

PRODUCT DATA

Miniature Triaxial DeltaTron[®] Accelerometers — Types 4506, 4506 B, 4506 B 002, 4506 B 003

The family of DeltaTron Accelerometers Types 4506 are miniature triaxial piezoelectric accelerometers housed in robust titanium with a single integrated Microtech compatible connector. The accelerometers are specifically designed for the automotive industry



USES AND FEATURES

USES

- Structural analysis measurements
- Multichannel modal analysis measurements
- Modal measurements for automotive body and power-train applications

FEATURES

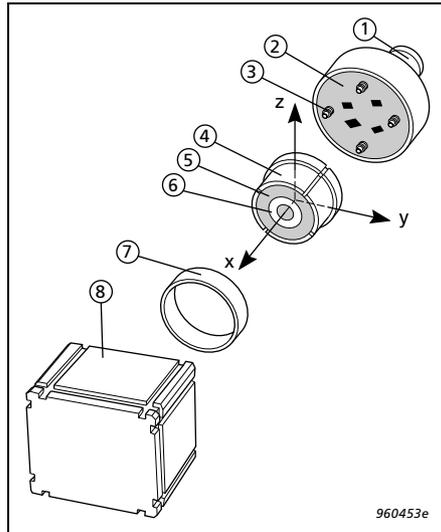
- ID (TEDS) “Smart Transducer Interface” IEEE P1451.4
- Five mounting surfaces
- Easily fitted to different test objects using a selection of mounting clips
- Robust titanium housing with integrated titanium 4-pin connector
- Compact, patented OrthoShear[®] design giving high sensitivity/weight ratio. The unique uni-mass construction ensures that all axes have the same point of reference
- Connects directly to DeltaTron power supply (ICP[®] compatible). The DeltaTron principle allows the use of inexpensive cables
- Low output impedance enables the use of long cables
- Built-in low-noise preamplifiers with ASICs for a dynamic range exceeding 100 dB (100 mV/g sensitivity)
- Electrically insulated for ground loop protection

Description

A combination of high sensitivity, low mass and small dimensions make Types 4506, 4506 B, B 002 and B 003 (hereafter referred to as Type 4506) ideally suited for triaxial modal analysis measurements of composite structures that require multiple measurement points, e.g., automotive body and power-train measurements, or modal analysis on aircraft, trains and satellites. The slots in the accelerometer housing allow easy mounting on five sides using inexpensive plastic clips that fit easily to the test object.

Design

Fig. 1
Exploded view of Type 4506



Normally, triaxial accelerometers consist of three individual accelerometers mounted in a single housing and positioned so that vibration can be measured in three mutually perpendicular directions. This approach sets limits to reducing the size of the accelerometer and also means that the three axes have different points of reference.

The OrthoShear design used in Type 4506 (see Fig. 1) is built around a common seismic mass (6). This uni-mass design results in a very compact triaxial accelerometer where all the axes have the same point of reference. The design also ensures accurate and consistent measurements, even when the accelerometer is exposed to complex vibration patterns. The seismic mass is surrounded by a piezoelectric ring (5) which is surrounded by four individually suspended,

curved plates (4). Because of the suspension pins (3), different sections are exposed to shear forces for different directions of acceleration. By appropriate summation of the signals, the outputs for the X, Y and Z axes are obtained. The assembly is clamped together by the outer ring (7). The preamplifiers (2), suspension pins (3) and Microtech-compatible connector (1) constitute an integral part which is hermetically welded to the titanium housing (8). Type 4506 is internally insulated from the housing. The risk of ground loops, which can be particularly troublesome in multichannel measurements, is therefore reduced considerably.

Mounting

Fig. 2
The cable can be fastened in the mounting clip



Special effort has been put into making mounting as flexible as possible. The accelerometer housing has slots that allow the use of mounting clips so that the accelerometers can be easily fitted to a number of different test objects, or removed, for example, for calibration. UA 1408, UA 1473 and UA 1474 are sets of one hundred plastic mounting clips. UA 1563 is a set of five high-temperature clips.

