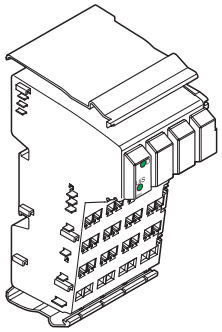
IB IL AI 8/IS
IB IL AI 8/IS-PAC

Inline Terminal With Eight Analog Input Channels and a Supply for Passive Sensors



6321B001

Data Sheet 6321B 03/2003

The IB IL AI 8/IS and IB IL AI 8/IS-PAC only differ in the scope of supply (see "Ordering Data" on page 45). Their function and technical data are identical.

For greater clarity, the Order Designation IB IL AI 8/IS is used throughout this document.

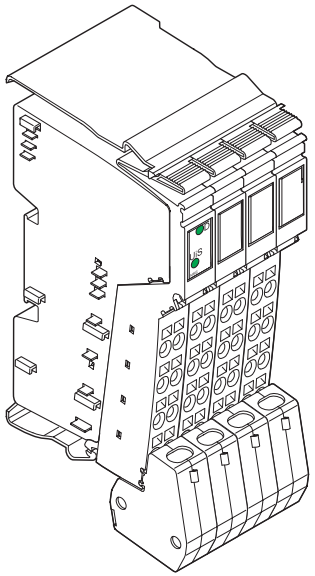
This data sheet is only valid in association with the IB IL SYS PRO UM E User Manual or the Inline System Manual for your bus system.

1 Function

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

1.1 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 protected 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-to-digital converter
- Process data multiplex mode
- LED diagnostic indicators



6321B002

Figure 1 IB IL AI 8/IS terminal with connector

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1.2 Local LED Diagnostic Indicators and Terminal Assignment

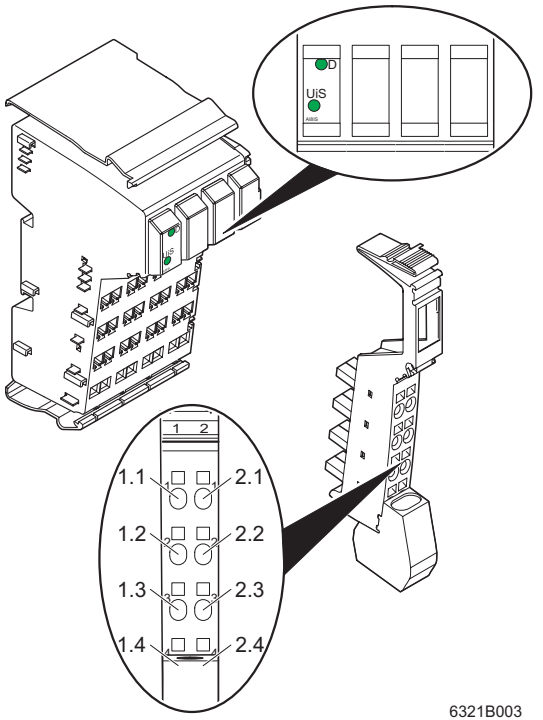

Figure 2 IB IL AI 8/IS terminal with an appropriate connector

Function Identification

Green

Local LED Diagnostic Indicators

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

If the initiator supply fails, the LED of the relevant slot number starts flashing. This is followed by a long pause after which the flashing resumes.

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 signals the failure of the supply voltage U_M to the preceding power terminal (UM LED off).

Terminal 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

2 Installation Instructions

High current flowing through potential jumpers U_M and U_S causes the temperature of the potential jumpers and the internal temperature of the terminal to increase. Observe the following instructions to keep the current flowing through the potential jumpers of the analog terminals as low as possible:

Create a separate main circuit for each analog terminal.

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 behind all the other terminals at the end of the main circuit.

