Solutions for electrifying mobile machines
The future of mobility. Experience it today.

From the component to the system solution: our holistic approach

HYDAC has mastered the system architecture of the electric machine: We are your capable development partner thanks to our expertise in all the key fields – from batteries, software and thermal management to electric drives and energy-efficient hydraulics – as well as our product portfolio that has already been proven in use.

We evaluate your challenges and offer you needs-based solutions that prove themselves both today and in the future.

Save development time!
With HYDAC’s pre-validated electrification solutions.

Contact us now!
Email: e-mobility@hydac.com
Web: www.hydac.com
Our solutions for electrifying mobile machines

HYDAC offers the best of both worlds. With over 60 years of know-how of a fluid technology, hydraulics and electronics company and the liveliness of a start-up, we devote our energies to the technologies of the future. From hydrogen applications to the electrification of mobile working machines – we draw on our decades of experience and comprehensive understanding of machine architectures to create our innovations.

Control technology, software and system integration
Our answer to increasing complexity: standardisation and modularisation.

Electric drive technology
Traction drive motor or hydraulic drive set, our solutions have proven their worth in the field for years.

Battery systems
Turnkey: we supply your complete battery system for the off-highway sector.

Thermal management
Solutions for electric machines – customised to suit your individual requirements.

Energy-efficient work functions
Optimise your machine’s efficiency. We know what levers to pull to enhance efficiency.

Hydrogen applications
We are by your side as experts in alternative energy sources.
Control technology, software and system integration

Electrification leads to an additional increase in the complexity in the system architectures of mobile machinery. In particular, the number of communication interfaces between the components poses further challenges. The demands are even higher when it comes to designing or integrating systems. With expertise in the fields of functional and electrical safety, we are your perfect partner for software and systems development. In this respect, we rely on three pillars: control technology, software and system integration.
Control technology made easy

Safety-certified control units

Designed for harsh conditions, the TTControl controller is suitable for the challenging areas of use encountered in off-highway applications.

- Functional safety according to ISO 26262, EN ISO 13849, ISO 25119, ISO 19014
- Maximum flexibility in machine development
- Support for multitasking and object-oriented programming
- Up to seven CAN bus connections in one controller
- Easy and fast code reusability within all products
- Full product lifecycle support and secure libraries through the MATCH software suite

Get started with the cloud

Connect your machine to the TTConnect Cloud Service platform over our TTConnect Wave IoT gateway.

This allows you to:

- configure your dashboard easily and intuitively
- update your fleet with the touch of a button
- customise the portal with your colours and logos to match your corporate identity
- collect and analyse machine data to enhance efficiency and cut costs

Innovative hardware solutions from TTControl

TTControl – a joint venture established by the TTTech Group and HYDAC International – offers control systems and operator interfaces for mobile machinery and off-highway vehicles. Being leaders in functional safety, TTControl’s software and hardware platforms enable equipment manufacturers to develop highly reliable electronic control systems quickly and economically.
A holistic approach: HYDAC electrification kits

Save precious time during development with our 48 V standard system

Pre-validated systems cut complexity – so you save even more time in developing your electrified machine. That is why we offer holistic electrification kits.

In addition to a uniform diagnostic interface, the overall solution provides all the basic functions.

**Scope:**
- Modular battery pack up to 25 kWh
- Up to two electric drive sets, e.g. for pump, fan, winch or traction drives
- AC charging up to 7 kW with EVSE functionality
- DC charging up to 12 kW (with off-board charger)
- Power distribution unit
- ECU with energy and power management and diagnostic interface

The requirements that complex system architectures are expected to meet are high

The architecture of electrified machines is highly complex. What counts in particular is all the components and their interfaces interacting in the best possible way. The demands are even higher when it comes to designing or integrating systems.
Control technology, software and system integration

AutoParkBrake and HillHold: Prevents rolling away and makes starting on slopes easier

RekuStager: Increase or decrease the recuperation rate

Velocity Pedal Scaler and Limiter: Interpretation of the driver’s wishes and mode-dependent scaling or limitation

WheelSlipControl: Wheel speed monitoring and wheelspin reduction during acceleration and deceleration

InverterDriver: With our component drivers, the inverter can be controlled within a short space of time

SpeedModeTorque: Torque limitation depending on the speed, operating mode and drive situation

And many more library modules with additional functions for your traction drive control.

Reducing complexity with modular function libraries and component drivers

Would you like to develop your very own software and shorten the development period at the same time? Rely on HYDAC’s know-how. Our tested, certified and documented libraries simplify your software development activities.