The mounting clips are glued to the object, or fitted with double-sided, adhesive tape. A mounting clip with thick base is also available and can be filed down to suit your mounting surface. A mounting clip with swivel base is a third option. This makes it easy to align the accelerometer in order to retain the co-ordinate system. A Spirit Level UA 1480 (Fig. 6) is also available for this purpose. Finally, a high-temperature mounting clip is available (Fig. 7).

Common Specifications for all Plastic Mounting Clips

Temperature range:

(For brief use, <1 hour):

– 54° to +50°C (– 65° to +122°F)

– 54° to +80°C (– 65° to +176°F)

Maximum acceleration:

(Perpendicular to mounting surface):

10 g peak

70 g peak

Material:

Glass reinforced polycarbonate

Fig. 3

Mounting Clip UA 1408

Specifications:

Weight: 2.1 gram

Upper limiting frequency, 10%

– 4506, 4506 B: 2 kHz

– 4506 B 002: 1.1 kHz

– 4506 B 003: 1.2 kHz



Fig. 4

Mounting Clip with Thick Base

UA 1474. This can be filed down to

suit your mounting surface needs

(see picture, far right)

Specifications:

Weight: 3.9 gram

Upper limiting frequency, 10%

– 4506, 4506 B: 2 kHz

– 4506 B 002: 1.1 kHz

– 4506 B 003: 1.2 kHz

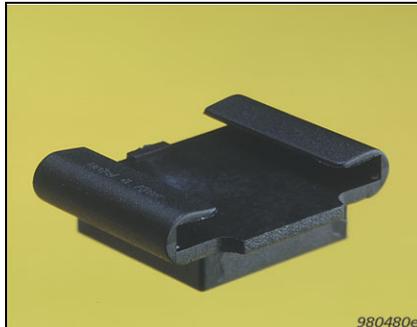


Fig. 5

Swivel Base UA 1473

Specifications:

Weight: 5.0 gram

Upper limiting frequency,

10% (mounted with grease):

– excited along one of the

accelerometer's axes of sensitivity

but with mounting surface of the

hemispherical part at 45° to the

direction of the excitation:

– 4506, 4506 B: 1 kHz

– 4506 B 002: 0.7 kHz

– 4506 B 003: 0.8 kHz



Fig. 6

Spirit Level UA 1480

Specifications:

Max. dimensions: 85 × 23 × 17 mm

Material: Black, anodised aluminium



Fig. 7

High Temperature Mounting Clip UA 1563

Specifications:

Temperature range: -55° to $+175^{\circ}\text{C}$ (-67° to $+347^{\circ}\text{F}$)

If discolouring can be accepted: -55° to $+250^{\circ}\text{C}$ (-67° to $+482^{\circ}\text{F}$)

Weight: 11 gram

Maximum acceleration (with a 17 gram accelerator): 10g peak

(Perpendicular to mounting surface): 50g peak

Material:

Base: Anodized aluminium; Spring: Stainless spring steel



Calibration

Fig. 8

Calibration Clip
DV 0460

Specifications:

Mounting-surface

diameter: 29 mm

Mounting thread: 10–

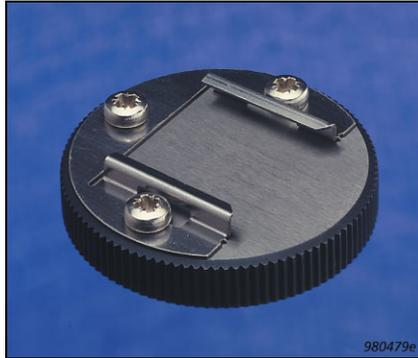
32 UNF

Weight: 44 gram

Material:

Base: Stainless steel
(hardened);

Spring: Stainless
steel spring



Each Type 4506 is individually calibrated and supplied with a comprehensive calibration chart. Long-term stability and reliability are ensured by artificial ageing during the production process. Field checking and system calibration are straightforward using Brüel & Kjær's hand-held Vibration Calibrator Type 4294.

