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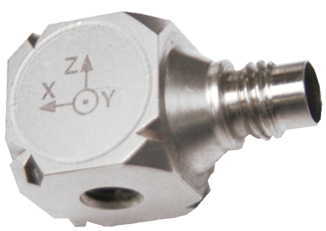
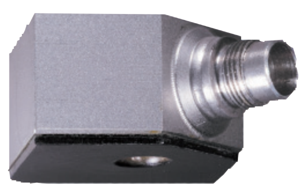
Instruction Manual

Ceramic Shear Triaxial IEPE Accelerometers





Types

8762A...,
8763B...,
8764B...,
8788A...

CE

8762A_002-681e-11.23

Foreword

Thank you for choosing a Kistler quality product characterized by technical innovation, precision and long life.

Information in this document is subject to change without notice. Kistler reserves the right to change or improve its products and make changes to the content without obligation to notify any person or organization of such changes or improvements.

Kistler Group
Eulachstrasse 22
8408 Winterthur
Switzerland

Tel. +41 52 224 11 11
info@kistler.com
www.kistler.com

Content

Total pages: 40

1. Introduction

Thank you for choosing a quality product from Kistler. Please read through this manual thoroughly to enable you to fully utilize the various features of your product.

To the extent permitted by law Kistler accepts no liability if this instruction manual is not followed, or if products other than those listed under *Accessories* are used.

These instructions describe Kistler ceramic shear triaxial IEPE accelerometers.

Performance features at a glance:
- Types 8762A/8763B/8788A feature threaded mounting holes for mounting in any direction
- Durable, hard anodized, ground isolated aluminum housing (Type 8762A) or titanium housing (Types 8763B/8788A)
- Type 8764B features center hole mounting for easy orientation, as well as a ground isolated base
- Type 8764B provides a lightweight, slim profile
- Types 8763B and 8764B feature a mini or standard, 4 pin connector option for lower mass and wider frequency operation
- Conforming to CE

Kistler offers a wide range of products for use in measuring technology:
- Piezoelectric sensors for measuring force, torque, strain, pressure, acceleration, shock, vibration and acoustic emission
- Strain gage sensor systems for measuring force and torque
- Piezoresistive pressure sensors and transmitters
- Signal conditioners, indicators and calibrators
- Electronic control and monitoring systems, as well as software for specific measurement applications
- Data transmission modules (telemetry)

Kistler also develops and produces measuring solutions for the application fields engines, vehicles, manufacturing, plastics and biomechanics sectors.

Our product and application brochures, in addition to our detailed data sheets, will provide you with an overview of our product range. All unit measurements provided are listed in order of metric units, followed by imperial units [in brackets].

If you require additional help beyond what can be located online or in this manual, please contact Kistler's extensive support organization or visit us online at **www.kistler.com**.

2. Important Information

It is essential for you to review the following information, which is intended to ensure your personal safety when working with the ceramic shear triaxial IEPE Accelerometers and contribute toward a longer service life.

2.1 For Your Safety

NOTE

This product has been manufactured in compliance with current valid safety regulations. It has left the factory in a perfect, safe condition. In order to maintain this condition and ensure safe operation, compliance is required with the instructions and warning notes contained within this manual or imprinted on the product itself.

Compliance with local safety regulations, which may apply to the use of power line operated electrical and electronic equipment, is strongly recommended.

- Do not drop the instrument.
- Store in the case provided and in a clean, dry environment.
- Power the instrument in accordance with the instructions provided in this manual.
- Do not mount accelerometers on high voltage surfaces.
- Keep cable clear of power lines and open machinery.

2.2 Precautions

CAUTION

Compliance with the following precautionary measures is vital to ensure safe and reliable operation:

- Never expose the instrument to contamination or oil mist.
- Never operate or store the instrument outside the specified temperature range.
- Never exceed the maximum stated voltage.
- **DO NOT OVER TIGHTEN** while stud or screw mounting the sensor
- Do not expose the unit to excessive shock, i.e. by using a hammer or dropping the unit.
- When not in use, store the accelerometer in the container supplied.
- The environment should be as dry, clean and free from vibrations as possible.
- Keep the connector clean and covered when not in use.
- Follow the recommendations detailed in Section 7.2.

If there is evidence that safe operation is no longer possible, the instrument must be powered off and rendered safe against accidental start-up. Safe operation is no longer possible when the product:

- shows visible signs of damage
- is no longer operating
- has been subjected to prolonged storage under unsuitable conditions

2.3 Disposal of Electronic Equipment

Do not discard old electronic equipment in municipal trash. For disposal at end of life, please return this product to the nearest authorized electronic waste disposal service or contact your Kistler sales office for disposal instructions.

3. Product Description

Kistler ceramic shear triaxial IEPE accelerometers are shear mode vibration measuring instruments. A self-generating piezoelectric sensing element is used in conjunction with the built-in internal circuit Piezotron® charge converter. As with most accelerometers, the sensitivity of this series is expressed in terms of the ratio of the electrical output to applied acceleration (e.g. mV/g). In the case of Piezotron devices such as ceramic shear, the output is a low impedance voltage signal, which is proportional to the applied acceleration.

Being a low impedance device, no external charge amplifier or special cabling is required and transmission over long lines is possible with a minimum of noise pick-up.

3.1 Piezoelectric Measurement Concept

Piezoelectric accelerometers convert acceleration into an electric charge. The charge derived by the accelerometer is proportional to the force, from a known mass, acting on the internal ceramic (piezoelectric) element. Accordingly, the mechanical variable (acceleration) is derived from a force measurement.

3.2 Ceramic Annular Shear Background

A typical Kistler sensing assembly (see Fig. 1) consists of a center post, piezoelectric ceramic element and a seismic mass mechanically preloaded. Since the unit is operated in a shear arrangement, it will sense motion perpendicular to the base. When the accelerometer is attached to a vibrating structure, the element mass exerts a shear force on the ceramic element. This applied force causes the piezoelectric material to produce an electric charge. Since force is mass x acceleration (from Newton's second law), the charge produced is proportional to acceleration. This is represented by the equation:

$$a = \frac{F}{m}$$

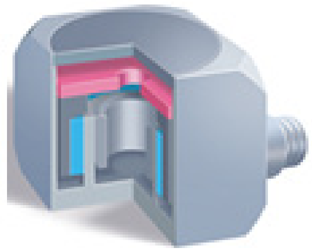


Fig. 1: Inside view of a typical single-axis, annular shear accelerometer

The ceramic shear sensing element, similar to the annular shear element shown in Fig. 1, offers many advantages over previous compression mode designs. Due to its shear construction, the accelerometer element is less sensitive to thermal transients, transverse (cross-axis) motion, and the effects of base strain than a compression element.

Kistler first introduced this design (annular shear) using a ceramic element that has become a standard with many users. Ceramic shear accelerometers employ similar ring or annular shear designs that provide the same advantages.

