

Inclinometers

For static applications 1- and 2-axis measurement	IN48	Fieldbus
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Compact. Precise. Versatile.

The IN48 series of inclinometers can reliably detect 2-axis inclinations in a measuring range of $\pm 85^\circ$ or 1-axis inclinations up to 360° . Thanks to their compact housing and high protection rating of up to IP68/IP69K, they are also suitable for use in demanding environments. Optionally selectable measuring ranges and integrated filter functions for different fieldbus systems enable flexible adaptation to different applications.



Features and benefits

- **For different fieldbus systems**
Variants for CANopen, SAEJ1939, or Modbus
- **Individual settings via the fieldbus interface**
 - Define preset (zero point / center position)
 - Setting the sensor filter
 - Reset to factory settings
- **For applications with limited installation space**
 - Economically viable solution with small size
- **Easy commissioning and diagnostics**
 - LED display for a quick overview of the operating status
- **For use in harsh environmental conditions**
 - IP68/IP69k protection rating for use in demanding environments
 - Protection against salt spray and rapid temperature changes

Order code 1-axis

8.IN48	. 1	7	X	1	. 1	X	X
Type		a	b		c	d	

- a** Measuring range
7 = 0 ... 360° ($\pm 180^\circ$)
- b** Interface
2 = CANopen
3 = SAE J1939
6 = Modbus RTU
- c** Supply voltage
1 = 7.5 ... 30 V DC
2 = 5 V DC
- d** Type of connection
2 = M12 connector, 5-pin
4 = cable 5-core, 1 m
B = cable 5-core, special lengths



Order code 2-axis

8.IN48	. 2	6	X	1	. 1	X	X
Type		a	b		c	d	

- a** Measuring range
6 = $\pm 85^\circ$
- b** Interface
2 = CANopen
3 = SAE J1939
6 = Modbus RTU
- c** Supply voltage
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Cables and connectors			Order no.
Preassembled cables	M12 female connector with coupling nut, 5-pin, A coded, straight single ended 5 m [16.40'] PVC cable		05.00.6091.A211.005M
	M12 female connector with coupling nut, 5-pin, A coded, straight single ended 2 m [6.56'] PUR cable		05.00.60F1.2211.002M
Connectors	M12 female connector with coupling nut, 5-pin, A coded, straight (metal/plastic)		05.B-8151-0/9

Further Kübler accessories can be found at: kuebler.com/accessories

Further Kübler cables and connectors can be found at: kuebler.com/connection-technology

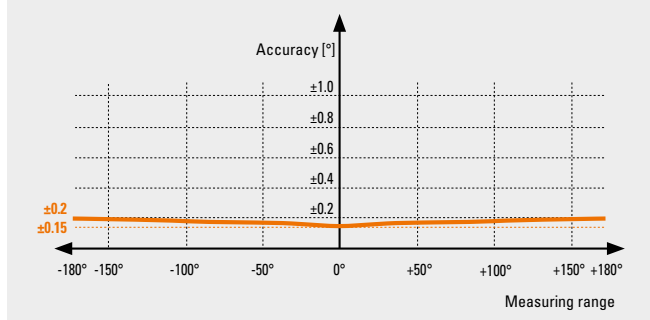
Inclinometers

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1- and 2-axis measurement** **IN48** **Fieldbus**

Technical data

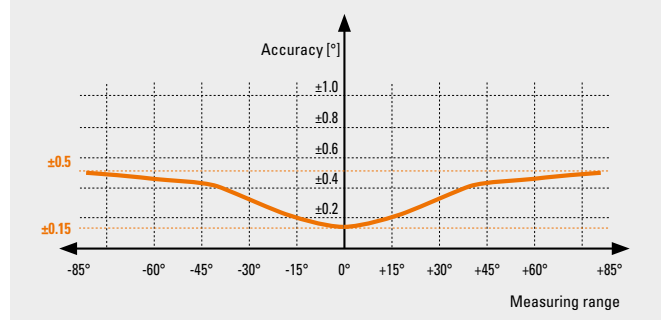
General data 1-axis measurement

Measuring range	0 ... 360°
Resolution	0.01°
Repeat accuracy	±0.2°
Linearity	±0.1°
Temperature coefficient	typ. ±0.006°/K
Accuracy (at 25°C)	±0.15 ... ±0.2° depending on the measuring range