3 Internal Circuit Diagram

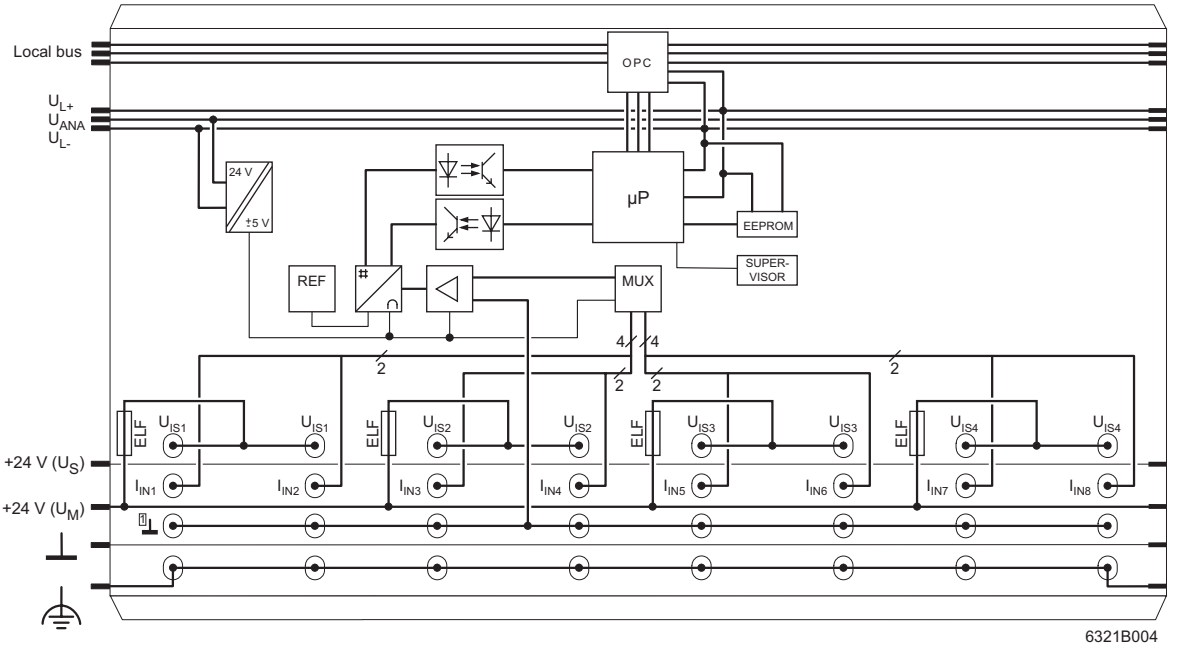

Figure 3 Internal wiring of the terminal points

Key:

OPC	Protocol chip		Analog-to-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 are explained in the IB IL SYS PRO UM E User Manual or in the Inline System Manual for your bus system.

4 Electrical Isolation

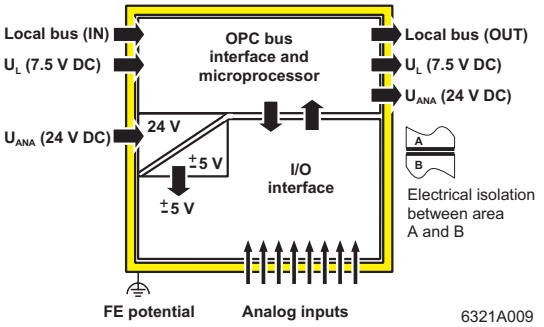

Figure 4 Electrical isolation of the individual function areas

5 Connection Notes

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

Always connect the analog sensors using shielded, twisted pair cables.

Connect the shielding to the Inline terminal using the shield 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.

6 Connection Examples

Observe the connection notes on page 7.

Figure 5 and Figure 6 show the connection schematically (without shield connector).

The sensors have the same reference potential.

6.1 Connection of Active Sensors

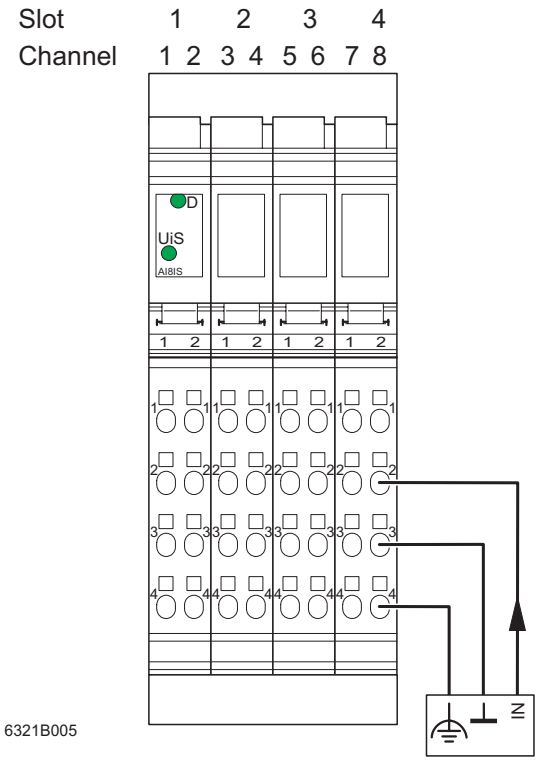

Figure 5 Signals for the connection of active sensors in 2-wire technology with shield connection

