



Hexapods

Platforms for Vibration and Motion Control

A hexapod is a robotic manipulator capable of moving a payload in all six degrees of freedom: lateral, longitudinal, and vertical translations as well as roll, pitch, and yaw rotations. Motions can be made simultaneously in multiple axes or independently in a single axis while preventing movement in the others. A hexapod's parallel actuator arrangement provides high load capacity, stiffness, and accuracy compared to other robotic manipulator architectures. Product models are distinguished by their actuation, sensing, control system, payload capacity, range, resolution, and bandwidth. Hexapod applications are generally divided into three primary categories: precise positioning, motion simulation, and vibration isolation.

Hexapods are needed for a wide variety of uses. They can allow a payload, such as an optic or laser source, to be precisely aligned and oriented relative to another object even as thermal or other forms of drift continually create misalignment. They can simulate road conditions for a vehicle suspension system eliminating costly field testing. Hexapods can also isolate payloads, including cameras or sensitive measurement instruments, from ground vibrations or aircraft jitter that would otherwise result in image blur, measurement errors, or potential damage. Other motion control devices can generally only provide positioning, motion simulation, or vibration isolation in one or two degrees of freedom, but hexapods are the ideal solution when multiple degree of freedom motion is required.



HEXAPODS

Applications

PRECISE POSITIONING

- Alignment of telescope optics
- Space vehicle docking system
- Munitions loading
- Assembly line positioning
- Surgical systems
- End effector for serial manipulators

MOTION SIMULATION

- Flight simulators
- Missile tracker simulations
- Automotive suspension system testing
- Simultaneous multi-axis vibration testing
- Disturbance sources
- Motion theater rides

VIBRATION ISOLATION

- Camera image stabilization
- Weapons stabilization
- Optical jitter isolation
- Protection for fragile items during shipping
- Isolation of industrial machinery
- Isolation of sensitive measurement equipment

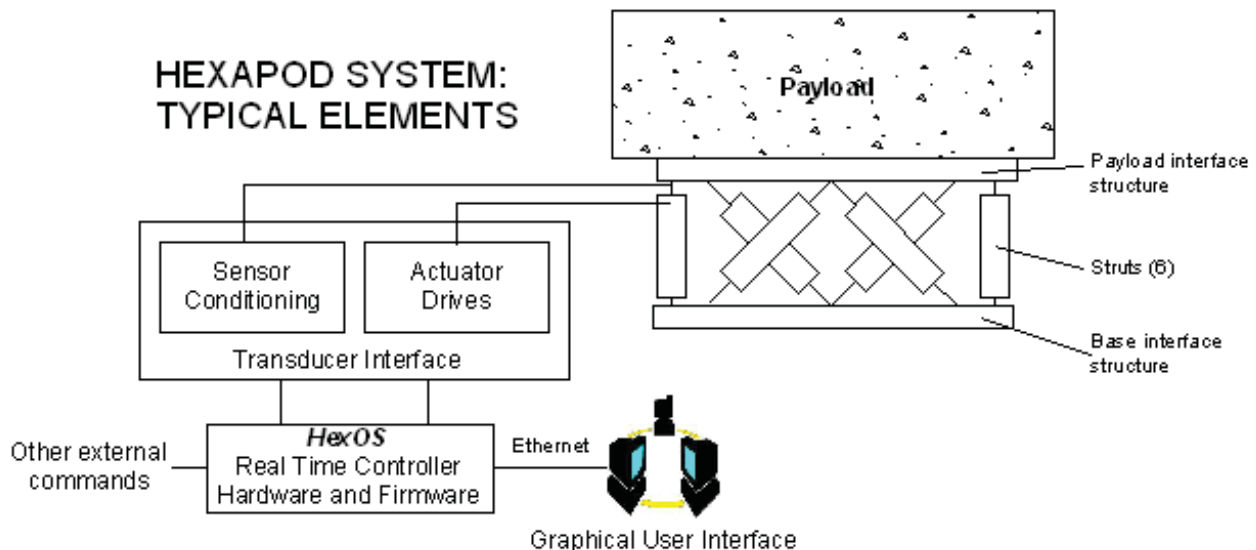
Why Use a Moog CSA Hexapod?

- We have the ability to modify our standard hexapods to meet specific customer requirements. We make the hexapod match the application rather than trying to make the application match the hexapod.
- Leveraging off of our heritage designs, we also build custom hexapods to fit unique applications.
- We are well-versed with many types of actuation: electromechanical, electromagnetic, piezoelectric, hydraulic, and pneumatic.
- We have experience with extreme environmental conditions: clean room, vacuum, cryogenic, cryovac, and outdoor use.
- Our intuitive and easy-to-use graphical user interface allows the pivot point to move to any desired location.
- Training, installation support, and continued service support is provided as needed.

