Inclinometers

For static applications 1- and 2-axis measurement	IN41	Analog

Compact. Precise. Versatile.

The IN41 series of inclinometers can reliably detect 2-axis inclinations in a measuring range of ±85° or 1-axis inclinations up to 360°. Thanks to their compact housing and high protection class of up to IP68/IP69K, they are also suitable for use in demanding environments. Optionally selectable measuring ranges, integrated filter functions, and various analog interfaces enable flexible adaptation to different applications.

Analog Output   Analog Output
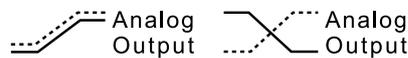
Features and benefits

- **Analog sensor for reliable inclination measurements**
  - 2-axis measurement up to ±85° or 1-axis measurement up to 360°
  - Accurate measurement performance across the entire measuring range (up to max. 0.1°)

- **For applications with limited installation space**
  - Economically viable solution with small size

- **Flexible adaptation to versatile applications**
  - Optional selectable measuring ranges and filter functions
  - Various analog interfaces

- **Easy commissioning and diagnostics**
  - LED display for a quick overview of the operating status
  - Individual "Easy-Teach" settings via teach adapter
  - Define preset (zero point/center position)
  - Scaling of the analog measuring range (start/end position)
  - Adjusting the sensor filter
  - Resetting to factory settings

- **For use in harsh environmental conditions**
  - IP68/IP69k protection rating for use in demanding environments
  - Protection against salt spray and rapid temperature changes

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Order code 1-axis

8.IN41 . 1 X X 1 . 11 X
Type   a b c   d

a *Measuring range*
7 = 0° ... 360° (±180°)
8 = 0° ... 180° (±90°)

b *Analog interface*
1 = 4 ... 20 mA
2 = 0.1 ... 4.9 V
3 = 0.5 ... 4.5 V
4 = 0 ... 5 V
5 = 0 ... 10 V

c *Filter*
1 = no filter
Preset filter functions up to 10 Hz available on request

d *Type of connection*
1 = M12 connector, 8-pin
2 = M12 connector, 5-pin
3 = cable 8-core, 1 m
4 = cable 5-core, 1 m
A = cable 8-core, special lengths
B = cable 5-core, special lengths

Order code 2-axis

8.IN41 . 2 X X 1 . 11 X
Type   a b c   d

a *Measuring range*
1 = ±10°
2 = ±15°
3 = ±30°
4 = ±45°
5 = ±60°
6 = ±85°

b *Analog interface*
1 = 4 ... 20 mA
2 = 0.1 ... 4.9 V
3 = 0.5 ... 4.5 V
4 = 0 ... 5 V
5 = 0 ... 10 V

c *Filter*
1 = no filter
Preset filter functions up to 10 Hz available on request

d *Type of connection*
1 = M12 connector, 8-pin
2 = M12 connector, 5-pin
3 = cable 8-core, 1 m
4 = cable 5-core, 1 m
A = cable 8-core, special lengths
B = cable 5-core, special lengths

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Accessories	Order no.

Teach adapter

for activating the control inputs for the following functions:
- Reset to factory setting
- Center point of the measurement
- Scaling of the analog measuring range (start/end position)
- Setting the sensor filter

Teach adapter, 5-pin — **05.TX40.1**

Teach adapter, 8-pin — **8.0010.9000.0017**

EMC shield terminal

For an EMC-compliant installation of the cable
- top-hat rail mounting
- spring steel, galvanized
- shield diameter 3.0 ... 12.0 mm

8.0000.4G06.0312

Cables and connectors	Order no.

Preassembled cables

M12 female connector with coupling nut, 5-pin, A coded, straight
single ended
2 m [6.56'] PVC cable — **05.00.6081.2211.002M**

M12 female connector with coupling nut, 5-pin, A coded, straight
DT04 connector, male contacts, 6-pin, straight
2 m [6.56'] PVC cable — **05.00.6091.22C7.002M**

M12 female connector with coupling nut, 5-pin, A coded, straight
single ended
2 m [6.56'] PUR cable — **05.00.60F1.2211.002M**

M12 female connector with coupling nut, 8-pin, A coded, straight
single ended
2 m [6.56'] PVC cable — **05.00.6041.8211.005M**

