# SIEMENS

**Manual**

# SIMATIC

## S7-1500 / ET 200MP

Analog Input Module
AI 16xU BA (6ES7531-7LH00-0AB0)

# SIEMENS

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## S7-1500/ET 200MP
## Analog input module AI 16xU BA
## (6ES7531-7LH00-0AB0)

**Equipment Manual**

**09/2020**
A5E47052556-AA

# Legal information

## Warning notice system

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

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

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

> ⚠ **CAUTION**
>
> indicates that minor personal injury can result if proper precautions are not taken.

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

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

## Qualified Personnel

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

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

# Preface

**Purpose of the documentation**

This manual supplements the system manual S7-1500/ET 200MP (https://support.industry.siemens.com/cs/ww/en/view/59191792).

Functions that relate in general to the systems are described in this system manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the systems.

**Conventions**

The term "CPU" is used in this manual both for the CPUs of the S7-1500 automation system, as well as for interface modules of the ET 200MP distributed I/O system.

Please also observe notes marked as follows:

**Note**

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

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Open-source software is used in the firmware of the I/O modules. Open Source Software is provided free of charge. We are liable for the product described, including the open-source software contained in it, pursuant to the conditions applicable to the product. Siemens accepts no liability for the use of the open source software over and above the intended program sequence, or for any faults caused by modifications to the software.

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# Table of contents

# S7-1500 / ET 200MP Documentation Guide

<div style="text-align: right; font-size: 2em;">1</div>

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

| General information | Function manuals on general topics |
|---|---|
| | • Diagnostics  • Cycle and response times |
| | • Communication  • PROFINET |
| | • Motion control  • PROFIBUS |
| | • Web server  ... |

| Device information | Manuals with detailed information about modules |
|---|---|
| | • CPUs  • Communication modules |
| | • Interface modules  • Technology modules |
| | • Digital modules  • Power supply module |
| | • Analog modules |

| Basic information | Information about the system |
|---|---|
| | • Getting Started S7-1500 |
| | • System Manual S7-1500/ET 200MP |
| | • TIA Portal online help |

## Basic information

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

## Device information

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

## General information

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

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742691).

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

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

## Manual Collection S7-1500/ET 200MP

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

You can find the Manual Collection on the Internet (https://support.industry.siemens.com/cs/ww/en/view/86140384).

## SIMATIC S7-1500 comparison list for programming languages

The comparison list contains an overview of which instructions and functions you can use for which controller families.

You can find the comparison list on the Internet (https://support.industry.siemens.com/cs/ww/en/view/86630375).

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

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

## Application examples

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

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

# Product overview

# 2

## 2.1 Properties

**Article number**

6ES7531-7LH00-0AB0

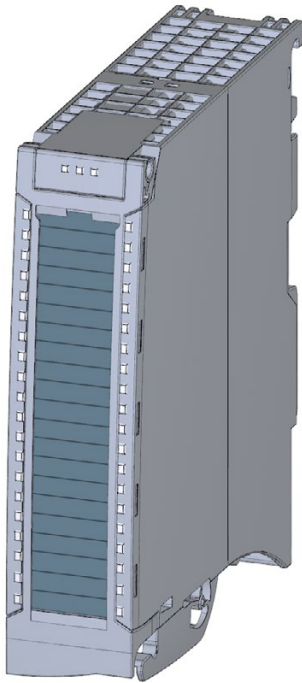**View of the module**



Figure 2-1    View of the AI 16xU BA module

## Properties

The module has the following technical properties:

- 16 analog inputs

- Measurement type voltage

  Measuring ranges +/- 1 V, +/- 5 V, +/- 10 V, 1 to 5 V can be set per channel

- Resolution 16 bits including sign

- Configurable diagnostics (per channel)

- Hardware interrupt on limit violation can be set per channel (two low and two high limits per channel)

The module supports the following functions:

Table 2- 1　　Version dependencies of the module functions

| Function | Firmware version of the module | Configuration software | |
| --- | --- | --- | --- |
| | | STEP 7 (TIA Portal) as of V16 and HSP 0312 | GSD file in STEP 7 (TIA Portal) V12 or higher, or STEP 7 V5.5 SP3 or higher |
| Firmware update | V1.0.0 or higher | X | X |
| Identification data I&M0 to I&M3 | V1.0.0 or higher | X | X |
| Parameter assignment in RUN | V1.0.0 or higher | X | X |
| Module-internal Shared Input (MSI) | V1.0.0 or higher | X (PROFINET IO only) | X (PROFINET IO only) |

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

## Accessories

The following accessories are supplied with the module and can also be ordered separately as spare parts:

- Shield bracket

- Shield terminal

- Power supply element

- Labeling strips

- U connector

- Universal front door

## Other components

You can find additional information on accessories and the article number in the system manual S7-1500/ET 200MP (https://support.industry.siemens.com/cs/ww/en/view/59191792).

# Wiring

# 3

This section contains the block diagram of the module and outlines various connection options.

You can find information on wiring the front connector, creating a cable shield, etc. in the Wiring section of the system manual S7-1500/ET 200MP (https://support.industry.siemens.com/cs/ww/en/view/59191792).

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**Note**

Do not insert the potential jumpers supplied with the front connector.

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## Abbreviations used

Meaning of the abbreviations used in the following figures:

$U_n+/U_n-$          Voltage input channel n
$M_{ANA}$            Reference potential of the analog circuit

## Infeed element

The module does not require supply voltage through the infeed element. The infeed element is inserted on the front connector and serves solely for shielding.
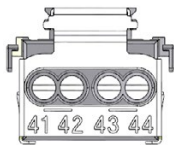


Figure 3-1      Infeed element

## Block diagram and pin assignment for voltage measurement

The example in the following figure shows the pin assignment for voltage measurement.
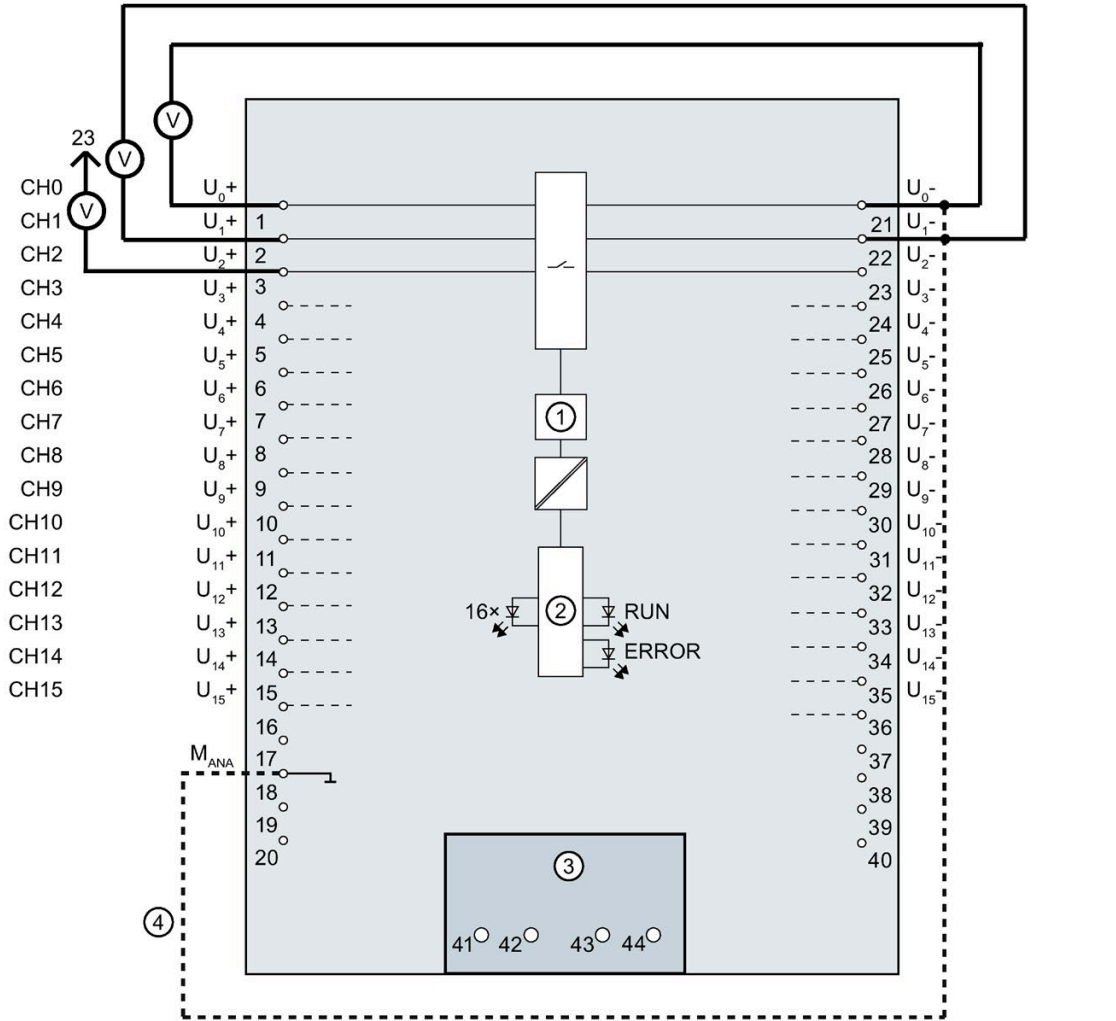


