0 Introduction: Challenges and innovations in the German transmission grid AC and DC onshore and offshore

Dr. Florian Martin
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At present Germany faces the challenge to implement the energy transition ‘Energiewende‘ which in detail means to shape the grid for transmission of vast amount of renewable energy. Fossile and nuclear power plants will be terminated and wind as well as solar power generation will play an important role in the near future. Unfortunately, environmentally friendly power plants are not located where they are needed: for this reason the transmission grid faces new challenges in order to cope with the changing requirements and to fulfill the goals of the stakeholders. As a matter of fact TSO’s must implement technical innovations in shorter time frames keeping the reliability of the grid in mind: this will be paralleled with higher load capabilities of the existing network grace to innovative monitoring systems. But also the investment of new lines and transmission corridors is on the agenda.

1.0 Testing of equipment I

Chairman: Prof. Steffen Großmann
Technische Universität Dresden

1.1 Progress in testing technology for gas-insulated transmission lines (GIL) and gas-insulated switchgear (GIS)

Enrico Bilinski
HIGHVOLT Prüftechnik Dresden GmbH

Ever increasing demands for electrical energy and the need to transmit and distribute electrical energy with the smallest possible space requirement, leads to increasingly powerful gas-insulated transmission lines with ever increasing operating voltages. The development of suitable high-voltage testing equipment has to keep pace with the requirements of both manufacturers and operators of gas-insulated transmission equipment. This paper gives an overview of the roadmap in the development of high-voltage testing equipment for gas-insulated components and systems. Suitable test systems, based on transformers and reactors, for factory tests as well as for on-site testing, are introduced and explained in detail.

1.2 Experience in testing of high-voltage DC gas-insulated systems and potential applications for rated voltages up to ±550 kV

Dr. Maria Hering
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The development of high-voltage direct current gas-insulated switchgear assemblies (DC GIS) of rated voltages up to ±550 kV is now completed. DC GIS provide a compact technical solution with a high functional density, optimized for the application in projects with limited space as in offshore HVDC converter platforms, onshore HVDC converter stations and transition stations between different transmission media. Up to now, no standards for the testing of gas-insulated DC systems are available, although some pre-standardization work is in progress within Cigré. Mechanical and some further tests can be performed as required in AC GIS standards. But the special aspects of DC voltage, that the electric field distribution of insulators is influenced by the accumulation of electrical charge carriers and the operation-related inhomogeneous temperature distribution, must be considered by additional electric and thermo-electric tests. This contribution summarizes the testing requirements for gas-insulated DC systems and describes the testing experience, especially the specific challenges of thermoelectric tests and the superposition of DC and impulse voltages. Furthermore, it provides an insight in the on-going standardization activities and gives an overview of the potential DC GIS application in converter and transition stations, showing its space-saving characteristics.

1.3 Qualification test procedures for HVDC extruded cable systems

Dr. Christian Frohne
Nexans Deutschland GmbH

CIGRE published in 2003 the TB219 [2] with test recommendations for extruded HVDC cables up to 250kV. This document was used as a reference for qualification of HVDC extruded cable systems. In 2012 the technical brochure TB219 was replaced by TB496 [1], where the scope was extended to voltages up to 500kV. The main test philosophy remained the same and was then taken as the base for the creation of IEC 62895 [3], which is the first international standard for testing of HVDC extruded cable systems. The spirit of the test procedure of all three documents is a system test under well controlled conditions to verify the performance under different load cases simulating the real application. Main parameters are the applied voltage, the operating temperature and the temperature gradient across the insulation during operating condition. In test conditions, it is difficult to meet all these parameters with just one test setup. For that reason in real test setups, the temperature gradient and the heating current often exceed the nominal values. The test remains valid as long as the test parameters are equal or more severe than the specified values. Since the time of the first CIGRE technical brochure, the technical community has gained relevant new experiences, which will influence the standardization work of future In this paper it is shown, what are the assumptions, under which the actual test conditions are specified, and where coming standards might require different or additional test conditions.

