Product Data

Cubic DeltaTron® Accelerometers — Types 4502 and 4503
Miniature Triaxial DeltaTron® Accelerometer — Type 4504

USES:

- ❍ Multichannel modal analysis measurements
- ❍ Axial and triaxial structural analysis and shock measurements on low-mass structures and in confined spaces
- ❍ General purpose vibration and structural analysis in automotive, aerospace and general machinery applications, especially where a large number of accelerometers is required

FEATURES:

- ❍ Low-weight ThetaShear® design giving high sensitivity/weight ratio and very low sensitivity to environmental factors
- ❍ Connects directly to DeltaTron® sockets
- ❍ ICP® compatible
- ❍ DeltaTron® allows the use of inexpensive coaxial cables. Low output impedance so that long extension cables can be used
- ❍ Choice of five mounting surfaces
- ❍ High resonance frequency giving a frequency range up to 23 kHz (±10%)
- ❍ Electrically insulated for ground loop protection
- ❍ High transverse resonance frequency
- ❍ Robust M3 titanium connector(s)

Fig. 1 Cubic DeltaTron® Accelerometer Type 4502 with top-mounted connector

Fig. 2 Cubic DeltaTron® Accelerometer Type 4503 with side-mounted connector

Fig. 3 Miniature Triaxial DeltaTron® Accelerometer Type 4504

Description

DeltaTron® Accelerometers Types* 4502, 4503 and 4504 are piezoelectric accelerometers providing a low sensitivity to extraneous environmental effects which is achieved through the new ThetaShear® design and the built-in preamplifier.

All types have been designed with particular emphasis on low-mass and small physical dimensions, combined with relatively high sensitivity and the greatest possible flexibility in mounting.

Types 4502 and 4503

The Cubic DeltaTron® Accelerometers Types 4502 and 4503 consist of a ThetaShear® accelerometer and a DeltaTron® preamplifier in a lightweight aluminium housing (see Fig. 5). The only difference is the position of the M3 sub-miniature coaxial connector which is positioned on

* Patented

the top surface which is perpendicular to the main axis for Type 4502 (top mounted connector) and on the side surface parallel to main axis for Type 4503 (side mounted connector) (Figs. 1 and 2).

Type 4504

The Miniature Triaxial DeltaTron® Accelerometer Type 4504 is composed of three separate ThetaShear® accelerometers with associated DeltaTron® preamplifiers in a single lightweight aluminium housing, and aligned so that vibration can be measured in three mutually perpendicular directions (see Fig. 4).

The Type 4504 has been designed for triaxial vibration measurement applications with particular emphasis on low-mass and small physical dimensions, combined with relatively high sensitivity and the greatest possible flexibility in mounting.

ThetaShear®

The ThetaShear® design (patented) is illustrated in Figs. 4. and 5. A slotted cylindrical stanchion (1) holds a central seismic mass (2) flanked by two piezoelectric disks (3). This assembly is clamped rigidly by the cover (4). The parts are firmly held together without the use of any bonding agent other than molecular adhesion, a principle which has proved extremely reliable in the Brüel&Kjær DeltaShear® Accelerometers.

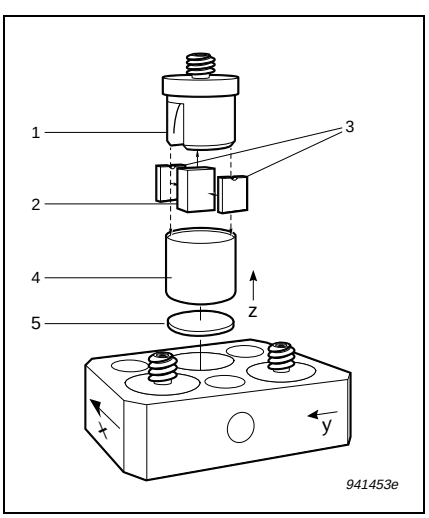

Fig. 4 Exploded view of Miniature Triaxial DeltaTron™ Accelerometer Type 4504 showing the ThetaShear® design and the built-in DeltaTron® preamplifier

Environmental Sensitivity

One of the most troublesome environmental factors encountered when using piezoelectric accelerometers is temperature transients. By careful choice of materials and mechanical design, this has been reduced to a minimum.

