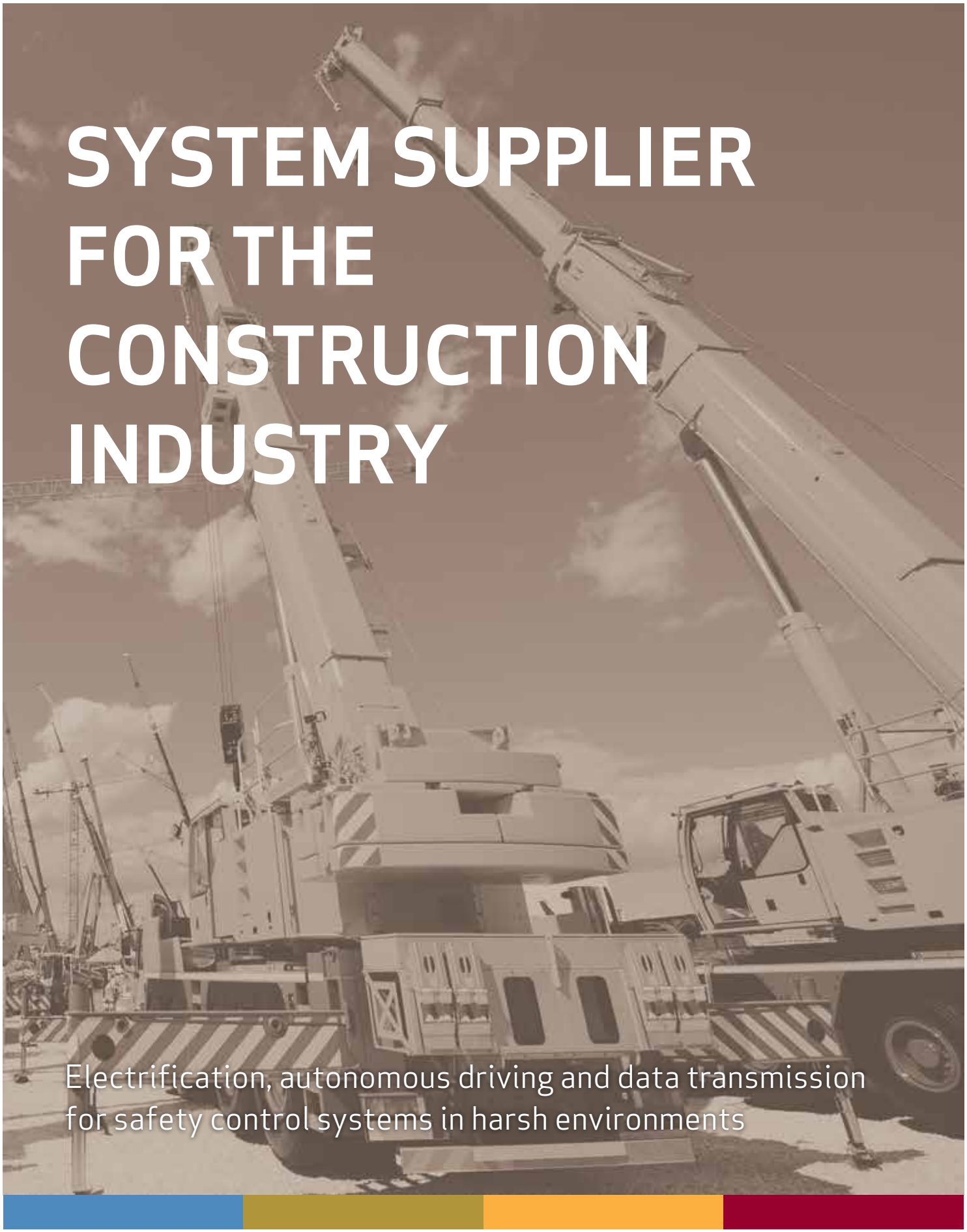

SYSTEM SUPPLIER FOR THE CONSTRUCTION INDUSTRY

Electrification, autonomous driving and data transmission for safety control systems in harsh environments

www.moog.com

MOOG

MOOG INC.