1.4 Construction of a DC current injection generator for HVDC long-term tests up to 5000 A DC at 660 kV DC potential

Martin Hallas
Technische Universität Darmstadt

DC current injection at high voltage potential allows adequate testing of HVDC components according to their later operation. Several concepts are possible. To achieve high current and high voltage ratings by stacking of several components, capacitive current injection is a reasonable concept. It consists of a feeding unit, the transmission path and the rectifier at high voltage potential. It is shown how the components can be built and which technical parameters are required inside the generator. The overall goal of the project is the upscaling of the concept up to 5000 A DC current on a high DC voltage potential of 660 kV. Challenges and solutions during the design phase of the upscaled generator are discussed. Pictures of the generator components are shown, as well as first experiences with the upscaled generator. Summarized, the contribution demonstrates that this generator concept for DC current injection at high voltage potential is technically feasible for high equipment ratings.

2.0 High voltage direct current

Chairman: Prof. Kay Rethmeier
Fachhochschule Kiel

2.1 Fundamental aspects of the electric conductivity in insulating materials and the conclusion on diagnosis

Dr. Karsten Backhaus
Technische Universität Dresden

The reliable power transmission using HVDC systems depend on the secure operation of its high voltage equipment. The general understanding of the electrical field strength distribution within insulation systems under HVDC stress is based on the assumption of a dominant ratio of specific conductivities of the insulation materials. These assumptions then also serve as a base for the design. For decades successful adapted RC-network models for the dielectric behaviour of the common materials under HVAC stress is one reason for the usage under HVDC stress. Fundamentally, these state of the art models do not cover the influence of space charges on the electrical field strength distribution and therefore mispredict the electric stress in insulation systems.
The contribution provides a summary on the physical assumptions of electric conductivity mechanisms in insulation materials and the alternative calculation method of charge density based modelling. By adapting these models, one can yield physical sound, calculated field strength distribution in insulation systems when stressed with high DC voltage. At the example of oil-paper insulation systems for HVDC power trans-formers and SF6-resin systems for GIS respectively. Fundamental effects on the dis-charge

behaviour such as partial discharges and breakdown are discussed with the charge carrier based electric conductivity model in order to provide fundamentals for the diagnosis of possible root causes of failures in HVDC equipment.

2.2 DC PD interpretation

Prof. Ronald Plath
Technische Universität Berlin

This paper discusses challenges related to the interpretation of DC PD measurement results, taking into account the physics of different insulation systems and insulation materials subjected to DC stress. Whenever possible, the impact of DC stress and
AC stress on PD is compared.

2.3 Calibration of UHF partial discharge measurements for power transformers

Prof. Stefan Tenbohlen
Universität Stuttgart

The application of regular condition checks and continuous monitoring of power transformers gains in importance. Common objective is to detect damages in the insulation system at early stage and thus to avoid outages. In addition to the electrical partial discharge (PD) measurement according IEC 60270, the electromagnetic measurement method starts to become common practice. It is suitable for diagnostic measurement on-site and also as continuous PD monitoring system because of its lower sensitivity to external interference compared with the electrical measurement. For electrical PD measurement a calibration procedure for the ratio between transformer capacitance and coupling capacitor is available. Although the actual PD charge still remains unknown, the associated comparability of electrical PD measurement systems has led to an acceptance level at transformer routine tests. A similar calibration of the electromagnetic UHF (ultra-high frequency: 300 MHz – 3 GHz) measurement has not been implemented yet, but is necessary for further standardization of this method.
In this contribution, a calibration procedure for the ultra-high frequency (UHF) method is proposed as it is necessary to ensure reproducibility and comparability of UHF measurements. Afterwards, a calibrated UHF method can be introduced supplementary to IEC60270 in acceptance tests of power transformers. This contribution compares the calibration procedures of the conventional electric method (IEC60270) and the electromagnetic method. A characterization of UHF sensors by the antenna factor (AF) is a precondition for the UHF calibration procedure. To provide profound knowledge of the equipment, the AF of the UHF sensor is determined under inside transformer conditions. To meet these conditions, an oil-filled GTEM cell is used for correct permittivity. Additional to the calibration procedure, the performance of the installed sensor has to be determined. The evaluation is based on the idea of transmitting electromagnetic waves through the transformer tank from one UHF sensor to another which is called performance check procedure.

