SIGMATEK

AI 022

S-DIAS Strain Gauge Input Module

Operating Manual

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Translation from German

S-DIAS Strain Gauge Input Module AI 022

with 2 analog inputs

The S-DIAS AI 022 strain gauge input module is used to analyze measuring bridges (e.g. strain gauge load cells). With a 24-bit resolution, measurement values with an overall accuracy of 0.035 % are provided.

Contents

1 Technical Data

1.1 Analog Channel Specifications

Number of channels	2				
Bridge supply voltage	+5 V				
Load cell rated values	0.25 mV/V	0.5 mV/V	1 mV/V	2 mV/V	16 mV/V
Measurement range (1)	±1.875 mV	±3.75 mV	±7.5 mV	±15 mV	±120 mV
Measurement value	±8388608 d				
	An open input returns -2147483632 in the hardware class.				
Resolution	24 bits				
Hardware filter	180 Hz, 1st order				
Filter setting, conversion time and noise-free resolution	filter word	2	...	5	...	1023
	filter type	Sinc4	...	Sinc4	...	Sinc4
	cutoff frequency (-3 dB)	144 Hz	...	57.7 Hz	...	0.282 Hz
	conversion time	4 msec	...	9 msec	...	1702 msec
	noise-free resolution (2)	15.5 bits	...	16 bits	...	20 bits
Sensor break detection	yes				
Load per channel	75-5000 Ω (when using one channel) 150-5000 Ω (when using both channels)				
Noise (3)	±0.0031 % referred to the full scale value for filter Word 2				
Temperature drift (3)	±0.001 % / °C referred to the full scale value of the measuring range				
Overall accuracy (3)	±0.035 % referred to the full scale value of the measuring range				
Calibration data Null-voltage protected	yes				
Calibratable	no				

(1) The measurement range is defined for a 50 % distention of the load cell.

(2) These are typical values with an active Sinc4 filter and measurement range of 2 mV/V

(3) To maintain the accuracy of the analog channel measurement, a system calibration with the sensor is required whereby the null point and full-scale deflection are calibrated. The system must be re-calibrated when a sensor is replaced or the measurement range changed. Basically, the null point calibration is performed followed by the calibration for the full-scale deflection. The full-scale deflection can only be calibrated between 50 and 100 % of the positive measurement range.

1.2 Electrical Requirements

Voltage supply from S-DIAS bus	+5 V	
Current consumption on the S-DIAS bus (+5 V power supply)	typically 50 mA	maximum 55 mA
Voltage supply from S-DIAS bus	+24 V	
Current consumption on the S-DIAS bus (+24 V power supply) without load on the measuring bridge supply voltage	typically 17 mA at +18 V typically 15 mA at +24 V typically 14 mA at +30 V	maximum 20 mA at +18 V maximum 18 mA at +24 V maximum 17 mA at +30 V
Current consumption on the S-DIAS bus (+24 V power supply) with maximum load on the both measuring bridge supply voltage	typically 41 mA at +18 V typically 34 mA at +24 V typically 29 mA at +30 V	maximum 48 mA at +18 V maximum 40 mA at +24 V maximum 34 mA at +30 V

If this S-DIAS module is connected to an S-DIAS supply module with several S-DIAS modules, the total current of the modules used must be determined and checked.

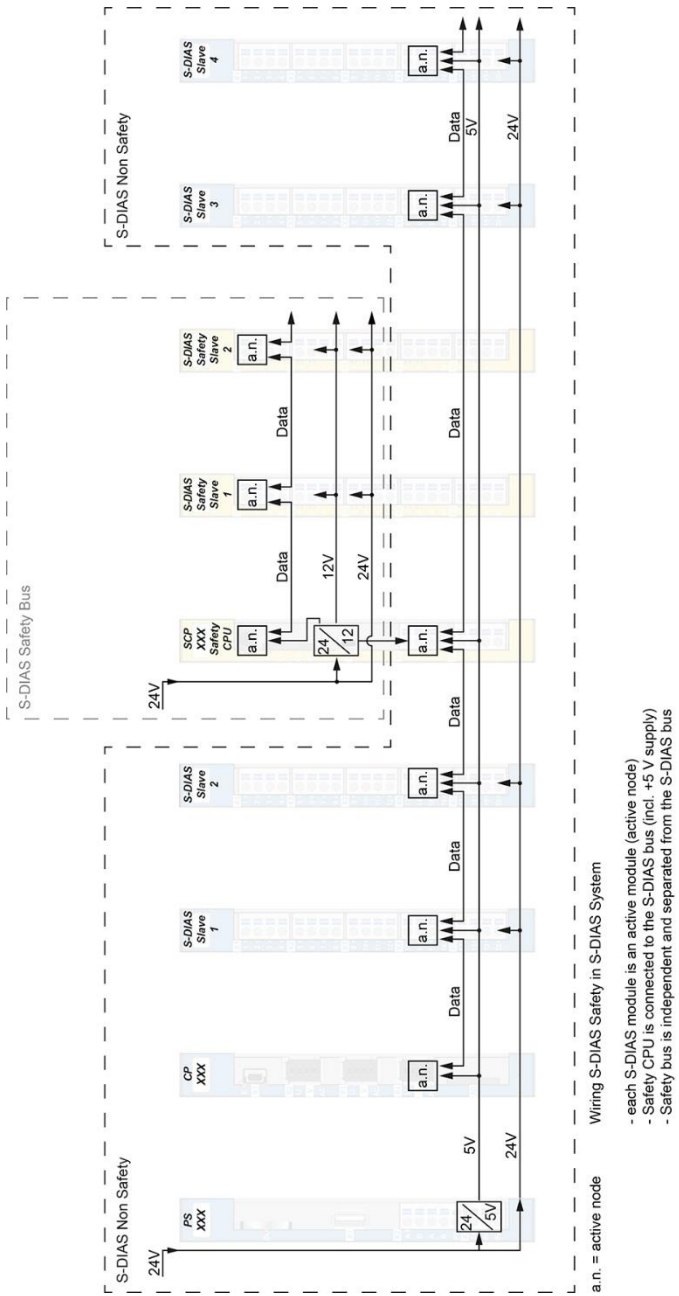
The total current of the +24 V supply cannot exceed 1.6 A!
The total current of the +5 V supply cannot exceed 1.6 A!

