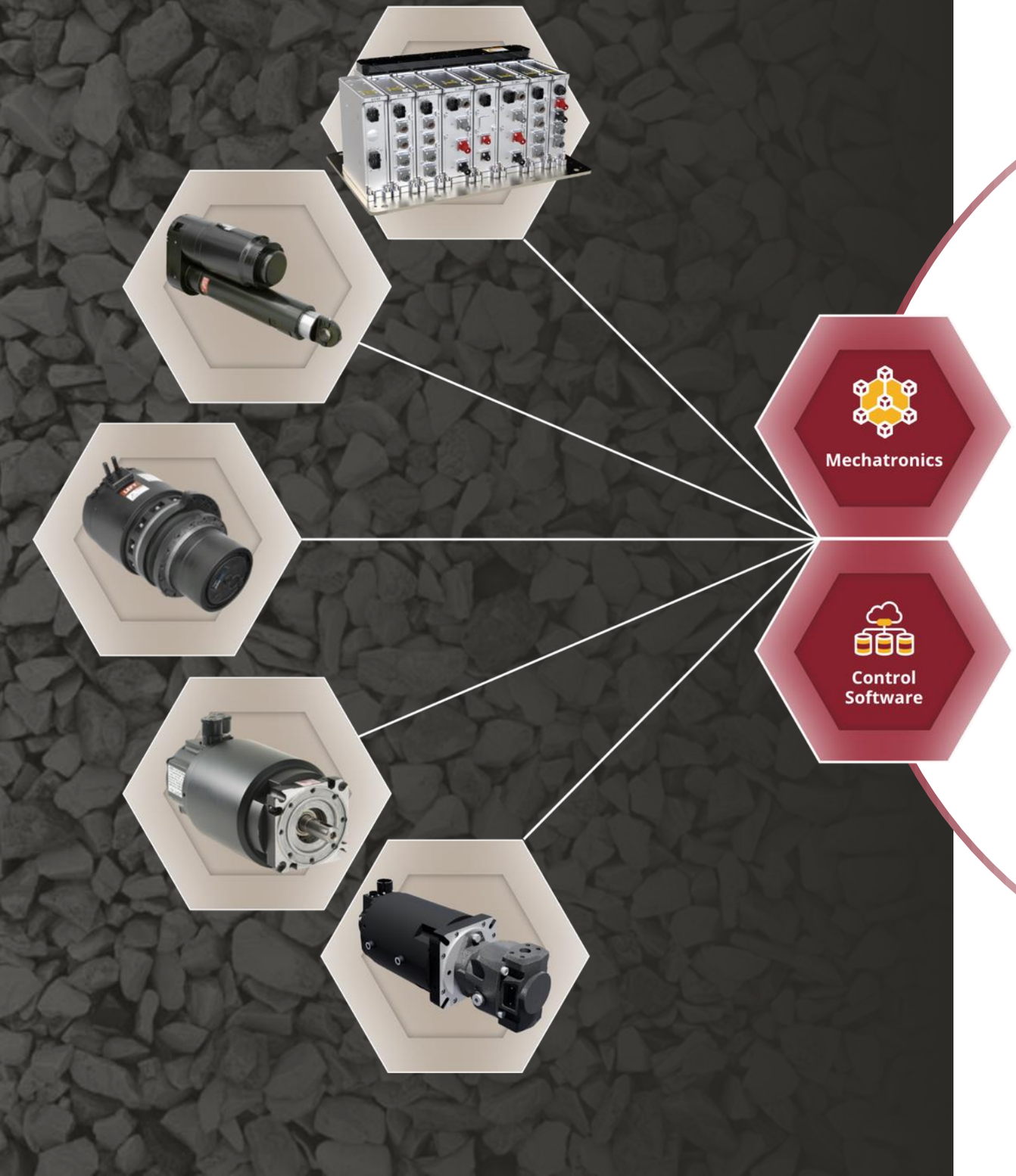
MOOG
CONSTRUCTION



TerraTech

Integrated Intelligence in Motion

Technical Brochure

TerraTech Electrification Ecosystem leverages earth friendly technology to increase productivity and provide better and safer jobs.

Full Electric Motion System Architecture

Scalable. Modular. Configurable.

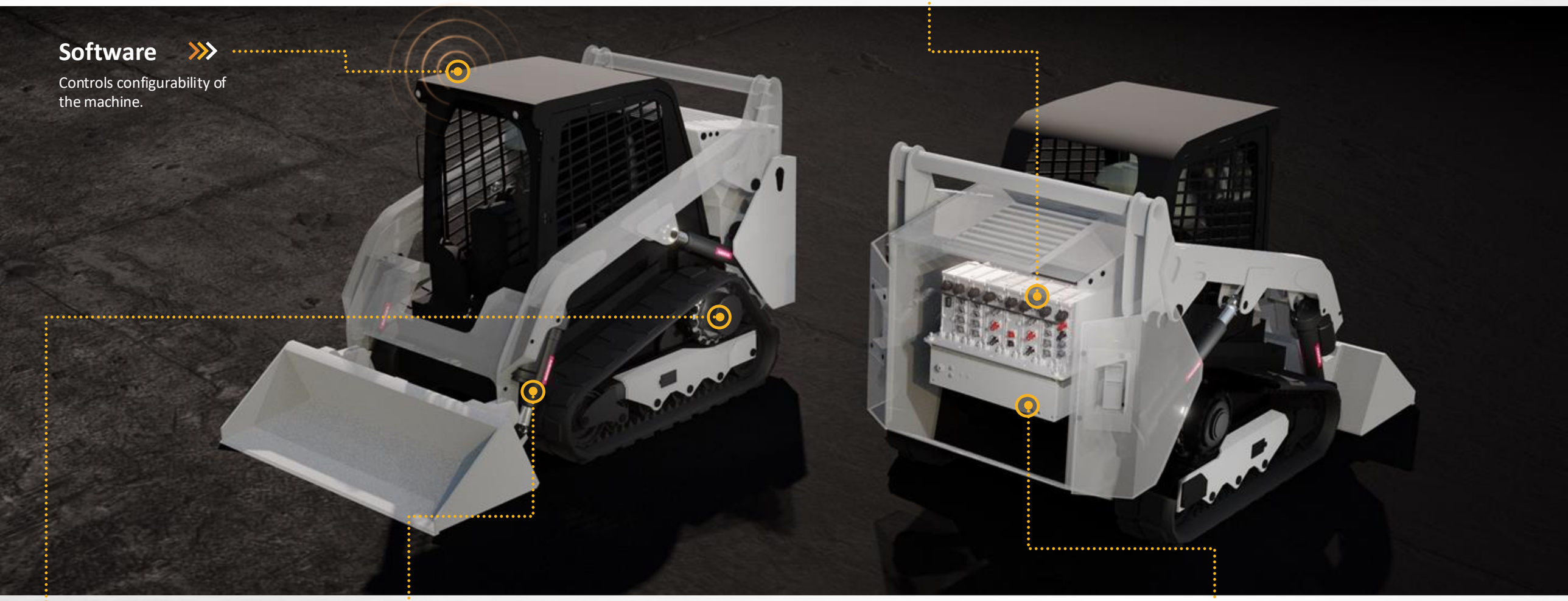
Adaptive Electrification Management System

Central Controller simplifying power management, enabling automated features, and configures component modules.

*Includes Controller, Inverters, High Voltage Distribution, etc.

Software

Controls configurability of the machine.



Traction Motor

Motor and gear assembly designed for **tracked vehicles**.

Electric Cylinder

Linear all electric actuation to replace hydraulic cylinders.

Drive Train Motor*

Electric motor for **wheeled vehicles**.

*Motor not shown in image. Available as needed based on machine architecture.

Battery

Battery and charging system for electric vehicles (Third party manufacturer).

TerraTech
Integrated Intelligence in Motion

Designed, Tested and Manufactured for the Construction Industry

What TerraTech Delivers

Low Cost

Lower Manufacturing and Development Costs:
One integrated solution with configurable software; decreasing component count, streamlining development, lowering production costs.

Decreased Maintenance and Support Costs:
Fewer components and systems to manage, requiring less maintenance and support.

Reusability

Standardized Software and Modular Components: Standardized components and software simplifying solutions for both all-electric and electrohydraulic solutions.

Design, Testing, Qualification, and Deployment:
Adaptive solution streamline development process making it easier and faster to bring new machines to market.