We started in 1951 with one product and a few people who worked out of an old airplane hangar in East Aurora, USA. Now, after nearly 60 years of continuous innovation, we're a world class, nearly three billion–dollar international company operating in more than 30 countries, and with customers in over 90 countries. Divided in three operating groups – Space and Defense, Industrial and Aircraft- we are offering our customers a comprehensive and industry knowledge.

The cutting–edge technology we produce today places our influence at the frontier of human endeavor. We helped put men on the moon in 1969 and right this minute our components are travelling through space, aiding satellites as they explore our universe. We make sure military aircrew are equipped to fly under the radar and our technology helps keep their devices absolutely precise. We enhance and control racing cars. We make sure patients recover more quickly by helping create medical advances that improve quality of life. And our job is it to work on the future of the construction market. Electrification, autonomous driving and data transmission for safety control systems in harsh environments are no dreams of the future, but actual subjects.

The work we do is meaningful, challenging and rewarding.

We design, manufacture and integrate precision motion control components and systems. Our high-performance solutions are used in automated industrial machinery, satellites, launch vehicles, missiles, commercial and military aircraft, and medical equipment.

Our aim is to make high performance products that are the best in the industry, admired by customers and envied by competitors. This means delving into very complex problems and inventing solutions based around the very latest technology, always staying a few steps ahead of the game. And if that means starting from scratch to make something that's never existed before, then we're pleased to accept the challenge – because delivering exceptional solutions to very specific needs is at the heart of what we offer to our customers.

OVERVIEW

Moog has many years expertise in supplying standard and customized construction products for harsh environments and is a leading manufacturer of high performance.

Whenever the highest levels of motion control performance and design flexibility are required, you'll find moog expertise at work. Through collaboration, creativity and world-class technological solutions, we help you overcome your toughest engineering obstacles. Enhance your machine's performance and help take your thinking further than you ever thought possible.

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PRODUCT SPECIFICATIONS – SLIP RINGS

Our products are designed to perform the needed functions under adverse conditions.

The slip rings from Moog are designed and developed for the construction machinery and crane markets. A challenge for construction machinery is that it must operate in diverse environmental conditions around the world. For example, the machinery must perform in the low temperatures of snow areas or in very hot conditions in dry regions. Slip rings from Moog guarantee reliable transfer of signals, high current, sensor electronic and data transfer.

TECHNICALINFORMATION

Operating speeds:	up to 100 rpm
Current rating:	< 1 mA up to 100 amps, customization to transfer > 1000 amps possible
Voltage rating:	< 1 mV up to 680 volts AC/DC, customization to transfer > 1000 volts AC/DC possible
Data transfer:	CANbus up to 1000 kbit/sec Ethernet up to 100 Mbit/sec
Temperature range:	-58 °F up to 212 °F (-50 °C up to 100 °C)
Contact material:	Brass, alternative silver, rhodium plated available
Protection class:	IP69K
Compatible:	With angle encoder: analog, digital CANopen, or customer specified With hydraulic rotary joint (swivel): fluid like: oil, gas, diesel, glycol, water Up to 7,300 psi in steel, casted steel, stainless steel Or 5,100 psi in aluminum

ADVANTAGES

- Maintenance free, more than 10 million revolutions
- Housing parts are designed for difficult environmental conditions
- Sea water, UV and oil resistant
- Compatible with additional sensors like an angle encoder
- Data transfer up to 400 Mbit/sec with contacted slip rings, up to 2 Gbit/sec with contactless slip rings
- Customized fixing flanges or torque arms
- Slip rings with customer specified connectors

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PRODUCT SPECIFICATIONS – FLUID ROTARY UNION

The fluid rotary unions are designed and developed under the respect of the needs in the construction machinery and crane industries. Our fluid rotary unions are used not only into the construction and crane industry. All of our customers in the automotive industry using in their manufacturing lines fluid rotary unions combined with electrical slip rings. Customers from the industries packaging, food & beverage and wind turbines trust also since years into the fluid technology from Moog.