Subsequent Calibration

Brüel & Kjær manufactures a range of equipment for frequency response, sensitivity and system calibrations. Details of these are available in separate Product Data Sheets.

DeltaTron

DeltaTron is a generic name for accelerometers and signal-conditioning products from Brüel & Kjær. It identifies products that operate on a constant-current power supply and give output signals in the form of voltage modulation on the power supply line. One of the advantages of this system is that it allows you to use inexpensive cables.

Type 4506 can be used with all vibration set-ups with DeltaTron or ICP[®] input modules.

The built-in, low-noise preamplifiers are made using thick film technology. They comprise ASICs including a special reference voltage that ensures a very stable bias voltage over the entire operating temperature range. Special efforts have been made to minimise interference from RF (Radio Frequency) electromagnetic fields.

The low output impedance means that you can connect long cables between the accelerometer and measurement equipment.

DeltaTron Power Supply

It is possible to use Type 4506 with only two powered axes provided they are the Y- and Z-axes. Single axial supply is not possible.

WB 1453 is a cost-effective and reliable, 3-channel, battery-operated power supply for DeltaTron accelerometers. The frequency range covers the full frequency range for the accelerometers and the transducer current is $3\text{ mA} \pm 20\%$. Both input and output are supplied with 4-pin, Microtech-compatible connectors.

Triaxial Accelerometer Type 4506 requires cables with a 4-pin Microtech connector. Brüel & Kjær can supply cables that are terminated with two 4-pin Microtech connectors (AO 0528), 4-pin Microtech to 3 × BNC connectors (AO 0526), 4-pin Microtech to 3 × 10–32 UNF connectors (AO 0527), or 4-pin Microtech to 3 × BNC connectors to 120°C (AO 0534). For powering two Type 4506 from a D-range subconnector, Cable AO 0536 is available.

Maximum Cable Length

The maximum output voltage of a DeltaTron accelerometer when driving long cables depends on the supply current at which it is operating, the frequency, and on the capacitance of the connecting cable.

The maximum cable length in metres (for distortion ≤ 1%) is given by:

$$L = 140000 \times \frac{I_s - 1}{f \times V_o \times C_m}$$

where:

I_s = supply current (mA)

f = frequency (kHz)

V_o = output voltage (V_{peak})

C_m = cable capacitance (pF/m)

IEEE P1451.4 “A Smart Transducer Interface for Sensors and Actuators”

Fig. 9
Types 4506 B, B 002 and B 003 each include three EEPROMs with TEDS. The figure shows a typical template for the Y-axis of Type 4506 B

The screenshot shows a window titled "IEEE P1451.4 TEDS editor - TEDS" with a menu bar (File, Node, Template). The main content area is titled "IEEE P1451.4 TEDS editor" and "Accelerometer, transfer function v0.91". It contains a table with the following data:

Node ID	8900000042648714
Manufacturer	Brüel & Kjær
Model number	4506
Version letter	B
Version number	0
Serial no.	2109964
Calibration date	maj 23, 2000
Sensitivity @ ref. cond. [S ref]	9,814mV/(m/s ²)
Reference frequency [f ref]	159Hz
Polarity [Sign]	+1
High pass cut-off frequency [f hp]	265,0mHz
Low pass cut-off frequency [f lp]	339,1kHz
Resonance frequency [f res]	9,70kHz
Quality factor @ f res [Q]	230
Amplitude slope [a]	-2,5%/decade
Temperature coefficient [b]	0,100%/°C
Reference temperature [T ref]	24,0°C
Sensitivity direction [x,y,z, n/a]	Y
Meas. position ID	0
User data [ascii 7-bit]	
CRC	OK

At the bottom right of the window is the Brüel & Kjær logo.

