User manual

Inclination Sensors with Current and Voltage Interface

Version: 1.12

Date: 2021-07-30

classicLINE

IS1BP360-I-CL
IS2BP090-I-CL
IS1BP360-U-CL
IS2BP090-U-CL

basicLINE

IS1MA360-I-BL
IS2MA090-I-BL
IS1MA360-U-BL
IS2MA090-U-BL
IS1BP360-I-BL
IS2BP090-I-BL
IS1BP360-U-BL
IS2BP090-U-BL

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Revision History

Date	Revision	Changes
2014-05-30	0	first version
2014-08-14	1	Update ordering information
2015-03-30	2	BasicLine sensors with analog output added
2015-08-12	3	Update permitted load resistance
2015-08-12	4	Designation Table 3 and Table 8 corrected
2015-11-12	5	EMC BasicLine added; Resolution BasicLine corrected
2017-01-25	6	MTTF values and digital filter default values added
2017-10-26	7	housing drawings
2018-05-22	8	Does not exist (conformation to German revision histoy)
2018-05-22	9	Updating CE conformity
2020-12-17	10	Updating CE conformity (DIN EN 13309 withdrawn)
2021-07-05	11	Housing changes on plastic housing / Outer dimensions not altered
2021-07-30	12	Applications “Solar thermal” and “photo-voltaic systems” deleted without replacement

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1 Overview

1.1 Characteristics

- Inclination sensors with measurement range: 360° / ±90° (X/Y)
- Linearized output, high accuracy (up to 0.06°)
- Compensated cross sensitivity
- Programmable vibration suppression
- Freely programmable current or voltage interface
- Robust, UV resistant, impact strength plastic housing
- compact, robust aluminum housing
- Suitable for industrial use:
  - Temperature range: -40 °C to +80 °C
  - Degree of protection: IP65/67

The 1-dimensional inclination sensors IS1xx360-I-xL and IS1xx360-U-xL are suitable to measure the inclination in the measurement range of 360°, the 2-dimensional inclination sensors IS2xx090-I-xL and IS2xx090-U-xL are suitable to measure the inclination in 2 dimensions (X/Y) of ±90°. To ensure a high accuracy, the sensors are calibrated at the factory.

The compact and robust design make the sensors a suitable angle measurement device in rough surroundings for different applications in industry and vehicle technology.

1.2 Applications

- Agricultural and forestry machinery
- Construction machinery
- Crane and hoisting technology

2 Technical Data IS1BP360-I-CL + IS2BP090-I-CL

General Parameters[1]	IS1BP360-I-CL	IS2BP090-I-CL
Measurement range	360°	±90°
Resolution	0.01°	0.01°
Accuracy	Range 0...360° typical ±0.04° maximum ±0.12°	Range up to ±60° / up to ±70° / up to ±80° / up to ±85° typical ±0.02° / ±0.04° / ±0.08° / ±0.16° maximum ±0.06° / ±0.12° / ±0.24° / ±0.48°
Cross Sensitivity (compensated)	-	typ. ±0.09° (±0.10 %FS) max. ±0.45° (±0.50 %FS)
Temperature coefficient (zero point)	typ. +0.0088 °/K, -0.0102 °/K	
Sampling rate	100 Hz	
Cut-off frequency	typ. 20 Hz, 2nd order (without digital filter) / 0.1 ... 25 Hz, 8th order (with digital filter) Default digital filter: critically damped filter 8th order at 2 Hz	
Operating temperature	-40 °C to +80 °C [2]	
Characteristics		
Current interface	freely adjustable output in the range 0...20.45 mA (factory default: 4...20 mA) freely adjustable angle in the range 0...360° / ±90°	
Functions	Teach input for zero point adjustment when installed Limit value , Axis direction and assignment of the outputs are adjustable Digital filter (critically damped (default) or Butterworth lowpass, 8th order)	
Electrical Parameters		
Supply voltage	17 to 35 VDC	
Current consumption	40 mA @ 24 V + I_{loop}	
Outputs (short-circuit proof)	inductive load less than 1 H, permitted load resistance depends on supply voltage, see table 3 and figure 2	
Mechanical Parameters		
Connection	Sensor connector 5-pole M12 (male)	
Degree of protection	IP65/67	
Dimensions / Weight	plastic housing: 66 mm x 90 mm x 36 mm / about 200 g	
Reliability according EN ISO 13849-1[3]		
MTTF	300 years	
MTTFd	559 years	
CE conformity		
EC Directives		
2014/30/EU	EMC directive	
2011/65/EU	RoHS directive	
Harmonized standards		
DIN EN 61326-1:2013-07	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements	
DIN EN 50581:2013-02	Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances	

Table 1: Technical Data IS1BP360-I-CL + IS2BP090-I-CL

1 All indicated angle accuracies are valid after a running time of 10 minutes at 25 °C, Cut-off frequency 0.3 Hz.
Absolute calibration accuracy (at 25 °C): ±0.05°.
2 For full temperature range up to 80 °C limited combinations of supply voltage and load resistance are permitted only, see figure 2.
3 This product is a standard product and no safety part in accordance with the machinery directive. The calculation is based on an average environment temperature of 40 °C and a usage of 8760 h/a.

Electromagnetic Compatibility (EMC)			
Transient Emissions			
Radiated disturbance / Radio field strength	Limit curves broadband and narrowband ECE R10		
	Limits according to CISPR 11		
Immunity to Radio Frequency Fields (RF fields)			
Strip line according to ISO 11452-5	Limits according to ECE R10		
Anechoic chamber according to ISO 11452-2	Limits according to ECE R10		
Radio Frequency Fields according to IEC 61000-4-3	Limits according to EN 61326-1		
Immunity to Conducted Disturbances			
Test pulse according to ISO 7637-2 (on-board power supply 24 VDC)	Test pulse 1 -450 V 2a +37 V 2b +20 V 3a -150 V 3b +150 V 4 -12 V 5a +70 V 5b +36 V	Severity level III III III III III III Ri = 1 Ω Ri = 0.5 Ω	Performance criteria C B C A A B A A
Burst according to IEC 61000-4-4	Limits according to EN 61326-1		
Surge according to IEC 61000-4-5	Limits according to EN 61326-1		
Conducted HF-Signals according to IEC 61000-4-6	Limits according to EN 61326-1		
Immunity to Electromagnetic Discharge (ESD)			
ESD according to ISO 10605	Limits according to DIN EN ISO 14982 (agricultural and forestry machinery) discharge combination 330 pF / 330 Ω Contact discharge 8 kV bipolar (metallic parts) Air discharge 15 kV bipolar Performance criteria A		
ESD according to IEC 61000-4-2	Limits according to EN 61326-1		

Table 2: Electromagnetic Compatibility (EMC) IS1BP360-I-CL + IS2BP090-I-CL

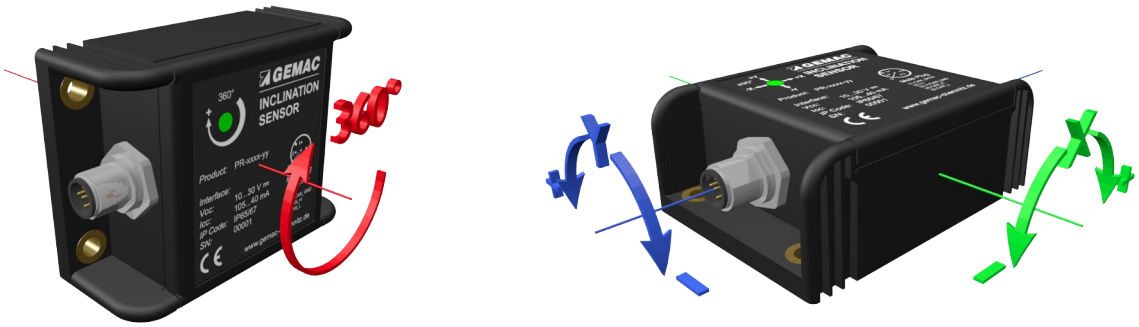


Figure 1: Measurement axes orientation - IS1BP360-I-CL + IS2BP090-I-CL big plastic housing (factory default settings)

2.1 Load Resistance IS1BP360-I-CL + IS2BP090-I-CL

Power dissipation depends on supply voltage and the load resistance. To reduce power dissipation, which may cause overheating, the load resistor should be chosen according to supply voltage. Table 3 and figure 2 show the relation between supply voltage and the permitted load resistance for different temperature ranges.

The green area in figure 2 shows the permitted load resistance depending on supply voltage for operating temperatures up to 80 °C. Combinations of supply voltage and load resistor within the gray colored area are permitted for a limited operating temperature range up to 65°C in addition.

The following values of minimum and maximum load resistance are meant as total resistance as sum of resistance of the load resistor and cable resistance (see 9.3 Cable length and minimum supply voltage for current interface).

U_{dd} [V]	R_L min. [Ω] @ Ta_{max} = 65 °C	R_L min. [Ω] @ Ta_{max} = 80 °C	R_L max. [Ω]
17	0	230	500
24	130	660	850
28	390	390	1050
35	830	1330	1410

Table 3: Minimum and maximum Load Resistance IS1BP360-I-CL + IS2BP090-I-CL at different Operating Temperatures

