BRÜEL & KJÆR® Calibration Systems

Vibration Transducer Calibration System Type 3629

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Vibration Transducer Calibration System Type 3629 is an easy-to-use, automatic vibration calibration system that provides traceable calibration of a wide range of transducers. The central hardware for the basic system consists of a LAN-XI front end, which provides the necessary input channels and generator output, a power amplifier, BK Connect® analysis software and a vibration exciter.

Type 3629 systems are available in standard configurations that include all relevant software licences, cables, connectors, and accessories.

Uses

- Comparison calibration of vibration transducers according to ISO 16063-21:2005 – magnitude and phase
- Primary calibration of vibration transducers according to ISO 16063-11:1999, Method 3 – magnitude and phase
- Calibration of vibration calibrators according to ISO 16063-44:2016 – level, distortion and frequency
- Calibration of DC sensitivity by use of earth's gravitation according to ISO 16063-16:2014
- Calibration of conditioning amplifiers – gain and phase
- Calibration of vibration meters – vibration level linearity at selected frequencies, velocity and acceleration
- Calibration at high excitation levels 1 km/s^{-2} to 10 km/s^{-2}, using a pneumatically operated projectile (POP) – suitable for shock transducers used in automotive/aerospace according to ISO 16063-22:2005
- Supervision of measuring instrumentation according to ISO 9000
- Quality assurance of sensors in manufacturing or use

Features

Ease of use

- Intuitive software user interface that does not require previous experience
- Comprehensive Microsoft® SQL® database:
  - Stores all pertinent data for the user's transducers, all data required for calibration, plus a history of all calibrations for each transducer. With this data, the entire setup and calibration procedure is made simple through automation
  - Provides possibility to share and use any selected equipment within a multi system setup running the same database
- Quick and easy display of results (pass/fail determination), and automatic storage to any user-defined drive
- ISO 17025:2017-compatible certificates that can be customized and printed

Accuracy

- Automated calibration of the front end that provides extremely high calibration accuracy. Correction factors are stored in the database for subsequent use and traceability
- Individual system frequency response characteristics are stored in database, minimising calibration uncertainties and calibration time by correcting for such characteristics

Security

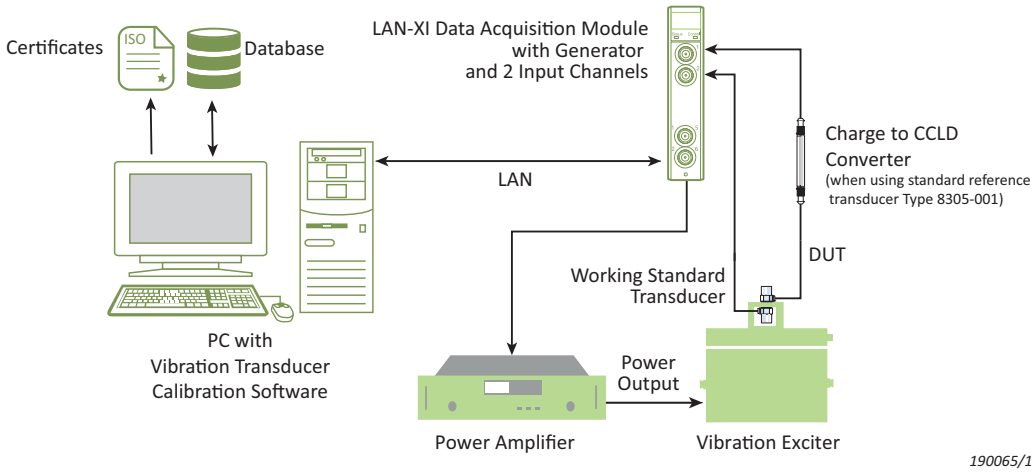
Ability to set multiple user levels with defined access rights for maximum system security

