Instruction Manual

4-20 mA
Vibration Sensor
Type

KSI84xx

v1.31.030

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Contents

1 Purpose

The vibration sensors of the KSI84xx family are used to measure vibration acceleration or velocity on machines and objects.

The sensors measure the vibration amplitude within a specified frequency range in axial sensor direction and outputs the measuring result as a 4-20 mA current loop signal. The sensor is supplied with power via the same signal line.

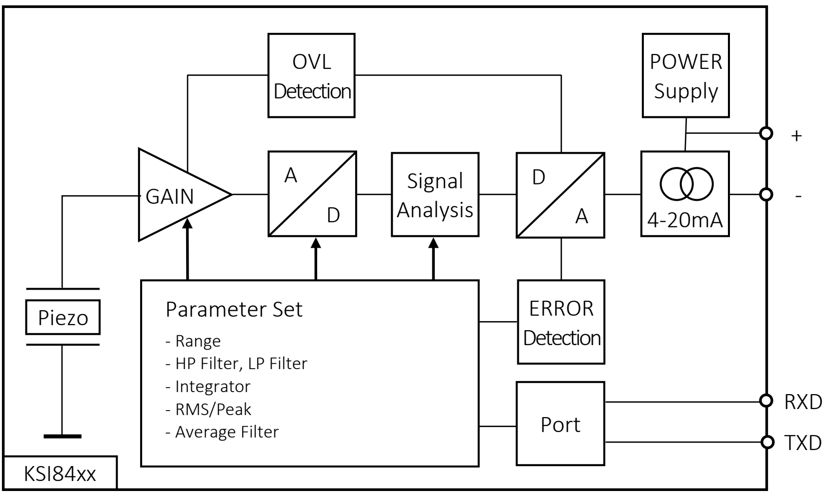
The sensor parameters are adjustable. There are different types for different applications in several measuring ranges. The sensors comply with the specifications for vibration measuring devices according to ISO 2954.

Possible applications are:

1. Measurement of the smooth running of rotating machines and reciprocating machines according to ISO 10816 / ISO 20816.
2. Measurement of bearing vibrations according to VDI 3832.
3. Measurement of vibrations in defined frequency ranges.

The sensors are suitable for use in harsh environmental conditions. The housing is double shielded, electrically isolated and complies with protection grade IP68.

2 Function



The sensors of the KSI84xx family are piezoelectric vibration sensors.

The sensing element is a piezoelectric material, which outputs an electrical signal proportional to acceleration. This signal is first amplified and then digitized.

The signal analysis is digital. The signal is filtered (HP, LP), optionally integrated and the amplitude value is calculated, either as RMS or PEAK value. Finally, the amplitude value is converted into a 4-20 mA current loop signal with a 16 bit DAC.

Either the acceleration (without integration) or the velocity (with integration) of the vibration can be measured.

In addition, proper sensor function and input signal are monitored. Defects or overloads are signaled by an error current value.

Before delivery, the sensor is parameterized according to the type code selected by the customer.

3 Type Selection

There are four different basic types, which differ in the measured quantity (acceleration or velocity) and the amplitude mode (RMS or PEAK).

Sensor type		KSI84AR-xx	KSI84AP-xx	KSI84VR-xx	KSI84VP-xx
Quantity	**Q**	Acceleration		Velocity	
Mode	**M**	RMS	PEAK	RMS	PEAK

