

OMICRON Magazine



WHAT REALLY MATTERS IN THE
COMPLEX FIELD OF CYBER REGULATIONS



DEAR READERS,

How secure will our energy systems be in the future?
How can we ensure the reliability of machines powering our industries? And what role does cybersecurity play in safeguarding critical infrastructure?

These are just some of the vital questions the latest issue of OMICRON Magazine addresses. As digitalization and connectivity continue to shape our world, our challenges are becoming more complex. We want to help you navigate this evolving landscape by sharing cutting-edge insights, solutions, and expert knowledge.

Our cover story and lead article focus on NIS2, the European directive redefining cybersecurity standards for critical infrastructure. With deadlines approaching and requirements becoming stricter, understanding the impact of these regulations is essential for all businesses operating in the energy sector. Our in-depth analysis explores what NIS2 means for companies, how it compares to international cybersecurity strategies, and the steps required for organizations to stay ahead of potential threats.

However, cybersecurity isn't just about policies and regulations – it's about practical solutions. The CMC 500 is the world's first protection relay test set to deliver cybersecurity by design. As cyberattacks on critical infrastructure become more sophisticated, integrating cybersecurity directly into testing equipment is no longer optional – it's essential. Learn how this innovative approach sets new security benchmarks for protection testing and helps close previously overlooked attack vectors.

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Cybersecurity guards against digital threats, but reliability is the other side of the coin. That's why maintaining the health of rotating machines is crucial for operational stability. This issue also delves into using Sweep Frequency Response Analysis (SFRA) to detect winding faults in turbo-generators, offering a more sensitive and objective approach than traditional methods.

This latest edition covers a broad spectrum of knowledge transfer, from regulatory compliance to cutting-edge security solutions and advanced testing methodologies. Whether you're an asset manager, a cybersecurity expert, or a testing professional, this issue is packed with valuable insights to help you protect, optimize, and future-proof your systems.

We invite you to explore, learn, and engage. Let us know your thoughts, share your experiences, and continue the conversation. The challenges ahead are significant, but we can face them confidently with the right tools and knowledge.

Enjoy reading!

Yours sincerely,

A handwritten signature in black ink, appearing to read 'Lia Thum'.

Lia Thum

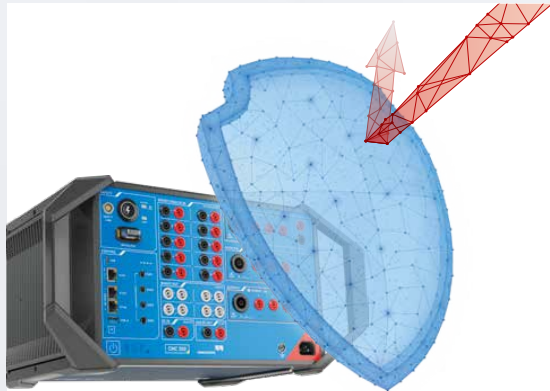
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KNOWLEDGE



SUPPORT



INNOVATION



QUALITY

FROM NIS2 TO StromVV

What really matters in the complex field of cyber regulations

Why cybersecurity is more important than ever

Nothing works without electricity; it's the lifeline of our modern society, without which everything from households to essential industries such as telecommunications, health-care, water supply, and financial systems cannot function.

This insight isn't new but is more relevant today than ever. Daily headlines and reports from Europe's ENISA, Austria's Federal Chancellery, and Germany's BSI show that the threat of cyber attacks is growing, and energy companies, in particular, are their focus.

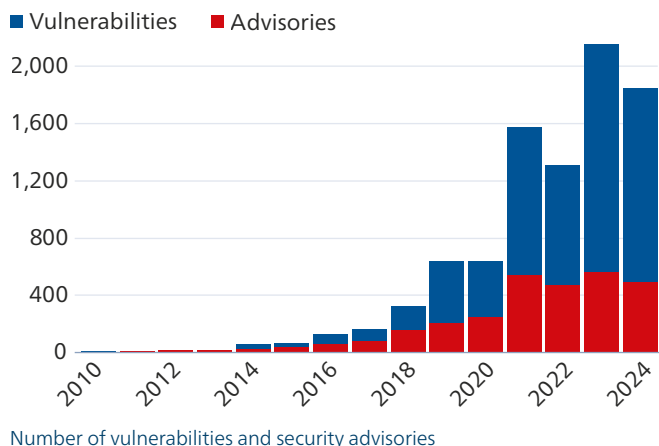
Digitalization has transformed the energy industry. Although new technologies open up opportunities, they also increase risks. Critical infrastructure's increas-

ing interconnectedness with IT systems make them more vulnerable than ever.

Looking into known vulnerabilities reveals the scale of the problem: OT system manufacturers regularly publish security advisories for their products. The number of reported vulnerabilities has increased significantly in recent years – a clear sign that cyberspace threats are continuing to grow. Therefore, protecting these supply-critical businesses from cyber and physical attacks is vital.

Recent developments in cyber security legislation

Since its introduction in 2022, the EU's NIS2 Directive has sparked intense discussions and debates about cybersecurity. It required member states to transpose enhanced ►



«The number of reported vulnerabilities has increased significantly in recent years – a clear sign that cyberspace threats are continuing to grow.»



HOWEVER, THE EU ISN'T THE ONLY PART OF THE WORLD WHERE CYBER SECURITY REGULATIONS ARE PROGRESSING:



USA

In May 2023, the US government updated the implementation plan for its National Cybersecurity Strategy, which aims to protect critical infrastructure from cyber threats. Executive Order 14028, which mandates strengthening the supply chain's security, is a prime example of this.



Switzerland

The Electricity Supply Ordinance (StromVV) will make the ICT Minimum Standard mandatory on July 1, 2024. It defines basic security measures for critical infrastructure operators and other companies. Examples include mandatory vulnerability analyses and implementing network segmentation.



Australia

Cyber Security Strategy 2023–2030 provides a clear framework that will be specified by the Cyber Security Act 2024. This law sets new cybersecurity standards for businesses and critical infrastructure.



Singapore

With a cybersecurity master plan specifically designed for OT, Singapore has made protecting industrial control systems a national priority.

security requirements into national law by October 2024 – a target that 23 of the EU's 27 member states have failed to meet.

This is a remarkable lapse, especially since cybersecurity issues are nothing new. The 2016 NIS Directive already requires member states to improve their protection of critical systems. NIS2 only reinforced these requirements and extended them to more sectors of the economy, including the food industry and public transport.

The vast number of planned or implemented regulations underscore that cybersecurity in the energy industry is no longer an option but an obligation. Specific companies that have been affected by this are defined by the regulations of the respective member states. For example, NIS2 addresses all entities that provide essential or important services to the European economy or society. However, in many countries, regulations still need to be developed.

The NIS2 directive's content

The NIS2 Directive outlines mandatory minimum cyber security measures that companies must implement. These include:

- › Reporting and managing security incidents: Companies must report incidents to the appropriate authorities within a short period of time.
- › Risk management: Companies are obligated to identify and assess security risks.
- › Vulnerability management: Companies must identify and remediate IT and OT system vulnerabilities.

Many of these measures are based on recognized standards such as ISO 27001, BSI IT-Grundschutz, or the NIST Cybersecurity Framework. The penalties for non-compliance are severe, making compliance a business-critical task.

Implications for businesses: Economic and security implications

Even without new legislation, investing in cybersecurity has always been advisable from a business perspective. However, the return on such investments has often been difficult to measure, as prevented disruptions or reputational damage to a business are difficult to quantify. ▶

RELEVANT ENERGY INDUSTRY LEGISLATION

Cybersecurity requirements play a central role in the energy industry and are regulated by numerous laws around the world. This is a selection of them:

› Energy Industry Act (EnWG) –

Germany: This law regulates, among other things, the security requirements of the energy infrastructure. When the NIS2 Implementation Act comes into force, it will be supplemented by equivalent requirements.

› Electricity Supply Act and Ordinance –

Switzerland: The ICT minimum standard defines binding measures for grid operators, energy producers, and service providers.

› NIS Implementation Act – Austria:

The current NIS Act of 2018 will be replaced by an NIS2 version, which is currently under development.

› Critical Infrastructure Cybersecurity

Act – USA: This law was designed to protect critical infrastructures, including the energy industry.

› Critical Entities Resilience (CER) – EU:

This regulation obliges companies to take physical protection measures to secure critical infrastructures.

› Cyber Resilience Act (CRA) – EU:

This law requires the security of digital products and their manufacturers to minimize cyber threats to product users.

These new regulations will make cybersecurity measures mandatory for all market participants. This will ensure greater security and a level playing field: companies that invest in security will no longer be at a competitive disadvantage.

As a result, investing in the latest security standards makes more sense from a business point of view—failure to comply results in the high costs associated with a successful attack and the penalty of sanctions.

At the same time, many cyber insurance policies depend on compliance with these standards. Failure to implement the necessary measures (e.g., contingency management, backup management, anti-virus protection) may result in reduced insurance coverage or none at all, which is a risk of its own.

What should you do first?

Even before the legal requirements are finalized, preparations can be made to strengthen your company's cybersecurity posture significantly.

- › **Conduct an impact assessment:** If it's unclear whether your company will be affected by NIS2 legislation, you should take advantage of a free assessment offered by national security institutions such as BSI (Germany) or the WKO Online Ratgeber (Austria).

- › **Define responsibilities:** Identify and train individuals responsible for IT and OT system information security. These individuals should also become the single contact point for reporting requirements.
- › **Involve senior management:** Senior management must communicate cybersecurity information to the rest of the organization.
- › **Determine security status:** Use requirement catalogs such as ISO 27001 Annex A, NIST CSF, or the ICT Minimum Standard to assess your organization's security status and prioritize actions. Service providers also offer specialized cyber risk assessments for this purpose.

A complete asset inventory is the foundation for effective risk and vulnerability management, especially in OT. Following the "I can only protect what I know" principle makes creating an inventory a top priority.

External experts can help establish security processes more effectively in an earlier stage. However, the knowledge gained by a company must be sustainably integrated.

Using NIS2 for concrete implementation

Cyber risk management is a key requirement for companies covered by NIS2 legislation. As mentioned above, the first step is identifying a cyber risk. The process consists of several steps:

- 1. Identify key business processes:** What processes are critical to your business or the delivery of business-critical services?
- 2. Identify the relevant IT/OT components:** Map processes to the appropriate assets, such as IT/OT assets or buildings, including responsibilities.
- 3. Perform risk analysis:** Use the asset inventory to determine the magnitude of damage and the likelihood of risks occurring. Relevant standards (ISO 27005, BSI IT-Grundschutz) may or may not be used.
- 4. Plan actions:** Reduce risks to an acceptable level with state-of-the-art measures. Implementing legally required measures, such as attack detection systems in Germany, should be a priority.
- 5. Document comprehensively:** All specifications, plans and implementation of measures must be documented. This includes regularly monitoring the effectiveness of measures.

*«External experts can help establish security processes more effectively in an earlier stage. **However, the knowledge gained by a company must be sustainably integrated.»***

In accordance with the NIS2 directive, the following topics are a minimum requirement for documentation:

- › Risk methodology for analysis, assessment, and treatment;
- › Cybersecurity requirements for IT and OT components;
- › Processes and responsibilities for handling security incidents;
- › Business continuity, e.g., backup management, disaster recovery, and crisis management;
- › Supply chain security and service providers relationships;
- › Security from the procurement, development, and maintenance of systems, especially when dealing with vulnerabilities;
- › Strategies for evaluating the effectiveness of cybersecurity measures;
- › Basic cyber hygiene and training;
- › Use of cryptography and encryption where appropriate;
- › Personnel security, access controls, and asset management;

- › The use of multi-factor authentication or other authentication methods.

These are familiar requirements from standards such as ISO 27001 or BSI IT-Grundschutz and the core of an information security management system (ISMS). However, it may be challenging for areas of OT that weren't covered by the scope of these standards. Adapting existing IT security processes to OT security requirements is useful.

Conclusion

New cybersecurity legislation presents a significant challenge, but also an opportunity to improve business operations with long-term security. A structured approach can help you comply with regulations and establish a robust level of security that meets legal requirements while building trust with customers and partners. ■

HELP FROM OMICRON

We offer comprehensive solutions that help your company meet NIS2 requirements:

StationGuard Solution

- › **Intrusion Detection System:** BSI-certified system for substations and control centers with intuitive operation and SIEM integration.
- › **Asset management:** Automatic IT/OT system recordings reduce the effort to create and maintain inventories.
- › **Vulnerability management:** Identifying affected OT systems makes patch management much easier.
- › **Functional monitoring:** Detects misconfigurations and increases reliability.

ADMO/Insight

- › **Workflow optimization:** Improves workflows while ensuring data integrity and availability.

- › **Data management:** Centralized planning and organization for engineering, testing, and maintenance tasks.

