Product Data

Vibration Transducer Calibration System — Type 9610

USES:

- ❍ Fast and accurate amplitude and phase calibration of accelerometers and velocity pick-ups
- ❍ Charge and voltage calibration of accelerometers, from 5 Hz to 10 kHz
- ❍ Voltage calibration of velocity pick-ups, from 5 Hz to 2 kHz
- ❍ Charge sensitivity calibration of accelerometers, from 0.002 to 500 pC/ms^{-2} (0.02 to 5000 pC/g)
- ❍ Voltage sensitivity calibration of accelerometers (with and without built-in electronics), from 0.1 to 1000 mV/ms^{-2} (1 to 10 000 mV/g)
- ❍ Voltage sensitivity calibration of velocity pick-ups, from 0.4 to 99 mV/mms^{-1} (10 to 2500 mV/in/s)

FEATURES:

- ❍ Typical calibration accuracy 5 to 10 Hz: 1.3%, 10 Hz to 4 kHz: 1.2%, 4 to 7 kHz: 1.8%, 7 to 10 kHz: 2.6%
- ❍ PC-based software control and complete database
- ❍ Graphical report of calibration results using linear or logarithmic frequency and amplitude scales
- ❍ Selection between SI or imperial units (g, in, in/s)
- ❍ Typical calibration time of 3 to 10 minutes

Introduction

The Vibration Transducer Calibration System Type 9610 is an easy-to-use PC-based system which, after a few preliminary manual control settings, enables automatic calibration of a wide range of accelerometers and velocity pick-ups.

Back-to-back Calibration by Substitution

In traditional back-to-back calibration, the Device Under Test is mounted back-to-back with a Working Standard Accelerometer, and the combination is mounted on a suitable vibration source (see Fig. 3). The input acceleration to each accelerometer is identical. Consequently, the ratio of their sensitivities is simply the ratio of their outputs.

The accuracy obtained with the back-to-back calibration method is improved by using the substitution technique, which is illustrated in Fig. 1.

Calibration by substitution involves making two back-to-back measurements. Initially, the transfer function between the Working Standard Accelerometer and the Standard Reference Accelerometer is measured and stored. Then the transfer function between the Device Under Test and the Working Standard is measured and stored.

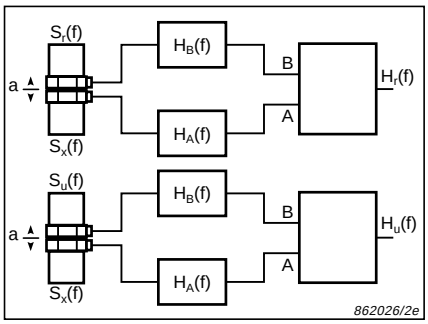

Fig.1 The principle of back-to-back calibration by substitution

During the two measurements, the Working Standard Accelerometer remains fixed to the exciter head, while the Standard Reference Accelerometer and the Device Under Test are individually compared to it. The charge sensitivity of the Device Under Test is then calculated as follows:

$$\frac{S_u(f)}{S_x(f)} * \frac{S_x(f)}{S_r(f)} = \frac{H_u(f)}{H_r(f)} \quad \text{, or}$$

$$S_u(f) = S_r(f) * \frac{H_u(f)}{H_r(f)} \quad \text{, where:}$$

- $\boldsymbol{S_u(f)}$, $\boldsymbol{S_r(f)}$ and $\boldsymbol{S_x(f)}$ are the charge sensitivities of the Device Under Test, the Standard Reference Accelerometer and the Working Standard Accelerometer.
- $\boldsymbol{H_u(f)}$ is the transfer function between the Device Under Test and the Working Standard Accelerometer.
- $\boldsymbol{H_r(f)}$ is the transfer function between the Standard Reference Accelerometer and the Working Standard Accelerometer.

The ratio $\boldsymbol{H_u(f)/H_r(f)}$ is given by the equalized frequency response function. This is a post-processing function of the analyzer, which calculates the complex ratio between the measured and stored data.

The method of back-to-back calibration by substitution offers the following advantages:

- Cancellation of systematic errors contributed by the electronics.
- Only the Standard Reference Accelerometer and the precision attenuator need to be recalibrated.
- Many mounting configurations are possible because the Device Under Test is mounted on the adaptor plate/Working Standard, not directly on the reference transducer.
- Simultaneous calibration over a wide frequency range by random excitation.

