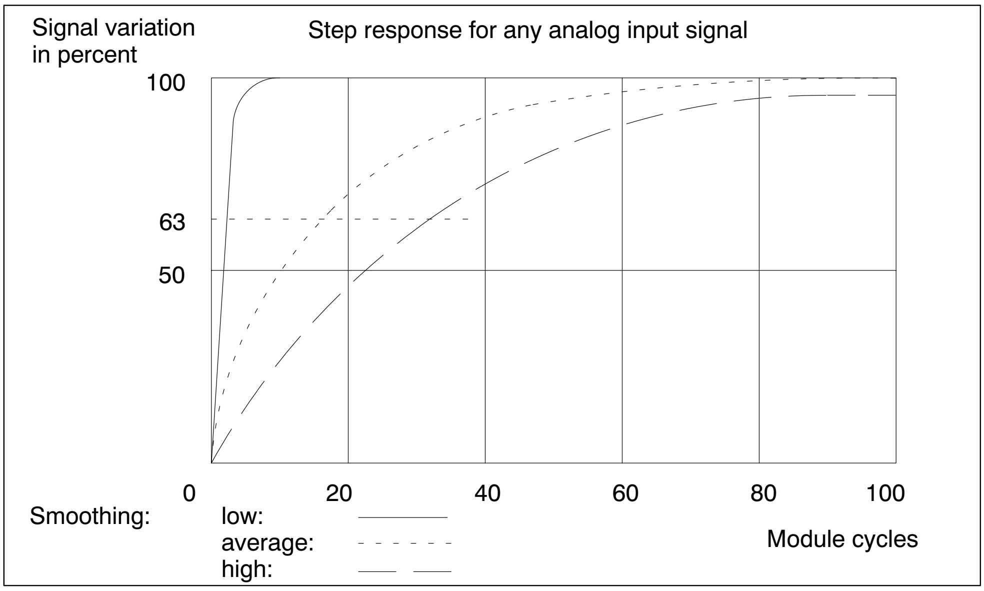


Figure 5-37 Step Response of the SM 431; AI 16 x 16 Bit (6ES7431-7QH00-0AB0)

Displaying Parameter Assignment Errors

The SM 431; AI 16 x 16 Bit has diagnostics capability. Below you will find an overview of the displays that are possible for modules with parameter assignment errors.

Table 5-64 Diagnostic Information of the SM 431; AI 16 x 16 Bit

Incorrect Parameter Assignment	Possible Display	Explanation
Of the module	• Module malfunction • Internal malfunction • Wrong parameters	You can find an explanation of the diagnostic information in Tables 4-7 and 5-46 on Pages 4-10 and 5-64.
Affecting certain channels	• Module malfunction • Internal malfunction • There is a channel error • Wrong parameters • Channel information available • Vector channel error • Channel parameter assignment error	

5.22.2 Measuring Methods and Measuring Ranges of the SM 431; AI 16 x 16 Bit

Measuring Methods

You can set the following measuring methods for the input channels:

- Voltage measurement
- Current measurement
- Resistance test
- Temperature measurement

You specify the setting by means of the measuring range modules on the module and the “Measuring Type” parameter in *STEP 7*.

Circuit Variants for the Channels

Two channels are set in each case with the measuring range module. There are therefore restrictions as regards the measuring method for the adjacent channels 0/1, 2/3, 4/5, 6/7, 8/9, 10/11, 12/13 and 14/15, as shown in the following table:

Table 5-65 Selection of the Measuring Method for Channel n and Channel n+1 of the SM 431; AI 16 x 16 Bit

Meas. Type Channel n+1 / **Meas. Type Channel n**	Disabled	Voltage	Current 4-DMU	Current 2-DMU	R-4L	R-3L	RTD-4L	RTD-3L	TC-L
Disabled	x	x	x	x					x
Voltage	x	x							x
Current four-wire transmitter	x		x						
Current two-wire transmitter	x			x					
Resistance four-conductor	x								
Resistance three-conductor	x								
Thermal resistor four-conductor	x								
Thermal resistor three-conductor	x								
Thermocouples	x	x							x

Example

If you have select “current (two-wire transmitter)” for channel 6, you can only disable the measuring method or set “current (two-wire transmitter)” for channel 7.

Circuit for Resistance and Temperature Measurement

The following conditions apply when measuring the resistance and temperature with the SM 431; AI 16 x 16 Bit:

Table 5-66 Channels for Resistance and Temperature Measurement of the SM 431; AI 16 x 16 Bit

Measuring Type Parameter	Permissible for Channel n	Condition
Resistor (four-conductor terminal)	0, 2, 4, 6, 8, 10, 12 or 14	You must disable the “Measuring Type” parameter for channels n+1 (1, 3, 5, 7, 9, 11, 13, 15). The reason The connections of channel n+1 are used to supply the resistance that is connected to channel n.
Resistor three-conductor terminal	0, 2, 4, 6, 8, 10, 12 or 14	
Thermal resistor (linear, four-conductor terminal)	0, 2, 4, 6, 8, 10, 12 or 14	
Thermal resistor (linear, four-conductor terminal)	0, 2, 4, 6, 8, 10, 12 or 14	
Thermocouple (linear)	0 to 15	You can select the reference junction. It is only advisable to specify a reference junction with thermocouples.

Circuit for Reference Junction Compensation for Thermocouples

If you select “RTD on Channel 0” as a reference junction for reference junction compensation for thermocouples, the following applies:

Table 5-67 Reference Junction Compensation via RTD on Channel 0 of the SM 431; AI 16 x 16 Bit

Reference Junction Parameter	Permissible for Channel n	Condition
RTD on Channel 0	2 to 15	You must connect and parameterize on channel 0 a resistance thermometer with linearization, a 3- or 4-conductor terminal in **climatic range**. This means that channels 0 and 1 are assigned. The reason If channel 0 is to be used as the reference junction, a resistance-type sensor must be connected there to establish the absolute temperatures in the climatic range.

Unused Channels

Unused channels can be left open. Set the measuring range modules to position “A”. You can improve the noise immunity of the module in a measuring environment with serious interference by short-circuiting the channels.

Disable the “Measuring Type” parameter for unused channels to reduce the scan cycle time of the module.

Measuring Ranges

You set the measuring ranges by means of the measuring range modules on the module and the "Measuring Type" parameter in *STEP 7*.

Table 5-68 Measuring Ranges of the SM 431; AI 16 x 16 Bit

Method Selected	Measuring Range (Type of Sensor)	Measuring Range Module Setting	Description
U: Voltage	± 25 mV ± 50 mV ± 80 mV ± 250 mV ± 500 mV ± 1 V ± 2.5 V ± 5 V 1 to 5 V ± 10 V	A	You will find the digitized analog values in Section 5.3.1 in the voltage measuring range
2DMU: Current (two-wire transmitter)	4 to 20 mA	D	To supply these transmitters with current you must connect 24 V to the L+ and M front connector terminals. You will find the digitized analog values in Section 5.3.1 in the current measuring range
4DMU: Current (four-wire transmitter)	± 5 mA ± 10 mA 0 to 20 mA 4 to 20 mA ± 20 mA	C	You will find the digitized analog values in Section 5.3.1 in the current measuring range
R-3L: Resistor (three-conductor terminal)	300 Ω 600 Ω 6000 Ω (max. 5000 Ω)	A	You will find the digitized analog values in Section 5.3.1 in the resistance measuring range
R-4L: Resistor (four-conductor terminal)	48 Ω 150 Ω 300 Ω 600 Ω 6000 Ω (max. 5000 Ω)		

Table 5-68 Measuring Ranges of the SM 431; AI 16 x 16 Bit, continued

Method Selected	Measuring Range (Type of Sensor)	Measuring Range Module Setting	Description
TC-L: Thermocouple (linear) (temperature measurement)	Type B Type N Type E Type R Type S Type J Type L Type T Type K Type U	A	You will find the digitized analog values in Section 5.3.1 in the temperature range
RTD-3L: thermal resistor linear, three-conductor terminal (temperature measurement) RTD-4L: thermal resistor linear, four-conductor terminal (temperature measurement)	Pt 100 climatic Pt 200 climatic Pt 500 climatic Pt 1000 climatic Ni 100 climatic Ni 1000 climatic Pt 100 standard Pt 200 standard Pt 500 standard Pt 1000 standard Ni 100 standard Ni 1000 standard	A	You will find the digitized analog values in Section 5.3.1 in the temperature range

Default Settings

The default measuring method of the module in *STEP 7* is “Voltage”, at a range of “ ±10 V”. You can use this combination of measuring method and measuring range without parameterizing the SM 431; AI 16 x 16 Bit in *STEP 7*.

Wire Break Check

The wire-break check is intended primarily for temperature measurements (TC, RTD) or resistance measurements. Always parameterize the wire break check in these cases as this ensures that in the event of a wire break the measured value provided by the module accepts the data for overrun 7FFFH.

Special Characteristics of the Wire Break Check for the Voltage Measurement Methods

In some transmitters, incorrect measured values may occur due to the fact that the wire break check is enabled. If so, disable the wire-break check.

The reason Some transmitters try to correct the test current and in doing so corrupt the setpoint value they provide.

Points to Note About the Wire Break Check when Current Sensors Are Connected

A wire break check of current sensors is not possible for the SM 431; AI 16 x 16 Bit except in life-zero areas. You can therefore only parameterize the wire break check for the “Current (four-wire transmitter)” measuring method and the “4 to 20 mA” measuring range.

Checking for Reference Channel Errors when Connecting Thermocouples

If you have connected a thermocouple, you can then enable the “Reference channel error” diagnosis if you have configured an “RTD on Channel 0” or “Reference Temperature Value” reference junction.

Points to Note About Checking for “Underflow” with some Measuring Methods and Measuring Ranges

There is now underflow in life-zero areas. A value that is too low or is negative is interpreted as a wire break. You can therefore **not** parameterize the underflow check for the SM 431; AI 16 x 16 Bit for the following measuring methods and ranges:

Table 5-69 Points to Note when Checking for “Underflow”

Measuring Method	Measuring Range
Voltage	1 to 5 V
Current (four-wire transmitter)	4 to 20 mA
Current (two-wire transmitter)	4 to 20 mA

Points to Note About the “Short Circuit to M” Diagnosis

You can only parameterize the check for “Short Circuit to M” for the SM 431; AI 16 x 16 Bit for the “Current (2-wire transmitter)” measuring method.

5.23 Analog Input Module SM 431; AI 8 x RTD x 16 Bit; (6ES7431-7KF10-0AB0)

Characteristics

The analog input module SM 431; AI 8 x RTD x 16 Bit has the following features:

- 8 differential inputs for the resistance thermometer
- Parameters can be assigned to the resistance thermometer
- Linearization of the resistance thermometer characteristic curves
- 16-bit resolution
- Update rate of 25 ms for 8 channels
- Programmable diagnostics
- Programmable diagnostic interrupt
- Programmable hardware interrupt when limit has been exceeded
- Analog section isolated from CPU
- The maximum permissible common mode voltage between the channel and the central ground point is 120 VAC

Calibration Software

The calibration software is only available on the Internet. You can find the current version under article ID 12443337.

After installing the software, you can define user-specific calibration values for each channel and and each module input range. You will find further information under ID 12436891 at the Customer Support FAQ site.

Block Diagram of the SM 431; AI 8 x RTD x 16 Bit

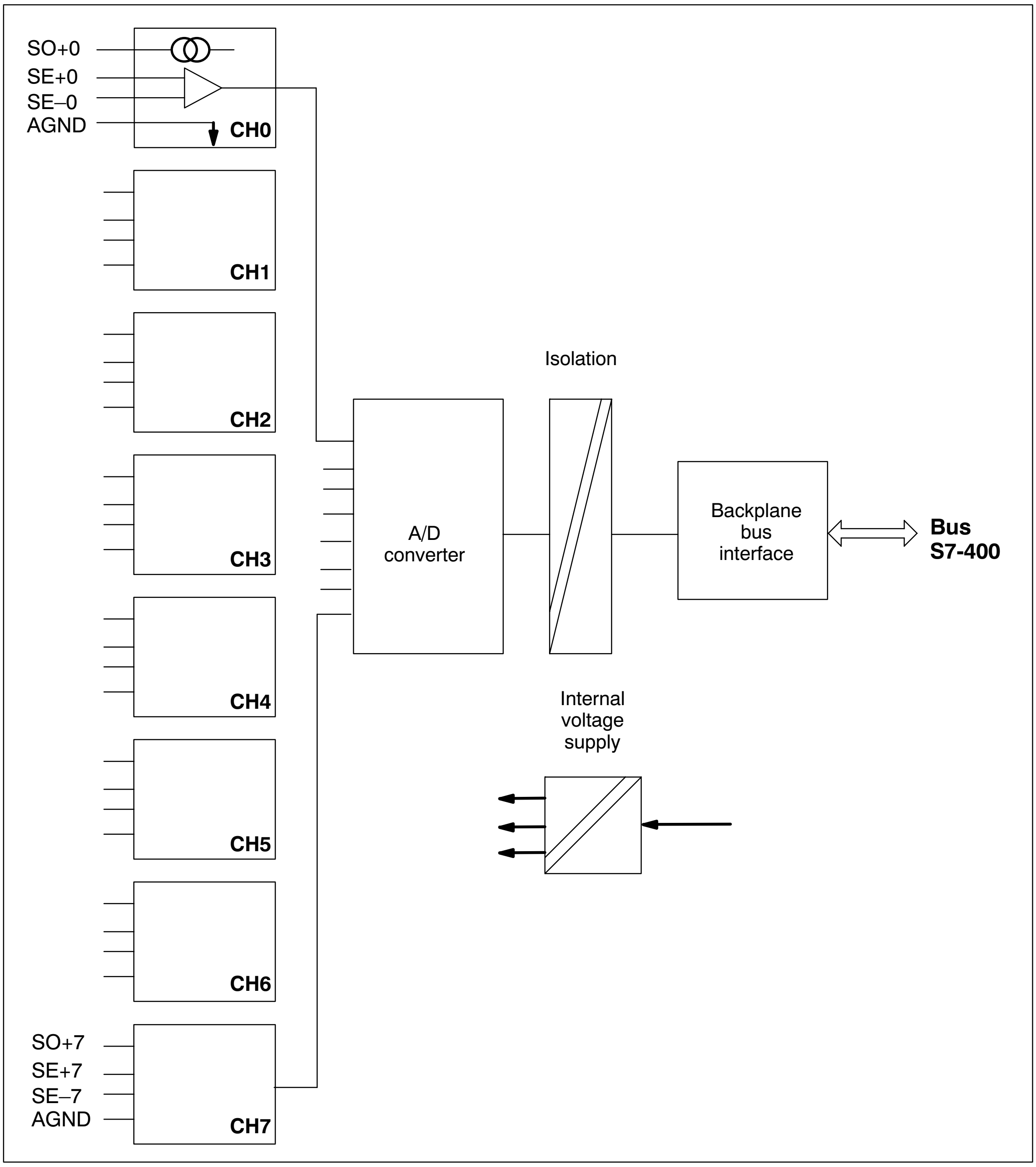


Figure 5-38 Block Diagram of the SM 431; AI 8 x RTD x 16 Bit

Warning

An external protective network is required in the signal leads in accordance with IEC 61000-4-5 (12 V MOV CT19-506, connected in series with all inputs as recommended by the manufacturer).

Terminal Assignment Diagram of the SM 431; AI 8 x RTD x 16 Bit

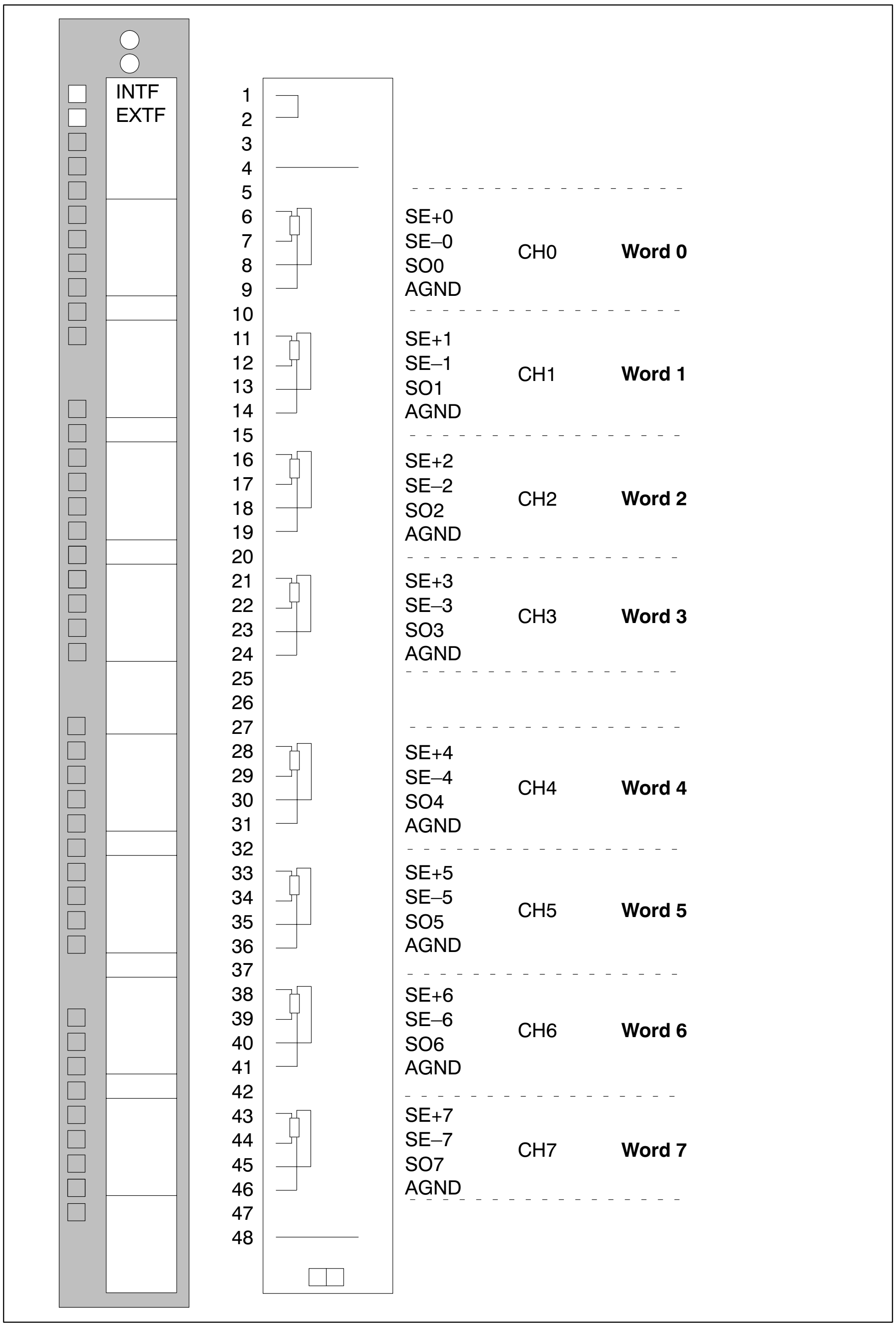


Figure 5-39 Terminal Assignment Diagram of the SM 431; AI 8 x RTD x 16 Bit

Technical Specifications of the SM 431; AI 8 x RTD x 16 Bit

Dimensions and Weight	
Dimensions W x H x D (in millimeters)	25 x 290 x 210
Weight	Approx. 650 g
Data for Specific Module	
Number of inputs	8
Length of cable	
• Shielded	Max. 200 m
Voltages, Currents, Potentials	
Constant current for resistance-type sensor	Max. 1 mA
Isolation	
• Between channels and backplane bus	Yes
Permitted potential difference	
• Between M_{ANA} and $M_{internal}$ (U_{ISO})	120 VAC
Insulation tested with	1500 VAC
Current consumption	
• From the backplane bus	Max. 650 mA
Power dissipation of the module	Typ. 3.3 W
Analog Value Generation	
Measuring principle	Integrative
Integration/conversion time/ resolution (per channel)	(Does not go into the response time)
• Parameterizable	Yes
• Basic conversion time in ms	22/25
• Additional conversion time for measuring resistance, in ms	Max. 200
• Resolution including sign	16/16 bit
• Noise suppression for interference frequency f1 in Hz	60/50
Smoothing of the measured values	Parameters can be assigned in 4 stages
Basic response time of module (all channels enabled)	22/25 ms
Suppression of interference, Limits of Error	
Noise suppression for f = n ~~(f1 < ± 1%),~~ (f1 = interference frequency) n = 1, 2, etc.	
• Common-mode interference (U_{CM} < 120V)	> 100 dB
• Series-mode interference (peak value of interference < rated value of the input range)	> 50 dB

Crosstalk between the inputs	> 70 dB
Operational limit (over entire temperature range, referred to 0 to 60 °C input range)	
• RTD-Input	RTD-4L RTD-3L
Pt 100	±1.8 °C ± 3.4 °C
Pt 200	± 0.8 °C ± 1.7 °C
Pt 500	± 0.4 °C ± 0.7 °C
Pt 1000	± 0.3 °C ± 0.4 °C
Ni 100	± 1.5 °C ± 2.1 °C
Ni 1000	± 0.2 °C ± 0.3 °C
Basic error (operational limit at 25 °C, referred to input range)	
• RTD-Input	CRTD-4L RTD-3L
Pt 100	± 0.5 °C ± 1.0 °C
Pt 200	± 0.3 °C ± 0.5 °C
Pt 500	± 0.3 °C ± 0.4 °C
Pt 1000	± 0.2 °C ± 0.2 °C
Ni 100	± 0.3 °C ± 0.6 °C
Ni 1000	± 0.2 °C ± 0.2 °C
Linearity error (with reference to the input range)	additional error
• RTD-Input	RTD-4L RTD-3L
Pt 100	± 0.2 °C ± 0.3 °C
Pt 200	± 0.2 °C ±0.2 °C
Pt 500	± 0.1 °C ± 0.1 °C
Pt 1000	± 0.1 °C ± 0.1 °C
Ni 100	± 0.1 °C ± 0.2 °C
Ni 1000	± 0.1 °C ± 0.1 °C
Repeat accuracy (in the steady state at 25 °C, referred to the input range)	additional error
• RTD-Input	CRTD-4L RTD-3L
Pt 100	± 0.5 °C ± 0.3 °C
Pt 200	± 0.3 °C ± 0.2 °C
Pt 500	± 0.3 °C ± 0.1 °C
Pt 1000	± 0.2 °C ± 0.1 °C
Ni 100	± 0.3 °C ± 0.2 °C
Ni 1000	± 0.2 °C ± 0.1 °C
Status, Interrupts, Diagnostics	
Interrupts	
• Hardware interrupt when limit has been exceeded	Parameters can be assigned
• Diagnostic Interrupt	Parameters can be assigned
Diagnostic functions	Parameters can be assigned
• Group error display	
– For internal fault	Red LED (INTF)
– For external fault	Red LED (EXTF)
• Diagnostic information can be displayed	Possible

Data for Selecting a Sensor	
Input range (rated values) input resistance	
• Resistance thermometer	Pt 100/> 10M Pt 200/> 10M Pt 500/> 10M Pt 1000/> 10M Ni 100/> 10M Ni 1000/> 10M
• Maximum input voltage for voltage input (destruction limit)	35 V continuous; 75 V for max. 1 s (duty factor 1:20)
Connection of the sensor	
• For measuring resistance	
With three-conductor terminal	Possible
With four-conductor terminal	Possible
Characteristic linearization	Parameters can be assigned
• For resistance thermometer	Pt100...1000, 0.00385 Alpha to DIN EN 60751 Ni 100...1000, 0.00618 Alpha to DIN 43760
[1]Measuring range	
• PT100, PT200	
• PT 500	–200 °C to +850 °C
• PT 1000	–200 °C to +800 °C
• NI 100	–200 °C to +240 °C
• NI 1000	–60 °C to +250 °C
	–60 °C to +130 °C
Unit for temperature measurement	Degrees Celsius; degrees Fahrenheit

5.23.1 Commissioning the SM 431; AI 8 x RTD x 16 Bit

You set the mode of operation of the SM 431; AI 8 x RTD x 16 Bit in *STEP 7*.

Parameters

You will find a description of the general procedure for assigning parameters to analog modules in Section 5.7.

An overview of the parameters that you can set and their default settings are shown in the table below.

Table 5-70 Parameters of the SM 431; AI 8 x RTD x 16 Bit

Parameter	Value Range	Default[2)]	Parameter Type	Scope
Enable • Diagnostic interrupt[1)] • Hardware interrupt[1)]	 Yes/no Yes/no	 No No	Dynamic	Module
• Destination CPU for interrupt	1 to 4	–	Static	Module
Trigger for hardware interrupt[3)] • High limit • Low limit	 32767 to – 32768 – 32768 to 32767	–	Dynamic	Channel
Diagnostics • Wire break • Underflow • Overflow	 Yes/no Yes/no Yes/no	 No No No	Static	Channel
Measurement • Measuring type	Disabled RTD-4L Thermal resistor (linear, four-conductor terminal) RTD-3L Thermal resistor (linear, three-conductor terminal)	RTD-3L	Static	Channel
• Measuring range	Refer to Section 5.23.2 for the measuring ranges of the input channels that you can set.	Pt 100 standard		
• Temperature unit	Degrees Celsius; degrees Fahrenheit	Degrees Celsius	Static	Module
• Temperature coefficient for temperature measurement with thermal resistor (RTD)	For platinium (Pt) 0.00385 Ω/°C/Ω 0.003916 Ω/°C/Ω 0.003902 Ω/°C/Ω 0.003920 Ω/°C/Ω For nickel (Ni) 0.00618 Ω/°C/Ω 0.00672 Ω/°C/Ω	0.00385	Static	Channel
• Interference suppression	60 Hz; 50 Hz; none	60 Hz		

Table 5-70 Parameters of the SM 431; AI 8 x RTD x 16 Bit, continued

Parameter	Value Range	Default[2)]	Parameter Type	Scope
• Smoothing	None Low Average High	None	Static	Channel

1) If you use the module in ER-1/ER-2, you must set this parameter to “No” because the interrupt lines are not available in ER-1/ER-2.
2) Only in the CC (central controller) is it possible to start up the analog modules with the default settings.
3) The limit values must be within the temperature range of the connected sensor.

Smoothing of the Measured Values

You fill find information that is generally applicable to the smoothing of analog values in Section 5.6.

The following figure shows for the module the number of module cycles, in the case of a step response, after which the smoothed analog value is applied to almost 100%, depending on the smoothing setting. The figure applies to every change of signal at an analog input.

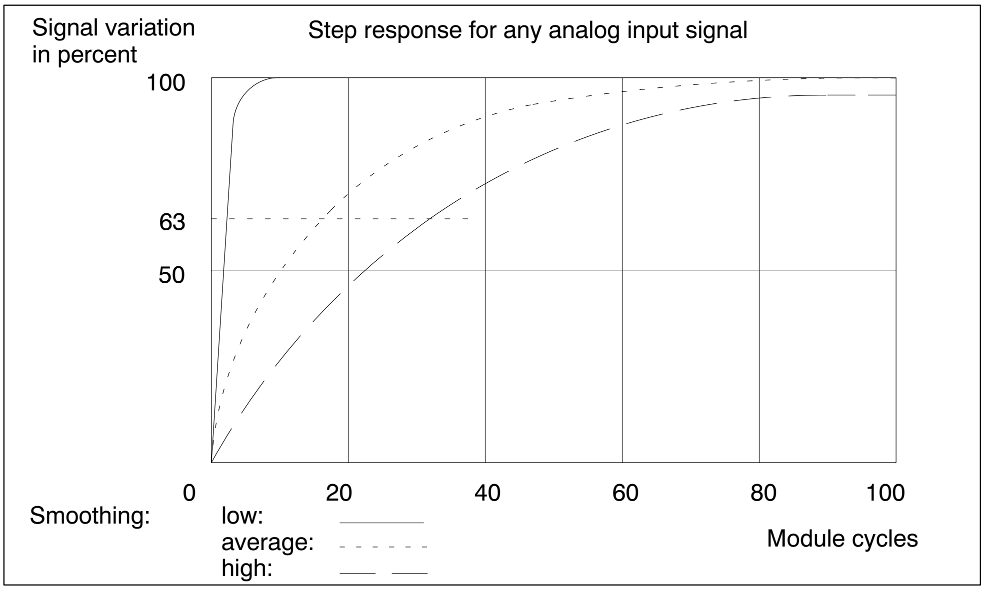


Figure 5-40 Step Response of the SM 431; AI 8 x RTD x 16 Bit

Displaying Parameter Assignment Errors

The SM 431; AI 8 x RTD x 16 Bit is capable of diagnostics. Below you will find an overview of the displays that are possible for modules with parameter assignment errors.

Table 5-71 Diagnostic Information of the SM 431; AI 8 x RTD x 16 Bit

Incorrect Parameter Assignment	Possible Display	Explanation
Of the module	• Module malfunction • Internal malfunction • Wrong parameters • Module not configured.	You can find an explanation of the diagnostic information in Tables 4-7 and 5-46 on Pages 4-10 and 5-64.
Affecting certain channels	• Module malfunction • Internal malfunction • There is a channel error • Wrong parameters • Channel information available • Vector channel error • Channel parameter assignment error • User calibration doesn’t correspond to the parameter assignment	

5.23.2 Measuring Methods and Measuring Ranges of the SM 431; AI 8 x RTD x 16 Bit

Measuring Methods

As the measuring method for the input channels, you can set the temperature measurement.

Unused Channels

Disable the “Measuring Type” parameter for unused channels. In this way you shorten the scan time of the module.

Measuring Ranges

You set the measuring ranges with the “Measuring Type” parameter in *STEP 7*.

Table 5-72 Measuring Ranges of the SM 431; AI 8 x RTD x 16 Bit

<table>
<tr><th>Method Selected</th><th>Measuring Range</th><th>Description</th></tr>
<tr><td>RTD-3L: Thermal resistor (linear, three-conductor terminal)
(temperature measurement)</td><td rowspan="2">Pt 100 standard
Pt 200 standard
Pt 500 standard
Pt 1000 standard
Ni 100 standard
Ni 1000 standard</td><td rowspan="2">You will find the digitized analog values in Section 5.3.1 in the temperature range</td></tr>
<tr><td>RTD-4L: Thermal resistor (linear, four-conductor terminal)
(temperature measurement)</td></tr>
</table>

Default Settings

The default settings of the module in *STEP 7* are “Thermal resistor (linear, 3-conductor terminal)” for the measuring method and “Pt 100 standard” for the measuring range. You can use this measuring method with this measuring range without parameterizing the SM 431; AI 8 x RTD x 16 Bit with *STEP 7*.

5.24 Analog Input Module SM 431; AI 8 x 16 Bit; (6ES7431-7KF00-0AB0)

Characteristics

The analog input module SM 431; AI 8 x 16 Bit has the following features:

- 8 isolated differential inputs for voltage/current/temperature measurement
- Unlimited measuring range selection
- Linearization of the thermocouple characteristic curves
- 16-bit resolution
- Programmable diagnostics
- Programmable diagnostic interrupt
- Programmable hardware interrupt when limit has been exceeded
- Analog section isolated from CPU
- The maximum permissible common mode voltage between the channels and between the channel and the central ground point is 120 VAC
- Field connection (6ES7431-7K00-6AA0) with internal reference temperature (included with the product)

Calibration Software

The calibration software is only available on the Internet. You can find the current version under article ID 12443337.

After installing the software, you can define user-specific calibration values for each channel and and each module input range. You will find further information under ID 12436891 at the Customer Support FAQ site.

