



# SOUND & VIBRATION SYSTEMS SELECTION GUIDE

# 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](http://www.modalshop.com/contact)

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

\*Front cover photo taken in cooperation with Belgian Defense.

# 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](http://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](mailto: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](http://www.modalshop.com/learn) where new topics are added regularly.



### Information and Downloads

From application information to downloadable catalogs, datasheets, and white papers, you can find a complete range of resources simply by visiting [www.modalshop.com](http://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](http://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 small payloads by attachment to 10-32 mounting top
- Provides ease of setup with trunnion mounting base and EasyTurn™ handles



RUGGED CARBON FIBER FLEXURES

EASY TURN™ HANDLES

BUILT - IN  
amp

### SMART FEATURES:

- SAFE STARTS IN MUTE TO AVOID TRANSIENTS
- SELECTABLE GAIN SETTINGS
- PROVIDES CLIPPING WARNING AND OVER TEMPERATURE/CURRENT SHUTDOWN

BNC INPUT FOR DRIVING SIGNAL CONNECTION

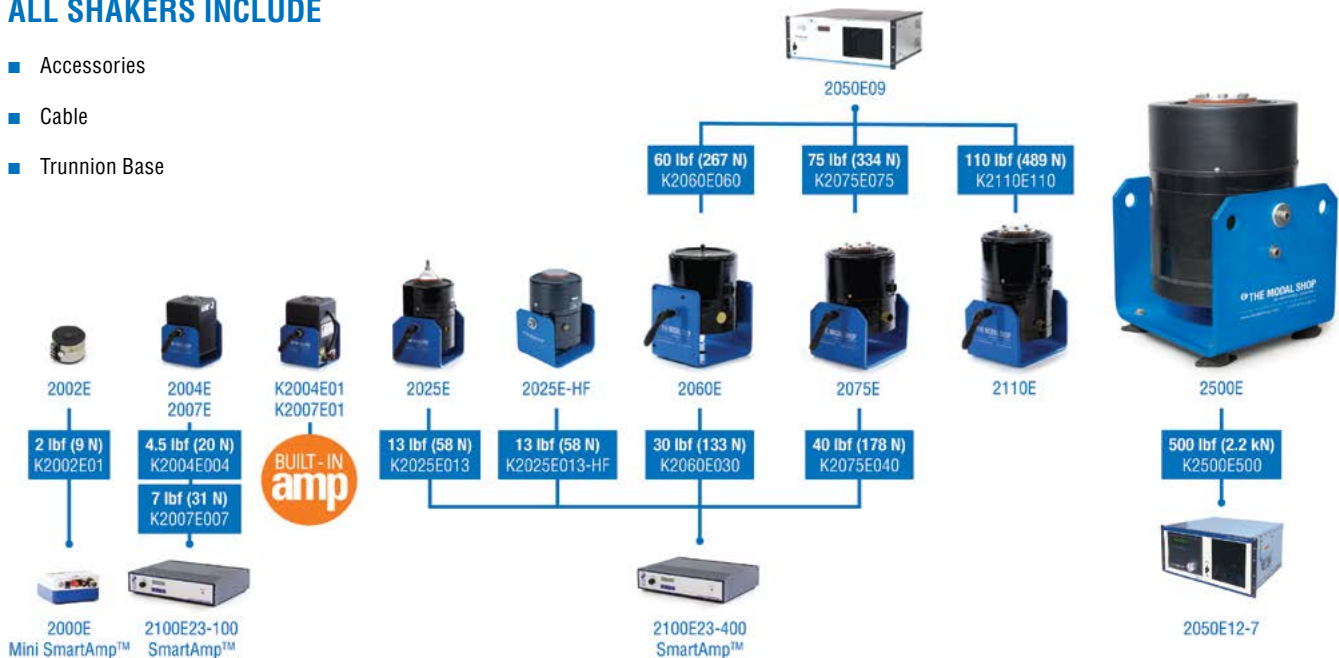
ELIMINATES NEED FOR BULKY SEPARATE AMPLIFIER

# 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, and 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

- Accessories
- Cable
- Trunnion Base



| SPECIFICATIONS |              |                         |                                      |                         |                 |                               |                                                                                                                            |
|----------------|--------------|-------------------------|--------------------------------------|-------------------------|-----------------|-------------------------------|----------------------------------------------------------------------------------------------------------------------------|
| Kit Model      | Shaker Model | Max Force<br>lbf (N) pk | Max Frequency <sup>[1]</sup><br>(Hz) | Stroke<br>in (mm) pk-pk | Amplifier Model | Shaker Type                   | Applications                                                                                                               |
| K2002E01       | 2002E        | 2 (9)                   | 3 000                                | N/A                     | 2000E           | Inertial                      | Modal analysis, general vibration,<br>small structures<br>[circuit boards, small devices]                                  |
| K2004E004      | 2004E        | 4.5 (20)                | 11 000                               | 0.2 (5)                 | 2100E23-100     | Mini                          |                                                                                                                            |
| K2004E01       | 2004E        | 4.5 (20)                | 11 000                               | 0.2 (5)                 | Integrated      | Mini                          |                                                                                                                            |
| K2007E007      | 2007E        | 7 (31)                  | 9 000                                | 0.5 (13)                | 2100E23-100     | Mini                          |                                                                                                                            |
| K2007E01       | 2007E        | 7 (31)                  | 9 000                                | 0.5 (13)                | Integrated      | Mini                          |                                                                                                                            |
| K2025E013-HF   | 2025E-HF     | 13 (58)                 | 20 000                               | 0.5 (13)                | 2100E23-400     | Calibration<br>Vibration Test | General vibration testing, calibration<br>of vibration sensors, high frequency                                             |
| K2025E013      | 2025E        | 13 (58)                 | 10 000                               | 0.7 (18)                | 2100E23-400     | Modal                         | Modal testing of small to large<br>structures<br>[sub-components, automotive,<br>aerospace]                                |
| K2060E030      | 2060E        | 30 (133)                | 6 000                                | 1.4 (36)                | 2100E23-400     | Modal                         |                                                                                                                            |
| K2060E060      | 2060E        | 60 (267)                | 6 000                                | 1.4 (36)                | 2050E09         | Modal                         |                                                                                                                            |
| K2075E040      | 2075E        | 40 (178)                | 6 500                                | 1.0 (25)                | 2100E23-400     | Modal<br>Vibration Test       | Dual purpose design, modal testing<br>of small to large structures, general<br>vibration testing                           |
| K2075E075      | 2075E        | 75 (334)                | 6 500                                | 1.0 (25)                | 2050E09         | Modal<br>Vibration Test       |                                                                                                                            |
| K2110E110      | 2110E        | 110 (489)               | 6 500                                | 1.0 (25)                | 2050E09 - FS    | Modal<br>Vibration Test       |                                                                                                                            |
| K2500E500      | 2500E        | 500 (2 224)             | 4 500                                | 1.0 (25)                | 2050E12-7       | Vibration Test                | General vibration testing,<br>small to medium test articles<br>[electronics, optical devices,<br>satellite sub-components] |

