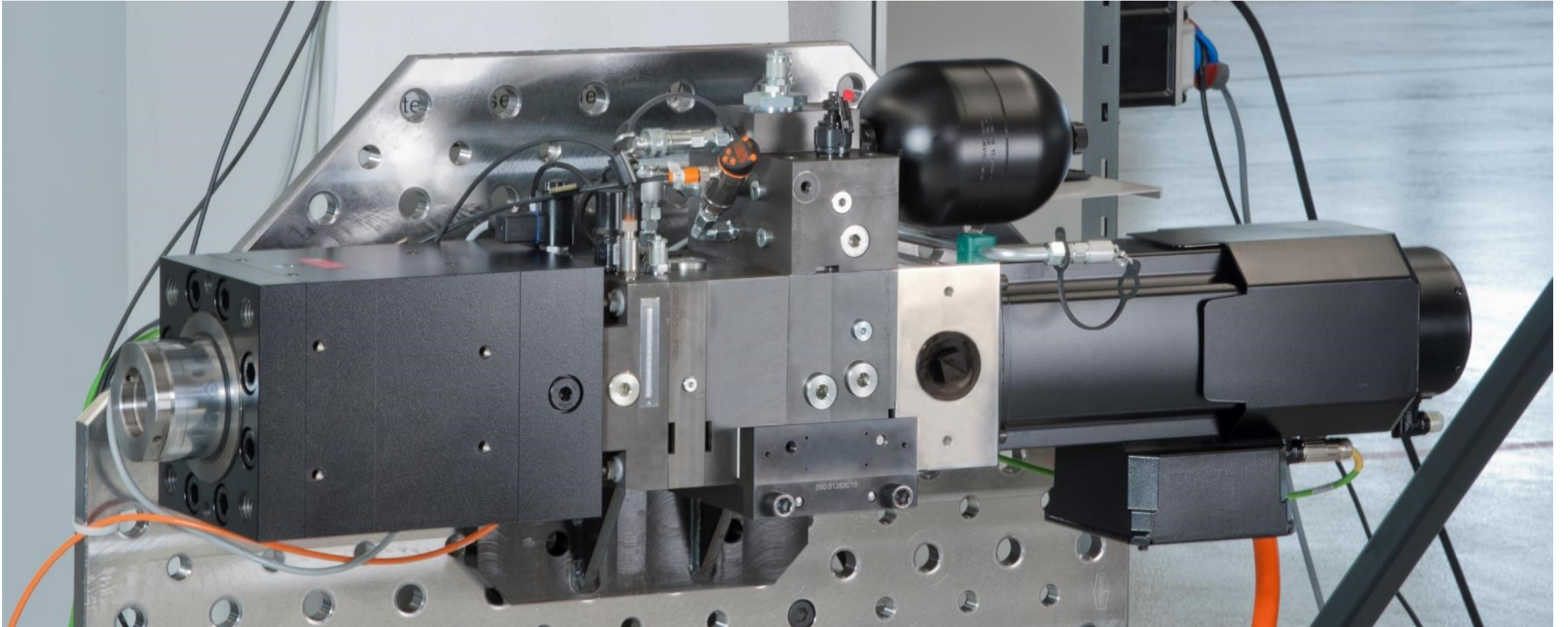




MOOG

Shaping the way our world moves™

ELECTROHYDROSTATIC ACTUATION
MOOG EHA TECHNOLOGY

V1.2, SEP 2024

TODAY'S CHALLENGES	4
OUR TECHNOLOGY	5
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TODAY'S CHALLENGES

MACHINE BUILDERS NEED FOR ADAPTION



| SUSTAINABILITY & ENERGY EFFICIENCY

We support our customers in complying with legal and regulatory requirements to reduce carbon emissions and improve energy efficiency.



| DIGITALIZATION & ELECTRIFICATION

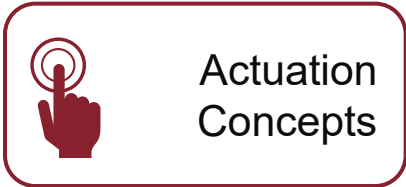
By providing market-leading electrohydraulic solutions and software modules, we support our customers in digitalization and electrification.



| SKILLED LABOR SHORTAGE

In the battle for skilled workers, hydraulic experts are rare. We support our customers with our motion control expertise and end-to-end solutions.

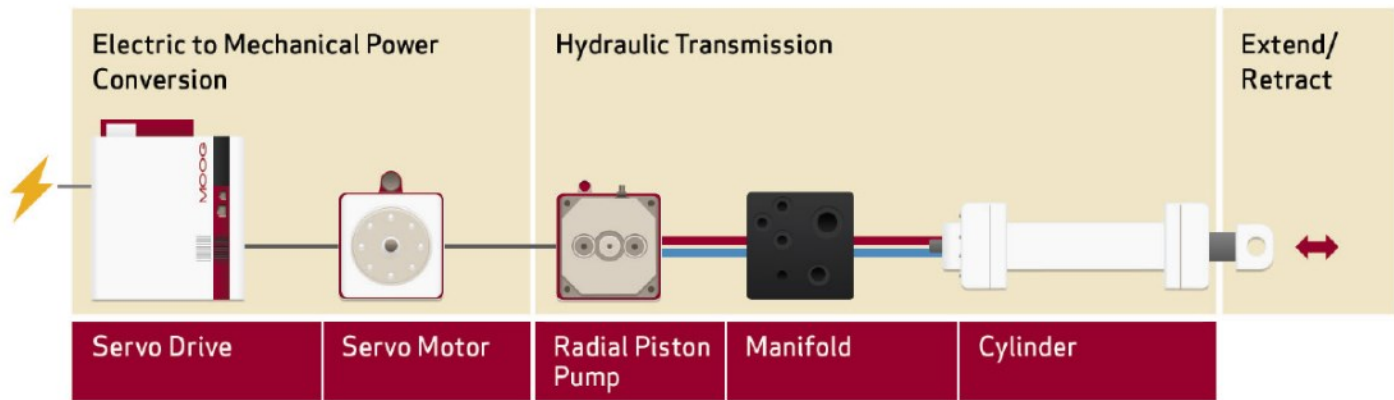
OUR TECHNOLOGY



ELECTRO-HYDROSTATIC ACTUATION (EHA)

Electro-hydrostatic Actuation (EHA) is a highly integrated, compact and eco-friendly option to conventional hydraulic solutions, combining the benefits of electro-mechanical (EM) and electro-hydraulic (EH) actuation

- › **EM** = high energy efficiency and low noise emission  
- › **EH** = high power-density, robustness and precise handling of large forces   



	EM	EH	EHA
Energy Efficient	✓	✗	✓
Eco-friendly	✓	✗	✓
Reduced Noise	✓	✗	✓
Smaller Footprint	✓	✗	✓
High Forces	✗	✓	✓
No Backlash	✗	✓	✓
Low Wear & Tear	✗	✓	✓

OUR TECHNOLOGY



Hydrostatic
Circuits

ELECTRO-HYDROSTATIC ACTUATION (EHA)

LOW OPERATING COSTS / TCO

FASTER TIME TO MARKET

FLEXIBILITY IN MACHINE
DESIGN AND INTEGRATION

SPEED UP ASSEMBLY AND
COMMISSIONING TIME

HIGH MACHINE AVAILABILITY



Electrification of motion control architecture

High Energy
Efficiency

Power on demand

No Throttling losses

Reduced
footprint

Compact and robust

Self-contained system

High
Adaptability

Plug'n'run

Simplify hydraulic concept

High force capability and power density

High ease of use and serviceability

OUR TECHNOLOGY

MAJOR MILESTONES



Detailed
Timeline



2001

**Radial Piston Pump
(RKP)**

- › constant speed operation
- › 2Q operation



2010

**Speed Controlled Pump
(SCP)**

- › variable speed operation
- › 2Q operation
- › Servomotor with coupling



2016

**Electrohydrostatic
Pump Unit (EPU)**

- › variable speed operation
- › 4Q operation
- › Servomotor without coupling



2023

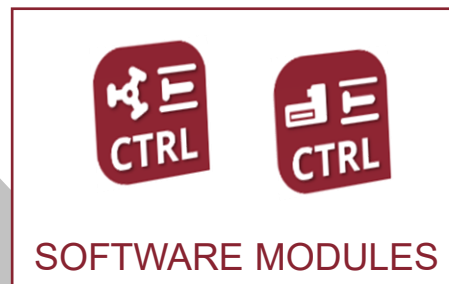
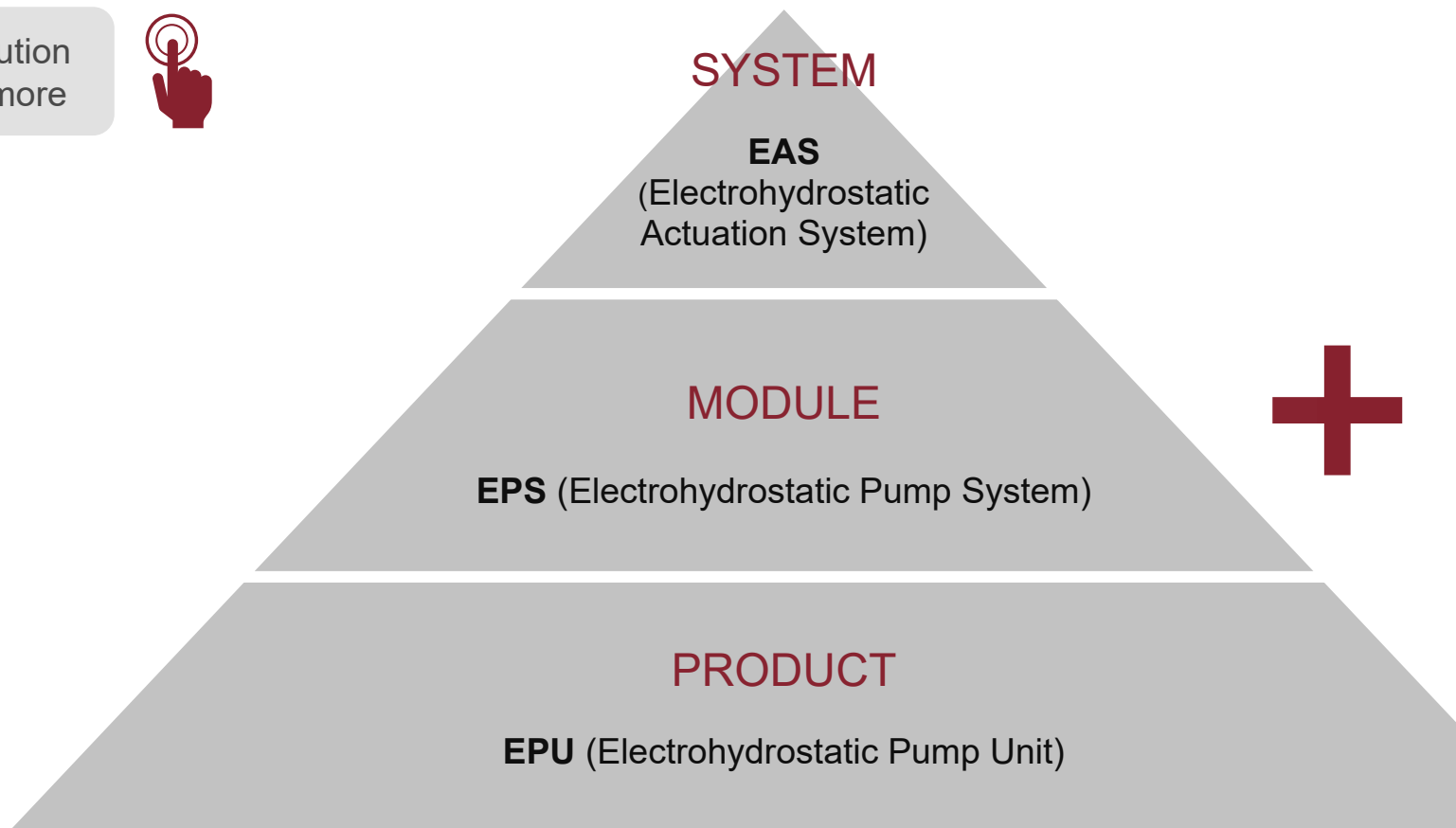
**Electrohydrostatic
Pump System (EPS)**

- › variable speed operation
- › 4Q operation
- › Manifold with accumulator

SOLUTION LEVELS

THE BEST OF TWO WORLDS TAILORED TO YOUR NEEDS

Click on the solution levels to learn more

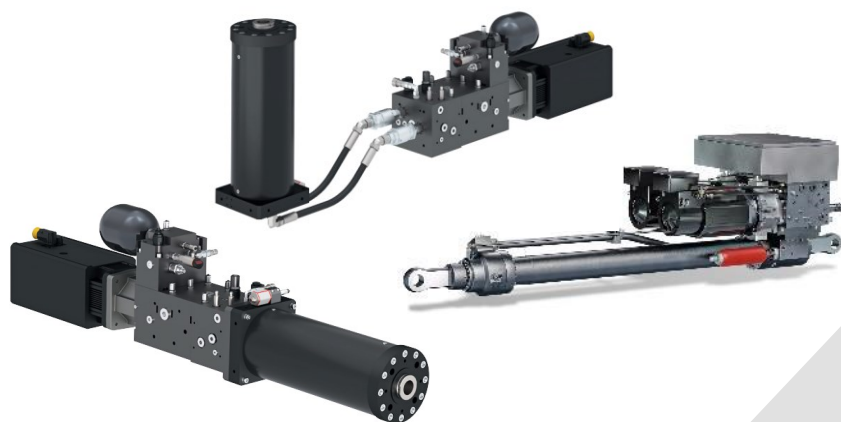


SOLUTION LEVELS



Solution Level
Pyramid

ELECTRO-HYDROSTATIC ACTUATION SYSTEM (EAS)



