review

Ideas matter

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ABB

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Tool-free, push-in wiring

ABB Ability™ Power Transformer

It's easy to talk about innovation, harder to be innovative, and extremely difficult to succeed over and over again. Any mission-critical challenge that starts with "what if?" must take into account a variety of requirements, specifications, and tolerances, and make sure to address issues of safety, reliability, and adaptability. The resulting "here's how" must also deliver performance and profitability. This annual issue of ABB Review highlights some of those recent innovation successes.

As always, your feedback is welcome at abb.com/abbreview

EDITORIAL

Ideas matter

Dear Reader,

Game-changing breakthroughs and disruptive innovations are rapidly becoming everyday fare for industries. Moving and staying ahead require the ability to continuously challenge and adapt to a fast evolving and often unpredictable market. In order to protect their investment, customers need systems that can be rapidly and painlessly reconfigured for different tasks, that readily collaborate and share information, and that learn and adapt autonomously. What may have sounded like science fiction only some years ago is fast becoming reality.

ABB is drawing on its broad and deep experience from across its traditional strengths, and combining these with new ideas to create and leverage advanced capabilities. Customers can receive comprehensive solutions rather than simply items of hardware.

ABB Review typically leads in its first edition of every year with short articles covering the latest breakthroughs. It is fitting that in this year's selection, virtually all solutions featured predominantly embrace these new paradigms.

Enjoy your reading,

Bazmi Husain
Chief Technology Officer

Innovation highlights 2019

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Innovating the innovation process is essential for success. A renaissance is underway in using data, and the visibility it provides, to innovate device and system design, operation, and maintenance, as shown by these examples. In March, 2019 ABB Customer World will provide an opportunity to see more innovations in action.

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Charting a course to autonomous shipping

Crossing an ocean in very good conditions can require so little intervention on the part of bridge personnel that it can cause mental fatigue. This can result in an associated loss of alertness that can lead to a situation where a human reacts too late to an event that might otherwise have been anticipated.

In view of this, and together with a focus on increasing the safety of navigation in areas where a high level of attention is required, ABB has introduced ABB Ability™ Marine Pilot Vision and ABB Ability™ Marine Pilot Control. The former is a situational awareness solution that provides real-time visualizations of a vessel's surroundings, while the latter provides a dynamic positioning (DP) system that simplifies ship maneuvering. Together, the two technologies create a powerful formula for enabling autonomous operations.

With its user-centric design, ABB Ability™ Marine Pilot Control reduces the workload related to navigational tasks and allows bridge officers to focus holistically on a vessel's overall control and positioning. To accomplish this, the system employs algorithms that calculate the optimal way of executing a command for controlling a vessel in any operational situation.

While the vessel is being maneuvered, ABB Ability™ Marine Pilot Vision provides a virtual model of the ship superimposed on real surroundings. Bridge personnel can switch between views instantaneously, making it easier to predict vessel motions and be alert to previously hidden obstacles or collision risks. The resulting improvement in situational awareness has significant benefits for safety and operational efficiency.[1] ●

ABB's NiTemp sensor initiates a new era in measurement

Traditionally, process industries install sensors through openings in otherwise intact pipes in order to regulate and monitor critical processes like temperature. Requiring intimate contact with the process medium, thermowells protect the sensitive temperature measuring inset from the jeopardizing effects of the flowing medium. However, these devices obstruct flow, can cause failure and adversely impact the measurement value. Introducing such a system to an existing industrial facility can result in downtime, safety risks and additional costs.

ABB's NiTemp is the first temperature sensor to match the performance of invasive devices without breaching the pipe wall, or sacrificing accuracy or response time.

The innovative double sensor architecture and advanced model-based approach results in the most accurate measurement of the surface temperature available in the market today. Temperature measurements deviate by less than 2 K per 100 K and response times are comparable or better than those obtained from invasive measurements. Installation costs can be reduced by up to 75 percent. There is no need to shut-down equipment, engineering workflow time is diminished and the time to deployment is reduced by an order of magnitude. State-of-the-art hardware components simplify requisition and maintenance of a fleet of such devices.

Developed and tested by ABB, and validated with partners in the food and beverage, and chemical, oil and gas industries, NiTemp was launched in November 2018; a wireless version will be available in 2019. NiTemp is ABB's first step toward providing the ultimate portfolio of noninvasive instrumentation solutions — making process measurements simpler and safer.[1] ●

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Footnote
1) For an in-depth article see *ABB's noninvasive temperature measurement creates digitization use cases* in the "Connected for productivity" section on p. 46.

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ABB Ability™ Conveyor Roller Inspection Services

For miners, the reliability of their conveyor belt systems is critical. Conveyor motors, drives, belts, and transformers are usually well monitored. However, the many thousand rollers, or idlers, that carry kilometer-long belts have, until now, been largely excepted from this monitoring world. Failing idlers do not only waste energy but also cause excessive belt wear and misalignment – or belt rupture or fire.

ABB has now developed a system that will do the idler inspection job not only fully automatically and very consistently but also with higher sensitivity and better cost-effectiveness than manual inspection. This new service uses a rail-guided vehicle to position the sensors automatically, accurately and repeatably.

The service is called ABB Ability Conveyor Roller Inspection Services (CRIS). The CRIS sensor head has a thermal camera, a visual camera with an LED light and an ultrasonic microphone.

The vehicle is a hanging (for stability) train with at least one locomotive and one sensor car. The sensor car controls the motion of the locomotive and the position of the sensor head on a pan-tilt unit. The vehicle design includes a rubber shell and a tilted roof to prevent damage from falling rocks.

Inspection tours are preprogrammed and executed on a regular schedule, which eliminates the need for continuous radio connection with the vehicle.

After each inspection tour, the vehicle docks at the battery-charging port of a base station and uploads its data. A graphical interface allows inspection scheduling and data analysis. By analyzing the history data of individual idlers, a complete idler condition map can be created. Furthermore, trend analysis can indicate imminent failure likelihood and allow replacements to be planned.[1]●

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Footnote
1) ABB Ability Conveyor Roller Inspection Services are discussed in greater detail in
ABB Ability™ Conveyor roller inspection services on pages 44-49 of ABB Review 04|2018.

ABB Ability™ Power Transformer sets new industry standards

Power transformers are critical grid infrastructure elements that today face more dynamic load conditions and stress than has traditionally been the case owing to the integration of distributed energy resources and electric-vehicle charging infrastructure, etc. Therefore, today's operators need actionable information and insights to better manage their fleet while ensuring the highest levels of reliability and availability.

This is why ABB has developed the ABB Ability Power Transformer (AAPT) as a new standard for power transformers. Developed as a future-proof, modular platform concept, the AAPT is an integrated solution with digital capabilities, which include electronic temperature monitoring and onboard intelligence on load and ageing conditions as standard features. This solution can be scaled up to a full monitoring package with plug-and-play connectivity to include the whole family of ABB eDevices (digitally enabled measurement and safety devices), ABB's dissolved gas analyzers (DGA) CoreSense and CoreSense M10, and the option to integrate third-party sensors and instrumentation.

The AAPT platform is independent of the type and size of the transformer and is fully compliant with relevant industry standards. To ensure system stability under adverse conditions, the solution has been subjected to testing with high-voltage impulses that mimic lightning strikes.

The transformer can easily be connected to the station control via a built-in Ethernet cable and fiber-optic interfaces, or wirelessly. All connectivity solutions are cyber-secure and different data architectures are possible based on customers' requirements.