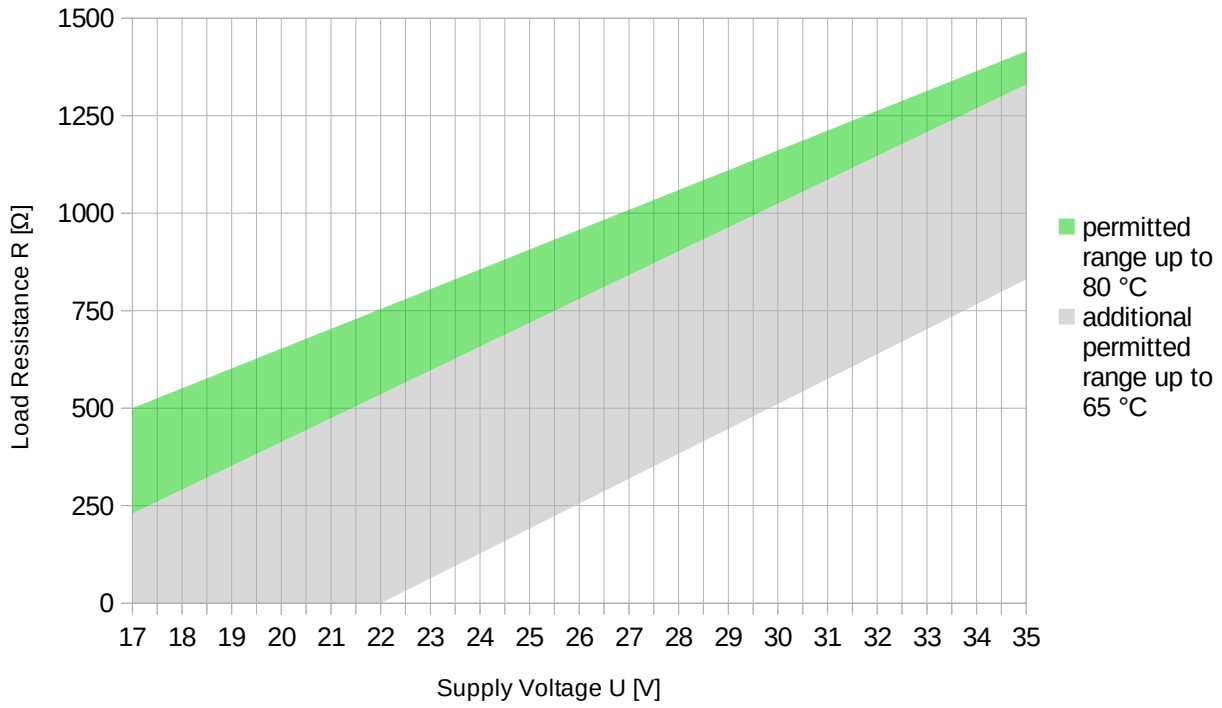


Figure 2: Permitted Load Resistance IS1BP360-I-CL + IS2BP090-I-CL

3 Technical Data IS1BP360-U-CL + IS2BP090-U-CL

General Parameters[4]	IS1BP360-U-CL	IS2BP090-U-CL
Measurement range	360°	±90°
Resolution	0.01°	0.01°
Accuracy	Range 0...360° typical ±0.04° maximum ±0.12°	Range up to ±60° / up to ±70° / up to ±80° / up to ±85° typical ±0.02° / ±0.04° / ±0.08° / ±0.16° maximum ±0.06° / ±0.12° / ±0.24° / ±0.48°
Cross Sensitivity (compensated)	-	typ. ±0.09° (±0.10 %FS) max. ±0.45° (±0.50 %FS)
Temperature coefficient (zero point)	typ. ±0.0083 °/K	
Sampling rate	100 Hz	
Cut-off frequency	typ. 20 Hz, 2nd order (without digital filter) / 0.1 ... 25 Hz, 8th order (with digital filter) Default digital filter: critically damped filter 8th order at 2 Hz	
Operating temperature	-40 °C to +80 °C	
Characteristics		
Voltage interface	freely adjustable output in the range -10.48...10.48 V (factory default: 0...10 V) freely adjustable angle in the range 0...360° / ±90°	
Functions	Teach input for zero point adjustment when installed Limit value , Axis direction and assignment of the outputs are adjustable Digital filter (critically damped (default) or Butterworth lowpass, 8th order)	
Electrical Parameters		
Supply voltage	10 to 35 VDC	
Current consumption	55 mA @ 24 V	
Outputs (short-circuit proof)	capacitive load less than 1.2 µF, resistive load greater than 2 kΩ	
Mechanical Parameters		
Connection	Sensor connector 5-pole M12 (male)	
Degree of protection	IP65/67	
Dimensions / Weight	plastic housing: 66 mm x 90 mm x 36 mm / about 200 g	
Reliability according EN ISO 13849-1[5]		
MTTF	287 years	
MTTFd	542 years	
CE conformity		
EC Directives		
2014/30/EU	EMC directive	
2011/65/EU	RoHS directive	
Harmonized standards		
DIN EN 61326-1:2013-07	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements	
DIN EN 50581:2013-02	Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances	

Table 4: Technical Data IS1BP360-U-CL + IS2BP090-U-CL

4 All indicated angle accuracies are valid after a running time of 10 minutes at 25 °C, Cut-off frequency 0.3 Hz. Absolute calibration accuracy (at 25 °C): ±0.05°.

5 This product is a standard product and no safety part in accordance with the machinery directive. The calculation is based on an average environment temperature of 40 °C and a usage of 8760 h/a.

Electromagnetic Compatibility (EMC)			
Transient Emissions			
Radiated disturbance / Radio field strength	Limit curves broadband and narrowband ECE R10		
	Limits according to CISPR 11		
Immunity to Radio Frequency Fields (RF fields)			
Strip line according to ISO 11452-5	Limits according to ECE R10		
Anechoic chamber according to ISO 11452-2	Limits according to ECE R10		
Radio Frequency Fields according to IEC 61000-4-3	Limits according to EN 61326-1		
Immunity to Conducted Disturbances			
Test pulse according to ISO 7637-2 (on-board power supply 24 VDC)	Test pulse 1 -450 V 2a +37 V 2b +20 V 3a -150 V 3b +150 V 4 -12 V 5a +70 V 5b +36 V	Severity level III III III III III III Ri = 1 Ω Ri = 0.5 Ω	Performance criteria C B C A A B A A
Burst according to IEC 61000-4-4	Limits according to EN 61326-1		
Surge according to IEC 61000-4-5	Limits according to EN 61326-1		
Conducted HF-Signals according to IEC 61000-4-6	Limits according to EN 61326-1		
Immunity to Electromagnetic Discharge (ESD)			
ESD according to ISO 10605	Limits according to DIN EN ISO 14982 (agricultural and forestry machinery) discharge combination 330 pF / 330 Ω Contact discharge 8 kV bipolar (metallic parts) Air discharge 15 kV bipolar Performance criteria A		
ESD according to IEC 61000-4-2	Limits according to EN 61326-1		

Table 5: Electromagnetic Compatibility (EMC) IS1BP360-U-CL + IS2BP090-U-CL

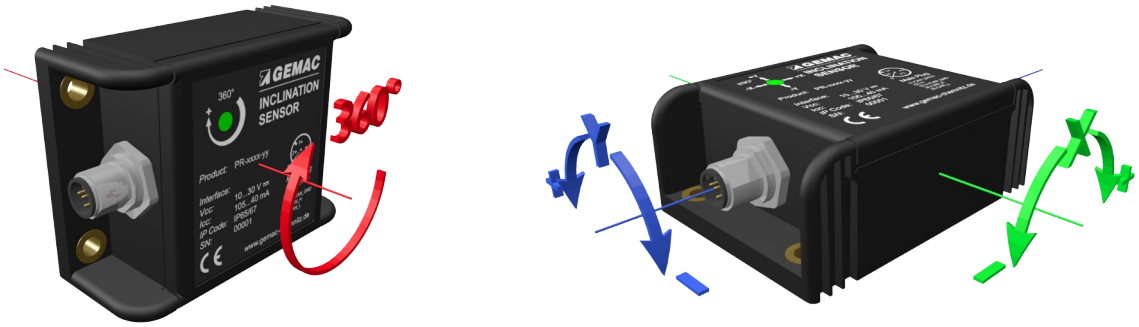


Figure 3: Measurement axes orientation - IS1BP360-U-CL + IS2BP090-U-CL big plastic housing (factory default settings)

4 Technical Data IS1MA360-I-BL + IS2MA090-I-BL

General Parameters[6]	IS1MA360-I-BL	IS2MA090-I-BL
Measurement range	360°	±90°
Resolution	0.01° (0.09° at measurement range 360°)	0.01° (0.045° at measurement range ±90°)
Accuracy	Range 0...360° typical ±0.15° maximum ±0.25°	Range up to ±60° typical ±0.10° maximum ±0.20° up to ±80° typical ±0.20° maximum ±0.40°
Cross Sensitivity (compensated)	-	typ. ±0.09° (±0.10 %FS) max. ±0.45° (±0.50 %FS)
Temperature coefficient (zero point)	typ. ±0.01 °/K	
Sampling rate	100 Hz	
Cut-off frequency	typ. 20 Hz, 2nd order (without digital filter) / 0.1 ... 25 Hz, 8th order (with digital filter)Default digital filter: critically damped filter 8th order at 2 Hz	
Operating temperature	-40 °C to +80 °C [7]	
Characteristics		
Current interface	freely adjustable output in the range 4...20 mA freely adjustable angle in the range 0...360° / ±90°	
Functions	Teach input for zero point adjustment when installed Limit value , Axis direction and assignment of the outputs are adjustable Digital filter (critically damped (default) or Butterworth lowpass, 8th order)	
Electrical Parameters		
Supply voltage	16 to 35 VDC	
Current consumption	35 mA @ 24 V + I_{loop}	
Outputs (short-circuit proof)	inductive load less than 50 mH, permitted load resistance depends on supply voltage (see table 8 and figure 5)	
Mechanical Parameters		
Connection	Sensor connector 5-pole M12 (male)	
Degree of protection	IP65/67	
Dimensions / Weight	aluminum housing: 58 mm x 90 mm x 31 mm / about 200 g	
Reliability according EN ISO 13849-1[8]		
MTTF	302 years	
MTTFd	572 years	
CE conformity		
EC Directives		
2014/30/EU	EMC directive	
2011/65/EU	RoHS directive	
Harmonized standards		
DIN EN 61326-1:2013-07	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements	
DIN EN 50581:2013-02	Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances	

Table 6: Technical Data IS1MA360-I-BL + IS2MA090-I-BL

6 All indicated angle accuracies are valid after a running time of 10 minutes at 25 °C, Cut-off frequency 0.3 Hz. Absolute calibration accuracy (at 25 °C): ±0.05°.
7 For full temperature range up to 80 °C limited combinations of supply voltage and load resistance are permitted only, see figure 5.
8 This product is a standard product and no safety part in accordance with the machinery directive. The calculation is based on an average environment temperature of 40 °C and a usage of 8760 h/a.

