INCLINOMETERS

FOR STATIC AND DYNAMIC APPLICATIONS
1- AND 2-AXIS MEASUREMENT

pulses for automation

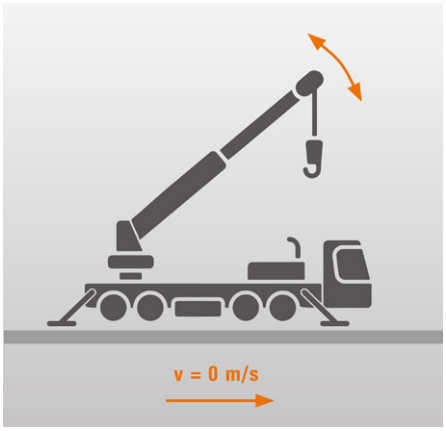
Inclinometers

Precise and reliable measurement - suitable for use in the harshest environmental conditions

The right solution for every application. Whether static or dynamic applications, Kübler offers the right sensor technology for both 1-axis and 2-axis inclination measurement. Compared to alternative measuring systems, inclinometers offer more flexibility and degrees of freedom in system design, as the sensor does not require a mechanical connection to a shaft or rotary axis, for example. This simplifies installation and significantly reduces sources of error. With the help of simple tools, the sensors can be individually adapted to the respective application requirements.

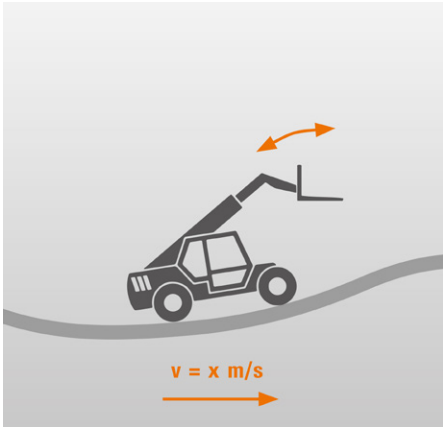
Inclinometers for static applications

Precise measurement in stationary applications with limited dynamic movements.
1- or 2-axis measurement (0 ... 360° or ±85°).



Inclinometers for dynamic applications

Thanks to innovative sensor fusion (acceleration and rotation rate), suitable for applications that move quickly or are exposed to a high degree of vibration.
1- or 2-axis measurement (0 ... 360° or ±85°).



Further information
about inclinometers

Portfolio overview

Inclinometers for static applications

Analog Output
Analog Output

Individually parameterizable

- Various analog interfaces adjustable
- Adjustable measuring range
- Filter functions depending on application area
- Easy-Teach via teach adapter
- IO-Link interface for parameterization (FDT/IODD)

IN61

PNP NPN

2 switching outputs

- Individual parameterization
- Simple commissioning
- Spirit level function
- IO-Link interface for parameterization (FDT/IODD)

IN62

IO-Link

Door opener for Industry 4.0 / IIoT

- Simple commissioning and diagnostics
- Adjustable measuring range
- Filter functions depending on the application
- Parameterization via FDT/IODD

IN68

Analog Output
Analog Output

Robust and precise

- Various analog interfaces
- Optionally with additional switching outputs
- Robust metal housing
- Stackable for redundant measurement
- High protection level IP69k

IN81

SAE J1939
Modbus
CANopen

Various fieldbus interfaces

- Parametric filter adjustment
- Robust metal housing
- Stackable for redundant measurement
- High protection level IP69k

IN88

Analog Output

Maximum compactness

- Suitable for the tightest installation spaces
- Various analog interfaces
- High protection level IP68/IP69k
- Simple commissioning

IS40

Inclinometers for dynamic applications

Analog Output
Analog Output

Individually parameterizable

- Various analog interfaces adjustable
- Adjustable measuring range
- Filter functions depending on application area
- Easy-Teach via teach adapter
- IO-Link interface for parameterization (FDT/IODD)

IN71

PNP NPN

2 switching outputs

- Individual parameterization
- Simple commissioning
- Spirit level function
- IO-Link interface for parameterization (FDT/IODD)

IN72

IO-Link

Door opener for Industry 4.0 / IIoT

- Simple commissioning and diagnostics
- Adjustable measuring range
- Filter functions depending on the application
- Parameterization via FDT/IODD

IN78

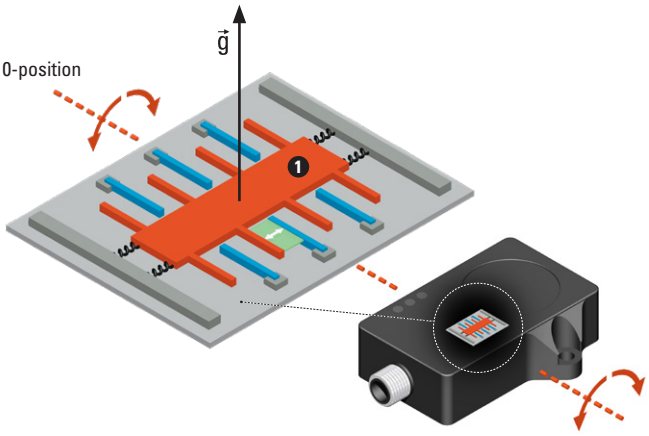
Functional principles of static / dynamic inclinometers