[1] Load dependent \* Cooling system not pictured and amplifiers not in scale

# MODAL SHAKERS

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



### THROUGH-HOLE ARMATURE

An axial through-hole allows a long stinger to be threaded to the force transducer, aligned, and secured with a shaker-side chuck and collet: a simple, time-saving feature essential for modern modal testing.

COLLET  
CHUCK  
ARMATURE  
STINGER  
SENSOR

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
  - 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<br>lbf (N) pk | MAX FREQUENCY<br>Hz <sup>[2]</sup> | STROKE<br>in (mm) pk-pk | WEIGHT<br>lb (kg) |
|-----------------------------------------|-------------------------|------------------------------------|-------------------------|-------------------|
| 2060E                                   | 60 (267)                | 6 000                              | 1.4 (36)                | 37 (17)           |
| 2025E                                   | 13 (58)                 | 9 000                              | 0.75 (19)               | 13 (6)            |
| 2007E <sup>[1]</sup>                    | 7 (31)                  | 9 000                              | 0.5 (13)                | 6 (3)             |
| SmartShaker™<br>K2007E01 <sup>[1]</sup> | 7 (31)                  | 9 000                              | 0.5 (13)                | 7 (3)             |
| 2004E <sup>[1]</sup>                    | 4.5 (20)                | 11 000                             | 0.2 (5)                 | 6 (3)             |
| SmartShaker™<br>K2004E01 <sup>[1]</sup> | 4.5 (20)                | 11 000                             | 0.2 (5)                 | 7 (3)             |
| 2002E <sup>[3]</sup>                    | 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.

# GENERAL PURPOSE SHAKERS

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



The Modal Shop's general purpose shakers are ideal for both vibration testing of small components and modal analysis. Small and lightweight, yet powerful electrodynamic shakers, the general 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 small payloads up to approximately 10 lb (4.5 kg). These units also offer a dual purpose capability with 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. The 2025E-HF offers an extended frequency range of 20 kHz for high frequency testing.

## 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<br>lbf (N) pk | MAX FREQUENCY<br>Hz <sup>[2]</sup> | STROKE<br>in (mm) pk-pk | WEIGHT<br>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 <sup>[1]</sup>                    | 7 (31)                  | 9 000                              | 0.5 (13)                | 6 (3)             |
| SmartShaker™<br>K2007E01 <sup>[1]</sup> | 7 (31)                  | 9 000                              | 0.5 (13)                | 7 (3)             |
| 2004E <sup>[1]</sup>                    | 4.5 (20)                | 11 000                             | 0.2 (5)                 | 6 (3)             |
| SmartShaker™<br>K2004E01 <sup>[1]</sup> | 4.5 (20)                | 11 000                             | 0.2 (5)                 | 7 (3)             |

<sup>[1]</sup> Models 2004E/2007E, 2025E-HF, and SmartShaker™ have no through-hole armature

<sup>[2]</sup> Load dependent

# VERSATILE VIBRATION TESTING

- CubeSat Satellites
- Avionics
- Consumer products
- Automotive parts, electronics
- Mechanical sub-assemblies
- Space components

## 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 horizontal slip table, head expander, and Modal-Pod CubeSat fixture for versatile mounting configuration
- System uses compact 2050E12-7 high efficiency digital amplifier

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

# STRUCTURAL TEST ACCESSORIES



## IMPEDANCE HEAD

MODEL TLD288D01

- ICP® impedance head (force/acceleration) for driving point measurements
- Force: 100 mV/lbf,  $\pm 50$  lbf
- Accel: 100 mV/g,  $\pm 50$  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 convenient 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 and tips to suit an array of testing needs

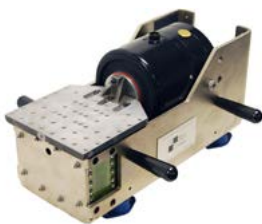


## ELECTRIC IMPACT HAMMER

MODEL 086P92-ES

- Repeatable force input
- Reliable operation, impact after impact
- Interchangeable force sensor

# EXPANDED TEST CAPABILITIES



## HORIZONTAL TABLE SYSTEMS

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

- Available for 2075E, 2110E, and 2500E shakers
- 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



## HEAD EXPANDER

MODELS 2000X01, M2000X01, 2000X14, M2000X14

- Facilitates attachment of larger test articles 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



## 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)
- Simplifies qualifications testing of CubeSats to NASA testing or other standards

## MORE TESTING TOOLS

- Drive Shakers
- Generate calibration certificates
- Test triaxial sensor cables
- Interface with TEDS sensors
- Measure rotational speed

### SMARTSINE™ CALIBRATION DRIVER

MODEL 9000A

The SmartSine™ Calibration Driver Model 9000A is a battery powered sinusoidal signal source used to drive shaker systems to predefined vibration levels and frequencies to calibrate individual sensors, vibration switches, and data collectors. The 9000A can also be used to drive an acoustic coupler for calibration of array microphones