Electromagnetic Compatibility (EMC)			
Transient Emissions			
Radiated disturbance / Radio field strength	Limit curves broadband and narrowband DIN EN ISO 14982 (agricultural and forestry machinery) 30 ... 1000 MHz (vertical and horizontal)		
	Limits according to CISPR 11		
Immunity to Radio Frequency Fields (RF fields)			
Strip line according to ISO 11452-5	Limits according to DIN EN ISO 14982 (agricultural and forestry machinery) 20 ... 400 MHz 120 V/m (1 kHz AM) Performance criteria A		
Anechoic chamber according to ISO 11452-2	Limits according to DIN EN ISO 14982 (agricultural and forestry machinery) 200 ... 1000 MHz vertical, 100 V/m (1 kHz AM, 80 %) 800 ... 2000 MHz vertical, 100 V/m (PM, t =577 µs, period 4600 µs) Performance criteria A		
Radio Frequency Fields according to IEC 61000-4-3	Limits according to EN 61326-1		
Immunity to Conducted Disturbances			
Test pulse according to ISO 7637-2 (on-board power supply 24 VDC)	Test pulse 1 -450 V 2a +37 V 2b +20 V 3a -150 V 3b +150 V 4 -12 V 5a +70 V	Severity level III III III III III III Ri = 1 Ω	Performance criteria C B C A A A A
Burst according to IEC 61000-4-4	Limits according to EN 61326-1		
Surge according to IEC 61000-4-5	Limits according to EN 61326-1		
Conducted HF-Signals according to IEC 61000-4-6	Limits according to EN 61326-1		
Immunity to Electromagnetic Discharge (ESD)			
ESD according to ISO 10605	Limits according to DIN EN ISO 14982 (agricultural and forestry machinery) discharge combination 330 pF / 330 Ω Contact discharge 8 kV bipolar (metallic parts) Air discharge 15 kV bipolar Performance criteria A		
ESD according to IEC 61000-4-2	Limits according to EN 61326-1		

Table 7: Electromagnetic Compatibility (EMC) IS1MA360-I-BL + IS2MA090-I-BL

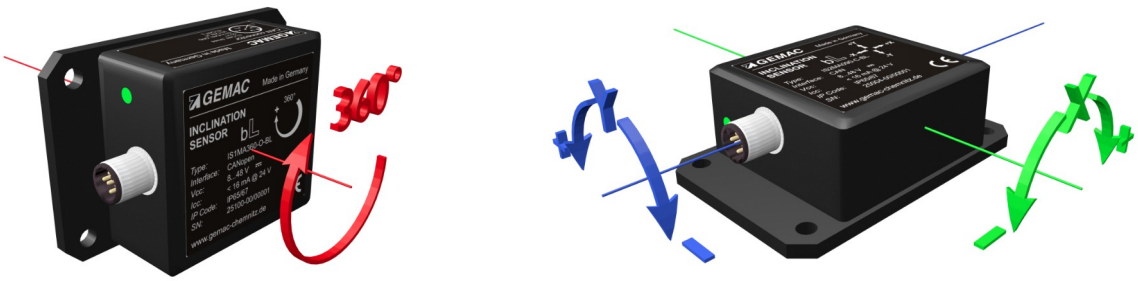


Figure 4: Measurement axes orientation - IS1MA360-I-BL + IS2MA090-I-BL aluminum housing (factory default setting)

4.1 Load Resistance IS1MA360-I-BL + IS2MA090-I-BL

Power dissipation depends on supply voltage and the load resistance. To reduce power dissipation, which may cause overheating, the load resistor should be chosen according to supply voltage. Table 8 and figure 5 show the relation between supply voltage and the permitted load resistance for different temperature ranges.

The green area in figure 5 shows the permitted load resistance depending on supply voltage for operating temperatures up to 80 °C. Combinations of supply voltage and load resistor within the gray colored area are permitted for a limited operating temperature range up to 65°C in addition.

The following values of minimum and maximum load resistance are meant as total resistance as sum of resistance of the load resistor and cable resistance (see 9.3 Cable length and minimum supply voltage for current interface).

U_{dd} [V]	R_L min. [Ω] @ Ta_{max} = 65 °C	R_L min. [Ω] @ Ta_{max} = 80 °C	R_L max. [Ω]
16	0	280	450
24	270	740	850
28	510	970	1050
35	930	1370	1400

Table 8: Minimum and maximum Load Resistance IS1MA360-I-BL + IS2MA090-I-BL at different Operating Temperatures

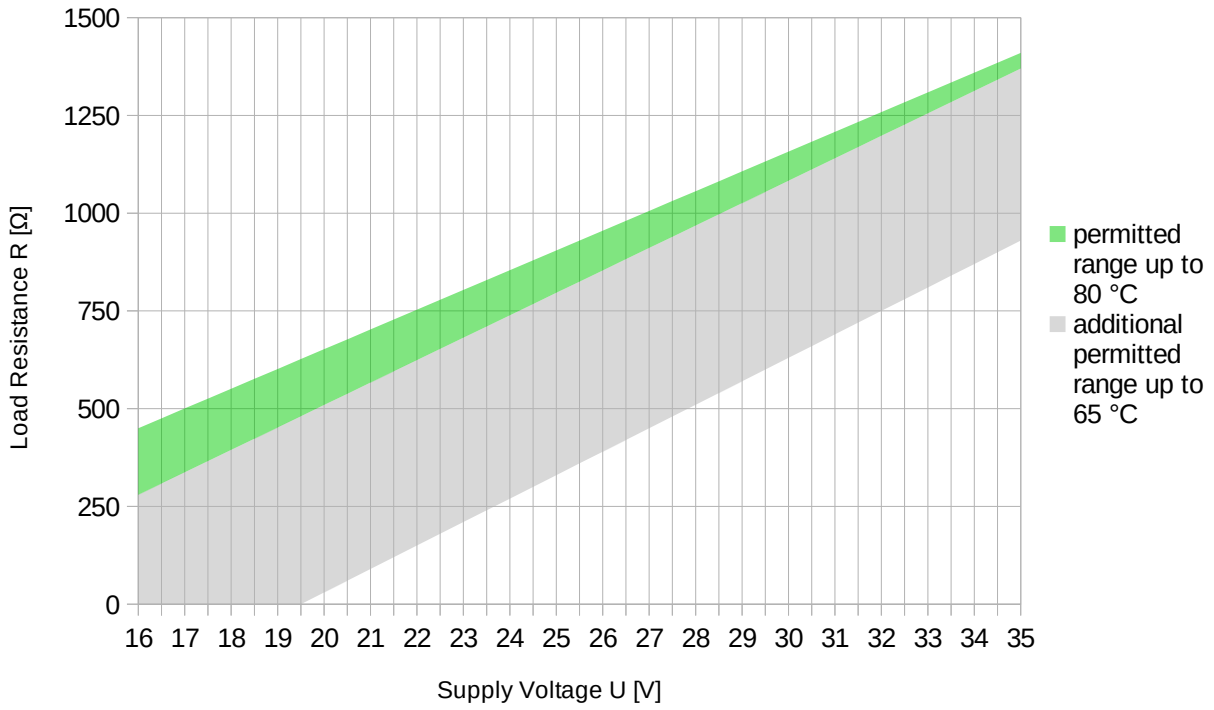


Figure 5: Permitted Load Resistance IS1MA360-I-BL + IS2MA090-I-BL

5 Technical Data IS1MA360-U-BL + IS2MA090-U-BL

General Parameters[9]	IS1MA360-U-BL	IS2MA090-U-BL
Measurement range	360°	±90°
Resolution	0.01° (0.09° at measurement range 360°)	0.01° (0.045° at measurement range ±90°)
Accuracy	Range typical maximum 0...360° ±0.15° ±0.25°	Range typical maximum up to ±60° ±0.10° ±0.20° up to ±80° ±0.20° ±0.40°
Cross Sensitivity (compensated)	-	typ. ±0.09° (±0.10 %FS) max. ±0.45° (±0.50 %FS)
Temperature coefficient (zero point)	typ. ±0.01 °/K	
Sampling rate	100 Hz	
Cut-off frequency	typ. 20 Hz, 2nd order (without digital filter) / 0.1 ... 25 Hz, 8th order (with digital filter) digital filter: critically damped filter 8th order at 2 Hz	
Operating temperature	-40 °C to +80 °C	
Characteristics		
Voltage interface	freely adjustable output in the range 0...10.48 V (factory default: 0...10 V) freely adjustable angle in the range 0...360° / ±90°	
Functions	Teach input for zero point adjustment when installed Limit value , Axis direction and assignment of the outputs are adjustable Digital filter (critically damped (default) or Butterworth lowpass, 8th order)	
Electrical Parameters		
Supply voltage	16 to 35 VDC	
Current consumption	35 mA @ 24 V	
Outputs (short-circuit proof)	capacitive load less than 1 µF, resistive load greater than 1 kΩ	
Mechanical Parameters		
Connection	Sensor connector 5-pole M12 (male)	
Degree of protection	IP65/67	
Dimensions / Weight	aluminum housing: 58 mm x 90 mm x 31 mm / about 200 g	
Reliability according EN ISO 13849-1[10]		
MTTF	354 years	
MTTFd	664 years	
CE conformity		
EC Directives		
2014/30/EU	EMC directive	
2011/65/EU	RoHS directive	
Harmonized standards		
DIN EN 61326-1:2013-07	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements	
DIN EN 50581:2013-02	Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances	

Table 9: Technical Data IS1MA360-U-BL + IS2MA090-U-BL

9 All indicated angle accuracies are valid after a running time of 10 minutes at 25 °C, Cut-off frequency 0.3 Hz. Absolute calibration accuracy (at 25 °C): ±0.05°.

10 This product is a standard product and no safety part in accordance with the machinery directive. The calculation is based on an average environment temperature of 40 °C and a usage of 8760 h/a.

