SOUND & VIBRATION SYSTEMS SELECTION GUIDE

THE MODAL SHOP
AN AMPHENOL COMPANY

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ABOUT THE MODAL SHOP

"SIMPLIFYING PEOPLE'S LIVES WITH SMART SENSING SOLUTIONS THAT HELP IMPROVE THE PERFORMANCE OF PEOPLE, PRODUCTS, AND PROCESSES."

CALIBRATION CONFIDENCE

at the highest level – serving Metrology Laboratories around the globe, The Modal Shop's laser primary vibration calibration sets the standard in vibration metrology confidence with world-class uncertainties. The Modal Shop is accredited to the ISO 17025 standard and is recognized worldwide for calibration quality and excellence. Our teams participate in developing global standards for calibration of sensors for vibration, shock, dynamic pressure, and acoustic transducers.

CULTURE OF QUALITY

and responsiveness – operating within a hybrid quality management system, The Modal Shop Quality System integrates standards (and philosophies) from ISO 9001, Lean Manufacturing, and Kaizen to ensure excellence. With a core commitment to Total Customer Satisfaction, expect fast, friendly service and reliable product performance within the global markets and sound and vibration testing, as well as precision dynamic calibration.

CRAFTSMANSHIP

in handmade attention to detail while building precise, yet robust dynamic testing components. Attention to minute details, like the tension of the coil windings on our precision calibration exciters, are the heart of the design and performance of every product from The Modal Shop. Striking the balance between performance, reliability, and simplicity, The Modal Shop engineering elegance has been a cornerstone in earning market leadership.

THE MODAL SHOP AND PCB AROUND THE WORLD

Our name was chosen to combine the science of modal analysis, or structural resonance testing, and the full-service attitude of our "shop-like" organization. Serving the sound and vibration measurement marketplace, our teams work with research, design, and manufacturing engineers throughout the public and private sectors. From miniature MEMS structures to colossal space structures, we strive to provide the dynamic testing and monitoring communities with a single source to simplify all your sound and vibration measurement challenges.

For information on offices in your region, visit: www.modalshop.com/contact

*Front cover photo taken in cooperation with Belgian Defense.

- Amphenol Advanced Sensors, St. Marys Pennsylvania
- PCB Headquarters, Depew, New York
- TMS Headquarters, Cincinnati, Ohio
- Worldwide PCB and Distributor Locations

SYSTEMS SELECTION GUIDE

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THANK YOU FOR CHOOSING THE MODAL SHOP

As your partner in sound and vibration testing and monitoring, we invite you to learn about the products and services in the following pages and on our website – **www.modalshop.com**. We look forward to helping you solve your toughest measurement challenges! The Modal Shop's team of Application Engineers is just a call or click away. You can reach us at 513.351.9919 or **info@modalshop.com**.

Learn Portal

Our site offers a growing list of product and application video tutorials and an extensive collection of technical articles covering sensor technology, applications, and best practices. All are available at **www.modalshop.com/learn** where new topics are added regularly.

Information and Downloads

From application information to downloadable catalogs, datasheets, and whitepapers, you can find a complete range of resources simply by visiting **www.modalshop.com** and navigating to your product area of interest.

FAQ

Whether you are interested in knowing how through-hole armatures work in modal shakers or the maximum payload of the Portable Vibration Calibrators, you can find the answers quickly and easily through Frequently Asked Questions pages in each product section.

Regional Seminars

As part of our commitment to the sound and vibration community, TMS Dynamic Calibration experts travel the world, offering seminars on dynamic sensor technology and calibration theory. Visit **www.modalshop.com/seminars** to see when a seminar will be at a location near you.

INNOVATION IN EXCITATION

- General Vibration Testing
- Electronic Assemblies
- Laboratory Experiments
- Biomedical Research
- Modal and Structural Testing

MINIATURE SMARTSHAKER™ WITH INTEGRATED AMPLIFIER

MODELS K2004E01 AND K2007E01

The SmartShaker™ is a small, portable, permanent magnet shaker with a new generation of ultra-compact, precision power amplifier integrated into its base. To initiate testing, simply plug the excitation signal from a dynamic signal analyzer or function generator directly into the BNC on the base of the shaker.

- Simplified testing with innovative integrated amplifier design
- Offers industry leading stroke of 0.5 in (1.27 cm) while providing up to 7 lbf (31 N) pk sine force
- Allows testing of payloads up to 2 lb (0.91 kg) by attachment to 10-32 mounting top
- Provides ease of setup with trunnion mounting base and EasyTurn™ handles

COMPLETE KIT

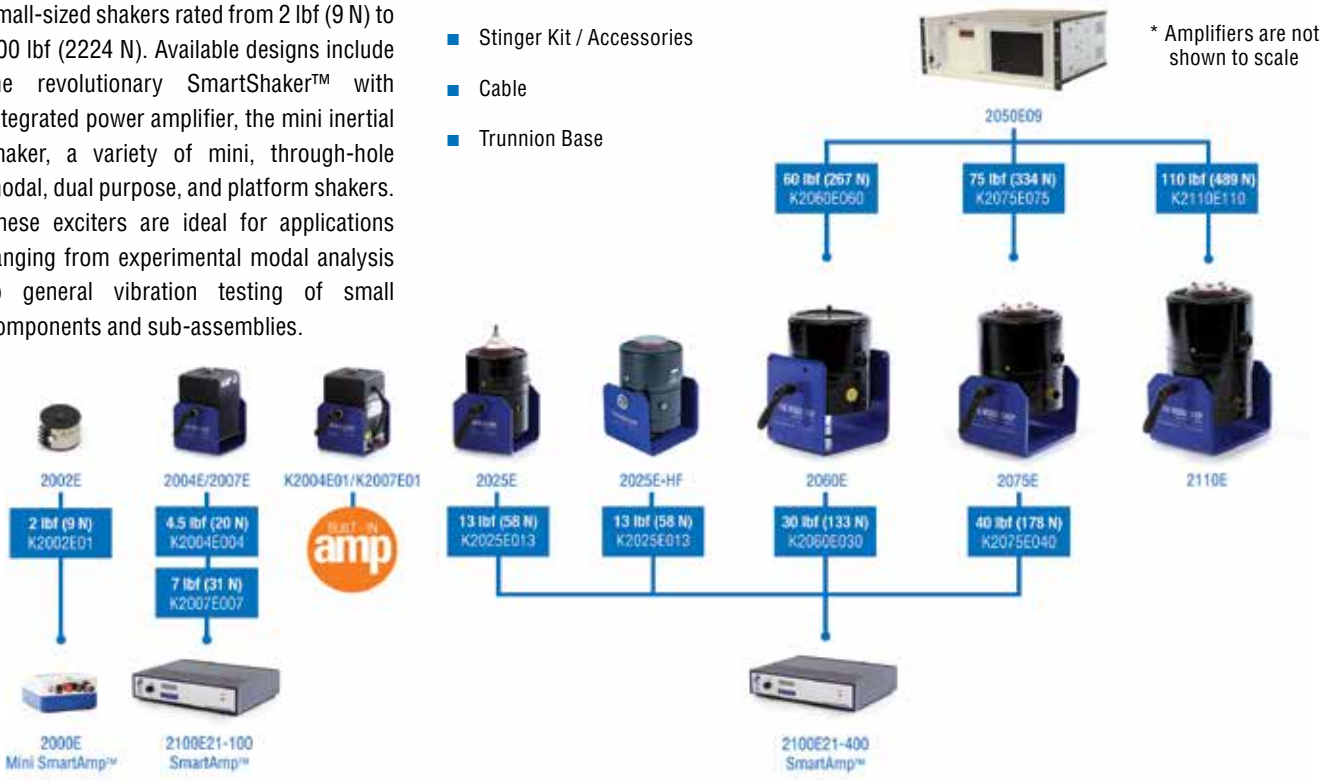
Heavy-duty case and stingers included

SHAKER KITS

The Modal Shop's family of shakers includes small-sized shakers rated from 2 lbf (9 N) to 500 lbf (2224 N). Available designs include the revolutionary SmartShaker™ with integrated power amplifier, the mini inertial shaker, a variety of mini, through-hole modal, dual purpose, and platform shakers. These exciters are ideal for applications ranging from experimental modal analysis to general vibration testing of small components and sub-assemblies.