3.3 Low Impedance (IEPE) Output

Contained within the accelerometer housing is a miniature electronic circuit. This circuit converts the high impedance charge signal generated by the piezoelectric element into a low impedance voltage output signal. All accelerometer Types 8762A, 8763B, 8764B, and 8788A have a nominal output less than 500 ohms.

The integral charge amplifier is powered by an external power source (coupler) that uses a two-wire cable between the accelerometer and coupler. The signal and power source share a common line. The coupler provides a constant current source to the accelerometer and decouples the DC bias (see Section 5.1.3) from the measuring instrument. The useable signal is seen as a varying voltage over an 11 VDC (nominal) bias.

Low impedance accelerometers are ideally suited for applications where long cables are required, in high humidity or other harsh environments. In addition, they eliminate the difficulties associated with high impedance outputs by providing a voltage signal with low impedance and high frequency response. The sensitivity of these accelerometers are given in mV/g.

Table 1 depicts a typical low impedance measurement chain. Couplers vary considerably in appearance, depending upon the application and the number of sensors making up the system. It can also be directly integrated to the data acquisition system.

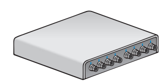
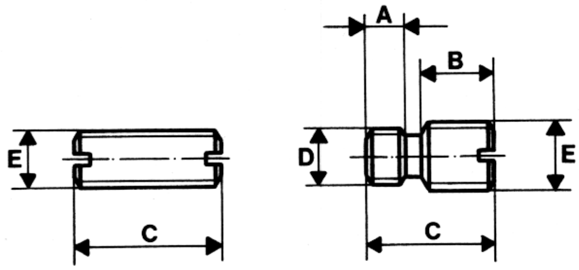
Measure	Connect	Amplify	Output	Analyze
 Low impedance (voltage output) accelerometer	 Coaxial cable	 Coupler (constant current supply) or dual mode amplifier	 Ethernet cable	 Read-out or analysis equipment

Table 1: Diagram of a low impedance acceleration system

3.4 Accessories

All accelerometers designed for stud mounting are supplied with the appropriate studs. See Table 2 for more details regarding mounting stud dimensions, or refer to the unit specifications listed on the respective data sheet for each model.

3.4.1 Studs



Type	A	B	C	D	E	Used with
8402	2.54 [0.10]	2.54 [0.10]	5.6 [0.22]	10-32	10-32	8762A...
8411	2.79 [0.11]	6.60 [0.26]	10.4 [0.41]	10-32	M6	8762A...
8416	2.28 [0.09]	3.30 [0.13]	6.60 [0.26]	5–40	10–32	8763B.../8788A...
8418	2.28 [0.09]	3.81 [0.15]	7.11 [0.28]	5–40	M6	8763B.../8788A...
8420	--	--	9.40 [0.37]	--	5–40	8763B.../8788A...

Table 2: Mounting studs (dimensions in mm [in])

3.4.2 Cables

Type 1784B(x)K03	· M4.5 mini 4 pin neg. to 3x BNC cable
Type 1784AK02	· M4.5 mini 4 pin neg. to ¼–28, 4 pin pos. · Intended for use with Type 1756C(x) cables
Type 1756C(x)K03/K04	· Fluoropolymer jacket · ¼–28, 4 pin neg. to 3x BNC pos. · Triaxial accelerometer cable
Types 1756B(x)Q1, KIG4898C...Q1	· Fluoropolymer jacket · IP68 ¼–28. 4 pin neg. to 3x BNC pos. · Triaxial accelerometer cable
Type 1734A(x)K03	· Silicone jacket · ¼–28, 4 pin neg. to 3x BNC pos. · Triaxial accelerometer cable
Type 1578A(x)	· Fluoropolymer jacketed · ¼–28, 4 pin neg. to ¼–28, 4 pin pos. · Extension cable for triaxial accelerometers
Type 1511x	· Output cable BNC pos. to BNC pos.

* Please refer to data sheet 000-471 for more details. Contact Kistler for any of your cable needs.

Table 3: Most commonly used cables from Kistler (x = cable length to be specified in meters)

3.5 Nomenclature

Throughout this manual, special designations and nomenclature are used for terms and concepts relating to ceramic shear sensors. These are identified in Table 4.

Term	**Definition**
Fs	Full-scale
Es	DC supply voltage (a/k/a compliance voltage)
Eb	Bias voltage (from calibration certificate)
f	Frequency in Hz
R_1	Output resistance of the coupler
R_2	Input resistance of the coupler
I	Current in Amperes
C	Decoupling Capacitor (Capacitance in Farads)
τ	Time Constant
E	Output in Volts, Peak
R	Read-out impedance
Z	Input impedance
$IEPE$	Integrated Electronics Piezoelectric
Rs	Source Resistor
$TEDS$	Transducer Electronic Data Sheet

Table 4: Manual nomenclature

4. Installation

This section provides the user with a quick means of placing the Kistler ceramic shear triaxial IEPE accelerometers into operation. Careful installation will result in optimal, high frequency response, accuracy and reliability. Dimensional characteristics can be found on their respective data sheets.

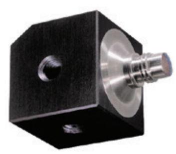
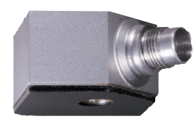
			
Type 8762A... stud, wax or adhesive mounting	**Type 8763BxA...** stud, wax or adhesive mounting	**Type 8764B...** screw, wax or adhe-sive mounting	**Type 8788A...** stud, wax or adhesive mounting

Table 5: Mounting options

4.1 Surface Preparation

A clean, flat surface is necessary for both stud and adhesive-mounted accelerometers. If the surface is not completely flat, the coupling between the accelerometer and the test article introduces distortion into the measurement. A rough surface creates voids between the mounting surfaces that reduce high frequency transmissibility.

For optimal frequency response with stud and screw mount units, the surface and hole preparation should be performed according to the instructions in Table 6. The roughness should not exceed 0.8 micrometers [32 micro inches].

4.2 Screw and Stud Mounting

Type 8762A… has three 10-32 UNC threaded holes while Types 8763B… and 8788A... have three 5-40 UNC threaded holes for stud mounting. Type 8764B... has a center through-hole design that accepts a screw with a special off-ground treatment to ensure off-ground operation when installed. Most Kistler mounting studs are machined from beryllium copper for high strength and low modulus of elasticity, coupled with high elastic limits. The studs are removable, allowing both stud and adhesive mounting. The following guidelines must be followed when stud mounting accelerometers:

1. Drill and tap an adequate hole to ensure a flush mount of the accelerometer. Make sure the stud does not bottom out, either in the mounting hole of the test structure or in the accelerometer base. A chamfer should be machined at the top of the mounting hole to ensure that the base of the accelerometer makes full contact with the mounting surface (see Table 6).