The ThetaShear® design also provides excellent immunity to other environmental effects such as base strains, magnetic sensitivity and acoustic fields.

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 coaxial cables.

The 4502, 4503 and 4504 accelerometers can be used with all vibration set-ups with DeltaTron® or ICP®* input modules.

The built-in preamplifier, (5) in Figs. 4 and 5, is a charge converter made using thick film technology. It comprises a low-noise MOS Field Effect Transistor as its input stage and a bipolar transistor to give low output impedance. A single-pole filter at the input extends the accelerometer's usable frequency range to approximately 35% (Types 4502/4503) to 45% (Type 4504) of the mounted resonance frequency. 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.

Electromagnetic Compatibility (EMC)

Susceptibility of DeltaTron® accelerometers to radio-frequency electromagnetic radiation is also low.

The accelerometers comply with EEC Standards EN 50081–1 and EN 50082–2 for emission and immunity, respectively.

EN 50081–1 covers:

- Radiated emission, 0.03 to 1 GHz
- Conducted emission from 0.15 to 30 MHz

EN 50082–2 covers the effects of:

- Radio frequency fields from 80 to 1000 MHz at a field strength of 3 and 10 V/m with an amplitude modulation of 80%
- Electrostatic discharge, 4 and 8 kV
- Transient bursts at 1 and 2 kV
- Magnetic fields with a strength of 30 A/m at 50 Hz
- Pulse modulated radio frequency fields at 900 MHz at a field strength of 10 V/m and a duty cycle of 50%

* ICP is a trademark of PCB Piezotronics, Inc.

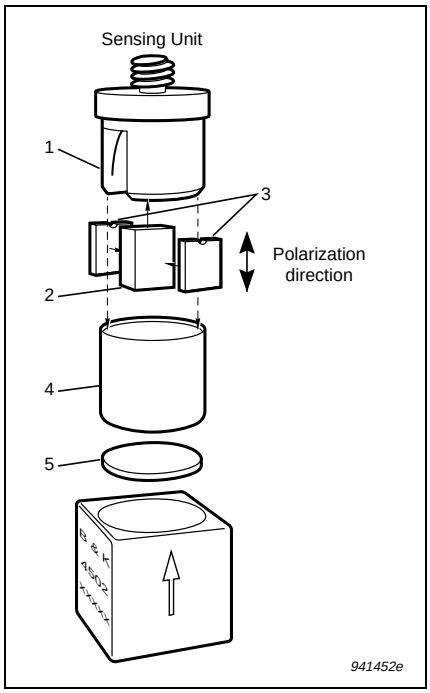

Fig. 5 Exploded view of Cubic DeltaTron® Accelerometer Type 4502 showing the ThetaShear® design and the built-in DeltaTron® preamplifier

Calibration

Each 4502/4503/4504 is individually calibrated and supplied with a comprehensive calibration chart. Long-term stability and reliability is ensured by artificial ageing during the production process. Field checking and system calibration is straightforward using the Brüel & Kjær hand-held Vibration Calibrator Type 4294.

Subsequent Calibration

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

Mounting

Special effort has been put into making mounting as flexible as possible. Five of the six surfaces can be used for mounting with adhesive cement, mounting wax or double-sided adhesive tape.

The triaxial accelerometer Type 4504 has 3 mm threaded holes for mounting with M2 screws or M3 studs. Where threaded holes can be provided in the test piece, the 4504 can be mounted from the top or two sides. The base can accommodate three M2 screws for top mounting, one M3 stud for bottom mounting, or one M3 stud for side mounting. Mica washers can be used to assist in angular positioning when mounting with M3 studs.