Compact axis (linear/orthogonal)
Customized in split/distributed design

SYSTEM

EAS
(Electrohydrostatic
Actuation System)

- › Compact axis or distributed design (also customized solutions)
- › Integration into closed or half-open circuits
- › Little hydraulic know-how required (Turn-key solution)

MODULE

EPS (Electrohydrostatic Pump System)

PRODUCT

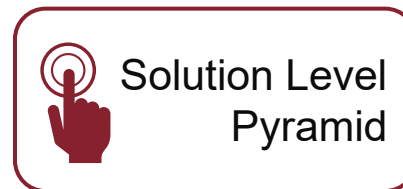
EPU (Electrohydrostatic Pump Unit)

POWER ELECTRONICS

ENERGY MANAGEMENT

SOFTWARE MODULES

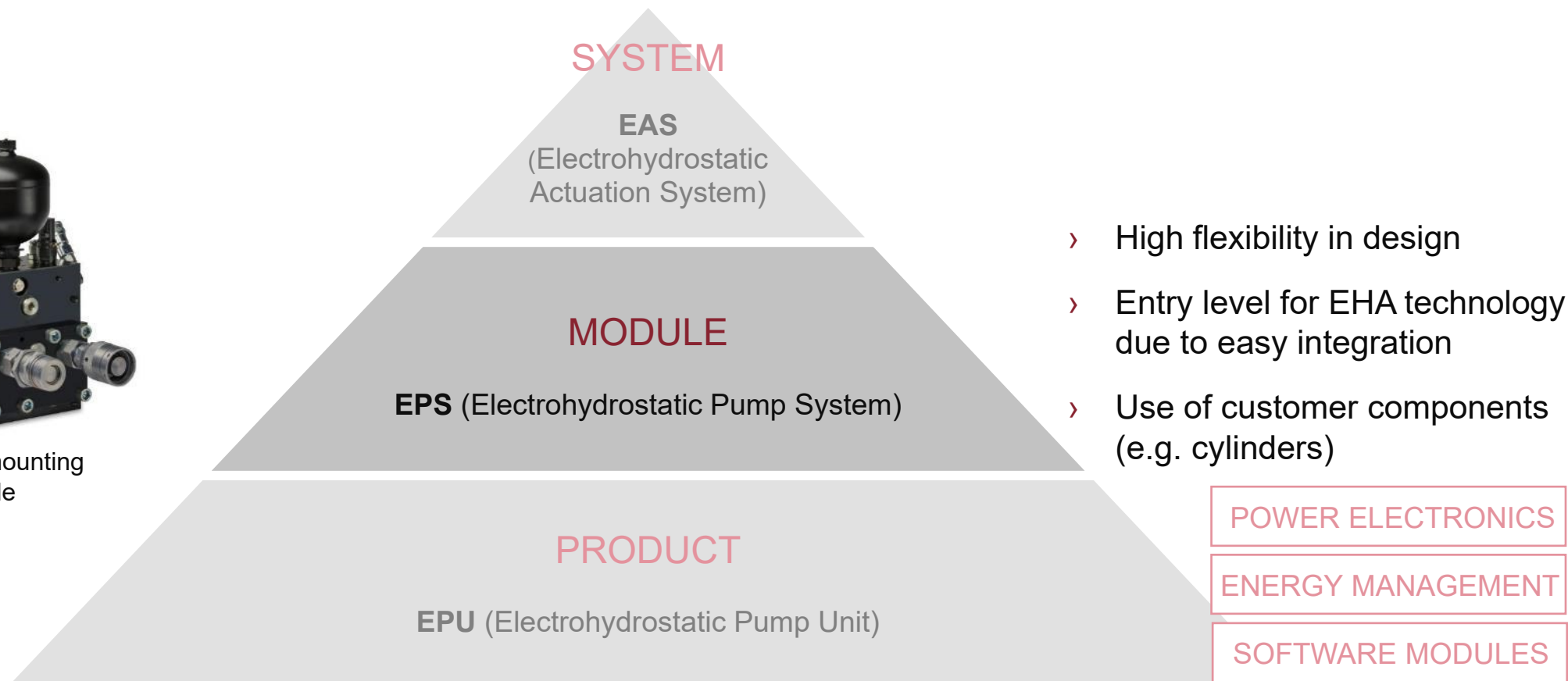
SOLUTION LEVELS



ELECTRO-HYDROSTATIC PUMP SYSTEM (EPS)



axial/radial mounting
possible



SOLUTION LEVELS

EPS – ELECTRO-HYDROSTATIC PUMP SYSTEM



Solution Level
Pyramid

POWER ELECTRONICS

ENERGY MANAGEMENT

SOFTWARE MODULES

SYSTEM

EAS
(Electrohydrostatic
Actuation System)

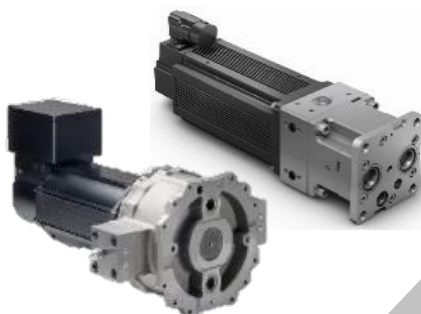
MODULE

EPS (Electrohydrostatic Pump System)

PRODUCT

EPU (Electrohydrostatic Pump Unit)

- › Max. freedom and flexibility in system design
- › Heart of Moog's EHA technology (proven in +50 applications)



EPU based on
4Q RKP / IGP

OUR PRODUCTS

PORTFOLIO OF ELECTRO-HYDROSTATIC ACTUATION

Click on the product
to learn more



EPU



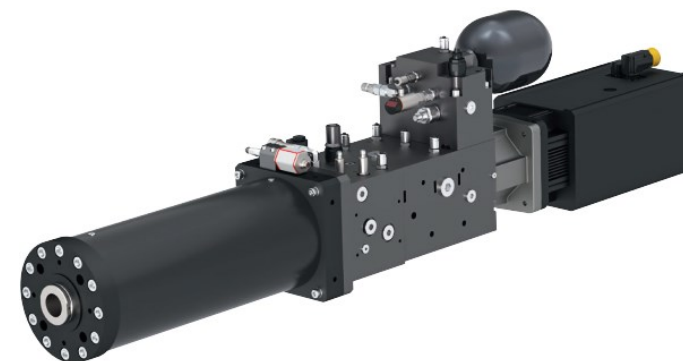
- › Variable speed pump in 4Q operation
- › Fixed, dual or variable displacement
- › Sizes from 16 to 250 cm³

EPS



- › Compact Pump system in 4Q operation
- › Self-contained or half-open system
- › Fixed or dual displacement

EAS



- › Self-contained compact axis in linear, orthogonal or split design (Size 10 to 40)
- › Customized design on request

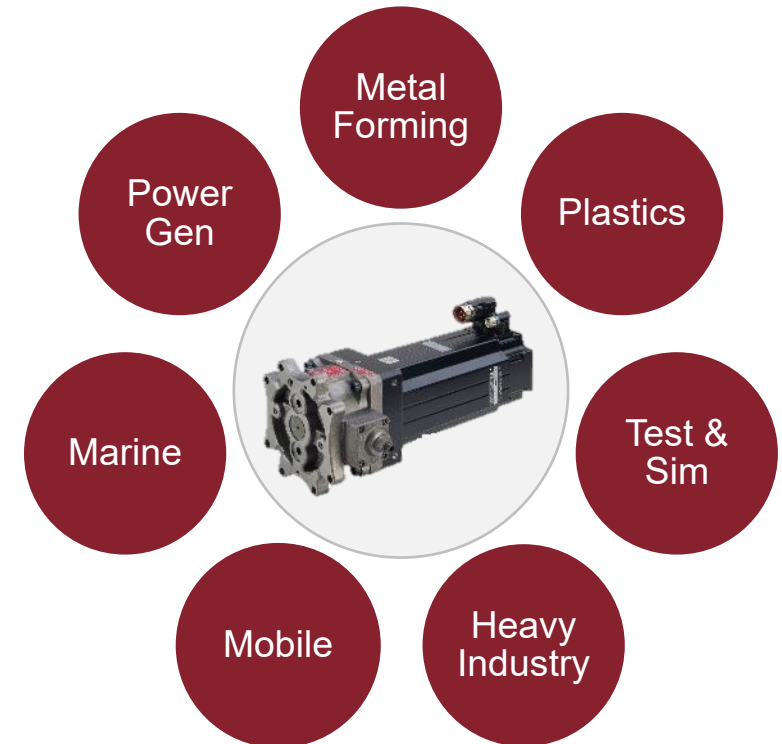
APPLICATIONS

IN-DEPTH MOTION CONTROL EXPERIENCE

With our motion control legacy and our expertise in EHA technology for over 20 years, we have served more than 100 major customers with more than 1000 EPU's and EAS

Why Choose Moog

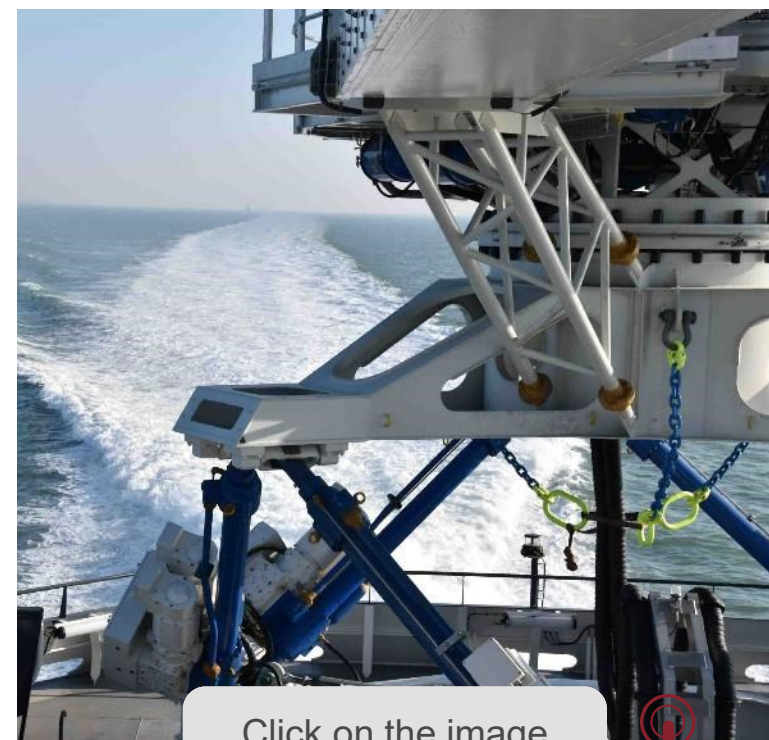
- › We support your transition from conventional Electrohydraulic to energy efficient and future-proof Electrohydrostatic Actuation
- › We offer products, modules and complete system solutions including drives, controllers, software and energy management.
- › We are proven experts in Electrohydrostatic actuation technology with decades of experience in aerospace and industrial applications



CASE STUDY – AMPELMANN

ELECTROHYDROSTATIC ACTUATION FOR MOTION COMPENSATED GANGWAY

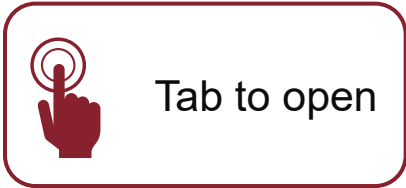
- The Customer** The Rotterdam based company is a leading supplier of Motion Compensated Gangways for service vessels on the open seas
- The Challenge** Limited space and weight for smaller vessels, as well as high demands on environmental friendliness, reliability (no oil contamination) and energy efficiency.
- Moog Solution**
- › 6x Electrohydrostatic Actuation Systems (EAS) with 12x EPU's for redundancy
 - › Energy Management System based on supercaps for wave energy recovery
 - › 12x MSD servo drives for motor control and power transmission
- Added Value**
- › Higher energy efficiency with a 90% reduction in input power
 - › Amount of hydraulic fluid reduced by 80%
 - › Total system footprint cut by 30%



Click on the image
to learn more



ADDITIONAL RESOURCES



WANT TO LEARN MORE?

Product Page (moog.com)

MOOG

PRODUCTS ▾ INDUSTRIES ▾ NEWS & EVENTS ▾ OVERSIGHTS ▾ CAREERS ▾ SUPPLIERS ▾ SUSTAINABILITY ▾ CONTACT

Products / Actuators & Servo Actuators / Industrial Actuators / Electrohydraulic Actuators

Industrial Electrohydraulic Actuation Systems



Moog Electrohydraulic Actuators are a component within a complete Electrohydraulic Actuation System (EHAS). Available as a modular, compact unit, fully customized systems, machine builders use this technology to generate linear motion with the simplicity of the power of electrohydraulic (PH) and the efficiency of electrohydraulic (EH) actuators.

A complete system is comprised of an electrohydraulic pump unit, a variable speed servo motor and a load or variable displacement pump, along with a manifold and optional, the energy input into the power train is provided by a servo drive. These building blocks make up Moog's Modular Electrohydraulic, an attractive solution for the industrial machine manufacturing market.

CONTACT OUR EXPERTS

Electrohydraulic Pump Systems



The Electrohydraulic Pump System (EPS) consists of an Electrohydraulic Pump Unit (EPU) and a standard and manifold with hydraulic accumulator. It is provided as a complete system with flow control and can be easily integrated into machine construction, whether retrofit or new construction.