2. Completely clean the surface prior to mounting.

3. Apply a thin coat of silicon grease to both the acclerometer and the mounting surface.

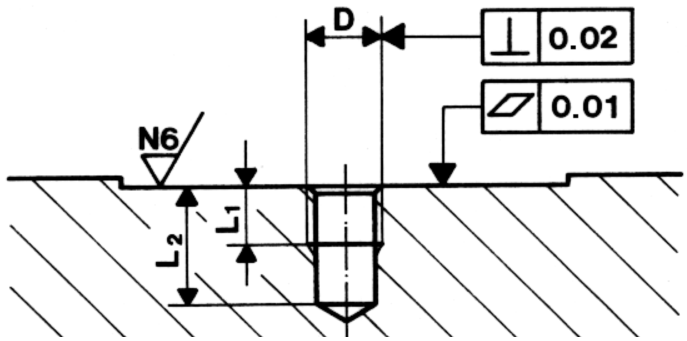
4. Always use the proper sockets and a torque wrench when installing accelerometers. **DO NOT OVERTIGHTEN.**

   a. **Type 8762A...** : tighten the accelerometer to a torque of 2±0.2 N·m [18±2 in-lb]

   b. **Type 8763B...** : tighten the accelerometer to a torque of 0.7±0.07 N·m [6.2±0.62 in-lbs]

   c. **Type 8764B...** : tighten the accelerometer to a torque of 0.7±0.07 N·m [6.2±0.62 in-lb]

   d. **Type 8788A...** : tighten the accelerometer to a torque of 0.7±0.07 N·m [6.2±0.62 in-lbs]



Stud type	D	L1 mm [in]	L2 mm [in]
8402	10-32	4.0 [0.16]	8.0 [0.31]
8411	M6	8.0 [0.31]	14.0 [0.55]
8416	10–32	4.0 [0.16]	8.0 [0.31]
8418	M6	8.0 [0.31]	14.0 [0.55]
8420	5–40	6.0 [0.24]	8.0 [0.31]
8446AE2	4–40	4.0 [0.16]	8.0 [0.31]
8446AM3	M2.5	4.0 [0.16]	8.0 [0.31]

Table 6: Stud mounting preparation

4.3 Direct Adhesive Mounting

A cyanoacrylate type adhesive, such as Eastman 910 or Loctite 496 super glue, is recommended. While epoxies can also be used, cyanoacrylate adhesives provide an extremely thin bond which provides optimal frequency response. The surface should be clean, smooth and flat in any case.

Knowing the operating temperature of the accelerometer aids in the appropriate selection of the adhesive. Some adhesives lose holding force at elevated temperatures. The accelerometer could fall from the test article and experience a damaging shock. Measuring information could be flawed if the accelerometer is not held in close contact to the surface under study.

When adhesive mounting an accelerometer with a tapped hole, make certain that no adhesive is allowed to enter the hole. This could eventually make stud mounting difficult.

Type 8788A... comes with a quick locking adhesive mounting clip Type 800M155. To install the sensor in the clip, use a thin layer of grease between the sensor surface and clip for the best frequency response. The sensor is "locked" into place by turning the sensor in the clip until the sensor edges are engaged by the clip. Figures 2 through 4 illustrate the clip mounting. The ground isolated clip is adhesively mounted to the test object. Remove the sensor with a manufacturer's recommended adhesive solvent. Acetone is effective for the removal of cyanoacrylate adhesives. Use the proper sized wrench to loosen the sensor from the adhesive mount. **DO NOT IMPACT!**

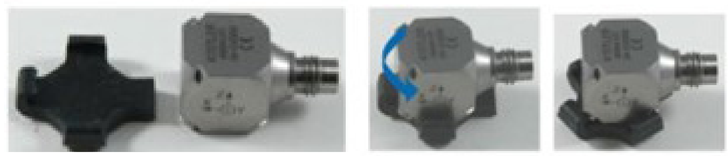


Figure 2: Type 8788A… with quick locking clip (+Z-Axis up)

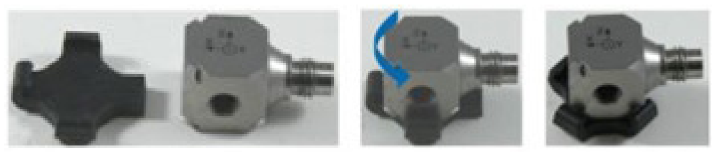


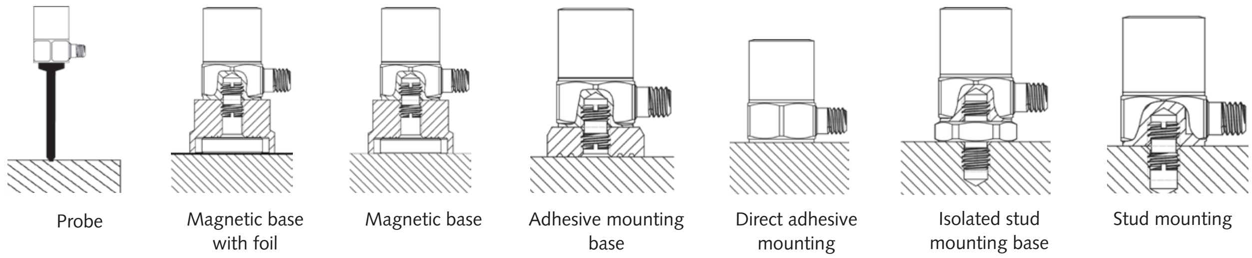
Figure 3: Type 8788A… with quick locking clip (+Y-Axis up)

Figure 4: Type 8788A… with quick locking clip (+X-Axis up)

4.4 Mounting with Wax

Bee's wax has been used as a mounting agent for many years. The provided Petro Wax (Kistler Type 8432 or P/N P102 from Katt and Associates; P.O. Box 623, Zoar, Ohio 44697, or equivalent) is a good replacement for bee's wax. It is formulated to provide improved frequency response. Wax is a good mounting agent for lightweight sensors in temporary installations where near room temperatures are encountered.

4.5 Summary of Mounting Methods



Mounting Method	Accessory Type	Advantages	Disadvantages	Remarks
Probe		Quick measurement	Lower accuracy	
Magnetic base	8450A, 8452A	Easy & quick installation	Adds considerably to mass loading, lowers resonant frequency	Limited to ferromagnetic materials
Adhesive mounting base	8466K01, 8434, 8436	Allows stud mounting, provides electrical isolation	Lowers resonant frequency	Pads are usually exposed to test specimen
Adhesive wax	8432 Petrowax, bees wax	Ideal for lightweight units	Limited temperature range; not sutable for larger sensors	Fast and clean
Adhesive cement	Loctite®, Permabond® (cyanoacrylate)	Good, strong coupling of sensor to specimen; higher temperature capability than wax	Difficult to remove sensor; requires solvents, removal tool and/or heat	Suited for more permanent applications & high frequency measurements
Isolated mounting stud	8400K04, 8400K06, 8400K07	Allows both strong coupling & ground isolation	Requires threaded hole in specimen; base slightly lower resonance frequency	Control mounting torque; use silicone grease
Mounting stud	8402, 8411, 8416, 8418, 8420	Best couping of sensor to test speciment for highest frequency response	Requires threaded hole in specimen	Control mounting torque; use silicone grease

*Please refer to data sheet 000-471 for more information.