Block Diagram of the SM 431; AI 8 x 16 Bit

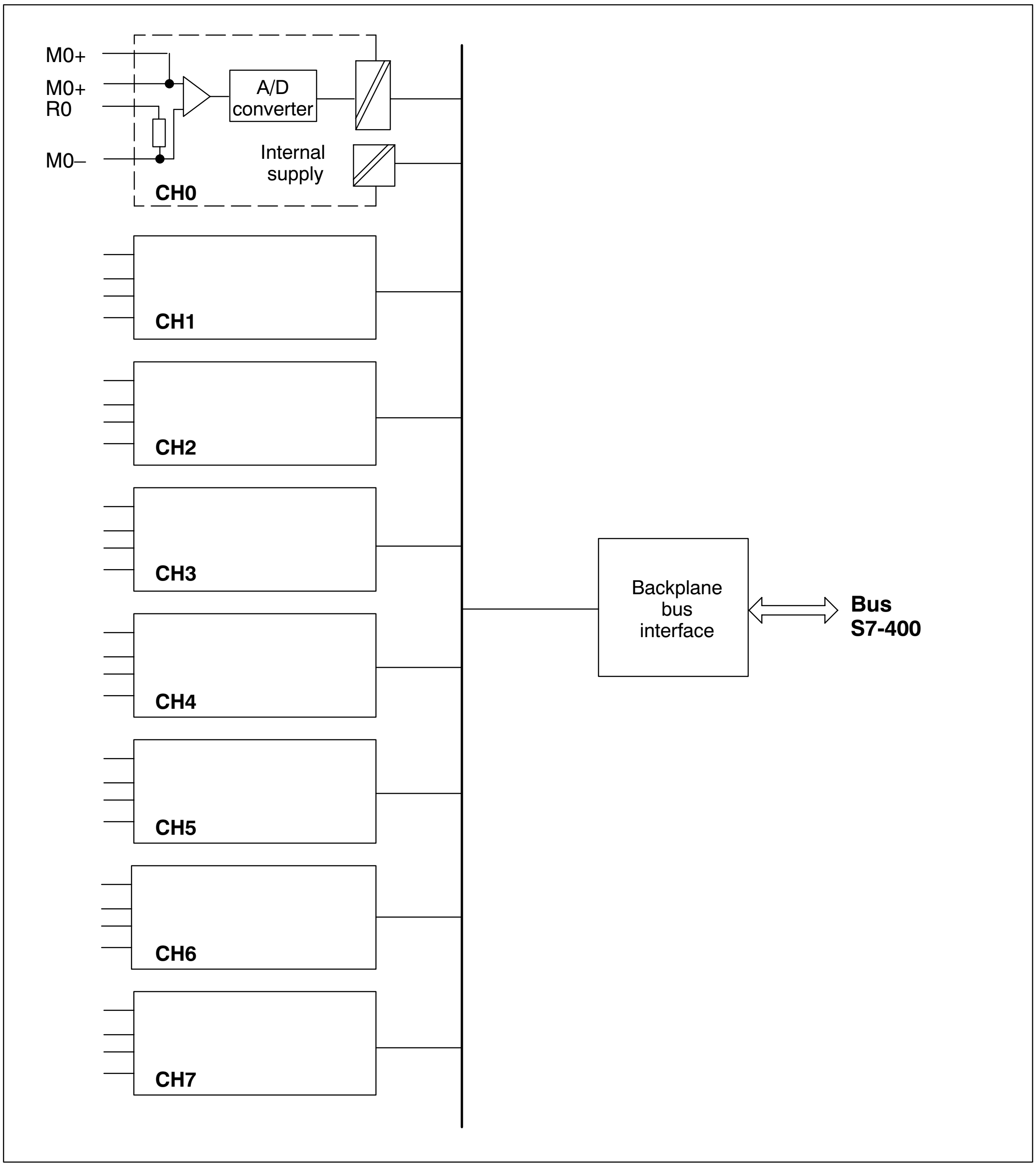


Figure 5-41 Block Diagram of the SM 431; AI 8 x 16 Bit

Warning

An external protective network is required in the signal lines in accordance with IEC 61000-4-5 (150 V/14 mm MOV across each + and – input to chassis ground)

Terminal Assignment Diagram of the SM 431; AI 8 x 16 Bit

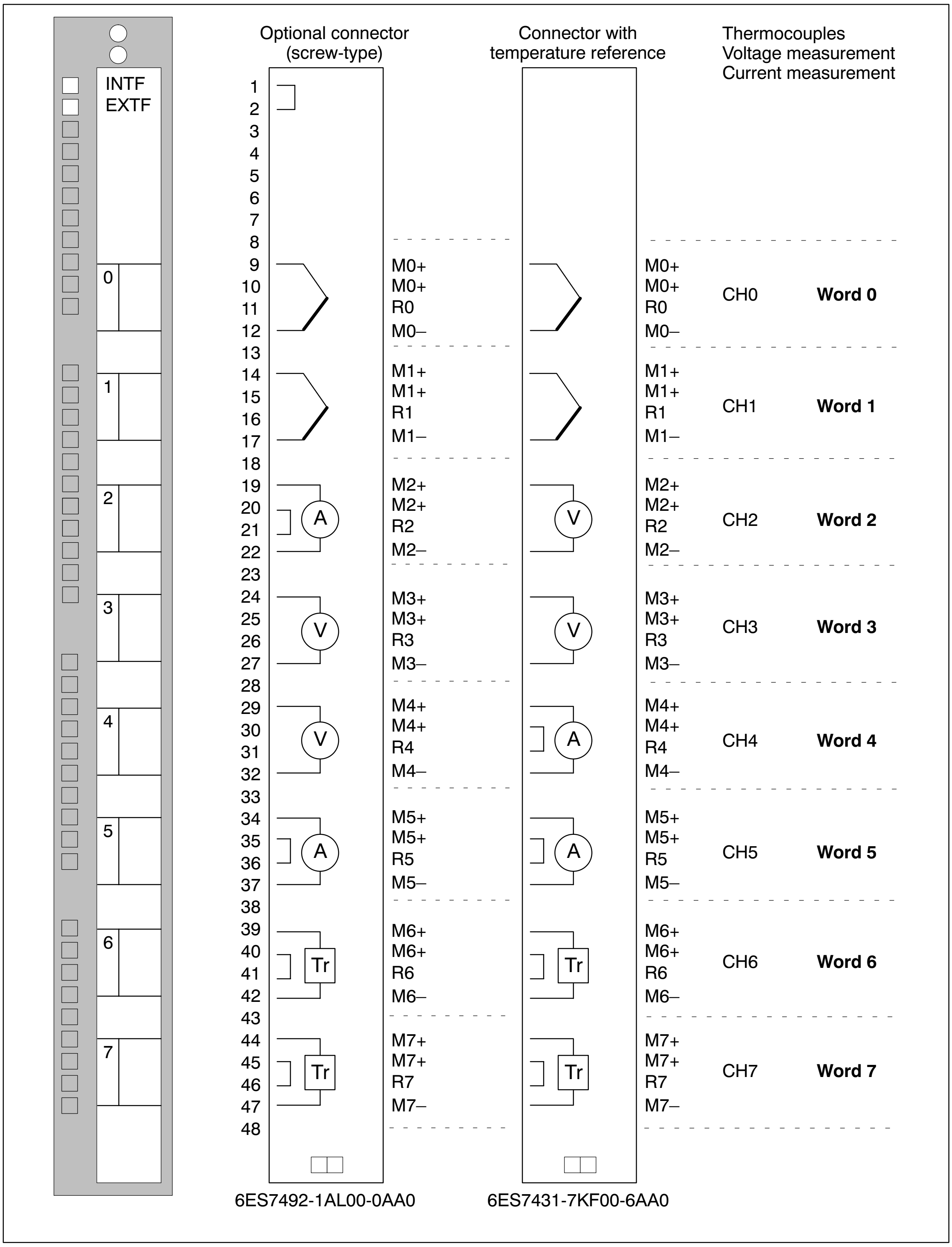


Figure 5-42 Terminal Assignment Diagram SM 431; AI 8 x 16 Bit

Technical Specifications of the SM 431; AI 8 x 16 Bit

Dimensions and Weight				
Dimensions W x H x D (in millimeters)	25 x 290 x 210			
Weight	Approx. 650 g			
Data for Specific Module				
Number of inputs	8			
Length of cable				
• Shielded	200 m			
Voltages, Currents, Potentials				
Isolation				
• Between channels and backplane bus	Yes			
• Between the channels	Yes			
Permitted potential difference				
• Between the inputs (UU)	120 VAC			
• Between M_{ANA} and $M_{internal}$ (UU_{ISO})	120 VAC			
Insulation tested with	1500 VAC			
Current consumption				
• From the backplane bus (5 V)	Max. 1200 mA			
Power dissipation of the module	Typ. 4.6 W			
Analog Value Generation				
Measuring principle	Integration			
Integration time/conversion time/resolution (per channel)	(Does not go into the response time)			
• Parameters can be assigned	Yes			
• Integration time in milliseconds	2.5	16.7	20	100
• Basic conversion time including integration time in milliseconds	10	16.7	20	100
• Resolution in bits (incl. overrange)	16 bits			
• Noise suppression for frequency f1 in Hz	400	60	50	10
Smoothing of the measured values	Parameters can be assigned in 4 stages			
Basic reaction time of module (enable all channels)	40	67	80	400

Suppression of Interference, Limits of Error	
Interference voltage suppression for f = n x (f1 ±1%), (f1 = interference frequency) n= 1.2 ...	
• Common-mode interference (U_{cm} < 120 V)	
Current, thermoelement and Voltage ranges < 2.5 V	> 120 dB
Voltage ranges ≥2.5 V	> 95 dB
Crosstalk between inputs (U_{cm} < 120 V)	
Current, thermoelement and Voltage ranges ≥2.5 V	> 120 dB
Voltage ranges ≥ 2.5 V	> 95 dB
• Series-mode noise (peak value of noise < nominal value of input range)	> 80 dB
Operational limit (in the entire temperature range, with reference to the input range)	
• Voltage input	±0.30 %
• Current input	±0.50 %
• Temperature error (reference to the input range)[2] across the temprature range of:	
Type U -100 °C to 600 °C	± 3.6 °C
Type L 0 °C to 900 °C	± 2.9 °C
Type T -100 °C to 400 °C	± 2.1 °C
Type J -100 °C to 1200 °C	± 5.0 °C
Type E -100 °C to 1000 °C	± 4.6 °C
Type K 0 °C to 1372 °C	± 3.8 °C
Type N 0 °C to 1300 °C	± 5.7 °C
Type S 200 °C to 1769 °C	± 5.3 °C
Type R 200 °C to 1769 °C	± 6.7 °C
Type B 400 °C to 1820 °C	± 7.3 °C

Suppression of Interference, Limits of Error	
Basic error (operational limit at 25 °C, referred to input range)	
• Voltage input	± 0.10 %
• Current input	± 0.17 %
• Temperature error (reference to the input range)[2] across temprature range of :	
Type U –100 °C to 600 °C	± 1.2 °C
Type L 0 °C to 900 °C	± 1.0 °C
Type T –100 °C to 400 °C	± 0.7 °C
Type J –100 °C to 1200 °C	± 1.7 °C
Type E –100 °C to 1000 °C	± 1.5 °C
Type K 0 °C to 1372 °C	± 1.3 °C
Type N 0 °C to 1300 °C	± 1.9 °C
Type S 200 °C to 1769 °C	± 1.8 °C
Type R 200 °C to 1769 °C	± 2.2 °C
Type B 400 °C to 1820 °C	± 2.2 °C
Linearity error (with reference to the input range)	Additional error ± 0.05%
Repeatability (in steady state at 25 °C, with reference to the input range)	Additional error ± 0.05%
Connection for compensating the cold junction	6ES7431-7KF00-6AA0
Operational limit	
• Error internal temperature compensation	Additional error ± 2.0 °C

Status, Interrupts, Diagnostics		
Interrupts		
• Hardware interrupt	Programmable	
• Hardware interrupt on exceeding the limit value	Programmable	
• Diagnostic interrupt	Programmable	
Diagnostic functions	Programmable	
• Group error display	Programmable	
– For internal fault	Red LED (INTF)	
– For external fault	Red LED (EXTF)	
• Diagnostic information can be displayed	Yes	
Monitoring on		
• wirebreak		
Data for Selecting a Sensor		
Input range (rated values)/Input resistance		
• Voltage	± 25 mV	>2 MΩ
	± 50 mV	>2 MΩ
	± 80 mV	>2 MΩ
	± 100 mV	>2 MΩ
	± 250 mV	>2 MΩ
	± 500 mV	>2 MΩ
	± 1 V	>2 MΩ
	± 2.5 V	>2 MΩ
	± 5 V	>2 MΩ
	± 10 V	>2 MΩ
• Current	± 20 mA 50 Ω + 4 to 20 mA 50 Ω ± 10 mA 50 Ω ± 5 mA 50 Ω ± 3,2 mA 50 Ω	
• Thermocouple	Types B, N, E, R, S, J, L, T, K, U	>2 MΩ
Maximum input voltage for voltage input (destruction limit)	35 V continuous; 75 V for max. 1 s (duty factor 1:20)	
Maximum input current for current input (destruction limit)	32 mA	
Connection of the sensor		
• For measuring voltage	Possible	
• For measuring current		
As four-wire transmitter	Possible	
Characteristic linearization		
• For thermocouples	Types B, N, E, R, S, J, L, T, K, U	
Temperature compensation	Yes, programmable	
• Internal temperature compensation	Possible	
Unit for temperature measurement	Degrees Celsius; degrees Fahrenheit	

Notes to the technical specifications

Warning

1) The 6ES7431-7KF00-0AB0 does not support the **high and low ranges** defined in S7 for thermocouples. When the module reaches the operational limit defined for S7, the system outputs a corrsponding underflow (32768) or overflow (32767) signal.

Warning

2) Thermocouples can be operated above the specified temperaturs.

- The specified accuracy improves in the lower range and at higher temperature.
- The accuracy of the thermocouple module can be calculated for other temperature ranges based on the accuracy limit values of the input voltage and the emf/°C of the thermocouple.

5.24.1 Commissioning the SM 431; AI 8 x16 Bit

You set the mode of operation of the SM 431; AI 8 x16 Bit in *STEP 7*.

Parameter

You will find a description of the procedure of assigning parameters to analog modules in Section 5.7.

An overview of the parameters that you can set and their default settings are shown in the table below.

Table 5-73 Parameters of the SM 431; AI 8 x16 Bit

Parameter	Value Range	Default[2)]	Parameter Type	Scope
Enable • Diagnostic interrupt[1)] • Hardware interrupt[1)]	 Yes/no Yes/no	 No No	Dynamic	Module
• Destination CPU for interrupt	1 to 4	–	Static	Module
Trigger for hardware interrupt[3)] • High limit • Low limit	 32767 to –32768 –32768 to 32767	 – –	Dynamic	Channel
Diagnostics • Wire break • Reference channel error • Underflow • Overflow	 Yes/no Yes/no Yes/no Yes/no	 No No No No	Static	Channel
Measurement • Measuring method	Disabled U Voltage 4DMU Current (four-wire transmitter) TC-L Thermocouple (linear)	TC-L	Static	Channel
• Measuring range	Refer to Section 5.24.2 for the measuring ranges of the input channels that you can set.	Type J	Static	Channel
• Reference temperature	–273.15 to 327.67 °C –327.68 to 327.67 °F	100 °C	Dynamic	Module
• Temperature unit[4)]	Degrees Celsius; degrees Fahrenheit	Degrees Celsius	Static	Module
• Interference suppression	400 Hz; 60 Hz; 50 Hz; 10 Hz	60 Hz	Static	Module
• Smoothing	None, Low, Average, High	None	Static	Module

Table 5-73 Parameters of the SM 431; AI 8 x16 Bit, continued

Parameter	Value Range	Default[2)]	Parameter Type	Scope
• Reference junction (reference to the cold junction)	None Internal Reference temperature value dynamic	Internal	Static	Module

1) If you use the module in ER-1/ER-2, you must set this parameter to "No" because the interrupt lines are not available in ER-1/ER-2.
2) Only in the CC (central controller) is it possible to start up the analog modules with the default settings.
3) The limit values must be within the temperature range of the connected sensor.
4) Valid for the format of the output temperature and the dynamic reference temperature

Smoothing of the Measured Values

You fill find information that is generally applicable to the smoothing of analog values in Section 5.6.

The cycle time of the module is a constant in the SM 431; AI 8 x 16 Bit that is not dependent on the number of channels that are enabled. It therefore has no effect on the step response, which is defined by the parameter assignment of interference frequency suppression and smoothing.

Step Response

Table 5-74 How Response Times Depend on the configured Interference Frequency Suppression and Smoothing of the SM 431; AI 8 x 16 Bit

Interference Frequency Suppression in Hz	Response Time in ms with Configured Smoothing:			
	None	Low	Average	High
10	100	200	1600	3200
50	20	40	320	640
60	16.7	33.3	267	533
400	10	20	160	320

The following figures illustrate the contents of Table 5-74. They show the response time required for a step response before the smoothed analog value is almost applied to 100%. The figures apply to every change of signal at an analog input.

Step Response at an Interference Frequency Suppression of 10 Hz

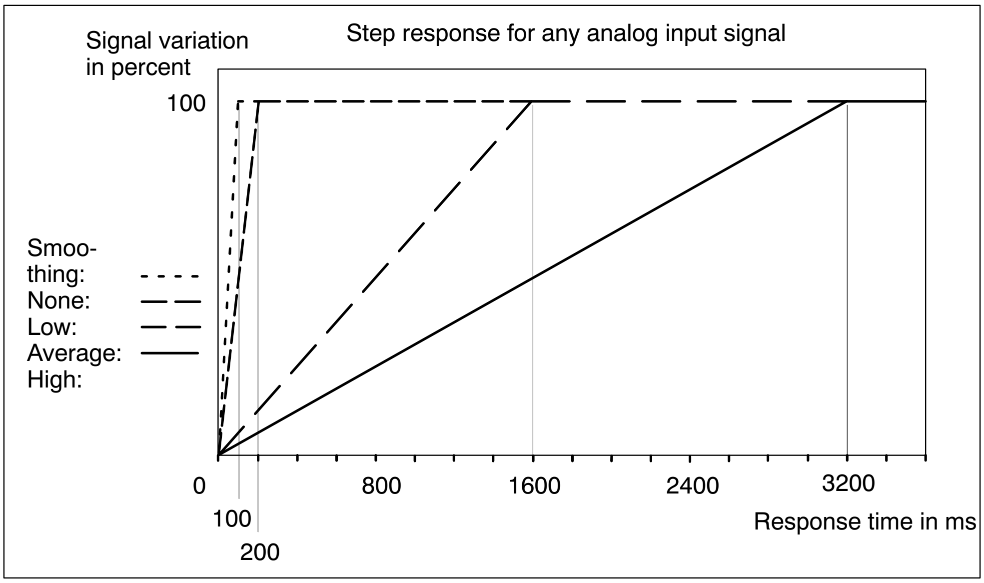


Figure 5-43 Step Response at 10 Hz Interference Frequency Suppression of the SM 431; AI 8 x 16 Bit

Step Response at an Interference Frequency Suppression of 50 Hz

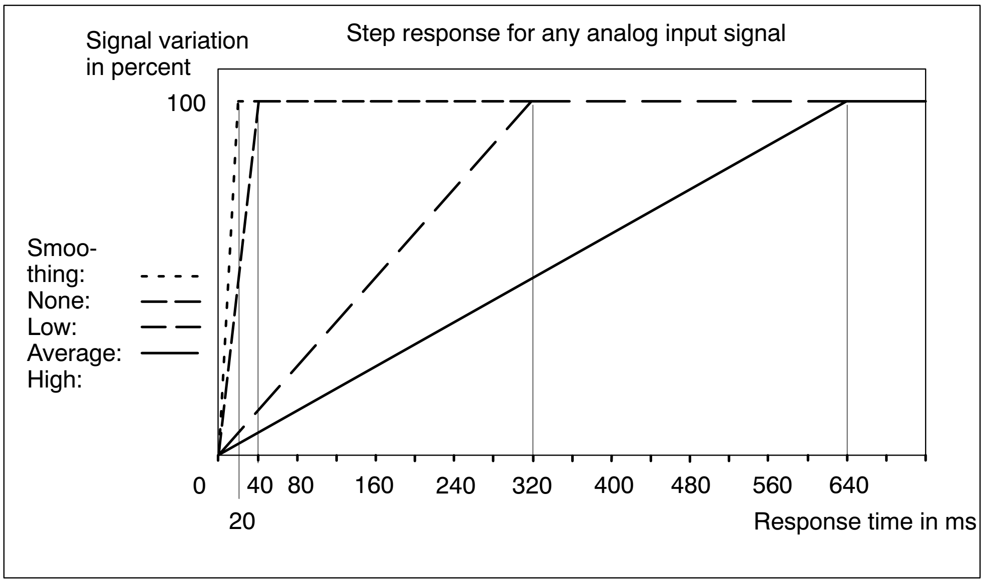


Figure 5-44 Step Response at 50 Hz Interference Frequency Suppression of the SM 431; AI 8 x 16 Bit

Step Response at an Interference Frequency Suppression of 60 Hz

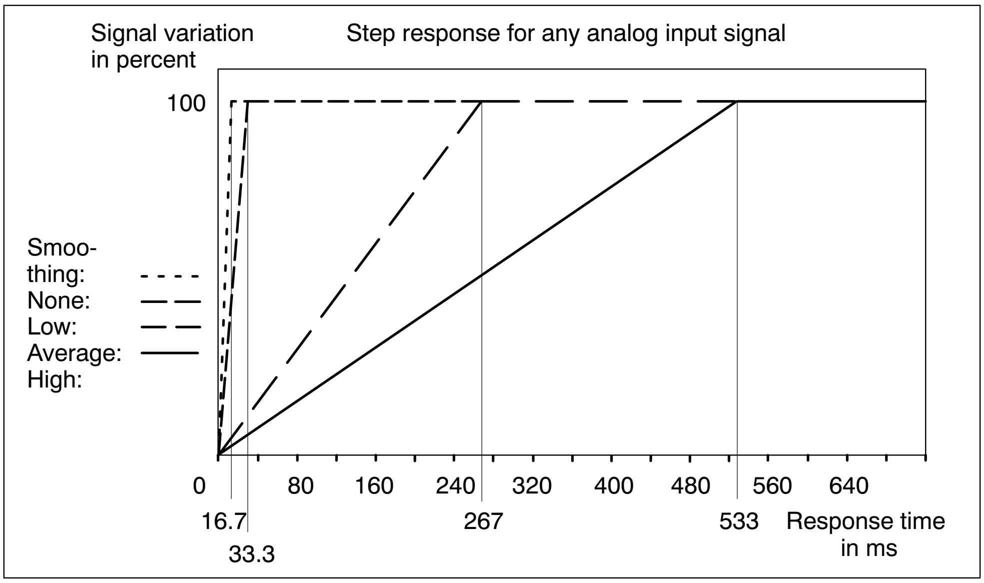


Figure 5-45 Step Response at 60 Hz Interference Frequency Suppression of the SM 431; AI 8 x 16 Bit

Step Response at an Interference Frequency Suppression of 400 Hz

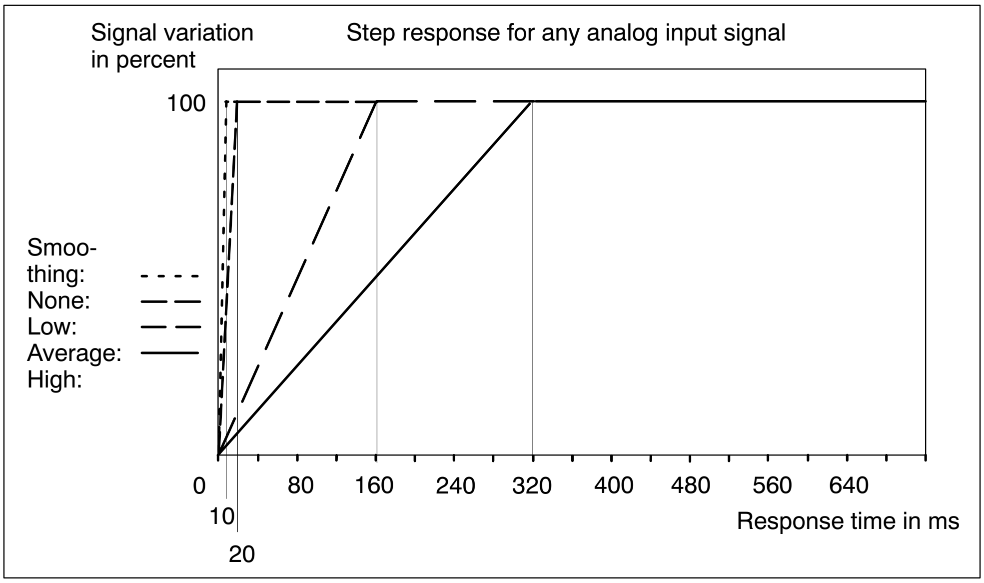


Figure 5-46 Step Response at 400 Hz Interference Frequency Suppression of the SM 431; AI 8 x 16 Bit

Displaying Parameter Assignment Errors

The SM 431; AI 8 × 16 Bit has diagnostics capability. Below you will find an overview of the displays that are possible for modules with parameter assignment errors.

Table 5-75 Diagnostic Information of the SM 431; AI 8 × 16 Bit

Incorrect Parameter Assignment	Possible Display	Explanation
Of the module	• Module malfunction • Internal malfunction • Wrong parameters • Module not configured.	You can find an explanation of the diagnostic information in Tables 4-7 and 5-46 on Pages 4-10 and 5-64.
Affecting certain channels	• Module malfunction • Internal malfunction • There is a channel error • Wrong parameters • Channel information available • Vector channel error • Channel parameter assignment error • User calibration doesn’t correspond to the parameter assignment	

5.24.2 Measuring Methods and Measuring Ranges of the SM 431; AI 8 x 16 Bit

Measuring Methods

You can set the following measuring methods for the input channels:

- Voltage measurement
- Current measurement
- Temperature measurement

You specify the setting by means of the “Measuring Type” parameter in *STEP 7*.

Unused Channels

Disable the “Measuring Type” parameter for unused channels. In this way you shorten the scan time of the module.

Measuring Ranges

You set the measuring ranges by means of the “Measuring Range” parameter in *STEP 7*.

Table 5-76 Measuring Ranges of the SM 431; AI 8 x 16 Bit

Method Selected	Measuring Range	Description
U: Voltage	±25 mV ±50 mV ±80 mV ±100 mV ±250 mV ±500 mV ±1 V ±2.5 V ±5 V ±10 V 1 to 5 V	You will find the digitized analog values in Section 5.3.1 in the voltage measuring range
4DMU: Current (four-wire transmitter)	±3.2 mA ±5 mA ±10 mA ±20 mA 0 to 20 mA 4 to 20 mA	You will find the digitized analog values in Section 5.3.1 in the current measuring range
TC-L: Thermocouple (linear) (temperature measurement)	Type B Type N Type E Type R Type S Type J Type L Type T Type K Type U	You will find the digitized analog values in Section 5.3.1 in the temperature range

Default Settings

The default settings of the module in *STEP 7* are “Thermocouple (linear)” for the measuring method and “Type J” for the measuring range. You can use this combination of measuring method and measuring range without parameterizing the SM 431; AI 8 x 16 Bit in *STEP 7*.

5.25 Analog Output Module SM 432; AO 8 x 13 Bit; (6ES7432-1HF00-0AB0)

Characteristics

The SM 432; AO 8 x 13 Bit has the following features:

- 8 outputs
- The individual output channels can be programmed as
  - Voltage outputs
  - Current outputs
- 13-bit resolution
- Analog section Isolated to CPU and load voltage
- Maximum permissible common mode voltage between the channels and the channels against M_{ANA} is 3 VDC

Block Diagram of the SM 432; AO 8 x 13 Bit

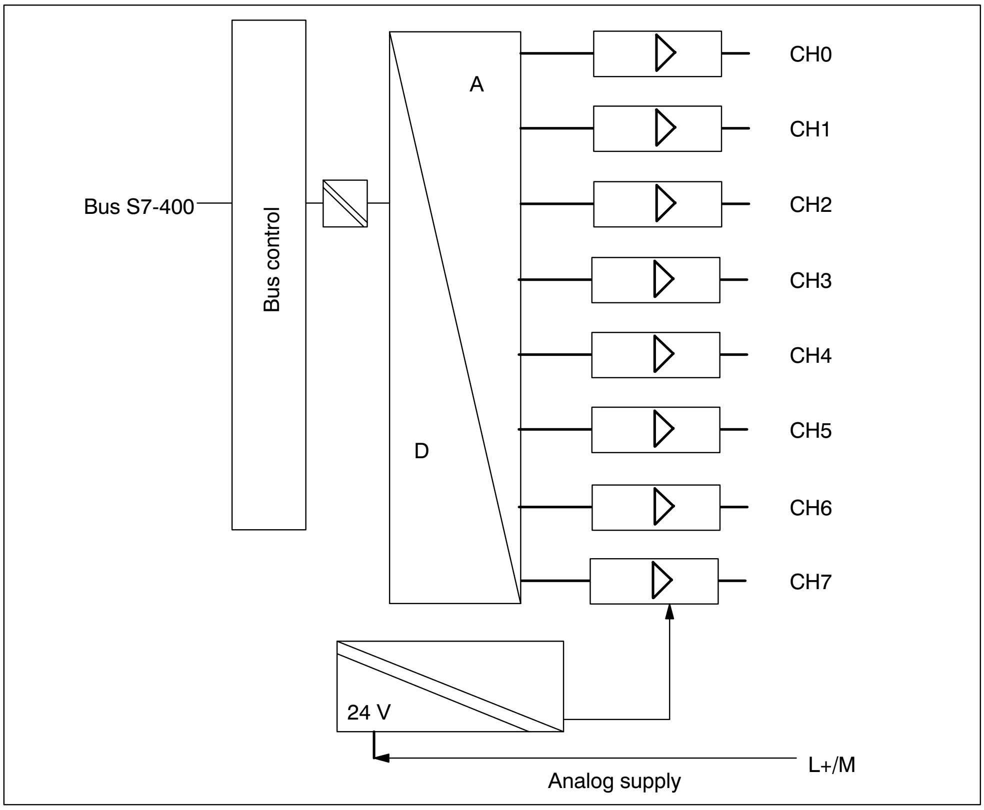


Figure 5-47 Block Diagram of the SM 432; AO 8 x 13 Bit

Terminal Assignment Diagram of the SM 432; AO 8 x 13 Bit

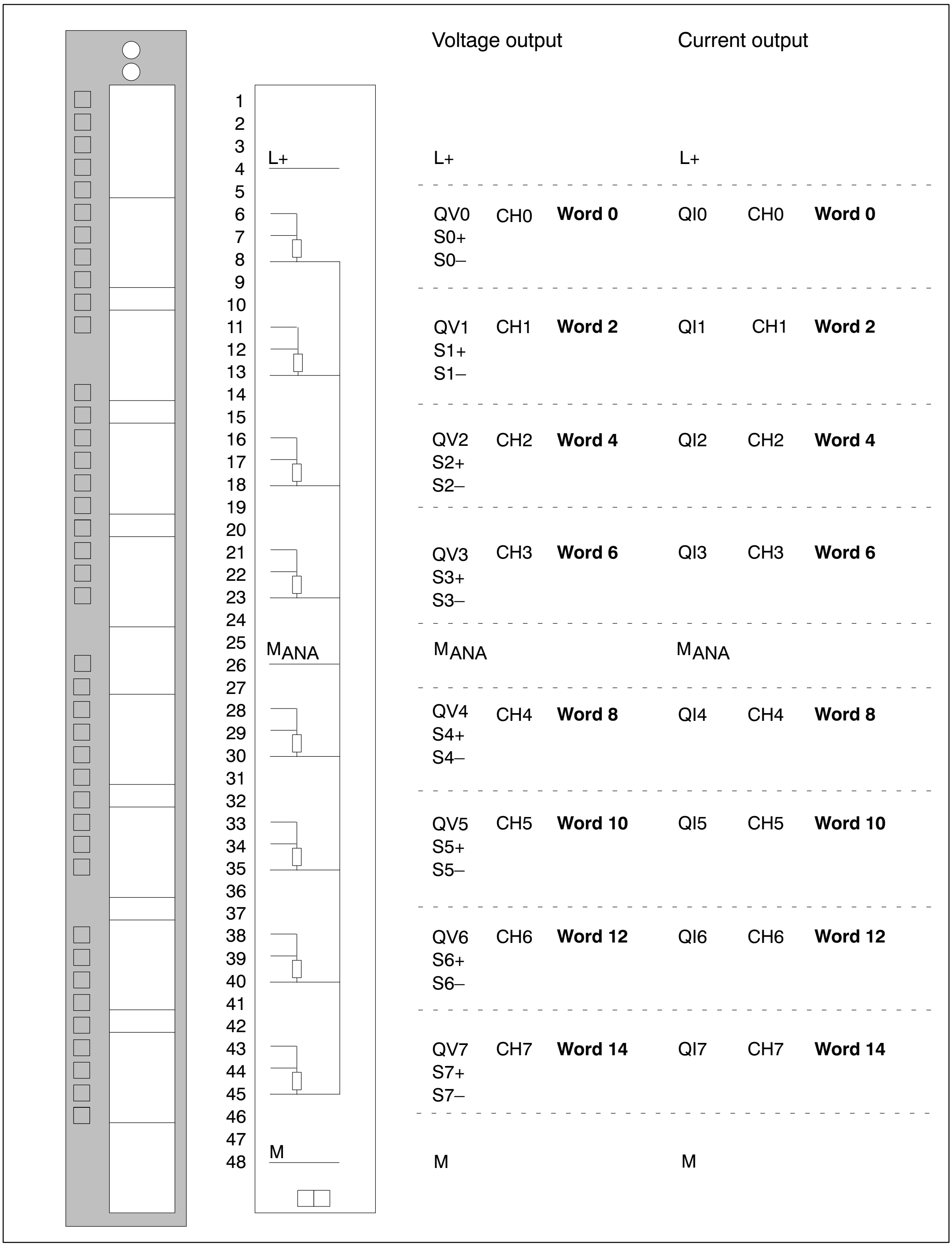


Figure 5-48 Terminal Assignment Diagram of the SM 432; AO 8 x 13 Bit

Technical Specifications of the SM 432; AO 8 x 13 Bit

Dimensions and Weight	
Dimensions W x H x D (in millimeters)	25 x 290 x 210
Weight	Approx. 650 g
Data for Specific Module	
Number of outputs	8
Length of cable	
• Shielded	Max. 200 m
Voltages, Currents, Potentials	
Supply voltage of the electronics L+	24 VDC
Rated load voltage L+	24 VDC
• Reverse polarity protection	Yes
Isolation	
• Between channels and backplane bus	Yes
• Between the channels	No
• Between channels and load voltage L+	Yes
Permitted potential difference	
• Between the outputs (E_{CM})	3 VDC
• Between S– and M_{ANA} (U_{CM})	3 VDC
• Between M_{ANA} and $M_{internal}$ (U_{ISO})	75 VDC/60 VAC
Insulation tested	
• Between bus and L+/M	2120 VDC
• Between bus and analog section	2120 VDC
• Between bus and chassis ground	500 VDC
• Between analog section and L+/M	707 VDC
• Between analog section and chassis ground	2120 VDC
• Between L+/M and chassis ground	2120 VDC
Current consumption	
• From the backplane bus	Max. 150 mA
• Power supply and load voltage L+ (with rated load)	Max. 400 mA
• Power supply and load voltage L+ (no load)	Max. 200 mA
Power dissipation of the module	Typ. max. 9 W

Analog Value Generation	
Resolution including sign	13 bits
Conversion time (per channel)	
• In the ranges 1 V to 5 V and 4 mA to 20 mA	420 μs
• In all ranges	300 μs
Basic response time of module (all channels enabled)	
• In the ranges 1 V to 5 V and 4 mA to 20 mA	3.36 ms
• In all the other ranges	2.4 ms
Settling time	
• For resistive load	0.1 ms
• For capacitive load	3.5 ms
• For inductive load	0.5 ms
Suppression of Interference, Limits of Error	
Interference voltage suppression for f = n x (f1 ±1%), (f1 = interference frequency) n= 1.2 ...	
• Common-mode interference (U_{CM} < AC 3 V_{ss}/50 Hz)	>60 dB
Crosstalk between the outputs	> 40 dB
Operational limit (in the entire temperature range, with reference to the output range)	
• Voltage outputs	
– ±10 V	±0.5 %
– 0 V to 10 V	±0.5 %
– 1 V to 5 V	±0.5 %
• Current outputs	
– ±20 mA	±1%
– 4 mV to 20 mV	±1%
Basic error (operational limit at 25 °C, referred to the output range)	
• Voltage outputs	
– ±10 V	±0.5%
– 0 V to 10 V	±0.5%
– 1 V to 5 V	±0.5%
• Current outputs	
– ±20 mA	±0.5%
– 0 mA to 20 mA	±0.5%
Temperature error (with reference to the output range)	±0.02% K
Linearity error (with reference to the output range)	±0.05%

Repeat accuracy (in the steady state at 25 °C, referred 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	None
Diagnostic functions	None
Substitute value can be applied	No
Data for Selecting an Actuator	
Output ranges (rated values)	
• Voltage	± 10 V 0 V to 10 V 1 V to 5 V
• Current	± 20 mA 0 mA to 20 mA 4 mA 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 600 Ω with reduced U_{CM} to < 1 V
– Inductive load	Max. 1 mH
Voltage outputs	
• Short-circuit protection	Yes
• Short-circuit current	Max. 30 mA
Current outputs	
• No-load voltage	Max. 19 V

Destruction limit for voltages/ currents connected from outside	
• Voltage at outputs to M_{ANA}	Max. 20 V continuous 75 V for 1 ms (cycle factor 1 : 20)
• Current	Max. 40 mA continuous
Connection of actuators	
• For voltage output	
– Two-conductor connection	Possible, without compensation for circuit resistance
– Four-conductor connection (measuring circuit)	Possible
• For current output	
– Two-conductor connection	Possible

5.25.1 Commissioning the SM 432; AO 8 x 13 Bit

Parameter

You will find a description of the procedure of assigning parameters to analog modules in Section 5.7.