Establishing a new industry standard, the ABB Ability Power Transformer drastically lowers the barriers for customers to reap the benefits of digital technologies and enables them to take control of their digital future, today. ●

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ABB's TXplore submersible robot inspects transformers

Until now, utilities have performed costly and hazardous internal visual human inspections of transformers to determine routine internal conditions and to isolate the exact location or severity of a fault. Always alert to customers' needs, ABB formed a multidisciplinary group of experts to redefine transformer inspection: the result is the submersible transformer inspection robot TXplore.

After successfully completing rigorous laboratory, field and near-real-world condition testing, this remotely driven craft was introduced at the Hanover Trade Fair on April 23, 2018. Especially suited to perform routine baseline inspections for future comparison of the internal condition of the transformer, TXplore visually maps the interior of oil-filled transformers while preserving the integrity of the oil, and allows personnel and customers to view the inspection results and images safely, in real-time. In these cases, human inspectors are not required and the risk of damage to the transformer is minimal. Inspections can be completed within a day or two, with two

personnel: a topside equipment manager to set up and manage the robot and a robot pilot to navigate, gather data and communicate with experts and customers. Consequently, routine transformer inspections are safe and efficient; downtime is shortened, and both human and capital costs are reduced.

TXplore production service inspections began in April 2018. By integrating the opportunity for inspections in their service agreement portfolio, ABB redefines transformer inspection and management and delivers unparalleled service.[1] ●

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Footnote
1) TXplore is discussed in greater detail in *ABB's TXplore robot redefines transformer inspection* on pages 28-35 of ABB Review 03|2018.

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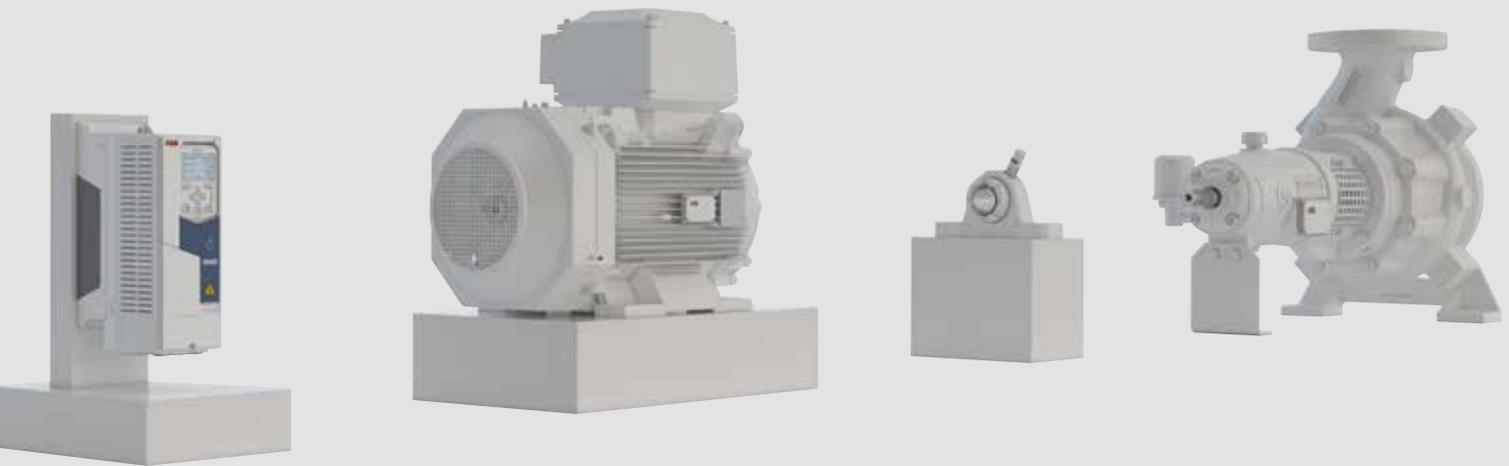
The ABB Ability™ Digital Powertrain for drives and motors

Electrical powertrains – the motors, generators, drives, converters, bearings and gearboxes that drive pumps, machinery or other process equipment – are particularly critical components of many processes and must be kept running. ABB has now introduced the ABB Ability Digital Powertrain to improve engineering efficiency, safety, equipment uptime and production output while reducing risks and costs in everyday operations. ABB Ability Digital Powertrain keeps operations running efficiently – and even predicts failures before they happen.

The Digital Powertrain is a suite of digital products, software and services for motors/generators, drives/converters and mechanical powertrain components such as bearings. Surprisingly, over 80 percent of powertrains are currently not monitored. Therefore, providing a simple, cost-efficient solution like the Digital Powertrain will be a game-changer.

Each powertrain can send data to the cloud that is then visible to the operator on a simple dashboard. Data analytics and connectivity with ABB experts make operations efficient, predictable and safe.

Digital Powertrain Internet of Things (IoT) solutions encompass devices, software and services. ABB Ability Condition Monitoring for powertrains, for example, is a service product that visualizes the data of the individual assets of an electric powertrain in a unified monitoring system and, with the help of ABB's expertise, delivers comprehensive insights as to maintenance, repair or replacement needs. Other service products in the ABB Ability Digital Powertrain cover life cycle assessment, virtual commissioning and remote assistance. These products are complemented by physical devices such as ABB Ability Smart Sensors for pumps, mounted bearings and motors, and wireless Internet gateways.

The digital powertrain opens up many fields for additional actionable insights, analyses and informed decision making. It shows the way forward so that modern industry can achieve better reliability, uptime and efficiency – and reduce costs. ●

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The PVS 175 1,500V solar inverter

Rapid growth in the photovoltaic (PV) power market is putting severe cost pressure on components. ABB has responded to this situation by introducing the PVS 175 string PV inverter – the first string inverter from ABB with a PV string voltage up to 1,500 V (a PV inverter converts the variable DC from solar panels into the AC the grid needs).

The output AC voltage from the PVS 175 is 800 VAC, which allows AC cable cross-sections to be halved compared to standard 400 VAC products, thus saving costs. To further reduce costs, and to improve reliability, the PVS 175 has 12 independent DC inputs that allow the direct connection of the PV strings to the inverter – without using protection fuses.

Each DC input employs a tracking algorithm that maximizes the energy that can be extracted from the PV array. This tracking and the large number of DC inputs available gives the PV plant designer great freedom when configuring the system.

The PVS 175 has a power rating of 175 kW up to an ambient temperature of 40 °C (185 kW up to 30 °C), making it well suited to operation in hot climates. The inverter can communicate via WiFi or Ethernet and be equipped with an integrated web server for fast commissioning.

The PVS 175 has a double-stage configuration: DC power from the PV panel is first stepped up to a stabilized DC voltage, which is then converted to grid AC power. The DC/DC converter uses a SiC MOSFET and diode to improve efficiency, reduce size and improve reliability. These SiC components have the advantage that they can operate at higher temperatures than conventional silicon equivalents. ●

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Prize winning panel harvests a world of drive data

As the leader in the standard and premium drive market, ABB has introduced the Drive Connectivity Panel, a unique plug & play device that has been awarded the "Innovation Product 2018" prize by Modern Manufacturing Magazine. The new panel offers an array of features designed to make an extremely broad range of information easily readable and visualizable. Customers can tap into data such as motor behavior settings, control macros, diagnostics, energy efficiency and energy savings, to name just a few key areas.