M12 female connector with coupling nut, 8-pin, A coded, straight
single ended
2 m [6.56'] PUR cable — **05.00.6051.8211.002M**

Connectors

M12 female connector with coupling nut, 8-pin, A coded, straight (metal) — **05.CMB 8181-0**

M12 female connector with coupling nut, 5-pin, A coded, straight (metal) — **8.0000.5116.0000**

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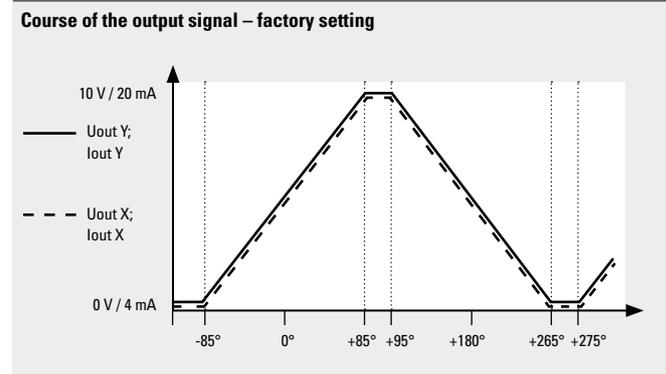
Inclinometers

For static applications 1- and 2-axis measurement	IN41	Analog

Technical data

General data 1-axis measurement

Measuring range	0 ... 360°
Resolution	
current interface	0.01° internal sensor
	12 bit D/A converter
voltage interface	12 bit 0 ... 10 V
	11 bit 0 ... 5 V / 0.1 ... 4.9 V / 0.5 ... 4.5 V
Repeat accuracy	≤ 0.2 % of the measuring range
Linearity deviation	±0.1 % of the measuring range
Temperature drift	typ. ±0.006 % / K
Accuracy (at 25°C)	±0.1 ... ±0.3°
	depending on the measuring range

Course of the output signal – factory setting
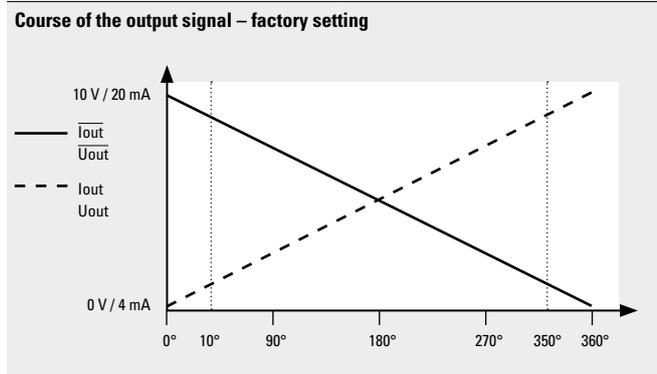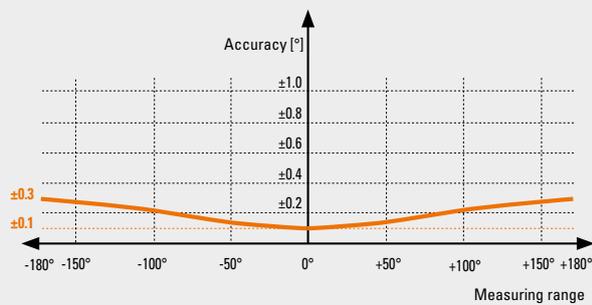
General data 2-axis measurement

Measuring range	-85° ... +85°
Resolution	
current interface	0.01° internal sensor
	12 bit D/A converter
voltage interface	12 bit 0 ... 10 V
	11 bit 0 ... 5 V / 0.1 ... 4.9 V / 0.5 ... 4.5 V
Repeat accuracy	≤ 0.2 % of the measuring range
Linearity deviation	±0.45 % of the measuring range
Temperature drift	typ. ±0.006 % / K
Accuracy (at 25°C)	±0.1 ... ±0.7°
	depending on the measuring range

