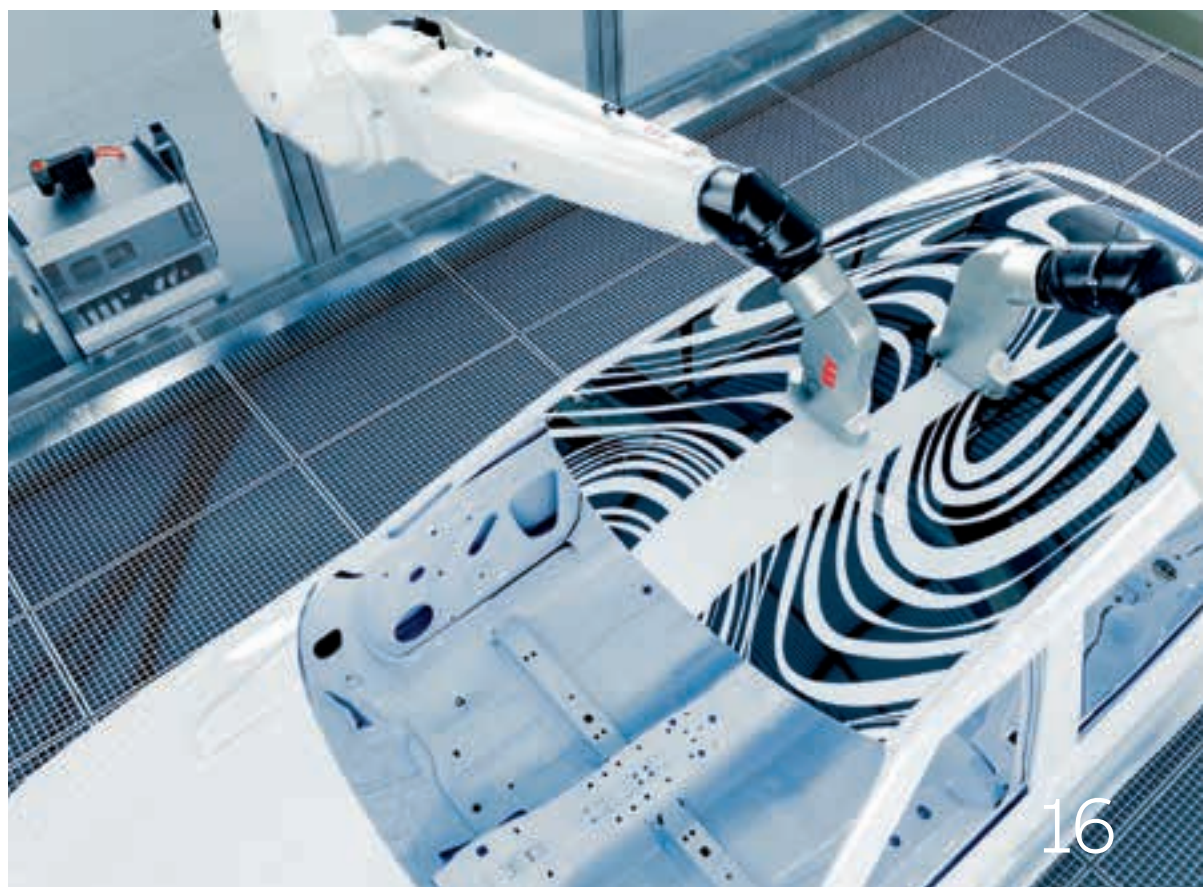


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Inspired by technology

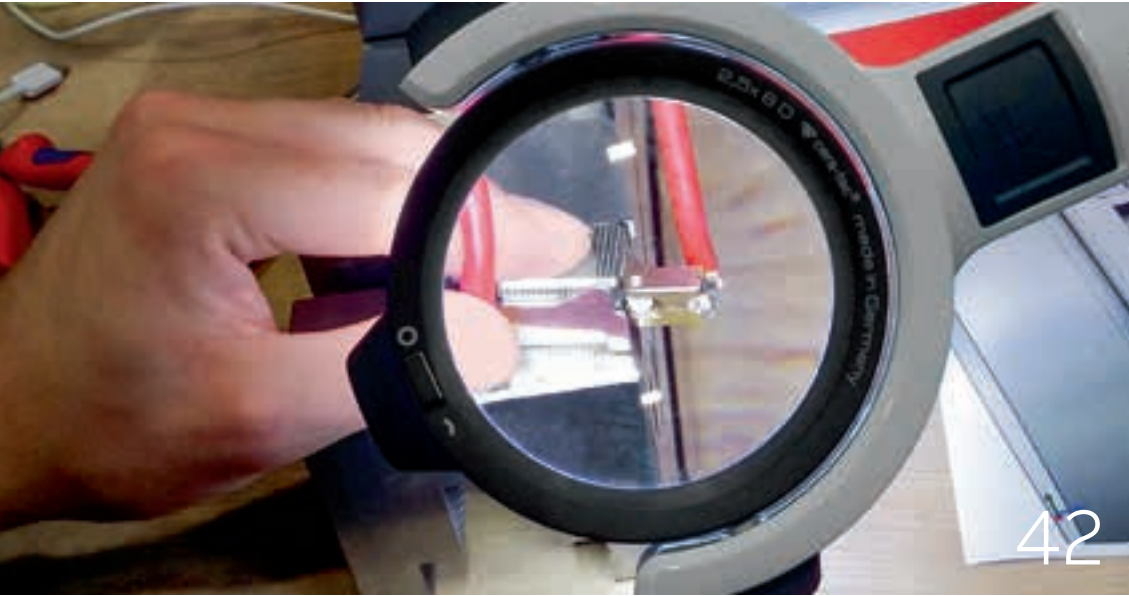


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Shaping the future



Beyond emissions monitoring

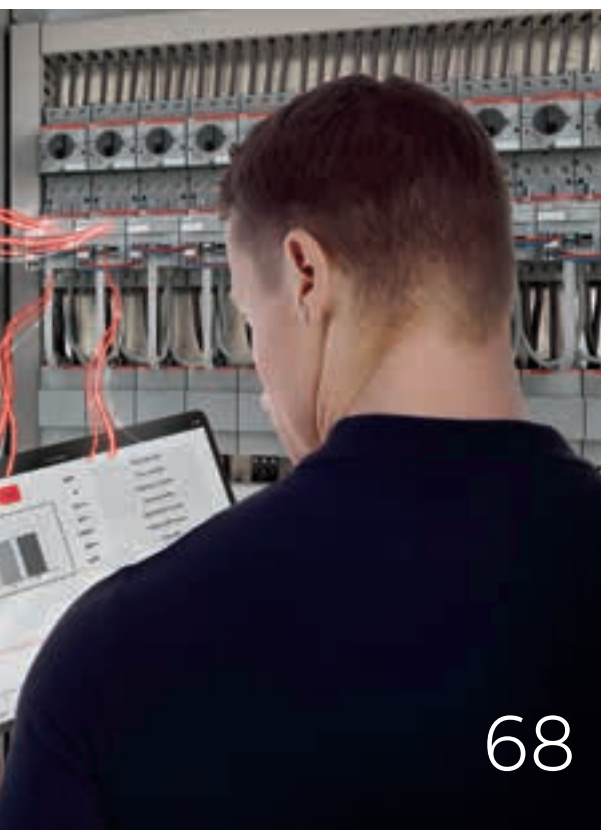






**A helping hand**

## Simply connect




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## **Inspired by technology**

**What will the future bring?**

**The answer at ABB is to ask a different question – What innovations will enable a more productive and sustainable world? – and it is this question that animates the latest research and applications explored in this annual innovation issue of ABB Review.**

**Share your thoughts with  
[abb.review@ch.abb.com](mailto:abb.review@ch.abb.com).**

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EDITORIAL

# Inspired by technology



Dear Reader,

By its very nature, innovation is about challenging the status quo. Innovation means creating new approaches to make products, systems and services more efficient, more sustainable and easier to use. The current issue of ABB Review showcases research successes and innovation breakthroughs from across the company, with contributions hand-picked by ABB's senior technical leaders.

Among the innovations presented are a method for custom-painting car bodies, involving less waste and more choice; and an easily programmable robot that works alongside humans in complete safety. We also look at different ways of using data to increase productivity and sustainability, including the prevention of water leaks, streamlining the design of control systems, and providing higher levels of integrity in emissions monitoring.

These and the many other innovations presented are helping industrial and commercial organizations to tackle the status quo in a host of settings.

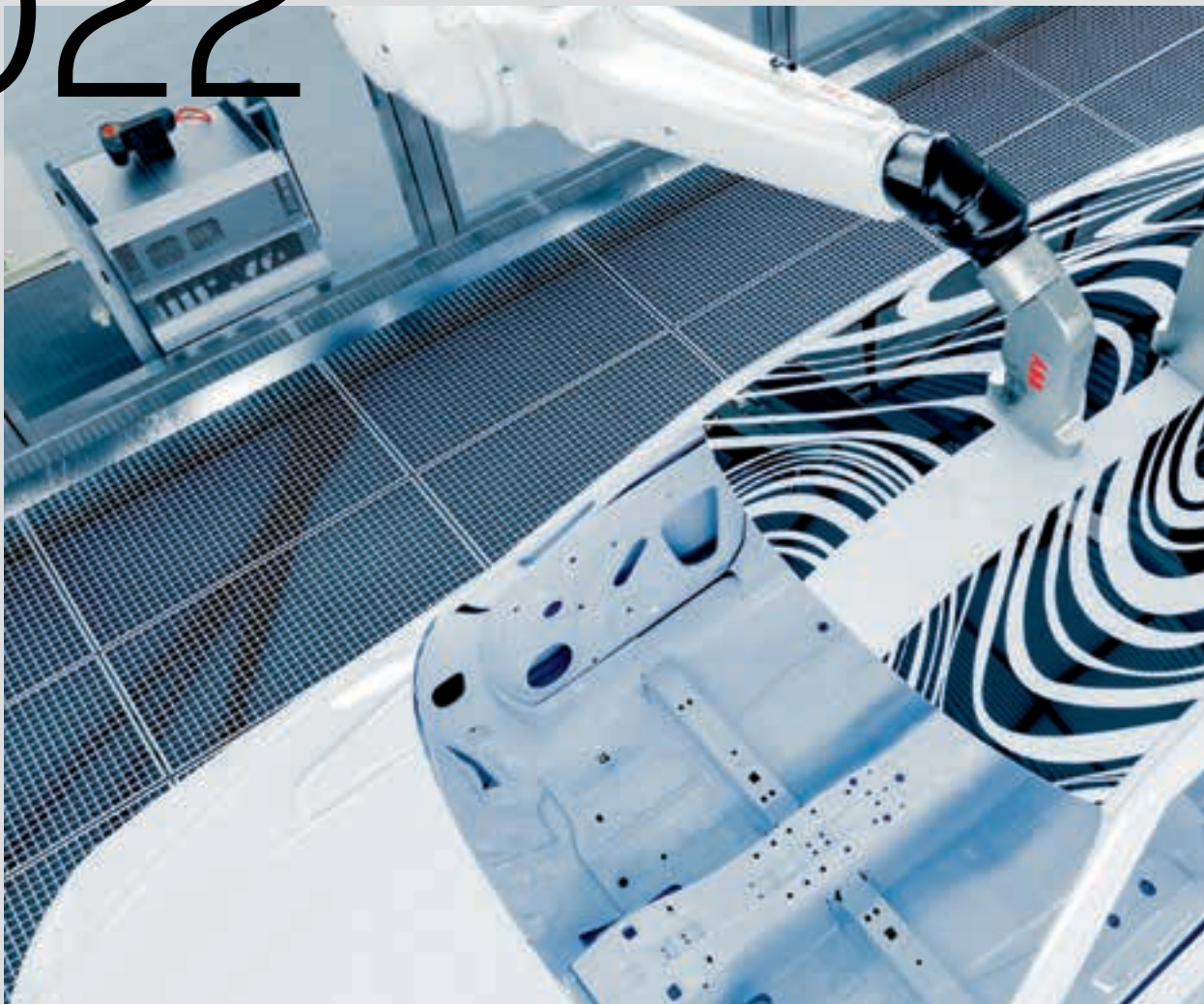
Enjoy your reading,

A handwritten signature in black ink, appearing to be 'Björn Rosengren'. The signature is stylized and fluid, with a long horizontal line extending to the right.

Björn Rosengren  
Chief Executive Officer, ABB Group



# Innovation highlights 2022







How will tomorrow's technologies differ from today's, and what will it take to get from here to there? This section collects some of the latest and best insights and offerings that can benefit ABB's customers this year and beyond. Consider it a menu of what's available for those journeys.

- 09 ACOPOS 6D heralds a new era of productivity
- 10 A solid-state circuit breaker for high currents
- 11 Safer, faster and simpler, GoFa™ CRB 15000 makes collaboration easy
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## ACOPOS 6D HERALDS A NEW ERA OF PRODUCTIVITY

Today's production machinery takes up a lot of space, only a fraction of which contributes to the production process directly. Far more real estate is dedicated to moving parts via conveyor belts, rotary tables, carousels, etc. B&R's ACOPOS 6D revolutionizes all that with magnetically levitated shuttles that carry parts freely through the production process. ACOPOS 6D creates a multidimensional manufacturing space in which each product moves independently from station to station without being bound to a rigid, sequential production flow. ACOPOS 6D is ideal for small-batch production with frequent design and dimension changes.

ACOPOS 6D is based on the principle of magnetic levitation: Shuttles with integrated permanent magnets float smoothly and silently over the surface of electromagnetic motor segments, carrying production parts of weights up to 14 kg. Shuttles can move freely in two-dimensional space, rotate and tilt along three axes and offer precise control over levitation height. These six degrees of motion control freedom give the "6D" in the product name.

A shuttle's location is known to within  $\pm 5 \mu\text{m}$  at all times, making ACOPOS 6D perfectly suited for applications with strict positioning requirements. Tight shuttle formations with no gaps further improve space utilization and enable groups of shuttles to collaborate to carry larger or heavier products. Since each shuttle can also serve as a high-precision ( $\pm 1 \text{g}$ ) scale, weighing stations can be eliminated, saving further space.

The contactless, noiseless, flexible and precise performance of ACOPOS 6D heralds a transition from strictly linear production to an open, adaptive manufacturing space – nothing less than a revolution in the way products are manufactured, assembled and packaged. •



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## A SOLID-STATE CIRCUIT BREAKER FOR HIGH CURRENTS



ABB's Infitus is a first-of-a-kind, solid-state circuit breaker for high-density currents. Infitus embeds – for the first time – switching, insulation and DC protection into one single device up to a rating of 5 kA.

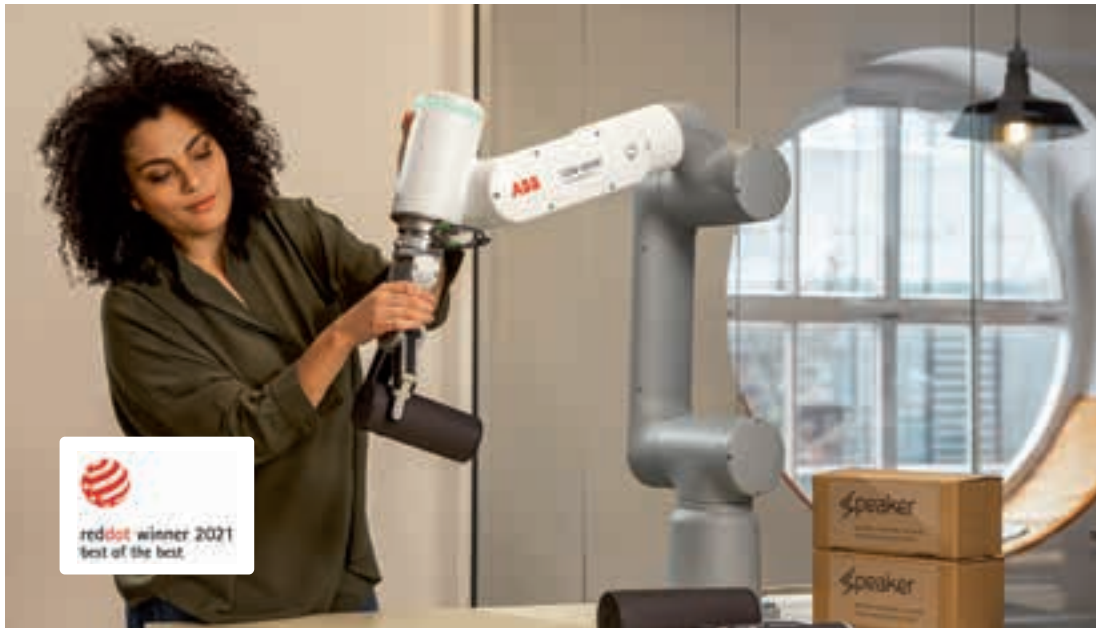
Instead of using separable contacts and an arc chamber to make and break the current, the Infitus solid-state breaker uses a lightning-fast power semiconductor: the low-loss reverse blocking integrated gate-commutated thyristor

(RB-IGCT). This semiconductor technology enables breaking times of around 10  $\mu$ s at up to 1 kV DC, compared to the tens of milliseconds needed by conventional electromechanical breakers. Such speed makes Infitus the best option for applications where fault currents may reach several hundred kiloamperes in a few milliseconds, such as in power converters, battery protection devices, or bus-ties in DC marine grids.

Compared to equivalent semiconductor solutions, Infitus has much lower power losses – for example, 75 percent lower than a comparable IGBT solution – and higher efficiency (about 99.9 percent at 1 kA, 1 kV). However, conventional circuit breakers have power losses that are much lower than those of Infitus. This extra power loss that Infitus has compared to circuit breakers means that Infitus needs integrated cooling. In Infitus, this temperature conditioning is accomplished by an innovative insulated liquid cooling system that does not require deionized water. This new approach avoids the complications (eg, continuous purification) that come with the use of the demineralized cooling water employed by other thyristor-based devices.

The Infitus technology started with the first feasibility study in 2010 and resulted in a new concept announcement at the 2019 Hannover Fair. The arrival of the breaker enables a wide range of new low-voltage DC applications and it simplifies the migration when applications have to be moved to DC for sustainability reasons.

Infitus customer pilot projects are running and the product will be launched in early 2022. •



## SAFER, FASTER AND SIMPLER, GOFA™ CRB 15000 MAKES COLLABORATION EASY

Heralding the era of collaborative robots, ABB's award-winning six-axis GoFa™ CRB 15000 Collaborative RoBot was released February 2021. Created to support the growing demand for safe human robot collaborations, GoFa is helping businesses automate processes involving heavier loads and longer reaches, faster than previously possible.

Ideal for applications from machine tending and material handling through to packing and packaging, GoFa has a maximum speed of up to 2.2 m/s, can handle payloads up to 5 kg (10 times more than one-arm YuMi™), weighs only 28 kg and has a minimal footprint of just 165 mm<sup>2</sup>. This sleek, compact and portable cobot can be mounted in any direction and easily moved between locations (eg, on Automated Guided Vehicles), thereby providing industries with heightened flexibility. With a reach of 950 mm, 70 percent longer than ABB's YuMi single-arm robot, GoFa outperforms other cobots of the same class; loads can be picked up and moved over greater distances, thereby reducing the number of cobots needed.

Safety certified to Category 3, PL d, GoFa needs no costly space-restricting barriers or fences. The intelligent torque sensors integrated in its six joints limit power and force for superior safety and performance – GoFa stops immediately if the robot detects any contact with a human worker. Moreover, the inclusion of SafeMove™ with an easy configurator app and the tablet-like Flex-Pendant make the set-up and configuration safe, even for novices.

Awarded the prestigious Red Dot: Best of the Best Design Award for groundbreaking design in 2021, GoFa is a game changer. This award celebrates the cobot's innovative, aesthetically appealing and accessible design. Because at ABB form follows function, GoFa communicates usability, utility and ease-of-use. Not only is GoFa fast and intelligent, it is approachable; this human-centric design ensures that robots, such as GoFa, will be adopted beyond traditional factory environments in the future. •

#### Further reading

"A helping hand" on pp. 48 - 53 of this edition, 1/2022, of ABB Review.



## LIFTING MINES TO A NEW LEVEL OF SAFETY

More and more mining companies, as well as a number of regional and national governments, are deciding to maximize the safety of their resource extraction operations. In view of this trend, the quality and reliability of mine hoists, the powerful elevator-like systems that transport rock and personnel, have become a fundamental consideration.

ABB, one of the world's largest suppliers of complete mine hoists, including mechanical and electrical systems, has introduced a newly developed platform of mine hoist safety products. Known as ABB Ability™ Safety Plus for hoists, the platform is composed of three solutions: Safety Plus Hoist Monitor (SPHM), Safety Plus Brake System (SPBS), and Safety Plus Hoist Protector (SPHP).

The platform provides the first SIL 3 fully-certified mine hoist solutions, enabling the highest level of safety on the market. In order to be assigned a SIL (Safety Integrity Level) rating, a hoist control and safety system needs to be designed from the ground up according to IEC 62061 functional safety standards.

The platform also offers a range of customer benefits, including best-in-class reliability, and easy (plug and play) integration into existing hoist systems.

ABB Ability™ Safety Plus for hoists includes a number of advanced self-testing and diagnostic functions that either automatically correct the performance of a degraded function or flag operations and maintenance personnel early on, if potential maintenance issues arise. These diagnostic functions occur while equipment is in operation, further reducing the downtime associated with equipment testing.

All in all, ABB's mine hoist solutions provide the lowest possible life cycle cost, the highest possible reliability and system availability, short project execution time, and a single source of supply for complete systems, including service and spare parts. •

**Further information is available at:**

<https://new.abb.com/mining/underground-mining/mine-hoist-systems/abb-ability-safety-plus-for-hoists>



## AUTONOMOUS AND REMOTE CONTROLLED VESSEL OPERATION WITH ABB ABILITY™ MARINE PILOT



Autonomous and remote control technologies make ship operations safer and more efficient by enhancing situational awareness, as well as automating navigational decision-making and control tasks. Such technologies can be applied to any vessel, eg, wind turbine installation vessels, cruise ships, ferries and tugs, thereby providing benefits such as detection of a wide range of obstacles, collision avoidance and dynamic positioning capabilities.

As a practical example, for tugs the technology can allow crew to rest on long transits by freeing them from some of the more tedious tasks such as continuous lookout, and enhance operational accuracy during critical tasks.

In April 2021, ABB in collaboration with Singaporean shipyard Keppel Offshore & Marine successfully conducted South Asia's first remote joystick control of a tugboat in the Port of Singapore, one of the world's busiest seaports with over 130,000 vessels calling annually [1]. The 32 m harbor tugboat was operated from a shore command center located at the Maritime and Port Authority of Singapore's Maritime Innovation Lab using an integrated solution based on the ABB Ability™ Marine Pilot product family. The ABB Ability™ Marine Pilot Vision, provided the augmented view of the vessel's surroundings, while ABB Ability™

Marine Pilot Control system allowed the operator to control the vessel via the joystick.

The ABB Ability™ Marine Pilot Vision creates a virtual picture of the ship's location in relation to other ships, buoys etc., by integrating the tug's navigational data, including radar, compass, GPS and Electronic Nautical Charts. The data is then streamed cyber-securely to the onshore command center; for the onshore operator to have augmented situational awareness [2] while controlling the vessel.

The ABB Ability™ Marine Pilot Control system permits optimal and complete all-speed vessel control from one operator position. Together these innovations are enabling easier, safer and more efficient ship operations. ●

### References

[1] ABB Press Release, June 21, 2021: <https://new.abb.com/news/detail/79622/abb-and-keppel-om-reach-key-autonomy-milestone-with-remote-vessel-operation-trial-in-port-of-singapore>

[2] K. Tervo, "Tug Project Putting Ideas into Action", *International Tug & OSV*, January/February 2020.

# ABB ABILITY™ GENIX DATALYZER™ FOR CONTINUOUS EMISSIONS MONITORING

Strict environmental regulations<sup>1</sup> and demanding analyzer availability requirements for emissions monitoring can lead to higher costs in industries such as cement, waste management and others. Enter ABB to provide customers with greater transparency and predictability for Continuous Emissions Monitoring (CEM) with ABB™ Ability Genix Datalyzer™ – ABB’s cloud-hosted data analytics platform for fleet-wide asset health monitoring.

