review

Journey of innovation

09

The shoulders of giants

44

Perfect circle

BORDLINE® ESS

62

—
Cover pictures

The picture on the left shows a DP200 computer. This computer was created by Brown Boveri for advanced tasks in process control. It could store 4,096 words (expandable to 32,768) of 20 bits, and had an interruptible architecture with parallel input and output channels. The operator's console and teletypewriter can be seen in the foreground. The cabinet with the central processor, storage and the input/output system are in the background. This computer and its applications are described in several articles in Brown Boveri Review 5-6/1965. This issue can be accessed through the QR code below.

The comparison picture on the right shows a modern control room. See also page 40 of this issue of ABB Review.
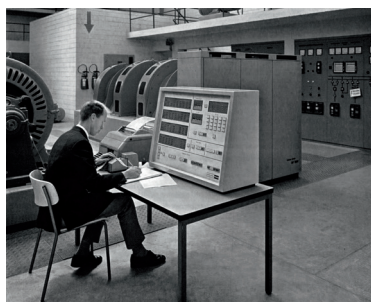
Committed to knowledge

Whereas Nobel Prize Outreach via its various initiatives involves Nobel Prize laureates who stand for the cutting edge of basic research, ABB is active at the other end of the spectrum, connecting that knowledge into applied research.

—

«Creativity is combining facts no one else has connected before»
**Christiane Nüsslein-Volhard
Nobel Prize in Physiology or
Medicine, 1995**

As a Nobel International Partner, ABB commits to innovation, education, and science by supporting Nobel Prize Outreach global programmes – activities that extend the reach of the Nobel Prize to millions of students, decision makers and curious minds around the world. As an inventor, entrepreneur, scientist and industrialist, Alfred Nobel was determined to support innovation "for the greatest benefit to humankind". Our capacity, as humans, to innovate comes from learning from what other people have done, benefitting from existing knowledge while incorporating new, important advances in basic science to create something new. On the occasion of the 900th issue of ABB Review, our partnership acknowledges once again the importance of creative minds for a more sustainable and resource-efficient future.

Laura Sprechmann,
CEO, Nobel Prize Outreach

EDITORIAL

Journey of innovation

Dear Reader,

I'm excited to share with you this quarter's issue of ABB Review, the 900th in the publication's history. As one of the longest-running corporate technical journal in the world, ABB Review embodies a spirit of innovation that has always been core to our company.

Our passion for research has cemented ABB as a key partner to the world's industry and to organizations committed to fostering innovation, such as the Nobel Prize Committee.

As we also celebrate the 140th anniversary of the founding of ASEA, a key pillar of ABB's heritage, we are, as we say in these pages, "standing on the shoulders of giants." The innovations we showcase here – charging for electric mining vehicles, a next-generation drive control platform, collaborative operations for shipping fleets and more – are among the latest examples of ABB's work to make possible what wasn't possible before.

Enjoy your reading,

Björn Rosengren
Chief Executive Officer, ABB Group

900th edition

A landmark achievement

Peter Voser
Chairman of the Board
of Directors, ABB Ltd.

As ABB chairman, I am pleased to see this landmark 900th edition of ABB Review. The journal exemplifies our company culture of customer-driven innovation and commitment to pushing technology boundaries in sectors like manufacturing, transportation, utilities and construction, for a more sustainable and resource-efficient future. Congratulations to ABB Review and thank you to all the people in its history who have contributed to this milestone. I can't wait to read what's next!

Here are three postcards for you to send notes or greetings. We hope you enjoy sharing this look back in time.
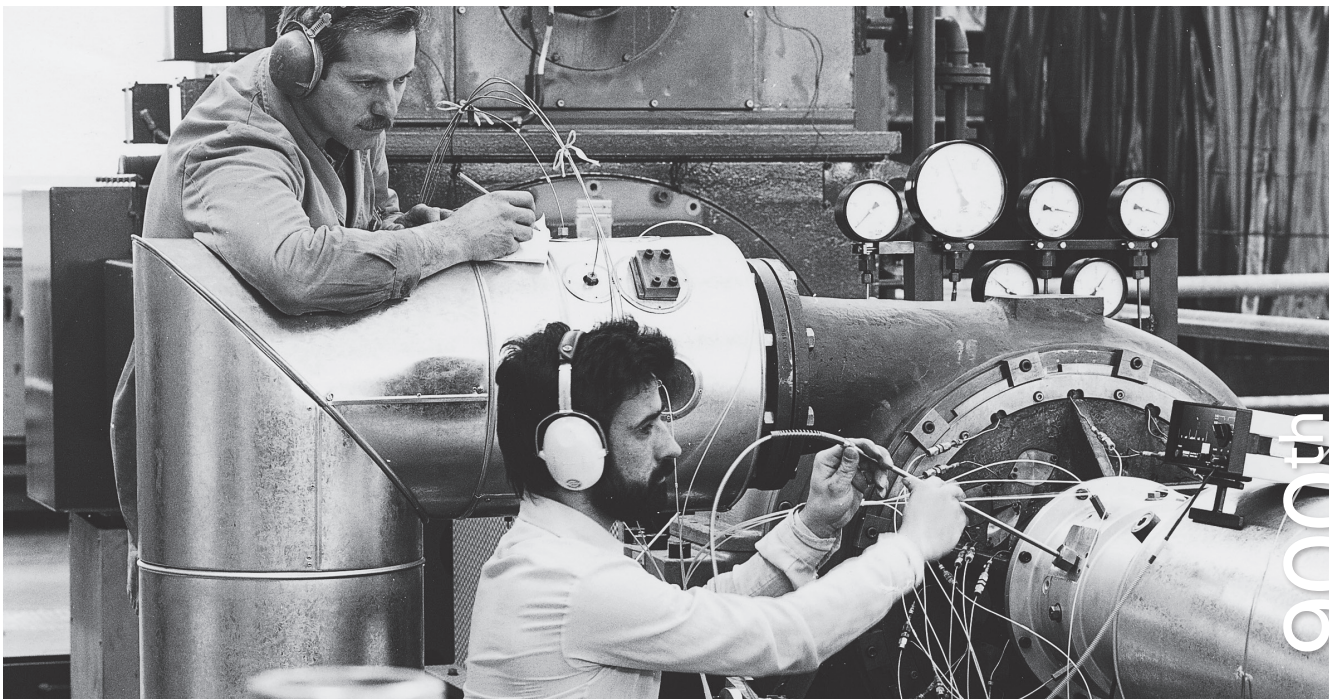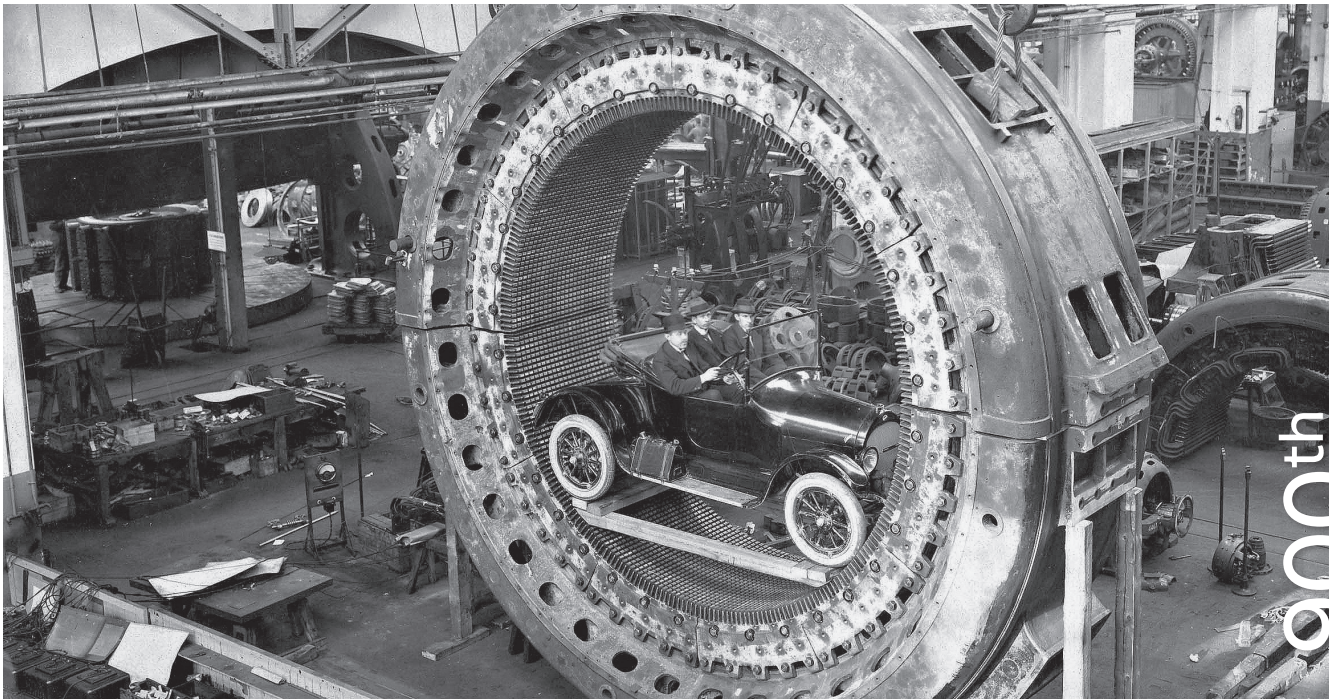
ABB

ABB's corporate technical journal, ABB Review, has been in continuous publication since 1914. Celebrating its 900th edition we see here the stator of a 22 MVA generator supplied by ASEA for Glomfjord, Norway, in 1919 (photo: ABB Review 03/2016).

Affix stamp here

ABB Review is free of charge to those with an interest in ABB's technology and objectives. Subscribe for your copy at **www.abb.com/abbreview**

ABB

ABB's corporate technical journal, ABB Review, has been in continuous publication since 1914. Celebrating its 900th edition we see here a locomotive for the three-phase electrification of the Simplon tunnel between Switzerland and Italy, seen at Brig station, Switzerland, in 1914 (photo: Historisches Archiv ABB Schweiz, N.1.1.271450).

Affix stamp here

ABB Review is free of charge to those with an interest in ABB's technology and objectives. Subscribe for your copy at **www.abb.com/abbreview**

ABB

ABB's corporate technical journal, ABB Review, has been in continuous publication since 1914. Celebrating its 900th edition we see here a test setup for a turbocharger in the 1970s (photo: IndustrieWelt - Historische Werkfotos der BBC 1890-1980, Norbert Lang and Tobias Wildi. Schwabe Verlagsgruppe AG, 2006)

Affix stamp here

ABB Review is free of charge to those with an interest in ABB's technology and objectives. Subscribe for your copy at **www.abb.com/abbreview**

ABB REVIEW PUBLISHES ITS 900TH ISSUE

The shoulders of giants

ABB Review is one of the world's oldest corporate publications. First published in 1914, the publication pre-dates Time Magazine by nine years. Now reaching its 900th edition, ABB Review reflects on its remarkable journey.

Andreas Moglestue
ABB Review
Zürich, Switzerland

andreas.moglestue@
ch.abb.com

900th edition
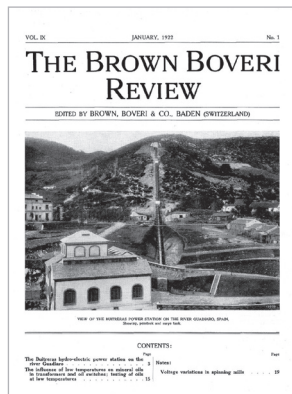
1/1922 (first edition in Englisch)
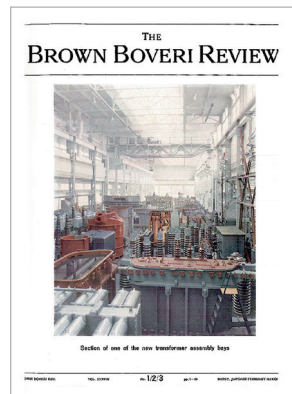
1/1951 (first color cover)
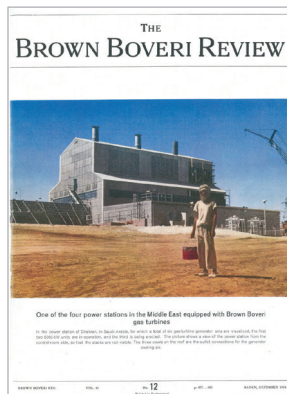
12/1954

1-2/1959

6-7/1966
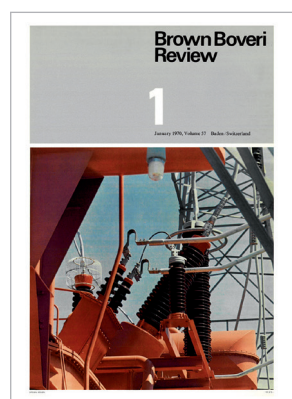
1/1970

1/1985

1/1988 (first edition following merger)

1/1994
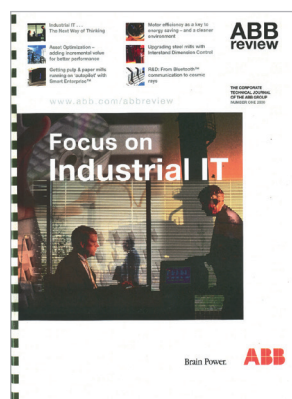
1/2000

1/2004
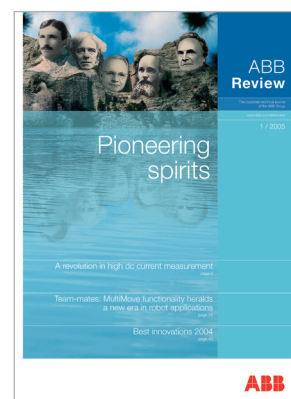
1/2005
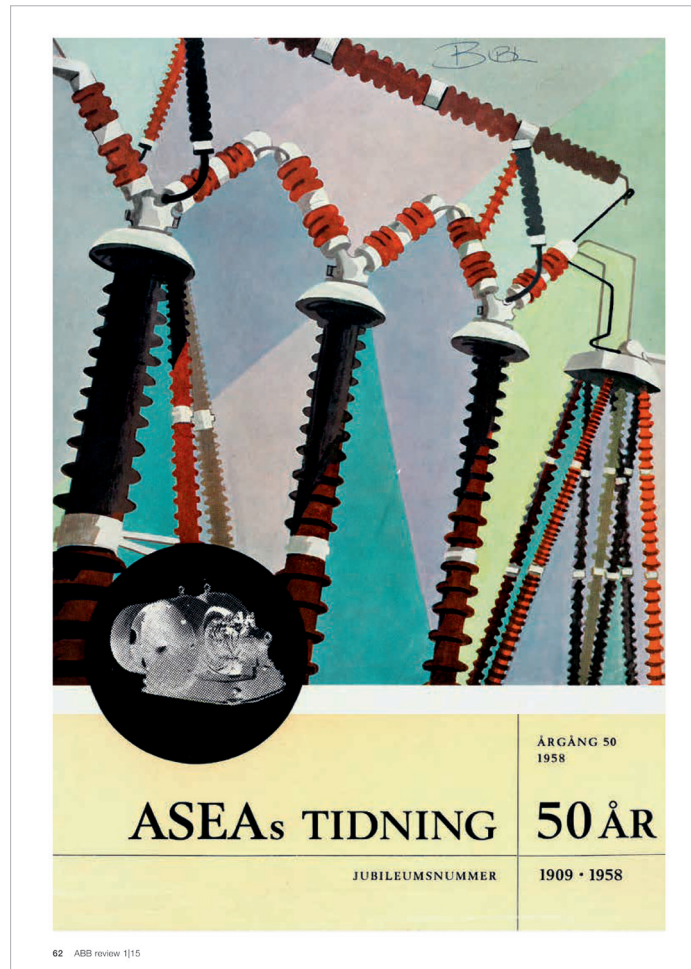
01

1/2010

1/2017

ÅRGÅNG 50
1958

ASEAs TIDNING | 50 ÅR

JUBILEUMSNUMMER | 1909 · 1958

62   ABB review 1|15

02

ABB (and its predecessor companies) have been involved in, if not lead, many groundbreaking developments stretching far beyond the company's core area of activity. This spirit of pioneering

—
ABB Review prides itself on being written "by engineers for engineers".

and curiosity is reflected in achievements as diverse as creating the first synthetic diamonds [1], pioneering mobile communications [2], or advancing LCD displays [3].

Despite these salient illustrations of the company's broad thinking and curiosity, most of the articles published in ABB Review cover fields of research and achivement that are closer to the company's core business interests. The journal has documented how, over the years, successive innovations and breakthroughs transformed and reshaped technologies and products. The archives of ABB Review provide a unique window

documenting these journeys. To strengthen this record and make it more accessible, most back issues of the journal have been scanned and are available online in a fully searchable format (abb.com/abbreview). The editorial staff hope to make the remaining issues available shortly.

109 years of continuous publication
ABB Review was launched in 1914 by one of ABB's predecessor companies, Brown, Boveri & Cie (BBC). The journal was initially published as "BBC Mitteilungen" (for the German-language version) and "Revue BBC" (for the French). English was added as a third language in 1922, and initially branded "The Brown Boveri Review". This was later shortened to "Brown Boveri Review" →01.

The very early issues were principally distributed to sales representatives across the globe to inform them of new products and ongoing developments. Already by the early 1920s there was a significant external readership driven by public interest in technological progress. The scope and style of articles developed to accommodate this interest, with research and technology-based content displacing pure product announcements.

900th edition

—
03 Every 100th edition from edition 1 to edition 500. The QR codes lead to the entire issues in the ABB library.

In 1988, ASEA and BBC merged to form ABB. ASEA had its own technology journal, ASEA Review, which had been in publication since 1924 [4] →02. The two journals were consolidated to form ABB Review.

Now entering its 110th year of continuous publication, ABB Review is, as far as its staff can ascertain, the world's oldest surviving corporate publication. Its launch is predated by other corporate publications, but as far as could be identified, none of these is still in production. Even in the world of newsprint in general, while far from ranking among the oldest, ABB Review still predates many great names. It was already nine years old, for example, when Time Magazine was launched, and predates Reader's Digest by eight years.

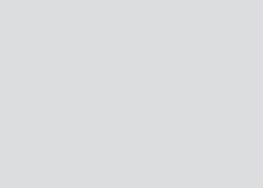ABB Review prides itself as being written "by engineers, for engineers". Authors, are for the most part, engineers and scientists from the forefront of research. Readership ranges from staff in customer organizations to the press and academia, as well as technologically interested members of the public at large. Many engineers presently working for ABB first learnt of or became interested in the company by reading the journal as a student. Numerous articles are reprinted in the trade press and even used as course material in universities.

In line with trends in aesthetics and typography, the journal underwent several visual changes over the years →01. ABB Review was also an early adopter of color printing, with the first color cover appearing in 1951. Color was gradually adopted in the inside pages later.

Throughout its history, the main appeal of ABB Review has arguably been that although it obviously serves corporate interests, the style and tone has always been objective and deeply informative. The journal has always placed scientific integrity and satisfying the curiosity of its readers before direct marketing interests. The appropriateness and success of this policy is reflected in the interest and support of readers. It is a compliment to the journals' appeal that the most frequent readership query received by the editorial team is "when will I receive the next edition?"

—
«If I have seen further it is by standing on the shoulders of giants.»
Sir Isaac Newton

The languages in which ABB Review has been offered have fluctuated over the years. At times there have been French, Spanish, Russian and Swedish editions. Today the journal is offered in English, German and Chinese (the Chinese edition is presently distributed in electronic form only, whereas English and German are available in both print and electronic formats).

The frequency of publication has also varied over the years. In the early decades, twelve editions were published per annum. In later years this varied between three and twelve. The present rate of four annual editions has been maintained since 2000. In the days of 12 editions per year, it took a little over eight years to publish 100 issues →03-04. A recent readership survey [5] confirmed that the vast majority of readers are happy with four editions per year which, if that continues, the 1,000th edition will be published in 2048.

At the service of research
Scientific curiosity almost always builds on the hard work and achievements of earlier researchers. Sir Isaac Newton, arguably one of the greatest scientific minds of all time, humbly admitted "if I have seen further it is by standing on the shoulders of giants" [1].

—
Footnote
[1] When Newton wrote this in 1675, he was probably quoting the French philosopher, Bernard de Chartres, who according to John of Salisbury, said as early as 1159, "we are like dwarfs sitting on the shoulders of giants." See also. "The meaning and origin of the expression: Standing on the shoulders of giants." Available: www.phrases.org.uk/meanings/268025.html [Accessed October 27, 2022]

900th edition

—
04 Every 100th issue from issue 600 to issue 900. The QR codes lead to the entire issues in the ABB library.

In order to be able to stand on the shoulders of giants, we must be able to access what they wrote in their own words – independently of whether they were, scientifically-speaking, right or wrong, or whether their contributions are still valid or have since been eclipsed or disproven. This is true in engineering and applied sciences as much as it is in purely theoretical research. Contrary to the narrative at times promoted in the popular press, science is not about blindly trusting expertise. Science is about logical discourse, questions, and objectively challenging

—
Articles from ABB Review are frequently cited in scientific and technical literature.

one's own work and that of others. A written and unchangeable record of previous contributions is paramount to creating the framework for such a discourse. Scientific results can be refuted at any time and theories challenged or adapted in the light of later research and interpretations, but if the claims and results these theories build on have not been recorded for posterity, any comments, observations or derivative research is without context, and in many cases, meaningless.

Newton's mechanics, for example, have long ago been superseded by Einstein's. Just as Newton could humbly admit to standing on the shoulders of his predecessors, Einstein undeniably stood on Newton's shoulders. Nevertheless, Newton's theories are still relevant and used today, and without them it would be much more challenging to understand Einstein.

Thinking digital
The digital world makes it easier than ever before to disseminate and find information. An Internet search engine can, in fractions of a second, throw up documents that previously might have evaded years of combing through libraries. The Internet has been an unprecedented driver in the democratization of knowledge. ABB Review is today very much part of the digital world, having been available online since 2001.

That said, online records lack the permanence of written records. How many web links of 20 or even 10 years ago still work today? Some of those sources may have been relocated to other

addresses, and – given enough patience – can be located through further searches. Many web pages, on the other hand, may be lost forever as the sites that hosted them are orphaned or deleted.

Underlining the authority and reputation that the journal enjoys, articles from ABB Review are frequently cited in scientific and technical literature. Figures and diagrams are also regularly re-used in books and other publications. ABB is always pleased to approve such requests, recognizing that they underpin the authority of the journal.

To facilitate such citations, the online pdf edition of ABB Review has identical content, pagination and page layout to the print edition. Citations thus do not need to differentiate between the print and pdf versions.

Despite its committal to the authoritative print (and pdf) edition, ABB Review is equally committed to more fully embracing the opportunities and possibilities of digital communication. The most recent readership survey [5] confirmed that readers are overwhelmingly satisfied with the journal's content and quality. It also revealed there is demand for more digital material. ABB Review is responding to this and will be testing various digital features and formats over the next few issues.

Change and evolution
The upcoming modifications will be far from the first time ABB Review adapted in the course of its long history. The company has undergone many changes in direction, portfolio and emphasis. ABB has lived through and played an important role in driving three of the four industrial revolutions – the second, electrification, the third, digitalization, and the presently ongoing fourth revolution being interconnectivity and artificial intelligence. Each of these revolutions has fundamentally changed the way industry operates. ABB Review has accompanied and evolved with these changes and looks forward to continuing to support researchers, industry and all those with an interest in technology over many more years to come. •
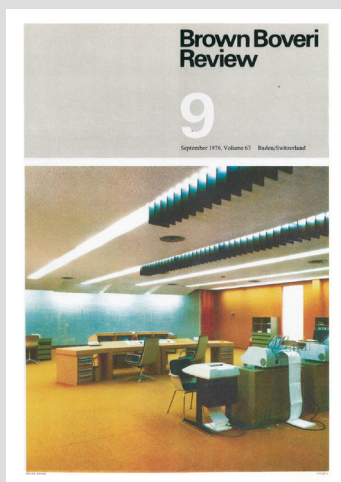
600TH EDITION 9/1976

The ED 1000 Module Family for Solving Problems of Industrial Data Systems

Man-Machine Interface for Control Rooms of Power Supply Networks

Load Dispatching in Electrical Power Systems

Automation of Out-Stations

Remote Control of the SEAS Power System in Denmark

Automation of the Public Water Supply System of the City of Zurich

Automation in Open-Cast Lignite Mining

Equipment for the Control Post of a Continuous Train Control System

Automation Aboard Ocean-Going Ships

Microcomputer Controls a Gear Hobbing Machine

Activities of the Swiss Group of Companies in the Field of Electronics
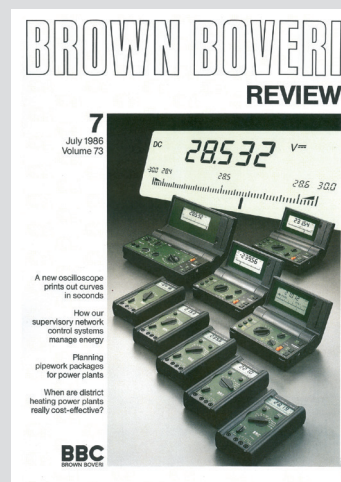
700TH EDITION 7/1986

A new oscilloscope prints out curves in seconds

How our supervisory network control systems manage energy

Planning pipework packages for power plants

When are district heating power plants really cost-effective?
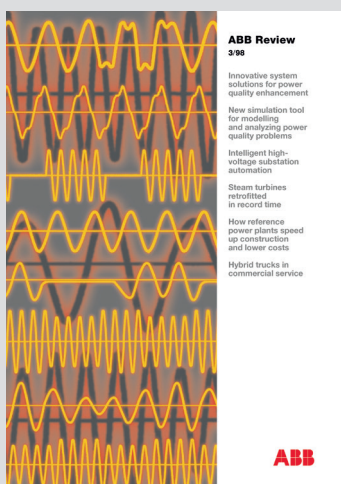
800TH EDITION 3/1998

Innovative system solutions for power quality enhancement

New simulation tool for modelling and analyzing power quality problems

Intelligent high-voltage substation automation

Steam turbines retrofitted in record time

How reference power plants speed up construction and lower costs

Hybrid trucks in commercial service

900TH EDITION 1/2023

900th edition

Best innovations

Digitalization

Transportation and efficiency

04

—
References

[1] A. Johnson, "Brainforce one, 100 years of ABB's first Corporate Research Center", *ABB Review* 3/2016, pp. 13–15.