Learn More >

Compact Electrohydraulic Actuation Systems



The compact, 300 mm pressure vessel, motor, with internal pump, hydraulic manifold, cylinder and compensation tank. Ideal for industrial applications requiring a flexible and compact solution.

Learn More >

Product Catalogues (moog.com)

ELECTROHYDROSTATIC PUMP UNIT



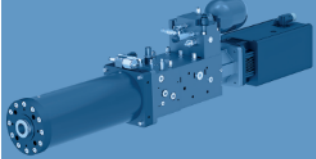
MODULAR ELECTROHYDROSTATIC PUMP UNIT FOR INDUSTRIAL APPLICATIONS

ELECTROHYDROSTATIC PUMP SYSTEM (EPS)



MODULAR AND ENERGY EFFICIENT DRIVE SOLUTION WITH A HIGH DEGREE OF FREEDOM FOR USERS AND OPERATORS

COMPACT ELECTROHYDROSTATIC ACTUATION SYSTEM



A COMPACT ENERGY EFFICIENT AND HIGH FORCE ALTERNATIVE TO TRADITIONAL ACTUATION SYSTEMS

WHAT MOVES YOUR WORLD

MOOG

WHAT MOVES YOUR WORLD

MOOG

WHAT MOVES YOUR WORLD

MOOG

15 CHALLENGES | TECHNOLOGY | SOLUTION LEVELS | PRODUCTS | APPLICATIONS | RESOURCES

MOOG



Shaping the way our world moves™

THANK YOU

LETS MAKE THE IMPOSSIBLE POSSIBLE
TOGETHER

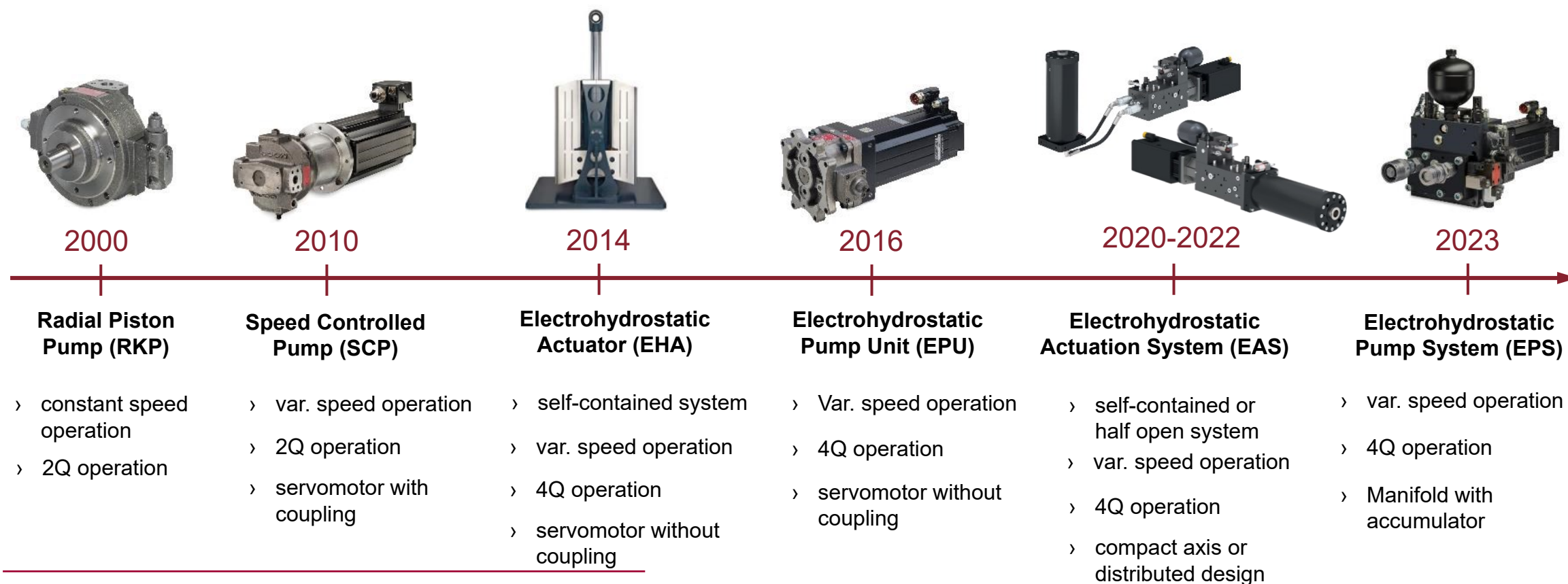
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OUR TECHNOLOGY



MAJOR MILESTONES



BASIC ACTUATION CONCEPTS



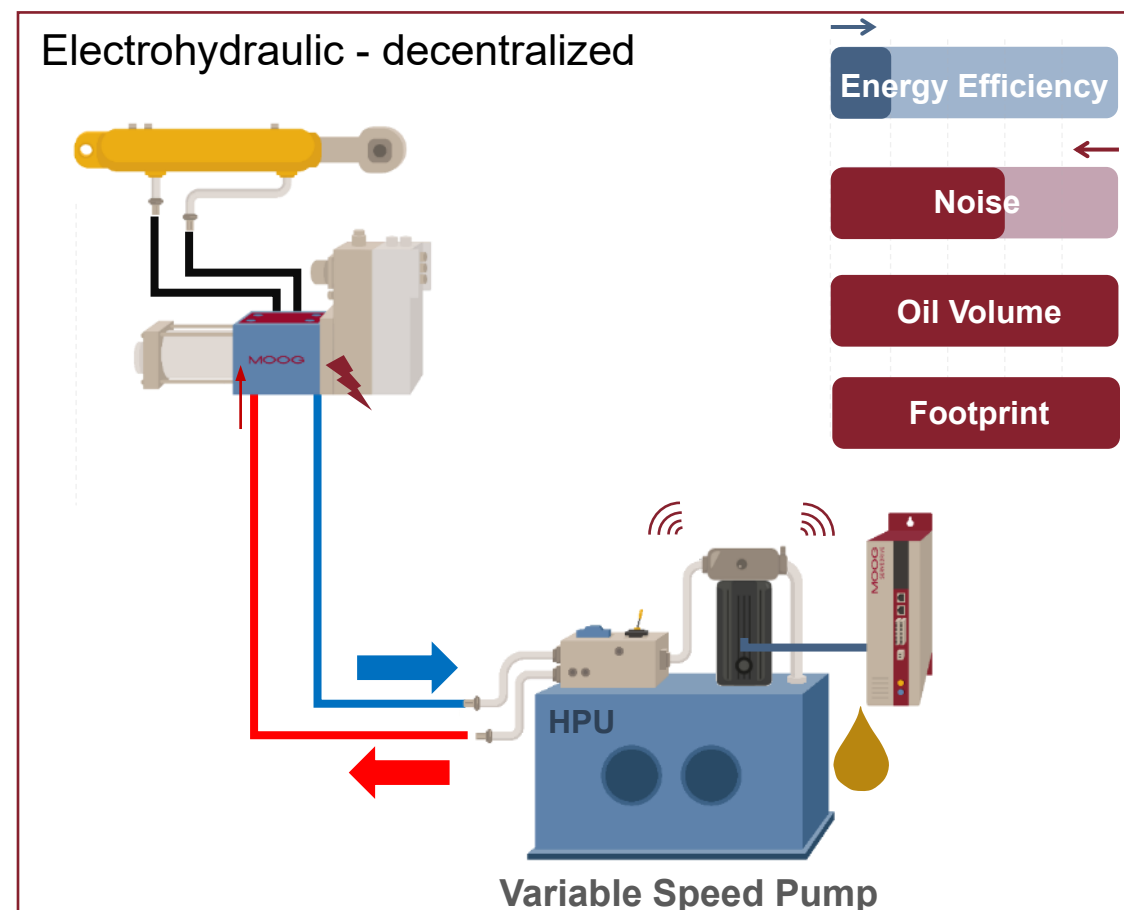
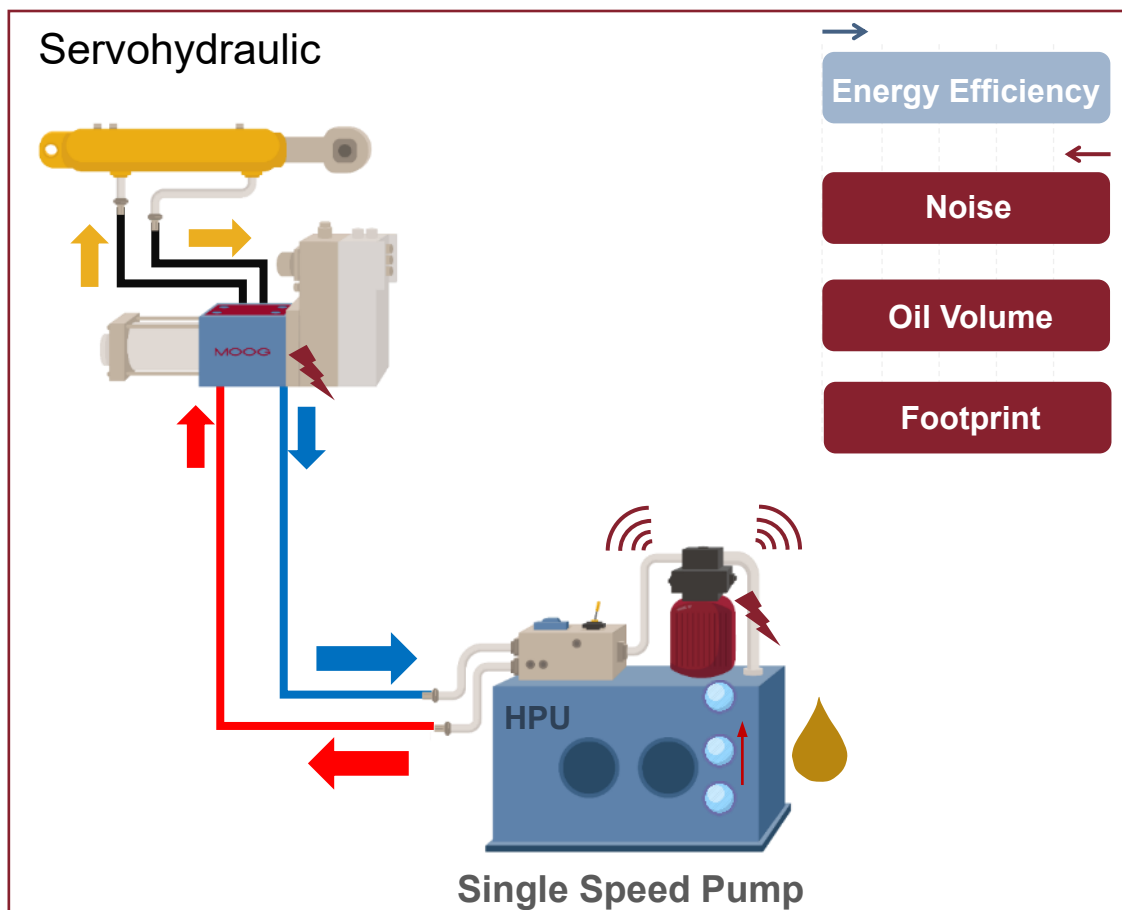
Back

(1) EH - single or variable speed pump, decentralized

(2) EH - single or variable speed pump, centralized

(3) EHA – 4Q variable speed pump, half open

(4) EHA – 4Q variable speed pump, self-contained



BASIC ACTUATION CONCEPTS



Back

(1) EH - single or variable speed pump, decentralized

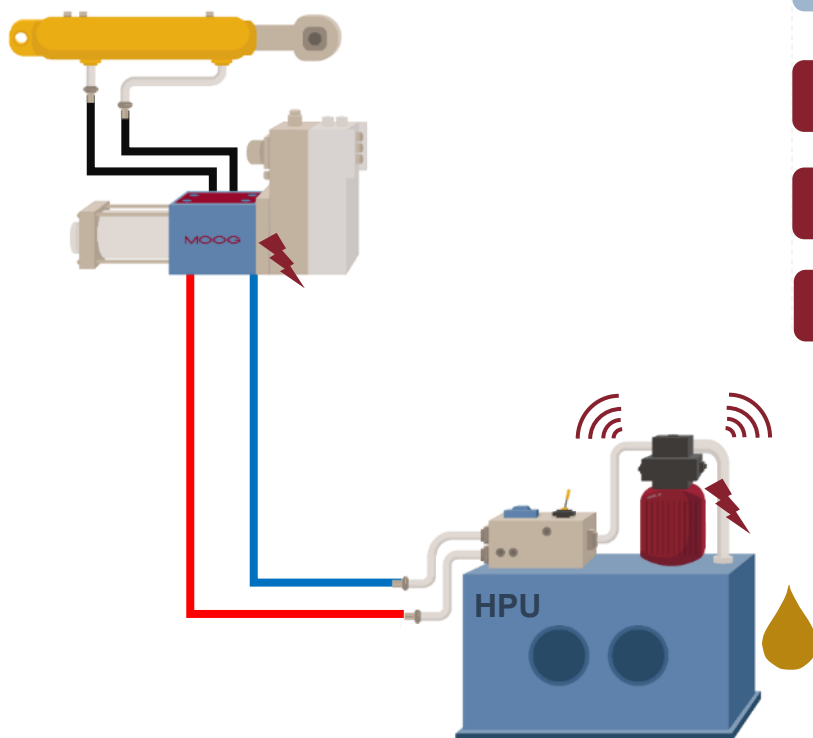
(2) EH - single or variable speed pump, centralized