| | | | | |
|---|---|---|---|---|
| ① | Analog-to-digital converter (ADC) | CHx | Channel or 16 x channel status (green/red) |
| ② | Backplane bus interface | RUN | Status display LED (green) |
| ③ | Infeed element (for shielding only) | ERROR | Error display LED (red) |
| ④ | Equipotential bonding cable (optional) | | |

Figure 3-2     Block diagram and pin assignment for voltage measurement

# Parameters/address space

# 4

## 4.1 Measuring types and ranges

### Introduction

The module is set to voltage measurement type with measuring range ±10 V by default. You need to reassign the module parameters with STEP 7 if you want to use a different measuring range.

Deactivate the input if it is not going to be used. The module cycle time is shortened and the interference factors that lead to failure of the module (for example, triggering a hardware interrupt) are avoided.

The following table shows the measurement type and the respective measuring range.

Table 4- 1    Measurement type and measuring range

| Measurement type | Measuring range | Representation of analog values |
|---|---|---|
| Voltage | ±1 V<br>1 V to 5 V<br>±5 V<br>±10 V | See Representation of analog values in voltage measuring ranges (Page 39) |
| Disabled | - | - |

The tables of the input ranges, overflow, underrange, etc. are available in the appendix Representation of analog values (Page 37).

---

**Note**

**Wire break in voltage measuring ranges**

 "Wire break" diagnostics can be configured for the "Voltage" measurement type with the "Measuring range 1 to 5 V". No "Wire break" diagnostics is available for the other measuring ranges.

If there is a wire break for these measuring ranges, the channel supplies a random value as an input value. This random value can also lie within the valid value range.

---

## 4.2        Parameters

**Parameters of AI 16xU BA**

When you assign the module parameters in STEP 7, you use various parameters to specify the module properties. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

• Central operation with a S7-1500 CPU

• Distributed operation on PROFINET IO in an ET 200MP system

• Distributed operation on PROFIBUS DP in an ET 200MP system

When assigning parameters in the user program, use the WRREC instruction to transfer the parameters to the module by means of data records; refer to the section Parameter assignment and structure of the parameter data records (Page 32).

The following parameter settings for the channels are possible:

Table 4- 2        Configurable parameters and their defaults

| Parameters | Range of values | Default setting | Parameter as-signment in RUN | Scope with configuration soft-ware, e.g., STEP 7 (TIA Portal) | |
|---|---|---|---|---|---|
| | | | | GSD file PROFINET IO | GSD file PROFIBUS DP |
| **Diagnostics** | | | | | |
| • Overflow | Yes/No | No | Yes | Channel | Module [2] |
| • Underflow | Yes/No | No | Yes | Channel | Module [2] |
| • Common mode error | Yes/No | No | Yes | Channel | Module [2] |
| • Wire break [1] | Yes/No | No | Yes | Channel | Module [2] |
| **Measuring** | | | | | |
| • Measurement type | Voltage | Voltage | Yes | Channel | Channel |
| • Measuring range | ±1 V<br>1 to 5 V<br>±5 V<br>±10 V | ±10 V | Yes | Channel | Channel |
| • Interference frequency suppression | 400 Hz<br>60 Hz<br>50 Hz<br>10 Hz | 50 Hz | Yes | Channel | Module |
| • Smoothing | None/low/medium/high | None | Yes | Channel | Channel |

| Parameters | Range of values | Default setting | Parameter assignment in RUN | Scope with configuration software, e.g., STEP 7 (TIA Portal) | |
|---|---|---|---|---|---|
| | | | | GSD file PROFINET IO | GSD file PROFIBUS DP |
| **Hardware interrupts** | | | | | |
| • Hardware interrupt low limit 1 | Yes/No | No | Yes | Channel | --- [3] |
| • Hardware interrupt high limit 1 | Yes/No | No | Yes | Channel | --- [3] |
| • Hardware interrupt low limit 2 | Yes/No | No | Yes | Channel | --- [3] |
| • Hardware interrupt high limit 2 | Yes/No | No | Yes | Channel | --- [3] |

[1] If "Wire break" diagnostics and "Value status" are deactivated, the module reports overflow / underflow ($7FFF_H$ / $8000_H$) in the event of a wiring error. The alarm depends on whether the connected cables are faulty. "Wire break" diagnostics is only available in the measuring range 1 V to 5 V.

Recommendation: Activate the "Wire break" diagnostics to obtain the correct value.

[2] You can set the effective range of the diagnostics for each channel in the user program with data records 0 to 15.

[3] You can configure the limits for hardware interrupts in the user program with data records 0 to 15.

# 4.3 Declaration of parameters

## Overflow

Enabling of the diagnostics if the measured value violates the high limit.

## Underflow

Enabling of the diagnostics when the measured value violates the low limit.

## Common mode error

Enabling of diagnostics if the valid common mode voltage is exceeded.

## Wire break

Enabling of the diagnostics if the module detects voltage that is too low at the configured input.

"Wire break" diagnostics is only available in the measuring range 1 V to 5 V.

### Interference frequency suppression

At analog input modules, this suppresses interference caused by the frequency of the AC network.

The frequency of the AC voltage network may interfere with measured values, particularly for measurements within narrow voltage ranges. For this parameter, the user defines the mains frequency prevailing on his system.

### Smoothing

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

Smoothing time = number of module cycles (k) x cycle time of the module.

The following figure shows the number of module cycles after which the smoothed analog value is almost 100%, depending on the set smoothing. It is valid for each signal change at the analog input.
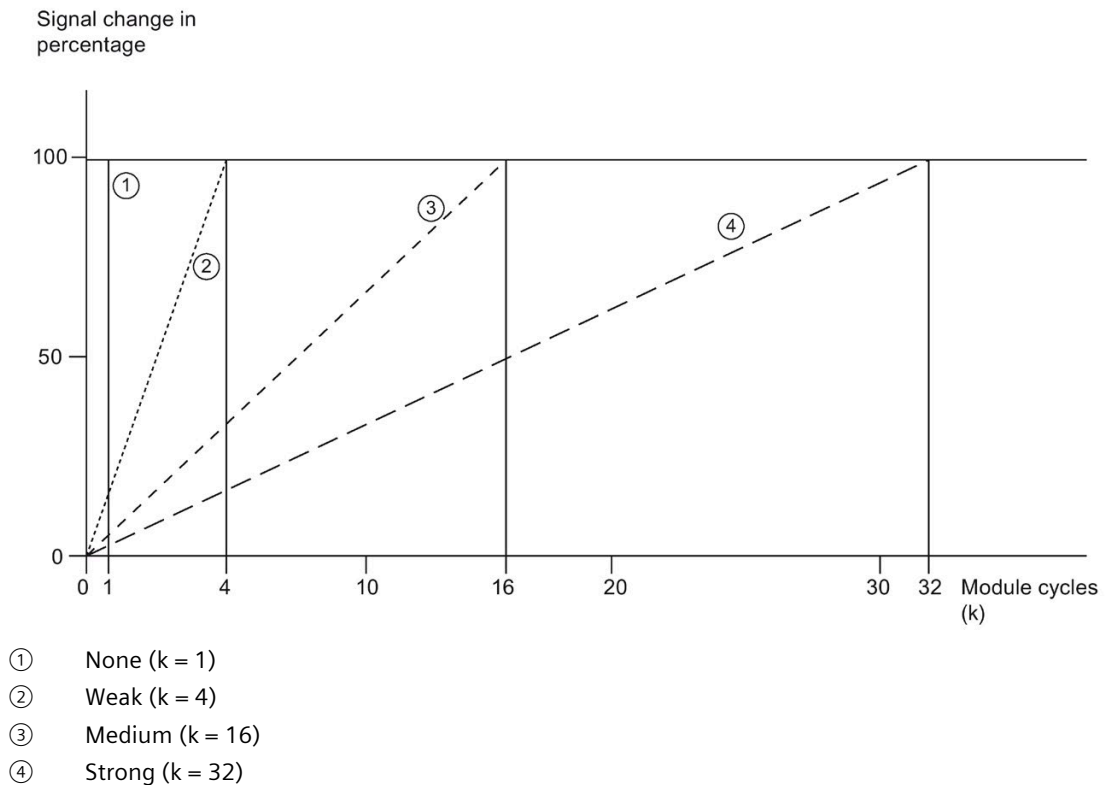


