Rexroth Inline Terminal With Eight Analog Input Channels

R911170486
Edition 02

R-IB IL AI 8/IS-PAC

8 analog current inputs
2 or 3-wire technology
0 - 20 mA, 4 - 20 mA, ±20 mA, 0 - 40 mA, ±40 mA

05/2007

1 Description

The terminal is designed for use within an Inline station. It is used to acquire analog current signals from active and passive sensors.

Features

- Eight analog single-ended signal inputs for the connection of active and passive current sensors
- Connection of sensors in 2 and 3-wire technology
- Provision of a short-circuit-proof supply voltage for passive sensors (U_{IS}; default 24 V)
- Various current measuring ranges
- Channels are configured independently of one another using the bus system
- Measured values can be represented in five different formats
- 16-bit analog/digital converter
- Process data multiplex mode
- Diagnostic indicators

This data sheet is only valid in association with the application descriptions for the Rexroth Inline system (see "Documentation" on page 4).

Make sure you always use the latest documentation.
It can be downloaded at www.boschrexroth.com.

Table of Contents

2 Ordering Data

Products

Description	Type	MNR	Pcs./Pck.
Rexroth Inline terminal with eight analog input channels and supply for passive sensors; complete with accessories (connectors and labeling fields)	R-IB IL AI 8/IS-PAC	R911308494	1

Documentation

Description	Type	MNR	Pcs./Pck.
"Automation Terminals of the Rexroth Inline Product Range" application description	DOK-CONTRL-ILSYSINS***-AW..-EN-P	R911317021	1
"Configuring and Installing the Rexroth Inline Product Range for INTERBUS" application description	DOK-CONTRL-ILSYSPRO***-AW..-EN-P	R911317023	1

For additional ordering data (accessories), please refer to the product catalog at www.boschrexroth.com.

3 Technical Data

General Data	
Housing dimensions (width x height x depth)	48.8 mm x 120 mm x 71.5 mm
Weight	215 g (with connectors)
Operating mode	Process data mode with 4 bytes
Connection method for sensors	2 and 3-wire technology
Ambient temperature (operation)	-25°C to +55°C
Ambient temperature (storage/transport)	-25°C to +85°C
Permissible humidity (operation/storage/transport)	10% to 95%, according to DIN EN 61131-2
Permissible air pressure (operation/storage/transport)	70 kPa to 106 kPa (up to 3000 m above sea level)
Degree of protection	IP20 according to IEC 60529
Protection class	Class 3 according to VDE 0106, IEC 60536
Connection data for Inline connectors	
Connection method	Spring-cage terminals
Conductor cross-section	0.2 mm^2 to 1.5 mm^2 (solid or stranded), 24 - 16 AWG

Interface	
Local bus	Data routing
Transmission Speed	
R-IB IL AI 8/IS-PAC	500 kbps

Power Consumption	
Communications power U_L	7.5 V DC
Current consumption at U_L	52 mA (typical)/65 mA (maximum)
I/O supply voltage U_{ANA}	24 V DC
Current consumption at U_{ANA}	31 mA (typical)/40 mA (maximum)
Total power consumption	1134 mW (typical)

Supply of the Module Electronics and I/O Through the Bus Coupler/Power Terminal	
Connection method	Potential routing

Initiator Supply Voltage	
U_{IS} (via supply of U_M)	
Nominal value	+24 V
Permissible range	+10 V to +30 V
Permissible temperature range (TA)	-25°C to +55°C
Nominal current I_{IS}	

Initiator Supply Voltage (Continued)	
I_{ISNom}/channel	+20 mA
I_{ISMAX}/I/O connector (=> total current for two channels)	+50 mA
Protection	Internal electronic fuse; short-circuit-proof

Analog Inputs	
Number	8 analog single-ended inputs
Signals/resolution in the process data word (quantization)	See tables in "Formats for the Representation of Measured Values" on page 18.
Measured value representation	In the following formats: IB IL (15 bits with sign bit) IB ST (12 bits with sign bit) IB RT (15 bits with sign bit) Standardized representation (15 bits with sign bit) PIO (16 bits)

Please read the notes on page 19 and page 23 on measured value representation in "IB IL" and "standardized representation" format.

Digital filtering (mean-value generation)	None or over 4, 16 or 32 measured values Default setting: over 16 measured values
Conversion time of the A/D converter	10 µs, maximum
Process data update of the channels	Bus synchronous
Firmware runtime depending on the command	
$0x00_{hex}$	< 800 µs
$5x00_{hex}$	< 850 µs
$7000_{hex}/7100_{hex}$	< 1500 µs
$7400_{hex}/7500_{hex}/7600_{hex}/7700_{hex}$	< 1300 µs

Analog Input Stages	
Input resistance	25 Ω (shunt)
Limit frequency (-3 dB) of the input filters	3.5 kHz
Behavior on sensor failure	Goes to 0 mA or 4 mA
Maximum permissible voltage between analog current inputs and an analog reference potential or between two current inputs	±2.5 V (corresponds to 100 mA via the shunts)
Maximum permissible current in every input	±100 mA (destruction limit)

Safety Equipment

None

Electrical Isolation/Isolation of the Voltage Areas

CAUTION

To provide electrical isolation between the logic level and the I/O area, it is necessary to supply the station bus coupler and the sensors connected to the analog input terminal described here from separate power supply units. Interconnection of the power supply units in the 24 V area is not permitted (see application description).

Common Potentials

The 24 V main voltage, 24 V segment voltage, and GND have the same potential. FE is a separate potential area.

Separate Potentials in the System Consisting of Bus Coupler/Power Terminal and I/O Terminal

- Test Distance	**- Test Voltage**
5 V supply incoming remote bus/ 7.5 V supply (bus logic)	500 V AC, 50 Hz, 1 min.
5 V supply outgoing remote bus/ 7.5 V supply (bus logic)	500 V AC, 50 Hz, 1 min.

Electrical Isolation/Isolation of the Voltage Areas (Continued)	
7.5 V supply (bus logic)/24 V supply U_{ANA}/ I/O	500 V AC, 50 Hz, 1 min.
7.5 V supply (bus logic), 24 V supply U_{ANA}/ functional earth ground	500 V AC, 50 Hz, 1 min.
I/O/functional earth ground	500 V AC, 50 Hz, 1 min.

Error Messages to the Higher-Level Control or Computer System	
Failure of the voltage supply U_{ANA}	Yes, peripheral fault
Peripheral fault/user error	Yes, error message via the IN process data (see page 25)

Approvals

For the latest approvals, please visit www.boschrexroth.com.

4 Local Diagnostic and Status Indicators and Terminal Point Assignment

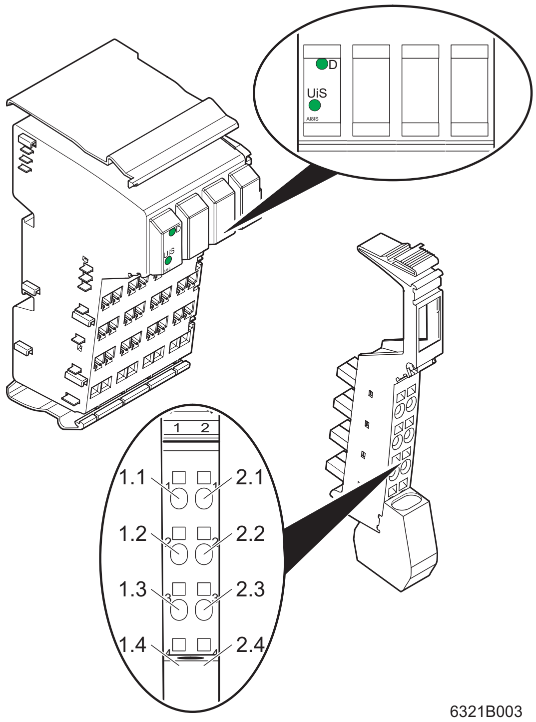

Fig. 1 Terminal with one of the appropriate connectors

4.1 Local Diagnostic Indicators

Des.	Color	Meaning
D	Green	Diagnostics
UiS	Green	Initiator supply
	ON	Initiator supply present
	Flashing ...	Overload/short circuit of the initiator supply at:
	... 1x	Slot 1
	... 2x	Slot 2
	... 3x	Slot 3
	... 4x	Slot 4 Or Supply voltage U_{iS} not present

If the UiS LED flashes four times, check the UM LED on the preceding power terminal. If the cause of the flashing is not an error at slot 4, but the failure of the supply voltage U_{iS}, the UM LED indicates the failure of the supply voltage U_M to the preceding power terminal (UM LED off).