3.0 DC systems

Chairman: Prof. Maik Koch
Hochschule Magdeburg-Stendal

3.1 Challenges on testing of DC cable systems

Dr. Ralf Pietsch
HIGHVOLT Prüftechnik Dresden GmbH

In future, the supply of electrical energy in Germany will also depend to a large extent on reliable high-voltage and extra-high-voltage cable systems operated with direct current. This will result in new requirements for the testing and monitoring of the systems and their components. The article deals with the challenges posed by the forthcoming use of HVDC transmission lines.
What is required are new concepts for quality assurance along the life cycle of the components, from testing in the factory to on-site testing as part of the commissioning. Even with systems already installed, there are special challenges in long-term monitoring, permanent monitoring and testing following repair or maintenance measures.

The thermally induced field shift (so-called field inversion) as well as the slowly building up space and surface charges with direct voltage must be taken into account during testing. The effects of the new DIN IEC 62895 (testing of HVDC cable systems) on AC testing with partial discharge measurement will be considered.
It is shown, which boundary conditions are to be considered in the practical implementation of tests of such long cable sections and which possibilities exist for the production and evaluation of diagnostic data.

3.2 Monitoring for HVDC and HVAC cables: Technologies, potentials, challenges

Dr. Christian Freitag
TennT TSO GmbH

For the monitoring of HV cables different technologies are applied. In detail Distributed Temperature Sensing (DTS), Distributed Acoustic Sensing (DAS) and online cable failure monitoring have to be considered. Those technologies are applied to AC and DC cables in the submarine as well as in the land cable section. The monitoring concepts at TenneT being the operator of one of the world’s largest cable grids will be presented and an insight in practical experiences during application of those technologies is given.

3.3 Compact switchgear for meshed offshore HVDC networks - between vision and reality

Dr. Uwe Riechert
ABB Schweiz

The EU funded project “Progress on Meshed HVDC Offshore Transmission Networks” (PROMOTioN) addresses the challenges for meshed HVDC offshore network development. The project does not only perform demonstrations of different HVDC switchgear, it also gives recommendations of how to test HVDC switchgear, and insight into typical requirements and expectations of HVDC switchgear and especially circuit-breakers in a grid. The project will finish in 2020 and all public material can be found on the project website. There is a need to move this work into standardization bodies to get an agreed and satisfactory testing procedure for the HVDC switchgear.
An option to decrease the footprint of HVDC substations is to use Gas Insulated Switchgear (GIS). Even though GIS can be used both onshore and offshore, the limited space on offshore platforms makes the technology particularly attractive for offshore applications. If future offshore grids would be considered with multi-terminal or switching stations offshore, the gain would be considerably larger. Moreover, the gas-insulated components can be applied in other HVDC applications like cable transition stations. Although GIS components have been developed, their performance is today relatively unknown to the market. The presentation will show that the new components in a HVDC substation are far into the development phase and are on a clear path to an even higher Technology Readiness Level (TRL). The activities to increase the technical assurance to implement these components in the grid are described. Based on the development and research results combined with the service experience a new type test philosophy including insulation system tests was developed. Standardization work has been started in committees like CIGRE and performance demonstrations are planned in the PROMOTioN project aligned with this standardization work. The presentation provides a comprehensive update on status of standardization and demonstration efforts and provides suggestions for future work.

3.4. Novel approach for HVDC converter valve testing using a high-power waveform generator

Julian Lange
Siemens AG Nürnberg

According to IEC 60700, operational type tests on HVDC thyristor modules can be performed either in a six-pulse back-to-back test circuit or in a synthetic test circuit.
Because of the high rating of modern thyristors the use of a six-pulse bridge configuration would require facilities with a high installed capacity. In a synthetic test circuit even high current and voltage stresses can be generated using less than 1/100 of that installed capacity. Thus, synthetic test circuits are an economic alternative to test a representative part of a modern thyristor valve.

Usually, synthetic test circuits consist of a high voltage part based on a resonant circuit and a high current part based on a B6-arrangement. This paper describes a novel test circuit for operational tests on thyristor modules. Within this novel approach both, the high voltage and high current circuit, benefit from modular voltage sourced converters (VSC) used as high-power wave form generators. While the flexible VSC voltage in the high voltage part is directly applied to the device under test, the VSC in the high current circuit sources a transformer and drives a high and flexible current through the device under test.