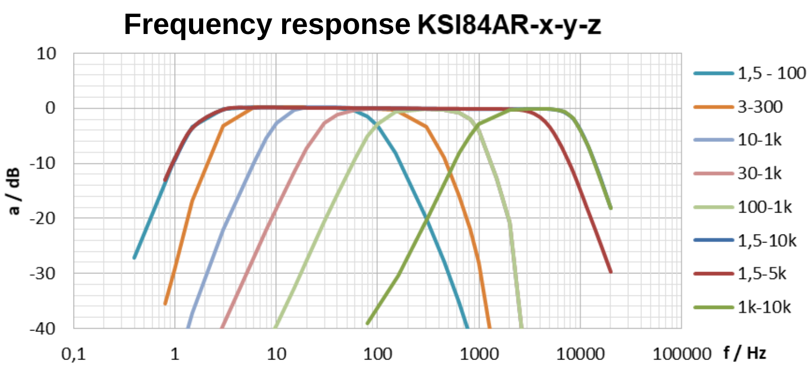
Furthermore, the types differ in the measured frequency range (HP, LP) and in their measuring range.

3.1 Frequency Range (HP, LP)

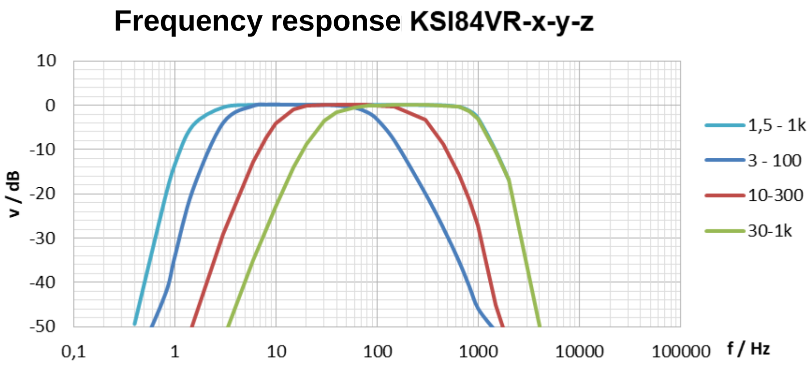
The used frequency range of a sensor type is described by the values HP and LP in the type table.

HP is the -3 dB cutoff frequency of the high pass filter and determines the lower cutoff frequency of the sensor.
LP is the -3 dB cutoff frequency of the low pass filter and determines the upper cutoff frequency of the sensor.
All frequencies between the lower and upper cutoff frequency have an impact to the measuring result.

Sensors measuring **acceleration** have a 2nd order IIR high pass and low pass filter with a stopband attenuation of -40 dB/decade.



The HP filter of **velocity** sensor types has a stopband attenuation of -50 dB/decade, the LP filter has a stopband attenuation of - 40 dB/decade.



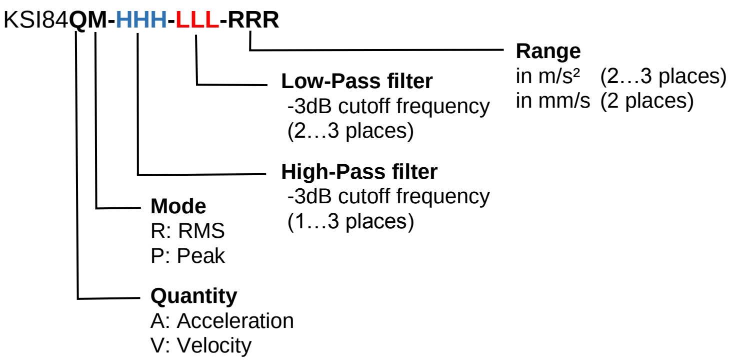
3.2 Measuring Range

The “Range” value in the type table corresponds to the measured value at which the sensor current is 20 mA. At this level the sensor output is regarded as 100 %.

The measured value must always be within the linear measuring range. This is the range from 1 % to 112.5 % referred to 20 mA.

3.3 Type Code

The type code is printed on the sensor housing. It is composed according to the following key. Note that only integer values without decimal places are printed in the type code.



4 Sensor Operation

4.1 Sensor Mounting

The choice of an appropriate measuring point on the target is important for accurate vibration measurement. It can be helpful to consult a specialist in machine monitoring for this purpose.