Table 7: Mounting methods

NOTE

Stud mounting must conform to manufacturer's complete specifications.

4.6 Securing Cables

Fig. 5 and Fig. 6 depict the correct and incorrect methods for installing cables. Allow a sufficient radius to ensure a proper strain relief. The actual radius will depend on the cables being used. It is recommended that the cables be secured to the vibrating surface to minimize cable and connector fatigue failures. Secure cables with a cable clamp. Tape is acceptable on temporary installations.

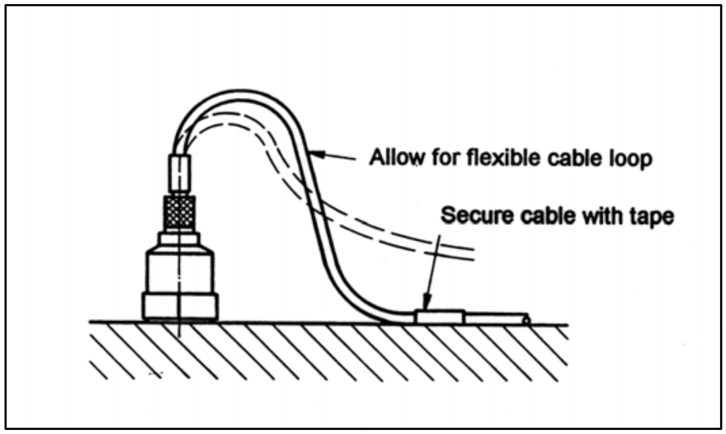


Fig. 5: CORRECT cable strain relief

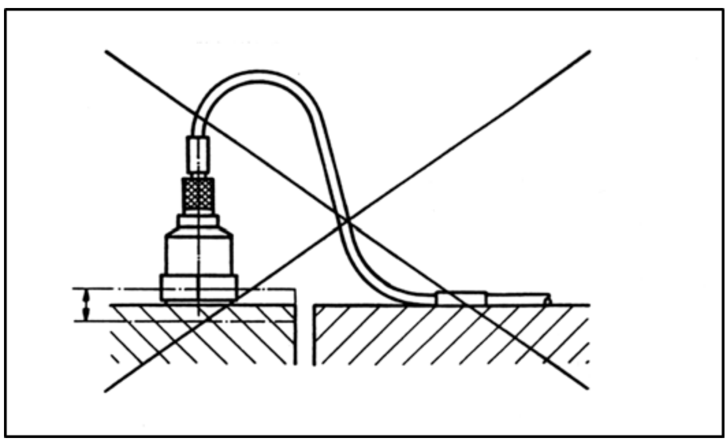


Fig. 6: INCORRECT cable strain relief

*See Section 3.4.2 for cables available upon request from Kistler.

4.7 Mass Loading Effects

When a device such as an accelerometer is attached to a test article, the acceleration to be measured will be altered. These effects can be reduced significantly by the proper selection of the measuring accelerometer. It should be assumed that the presence of an accelerometer does not significantly affect the system response, provided the dynamic mass of the accelerometer is considerably less than the test specimen. As a general 'rule-of-thumb', the weight of the accelerometer should be no greater than 10 % of the weight of the test specimen. An example of possible accelerometer-induced distortion is the instance of a heavy sensor mounted in the center of a thin printed circuit board.

5. Operating Instructions

Piezoelectric accelerometers are self-generating sensors. While the ceramic piezoelectric sensor does not require an external power source, it is necessary to provide power to the ceramic shear's internal electronic charge amplifier. This section is intended to provide the user with the information necessary to ensure accurate measurements with ceramic shear accelerometers. Topics to be covered include powering, signal conditioning, frequency response and driving long cables.

5.1 Powering

5.1.1 Using "Built-In" Power Sources

Many FFT analyzers and vibration monitors are available with internal accelerometer power supplies that provide constant current power to Kistler and other low impedance sensors. These power supplies are typically known as constant current source supplies. The industry also recognizes these power sources as voltage mode piezoelectric units by the universal designation, Integral Electronic PiezoElectric (IEPE).

Prior to using the built-in power source, compare the measurement instrument current source specifications with the current and voltage specifications of the accelerometer to be used. If the instrument accelerometer power is within the range required by the specific ceramic shear accelerometer, there should be no issues with compatibility. If the user plans to drive long cables over 130 m [430 ft], the guidelines in Section 5.1.7 should be followed. The accelerometer low frequency response may be affected by the input impedance of the measuring instrument, as discussed in Section 5.1.14.

Many industrial monitors have adjustable current controls. Exceeding the maximum current rating of any accelerometer may cause permanent damage and void the warranty.

5.1.2 Kistler Couplers

Kistler offers a comprehensive line of power supply/ couplers and dual mode amplifiers. They are designed for compatibility with ceramic shear accelerometers. Please refer to Kistler Acceleration catalog ref. 900-380.

5.1.3 The Constant Current Power Supply/Coupler

To better understand the purpose of the current source, a review of the Piezotron® charge amplifier is in order. Fig. 7 is a simplified schematic diagram of the ceramic shear accelerometer. When excited, the piezoelectric element produces a charge proportional to the measurand. The resulting voltage (developed across CR in Fig. 7) is applied to the input of the internal charge amplifier. The charge amplifier will produce an output voltage that follows the input accordingly.