[2] D. Dzung, A. Moglestue, "Wireless but connected", *ABB Review* 4/2017, pp. 64–65.

[3] A. Moglestue, "The wristwatch connection, BBC's contribution to the LCD", *ABB Review* 2/2014, p. 12.

[4] A. Moglestue, "From the ASEA archives, Looking back on more than a century in print", *ABB Review* 1/2015, pp. 62–66.

[5] A. Moglestue, "Readership trends, Results of the 2022 readership survey", *ABB Review* 4/2022, pp. 66–67.

900th edition

Best innovations
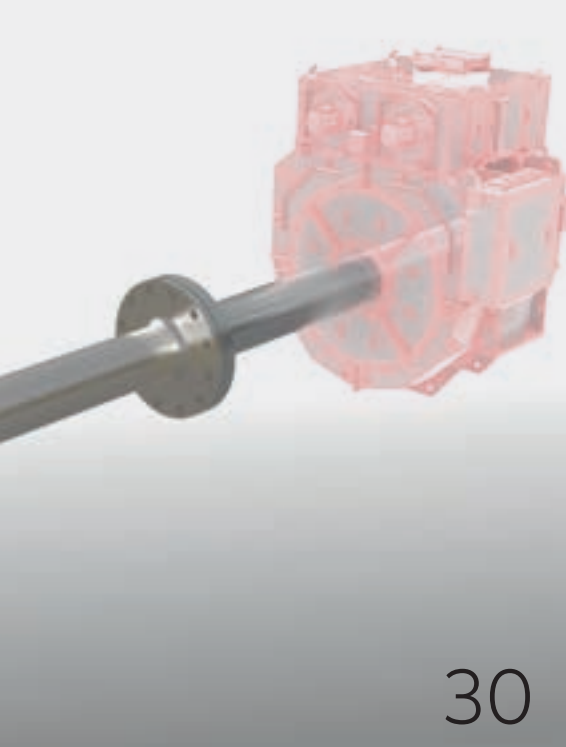
The Chief Technology Officers of ABB's four business areas handpicked the most recent research and development breakthroughs that could have the greatest impact on customers' business this year and going forward. These solutions evidence the unique alchemy of novel ideas wedded to purpose.

30

23

—

INSTANT ACCESS TO PRODUCT DATA

In compliance with European Union Ecodesign requirements, ABB has introduced a QR code-based digital platform designed to provide easy access to information regarding ABB products.

Thanks to the new platform, technicians, commissioning engineers, customers and distribution partners can now use a handheld device such as a mobile phone to access a world of information from their ABB drives, motors and PLCs by simply scanning a device's QR code. The key is ABB Access, a responsive web application that links users to product-specific information, such as manuals, installation guides, and step-by-step instructions regarding commissioning and troubleshooting. The responsive web application also allows users to rapidly and easily reach expert support from ABB to report and solve problems on-site.

The result is faster troubleshooting, which results in higher uptime and lower downtime, as well as a unified user experience across a range of ABB products. As the web application facilitates self-service, troubleshooting can be performed by any user with basic knowledge, thus allowing more bandwidth for experts to handle challenging issues.

ABB Access architecture is based on a representational state transfer application programming interface (REST API) and microservice architecture policies in which data is communicated using front-end, backend and service layers. The platform draws data from ABB-approved data service providers, but, in compliance with standard security policies and principles, does not store any data. Instead, ABB Access uses an Auto ID redirection feature to access content from different products through its QR code scan feature.

Future enhancements of the web application will cover additional ABB products and will provide a wider range of information, including product maintenance history, warranty information, and additional information for special access users.

ABB Access complies with DIN SPEC standard 91406:2019-12, thus making it easier for OEMs and end users to read QR codes using commercially available hardware and software. •

FAST, ACCURATE NATURAL GAS QUALITY MONITORING

Natural gas producers and distribution network operators are constantly on the lookout for excessive levels of contaminants in their gas streams. Monitored substances include water (H_2O), hydrogen sulfide (H_2S) and carbon dioxide (CO_2). Elevated levels of these substances can lead to accelerated infrastructure deterioration and even critical failures. In view of these risks, ABB has developed the GLA533-NG Sensi+™, an instrument based on a unique laser absorption technology called Off-Axis Integrated Cavity Output Spectroscopy (OA-ICOS) that is able to simultaneously monitor three types of contaminants in natural gas.

Patented by ABB, OA-ICOS, represents the latest advance in tunable diode laser absorption spectroscopy and delivers superior performance and reliability, yet is orders-of-magnitude less sensitive to internal alignment of

—

OA-ICOS is ideal for even the most demanding applications in remote and/or hazardous locations.

components and to variations in local temperature and pressure than other methods. As a result, OA-ICOS is ideal for use in industrial instruments for even the most demanding applications in remote and/or hazardous locations.

Integrated in a customized explosion-proof enclosure, ABB's GLA533-NG Sensi+ instrument is

compact yet ensures ease of assembly and service. The modular character of the instrument's gas manifold eliminates all internal piping, allowing critical components to be swapped rapidly without the need of special tools or advanced training. The instrument also benefits from a new ICOS electronic platform that offers a level for accuracy, precision and stability that provide outstanding measurement performance while minimizing cost of operation.

Among the many advantages of Sensi+, users will find the latest in cyber security, an excellent user interface, data exportability, and easy software upgradability. The instrument is designed to maximize response time while lowering the cost of ownership. ●

—

MINING THE BENEFITS OF AUTOMATED EV CHARGING

Mining environments are routinely referred to as rugged, harsh, or challenging. They are also places where safety must be maximized and human exposure minimized. With this in mind, ABB has developed a pilot version of an automated charging system that can be used by any electric haul truck without human intervention. Fast, flexible, and fully automated, the solution

—

ABB has developed a pilot version of an automated charging system that can be used by any electric haul truck.

provides the highest power available on today's market, thus minimizing mobile asset downtime. Known as eMine™ FastCharge, the system can be remotely monitored and controlled to optimize the charging process and energy usage in real time, hence reducing an operation's environmental impact while improving its productivity.

Based on widely adopted and open automotive industry standards that are interoperable and

BEV OEM agnostic, eMine™ FastCharge does not require complex installation, thus lowering infrastructure costs and optimizing CAPEX/OPEX. Indeed, the entire charging station and its modules can be located separately, allowing the solution to seamlessly adapt as a mine's configuration and requirements evolve.

Once up and running, the solution's charging process is enhanced by a vehicle recognition camera system designed for maximum safety throughout the operation. Modular in design, eMine™ FastCharge's building block configuration makes it easy to adapt to a mine's operational and infrastructure needs, while making it future-ready for higher charging powers.

Thanks to an enclosure specifically designed to prevent ingress from dust and dirt, the solution is ready-made for the harshest environmental conditions prevailing in mining. •

ABB ABILITY™ CYBER SECURITY WORKPLACE

With their complex IT and operational technology (OT) infrastructures, industrial plants can pose significant cyber security challenges.

Plant operators are, however, well aware of the risk from cyber attacks and usually implement a cyber security software solution for each system in the plant. However, because these solutions are typically from different vendors, maintaining them is not easy and any lapses can open the door to cyber attackers.

What is needed is a way to simplify security by consolidating tools, auto-mating risk detection and remediating risks sooner. This is exactly what ABB Ability Cyber Security Workplace does.

Data from ABB and third-party cyber security solutions is collected by ABB Ability Cyber Security Workplace and forwarded to a consolidating native application, which presents it on a simple user interface. Operators can then monitor the status of all their security controls, perform mainte-nance activities to increase resilience and receive alerts with actionable insights to remediate threats and reduce risks.

Inbuilt risk root-cause analysis with remediation procedures evaluates any issue and suggests the steps required to fix it. Such inbuilt intelli-gence reduces the expertise needed to maintain cyber control systems. Further, these step-by-step guides cut remediation times, thus reducing operating costs and shortening the length of time the issue is present in the plant.

Moreover, ABB Ability Cyber Security Workplace installs patches against known exploits as quickly as they become available. Backup manage-ment is also included, as is the ability to isolate particular OT and IT environ-ments to protect them from external intrusions. There is also a cyber asset inventory facility that monitors all the traffic on the network in real time, lists all assets based on an analysis of the traffic and informs users about newly added assets. ●

For more information, see:
www.abb.com/cybersecurity/workplace

—
NEW DRIVE CONTROL PLATFORM IS BUILT FOR A DIGITAL FUTURE

Electric drives have come a long way since the days when their sole purpose was to deliver power from source to consumer. For instance, the growing computational performance of the processing units in today's drives can be used to

—
The platform has been designed to support critical security features such as authenticity and firmware encryption.

collect and analyze a steadily increasing quantity of information from the systems they are connected to. This ranges from more accurate estimates of torque and load characteristics to detailed information regarding the electrical grid.

However, as more and more interfaces are opened up to enable connectivity features, cyber security is becoming a key factor. With this in mind, ABB is about to introduce a next generation control platform for all its premium drives. The platform has been designed from the ground

up to support critical security features such as authenticity and encryption of firmware, files, and applications.

The new platform is backwards compatible with ABB's current generation of drives, making its introduction simple and familiar. To further enhance security and performance, drives can now also be equipped with an edge gateway capable of securely connecting to cloud back-ends and performing local analytics or process optimization from data collected from a drive or surrounding sensors.

The security features and high performance of ABB's new control platform can also be harnessed by partners and customers. For instance, it is now possible for the first time to allow direct extension of the drive firmware via a software development kit. The kit allows development of latency-free applications directly in the drive using familiar technologies such as Matlab Simulink or even C++ programming. The applications are secured via authentication and encryption and utilize the latest hardware technologies to isolate them from the core firmware. •

—
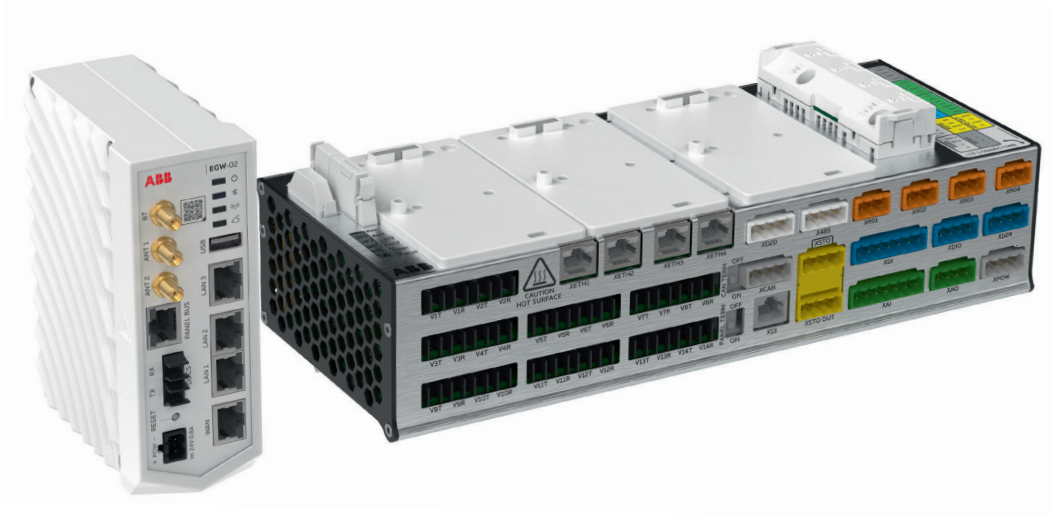
FASTER, EASIER AND BETTER WITH HIGH SPEED ALIGNMENT

With industry robots expected to perform ever more advanced tasks and interact with increasingly varied environments, it is essential to boost their performance as well as achieve rapid deployment and cycle times: In other words, the speed and accuracy of robots are essential. Following investigation of the challenges faced on high-precision assembly lines, ABB responded by offering its High Speed Alignment software.

In contrast to the conventional look-then-move approach, High Speed Alignment relies on sensors for an adaptive vision approach to achieve high accuracy and short cycle time, simultaneously. Thanks to the sensors and advanced motion control algorithm, the system controls the position of a robot's device, or tool, relative to the workpiece in real-time. High Speed Alignment not only reduces the average cycle time by 70 percent, from ~5.6s to ~1.7s, it increases accuracy from 20μ to 10μ, or by 50 percent.

By paralleling the development of technical readiness prototypes and in-house customer cases with validation through real-world pilot studies, ABB achieved rapid market readiness. High Speed Alignment is the first software package in the market to provide visual servoing technology for 6-axis and 4-axis robots.

The inclusion of an auto-tuning feature, which automatically calculates the time delay of sensors, filter buffer length, control gain, delay of robot and dead zones etc., allows expert- and novice users alike to operate the system and reach their alignment goals. Ease of commissioning is ensured thanks to auto-calibration and tuning: Deployment time is reduced from an entire shift to just one hour.

Designed for the segment of the electronics industry that uses robotic alignment for high precision assembly and pick and place tasks, High Speed Alignment has many other potential applications, eg, consumer segments and service robots (CSSR), auto industry/tier 1, etc. In all these cases, the software ensures fast cycling time and phenomenal accuracy for better performance. •

—
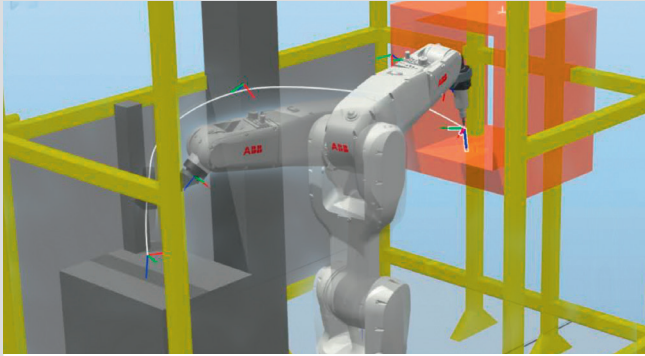
AUTOMATIC GENERATION OF COLLISIONFREE PROGRAMS

Boxes are stacking up, space is tight. Time is short. Wouldn't it be nice to have a robot that could just be told what to do without any ifs, ands, or buts? In view of the fact that the integration and programming of robots represent a major part of any company's investment in automation, ABB has introduced an innovation that allows its RobotStudio tool to automatically generate programs that guarantee collision-free motion of robots in a workspace.

Automatically generated programs result in smoother and shorter movements compared to what an average user can achieve and require orders of magnitude less time to program. In addition, the resulting movement paths provide faster motion time and often reduce energy consumption.

In a preliminary internal study, an intermediate-level programmer spent up to 20 minutes to program a collision-free motion for a robot in a cluttered environment, while automatic generation needed only seconds.

RobotStudio's innovation is the product of a combination of open source and in-house software, together with the virtual world in the tool itself. All in all, the innovation opens the door to a transformation of robotics in which systems become easier to use for non-experts. •

—

TWO NEW FAMILIES OF LARGE ROBOTS

ABB has added two new robot families to its portfolio of large robots. Based on a new modular platform design, the IRB 5710 and 5720 are up to 25 percent faster than other large robots. The robots are more compact and robust, offer integrated process cabling, with higher uptime for multiple applications, including electric vehicle manufacturing.

The robot families are suitable for a wide range of production tasks, including materials and parts handling, machine tending and assembly, and high-precision assembly. All variants have multiple mounting options and can operate hanging upside down. Payload options range from 70 kg to 180 kg and reaches from 2.3 m to 3 m.

The robots' platform includes a new generation of motors and compact gearboxes. The former, together with smart brake release technology, enable reduced energy consumption.

Both robot families are powered by ABB's new OmniCore™ controller V250XT. Featuring ABB's TrueMove and QuickMove motion control technology, the OmniCore V250XT controller enables the IRB 5710 and IRB 5720 to offer class-leading speed and excellent position (≤0.05 mm) and path repeatability. •

—

SUPPORTING THE SHIPPING INDUSTRY WITH OVERSEA
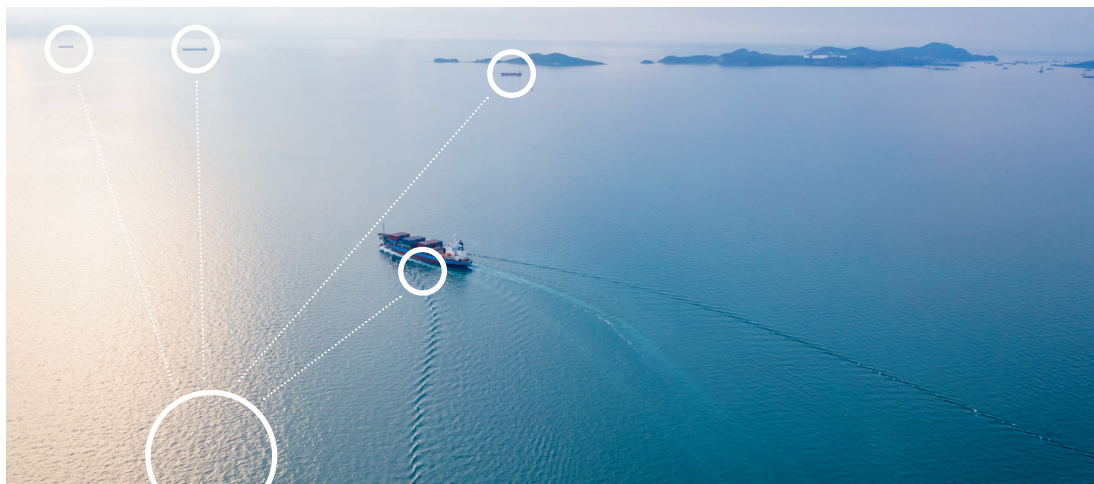
Bulit on ABB's industrial software platform, ABB Ability™ Genix, Oversea is being developed by ABB and Wallenius Marine. This solution is being customized for the shipping industry to improve a vessel's operational sustainability, efficiency and safety. This is accomplished by providing ship operators with a scalable system and services for centralized support, providing a fleet support center as a service.

This groundbreaking comprehensive digital solution, designed by ship masters, chief engineers and remote support experts, focuses on three areas that influence operational performance: technical-, environmental- and voyage performance. Oversea Digital Solution collects, transforms, aggregates and contextualizes data, and visualizes it in an actionable way. Data is turned into insights and insights into actions that can be applied to a single vessel or an entire fleet, thanks to the Oversea Support Center.

Collaborating with Wallenius Marine, ABB successfully completed an Oversea single vessel pilot study and is currently conducting an extended three-vessel pilot operation in a real-world environment. The user will test the functionalities that optimize technical performance, identify improvement areas using basic and advanced analytics, and ship-to-shore communication and workflows. The full-scope Oversea solution,

under development, will include environmental- and voyage performance capabilities[1].

Oversea's underlying performance analysis enables a breakdown of the overall environmental performance into technical performance and voyage performance contributors; this enables the identification of under-performance and the appropriate corrective actions. Cutting-edge models, combining machine-learning and physics-based methods, are used to enable accurate results in all areas.

Ultimately, the Oversea Digital Solution will connect vessels, client office and the fleet support center to enable collaboration, provide insights and real-time recommendations to turn insights into actions. In this way, ABB and Wallenius Marine are enabling the shipping industry to achieve optimal operational performance while reducing emissions for a more efficient and sustainable future. ●

—
Footnote:
[1] Two further releases of Oversea Digital Solution are planned for 2023.

—

ABB ABILITY™ SMART MASTER MAKES BETTER SERVICE DECISIONS FOR ABB MEASUREMENT DEVICES
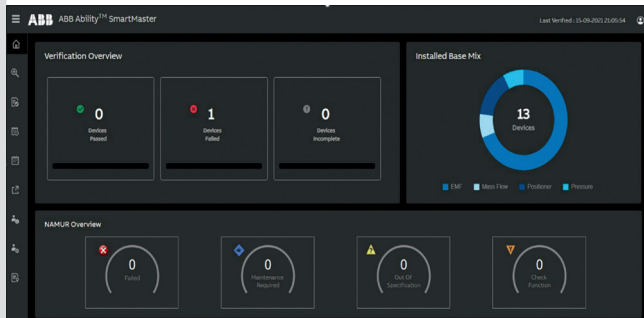
The global installed base of field devices that perform sensing duties – such as flow meters, level meters, temperature sensors, pressure sensors and valve positioners – is enormous. ABB is a major supplier to this multi-billion dollar market.

Measurement accuracy, regulatory compliance, operational status and failure diagnosis and prediction are critical aspects of a field device's

—

Smart Master collects data remotely from field devices for condition monitoring purposes.

performance. To manage these aspects in such a vast installed base, what is needed is a comprehensive asset performance management platform.

The ABB Ability Smart Master is just such a platform, designed specifically to cater to large installed bases of field devices.

Based on a prescribed schedule, Smart Master collects data remotely from field devices for condition monitoring purposes. Device health is verified and the device NAMUR status [1] is read

to help the customer obtain an installed base overview. This knowledge enables ABB service-assisted clients and self-service customers to plan service operations, spare part orders and device replacement. If there is a pattern of device failures, a calendar view analysis and an analytical report provide more insight into the failure scenarios.

Smart Master provides a three-tier solution:
• On-premise: remote monitoring support. Collected data is managed within the customer network.
• Dedicated cloud: dedicated link to each customer for monitoring. Collected data is managed securely in ABB's dedicated infrastructure for customers.
• Shared cloud: global link to all customers for monitoring. Collected data is managed securely in ABB's common cloud infrastructure for all customers.

With remote access, costs are lowered as remote experts can carry out pre-compliance activities and, later, routine visits to site by an engineer are reduced.

Often, measurement devices are deployed in places where connection is difficult. In such cases, field device integration (FDI) technology connects the devices without additional wiring or disturbing operations. Smart Master can also connect via 3G/4G and NB-IoT. ●

—
Footnote
[1] NAMUR is an international user association for automation technology and digitalization, and creator of associated standards.

ABB ROLLS OUT SERVO DRIVES R&D HUB IN NANJING

ABB servo products provide an extensive range of motion and machine control solutions for diverse industrial applications, such as packaging, textiles, printing, food and beverage, electronics and electrical. Such solutions help system integrators, OEMs and machine builders reduce energy consumption, increase their equipment uptime, and thus minimize maintenance costs while increasing productivity.

With a view to offering ever-more advanced servo products, as well as providing complete and more valuable motion control system solutions for the market, ABB opened a new R&D hub for servo products in Nanjing, China in 2020.

The new R&D hub is a significant milestone for ABB on the road to becoming a key player in China's growing servo business market. Its strategic significance for ABB and its customers is that the business will be close to local customers in the biggest market in China and will thus be able to provide faster delivery and response times than in the past.

What is more, by combining its new servo product line with research and development, the hub will be able to rapidly funnel customer input from ideas to implementation – a capability that can pay significant dividends in terms of recruiting from local universities and local competitors.

Since its inception, the R&D hub has expanded from 14 employees to 40 and has grown to offer services in areas such as hardware, firmware, testing and product management. The hub's first products are expected to be released by the end of 2022. •

BORDLINE® ESS MODULAR ENERGY STORAGE

Low-carbon drive systems with an embedded onboard energy storage system (ESS) are becoming an integral part of the rail industry's transition to sustainable mobility. The increased adoption of these systems not only helps to decarbonize transport but also provides a variety of other benefits, such as lower total cost of ownership, more operational flexibility and improved vehicle performance.

Traction batteries for mass transportation must deliver the required performance with maximum reliability over long service periods. To address

—

Modular design ensures easy scalability, high availability and safety without affecting design flexibility.

this market need, ABB has developed a portfolio of high-performance products called BORDLINE ESS.

BORDLINE ESS battery packs have a modular architecture, which allows standardization at the subsystem level without compromising on the required flexibility at the product level. The modular design ensures easy scalability in terms of voltage and installed energy with a minimal set of module variants.

At the core of each battery pack are modules equipped with high-power prismatic lithium-ion cells that incorporate a lithium titanium oxide (LTO) anode. The Bordline ESS offers a high level of inherent safety (such as tolerance to abuse), a long cycle life, fast charging capability, excellent lifetime even at 35 °C and good low-temperature performance.

