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USER MANUAL
ACCELENS INCLINOMETER CANOPEN

ACCELENS INCLINOMETER SERIES WITH CAN-BUS INTERFACE
USER MANUAL

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Table of Content

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General Security Advise

Important Information

Read these instructions carefully, and look at the equipment to become familiar with the device before trying to install, operate, or maintain it. The following special messages may appear throughout this documentation or on the equipment to warn of potential hazards or to call attention to information that clarifies or simplifies a procedure.

The addition of this symbol to a Danger or Warning safety label indicates that an electrical hazard exists, which will result in personal injury if the instructions are not followed.

This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

Please Note

Electrical equipment should be serviced only by qualified personnel. No responsibility is assumed by POSITAL for any consequences arising out of the use of this material. This document is not intended as an instruction manual for untrained persons.

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About this Manual

Background

This user manual explains how to install and configure the following inclinometer with CANopen interface.

Relate Note

Version date: 11. February 2007
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Imprint

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User Annotation

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USER MANUAL
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1. Introduction

This manual explains how to install and configure the ACS gravity referenced inclinometers suitable for both military and industrial applications with CANopen interface. The products are fully compliant with standard DS410 and is CiA certified.

Absolute inclinometers identify all the points of a movement by means of a single digital signal. Due to their capacity to give a single, exact position value to all X and Y inclinations positions, inclinometers have become one of a very interesting alternative to a singleturn absolute encoder as a links between the mechanical system and the control system. The basic principle behind this ACS inclinometer is the Micro-Electro-Mechanical Systems (MEMS) sensor cell.

The CANopen bus interface on this inclinometers permits speeds up to 1Mbaud (30m cable for a maximum speed of 1Mbaud, 5000 m cable for a maximum speed of 10 kbaud).
The inclinometer connection base, provides access to three rotary switches for configuring the address and transmission speed. It also incorporates two LEDs that provide assistance with diagnostics.
There are two types of inclinometers. One type of inclinometer uses one M12 connector for BUS IN. The other type of inclinometer acts as a T-junction with two M12 connectors for the BUS IN and BUS OUT signals.

1.1 General CANopen Information

The CANopen system is used in industrial applications. It is a multiple access system (maximum: 127 participants), which means that all devices can access the bus. In simple terms, each user checks whether the bus is free, and if it is the user can send messages. If two users try to access the bus at the same time, the user with the higher priority level (lowest ID number) has permission to send its message.
Users with the lowest priority level must cancel their data transfer and wait before re-trying to send their message. Data communication is carried out via messages. These messages consist of 1 COB-ID followed by a maximum of 8 bytes of data. The COB-ID, which determines the priority of the message, consists of a function code and a node number. The node number corresponds to the network address of the device. It is unique on a bus. The function code varies according to the type of message being sent:

- Management messages (LMT, NMT)
- Messaging and service (SDOs)
- Data exchange (PDOs)
- Predefined messages (synchronization, emergency messages)

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The inclinometer support the following operating modes:

- Pooled mode: The position value is only given on request.
- Cyclic mode: The position value is sent cyclically (regular, adjustable interval) on the bus.
- SYNC mode: The position value is sent after a synchronization message (SYNC) is received. The position value is sent every n SYNCs (n ≥ 1).
- State change mode: The position value is transferred as soon as it changes.

Other functions (offset values, resolution, etc) can be configured. The inclinometer corresponds to the class 2 inclinometer profile (DS 410 in which the characteristics of inclinometers with CANopen interface are defined). The node number and speed in bauds are determined via rotary switches. The transmission speed can range from 10kbauds up to 1Mbaud. Various software tools for configuration and parameter-setting are available from different suppliers. It is easy to align and program the inclinometers using the EDS (electronic data sheet) configuration file provided.

1.2 Typical Applications

• Platform leveling and stabilization
• 360° vertical orientation measurement
• Leveling instruments
• Construction levels
• Any industrial application where 2 axis leveling is required

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2. Installation

2.1 Elektrical Connection

Every of this ACS devices has an integrated T-coupler, a switchable terminal resistor and BCD rotary switches for baudrate and node number.

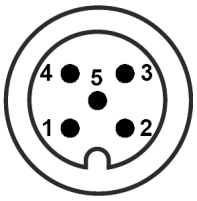
List of Connecion Types

Description	Article Name
Aluminum housing with one M12 5 pin male connector (CAN in)	ACS-xxx-xxxxxxx-x-P5
Aluminum housing with two M12 5 pin male connector (CAN in / CAN out)	ACS-xxx-xxxxxxx-x-TM
Aluminum housing with cable exit (CAN in)	ACS-xxx-xxxxxxx-x-CW