You will find an overview of the programmable parameters and their default values in Table 5-42, on page 5-41.

Assigning Parameters to Channels

You can configure each output channel of the SM 432; AO 8 x 13 Bit individually. You can thus assign different parameters to each output channel.

5.25.2 Output Ranges of the Analog Output Module SM 432; AO 8 x 13 Bit

Wiring the Analog Outputs

You can wire the outputs as voltage or current outputs, or disable them. You wire the outputs by means of the "Type of Output" parameter in *STEP 7*.

Unused Channels

To ensure that output channels of the SM 432; AO 8 x 13 Bit remain de-energized, you must disable the "Type of Output" parameter and leave the terminal open.

Output Ranges

You program the output ranges for voltage and current outputs in *STEP 7*.

Table 5-77 Output Ranges of the Analog Output Module SM 432; AO8 x 13 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 5.3.2 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 432; AO 8 x 13 Bit in *STEP 7*.

Interface Modules 6

Chapter Overview

You will find a description of the IM 463-2 in Chapter 7.

6.1 Common Features of the Interface Modules

Function

Interface modules (a send IM and a receive IM) are required if one or more expansion units (EU) are to be connected to a central controller (CC). This configuration is described in the *Installation Manual,* Chapter 4.

Configuration

Interface modules must always be used together. The send modules (send IMs) are inserted in the CC, whilst the corresponding receive modules (receive IMs) are plugged into the series-connected EU.

Table 6-1 Interface Modules of the S7-400

Partner	Areas of Application
IM 460-0	Send IM for local link without PS transfer; with communication bus
IM 461-0	Receive IM for local link without PS transfer; with communication bus
IM 460-1	Send IM for local link with PS transfer; without communication bus
IM 461-1	Receive IM for local link with PS transfer; without communication bus
IM 460-3	Send IM for remote link up to 102.25 m; with communication bus
IM 461-3	Receive IM for remote link up to 102.25 m; with communication bus
IM 460-4	Send IM for remote link up to 605 m; without communication bus
IM 461-4	Receive IM for remote link up to 605 m; without communication bus

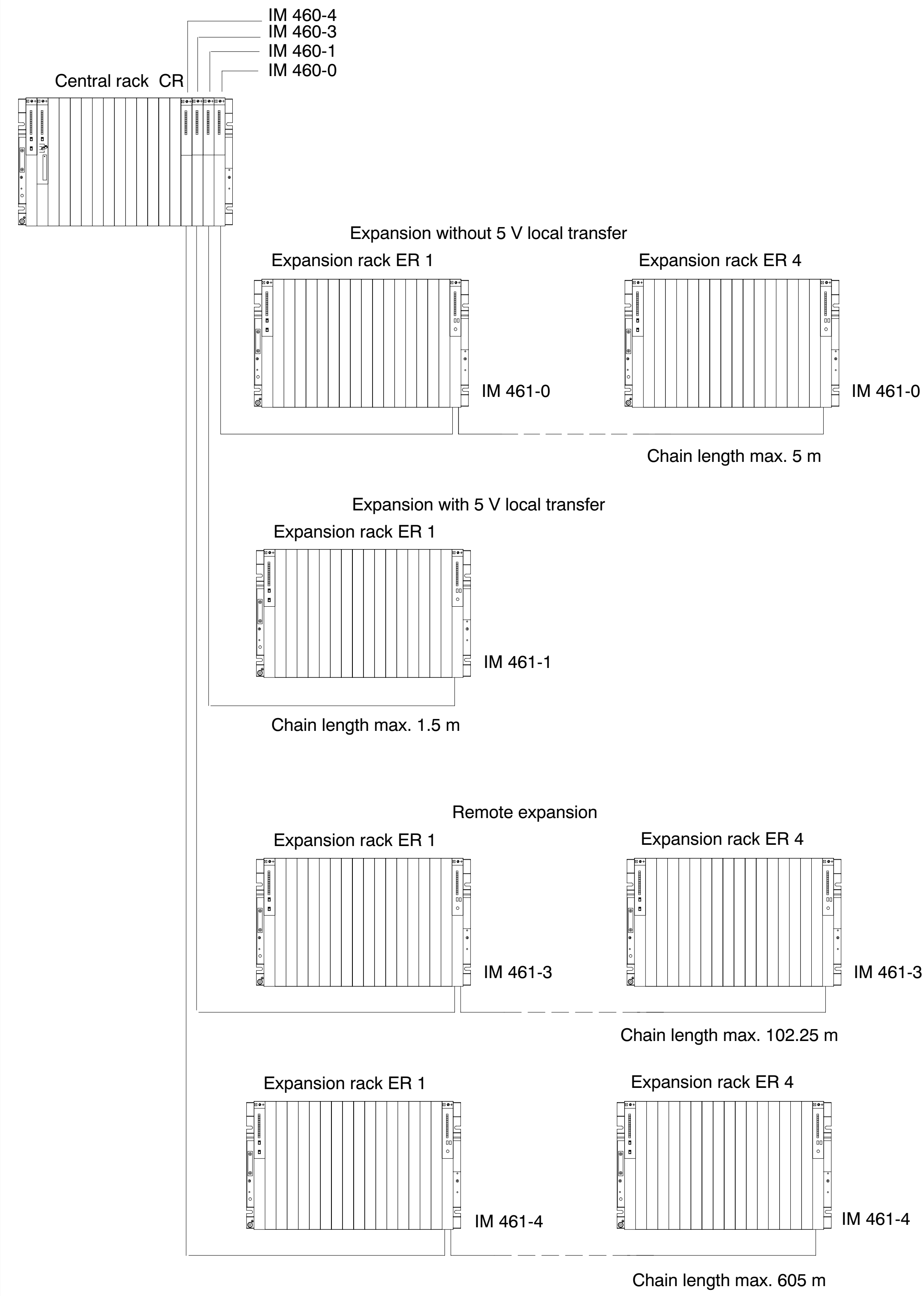
Overview of the Properties of the Connections

Note the rules for connections in the section after next.

Table 6-2 Overview of the connections

	Local connection		Remote connection	
Send IM	460-0	460-1	460-3	460-4
Receive IM	461-0	461-1	461-3	461-4
Max. number of connectable EMs per chain	4	1	4	4
Max. distance	5 m	1.5 m	102.25 m	605 m
5 V transfer	No	Yes	No	No
Max. current transfer per interface	–	5 A	–	–
Communication bus transmission	Yes	No	Yes	No

Connection possibilities for central racks and expansion racks



Rules for Connection

When you connect a central rack to expansion racks, you must observe the following rules:

- You can connect up to 21 ERs of the S7-400 to one CR.
- The ERs are assigned numbers to identify them. The rack number must be set on the coding switch of the receive IM. Any rack number between 1 and 21 may be assigned. Numbers must not be duplicated.
- You may insert up to six send IMs in one CR. However, only two send IMs with 5 V transfer are allowed in one CR.
- Each chain connected to the interface of a send IM can comprise up to four ERs (without 5 V transfer) or one ER (with 5 V transfer).
- The exchange of data via the communication bus is limited to 7 racks, meaning the CR and ER numbers 1 to 6.
- The maximum (total) cable lengths specified for the type of connection must not be exceeded.

Table 6-3 Cable for different connections

Connection type	Maximum (total) line length
Local connection with 5 V transfer via IM 460-1 and IM 461-1	1.5 m
Local connection without 5 V transfer via IM 460-0 and IM 461-0	5 m
Remote connection via IM 460-3 and IM 461-3	102.25 m
Remote connection via IM 460-4 and IM 461-4	605 m

Terminator

The bus must be terminated in the last EU of a line. To do this, plug in the appropriate terminator in the lower front connector of the receive IM in the last EU of the line. Unused front connectors in a send IM do not have to be terminated. The IM 461-1 does not require a terminator.

Table 6-4 Terminators for the Receive IMs

Receive IM	Terminator
IM 461-0	6ES7461-0AA00-7AA0
IM 461-3	6ES7461-3AA00-7AA0
IM 461-4	6ES7461-4AA00-7AA0

The following figure shows you a typical configuration with send IMs, receive IMs and terminators.

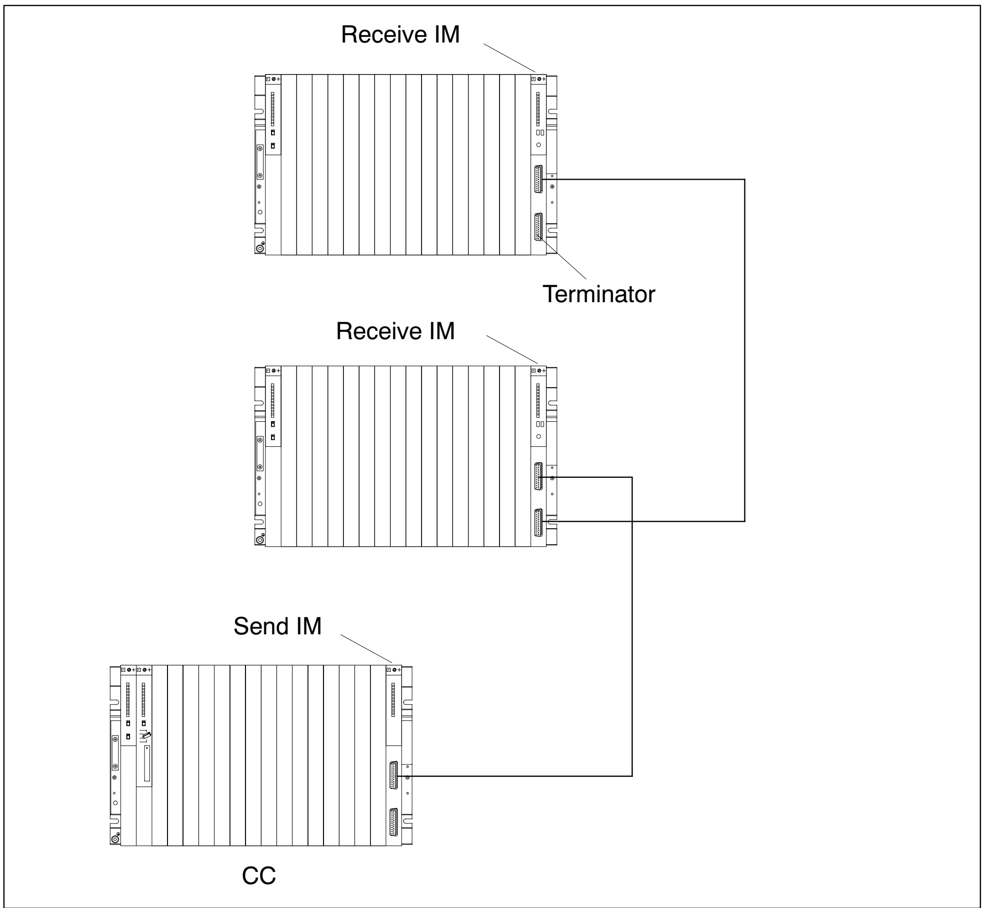


Figure 6-1 Example: Configuration with Send IMs, Receive IMs and Terminators

Connecting Cable

Precut cables are available in different fixed lengths for connecting the individual interface modules. (See Appendix C: Accessories and Spare Parts)

Table 6-5 Connecting Cable for Interface Modules

Interface Modules	Connecting Cable
IM 460-0 and IM 461-0 IM 460-3 and IM 461-3	6ES7468-1... (P bus and communication bus are transferred)
IM 460-1 and IM 461-1	6ES7468-3... (P bus is transferred; mounting rack is supplied with current via the IM)
IM 460-4 and IM 461-4	6ES7468-1...

Installation and Removal of the Modules During Operation

Please read the following warning on the insertion and removal of the interface modules and associated connecting cables.

Caution

Data may be lost or corrupted.

Removing or inserting the interface modules and/or their associated connecting cables under voltage can result in the loss or corruption of data.

Switch off the power supply modules to the CC and EUs you are working on before you carry out any changes.

6.2 The Interface Modules IM 460-0; (6ES7460-0AA01-0AB0) and IM 461-0; (6ES7461-0AA01-0AA0)

Position of the Operator Controls and Indicators of the IM 460-0 and IM 461-0

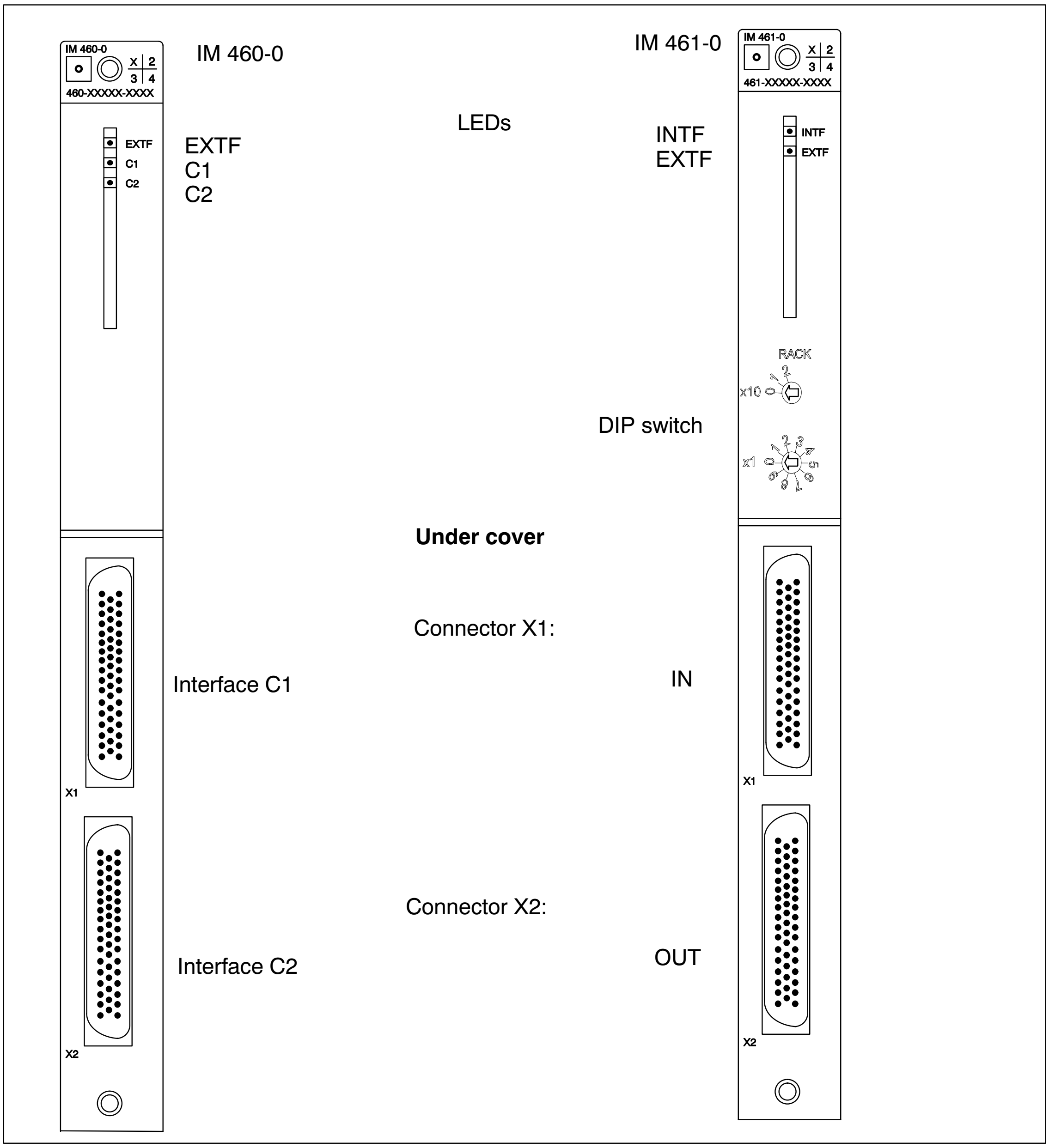


Figure 6-2 Position of the Operator Controls and Indicators of the IM 460-0 and IM 461-0

Function

The interface module pair IM 460-0 (send IM) and IM 461-0 (receive IM) are used for a local link.

Parameter Assignment for the Mounting Rack Number

Using the DIP switch on the front panel of the module, you must set the number of the mounting rack in which the receive IM is installed. The permitted range is 1 to 21.

Setting/Changing the Number

Proceed as follows:

1. Put the switch of the power supply module in the EU in which you want to make a change in the position ⏻ (Output voltage 0 V).
2. Enter the number using the DIP switch.
3. Switch the power supply module on again.

Operator Controls and Indicators on the Send IM

Table 6-6 Operator controls and Indicators on Send IM

EXTF LED (red)	Lights up in the event of an external fault. Line 1 or line 2 is faulty (terminator missing or broken cable). Prerequisite: A cable must already have been connected once.
C1 LED (green)	Line 1 (via front connector X1, connection 1) is correct.
C1 LED (flashing green)	An EU in the line is not ready for operation because • The power supply module is not switched on or • A module has not yet completed the initialization process
C2 LED (green)	Line 2 (via front connector X2, connection 2) is correct.
C2 LED (flashing green)	An EU in the line is not ready for operation because • The power supply module is not switched on or • A module has not yet completed the initialization process
Front connectors X1 and X2	Connector (output) for line 1 and line 2 X1 = upper front connector; X2 = lower front connector

Operator Controls and Indicators of the Receive IM

Table 6-7 Operator controls and Indicators on Receive IM

INTF LED (red)	Lights up if a rack number > 21 or = 0 was set. Lights up if you have changed the rack number under voltage.
EXTF LED (red)	Lights up in the event of an external fault (line fault, for example, if the terminator is not inserted or if a module has not yet completed the initialization process).
DIP switch	DIP switch to set the number of the mounting rack.
Front connector X1	Upper connector (input) for the connecting cable from the previous interface module.
Front connector X2	Lower connector (output) for the connecting cable to the next interface module or for the terminator.

Technical Specifications of the IM 460-0 and IM 461-0

Maximum line length (total)	5 m
Dimensions W x H x D (mm)	25 x 290 x 280
Weight • IM 460-0 • IM 461-0	 600 g 610 g
Current consumption from the S7-400 bus 5 VDC • IM 460-0 • IM 461-0	 Typ. 130 mA Max. 140 mA Typ. 260 mA Max. 290 mA
Power loss • IM 460-0 • IM 461-0	 Typ. 650 mW Max. 700 mW Typ. 1300 mW Max. 1450 mW
Terminator	6ES7461-0AA00-7AA0
Backup current	No

6.3 The Interface Modules IM 460-1; (6ES7460-1BA01-0AB0) and IM 461-1; (6ES7461-1BA01-0AA0)

Position of the Operator Controls and Indicators of the IM 460-1 and IM 461-1

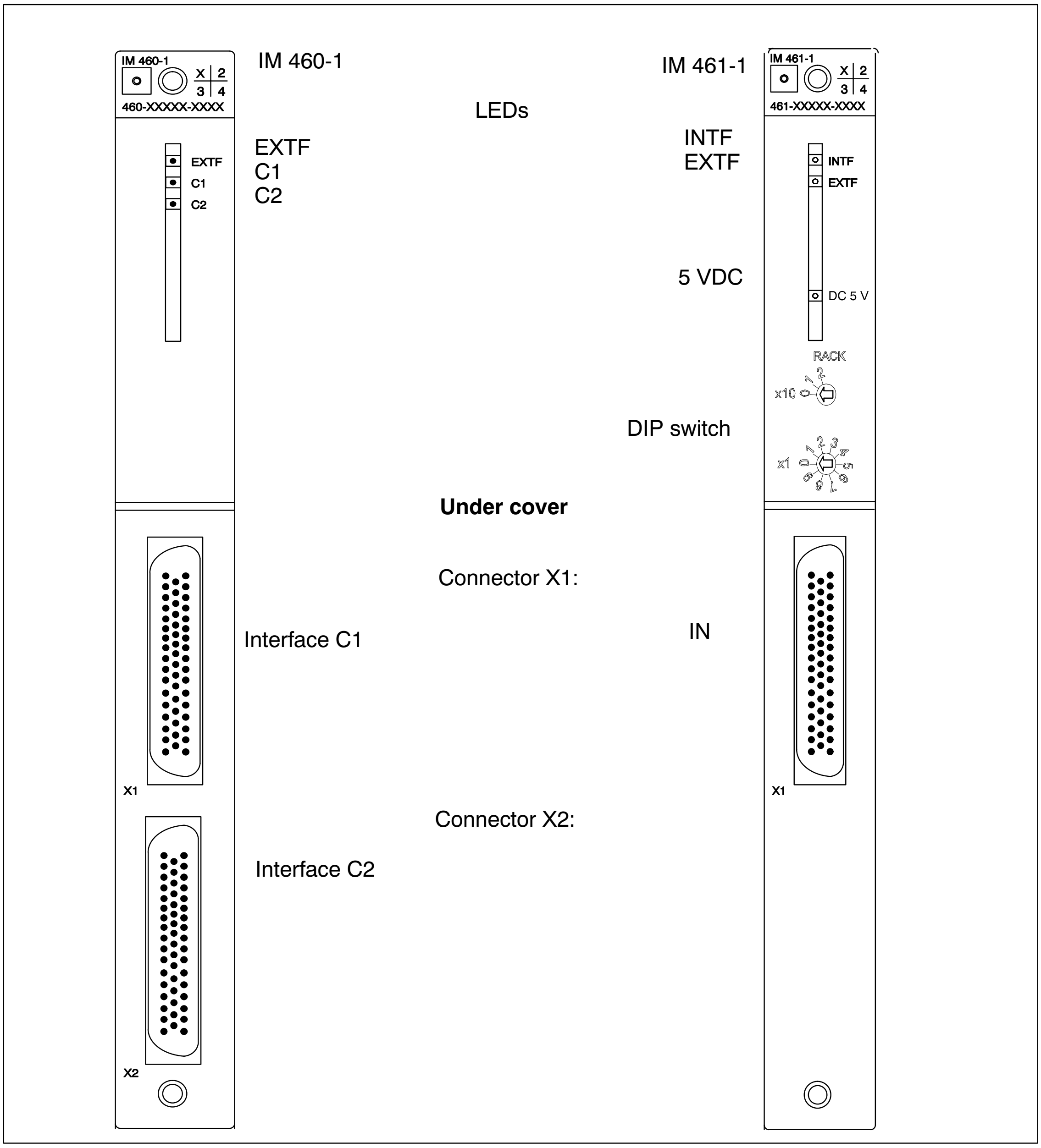


Figure 6-3 Position of the Operator Controls and Indicators of the IM 460-1 and IM 461-1

Function

The interface module pair IM 460-1 (send IM) and IM 461-1 (receive IM) are used for a local link (up to a maximum 1.5 m in total). A 5 V supply voltage is also transferred with these interface modules. Please particularly remember the following points:

- The current requirements of the module plugged into the EU must not exceed 5 V/5 A.
- You can only connect one EU per line.
- The modules in this mounting rack are not supplied with 24 V and are not backed up.
- The communication bus is not transferred with the interface module pair IM 460-1 and IM 461-1.
- You must not use a power supply module in the EU.

Warning

If you connect an EU via a local link with 5 V transmission, ungrounded operation is prescribed for the EU (see *Installation Manual,* Chapter 4)

Parameter Assignment for the Mounting Rack Number

Using the DIP switch on the front panel of the module, you must set the number of the mounting rack in which the receive IM is installed. The permitted range is 1 to 21.

Setting/Changing the Number

Proceed as follows:

1. Put the power supply module in the CC into the position ⏻ (Output voltage 0 V).
2. Enter the number using the DIP switch.
3. Switch the power supply module on again.

Operator Controls and Indicators on the Send IM

Table 6-8 Operator controls and indicators on the Send IM

EXTF LED (red)	Lights up in the event of an external fault. Line 1 or line 2 is faulty (terminator missing or broken cable). Prerequisite: A cable must already have been connected once.
C1 LED (green)	Line 1 (via front connector X1, connection 1) is correct.
C1 LED (flashing green)	A module has not yet completed the initialization process
C2 LED (green)	Line 2 (via front connector X2, connection 2) is correct.
C2 LED (flashing green)	A module has not yet completed the initialization process
Front connectors X1 and X2	Connector (output) for line 1 and line 2 X1 = upper front connector; X2 = lower front connector

Operator Controls and Indicators of the Receive IM

Table 6-9 Operator controls and indicators on the Receive IM

INTF LED (red)	Lights up if a rack number > 21 or = 0 was set. Lights up if you have changed the rack number under voltage.
EXTF LED (red)	Lights up in the event of an external fault (line fault, for example, if the terminator is not inserted or if a module has not yet completed the initialization process, but not when the CC is switched off)
5 VDC (green)	Power supply in the EU is correct.
DIP switch	DIP switch to set the number of the mounting rack.
Front connector X1	Upper connector (input) for the connecting cable from the previous interface module.

Caution

Modules can be damaged.

If you want to connect an EU via the IM 461-1 interface module and use a power supply module in this EU, you might damage the modules.

Don’t use a power supply module in an EU that you want to connect to the CC via the IM 461-1 interface module.

Technical Specifications of the IM 460-1 and IM 461-1

Maximum line length (total)	1.5 m
Dimensions W x H x D (mm)	25 x 290 x 280
Weight • IM 460-1 • IM 461-1	 600 g 610 g
Current consumption from the S7-400 bus 5 VDC • IM 460-1 • IM 461-1	Typ. 50 mA max. 85 mA Typ. 120 mA max. 100 mA
Power loss • IM 460-1 • IM 461-1	 Typ. 250 mW max. 425 mW Typ. 500 mW max. 600 mW
Power supply for EU	5 V/5 A per line
Backup current	No

6.4 The Interface Modules IM 460-3; (6ES7460-3AA01-0AB0) and IM 461-3; (6ES7461-3AA01-0AA0)

Position of the Operator Controls and Indicators of the IM 460-3 and IM 461-3

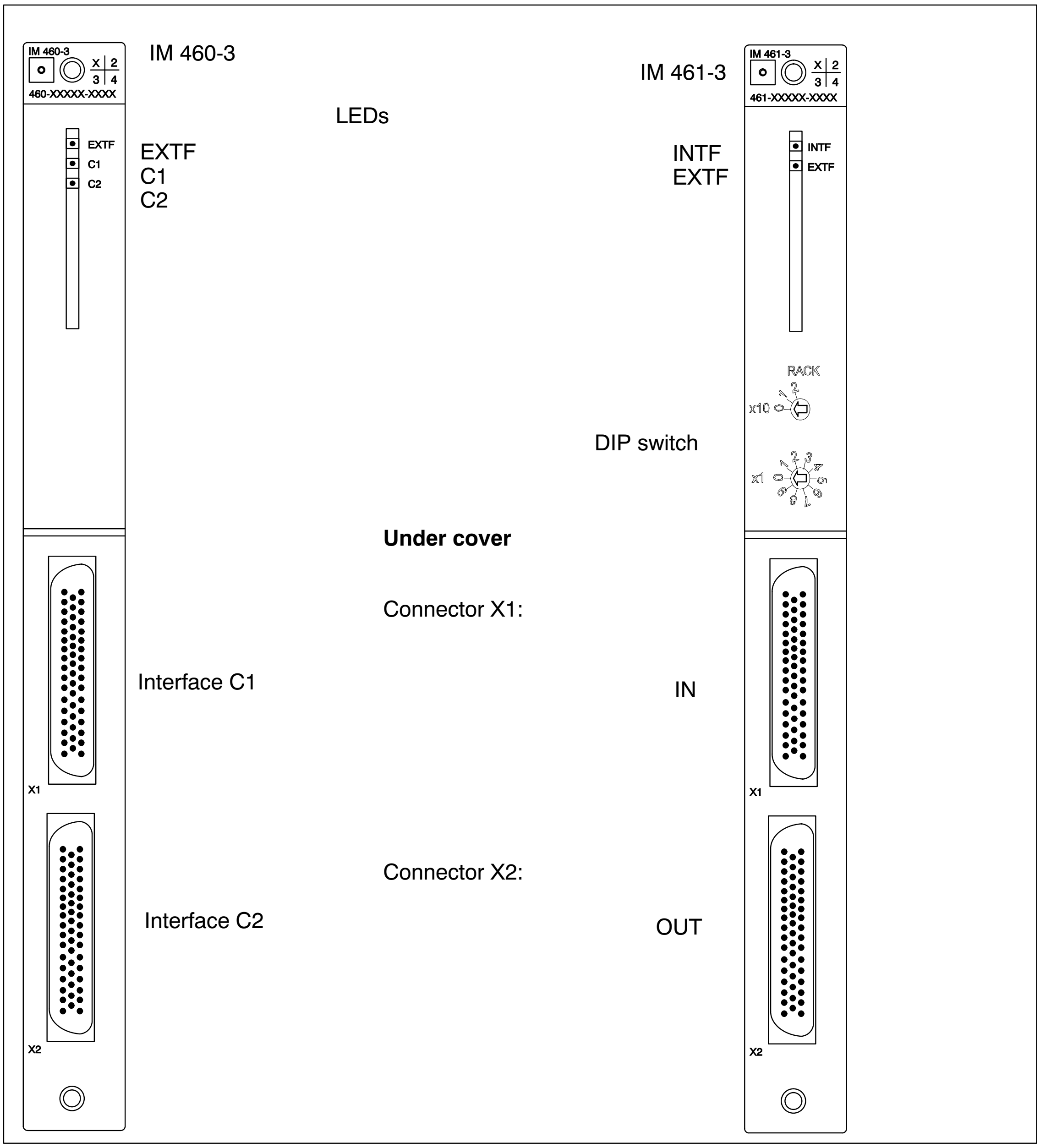


Figure 6-4 Position of the Operator Controls and Indicators of the IM 460-3 and IM 461-3

Function

The interface module pair IM 460-3 (send IM) and IM 461-3 (receive IM) are used for a remote link of up to a maximum 102.25 m (exactly: 100 m plus inputs/outputs of 0.75 m in the line).

Parameter assignment

Using the DIP switch on the front panel of the module, you must set the number of the mounting rack that the receive IM is installed on. The permitted range is 1 to 21.

If required, you can change the distance setting for the line on the programming device using STEP 7.

The default setting for the distance is 100 m.

Ensure that the distance corresponds as closely as possible to the current length (the sum of all the connecting cables per line) as this will accelerate data transmission.

Warning

The distance set must always be longer than the actual length of cable per line.

Setting/Changing the Number

Proceed as follows:

1. Put the switch of the power supply module in the EU in which you want to make a change in the position ⏻ (Output voltage 0 V).
2. Enter the number using the DIP switch.
3. Switch the power supply module on again.

Operator Controls and Indicators on the Send IM

Table 6-10 Operator controls and indicators on the Send IM

EXTF LED (red)	Lights up in the event of an external fault. Line 1 or line 2 is faulty (terminator missing or broken cable). Prerequisite: A cable must already have been connected once.
C1 LED (green)	Line 1 (via front connector X1, connection 1) is correct.
C1 LED (flashing green)	An EU in the line is not ready for operation because • The power supply module is not switched on or • A module has not yet completed the initialization process
C2 LED (green)	Line 2 (via front connector X2, connection 2) is correct.
C2 LED (flashing green)	An EU in the line is not ready for operation because • The power supply module is not switched on or • A module has not yet completed the initialization process

Operator Controls and Indicators of the Receive IM

Table 6-11 Operator controls and indicators on the Receive IM

INTF LED (red)	Lights up if a rack number > 21 or = 0 was set. Lights up if you have changed the rack number under voltage.
EXTF LED (red)	Lights up in the event of an external fault (line fault, for example, if the terminator is not inserted or if a module has not yet completed the initialization process, or if the CC is switched off)
DIP switch	DIP switch to set the number of the mounting rack.
Front connector X1	Upper connector (input) for the connecting cable from the previous interface module.
Front connector X2	Lower connector (output) for the connecting cable to the next interface module or for the terminator.