ABB has successfully delivered, or is in the process of delivering, high performance traction batteries to more than 700 vehicles with references in railway rolling stock, e-bus, trolleybus and mining vehicle segments. ●

—

RESEARCH TOWARDS AUTONOMOUS SOLUTIONS AT SEA
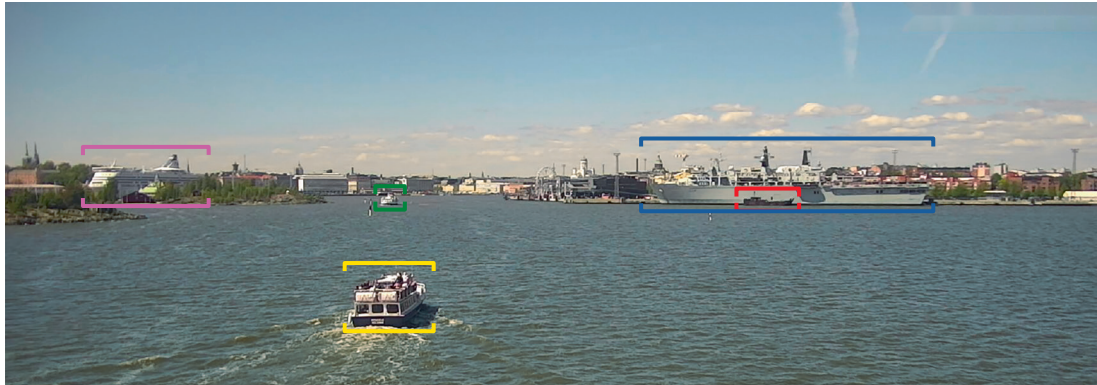
New technologies bring opportunities to look at familiar things with new perspectives. Consider ship navigation; a central task in navigation is lookout, keeping a close eye on the ship's surroundings to be able to warn of and avoid any potential obstacles or danger. Another important task for navigation is determining distance to obstacles. Known as water clearance , this is particularly important when maneuvering in harbor or confined waters. These are both tasks that cameras and autonomous systems can very successfully help support the bridge crew with. So how does ABB go about developing such a system?

ABB is conducting research on vision systems for marine applications. Specifically, making added value from the information gathered from the myriad of cameras already installed onboard. Leveraging machine perception changes the way we look at things and can enable safer, more efficient, and more autonomous maritime operations. A system of cameras and machine perception algorithms can support the human lookout/ bridge crew by providing continuous, relentless, lookout, and accurate water clearance measurements, as well as covering blind spots not visible from the bridge. A camera-based system will also be able to detect small, non-metallic obstacles that might go unnoticed to radar.

The key technologies that enable machines to process image streams are object detection and semantic segmentation. The goal of object detection is to detect all instances of objects from one or more classes. To do this successfully the machine has to interpret every pixel of an image to the right class. The state-of-the-art of these technologies are models based on artificial neural networks.

ABB's research is central to the development of more autonomous solutions for vessels, such as ABB Ability™ Marine Pilot Vision, which is part of ABB's autonomous solutions portfolio for ships.

—

Leveraging machine perception changes the way we look at things.

The research shows the potential of vision-based solutions, in this case a monocular-vison system, and their benefits when integrated into the suite of marine safety systems.

A full article in an upcoming issue of ABB Review will dive deeper into the development of this technology, explaining how the vision-based system understands its surroundings and ultimately helps seafarers navigate more safely. ●

—

PERMANENT MAGNET TECHNOLOGY: THE ENERGY-EFFICIENT INNOVATION FOR SHAFT GENERATORS

Producing electrical power from a generator mounted directly onto a marine vessel's main propulsion shaft is generally more efficient than running auxiliary gensets. To maximize such a shaft generator's advantages, and especially to boost energy efficiency, its rotor can be designed with permanent magnets (PMs) in place of conventional rotor windings. Eliminating rotor windings and associated equipment removes factors that account for much of a generator's total energy losses. Compared to conventional generators, the PM type achieves higher power density and efficiency at a smaller size. Energy savings are significant at full load but even greater (as much as 10 percent) in partial-load regimes (where vessels usually operate) compared to induction type shaft generators. Adding a variable-speed drive (VSD) enables the propulsion plant to run at the most efficient operation point.

For shipbuilders and system integrators, the beauty of PM shaft generators is their smaller and lighter construction, which enables quick and easy installation.

For owners and operators, there are savings in fuel consumption and maintenance expenses: Compared to previous solutions, a PM shaft generator should immediately cut fuel costs by up to 4 percent. Emissions are lowered, too and because a PM rotor has fewer components, maintenance and downtime costs are reduced.

PM shaft generators offer a choice of operating modes, bringing further flexibility, redundancy and safety. The generator mode – the one discussed so far – is called Power Take Off (PTO) mode. In Power Take In (PTI) mode, the generator works instead as a motor – delivering a temporary power boost to the propulsion shaft, which may allow downsizing of the main engine. Further, a Power Take Home (PTH) mode allows a vessel to return safely to port under electric power if the main engine fails.

ABB's newest PM shaft generator, the AMZ 1400, will be fitted to a fleet of 12 Himalaya Shipping bulk carriers. The package includes ABB ACS880 VSDs, which will optimize the vessels' performance in response to variations in speed, bulk freight weight and electrical load. •
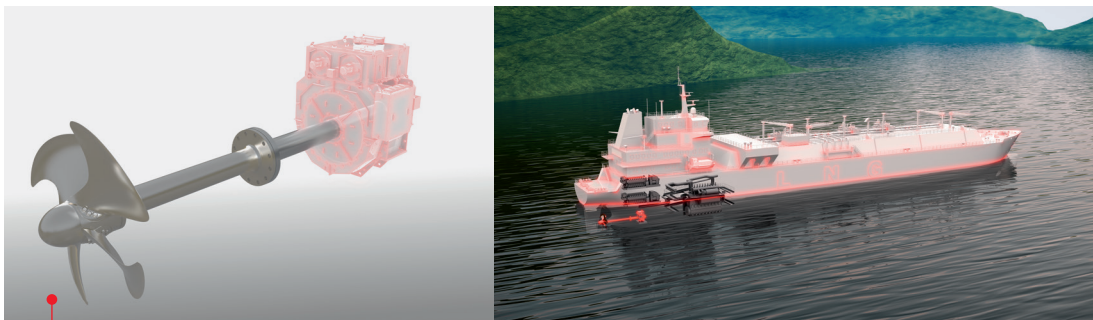
Permanent magnet technology **enhances efficiency, performance and reliability** of vessels

Cuts CO_2 **emissions** by several tons per day

20 % smaller, 30 % lighter than conventional generators

—

SYNCHRONOUS CONDENSERS PROVIDE INERTIA FOR GRID STABILIZATION

As renewable energy sources proliferate in power grids, the number of high-inertia generators, traditionally provided by fossil-fuel plants, decreases, both in actual numbers and as a share of the total power generating capacity. This reduction can have severe effects: Inertia is vital for compensating for sudden changes in the grid – such as when a generator trips and goes offline – to ensure grid frequency remains within tightly controlled limits.

How can a power grid's inertia be maintained in the face of the removal of high-inertia generators? The answer lies with synchronous condensers.

A synchronous condenser is a large rotating device that stores physical inertia to deliver instantaneous support for grids, enabling them to maintain stability irrespective of the upstream network voltage or frequency.

Fifty or more years ago, synchronous condensers were used widely but are now much less common as their former primary function – reactive power compensation – is now handled by a diversity of other solutions. However, this equipment cannot provide grid stability as well as a synchronous condenser, whose capabilities extend beyond reactive power compensation.

When additional inertia is needed in a system, an effective and economical approach is to add a fly-wheel to an existing synchronous condenser. This measure improves the potential to reduce losses compared to fulfilling the inertia requirement by installing a larger synchronous condenser.

ABB has chosen to upgrade its synchronous condenser flywheel with a patent-pending integrated safety device rather than relying on external protective functions.

The networks of the future will require decentralized solutions to maintain grid stability and resilience. Synchronous condensers are a well-proven solution that can be activated almost instantaneously to strengthen weak or compromised networks, even in remote areas. •

For more information, see the article "Grid support" on pages 66-71 of this edition of ABB Review.

Digitalization

40

50

The promise of digitalization is well known. It's also often difficult, time-consuming, and expensive to realize. ABB has made a priority of simplifying and speeding its customers' progress in unleashing the full power of automation. Digitalization shouldn't just stand for transformation; it should be transforming.

34

5G FOR PROCESS AUTOMATION

Cutting the cables

The potential of 5G in industry has been frequently discussed. With commercial 5G available in consumer markets since 2020, is the time now right to use 5G mobile broadband technology for process automation →01?

Asset management
- Condition monitoring*
- Asset tracking

Mobile workforce
- Video*
- Voice*, PA, TETRA replacement
- AR
- Mobile devices (operation, maintenance)*
- Drones

Process critical
- Regulatory control*
- Alarming
- Remote control for mobile equipment
- Fire and gas

Public networks, connectivity as a service (lower CAPEX)

Private networks (higher CAPEX, lower risk)

Process environment   Hazard containment   Site infrastructure   Operations

* Focus of ABB/Ericsson joint R&D within process environment

Beyond the process – convergence of IT, OT, and telecoms with 5G as common connectivity

02

—
01 5G is taking off in many sectors – can it be exploited to improve and simplify process automation?

—
02 Converged applications in process automation.

Currently, 5G standardization efforts aim to deliver a common communication infrastructure that integrates wired and wireless media and converges all information technology (IT) and operational technology (OT) domain communication [1]. For half a decade, ABB has been active in shaping 5G technology from the automation perspective to unlock its value for customer applications.

5G seeks to support almost any industrial application – for example, asset telemetry data transmission, mobile workforce infrastructure, or time-critical control signaling – based on one set of technologies and using one infrastructure →**02**. While some of these applications may

—

5G allows just one set of infrastructure assets to deliver communication services to all applications.

be run over public 5G networks, others would require the control of network resources and data security that only isolated, on-premise 5G networks can offer. Furthermore, 5G aims to converge OT (automation), IT and telecommunications onto the same wireless-centric network.

In this context, ABB and Ericsson have investigated the readiness of currently available 5G mobile broadband technology for use in process automation applications. These investigations

Dirk Schulz
ABB Corporate Research
Ladenburg, Germany

dirk.schulz@de.abb.com

have provided insights into network performance and understanding regarding viable approaches to 5G system configuration and management.

Value of common wireless infrastructure
The 5G ambition of providing a common wireless infrastructure leads to a wide range of value propositions →**03**. Most importantly, 5G allows just one set of infrastructure assets to deliver communication services to all applications and support any form of mobility. The technology also offers the flexibility to reconfigure production processes with less cabling or increase sensor coverage for better asset availability and product or process insight. Customers can choose to invest in and control these infrastructure assets or source connectivity as a service, making infrastructure cost scale with the value delivered by converged wireless connectivity. Instead of using multiple IT and OT wired and wireless systems and security solutions, one secure, high-availability infrastructure could serve all customer needs.

5G deployment and reality
Cellular standardization and development is a continuous process, and, like previous generations of cellular technology, 5G functionality will be delivered in increments. Each standard release focuses on a different class of application, starting with mobile broadband (release 15), which has been the basis for commercially available solutions and public networks since 2020. Subsequent standard releases 16 through 18 are partly finalized and focus on low-latency communication and massive numbers of Internet of Things (IoT) devices – though corresponding products and private or public networks are not

5G VALUE PROPOSITIONS	BASIC VALUE TYPES	TOTAL VALUE

03

Diagram mapping 5G value propositions to basic value types:

- Sensing coverage for product insight → Quality
- Personnel tracking / Asset tracking → Safety
- Secure communication → Security
- Sensing coverage for asset insight / Private spectrum and networks → Availability
- Asset tracking / Remote control / Sensing coverage for product insight → Productivity
- Public network services / Network convergence → CapEx
- Scalability of public services / Private network ownership → OpEx
- Plug and produce/flexibility → Time-to-market

Total Value:
- Improved productivity / Reduced operational risk
- + Business model
- + Sustainability

---

yet commercially available. To date, 5G standards have, understandably, focused on the mobile consumer market requirements. It now makes sense for domain-experienced partners, here ABB and Ericsson, who understand both automation and 5G, to explore the differences between what emerging standards include and what is readily available and possible.

Putting 5G to the test
Fulfilling the value propositions outlined above requires 5G to be technically capable of replacing wired communication on an industrial system scale. This condition comes with the need for a detailed technology assessment

To date, 5G standards have, understandably, focused on the mobile consumer market requirements.

and development of new features, specifically addressing the following questions relating to the provision of a complete automation solution such as that shown in →04:

- Performance: Is 5G able to run typical process automation applications over one and the same (converged) network infrastructure and how can Ethernet-based protocols such as PROFINET IO be run over a network based on IP? The relevant applications include regulatory core control with cycle times down to 250 ms, device and asset management, and IoT telemetry data collection. This first assessment does not consider motion control, sequence of events (SoE), or high-integrity communication for safety applications.

- Convergence: Can automation and telecoms applications be converged onto the same network infrastructure? Such convergence entails running core control and digital applications alongside video, voice, access control, etc., without compromising performance and without added investment beyond the converged network infrastructure.

- Automation: How can a whole cellular network be easily and securely operated from an automation perspective? Users with automation backgrounds – including operators, engineers and even networking experts – should not need detailed training or understanding of cellular technology [2].

Secure automated operation
ABB Ability integrating/managing 5G and automation

I/O*   5G   TSN   Controller*

Performance for productivity
ABB Select IO and AC800M connected over 5G/TSN

*Benchmark measuring point

Converged connectivity
Scalable infrastructure for digital control systems, telecoms, workforce and more

04
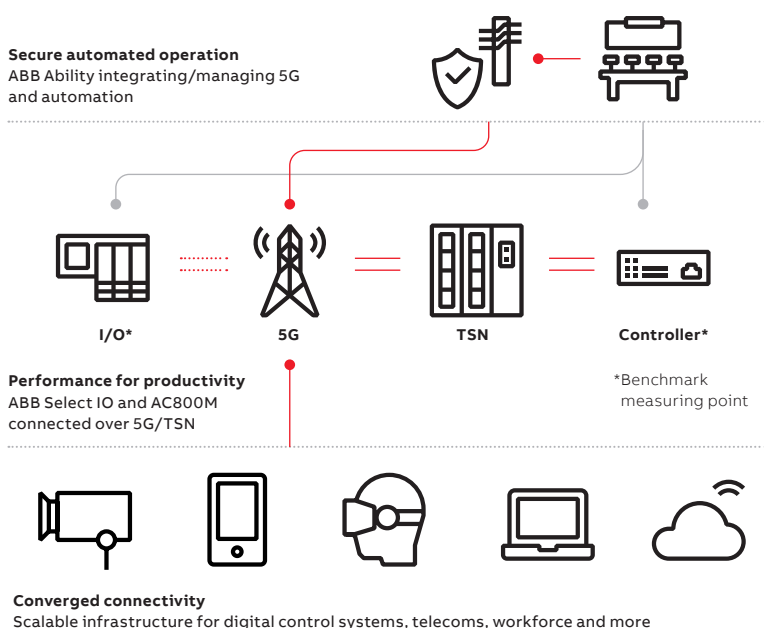
—
03 Value propositions
of individual 5G
features.

—
04 ABB automation
environment with 5G
infrastructure co-
created with Ericsson.

—
05 Security is a vital
aspect of any new
technology.

• Security: Does 5G comply with network secu-rity needs, given the level of exposure from the use of wireless, Internet technology and application convergence →05?

To address these questions, tests and devel-opment activities were carried out by ABB and Ericsson on a dedicated lab network, illustrated in →04.

A particular highlight of the lab setup is the distributed 5G campus network set up between ABB's research centers in Sweden and Germany and based on released Ericsson products. This so-called 5G non-standalone (NSA) network uses 4G/LTE for network management traffic and 5G New Radio (NR) connectivity to transmit industrial application traffic, such as monitoring or time-critical application data. No network operator was required – instead, a so-called local spectrum band (3.7 to 3.8 GHz in Germany and Sweden) was used [3].

On the application side, a simple control system consisting of an ABB AC800M controller and ABB Select I/O remote I/O, connected via PROFINET IO, was migrated to 5G. Instead of an Ethernet ring, the remote I/O was connected through redundant industrial 5G routers. A traffic gener-ator was used to assess the scalability of such control applications and verify co-existence with, for example, digital services or telecommunica-tions traffic.

Comparisons were made of communication latency and failover behavior (ie, reversion to a backup system) between the wireless 5G network and today's fiber-based wired networks. To this end, low-level measurements were taken directly at the Ethernet interfaces of the controller and I/O devices →04.

To automate the operation of the cellular network, 5G configuration and management functions were built into the ABB Ability™ Edgenius edge/cloud platform. This step allows security-related 5G features – such as mutual

—
Tests and development activi-ties were carried out by ABB and Ericsson on a dedicated lab network.

authentication, usage control and secure commu-nication – to be used through ABB's automation environment, addressing requirements set out in the IEC 62443 cybersecurity standard.

Readiness of 5G for process automation
The leading 5G research question is about performance – ie, ensuring 5G can guarantee the latency and availability needed to replace cable-based communication. The lab performance tests showed that it is possible to achieve uplink and downlink latencies of 64 ms with 99.9999 percent availability only after optimizing the radio access network (RAN) settings of the 5G campus network. This improvement is sufficient to run regulatory control with a 250 ms cycle time

05

Typical 250 ms cycle time .... **Next cycle**

I/O scan/output   Latency to upload   Control algorithm   Latency of download   I/O scan/output
                   sensor values (input)   to actuators (output)

8 ms*		100 ms	
	64 ms		**64 ms**
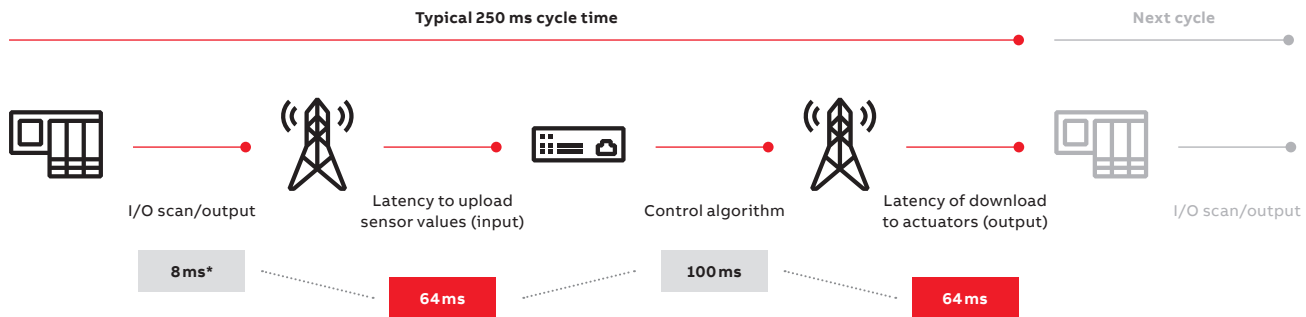
06

→**06**. Lower latencies are possible if consecutive packet timeouts or late deliveries, or even lower availability, can be tolerated by an application. Furthermore, the replication of I/O data over two independent network paths allows applications to tolerate the failure of a 5G router or radio connection in the RAN and further improves the availability of the 5G communication service in a healthy system.

IP-based protocols such as OPC UA or Modbus TCP can be used to talk natively with 5G. Even PROFINET IO solutions with ABB's AC800M and Select I/O can be achieved by using a Layer 2 Tunnelling Protocol (L2TP). With a suitable module configuration of the Select I/O, packet size limits introduced by the tunneling overhead can be avoided.

To scale a 5G system infrastructure for use with tens of thousands of I/O signals, hundreds of video cameras and mobile equipment, the efficiency of the network operation processes is of very high importance. For this reason, a management application programming interface

—
5G is ready to pilot regulatory process control in IT/OT-converged networks.

(API), called 5G Network Exposure Interface, was developed by Ericsson and integrated into the ABB digital ecosystem to securely onboard and offboard cellular devices or configure and monitor quality of service (QoS) for individual data connections – eg, between a controller and a remote I/O – from within the automation environment. The API introduces the needed simplicity into the everyday operation of a 5G cellular network without compromising security or performance from the management perspective →**07**. Integration of the API makes use

of the existing 5G security mechanisms, using strong cryptography first to provide mutual authentication between industrial 5G routers and 5G networks and then to encrypt communication over the air.

The next steps
As described above, out-of-the-box 5G mobile broadband technology comes with limits related to industrial use, particularly in time-critical applications. However, ABB and Ericsson overcame those limits in IT/OT-converged networks. Remedies included performance optimization to use 5G for regulatory control at 250 ms cycle time; operating the 5G network securely and simply from within the automation system, ie, with no particular cellular expertise or support from a network operator; and finding best practices for selecting and configuring the communication devices. Using local industrial spectrum (where available) puts control of this critical resource into the hands of plant owners for a nominal fee.

While the lessons from this joint technology development are being taken from the lab into the next generation of products as well as into standards in the 3GPP or 5G-ACIA communities, 5G is generally ready for use in pilot tests or front-end engineering design (FEED) studies in real process environments. In addition to control and asset management, mobile workforce aspects and the integration of mobile equipment can also be converged onto one 5G network. •

—
06 Example of a typical cycle time for regulatory control in process automation (* ABB Select I/O with 128 channels, eight general-purpose I/Os with 16 channels each).

—
07 Proof of concept using Edgenius-enabled orchestration of the 5G network. The user experience of 5G integration comes via a dashboard on top of ABB Ability.
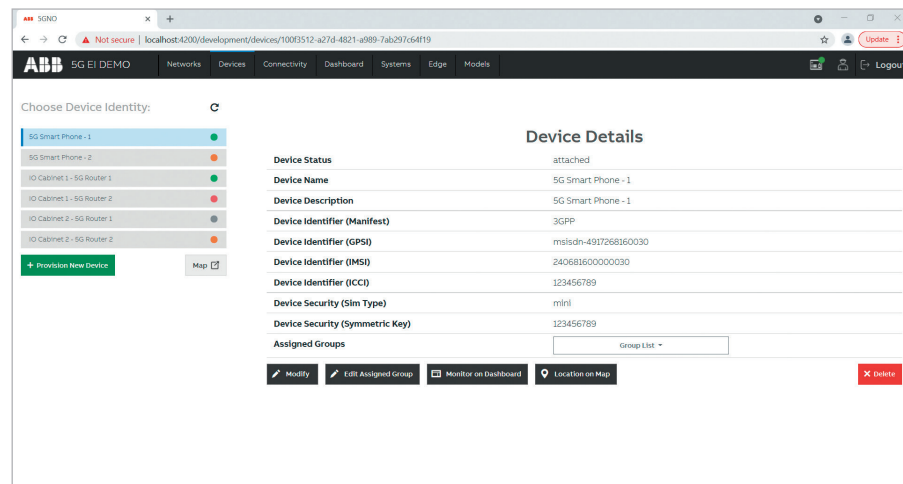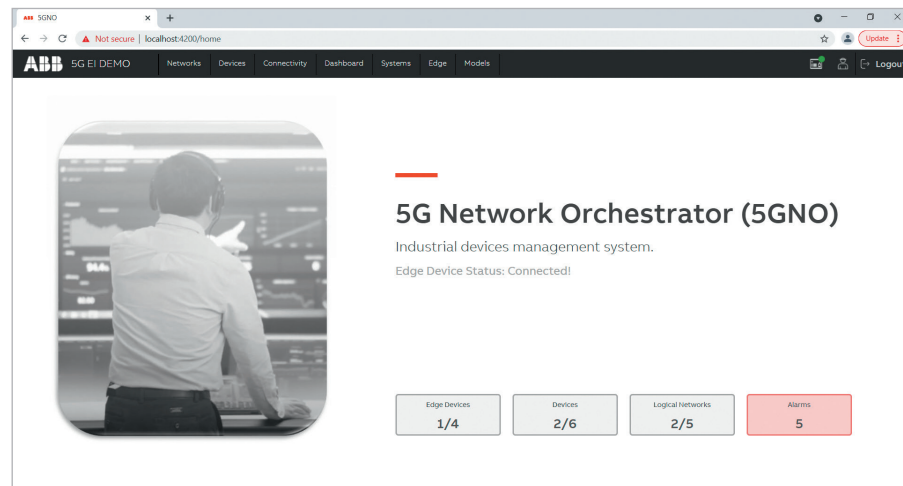
—
References

[1] D. Schulz, "5G for Digital Industries," *ABB Review* 1/2020, pp. 30–36.

[2] 5G-ACIA, "Exposure of 5G Capabilities for Connected Industries and Automation Applications, 5G-ACIA, Whitepaper," Feb 2021. Available: https://5g-acia.org/wp-content/uploads/WP_039_Network-Exposure-Interface.pdf. [Accessed July 12, 2022.]

[3] Bundesnetzagentur, "5G spectrum fees for local usages." Available: https://bundesnetza-gentur.de/SharedDocs/Pressemitteilungen/EN/2019/20191031_LokalesBreitband.html. [Accessed July 12, 2022.]