Training and engineering services

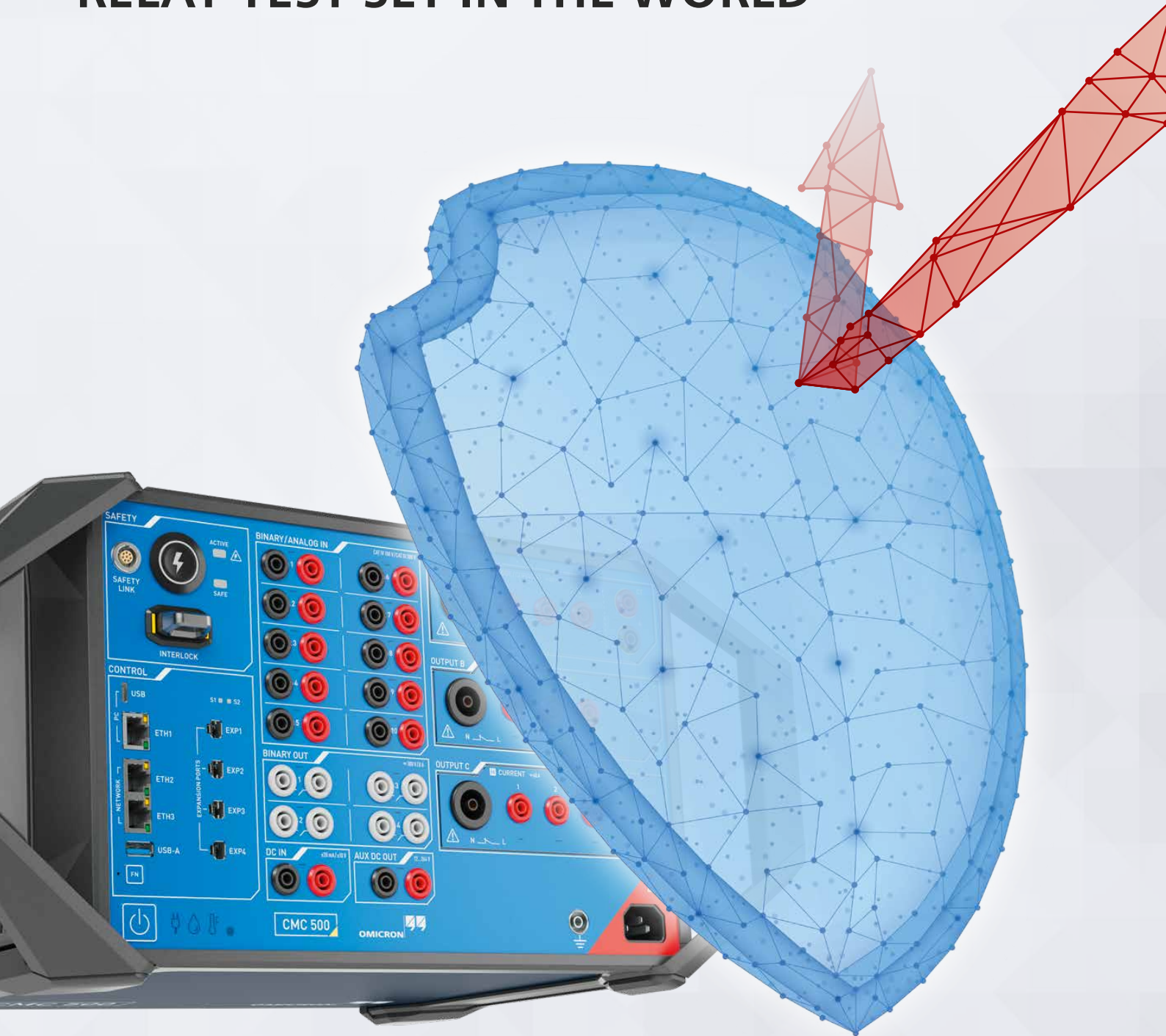
- › Conducting **security risk assessments** and audit preparation
- › Support for creating and implementing **security concepts**
- › Secure OT network configuration
- › **24/7 support** for security incidents
- › **Customized training** for IT and OT specialists

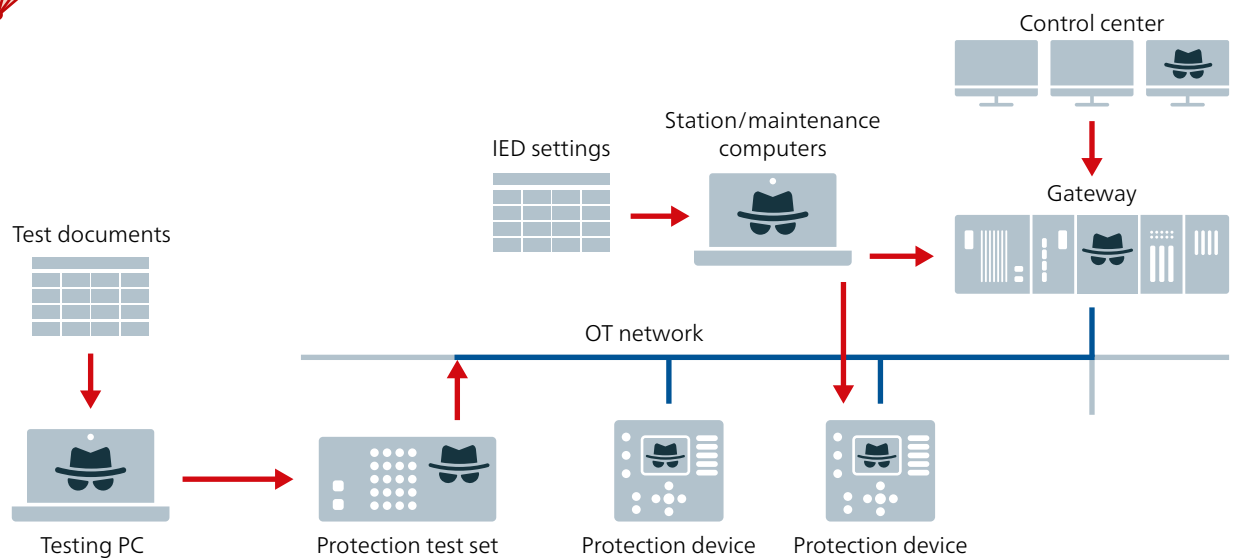
Our solutions facilitate security process automation while helping you meet standards such as ISO 27001 and NIS2 requirements. For more information, please visit:

 [omicroncybersecurity.com](https://www.omicroncybersecurity.com)

CMC 500

THE FIRST CYBER-HARDENED PROTECTION
RELAY TEST SET IN THE WORLD





If protection is inadequate, there are several ways for attackers to gain access to the station bus of critical infrastructures.

You need to take a holistic approach if you want to provide substations with effective protection against cyber-attacks. Cybersecure protection relay test sets are an essential element that should be featured in every security concept. Find out why this is and discover the extensive measures we've implemented to establish a new cybersecurity standard for protection testing.

A cyber-attack on critical infrastructure isn't just something that happens in books – and plenty of real cases exist to prove it. The most well-known incident occurred in Ukraine in 2016, when attackers exploited the connection to a control center. Since then, the necessity of protecting critical infrastructure has been stipulated through various legal requirements. For example, the NIS2 Directive (network and information security) lays out the framework for improving cybersecurity in the EU.

A comprehensive threat analysis covering as many attack vectors and vulnerabilities as possible, forms

the basis for hardening substations. As shown in a study by the Ponemon Institute, known vulnerabilities were exploited in 100% of the attacks they examined. Eliminating all vulnerabilities poses a real challenge for utilities, as there are many attack vectors, such as:

- › The connection to the control center and remote maintenance channels
- › Station and maintenance computers
- › The firmware and settings files for the protection devices themselves
- › Test sets used in the substations

While the awareness of cyber threats has grown, a closer look makes it clear that there's a lack of more specific solutions.

In terms of protection testing, the protection relay test set and the test laptop represent attack vectors that can be exploited. A secure test set has the advantage of addressing both of these attack paths. Until now, ▶

«Referring to a product as having cybersecurity by design requires more than employing measures at hardware and software levels. **Analyzing potential attack vectors begins with an entire company and encompasses all its processes.»**

cybersecure protection relay test sets weren't available in the market – but our new CMC 500 offers a solution.

Test sets can be an attack vector

We've addressed this issue by developing the CMC 500, the world's first cyber-hardened protection relay test set. But what kind of measures were required? And what do we mean by cybersecure? Like a threat analysis for critical infrastructure, the first step was identifying potential attack vectors in test sets and addressing them step by step. The years of experience we've gained with StationGuard – our intrusion detection system (IDS) tailored to the energy sector – proved extremely helpful. A holistic approach was required to develop the CMC 500 for maximum cybersecurity. So, our company took the necessary steps in our processes, production, software, and hardware. These combined measures more than lived up to the concept of cybersecurity by design.

Secure test hardware

At the hardware level, the CMC 500 features an ISO/IEC-11889-compliant trusted platform module (TPM 2.0). This cryptoprocessor establishes the basis for several security measures, as a range of keys and certificates can be securely stored on it. This ensures communication is reliably encrypted and allows the test set to be uniquely identified – just like with a fingerprint. Attacks such as machine-in-the-middle attacks can thereby be prevented.

Likewise, checks can be carried out during the boot process using secure boot and measured boot, which check the firmware authenticity and prevent the device from starting up if these checks fail. All communication can also be protected on an additional level by setting a password.

Secure test software

Hardened hardware cannot serve its purpose without the proper test software. Therefore, we also developed our software with a clear set of guidelines. Our Secure Software Development Life Cycle (SSDLC) process was already introduced during StationGuard's development. It ensures high quality standards and code security, laying out our approach to potential vulnerabilities and their disclosure. Transparency is one of the essential cornerstones ensuring the cybersecurity of our products.

To find out more about how we handle vulnerabilities, please visit omicronenergy.com/product-security.

Secure production and repair

We don't simply rely on selected suppliers and trusted partners for production and repair, we carry out the most crucial steps ourselves. That's why only a few of our employees are authorized to set up the CMC 500's certificates and keys. The process is structured without interruption to prevent any manipulation while it's carried out. Based on a hardware security module (HSM), our internally developed software

services also ensure that keys cannot be stolen. Any attempt to physically access a key in the HSM results in its destruction. Housing the modules in our secure server room is the final stage of our comprehensive security measures.

Secure processes throughout the entire company

Whether it's hardware or software development, production, or repair, people are at the heart of all these processes. Raising awareness about data and IT security is one of the most important factors in making life for cyber criminals more difficult. In addition to ensuring that our employees are properly trained, they must demonstrate their knowledge and skills regularly as part of internal phishing simulations and ISO/IEC 27001 audits.

Redefining cybersecurity

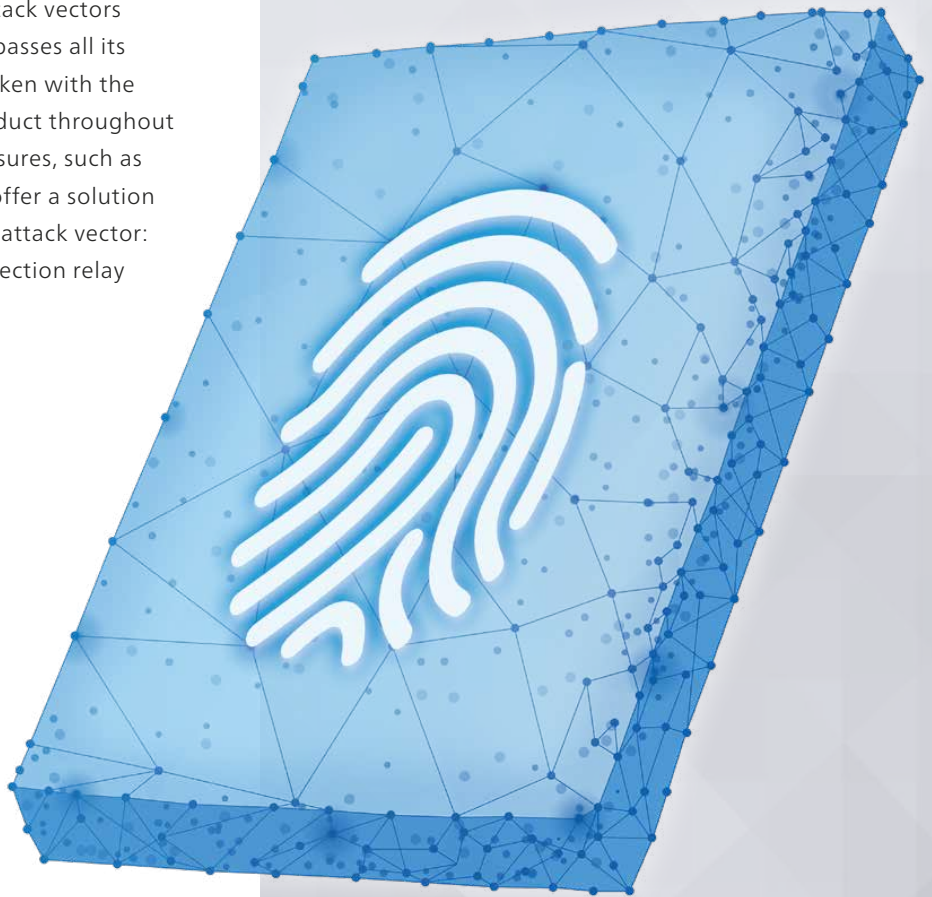
Referring to a product as having cybersecurity by design requires more than employing measures at hardware and software levels. Analyzing potential attack vectors begins with an entire company and encompasses all its processes. This is the precise route we've taken with the CMC 500. Additionally, we support our product throughout its entire life cycle with corresponding measures, such as vulnerability management. This is why we offer a solution unlike any other for addressing the test set attack vector: our CMC 500, the first cyber-hardened protection relay test set on the market. ■

«This cryptoprocessor establishes the basis for several security measures, as a range of keys and certificates can be securely stored on it.»

Find out more
about the new
CMC 500!



 omicron.energy/new-cmc



THE MAKING OF THE VBX

The virtual solution for a changing power grid.

The VBX marks a significant milestone in virtualization. This innovative platform is designed to host our existing solutions, including StationScout, StationGuard, and IEDScout. It provides the same reliability and versatility of our MBX and RBX hardware platforms in a virtualized environment. VBX opens

up new possibilities for service providers, utilities, and manufacturers by eliminating the need for physical hardware and offering flexible subscription-based licensing. But how did this innovative solution come to life? Here's the inside story of the VBX, as told by the team behind its development.



«Virtualization is the future.»

The idea

"We saw a clear trend toward virtualization across industries. The question was: how could we bring this trend to power grid operations in a way that truly adds value? The idea for the VBX was born from observing customer pain points – lugging physical devices around, managing hardware in increasingly virtualized environments – and

wondering how we could simplify their lives. The potential for a software-based testing solution was too compelling to ignore."

Ali Abdulla,
Regional Application Specialist,
IEC 61850 and OT Cybersecurity



«The need was already there.»

Greenlights

"From the start, we knew this was about meeting an existing need. Utilities and manufacturers are moving toward virtualized environments, and our testing tools must align with this shift. Customers didn't just want innovation – they needed practical solutions that fit seamlessly into their evolving workflows. We also wanted to make the product

as accessible as possible. That's why we introduced a flexible subscription model that gave customers the freedom and flexibility to scale their usage up or down based on project needs."

Andreas Klien,
Business Area Manager,
Power Utility Communication



«Every challenge was an opportunity in the end.»

Development

"Adapting our testing tools for virtualization wasn't straightforward. We had to ensure the VBX would perform reliably while maintaining the high standards of accuracy and functionality that our customers expect. It wasn't just about making a virtual version of existing tools but rethinking how they could be integrated into digital environments. New collaborations within the company needed to

be formed, and testing was rigorous and thorough. Those challenges ultimately pushed us to innovate in ways we hadn't anticipated, with a final result that we're genuinely proud of." ▶

Jakob Birnbaumer,
Technical Product Owner,
Automation, Communication, and Control



«We needed collaboration with innovation.»

Process Changes

"Bringing the VBX to life was real pioneering work that involved technical innovation and process alignment across different teams. Introducing a virtual machine as an additional platform for our PUC software wasn't just about the technology – it was about finding out how to set up licensing, ensure seamless online delivery, and take sales item con-

figuration to the next level. Through these efforts, we've ensured we can offer efficient products that meet our customers' requirements."

Ines Märk,
Operations Manager,
Power Utility Communication



«Fostering another mindset.»