(3) EHA – 4Q variable speed pump, half open

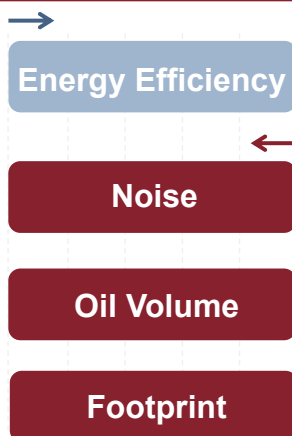
(4) EHA – 4Q variable speed pump, self-contained



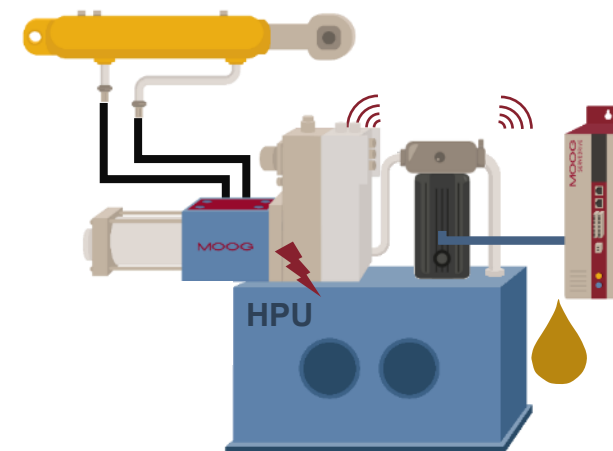
Servohydraulic



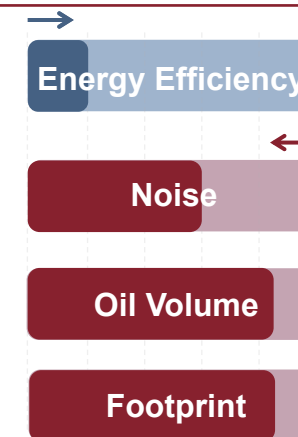
Single Speed Pump



Electrohydraulic - centralized



Variable Speed Pump



BASIC ACTUATION CONCEPTS



Back

(1) EH - single or variable speed pump, decentralized

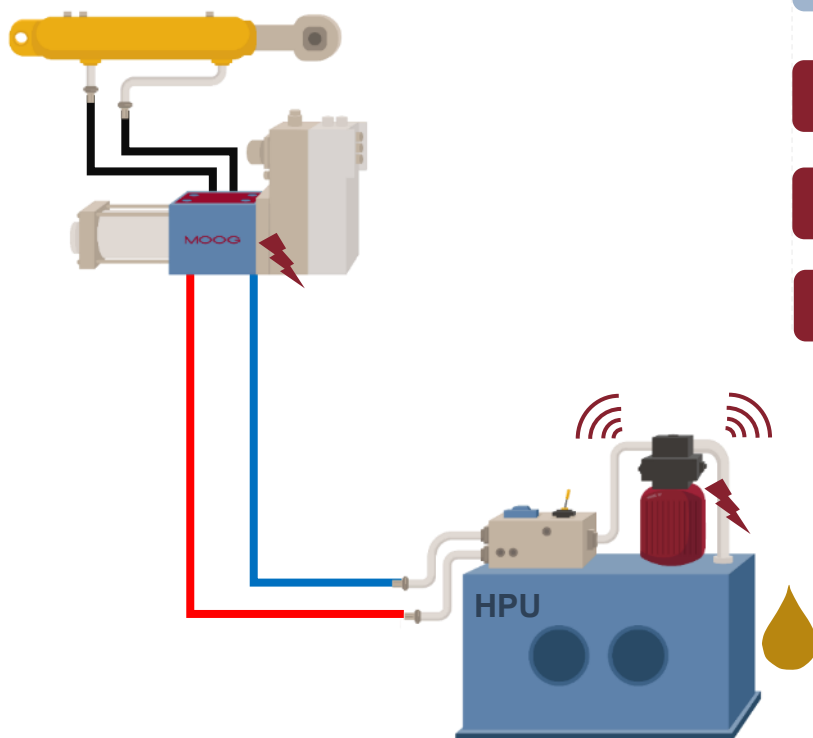
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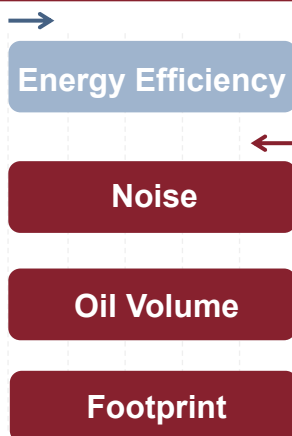
(4) EHA – 4Q variable speed pump, self-contained



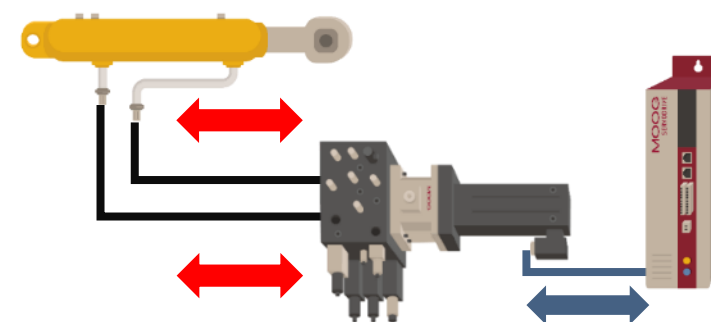
Servo-hydraulic



Single Speed Pump

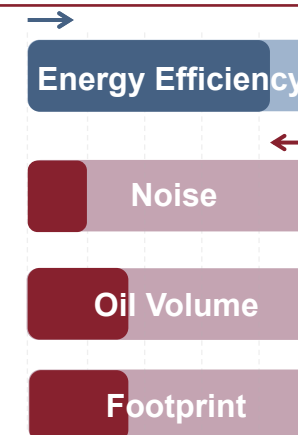


Electro-hydrostatic – half open



Hydraulic

Electric



BASIC ACTUATION CONCEPTS



Back

(1) EH - single or variable speed pump, decentralized

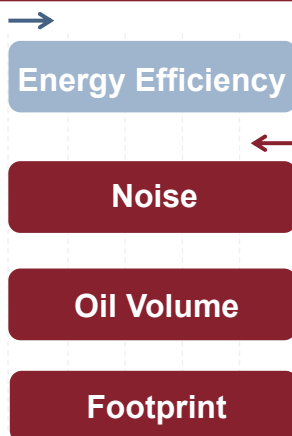
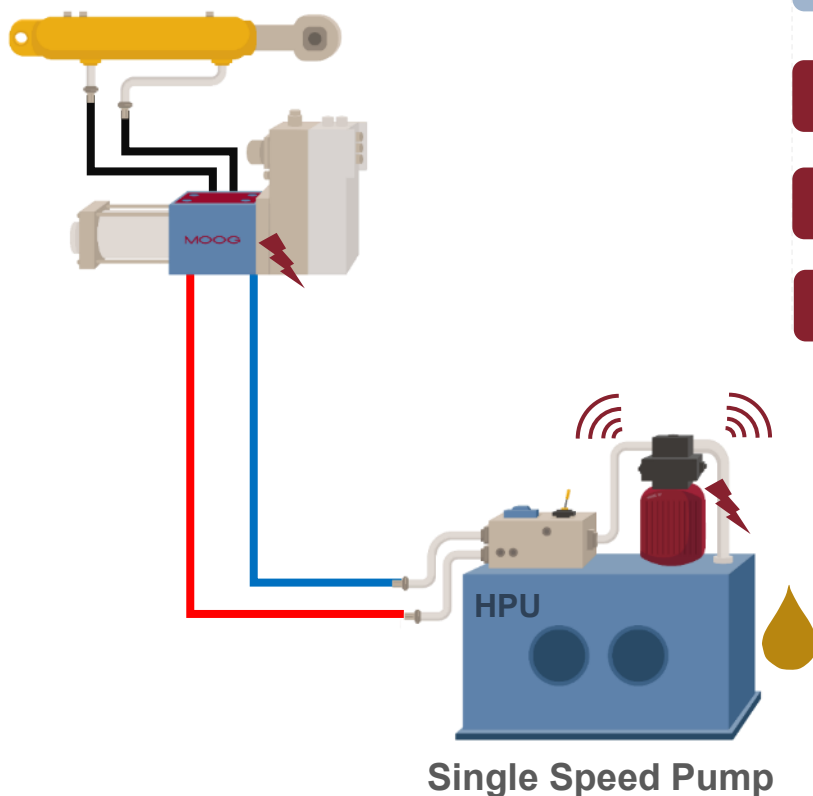
(2) EH - single or variable speed pump, centralized

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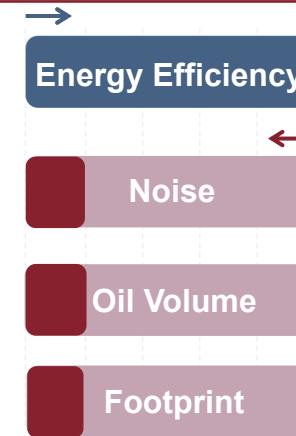
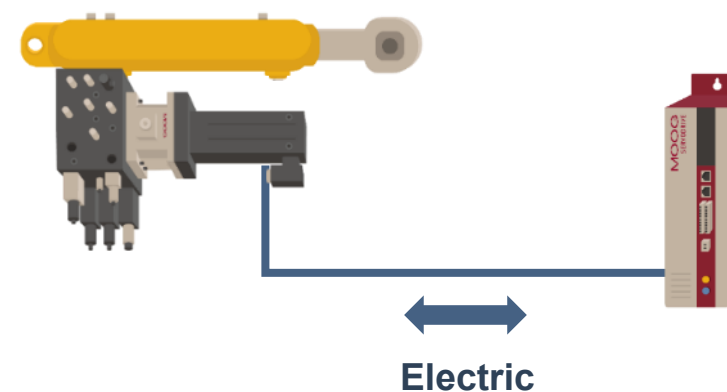
(4) EHA – 4Q variable speed pump, self-contained



Servo-hydraulic



Electro-hydrostatic – self contained



HYDROSTATIC ACTUATION



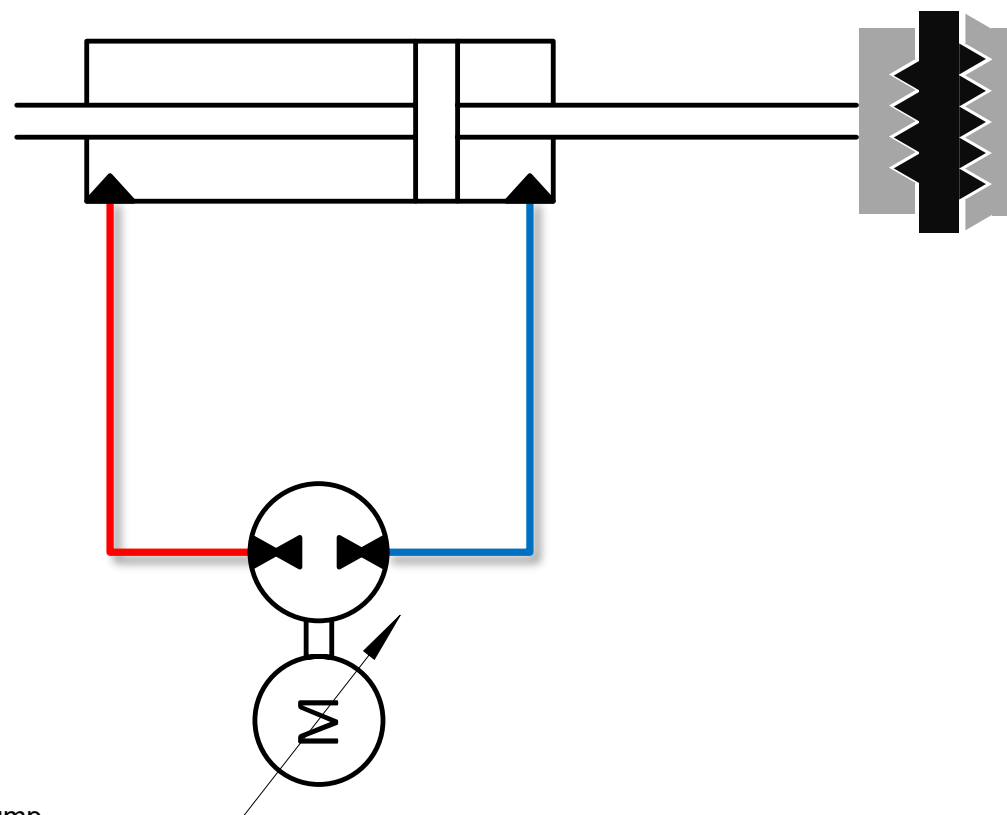
Back

(1) Basic Circuit

(2) Closed/self-contained
Half-open (cooling)

(3) Closed/self-contained
Half-open (cooling & flushing)

(4) Cylinder types (Double-/
Single-rod, Multi-chamber)