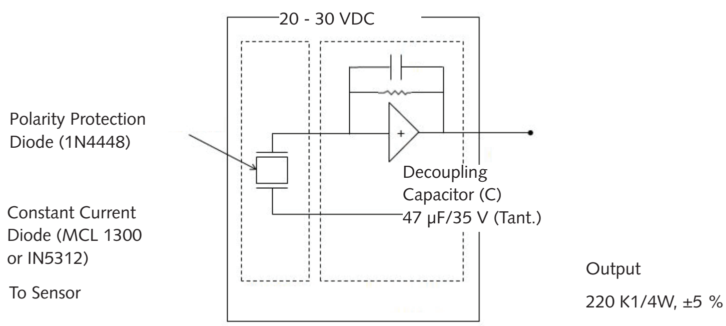


Fig. 7: Basic diagram of accelerometers utilizing an internal charge amplifier

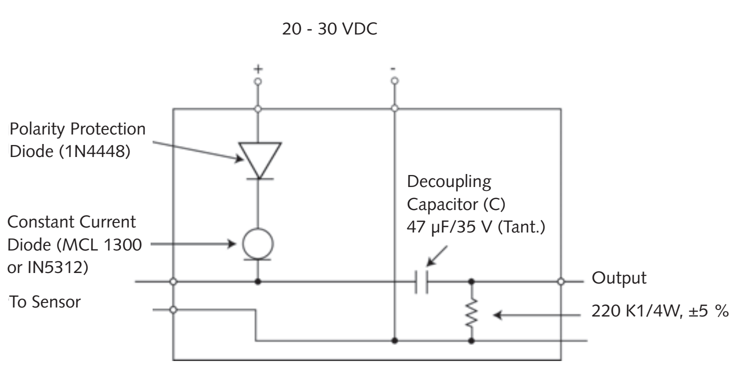


Fig. 8: Schematic diagram of a basic coupler

A source resistor (Rs), while located in the coupler, is part of the source follower circuit. In order for the Piezotron to provide enough gain, Rs must have a high dynamic resistance while being able to provide enough current (low DC resistance) as not to affect the high frequency response of the system. Replacing Rs with a constant current diode (Fig. 8) provides a device with a high dynamic resistance while allowing sufficient current to flow.

Fig. 8 shows a schematic of a simple power supply coupler for ceramic shear accelerometers. DC power is supplied from a 24-Volt source, such as a regulated power supply or batteries. The Piezotron system houses an advantageous, two-wire coaxial cable sharing both the power source and the signal across the same line. Therefore, it is necessary to include the capacitor C to decouple (or block) the DC from the measurement instrument input.

Operating within the voltage range of 20 ... 30 VDC ensures full, undistorted ±5 V output amplitude (see Fig. 9). If the source voltage is reduced, distortion and clipping of the signal will occur if one attempts to use the full amplitude range of the accelerometer (see Fig. 10). The following equations are provided to calculate the maximum full-scale voltage available when operating with reduced voltage.

Maximum positive amplitude:
$+Fs = (Es - 1) - Eb$

Maximum negative amplitude:
$-Fs = Eb - 1$

Nomenclature:

Fs = full-scale output voltage (peak)
Es = DC supply voltage (i.e. "compliance voltage")
Eb = bias voltage (from calibration certificate)

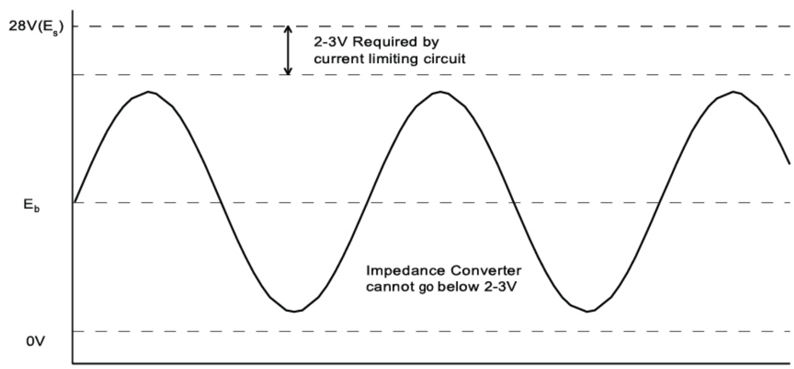


Fig. 9: Output signal when operated with 28 V supply

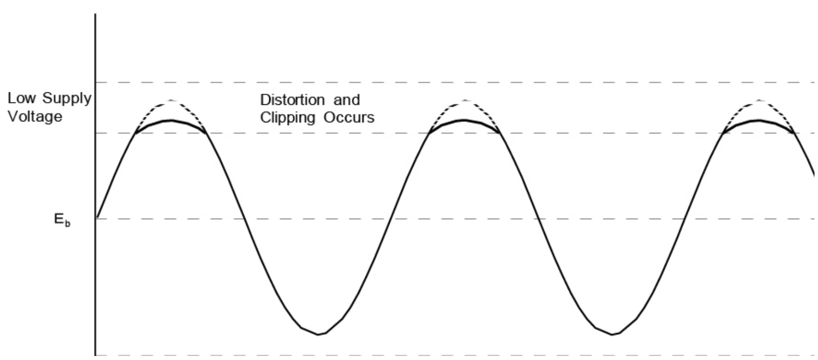


Fig. 10: Example of output distorting and clipping when supply voltage is low

5.1.4 Sensor Power-Up

When power is first applied to the sensor through an AC coupled coupler, a voltage will appear at the output of the coupler (see Fig. 11). As the coupling capacitor discharges, the DC output from the coupler will drop to zero volts. This 'settling time' is equal to 5 x’s the time constant of the parallel combination of coupler and sensor employed. Allow time for the unit to "settle" before making measurements.

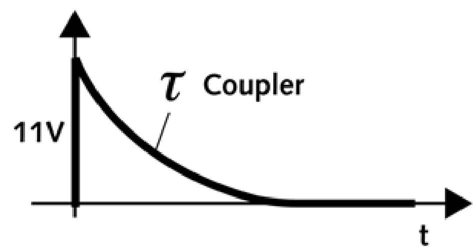


Fig. 11: Behavior of the output signal during power-up

5.1.5 Overload Recovery

Whenever the charge amplifier is driven by a signal exceeding the normal operating range, certain components will become non-operational. During this non-operational state, the amplifier components are protected from overload damage. The amount of time required for recovery from an overload depends upon several factors. Important for overload recovery time is the size of the overload. As with power-up, the time constant makes the biggest contribution to the recovery time. Fig. 12 illustrates a typical overload and recovery sequence.

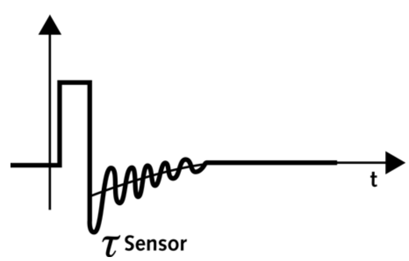


Fig. 12: Output behavior during overload and recovery

5.1.6 Supply Voltage Effects

Long-term fluctuations in the power supply level between 24 and 30 Volts can be tolerated. The sensitivity shift caused by such deviation is less than 0.05 %/V. A normal noise level is maintained if the power supply ripple is 25 mV RMS or less. The polarity must be maintained throughout the system. Applying reversed polarity power may cause damage to the accelerometer.

5.1.7 Driving Long Cables

The Piezotron circuit allows for long cable runs with low-noise susceptibility. Most laboratory instruments with built-in accelerometer power provide current in the range of 2 … 4 mA. Most Kistler couplers are set at factory default to provide 4 mA of source current. To insure maximum frequency response and high reliability, 4 mA is a fair compromise value.