Marketing

"When you're introducing a new approach, there's always some resistance. Our internal teams were used to traditional hardware sales, so introducing a subscription-based virtual product involved addressing concerns and educating colleagues and customers. The more we addressed those concerns, the more excitement we saw. So far, we

have been able to position the VBX as a flexible, future-ready solution, and the growing demand for it has motivated the entire team."

Onur Durak,
Product Manager,
Automation, Communication, and Control



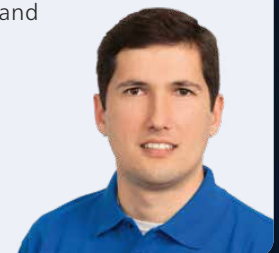
«The market is responding.»

The First Sale

"I wouldn't say customers were impatiently waiting for the VBX. But once it was available, it opened up opportunities. Virtualization is a hot topic in the power grid industry, with alliances like VPAC driving the conversation. Having the VBX keeps us at the forefront of those discussions. We made our first sale to a service provider that chose VBX because it fit perfectly within their virtual-

ized environment – they didn't want physical hardware, and the subscription model aligned well with their project-based work. It's about being ready for where the market is heading, and we're ready for it."

Eugenio Carvalheira,
International Business Development,
OT Power Grid



LEARN MORE ABOUT THE VBX

The VBX represents a bold step forward, but its journey is just beginning. Visit our website to explore more

about our newest platform and how it's reshaping substation automation:

 omicronenergy.com/vbx1



ISO/IEC 27001:2022 – OUR NEWEST MILESTONE



We received ISO/IEC 27001:2022 certification – the leading international Information Security Management Systems standard.

This achievement underscores our commitment to maintaining the highest information security and data protec-

tion standards as a trusted industry partner. An independent, accredited certification body has assessed our fulfillment of the standards' requirements through an extensive audit process. ▶



Increased cyber threats

Cyber-attacks are increasing – critical infrastructure and its supply chain are popular targets.

Sophisticated cyber-attacks target the foundational systems that support everything from energy and water to transportation and communications, with far-reaching and potentially catastrophic consequences. They impact the operations of these services and the daily lives of millions of people.



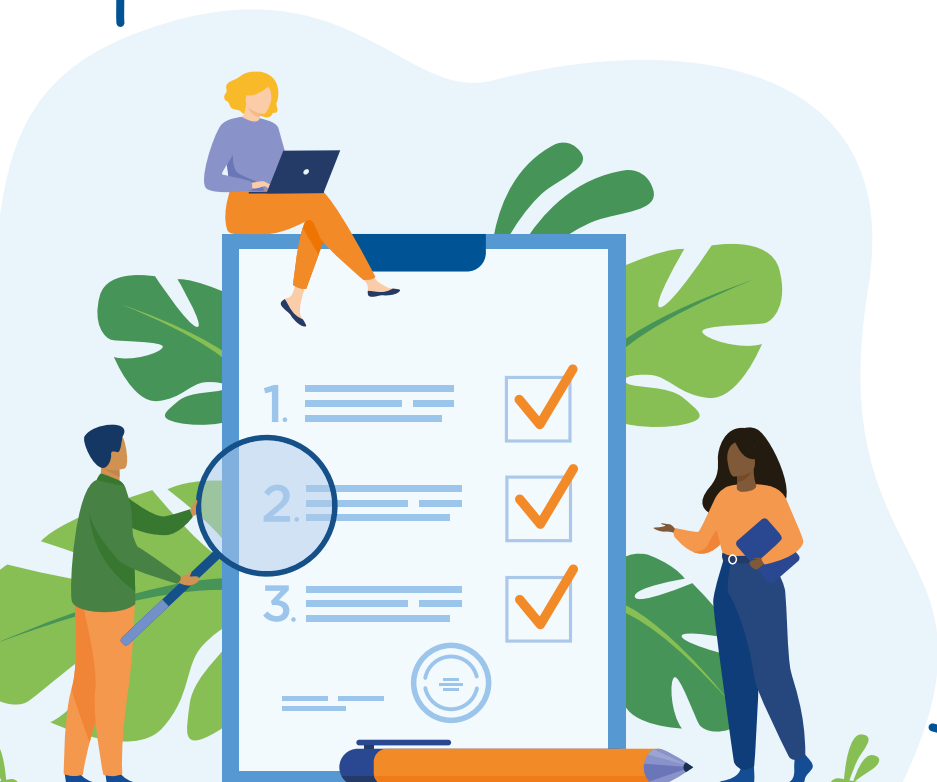
An increased industry effort

As the threat landscape constantly evolves, industries must increase their cyber security supply chain risk management efforts.

“We recognize that cyber security is an increasingly strong driver for our customers and within our markets. With ISO/IEC 27001:2022 certification, we can meet our customer’s current and emerging requirements, particularly those serving critical infrastructure,” says Daniel Wiesner, Global Key Account Manager at OMICRON electronics.

Our established Information Security Management System provides the necessary framework to address these challenges by systematically approaching effective risk management and implementing robust security controls.

Certification to ISO/IEC 27001:2022 demonstrates our compliance with the leading international standard for Information Security Management Systems.



«We recognize that cyber security is an increasingly strong driver for our customers and within our markets. With ISO/IEC 27001:2022 certification, we can meet our customer's current and emerging requirements, particularly those serving critical infrastructure.»

Daniel Wiesner,
Global Key Account Manager,
OMICRON



The ongoing journey of cyber security

Adapting to new threats, risks, and emerging technologies is crucial. Our worldwide team members play the most vital role in this process. We aim to inform our colleagues about the latest threats and best practices for avoiding them by providing state-of-the-art training and awareness resources.

“Our commitment to continually improving our Information Security Management System ensures we protect the information our customers, partners, and employees have entrusted us with. Secure, worry-free use of our products and services, and preserving our knowledge is the basis for future innovation,” says Jakob Halder, General Manager at OMICRON electronics.

What is ISO/IEC 27001:2022?

ISO/IEC 27001:2022 is the leading international standard for Information Security Management Systems. It provides organizations with guidance for establishing, implementing, maintaining, and continually improving an Information Security Management System to ensure the confidentiality, integrity, and availability of information and other related assets. ■

WHEN SOMEONE GOES ON A JOURNEY, THEY HAVE A STORY TO TELL

Insights into the life of an Application Engineer at OMICRON

The daily life of an OMICRON Application Engineer is more than just packing and unpacking testing equipment, performing measurements and leaving. OMICRON's eight-member primary testing team often faces various challenges that range from minor to major incidents. Some of them involve pleasant environmental conditions, while others are more harsh. It's a job that can be predictable or contain unexpected surprises. Two of our colleagues Stefan Böhler and Alexander Herrera, gave us a brief, lighthearted glimpse into their daily routines.

Stefan began working for OMICRON in the generator testing field in 2013. He's also a father of four who's worked as a part-time professor at HTL in Bregenz since 2023. Alexander specializes in circuit breaker testing and also began

working at OMICRON in 2013. He's originally from Guatemala, and love drew him and his family to Austria – more specifically, his love of performing electrical diagnostic tests.

Application engineers are usually called when there's an emergency. Ideally, they should be called before a situation becomes an emergency, but with 170 worldwide customers, there are more opportunities for critical situations to occur, and support may be required on short notice.

Alexander remembers an unusual call he received on short notice that went something like this: "Hey Alex, how would you like to take a trip to Estonia?" – "Ummm, okay, that sounds great. When?" – "Now. A taxi will be there in one hour to pick you up." So, as

you can see, besides possessing extensive technical knowledge, being able to react spontaneously to situations and remaining flexible are some other characteristics application engineers require.

Sometimes, improvisational skills may even be necessary: After the CIBANO 500 launch took place a few years ago, Alexander was summoned to Norway "for a switchgear measurement." It resulted in performing daily measurements at different substations over a five day period in harsh winter weather. However, the intense technical exchange was rewarding, and even led to a lifelong partnership with the colleague there. The device was robust and reliable, just as promised. However, with constant temperatures of $-15^{\circ}\text{C} / 5^{\circ}\text{F}$, and little opportunity for any exercise to stay warm, the human factor proved to be more of a struggle.

"In addition to that," adds Stefan, "it often leads to unconventional setups or facilities that aren't always easy to access." An experience that highlighted this point for him occurred during a customer's project at a bank in Hong Kong: An entire generator test setup that consisted of a CPC 100, a CP TD1, and an MPD 600 system was spread out between the coffee machine, dishwasher, and kitchen appliances in the break room. On top of that, the only access to the generator we needed to test was through a narrow doorway.



Since 2013, Stefan
has travelled to
37 countries



Since 2013, Alexander
has travelled to
33 countries



"At least there was plenty of fresh coffee." He concluded.

A healthy sense of humor and the ability to remain calm under duress is another requirement: During a customer seminar in Ghana, a sales partner arranged to have the testing equipment on-site in advance, recalls Alexander. As the minimalist saying goes "Sometimes less is more," the CT Analyzer was packed into a suitcase and flown from point A to point B. We began to prepare everything in the evening, and the customer seminar was set to begin the following day. However, our sales partner's jaw dropped when we opened the suitcase because instead of seeing the CT Analyzer inside, he found himself staring at a large sack of potatoes. The crisis was resolved after an unexpected trip back to the airport. Calm was finally restored when the missing suitcase with the CT Analyzer was found.

When other OMICRON application engineers begin to reminisce about their travels, the conversations are often similar. They're always entertaining, captivating, and full of unexpected twists. We'd also love to hear any anecdotes you have that relate to OMICRON and our solutions! Feel free to email us at CD-magazine@omicronenergy.com – we look forward to reading your stories! ■



TWO MILLION VOLTAGE & CURRENT MEASUREMENT POINTS PER SECOND!

How can we help mitigate the challenges introduced by vacuum circuit breakers (VCBs) in high-voltage applications?





New circuit breaker technologies, particularly vacuum circuit breakers (VCBs) rated from 72,5 kV up to 420 kV, have been launched or are entering the market. They've been considered state-of-the-art in medium-voltage grids for decades. However, whether this advancement is also occurring in high-voltage (HV) grids remains an open question without a definitive answer. Vacuum technology promises minimal maintenance, long operational life, and environmental friendliness. The environmental angle has become increasingly vital due to impending updates to the EU F-Gas Regulation, which aims to ban and restrict the use of fluorinated greenhouse insulation gases like SF₆ to reduce greenhouse gas emissions.

Phenomena: "pre-strikes" and "multiple re-ignitions"

Interactions with vacuum technology in medium-voltage circuit breakers have revealed "pre-strikes" and "multiple re-ignitions".

- › "Pre-strikes" occur during closing operations.
- › "Multiple re-ignitions" occur during breaking operations, accompanied by "current chopping", where the current is interrupted before the AC current naturally crosses zero.

These processes emit steep fronted transient voltages and current impulses, causing non-homogeneous voltage distributions inside adjacent assets and over-voltages that cause higher dielectric stress.

What about high voltage grids?

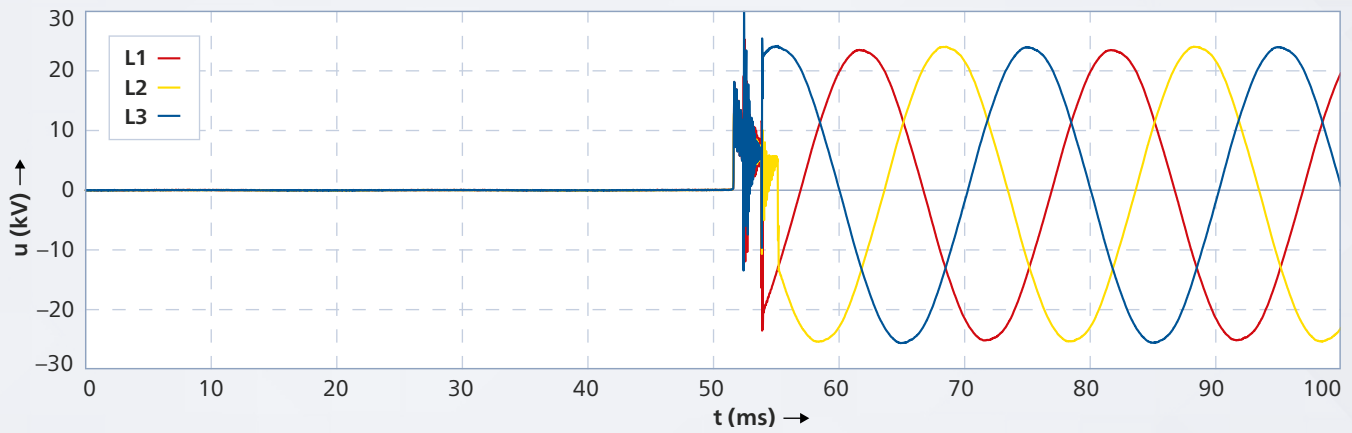
Until now, very little is known about combining HV grids with the measured electrical stress caused by vacuum CBs. This knowledge gap has motivated

utilities to gain operational experience under realistic conditions throughout a VCBs lifetime. High-frequency transients are particularly undesirable because they can harm insulation systems and affect inductive components such as shunt reactors or current transformers in the grid. These transients can lead to significant internal overvoltages and stress on the electrical infrastructure, resulting in potential equipment failure or reduced lifespan.

Utilities looking to apply these new technologies in their standard high-voltage applications usually install pilot installations to gain more confidence. Part of that is evaluating the need for countermeasures, such as adding circuits that dampen transient signals. We've supported pilot projects with our knowledge and expertise by specifying required voltage measurement systems, selecting appropriate technology, and generating meaningful reports throughout the one-to-two-year evaluation period.

Voltage measurement system specification

Selecting the appropriate instrument transformer is essential when capturing true signals in the electrical grid. Conventional voltage transformers (VTs), which operate on the inductive principle, are designed for grid frequency and are incapable of capturing transient voltage signals. CR-dividers are recommended for measuring transient signals. These devices are capacitive and resistive components connected in series and belong to the low-power instrument transformers (LPIT) class. The capacitive component offers high accuracy across a wide frequency range, from 50 Hz to lightning-impulse voltage frequency, while the resistive component uses ▶



Typical closing operation with pre-strikes in all phases.

damping to minimize reflections, thereby reducing measurement errors.

Selecting the right measuring system

Measuring transient voltage and current signals requires a sophisticated transient recorder capable of capturing all fast-front transient events. Such a device should record at least two million voltage and current measurement points per second and phase. Since it's located directly in the substation's switching bay, it must also operate reliably and accurately 24/7 under harsh climate and EMC conditions. Additionally, it has to provide suitable interfaces for experts to analyze mea-

surement data. Ideally, they should have remote access to measurement results and relevant information that's easy to extract.

Generating reports

Time-frequency signals need to be analyzed using advanced tools such as wavelet transformation in order to create meaningful and easily interpretable reports. This analysis condenses relevant data; for instance, it extracts and presents the number of re-ignitions, the time intervals between them, and the maximum amplitudes of over-voltage occurrences in a well-structured and easy-to-read report.