6.2 Connection of Passive Sensors

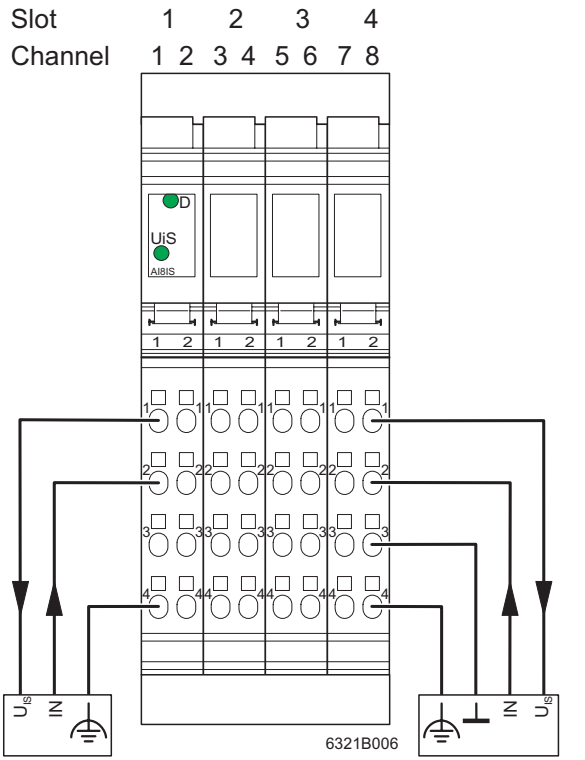

Figure 6 Signals for the connection of passive sensors in 2 and 3-wire technology with shield connection

The voltage U_{iS} for passive sensors is provided with short-circuit protection for each connector. It is tapped 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 40).

6.3 Connection of Several Analyzing Units

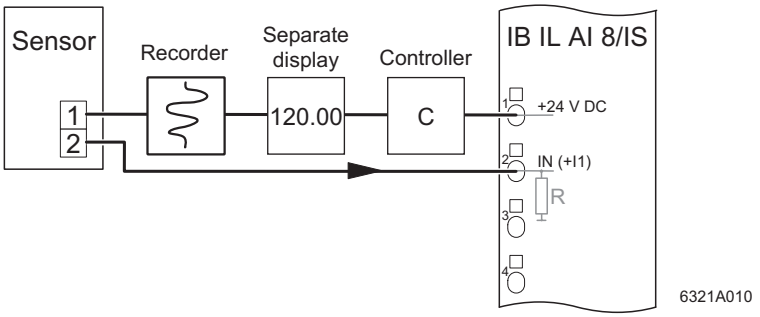

Figure 7 Connection of several analyzing units

The resistor R is part of the internal wiring.

7 Programming Data/Configuration Data

7.1 INTERBUS

ID code	$5F_{hex}$ (95_{dec})
Length code	02_{hex}
Process data channel	32 bits
Input address area	4 bytes
Output address area	4 bytes
Parameter channel (PCP)	0 bytes
Register length (bus)	4 bytes

7.2 Other Bus Systems

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

8 Process Data Words

8.1 Process Data Output Words for the Configuration of the Terminal (see page 11)

Process data output word 0 (OUT[0])		Process data output word 1 (OUT[1])	
Byte 0	Byte 1	Byte 2	Byte 3

		OUT[0]															
(Byte.bit) view	Byte	Byte 0								Byte 1							
	Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
	Assignment	0	Command							0	0	0	0	0	0	0	0

		OUT[1]															
(Byte.bit) view	Byte	Byte 2								Byte 3							
	Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
	Assignment	0	0	0	0	0	0	Filter		0	Format			Measuring range			

8.2 Process Data Input Words (see page 15)

Process data input word 0 (IN[0])		Process data input word 1 (IN[1])	
Byte 0	Byte 1	Byte 2	Byte 3

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

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

For the assignment of the illustrated (byte.bit) view to your **INTERBUS** control or computer system, please refer to data sheet DB GB IBS SYS ADDRESS, Order No. 90 00 99 0.

9 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 the mean-value generation (filtering)
– Changing the formats for the representation of measured values

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 scanned. The message is displayed until the appropriate 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.

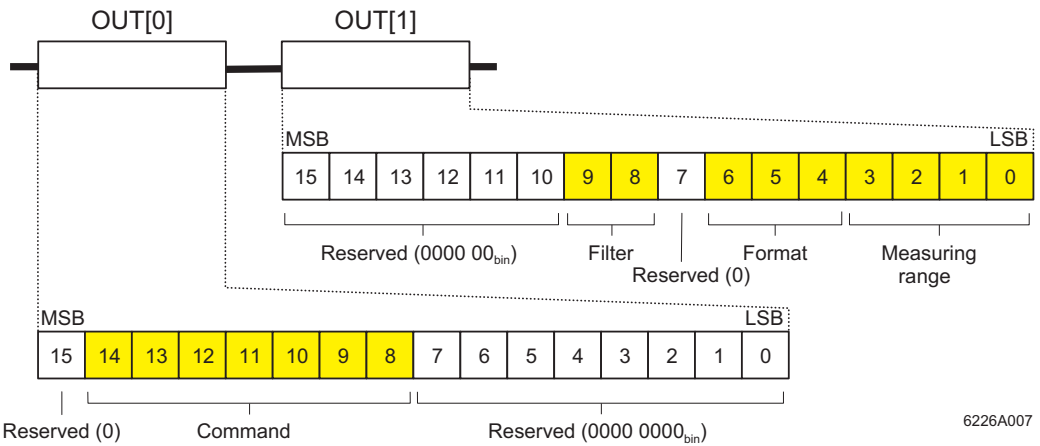

Figure 8 Process data output words

MSB Most significant bit LSB Least significant bit

Set all reserved bits to 0.