Course of the output signal – factory setting
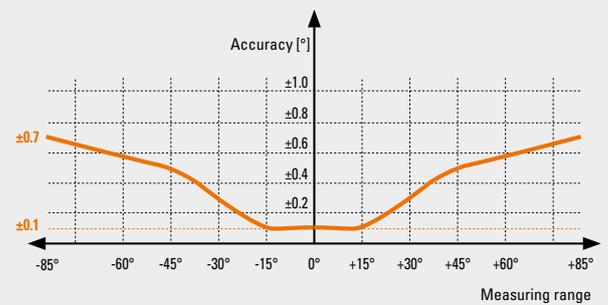
Inclinometers

For static applications
1- and 2-axis measurement

IN41 | **Analog**

Electrical characteristics current interface

Supply voltage	10 ... 30 V DC
Current consumption (no load)	max. 40 mA
Reverse polarity protection of the supply voltage	yes
PowerON Time (PowerOn until valid output value)	< 0.5 s
Output load at 10 VDC	max. 200 Ohm
at 24 VDC	max. 900 Ohm
at 30 VDC	max. 1200 Ohm
Setting time	< 1 ms (R_{load} = 900 Ohm, 25 °C)
Sampling rate	50 Hz (20 ms)
Limit frequency with Butterworth filter	0.1 ... 10 Hz, 8th order

Electrical characteristics voltage interface

Supply voltage		
4 ... 20 mA / 0.1 ... 4.9 V / 0.5 ... 5 V / 0 ... 5 V	10 ... 30 V	
0 ... 10 V	15 ... 30 V	
Current consumption (no load)	max. 40 mA	
Reverse polarity protection of the supply voltage	yes	
PowerON Time (PowerOn until valid output value)	< 0.5 s	
Output load	max. 10 mA	
Setting time	< 1 ms (R_{load} = 1000 Ohm, 25 °C)	
Sampling rate	50 Hz (20 ms)	
Limit frequency with Butterworth filter	0.1 ... 10 Hz, 8th order	

Mechanical characteristics

Electrical connection	M12 connector, 8-pin
	M12 connector, 5-pin
	cable, 8-pin
	cable, 5-pin
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	plastic, PC
Shock resistance acc. to EN 60068-2-27	100 m/s^2, 10 ... 2000 Hz
Vibration resistance acc. to EN 60068-2-6	1000 m/s^2, 6 ms
Dimensions	44.5 x 42.5 x 20 mm [1.75 x 1.67 x 0.79"]

Approvals

CE compliant in accordance with

EMV Directive	2014/30/EU
RoHS Directive	2011/65/EU

For static applications 1- and 2-axis measurement	IN41	Analog

Terminal assignment, 1 dimensional

Type of connection	M12 connector, 8-pin								
1	Signal – Interface 1 (current):	0 V	+V	Iout+	Iout-	$\overline{\text{Iout}+}$	$\overline{\text{Iout}-}$	Teach 1	Teach 2
	Signal – Interface 2, 3, 4, 5 (voltage):	0 V	+V	Uout+	Uout-	$\overline{\text{Uout}+}$	$\overline{\text{Uout}-}$	Teach 1	Teach 2
	Pin:	1	2	3	4	5	6	7	8

Type of connection	M12 connector, 5-pin					
2	Signal – Interface 1 (current):	+V	$\overline{\text{Iout}+}$	0 V	Iout+	Teach
	Signal – Interface 2, 3, 4, 5 (voltage):	+V	$\overline{\text{Uout}+}$	0 V	Uout+	Teach
	Pin:	1	2	3	4	5

Type of connection	Cable, 8-pin								
3, A	Signal – Interface 1 (current):	0 V	+V	Iout+	Iout-	$\overline{\text{Iout}+}$	$\overline{\text{Iout}-}$	Teach 1	Teach 2
	Signal – Interface 2, 3, 4, 5 (voltage):	0 V	+V	Uout+	Uout-	$\overline{\text{Uout}+}$	$\overline{\text{Uout}-}$	Teach 1	Teach 2
	Core color:	WH	BN	GN	YE	GY	PK	BU	RD

Type of connection	Cable, 5-pin					
4, B	Signal – Interface 1 (current):	+V	$\overline{\text{Iout}+}$	0 V	Iout+	Teach
	Signal – Interface 2, 3, 4, 5 (voltage):	+V	$\overline{\text{Uout}+}$	0 V	Uout+	Teach
	Core color:	BN	GY	WH	GN	BU

