

ULTIMATE POWER DENSITY

MINIATURE ACTUATION FOR HIGH PERFORMANCE APPLICATIONS

MOOG



ULTIMATE POWER DENSITY

- MINIATURE ACTUATION
- ON CAR
- OTHER APPLICATIONS
- PRODUCT DEVELOPED FOR MOTORSPORT
- OTHER MOOG SPECIAL PRODUCTS SUPPORTING MOTORSPORT

Hydraulic technology offers unparalleled levels of power density in actuation systems compared with electric or pneumatic technology.

Its compact high power actuation capability is ideally suited to high performance sports such as motor-sport, yacht racing and other niche applications where space and weight are crucial. These include oil and gas, nuclear decommissioning, autonomous robotics, high performance road cars and medical devices.



MOTORSPORT

Established supplier of miniature hydraulics to motorsport teams including Formula 1.



NICHE PRECISION AUTOMATION

Performance-driven companies developing their next-generation machines turn to Moog to solve their high performance automation challenges.



ROBOTICS

Advanced autonomous robots use Moog's range of products and expertise where mobility, agility, dexterity and speed are required.



HYPERCAR

Providing high performance car manufacturers with Formula 1 technology to deliver enhanced drive-train, chassis, braking, steering and advanced aerodynamic systems.



MARINE

Actuator supplier for flight control systems used on advanced foiling for racing and leisure yachts.



OIL AND GAS

Products and systems used in exploration drilling, subsea control systems and ROVs for demanding environments where space is at a premium.