ALL SHAKERS INCLUDE

- Stinger Kit / Accessories
- Cable
- Trunnion Base



	KIT MODEL	MAX FORCE lbf (N) pk	MAX FREQUENCY Hz [2]	STROKE in (mm) pk-pk	SHAKER MODEL	AMPLIFIER MODEL	STINGER KIT/ ACCESSORIES	APPLICATION
MINI	K2002E01	2 (9)	3 000	N/A	2002E	2000E	2000X08	Modal analysis, general vibration, small structures [circuit board to small appliance]
	K2004E004	4.5 (20)	11 000	0.2 (5)	2004E	2100E21-100	2110G06	
	K2004E01	4.5 (20)	11 000	0.2 (5)	2004E	Integrated	2110G06	
	K2007E007	7 (31)	9 000	0.5 (13)	2007E	2100E21-100	2110G06	
	K2007E01	7 (31)	9 000	0.5 (13)	2007E	Integrated	2110G06	
MODAL	K2025E013	13 (58)	9 000	0.75 (19)	2025E	2100E21-400	2000X03	Modal analysis, small to medium structure [component to automotive]
	K2025E013-HF	13 (58)	20 000	0.5 (13)	2025E-HF	2100E21-400	2000X03	
	K2060E030	30 (133)	6 000	1.4 (36)	2060E	2100E21-400	2000X03	Modal analysis, medium to large structures [washing machine to auto/aerospace]
	K2060E060 [1]	60 (267)	6 000	1.4 (36)	2060E	2050E09	2000X03	
DUAL PURPOSE	K2075E040	40 (178)	6 500	1.0 (25)	2075E	2100E21-400	2000X03	Dual purpose design, modal and general vibration testing
	K2075E075 [1]	75 (334)	6 500	1.0 (25)	2075E	2050E09	2000X03	
	K2110E110 [1]	110 (489)	6 500	1.0 (25)	2110E	2050E09 - FS	2000X03	
	K2500E500 [1]	500 (2 224)	4 500	1.0 (25)	2500E	2050E12-7	2000X12	General vibration testing

[1] Requires Cooling (included with kit)
[2] Load dependent

MODAL SHAKERS

- Modal Testing
- Appliances
- Automotive/NVH
- Aerospace/GVT

MODEL
2060E

MODEL
2025E

MODELS
2004E
2007E

SMARTSHAKER™
MODELS
K2004E01
K2007E01

MODEL
2002E

The Modal Shop's modal shakers are a proven solution in test laboratories throughout the world. With force ratings from 2 to 60 lbf (9 to 133 N), these shakers are suitable for a wide range of modal analysis applications. When performing experimental modal analysis and structural testing, the choice of excitation function and system will make the difference between a good measurement and a poor one. For many applications, an electrodynamic shaker system is the ideal choice.

The Modal Shop's line of modal shakers is designed to be highly portable, rugged, and easy to set up in order to facilitate the best testing results. The exciter size allows a diversity of placement locations relative to the test structure, while minimizing any unwanted interaction between the exciter and test structure.

HIGHLIGHTS

- Ensures simple stinger setup and adjustment via through-hole armature design with chuck and collet attachment
- Easier test setup with lightweight and portable designs from 0.56 lb (0.25 kg) to 37 lb (17 kg)
- Provides flexibility when mounting and aligning the shaker to the structure with trunnion base and EasyTurn™ handles
- Extended stroke and broad frequency range supply adequate input energy for modal applications

MODEL NUMBER	MAX FORCE lbf (N) pk	MAX FREQUENCY Hz [2]	STROKE in (mm) pk-pk	WEIGHT lb (kg)
2060E	60 (267)	6 000	1.4 (36)	37 (17)
2025E	13 (58)	9 000	0.75 (19)	13 (6)
2007E [1]	7 (31)	9 000	0.5 (13)	6 (3)
SmartShaker™ K2007E01 [1]	7 (31)	9 000	0.5 (13)	7 (3)
2004E [1]	4.5 (20)	11 000	0.2 (5)	6 (3)
SmartShaker™ K2004E01 [1]	4.5 (20)	11 000	0.2 (5)	7 (3)
2002E [3]	2 (9)	3 000	0.35 (8.9)	0.56 (0.25)

[1] Models 2004E/2007E and SmartShaker™ have no through-hole armature
[2] Load dependent
[3] No stingers used, mounting hardware included.

STRUCTURAL TEST ACCESSORIES

IMPEDANCE HEAD

MODEL TLD288D01

- ICP® impedance head (force/acceleration) for driving point measurements
- Force: 100 mV/lbf, ± 50 lbf
- Accel: 100 mV/g, ± 50 g
- Available with TEDS functionality

AIRRIDE® MOUNT

MODEL 8032S

- Provides extremely low mounting frequencies for large rigid body test structures
- Eliminates multiple mounting frequencies, as AirRide® natural frequency does not shift significantly with changes in load

LATERAL EXCITATION STAND

MODEL 2050A

- Combining lateral and vertical excitation distributes input energy and helps excite uncoupled lateral modes
- Provides versatility to adapt a modal shaker for horizontal input
- Ensures proper alignment with coarse and fine vertical adjustment

MODAL SHAKER STINGERS

2100 SERIES

- Provides conveniant excitation connection between shaker and structure
- Isolates fragile exciter armatures
- Reduces force sensor measurement error

MODAL IMPACT HAMMER

086 SERIES

- Modally Tuned® to provide more consistent results
- Variety of hammer sizes to suit an array of testing needs
- Assortment of tips offers frequency tailored impulse

ICP® LASER TACHOMETER

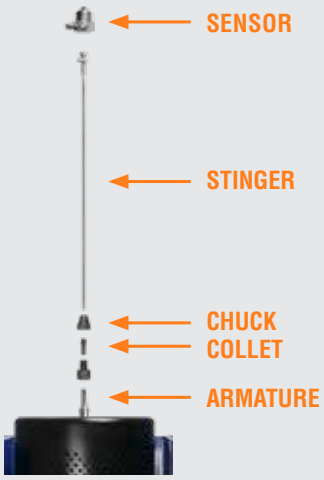
MODEL LT2

- Operates with standard ICP® signal conditioning; simplifies cabling
- One pulse/rev eliminates need to oversample all channels for a high frequency tach
- Offers continuous laser for jitter-free operation

TECH TALK: THROUGH-HOLE ARMATURE

The implementation of the through-hole armature shaker has simplified and improved modal testing. In the early days of modal testing, electrodynamic shakers were attached to the test structure with a long threaded stinger and used to apply low-level excitation. The rod was threaded directly to the top of the exciter and to the base of the reference force transducer, making difficult orientation, tedious alignment, and customization of stinger lengths a part of every test. The through-hole armature design eliminates these problems. With a hole that runs the length of the shaker along the axis of actuation, a long stinger can be threaded to the force transducer attached to the test article, properly aligned and then clamped down with the chuck and collet at the appropriate length. This simple, time-saving feature is key to ensuring modern modal testing.

Check out videos and tutorials at **www.modalshop.com/learn**



DUAL PURPOSE VIBRATION SHAKERS

- Automotive Components
- Aerospace Devices
- Electronic Modules
- Sub-Assemblies
- Environmental Testing
- Vibration/Modal Testing

MODEL
2110E

MODEL
2075E

MODEL
2025E-HF

MODELS
2004E
2007E

SMARTSHAKER™
MODELS
K2004E01
K2007E01

The Modal Shop's dual purpose shakers are ideal for both vibration testing of small components and modal analysis. Small and lightweight, yet powerful electrodynamic shakers, the dual purpose line provides up to 110 lbf (489 N) pk sine force across a wide frequency range.

In both the 2075E and 2110E models, a large 3.25 in (8.3 cm) diameter platform table is ideal for payloads up to 10 lb (4.5 kg). These units also offer a through-hole armature that includes a chuck and collet attachment, providing simple stinger setup if used for modal applications. The 2004E and 2007E miniature shakers, as well as the SmartShaker™, offer a 10-32 threaded mounting surface which allows for stinger or test article attachment.

HIGHLIGHTS

- Innovative dual purpose design integrates a platform table for traditional vibration testing and modal testing
- Provides flexibility and full rotation when positioning and aligning the shaker through trunnion base
- Offers necessary input energy for modal applications with extended stroke and broad frequency range

MODEL NUMBER	MAX FORCE lbf (N) pk	MAX FREQUENCY Hz [2]	STROKE in (mm)	WEIGHT lb (kg)
2110E	110 (489)	6 500	1.0 (25)	54 (25)
2075E	75 (334)	6 500	1.0 (25)	35 (16)
2025E-HF	13 (58)	20 000	0.5 (13)	11 (5)
2007E [1]	7 (31)	9 000	0.5 (13)	6 (3)
SmartShaker™ K2007E01 [1]	7 (31)	9 000	0.5 (13)	7 (3)
2004E [1]	4.5 (20)	11 000	0.2 (5)	6 (3)
SmartShaker™ K2004E01 [1]	4.5 (20)	11 000	0.2 (5)	7 (3)

[1] Models 2004E/2007E and SmartShaker™ have no through-hole armature
[2] Load dependent

VERSATILE VIBRATION TESTING

- CubeSat Satellites
- Avionics
- Consumer products
- Automotive parts, electronics
- Mechanical subassemblies

500 LBF ELECTRODYNAMIC EXCITER

MODEL 2500E

The Modal Shop's Electrodynamic Shaker Model 2500E is a 500 lbf pk sine force shaker designed for general-purpose vibration testing of small components, as well as stress screening of electronic and mechanical sub-assemblies.