① None (k = 1)
② Weak (k = 4)
③ Medium (k = 16)
④ Strong (k = 32)

Figure 4-1    Smoothing for AI 16xU BA

## Hardware interrupt 1 or 2

Enabling of a hardware interrupt at violation of high limit 1 or 2 or low limit 1 or 2.

## Low limit 1 or 2

Specifies the low limit threshold that triggers hardware interrupt 1 or 2.

## High limit 1 or 2

Specifies the high limit threshold that triggers hardware interrupt 1 or 2.

# 4.4 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image of the inputs.

## Configuration options of AI 16xU BA

You can configure the module with STEP 7 (TIA Portal) or with a GSD file.

When you configure the module by means of the GSD file, the configurations are available under different abbreviations/module names.

The following configurations are possible:

Table 4- 3    Configuration options

| Configuration | Short designation/ module name in the GSD file | Configuration software, e.g., with STEP 7 (TIA Portal) | |
| --- | --- | --- | --- |
| | | Integrated in the hardware catalog STEP 7 (TIA Portal) as of V16 and HSP 0312 | GSD file in STEP 7 (TIA Portal) V12 or higher or STEP 7 V5.5 SP3 or higher |
| 1 x 16-channel without value status | AI 16xU BA | X | X |
| 1 x 16-channel with value status | AI 16xU BA QI | X | X |
| 1 x 16-channel with value status for module-internal shared input with up to 4 submodules | AI 16xU BA MSI | X (PROFINET IO only) | X (PROFINET IO only) |

## Value status (Quality Information, QI)

The value status is always activated for the following module names:

• AI 16xU BA QI

• AI 16xU BA MSI

An additional bit is assigned to each channel for the value status. The value status bit indicates if the read in digital value is valid. (0 = value is incorrect).

### Address space of AI 16xU BA

The figure below shows the address space allocation for the configuration as 16-channel module. You can freely assign the start address for the module. The addresses of the channels are derived from the start address.

"IB x" stands, for example, for the module start address input byte x.
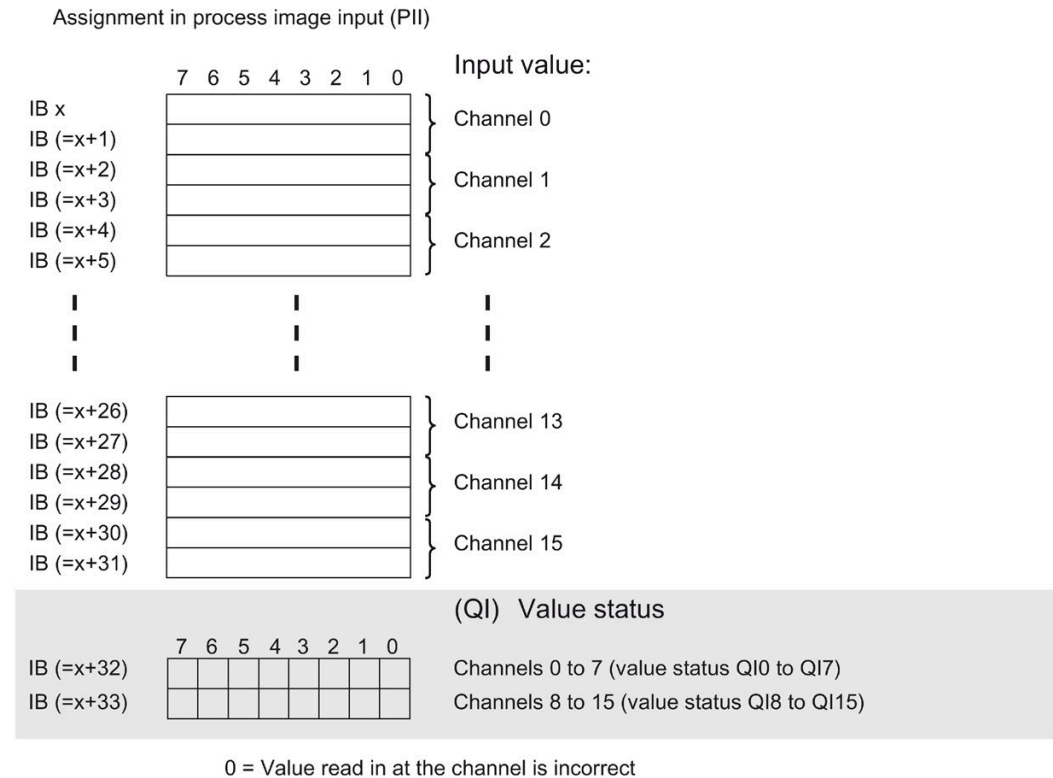


Figure 4-2    Address space for configuration as 1 x 16-channel AI 16xU BA with value status

### Address space for configuration as 1 x 16-channel AI 16xU BA MSI

The channels 0 to 15 of the module are copied in up to four submodules with configuration 1 x 16-channel module (module-internal shared input, MSI). Channels 0 to 15 are then available with identical input values in different submodules. These submodules can be assigned to up to four IO controllers when the module is used in a shared device. Each IO controller has read access to the same channels.

The number of usable IO controllers depends on the interface module used. Please observe the information in the manual for the particular interface module.

**Value status (Quality Information, QI)**

The meaning of the value status depends on the submodule on which it occurs.

For the first submodule (=basic submodule), the value status 0 indicates that the value is incorrect.

For the 2nd to 4th submodule (=MSI submodule), the value status 0 indicates that the value is incorrect or the basic submodule has not yet been configured (not ready).

The figure below shows the assignment of the address space with submodules 1 and 2.

Assignment in process image input (PII)

Input value 1st submodule (Basic submodule):

```
            7 6 5 4 3 2 1 0
IB a        ┌───────────────┐  ┐ Channel 0
IB (=a+1)   ├───────────────┤  ┘
IB (=a+2)   ├───────────────┤  ┐ Channel 1
IB (=a+3)   ├───────────────┤  ┘
IB (=a+4)   ├───────────────┤  ┐ Channel 2
IB (=a+5)   ├───────────────┤  ┘
IB (=a+6)   ├───────────────┤  ┐ Channel 3
IB (=a+7)   └───────────────┘  ┘

IB (=a+28)  ┌───────────────┐  ┐ Channel 14
IB (=a+29)  ├───────────────┤  ┘
IB (=a+30)  ├───────────────┤  ┐ Channel 15
IB (=a+31)  └───────────────┘  ┘
```

```
            7 6 5 4 3 2 1 0
IB (=a+32)  ┌─┬─┬─┬─┬─┬─┬─┬─┐  Channels 0 to 7 (value status QI0 to QI7)
IB (=a+33)  └─┴─┴─┴─┴─┴─┴─┴─┘  Channels 8 to 15 (value status QI8 to QI15)
```