The specification for the current can be found in the module-specific documentation under "Electrical Requirements".

Si ce module S-DIAS est connecté à un module d'alimentation S-DIAS suivi de plusieurs modules S-DIAS, le courant total des modules utilisés doit être déterminé et vérifié.

Le courant total de l'alimentation +24 V ne peut pas dépasser 1,6 A!
Le courant total de l'alimentation +5 V ne peut pas dépasser 1,6 A!

Le cahier des charges pour le courant peut être trouvé dans la documentation spécifique au module sous "Spécifications électriques".


S-DIAS Non Safety
S-DIAS Safety Bus
S-DIAS Non Safety
24V
PS XXX
CP XXX
S-DIAS Slave 1
S-DIAS Slave 2
SCP XXX Safety CPU
S-DIAS Safety Slave 1
S-DIAS Safety Slave 2
S-DIAS Slave 3
S-DIAS Slave 4
a.n.
Data
5V
12V
24V
24/5V
24/12
a.n. = active node
Wiring S-DIAS Safety in S-DIAS System
- each S-DIAS module is an active module (active node)
- Safety CPU is connected to the S-DIAS bus (incl. +5 V supply)
- Safety bus is independent and separated from the S-DIAS bus

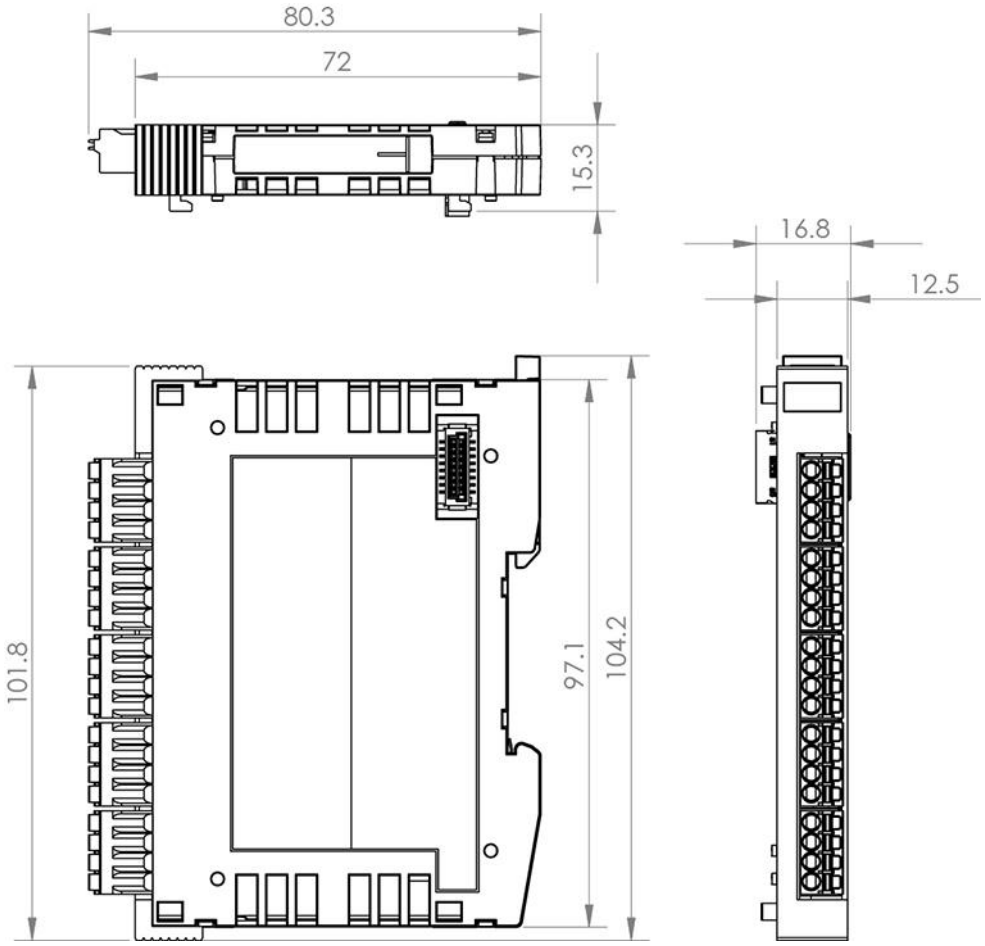
1.3 Miscellaneous

Article number	20-009-022
Hardware version	1.x
Standard	UL 508 (E247993)
Approvals	UL, cUL, CE