Cable Clamping

When using miniature accelerometers, the accelerometer cable can affect the measurement result because of forces exerted by the cable on the accelerometer connector. This causes amplitude irregularities in the output from the accelerometer at frequencies up to approximately 200 Hz. The problem can be reduced by using a flexible cable. However, to effectively reduce the problem at low frequencies, it is recommended to clamp the cable. One way of doing this is to make a small loop in the cable close to the accelerometer (max. diameter 30 mm) and clamping the cable beside the base of the accelerometer with mounting wax or double-sided tape.

Ground Insulation

The base of the accelerometers is insulated and has a ground insulation of minimum 10 MΩ. Ground loops, which can be particularly troublesome in multi-channel measurements, are avoided as the sensor is electrically insulated from the aluminium body and thus from the test piece. Furthermore, all mounting surfaces are hard anodized, providing additional insulation.

Cables and Connectors

For general non-critical use, the standard Cable AO 0339 is recommended since it is very flexible and easy to install. To avoid EMC problems the 1.2 m double screened cable AO 1381 is recommended. This cable has a Brüel & Kjær M3 sub-miniature coaxial connector to match the accelerometer output at one end, and a 10–32 UNF Microdot connector at the other end. A special cable mounting tool (QA 0220) is available to enable easy cable fitting in confined spaces.

With Cable AO 0406 and Extension Adaptor Set UA 0186 you can extend your accelerometer cable by 5 m. A number of standard extension cables are available. If longer extension cables are required you can make them with Connector Set UA 0130 (25 Connectors JP 0012), back piece DB 2749 and cable AC 0104 which is available per metre.

For measurements in less critical EMC environments, you can use cable AO 0283, and if longer cable runs are required you can make your own extension cables with Connector Set UA 0130 and super low-noise cable AC 0005 or the flexible low cost cable AC 0208 (for detailed information about these options see the Ordering Information).

In order to distinguish the individual accelerometers in a multichannel measurement set-up, or the x-y-z signals from the triaxial accelerometer, coloured cable markers are available to fit both the AO 1381 and AO 0283 cables and the thicker AC 0005 and AC 0208 cables.

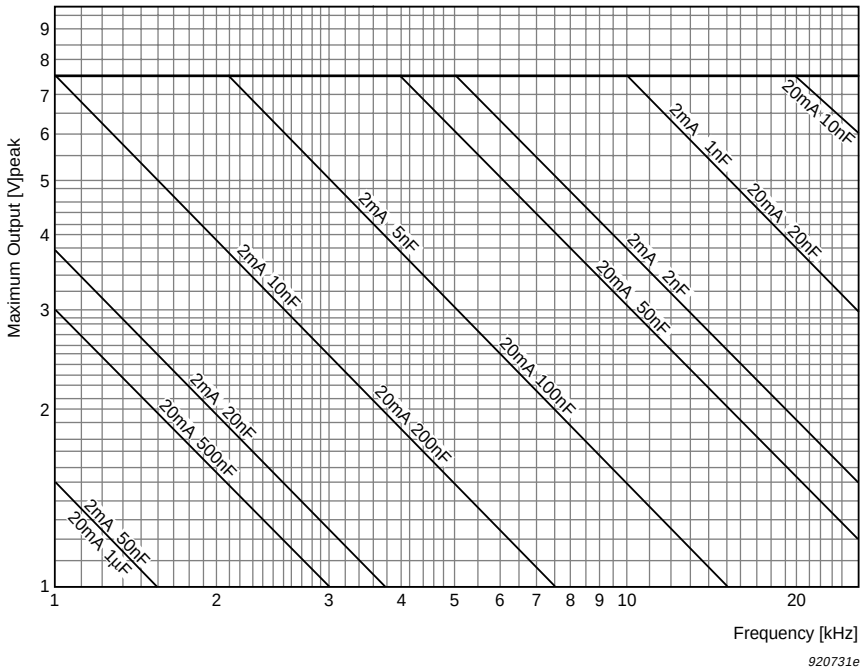

Fig. 6 Typical curves for maximum output level of DeltaTron® accelerometers, showing maximum capacitive load over the recommended current supply range

Maximum Cable Length

The maximum output voltage of a DeltaTron® accelerometer depends on the supply current at which it is operating, and on the capacitive load due to the connecting cable.