General data 2-axis measurement

Measuring range	-85 ... +85°
Resolution	0.01°
Repeat accuracy	±0.2°
Linearity	±0.3°
Temperature coefficient	typ. ±0.006°/K
Accuracy (at 25°C)	±0.15° ... ±0.5° depending on the measuring range



General electrical characteristics

Supply voltage	7.5 ... 30 V DC 5 V DC
Current consumption (no load)	max. 40 mA
Reverse polarity protection of the supply voltage	yes
Sampling rate	50 Hz (20 ms)
Limit frequency with Butterworth filter factory setting	0.1 ... 10 Hz, 8. Ordnung typ. 10 Hz

Mechanical characteristics

Electrical connection	M12 connector, 5-pin cable, 5-core
Weight	approx. 60 g [2.1 oz]
Protection acc. to EN 60529	IP68/IP69k
Working temperature range	-40 °C ... +85 °C [-40 °F ... +185 °F]
Material housing	Kunststoff, PC
Shock resistance acc. to EN 60068-2-27	1000 m/s ² , 6 ms
Vibration resistance acc. to EN 60068-2-6	100 m/s ² , 10 ... 2000 Hz
Dimensions	44.5 x 42.5 x 20 mm [1.75 x 1.67 x 0.79"]

EMC

Relevant standards	EN 61326-1	Electrical equipment for measurement, control and laboratory use
	EN 61000-6-2	Immunity for industrial environments
	EN 55011 Klasse B, EN 61000-6-3	Emitted interferences for residential environments
	EN ISO 14982	Agricultural and forestry machinery, electromagnetic compatibility, test methods and acceptance criteria
	EN 13309:2010-07	Construction machinery - Electromagnetic compatibility of machines with internal supply voltage

Approvals

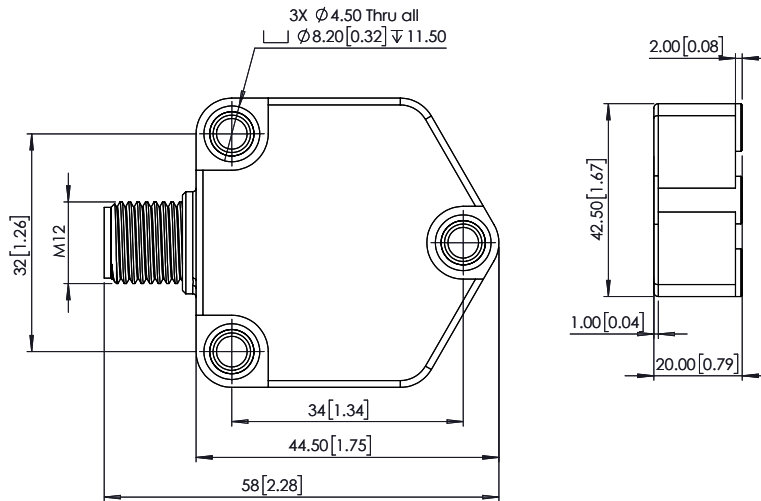
CE compliant in accordance with		
	EMC Directive	2014/30/EU
	RoHS Directive	2011/65/EU

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Dimensions

Dimensions in mm [inch]



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Interface characteristics CANopen

General information on CANopen

The CANopen inclinometers support the latest CANopen communications profile according to DS301. In addition, device-specific profiles such as the inclinometer profile DS410 and DS305 (LSS) are available.

The following operating modes may be selected: Polled Mode, Cyclic Mode, Sync Mode. Moreover, scale factors, preset values and many other additional parameters can be programmed via the CAN bus. When switching the appliance on, all parameters are loaded from a flash memory. These parameters have previously been stored in a zero-voltage secure manner. The output values **position, position raw value, sensor temperature and sensor information** can be combined very variably as a PDO (PDO mapping). The inclinometers are available with one or two connectors.