Flexibility

- Flexible configuration to support the full frequency range:
  - Calibrations from 0.1 Hz – 20 kHz
  - Frequency response testing from 40 Hz – 50 kHz
- Calibrates practically all transducer types: charge, CCLD, piezoresistive, variable capacitance, voltage, servo and electrodynamic (for example, velocity pick-ups)
- Virtually any electrodynamic vibration exciter can be added
- PC processing power not critical to software performance
- Selection between SI or imperial units
- Complete standard systems include the necessary hardware to fit your specific application and needs
- Multiple excitation methods:
  - Random excitation – for fast measurement speed and real-time frequency response information
  - Sine excitation – to concentrate the energy for low-frequency calibrations and to satisfy special requirements
  - Swept-sine excitation – for fast measurement speed using an SSR analyzer

System Description

Fig. 1 *Basic system and workflow*



The basic Vibration Transducer Calibration System consists of a LAN-XI front end, which provides the necessary inputs and generator output, a power amplifier and an exciter. The front end is connected via network to a standard PC. A calibrated reference or a calibrated working standard using working standard spectrum is used during calibration. With charge and piezoresistive transducers, a suitable preamplifier must be included. With CCLD transducers (constant current line drive transducers, known as IEPE, DeltaTron®, ISOTRON® and ICP®) or voltage output types, no preamplifier is needed.

There are a couple of standard reference transducers available:

- Type 8305-001: Used in the mid/high-frequency range
- Type 4575-D-001: Used in the low-frequency range

For piezoresistive and other bridge type transducers, Differential Amplifier Type 2697 is used for powering and conditioning through the LAN-XI front end. Type 2697 can also be used for powering variable capacitance and other transducers and can be configured with different excitation voltages.

The system software, Vibration Transducer Calibration Software Type 5308, runs on the PC with no external processing, which means that software performance increases in line with the PC. The operating system is Microsoft® Windows®, providing you with familiar user interfaces and a Microsoft® SQL® database that is accessed transparently by the system, is used for the storage and organization of data. The database also provides possibility to share and use any selected equipment for multiple systems.

Virtually any electrodynamic vibration exciter can be added covering the desired frequency range, excitation level and required payload.

See the Ordering Information for a complete overview of standard system configurations. Note that any system can be customized to fit special requirements.

Calibration

The system measures the FFT auto-spectra and cross-spectra between the transducer signals and calculates the frequency response function. This removes nearly all influence from distortion and noise outside the single FFT band in which the measurement is made. Very narrow bandwidths are used for the low-frequency measurements, to minimise influence and contribution of noise on measurement results.

For the highest measurement speed and real-time frequency response information, random excitation is used, while sine excitation is used mainly to concentrate the energy for low-frequency calibrations and to satisfy special requirements.

Depending on the system configuration and type of calibration and uncertainty of measurement result needed, Type 3629 can perform direct comparison to calibrated reference standard accelerometers, comparison by substitution using calibrated working standard accelerometers and reference spectrum, or absolute calibrations on virtually any type of vibration transducer. Calibrations based on the comparison method determine DUT characteristics by comparison to either a working standard or a reference standard accelerometer usually calibrated at a national metrology institute, for example, DPLA (Danish Primary Laboratory of Acoustics).

Back-to-back Calibration by Substitution

The sensitivities of two transducers can be compared by using random excitation and the FFT analysis capability of the system to measure the ratio of their outputs. By supplying the output from the reference standard accelerometer Input 1, and the output from the

DUT to Input 2, the sensitivity of the DUT can be displayed as the frequency response function (magnitude and phase).

However, accuracy and ease of use can be improved by employing the back-to-back calibration method, using the well-established calibration by substitution technique.

