

# Reliable and Precise Testing of Energy Storage Devices

## Challenges on the market

Energy storage devices are becoming increasingly important, not just in the industrial field and the automotive sector but also in the field of alternative energies. Modern battery systems for mobile, industrial and stationary applications have to meet high quality and market demands. This creates pressure to develop numerous innovations with a comprehensive range of functions as quickly as possible. Power and energy density, safety, durability and, last but not least, costs have to be optimized in order for a product to survive on the market.

For these reasons, comprehensive tests must be carried out during the research, production and quality assurance phases in order to successfully develop and produce electrochemical energy storage devices. Thanks to a greater awareness of the use of energy resources, energy efficiency is becoming increasingly important.



## The solution

The test requirements from battery developers and producers vary considerably and with their Scienlab test systems, Keysight can react flexibly to meet individual needs. The modular arrangement of the test systems can be adapted to cater to very different solutions: from customer-specific stand-alone solutions through integrated test systems, to ready-to-use test laboratories. It is simply a matter of course to integrate the specific demands of the test sample and its environment into the test procedure. This includes the battery management system or environment simulation.

The outstanding features of our test systems include precise measuring technology, extremely reliable power electronics for accurate measuring results, and regeneration capability which ensures highly energy- and cost-efficient operation. The state-of-the-art Energy Storage Discover software makes efficient control of the test bench possible. This software ensures that tests can be carried out quickly and conveniently. The user can achieve the best quality test results for the characterization of energy storage devices and the verification of the test sample's characteristics.

Keysight offers an excellently-designed complete solution from a single source – from planning through organization to implementation of the test bench, with all steps accompanied and supported by the professional Service team. This enables our customers to reduce their product development phase and launch the product quickly.