In general, it is advisable to measure vibrations as near as possible to their source. This minimizes errors by transmitting mechanical components.
Suitable measuring points are rigid components, for instance the housing of bearings or gearboxes. Not recommended for vibration measurement are lightweight, flexible and soft components. The standard ISO 10816-1 gives some recommendations for suitable measuring points.

The KSI84xx is mounted via the M8 thread in the sensor base. The sensor can either be mounted directly using the M8 mounting stud type 043 or with the help of the mounting pad type 229 with M8 stud by epoxy cementing on the object.

Alternatively, the senor can also be fixed by the magnetic base type 208 (M8) or type 008 (M5) in combination with the thread adapter type 044.

The sensor should be in touch with the target by its complete mounting surface. Rough, scratched or too small measuring points may cause errors. Cast or varnish surfaces are unsuited.

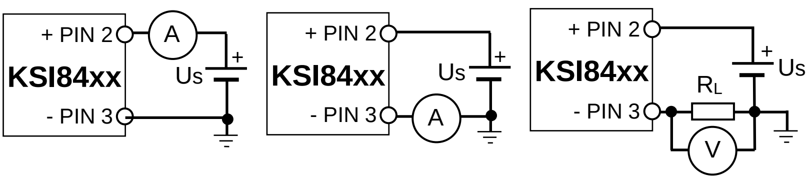
A thin layer of silicone grease between the mounting surfaces also improves vibration transmission.

4.2 Sensor Connection

The sensor is connected via PIN 2 (+) and PIN 3 (-) of the output connector to the loop supply voltage. PIN 1 and PIN 4 are not to be connected.

The loop supply voltage U_S should be within 10 to 30 V and free of noise.
It is recommended to prefer a lower voltage at ambient temperatures above 80 °C in order to reduce self-heating due to the power dissipation inside the sensor.

The following figures show possibilities to measure the sensor current.



The sensor current can be measured either directly by a current meter connected in series or indirectly by measuring the voltage drop across the load resistance R_L between PIN 3 and the negative terminal.

The voltage drop u_L across R_L is calculated from the sensor current as follows:

$$u_L = R_L \cdot i_{Sensor}$$

The following table shows the voltage drop u_L as a function of the sensor current at different load resistors R_L.

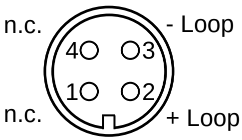
		Voltage drop over R_L		
Level	i_{Sensor}	**125 Ω**	**250 Ω**	**500 Ω**
0 %	4 mA	0,5 V	1 V	2 V
10 %	5,6 mA	0,7 V	1,4 V	2,8 V
20 %	7,2 mA	0,9 V	1,8 V	3,6 V
50 %	12,0 mA	1,5 V	3 V	6 V
100 %	20,0 mA	2,5 V	5 V	10 V
112,5 %	22,0 mA	2,75 V	5,5 V	11 V

Metra offers the following connection accessory:

4. Type 080G/W: Binder 713, female, straight (G) or angled (W) with screw terminals for connection an existing sensor cable; protection grade IP67
5. Type 082-B713G-PIG-x or type 082-B713G-PIG-x:
   Shielded sensor cable, x m length with Binder 713, female, straight (G) or angled (W) and cable end sleeves; protection grade IP67

The pin assignment is as follows:

View at sensor pins



1: Do not connect
2: + current loop
3: - current loop
4: Do not connect

We recommend using shielded cable for best EMI protection. The cable shield must be connected to earth potential at one end.

Make sure that the cable is not routed alongside AC power lines. It must cross AC power lines at right angles. The cable should also be routed in distance to potential EMI sources.

The sensor housing must be connected to earth potential via the mounting surface.

4.3 Maximum Load Resistance

The maximum load resistance R_L depends on the loop supply voltage U_S. It results from the fact that the sensor requires at least 7 V at the highest possible loop current.