Overview of the HYDAC toolbox development:

In detail: electric traction drive control

Find your ideal solution the quick and easy way with our EGD (electric ground drive) toolbox

Velocity Pedal Scaler and Limiter:
Interpretation of the driver’s wishes and mode-dependent scaling or limitation

RekuStager:
Increase or decrease the recuperation rate

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Development environment + function library

Simplified EGD SW architecture

Ground Drive SW app

EGD EVM BTM VTM HGD

Exemplary toolbox workflow using EGD

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Simplified EGD SW architecture

Ground Drive SW app
Electric drive technology

HYDAC overcomes your challenges by drawing on its expertise in the best possible system design. Our components have been proving themselves in use since 2018. With several thousand drives in the field, you benefit from our proven application experience, high quality and modular design. In addition to series motors, we also offer complete drive sets consisting of an electric motor, a perfectly matched inverter and a matching cable harness.
Modular drive systems, tailored to your requirements

Proven in use since 2018: our powerful motors

Mobile working machines are as diverse as the requirements they have to meet. That is why we focus on designing our electric motors to be application-specific and modular – so you use precious energy in the right place.

ENGIRO: the drive specialist of the HYDAC Group

Founded in 2010 in Aachen and since January 2022 part of the HYDAC group of companies, ENGIRO develops and produces electric drive solutions for mobile applications. The company has a large portfolio of highly efficient electric motors and generators with high power and torque densities and a robust design in the range of 5 – 400 kW drive power in voltage ranges from 48 V to 800 V.
**In detail: drive sets**

Save precious time and use turnkey sets

We test and parameterise all the sets on our very own test benches and deploy them with a complete parameter set. They are immediately ready for use following installation in the application. Speed and torque ramps can be adapted in this regard to suit customer requirements.

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### 48 V hydraulic set

14 kW drive unit for hydraulic applications

**Special features**

- Interior Permanent Magnet Motors
- 48 V three-phase motor control with CAN interface
- Full torque at zero speed
- Air-cooled
- Standardised, but adaptable in a modular manner

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### 800 V hydraulic set

96 kW drive unit for hydraulic applications

**Special features**

- Interior Permanent Magnet Motors
- 800 V three-phase motor control with CAN interface
- Water-cooled
- Screw flange on the shaft enables flexible drive adjustment
- Flange adapter for SAE-2, SAE-3 and SAE-4 available
- Double shaft end with screw flange possible

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### 700 V traction set

260 kW drive unit for traction applications

**Special features**

- Interior Permanent Magnet Motors
- 800 V three-phase motor control
- Water-cooled
- Full torque at zero speed (3650 Nm)
- External splined shaft according to DIN 5480
- Flange prepared for SAE-3 adapter

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In addition to these examples, we supply many other turnkey drive sets and motor controller sets. Contact us now and find your custom-fit drive solution.
# The right motor/inverter combination for your application

<table>
<thead>
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<th>Voltage</th>
<th>48 V</th>
<th>96 V</th>
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<table>
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<td>184</td>
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</table>
Battery systems

The battery is the heart of the electrified working machine. The requirements here are particularly high – the contacting and cooling in particular are challenging for manufacturers and developers. But there are innovative solutions. INVENOX battery systems rely on simply clamping the cells between printed circuit boards and thus completely do without welded joints. Another advantage is that Fantastium – the special contacting material – dampens vibrations and provides greater stability.
Our patented technology

Benefit from the unique advantages of the INVENOX system

Cylindrical cell in conventional systems

- Welds as potential weak points
- Effective cooling is challenging
- Welded and bonded cells “irreversible connections”

Cylindrical cell in the INVENOX system

- Increased safety level
- More efficient systems with more power
- Optimal for service, Second-life and recycling
- Damping of vibrations due to the Fantastium contact material
- Powerful cooling through pole contacts
- Reversible modular design

Advanced battery systems as part of the HYDAC Group

Established in 2014, INVENOX develops advanced battery systems. In addition to high-quality lithium-ion energy storage systems, the company provides comprehensive support in both pre-series and series product development, not to mention data management and the associated testing. With their compact design, the systems are ideally suited to mobile working machines. With an integrated BMS and PDU, the energy specialist supplies complete turnkey systems.
At a glance: get to know our portfolio

Modular and versatile: Thanks to the battery systems’ modular design, you have access to a wide range of INVENOX modules in different sizes – up to a voltage level of 800 V.