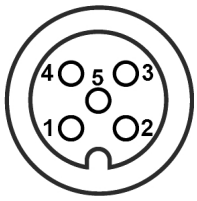
2.2 Connector and Cable Outputs

Signal	5 pin round connector pin number	open cable
CAN Ground	1	green
24 V supply voltage	2	white
0 V supply voltage	3	brown
CAN High	4	yellow
CAN Low	5	pink

Connector Types



Bus IN
5 pin connector male M12
connector male inlay / counterpart **soldering side**



Bus OUT
5 pin connector female M12
connector female inlay / counterpart **soldering side**

2.3 Accessories

Description		Article Name	Article Number
Terminal resistor	External terminal resistor for female connector	TR-B	
User manual *	Installation and configuration manual, german	UMD-CA	
User manual *	Installation and configuration manual, english	UME-CA	
EDS-File *	Disc containing EDS-file for configuration	DK-CA	

Note:
* The documentation and the EDS file can be downloaded from our website www.posital.com

2.4 Installation Precautions

WARNING
Do not remove or mount while the inclinometer is under power!

Do not stand on the inclinometer!

Avoid mechanical load!

2.3 Mounting and Installation Instruction

There are two different mounting solutions for the ACS inclinometer, i.e. the base plate of the inclinometer with the three mounting holes needs to be placed on the horizontal plane of the object to be measured. It can be mounted with M4 screw as a maximum. The mounting surface must be plane and free of dust and grease. We recommend cheese head screws with metrical thread M4 for the mounting. Maximum fastening torque for the mounting screws is 10 Nm.

2.4 Installation

Prior to installation, please check for all connection and mounting instructions to be complied with. Please also observe the general rules and regulations on low voltage technical devices.
Avoid shock and vibration during measurement, as these could corrupt the measurement results. Inclination sensors that base on a MEMS principle are optimal for fast measurements.

2.5 Measurement

The measurement of the tilt angle of the single measurement axis is carried out over the respective longitudinal and lateral axis of the inclination sensor. Reference is always the horizontal plane.

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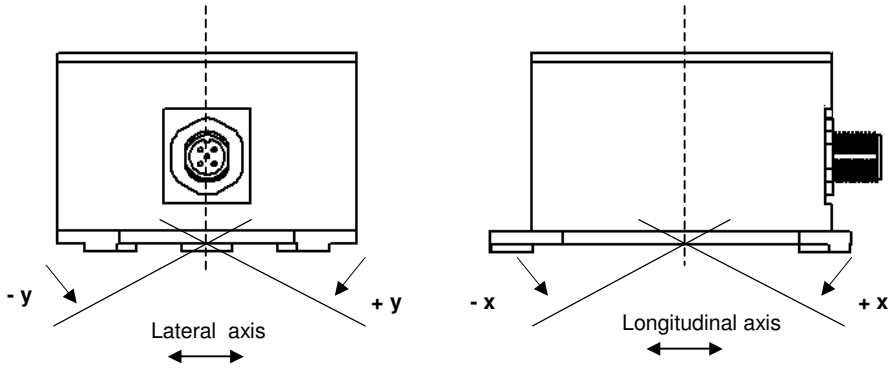
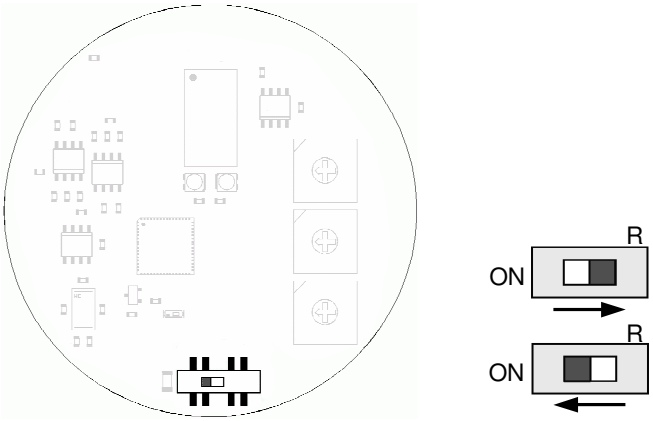


2.6 Bus Termination

If the inclinometer is connected at the end or beginning of the bus the termination resistor must be switched on. The termination resistor is switched on when the dip-switch is in the 'ON' position. To switch the resistor on, the cap of the inclinometer has to be unscrewed.

This resistor is provided in the inclinometer, which must be used as a line termination on the last device.