The device address and baud rate can be set/modified by means of the software.

The two-color LED indicates the operating or fault status of the CAN bus, as well as the status of the internal diagnostics.

LSS layer setting services DS305 V2.2

- Global command support for node address and baud rate configuration.
- Selective protocol via identity object (1018h).

CANopen communication profile DS301 V4.2

Among others, the following functionality is integrated (Class C2 functionality):

- NMT slave.
- Heartbeat protocol.
- Identity object.
- Error behavior object.
- Variable PDO mapping, 2 sending PDO's.
- Node address, baud rate and programmable CANbus termination.

Characteristics CANopen

Interface	CAN high-speed acc. to ISO 11898, Basic- and Full-CAN, CAN specification 2.0 B	
Protocol	CANopen profile DS410 V1.3 with manufacturer-specific add-ons, communication profile DS301 V4.2	
Baud rate	software configurable default	10 kbit/s, 20 kbit/s, 50 kbit/s, 125 kbit/s, 250 kbit/s, 500 kbit/s, 800 kbit/s, 1 Mbit/s 250 kbit/s
Node address	software configurable default	1... 127 62
Termination	software configurable default	0 = OFF, 1 = ON 1 = ON
LSS protocol	DS305 layer setting services 2.2	

CANopen Inclinometer profile DS410 V1.3

The following parameters can be programmed:

- Variable PDO mapping of position, position raw value, sensor temperature and sensor information.
- Extended failure management.
- User interface with visual display of bus and failure status - 1 LED two-color.
- Customer-specific protocol.
- "Watchdog controlled" device.

Terminal assignment

Interface	Type of connection	1 x M12 connector, 5-pin					
2	2	Bus IN					
		Signal:	+V	0 V	CAN_GND	CAN_H	
		Pin:	2	3	1	4	5

Interface	Type of connection	Cable						
2	4, B	Bus IN						
		Signal:	+V	0 V	CAN_GND	CAN_H	CAN_L	
		Core color:	BN	WH	GY	GN	BU	

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1- and 2-axis measurement**

IN48

Fieldbus / CANopen

Interface characteristics CANopen

CANopen object dictionary

Index (hex)	Sub Index	Data type	Name	Default value
1005h	0	U32	COB-ID Sync	80h
1014h	0	U32	COB-ID Emcy	BEh
1017h	0	U32	Producer heartbeat time	0
	1	U8	Communication Error	0
	2	U8	Sync Error	0
	3	U8	Internal Device Error	0
1800h			TPDO1 Communication Parameter	
	1	U32	COB-ID	1BEh
	2	U8	Transmission Type	255
	5	U16	Event timer	0 [step 1 ms]
1801h			TPDO2 Communication Parameter	
	1	U32	COB-ID	2BEh
	2	U8	Transmission Type	1
	5	U16	Event timer	0 [step 1 ms]
Mapping at 2-dimensional				
1A00h			TPDO1 Mapping	
	0	U8	Number of Entries	3
	1	U32	1.Mapped Object	0x60100010
	2	U32	2.Mapped Object	0x60200010
	3	U32	3.Mapped Object	0x50000010
	4	U32	4.Mapped Object	0
1A01h			TPDO2 Mapping	
	0	U8	Number of Entries	3
	1	U32	1.Mapped Object	0x60100010
	2	U32	2.Mapped Object	0x60200010
	3	U32	3.Mapped Object	0x50000010
	4	U32	4.Mapped Object	0
Mapping at 1-dimensional				
1A00h			TPDO1 Mapping	
	0	U8	Number of Entries	2
	1	U32	1.Mapped Object	0x60100010
	2	U32	2.Mapped Object	0x50000010
	3	U32	3.Mapped Object	0
	4	U32	4.Mapped Object	0
1A01h			TPDO2 Mapping	
	0	U8	Number of Entries	2
	1	U32	1.Mapped Object	0x60100010
	2	U32	2.Mapped Object	0x50000010
	3	U32	3.Mapped Object	0
	4	U32	4.Mapped Object	0