Terminal assignment, 2 dimensional

Type of connection	M12 connector, 8-pin								
1	Signal – Interface 1 (current):	0 V	+V	Iout+ X	Iout- X	Iout+ Y	Iout- Y	Teach 1	Teach 2
	Signal – Interface 2, 3, 4, 5 (voltage):	0 V	+V	Uout+ X	Uout- X	Uout+ Y	Uout- Y	Teach 1	Teach 2
	Pin:	1	2	3	4	5	6	7	8

Type of connection	M12 connector, 5-pin					
2	Signal – Interface 1 (current):	+V	Iout+ Y	0 V	Iout+ X	Teach
	Signal – Interface 2, 3, 4, 5 (voltage):	+V	Uout+ Y	0 V	Uout+ X	Teach
	Pin:	1	2	3	4	5

Type of connection	Cable, 8-pin								
3, A	Signal – Interface 1 (current):	0 V	+V	Iout+ X	Iout- X	Iout+ Y	Iout- Y	Teach 1	Teach 2
	Signal – Interface 2, 3, 4, 5 (voltage):	0 V	+V	Uout+ X	Uout- X	Uout+ Y	Uout- Y	Teach 1	Teach 2
	Core color:	WH	BN	GN	YE	GY	PK	BU	RD

Type of connection	Cable, 5-pin					
4, B	Signal – Interface 1 (current):	+V	Iout+ Y	0 V	Iout+ X	Teach
	Signal – Interface 2, 3, 4, 5 (voltage):	+V	Uout+ Y	0 V	Uout+ X	Teach
	Core color:	BN	GY	WH	GN	BU

+V	Supply voltage +V DC	Uout+ X	X axis voltage output	Iout+ X	X axis current output
0V	Supply voltage ground GND (0 V)	Uout- X	X axis voltage output GND	Iout- X	X axis current output GND
		Uout+ Y	Y axis voltage output	Iout+ Y	Y axis current output
Teach 1	Input 1 for various teaching functions	Uout- Y	Y axis voltage output GND	Iout- Y	Y axis current output GND
Teach 2	Input 2 for various teaching functions				

1-axis version

Uout+	Voltage output	Iout+	Current output
Uout-	Voltage output GND	Iout-	Current output GND
$\overline{\text{Uout}+}$	Inverted voltage output	$\overline{\text{Iout}+}$	Inverted current output
$\overline{\text{Uout}-}$	Inverted voltage output GND	$\overline{\text{Iout}-}$	Inverted current output GND

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Dimensions
Dimensions in mm [inch]
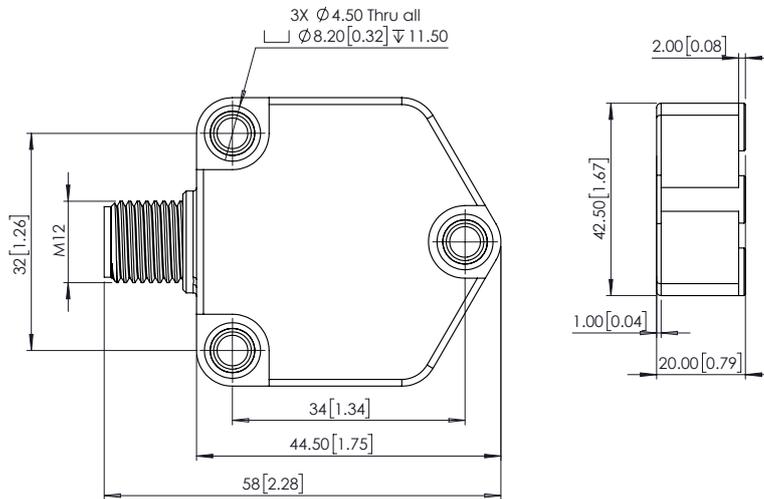
3X ⌀ 4.50 Thru all
⌀ 8.20 [0.32] ⯆ 11.50

32 [1.26]

M12

34 [1.34]

44.50 [1.75]

58 [2.28]

2.00 [0.08]

42.50 [1.67]

1.00 [0.04]

20.00 [0.79]