Thanks to the latest Internet of Things (IoT) mobile technology available anywhere – including both narrowband (NB) IoT and Bluetooth – the panel can interact with drives in a spectrum of industrial environments. And thanks to the panel's connectivity to ABB Ability cloud services, data encryption and resulting high level of cybersecurity,

customers are able to remotely monitor the status of their ABB drives, operational KPIs, events, and real time and historical parameter trends through continuous data uploads. Remote assistance provides easy access to ABB expertise on-site to track down problems.

All of this adds up to substantial customer value in areas such as device and asset management, remote condition monitoring, predictive maintenance, product insights, product use analysis, and product optimization and customization. Indeed, data provided by this new platform can reveal the true potential of drives and help create new business models and customized services. ●

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Wireless diagnostics for every bearing

Downtime due to a failed bearing can be very costly, but inspecting these components, which are often located in hard-to-access locations, is generally difficult and time-consuming. With this in mind, ABB has developed the ABB Ability™ Smart Sensor for Mounted Bearings, which allows users to monitor these difficult locations and identify potential issues early. The sensor is part of the ABB Ability Digital Powertrain.

Customer interviews revealed that ever more highly-skilled maintenance mechanics, who could often diagnose bearing issues by small changes in sound or temperature, are nearing retirement age and companies are not able to replace them with like-minded workers.

In view of this, an R&D project was mounted, between ABB and external vendors, that took advantage of technological advances in electronics, connectivity, sensing, and the Cloud. The resulting bearing sensor is a wireless condition monitoring solution that allows

customers to quickly assess their bearings' health. Built-in diagnostic capabilities reduce the need for condition monitoring analysts, and asset health knowledge will allow ABB customers to make better decisions.

Embedded into the sensor's on-board microprocessor are advanced fault detection algorithms. Validation of the algorithms and sensor performance was accomplished through extensive testing in ABB laboratories on bearings with seeded faults. Feedback has been very positive. The sensor has 30 days of data storage capacity, so customers can look at trends directly from the sensor. New versions of firmware can be installed by an over-the-air feature built into the sensor. The product is scheduled to be launched at the end of 2018.[1] ●

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Footnote
1) ABB's wirless condition-monitoring bearing sensor is discussed in greater detail in *New bearing sensor enhances safety and decsion making* on pages 64-67 of ABB Review 01|2019.

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Terra HP: the next step in EV charging

Since the introduction of first-generation electric vehicles (EVs), starting around 2010, ABB has become the global market leader in DC fast charging systems.

Now a new generation of EVs with larger batteries, higher drive train voltage and faster charging capability is ready to appear on the market. To support these vehicles, ABB created Terra HP, a modular high-power charging system that supports CCS and CHAdeMO – two of the dominant charging schemes.

Terra HP delivers up to 350 kW, 500 A and 920 VDC. That is seven times the power, four times the current and twice the voltage of a traditional 50 kW charging system – a big step forward in EV charging. The Terra HP high-power charging system is modular and expandable, which allows charging sites to be scaled up as the EV base grows.

A key technology is the use of liquid-cooled charging cables. Conducting 500 A using traditional technology would require a copper cable too stiff and too heavy to use. Instead, ABB and its suppliers developed a relatively light, thin and flexible cable with active cooling and temperature monitoring.

The Terra HP project went from concept to field commissioning in under 18 months, with over 10 patent proposals submitted to secure technology leadership in high-power charging.

Terra HP is the first 350 kW system operational in the field globally. It is selected by leading charge point operators including some of the largest EV charging networks in the world: Electrify America, EVgo, Fastned and IONITY. ●

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Superior reliability with ABB's ring bus with static UPS

ABB's ring bus architecture with static uninterruptible power supply (UPS) is designed to provide reliable and available power at minimal costs to mission critical facilities, like, data centers. Currently deployed, this unique system has many advantages over conventional ring bus architecture with rotary UPSs and over conventional architectures with static UPS: faults are detected and isolated without risking system failure or shut down; systems remain operational because remaining UPSs share load equally.

To locate and isolate faults a number of circuit breakers and the related logic and relays are included. During a phase-phase short circuit on the ring bus, the worst case scenario, the UPS output current remains at the limit of the inverter current limitation regime, thereby establishing the minimal inductance of the ring bus choke. If a fault occurs on the output of one UPS, the other UPSs are decoupled from that fault through two chokes; this ensures fault isolation. Furthermore, synchronized inputs are not required,

nor is there a need for connecting switchgear in parallel. This protection scheme creates a virtually self-healing structure.

Currently available systems have been developed using reliability estimation models and transient simulation software to analyze system performance and power transfer capability for ring bus systems of any size. Rigorous testing demonstrates the superior reliability of ABB's ring bus architecture with static UPSs, due to the lack of interaction between UPSs. Even during a worst case scenario with 4 UPSs and a voltage window of 86.5 percent after 10ms – a utilization rate of 60 percent is possible – an excellent result.

By choosing ABB's unique ring bus configuration with static UPS, customers get a cost-effective power solution that is scalable and self-healing. Thus, successful uninterrupted operation is attainable now and in the future.[1] ●

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Footnote
1) For an in-depth article see *ABB's ring bus with static UPS for critical power applications* in the "Connected for productivity" section on p.54.

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Meeting customers in The Matrix

Engineers working in the grid integration unit of ABB's Power Grids vision are now using a virtual reality (or VR) platform to model and review designs in collaboration with their customers.

The platform is based on a popular development platform called Unity, which is used for real-time animation in animation and video gaming, and it allows engineers to drag-and-drop 3D models into virtual renderings into any context, such as potential or existing installations. By flipping the traditional approach of using 3D models to support creation of 2D drawings, the platform makes review and revision of designs far easier and more cost-efficient (as more robust and complete renderings enable decisions earlier in the process). Using it requires no special software.

More intriguingly, customers can put on a VR headset and walk around as "avatars" within the virtual worlds of projects, thereby literally seeing how items fit into spaces, and exploring the implica-tions for processes, safety, and other design considerations. ABB has also built upon a core element of video gaming – playing together from remote locations – and set up virtual collaboration rooms in Turgi, Chennai, Beijing, Ludvika and Västerås. In these online rooms, collaborators and customers can explore a virtual power plant together, as avatars, even though they may be physically located at other sides of the planet.

The new platform enables a new level of development efficiency and customer collaboration, even if the experience might not be as viscerally immersive as the VR in movies like *The Matrix*. At least not yet. ●

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Synerleap helps make the move from innovation to product

Even the most casual observer can appreciate just how tumultuous and dynamic the pace of technology development has become. This hectic environment makes it difficult to advance innovations from their early idea stage to a market-ready product fast enough.

To speed the trajectory of innovation with external partners in this dynamic world, ABB has set up SynerLeap – an innovation growth hub located at the heart of the ABB Corporate Research Center in Västerås, Sweden that helps companies reach a global market and scale up their business. SynerLeap partners with entrepreneurs and startups, and enables them to benefit from the resources, the internal network and the competences available to a major multinational like ABB. The vision is to reach shorter innovation cycles, decreased time to market and mutual strengthened competitiveness.

One important membership criterion is how well the member's contribution can enhance or complement ABB's existing or up-and-coming solutions – mutual benefit is a key aspect of the SynerLeap approach. With SynerLeap, ABB demonstrates how close interaction with startups leads to actual business value in terms of concrete projects, knowledge exchange and faster innovation.