9.1 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)

9.2 OUT[1] (Parameter Word)

The parameters for the 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 confirmed 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 (default)**
01	1	No mean-value generation
10	2	4-sample average
11	3	32-sample average

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 display
100	4	PIO (for the 4 mA to 20 mA range only)
101	5	Reserved
110	6	
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

10 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.

10.1 IN[0] and IN[1] for Commands $0x00_{hex}$ to 6000_{hex}

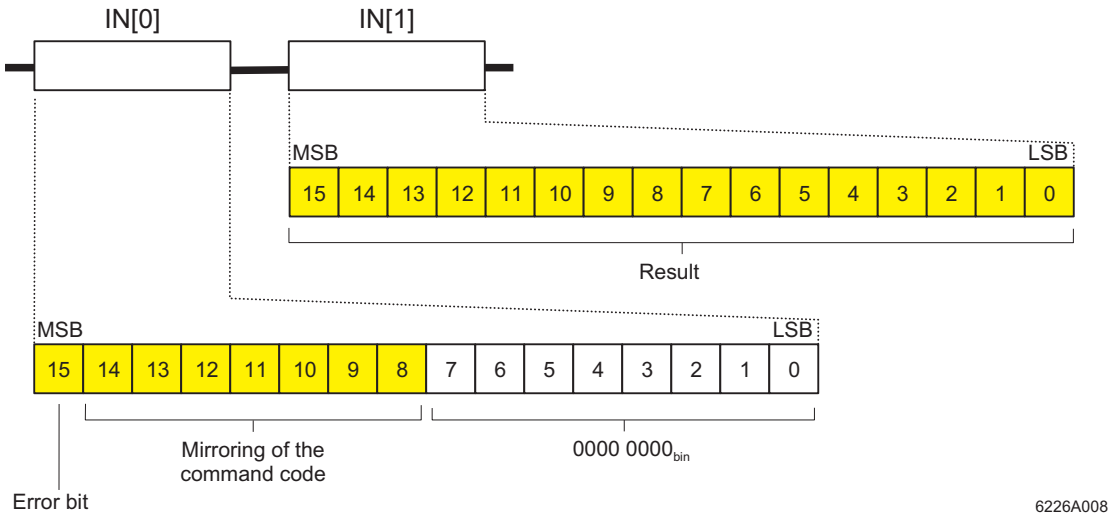

Figure 9 Process data input words

IN[0]

The output word OUT[0], which contains the command code, is mirrored in the 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 the input word IN[0].

The error bit is set for one of the following reasons (see page 30):

– There is no valid configuration for the channel scanned
– 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 the $5x00_{hex}$ command is only mirrored after the value has been read and not after reconfiguration.

IN[1]

The input word IN[1] varies depending on the command.

IN[1] contains the firmware version and module ID for the $3C00_{hex}$ command.

	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 the 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 the $0x00_{hex}$ and $5x00_{hex}$ commands, 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 appropriate format															

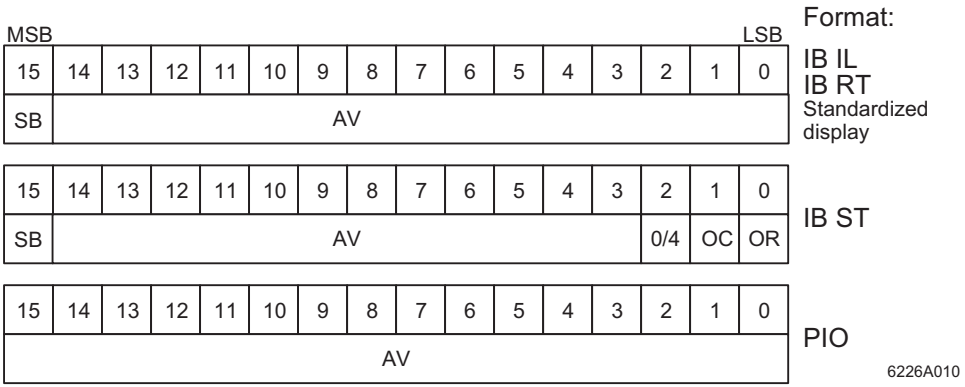

Figure 10 Representation of the measured values in the different formats

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

The individual formats are explained in "Formats for Representation of Measured Values" on page 20.