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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 ❷ of a test mass ❶ changes the distance and therefore also the capacity Ⓕ between fixed ③ and moving ④ electrodes in the measuring cell. This measured capacity is directly related to the inclination of the sensor.
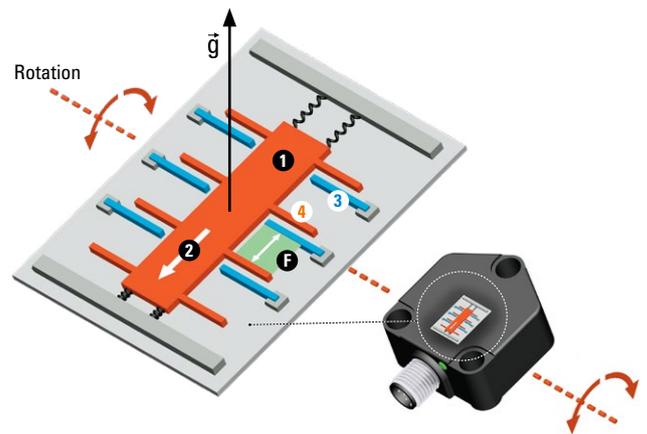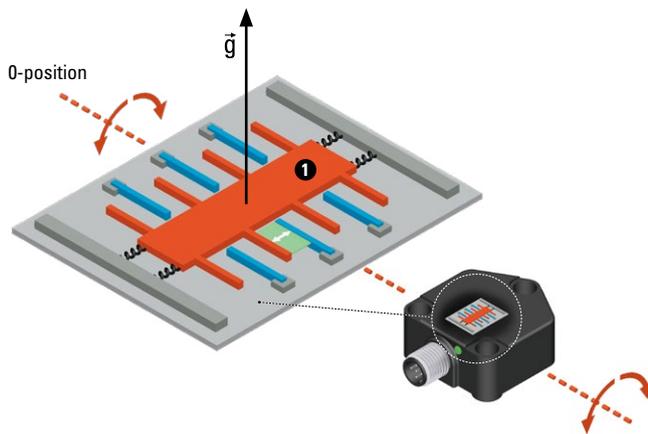
Optimization of the measurement using filter functions
The inertia of the test mass, particularly in the case of fast or rapidly changing rotations and vibrations, can lead to inaccuracies in the detected measurement data ⓑ compared to the actual movement ⓐ. To compensate for these undesirable effects, various filters ⓒ + ⓓ can be parameterized in the inclinometer.
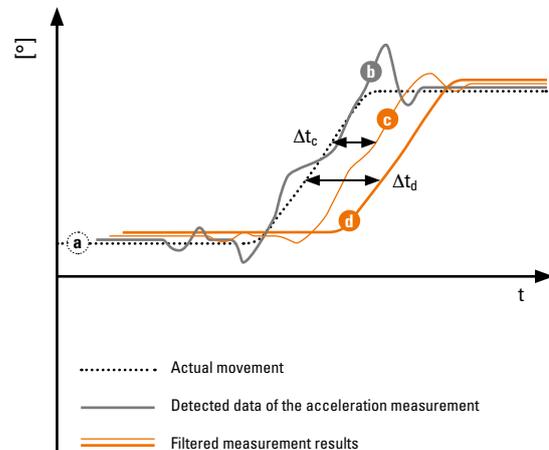
Restrictions due to filters
However, this leads to a time delay ($\Delta t_c + \Delta t_d$) for the output of the measurement result (the more precise the desired measurement, the greater the time delay).

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 IN51 with intelligent sensor fusion from Kübler for further optimization of the measurement result.

.... Actual movement

———— Detected data of the acceleration measurement

———— Filtered measurement results

Inclinometers

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Technology in detail

Quick setting options via the Easy-Teach function with teach adapter

Connection
The teach adapter ❷ is connected between the sensor ❶
and the connection cable to the application ❹.

Parameterization
The following settings can be made quickly and easily by pressing
the toggle switch ❸ :
- Reset to factory setting
- Start/end point of the measuring range
  (for 1-axis measurement)
- Midpoint of the measuring range
- Setting the sensor filter:
  no filter, 0.1 Hz, 0.3 Hz, 0.5 Hz, 1.0 Hz, 2.0 Hz, 5.0 Hz or 10.0 Hz