How does the Datalyzer accomplish this? In the network architecture, multiple analyzers are connected to an edge device (MicroPC) that comprises CPM+ and the Genix Edgebase; CPM+ and SW communicate with the analyzers and captures the data while the Edgebase securely communicates the analyzer data to the cloud. This process allows the contextual integration of operational technology (OT) data with information technology (IT) data and engineering technology (ET) data.

With ABB’s Datalyzer cloud solution, customers can gather all data points from the analyzer, relay them to the cloud and access the data in one location. Because the assets create digital footprints and data points, companies can monitor their gas analyzer health and performance,

process and safety in real-time, which is necessary for compliance, efficiency and performance. With capabilities such as analysis of analyzer health data, and live system diagnostics; data analyzer health score and correlation plots, etc., users can benchmark or troubleshoot. By correlating key parameters live, customers can pre-empt disruptions and major failures – predictive maintenance is possible.

ABB’s Datalyzer, with its seamless and instant connectivity and scalable computing power results in lower costs and better performance – value is added. This enterprise-grade comprehensive cloud-based solution helps customers fulfill compliance needs while lowering the cost of ownership, improving reliability, extending the life of equipment, improving asset integrity and process safety while reducing costs and increasing margins. •

**Further reading**

“Beyond emissions monitoring” on pp. 54 – 61 of this edition, 1/2022, of ABB Review.

**Footnote**

<sup>1</sup> As per emission legislation EN-14181 guidelines, companies must employ suitable equipment (QAL1), set-up correctly (QAL2), and maintain correct operation (QAL3).



**FLEET OVERVIEW**

- GIS data & location of each analyzer in site
- Number, of total online & offline analyzers
- Heat map showing performance of all installed analyzers
- Top 5 analyzers with most process alarms in last 24 hours



**PROCESS OVERVIEW**

- Process overview
- Health score analysis
- Analyzer availability indication
- Process measurements
- Historical trends



**ANALYZER ASSET OVERVIEW**

- System diagnosis
- Constructional parameters
- Parameter correlation chart
- KPI display
- Asset parameter trends
- Enhanced visualization using heat maps & charts



**VALUE ADDED INSIGHTS**

- QAL-3 assessment & report
- Health index, correlation plots
- System anomaly detection\*
- PEMS integration\*
- \*Future additions





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## TAPPING NEW RESERVOIRS OF DATA

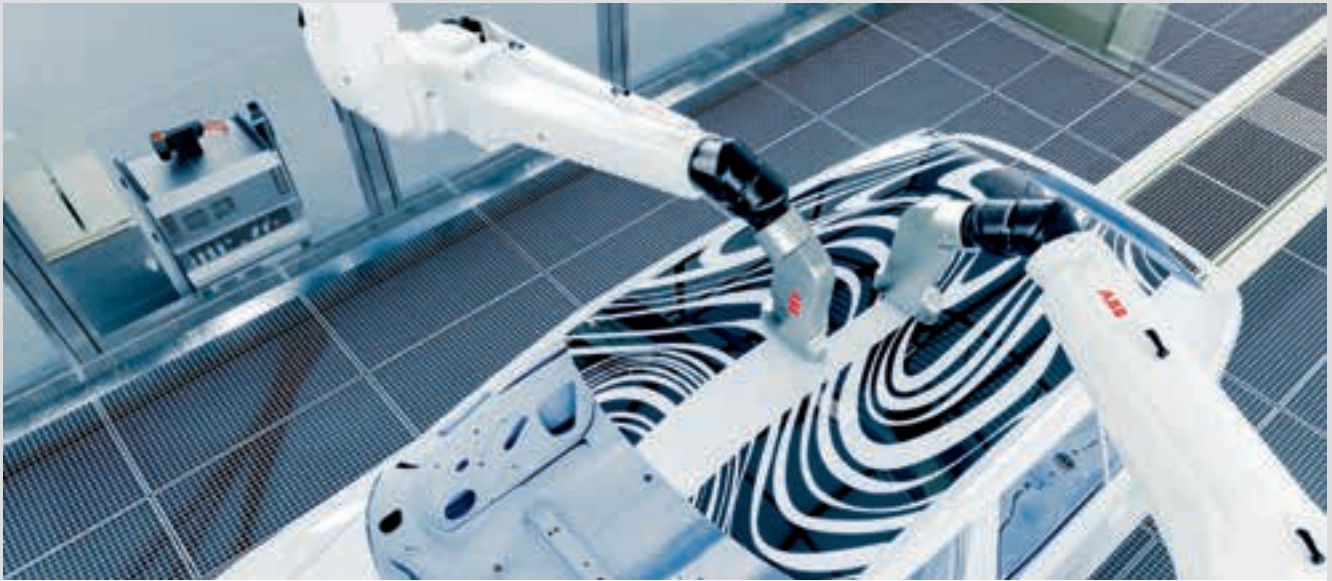
The worldwide water industry is experiencing an unprecedented transformation. Challenges include increasing levels of water scarcity, growing coastal salinity, pollution, ageing infrastructures, and tightening regulations. As a result, operators of water systems are responding with a renewed focus on efficiency, which is being driven by adopting innovative solutions and an increasingly data-driven approach to operations.

In view of these circumstances, ABB has introduced its Water Management System (WMS) software solution, a highly extensible and configurable platform. The platform allows operators to completely integrate existing third-party components, be they systems or devices, regardless of their interfaces or application verticalizations. This bridges the gap between operational technologies and information technology layers and opens the door to new functions. The software's ability to connect dots holds potentially enormous value in areas such as strategic planning, asset management, and reporting, as it helps operators to spot anomalous conditions, identify the root causes of problems, compare patterns, and even simulate scenarios.

The platform's design is based on several fully decoupled and modular layers that allow it to integrate data sources, regardless of whether they are external systems or IoT devices.

Information converges toward middleware that offers transverse services, focusing on security (in terms of access control and data exchange) and performance (caching mechanisms, data ingestion and storage, message brokering) tailored to domain-specific analytics and intelligence.

All in all, the WMS results in a single-view cockpit Web application that is complemented by a modern and fully responsive HMI, where design and usability are balanced to provide actionable information. •



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## ABB UNMASKS THE FUTURE OF CUSTOMIZED AUTOMOTIVE PAINTING WITH PIXELPAINT

Applying a two-tone or customized design onto bodywork is a time- and labor-intensive process that requires the vehicle to be put through the painting line twice: once for the first layer and then, after the appropriate areas have been masked off, again for the second color. The task of masking and demasking the bodywork alone is laborious. And with only 70 to 80 percent of the paint going where it should, significant quantities of paint are wasted.

ABB's PixelPaint overcomes these issues, providing a faster, highly accurate solution for customized painting. With reduced volatile organic compound (VOC) and CO<sub>2</sub> emissions, PixelPaint improves environmental performance and long-term sustainability too.

A PixelPaint cell configuration is a flexible combination of inkjet heads, ABB IRB 5500 paint robots, dosing control packages and ABB Robot-Studio® programming software for two-tone and decorative painting applications.

The key to PixelPaint's performance is its pioneering nozzle design, along with a variable droplet control method. This combination delivers fast and accurate high-resolution printing of two-tone and customized designs directly onto vehicle bodies. PixelPaint enables droplets to be

applied at sizes ranging from 20 to 50 µm at a rate of over 1,000 droplets per second, allowing precise control of thickness and overlapping. The inkjet printer head features over 1,000 nozzles, each of which can be individually controlled. By enabling precise application of the amount of paint applied to a given area, PixelPaint ensures that images are printed to the highest quality while reducing paint wastage.

ABB's PixelPaint robotic non-overspray technology for the automotive industry won the 2021 Innovation and Entrepreneurship in Robotics & Automation (IERA) Award for Outstanding Achievements in Commercializing Innovative Robot and Automation Technology. •

## STREAMLINING CONTROL SYSTEM ENGINEERING

ABB Adaptive Execution™ allows software engineering to be performed in a virtualized cloud-based engineering environment, using a continuous modular configuration and testing methodology conducted with simulation models. In this approach, software is more thoroughly tested before deployment – which reduces expensive site-based commissioning – and remote acceptance testing is enabled.

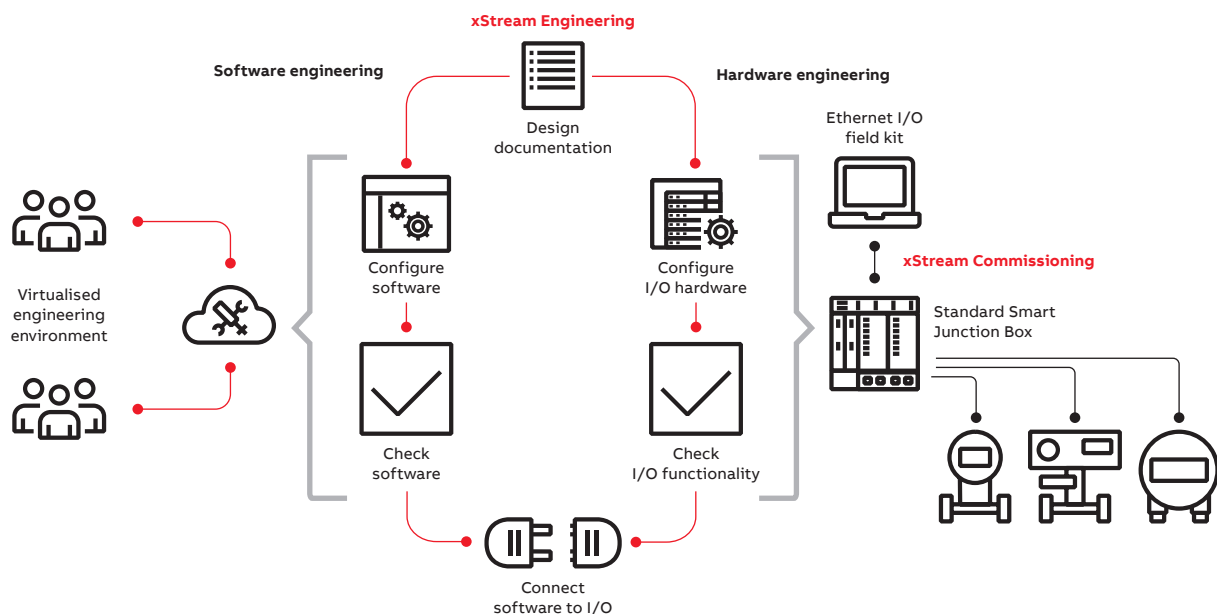
ABB Adaptive Execution exploits System 800xA Select I/O, the foundation for two new project execution streamlining methodologies that reduce costs and shorten schedules in digital control system (DCS) projects: xStream Commissioning and xStream Engineering.

System 800xA Select I/Os mounted in standardized remote field enclosures known as Smart Junction Boxes are used to significantly reduce the cost and time associated with connecting hundreds of field devices to the System 800xA DCS I/O system. Instead of routing the field device cabling via specific junction boxes to a, possibly distant, marshaling cabinet, they can

simply be connected through a single home-run cable to a free Select I/O channel in the nearest Smart Junction Box. Once so connected, the System 800xA Ethernet I/O Field Kit is used to perform automatic loop checks, reducing verification effort. This streamlining is referred to as xStream Commissioning.

Further, System 800xA Select I/O allows the application software and hardware engineering to be decoupled and run in parallel. This is xStream Engineering.

ABB Adaptive Execution will also use System 800xA's support for NAMUR modular type package (MTP) technology to streamline automation system integration further. NAMUR MTP is a comprehensive, machine-readable definition of the automation setup used by the DCS engineering tool to simplify the integration of the module into the overall DCS. •





## MINING CITIES' INFORMATION PIPELINES



By 2030, demand for fresh water is expected to exceed current sustainable supplies by 40 percent. Nevertheless, much can be done to reverse this trend. For instance, the UN estimates that up to 120 billion cubic meters of water could be saved in urban centers simply by reducing leaks [1]. ABB's AquaMaster4 Mobile Comms can help. One of the first Internet-connected flow measurement products and one of the world's first electromagnetic flowmeters with 4G LTE Cat.1/narrowband IoT, the AquaMaster4 can reduce operational expenses and waste while allowing for better control of supply and demand.

For instance, the flowmeter's built-in logger and cellular engine provide flexibility and allow interrogation of high-resolution data, thus helping operators tailor resources to specific periods of interest. In addition, thanks to the fact that the AquaMaster4 offers the widest flow range (up to R1000) and highest accuracy (up to  $\pm 0.2$  percent

of reading  $\pm 0.5$  mm/s) on the market, operators can rely on it to deliver bills that accurately reflect actual consumption, not estimates – and to discover leaks at an early stage. Furthermore, the AquaMaster4 is the first transmitter-equipped flowmeter to feature a contactless interface that uses the Near Field communication (NFC) standard, which allows offline configuration and updates.

AquaMaster4 includes predictive maintenance and enhanced diagnostics, such as self-checking and configuration to a predefined power mode. In case a fault is detected, the device can reboot itself and is capable of in-situ verification. Furthermore, the device enables operators to make ad-hoc requests for detailed information, to update its configuration, and to obtain audit log details – all with one of the first Internet-facing cyber security solutions offered by ABB. •

Further information is available at:  
<https://campaign.abb.com/aquamaster4>

### Reference

[1] UN. Half the world to face severe water stress by 2030. June, 2016. <https://www.unep.org/news-and-stories/press-release/half-world-face-severe-water-stress-2030-unless-water-use-decoupled>. [Accessed October 17, 2021]

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## GOLDEN BATCH ANALYTICS PRODUCE CONSISTENT TOP QUALITY

One area where Big Data can be exploited to make significant improvements is the batch process industry. Batch processes, though, are complex, dynamic and nonlinear, which often makes them tough to control and troubleshoot. Accordingly, ABB, in collaboration with experienced end users at a pilot customer, has developed ABB Ability™ BatchInsight, a process operator support system. ABB Ability™ BatchInsight uses historical data to learn the expected behavior of the batch process under nominal conditions and build a statistical “golden batch” model, which is then used as a reference for the batch currently under production. Online multiway principal component analysis (MPCA) of process data can then, in real time, detect evolving abnormalities and generate alarms. The relevant process variables are isolated so the operator can undertake corrective action and analyze the reasons for the failure. In this

way, the operator can reduce off-specification product and energy consumption and increase productivity.

Tests of ABB Ability™ BatchInsight were run together with an end user (a batch chemical plant) to analyze an occasional foaming problem. The model was trained only with non-foaming batches. In 83 percent of cases, foaming events were predicted at least 5 min in advance; often they were predicted hours before. Although foaming was wrongly predicted in 20 percent of the cases, the predictions are very helpful as the operator could then focus on suspect batches. •

#### Further reading

“Golden batch analytics produce consistent top quality,”  
*ABB Review* 2/2021, pp. 31–35.





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## TOPOLOGY-BASED CONTEXTUAL ALARMS

Industrial plant control systems typically have a large number of devices that receive or transmit signals. Monitoring such a complex array of data and equipment and reacting appropriately to the events and alarms they produce can place a high cognitive load on the operator, especially during an alarm flood. Failure to rapidly detect and interpret alarms and remedy critical situations can lead to safety risks, unnecessary costs and environmental damage.

While a traditional alarm list offers a comprehensive way to access information related to alarms, it lacks the context needed to identify topological and chronological relationships between them, often making it difficult for the operator to interpret a particular situation.

ABB's novel, dynamic, topology-based approach to industrial process alarms presents an effective alarm list summary enriched with contextual information, making it easier for the operator to interpret the situation. The method utilizes both engineering information (ie, the process topology model) and operational information (ie, event and alarm history data) to derive the context for a set of triggered alarms.

The result of this contextual analysis is presented on the user interface as a smart alarm list in which topology-connected alarms are linked and ordered over the timeline. The display of the topological and chronological relations provides vital information for root-cause analysis and decreases operator cognitive load. The visualization approach can, for example, bundle alarms caused by the same disturbance, such as a stuck valve.

The concept developed for the smart alarm list can be used for any continuous or batch process. ABB applied it to a water reinjection pump on an oil rig and achieved a reduction of 95.5 percent in critical events presented to the operator when looking for causes of a pump trip alarm. •



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## ENERGY STORAGE SYSTEM FOR MASS TRANSPORTATION

Energy storage systems are becoming an integral part of electric vehicles in both road and rail transport, and will play a key role in the transition towards energy efficient mobility. To address this need, ABB has developed the BORDLINE® Energy Storage System (ESS), a powerful and modular lithium-ion battery based energy storage system designed for use in rail, road and off-road vehicles used for mass transportation.

The batteries used in mass transportation applications like railways, buses and mining trucks must have high power charging capabilities, a long lifetime to endure continuous use, and a high inherent safety level, which requires a specialized and robust solution.

The BORDLINE ESS battery modules are highly standardized and can be connected in series to form a modular battery pack. Multiple packs can

be connected in parallel according to the needs of the application. Series connection of modules is realized with insulated quick coupling power connectors and with a wired serial bus between the modules and the master control unit. The modular battery design allows easy scalability in terms of installed energy and allows mechanical integration either on the roof, in the machine room or under the floor of the vehicle. The standardized, yet versatile, modular design is not only flexible to configure but also enhances availability and safety and enables faster service.

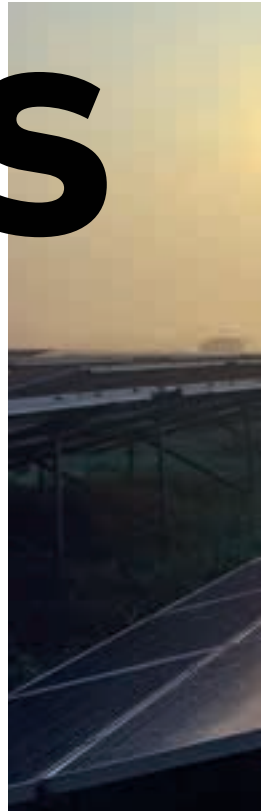
BORDLINE ESS is field proven and is being used in a wide variety of rail and road vehicles ranging from hybrid railway vehicles (diesel and fuel-cell hybrid), battery electric multiple units, railway maintenance vehicles, trolleybuses, full electric buses, mining dump trucks etc. •







# Inspired solutions





The driving force behind ABB's continuous quest for innovation is the desire to provide new solutions for customers. This can mean finding ways to do more with less, or make possible what was previously considered impossible. Here are examples of ABB's deep knowledge combined with curiosity and bold thinking that transcend "what if?" to yield "why not?"



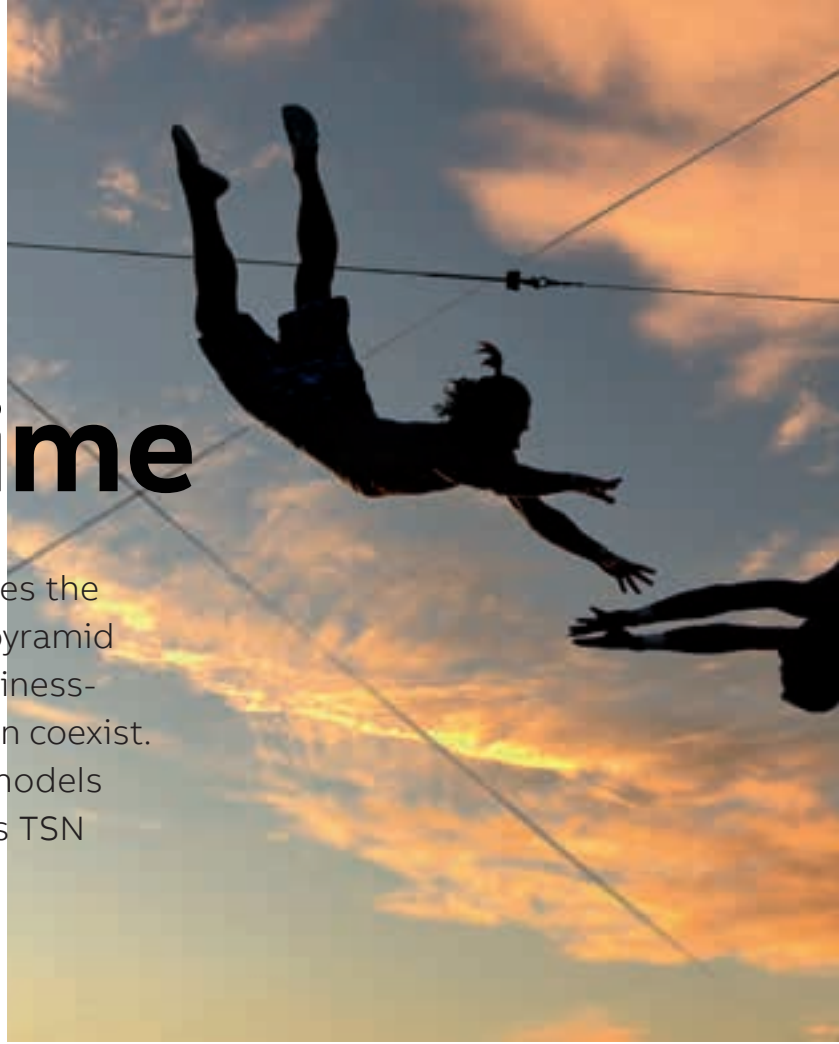
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Time-sensitive networking from an ABB perspective
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Combining simulation tools to predict breaker part endurance
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## TIME-SENSITIVE NETWORKING FROM AN ABB PERSPECTIVE

# Right on time

Time-sensitive networking (TSN) enables the transition from a classical automation pyramid to network-centric solutions where business-critical and production-critical traffic can coexist. This move also creates new business models and stimulates innovation. How ready is TSN for this evolution?



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Former ABB employees

TSN is a family of network enhancement mechanisms that makes regular Ethernet networks deterministic and capable of real-time performance. They are described in a set of IEEE standards that define traffic shaping methods, system-wide synchronization, frame preemption,

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**TSN resolves fieldbus interoperability problems with standardized interfaces and mechanisms.**

quality of service (QoS) handling, etc. These features are built on top of existing, mature Ethernet standards. TSN also specifies further mechanisms, such as distributed or centralized network orchestration, on-the-fly data stream scheduling, etc.

### Why have TSN?

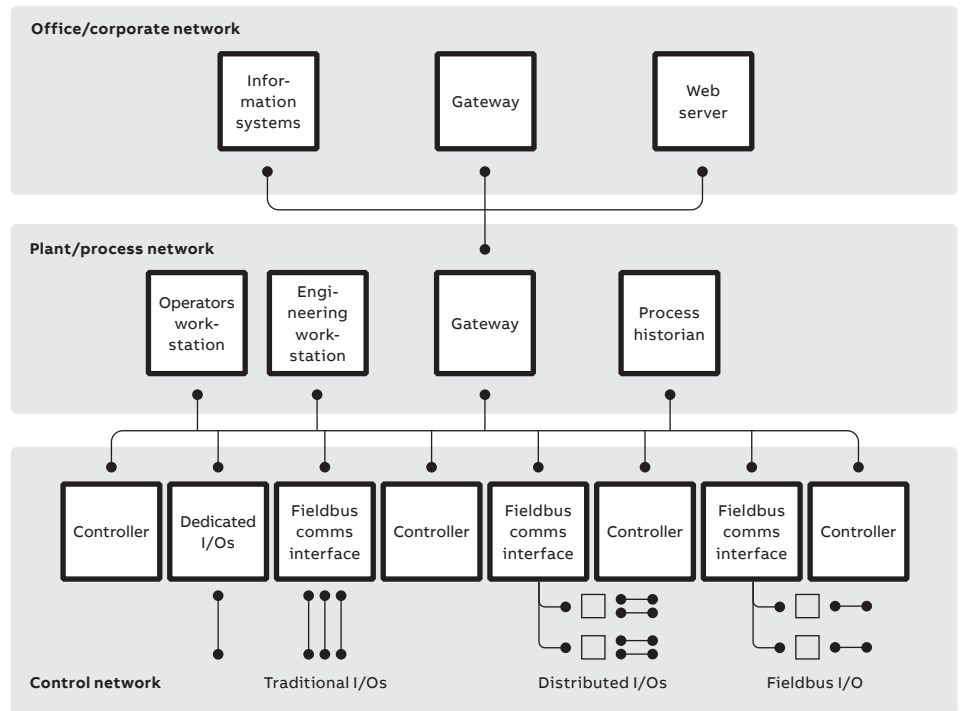
The driver for TSN is the proprietary, and thus vendor-bound, nature of existing fieldbuses and

all the equipment, license, upgrade and modification restrictions this entails. Further, industrial Ethernet solutions such as EtherCAT and PROFINET are not interoperable due to proprietary upper layers on top of the Ethernet-based fieldbuses. TSN resolves this interoperability problem with standardized interfaces and mechanisms. Also, TSN is a converged network, which allows the coexistence of multiple traffic types – for example, high-priority control applications and low-priority tasks, such as Internet browsing – on the same “wire.”