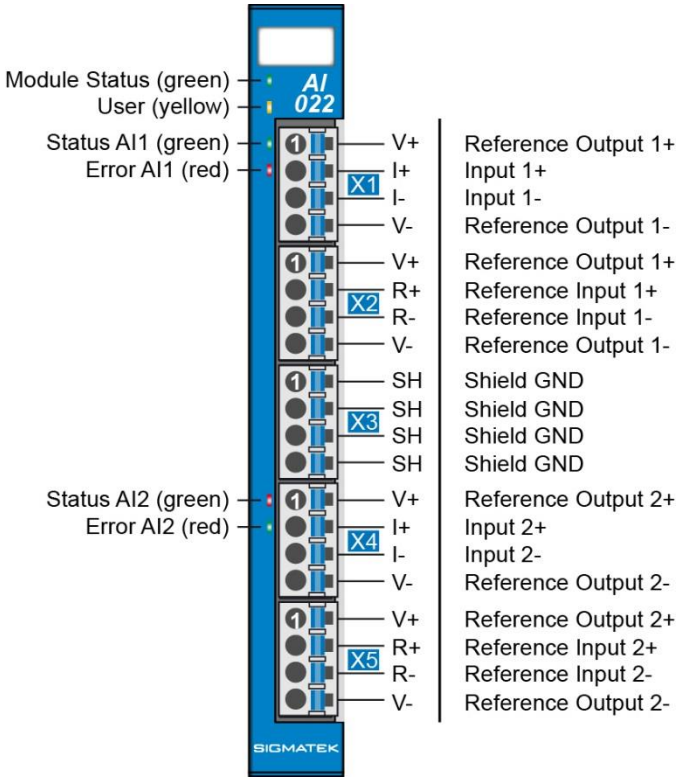
1.4 Environmental Conditions

Storage temperature	-20 ... +85 °C	
Environmental temperature	0 ... +60 °C	
Humidity	0-95 %, non-condensing	
Installation altitude above sea level	0-2000 m without derating > 2000 m with derating of the maximum environmental temperature by 0.5 °C per 100 m	
EMC resistance	in accordance with EN 61000-6-2:2007 (industrial area)	
EMC noise generation	in accordance with EN 61000-6-4 (industrial area)	
Vibration resistance	EN 60068-2-6	3.5 mm from 5-8.4 Hz 1 g from 8.4-150 Hz
Shock resistance	EN 60068-2-27	15 g
Protection type	EN 60529	IP20

2 Mechanical Dimensions



3 Connector Layout



3.1 Status LEDs

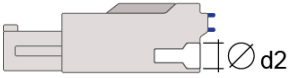
Module Status	green	ON	module active
		OFF	no supply available
		BLINKING (5 Hz)	no communication
User	yellow	ON	can be set from the application (e.g. the module LED can be set to blinking through the visualization so that the module is easily found in the control cabinet)
		OFF	
		BLINKING (2 Hz)	
		BLINKING (4 Hz)	
Status AI1/AI2	green	BLINKING (3 Hz)	A/D converter active
		OFF	A/D converter inactive
Error AI1/AI2	red	ON	sensor break or overload/short circuit of the bridge supply.
		OFF	no errors
		BLINKING (1 Hz)	input initialization error

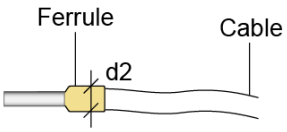
3.2 Applicable Connectors

Connectors:
X1-X5: Connectors with spring terminals (included in delivery)
The spring terminals are suitable connecting ultrasonically compacted (ultrasonically welded) strands.

Connections:

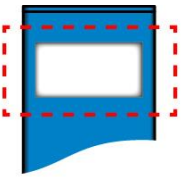
Stripping length/Sleeve length:	10 mm
Plug-in direction:	parallel to conductor axis or to PCB
Conductor cross section, rigid:	0.2-1.5 mm^2
Conductor cross section, flexible:	0.2-1.5 mm^2
Conductor cross section, ultrasonically compacted	0.2-1.5 mm^2
Conductor cross section AWG/kcmil:	24-16
Conductor cross section flexible, with ferrule without plastic sleeve:	0.25-1.5 mm^2
Conductor cross section flexible, with ferrule with plastic sleeve:	0.25-0.75 mm^2 (ground for reducing d2 of the ferrule)





d2 = max. 2.8 mm

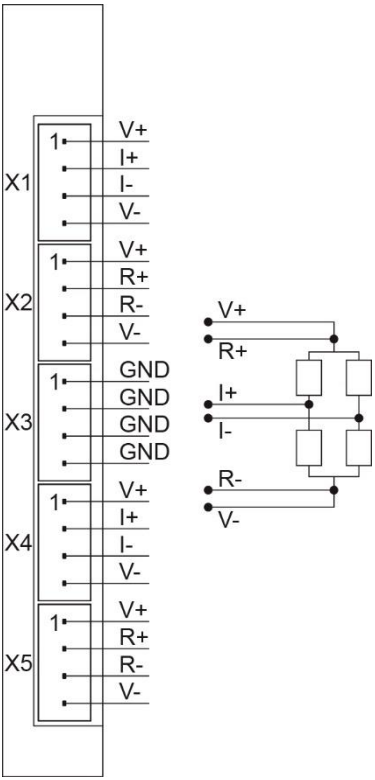
3.3 Label Field



Manufacturer	Weidmüller
Type	MF 10/5 CABUR MC NE WS
Weidmüller article number	1854510000
Compatible printer	Weidmüller
Type	Printjet Advanced 230V
Weidmüller article number	1324380000