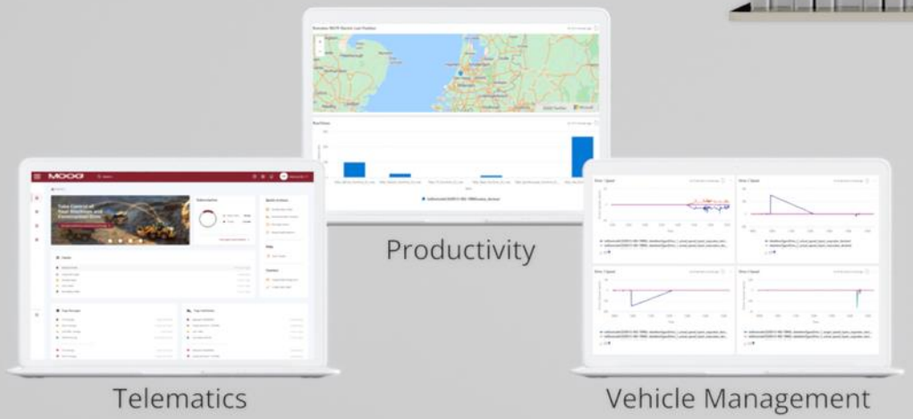
Serviceability

Repair Process:
modular components can be quickly configured and replaced, minimizing downtime and ensuring that operations continue smoothly.

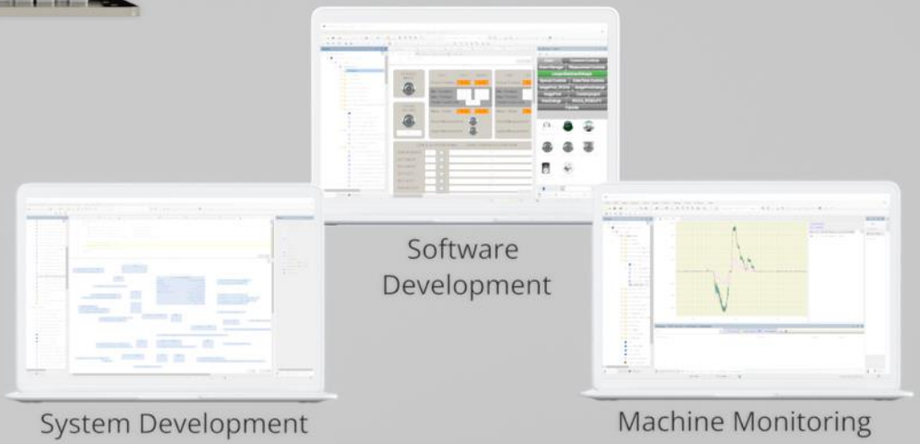
Data Insights and Quick Diagnostics:
Advanced fault detection, vehicle utilization insights, and remote service capabilities.

EVCM With Common Digital and Software Platform for All Your Machines

Digital Insights



Software



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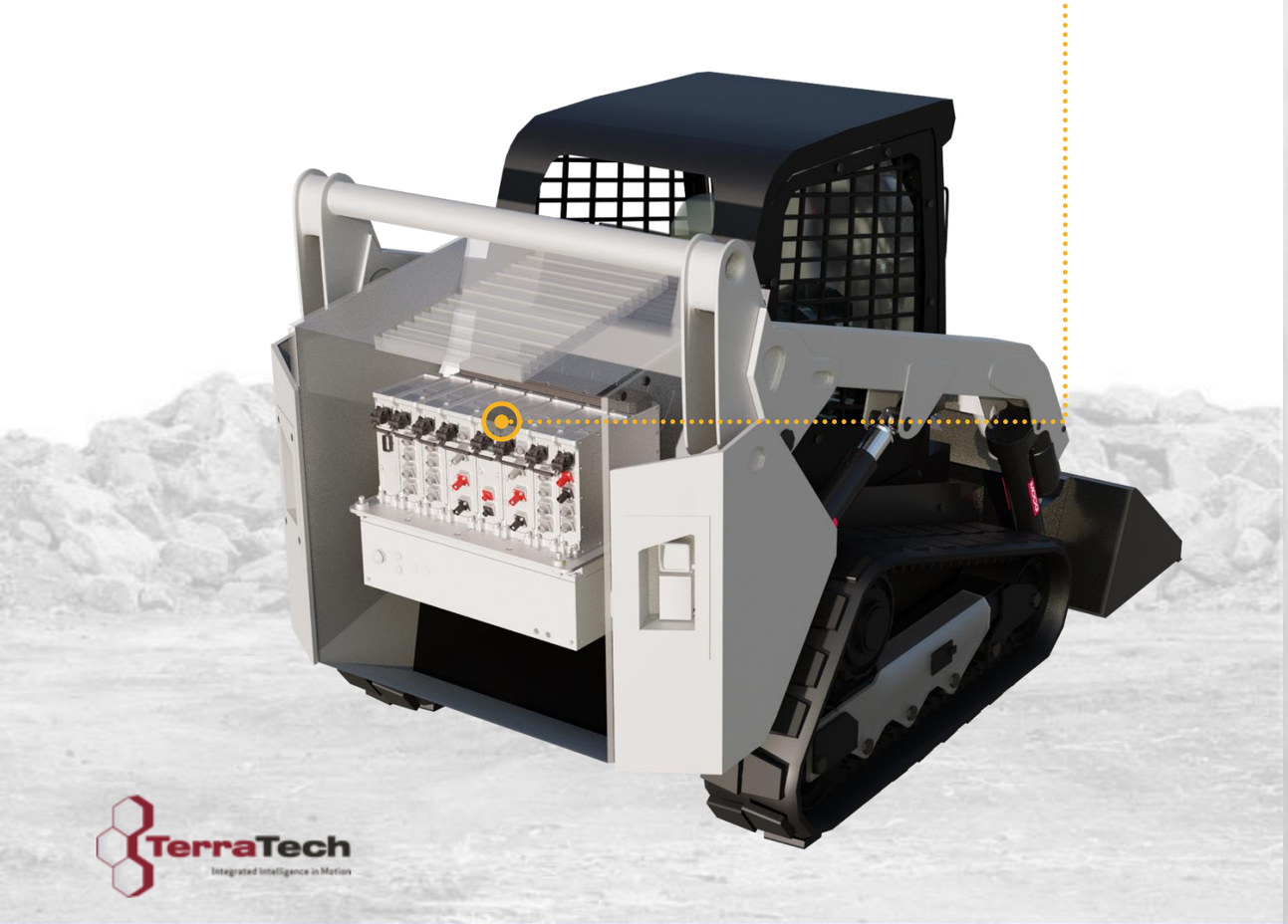
Adaptive Electrification Management System

The Adaptive Electrification Management System by Moog Construction simplifies the power management and control of functions on electric vehicles. It integrates key components, reduces complexity and cost, and can be easily updated. It manages power, enables automated features, and configures component modules for specific applications.



Features

Patented common high voltage busbar & coolant modules	• Reduces cable connections • Increases reliability • Increases efficiency • Reduces component count
Bookcase Architecture	• Minimizes integration time, including pluggable connections • Minimizes costly downtime • Minimizes cost of repair
Designed to meet the highest global standards and regulations	• EMC: ISO 13766, Electrical Safety: ISO 14990, Environmental: ISO 16750 • Tested and verified as a complete system solution, CE, CSA
Optimized voltage ranges	• ISO 21498: Udc nom Unlimited • 400: 270Vdc-480Vdc & 800: 400Vdc-800Vdc • Optimizes system costs • Optimizes system/solution size (compact)
Integrated functionality safety (as optional variant)	Integrated functional safety to Performance Level D in accordance with ISO 13849

Electric Control Module

An electronic component used to control and manage the solution modules.

Features

MOOG Hosted CODESYS Programmable Software*	Allows component configuration and machine differentiation
Fieldbus: CANOpen, J1939	Common vehicle communication protocols
Interfaces: Ethernet, USB, WIFI & Bluetooth, LTE	Diverse vehicle connectivity and communication
General Purpose IO & High Current Outputs	versatility and ability to handle a wide range of input and output operations
Dedicated IO	On board charging and dynamic brake control

*CODESYS® is a registered trademark of 3S0Smart Software Solutions GmbH.