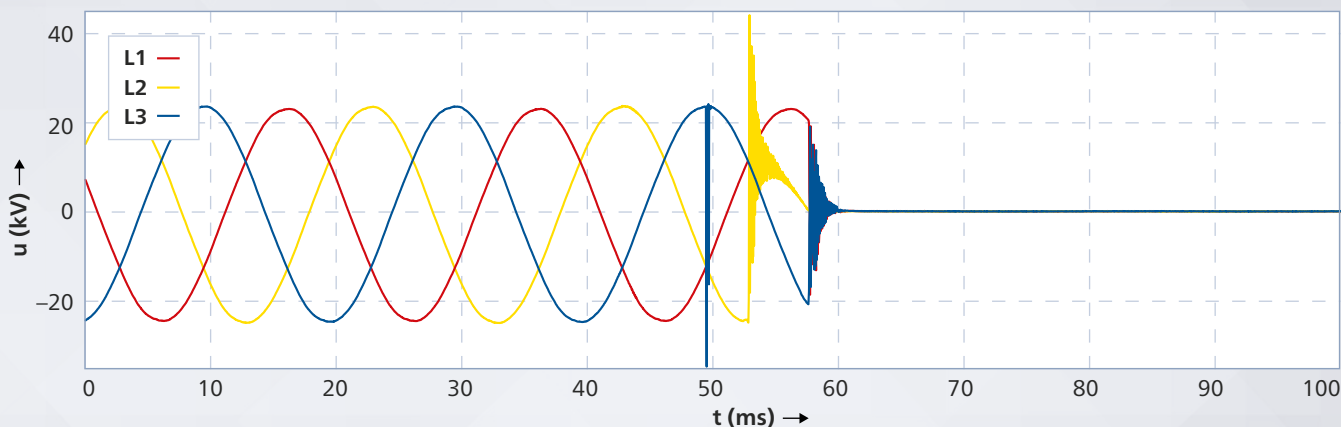
A three-phase analysis is performed on all signals to determine if the circuit breaker pole is related to electrical stresses. Furthermore, the long-term behavior of the electrical stresses and the VCBs switching behavior (pre-strike and re-ignition performance) are evaluated to detect potential changes over time. This allows assumptions to be made about the VCBs long-term performance and suitability for the application under investigation.

Successful project implementation

One of these projects was made possible by our collaboration with 50Hertz Transmission GmbH in Germany.

Event	Day	Time	OP	Number of re-ignitions			$u_{\max} (\hat{u}_{L1-E})$			$u_{\text{ext}} \text{ (kV)}$		
				L1	L2	L3	L1	L2	L3	L1	L2	L3
		hh:mm:ss										
1	1	10:42:26	open	0	0	0	1.85	0.91	1.02	-44.2	21.8	-24.4
2	1	19:53:07	close	13	21	8	2.11	1.18	2.12	-51.4	-28.7	-51.7
3	3	05:03:49	open	0	0	0	1.83	0.89	1.02	-44.2	21.5	-24.6
4	3	13:52:17	close	10	21	0	1.81	1.21	1.39	-44.0	-29.5	-33.8
5	5	06:03:53	open	0	0	0	0.91	1.02	1.83	21.8	-24.4	-43.9
6	5	14:55:56	close	14	20	8	1.32	1.12	1.18	-32.0	27.3	-28.7

Transient recordings and their evaluation parameters



Typical breaking operation with multiple re-ignitions in phase L3 and damped TRV oscillation.

During the project, a 30 kV shunt reactor of 75 MVar was often switched by a 123 kV vacuum circuit breaker for reactive power compensation, amounting to roughly 20 to 25 monthly switching operations.

Our experts specified three dedicated CR-dividers. They were built and successfully tested by CONDIS SA. An edge computing system was defined, and our experts supported its development, making a final selection from our CTlab. This included recording the transient capability of four voltage and current input terminals and having the option to connect and submit the recorded data to a secured cloud. In August 2023, the measurement system was assembled and commissioned by GÖBEL and 50Hertz Transmission GmbH.

So far, several projects have been realized, and their findings will be shared with the power community. For instance, at the Cigrè Symposium in Trondheim 2025, a paper titled "Long-term transient signal monitoring in inductive load switching with VCB" will be published.

Environmentally-friendly solutions

Addressing these technical challenges is crucial as the industry moves towards more environmentally friendly solutions. The successful integration

of vacuum circuit breakers into high voltage grids hinges on balancing the benefits of vacuum technology with effective strategies for managing its inherent transient phenomena. ■

«The project was handled with expertise, and a professional technical solution for CB monitoring was found. The support from OMICRON was outstanding. Thus, a second VCB pilot project for measuring transient electrical stresses between 50Hertz Transmission GmbH and OMICRON was established at the Jessen/Nord substation on a 110 kV transformer bay.»



Christian Trempler,
Asset Manager – Circuit Breaker Assets,
50Hertz



THE NON-STOP PROCESS OF MPD TECHNOLOGY DEVELOPMENT

Continuous MPD 800 optimization is driven by innovation and listening carefully to our users.



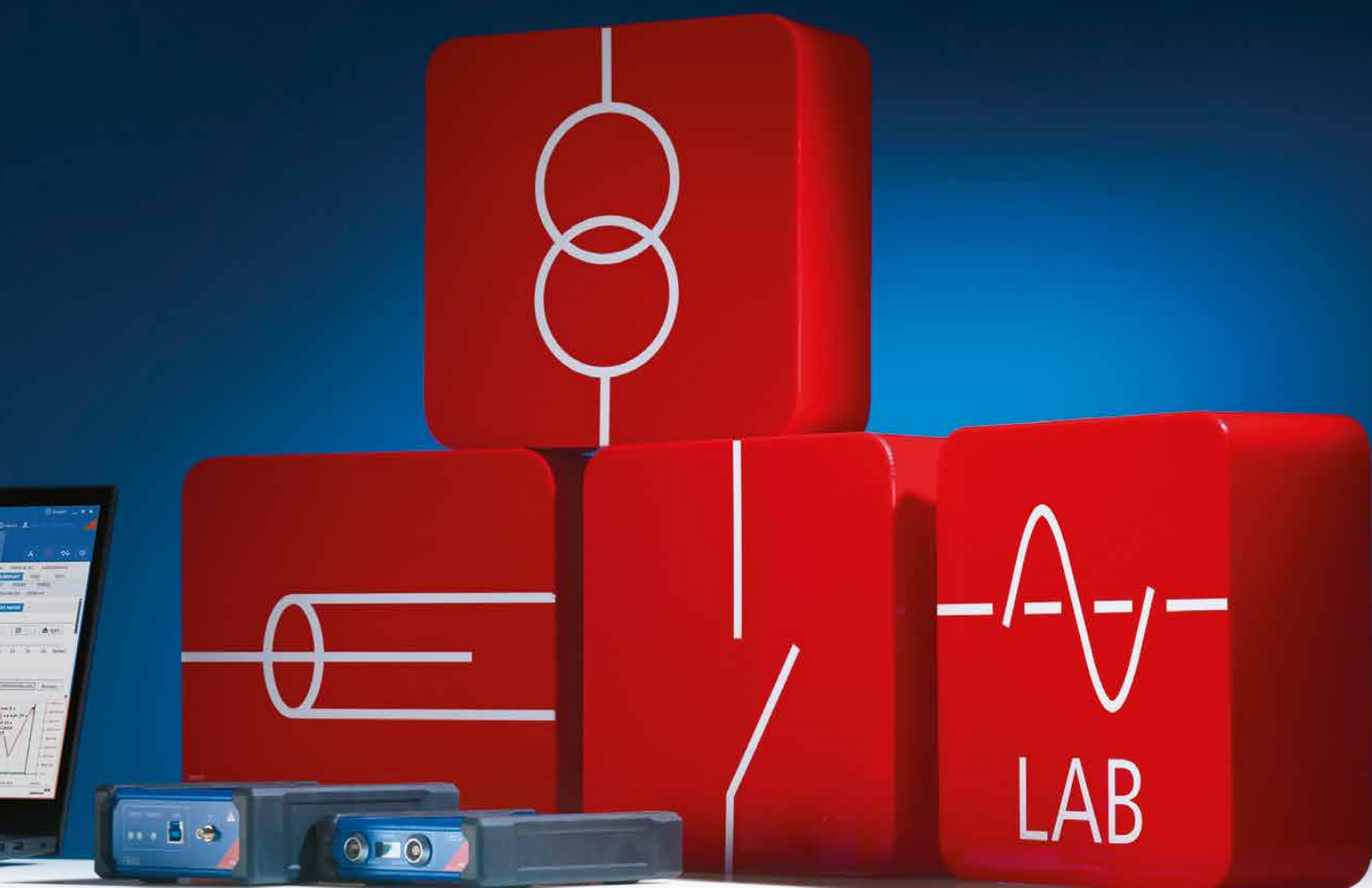
Twenty-five years ago, a partial discharge (PD) measurement technology that could provide real-time, geographically distributed, and highly sensitive PD measurements at multiple unsupervised sites didn't exist. This led to the development of fiber optic connections, synchronized, multi-channel PD measurements, and the ability to record all PD data in real-time for post-analysis. These requirements were the impetus for MPD development, which began in 2000 and resulted in product solutions, like the MPD 540 in 2003, the MPD 600 in 2007, and the MPD 800 in 2020.

Ground-breaking PD testing technology

Today, MPD technology offers a highly compact and complete solution, making PD testing available to all types of users. It enables a quick and easy setup that only requires minor training, maintaining complete IEC 60270 standard-

compliant and fully traceable PD measurements with the kind of quality documentation users require. MPD technology also has advanced functionality that helps specialists and experts solve the most complex challenges on-site and in the lab.

We followed our latest MPD 800 PD measurement and analysis system in 2022 with the UHF 800 for ultra-high frequency range PD testing for testing environments with high levels of external noise. They both feature the latest PD measurement technology, including two PD measurement channels, optimized filtering for highly effective noise suppression, and reliable PD source separation techniques. In addition, users can customize testing profiles by only selecting the PD measurement and analysis features they need for the type of test they're performing.



Enhanced system compatibility

MPD 800 and UHF 800 units are compatible with one another, use the same MPD Suite measurement and analysis software, and can be daisy-chained in the same measurement setup. Even users of our previous MPD 600 PD measurement device can update their system to take advantage of the new software features and combine their newer MPD 800 with older MPD 600 devices in the same measurement setup.

MPD Suite software – Future-proof technology

After the MPD 800 and UHF 800 PD testing devices debuted, the accompanying MPD Suite Software was continuously optimized to solve the challenges users face in all types of testing applications. Right from the start, our focus was squarely placed on the quality and reliability of our MPD products. ▶

«Right from the start, our focus was squarely placed on the quality and reliability of our MPD products.»

Continuous updates for optimized performance

Since we launched our latest-generation MPD 800 and UHF 800 systems, we've released a new software update each year. These updates included original features that were greatly enhanced, and new capabilities were added to optimize the overall performance and extend the available toolset to help users accomplish a wide variety of testing needs. Some of these significant enhancements included the following:

› Very-Low Frequency (VLF) PD Testing

MPD Suite software updates have greatly simplified PD testing with Very-Low Frequency (VLF) test voltages in the 0.1 Hz or 0.01 Hz range. VLF PD testing on power cables is easily performed with one click of a mouse rather than manually as before.

› GPS-synced PD datasets

For PD testing applications on power cables where it is impossible to lay fiber optical cables, PD datasets are recorded with two or more MPD 800 systems at different positions along a power cable, such as joints or terminations. These PD dataset files can be merged for post-analysis and PD localization. They're displayed as one file when replaying the recorded data. This not only simplifies reporting but also allows users to perform PD localization.

› Automatic PD event triggered trending

This feature supports users when triggering condition-based measurement actions. Now, creating automatic PRPD screenshots and recording dataset files is possible when certain conditions are met. These include conditions such as repetition after a certain time interval, a measurement reading exceeding a configurable threshold for a

certain time, or a certain minimum number of PD pulses appearing in the PRPD in a certain place. This allows unsupervised PD measurements during commissioning or prolonged PD tests without overlooking critical events.

› IEC 60270-compliant performance check for MPD 800

The IEC 60270 standard, which forms the basis for most PD measurements, mandates that PD measurement devices undergo a performance check once per year. This check ensures that the PD filters used in those measurement devices continue to operate correctly. The MPD Suite software (starting with Version 1.50) now includes a Performance Check Wizard, which automates this process for MPD 800 devices. It guides users through the necessary measurements, collects data results, compares them with results from previous measurements, and reports whether all MPD 800 devices comply with the limits outlined in the IEC 60270 standard. As a result, users no longer need to send their MPD 800 devices to a calibration lab or spend a lot of time performing tedious measurements.

Watch the video

Scan the QR code here to watch our video demonstration of the MPD 800 Performance Check Wizard:
youtu.be/KDCdFDaHXJI



› PD trigger functionality for MPD 800

Simply drawing a trigger window in the PRPD (Phase-Resolved PD Diagram) displays pulses within that area in the PD scope. This feature is useful for a variety of applications, including detailed pulse shape analysis on all assets or triggering acoustic PD localization with PDL 650 via the MPD 800 optical output.

LISTEN TO THE PODCAST

Interested in this topic?



Scan the QR code here to listen to our Energy Talks podcast Episode 94 with our PD expert Caspar Steineke to learn about the history and evolution of MPD PD testing technology.

omicon.energy/episode94



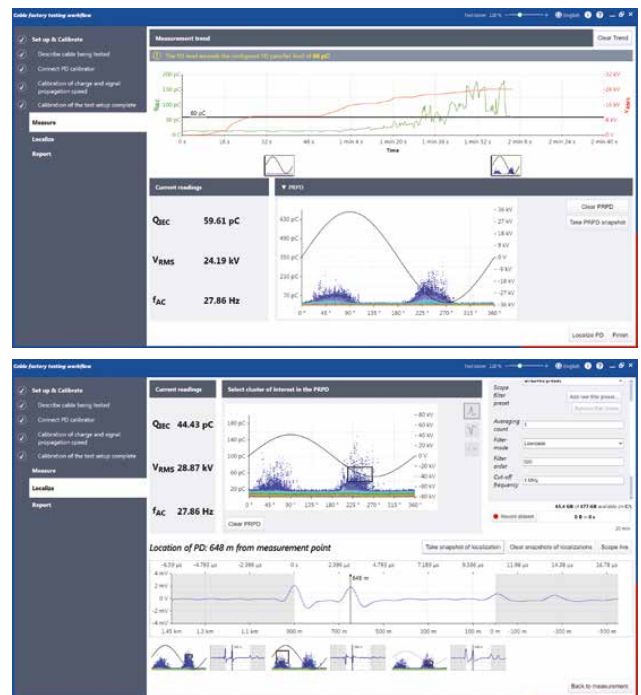
› Cable Factory Testing Workflow for MPD 800

In Version 1.50, we added our Cable Factory Testing Workflow, which is a separate user interface for performing quick and easy factory tests, such as FAT, on high-voltage or medium-voltage cables. The workflow guides the user through the process of PD testing on factory cables and only shows relevant information and controls for each test step. It can also locate PD faults and contains comprehensive reporting capabilities. The workflow is part of the MPD Suite Software Cable Factory Testing and the Multi-Application packages. A license update is required to enable the workflow.