Another advantage of TSN is the ease of access to information it provides. Even in Ethernet-based fieldbuses, it is difficult to access auxiliary information from field devices used for engineering, monitoring, predictive maintenance, etc. since the fieldbuses would need gateways for data caching and bridging. TSN builds on standard and known Ethernet mechanisms, and requires no low-level gateways.

### What does TSN offer to ABB?

To an automation business, TSN adoption brings both benefits and challenges. An evident benefit is that TSN can replace multiple fieldbuses



02

— 01 TSN creates business and technical opportunities in the process industries by opening up the data infrastructure.

— 02 Automation hierarchy from the top-level controls down to I/Os: network-centric systems. TSN can replace multiple networks like these with just one and increase traffic capacity.

with one network that supports more deterministic behavior while providing higher traffic capacity →02. Further, the introduction of TSN standards means that network equipment and orchestration tools will no longer be proprietary – a significant advantage for customers. One challenge faced by TSN is that the relevant standards are still to be finalized and network orchestration tools must then be implemented according to these standards. Furthermore, the automation end systems must be prepared for TSN, with software and, sometimes, hardware modifications.

**What is a “TSN-ready” device?**

On the system and software level, the definition “TSN-ready” might include a product that has an orchestration tool to enable efficient TSN management. Hardware-wise, there are at least two types of devices that can be labeled as TSN-ready: the network bridge and the end system.

Today, some network bridges are already designated as TSN-ready, which can be misleading since they often support different sets of TSN features. However, the consensus here is that two features are essential in TSN-ready network

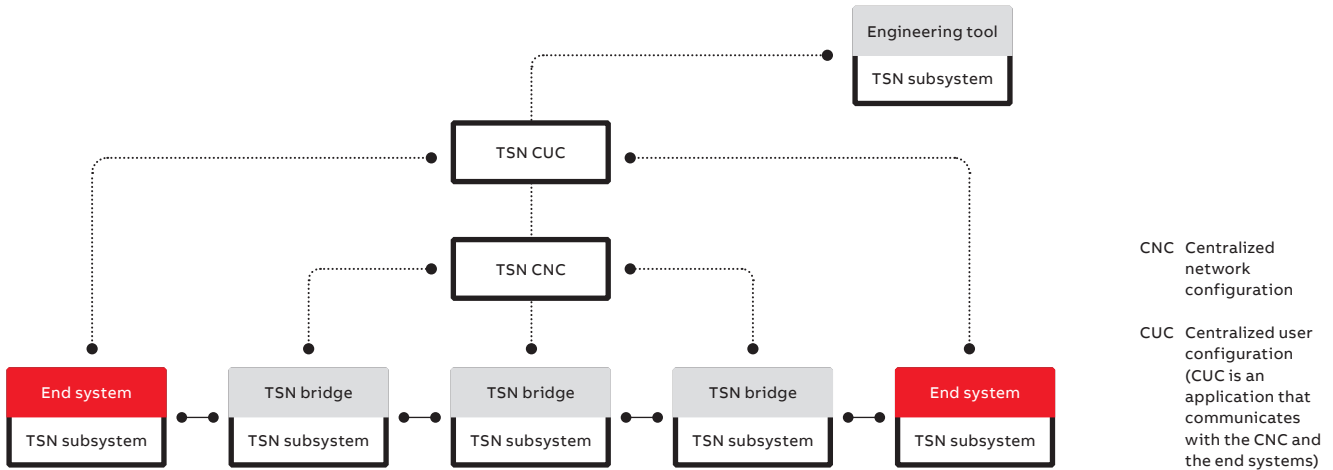
bridges: time-synchronization and time-aware traffic shaping (ie, traffic scheduling). These features allow any bridge to precisely synchronize

— Introducing TSN standards means that network equipment and orchestration tools will no longer be proprietary.

with the network and transmit data at defined times with up to nanosecond precision. Some bridges already offer frame preemption, where important data frames can preempt unimportant data frames on the fly.

For end systems, the story is similar: Depending on the use case, TSN features might be implemented in specific hardware or, with lower cost, in software. In this latter case, TSN performance will not be the best, but first tests show that the determinism achieved suits use cases with millisecond-granular control loops. Faster,





03

microsecond-granular control loops will require specific TSN hardware and software upgrades for the end systems.

**The system perspective and open configuration and orchestration**

As shown in →03, an automation system using TSN is built on end systems that produce and consume data transported via a TSN network using real-time, scheduled TSN bridges. To guarantee high determinism, these bridges need to be configured to define what data should be forwarded to where and when. TSN has an advantage here as it offers a method by which this configuration can be negotiated by the network configuration entities – CUC and CNC in

The advantage of TSN is that it is agnostic to higher-level protocols.

→03 – based on the device requests. Engineering tools can also play a role in configuration via standard protocols such as NETCONF, the network configuration protocol, or RESTCONF (an HTTP protocol), as opposed to the proprietary configuration methods of fieldbuses.

While the debate on which specific protocol to adopt is ongoing, some switch vendors are already implementing the openly available NETCONF on their bridges. Such adoption hints that automation networks with TSN will not be owned by fieldbus vendors but instead will become an open market for network orchestration tools.

**OPC UA and other higher-level protocols**

OPC UA (which stands for “Open Platform Communications United Architecture” – a vendor-neutral architecture) is often named next to TSN as one of the pillars of the Industry 4.0 communication architecture. “OPC UA over TSN” generally refers to OPC UA PubSub (an OPC UA publish-subscribe standard) and, less often, to OPC UA client-server. This differentiation is based on PubSub’s real-time capabilities (currently in the last stages of standardization) and the lack of those in OPC UA client-server.

In any case, the advantage of TSN is that it is agnostic to the higher-level protocols, be they PubSub, OPC UA client-server, or any non-OPC UA application. As shown in →04, TSN provides communication on the lower levels, below the network level (“3”) of the Open Systems Interconnection/Reference Model (OSI/RM) and thus delivers standard interfaces to the applications and protocols above it in the diagram. Evaluations show that in a multi-hop network, TSN can ensure request-response latencies in the millisecond range even for constrained embedded devices running an OPC UA client-server.

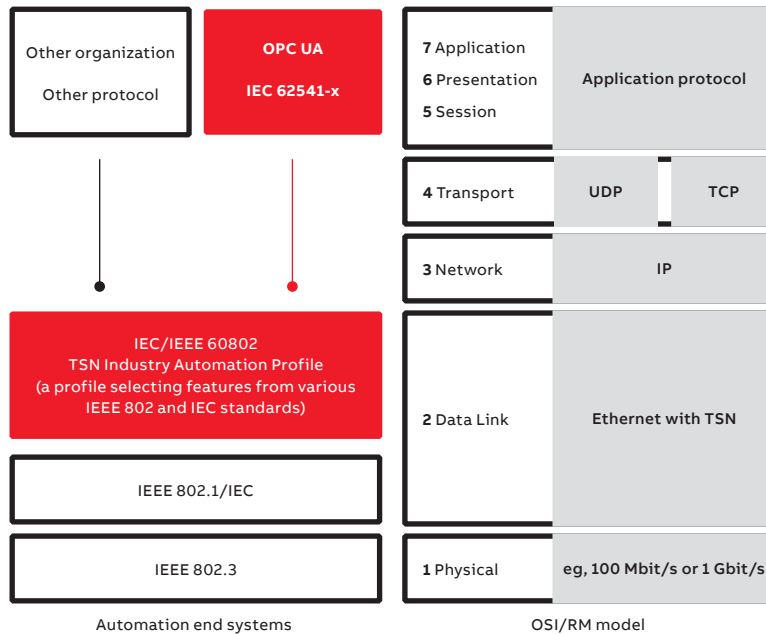
**Use case: TSN for next-generation train communication networks**

The European railway industry is currently investigating a new-generation onboard train control and management system (TCMS). A TCMS would interconnect all onboard devices, including passenger Wi-Fi, door and brake safety controls and operator-oriented services using the existing train Ethernet network →05. The new TCMS aims to use a converged network infrastructure to integrate mixed-criticality safety functions,

03 TSN support is required for bridges, end systems, engineering tools and more.

04 OPC UA and TSN in a layered stack for automation end systems and the OSI/RM model.

05 Traditional automation hierarchy and future control architecture with IT/OT convergence.



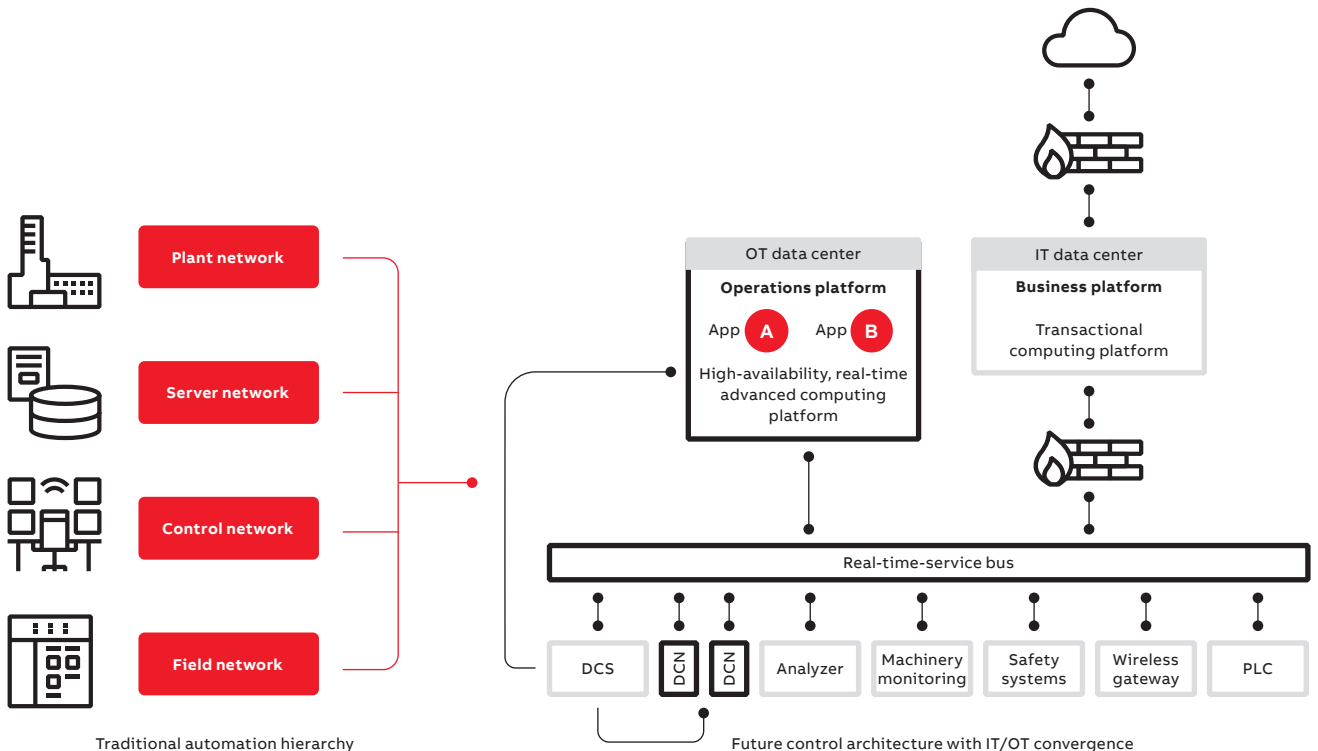
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time-critical and mission-critical functions, and non-critical train functions. TSN capabilities match these requirements perfectly.

**Use case: TSN early enablement for process automation**

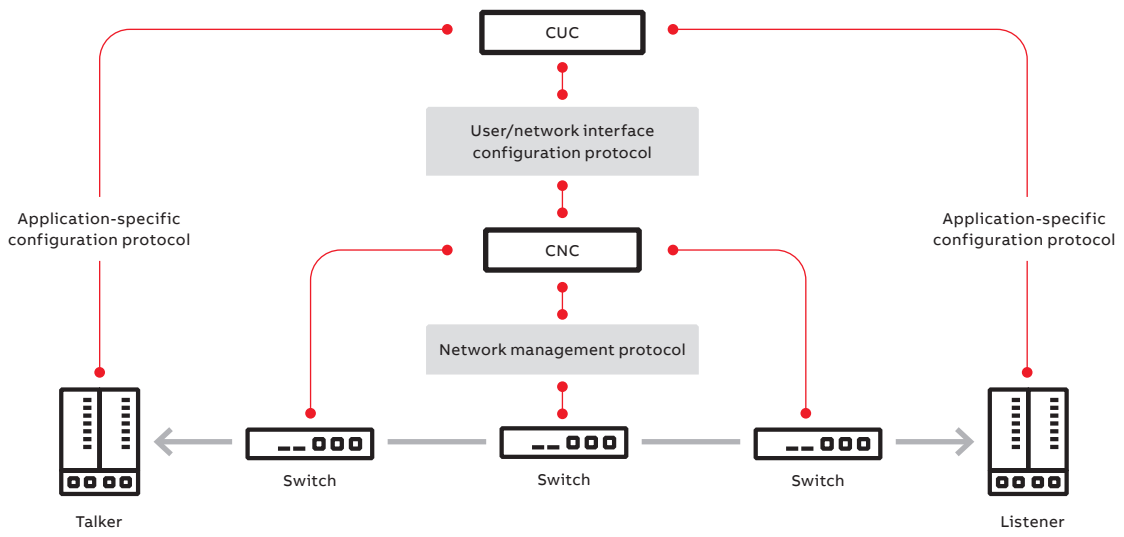
Process automation rarely requires microsecond-granular latencies and negligible jitter in data exchanges, but it will still benefit from the network determinism of TSN. TSN can ensure synchronicity between end devices and guarantee timely data exchange with very low jitter, fostering process control stability.

In today's process automation, the operational technology (OT) and information technology (IT) networks are separate and the data in each domain is locked within it. TSN can unlock the domains to open up new opportunities via IT/OT integration, while still guaranteeing determinism in such converged networks. The IT/OT convergence on one network could enable the OT staff to access directly the intranet/Internet and download software updates or manuals. Moreover, universal and uniform data access simplifies maintenance and diagnostics and enables Big Data applications →05.



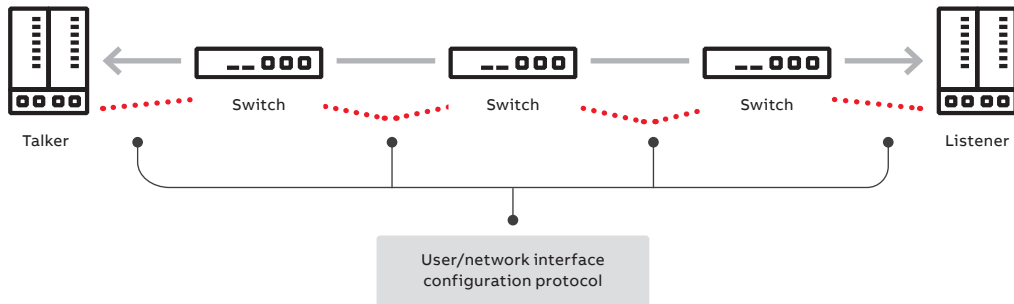
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### Centralized



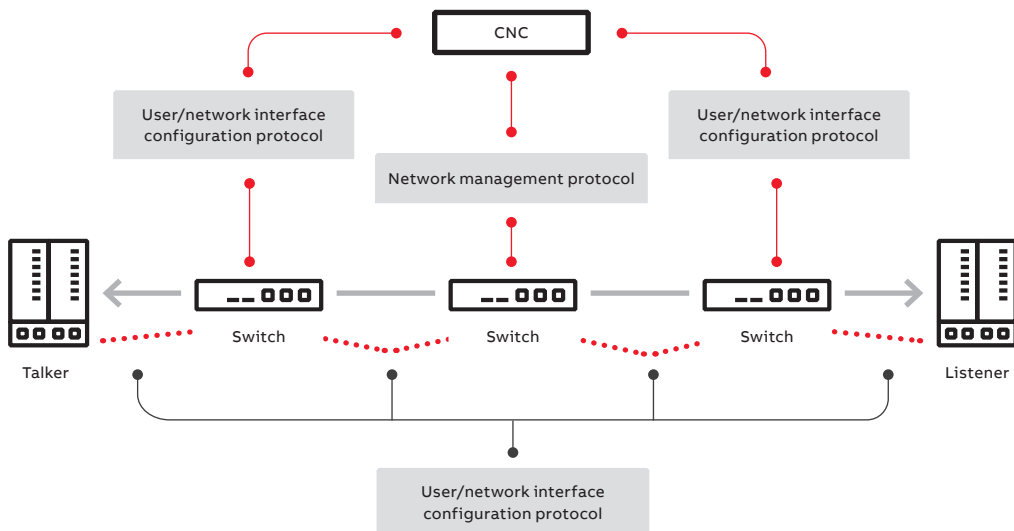
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### Decentralized



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### Hybrid



08

—  
06 TSN with a centralized configuration: a single CUC and single CNC.

—  
07 TSN with decentralized configuration: CNC and CUC are distributed among the switches.

—  
08 TSN with hybrid configuration: a single CUC/CNC plus distributed elements.

### Network orchestration requirements

A vital part of TSN adoption is that the proprietary network orchestration mechanisms open up. Essential aspects here are the general network configuration and the items specific to end systems.

In large distributed systems with varying requirements, network configuration can quickly become complex. To mitigate this, TSN breaks down the system configuration. First, TSN splits end systems into Talkers (producers of data) and Listeners (data consumers). Next, the TSN network orchestration defines two configuration modules – the CUC (to serve Talker/Listener requirements) and the CNC (to manage the network topology and resource allocation). In a simple example, the CUC module collects the service requests from Talkers and Listeners and checks with the CNC whether these requests are feasible in the current network. Then, the CNC configures the network infrastructure, while the CUC provides the resulting configuration to the end systems.

TSN foresees the implementation of the CUC and CNC in one of three models. In the centralized system →06, these network orchestration tools are located in one place. In the distributed system →07, the CUC and CNC are distributed over

—  
Stepwise adoption of already-mature TSN mechanisms could be a solution for both greenfield and brownfield applications.

the bridges as a set of communicating modules. These two models can be merged to create a hybrid system →08. The appropriate model is chosen based on the system's complexity, the set of configured features and the capabilities of the end systems and bridges.

### TSN enables the future of networks

With TSN, automation vendors will have the opportunity to provide solutions – ie, suitable combinations of TSN tools – that exploit the advantages of TSN to ensure the vendor's own control over network performance in new projects. Moreover, brownfield sites with TSN-unaware end systems present an additional upgrade opportunity. The stepwise adoption of already-mature TSN mechanisms could be a solution for both greenfield and brownfield applications.

There are competitive advantages and business opportunities to be found in opening up information in the process industries. TSN enables the transition of today's industrial automation pyramid to cloud solutions and an industrial Internet of Things, which will help exploit this information. TSN can enable coexistence of business-critical and production-critical traffic and create entirely new business models and innovations in many different industry segments. •



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## COMBINING SIMULATION TOOLS TO PREDICT BREAKER PART ENDURANCE

# Joining forces

Power grid topologies are evolving rapidly. This evolution places higher demands on the circuit breakers that protect the grid. New designs of circuit breakers are needed. How can the creation of these designs be speed up to match the fast rate of grid evolution?

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01 Comparison of the current and future power grid.

As more renewable energy sources come online, the traditional dominance of centralized utilities diminishes. This shift forces a reconfiguration of the power grid from a pyramid to an interconnected net →01. Further change is driven by the rise of e-mobility and private photovoltaic feed-in to the grid. All this increased complexity places additional demands on the power grid, especially on the devices that protect it, such as vacuum circuit breakers.

### The circuit breaker

At the heart of the vacuum circuit breaker sit three vacuum chambers (one per phase) that contain moving and stationary contacts. In normal operation, these contacts are closed

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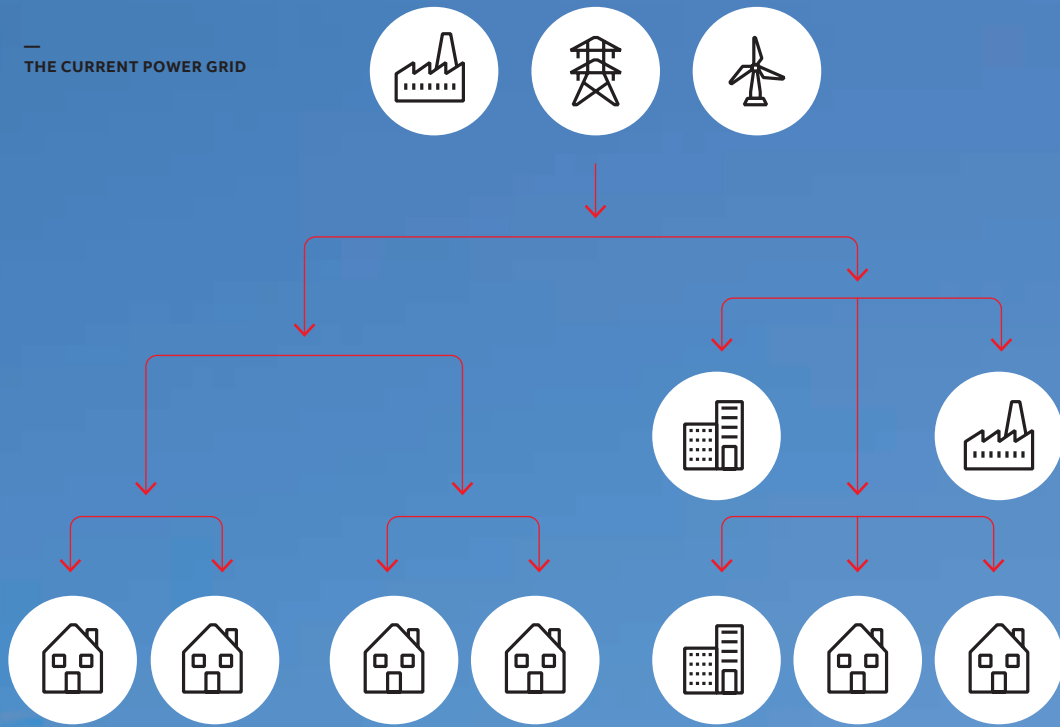
Increased grid complexity places additional demands on the devices that protect it, such as vacuum circuit breakers.

and pressed together. When a failure occurs, the contacts are separated very quickly to protect the circuit. Reclosing is also fast to prevent an electrical arc igniting and, thus wearing, the contacts.