This involves making two measurements:

1. The transfer function between the working standard transducer and the reference standard transducer is measured and stored for subsequent use over a specified time. (This can be considered an extended transfer calibration and is normally referred to as a reference spectrum)
2. The transfer function between the DUT and the working standard is measured, the resulting frequency response is calculated using the reference spectrum and the result is stored. The working standard remains fixed to the exciter head

The method offers the following advantages:

- Fast calibration, typically < 50 seconds, with real-time frequency response information by use of random excitation
- Cancellation of systematic errors contributed by the electronics and dynamic properties
- Coverage of all frequencies in the range, effectively catching possible glitches
- Coverage of a dynamic range dependent upon the exciter
- Use of coherence to check linearity
- System availability during recalibration of reference standard transducers
- Extremely high accuracy of FFT calibration technique using the substitution method and correction after

To further improve the accuracy of the system, an automated calibration of all ranges in level and frequencies of the front end can be performed using a high-precision voltmeter together with appropriate IEEE 488.2 interface or network for the PC*. Correction factors are stored in the database for subsequent use and traceability.

Primary Calibration

Absolute calibrations are performed using a laser interferometer with quadrature output and a routine to convert these outputs to the absolute displacement value as a function of time. This means that measurements are based on the absolute parameters of time and the wavelength of light from a helium-neon laser following ISO 16063-11:1999, Method 3 (sine approximation).

Type 3629 can operate in the frequency range determined by the capabilities of the exciter and transducers used. Where signal conditioning is needed (for example, for piezoelectric transducers), the software is able to measure and store the frequency response characteristics of the conditioners, and then compensate for these characteristics during operation. Similarly, the controller is designed to characterize and drive virtually any vibration source, and to use any reference transducer, with or without the use of a conditioning amplifier.

Calibration of DC sensitivity of vibration transducers with DC response such as piezoresistive, variable capacitance, and servo accelerometer types is done according to ISO 16063-16:2014. This is a primary calibration method by use of earth's gravitation.

Compliance with Standards

	The CE marking is the manufacturer's declaration that the product meets the requirements of the applicable EU directives. RCM mark indicates compliance with applicable ACMA technical standards – that is, for EMC and EME in Australia. China RoHS mark indicates compliance with administrative measures on the control of pollution caused by electronic information products according to the Ministry of Information Industries of the People's Republic of China WEEE mark indicates compliance with the EU WEEE Directive.
Safety	EN/IEC 61010-1: Safety requirements for electrical equipment for measurement, control and laboratory use. ANSI/UL 61010-1: Safety requirements for electrical equipment for measurement, control and laboratory use. IEC 60204-1/EN 60204-1: Safety of machinery – Electrical equipment of machines – Part 1: General requirements.
EMC	EN/IEC 61326: Electrical equipment for measurement, control and laboratory use – EMC requirements.
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 32: Radio disturbance characteristics of information technology equipment. Class B Limits. FCC Rules, Part 15: Complies with the limits for a Class B digital device. This ISM device complies with Canadian ICES-001 (standard for interference-causing equipment).
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. **NOTE:** The above is only guaranteed using accessories listed in this document.
Temperature	IEC 60068-2-1 & IEC 60068-2-2: Environmental Testing. Cold and Dry Heat. Operating Temperature: +5 to +40 °C (+41 to 104 °F). Storage Temperature: –25 to +70 °C (–13 to +158 °F).
Humidity	Only with LAN-XI Type 3160-A-042 module: IEC 60068-2-78: Environmental Testing. Damp Heat 40 °C, 93% RH for 96 hours.
Mechanical	Non-operating. Only with LAN-XI Type 3160-A-042 module: IEC 60068-2-6: Vibration: 0.3 mm, 20 m/s^2, 10 – 500 Hz IEC 60068-2-27: Shock: 1000 m/s^2 IEC 60068-2-29: Bump: 1000 bumps at 250 m/s^2

* The front end can also be sent to Brüel & Kjaer to be calibrated. It will be returned with new updated calibration data.