In the event of an initiator supply error, the LED for the corresponding slot number starts flashing. This is followed by a long pause after which the flashing resumes.

4.2 Function Identification

Green

Terminal Point Assignment for Each Connector

Terminal Points	Signal	Assignment
1.1	**$+U_{iS}1$**	Initiator supply channel 1
2.1	**$+U_{iS}2$**	Initiator supply channel 2
1.2	**+I1**	Current input channel 1
2.2	**+I2**	Current input channel 2
1.3, 2.3	**-1, -2**	Minus input
1.4, 2.4	**Shield**	Shield connection

5 Installation Instructions

High current flowing through potential jumpers U_M and U_S leads to a temperature rise in the potential jumpers and inside the terminal. Observe the following instructions to keep the current flowing through the potential jumpers of the analog terminals as low as possible:

CAUTION

Create a separate main circuit for the analog terminals

If this is not possible in your application and you are using analog terminals in a main circuit together with other terminals, place the analog terminals after all the other terminals at the end of the main circuit.

6 Internal Circuit Diagram

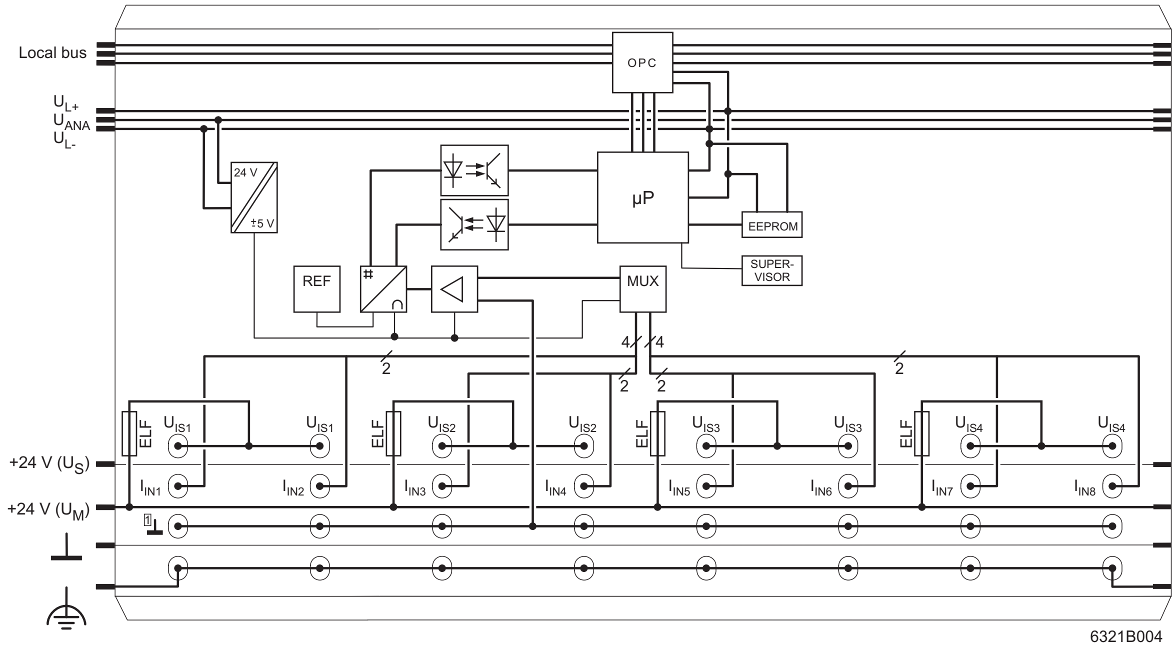

Fig. 2 Internal wiring of the terminal points

Key:

OPC	Protocol chip		Analog/digital converter
	Optocoupler		Amplifier
µP	Microprocessor	MUX	Multiplexer
EEPROM	Electrically erasable programmable read-only memory	ELF	Electronic fuse
SUPER-VISOR	Microprocessor monitoring		
	Power supply unit with electrical isolation		
REF	Reference voltage source		

☞ Other symbols used are explained in the DOK-CONTRL-ILSYSINS***-AW..-EN-P application description or the application description for your bus system.

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7 Electrical Isolation

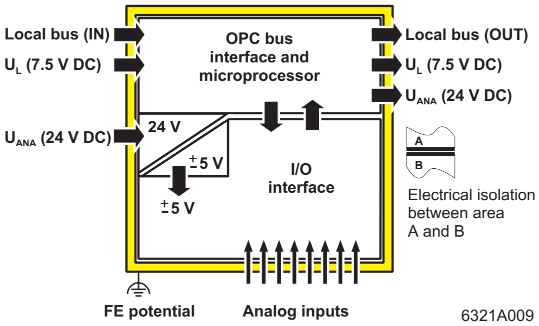

Fig. 3 Electrical isolation of the individual function areas

8 Connection Notes

CAUTION

Do not connect voltages above ±2.5 V to a current input. The module electronics will be damaged, as the maximum permissible current of ±100 mA will be exceeded.

Always connect the analog sensors using shielded, twisted pair cables.
Connect the shielding to the Inline terminal using the shield connection clamp. The clamp connects the shield directly to FE on the terminal side. Additional wiring is not required.
Isolate the shielding at the sensor or connect it with a high resistance and a capacitor to the PE potential.

9 Connection Examples

Observe the connection notes on page 9.

Fig. 4 and Fig. 5 show the connection schematically (without shield connector).

The sensors have the same reference potential.

9.1 Connection of Active Sensors

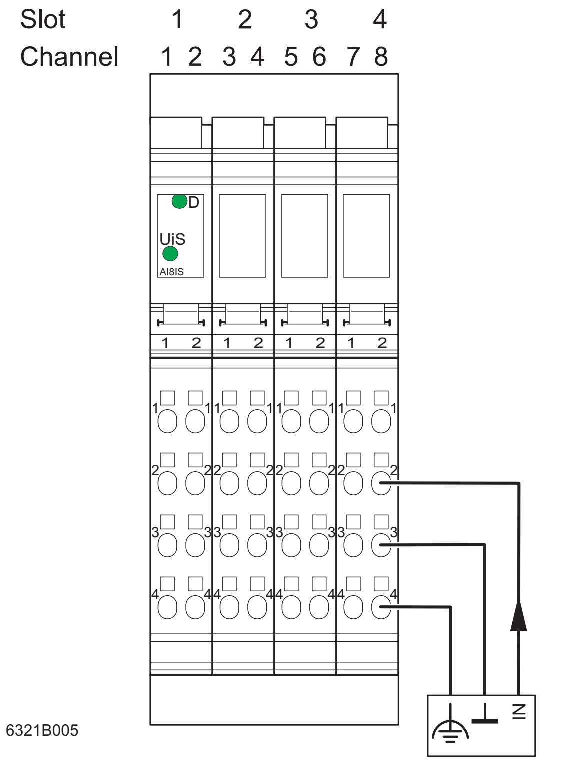

Fig. 4 Signals for the connection of active sensors in 2-wire technology with shield connection

9.2 Connection of Passive Sensors

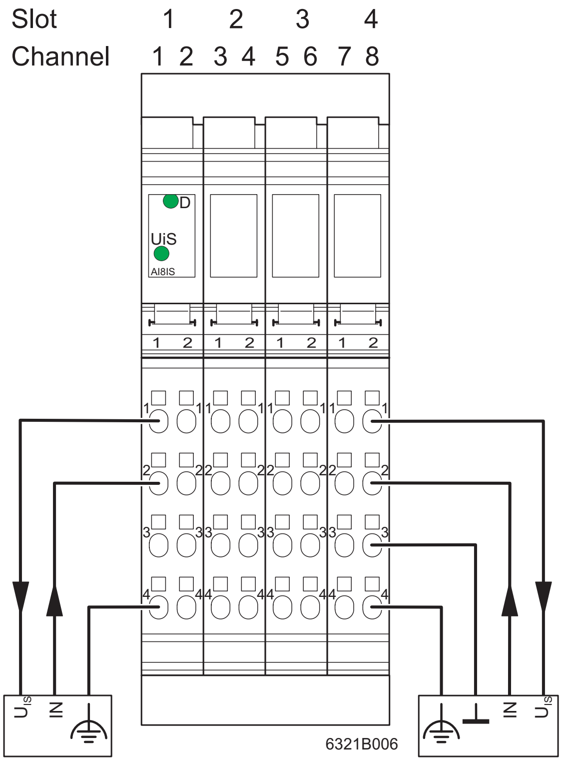

Fig. 5 Signals for the connection of passive sensors in 2 and 3-wire technology with shield connection

CAUTION

The voltage U_{IS} for passive sensors is provided with short-circuit protection for each connector. It is taken from the main voltage U_M. U_M is usually 24 V, but can also be supplied to the preceding power terminal with a lower voltage, if required (see "Passive Sensors" on page 34).

