Cubic Triaxial CCLD Accelerometer Types 4524, 4524-B and 4524-B-001
Piezoelectric Accelerometer

The Type 4524 series consists of lightweight triaxial piezoelectric OrthoShear™ accelerometers, each with three independent outputs for simultaneous measurements in three mutually perpendicular directions. Each accelerometer is engraved with a data matrix code. Scan the matrix code with your smartphone to:

- Together with the Transducer Smart Setup app, simplify and automate multichannel test setups
- Quickly access the individual accelerometer’s specifications, calibration information, etc.

The accelerometer’s clip mounting facility combined with the ability to mount the transducer on five of its six surfaces, makes mounting on structures very flexible and quick and thus ideal for structural and modal analysis measurements.

Uses and Features

Uses
- Structural analysis measurements
- Multichannel modal analysis measurements
- Modal measurements for automotive body and power train applications
- Hand and arm measurements (Type 4524-B-001)

Features
- High sensitivity-to-weight ratio
- Light weight (<5 gram)
- Excellent low-frequency response
- Electrically insulated
- Hermetically sealed
- Easy mounting on five of six surfaces
- B-versions utilise transducer electronic data sheets (TEDS)
- 4-pin connector
- Data matrix code providing Web-based transducer-specific information and enabling Transducer Smart Setup

CCLD: Constant Current Line Drive, also known as DeltaTron®, ICP® and IEPE compatible. CCLD 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 4524 is a piezoelectric accelerometer that features a built-in preamplifier. The sensitivity is expressed in terms of voltage per unit acceleration (mV/g).

The OrthoShear design used in Type 4524 (Fig. 1) is built around a common seismic mass. This uni-mass design results in a very compact triaxial accelerometer where all the axes have the same point of reference and ensure accurate and consistent measurements, even when the accelerometer is exposed to complex vibration patterns. The seismic mass is surrounded by a piezoelectric ring, which is surrounded by three individually suspended, curved arms. Because of the suspension pins, 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.

B Versions

Types 4524-B and 4524-B-001 include a transducer electronic data sheet (TEDS) containing sensor- and application-specific information, including frequency response compensation.

CCLD Power Supply

Type 4524 requires all three axes to be powered for operation. Single- or dual-axial supply is not possible. The accelerometers can be used with any constant current (2 to 10 mA) power supply setup.

For a cost-effective and reliable power supply, the optional CCLD Power Supply WB-1453 is a 3-channel, battery-operated power supply for CCLD accelerometers. The frequency range covers the full frequency range for the accelerometers and the transducer current is 3 mA ±20%. Both input and output are supplied with 4-pin, Microtech-compatible connectors.

Frequency Compensation with REq-X

REq-X stands for Response Equalisation Extreme, which is a technique that allows you to flatten the frequency response of a transducer in real time. This flattening is done by filtering the time signal of a transducer by the inverse of the frequency response.

The calibration chart includes 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:

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

- **Sign** = Polarity
- **T** = Temperature
- **f** = Frequency
- **f_{hp}** = High-pass Cut-off Frequency
- **f_{lp}** = Low-pass Cut-off Frequency
- **f_{ref}** = Reference Frequency
- **T_{ref}** = Reference Temperature
- **b** = Temperature Coefficient
- **Q** = Quality Factor
- **a** = Amplitude Slope/Decade

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

$$S(f, T) = S_{ref} \times \frac{S_{ref}(f, T)}{S_{ref}(f_{ref}, T_{ref})}$$
Implementation of this formula in real-time measurement and post-processing systems, such as with BK Connect, will extend the usable frequency range, improve accuracy or allow a combination of the two.

**Fig. 2**
Typical frequency responses with and without REq-X applied

**Transducer Smart Setup**

Transducer Smart Setup is a mobile app that works in combination with the data matrix code engraved on the transducer. With the Transducer Smart Setup app, you can scan the data matrix code using your smartphone’s camera. It will then recognize the transducer and allow you to add associated data such as location and orientation, minimizing the risk of data entry errors. The data can be imported into BK Connect™ as hardware setup tables for easy front-end configuration. If you change connections, just reimport the setup and the configuration will align as necessary – no need to trace cables.

The Transducer Smart Setup app is available for free in the App Store™.

**Use the Data Matrix Code to Access Transducer Information**

Even without the app, scanning the data matrix code on the transducer provides fast and easy access to detailed product information such as:

- Specifications
- Technical documentation
- Specific calibration data
- Information about Transducer Smart Setup
Mounting

Special effort has been put into making mounting as flexible as possible. The accelerometers can be easily fitted to or removed from a number of different test objects. In addition to adhesive mounting directly on the test object, the accelerometer housing has slots that allow the use of mounting clips.