- Forced air cooling sufficient to meet full shaker performance (500 lbf / 2224 N) specifications
- Large 6 in (152 mm) specimen mounting table offers ease of mounting
- 1.0 in (25.4 mm) stroke and wide frequency range (to 4500 Hz) support broad range of applications
- Trunnion base provides flexibility when choosing best exciter location
- Available head expander and Modal-Pod CubeSat fixture for versatile mounting configurations
- System uses compact 2050E12-7 high efficiency digital amp

RUGGED, LATERALLY STIFF CARBON COMPOSITE SUSPENSION

INTERNALLY THREADED ATTACHMENT POINTS FOR COMPONENT MOUNTING

DIGITAL POWER AMPLIFIER
MODEL 2050E12-7

SMART FEATURES:

- SAFE START IN MUTE TO AVOID TRANSIENTS
- AIR COOLING FLOW INTERLOCKS
- OVER TRAVEL SWITCH PROTECTION
- COMPACT AND RACK MOUNTABLE

EXPANDED TEST CAPABILITIES

HORIZONTAL TABLE SYSTEMS

MODELS K2075E-HT, K2110E-HT, K2500E500-HT

- Available for 2075E, 2110E, and 2500E shakers
- Systems include shaker mounted in horizontal table, amplifier, cooling package, and accessories
- Expands dynamic testing capabilities for objects larger or heavier than what can be mounted directly to the shaker
- Allows shaker operation vertically (not connected to table) and horizontally while connected to horizontal table
- Removes side load from shaker suspension

HEAD EXPANDER

MODELS 2000X01, M2000X01, 2000X14, M2000X01

- Allows attachment of larger, less dense test loads by providing an increased mounting footprint
- 7 in (18 cm) diameter 2000X01 for use with the 2075E and 2110E shakers
- 12 in (305 mm) square 2000X14 designed for 2500E shaker
- Machined, lightweight magnesium alloy with threaded mounting holes (standard or metric) on a square pattern

MODAL POD

MODEL 2000X15

- Modal-Pod test fixture for CubeSat vibration testing, used with 2500E shaker
- Supports the mounting of various size CubeSats to the shaker in different orientations (up to 3U)
- Includes lightweight magnesium mounting fixture, dead mass loads, mounting accessories, tools, and a heavy duty transportation case
- Simplifies qualifications testing of CubeSats to NASA testing or other standards

TECH TALK: SHAKER PERFORMANCE CURVES

Shaker performance curves, known as payload curves, are commonly used to select the right shaker system for a particular application. They describe the shaker system acceleration potential over a range of payloads and frequencies. Payload curves provide a graphical way to evaluate the compatibility between testing requirements and system capabilities. Visit **www.modalshop.com/payload** for more details.

1. What is the total payload for the test?

Add the mass of the test article to the mass of any adapter or fixture required to attach it to the shaker table. The payload curves already take into account the mass of the shaker armature.

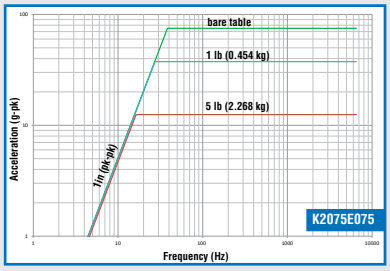
2. What are the required vibration levels?

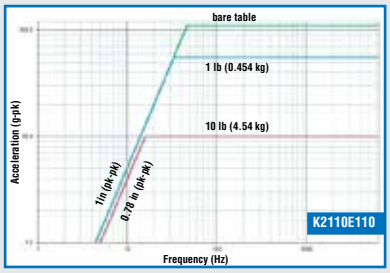
Check the acceleration and frequency requirements for the test. If the vibration specifications are provided in a different unit (e.g. velocity or displacement), convert into acceleration units. Use g peak for sine testing or g RMS for random testing. Any test requirements below the curve for a given payload indicate a shaker candidate to serve the basic functions required for the testing.

3. Evaluate the shaker displacement range

Check the test frequency requirements to verify that the shaker's stroke capability will not be exceeded. In the graph to the left, the stroke limit is shown by the slanted portion of the line. Using the acceleration levels (a) in g-pk units at low frequencies (f) in Hz, calculate the displacement using the following equations:

$$d = 19.56\ a/f^2\ \text{[in, pk-pk]}\ \text{or}\ d = 496.82\ a/f^2\ \text{[mm, pk-pk]}$$





For more information about shaker system capabilities, visit:
www.modalshop.com/shakers

DIGITAL SENSING SOLUTONS

- Vibration Testing & Troubleshooting
- Automotive NVH
- Universities and Educational Research
- Predictive Maintenance

The Modal Shop's digital sensing solutions offers versatile, on-the-go data dynamic measurement capabilities in the palm of your hand. Using standard USB audio digital output and no driver installation required, these solutions can be connected to a PC, smartphone, tablet, or other devices for an variety of applications. The Digiducer® USB digital accelerometer family provides quick, expert level vibration measurements. The dual channel Digital ICP® Signal Conditioners offers more capability supporting ICP® (IEPE) and Voltage inputs via BNC connection to view signals form accelerometers, microphones, modal hammers, and many other sensor types.

DIGIDUCER® USB DIGITAL ACCELEROMETER

MODELS 333D01, 333D04, 333D05, 333D06

- Rugged piezoelectric sensing technology
- Broad frequency and dynamic range
- Embedded calibration data
- Available in integral cable and removable cable options

MODEL	AMPLITUDE RANGE (± g pk)	FREQUENCY RANGE Hz (± 5%)	CABLE TYPE AND CONNECTOR
333D01	20	2 to 8 000	Integral 9.6 ft (2.9 m), USB-A
333D04	100	2 to 8 000	Integral 9.6 ft (2.9 m), USB-A
333D05	20	2 to 8 000	Removable 10 ft (3 m), M12 to USB-A [1]
333D06	100	2 to 8 000	Removable 10 ft (3 m), M12 to USB-A [1]

[1] 10 ft standard, other lengths available

DIGITAL ICP® SIGNAL CONDITIONER

MODELS 485B39, V485B39, IV485B39

- High-quality, 24-bit ADC resolution
- 2-channel ICP® (IEPE) and/or Voltage sensor inputs
- Broad frequency range, 0.8 Hz to 20.7 kHz
- LED Data / Power indicator

MODEL	INPUT TYPE SUPPORTED	FREQUENCY RANGE Hz (± 5%)	CABLE TYPE AND CONNECTOR
485B39	x2 ICP	0.8 to 20 700	Integral 11 in (28 cm), USB-A
IV485B39	x1 ICP x1 Voltage	0.8 to 20 700	Integral 11 in (28 cm), USB-A
V485B39	x2 Voltage	0.8 to 20 700	Integral 11 in (28 cm), USB-A

SOFTWARE SELECTION

A range of software applications are available to use when testing with Digiducer® or the Digital ICP® USB Signal Conditioner. Whether you are utilizing a Windows, iOS, Android, or macOS device, there are solutions with an array of testing capabilities ranging from turnkey options, to developer environments like MATLAB or Python.
To learn more, visit **www.modalshop.com/digital-sensing-software** or contact The Modal Shop.

ON-SITE VALIDATION

- Pre- and post-test sensor verification
- Test accelerometers, velocity sensors, proximity probes
- Test complete measurement chains
- Verify alert/alarm levels for plant machinery

PORTABLE VIBRATION CALIBRATORS

MODELS 9110D, C9110D, AND 9210D

The Modal Shop's line of Portable Vibration Calibrators, Models 9110D, C9110D, 9210D, provides a durable, proven, standalone systems for validation of vibration sensors, proximity probes and related vibration monitoring equipment – whether in the lab, at the test site, or on the plant floor.

Ideal for use when performing a validation of entire measurement chains during test setup, for calibrating an individual sensor, or pre- and post-test sensor verification to ensure quality data is being collected.

The flexibility of the portable vibration calibrators offers a wide frequency and amplitude range, a payload capacity to support larger industrial sensors, and a variety of sensor input types to suit an array of testing needs.

- Displays test sensor sensitivity on the read out in real time
- Allows creation of calibration certificates with supplied Microsoft Excel® workbook template
- CALROUTE firmware for 9110D and C9110D allows technicians to program repetitive calibration test points and pass/fail tolerances.