TECHNICALINFORMATION

Operating speeds:	up to 250 rpm
Maximum pressure:	Up to 7,300 psi / 500 bar in steel / Inox Or 5,100 psi / 350 bar in aluminum
Medias:	Oil, hydraulic oil, diesel, air, gas, glycol, di/tap water, chemicals, glue and others
Temperature range:	-58 °F up to 212 °F (-50 °C up to 100 °C)
Protection class:	Protected against dust and water ingress (IP65)
Compatible:	With all Moog slip rings.

ADVANTAGES

- Maintenance free, more than 10 million revolutions
- Fluid rotary unions are designed for difficult environmental conditions
- Resistance against environmental and sea water
- Compatible with slip rings and sensors like an angle encoder
- Pressures up to 7,300 psi
- Customized designs
- Fluid rotary unions in aluminum to save weight in the customer application. Fire Trucks save up to 60 kg

PRODUCT SPECIFICATIONS – SPRING DRIVEN CABLE REEL

The spring driven cable reels from Moog construed for harsh environments in the construction machinery and crane industry application. Slip rings from Moog assembled at the end of ship winches or motor driven cable reels in harbor cranes. In special application, like remote controlled robots, Moog designed motor driven cable reels with contact less fiber optical rotary joints.
Customers from the industries military, fire departments and automotive assembly lines trust the spring driven cable reels from Moog.

TECHNICALINFORMATION

Current rating:	< 1 mA up to 1000 amps,
Voltage rating:	< 1 mV up to 20,000 volts AC/DC possible
Data transfer:	CANBus up to 1000 kbit/sec Ethernet up to 100 Mbit/sec 2Gbit/sec per fiber optical rotary joints
Temperature range:	-58 °F up to 212 °F (-50 °C up to 100 °C)
Contact material:	Brass, alternative silver, rhodium plated
Protection class:	up to IP69K
Compatible:	With angle encoder: analog, digital CANOpen With hydraulic rotary joint (swivel): fluid like: oil, gas, diesel, glycol, water Up to 7,300 psi in steel, casted steel, stainless steel Or 5,100 psi in aluminum

ADVANTAGES

- Maintenance free, more than 10 million revolutions
- Housing parts are designed for difficult environmental conditions
- Sea water, UV and oil resistant
- Compatible with additional sensors like an angle encoder
- Data transfer up to 400 Mbit/sec with contacted slip rings, up to 2 Gbit/sec with contactless slip rings
- Customized fixing flanges or torque arms
- Reels with customer specified connectors
- A very compact design where the slip ring part is assembled in the spring

PRODUCT SPECIFICATIONS – RADIAL PISTON PUMP (RKP)

Moog Radial Piston Pumps (RKP) are variable displacement piston pumps, and available in various sizes from 19 to 250 cm3 per revolution. This product family offers highly dynamic control of pressure, flow and horsepower for rugged industrial applications.

The RKP is available with both analog and digital control, as well as with designs that are well suited for a broad variety of special fluids and for use in potentially explosive environments (ATEX Certification).