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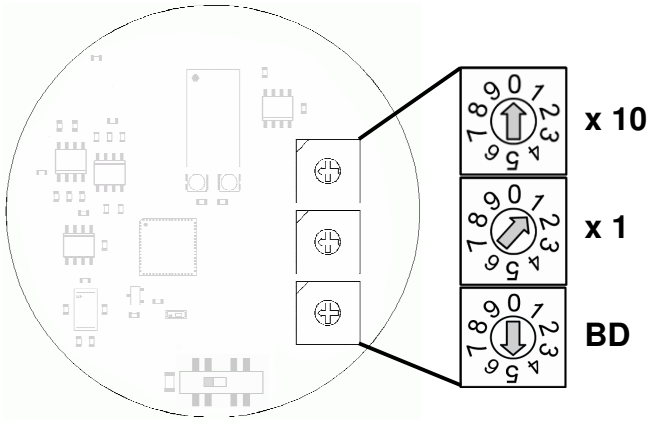
2.7 Bus address

The setting of the node number is achieved via SDO-Object. Possible (valid) addresses lie between 0 and 96 whereby every address can only be used once.

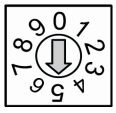
The CANopen inclinometer adds internal 1 to the adjusted device address.

Adjusting Baudrate:

Baudrain in kBaud/s	max. cable length (m)	Switch value
10	5000	0
20	2500	1
50	1000	2
100	750	3
125	500	4
250	250	5
500	100	6
800	40	7
1000	20	8
reserved	-	9

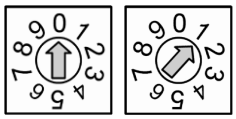


Example for setting the Baudrate



BD

Switch value is set to 5. If you compare this with the value in the table above, you can see that this means a bus speed of 250kBaud/s.



x 10 **x 1**

In this sample, the switch values for the note number is set to 0 (x10) and 1 (x1). This means that the value from the switch is 01d. The node number will be 02, because of the internal addition of 1 to the adjusted value.

Switch Value + 1 = Node Number

Info:
The value 1 is added to the node number to avoid conflicts at the note number 0 with is normally used for the Master.

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3. Technical Data

3.1 Electrical Data

Model	ACS080	ACS360
Measuring range	+/- 80°	360°
Resolution	0,18°	0,18°
Accuracy (-25…85 °C)		
Damping period (0° -> 15°, t=90%)	min. 125ms	
offset error (-25...85°C) (-40...125°C max)	+/- 0,008 ° / °C +/- 0,86 °	
Interface	Transceiver according ISO 11898, galvanically isolated by opto-couplers	
Transmission rate	max. 1MBaud	
Device addressing	Via SDO	
Supply voltage	10 - 30 V DC (absolute limits)	
Current consumption	max. 230 mA with 10 V DC, max. 100 mA with 24 V DC	
Power consumption	max. 2,2Watts	
EMC	Emitted interference: EN 61000-6-4	
	Noise immunity: EN 61000-6-2	
Electrical lifetime	> 10^5 h	

Inclinometer should be connected only to subsequent electronics whose power supplies comply with EN 50178 (protective low voltage)

3.2 Mechanical Data

Housing	Aluminum
Lifetime	> 10^5 h
Shock (EN 60068-2-27)	A=30g; t= 11ms, halfsine
Shock (EN 60068-2-27)	≤ 100 g (half sine, 6 ms)
Permanent shock (EN 60028-2-29)	≤ 10 g (half sine, 16 ms)
Vibration (EN 60068-2-6)	≤ 10 g (10 Hz ... 1,000 Hz)
Weight (standard version)	Horizontal: ≈ 250 g
	Vertical: ≈ 450 g
Weight (stainless steel version)	Horizontal: ≈ 650 g
	Vertical: ≈ 1,000 g

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3.3 Environmental Conditions

Operating temperature	- 40 .. + 85°C*
Storage temperature	- 40 .. + 85°C*
Humidity	98 % (without liquid state)
Protection class (EN 60529)	IP 67 (connected)

Note:
* Cable exit: -30 … + 70 °C (static), -5 … + 70 °C (flexing)

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4. Configuration

The purpose of this chapter is to describe the configuration parameters of the inclinometers with a CANopen interface.

4.1 Operating Modes

4.1.1 **Principle**

The inclinometer accesses the CAN network after powerup in pre-operational mode:

FC	NN	Comand	Index	Subindex	S-/P-Data	Description
1110	XXXXXXX	“HEX – Value”				Boot-Up message

It is recommended that the parameters are entered when the encoder is in preoperational mode. Pre-operational mode entails reduced activity on the network, which simplifies the checking of the accuracy of the sent/received SDOs. It is not possible to send or receive PDOs in pre-operational mode.

4.1.2 Mode: Preoperational

To set a node to pre-operational mode, the master must send the following message:

FC	NN	Command	Index	Subindex	S-/P-Data	Description
0000 b	0 d	80 h	NN			NMT-PreOp, NN

NN: node number

4.1.3 Mode: Start - Operational

To put one or all nodes in the operational state, the master have to sends the following message:

FC	NN	Command	Index	Subindex	S-/P-Data	Description
0000 b	0 d	01 h	00			NMT-Start, all nodes
0000 b	0 d	01 h	NN			NMT-Start, NN

NN: node number

It is possible to set all nodes (Index 0) or a single node (Index NN) to operational mode.