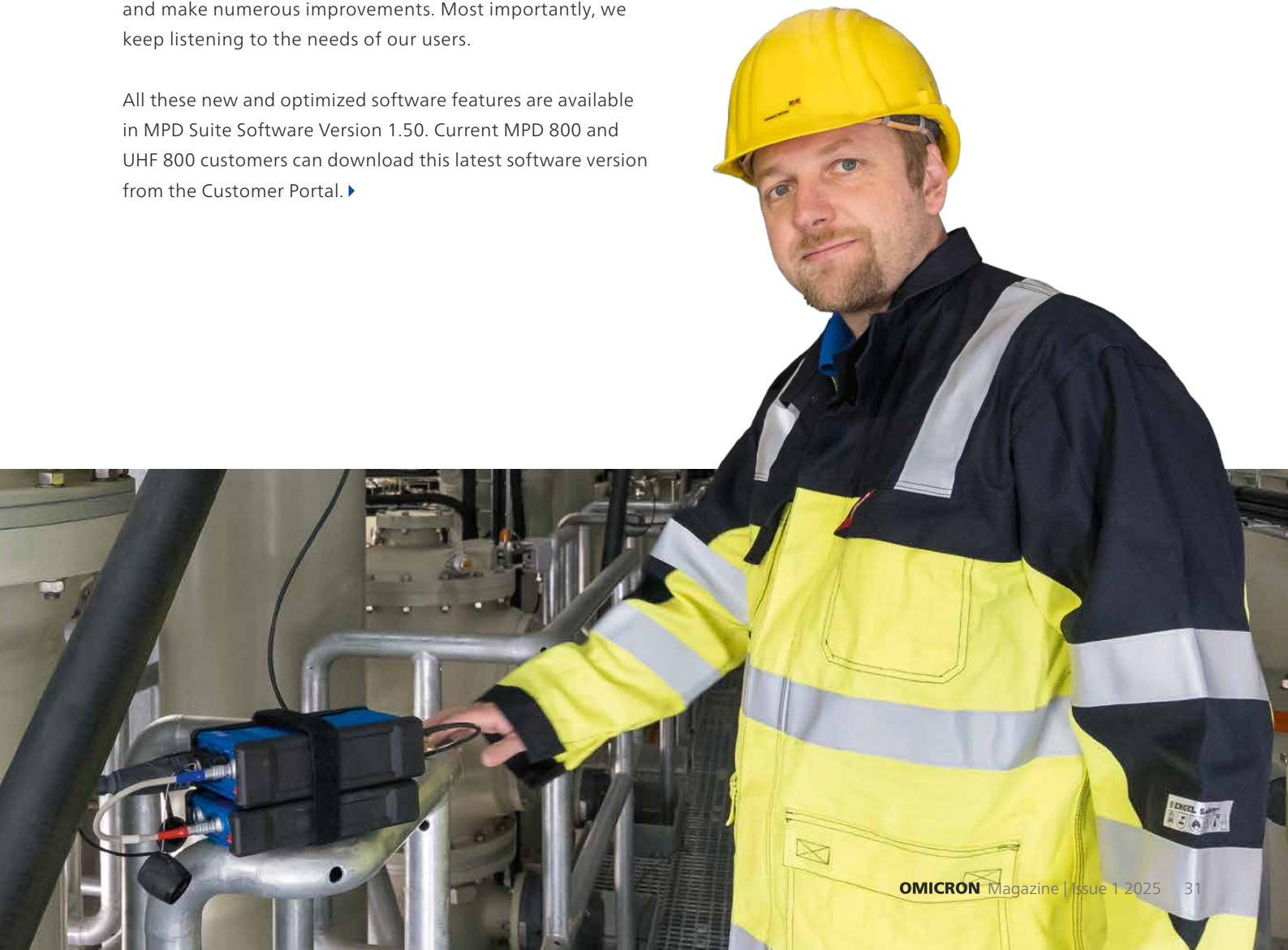
MPD technology continues to evolve – a process without end.

Our MPD 800 and UHF 800 PD testing systems and the accompanying MPD Suite software offer a great return on investment into the future with continuous product improvements and high-quality standards to ensure the reliability of high-voltage assets. To make this happen continuously, we constantly invest in research, try out new features, and make numerous improvements. Most importantly, we keep listening to the needs of our users.

All these new and optimized software features are available in MPD Suite Software Version 1.50. Current MPD 800 and UHF 800 customers can download this latest software version from the Customer Portal. ▶



A Cable Factory Testing Workflow is included in MPD Suite software for MPD 800 devices.



NEW ACCESSORIES AND SERVICES FOR THE MPD 800

New accessories are available for our MPD 800 and UHF 800 devices to make work in different application areas easier. The following are our latest accessories and services:

MPC1 PROTECTIVE CASE

Our MPC1 is a special protective case for MPD 800 and UHF 800 PD measurements. Its rugged design protects the PD measurement devices and external batteries placed inside the case from moisture, dust, and other damaging conditions when performing PD tests outdoors or in harsh industrial environments. The MPC1 case can be configured with one PD measurement device and up to three external batteries or two PD measurement devices and two external batteries. Users can conveniently charge the

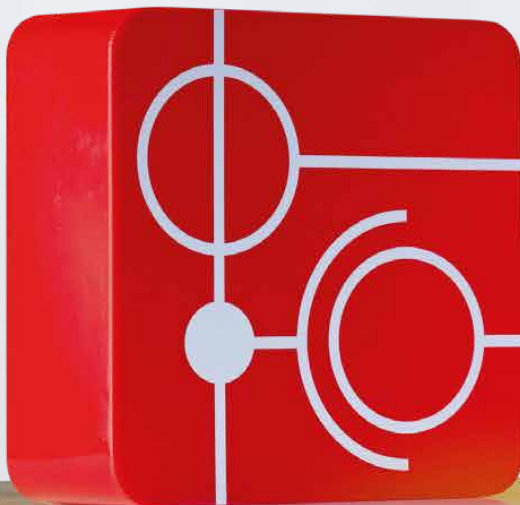
RBP1 inside the MPC1 without opening the case.

Device connections can be made easily from the MPC1 front panel to up to four PD sensors, such as coupling capacitors, high-frequency current transformers (HFCTs), bushing tap adapters, and ultra-high-frequency sensors. The MPC1 front panel also has ports for connecting it via fiber optic cables to the MCU2 master control unit and other MPC1 transport cases linked with fiber optic cables in a daisy chain.



Scan the QR code here and watch our short video about the MPC1.

youtu.be/xYlxT3ej0n8



TEV1 SENSOR FOR NON-INVASIVE PD DETECTION

Our TEV1 is a passive and broadband sensor that can decouple transient earth voltages (TEV) or capacitively coupled signals from metal surfaces. Transient earth voltages can originate from partial discharge (PD) activities within medium-voltage (MV) switchgear and can be detected on its outer surface. The TEV1 sensor is also designed for installations on the surface of high-voltage equipment, such as metal walls of power transformers or power cable terminations. Magnets in the TEV1 sensor housing securely attach the sensor to metal surfaces.

TEV detection can be performed online without interrupting operations and offers a reliable, nonintrusive, but less sensitive alternative to a standard-compliant PD measurement. Comparing the TEV readings provides essential information about which equipment needs to be checked for suspected PD activity with an offline PD measurement using our MPD 800 for more precise PD measurement and identification to determine corrective action.

More information:

[omicronenergy.com/tev1](https://www.omicronenergy.com/tev1)



FULL-SERVICE IEC 17025 AND FACTORY CALIBRATIONS

OMICRON Calibrations offers IEC 60270 standard-compliant calibrations for existing MPD 800 and MPD 600 devices, CPL devices, and CAL 542 charge calibrators in its accredited IEC 17025 calibration laboratory.

Existing MPD 800 devices can also benefit from a full-service IEC 17025

calibration, which also includes an OMICRON (ISO 9001) factory calibration. The MPD 800 is automatically tested, calibrated, and adjusted during OMICRON's factory calibration. New MPD 800 devices can be purchased with both OMICRON factory and IEC 17025 calibrations before delivery. ■



ON SITE: OMICRON IN SOUTH AFRICA

Riaan Louw from Alectrix (Pty) Ltd, shares his insights about the power sector with us.

Alectrix (Pty) Ltd, based in Cape Town, South Africa, has been active for almost 30 years since its founding in 1997. As the authorized sole and exclusive Sales Partner for OMICRON electronics in Southern Africa, Alectrix specializes in distribution, after-sales service, application support, and training for OMICRON products and solutions. Alectrix is also known for hosting one of the largest OMICRON User Conferences in the world, the South African User Conference.

How is the energy grid structured?

Riaan Louw: The South African energy grid has three main components: generation, transmission, distribution, and microgrids. Generation includes power stations with up to 58 GW capacity, mainly from coal, nuclear, hydro, solar, and wind. Transmission involves 28,000 km of high-voltage lines with rated voltages ranging from 400 to 765 kV. Distribution covers 325,000 km of lower-voltage lines to end-users. Additionally, microgrids add 5,400 MW of power to the main grid's total capacity.

What resources are being used to generate power?

South Africa's power generation relies heavily on coal, which provides about 80% of the total energy mix. Other resources include nuclear (5.4%), renewable energy sources like wind

and solar (7.3%), and hydroelectric power. Efforts are ongoing to diversify the energy mix by increasing the share of renewables and natural gas.

What are the current hot topics in the energy supply market?

Trending topics in the South African power and energy supply industry are:

- › Renewable Energy Expansion: Increasing wind and solar capacity.
- › Eskom's Restructuring: Improving efficiency and reliability.
- › Grid Upgrades: Investing in an R390-billion expansion.
- › Energy Policy Reforms: Diversifying the energy mix.
- › Just Transition: Supporting workers and communities shifting from coal to renewables.

What kinds of challenges are your customers facing?

Alectrix's customers in South Africa's power sector are presented with unique opportunities to innovate and improve. They are navigating through frequent load shedding and disruptive schedules, which drive the need for creative solutions and resilience. The aging infrastructure and maintenance needs offer a chance to modernize and upgrade systems. Ensuring the industry maintains a focus on training and development fosters a culture of continuous learning. Despite these

challenges, we should encourage resourcefulness and adaptability.

When looking towards the future, where do you see the biggest challenges in the power sector and in general?

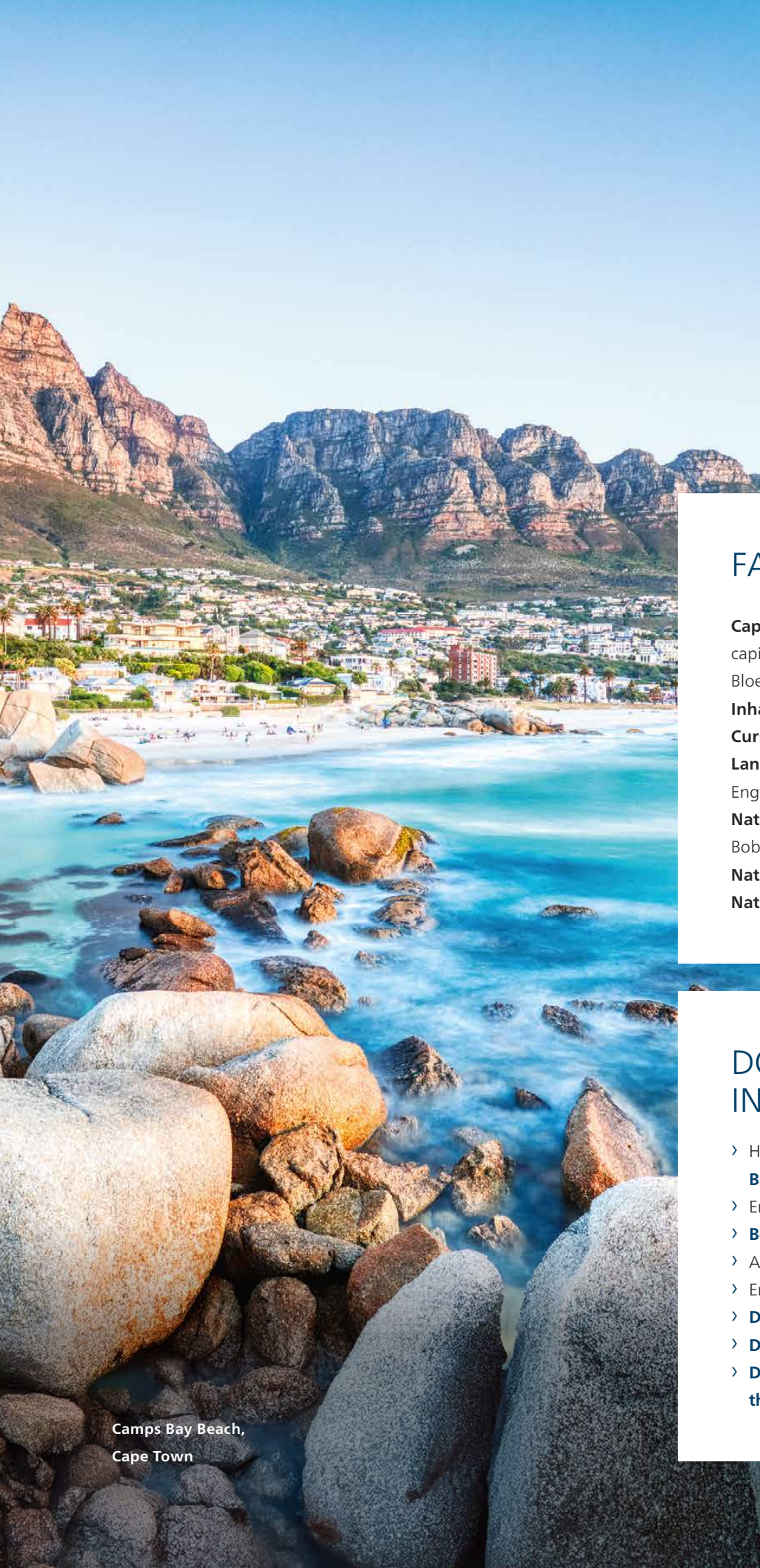
The South African power sector has exciting opportunities for growth and improvement. Addressing frequent load shedding and aging infrastructure can lead to innovative solutions and modernization efforts from the industry and its suppliers. The gradual transition to new products and technology presents a chance to enhance reliability and efficiency. While slow grid upgrades pose challenges, they also offer the potential for significant advancements. Alectrix is proud to support the South African power sector in its pursuit of excellence and reliability.