9.3 Connection of Several Evaluating Devices

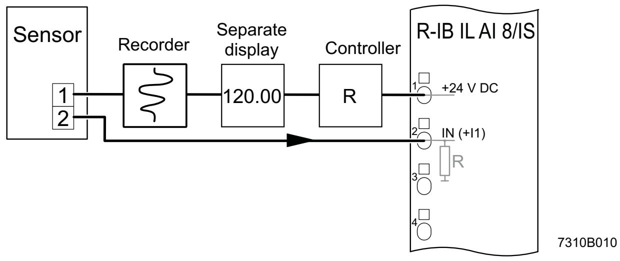

Fig. 6 Connection of several evaluating devices

The resistor R is part of the internal wiring.

10 Programming Data/ Configuration Data

10.1 Local Bus

ID code	$5F_{hex}$ (95_{dec})
Length code	02_{hex}
Process data channel	32 bits
Input address area	2 words
Output address area	2 words
Parameter channel (PCP)	0 bytes
Register length (bus)	2 words

10.2 Other Bus Systems

For the configuration data of other bus systems, please refer to the corresponding electronic device data sheet (e.g., GSD, EDS).

11 Process Data Words

11.1 Process Data Output Words for Configuring the Terminal (See page 12)

Process data output word 0 (OUT[0])		Process data output word 1 (OUT[1])	
Bit 15	Bit 0	Bit 15	Bit 0

(Word.bit) view	Word	OUT[0]															
	Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	Assignment	0	Command							0	0	0	0	0	0	0	0

(Word.bit) view	Word	OUT[1]															
	Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	Assignment	0	0	0	0	0	0	Filter		0	Format			Measuring range			

11.2 Process Data Input Words (See page 15)

Process data input word 0 (IN[0])		Process data input word 1 (IN[1])	
Bit 15	Bit 0	Bit 15	Bit 0

(Byte.Bit) view	Byte	IN[0]															
	Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	Assignment	Depends on the command															

(Word.bit) view	Word	IN[1]															
	Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	Assignment	Depends on the command															

12 Process Data Output Words OUT[0] and OUT[1]

The terminal can be configured using the two process data output words. Word OUT[0] contains the command and word OUT[1] contains the parameters for this command.

The following configurations are possible:

- Selecting a measuring range according to the input signal
- Selecting mean-value generation (filtering)
- Changing the formats for the representation of measured values

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☞ After applying voltage (power up) to the Inline station, the message "Measured value invalid" (diagnostic code 8004_{hex}) appears in the process data input words for every channel requested. The message is displayed until the corresponding channel has been configured.
If the configuration is changed, the message "Measured value invalid" (diagnostic code 8004_{hex}) appears for a maximum of 100 ms.

☞ Please note the extended runtime when a channel is configured for the first time and every time a channel is reconfigured.

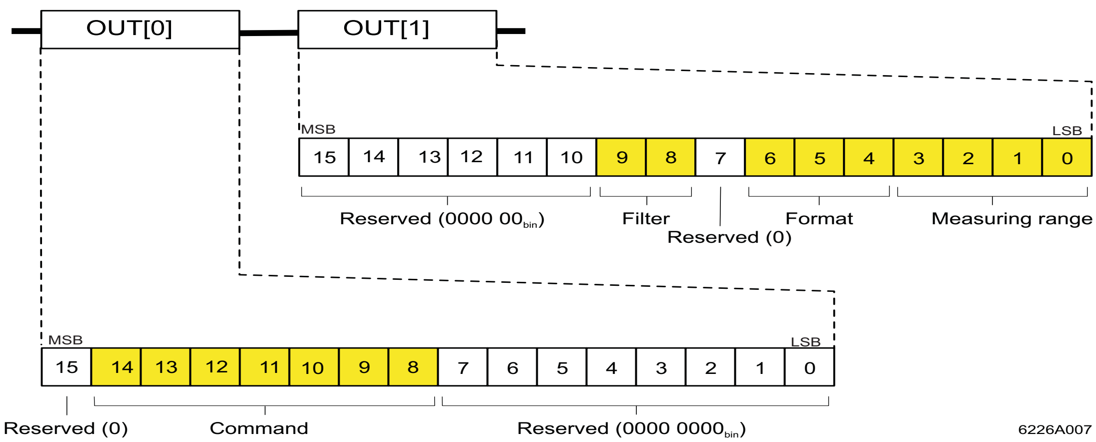

Fig. 7 Process data output words

MSB Most significant bit LSB Least significant bit

☞ Set all reserved bits to 0.

12.1 OUT[0] (Command Code)

	OUT[0]															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Assignment	0	Command							0	0	0	0	0	0	0	0

Bit 15 to bit 8 (command):

Bit 15 to Bit 8								OUT[0]	Command Function
0	0	0	0	0	**Z_2**	**Z_1**	**Z_0**	$0x00_{hex}$	Read measured value of channel **x**
0	0	0	1	0	**Z_2**	**Z_1**	**Z_0**	$1x00_{hex}$	Read configuration of channel **x**
0	0	1	1	1	1	0	0	$3C00_{hex}$	Read firmware version and module ID
0	1	0	0	0	**Z_2**	**Z_1**	**Z_0**	$4x00_{hex}$	Configure channel **x**
0	1	0	1	0	**Z_2**	**Z_1**	**Z_0**	$5x00_{hex}$	Configure channel **x** and read measured value of channel **x**
0	1	1	0	0	0	0	0	6000_{hex}	Configure entire terminal (all channels)
0	1	1	1	0	**Y_2**	**Y_1**	**Y_0**	$7x00_{hex}$	Commands for groups without mirroring

Z_2 Z_1 Z_0 Channel number
Y_2 Y_1 Y_0 Group number

	OUT[0]															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Assignment	0	Command							0	0	0	0	0	0	0	0
Channel/group	0	X	X	X	X	X	X	X	0	0	0	0	0	0	0	0

Bit 10 to bit 8 (channel number $Z_2Z_1Z_0$ or group number $Y_2Y_1Y_0$):

Code		Channel
bin	**dec**	
000	0	1
001	1	2
010	2	3
011	3	4
100	4	5
101	5	6
110	6	7
111	7	8

Code		Group
bin	**dec**	
000	0	4 x 8-bit group A (channel 1, 2, 3, and 4)
001	1	4 x 8-bit group B (channel 5, 6, 7, and 8)
010	2	Reserved
011	3	Reserved
100	4	2 x 16-bit group A (channel 1 and 2)
101	5	2 x 16-bit group B (channel 3 and 4)
110	6	2 x 16-bit group C (channel 5 and 6)
111	7	2 x 16-bit group D (channel 7 and 8)

12.2 OUT[1] (Parameter Word)

The parameters for commands $4x00_{hex}$, $5x00_{hex}$, and 6000_{hex} must be specified in OUT[1]. This parameter word is only evaluated for these commands.

	OUT[1]															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Assignment	0	0	0	0	0	0	Filter		0	Format			Measuring range			

If invalid parameters are specified in the parameter word, the command will not be executed. The command is acknowledged in the input words with the set error bit.

