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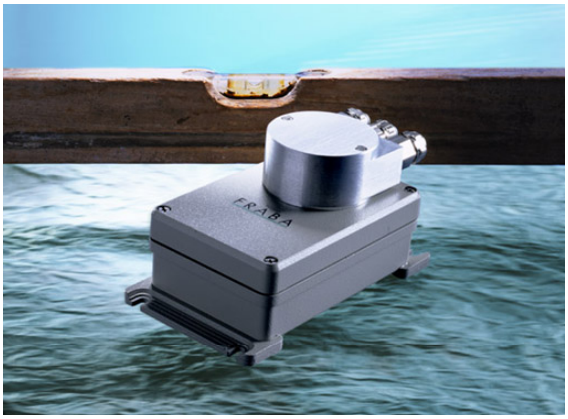
ABSOLUTE INCLINOMETER WITH DEVICE NET INTERFACE
USER MANUAL



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1. Introduction

Absolute inclinometers provide a definite value for every possible inclinations.
Applications are structural engineering, levelling and measuring techniques or inclinations.

The absolute inclinometer has got a maximum resolution of 45° per each axis. Totally a 2 axis version is available in one housing. A update cycle time for the inclination is 5 times per second. This depends on the internal measurement principle.

The integrated CAN-Bus interface of the absolute inclinometer supports all the DeviceNet functions. The following modes can be programmed and enabled or disabled:

- Polled Mode
- Change of State
- Cyclic Mode

The protocol supports the programming of the following additional functions:

- Preset value for Axis X
- Preset value for Axis Y
- Out of range measurement detection
- Status information

The general use of absolute inclinometer with DeviceNet interface is guaranteed.

2. Data Transmission

The data transmission in the DeviceNet network is realized by message telegrams. Basically, these telegrams can be divided into the CAN-ID and 8 following bytes as shown in the table below:

COB-ID	Message Header	Message Body
11 Bit	1 Byte	7 Byte

2.1. The Object Dictionary

Instance Attribute of the Position Sensor Objects

Class Code: 65 hex

Attribute ID	Access	Name	Data length	Description
65 hex	Get	Number of Attributes	USINT	Number of supported Attributes
66 hex	Get	Attribute	Array of USINT	List of supported Attribute
67 hex	Get	Inclination value	DINT	current inclination
68 hex	Get / Set	Preset Value X-Axis	SINT	setting a defined value
69 hex	Get / Set	Preset Value Y-Axis	SINT	setting a defined value
70 hex	Get / Set	Operating Parameter	BYTE	Out of range measurement detection
71 hex	Get	Status	BYTE	Status information

Get / Set: read, write

2.2. CAN Identifier Definition

The inclinometer is a Group 2 Server which uses the Predefined Master/Salve Connection Set.
In the following table a user can see the necessary identifier for communication.

10	9	8	7	6	5	4	3	2	1	0	Identity Usage	Hex Range
0	Group 1 Message ID				Source MAC ID						GROUP 1 Message	000-3ff
0	1	1	0	1	Source MAC ID						Slave's I/O Change of State or Cyclic Message	
0	1	1	1	1	Source MAC ID						Slave's I/O Poll Response or Change of State/Cyclic Acknowledge Message	
1	0	MAC ID						Group 2 Message ID			GROUP 2 Messages	400 - 5ff
1	0	Destination MAC ID						0	1	0	Master's Change of State or Cyclic Acknowledge Message	
1	0	Source MAC ID						0	1	1	Slave's Explicit/Unconnected Response Messages	
1	0	Destination MAC ID						1	0	0	Master's Explicit Request Message	
1	0	Destination MAC ID						1	0	1	Master's I/O Poll Command/Change of State/Cyclic Message	
1	0	Destination MAC ID						1	1	0	Group 2 Only Unconnected Explicit Request Message (reserved)	
1	0	Destination MAC ID						1	1	1	Duplicate MAC ID Check Messages	

3. Programmable Parameter

3.1.1. Preset value X-Axis

The preset value is the desired position value, which should be reached at a certain physical position of the axis. The position value of the inclinometer is set to the desired process value by the parameter preset. The preset value **must not** exceed the physical resolution of the sensor.

Attribute ID	Default value	Value range	Data length
68 hex	0 hex	0hex - total measuring range	Signed Integer 16

3.1.2. Preset value Y-Axis

The preset value is the desired position value, which should be reached at a certain physical position of the axis. The position value of the inclinometer is set to the desired process value by the parameter preset. The preset value **must not** exceed the physical resolution of the sensor.