#### HIGHLIGHTS

- Acceleration, velocity, displacement, and acoustic readout units
- Battery-powered unit is self-contained solution
- Compact and integrated sinusoidal source, ICP inputs, and meter system
- Portable by design with heavy duty case

#### APPLICATIONS

- Accelerometer or velocity sensor calibration
- Large sensor verification (geophones, vibration switches, etc.)
- Microphone calibration by comparison method with 9917C
- Testing of electronic devices with embedded vibration sensors



### TRIAXIAL CABLE TESTER

MODEL 9010A

- Test triaxial cables for faults or opens, and identify issues to inner or outer conductor or shorts
- Includes 8-36 and 1/4-28 connectors for each cable end



### TEDS SENSOR INTERFACE KIT

MODEL 400B76

- Allows updating of sensor calibration data
- Enables communication (both read and write) to TEDS Sensors
- USB powered, plug-and-play
- Triaxial accelerometer support



### ICP® LASER TACHOMETER

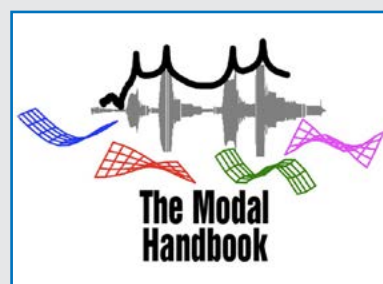
MODEL LT2

- 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: THE MODAL HANDBOOK

This easy to use multimedia package brings all the important issues of experimental modal testing to a very simple level of explanation and understanding. A straightforward user interface allows the modal test engineer/technician to quickly access information pertinent to running modal tests.

Visit [www.modalshop.com/modal-handbook](http://www.modalshop.com/modal-handbook) for more details.



# ON-SITE VALIDATION

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

## PORTABLE VIBRATION CALIBRATORS

MODELS C9110D-T, C9110D, 9110D, 9210D

The Modal Shop's line of Portable Vibration Calibrators, Models C9110D-T, C9110D, 9110D, 9210D, provides 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 allows technicians to program repetitive calibration test points and pass/fail tolerances.
- Supports piezoresistive, capacitive and modulated current sensor types with external signal conditioning



| MODEL    | APPLICATION  | INPUTS               | SUPPLIED MOUNTING ACCESSORIES         | FREQUENCY RANGE (Hz) |
|----------|--------------|----------------------|---------------------------------------|----------------------|
| C9110D-T | Calibration  | ICP, Charge, Voltage | Adhesive, 10-32, 5-44, 1/4-28         | 5 to 10 000          |
| C9110D   | Calibration  | ICP, Charge, Voltage | 1/4-28, 10-32, M8, Thru Bolt Patterns | 5 to 10 000          |
| 9110D    | Calibration  | ICP, Voltage         | 1/4-28, 10-32, M8, Thru Bolt Patterns | 5 to 10 000          |
| 9210D    | Calibration  | ICP, Voltage         | 1/4-28, 10-32, M8                     | 0.7 to 2 000         |
| 9100D    | Channel Test | None                 | 1/4-28, 10-32, M8, Thru Bolt Patterns | 5 to 10 000          |
| 9200D    | Channel Test | None                 | 1/4-28, 10-32, M8                     | 0.7 to 2 000         |

# METROLOGY MADE PORTABLE

## 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.

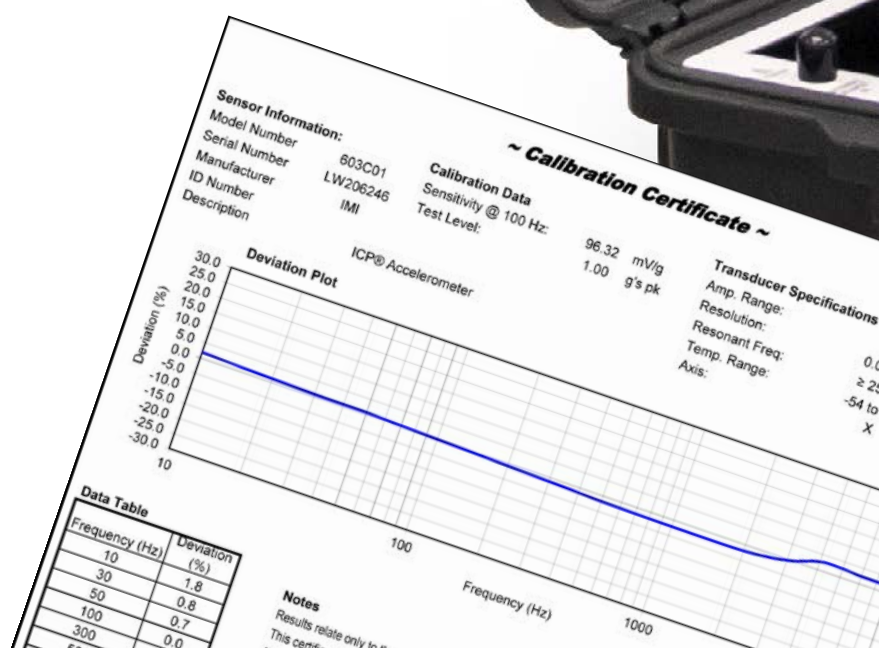
The 9140 Series combines two world class measurement platforms – the Portable Vibration Calibrator Model C9110D-T and the Precision Sensor Calibration Workstation Model 9155D. The Portable Vibration Calibrator offers ruggedness and reliability for vibration sensor calibration in some of the toughest 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.