10.2 IN[0] and IN[1] for the Group Commands 7x00$_{hex}$

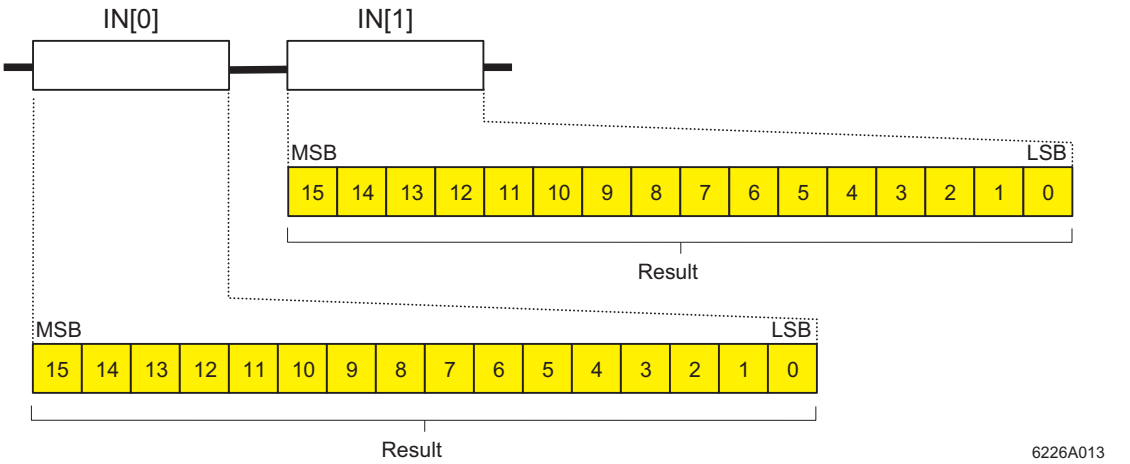

Figure 11 Process data input words

For the 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 the input word IN[1] for the 0x00$_{hex}$ and 5x00$_{hex}$ commands.

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

	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 appropriate 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 appropriate 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): 7000_{hex} Command

	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 appropriate format								8-bit measured value **channel 2** in the appropriate format							

	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 3** in the appropriate format								8-bit measured value **channel 4** in the appropriate format							

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

11 Formats for 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. The "IB IL" format is the default.

Abbreviations used in the following tables:

OR Overrange

UR Under range

11.1 "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 was not configured)
8010	Configuration invalid
8020	I/O supply voltage faulty
8040	Module faulty
8080	Under range

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

11.2 "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	4 mA to 20 mA measuring range	OR	Out of range

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

11.3 "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	+0.4884 µA
0000	**0**	**+4.0**
0000	0	+3.2 to +4.0
7FFF	32767	< +3.2

11.4 "Standardized Display" 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 on the measuring range is standardized 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 was not configured)
8010	Configuration invalid
8020	I/O supply voltage faulty
8040	Module faulty
8080	Under range

Measured value representation in "standardized display" 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)		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

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

11.5 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 display	2710	10,000	10 mA

11.6 "PIO" Format

The 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 detected 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
Format: PIO
Measuring range: 4 mA to 20 mA (PIO format is only supported in this measuring range)

Option 1:

1 Configuring channel 1

OUT[0] 4000_{hex}

OUT[1] $004A_{hex}$

2 Reading the measured value

OUT[0] 0000_{hex}

OUT[1] 0000_{hex}

Option 2:

Configuring channel 1 and reading 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

12 Process Data Input Words in the Event of an Error

In the event of an error, the command is mirrored in the input word IN[0] and displayed with the set error bit. The 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_{BT}). – Check the potential jumper connection.
After module start	8040	X	Module faulty.	Replace module.
0x00	8004		There is no valid configuration for the channel scanned.	Configure channel.
5x00	8004		The configuration just specified is invalid.	Check and correct configuration.
1x00	8010		There is no valid configuration for the channel scanned.	Configure channel.
4x00 and 6000	8010		Invalid parameter.	Check and correct parameter.

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 display" formats offer additional diagnostic functions. These are specified on page 20 and page 26.

13 Startup Options

The following startup options illustrate how to use the IB IL AI 8/IS terminal.

13.1 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 (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 appearance of the process data output words is 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 electronics module. 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]	$F000_{hex}$	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.