Mounting Clips
There are four clip-mounting possibilities:

High-temperature Mounting Clip
For mounting in high temperatures, use High-temperature Mounting Clip UA-1564.

- **Temperature range**: Full operating range of Type 4524
- **Maximum acceleration**:
  - With a 5 g accelerometer: 50 g peak
  - Perpendicular to mounting surface: 250 g peak
- **Base material**: Anodised aluminium
- **Spring material**: Stainless steel
- **Weight**: 5.7 g

Thin, Polycarbonate Mounting Clip
For mounting on planes and similar surfaces, use Mounting Clip UA-1407.

- **Upper limiting frequency (10%)**:
  - X-axis: 2.7 kHz
  - Y- and Z-axes: 2.0 kHz
- **Weight**: 0.4 g

Thick-base Mounting Clip
To shape and customize the mounting to fit your needs, use Mounting Clip with Thick Base UA-1475. The thick base can be filed down as needed.

- **Upper limiting frequency (10%)**:
  - X-axis: 2.7 kHz
  - Y- and Z-axes: 2.0 kHz
- **Weight**: 0.7 g
**Swivel-base Mounting Clip**

To align and realign the accelerometer without changing the coordinate system, use Swivel Base Clip UA-1478. Together with Spirit Level UA-1480, you can change the accelerometer’s direction and still maintain the coordinate system.

Excitation must be along one of the accelerometer’s axes of sensitivity but with the mounting surface of the hemispherical part at 45° to the direction of the excitation.

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**Swivel Base Clip**
- **Upper limiting frequency (10%)**:
  - X-axis: 2.5 kHz
  - Y- and Z-axes: 1.9 kHz
- **Weight**: 0.8 g

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**Spirit Level**
- **Max. dimensions**: 85 × 23 × 17 mm (3.35 × 0.9 × 0.67 in)
- **Material**: Black, anodised aluminium

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**Common Specifications for UA-1407, UA-1475 and UA-1478**
- **Temperature range**: −54 to +50 °C (−65 to +122 °F)
  - For brief use, <1 hour: −54 to +80 °C (−65 to +176 °F)
- **Maximum acceleration**: 10 g peak
  - Perpendicular to mounting surface: 70 g peak
- **Material**: Glass-reinforced polycarbonate

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**Calibration**

**Calibration Clip DV-0459**
- **Mounting surface diameter**: 21 mm
- **Mounting thread**: 10–32 UNF
- **Base material**: Stainless steel (hardened)
- **Spring material**: Stainless steel
- **Weight**: 17 g

The transducers are individually calibrated and supplied with a comprehensive calibration chart, using state-of-the-art, random FFT technology, providing an 1600-point high-resolution calibration (magnitude and phase) ultimately giving a unique characterization and securing the integrity of the vibration measurement.

The sensitivity given on the calibration chart has been measured at 159.2 Hz with a 95% confidence level, using a coverage factor $k = 2$. 
Table 1 Cables compatible with Type 4524

<table>
<thead>
<tr>
<th>Cable No.</th>
<th>Connector A</th>
<th>Connector B</th>
<th>Temperature</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>AO-0526</td>
<td></td>
<td>BNC (M)</td>
<td>90 °C (194 °F)*</td>
<td>Flexible</td>
</tr>
<tr>
<td></td>
<td></td>
<td>¼–28 UNF 4-pin (F)</td>
<td>90 °C (194 °F)*</td>
<td>Single cable to 3 x super low-noise cables</td>
</tr>
<tr>
<td>AO-0527</td>
<td></td>
<td>10–32 UNF (M)</td>
<td>90 °C (194 °F)*</td>
<td>Flexible</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Single cable to 3 x super low-noise cables</td>
</tr>
<tr>
<td>AO-0534</td>
<td>¼–28 UNF 4-pin (F)</td>
<td>BNC (M)</td>
<td>250 °C (482 °F)*</td>
<td>Flexible</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Single cable to 3 x super low-noise cables</td>
</tr>
<tr>
<td>AO-0740</td>
<td>¼–28 UNF 4-pin (F)</td>
<td>10–32 UNF (M)</td>
<td>250 °C (482 °F)</td>
<td>Flexible</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Four-wire cable</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Single-screened, coaxial</td>
</tr>
<tr>
<td>AO-0528</td>
<td>¼–28 UNF 4-pin (F)</td>
<td>BNC (M)</td>
<td>90 °C (194 °F)</td>
<td>Flexible</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Connects two triaxial accelerometers</td>
</tr>
<tr>
<td>AO-0714</td>
<td>¼–28 UNF 4-pin (M)</td>
<td>10–32 UNF (M)</td>
<td>250 °C (482 °F)</td>
<td>Flexible</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Four-wire cable</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Single-screened, coaxial</td>
</tr>
<tr>
<td>AO-0536</td>
<td>D-sub 37-pin (F)</td>
<td></td>
<td>90 °C (194 °F)</td>
<td>Flexible</td>
</tr>
</tbody>
</table>