The calculation is as follows:

$$R_L \leq \frac{U_S - 7\,V}{24\,mA} \approx 40 \cdot (U_S - 7) * ohm$$

R_L : Load resistance of current loop
U_S: Loop supply voltage in V

It can be seen that the load resistance R_L must not exceed 680 Ω with a supply voltage U_S = 24 V.

4.4 Sensor Self-Test

The sensor starts with a self-test once it is connected to the loop supply voltage.

During self-test, the sensor outputs the test currents 22 mA and 4 mA for a duration of 2 seconds. These currents can be measured with an ampere meter to ensure proper function.

If there is no error, the sensor continues with normal measurement afterwards. The sensor current rises to the current value corresponding to the vibration amplitude.

There is a LOOP Error if the sensor cannot drive 22 mA in the loop line. In this case the sensor will remain in self-test mode and attempt to deliver 22 mA until the problem is fixed.

4.4.1 Steps to Fix a LOOP Error

1. Check the value of the load resistance and reduce it if possible
2. Check the value of the loop supply voltage and increase it if possible

4.5 Measurement Mode

4.5.1 Sensitivity

In measurement mode, the sensor output current i_{Sensor} is proportional to the vibration amplitude.

$$\boldsymbol{i_{Sensor} = B_{ia} \cdot a + 4\ mA} \quad or \quad \boldsymbol{i_{Sensor} = B_{iv} \cdot v + 4\ mA}$$

The proportionality factor B_{ia} or B_{iv} is called transducer sensitivity.

The sensitivity depends on the measuring range of the sensor. It is calculated with the ratio between the change of current at 100 % excitation and the measuring range.

$$\boldsymbol{B_{ia,iv} = \frac{(20\ mA - 4\ mA)}{Range} = \frac{16\ mA}{Range}}$$

The following table shows the sensitivity of the acceleration and velocity types for different measuring ranges.

	Range					
KSI84Ax	**10**	**20**	**50**	**100**	**200**	**500**
B_{ia} / mA/m/s²	1.6	0.8	0.32	0.16	0.08	0.032

	Range					
KSI84Vx	**10**	**12.7**	**20**	**25.4**	**40**	**50.8**
B_{iv} / mA/mm/s	1.6	1.26	0.8	0.63	0.4	0.315

4.5.2 Sensor Output – Averaging Filter

The sensor output is updated every 0.5 seconds in RMS mode and once per second in PEAK mode.

To reduce signal ripple and to improve the signal-to-noise ratio, the output signal is additionally filtered using a moving average filter. This averaging causes a signal delay by which short signal spikes (interference pulses) are attenuated.

The default setting of the average filter is *auto* at delivery. Optionally, the sensors can also be supplied with a different setting of *N = 1, 2, 4, 8*.

4.5.3 Settling Time

The table below shows the relationship between the number of averages *N* and the settling time *T* after a step shaped change of the vibration signal. For *N = auto* the value *T* depends on the setting of the high pass filter.

N	***T* (RMS)**	***T* (PEAK)**	**HP filter setting**
auto	4 s	4 s	1.5 Hz / 3 Hz / 10 Hz
	2 s		30 Hz / 100 Hz / 1 kHz
1	0.5 s	1 s	
2	1 s	2 s	
4	2 s	4 s	
8	4 s	8 s	

4.5.4 Linear Measuring Range

The range for valid measurements extends from …

	Minimum level	Maximum level	Types
(1)	**1 % (4.16 mA)**	**112.5 % (22 mA)**	All types except (2)
(2)	**2 % (4.32 mA)**		KSI84**AP**-xx-**10k**-xxx

Within this range the specified accuracy of the sensor is guaranteed.

If the sensor signal is lower than the minimum level the measurement error will increase due to noise and resolution of the AD converter.

At amplitudes higher than the maximum level the output signal will no longer increase. It is clipped at **22 mA**. In this case please select a sensor with a larger measuring range.