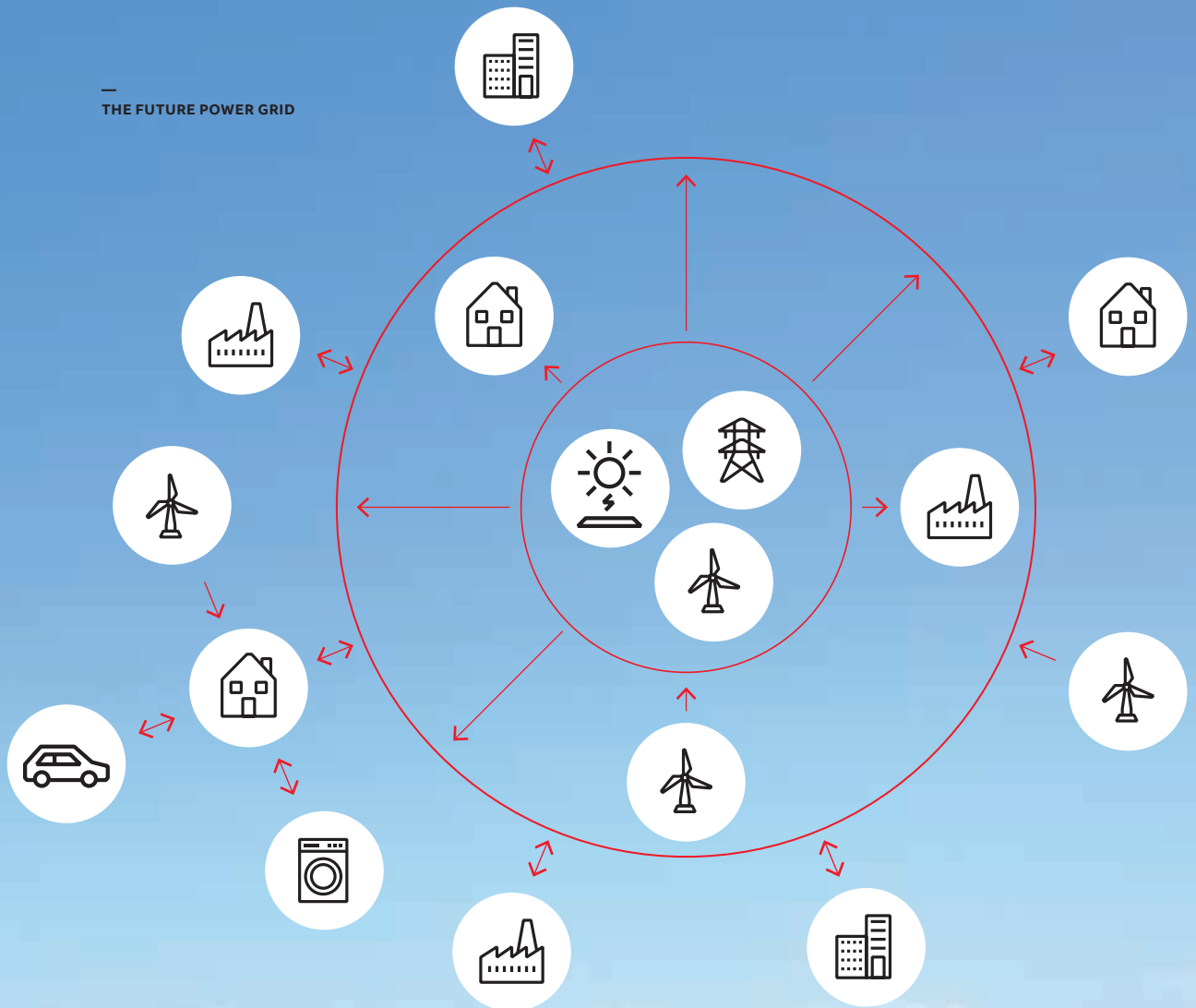
When closed, the contacts must be pressed together very firmly to minimize electrical

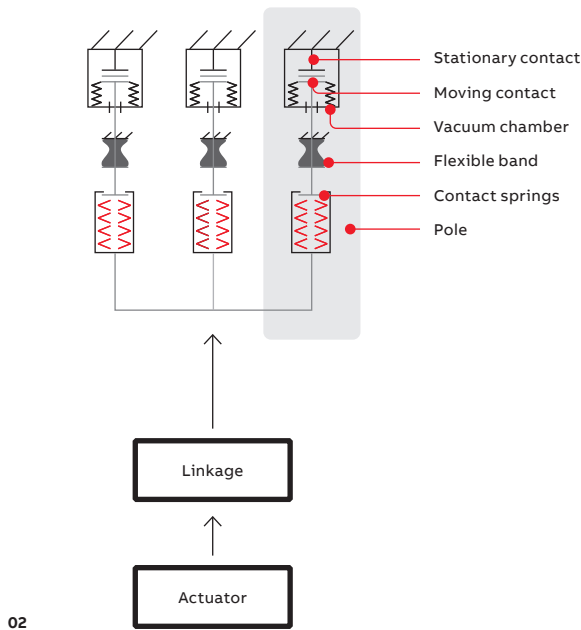


THE CURRENT POWER GRID



THE FUTURE POWER GRID



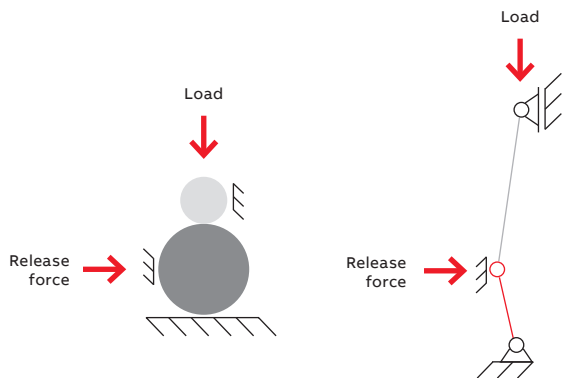


02

a linkage →02. To attain the high contact speeds and compressions required, high mechanical energy is needed. This energy usually comes from a closing spring. Releasing and stopping this high mechanical energy in combination with the high speeds involved leads to excessive impact loading on the actuator.

When opening the breaker by pressing the actuator button, the spring force of several kilonewtons must be restored via a finger force of approximately 20 N – a challenging transmission ratio. One way to accomplish such a high transmission ratio is the application of mechanisms

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 Creating new circuit breaker designs quickly enough requires a computer-aided workflow.



03

in singular positions. When a mechanism is in a singular position (a “singularity”), it can undergo sudden and dramatic change →03. Mechanical actuators in circuit breakers must include several stages of mechanisms close to their singular position to reach the high transmission ratios required. These singularity mechanisms must be geometrically precise, which places demands on assembly and production tolerances, and production methods.

As new grid realities require circuit breakers to operate faster and more often, the question arises as to how new breaker designs can handle faster switching times, higher mechanical impacts and increased frequency of operation →04, →05. And how can these designs be created quickly enough to match the speed of grid transformation? The answer lies with a computer-aided workflow that takes advantage of a combination of modern simulation methods.

resistance at the interface and eliminate the risk of heat welding the contacts together.

Together with these three requirements – high opening and closing speeds and a high contact force in the closed state – it must also be borne in mind that circuit breakers must be able to survive severe operating conditions over tens of thousands of operations. Other requirements also exist, but these will not be discussed here.

**Circuit breaker actuator**

The circuit breaker is driven by an actuator connected to the three vacuum interrupters by

**Multibody and static approaches**

The most straightforward simulation tool available to tackle the breaker design challenge is multibody simulation, which analyzes motion and forces in mechanical systems, including flexible bodies. This tool is useful for initial, rough calculations but is not suitable for the determination of stresses in the circuit breaker actuator. Such stresses can be examined using finite element method (FEM) simulation, which

—  
02 Schematic of a typical circuit breaker.

—  
03 Mechanisms in singular positions.

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04 Traditional power sources, such as hydro-electric power stations, are being augmented by many types of distributed renewable energy generators. These new arrivals place a higher stress on grid components.

adds deformation and strength data to the information on motion and forces from the multibody methodology.

A dynamic simulation of a circuit breaker is too challenging for FEM simulation but the method is useful for static simulations of critical system situations, for example:

- The circuit breaker with a charged closing spring.
- The beginning of closing, ie, the instant when the closing spring is unlatched and the contacts of poles or linkages are still “blocked” – this is a virtual state that can be imagined as the closing of poles with high inertia.
- The closed circuit breaker.

Though FEM simulation does not describe dynamic behavior or stresses caused by impacts, the method should not be underestimated. For example, it describes well the high-stress state “beginning of closing,” which experience shows to be the critical moment for the lifetime of the majority of the circuit breaker actuator parts. Further advantages are that only the model of the actuator needs to be used, computational times are low and model convergency is feasible.

The method delivers a rough overview of critical spots and an approximate value of stresses. The

stresses, however, cannot be used for any fatigue computations.

### Dynamic approach

Since circuit breakers are loaded repetitively, a fatigue tool must be used to characterize device endurance. The fatigue tool determines a part’s lifetime – or maximum recommended number of load cycles – based on the stress results from the FEM simulation. However, to simulate such a complex system dynamically as an entire circuit

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Roughly discretized parts of the dynamic systems describe sufficiently the dominant and most important loading effects.

breaker is very difficult and many assumptions and simplifications must be made. For instance, to reach reasonable computation times of some days, parts must be meshed very coarsely. Roughly discretized parts of the dynamic systems describe sufficiently the dominant and most important loading effects – for instance, first bending and torsional modes.





Stress value results are, however, inferior for roughly meshed parts – a serious issue as the error in lifetime estimation can be an order of magnitude higher than the error in stresses. In other words, the stresses from a roughly meshed global dynamic model cannot be considered for further fatigue post-processing. Another idea would be to mesh the global dynamic model finely enough to use stresses in a fatigue tool. This approach is impracticable for many reasons.

The individual deficiencies of the multibody, FEM and dynamic approaches described are the main reasons why a workflow for endurance prediction of circuit breaker parts that combines these techniques in a novel way had to be developed.

### **Novel workflow for endurance prediction of circuit breaker parts**

The novel workflow's target is to largely overcome the disadvantages of the approaches described so far by utilizing a creative combination of the simulation tools described above. The first, optional, stage sees a reference model or set of measurements generated from a multibody analysis →06. Since the most important global kinematic factors influencing stress values are closing and opening speeds, the values of these parameters generated here should be used for validation in stage two – preparing the global dynamic model of the entire circuit breaker. This stage is the most critical in the novel workflow.

In stage two, the farther a point is from the locality of interest, the coarser is the mesh chosen there. Mesh coarseness is selected so the calculation only just converges. A rough mesh is usually sufficient for a good deformation description, as illustrated in →07. In this example, the point of interest is the actuator, so the linkage (actually, its housing) is simulated by just a shell element whereas the actuator is modeled by solid elements.

This method allows adequate deformation and motion to be observed, specifically around joints. The rough stress values indicate critical parts worthy of further examination.

In stage three, submodels of the critical parts are run with improved discretization. A simple copy of the global model is enough. Irrelevant parts are suppressed and only critical parts and their neighbors are used for simulation. Waveforms of the joint coordinates are applied to the parts neighboring them as application of these waveforms too close to the critical areas produces

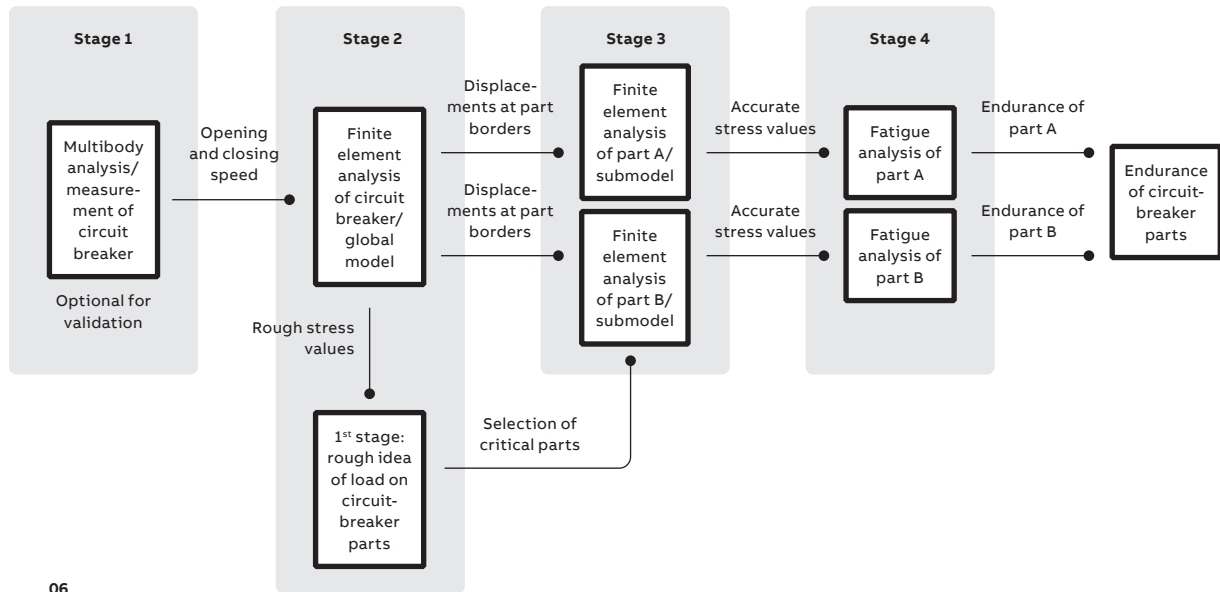
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**In stage three, submodels of the critical parts are run with improved discretization.**

inaccuracies. There are as many submodels as critical parts and the submodels must have a mesh finer than the global model. The result of stage three is a precise stress field mapping of critical parts over time.

Stage four is the post-processing of stress values in a fatigue module. Stress waveforms must be





06

05 Solar power is just one example of the distributed renewable energy sources that are driving rapid change in the grid.

06 Flowchart of novel workflow for endurance prediction of circuit breaker parts.

07 Example of global dynamic model of circuit breaker.

imported as time functions since the associated parts are loaded many times in many different directions during circuit breaker operation, which results in many stress peaks, all of which contribute to part fatigue.

The result of these four stages is the number of operations the circuit breaker will be capable of and the lifetime of each of its parts.

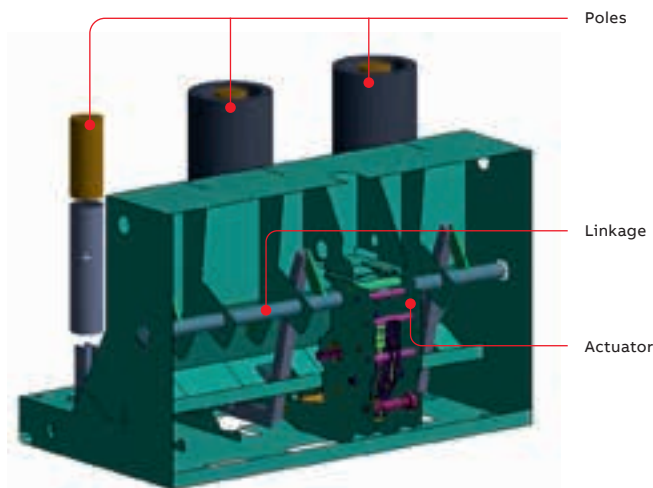
**Keeping up with a changing grid**

Combining simulation tools in the manner described speeds the development path for vacuum circuit breakers, allowing the rapid creation of new designs of this complex device that can handle the increased demands placed on them by the shifting power grid landscape.

The novel workflow results in a model that is roughly discretized in some places and finely in others. This approach offers a low computational time and ample opportunity for multiple model runs. Despite the roughness of some parts of

Combining simulation tools speeds vacuum circuit breaker development, allowing the rapid creation of new designs.

the model, the predictions of lifetimes were very precise when verified by comparison with tests. Presentation of the comparison in detail would exceed the scope of this article, but will form part of a future publication. •



07



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IDENTIFYING THE BEST ENERGY EFFICIENCY MEASURES

# Energy savings at your fingertips

ABB's new site assessment calculator for ABB energy management systems (EMSs) allows an enterprise to quickly and accurately determine the potential to minimize its energy consumption, energy cost and CO<sub>2</sub> emissions.

The world is undergoing rapid change. For example, the three megatrends of urbanization, decarbonization and digitalization have combined with climate change concerns and calls for a sustainable society to produce seismic shifts that are transforming everyday life.

These global developments are disrupting the energy landscape, resulting in huge pressure for change on utilities, power providers, municipalities and energy users in industrial, commercial and domestic settings. Optimization of energy resources and consumers is a key aspect of accommodating this change.

Due to the increasing complexity of energy systems, this optimization task can only be dealt with by automation and tools that determine the best setpoints for each situation, the optimal mix of energy generation and consumers, and the best way to exploit ancillary systems, such as a battery energy storage system (BESS) →06. This requirement for automation and tools encourages creative thinking and presents opportunities to develop new solutions. One such new solution is the “ABB Energy Management Rapid Site Assessment Value Calculator” (EMS site assessment calculator, for short), which allows ABB, together with an energy manager or site manager, to calculate quickly what financial benefit an EMS would bring through optimized site operation. Additionally, investment decisions leading to further reduced consumption and minimized CO<sub>2</sub> emissions can be supported by scenario calculations.

### Industries can contribute to sustainability – and profit from it

Industrial and commercial sites account for about half of all global electricity consumption [1] and 30 to 40 percent of greenhouse gas emissions. The desire to reduce these figures – and lower environmental impact – is driving ever more investment in technologies such as photovoltaic (PV) energy generation, electric vehicle (EV) charging, BESS technology and energy capture from combined heat and power (CHP) plants. But the decisions to invest in these technologies must be made wisely as they do not automatically pay off financially and may even have unexpected adverse effects such as an overloading of a site’s grid connection.

### ABB Ability™ Energy Management – OPTIMAX

An EMS, such as ABB Ability™ Energy Management – OPTIMAX® (OPTIMAX EMS), is usually an investment that pays off quickly. An EMS collects

and reports consumption information, reducing the time needed for regulatory reporting – as required, for example, by ISO 50001 – by up to 50 percent. Additionally, an EMS comes with visualization tools and dashboards that enable energy managers to identify the hidden energy saving potential of the site. By taking adequate measures (eg, thermal insulation, sensorization of energy consumers, or replacement of old equipment), energy savings of up to 40 percent are achievable, as proven in projects.

On top of those benefits, ABB’s OPTIMAX EMS unlocks the full cost savings potential of industrial sites by optimally coordinating all assets in real-time. This is done by continuously optimizing different energy resource options, load and

—  
**The ABB Energy Management Rapid Site Assessment Value Calculator delivers a quick energy optimization calculation.**

market dynamics, and flexible assets, such as EV charging or storage hardware, for the benefit of the site owner and the environment. If required, OPTIMAX EMS’s accuracy can be enhanced by AI-based weather and market development forecasting.

To demonstrate how ABB’s vision of a zero-emission tomorrow can be realized today, OPTIMAX EMS was implemented at some ABB sites – for example, at the ABB Busch-Jaeger site in Germany, where OPTIMAX EMS balances flexible loads, solar infeed, a CHP plant and a BESS →02. OPTIMAX EMS helps the site become CO<sub>2</sub>-neutral, making a big step toward ABB’s “mission to zero.”

### Quick calculation of the value proposition

To estimate the savings potential achievable through optimized operations, online tools such as ABB’s Energy Management Calculator [4] can be used. For a detailed individual – and thus more accurate – assessment, the ABB Energy Management Rapid Site Assessment Value Calculator delivers a quick and reliable optimization calculation. The tool guides the ABB specialists – together with the interested partner – through the process of collecting relevant data and runs a live calculation over a given time frame to

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 01 Care must be taken when investing in energy-saving measures. ABB’s new tool allows fast identification of the correct approach.

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compare optimized operation with OPTIMAX EMS versus a non-optimized operation to quickly quantify the specific savings potential. The guiding principles of the tool are:

- Obtain good accuracy with little data.
- Propose reasonable default values when actual site data is not available.
- Perform an online optimization on historic measurement data (typically one year’s worth) in under 10 min.
- Show meaningful results that are useful for taking an informed next step.

The customizable model in the EMS site assessment calculator is identical to the one in the operations tool (OPTIMAX EMS) →03.

**Data entry**

In a first step, all relevant site assets are identified. →04 shows an example site configuration. The elements identified determine the data needed – for example, time series, size and cost parameters of (flexible) loads, on-site generation, storage and grid-connection data. With this

information, the optimization calculation can be started.

To achieve the accuracy goal, it is necessary to base the calculation on actual historic time-series data from the site under investigation. This precaution ensures that real values with realistic

—  
**In a first step, all relevant site assets are identified.**

time correlations are evaluated. If some data is not easily available, realistic defaults can be generated by the tool. For time-series data, the following default alternatives have been implemented:

- The real grid intake (the residual load at the point of common coupling, ie, where the facility’s local electric system connects to the utility’s) can be approximated by specifying



—  
02 The ABB Busch-Jaeger site in Germany runs OPTIMAX EMS [3].

—  
03 All elements of the generic model that can be customized to the specific requirements at each site.

the fixed loads and adding them to the time series of flexible load and generation.

- If heat-load curves are not available, they are automatically calculated from a few building parameters and ambient temperature curves for the location in question.
- PV generation curves can be calculated from the installed capacity and solar radiation information based on location-specific historic data.

—  
Besides generation, consumption and technical asset parameters, the calculation requires realistic cost information.

- EV-charging time series can be simulated based on the number of chargers, vehicles and schedule of site operations →05.

**Tariff information is important**

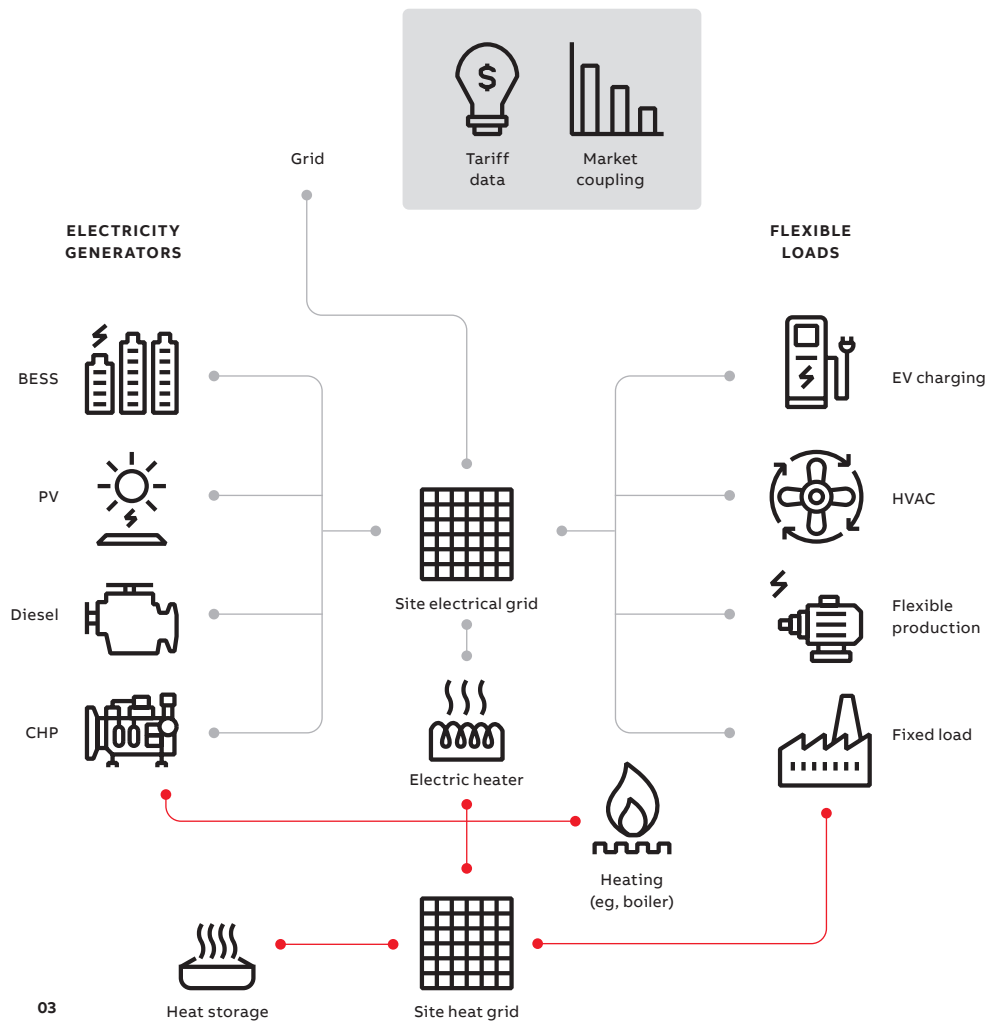
Parameters relating to asset sizes (eg, energy or power) must also be accounted for in the calculation. For most other required values (eg, efficiency), typical defaults are proposed.