Brushless servomotor



Var. 4Q speed pump

HYDROSTATIC ACTUATION



Back

(1) Basic Circuit

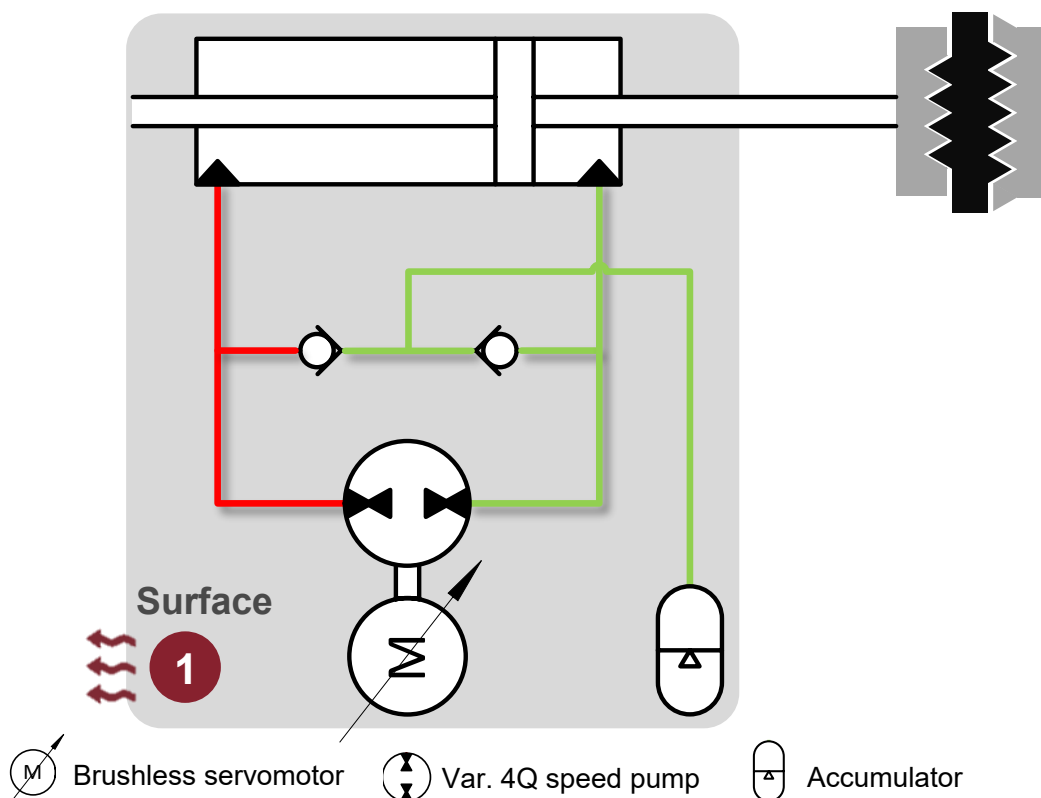
(2) Closed/self-contained
Half-open (cooling)

(3) Closed/self-contained
Half-open (cooling & flushing)

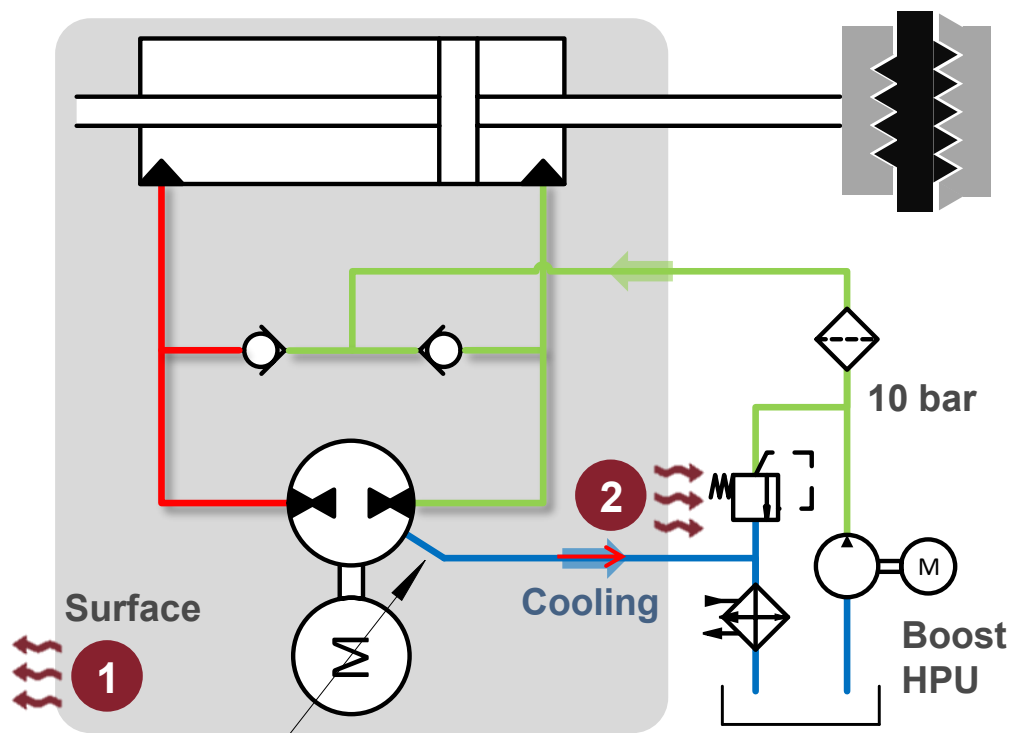
(4) Cylinder types (Double-/
Single-rod, Multi-chamber)



Closed / Self-Contained



Half open with cooling option



HYDROSTATIC ACTUATION



Back

(1) Basic Circuit

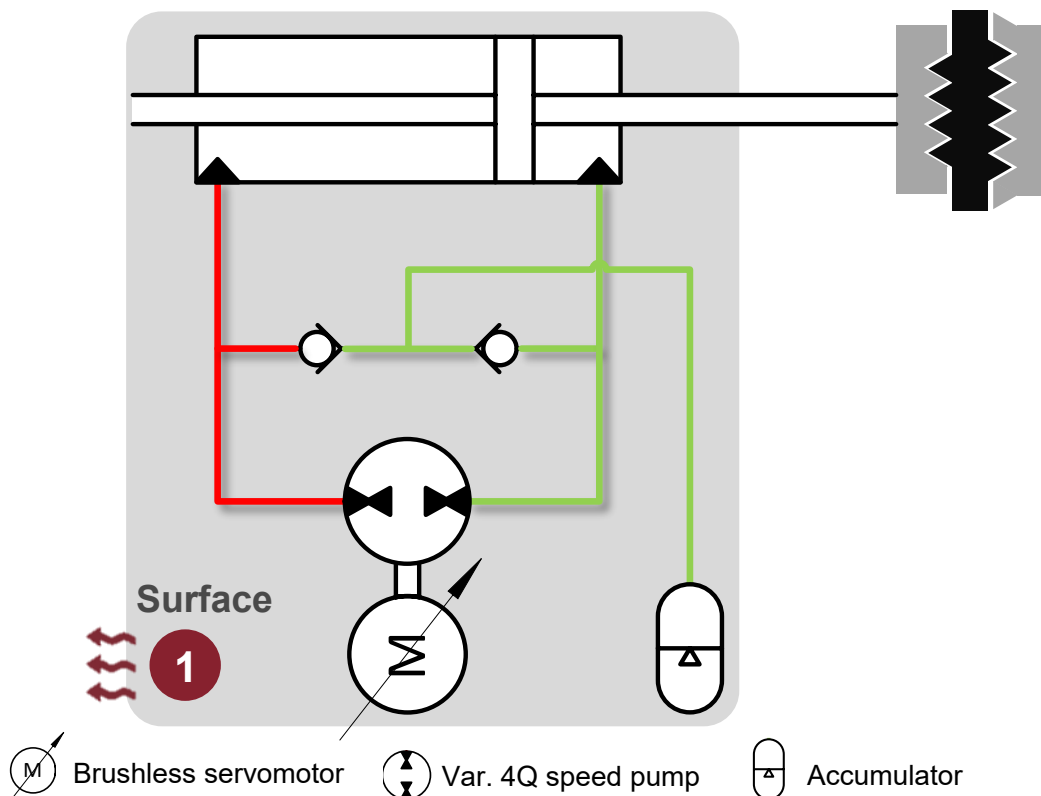
(2) Closed/self-contained
Half-open (cooling)

(3) Closed/self-contained
Half-open (cooling & flushing)

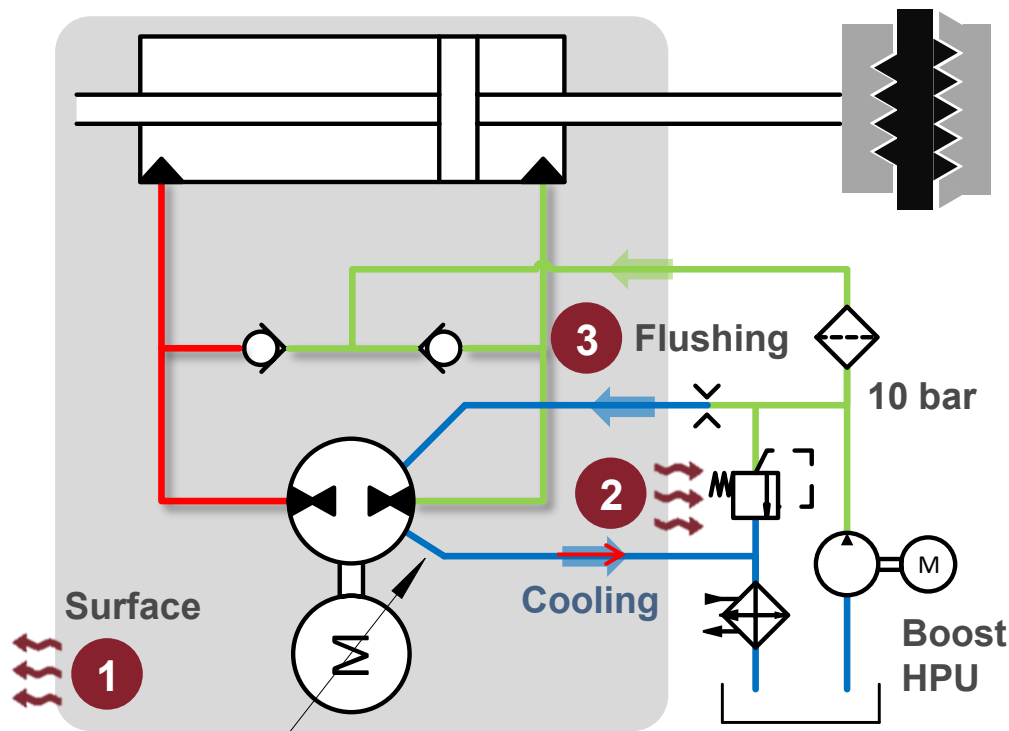
(4) Cylinder types (Double-/
Single-rod, Multi-chamber)



Closed / Self-Contained



Half open with cooling and flushing option



HYDROSTATIC ACTUATION



Back

(1) Basic Circuit

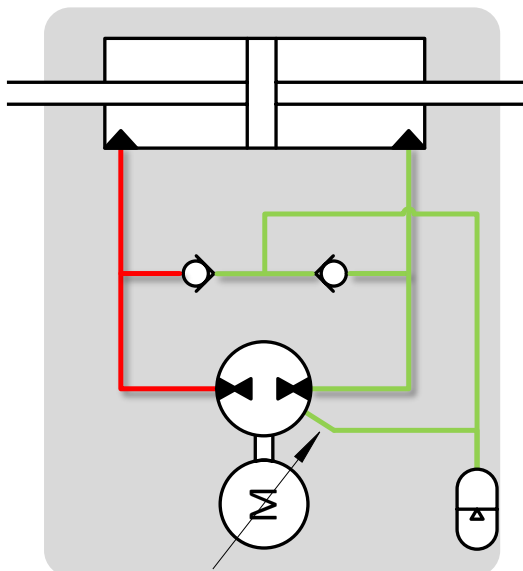
(2) Closed/self-contained
Half-open (cooling)

(3) Closed/self-contained
Half-open (cooling & flushing)

(4) Cylinder types (Double-/
Single-rod, Multichamber)

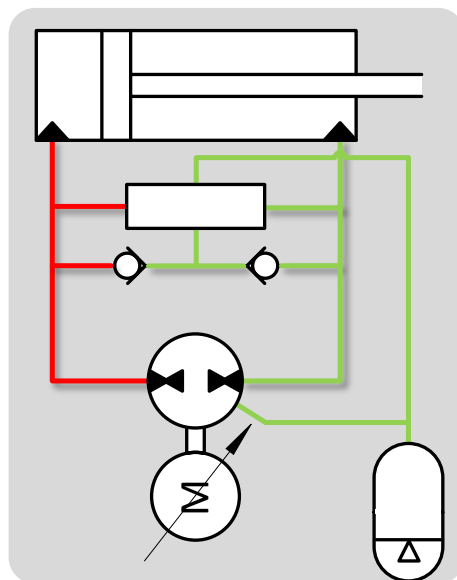


Double Rod Cylinder
with 4Q EPU

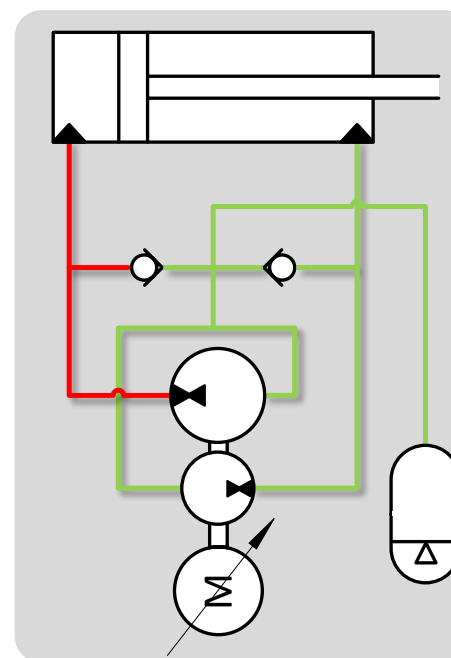


- Brushless servomotor
- Var. 4Q speed pump
- Accumulator

Single Rod Cylinder
with 4Q EPU

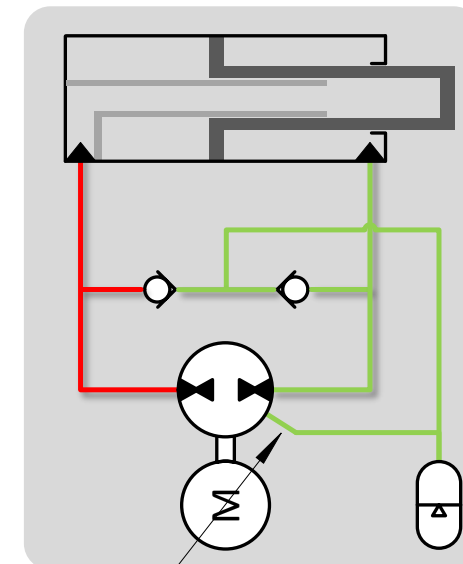


Single Rod Cylinder
with 2 x 2Q EPU



- Var. 2Q speed pump

Multichamber Cylinder
with 4Q EPU



SOLUTION LEVELS

POWER ELECTRONICS

- › Broad portfolio of **centralized and decentralized** servo drives, controllers and other power electronics for cabinets and distributed control architectures
- › Modular (MSD), Digital (DM2020) and Ultra Compact **Single-Axis** (DS2020) and **Multi-Axis** Servo Drive Systems with Safety PLC and GUI to simplify commissioning and monitoring