Currently, SynerLeap has over 30 members with around a dozen joining annually. With each startup, the SynerLeap team and the relevant ABB business map out a specific collaboration project to ensure maximum value extraction for all parties involved.

As the pace of technology development increases, partnership with startups will become an even more important aspect of how ABB embraces open innovation.

This issue of ABB Review contains an interview with key SynerLeap members (p. 24) as well as an article (p. 28) that describes how the SynerLeap model has worked for two of the member companies. ●

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Partnersh

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Innovating the processes of innovation is the key to success, and ABB works with startups and others in the open innovation ecosystem to find news ideas, and operationalize them in new ways for the benefit of its customers.

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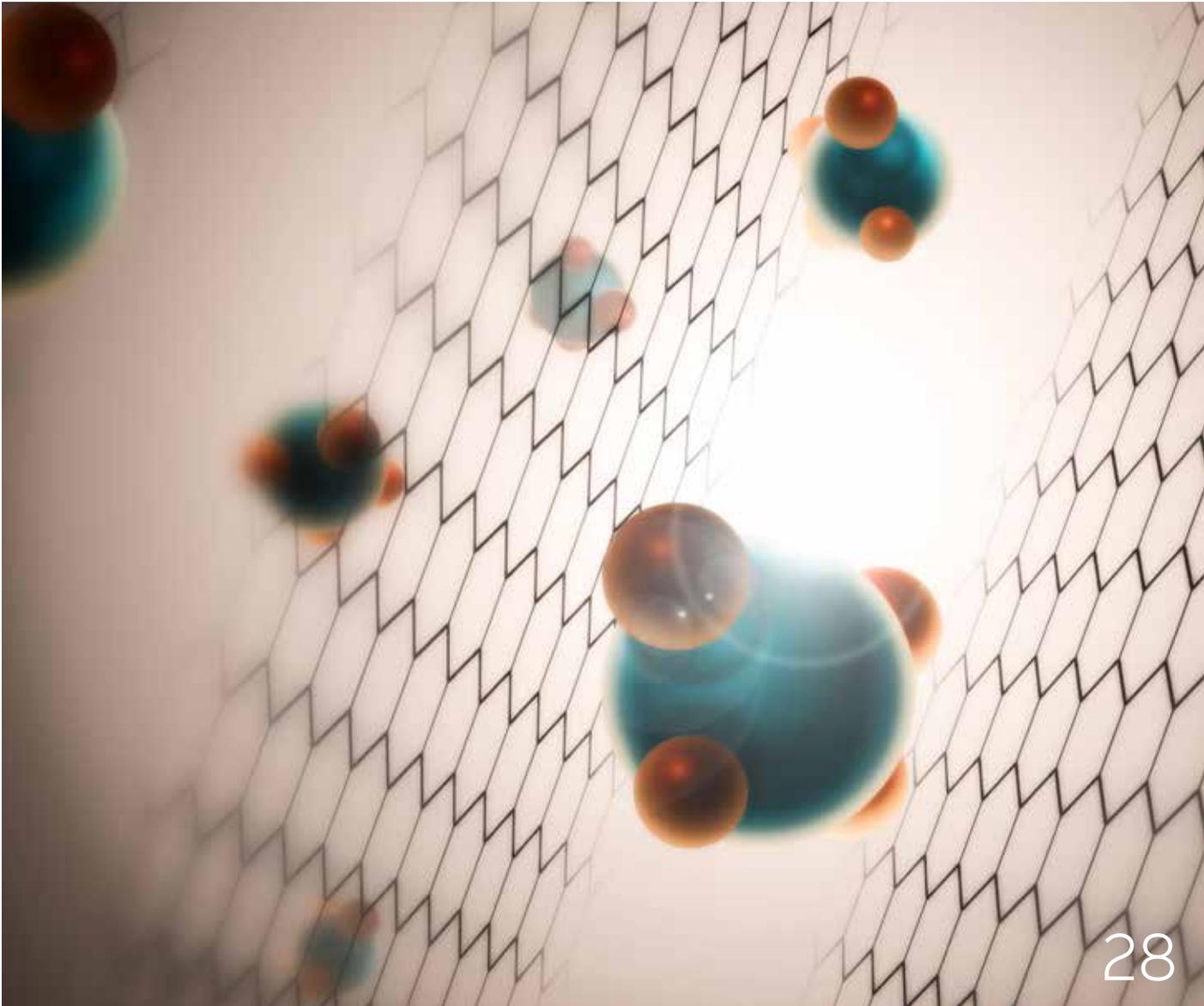
INTERVIEW

Interview with SynerLeap

Malin Carlström   **Peter Löfgren**

Partnering with startups has become a vital component of how ABB embraces open innovation. A key pillar of this approach is SynerLeap. To understand better how SynerLeap supports ABB innovation and works with its startups, ABB Review met with Peter Löfgren, CEO of SynerLeap, and Malin Carlström, Investment Director at SynerLeap and Senior Vice-President, Northern Europe, ABB Technology Ventures.

ABB Review (AR): Before we start talking about SynerLeap, can you both tell us a bit more about yourselves and how you ended up at ABB and eventually at SynerLeap?

Peter Löfgren (PL): I joined ABB as an Executive Trainee many years ago and I have spent my whole career within the company – chiefly with one foot in R&D, creating a bridge to other functions and ecosystems. My roles have covered project and line management, Head (and founder) of the ABB Simulation Network and Head of Strategic Collaboration and Business Development at Corporate Research in Sweden. I have a passion for value creation and love to drive change in a rapid AND sustainable way.

Malin Carlström (MC): I have spent my entire career in the Swedish and Nordic venture capital industry, placing investments in a wide array of segments. Some of my previous success stories include Tail-f, Fishbrain and Soundtrap – companies spanning the range from B2B to angler communities to online music studios. I advise startups and have been an entrepreneur myself. I met with SynerLeap when at my former employer and was impressed by what they were doing. I joined ABB at the end of 2017 after discussions with SynerLeap, the Swedish ABB organization and ABB Technology Ventures, as ABB was seeking to strengthen its investment efforts in the Northern European market.

AR   Can you please describe the innovation eco-system at ABB and how it has changed in the last few years?

PL   Working in an ecosystem is necessary for staying ahead in innovation. Alone, you easily become slow and miss out on disruption. What is happening now is that ecosystems tend to be larger. For example, before, working cross-border with universities and other corporates was quite enough, but today you need to engage very closely also with entrepreneurs, startups, accelerators, science parks and various other partners →1. Entrepreneurs and startups bring speed and great technology – perfect attributes when combined with the global presence, muscle and industry experience of ABB!

AR What are the biggest trends you see when it comes to corporate R&D and open innovation?

PL I have the pleasure to meet with many global corporates and external innovation groups. In fact, we have delegations visiting SynerLeap regularly. I often feel that there is an innovation anxiety driving those visitors. What I mean is that they realize that they need to do something in order to improve their innovation, but they are still searching for the right recipe. I see this as the first step in a transformation toward more open innovation, which is the trend. Many come back a year later, and by then they have realized that there is not a single, simple recipe – you just have to start by doing something and then iterate your way forward, instead of just discussing. What comes next is the cultural change in the corporation, to really understand and leverage benefits.

AR Tell us a bit more what role SynerLeap plays in this market environment?