Choose the best for your machine’s energy supply with INVENOX

**Powerful:** Achieve up to 40% more energy per vehicle. Thanks to the modular design, we can find the perfect solution for almost any application.

**Robust:** Our flexible contacting material ensures that the cells are installed in a vibration-resistant manner. And without sacrificing efficiency. The highly thermally and electrically conductive material enables perfect performance.

**Flexible:** One design, multiple possibilities – we offer you high-energy or high-performance cells in an ideal design. If required, various cooling options are available for each module. Whether they are air-cooled or liquid-cooled.
Robust battery systems – perfectly suited to mobile applications

Product range: 24/48/96 V lithium-ion battery system

Technical data
- Multi-master function
- Voltage range from 18 – 30 V or 35 – 59 V
- Discharge current continuous 120 A
- Discharge current peak 350 A (10 s)
- Charging current up to 80 A
- Integrated electric heating
- Passive cooling through stainless steel housing
- IP 6k7 protection class

Special features
Benefit from a robust and sealed housing and an integrated BMS. Our patented cell contacting system enables an extremely compact design. Specifically designed for mobile applications, the 24 V, 48 V and 96 V solutions offer high performance and durability combined with easy installation.

400 V lithium-ion standard module

Technical data
- Multi-master function
- Expandable up to 150 kWh with six submodules
- Voltage range from 240 V to 403 V
- Discharge current continuous 100 A
- Discharge current peak 150 A (10 s)
- Charging current up to 25 A
- IP 6k7 protection class
- Integrated PDU with 1 x HV intermediate circuit, 2 x precharger, 1 x post-discharger, current sensor, main fuse, insulation monitor

Special features
With liquid cooling and integrated power distribution unit. The standardised 400 V battery system benefits from a robust and compact design thanks to our patented cell bonding process. At the same time, the system is easy to install with high performance and durability.
Thermal management

Needs-based thermal management forms the foundation of the electrified working machine – because smart systems offer greater convenience, range and productivity. With a high level of system understanding for your vehicle, HYDAC offers you holistic thermal management solutions for electric drive components – tailored to suit your individual requirements.
Cooling systems in electric machines are demanding

The interaction between the heat emitted and the heat required in mobile working machines is more complex than ever before. An electrified machine’s heat balance is fundamentally different from that of an internal combustion engine.

The need for thermal management solutions in electrified machines is increasing

<table>
<thead>
<tr>
<th></th>
<th>Diesel engine</th>
<th>Transmission</th>
<th>Working hydraulics</th>
<th>Cabin</th>
<th>Battery</th>
<th>E-motor + converter</th>
<th>Onboard-charger</th>
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<td>25 – 85 °C</td>
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</tbody>
</table>

Whether in summer or winter: thermal management is the key to the efficiency of electric machines

A coordinated system ensures maximum efficiency – regardless of the ambient temperature. This is because dissipating heat to protect the components and using it efficiently for air conditioning purposes is an important part of the discipline.

Winter

Passive battery cooling – energy-saving method

Active battery cooling to keep the temperature in the ideal temperature range

Heating the driver’s cab with waste heat from the hydraulics and the electric drives

Air conditioning in the driver’s cab with battery thermal management system

Cooling the electric motor and converter with a speed-controlled air cooler

Cooling the electric motor and converter with a speed-controlled air cooler

Summer
### Vehicle thermal management system (VTMS): your pre-validated overall solution

Make the design and selection of high-voltage components as cost-effective as possible. Our holistic approach offers a VTMS designed for your machine.

The interaction of cooling and refrigerant circuits coordinates energy storage, power electronics, traction and working drive and keeps them within an optimal operating window for your application. The accompanying scheme shows an example of the tasks mentioned.

Compared with conventional combustion technology, the high efficiencies of the high-voltage components do not generate sufficient power losses to heat the cabin of a working machine. The existing heat flows must therefore be conducted efficiently and supplemented by fast-response components.

#### The right cooling strategy for your system

Depending on the respective requirements, the energy storage system can be tempered by the refrigerant circuit under ambient conditions or already by passive cooling. We search for and find the cooling strategy that fits your system best as well as implement it.