IEEE P1451.4 proposes a mixed-mode, smart transducer communication protocol that is based on existing analogue connections. It also specifies Transducer Electronic Data Sheet (TEDS) formats for interfacing analogue transducers with additional, smart features to legacy systems. The proposed interface is designed to be compatible with other P1451 network-capable transducer interfaces. The draft specification of IEEE P1451.4 is subject to change until approval by IEEE.

Characteristics

Frequency Response

The following information on frequency response is included on each accelerometer’s accompanying calibration chart. However, Types 4506 B, 4506 B002 and 4506 B 003 have this information built-in electronically (TEDS) as well.

The upper frequency limits given in the specifications are the frequencies where the deviation from the reference sensitivity is less than 10%. It is approximately 30% of the mounted resonance frequency. This assumes that the accelerometer is correctly mounted onto the test structure – a poor mounting can have a marked effect on the mounted resonance frequency.

The lower frequency limits and phase response are determined by the built-in preamplifiers. The lower frequency limits are given in the specifications for deviations from reference sensitivity of less than 10%.

Increased measurement accuracy can be achieved by dividing the actual measurement with the individual frequency response.

The calibration chart includes the individual TEDS values that, together with a general formula, best fit the measured frequency response. The expression can be used for frequency response compensation in the specified frequency range. The relative frequency response including amplitude and phase is:

$$S_{\text{rel}}(f,T) = (\text{Sign}) \times (1 + b(T - T_{\text{ref}})) \times \frac{j \frac{f}{f_{\text{hp}}}}{\left(1 + j \frac{f}{f_{\text{hp}}}\right)} \times \frac{1}{\left(1 + j \frac{f}{f_{\text{lp}}}\right)} \times \frac{1}{\left(1 + \left(j \frac{f}{f_{\text{res}}}\right)^2 + j \frac{f}{Q f_{\text{res}}}\right)} \times \left(j \frac{f}{f_{\text{ref}}}\right)^{\frac{a}{\ln 10}}$$

where:

Sign = Polarity

T = Temperature

f = Frequency

f_{lp} = Low-pass Cut-off Frequency

f_{ref} = Reference Frequency

a = Amplitude Slope/Decade

b = Temperature Coefficient

T_{ref} = Reference Temperature

f_{hp} = High-pass Cut-off Frequency

f_{res} = Resonance Frequency

Q = Quality Factor

Combining this equation with the amplitude sensitivity S_{ref} and f_{ref} and T_{ref} we have:

$$S(f,T) = S_{\text{ref}} \times \frac{S_{\text{rel}}(f,T)}{|S_{\text{rel}}(f_{\text{ref}}, T_{\text{ref}})|}$$

Implementation of this formula in either real-time data acquisition systems or in post-processing will support an automatic update of amplitude and/or phase.

Special Type

Type 4506 W 001 is a special biaxial version of Type 4506 that measures on the Y- and Z-axes. It has ultra-low residual noise of only 20 μg broadband, a sensitivity of 500 mV/g and weighs 24 grams (0.84 oz.). Its dimensions are 17 \times 17 \times 18 mm (0.67 \times 0.67 \times 0.71").