The appearance of the process data output word OUT[0] is 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			

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

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

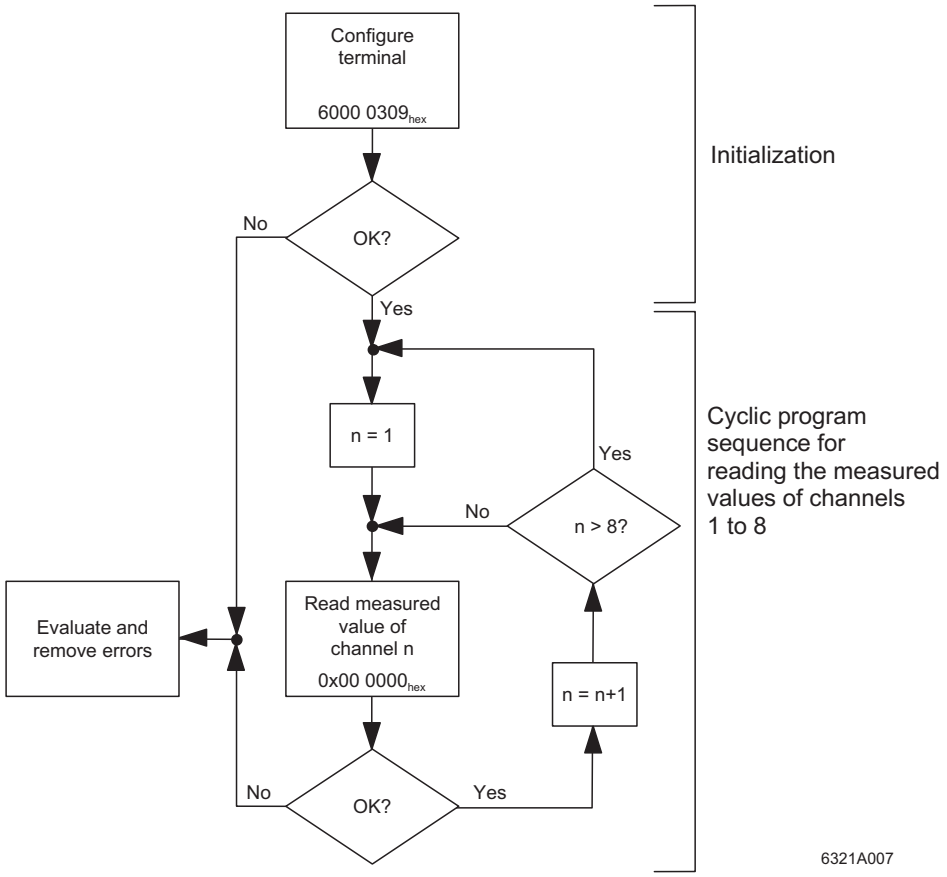

Figure 12 Schematic initialization and cyclic program sequence when configuring the entire terminal

13.2 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 (00_{bin}, 0_{dec})	4-sample average (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:

The appearance of the process data output word OUT[0] is 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			

The 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				12			

With the command in OUT[0], the configuration according to OUT[1] is sent to the electronics module 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.

The appearance of the process data output word OUT[0] is 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			