4.0 Panel discussion

Chairman: Prof. Andreas Küchler
Fachhochschule Würzburg-Schweinfurt

5.0 Influences of power electronics on energy grid and during testing

Chairman: Prof. Markus Zink
Fachhochschule Würzburg-Schweinfurt

5.1 Current and future trends in power electronics for grids

Dr. Olivier Stalter
Fraunhofer ISE

Because of global warming, the need for a sector-wide energy transition based on renewable energies is gaining importance all over the world. Photovoltaic and wind power systems have shown impressive cost reduction potential and ease of deployment. In addition, electric mobility and heat pumps are now also growing faster worldwide, opening the way for sector-coupling. These volatile electricity sources and new types of loads are increasingly being interfaced with the electricity grid through power electronic converters. As a consequence, grid-connected inverters are gaining importance and their responsibility regarding their role in future, sustainable electricity grids is growing as well. Ancillary services are provided by grid-feeding inverters since more than a decade and they are constantly evolving in grid-codes. They back-up on well-proven stability mechanisms related to synchronous machines such as frequency and voltage control through respectively active and reactive power. Thanks to the huge progresses of power electronics in the last decades in terms of hardware and control, grid-connected inverters could now provide more stability features to grid operators as they are asked to do. However, new stability and grid control features are not yet requested in technical guidelines and therefore not implemented or not activated by the component manufacturers. We therefore see a further growing share of modern and powerful power electronics in the electricity grid with only little steps forward to enable a stronger grid control through these. This paper will describe different suggestions to move forward and empower inverters equipping both sources and loads so that they can take over more of the grid control in future.

5.2 Challenges of power quality measurement in transmission systems

Dr. Jan Meyer
Technische Universität Dresden

The “Energiewende” in Germany has initiated a transformation of the power system, which is characterized by a significantly growing penetration of power electronics in all voltage levels. This has resulted in an increased awareness of network operators for voltage quality, also in the transmission system. To measure the voltage quality parameters, in many case voltage instrument transformers are used, which can impact the accuracy of the measurement results significantly due to their frequency response characteristic. After a brief introduction to the topic, the new challenges related to power quality in transmission systems, the impact of instrument transformers on the accurate measurement of voltage harmonics and possible methods for its determination are described. Available solutions to enable accurate harmonic measurements in transmission systems will conclude the contribution.

5.3 Challenges in testing cables with variable frequency converter based power supplies

Robert Nowak
HIGHVOLT Prüftechnik Dresden GmbH

The energy transition is characterized by a broad application of power electronic systems and components in power supply systems. The higher dynamics and flexibility of these systems also poses new challenges for high-voltage testing technology, which can also be advantageously solved by the use of power electronic actuators.
Variable frequency converter based power supplies for high voltage test systems best meet technical and market requirements if they can be modularly adapted to different power classes and at the same time are cost neutral compared to conventional technology.
A high test voltage quality, low electromagnetic emissions with respect to partial discharge measurements and low electromagnetic disturbances in the network are only some of the requirements, but their solution also represents an added value compared to conventional supplies for HV test systems.
The article describes the changes of a cable test with a frequency converter based power supply. This supply replaces the classic actuator with improved performance. The implementation of the requirements is discussed and concrete measurement results of the test system are presented which prove the suitability and describe the advantages of the new inverter platform for high-voltage testing technology.

6.0 Challenge for medium-voltage components and their automated testing

Chairman: Prof. Peter Werle
Leibniz Universität Hannover

6.1. New methods of data integration in the automated testing of distribution transformers

Raoul Harkenthal
HIGHVOLT Prüftechnik Dresden GmbH

The article gives an overview of the current state of the art in testing technology for the automated testing of the electrical quality of distribution transformers. The setup and the components of a typical test bench are presented and the intensive interaction between the electrical test equipment and the different levels of the control system is discussed. Possibilities are shown to minimize the time required for routine testing by optimizing the work flow on site, the control system and the test equipment in order to increase the efficiency of the test field. On the basis of an implemented project for the integration between the test equipment and the ERP system of a transformer plant, tried and tested solutions for the trend of increasing data integration and analysis, which is also clear in test equipment, will also be presented.