4.1.4 Mode: Stop - Operational

To put one or all nodes in the operational state, the master have to sends the following message:

FC	NN	Command	Index	Subindex	S-/P-Data	Description
0000 b	0 d	02 h	00			NMT-Stop, all nodes
0000 b	0 d	02 h	NN			NMT-Stop, NN

NN: node number

It is possible to set all nodes (Index 0) or a single node (Index NN) to operational mode.

4.1.2 Reinitialization of the Absolute Rotary Encoder

If a node is not operating correctly, it is advisable to carry out a reinitialization:

FC	NN	Command	Index	Subindex	S-/P-Data	Description
0000 b	0 d	82 h	00			NMT-Start, all nodes
0000 b	0 d	81 h	NN			NMT-Start, NN

NN: node number

After reinitialization, the inclinometer accesses the bus in pre-operational mode.

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4.2 Normal Operating

Polled Mode	By a remote-transmission-request telegram the connected host calls for the current process value. The inclinometer reads the current position value, calculates eventually set-parameters and sends back the obtained process value by the same identifier.
Cyclic Mode	The inclinometer transmits cyclically - without being called by the host - the current process value. The cycle time can be programmed in milliseconds for values between 1 ms and 65536 ms.
Sync Mode	After receiving a sync telegram by the host, the inclinometer answers with the current process value. If more than one node number (encoder) shall answer after receiving a sync telegram, the answer telegrams of the nodes will be received by the host in order of their node numbers. The programming of an offset-time is not necessary. If a node should not answer after each sync telegram on the CAN network, the parameter sync counter can be programmed to skip a certain number of sync telegrams before answering again.

4.3 Storing Parameter

4.3.1 List of storable Parameter

Resolution per 1°	The parameter resolution per 1 degree is used to program the desired number of steps per revolution. The values 1, 10, 100 and 1000 can be programmed.
Preset Value	The preset value is the desired position value, which should be reached at a certain physical position of the axis. The position value is set to the desired process value by the parameter pre-set.
Baudrate	The Baudrate can be programmed via SDO, **default 20Kbaud** or have to be set by hardware switches.
Node Number	The setting of the node number is achieved via SDO-Object. Possible (valid) addresses lie between 0 and 89 whereby every address can only be used once. The CANopen inclinometer adds internal 1 to the adjusted device address. **Defauld 20Hex = Node Number 32**

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5. Programmable Parameter

Objects are based on the CiA 410 DS V1.2: CANopen profile for inclinometer (www.can-cia.org)

Command	Function	Telegram	Description
22h	Domain Download	Request	Parameter to inclinometer
60h	Domain Download	Confirmation	Parameter received
40h	Domain Upload	Request	Parameter request
43h, 4Bh, 4Fh (*)	Domain Upload	Reply	Parameter to Master
80 h	Warning	Reply	Transmission error

Tabelle 1 Command description

(*)The value of the command byte depends on the data length of the called parameter:

Command	Data length	Data length
43h	4 Byte	Unsigned 32
4Bh	2 Byte	Unsigned 16
4Fh	1 Byte	Unsigned 8

Tabelle 2 Data length against command byte

5.1 Object Table

Type				
Device Typ				**r**
device_type	0x1000	-		
Device Name				**r**
device_name	0x1008	-		

Version				
Hardware Version				**r**
hardware_version	0x1009	-		
Software Version				**r**
software_version	0x100A	-		

EEProm Command				
Store Parameter				**w**
store_parameters	0x1010	1	code to save parameter: 73 61 76 65	
Restore Parameters				**w**
restore_parameters	0x1011	1	code to restore parameter: 6C 6F 61 64	

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Node Guarding			
Heartbeat			**r/w**
con_heartbeat_time	0x1016	1	
pro_heartbeat_time	0x1017	-	
Node Guarding			**r/w**
guard_time	0x100C	-	
life_time_factor	0x100D	-	

PDO 1, 2 und 3			
Operating Mode COS, Cyclic (Subindex 2)			**r/w**
transmit_PDO_1_communi_PAR	0x1800	2	
transmit_PDO_1_communi_PAR	0x1801	2	
transmit_PDO_1_communi_PAR	0x1802	2	not supported
Operating Mode Cyclic, CyclicTime (Subindex 5)			**r/w**
transmit_PDO_1_communi_PAR	0x1800	5	
transmit_PDO_1_communi_PAR	0x1801	5	
transmit_PDO_1_communi_PAR	0x1802	5	not supported

