

# Manual

With application basics

## **KAS200 series** **Measuring acceleration, inclination and vibration**



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# 1 Application

Typical applications for the KAS200 series sensors are:

- Inclination limiter (tilt sensor)
- Levelling
- Inclination
- Acceleration
- Vibration

Depending on the specific application the best suitable type must be selected.  
Please contact our product specialists for information. Phone: +41 44 806 22 00.

## 1.1 Tilt and levelling applications

Typical applications can be tilt limiters, levelling of machinery, apparatuses or measuring equipment, automatic levelling of jibs / booms, excavator shovels, platforms etc.

Examples:

High resolution for small angle / small inclination ranges:

KAS211-4xA for ranges from +/- 1,5° to +/- 9° (Example KAS211-42A has +/- 3° measuring range)

KAS201-50A: Measuring range +/- 20°, dual axis

KAS201-51A: Measuring range +/- 30°, dual axis

KAS201-52A: Measuring range +/- 90°, dual axis

## 1.2 Inclination and angle measuring

Examples: inclination measuring in measuring equipment like lasers, in vehicles, robots, surgical operation tables, building and production machinery.

Examples: (Please see also chapter 1.1)

KAS201-50A: Measuring range +/- 20°, dual axis

KAS201-51A: Measuring range +/- 30°, dual axis

KAS201-52A: Measuring range +/- 90°, dual axis

## 1.3 Acceleration measuring

Applications such as shock and crash monitoring, movement monitoring and recording for fitness analysis or elderly / handicapped persons combined with alert systems, free fall detection, automobile equipment as ESP (electronic stabilising program) and ABS (anti blocking system).

Examples:

KAS201, KAS202 and KAS203 Versions with +/-1.7, +/-2, +/-4, +/-6, +/-12 and +/-18g measuring ranges and damping's from 50 to 1000 Hz (different versions)

(Please see also chapter 1.4)

## 1.4 Vibration measuring

Applications are for example bearing damage monitoring, theft protection, earth quake safety switch-off devices.

Examples:

KAS201, KAS202 and KAS203 Versions with +/-1.7, +/-2, +/-4, +/-6, +/-12 and +/-18g measuring ranges and damping's from 50 to 1000 Hz (different versions)

For very small Vibration (ranges +/- 0,026... +/- 1g and 0...18 Hz 3db) the series KAS211, KAS201 und KAS202 could be used.

There are resolution up to 1,1mA/mg possible (KAS211-41A)

## 2 Specifications / Technology

### 2.1 Shock resistance of the sensing element

The sensing elements based on capacitive measuring principle feature high precision and high shock resistance, resulting from the particular three dimensional micromechanics technology made of high purity silicon. Thanks to the optimized structure, no drifts caused by deformation must be expected, even after severe shocks (20'000g).

### 2.2 Repeatability and long term stability

Repeatability up to 0,01° or 0,2mg and long term stabilities of the same order can be achieved. The hysteresis (e.g. 0,01°) caused by quick temperature (e.g. from 20° to -10°C in few seconds) changes degenerates mostly to zero within a short time.

HTB Simulations has shown long-term stabilities by the pendulum from 0,036° / 0,6mg in 10 years