Bit 9 and bit 8:

Code		Filter (Filtering by Mean-Value Generation)
bin	dec	
00	**0**	**16-sample average value (default)**
01	1	No mean-value generation
10	2	4-sample average value
11	3	32-sample average value

Bit 6 to bit 4:

Code		Format
bin	dec	
000	**0**	**IB IL (15 bits) (default)**
001	1	IB ST (12 bits)
010	2	IB RT (15 bits)
011	3	Standardized representation
100	4	PIO (for the 4 mA to 20 mA range only)
101	5	
110	6	Reserved
111	7	

Bit 3 to bit 0:

Code		Measuring Range
bin	dec	
0000	0	Reserved
0001	1	Reserved
0010	2	Reserved
0011	3	Reserved
0100	4	Reserved
0101	5	Reserved
0110	6	Reserved
0111	7	Reserved

Code		Measuring Range
bin	dec	
1000	**8**	**0 mA to 20 mA**
1001	9	±20 mA
1010	10	4 mA to 20 mA
1011	11	Reserved
1100	12	0 mA to 40 mA
1101	13	±40 mA
1110	14	Reserved
1111	15	Reserved

13 Process Data Input Words IN[0] and IN[1]

The measured values and diagnostic messages (diagnostic codes) are transmitted to the controller board or computer using the two process data input words. The contents of the words vary according to the command.

13.1 IN[0] and IN[1] for Commands 0x00$_{hex}$ to 6000$_{hex}$

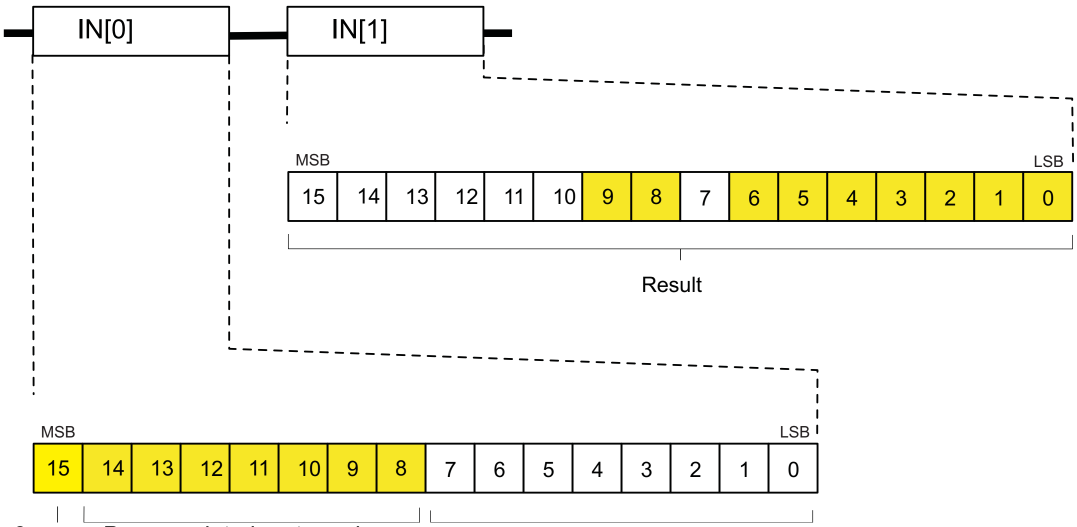

Fig. 8 Process data input words

IN[0]

Output word OUT[0], which contains the command code, is mirrored in input word IN[0]. This confirms that the command has been executed correctly. If the command was not executed correctly, the error bit is set in bit 15 of input word IN[0].

The error bit is set for one of the following reasons (see also page 25):

- There is no valid configuration for the requested channel
- There was an invalid parameter during configuration
- A reserved bit was set

The command is only mirrored if it has been executed completely. This means, for example, that command 5x00$_{hex}$ is only mirrored after the value has been read and not following reconfiguration.

IN[1]

Input word IN[1] varies depending on the command.

IN[1] contains the firmware version and module ID for command 3C00$_{hex}$.

	IN[1]															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Assignment	Firmware version												Module ID			
	Example: 123$_{hex}$: Terminal equipped with firmware Version 1.23												6$_{hex}$: IB IL AI 8/SF			
													3$_{hex}$: IB IL AI 8/IS			

For commands 1x00$_{hex}$, 4x00$_{hex}$, and 6000$_{hex}$, IN[1] contains the mirroring of the specified configuration.

	IN[1]															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Assignment	0	0	0	0	0	0	Filter		0	Format			Measuring range			

For commands 0x00$_{hex}$ and 5x00$_{hex}$, IN[1] contains the analog measured value.

	IN[1]															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Assignment	Measured value in the corresponding format															

Format:	MSB 15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	LSB 0
IB IL IB RT Standardized representation	SB	AV														
IB ST	SB	AV												0/4	OC	OR
PIO	AV															

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Fig. 9 Representation of the measured values in the different formats

SB	Sign bit	OC	Open circuit
AV	Analog value	OR	Overrange
0/4	Measuring range 4 mA to 20 mA		
MSB	Most significant bit	LSB	Least significant bit

The individual formats are explained in "Formats for the Representation of Measured Values" on page 18.

13.2 IN[0] and IN[1] for Group Commands $7x00_{hex}$

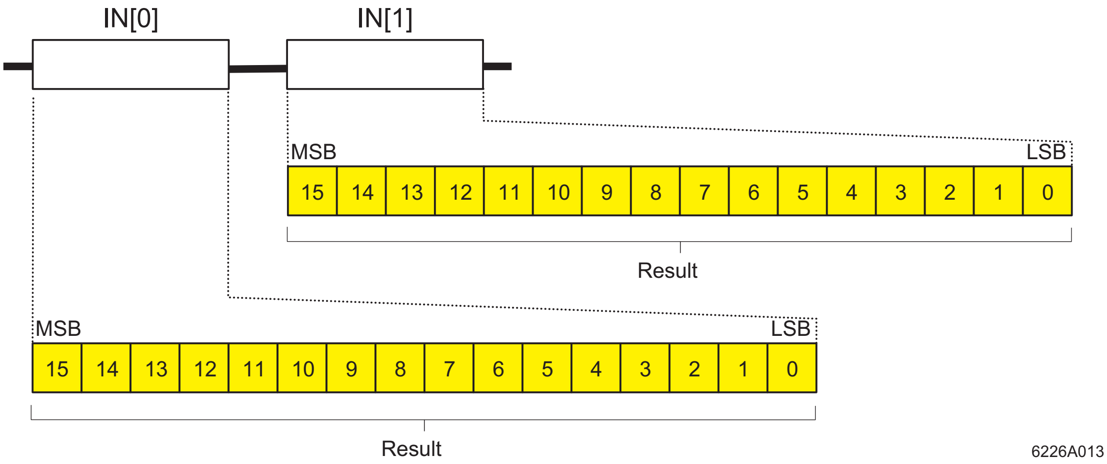

Fig. 10 Process data input words

For group commands $7x00_{hex}$, both input words contain the measured values of the channels that correspond to the group command.

Group Commands for Two 16-Bit Channels: 7400_{hex}, 7500_{hex}, 7600_{hex}, and 7700_{hex}

With commands for two 16-bit channels, the analog value of one channel is mapped to every input word. The representation corresponds to the representation in input word IN[1] for commands $0x00_{hex}$ and $5x00_{hex}$.

Example 2 x 16-Bit Group A (Channels 1 and 2): Command 7400_{hex}

	IN[0]															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Assignment	16-bit measured value **channel 1** in the corresponding format															

	IN[1]															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Assignment	16-bit measured value **channel 2** in the corresponding format															

Group Commands for Four 8-Bit Channels: 7000_{hex} and 7100_{hex}

With commands for four channels, the analog values for two channels are mapped to every input word. The measured value for each channel is represented in eight bits. This measured value corresponds to bits 15 to 8 in the format representations of a 16-bit value.

Example 4 x 8-Bit Group A (Channels 1, 2, 3, and 4): Command 7000_{hex}

	IN[0]															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Assignment	8-bit measured value **channel 1** in the corresponding format								8-bit measured value **channel 2** in the corresponding format							

	IN[1]															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Assignment	8-bit measured value **channel 3** in the corresponding format								8-bit measured value **channel 4** in the corresponding format							

The status bits in "IB ST" format and the diagnostic messages in "IB IL" and "standardized representation" format are not displayed in this configuration.

14 Formats for the Representation of Measured Values

To ensure that the terminal can be operated in previously used data formats, the measured value representation can be switched to different formats. "IB IL" format is the default.

Abbreviations used in the following tables:

OR Overrange

UR Underrange

14.1 "IB IL" Format

The measured value is represented in bits 14 to 0. An additional bit (bit 15) is available as a sign bit.

This format supports extended diagnostics. Values > 8000_{hex} and < 8100_{hex} indicate an error.