Index (hex)	Sub Index	Data type	Name	Default value
Profile DS410 Inclinometer				
6000h	0	U16	Resolution	0
6011h	0	U8	Slope long16 operating parameter	0
6012h	0	I16	Slope long16 preset value	0
6013h	0	I16	Slope long16 offset	0
6014h	0	I16	Differential Slope long16 offset	0
6021h .. 6024h only at 2-dimensional				
6021h	0	U8	Slope lateral16 operating parameter	0
6022h	0	I16	Slope lateral16 preset value	0
6023h	0	I16	Slope lateral16 offset	0
6024h	0	I16	Differential Slope lateral16 offset	0
Manufacturer specific objects				
2100h	0	U8	Baud rate	5 (250 kBit/s)
2101h	0	U8	Node Number	0x3E (62d)
2102h	0	U8	Termination	1 = ON
2105h	0	U32	Save All Bus Parameters	0x65766173
3000h	0	U16	Digital Filter Active	1 = ON
3001h	0	F32	Digital Filter Coefficient	10.0

Uxx = UNSIGNED
 lxx = SIGNED
 Fxx = FLOAT
 Name = Name of the object

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Interface characteristics SAE J1939

General information concerning SAE J1939

The protocol J1939 originates from the international Society of Automotive Engineers (SAE) and operates on the physical layer with high speed CAN as per ISO11898. The application emphasis lies in the area of the power train and chassis of commercial vehicles. It serves to transfer diagnostic data (for example, motor speed, position, temperature) and control information. The inclinometers IN88 support the total functionality of J1939.

This protocol is a multimaster system with decentralized network management that does not involve channel-based communication.

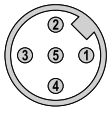
It supports up to 254 logic nodes and 30 physical control devices per segment. The information is described as parameters (signals) and combined on 4 memory pages (data pages) into parameter groups (PGs). Each parameter group can be identified via a unique number, the parameter group number (PGN). Independently of this, each signal is assigned a unique SPN (suspect parameter number).

The major part of the communication occurs cyclically and can be received by all control devices without the explicit request for data (Broadcast). Furthermore the parameter groups are optimized to a length of 8 data bytes. This enables very efficient utilization of the CAN protocol. If greater amounts of data need to be transferred, then transport protocols (TP) can be used: BAM (broadcast announce message) and CMDT (connection mode data transfer). With BAM TP the transfer of data occurs as a broadcast.

- Inclinometer implementation SAE J1939**
- PGNs that are adaptable to the customer's application.
 - Resolution of address conflicts -> Address Claiming (ACL).
 - Continuous checking whether control addresses have been assigned twice within a network.
 - Change of control device addresses during run-time.
 - Unique identification of a control device with the help of a name that is unique worldwide. This name serves to identify the functionality of a control device in the network.
 - Predefined PGs for position, speed and alarm.
 - 250 kbit/s, 29 bit identifier.
 - Watchdog controlled device.
- A two-color LED signals the operating and fault status of the SAE J1939 protocol, as well as the status of the internal diagnostics.

Characteristics SAE J1939	
Interface	CAN high-speed acc. to ISO 11898, CAN specification 2.0 B
Baud rate	250 kbit/s, switchable by software to 500 kbit/s
Node address	software configurable
Termination switchable	software configurable

Terminal assignment

Interface	Type of connection	1 x M12 connector, 5-pin						
3	2	Bus IN						
		Signal:	+V	0 V	CAN_GND	CAN_H		CAN_L
		Pin:	2	3	1	4		5
Interface	Type of connection	Cable						
3	4, B	Bus IN						
		Signal:	+V	0 V	CAN_GND	CAN_H		CAN_L
		Core color:	BN	WH	GY	GN		BU

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Interface characteristics SAE J1939