Technical Data

Quiescent current	<1mA
Ambient Temperature Range	-40°C to +70°C
Ingress Protection	IP67, IP6K9K
Weight	<5kg
Vibration & Shock	5.91g & 50g
Dimensions	L:262mm W:72mm H:293mm
Compliance	ISO 13766, ISO 14990, ISO 16750, ISO 13489, CE

High Voltage Distribution Module

An electronic component used to safely distribute high voltage to various auxiliary devices on the vehicle. Excess regenerative energy is also managed within the module.

Features

Common DC Bus interface	Connects all the system modules without needing cables and connectors
Cooling	Reduces number of Liquid cooling lines, while increasing component life
High voltage distribution	Distributes high voltage DC power
Integrated branch fuses	On-board branch fuse protection
Integrated dynamic brake circuit	Removes energy from the system and reduces the number of cables and connections
Configurable options	Insulation monitoring, EMI filtering, battery connections - increases fault detection, ensures reliable electrical signals, can connect to 3rd party high voltage batteries

Technical Data

Input Voltage Range	270Vdc– 800Vdc
Ambient Temperature Range	-40°C to +85°C
Ingress Protection	IP67, IP6K9K
Weight	<10kg
Vibration & Shock	5.91g & 50g
Dimensions	L:358mm W:77mm H:293mm
Compliance	ISO 13766, ISO 14990, ISO 16750

DCDC Converter Module

An electronic component used to convert a high voltage dc supply to a lower 14V or 28V DC output. The DC output is used to power a vehicle's low voltage system.

1. Common High Voltage DC Bus
2. Low Voltage Interface
3. Motor Feedback & Brake Interface
4. Motor Connections
5. Coolant Ports

Features

Common DC Bus interface	Reduces the number of electrical cables and connectors
Common liquid coolant connection	Reduces number of Liquid cooling lines, while increasing component life
Fieldbus control & monitoring	Supports status monitoring and output voltage control via fieldbus
Output reverse polarity protection	Allows the system to withstand a reversed battery connection
Pluggable connections	Optimized integration and ease of use
ASIL compliant	Increased human/vehicle safety

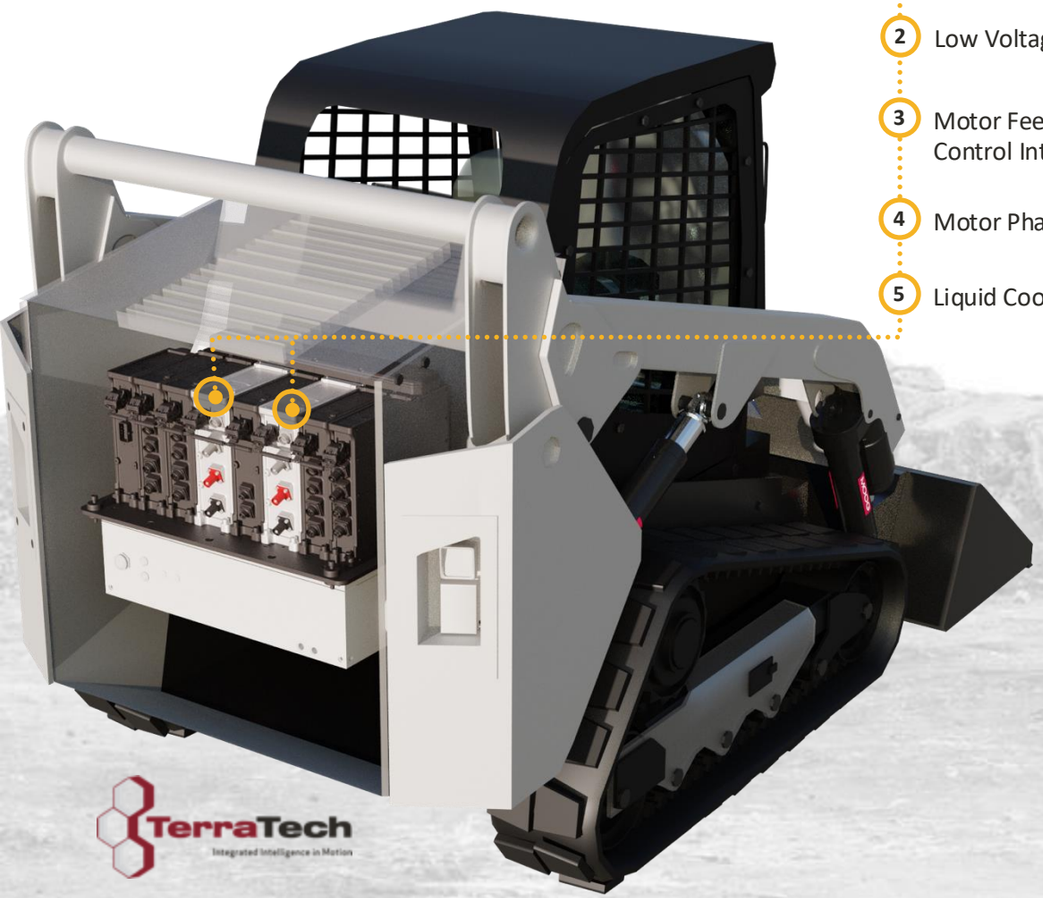
Technical Data

Input Voltage Range	**400:** 270 VDC-480 VDC **800:** 400 VDC – 800VDC
Output	14 VDC/130 A 28 VDC/ ??
Ambient Temperature Range	-40°C to +85°C
Ingress Protection	IP67, IP6K9K
Weight	<7kg
Vibration & Shock	5.91g & 50g
Dimensions	L:358mm W:77mm H:293mm
Compliance	ISO 13766, ISO 14990, ISO 16750, CE

Single Axis Inverter Module

An electronic component used to invert a high voltage dc supply to a variable amplitude and frequency, AC output. The AC output is used to control the torque and speed of a single 3-phase motor.

1. Common High Voltage DC Bus
2. Low Voltage Interface
3. Motor Feedback & Brake Control Interface
4. Motor Phase Connections
5. Liquid Coolant Ports



Features

Common DC Bus interface	Distributes high voltage power among modules, while Reducing electrical cables and connectors
Common liquid coolant connection	Increases component life while reducing number of Liquid cooling lines
Combined motor brake and motor feedback interface	Reduces the number of electrical cables, connectors, and electric modules
Pluggable connections	Optimized integration and ease of use
Advanced Diagnostic Tools\Fault Detection	Optimized service capabilities
Integrated functional safety	Increased vehicle/human safety

Technical Data

Input Voltage Range	**400:** 270Vdc-480Vdc **800:** 400Vdc – 800Vdc
Output Current	128Arms\256Apk
Ambient Temperature Range	-40°C to +85°C
Ingress Protection	IP67, IP6K9K
Weight	<10kg
Vibration & Shock	5.91g & 50g
Dimensions	L:358mm W:77mm H:293mm
Compliance	ISO 13766, ISO 14990, ISO 16750, ISO 13489, CE

Dual Axis Inverter Module

An electronic component used to invert a high voltage dc supply to a variable amplitude and frequency, AC output. The AC output is used to control the torque and speed of two independent 3-phase motors.