MODEL	FREQUENCY RANGE (Hz)	MAX AMPLITUDE (g pk)	SENSOR UNDER TEST INPUT
9110D	5 to 10 000	20 [1]	ICP, Charge, Modulated current, Piezoresistive, Capacitive, Voltage [3]
C9110D	5 to 10 000	20 [1]	ICP, Charge, Modulated current, Piezoresistive, Capacitive, Voltage [4]
9210D	0.7 to 2 000	2 [2]	ICP, Voltage
9100D	5 to 10 000	20 [1]	No Sensor Input
9200D	0.7 to 2 000	2 [2]	No Sensor Input

[1] 50 Hz, 10-gram payload
[2] 100 Hz, no payload
[3] External signal conditioning required for Charge, Modulated Current, Piezoresistive, Capacitive, and Voltage sensor types
[4] External signal conditioning required for Modulated Current, Piezoresistive, Capacitive, and Voltage sensor types

PORTABLE SHAKER TABLES

Portable Shaker Tables, Models 9100D and 9200D, from The Modal Shop are an ideal tool for on-site checking of accelerometers, velocity transducers, and proximity probes (using the proximity probe fixture) over a wide operating frequency and amplitude range. The units are compact, battery-powered, and completely self-contained vibration reference sources – which can be conveniently used to calibrate individual sensors, vibration switches, and data collectors on the plant floor.

Aside from checking sensors, the Portable Shaker Tables are also used to validate the entire measurement channel of a condition monitoring or recording system. The built-in quartz reference sensors and digital closed-loop level control is shared with the 9110D and 9210D to give the 9100D and 9200D enhanced stability. Packaged in a rugged case, Portable Shaker Tables are always ready for travel to industrial test sites, bringing laboratory accuracy to the field to protect vital equipment.

TEST UNITS	
Acceleration	g pk, g RMS, m/s^2 pk, m/s^2 RMS
Velocity	in/s pk, in/s RMS, mm/s pk, mm/s RMS
Displacement	mil pk-pk, µm pk-pk
Frequency	Hz, CPM

PROXIMITY OPTION

9100-PPA01 fixture is used to check the static and dynamic output of an eddy current proximity probe.

TECH TALK: VIBRATION MONITORING

Protecting process quality and critical plant machinery from damage or destruction is a constant concern in the industrial environment. Quality affects customer satisfaction and yield. Maintenance and shutdown related issues cost companies both time and money. Validating an installed monitoring system is key to ensuring overall success. Vibration sensors, cabling, and data acquisition systems must be operating accurately to ensure facility and machinery safety.

Portable Shaker Tables from The Modal Shop perform on-site calibration of accelerometers, velocity sensors, and proximity probes. Designed to withstand the harsh conditions of the industrial environment, the Shaker Table can be taken directly to the location of installed sensors, eliminating downtime and making regular calibration a viable option. The unit can validate the entire measurement channel from sensor through signal conditioning, acquisition system and display console, providing peace of mind that the entire system, is accurate and functioning. Vibration monitoring alert and alarm trip points can also be tested to confirm function and accuracy of condition monitoring systems.

Portable Shaker Tables solve on-site vibration monitoring needs in a self-contained, battery-powered unit. They generate calibrated vibration excitation levels and offer standardized, traceable results for each test.

Rugged hardware, an easy-to-use system interface, extensive battery life and precision electronics have proven the 9100D and 9200D as ideal tools for field calibrations and validation of the monitoring measurement channel at sites around the world.

Avoid catastrophic failures by performing system validation with the 9100D

METROLOGY MADE PORTABLE

- Portability, Reliability, Usability
- Calibrate accelerometers and velocity sensors
- ISO 16063-21 Standard Compliance
- Designed for ISO 17025 accreditation requirements

PORTABLE VIBRATION CALIBRATION SYSTEM

9140 SERIES

The Portable Vibration Calibration System 9140 Series brings the calibration laboratory onsite to your sensors. Calibrate vibration sensors with unprecedented portability and automation, with confidence in the results, the future availability of the data, Immediate on-site pre- and post-test sensor validation, and the ability to withstand the scrutiny of ISO 17025 metrology requirements.

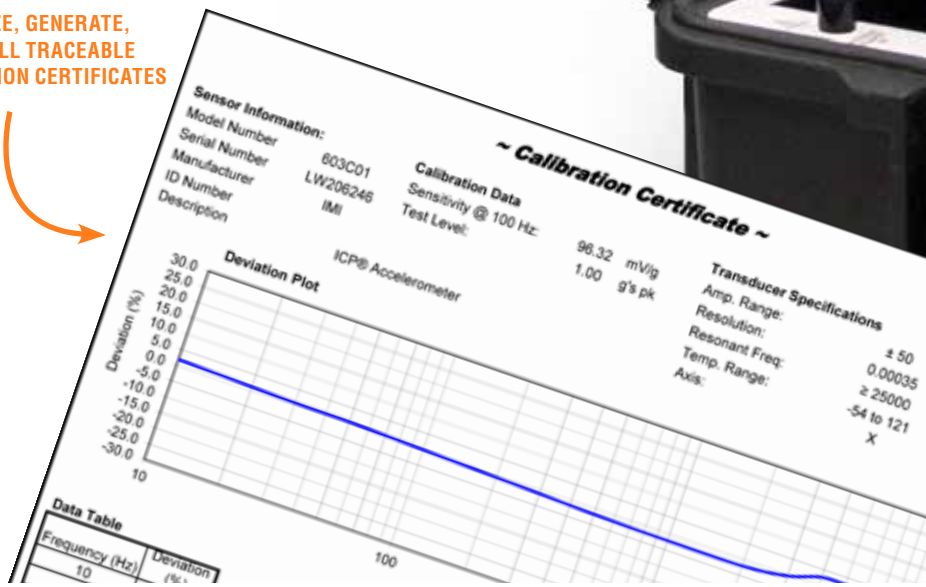
The 9140 Series combines two world class measurement platforms – the Portable Vibration Calibrator Model C9110D and the Precision Sensor Calibration Workstation Model 9155D. The Portable Vibration Calibrator offers ruggedness and reliability for vibration sensor calibration in some of the toughest testing environments, while the 9155D Software delivers laboratory-style control, automation, and databasing of measurements.

The 9140 Series system enables travel from one site to another, keeping the test sensor in immediate proximity of the test article or monitoring location minimizing downtime. The 9155 software automates the calibration process by controlling the Calibrator to perform a frequency or amplitude sweep with a mouse click from test setups that are stored in the 9155D software database. Likewise, test results transmit directly from Calibrator to the PC where the 9155D Software stores the data, produces calibration certificates, and recalls test data.

HIGHLIGHTS

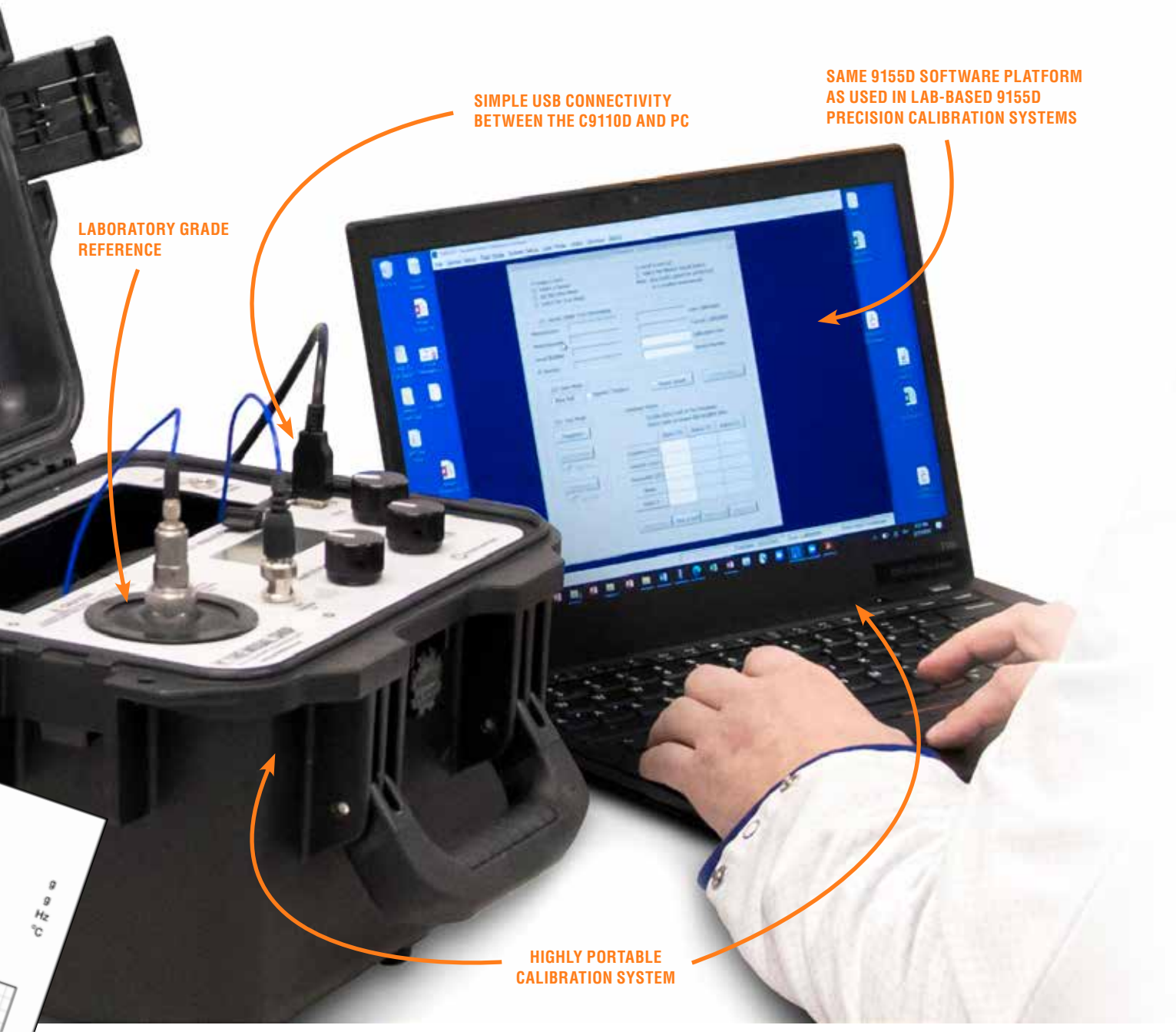
- Battery-powered system is designed for travel in the field
- Portable Vibration Calibrator is packaged in rugged Pelican Storm Case™
- Users are fully trained on system operation in a few hours
- Bring the calibration lab on-site to your sensors
- Support of multiple sensors types