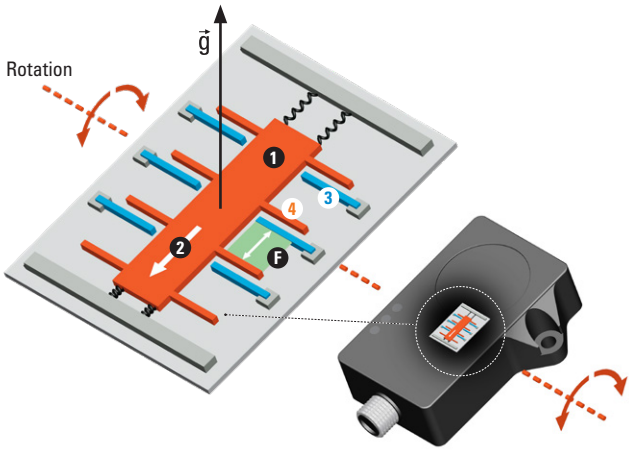
Exact angular position via acceleration measurement in static inclinometers (types IN6x, IN8x, IS40)

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.





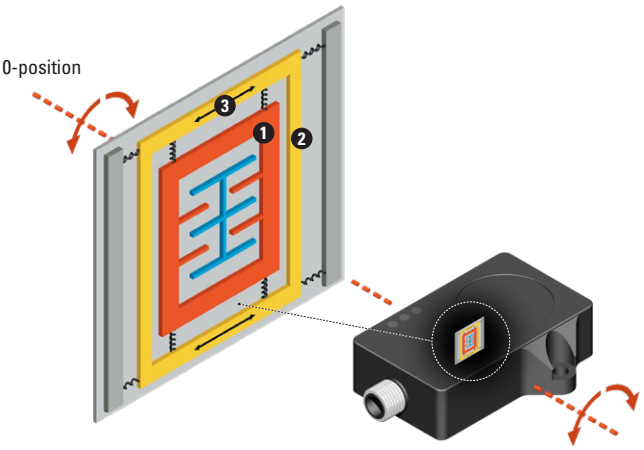
Intelligent sensor fusion of acceleration and rotation rate measurement for dynamic applications (types IN7x)

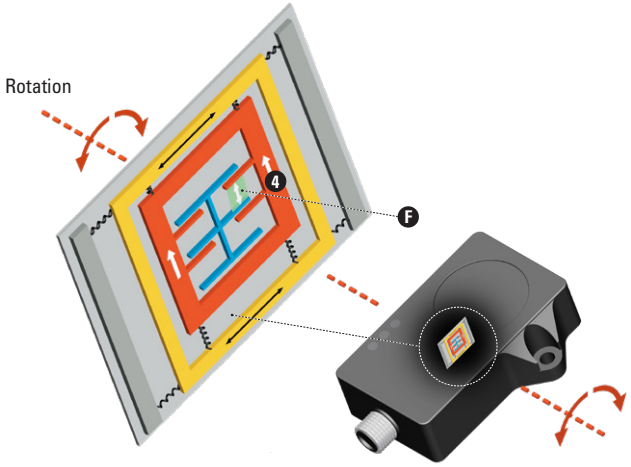
Both measured values are combined in the inclinometers for dynamic applications. The effect is even faster and more accurate output results.

Rotation rate measurement

In the rotation rate measuring cell (gyroscope), the Coriolis force resulting from a rotation is evaluated in order to determine the angle of rotation in relation to the starting position.
An arrangement of frame ❷ and test mass ❶ is in a permanent linear movement ❸ (oscillating).
If this system is brought into rotation, this results in a force (Coriolis force) ❹ that leads to a displacement of the test mass.

This displacement is also determined by the change in capacity Ⓕ between fixed and moving electrodes and is directly related to the rotational speed (rotation rate).
The angle of rotation is determined from the speed of rotation and the duration of rotation.