TECHNICALINFORMATION

Size:	From 19 to 250 Size in cm3 per revolution
Flow:	@1.500 rpm Up to 375 l/min @1.800 rpm Up to 450 l/min

ADVANTAGES

- Flexible configuration according to application demands
- Reduced effort for noise damping measures
- Improved control in hydraulic cycle
- Less installed power, less effort to cool fluid
- Increased machine productivity, process stability and repeatability and condition monitoring capability
- Well suited for a broad variety of special fluids and for use in potentially explosive environments (ATEX Certification)

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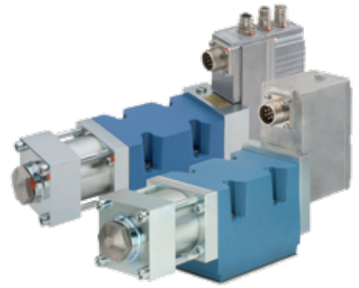
PRODUCT SPECIFICATIONS – DIRECT DRIVE SERVO VALVE (D633 AND D634 SERIES)

Moog offers an extensive product range of servo and proportional valves specifically designed for precise control of position, velocity and force. Equipped with onboard electronics the D633 and D634 Series Servo Valve is directly operated by a permanent magnet linear force motor with high actuation forces. This product series is renowned for its high static and dynamic performance, along with high durability even for the most demanding applications.

Versions with analog and digital onboard electronics, failsafe operation, multiple fieldbus interfaces options, axis control functionality and certifications for use in potentially hazardous environments (explosion-proof) are available.



TECHNICALINFORMATION

Rated Flow:	5 to 100 l/min (1.3. to 26.4 gpm) (@ Δp 70 bar (1,000 psi)
Maximum Operating Pressure	350 bar (5.000 psi)
100% Step Response	From 8 to 20 ms @ 210 bar (3,000 psi)
Mounting Pattern/Size	D633: Size 03 ISO 4401-03-03-0-05 D634: Size 05 ISO 4401-05-05-0-05

ADVANTAGES

- Linear force motor with high force range improves operating limits:
- Spool-in-bushing design for high wear resistance and a long service life
- Dynamic response is mostly independent from supply pressure
- Low power demand near center position
- Shock and vibration resist and ruggedized models available

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PRODUCT SPECIFICATIONS – INTEGRATED HYDRAULIC MANIFOLDS

Moog's Integrated Hydraulic Manifold Systems are fully self-contained systems comprised of hydraulic manifolds, cartridge valves, and servo cartridge valves.

Designed and built for specific customer applications, the circuit logic and functionality of the manifold is engineered to meet exact performance, safety and mounting requirements.

TECHNICALINFORMATION

Custom-designed to application-specific requirements

Flow Rates	Up to 1,100 lpm (300 gpm)
Pressure capabilities	Up to 350 bar (5,000 psi)

Can be configured with Hazardous Area Certified (HAC) components

ADVANTAGES

- Application-specific circuits enhance machine performance, reduce system cost, and increase safety
- Self-contained units reduce envelope size and piping
- Complete testing at Moog reduces the required installation time and eliminates start-up problems
- High flow and active cartridge valves improve safety and reduce system costs
- Manifold-based systems provide a cleaner, leak-free solution that eliminates the need for hard or flexible piping, connectors and clamps

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PRODUCT SPECIFICATIONS – INTEGRATED HYDRAULIC CONTROL AXIS FOR MOBILE MACHINERY

Automating tasks performed by mobile machinery puts unique new demands on the machine's control system. Most controls products available for mobile machinery are not designed for automation and therefore lack the sensing and performance necessary to change from a human operator to a closed loop control system. Moog integrated hydraulic axis was designed from the ground up for automation applications. The highly integrated solution includes all communication and control electronics, a high response control valve, pressure and position sensing, and built-in safety stop functionality. This design simplifies the hydraulic and electric architecture of the machine and enables precise control of force, position, and velocity. The integrated axis solution is ideal for dynamic application such as active suspension, stabilization, digging, and drilling.

