QUANSER
INNOVATE · EDUCATE

BENCH-SCALE SHAKE TABLES

Elevate Structural Dynamics Education and Research

The single-axis Shake Table I-40 is ideal for teaching a variety of earthquake engineering courses. It is a cost-effective experiment that offers plug-and-play convenience while providing accurate positioning and robust actuation.

While the dynamic behavior of buildings and bridges is of fundamental importance in modern structural design, undergraduate engineering students must also understand how these structures respond when acted upon by time-varying loads.

To help undergraduate engineering students comprehend structural dynamics and control principles, Quanser developed a number of bench-scale instructional shake tables on which students can perform hands-on experiments. These experiments allow students to see how structures respond to an earthquake loading, plus they can modify the dynamic characteristics of test cases, select different earthquake inputs, measure and analyze structural responses.

"It has been a lot of fun working with Quanser's equipment and teaching students things they wouldn't otherwise have a chance to see."

Dr. Shirley Dyke,
Professor of Mechanical and Civil Engineering,
Purdue University, USA

Proudly partnering with:

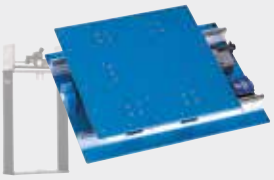
NEES UCIST

CAPTIVATE. MOTIVATE. GRADUATE.

SHAKE TABLES AND SMART STRUCTURES FOR TEACHING AND RESEARCH

This section provides a detailed overview of the cutting- edge laboratory systems available for teaching or research.
There are seven turn-key earthquake engineering experiments. Their key attributes and technical specifications are presented here.

SHAKE TABLES

PRODUCTS	DESCRIPTION	KEY FEATURES
SHAKE TABLE I–40 **Linear shaker**  Optional add-on	The Shake Table I-40 system is a single-axis seismic device that can be used to teach structural dynamics and control, earthquake engineering and other topics related to Civil Engineering. Shake Table I-40 is a portable yet powerful shake table which can be easily run through a Graphical User Interface environment. The provided software eliminates any need for hand coding while it enables you to monitor and analyze the response. This inexpensive platform facilitates an easy-connect setup for a quick and effortless interface with computer.	• Compact, portable, clean and low maintenance • Precise and accurate positioning: high-resolution encoder and low-backlash guide • Ball-screw mechanism for robust actuation • Can be run with simple standalone software operation using Shake Table I-40 Software; or • Highly-flexible operation and control design using MATLAB®/Simulink® via QUARC® • Complete, cost-effective turnkey system • Integrated safety features and limits • Fully documented system models and parameters
SHAKE TABLE II **Heavy-load linear shaker**  Optional add-on	Developed in cooperation with the University Consortium on Instructional Shake Tables (UCIST) and recommended by the Consortium to more than 100 institutional members, the Shake Table II offers a wide table-top surface which can accommodate several structures to increase the complexity of the experiment. Shake Table II has been used in outreach programs involving community services as well as K-12 education. This portable, bench-scale table moves along a single axis, however, two tables can be coupled for dual axis, x-y operation.	• Designed and built for the University Consortium on Instructional Shake Tables (UCIST) a partner of the National Network for Earthquake Engineering Simulation (NEES) • Clean and low maintenance • Easy integration of your structures, sensors and actuators • Simple, software operation using Shake Table II Software (requires QUARC and LabVIEW Run-Time) • Flexible operation and control design from MATLAB®/Simulink® via QUARC® or from LabVIEW™ via QRCP[3] • Fully documented system models and parameters • Shared lab resources contributed by a large community of like-minded users • Single (x) or Dual (x-y) axis configurations • Complete, cost-effective turnkey systems provided • Supports scaling and playback of earthquake data • Integrated safety features and limits
XY SHAKE TABLE III **Heavy-load planar shaker**  Optional add-on	The XY Shake Table III is a high-power system that can deliver high accelerations and velocities for heavy loads. It presents more advanced analysis with the introduction of multi-dynamics of particular interest. It is also useful for structural dynamics research relating to earthquake loss reduction. It is powered using linear motor technology, eliminating the need for hydraulics. It has three linear motors, two of them operate in parallel to actuate the x axis, while a single motor is used to actuate the y axis.	• Dual-axis operation • Clean and low maintenance • Turnkey and easy-to-use • Linear motors for reliable and quiet operation • Extensive data acquisition and control capability • Easy integration of your structures, sensors and actuators • Flexible operation and control design from MATLAB®/Simulink® via QUARC® • Fully documented system models and parameters • Supports scaling and playback of earthquake data • Synchronize motion profiles with multiple tables and/or other data acquisition systems • Integrated safety features and limits
HEXAPOD **Multi-axial shaker**  Optional add-on	This multi-axial shake table is a parallel robotic device capable of moving heavy loads at high accelerations, within a small work-space. Featuring six Degrees of Freedom (DOF), this industrial grade platform is suitable for research in earthquake simulation, vibration, structural dynamics, rehabilitation and more. Unlike most commercially available Stewart platforms, the Hexapod is driven by superior electrical motors which make this six DOF motion platform precise, responsive and low-maintenance. Please Note: The Hexapod is not available for purchase in North America, Japan and Taiwan.	• High precision ball screw mechanism • Safety brake logic circuit and built-in mechanical brakes, limit switches • Easy interface through USB connection • Optional six DOF force/torque sensor • High performance amplifier (built-in) • Easy integration of third party structures, sensors and actuators • Built-in software safety watchdog including run-away detection and collision avoidance • Flexible operation and control design from MATLAB®/Simulink® via QUARC® • Precise, stiff and heavy-duty machined components • Fully documented system models and parameters • High-resolution optical encoders to measure the joint positions