The following diagnostic codes are possible:

Code (hex)	**Error**
8001	Overrange
8002	Open circuit
8004	Measured value invalid/no valid measured value available (e.g., because the channel has not been configured)
8010	Invalid configuration
8020	I/O supply voltage faulty
8040	Module faulty
8080	Underrange

Measured value representation in "IB IL" format (15 bits):

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
SB	Analog value														

SB Sign bit

Significant Measured Values:

Input Data Word (Two's Complement)		0 mA to 20 mA I_{IN}	0 mA to 40 mA I_{IN}
hex	**dec**	**mA**	**mA**
8001	OR	> +21.6746	> +43.3493
7F00	32512	+21.6746	+43.3493
7530	**30000**	**+20.0**	**+40.0**
0001	1	+0.66667 µA	+1.3333 µA
0000	**0**	**0**	**0**
0000	0	< 0	< 0

Input Data Word (Two's Complement)		±20 mA I_{IN}	±40 mA I_{IN}
hex	**dec**	**mA**	**mA**
8001	OR	> +21.6746	> +43.3493
7F00	32512	+21.6746	+43.3493
7530	**30000**	**+20.0**	**+40.0**
0001	1	+0.6667 µA	+1.3333 µA
0000	**0**	**0**	**0**
FFFF	-1	-0.6667 µA	-1.3333 µA
8AD0	**-30000**	**-20.0**	**-40.0**
8100	-32512	-21.6746	-43.3493
8080	UR	< -21.6746	< -43.3493

Input Data Word (Two's Complement)		4 mA to 20 mA I_{IN}
hex	**dec**	**mA**
8001	OR	> +21.339733
7F00	32512	+21.339733
7530	**30000**	**+20.0**
0001	1	+4.00053333
0000	**0**	**+4.0 to 3.2**
8002	Open circuit	< +3.2

14.2 "IB ST" Format

The measured value is represented in bits 14 to 3. The remaining 4 bits are sign, measuring range, and error bits.
This format corresponds to the data format used on INTERBUS ST modules.

Measured value representation in "IB ST" format (12 bits):

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
SB	Analog value												0/4	OC	OR

SB	Sign bit	OC	Open circuit
0/4	Measuring range 4 mA to 20 mA	OR	Over/underrange

Significant Measured Values:

Input Data Word (Two's Complement)		0 mA to 20 mA I_{IN}	0 mA to 40 mA I_{IN}
hex	**dec**	**mA**	**mA**
7FF9	32761	> +21.5	> +43.0
7FF8	32760	+19.9951 to +21.5	+39.9902 to +43.0
4000	**16384**	**+10.0**	**+20.0**
0008	8	+4.8828 µA	+9.7656 µA
0000	**0**	**< 0**	**< 0**

Input Data Word (Two's Complement)		±20 mA I_{IN}	±40 mA I_{IN}
hex	**dec**	**mA**	**mA**
7FF9	32761	> +21.5	> +43.0
7FF8	32760	+19.9951 to +21.5	+39.9902 to +43.0
4000	**16384**	**+10.0**	**+20.0**
0008	8	+4.8828 µA	+9.7656 µA
0000	0	0	0
FFF8	-8	-4.8828 µA	-9.7656 µA
C000	**-16384**	**-10.0**	**-20.0**
8000	-32768	-20.0 to -21.5	-40.0 to -43.0
8001	-32767	< -21.5	< -43.0

Input Data Word (Two's Complement)		4 mA to 20 mA I_{IN}
hex	**dec**	**mA**
7FFD	32765	> +21.5
7FFC	32764	+19.9961 to +21.5
4000	**16384**	**+10**
000C	12	+4.003906
0004	4	+3.2 to +4.0
0006	6	< 3.2

14.3 "IB RT" Format

The measured value is represented in bits 14 to 0. An additional bit (bit 15) is available as a sign bit.

This format corresponds to the data format used on INTERBUS RT modules.

Diagnostic codes and error bits are not defined in this data format. An open circuit is indicated by the positive final value $7FFF_{hex}$.

Measured value representation in "IB RT" format (15 bits):

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
SB	Analog value														

SB Sign bit

Significant Measured Values:

Input Data Word (Two's Complement)		**0 mA to 20 mA I_{IN}**	**0 mA to 40 mA I_{IN}**
hex	**dec**	**mA**	**mA**
7FFF	32767	≥ +19.9993896	≥ +39.9987793
7FFE	32766	+19.9987793	+39.9975586
4000	**16384**	**+10**	**+20**
0001	1	+0.6104 µA	+1.2207 µA
0000	**0**	**0**	**0**

Input Data Word (Two's Complement)		**±20 mA I_{IN}**	**±40 mA I_{IN}**
hex	**dec**	**mA**	**mA**
7FFF	32767	≥ +19.999385	≥ +39.9987739
7FFE	32766	+19.998779	+39.9975586
4000	**16384**	**+10.0**	**+20.0**
0001	1	+0.6104 µA	+1.2207 µA
0000	**0**	**0**	**0**
FFFF	-1	-0.0006105	-0.0012207
C000	**-16384**	**-10.0**	**-20.0**
8001	-32770	-19.999385	-39.9987793
8000	-32768	≤ -20.0	≤ -40.0

Input Data Word (Two's Complement)		**4 mA to 20 mA I_{IN}**
hex	**dec**	**mA**
7FFF	32767	≥ +19.9995117
7FFE	32766	+19.9990234
4000	**16384**	**+12**
0001	1	+4.0004884 µA
0000	**0**	**+4.0**
0000	0	+3.2 to +4.0
7FFF	32767	< +3.2

14.4 "Standardized Representation" Format

The data is represented in bits 14 to 0. An additional bit (bit 15) is available as a sign bit.

In this format, data is standardized to the measuring range and represented in such a way that it indicates the corresponding value without conversion.

In this format, **one bit** has the following validity for the measuring ranges stated:

Measuring Range	Validity of One Bit
0 mA to 20 mA; 4 mA to 20 mA	1 µA
0 mA to 40 mA	10 µA

This format supports extended diagnostics. Values > 8000_{hex} and < 8100_{hex} indicate an error.

The following diagnostic codes are possible:

Code (hex)	Error
8001	Overrange
8002	Open circuit
8004	Measured value invalid/no valid measured value available (e.g., because the channel has not been configured)
8010	Invalid configuration
8020	I/O supply voltage faulty
8040	Module faulty
8080	Underrange

Measured value representation in "standardized representation" format (15 bits):

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
SB	Analog value														

SB = Sign bit

Significant Measured Values:

Input Data Word (Two's Complement)		0 mA to 20 mA I_{IN}
hex	**dec**	**mA**
8001	OR	> +21.6747
54AA	21674	+21.6747
4E20	**20000**	**+20.0**
0001	1	+1.0 µA
0000	**0**	**0**
0000	0	< 0

Input Data Word (Two's Complement)		4 mA to 20 mA I_{IN}
hex	**dec**	**mA**
8001	OR	> +21.339
43BB	17339	+21.339
3E80	**16000**	**+20.0**
0001	1	+4.001
0000	**0**	**+4.0 to +3.2**
8002	Open circuit	< +3.2

Input Data Word (Two's Complement)		0 mA to 40 mA I_{IN}
hex	**dec**	**mA**
8001	OR	> +43.3493
10EE	4334	+43.3493
0FA0	**4000**	**+40.0**
0001	1	+10.0 µA
0000	**0**	**0**
0000	0	< 0

Input Data Word (Two's Complement)		±20 mA I_{IN}
hex	**dec**	**mA**
8001	OR	≥ +21.6747
54AA	21674	+21.6747
4E20	**20000**	**+20.0**
0001	1	+1.0 µA
0000	**0**	**0**
FFFF	-1	-0.001
B1E0	**-20000**	**-20.0**
AB56	-21674	-21.6747
8080	UR	< -21.6747

Input Data Word (Two's Complement)		±40 mA I_{IN}
hex	**dec**	**mA**
8001	OR	> +43.349
10EE	4334	+43.349
0FA0	**4000**	**+40.0**
0001	1	+10.0 µA
0000	**0**	**0**
FFFF	-1	-10.0 µA
F060	**-4000**	**-40.0**
EF12	-4334	-43.349
8080	UR	< -43.349

14.5 Examples of Measured Value Representation in Various Data Formats

- Measuring range: 0 mA to 20 mA
- Measured value: 10 mA

Input data word:

Format	hex Value	dec Value	Measured Value
IB IL	3A98	15,000	10 mA
IB ST	4000	16,384	10 mA
IB RT	4000	16,384	10 mA
Standardized representation	2710	10,000	10 mA

14.6 "PIO" Format

PIO format enables high-resolution representation of measured values in the 4 mA to 20 mA current measuring range. In this format, a hypothetical measuring range of 0 mA to 25 mA is divided into 2^{16} quantization steps (65,536 steps). Thus, unipolar measured currents with a resolution of 0.38 µA/LSB can be represented. Although this format is designed for the 4 mA to 20 mA range, signals between 0 mA and 24 mA can be acquired so the overrange limits and the open circuit threshold in the higher-level control system can be freely defined.