1. Common High Voltage DC Bus
2. Low Voltage Interface
3. Motor Feedback & Brake Interface
4. Motor Phase Connections
5. Liquid Coolant Ports

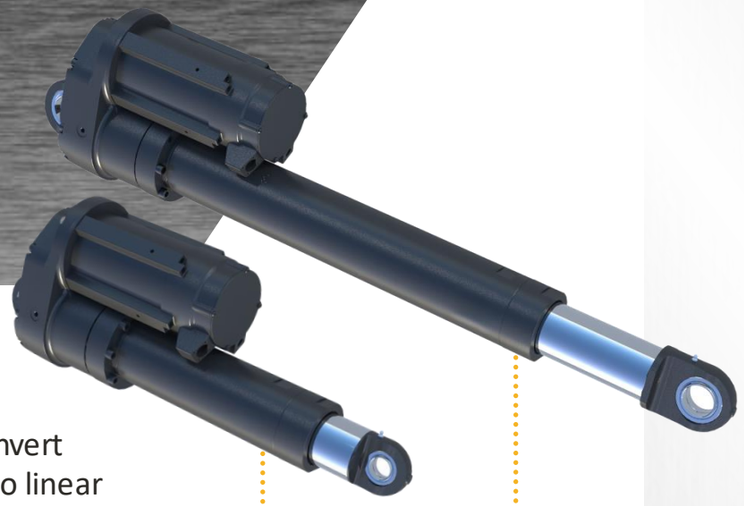
Features

Dual Axes	Provides power to two lower control axes for a compact solution
Common DC Bus interface	Distributes high voltage power among modules, while reducing electrical cables and connectors
Common liquid coolant connection	Reduces number of Liquid cooling lines, while increasing component life
Combined motor brake and motor feedback interface	Reduces the number of electrical cables, connectors, and electric modules
Brake Bypass functionality	Supports the use of a dynamic brake to remove energy from the system
Advanced Diagnostic Tools\Fault Detection	Optimized service capabilities
Integrated functional safety	Increased vehicle/human safety
Pluggable connections	Optimized integration and ease of use

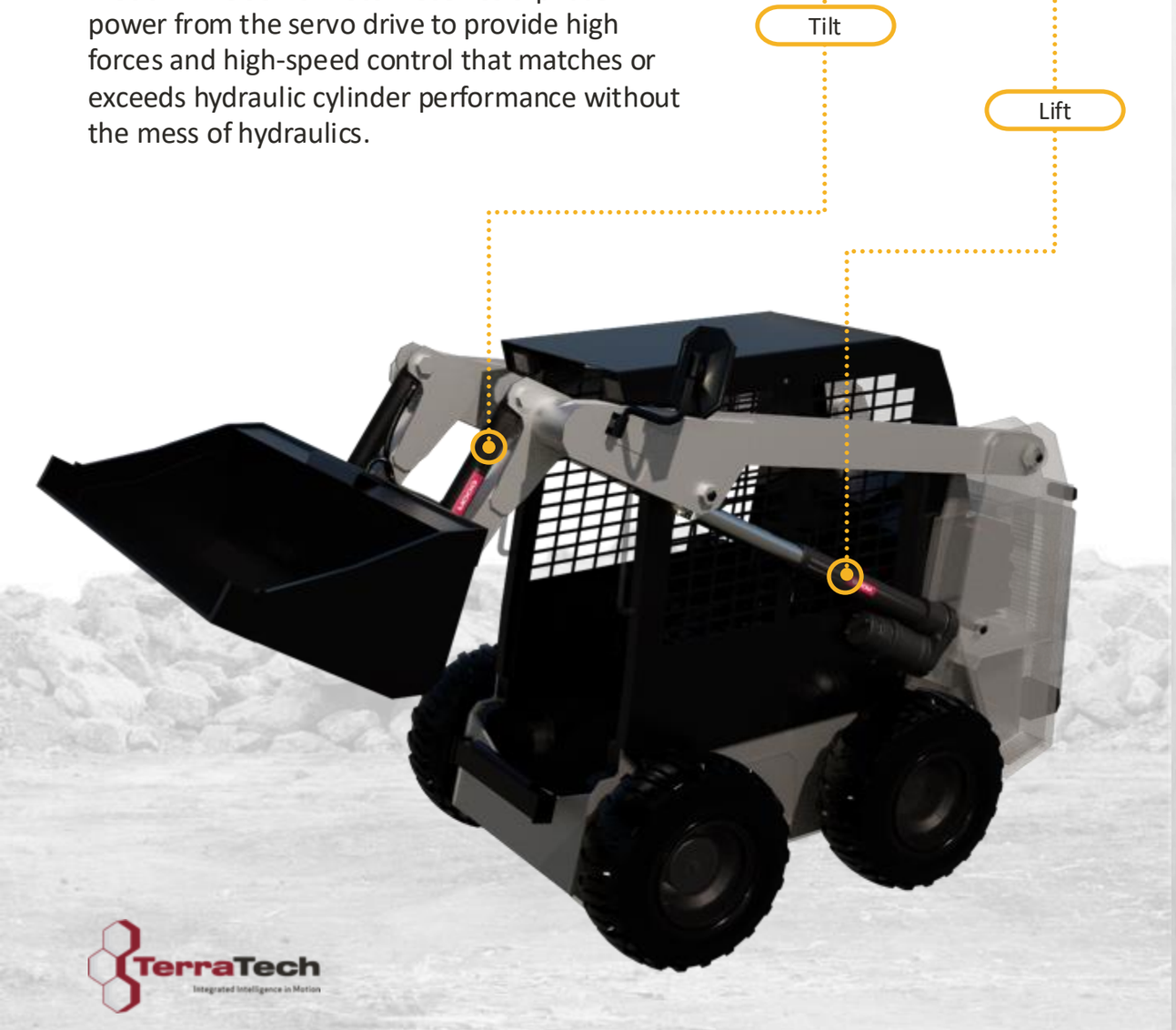
Technical Data

Input Voltage Range	**400:** 270Vdc-480Vdc **800:** 400Vdc – 800Vdc
Output Current	2x 32Arms\96Apk
Ambient Temperature Range	-40°C to +85°C
Ingress Protection	IP67, IP6K9K
Weight	<10kg
Vibration & Shock	5.91g & 50g
Dimensions	L:358mm W:77mm H:293mm
Compliance	ISO 13766, ISO 14990, ISO 16750, ISO 13489, CE

Electric Cylinder

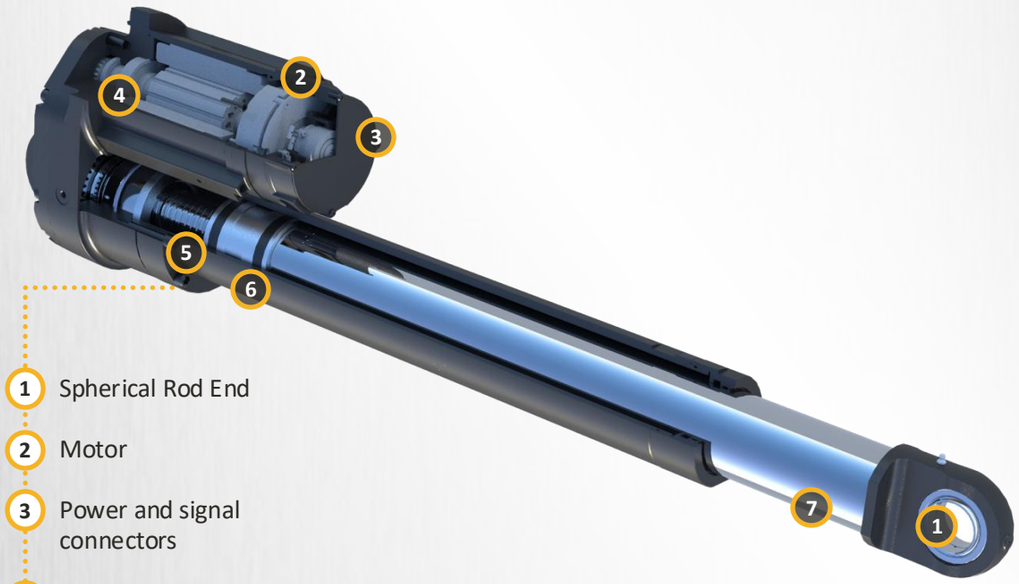


Electric cylinders, also known as Electromechanical Actuators (EMAs), convert the rotary motion of the servo motor into linear motion. The servo motor receives 3-phase power from the servo drive to provide high forces and high-speed control that matches or exceeds hydraulic cylinder performance without the mess of hydraulics.