Electromagnetic Compatibility (EMC)			
Transient Emissions			
Radiated disturbance / Radio field strength	Limit curves broadband and narrowband DIN EN ISO 14982 (agricultural and forestry machinery) 30 ... 1000 MHz (vertical and horizontal)		
	Limits according to CISPR 11		
Immunity to Radio Frequency Fields (RF fields)			
Strip line according to ISO 11452-5	Limits according to DIN EN ISO 14982 (agricultural and forestry machinery) 20 ... 400 MHz 120 V/m (1 kHz AM) Performance criteria A		
Anechoic chamber according to ISO 11452-2	Limits according to DIN EN ISO 14982 (agricultural and forestry machinery) 200 ... 1000 MHz vertical, 100 V/m (1 kHz AM, 80 %) 800 ... 2000 MHz vertical, 100 V/m (PM, t =577 µs, period 4600 µs) Performance criteria A		
Radio Frequency Fields according to IEC 61000-4-3	Limits according to EN 61326-1		
Immunity to Conducted Disturbances			
Test pulse according to ISO 7637-2 (on-board power supply 24 VDC)	Test pulse 1 -450 V 2a +37 V 2b +20 V 3a -150 V 3b +150 V 4 -12 V 5a +70 V 5b +36 V	Severity level III III III III III III Ri = 1 Ω Ri = 0.5 Ω	Performance criteria C B C A A A B B
Immunity to Electromagnetic Discharge (ESD)			
ESD according to ISO 10605	Limits according to DIN EN ISO 14982 (agricultural and forestry machinery) discharge combination 330 pF / 330 Ω Contact discharge 8 kV bipolar (metallic parts) Air discharge 15 kV bipolar Performance criteria A		
ESD according to IEC 61000-4-2	Limits according to EN 61326-1		

Table 10: Electromagnetic Compatibility (EMC) IS1MA360-U-BL + IS2MA090-U-BL

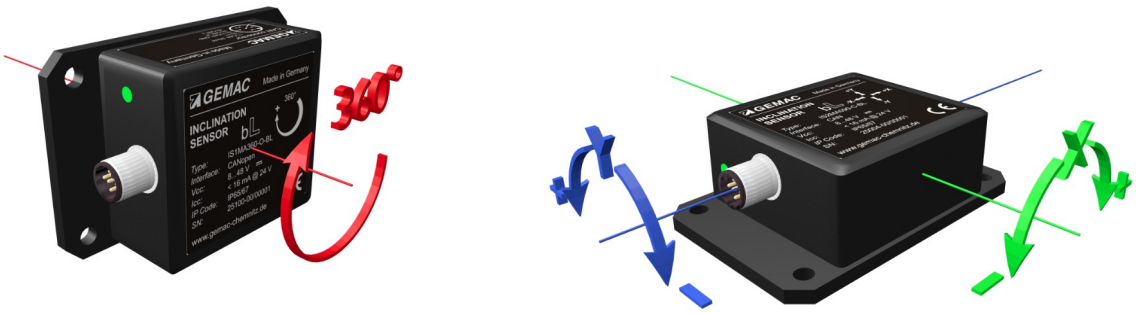


Figure 6: Measurement axes orientation - IS1MA360-U-BL + IS2MA090-U-BL aluminum housing (factory default setting)

6 Technical Data IS1BP360-I-BL + IS2BP090-I-BL

General Parameters[11]	IS1BP360-I-BL	IS2BP090-I-BL
Measurement range	360°	±90°
Resolution	0.01° (0.09° at measurement range 360°)	0.01° (0.045° at measurement range ±90°)
Accuracy	Range 0...360° typical ±0.15° maximum ±0.25°	Range up to ±60° typical ±0.10° maximum ±0.20° up to ±80° typical ±0.20° maximum ±0.40°
Cross Sensitivity (compensated)	-	typ. ±0.09° (±0.10 %FS) max. ±0.45° (±0.50 %FS)
Temperature coefficient (zero point)	typ. ±0.01 °/K	
Sampling rate	100 Hz	
Cut-off frequency	typ. 20 Hz, 2nd order (without digital filter) / 0.1 ... 25 Hz, 8th order (with digital filter)digital filter: critically damped filter 8th order at 2 Hz	
Operating temperature	-40 °C to +80 °C [12]	
Characteristics		
Current interface	freely adjustable output in the range 4...20 mA freely adjustable angle in the range 0...360° / ±90°	
Functions	Teach input for zero point adjustment when installed Limit value , Axis direction and assignment of the outputs are adjustable Digital filter (critically damped (default) or Butterworth lowpass, 8th order)	
Electrical Parameters		
Supply voltage	16 to 35 VDC	
Current consumption	35 mA @ 24 V + I_{loop}	
Outputs (short-circuit proof)	inductive load less than 50 mH permitted load resistance depends on supply voltage (see table 13 and figure 8)	
Mechanical Parameters		
Connection	Sensor connector 5-pole M12 (male)	
Degree of protection	IP65/67	
Dimensions / Weight	plastic housing: 66 mm x 90 mm x 36 mm / about 200 g	
Reliability according EN ISO 13849-1[13]		
MTTF	302 years	
MTTFd	572 years	
CE conformity		
EC Directives		
2014/30/EU	EMC directive	
2011/65/EU	RoHS directive	
Harmonized standards		
DIN EN 61326-1:2013-07	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements	
DIN EN 50581:2013-02	Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances	

Table 11: Technical Data IS1BP360-I-BL + IS2BP090-I-BL

11 All indicated angle accuracies are valid after a running time of 10 minutes at 25 °C, Cut-off frequency 0.3 Hz. Absolute calibration accuracy (at 25 °C): ±0.05°.
12 For full temperature range up to 80 °C limited combinations of supply voltage and load resistance are permitted only, see figure 8.
13 This product is a standard product and no safety part in accordance with the machinery directive. The calculation is based on an average environment temperature of 40 °C and a usage of 8760 h/a.

Electromagnetic Compatibility (EMC)			
Transient Emissions			
Radiated disturbance / Radio field strength	Limit curves broadband and narrowband DIN EN ISO 14982 (agricultural and forestry machinery) 30 ... 1000 MHz (vertical and horizontal)		
	Limits according to CISPR 11		
Immunity to Radio Frequency Fields (RF fields)			
Strip line according to ISO 11452-5	Limits according to DIN EN ISO 14982 (agricultural and forestry machinery) 20 ... 400 MHz 120 V/m (1 kHz AM) Performance criteria A		
Anechoic chamber according to ISO 11452-2	Limits according to DIN EN ISO 14982 (agricultural and forestry machinery) 200 ... 1000 MHz vertical, 100 V/m (1 kHz AM, 80 %) 800 ... 2000 MHz vertical, 100 V/m (PM, t =577 µs, period 4600 µs) Performance criteria A		
Radio Frequency Fields according to IEC 61000-4-3	Limits according to EN 61326-1		
Immunity to Conducted Disturbances			
Test pulse according to ISO 7637-2 (on-board power supply 24 VDC)	Test pulse 1 -450 V 2a +37 V 2b +20 V 3a -150 V 3b +150 V 4 -12 V 5a +70 V	Severity level III III III III III III Ri = 1 Ω	Performance criteria C B C A A A A
Burst according to IEC 61000-4-4	Limits according to EN 61326-1		
Surge according to IEC 61000-4-5	Limits according to EN 61326-1		
Conducted HF-Signals according to IEC 61000-4-6	Limits according to EN 61326-1		
Immunity to Electromagnetic Discharge (ESD)			
ESD according to ISO 10605	Limits according to DIN EN ISO 14982 (agricultural and forestry machinery) discharge combination 330 pF / 330 Ω Contact discharge 6 kV bipolar (metallic parts) Air discharge 8 kV bipolar Performance criteria A		
ESD according to IEC 61000-4-2	Limits according to EN 61326-1		

Table 12: Electromagnetic Compatibility (EMC) IS1BP360-I-BL + IS2BP090-I-BL

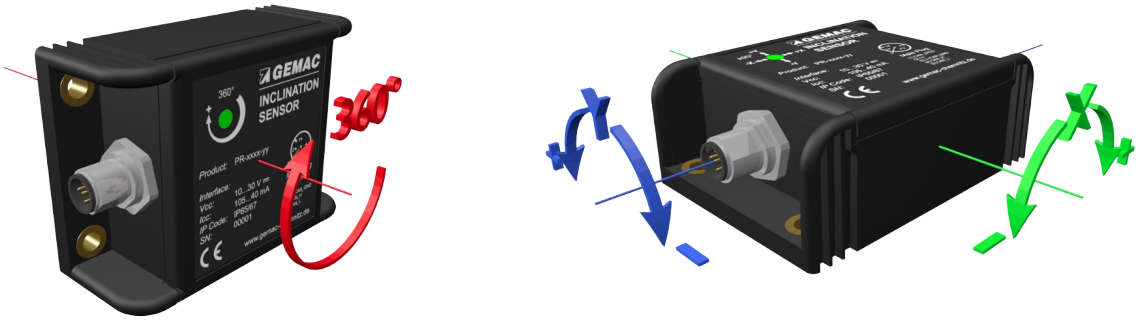


Figure 7: Measurement axes orientation - IS1BP360-I-BL + IS2BP090-I-BL big plastic housing (factory default settings)

6.1 Load Resistance IS1BP360-I-BL + IS2BP090-I-BL

Power dissipation depends on supply voltage and the load resistance. To reduce power dissipation, which may cause overheating, the load resistor should be chosen according to supply voltage. Table 13 and figure 8 show the relation between supply voltage and the permitted load resistance for different temperature ranges.

The green area in figure 8 shows the permitted load resistance depending on supply voltage for operating temperatures up to 80 °C. Combinations of supply voltage and load resistor within the gray colored area are permitted for a limited operating temperature range up to 65°C in addition.

The following values of minimum and maximum load resistance are meant as total resistance as sum of resistance of the load resistor and cable resistance (see 9.3 Cable length and minimum supply voltage for current interface).

U_{dd} [V]	R_L min. [Ω] @ Ta_{max} = 65 °C	R_L min. [Ω] @ Ta_{max} = 80 °C	R_L max. [Ω]
16	0	280	450
24	270	740	850
28	510	970	1050
35	930	1370	1400

Table 13: Minimum, typical and maximum Load Resistance IS1BP360-I-BL + IS2BP090-I-BL