Input value 2nd submodule (MSI submodule):

```
            7 6 5 4 3 2 1 0
IB b        ┌───────────────┐  ┐ Channel 0
IB (=b+1)   ├───────────────┤  ┘
IB (=b+2)   ├───────────────┤  ┐ Channel 1
IB (=b+3)   ├───────────────┤  ┘
IB (=b+4)   ├───────────────┤  ┐ Channel 2
IB (=b+5)   ├───────────────┤  ┘
IB (=b+6)   ├───────────────┤  ┐ Channel 3
IB (=b+7)   └───────────────┘  ┘

IB (=b+28)  ┌───────────────┐  ┐ Channel 14
IB (=b+29)  ├───────────────┤  ┘
IB (=b+30)  ├───────────────┤  ┐ Channel 15
IB (=b+31)  └───────────────┘  ┘
```

```
            7 6 5 4 3 2 1 0
IB (=b+32)  ┌─┬─┬─┬─┬─┬─┬─┬─┐  Channels 0 to 7 (value status QI0 to QI7)
IB (=b+33)  └─┴─┴─┴─┴─┴─┴─┴─┘  Channels 8 to 15 (value status QI8 to QI15)
```

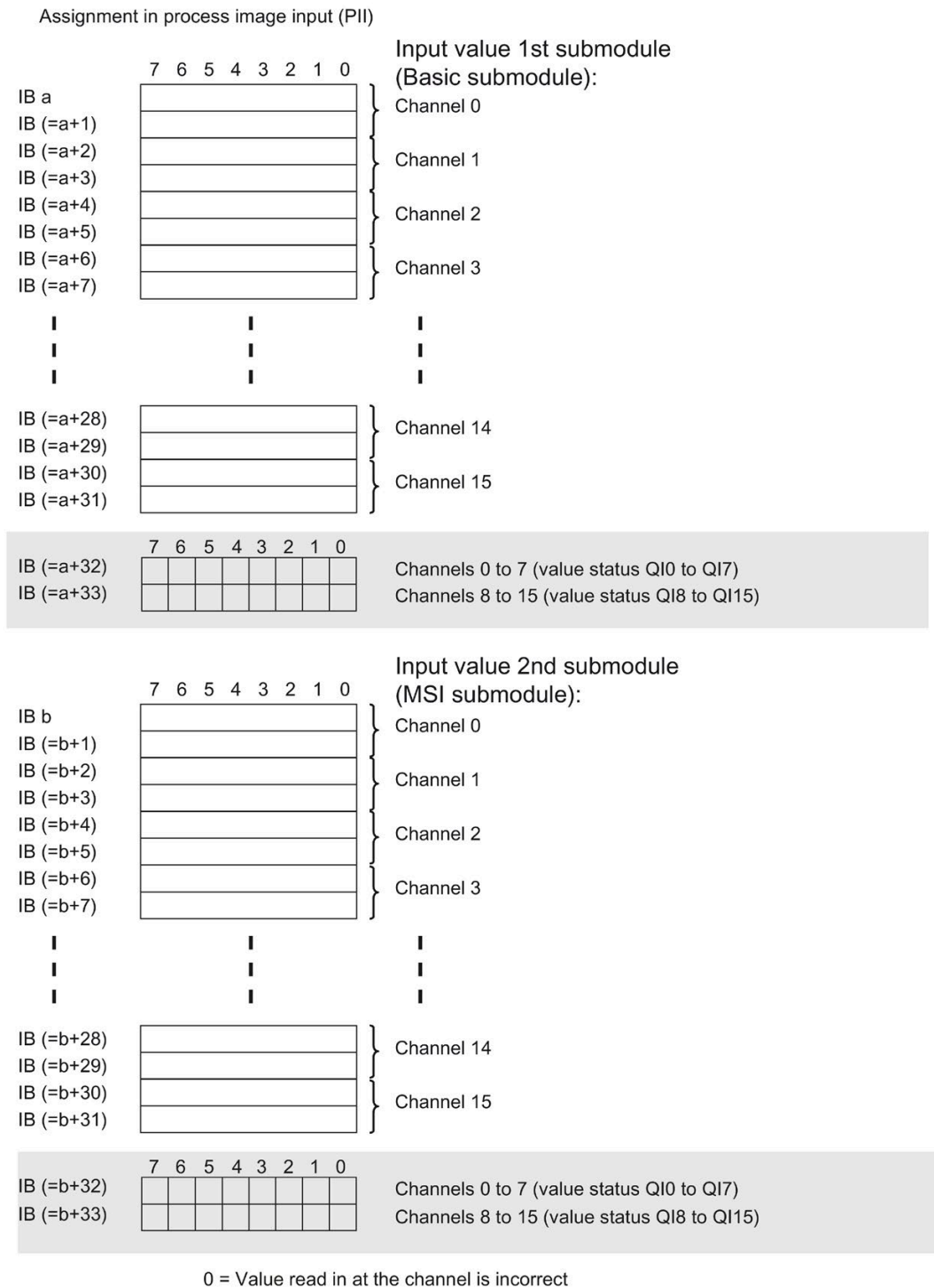0 = Value read in at the channel is incorrect

Figure 4-3     Address space for configuration as 1 x 16-channel AI 16xU BA MSI with value status

The following figure shows the assignment of the address space with submodule 3 and 4.
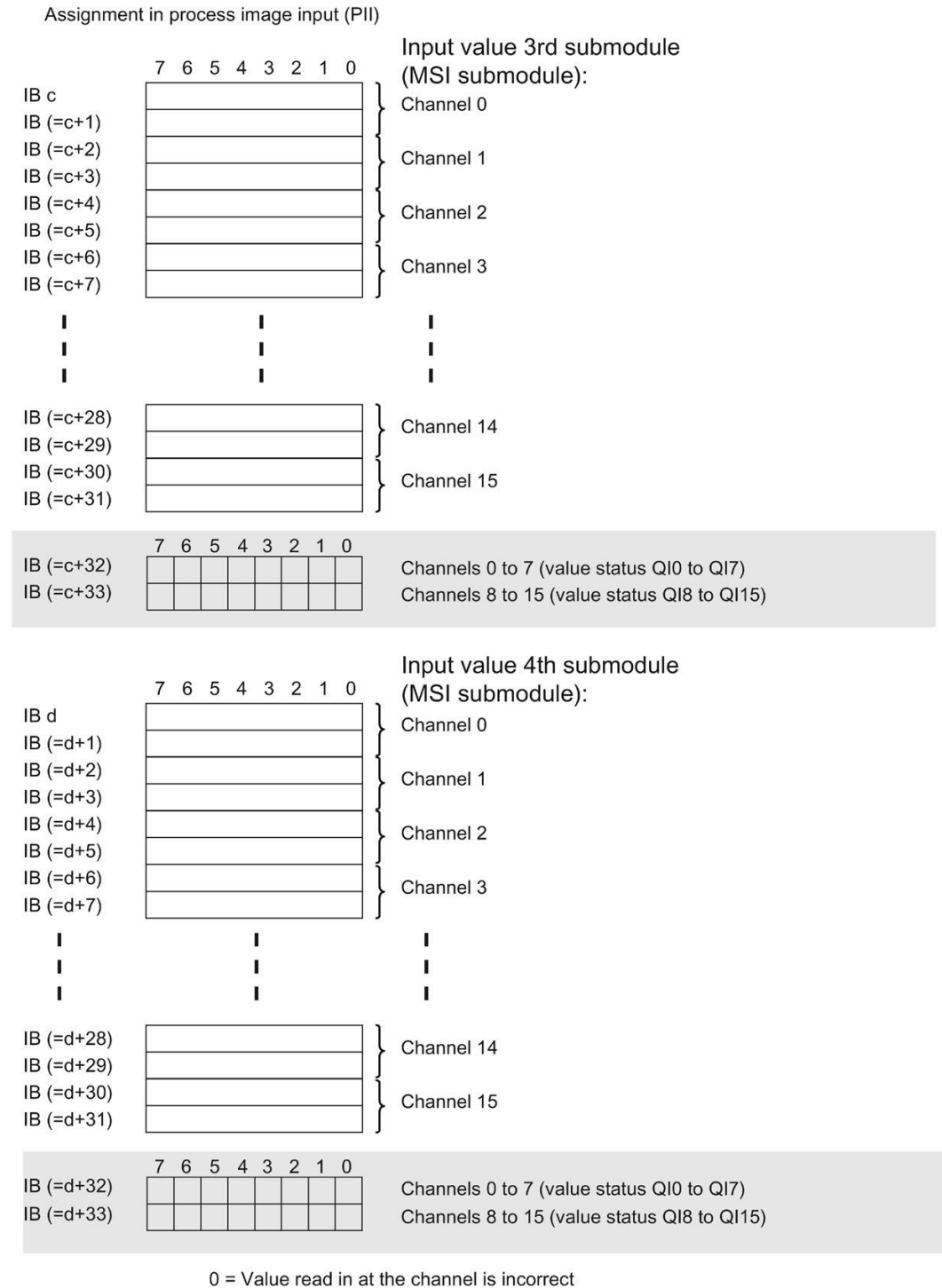
Assignment in process image input (PII)