Features	
Flexible Configurations	Ability to modify standard series to meet performance requirements.
Variable Stroke Lengths	Capable of meeting the pin-to-pin requirements of the machine and motion envelope requirements.
Sensors	Resolver or absolute multiturn encoder provides actuator speed and position. Thermistor monitors internal motor temperature.
Load Holding Brake	Integrated load holding brakes provide load holding capabilities of vertical loads for safety and energy saving purposes.
Equal Extend and Retract Force	Peak forces are the same during both extension and retraction, unlike in a single rod hydraulic cylinder.
Efficient Design	High efficiency decreases total energy usage and leads to longer battery life.
Designed for Cost	A simplified design lowering production cost

Sectional View of an Electric Cylinder

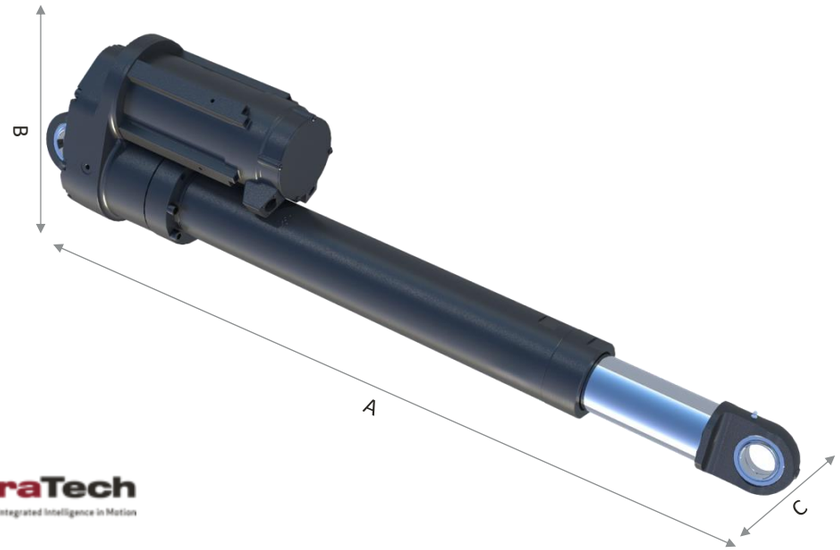


1. Spherical Rod End
2. Motor
3. Power and signal connectors
4. Gearbox
5. Ball screw
6. Nut
7. Rod

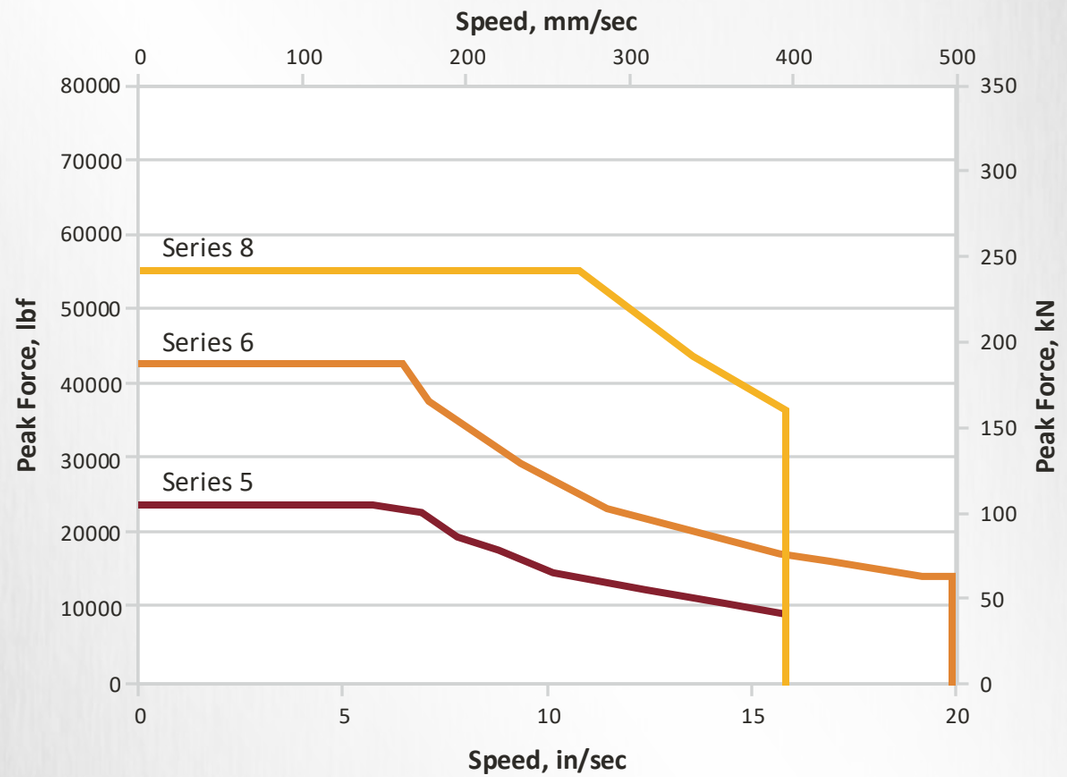
Electric Cylinder

General Performance Capabilities

Specifications	Series 5	Series 6	Series 8
Peak Force (Extend & Retract)	106 kN (23,830 lbf)	190 kN (55,980 lbf)	249 kN (55,980 lbf)
No Load Speed mm/s (in/s)	400 (16)	500 (20)	400 (16)
A Length mm (in)	515 + Stroke (20.3 + Stroke)	508 + Stroke (20 + Stroke)	732 + Stroke (28.8 + Stroke)
B Length mm (in)	354 mm (13.9)	388 mm (15.3)	544 mm (21.4)
C Length mm (in)	162 mm (6.4)	210 mm (8.3)	270 mm (10.6)
Operating Voltage	400V - 800V		
Shock and Vibration	50g, 6g		
Environmental Ratings	IP66 & IP67 (Protected against hose down and temporary immersion) -40°C to +85°C (Ambient temperature)		



Speed Force Curve



Traction Drive Assembly

Features

Flexible Configurations	Ability to modify standard series to meet performance requirements.
Sensors	Resolver or absolute multiturn encoder provides actuator speed and position. Thermistor monitors internal motor temperature.
Load Holding Brake	Integrated load holding brakes provide load holding capabilities.
Thermal Protection	Thermistor monitors internal motor temperature to prevent overheating.
Liquid Cooled	Liquid cooling increases the life and longevity of the traction motor.

1. Motor
2. Internal Brake
3. Gearbox
4. 3 Phase Power Connectors
5. Coolant Ports

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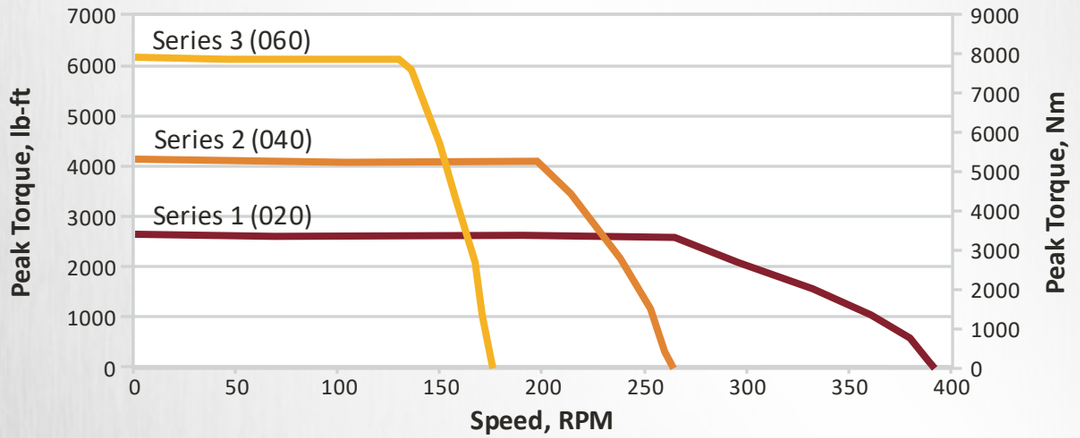
General Performance Capabilities

Specifications	Series 1	Series 2	Series 3
Peak Torque	3,566 Nm (2,630 lb-ft)	5,586 Nm (4,120 lb-ft)	8,379 Nm (6,180 lb-ft)
Max No Load Speed	390 RPM	260 RPM	175 RPM
D - Flange	285 mm (11.2)	285 mm (11.2)	285 mm (11.2)
L1 – Total Length mm (in)	478 mm (18.8)	529 mm (20.8)	579 mm (22.8)
L2 – Brake & Gearbox Length mm (in)	228 mm (9.0)	228 mm (9.0)	228 mm (9.0)
Operating Voltage	400V - 800V		
Shock and Vibration	50g, 6g		
Environmental Ratings	IP66 & IP67 (Protected against hose down and temporary immersion) -40°C to +85°C (Ambient temperature)		