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

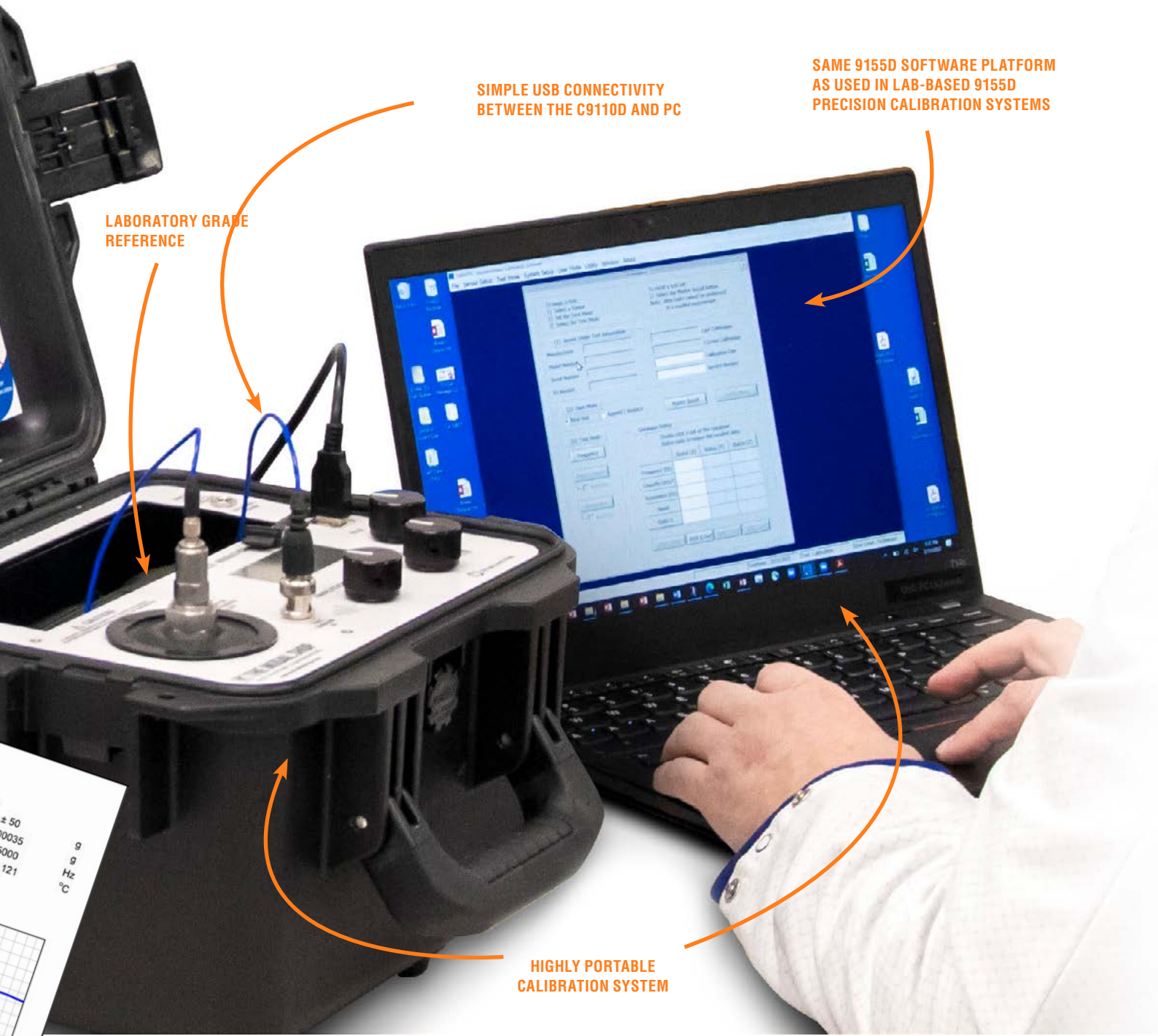
## HIGHLIGHTS

- 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 sensor types: ICP, Charge, Modulated current, Piezoresistive, Capacitive, Voltage



# VIBRATION CALIBRATION LABORATORY IN A BOX

| MODEL    | DESCRIPTION                                                                                                                                                                                      |
|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| K9140D10 | Complete kit of C9110D-T Portable Vibration Calibrator, Windows® laptop PC with complete software configuration, verification sensor, 003C03 sensor cable, and specialized USB connection cable. |
| K9140D   | Includes C9110D-T Portable Vibration Calibrator, 9100-USB00 USB Cable, and software. Customer installs software on customer-supplied Windows® PC.                                                |
| K9140-SW | 9140 Series vibration calibration software only. Includes 9100-USB00 USB Cable. Customer installs software on customer-supplied Windows® PC to use with existing compatible PVC.                 |



# DIGITAL SENSING SOLUTIONS

- Vibration Testing & Troubleshooting
- Automotive NVH
- Field Service / Portable Measurements
- Universities and Educational Research
- Condition Monitoring / Predictive Maintenance
- End-of-Line QC Testing

The Modal Shop's digital sensing solutions offer versatile, on-the-go dynamic measurement capabilities in the palm of your hand. Using standard USB audio digital output these solutions can be connected to a PC, smartphone, tablet, or other devices offering USB plug-and-play capability for a variety of applications and measurement types.

## DIGIDUCER® USB DIGITAL ACCELEROMETER

MODELS 333D01, 333D04, 333D05, 333D06, 333D05-C, 333D06-C

The Digiducer® USB digital accelerometer family provides quick and easy, accurate vibration measurements in the field or lab with a variety of connectivity options.

- Rugged piezoelectric sensing technology
- Broad frequency and dynamic range
- Embedded calibration data
- Phone, Tablet, and PC Ready
- Available in integral cable and removable cables options with USB-A or USB-C connectivity
- USB Plug-and-Play connectivity
- Easy data collection and sharing

| MODEL    | AMPLITUDE RANGE<br>(± g pk) | FREQUENCY RANGE<br>Hz (± 5%) | CABLE TYPE AND CONNECTOR |
|----------|-----------------------------|------------------------------|--------------------------|
| 333D01   | 20                          | 2 to 8 000                   | Integral, USB-A          |
| 333D04   | 100                         | 2 to 8 000                   | Integral, USB-A          |
| 333D05   | 20                          | 2 to 8 000                   | Removable, M12 to USB-A  |
| 333D06   | 100                         | 2 to 8 000                   | Removable, M12 to USB-A  |
| 333D05-C | 20                          | 2 to 8 000                   | Removable, M12 to USB-C  |
| 333D06-C | 100                         | 2 to 8 000                   | Removable, M12 to USB-C  |

