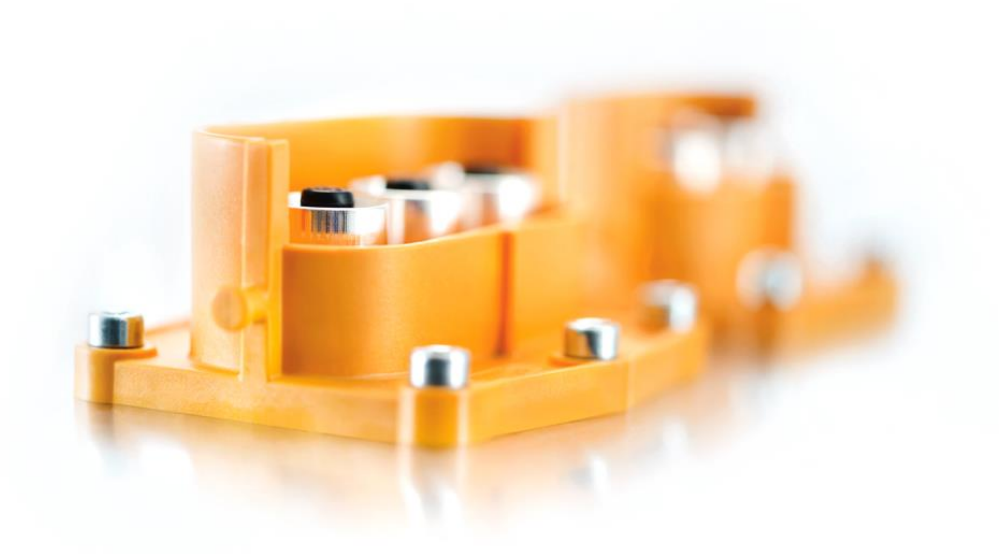
Independent and Comprehensive Testing of Inverters

SL1042A SL1044A

Inverters are essential components for numerous applications since they convert electrical voltage bi-directionally. One example is the conversion of DC voltage from a battery to AC voltage for an electric machine. An inverter is also required to convert the AC voltage from the grid power supply into DC voltage for electrical consumers. This functionality makes inverters an important component in electromobility, as well as numerous industrial applications.

In the automotive sector, the requirements made on quality, durability and safety are extremely demanding. In order for these to be secured, all components are subject to stringent test requirements throughout development and production. The earlier the tests can be performed during development, the more efficient the next development steps can be. Comprehensive test scenarios and independent component testing allow development expenditure to be reduced and innovations to be achieved faster.



KEYSIGHT TECHNOLOGIES

Comprehensive testing on the basis of the V-model

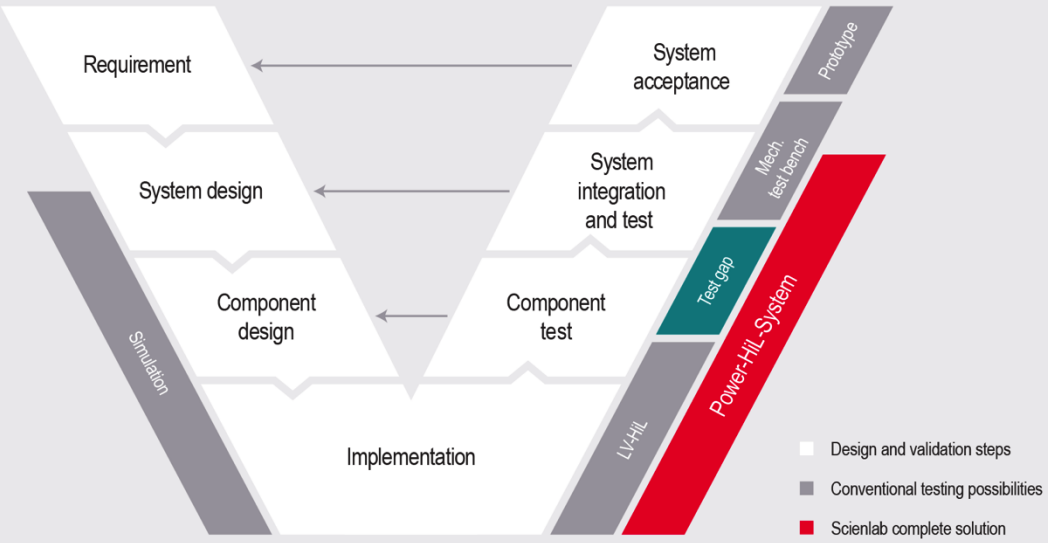
The V-model development process is used for launching new technologies on the market. First of all, the requirements are defined and the system design is specified. Once the components have been defined, test execution begins. The first tests on the new technology are carried out during this stage: component behavior is simulated on the basis of software models. After the individual components are created they are tested individually. The low voltage HiL is used for this purpose and allows tests on the signal level. The electric power cannot be monitored.