Fig. 6 shows typical curves for maximum output levels with supply currents of 2 and 20 mA (for distortion ≤ 1%). The maximum cable length in metres (L) is given by:

$$L = 75000 \times \frac{I_s}{f \times V_o \times C_m}$$

where:

I_s = supply current [mA]
f = frequency [kHz]
V_o = output voltage [V_{peak}]
C_m = cable capacitance [pF/m]

If the supply current is less than 4 mA, the power consumption of the built-in preamplifier becomes significant and this formula cannot be applied.

DeltaTron® Power Supply WB 1372

WB 1372 is a cost-effective and reliable single-channel, battery operated power supply for DeltaTron® accelerometers. The frequency range covers the full frequency range for the accelerometers (0.07 Hz to 25 kHz ±5%) and the transducer current is 3 mA ±20%.

Specifications 4502 and 4503

Dynamic

SENSITIVITY (at 159.2 Hz, 4 mA): 1.0 mV/ms^{-2} (10 mV/g) ±20%

MEASURING RANGE (peak):
±7500 ms^{-2} at <100°C (212°F)
±5000 ms^{-2} at <125°C (257°F)

FREQUENCY RESPONSE:
1 Hz to 23 kHz ±10% re sensitivity at 159.2 Hz
Note: This specification is only valid if the cable is clamped as described in this Product Data

MOUNTED RESONANCE FREQUENCY:
50 kHz

TRANSVERSE RESONANCE FREQUENCY:
>20 kHz

TRANSVERSE SENSITIVITY: ≤5% of sensitivity

Electrical

CONSTANT CURRENT SUPPLY:
+2 to +20 mA at <100 °C (212 °F)
+2 to +10 mA at <125 °C (257 °F)

SUPPLY VOLTAGE (unloaded):
+24 to +30 V DC (for full specification range)
Min. +18 V DC (reduced measuring range)

OUTPUT IMPEDANCE: <100 Ω

BIAS VOLTAGE:
12 ±0.5 V at 25 °C, 4 mA
8 to 15 V for full temperature and current range

RESIDUAL NOISE (1 Hz to 22 kHz):
<40 µV
0.040 ms^{-2} equivalent acceleration

CASE INSULATION TO GROUND (at 100 V):
>10 MΩ

INSULATION BREAKDOWN VOLTAGE: 1 kV

POLARITY:
Positive (for an acceleration directed from base into the accelerometer body)

OVERLOAD RECOVERY TIME (2×max. level):
<10 µs

Environmental

MAX. NON-DESTRUCTIVE SHOCK (±Peak):
30 kms^{-2}; 3000 g

HUMIDITY: Sealed

ACOUSTIC SENSITIVITY:
0.04 ms^{-2} at 154 dB SPL

TEMP. TRANSIENT SENSITIVITY (3 Hz lower limiting frequency): 1 ms^{-2}/°C

BASE STRAIN SENSITIVITY: 0.05 ms^{-2}/µε

MAGNETIC SENSITIVITY (50 Hz): 10 ms^{-2}/tesla

Physical:

CASE MATERIAL: Aluminium/anodized

BASE MATERIAL: Titanium

PIEZOELECTRIC ELEMENT:
Design Configuration: ThetaShear®

Material: Type PZ 23

CONNECTOR: M3 coaxial

MOUNTING SURFACE FLATNESS: <10 µm

SEISMIC MASS: 0.8 gram (0.03 oz.)

CENTRE OF GRAVITY OF ACCELEROMETER: 5.2 mm (0.20″) from the connector surface on the rotationally symmetrical axis

DIMENSIONS (H×W×L): 11×11×11 mm (0.43″)

WEIGHT: 4.5 gram (0.16 oz.)