6.2 Partial discharge measurements on cast-resin transformers made on-site – a technical challenge?!

Frank Busse
IPH Berlin GmbH

The on-site condition analysis of cast-resin transformers by means of partial discharge measurements forms an important aspect for the ensured availability or the strategically planned replacement of the operating equipment, respectively.
This aspect is of special importance because of the high costs in case of damage and/or failure and the required high availability of transformers at wind turbine applications. But also for strategically important transformers in use in the industry, condition analysis is increasingly gaining significance.
This paper derives the normative basis for on-site partial discharge measurement and explains the necessity of a three-phase partial discharge measurement.
With the WV 18-18/1.4 test source for induced voltage testing, there is available a source the modular design of which allows to perform these measurements on transformers up to a power size of 8000 kVA even at poorly accessible locations.
Based on case studies, various aspects of the performance of on-site partial discharge measurements shall be explained and discussed

6.3 On-site testing of 66 kV subsea array cables for off-shore windfarms

Dr. Uwe Kaltenborn
HIGHVOLT Prüftechnik Dresden GmbH

Off-shore windfarms are moving towards higher generation power per wind turbine. To connect the wind turbines in the most efficient way, the voltage level of the connecting array cables is more and more moved to 66 kV. This allows the increase of the power capacitance, leading to an increase of the number of connected wind turbines and therefore the maximum length of the string. Utilizing 66 kV cables off-shore, the experience regarding failures and failure mechanisms during installation and operation is limited. To guide manufacturers, test service providers and operators a new standard is under development: IEC 63026. For the practical application two different set of requirements can be defined: the installation of an individual wind turbine and its connection to the wind farm and the connection of a complete string of wind turbines to the collector platform for full operation. To ensure the quality of the cable system, it is important to apply a test voltage in such a way, that potential partial discharges (PD) and therefore potential failures can be detected safely.
In a first step the physical background how PD in a cable system can be initiated and measured will be discussed. Based on that background the different methods to generate a suitable test voltage to ensure the dielectric integrity of the cable as well as the sufficient amount of energy to initiate PDs in wrongly mounted cable joints and terminations are compared.
As a solution it was found that a resonant test circuit shows the preferred performance to detect PD in cables and cable accessories. The structure of such a test system is explained, especially the necessary adaptations for offshore applications for cable systems with rated voltages up to 66 kV. These adaptations are covering the test circuit as such and also the infrastructure for the transportation, installation and application of the resonant test system. The integration of the PD measurement is one of the key discussion points. Finally, experiences of PD measurements with resonant test circuits are explained and discussed.

6.4 Contribution to the behavior of the breakdown voltage in air as a function of humidity and temperature for small electrode distances (< 20 cm)

Prof. Stefan Kornhuber
Hochschule Zittau/Görlitz

Currently the climate correction of IEC 60060:2010 is under consideration of the CIGRE WG D1.50 as well also the IEC 60071 is updated with an adapted climate correction. Anyhow, the available corrections either do not cover the voltage range (IEC 60060-1:2010) below a system voltage of 72.5 kV or are considered to have too small reproduceable data base (IEC 62271-1:2017). Additional in connection with the investigations for alternatives for the insulating gas SF_6, air-insulated switchgear in the medium voltage range is again interest. In order to keep these switchgear systems as small as possible and still usable in climatically difficult areas, a suitable climate correction is required for the voltage range up to 72.5 kV and strike distances smaller than 20 cm. The insulating behavior of air gaps depends on several factors, beside the electrode configuration. These include, among other things as pressure and ion density, the temperature and the humidity. The aim of the project is to create a climate correction on a sufficiently reproducible broad database for system voltages up to 72.5 kV and a climate range of 5 to 40 °C and 1 to 40 g/m³ absolute humidity. It is intended for future use in IEC 60060-1:2010 and may be suitable for converting measurements and results from high voltage tests to standard atmospheric conditions. In order to investigate the temperature and humidity behavior, a climate chamber was designed and set up in the high voltage laboratory. The special climate chamber was built up by using a pressure vessel, a customized temperature and humidity preparation system and an electrode fixing system with precise distance setting. The chamber has an air volume of about 1.2 m³ and can be used for alternating and direct voltages up to 100 kV as well as lightning impulse voltages up to about 300 kV. The air conditioner is able to provide temperatures of -20...+ 80 °C in the test room, with variable air humidity above 0 °C. The climate (temperature, humidity, air pressure) is measured close to the discharge area. As spark gaps as ball-ball electrodes are used. The impact widths are initially 5 to 50 mm, which covers the range up to 90 kV AC and 250 kV lightning impulse voltage. In this paper the measurement setup and results are provided and compared with existing models.