Besides generation, consumption and technical asset parameters, the calculation requires realistic cost information. The grid tariff information on energy and power prices can be entered in the most common forms, for example:

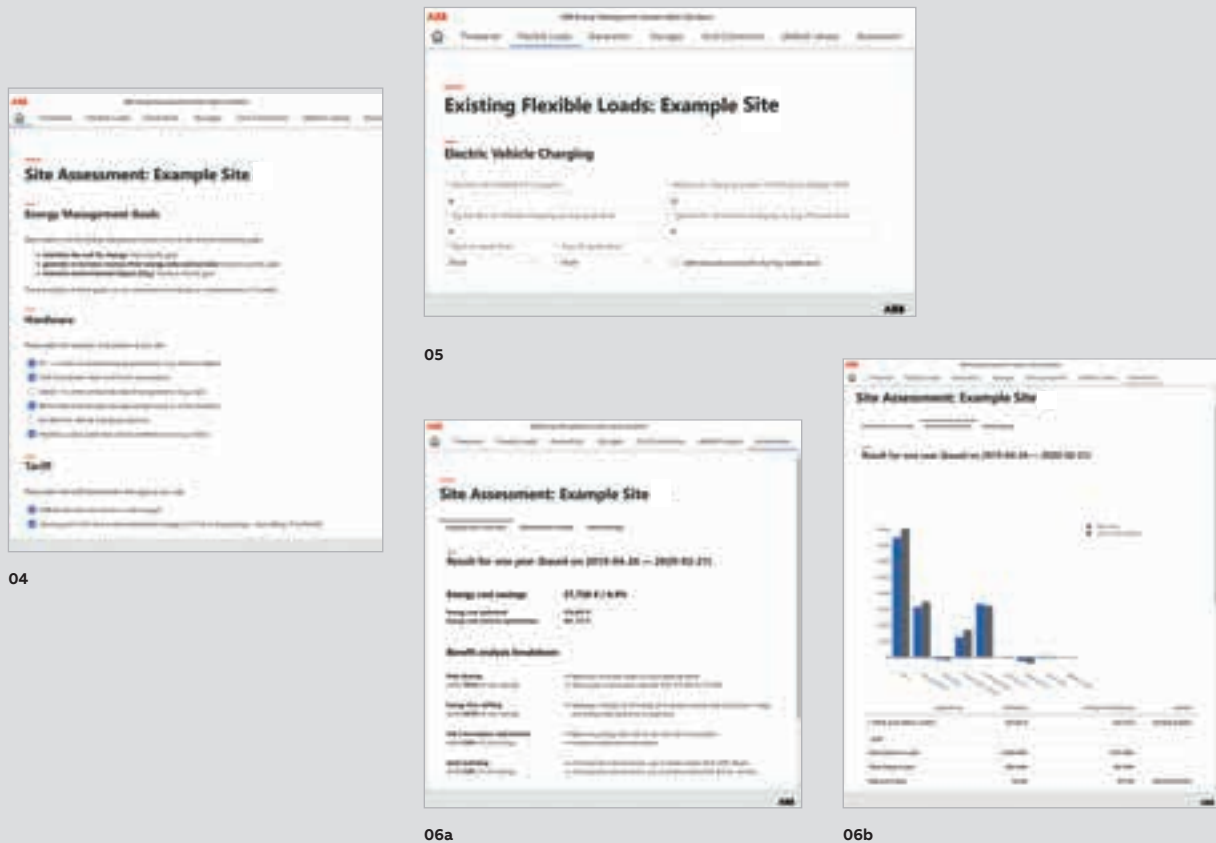
- Energy: fixed price, time-of-use models or flexible spot market tariff
- Power: peak-demand charge and energy excess model

Additional information such as feed-in tariffs or heating fuel costs will be asked for when applicable.

After data entry completion and automatic validation of data consistency, the optimization calculation can be started with a simple press of a button.



03



### Optimization results

After an average calculation time of under 5 min, the assessment of the energy costs, with and without optimization, is displayed →06.

First applications of the tool to real site data confirmed an average annual electricity cost savings potential of 8 percent. The method's

—  
By running a series of scenarios, even the optimal sizing of added battery capacity can be ascertained.

accuracy implies that the specific result for similar sites can vary due to differing assets, tariffs, time series and equipment flexibility. Depending on the details, the chosen optimization strategy will vary. The effect of different strategies is given in →07.

### Scenario calculation – total site assessment

Once site data is entered, scenarios can be modeled – for example, the effect of adding PV and/or a BESS, increasing EV charging activities,

changing the utility tariff, or switching to spot market trading. By running a series of scenarios, even the optimal sizing of added battery capacity or the upper limit of additional EV chargers can be ascertained, thus massively reducing, for example, CAPEX investment in excessive grid extension.

### Lessons from the optimization calculations

Initial runs of the tool on real industrial cases not only confirmed its benefit but gave interesting insights into savings potentials →08.

Lessons were learned from site calculations:

- A typical site has an electricity cost savings potential of 6 to 9 percent when using an EMS to optimize its operations.
- Among the four contributing strategies, peak shaving is often the most valuable, with an average peak demand reduction of 20 to 40 percent.
- Higher equipment flexibility results in higher savings. The highest savings can typically be achieved through smart EV charging, intelligent battery operation, load shifting, and optimized CHP and heat storage.
- An EMS can provide non-tangible benefits, eg, when it prevents violation of technical grid limits that could otherwise damage equipment

Strategy	Explanation of contributions	CO <sub>2</sub> savings
Energy time shift	Shifting the time of energy trading and usage to benefit from time-varying energy prices (arbitrage); buy cheaper and/or sell at a higher price.	Most probably
Self-consumption optimization	Balancing "selling and re-buying energy later" against "immediate self-consumption." Renewable curtailment minimization – ie, reducing the time a PV or wind generator is forced to operate at reduced capacity due to, eg, lack of demand.	Yes
Asset switching	Choosing the most economical way to obtain power (grid, CHP, diesel). Choosing the most economical way to produce heat (CHP, burner, electric).	Maybe
Peak shaving	Reduction of power peaks to avoid peak charges	No

07

Example site	Existing flexibilities	Optimization savings	Main optimization lever	Improvement calculations
Manufacturing (Europe)	BESS, CHP, HVAC	6.4%	1) Improved asset allocation 2) Demand peak reduced by 26%	No benefit switching to spot market
Woodcutting (Europe)	BESS	29.6%	1) Demand peak reduced by 39% 2) Autarky increased by 23%	–
Production and R&D (Europe)	CHP	1.8%	1) Self-consumption optimization	8 year payback time for BESS (300 kWh)
Office (Europe)	EV charging, CHP	8.6%	1) EMS prevents violation of technical limits 2) Demand peak reduced by 43%	No value of BESS or spot market participation
Cement production (Asia)	None	None	None	6.5 year payback time for PV (500 kW) & BESS (300 kWh)
Manufacturing (Americas)	BESS, CHP, spot market	7.1%	1) Demand peak reduced by 21% 2) Energy cost reduction of 4% by energy time shift	–

08

04 Example configuration page.

05 EV charging details to be entered as an alternative to time series upload. Based on this data, a simulated time series will be generated to be used in the calculation.

06 Example energy assessments from the tool.

06a Result overview.

06b Detailed output.

07 Four contributing strategies to optimize energy consumption: three of them are dedicated to reducing energy costs, one to reducing (peak) power costs and most of them contribute to CO<sub>2</sub> reduction.

08 Example results obtained using real site data. Depending on existing flexibilities, the additional EMS savings potential varies between 0 and 30 percent and additional investment decisions may or may not be favorable.

or when it enables larger on-site loads (eg, EV charging) without the need to upgrade the grid connection.

- Important factors for the calculation accuracy are actual time series, correct tariff information and the extent of flexible equipment available. On the other hand, the method is quite robust when analyzing short, data-lean timespans (under one year).

An EMS can pinpoint unnecessary energy losses of up to 40 percent that can be reduced by static measures. On top of that, OPTIMAX EMS provides, on average, an additional energy cost reduction of 8 percent. The actual value, however, depends on the specific customer conditions and can vary greatly. Here, the new ABB Energy Management Rapid Site Assessment Value Calculator comes to the rescue. The tool can be filled out by ABB together with the energy manager to calculate

This rapid, detailed, service helps customers make the right decisions to become a sustainable and cost-efficient enterprise.

accurately – in about ten minutes – the potential to further minimize the site’s energy bill. By doing this, the tool helps industrial energy managers to gauge the benefits an EMS such as OPTIMAX EMS and additional assets could deliver.

ABB believes this rapid, yet detailed, service supports commercial, business and industrial customers in making the right decision on their way to becoming a sustainable and cost-efficient enterprise. •

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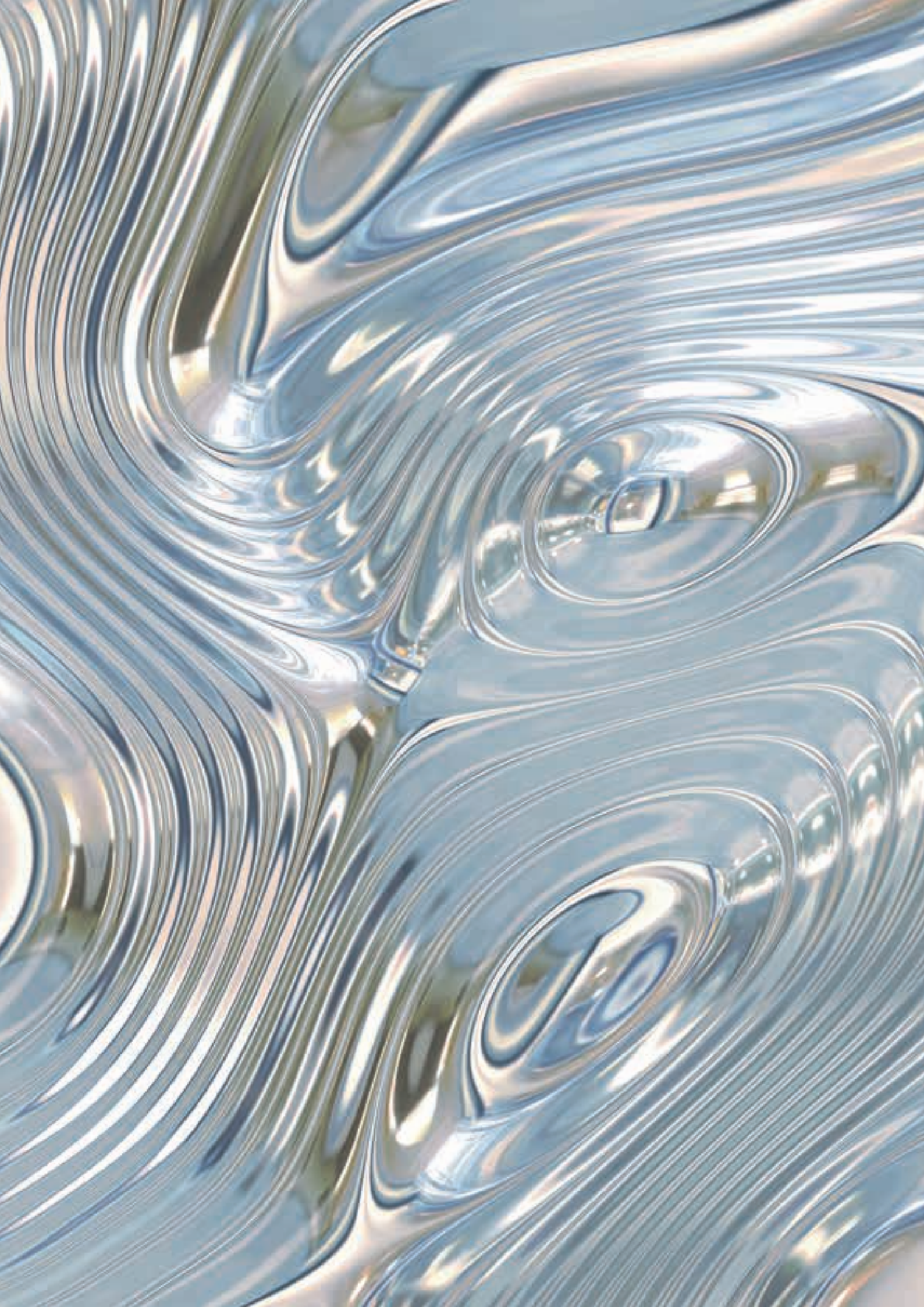
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MAGNETIC SHAPE MEMORY ALLOYS IN A MINIATURE CIRCUIT BREAKER

# Shaping the future

Magnetic shape memory alloys (MSMAs) form a class of smart materials that holds great promise as the basis for a wide variety of sensors and actuators. The miniature circuit breaker (MCB) is one common product that could benefit from the magnetic, thermal and physical properties of MSMAs.

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There is no strict definition of “smart materials.” The worldwide community that investigates such materials and their application does, however, loosely define them as materials that can be used for actuation, sensing and energy harvesting without modifying the material itself.

The simplest and most widely used smart materials are those that exhibit piezoelectric properties, where an applied force causes a voltage to be generated and vice versa. Thermal shape memory alloys (SMAs) constitute another class of mature smart material. SMAs – alloys of nickel

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 Smart materials can be used for actuation, sensing and energy harvesting without modifying the material itself.

and titanium, for example – have two different crystal structures, which are temperature-dependent. At ambient temperature, the material is in its “cold” crystal structure. The SMA’s “warm” crystal structure can be trained by temperature cycling thousands of times. When, subsequently, mechanically deformed and then heated above

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 01 MSMAs can be used in a wide range of applications.

the transition temperature at which the crystal re-orient its internal structure, the material “remembers” its trained shape, to which it then changes →02. The transition temperature for standard materials is around 60 °C.

For industrial SMA actuators, a standard design is a simple wire that can be stretched and is then pulled back when heated. This structural change can exert high forces if a large cross-section is used. Commonly, the resetting is not done by gravity as suggested by →03, but via a resetting spring. The most straightforward active control is heating by passing an electric current through the wire.

**Smart materials that react to heat and magnetic fields**

Similar to SMAs are magnetic shape memory alloys (MSMAs), which are composed of nickel,

manganese and gallium. This class of smart material shows a dominant effect when exposed to a magnetic field but also reacts to temperature in the same way as SMAs. The material elongates when a perpendicular magnetic field is applied and thereby provides force and motion.

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MSMA manufacture is challenging as casting the monocrystalline ingot is complex.

A magnetic flux density of approximately 0.4 T is required to trigger this physical response. Full elongation is reached at approximately 1 T, depending on the load. Higher magnetic fields will have no added effect, but will not damage the materials, which is an advantage in some applications. Usually, an external force in the axial direction is used to reset the element.

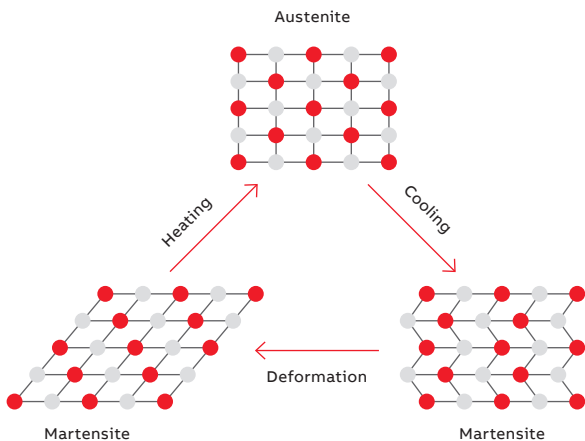
MSMA performance characteristics fall into three categories:

- Force: Element cross-sectional area defines the forces.
- Stroke: Element length defines the stroke.
- General stress, strain and other properties: Defined by the element and its alloy composition.

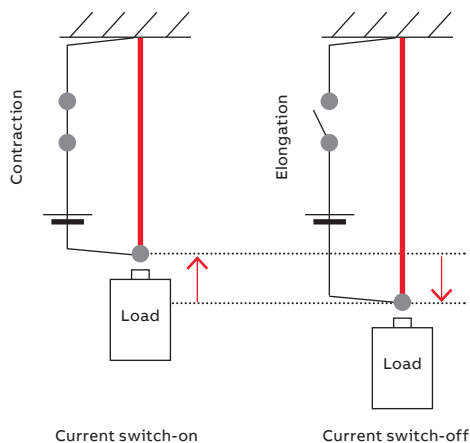
As with thermal SMAs, the response to temperature is based on the change of the crystal structure by a phase transition between a martensite and an austenite structure – ie, between a body-centered cubic and face-centered cubic crystal arrangement →04. In general, the forces provided by the thermal actuation are approximately 20 times higher than by the magnetic actuation, whereas the stroke is comparable or slightly reduced.

The manufacture of MSMAs is challenging because casting the required monocrystalline ingot is a complex process. Within this ingot, a polarized and folded magnetic crystal structure will evolve during solidification. The MSMA elements, called “sticks,” are cut out of the ingot in a beneficial orientation. It is the folded, magnetically polarized crystal structure within these sticks that allows them to deform when an external magnetic field is applied.

The combination of thermal and magnetic effects makes MSMAs ideal for applications where both a thermal and a magnetic response is required – for example, in a domestic miniature circuit breaker (MCB).



02



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02 When heated, the MSMA changes to its trained shape.

—  
03 Actuation arrangement.

—  
04 A transition in the crystal structure gives rise to SMA and MSMA properties.

### The MCB

An MCB is a protective device that breaks an electrical circuit in the event of a short circuit or thermal overload →05a. The latter occurs much more often than the former, but the MCB response to a short circuit must be much faster (1 ms) than to a thermal overload (several seconds). In conventional MCBs, separate actuators are installed for short circuit and thermal overload tripping functions – typically, a bimetallic strip and a solenoid, respectively →05b. The aim of the work described in this article is to replace these two actuators with one MSMA actuator. Such dual use of an MSMA actuator was described in a 2004 ABB patent application [1].

### One MSMA actuator replaces two conventional ones

An additional benefit of MSMA technology is that the required tripping field can be achieved with a simple straight conductor surrounded by an iron core. Such a magnetic design is inherently more suitable for MCBs of higher nominal currents, where the conduction losses of conventional solenoids are more pronounced.

A parallel arrangement was chosen for the mechanism that transforms the linear motion of the MSMA into the linear mechanical motion of the plunger. Though this setup requires an

additional linkage and has slightly more inertia, it is compact and provides the stroke required to eliminate arc re-ignition.

In iterative steps, a final technology demonstrator was developed that consists of a hollow straight conductor, in which the plunger as well as the resetting spring is integrated. A single-gap iron core surrounds the conductor and the MSMA element is placed in the air gap of the core. To adjust the MSMA element strain to the requirements of the MCB, a lever arm is used →06–07.

The fast actuation of the MCB when a short-circuit current occurs is ensured if a sufficiently high magnetic field intensity (H) can be applied to the MSMA at the required tripping currents. Therefore, the primary goal of the actuator's geometric optimization is to maximize the H field on the MSMA while staying within the geometric space constraints defined by the MCB housing.

### Electrical losses

A key performance indicator of the MSMA/MCB arrangement is the total (copper and core) losses at the rated current. As with any other electrical device, a primary design goal is to minimize such losses while maintaining the functionality required. On the other hand, the thermal over-

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With MSMA technology, the bimetallic strip heat source is eliminated and the coil has much higher energy efficiency.

load trip requires some heat to be generated by the losses in the MCB. The approach taken was to focus on the short-circuit tripping first and design an actuator with the lowest possible losses and only then to take care of the thermal tripping and adjust the thermal budget accordingly (eg, by thermal insulation).

One of the key benefits of using MSMA technology is that the bimetallic strip heat source is eliminated. Also, the coil has a much higher energy efficiency since it consists only of a straight copper conductor instead of a coil. Thereby, the electrical losses can be reduced by around 75 percent →07.

Temperature rise tests in accordance with the IEC 60898-1 standard were carried out on the MCB itself at a 63 A nominal current. The temperature



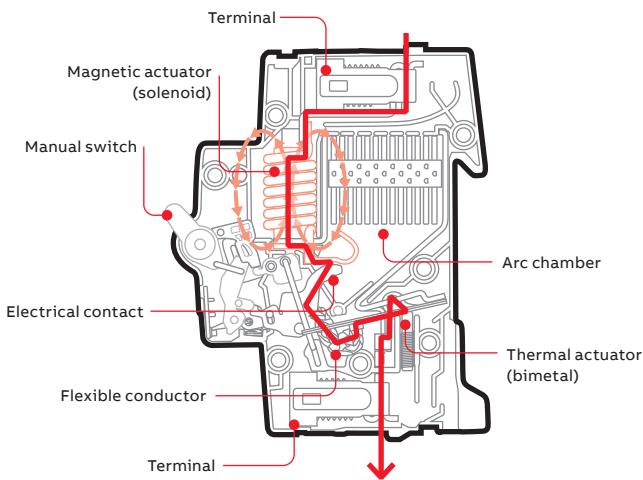


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**Magnetic tripping**

Some MSMA MCBs were prepared to accommodate high-speed camera monitoring so that the moving contact could be tracked. Opening times comparable to conventional MCBs were observed but with less back-travel, which reduces the risk of arc re-ignition.

The MCB plunger is accelerated and impacts onto the beat lever after a short flight in the millimeter range. The effect of different plunger masses was investigated and a clear difference



05b

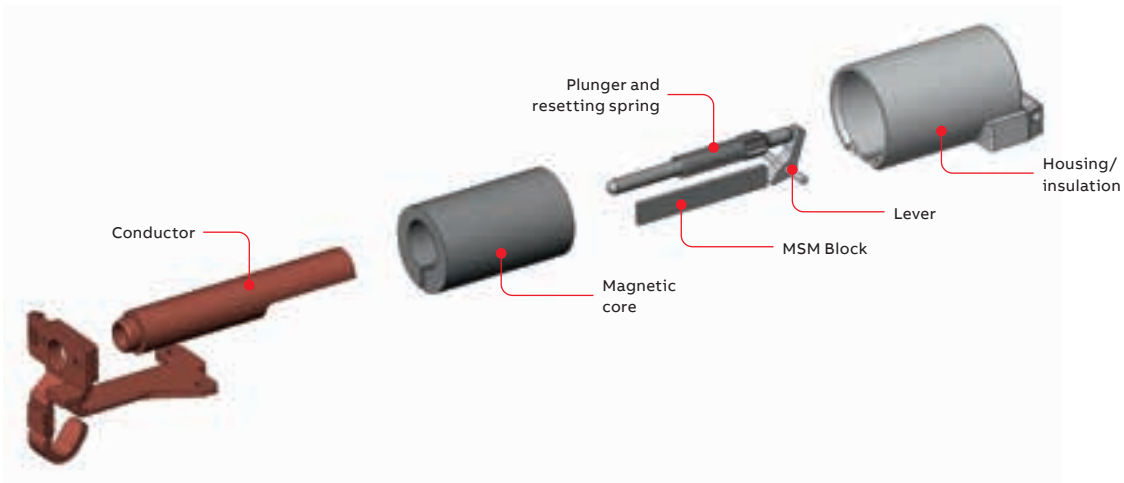
Opening times comparable to conventional MCBs were observed.

in plunger motion for different phase angles was observed. At the same time, repeatability was high. Higher plunger mass gives a higher impact force, but actuation time is lengthened due to increased inertia. Here, there is room for future optimization.

at the lower terminal on the MSMA MCB was found to be approximately 45 percent lower than on a conventional MCB. Thereby, it can be concluded that the temperatures inside the MCB in general and also the temperature on the contact surfaces itself are also much lower, which allows for a higher nominal current rating, with suitable dissipation of heat.

**Thermal tripping**

Thermal tripping using MSMA sticks with different thermal transition temperatures was explored. Today's maximum transition temperature is approximately 60 °C. Initially, the MCB was manually switched on and, thereby, the current applied. The MCB trips after 40 s at 2.55 times nominal current (160 A) and thereby fulfills the requirement for tripping at ambient temperature. Temperature rise tests show that materials with a transition temperature of 85 °C are required to guarantee functionality at +55 °C.



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05 MCBs are found in a multitude of electrical applications.

05a A typical MCB.

05b In a standard electrical installation, the main current always runs through the MCB from terminal to terminal.

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06 The technology demonstrator, an exploded view.

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07 Hardware demonstrators.

07a An early actuator prototype.

07b Another prototype (silver cube) showing the scale of the device.



07b

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An important further observation was that the performance of the first magnetic trip after a thermal transition was degraded. This phenomenon is being more fully explored.

### Products within five years

Currently, MSMA technology is not implemented in any commercial product, so neither mature manufacturing processes nor quality processes exist. Hence, economic aspects are not addressed here. The forecast viability of MSMA technology, however, makes a continuation of the development imperative. The technical suitability of MSMA for use in applications such as the MCB has been established [2–4]. Some work still

—  
The first products exploiting MSMA technology are expected to be on the market within five years.

needs to be done – for example, the development of materials with high (85 °C) transition temperatures as well as general optimization to facilitate production practicalities of the actuator mechanics. Further characterization of MSMA technology regarding lifetime, long-term stability, etc., also needs research, as does the reason why the first shot after a thermal transition is different.

