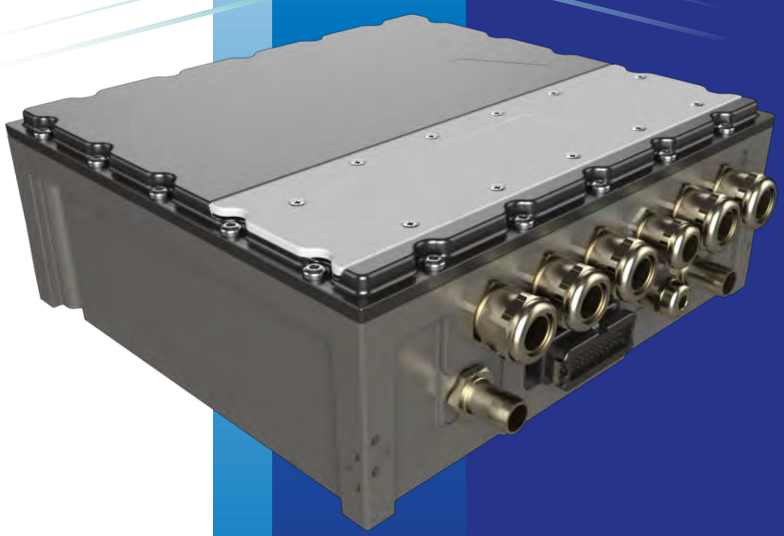
AVL Inverter TS™

Full test coverage for drive inverters makes the difference in power electronics testing



The inverter is an intelligent mini-computer in electrified and electric vehicles. Together with battery and e-motor, they form the basis for the final driving experience. But, before all these components are tested together, every single one should be developed and validated on a specific test system. The frontloading of tests leads to shortened integration tests and therefore shorter time to market.

The inverter controls and monitors all driving conditions and the vehicle's safety-critical functionalities. Power electronics, in combination with a high level of signal complexity, require an appropriate test methodology and the use of adequate testing equipment.

The AVL Inverter TS™ consists basically of an e-motor emulation and a battery emulator – so there is no need to have the real e-motor and the real battery available. This test system design provides a safe test environment where all inverter functionalities and failure modes can be tested and optimized. Especially failure testing is simply not possible or extremely dangerous on an e-motor test system with rotating parts. In addition, compared to the inverter validation in a real-world prototype vehicle, the testing time can be reduced significantly.

The **INVERTER** is the heart and brain of an electric drivetrain.

AVL Inverter TS™

ADVANTAGES

- Reliable and reproducible test results – globally
- Fully comprehensive, accompanying test methodology development
- Flexible, accurate and fast mapping of all common motor concepts
- Emulating fault situations and inverter behavior testing

Dedicated test systems for efficient development and validation:

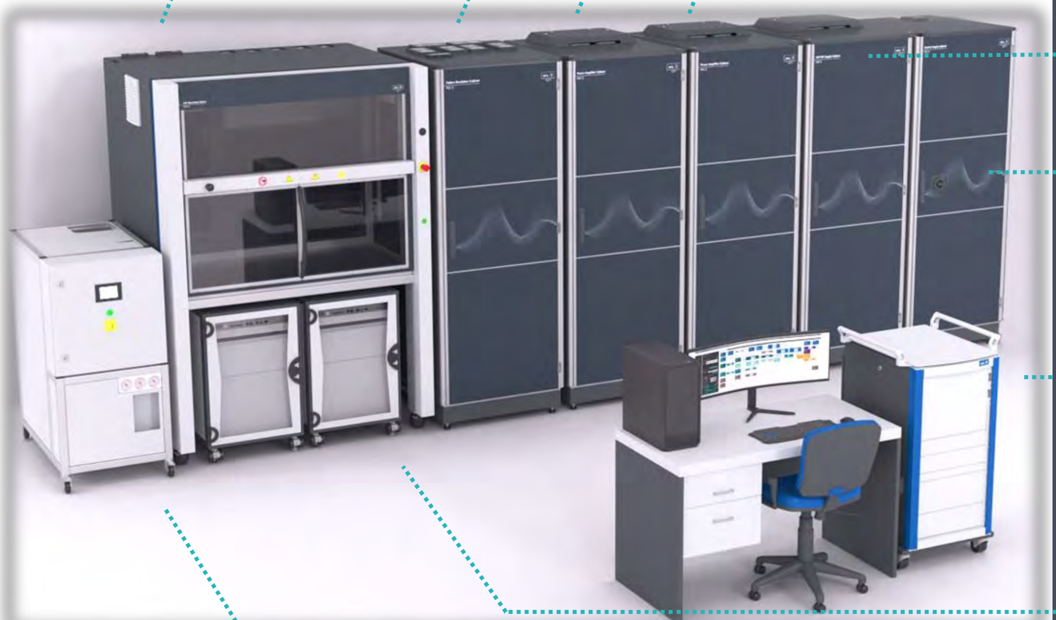
Inverter development must cover three main design aspects

SAFETY & STANDARDS

PERFORMANCE

RELIABILITY & LIFETIME

Basic Test System Setup



UUT Mounting Cabinet (UMC)
The UMC is the safe housing to place the UUT for operation with the emulators. It provides all the connectors that are needed for a fast coupling of the UUT with the test system.