Specifications 4506, 4506 B, 4506 B 002, 4506 B 003

	4506	4506 B	4506 B 002	4506 B 003
DYNAMIC				
Sensitivity (at 159.2 Hz)	10 mV/ms ⁻² ± 10% (100 mV/g + 8, -12%)		100 mV/ms ⁻² ± 10% (1 V/g + 8, -12%)	50 mV/ms ⁻² ± 10% (500 mV/g + 8, -12%)
Measuring Range	± 700 ms ⁻² (70 g)		± 70 ms ⁻² (7 g)	± 140 ms ⁻² (14 g)
Frequency Range (± 10%)	X: 0.3 Hz to 5.5 kHz; Y, Z: 0.6 Hz to 3.0 kHz		X: 0.3 Hz to 3.5 kHz; Y, Z: 0.3 Hz to 1.6 kHz	X: 0.3 Hz to 4.0 kHz; Y, Z: 0.3 Hz to 2.0 kHz
Phase Response	3 Hz to 3 kHz, ± 5°		2 Hz to 2.5 kHz, ± 5°	
Mounted Resonance Frequency	X: 19.0 kHz; Y, Z: 10.0 kHz		X: 12.5 Hz Y, Z: 5.5 Hz	X: 14.0 kHz Y, Z: 7.0 kHz
Transverse Sensitivity	<5% of the sensitivity of the axis in question			
ELECTRICAL				
Residual Noise	(1 Hz to 6 kHz) X: < 40 μV RMS; Equivalent to < 0.004 ms ⁻² (< 400 μg) Y, Z: < 20 μV RMS; Equivalent to < 0.002 ms ⁻² (< 200 μg)		(1 Hz to 3 kHz) X: < 60 μV RMS; Equivalent to < 0.0006 ms ⁻² (< 60 μg) Y, Z: < 30 μV RMS; Equivalent to < 0.0003 ms ⁻² (< 30 μg)	(1 Hz to 3 kHz) X: < 60 μV RMS; Equivalent to < 0.0012 ms ⁻² (< 120 μg) Y, Z: < 30 μV RMS; Equivalent to < 0.0006 ms ⁻² (< 60 μg)
ENVIRONMENTAL				
Max. Non-destructive Shock (±Peak)	50 kms ⁻² (5000 g)		10 kms ⁻² (1000 g)	20 kms ⁻² (2000 g)
Temp. Transient Sensitivity (3 Hz Lower Limiting Frequency)	3 ms ⁻² /°C			5 ms ⁻² /°C
Base Strain Sensitivity Mounted on mounting clip or on adhesive tape 0.09 mm thick:	0.03 ms ⁻² /μϵ		0.01 ms ⁻² /μϵ	0.02 ms ⁻² /μϵ
Magnetic Sensitivity	6 ms ⁻² /T		3 ms ⁻² /T	6 ms ⁻² /T
Temperature Coeff. of Sensitivity	X: +0.05%/°C; Y, Z: +0.1%/°C		X: +0.15%/°C; Y, Z: +0.12%/°C	
PHYSICAL				
Sensing Element	Piezoelectric, Type PZ 23		Piezoelectric, Type PZ 27	
Dimensions (H×W×L)	17 × 17 × 14.5 mm (0.67" × 0.67" × 0.57"), excl. connector		17 × 17 × 17 mm (0.67" × 0.67" × 0.67"), excl. connector	
Weight	15 gram (0.53 oz.)		21 gram (0.74 oz.)	18 gram (0.63 oz.)
Built-in ID (TEDS)	No	Yes	Yes	Yes

Note: Except for the frequency range, all values are typical at 25°C (77°F), unless measurement uncertainty is specified. All uncertainty values are specified at 2σ (i.e., expanded uncertainty using a coverage factor of 2)

Common Specifications 4506, 4506 B, 4506 B 002, 4506 B 003

Electrical

Constant Current Supply: 2 to 10 mA per axis

Note: The Y and Z axes must be powered! If you only need two powered axes, you must choose the Y and Z axes. Single axial supply is not possible

Supply Voltage (Unloaded):

+24 to +30 VDC (for full specification range)

Min. +18 VDC (reduced measuring range)

Output Impedance: < 2 Ω (4506); < 30 Ω (4506 B/B 002/B 003)

Bias Voltage: 12 ± 1 V (4506); 13 ± 1 V (4506 B/B 002/B 003)

over the full temperature and current range

Insulation To Ground (Internal Insulation): > 1 GΩ

Polarity: Positive (on the X, Y and Z axes) for an acceleration in the direction of the engraved arrows