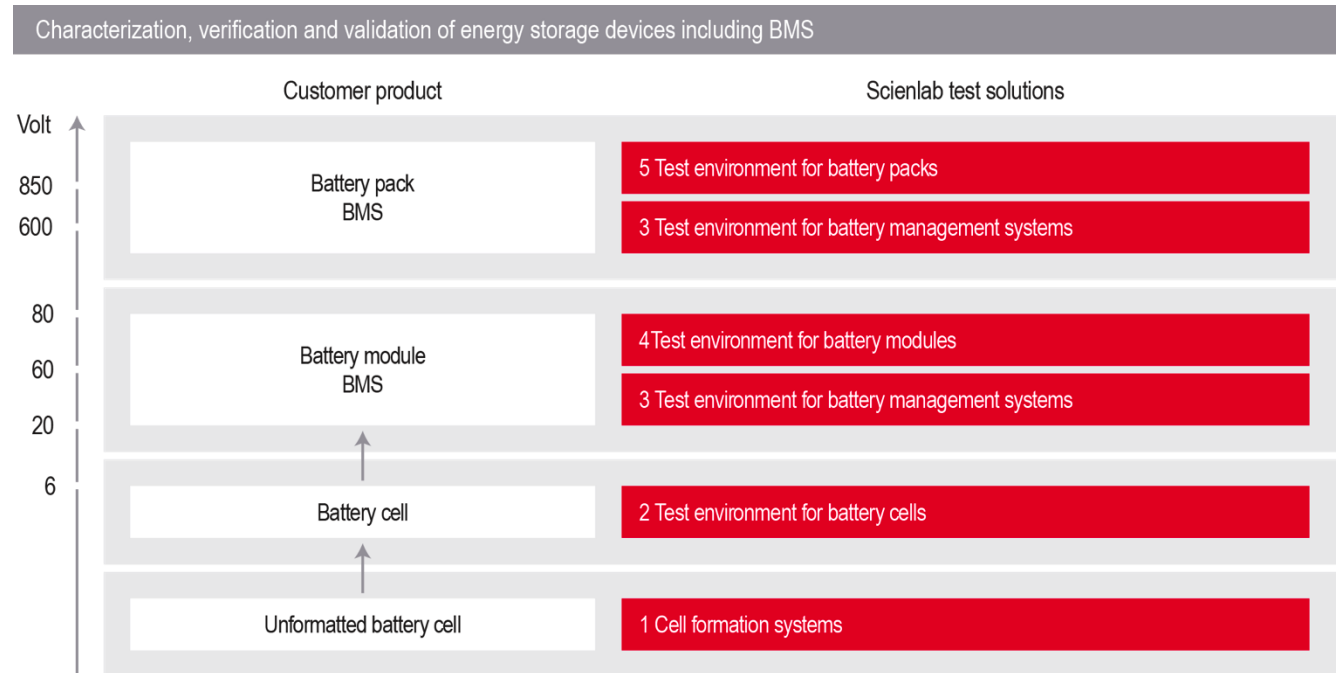


## TEST ENERGY STORAGE DEVICES RELIABLY AND ACCURATELY

Area of use	<p>Characterization, verification and validation of energy storage systems in:</p> <ul style="list-style-type: none"> <li>• Research &amp; development</li> <li>• Production</li> <li>• Quality assurance</li> </ul>
Device Under Test (DUT)	<ul style="list-style-type: none"> <li>• All energy storage systems for mobile, industrial and stationary use</li> <li>• From cells, through modules, to battery packs including battery management system</li> </ul>
Test systems	<ul style="list-style-type: none"> <li>• Voltage classes: 6 V, 20 V, 60 V, 80 V, 600 V, 850 V</li> <li>• Current range: <math>\pm 5</math> A, <math>\pm 50</math> A, <math>\pm 100</math> A, <math>\pm 300</math> A, <math>\pm 600</math> A, <math>\pm 1200</math> A</li> <li>• Power range: up to 360 kW</li> <li>• Parallel connection of up to 6 channels</li> </ul>
Regeneration capability	<ul style="list-style-type: none"> <li>• All test systems have a highly-efficient regeneration capability</li> <li>• Highly efficient, cost-effective, and environmentally friendly operation</li> </ul>
System design	<ul style="list-style-type: none"> <li>• Compact and robust hardware for convenient and long-term operation</li> <li>• Extremely maintenance- and service-friendly</li> </ul>
System configuration	<ul style="list-style-type: none"> <li>• Modular concept for maximal flexibility and individuality when configuring the test environment</li> <li>• Fast and cost-effective adaptation for future test demands</li> </ul>
Test environment of the device under test	<p>The test environment of the DUT can include various components depending on requirements:</p> <ul style="list-style-type: none"> <li>• Temperature and climate chambers</li> <li>• Conditioning of the DUT</li> <li>• Standardized contacting systems for the user-friendly and fast connection of the DUT</li> <li>• Integration of customer chargers</li> </ul>
Control and test software	<p>The Energy Storage Discover (ESD) software is the most sophisticated battery test software on the market:</p> <ul style="list-style-type: none"> <li>• Central and convenient control and monitoring of all components in the test environment</li> <li>• Predefined standard tests as well as customized test procedures (including impedance measuring)</li> <li>• Recording of data with common time stamp for synchronized analysis of measurement data in a millisecond pattern</li> <li>• Direct and flexible determination of characteristic specifications even during the test procedure</li> <li>• Powerful visualization of extensive measurement data with export function to all common file formats</li> </ul>
Safety	<p>The safety of the customer, the test bench, and the DUT are essential:</p> <ul style="list-style-type: none"> <li>• Compilation and implementation of extensive safety concepts</li> <li>• Monitoring of the test bench independently-operating Test Bench Guard and the visualization of this in the ESD software</li> <li>• Preventative safety mechanisms to avoid hazardous situations caused by the redundant monitoring of the DUT limits</li> <li>• Passive security mechanisms to confine any damage caused in the event of an accident</li> </ul>
Measuring and controlling	<p>Completely integrated communication interface to the device under test (Scienlab CommInterface):</p> <ul style="list-style-type: none"> <li>• Communication with the BMS (CAN, XCP, FlexRay)</li> <li>• Control of terminals for the BMS low voltage supply</li> <li>• Analog measurement recording</li> </ul>
Service & Support	<p>Customer satisfaction is of paramount importance. Our professional Service team is available to help customers and offer support in all areas concerning our systems and can also be called to help on site with:</p> <ul style="list-style-type: none"> <li>• Initial operation</li> <li>• Run-up support</li> <li>• Maintenance</li> <li>• Calibration</li> <li>• Training</li> </ul>

# Accompany the Development Process of an Energy Storage Device with Scienlab Systems from Keysight

From cell formation to battery system validation



## 1. Cell formation systems

For an energy storage device cell (e.g. lithium ion cell) to acquire the characteristics of an accumulator after mechanical production and achieve maximal electrical capacity, the cell must be formatted by repeated and controlled charging and discharging.

We have developed various formation systems to serve this purpose. They can easily be integrated into overriding control systems. Each cell can be parameterized, controlled and monitored from a central point. The system is extremely accurate and integrates important parameters including voltage, current, time, capacity, energy and temperature. There is also the option to connect a number of channels in parallel for higher powers and currents.

The compact and modular structure of the formation systems makes it possible to operate many channels in a very small space and to fulfill a wide range of customer demands thanks to the flexible system configuration. Battery cells can be formatted selectively in small numbers within the context of research and development, or in a fully automated process during large-scale production. Active connection to the supply grid and the resulting regeneration capacity of the systems significantly reduce energy costs, particularly when used with a high number of formation channels.

## 2. Test environment for battery cells

The cell is the basis of every energy storage device and has a direct influence on the quality of battery modules and packs. It is therefore essential to extensively characterize and develop the function of a cell at an early stage in development.

To achieve this, we offer reliable test systems for precise and reproducible measuring results in order to evaluate the characteristics of future systems and to develop battery models. Depending on requirements, the cell test system can comprise a number of channels, each of which is equipped with integrated impedance spectroscopy. The test environment is modular and can be adapted to changing requirements at any time, with an additional extension option for a temperature or climate chamber. Ergonomic contact systems for different cell types allow electrical and thermal connection.