4 Wiring

4.1 Wiring Example



4.2 Notes

The signals recorded by the analog modules are very small, as compared to the digital signals. To ensure error-free operation, a careful wiring method must be followed:

- The DIN rail must have an adequate ground connection.
- The lines connected to the source of the analog signals must be as short as possible and parallel wiring to digital signal lines must be avoided.
- The signal lines must be shielded.
- The shielding must be connected to a shielding bus.
- Avoid parallel connections between input lines and load-bearing circuits.
- Protective circuits for all relays (RC networks or free-wheeling diodes).

The ground bus should be connected to the control cabinet when possible!

Si possible la terre doit être connectée à l'armoire de commande!

IMPORTANT:
The S-DIAS module CANNOT be connected or disconnected while voltage is applied!

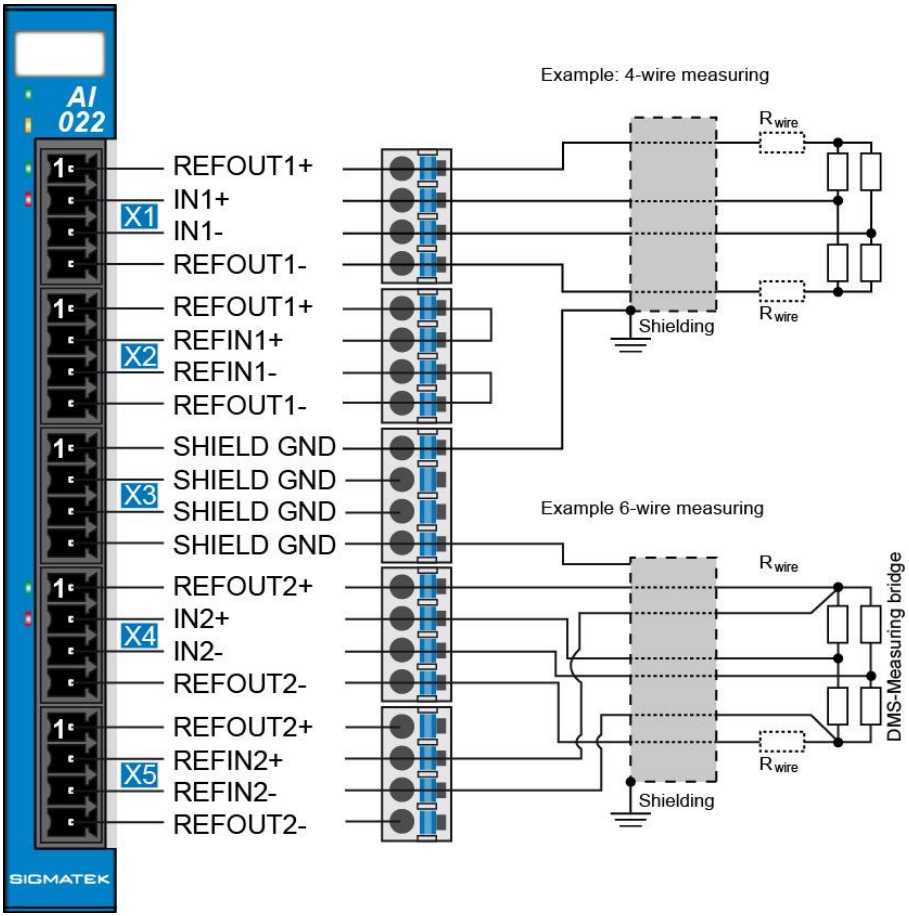
IMPORTANT:
Le module S-Dias NE PEUT PAS être inséré ou retiré sous tension.

4.3 Connection Variants

Two connection Types can be used when measuring with strain gauges:

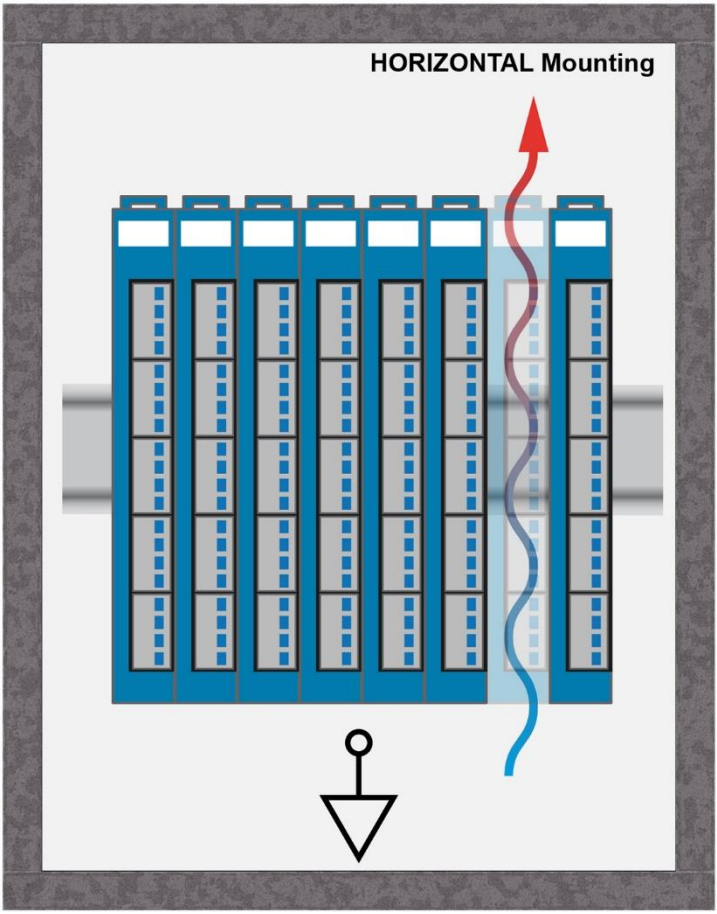
4-wire measurement:
The advantage of this variant is that a 4-pin connector cable can be used for the strain gauge. The voltage drop on over the circuit for the bridge voltage supply, however, cannot be compensated.

6-wire measurement:
This configuration provides the advantage of voltage compensation using the bridge voltage supply on the strain gauge directly.

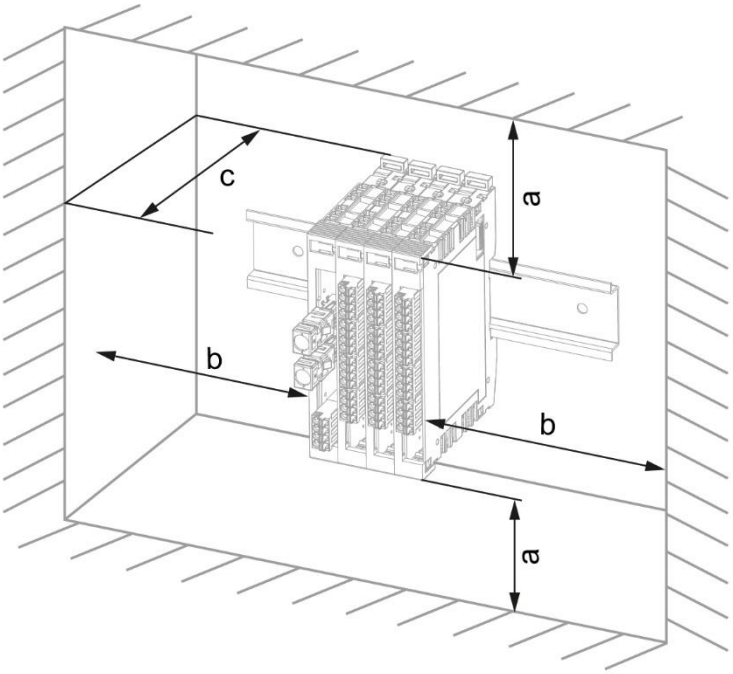


5 Mounting

The S-DIAS modules are designed for installation into the control cabinet. To mount the modules a DIN-rail is required. The DIN rail must establish a conductive connection with the back wall of the control cabinet. The individual S-DIAS modules are mounted on the DIN rail as a block and secured with latches. The functional ground connection from the module to the DIN rail is made via the grounding clamp on the back of the S-DIAS modules. The modules must be mounted horizontally (module label up) with sufficient clearance between the ventilation slots of the S-DIAS module blocks and nearby components and/or the control cabinet wall. This is necessary for optimal cooling and air circulation, so that proper function up to the maximum operating temperature is ensured.



Recommended minimum distances of the S-DIAS modules to the surrounding components or control cabinet wall:



a	b	c
30 mm (1.18″)	**30 mm** (1.18″)	**100 mm** (3.94″)

a, b, c … distances in mm (inches)

6 Addressing

6.1 Address Mapping Overview

Address (hex)	Size (bytes)	Access Type	Description
0000	**128**	w	**Cyclic Data for Firmware**
0000	0	-	-
0080	**128**	**r**	**Cyclic Data for the HW Class**
0080	2	r	Status Bit 0 not used Bit 1 no SYNC Bit 2 FLASH data CRC error Bit 3 RAM data CRC error Bit 4 unsafe FLASH data Bit 5 bridge 1 DC not OK Bit 6 bridge 2 DC not OK Bit 7 offset ADC 1 not valid Bit 8 offset ADC 2 not valid Bit 9 filter ADC 1 not ready Bit 10 filter ADC 2 not ready
0082	4	r	Analog input 1
0086	4	r	Analog input 2
1x	2	r	ADC controller statuses Byte 0 ADC 1 Byte 1 ADC 2
0100	**128**	w	**CFG for the Firmware**
0100	2	w	CRC
0102	2	w	Data length
0104	1	w	Info (special purpose or status bits) Bit 0 PMB mode Bit 1 boot loader/update request
0105	1	w	Bit 0 toggle bit