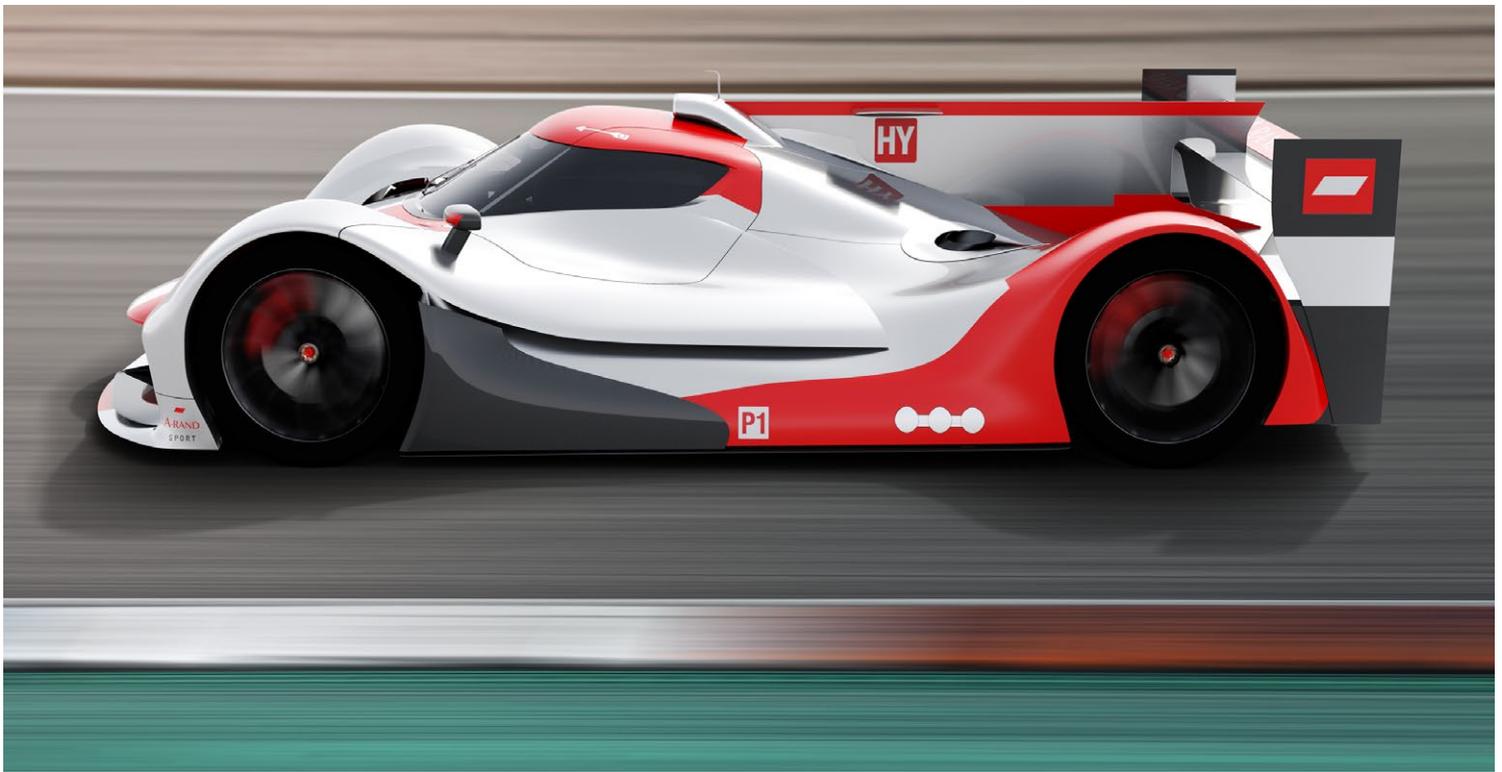
MEDICAL

Precise motion control products and systems requiring similar miniaturization to those of motorsport for a diverse range of medical applications such as sophisticated athletic training and rehabilitation machines.



SPECIAL EFFECTS

Supporting film and theatre where control systems for applications such as robotics with motion bases used for special effects, often in conjunction with CGI imagery.



MEETING YOUR MOTORSPORT CHALLENGES

Motorsport presents a number of unique challenges to motion control suppliers. Whereas Formula 1 looks for low weight, small size and performance, rallying looks for ruggedness and the ability to perform reliably in fairly brutal conditions such as extreme temperatures, adverse weather and demanding time constraints.

Moog has been at the forefront of sub miniature actuation systems in motorsport since 1982, initially supplying active ride height equipment to Team Lotus for use on their Lotus 92 Formula 1 car. Over the intervening years, Moog has continuously developed a range of products and systems for actuation in many types of motorsport including Formula 1, World Rally Championship (WRC), Moto GP, Touring Cars, and WEC prototypes.

PRODUCT HOMOLOGATION



All Moog electro-hydraulic and hydro-mechanical products used in Formula 1 are homologated by the FIA, this indicates they are approved for use with the standard Formula 1 Electronic Control Unit (ECU).

CAPABILITY

Moog has a dedicated global motorsport design, development, manufacture and service center based at its Tewkesbury facility in the UK. This center has a specialist team of engineers, designers and product managers working on motorsport product development and custom systems. Moog's application engineers stay abreast of the latest motorsport regulations, and offer expert advice on the design of systems. Moog can also offer assistance with system simulation and modelling.



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DELIVERING AN EVOLVING HIGH-END TECHNOLOGY TO NICHE CUSTOMERS AND MEETING CHANGING REGULATIONS

Surprisingly, current Formula 1 cars weighing just 746 kg require Power Assisted Steering (PAS) systems because of the extreme levels of downforce generated at speeds of over 300 km/h.

MARKET



Motorsport Automotive Niche Automation

OTHER APPLICATIONS



Simulation Test Oil & Gas

CAPABILITY



Global Focus Established Culture Support Expertise Modelling & Simulation



THE CHALLENGE

Initially, Formula 1 allowed complex software controlled PAS systems, featuring multiple redundancy for safety. However, in 2002 an FIA cost-cutting initiative, outlawed the use of any electronic controls in power steering. The teams first investigated electric motor based solutions but reverted to more 'power dense' hydraulic technology. Following this regulation change, a variety of hydro-mechanical approaches were tried, however these were larger than ideal and challenging to set up.

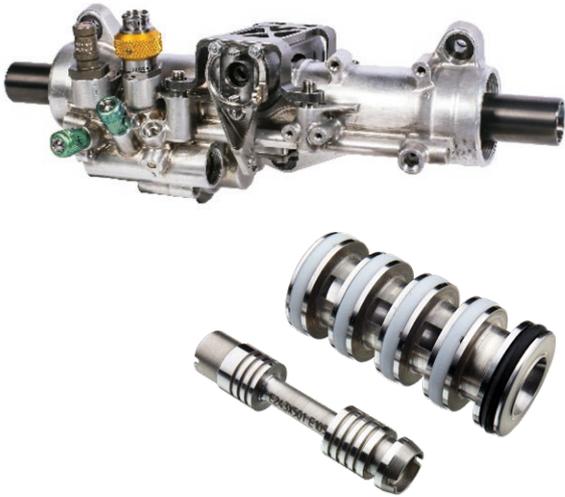
THE RESULT

To address this issue, in 2005 Moog introduced a miniature linear hydro-mechanical power steering valve, the E243 Series, which was quickly adopted by the F1 teams.