Input value 3rd submodule
(MSI submodule):

```
           7  6  5  4  3  2  1  0
IB c      [                      ]  } Channel 0
IB (=c+1) [                      ]
IB (=c+2) [                      ]  } Channel 1
IB (=c+3) [                      ]
IB (=c+4) [                      ]  } Channel 2
IB (=c+5) [                      ]
IB (=c+6) [                      ]  } Channel 3
IB (=c+7) [                      ]
            :      :      :
            :      :      :
            :      :      :
IB (=c+28) [                     ]  } Channel 14
IB (=c+29) [                     ]
IB (=c+30) [                     ]  } Channel 15
IB (=c+31) [                     ]
```

```
            7  6  5  4  3  2  1  0
IB (=c+32) [ | | | | | | | | ]   Channels 0 to 7 (value status QI0 to QI7)
IB (=c+33) [ | | | | | | | | ]   Channels 8 to 15 (value status QI8 to QI15)
```

Input value 4th submodule
(MSI submodule):

```
           7  6  5  4  3  2  1  0
IB d      [                      ]  } Channel 0
IB (=d+1) [                      ]
IB (=d+2) [                      ]  } Channel 1
IB (=d+3) [                      ]
IB (=d+4) [                      ]  } Channel 2
IB (=d+5) [                      ]
IB (=d+6) [                      ]  } Channel 3
IB (=d+7) [                      ]
            :      :      :
            :      :      :
            :      :      :
IB (=d+28) [                     ]  } Channel 14
IB (=d+29) [                     ]
IB (=d+30) [                     ]  } Channel 15
IB (=d+31) [                     ]
```

```
            7  6  5  4  3  2  1  0
IB (=d+32) [ | | | | | | | | ]   Channels 0 to 7 (value status QI0 to QI7)
IB (=d+33) [ | | | | | | | | ]   Channels 8 to 15 (value status QI8 to QI15)
```

0 = Value read in at the channel is incorrect

Figure 4-4    Address space for configuration as 1 x 16-channel AI 16xU BA MSI with value status

**Reference**

You can find information on the Shared Input/Output (MSI/MSO) function in the section Module-Internal Shared Input/Output (MSI/MSO) of the PROFINET with STEP 7 V16 (https://support.industry.siemens.com/cs/ww/en/view/49948856) function manual.

# Interrupts/diagnostics alarms

# 5

## 5.1    Status and error displays

**LED displays**

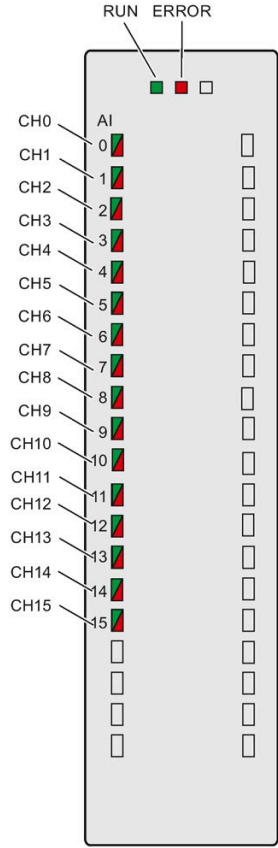The figure below shows the LED displays (status and error displays) of AI 16xU BA.



Figure 5-1      LED displays of the AI 16xU BA module

## Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Remedial measures for diagnostic alarms can be found in section Diagnostic alarms (Page 25).

## RUN and ERROR LED

Table 5- 1     Status and error displays RUN and ERROR

| LEDs | | Meaning | Remedy |
|---|---|---|---|
| **RUN** | **ERROR** | | |
| □ Off | □ Off | Voltage missing or too low at backplane bus. | • Switch on the CPU and/or the system power supply modules.<br>• Verify that the U connectors are inserted.<br>• Check whether too many modules are inserted. |
| ☼ Flashes | □ Off | The module starts and flashes until the valid parameter assignment is set. | --- |
| ■ On | □ Off | Module is configured. | |
| ■ On | ☼ Flashes | Indicates module errors (at least one error at one channel, e.g., wire break). | Evaluate the diagnostics data and eliminate the error (e.g., wire break). |
| ☼ Flashes | ☼ Flashes | Hardware defective. | Replace the module. |

## CHx LED

Table 5- 2     CHx status display

| LED CHx/COMP | Meaning | Remedy |
|---|---|---|
| □ Off | Channel disabled | --- |
| ■ On | Channel configured and OK. | --- |
| ■ On | Channel is configured (channel error pending). Diagnostic alarm: e.g. wire break | Check the wiring. Disable diagnostics. |

## 5.2 Interrupts

Analog input module AI 16xU BA supports the following diagnostic and hardware interrupts.

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

### Diagnostic interrupt

The module generates a diagnostic interrupt at the following events:

- Wire break
- Overflow
- Underflow
- Common mode error
- Parameter assignment error

### Hardware interrupt

The module generates a hardware interrupt at the following events:

- Low limit violated 1
- High limit violated 1
- Low limit violated 2
- Above high limit 2

The module channel that triggered the hardware interrupt is entered in the start information of the organization block. The diagram below shows the assignment to the bits of double word 8 in local data.
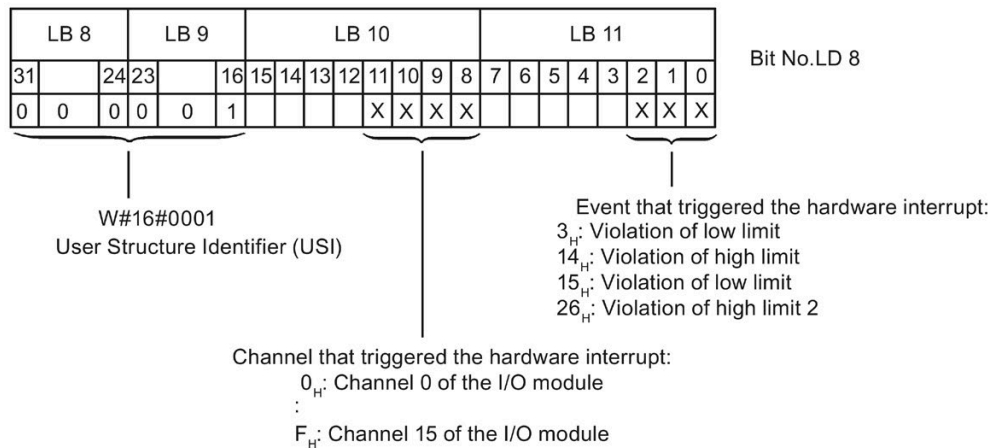


Figure 5-2    OB start information

## Reaction when reaching limits 1 and 2 at the same time

If the two high limits 1 and 2 are reached at the same time, the module always signals the hardware interrupt for high limit 1 first. The configured value for high limit 2 is irrelevant. After processing the hardware interrupt for high limit 1, the module triggers the hardware interrupt for high limit 2.

The module has the same reaction when the low limits are reached at the same time. If the two low limits 1 and 2 are reached at the same time, the module always signals the hardware interrupt for low limit 1 first. After processing the hardware interrupt for low limit 1, the module triggers the hardware interrupt for low limit 2.

## Structure of the additional interrupt information

Table 5- 3    Structure of USI = W#16#0001

| Data block name | | Contents | Remark | Bytes |
|---|---|---|---|---|
| **USI**<br>(User Structure Identifier) | | W#16#0001 | Additional interrupt info for hardware interrupts of the I/O module | 2 |
| The channel that triggered the hardware interrupt follows. | | | | |
| | **Channel** | B#16#00 to B#16#n | Number of the event-triggering channel (n = number of module channels -1) | 1 |
| The event that triggered the hardware interrupt follows. | | | | |
| | **Event** | B#16#03 | Low limit violated 1 | 1 |
| | | B#16#04 | High limit violated 1 | |
| | | B#16#05 | Low limit violated 2 | |
| | | B#16#06 | Violation of high limit 2 | |

## 5.3 Diagnostics alarms

A diagnostics alarm is generated and the ERROR LED flashes on the module for each diagnostics event. The diagnostics alarms can be read out in the diagnostics buffer of the CPU, for example. You can evaluate the error codes with the user program.