Speed Torque Curve



Drive Train Motor

1. Stator
2. Rotor Shaft
3. 3 Phase Power Connection
4. Coolant Ports

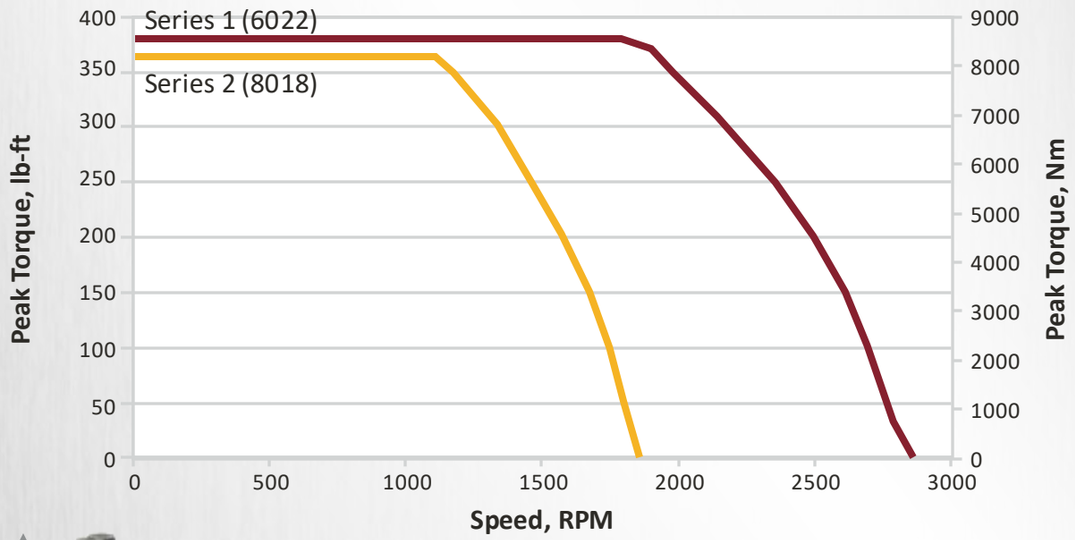
Features

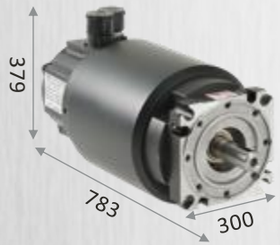
Flexible Configurations	Ability to modify standard series to meet performance requirements.
Sensors	Resolver or absolute multiturn encoder provides actuator speed and position. Thermistor monitors internal motor temperature.
Load Holding Brake	Integrated load holding brakes provide load holding capabilities.
Thermal Protection	Thermistor monitors internal motor temperature to prevent overheating.
Liquid Cooled	Liquid cooling increases the life and longevity of the traction motor.

General Performance Capabilities

Specifications	Series 1	Series 2
Peak Torque	515 Nm (380 lb-ft)	735 Nm (542 lb-ft)
Max No Load Speed	2850 RPM	1850 RPM
A Length mm (in)	732 mm (28.8)	783 mm (30.8)
B Length mm (in)	379 mm (14.9)	379 mm (14.9)
C Length mm (in)	300 mm (11.8)	300 mm (11.8)
Operating Voltage	400V - 800V	
Shock and Vibration	50g, 6g	
Environmental Ratings	IP66 & IP67 (Protected against hose down and temporary immersion) -40°C to +85°C (Ambient temperature)	

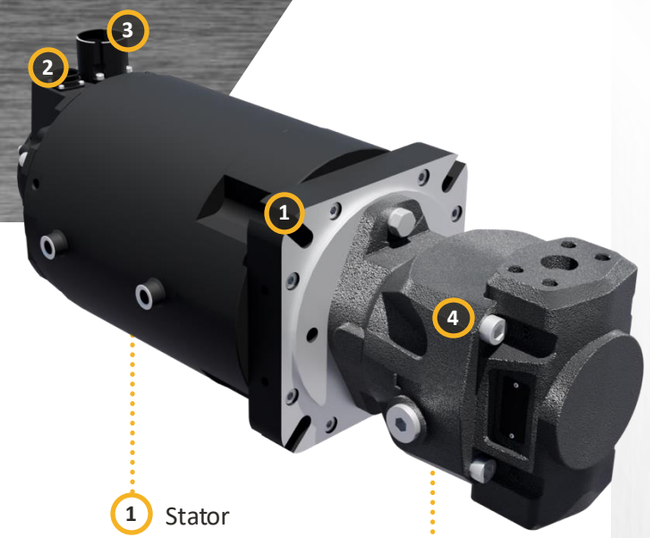
Speed Torque Curve





Pump Drive Motor

Pump drive motors convert electrical energy into mechanical energy that then drives a hydraulic pump. The servo motor receives 3-phase power from the inverter to provide immediate and efficient power to the hydraulic pump, unlike a diesel engine.



1. Stator
2. 3 Phase Power Connection
3. Coolant Ports
4. Pump

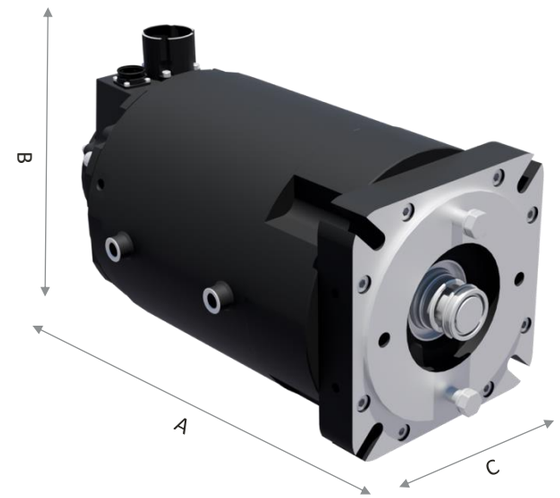
Features

Flexible Configurations	Ability to modify standard series to meet performance requirements.
Standard Pump Mount Configurations	Integrated pump mounting flange for ISO 3019-1 and ISO 3019-2 2-Bolt and 4-Bolt mounting dimensions
Sensors	Resolver or absolute multiturn encoder provides pump speed and position. Thermistor monitors internal motor temperature.
Load Holding Brake	Integrated load holding brakes provide load holding capabilities.
Thermal Protection	Thermistor monitors internal motor temperature to prevent overheating.
Liquid Cooled	Liquid cooling increases the life and longevity of the traction motor.