CANopen Inclinometer DS-410			
Resolution			**r/w**
resolution	0x1800	-	possible HEX values: 1, A, 64, 3e8 *(see bellow)
Actual Position Value (X, Y)			**r**
slope_long32	0x6010	-	
slope_lateral32	0x6020	-	
Operating Parameter (X, Y)			**r/w**
slope_long32_operat_parameter	0x6011	-	possible values 0 or 1
slope_LAT32_operat_parameter	0x6021	-	possible values 0 or 1
Preset value (X, Y)			**r/w**
slope_long32_preset_value	0x6012	-	
slope_lateral32_preset_value	0x6022	-	
Offset (X, Y)			**r**
slope_long32_offset	0x6013	-	
slope_lateral32_offset	0x6023	-	

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Customer specific objects			
Cyclic Time (r/w)			**r/w**
CYCLIC_TIME	0x2200	-	
Store Parameter (w)			**w**
flash_programming	0x2300	-	Code: 55 aa aa 55
Preset value (X, Y)			**r/w**
preset_X_achse	0x2600	-	set value to 0
preset_Y_achse	0x2601	-	set value to 0
Node Number			**r/w**
node number	0x3000	-	set value to needed node number
hardware switch	-	-	AT HIGH END INCLINOMETER
Baudrate (r/w)			**r/w**
baudrate	0x3001	-	set value to needed baudrate
hardware switch	-	-	AT HIGH END INCLINOMETER (see page 11)

Filter			
Average Filter			**r/w**
calculate average value	0x3005	-	filter can set between 0 … 100 values 0 values = 50ms - settling time 100 values = 760ms - settling time
Butterworth Filter			**r/w**
Butterworth Filter at 5Hz to cut all values above 5Hz	0x3021	-	0 = OFF; 1 = ON settling time will increase up to 1600ms at a angle jump of 40 degrees

* Resolution Values	
1h	0,001°
Ah	0,01°
64h	0,1°
3E8h	1°

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5.2 Programming exsample: Preset and Average Value

If a CANopen device is connected and configured by the turning switches with the right baudrate and also configuratet to a unused node number, it will stard up into the preoperational mode and send a bootup massage to the master. The RUN LED of the device is now blinking.

5.2.1 Set Preset Value for X- and Y- Axes

Master to Inclinometer with Node Number 1

X-Axes

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN 1		Download	2600h			Byte 4	Byte 5	Byte 6	Byte 7
601	8	22	00	26	00	00	00	00	00

Y-Axes

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN 1		Download	2601h			Byte 4	Byte 5	Byte 6	Byte 7
601	8	22	01	26	00	00	00	00	00

Save Preset Values

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN 1		Download	1010h			Byte 4	Byte 5	Byte 6	Byte 7
601	8	22	10	10	01	73	61	76	65

5.2.2 Set Average Value

Master to Inclinometer with Node Number 1

The average value can be set between 0…100. If you want to use 50 values for calculating the average, the filter have to be set to 58 dec ➔ 3A hex

Average

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN 1		Download	3005h			Byte 4	Byte 5	Byte 6	Byte 7
601	8	22	05	30	00	**3A**	00	00	00

Save Preset Values

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN 1		Download	1010h			Byte 4	Byte 5	Byte 6	Byte 7
601	8	22	10	10	01	73	61	76	65

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6. Diagnosis

6.1 LED Diagnosis

6.1.1 States

The RUN LED indicator states are specified in the following Table

RUN State	Status	Description	Category
OFF	INIT	The device is in state INIT	Mandatory
Blinking	PRE-OPERATIONAL	The device is in state PRE-OPERATIONAL	Mandatory
Single flash	STOPPED	The device is in STOPPED	Mandatory
ON	OPERATIONAL	The device is in state OPERATIONAL	Mandatory

6.1.2 ERR Indicators

The ERR LED indicator show errors such as watchdog timeouts and unsolicited state changes. The color is red. If at a given time several errors are present, the error represented by the highest indicator activity shall be signaled.

ERR State	Status	Description	Category
OFF	No error	The CANopen communication is working	Mandatory
Blinking	Invalid Configuration	General Configuration Error	Mandatory
Single flash	Warning limit reached	Error counter has reached the warning level	Mandatory
Double flash	Error control event	A guard or heartbeat event has occurred	Mandatory
ON	PDI Watchdog	A PDI Watchdog timeout has occurred	Optional

6.2 Troubleshouting Guide

6.2.1 Power on – Inclinometer doesn't respond

Problem:

The bus is active but the installed inclinometer transmitted the false node number.

Possible solution:

- modus pre-operational
- adressing the inclinometer via SDO
- reset or power off
- power on

6.2.2 Malfunction of the position value during transmission

Problem:

During the transmission of the position value occasional malfunctions occur. The CAN bus can be temporabily in the bus off state also

Possible solution:

Check, if the last bus nodes have switched on the terminal resistor. If the last bus node is an inclinometer the terminal resistor is to activate.

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6.2.3 Too much ERROR-Frames

Problem:
The bus load is too high in case of too much error frames.

Possible solution:
Check if all bus node has the same baudrate. If one node has another baudrate error frames are produced automatically. The setting of the baudrate is descripted in this manual under 4.6.