Thank you for the interview. ■



Riaan Louw,
General Manager, Alectrix (Pty) Ltd

 www.alectrix.co.za



Camps Bay Beach,
Cape Town



FACTS

Capital: Pretoria: Administrative capital; Cape Town: Legislative capital; Bloemfontein: Judicial capital

Inhabitants: 64 million people

Currency: South African Rand (ZAR)

Language: Eleven official languages, with English as the official business language

National Dish: Braaivleis, Biltong and Bobotie

National Drink: Rooibos Tea

National Sport: Rugby

DOS AND DON'TS IN SOUTH AFRICA

- › Have a **braai** (barbeque) and taste the **Biltong** (dried meat). Try the **wine**.
- › Enjoy **the sport and outdoors**.
- › **Be patient. Have a laugh.**
- › Appreciate **nature**.
- › Embrace **the culture**.
- › **Don't feed wild animals.**
- › **Don't forget your hat and sunscreen.**
- › **Don't wander or travel alone in the veld.**



RELIABLY DIAGNOSING ROTOR WINDINGS IN TURBO GENERATORS

Using frequency response analysis to identify inter-turn short circuits and avoid unexpected outages

Rotor windings in rotating electric machines are subjected to high mechanical forces that often cause unexpected outages. This makes turbo generators particularly vulnerable due to the high speeds of their rotors. These systems are usually essential components in energy generation and industrial production, so outages can incur significant additional costs. Short circuits between a rotor pole's windings are one of the leading causes of these outages, making their reliable diagnosis crucial to prevention measures.

In the world of transformers, frequency response analysis (SFRA, Sweep Frequency Response Analysis) is a widely used, highly sensitive method for carrying out diagnosis measurements. This method can also detect interturn short circuits in

a rotating machine's rotor poles. Until now, there hasn't been an objective data-based evaluation method that ensures precise diagnostics – although they're essential for accurately evaluating rotor windings.

This prompted EMIS, a German service provider in electrical engineering, automation, and energy supply, to explore the potential advantages of applying frequency response analysis to the rotors of the turbo generators they service. This investigation was undertaken as part of an internal master's thesis project.

Pascal Fröhlich, who worked at the company while pursuing his master's degree, conducted the research with the encouragement of Johannes Ohde, Head of the

Electric Machines department. Both were kind enough to answer our questions regarding their work.

Johannes, what kind of rotors are we talking about here?

Johannes Ohde: Although EMIS specializes in turbo generator maintenance, the scope of their expertise also covers an entire range of machines. We wanted the thesis to focus on high-speed machines, with 1,500 or 3,000 rpm speeds as we usually work in the 50 Hz power system.

Pascal measured various rotors for his thesis, including salient pole and non-salient pole machines. Seven pieces of equipment find their way into the thesis with nominal powers ratings from 1.8 MVA up to 588 MVA. ▶

«Existing methods are highly subjective interpretations, so we were looking for a more sensitive method with objective evaluation criteria.»



Johannes Ohde,
Head of the Electric Machines department, EMIS Electrics GmbH

«We were able to show that SFRA is more sensitive than the RSO method our company has been using, in addition to **establishing objective evaluation criteria for rotors.**»



Pascal Fröhlich,
Academic employee, EMIS Electrics GmbH

What was the motivation behind the thesis?

Johannes Ohde: When we serviced the rotors of the machines at one of our sites, we previously tested them with impulse voltage at the respective winding access points. This recurrent surge oscillograph (RSO) measurement feeds several defined impulses into the connected winding. After measuring the response in the time domain, we reverse the measurement and injection direction and compare both responses again in the time domain. This method is very subjective, especially in the evaluation, so we were looking for a sensitive procedure that allows objective evaluation criteria.

Pascal, can you explain your approach to frequency response analysis?

Pascal Fröhlich: In collaboration with OMICRON, I immediately found that the sweep frequency response analysis is a highly sensitive method for detecting interturn short circuits in rotor windings. However, a reference measurement is usually required

to compare results. This procedure is applied to transformers where a comparison to a fingerprint measurement detects damages in the winding and other parts. This is an obstacle for service providers like us because reference measurements are hardly ever available to us.

Based on my experience with the RSO method, I investigated the possibility of applying the procedure of swapping the injection and measurement point using the SFRA principle. If you imagine the rotor winding's terminals, a frequency response with the injection and the reference signal in terminal "A" and the response measurement in terminal "B" are recorded first. Then, the frequency response in terminal "A" is measured, and the injection and reference measurement occur in terminal "B". The thesis shows these are practically identical for an intact winding, especially in comparatively low frequencies up to 600 kHz. If there are interturn short circuits, you can detect clear deviations. This

enables the advantages of the SFRA on rotor windings without need of a fingerprint measurement.

How large are these differences?

Pascal Fröhlich: They are not particularly large. However, the smallest differences can still be identified because the curves are identical when the winding is intact. An increased intensity of the error also indicates an increased degree of deviation of the two characteristic lines from one another. At this point, however, a machine-specific distinction must be made since differences in the frequency response do not always occur at the same point or with the same intensity.

How can I imagine the effect on the measurement result of a possible error in the winding?

Pascal Fröhlich: On the one hand, these are identifiable to the eye by all test engineers, but then we run the risk of ending up in subjectivity again, as mentioned at the beginning.



The thesis is aimed at developing objective evaluation criteria for identifying damaged windings. These evaluation criteria were based on the algorithms already present in the frequency response analysis software and a separate assessment method. The frequency ranges must be slightly modified and adapted to the rotor equipment for the evaluation algorithms already present in the software. Based on the equipment we investigated for the thesis, we were able to show that SFRA is more sensitive than the RSO method our company has been using. Additionally, we were able to establish objective evaluation criteria for the rotors.

You mentioned that the objects you investigated revealed the new method to be more sensitive than the RSO. Is this something you can quantify?

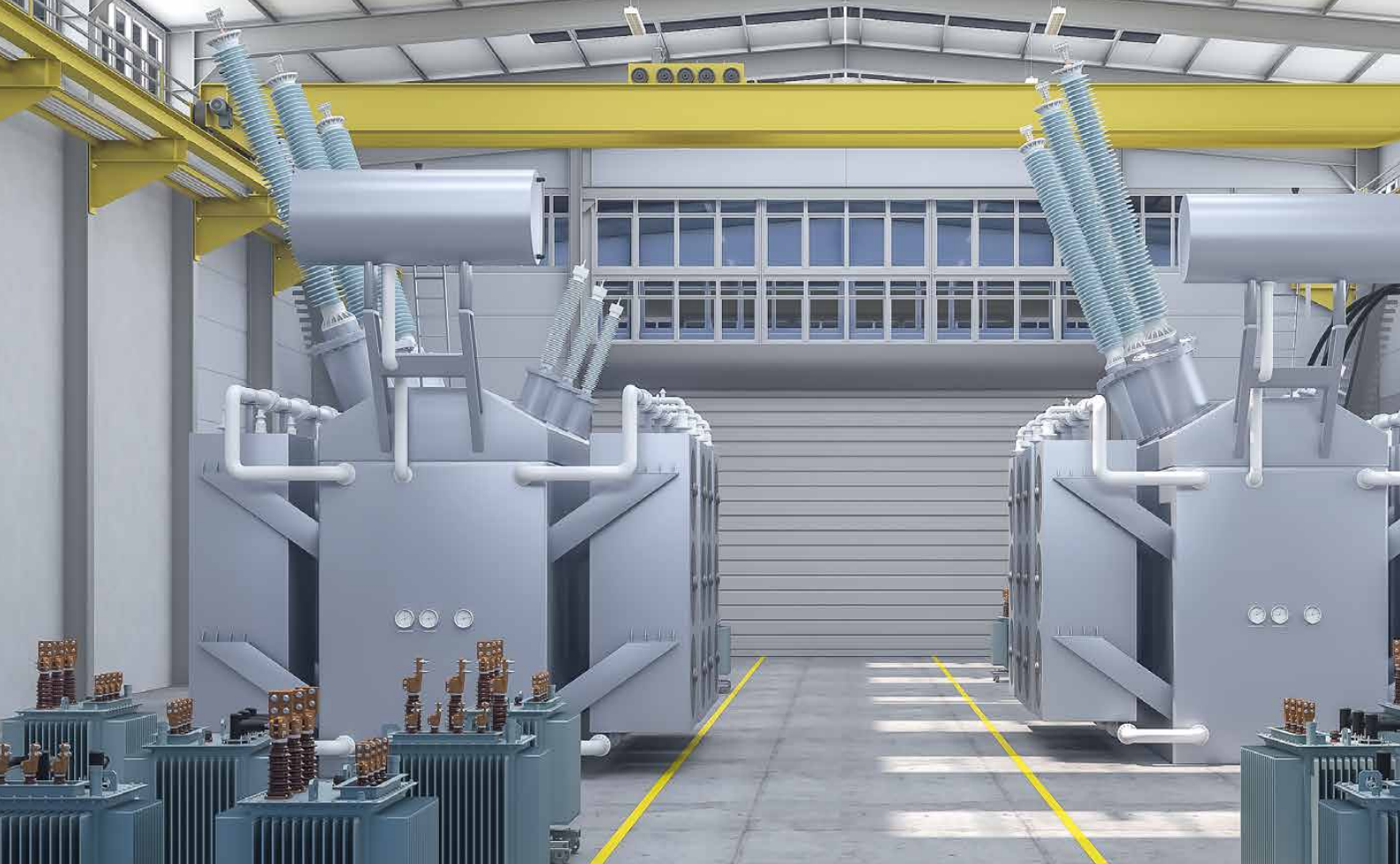
Pascal Fröhlich: During the thesis, we looked at seven rotors in detail.

We investigated criteria such as reproducibility, differences in the rotor types (non-salient pole or salient pole), measurements when the rotor was pulled or in the stator, and other parameters. Coincidentally none of the seven rotors investigated had interturn short circuits. To achieve a comparison between the two methods and a conclusion which is the most suitable way we recreated measurements with various artificial faults. The faults created should be small, which means a short-circuit of one or just a few turns to simulate the reality as close as possible and to create a challenging situation for the measurement methods. Such shorts could be the result of the rotor's designs or combined stresses during operation. Frequency response analysis detected all the faults, but RSO only recognized the most significant one, meaning single interturn faults would go undetected with RSO.

What are the limitations of frequency response analysis?

Pascal Fröhlich: In principle, a fault located exactly in the winding's center won't be detected, but the same is true of an RSO measurement. These interturn short circuits could only be detected when compared with a fingerprint reference measurement. I'd like to refer to the rotor winding's electrical equivalent circuit diagram, which can be divided into infinite consecutive individual parts depending on your point of view. So, a situation where a fault occurs in the absolute center is highly unlikely and doesn't constitute a limitation in practice. Additionally, the evaluation criteria were derived from seven rotors. Although our findings have been verified several times since the thesis, I could still imagine further investigations being carried out.

We'd like to thank both of you for taking the time to speak with us. ■



STREAMLINED POWER TRANSFORMER TESTING

Efficient, comprehensive, and reliable testing with TESTRANO 600 and PTM

Performing electrical measurements on power transformers is a crucial part of the manufacturing process that verifies the system's integrity. Since factory and site acceptance test (FAT and SAT) results determine whether an asset condition requires further diagnostic evaluation, these measurements must be conducted thoroughly to yield reliable results. At the same time, the manufacturing process runs

on a rigorous schedule that must be adhered to.

The TESTRANO 600 and the Primary Test Manager (PTM) offer a tailored solution for testing power transformers and sharing data with multiple teams. The TESTRANO 600 is a dedicated power transformer test device that provides a wide variety of diagnostic measurements that

can assess any power transformer's condition. The testing scope covers conventional tests such as turns ratio and winding resistance measurement, in addition to more in-depth procedures like dissipation factor and short-circuit impedance measurements. Furthermore, the on-load tap changer's condition is assessed using various tools ranging from dynamic resistance (DRM) and motor current



*«TESTRANO 600 allows users to perform three-phase measurements, such as winding resistance, **saving up to 66% of testing time compared to conventional single-phase testing.**»*

measurements to vibro-acoustic measurements (VAM).

Since testing time is often a crucial factor during manufacturing, TESTRANO 600 allows users to perform three-phase measurements, such as winding resistance, saving up to 66% of testing time compared to conventional single-phase testing. Additionally, the TESTRANO 600's connection concept is designed for minimum effort when connecting the test object with a large power transformer or small distribution transformer.

When implementing a data collection strategy, storage and exchange are key to establishing efficient cooperation with teams tasked with performing measurements and assessing the condition of an asset under test. PTM eases these tasks with a database approach, allowing users to feed the system relevant information about the asset location, e.g., substation information and nameplate data. Consequently, all measurement results are linked to the asset, which allows users to easily obtain a testing history overview. The results of a single measurement session can be summarized in a customizable report. A corresponding PTM file with all relevant metadata about the location and asset can be exported and exchanged with various parties involved in a test. This also enables testing templates to be created, ensuring that all measurements are performed similarly.

Further diagnostic measurements, such as sweep frequency response analysis (SFRA) or dielectric response measurements that can be conducted using FRANEO 800 and DIRANA are included in the overall test report to complete the testing scope. Additionally, manual task templates, such as inspection

tests, are covered. Finally, the results of one measurement session, e.g., during FAT or SAT, are summarized in a customizable report.

This unified testing approach that supports on-site measurements can also be performed during the power transformers' manufacturing process. The ability to Pre-dine every measurement step with testing templates allows users to set up an efficient and reproducible testing workflow. Furthermore, factory results can easily be shared with on-site personnel as a comparison reference.

TESTRANO 600 and PTM provide an efficient, comprehensive, and reliable solution for power transformer testing. By offering a wide range of diagnostic measurements and the ability to perform three-phase testing, the TESTRANO 600 significantly reduces testing time and effort. The PTM enhances data management and team collaboration, ensuring consistent and thorough testing processes. This unified approach benefits the manufacturing process and on-site measurements, facilitating a streamlined and reproducible workflow that ensures the integrity and reliability of power transformers. ■



COMMISSIONING TESTS IN A 110 KV GIS SUBSTATION WITH LPITs AND PROCESS BUS

For decades, sulfur hexafluoride (SF_6) has been the insulation medium of choice for gas-insulated switchgear (GIS). However, SF_6 is the most potent greenhouse gas known, with a global warming potential (GWP) of 23,500. The European Union (EU) aims to reduce greenhouse gas emissions by 55% by 2030 and achieve climate neutrality by 2050. In line with these ambitious targets, efforts are being

made across various sectors to adopt more sustainable practices.