That said, for an MCB, the combination of magnetic and thermal actuation integrated into one MSMA unit can improve performance, reduce costs for different actuators and associated individual adjustment processes, lower part count, simplify construction, eliminate potential hotspots and make the MCB substantially more energy-efficient. The first products exploiting the beneficial magnetic, thermal and physical properties of MSMA are expected to be on the market within five years. •

### Acknowledgment

The work described in this article was performed under a publicly-funded joint project called MAREGA (Magnetic Actuators with Reduced Gallium fraction) [5]. ETO Magnetic GmbH – a medium-sized enterprise with a focus on MSMA materials and applications – had the consortia lead. The company is part of the ETO Group, a leading supplier of electromagnetic actuators and sensors for the automotive industry.

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GOFA™ CRB 15000

# A helping hand

ABB's newest collaborative robot, the easy-to-use and award-winning GoFa™ CRB 15000, features intelligent sensors in each joint to support close human and robot collaboration. This highly approachable cobot enables class-leading reach and speed for payloads up to 5 kg.



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A new era of robotics is gaining momentum – that of collaborative robots (cobots) – robots that work safely alongside humans without the need for protective barriers and without jeopardizing speed and safety. Having introduced the world's first collaborative robot, YuMi™, in 2015, ABB is recognized as a global leader in robots with more than 500,000 robot solutions shipped to date.

In February 2021, the newest members of ABB's family of collaborative robots, GoFa™ and SWIFTI™ were introduced in a virtual launch event with around 10,000 live viewers [1]. GoFa handles 10 times heavier loads than YuMi, has higher maximal speed than other cobots on the market; and the integrated sensors in each of its joints ensure collaborative safety. Gofa also comes equipped with Wizard easy programming, which enables first time users to teach the robot programs within minutes. By supporting new tasks and applications, ABB's GoFa is a game changer.

#### Robotics to meet industry's needs

For many years, industrial robots like those used in the automotive industry, have handled heavy and large payloads, yet required safety fences to keep anyone from coming too close to the robot's fast-moving arm – a potential hazard. These robots have helped businesses lower operation and labor costs, while improving production output, product quality, and employee safety as they take on the hazardous and repetitive work of humans.

With data services, machine-learning, artificial intelligence, decreased product life cycles and differentiated products driving technology and business nowadays, ABB believes that cobots could speed up automation processes and help businesses adapt quickly to changing circumstances and respond to changing customer

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The new six-axis GoFa™ CRB 15000 Collaborative Robot supports the growing demand for varied robot solutions.

demand. But, this requires newly designed and engineered robots to work faster, reach further, operate more flexibly and safely alongside humans. ABB's newest collaborative robot, GoFa, is designed and engineered with this in mind – as a helping hand for enhanced flexibility and efficiency.

#### New collaborative solution

Built on the success of YuMi, the new six-axis GoFa™ CRB 15000 Collaborative robot supports the growing demand for varied cobot solutions. Designed to safely work with humans and other robots, GoFa helps businesses automate processes involving heavier loads and longer reaches than previously possible.

Designed to minimize its footprint and weight while maximizing speed and reach, GoFa provides heightened flexibility. Designed with a maximum speed of up to 2.2 m/s and to handle payloads up to 5 kg (10 times more than one-arm YuMi), GoFa weighs only 28 kg, and has a footprint of just 165 mm<sup>2</sup> and can be mounted in any direction →01 – 02 [2,3,4]. This sleek, compact and portable cobot can be easily moved between locations as needed. And with a reach of 950 mm, GoFa outperforms other cobots that can handle up to 5 kg by approximately 12 percent →01 – 02. With a 70 percent longer reach than ABB's YuMi single-arm robot, GoFa enables loads to be picked up and moved over greater distances, thereby helping to reduce the number of cobots that may be needed in a single space.

All of these features make GoFa ideal for diverse applications, from machine tending and material handling through to picking and packaging [4]. GoFa meets industry needs – stepping in whenever and where ever needed to assist humans and robots directly and continuously.

#### **Better performance and productivity**

In addition to assisting workers with repetitive, dangerous and ergonomically challenging tasks, GoFa can support short-term process changes and be deployed quickly to perform new tasks in production lines as required, eg, when there is fluctuating demand or production batches are small. Faster than other cobots in its class →02a, GoFa can perform more operations in a set period than competing cobots.







Interactive light



Axis 6 with standard flange and enhanced user interaction (Arm-Side Interface)

**GOFA**  
EASY TO OPERATE.  
HANDLES UP TO  
5 KG.

Range  
**950 mm**



Lead through function anywhere on the robot enabled by joint sensors and advanced motion control



Lightweight and small footprint  
**28 kg**



01

GoFa is therefore, ideal for assembly or picking and packaging tasks where items need to be quickly and accurately transferred between locations. GoFa can even be mounted easily on Automated Guided Vehicles (AGV). The author of this article finds that this ability provides

GoFa is ideal for assembly or picking and packaging tasks in an environment with other people nearby.

users of all sizes, from SMEs to large companies, with the flexibility to quickly adapt to changing circumstances and respond instantly to changing

customer demand without having to incur delays arising from having to find extra staff at short notice.

GoFa is powered by OmniCore™ with its best-in-class motion control and path accuracy →02a. OmniCore features a 50 percent reduction in footprint compared with previous robot controllers and can be easily integrated with the latest digital production technologies, including a wide variety of communication protocols, fieldbuses and advanced vision systems. →02b.

**A safer working partner**

With GoFa's advanced and comprehensive safety functions (certified to Category 3, PL d) risk to human workers is prevented and the need for costly and space-restricting barriers and cages is no longer required [3,4]. Safety is accomplished by factoring in the robot's speed, the combined

Specification of GoFa	
Robot version	CRB 15000
Reach	950 mm
Payload	5 kg
Armload	No armloads
Number of axes	6
Protection	IP54
Mounting	Any angle, including table mounting, wall mounting, and ceiling mounting
Controller	OmniCore C30
Customer power supply	24V/1.5A supply
Customer signals	4 signals (for IO, Fieldbus, or Ethernet)
Tool flange	Standard ISO 9409-1-50
Functional safety	SafeMove Collaborative included All safety functions certified to Category 3, PL d

**02a**

Performance (according to ISO 9283)	
Max TCP velocity	2.2 m/s*
Max TCP acceleration (normal control motion @nominal load)	36.9 m/s <sup>2</sup>
Max TCP acceleration (e-stop @nominal load)	61.6 m/s
Acceleration time 0–1 m/s	0.097 s
Pose repeatability	0.05 mm
1 kg picking cycle 25 × 300 × 25 mm	0.66 s

**02b**

01 GoFa's main beneficial features at a glance.

02 Important specification and performance information for GoFa CRB 15000.

02a A summary of specifications for GoFa CRB 15000.

02b List of performance according to ISO 9283.

\* Safe collaborative speed will be lower, refer to the SafeMove configurator app for recommendation. Customers should always do a safety risk assessment of their cobot application.

mass of the robot and its payload; and the ability of the robot to stop immediately upon contact. Designed with integrated intelligent torque sensors in each of its six joints, GoFa offers superior power and force-limiting performance →01–02. Together, these features prevent the risk of injury by bringing GoFa to an immediate stop if the robot detects any contact with a human worker.

Moreover, the aluminum and plastic joints that feature a rounded geometry, have no pinch or trap points that could ensnare a human worker.

The additional comprehensive set of safety functions provided by ABB's SafeMove™, with an easy configurator app, ensure safe installation.

Because safety is crucial for all, even first-time users, ABB included a visual safety configurator on its tablet-like FlexPendant to ensure that even novice users can configure the robot safely with SafeMove. Thus, users can avoid issues such as clamping that can affect safe robot operation. Further, with an interaction status light that varies in color, depending on GoFa's operating status, users quickly know whether the cobot is in standby, programming, operating or in stop mode →01 [2,3].

**Form follows function**

Despite GoFa's superb built-in safety features,

Designed with the user at the forefront, technological and physical features make GoFa safe, approachable and easy to use.

ABB knows the importance of ensuring workers feel safe and comfortable working alongside cobots. Observations of YuMi, made over five years by the author of this paper, confirm that workers feel safe working alongside the robot thanks to its unique and non-intimidating design. As with YuMi, GoFa was designed with the user at the forefront, using a combination of technological and physical features to make the new cobots approachable and easy to use.

GoFa employs slim, straight arms that give the cobot a user-friendly, yet strong appearance, while the advanced use of color, material and finish gives GoFa a modern, sleek look. Its simple arm-side interface (ASI) design with two buttons and light ring resembles the easy-to-use interfaces of consumer products. GoFa is therefore more accessible even for first-time robot users who are more accustomed to consumer technology than to industrial machinery.

**Award-winning design**

Safe, approachable and appealing, GoFa stands out. In 2021, ABB's GoFa cobot was awarded the prestigious Red Dot Best of the Best Design Award in recognition of its unique design concept, to make the new robot appealing and accessible to users [5].

With the jury assessing thousands of entries every year, Red Dot’s “Best of the Best” award is for groundbreaking design and is the highest award in the competition, reserved for the most aesthetically appealing, functional, smart or innovative design.

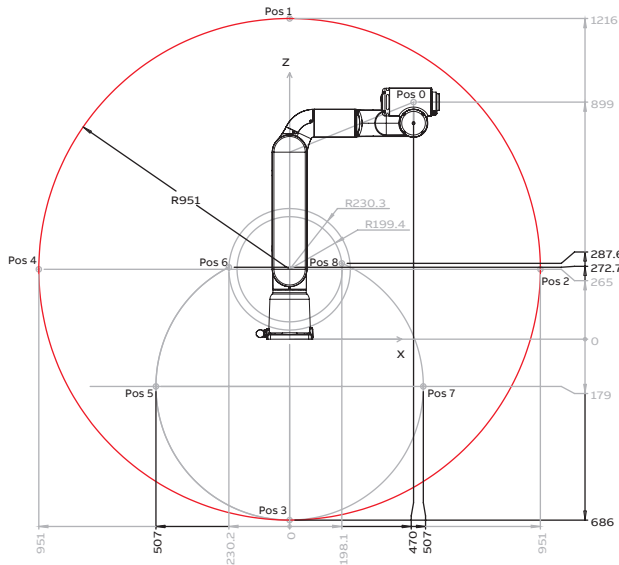
Sami Atiya, President of ABB’s Robotics & Discrete Automation Business Area said “Making robots more approachable, easier to use and more intuitive is key to our vision to make robots as familiar in the workplace as a laptop is today.” He added, “GoFa is a gamechanger, reinforcing the importance of good industrial design to make it easier for more people to work with robots. Creating an approachable design will ensure robots are adopted across a range of workplaces outside traditional factory environments.”

**Easy to set up and use**

Beyond world class design, ABB provides innovative, advanced and connected solutions for all of their collaborative robots and GoFa is no exception. With all functions implemented on the intuitive, graphical, tablet-like FlexPendant, eg, SafeMove configurator, GoFa is a snap to set up, configure and operate →04. Installation includes a start-up package that provides ABB Ability™ condition monitoring and diagnostics as well as a support hotline to access ABB’s expert technical assistance.

The Wizard easy programming feature, possessed by all ABB’s families of new cobots (GoFa™, SWIFTI™, single arm YuMi™) and an increasing number of industrial robots, allows novices to quickly and easily create robot programs even without the ability to code. Users can teach their robot new tasks in minutes by simply dragging and dropping graphical boxes in the

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In 2021, GoFa was awarded the Red Dot, Best of the Best design award in recognition of its unique design concept.



03a

app. ABB has added online tutorials and how-to videos on topics from setup and programming, through to operation and troubleshooting.

Experienced ABB robot users have not been neglected either. Wizard Skill Creator allows expert users to create their own customized blocks, known as Skills, which can be produced to control grippers or create actions for specific applications such as laboratory automation.

Existing customers appreciate that their expert ABB robot users can continue to access engineering tools, eg, RAPID programming, RobotStudio®, as they have previously without the need to learn new systems for ABB’s cobots. Overall, GoFa offers beginners and experts alike all the engineering and programming tools they need to create programs and teach their robots easily [1].

**Customer value**

Not surprisingly, since its launch in 2021, GoFa has received an overwhelmingly positive response from ABB’s customers. Customers especially like the Wizard easy programming feature. Further, both novice and experienced



03b

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03 GoFa's working range is depicted.

03a The working range of the robot arm is shown from the side view.

03b Gofa's working range makes it useful in diverse settings such as the example shown here.

—  
04 Wizard Easy programming allows novice users to easily drag and drop existing boxes and with Wizard Skill Creator users can create their own customized blocks.

—  
05 RobotStudio® is ABB's simulation and offline programming software for programming, configuration and virtual commissioning before installation.

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customers appreciate the user-friendly experience, akin to that of tablets, resulting from having functions implemented as apps on the FlexPendant.

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Approachable, fast and intelligent, GoFa stops immediately upon contact, thereby protecting workers of all kinds.

Overall, GoFa™ CRB 15000 Collaborative Robot is ushering in a new era of collaborative robots – approachable, fast and intelligent; this cobot reaches further than ever, yet stops in milliseconds upon contact, exactly what workers need from a helping hand. •



ABB ABILITY™ GENIX DATALYZER™

# Beyond emissions monitoring

With ABB's new cloud-hosted analytics platform, industries can make the leap from preventive to predictive maintenance. By monitoring asset health in real-time, customers can better meet compliance and regulatory requirements for Continuous Emissions Monitoring.

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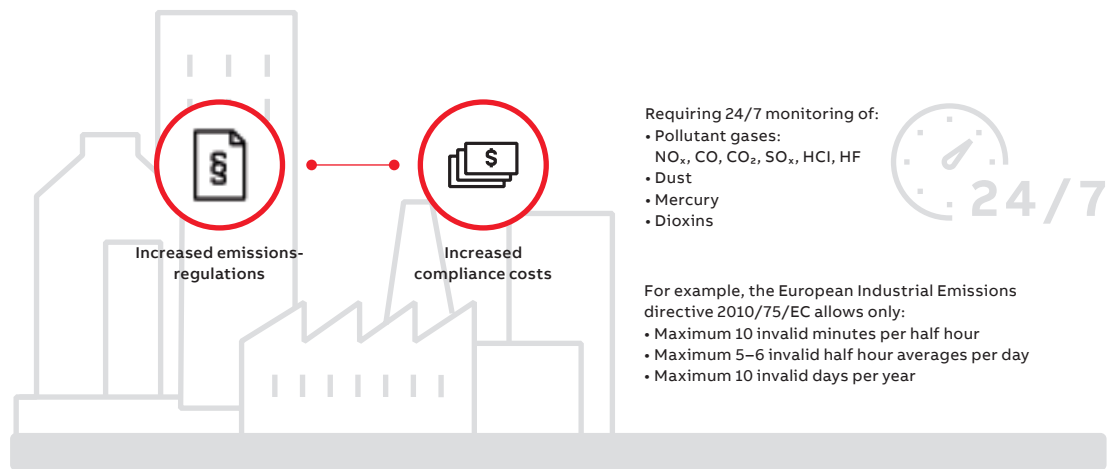
Over the past decade, increasingly stringent environmental regulations have been implemented throughout the world. Although emission monitoring regulations vary, locally, nationally as well as internationally, regulators often require clients to continuously measure and control

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Despite their benefits, regulations pose challenges for industries, such as waste management and power generation.

a battery of pollutants (gases, such as sulfur dioxide (SO<sub>2</sub>) and carbon dioxide (CO<sub>2</sub>) and particulates). To accomplish this, regulators have instituted demanding analyzer availability requirements →01. Enter ABB to provide customers with greater transparency and predictability for Continuous Emissions Monitoring (CEM). Launched in 2021, ABB's Genix Datalyzer™ is



01 Tighter emission restrictions impact costs to businesses as illustrated in this diagram.



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ABB's cloud-hosted data analytics platform for fleet-wide asset health monitoring →02.

### Compliance challenges

Despite the environmental benefits that regulations bring to society, they pose critical challenges for industries, eg, cement, waste management and power generation, that must comply. First and foremost is cost: the cost associated with meeting compliance and the costs of non-compliance have never been higher than they are today. So, industries seek cost-effective solutions that are accurate and reliable yet meet strict compliance regulations and standards for quality assurance<sup>1</sup>.

Even though gas analyzers provide real-time data that customers require for compliance, data availability alone is not sufficient for compliance. Advanced equipment requires skilled maintenance and service support staff to ensure regulatory compliance. Herein lie further industry challenges. Finding local skilled staff can be difficult; and those available are often overstretched. Staff might not be available around-the-clock in some localities; and, for some operations it may not even be possible to have on-site expertise at all. Any of these situations can result in non-compliance, additional costs and reduced performance.

### ABB Ability™ Genix

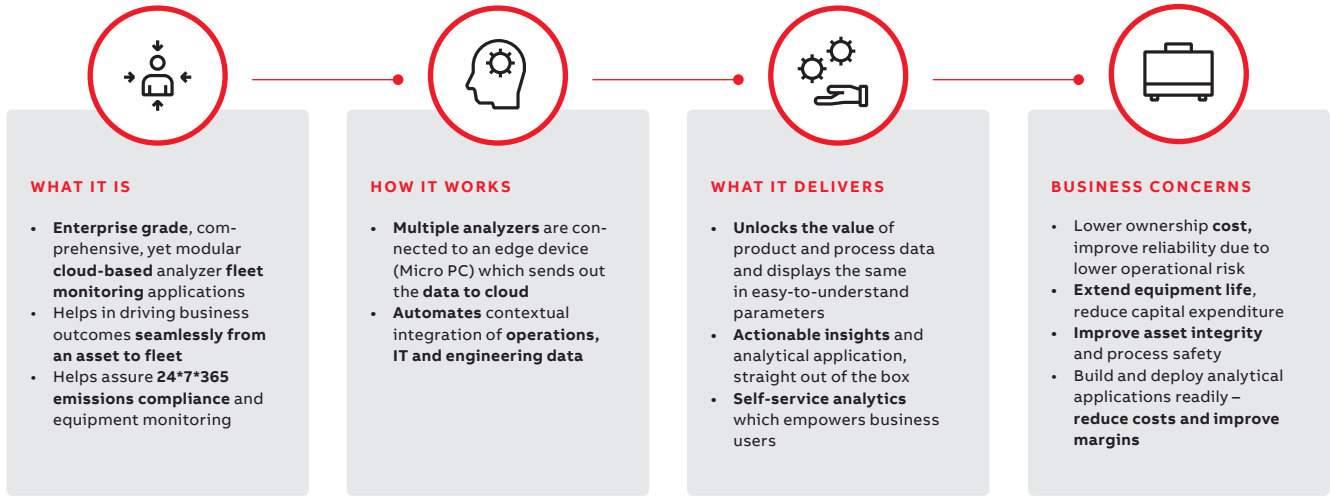
With over 60 years of experience in emissions monitoring, ABB is able to provide their gas analyzer customers with cost-effective,

emission-compliant, and sustainable emission monitoring solutions that are dependable and offer reliable performance along with safety. With the launch of ABB Ability™ Genix Analytics and AI Suite in 2020, ABB demonstrated their ability to marry their industrial and automation experience with digital innovation to help industries in their digital transformation [1] to reduce costs and increase performance. ABB can now automate and contextualize operational technology (OT), information technology (IT) and engineering technology (ET) data. With assets, such as gas analyzers, at its core, this powerful platform

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**ABB provides their customers with cost-effective, emission-compliant, and sustainable emission monitoring solutions.**

includes the collation of the massive data that each asset generates. Since customers rely on assets designed and delivered by ABB, eg, analyzers, ABB is ideally positioned to know how to extract, converge, contextualize and utilize data for prediction possibilities, and suggest improvements. With Datalyzer, ABB can now add another value-added digital service to their market leading Continuous Emissions Monitoring System (CEMS) offering.



02

Through analysis of emissions data and associated equipment, including sample handling systems, this new solution helps improve accuracy and availability while reducing personnel challenges; such as the need for local employee intervention and eliminating or reducing the need for personnel to operate these monitoring

By analyzing emission data and equipment, Datalyzer helps to improve accuracy and availability.

systems. Through an innovative service agreement delivered by service engineers, ABB has reinvented their business model and now offers customers ABB Measurement Care Agreements. With costs known, customers can now focus on business.

**Conceptualization**

Based on experience with hundreds of customers, ABB recognized six core dimensions that an emission monitoring solution must address: compliance, asset availability, asset quality and accuracy, resource availability, scheduled maintenance as well as safety and cybersecurity. These areas have been incorporated into ABB’s analyzer fleet monitoring solution.

Compliance is crucial as non-compliance with regulations has never been more expensive nor important than it is today, in terms of both fines and the threat of possible shutdown(s). Simply fulfilling the demands of increased regulations results in an increase in compliance costs; the round-the-clock monitoring of pollutant gases seven days per week without disruption is daunting indeed.

Asset availability is also key because the failure of a single part of an analyzer can cause cascaded damage to the entire system. Thus, end users need to ensure maximum analyzer up-time through regular monitoring of key parameters. For a holistic view of the system, one needs to gather the information from different sources. This added layer of complexity makes the monitoring process difficult.

Clients must also assure high asset quality and accuracy to fulfill emission monitoring regulations. There are disadvantages to utilizing preventive maintenance to do this. Because preventive maintenance is designed to keep the analyzer from failing, it is driven by a calendar – parts are replaced based on statistically determined lifetime averages. When parts wear out faster than expected, due to abnormal, particularly harsh conditions, or an undetected component issue, a fault occurs and troubleshooting follows →04. The quality of the analyzer is thus, diminished;



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02 ABB's ACF5000/  
ACF-NT Fleet  
monitoring solution  
helps companies add  
business value by  
removing complexity,  
and thus barriers.

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03 The ACF5000 CEMS  
solution was chosen for  
the Amagerforbraending  
waste-to-energy  
plant near central  
Copenhagen shown  
here. ABB's Datalyzer  
analytical solution for  
CEMS helps customers  
maintain regulatory  
compliance.

and this ultimately affects the measurement accuracy of different components.

Another factor is resource availability: Employee retirements and departures erode the “institutional knowledge” available to companies. Staff fluctuations challenge a company’s ability to standardize maintenance practices across multiple sites. Further, traditional maintenance personnel do not have sufficient time to keep up with IT advances such as, cybersecurity, technical bulletins, etc.

Scheduled maintenance must also be addressed. Obviously, there are more and less convenient times for scheduled maintenance. If a major disruptive event is not pre-empted with the help of condition monitoring or predictive maintenance solutions, companies face having to perform maintenance at the least convenient times, eg, at night, and this can be problematic and costly.

Further, safety and cybersecurity is critical, including safety of the personnel, operating systems and data. Recently, data breaches in major companies and ransomware attacks demonstrate such threats, eg, Colonial pipeline [2].

Despite the knowledge that these previously discussed six dimensions affect the performance of an emissions monitoring solution in one or the other way, it would be difficult to achieve the right asset quality using current conventional industrial preventive maintenance solutions. Consequently, end users can tend to overreact to minor events; this leads to a reduction in

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**Emission monitoring solutions must address core dimensions, eg, compliance, asset availability, quality, accuracy and safety.**

efficiency and impacts service costs as well. The result of such preventive maintenance is that costs and schedules become unpredictable. ABB strives to eliminate this unpredictability with Datalyzer.







— 04 Industries such as cement and waste management are required to monitor various gas and particulate emissions; this is a costly and difficult challenge.

— 05 A schematic of the Datalyzer network architecture.