In the next step, the individual components are put together to form a system, and their functionality is tested on mechanical test benches with the aid of a load machine to simulate different power states. Faults which occur during this phase are extremely difficult to reproduce and trace back to individual components. In addition, the test bench does not have high dynamism. And, standards-related fault cases cannot be tested at a mechanical test bench.

Testing from execution through system acceptance shows clearly the component testing on the signal level is directly followed by testing of the complete system under load. Independent testing of the individual components with real electric power cannot be carried out using conventional test systems. This gap can be closed by the Power-HiL system from Keysight. The advantages:

- Complete scope of standards-conformity testing
- Efficient implementation of tests according to the V-model
- Faster component development due to reproducible test cases
- Efficient verification of the complete system possible through independent tests on each component

Close the test gap using the Power-HiL system



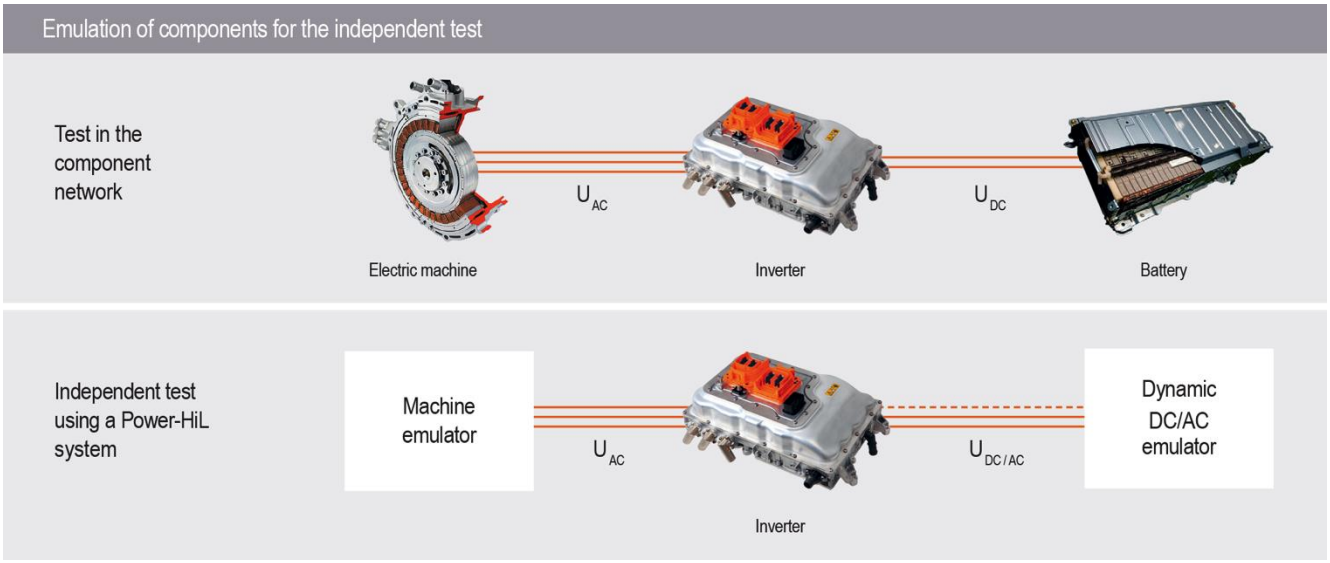
Replacing the components

Components are developed on the basis of models. The Power-HiL system uses these models as a test basis. In the case of the inverter, this means that the machine to be executed is emulated as a model on the test bench. The battery is not real either – it is replicated by an emulator on the test bench. The same is possible for the grid power supply, which can vary from one region to another.

In other words, the real components are idealized and their parameters are all replaced by the emulators. This allows the behavior of the inverter to be checked comprehensively under power in this test phase.