To align with these goals and gain operational experience with new technologies, Netze BW, a large distribution system operator in southern Germany, built a new substation in Burladingen with SF_6 -free GIS for the 110 kV voltage level. This GIS uses "clean air" (80% N_2 and 20% O_2) as the insulation medium,

which has a GWP of 0. Additionally, the substation features other innovations, including low-power instrument transformers (LPITs), process bus, and vacuum circuit breakers.

Low power instrument transformers (LPITs)

LPIT technology offers significant space savings due to its small dimensions. The LPIT consists of a GIS cast

resin partition with integrated voltage and current measurements. Voltage measurement is based on a capacitive voltage sensor, while current measurement is redundant with two separate Rogowski coils. The merging units (MUs) are also redundant and equipped with dedicated LPIT-IO-cards. MU1 digitizes the voltage measurement and one current measurement for main 1 protection (line protection), while MU2 digitizes the other current measurement for main 2 protection (busbar protection).

Comprehensive commissioning tests of the LPIT system

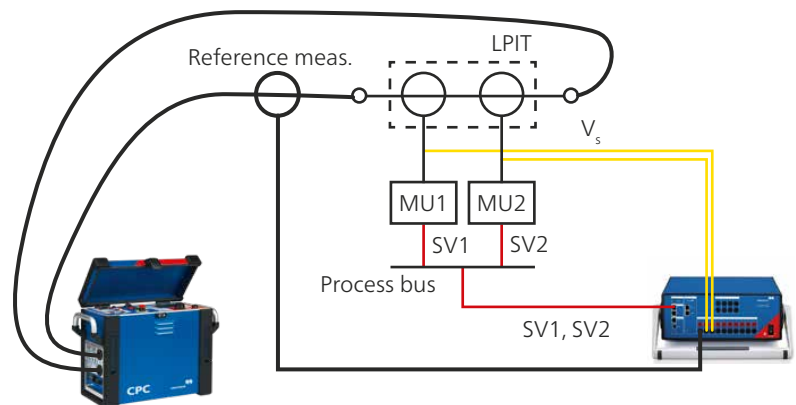
To test the LPITs, the test setup consisted of a CPC 100 for primary injection and a DANEQ 400 hybrid signal analyzer. This allowed analysis of the SV streams of both MUs, the primary test current, and the secondary voltages of the Rogowski coils together.

A special characteristic of LPITs is that they usually have individual ratios, which are determined and made available by the manufacturer. To avoid typos, these parameters can be obtained in a file or by entering the LPIT serial number in the engineering software. Possible errors include a wrongly selected Rogowski coil and incorrect assignment of the LPIT pole to the power system phase. Pole 1 / phase L3 is a good example, as the ratios between the two Rogowski coils (0.76%) and also in comparison to the other poles (up to 1.8%) are significantly different. The secondary voltage measurement showed a difference of 0.73%, which was expected, while the SV streams of both MUs showed this difference was eliminated. This confirmed correct connections and parameter loading.

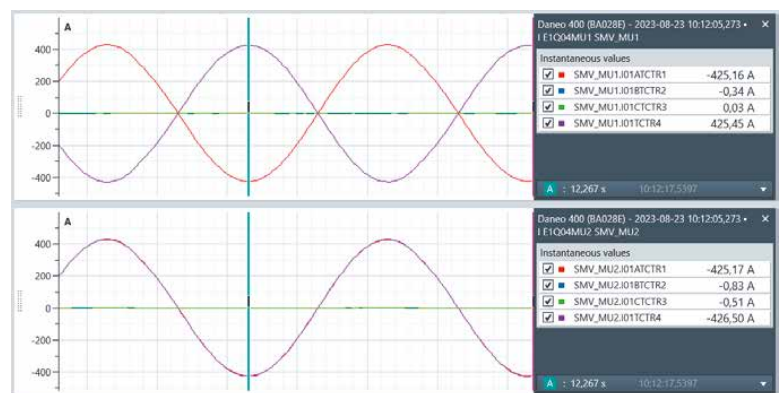
The MUs also calculate neutral current and voltage from phase measurements. A single-phase injection is ideal for checking these neutral quantities. It was found that the neutral current of

one MU was in phase with the tested phase current, while the other had a 180° phase shift due to different configurations ("IN = -310" vs. "IN = +310"), which was then corrected. ▶

«This GIS uses <clean air> (80% N₂ and 20% O₂) as the insulation medium. Additionally, the substation features other innovations, including low-power instrument transformers (LPITs), process bus, and vacuum circuit breakers.»



Setup for the LPIT test with CPC 100 and DANEQ 400



Recording of IN and IL1, top with "IN = -310", bottom with "IN = +310"

The MUs offer the possibility to have SV streams for measurement and protection with different resolution and range. In Burladingen, only the SV stream for protection is configured, with a measurement range up to 100 x the rated current, whereas for

measurement it is only 1.6 x. Similar to conventional CTs, it is essential that the protection relay is connected to a protection "core". With a rated current of 300 A, the LPIT system was tested with 2 x rated current, and the SV streams were accurate, indicating a protection

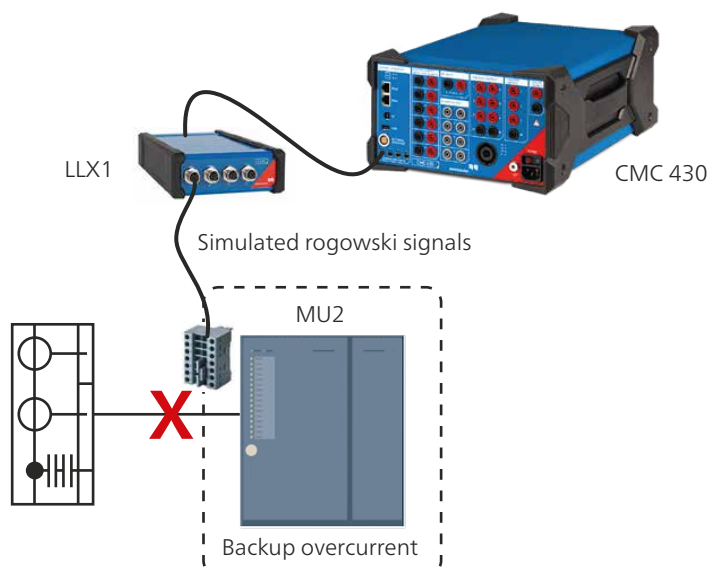
stream. If required test currents could not be met, an alternative would be to simulate Rogowski secondary voltages with test equipment at the MU inputs. This method was not necessary here but useful for testing backup overcurrent protection integrated into MU2.

«The MUs in Burladingen are not «pure» Merging Units; they also include other functions such as fault recorders and backup overcurrent protection in MU2, which remains operational even if the process bus fails.»

Test of backup overcurrent protection integrated in MU

The MUs in Burladingen are not "pure" Merging Units; they also include other functions such as fault recorders and backup overcurrent protection in MU2, which remains operational even if the process bus fails. To be able to test the correct settings of the backup overcurrent protection, the MU allows for a "reverse injection" of an SV stream dedicated for testing, by temporarily changing the inputs from the LPIT to this stream. But obviously, this method bypasses the LPIT inputs, making it impossible to verify the internal measurement chain. Therefore, tests were carried out by applying the required Rogowski secondary voltages to the LPIT interface of the IED. This test worked well, but connecting the test equipment to the LPIT inputs was a challenge due to the lack of test terminals. The terminal block on the IED was removed entirely to avoid changes to the wiring, and testing connections were established with a spare terminal block. To ensure everything was left as found, the tests concluded with a primary injection test into the LPIT.

In conclusion, in a digital substation using process bus, the protection system depends on the correct measurement acquisition by the instrument transformers and the MUs. The tests confirmed the reliability and accuracy of the measurements as well as the integrated backup overcurrent protection, ensuring its readiness for operational use. ■



Testing using simulated Rogowski signals at the LPIT inputs

SOFTWARE SOLUTIONS THAT MAKE A DIFFERENCE

Bringing the CMC 500 to life: Test Universe, RelaySimTest, EnerLyzer, and CMC Swift



The launch of the CMC 500 has been a major step forward for protection testing that introduces several innovations and exciting features. The CMC 500 test set's superb hardware is a foundation for high efficiency and test quality, user safety, cyber security, and versatility that covers an extensive range of applications. We consider the hardware to be the heart of our latest testing solution with software that brings its diverse functionality to life.

We're honoring our commitment to continually develop and maintain our software solutions by updating our test software suite with the release of our latest solution. In version 5.00, Test Universe, RelaySimTest, EnerLyzer, and CMC Swift offer new features that further enhance functionality and fully support the CMC 500.

VERIFIED BY THE WORLD OF PROTECTION TESTING

Test Universe is a comprehensive and easy-to-use testing software for the CMC device family. Its modular structure provides enough versatility to meet the specifics of various testing requirements.

RelaySimTest is a software solution for system-based protection testing with a future-oriented approach. It verifies the protection system's behavior independent of relay type and parameter settings.

EnerLyzer is a software solution for turning your CMC into a versatile measurement tool. It provides

the functions of an oscilloscope, recorder, and analyzer.

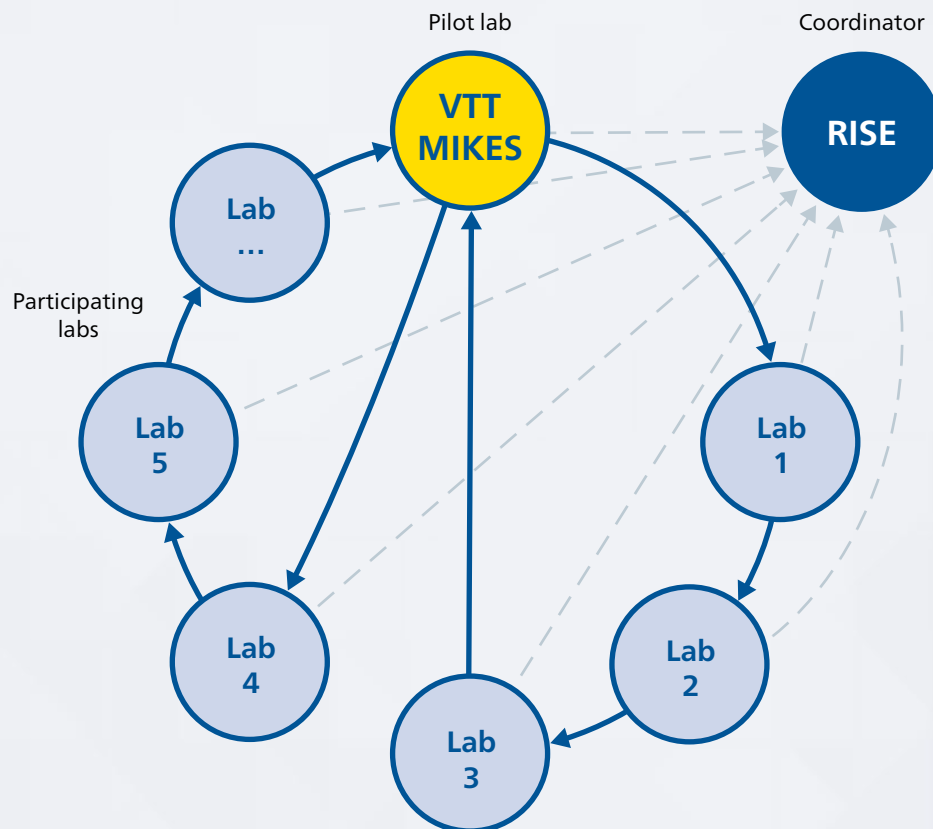
CMC Swift is a mobile testing app designed for convenient and wireless control of your CMC test set, maximizing your freedom to perform quick and simple testing tasks.

The combination of the CMC 500 with the latest versions of Test Universe, RelaySimTest, EnerLyzer, and CMC Swift sets several new benchmarks to help users tackle today's and tomorrow's protection testing challenges with maximum efficiency. ■

Scan the QR code to find out more about the CMC 500's potential or visit:

 omicron.energy/new-cmc





ENABLING CORRECT PD MEASUREMENTS WORLDWIDE

How we became part of the largest world-wide partial discharge measurement comparison

This is a story about a highly successful, yet technically challenging project we participated in, which aimed to ensure correct partial discharge measurements worldwide. With measurement variables like partial discharge, which are difficult to measure, who can be sure that measurement results are correct?

The basis for correct measurement begins with agreeing on a reference so the same results can be compared and measured. Providing such references is one of the core duties of National Metrological Institutes (NMI), which allow them to compare international results and maintain the basis of

an unbroken traceability chain (see factbox “Traceability results”).

The easiest way to compare results is a so-called ring comparison, which is typically offered by an NMI with high technical competency for the measurement variable. In August 2021,

TRACEABILITY RESULTS FOR INTERNATIONAL AND NATIONAL REFERENCE STANDARDS AND COHERENT SI UNITS

We'd all like to know the actual value of a measurement, but we have to make compromises. In the real world, we're a long way from being able to provide an absolute True Value for a measurement. It's comprised of an array of uncertainties that add up to what's often referred to as accuracy; the technically correct term is Measurement Uncertainty.

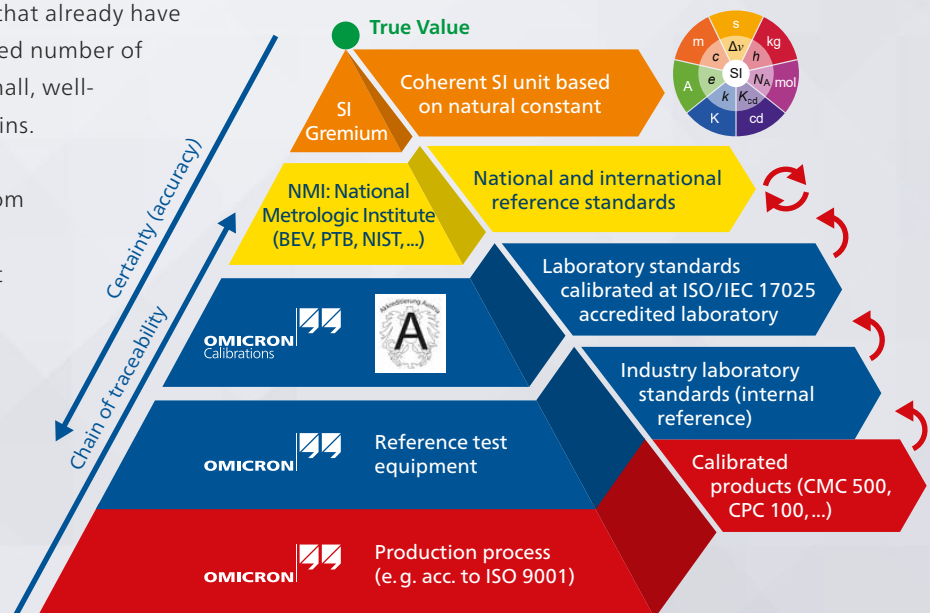
Within the Coherent International System of Units (SI), all measurement values are based on one or a combination of several of the seven defined Natural Constants. These natural constants are theoretic values that already have a specific error resulting from the limited number of places after the decimal point – this small, well-defined error is where uncertainty begins.