Technical Specifications of the IM 460-3 and IM 461-3

Maximum line length (total)	102 m
Dimensions W x H x D (mm)	25 x 290 x 280
Weight • IM 460-3 • IM 461-3	 630 g 620 g
Current consumption from the S7-400 bus 5 VDC • IM 460-3 • IM 461-3	 Typ. 1350 mA Max. 1550 mA Typ. 590 mA Max. 620 mA
Power loss • IM 460-3 • IM 461-3	 Typ. 6750 mW Max. 7750 mW Typ. 2950 mW Max. 3100 mW
Terminator	6ES7461-3AA00-7AA0
Backup current	No

6.5 The Interface Modules IM 460-4; (6ES7460-4AA01-0AB0) and IM 461-4; (6ES7461-4AA01-0AA0)

Position of the Operator Controls and Indicators of the IM 460-4 and IM 461-4

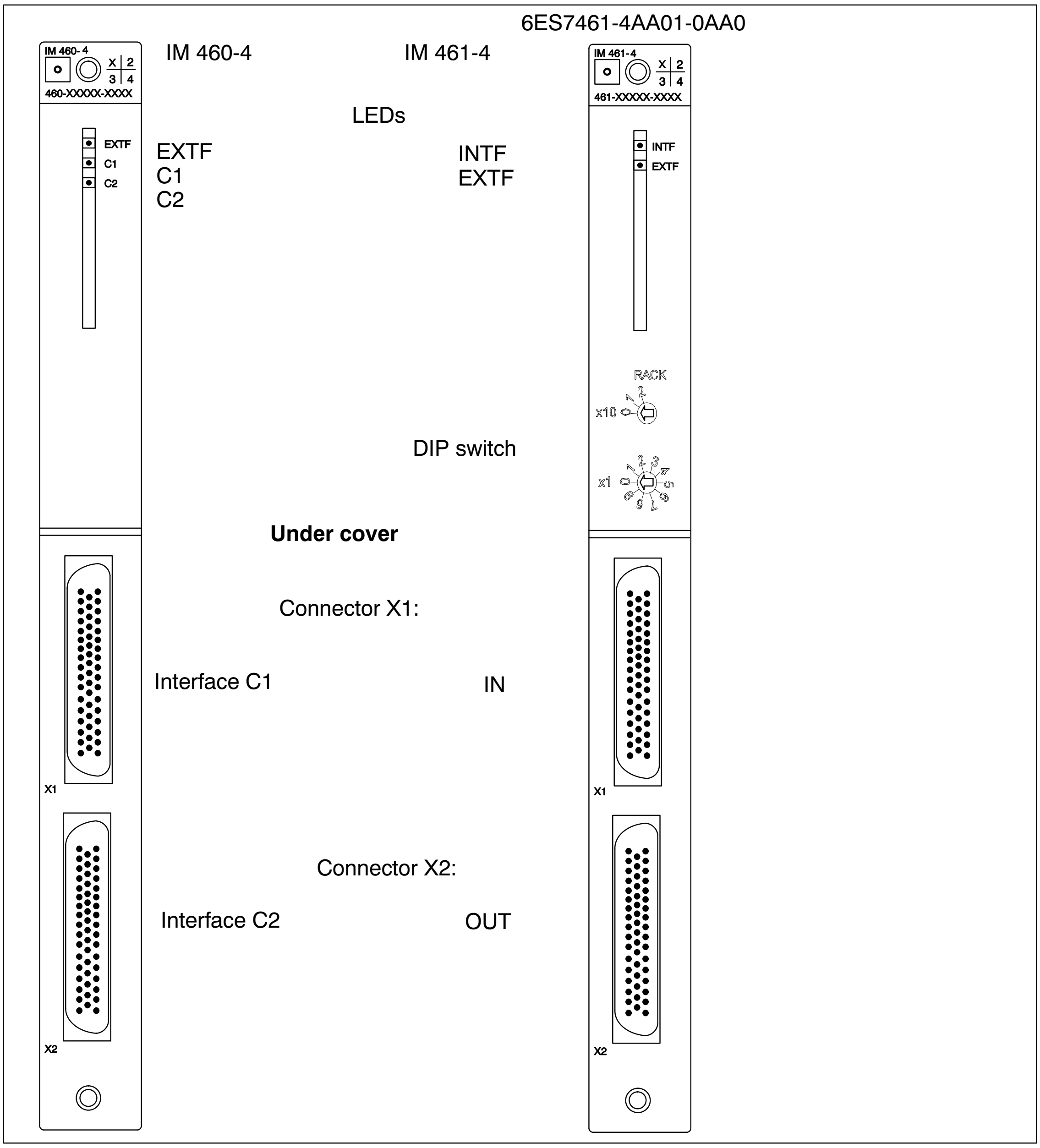


Figure 6-5 Position of the Operator Controls and Indicators of the IM 460-4 and IM 461-4

Function

The interface module pair IM 460-4 (send IM) and IM 461-4 (receive IM) are used for a remote link of up to a maximum 605 m (exactly: 600 m plus inputs/outputs of 1.5 m in the line).

Parameter assignment

Using the DIP switch on the front panel of the module, you must set the number of the mounting rack in which the receive IM is installed. The permitted range is 1 to 21.

If required, you can change the distance setting for the line on the programming device using STEP 7.

The default setting for the distance is 600 m.

Ensure that the distance corresponds as closely as possible to the current length (the sum of all the connecting cables per line) as this will accelerate data transmission.

Warning

The distance set must always be longer than the actual length of cable per line.

Setting/Changing the Number

Proceed as follows:

1. Put the switch of the power supply module in the EU in which you want to make the change in the position ⏻ (Output voltage 0 V).
2. Enter the number using the DIP switch.
3. Switch the power supply module on again.

Operator Controls and Indicators on the Send IM

Table 6-12 Operator controls and indicators on the Send IM

EXTF LED (red)	Lights up in the event of an external fault. Line 1 or line 2 is faulty (terminator missing or broken cable). Prerequisite: A cable must already have been connected once.
C1 LED (green)	Line 1 (via front connector X1, connection 1) is correct.
C1 LED (flashing green)	An EU in the line is not ready for operation because • The power supply module is not switched on or • A module has not yet completed the initialization process
C2 LED (green)	Line 2 (via front connector X2, connection 2) is correct.
C2 LED (flashing green)	An EU in the line is not ready for operation because • The power supply module is not switched on or • A module has not yet completed the initialization process

Operator Controls and Indicators of the Receive IM

Table 6-13 Operator controls and indicators on the Receive IM

INTF LED (red)	Lights up if a rack number > 21 or = 0 was set. Lights up if you have changed the rack number under voltage.
EXTF LED (red)	Lights up in the event of an external fault (line fault, for example, if the terminator is not inserted or if a module has not yet completed the initialization process, or if the CC is switched off)
DIP switch	DIP switch to set the number of the mounting rack.
Front connector X1	Upper connector (input) for the connecting cable from the previous interface module.
Front connector X2	Lower connector (output) for the connecting cable to the next interface module or for the terminator.

Technical Specifications of the IM 460-4 and IM 461-4

Maximum line length (total)	605 m
Dimensions W x H x D (mm)	25 x 290 x 280
Weight • IM 460-4 • IM 461-4	 630 g 620 g
Current consumption from the S7-400 bus 5 VDC • IM 460-4 • IM 461-4	Typ. 1350 mA Max. 1550 mA Typ. 590 mA Max. 620 mA
Power loss • IM 460-4 • IM 461-4	 Typ. 6750 mW Max. 7750 mW Typ. 2950 mW Max. 3100 mW
Terminator	6ES7461-4AA00-7AA0
Backup current	No

Compatibility

You cannot use the IM 460-4 and IM 461-4 interface modules with CPUs that have the following order numbers:

- 6ES7412-1XF00-0AB0
- 6ES7413-1XG00-0AB0
- 6ES7413-2XG00-0AB0
- 6ES7414-1XG00-0AB0
- 6ES7414-2XG00-0AB0
- 6ES7416-1XJ00-0AB0

IM 463-2

7

Chapter Overview

Order Number

IM 463-2	6ES7463-2AA00-0AA0

7.1 Using SIMATIC S5 Expansion Units in an S7-400

Area of Application

The IM 463-2 interface module is used for distributed connection of S5 expansion units to an S7-400.

You can use the IM 463-2 in the CR of the S7-400. In the S5 expansion unit, you use an IM 314.

This allows you to connect the following S5 expansion units to an S7-400:

- EU 183U
- EU 185U
- EU 186U
- ER 701-2
- ER 701-3

Accordingly, you can use all digital and analog I/O modules suitable for these EUs or ERs.

Basic Requirement

If you connect an S5 expansion unit to a CR of the S7-400 via an IM 463-2, the SIMATIC S5 basic requirements concerning EMC, ambient conditions, etc., apply for the overall system.

Warning

In environments contaminated by radiated noise, you must apply the type 721 cable shield (see *Installation Manual*, Chapter 4).

Expanding the Distributed Connection

You can also centrally expand the EUs connected in a distributed configuration via an IM 463-2. The following table lists the S5 interface modules that you can use for this purpose.

Table 7-1 S5 Interface Modules

Module	Order Number
IM 300	6ES5300-5CA11 6ES5300-3AB11 6ES5300-5LB11
IM 306	6ES5306-7LA11

7.2 Rules for Connecting S5 Expansion Units

Introduction

When you connect S5 expansion units to an S7-400 via the IM 463-2, there are rules to observe with regard to cable length, maximum expansion, use of a terminating connector and permissible potential differences.

Cable Length

The maximum cable length per IM 463-2 from the CR of the S7-400 to the last S5 expansion unit is 600 m. You set the actual cable length at the IM 463-2 (see Section 7.3).

Maximum Expansion

You can use up to four IM 463-2s in one S7-400 CR.

At each IM 463-2 interface (C1 and C2), you can connect up to four S5 expansion units in a distributed configuration.

You can connect further EUs centrally to the EUs connected in the distributed configuration.

Addressing of the S5 modules

All S5 address areas are available (P, Q, IM3, IM4)

Warning

Note that every S5 address can only be used once, even **across different chains**.

Terminating Connector

You must terminate the IM 314 of the last EU in each chain with the 6ES5760-1AA11 terminating connector.

Permissible Potential Differences

For the safe functioning of the distributed configuration, you must ensure that the potential difference between two devices is not more than 7 V. Use an equipotential bonding conductor.

7.3 Operator Controls and Indicators

Introduction

All controls and indicators on the IM 463-2 are arranged on the front plate. The following figure shows the arrangement of the controls and indicators.

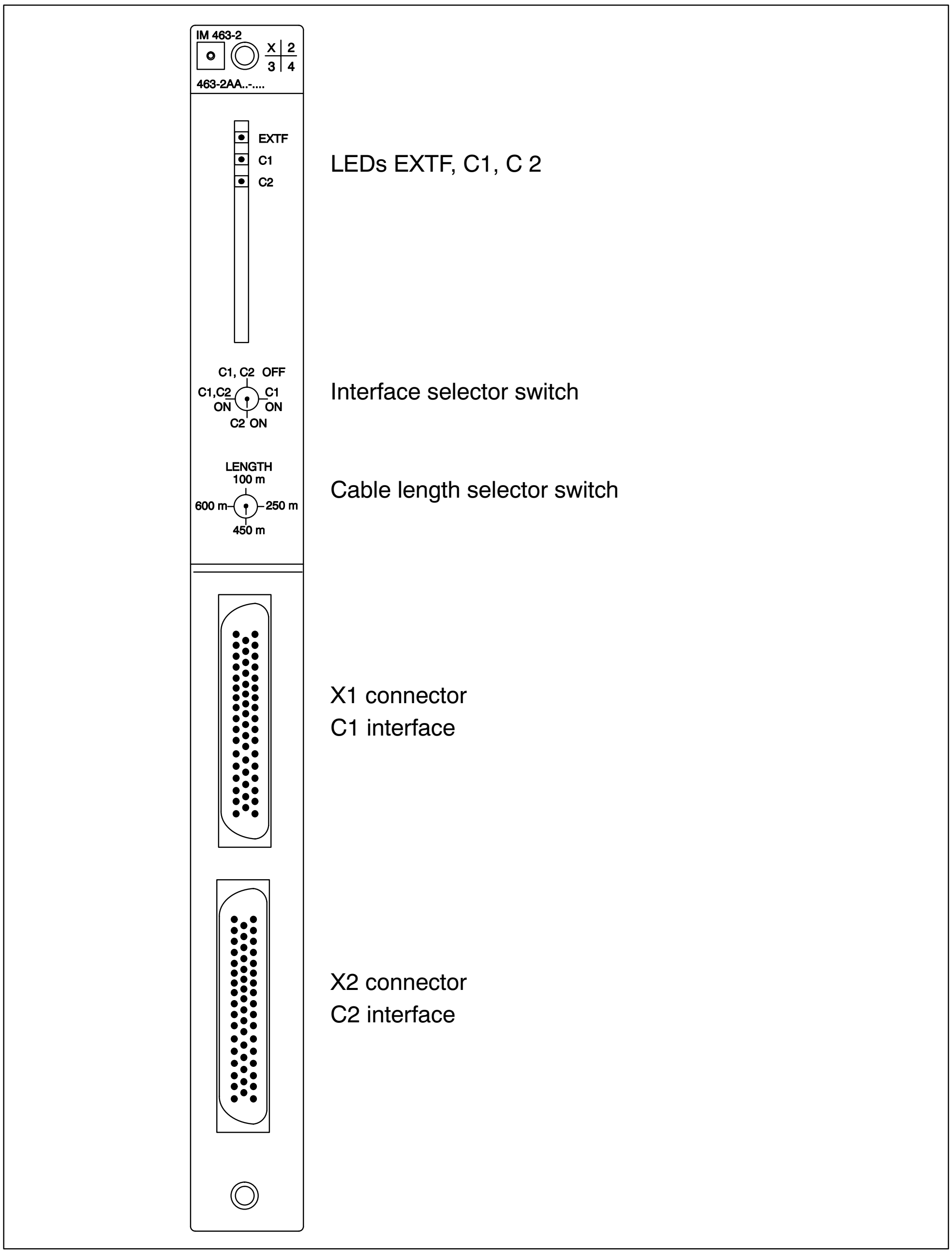


Figure 7-1 Layout of the Controls and Indicators of the IM 463-2

LEDs

Table 7-2 LEDs of the IM 4632

LED	Meaning
LED EXTF (red)	Lights up in the event of an external fault. Chain 1 or chain 2 has a fault (power supply failed in the EU; terminating connector missing; wire break, or interface selector switch wrongly set).
LED C1 (green)	Chain 1 (via front connector X1, connection 1) is in order.
LED C2 (green)	Chain 2 (via front connector X2, connection 2) is in order.
Front connector X1 and X2	Connector plug (output) for chain 1 and chain 2. X1 = upper front connector; X2 = lower front connector

Interface Selector Switch

Table 7-3 Switch Position: Interface Selector of the IM 463-2

Switch Position	Meaning
C1 ON	You use only interface C1.
C2 ON	You use only interface C2.
C1, C2 ON	You use both interfaces.
C1, C2 OFF	You use neither of the two interfaces. You do not want to operate an S5 EU at present.

Cable Length Selector Selector

Table 7-4 Switch Position: Cable Length Selector of the IM 463-2

Switch Position	Meaning
100	Cable length 1 to 100 m
250	Cable length 100 to 250 m
450	Cable length 250 to 450 m
600	Cable length 450 to 600 m

Warning

Danger of data loss.

Changing the setting of the interface selector switch and the cable length selector switch in RUN mode can result in loss of data.

Change the settings of these switches only in STOP mode of the CPU.

7.4 Installing and Connecting the IM 463-2

Introduction

To install an IM 463-2 in a CR of the S7-400, proceed in the same way as when installing other S7-400 modules (see *Installation Manual*, Chapter 5).

To connect an IM 463-2, follow the steps outlined below:

1. Prepare the connecting cable
2. Plug in the connecting cable
3. Select the interface
4. Select the cable length

Preparing the Connecting Cable

You can use the 721 connecting cable. However, you must change the connector housing on the connection side of the IM 463-2.

Two connector housings are enclosed with every IM 463-2. You can prepare a connecting cable for an IM 463-2 using one of these connector housings and a 721 connecting cable (see *Catalog ST 54.1*). To prepare the connecting cable, follow the steps outlined below:

1. Remove one connector housing on the 721 connecting cable.
2. Open one of the connector housings enclosed with the IM 463-2.
3. Attach this connector housing to the 721 connecting cable.
4. Close the connector housing.

Plugging in the Connecting Cable

To plug in the connecting cable, follow the steps outlined below:

1. Open the cover of the IM 463-2.
2. Plug the new connector of the connecting cable into one of the connectors of the IM 463-2.

   Interface C1 corresponds to the upper connector; interface C2 corresponds to the lower connector.
3. Screw the connector of the connecting cable onto the connector of the IM 463-2.
4. Close the cover.

Selecting the Interface

You select the interface with the selector switch on the front plate. Set the interface(s) here that you want to use. Make the settings on the IM 463-2 only when the CPU is in STOP mode.

Selecting the Cable Length

You select the cable length with the selector switch on the frontplate. Set the range corresponding to the chain length. Make the settings on the IM 463-2 only when the CPU is in STOP mode.

7.5 Setting the Operating Modes of the IM 314

Introduction

To operate the IM 463-2, you must set on the IM 314 the S5 expansion unit used and the address area of the S5 I/O modules.

Setting the S5 Expansion Unit

You set the S5 expansion unit in which you want to use the IM 314 using jumpers BR1, BR2, and BR3 on the IM 314.

The following figure shows where these jumpers are located on the IM 314 and which setting corresponds to which expansion unit.

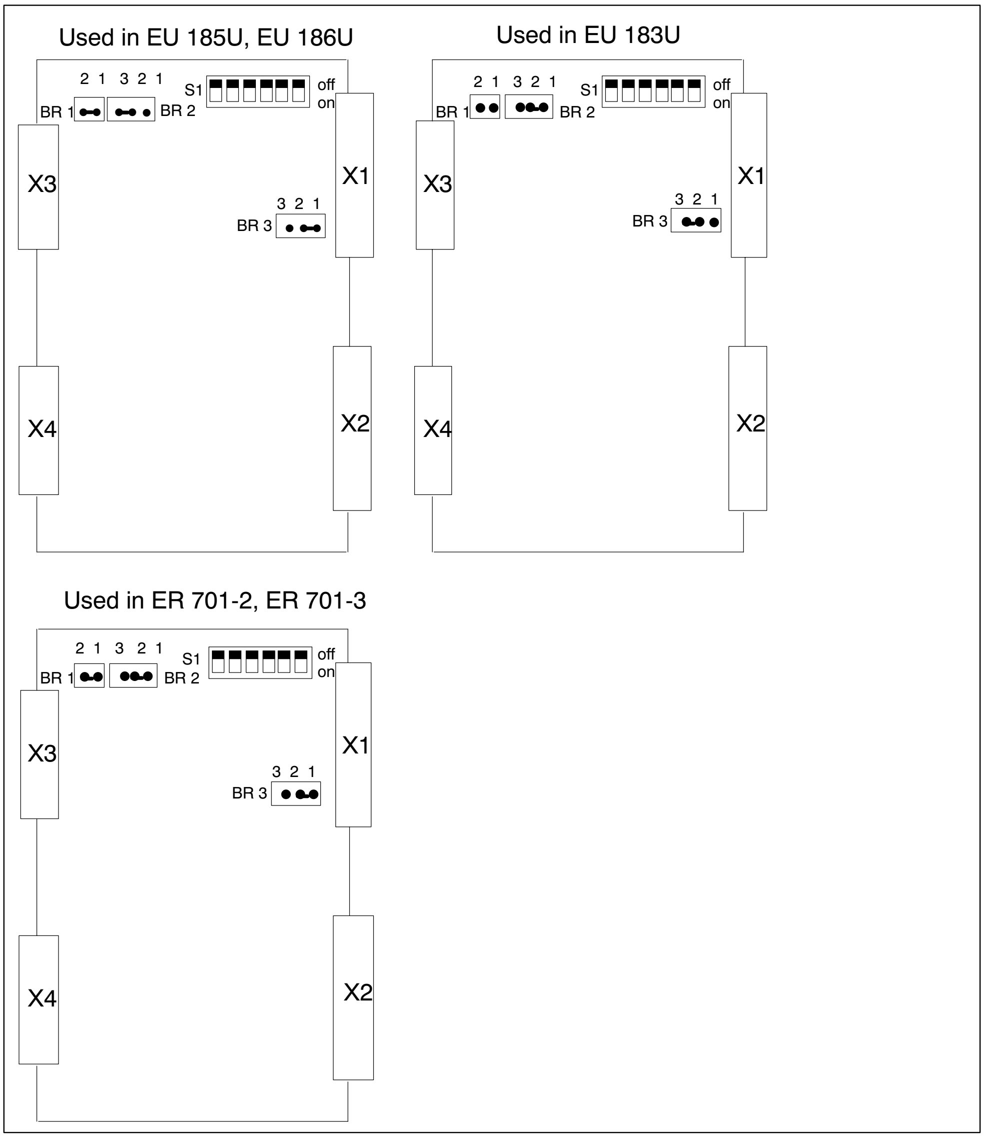


Figure 7-2 Settings of the IM 314 with Expansion Units

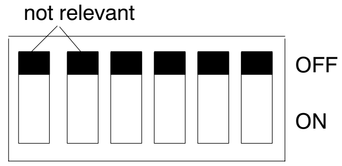
Setting the Address Area

The address area of the S5 I/O modules is set on the IM 314. This setting applies only for the digital and analog I/O modules.

The address areas P, Q, IM3, and IM4 are available. Set the switch to the relevant position to address the digital and analog I/O modules in these areas.

Table 7-5 Settings Address Areas on the IM 314

I/O Area Address		Switch Position	
		O = OFF,	1 = ON
P area:	F000 - F0FF	S1:	0000 *)
Q area:	F100 - F1FF		0001
IM3 area:	FC00 - FCFF		1100
IM4 area:	FD00 - FDFF		1101



*) Status as shipped

7.6 Configuring S5 Modules for Operation in the S7-400

You configure the S5 modules using STEP 7. See the description of STEP 7 or the online help function for details of how to proceed.

The following figure shows a possible connection of CRs and EUs via the IM 463-2 and IM 314.

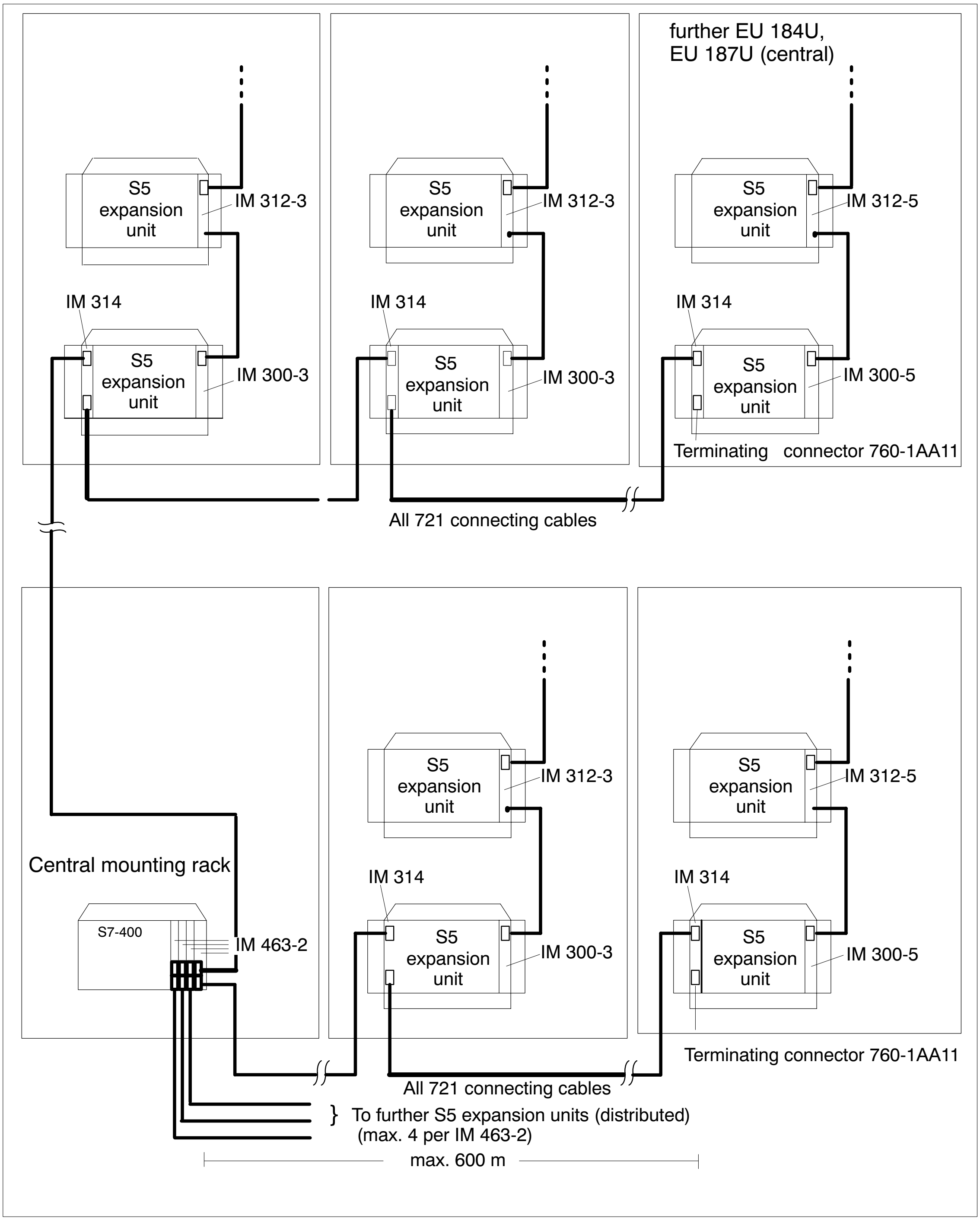
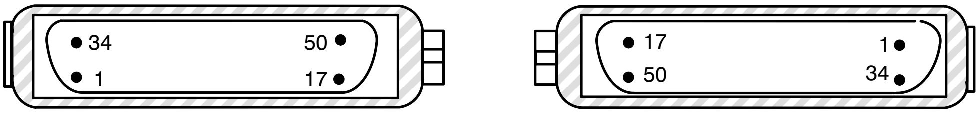


Figure 7-3 Connection Variant for CCs and EUs via the IM 463-2 and IM 314

7.7 Pin Assignments of the 721 Connecting Cable

Table 7-6 Assignment of the Connecting Cable 721



Connector 50-Pin Contact	Bundle Ident. Sheath	Identification Foil	Core Color	Connector 50-Pin Contact
20	1 No. 16	red	white	20
21			brown	21
4			green	4
5			yellow	5
18			gray	18
19			pink	19
2			blue	2
3			red	3
24	2 No. 17	green	white	24
25			brown	25
8			green	8
9			yellow	9
22			gray	22
23			pink	23
6			blue	6
7			red	7
26	3 No. 18	yellow	white	26
27			brown	27
10			green	10
11			yellow	11
42			gray	42
43			pink	43
44			blue	44
45			red	45
28	4 No. 19	brown	white	28
29			brown	29
12			green	12
13			yellow	13
46			gray	46
47			pink	47
30			blue	30
31			red	31

Table 7-6 Assignment of the Connecting Cable 721, continued

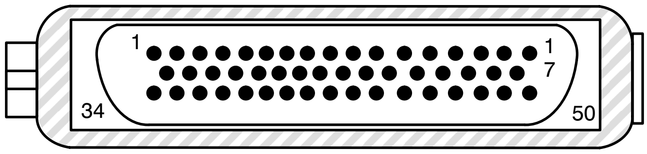
Connector 50-Pin Contact	Bundle Ident. Sheath	Identification Foil	Core Color	Connector 50-Pin Contact
34	5 No. 20	black	white	34
35			brown	35
36			green	36
37			yellow	37
38			gray	38
39			pink	39
40			blue	40
41			red	41
48	6 No. 21	blue	white	48
49			brown	49
14			green	14
15			yellow	15
32			gray	32
33			pink	33
-	Shield			-

7.8 Terminating Connector for IM 314

Introduction

The IM 314 of the last expansion unit of each chain is terminated with the 6ES5760-1AA11 terminating connector.

Table 7-7 Assignment of the Terminator 760-1AA11



Plug Connection	180-Ohm Resistance or Jumper		Plug Connection
28			8
29			9
26			6
27			7
48			4
47			5
44			2
45			3
42			24
43			25
38	1)		22
39			23
34	1)		20
35			21
36	1)		18
37			19
40	1)		12
41			13
48	2)		10
49			11
15			30
16			31
14			
50			

1) 100 Ω
2) 200 Ω

7.9 Technical Specifications (6ES7463-2AA00-0AA0)

Programming package	
Associated programming package	As of STEP 7 V 2.1
Dimensions and Weight	
Dimensions WxHxD (mm)	25x290x280
Weight	360 g
Module-Specific Data	
Number and type of interfaces	2 parallel, symmetrical interfaces
Cable length: from IM 463-2 to the last IM 314 (per interface)	max. 600 m
Transmission rate	2 Mbytes/s to 100 Kbytes/s
Parameter sets of the signal modules	differential signal in accordance with RS 485
Front connector	2 connectors, 50-pin male

Voltages, Currents, Potentials	
Supply voltage from S7-400 bus	+5 V
Current consumption	typ. 1.2 A max. 1.32 A
Power losses	typ. 6 W max. 6.6 W
Backup current	no

PROFIBUS DP Master Interface IM 467/IM 467 FO

8

Chapter Overview

8.1 PROFIBUS DP Master Interface IM 467/IM 467 FO

Order Numbers

IM 467	6ES7467-5GJ02-0AB0 (RS 485)
IM 467 FO	6ES7467-5FJ00-0AB0 (F0)

Application

PROFIBUS DP, standardized to IEC 61784–1:2002 Ed1 CP 3/1, enables rapid communication in the field between programmable controllers, PCs and field devices. Field devices are devices such as: ET 200 distributed I/O devices, drives, valve terminals, switchgear and many others.

The IM 467/IM 467 FO interface module is meant to be used in an S7-400 programmable controller. It permits the S7-400 to be connected to PROFIBUS DP.

Warning

The PROFIBUS DP master interface IM 467 or IM 467 FO is not a DP master in accordance with DPV 1.

Configuration

- Configured as for the S7-400
- Can be operated without a fan
- A maximum of 4 IM 467/IM 467 FO can be used in the central controller. There are no slot rules.
- The IM 467/IM 467 FO and the CP 443-5 Extended cannot be used together.
- The transmission rate of 9.6 kbps to 12 Mbps can be set in steps using software
- Configuration and programming are possible via PROFIBUS DP.
  You must **not**, however, change the PROFIBUS DP parameters.
- IM 467 with 9-pin subminiature D female connector for connection to PROFIBUS DP (6ES7467-5GJ02-0AB0)
- IM 467 FO with fiber-optic cable for connection to PROFIBUS DP (6ES7467-5FJ00-0AB0)

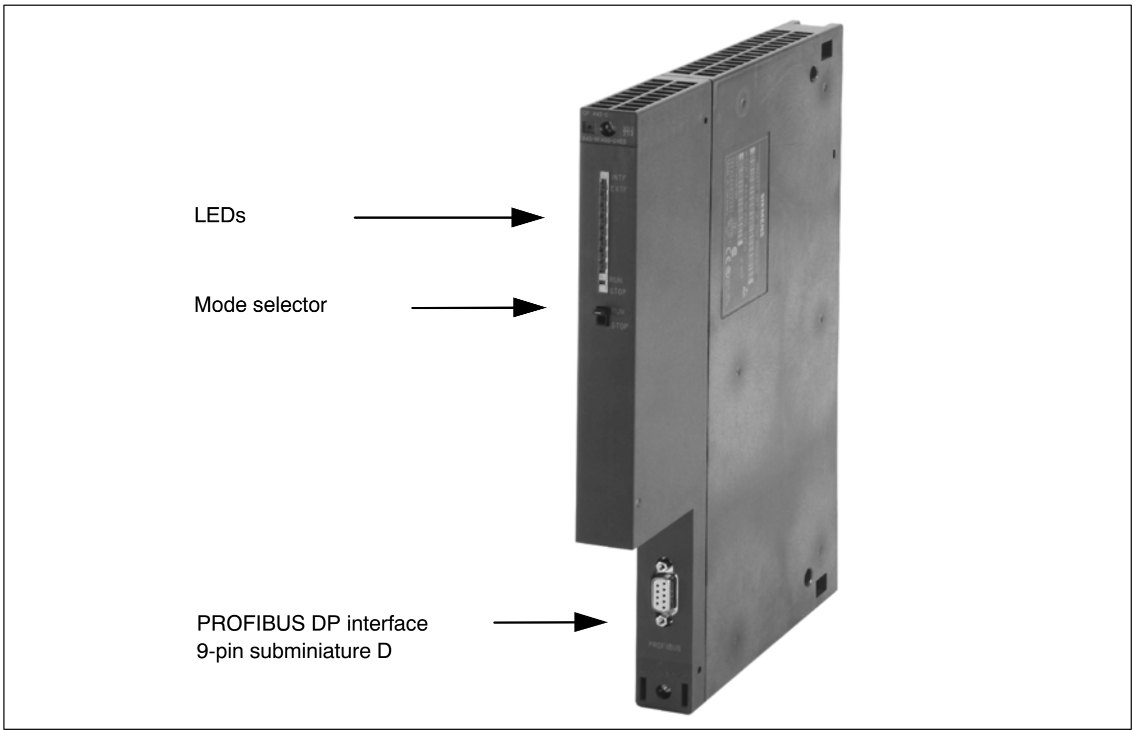


Figure 8-1 Configuration of the IM 467/467 FO

Communication Services

The IM 467/IM 467 FO offers two communication services:

- PROFIBUS DP

  The IM 467/IM 467 FO is a PROFIBUS DP master in accordance with EN 50 170. It is configured entirely with STEP 7. It behaves in basically the same way as the integrated PROFIBUS DP interfaces on the CPU modules (see the technical specifications of the IM 467/IM 467 FO for the differences).

  DP communication does not require any function calls in the STEP 7 user program.

- S7 functions

  The S7 functions guarantee optimal and easy communication in a SIMATIC S7/M7/C7 automation solution. The following S7 functions are enabled for the IM 467/IM 467 FO:

  – Programming device functions via PROFIBUS DP

  – Operator control and monitoring functions via PROFIBUS DP

  Communication takes place without any additional configuration on the IM 467/ IM 467 FO.

  S7 functions can be used on their own or in parallel with the PROFIBUS DP protocol. If they are used in parallel with DP communication, this affects the PROFIBUS DP bus cycle time.

8.1.1 Indicators and the Mode Selector

LED

The LED plate on the front panel of the IM 467/
IM 467 FO has the following four indicators:

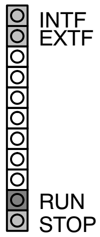


Figure 8-2 LEDs of the IM 467/467 FO

IM Operating Mode

The LEDs indicate the operating mode of the IM in accordance with the following table:

Table 8-1 Operating Modes of the IM 467/467 FO

STOP LED (yellow)	RUN LED (green)	EXTF LED (red)	INTF LED (red)	CP Operating Mode
On	Flashing	Off	Off	Startup
Off	On	Off	Off	RUN
Flashing	On	Off	Off	STOPPING
On	Off	Off	Off	STOP
On	Off	Off	On	STOP with internal error (IM not configured, for example)
Flashing	Off	Off	Off	Waiting for FW update (takes 10 sec. after power up)
Flashing	Off	On	On	Waiting for FW update (IM currently contains an incomplete FW version).
Off	On	On	Off	RUN and PROFIBUS DP bus fault
Off	On	Flashing	Off	RUN; but there are faults on the DP line (the DP slave is not taking part in data transfer, or the module in the DP slave is faulty, for example)
Flashing	Flashing	Flashing	Flashing	Module error/ System error

Controlling the Operating Mode

There are two ways to control the operating mode of the IM 467/IM 467 FO:

- By using the mode selector
- By using the programming device/PC

Mode Selector

You can switch operating modes as follows using the mode selector:

- From STOP to RUN

  All the configured communication services and S7 communication services are available in RUN.