Failure Emuation Cabinet (FEC)
The FEC enables the possibility to stimulate even safety-critical failure scenarios, as they really occur in the original components of the vehicle. All scenarios can be reproduced without re-configuration of the test set-up and without any damages on the unit under test.

Power Amplifier Cabinet (PAC)
The PAC emulates the e-motor on the power level and generates the required phase current based on the data calculated by the motor model running on the SPC.

UUT DC Supply Cabinet (USC)
The USC replaces the battery and is a high dynamic DC current emulator.

System Supply Cabinet (SSC)
The SSC is the power and cooling supply for the e-motor and battery emulation. It feeds the power from the grid into the system and therefore only needs to compensate the power losses.

Automation System
To execute complex and standardized test runs in a reproducible and efficient way, using an automation system such as AVL PUMA 2™ Inverter is advisable, as you are able to execute automated, reproducible and predefined test runs.

Signal Processing Cabinet (SPC)
The SPC is a controller cabinet and contains mainly the platform on which the motor models run, i. e. it is the intelligence of the e-motor emulation and the whole test system.

UUT Conditioning
Usually the UUT is watercooled and needs a seperate cooling circuit. This is provided by the UUT conditioning unit.

E-MOTOR EMULATION TECHNOLOGY AND USE CASES

Use Case 1 **CONCURRENT ENGINEERING**

How can you test your inverter when e-motor and gearbox are not yet available?

Usually, there are different development teams working on the overall powertrain design – for e-motor, for inverter, for gearbox. Each team wants to test and develop its component completely and independently, although they must ultimately interact together in a system.

The dependency for the inverter is huge, since no test can be run without an existing e-motor. In addition, the first sample of an e-motor never meets the specifications (e. g. speed, torque). Nevertheless, the inverter must already be developed to the specification of the e-motor. The goal is to achieve the lowest possible dependencies.

The AVL Inverter TS enables an accurate e-motor emulation so that no real e-motor is required, just the motor data. Only a few parameters are sufficient to start the testing process and further data can be generated by FMEA or engine parameterization.

That means that the inverter development can be done independently on the inverter test system, but in parallel to the other components. Therefore, you don't lose too much time until the final integration of all components into one powertrain needs to be completed.

Use Case 2 **SAVING BATTERY COSTS**

How can the powertrain of an electric vehicle be optimized?

The range of an internal combustion vehicle can be extended via a larger tank. Similarly, the battery capacity of an electrified vehicle would have to be increased to enable a greater driving range. However, this is very expensive as battery costs are high.

It is important to know that every component in the powertrain loses energy (mostly in the form of heat). If the efficiency of the powertrain is improved, it is possible to keep the range constant with a smaller battery. This can be realized by increasing efficiency through optimized control methods of the inverter.

The AVL Inverter TS is the right tool to optimize the inverter's control strategy and this leads to an overall increased efficiency of the complete powertrain. The effects of such an increased efficiency are cost savings in battery design or increased driving range.

That means, by optimizing the inverter's operating strategy, our customers can save also money for other components – as you can also draw conclusions about the e-motor or the battery management system. Moreover, it is always a question of the overall drivetrain efficiency and the single components' interplay to offer a cost-optimized vehicle to the final customer.

Use Case 3 **HANDLING OF E-MOTOR PRODUCTION TOLERANCES**

How can manufacturing tolerances of the e-motor be handled in the real vehicle?

During the manufacturing of the e-motors, there is always a tolerance range which is often up to about ± 10 % of the nominal value. These tolerances come from the treatment and aging of the production tools that are used during the manufacturing process. Reducing or avoiding tolerance ranges would lead to higher production costs as the tools would have to be replaced earlier. But even worse, tolerances lead to control problems within the drivetrain and possibly to failures.

The motor tolerances are never completely known, but the specified manufacturing tolerances can be assumed for testing with the AVL Inverter TS and a real inverter. How does this work in detail? In FEM simulations, the known variations can be specifically introduced. The characteristic diagrams used in the test system are then generated in a targeted manner and thus represent these tolerances. Basically, the point is that you can parameterize the test system so that the mapping of the furthest nominal e-motor is allowed. On the Inverter TS, the inverter is always protected – and you can optimize it quickly and easily for any e-motor without the risk of damaging the unit under test.

This results in a perfect driving experience for the driver – despite existing e-motor tolerances or the requirement to avoid them.