	Standard Mode (info-register bit 0 = 0)		
0106	2	w	CFG data for ADC 1 Bit 0-9 filter limit frequency Bit 10 SINC Bit 11-13 mode
0108	2	w	CFG data for ADC 1 Bit 0-2 Gain
101A	2	w	CFG data for ADC 2 Bit 0-9 filter limit frequency Bit 10 SINC Bit 11-13 mode
101C	2	w	CFG data for ADC 2 Bit 0-2 Gain
010E	4	w	Zeroscale Offset ADC 1
0112	4	w	Fullscale Offset ADC 1
0116	4	w	Zeroscale Offset ADC 2
011A	4	w	Fullscale Offset ADC 2
0180	**128**	**r**	**CFG for the HW class**
0180	2		CRC
0182	2		Data length
0184	2		Firmware version
0190	**128**		**SDO data for the HW class**
0190	2		CRC of the actual Config data (after re-configuration, the hardware class must be tested as to whether this CRC matches the CRC sent with the Config).
0192	4	r	Zeroscale Offset ADC 1
0196	4	r	Fullscale Offset ADC 1
019A	4	r	Zeroscale Offset ADC 2
019E	4	r	Fullscale Offset ADC 2
0200	X		**Firmware update**
0200	x		Firmware update

6.2 Address Mapping Overview – Factory Calibration

The factory calibration data are in the FLASH of the µC at a defined address.
With the intelligent SDO access “CMD 18” with the “SubCMD 3” for reading the internal configuration memory and the offset information 0x20 this Flash memory area of the module can be accessed directly (since FW 01.80).

Address (hex)	Size (bytes)	Access type	Description
20	2	r	CRC (incl. version)
22	2	r	Length (incl. version)
24	2	r	Version (e.g. 0x0100)
26	2	r	Reserved
28	4	r	Zeroscale offset ADC1
2C	4	r	Fullscale offset ADC1
30	4	r	Gain ADC1
34	4	r	Zeroscale offset ADC2
38	4	r	Fullscale offset ADC2
3C	4	r	Gain ADC2

7 Supported Cycle Times

7.1 Cycle Times below 1 ms (in µs)

FW	50	100	125	200	250	500
V3.00		x	x	x	x	x

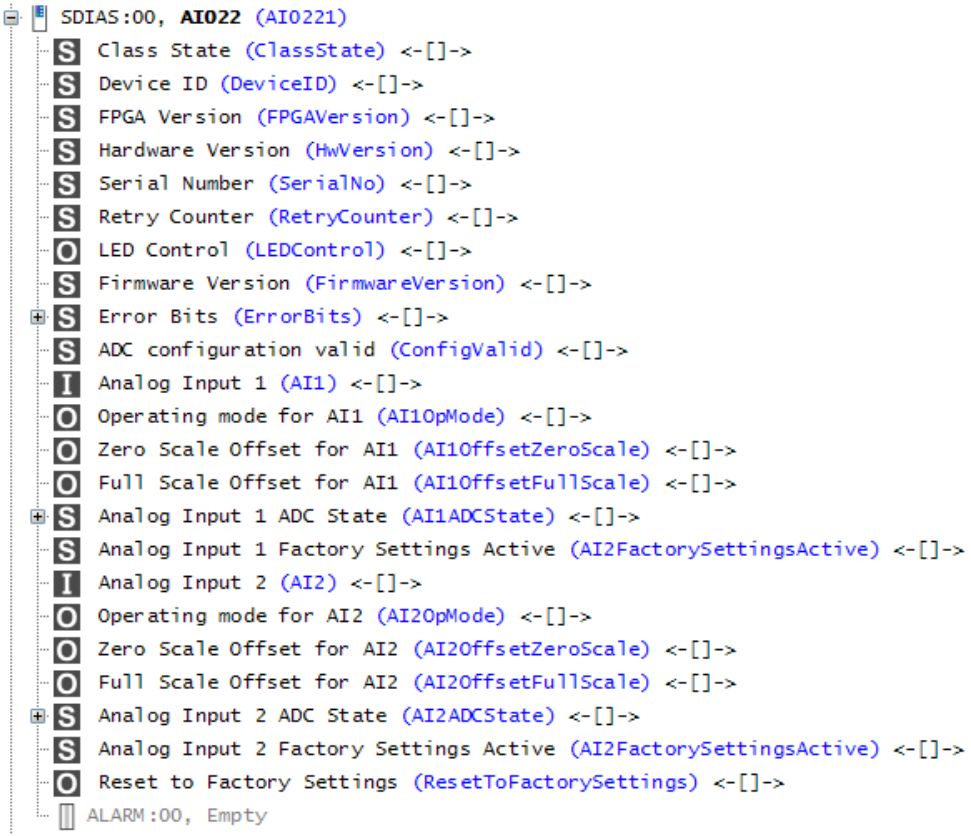
7.2 Cycle Times equal to or higher than 1 ms (in ms)

FW	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
V3.00	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

FW	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
V3.00	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

8 Hardware Class AI022

Hardware class AI022 for the S-DIAS AI022 analog module



This hardware class is used to control the AI 022 hardware module. The module has two analog inputs for resistance bridges (e.g. DMS load cells). More information on the hardware can be found in the module documentation.