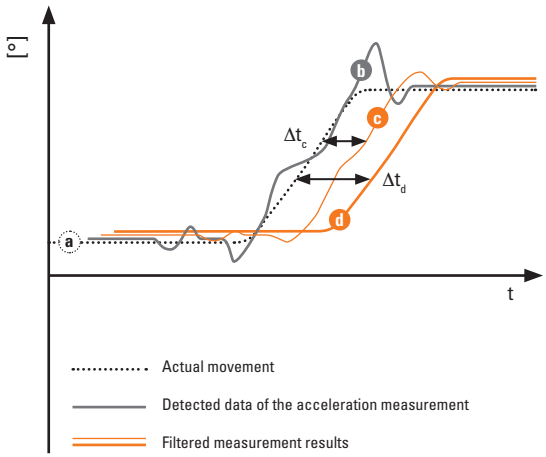


Optimization of the measurement using filter functions

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).

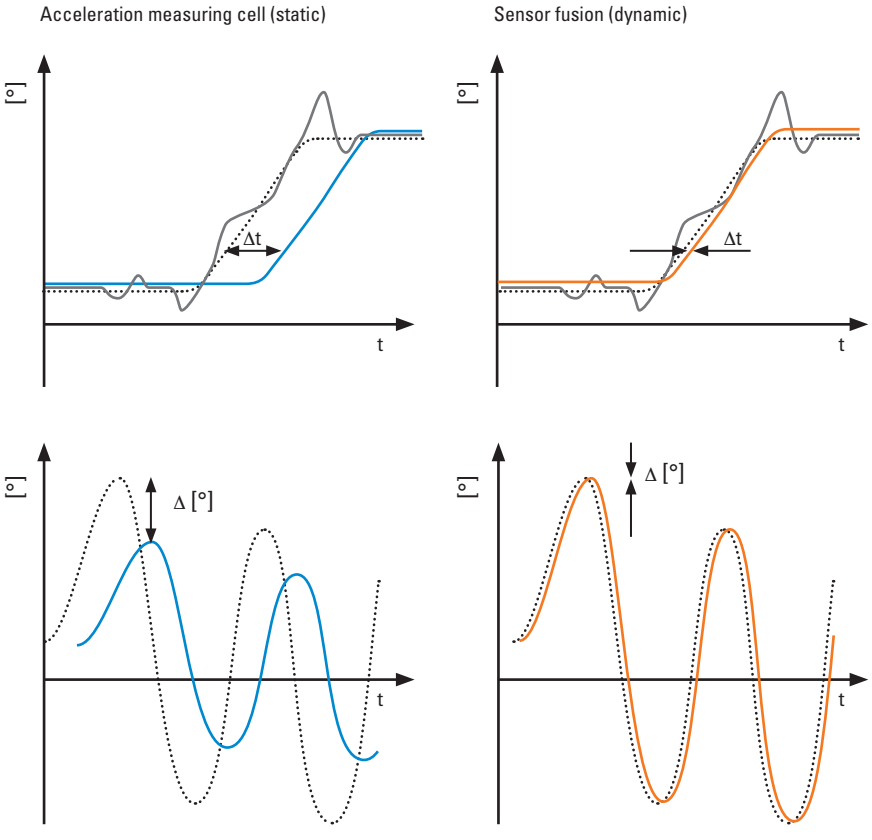
Further optimization with dynamic inclinometers
This time delay is not relevant for many static applications (such as solar panels, crane masts, etc.). In dynamic applications (e.g. vehicles in motion), however, this can lead to problems, as a reaction to the movement can only occur with a delay. In this case, it is advisable to use a dynamic inclinometer IN7x with intelligent sensor fusion from Kübler for further optimization of the measurement result.



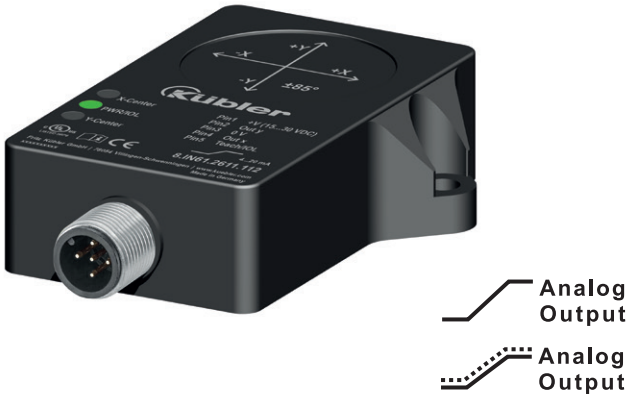
Comparison static inclinometer (accelerometer only) - dynamic inclinometer (sensor fusion)

Fast measurement
Inaccuracies due to the inertia of the test mass can be compensated for in acceleration measurement via filters. However, there is a time delay Δt for the output of the measurement result. This time delay is minimized with sensor fusion.

Accurate measurement
The sensor fusion leads to more accurate measurement results when changing direction quickly.