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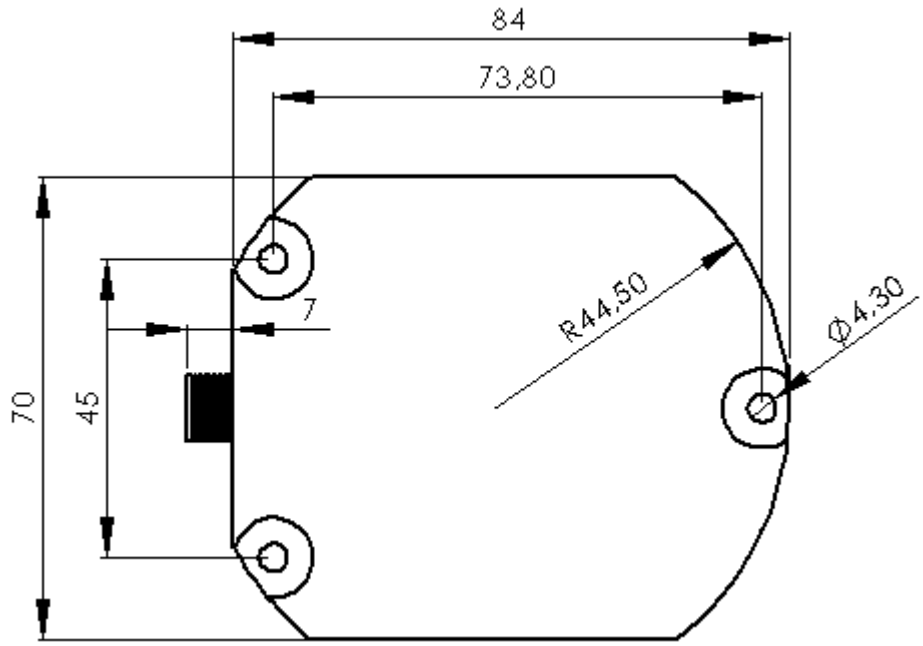
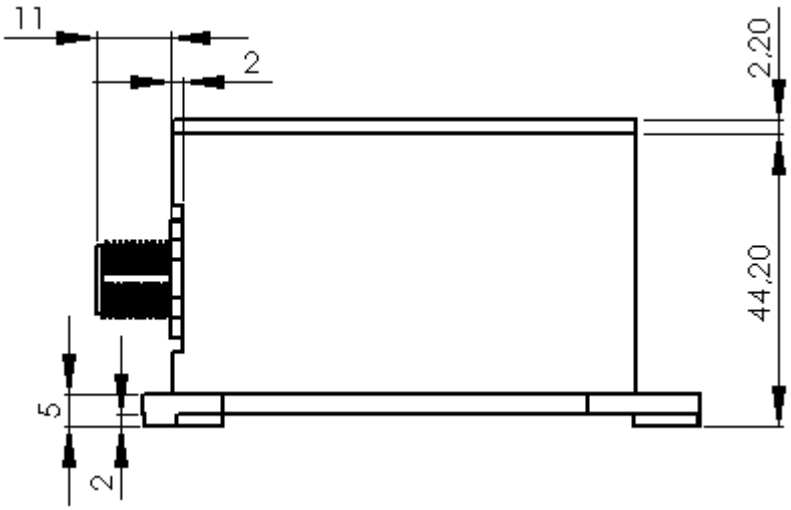
7 Mechanical Drawings

7.1 Horizontal Housing

7.1.1 Bottom View



7.1.2 Side View



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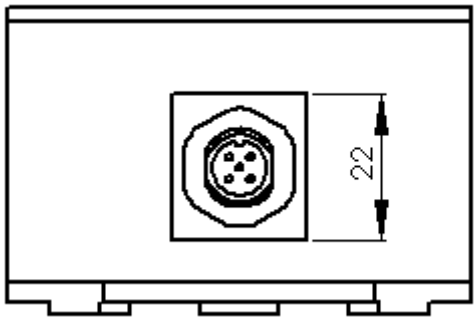
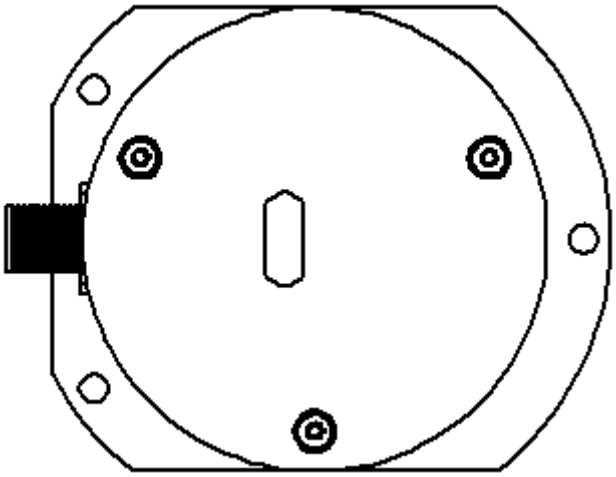
7.1.3 Front View