SMART STRUCTURES

SMART STRUCTURE **Flexible beam and pendulum** 	This stand-alone structure consists of a flexible beam and a servomotor driving an eccentric load. A large pendulum with an inertial load is used to actively compensate the swaying motion of the structure. This experimental platform teaches undergraduate students how to dampen vibrations of the structure using various control concepts. The Smart Structure can be used as a standalone or as an add-on to any shake table.	• Inertia load consisting of two rigid beams and a round crossbeam • Base plate instrumented with a precise strain gage • Flexible operation and control design from MATLAB®/Simulink® via QUARC® • High quality DC servo motor and gearbox • High resolution optical encoder • Precisely machined solid aluminum parts • Fully documented system models and parameters • Open architecture design
AMD 01* **1 Floor Active Mass Damper** 	This experiment is similar in nature to active mass dampers used to suppress vibrations in tall structures against earthquakes and strong wind. It is a tall building-like structure, instrumented with an accelerometer to measure the acceleration of the "roof" relative to earth. The structure is flexible along its facade. A cart driven by a rack and pinion mechanism is mounted at the top of the structure and is free to move along in the same direction as the structure. The cart is controlled to minimize the building deflection. The AMD can be used as a standalone or as an add-on to any shake table.	• Flexible operation and control design from MATLAB®/Simulink® via QUARC® • High quality DC servo motor and gearbox • High resolution optical encoder, to sense the cart position • Precisely machined solid aluminum cart • Fully documented system models and parameters • Variable cart load mass • Open architecture design
AMD 02* **2 Floor Active Mass Damper** 	This advanced active mass damping experiment is useful to study the benefits of employing AMD on a two floor structure. A tall building-like structure consisting of two floors is instrumented with an accelerometer on each floor to measure their acceleration. The structure is flexible along its facade. A cart driven by a rack pinion mechanism is mounted at the top of the second floor. The cart is controlled to minimize the building deflection. AMD 02 is particularly valuable for teaching and research in structural dynamics as it includes two dynamic modes.	• Flexible operation and control design from MATLAB®/Simulink® via QUARC® • High quality DC servo motor and gearbox • High resolution optical encoders, to sense the cart position • Precisely machined solid aluminum cart • Fully documented system models and parameters • Variable cart load mass • Open architecture design