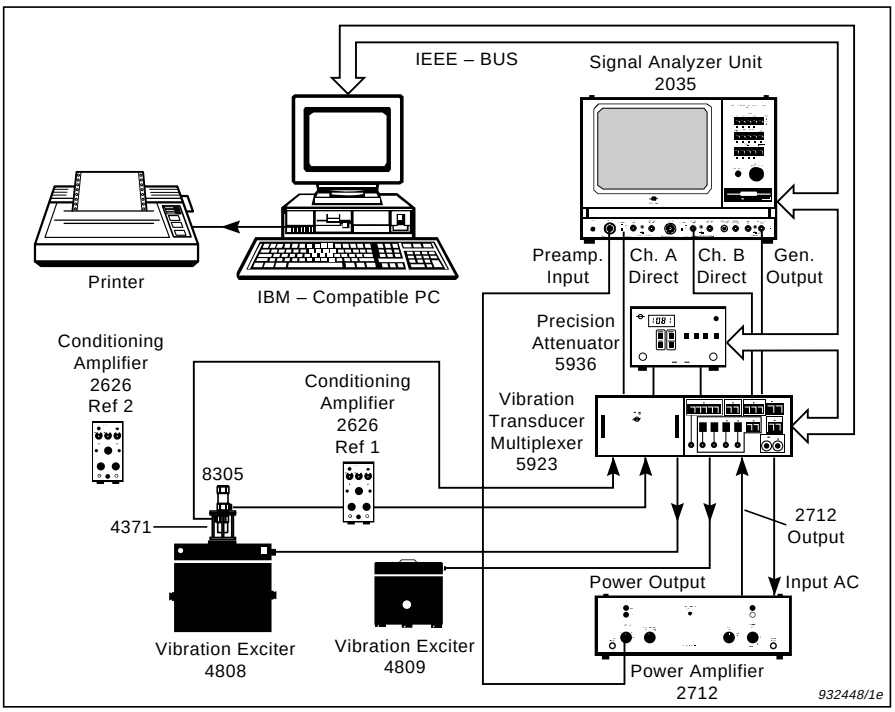

Fig.2 Vibration Transducer Calibration System Type 9610

The accuracy of the presented FFT-calibration technique is comparable to that attained by dedicated comparison systems.

Instrumentation

The configuration of the Vibration Transducer Calibration System Type 9610 is shown in Fig.2. The system uses two vibration exciters. Type 4808 covers the frequency range 5 Hz to 5 kHz, and Type 4809 covers 10 Hz to 10 kHz. The vibration exciters can be supported by an optional stand mounted on a granite block on vibration isolation pads. The stand rests on shock absorbers and levellers, or wheels.

A fixture mounted on top of the Type 4808 vibration exciter houses the Working Standard Accelerometer. The Standard Reference Accelerometer or the Device Under Test is mounted on top of the fixture (see Fig.3). No fixture is used with the Type 4809 vibration exciter; the Working Standard is mounted directly onto the exciter table, and the Standard Reference or the Device Under Test is mounted on top of the Working Standard.

The system includes two matched Reference Standard Calibration Sets Type 3506 (Type 9623). One set is used as a reference. The other is used in verification measurements to check the reference. Each calibration set consists of a Standard Reference Accelerometer Type 8305 and a Conditioning Amplifier Type 2626, which are laser calibrated as a pair.

The Signal Analyzer Type 2035 measures the auto-spectra of the transducer signals and the cross-spectrum between them. It then calculates the transfer function between the two signals. The analyzer also generates the random noise signal supplied to the vibration exciters.

The Precision Attenuator Type 5936 is used in the calibration system to minimize systematic error by eliminating range switching in the analyzer.

The Vibration Transducer Multiplexer Type 5923 is especially designed to interface between the transducers and other instruments.

The system includes an IBM-compatible PC and printer. Vibration Transducer Software Type WT 9301 runs on the PC and controls the calibration system.

System Description

The Vibration Transducer Calibration System Type 9610 is a turn-key system which is installed by a Brüel & Kjær calibration engineer.