7.1.4 Top View



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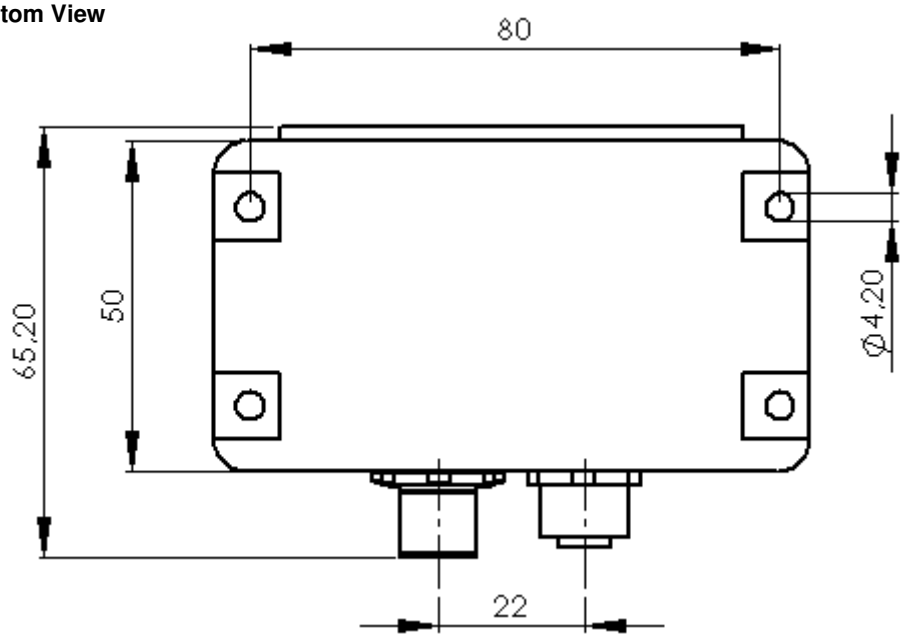
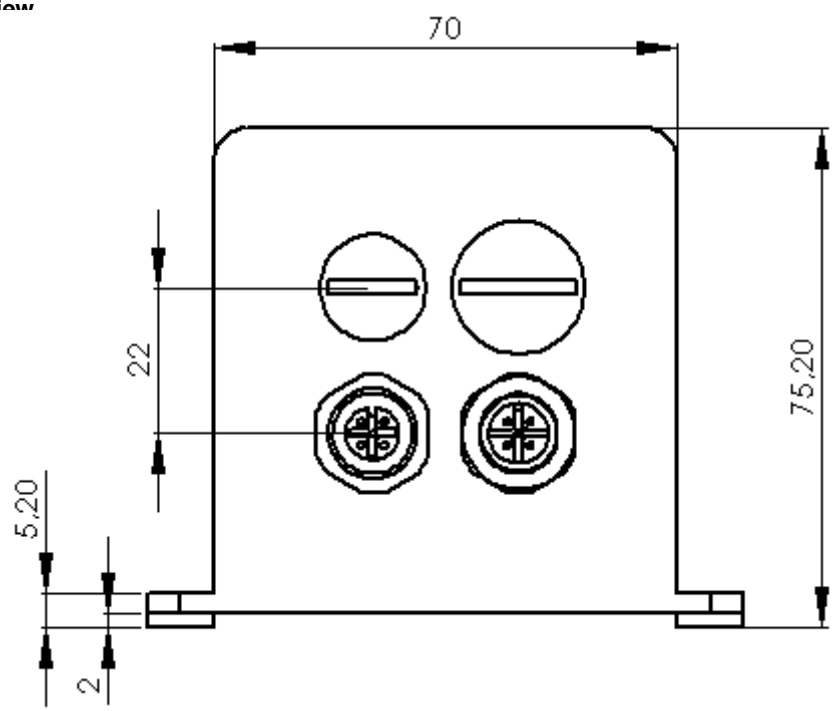
7.2 Vertical Housing