MSD Series (Modular Multi-Axis Servo Drive System)



- › highest levels of dynamic response, performance and application versatility
- › Modular and single-axis servo drive options with shared power supply (PSU) to coordinate the motion across multiple axes and feedback power to the grid
- › Boost functionality and large power range from 26-360 kW are designed for mid-to large-size applications like EAS-based presses, test benches or hexapods



Solution Level
Pyramid

POWER ELECTRONICS

ENERGY MANAGEMENT

SOFTWARE MODULES



Best-fit
Solution



Modularity



Space
Savings



High
Accuracy

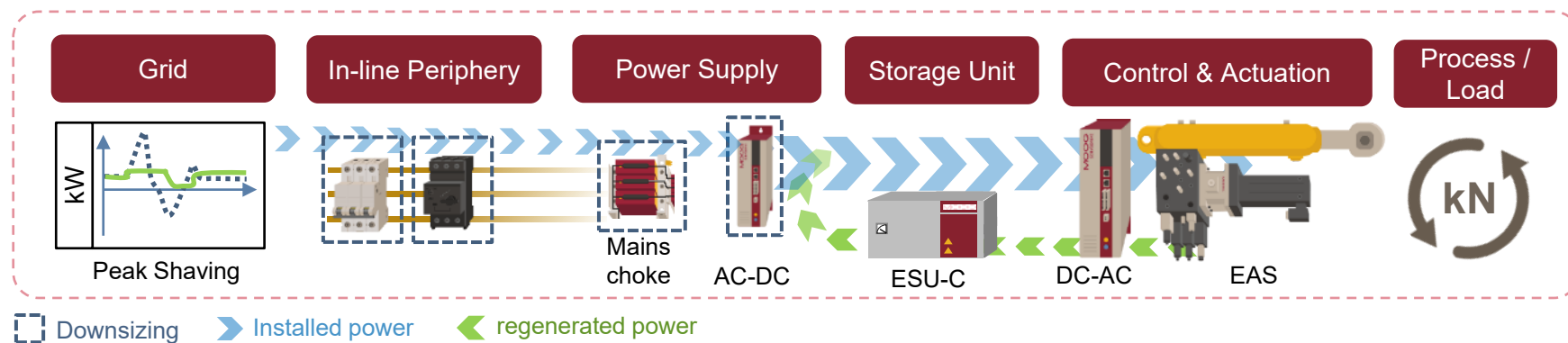


High
Dynamic

SOLUTION LEVELS

ENERGY MANAGEMENT SYSTEM (EMS)

- › 4Q capability of Electrohydrostatic Pump Unit (EPU) with inverter enables **storing and reuse** of regenerative power flows during braking or fluid decompression
- › By using **Energy Storage Units** based on capacitors (ESU-C) dissipated thermal losses at the braking resistor can be recovered.
- › Active **peak shaving** can significantly reduce the peak power requirement and connected load and thus considerably downsize the system periphery / in-feed components



Solution Level
Pyramid

POWER ELECTRONICS

ENERGY MANAGEMENT

SOFTWARE MODULES



Peak
Shaving



Energy reuse



Reduced
installed power



Downsizing
possible



Reduced
costs

SOLUTION LEVELS

SOFTWARE MODULES

- › Long history and experience in developing software solutions for **various applications**
- › Intended as a **function block** to import into PLC applications, e.g. *CODESYS V3.5*, *TwinCAT-3* or *Siemens TIA* environments.
- › **Multiplatform capability** allows users to benefit from the rapidly increasing computing power of their preferred PLC
- › Eliminating the need for a dedicated motion controller can reduce the **variety of fieldbuses**

Moog EAS Control



- › Designed for multi-axis systems in which Electrohydrostatic products are used
- › Variable speed control via position and pressure sensors



Solution Level
Pyramid

POWER ELECTRONICS

ENERGY MANAGEMENT

SOFTWARE MODULES



Reduced
Complexity



Multi-
Plattform



No-code
Solution



IoT ready



Pay-per-
Machine

EPU - ELECTROHYDROSTATIC PUMP UNIT

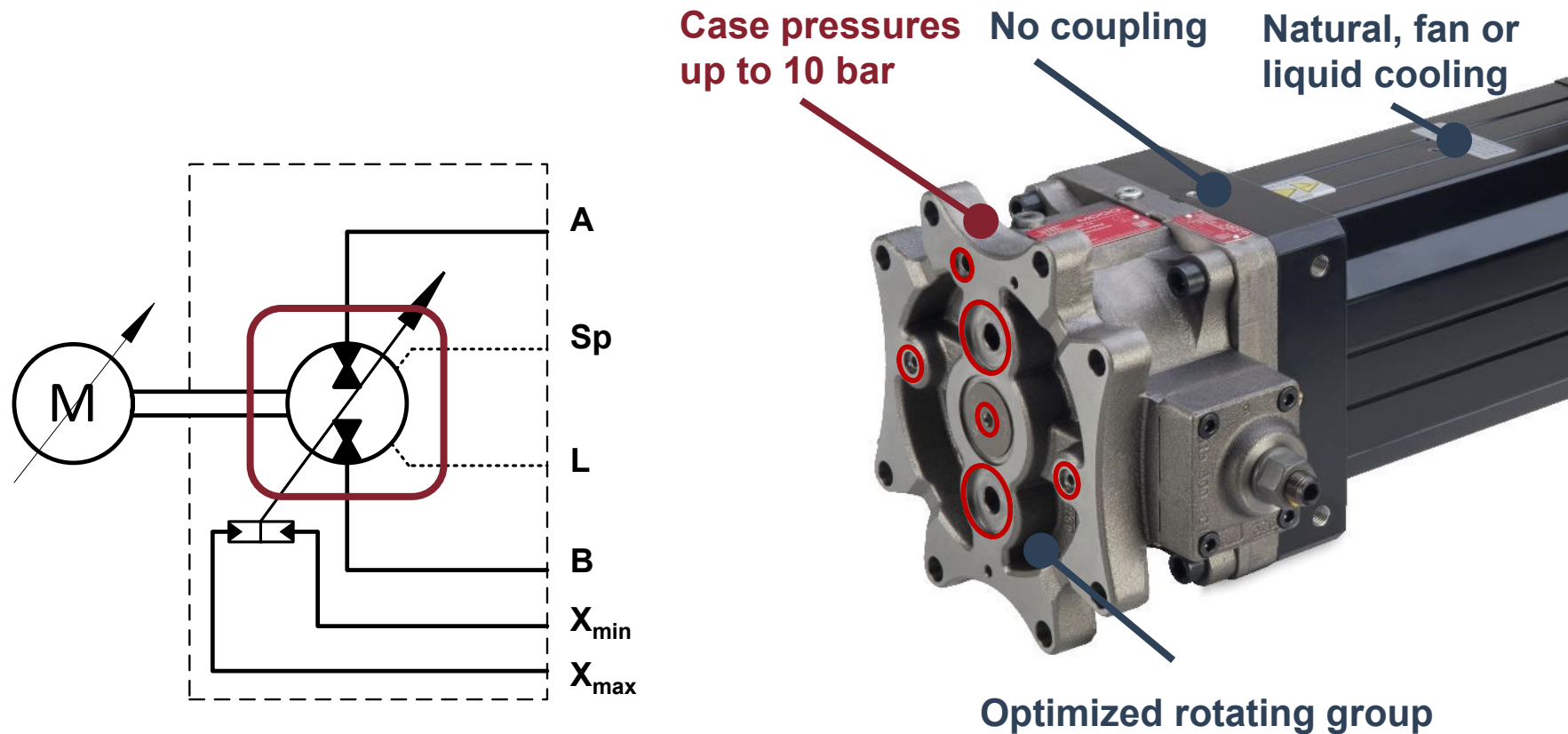
(1) Circuit, Design and Features

(2) Dynamic Response

(3) Building Blocks of EAS



Back



4Q Operation

High Response

High p / Low n

Variable V_p

Flushing

Motor Cooling

Case Pressure

Compact

EPU - ELECTROHYDROSTATIC PUMP UNIT

(1) Circuit, Design and Features

(2) Dynamic Response

(3) Building Blocks of EAS

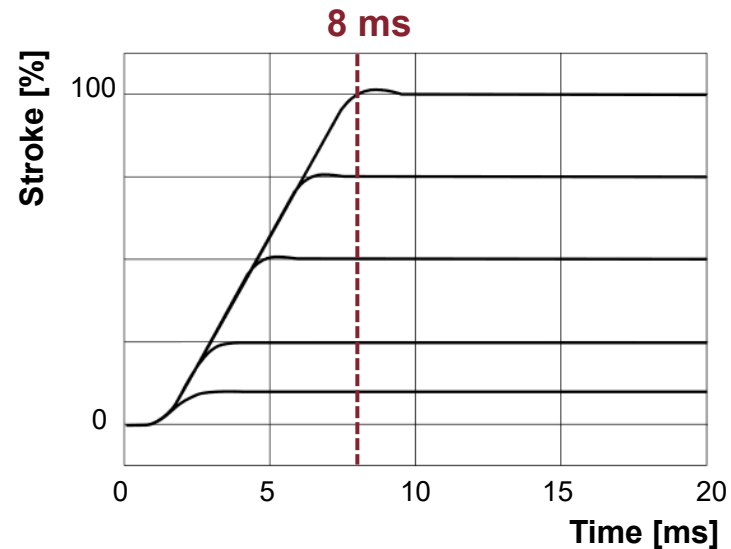
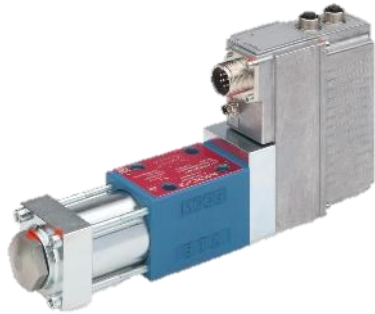