4.5.5 Overload Indication

The maximum sensor current is 22 mA. This is the upper limit of the linear measuring range. In addition, the value of 22 mA is used to indicate a vibration overload.

A vibration overload can either occur within the pass band frequency range of the senor type or outside its frequency range within the stopband. In this case the measurement result will be incorrect and you should use a sensor type with a higher measuring range.

4.5.6 Overload Headroom

The overload headroom represents the maximum amplitude that can be processed without an overload occurring. It is shown in the following table relative to measuring range of the sensor.

		Range					
KSI84AR-xx-xx-		**10**	**20**	**50**	**100**	**200**	**500**
Headroom		330 %	165 %	135 %	135 %	135 %	108 %
KSI84AP-xx-xx-		**10**	**20**	**50**	**100**	**200**	**500**
Headroom		470 %	235 %	190 %	190 %	190 %	150 %
KSI84VR-xx-xx-		**10**	**12**	**20**	**25**	**40**	**50**
Headroom	@160 Hz	660 %	520 %	660 %	520 %	660 %	520 %
	@640Hz	165 %	130 %	165 %	130 %	165 %	130 %
KSI84VP-xx-xx-		**10**	**12**	**20**	**25**	**40**	**50**
Headroom	@160 Hz	930 %	735 %	930 %	735 %	930 %	735 %
	@640Hz	233 %	184 %	233 %	184 %	233 %	184 %

For all acceleration types, the overload headroom is independent of the frequency. In contrast, for velocity types the overload headroom is halved when the frequency doubles.

4.5.7 Error Output

If the sensor current is between 4 mA and 22 mA, the sensor is in normal operational mode.

Any current outside this range indicates a specific error. The following table shows the values used.

Current	Error event	Cause of error	Workaround
3.75 mA	LOOP error	The sensor cannot output the correct current value because the current loop is incorrectly dimensioned.	Restart the sensor. There is a LOOP-Error if the sensor remains in self-test after restart. Please follow the steps to fix the problem.
3.75 mA	SENSOR error	The signal processing of the sensor is not working properly.	Restart the sensor. There is a sensor error if the sensor current remains constant at 3.75 mA. Please replace the sensor.
22 mA	Overload (OVL)	Vibration signal too high	Use a sensor type with a higher measuring range.

5 Technical Data

5.1 Technical Characteristics of the 4-20mA Signal Conditioning			
Sensor system		Piezoelectric accelerometer	
Measured quantity	Q KSI84**A**x-x-x-x KSI84**V**x-x-x-x	according to type code Acceleration Velocity	 m/s² mm/s
Mode	M KSI84x**R**-x-x-x KSI84x**P**-x-x-x	according to type code RMS PEAK	 ... pk
Linear frequency range High pass filter [1] -3dB Low pass filter [2] -3dB	 f_{HP} KSI84xx-**HP**-x-x f_{LP} KSI84xx-x-**LP**-x	according to type code 1.5 / 3 / 10 / 30 / 100 / 1k 100 / 300 / 1 k / 5k / 10k	 Hz Hz
Nominal measuring range[1] ± accuracy	x_N @20 mA, @23°C KSI84Ax-x-x-**R** KSI84Vx-x-x-**R**	according to type code 10/20/50/100/200/500 ± 2 % 10/12.7/20/25.4/40/50.8 ± 2 %	 m/s² mm/s
Linear measuring range	x_{min} ... x_{max}	1...112.5 ; (2...112.5) [3]	% of x_N
Nonlinearity	@x_{min} ... x_{max} @23°C	± 2	%
Temperature coefficient of sensitivity	@T < 23 °C @T > 23 °C	- 0.02 + 0.02	%/K
Noise		see type table	
Transverse sensitivity	G_{90max}	< 5	%
5.2 Electrical Characteristics			
Current output	I_{OUT}	4...22	mA
Loop supply voltage	U_S	10...30	V
Settling time [4]	T	< 5	s
Load resistance	R_L	< 40 · (U_s - 7)	Ω
Ground insulation	R_{ISO}	> 10^8	Ω
5.3 Mechanical Characteristics			
Dimensions	Ø / h	SW22 / 43.1	mm
Weight	m	60 / 2.1	g / oz
Housing material		Stainless steel	
Mounting		M8 thread in base	
Connector		Binder 713, 4 pole, male	
5.4 Environmental Characteristics			
Operating temperature	T_{min} / T_{max}	-40 / 100	°C
Protection grade		IP68	
Destruction shock limit	a_{max}	5000	g
EMI		EN 61326-2-3:2013	

