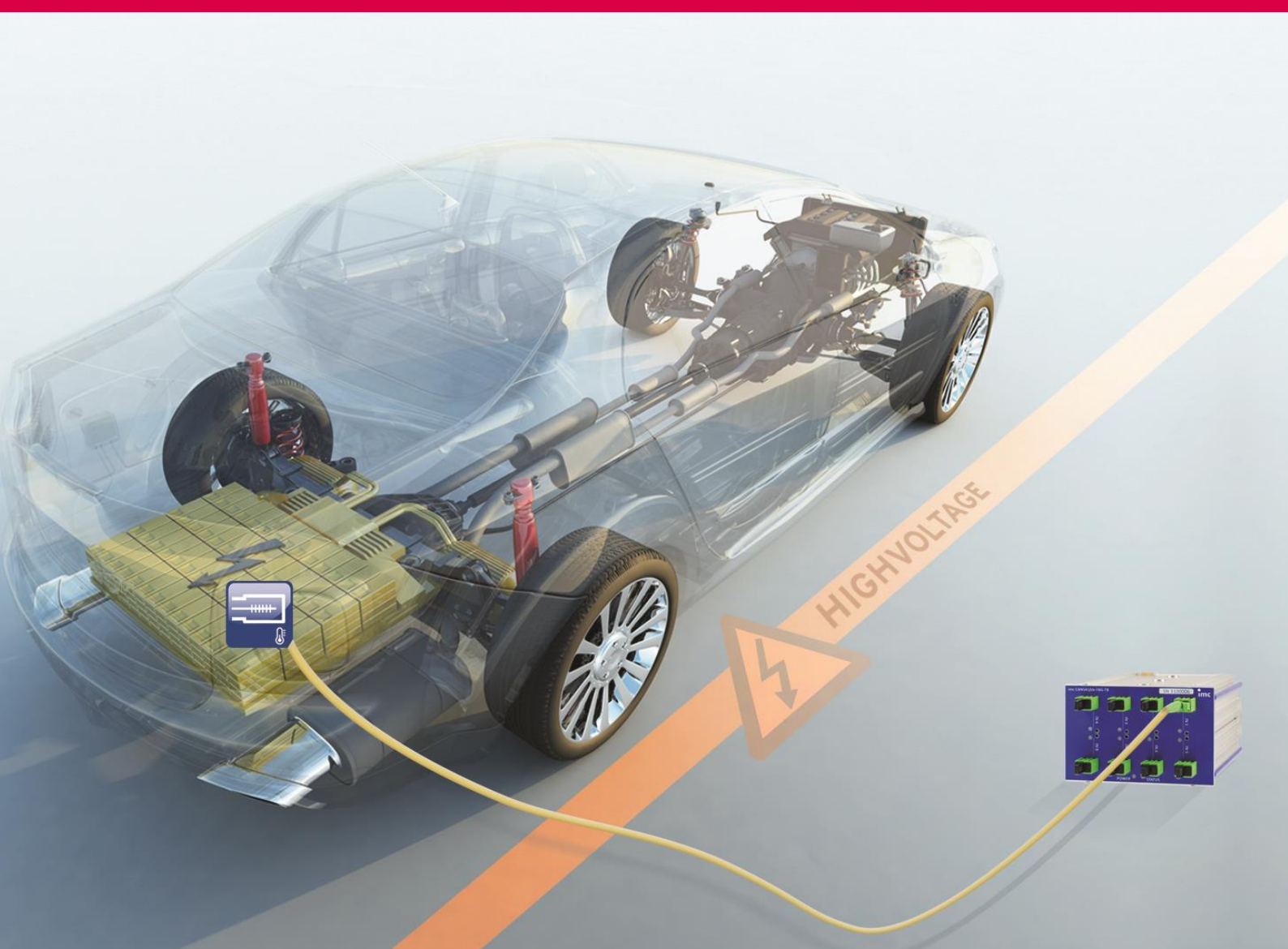


Fiber-optic temperature measurement solves HV challenges in e-mobility

White Paper



Measurement data acquisition in the field of e-mobility

Between 2017 and 2018, the number of new registrations of electric vehicles rose sharply compared with previous years. Tax benefits granted to buyers since January 2017 create a favorable climate for a growing e-mobility market in Germany.