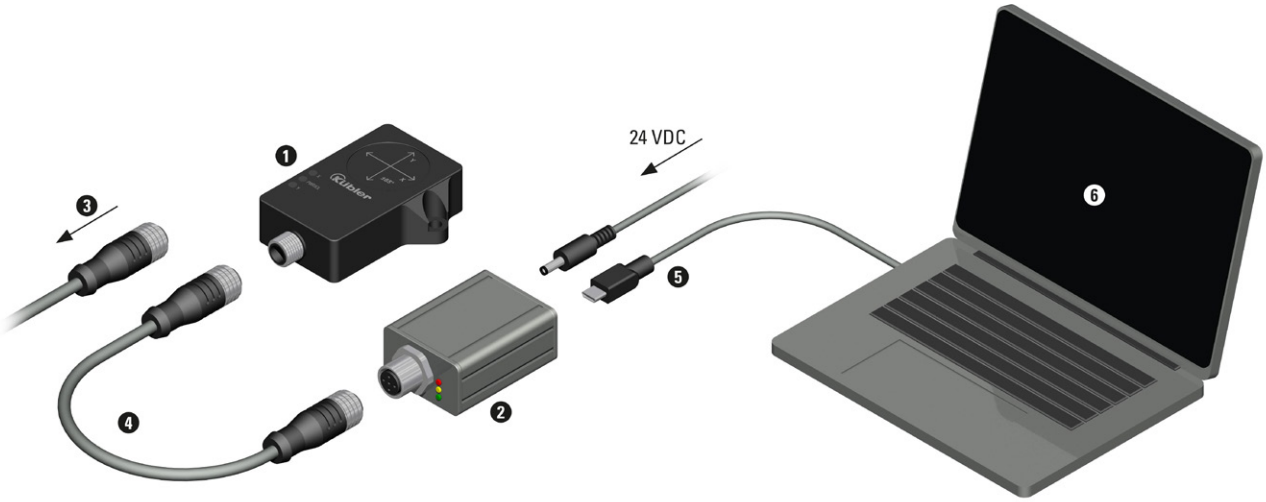
Technology in detail – inclinometers IN61 / IN71



- **Analog sensor with integrated IO-Link communication**
  - Configurable interfaces
  - Parameterization via IO-Link
  - Redundant / counter-rotating signals possible (1-axis)

- **Precise measurement even under harsh environmental conditions**
  - Temperature range -40 °C ... +85 °C and protection level IP68 / IP69k
  - Protection against the influence of salt spray and rapid temperature changes

Individual setting options via FDT/IODD with IO-Link Master USB



Connection

The inclinometer ❶ is or will be disconnected from the application ❸. The IO-Link Master USB ❷ is connected to the inclinometer with the adapter cable ❹ and connected to the PC via the USB interface ❺. The following parameters can be set using the appropriate software ❻ (e.g. PACTware):

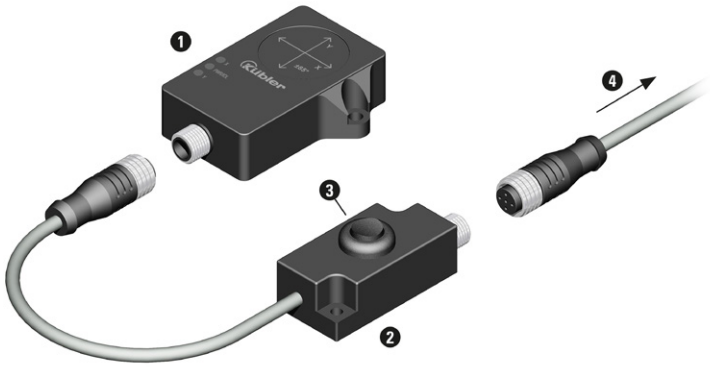
Setting options

Spirit level function	Can be activated as an assembly aid
Easy Teach	Parameterization via Easy Teach can be deactivated
Direction of rotation	Setting the direction of rotation of the axes. Output of the increasing analog values clockwise or counterclockwise.
Analog output	Possible analog outputs independent of the factory setting: Current outputs: 0 ... 20 mA 4 ... 20 mA Voltage outputs: 0.1 ... 4.9 V 0.5 ... 4.5 V 0 ... 5 V 0 ... 10 V
Starting point / End point	The start/end point of the output characteristic curve can be defined by entering the angle or the current tilt angle; for 2-axis devices, a different measuring range can be set using this function.
Filters	Balanced / Very slow / Slow Fast / Very fast (factory setting)

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:
- Start/end point of the measuring range (for 1-axis measurement)
- Midpoint of the measuring range
- Reset to factory setting



Easy start-up

Operating status – LED green

Permanent light	Appliance ready for operation
Blinking	FDT/IODD communication

Spirit level function – LED(s) yellow

Permanent light	Center position reached
Blinking with increasing frequency	Approaching the center position
Blinking with decreasing frequency	Move away from center position