Note: 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)

COMPLIANCE WITH STANDARDS:

CE	CE-mark indicates compliance with: EMC Directive.
Safety	EN 61010–1 and IEC 1010–1: Safety requirements for electrical equipment for measurement, control and laboratory use.
EMC Emission	EN 50081–1: Generic emission standard. Part 1: Residential, commercial and light industry. EN 50081–2: Generic emission standard. Part 2: Industrial environment. 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 50082–1: Generic immunity standard. Part 1: Residential, commercial and light industry. EN 50082–2: Generic immunity standard. Part 2: Industrial environment.
Temperature	IEC 68–2–1 & IEC 68–2–2: Environmental Testing. Cold and Dry Heat. Operating Temperature: –50 to +125 °C (–58 to +257 °F)

The ThetaShear® design is a Brüel&Kjær patent

Specifications 4504

Dynamic

SENSITIVITY (at 159.2 Hz, 4 mA): 1.0 mV/ms^{-2} (10 mV/g) ±20%
MEASURING RANGE (peak):
±7500 ms^{-2} at <100°C (212°F)
±5000 ms^{-2} at <125°C (257°F)
FREQUENCY RESPONSE:
X-axis: 1 to 15000 Hz ±10%
Y-axis: 1 to 10000 Hz ±10%
Z-axis: 1 to 23000 Hz ±10%
re sensitivity at 159.2 Hz
Note: The frequency tolerances are only valid if the cables are clamped as described in this Product Data
MOUNTED RESONANCE FREQUENCY:
X-axis: 40 kHz
Y-axis: 30 kHz
Z-axis: 50 kHz
TRANSVERSE RESONANCE FREQUENCY:
X-axis: >18 kHz
Y-axis: >18 kHz
Z-axis: >20 kHz
TRANSVERSE SENSITIVITY: ≤5% of sensitivity

Electrical

CONSTANT CURRENT SUPPLY:
+2 to +20 mA at <100 °C (212 °F)
+2 to +10 mA at <125 °C (257 °F)
SUPPLY VOLTAGE (unloaded):
+24 to +30 V DC (for full specification range)
Min. +18 V DC (reduced measuring range)
OUTPUT IMPEDANCE: <100 Ω
BIAS VOLTAGE:
12 ±0.5 V at 25 °C, 4 mA
8 to 15 V for full temperature and current range
RESIDUAL NOISE (1 Hz to 22 kHz):
<40 μV
0.040 ms^{-2} equivalent acceleration
CASE INSULATION TO GROUND (at 100 V):
>10 MΩ
INSULATION BREAKDOWN VOLTAGE: 1 kV
POLARITY:
Positive (on the X, Y and Z-axes for an acceleration directed from the corresponding mounting surface into the accelerometer body)

OVERLOAD RECOVERY TIME (2×max. level):
<10 μs

Environmental

MAX. NON-DESTRUCTIVE SHOCK (±Peak):
30 kms^{-2}; 3000 g
HUMIDITY: Sealed
ACOUSTIC SENSITIVITY:
0.04 ms^{-2} at 154 dB SPL
TEMP. TRANSIENT SENSITIVITY (3 Hz lower limiting frequency): 1 ms^{-2}/°C
BASE STRAIN SENSITIVITY: 0.05 ms^{-2}/με
MAGNETIC SENSITIVITY (50 Hz): 10 ms^{-2}/tesla

Physical:

CASE MATERIAL: Aluminium/anodized
BASE MATERIAL: Titanium
PIEZOELECTRIC ELEMENT:
Design Configuration: ThetaShear®
Material: Type PZ 23
CONNECTORS: 3×M3 coaxial
MOUNTING SURFACE FLATNESS: <10 μm
SEISMIC MASS: 3×0.8 gram (3×0.03 oz.)
CENTRE OF GRAVITY OF ACCELEROMETER: 5.8 mm (0.23″) above the mounting surface for the Z-direction, on the central axis of gravity
DIMENSIONS (H×W×L):
11×17.5×22.5 mm (0.43″)
WEIGHT: 14 gram (0.43″×0.69″×0.89″)

