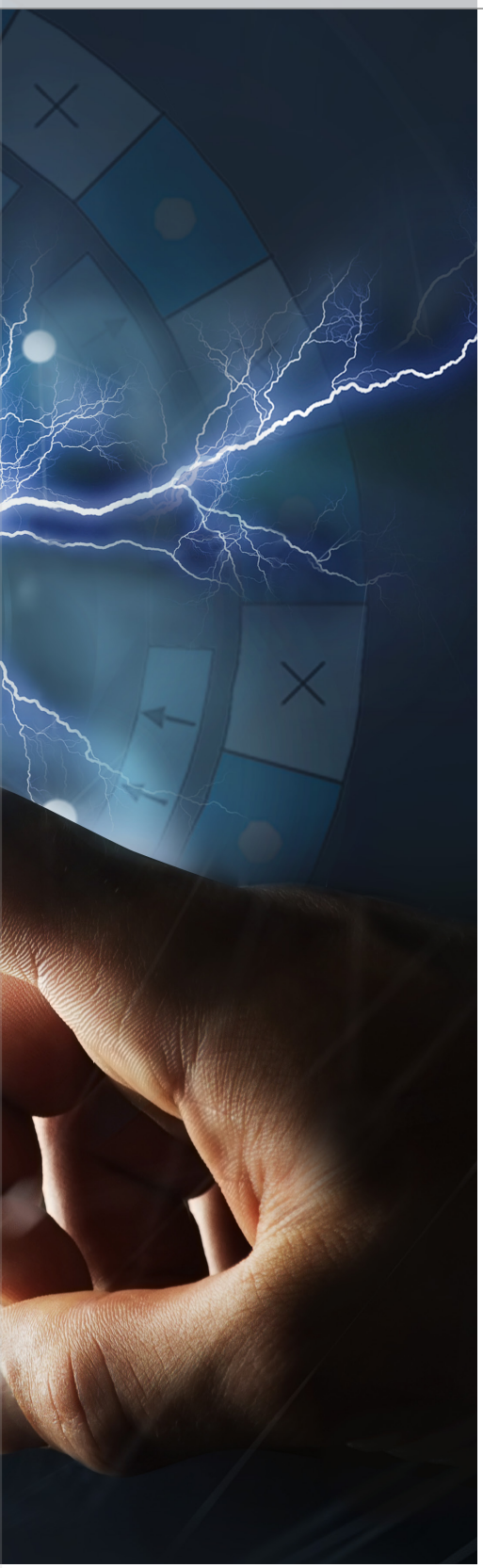
High-voltage electronic loads for motor and battery emulation

Electrifying Emulations

dSPACE has developed a new high-voltage electronic load for emulating motors and batteries with voltages of up to 700 V. In combination with the required simulation models, this makes for a single-source, ready-to-use test system for all traction applications.



The ideal test system for electronic control units (ECUs) of electric drives is flexible, open for modifications, compact, and powerful. This is where dSPACE's new high-voltage electronic load comes into play. It is the heart of highly dynamic electric motor and battery emulation up to 700 V. Open and flexible dSPACE simulation models and a dSPACE SCALEXIO hardware-in-the-loop (HIL) simulator complement the load. The ECU under test is the only real component needed, making the test setup flexible and cost-effective.

Motor Emulation for HIL Testing

ECUs for electric motors have to use their integrated electronic loads to process the entire drive power of vehicles with electric drives. During HIL tests, this type of ECU therefore has to be subjected to real motor currents. Until now, the ECU was usually operated together with the real drive motor on a mechanical test bench that includes a dynamic load machine. However, this method has some drawbacks. The high mechanical energies of the rotating machines require complex safety measures, and test benches are both expensive and inflexible when it comes to testing different motors. The dynamics that can be achieved are limited by the dynamics of the load machine. The device under test (DUT) cannot always be operated safely and fault simulation is possible only to a certain extent. Emulating the motor and battery circumvents these drawbacks and gives the testers new possibilities. During the emulation, the motor and battery are simulated, and highly dynamic loads are used to subject the DUT to the real currents and voltages – without any mechanical components.

Years of Experience

With its new high-voltage electronic load, dSPACE adds to its range of products and now offers a ready-to-use system for the complete virtualization of vehicles with real energy flows from a single source. Users benefit from dSPACE's years of experience with low-voltage motor emulation. The established concepts have now been transferred to high-voltage motor emulation and have been advanced further. The complete hardware was developed by dSPACE and patent applications have been filed for key technologies. Since users have to contact only a single company, the effort required for coordinating the system setup and operation is reduced considerably.