If the module is operated distributed with PROFIBUS DP in an ET 200MP system, you have the option to read out diagnostics data with the instruction RDREC or RD_REC using data record 0 and 1. The structure of the data records is available in the "Manual for interface module IM 155-5 DP ST (6ES7155-5BA00-0AB0)" on the Internet (https://support.industry.siemens.com/cs/ww/en/view/78324181).

Table 5- 4 Diagnostics alarms, their meaning and corrective measures

| Diagnostics alarm | Error code | Meaning | Solution |
|---|---|---|---|
| Wire break | 6$_H$ | Impedance of encoder circuit too high | Use a different encoder type or modify the wiring, for example, using cables with larger cross-section |
| | | Wire break between the module and sensor | Connect the cable |
| | | Channel not connected (open) | • Disable diagnostics<br>• Connect the channel |
| Overflow | 7$_H$ | Measuring range violated | Check the measuring range |
| Underflow | 8$_H$ | Measuring range violated | Check the measuring range |
| Parameter assignment error | 10$_H$ | • The module cannot evaluate parameters for the channel<br>• Incorrect parameter assignment | Correct the parameter assignment |
| Common mode error | 118$_H$ | Valid common mode voltage exceeded | Check the wiring, e.g. sensor ground connections, use equipotential cables |

### Diagnostics alarms with value status (QI)

If you configure the module with value status (QI), the module always checks all errors even if the respective diagnostics is not enabled. But the module cancels the inspection as soon as it detects the first error, regardless if the respective diagnostics has been enabled or not. The result may be that enabled diagnostics may not be displayed.

**Example:** You have enabled "Underflow" diagnostics, but the module detects the "Wire break" diagnostics first and aborts after this error message. The "Underflow" diagnostics is not detected.

**Recommendation:** To ensure that all errors can be diagnosed reliably, select all check boxes under "Diagnostics".

# Technical specifications

<div style="text-align: right; font-size: 2em;">6</div>

## Technical specifications of AI 16xU BA

The following table shows the technical specifications as of 09/2020. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/td).

Enter the article number or the short designation of the module on the website.

| Article number | 6ES7531-7LH00-0AB0 |
|---|---|
| **General information** | |
| Product type designation | AI 16xU BA |
| HW functional status | FS01 |
| Firmware version | V1.0.0 |
| • FW update possible | Yes |
| **Product function** | |
| • I&M data | Yes; I&M0 to I&M3 |
| • Prioritized startup | No |
| **Engineering with** | |
| • STEP 7 TIA Portal configurable/integrated from version | V16 with HSP 312 / V17 |
| • STEP 7 configurable/integrated from version | V5.5 SP3 / - |
| • PROFIBUS from GSD version/GSD revision | V1.0 / V5.1 |
| • PROFINET from GSD version/GSD revision | V2.3 / - |
| **Operating mode** | |
| • Oversampling | No |
| • MSI | Yes |
| **CiR - Configuration in RUN** | |
| Reparameterization possible in RUN | Yes |
| Calibration possible in RUN | No |
| **Power** | |
| Power available from the backplane bus | 0.85 W |
| **Power loss** | |
| Power loss, typ. | 0.75 W |

| Article number | 6ES7531-7LH00-0AB0 |
|---|---|
| **Analog inputs** | |
| Number of analog inputs | 16 |
| • For voltage measurement | 16 |
| permissible input voltage for voltage input (destruction limit), max. | 12 V; 12 V continuous, 30 V for max. 1 s |
| **Input ranges (rated values), voltages** | |
| • 0 to +5 V | No |
| • 0 to +10 V | No |
| • 1 V to 5 V | Yes |
| – Input resistance (1 V to 5 V) | 10 MΩ |
| • -1 V to +1 V | Yes |
| – Input resistance (-1 V to +1 V) | 10 MΩ |
| • -10 V to +10 V | Yes |
| – Input resistance (-10 V to +10 V) | 10 MΩ |
| • -2.5 V to +2.5 V | No |
| • -25 mV to +25 mV | No |
| • -250 mV to +250 mV | No |
| • -5 V to +5 V | Yes |
| – Input resistance (-5 V to +5 V) | 10 MΩ |
| • -50 mV to +50 mV | No |
| • -500 mV to +500 mV | No |
| • -80 mV to +80 mV | No |
| **Cable length** | |
| • shielded, max. | 200 m |
| **Analog value generation for the inputs** | |
| Measurement principle | integrating |
| **Integration and conversion time/resolution per channel** | |
| • Resolution with overrange (bit including sign), max. | 16 bit |
| • Integration time, parameterizable | Yes |
| • Integration time (ms) | 2,5 / 16,67 / 20 / 100 ms |
| • Basic conversion time, including integration time (ms) | 10 / 24 / 27 / 107 ms |
| – additional conversion time for wire-break monitoring | 4 ms (to be considered for 1 to 5 V measurement) |
| • Interference voltage suppression for interference frequency f1 in Hz | 400 / 60 / 50 / 10 Hz |

| Article number | 6ES7531-7LH00-0AB0 |
|---|---|
| **Smoothing of measured values** | |
| • parameterizable | Yes |
| • Step: None | Yes |
| • Step: low | Yes |
| • Step: Medium | Yes |
| • Step: High | Yes |
| **Encoder** | |
| **Connection of signal encoders** | |
| • for voltage measurement | Yes |
| **Errors/accuracies** | |
| Linearity error (relative to input range), (+/-) | 0.1 % |
| Temperature error (relative to input range), (+/-) | 0.006 %/K |
| Crosstalk between the inputs, max. | -50 dB |
| Repeat accuracy in steady state at 25 °C (relative to input range), (+/-) | 0.1 % |
| **Operational error limit in overall temperature range** | |
| • Voltage, relative to input range, (+/-) | 0.5 % |
| **Basic error limit (operational limit at 25 °C)** | |
| • Voltage, relative to input range, (+/-) | 0.3 % |
| **Interference voltage suppression for f = n x (f1 +/- 1 %), f1 = interference frequency** | |
| • Series mode interference (peak value of interference < rated value of input range), min. | 40 dB |
| • Common mode voltage, max. | 4 V |
| • Common mode interference, min. | 60 dB |
| **Interrupts/diagnostics/status information** | |
| Diagnostics function | Yes |
| **Alarms** | |
| • Diagnostic alarm | Yes |
| • Limit value alarm | Yes; two upper and two lower limit values in each case |
| **Diagnoses** | |
| • Monitoring the supply voltage | No |
| • Wire-break | Yes; Only for 1 ... 5 V |
| • Short-circuit | No |
| • Group error | No |
| • Overflow/underflow | Yes |

| Article number | 6ES7531-7LH00-0AB0 |
|---|---|
| **Diagnostics indication LED** | |
| • RUN LED | Yes; green LED |
| • ERROR LED | Yes; red LED |
| • MAINT LED | No |
| • Monitoring of the supply voltage (PWR-LED) | No |
| • Channel status display | Yes; green LED |
| • for channel diagnostics | Yes; red LED |
| • for module diagnostics | Yes; red LED |
| **Potential separation** | |
| **Potential separation channels** | |
| • between the channels | No |
| • between the channels, in groups of | 16 |
| • between the channels and backplane bus | Yes |
| **Permissible potential difference** | |
| between the inputs (UCM) | 8 V DC |
| Between the inputs and MANA (UCM) | 4 V DC |
| **Isolation** | |
| Isolation tested with | 707 V DC (type test) |
| **Ambient conditions** | |
| **Ambient temperature during operation** | |
| • horizontal installation, min. | -30 °C; No condensation |
| • horizontal installation, max. | 60 °C |
| • vertical installation, min. | -30 °C; No condensation |
| • vertical installation, max. | 40 °C |
| **Altitude during operation relating to sea level** | |
| • Installation altitude above sea level, max. | 5 000 m; Restrictions for installation altitudes > 2 000 m, see manual |
| **Dimensions** | |
| Width | 35 mm |
| Height | 147 mm |
| Depth | 129 mm |
| **Weights** | |
| Weight, approx. | 250 g |