* This cable has a splitter with an operating temperature range of –40 to +150 °C (–40 to +302 °F)

Fig. 4 Typical configurations with Type 4524
Specifications – Cubic Triaxial CCLD Accelerometers Types 4524, 4524-B and 4524-B-001

All values are typical at 25 °C (77 °F) unless measurement uncertainty is specified. All values are valid with 4 mA supply current and all three axes powered.

Dynamic Characteristics

<table>
<thead>
<tr>
<th>Units</th>
<th>4524</th>
<th>4524-B</th>
<th>4524-B-001</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage Sensitivity (@ 159.2 Hz)</td>
<td>mV/ms(^{-2}) (mV/g)</td>
<td>10 (\pm 5%) (100(\pm 5%))</td>
<td>1 (\pm 10%) (100(\pm 7%))</td>
</tr>
<tr>
<td>Measuring Range</td>
<td>ms(^{-2}) (g)</td>
<td>(\pm 500) ((\pm 50))</td>
<td>(\pm 5000) ((\pm 500))</td>
</tr>
<tr>
<td>Frequency Response</td>
<td>See Typical Frequency Response (Fig. 2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mounted Resonance Frequency</td>
<td>kHz</td>
<td>X: 18</td>
<td>Y: 9</td>
</tr>
<tr>
<td>Amplitude Response (\pm 10%)</td>
<td>Hz</td>
<td>X: 0.2 to 5500 Y: 0.25 to 3000 Z: 0.25 to 3000</td>
<td></td>
</tr>
<tr>
<td>Amplitude Response (\pm 10%) with REq-X</td>
<td>Hz</td>
<td>X: 0.2 to 10000 Y: 0.25 to 5000 Z: 0.25 to 5000</td>
<td></td>
</tr>
<tr>
<td>Phase Response (\pm 5\°)</td>
<td>Hz</td>
<td>1.5 to 3000</td>
<td></td>
</tr>
<tr>
<td>Temperature Response</td>
<td>%/°C (%/°F)</td>
<td>0.14 (0.08)</td>
<td>0.11 (0.05)</td>
</tr>
<tr>
<td>Residual Noise (1 to 6000 Hz) Broadband</td>
<td>mg</td>
<td>X:&lt;0.4 Y:&lt;0.2 z:&lt;0.2</td>
<td>X:&lt;0.7 Y:&lt;0.7 Z:&lt;0.9</td>
</tr>
<tr>
<td>Transverse Sensitivity</td>
<td>%</td>
<td>&lt;5</td>
<td></td>
</tr>
</tbody>
</table>

Electrical Characteristics

| DC Output Bias Voltage | V DC | +12 \(\pm 1\) | +13 \(\pm 1\) |
| Output Impedance | Ω | <2 | <30 |
| Grounding | Insulated from case |

Power Requirements (NOTE: All three axes must be powered during operation)

| Supply Voltage (Unloaded) | V DC | 24 to 30 |
| Constant Current Supply | mA | 2 to 10 |
| Warm-up Time (90% of stabilised bias) | s | 10 |

Environmental Characteristics

| Temperature Range | °C (°F) | –54 to +100 (–65 to +212) |
| Humidity | Hermetic |
| Max. Operational Sinusoidal Vibration (peak) | ms\(^{-2}\) (g) | 5000 (500) |
| Max. Operational Shock (± peak) | ms\(^{-2}\) (g) | 50,000 (5000) |
| Base Strain Sensitivity | Equiv. ms\(^{-2}\)/μ strain (g/μ strain) | Mounted in clip: 0.0005 (0.00005) Cemented to measuring object: 0.02 (0.002) |
| Thermal Transient Sensitivity | Equiv. ms\(^{-2}\)/°C (g/°F) | 0.1 (0.005) |
| Magnetic Sensitivity (50 Hz – 0.03 tesla) | ms\(^{-2}\)/T (g/T) | 20 (2) | 30 (3) |

Physical Characteristics

| Dimensions | See outline drawing (Fig. 6) |
| Weight | g (oz) | 4.4 (0.15) | 4.8 (0.17) |
| Case Material | Titanium |
| Connector | Hermetic 4-pin receptacle \(\frac{1}{4}\)-28 UNF-2A |
| Mounting | Adhesive or clip |

Fig. 6 Dimensions (millimetres) of Types 4524 (left) and 4524-B/4524-B-001 (right)
MAXIMUM CABLE LENGTH