This also influences the development requirements for components of the electric motor drive train. At the same time, the testing of components has to meet new and different requirements than conventional tests for the development of vehicles with combustion engines.

When testing the various components of an electric car – be it different electric motors, inverters or the battery – the focus is on the performance of the individual components as well as how they interact. The focus also lies on safety aspects, cooling and heating of (electrical) subsystems, energy consumption and user experience. The assessment of electronic components and systems is also specific to the e-mobility test environment. Load balances, efficiencies, energy flows, insulation and personal safety or exposure to electromagnetic interference are examined. The test and measurement equipment used on the test bench as well as in road tests must be adapted, in particular, to the test environment with high electrical voltages.

Temperature measurements on e-motors and components

One of the new measurement tasks and applications in the field of e-mobility is temperature measurement in the high-voltage environment of e-motors. Here, questions of stress and performance, efficiency, heat management or overload are addressed. This is because high temperatures in electric motors cause the materials used for winding insulation to age more rapidly and reduce the robustness and service life of the motor. For example, the service life of the insulation of the copper wires is already cut in half with an average increase in the operating temperature of 10 °C. The service life of the bearing lubrication is also affected by high temperatures, which is another motive for careful heat management.

In addition to the motor, up to 400 temperature measuring points on components can also be detected on an electric vehicle. These are typically located between the charging unit and the external charging infrastructure, as well as on the battery, the PTC heater and the electric air-conditioning compressor. The tests include battery systems, fuel cells, supply circuits, drives, power electronic components, cable harnesses and plugs.

In general, the challenges of temperature measurement in high-voltage environments are that increased attention must be paid to personal safety. Conventional electrical measurement technology, based on thermocouples, RTDs (PT100/1000) and NTCs takes this into account by means of galvanically highly isolated measurement electronics, sensors and specially insulated cables. imc also offers measurement systems in this technology, such as the imc CANSASfit HISO-T-8-2L measurement module, for example [Fig.1]. These conventional sensors have established themselves and have been safely mastered for decades.



Fig. 1: imc CANSASfit HISO-T-8-2L

When using electrical sensors for temperature measurement in HV environments, however, some disadvantages have to be accepted. Both the instrumentation and the handling of the test vehicles must be carried out by a qualified electrician. All elements of the measurement system – from the module to the cables to the sensors – must be designed for personal safety (CAT specification). The strong insulation of the cables and the diameters of conventional sensor types of approximately 3 - 4 mm can also influence the properties of the test object during installation in an inadmissible way, for example by drilling holes. The thick insulation of the cables also means that multi-channel applications are very difficult to lay in a vehicle. In addition, in the event of a defective sensor, the cable, sensor and connector must be completely replaced, always as a completely encapsulated and tested unit. This leads to loss of time in the test sequence.

Despite their isolation, the signal quality of conventional sensors can be influenced by electromagnetic disturbances (EMC), electrostatic discharges (ESD) and high electrical potentials, as they predominate in power electronics (inverters).

A new, in many respects more suitable measuring principle for the HV environment, however, is fiber-optic measurement technology with fiber Bragg sensors, as used in the CAN-based imc CANSAS-FBG-T8 measurement module [Fig. 2]. The sensors have only very small diameters, offer a perfect isolation concept against high voltage due to the purely optical measuring principle and are completely immune to electromagnetic interference.



Fig. 2: imc CANSASflex-FBG-T8

Properties of FBG sensors and measurement technology

Fiber Bragg gratings (FBG) are optical interference filters in the core of a glass fiber. During measurement, “white” light from a broadband laser source fed into the fiber is selectively reflected at this interference grating. The narrow spectrum returned by the sensor with the characteristic Bragg wavelength λ_B represents the measured quantity. λ_B is proportional to the strain and temperature of the active zone, because these determine the optical grating distance. In temperature sensors, the sensitive area may only react to the inherent temperature expansion $\alpha(T)$ and the refraction behavior of quartz glass as a function of $f(T)$. The fiber is therefore embedded stress-free in order to avoid the influence of external stress or mechanical strain [Fig. 3].