MC SynerLeap is actually at the forefront of collaboration between large corporates and startups in the Nordics. With SynerLeap, ABB is demonstrating how close interaction with startups leads to actual business value in terms of concrete business projects, knowledge exchange and the increase in innovation speed. When startups and

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With SynerLeap, ABB is demonstrating how close interaction with startups leads to actual business value in terms of concrete business projects, knowledge exchange and the increase in innovation speed.

big corporations meet, both learn that the other party operates with a different clock frequency than themselves. This difference challenges both sides, especially the big company as it is forced to shift focus from quarterly reports and annual budgeting to taking rapid and efficient decisions and actions in a controlled manner. And as Peter points out, innovation thrives in environments where openness and a willingness to share insights come from all parties involved – creating yet another way for bigger companies to think about open-source initiatives and collaboration interfaces.

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01 The SynerLeap ecosystem of startups, entrepreneurial solution providers and partners joins forces with ABB's internal innovation and businesses. One SynerLeap startup alumni member, Mobilaris – now a world-leading location-based intelligence and decision support company that provides solutions for multiple industries, including mining – collaborates with ABB in mine automation.

AR   How was the idea about SynerLeap born?

PL   Working in a new role as Head of Strategic Collaboration and Business Development at ABB Corporate Research in Sweden a few years back, I soon realized that working cross-border between corporates was quite easy – though the actual initiation of a joint activity was never fast – but the same did not apply between a corporate and a startup. The simple conclusion

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When it comes to establishing collaboration between startups and ABB, we have a hit rate ten times higher and an effort ten times lower than traditional methods of hooking up with startups.

was that there was a large gap of trust. And this is a pity because some of the best and disruptive technology comes from startups. Not only that, but their small size makes them very nimble and they can get to the prototype stage without the interdepartmental or organizational obstacles that can sometimes slow things down in the bigger companies. This is why, when I visited Astra Zeneca and was introduced to their Innovation Hub, where the startups sit openly in the same R&D environment as the corporation in order to maximize interaction and to build trust, the SynerLeap vision was born! Eight months later we inaugurated SynerLeap and on-boarded the first four startups. Three months later we were already ten startups.

AR   How can a startup get into SynerLeap and what does it get out of the participation?

PL   Just contact anyone in our team or apply at the website. All details are at www.synerleap.com. We bring in one to two companies every month. Companies can accelerate development by accessing the unique ABB infrastructure – for example, our labs within power and automation that cover topics such as robotics, communication and high voltage as well as ABB's industry knowledge from innovation professionals – 60 percent of whom have a PhD – from 50+ countries. In addition, we will help with matchmaking between industrial needs and their technology. When it comes to establishing collaboration between startups and ABB, we have a hit rate ten times higher and an effort ten times lower than traditional methods of connecting with startups. Sometimes ATV, ABB's strategic venture capital unit, also invests in a SynerLeap startup. Both teams generally work closely together in order to fully leverage startup partnerships and value extraction.

AR   What does a typical collaboration between ABB and a SynerLeap member look like?

PL   All sorts of collaborations already exists. We have R&D collaborations, business collaborations, vendor-client collaborations, but we also see that individuals can move between the two worlds. As a concrete example, together with one of the SynerLeap members, Mobilaris, ABB delivered mine automation to a mine in Russia →1. ABB delivered the 800xA system, and Mobilaris plugged in their top-notch localization engine. I really like these types of synergies! On the R&D side, we have a lot of exciting synergies – for example,

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02 MTEK adds value to ABB's YuMi dual-arm collaborative robot.

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03 Yazzoom improves company processes by means of signal processing, artificial intelligence, computer modelling, software engineering, data mining and advanced process control.

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04 Imagimob is a specialist in artificial intelligence products for movement analytics of things and people. One such product is SensorBeat, which takes sensor data or any signal as input and translates this into actionable insights in real time. SensorBeat is a unique solution in which the AI runs on small devices. The edge approach differs from solutions where all sensor data is streamed from the device to the cloud, where all the intelligence is located.

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a company with real-time algorithms for use in stock exchange markets combining with our robot technology to generate new ways of programming and interacting with robots. Disruption typically happens at network boundaries, so what we can do is make sure these people and networks get a chance to interact!

AR   Malin, what role do you play in enabling collaboration?

MC   As a part of the SynerLeap team, I am always accessible to the member companies when they seek advice and connections into the Swedish and global ABB organization. I try to identify key BUs as well as individuals for each specific entrepreneur and startup. In some cases, we cement a collaboration match with an equity investment, as in the case of Graphmatech. And for ABB, I am often asked by BUs and research centers to give presentations on what the SynerLeap concept comprises and how ABB divisions can cooperate with the member companies to a larger and more frequent extent.

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We will seek to expand SynerLeap in a more scaleable and global manner, not least by digitizing the concept.

AR   Tell us a bit about one of the latest companies that joined SynerLeap?

MC   We have just welcomed MTEK Industry to the SynerLeap family. MTEK happens to be an authorized value provider to ABB. MTEK's focus lies in developing YuMi concepts in Industry 4.0 directions. MTEK constructs fully digital and real-time collaborative containerized manufacturing solutions with deep technical integration with YuMi →2. Other recent additions include Univrses, Ekkono and Yazzoom [1–3] →3.

AR   What is next for SynerLeap?

MC   We will seek to expand SynerLeap in a more scaleable and global manner. Yazzoom would be a good example here as it is the first non-Swedish company joining. We are also exploring additional partnership opportunities to further increase the connections between ABB, SynerLeap, ATV and the international startup and investment communities.

PL   Yes, agree! Overall, we also need to be even faster in many parts of our execution, for example in on-boarding companies, starting collaboration, etc. Additionally, a lot of our efforts will continue to go into optimal value extraction for the startup and ABB by continuously focusing on actively facilitating collaboration projects and simplifying internal processes.

AR   Can you give us some concrete examples of technologies that you believe are bound to cause disruption for ABB?

PL   There are so many exciting technologies and opportunities ahead. My favorites at the moment are probably AI, vision technologies and machine learning, followed by blockchain. Some examples of SynerLeap companies covering these fields are Imagimob →4, Ekkono Solutions, Univrses and BIP On.

MC   I believe the application technologies of graphene now have reached a maturity level that makes it a material that we will soon see in a wide array of applications, not least in additive manufacturing. Energy-related technologies that include photovoltaic, batteries and grid management will have a significant impact on many of ABB's core markets. We will further continue and speed up the process of moving ABB's business model into software-as-a-service (SaaS) and data-driven structures.

AR   Malin and Peter, thank you for the interview.

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04

TECHNOLOGY VENTURES

SynerLeap collaboration with Graphmatech and Algoryx

ABB's SynerLeap innovation hub in the Nordics demonstrates how close interaction with startups leads to value in terms of new products, knowledge exchange and faster innovation. Collaborations with two SynerLeap members, Graphmatech and Algoryx, illustrate well the benefits of the partnership.

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Nowadays, enterprises have to be nimble so they can harness and exploit the latest technology before that technology is stale or superseded, or before a competitor dominates it. In other words, development has to take place in a fast-moving, dynamic and innovative environment.

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SynerLeap is an ABB innovation hub that helps early- and mid-stage companies quickly progress from concept phase through adolescence and into young adulthood.

ABB has recognized this need to work in an innovative ecosystem and has set up SynerLeap. SynerLeap is an ABB innovation hub based in Sweden, that helps early- and mid-stage companies accelerate and expand in a global market. Members of SynerLeap have fast-growing potential in the area of automation, robotics, energy and industrial digitalization. Entrepreneurs, startups, accelerators and various other partners are likely members of SynerLeap. Some of these may be recipients of a capital investment from ABB.