Use Case 4 **TESTING INVERTER FAILURE HANDLING**

How can you evaluate the inverter´s fault response in case of different failure situations?

In general, the testing of inverter fault reactions on a rotating testbed with a real e-motor is either very limited or dangerous, possibly leading to the destruction of the inverter and electric motor. In addition, some failure situations can even not be done in a realistic test setup and lead to wrong results. These faults may range from cable breaks and short circuits to rotor sensor and e-motor faults.

With the AVL Inverter TS, all kind of fault tests - that might occur in a real vehicle where the inverter needs to react properly - can be performed. The Failure Emulation Cabinet (FEC) offers a simple, safe and reproducible emulation of fault scenarios in the high-voltage circuit. Based on the diagnosis of the inverter response, an ideal vehicle behavior in these fault situations can be realized.

AVL SET

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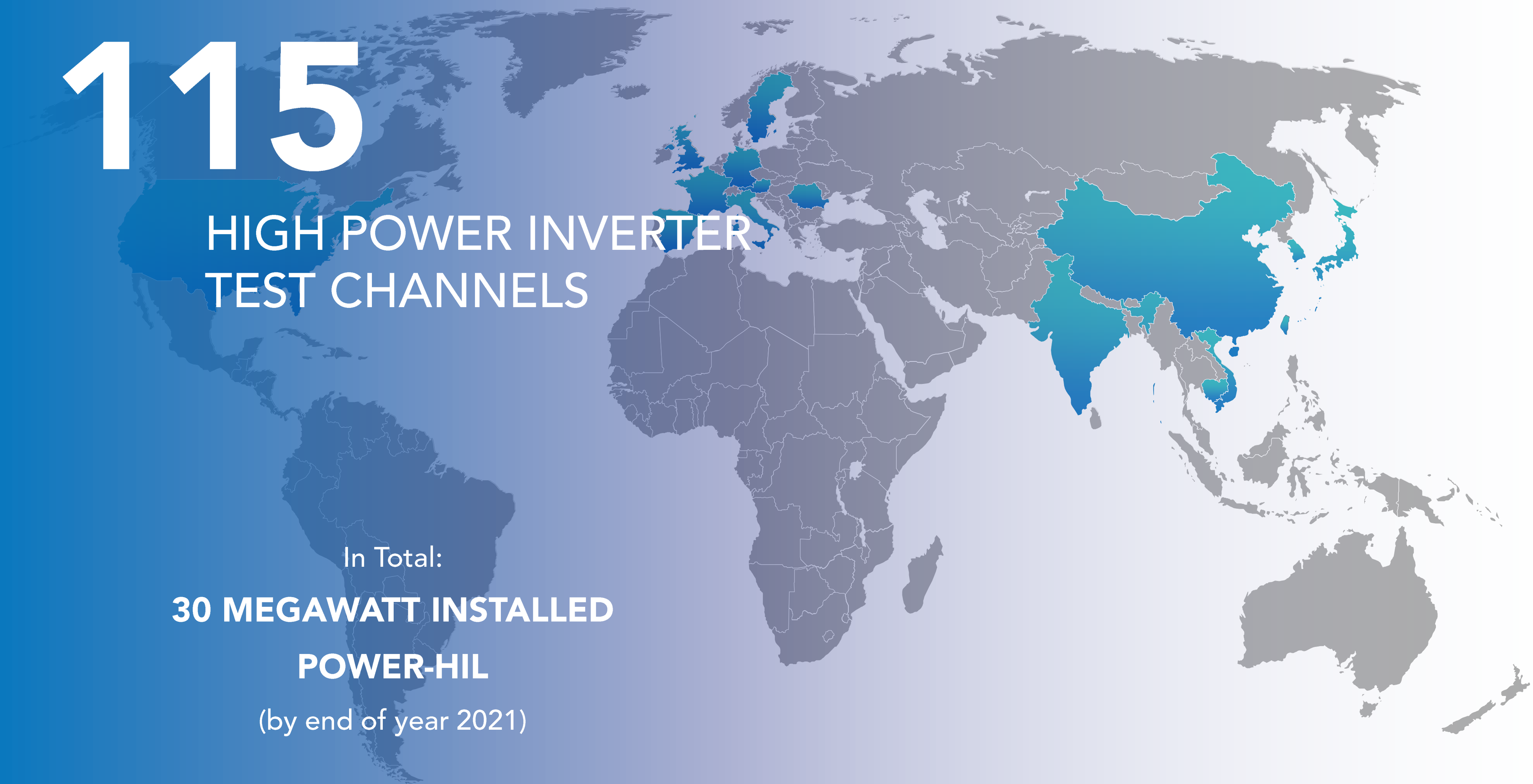
HIGH POWER INVERTER TEST CHANNELS



In Total:

30 MEGAWATT INSTALLED

POWER-HIL

(by end of year 2021)

FIND OUT MORE

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