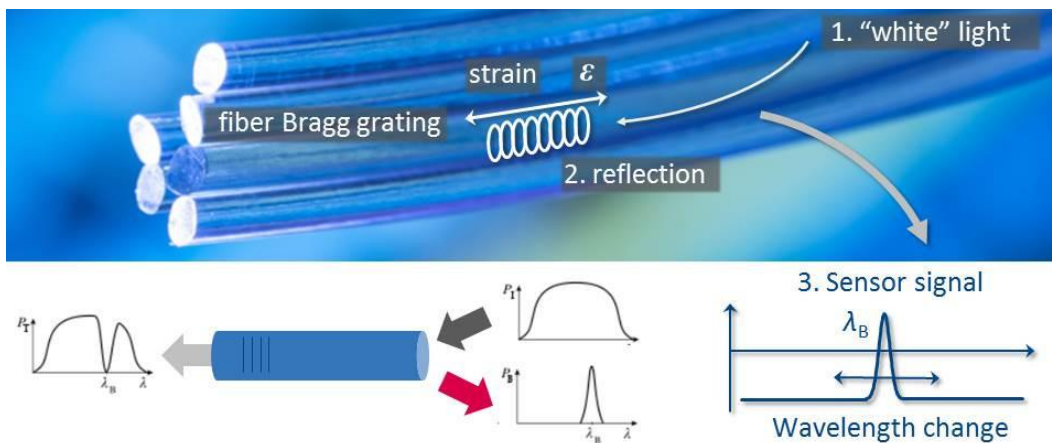


Fig. 3: FBG sensors: The fiber Bragg principle

The specially developed fiber-optic sensor technology offered by imc achieves this with a glass capillary with a diameter of only 0.51 mm, which covers the fiber [Fig. 4]. Variants with additional ceramic and Teflon cladding are mechanically even more robust and yet only enlarged to 1.0 and 1.5 mm respectively. The extremely small design and thermal mass ensure a correspondingly fast response speed with a time constant of 100 ms. Such extreme dynamics are relevant for start-up tests on electric motors. For the first time, these processes can be systematically observed and optimized. Evaluation units, in FBG technology also referred to as “interrogators”, use various methods to evaluate the Bragg wavelength of the recorded spectrum. The FBG module from imc is based on an innovative

technology that enables a very compact, robust and portable design. A further advantage is the attractive price level and the practicability of conventional HV measurement technology.

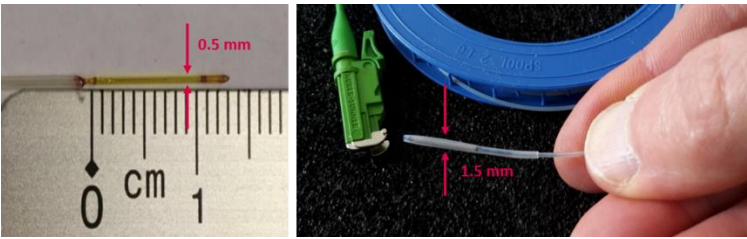


Fig. 4: Miniaturized, highly dynamic and metal-free sensors

The fiber-optic measurement module imc CANSAS-FBG-T8

The 8-channel imc CANSAS FBG-T8 module fits into the concept design of the flex series. It is a modular system developed by imc in which the housings of measurement and digitization modules (imc CANSASflex), as well as suitable CAN bus data loggers (imc BUSDAQflex), can be attached to form blocks. This allows the user to very flexibly click together a customized measurement system in a matter of seconds, in line with the current requirements of the sensors and signal sources used. The imc CANSAS-FBG-T8 is equipped with a CAN interface and can be easily integrated into the existing test environment of a test bench or into a mobile driving test [Fig. 5].