Dynamic High-Voltage Loads

The high-voltage electronic load (figure 1) can be used to emulate loads, such as motors, and other sources, such as batteries and AC

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With the new high-voltage load, vehicles can be simulated completely virtually with real energy flows, all ready-to-use and from a single source.

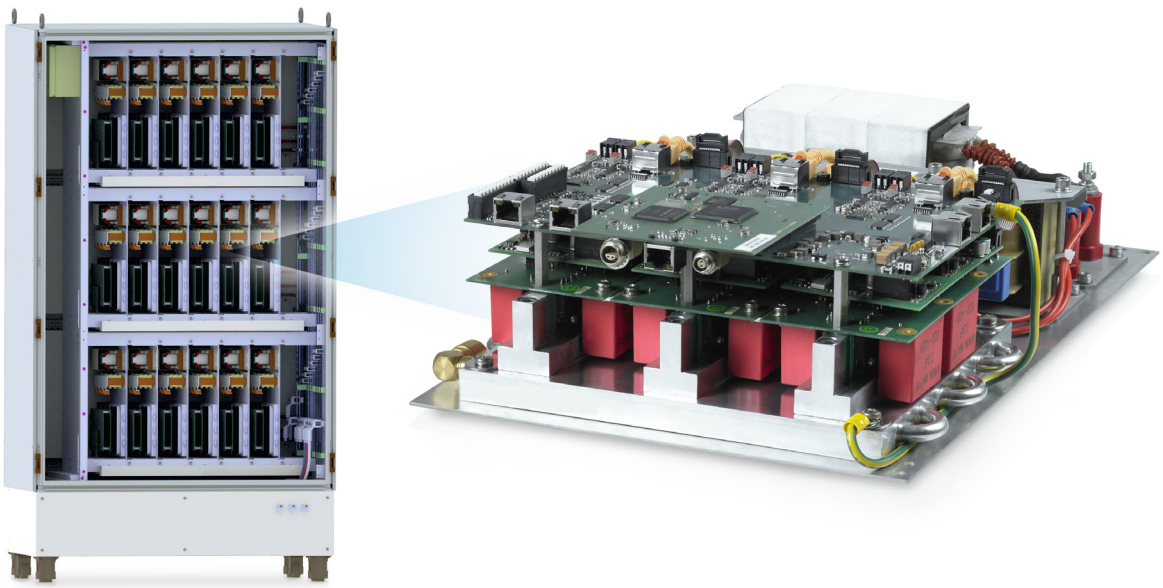

Figure 1: The high-voltage electronic load makes it possible to emulate motors and batteries with voltages of up to 700 V.

power supplies. Using the same hardware for both applications reduces the training effort for using the overall system and makes it easier to change the configuration. Because the hardware provides a highly dynamic rate of current change, a high bandwidth of the emulated inductance values, and a current range of up to 700 V, it meets all requirements for traction applications. By using any loads in parallel, it is possible to achieve up to several hundreds of kilowatts of power. With measurements of 45 cm x 30 cm (approx. 18 in x 12 in), the module is very compact.

Open Simulation Models

The motors and incremental encoders are simulated with open FPGA-based models from the dSPACE XSG Electric Components Library. The models can be used to induce real phase currents that allow for very precise and fast computation. If needed, customers or the dSPACE experts can adjust and extend the models for special requirements. The dSPACE Automotive Simulation Models (ASM) give users various model libraries with open simulation models for the processor, which they can extend themselves for special applications. The libraries include models for different battery types (ASM Electric Components) as well as for complete drivetrains and vehicles (ASM Vehicle Dynamics), etc. The simulation models for testing at the power level are the same as the ones used for simulation at the signal level. Therefore, users have to learn how to use the models only once and can reuse existing configurations.

Powerful Simulator

A SCALEXIO simulator is used as the HIL system. Due to the high number of flexible I/O cards, the system is easy to adjust to a wide range of applications. With the powerful SCALEXIO Processing Unit and FPGA-based motor emulation, there are no limits to simulation and emulation. All operating points of an electric motor can be emulated, in both motor and generator mode. It is also possible to emulate harmonic frequencies, allowing for a highly precise simulation of motor currents. Therefore, SCALEXIO is the ideal HIL environment for load and function tests at the power level.