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[1] *Type code contains only integer values without decimal places*
[2] *The condition LP ≥ 10 HP must be met*
[3] *Restricted linear measuring range for type code KSI84AP-x-10k-x*
[4] *Settling time for average filter= auto, 1...9 s optionally available*

5.5 Type Tables

5.5.1 Acceleration, RMS

Q	M	HP Hz	LP Hz	Range m/s²	Type code	Noise m/s²
a	RMS	1.5	100 300 1k	10	KSI84AR-1-**LP**-10	0.005
				20	KSI84AR-1-**LP**-20	0.005
				50	KSI84AR-1-**LP**-50	0.007
				100	KSI84AR-1-**LP**-100	0.007
				200	KSI84AR-1-**LP**-200	0.008
				500	KSI84AR-1-**LP**-500	0.016
			5k	10	KSI84AR-1-5k-10	0.020
				20	KSI84AR-1-5k-20	0.020
				50	KSI84AR-1-5k-50	0.030
				100	KSI84AR-1-5k-100	0.060
				200	KSI84AR-1-5k-200	0.080
				500	KSI84AR-1-5k-500	0.160
			10k	20	KSI84AR-1-10k-20	0.050
				50	KSI84AR-1-10k-50	0.090
				100	KSI84AR-1-10k-100	0.180
				200	KSI84AR-1-10k-200	0.200
				500	KSI84AR-1-10k-500	0.250
		3 10 30 100	100 [1)] 300 [1)] 1k	10	KSI84AR-**HP**-**LP**-10	0.005
				20	KSI84AR-**HP**-**LP**-20	0.005
				50	KSI84AR-**HP**-**LP**-50	0.007
				100	KSI84AR-**HP**-**LP**-100	0.007
				200	KSI84AR-**HP**-**LP**-200	0.008
				500	KSI84AR-**HP**-**LP**-500	0.016
		1k	10k	20	KSI84AR-1k-10k-20	0.050
				50	KSI84AR-1k-10k-50	0.090
				100	KSI84AR-1k-10k-100	0.180
				200	KSI84AR-1k-10k-200	0.200
				500	KSI84AR-1k-10k-500	0.250

[1)] *The condition LP ≥ 10 HP must be met*

5.5.2 Acceleration, PEAK

Q	M	HP Hz	LP Hz	Range m/s² pk	Type code	Noise m/s² pk
a	Peak	1.5	100 300 1k	10	KSI84AP-1-LP-10	0.005
				20	KSI84AP-1-LP-20	0.005
				50	KSI84AP-1-LP-50	0.007
				100	KSI84AP-1-LP-100	0.007
				200	KSI84AP-1-LP-200	0.008
				500	KSI84AP-1-LP-500	0.016
			5k	10	KSI84AP-1-5k-10	0.020
				20	KSI84AP-1-5k-20	0.020
				50	KSI84AP-1-5k-50	0.030
				100	KSI84AP-1-5k-100	0.060
				200	KSI84AP-1-5k-200	0.080
				500	KSI84AP-1-5k-500	0.160
			10k	50	KSI84AP-1-10k-50	0.090
				100	KSI84AP-1-10k-100	0.180
				200	KSI84AP-1-10k-200	0.200
				500	KSI84AP-1-10k-500	0.250
		3 10 30 100	100 [1)] 300 [1)] 1k	10	KSI84AP-HP-LP-10	0.005
				20	KSI84AP-HP-LP-20	0.005
				50	KSI84AP-HP-LP-50	0.007
				100	KSI84AP-HP-LP-100	0.007
				200	KSI84AP-HP-LP-200	0.008
				500	KSI84AP-HP-LP-500	0.016
		1k	10k	50	KSI84AP-1k-10k-50	0.090
				100	KSI84AP-1k-10k-100	0.180
				200	KSI84AP-1k-10k-200	0.200
				500	KSI84AP-1k-10k-500	0.250