The national metrological institutes from each country usually provide and run national standards, which are the most accurate local comparison solutions. These National Reference Standards have a defined uncertainty that is expressed in relation to the theoretical Natural Constant(s).

International services like EURAMET or BIPM offer programs to compare

National References. Ring comparisons compare results to ensure they're similar and correct, to determine if drifting has occurred, if instruments have failed, or to detect bad measurement principles.

Accredited labs such as OMICRON Calibrations can buy calibration services from these National Metrologic Institutes to ensure a guaranteed unbroken chain of traceability and that measurement and calibration equipment function properly.



EURAMET started a cross-continental project related to partial discharge measurements, featuring a ring comparison with 14 worldwide participants (EURAMET.EM-S36).

The process starts with selecting a stable test object that is analyzed precisely and calibrated (measured) before being sent to the participants. The participants then perform identical measurements and share the results (measurement value plus guaranteed

uncertainty per test point) with the first NMI. Afterward, the test object is sent to the next participant, and the process repeats.

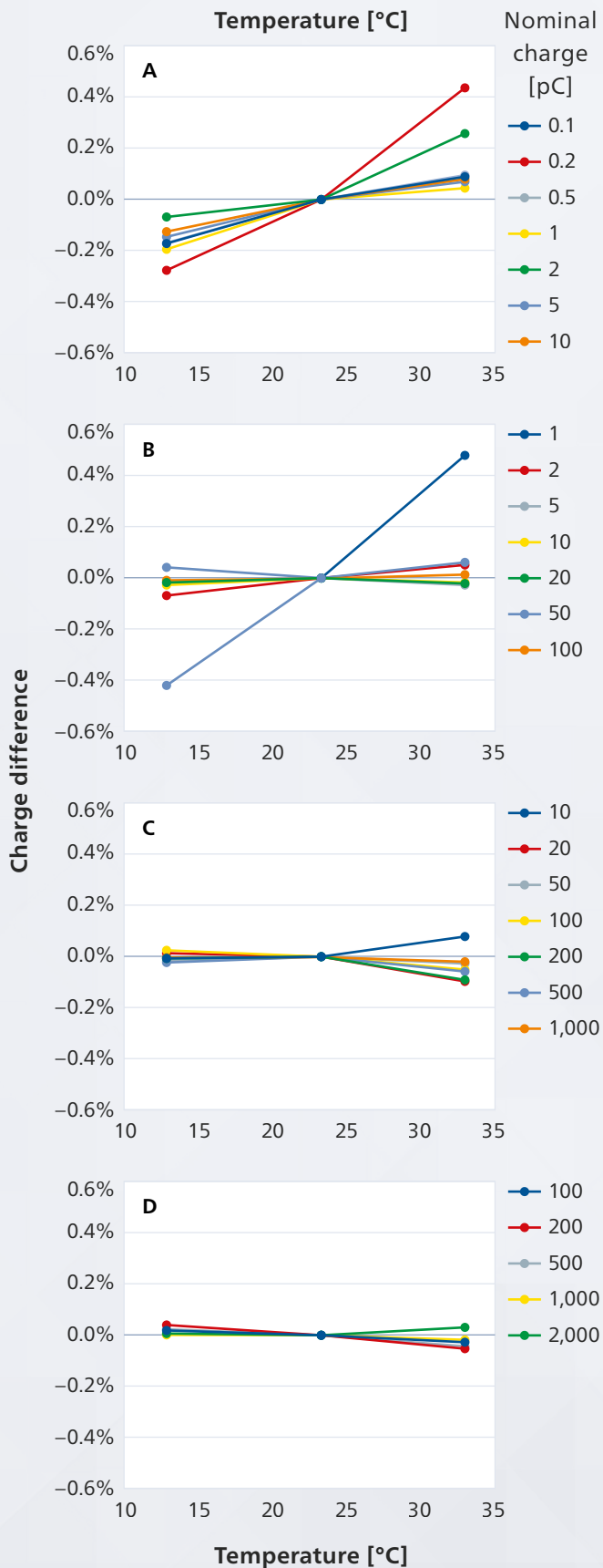
Following this, the leading intercomparison laboratory calibrates the test object again. Finally, the comparison's coordinator collects and shares the anonymized data with all participants.

RISE, the Swedish National Metrologic Institute, was the coordinating lab,

and VTT MIKES (National Metrological Institute of Finland), one of the leading labs for small partial discharge measurements, was the pilot lab. It was a truly unique process for a unique measurement.

On tour with OMICRON's CAL 542 PD calibrators

VTT MIKES chose our CAL 542 A, B, C, and D to be their test objects, knowing from experience how reliable and stable they were. This was truly an ▶



Temperature dependence of calibrator charge (CAL 542 A, B, C, D). Results are normalized to 23 °C / 73,4 °F.

honor for OMICRON electronics and the CAL 542, and for OMICRON Calibrations, a small ISO/IEC 17025 accredited calibration laboratory, it presented a unique opportunity to participate in a ring comparison with various NMIs, albeit incognito.

We conducted a detailed analysis of the CAL 542 and calibrated it before and after the intercomparison. The calibration reports to the left from VTT MIKES show the calibrator's temperature stability drift over time.

Reference	Change in charge due to temperature (23.0 ± 2.0 °C)
CAL 542 A	0.035%
CAL 542 B	0.045%
CAL 542 C	0.012%
CAL 542 D	-0.005%

Temperature dependence of CAL 542:

The highest temperature dependency we observed using the CAL 542 B calibrator was 0.045%/K, which is well within guaranteed tolerances of less than ±0.1% (for 23.0±2.0 °C).

Traveling standards' drift behavior over time

Being able to remain this stable over time is even more amazing, as seen in an original statement from the preliminary report: "The measurements carried out at the pilot laboratory (VTT) before starting the comparison (Nov 2021), in the middle of the loops (Nov 2022), and at the end of the comparison (Aug 2023) were used to establish the standards' drift behavior. The calibration history for an apparent charge is presented in the figures on the next page. Error bars present the calibration uncertainty at the end-comparison (Aug 2023). No significant drift was observed."

After more than two years of traveling, including several flights and road trips and the intense usage of 14 worldwide NMIs, the measurement results remained accurate and extremely close to the initial values. The specified tolerances were easily met. Remarkably, our results were almost identical to VTT MIKES' reference results.

We already knew our calibrators were reliable and stable, but now, an international ring comparison proved our PD measurements were also correct.

The combination of correct results with long-term stability and robustness made our PD calibrators a resounding success. In fact, they were so convincing that one of the NMI participants even bought two CAL 542 calibrators! ■

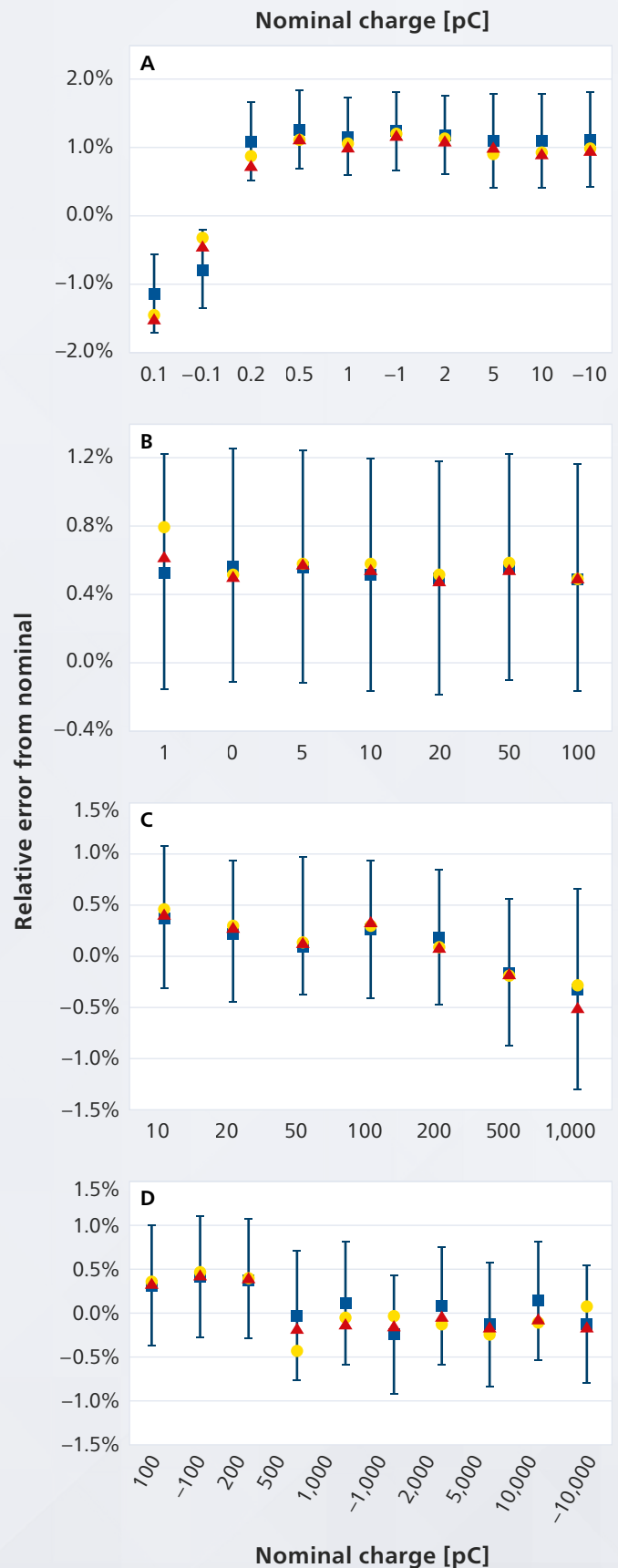


5 YEARS OF OMICRON CALIBRATIONS

We are celebrating 5 years of OMICRON Calibrations, our ISO/IEC 17025 accredited calibration lab for electrical measurands, partial discharge, frequency, and current transformer analyzers.

- › New calibration services available for PD linearity according to IEC 60270 for MPD 600 and MPD 800 (including system calibration).
- › New calibration services are also available for CPC 100
- › We offer the best worldwide calibration services for OMICRON products.

● Nov 2021 ▲ Nov 2022 ■ Aug 2023



Travelling references observed by the pilot laboratory during repeated calibrations showed no significant drift.

EVENT IN NORTH AMERICA IN 2025

10TH ANNUAL NORTHEAST POWER & ENERGY CONFERENCE (NEPEC)

May 20–22, 2025, Portland, ME, USA

NEPEC's mission is to foster a special community of power professionals in the Northeast. This event continues to provide professionals from industry, academia, utilities, government, and manufacturers an opportunity to exchange knowledge on systems, equipment and designs responsible for generating, transmitting, and distributing electric power. It also provides the latest updates on industry regulations and standards.



events.omicronenergy.com/nepec

OMICRON ENERGY FORUM

April 29–30, 2025, Houston, TX, USA

The OMICRON Energy Forum brings together technically focused customers from around the region to share expertise, best practices, and experiences of power system monitoring and testing from their respective industries. It will foster stronger relationships, partnering with service providers & key stakeholders. Through knowledge sharing, community building, and collaborative discussions, we aim to unite the industry, share experiences and collectively learn to optimize our solutions for a sustainable future.



events.omicronenergy.com/oef

10TH ANNUAL CANADA PROTECTION SYMPOSIUM

November 11–13, 2025, Toronto, ON, Canada

The Canada Protection Symposium will cover emerging and new technologies in the electric power industry on protection, automation, and control. This event is truly unique in our industry. You will be able to hear from industry expert speakers, network with your peers, and hear from utilities sharing best practices and case studies. Take this opportunity to learn from industry experts and listen to their experiences.



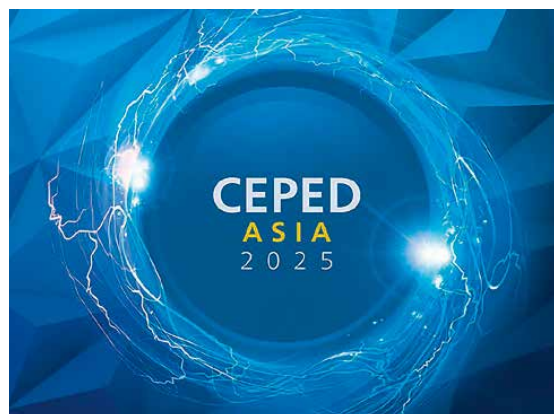
events.omicronenergy.com/cps

EVENTS IN ASIA-PACIFIC IN 2025

CONFERENCE ON ELECTRICAL POWER EQUIPMENT DIAGNOSTICS ASIA 2025 (CEPED ASIA 2025)

November 18–19, 2025, Kuala Lumpur, Malaysia

CEPED Asia 2025 provides a platform for exploring cutting-edge insights on power system equipment. Join experts from our organization, universities, manufacturers, service providers, and utilities as they meet, share, and learn about their experiences, case studies, and the latest developments in electrical power equipment diagnostics and monitoring.



events.omcronenergy.com/CEPEDAS25

OMICRON VIRTUAL WORKSHOP: PROTECTION, AUTOMATION AND CONTROL

June 10–11, 2025, Online

Join the OMICRON Virtual Workshop: Protection, Automation and Control. Meet IEC 61850 specialists and explore protection testing in the IEC 61850 environment, along with automation and control system testing. Empower the future of power system testing.



events.omcronenergy.com/VPACW2025

CONFERENCE ON ELECTRICAL POWER EQUIPMENT DIAGNOSTICS KOREA 2025 (CEPED KOREA 2025)

June 25–26, 2025, South Korea

Join us at this event to share knowledge and case studies on power system equipment. This conference will be a valuable opportunity for technological exchange, contributing to the advancement of the domestic power system. Topics include trends in power technology, testing techniques, fault cases, and diagnostic methods. Enhance your understanding and stay updated with the latest developments in the power industry.



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WHAT'S GOING ON

We are continuing to share our knowledge. We are going to reach out to you physically or digitally with our events, trade shows, conferences, webinars and training courses. Keep yourself up to date by checking out our events and training courses.

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WE ARE LOOKING FORWARD TO SEEING YOU.