NO DRIVERS REQUIRED



MODELS 333D01, 333D04



MODELS 333D05-C, 333D06-C

## DIGIDUCER® DIGITAL VIBRATION METER KIT

MODEL K333D01-VM

Digital Vibration Meter Kit Model K333D01-VM turns your smartphone into a portable vibration meter. The kit provides the 333D01 Digiducer, software, mounting hardware, and connections, with pre-programmed ISO-based vibration severity scales to provide instant feedback on machine health and vibration exceedance. Share reports right from your smartphone. Digital Vibration Meter Kit is an easy-to-use and cost-effective way to start monitoring machine health or enhance an existing machinery vibration monitoring program. The app collects, records, and stores data for multiple machines. Users can attach pictures of and create notes about each machine, making the Digital Vibration Meter Kit an ideal tool for route-based vibration screening.



# DIGITIZE YOUR SENSORS



## DIGIDAQ® USB SIGNAL CONDITIONER

MODELS 485B39, V485B39, IV485B39

The DigiDAQ® dual channel Digital USB Signal Conditioners offer additional capability supporting ICP® (IEPE) and voltage inputs via BNC connection to view signals from accelerometers, microphones, modal hammers, and other sensors in a pocket-size form factor.

- High-quality, 24-bit ADC resolution
- 2-channel ICP® (IEPE) and/or voltage inputs
- Broad frequency range, 0.8 Hz to 20.7 kHz
- LED Data / Power indicator
- Available with USB-A or USB-C connectivity



| MODEL      | INPUT TYPE SUPPORTED | FREQUENCY RANGE<br>Hz ( $\pm 5\%$ ) | CABLE TYPE AND CONNECTOR |
|------------|----------------------|-------------------------------------|--------------------------|
| 485B39     | x2 ICP               | 0.8 to 20 700                       | Integral, USB-A          |
| IV485B39   | x1 ICP<br>x1 Voltage | 0.8 to 20 700                       | Integral, USB-A          |
| V485B39    | x2 Voltage           | 0.8 to 20 700                       | Integral, USB-A          |
| 485B39-C   | x2 ICP               | 0.8 to 20 700                       | Integral, USB-C          |
| IV485B39-C | x1 ICP<br>x1 Voltage | 0.8 to 20 700                       | Integral, USB-C          |
| V485B39-C  | x2 Voltage           | 0.8 to 20 700                       | Integral, USB-C          |

## SOFTWARE SELECTION FOR DIGITAL SENSING SOLUTIONS

A common question regarding use of the digital products is "what software options are available for these devices?" Digiducer® and DigiDAQ® use standard USB audio digital output with no driver installation required, making them easily compatible with turnkey software packages already available or with custom software you build to meet your needs.

A range of ready-to-go software applications are available to use whether you are utilizing a Windows®, iOS®, Android™, or macOS® device. For an overview of what is available visit [www.modalshop.com/digital-sensing-software](http://www.modalshop.com/digital-sensing-software) or contact The Modal Shop for assistance in choosing the best application for your needs.

For those building their own program in Python, MATLAB®, LabVIEW™, or other languages, The Modal shop has a host of useful tools to help you along the way:

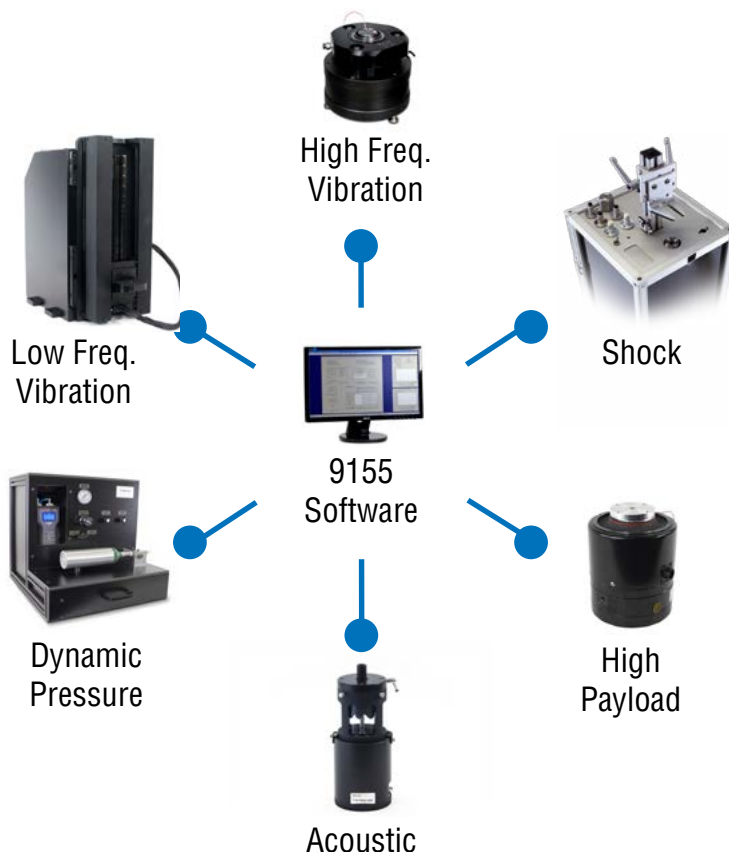
- Software developer information: [www.digiducer.com/developers](http://www.digiducer.com/developers)
- USB Audio Interface Guide: [www.digiducer.com/usb-audio-interface-guide](http://www.digiducer.com/usb-audio-interface-guide)
- The Modal Shop's GitHub with example code: [www.github.com/digiducer](http://www.github.com/digiducer)

# 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.

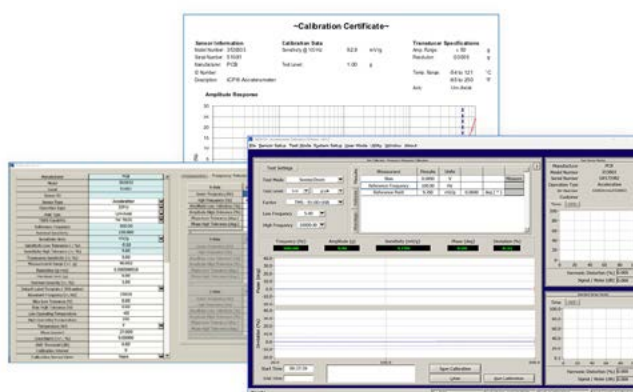
Each system provides all the necessary components ‘out-of-the-box’ – from precision actuators to versatile signal conditioners to state-of-the-art data acquisition hardware paired with the 9155D Windows® PC software controller.