**From preventive to predictive with the cloud**

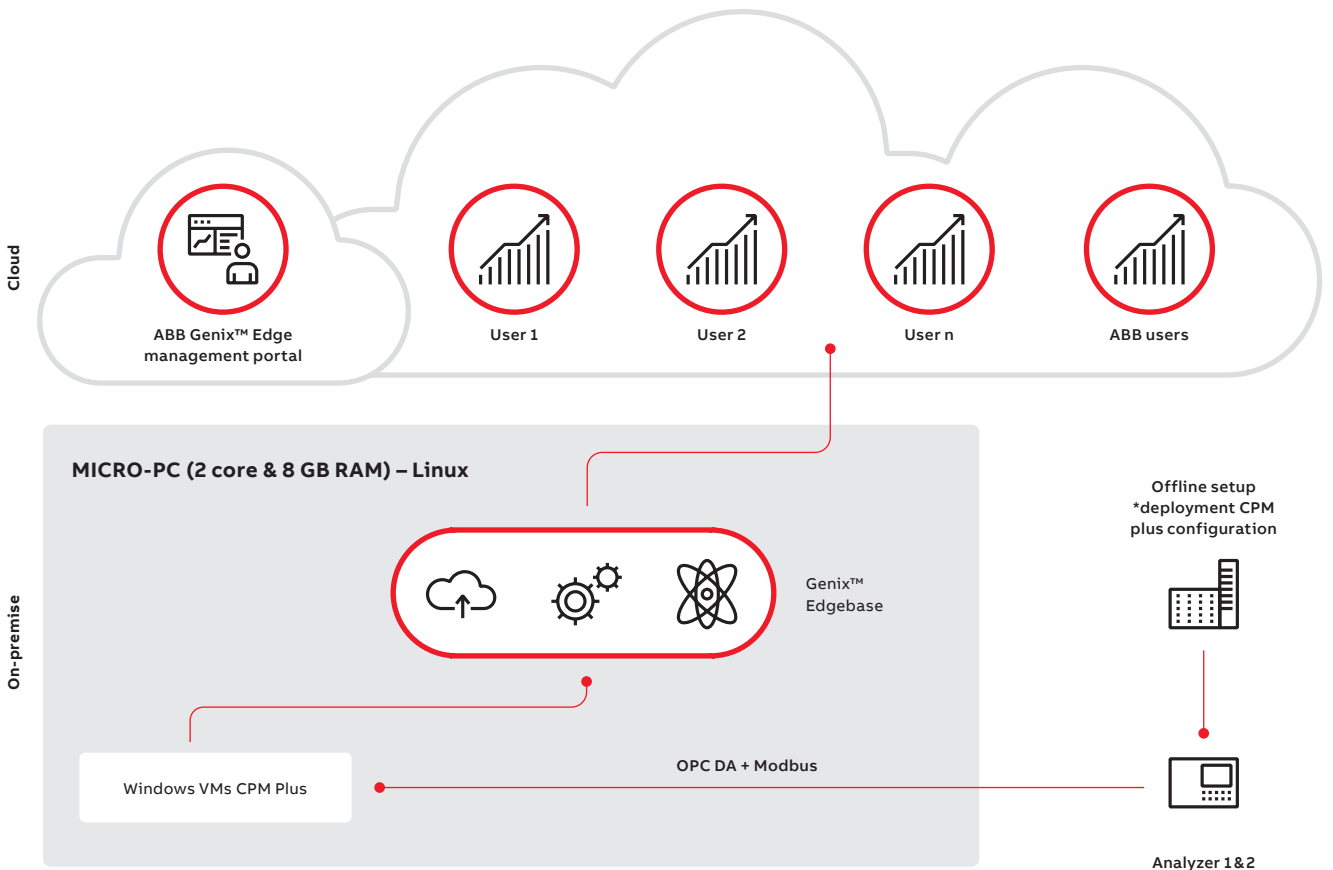
The central problem with conventional maintenance solutions is that whenever an end user wants to troubleshoot an issue with the analyzer, they must access various points of contact (POC) to fetch all relevant data points eg, for process data derived from Distributed Control Systems (DCS), or for system diagnostics accessed from a condition monitoring report, etc. Not only is this process troublesome, it creates barriers to

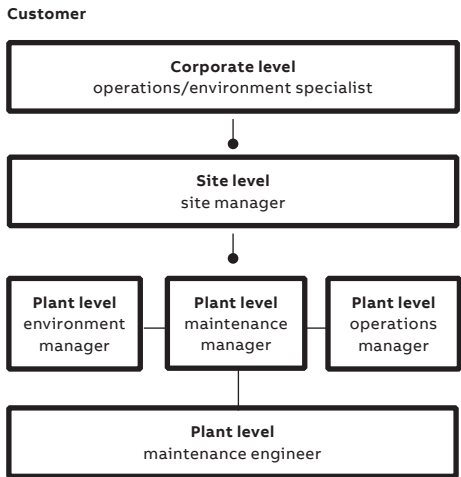
health and performance, process and safety in real-time. Only then can digital value-driver solutions be implemented.

By employing the Datalyzer cloud solution, customers can gather all the data points from the analyzer, relay them to the cloud and access the data in one location →05. Multiple analyzers are connected to an edge device (MicroPC) which sends out the data to the cloud. MicroPC acts as a virtual machine comprising CPM+ and Genix Edgebase as its two components. This allows for the contextual integration of OT data with IT data and ET data. Customers can then correlate the necessary variety of parameters live and pre-empt disruptions and major failures – predictive maintenance becomes a reality. By creating digital footprints and data in real time, value is created. ABB’s cloud solution with its seamless and instant connectivity, scalable computing power and associated lower costs, dismantles the existing barriers to value-added performance that hold industries such as waste management back.

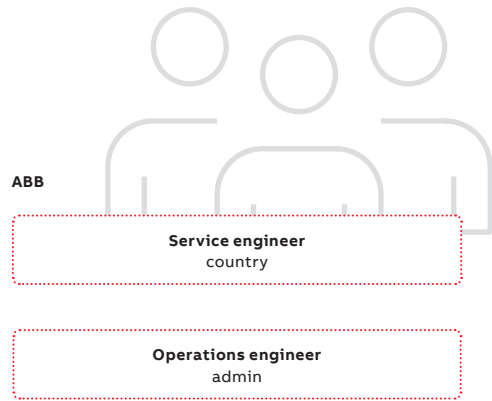
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 With Datalyzer, clients can gather analyzer data, relay the data to the cloud and access it in one location.

efficiency and productivity – no value is added. When assets create digital footprints and data points, companies can monitor their gas analyzer





06



**Role-based access for more control**

Because Datalyzer architecture is modular, a role-based access functionality is included →06; users can issue the right kind of access to the right team members. From an end user’s perspective, ABB has followed the UX principle of ‘progressive disclosure’ ie, the solution access will move from corporate to site to plant level.

Six types of access rights are offered: corporate-, site-, maintenance manager-, maintenance engineer-, operations manager- and environmental manager access. Corporate access allows operations or technical specialists to access the corporate-level dashboard, encompassing various sites and plants and all relevant associated data. Site access is provided to site managers covering various plants and plant data access. ABB has included separate access rights for maintenance managers, maintenance engineers, operations managers and environment managers at the plant level. Because each user has specific roles and responsibilities, the access rights are tailored accordingly and provided based on the target users’ focus areas.

**Datalyzer features**

For compliance, efficiency and performance, the step to value begins with the ability to monitor asset health and performance, process, and safety, etc. with real-time data →07a. Datalyzer achieves this by featuring capabilities such as analysis of analyzer health data, and live system diagnostics data. Historical data trend analysis is also available for as far back as five years →07b. In this way, ABB’s Datalyzer provides value-added insights by means of the analyzer health score and correlation plots, etc. With the

health score function, the user can benchmark; compare different analyzers’ health and troubleshoot an issue; in case a health score indicates a downward trend of a particular analyzer.

The QAL3 reporting and assessment function is a key regulatory feature →07b. The QAL3 regulation requires companies to maintain and demonstrate the required quality of the measurement results during the normal operation of the analyzer management system by checking that the zero and span characteristics are consistent with those determined during QAL1. Essentially, the standard requires suitable equipment (QAL1) to be set-up correctly (QAL2) and maintain correct

The QAL3 reporting and assessment function is a key regulatory feature of ABB’s Datalyzer solution.

operation (QAL3). As per emission legislation EN- 14181 guidelines, customers must perform the QAL3 validation using any, or, a combination of CUSUM, SHEWHART and EWMA charts. ABB’s solution provides the customer with automated charts (CUSUM, SHEWHART and EWMA) for any interval (up to one year). Users can also generate reports in PDF- and EXCEL format for analysis documentation or for submission.

**Looking ahead**

Because data is now easily available and accessible, ABB will develop further applications

06 By issuing user roles and access rights according to needs, the solution access moves across different levels from corporate to site to plant level.

07 The key benefits of implementing ABB's cloud-based solutions.

07a A schematic that illustrates how Datalyzer helps companies to make the shift from preventive (before) to predictive (after) maintenance.

07b The diagram shows the key benefits of implementing Datalyzer: more data means more insights and more control; measurements are made easy and compliance is a snap.

to provide customers with more value-added benefits, eg, sending automatic notifications for possible future events. Also planned for a future

The next application release will include AI and ML cognitive models for more predictive and prescriptive capabilities.

release, is a system anomaly detection application that will enable prediction of major failure events by analyzing the outlier data.

By providing industries with a modular cloud-based platform that can be easily adapted, ABB reinforces a fundamental stance: supply a range of software, applications and services to help customers improve productivity, process performance, product quality, efficiency and safety. The next Datalyzer release will extend the capabilities to include advanced artificial intelligence (AI) and machine-learning (ML) cognitive models that will provide the end user with even more predictive and prescriptive capabilities (PEMS integration and dispersion modelling). Thus, ABB creates value beyond the asset to include the entire enterprise. •

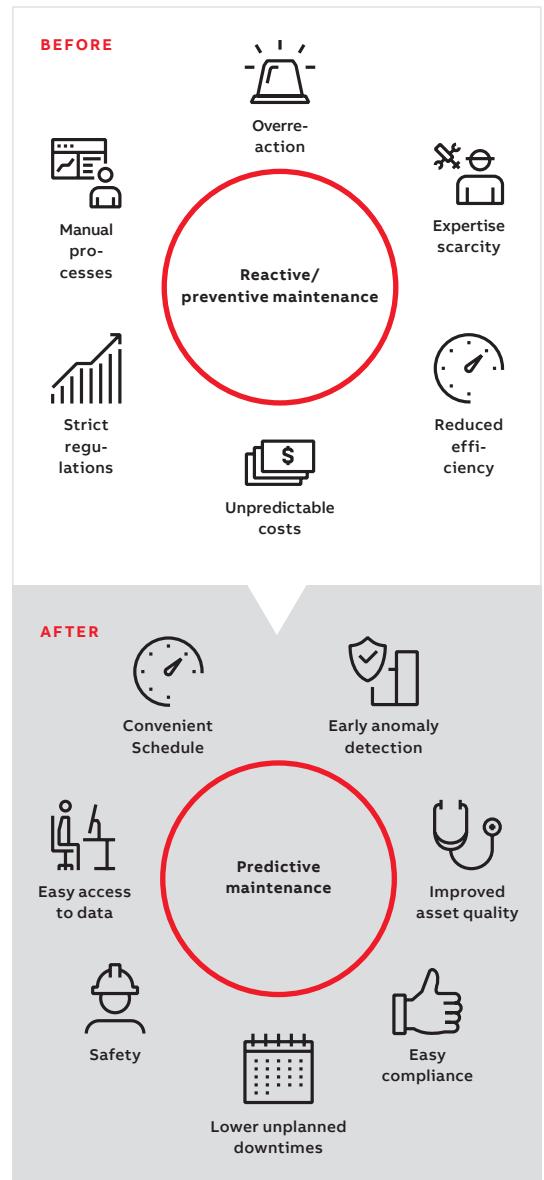
Footnote

<sup>3</sup> Nowadays, industries must comply with various regulations such as Industrial Emissions Directive (IED), or the Integrated Pollution Preventive Control (IPPC) Directive or the Waste Incineration Directive (WID) and the European standards, eg, QAL2, QAL1, QAL3, EN 14181.

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[1] R. Ramachandran and S. Bhot, "ABB Ability™ Genix makes operations and asset management easy", *ABB Review* 3/2021, pp. 8–13.

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07a



07b



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## MULTIPHYSICS VORTEX FLOWMETER MODEL

# Go with the flow

ABB's validated high-fidelity multi-physics model of the vortex flowmeter predicts flowmeter performance with high accuracy, enabling design modification for improved performance, even at low flow rates. Applied to other flowmeters this model approach can be used as a digital twin. By complimenting business efforts to modify existing designs, this digital asset enables faster time to market.

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A key enabler of effective process monitoring is the ability to measure and hence, monitor physical parameters like flowrate, pressure and temperature. ABB, with over a century of experience in flow measurement and control technology, meets measurement requirements across industries such as oil and gas, chemical processing and power generation. Here, the vortex flowmeter is an invaluable member of ABB's flowmeter portfolio.

The global demand for the vortex flowmeter, stems from its unique capability to measure flowrates of diverse fluids, eg, clean gases, steams and liquids, with high accuracy while

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The vortex flowmeter is unique in its capability to measure flowrates of diverse fluids with high accuracy.

being relatively simplistic in construction. These attributes ensure that industries such as oil, gas and chemical (OGC) as well as power generation have access to a cost-effective, low maintenance, and reliable method to measure flow in pipelines, tanks, and industrial chambers, etc. ABB's vortex flowmeter varieties like VortexMaster

flowmeters (FSV 430, FSV 450) are ideal for use on petrochemical raw materials, demineralized water and for direct, cost-effective steam mass flow measurement under diverse conditions →01. While these flowmeters promise the customer high quality performance, there is still scope to push the performance standards beyond current limits. Why is this so? Because measuring flow accurately with vortex flowmeters at low flow velocities is a well-known challenge.

Marrying their experience and expertise in measurement technology with their ability to drive digital innovation, ABB researchers embarked on a journey to develop a high-fidelity multi-physics model of the vortex flowmeter: a tool to evaluate new design ideas for improvement in performance.

### Vortex flowmeter ideation and planning

ABB's existing range of vortex flowmeters are built to allow an excellent flow signal detection and provide measurement immunity from the effects of hydraulic noise and pipeline vibration [1].

Despite the market success of these products, beginning in 2019 and continuing throughout 2020, ABB's researchers leveraged their commitment, experience and expertise to develop multi-physics models of vortex flowmeters with a clear purpose: improvise existing designs and offer flowmeters with a high degree of



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— 01 One of ABB's vortex flowmeters, the VortexMaster FSV430. This basic meter is successfully used for accurate measurement of the flow of gases, liquids and steam over a wide range of temperatures.

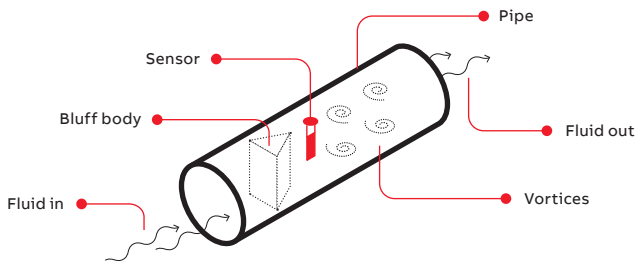
measurement accuracy at low flow velocity (lower than 0.2 m/s). The idea was to employ computational fluid dynamics (CFD) in conjunction with structural mechanics analysis, to evolve models that could resolve the complicated flow and structural dynamic events within the flowmeter. And, this would allow for an optimal design, thereby promising quality measurement at low flowrates.

Anticipating the results of rigorous testing of a multi-physics model of the vortex flowmeter, ABB posed the next question, so relevant for innovating: Could such a modeling approach be used as a predictive tool or digital twin for other

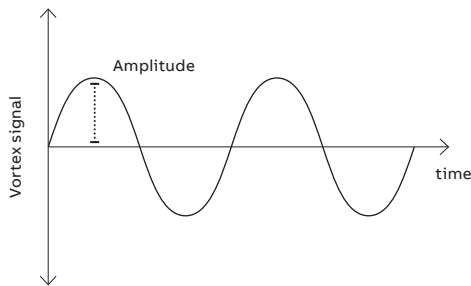
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**ABB believes there is scope to push flowmeter performance standards beyond current limits.**

flowmeters in the future? If so, then this innovative modeling platform would be an invaluable asset to ABB's flow measurement portfolio and a gamechanger for customers.

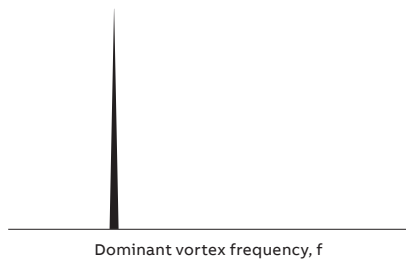




02a



02b



02c

### Vortex flowmeter from the ground up

The vortex flowmeter functions according to the Karman vortex shedding principle. In short, when a fluid flows through a pipe provided with an obstructing bluff body – a non-streamlined object, vortices are shed on either side of the obstruction, and the pulsating disturbance is recorded by a downstream sensor →02a. The fundamental frequency of the pulsations,  $f$ , calculated by the processing unit, is proportional to the velocity, and is hence used to estimate the velocity. The Strouhal number, which characterizes flowmeter performance and is related to its calibration factor, is given by the product of pulsation frequency and bluff body characteristic dimensions divided by the corresponding velocity. Ideally, the Strouhal number, should be

independent of fluid velocity, thereby ensuring linearity in performance across a wide range of velocities.

In addition to linearity in performance, strength or amplitude of the raw vortex signal should be adequate for detection under low velocity conditions →02b–c. This is crucial because low velocities are associated with weak signals, and prone to noise adulteration that could result in measurement inaccuracy – a possibly disastrous scenario. Hence, the need to improvise flowmeter designs.

The aim is to generate sufficiently strong vortex signals, so that low flowrate detectability is enhanced. At a given flow rate, the signal strength primarily depends on design features of the flowmeter components. Conventional use of experimental approaches to perform parametric studies on design features to optimize design is cost-intensive and time-consuming due to hardware requirements, availability of resources, etc. Further, complicated physical events are extremely difficult to resolve using experimental studies alone. Models capture a holistic view of critical physical parameters like flow and pressure, whereas experimental studies can only provide a superficial picture of complex

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**ABB's model-based approach enables the optimal design to improve flowmeter performance standards.**

physical events. With hesitancy justified, how can accurate, cost-efficient and easy-to-engineer flow meters be designed? Enter ABB's innovative model-based approach to flow meter design. By adopting this approach to perform a series of parametric studies, ABB creates the optimal design to improve flowmeter performance standards, thereby minimizing the time-to-market and obviating the need for arduous experimental procedures.

### CFD model and physics-based digital twin

A CFD model was developed to simulate the complicated fluid dynamics within the vortex flowmeter using the finite volume analysis scheme and leading edge mathematical techniques, such as advanced turbulent wall formulations, to solve the fluid flow conservation equations of mass

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02 Schematics indicating vortices origin and characteristics during flow.

02a This schematic illustrates how vortices are generated as fluids pass through a pipe.

02b The strength or amplitude of the raw vortex signal varies over time and should be strong enough for easy detection.

02c The dominant vortex frequency is shown.

—  
03 CFD model simulated the complicated fluid dynamics within the vortex flowmeter as shown.

03a CFD model: Fine spatial and temporal resolution is shown.

03b The image shows the distribution of predicted complex flow.

03c The model calculates the coefficient of lift over time.

and momentum, in a 3-dimensional space within the flowmeter domain →03a. Complex time-varying velocity patterns that could be well-resolved by the model contributed to an understanding of the intricacies inherent in the flow process and ultimately led to an ability to predict performance →03b.

The model calculated the coefficient of lift acting on the sensor as a function of time or the signal profile →03c. A fast Fourier Transform of the signal yielded the dominant frequency at the given flowrate. This was possible because a Fourier Transform decomposes functions dependent on space or time into functions dependent on spatial or temporal frequency.

#### Testing and validating the model

The model was initially validated by comparing the computed results with measurement data gathered from previous tests run on a standard flowmeter, a close agreement between the computed and measured vortex frequencies across the selected range of fluid velocities was

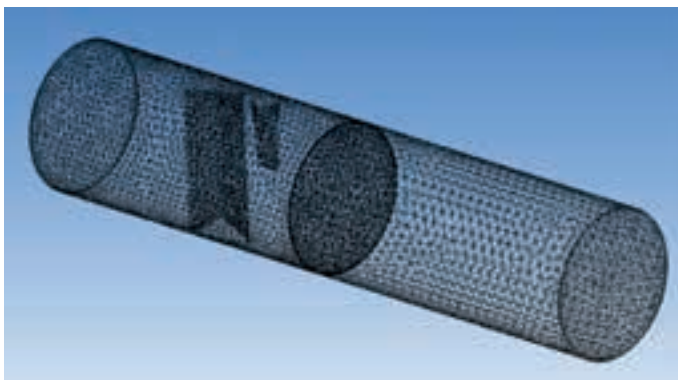
realized; this included velocities below 0.2 m/s →04. These results established confidence in the modeling approach.

#### Linearity in performance

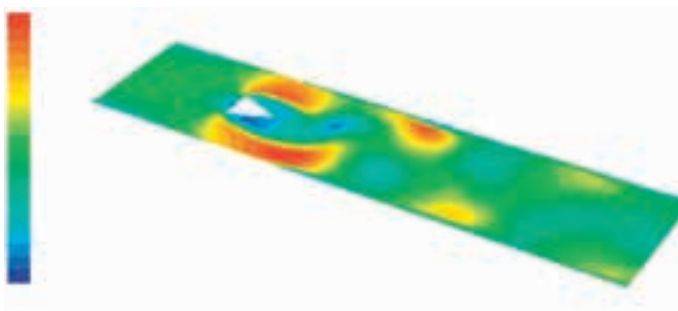
In addition to achieving adequate signal strength, it was essential to ensure a high degree of linearity in flowmeter performance. In this way, the device calibration factor obtained at high flowrate will also hold true at low flowrates. For this purpose, the dimensionless Strouhal numbers were calculated and compared with selected Reynolds numbers. Reynold's numbers

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Following model development and validation, several flowmeter design modifications were evaluated.

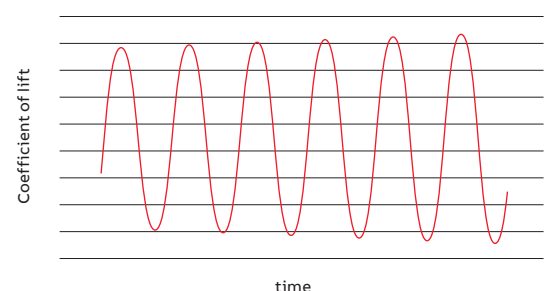
for a flow are a measure of the ratio of the inertial force to viscous forces in the flow of fluid bound to a body or channel; it is a non-dimensional parameter of the speed of fluid flow used for flow prediction. Used to describe oscillating flow mechanisms, Strouhal numbers, which are proportional to the pulsation frequency and the buff dimensions and inversely proportional to said velocity; were calculated from the computed and measured vortex shedding frequencies. The Strouhal numbers were found to be independent of the fluid velocities or Reynolds numbers selected in the studies →05, thus ensuring linearity in performance across the selected flow range.



03a

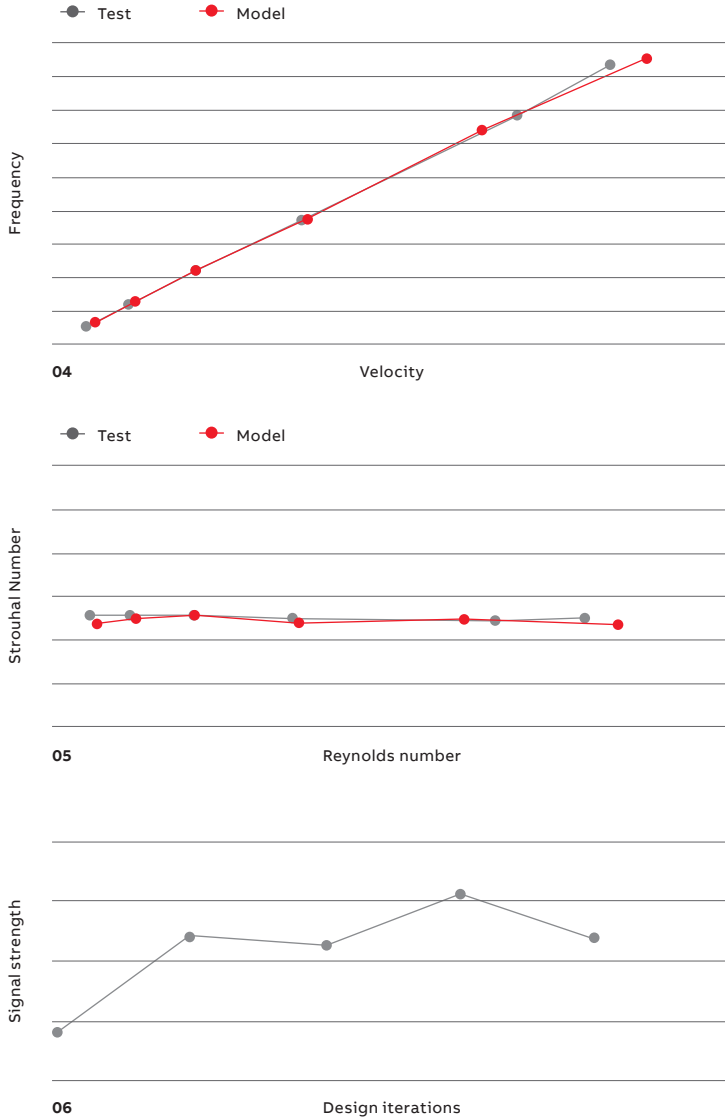


03b



03c





**Model-based design optimization**

Once the model was validated, several flowmeter design modifications were evaluated. These design modifications were simulated to arrive at the optimum design; one that yields the best signal strength →06.