[1)] *The condition LP ≥ 10 HP must be met*

5.5.3 Velocity, RMS

Q	M	HP Hz	LP Hz	Range mm/s	Type code	Noise mm/s
v	RMS	1,5	100	40	KSI84VR-1-**LP**-40	0.100
			300, 1k	50,8	KSI84VR-1-**LP**-50	
		3	100 300 1k	20	KSI84VR-3-**LP**-20	0.035
				25.4	KSI84VR-3-**LP**-25	
				40	KSI84VR-3-**LP**-40	
				50.8	KSI84VR-3-**LP**-50	
		10 [1)]	100 300 1k [1)]	10	KSI84VR-10-**LP**-10	0.010
				12.7	KSI84VR-10-**LP**-12	
				20	KSI84VR-10-**LP**-20	
				25.4	KSI84VR-10-**LP**-25	
				40	KSI84VR-10-**LP**-40	
				50.8	KSI84VR-10-**LP**-50	
		30	300 1k	10	KSI84VR-30-**LP**-10	0.005
				12.7	KSI84VR-30-**LP**-12	
				20	KSI84VR-30-**LP**-20	
				25.4	KSI84VR-30-**LP**-25	
				40	KSI84VR-30-**LP**-40	
				50.8	KSI84VR-30-**LP**-50	

[1)] *Complies with the requirements of ISO 2954*

5.5.4 Velocity, PEAK

Q	M	HP Hz	LP Hz	Range mm/s pk	Type code	Noise mm/s pk
v	Peak	10	100 300 1k	20	KSI84VP-10-**LP**-20	0.010
				25.4	KSI84VP-10-**LP**-25	
				40	KSI84VP-10-**LP**-40	
				50.8	KSI84VP-10-**LP**-50	
		30	300 1k	10	KSI84VP-30-**LP**-10	0.005
				12.7	KSI84VP-30-**LP**-12	
				20	KSI84VP-30-**LP**-20	
				25.4	KSI84VP-30-**LP**-25	
				40	KSI84VP-30-**LP**-40	
				50.8	KSI84VP-30-**LP**-50	

Limited Warranty

Metra warrants for a period of

24 months

that its products will be free from defects in material or workmanship and shall conform to the specifications current at the time of shipment.

The warranty period starts with the date of invoice.
The customer must provide the dated bill of sale as evidence.
The warranty period ends after 24 months.
Repairs do not extend the warranty period.

This limited warranty covers only defects which arise as a result of normal use according to the instruction manual.

Metra's responsibility under this warranty does not apply to any improper or inadequate maintenance or modification and operation outside the product's specifications.
Shipment to Metra will be paid by the customer.

The repaired or replaced product will be sent back at Metra's expense.

Declaration of Conformity

According to EMC Directive 2014/30/EC

Product: Vibration Sensor
Type: KSI84xx

It is hereby certified that the above mentioned product complies with the demands pursuant to the following standards:

EN 61326-2-3:2013
EN61000-6-4:2006 + A1:2011
EN61000-6-2:2005

The producer is responsible for this declaration

Manfred Weber Metra Mess- und Frequenztechnik in Radebeul e.K.
Meissner Str. 58, D-01445 Radebeul
declared by:

Michael Weber, Radebeul, July 28, 2020