07
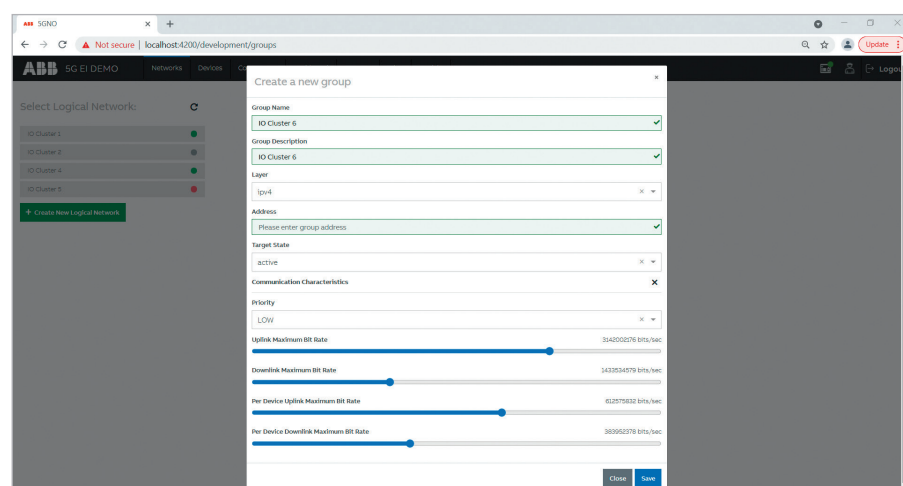
OPC UA HELPS MAKE INDUSTRIAL COMMUNICATION SECURE

Secure onboarding

Integrating the equipment needed to enable the digital transformation in industry requires a careful and stepwise approach to cyber security. How can the inbuilt security capabilities of OPC Unified Architecture (UA) assist the secure onboarding of industrial devices?

01

—
Sören Finster
Florian Kohnhäuser
Thomas Gamer
ABB Corporate Research
Ladenburg, Germany

soeren.finster@
de.abb.com
florian.kohnhaeuser@
de.abb.com
thomas.gamer@
de.abb.com

Frank Fengler
Ragnar Schierholz
ABB Process Automation
Minden, Germany

frank.fengler@
de.abb.com
ragnar.schierholz@
de.abb.com

Tilo Merlin
ABB Process Automation
Frankfurt, Germany

tilo.merlin@de.abb.com

The higher autonomy delivered by the rapidly proceeding digitalization of industry promises higher productivity, lower costs, smaller energy bills and improved health and safety conditions as well as better sustainability [1,2]. But the digital transformation brings challenges, too – that of interoperability, for instance, which requires global standards for connectivity, interfaces, information models, semantics and cyber security. OPC UA is emerging as one of the core technologies that will help achieve this interoperability – and in a secure way →01.

OPC UA addresses interoperability head-on, combining connectivity, modeling, semantics and security by design [3]. The inbuilt cyber security capabilities of OPC UA, while being optional modes, come into play as soon as a new device is integrated into a system – though in most cases, as a prerequisite for secure communication, certain cryptographic assets must be distributed to the participating devices ahead of time →02. Unfortunately, OPC UA's cyber security capabilities are often ignored due to the complexity of security processes and lifecycle security, as well as perceived limited usability.

Secure device onboarding and OPC 10000-21
While up until now, Ethernet was used in process industries primarily to connect operator stations, engineering stations and controllers in a

well-controlled and protected environment, one now sees Ethernet moving into the shopfloor infrastructure and sensor and actuator networks. This trend calls for secure communication with trustworthy identities for all devices, whether related to process control or maintenance and operations.

In such a scenario, so-called onboarding – ie, unboxing a new device and commissioning it into a system – is a critical phase in a device's life cycle as it creates first relationships, seen as trusted thereafter. The trust in these rela-

—
Onboarding is a critical phase as it creates first relationships, seen as trusted thereafter.

tionships and related cryptographic assets, however, can only be as strong as the security of the onboarding process that integrates them. During secure onboarding, malicious or erroneous actors must be excluded, so device identification and authentication are important first steps. Afterward, the new device is put into an operational state by configuring the necessary parameters. For a secure functional state,

by the manufacturer's certificate authority (CA) →03. Using the certificate, one can make an initial authenticity check of the device's identity. And by verifying that the device in question holds the corresponding private key, the device can be securely identified and authenticated.

Trust in this process is rooted in the integrity of the manufacturer's CA. This certificate must be obtained in a secure manner – for example, by downloading it from the secure internet presence of the manufacturer or via a ticketing mechanism specified in OPC-10000-21.

An IDevID certificate is static and, thus, not tailored to the customer who bought the device, so it cannot include information that is only available after deployment, such as IP addresses or host names. While this deployment-specific

—

The onboarding process, a key aspect of OPC 10000-21, comes with some infrastructure requirements.

this procedure includes configuring security parameters – for example, a device certificate and matching cryptographic keys – and ensuring connection to legitimate networks only.

In summary, the key challenges in device onboarding are:
- Identity and authentication: Attach a globally verifiable identity to the device to ensure only legitimate devices can connect to an operator's system.
- Initial key distribution: Supply needed security credentials, configurations and trust relationships to the device to ensure secure operation.
- Lifecycle security: Manage security credentials and configurations over a device's lifetime, including updates, upgrades, revocations, etc.

The most promising standardization effort for secure device onboarding in industrial automation systems is OPC 10000-21 [4]. This specification enables secure and automated onboarding of OPC UA devices by allowing full authentication of devices toward the operator's network based on a unique device identity →02.

Manufacturers certify authenticity
During manufacture, OPC UA-compliant devices are equipped with a device-specific, unique asymmetric key pair and an IEEE 802.1AR [5] Initial Device Identity (IDevID) certificate signed

information is expected to be present and correct in certificates in an operational state of OPC UA, the OPC 10000-21 standard allows for these checks to be omitted during automated secure device onboarding using static IDevID certificates. Still, even without these checks, achieving this first step of secure device identification already delivers significant value and opens up new opportunities.

Solution roadmap for secure OPC UA device onboarding
The onboarding process described above, a key aspect of OPC 10000-21, comes with some infrastructure requirements: Manufacturers must adjust their manufacturing processes to generate unique device credentials (usually on the target device itself) and sign them via a manufacturer CA as a first step. The reference standard for identities, IEEE 802.1AR, demands the storage of key material in a hardware security module (HSM) to prevent the extraction of private keys and to improve cryptography performance for resource-constrained devices. Using a manufacturer-created "ProductInstanceURI" [6] – a globally unique resource identifier compliant with IEC 61406, a standard dealing with automatic identification of physical objects – within the IDevID SubjectAltName field additionally allows for linking to a device.

OPC UA client

OPC UA server

Application instance

Client certificate*   Client key*

Server certificate*   Server key*

1 Exchange certificates + setup cryptography

Encryption   Client certificate

Server certificate   Encryption

*Certificates and keys that need to be securely provisioned before establishing the connection.

Application instance

Server certificate*   Server key*

Trust list

CA 1 certificate*   Server certificate*   Server certificate

2 Verify exchanged certificates based on local trust lists

Trust list

CA 1 certificate*   CA 3 certificate*   Client certificate

Encryption   Session keys

3 Derive symmetric keys

4 Use session keys to encrypt and authenticate communication

Encryption   Session keys

Secure OPC UA channel

02

In practice, this means that the device contains an HSM, which is used during manufacturing to generate a public and private key pair for the device identity. The device then generates a certificate signing request (CSR), which is submitted through the factory infrastructure to the manufacturer CA. In that process, the ProductInstanceURI is associated with the request. The manufacturer CA issues the IDevID certificate and responds to the CSR with the certificate. The device receives the response through the factory infrastructure and installs the certificate in its memory.

As a second step, a ticket containing metadata about the device is issued and signed in the manufacturer's infrastructure. This ticket includes the trust anchor – a public key for which trust is known, not derived – needed to validate the IDevID certificate. Finally, the ticket is stored on the device and may be delivered to the device purchaser via an out-of-band channel.

It will be some time before OPC 10000-21 is fully implemented and available at scale, but this first step for secure device identification already opens up new opportunities and shows that OPC 10000-21 can be delivered iteratively, with future generations and further improved security being delivered as software upgrades later.

Quick wins from secure device identities
"Quick wins" build on the assumption that an IDevID certificate of a single device can be verified by the operator, proving it is a genuine device from the vendor.

To verify the IDevID, the operator requires the vendor's CA certificate with which the IDevID has been signed. OPC 10000-21 tickets can be used to transmit this CA certificate from the vendor to the operator, or it can be pre-installed in

—

It will be some time before OPC 10000-21 is fully implemented and available at scale.

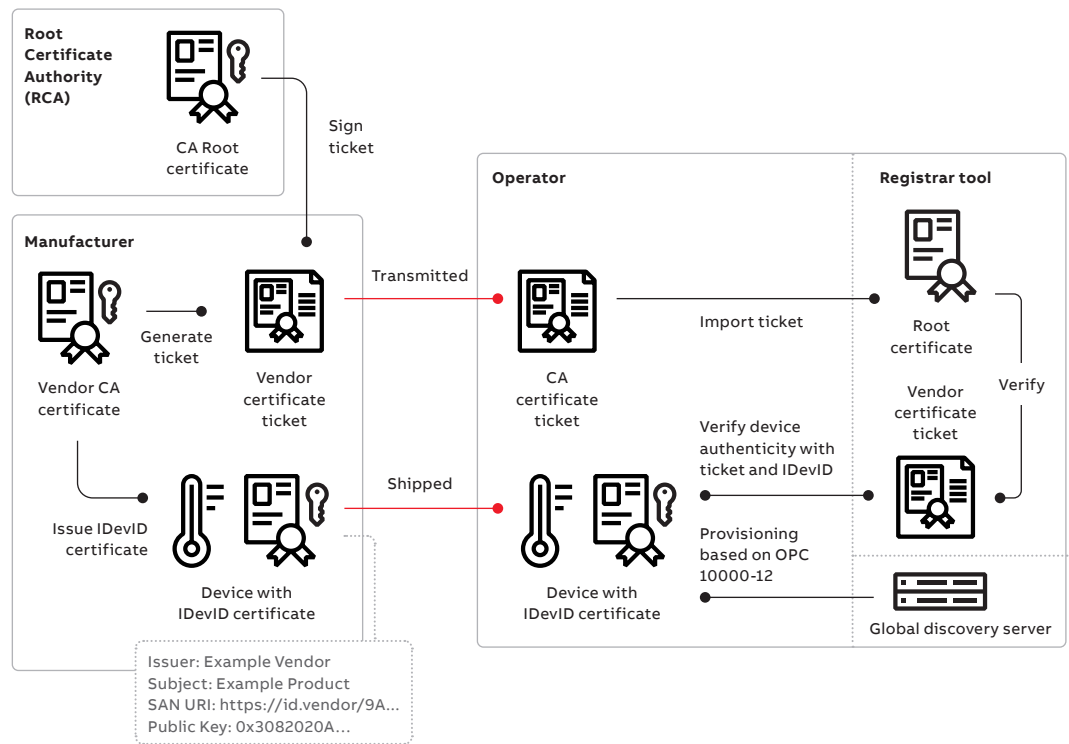software or hardware that the operator is using. This way, IDevIDs can already provide a security benefit without needing a full implementation of OPC 10000-21.

Further, each IDevID is bound to the ProductInstanceURI identifier of the device, provided by the vendor. A ProductInstanceURI identifier typically points to a globally available resource, such as a website that offers additional information

03

Issuer: Example Vendor
Subject: Example Product
SAN URI: https://id.vendor/9A...
Public Key: 0x3082020A...

about the device. Therefore, this information can be used for authentication using the manufacturer's backend and to obtain additional life cycle information for the device, which, in turn, allows for some new, trustworthy features, such as

- Access to reliable product information without searching for exact device type or numbering as type- and instance-specific information is available from authentication information. Examples of product information might be mostly static data such as device description, specification, manuals, production data, vendor services, or CO_2 footprint.
- Access to digital twin submodels, which can provide authentic, correct and reliable device data such as runtime data. Such access eliminates manual errors when transferring data between systems and can help fulfill documentation or audit trail obligations.
- Easy and flexible feature enablement by the device being able to authorize features directly or enable service contracting, eg, via manufacturer cloud facilities.
- "Software-ization" of updates, including firmware updates for security reasons and investment protection in long-living and flexible systems.

OPC UA is still evolving
OPC UA, with its built-in security features, contributes to the overall security of the digital transformation, especially device onboarding. While OPC UA security capabilities include full authentication of devices toward the operator's network, support for authentication of the operator's network towards devices is not

implemented in the current version of OPC 10000-21. The main challenge here is that the customer's trust anchors are unavailable during device manufacture. The otherwise high level of security and usability achieved, however, will

—
IDevIDs can already provide a security benefit without needing a full implementation of OPC 10000-21.

improve deployed security significantly. And there is the possibility of future extensions to the protocol that will bring interoperable solutions for deploying customers' trust anchors to devices during manufacturing or at a later stage before onboarding.

With features enabled by having secure device identities and the standardization of secure and automated device onboarding, a roadmap emerges that provides solutions with usable and automatable security to ABB customers and equips them for their journey through a demanding and evolving security landscape. •

—
References

[1] T. Gamer et al., "The Autonomous Industrial Plant – Future of Process Engineering, Operations and Maintenance," *Journal of Process Control*, vol. 88, pp. 101–110, 2020.

[2] ABB. "Billions of better decisions," Study report, 2022. Available: https://stories.ability. abb.com/better-decisions/introduction/. [Accessed September 1, 2022.]

[3] M. Kiener, "OPC UA" *ABB Review* 1/2023, pp. 80–81.

[4] OPC Foundation, "OPC 10000-21 Device Onboarding, Release Candidate 1.05.02 RC1, 2022-07-1."

[5] IEEE, "802.1AR: Secure Device Identity," Standard, Revision -2018, 2017. Available: https://1.ieee802. org/security/802-1ar/. [Accessed September 1, 2022.]

[6] OPC Foundation, "OPC 10000-100 Devices – Section 5.5.2 VendorNameplate Interface", Release 1.02.02, 2020.

DIGITALIZATION AND SUSTAINABILITY

Perfect circle

ABB aims to achieve a full life cycle circular approach for 80 percent of its products and solutions by 2030. To achieve this ambitious goal, all relevant product data over the life cycle must be available. Digitalization is the key enabler to making access to this large amount of data feasible.

01

—
Sten Grüner
Thomas Gamer
Ralf Gitzel
Jan-Christoph Schlake
Marco Ulrich
ABB Corporate Research
Ladenburg, Germany

sten.gruener@
de.abb.com
thomas.gamer@
de.abb.com
ralf.gitzel@de.abb.com
jan-christoph.schlake@
de.abb.com
marco.ulrich@
de.abb.com

Kai Garrels
ABB Electrification
Heidelberg, Germany

kai.garrels@de.abb.com

Sustainability is central to ABB's purpose. In line with the UN's global goals for sustainable development, ABB aims to achieve a full life cycle circular approach for 80 percent of products and solutions by 2030.

The circular economy concept implements a self-sufficient system: Products are used as normal, but when they are no longer needed or no longer work, they are repaired or reused by others. At the end of their life cycle, they are dismantled and their components and raw materials are used to manufacture new products →01. Along with environmental benefits, a circular economy also boosts economic competitiveness and resilience. ABB's circular approach includes both ABB's and the customer's perspectives of the entire product lifetime.

To reach the ambitious 80 percent goal, all relevant product data – over the entire life cycle – that relates to materials and processes has to be transparent, traceable and easily accessible. For example, manufacturers need to understand the environmental costs of their actions over a product's lifetime and plant operators must understand the CO_2 footprint and optimization

—

Along with environmental benefits, a circular economy also boosts competitiveness and resilience.

potential of their operation. Unfortunately, such insights are often unavailable as the amount of data needed to create them is vast.

Digitalization is the key enabler that makes these large amounts of data manageable, accessible

and usable [1]. The following exemplar describes three ABB activities that address the different sectors of ABB circularity and the role of digitalization in these.

**Circularity and carbon footprint data availability**
The ABB closed-loop circularity approach encompasses ABB's view of solution design and materials, sourcing, operations, logistics and waste avoidance, as well as the customer's perspective of optimized efficiency and lifetime, and end-of-life processing [2] →02. Such a system requires comprehensive information about a product's environmental footprint – for example, its CO_2 equivalent. This type of information is the focus of an ongoing digital product passport (DPP) initiative driven by the European Commission.

Guidance is also given by ISO 14067, which is part of the ISO 14060 family of standards for quantifying, monitoring, reporting and validating greenhouse gas emissions. ISO 14067 defines

—

The system needs comprehensive data about a product's environmental footprint – eg, its CO_2 equivalent.

the product carbon footprint (PCF) as a sum of all emissions and removals of greenhouse gases along its life cycle, expressed in a CO_2 equivalent. The PCF can include the so-called cradle-to-grave life cycle part of a product's life cycle – ie, the CO_2 equivalent of the product's components, production and intralogistics. A cradle-to-grave PCF additionally incorporates the CO_2 footprint of a product's runtime aspects – for example, transport to the place of use, installation, use and end-of-life events.

ABB participates in a German initiative [3] to showcase how carbon footprint information can
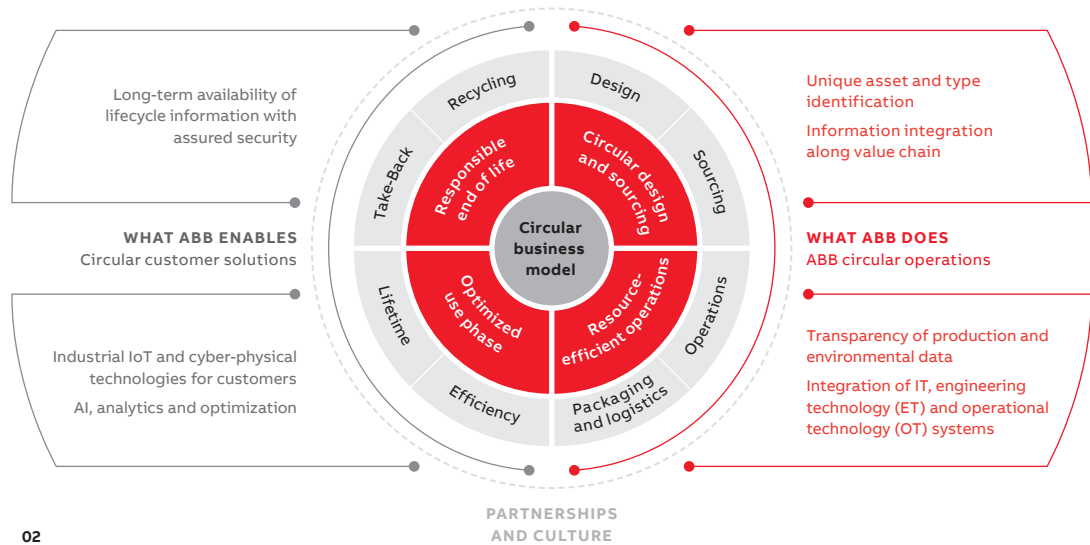
be exchanged between companies and combined into a PCF for a complex product based on open standards and Industry 4.0 technologies. To this end, a demonstrator electrical cabinet has been equipped with components from 14 vendors. The cabinet includes components implementing Industry 4.0 standards, such as QR-code-based identification of assets and access to each asset PCF via a so-called Asset Administration Shell (AAS) →03. An AAS is a technology- and vendor-neutral, interoperable implementation of

—

The cabinet includes components implementing Industry 4.0 standards, such as QR-code-based asset identification.

an industrial digital twin that covers an asset's representation through its full life cycle [4]. A digital twin, in turn, is a digital representation of a physical asset that enables industrial applications by providing data, models and services around the asset.

With access to each asset's digital twin and the cabinet's digital twin containing the component topology, analytics applications can sum up a correct cradle-to-gate PCF value of the cabinet based on the known PCF of its components.

Material flow optimization
The mining industry provides a good backdrop for demonstrating how digitalization and

digital twins can help improve sustainability. Mining accounts for 4 to 7 percent of the world's emissions of CO_2 [5] and about 6 percent of global energy consumption [6]. It is unlikely that this share will decrease fast but nonetheless, key players are targeting carbon neutrality by 2050. To meet this target, a holistic approach to optimization of energy consumption and CO_2 emission from pit to port is needed. Here, an ABB research concept called material flow digital twin (MFDT) helps to provide the necessary transparency that allows tracking of the continuous flow of material. An MFDT consists of an information metamodel based on international standards, a discrete event simulator, a model library and analytics modules that allow calculation of online key performance indicators (KPIs) like specific CO_2 emission per produced ton or specific energy consumption per produced ton.

Activity-based analytics derived from International Panel on Climate Change (IPCC) guidelines can be fueled by material flow information provided by the MFDT →04. This combination provides an online overview of the entire value chain and its actual emissions. MFDT digital technologies like state estimation, uncertainty quantification, what-if analysis and flow optimization help identify strategic actions to reduce emissions in mining processes.

Resource-efficient operations:
ABB's Mission to Zero
Digitalization and digital twins are crucial elements of ABB's Mission to Zero – a carbon-neutral and energy self-sufficient ecosystem for industry, homes and cities [7]. Transparency of Internet of Things (IoT) data from production,

—
02 ABB circularity approach with key digitalization technologies.

—
03 Cabinet demonstrator presented at the Hannover Fair 2022 showing digital-twin-based access and aggregation of PCF information of components provided by 14 vendors.

electrification and buildings is mandatory for a more resource-efficient operation and the fulfillment of Mission to Zero aims. Such transparency is achieved by collecting IoT data from

—
A unique asset identification can be linked via a QR code or NFC tag, as set out in the IEC 61406 standard.

all involved entities and digitally connecting the physical entities such as electric vehicle (EV) chargers, solar panels, or building automation appliances to achieve interoperability and allow for holistic optimization.

An installation at an ABB Busch-Jaeger site in Lüdenscheid, Germany, demonstrates how IoT data and digital energy management enable energy transition and sustainability. Featuring a 1,100 MWh/year solar power plant, the installed ABB equipment, which includes ABB's OPTIMAX® scalable energy management system, can cover the site's entire power requirements on sunny days, reducing CO_2 emissions by 630 t per year.

Requirements and Industry 4.0 technologies
From the discussed use cases above, two key prerequisites for a digital solution to a life

cycle-based sustainability approach emerge:
• Asset life cycle information needs to be collected in the digital twin during the life cycle.
• Infrastructure is required to store, serve and connect the digital twin data.

Further high-level requirements can be derived from these prerequisites and the Industry 4.0 technology solutions proposed. Regarding life cycle information, high-level requirements are:
• Unique identification of an asset.
• Knowledge about the asset type and structure, and semantically enriched other information.
• Versioning of changes directly related to an asset over its life cycle.
• Migration and backward compatibility of updates to the Industry 4.0 ecosystem – eg, of the Industry 4.0 information metamodel.

And for the infrastructure to store, serve and connect digital twins, it is necessary to have the following:
• Interoperability of all involved entities, eg, IT, OT and ET systems of different organizations.
• Connections to physical objects and digital representations, using, for example, industrial IoT and cyber-physical systems (CPS).
• Lifelong availability of information via long-time storage.
• Immutability and consistency of information.

Technologies that partially address these requirements already exist. For example, a unique asset identification can be linked via a QR code or

03
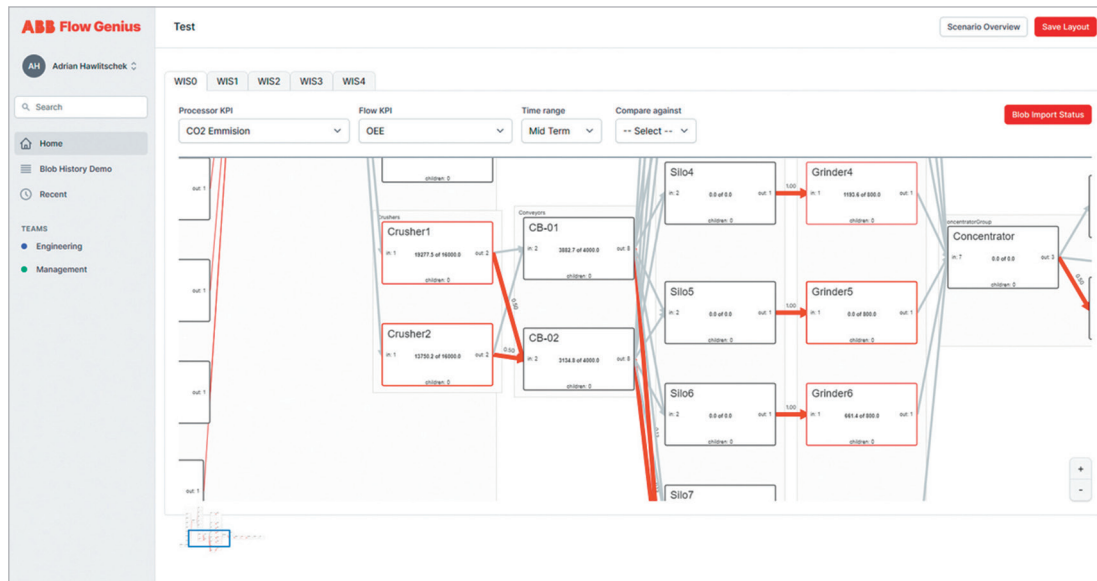
04a
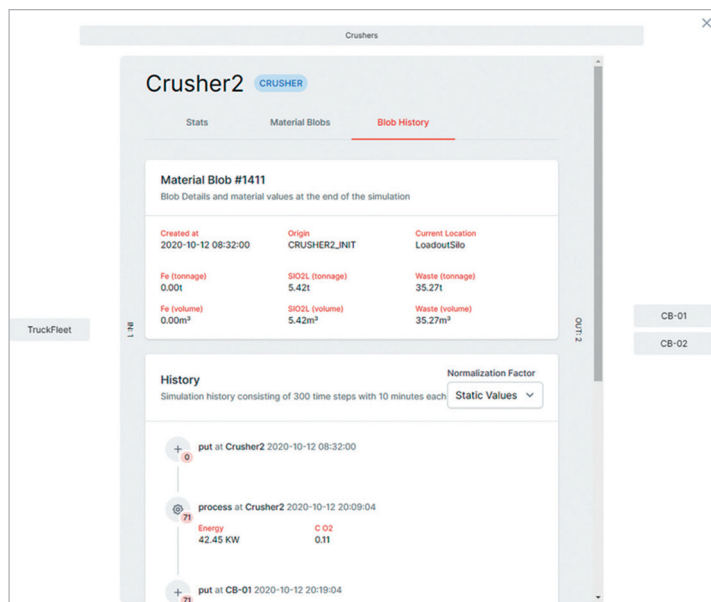
04b

The secure connection of the physical object to the digital representation – by, for example, industrial fieldbuses, Ethernet-based industrial IoT technologies, or interoperable technologies like OPC UA – is transparent to the user when interfacing with an AAS. Interoperability is accomplished by integrating vendor-specific models, such as ABB Ability™ Information Model, with vendor-independent and standardized

—

Digital twins can also help meet requirements related to environmental laws and sustainability regulations.