Back

D636 Servo valve

$Q_N = 40 \text{ l/min}$

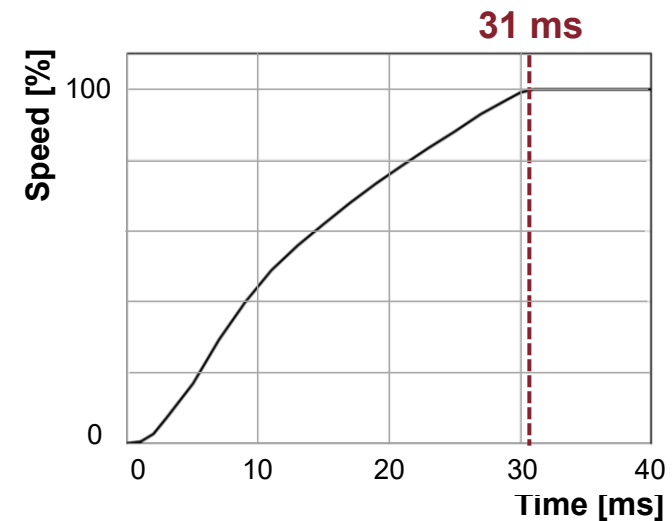
$\Delta p = 35 \text{ bar}$



EPU 19cc

$Q_{\max} = 85 \text{ l/min}$

$n_{\max} = 4.500 \text{ rpm}$



EPU - ELECTROHYDROSTATIC PUMP UNIT

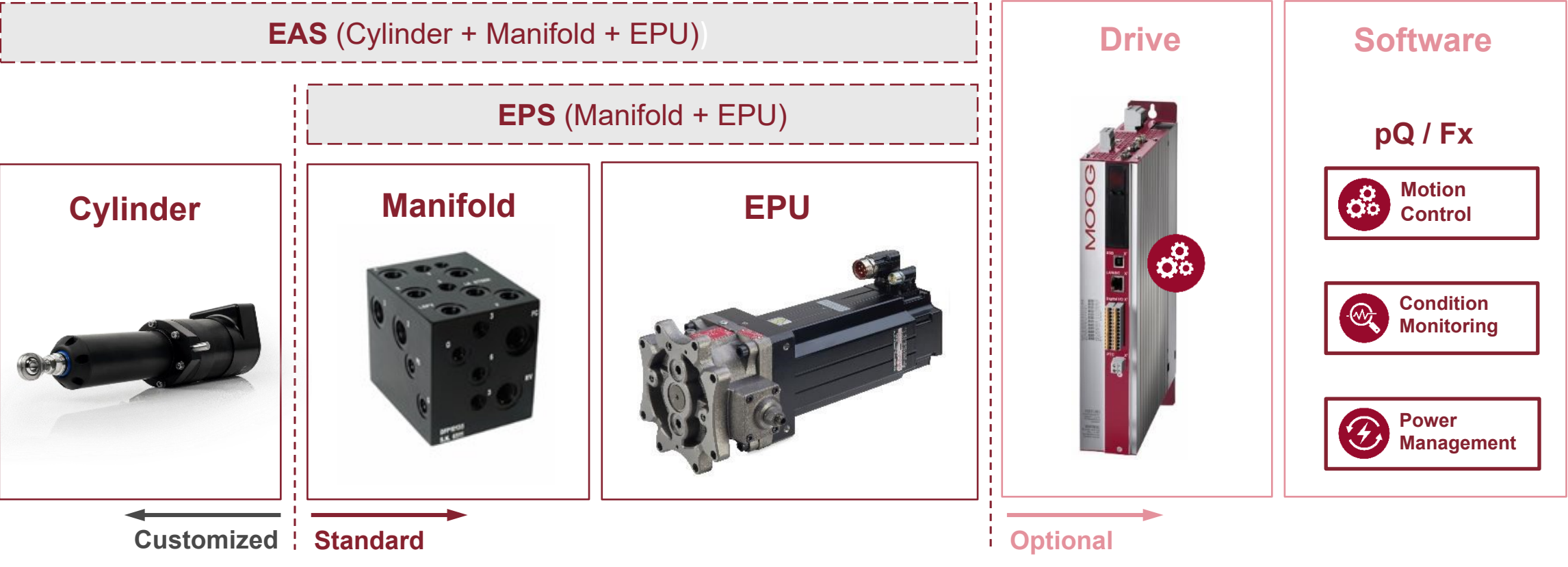
(1) Circuit, Design and Features

(2) Dynamic Response

(3) Building Blocks of EAS



Back



EPS - ELECTROHYDROSTATIC PUMP SYSTEM

(1) Circuit and Components

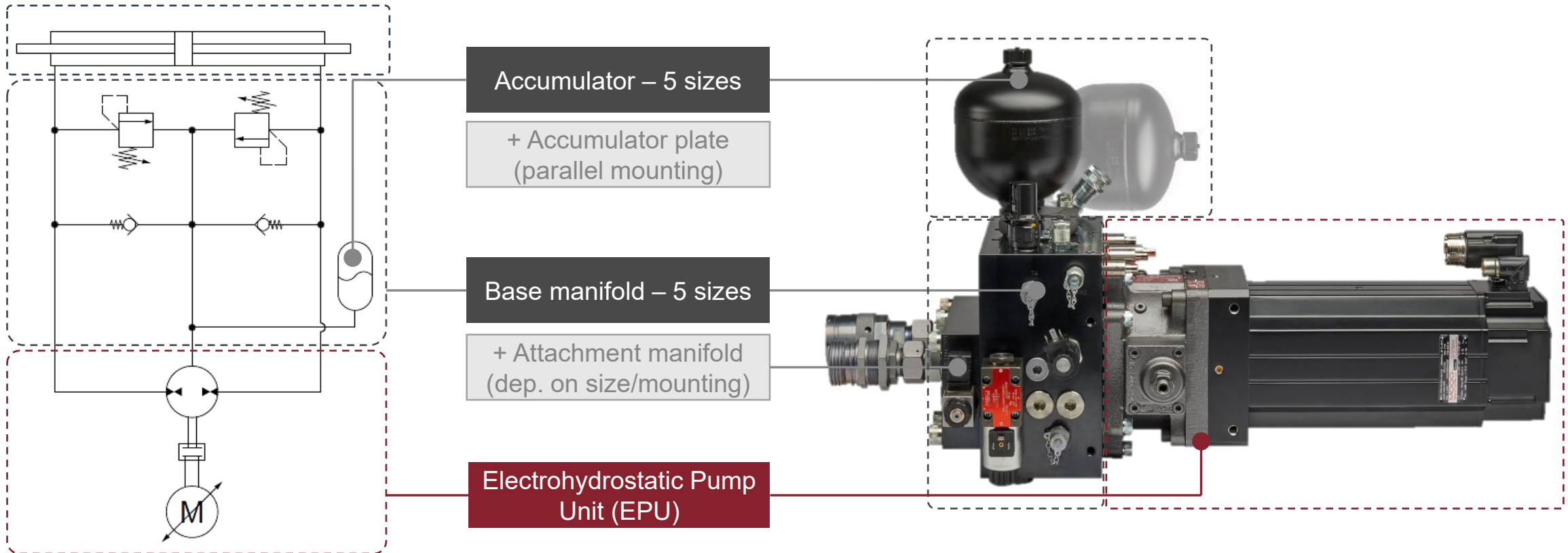
(2) Design and Mounting

(3) System Integration



Back

Double-rod cylinder



EPS - ELECTROHYDROSTATIC PUMP SYSTEM

(1) Circuit and Components

(2) Design and Mounting

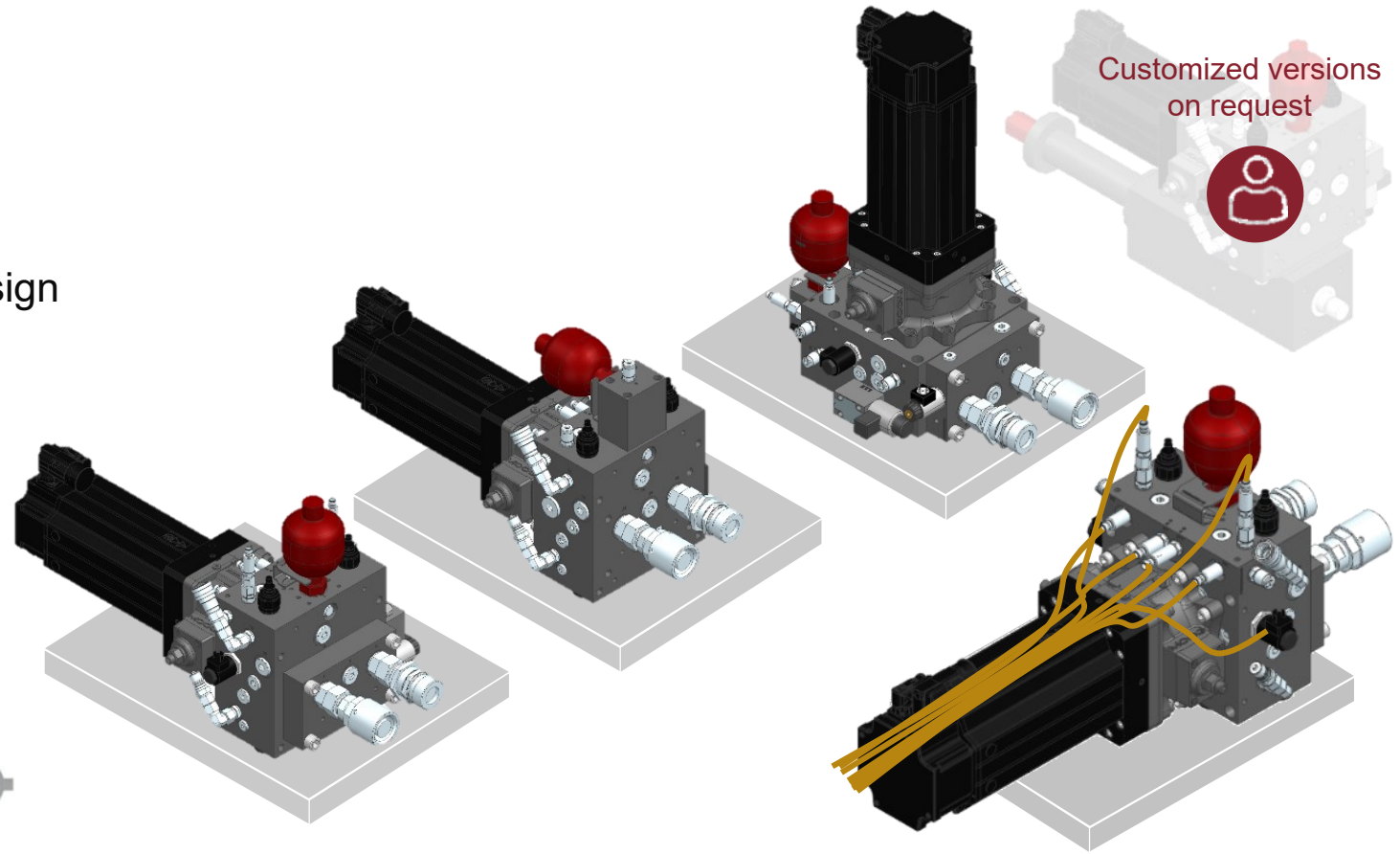
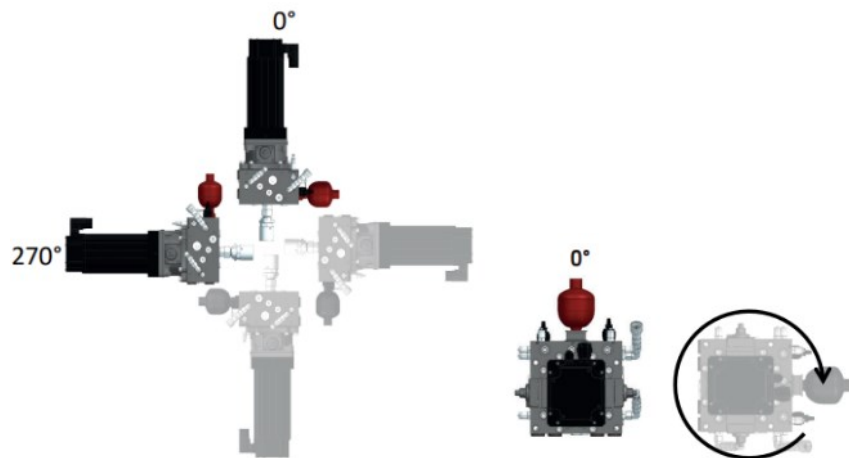
(3) System Integration



[Back](#)

Different mounting options

- › Axial or radial mounting
(parallel or orthogonal to motion axis)
- › Accumulator in parallel or orthogonal design
- › All cables can be bundled



EPS - ELECTROHYDROSTATIC PUMP SYSTEM



Back

(1) Circuit and Design

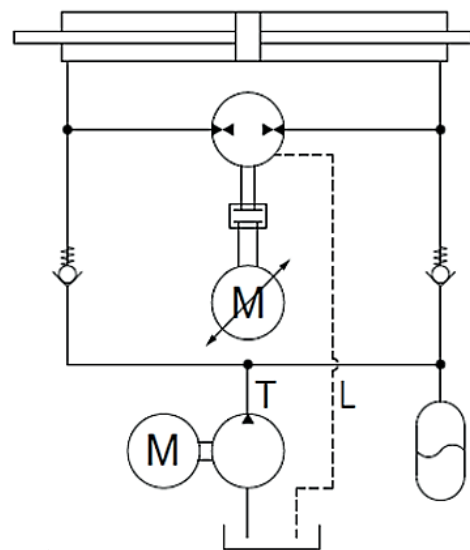
(2) Design and Mounting

(3) System Integration

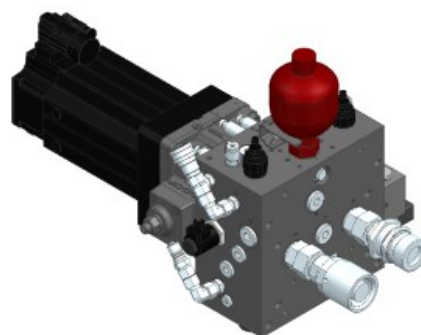


Self-contained System

- › No HPU needed
- › Very compact design

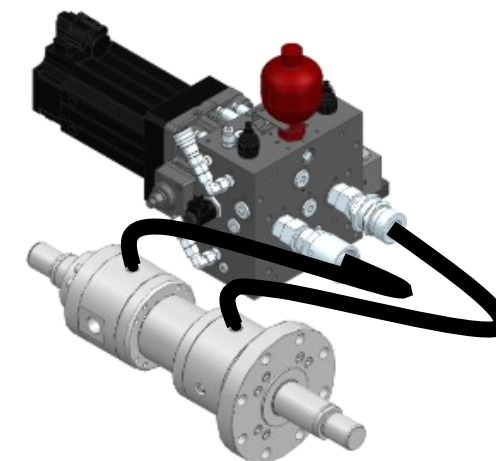
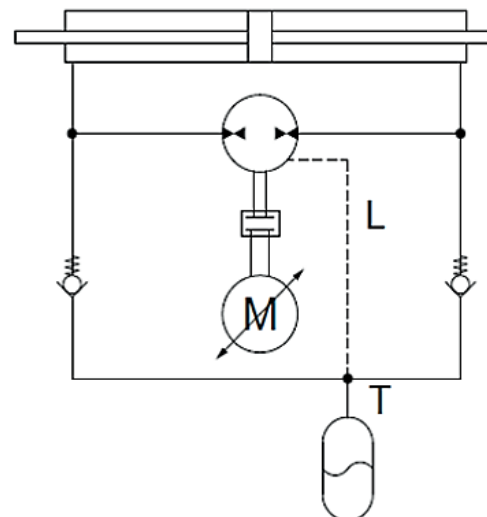