8.1 General

Class State	State	This server shows the actual status of the hardware class.
Device ID	State	The device ID of the hardware module is shown in this server.
FPGA Version	State	FPGA version of the module in 16#XY (e.g. 16#10 = version 1.0).
Hardware Version	State	Hardware version of the module in format 16#XXYY (e.g. 16#0120 = Version 1.20)
Serial Number	State	The serial number of the hardware module is shown in this server.
Retry Counter	State	This server increments when a transfer fails.
LED Control	Output	With this server, the application LED of the S-DIAS module can be activated to find the module in the network more quickly. The following statuses are possible: 0 LED off 1 LED on 2 blinks slowly 3 blinks rapidly
Required	Property	This client is active by default, which means that the S-DIAS hardware module at this position is mandatory for the system and can under no circumstances be disconnected or return an error. Otherwise, the entire hardware deactivated. If the hardware module is missing or removed, an S-DIAS error is triggered. If his client is initialized with 0, the hardware module located in this position is not mandatory. This means that it can be inserted or removed at any time. However, which components identified as "not required" should be selected with regard to the safety of the system.
Firmware Version	State	The firmware version of the hardware module is shown in this server.
Error Bits	State	In this server, the error bits of the module are shown. The respective bits mean the following: Bit 0 Not used Bit 1 no Sync available Bit 2 Flash Data CRC Error Bit 3 Ram Data CRC Error Bit 4 invalid EEProm version Bit 5 Bridge 1 DC not OK Bit 6 Bridge 2 DC not OK Bit 7 incorrect gain setting of ADC1 – current setting does not match the calibrated data Bit 8 incorrect gain setting of ADC2 – current setting does not match the calibrated data Bit 9 Bridge1 filter is not yet filled Bit 10 Bridge1 filter is not yet filled The error bits 7 and 8 go to null as soon as the gain setting matches the defined values. The application must ensure that the correct gain (as well as filter type and filter depth) is set correctly after each restart. This is necessary, since the calibration data no longer matches when the gain is changed and the measurement results are thereby incorrect. If the gain must be changed, a new calibration must be performed.

8.2 Analog Inputs

ADC configuration valid	State	1: the configuration of the ADCs is valid => the analog values can be used in the application 0: the configuration of the ADCs is invalid -1: error while sending the configuration to the ADCs
Analog Input [1-2]	Input	Current value of the respective analog channel (if AI[1-2]ConfigValid, as well as the Ready bit of the AI[1-2]ADCState is set). Shows the value 16#80000010, if the ErrorBit on server AI[1-2]ADCState is set.
Zero Scale Offset for AI [1-2]	Output	Scale null point according to the last calibration (updated with each change in the FilterDepth, SincSetting, Gain or OpMode settings)
Full Scale Offset for AI [1-2]	Output	Scale end value according to the last calibration (updated with each change in the FilterDepth, SincSetting, Gain or OpMode settings)
AI[1-2]ADCState	State	Shows the status of the respective input. Bit 0-4: Not used Bit 5: No reference (set if the reference voltage is too low) Bit 6: error The ADC error bit is set when all bits in the analog value were referenced to 0 or 1. The bit is cleared when the error no longer exists and the analog value valid again. Possible Causes: - Value outside of the valid measurement range - No reference voltage Bit 7: Not Ready Indicates when newly converted values are available (for valid values, it is always set to 0 in Continuous mode)
AI[1-2]FilterDepth	Property	Value setting for the filter depth of the respective ADS (default value = 2) Valid range of values: 2-1023
AI[1-2]SincSetting	Property	Selection of the sinc filter type of the respective ADC: 0: sinc 4 Filter is used (default) 1: sinc 3 Filter is used (default) The advantage of the sinc 3 filter, as compared with sinc 4 filter, is the lower settling time. The sinc 4 filter however, provides better 50 / 60 Hz suppression.
AI[1-2] Gain	Property	Gain selection for selecting the input range of the corresponding ADC: 0: Gain 1 (± 120 mV) 1: not used (for selection, the default value is used) 2: not used (for selection, the default value is used) 3: Gain 8 (± 15 mV) (default) 4: Gain 16 (± 7.5 mV) 5: Gain 32 (± 3.75 mV) 6: Gain 64 (± 1.875 mV)
Operating mode for AI[1-2]	Output	Operating mode selection for the corresponding ADC: 1: continuous conversion mode (default) 6: system zero-scale calibration 7: system full-scale calibration

Reset to Factory Settings	Output	-1 function not available (available starting with FW version 1.80) -2 invalid CRC in the factory settings -3 invalid input parameters (must be 1, 2 or 3) 0 reset successful, if ConfigValid goes to 1
Analog Input [1-2]Factory Settings Active	State	Shows, whether the ADC for the according channel is set to factory settings. 0 ADC configuration is different to factory settings 1 ADC configuration matches with factory settings -1 factory settings are not available (too old FW version (at least 1.80 or higher) or invalid CRC in the factory settings data (can occur with firmware update with update stick)

8.3 Communication Interfaces

ALARM	Downlink	With this downlink the corresponding alarm class can be placed via the hardware editor.

8.4 Setting the Filter Depth

When setting the filter depth, it is important to ensure that the conversion time is dependent on it.