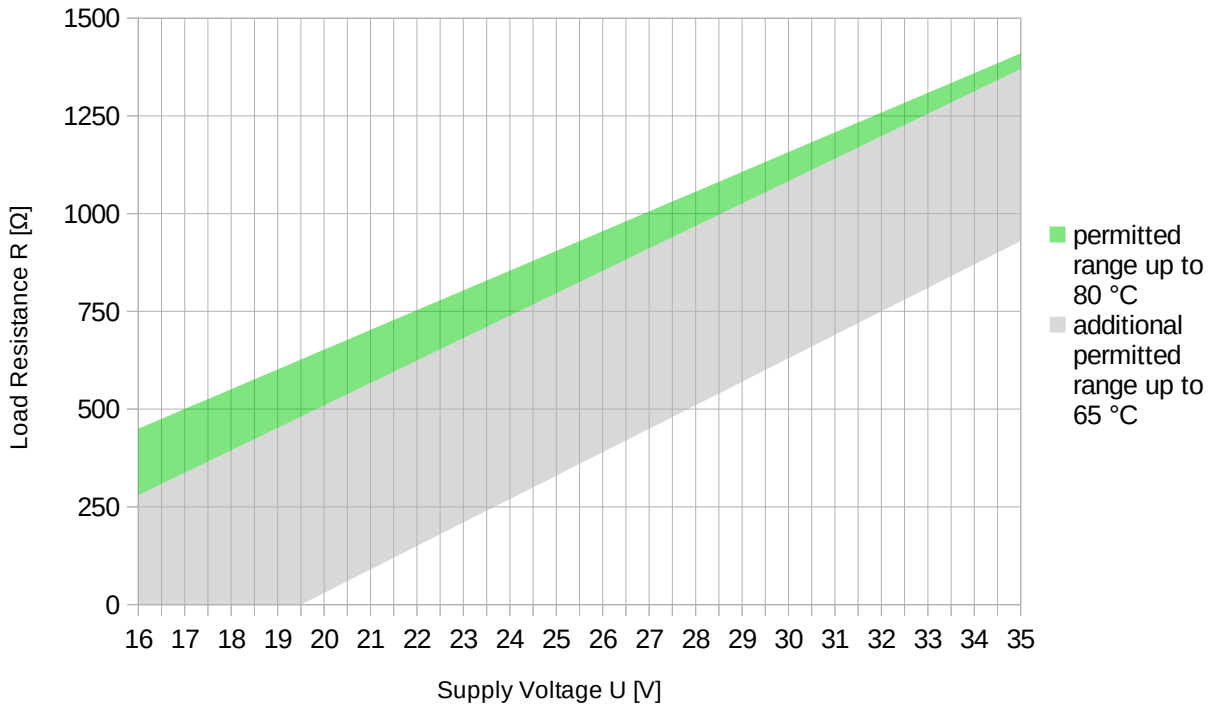


Figure 8: Permitted Load Resistance IS1BP360-I-BL + IS2BP090-I-BL

7 Technical Data IS1BP360-U-BL + IS2BP090-U-BL

General Parameters[14]	IS1BP360-U-BL	IS2BP090-U-BL
Measurement range	360°	±90°
Resolution	0.01° (0.09° at measurement range 360°)	0.01° (0.045° at measurement range ±90°)
Accuracy	Range 0...360° typical ±0.15° maximum ±0.25°	Range up to ±60° typical ±0.10° maximum ±0.20° up to ±80° typical ±0.20° maximum ±0.40°
Cross Sensitivity (compensated)	-	typ. ±0.09° (±0.10 %FS) max. ±0.45° (±0.50 %FS)
Temperature coefficient (zero point)	typ. ±0.01 °/K	
Sampling rate	100 Hz	
Cut-off frequency	typ. 20 Hz, 2nd order (without digital filter) / 0.1 ... 25 Hz, 8th order (with digital filter)filter: critically damped filter 8th order at 2 Hz	
Operating temperature	-40 °C to +80 °C	
Characteristics		
Voltage interface	freely adjustable output in the range 0...10.48 V (factory default: 0...10 V) freely adjustable angle in the range 0...360° / ±90°	
Functions	Teach input for zero point adjustment when installed Limit value , Axis direction and assignment of the outputs are adjustable Digital filter (critically damped (default) or Butterworth lowpass, 8th order)	
Electrical Parameters		
Supply voltage	16 to 35 VDC	
Current consumption	35 mA @ 24 V	
Outputs (short-circuit proof)	capacitive load less than 1 µF, resistive load greater than 1 kΩ	
Mechanical Parameters		
Connection	Sensor connector 5-pole M12 (male)	
Degree of protection	IP65/67	
Dimensions / Weight	plastic housing: 66 mm x 90 mm x 36 mm / about 200 g	
Reliability according EN ISO 13849-1[15]		
MTTF	354 years	
MTTFd	664 years	
CE conformity		
EC Directives		
2014/30/EU	EMC directive	
2011/65/EU	RoHS directive	
Harmonized standards		
DIN EN 61326-1:2013-07	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements	
DIN EN 50581:2013-02	Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances	

Table 14: Technical Data IS1BP360-U-BL + IS2BP090-U-BL

14 All indicated angle accuracies are valid after a running time of 10 minutes at 25 °C, Cut-off frequency 0.3 Hz. Absolute calibration accuracy (at 25 °C): ±0.05°.

15 This product is a standard product and no safety part in accordance with the machinery directive. The calculation is based on an average environment temperature of 40 °C and a usage of 8760 h/a.

Electromagnetic Compatibility (EMC)			
Transient Emissions			
Radiated disturbance / Radio field strength	Limit curves broadband and narrowband DIN EN ISO 14982 (agricultural and forestry machinery) 30 ... 1000 MHz (vertical and horizontal)		
	Limits according to CISPR 11		
Immunity to Radio Frequency Fields (RF fields)			
Strip line according to ISO 11452-5	Limits according to DIN EN ISO 14982 (agricultural and forestry machinery) 20 ... 400 MHz 120 V/m (1 kHz AM) Performance criteria A		
Anechoic chamber according to ISO 11452-2	Limits according to DIN EN ISO 14982 (agricultural and forestry machinery) 200 ... 1000 MHz vertical, 100 V/m (1 kHz AM, 80 %) 800 ... 2000 MHz vertical, 100 V/m (PM, t =577 µs, period 4600 µs) Performance criteria A		
Radio Frequency Fields according to IEC 61000-4-3	Limits according to EN 61326-1		
Immunity to Conducted Disturbances			
Test pulse according to ISO 7637-2 (on-board power supply 24 VDC)	Test pulse 1 -450 V 2a +37 V 2b +20 V 3a -150 V 3b +150 V 4 -12 V 5a +70 V 5b +36 V	Severity level III III III III III III Ri = 1 Ω Ri = 0.5 Ω	Performance criteria C B C A A A B B
Immunity to Electromagnetic Discharge (ESD)			
ESD according to ISO 10605	Limits according to DIN EN ISO 14982 (agricultural and forestry machinery) discharge combination 330 pF / 330 Ω Contact discharge 6 kV bipolar (metallic parts) Air discharge 8 kV bipolar Performance criteria A		
ESD according to IEC 61000-4-2	Limits according to EN 61326-1		

Table 15: Electromagnetic Compatibility (EMC) IS1BP360-U-BL + IS2BP090-U-BL

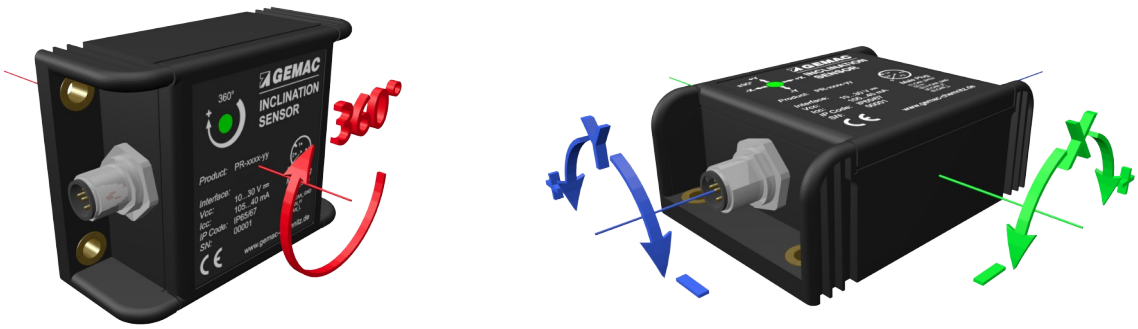


Figure 9: Measurement axes orientation - IS1BP360-U-BL + IS2BP090-U-BL big plastic housing (factory default settings)

8 Mounting

8.1 Position of Drilling Holes

The four drilling holes to mount the sensor are situated in the base plate of the plastic- (figure 10) or aluminum housing (figure 11) respectively.

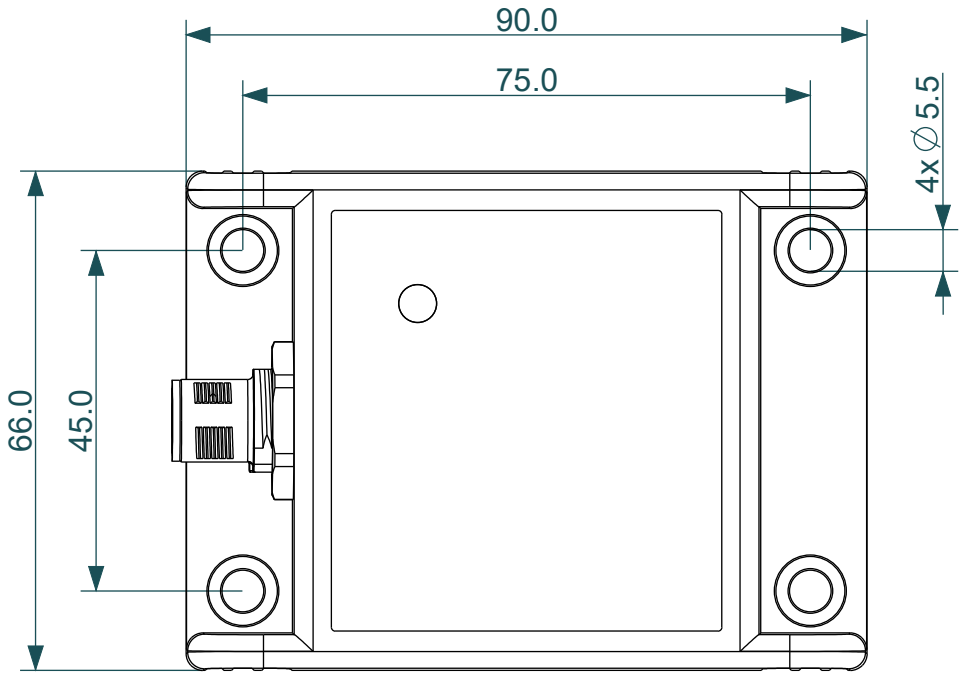


Figure 10: Dimensioned Sketch of big plastic housing (BP) (dimensions in mm)