Assuming a cable capacitance of 98 pF/m [30 pF/ft], the full frequency range of ceramic shear accelerometers can be realized (±5 V output) up to a length of 130 m [430 ft] with 4 mA of drive current. Most Kistler cable types and common RG58 coaxial cable have a rated capacitance of 98 pF/m [30 pF/ft]. For most laboratory applications, this is sufficient.

As cable length is increased, the cable capacitance becomes significant thereby loading the Piezotron charge amplifier. If the current is not sufficient enough to charge the cable at an adequate rate, high frequency distortion will result. The solution is to increase the drive current.

For your convenience, a chart is provided below (see Table 8). The values provided are based on a cable capacitance of 98 pF/m [30 pF/ft]. A list of cables available from Kistler can be found in Section 3.3.2.

Maximum Frequency ±**5** %	**Cable Length m (ft)**	**Current (mA) Required for Output Signal** ±**1 V**	**Current (mA) Required for Output Signal** ±**5 V**
10 kHz	300 [1,000] 600 [2,000]	2 4	10 18
9 kHz	300 [1,000] 600 [2,000]	2 4	9 17
8 kHz	300 [1,000] 600 [2,000]	2 3	8 15
7 kHz	300 [1,000] 600 [2,000]	2 3	7 14
6 kHz	300 [1,000] 600 [2,000]	2 3	6 12
5 kHz	300 [1,000] 600 [2,000]	2 2	5 10

* Based on 98 pF/m [30 pF/ft]

Table 8: Current requirements for driving long cables

The current requirements can be calculated using the following equation:

$$Ic = 2\pi fCcE$$

Nomenclature:

Ic = Current in Amperes
f = Frequency in Hz
C = Capacitance in Farads
E = Output in Volts, Peak

Never use more current than required to make the desired measurement. Never exceed the maximum current.

If a requirement calls for 300 m [1,000 ft] of cable and the maximum frequency of interest is only 5 kHz, the user should select 5 mA of current rather than 10 mA for the full 10 kHz range (see Table 8). As current is increased the noise produced by the Piezotron circuit will also increase. The internal Piezotron amplifier will produce more heat as current is increased, resulting in reduced life and reliability.

The specified maximum temperature range is based on 4 mA of supply current. The graph in Fig. 13 depicts the approximate maximum temperature versus operating current.

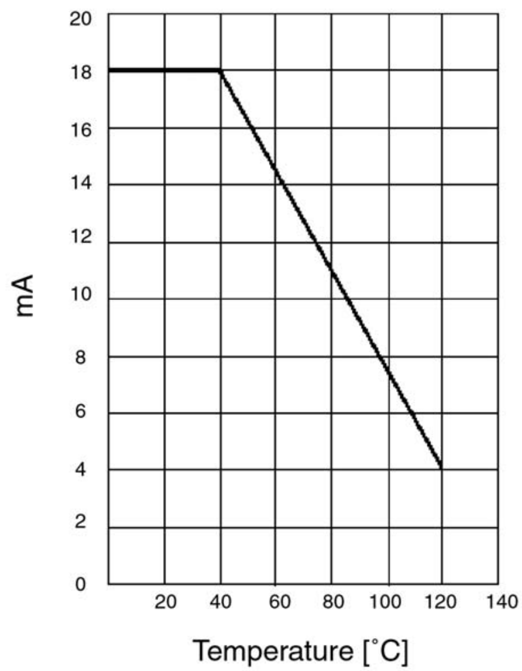


Fig. 13: Maximum Piezotron® current as a function of operating temperature

The equation for computing the maximum current for a specific temperature is:

$$I_{max} = 0.16\,(150 - T_{max})$$

Nomenclature:

I = Current in mA
T = Temperature in °Celsius

5.1.8 Ground Loops

The ground loop is one of the most common causes of ground noise. It will usually manifest itself as unwanted noise occurring at the line frequency (50 … 60 Hz). Ground loops occur when current flows between the accelerometer and coupler/conditioner grounds. If the coupler ground and the accelerometer ground are at exactly the same potential, there will be no resulting ground loop between these two devices. If the ground potential varies between the accelerometer mounting surface and the coupler ground, a slight current will flow causing a ground loop to occur (see Fig. 14).

While the amount of current might seem insignificant, the measurement levels are generally very low and the ground current will appear on the signal at a measurable level. There can be many causes of ground loops in a complete measurement system. However, the ground path between the accelerometer and coupler is among the most common.

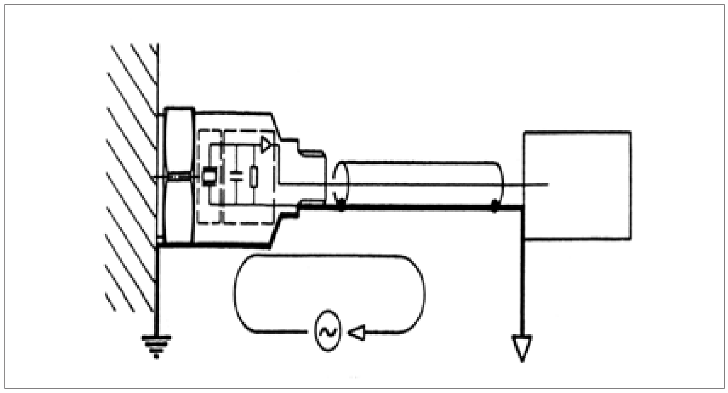


Fig. 14: Current path (loop) between the coupler and accelerometer ground

One method used to eliminate ground loops is to isolate the ground of the accelerometer from the ground of the test article (see Fig. 15 and Fig. 16).

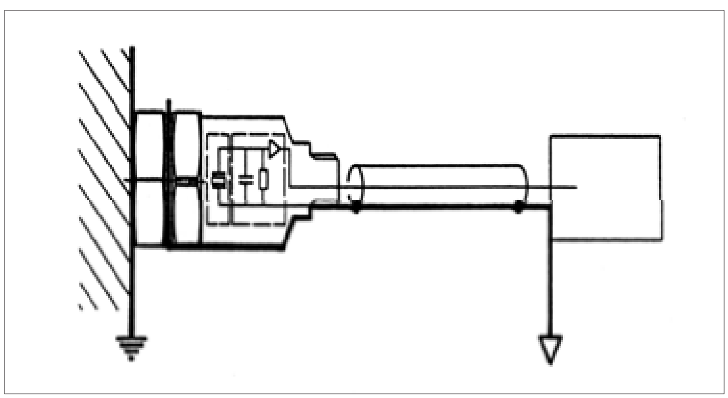


Fig. 15: The current path is broken with the use of a ground isolation pad

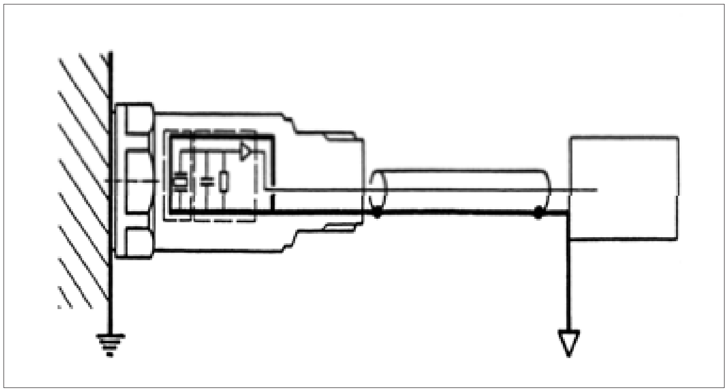


Fig. 16: Isolated accelerometer eliminates current path

Kistler offers isolation mounting studs for non-isolated ceramic shear accelerometers. See Section 5.1.9 for details.