1-axis = 2 LEDs

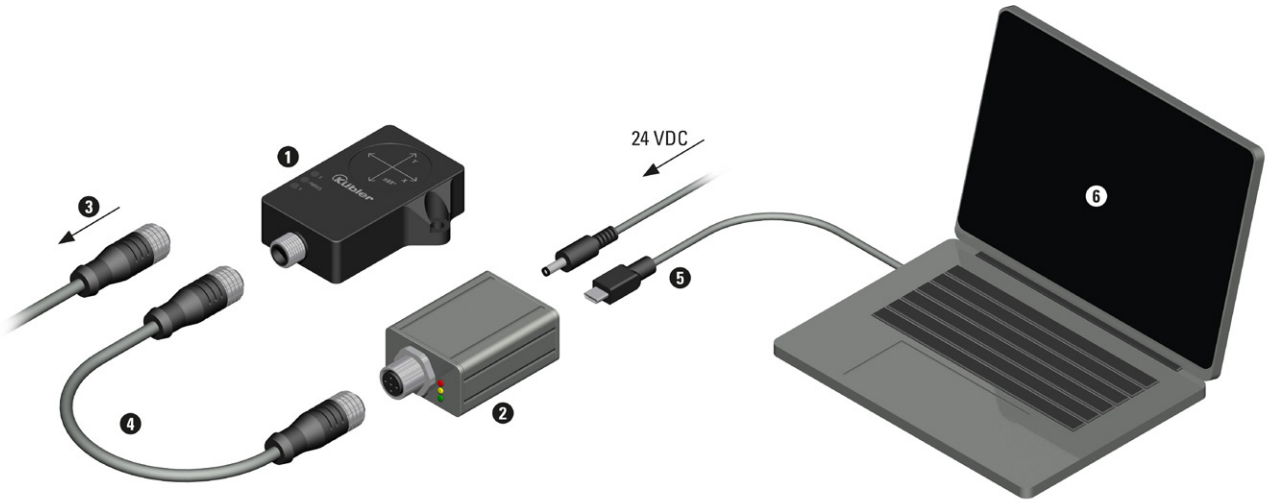
2-axis = 3 LEDs

Technology in detail – inclinometers IN62 / IN72

- **Two freely parameterizable switching outputs/ranges (PNP/NPN)**
  - Simple setting of the required end position / ranges via integrated IO-Link interface
  - Two different switching ranges or redundant output of the same switching range possible
- **Precise measurement even under harsh environmental conditions**
  - Temperature range -40 °C ... +85 °C and protection level IP68 / IP69k
  - Protection against the influence of salt spray and rapid temperature changes

PNP NPN

Individual setting options via FDT/IODD with IO-Link Master USB



Connection

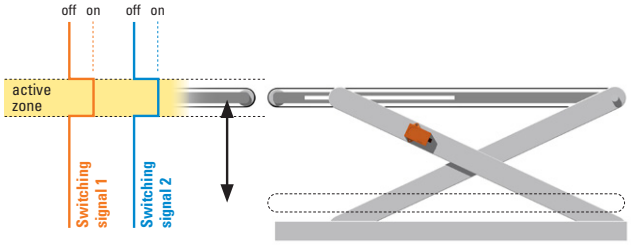
The inclinometer ❶ is or will be disconnected from the application ❸. The IO-Link Master USB ❷ is connected to the inclinometer with the adapter cable ❹ and connected to the PC via the USB interface ❺. The following parameters can be set using the appropriate software ❻ (e.g. PACTware):

Setting options

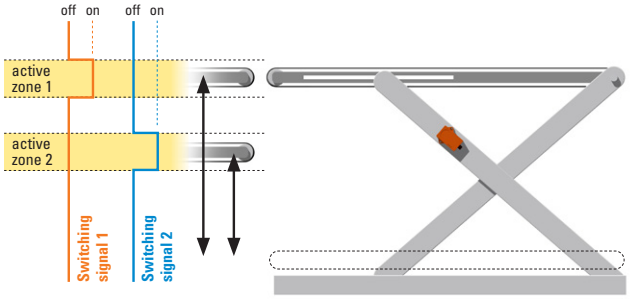
Spirit level function	Can be activated as an assembly aid
Center point	Set current inclination as new measuring range center point
Switching outputs	Configurable as PNP or NPN
Axes	The detection axis can be adjusted (2-axis devices)
Starting point / End point	The start and end point of the switching window can be set by input or via the current tilt angle. The awitching area must be > 1°.
Hysteresis	The area of the hysteresis behavior can be set. The hysteresis must be smaller than the switching area.
Filters	Balanced (factory setting) Slow

Two freely parameterizable switching outputs/ranges (Example)