The maximum output voltage of a CCLD accelerometer when driving long cables depends on the supply current at which it is operating, and on the capacitive load due to the connecting cable. The maximum cable length in meters (for distortion ≤1%) is given by:

\[ L = \frac{I_s - 1}{f \times V_o \times C_m} \]

where:
- \( I_s \) = supply current (mA)
- \( f \) = frequency (kHz)
- \( V_o \) = output voltage (Vpeak)
- \( C_m \) = cable capacitance (pF/m)

Ordering Information

Type 4524 Cubic Triaxial CCLD Accelerometer, 10 mV/ms\(^{-2}\)
Type 4524-B Cubic Triaxial CCLD Accelerometer with TEDS, 10 mV/ms\(^{-2}\)
Type 4524-B-001 Cubic Triaxial CCLD Accelerometer with TEDS, 1 mV/ms\(^{-2}\)

All accelerometers include the following accessories:
- Carrying Box
- Calibration Chart
- One Mounting Clip

Optional Accessories

CABLES AND ADAPTERS
- AO-0526-D-xxx* Cable with circular 4-pin to 3 × BNC connectors, 90 °C (194 °F)
- AO-0527-D-xxx* Cable with circular 4-pin to 3 × 10–32 UNF connectors, 90 °C (194 °F)
- AO-0534-D-xxx* Cable with circular 4-pin to 3 × BNC connectors, 250 °C (482 °F)
- AO-0536-D-050 Cable with 2 × circular 4-pin to 37-pin D-sub- connectors, 5 m (16.7 ft), 90 °C (194 °F)
- AO-0714-D-xxx* Cable with circular 4-pin (F) to 4-pin (M) connectors, 250 °C (482 °F)
- AO-0740-D-xxx* Cable with 4-pin to 3 × 10–32 UNF connectors, 250 °C (482 °F)
- JP-0145 Plug Adapter, 10–32 UNF (F) to BNC (M)
- WA-1705 Plug Adapter, 10–32 UNF (F) to SMB (F)

TRANSDUCER SMART SETUP
Free download from the App Store (requires iOS 8.0 or later)
CALIBRATION
- DV-0459 Calibration Clip
- Type 4294 Vibration Calibrator

MOUNTING
- UA-1407 Set of 100 Mounting Clips
- UA-1418 Set of 25 Dummy Accelerometers for mass loading
- UA-1475 Set of 100 Mounting Clips with thick base
- UA-1478 Set of 100 Swivel Base Clips
- UA-1480 Spirit Level Set (including 100 Swivel Base Clips)
- UA-1564 Set of 5 High-temperature Mounting Clips
- UA-3015 Hand Adapter (clip) T-shaped
- UA-3016 Handle Adapter (clip) L-shaped
- UA-3017 Mounting Adapter with strips (clip)
- YI-0216 Mounting Wax

POWER SUPPLY
- WB-1453 CCLD Power Supply

SIGNAL CONDITIONING AND DATA ACQUISITION
- Type 2693 NEXUS Conditioning Amplifier
- Type 2694-A/B/C/D 16-channel CCLD Conditioning Amplifier
- Type 3050 LAN-XI 4/6-ch. Input Module, 51.2 kHz
- Type 3052 LAN-XI 3-ch. Input Module, 102.4 kHz
- Type 3053 LAN-XI 12-ch. Input Module, 25.6 kHz
- Type 3160 LAN-XI Generator, Input/Output Module, 51.2 kHz
- Type 2100-0xy LAN-XI General Purpose Front Panel, BNC connectors (2 to 6 channels: x = no. of input channels, y = no. of output channels)
- Type 2103 LAN-XI 6-ch. D-sub Connector Front Panel
- Type 2107-120 LAN-XI 12-ch. High-density Front Panel, SMB connectors
- Type 2107-A-120 LAN-XI 12-ch. High-density Front Panel, Microdot (10–32 UNF) connectors
- Type 2108-xx0 LAN-XI Triaxial Accelerometer Front Panel, 4-pin connectors (6 or 12 input channels, x = no. of channels)

Calibration Services
- ACC-T-CAF Accredited Calibration
- ACC-T-CAI Accredited Initial Calibration
- ACC-T-CFF Factory Standard Calibration with calibration chart
- ACC-T-CTF Traceable calibration

* Available in various lengths. D = decimetres, xxx = length. Please specify when ordering

† For more information, see the individual product data: NEXUS conditioning amplifier, see BP 1702; CCLD conditioning amplifiers, see BP 1882; LAN-XI data acquisition modules, see BP 2215; and LAN-XI interchangeable front panels, see BP 2421

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