### 2.3 Resolution

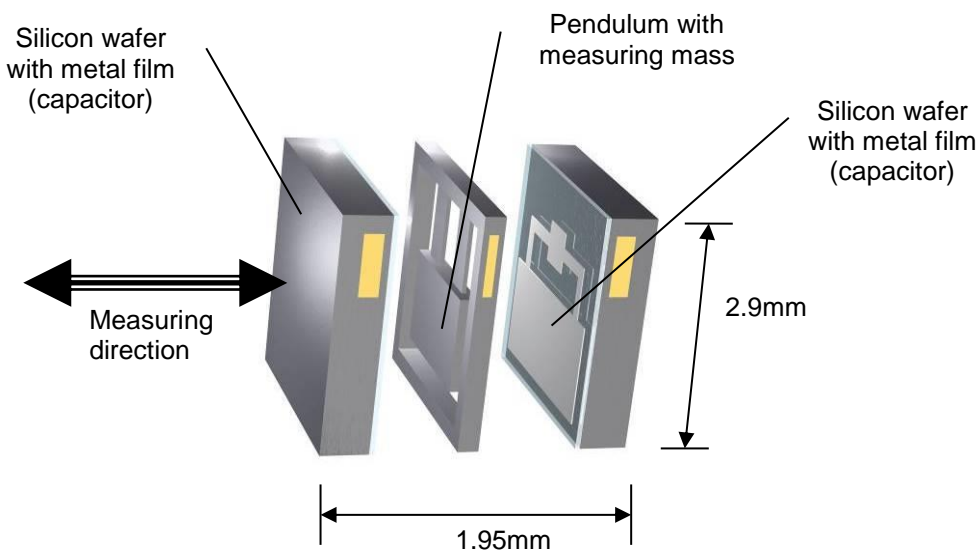
The sensing elements formed by a dual capacitor produce extremely low noise levels and a high output signal. The major part of the noise is caused by the signal conditioning circuitry. Belong to the Types resolutions of >0,001° (KAS211-Serie up to 5,33mA/°) are possible. To reach this there may be additional averaging in the control unit necessary.

### 2.4 Advantages by gas damping

Influences by vibrations may interfere with **inclination** measuring. The gas attenuation in the sensing element filters a good part of such interferences and in addition helps avoid overshooting of the sensing pendulum. For inclination sensors the influence of vibrations is reduced, for vibration sensors the sensor's natural resonance is damped. This means that the appropriate sensor type must be selected for each application.

In Vibration sensing frequency selection are so optimal possible. Also **Resonance frequency effects** are excluded.

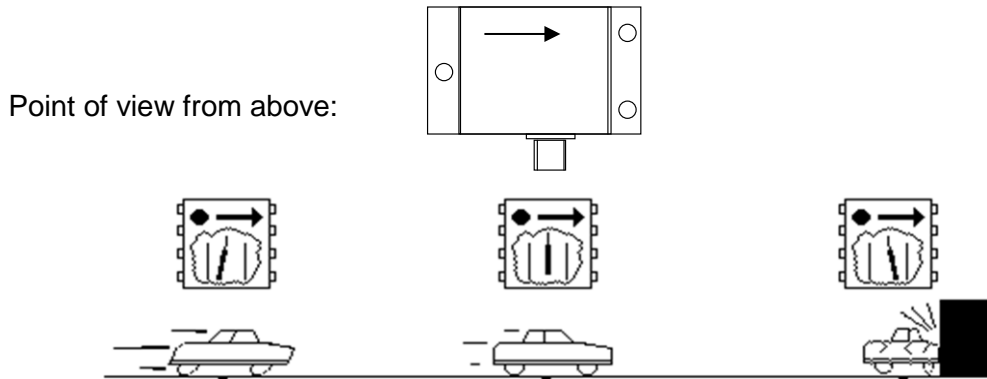
### 2.5 Structure of the sensing element



**2.6 Functional principle**

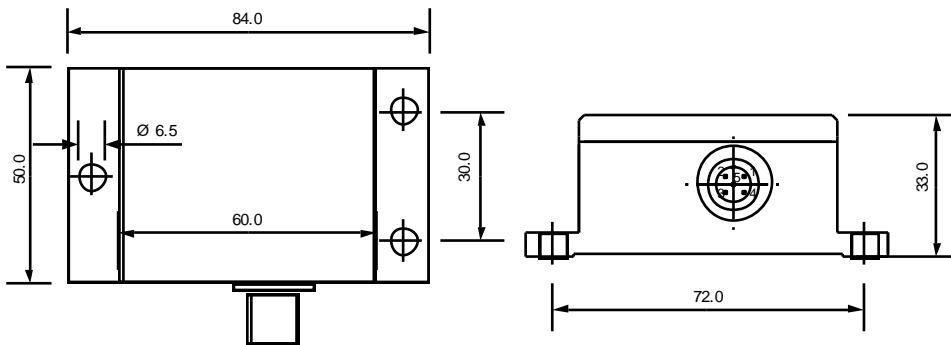
The pendulum with the measuring mass is moved in the measuring direction by a force (acceleration, inclination, vibration) acting in this direction. The movement of the measuring mass causes a change of capacitance which is registered as primary measuring signal. The 4...20mA signal output is proportional to the deflection, thus to the acceleration. For inclination measuring the conversion from  $g = 9.81 \text{ m/s}^2$  into angular degrees is a sine function. For a sensor with small measuring range (e.g. KAS211-42A with +/- 3° measuring range) the sinus function has in our meaning no relevance.