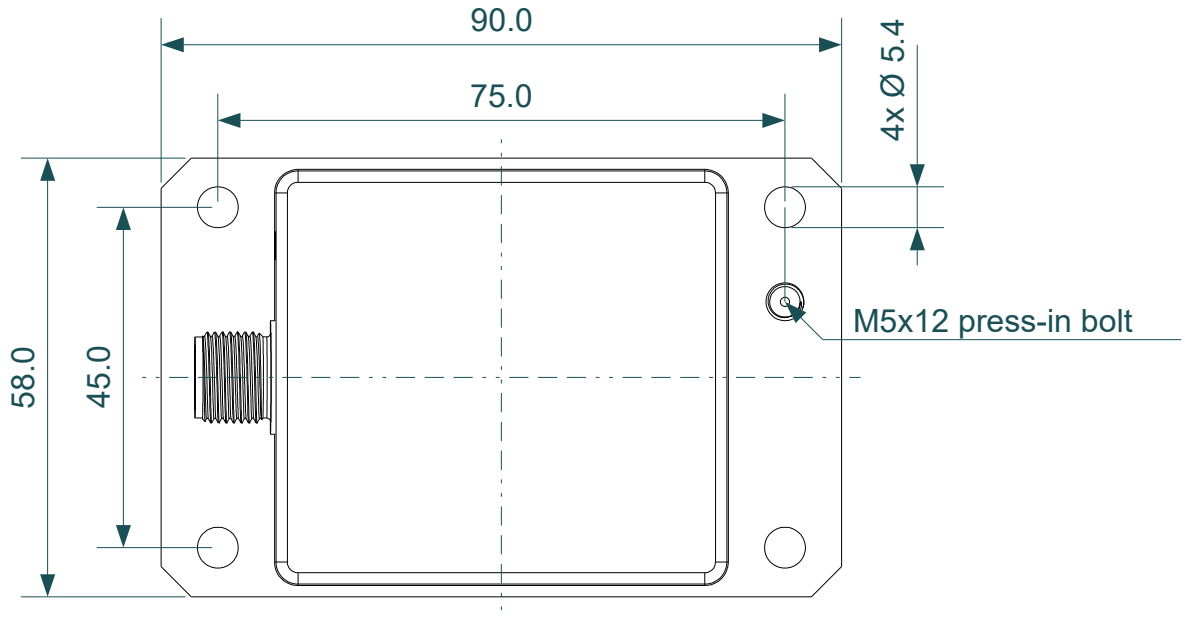


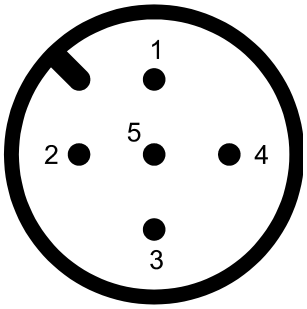
Figure 11: Dimensioned Sketch of aluminum housing (MA) (dimensions in mm)

9 Connection

9.1 Connector Pin Out

The inclination sensors ISxxxxxx-I-xL and ISxxxxxx-U-xL are equipped with a common 5-pole round plug M12 (A-coded).

Pin	Signal	Allocation
1	V+	Supply voltage (+24 V)
2	B-OUT (Standard Y)	Sensor output B
3	V- / GND	Supply voltage ground / Sensor ground
4	A-OUT (Standard X)	Sensor output A
5	TEACH	Input for zero point adjustment



(View from the outside)

Figure 12: Connector Pin Out

9.2 Connection diagram

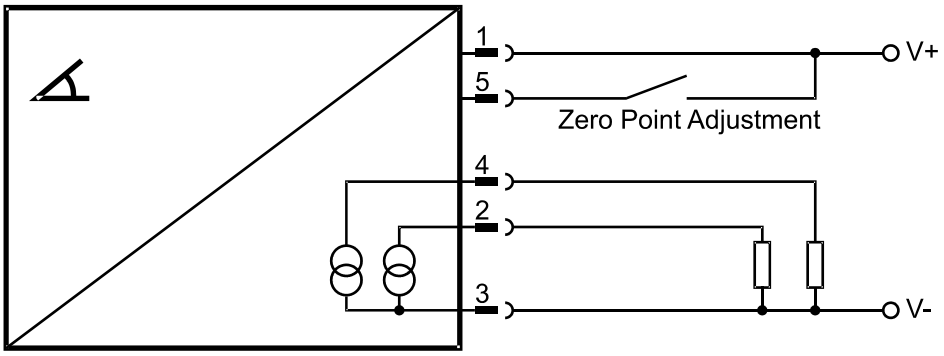


Figure 13: Connection diagram: current interface

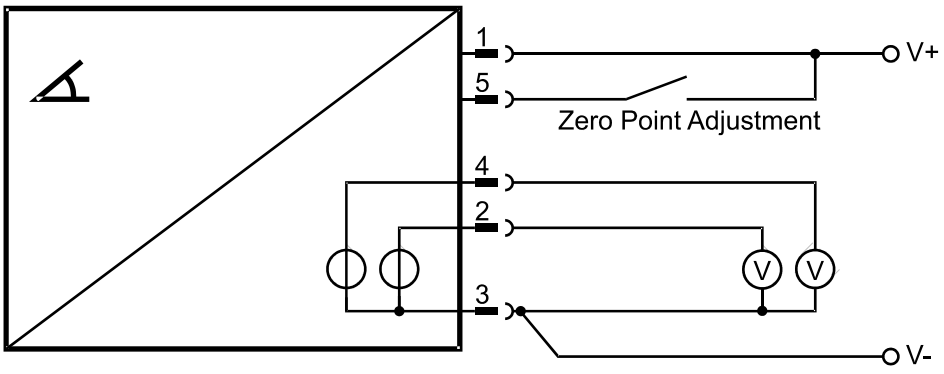


Figure 14: Connection diagram: voltage interface

9.3 Cable length and minimum supply voltage for current interface

At current interface (IS1xx360-I-xL + IS2xx090-I-xL), the required supply voltage is increased by the voltage drop on the connected cable. The highest voltage drop on the cable is produced when the maximum current of 20 mA is flowing through the resistance of the cable (R_L). Here, the resistance of the outgoing and the incoming wire must be taken into account (refer to figure 15).

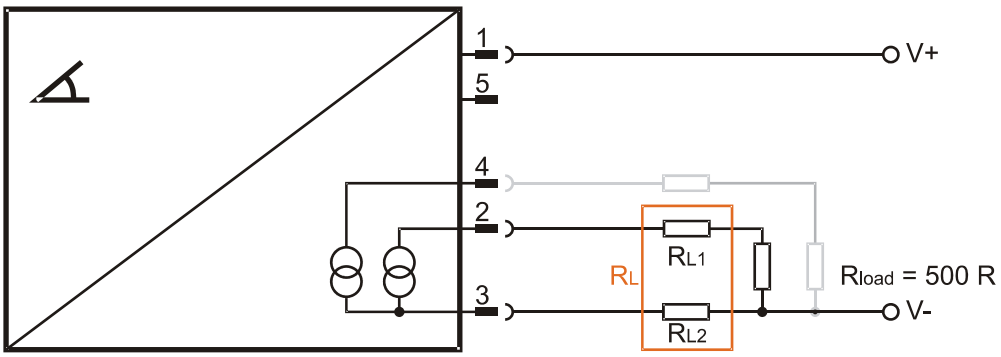


Figure 15: Cable length at current interface

It is necessary to ensure, that the total load resistance as sum of resistance of the load resistor and cable resistance is within the permitted range.

The following table shows examples of the possible cable length at minimum supply voltage and the corresponding wire size (cross section). The table is based on the calculation of the line resistance according to VDE 0295 and a load resistance (R_{load}) of 500 Ω.

Minimum supply voltage in V	Cable resistance in Ω	Maximum cable length in m at wire sizes of:				
		0.14 mm²	0.25 mm²	0.34 mm²	0.50 mm²	0.75 mm²
18	50	176	304	423	623	936
20	150	528	914	1271	1870	2808
22	250	880	1524	2118	3117	4681
24	350	1232	2134	2966	4364	6554
26	450	1584	2743	3813	5610	8426
28	550	1936	3353	4661	6857	10299
30	650	2288	3963	5508	8104	12172

Table 16: Cable length at minimum supply voltage and different wires sizes

10 Functional description

10.1 Axis assignment / Axis direction

All inclination sensors ISxxxxxx-I-xL and ISxxxxxx-U-xL have two analog outputs A and B that can be assigned to any in hardware available X and Y axes for the 2-dimensional inclination sensor and to the rotation axis in the 1-dimensional inclination sensor. An assignment of both outputs to the same axis is also possible. With the optional inversion of the axis direction, every conceivable constellation of the output assignment is possible. The axis direction can be changed by swapping the upper and lower current or voltage output values.

10.2 Zero Point Adjustment

For all inclination sensors ISxxxxxx-I-xL and ISxxxxxx-U-xL, the zero point can be adjusted. This allows to set the zero position in the installed state of the sensor. This can either be made via the PC program ISD-Control in combination with the starter-kit ISPA2 (PR-23999-10), by the teach adapter TA1 (PR-23998-00) or by means of the teach input. To set the zero point using the teaching input, it has to be connected for a period of at least one second with the supply voltage (V+, pin 1). The current position of the inclination sensor is then set for each output to zero degree angle. The sensor will confirm this by turning off the Status LED for the duration of one second. To reset the zero point to factory defaults, the teaching input has to be connected for the duration of three additional seconds to the supply voltage. The sensor will indicate this by turning off the Status LED also for three seconds.

10.3 Digital Filter

The inclination sensors ISxxxxxx-I-xL und ISxxxxxx-U-xL offers the possibility to suppress the influence of external disturbing vibrations. The internal lowpass digital filters (8th order) are programmable down to 0.1 Hz. The sensor has two digital filters that can be selected according to the application of the sensor.

Filter	Adjustable frequency range	Applications
Butterworth	0.1 Hz ... 25 Hz	Static inclination measurement with high damping to vibration
Critically damped	0.1 Hz ... 8 Hz	Inclination measurement in applications that requires a certain dynamism, without overshoot at angle changes with good damping

Table 17: Filter selection

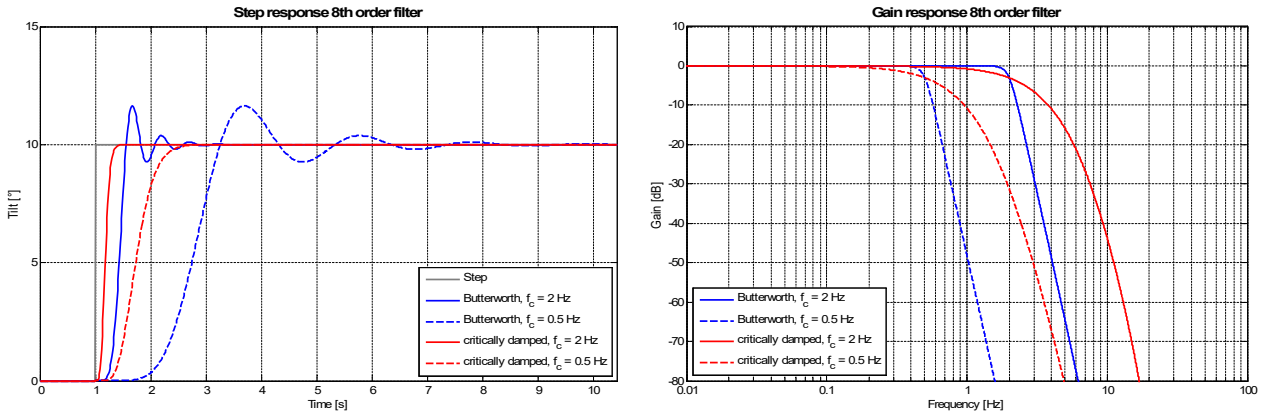


Figure 16: Impulse and amplitude response of the two filters

10.4 Status LED

The integrated two-color Status LED signals the recent device state. The color of the LED distinguish the different device states as shown in Table 18.