NOTE: The following specifications are typical. Individual specifications depend on the exciter, transducers and setup used

INPUT
Charge: 0.004 to 400 pC/ms^{-2} (0.04 to 4000 pC/g) (at 10 ms^{-2})
Voltage: 0.004 to 400 mV/ms^{-2} (0.04 to 4000 mV/g) (at 10 ms^{-2})
Velocity: 0.4 to 99 mV/mms^{-1} (10 to 2500 mV/in/s)
Noise (Device Under Test Channel):
- Charge Input < 4 × 10^{-4} pC/Hz$^{0.5}$ (above 10 Hz) with Charge-to-CCLD Converter Type 2647
- Charge Input <2 × 10^{-4} pC/Hz$^{0.5}$ (above 10 Hz) with Charge-to-CCLD Converter Type 2647-B
- Charge Input <0.5 × 10^{-4} pC/Hz$^{0.5}$ (above 10 Hz) with NEXUS Conditioning Amplifier Type 2692

INPUT IMPEDANCE
Voltage: ≤1 MΩ
Velocity: ≤1 MΩ

FREQUENCY RANGE
Accelerometers:
- Calibration: 0.1 Hz to 20 kHz
- Frequency response testing: 10 Hz to 50 kHz

Velocity Pick-ups: 5 Hz to 10 kHz

MAXIMUM TRANSDUCER PAYLOAD
0.1 to 200 Hz: ≤11 kg, using APS 129 ELECTRO-SEIS® Long Stroke Shaker*
5 Hz to 10 kHz: ≤2000 g, using Vibration Exciter Type 4808
10 Hz to 20 kHz: ≤500 g, using Vibration Exciter Type 4809
10 Hz to 50 kHz: ≤100 g, using Mini-shaker Type 4810

CALIBRATION ACCURACY
Estimated errors (using *k* = 2 and including temperature and transverse sensitivity effects) as per ISO 16063-21:2005:
- 1.0% @ 0.1 to 0.5 Hz
- 0.8% @ >0.5 to 10 Hz
- 0.6% @ >10 to 2000 Hz
- 0.8% @ >2000 to 5000 Hz
- 1.0% @ >5000 to 8000 Hz
- 1.2% @ >8000 to 10,000 Hz
- 1.5% @ >10,000 to 16,000 Hz
- 2.5% @ >16,000 to 20,000 Hz

Estimated errors (using *k* = 2 and including temperature and transverse sensitivity effects) as per ISO 16063-11:1999, Method 3:
- 0.5% @ 0.1 to 0.5 Hz
- 0.4% @ >0.5 to 5000 Hz
- 0.6% @ >5000 to 10,000 Hz
- 0.8% @ >10,000 to 12,500 Hz
- 1.2% @ >12,500 to 16,000 Hz
- 2.0% @ >16,000 to 20,000 Hz

DATABASE
Microsoft® SQL®

GENERATED CERTIFICATES
ISO 17025:2017-compatible certificates available for generation in Microsoft® Word

Standard Configuration Overview

Type 3629 systems are available in standard configurations that include all relevant software licences, cables, connectors, and accessories.
On delivery, systems are validated and fully operational and a full individual system validation report is produced and attached

All systems are pre-installed and come with:
- Standard Dell™ tower PC, running Windows® with Microsoft® Office® Pro
- Dell PC monitor (25″ LCD, 2560 × 1440 at 60 Hz, flat panel, colour)