AAS or OPC UA information models. Moreover, digital concepts such as AAS provide an easy way to integrate digital twins with, for example, simulations in a CPS. Finally, analytics and optimization based on machine learning (ML) or artificial intelligence (AI) techniques provide the means to benefit from the large amounts of data accessible via digital twins and digital infrastructure. There is research and standardization work ongoing in addressing as yet uncovered requirements.

Digital twins can also be highly beneficial in meeting requirements related to environmental laws and regulations for sustainability – after all, the circular economy is only possible if products can be properly reprocessed without loss of material or the release of dangerous substances.

near-field communication (NFC) tag, as proposed by the vendor-independent "Identification Link" set out in the IEC 61406-1 standard. Such a link delivers both a stable identification and a connection between the physical object (the QR code or NFC tag is physically attached to the asset) and its digital representation.

To store and access knowledge about asset type and structure, Plattform Industrie 4.0 (a network of research facilities and industrial companies driving Industry 4.0 and the digital transformation [8]) and the Industrial Digital Twin Association (IDTA) [9] have specified and agreed on the AAS that implements the generic digital twin concept.

—
04 MFDT-based material tracking in continuous industries helps calculate specific CO₂ emissions per produced ton.

04a A dashboard study indicates deviations from the average.

04b Drill-down functionality allows the evaluation of specific material units.

—
05 Progress toward a healthier and more prosperous world lies at the core of ABB's drive for sustainable development.

05

Many laws and regulations – such as RoHS, WEEE, or REACH – typically require specific types of documentation. These can be provided using digital twin technologies and models adaptable to changes over the product or material life cycle and guarantee accessibility over the long term.

A full life cycle circular approach
Sustainability is central to ABB's purpose and the value that ABB creates for stakeholders. To ABB, sustainable development means progress toward a healthier and more prosperous world [2] →**05**. The digitalization concepts and solutions described in this article are central to this purpose and will help to achieve a full life cycle circular approach for 80 percent of products and solutions by 2030. Further, the opportunities that

—
To ABB, sustainable development means progress toward a healthier and more prosperous world.

digitalization offers – especially where digital twins are concerned – are open to almost any company to assist them in further improving sustainability within the organization and across their value chains. •

—
References

[1] M. W. Hoffmann et al., "Developing Industrial CPS: A Multi-Disciplinary Challenge," *Sensors Journal*, 21(6), 2021.

[2] ABB, "SUSTAINABILITY REPORT 2021: From ambition to action," March, 2022. Available: https://sustainabilityreport.abb.com/2021/servicepages/downloads/files/sustainability-performance-abb-csr21.pdf. [Accessed August 20, 2022.]

[3] German association of electrotechnical industry (ZVEI), "White Paper: ZVEI-Show-Case PCF@Control Cabinet," 2022. Available: https://www.zvei.org/fileadmin/user_upload/Presse_und_Medien/Publikationen/2022/Mai/Show-Case_PCF%40Control-Cabin/22-05-25_White-paper_ZVEI-Show-Case-PCF-Control-Cabinet-HMI2022.pdf. [Accessed August 20, 2022.]

[4] S. Grüner et al., "Products have a digital twin and you can find it too!" *ABB Review* 03/2021, pp. 26–31. Available: https://new.abb.com/news/detail/80772/products-have-a-digital-twin-and-you-can-find-it-too. [Accessed August 20, 2022.]

[5] McKinsey & Company, "Metals & Mining and Sustainability Practices. Climate risk and decarbonization: What every mining CEO needs to know," 2020.

[6] K. Holmberg, et al., "A. Global energy consumption due to friction and wear in the mining industry," *Tribology International*, Volume 115, November 2017, pp. 116–139.

[7] ABB, "Mission to Zero™ – The future of electrification is safe, smart and carbon neutral." Available: https://new.abb.com/mission-to-zero/about. [Accessed August 20, 2022.]

[8] https://www.platform-i40.de [Accessed August 20, 2022.]

[9] https://industrialdigitaltwin.org [Accessed August 20, 2022.]

ABB'S NEXT GENERATION DRIVE CONTROL PLATFORM

Digital future

The latest drives are connected to multiple systems and sensors and are increasingly involved in providing information that supports remote maintenance, data analysis, and just-in-time service. However, as more and more interfaces are opened up to enable connectivity features, cyber security is becoming a key factor.

Pekka Jarvinen
Motion System Drives
Västerås, Sweden

pekka.jarvinen@
se.abb.com

Electric drives have come a long way since the days when their sole purpose was to deliver power from source to consumer. Advances in the computational power of processors, the growing capacity of memories, and faster interfaces allow them to do a lot more than just drive the rotation of an electric motor. Indeed, the increased performance of the processing units in today's drives can be used to analyze a steadily increasing amount of information from the systems they are connected to, ranging from more accurate load-related torque estimates to detailed information regarding the electrical grid that the inverter is connected to.

Best possible sensor
In an automation system, the drive is typically the only component that has full knowledge of the components it is connected to. It measures three-phase current and voltage in high resolution and is sometimes equipped with additional sensing capacity such as an encoder and thermal sensors.

When it comes to motors, the complex matheatical models that are needed for the normal operation of a drive constantly calculate accurate torque and speed values and perform grid-positive and negative sequence decompositions and harmonic analyses for their grid-facing interfaces. In short, the drive is, in all probability, the

best possible sensor available in a system – and all at no extra charge! The challenge, however, is how to collect, transform and move all the information to where it is needed.

As noted, drives are connected to multiple surrounding systems →01. Locally, they are connected to other automation devices, sensors or commissioning and monitoring tools, and are increasingly involved in providing information that supports remote maintenance, data analysis, and just-in-time service. However, as more and more interfaces are opened up to enable connectivity features, cyber security is becoming a key factor.

With this in mind, ABB is about to introduce a next generation control platform for all its premium drives →02. The platform has been designed from the ground up to support critical security features such as authentication and encryption of firmware, files and applications, and secure connectivity. Furthermore, the new platform is backwards compatible with ABB's current generation of drives, making its introduction simple and familiar.

Added alongside all of the platform's pre-existing features, there are now two dual-port Ethernet interfaces one of which can support all Ethernet-based field bus protocols. The processor is

now a state-of-the-art system-on-a-chip from AMD featuring a powerful cluster of ARM cores and a field-programmable gate array (FPGA) paired with a powerful, fast memory. In addition, the control platform features multiple hardware upgrades and is now harmonized over ABB's entire portfolio of premium drives to further simplify the handling of spare parts.

Cryptographic keys
With a view to ensuring the platform's security, asymmetric and symmetric cryptographic keys are stored in a secure enclave within the device during its manufacturing stage. Asymmetric keys (RSA-4096) are used to validate and confirm that the firmware executing in the device is an authentic ABB firmware release, thus assuring the user that no malicious modifications have been performed to the drive. Encryption keys (AES-256-GCM), on the other hand, protect both the end user's and ABB's IP, thus ensuring that valuable data cannot be stolen.

When operating in the IoT domain, one key insight is that the cost of moving and storing data must increase in proportion with the distance it moves away from the device. For example, if all the real-time data of a single drive were moved outside of the drive, the bandwidth required to do this would be of the order of hundreds of megabits per second. As the number of drives increases in an installation, the bandwidth and storage requirements do as well. Moving and storing all this data to the cloud would be economically unfeasible. Traditional compression could be used to reduce the amount of data; however, by utilizing domain knowledge, there is an even more sophisticated way to do this while simultaneously adding value to the data stream.

—
01 Drives and motors are connected to an increasing number of systems.

Real-time applications that require accuracies below the microsecond level and never miss a single execution cycle over the entire lifetime of a product typically run on specialized systems known as real-time operating systems (RTOS). The advantage of an RTOS is that all execution cycles are deterministic and accurate. However, the disadvantage is that tools such as high-level programming languages and algorithms from desktop or web development cannot be used since they often rely on asynchronous and non-constrained execution.
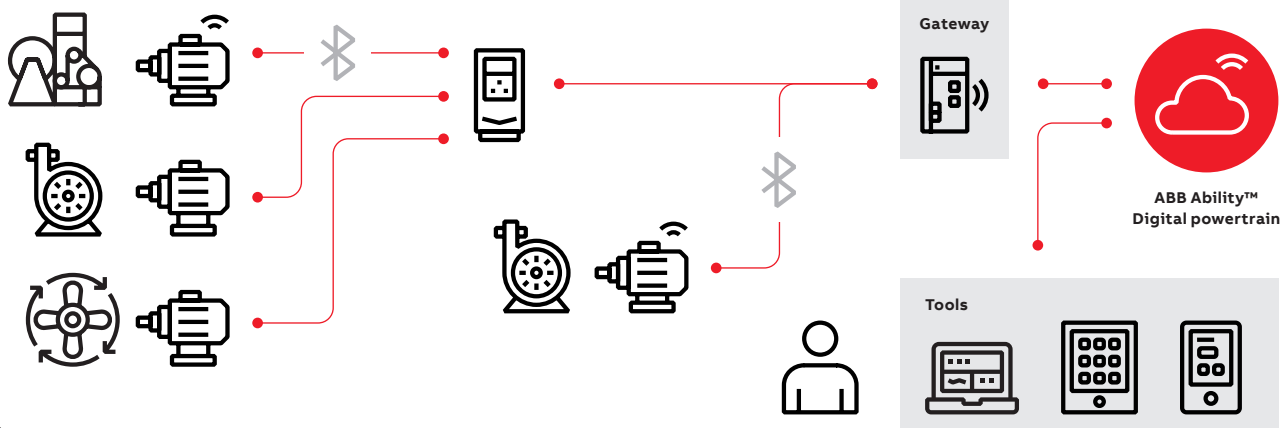
To solve this problem ABB is introducing an embedded edge device →**03** with a Linux platform specifically designed for executing
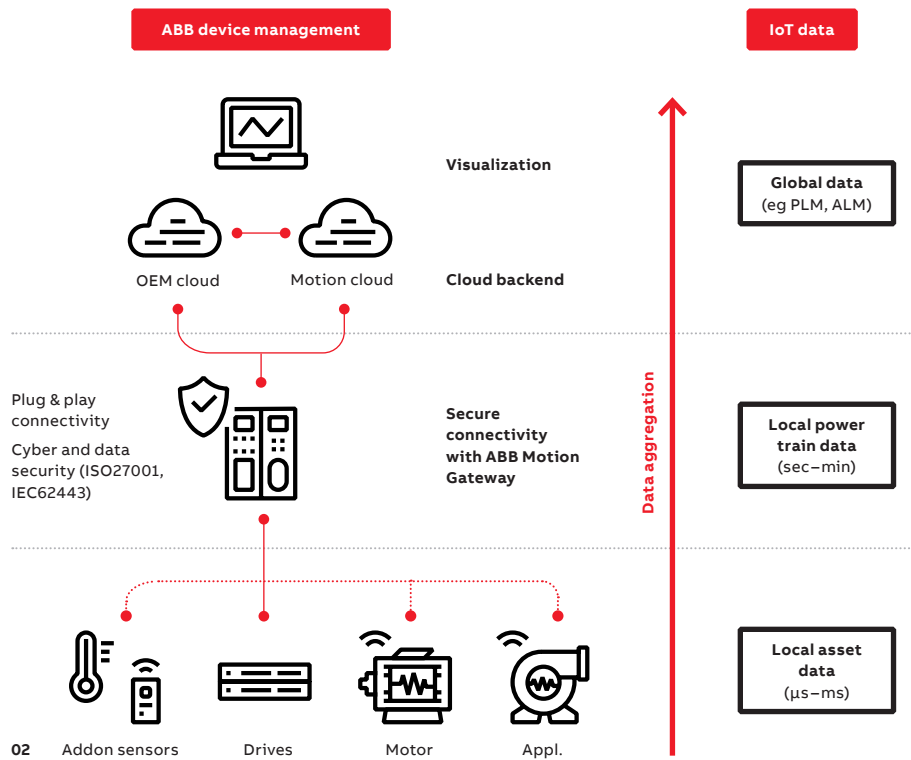
—
The new platform supports authentication and encryption of firmware, files and applications, and secure connectivity.

asynchronous applications while simultaneously enhancing associated cyber security functions, thus further enabling users to utilize their domain knowledge of the automation system to reduce the amount of data.

The edge device is connected directly to the processing unit of the drive and features the same communication libraries as does ABB's drive commissioning tool, Drive Composer. This allows the device to access any function or data available in the drive. While Ethernet is the connection mechanism that offers the fastest performance, the device is nevertheless compatible with ABB's older generation of drives, such as ACS800 and ACS600, which use DDCS optic fiber links. Furthermore, by using its panel port, it is also compatible with drives that are not equipped with Ethernet.

Gateway

ABB Ability™ Digital powertrain

Tools

01

**02** Addon sensors | Drives | Motor | Appl.

For connectivity to the cloud or local servers the device features both an Ethernet interface and an LTE modem. A bluetooth modem is also included for connecting to wireless sensors. Both the edge device and control unit feature the same processing core, with the sizes of their memories and their clock frequencies carefully tailored to their respective use cases.

Containerized software environment
The edge device features a fully containerized software environment that allows secure separation of applications and their independent updates. This means that even if a breach of an application occurs, it will not compromise the entire system. When the edge device rolls off ABB's production line, it contains only a secure

Linux distribution, a boostrapped device management solution, and drivers for its hardware interfaces. Applications that are needed for a specific use case are then loaded to the device ensuring that only functions required by the installation are present, thus minimizing the cyber security attack surface. For example, when connecting to ABB's drives, an application capa-

—

The edge device is connected directly to the drive's processing unit, allowing it to access the same functions and data.
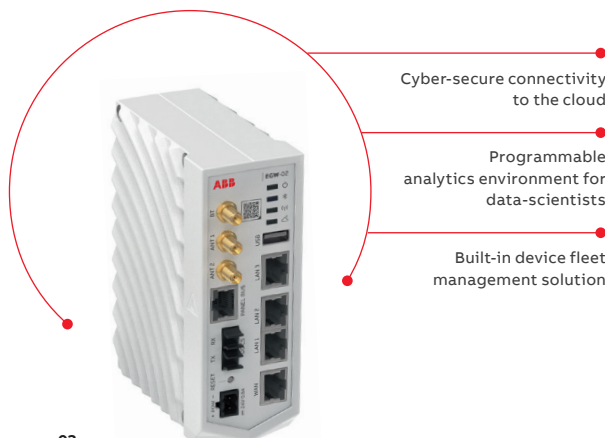
ble of interfacing with the drive would be loaded, along with a database application for storing data from the drive. Finally, a cloud interface application for moving the data to a desired cloud backend would be added. If additional features, such as connecting to ABB's smart sensor, are required later associated applications can be added securely and remotely from ABB's device management interface.

Empowering users
The edge gateway enables partners and customers to create additional value quickly and easily. Now that real-time and asynchronous operations have been separated, users with a data science or application development background can

Cyber-secure connectivity to the cloud

Programmable analytics environment for data-scientists

Built-in device fleet management solution

03

—
02 Designed from the ground up with cyber security in mind, ABB's new control platform supports the trend toward data aggregation from a growing number of sources.

—
03 ABB is introducing an embedded edge device based on the Linux platform.

—
04 ABB's new drive platform is suitable for real-time applications that are tightly coupled with the drive's core firmware. The edge unit executes asynchronous operations.

develop applications using familiar technologies such as Python programming, and even use state-of-the-art machine learning technologies like TensorFlow, while still being able to harness all the data available in the drive. For example, an OEM winch manufacturer could utilize the

—
The concept of the programmable environment has been extended to the real-time world of the drive control unit itself.

drive to collect a high-resolution torque profile chronology of the motor connected to the winch, and then embed a model of an aging rope in the edge device. The resulting metric covering performance during aging could then be transmitted to the OEM's own service system, allowing the OEM's end customer's winch to be serviced at optimized intervals.

Augmented programmability
The concept of the programmable environment has also been extended down to the real-time world of the drive control unit itself. For example, it is now possible for the first time to allow direct extension of the drive firmware via a software development kit. The kit allows development

of latency-free applications directly in the drive using technologies such as Matlab Simulink or even C++ programming.

The user can first simulate an application in a PC environment using ABB's Virtual Drive →04. The application can then be directly programmed to the drive without needing to restart. The applications, while constrained by strict execution timing and cyclic execution, augment the programmability already enabled by the edge gateway. For instance, an application within the drive could calculate a sliding window fast fourier transform over high-speed signals and then transmit the spectrum along with other needed characteristics of the fast signal to the edge device, thus vastly reducing the amount of data. The edge device could then inject the data into a specifically trained machine learning model, which would detect errors in system behavior and send notifications to the cloud on demand

The programmable environment in the control unit can also be used independently. It is possible, for example, to replace the drive's speed or DC voltage controller with a different application-specific version of the controller or to add an application that performs specific torque injection to achieve active damping of resonances.

With its new drive control platform, ABB is taking the digital future seriously. Cyber security has been built into the system from the very first millisecond of device service to the product's end of life. The authenticity of all software is verified before execution. And all sensitive IP has been encrypted and critical communication interfaces have been secured. Thanks to these features, ABB's partners and customers can focus on value creation using these innovative tools without worrying about malware, cyber-attacks, or the complexity of writing firmware-level software. •

04
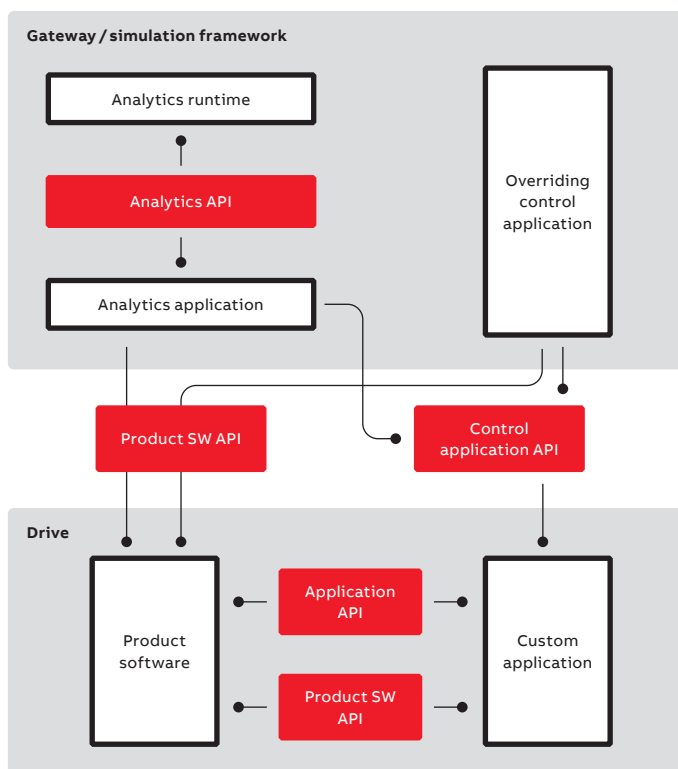
Transportation & efficiency

66

72

ABB has helped customers innovate electric trains since they first came into broad use, and it has been a leader in the industry ever since. The growing importance of electrification to a sustainable future means generating, distributing, storing, and using electricity more efficiently. ABB is assisting customers in making optimal application of these innovations.

62

SUSTAINABILITY IN THE LIFE OF AN ELECTRIC MOTOR

A circular future

By developing a circularity framework, ABB is taking steps to embed a mindset of sustainability in all it does, from designing out waste to efficient use and reuse. The design and use of highly efficient motors and handling motors responsibly at the end-of-life shows just how ABB's strategic ambitions translate into impactful actions.

—
Santanu Singha
Erik Johansson
ABB Corporate Research
Västerås, Sweden

santanu.singha@
se.abb.com
erik.x.johansson@
se.abb.com

Peter J. Isberg
ABB Motion Service
Västerås, Sweden

peter.j.isberg@
se.abb.com

Emma Westberg
ABB MO Discovery
Västerås, Sweden

emma.westberg@
se.abb.com

Global energy usage, including industrial energy consumption [1], is projected to increase by almost 50 percent by 2050. Today, electric motors are among the biggest consumers of electricity world-wide, accounting for between 43 and 46 percent of global electricity consumption (7,108 TWh) [2]. Hence, the energy efficiency of electric motors impacts energy usage considerably .

Used in a wide range of applications, eg, fans, blowers, and machine tools, the 8 million electric motors operating within the European Union, for example, consume nearly 50 percent of the electricity currently produced in the region [3]. A leading driver for increased electricity consumption, industrial motors are predicted to contribute to over 30 percent of the total growth in consumption until 2040 [4].The significant role that electric motors could play in driving sustainability and influencing climate change going forward is apparent →01.

Without a doubt, sustainability is critical to industrial business strategies, including ABB's. Sustainability is key to ABB's company purpose and the value they create for all stakeholders. This strategy rests on three pillars: reducing carbon emissions, preserving resources, and promoting social progress. By developing and implementing a circular approach business strategy, ABB is not only true-to-purpose but is generating tangible data-driven results that customers can use to make a difference.

Circular approach and life cycle thinking
Since the early days of industrialization, the traditional model of running a business has been based on a linear approach to resource consumption that follows a take-make-dispose pattern [5] →02, in which raw materials are extracted from mines and used to manufacture a product, sold to customers, who then dispose of it when it no longer serves their purpose →02a. However, a linear approach does not necessarily help eliminate waste optimally, nor can it protect industries exposed to business risks associated with resource-connected supply chain disruptions [5]. Such challenges call for a different economic

—
Sustainability is key to ABB's company purpose and the value they create for all stakeholders.

model, one based on a circular approach to value creation – a circular economy →02b. Following a take-make-take pattern, this industrial system is restorative or regenerative by intention and design. The core aim is to "design-out" waste, not simply "eliminate" waste [5]. A circular approach (also known as "closing the loop") encompasses three basic strategies:
1) Design out waste and pollution (focus on product design)
2) Keep products and materials in use (focus on business models)
3) Regenerate natural systems (focus on regenerating resources)

Grounded on the concept of "life cycle thinking", defined as a "way of thinking that includes the economic, environmental, and social

01

consequences of a product or process over its entire life" [6], the circular approach considers a product, process or service in the system holistically – from raw materials, through to manufacturing, consumption (or use) to end-of-life, with the possibility of influencing sustainability at every stage – an absolute must for product sustainability.

Life-cycle assessment of an induction motor – making data-driven decisions
A life cycle assessment (LCA), based on life cycle thinking, is a structured and scientific process used to understand and assess the impact of a

—

The circular economy is restorative or regenerative by intention and design.

product, process, or service over its life cycle as the materials flow within the economy through different stages. Relying on the principles and framework described in ISO 14040:2006, material flows are measured against several different

impact categories linked to the environment and ecosystem, typically carbon emissions, global warming potential, ozone-depleting potential, water scarcity, etc.

For an LCA evaluation, ABB chose a low-voltage (LV) induction-type motor. The environmental impact caused by material and energy flows across different phases in the motor's life-cycle was determined using SimaPro. In a LV motor's 20-year life cycle, the usage phase contributes to more than 99 percent of direct/indirect carbon emissions. The significance of a motor's energy efficiency to sustainability is evident →03. Nevertheless, the materials in a motor are no less important from a sustainability viewpoint. Metals, which constitute more than 98 percent of a motor's structure, are recyclable and therefore reusable – a sustainability advantage →04.

 LV motors are already manufactured efficiently nowadays: The design phase uses materials optimally and production is automated in energy efficient factories. Based on ABB's results, the most practical way to enhance the sustainability footprint of a motor is to design/use motors with high efficiency and to handle the materials appropriately and responsibly at end-of-life.