5.1.9 Ground Isolation

As mentioned in section 5.1.8, ground isolation is used to eliminate ground loops. Ground isolation can be achieved by using isolation mounting studs with non-isolated accelerometers, or by using an accelerometer with built-in ground isolation. Fig. 15 and Fig. 16 illustrate how the ground path is modified using these techniques.

These units rely upon a built-in anodized aluminum pad to achieve ground isolation. The anodizing acts as a dielectric to provide isolation. The pad is completely anodized providing isolation both on the upper side, in contact with the accelerometer body, and bottom mounting surface. If unusually rough conditions should penetrate the anodizing on the mounting surface, isolation will be provided by the upper surface pad.

Type 8762A... is made of anodized aluminum which makes the sensor already ground isolated. Types 8763B... and 8788A... can be ground isolated with the use of an isolated accessory, such as Kistler Type 8440K01. Through aluminum anodized base plate and supplied screws, Type 8764B... is also ground isolated.

5.1.10 Frequency Response Limits

All accelerometers have specified frequency limits, which are a function of the mechanical and electrical design. In order to better understand the measurement process and limitations, the following sections will describe both the inherent limitations and limitations imposed by the installation, operation and measurement-analysis instrumentation.

5.1.11 Frequency Response Definition and Standards

Frequency response is defined as a maximum specified amplitude variation, from an established reference frequency, over a specified bandwidth. Ceramic shear accelerometers are specified with maximum variations of ±5 and ±10 %. Kistler uses the industry standard reference frequency of 100 Hz in the U.S., and 1,000 rads [159.2 Hz] internationally.

Some users may be more familiar with the common frequency response standard for electronic equipment, which is generally ±3 dB. In most mechanical applications, an error of ±3 dB (about ±30 %) does not provide the necessary accuracy. Therefore, ±5 % (±10 % in some cases) is considered a more reliable and accurate limit.

5.1.12 High Frequency Limitations

The inherent high frequency limit of an accelerometer is a function of its mechanical characteristics. Ceramic shear accelerometers can be represented as an undamped, single degree-of-freedom, spring-mass system.

As seen with any single degree-of-freedom system, a resonance condition will occur causing the sensitivity to increase with frequency.

It is desirable to have a uniform frequency response over the specified frequency range. As depicted in Fig. 17, the sensitivity greatly increases when approaching resonance. A 5 % amplitude rise can be expected at 0.22 of the resonant frequency. It is possible to operate above the maximum specified frequency by applying the appropriate correction factors, or filtering to compensate for the resonant rise in response.

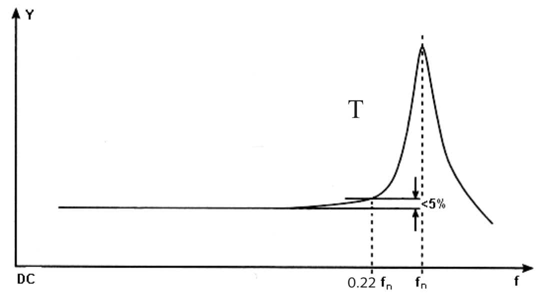


Fig. 17: Typical frequency response of a piezoelectric accelerometer

Section 4 outlines important information regarding mounting. It is important to follow these mounting instructions in order to ensure optimal transmissibility at high frequencies. Mounting to rough surfaces, using soft adhesives and magnetic mounts, will limit the high frequency range to a value lower than the specified frequency range.

5.1.13 Low Frequency Limitations - Accelerometer

The low frequency response of accelerometers is an electrical limitation. The ceramic shear is designed for low frequency drift, caused by temperature variations, to be virtually eliminated.

At low frequencies, the amplifier input circuit acts as a single-order, high-pass filter (see Fig. 15), whose amplitude and phase are:

$$\frac{V_o}{V_{in}} = \frac{2\pi f(\tau)}{\sqrt{1 + [2\pi f(\tau)]^2}}$$

$$\text{phase lead (deg)} = \text{arc tan}\left(\frac{1}{2\pi f(\tau)}\right) \quad {}^{\sim}80\sqrt{\frac{V_{in} - V_o}{V_{in}}}$$

The high-pass filter has a time constant (τ) determined by the feedback capacitor and time constant resistor of the internal amplifier gate circuit. The time constant is defined as the time required for the capacitors to reach 63.3 % of full charge, as determined by τ = RC. As capacitance and/or resistance increases, the time constant becomes longer. This results in a widening toward the lower frequency response (frequency is the reciprocal of time).

5.1.14 Low Frequency Limitations - Coupler and Read-Out Instrumentation

When making low frequency measurements with ceramic shear accelerometers, it is important for the user to consider the effects of the coupler and measurement instrumentation on the low frequency response.

If the coupler selected includes an isolated amplifier, the low frequency cutoff will be specified in the coupler data sheet and the read-out instrument's specifications. The actual low frequency limit will be the higher of the two. For example, if an FFT analyzer is being used that has a low frequency cutoff of 0.5 Hz and a coupler with a 0.07 Hz low frequency cutoff, the low frequency response limit will be 0.5 Hz.

If DC methods of bias decoupling are utilized, the accelerometer’s time constant will be unchanged, thereby providing optimal low frequency response.

When using a simple coupler circuit (see Fig. 8) with AC coupling, a time constant equal to the product of the decoupling capacitor's (C) capacitance and the read-out instrument's input impedance will be achieved.

Using the formula $\tau = RC$ (readout instrument’s impedance = R), the lower the read-out instrument's input impedance (Z), the shorter the time constant, thereby degrading the low frequency response. In systems with AC bias decoupling, the time constant can be approximated by taking the product of the accelerometer and coupler time constants and dividing by their sum.

When using a simple coupler (see Fig. 8), the system formed by the coupler and read-out instrumentation can shorten the time constant, thereby degrading the low frequency response. The new system time constant can be approximated by the equation:

$$T = ((R1 \times R2) / (R1+R2)) \times C$$

Nomenclature:

R_1 = output resistance of the coupler
R_2 = input resistance of the coupler
C = capacitance of the coupler’s output capacitor

6. Technical Data

For detailed specifications, please refer to each sensor Type's corresponding data sheet or contact Kistler for more information.