CUSTOMIZE, GENERATE, AND RECALL TRACEABLE CALIBRATION CERTIFICATES



VIBRATION CALIBRATION LABORATORY IN A BOX

MODEL	DESCRIPTION
K9140D10	Complete kit of C9110D Portable Vibration Calibrator, Windows® laptop PC with complete software configuration, verification sensor, 003C03 sensor cable, and specialized USB connection cable.
K9140D	Includes C9110D Portable Vibration Calibrator, 9100-USB00 USB Cable, and software. Customer installs software on customer supplied Windows® PC.
K9140D-SW	9140 Series vibration calibration software only. Includes 9100-USB00 USB Cable. Customer installs software on customer supplied Windows® PC.

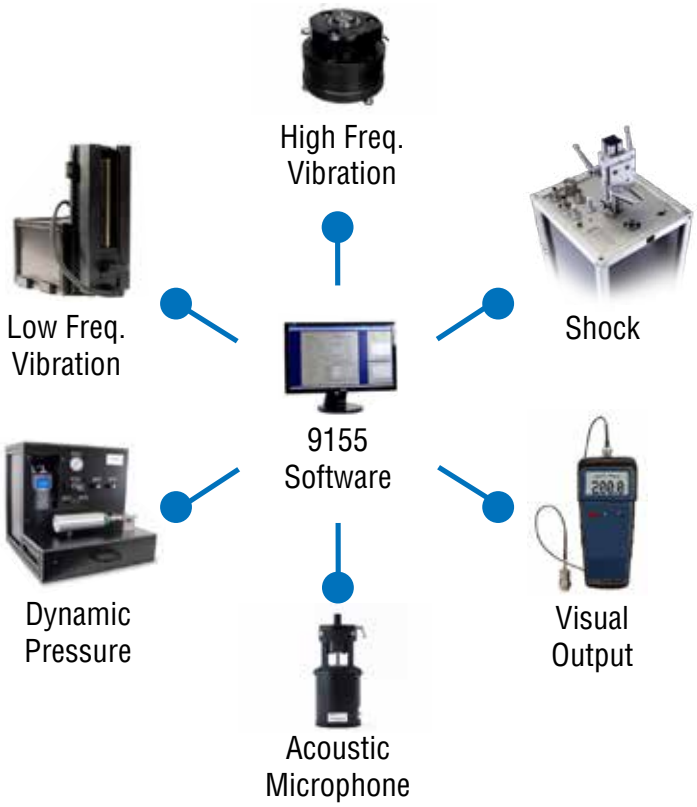


DYNAMIC SENSOR CALIBRATION WORKSTATION

- Configurable modular system for range of needs
- Local language software support
- "Out-of-the-box" turnkey system
- Calibrate up to 200 user defined frequencies

The versatile Precision Sensor Calibration Workstation Model 9155 provides options to calibrate accelerometers, acoustic microphones, dynamic pressure sensors, and more in one modular system. The Model 9155 delivers accurate back-to-back comparison calibration of accelerometers in accordance with ISO 16063-21:2003, ISO 16063-22:2005 (shock accelerometers), and/or IEC 61094-5 (microphones). Options to calibrate piezoresistive, capacitive, velocity, 4-20 mA, visual output (meters), and dynamic pressure sensors are available through various software options to pair with a range of acoustic, vibration, and shock exciters bring you a wide scope of capabilities.

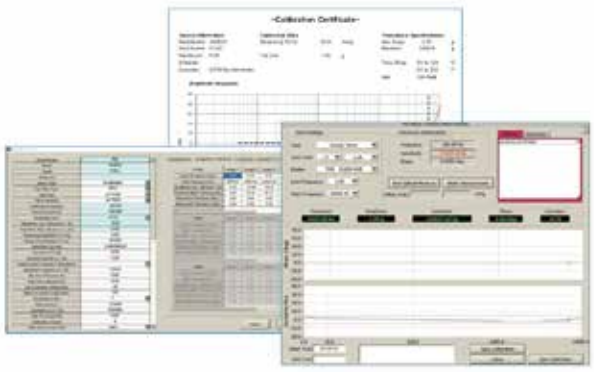
Each system provides all the necessary components 'out-of-the-box' – from precision actuators to state-of-the-art data acquisition hardware paired with the 9155D Windows® PC software controller.



HIGHLIGHTS

- Assures accurate, NIST and/or PTB traceable calibrations
- Stepped sine controller optimized for precision and throughput
- Setup tests, acquire data, save results, and print reports quickly
- Define multiple pass/fail criteria for each test and automatically recall them from the internal database
- Customizable printed calibration certificates comply with ISO 17025 and ISO 16063-21 requirements

The 9155D Windows® PC software controller serves as the central hub of each 9155 Calibration System. It controls system hardware and acquires data for the wide range of SUT's. This common user interface reduces customer training costs by providing a familiar experience for test setup, data management, and report generation while allowing operators to focus on the intricate details of SUT mounting and operation, reducing the risk of procedural errors.



PRECISION CALIBRATION SYSTEMS

- Reduce uncertainty
- Allow high throughput with simple mounting and setup
- Rugged, reliable design proven on PCB Piezotronics production lines
- Exceeds ISO 16063-21 requirements

AIR BEARING VIBRATION CALIBRATION SHAKER

SHAKER MODEL K394B30 AND K394B31
INCLUDED IN SYSTEM OPTION 9155D-830
AND 9155D-831

Our Air Bearing Calibration shakers represent the de facto global standard in calibration-grade hardware while continuing the award-winning PCB tradition of providing superior performance characteristics and ease of use alongside exceptional value and simplicity.

- Wide frequency range of 2 Hz to 50 kHz (calibration from 5 Hz to 20 kHz)
- Drastically reduces uncertainty by virtually eliminating transverse motion
- Integral quartz ICP® reference ensures low noise operation with long-term stability
- Lorentz force coil enables rapid centering of sensors with varying mass
- High stiffness beryllium insert yields high frequency calibration

ACCELEROMETER CALIBRATION WORKSTATION

Model 9155 Automated Accelerometer Calibration Workstation system shown to the left with options -100, -443, -445, -478, -830C

The Accelerometer Calibration Workstation Model 9155 is a turnkey solution that provides all the necessary components out of the box. Principal components include a Windows® PC Controller, software, printer and 24-bit data acquisition card and software. System options allow custom configuration of the modular system with a variety of calibration-grade exciter systems, accelerometer signal conditioning, test software modules and mounting accessories.

To learn more about how a 9155 system can meet your specific needs, visit **www.modalshop.com/configuration** for a custom calibration configuration guide or contact The Modal Shop's Calibration Team.