To ensure high calibration accuracy, special attention has been paid to system and standard verifications. The system verification involves a series of automatic measurements to check that the system is warmed up

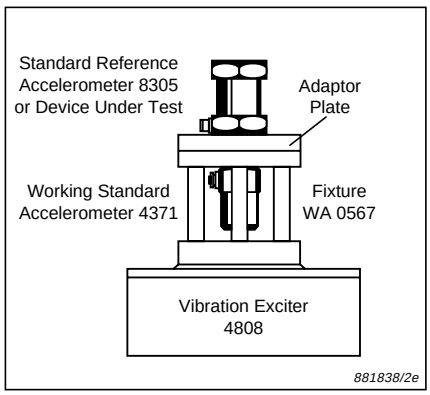

Fig.3 The fixture and transducers mounted on the vibration exciter

and producing stable measurement results.

The standard verification ensures that the Standard Reference Accelerometers Type 8305 and Calibration Sets Type 3506, which are used as charge and voltage standards, are within the tolerance for valid calibration measurements. The calibration system must pass the verification tests before a valid calibration can be performed.

The Software

The calibration software is a user-friendly program that minimizes manual operations, making transducer calibration an automated and simple procedure. The software includes on-screen help, plus built-in checks to prevent errors. For example, highlighted fields indicate whether the following checks have been performed:

- System Warm-up
- System Verification,
- Voltage Verification
- Charge Verification

When the system is switched on, each field is highlighted in red, indicating that the functions have not been performed. After a 30 minute warm-up period, the first field turns green. The other fields also change to green when the associated verification has been made.

A valid measurement can be made only when all of the indicators are green, although it is possible to override the system checks and proceed with measurements immediately. However, when this is done, all resulting data is automatically marked to indicate that it might not be valid.

A measurement report showing the charge sensitivity response (magnitude) of an accelerometer is shown in Fig.4. The phase response for the same accelerometer is shown in Fig.5. When displaying results, you can choose between a linear or logarithmic scale for both axes. All measurement results can be printed out.

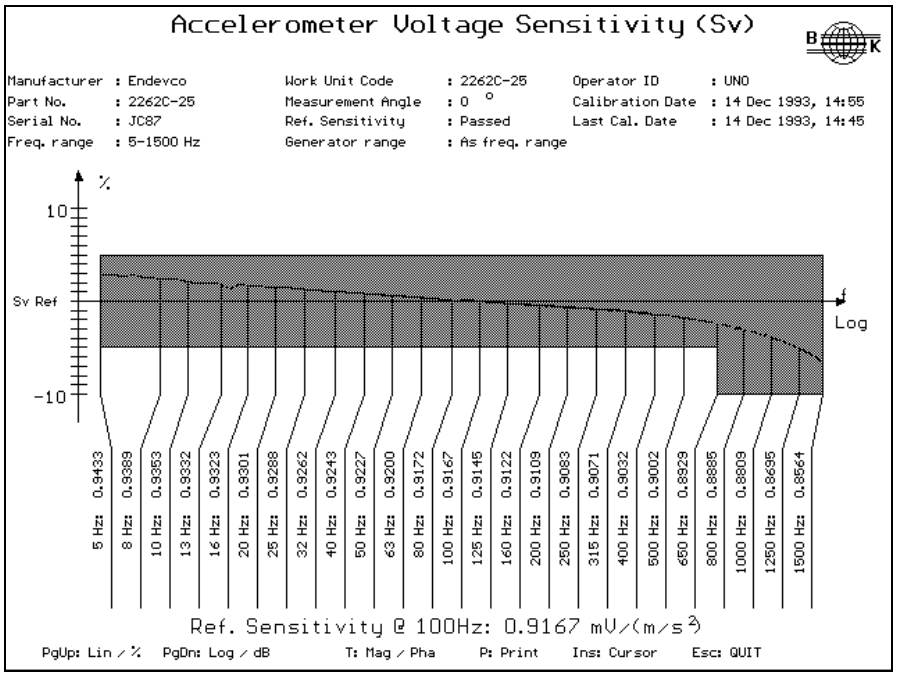

Fig.4 A measurement report produced by the system, showing the charge sensitivity magnitude response of an accelerometer