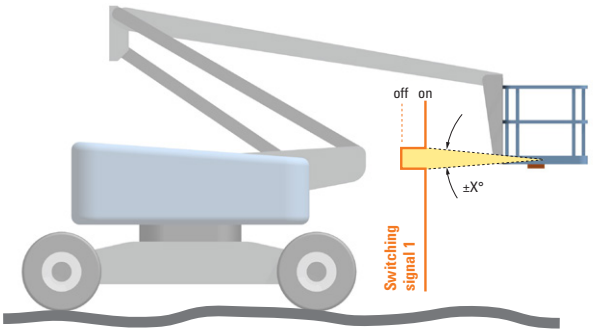
1-axis measuring / two identical switching ranges (redundancy)



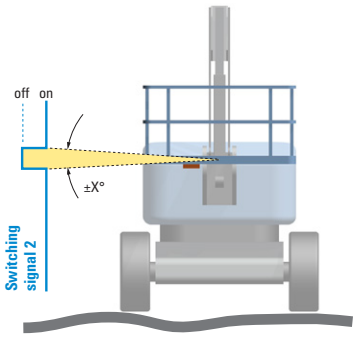
1-axis measuring / two different switching ranges



2-axis measuring / switching range X-axis



2-axis measuring / switching range Y-axis



Easy start-up

Operating status – LED green

Permanent light	Appliance ready for operation
Blinking	FDT/IODD communication

Switching status – LEDs yellow

Permanent light	Switching output active

Spirit level function – LEDs yellow

Permanent light	Center position reached
Blinking with increasing frequency	Approaching the center position
Blinking with decreasing frequency	Move away from center position

1-axis = 3 LEDs

2-axis = 3 LEDs

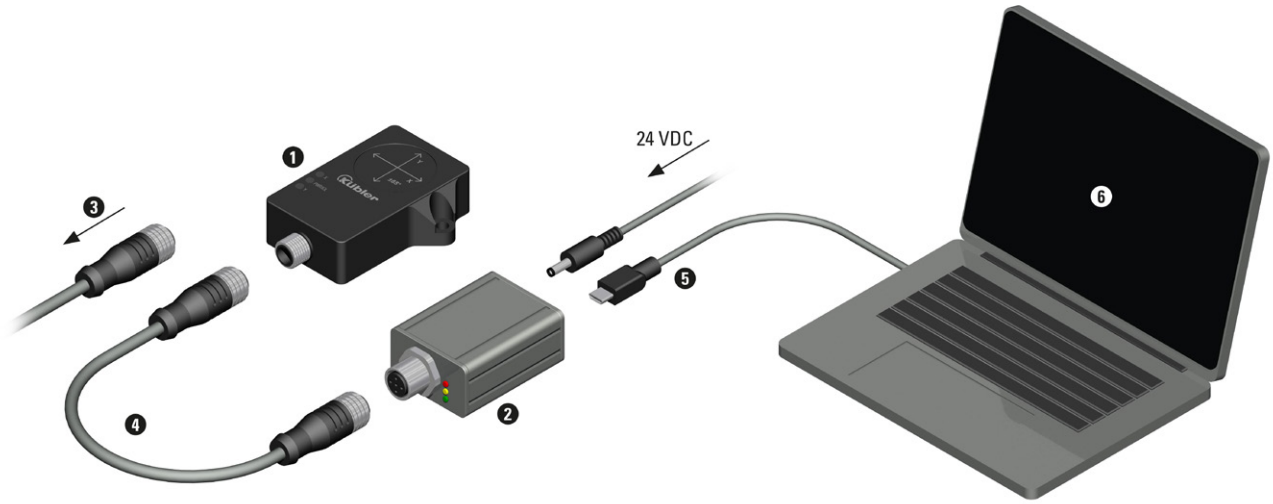
Technology in detail – inclinometers IN68 / IN78

- **IO-Link interface**
  For easy integration into Industry 4.0 / IIoT networks.

- **Precise measurement even under harsh environmental conditions**
  - Temperature range -40 °C ... +85 °C and protection level IP68 / IP69k
  - Protection against the influence of salt spray and rapid temperature changes

IO-Link

Individual setting options via FDT/IODD with IO-Link Master USB



Connection

The inclinometer ❶ is or will be disconnected from the application ❸. The IO-Link Master USB ❷ is connected to the inclinometer with the adapter cable ❹ and connected to the PC via the USB interface ❺. The following parameters can be set using the appropriate software ❻ (e.g. PACTware):

Setting options

Spirit level function	Can be activated as an assembly aid
Center point	Set current inclination as new measuring range center point
Direction of rotation	Setting the direction of rotation of the axes. Output of the increasing analog values clockwise or counterclockwise.
Configuring process data	The process data is structured in accordance with the IO-Link Smart Sensor Profile. For 1-axis measurement, the angle value is transmitted twice (inverted once). Angle information can be transmitted with a sign (1 bit - sign / 15 bit - angle information) or without a sign (16 bit) with an accuracy of 0.01°.
Filters	Balanced (factory setting) Slow