02a

02b
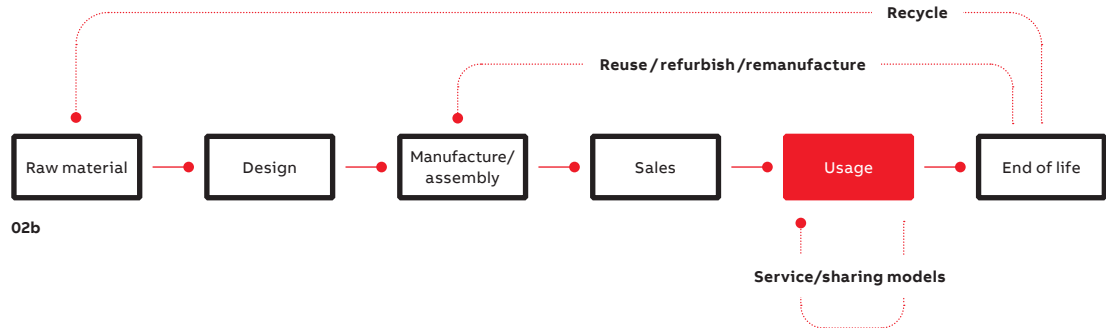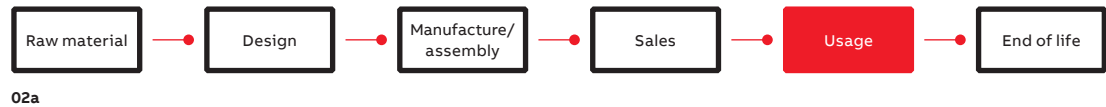
Energy efficiency: a key sustainability driver
Energy efficiency has become a business-critical topic [7], often used in conjunction with sustainability. A recent global survey on energy efficiency reported that 97 percent of industry leaders are already investing, or plan to invest, in improving energy efficiency [7], primarily citing cost savings followed by corporate sustainability commitments as grounds.

Because motors are among the largest consumers of electricity, their design and use contains tremendous potential to save energy. Electrical motors are robust with a long technical life: It is common to find working motors that are 50 or

—
Designing and using highly efficient motors is one way to impact the sustainability footprint of a motor.

60 years old. Thus, the installed base in industry and infrastructure does not, in general, meet the efficiency standards of today. Replacing such old inefficient systems as well as motors that are over-dimensioned and consume more power
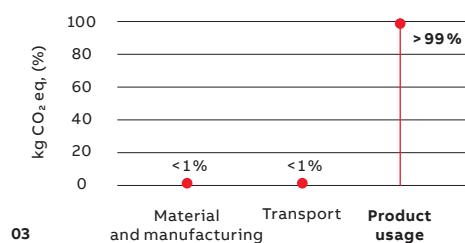
than necessary with more efficient alternatives would be one of the most cost-effective and impactful ways to reduce energy consumption and related emissions [8]. For example, installing an IE5 SynRM motor to replace an IE3 motor could reduce annual CO_2 emissions by 22,000 kg for an application rated at 315 kW [9]. And, from a resource perspective, the rotor of a SynRM motor does not utilize magnets or rare-earth materials, making this product even more sustainable.

Despite the significant savings customers can achieve by upgrading a motor, still greater energy savings result if a high-efficiency motor is used in combination with a variable-speed drive (VSD). For applications, eg, in pumps, fans, and compressors, adding a VSD can typically reduce energy usage by 25 percent [10]. If the more than 300 million industrial electric motor-driven systems currently in operation would be replaced by optimized, high-efficiency equipment, global electricity consumption could be reduced by up to 10 percent [11] – a phenomenal reduction.

Recognizing this potential, the EU has introduced the Ecodesign Directive to mandate the use of energy efficient motors and drives within industries [12] to limit energy consumption and the impact on climate. In this way, motor effiiency will play a large role in the EU's aims to cut energy consumption by 32.5 percent by 2030.

Environmental value of end-of-life management
According to a World Bank report [13], a low carbon future will be mineral intensive due to an increased need to source more materials to enable clean energy technologies. Because the supply and availability of key minerals will probably be impacted, recycling could play an increased role in meeting this demand, thereby supplying the low-carbon transition. Recycling of motors and their components could contribute

03

04

—
02 Typical stages of a product's life cycle are shown based on the traditional approach and the circular economic approach. While eliminating waste and conserving resources are both key objectives, the primary resources of concern are materials and energy in the scenario evaluated.

02a Linear approach is shown.

02b Circular approach is shown.

—
03 Distribution of CO_2 footprint in a LV motor's 20 year life cycle. The results allow ABB to make data-driven decisions.

—
04 Materials such as metals used in motors and their components are designed, produced and used with a sustainable material flow in mind; this includes recycling and reutilization.

—
05 Environmental impact results of recycling metals corresponding to 10 tons of electric motors. The results are compared with water, energy use in a typical villa over time.

to material availability, reducing the need for virgin materials and massively reducing the environmental impact.

ABB estimated this potential using SimaPro to perform a detailed analysis of the environmental impact of recycling the metals in the motors

—
Recycling of motors could contribute to the demand for key minerals needed for the low-carbon transition.
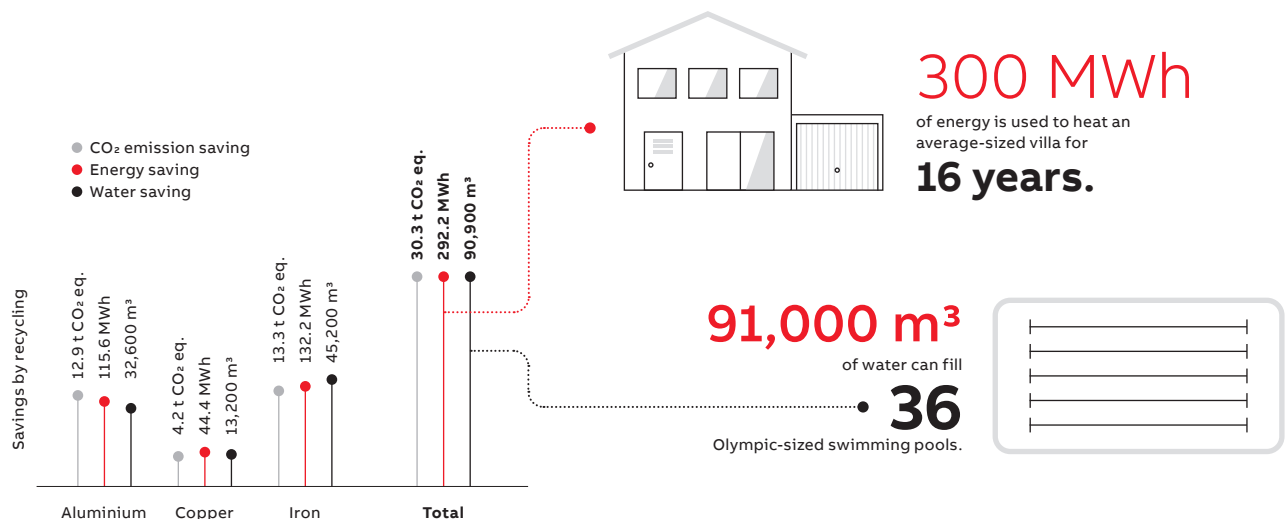
at the end-of-life →05. Practical scenarios were modeled utilizing realistic data associated with the recycling processes and transport. Recycling 10 tons of motors has the potential to save
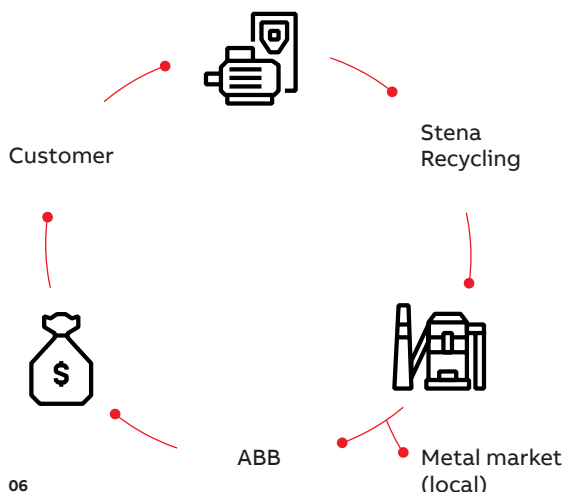
30 tons of CO_2 emissions, 300 MWh of energy and 91,000 m³ of water – a highly positive outcome →05. In comparison, approximately 300 MWh of energy is used to heat an average-sized villa for 16 years; 91,000 m³ of water can fill 36 Olympic-sized swimming pools →05.

Nonetheless, metals have another advantage – they can be continually and endlessly recycled and reutilized →04. Imagine the environmental benefits if a product's metals would always be recycled at the end-of-life. Recognizing this potential, ABB is keenly interested in the end-of-life management of electric motors and other products – circular material flows are the future.

Closing the motor loop through collaboration and digitalization
Because sustainability is inherently collaborative, encompassing planet, people and profit, an organization's sustainable growth is tied to the optimization of these three factors. However,

- ● CO_2 emission saving
- ● Energy saving
- ● Water saving

Savings by recycling

	Aluminium	Copper	Iron	Total
CO_2	12.9 t CO_2 eq.	4.2 t CO_2 eq.	13.3 t CO_2 eq.	30.3 t CO_2 eq.
Energy	115.6 MWh	44.4 MWh	132.2 MWh	292.2 MWh
Water	32,600 m³	13,200 m³	45,200 m³	90,900 m³

05

300 MWh
of energy is used to heat an average-sized villa for **16 years.**

91,000 m³
of water can fill **36**
Olympic-sized swimming pools.

Customer

Stena
Recycling

ABB

Metal market
(local)

06

thereby triggering appropriate decisions to optimize and improve energy efficiency. For example, ABB placed smart sensors for energy analysis on motors at SCA facilities in Munksund, Sweden, one of ABB's customers [14]. The smart sensors delivered information about the condition and active power on the motor shaft that was used. Data assessment makes it possible to

—

ABB and Stena Recycling offered customers the opportunity to recycle end-of-life and inefficient electric motors.

organizations cannot directly influence and control these parameters in isolation, there are other stakeholders in the value chain whose interests, interconnected and equally important, must be simultaneously optimized. Collaborations, alliances or partnerships form the foundations from which a greater impact and a successful sustainable transformation is achieved. By working together with all key stakeholders, a shared sustainability value can be created; one that is long-lasting, scalable, and transformative.

Encouraged by the positive environmental impact results of metal recycling, ABB pioneered a collaboration with the Swedish company Stena Recycling to offer customers the opportunity to recycle their old, end-of-life and inefficient electric motors (smaller LV- and larger HV variants) [14,15], sustainably →06. Beyond lowering emissions, this motor take-back and recycling business model prevents the risk of old, inefficient electric motors from landing in the second-hand market and impacting the environment adversely.

Optimized for the lowest environmental impact, the entire take-back and recycling process is sustainable by design; it considers the total weight of the to-be-recycled motors, distances to be covered, type of transport to be utilized and frequency of transport.

Bringing about sustainable transformation through collaboration can be further strengthened and accelerated through the digital transformation. With the Industrial Internet of Things (IIoT) revolution fully underway, data-driven decision-making can be used to minimize waste and enable a productive and sustainable future. Digitally enabled products, solutions and services can be used to capture real-time data to disclose the status of equipment and systems,

determine the active and reactive power used, annual active and reactive power consumption, and whether the motor is correctly dimensioned for the application as well as savings potential (kWh, € and kg CO_2) if the motor is replaced. So far, SCA Munksund has recycled 28 tons of motors with ABB's recycling circular model. Based on the assessment, eleven tons of motors were identified, replaced and transported to the Stena Recycling plant [14].

ABB's motor take-back and recycling business model is flexible. The scheme can be tailored to include relevant digital solutions, energy-efficient motor offerings, primarily to improve the sustainability value of the whole process. In fact, a combination of processes involving recycling inefficient motors and replacing these with new and more energy efficient motors – an "upcycling" initiative – lowers carbon emissions in both process steps – a winning solution for customers. There is also the opportunity for still greater

07
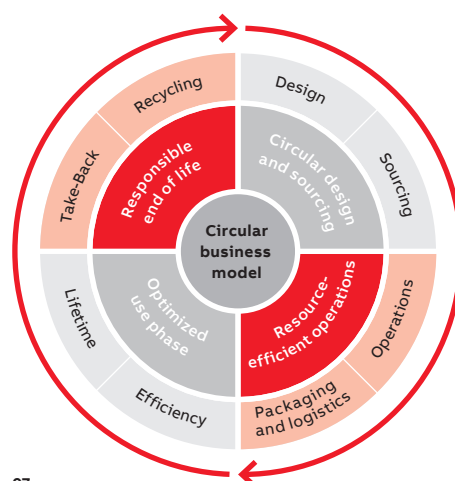
—
06 Motor take-back and recycling business model is depicted, which emphasizes the collaboration between ABB, Stena and the customer.

—
07 ABB's circular framework business model is shown, which highlights the importance of efficient operations and responsible end-of-life management.

sustainability benefits: ABB can, in specific cases, offer customers economic incitements based on the value of the recycled metals, such as a certificate of destruction and an environmental report together with Stena Recycling, when they purchase new products from ABB [15].

Making change happen with circularity
Decision-making for product sustainability must start with data and an understanding of the environmental impact associated with the entire-life cycle of the product, which in this case, is an electric motor. Depending on the carbon footprint at different phases of the life cycle, appropriate opportunities exist for sustainable improvements as assessed through LCA modeling and brainstorming →07. While the presented case is specific to a scenario in which the motor has an expected application life of 20 years; another scenario with a motor characterized by a shorter life, and hence different sustainability assessment results, would require other approaches to be adopted to minimize environmental impact.

By focusing on energy efficiency during the use-phase and a recycling business model at the end-of-life →06, ABB achieved the most positive environmental contribution possible. Looking ahead, more opportunities to further strengthen the motor's sustainability will certainly arise,

eg, utilizing better materials or other business models that allow the circular approach within a phase or multiple phases →07.
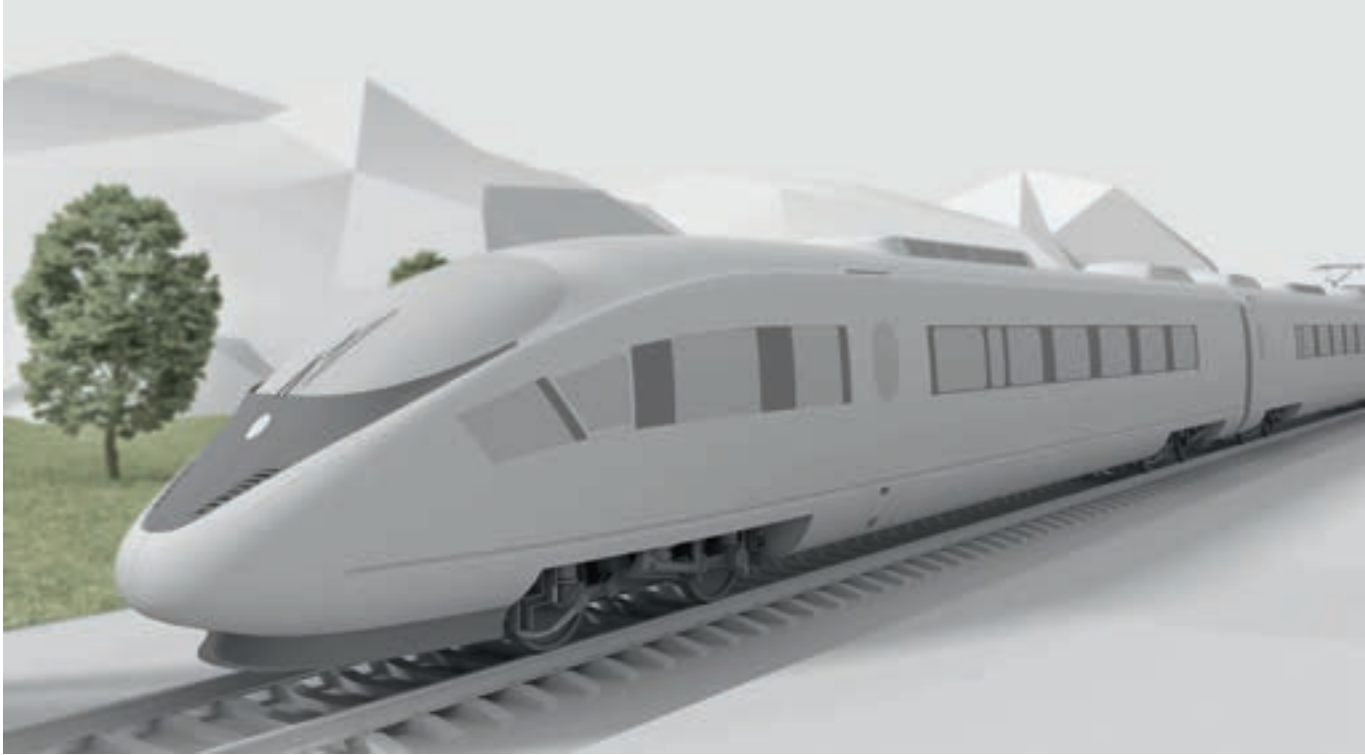
With increasing awareness and future technological developments, the vast opportunities to improve a product's sustainability can be daunting, and, yet the concept of "circular thinking" will remain at the core of product sustainability.

—
ABB's circular framework provides the opportunity to ponder the most appropriate circular approach to sustainability.

Adopting the right circular approach will be the key to the best sustainable solution. ABB's circular framework provides the opportunity to ponder the most appropriate circular approach for an existing- or future product. Ultimately, the responsibility lies with ABB to define how to create a circular future for their products and ABB is doing just that. •

—
References

[1] U.S. Energy Information Administration (EIA), "International Energy Outlook 2021", p. 12, Available: https://www.eia.gov/outlooks/ieo [Accessed November 24, 2022].

[2] C.U. Brunner and P. Waide, "Energy-Efficiency Policy Opportunities for Electric Motor-Driven Systems" *IEA- International Energy Agency*, 2011, pp. 1–128

[3] European commission, "Electric motors | European Commission", 2020.

[4] International Energy Agency, "Energy Policies of IEA Countries: Sweden 2019" *OECD (Energy Policies of IEA Countries)* , 2019, pp. 1–165.

[5] Ellen MacArthur Foundation, "Towards the Circular Economy", 2013, pp. 1–98.

[6] United Nations Environment Programme Life Cycle Initiative Website, [Online] Available: https://www.lifecycleinitiative.org/starting-life-cycle-thinking/what-is-life-cycle-thinking/ [Accessed September 8, 2022].

[7] ABB Website, The Energy Efficiency Movement, Available: https://www.energyefficiencymovement.com/en/ [Accessed: November 4, 2022].

[8] A. Guggisberg "Data is key to boosting industrial energy efficiency", *The Business Reporter*, Available: https://www.reuters.com/brandfeature/the-business-reporter/sustainability-hub/data-is-key-to-boosting-industrial-energy-efficiency [Accessed September 8, 2022].

[9] ABB webstory, "ABB IE5SynRM motors are awarded Efficient Solution label", 2020, Available: https://new.abb.com/news/detail/71053/abb-ie5-synrm-motors-are-awarded-efficient-solution-label [Accessed September 8, 2022].

[10] ABB white paper, "Reaching IE5 efficiency with magnet-free motors", 2021, pp. 1–9.

[11] Stefan Floeck, "Circularity: the new direction of choice", The Business Reporter Website, Available: https://www.reuters.com/brandfeature/the-business-reporter/sustainability-hub/circularity-the-new-direction-of-choice [Accessed: November 1, 2022].

[12] Website of the European Commission for Energy, climate change and the environment, Available: https://ec.europa.eu/info/energy-climate-change-environment/standards-tools-and-labels/products-labelling-rules-and-requirements/energy-label-and-ecodesign/energy-efficient-products/electric-motors_en [Accessed: September 8, 2022].

[13] K. Hund et al., "Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition", *The International Bank for Reconstruction and Development World Bank*, 2020, pp. 1–112.

[14] ABB Press release, "ABB's recycled motors provide significant environmental savings – reduced 34 tons of carbon dioxide emissions in pilot projects", 2021, Available: https://new.abb.com/news/sv/detail/80118/abbs-recycled-motors-provide-significant-environmental-savings-reduced-34-tons-of-carbon-dioxide-emissions-in-pilot-projects [Accessed September 8, 2022].

[15] ABB press release, Partnering Together for a Circular Economy: ABB Large Motors and Generators Sweden and Stena Recycling, May 10, 2022, Available: https://new.abb.com/news/detail/90905/partnering-together-for-a-circular-economy-abb-large-motors-and-generators-sweden-and-stena-recycling [Accessed September 8, 2022].

01

—

HIGH-PERFORMANCE LITHIUM-ION BATTERIES FOR ROLLING STOCK

BORDLINE® ESS

ABB's BORDLINE series onboard energy storage system (ESS) is a modular and versatile solution to decarbonize railway vehicles that helps to lower the total cost of ownership, improve safety and make operations more sustainable.

Senthilnathan Mariappan
ABB Motion, Traction
Untersiggenthal,
Switzerland

senthilnathan.
mariappan@ch.abb.com

Of all transport modes, rail is one of the most electrified and is a sustainable alternative to other transport modes, both in terms of energy use and carbon emissions per passenger-kilometer or ton-kilometer. In fact, trains are significantly more efficient than cars and trucks even when they are powered by fossil fuels. The rail business is also an exception in the transport sector in that it has consistently reduced its emissions while increasing passenger and freight volumes.

Nevertheless, the railway sector is striving toward further improvements in energy efficiency and lower carbon footprint so that it can maintain its environmental advantage and become the backbone of a sustainable, multimodal and safe transport system.

Further, the pace of electrification is too slow in many countries for various reasons. Therefore,

it is essential to find alternative solutions that either eliminate the need for fossil-fuel-powered rail vehicles or, at the very least, lower their carbon footprint, since complete electrification of the railway network is not always economically feasible. →01.

Alternative traction systems in railways
Alternative low-carbon traction systems with embedded onboard ESSs are becoming integral to the transition toward sustainable transportation solutions. The increasing adoption of these technologies across a broad spectrum of applications from light rail vehicles to heavy haul locomotives and infrastructure maintenance vehicles not only helps to decarbonize rail transport but also delivers other benefits, including lower total cost of ownership (TCO) when compared to incumbent combustion engine-based solutions.

02

03

—
01 Major investments
are being made to
decarbonize rail
transport.

—
02 BORDLINE high-
power battery module.

—
03 Single battery pack.

—
04 Roof-mounted
multi-battery pack.

Further, they help to improve the operational performance of the vehicle, provide more flexibility and lower capital investment in infrastructure.

Application diversity in railway applications
An onboard ESS can be used as the main energy source in battery electric vehicles and enable them to operate over non-electrified sections. In hybrid vehicles, the ESS works as a buffer storage and provides peak power that helps to reduce the installed power of the primary power source, be it the diesel engine or a fuel cell, and allows the recuperation of braking energy. Further, peak shaving helps to operate the primary power source more often at its maximum efficiency point and reduce fuel consumption.

In diesel-hybrid applications, the presence of an onboard ESS further helps to reduce harmful emissions when the vehicle is at a station by utilizing the energy stored in the batteries to feed auxiliary loads and accelerate the vehicle out of the station.

04

In vehicles operating with a DC catenary supply, the use of an ESS helps to maximize the recuperation of braking energy in networks with receptivity limitations, stabilize the line voltage due to peak shaving – which allows a network density increase without costly infrastructure upgrades – and reduce the rail-to-ground potential.

Meeting all these demands calls for robust and reliable traction batteries that can deliver the required performance with maximum safety and reliability over a long service life that can extend up to 15 years or more.

Characteristics necessary for rolling stock traction batteries
Performance requirements for rolling-stock traction batteries are more demanding than those of an electric car due to the operating environment, applied stress levels and utilization level. To put this in context, most electric cars are typically parked for around 95 percent of their lifetime and cover under 100,000 km in 10 years. In contrast, a typical commuter train has an operational life-

—

Performance requirements for rolling-stock traction batteries are more demanding than those of an electric car.

time of around 30 to 35 years, is in operation for 16 to 18 hours a day, 350 days a year and travels 1,000,000 km in under five years. These factors result in a cumulative stress on the battery that is around 20 times higher than that for an electric car battery. Furthermore, traction batteries must also offer a high level of inherent safety, provide high availability, avoid performance drop-off during hot or cold days, have a long lifetime and have high power capabilities (in both charge and discharge) over wide temperature and state-of-charge (SoC) ranges.

These considerations mean that the selection of rolling stock traction batteries must not be made exclusively using cost per kWh or specific energy as key performance indicators (KPIs). Instead, purchasing decisions must be based on the expected TCO over the vehicle's lifetime and place emphasis on selecting a battery that can operate reliably under harsh environmental conditions.

Modular high-performance batteries
To address these requirements, ABB has developed BORDLINE ESS – a high-performance Li-ion

battery based on ABB's deep technological knowledge and domain expertise honed over years of experience in the railway sector.

To ensure high quality and reliability, BORDLINE battery packs are based on modular hardware and software building blocks. This approach allows a high level of standardization at both the battery module and pack level without compromising the flexibility required to tailor solutions according to OEM needs and ensure a faster time to market →02-03.