Wide Range of Applications

The high-voltage electronic load has been optimized for the highly dynamic motor and battery emula-

> The compact, modular setup of the emulation system as well as the open simulation models make it easy to adapt the system to a wide range of applications.

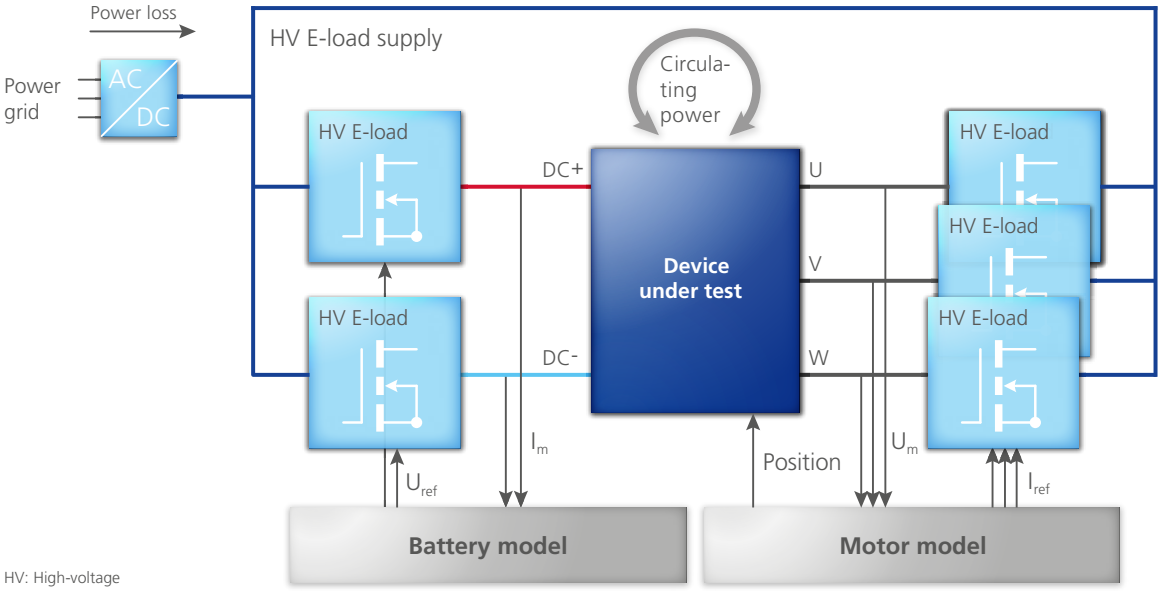

Figure 2: Schematic of a typical test setup.

tion for electric drive systems. Other application areas include tests of industrial inverters, wind and solar power inverters, DC/DC inverters, and the emulation of AC power grids. The flexible configuration covers all common frequency ranges, e.g., two or three phases at 50 Hz or 400 Hz for projects in aerospace engineering. The emulation system can be used in various development phases and test processes:

- Tests of new control algorithms for power electronics systems
- Reliability and fault tests
- Release and approval tests with controlled fault insertion
- Robustness tests, e.g., with different motor parameters
- System tests in which the high-voltage components of a vehicle interact

Because the components are emulated, all of these tests can be performed without risks – even at critical operating points that could put a real motor at risk or even destroy it. The continuous monitoring of currents and voltages ensures that the DUT is protected even when tested under extreme conditions.

The Overall System

The overall system consists of the emulator cabinet with the high-voltage loads, the HIL simulator for calculating the simulation models, and a cooling device. The SCALEXIO simulator and the emulator cabinet are connected by the dSPACE network technology IOCNET. It allows for fast, low-latency communication with the SCALEXIO real-time processor. Only an affordable standard mains supply is required for installation, because no energy is fed back into the power grid. Due to the internal energy flow between the motor and the battery emulation, the overall system is very efficient and requires only a relatively low connected load of usually 20% of the power rating. A typical test setup for a traction drive includes two electronic loads for emulating the battery currents, three loads for emulating the motor, the ECU to be tested, and a mains adapter for compensating for the dissipating power (figure 2). Due to the compact design, this example configuration requires only one emulator cabinet to emulate a 150 kW motor and the battery.

Integration into the Existing Tool Chain

In addition to the simulation models, other dSPACE software can be employed as usual, e.g., ModelDesk for model parameterization, ControlDesk for simulation monitoring, MotionDesk for visualization, and AutomationDesk for test automation. The new high-voltage electronic load becomes available in 2017 as part of engineering projects. ■