Measuring principle and alignment (e.g. for acceleration / shocks)



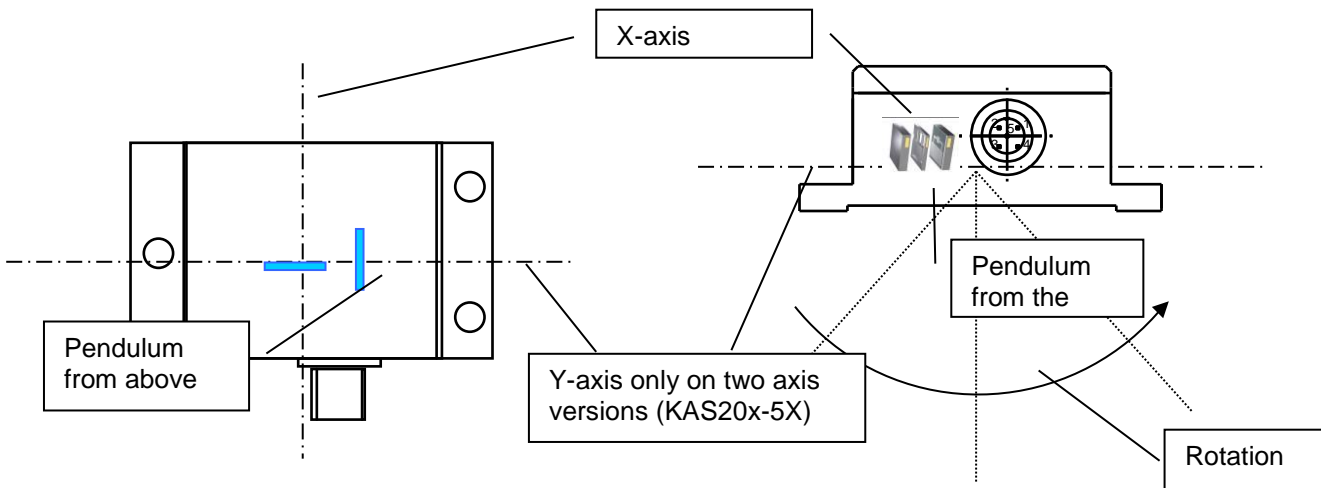
### 3 Mechanical mounting

#### 3.1 Positioning for inclination measuring



The housings are marked with a symbol indicating the measuring direction.

##### 3.1.1 Typical Application

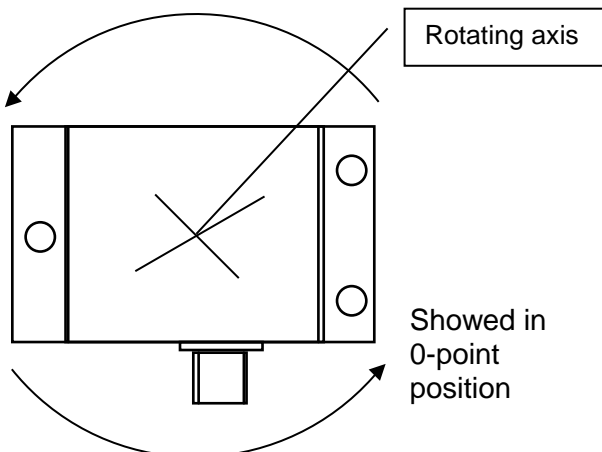


The position of the axis shown is only indicative for illustration and does not show the exact position  
**Position on 0g = 0° position**

##### 3.1.2 360° angle measuring

(Versions KAS201-xx and KAS202-xx)

To reach 360° output the two output channels should be miscalculate on the controlling unit.  
**For real 360° (+/-180°) with calibrate output we recommend our KAS1001-06A with RS485 output.**