Easy start-up

Operating status – LED green

Permanent light	Appliance ready for operation
Blinking	FDT/IODD communication

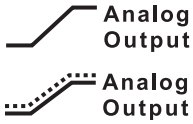
Spirit level function – LED(s) yellow

Permanent light	Center position reached
Blinking with increasing frequency	Approaching the center position
Blinking with decreasing frequency	Move away from center position

1-axis = 2 LEDs

2-axis = 3 LEDs

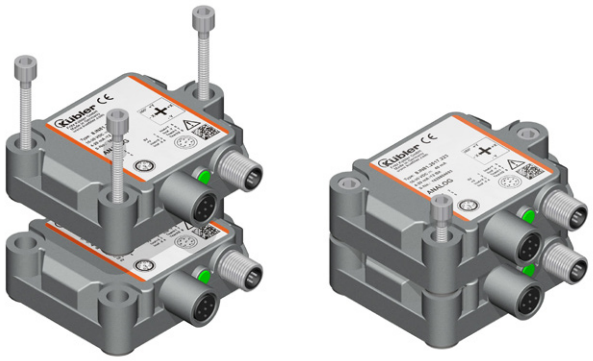
Technology in detail – inclinometers IN81



- **Analog sensor for precise measurement**
  - Stable accuracy over the entire temperature range
  - Analog interface for different current and voltage ranges
- **Simple start-up and diagnostics**
  LED display for quick and visual detection of the operating status.
- **Maximum robustness**
  The robust metal housing also protects the electronics from extreme mechanical influences.

Simple redundancy thanks to stackability

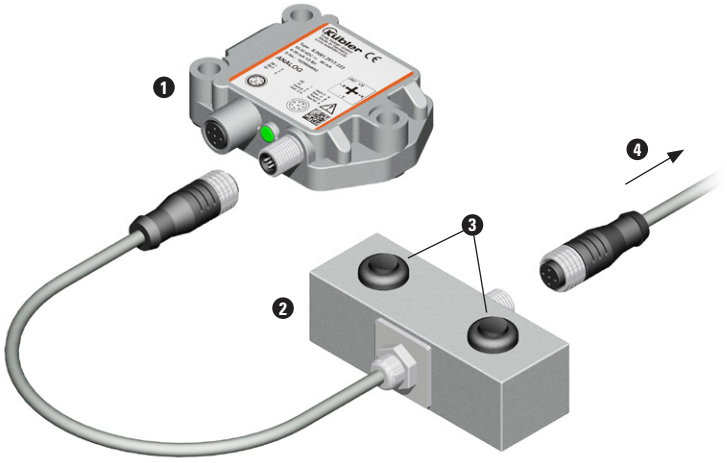
Using the same fastening devices on the application, 2 inclinometers type IN81 can be mounted stacked.



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

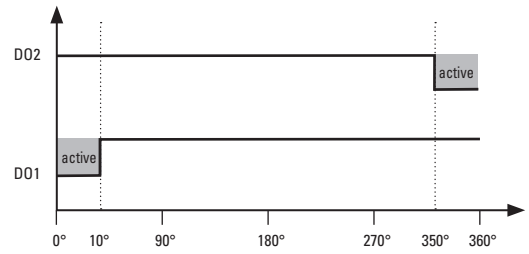
Connection
The teach adapter ❷ is connected between the sensor ❶ and the connection cable to the application ❹.

Parameterization
The following settings can be made quickly and easily by pressing the toggle switches ❸ :
- Define preset (zero point / midpoint position)
- Scaling of the analog measuring range (start/end position)
- Setting the sensor filter
- Setting the switching points of the optional switching outputs
- Resetting to factory settings

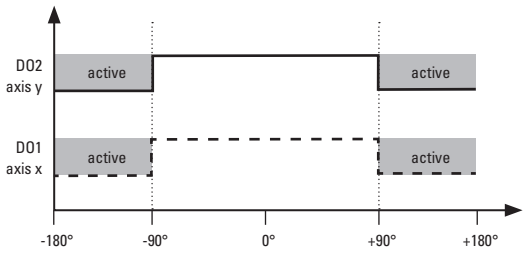


Defining the switching points for the optional switching outputs

1-axis measurement – factory setting

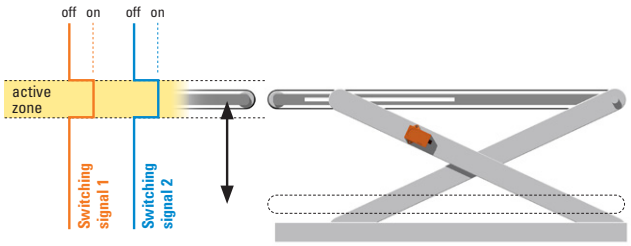


2-axis measurement – factory setting

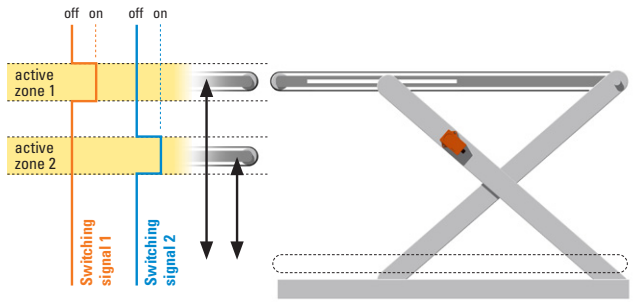


1-axis measurement – individual setting (examples)