At the core of each battery pack are modules equipped with high-power prismatic lithium-ion cells that incorporate a lithium titanium oxide (LTO) anode. Batteries with an LTO anode are an ideal choice for rolling-stock applications as they offer high inherent safety (such as tolerance to abuse), a long cycle life, fast charging capability, excellent lifetime (even at 35 °C) and good low-temperature performance. LTO batteries also allow operation over a wide SoC without power restriction.

The battery module features a patented liquid-cooling concept that helps to maximize battery performance and lifetime in even the most demanding applications. The cells are laser welded, a fusion process with less heat input to the cell. The process is precise, highly repeatable and ensures a very stable electrical connection with low contact resistance. Laser welding minimizes contact degradation over the cell lifetime due to the reduced risk of oxidation or corrosion between cell tabs and bus bars.

Benefits of standardized modular building blocks
ESSs based on standardized and modular building blocks offer several advantages, including:
- Scalability: The voltage and energy of the ESS can be easily set according to customer needs. This design approach results in a minimal set of modules that can cover many applications.
- Higher availability: Failure in one battery pack will not result in failure of the total system. The vehicle can continue operation after the faulty pack is isolated.
- Excellent safety: In the unlikely event of a thermal runaway, it is limited to and contained within a single sub-pack within the larger system. At the same time, the design and cell selection in BORDLINE ESS make a thermal runaway event very unlikely to start with.
- Faster service: Individual packs can be exchanged instead of having to dismount the entire system from the train.
- Flexibility: The battery system can be easily adapted to changing needs by increasing or reducing the number of packs, even in operating fleets.

- Versatility: The standardized system can be integrated flexibly and easily into the train – on the roof, underfloor, or in the machine room, with only adaptations to the mounting interfaces. →04.

Production and testing of modules
The battery modules are produced on a semi-automated production line in Baden, Switzerland that includes robots for pick and place →05, laser welding and quality checks. Burn-in test results and other relevant parameters are recorded and fed into a remote condition monitoring system to establish the basis for monitoring field performance.

Digital solutions enhance customer value
To further enhance customer value, ABB has developed a suite of remote service solutions that ensure optimal utilization of the ESS, offer an overview of the installed base and carry out a cross-fleet analysis. Analysis of field data

—
ABB has now introduced a high-performance lithium-ion-based onboard ESS called BORDLINE ESS.

provides valuable insights into the current health of the battery and can be used to identify and implement corrective actions or make informed decisions regarding optimization and safety. Remote access to field data also speeds up troubleshooting and implementation of corrective measures.

ABB has successfully delivered or is delivering high-performance traction batteries to more than 550 railway vehicles with references covering the entire range of railway applications. Two such examples are presented below.

Battery electric trains for northern Germany
ABB is working on an order for the Swiss rail vehicle manufacturer Stadler to deliver energy-efficient traction converters and ESSs for the operator Nahverkehrsverbund Schleswig-Holstein GmbH (NAH.SH) in northern Germany. ABB's traction components will be installed on 55 new bi-mode electric multiple units that will operate on a partially electrified network on which the longest unelectrified route is around 80 km →06. The use of high-performance batteries ensures that the vehicle has the same performance in both electric and battery mode.

05

—
05 Pick-and-place of
battery cells using an
ABB robot.

—
06 BORDLINE will be
installed in 55 new
Stadler trains.

06

Bi-mode hybrid trains for Trenitalia
ABB is delivering BORDLINE ESS and DC-DC converters to Hitachi Rail's Masaccio Hybrid Bi-Mode Multiple Units being delivered to Trenitalia. The ESSs for the 70 trains are primarily intended for

—

With BORDLINE, the need for high-performance, long-life and safe traction batteries is no longer an Achilles heel.

storing the energy regenerated during braking while operating in diesel mode. The stored energy will be re-used to provide motive power support to the vehicle during the acceleration phase and to feed onboard auxiliary loads at specified station stops, thereby removing the need to operate the diesel engine and thus reduce local emissions.

Accelerating the transition to a low-carbon future
Globally, the railway industry is working to improve energy efficiency and meet emissions targets that will further strengthen its position as the most efficient and environmentally friendly mode of transport. The technologies required to deliver significant improvements are not only available but also proven. Furthermore, with BORDLINE, the need for high-performance, long-life and safe traction batteries is no longer an Achilles heel for the rolling stock industry. •

SYNCHRONOUS CONDENSERS PROVIDE INERTIA
FOR GRID STABILIZATION

Grid support

As renewable energy sources proliferate, the number of high-inertia generators – ie, fossil-fuel plants – decreases, both in unit numbers and as a share of the total power capacity. ABB's grid synchronous condensers can replace lost inertia and stabilize grid frequency and voltage.

Carl Nilsson
ABB Large Motors &
Generators Division
Stockholm, Sweden

carl.nilsson@se.abb.com

The electrical power landscape is predicted to change more in the next 10 years than it has in the last 100 [1]. This shift is primarily due to the move from large, stable, centralized fossil-fuel power stations that supply consumers with electricity via transmission and distribution net-

—

Reducing spinning inertia can disrupt more than production: Inertia is also vital for compensating sudden grid changes.

works toward a topology that features increasing numbers of widely distributed renewable energy resources →01. This evolution has the double impact of adding volatile supply sources while removing traditional high-inertia generators such as oil- and coal-fired power stations.

The removal of high-inertia generators has serious implications as replacing these stable, predictable and controllable energy sources with an increasing number of fluctuating renewable sources means energy supply and price cannot be taken for granted anymore. Most renewable energy sources – such as wind and solar – are non-controllable and have availability that depends on weather conditions. This

unpredictability impacts the price of electricity and has made tools for planning the purchase and use of electricity a necessity for large consumers.

Moreover, because energy must always be available exactly at the time of consumption and energy storage technologies are still relatively costly, large consumers are expected to help by implementing demand-side management – ie, by shaping their grid loading schedule to fit energy availability and price profiles. However, such forward planning may not always be possible and adaption must then be done on the fly, which can impact production stability and quality or, in some cases, lead to process shutdown.

The dramatic reduction in the amount of spinning inertia, also known as kinetic reserve, in the grid can have an effect even more severe than production disruption: Inertia is vital for compensating sudden changes in the grid – such as when a generator trips and goes offline – to ensure grid frequency remains within tightly

—

Inertia helps compensate for sudden grid changes and ensures grid frequency remains tightly controlled.

controlled limits (reduced frequency can cause other equipment, such as power electronics, to trip, possibly resulting in a blackout). Grid inertial capacity is like a car's shock absorbers smoothing out a sudden bump in the road to keep it
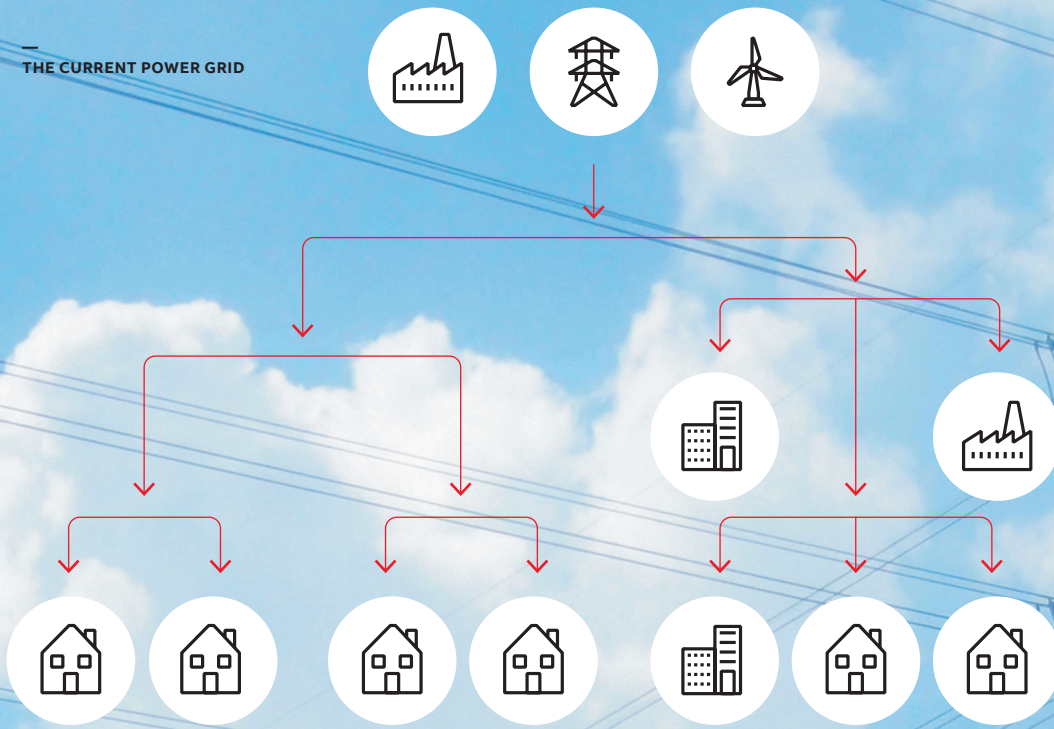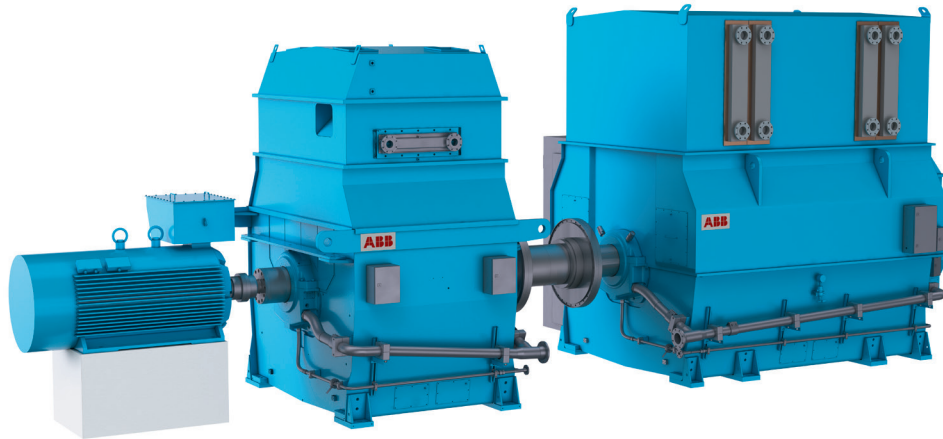
02

—
01 As more renewable
energy sources come
online, power grid
topology evolves
from a pyramid to an
interconnected net.

—
02 The ABB synchro-
nous condenser.

safely straight and level. Power grids rely on their
inertia reserves to keep them in balance.

How can a power grid's inertia be maintained in
the face of the removal of high-inertia generators
in fossil plants? The answer lies with synchro-
nous condensers.

**Synchronous condensers deliver vital inertia for
grid stability**
A synchronous condenser is a large rotating
device that stores physical inertia to deliver
instantaneous support for grids, enabling them
to maintain stability irrespective of the upstream
network voltage or frequency →**02-03**.

In essence, a synchronous condenser is a motor
without an active load, or a generator without a
prime mover. Apart from the pony motor used for
starting and the possible addition of a flywheel,
there would be no need for any shaft ends to
protrude from the synchronous condenser

Fifty or more years ago, synchronous condensers
were used widely in the power industry, but are
now much less common. The reason for their
decline is that their former primary function
– reactive power compensation – is now handled
by a diversity of other solutions.

Physical inertia from a rotating synchronous
condenser delivers exactly the amount of inertia
needed to counteract any frequency variation,
purely electromechanically, without the need for
the control system and algorithms required by
other methods of stabilization.

However, a synchronous condenser's capabilities
are not confined to reactive power compensa-
tion. In other words, grid stabilization is often
about more than simply injecting or absorbing
reactive power and a synchronous condenser can
provide this extra performance.

Adding a flywheel
When additional inertia is needed in a system,
additional synchronous condensers can be
added to the configuration. A more effective
and economical approach is to include a
flywheel in the synchronous condenser design.

—

The synchronous condenser
delivers exactly the inertia
needed to counteract any
frequency variation.

Combining a mid-size synchronous condenser
and a flywheel has the advantage of multiplying
the available inertia several times. Moreover,
this measure improves the potential to reduce
losses compared to fulfilling the inertia
requirement by installing a larger synchronous
condenser.

In an arrangement where two mid-sized synchro-
nous condensers are connected via a three-wind-
ing transformer, the utilization of flywheels
provides a cost-effective way not only to increase

the available inertia by a significant amount but also to deliver a higher level of redundancy, lower maintenance demands and offer greater controllability.

Safety enclosure
A large rotating synchronous condenser contains a considerable amount of stored energy. Therefore, it is vital that the installation is designed

—

ABB has upgraded its synchronous condenser flywheel with a patent-pending integrated safety device.

with the highest levels of safety in mind and that potential risks are handled correctly. Risks are usually defined as the product of probability and consequence and therefore, ABB's synchronous condenser flywheel design seeks to minimize

these two aspects. The probability of an adverse event is reduced by safe design, extensive testing and well-proven materials. Potential consequences are handled as a secondary safety function by providing reliable protection devices.

For efficient planning, commissioning and operation purposes, ABB has chosen to upgrade its synchronous condenser flywheel with a patent-pending integrated safety device rather than relying on external protective functions. The device encloses the flywheel and is dimensioned in a way similar to that of the stator that encloses the rotor in an electrical machine.

Grid support in the field
Two ABB synchronous condensers have been installed as an integral part of the Darlington Point 275 MW (AC), 333 MW (DC) solar farm in New South Wales, Australia – currently the largest solar farm connected to Australia's grid. The technology will enhance the stability of the local power grid as the penetration of renewable energy increases in this area of the country →**04-05**.
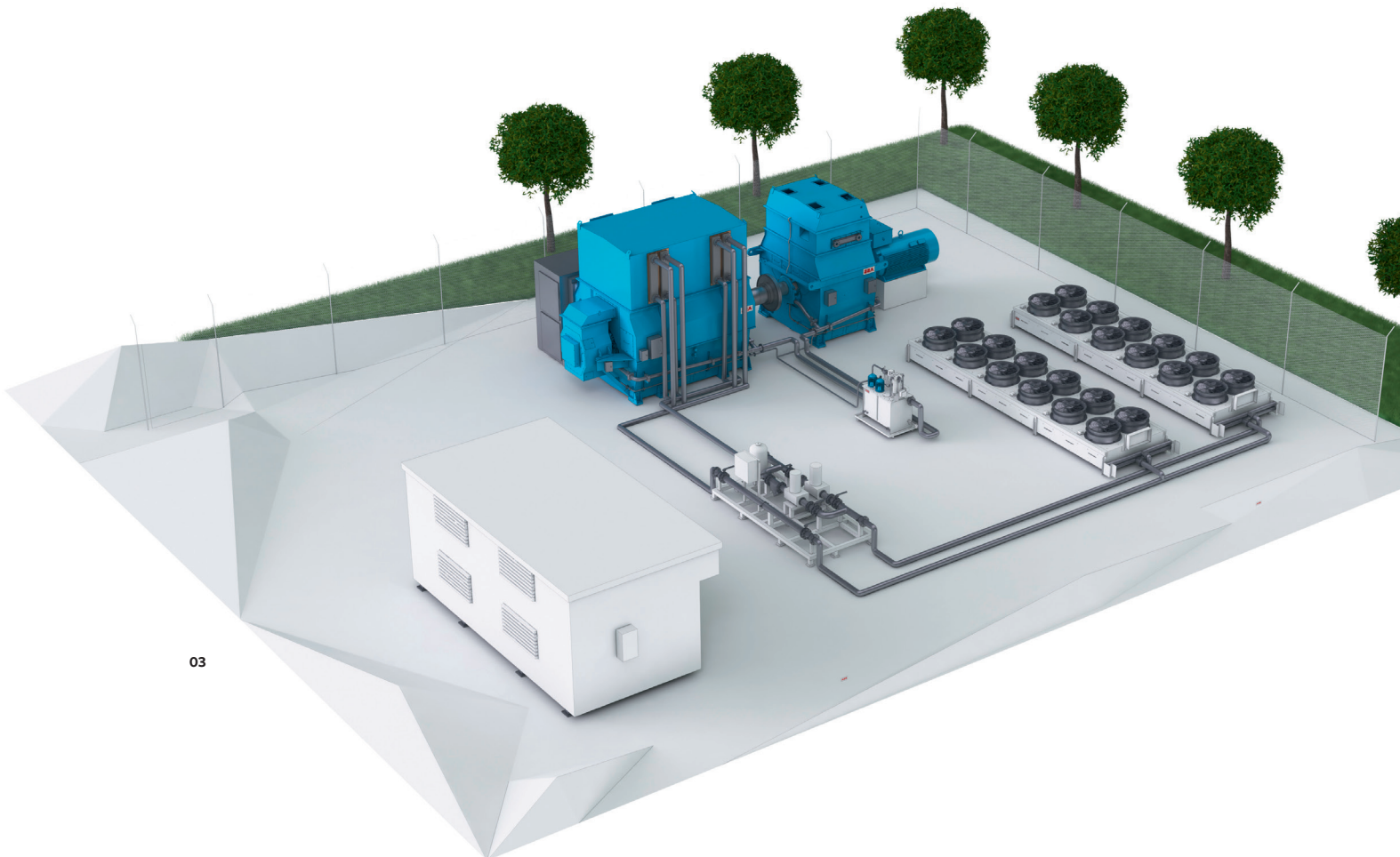
04

—
03 Typical synchronous condenser setup.

—
04 The two ABB synchronous condensers at the Darlington Point solar farm.

—
05 Aerial view of the two ABB synchronous condensers at Darlington Point in relation to the associated electrical equipment.

05

—
References

[1] World Economic Forum, with analytical support from McKinsey & Company, "Fostering Effective Energy Transition A Fact-Based Framework to Support Decision-Making." Available: http://www3. weforum.org/docs/ WEF_Fostering_Effective_Energy_Transition_report_2018.pdf. [Accessed September 9, 2022].

Spinning into the future
The networks of the future will require decentralized solutions to maintain grid stability and resilience. Synchronous condensers are

—
It is anticipated that the need for synchronous condensers will continue to grow.

a well-proven solution that can be activated almost instantaneously to strengthen weak or compromised networks, even in remote areas. The devices offer a number of advantages, such as inertial support for frequency stability, voltage

regulation and short-circuit current contribution to help resolve faults. These are all functions that can be demanding to provide using power electronic systems on their own.

It is anticipated that the need for synchronous condensers will continue to grow as grid operators seek new approaches to address network quality issues and ensure reliability and continuity of supply. As well as entirely new systems, rotating equipment from decommissioned fossil fuel plants can also be harnessed to provide a reserve of inertia for grid stabilization. Over the next decade, it is expected that several hundred new synchronous condensers will be deployed, either on their own or in combination with static power electronic devices. •

SOLID-STATE PROTECTION FOR DC DISTRIBUTION ONBOARD

Breaking ground

The benefits of DC distribution drive its evolution onboard. Hence, a clear understanding of optimal protection against possible electric faults is crucial. ABB created SACE Infinitus solid state circuit breaker to guarantee protection, safety and service continuity.

01

Traditional AC system   **DC grid onboard**

02
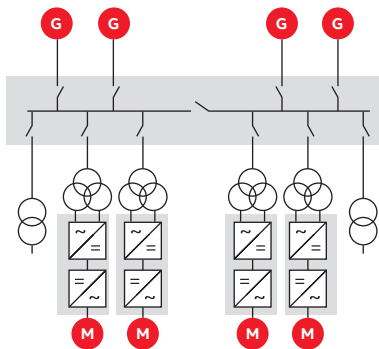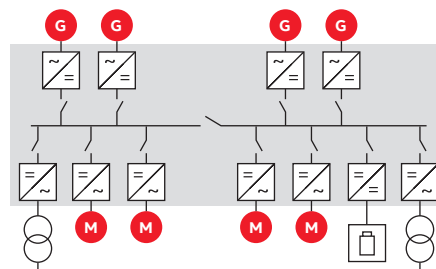
The driving factors behind DC evolution are:
- ~80% of consumers with frequency converters
- Energy storage is largely DC-based
- AC forces synchronization
- Multi-winding transformers to feed multi-phase converters

—
01 DC distribution grid systems are gaining in popularity onboard; this is demonstrated by the innovative light-weight and compact system that ABB supplied to this hybrid ferry navigating a Norwegian fjord in order to control and manage energy flow.

—
02 The driving factors behind the DC Distribution evolution onboard are shown.

With the shipping industry seeking to enhance flexibility and energy efficiency to reach sustainability and performance targets, ever more conventional energy production and distribution systems are being replaced by hybrid- or fully electric energy production and distribution architectures, especially in small- and medium-sized vessels and ferries. While electric systems rely

—
DC energy distribution onboard is rapidly becoming the system of choice outpacing AC distribution systems.

on motors powered solely by efficient, high-performance batteries, hybrid systems maintain a combination of battery storage systems and fuel generator sets (gensets) to power motors. This increasingly electrified world favors the use of DC energy distribution onboard; it is rapidly becoming the system of choice, outpacing traditional AC distribution systems.

Marco Carminati
ABB Electrification
Bergamo, Italy

marco.carminati@
it.abb.com

DC distribution has many benefits, however it does come with its unique challenges: power electronic converter protection, capacitor discharge current detection and interruption, selectivity among interruptive devices and isolation of the faulty zone. ABB has conducted an in-depth examination to understand these challenges and develop an optimized solution.

The result is a blueprint for a revolutionary all-in-one-circuit breaker based on an optimized

solid-state technology for switching electric current that overcomes all inherent challenges to enable safe and efficient DC distribution onboard.