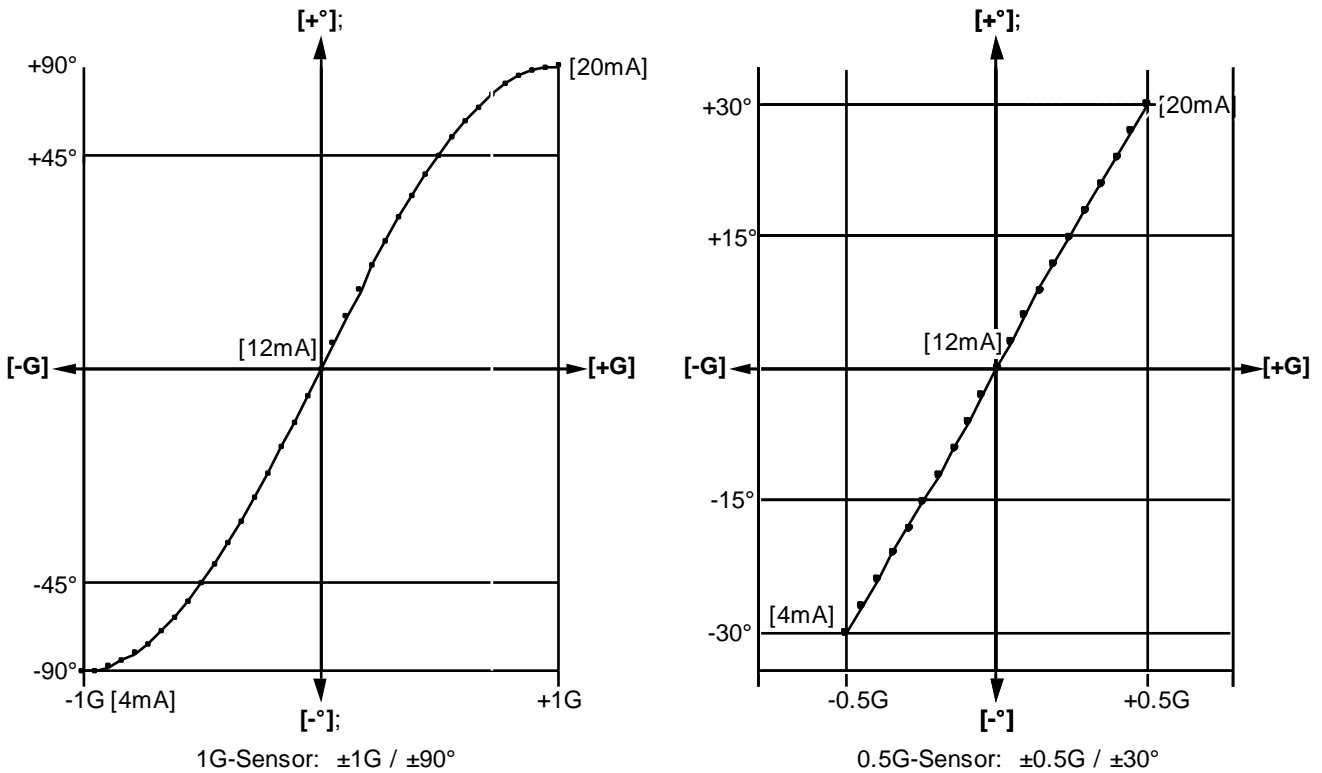
**Alternative Mounting for KAS201-xx, KAS202-xx and KAS211-xx Versions**

The Position on the left hand side showed can also use for **one-axis** Applications

It may reduce be the precision slightly.