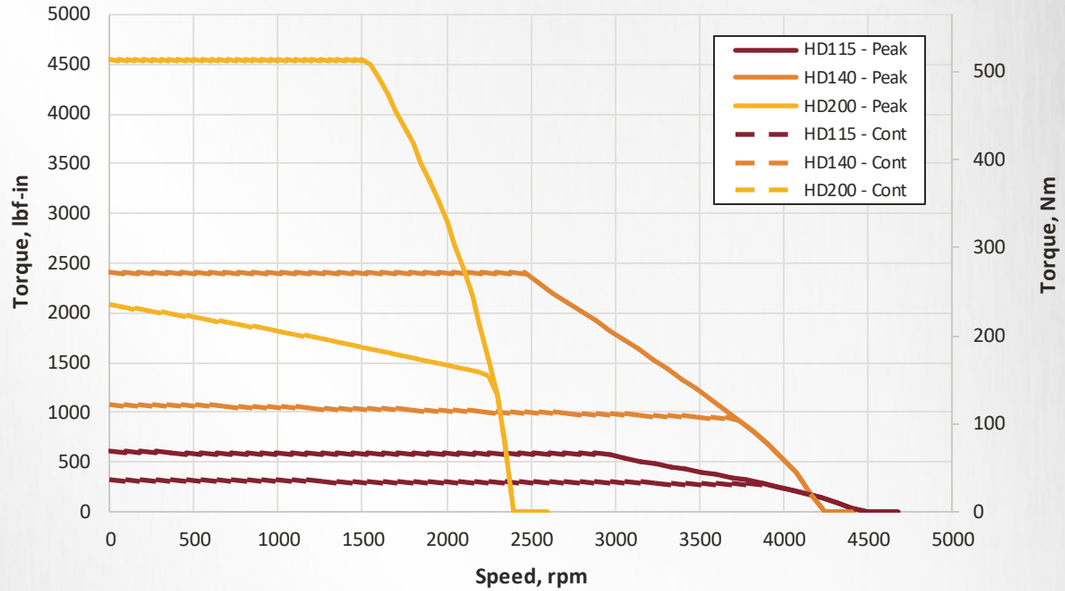
Pump Drive Motor

General Performance Capabilities

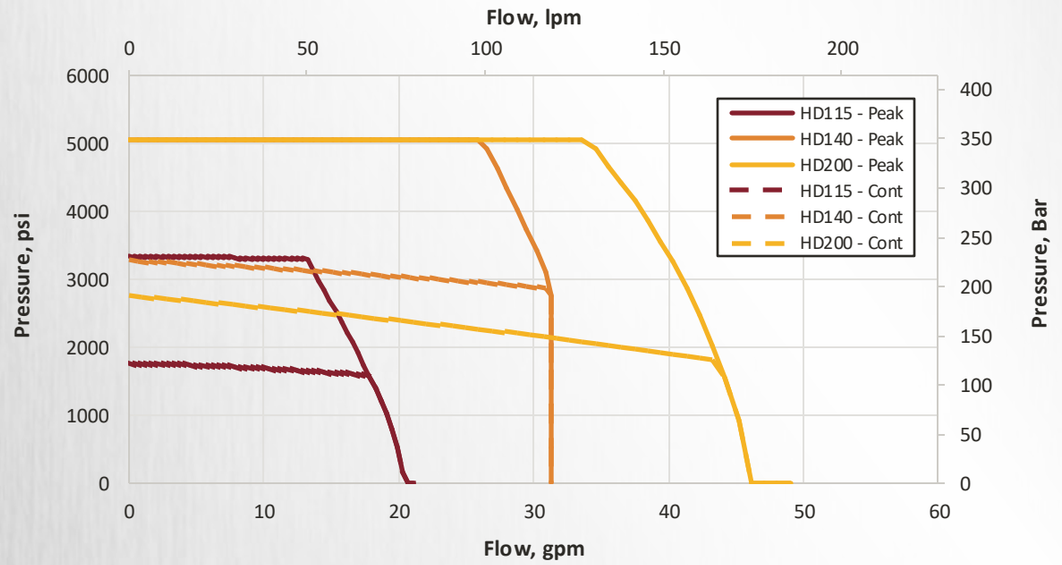
Specifications	HD115	HD140	HD200
Peak Torque* Nm (lb-ft)	68 Nm (602 lb-ft)	182 Nm (725 lb-ft)	513 Nm (4544 lb-ft)
Max No Load Speed* RPM	7700 4500	5030 4750	4460 2400
A Length mm (in)	130 (5.11)	165 (6.50)	215 (8.46)
B Length mm (in)	167 - 253 (6.57 - 9.96)	209 - 263 (8.23 - 10.35)	275 - 426 (10.83 - 16.77)
C Length mm (in)	149 (5.87)	199 (7.83)	252 (9.92)
Operating Voltage	400V - 800V		
Shock and Vibration	50g, 6g		
Environmental Ratings	IP66 & IP67 (Protected against hose down and temporary immersion) -40°C to +85°C (Ambient temperature)		



Motor Speed Torque Capabilities Curve*



Hydraulic Pump Flow Pressure Capabilities Curve*



Scalability Across Machine Types & Sizes

Scalable. Modular. Configurable.

Configurable Software Environment

Figure 1 | **Configurable Software in Device Tree and Display Editor**

MOOG provides a developed and field-tested functions Library/Toolbox for fast development and implementation of vehicle control and automated functionality.

- Vehicle Kinematics
- Actuator Protection
- Traction Control
- Power Management
- Thermal Management
- Advanced Diagnostics

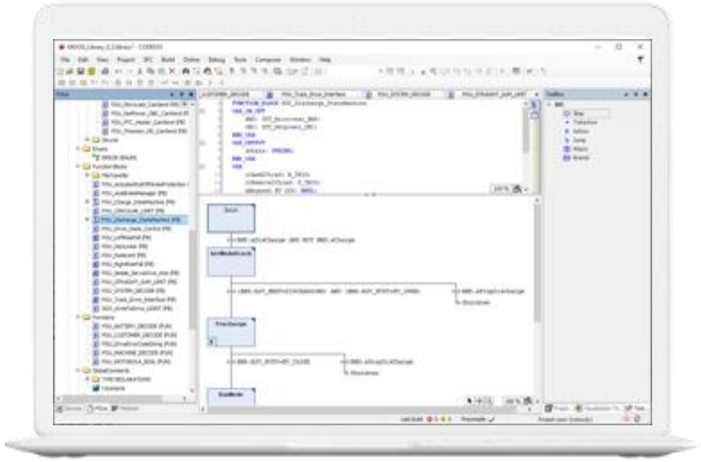


Figure 2 | **State Machine in Sequential Function Change**

The software developer is free to mix-and-match **between** the available programming languages and choosing the type than best fits the task a hand.

Machine Monitoring Software

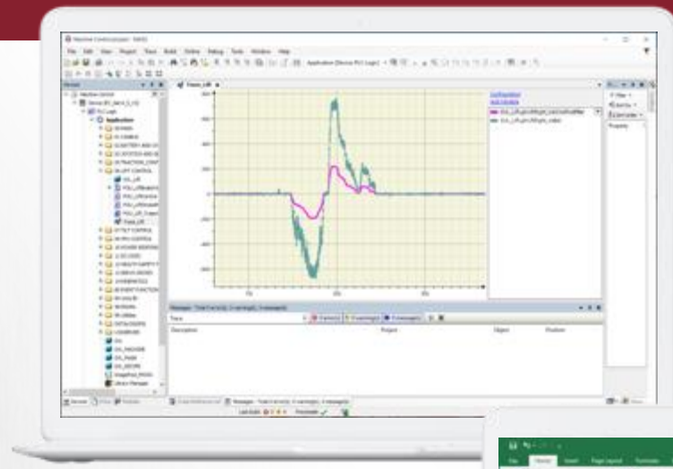


Figure 3 | **Tracking of Machine Data**

For advanced diagnostics it is possible to capture high resolution data.

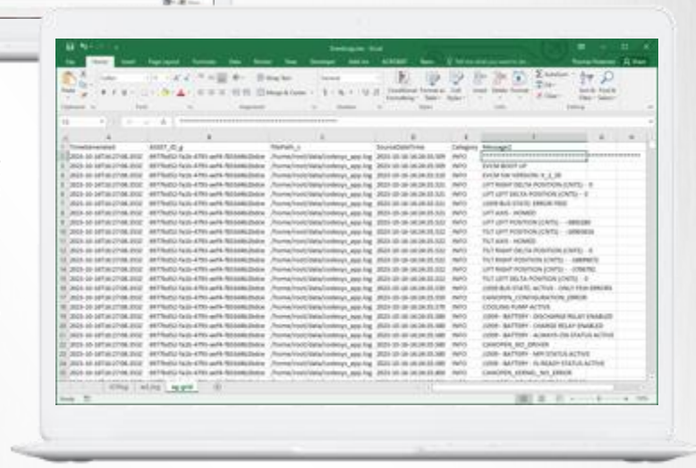
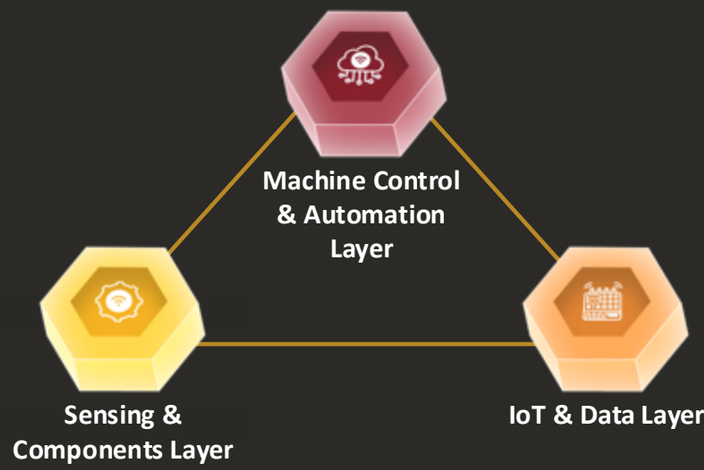


Figure 4 | **Machine Event Logging During Power Up and Operation of the Machine**

Event and Data logging available on machine or over the air through IoT for easy machine diagnostics.

HMI and display and graphics integrated into Wheel Loader.



Integrated Intelligence in Motion

Integrated Intelligence in Motion

The TerraTech Ecosystem is a revolutionary solution that enables the accelerated adoption of zero-emission vehicles.