Configuration data signals PG				
Configuration data	Data length in byte	Hex value	Hex value in decimal	Endian hex value
INCLIN_CFG_Resolution	2	0x0064	100	0x6400
INCLIN_CFG_LongOperatingPar	1	0x02	2	0x02
INCLIN_CFG_SlopeLongPreset_Activate	1	0x01	1	0x01
INCLIN_CFG_SlopeLongPresetValue	2	0x0000	0	0x0000
INCLIN_CFG_LatOperatingPar	1	0x02	2	0x02
INCLIN_CFG_SlopeLatPreset_Activate	1	0x01	1	0x01
INCLIN_CFG_SlopeLatPresetValue	2	0x0000	0	0x0000
INCLIN_CFG_TxCycleTime	2	0x0032	50	0x3200
INCLIN_CFG_NodeID	1	0x20	32	0x20
INCLIN_CFG_BitRate	1	0x00	0	0x00
INCLIN_CFG_CAN_Termination	1	0x01	1	0x01
INCLIN_CFG_FilterConfig	1	0x06	6	0x06

Inclinometers

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Interface characteristics Modbus

General information on Modbus

Modbus communication profile V 1.02
Node number, baud rate and bus termination programmable.

Modbus application protocol V1.1b3

Characteristics Modbus	
Interface	Modbus V1.02
Protocol	Modbus RTU V1.1b3
Baud rate	4800 ... 115200 kbit/s, software configurable
Node address	1 ... 63, software configurable
Termination	software configurable

Read Holding Register – Function code 03 ¹⁾				
Reg.	Data name	ATT	Value	Default
00001	ANGLE OF INCL. X-AXIS	I16	Inclination angle in 0.01 °	-85.00 ... +85.00
00002	ANGLE OF INCL. Y-AXIS	I16	Rotation angle in 0.01 °	-85.00 ... +85.00
00003	EULER ANGLE X-AXIS	I16	Euler angle (1 axis)	0 ... 180.99°
00004	EULER ANGLE Y-AXIS	U16	Euler angle (1 axis)	0 ... 359.99°
00007	SUPPLY VCC	U16	VCC in 0.1 VDC	240
00008	TEMPERATURE IN 0.1°C	U16	Temp. in 0.1°	210
00016	SIDEVIEW	U16	Back = 0, Front = 1	0
00023	SYSTEM STATE	U16	No errors = 0	0
00140	BAUD RATE	U16	Current baud rate	19200 Baud (2)
00144	NODE-ID	U16	Current node address	63
00145	TERMINATION	U16	Termination on/off	2 (on)
00146	FILTER ACTIVATION	U16	Filter on/off	1 (on)
00147	FILTER SETTING	F32	Filter value in HZ	5.0
00148	SERIAL NUMBER	U32	Serial number	YYDDNNNNN
00149	PRODUCT CODE	U32	Device type	x88616100
00150	RESOLUTION	U16	Resolution X/Y axis	0.01° (10)
00151	OPERATING PARAMETER	U16	Setting X axis	0
00152	PRESET X-AXIS	U16	Preset X axis	0
00153	OFFSET X-AXIS	U16	Offset X axis	0
00154	DIFF.OFFSET X-AXIS	U16	Differential offset	0
00155	Operating Parameter	U16	Setting Y axis	0
00156	PRESET Y-AXIS	U16	Preset Y axis	0
00157	OFFSET Y-AXIS	U16	Offset Y axis	0
00158	DIFF.OFFSET Y-AXIS	U16	Differential offset	0
00159	OFFSET EULER ANGLE	U16	Offset Euler axis Y	0

Write Holding Register – Function code 16 (0x10)					
Reg.	Value	R/W	Format	Content	Default
300	VAR	W	U16	Baud rate	19200 Baud (2)
301	VAR	W	U16	Parity	1 = none
302	VAR	W	U16	Stoppbit	1 = 1 Stoppbit
304	VAR	W	U16	Node Number	0x3E (62d)
305	VAR	W	U16	Termination	2 = ON
306	VAR	W	U16	Digital Filter Active	1 = ON
307	VAR	W	F32	Digital Filter Coefficient	5.0
310	VAR	W	U16	Resolution of axis	10
311	VAR	W	U16	Slope long16 operating parameter	0
312	VAR	W	I16	Slope long16 preset value	0
313	VAR	W	I16	Slope long16 offset	0
314	VAR	W	I16	Differential Slope long16 offset	0
315	VAR	W	U16	Slope lateral16 operating parameter	0
316	VAR	W	I16	Slope lateral16 preset value	0
317	VAR	W	I16	Slope lateral16 offset	0
318	VAR	W	I16	Differential Slope lateral16 offset	0
320	VAR	W	U16	Preset Euler axis (only 0)	0
261	VAR	W	U16	Delaytime for Transmission	1
360	VAR	W	U16	Save All Application Parameters	0x1010
361	VAR	W	U16	Load All Parameters (Factory default)	0x10101