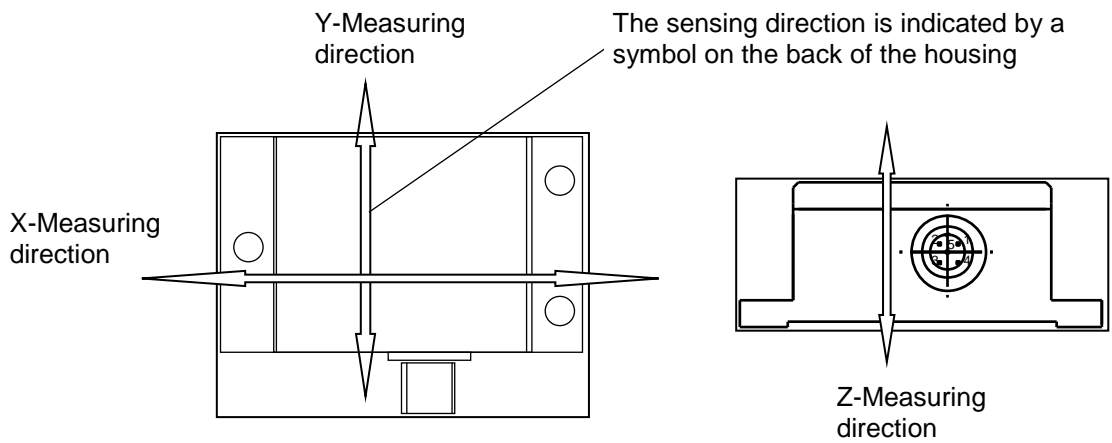
**3.2 Output signal depending on inclination (° versus g)**

As the angle between earth gravity's direction (always vertical) and the sensing elements' measuring tongue changes with inclination, the relation between inclination angle and output signal is a sine function.



For horizontal acceleration, the output is linear proportional to the acceleration. (For vertical acceleration an offset of 1g is to be considered, so a g-Range higher than 1g must be selected).

**3.3 Mounting for acceleration and vibration measuring**



**3.4 Offset-Alignment**

Caused by the integration into the application a mechanical offset between the sensor and the application may occur. For precise measuring we recommend an offset alignment adjustment on the controlling unit at the position 0g ⇔ 0°.

On our the **digital** inclination and angle sensor KAS100x there is possible to adjust the 0-point into the sensor itself. Thus the absolute precision increases considerably.

### 3.5 Temperature compensation

Due to shrinking / dilatation of the sensing element at temperature variations the geometry of the element slightly varies. This will have an effect on the result of the measurement. Due to the symmetrical shape of the sensing element, most of this effect is automatically compensated. The remaining drift caused by temperature variation is very low, but should be compensated additionally for high precision applications.

The temperature dependency in the KAS211-series (caused by the dual pendulum system) much better.

#### Methods/Options:

- Developed new from **KELAG developed stabilization method**.
- If simulation of temperatures in application possible, then could this dependency stored in the control-unit of the customer. The internal temperature-sensor may be a help. This command is available to request.
- Customized sensor with stored temperature coefficients: This method request expensive calibration method from each sensor.

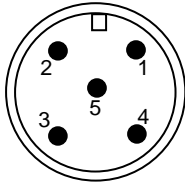


## 4 Electrical Specifications

### 4.1 Power supply

Input supply voltage: 20...30 (max. 36) VDC  
 Power consumption 0°: 18mA

### 4.2 Connector and pinout



Connector	Cable	Function
1	brown	Inputvoltage
2	white	Ground
3	blue	Direction 1 4..20mA
4	black	Direction 2 4..20mA
5	grey	Shield
Housing	Shield	

Mating connector

M12 Connection cable

### 4.3 Connection cable

(Not included in the delivery)

#### 4.3.1 Wiring

If you use an cable with standardized colours (like ours: 40PKabelM12 with M12 connector) following colours are valid :

1 = brown, 2 = with, 3 = blue, 4 = black, 5 = grey

#### 4.3.2 Leak Tightness

Please use only cable with connector which guarantees IP67 or/and IP68. *For this we recommend our overmolded PUR-cable with connector.*

Alternatively we can offer Sensor with implemented PUR-cable with IP69 cable clamp. This version we tested 5 weeks in depth of 10m under water.