Note: 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)

COMPLIANCE WITH STANDARDS:

CE	CE-mark indicates compliance with: EMC Directive.
Safety	EN 61010–1 and IEC 1010–1: Safety requirements for electrical equipment for measurement, control and laboratory use.
EMC Emission	EN 50081–1: Generic emission standard. Part 1: Residential, commercial and light industry. EN 50081–2: Generic emission standard. Part 2: Industrial environment. 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 50082–1: Generic immunity standard. Part 1: Residential, commercial and light industry. EN 50082–2: Generic immunity standard. Part 2: Industrial environment.
Temperature	IEC 68–2–1 & IEC 68–2–2: Environmental Testing. Cold and Dry Heat. Operating Temperature: –50 to +125 °C (–58 to +257 °F)

The ThetaShear® design is a Brüel&Kjær patent

Ordering Information

Optional Accessories

AO 0339: 1.2 m (4 ft) flexible low-noise standard cable.
AO 1381: 1.2 m (4 ft) Teflon insulated double screened cable* with Microdot and M3 connectors
AO 0283: 1.2 m (4 ft) super low-noise cable
QA 0220: Cable connecting/removal tool
UA 1243: 3×30 pieces of red/green/yellow cable markers for AO 0283, AO 1381 and AC 0104

* Improved EMC performance

UA 1244: As above, for Cable AC 0005 and AC 0208
AC 0104: Teflon insulated double screened cable* (excl. connectors; available per metre)
AC 0005: Teflon insulated super low-noise cable (excl. connectors; available per metre)
AC 0208: Low cost PVC insulated flexible cable (excl. connectors; available per metre)
AO 0406: 5 m (16 ft) cable AC 0104 fitted with Microdot connectors. Supplied with a Microdot to BNC adaptor*

UA 0130: Connector Set, consisting of 25 Connectors JP 0012 for Cable AC 0005, AC 0208 and AC 0104 (Back-piece DB 2749 required with Cable AC 0104)
QA 0035: Connector Assembly Tool for Connector JP 0012
UA 0186: Extension Adaptor Set, consisting of 25 Extension Adaptors (JJ 0032) for cables with Connector JP 0012
YJ 0216: Mounting Wax
QS 0007: Cyanoacrylate adhesive
WB 1372: DeltaTron® Power Supply

Brüel & Kjær

WORLD HEADQUARTERS:

DK-2850 Naerum · Denmark · Telephone: +45 45 80 05 00 · Fax: +45 45 80 14 05 · Internet: http://www.bk.dk · e-mail: info@bk.dk

Australia (02) 9450-2066 · Austria 00 43-1-865 74 00 · Belgium 016/44 92 25 · Brazil (011) 246-8166 · Canada: (514) 695-8225 · China 10 6841 9625 / 10 6843 7426
Czech Republic 02-67 021100 · Finland 90-229 3021 · France (01) 69 90 69 00 · Germany 0610 3/908-5 · Holland (0)30 6039994 · Hong Kong 254 8 7486
Hungary (1) 215 83 05 · Italy (02) 57 60 4141 · Japan 03-3779-8671 · Republic of Korea (02) 3473-0605 · Norway 66 90 4410 · Poland (0-22) 40 93 92 · Portugal (1) 47114 53
Singapore (65) 275-8816 · Slovak Republic 07-37 6181 · Spain (91) 36810 00 · Sweden (08) 71127 30 · Switzerland 01/94 0 09 09 · Taiwan (02) 713 9303
United Kingdom and Ireland (0181) 954-236 6 · USA 1 - 800 - 332 - 2040
Local representatives and service organisations worldwide

BP 1451 – 12

96/12