Two identical switching ranges (redundancy)

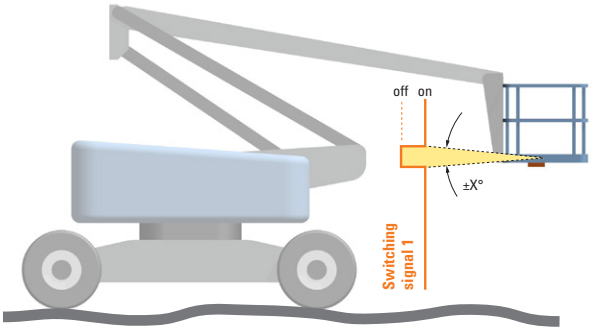


Two different switching ranges

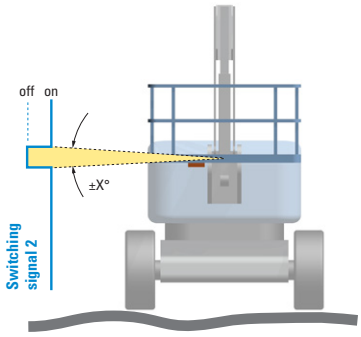


2-axis measurement – individual setting (examples)

Switching range X-axis



Switching range Y-axis



Technology in detail – inclinometers IN88

- **For different fieldbus systems**
  Variants for CANopen, SAEJ1939 or Modbus
- **Individual settings via the fieldbus interface**
  - Define preset (zero point / midpoint position)
  - Setting the sensor filter
  - Resetting to factory settings
- **Maximum robustness**
  The robust metal housing also protects the electronics from extreme mechanical influences.

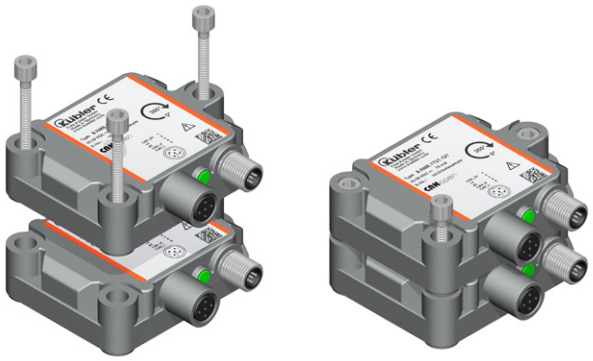
SAE J1939

Modbus

CANopen

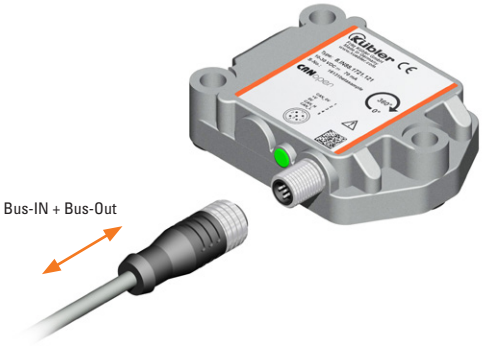
Simple redundancy thanks to stackability

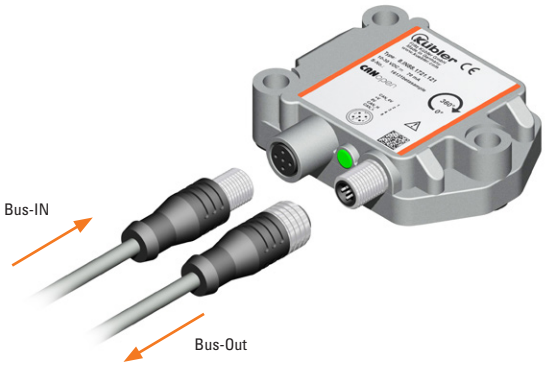
Using the same fastening devices on the application, 2 inclinometers type IN88 can be mounted stacked.



Flexible use in different network topologies

1- or 2-connector technology for bus-in/bus-out





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Kübler Group
Fritz Kübler GmbH
Schubertstrasse 47
78054 Villingen-Schwenningen
Germany

Phone +49 7720 3903-0
Fax +49 7720 21564
info@kuebler.com

kuebler.com