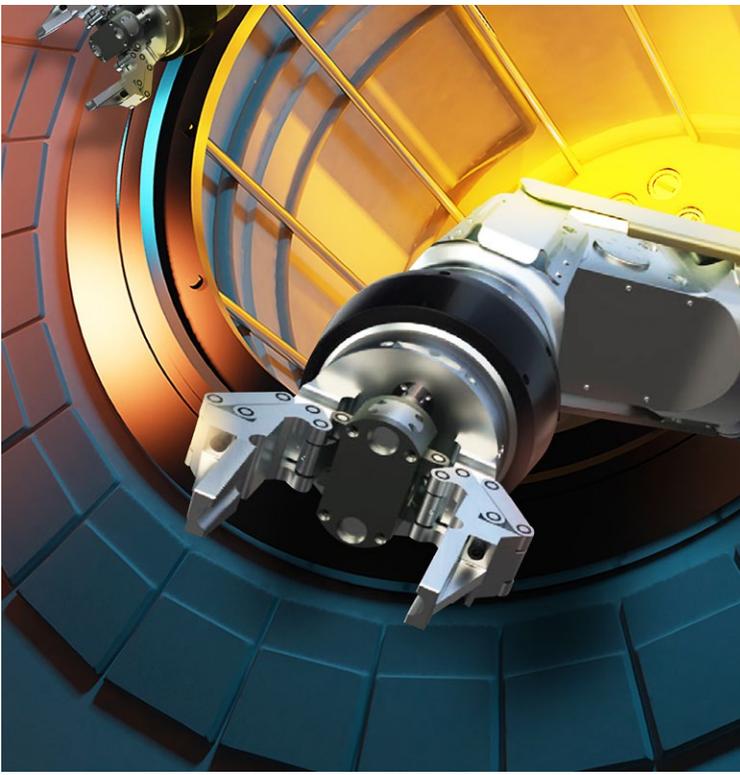
The E243 valve, incorporated hydro-mechanical servo technology that Moog had first used in the US space programme back in the 1960s, when electronics were not considered sufficiently reliable for some critical systems.

Moog selected the power stage of a conventional servovalve, as a control element that could be integrated in the car's steering rack. Using an innovative approach, 'shaped' hydraulic ports within the E243 valve, along with springs and orifices were used to replicate software "lookup table" functionality. This approach allowed easy tuning of assistance level and system linearity, to give the driver the precise steering "feel" required.

Over the intervening years the Moog E243 valve range has been refined to reduce weight and improve controllability and today the entire F1 grid uses these tiny but essential devices.



E243-500/501 FAILSAFE SWITCHING VALVES



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SOLUTIONS THAT PUSH THE LIMITS

Moog miniature hydraulics technology originally developed for Motorsport has found its way into other varied applications.

AUTONOMOUS ROBOTICS

The technical requirements of Formula 1 and sophisticated autonomous robotics have many similarities. In particular the focus on energy efficiency combined with minimum payload, that translates into high speed in a race car or long range and endurance in a roaming robot. The E024 series – used across the Formula 1 grid – is also widely applied in the propulsion of ‘legged’ robots.

RACING YACHTS

Racing yachts have a small, finite amount of energy available for automated actuation systems. In some cases, racing regulations stipulate that the power source must be only the muscles of the crew themselves! This limitation, plus the high response of actuation required to control advanced foiling systems makes the Moog E242 range of rally car valves with their near 100% efficiency, an ideal match.

OIL & GAS

Moog’s miniature hydraulics are widely used to operate underwater robotic manipulator arms fitted to subsea ROV’s (Remotely Operated Vehicles). These are essentially small unmanned submarines, often also propelled and manoeuvred via larger Moog servo valves.

Moog’s E050 miniature hydraulics valves are also used in exploration drilling systems to ‘steer’ the drill, which can actually turn corners or even drill horizontally. Designed to survive the extreme heat and vibration found in motor racing, they are ideally suited to the challenging conditions far underground.