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

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

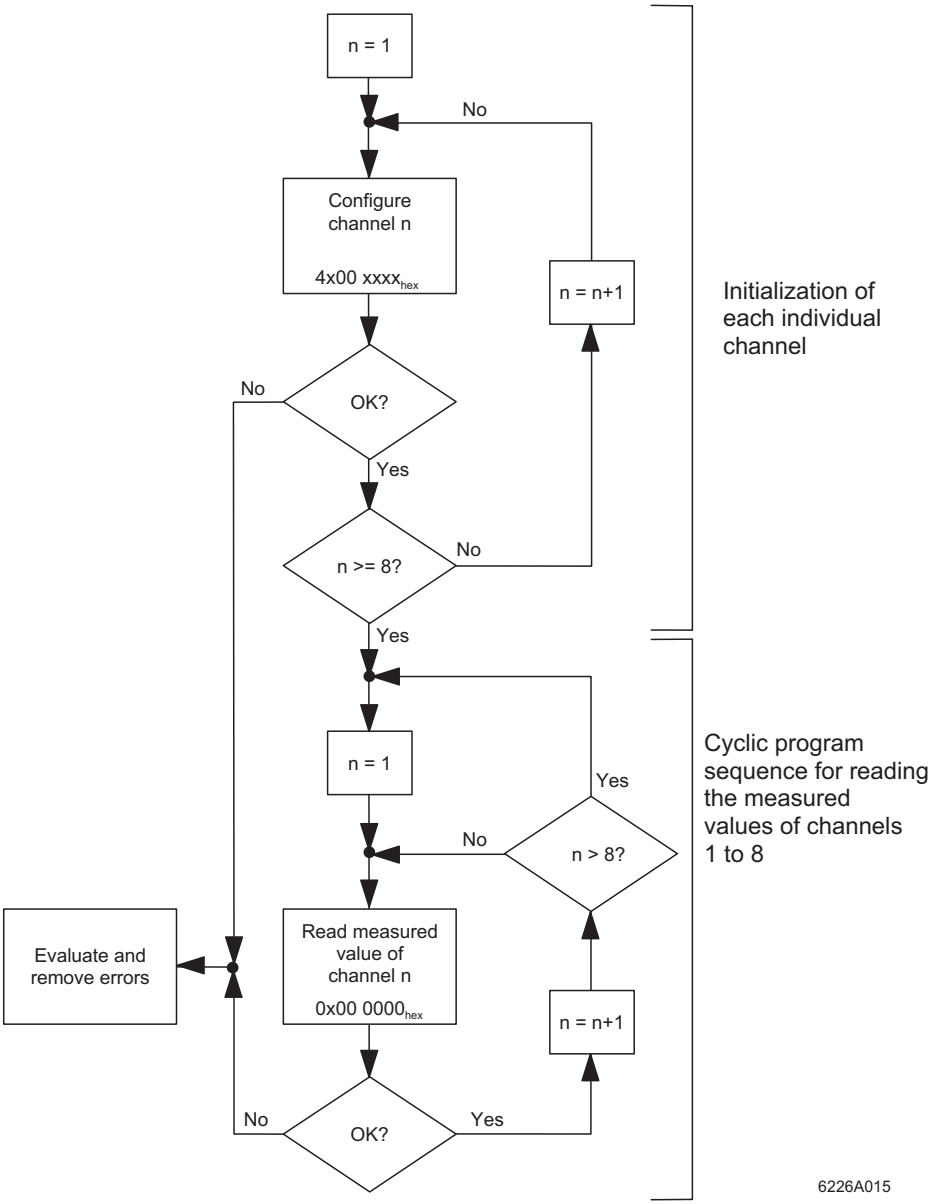

Figure 13 Schematic initialization and cyclic program sequence when configuring channels with different parameters

13.3 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 the $4x00_{hex}$ command.

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.

13.4 Advantages of the Standard Methods Compared With the Special Methods

– The 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.
– The standard methods enable more accurate error diagnostics than the 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.

14 Application Notes

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

14.1 Precision DC Measurements

Precision DC measurements constitute an optimal area of application for the IB IL AI 8/IS terminal. The high-resolution analog-to-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

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

14.2 Closed-Loop Control Tasks

The IB IL AI 8/IS terminal makes closed-loop control tasks particularly easy to carry out. 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, the 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.

14.3 Signal Scanning or Fast, Sudden Signals

The IB IL AI 8/IS terminal is ideal for scanning signals. As a result of the high input cut-off 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 local bus cycle time.

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.

14.4 Current Loops

If the IB IL AI 8/IS terminal is used to measure currents in current loops, please ensure that the eight current inputs operate on a common ground potential (single-ended). Thus, the measured input should always be on the GND potential with the minus input.

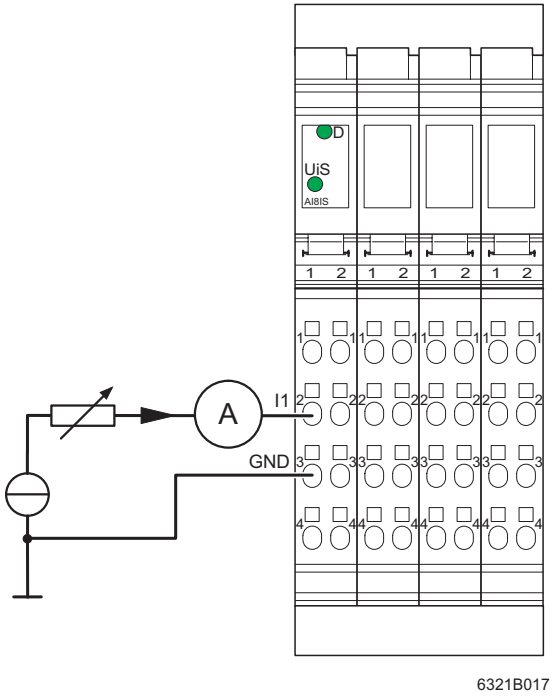

Figure 14 Measuring currents

14.5 Passive Sensors

The standard use of passive sensors is shown in Figure 6 on page 8.

If a lower supply voltage is required, this must be supplied via a power terminal.
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.