Attribute ID	Default value	Value range	Data length
69 hex	0 hex	0hex - total measuring range	Signed Integer 16

3.1.3. Out of range measurement detection

This feature allows the user to detect an over- or underrange detection of the measurement value. An out of range status is indicated by a status byte in the I/O connection.

When this feature should be activated, the operating parameter must be configured.

Attribute ID	Default value	Value range	Data length
70 hex	0 hex	0hex - 1hex	BYTE

3.1.4. Status information

This parameter is also transmitted in the I/O connection. Two flags in the status byte indicates independently an overrange for each axis.

Attribute ID	Default value	Value range	Data length
71 hex	0 hex	0hex - 3hex	BYTE

4. Operating Mode

4.1. Polled Mode

For switching the polled mode on the following telegrams are needed. Further it is assumed in the following example a master MAC ID of 0A hex and a slave MAC ID of 03 hex.

Allocate Master / Slave Connection Set

Allocate Polling

Byte Offset	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Frag [0]	XID	MAC ID					
1	R/R [0]	Service [4B]						
	Class ID [03]							
	Instance ID [01]							
	Allocation Choice [03]							
	0	0	Allocator MAC ID					

CAN Identifier Definition

10	9	8	7	6	5	4	3	2	1	0	Identity Usage	Hex Range
1	**0**	**Destination MAC ID**						**1**	**1**	**0**	**Group 2 Only Unconnected Explicit Request Message (reserved)**	

Example:

CAN-ID	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
41E	0A	4B	03	01	03	0A

Setting the Expected_packet_rate of the Explicit Message Connection on 0:

- CAN Identifier Definition

10	9	8	7	6	5	4	3	2	1	0	Identity Usage	Hex Range
1	**0**	**Destination MAC ID**						**1**	**0**	**0**	**Master's Explicit Request Message**	

Example:

CAN-ID	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
41C	0A	10	05	01	09	00	00

Setting the Expected_packet_rate of the Polling Connection on 0:
Example:

CAN-ID	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
41C	0A	10	05	02	09	00	00

Release Master / Slave Connection Set
Release Polling

Byte Offset	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Frag [0]	XID	MAC ID					
1	R/R [0]	Service [4C]						
	Class ID [03]							
	Instance ID [01]							
	Release Choice [03]							

Example:

CAN-ID	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4
41E	0A	4C	03	01	03

4.2. Change of State Mode

The inclinometer is sending without any request from the host, when the actual process value is changing. No telegram will occur when the position value is not changing. The result is a reduced bus loading.

Allocate Master / Slave Connection Set

1. Allocate COS

Byte Offset	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Frag [0]	XID	MAC ID					
1	R/R [0]	Service [4B]						
	Class ID [03]							
	Instance ID [01]							
	Allocation Choice [51]							
	0	0	Allocator MAC ID					

Example:

CAN-ID	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
41E	0A	4B	03	01	51	0A

2. Setting Expected_packet_rate of the Explicit Message Connection on 0:
Example:

CAN-ID	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
41C	0A	10	05	01	09	00	00

Setting Expected_packet_rate of the Change of State Connection on 0:
Example:

CAN-ID	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
41C	0A	10	05	04	09	00	00

Release Master / Slave Connection Set
Release COS

Byte Offset	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Frag [0]	XID	MAC ID					
1	R/R [0]	Service [4C]						
	Class ID [03]							
	Instance ID [01]							
	Release Choice [51]							

Example:

CAN-ID	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4
41E	0A	4C	03	01	51

4.3. Saving Parameter

The parameter of the inclinometer are saved in a non-volatile FLASH memory. Because of a limited number of writing cycles (≈ 1.000), it is useful to transmit the modified parameter in the first step only in the RAM area. After adjusting and examination those values should be saved in the FLASH memory.

After successful saving of the parameter the encoder is sending his MAC-ID on the bus. To get the process value a new allocation of the slave is required.

Byte Offset	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Frag [0]	XID	MAC ID					
1	R/R [0]	Service [32]						
	Class ID [65]							
	Instance ID [01]							

Example: (MAC-ID Master: 0A hex, MAC-ID Slave: 03 hex)

CAN-ID	Byte 0	Byte 1	Byte 2	Byte 3
41C	0A	32	65	01

5. Transmission of the actual position

The process value is transmitted according to the following table.

