0~1 000 V
±300 A
100 kW

EMC Test Facility for Hybrid, Electric and Fuel Cell Drives

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In order to ensure electromagnetic compatibility, hybrid, electric and fuel cell automotive drives require new test systems. To this end, Mooser EMC Technik GmbH in Ludwigsburg (Germany) have commissioned what is currently probably the most modern and powerful EMC testing centre. It fulfils all requirements current or to be expected in the next years.

The development of hybrid, electric and fuel cell drives in automotive technology is progressing at breathtaking speed.

All automotive manufacturers are working flat out on these new systems.

The faster you get to the market, the better your chances for your system to succeed on the market. New research and development activities are running at full throttle in all fields: battery technologies, fuel cells, inverters, electric drives.

The new products must demonstrate their fitness as soon as possible, well before the car prototype stage. This includes for Electromagnetic Compatibility of the new systems, too.

For the electric drives, high-DC-voltage is converted into a three-phase current with variable frequency, resulting in very high and wide high-frequency noise spectra. The considerably higher voltages alone produce interferences which are about 50 times (34 dB) higher than with conventional automotive electronics. Therefore, the complete high voltage (HV) section including the connector is shielded. However, there are spatial and functional connections between the high voltage and the low voltage (LV, 12 V) sections. Insufficient decoupling between HV and LV would result in the high interference level causing disturbances in radio reception via the LV net.

In order to study and ensure electromagnetic compatibility of the components at an early time, Mooser EMC Technik GmbH has developed and built up a new EMC test system. The system has been operative for more than a year, and currently a second system is being built. Here electromagnetic compatibility can be tested as early as during the develop-mental stage on individual components (battery, fuel cell, inverter, motor) or in subsystems such as battery-inverter-motor. For the tests and the further development, experienced EMC engineers are available. All EMC tests as defined in CISPR 25 and ISO 11452 can be performed.

CISPR 25 Conducted emissions, voltage probe
CISPR 25 Conducted emissions, current probe
CISPR 25 Radiated emissions
ISO 11452-2 Radiated immunity
ISO 11454-4 Bulk current injection (BCI)
ISO 11452-7 Direct radio frequency power injection (DPI)
ISO 11452-8 Immunity to magnetic fields
ISO 11452-9 Portable transmitters
ISO 11452-10 Immunity to conducted disturbances in the extended audio frequency range

The system is suitable for tests both in static and dynamic mode. Dynamic mode means driving and braking (recuperation).

For tests of the vehicle power system, another test bench was set up. Interference resistance to transients