The Scienlab ESD software allows the entire test environment to be controlled and monitored conveniently. Extensive standard-compliant and customer-specific tests can be carried out. In particular, parameters relevant to cell characterization, such as internal resistance, efficiency, capacity and reaction to temperature, can be analyzed through stress and endurance tests. Operation is extremely energy-efficient since the test systems also have regeneration capability, which allows costs to be reduced considerably, particularly for endurance tests with many channels.

## 3. Test environment for battery management systems

The introduction of new storage technologies and the ability to connect a number of energy storage device cells to form modules or packs requires an intelligent battery management system. This takes over important safety, control and regulation functions including the monitoring of various parameters such as voltage, current, temperature or state of charge (SOC) and is also responsible for thermal management, energy management, cell-balancing and performance.

The implementation of this function is a challenge for BMS development and validation. To achieve reproducible testing and the optimization of the BMS, we deliver a Hardware-in-the-Loop (HiL) test environment: cell emulators replicating various cell types of a range of cell models are connected. The emulators accurately replicate voltage between 0 V and 5 V, the cell temperature and the battery current sensors, and are designed for balancing current of up to  $\pm 10$  A. It is also possible to emulate individually-defined errors such as line breaks or short-circuits. Furthermore, the solution allows replication of different charging scenarios. This is controlled via the intuitive user interface of the automation system.



Test bench controls with communication interface connected to the DUT (CommInterface)

## 4. Test environment for battery modules

Connecting battery cells to form modules results in further demands on the test equipment. In particular, higher voltages and increasing electrical power are required. In order to test the mutual electrical and thermal influences of the cells, several temperatures and single-cell voltages must be recorded. Mechanical connections and the technical capabilities of the module must be tested. Communication with control electronics, the BMS (monitoring, load balancing), may also be necessary.

For this complex task, Keysight offers an entire Scienlab test environment with energy-regenerating module test systems, climate chambers, contacting systems and our test and control software, ESD. The test environment allows the user to carry out extensive tests on the battery modules in conjunction with the BMS and produces reliable measurement results. This can determine how great the temperature increase is in a module, the extent to which the BMS limits the module's performance, and how precise and plausible the function of the BMS is. In this battery development stage, the ability to accurately test these functions is decisive in order to increase performance and thus create a solid basis for the next step – the development of the battery pack.

## 5. Test environment for battery packs

An energy storage device pack together with the BMS including a cooling system and electronics is a complex system with high voltages and currents. Due to the range of battery pack applications considerable safety requirements in all operating modes must be taken into consideration. Extensive testing is essential in order to make the pack safe and to optimize range, durability, performance and functions.

To achieve this, we offer a complete test environment from a single source, including pack test systems capable of energy regeneration, cooling and temperature control systems, DUT conditioning, contacting systems and a comprehensive safety concept. With our CommInterface, a fully integrated communication interface connected to the DUT, all the relevant signals and measurement data can be synchronized and recorded accurately. They are visualized impressively using our ESD software, provides central control and a user-friendly interface, and monitors the entire test environment.

With our solution, typical tests can be carried out on the pack as a complete system. These include:

- Validation of the functions
- Interaction of all the components involved and their mutual impact
- Analysis of thermal management
- Internal communication of all electrical and mechanical components
- External communication
- Function of the cooling system
- Thermal and electrical reactions of the battery pack

Various test scenarios can be implemented to achieve this, such as dynamic, electrical, and climatic stress tests, operational cycle tests, standard tests, endurance tests or calendar and life-cycle aging tests.

### Experience the quality of our test systems on your own device under test.

The Scienlab 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](mailto:sales.sl@keysight.com).

## What Makes Scienlab Systems from Keysight Stand Out

Keysight Scienlab offers individual test environments for testing tomorrow 's energy storage devices today. Numerous companies and research facilities worldwide trust our know-how to develop and test their products.

### Test systems for energy storage devices and beyond

When developing battery test systems, our employees have more than just the development of energy storage devices 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 energy storage devices, Keysight also develops Scienlab test systems for other applications including

- Fuel cell stack and systems
- Chargers and charging infrastructure
- Power inverters as well as DC/DC converters
- The connection of several components

Everything from a single source – from the initial idea to on-site commissioning

Keysight's Scienlab employees are the guarantee for first-rate customized engineering services: products are developed and produced at our factory in Bochum – from hardware production through software development to system acceptance. An understanding of 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.

**We are full of ideas**

that are translated into new products by team – premium solutions that put our customers one step ahead.

**We work in partnership**

and places 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.

Learn more at: [www.keysight.com](http://www.keysight.com)

For more information on Keysight Technologies' products, applications or services, please contact your local Keysight office. The complete list is available at: [www.keysight.com/find/contactus](http://www.keysight.com/find/contactus)