Complex interactions between components which occur on the mechanical test bench and require detailed analysis can be avoided by means of this emulator-based system of testing. At the same time, faults too dangerous to emulate at the mechanical test bench (such as short-circuits, for example), can be checked safely using the Power-HiL system.

The implementation of the testing can be controlled individually by the user. This way, interactions between the components can be represented in a controlled way or hidden. The fact that the other components for these tests do not have to be available in a real form saves an enormous amount of time in the parallel development of various components. Planned changes to components can be integrated into the inverter test with the aid of the emulator, allowing implications to be examined on the real inverter during early phases of development.



The structure of the test laboratory

The inverter test laboratory emulates the environment of the device under test in the later application. The benefit for the user: the environment at the test bench is idealized and can be parameterized as required.

Controlling the test bench

The HiL system is at the heart of the inverter test laboratory. It controls the entire test bench: the emulators, safety installations, climate chamber, conditioning unit and the specimen itself. Keysight's Scienlab systems support all standard HiL systems and thus provides maximum compatibility with existing systems. Through the graphical user interface, the user can always access and control the HiL system and all its parameters and measurement data.

Moreover, automation permits fully automatic testing e.g. with standardized drive cycles. The emulators replicate the electric behavior of the power source and electric machine according to the respective model used.

Modular design

The entire test bench has a modular design. This enables 100% alignment to customer requirements and flexible test scenarios over the long-term use of the test bench. The on-site set-up can also be adapted to requirements within the laboratory.

Emulation of different components

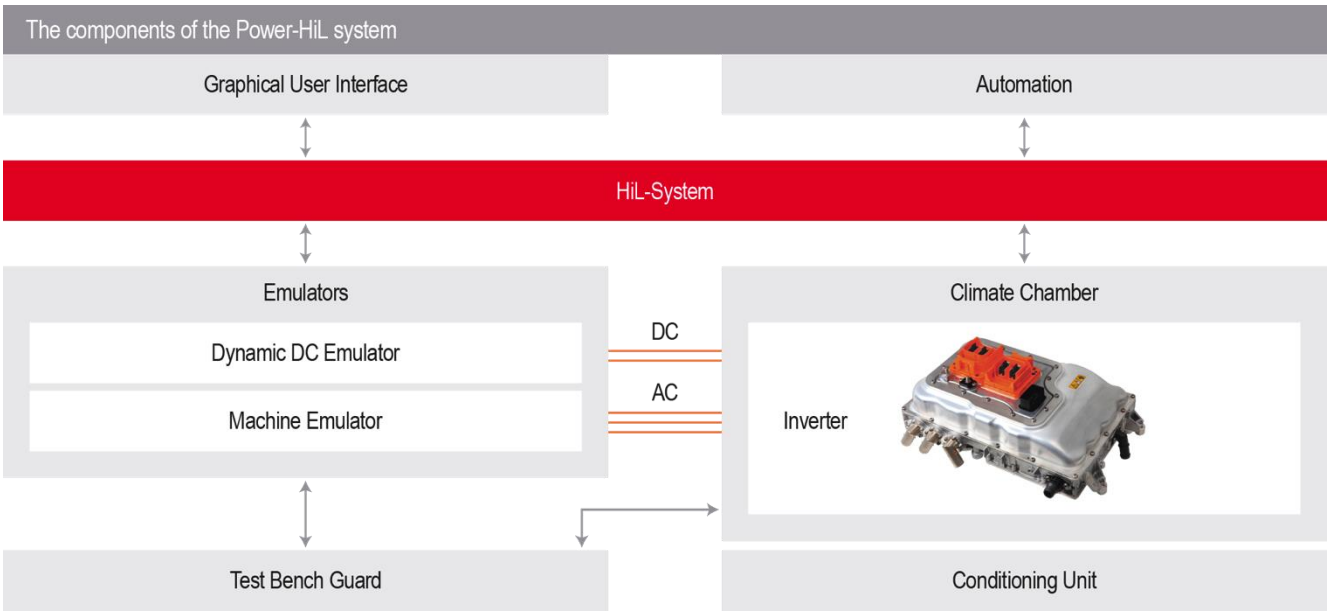
The emulators can provide AC and DC parameters dynamically as source and sink. This is necessary for the simulation of high-frequency effects such as harmonic waves and drops in voltage. The DC emulator can be used as a simple voltage source or for the highly dynamic emulation of the real battery. Alternatively, the DC emulator can replicate grid power supply rather than a battery, making it possible to emulate different grid types and topologies under power.