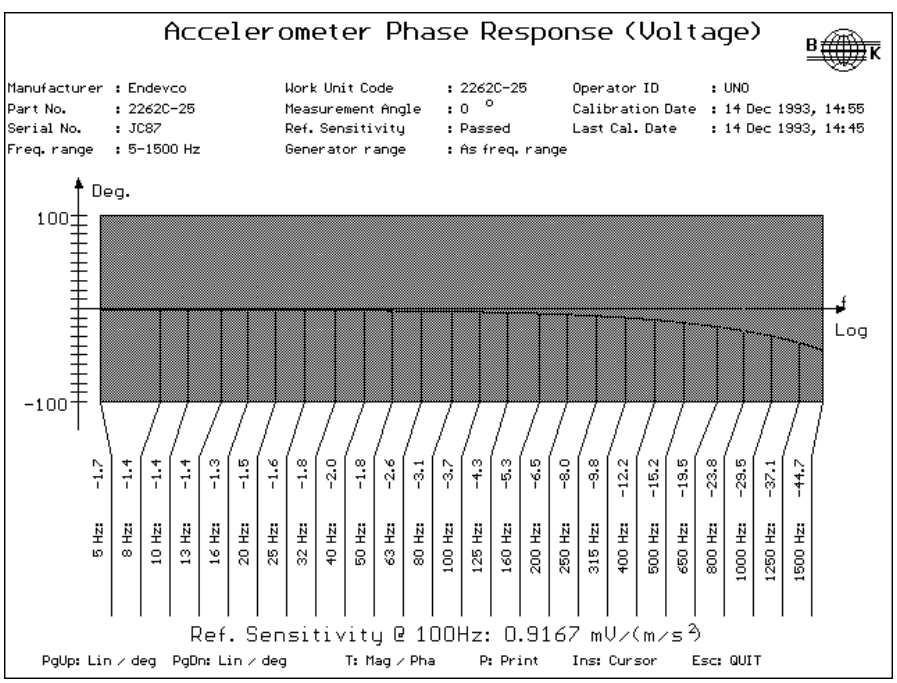

Fig.5 A measurement report produced by the system, showing the charge sensitivity phase response of an accelerometer

The calibration software package includes a comprehensive database that includes all relevant data for your vibration transducers. When a particular transducer is selected for calibration, the software automatically sets the nominal sensitivity, frequency range and tolerance limits for the calibration measurement, based on the database. It also selects either accelerometer charge, voltage, or velocity pick-up calibration. You are then prompted to select the correct

calibration standard, and to set the correct control values on the conditioning amplifiers.

The software includes a "product information" database (see Fig.6), which contains all relevant data for calibrating each transducer. The data is saved with the calibration results for subsequent print-out.

The software also features a calibration database, which contains a history of calibrations for each transducer. The 3506 database contains all the relevant data for the two matched Reference Standard Calibration Sets Type 3506 (Type 9623).

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Brüel & Kjær | Accelerometer Product Information | 14 Dec 1993, 14:59

                                        Operator ID      :        UNO
Manufacturer:          Endevco          Work unit code   :   2262C-25
Part number :          2262C-25         Measurement angle:          0°

Charge  sensitivity : (    0.001   +  0.000   -  0.000) pC/(m/s²) @   160 Hz
Voltage sensitivity : (    1.020   +  0.102   -  0.204) mV/(m/s²) @   100 Hz
Parameter to test   : Voltage      Internal electronics:         None

      Frequency band       Permissible deviation      Graphics scaling
         5 -   650 Hz         + 5.0 %  - 5.0 %          X axis : Log
       650 -  1500 Hz         + 5.0 %  -10.0 %          Y axis :  %
         0 -     0 Hz         + 0.0 %  - 0.0 %          Y max  :  10 %

Coupling diam.: 13.7 mm.  Capacitance   :    0.0 pF
Adapter plate : WS3104    Mount res freq:   2500 Hz   Xducer weight:  28.00 g
Mounting screw:  12 mm    Storage frequencies in Hz:      5     8    10    13
   16    20    25    32    40    50    63    80   100   125   160   200   250
  315   400   500   650   800  1000  1250  1500     0     0     0     0     0
Comments:    #SFR#CConnect the 10.0 VDC to the red & black wires on the acc.
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Fig.6 A print-out of a product information record