## 5 Specification

### 5.1 KAS201-Serie

Parameter	Condition	KAS201-50A	KAS201-51A	KAS201-52A	Unit
Measuring range <sup>4)</sup>		+/- 0.34 +/- 20	+/- 0.5 +/- 30	+/- 1 +/-90	g °
Repeatability at 0° (horizontal position) <sup>1)</sup>	at 20°C, typically	0,25 0,014			mg °
Resolution at 0° / 1g	DC .. 1Hz typisch	0,015 0,002		0,015 0,003	mg °
typ. Offset temperature dependency <sup>7)</sup>	20..60°C	-0 / +0,066 -0 / +0,006			mg / °C ° / °C
long term stability <sup>6)</sup>	10 years <sup>6)</sup>	0,62 0,036			mg °
Measuring direction	axis	X / Y			
Cross axis sensitivity <sup>2)</sup>	max/typ	4/1			%
Damping	-3 dB	18 <sup>5)</sup>			Hz
Operating temperature range	not condensing	-40 .. +85			°C
Shock resistance Chip	min.	20'000			g
Output signal I <sub>out</sub>		4 .. 20			mA
Output signal 0°-position		12			mA
Sensitivity	nominal <sup>4)</sup>	0.41	0.28	0.14	mA/°
	nominal	23.5	16	8	mA/g
Power supply <sup>3)</sup>	stabilized	20 .. 30			VDC
Connection		M12male			
Water resistance <sup>8)</sup>		IP67/68/69 <sup>8)</sup>			IP-class

1) **Repeatability:** maximum offset occurring with position change after return to initial position (corresponds to achievable precision, including temperature hysteresis after temperature compensation and linearization).

2) **Cross axis sensitivity:** maximum error occurring with (additional) inclination or acceleration from another direction than the measuring plane

3) **Supply** stabilized

4) **Measuring range:** Trigonometric function

$$\text{angle} = \arcsin\left(\frac{I_{\text{out}} - 12(\text{Off set})}{\text{Sensitivity}}\right)$$

(values without units)

5) Typical values

6) **Long term stability:** calculated values from HTB tests. Test results available at request.

7) Related to sensing element

8) IP69 : cable with cable clamp instead of connector

**5.2 KAS202-Series**

Parameter	Condition	KAS202-57A	KAS202-58A	Unit
Measuring range <sup>4)</sup>		+/- 2	+/- 4	g °
Repeatability at 0° (horizontal position) <sup>1)</sup>	20°C typically	2 (0,2)	<4	mg °
Resolution at 0° / 1g	DC .. 1Hz typically	0,08	<2	mg °
typ. Offset temperature dependency <sup>7)</sup>	20..60°C	ca. 0,5	ca. 1,1	mg / °C ° / °C
long term stability <sup>6)</sup>	10 years <sup>6)</sup>	ca. +/- 2 <sup>7)</sup>	ca. +/- 4 <sup>7)</sup>	mg °
Measuring direction	axis	X / Y		
Cross axis sensitivity <sup>2)</sup>	max / typ	4/1		%
Damping	-3 dB	115 <sup>5)</sup>		Hz
Operating temperature range	not condensing	-40 .. +85		°C
Shock resistance Chip <sup>7)</sup>	min	20'000		g
Output signal I <sub>out</sub>		4 .. 20		mA
Output signal I <sub>out</sub> 0°-position		12		mA
Sensitivity	nominal <sup>4)</sup>	(0.07)		mA/°
	nominal	4	2	mA/g
Power supply <sup>3)</sup>	stabilized	20 .. 30		VDC
Connection		M12male		
Water resistance <sup>8)</sup>		IP67/68/69 <sup>8)</sup>		IP-class

- 1) **Repeatability:** maximum offset occurring with position change after return to initial position (corresponds to achievable precision, including temperature hysteresis after temperature compensation and linearization).
- 2) **Cross axis sensitivity:** maximum error occurring with (additional) inclination or acceleration from another direction than the measuring plane
- 3) **Supply stabilized**
- 4) **Measuring range:** Trigonometric function

$$\text{angle} = \arcsin\left(\frac{I_{\text{out}} - 12 (\text{Offset})}{\text{Sensitivity}}\right)$$

(values without units)

- 5) Typical values
- 6) **Long term stability:** calculated values from HTB tests. Test results available at request.
- 7) Related to sensing element
- 8) IP69 : cable with cable clamp instead of connector