 Brushless servomotor  Var. 4Q speed pump  Accumulator



Half-open system

- › Pre-pressure up to 25 bar
- › Optimal heat transfer



EAS - ELECTROHYDROSTATIC ACTUATION SYSTEM

(1) Circuit and Components

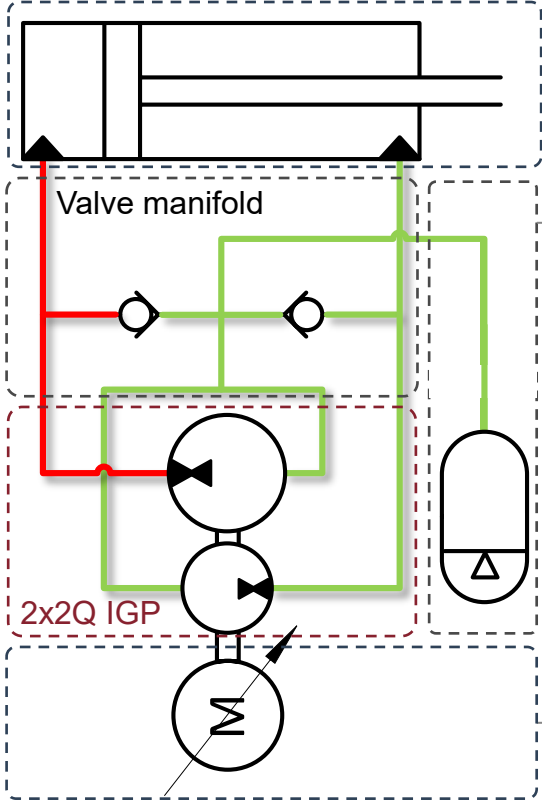
(2) Design and Mounting

(3) Customized design



 Back

Single-rod cylinder



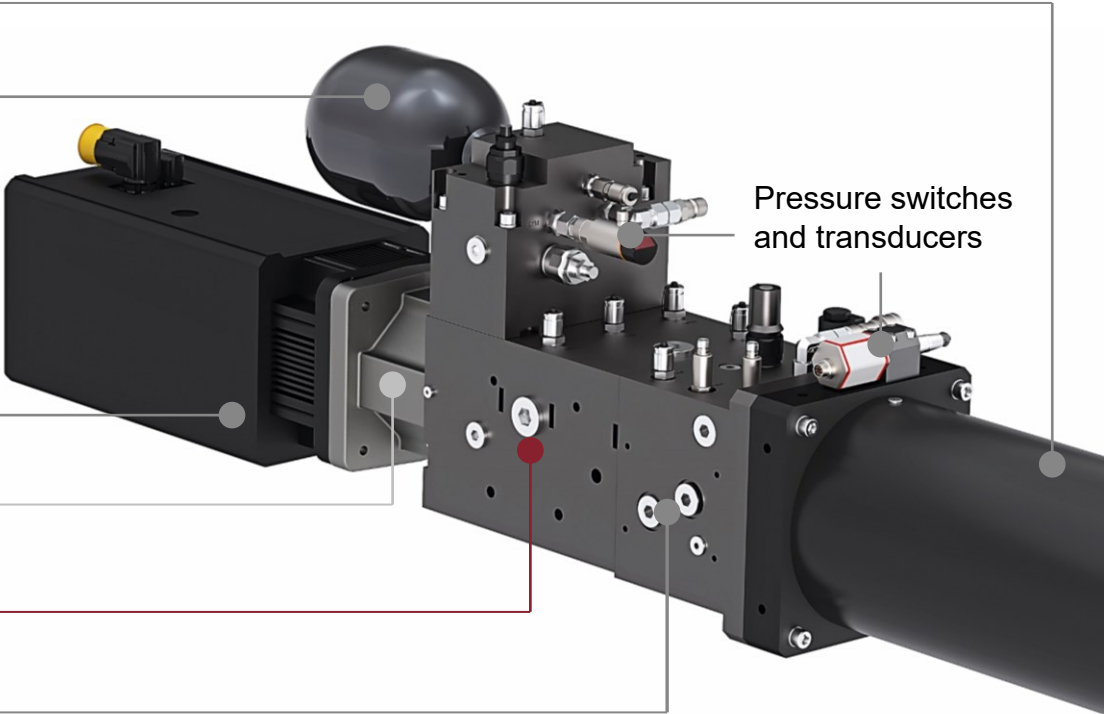
Standard cylinder –
9 sizes up to 100/70

Accumulator – 5 sizes
+ Accumulator manifold

Servo motor – 6 sizes
+ Bellhousing – 2 sizes

2 x 2Q Internal Gear
Pump (IGP) – 5 sizes

Valve manifold – 2 sizes



EAS - ELECTROHYDROSTATIC ACTUATION SYSTEM

(1) Circuit and Components

(2) Design and Mounting

(3) Customized design

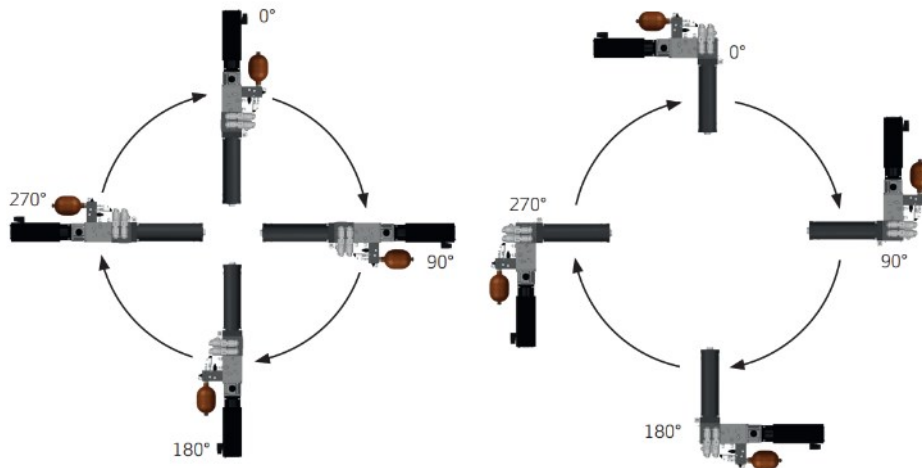
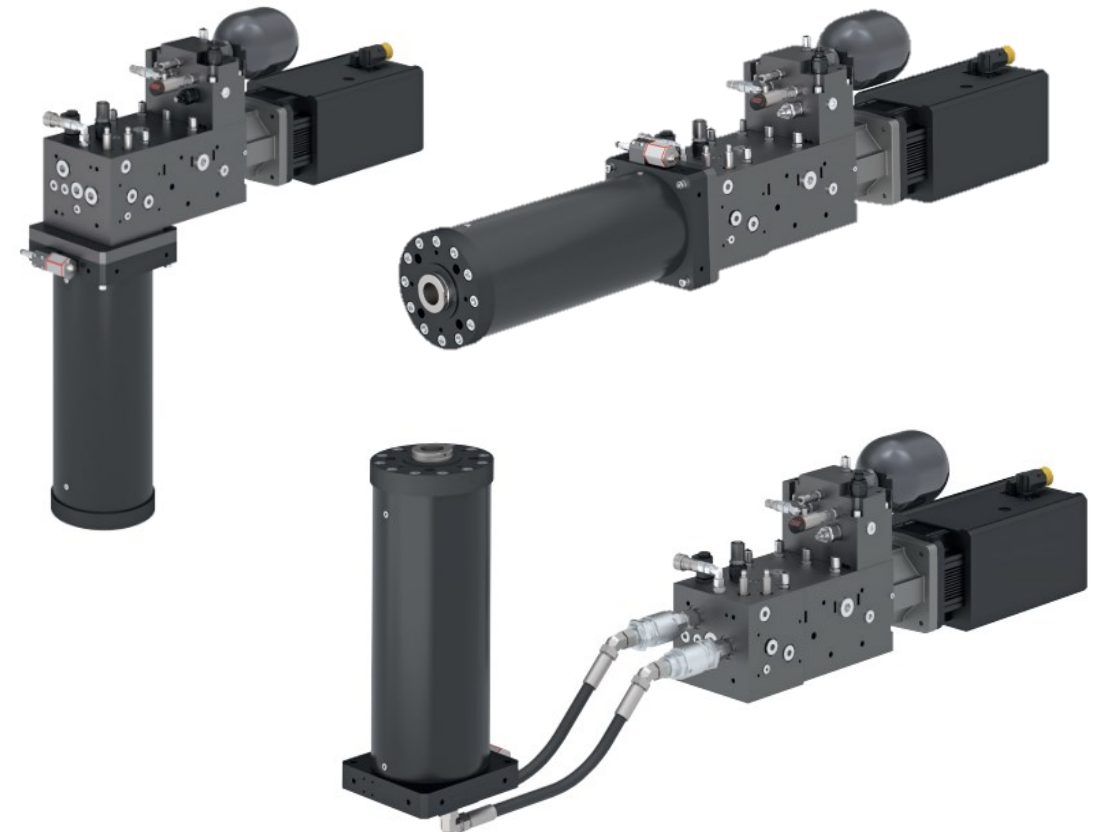


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Linear and Orthogonal as standard

Special Designs

- › developed for use in cramped installation situations
- › extended design options compared to standard series



EAS - ELECTROHYDROSTATIC ACTUATION SYSTEM

(1) Circuit and Components

(2) Design and Mounting

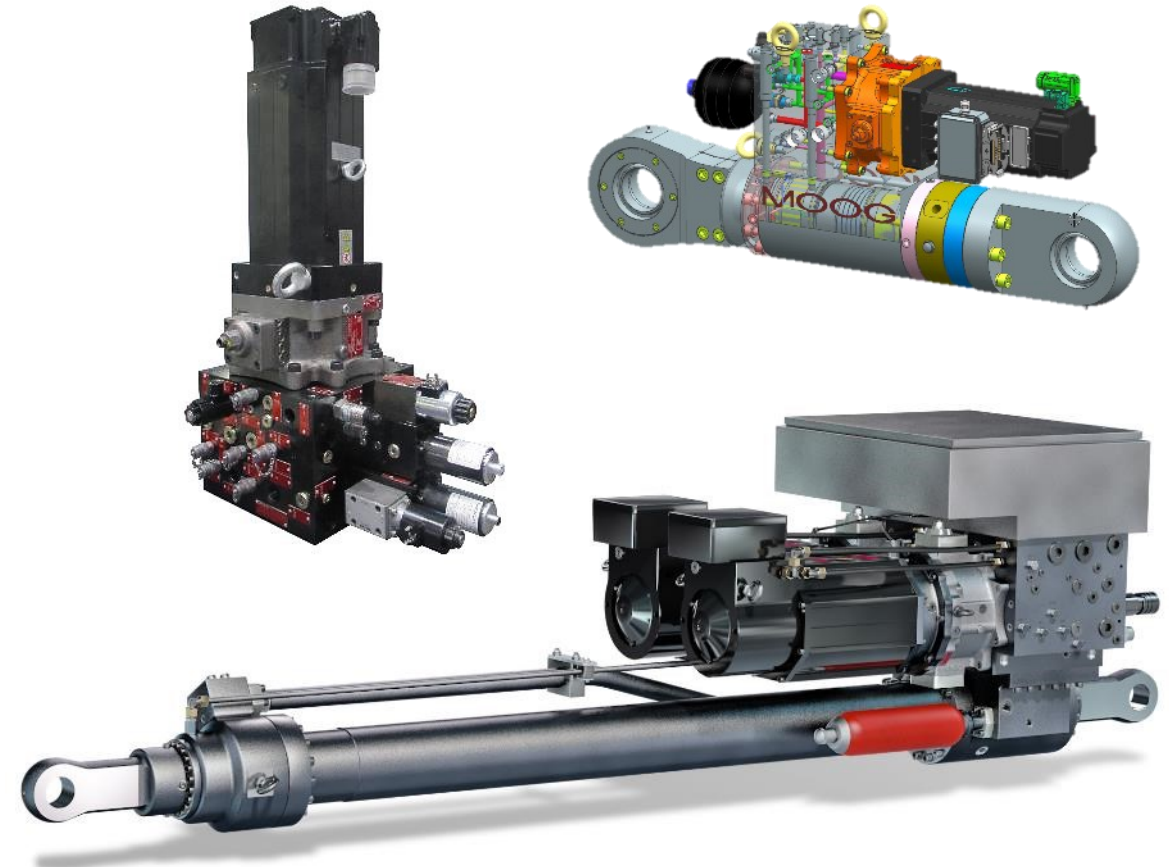
(3) Customized design



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Customized designs

- › Making added value and benefits of EHA technology accessible
- › Tailored to specific applications and customers requirement
- › Integration into retro-fit and new machine generation
- › Standard building blocks enable fast commissioning and easy maintenance
- › Decentralized closed or half-open system eliminates need for large hydraulic power units (HPU)
- › Reduced design, setup and operation costs
= Reduced Total Cost of Ownership (TCO)



CASE STUDY – AMPELMANN



More Details



Key Benefits

- › 90% reduction of connected load (30 kW vs. 300 kW)
- › 80% less hydraulic oil in closed loop (300 l vs. 1,700 l)
- › 35% weight reduction (26 tons vs. 40 tons)
- › 30% space reduction of base (30 sqm vs. 45 sqm)

"Successful performance of a silent system!"

Ampelmann



Moog Electrohydrostatic Actuation System (EAS)



Ampelmann Type-A Gangway with Hexapod base



Type-A Gangway with Moog EAS