Status LED	Description
Off	No power supply or teach confirmation
Green	The device is in working condition
Red	Current interface: one or both outputs in open circuit condition or wrong connected Voltage interface: one or both outputs in short circuit condition or wrong connected

Table 18: Status and Error Display through Status LED

11 Service

11.1 Calibration

Every sensor is calibrated by the manufacturer GEMAC Chemnitz GmbH as standard before delivery.

Even the highest quality sensors have to be recalibrated at certain intervals in order to continue to deliver reliable, safe and error-free measurement results. We therefore recommend regular recalibration. This shall be done exclusively by the manufacturer GEMAC GmbH.

11.2 Service

11.2.1 Reshipment

Reshipment of the sensor for calibration or repairing purposes must be executed in the original packaging or an equivalent packaging. Please indicate a short error description and your phone number for further inquiries.

11.2.2 Support

Please indicate the serial number and the firmware revision of your inclination sensor for technical support.

Manufacturer: GEMAC Chemnitz GmbH
Zwickauer Str. 227
09116 Chemnitz
Germany
Phone: +49 371 3377-0
Fax: +49 371 3377-272
Web: www.gemac-chemnitz.com
Mail: info@gemac-chemnitz.de

11.2.3 Warranty and limitation of liability

We will assume a warranty of 24 months for the sensor, commencing from the date of delivery. Any repairs which are required during this time and fall under the manufacturer's obligation to give a warranty will be performed free of charge. Any damage resulting from improper use of the device or from exceeding of the specified technical parameters is not covered by the manufacturer's obligation to give a warranty.

GEMAC Chemnitz GmbH will only be liable for consequential damage resulting from use of the product in case of deliberate action or gross negligence on its own part.

The General Terms and Conditions of GEMAC Chemnitz GmbH shall apply.

12 Sensor configuration

12.1 Inclination sensor programming adapter

With the optional inclination sensor programming adapter (starter kit ISPA2 - PR-23999-10) it is possible to adjust all inclination sensors with CAN/CANopen, current or voltage interface. The programming adapter is connected via USB to a PC. The connection of the sensors with the programming adapter is realized through various included adapter cables. The inclination sensor is supplied with power through the adapter. Except for the ISxTKxxx-C-RL there is no additional power supply necessary.

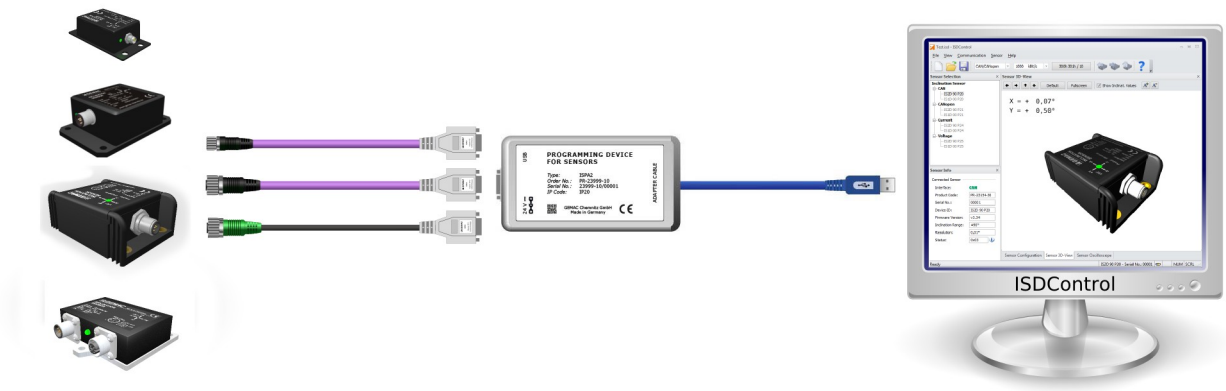


Figure 17: Starter kit

12.2 PC software ISDControl

The parametrization of all possible values is done with the PC software ISDControl, which is included in all starter kits. Each configuration can be stored in a file.

12.2.1 Configuration of all values

For all inclination sensors, the adjustment of the parameters can be done either numerically or graphically. (refer to figure 18 and figure 19).

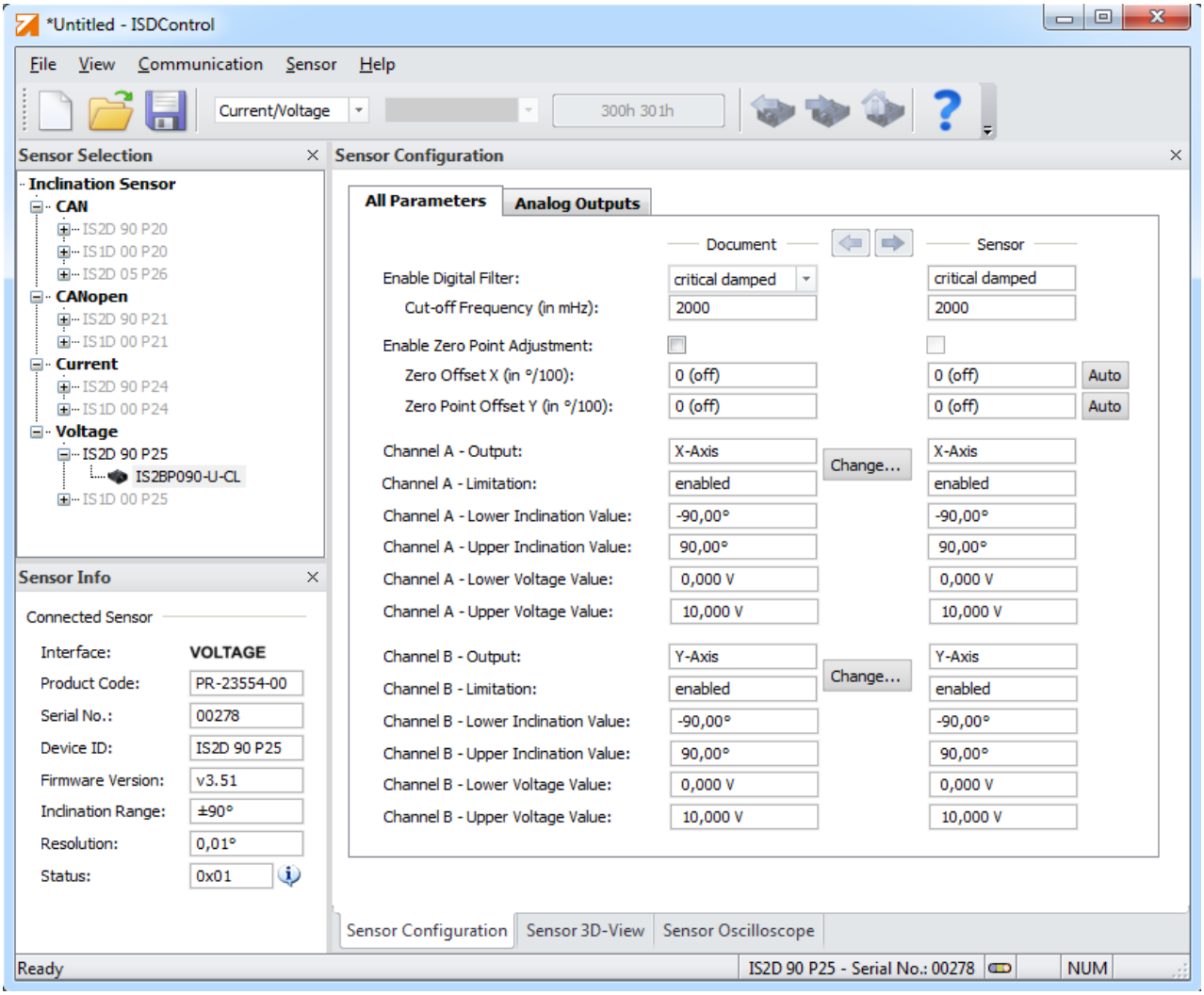


Figure 18: Numerical configuration of the inclination sensor

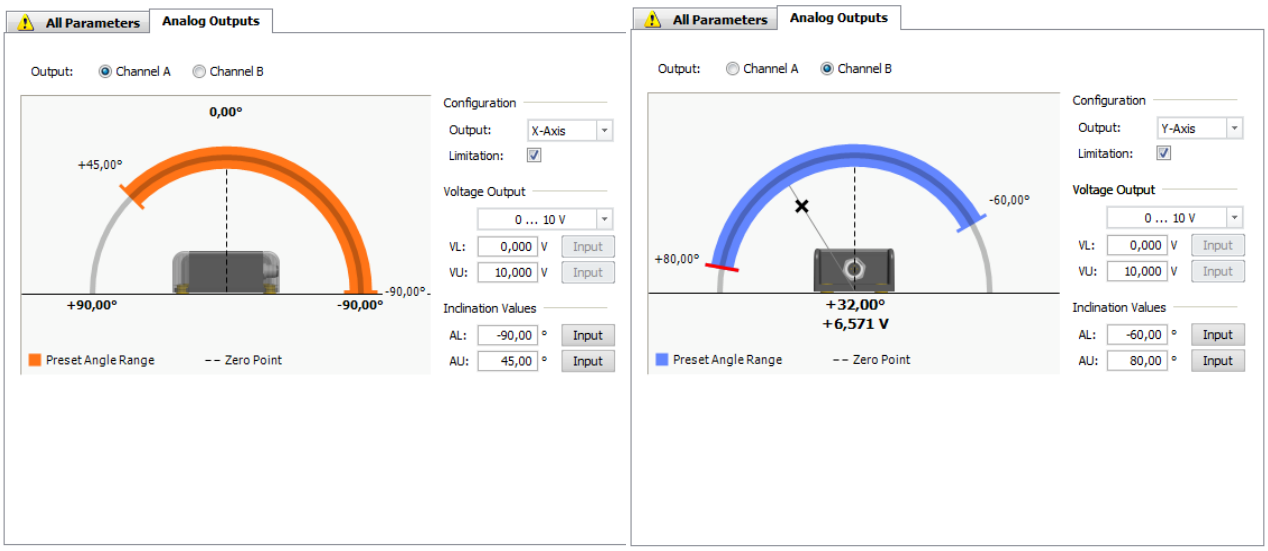


Figure 19: Graphical configuration of the outputs A and B

12.2.2 3D imaging and display of the current angle

Using the programs integrated 3D view, the position of the sensor in space can be visualized.