  The IM operating mode can only be controlled from the programming device/PC when the switch is in the RUN position.

- From RUN to STOP

  The IM goes into STOP mode. Any existing S7 connections are cleared down, and the DP slaves are no longer supplied.

Loadable Firmware

The IM 467/IM 467 FO supports the updating of firmware (FW) by means of the FW loader. The FW loader is a component of the NCM S7 configuration software for PROFIBUS DP. Authorization is not required for this. After a FW update, the central controller must be switched off and on again before normal operation can be resumed.

Warning

You can find additional information on loading firmware in the NCM S7 for PROFIBUS DP manual and in the readme file of the NCM S7 for PROFIBUS DP configuration software.

Warning

An optical bus terminal (OBT) is required to load FW in the IM 467 FO.

8.2 Configuration

The IM 467/IM 467 FO is configured with STEP 7. The configuration data are retained even in the event of a power failure; a memory module is not required. Using the S7 functions it is possible to program and configure remotely all the IM 467/IM 467 FO connected to the network and all the CPUs connected via the SIMATIC S7-400 backplane bus.

SIMATIC STEP 7 as version 5.00.

Module Replacement Without a Programming Device

The configuration data are stored in the load memory of the CPU. The non-volatile storage of configuration data in the CPU is ensured by battery backup or EPROM module cards.

The IM 467/IM 467 FO can be replaced without the need to explicitly reload the configuration data.

It is only possible to remove and insert the IM 467/IM 467 FO in a deenergized state.

Multiprocessor Operation

The connected DP slaves can only be assigned to and processed by one CPU.

Configuration and Diagnostics Cannot Be Carried Out Simultaneously

When configuration is in progress, the IM 467/IM 467 FO cannot be diagnosed at the same time via MPI.

Warning

The 3 MB and 6 MB transmission rates are not enabled for the IM 467-FO.

8.3 Connection to PROFIBUS DP

There are two ways of connecting to PROFIBUS DP:

- Electrical connection via a bus connector
- Optical connection using a fiber-optic cable

8.3.1 Bus Connector

Only with 6ES7467-5GJ02-0AB0.

The bus cable is connected to the IM 467 by means of this connector. (See the detailed description in the chapter on networking in the S7-400, Hardware and Installation manual.)

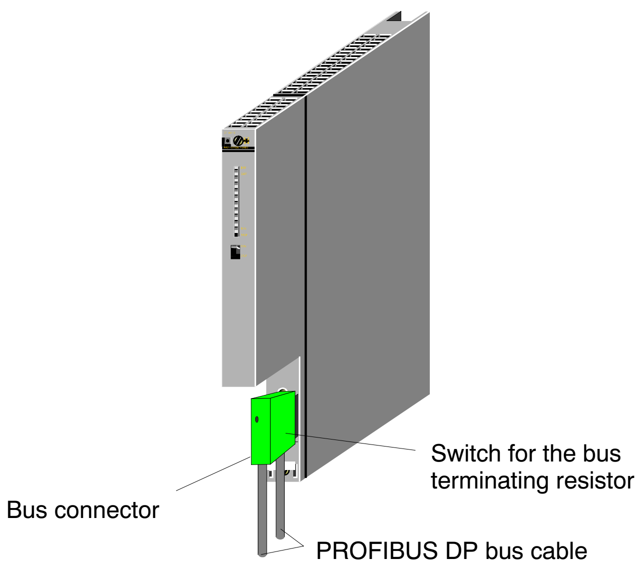


Figure 8-3 Connecting the Bus Connector to the IM 467

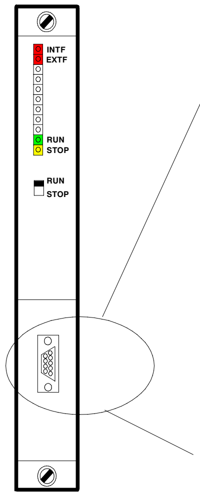
Maximum Cable Lengths for PROFIBUS DP

Transmission Rate in Kbps	9.6	19.2	93.75	187.5	500	1500	3000	6000 W	12000
Max. Length of a Bus Segment in m	1.000	1.000	1.000	1.000	400	200	100	100	100
Max. Number of Bus Segments 1)	10	10	10	10	10	10	10	10	10
Max. Length in m	10.000	10.000	10.000	10.000	4.000	2.000	1.000	1.000	1.000

1) Bus segments are interconnected by means of RS 485 repeaters

Connector Pin Assignment

The electrical interface used to connect to PROFIBUS DP (9-pin subminiature D female connector) is specified in the following table.



Pin No.	Signal Name	PROFIBUS DP Designation	Ass. with RS 485
1	PE	Protective earth	yes
2	–	–	–
3	RxD/TxD-P	Data transfer line – B	yes
4	RTS (AG)	Control –A	–
5	M5V2	Data reference potential	yes
6	P5V2	Supply plus	yes
7	BATT	–	–
8	RxD/TxD-N	Data transfer line – A	yes
9	–	–	–

Figure 8-4 Connector Pin Assignment

8.3.2 Optical Connection to PROFIBUS DP

Only in the case of 6ES7467-5FJ00-0AB0.

The IM 467 F0 with an integrated fiber-optic cable interface is available for connecting to the optical version of PROFIBUS DP.

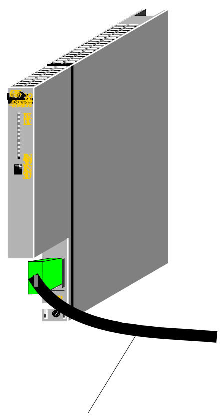


Figure 8-5 Optical Connection to PROFIBUS DP

8.3.3 Connecting a Fiber-Optic Cable to the IM 467 FO

Accessories Required

- Pack of Simplex connectors and polishing sets (6GK1901-0FB00-0AA0)
- Pack of plug-in adapters (6ES7195-1BE00-0XA0)

Installing Connectors

1. Remove approximately 30 cm of the sheath of the fiber-optic duplex cable.
2. Install the fiber-optic duplex cable with the associated Simplex connectors. You can find a detailed description of Simplex connectors in the ”*SIMATIC NET PROFIBUS Networks*” manual.

   TIP: Close the two Simplex connectors together rather than separately to obtain a Duplex connector. This ensures a more secure position in the plug-in adapter.

   IMPORTANT: The polished surface of the plastic fibers must be absolutely smooth and even. The plastic sheath must not stick out or be cut unevenly. If this is not the case, considerable attenuation of the light signal via the fiber-optic cable may occur.
3. Place the Simplex connectors in the plug-in adapter for the IM 467 FO and the fiber-optic cable in the cable guides provided. Insert the plug-in adapter until you hear the sides clearly latch into position.

   Make sure when you insert the plugs in the plug-in adapter that the sender is always at the top and the receiver is underneath.

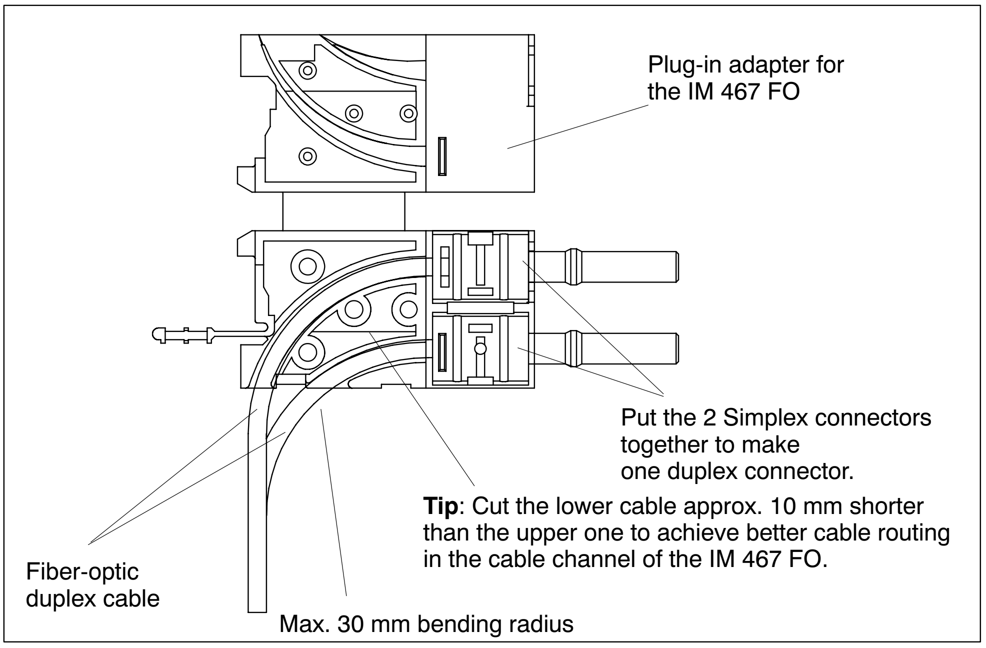


Figure 8-6 Installing the Connector

Reusing Fiber-Optic Cables

Warning

If you insert used fiber-optic cables in the plug-in adapter again, you must cut off the bent lengths of both fiber-optic cable cores and install the Simplex connectors again.
This avoids any attenuation losses due to parts of the cores of the fiber-optic duplex cables being bent again and overstressed.

Inserting the Fiber-Optic Cables into the IM 467 FO

Insert the fiber-optic cables and attached plug-in adapters into the IM 467 FO. Move the protruding handle of the plug-in adapter upwards.

Make sure that it is correctly positioned: The sender fiber-optic cable is plugged into the receiver socket, and the receiver fiber-optic cable is inserted into the sender socket of the fiber-optic interface of the IM 467 FO.

If the IM 467 FO is the last node in the fiber-optic network, you must close the unoccupied fiber-optic cable interface with filler connectors (the connectors are already in place when the IM 467 FO is delivered).

Caution

Do not look directly into the opening of the optical sender diodes.
The light beam could damage your eyes.

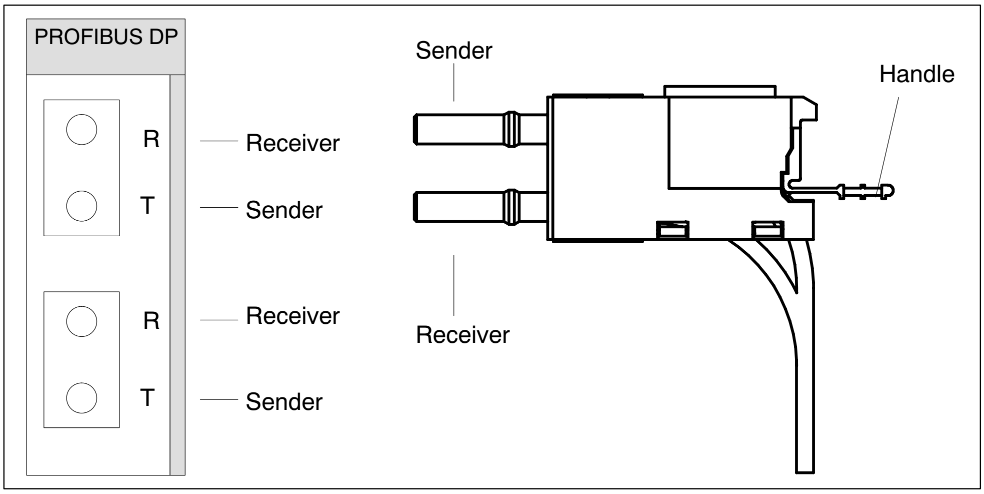


Figure 8-7 Inserting the Fiber-Optic Cables into the IM 467 FO

Bending Radius for the Fiber-Optic Cable

Make sure when you wire the fiber-optic duplex cable cores and insert them into the plug-in adapter that the permissible bending radius of 30 mm is not violated. See also the installation guidelines on fiber-optic cables in the SIMATIC NET PROFIBUS Networks manual.

8.4 Technical Specifications

8.4.1 Technical Specifications of the IM 467

6ES7467-5GJ02-0AB0.

Dimensions and Weight	
Dimensions W x H x D (mm)	25 x 290 x 210
Weight	700 g
PROFIBUS DP	
• Standard	PROFIBUS DP, EN 50 170
• Transmission rate	9.6 kbps to 12 Mbps, parameterizable in steps
• Transmission technology	RS 485 via 9-pin subminiature D female connector
Current consumption	
Current consumption from the S7-400 bus (24 VDC) The IM does not consume any current at 24 V, and it only makes this voltage available at the MPI/DP interface.	Total current consumption of the components connected to the DP interfaces, with a maximum of 150 mA

PROFIBUS DP	
Conditions of Use	
Can be used in	SIMATIC S7-400, max. 4 IM 467 in the central controller
IM 467 cannot be used together with the CP 443-5	
Supply voltage	5 VDC via the backplane bus
Current consumption • From 5 VDC	1.3 A
Addressing range	Max. 4 KB for inputs and 4 KB for outputs
DP master	Yes
• DPV 1	No
• Enable/disable	No
Number of connectable I/O devices (slaves)	96
Number of connections for S7 functions for the programming device and operation and monitoring	32 + 1 diagnostic connection
Data volume per slave	Max. 244 bytes
Consistency	Max. 128 bytes
Configuration software	STEP 7
DP slave	No
Deviations from the DP Interface Integrated in the CPU	
• Different SSL IDs for system diagnostics • Possibly extended SFC run times • Additional return codes for SFC 14 and SFC 15	

8.4.2 Technical Specifications of the IM 467 FO

6ES7 467-5FJ00-0AB0

Dimensions and Weight	
Dimensions W x H x D (mm)	25 x 290 x 210
Weight	700 g
PROFIBUS DP	
• Standard	PROFIBUS DP, EN 50 170
• Transmission rate	9.6 kbps to 12 Mbps, configurable in steps (3 Mbps and 6 Mbps not possible)
• Transmission technology	FOC Wavelength l = 660 nm 2 x Duplex socket
Current consumption	
Current consumption from the S7-400 bus (24 VDC) The IM does not consume any current at 24 V, and it only makes this voltage available at the MPI/DP interface.	Total current consumption of the components connected to the DP interfaces, with a maximum of 150 mA

PROFIBUS DP	
Conditions of Use	
Can be used in	SIMATIC S7-400, max. 4 IM 467 in the central controller
IM 467 cannot be used with the CP 443-5	
Supply voltage	5 VDC via the backplane bus
Current consumption • From 5 VDC	1.3 A
Addressing range	Max. 4 KB for inputs and 4 KB for outputs
DP master	Yes
• DPV 1	No
• Enable/disable	No
Number of connectable I/O devices (slaves)	96
Number of connections for S7 functions for the programming device and operator control and monitoring	32 + 1 diagnostic connection
Data volume per slave	Max. 244 bytes
Consistency	Max. 128 bytes
Configuration software	STEP 7
DP slave	No
Deviations from the DP Interface Integrated in the CPU	
• Different SSL IDs for system diagnostics	
• Possibly extended SFC run times	
• Additional return codes for SFC 14 and SFC 15	

Cable Duct and Fan Subassemblies 9

Chapter Overview

Characteristics

The cable duct and the fan subassembly have the following characteristics

- The air inflow area is variable.
- Shield and cable clamping are possible.

In addition, the fan subassembly has the following characteristics:

- Fans and filter frames can be replaced from the front during operation.
- The fan function is controlled by means of speed monitoring.
- Operation with filter frames is optional.

9.1 Fan Monitoring in the Fan Subassemblies

In this section, you will find out how to monitor the fans.
There is a signaling concept example at the end of the section.

LEDs

The three red LEDs are assigned to the individual fans. From left to right, these are:

F1 – for fan 1

F2 – for fan 2

F3 – for fan 3

Fans

The fans have a redundant design. The fan subassembly continues to function even if one fan fails.

Fan Monitoring

The function of the fans is controlled by means of speed monitoring. If the speed of a fan drops below the limit speed of 1750 rpm, the LED assigned to it lights up. In addition, the relay K1 drops out.

If the speed of a second fan drops below the limit speed, the LED assigned to it lights up; in addition, the relay K2 drops out.

The following table is the function table for the fan monitoring.

Table 9-1 Function of Fan Monitoring

Fan1	Fan2	Fan3	LED F1	LED F2	LED F3	Relay K1	Relay K2
–	–	–	L	L	L	–	–
–	–	+	L	L	D	–	–
–	+	–	L	D	L	–	–
+	–	–	D	L	L	–	–
–	+	+	L	D	D	–	+
+	–	+	D	L	D	–	+
+	+	–	D	D	L	–	+
+	+	+	D	D	D	+	+
–*	–*	–*	D*	D*	D*	–*	–*

+ Fan in operation or relay picked up

– Fan failed or relay dropped out

D LEDs dark

L LEDs lit

* Power off

Signaling Concept Example

You can check the fault-free functioning of the fan subassembly using digital inputs.

You can cause the power supply to be cut off after the failure of at least two fans by using the relay K2. For example, you can use an intermediate contactor to interrupt the mains.

The relay contacts are labeled as follows:

Relay K1: No. 1...3

Relay K2: No. 4...6

The following diagram explains the circuit in the fan subassembly when all fans are functioning.

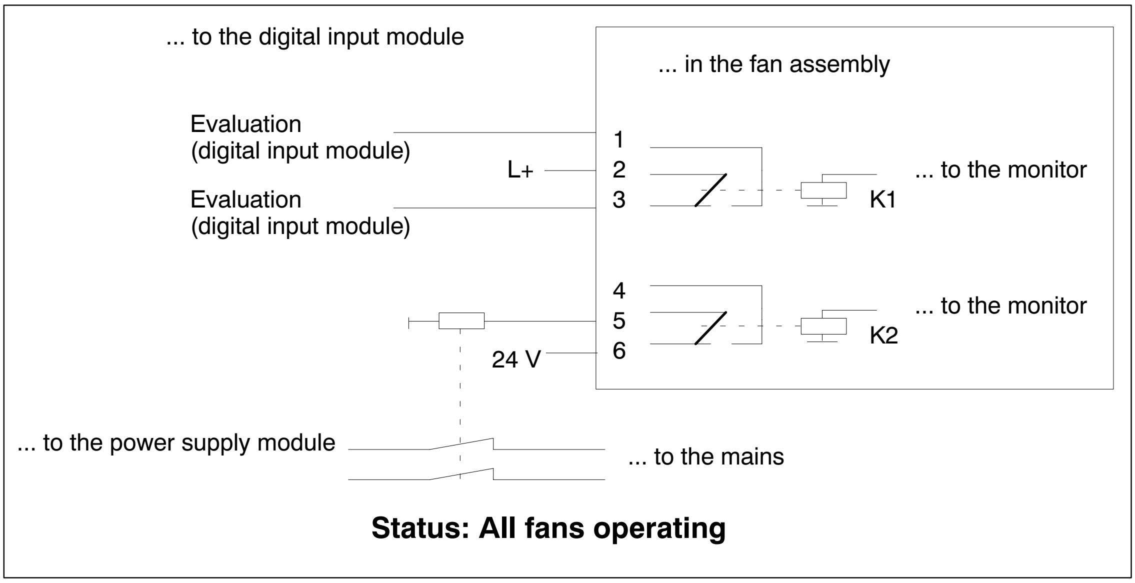


Figure 9-1 Example of a Message Concept

9.2 Cable Duct; (6ES7408-0TA00-0AA0)

Function

The cable duct is used in installations outside the cabinet for

- Cable clamping and/or for
- Shielding or for
- Air circulation without fan assistance

Front View of the Cable Duct

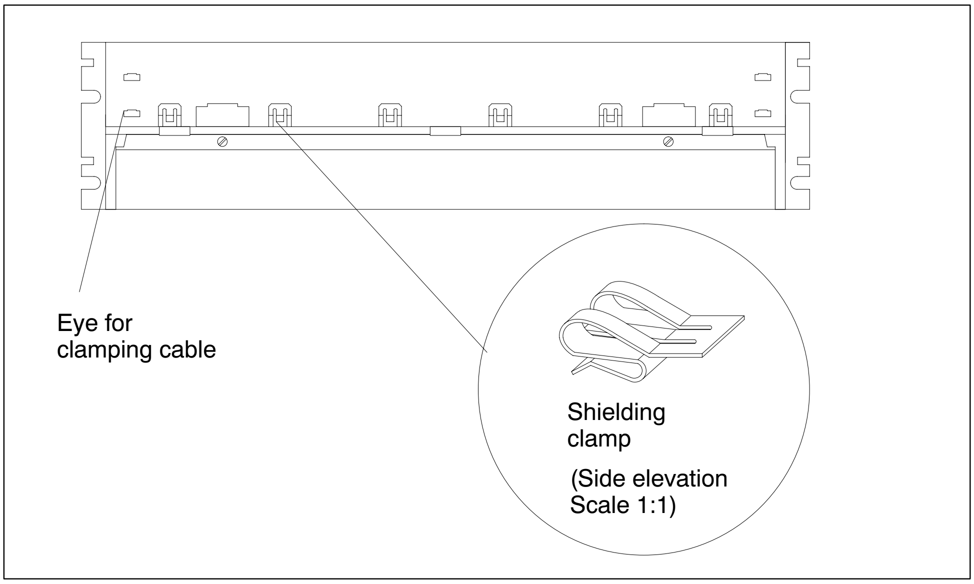


Figure 9-2 Front View of the Cable Channel

Shielding Clamps

If you do not require the shielding clamps supplied, do not install them in the cable duct.

Technical Specifications

Dimensions W x H x D (mm)	482.5 x 109.5 x 235
Weight	ca. 1200 g

9.3 The 120/230 VAC Fan Subassembly; (6ES7408-1TB00-0XA0)

Operator Controls and Indicators on the 120/230 VAC Fan Subassembly

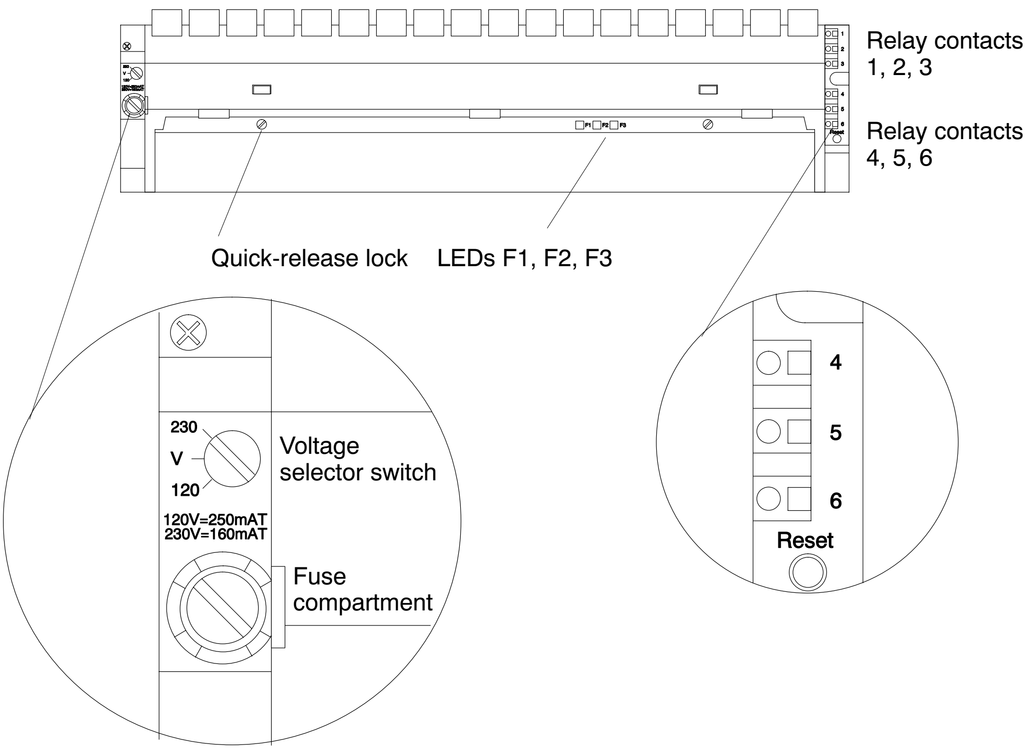


Figure 9-3 Controls and Indicators of the Fan Subassembly 120/230 VAC (6ES7408-1TB00-0XA0)

Fuse

Included in this fan subassembly are standard cartridge fuse links, 5 x 20 mm, conforming to DIN

- 250 mAT for 120 V
- 160 mAT for 230 V.

The fuse for the 230 V range is already installed on shipping from the factory.

Warning

If you change the voltage range, you must also insert the fuse for this voltage range in the fan subassembly. You will find a description of how to change the fuse in the *Installation Manual*, Chapter 9.

Shielding Clamps

If you do not require the shielding clamps supplied, do not install them in the fan subassembly.

Technical Specifications

Dimensions, Weights	
Dimensions WxHxD (mm)	482.5×109.5×235
Weight	appr. 2000 g
Cable diameter	3 to 9 mm
Nominal Sizes	
Lifespan of the fans	
• at 40 °C	typ. 70000 h
• at 75 °C	typ. 25000 h
Max. contact load of relay contacts 1 to 6	
• Switching voltage	24 VDC
• Switching current	200 mA

Voltages, Currents, Potentials		
At nominal voltage of	230 VAC	120 VAC
Power consumption		
• with fan	17 W	18 W
• without fan	5 W	4 W
Starting current	0.6 A	1.15 A
Fuses	160 mA	250 mA

Warning

Electrical current can lead to personal injury.

If you remove the left cover when installing or removing the fan subassembly, the terminals on the transformer are accessible briefly.

Remove the voltage from the fan subassembly before you install or remove it. Disconnect the supply cable before you remove the fan subassembly.

Caution

Danger of damage to equipment.

If you mix up the power supply PCB and the monitoring PCB in the fan subassembly, the fan subassembly may be damaged.

During maintenance of the unit, make sure you do not mix up the power supply PCB and the monitoring PCB.

Monitoring Function

In the case of a fault (defective fans) the fans are not switched off. Once you have replaced the defective fan(s), the fault is acknowledged automatically as soon as the fans have reached the required speed. Any faults that occur are not stored. When you switch on the fan subassembly, the fans start running. After approximately 10 s the current status of the fans is indicated via LEDs and relays.

9.4 The 24 VDC Fan Subassembly; (6ES7408-1TA00-0XA0)

Operator Controls and Indicators on the 24 VDC Fan Subassembly

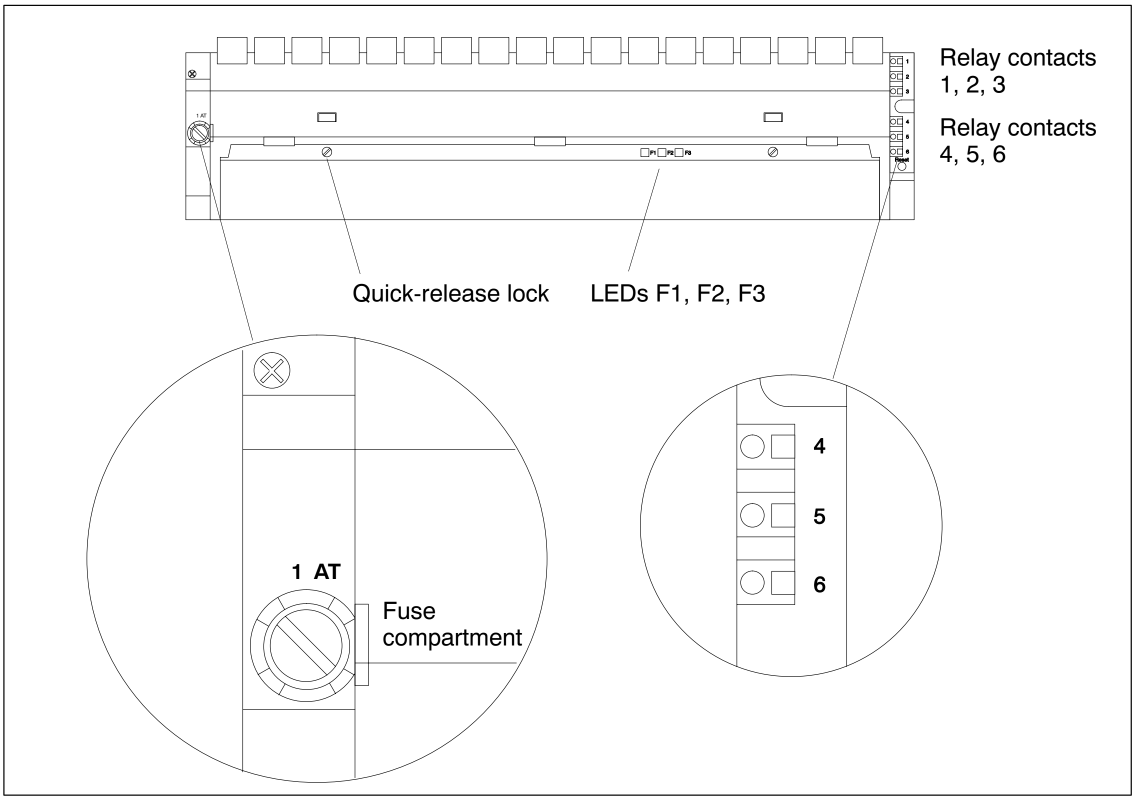


Figure 9-4 Controls and Indicators of the Fan Subassembly 24 VDC (6ES7408-1TA00-0XA0)

Characteristics

The 24 VDC fan subassembly has the same construction and functional characteristics as the 120/230 VAC fan subassembly.

Installation

Installing the 24 VDC fan subassembly is the same as for the 120/230 VAC fan subassembly.

Wiring

You connect the 24 VDC fan subassembly to the 24 VDC supply in the same manner as for the 120/230 VAC fan subassembly. You should note the polarity of the spring connections L+ and L–.

Signaling Concept

The signaling concept of the 24 VDC fan subassembly is identical to the signaling concept of the 120/230 VAC fan subassembly.

Fuse

Included in this fan subassembly are standard cartridge fuse links, 5 x 20 mm, conforming to DIN

- 1.0 AT for 24 V

The fuse is already installed on shipping from the factory.

Shielding Clamps

If you do not require the shielding clamps supplied, do not install them in the fan subassembly.

Technical Specifications

Dimensions, Weights	
Dimensions WxHxD (mm)	482.5 x 109.5 x 235
Weight	appr. 1600 g
Cable diameter	3 to 9 mm
Nominal Sizes	
Lifespan of the fans	
• at 40 °	typ. 70000 h
• at 75 °	typ. 25000 h
Max. contact load of relay contacts 1 to 6	
• Switching voltage	24 VDC
• Switching current	200 mA

Voltages, Currents, Potentials	
Input voltage	
• Nominal value	DC 24 V
• Valid range	Static 19.2 V up to 30 V Dynamic: 18.5 up to 30.2 V
Starting current	0.9 A at 24 V
Fuses	1.0 AT
Power consumption	
• with fan	12 W
• without fan	1.4 W

Caution

Danger of damage to equipment.

If you insert the monitoring PCB in the wrong position in the fan subassembly, the fan subassembly may be damaged.

During maintenance of the unit, make sure you do not replace the monitoring PCB in the wrong position.

Monitoring Function

In the case of a fault (defective fans) the fans are not switched off. Once you have replaced the defective fan(s), the fault is acknowledged automatically as soon as the fans have reached the required speed. Any faults that occur are not stored.

When you switch on the fan subassembly, the fans start running. After approximately 10 s the current status of the fans is indicated via LEDs and relays.

RS 485 Repeater

10

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 *Installation* manual, Chapter “Configuring an MPI or PROFIBUS DP network”.

Chapter Overview

10.1 Application and Characteristics (6ES7972-0AA01-0XA0)

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
- ungrounded segments are to be operated on the bus, or
- the maximum cable length of a segment is exceeded. (See table 10-1).

Table 10-1 Maximum Cable Length of a Segment

Baud Rate	Max. Cable Length of a Segment (in m)
9.6 to 187.5 kbaud	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 10-2.

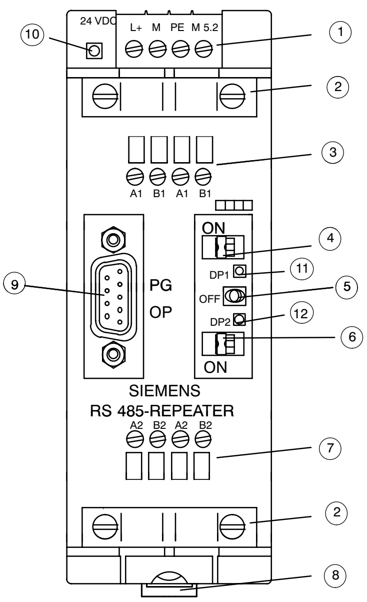
Table 10-2 Maximum Cable Length between Two RS 485 Repeaters

Baud Rate	Maximum Length of Cable between 2 Nodes (in m) with RS 485 Repeater (6ES7972-0AA01-0XA0)
9.6 to 187.5 kbaud	10000
500 kbaud	4000
1.5 Mbaud	2000
3 to 12 Mbaud	1000

10.2 Appearance of the RS 485 Repeater; (6ES7972-0AA01-0XA0)

The table below shows the appearance of the RS 485 repeater and lists its functions.

Table 10-3 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

10.3 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

---

Warning

The bus segment 1 is grounded if you connect a programming device which has a pure MPI interface 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. This does not apply if the PG is equipped with a combo MPI/DP interface.

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 10-1) to the protective conductor.