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01 Aros Graphene is a hybrid ionic graphene material that is easy and eco-friendly to manufacture. It can be applied as an additive into a matrix or coating, or even by 3D printing.

—
02 Swedish-based Graphmatech's graphene-based nanocomposite materials and services were the basis of SynerLeap's interest in the company.

01

The SynerLeap idea is to foster and facilitate innovation across the board. The SynerLeap environment can be thought of as being similar to that of an incubator or accelerator, in which potentially profitable ideas are developed and supportive surroundings offered – all within the environs of a big company.

A companion article in this issue of ABB Review offers an interview that covers SynerLeap itself in more detail [1]. Below, work with two member companies – Graphmatech and Algoryx – is discussed to show how SynerLeap encourages innovation to thrive in an environment where an openness and a willingness to share insights from the parties involved is of benefit to all.

—

SynerLeap encourages innovation to thrive in an environment where an openness and a willingness to share insights from the parties involved is of benefit to all.

Graphene and Graphmatech

If there ever was a material that is all things to all men, it is graphene. Derived from the graphite form of carbon, graphene has the form of a sheet of carbon atoms just one atom thick. It was first isolated from graphite in 2004 – work that lead to a Nobel Prize for the researchers in 2010. Despite its two-dimensional structure of solely carbon atoms, arranged hexagonally, graphene is highly flexible and has 100 times the strength of steel. It is transparent, conductive and impermeable to a wide range of gases and liquids, except – notably and usefully (filtering/desalination) – water, for instance. The substance has potential in more applications than can be listed here.

02

Graphmatech is a Swedish graphene materials technology company that invents, develops and sells novel graphene-based nanocomposite materials and services. Graphmatech has invented a material called "Aros Graphene" as well as processes for implementing graphene at full industrial scales →1–2.

—
Aros Graphene is a solution to the upscaling issues that graphene technology faces and can be used in many different ways.

This work will contribute substantially to bringing the world into the graphene age. Aros Graphene displays extreme thermal and electrical conductivity as well as very low dry friction →3–4. It is self-lubricating, self-cooling and lightweight.

Aros Graphene is a solution to the upscaling issues that graphene technology faces and can be used in many different ways: It can be applied as a coating, used as an additive to a matrix and can even 3D printed. So useful is this novel material that Graphmatech comes up with new applications for it on a monthly basis.

How Graphmatech found SynerLeap
Mamoun Taher, founder of Graphmatech, worked as a researcher at Uppsala University in Sweden on a project together with ABB. Just as SynerLeap started, Mamoun's university project was finishing and he heard of the enterprise through his ABB contacts. The timing was therefore perfect for Mamoun to take the leap, appropriately, with SynerLeap and learn how to turn the knowledge and experience gained from his university work on graphene hybrid materials into innovation that would underpin a viable business.
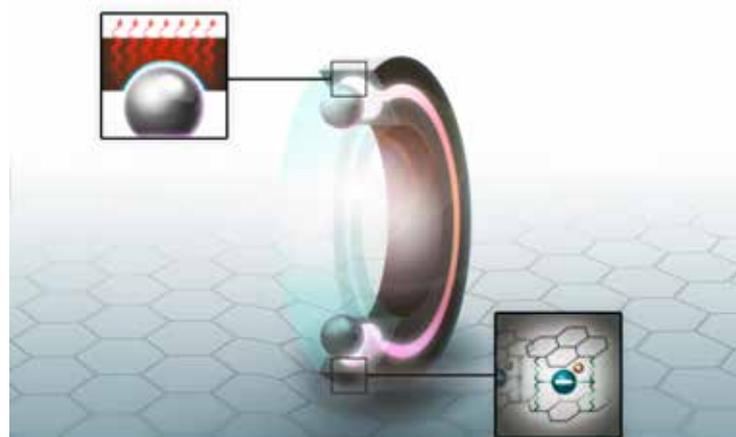
—
03 Aros Graphene
is expected to
revolutionize the
design of electronics,
energy storage and
mechanical systems.

—
04 Aros Graphene
displays extreme
thermal and electrical
conductivity.

—
05 Algoryx's
speciality is physics-
based simulation of
the motion dynamics
of multibody,
complex systems.

Bureaucracy in multinationals can often be wearisome. However, Graphmatech found that the SynerLeap processes were smooth and efficient, which was largely down to the SynerLeap management, who placed great emphasis on making the path to ABB for entrepreneurs and startups an easy one. For instance, recognizance was taken of the fact that small companies do not have extensive legal or intellectual property resources and care was taken to simplify this end of the business, while at the same time appropriately safeguarding the interests of both parties.

—
The ABB/Graphmatech collaboration is mutually beneficial as ABB can exploit Graphmatech's state-of-the-art materials technology in its products.

ABB's venture capital arm, ABB Technology Ventures (ATV) led an investment round in Graphmatech, during which ABB assisted the company with the due dilligence process regarding their technology roadmap, product/market fit, etc.

Mamoun says, "I'd heard about SynerLeap via my contact with ABB at the university and made the good decision to meet up with them. They mentored me all the way through, arranged for me to meet with decision makers at ABB and introduced Graphmatech to ATV, which was critical from the funding point of view. Not only that but they opened doors into relevant ABB business units and facilitated access to the ABB laboratories that helped us develop and test our graphene technologies."

The long road to productization and market acceptance was shortened by the collaboration. ABB contributed its extensive experience in this area by, for example, helping Graphmatech to carefully analyze the business case and the market for their product, and to closely collaborate with different partners at different points on the value chain – eg, to ensure early involvement of sub-suppliers and end users as well as exercising the right timing in the right market.

The Graphmatech collaboration with ABB is mutually beneficial as ABB can exploit Graphmatech's state-of-the-art materials technology in its products. One example from the Graphmatech-ABB collaboration is the development of new sliding electrical contact materials with a lifetime an order of magnitude longer than silver. This extended lifetime arises from the much higher wear resistance of the new materials. This advance, in turn, enables a dramatic reduction of silver content in ABB products, safer and more reliable products and a significant lengthening of maintenance intervals.

Mamoun has ideas, too, concerning the next big material trends that will come into play in the next ten years: "Changes are happening everywhere – and quicker than we think. From the materials perspective, more new and smart materials are under development. When development is sufficiently advanced, those materials will revolutionize industries. Very lightweight, flexible, even more high-power-density electronics, lubricant-free engines and gearboxes, self-sensing and healing materials, programmable composite materials, and local manufacturing at customer sites via high-productivity additive manufacturing – these are just some of the ways I see materials technology supporting Industry 4.0 and associated movements in the coming decade."

Algoryx
Algoryx specializes in physics-based simulations of motion dynamics of multibody, complex systems →5. What makes Algoryx unique is that they can combine high precision, complex modeling and very high computing performance. They also make all simulations highly available and interactive using 3D graphics.