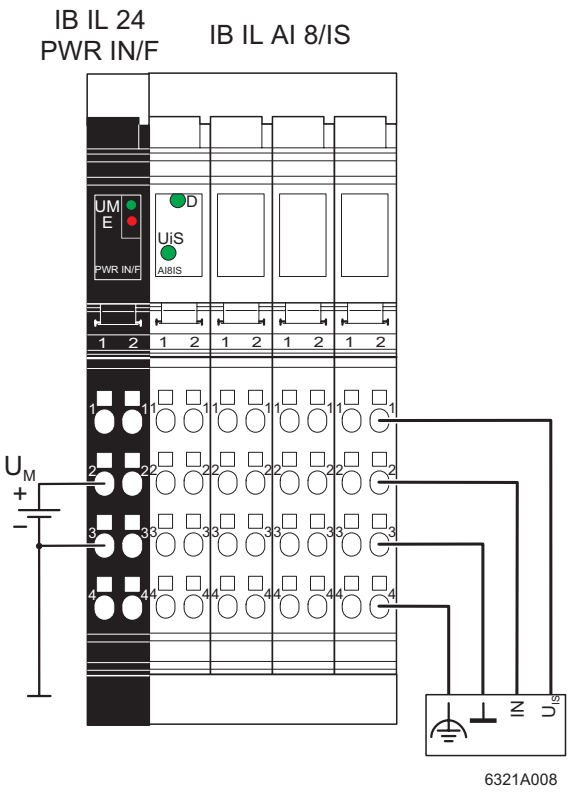

Figure 15 Supplying voltage U_M between 10 V and 30 V

15 Tolerance and Temperature Response

T_A = 25°C (77°F)

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 (-13°F to +131°F)

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 (bursts) 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.

16 Technical Data

General Data		
Order Designation	(Order No.)	IB IL AI 8/IS (27 42 74 8) IB IL AI 8/IS-PAC (28 61 66 1)
Housing dimensions (width x height x depth)		48.8 mm x 120 mm x 71.5 mm (1.921 in. x 4.724 in. x 2.815 in.)
Weight		125 g (without connectors)
Operating mode		Process data mode with 2 words
Type of sensor connection		2 and 3-wire technology
Permissible temperature (operation)		-25°C to +55°C (-13°F to +131°F)
Permissible temperature (storage/transport)		-25°C to +85°C (-13°F to +185°F)
Permissible humidity (operation)		75% on average, 85% occasionally

In the range from -25°C to +55°C (-13°F to +131°F) appropriate measures against increased humidity (> 85%) must be taken.

Permissible humidity (storage/transport)	75% on average, 85% occasionally

For a short period, slight condensation may appear on the outside of the housing if, for example, the terminal is brought into a closed room from a vehicle.

Permissible air pressure (operation)	80 kPa to 106 kPa (up to 2000 m [6562 ft.] above sea level)
Permissible air pressure (storage/transport)	70 kPa to 106 kPa (up to 3000 m [9843 ft.] above sea level)
Degree of protection	IP 20 according to IEC 60529
Class of protection	Class 3 according to VDE 0106, IEC 60536

Interface	
Local bus interface	Data routing

Power Consumption	
Communications power U_L	7.5 V
Current consumption from 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 Terminal/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 (-13°F to +131°F)
Nominal current I_{IS}	
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 Representation of Measured Values" on page 20
Measured value representation	In the formats IB IL (15-bit with sign bit) IB ST (12-bit with sign bit) IB RT (15-bit with sign bit) Standardized display (15-bit with sign bit) PIO (16-bit)
Please read the notes on page 21 and page 27 on measured value representation in "IB IL" and "standardized display" 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

Analog Inputs (Continued)	
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 filter	3.5 kHz
Behavior upon sensor failure	Goes to 0 mA/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 Measures
None

Electrical Isolation/Isolation of the Voltage Areas

To provide electrical isolation between the logic level and the I/O area, it is necessary to supply the station bus terminal and the sensors connected to the analog input terminal, from separate power supply units. Interconnection of the 24 V power supplies is not permitted. (See user manual)

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 Terminal/Power Terminal and an 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.
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 message
Peripheral fault/user error	Yes, error message via the process data input words (see page 30)

17 Ordering Data

Description	Order Designation	Order No.
Terminal with eight analog input channels and a supply for passive sensors	IB IL AI 8/IS-PAC	28 61 66 1
Terminal with eight analog input channels and a supply for passive sensors	IB IL AI 8/IS	27 42 74 8
Four connectors with shield connection for the connection of two cables are needed for complete fitting of the IB IL AI 8/IS terminal.		
Connector with shield connection for the connection of two cables; pack of 10	IB IL SCN 6-SHIELD-TWIN	27 40 24 5
Terminal with eight analog input channels including connectors and labeling fields	IB IL AI 8/SF-PAC	28 61 41 2
Terminal with eight analog input channels	IB IL AI 8/SF	27 27 83 1
"Configuring and Installing the INTERBUS Inline Product Range" User Manual	IB IL SYS PRO UM E	27 43 04 8

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