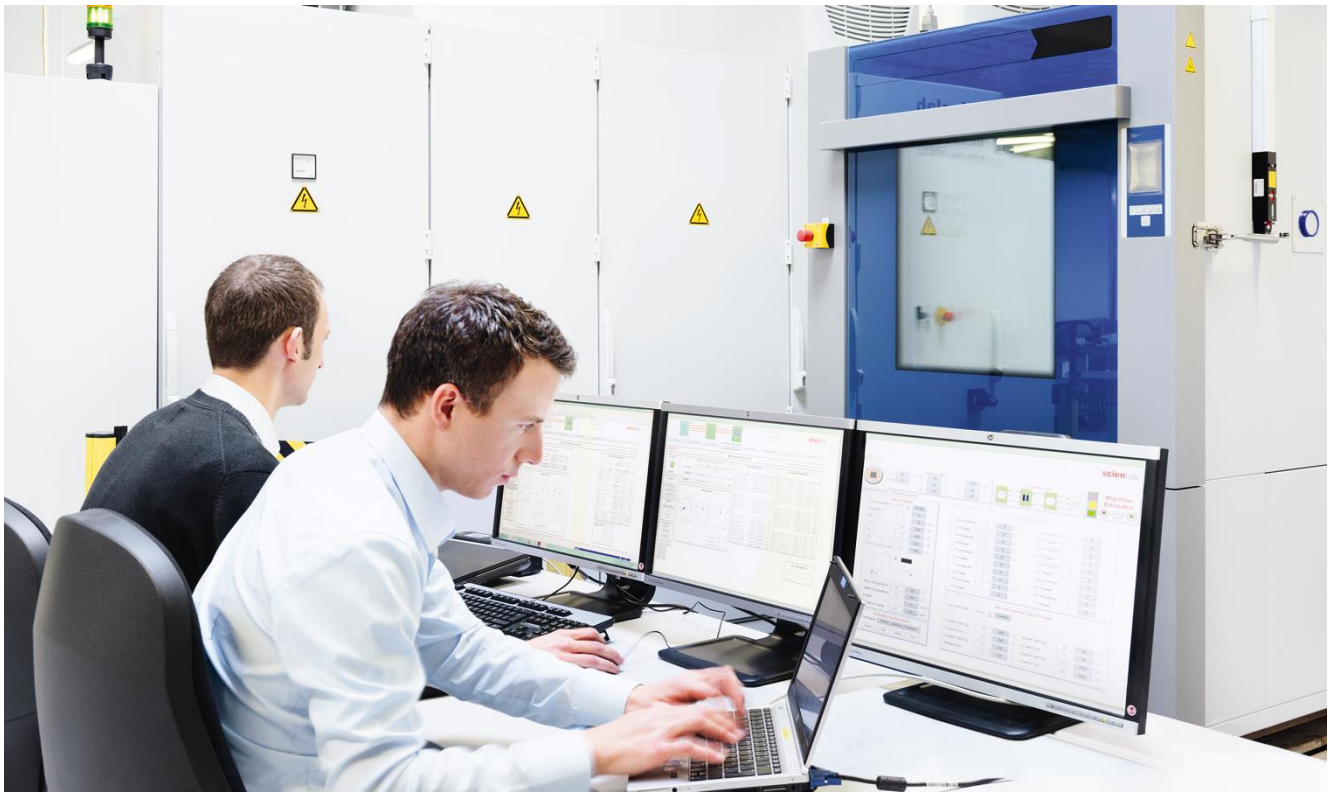
Safety of the laboratory and the specimen

The test bench is completely intrinsically safe, so that even faults in software development, operation or parameter setting do not represent a risk to users or the laboratory itself. At the same time, the specimen is protected as well as possible from destruction caused by operating errors. The safety parameters are defined by customer need and monitored continuously with the Test Bench Guard.

Energy efficiency

The test bench makes operation possible with little impact on the grid power supply. Most of the energy drawn from the supply, e.g. in the Dynamic DC Emulator, is sent back to the grid supply in the Machine Emulator, allowing a significant reduction in energy costs.