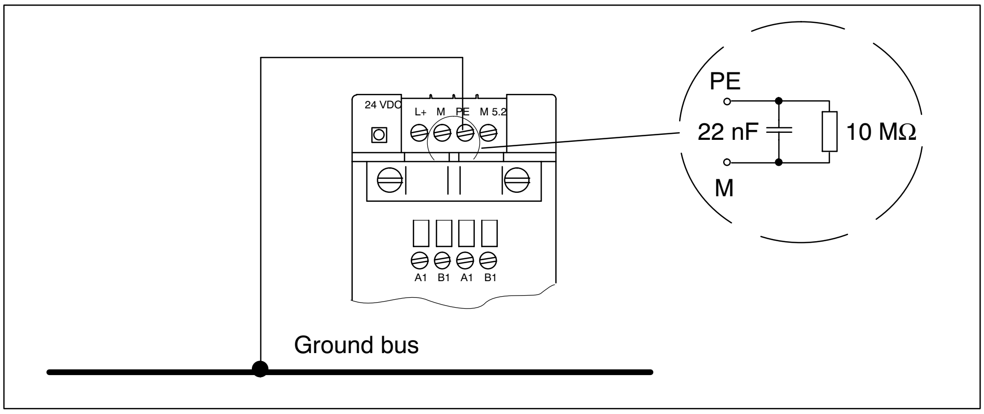


Figure 10-1 RC Network with 10 MΩ for Configuration with Ungrounded Reference Potential

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 10-2 shows the front panel of the RS 485 repeater.

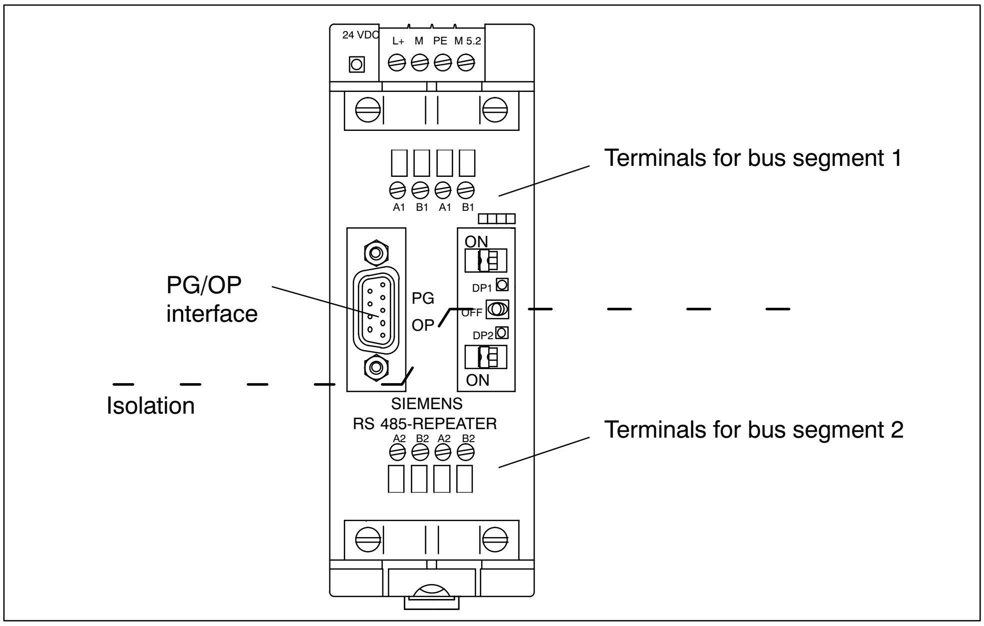


Figure 10-2 Isolation Between the Bus Segments

Amplification of the Bus Signals

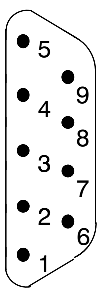
The amplification of the bus signals takes place between the port for bus segment 1 or the PG/OP interface and the port for bus segment 2.

10.4 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

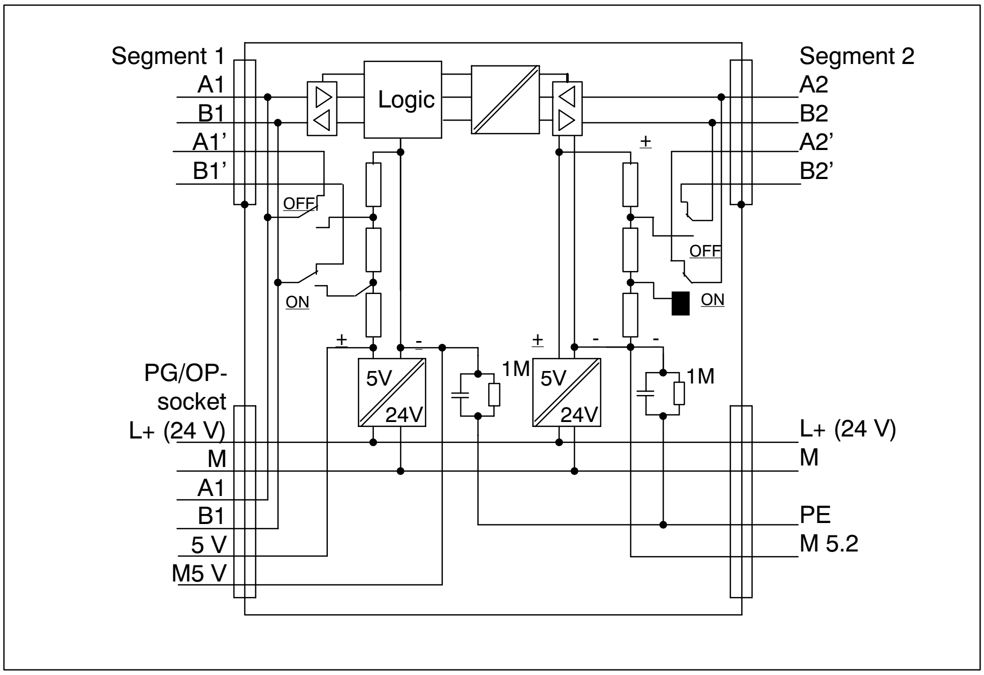


Figure 10-3 Block Diagram of the RS 485 Repeater

Parameter Sets for Signal Modules

A

Chapter Overview

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

Parameters Stored in Data Records

The signal module parameters are stored in data records 0 and 1.

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 of modifiable parameters (data record 1) to the addressed signal module.
56	WR_DPARM	Transfer of parameters (data record 0 **or** 1) from the CPU to the addressed signal module.
57	PARM_MOD	Transfer of all parameters (data record 0 **and** 1) 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 online 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

You can find 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 this purpose 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 to the module with SFCs 56 and 57 (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	**... STEP 7**
Destination CPU for interrupts	0	No	Yes
Input delay		No	Yes
Diagnostics		No	Yes
Hardware interrupt enable	1	**Yes**	Yes
Diagnostic interrupt enable		**Yes**	Yes
Reaction to error*		**Yes**	Yes
Hardware interrupt with rising edge		**Yes**	Yes
Hardware interrupt with falling edge		**Yes**	Yes
Substitute “1”*		**Yes**	Yes

* Only in 6ES7421-7BH00-0AB0

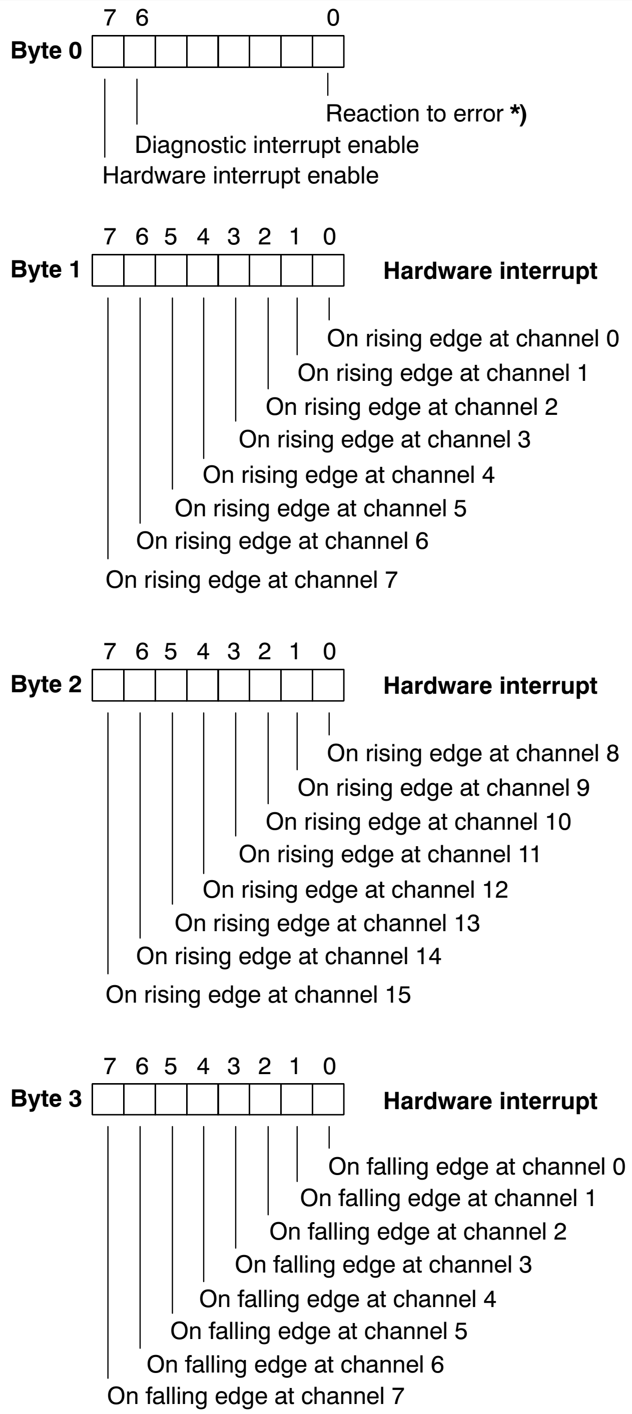
Warning

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 (bytes 0, 1, 2 and 3) for the parameters of the digital input modules.

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



***)** Only in 6ES7421-7BH00-0AB0

Figure A-1 Data Record 1 of the Parameters of the Digital Input Modules

The figure below shows the structure of data record 1 (bytes 4, 5 and 6) for the parameters of the digital input modules.

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

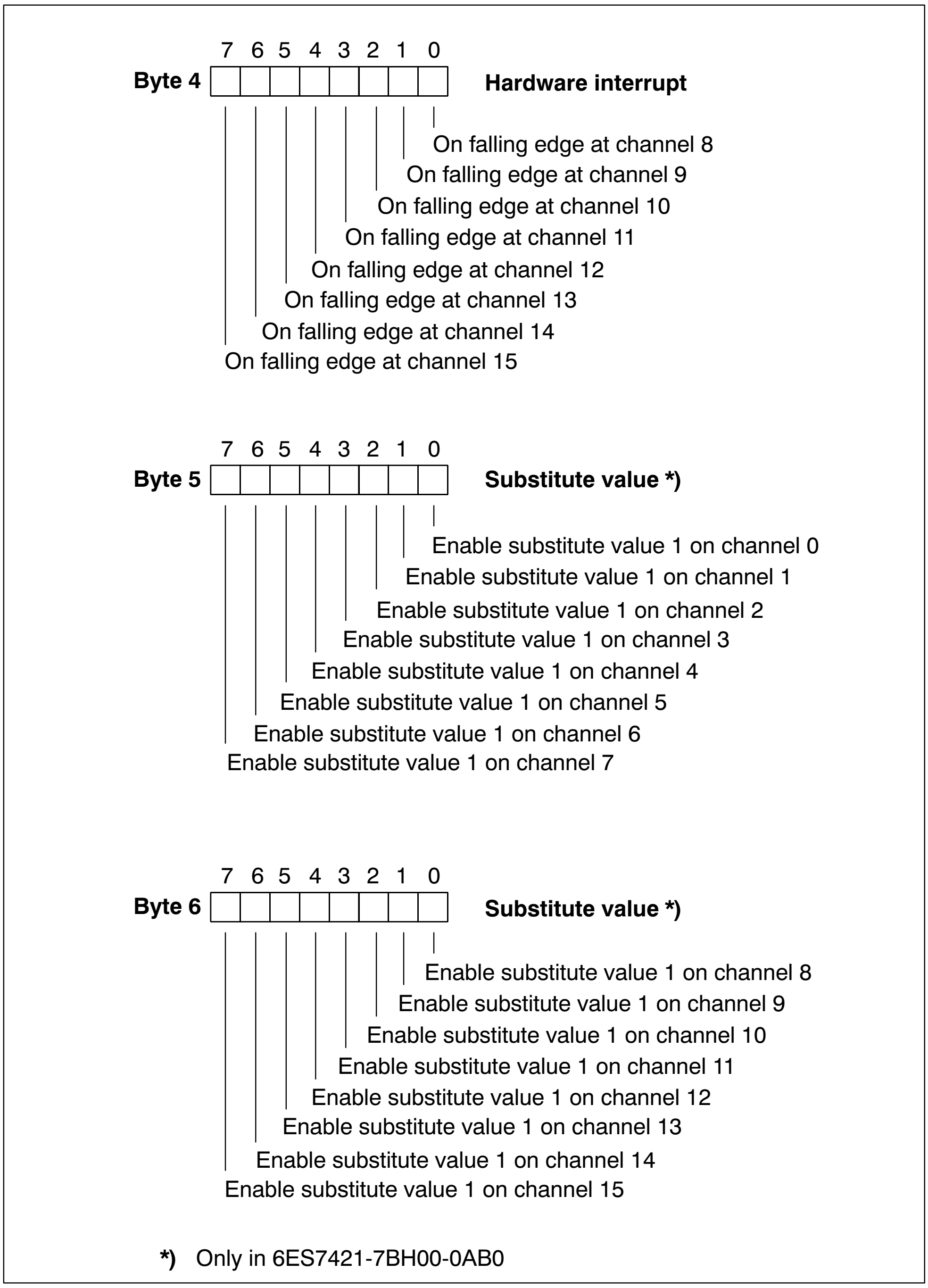


Figure A-2 Data Record 1 for Parameters of the Digital Input Modules

A.3 Parameters of the Digital Output Modules

Parameters

The table below contains all the parameters you can set for digital output modules. The comparison shows:

- Which parameters you can change with STEP 7 and
- Which parameters you can change with SFC 55 “WR_PARM”

The parameters set with STEP 7 can also be transferred to the module with SFCs 56 and 57 (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	**... STEP 7**
Destination CPU for Interrupts	0	No	Yes
Diagnostics		No	Yes
Diagnostic interrupt enable	1	**Yes**	Yes
Reaction to CPU STOP		**Yes**	Yes
Enable substitute value “1”		**Yes**	Yes

Warning

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 (bytes 0, 1 and 2) for the parameters of the digital output modules.

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

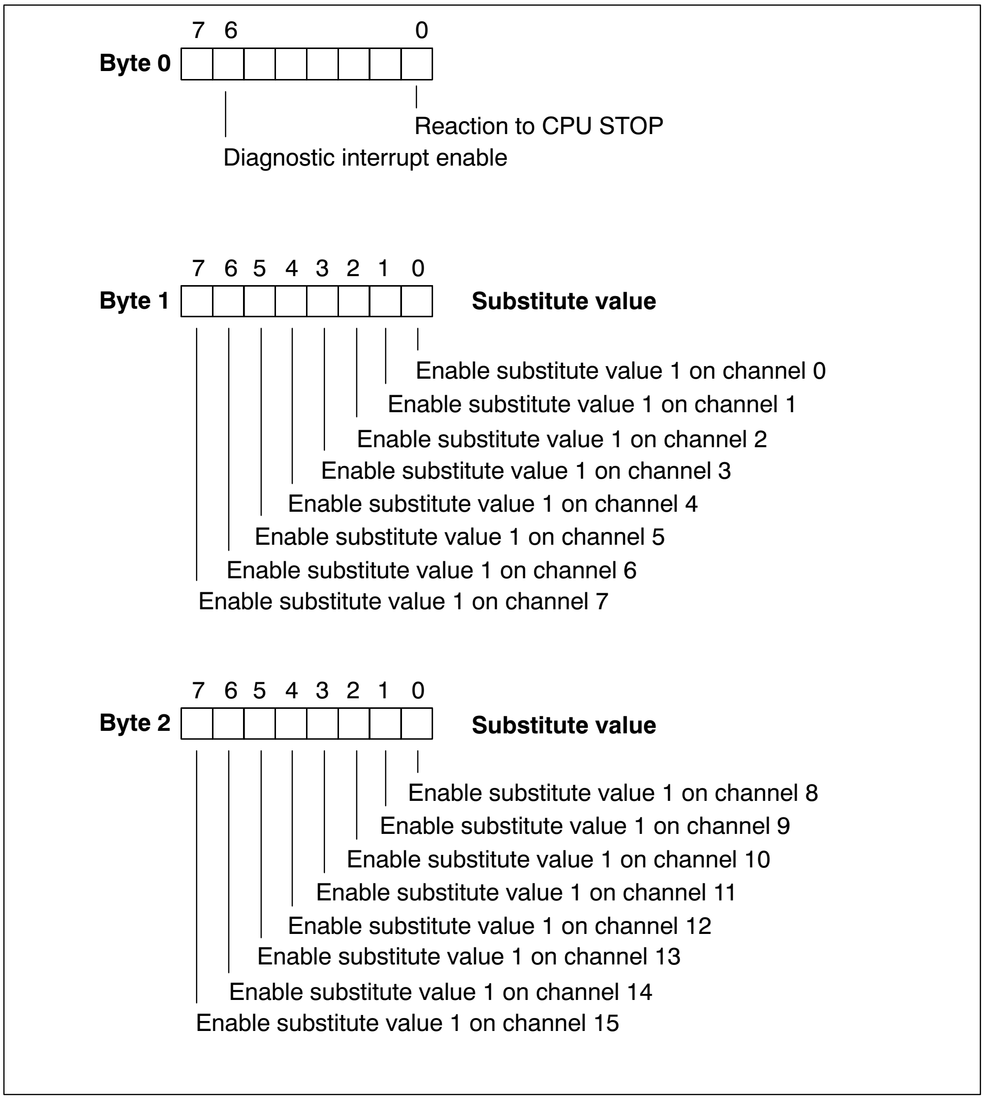


Figure A-3 Data Record 1 for Parameters of the Digital Output Modules

The figure below shows the structure of data record 1 (bytes 3 and 4) for the parameters of the digital output modules.

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

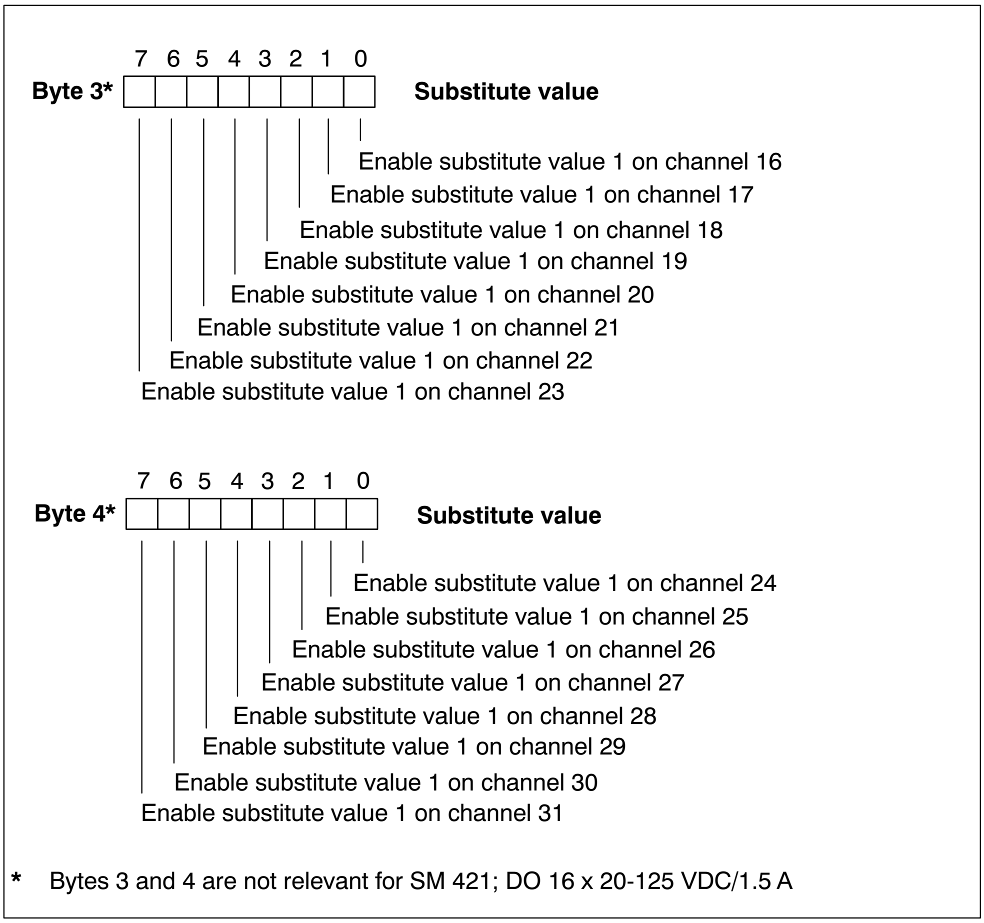


Figure A-4 Data Record 1 for Parameters of the Digital Output Modules

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 to the module with SFCs 56 and 57 (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	**... STEP 7**
Destination CPU for Interrupts	0	No	Yes
Measuring Type		No	Yes
Measuring Range		No	Yes
Diagnostics		No	Yes
Temperature Unit		No	Yes
Temperature Coefficient		No	Yes
Interference Suppression		No	Yes
Smoothing		No	Yes
Reference Junction		No	Yes
End-of-scan-cycle interrupt		No	Yes
Diagnostic interrupt enable	1	**Yes**	Yes
Hardware interrupt enable		**Yes**	Yes
Reference Temperature	1	**Yes**	Yes
High Limit	1	**Yes**	Yes
Low Limit	1	**Yes**	Yes

Warning

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 the parameters of the analog input modules.

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

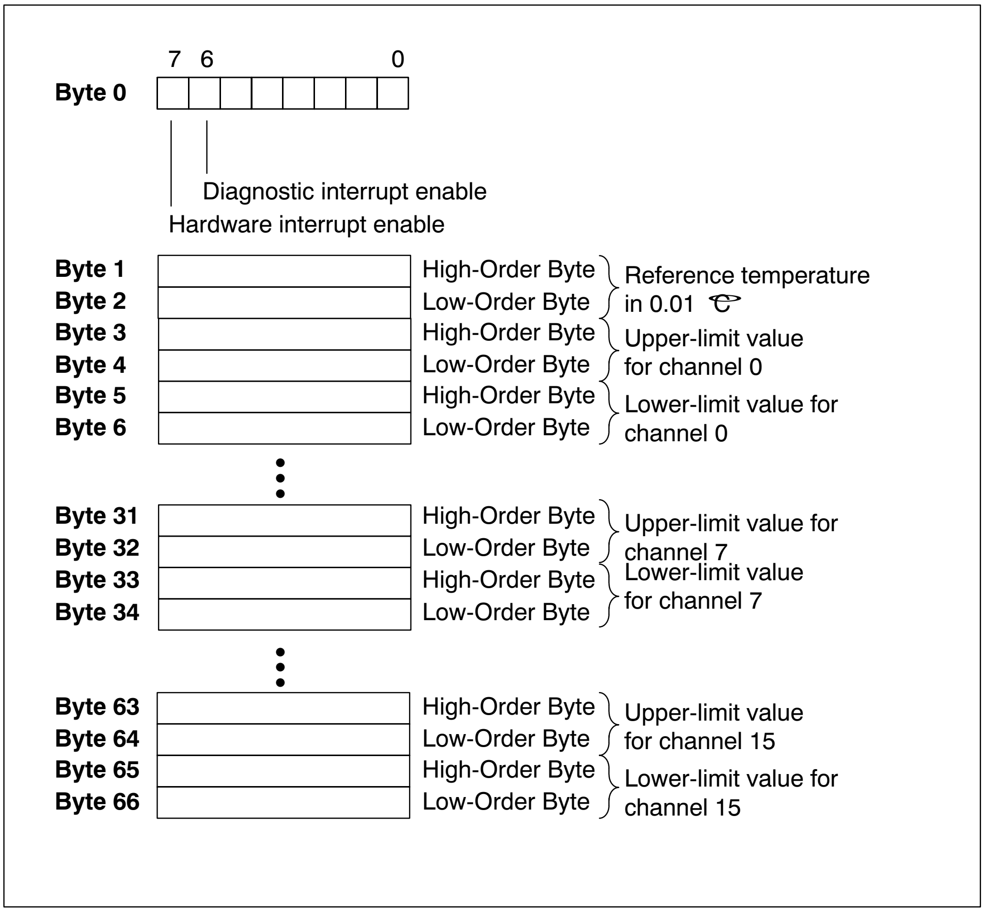


Figure A-5 Data Record 1 for Parameters of the Analog Input Modules

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Warning

The representation of the limit values and the reference temperature corresponds to the analog value representation (see Chapter 6). Please observe the range limits when setting the limit values.

Diagnostic Data of the Signal Modules

B

Chapter Overview

B.1 Evaluating the 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 structure if you want to evaluate the diagnostic 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 43 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 controller.
- Data record 1 contains the four bytes of diagnostic data that are also contained in data record 0 **and** as many as 39 bytes of module-specific diagnostic data.

Further Reading

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 Contents of Diagnostic Data Bytes 0 and 1

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

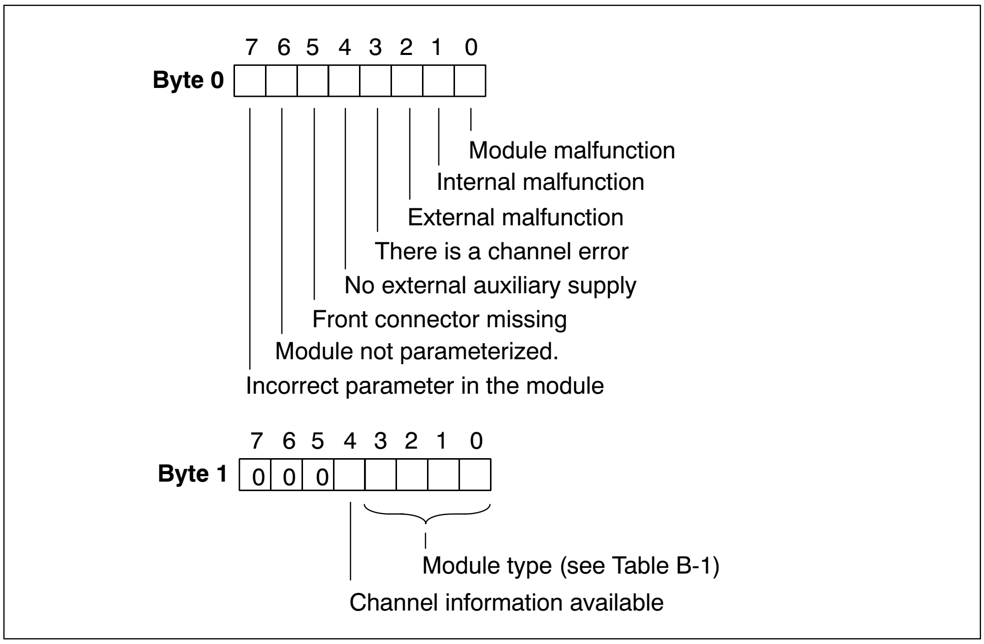


Figure B-1 Bytes 0 and 1 of the Diagnostic Data

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

B.3 Diagnostic Data of the Digital Input Modules as of Byte 2

The structure and contents of the different bytes of the diagnostic data for special digital input modules are described below. 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”.

Bytes 2 and 3 of the SM 421; DI 16 24 VDC

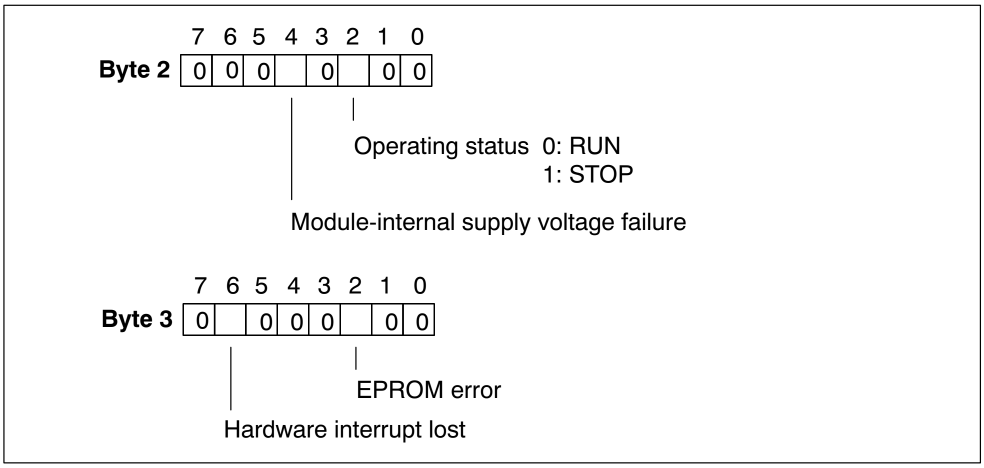


Figure B-2 Bytes 2 and 3 of the Diagnostic Data of the SM 421; DI 16 x 24 VDC

Bytes 4 to 8 of the SM 421; DI 16 x 24 VDC

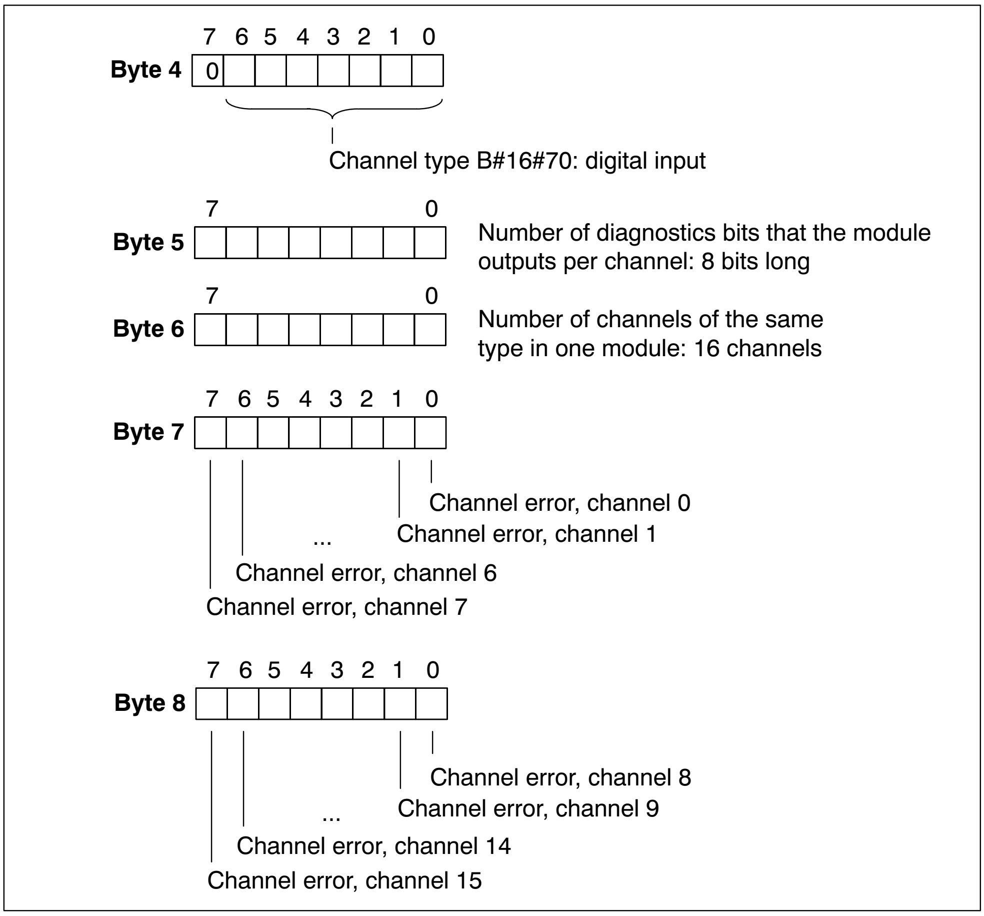


Figure B-3 Bytes 4 to 8 of the Diagnostic Data of the SM 421; DI 16 x 24 VDC

Bytes 9 to 24 of the SM 421; DI 16 24 VDC

Data record 1 with bytes 9 to 24 contains the channel-specific diagnostic data. The figure below shows the assignment of the diagnostic byte for a channel of the module.