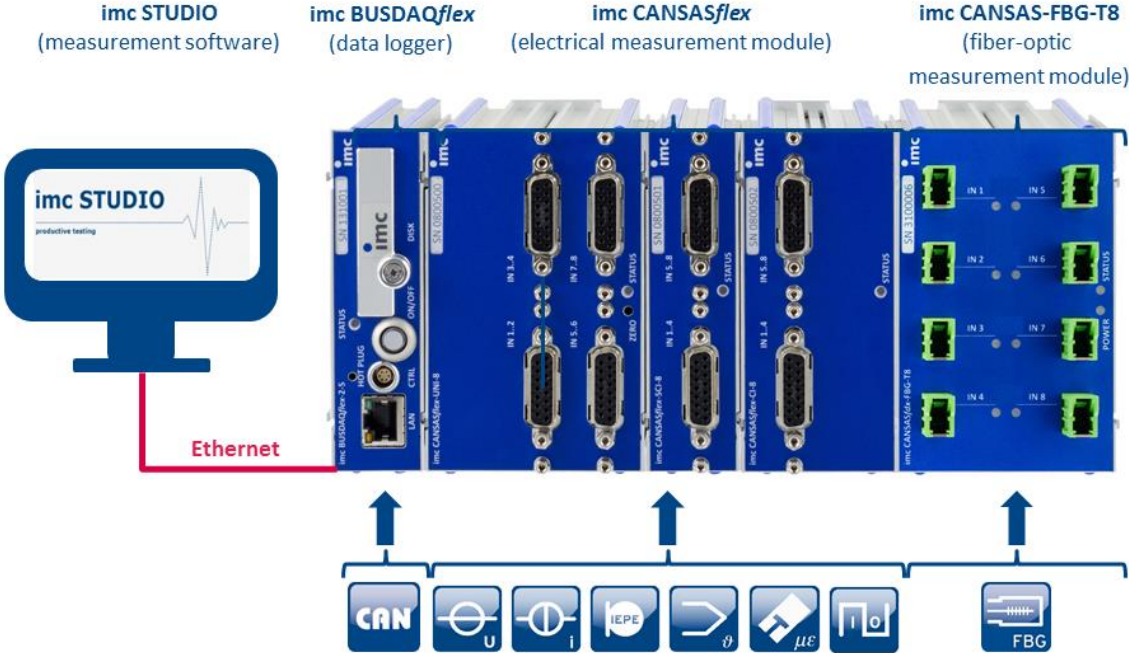


Fig. 5: Integration into universal CAN-based measurement system for mechatronic testing

The advantages of an FBG measurement module are obvious: in addition to reliable and trouble-free measurement due to the lack of conductivity of the glass fiber, the small cable diameters of the sensors allow easy handling. The vehicle installations become simpler and use up to 80% less space for instrumentation. The small sensors hardly change the properties of the test object – they offer completely new mechanical instrumentation possibilities. This makes it possible to measure at locations

that are hardly accessible with conventional sensor technology, such as within plug connectors or cables.

This is particularly important for the e-mobility and automotive sectors. The newly added measuring points on HV components with their special requirements must be recorded and correlated together with a large number of other sensors, measured variables and ECU process variables. imc's metrological approach makes it possible to use conventional measurement technology and fiber-optic technology synchronously in one application. Productivity and efficiency in testing electric vehicles can be increased by completely decoupling the hazardous HV environment from operator and data acquisition and selecting the appropriate technology for each measuring point.

Author: Dipl. Ing. Martin Riedel, imc, Head of Product Marketing

Additional information:

imc Test & Measurement GmbH

Voltastr. 5
13355 Berlin, Germany

Telephone: +49 (0)30-46 7090-0
Fax: +49 (0)30-46 31 576
E-mail: hotline@imc-tm.de
Internet: <http://www.imc-tm.com>

imc Test & Measurement GmbH is a manufacturer and solution provider of productive test and measurement systems. imc implements metrological solutions for research, development, service and production. imc has particular expertise in the design and production of turnkey electric motor test benches. Precisely outfitted sensor and telemetry systems complement our customer applications.

Our customers from the fields of automotive engineering, mechanical engineering, railway, aerospace and energy use imc measurement devices, software solutions and test stands to validate prototypes, optimize products, monitor processes and gain insights from measurement data. As a solution

provider, imc offers their customers an attractive and comprehensive range of services. These include project consulting, contracted measurements, data evaluation, specialist deployment, customer-specific software development and system integration. imc consistently pursues its claim of providing services for “productive testing”.

If you would like to find out more specific information about imc products or services in your particular location, or if you are interested in becoming an imc distributor yourself, please go to our website where you will find both a world-wide distributor list and more details about becoming an imc distributor yourself:

<http://www.imc-tm.com/our-partners/>



Terms of use:

This document is copyrighted. All rights are reserved. Without permission, the document may not be edited, modified or altered in any way. Publishing and reproducing this document is expressly permitted. If published, we ask that the name of the company and a link to the homepage www.imc-tm.com are included. Despite careful preparation of the content, this document may contain errors. Should you notice any incorrect information, we kindly ask that you please inform us at marketing@imc-tm.de. Liability for the accuracy of the information is excluded.