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QUADRUPED ROBOT TAKES BIG STRIDES TOWARDS SAVING LIVES

When Researchers at the Istituto Italiano Di Tecnologia (IIT) wanted to bring to life their HyQ “Hydraulically actuated Quadruped”, to assist humans in their response to emergencies such as search and rescue operations in dangerous places, they approached Moog for a solution.

MARKET



OTHER APPLICATIONS



CAPABILITY



THE CHALLENGE

To provide the IIT with a sub miniature and extremely high response hydraulic solution to control the leg motion of the HyQ which would have to react rapidly when the legs hit the ground, enabling precise reactive control of the rigidity/elasticity of the limbs, absorbing the shock of impact, and preventing stress and damage to the centre body.

THE SOLUTION

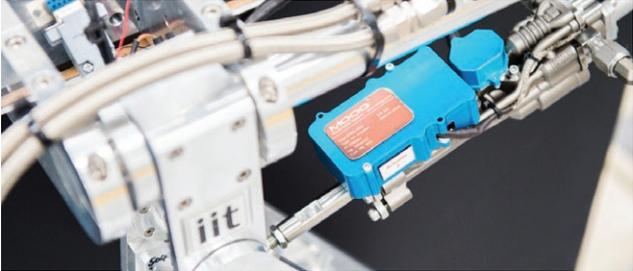
The concept of “actively compliant” legs was made possible by the extremely high response of the Moog E024-LA miniature hydraulic servo valve integrated with a Moog servo actuator and additive manufactured manifold to control leg motion.



THE RESULT

A migration of F1 micro hydraulics technology to human emergencies providing:

- Precise reactive control of the rigidity/elasticity of the limbs of the quadruped.
- Shock absorption of impact and prevention of stress and damage to the central body.
- A robust, reliable, ultra-compact light-weight hydraulic solution capable of precise control in milliseconds.
- One of the few robots capable of doing the “flying trot” where all four legs leave the ground simultaneously.



COMPLEX SIMULATION

HIGH PERFORMANCE MOTION SOLUTIONS

Moog primarily known for its range of precision electro-hydraulic servo valves. However, they also offer a variety of miniature proportional valves and actuators and associated components, applied in Motorsport and other applications requiring high performance solutions and minimum size and weight.

E024 SERVO VALVE

This is the smallest servovalve that Moog produce – with a maximum flow rate of 7.5 l/min and a mass of just 92g.

It is ideal for motorsport applications where very high levels of power density are required, it can control up to 3kW of hydraulic power.



E050 SERIES SERVO VALVES

A larger version of the E024 series this unit was developed from established Moog 30 Series Aerospace Servo Valve. These valves have a higher flow rating (10.5 l/min) than the E024 series but at 195g are still remarkably light.



E242 CARTRIDGE DIRECT DRIVE VALVE (DDV) PROPORTIONAL VALVE

Not to be confused with a conventional proportional valve, the Moog E242 DDV offers unparalleled response time, metering accuracy and energy efficiency. Widely used in Rally Cars this robust valve offers a maximum flow of 18 l/min on a compact package with a mass of 429g



E243 2-STATE VALVES FOR SYSTEM OVERRIDE

These hydro-mechanical fail-safe valves are designed to allow a servo-system to revert to a back-up control mode in the event of a component failure. It can be applied to any critical closed-loop servo system and is widely used in Braking or active aerodynamic applications.



E243 LINEAR POWER ASSISTED STEERING (PAS) VALVES

An alternative to a heavy and bulky Electric assist system, the E243 linear PAS valve provides very high levels of assistance in a miniature closed-centre Power Steering Valve. This valve can be easily applied to any vehicle having a high constant-pressure hydraulic supply. The flexible design allows easy tuning both for the level and the linearity of assistance.



E085 MINIATURE ACTUATOR WITH EDDY CURRENT SENSOR

Moog's range of sub-miniature hydraulic actuators extend to units with piston diameters as small as 9mm and a stroke of 25mm. They are custom designed to a customer specification and have a range of mounting options and are available with integrated position sensors if required.



MINIATURE HYDRAULIC POWER UNITS

Moog offers a range of miniature hydraulic power units for both low and high voltage operation. An optional electronic controller can provide provides closed-loop control of a constant pressure hydraulic system.



SERVO CONTROLLERS

A wide range of 12 and 24 volt electronics for automotive/mobile applications are available from Moog. These include analogue/digital servo controllers as well as a wide range of signal conditioning modules.