CALIBRATION EXCITERS

SMARTSTROKE™ LOW FREQUENCY SHAKER

SHAKER MODEL 2129E025; SYSTEM OPTION 9155D-771 AND 9155D-779

- Achieves significantly faster calibration times with SmartStroke™ technology
- Improves signal to noise ratio at low frequency with 10 in (25 cm) stroke length
- Both options utilize a stable, quartz ICP® low frequency reference accelerometer
- Option 9155D-779 offers improved ultra low frequency using patented optical encoder reference technology from 0.1 – 10 Hz (Patent 8,577,641)

PNEUSHOCK™ SHOCK CALIBRATION EXCITER

EXCITER KIT MODEL K9525C
SYSTEM OPTION 9155D-525

- Easy amplitude linearity calibration of shock and crash sensors from 20 to 10 000 g
- Controlled and consistent impacts using state-of-the-art pneumatic actuator
- Easy refinement of impulse shape and frequency content using a wide variety of impact anvils
- Superior impact control through drive pressure and impulsive duration control

HIGH PAYLOAD CALIBRATION SHAKER

SHAKER MODEL 2075E-875
SYSTEM OPTION 9155D-875

- Supports heavy payload and hard line cabled transducers with sturdy flexure armature
- Includes test sensor mounting platform with integral stability, quartz ICP® reference accelerometer and paired signal conditioning
- Operates from 10 to 10 000 Hz

OPTION	RANGE	SHAKER MODEL	APPLICATION
9155D-525	20 – 10 000 g	9525C	Shock
9155D-771	0.5 – 500 Hz	2129E025	Low Frequency
9155D-779	0.1 – 500 Hz	2129E025	Ultra Low Frequency
9155D-830C	5 – 15 000 Hz	K394B30	Broad Frequency
9155D-831	5 – 20 000 Hz	K394B31	Extended High Frequency
9155D-875	10 – 10 000 Hz	2075E-875	Heavy Payload

VIBRATION CALIBRATION SYSTEMS

The Accelerometer Calibration Workstation Model 9155 allows accurate back-to-back comparison calibration of ICP® (IEPE), charge, piezoresistive, capacitive, and voltage mode accelerometers in accordance with ISO 16063-21:2003. Every system is delivered with its reference calibrated directly by The Modal Shop's ISO 16063-11 compliant, A2LA accredited Laser Primary system, assuring world-class uncertainties. Factory acceptance test (FAT) and site acceptance test (SAT) by trained calibration professionals ensure proper installation of every 9155 system around the globe.

HIGHLIGHTS

- Accelerometer calibrations in under one minute per axis
- Uncertainties as low as 0.75% with laser primary
- Calibrations are NIST or PTB traceable
- Modular system fits any application
- Compliance to ISO 16063-11, -21, -22 vibration calibration standards
- System offers ISO 17025 compliant customizable certificates
- Back-to-back comparison calibration as low as 0.75% uncertainty

UNCERTAINTY*	FREQUENCY RANGE	SYSTEM OPTION	DESCRIPTION
0.75 %	100 Hz and 159 Hz	9155D-830C or 831	Reference Frequency
3.0 %	0.25 – <0.5 Hz	9155D-779	Optical Encoder Reference
1.1 %	0.5 – <1 Hz	9155D-779	Optical Encoder Reference
0.8 %	1 – <10 Hz	9155D-779	Optical Encoder Reference
1.2 %	10 – <100 Hz	9155D-830C or 831	ICP® Primary Reference Accelerometer
1.0 %	>100 – 1 000 Hz	9155D-830C or 831	ICP® Primary Reference Accelerometer
1.4 %	>1 000 – 5 000 Hz	9155D-830C or 831	ICP® Primary Reference Accelerometer
1.9 %	>5 000 –10 000 Hz	9155D-830C or 831	ICP® Primary Reference Accelerometer
2.2 %	>10 000 – 15 000 Hz	9155D-830C or 831	ICP® Primary Reference Accelerometer
2.8 %	>15 000 – 20 000 Hz	9155D-831	ICP® Primary Reference Accelerometer

* 95 % confidence interval (coverage factor of k=2)

TECH TALK: WHY CALIBRATE?

When considering accelerometer calibration and intervals you must ask, "What is the cost of failure?" If the test is a simple learning experiment in a university measurements course, the cost of retaking the data may be nothing. Many lab tests allow easy access or re-access to the test structure coupled with redundancy in the measurement channels. Here, the cost of a single bad measurement is low.

Costs can, however, escalate rapidly depending on certain factors. If the test structure is a prototype costing millions of dollars, every extra day spent in development escalates cost. Another extreme category is the "one shot" test. Channels are checked, double checked, calibrated, re-verified and data is backed up concurrently. The measurement has to be correct.

Another motivation for calibration is measurements made for legal purposes. Health and human exposure measurements used in legal proceedings for noise or vibration must withstand the scrutiny of the legal system.

SENSOR CALIBRATION SYSTEM OPTIONS

The modular nature of the 9155 Accelerometer Calibration System allows systems to be configured or expanded to meet the needs of your laboratory or testing facility. In addition to a variety of exciters, a range of hardware and software choices are available to expand your capabilities. From options to perform a resonance check or a laser primary calibration to a range of sensor signal conditioning options, the 9155 system can be customized to fit a variety of testing needs.

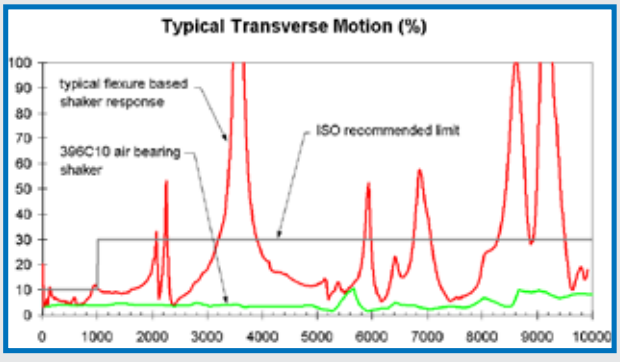
OPTION	DESCRIPTION
9155D-100	Rack Integration (system components in 19 in equipment rack)
9155D-120	Shaker Mount Option (provides wood pedestal to support calibration shaker)
9155D-350	Automated Label Printing (includes label printer)
9155D-400	Automated TEDS Sensor Support (requires 9155D-443)
9155D-421	Signal Conditioning ICP® and Charge (Includes PCB model 482A21 and 422E02)
9155D-427	Signal Conditioning ICP®, Charge, and Bridge/Differential (Includes PCB model 482C27 and 422E02)
9155D-442	Signal Conditioning ICP® (includes PCB Model 442A102)
9155D-443	Signal Conditioning Dual Mode Charge Amplifier (ICP®/Charge) (includes PCB Model 443B101)
9155D-445	Signal Conditioning Capacitive Sensor (includes PCB Model 445B101)
9155D-USC	Universal signal conditioner supporting ICP, charge, voltage, bridge/differential sensor types.
9155D-501	Automated Linearity Check, up to 40 g pk (requires 9155D-830C or 9155D-831)
9155D-550	Automated Resonance Test, up to 50 kHz (requires 9155D-830C or 9155D-831)
9155D-575	Laser Primary System (includes two dual pass laser interferometers and accessories)
9155D-600	Automated Velocity Sensor Calibration
9155D-610	Automated Displacement Sensor Calibration
9155D-650	Automated 4-20 mA Velocity Sensor Calibration
9155D-680	Visual Output Sensor Option.
9155D-901	Environment Monitoring option for Model 9155 Calibration System. Includes calibrated external temperature, humidity and pressure gauge.
9155D-910	Acoustic Microphone Calibration Support. IEC 61094-5 Comparison Method With Acoustic Field Correction (requires TMS model 9919C or 9917C-HW options)

TECH TALK: SENSOR AND CALIBRATION TIPS

The Modal Shop's *Dynamic Sensors & Calibration Tips* newsletter offers an ideal opportunity for you to learn more about the theory and best practices used in sensor applications and calibration. Visit **www.modalshop.com/calibration/learn** for more info

Transverse Motion in Calibration

ISO 16063 Part 21:2003 defines the back-to-back comparison technique for accelerometer calibration. It includes a recommendation for acceptable limits on shaker transverse motion characteristics. The differences between mechanical flexure-based electrodynamic shakers and air bearing shakers result in effects on calibration accuracy and uncertainty, as shown in the graph to the right.



Plot details show transverse motion measured on air bearing shaker and flexure shaker vs ISO recommended limits

ACOUSTIC MICROPHONE CALIBRATION

Precision Measurement Microphone Calibration Systems from The Modal Shop are designed to simplify your calibration process. Systems offer calibration of precision condenser microphones – 1", ½", ¼", ⅛" – as well as electret array microphones – ½", ¼".

Available systems comply with IEC 61094-6 Electrostatic Actuator Technique, combined with the insert voltage technique (Model 9350C) or IEC 61094-5 Comparison Calibration Technique (Models 9919C and 9917C).