Calculating the ADC data rate f_{ADC} (with f_{CLK} = 4.92 MHz) for the sinc 4 filter:
$f_{ADC} = f_{CLK} /(4 * 1024 *$ AI[1-2]FilterDepth)

Calculating the ADC data rate f_{ADC} (with f_{CLK} = 4.92 MHz) for the sinc 3 filter:
$f_{ADC} = f_{CLK} /(3 * 1024 *$ AI[1-2]FilterDepth)

This results in the conversion time t_{SETTLE}: $t_{SETTLE} = 2/ f_{ADC}$

Calculating the cutoff frequency f_{3DB}: $f_{3DB} = 0.24 * f_{ADC}$

Ex.: Sync 4, filter depth 5 : conversion time = 9 ms; cutoff frequency = 57.7 Hz

8.5 Setting the Force Measurement Sensor:

1. The ADC gain is correctly set using the data sheet of the measurement device. The module should be set so that the defined range of the force recorder uses as much of the ADC value range without exceeding it.
2. Null point calibration (Tara) of the measurement recorder with AI[1-2]OpMode – 6. AI[1-2]OffsetZeroScale is therewith defined.
3. Calibration of the full-scale deflection: The sensor is loaded with the maximum force used and end value of the scale is defined in the register AI[1-2]OffsetFullScale with AI[1-2]OpMode – 7. The full-scale deflection calibration is only possible between 50 and 100 % of the positive measurement range.

8.6 Example


HwControl
HwControl1
HC
IODebug
SafetyDomainTimeout
Control
State
_ClassOk
DiasMaster
SafetyState
DomainNr
VaranManager_1
VaranManager_11
To_HwControl
VaranManagerTime
1000000
VaranManagerNr
PreventManagerError
IsoStartPoint
50
IRQTaskTime
IsAlsoClient
SuperiorSystemTime
Control
State
_ClassOk
ManagerOn
1
Release
16#00000011
RetryCounter
IsoVaranTime
9840
AsyVaranTime
Act_RtTime
15
Min_RtTime
5
Max_RtTime
31
Act_RtCallTime
995
Min_RtCallTime
984
Max_RtCallTime
1015
SuperiorSystemOK
-1
VaranOut_1
VI021
VI0211
VaranIn
Required
UserAction
SerNoValidation
Transparent
State
_ClassOk
Online
1
Release
16#00000012
DeviceSubfeature
16#00010000
VendorID
1
DeviceID
1187
SerialNr
"00000000"
RetryCounter
ValidateSerNo
-2
FirmwareVersion
16#00000007
SdiasState
_ClassOk
SdiasRetryCounter
SdiasOut_1
VaranOut_1
AI022
AI0221
SdiasIn
Place
Required
ClassState
_ClassOk
DeviceID
1016
FPGAVersion
16#00000011
SerialNr
"0815"
RetryCounter
LEDControl
FirmwareVersion
16#00000020
ErrorBits
ConfigValid
1
AI1
16777215
AI1OffsetZeroScale
8388608
AI1OffsetFullScale
10997437
AI1ADCState
32
AI1FilterDepth
1
AI1SincSetting
AI1Gain
AI1OpMode
AI2
8390545
AI2OffsetZeroScale
8323316
AI2OffsetFullScale
5597075
AI2ADCState
128
AI2FilterDepth
1
AI2SincSetting
AI2Gain
AI2OpMode

Documentation Changes

Change date	Affected page(s)	Chapter	Note
26.09.2013	3 8 12	1.1 3.1 7.1	Updated complete chapter (values and description) Status AI1/AI2: changed from *ON* to *BLINKING (3 Hz*) Address 0080: changed Bit0 from *24V DC not OK* to *not used*
04.10.2013	4	1.2	Note
23.10.2013	5	1.4	Added Vibration resistance
23.12.2013	7 9	3 Connector Layout 4.1 Wiring Example	Changed image Added wiring example
11.02.2014	7 8	3 Connector Layout 3.2 Applicable Connectors	Changed image Connection capacity added French notes added
01.04.2014	4 12	1.3 Miscellaneous 5 Mounting	UL added Text updated
30.01.2015	10 13	4.2 Notes 6.1 Address-Mapping Overview	Added note concerning connecting the S-DIAS module while voltage is applied Added Bits 7, 8, 9 and 10 at Address 0080
11.02.2015	8	3.1 Status LEDs	Added blinking (Error AI1/AI2)
26.03.2015	8	3.2 Applicable Connectors	Added connections
15.07.2015	4	1.2 Electrical Requirements	Changed electrical requirements
22.01.2016	5	1.2 Electrical Requirements	Graphics added
28.04.2016	14	5 Mounting	Graphics distances
02.05.2016	15 17	6.1 Address Mapping Overview 6.2 Address Mapping Overview – Factory Calibration	Extended Added
08.02.2017	3	1.1 Analog Channel Specifications	Load per channel more detailled

01.03.2017	3	1.1 Analog Channel Specifications	Hardware filter added
27.03.2017	3	1.1 Analog Channel Specifications	Added value for sensor break detection
17.08.2017	6 9	1.4 Environmental Conditions 3.2 Applicable Connectors	Added operating conditions Added sleeve length Added info regarding ultrasonically welded strands
18.10.2017	10 15	3.3 Label Field 5 Mounting	Added chapter Graphic replaced
25.10.2017	3	1.1 Analog Channel Specification	Load per channel changed to 75-5000 Ω
21.03.2019	3	1.1 Analog Channel Specification	Noise, Temperature drift and overall accuracy appended
18.12.2019		7 Supported Cycle Times	Chapter added
08.09.2020	21	8 Hardware Class AI022	Chapter added
04.11.2020	15	5 Mounting	Expansion functional connection