CAN-ID	**process value**				
	X-Axis		**Y-Axis**		**Status**
11 Bit	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4
VALUE	2^7 bis 2^0	2^{15} bis 2^8	2^0bis 2^7	2^8bis 2^{15}	2^7 bis 2^0

Attention: 5°/15° version: resolution 0,001 °, 45° version: resolution 0,01 °

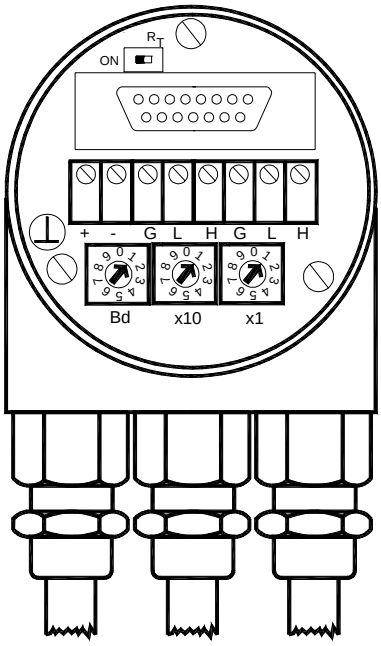
Status	**Bit 7**	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
Flag	0	0	0	0	0	0	Y-Axis Overrange	X-Axis Overrange
Meaning	-	-	-	-	-	-	‘0’ in range ‘1’ out of range	‘0’ in range ‘1’ out of range

‘-’: no meaning, default value
‘0’. Reserved for extensions in future.

6. Installation

6.1. Electric connection

The rotary encoder is connected by three cables. The power supply is achieved with a two-wire connection cable through one PG 9. Each one of the twisted-pair and shielded bus lines are guided in and out through two PG 9 on the right side (as seen on clamps)

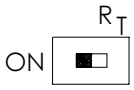


Clamp	Description
⊥	Ground
+	24 V Supply voltage
-	0 V Supply voltage
CG	CAN Ground
CL	CAN Low
CH	CAN High
CG	CAN Ground
CL	CAN Low
CH	CAN High

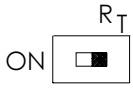
There is a resistor provided in the connection cap, which must be used as a line termination on the last device.

Resistor:

Last Device



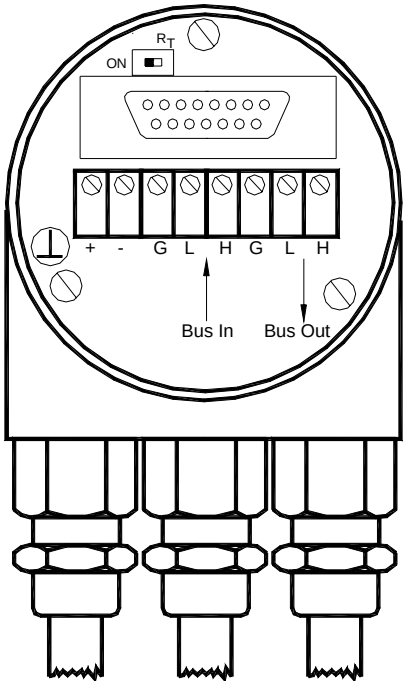
Device X



The setting of the node number is achieved by 2 turn-switches in the connection cap. Possible addresses lie between 0 and 63 whereby every address can only be used once. Inside the encoder the defined address is increased by one. 2 LEDs on the backside of the connection cap show the operating status of the encoder.

6.2. Settings in the Connection Cap

Baudrate in kBit/s	BCD-Drehschalter BCD coded rotary switches
125	0
250	1
500	2
125	3
reserved	4...9



Bus connection

The connection cap fulfills the function of a T-coupler. From there the wiring must be done according to the drawing on the left side. Please note the assignment of incoming and outgoing bus signals. **An activated bus termination resistor will lead into a separation of bus in and bus out signals!**

7. Power On

7.1. Operational Status

After power on the inclinometer is sending for twice times its MAC ID telegram on the bus. Between each telegram is a defined pause of 1 second. This behaviour is defined by the DeviceNet protocol.

Before communication is possible the user must wait 1 second again after the 2nd MAC-ID check to establish a connection. If the time interval is not kept the master must try allocation again.

7.2. Programming

If some parameters should not be modified you could step over this chapter.
The following numerical are given in hexadecimal spelling. In the examples for CAN ID and MAC ID is *Master 0A (hex)* and for the *slave 03 (hex).*

The changeable values are written in an italic spelling.