Measured value representation in "PIO" format (16 bits):

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Analog value															

Example of Parameterization Using PIO Format

Channel:	1
Filtering:	16-sample average value
Format:	PIO
Measuring range:	4 mA to 20 mA (PIO format is only supported in this measuring range)

Option 1:

1 Configure channel 1

OUT[0] 4000_{hex}
OUT[1] $004A_{hex}$

2 Read the measured value

OUT[0] 0000_{hex}
OUT[1] 0000_{hex}

Option 2:

Configure channel 1 and read the measured value

OUT[0] 5000_{hex}
OUT[1] $004A_{hex}$

Significant Measured Values

Input Data Word (Two's Complement)		PIO I_{IN}
hex	**dec**	**mA**
F5C2	62914	+24.0
CCCD	52429	+20.0
6666	26214	+10.0
0A3D	2621	+1.0
0001	1	+0.3815 µA
0000	0	+0

15 Process Data Input Words in the Event of an Error

In the event of an error, the command is mirrored in input word IN[0] and displayed with the set error bit. Input word IN[1] indicates the error cause.

The following diagnostic codes are valid for configuration or hardware errors **in all data formats**:

Command (hex)	Code (hex)	PF	Meaning/Note	Remedy
Any command	8020		I/O supply voltage faulty.	• Check the supply voltage of the station head (e.g., U_{BC}). • Check the potential jumper connection.
After module start	8040	X	Module faulty.	Replace module.
0x00	8004		There is no valid configuration for the requested channel.	Configure channel.
5x00	8004		The configuration just specified is invalid.	Check and correct configuration.
1x00	8010		There is no valid configuration for the requested channel.	Configure channel.
4x00 and 6000	8010		Invalid parameters.	Check and correct parameters.

PF A peripheral fault is reported to the higher-level control system

In addition to the indicator in the input words, for diagnostic codes 8040_{hex} (module faulty) and 8020_{hex} (I/O supply voltage faulty), a peripheral fault is reported to the higher-level control system.

The "IB IL" and "standardized representation" formats offer additional diagnostic functions. These are specified on page 18 and page 22.

16 Startup Options

The following startup options illustrate how to use the terminal.

16.1 Standard Method 1

Task:

- **All input channels** are to be operated **in the same** configuration (6000_{hex})
- Filtering by mean-value generation: 32-sample average value (11_{bin}, 3_{dec})
- Format: IB IL (000_{bin}, 0_{dec})
- Measuring range: ±20 mA (1001_{bin}, 9_{dec})

Procedure:

1 Install the terminal.

2 Connect the voltage (power up).

3 Configure the terminal (initialization phase, e.g., in the initialization phase of the application program).

4 Read the measured value for each channel in turn.

Initialization Phase:

According to the task, the process data output words appear as follows:

	OUT[0]															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Assignment	0	Command							0	0	0	0	0	0	0	0
bin	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
hex	6				0				0				0			

	OUT[1]															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Assignment	0	0	0	0	0	0	Filter		0	Format			Measuring range			
bin	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	1
hex	0				3				0				9			

With the command in OUT[0], the configuration according to OUT[1] is sent to the module electronics. After configuration is complete, the command and the configuration are mirrored in the process data input words.

Configure terminal:	OUT[0]:	6000_{hex}	OUT[1]:	0309_{hex}
Configuration completed successfully:	IN[0]	6000_{hex}	IN[1]:	0309_{hex}
Error during configuration:	IN[0]	$E000_{hex}$	IN[1]:	0309_{hex}

A **cyclic program sequence, which reads the measured values of the individual channels,** takes place after configuration has been successfully completed.

Process data output word OUT[0] appears as follows:

	OUT[0]															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Assignment	0	Command							0	0	0	0	0	0	0	0
bin	0	0	0	0	0	Z_2	Z_1	Z_0	0	0	0	0	0	0	0	0
hex	0				x				0				0			

Command $0x00_{hex}$ does not require any parameters and the value of parameter word OUT[1] is 0000_{hex}.

With the command in OUT[0], the read request is sent to the module electronics. After the command has been executed, it is mirrored in process data input word IN[0] and the analog value ($xxxx_{hex}$) or a diagnostic message ($yyyy_{hex}$) is displayed in process data input word IN[1].

Read measured value for channel 1:	OUT[0]:	0000_{hex}	OUT[1]:	0000_{hex}
Command executed successfully:	IN[0]	0000_{hex}	IN[1]:	$xxxx_{hex}$
Error during execution:	IN[0]	8000_{hex}	IN[1]:	$yyyy_{hex}$
Read measured value for channel 2:	OUT[0]:	0100_{hex}	OUT[1]:	0000_{hex}
Command executed successfully:	IN[0]	0100_{hex}	IN[1]:	$xxxx_{hex}$
Error during execution:	IN[0]	8100_{hex}	IN[1]:	$yyyy_{hex}$
And so on until:				
Read measured value for channel 8:	OUT[0]:	0700_{hex}	OUT[1]:	0000_{hex}
Command executed successfully:	IN[0]	0700_{hex}	IN[1]:	$xxxx_{hex}$
Error during execution:	IN[0]	8700_{hex}	IN[1]:	$yyyy_{hex}$

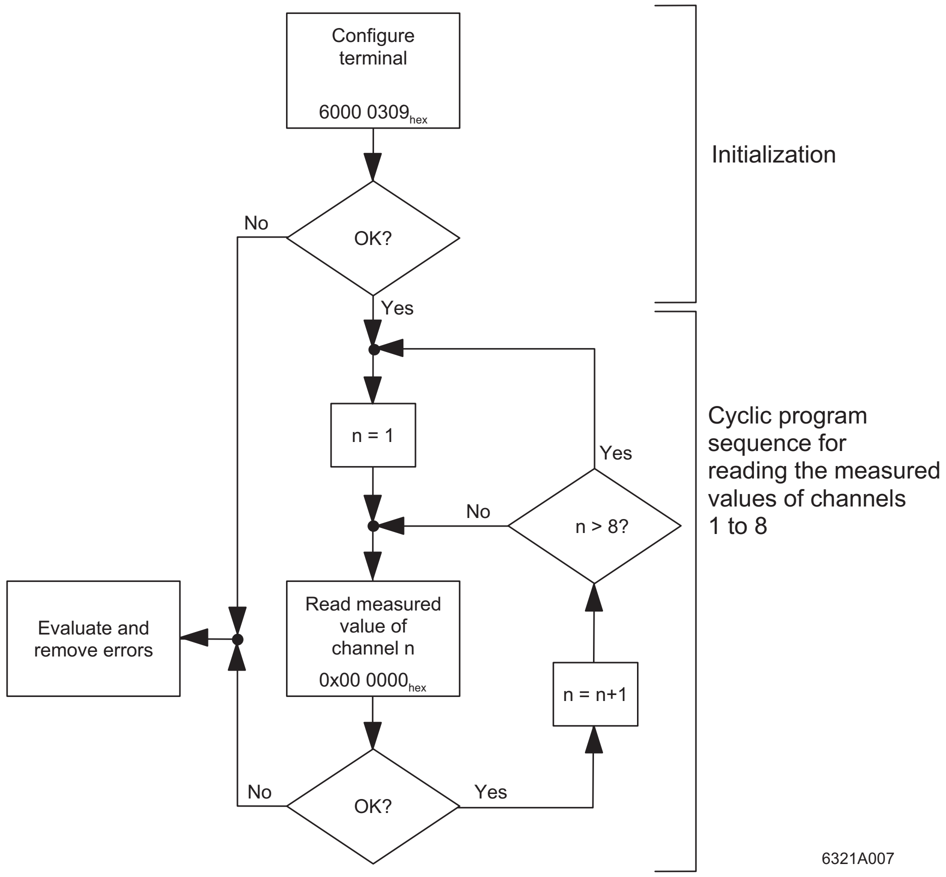

Fig. 11 Schematic initialization and cyclic program sequence when configuring the entire terminal

16.2 Standard Method 2

Task:

- The input channels are to be operated **in different** configurations.
  The channels are to be configured first ($4x00_{hex}$).
  After configuration, the measured values are to be read ($0x00_{hex}$).
- Configuration of the channels:

Parameter	Channel 1	Channel 2	Channel 3	...
Filtering by mean-value generation:	No filtering (01_{bin}, 1_{dec})	16-sample average value (00_{bin}, 0_{dec})	4-sample average value (10_{bin}, 2_{dec})	...
Format:	IB IL (000_{bin}, 0_{dec})	IB IL (000_{bin}, 0_{dec})	IB IL (000_{bin}, 0_{dec})	...
Measuring range:	0 mA to 40 mA (1100_{bin}, 12_{dec})	±40 mA (1101_{bin}, 13_{dec})	4 mA to 20 mA (1010_{bin}, 10_{dec})	...