Terminal assignment

Interface	Type of connection	1 x M12 connector, 5-pin						
6	2	Bus IN						
		Signal:	+V	0 V	D0	D1		TG
		Pin:	2	3	5	4		1
Interface	Type of connection	Cable						
6	4, B	Bus IN						
		Signal:	+V	0 V	D0	D1		TG
		Core color:	GY	WH	BU	GN		BN

1) Reads the binary contents of holding registers (4XXX references) in the encoder slave. Broadcast is not supported.

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1- and 2-axis measurement

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Fieldbus

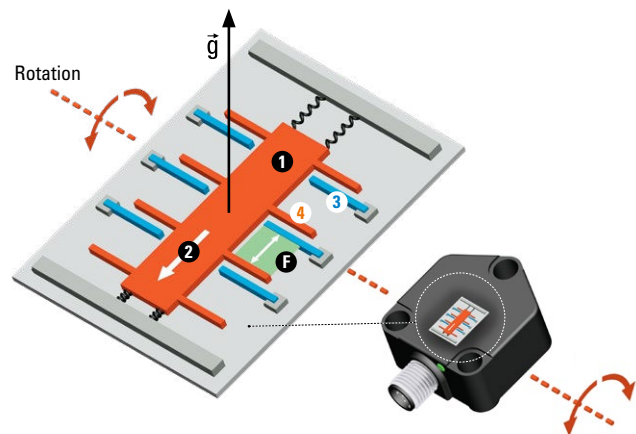
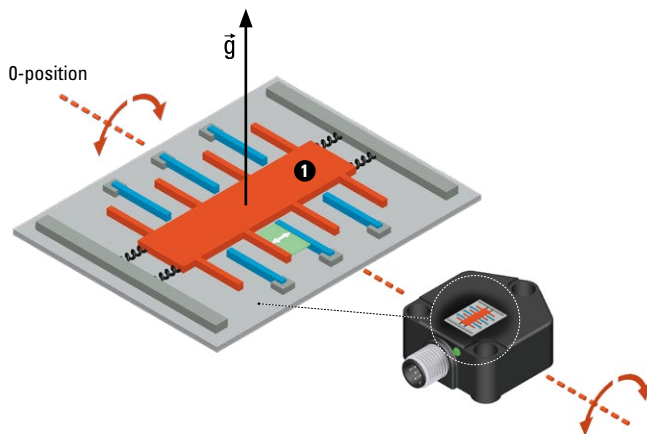
Technology in detail

Exact angular position via acceleration measurement

Acceleration measurement

In the acceleration measuring cell, the absolute angular position is determined capacitively in relation to the gravity acceleration \vec{g} .

The displacement **2** of a test mass **1** changes the distance and therefore also the capacity **F** between fixed **3** and moving **4** electrodes in the measuring cell. This measured capacity is directly related to the inclination of the sensor.



Optimization of the measurement using filter functions

The inertia of the test mass, particularly in the case of fast or rapidly changing rotations and vibrations, can lead to inaccuracies in the detected measurement data **b** compared to the actual movement **a**. To compensate for these undesirable effects, various filters **c** + **d** can be parameterized in the inclinometer.

Restrictions due to filters

However, this leads to a time delay ($\Delta t_c + \Delta t_d$) for the output of the measurement result (the more precise the desired measurement, the greater the time delay).

Further optimization with dynamic inclinometers

This time delay is not relevant for many static applications (such as solar panels, crane masts, etc.). In dynamic applications (e.g. vehicles in motion), however, this can lead to problems, as a reaction to the movement can only occur with a delay. In this case, it is advisable to use a dynamic inclinometer IN58 with intelligent sensor fusion from Kübler for further optimization of the measurement result.