7.2.1. Preset Value for X-Axis

CAN Identifier Definition

10	9	8	7	6	5	4	3	2	1	0	Identity Usage	Hex Range
1	**0**	**Destination MAC ID**						**1**	**0**	**0**	**Master's Explicit Request Message**	

Master to Inclinometer: Set-Parameter

CAN ID	MAC ID	Service Code	Class ID	Instance ID	AttributeID			
	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
41C	*0A*	10	65	01	68	X	X	

X: desired Preset Value
Inclinometer to Master: Confirmation

CAN ID	MAC ID	Service Code
	Byte0	Byte1
41B	0A	90

7.2.2. Preset Value for Y-Axis

CAN Identifier Definition

10	9	8	7	6	5	4	3	2	1	0	Identity Usage	Hex Range
1	**0**	**Destination MAC ID**						**1**	**0**	**0**	**Master's Explicit Request Message**	

Master to Inclinometer: Set-Parameter

CAN ID	**MAC ID**	**Service Code**	**Class ID**	**Instance ID**	**AttributeID**			
	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
41C	*0A*	10	65	01	69	X	X	

X: desired Preset Value

Inclinometer to Master: Confirmation

CAN ID	**MAC ID**	**Service Code**
	Byte0	Byte1
41B	0A	90

7.2.3. Operating Parameter

Enables the flags in the status byte. In the following table is listed, which kind of flags can be configured.

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	0	0	0	0	0	0	Overrange Detection for X-/Y-axis '0' no out of range measurement detection activated '1' out of range measurement detection activated

CAN Identifier Definition

10	9	8	7	6	5	4	3	2	1	0	Identity Usage	Hex Range
1	**0**	**Destination MAC ID**						**1**	**0**	**0**	**Master's Explicit Request Message**	

Master to Inclinometer: Set-Parameter

CAN ID	MAC ID	Service Code	Class ID	Instance ID	AttributeID			
	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
41C	*0A*	10	65	01	70	X		

X: desired Value

Inclinometer to Master: Confirmation

CAN ID	MAC ID	Service Code
	Byte0	Byte1
41B	0A	90

7.2.4. Status Byte

The status byte offers the user very easy detection of alarm or warning messages. If the inclination sensor is out of range this is indicated by a flag for each axis. This flag is valid for under / overflow.

Status	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Flag	0	0	0	0	0	0	Y-Axis Overrange	X-Axis Overrange
Meaning	-	-	-	-	-	-	'0' in range '1' out of range	'0' in range '1' out of range

'-': no meaning, default value

'0'. Reserved for extensions in future.

This information can only be read and is not writeable.

7.2.5. Parameter Saving

Master to Inclinometer: Set-Parameter

CAN ID	MAC ID	Service Code	Class ID	Instance ID
	Byte0	Byte1	Byte 2	Byte 3
		32	65	01

If the transfer has been successful the inclinometer quotes after 3s with the Duplicate MAC-ID. After that the master has got to re-allocate the slave.

If the transfer is not successful, an error message will be send. The used service code to save the parameter set is manufacturer specific.

8. Technical Data

8.1. Electrical Data

General Layout	according to DIN VDE 0160
Supply Voltage	10 - 30 V DC (absolute limits)
Power Consumption	max. 5 Watt
EMC	electro-magnetical emission according to EN 50 081-2 electro-magnetical compatibility according to EN 50 082-2
Bus connection	galvanically separated by opto-couplings CAN Transceiver according to ISO/DIS 11898
Resolution	up to 45° degrees up to 2 axis
Code	Binary
Electrical Lifetime	> 10^5 h
Baudrate	3 values programmable by 2 rotary-switches
Node Number	programmable by 1 rotary-switch in the connection cap

8.2. Mechanical Data

Housing	Aluminium
Connection	Connection Cap as T-Coupling with clamps
	optional: axial connector, D-Sub, 9 pins
Operating temperature	0 ... + 70° C
Storage temperature	-40 ... + 85°C
Humidity	98% (without liquid state)
Degree of protection(EN 60529) Housing	IP 65

POSITAL
FRABA

Imprint
FRABA POSITAL GmbH
Schanzenstr. 35
D-51063 Köln
Phone +49 (0) 221-96213-0
Fax +49 (0) 221-96213-20
Internet http://www.posital.de
e-mail info@posital.com

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For technical support, questions and suggestions for improving our products and documentations call our telephone line: +49 (0) 221 – 96213-28