Environmental

Temperature Range: -54 to +100°C (-65 to 212°F)

Humidity: Sealed (welded)

Physical

Construction: OrthoShear

Case Material: Titanium

Connector: Microtech-compatible, 4-pin. 1/4"-28 thd. (titanium)

Mounting: 1 × 1.6 mm slots for clip mounting on five sides

Compliance with Standards

 	CE-mark indicates compliance with: EMC Directive and Low Voltage Directive. C-Tick mark indicates compliance with the EMC requirements of Australia and New Zealand.
Safety	EN 61010-1 and IEC 61010-1: Safety requirements for electrical equipment for measurement, control and laboratory use. UL 3111-1: Standard for Safety – Electrical measuring and test equipment.
EMC Emission	EN/IEC 61000-6-3: Generic emission standard for residential, commercial and light industrial environments. EN/IEC 61000-6-4: Generic emission standard for industrial environments. CISPR 22: Radio disturbance characteristics of information technology equipment. Class B Limits. FCC Rules, Part 15: Complies with the limits for a Class B digital device.
EMC Immunity	EN/IEC 61000-6-1: Generic standards – Immunity for residential, commercial and light industrial environments. EN/IEC 61000-6-2: Generic standards – Immunity for industrial environments. EN/IEC 61326: Electrical equipment for measurement, control and laboratory use – EMC requirements. Note 1: The above is only guaranteed using accessories listed in this Product Data sheet. Note 2: Sensitivity to RF (in accordance with EN 50082-2) <math> < 50 \mu V </math>.
Temperature	IEC 60068-2-1 & IEC 60068-2-2: Environmental Testing. Cold and Dry Heat. Operating Temperature: -54 to +100°C (-65 to 212°F).

Ordering Information

Types 4506, 4506 B, 4506 B 002 and 4506 B 003 Miniature Triaxial DeltaTron Accelerometers include the following accessories:
Carrying Box
Individual Calibration Chart
One Mounting Clip

Customer specified lengths:

AO 0526V – AC 0220-X
AO 0527V – AC 0220-X
AO 0528V – AC 0220-X
AO 0534V – AC 0223-X
AO 0536V – AC 0220-X

where X specifies the length in metres

Optional Accessories

AO 0526 Cable with 4-pin Microtech to 3 × BNC connectors, 5 m (16 ft) 85°C (185°F)
AO 0527 Cable with 4-pin Microtech to 3 × 10-32 UNF connectors, 5 m (16 ft) 85°C (185°F)
AO 0528 Cable with 4-pin Microtech to 4-pin Microtech connectors, 5 m (16 ft) 85°C (185°F)
AO 0534 Cable with 4-pin Microtech to 3 × BNC connectors, 5 m (16 ft) 120°C (248°F)
AO 0536 Cable with 37-pin D-range subconnector to 2 × 4-pin Microtech, 10 m (33 ft) 85°C (185°F)

YJ 0216 Mounting Wax
WB 1453 DeltaTron Power Supply
UA 1408 Set of 100 Mounting Clips
UA 1473 Set of 100 Swivel Base Clips
UA 1474 Set of 100 Mounting Clips with thick base
DV 0460 Calibration Clip
UA 1563 Set of 5 High Temperature Mounting Clips
UA 1417 Set of 25 Dummy Accelerometers for mass loading
4506-CFF Factory Standard Calibration with Calibration Chart

All cables are available in other lengths. The following suffixes to the Type number are used to specify the length when ordering
F: 3 m (10 ft) (AO 0526 only)
H: 10 m (33 ft) (AO 0526 only)
I: 15 m (50 ft) (AO 0526 only)

TRADEMARKS

ICP is a registered trademark of PCB Group, Inc., Depew, New York.

Brüel & Kjær reserves the right to change specifications and accessories without notice

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