Specifications 9610

PRINCIPLE OF CALIBRATION:
Improved FFT Method (Calibration by Substitution)

INPUT TYPES:
- Charge input for piezoelectric transducers
- Voltage input with constant current supply (for example DeltaTron)
- Current input with constant voltage supply (for example Line-drive)
- Voltage input with variable loads for velocity transducers
- High impedance voltage input for piezoelectric accelerometers and other devices with voltage output (for example strain gauges)

INPUT RANGE:
Charge: 0.002 – 500 pC/ms^{-2} (0.02 – 5000 pC/g)
Voltage: 0.1 – 1000 mV/ms^{-2} (1 – 10 000 mV/g)
Velocity: 0.4 – 99 mV/mms^{-1} (10 – 2500 mV/in/s)
Noise Device Under Test Channel: (charge input) 20×10^{-6} pC/Hz$^{0.5}$ (frequency band 6.4 kHz) with Type 2626 at max. gain

INPUT IMPEDANCE:
Voltage: 300 MΩ // < 3 pF
Velocity: 10 kΩ, 20 kΩ, 1 MΩ, 2 MΩ and 300 MΩ

FREQUENCY RANGE:
Accelerometers: 5 Hz – 10 kHz
Velocity Pick-ups: 5 Hz – 2 kHz

MAX. TRANSDUCER WEIGHT:
5 Hz – 5 kHz: 500 g
5 Hz – 10 kHz: 60 g
CALIBRATION ACCURACY:
Typical estimated absolute errors (including temperature and transverse sensitivity effects) for charge calibrations of transducers having sensitivities within the range 0.1 – 12 pC/ms^{-2} are as follows:
5 – 10 Hz: 1.3%
10 Hz – 4 kHz: 1.2%
4 – 7 kHz: 1.8%
7 – 10 kHz: 2.6%
A comprehensive error analysis is included in the user literature

Ordering Information

Type 9610: Vibration Transducer Calibration System
Includes the following:

Type 2035:	Signal Analyzer Unit
Type 7649:	Dual-channel Analysis Software
2×Type 3019:	25 kHz Input Module
Type 3156:	25 kHz Zoom Processor
Type 3106:	Generator & Sampling Module
Type 5923:	Vibration Transducer Multiplexer
2×WB 0693:	Differential Charge Amplifier
Type 5936:	Precision Attenuator
Type 9623:	Two matched Calibration Sets Type 3506 (REF I and REF II) including laser calibration certificates from the Danish Primary Laboratory of Acoustics (DPLA):
	REF I: Type 2626/WH 2370 Type 8305/WH 2335
	REF II: Type 2626 Type 8305
Type 2712:	Power Amplifier
Type 4371/ WH 2525:	Working Standard Accelerometer/ Type 4371 Unit Selection
Type 4808/ WH 2651:	Vibration Exciter/ Type 4808 Unit Selection
Type 4809:	Vibration Exciter
WA 0567:	Calibration Fixture
WF 0037:	Rack, cables, panels, etc. — all mounted and tested in rack
Type 9610X:	System assembly, test, installation and training
WQ 1109:	IBM-compat. PC, DOS & col. scr.
WQ 0625:	GPIB Interface
WQ 1037:	IBM 2380 Matrix Printer
WT 9301:	Vibration Transducer Software

Optional Accessories:

WQ 1118:	Laser Printer (replaces WQ 1037)
WA 0506:	Vibration Exciter Support Stand
WA 0507:	Granite Block for WA 0506
WA 0523:	Carriage for WA 0506

PC Requirements:
If a PC other than the one included in the system is used, it must fulfil the following minimum requirements:
- An IBM PC or compatible with a 80386 microprocessor (≥ 33 MHz) and a coprocessor
- ≥ 2 Mb RAM, ≥ 130 Mb hard disk
- MS-DOS, Version 5.0 or higher
- VGA display
- National Instruments IEEE-488 GPIB Interface
- Printer (optional): IBM Proprinter-compatible 9-pin dot matrix printer, or HP Laserjet II-compatible laser printer

Brüel & Kjær

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