#### Your smart thermal management system

The implementation of the appropriate logic ensures that the cooling and heating system becomes a smart thermal management system. The Electronic Control Unit as the control unit interacts with the component library of the HYDAC software to create the machine-specific TMS functions. By relying on pre-validated components of the MATCH Toolbox, you gain time and save costs.
In detail: robust cooling solutions

Whether a cooler, a cooling system or a custom development

**BTMS – active battery thermal management system**

Shock- and vibration-resistant mobile chiller in a compact and highly integrated designer

Our system ensures that the temperature of the battery remains in the optimal range. In addition, other functions can be integrated which heat or cool the driver’s cab. A compact system for a controlled temperature of the battery and passenger comfort.

- Stable battery performance with the best possible lifespan
- Standardised, but optionally adaptable and customisable
- Validated E/E architecture based on modular software
- Allows fast charging of the battery

**Passive cooling systems for motor, inverter & hydraulics**

**Mobile air coolers**

**AC-M series**

Specifically designed for mobile applications where high performance is required in combination with a compact design and simple installation.

- DC motor
- Standard cooler
- Lightweight and compact, simple installation

**Mobile liquid cooling system**

**FLKS-SC1**

Our versatile liquid cooling systems deliver your cooling liquid at the right temperature and pressure for an efficient result.

- Cooling system
- Lightweight and compact
- Standard cooler

**Custom cooler**

**CFT**

The HYDAC CFT was specially developed to meet the high demands encountered in mobile applications.

- Cooler-filter-tank
- Many functions integrated
- Weight optimisation and optimised in terms of installation space
- Individually adapted
Energy-efficient work functions

Optimise your machine’s efficiency: How do you use the strengths of robust and compact hydraulics while increasing their efficiency in the drive train? With clever solutions and optimisation concepts that our experts develop regardless of the machine and the performance class.
For greater energy efficiency with optimised working hydraulics

Discover the savings potential lurking in your work functions. Based on decades of experience in component development, HYDAC has established itself as a reliable partner for efficient drive systems. Rely on our proven hydraulic products for your electrified machine – from the supply via adaptive main control and actuator technology to the holistic system view.

Our approach to optimising your hydraulics

At component level
Initial energy efficiency measures can be implemented directly in the existing machine architecture. Improvements can be achieved with little effort and are easily integrated.

At a functional level
With our pre-validated functional modules, efficiency can be further increased by adapting them to the machine. The functions are scalable to different machine sizes.

At system level
Whether hydraulics or electromechanics, with our know-how for system architectures we offer comprehensive approaches for optimising the efficiency of your machine.
Harness the potential
For greater energy efficiency in your mobile machine

Load compensation – to minimise dead loads
We offer components and individual solutions to efficiently minimise dead loads in your work functions.

HYDAC load compensation components
- SK series standard piston accumulators
- Customised load compensation cylinders
- Special blocks for individual function adaptation

Electric cylinders – for maximum efficiency
Find the ideal drive solution to meet the highest efficiency and eco footprint requirements in your linear work functions.

HEC – HYDAC electric cylinder
- High efficiency > 80 %
- Powerful up to 250 kN
- Simple commissioning and service

Gravity – the free energy
Find a wide range of electrical counter-balance valve solutions to lower your loads safely and without energy.

Electrohydraulic counter-balance blocks
- Standard blocks
- Special blocks for optimum adaptation to the installation situation and functionality
- Benefits of high-precision PWS cartridge technology
- Volume flow rates up to 200 l/min
- Load pressures up to 350 bar
Smart power pack solutions – for efficient hydraulic circuit supply

We offer you a custom-fit and easy-to-install supply for your working hydraulics to keep potential primary losses as low as possible. From classic power packs to smart supply units.

HYDAC modular power pack portfolio

- Can be configured in a modular manner (controller, inverter, motor, pump, control block)
- High-efficiency IPM motor technology in combination with gear pumps (AZP/IZP)
- Pump combinations with “Low Noise” or “Torque Control” option
- Rated power: 3 – 30 kW (other power levels on request)
- Pressure range: up to 250 (320) bar
- Voltage supply: 24 V to 400 V DC

Adaptive pump solutions – to minimise the drive load

With individual adjustment options, we help you to make your drive as compact and efficient as possible.

HYDAC pumps

- Proportional torque adjustment with PPV100M
- Discrete torque adjustment with PGE104 (PGI)
- Equalisation (parallel functions) with Multi PPV100M

Enhancing efficiency – the quick and easy way

Initial efficiency measures can be implemented directly in the existing machine architecture.

Pressure losses can be minimised with the help of innovative valve solutions and flow simulations and by optimising the design of existing hydraulic solutions.

Load-sensing valves of the LX series – for minimum pressure losses with maximum compactness

With the load-sensing valves of the LX series, pressure losses are reduced by up to 50% compared to comparable valves in the performance class.