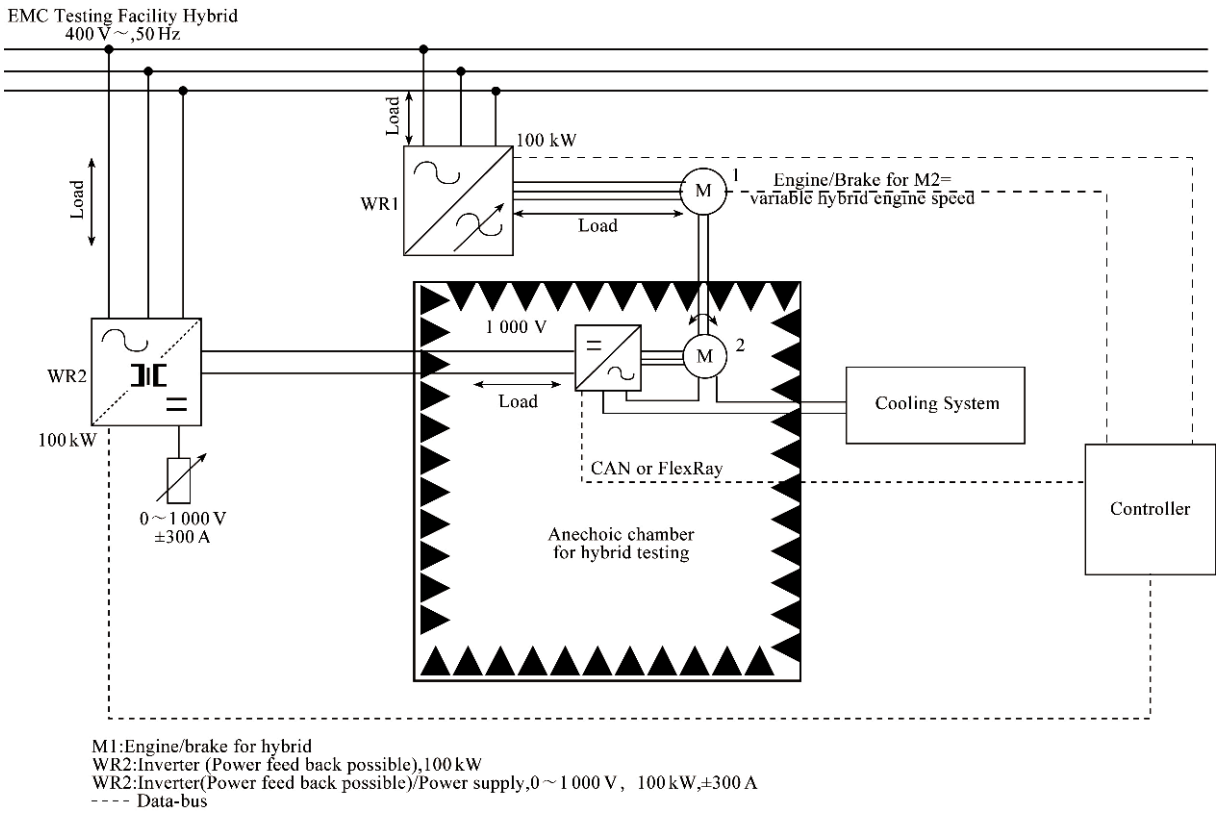


Figure 1 Basic setup of the new absorber chamber

(ISO 7637), residual alternating voltage, ground shift etc. can likewise be tested, also in the HV section. For these tests, in addition a temperature cabinet with a volume of 1 000 L and a temperature range of -45 °C to +180 °C is available.

Description of the New Absorber Chamber

With a test range of up to 1 000 V, 300 A and 100 kW output of the HV supply and the brake motor, the test centre provides ideal conditions for effective tests. With the external M1 motor, the system can also test dynamic braking (recuperation). The individual systems of the test facility have been developed, with regard to both hardware and functional software, to form an absolutely functional complete system.

A powerful controller in the 19" cabinet and a software specifically developed for this system control the entire facility. Using the CAN or Flex-Ray bus systems, the DUTs are functionally integrated into the complete system. Control and monitoring of the DUT can be integrated into the EMC software and the test bench software.

The mounting for the motors to be tested is designed so that motors of arbitrary length and diameter can be installed and tested using simple adapters.

The DUTs are cooled by an external liquid cooling system.

Which Further Advantages Does the System Offer?

■ In both operative mode of a drive-driving and braking (recuperation)-the energy released is fed back in turn into the other drive unit (WR1 or WR2). This reduces the overall power consumption of the system, thereby reducing operating costs and also, significantly, lost heat.

■ If during the developmental phase the M2 motor (DUT) should not be available yet, it can be replaced with a static load simulation, and EMC testing on an inverter can be performed without a motor, too.

■ If the DUT (inverter) should additionally comprise a DC/DC converter for 12 V or 24 V, this voltage can be

filtered outwards and there be connected to a load for up to 500 A.

Measurement Results

In component measurements, the limit values curves 5 as defined in CISPR 25 must generally be complied with. Then there is a high probability that radio, TV and RF reception in a car will not be disturbed.