Solutions range from portable systems, to options that integrate with the Precision Sensor Calibration Workstation Model 9155D, to a full laboratory system (Model 9350C).

	9350C	9919	9917
Precision Measurement Microphones			
1"	✓	–	–
½"	✓	✓	✓
¼"	✓	✓	✓
⅛"	✓	–	–
Array Microphones			
½"	–	✓	✓
¼"	–	✓	✓

PRECISION ACOUSTIC

MODEL 9350C

- Calibrates condenser measurement microphones, preamplifiers, and sound sources
- Complies with IEC 61094-6 and IEC 60942
- Streamlined, easy-to-use GUI

*Systems not shown to scale.

HIGH RANGE MICROPHONE

MODEL 9919C

- Calibrate acoustic microphones from 20 Hz to 20 kHz
- Complies with IEC 61094-5
- Calibrates both condenser and array microphones
- Calibrate with or without removing grid cap

COMPACT MICROPHONE

MODELS 9917C AND 9000A

- Compatible with both condenser and array microphones
- Complies with IEC 61094-5
- Simple, fast, portable acoustic calibration
- Frequency range of 20 Hz to 10 kHz

TECH TALK: IEC 61094-5 COMPARISON TECHNIQUE

While IEC 61094 defines calibration techniques for condenser microphones, we also use parts of it to calibrate array microphones, such as PCB 130 Series array mics. In the comparison technique, the microphone under test and a reference microphone are used. The reference microphone needs to have been recently calibrated precisely at a high level in the chain of traceability. The two microphones are placed face-to-face using calibration equipment, like the Model 9919C, and exposed to a sound field simultaneously. A simple comparison is made between the voltage output of the microphone under test and the reference microphone. Since the sensitivity of the reference microphone is known, we simply measure the voltage output of both microphones to calculate the sensitivity of the microphone under test, in mV/Pa. This measurement is performed at multiple frequencies, with either sinusoidal or broadband excitation.

For the purpose of calibration, we must understand that the IEC 61094-5 method specifies a pressure response measurement, as does the 61094-6 Electrostatic Actuator Technique. For this reason, a pressure response microphone is used as the reference microphone. To calibrate a free field or random incidence microphone, the appropriate correction curve should be applied to the results from the pressure field calibration. This 'corrects' the pressure field measurement (the pressure response) to a free field or random incidence response. The IEC 61094-5 comparison method with correction curve applied when necessary is a cost-effective and straightforward method for calibrating array and condenser microphones.

DYNAMIC PRESSURE CALIBRATION SYSTEMS

To service the wide range of pressure events measured by dynamic pressure sensors, The Modal Shop offers systems that calibrate sensors designed for atmospheric blast experiments, gas turbine exhaust fluctuations, internal combustion engine measurements, ammunition brass calibrations, and hydraulic or fuel line measurements. These systems have been proven in tens of thousands of factory calibrations performed at PCB Piezotronics, and this rich metrology heritage is leveraged with a digital hardware and software platform that is shared with the Precision Sensor Calibration Workstation Model 9155D.

By combining PCB's factory calibration hardware with The Modal Shop system software and expertise, pressure calibration systems meet the needs of the most discerning user. These turnkey systems reproduce the factory calibration techniques of pressure sensors for customers with the added advantage of a single point for product support and Total Customer Satisfaction.

HIGHLIGHTS

- Assures accurate, traceable calibrations
- Integrated system includes all necessary components
- Windows® PC supplies familiar, intuitive user interface
- Set up tests, acquire data, save results and print reports quickly with precision and automation
- Define pass/fail criteria for each test and automatically recall them from the internal database

PRESSURE SENSOR CALIBRATION SYSTEMS					
PRESSURE	MAX RANGE psi (MPa)	MEASUREMENT TECHNIQUE	UNCERTAINTY	TURNKEY WORKSTATION	9155D MODULAR OPTION
Low Pressure	150 (1)	Dynamic Step	±1.5 %	K9903C	9155D-903
Medium Pressure	1 000 (6.9)	Dynamic Step	±1.5 %	K9907C	9155D-907
High Pressure	15 000 (103)	Dynamic Impulse	±4.1 %	K9913C	9155D-913
Ultra-High pressure	80 000 (550)	Dynamic Step	±2.0 %	K9905D	-

LOW PRESSURE

MODEL K9903C

- Maximum pressure: 150 psi (1 MPa)
- Options available for lower pressures
- Pneumatic calibration media
- 'Step' pressure input
- 5 ms using manual release valve
- Automated Pressure Controller

MEDIUM PRESSURE

MODEL K9907C

- Maximum pressure: 1000 psi (6.9 MPa)
- Compressed air or industrial helium media
- 'Step' pressure input
- Fastest rise times using poppet valve mechanism

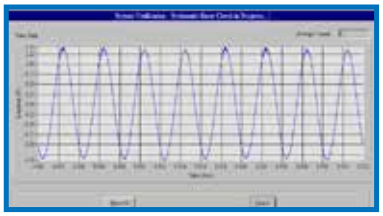
HIGH PRESSURE

MODEL K9913C

- Maximum pressure: 15 000 psi (103 MPa)
- Silicon oil media
- 'Impulse' pressure input
- 3 ms rise time with 7 ms pulse duration using drop mass

PRESSURE CALIBRATION METHODOLOGY

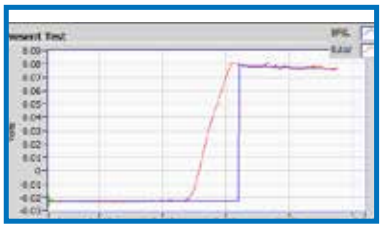
Dynamic pressure sensors are typically calibrated by varying the amplitude, rather than the frequency, of the physical input. It so happens that the physics of building a controlled actuator that covers the dynamic range of piezoelectric and piezoresistive pressure sensors is, in a word, challenging. As a result, multiple dynamic pressure calibration techniques have been developed.



Periodic Measurement from 9350C

PERIODIC INPUT

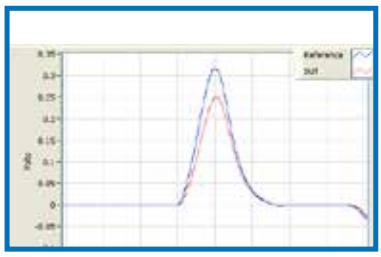
Periodic inputs are classified as a steady state and repeating input signal. In general, periodic signals are used to calibrate high sensitivity acoustic microphones whereas aperiodic (transient) methods are used for piezoelectric pressure sensor. The Models 9350C, 9919C and 9917C are systems used to calibrate acoustic microphones with a periodic stepped sine input (as shown in the figure to the left) at multiple frequency points within the microphones usable range.



Step Pressure Rise – Transient

STEP INPUT

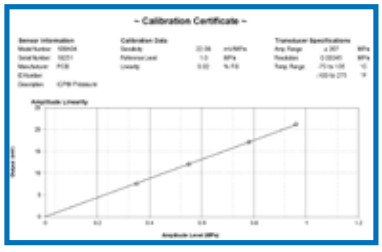
Step Inputs provide a quick rise in pressure to the sensor under test. The pressure rise is created by first pressurizing a large volume of gas and measuring the pressure very precisely using a static pressure gauge. This large pressurized volume is released into a very small volume wherein the sensor under test is mounted. The voltage output rise of the sensor under test is measured. The drop in pressure of the combined volume due to the gas expansion is known to be very small, and it is included in the estimate of measurement uncertainty. Errors due to acoustic resonances and long-term signal decay effects are compensated using signal processing, resulting in the synthesized step response (blue curve in figure to the left). The output of the sensor is then normalized by the reference pressure to calculate the sensitivity of the sensor under test. The low pressure (K9903C), medium pressure (K9907C) and ultra-high pressure (K9905D) systems use this method.



Impulse Pressure Rise – Transient

IMPULSE INPUT

Impulse inputs provide a quick rise and fall of the pressure level. A sensor under test and a reference sensor are mounted very closely in a closed volume of oil. A third port on the volume is occupied by a piston. The piston is struck on the outside of the volume, which applies a force to the oil creating a pressure impulse that is simultaneously observed and measured by the two sensors (as shown in figure to the right). The instantaneous peak voltage output of both the sensor under test and the piezoelectric reference sensor are recorded. The sensitivity of the reference sensor is known. These three values (two voltage measurements and reference sensitivity) are used to calculate the sensitivity of the sensor under test. The high pressure (K9913C) system uses this method.



Model K9903 Calibration Certificate

In all cases the Model 9155D software will measure the reference and sensor under test output to compute the sensitivity values and linearity of a user identified pressure range. The software displays the pressure response data for the technician to view and check for any anomalies. Once accepted, the software automatically generates a customizable certificate showing % deviation for printing and archives the data.