Hexapod Features

A hexapod consists of six legs or struts arranged in parallel between a stationary base and a moving platform, and each leg is comprised of a linear actuator, one or more sensors, and joints at both ends. A controller is needed to receive and interpret sensor signals and send coordinated commands to the actuator drives to generate the desired payload motion or position. An operator typically interacts with a graphical user interface on a laptop or PC to supply commands to a hexapod and monitor its status.

- Actuators, sensors, and end joints that are optimized for the application
- Strut geometry and mechanical interface customizable per application
- Real time controller with 2 kHz sampling rate
- Web browser graphical user interface
- Standard libraries for multi-axis control
- Calculates kinematics in real time
- XML-RPC communication between host and target for simple system integration
- Real time data logging
- Options for automated operation and acceptance of remote commands
- Completely passive units available for vibration isolation
- Options for vacuum compatibility on most hexapod models



Standard and Custom Systems

Most of Moog CSA's standard hexapods are for small payloads, but we have delivered systems ranging in size from 130 mm to 3 m, with load capacities between 0.5 and 15,000 kg. CSA also builds octopods and reduced degree of freedom systems when appropriate for specific applications. The table on the following page summarizes specifications of selected standard hexapod units.



Model	HX-M300	HX-M350	HX-P300	HX-P500	HX-V100	HX-V500	HX-MV500
Purpose	Motion Simulation	Motion Simulation	Pointing	Pointing	Isolation	Isolation	Isolation/Motion Simulation
Payload Mass	Up to 50 kg	Up to 180 kg	Up to 225 kg	Up to 15,000 kg	2-20 kg	Up to 225 kg	Up to 180 kg
Height	330 mm	330 mm	635 mm	810 mm	200 mm	600 mm	1000 mm
Diameter	564 mm	914 mm	915 mm	1850 mm	215 mm	1675 mm	2100 mm
Range							
<i>x</i>	±15 mm	±25 mm	±100 mm	±150 mm	±30 µm	±25 mm	±45 mm
<i>y</i>	±15 mm	±30 mm	±90 mm	±150 mm	±30 µm	±25 mm	±45 mm
<i>z</i>	±12 mm	±11 mm	±60 mm	±85 mm	±20 µm	±20 mm	±40 mm
<i>theta x</i>	±7 deg	±2.5 deg	±14 deg	±7.5 deg	±0.05 deg	±2.0 deg	±2.5 deg
<i>theta y</i>	±7 deg	±2.5 deg	±13.5 deg	±7.5 deg	±0.05 deg	±2.0 deg	±2.5 deg
<i>theta z</i>	±12 deg	±6 deg	±20 deg	±13 deg	±0.05 deg	±4.0 deg	±5.0 deg
Resolution							
<i>x</i>	1 µm	1 µm	50 µm	0.5 µm	0.1 µm	NA	50 µm
<i>y</i>	1 µm	1 µm	50 µm	0.5 µm	0.1 µm	NA	50 µm
<i>z</i>	0.5 µm	0.5 µm	25 µm	0.5 µm	0.1 µm	NA	25 µm
<i>theta x</i>	5 µrad	2 µrad	100 µrad	1 µrad	10 µrad	NA	35 µrad
<i>theta y</i>	5 µrad	2 µrad	100 µrad	1 µrad	10 µrad	NA	35 µrad
<i>theta z</i>	7 µrad	5 µrad	150 µrad	1 µrad	10 µrad	NA	35 µrad
Bandwidth							
	150 Hz	200 Hz	10 Hz	< 1 Hz	250 Hz	NA	40 Hz
Suspension Freq.							
	NA	NA	> 30 Hz	> 40 Hz	30-90 Hz	< 3.3 Hz	<5 Hz
Test Payload Mass							
	3 kg	30 kg	20 kg	650 kg	2 kg	90 kg	90 kg
Power							
Standby	350 W	350 W	200 W	0 W	40 W	50 W	200 W
Peak	1.5 kW	3 kW	1.25 kW	500 W	60 W	50 W	1.5 kW
Actuation							
	EM	EM	MS	MS	PZ	PN	PN&EN

EM- electromagnetic, MS- motor-driven screw, PZ- piezoelectric, PN- pneumatic

U.S. LOCATIONS

Moog Space and Defense:

Albuquerque, NM

Chatsworth, CA

Decatur, GA

East Aurora, NY

Gaithersburg, MD

Golden, CO

Mountain View, CA

Niagra Falls, NY

Northbrook, IL

Orlando, FL

Orrville, OH

Salt Lake City, UT

Santa Barbara, CA



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