- Reduce flow losses in the valve with a uniquely compact design
- High stability and control quality
- Minimum load-sensing control margin as the basis for energy-efficient use
- Additional energy savings potential when using the ICU electromechanical motor control unit
Hydrogen

Not all questions about hydrogen have been answered yet. The production, supply and use of hydrogen pose challenges for companies. With HYDAC, you talk to an expert who brings not only innovative solutions but also proven products and decades of industry know-how. From new development to series production – we help to make your project successful.
Gain insights into our areas of expertise

Fuel cell systems & H₂ combustion engines

As the technology of the future, fuel cells hold a lot of potential in mobile and industrial solutions, because hydrogen-powered trains and other emission-free transport technologies are being driven forward. In order to operate these in a functionally safe and energy efficient way, we are already able to offer you an extensive product portfolio which we are constantly expanding.

Hydrogen refuelling infrastructure

Hydrogen is gaining importance worldwide. The refuelling station infrastructure is constantly evolving and so are refuelling technologies in terms of availability, energy efficiency and costs. And HYDAC is right in the middle of it – we are constantly expanding our portfolio with new developments and innovations.
Fuel cell systems & H₂ combustion engines

Rely on alternative energy sources for your mobile machinery

Filter & Separator Technologies
Fuel cells react to the smallest particles and harmful gases – that is why our reliable filter and separator technologies are essential to protect the fuel cell from contamination.
- Extends service life
- Ensures high air & hydrogen quality
- Avoids breakdowns during operation
- Certified according to EC 79/2009

Thermal management fuel cells
Compared to combustion engines, almost 100% of the heat energy is dissipated into the cooling water, which significantly increases the cooler surface area. As a result, cooling and thermal management systems become more complex – but HYDAC is by your side.
- Innovative solutions for complex cooling systems
- Development partner
- Broad standard product portfolio

Control technology
In order to operate fuel cell and tank systems in a functionally safe and energy efficient manner, a full understanding of power, material and information flows is required. With this understanding and our ability to develop complex software systems, HYDAC is in the position to offer customised control architectures.
- Extremely powerful controllers
- Functionally safe software architecture
- Customised controller architecture

Hydrogen tank systems
Hydrogen is stored at 350 or 700 bar in carbon fiber tanks. Operation is enabled by “On-Tank-Valve” (OTV) multifunctional assemblies, together with fusible valves (TPRD) and pressure regulators. As a leading company, HYDAC offers customised solutions for your H₂ tank system.
- Years of experience in assembling cylindrical pressurised gas tanks (CNG & FCEV) using flexible stainless steel bands & neckmount systems
- Pressure transmitters for high & low pressure applications (EC79-2009 certified)
Hydrogen refuelling infrastructure
Innovation and know-how: solutions for hydrogen refuelling stations

Particulate Contamination/Hydrogen Gas Cleanliness
Hydrogen is subject to high cleanliness requirements, because particulate contamination causes system failures. As a long-standing expert in technical cleanliness, we offer the right products for maximum cleanliness.
- PSA-H70: Sampling of filling stations & evaluation of the particulate contamination load
- Complete gas filtration portfolio for low to high pressure range, suitable for particulate & liquid separation

Hydrogen cooling
For the cooling of compressor systems we supply efficient cooling systems and heat exchangers adapted to your requirements. With our proven standard products as well as customised solutions, we offer an all-round package for hydrogen cooling.
- Customised solutions for compressor cooling
- Cooling systems for hydrogen precooling according to SAE J2601

Pressure sensors
The refuelling process at hydrogen stations is pressure controlled, which means reliable and safe sensor technology is required. HYDAC offers you a complete portfolio of pressure sensors, especially developed for hydrogen applications.
- Hydrogen pressure sensors from low to high pressure range (16 – 1050 bar)
- Reliable, safe sensor technology
- ATEX and SIL2 certified

Drive technology for compressors (compressor systems)
The wish of many operators for hydrogen compressors is a fail-safe, energy-efficient and resource-saving operation. We check whether a conventional or variable speed drive unit has the greatest possible savings potential for you.
- Conventional & variable speed drive units
- Continuous condition monitoring on request
- Oil analysis in the HYDAC FluidCareCenter on request
Global presence.
Local expertise.
www.hydac.com

Note
The information contained in this brochure refers to the operating conditions and applications described. Please contact the relevant specialist department in the case of deviating applications and/or operating conditions. We reserve the right to make technical changes.