7.2.1 Bottom View



7.2.2 Side View



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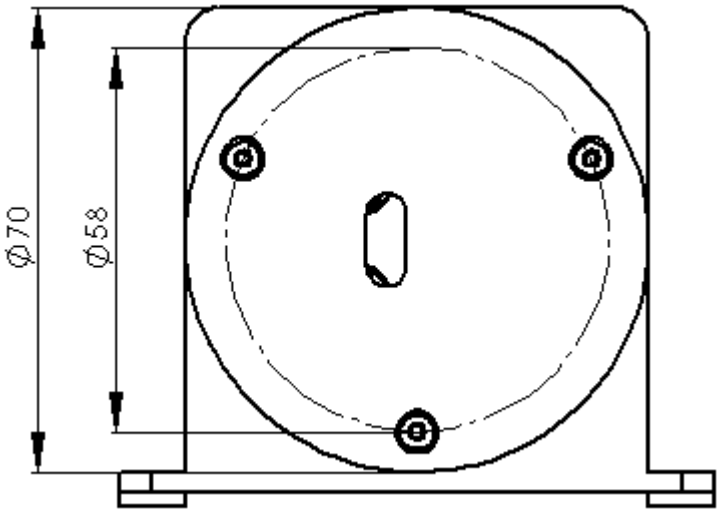
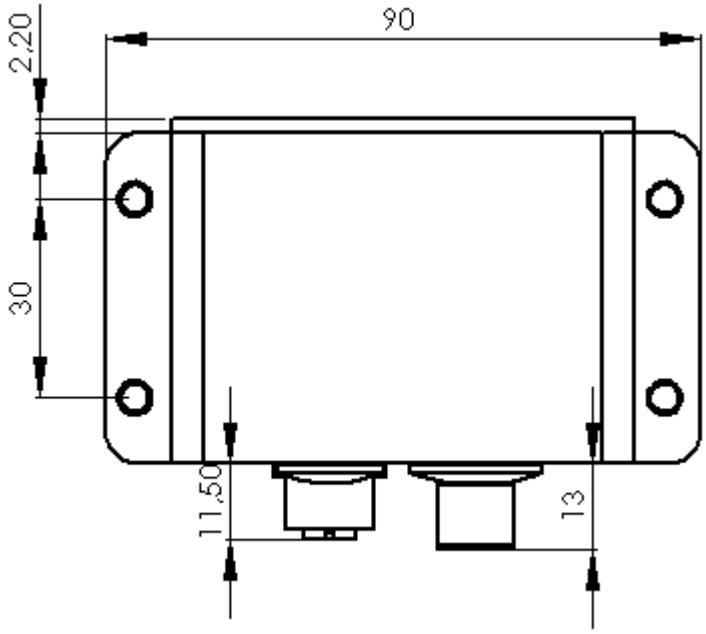
7.2.3 Front View



7.2.4 Top View



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Appendix A: Ordering Code

Description	**Type Key**								
Accelens	**ACS-**	_ _ _ -	_	_ _	_ _	_	_ -	_ -	_ _
Measuring Range		080							
		360							
Number of Axes			1						
			2						
Interface	CANopen			CA					
Version					00				
Mounting (Housing)	Horizontal					H			
	Vertical					V			
Material Housing	Aluminum						A		
Model	Basic							B	
	Advanced							A	
	High End							H	
	Customer Specific							C	
Connection	Cable Exit 1m								CW
	1x 5 pin. M12 Male Connector								P5
	1x 5 pin. M12 Male Connector + 1x 5 pin. M12 Female Connector								TM

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Glossary

A

Address	Number, assigned to each node, irrespective of whether it is a master or slave. The inclinometer address (non-volatile) is configured in the base with rotary switches.
APV	Absolute Position Value.

B

Baud rate	Transmission speed formulated in number of bits per second. Bus node Device that can send and/or receive or amplify data by means of the bus.
Byte	8-bit unit of data = 1 byte.

C

CAL	CAN application layer.
CAN	Controller Area Network or CAN multiplexing network.
CANopen	Application layer of an industrial network based on the CAN bus.
CCW	Counter-clockwise
CiA	CAN In Automation, organization of manufacturers and users of devices that operate on the CAN bus.
COB	Elementary communication object on the CAN network. All data is transferred using a COB.
COB-ID	COB-Identifier. Identifies an object in a network. The ID determines the transmission priority of this object. The COB-ID consists of a function code and a node number.
CW	Clockwise

E

EDS file	Standardized file containing the description of the parameters and the communication methods of the associated device.

F

FAQ	Frequently Asked Questions
FC Function code.	Determines the type of message sent via the CAN network.

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L

Line terminator	Resistor terminating the main segments of the bus.
LMT	Network management object. This is used to configure the parameters of each layer in the CAN. Master "Active" device within the network, that can send data without having received a request. It controls data exchange and communication management.

N

NMT	Network management object. This is responsible for managing the execution, configuration and errors in a CAN network.
NN	Node number

P

PCV	Process Value
PDO	Communication object, with a high priority for sending process data.
PV	Preset Value: Configuration value

R

RO	Read Only: Parameter that is only accessible in read mode.
ROMAP	Read Only MAPable: Parameter that can be polled by the PDO.
RW	Read/Write: Parameter that can be accessed in read or write mode.

S

SDO	Communication object, with a low priority for messaging (configuration, error handling, diagnostics). Slave Bus node that sends data at the request of the master. The inclinometers are always slaves.

W

WO	Write Only: Parameter that is only accessible in write mode.

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