Engineers who design machines and control systems need this type of capability for virtual prototyping and optimization. Further, physics-based simulation is a key enabling technology for training machine learning systems.
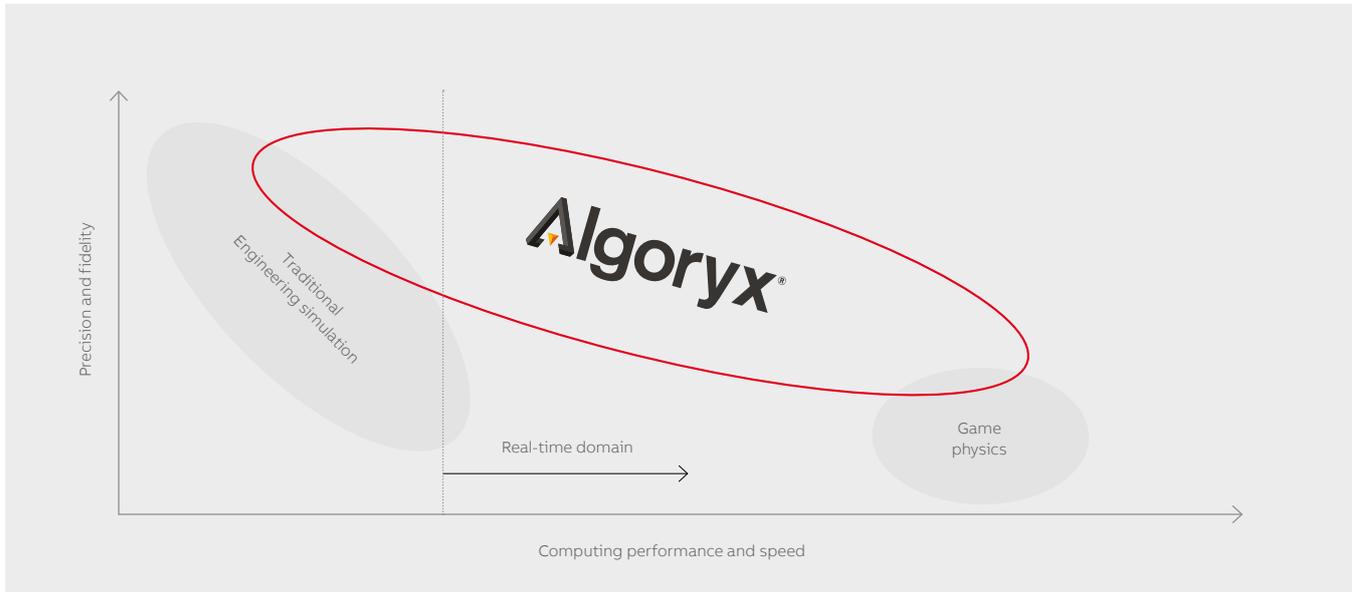
Algoryx®

06

Algoryx had worked with ABB for several years and heard about SynerLeap from ABB contacts. Not only that, but SynerLeap took an interest and contacted Algoryx directly. Participation in SynerLeap was made easy for the company and they were signed up in a very short time. Algoryx is more of a client-venture model and, at this point, no ABB investment in Algoryx has been found to be necessary.

Kenneth Brodin is the CEO of Algoryx: "ABB is a huge corporation and getting in contact with the right decision makers and specialists had been rather difficult. However, SynerLeap provides efficient guidance and door opening. SynerLeap also provides a strong level of mutual trust."

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06 Algoryx's product, AGX Dynamics, can perform high-fidelity simulation of large and complex multibody systems with contact mechanics in real time.

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07 Algoryx's simulation software, AGX Dynamics is fully integrated into ABB's RobotStudio and is also used in the virtual reality interface shown in this photograph.

—
08 The Algoryx technology holds out much promise for future applications, such as machine learning and simulations of very complex processes.

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Reference
[1] "Interview with SynerLeap," ABB Review, 1/2019, pp. 24–27.

As with the Graphmatech example above, Algoryx brings value for ABB: The Algoryx simulation software, AGX Dynamics, is used inside ABB RobotStudio and thus creates end-user value for automation engineers who perform offline programming of ABB industry robots in RobotStudio →6–7. In addition, Algoryx technologies are also used in the research and development of new and improved robots. In a general sense, Algoryx simulations enable engineers to do efficient virtual prototyping, which is often considered to be one of the most important methods for bringing better solutions faster to the market.

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The Algoryx simulation software, AGX Dynamics, is used inside ABB RobotStudio and thus creates end-user value for automation engineers.

Besides the mutual business benefits, ABB also guides Algoryx in their own continued research and development by providing requirements, expectations and expertise.

The collaboration has many fertile areas for future growth. Kenneth Brodin: "Obviously the big thing is machine learning so we see a lot of activities there. We're also looking at full system simulations of even more complex processes, such as the virtual commissioning of entire factories and mines, where we have software solutions that have not yet been employed in the Algoryx-ABB relation" →8. Kenneth sees the collaboration with ABB in a very positive light: "SynerLeap is a brilliant idea. Large corporations are dependent on innovation in SMEs but generally have a very hard time coordinating the relationship. SynerLeap solves this conundrum and I expect other companies to follow SynerLeap's example."

08

Kenneth also has ideas about the future: "Digitalization and autonomous systems will transform everyday life for everyone and we need to make sure everyone can have meaningful lives during and after the transformation. This requires additional innovation! Looking at the overall development of society and the impact of digitalization in social media, we need to work very hard to defend humanism and democracy. We also need to promote education and science even more than today – an undertaking in which industry has a key role to play."

This forward-looking attitude underlines how important it is for ABB to partner with startups in a way that embraces open innovation. It remains to be seen how these trends will play out, but in the meantime, the collaborations with Graphmatech, with its disruptive materials technology, and Algoryx are exactly the type of mutually beneficial exercise that ABB, via SynerLeap, is so keen to foster. ●

36

Connecte
productiv

46

d for ity

Ships that steer themselves and are aware of their operational health. Industrial temperature measurement that doesn't intrude on operations, and a unique ring bus design that delivers power more reliably. Digital connectivity makes it possible.

61

39

CONNECTED FOR PRODUCTIVITY

Charting a course to autonomous shipping

Pioneering digital technologies from ABB are opening the door to autonomous shipping. Together, a dynamic positioning (DP) system that simplifies ship maneuvering and a situational awareness solution that provides real-time visualizations of a vessel's surroundings create a powerful formula for enabling autonomous operations.

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Although crew sizes, especially in oceangoing cargo vessels, have decreased in recent decades, regulations call for at least one person to be on the bridge regardless of conditions. While this is very much justified in situations where a ship is approaching other ships or in areas where more traffic is anticipated, crossing an ocean in very good and clear conditions can lead to a situation where the Officer of the Watch (OOW) is on the bridge for an entire shift without touching any equipment or doing anything but looking at radar screens and outside the window to ensure that there are no threats. This can cause mental fatigue with an associated loss of alertness and can lead to a situation where a human reacts too late to an event that might otherwise have been anticipated earlier.

Enabling a better quality of rest during good conditions when there is no need for major navigation actions has an impact on crew alertness and decreased fatigue when approaching coastal areas or routes that have traffic.

In view of this, and with a focus on increasing the safety of navigation in areas where manned bridges are required, ABB has introduced ABB Ability™ Marine Pilot Vision and ABB Ability™ Marine Pilot Control. Together, these pioneering technologies provide bridge personnel with full 3D situational awareness and an intuitive environment

designed to operate vessels in a safe and efficient manner. "This technology, which is already available, will act as a stepping stone into the future of autonomous shipping," says Mikko Lepistö, Senior Vice President Digital Solutions at ABB Marine & Ports.

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ABB has introduced a pioneering technology that provides bridge personnel with full 3D situational awareness.