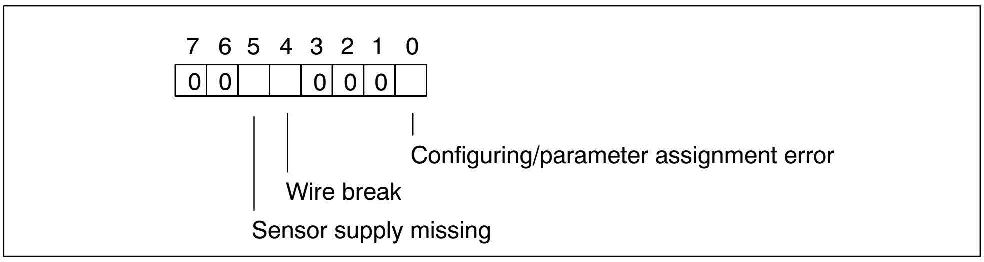


Figure B-4 Diagnostic Byte for a Channel of the SM 421; DI 16 x 24 VDC

Bytes 2 and 3 of the SM 421; DI 16 x 24/60 VUC

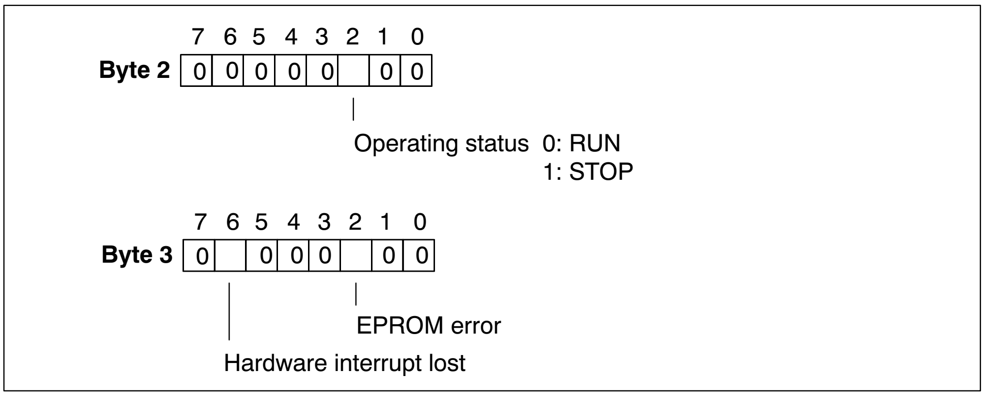


Figure B-5 Bytes 2 and 3 of the Diagnostic Data of the SM 421; DI 16 x 24/60 VUC

Bytes 4 to 8 of the SM 421; DI 16 x 24/60 VUC

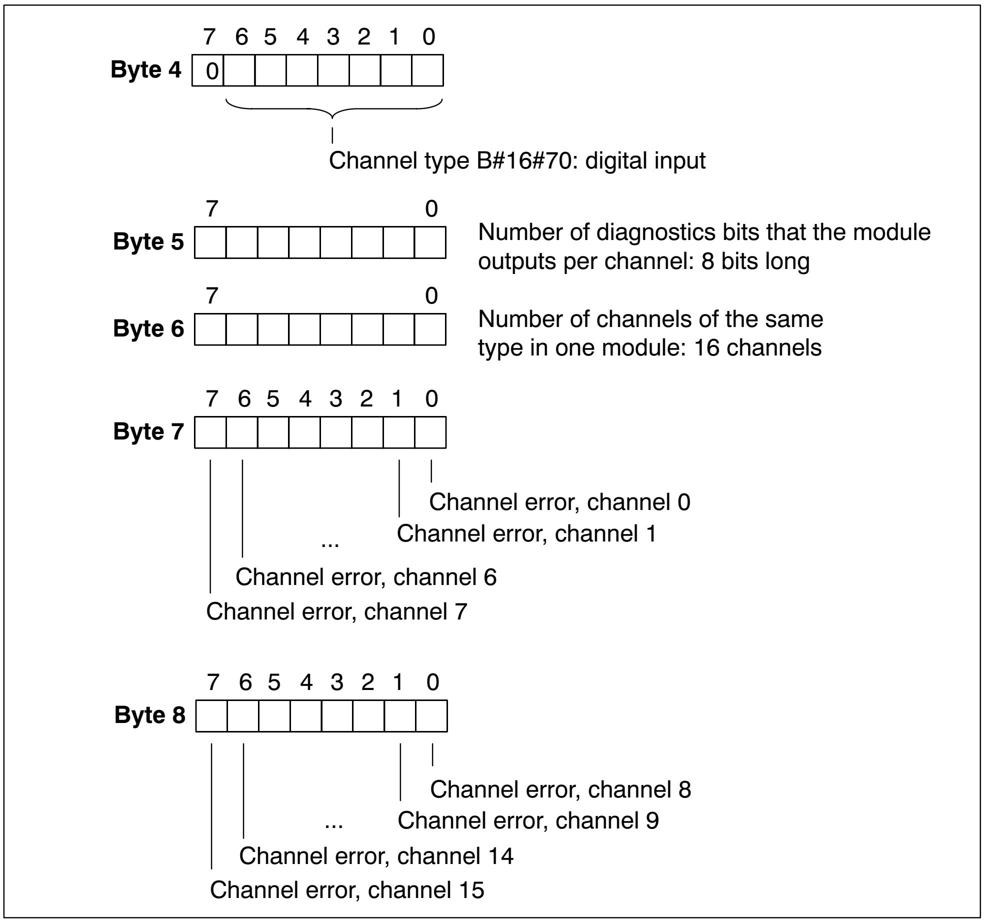


Figure B-6 Bytes 4 to 8 of the Diagnostic Data of the SM 421; DI 16 x 24/60 VUC

Bytes 9 to 24 of the SM 421; DI 16 x 24/60 VUC

Data record 1 with bytes 9 to 24 contains the channel-specific diagnostic data. The figure below shows the assignment of the diagnostic byte for a channel of the module.

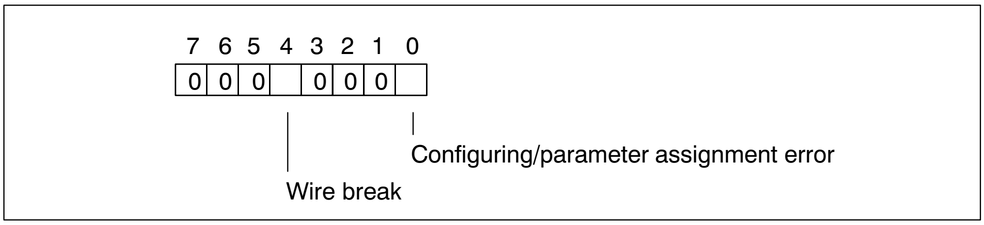


Figure B-7 Diagnostic Byte for a Channel of the SM 421; DI 16 x 24/60 VUC

B.4 Diagnostic Data of the Digital Output Modules as of Byte 2

The structure and contents of the different bytes of the diagnostic data for special digital output modules are described below. 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 on the special module.

Bytes 2 and 3 of the SM 422; DO 16 x 20-125 VDC/1.5 A

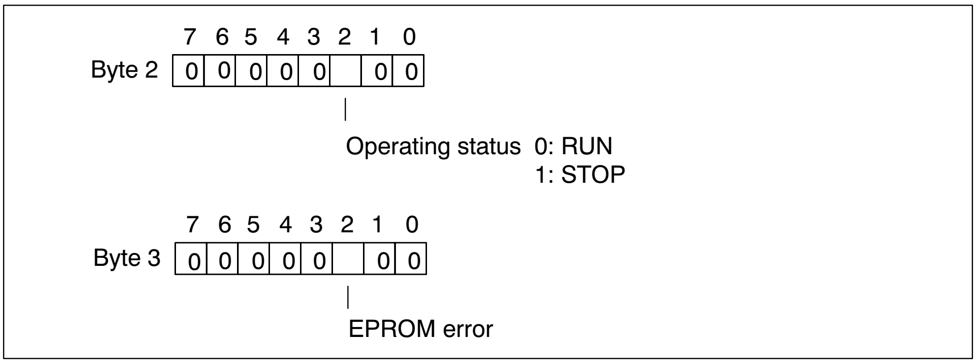


Figure B-8 Bytes 2 and 3 of the Diagnostic Data of the SM 422; DO 16 x 20-125 VDC/1.5 A

Bytes 4 to 8 of the SM 422; DO 16 x 20-125 VDC/1.5 A

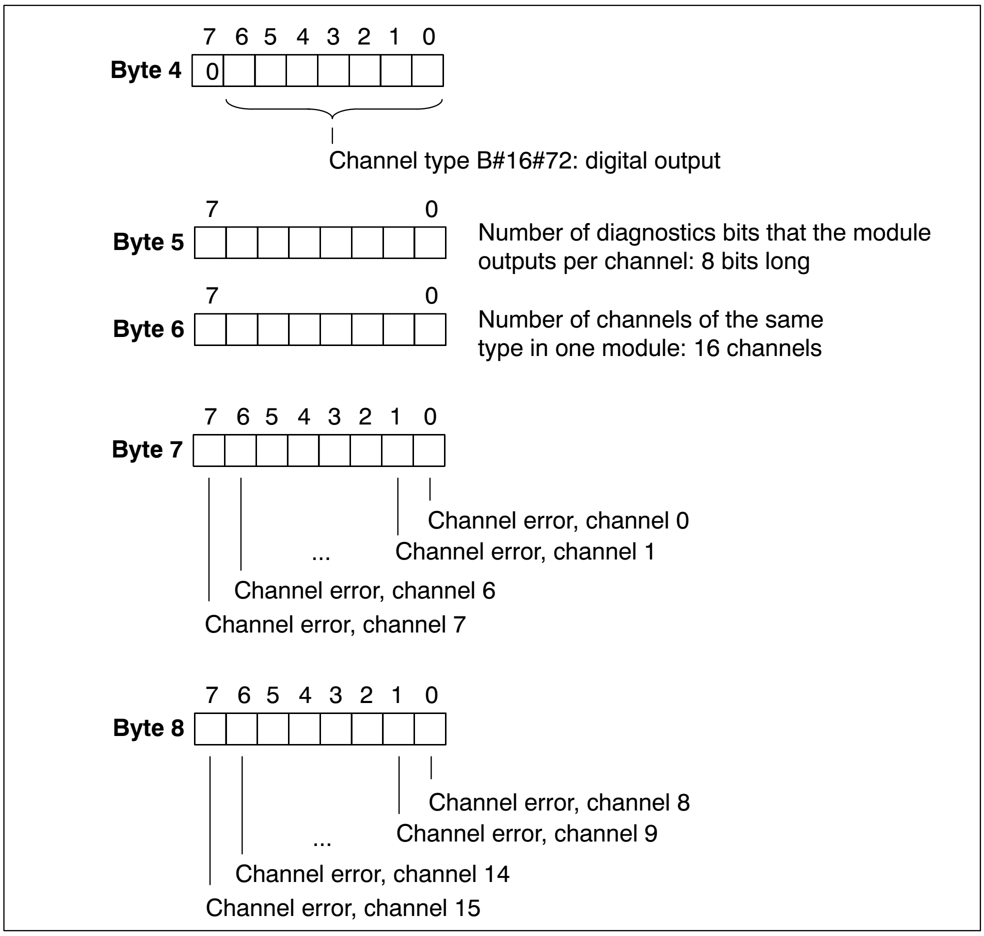


Figure B-9 Bytes 4 to 8 of the Diagnostic Data of the SM 422; DO 16 x 20-125 VDC/1.5 A

Bytes 9 to 24 of the SM 421; DO 16 x 20-125 VDC/1.5 A

Data record 1 with bytes 9 to 24 contains the channel-specific diagnostic data. The figure below shows the assignment of the diagnostic byte for a channel of the module.

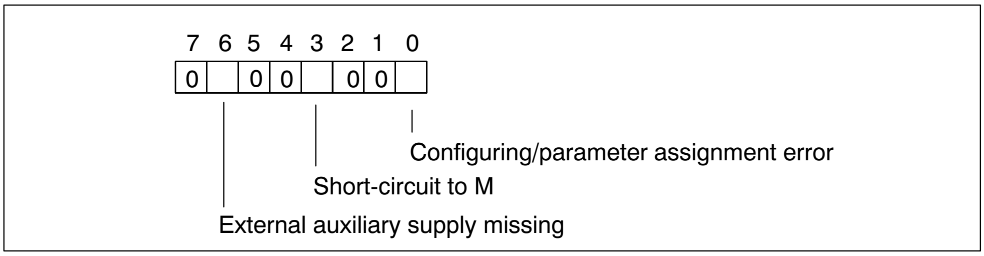


Figure B-10 Diagnostic Byte for a Channel of the SM 422; DO 16 x 20-125 VDC/1.5 A

Bytes 2 and 3 of the SM 422; DO 32 x 24 VDC/0.5 A

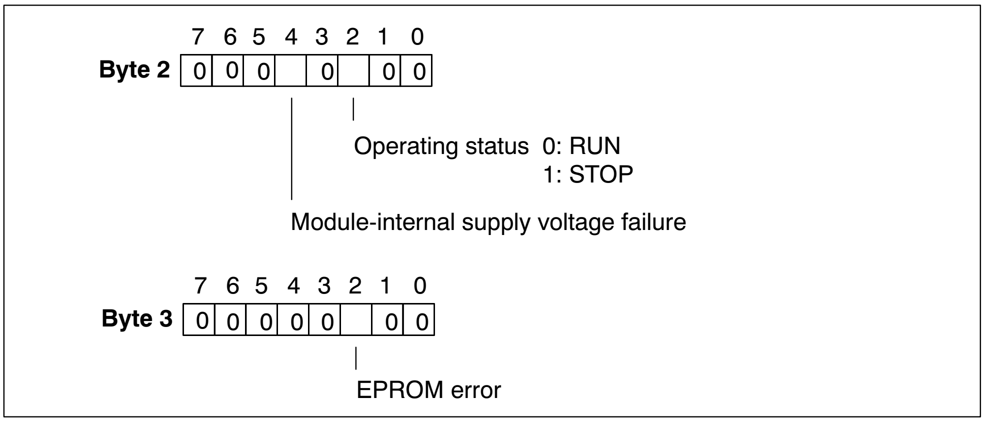


Figure B-11 Bytes 2 and 3 of the Diagnostic Data of the SM 422; DO 32 x 24 VDC/0.5 A

Bytes 4 to 10 of the SM 422; DO 32 x 24 VDC/0.5 A

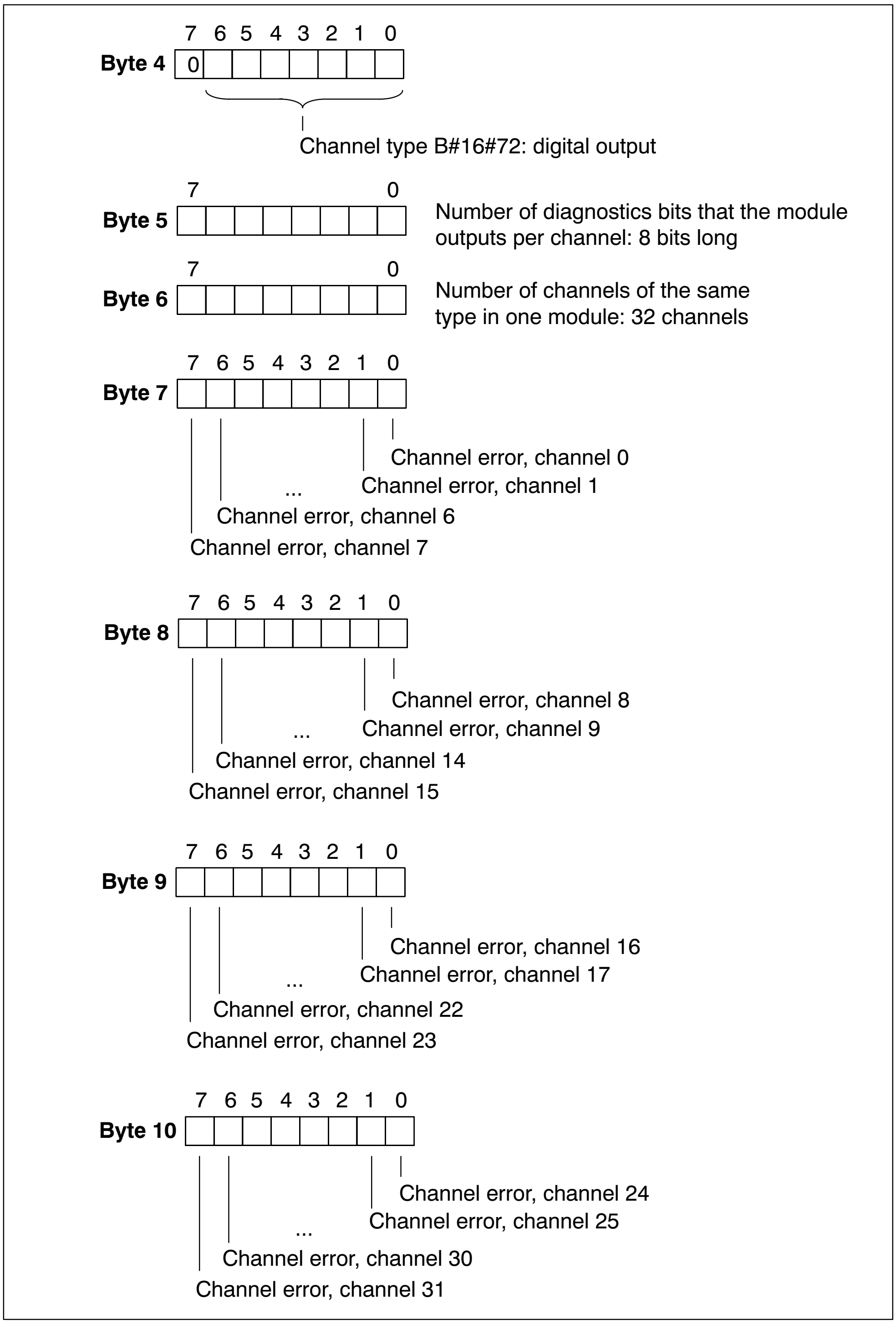


Figure B-12 Bytes 4 to 10 of the Diagnostic Data of the SM 422; DO 32 x 24 VDC/0.5 A

Bytes 11 to 42 of the SM 422; DO 32 x 24 VDC/0.5 A

Data record 1 with bytes 11 to 42 contains the channel-specific diagnostic data. The figure below shows the assignment of the diagnostic byte for a channel of the module.

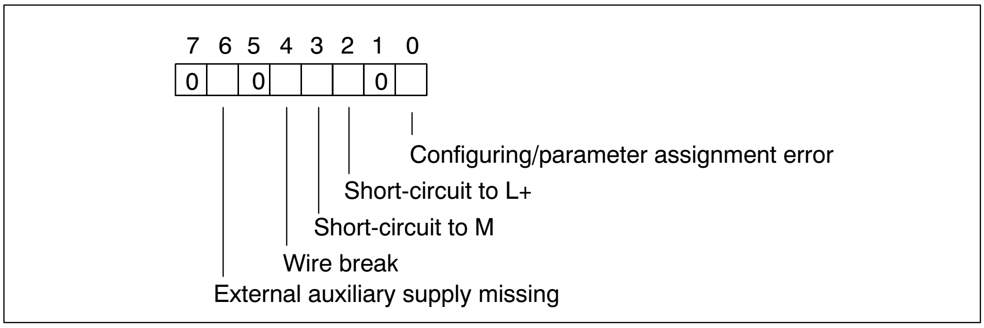


Figure B-13 Diagnostic Byte for a Channel of the SM 422; DO 32 x 24 VDC/0.5 A

Bytes 2 and 3 of the SM 422; DO 16 x 20-120 VAC/2 A

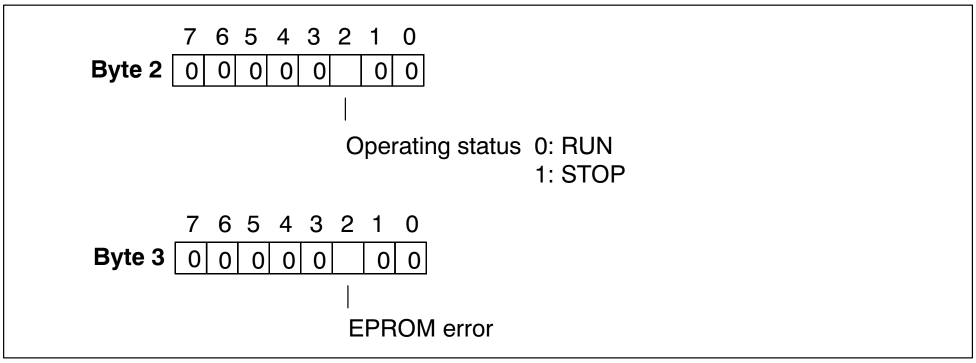


Figure B-14 Bytes 2 and 3 of the Diagnostic Data of the SM 422; DO 16 x 20-120 VAC/2 A

Bytes 4 to 8 of the SM 422; DO 16 x 20-120 VAC/2 A

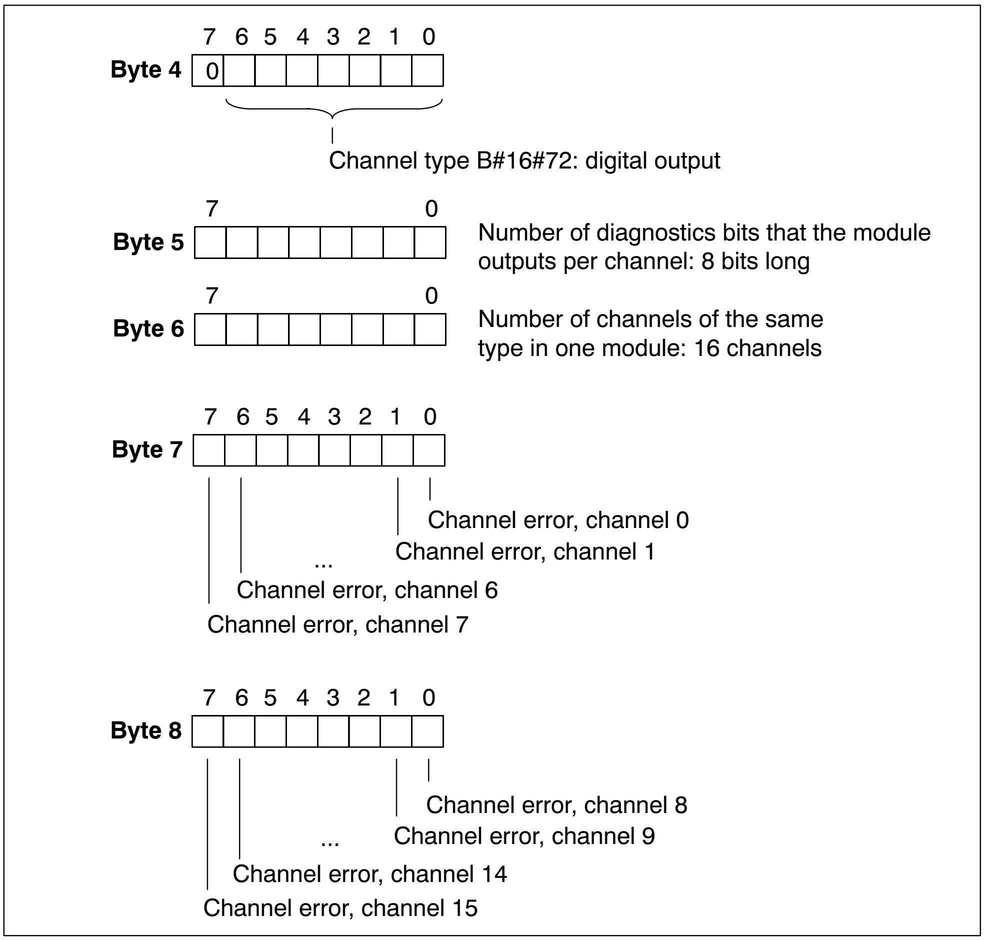


Figure B-15 Bytes 4 to 8 of the Diagnostic Data of the SM 422; DO 16 x 20-120 VAC/2 A

Bytes 9 to 24 of the SM 422; DO 16 x 20-120 VAC/2 A

Data record 1 with bytes 9 to 24 contains the channel-specific diagnostic data. The figure below shows the assignment of the diagnostic byte for a channel of the module.

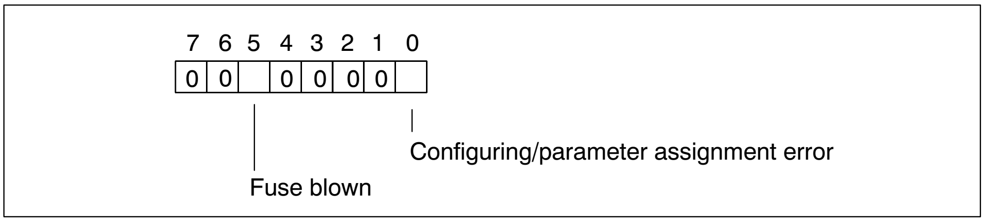


Figure B-16 Diagnostic Byte for a Channel of the SM 422; DO 16 x 20-120 VAC/2 A

B.5 Diagnostic Data of the Analog Input Modules as of Byte 2

The structure and contents of the different bytes of the diagnostic data for the special analog input modules are described below. 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 on the special module.

Bytes 2 and 3 of the SM 431; AI 16 x 16 Bit

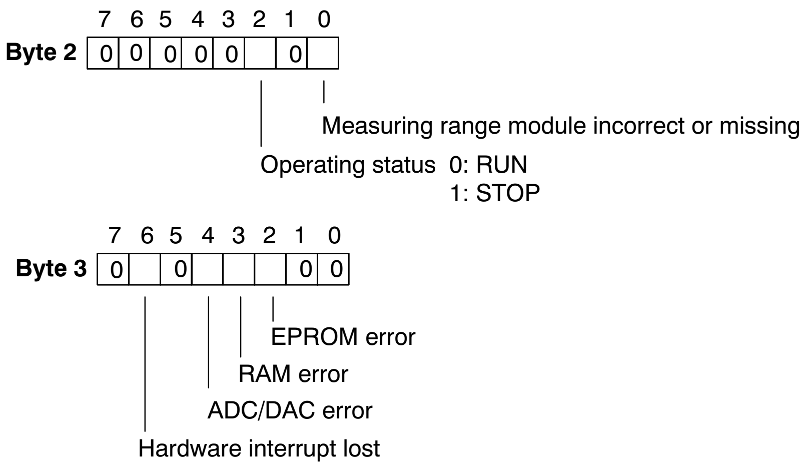


Figure B-17 Bytes 2 and 3 of the Diagnostic Data of the SM 431; AI 16 x 16 Bit

Bytes 4 to 8 of the SM 431; AI 16 x 16 Bit

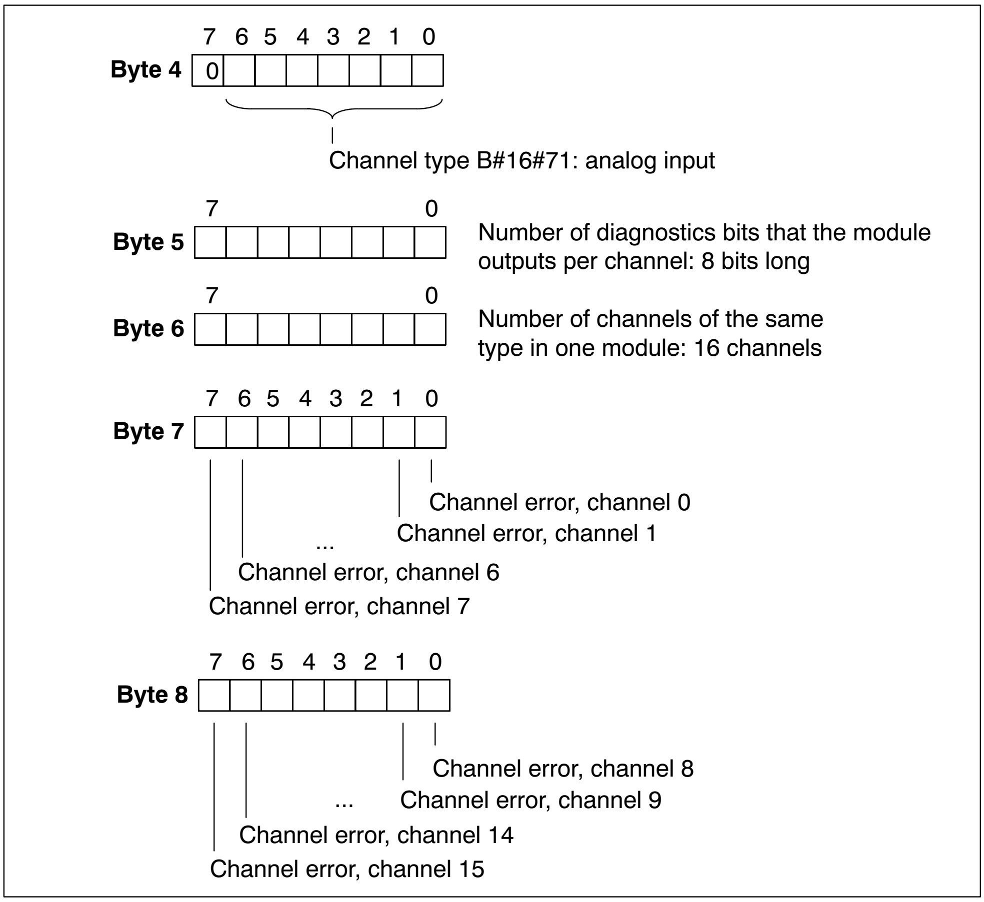


Figure B-18 Bytes 4 to 8 of the Diagnostic Data of the SM 431; AI 16 x 16 Bit

Bytes 9 to 24 of the SM 431; AI 16 x 16 Bit

Data record 1 with bytes 9 to 24 contains the channel-specific diagnostic data. The figure below shows the assignment of the diagnostic byte for a channel of the module.

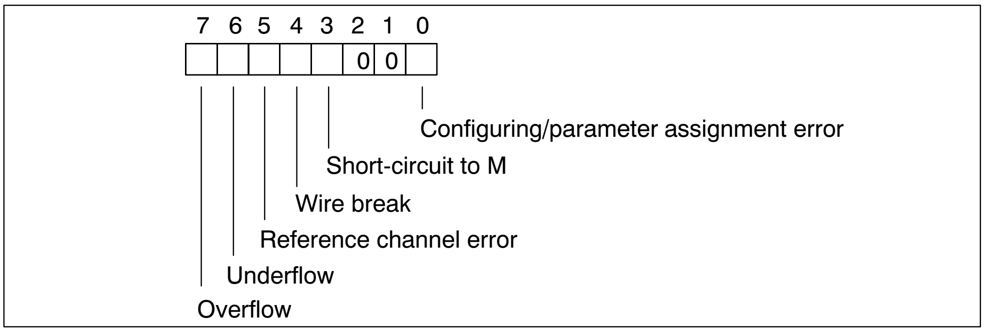


Figure B-19 Diagnostic Byte for a Channel of the SM 431; AI 16 x 16 Bit

Bytes 2 and 3 of the SM 431; AI 8 x RTD x 16 Bit

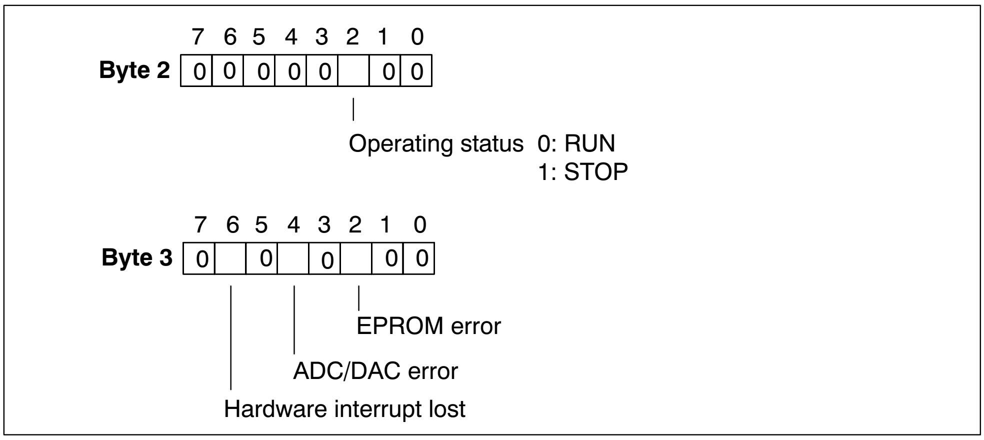


Figure B-20 Bytes 2 and 3 of the Diagnostic Data of the SM 431; AI 8 x RTD x 16 Bit

Bytes 4 to 7 of the SM 431; AI 8 x RTD x 16 Bit

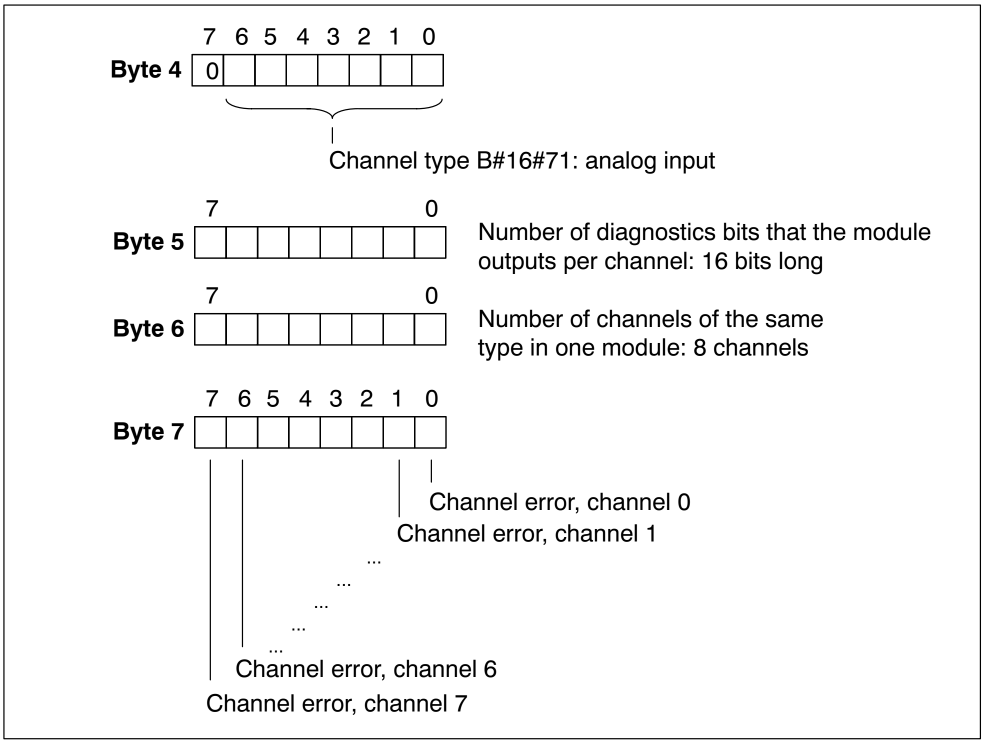


Figure B-21 Bytes 4 to 7 of the Diagnostic Data of the SM 431; AI 8 x RTD x 16 Bit

Bytes 8 to 23 of the SM 431; AI 8 x RTD x 16 Bit

Data record 1 with bytes 8 to 23 contains channel-specific diagnostic data. The following figure shows the assignment of the **even** diagnostic bytes (bytes 8, 10, to 22) for a channel of the module.

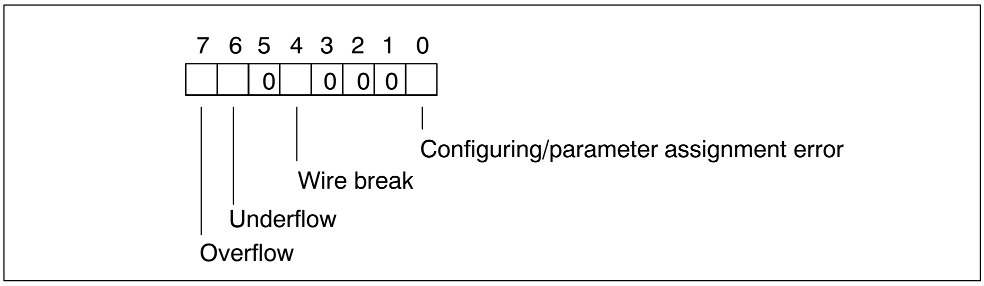


Figure B-22 Even Diagnostic Byte for a Channel of the SM 431; AI 8 x RTD x 16 Bit

The following figure shows the assignment of the **odd** diagnostic bytes (bytes 9, 11, to 23) for a channel of the module.