QUANSER
INNOVATE·EDUCATE

FOR MORE INFO, VISIT WWW.QUANSER.COM/PRODUCTS/STRUCTUR

To request a demonstration or quotation, please visit www.quanser.com

WORKSTATION COMPONENTS	TECHNICAL SPECIFICATIONS			
• Shake Table I-40 • VoltPAQ-X1 amplifier • Q2-USB data acquisition device • QUARC® control software Optional: • 1-Floor Active Mass Damper (AMD 01)* with VoltPAQ-X1 or VoltPAQ-X2 amplifier	Shake table overall dimensions (L x W x H) Shake table mass Stage dimensions /payload area (L x W) Maximum travel Maximum payload at 1.0 g[1] Maximum acceleration with 1.5 kg payload[1] Maximum velocity with 1.5 kg payload[1] Operational bandwidth[1]	57.5 cm x 12.7 cm x 7.62 cm 5.88 kg 43.2 cm x 10.2 cm ±2 cm 1.5 kg 1.0 g 0.417 m/s 10 Hz	Lead screw pitch Servo motor power Amplifier maximum continuous current Motor maximum torque Lead screw encoder resolution (quadrature) Effective stage position resolution Accelerometer range Accelerometer sensitivity	1 cm/rev 70 W 3 A 3.53 N.m 8192 counts/rev 1.22 µm ±49 m/s² 1.0 g/V
• Shake Table II • AMPAQ-PWM amplifier • Q8-USB data acquisition device • QUARC® control software Optional: • 1 or 2-Floor Active Mass Damper (AMD 01 or AMD 02)* with VoltPAQ-X1 or VoltPAQ-X2 amplifier.	Shake table overall dimensions (L x W x H) Shake table mass Stage dimensions/payload area (L x W) Maximum travel Maximum payload at 2.5 g[1] Maximum acceleration with 7.5 kg payload[1] Maximum velocity with 7.5 kg payload[1] Operational bandwidth[1]	61 cm x 46 cm x 13 cm 27.2 kg 46 cm x 46 cm ±7.6 cm 7.5 kg 2.5 g 0.665 m/s 10 Hz	Lead screw pitch Servo motor power Amplifier maximum continuous output current Motor maximum torque Lead screw encoder resolution (quadrature) Effective stage position resolution Accelerometer range Accelerometer sensitivity	1.27 cm/rev 400 W 3.75 A 4.82 N.m 8192 counts/rev 1.55µm ±49 m/s² 1.0 g/V
• XY Shake Table III • 230 VAC Integrated Power System • Rack-mount Shake Table III-ready PC • Q8 Real-Time Control Board • QUARC® control software Optional: • 1 or 2-Floor Active Mass Damper (AMD 01 or AMD 02)* with VoltPAQ-X1 or VoltPAQ-X2 amplifier.	Shake table overall dimensions (L x W x H) Shake table mass Stage dimensions/payload area (L x W) Stage mass Maximum travel Maximum payload at 1.0 g[1] Maximum acceleration with 100 kg payload[1] Maximum velocity with 100 kg payload[1] Maximum force with 100 kg payload[1] Operational bandwidth[1]	106.7 cm x 106.7 cm x 20.3 cm 550 kg 71.1 cm x 71.1 cm 175.5 kg (x), 95.22 kg (y) ±10.8 