### 5.3 KAS203-Series

Parameter	Condition	KAS203 -11A	KAS203 -12A	KAS203 -01A	KAS203 -02A	KAS203 -21A	KAS203 -22A	Unit
Measuring range <sup>4)</sup>		+/- 6	+/- 6	+/- 12	+/- 12	+/- 18	+/- 18	g
Repeatability at 0° (horizontal position) <sup>1)</sup>	20°C	<4				<6		mg
Typ Resolution at 0° / 1g	DC ... 400Hz	2				3		mg
Noise sensig element		100				150		µg√Hz
typ. Offset temperature dependency	13...37°C	1,25				1,9		mg / °C
long term stability <sup>5)6)</sup>	10 Jahre	7				11		mg
Cross axis sensitivity <sup>2)</sup>	max. / typ	4/1						%
Measuring direction		X / Y						
Damping	-3 dB	400	1000	400	1000	400	1000	Hz
Operating temperature range <sup>8)</sup>	not condensing	-40..+85						°C
Shock resistance Chip <sup>7)</sup>	Min.	20'000						g
Output signal I <sub>out</sub>		4..20						
Output signal I <sub>out</sub> 0°-position		12 <sup>7)</sup>						
Sensitivity	Nominal	1.333 <sup>7)</sup>		0.666 <sup>7)</sup>		0.444 <sup>7)</sup>		mA/g
Power supply <sup>3)</sup>	stabilized	20... 30						VDC
Connection		M12						
Water resistance		IP67/68/69 <sup>8)</sup>						IP-class

- 1) **Repeatability:** maximum offset occurring with position change after return to initial position (corresponds to achievable precision, including temperature hysteresis after temperature compensation and linearization).
- 2) **Cross axis sensitivity:** maximum error occurring with (additional) inclination or acceleration from another direction than the measuring plane
- 3) **Supply** stabilized
- 4) Static angle (inclinometer) measuring possible: 1g = 90°, Trigonometric function

$$\text{angle} = \arcsin\left(\frac{I_{\text{out}} - 12 (\text{Off set})}{\text{Sensitivity}}\right)$$

(values without units)

- 5) Typical values
- 6) **Long term stability:** calculated values from HTB tests. Test results available at request.
- 7) Related to sensing element
- 8) IP69 : cable with cable clamp instead of connector

**5.4 KAS211-Series**

Parameter	Condition	KAS211 -41	KAS211 -42	KAS211 -44	KAS211 -46	Unit
Measuring range <sup>4)</sup>	nominal	+/- 1,5 0,026	+/- 3 0,052	+/- 6 0,104	+/- 9 0,156	° g
Measuring direction		X ( horizontal )				
Repeatability at 0° <sup>1)</sup>	20°C typ.	0,01 0,17				° mm/m & mg
Resolution	20°C typ.	<0,001				°
Noise (Sensor element)		<0,017				mm/m & mg
Temperature dependency <sup>9)</sup> Typically <sup>9)</sup>	23...70°C	0,0015 0,026 0,026				°/ °C mm/m °C mg °C
	-22...+23°C	0,0023 0,04 0,04				° / °C mm/m °C mg °C
long term stability <sup>5)6)</sup>	10 Jahre <sup>6)</sup>	0,036 0,63				° mm/m & mg
Cross axis sensitivity <sup>2)</sup>	max. / typ	4/1				%
Damping (vibration) <sup>5)</sup>	-3 dB	18				Hz
Operating temperature range	not condensing	-40... +85				°C
Shock resistance <sup>7)</sup>	min.	20'000				g
Output signal I <sub>out</sub>	nominal	4...20				mA
Output signal I <sub>out</sub> 0°-position	nominal	12				mA
Sensitivity	nominal nominal	5,6 307,7	2,8 153,8	1,4 76,9	0,933 52,3	mA/° mA/g
Power supply <sup>3)</sup>	stabilized	20... 30				VDC
Connection		M12male				
Water resistance <sup>8)</sup>		IP67/68/69 <sup>8)</sup>				IP-class

- 1) **Repeatability:** maximum offset on horizontal position occurring with position change after return to initial position (corresponds to achievable precision, including temperature hysteresis after temperature compensation and linearization).
- 2) **Cross axis sensitivity:** maximum error occurring with (additional) inclination or acceleration from another direction than the measuring plane
- 3) **Supply** stabilized
- 4) **Measuring range:** Trigonometric function:  

$$\text{angle} = \arcsin\left(\frac{I_{\text{out}} - 12 (\text{Off set})}{\text{Sensitivity}}\right)$$

(paste values without units)
- 5) Typical values
- 6) **Long term stability:** calculated values from HTB tests. Test results available at request.
- 7) Related to sensing element
- 8) IP69 : cable with cable clamp instead of connector