7.0 Testing of equipment II

Chairman: Prof. Uwe Schichler
Technische Universität Graz

7.1 Development of a modular high power test setup for components of future DC grids

Nils Langenberg
RWTH Aachen

High voltage direct current (HVDC) transmission is widely identified as one possible technology to implement the necessary change in the transmission grid infrastructure to cope with future energy demands. This poses new complex operational challenges for the equipment and components of future grids. Regarding this, technically proven equipment from the alternating current (AC) technology cannot be used for DC applications. Such components include switching elements, fault current limiting elements as well as measurement equipment. Similarly, conventional test circuits and facilities are only suitable to a limited extent to reproduce and simulate prospective DC fault currents. The result is a growing necessity for research and development to ensure the functionality of DC systems in nominal operation as well as during the occurrence of faults. For this reason, the Institute for High Voltage Technology at RWTH Aachen University develops and implements a novel high-power test circuit for investigations on DC equipment. Due to different requirements and stresses on the components during nominal operation and in the event of a fault, a two-level approach is taken to implement a global testing environment. For nominal and overload scenarios a high-current source (5 kA_{DC}, 120 kW) is used to investigate the thermal load capacity of electrical devices in continuous operation. To reproduce a prospective DC fault current on the other hand, a modular high-power source based on the principle functionality of a power electronic buck converter is designed. This source is capable of generating high DC fault currents derived from grid simulations or field measurements as well as arbitrary monopolar test current waveforms such as mathematical functions. Test current amplitudes of up to 30 kA, a maximum test circuit energy of 1.92 MJ and a driving voltage of 8 kV provide for realistic investigations on components of future DC grids. This paper gives an overview of the basic requirements for such a novel high-power test circuit and introduces its principle of operation. In addition, possible areas of application and research possibilities for equipment of future DC grids are outlined.

7.2 Testing of extra high voltage shunt reactors with huge power range

Dr. Ulrich Sundermann
Amprion GmbH

The structural change of the power system and the attendant decrease of conventional energy production based on rotating synchronous generators results that the transmission system operators (TSO) have to take care for the necessary reactive power to operate the grid by other means. This new demand of reactive power supply leads to the application of STATCOM, MSCDN facilities and of shunt reactors with huge power range. With respect to shunt reactors the application of variable shunt reactors with huge power range is an alternative to fixed shunt reactors with lower power range operating in parallel. The contribution illustrates the design of a variable shunt reactor with huge power range, followed by a description of the test requirements and reports experience collected during testing of variable shunt reactors.

7.3 What does industry 4.0 mean for online and offline test systems and diagnostic equipment?

Michael Baronick
HIGHVOLT Prüftechnik Dresden GmbH

The author is quite critical of the term "Industry 4.0" and the often cited 4th Industrial Revolution. The formulation of "a second phase of digitization" used by industrial researcher Hartmut Hirsch-Kreinsen seems to make more sense. As a rule, revolutions do not take place on a specific date; they have various causes, such as the increasing frequency of conflicts. This accumulation occasionally leads to a change in quality on a certain occasion. As a rule, the point in time for the revolution can only be precisely determined in retrospect.

Irrespective of the choice of the term, the potential and effects of this "revolution" are undisputed both for manufacturers of high-voltage test and measurement equipment and for their customers. This article attempts to describe the potential of the so-called 4^{th} Industrial Revolution for manufacturers and customers from the point of view of a test system manufacturer.

7.4 Digitalization in testing and measurement technology

Volker Schmidt
HIGHVOLT Prüftechnik Dresden GmbH

Test fields provide important information about the results of the entire value chain. The quality determined in comparison to the target condition or to previous batches is an essential indicator for the evaluation of the manufacture of products. In addition to other sources of information, test fields thus provide the data for a control loop that is required to control quality. During the operation of electrical equipment, diagnostic devices provide further information which can also be used to control quality. The general trend toward digitization and the concepts of Industry 4.0 will make it possible in the future to use the available data across manufacturers and industries to optimize the value chain and make the best possible use of assets. In order for this to be efficient, high-voltage test equipment as well as measuring and diagnostic equipment must be networked in such a way that the data can be evaluated without delay and thus influence value-added processes and asset management.
In the article Digitalization in test and measurement technology, 2 examples are shown, which use the already available technical possibilities of networking. In example 1, the value-added process of electrical equipment is improved by increasing the availability of high-voltage test fields. In example 2, the immediate determination of the fault location in a high-voltage cable network of the power supply leads to an increase in supply reliability.