Application Cases in the Inverter Test Laboratory

Control algorithms in function development

The idealized model-based behavior of the emulators allows variables to be separated: one parameter is varied while all the others are kept constant. This way, the Power-HiL system makes function development easier. For example, software engineers can systematically develop and optimize:

- Phase current controllers
- Torque and speed controllers
- Controllers for compensating machine harmonic waves
- Field suppressor controllers

This functionality has a further advantage in that hardware can be validated faster and more comprehensively. In addition, it is possible to identify the parameters of the simulation modules used during the design phase in terms of measuring technology.

Characterization of inverters

Inverters are subjected to tested under load at the test bench in exactly the same way as under real conditions. The AC and DC factors of influence can be varied precisely, flexibly and individually – including the vehicle electric supply in the automotive sector – allowing the user to carry out precise tests to characterize the inverter. Possible application examples:

- On the Power-HiL system, working points of the machine speed and torque maps can be approached step by step in order to record effectiveness systematically. During this process, the DC voltage and the internal resistance of the HV battery are typically varied on the source side.
- On the load side, machine parameters can be varied within the permissible scatter; the parameters can be applied to a modified machine or different drive cycles can be analyzed.

Use in different vehicle models

Quite often, devices under test are to be used in different models or design series. Conventional testing is very complex in this case: the mechanical test bench must be converted – costing both time and money. In addition, all the components must be complete and available for testing to be carried out.

The Power-HiL system shortens this test phase considerably and provides comprehensive results: it is possible to switch between different battery or machine modules of different vehicles at the test bench by simply pushing a button and without any further conversion required. In industrial applications, the mechanical load on a motor can be parameterized as a pump with varying load torque or as a dynamic actuator load. All that's necessary is provision of the application parameters through the graphical user interface.

Standard-conform behavior in the case of a fault

In the component network, the inverter must also react adequately and safely to faults in the other components. Checking this behavior is a part of numerous standardization processes. In conventional test laboratories, the limits of such tests are quickly reached.

With the Power-HiL system machine faults can be emulated safely and realistically. Software functions for monitoring and as an adequate reaction to these system states can be implemented and tested at the emulator, e.g. according to the standard LV123. Examples of machine faults which must be detected and remedied include interwinding faults, slipping of magnets or idling and short-circuits on power and sensor cables. Thanks to the Power-HiL system, it can be validated that no hazards will occur for users even if these faults occur.

Reliability under permanent load

The emulators have been designed for a significantly higher permanent load than the real components which are tested. This way, studies can be done for accelerated aging, such as temperature cycle tests under real load patterns. The emulators work 24/7, even during endurance tests lasting months without any failures and with reproducible results.

Experience the quality of Keysight's Scienlab test systems on your own test bench.

The reference systems at our plant in Bochum offer you the opportunity to experience our products and their extensive possibilities. Get in touch to make an appointment at sales.sl@keysight.com.

What Makes the Scienlab Systems from Keysight Stand Out

With Scienlab test systems, Keysight offers individual test environments for testing tomorrow's inverters today. Numerous company groups, medium-sized companies and research facilities worldwide trust our know-how to develop and test their products.

Test systems for inverters and beyond

When developing inverter test systems, our employees have more than just the development of inverters in mind. In our laboratory, test systems are created for a wide range of industrial products as well as for the automotive components of electrical powertrains. We always aim to exceed the quality demands of our customers.

In addition to ready-to-use test environments for inverters, we also develop test systems for other applications including:

- Chargers and charging infrastructure
- Energy storage devices
- DC/DC converters
- The connection of several components

Everything from a single source, from the initial idea to on-site start-up

Our employees are the guarantee for first-rate customized engineering services: all products are developed and produced at our factory in Bochum – from hardware production, through software development, to acceptance certification. Understanding user needs is a key focus and is continuously developed through customer dialog. This is the basis for products that our customers can use to efficiently and reliably carry out tasks in a target-driven way, thus creating high-end solutions that give our customers a decisive competitive advantage.

Keysight solves problems for its customers
and makes it possible to launch innovative technologies more quickly.

Keysight is full of ideas
that are translated into new products by our team – premium solutions that keep our customers one step ahead.

We work in partnership
and place great importance on long-term working relationships with customers and partners. Together, we make success and technological progress possible – a fact reflected in our innovative products.

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