CALIBRATION REFERENCE STANDARD KITS

Primary vibration calibration utilizes a laser interferometer as reference, providing traceability to a physical constant (wavelength of light) and the lowest possible measurement uncertainty. Secondary calibration techniques use a transfer standard or reference accelerometer to calibrate another accelerometer under test and provide traceability to the primary standard. Reference accelerometers, often called “double ended” or “piggy-back” standards, are designed specifically to carry a sensor under test to perform a secondary back-to-back calibration. Transfer standards are designed specifically to calibrate working standard reference accelerometers. All calibration standard kits include a quartz ICP® accelerometer paired with PCB ICP® signal conditioner, calibrated directly against The Modal Shop’s A2LA accredited laser primary calibration system.

HIGHLIGHTS

- Low noise ICP® electronics simplify connectivity
- Quartz offers best long-term stability
- Hermetic package ensures long-term reliability
- Low 0.2% measurement uncertainty at reference frequency

TRANSFER STANDARDS (SINGLE ENDED)	
MODEL NUMBER	**RANGE**
9105C01	Broad Frequency 5 – 11 000 Hz
9105C11	Extended High Frequency 5 – 20 000 Hz
9105C21	Low Frequency 0.1 – 4 000 Hz
9105C31	Shock 100 – 10 000 g

REFERENCE ACCELEROMETERS (DOUBLE ENDED)	
MODEL NUMBER	**RANGE**
9106C01	Broad Frequency 5 – 14 000 Hz
9106C11	Extended High Frequency 5 – 20 000 Hz
9106C21	Low Frequency 0.5 – 3 500 Hz
9106C31	Shock 100 – 10 000 g

TECH TALK: INTERLABORATORY COMPARISON

The Modal Shop’s Interlaboratory Comparison (ILC) Program is designed to help laboratories achieve proficiency confidence in vibration calibration results, publish reliable uncertainty levels and meet ISO 17025 certification requirements. With anonymous participation and blind results, the program provides precision data with confidentiality. After enrolling with The Modal Shop, the participating accelerometer calibration laboratory will:

1. Receive comparison accelerometer to calibrate
2. Calibrate sensor over applicable range(s)
3. Return accelerometer and results to The Modal Shop
4. Receive a report detailing double blind comparison with other independant labs.
5. Have the Opportunity for expert discussion on practices, variances, and other process improvements

Visit **www.modalshop.com/ILC** for more information.

ACCREDITED CALIBRATION SERVICES

The Modal Shop's in-scope, in-house calibration laboratory holds accreditation to ISO / IEC 17025:2005 and ANSI / NCSL Z540-1-1994, internationally recognized standards which specify general requirements necessary to exhibit technical competence in carrying out various testing and calibration methods. Accordingly, The Modal Shop can be your partner in a well-documented transducer calibration program.

As part of this accreditation, The Modal Shop offers primary and secondary calibration of accelerometers, as well as services for condenser microphones, impulse force hammers, force sensors, and associated signal conditioning electronics.

Certificate Number 2649.01 Calibration Lab

In conjunction with sister company PCB Piezotronics, The Modal Shop and PCB have available the industry's most extensive calibration test services and equipment offerings.

COMMON CALIBRATION SERVICES

The Modal Shop provides a wide range of vibration, force, acoustic, system, and signal conditioning calibration services. As your partner, The Modal Shop can provide an accurate, controlled, and confident transducer calibration program. Please visit **www.modalshop.com/scope** for more information on our A2LA ISO 17025 Scope of Accreditation and for applicable calibration services.

ACCELEROMETER CALIBRATION SERVICES		
MCS-A001	Calibration of accelerometer, single axis amplitude and phase response from 5 Hz to upper 5% frequency.	N A
MCS-A001T	Calibration of accelerometer, triaxial amplitude and phase response from 5 Hz to upper 5% frequency.	N A
MCS-A004	Calibration of accelerometer, single axis, low frequency phase and amplitude response from 0.5 to 10 Hz. Includes 100 Hz reference frequency calibration.	N A
MCS-A004T	Calibration of accelerometer, triaxial, low frequency phase and amplitude response from 0.5 to 10 Hz. Includes 100 Hz reference frequency calibration.	N A
MCS-A065	Primary calibration via laser interferometry per ISO 16063-11 from 5 Hz to 20 kHz at up to 45 specific user-defined frequencies.	A
MCS-31	High g shock accelerometer calibration using PneuShock™ to max 10 000 g range.	N A

N - NIST traceable
A - A2LA accredited

For the full list of calibration services, visit **www.modalshop.com/calibration-services**

HANDHELD AND PORTABLE CALIBRATION		
MCS-A009	Calibration of handheld calibrator, models 394C05, 394B06 and 394C06.	N
9100-CAL01	Calibration of 91xx Series Portable Vibration Calibrator.	N A
IMPACT HAMMER CALIBRATION SERVICES		
MCS-H002	Calibration of 086 Series instrumented hammer or similar.	N A
MCS-H005	Calibration of hammer with up to six tips and one extender mass.	N A
MCS-H003	Calibration of 288 Series Impedance Head.	N A
ACOUSTIC CALIBRATION SERVICES		
MCS-1	Calibration of 130 Series array microphone and preamplifier pair.	N
MCS-2	Calibration of standard precision condenser microphones.	N A
MCS-9	Calibration of precision microphone/ preamplifier pair.	N A
MCS-56	Calibration of speakerphone.	N
SIGNAL CONDITIONER ELECTRONICS CALIBRATION SERVICES		
MCS-E001	Calibration of in-line charge converters 422E Series and equivalent.	N A
MCS-E004	Calibration of single channel signal conditioner 480 Series and equivalent.	N A
MCS-Exxx	Many multichannel signal conditioner calibrations with various options available	

TEST EQUIPMENT RENTAL

The Modal Shop's Sound and Vibration Rental Program provides a single source for varied – and often difficult to procure – dynamic test equipment, sensing systems, and expertise. Whether you simply need a single accelerometer and cable, a complete vibration shaker kit or a complex sound level meter system, The Modal Shop can help. As more test engineers are restrained with limited capital budgets, The Modal Shop's Rental Program expands existing capabilities and ensures the viability of particular models prior to purchase for permanent test setups.

WHY RENT?

- Try before you buy – eliminate concerns of buying the wrong thing
- Remain flexible – take on projects with a large and wide variety of equipment
- Choose from a wide variety of units and use the right sensor, every time
- Avoid ownership costs of capital investment and calibration
- Eliminate hassle and cost of repairs, storage, warranties, and calibration
- Ship calibrated equipment worldwide – keep your equipment back in the lab
- Obtain a wealth of knowledge from a team of experts trained and ready to help

DOWNLOAD OUR RENTAL SELECTION GUIDE

Interested in learning more about rentals from The Modal Shop? The in-depth Sound and Vibration Rental Selection Guide offers 30+ pages of information on our extensive equipment inventory. Visit **www.modalshop.com/rental-guide** to download a copy or email us at **rental@modalshop.com** to request a printed version.

Expert application support from the TMS Application Engineering Team is only a call, click or email away.

FROM SENSORS TO SYSTEMS

ACCELEROMETERS

- Single axis and triaxial
- Digiducer® USB Digital Accelerometer
- General purpose, miniature, shock, seismic, and more
- Low frequency and high temperature units
- ICP®/IEPE, charge mode, capacitive, and MEMS
- TEDS and water-resistant options
- Cabling and mounting accessories

MICROPHONES

- Precision condenser and array
- 0 V prepolarized and 200 V historic
- Freefield, pressure, and random response
- Power supplies, cabling, windscreens, stands, and other accessories
- Specialty units

EXCITATION

- Full range of impact hammers
- Complete modal shaker kits
- Amplifiers, stinger kits, and more
- Vibration control systems

SOUND LEVEL METERS

- Type 1 / Class 1 standalone meters
- Logging, community noise, 1/1 and 1/3 octave
- Event logging and event sound recording
- Complete kits for unattended monitoring
- Options for room acoustics, FFT, and audiometry

STRUCTURAL TEST ACCESSORIES

- Calibration equipment
- Cabling and mounting equipment
- Data acquisition
- Visualization software
- Signal conditioning
- AirRide® supports

SPECIALTY ACOUSTICS

- Hydrophones
- Sound intensity probes and kits
- Probe mics for high temperature
- Acoustic calibrators: speakerphones, pistonphones
- Building acoustics: sources and tapping machines

OTHER TRANSDUCERS

- Dynamic force and strain
- Dynamic pressure
- Rotational speed/tachometer
- Force limited vibration systems
- Torque telemetry systems
- Torque and angle transducers

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