## 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 K394B30C AND K394B31  
INCLUDED IN SYSTEM OPTION  
9155D-830C 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

REMOVABLE MOUNTING INSERT FOR EASY  
REFERENCE RECALIBRATION

PRECISION AIR BEARING LIMITS  
TRANSVERSE MOTION AND DISTORTION  
(ISO 16063-21 COMPLIANCE)



INNOVATIVE ARMATURE DESIGN  
AUTOMATICALLY LOCKS DURING SENSOR  
MOUNTING

RUGGED, RELIABLE DESIGN PROVEN IN  
PCB® PRODUCTION LINES

# ACCELEROMETER CALIBRATION WORKSTATION



Model 9155 Automated Accelerometer Calibration Workstation system shown to the left with options USC-100, -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](http://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 2129F025; 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 K9535C, K9525C  
SYSTEM OPTION 9155D-535, 9155D-525

- Easy amplitude linearity calibration of shock and crash sensors from 20 to 10 000 g
- Electronic control of unit provides Automated and Manual control of projectile drive pressure
- 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



### 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-535, 9155D-525 | 20 – 10 000 g  | 9525C        | Shock                   |
| 9155D-771            | 0.5 – 500 Hz   | 2129F025     | Low Frequency           |
| 9155D-779            | 0.1 – 500 Hz   | 2129F025     | Ultra Low Frequency     |
| 9155D-830C           | 5 – 15 000 Hz  | K394B30C     | 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 <sup>[1]</sup> | FREQUENCY RANGE     | SYSTEM OPTION     | DESCRIPTION                          |
|----------------------------|---------------------|-------------------|--------------------------------------|
| 0.59 %                     | 100 Hz and 159 Hz   | 9155D-830C or 831 | Reference Frequency                  |
| 0.8 %                      | 0.5 – <1 Hz         | 9155D-779         | Optical Encoder Reference            |
| 0.49 %                     | 1 – <10 Hz          | 9155D-779         | Optical Encoder Reference            |
| 0.8 %                      | 10 – <100 Hz        | 9155D-830C or 831 | ICP® Primary Reference Accelerometer |
| 0.74 %                     | >100 – 1 000 Hz     | 9155D-830C or 831 | ICP® Primary Reference Accelerometer |
| 0.95 %                     | >1 000 – 5 000 Hz   | 9155D-830C or 831 | ICP® Primary Reference Accelerometer |
| 1.7 %                      | >5 000 –10 000 Hz   | 9155D-830C or 831 | ICP® Primary Reference Accelerometer |
| 1.8 % <sup>[2]</sup>       | >10 000 – 15 000 Hz | 9155D-830C or 831 | ICP® Primary Reference Accelerometer |
| 2.3 %                      | >15 000 – 20 000 Hz | 9155D-831         | ICP® Primary Reference Accelerometer |

[1] 95 % confidence interval (coverage factor of k=2)  
 [2] Using 9155D-831 system option

## 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.

# CALIBRATION WORKSTATION SIGNAL CONDITIONING

A vital component to the Model 9155D Precision Sensor Calibration Workstation is the signal conditioning. The modularity of the 9155D system allows for a variety of options to best meet your particular calibration needs ranging from a light weight, desktop ICP®/charge mode only option to the 9155D-USC option covering a wide range of sensor types and additional measurement capabilities.

The 9155D-USC is computer-controlled via the 9155D calibration software supercharging the systems calibration throughput with quick set up of the conditioner by the software. Rack integrated and paired with the 9155-SWITCH as standard, this system simplifies measurement workflow by eliminating clumsy cabling manipulation when changing the measurement type for easier system operation.



**PRECISION SENSOR CALIBRATION**  
MODEL 9155D-USC

| COMPARISON                        |                      |                                 |            |
|-----------------------------------|----------------------|---------------------------------|------------|
| DESCRIPTION                       | 9155D-USC-100        | 9155D-427                       | 9155D-405  |
| Form Factor                       | Instrumentation Rack | Benchtop                        | Benchtop   |
| ICP® (IEPE) Sensors               | ✓                    | ✓                               | ✓          |
| Charge Mode (PE) Sensors          | ✓                    | ✓ [1]                           | ✓ [1]      |
| Voltage Mode Sensors              | ✓                    | ✓ [2]                           | ✓ [2]      |
| Piezoresistive (PR) Sensors       | ✓                    | ✓                               | -          |
| Variable Capacitance (VC) Sensors | ✓                    | ✓                               | -          |
| Sensor Type Selection             | TMS 9155 Software    | PCB MCSC Software / Front Panel | -          |
| Output Signal Gain Control        | TMS 9155 Software    | PCB MCSC Software / Front Panel | -          |
| Bridge Excitation Voltage Control | TMS 9155 Software    | PCB MCSC Software / Front Panel | -          |
| Bridge Excitation Measurement     | TMS 9155 Software    | -                               | -          |
| TEDS Read/Update Capable          | 9155D-400            | PCB MCSC Software               | TMS 400B76 |
| Bridge Resistance Measurement     | 9155D-516            | Manual                          | -          |
| Bridge Shunt Insertion            | 9155D-511            | -                               | -          |

[1] Charge supported with use of PCB 422E series charge converter

[2] Voltage mode is by direct to DAQ connection



**VERSATILE BENCHTOP CONDITIONER**  
MODEL 9155D-427



**BASIC BENCHTOP CONDITIONER**  
MODEL 9155D-405

## 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 independent labs.
5. Have the Opportunity for expert discussion on practices, variances, and other process improvements



Visit [www.modalshop.com/ILC](http://www.modalshop.com/ILC) for more information.