INTEGRATED MOTORSPORT SYSTEMS

In addition to niche products, Moog can offer the design and deliver complete miniature actuation systems, utilizing either hydraulic or electric technology. Typically, these systems are fully tested at Moog with the customer's hardware, before delivery.



E050 FUEL AND OIL REGULATING VALVES

The E050 Fuel Regulating Valve is a precision two-stage pressure regulator designed to be used in conjunction with a fixed displacement fuel pump. This design can also be used in conventional hydraulic systems.



COMPLIMENTARY PRODUCTS

PRECISION BALL SCREWS

Moog offer a range of highly customized precision ball and roller screws for compact high performance applications. These units have been successfully applied to inertial damper (J-damper) applications in the Motorsport industry.



BRUSHED AND BRUSHLESS MOTORS

Complimenting Moog's miniature hydraulics offering, is a portfolio of unique products for electric actuation. These include miniature brushed and brushless motors, intelligent motors with integral drives and a CAN and Ethernet command interface, as well as compact direct acting linear electric motors



FORMULA 1 HYDRAULIC SYSTEMS TODAY

Today's FIA regulations mandating hybrid F1 cars has produced technology focussed on fuel efficiency and seamless deployment of electric propulsion.

This has led to a profiteration of control systems on the transmission, braking and engine ancillary controls particularly on the compound turbocharger.



TEST AND SIMULATION

Moog can help you increase your test lab productivity, enabling you to react faster to market changes by removing product development boundaries, validate and launch new designs faster and conduct more cost-effective testing.

Our technological expertise and reputation for innovation, along with close customer collaboration, are key reasons we have rapidly become a leader in high performance test and simulation systems.

TEST CONTROLLER

Moog's latest Digital Test Controller provides a reliable configurable platform for precise control of your tests. Available as multi-channel or single channel it delivers reliable results, is simple and user friendly, provides unsurpassed precision and can be used for simple fatigue tests to highly integrated full vehicle road tests.

SIMULATION TABLE

Our Hydraulic and Electric Moog Simulation Tables provide a full six degrees of freedom to simulate acceleration and displacement outputs reproducing key data collected on proving grounds, to assist car development and driver training.



MULTI-AXIS TEST SYSTEM

Our Electric and Hydraulic Multi-Axis Test Systems deliver highly reliable and flexible solutions to a variety of applications, and can be used for structural testing applications that require higher performance in both acceleration and frequency response.

4-POSTER TEST RIG

With a variety of control axes offered, Moog test rigs can be used with body in white and full vehicles to perform validation, durability, buzz, squeak and rattle (BSR), and noise, vibration and harshness (NVH) testing.



MOOG DRIVING SIMULATOR HEIGHTENS REALITY OF VIRTUAL TEST LAPS FOR FERRARI DRIVERS

Ferrari and Moog teamed up on a multi-million euro development project, which led to the creation of the Ferrari Driving Simulator. This new collaborative development simulates real race track scenarios and tests different aspects of an F1 racing car. The Driving Simulator has an integrated motion control and testing system, complete software package, cockpit and a dedicated operator workstation.

THE CHALLENGE

Ferrari required mechanical frequencies high enough to help drivers get the most accurate feel of the car. Velocity and acceleration levels had to reach a level never met before by such a system.

THE SOLUTION

Moog's project management and engineering teams worked very closely with Ferrari engineers at Moog's facility during the development of this driving simulator. Moog met Ferrari's every specification and expectation for a system that can develop car designs as well as deliver driver training. This helped Ferrari to realize the maximum benefit from high performance motion control systems and the design of new actuators to deliver the desired strength and stiffness at a lower weight.



THE RESULT

- The new simulator offers test drivers a heightened sense of driving reality as well as a being highly responsive and receiving immediate feedback from their actions.
- High bandwidth and low latency makes braking and steering more responsive creating the high fidelity test drivers need to correctly feel and assess the car's behaviour.
- Test drivers can feel the difference of a modification to a part or component of the car without the risk of a high acceleration rate of real test driving.
- Current and future car designs, the training of new drivers on multiple F1 circuits, cuts track time, enabling better planned training which is not determined by the weather conditions.

TAKE A CLOSER LOOK

Moog designs a range of products that complement the performance of those featured in this catalogue. Visit our website for more information or contact the Moog facility nearest you.



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Ultimate Power Density - Miniature Products and Systems
OYS/PDF/Rev.A. October 2021. ID.63063