cm (x), ±10.8 cm (y) 100 kg 1.0 g (x), 1.0 g (y) 1.55 m/s (x), 1.29 m/s (y) 2626 N (x), 2189 N (y) 10 Hz (x), 10 Hz (y)	Linear motor maximum peak power Linear motor maximum current Amplifier maximum peak current Amplifier maximum continuous current Maximum operating peak current limits Encoder resolution (quadrature) Effective stage position resolution Accelerometer range Accelerometer sensitivity	4554 W 36.0 A peak 12.0 A continuous 40 A (x), 30 A (y) 20 A (x), 15 A (y) 36 A (x), 30 A (y) 1,000,000 count/m 1 µm ±49 m/s² 1.0 g/V
• Hexapod • Hexapod-ready PC • QUARC® control software Optional: • Force/torque sensor • 1 or 2-Floor Active Mass Damper (AMD 01 or AMD 02)* with VoltPAQ-X1 or VoltPAQ-X2 amplifier.	Hexapod overall dimensions (L x W x H) Hexapod mass Platform boundary radius/payload area Arm length Workspace[2] Maximum payload[1] Maximum acceleration[1] Maximum joint speed[1] Operational bandwidth[1] Lead screw pitch	110 cm x 110 cm x 75 cm 100 kg 25 cm 37.5 cm ±13 cm (x), ±7.5 cm (y), ±7.5 cm (z) ±20 deg (roll), ±23 deg (pitch), ±27 deg (yaw) 100 kg 1 g 0.67 m/s 0-10 Hz 1 cm/rev	Actuator maximum force Actuator travel Lead screw encoder resolution (quadrature)	403 N ±15.0 cm 10,000 counts/rev
• Smart Structure • VoltPAQ-X1 amplifier • Q2-USB data acquisition device • QUARC® control software	Smart Structure overall dimensions (L x W x H) Smart Structure mass Rigid beam length Flexible beam length Encoder resolution Strain gage sensitivity	25.5 cm x 11.5 cm x 85.5 cm (with pendulum in upright position) 2.6 kg 29.2 cm 44.0 cm 4096 counts/rev 2.54 cm/V		
• AMD 01 • VoltPAQ-X1 amplifier • Q2-USB data acquisition device • QUARC® control software	Structure overall dimensions (L x W x H) Structure mass Flexible structure height Cart rack height Flexible structure natural frequency Flexible structure linear stiffness Cart travel Cart encoder resolution Accelerometer sensitivity	32 cm x11 cm x 63 cm 2.85 kg 50 cm 13 cm 2.5 Hz 500 N/m ±9.5 cm 4096 counts/rev 1.0 g/V		
• AMD 02 • VoltPAQ-X2 amplifier • Q2-USB data acquisition device • QUARC® control software	Structure overall dimensions (L x W x H) Structure mass Flexible structure height Cart rack height 1st floor flexible structure linear stiffness (relative to the ground) 2nd floor flexible structure linear stiffness (relative to the first floor) Cart travel Cart encoder resolution Accelerometers sensitivity	32 cm x11 cm x 113 cm 4.45 kg 50 cm 13 cm 500 N/m 500 N/m ±9.5 cm 4096 counts/rev 1.0 g/V		