WHAT IS INTEGRATED

- High response valve
- State of the art position & force sensing
- Control and communication electronics
- Built in safety functions
- Condition monitoring

WHY IS IT DIFFERENT

- Closed loop response times an order of magnitude better than traditional mobile hydraulic solutions
- Precise force, velocity, & position control with ability to reject external disturbances
- Energy consumption reduced by up to 60%
- Condition monitoring enables predicative maintenance
- A Highly integrated package reduces number of hoses & wires, reduces likelihood of damage and eases system integration

APPLICATIONS

- Digging
- Active suspension
- Boom stabilization
- Drilling
- Handling unstable loads
- Cutting

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PRODUCT SPECIFICATIONS – NAVIGATION AND CONTROL SYSTEM FOR AUTONOMOUS VEHICLE IN GPS DENIED ENVIRONMENTS

Some of the many challenges that exist in this environment are a dense tree canopy that blocks GPS signals, overhanging branches in the path of the vehicle, and a variety of weather and terrain conditions. Moog's solution included an intelligent perception, localization, navigation & control system to meet the challenges of this complex autonomy application. The result is that growers can more optimally utilize their workforce and rethink their operations with this new tool at their disposal.

Operations in tree nut orchards require many passes down each row for tasks such as weed spraying, foliage spraying, irrigation, and harvest. With over 1.5 million acres of tree nuts in California alone, driving down each row becomes a highly repetitive task and time-consuming task. To reduce this burden for growers, Moog and Flory Industries worked together to implement full autonomous control on Flory's sweeper machine.

BENEFITS

- Increase productivity & efficiency of existing machines
- Reduce people and skill needed to operate vehicle
- Mechanize/automate tasks that are currently done by a large # of laborers by hand or with hand tools
- A future platforms for tasks such as weeding, pruning, harvesting, tiling, bricks, scouting
- Safety operation
- Reduce cost

PRODUCT SPECIFICATIONS – ELECTRO-HYDROSTATIC ACTUATION

An Electrical Mechanical System with the Benefits of Hydraulic System

Electro-hydrostatic actuators (EHA) are opening new possibilities for a variety of new applications because they combine the best of electro-mechanical and electro-hydraulic technologies. Moog developed an EHA with additive manufacturing that is ideal for constructive devices reducing size and weight, increasing power density, lowering energy and investment costs.

EHA converts power from electric to hydraulic to mechanical. Electric servo motor drives a bi-directional, variable speed pump connected to the two chambers of a hydraulic cylinder. Depending on the direction of the flow, the axis extends or retracts. In contrast to a hydraulic system, the pump does the power control. Varying the speed of the pump means varying the flow or the pressure, and thus the hydraulic power. This enables the electro-hydrostatic actuator to efficiently use energy and deliver power on demand.

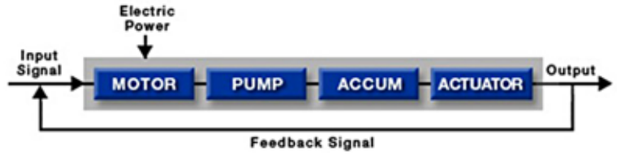

Figure: General layout of an electro-hydrostatic actuator (EHA)

Using EHA technology saves a substantial amount of energy via power on demand, while the dynamic performance is comparable to conventional EH or EM servo systems. Such a self-contained system enables a decentralized system design, which optimizes axis performance and eliminates hydraulic infrastructure when compared with traditional hydraulic systems. When combined with additive manufacturing, you have less design and manufacturing constraint, which gives you the freedom to optimize the geometric design. EHA is installed like an EM system while maintaining the benefits of an EH system.