Toward DC distribution
Many salient factors drive the DC distribution evolution onboard nowadays →**02**:
- Hybrid- and fully electric configurations rely on energy storage systems, eg, batteries that are largely DC-based.
- Most loads require frequency converters, eg, motor supply in which speed is controlled by varying frequency and voltage →**02**. Typically, frequency converters utilize a double conversion process – use of DC distribution eliminates one of these two conversion stages.
- For AC distribution, multi-phase converters require a supply voltage with a different phase displacement (provided by multi-winding transformers).
- AC distribution forces synchronization (matching frequency, etc.) eg, for generators prior to connection in parallel to the main Bus; and for two sources prior to parallel connection, if a bus-tie must be closed.
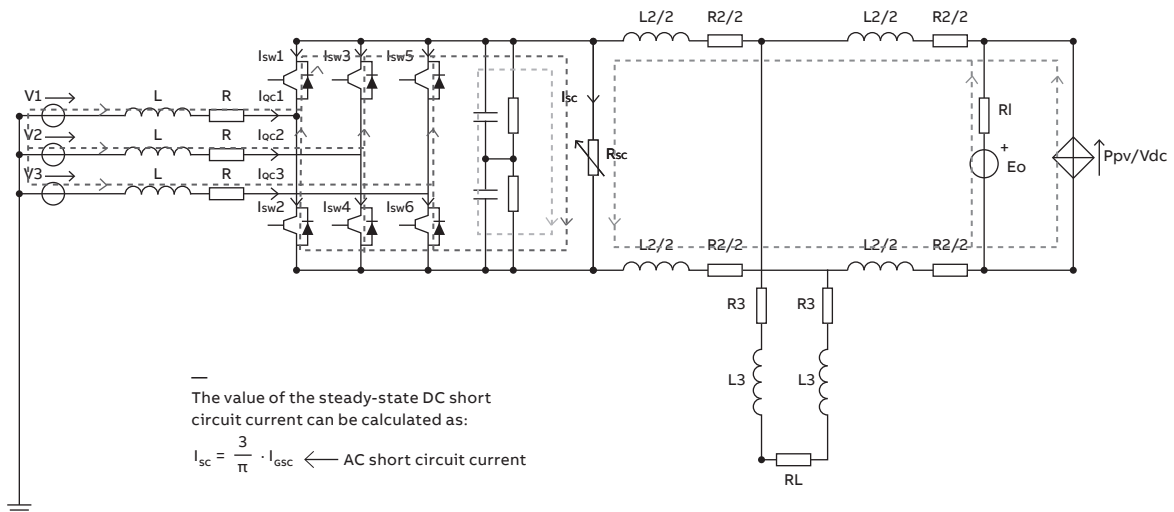
Protection is paramount
DC evolution requires advanced protection, whereas for AC distribution systems protection is a snap: The ability to leverage the AC natural zero crossing enables current interruption during normal operating and fault conditions with ease. In contrast, DC interruption is complex during normal operation and during faults. Without the current natural zero crossing, DC current must be forced to zero, eg, by installing circuit breaker poles in series to create a higher arc voltage.
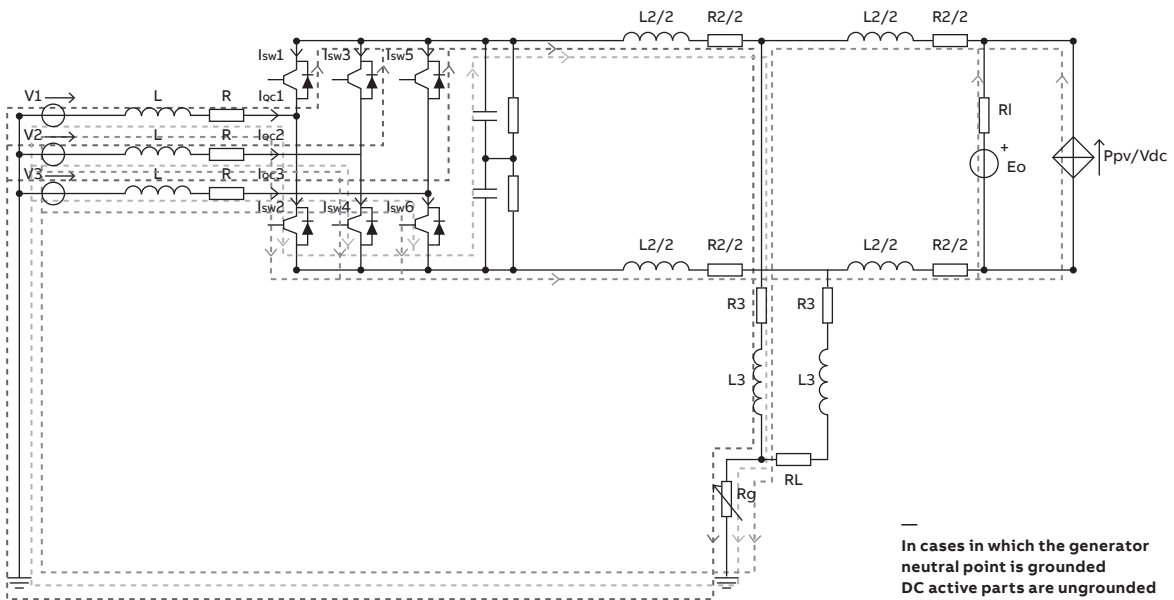
The value of the steady-state DC short circuit current can be calculated as:

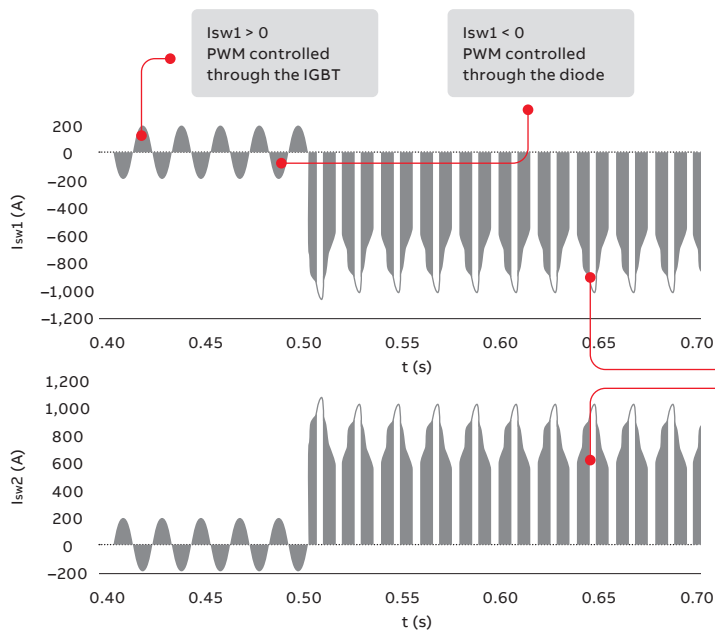$$I_{sc} = \frac{3}{\pi} \cdot I_{GSC} \longleftarrow \text{AC short circuit current}$$

03

In cases in which the generator neutral point is grounded DC active parts are ungrounded and exposed conductive parts are grounded:

- DC sources feed the fault through the lower IGBTs
- Genset contribution passes through upper freewheeling diodes

Isw1 > 0
PWM controlled through the IGBT

Isw1 < 0
PWM controlled through the diode

No PWM control due to overmodulation

04

Because AC has been a market standard for so many years, the protection system is well developed and readily available commercially. DC distribution onboard is, by comparison, relatively new and is yet to have the same wide variety of market options available. In addition, chronoamperometric protection selectivity among several protective devices is problematic for DC distribution systems; circuit breakers with electronic trip units would resolve this challenge, yet, few such devices exist for DC distribution.

The trouble with AC distribution
Despite inherent benefits, AC distribution has significant drawbacks: Characteristically, lower power transmission capability result from higher power losses, especially in the presence of a low power factor; this is a major disadvantage of AC distribution. And, with engines operating at a fixed speed because generators have to produce electric energy at a fixed frequency, reduced engine efficiency results. Further, power quality

—
03 For a DC short circuit, the AC/DC converter reaction is depicted.

—
04 A diagram showing the DC ground fault AC/DC converter reaction for cases in which the generator neutral point is grounded, DC active parts are ungrounded and exposed conductive parts are grounded.

—
05 Shown is the DC short circuit and ground fault AC/DC converter reaction in considering of the converter protection effect (DESAT) in various cases.

issues are possible due to increased harmonics; the reactive power flow through the whole distribution system must also be managed.

DC distribution wins out
Greater simplicity and higher efficiency highlight DC distribution with easy connection to power sources, eg, battery storage systems, generators; batteries can be directly connected to the main DC bus, or through DC/DC converters; synchronization is unnecessary because generators

—
DC distribution has its intrinsic challenges: ABB conducted an in-depth examination of these to develop optimal solutions.

are connected to the main DC bus by an AC/DC converter via an Insulated Gate Bipolar Transistor (IGBT). Variable frequency generators can be used, which results in fuel savings – the prime mover can work at maximum efficiency. Space is saved too, thanks to the lower volume/weight of high frequency generators and the need for fewer system parts. And, fewer circulating harmonics mean less harmonic issues and better electromagnetic compatibility. Managing reactive power flow is unnecessary. Lower power losses result because a conversion stage to feed variable frequency loads is avoided. These benefits strongly boost the argument in favor of DC distribution.

DC short circuit analysis
With simplicity and efficiency in focus, DC distribution is expedient – as long as protection is suitably handled. Enter ABB to establish a new baseline for DC protection. First, various fault types were evaluated, eg, short circuit and ground fault. ABB analyzed a short circuit on the main DC-bus; the short circuit can be represented by its fault resistance (for short circuit on a feeder too) →**03**; relevant fault contributions have been considered: DC sources, eg, batteries; DC capacitor discharge, onboard AC generators and AC/DC non-isolated IGBT-based converter →**03**.

Considering the worst case scenario – a bolted short circuit, it follows that:
- The DC capacitor discharge fault contribution can be high (up to hundreds of kA) also according to cable/busbar impedance among the capacitors and fault location (discharge current peak possibly reached < 1ms).
- Fault contribution from batteries can be high, especially for Li Ion-type batteries, in

—
In cases in which the generator neutral point is grounded DC active parts are ungrounded and exposed conductive parts are grounded:

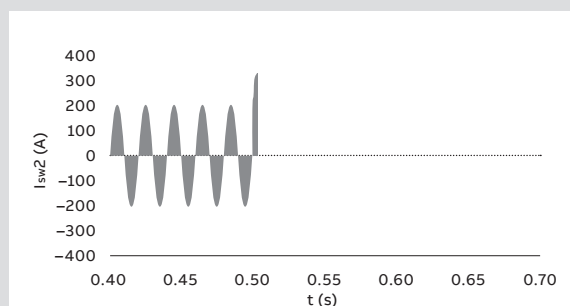IGBT embedded protection for DC short circuit is:
- ineffective because the front end converter works like diode rectifier.
- not able to limit neither genset contribution nor DC sources contribution because it does not pass through the converter
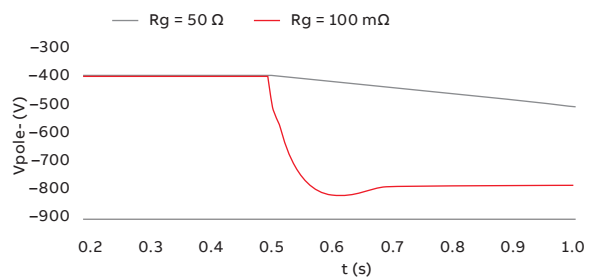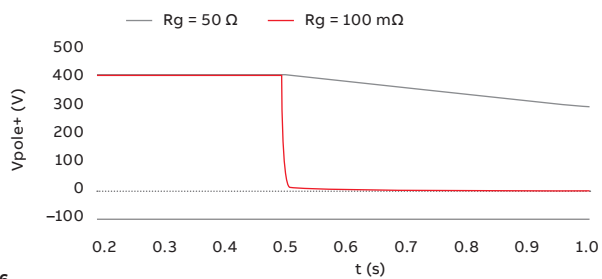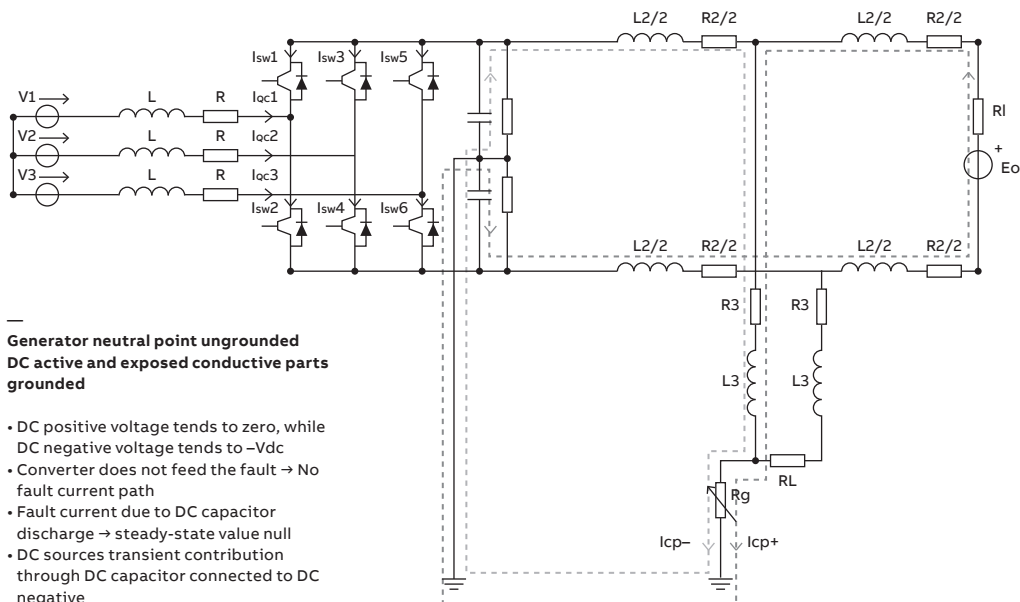
IGBT embedded protection for DC ground fault means that:
- since DC sources contribution flows only in the IGBT, the fault is interrupted
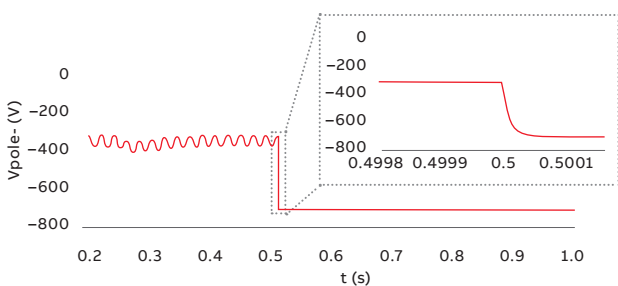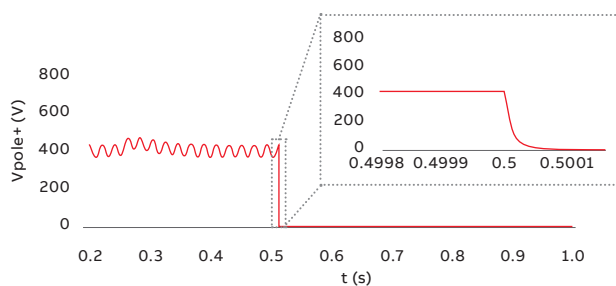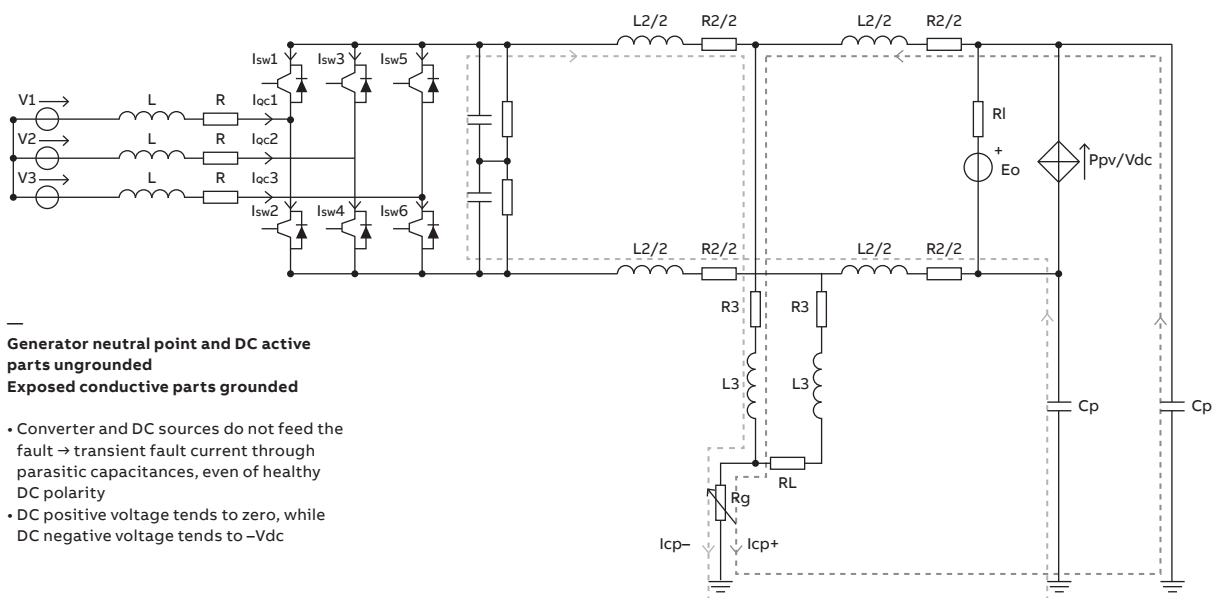- the ground fault current still remains high due to genset contribution

—
In cases in which the generator neutral point is ungrounded DC active- and exposed conductive parts are grounded:

- a ground fault is equivalent to a DC short circuit in negative grounded systems

05

**Generator neutral point ungrounded
DC active and exposed conductive parts
grounded**

- DC positive voltage tends to zero, while DC negative voltage tends to –Vdc
- Converter does not feed the fault → No fault current path
- Fault current due to DC capacitor discharge → steady-state value null
- DC sources transient contribution through DC capacitor connected to DC negative

06

**Generator neutral point and DC active
parts ungrounded
Exposed conductive parts grounded**

- Converter and DC sources do not feed the fault → transient fault current through parasitic capacitances, even of healthy DC polarity
- DC positive voltage tends to zero, while DC negative voltage tends to –Vdc

07

accordance with the total rated power of the battery system.
- The non-isolated converter cannot limit or interrupt the short circuit current because the current will flow through the freewheeling diodes.
- From the formula given in →03, it follows that the steady-state DC short circuit at the DC converter's terminals is practically equal to a prospective short-circuit current at the AC converter terminals.
- The higher the number of AC generators in parallel on the DC-bus, the higher the total DC short circuit contribution provided that passes through the converters.

If non-isolated mono- or bidirectional step-up converters (DC bus voltage is higher than DC sources voltage) are installed, they will usually be unable to limit or interrupt the DC source's fault contribution since the current will flow through the freewheeling diode.Thus, suitable protective devices are required to detect and interrupt the large fault contributions, especially from batteries and the DC capacitor; as well as to protect the converters.

DC ground fault analysis
If the generator neutral point is directly grounded or grounded by a low resistance, the DC active parts are ungrounded while exposed conductive parts are grounded to detect and interrupt a ground fault, even if no one touches the faulty exposed conductive part.

Exposed conductive parts can be grounded using TT or TN systems. In TT systems active parts are grounded, exposed conductive parts are connected to a separated grounding system. Whereas in TN systems: active parts are grounded, exposed conductive parts are connected to the same

—
ABB has designed SACE Infinitus to provide safe, consistent and efficient protection for DC distribution onboard.

grounding system. In TT systems, no reclosing path exists for any possible current contribution to the fault by the DC sources; they only feed the load; whereas converters feed the load and ground fault. Contrastingly, in a TN system, a reclosing path exists for the fault current contribution of the DC sources; they feed the load and the

ground fault; whereas converters feed only the fault, DC sources feed the fault through the lower IGBTs, while the generators' contribution passes through the upper freewheeling diodes →04.

With IGBT embedded protection, the IGBT can be opened automatically whenever the current that is passing through increases above a specific limit →04. Hence, considering the DC ground fault with a TN system it follows that:
- Since the DC sources' contribution flows only in the lower converter IGBTs, such a contribution can be limited and interrupted thanks to the embedded IGBT protection →05.
- The ground fault current remains high due to the generators' contribution, which flows through the converter upper freewheeling diodes.

Therefore, suitable protective devices will still be necessary to interrupt the fault contribution provided by the generators, and to protect the converters by a very high interruptive speed.

If the generator neutral point is ungrounded or grounded by a high resistance, the DC active parts and exposed conductive parts are grounded, a ground fault on the positive polarity is equivalent to a DC short circuit from the fault contributions and converter behavior standpoint. Thus, the considerations for the DC short circuit event are also valid for the DC ground fault condition →05.

If the generator neutral point is ungrounded or grounded by a high resistance, the DC midpoint and exposed conductive parts are grounded – during a ground fault:
- DC faulty polarity toward ground voltage tends to zero, while DC healthy polarity toward ground voltage tends to minus the rated DC voltage.
- The AC/DC converter does not feed the fault because there is no fault current path.
- High transient DC capacitor discharge contribution exists, but the steady-state value is zero.
- DC sources' transient contribution through the DC capacitor is connected to healthy polarity.

Nonetheless, the increase of the healthy polarity to ground voltage may create isolation issues. Suitable protective devices are required to detect and interrupt the high DC capacitor discharge current.

Considering that the generator neutral point and DC active parts are ungrounded or grounded by a high resistance and exposed conductive parts are

—
08 The solid state circuit breaker internal core architecture and SACE Infinitus unit are shown.

08a SACE Infinitus, shown here, is the all-in-one device that provides DC power protection and control.

08b The SACE Infinitus solid state circuit breaker internal core architecture.

08c The SACE Infinitus internal core architecture in the back-to-back configuration.
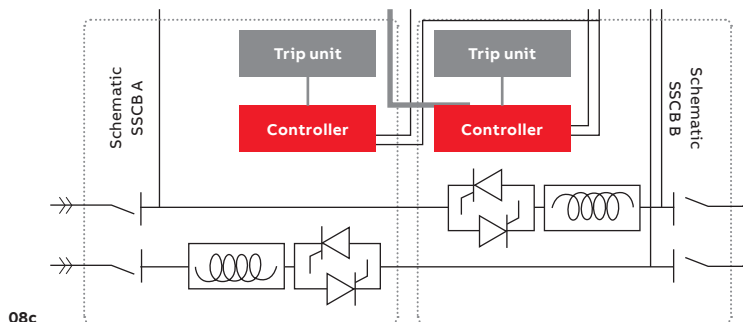
—
09 With SACE Infinitus such hybrid ferries will be able to navigate Norwegian fjords and beyond, sustainably and safely because it will now be simpler to integrate, protect and control the new DC network architectures.

08a
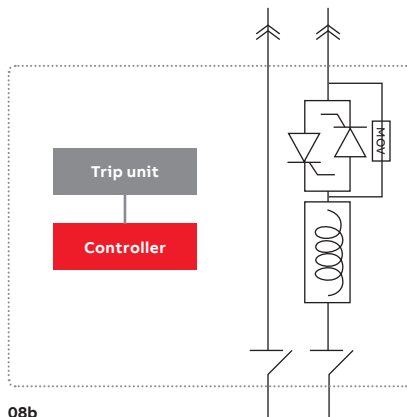
08b

08c

and analyses, ABB has designed SACE Infinitus →**08a**, the new circuit breaker with RB-IGCT, a semiconductor technology optimized for a solid-state circuit breaker application capable of reducing losses by up to 70 percent compared to previous technology →**08b**. SACE Infinitus provides safe, consistent and efficient protection for DC distribution onboard [1], also in the back-to-back configuration for the bus tie circuit breaker application →**08c**.

SACE Infinitus has 1 kVDC rated voltage, 2,500 A frame size and is capable of detecting and isolating the faulty zone completely and safely; clearing the fault rapidly, reducing the negative effects in the faulty area through limitation of the short circuit; and maintaining supply in the non-faulty area. It will also reconfigure the system rapidly to allow the quick resupply of the

—
ABB developed SACE Infinitus to fulfill all requirements and be fully compliant with IEC 60947-2.

critical loads.Unlike other breakers, SACE infinitus does not cause efficiency or power losses, and it works well in closed bus-tie configurations. Significantly, the circuit breaker integrates fully with other protection system components and control/management systems. Further, SACE Infinitus is the world's first solid state circuit breaker to be fully compliant with the strict IEC 60947-2 certification requirements.

With SACE Infinitus, ABB provides marine vessels with a new means to control, protect, and integrate DC network architectures. Providing service continuity and safety in one integrated package with the lowest cost of ownership, this revolutionary solid state circuit breaker is thus helping the shipping industry become more sustainable and energy efficient →**09**. •

grounded – during a ground fault →**06,** it follows that:
• The AC/DC converters and DC sources do not feed the fault →**07**.
• There is a transient fault current through parasitic capacitances, even when DC polarity is healthy.
• As previously stated, DC faulty polarity toward ground voltage tends to zero, while DC healthy polarity toward ground voltage can vary from half the rated DC voltage value to the whole rated value →**07**.

—
Reference

[1] A. Antoniazzi, et al., "One of a kind", *ABB Review* 4/2022, pp. 14–19.

Overcoming complex challenges
Based on ABB's findings, complete fault protection in demanding onboard applications is needed. By combining this knowledge with ideas

OPC UA

OPC stands for Open Platform Communications and is one of the most important communication standards for Industry 4.0 and the IIoT.

Michelle Kiener
ABB Review
Zürich, Switzerland

michelle.kiener@
ch.abb.com

With OPC, access to machines, devices and other systems in the industrial environment is standardized and enables similar and manufacturer-independent data exchange in the industrial automation domain and other industries. The specifications provide separate definitions for accessing process data, alarms and historical data:

- **OPC Data Access (OPC DA)** defines the exchange of data including values, time and quality information.
- **OPC Alarms & Events (OPC AE)** defines the exchange of alarm and event type message information, as well as variable states and state management.
- **OPC Historical Data Access (OPC DA)** defines query methods and analytics that may be applied to historical, time-stamped data.

The OPC Foundation is the organization behind the standard and counts ABB among its 850 plus members. Founded in 1994, the first version of the OPC standard was released in 1996. Membership of the foundation is not required for the use of OPC UA technology.

01

UA Unified Architecture
The UA in OPC UA stands for Unified Architecture and refers to the latest specification of the standard which was released in 2008. Although OPC UA is functionally equivalent to its predecessor, now called OPC Classic, it enhances and surpasses its capabilities by being a platform-independent service-oriented architecture [1] which has moved away from COM/DCOM to purely binary TCP/IP or alternatively Simple Object Access Protocol (SOAP). OPC UA
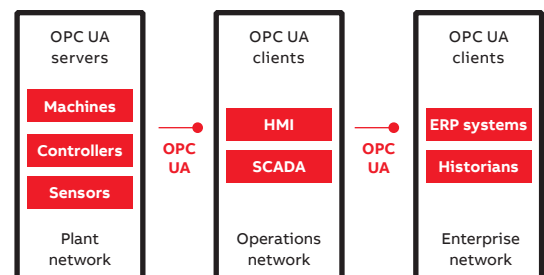
—

The UA in OPC UA stands for Unified Architecture and refers to the latest specification of the standard.

integrates all the functionality of the classic OPC specifications into one extensible framework. Integration between OPC UA products and OPC

—
References

[1] OPC Technologies Unified Architecture. Available: https://opcfoundation.org/about/opc-technologies/opc-ua/ [Accessed November 15, 2022].

—
01 Connectivity islands
linked by OPC UA.

Classic products can be accomplished with COM/ Proxy wrappers that are available from the OPC Foundation.

In addition to many other improvements, OPC UA supports semantic data description and was developed to be "firewall-friendly" ie, it can be managed and steered using standard network techniques. 128 or 256 bit encryptions are used to secure data during transmission, as well as certificate exchange, sequenced packets and message signing, amongst other techniques.

The multi-layered architecture of OPC UA is intended to provide a "future proof" framework, capable of incorporating, for example, new security algorithms or transport protocols, whilst also maintaining backwards compatibility.

Within organizations one will always find islands of data and they don't necessarily share information between them easily. OPC UA overcomes this and makes it very easy to move data between enterprise systems and monitoring devices and

—

OPC UA makes it very easy to move data between system, device and sensor "islands".

sensors that interact with real world data →01. One of the key features of OPC UA is that it can be supported on a wide range of components from low end sensors and tiny embedded controllers to high end servers, making it an important and useful standard that can be widely applied to connect and share between the data islands. ●

Next edition
02/2023
Enhanced knowledge

Welcome to a world of innovators.

The more people who are empowered
to write the future, the better it will be.
See why at **go.abb/progress**

ABB