*Quanser Shake Tables can be expanded by adding test building-like structures with active mass damper. This makes the Shake Table workstations adaptable for real-life earthquake studies and enables experiments in the absence of your own building models.

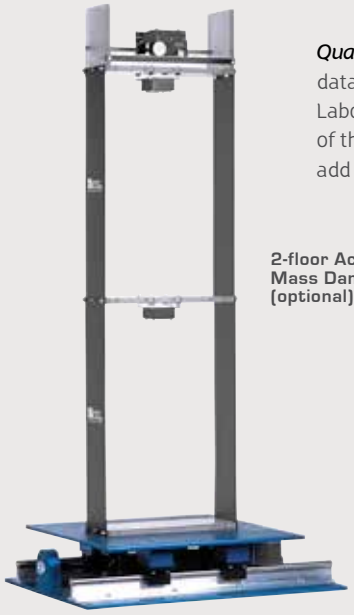
[1] Please contact Quanser for full operational bandwidth specification

[2] Assuming other five DOF's held at home position

[3] For availability, please contact sales@quanser.com

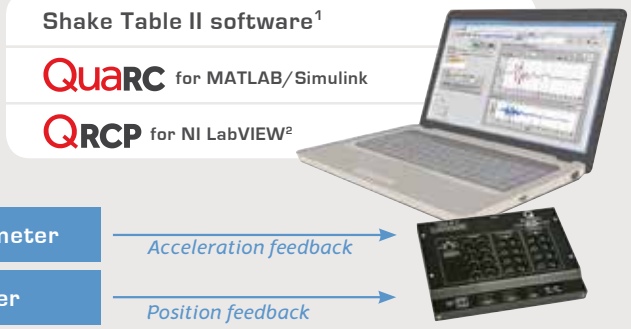
RELIABLE AND ROBUST TURN-KEY WORKSTATIONS

QUANSER
INNOVATE · EDUCATE



2-floor Active Mass Damper (optional)

Quanser's Shake Tables come complete with all components you need: the Shake Table platform, amplifier, data acquisition device and control software. The comprehensive documentation includes User Manuals, Laboratory Guides with dynamic models and operating procedures, and pre-designed controllers. The value of these turn-key solutions is extended further by their open architecture and scalable design, allowing you to add sensors, or use your own test structures.



[1] requires QUARC and LabVIEW Run-Time (free version available at ni.com)
[2] for availability, contact sales@quanser.com

HOW LEADING EDUCATORS AND RESEARCHERS USE QUANSER SHAKE TABLES

At the **University of Cincinnati's** School of Aerospace Systems, Professor Kelly Cohen has taken full advantage of the **Shake Table I-40's** versatility, using it to teach vibration control to his undergraduates. Dr. Cohen has also integrated the Shake Table I-40 within a remote lab setup that offsite students can use. Once they log on, they can tune different control parameters, view the measured response on the graphical interface and examine the results in real time via webcam. Dr. Cohen can also view their data once it's saved.

Professor Haibei Xiong, Dean of **Tongji University's** College of Civil Engineering, finds five **Shake Table II's** her college acquired a worthy addition to the lab. With multiple earthquake simulators, they can study complex structural dynamics and earthquake engineering concepts, conduct multi-point shaking experiments on bridge structures, and also work on testing bigger structures, using several shake tables with synchronized motion to share the load.

Professor Bicanic and his team of graduate students at the **University of Rijeka**, Croatia, are studying how vibrations effect structures with gaps between blocks, such as brick walls, or even arrangements of graphite rods in a nuclear reactor core, and testing various compensation techniques. By running two **XY Shake Table III** systems synchronously, they can examine the effects of vibrations on different structures, or on the same structures with different damping measures. They can also study the effect of propagation by introducing signal delays to one table, with the second table replicating the same motion with a short delay, and test various compensation techniques

A research group at **Barcelona TECH's** Control, Dynamics and Applications Lab, led by Dr. Francesc Pozo,works on a system that can help better protect buildings and infrastructure from earthquakes. The roll-n-cage (RNC) anti-vibration device placed between the building and the ground can reduce motion induced in buildings and bridges by earthquakes or other vibration sources. To model the RNC isolator, and test its performance, Dr. Pozo and his group use the Quanser **Hexapod.**

About Quanser:
Quanser is the world leader in education and research for real-time control design and implementation. We specialize in outfitting engineering control laboratories to help universities captivate the brightest minds, motivate them to success and produce graduates with industry-relevant skills. Universities worldwide implement Quanser's open architecture control solutions, industry-relevant curriculum and cutting-edge work stations to teach Introductory, Intermediate or Advanced controls to students in Electrical, Mechanical, Mechatronics, Robotics, Aerospace, Civil, and various other engineering disciplines.

For more information, please visit quanser.com

INFO@QUANSER.COM +1-905-940-3575 QUANSER.COM

Solutions for teaching and research. Made in Canada.