# 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.

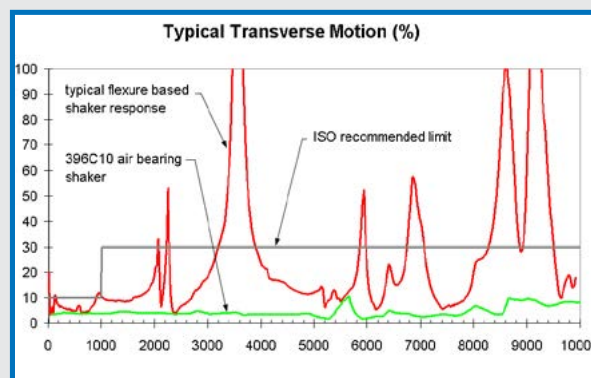
| OPTION                               | DESCRIPTION                                                                                                                                                                                       |
|--------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Signal Conditioner Options</b>    |                                                                                                                                                                                                   |
| 9155D-USC-100                        | Universal Signal Conditioner. PC controlled by 9155 Calibration Software and rack mounted. Supports ICP®, Charge, Piezoresistive, Bridge, Capacitive sensor types and TEDS read/write capability. |
| 9155D-427                            | Supports ICP®, Charge, Piezoresistive, Bridge, and Capacitive sensor types (Includes PCB model 482C27 and 422E52)                                                                                 |
| 9155D-405                            | Supports ICP® and Charge sensor types (Includes PCB model 482C05 and 422E52)                                                                                                                      |
| <b>Usability Options</b>             |                                                                                                                                                                                                   |
| 9155D-120                            | Shaker Mount Option (provides wood pedestal to support calibration shaker)                                                                                                                        |
| 9155D-160                            | Tool Kit Option for Model 9155 Calibration System.                                                                                                                                                |
| 9155D-350                            | Automated Label Printing (includes label printer)                                                                                                                                                 |
| 9155D-400                            | Automated TEDS Sensor Support (requires 9155D-USC)                                                                                                                                                |
| 9155D-901                            | Environment Monitoring option for Model 9155 Calibration System. Includes calibrated external temperature, humidity and pressure gauge.                                                           |
| <b>Additional Testing Capability</b> |                                                                                                                                                                                                   |
| 9155D-680                            | Visual Output Sensor Option.                                                                                                                                                                      |
| 9155D-650                            | Automated 4-20 mA Velocity Sensor Calibration                                                                                                                                                     |
| 9155D-600                            | Automated Velocity Sensor Calibration                                                                                                                                                             |
| 9155D-550                            | Automated Resonance Test, up to 50 kHz (requires 9155D-830C or 9155D-831)                                                                                                                         |
| 9155D-516                            | Input and output resistance measurement option used for piezoresistive sensors. Includes software and hardware.                                                                                   |
| 9155D-501                            | Automated Linearity Check, up to 40 g pk (requires 9155D-830C or 9155D-831)                                                                                                                       |
| <b>Laser Primary Calibration</b>     |                                                                                                                                                                                                   |
| 9155D-575                            | Laser Primary System (includes two dual pass laser interferometers and accessories)                                                                                                               |

## 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](http://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

# 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<br>psi (MPa) | MEASUREMENT<br>TECHNIQUE | UNCERTAINTY | TURNKEY<br>WORKSTATION | 9155D MODULAR<br>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+AUTO            | -                       |



## 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



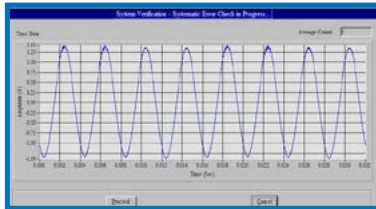
## HIGH PRESSURE

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

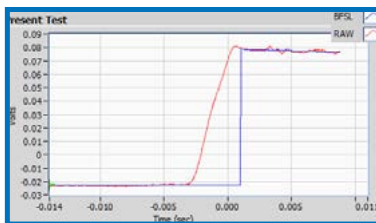
Dynamic pressure sensors are typically calibrated by varying the amplitude, rather than the frequency, of the physical input. It so happens that the physics of building a controlled actuator that covers the dynamic range of piezoelectric and piezoresistive pressure sensors is, in a word, challenging.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



Periodic Measurement from 9350C

## PERIODIC INPUT

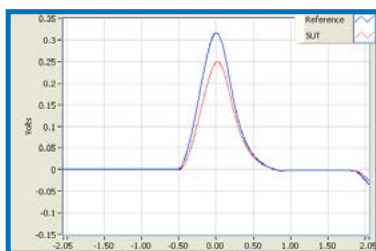
Periodic inputs are classified as a steady state and repeating input signal. In general, periodic signals are used to calibrate high sensitivity acoustic microphones whereas aperiodic (transient) methods are used for piezoelectric pressure sensor. The Models 9350C, 9919C and 9917C are systems used to 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

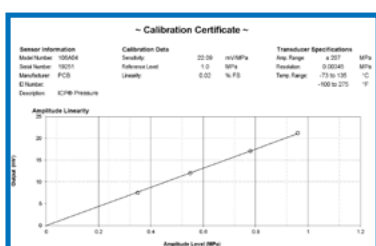
Step Inputs provide a quick rise in pressure to the sensor under test. The pressure rise is created by first pressurizing a large volume of gas and measuring the pressure very precisely using a static pressure gauge. This large pressurized volume is released into a very small volume wherein the sensor 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.

# 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 in compliance with IEC 61094-5
- Fully supported by 9155D Calibration Software (option 9155D-919)
- 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: CALIBRATION PER IEC 61094

IEC 61094 covers mechanical dimensions, characteristics, and calibration options for measurement microphones.