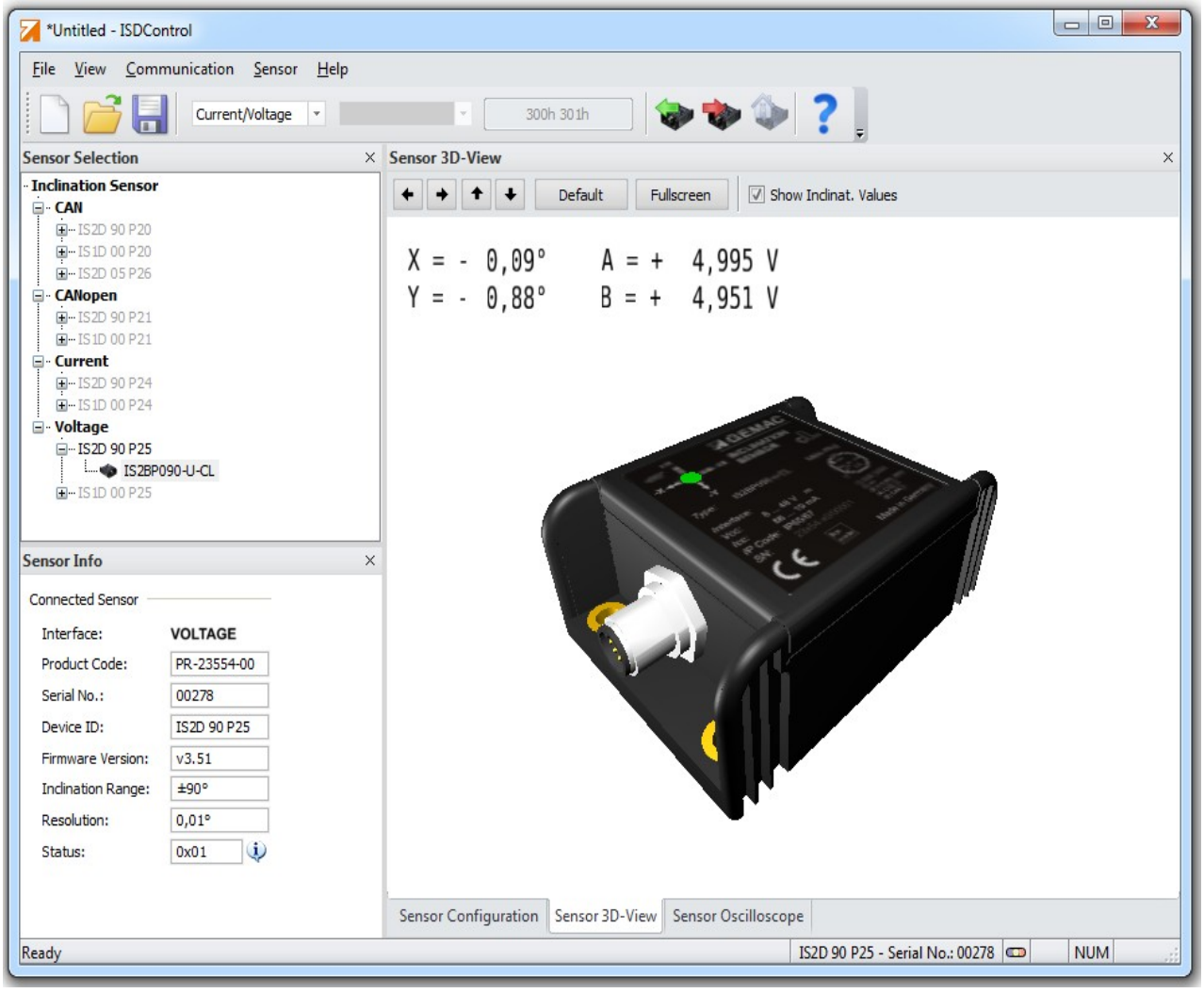


Figure 20: 3D imaging and display of the current angle

12.2.3 Oscilloscope display of the current angle

In the oscilloscope display, the influence of the adjustable digital filter can be controlled directly. Time base of the view, and amplitude and offset can be set analog to the operation of an oscilloscope.

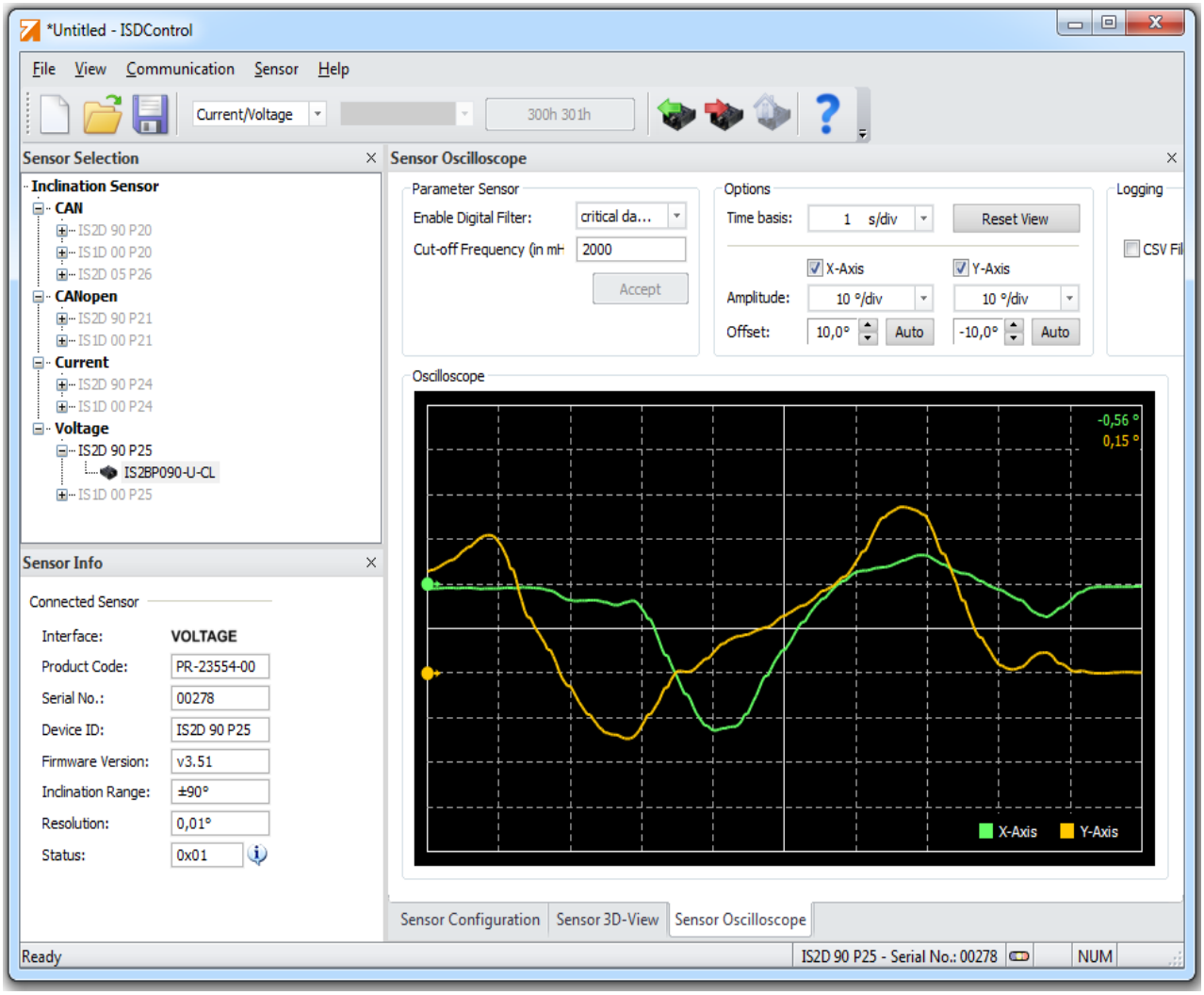


Figure 21: Oscilloscope display of the current angle

13 Ordering Information

Article Number	Product Type	Interface (default)	Axes / measurement range	Housing
PR-23450-00	IS1BP360-I-CL	4 ... 20 mA	1-dimensional, 360°	big plastic housing
PR-23454-00	IS2BP090-I-CL	4 ... 20 mA	2-dimensional, ±90°	big plastic housing
PR-23550-00	IS1BP360-U-CL	0 ... 10 V	1-dimensional, 360°	big plastic housing
PR-23554-00	IS2BP090-U-CL	0 ... 10 V	2-dimensional, ±90°	big plastic housing
PR-25400-00	IS1MA360-I-BL	4 ... 20 mA	1-dimensional, 360°	aluminum housing
PR-25404-00	IS2MA090-I-BL	4 ... 20 mA	2-dimensional, ±90°	aluminum housing
PR-25500-00	IS1MA360-U-BL	0 ... 10 V	1-dimensional, 360°	aluminum housing
PR-25504-00	IS2MA090-U-BL	0 ... 10 V	2-dimensional, ±90°	aluminum housing
PR-25450-00	IS1BP360-I-BL	4 ... 20 mA	1-dimensional, 360°	big plastic housing
PR-25454-00	IS2BP090-I-BL	4 ... 20 mA	2-dimensional, ±90°	big plastic housing
PR-25550-00	IS1BP360-U-BL	0 ... 10 V	1-dimensional, 360°	big plastic housing
PR-25554-00	IS2BP090-U-BL	0 ... 10 V	2-dimensional, ±90°	big plastic housing
PR-23998-00	TA1	Teach adapter		
PR-23999-10	ISPA2	Inclination sensor programming adapter (Starter kit including programming adapter, cables and PC software)		

Table 19: Ordering Information