**Structural issues**

The story would be finished here but for the possibility of disadvantageous structural issues. One possible source of noise that could impair the accuracy of vortex flowmeters is structural vibration of the sensor assembly. Such impulsive forces can negatively affect the output signal. Complimenting the CFD model, a finite element, structural dynamics model was developed that is capable of evaluating vibrational characteristics

of the sensor to rectify this affect. Significantly, model results revealed minimum interference between the vortex frequencies and the sensor’s natural frequency →07; thereby providing assurance of the absence of vibration-related artifacts in the flowmeter output signal.

**Manufacturing modified flowmeters and subsequent testing**

Based on the guidelines from the CFD model, the vortex flowmeter was re-designed and prototyped using the additive manufacturing 3D printing method →08a at an ABB PAMA facility in Shanghai, China. Subsequently, the modified flowmeter was installed in the test rig at ABB’s business testing center →08b, tested to measure the signal strength; this was then compared with the signal strength of the existing conventional flowmeter designs in current use.

As per the findings in the CFD modeling studies, the preliminary test results showed a significant increase in signal strength of the modified flowmeter with respect to that of the existing flowmeter – under constant, yet, low velocity conditions. Thus, ABB’s primary goal, to improve vortex flowmeter capability by measuring accurately at low flowrates was achieved.

**Future flows**

The promising success of the model-based approach to improvise the vortex flowmeter has encouraged ABB’s modelling and physics experts to develop extensive prototypes and conduct further testing of modified designs. One important possible application currently under investigation is the expansion of the modeling-approach to

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 Simulated design modifications led to the optimal design; one that yields the best signal strength.

evaluate possible design modification benefits in other flowmeters eg, ABB’s swirl flowmeter. Operating according to the same shedding vortex principle, swirl flowmeters are important for measuring volume flow where piping requirements are tight, eg, petrochemical raw material flow. Unlike vortex flowmeters, swirl flowmeters create their own flow profile within the meter, they require only a 3 diameter upstream straight pipe run after a pipe reduction and a 5 diameter after a control valve plus 1 diameter downstream.

— 04 ABB's model is in close agreement with test results; this supports the use of the modeling methodology.

— 05 Excellent linearity across extreme flow conditions is confirmed by tests and the model.

— 06 The model identifies the optimum design, the one yielding the highest signal strength.

— 07 Finite element structural model investigated possibility of vibratory influence on flowmeter output signal.

— 08 Prototype production and test rig.

08a 3-D printing set up used for the prototype production is shown.

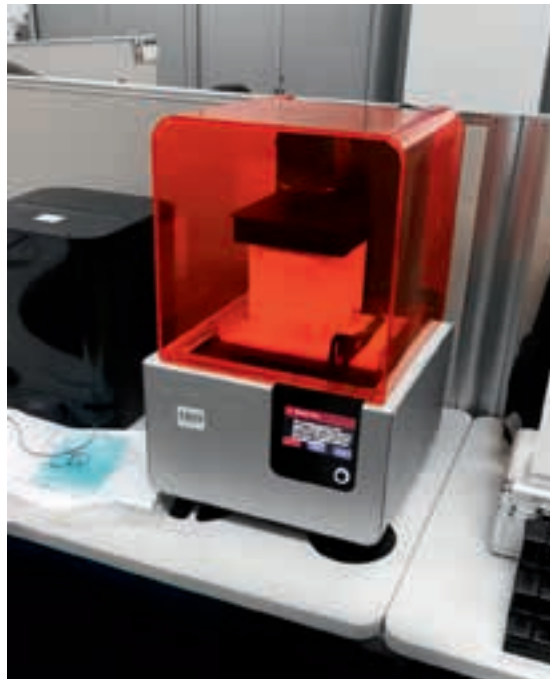
08b The test rig used to measure signal strength, etc. is shown.

## Prototyping and testing results confirmed improved vortex flowmeter measuring accuracy, even at low flowrates.

By expanding this modeling approach to other flowmeter types, ABB addresses the diverse needs of the oil, gas and chemical sectors.

By iterating the vortex flowmeter model approach to other flowmeter applications ABB takes another step to enable innovation.

Through invention, testing and validation, learning, and applying their knowledge and success elsewhere, ABB drives technical innovation in an expanding digital world. For flowmeter customers, this innovation results in optimal performance and cost-effective solutions. •



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ABB'S EASY-TO-FIT NOVOLINK™  
DIGITALIZES MOTOR STARTERS

# Simply connect

ABB's all-new ABB Novolink™ devices digitalize motor starting solutions and give insights into the connected loads. The devices connect directly to standard AF contactors, making them easy to install. Novolink also enables predictive maintenance, increases efficient motor operation and reduces costs.



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Electric motors make the industrial world go round – literally. There are millions of motors installed worldwide and around one-third of the world's electricity is converted into motion by electric motors. The number of such motors is expected to double by 2040. How can this large

Uniquely, Novolink offers the highest levels of out-of-the-box digitalization using AF contactors and no specialist cabling.

installed base profit from the very substantial benefits that can be accrued from digitalization, without incurring prohibitive costs →01? ABB's new Novolink devices supply the answer.

Novolink is the only solution to offer the highest levels of out-of-the-box digitalization using AF contactors and no specialist cabling. Novolink

delivers high-grade motor protection and monitoring in the simplest, most efficient way possible. Novolink's remote monitoring capabilities identify issues early on, keeping maintenance well ahead of any problems. By monitoring key electrical measurements, as well as significant maintenance aspects that are important for motors and general load feeders, the Novolink smart devices take Industry 4.0 digitalization strategies to a new level.

#### ABB Novolink

ABB Novolink modules equip traditional control gear with digital capabilities →02. The modules enable the predictive maintenance, remote control, fault diagnostics and data analytics required for the world of Industry 4.0. Novolink connects electric motors into higher-level automation and smart factory systems, giving customers the real-time data and analytics they need to implement energy-saving strategies and make an impact on their operational efficiency →03.

With Novolink, there is no need to replace existing AF contactors. The Novolink devices can be



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01 Digitalization of industrial electric motors saves energy, reduces costs and improves production performance.

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02 ABB's Novolink devices help digitalize industrial electric motors.

simply snapped onto any AF contactor from an AF09 up to an AF96 equipped with a 24 V DC coil. ABB's AF contactors have an advanced, electronically controlled magnet system that covers the complete power range and are complemented by a full list of accessories.

#### ABB Novolink smart modules

ABB Novolink consists of two modules: the SFM1 and the SCV10.

The SFM1 Novolink contactor module monitors key maintenance statistics, including motor operating hours, contactor switching cycles and trips. The module is equipped with two X2X interfaces for incoming and outgoing connections. The module and contactor are supplied by the 24 V DC that goes to the SFM1 module. A digital input makes it possible to pick up an auxiliary signal, eg, from a device with short-circuit protection functionality, such as the ABB MO132.

The AF contactor is mechanically linked to a lever, which provides a visual feedback of the contactor position on the front of the SFM1. The lever also

allows the manual operation of the contactor for test purposes. A status LED displays the operational state of the SFM1 module itself.

The optional SCV10 Novolink smart current and voltage module provides motor protection and monitors the status of connected equipment. This module connects to the SFM1 module and measures line voltages, phase currents, power, frequency, total harmonic distortion and other

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The SFM1 Novolink contactor module monitors key maintenance statistics.

important parameters →04–05. The SFM1 module is equipped with feed-through current sensors to measure the current in all three phases of the connected load. The device also offers the option to measure the line-to-line voltage of the three phases up to 690 V AC. A ribbon cable



connects the SCV10 module with the SFM1 module and it is also supplied with power from there.

The SCV10 module offers advanced protection according to IEC/EN 60947 for single- and three-phase induction motors. Relevant parameters such as the trip class and nominal current can be configured from within a programmable logic

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**Novolink installation is fast and simple, thanks to less wiring and fewer components than traditional approaches.**

controller (PLC). For optimized control of selectable trip classes 5E-30E, an advanced thermal model calculates the actual thermal load, time to trip and time to cool. The model considers both the copper and iron parts of the motor, thus providing the best protection for the motor. Before an overload trip occurs, a warning can be generated in the PLC by monitoring the thermal load. Novolink supplies cos-phi and real power

data to allow the user to monitor and protect pumps and other connected loads.

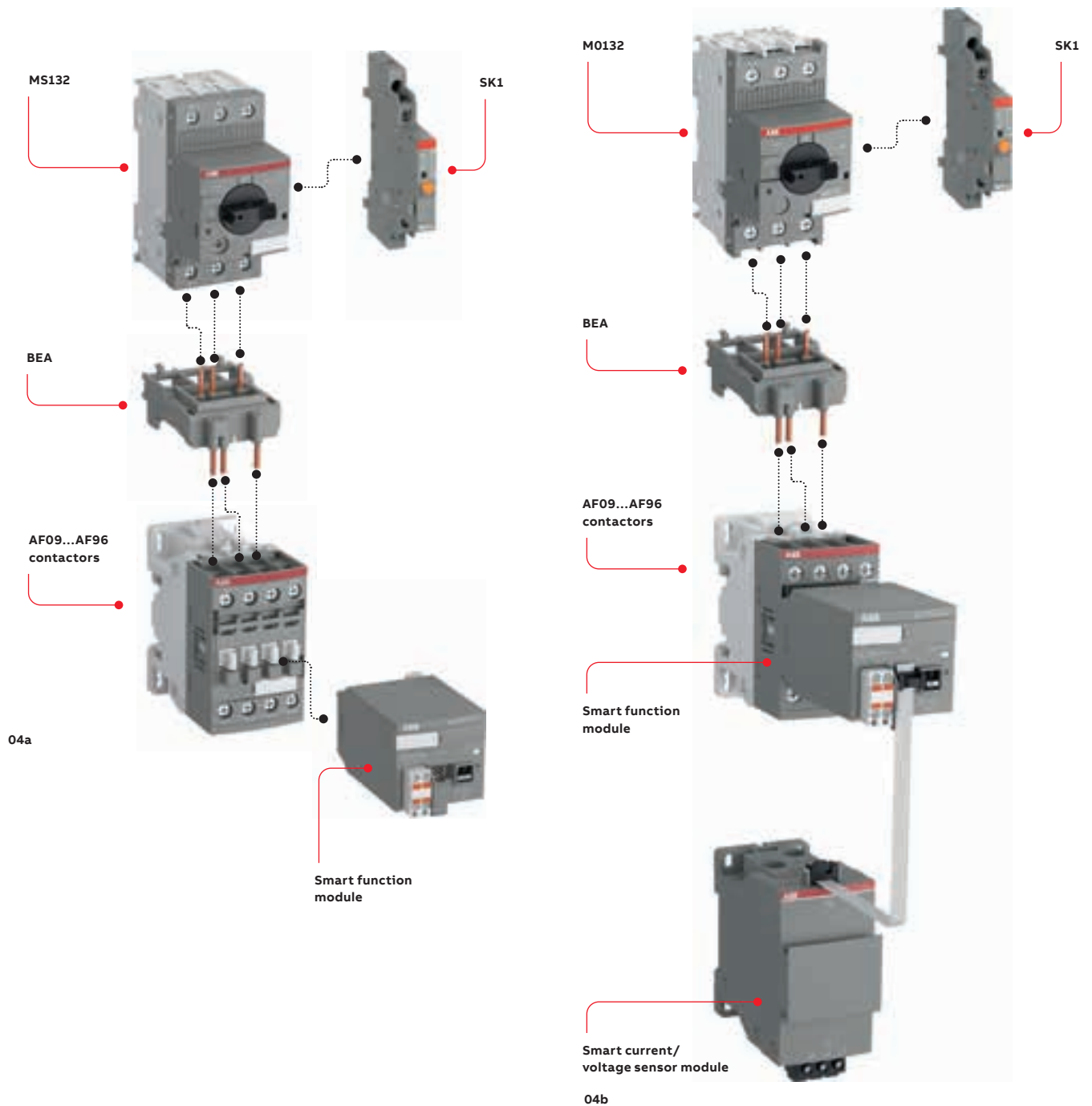
These two Novolink devices help detect load, supply, or feeder issues, making problem-solving faster.

#### **Reduced engineering effort**

Installation of Novolink modules is fast and simple, thanks to less wiring and fewer components than the traditional approach. The SFM1 snaps on to the existing 24 V DC coil contactors of ABB's AF range without increasing the effective width of the contactor. Novolink devices are compatible with 24 V DC coil contactors – from AF09 up to AF96 in screw versions and from AF09 up to AF38 in push-in spring versions. Because standard AF contactors can be used, retrofitting existing solutions is simple – in many cases only the control wiring needs to be changed.

Data from the contactors, the motor and connected loads is taken into the B&R Automation Studio integrated software development environment (see below) via the Novolink device's X2X bus. X2X provides some very useful features not available in other bus systems. For example, is it not necessary to set any bus address on the





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03 Novolink gives the user real-time data and analytics.

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04 Novolink modules.

04a Basic solution with a MS132 for motor protection, SK1, BEA and the SFM1 smart function module for remote control.

04b Full-featured solution consisting of a direct-online (DOL) starter with a MO132 as short-circuit protection device, AF contactor, SK1 signal contact, BEA connecting link, SFM1 smart function link, SFM1 smart function module and SCV10 smart current and voltage module for an encompassing motor protection.

module as bus addresses are automatically set by the system. This configuration feature removes a lot of pitfalls often encountered during commissioning or module replacement. It is also possible to update the firmware of the X2X modules via the bus, thus ensuring the system stays in a known state. Programming is simple, with all the data available from a single feeder node, making it easy to customize protection functions to the needs of the application.

Standard controls are ready to use out of the box without additional engineering and there is no need for expensive specialist cabling or further

training. Through the integrated connectivity and integration into B&R solutions, valuable information can be derived readily from raw data. Integration into other systems is catered for via B&R's OPC UA server and other gateways. Novolink's modules allow the remote control and monitoring of AF contactors via the B&R X20 bus from within a B&R PLC, reducing costs and increasing overall uptime.

Novolink devices can be connected in a daisy chain with multiple devices working in a sequence using standard Ethernet cables →06.



PLC



Drag and drop integration in B&R automation studio.

X2X



X2X

Binary I/O signals



### Level 3

Advanced motor protection and connected equipment monitoring.

### Level 2

Basic maintenance counters. Integrated check-back monitoring.

### Level 1

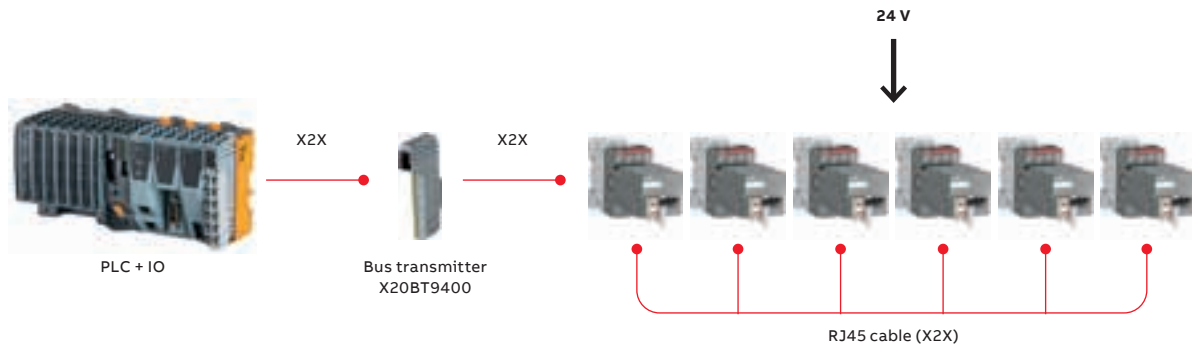
Auxiliary contactors to build local control logic and realize connection to a PLC via I/O signals.

Data from the Novolink devices can be used directly with a wide range of B&R system applications, including those that facilitate supervisory control and data acquisition (SCADA), human-machine interfaces (HMIs), audit trail, enterprise resource planning (ERP) systems, manufacturing execution systems (MESs) and cloud infrastructure functions.

**From corrective to predictive maintenance**  
Getting ahead of faults and problems is key to preserving uptimes, maintaining the longevity of equipment and ensuring the uninterrupted flow of production. With Novolink, it is possible to set thresholds and receive warnings of incipient

Data from the Novolink devices can be used directly with a wide range of B&R system applications.

equipment failure so that operational parameters can be adjusted to accommodate the changed situation while optimizing production and reducing energy consumption – all with the next maintenance window in mind.



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— 05 Novolink provides a top-level full suite of functions.

— 06 Connection is primarily via an X2X connector; daisy chaining is possible via RJ45 cables.

Advanced diagnostic capabilities make it simple to optimize performance by, for instance, switching off idle processes. The user can combine real-time diagnostics with long-term data trend analysis to unlock new service models.

The Novolink diagnostic capabilities allow operatives to immediately isolate problem areas (such as a malfunctioning load) without initiating a system-wide shutdown and arrive more quickly at a solution, thus minimizing disruption. For ease of use, all control, monitoring and diagnostic signals are fully visible and there is clear fault localization indication.

With B&R PLCs, monitoring can be carried out from a remote location via cloud connectivity, eliminating the need for maintenance personnel to conduct regular on-site checks.

Novolink's fully digitalized approach means that data trends can be analyzed over the long term so processes can be adapted to maximize performance.

#### The B&R Automation Studio

The B&R Automation Studio offers an integrated software development environment with tools for every project phase, including a wide range of diagnostics for system optimization. The user can access extensive target system information via the Web with the System Diagnostics Manager. The controller, drive, communication and visualization are all configurable in one environment, reducing integration time and maintenance costs.

#### The future of motor digitalization

Novolink is the only solution to offer such high levels of functionality using AF contactors and no specialist cabling. Novolink – which is fully integrated into the B&R automation system – delivers high-grade motor protection and monitoring in a very simple way. Remote monitoring enables

early identification of issues, prompting maintenance and ensuring equipment lasts longer. By monitoring the principal electrical parameters and maintenance aspects, Novolink smart

— **Novolink delivers high-grade motor protection and monitoring in a very simple way.**

devices take Industry 4.0 digitalization strategies into new areas. Data-driven functions, including predictive maintenance, remote control, real-time optimization, instant fault diagnosis and predictive analytics, will help factories by improving operational performance, reliability and long-term costs. •





## BUZZWORD DEMYSTIFIER

# ABB Ability™

ABB Ability is the brand name for ABB's holistic portfolio of digital solutions. All ABB Ability solutions have one thing in common: they empower ABB's customers to generate some form of insight that allows them to make better decisions about their operations →01.



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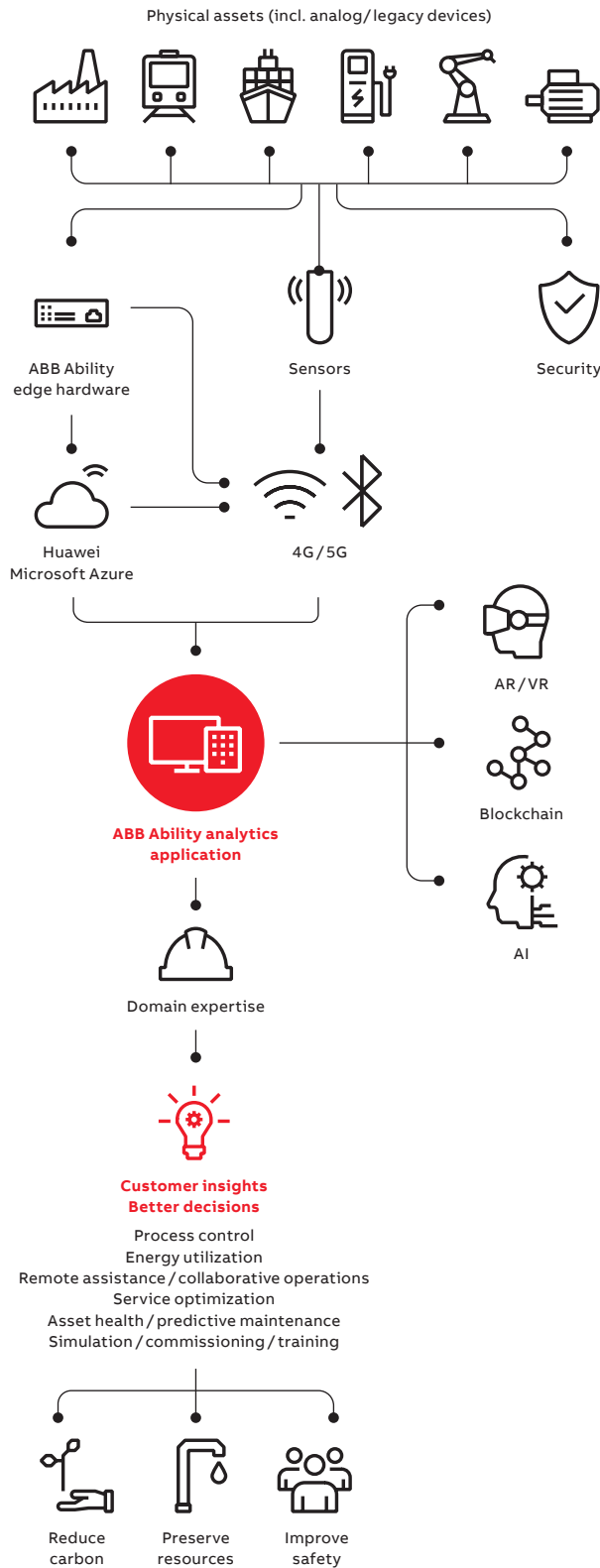
Spanning all four of ABB's business areas, and serving sectors like manufacturing, energy, transportation, marine, cities and construction, ABB Ability solutions are grounded in software but also rely on hardware and services to connect, secure, monitor, contextualize, visualize and analyze field data. Solutions are designed to enable a host of industrial use cases, including condition monitoring, asset health and management, predictive maintenance, energy management, simulation and virtual commissioning, remote/collaborative support and more, all falling under the umbrella of the "Industrial Internet of Things" (IIoT). Examples include ABB Ability™ Genix industrial analytics and AI suite; ABB Ability™ Energy and Asset Manager; ABB Ability™ Condition Monitoring for Powertrains; and ABB Ability™ Connected Services.

01 ABB Ability basics.

In general, ABB Ability solutions use sensors placed on (or embedded in) physical assets like motors, drives, pumps, fans, compressors, robots, buildings and electrical infrastructure. Data from these devices is transmitted across all manner of protocols and networking standards to edge devices or to the cloud for processing. From here, organizations can aggregate data and feed various operational and enterprise systems to perform analytics that help users make better decisions about how to manage an asset, fleet or value chain.

Many solutions in the ABB Ability portfolio leverage platform-as-a-service (PaaS) capabilities from partners like Microsoft and Huawei for compute, storage, database, identity management and other functionality to create a secure and highly scalable industrial cloud architecture. On top of this foundation, ABB incorporates relevant hardware (eg, switchgear, edge gateways), enterprise-grade cybersecurity for key workflows, and specialized, domain-specific software algorithms. •





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