**IEC 61094-5** defines a comparison calibration for microphones with or without removable grid caps, including precision condenser, array, and ruggedized microphones. A pressure-response lab reference microphone with a high chain-of-traceability calibration is placed face-to-face with the microphone under test in a specialized chamber, such as **Model 9919C**. Both microphones are exposed to sinusoidal acoustic excitation, and a ratiometric measurement provides microphone sensitivity across frequencies.

**IEC 61094-6** provides calibration guidelines for precision condenser measurement microphones with removable grid caps and metal diaphragms using an electrostatic actuator, as included with **Model 9350C**.

**IEC 61094-5 and -6** both provide pressure response measurements with similar uncertainties, applying standard field correction factors. IEC 61094-6 typically aligns with original factory calibration methods, supports higher frequency capability, and calibration for microphones up to 1".

**IEC 61094-8** defines methods for determining microphone sensitivity in a true free field using an anechoic environment. PCB offers compliant calibrations for select microphones.

# 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. [www.modalshop.com/scope](http://www.modalshop.com/scope) for more information.



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.

For the full list of calibration services, Visit [www.modalshop.com/calibration-services](http://www.modalshop.com/calibration-services)

## COMMON CALIBRATION SERVICES

The Modal Shop's accelerometer calibration services include a reference sensitivity check (typically 100 Hz), multi-frequency sweep amplitude and phase response, calibration certificate, light cleaning, and TEDS updating when applicable. Common service codes are shown below. Please contact the calibration services team for more details at [recal@modalshop.com](mailto:recal@modalshop.com).

| ACCELEROMETER CALIBRATION SERVICES |                                                                                                                                                 |
|------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| MCS-A001                           | Single axis, amplitude and phase from 5 Hz* to upper 5% frequency. <span>N</span><br><span>A</span>                                             |
| MCS-A001T                          | Same as above, but for triaxial. <span>N</span><br><span>A</span>                                                                               |
| MCS-A001-61                        | Same as above, adds DC sensitivity calibration** for non-voltage VC and similar accelerometers. <span>N</span><br><span>A</span>                |
| MCS-A001-61T                       | Same as above, but for triaxial. <span>N</span><br><span>A</span>                                                                               |
| MCS-A001-A004                      | Calibration of accelerometer, single axis amplitude and phase response from 0.5 Hz to upper 5% frequency. <span>N</span><br><span>A</span>      |
| MCS-A001-A004T                     | Same as above, but for triaxial. <span>N</span><br><span>A</span>                                                                               |
| MCS-35                             | Single axis, amplitude and phase from 5 Hz* to 20 kHz. Add "T" to service code for triaxial. <span>N</span><br><span>A</span>                   |
| MCS-31                             | Single axis, shock calibration using Pneushock™ to max 10 000 g range. <span>N</span><br><span>A</span>                                         |
| MCS-31T                            | Same as above, but for triaxial. <span>N</span><br><span>A</span>                                                                               |
| 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. <span>A</span> |
| "-SP" suffix                       | Allows custom calibration when available to any of the above.                                                                                   |

| HANDHELD AND PORTABLE CALIBRATION          |                                                                                                              |
|--------------------------------------------|--------------------------------------------------------------------------------------------------------------|
| MCS-A009                                   | Calibration of handheld calibrator, models 394C06 or 699B02 or similar. <span>N</span>                       |
| 9100-CAL01                                 | Calibration of 91xx Series Portable Vibration Calibrator. <span>N</span><br><span>A</span>                   |
| HAMMER AND IMPEDANCE HEAD CALIBRATION      |                                                                                                              |
| MCS-H005                                   | Calibration of hammer with up to six tips and one extender mass. <span>N</span><br><span>A</span>            |
| MCS-H003                                   | Calibration of 288 Series Impedance Head. <span>N</span><br><span>A</span>                                   |
| ACOUSTIC CALIBRATION SERVICES              |                                                                                                              |
| MCS-9                                      | Precision Mic/Preamp pair, per ISO 61094-6 <span>N</span><br><span>A</span>                                  |
| MCS-70                                     | Precision Mic/Preamp pair, per ISO 61094-5 <span>N</span><br><span>A</span>                                  |
| MCS-1                                      | PCB 130 Series Array Mic/Preamp <span>N</span>                                                               |
| MCS-56                                     | Calibration of speakerphone. <span>N</span><br><span>A</span>                                                |
| SIGNAL CONDITIONER ELECTRONICS CALIBRATION |                                                                                                              |
| MCS-E001                                   | Calibration of in-line charge converters 422E Series and equivalent. <span>N</span><br><span>A</span>        |
| MCS-E004                                   | Calibration of single channel signal conditioner 480 Series and equivalent. <span>N</span><br><span>A</span> |
| MCS-Exxx                                   | More multichannel signal conditioner calibrations with various options available                             |

\* - low frequency start point dependent on sensor specifics  
 \*\* - DC sensitivity calibration traceable but not accredited

N - NIST traceable A - A2LA accredited

# 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.



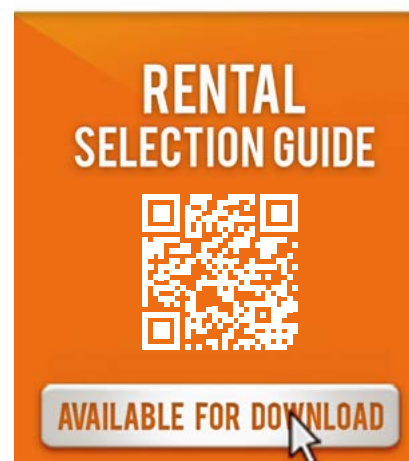
## WHY RENT?

- 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](http://www.modalshop.com/rental-guide) to download a copy or email us at [rental@modalshop.com](mailto: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 low frequency and low noise units

## 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

## SPECIALTY ACOUSTICS

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



## EXCITATION

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

## STRUCTURAL TEST ACCESSORIES

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

## OTHER TRANSDUCERS

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