KEY BENEFITS FOR EHA:

- Significant energy savings - Using EHA technology saves a substantial amount of energy via power on demand, while the dynamic performance is similar to conventional electro-hydraulic (EH) or electro-mechanical (EM) systems
- High forces without the need for a mechanical gearbox - For those motion control axes that require higher forces and therefore a high gearbox ratio, EHA is an attractive solution
- Power density - The power capacity and power density of an EHA can be higher than that of an Electro-Mechanical solution, as it allows machine builders to create higher forces in a given envelope size
- Fail-safe functionality - Can be easily integrated into an EHA with the same functionality and flexibility known from EH systems
- Easily integrated into existing infrastructure - Best of both technologies means machine builders can use EHA for machines that otherwise use EM actuation and the system design eliminates traditional hydraulic infrastructure, saving space and costs

PRODUCT SPECIFICATIONS – INTEGRATED SMART ACTUATOR (ISA) FOR CONSTRUCTION ROBOTICS

Moog's new integrated, plug and play solution called the Integrated Smart Actuator (ISA) includes integrated servo valves, control electronics, fieldbus communications (EtherCAT and CANbus), and on-board sensors. Moog is now leveraging advances in additive manufacturing to optimize weight and size while also offering the capability to provide customizable solutions quickly and affordably.

Moog has leveraged its unique expertise and core building block products designed for demanding applications to provide optimized control solutions to researchers, designers and manufacturers of construction robotics. With proven solutions in the oil exploration, subsea, aerospace and motorsports industries, Moog specializes in fully customized solutions in an optimized, compact size that perform reliably in extreme environments for a long service life.

Image Source: Gramazio Kohler Research, NCCR Digital Fabrication

ON-SITE DIGITAL FABRICATION

Digital fabrication, on site, enabled by robotic fabricators, will allow architects to create buildings in a new way, allowing new shapes, higher functional integration, and better material efficiency. The on-site digital fabrication field is one of the unstructured environments where human scale robots offer many advantages, but this application also presents many challenges such as ensuring humans can safely work in the same space as the robot. Our solutions include core building block products that our engineers apply to optimize control, provide a higher level of safety and increase productivity of operations. Our family of state-of-the-art microhydraulic products that provide lightweight, power-dense actuation, leveraging additive manufacturing.

ADVANTAGES

- Fully integrated actuator, servo valve, sensor and controller for an optimized lightweight, compact plug-and-play system for easy incorporation into your latest designs
- High power to weight ratio and efficiency for longer operation on battery powered mobile robotic application
- High dynamics and precise force control provides better overall system control for enhanced responsiveness and a higher level of safety for challenging robotic applications
- Robust, proven hardware for reliable operation even in extreme environments

FAMILY OF MICRO-HYDRAULIC PRODUCTS

- Integrated Smart Actuator
- 30 Series Micro-Servo Valves
- 24 Series Micro-Servo Valves

PRODUCT SPECIFICATIONS – HAPTICS FOR CONSTRUCTION AND MINING ROBOTIC ARM

The Moog developed a highly realistic haptic feedback system that can be used in construction robotic arm and master – slave type operation, which gives the operator real touch and feel of the subject they are handling through robotic arm. Our system can incorporate force feedback in three degrees of freedom. Using Moog's unique admittance control, the system provides a crisp and accurate haptic experience. We will work with you on extensive software interface on user defined applications.

Stylus hand piece with gripper as a desktop demo

Desktop demonstration for a master-slave manipulation

ADAVANTAGES

- Realistic, crisp touch and feel based on Moog's proven force control technology
- Easy programming using interfaces for control with common software packages
- Reliable, proven technology with a control algorithm allowing the full spectrum of movement from very high to very delicate forces
- A variety of designs including gripper wings for easy manipulation
- Same haptic technology can be used for virtual reality machine operation training, which we have applied on the flight simulation for pilot training.

APPLICATION

- Provide haptic feedback as a master system in master-slave manipulation
- User interface design
- Provide 'touch and feel' during machine operation
- Design a virtual reality system for fine motor skill training for machine operators

MORE PRODUCTS. MORE SUPPORT.

Moog designs a range of motion control products to complement those featured in this document. Moog also provides service and support for all of our products. For more information contact the Moog facility closest to you.

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For product information, visit **www.moog.com/industrial**
For service information, visit **www.moogglobalsupport.com**

System supplier for the construction industry
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WHAT MOVES YOUR WORLD

MOOG