Figure 2 shows an exemplary diagram as defined in CISPR 25 with limit values class 5 for peak and average assessment. The two measurement curves show the empty space in the absorber cabin with the M1 motor running. The curves show that no environmental influences or the shaft current of the external motor M1 falsify the measurement results.

The exemplary enveloping curve 1 shows interference emission by a DUT at the begin of shielding development.

The exemplary enveloping curve 2 already shows marked improvement of interference emission during the development phase.

CISPR 25, class 5 is not reached yet.

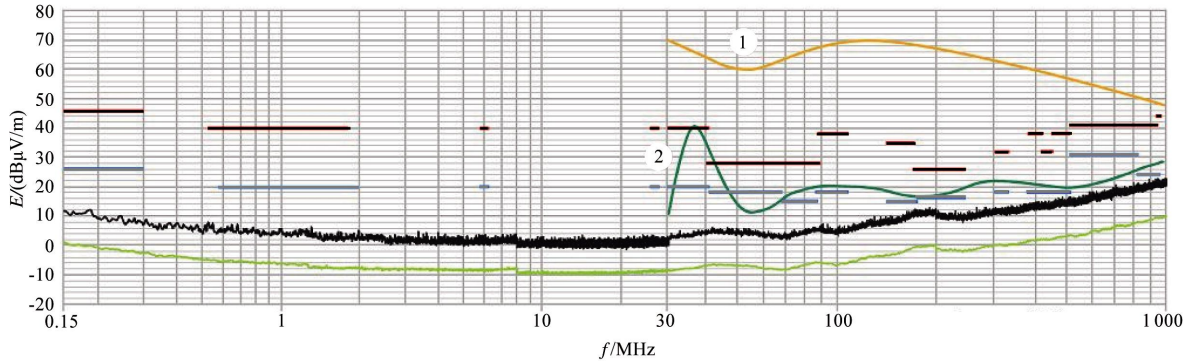


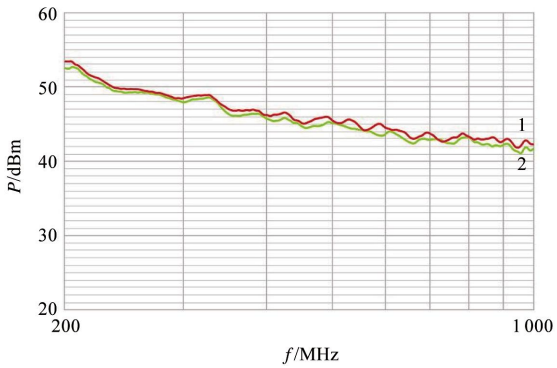
Figure 2 Ambient noises in the chamber with rotating external motor. The chart shows the limit value curves 5 for peak and average assessment as defined in CISPR 25. Curves 1 and 2 during shielding development

In the Field of Interference Resistance, the DUTs are Likewise Subjected to Extreme Testing

E.g., in the 0.15 ~ 400 MHz frequency range the interference resistance requirements as defined in ISO 11452 are from 100 mA to 300 mA of high frequency interference currents, coupled to all lines.

In the 200 ~ 1 000 MHz frequency range, interference field strengths from 100 V/m to 300 V/m are required.

Beyond 1 GHz, partly testing at field strengths of up to 600 V/m is required.The system meets all requirements. The measurement results are not affected by the HV-specific components.



Curve1: reference curve for comparable absorber chamber
Curve2: absorber chamber measurement curve for HV components and E drives

Figure 3 Interference resistance curves as defined in ISO 11452-2 required activating power for 50 V/m at the reference point

Conclusions

With the new EMC test centre for hybrid, electric and fuel cell motors, Mooser EMC Technik GmbH are currently running what is probably the most modern and powerful facility of its kind. Thanks to its forward-looking design, it fulfils all requirements current or to be expected in the next years for an EMC test centre for HV applications. The insights from EMC tests of inverters, motors, HV batteries and complete systems are used not only for the customers' development projects but also for the ongoing development of national and international norming.