Procedure:

1 Install the terminal.

2 Connect the voltage (power up).

3 Configure each individual channel in the terminal in turn (initialization phase, e.g., in the initialization phase of the application program).

4 Read the measured value for each channel in turn.

Initialization Phase:

Process data output word OUT[0] appears as follows for **all channels**:

	OUT[0]															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Assignment	0	Command							0	0	0	0	0	0	0	0
bin	0	1	0	0	0	Z_2	Z_1	Z_0	0	0	0	0	0	0	0	0
hex	4				x				0				0			

Process data output word OUT[1] indicates the parameters for each channel according to the task. For **channel 1**, it looks like this:

	OUT[1]															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Assignment	0	0	0	0	0	0	Filter		0	Format			Measuring range			
bin	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0
hex	0				1				0				C			

With the command in OUT[0], the configuration according to OUT[1] is sent to the module electronics for each channel. After configuration of a channel is complete, the command and the configuration are mirrored in the process data input words.

Configure channel 1:	OUT[0]:	4000_{hex}	OUT[1]:	$010C_{hex}$
Configuration completed successfully:	IN[0]	4000_{hex}	IN[1]:	$010C_{hex}$
Error during configuration:	IN[0]	$C000_{hex}$	IN[1]:	$010C_{hex}$
Configure channel 2:	OUT[0]:	4100_{hex}	OUT[1]:	$000D_{hex}$
Configuration completed successfully:	IN[0]	4100_{hex}	IN[1]:	$000D_{hex}$
Error during configuration:	IN[0]	$C100_{hex}$	IN[1]:	$000D_{hex}$
Configure channel 3:	OUT[0]:	4200_{hex}	OUT[1]:	$020A_{hex}$
Configuration completed successfully:	IN[0]	4200_{hex}	IN[1]:	$020A_{hex}$
Error during configuration:	IN[0]	$C200_{hex}$	IN[1]:	$020A_{hex}$

Configure **channels 4 to 8** according to the example configurations shown.

A **cyclic program sequence, which reads the measured values of the individual channels**, takes place after the configuration for each individual channel has been completed successfully.

Process data output word OUT[0] appears as follows:

	OUT[0]															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Assignment	0	Command							0	0	0	0	0	0	0	0
bin	0	0	0	0	0	Z_2	Z_1	Z_0	0	0	0	0	0	0	0	0
hex	0				X				0				0			

Command $0x00_{hex}$ does not require any parameters and the value of parameter word OUT[1] is 0000_{hex}.

With the command in OUT[0], the read request is sent to the module electronics. After the command has been executed, it is mirrored in process data input word IN[0] and the analog value ($xxxx_{hex}$) or a diagnostic message ($yyyy_{hex}$) is displayed in process data input word IN[1]. The appearance of the process data input and output words is the same as in example 1.

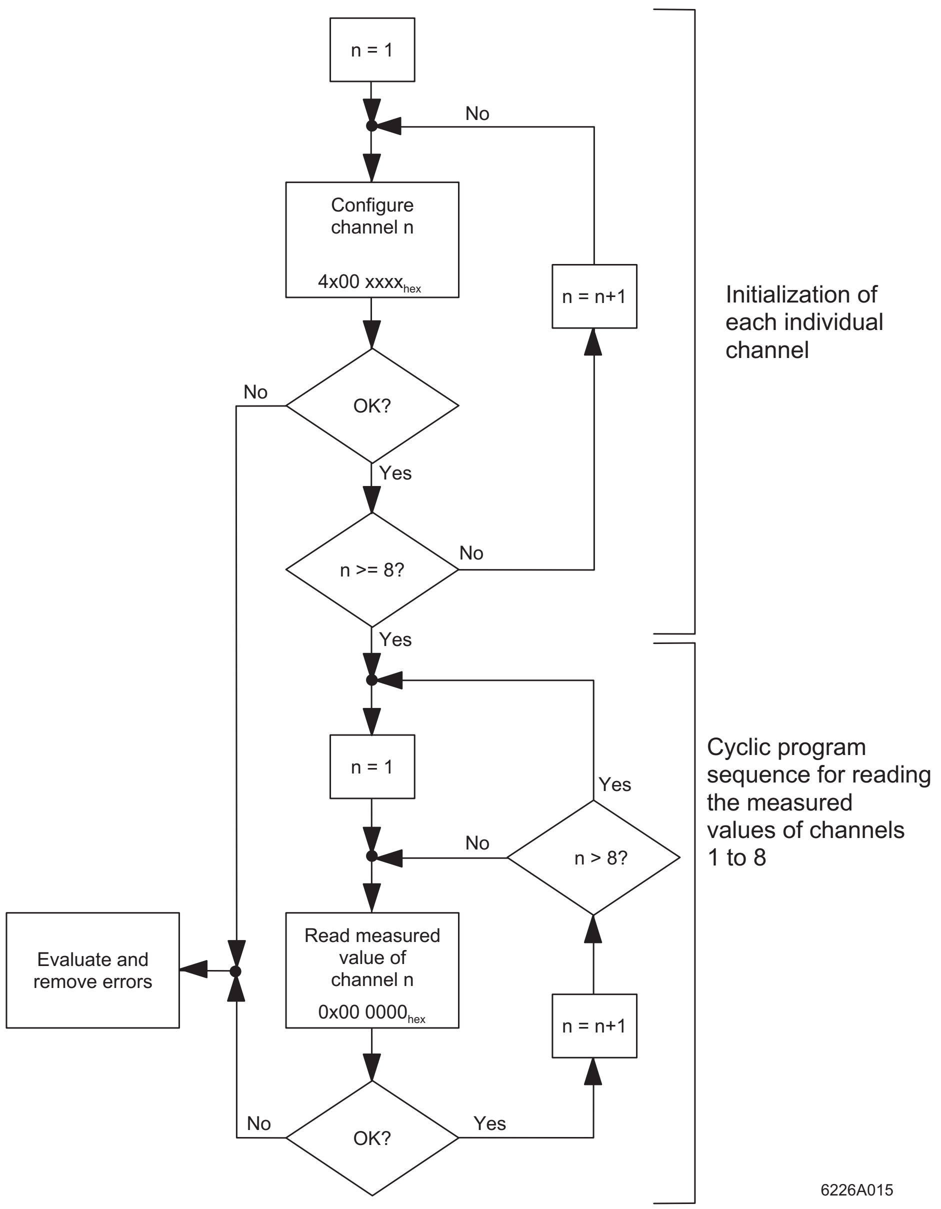

Fig. 12 Schematic initialization and cyclic program sequence when configuring channels with different parameters

16.3 Special Methods

The group commands are regarded as special methods.

Task:

- The measured values of channels 1 to 4 (group A) are to be read in one cycle and the measured values of channels 5 to 8 (group B) in another cycle (7000_{hex} for group A; 7100_{hex} for group B).
- The input channels are to be operated **in different** configurations (e.g., as in example 2).

Procedure:

1 Install the terminal.

2 Connect the voltage (power up).

3 Configure each individual channel in the terminal in turn (e.g., in the initialization phase of the application program).
As the channels are to have different configurations, they must be configured using command $4x00_{hex}$.