# Dimensional drawing A

The dimensional drawing of the module on the mounting rail, as well as a dimensional drawing with open front panel are provided in the appendix. Always adhere to the specified dimensions for installations in cabinets, control rooms, etc.
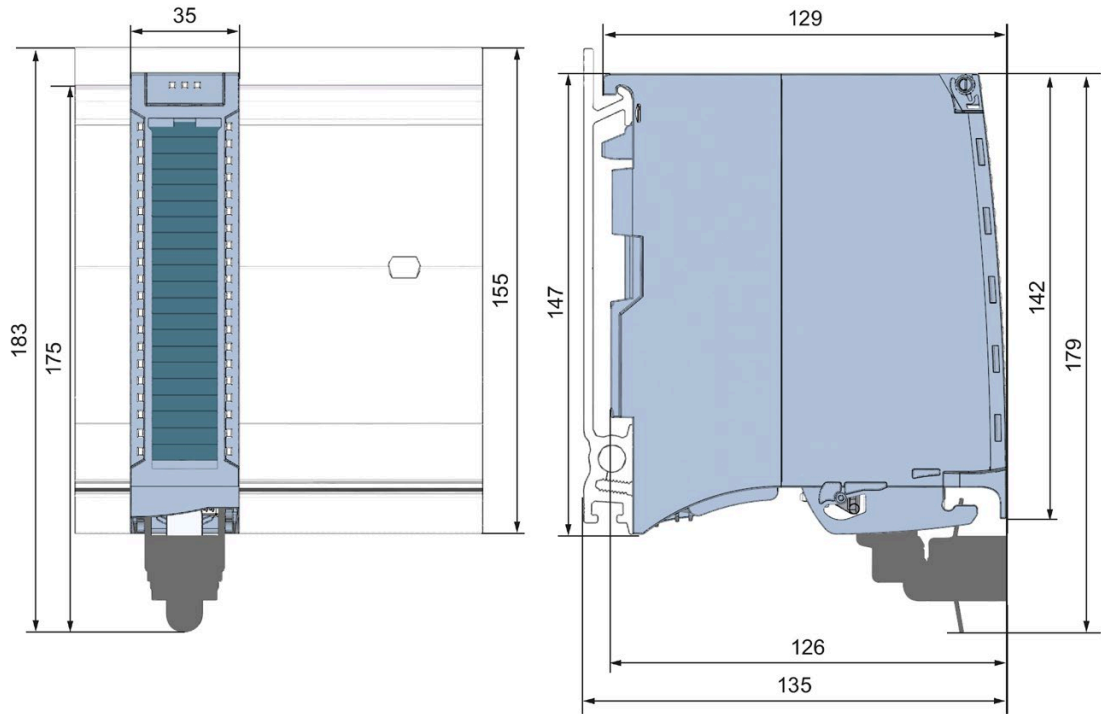


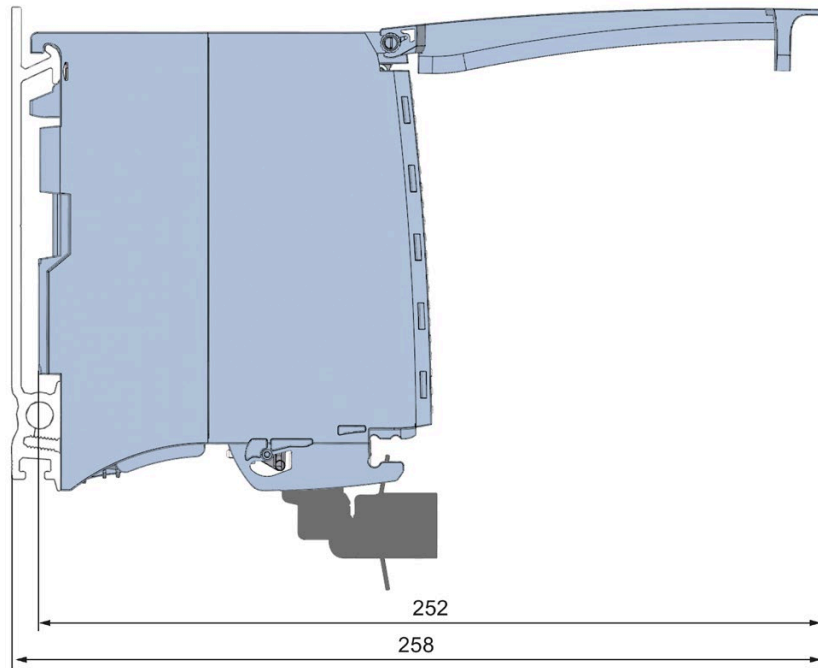Figure A-1    Dimensional drawing of the AI 16xU BA module

Figure A-2      Dimensional drawing of the AI 16xU BA module in side view with open front cover

# Parameter data records

<div style="text-align: right; font-size: 2em; font-weight: bold;">B</div>

## B.1 Parameter assignment and structure of the parameter data records

The data records of the module have an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO.

### Dependencies for configuration with GSD file

When configuring the module with a GSD file, remember that the settings of some parameters are dependent on each other. The parameters are only checked for plausibility by the module after the transfer to the module.

The following table lists the parameters that depend on one another.

Table B- 1    Dependencies of parameters for configuration with GSD file

| Device-specific parameters (GSD file) | Dependent parameters |
|---|---|
| Wire break | Only for **measurement type** voltage with **measuring range** 1 to 5 V |
| Hardware interrupt limits | Only if hardware interrupts are enabled. |

### Parameter assignment in the user program

The module parameters can be assigned in RUN (for example, measuring ranges of selected channels can be edited in RUN without having an effect on the other channels).

### Parameter assignment in RUN

The WRREC instruction is used to transfer the parameters to the module using data records 0 to 15. The parameters set in STEP 7 do not change in the CPU, which means the parameters set in STEP 7 are still valid after a restart.

The parameters are only checked for plausibility by the module after the transfer to the module.

### Output parameter STATUS

The module ignores errors that occurred during the transfer of parameters with the WRREC instruction and continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.

The description of the WRREC instruction and the error codes is available in the STEP 7 online help.

## Operation of the module behind a PROFIBUS DP interface module

If the module is operated behind a PROFIBUS DP interface module, the parameter data records 0 and 1 are not read back. You obtain the diagnostics data records 0 and 1 with the read back parameter data records 0 and 1. You can find additional information in the Interrupts section of the manual for the PROFIBUS DP interface module on the Internet (http://support.automation.siemens.com/WW/view/en/78324181).

## Assignment of data record and channel

For the configuration with 1 x 16-channel, the parameters are located in data records 0 to 15 and are assigned as follows:

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

## Data record structure

The figure below shows the structure of data record 0 for channel 0 as an example. The structure is identical for channels 1 to 15. The values in byte 0 and byte 1 are fixed and may not be changed.