This a cutting-edge solution that combines advanced technology, cost-effectiveness, customization, and adaptability to meet the evolving needs of the construction industry.

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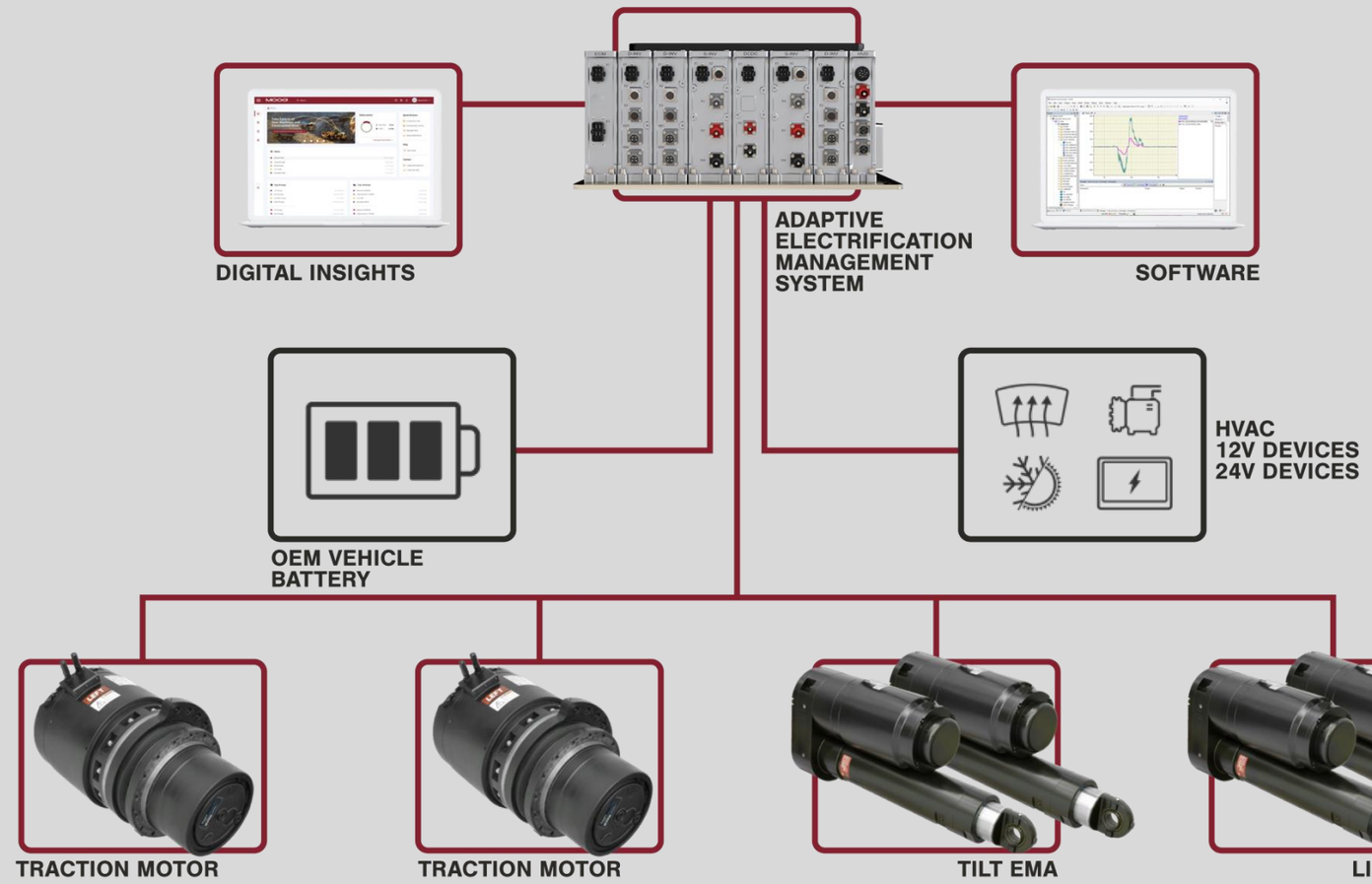
All Electric Track Loader System Architecture



Moog Construction provided

Customer provided

A Future-Proofed Solution

TerraTech offers a comprehensive and advanced solution for the construction industry.

Its use of standardized components, modular design, customization capabilities, over-the-air updates, and future-proofing features make it an ideal choice for OEMs and end users looking to accelerate the adoption of zero-emission vehicles while staying ahead of industry advancements.

TerraTech
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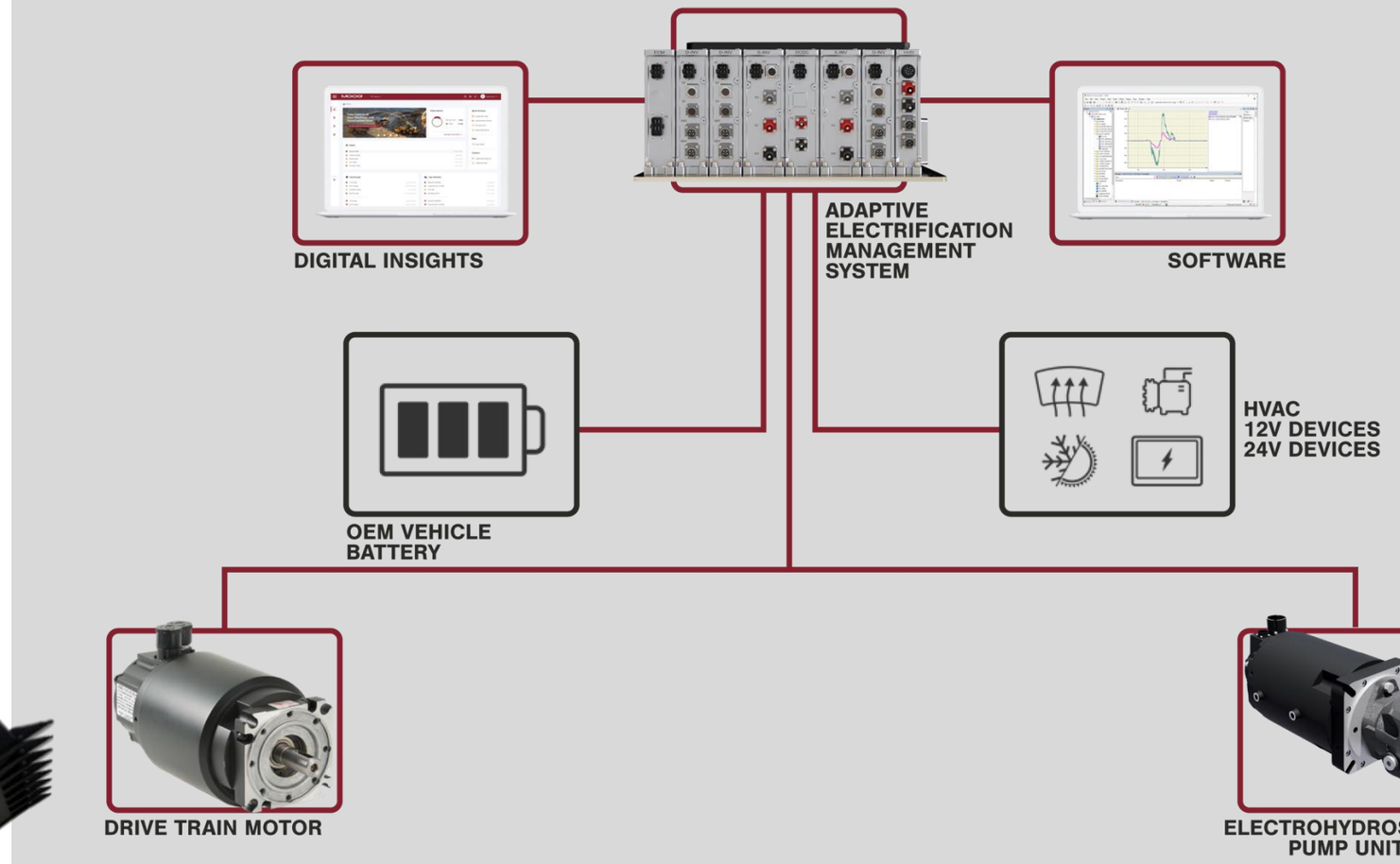
Electro-Hydraulic Track Loader Backhoe System Architecture



Moog Construction provided

Customer provided

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