Recommended data sheets:

Accessories	000-281
Cables	000-471
Type 8762A...	000-456
Type 8763B...	000-928
Type 8764B...	003-201
Type 8788A...	003-633

7. Calibration and Maintenance

7.1 Calibration

Calibration consists of the precise determination of the accelerometer sensitivity by direct comparison, at various frequencies, to a National Institute of Standards and Technology (NIST) traceable standard accelerometer. The test accelerometer is attached to the top of the reference accelerometer in a 'back-to-back' configuration. The reference and test accelerometer are excited at equivalent frequencies and levels. The resulting amplitudes of both accelerometers are then compared to determine if the test unit is within tolerance of the specified acceptance parameters.

7.2 Maintenance

Clean the accelerometer with Isopropyl alcohol and lint free paper wipes. Never use an air-blast to clean the connector; it may deposit a water vapor film causing the connector to short. Excess cyanoacrylate adhesive on the mounting surface may be removed with dimethylformamide or acetone. Refer to the adhesive manufacturer's product label for recommended removal agent.

Do not use an abrasive on the base surface. This can affect the flatness, thereby reducing high frequency transmissibility.

Factory repair is recommended where trained personnel and appropriate measuring equipment and fixtures are available. Recalibration is recommended when returning an accelerometer to the factory. Kistler is an accredited ISO 17025 Laboratory and offers such calibration services. A calibration certificate will be supplied showing calibration results from standards traceable to NIST.

8. Troubleshooting

Should the user experience issues with a ceramic shear accelerometer, the following procedure should be followed:

- Check for possible intermittent cables. Faulty cables are the most common cause of accelerometer measurement issues. The application of a test signal at the accelerometer end of the cable is an effective means to determine if the issue is with the accelerometer, cable, or measurement instrument

Kistler couplers are equipped with a bias monitor, which can be used to check the cable integrity and detect malfunctions in the accelerometer. Use the bias monitor as follows:

- With the accelerometer connected, check for a normal reading on the bias indicator (normal range should be around 13 VDC).
- If the bias reading is high, disconnect the accelerometer at the accelerometer end of the cable.
- If the bias indicator reading decreases, the accelerometer is defective.
- If the bias indicator reads low, disconnect the accelerometer.
- If the bias indicator still reads low, replace the cable.
- If the bias level changes when the cable is disconnected, the accelerometer is defective.

Analysis and measurement equipment with built-in accelerometer sources generally do not have bias monitors. In this case, the user can attach a T-connector to the measurement/analysis instrument and measure the actual bias voltage using a DMM. If the system is operating properly, the bias voltage should measure close to the bias level indicated on the calibration certificate.

If it is determined that the accelerometer requires repair, please contact your local Kistler representative for repair instructions.

9. Storage and Transit Considerations

If the instrument is to be stored or transported for an extended period of time, please follow these safety precautions:

- The temperature should be maintained between –20 °C and 60 °C [–4 °F and 140 °F].
- All connectors must be covered with dust caps.
- Contamination must be prevented from entering the unit.
- The environment should be dry.
- Do not store or transport the instrument in such a manner that pressure is applied on the sensor.
- When not in use, the instrument should be stored in the original packing materials or carrying case when not in use.

10. Warranty

Please reference the Kistler Instrument Standard Product Warranty under Terms and Conditions for Sales and Service.

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11. Declaration of Conformity

DECLARATION OF CONFORMITY
KONFORMITÄTSERKLÄRUNG / DÉCLARATION DE CONFORMITÉ

Manufacturer *Hersteller* / Fabricant	**Kistler Instrument Corporation** Amherst, New York 14228 USA
declares that the product *erklärt, daß das Produkt* / déclares que le produit	
Name / *Name* / Nom	Triaxial Ceramic Shear Accelerometer
Type / *Typ* / Type	8762A5, 8762A10, 8762A50, 8762A5T, 8762A10T, 8762A50T
Module / *Module* / Module	none / *keine* / sans
Options / *Optionen* / Options	none / *keine* / sans

conforms with the following standards
mit den folgende Normen übereinstimmt / est conforme aux norme

EMC Emissions / *EMV Emission* / EMC Emission	EN61000-6-3:2007 / IEC61000-6-3:2005, PART 6-3 LIGHT INDUSTRIAL, COMMERCIAL, RESIDENTIAL EMC
EMC Immunity / *EMV Immunität* / EMC Immunité	EN61000-6-1:2007 / IEC61000-6-1:2005, PART 6-1 LIGHT INDUSTRIAL, COMMERCIAL, RESIDENTIAL EMC

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Amherst, New York USA Date 9-7-11

Paul Hufnagel, CE Manager

Kistler Instrument Corp.
75 John Glenn Drive
Amherst, NY 14228-2171

Tel 716-691-5100
Fax 716-691-5226
info.us@kistler.com

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Name / *Name* / Nom	PiezoBEAM® Accelerometer
Type / *Typ* / Type	8763B050AB, 8763B050BB, 8763B050AT, 8763B050BT, 8763B100AB, 8763B100BB, 8763B100AT, 8763B100BT, 8763M010
Module / *Module* / Module	none / *keine* / sans
Options / *Optionen* / Options	none / *keine* / sans

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Paul Hufnagel, CE Manager

Kistler Instrument Corp.
75 John Glenn Drive
Amherst, NY 14228-2171
Tel 716-691-5100
Fax 716-691-5226
info.us@kistler.com

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Name / *Name* / Nom	PiezoBEAM® Accelerometer
Type / *Typ* / Type	8763B250BB, 8763B250BT, 8763B500BB, 8763B500BT, 8763B1K0AB, 8763B1K0AT, 8763B2K0AB, 8763B2K0AT
Module / *Module* / Module	none / *keine* / sans
Options / *Optionen* / Options	none / *keine* / sans

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Paul Hufnagel, CE Manager

Kistler Instrument Corp.
75 John Glenn Drive
Amherst, NY 14228-2171

Tel 716-691-5100
Fax 716-691-5226
info.us@kistler.com

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Name / *Name* / Nom	PiezoBEAM® Accelerometer
Type / *Typ* / Type	8764B050AB, 8764B050BB, 8764B050AT, 8764B050BT, 8764B100AB, 8764B100BB, 8764B100AT, 8764B100BT,
Module / *Module* / Module	none / *keine* / sans
Options / *Optionen* / Options	none / *keine* / sans

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EMC Emissions / *EMV Emission* / EMC Emission	EN61000-6-1:2007 / IEC61000-6-1:2005, PART 6-1 LIGHT INDUSTRIAL, COMMERCIAL, RESIDENTIAL EMC
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Amherst, New York USA Date 16th Nov 2015

Peter C. Tack, Engineering Director, KIC