FUNCTIONS AND FEATURES	TYPE NO.			
	3629-A	3629-B	3629-C	3629-D
Comparison calibration of vibration transducers according to ISO 16063-21:2005 – acceleration, velocity or displacement	✓	✓	✓	✓
Calibration of conditioning amplifiers – gain and phase				✓
Calibration of vibration meters – vibration level linearity at selected frequencies, velocity and acceleration	✓	✓	✓	✓
Calibration of vibration calibrators according to ISO 16063-44:2016 – level, distortion and frequency				✓
Calibration of force transducers (using 2 or more calibrated weights from Weight Set UA-2228)	✓	✓		✓
Low-frequency vibration exciter (0.1 Hz – 200 Hz)			✓	✓
Mid-frequency vibration exciter (5 Hz – 10 kHz)		✓		
High-frequency vibration exciter (10 Hz – 20 kHz)	✓			✓
Resonance curve testing (40 Hz – 50 kHz)				✓
Maximum payload of 11 kg (0.1 Hz – 200 Hz)			✓	✓
Maximum payload of 2000 g (5 Hz – 10 kHz)		✓		
Maximum payload of 500 g (10 Hz – 20 kHz)	✓			
Differential amplifier and break-out for piezoresistive and bridge types			✓	✓
DC calibration as per ISO 16063-16:2014			✓	✓
Calibration according to ISO 16063-21:2005	✓	✓	✓	✓
Measurement of bias voltage on CCLD accelerometers and offset on DC type accelerometers	✓	✓	✓	✓
Reference Standard Accelerometer Type 8305-001 (incl. DPLA primary accredited calibration)	✓	✓		✓
Reference Standard Accelerometer Type 4575-D-001 (incl. DPLA primary accredited calibration)			✓	✓
Precision reference capacitor for conditioner calibration (incl. 1 nF, accredited calibration)				✓
Calibration Weight Set UA-2228 (incl. traceable factory calibration)				✓
TEDS transducer support (IEEE 1451.4, versions 0.9 and 1.0)	✓	✓	✓	✓
Linearity calibration at selected frequency	✓	✓	✓	✓

* Manufactured by APS Dynamics, Inc.

Ordering Information

Calibration systems, along with any optional extensions, are only delivered as complete, ready-to-use systems with Microsoft Office® Professional and calibration software installed on the PC. Therefore, an order for a calibration system must include all the components of a complete system: hardware, software, software support, on-site training and installation services. All systems are delivered with 1-year standard warranty. An extended warranty is optional.

VIBRATION CALIBRATION SYSTEM TYPE 3629-A

Hardware:

Type 3629-A-001	Hardware for calibration in frequency range of 10 Hz to 20 kHz

Software:

Type 5308-N	Vibration Transducer Calibration Software

Software Maintenance Contracts:

M1-5308-N	Maintenance Contract for Type 5308-N software

Extended Warranty:

3629-A-EW1	Extended Warranty for Type 3629-A, 1-year extension after standard warranty

VIBRATION CALIBRATION SYSTEM TYPE 3629-B

Hardware:

Type 3629-B-001	Hardware for calibration in frequency range of 5 Hz to 10 kHz

Software:

Type 5308-N	Vibration Transducer Calibration Software

Software Maintenance Contracts:

M1-5308-N	Maintenance Contract for Type 5308-N software

Extended Warranty:

3629-B-EW1	Extended Warranty for Type 3629-B, 1-year extension after standard warranty

VIBRATION CALIBRATION SYSTEM TYPE 3629-C

Hardware:

Type 3629-C-001	Hardware for calibration in frequency range of 0.1 Hz to 20 kHz

Software:

Type 5308-N	Vibration Transducer Calibration Software

Software Maintenance Contracts:

M1-5308-N	Maintenance Contract for Type 5308-N software

Extended Warranty:

3629-C-EW1	Extended Warranty for Type 3629-C, 1-year extension after standard warranty

VIBRATION CALIBRATION SYSTEM TYPE 3629-D

Frequency response testing in frequency range of 40 Hz to 50 kHz.
Calibration of vibration calibrators including calibrated weight sets.
Calibration of conditioning amplifiers including calibrated precision reference capacitor

Hardware:

Type 3629-D-001	Hardware for calibration in frequency range of 0.1 Hz to 20 kHz

Software:

Type 5308-N	Vibration Transducer Calibration Software
Type 5312-N	Conditioning Amplifier Calibration Software

Software Maintenance Contracts:

M1-5308-N	Maintenance Contract for Type 5308-N software
M1-5312-N	Maintenance Contract for Type 5312-N software

Extended Warranty:

3629-D-EW1	Extended Warranty for Type 3629-D, 1-year extension after standard warranty

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