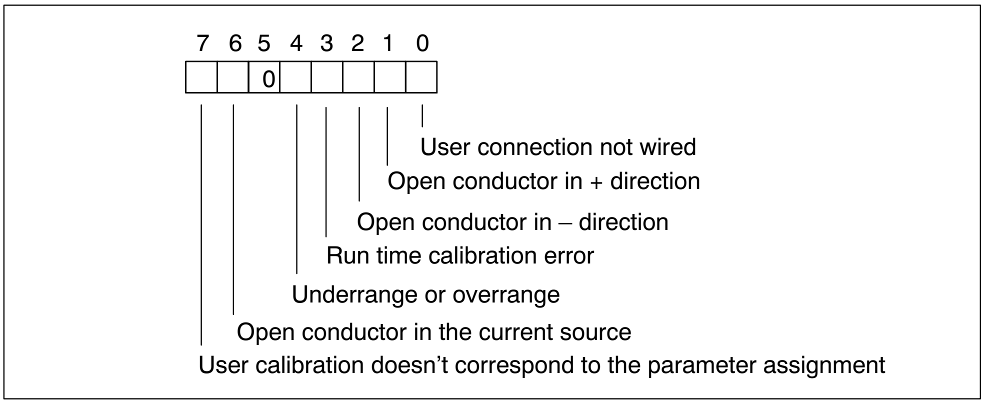


Figure B-23 Odd Diagnostic Byte for a Channel of the SM 431; AI 8 x RTD x 16 Bit

Bytes 2 and 3 of the SM 431; AI 8 x 16 Bit

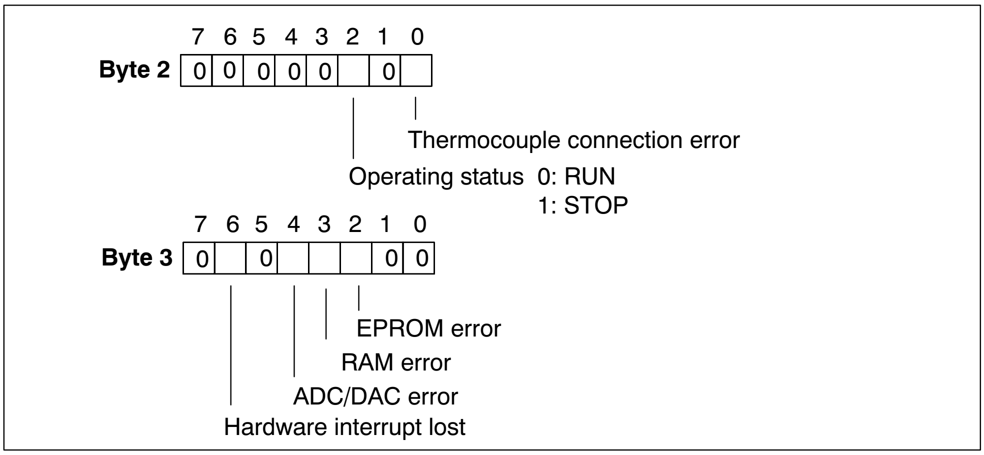


Figure B-24 Bytes 2 and 3 of the Diagnostic Data of the SM 431; AI 8 x 16 Bit

Bytes 4 to 7 of the SM 431; AI 8 x 16 Bit

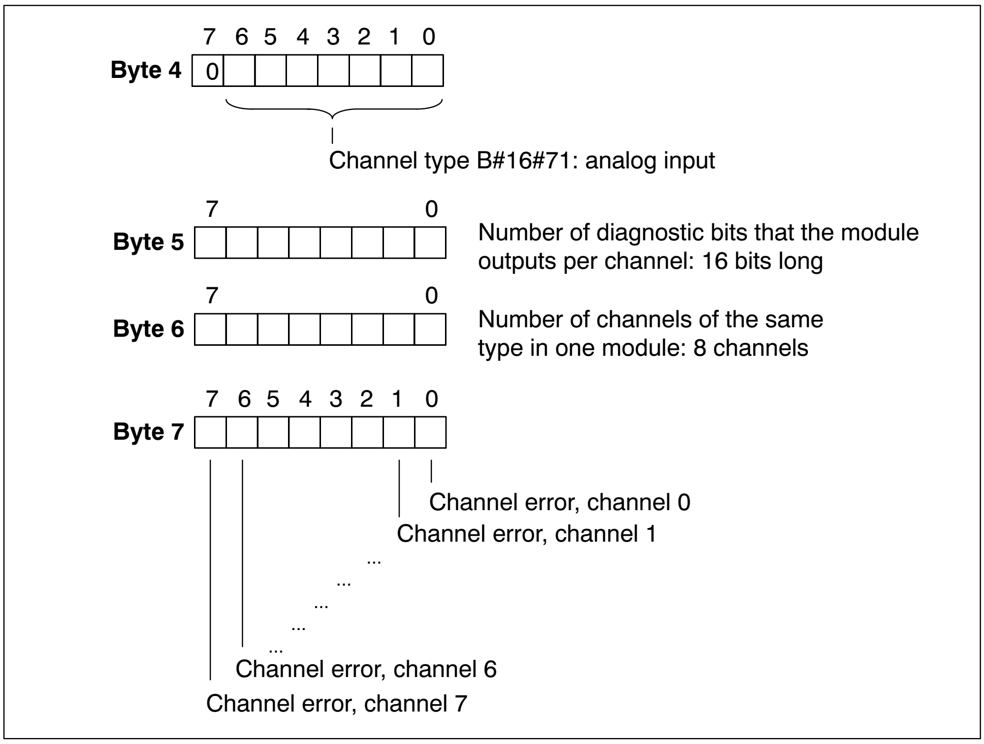


Figure B-25 Bytes 4 to 7 of the Diagnostic Data of the SM 431; AI 8 x 16 Bit

Bytes 8 to 23 of the SM 431; AI 8 x 16 Bit

Data record 1 with bytes 8 to 23 contains channel-specific diagnostic data. The following figure shows the assignment of the **even** diagnostic bytes (bytes 8, 10, to 22) for a channel of the module.

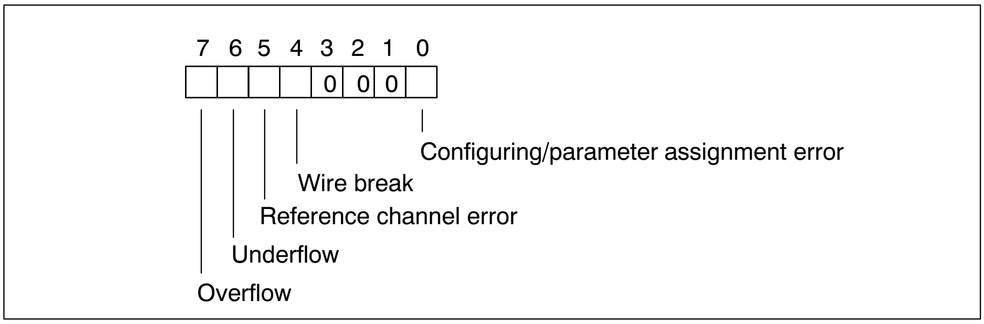


Figure B-26 Even Diagnostic Byte for a Channel of the SM 431; AI 8 x 16 Bit

The following figure shows the assignment of the **odd** diagnostic bytes (bytes 9, 11, to 23) for a channel of the module.

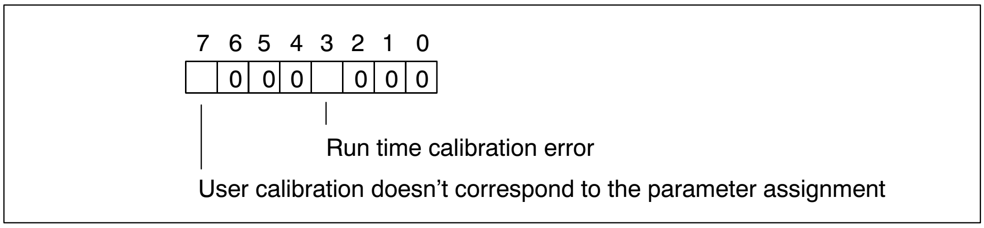


Figure B-27 Odd Diagnostic Byte for a Channel of the SM 431; AI 8 x 16 Bit

Spare Parts and Accessories

C

Spare Parts and Accessories

For Racks	
Number wheel for slot labeling	C79165-Z1523-A22
Spare slot covers (qty 10)	6ES7490-1AA00-0AA0
For Power Supplies	
Spare connector for PS 405 (DC)	6ES7490-0AA00-0AA0
Spare connector for PS 407 (AC)	6ES7490-0AB00-0AA0
Backup battery	6ES7971-0BA00
For Digital Modules/Analog Modules	
Cover foil (10 x) for labeling strips of the SMs	6ES7492-2XX00-0AA0
Cover flap for fuse receptacle on the AC modules	6ES7422-0XX00-7AA0
Measuring range module for analog modules	6ES7974-0AA00-0AA0
Front connector screw-type connection	6ES7492-1AL00-0AA0
Front connector spring connection	6ES7492-1BL00-0AA0
Front connector crimp connection	6ES7492-1CL00-0AA0
Crimping tool for crimp contacts	6XX3 071
Crimp contacts (package of 250)	6XX3 070
Extraction tool for crimp contacts	6ES5 497-8MA11
Fuses, 8 A, quick blow • Wickmann • Schurter • Littelfuse	 194-1800-0 SP001.1013 217.008
Labeling sheet for the front connector, petrol blue	6ES7492-2AX00-0AA0
Labeling sheet for the front connector, beige	6ES7492-2BX00-0AA0
Labeling sheet for the front connector, yellow	6ES7492-2CX00-0AA0
Labeling sheet for the front connector, red	6ES7492-2DX00-0AA0

For IMs	
Terminating connector for IM 461-0	6ES7461-0AA00-7AA0
Terminating connector for IM 461-1	6ES7461-1AA00-7AA0
Terminating connector for IM 461-3	6ES7461-3AA00-7AA0
IM 463-2, send IM, 600 m to IM 314 of the S5	6ES7463-2AA00-0AA0
IM cable with communication bus, 0.75 m	6ES7468-1AH50-0AA0
IM cable with communication bus, 1.5 m	6ES7468-1BB50-0AA0
IM cable with communication bus, 5 m	6ES7468-1BF00-0AA0
IM cable with communication bus, 10 m	6ES7468-1CB00-0AA0
IM cable with communication bus, 25 m	6ES7468-1CC50-0AA0
IM cable with communication bus, 50 m	6ES7468-1CF00-0AA0
IM cable with communication bus, 100 m	6ES7468-1DB00-0AA0
IM cable with current transmission, 0.75 m	6ES7468-3AH50-0AA0
IM cable with current transmission, 1.5 m	6ES7468-3BB50-0AA0
Package with plug adapters for IM 467 FO	6ES7195-1BE00-0XA0
Package with simplex plugs and polishing set for IM 467 FO	6GK1901-0FB00-0AA0
For Interfacing / Networking	
DIN rail 35 mm	6ES5710-8MA...
PROFIBUS bus cable	6XV1830-0BH10 6XV1830-3BH10
PROFIBUS internal cable	6XV1830-0BH10
PROFIBUS grounding cable	6XV1830-3BH10
PROFIBUS bus connector without PG socket	6ES7972-0BA00-0XA0
PROFIBUS bus connector with PG socket	6ES7972-0BB10-0XA0
PROFIBUS bus connector without PG socket for CPU 417	6ES7972-0BA40-0X40
PROFIBUS bus connector with PG socket for CPU 417	6ES7972-0BB40-0X40
PROFIBUS RS 485 bus terminal	6GK1500-0AA00 6GK1500-0AB00 6GK1500-0DA00
PC/MPI cable (5 m)	6ES7901-2BF00-0AA0
For Fan Subassembly	
Spare fan for fan subassembly	6ES7408-1TA00-6AA0
Filters (qty 10) for fan subassembly	6ES7408-1TA00-7AA0
Monitoring PCB for fan subassembly	6ES7408-1TX00-6XA0
Power supply PCB for fan subassembly	6ES7408-1XX00-6XA0
Cabinets	
Cabinet 2200 x 800 x 400 with extension set for SIMATIC S7-400	8 MC 2281-7FC11-8DA1
Extension set for SIMATIC S7-400	8 MC 1605-0BS70-0AA0

Cables	
Connecting cables for printers with • Serial port (COM, 10 m) • Parallel port (Centronics)	 9AB4173-2BN10-0CA0 6AP1901-0AL00
Connecting cable for interface module • 1 m • 2.5 m • 5 m • 10 m	 6ES7368-3BB00-0AA0 6ES7368-3BC00-0AA0 6ES7368-3BF00-0AA0 6ES7368-3CB00-0AA0
V.24 cable	9AB4173-2BN10-0CA0
Connector housing, gray • 9-pin • 15-pin • 25-pin Connector housing, black • 9-pin • 15-pin • 25-pin	 V42254-A6000-G109 V42254-A6000-G115 V42254-A6000-G125 V42254-A6001-G309 V42254-A6001-G315 V42254-A6001-G325

Guidelines for Handling Electrostatic Sensitive Devices (ESD)

D

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.

Chapter Overview

This chapter contains the following sections on electrostatic sensitive devices:

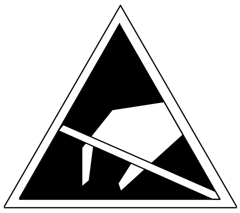
D.1 What is ESD?

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.

D.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 D-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 61000-4-2.

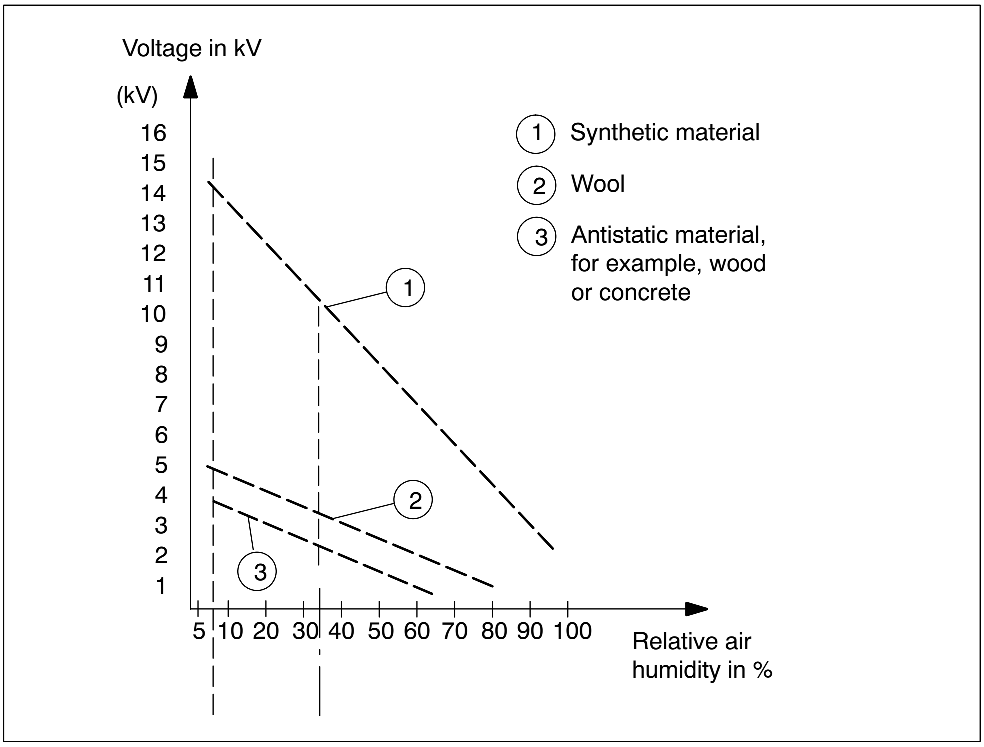


Figure D-1 Electrostatic Voltages which can build up on a person

D.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

E

Abbreviation	Explanation
AC	Alternating current
ADC	Analog to digital converter
AI	Aanalog input
AO	Analog output
AS	Automation system
BAF	Battery failure
BUSF1; BUSF2	LED – bus failure on the MPI/Profibus DP interface 1 or 2
CD	Central device
CH	Channel
COMP	Compensating terminal
CP	Communications processor
CR	Central rack
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
EEPROM	Electrically erasable programmable read-only memory
EPROM	Erasable programmable read-only memory
ER	Expansion rack
ES	Encoder supply
ESD	Electrostatic sensitive devices
EWS	Apply substitute value
EXM	Extension module
EXTF	Error LED “external fault”
FB	Function block
FBD	Function block diagram
FC	Function
FEPROM	Flash erasable programmable read only memory

FM	Function module
FOC	Fiber-optic cable
FRCE	Force
GD	Global data communication
I_C	Constant-current lead
ID	Input delay
IFM1F; IFM2F	LED error at interface module 1/2
IM	Interface module
INTF	Error LED “internal fault”
IP	Intelligent periphery
L+	Terminal for 24 VDC supply voltage
LAD	Ladder logic diagram
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
MRES	Master reset position of the toggle switch
MSM	Mass storage module
MSTR	Master
OB	Organization block
OP	Operator panel
OS	Operator system
PIQ	Process-image output table
PII	Process-image input table
PLC	Programmable logic controller
PG	Programming device
PS	Power supply
Q_I	Analog output current
Q_V	Analog output voltage
RAM	Random access memory
REDF	Redundancy fault
R_L	Load impedance
S +	Sensor lead (positive)
S –	Sensor lead (negative)
SCL	Structured control language
SP	Sensor power

SF	“Group error” LED
SFB	System function block
SFC	System function
SM	Signal module
SSI	Synchronous serial interface
SSL	System status list
STL	Statement list (representation type in *STEP 7*)
TD	Text display
TR	Transducer
U_{CM}	Common mode voltage
U_H	Auxiliary voltage
U_{iso}	Potential difference between M_{ANA} and local ground
UC	Universal current
UR	Universal rack
USR	USR
Vs	Sensor voltage
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 that defined data areas and memory markers, timers and counters are kept → retentively.

Backup voltage, external

You can obtain the same kind of backup if you apply backup voltage to the “EXT.-BATT.” socket of the CPU (DC voltage between 5 V and 15 V) as you can with a backup battery.
External backup voltage is required if you want to replace a power supply module and to provide a backup supply while the user program and data (for example, memory markers, timers, counters, system data, integrated clock) stored in RAM are to be buffered for the time it takes to replace the module.

Basic error limit

The basic error limit is the operation limit at 25 °C, referenced to the rated range of the analog module.

Bus segment

A bus segment is a self-contained section of a serial bus system. Bus segments are interconnected by means of → repeaters.

Central controller

An S7-400 consists of a central controller (CC) that can be allocated expansion units (EU), as required. The central controller is the mounting rack that contains the → CPU.

Central processing unit

→ CPU

Cold restart

→ Restart of the programmable controller and its user program, after all the dynamic data (variables of the input/output image, internal registers, timers, counters, etc. and the corresponding program sections) have been reset to a specified value.
A cold restart can be automatically triggered, such as after a power failure or loss of information in dynamic memory sections, etc., or manually by pressing the reset key.

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 load

This is the load on the cyclic program scanning of a CPU caused by communication operations (for example, via → PROFIBUS DP).
To prevent communication operations overloading cyclic program scanning, you can set the maximum permissible load that communication can place on the scan cycle by parameter assignment in *STEP 7*.

Communication processor

Programmable module for communication tasks, such as networking, point-to-point connection.

Comparison point

Parameter in *STEP 7* for analog input modules. Using this parameter, you can determine the reference junction (the point where the temperature is known) when thermocouples are used. The following can be reference junctions: resistance thermometer on channel 0 of the module; → compensating box, → reference temperature.

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 → reference junction.

CP

→ Communication processor

CPU

The CPU (central processing unit) is a CPU module of the → programmable controller that stores and runs the user program. It contains the operating system, memory, processing unit and communication interface.

Data block

Data blocks (DB) are data areas in the user program that contain user data. Global data blocks can be accessed by all code blocks, whereas instance data blocks are assigned to a specific FB call.

Data, static

Static data is data that can only be used within a → function block. The data is saved in an instance data block belonging to the function block. The data stored in this way is retained until the next function block call.

Data, temporary

Temporary data are → local data of a block that are stored in the L stack during execution of a block and that are no longer available after execution.

Declaration

Assigning variables (parameters or local data of a block, for example) with a name, data type, comment, etc.

Default setting

The default setting is a sensible basic setting that is used whenever no other value is used.

Destruction limit

Limit of the permissible input voltage / current. The accuracy of the measurement may deteriorate if this limits is violated. The internal measurement circuit could be destroyed if this limit is exceeded.

Diagnostic buffer

The diagnostic buffer is a buffered memory area in the CPU in which the diagnostic events are stored in the order in which they occur.
For troubleshooting, the user can read out the exact error cause in *STEP 7* (PLC → Module Information) from the diagnostic buffer.

Diagnostic data

All the diagnostic events that occur 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 to the → CPU by means of diagnostic interrupts. The operating system of the CPU calls OB 82 in the course of a diagnostic interrupt.

Diagnostics

Generic term for → system diagnostics, process error diagnostics and user-defined diagnostics.

Direct communication

Direct communication involves assigning local input address areas of an intelligent DP slave (for example, CPU 315-2 with PROFIBUS DP connection) or of a DP master to the input address areas of a PROFIBUS DP partner. The intelligent DP slave or DP master receives the input data that the PROFIBUS DP partner sends to its DP master via these assigned input address areas.

DP master

A node with a master function in the PROFIBUS DP. A master that behaves in accordance with the EN 50170 with the DP protocol is a DP master. The bus access right (token) is only passed amongst masters. The slaves, in this case DP slaves, can only respond on the request of a master. The following distinctions are made:
DP master (class 1): executes the user data communication with the DP slaves assigned to it.
DP master (class 2): provides services such as: reading of the input/output data, diagnostics, global control.

DP slave

A → slave that is operated on the PROFIBUS bus system with the PROFIBUS DP protocol is called a DP slave.

Constant bus cycle time

The constant bus cycle time is a DP bus cycle that is accurate to a few μs and can be configured in *STEP 7*.

Equipotential bonding

An electrical connection (equipotential bonding conductor) that 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

FB

→ Function block

FC

→ Function

Fiber-optic cable

A fiber-optic cable is a transmission medium made of glass fiber or plastic. Fiber-optic cables are resistant to electromagnetic faults and they make fast data transfer rates possible.

Force

The “Force” function overwrites a variable (for example, memory marker, output) with a value defined by the user.
At the same time, the variable is assigned write protection so that this value cannot be modified from any point (including from the *STEP 7*user program). The value is retained after the programming device is disconnected.
Write protection is not canceled until the ”Unforce” function is called and the variable is written again with the value defined by the user program.
During commissioning, for example, the “Force” function allows certain outputs to be set to the ”ON” state for any length of time even if the logic operations of the user program are not fulfilled (for example, because inputs are not wired).

FREEZE

Control command. The inputs of the → DP slaves are frozen to the current value.

Function

A function (FC) in accordance with IEC 1131-3 is a → code block **without** → static data. A function allows parameters to be passed in the user program. Functions are therefore suitable for programming complex functions, such as calculations that are frequently repeated.

Functional grounding

Grounding which has the sole purpose of safeguarding the intended function of the electrical equipment. Functional grounding short-circuits interference voltage that would otherwise have an impermissible impact on the equipment.

Function block

A function block (FB) in accordance with IEC 1131-3 is a → code block **with** → static data. Because an FB has a memory, its parameters (outputs, for example) can be accessed from any position in the user program.

Fuse blown

Parameter in *STEP 7* for digital output modules. When the parameter is enabled, the failure of one or more fuses is detected by the module. With corresponding parameter assignment, a → diagnostic interrupt is triggered.

Global data

Global data are data that can be addressed from any → code block (FC, FB, OB). In detail, this refers to bit memories (M), inputs (I), outputs (Q), timers, counters and data blocks (DB). Absolute or symbolic access is possible to global data.

Global data communication

Global data communication is a method of transferring → global data between CPUs.

Ground

The ground is the total number of all the interconnected inactive parts of a device that cannot take on a hazardous voltage in the event of a fault.

Ground

The conductive ground whose electric potential can be set to zero at any point. In the proximity of grounding electrodes, the ground can have a potential other than zero. The term ”reference ground” is frequently used to describe such circumstances.

Ground, to

To ground means to connect an electrically conductive part via 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 in response to a particular event in the process (limit value violation; the module has completed the cyclic change 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 processed.

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 that can be obtained 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

The integration time is the inverse value of the → interference frequency suppression in ms.

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

→ Hardwareinterrupt

Interrupt, hardware

→ Hardware interrupt

Interrupt response time

The interrupt response time is the time from when an interrupt signal first occurs to calling the first instruction in the interrupt OB. The following general rule applies: Higher priority interrupts take precedence. This means that the interrupt response time is increased by the program processing time of the higher priority interrupt OBs and interrupt OBs with the same priority that have not yet been processed (queue).

I/O bus

This is part of the → backplane bus in the programmable controller, optimized for the rapid exchange of signals between the CPU(s) and the signal modules.
User data (for example, digital input signals of a signal module) and system data (for example, default parameter data records of a signal module) are transferred via the I/O bus.

Isolated

With optically isolated input/output modules, the reference potentials of the control and load circuit are galvanically isolated (by an optocoupler, contact assembly or repeater, for example). Input/output circuits can be connected to common potential.

Keep last value (KLV)

The module retains the last value read out before STOP mode.

Linearity error

Defines the maximum offset between the measured / output value and the ideal linear relationship between those signals and the digital value. The value is defined as a percentage and refers to the rated range of the analog module.

Load memory

The load memory is part of a programmable module (CPU, CP). It contains objects generated by the programming device (load objects). It is implemented either as a plug-in memory card or a permanently integrated memory. In the case of SIMATIC, the load memory can also be defined as a directory on the hard disk.

Measuring principle, instantaneous value encoding

A module with instantaneous value encoding is always used for very fast measuring operations or variables that change very rapidly. In this process, the module accesses the variable to be measured as fast as possible and delivers an instantaneous snapshot of the signal at a particular time. Due to this measuring procedure, the modules are more “sensitive” than modules with an integrating measuring procedure. Interference affecting the measured value can thus corrupt the result. You must ensure when using these modules that the measuring signal is clean by adhering strictly to the installation guidelines, for example.

Measuring principle, integrating

A module with an integrating measuring procedure is always used for non-time-critical measuring operations. The integration time is inversely proportional to the line frequency. You can set the latter in STEP 7. This then gives you the integration time. If the line frequency is 50 Hz, the integration time is 20 ms or an even multiple of that. Because the measured value is included up to exactly this time period, at least one or more whole periods of the line frequency, which may overlay the measuring signal, are also included. The average value of the error is therefore included as zero (positive part of the first half period = negative part of the second half period). Only the user signal is thus recorded.

Measuring range module

Measuring range modules are plugged into the analog input modules for adaptation to different measuring ranges.

Memory reset

In a memory reset, the following memories of the CPU are deleted: working memory, write/read area of the load memory, system memory.
The MPI parameters and diagnostic buffer are preserved.

Mode selector

Using the mode selector, the user can set the current operating mode of the CPU (RUN, RUN-P, STOP) or reset the memory of the CPU (MRES).

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

Non-isolated

In the case of non-isolated input/output modules, the reference potentials of the control and load circuit are electrically connected.

Operating mode

The SIMATIC S7 programmable controllers have the following operating modes: STOP, → STARTUP, RUN and STOP.

Operating limit

Defines the measured / output value of the analog module within its entire temperature range, referenced to the rated range of the analog module.

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.

Parameters

1st tag of a → logic block
2nd 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*.

PG

→ Programming device

PLC

→ Programmable controller

Point-to-point connection

Only two nodes are physically linked with one another in a point-to-point connection. This type of communication link is used if the use of a communication network is not recommended or when, for example, different types of partners, such as a PLC and a process computer, are to be connected.

Priority class

The operating system of an S7 CPU has a maximum of 28 priority classes (= program execution levels) – for cyclic program scanning or program scanning controlled by hardware interrupt, for example.
Each priority class is assigned → organization blocks in which the user can program a response. By default, the OBs have different priorities determining the order in which they are executed or interrupted in the event that they are activated simultaneously. The user can change the default priorities.

Process image

The signal states of the digital input and output modules are stored in the CPU in a process image.
A distinction is made between the process input image and the process output image. 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 complying with EN 50170, Part 3, such as drives or valve terminals, are moved by the automation system to the process on site, over a distance of up to 23 km. The modules and field devices are connected to the programmable controller by means of the PROFIBUS-DP fieldbus and addressed in the same way as central I/O.

Programmable controller

A programmable controller → consists of a → central device, a CPU and diverse input/output modules.

Programming device

A programming device (PG) is an industry-standard, compact personal computer. A PG is completely equipped for programming SIMATIC programmable controllers.

Protection level

The SIMATIC S7 access protection concept prevents the central processing unit from being accessed by unauthorized persons. It has three protection levels:
Protection level 1: all program device functions allowed
Protection level 2: read-only program device functions allowed
Protection level 3: no program device functions allowed

RC element

Series connection of ohmic resistance and capacitor. When a load is disconnected, overvoltage occurs in circuits with inductive load. This can result in an arc and reduce the lifetime of the contacts. To suppress this arc, you can bridge the contact with an RC element.

Reference ground

→ Ground

Reference channel error

Parameter in *STEP 7* for analog input modules. Using this parameter, you can enable the group error message of the reference junction when thermocouples are used. A reference channel error occurs when thermocouples are used and the following occurs:

- If an error occurs (for example, wire break) on a reference channel on which a thermal resistor (RTD) is connected to compensate for temperature drift (channel 0).
- If the → reference temperature is outside the permissible range of values.

Each input channel that is assigned the “RTD on Channel 0” reference junction has a reference channel error in the situation described above. The measured temperature is no longer compensated.

Reference potential

Potential from which the voltages of the circuits involved are viewed and measured.

Reference temperature

Parameter in *STEP 7* for analog input modules. The reference temperature is the temperature at the reference junction (in 1/100 ºC climatic temperature range) when thermocouples are used. The reference temperature makes it possible to measure the temperature correctly using thermocouples. The temperature at the reference junction must be known because a thermocouple always measures the difference in temperature between the measuring point and the reference junction.

Repeater

A device for the amplification of bus signals and connection of → bus segments over long distances.

Repetitive accuracy

The repetitive accuracy identifies the maximum deviation between measured/output values when recursive input or output values are applied. Refers to the rated range of the module and applies to the transient state at a specific temperature.

Resolution

With analog modules, the number of bits which represent the digitized analog value in binary. The 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.

Response time

The response time is the time from an input signal being detected to the change to an output signal linked to it.
The actual response time is somewhere between a shortest and a longest response time. When configuring a system, you must always assume the longest response time.

Restart

When a CPU starts up (through the use of the mode selector, for example, or when the power is switched on), either OB 101 (restart), OB 100 (reboot: warm restart) or OB 102 (cold restart) is processed before cyclic program scanning (OB 1). It is essential for a restart that the CPU is up.
The following applies: All the data areas (timers, counters, memory markers, data blocks) and their contents are preserved. The → process input image is read, and processing of the *STEP 7* user program is continued from the point at which it was last terminated (STOP, power off).
Other types of startup are → cold restart and reboot (→ warm restart).

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.

S7 basic communication

Communication functions integrated in the CPU of the SIMATIC S7/M7/C7 that can be called by the user. The call is executed in the user program by means of → system functions. The user data volume can be up to 76 bytes (small data volume). S7 basic communication is implemented via → MPI.

S7 communication

Communication functions integrated in the CPU of the SIMATIC S7/M7/C7 that can be called by the user. The call is executed in the user program by means of → system function blocks. The user data volume can be up to 64 Kbytes (large data volume). S7 communication offers a network-independent interface between devices of the type SIMATIC S7/M7/C7 and the programming device/PC.

Segment

→ Bus segment

Shunt resistor

Parallel or shunt resistor in electrical circuits.

Signal module

Signal modules (SM) form the interface between the process and the programmable controller. There are input modules, output modules, input/output modules (both digital and analog).

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.

Standard communication

Communication via standard and standardized protocols, such as PROFIBUS DP or PROFIBUS FMS.

STARTUP

The STARTUP mode is traversed during the transition from STOP mode to RUN mode.
STARTUP can be triggered by the → mode selector or following power-on or by means of an operator input on the programming device.
Rebooting and restarting are the two different types of startup. Depending on the position of the mode selector, either a reboot or restart is executed in the case of the S7-400. A reboot is executed in the case of the M7-300/400.

STEP 7

Parameter assignment and programming software for the parameterization and 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.

SYNC

Control command of the → master to the → slave: freeze the outputs at their current value.

System diagnostics

System diagnostics is the detection, analysis and reporting of errors that occur within the programmable 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 integrated in the operating system of the CPU that can be called in the *STEP 7* user program like a function (→ FC), as required.

System function block

A system function block (SFB) is a → function block integrated in the operating system of the CPU that can be called in the *STEP 7* user program like a function block (FB), as required. The associated instance data block is in working memory.

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).

Temperature error

Defines the drift of the measured / output value of the analog module due to changes in temperature. The value is defined in a percentage per Kelvin and refers to the rated range of the analog module.

Temperature error of the internal compensation

This error occurs only when measurements are carried out with thermocouples. In addition to the actual temperature error, it also identifies the additive error when ”internal comparison” is selected. The error is defined either as a percentage of the physical range of the analog module, or as the absolute value in °C.

Transmission rate

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)

Unforce

→ Force

Ungrounded

Without galvanic connection to ground

Warm restart

This is a reboot after a power failure using a set of dynamic data programmed by the user and a user program section defined in the system.
A warm restart is indicated by setting a status bit or by some other appropriate means that can be read by the user program and indicate that the standstill of the programmable controller, brought about by a power failure, has been detected in RUN mode.

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.

Working memory

The working memory is a → random access memory in the → CPU which the processor accesses during program execution of the user program.

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