4 Use group command 7000_{hex} to read the measured values for channels 1 to 4 simultaneously. Then use group command 7100_{hex} to read the measured values for channels 5 to 8.
Both groups can be reread cyclically.

16.4 Advantages of Standard Methods Over Special Methods

- Standard methods read the measured values with greater reliability because the command is mirrored for every measured value. Thus, it is possible to detect precisely which channel supplied the measured value.
- Standard methods enable more accurate error diagnostics than special methods.
- If you switch the group command for reading the channels (e.g., between 7000_{hex} and 7100_{hex} when reading two groups of four channels each), you must allow sufficient time to do so. It must be ensured that the received measured values belong to the requested group. This can only be ensured using waiting times.

17 Application Notes

Notes on typical applications are provided here in order to facilitate optimum use of the IB IL AI 8/IS terminal in different operating modes.

17.1 Precision DC Measurements

Precision DC measurements constitute an optimum area of application for the IB IL AI 8/IS terminal. The high-resolution analog/digital converter and excellent instrumentation amplifier technology achieve a very high level of accuracy (typically 0.04%).

In order to take full advantage of these features, the following configurations are recommended:

- Measured value acquisition: According to standard method 1 or 2
- Format: IB IL (high-resolution)
- Filtering: 32-sample average value

This suppresses undesirable interference signals and provides a low-noise, accurate measured result. Non-time-critical, slow, processes are a prerequisite for this configuration.

17.2 Closed-Loop Control Tasks

The terminal makes closed-loop control tasks particularly easy to implement. In INTERBUS networks, the terminal supports the advantages with regard to time equidistance. As the terminal scans input signals synchronously with the bus clock and the bus runtime has a very small jitter, the input signals can be scanned equidistantly. Thus, the measured results are particularly suitable for use in closed-loop control.

The following configurations and measures are recommended:

- Measured value acquisition: According to standard method 1 or 2
  In special cases, group commands ($7x00_{hex}$) can be an exception.
- Filtering: No mean-value generation
  As total accuracy is often irrelevant in closed-loop control tasks, filtering is not necessary. This increases the dynamic response of the terminal and speeds up the closed-loop control circuit.
- Adjust the INTERBUS cycle time to the firmware runtime
  Example: In standard method 1, the firmware runtime is < 800 µs, i.e., the INTERBUS cycle time should be set to 800 µs.

In applications in which an 8-bit resolution is sufficient, group commands 7000_{hex} and 7100_{hex} can be used to read four channels simultaneously. Scanning is synchronous with the bus clock here too. Four channels require < 1500 µs.

17.3 Signal Scanning or Fast, Sudden Signals

The terminal is ideal for scanning signals. As a result of the high input limit frequency (3.5 kHz), there are no limiting elements in the analog stage. The maximum signal frequency that can be scanned depends on the firmware runtime and the cycle time in the local bus.

The terminal measuring device can measure signals with a frequency of 1/800 µs = 1.25 kHz. According to Shannon's sampling theorem, therefore, the signal frequency that can be scanned is 1.25 kHz/ 2 = 0.625 kHz.

This signal frequency can only be achieved if sufficiently fast bus operation can be ensured.

The following configurations and measures are recommended:

- Measured value acquisition: According to standard method 1 or 2
- Filtering: No mean-value generation
  This increases the dynamic response of the terminal.
- Adjust the local bus cycle time to the firmware runtime.
  This achieves discrete periods of scanning.
  Example for INTERBUS: In standard method 1, the firmware runtime is < 800 µs, i.e., the INTERBUS cycle time should be set to 800 µs.

17.4 Current Loops

If the terminal is used to measure currents in current loops, make sure that the eight current inputs operate on a common ground potential (single-ended). Thus, the measuring input should always be on the GND potential with the minus input.

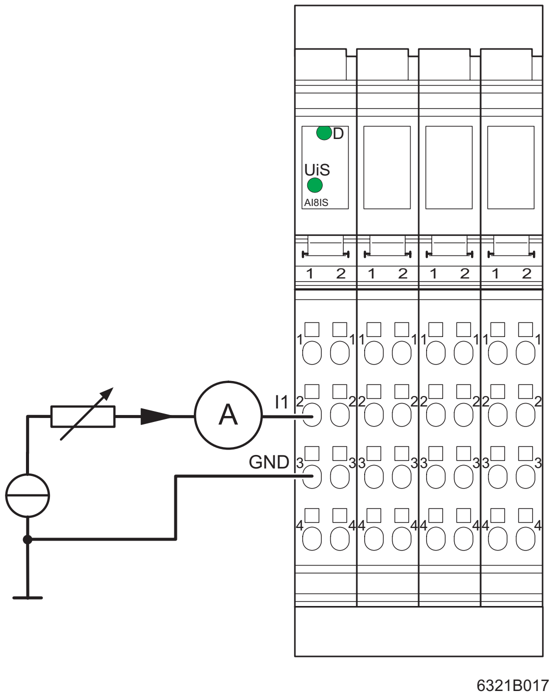

Fig. 13 Measuring currents

17.5 Passive Sensors

The standard use of passive sensors is illustrated in Fig. 5 on page 10.

If a lower supply voltage is required, this must be supplied via a power terminal. However, the supply voltage must be at least 10 V.

If several terminals require the lower supply voltage, they can all be supplied via one power terminal.

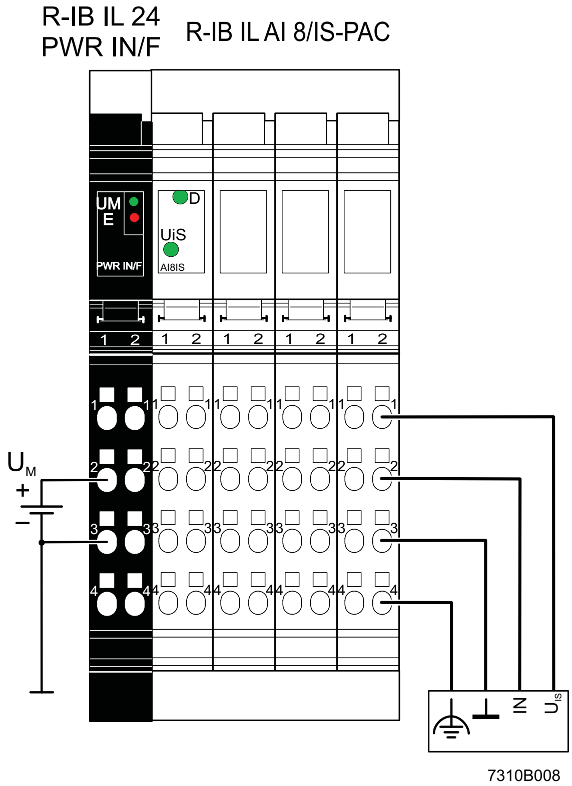

Fig. 14 Supplying voltage U_M between 10 V and 30 V

18 Tolerance and Temperature Response

T_A = 25°C

Measuring Range	Absolute (Typical)	Absolute (Maximum)	Relative (Typical)	Relative (Maximum)
0 mA to 20 mA; 4 mA to 20 mA; ±20 mA	±8.0 µA	±40.0 µA	±0.04%	±0.20%
0 mA to 40 mA; ±40 mA	±16.0 µA	±80.0 µA	±0.04%	±0.20%

T_A = -25°C to +55°C

Measuring Range	Absolute (Typical)	Absolute (Maximum)	Relative (Typical)	Relative (Maximum)
0 mA to 20 mA 4 mA to 20 mA ±20 mA	±28.0 µA	±80.0 µA	±0.14%	±0.40%
0 mA to 40 mA; ±40 mA	±56.0 µA	±160 µA	±0.14%	±0.40%

Additional Tolerances Influenced by Electromagnetic Fields

Type of Electromagnetic Interference	Typical Deviation of the Measuring Range Final Value
	Relative
Electromagnetic fields; field strength 10 V/m according to EN 61000-4-3/IEC 61000-4-3	< ±2%
Conducted interference Class 3 (test voltage 10 V) according to EN 61000-4-6/IEC 61000-4-6	< ±1%
Fast transients (burst) 4 kV supply, 2 kV input according to EN 61000-4-4/IEC 61000-4-4	< ±1%

The specified tolerances are valid for nominal operation. When connecting passive sensors, observe the ripple of the supplied supply voltage U_M.

Notes:

DOK-CONTRL-ILAI8/
IS***-KB02-EN-P

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