Enable a parameter by setting the corresponding bit to "1".
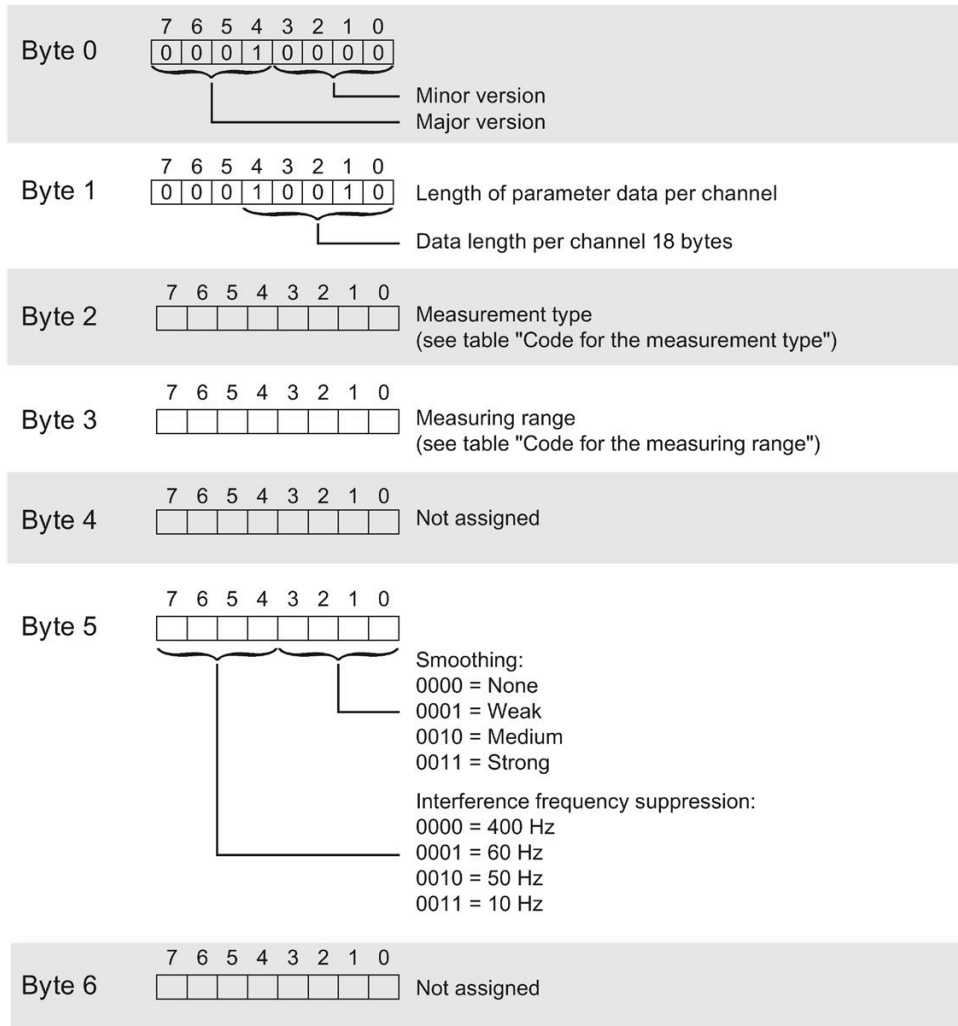


Figure B-1    Structure of data record 0: Bytes 0 to 6

Byte 7    7 6 5 4 3 2 1 0   [ | | | | 0 | 0 | 0 | 0 ]
- Hardware interrupt high limit 2*
- Hardware interrupt low limit 2*
- Hardware interrupt high limit 1*
- Hardware interrupt low limit 1*

Byte 8    7 6 5 4 3 2 1 0   [ | | 0 | | 0 | 0 | 0 | 0 ]   Enable diagnostics:
- Wire break (only with voltage measurement type 1 to 5 V)
- Underflow
- Overflow

Byte 9    7 6 5 4 3 2 1 0   [ | 0 | 0 | 0 | 0 | 0 | 0 | 0 ]   Enable diagnostics:
- Common mode error

Byte 10   15 14 13 12 11 10 9 8
Byte 11   7 6 5 4 3 2 1 0    } Not assigned

Byte 12   15 14 13 12 11 10 9 8
Byte 13   7 6 5 4 3 2 1 0    } Hardware interrupt high limit 1** (see section "Hardware interrupt limits")

Byte 14   15 14 13 12 11 10 9 8
Byte 15   7 6 5 4 3 2 1 0    } Hardware interrupt low limit 1** (see section "Hardware interrupt limits")

Byte 16   15 14 13 12 11 10 9 8
Byte 17   7 6 5 4 3 2 1 0    } Hardware interrupt high limit 2** (see section "Hardware interrupt limits")

Byte 18   15 14 13 12 11 10 9 8
Byte 19   7 6 5 4 3 2 1 0    } Hardware interrupt low limit 2** (see section "Hardware interrupt limits")

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

\*\* High limit must be greater than low limit

Figure B-2     Structure of data record 0: Bytes 7 to 19

## Codes for measurement types

The following table lists all measurement types of the analog input module along with their codes. Enter these codes at byte 2 of the data record for the corresponding channel (see the figure Structure of data record 0: Bytes 7 to 19).

Table B- 2     Code for the measurement type

| Measurement type | Code |
|---|---|
| Deactivated | 0000 0000 |
| Voltage | 0000 0001 |

## Codes for measuring ranges

The following table lists all measuring ranges of the analog input module along with their codes. Enter these codes accordingly at byte 3 of the data record for the corresponding channel (see the figure Structure of data record 0: Bytes 7 to 19).

Table B- 3     Code for the measuring range

| Measuring range | Code |
|---|---|
| **Voltage** | |
| ±1 V | 0000 0101 |
| ±5 V | 0000 1000 |
| ±10 V | 0000 1001 |
| 1 V to 5 V | 0000 1010 |

## Hardware interrupt limits

The values that you can set for hardware interrupts (high/low limit) must not violate the over/underrange of the respective rated measuring range.

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

Table B- 4     Voltage limits

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

# Representation of analog values

# C

**Introduction**

This appendix shows the analog values for all measuring ranges supported by the AI 16xU BA analog module.

**Measured value resolution**

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

Table C- 1    Resolution of the analog values

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

## C.1    Representation of input ranges

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

Table C- 2    Bipolar input ranges

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

Table C- 3     Unipolar input ranges

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

## C.2 Representation of analog values in voltage measuring ranges

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

Table C- 4     Voltage measuring ranges ±10 V, ±5 V, ±1 V,

| Values | | Voltage measuring range | | | Range |
|---|---|---|---|---|---|
| dec | hex | ±10 V | ±5 V | ±1 V | |
| 32767 | 7FFF | >11.759 V | >5.879 V | > 1.176 V | Overflow |
| 32511 | 7EFF | 11.759 V | 5.879 V | 1.176 V | Overshoot range |
| 27649 | 6C01 | | | | |
| 27648 | 6C00 | 10 V | 5 V | 1 V | Rated range |
| 20736 | 5100 | 7.5 V | 3.75 V | 0.75 V | |
| 1 | 1 | 361.7 µV | 180.8 µV | 36.17 µV | |
| 0 | 0 | 0 V | 0 V | 0 V | |
| -1 | FFFF | | | | |
| -20736 | AF00 | -7.5 V | -3.75 V | -0.75 V | |
| -27648 | 9400 | -10 V | -5 V | -1 V | |
| -27649 | 93FF | | | | Undershoot range |
| -32512 | 8100 | -11.759 V | -5.879 V | -1.176 V | |
| -32768 | 8000 | < -11.759 V | < -5.879 V | < -1.176 V | Underflow |

Table C- 5     Voltage measuring range 1 to 5 V

| Values | | Voltage measuring range | Range |
|---|---|---|---|
| dec | hex | 1 to 5 V | |
| 32767 | 7FFF | >5.704 V | Overflow |
| 32511 | 7EFF | 5.704 V | Overshoot range |
| 27649 | 6C01 | | |
| 27648 | 6C00 | 5 V | Rated range |
| 20736 | 5100 | 4 V | |
| 1 | 1 | 1 V + 144.7 µV | |
| 0 | 0 | 1 V | |
| -1 | FFFF | | Undershoot range |
| -4864 | ED00 | 0.296 V | |
| -32768 | 8000 | < 0.296 V | Underflow |

## C.3          Measured values for wire break diagnostic

**Measured values on diagnostic event "wire break", dependent on diagnostics enables**

Error events initiate a diagnostics entry and trigger a diagnostics interrupt if configured accordingly.

Table C- 6          Measured values for wire break diagnostic

| Format | Parameter assignment | Measured values | | Explanation |
|---|---|---|---|---|
| S7 | • "Wire break" diagnostics enabled<br>• "Overflow/Underflow" diagnostics enabled or disabled<br>("Wire break" diagnostics takes priority over "Overflow/Underflow" diagnostics) | 32767 | 7FFF$_H$ | "Wire break" or "Open circuit" diagnostic alarm |
| | • "Wire break" diagnostics disabled<br>• "Overflow/Underflow" diagnostics enabled | -32768 | 8000 $_H$ | • Measured value after leaving the under-shoot range<br>• Diagnostic alarm "Low limit violated" |
| | • "Wire break" diagnostics disabled<br>• "Overflow/Underflow" diagnostics disabled | -32768 | 8000 $_H$ | Measured value after leaving the undershoot range |