"To enable autonomous shipping, we need a DP system that replaces traditional solutions designed for disconnected operations. Embracing new technologies for the human-machine interface and offering tangible safety and efficiency benefits, ABB Ability™ Marine Pilot Control does exactly that."

76 5° HDG

0 °/min
ROT | Act.

ROTATE VESSEL

Target Angle
-45°

Target Heading
32°

Surge:
0.00 m
0.00

Sway:
0.00 m
0.00

Distance to Ref.
0.00 m

✓ Accept

✕ Cancel

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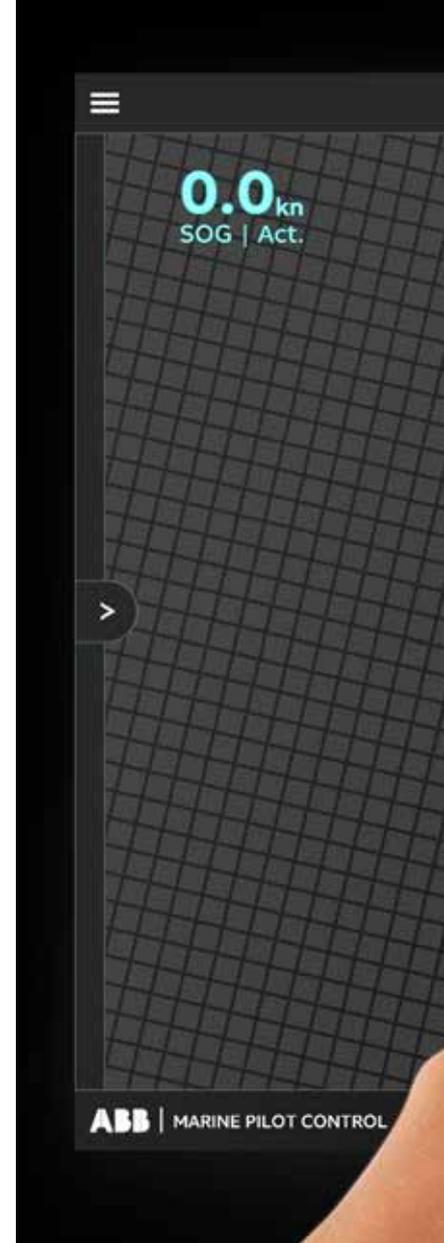
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01 Marine Pilot Control utilizes a novel touchscreen interface. The interface accesses advanced algorithms that calculate the optimal execution of a bridge officer's command in any operational situation.

Holistic Control

With its user-centric design, ABB Ability™ Marine Pilot Control reduces the workload related to navigational tasks and allows bridge officers to focus holistically on a vessel's overall control and positioning. The system integrates seamlessly with existing onboard equipment and ensures ease of installation and maintenance, adding significant "bridge-to-propeller" value for shipowners.

One of the key benefits of the new system is that it allows the operator to switch to joystick control for maneuvering a vessel at any speed and all the way to docking. To accomplish this, ABB Ability™ Marine Pilot Control employs algorithms that calculate the optimal way of executing a command for controlling a vessel in any operational situation. The overall safety of the operation is increased because the crew is able to maintain full situational awareness, rather than having to focus on changing control modes.

Unveiled at the SMM maritime trade fair in Hamburg, Germany, on September 5, 2018, ABB Ability™ Marine Pilot Control has obtained Lloyd's Register's (LR) Approval in Principle (AiP) certificate. LR is a leading international provider of classification, compliance and consultancy services to the marine industry. "Lloyd's Register is focused on supporting the introduction of new solutions to the shipping industry that enhance safer, more efficient and sustainable ship operations," says David Barrow, Commercial Director, Marine & Offshore, Lloyd's Register.

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Algorithms calculate the optimal way of executing a command for controlling a vessel in any operational situation.

"As digital technologies progress, increased collaboration between original equipment manufacturers, classification societies and ship owners will become key. This project highlights the collaborative work ethic between LR and ABB to achieve this milestone." ●

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02 Marine Pilot Vision
provides unparalleled
situational awareness
for ship crews with
real time information
presented in augmented
reality and 3D virtual
views around the
vessel, allowing for
perspectives that were
not previously available.

02

Bird's Eye View
ABB Ability™ Marine Pilot Vision takes
advantage of the latest advances in sensor
technology and computer vision to offer
new ways of perceiving a vessel's situation.
A virtual model of the ship is superimposed on
real surroundings, making it possible to see a
vessel's position and movements from a bird's
eye view perspective. Bridge personnel can
switch between views instantaneously, making
it easier to predict vessel motions and be alert
to previously hidden obstacles or collision
risks. The resulting improvement in situational
awareness has significant benefits for safety
and operational efficiency.

THE BENEFITS OF AN INTUITIVE OPERATING ENVIRONMENT

- User-centric design that helps increase overall operational safety as the crew is
  able to maintain full situational awareness, rather than having to focus on changing
  control modes.
- The operator can switch to joystick control for maneuvering the vessel at any speed
  and all the way to docking. ABB Ability™ Marine Pilot Control employs algorithms
  that calculate the optimal way of executing a command for controlling the vessel
  in any operational situation.
- Seamless integration with existing onboard equipment and ease of installation
  and maintenance.
- Together with the advanced situational awareness provided by ABB Ability™ Marine
  Pilot Vision, the new system creates an intuitive operating environment with the
  dedicated purpose of operating a ship in a safe and efficient manner.
- ABB Ability™ Marine Pilot Control can be connected to the ABB Ability™
  Collaborative Operations Center infrastructure, which monitors the performance of
  ABB technology on board and remotely connects operators with ABB experts.

"Computer vision has advanced significantly in
recent years. With this new solution, ABB is
leveraging it in order to present vessels in their
environment in ways beyond ordinary perception.
Crucially, we can do this in real-time in an intuitive
fashion, which does not distract the crew from
their work. In this sense, Ability™ Marine Pilot
Vision extends the capabilities of the human
senses," said Lepistö.

—

The technology makes it
possible to see a vessel's position
and movements from a bird's eye
view perspective.

"The solution can easily be installed on
conventional vessels to improve situational
awareness. What's more, it enables new shoreside
remote services, as well as totally new design
options for new vessels as it provides unrestricted
views of the surroundings from any location on
board and even on shore." ●

CONNECTED FOR PRODUCTIVITY

The ABB Ability™ Power Transformer sets new industry standards

With its standard digital capabilities, the ABB Ability Power Transformer provides a future-proof platform that delivers health data and actionable intelligence. Users gain access to ABB's digital ecosystem and can thus optimize reliability, availability and productivity while improving capital efficiency.

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The power landscape is predicted to change more in the next ten years than it has in the last 100 [1] →1. This is mostly due to the change in generation mix, where the integration of renewables and distributed energy resources are having the double impact of adding volatile supply sources while causing a decline in traditional high-inertia generation such as coal. This volatility will increase further, on the demand side, as e-mobility plays a greater role in the near future. At the same time, many utilities and industrial companies are under pressure to increase their efficiency and productivity in order to remain competitive in their respective fields.

As critical elements in the electrical grid infrastructure, power transformers are impacted by these changes. While nobody can predict the exact effects on a typical power transformer over its lifetime of 30 to 50 years, it is certain that changing demand patterns will result in a more dynamic loading of the transformer, which can be detrimental to its remaining life →2.

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01 The ABB Ability Power Transformer delivers health data and actionable intelligence so users can optimize reliability, availability and productivity while improving capital efficiency.

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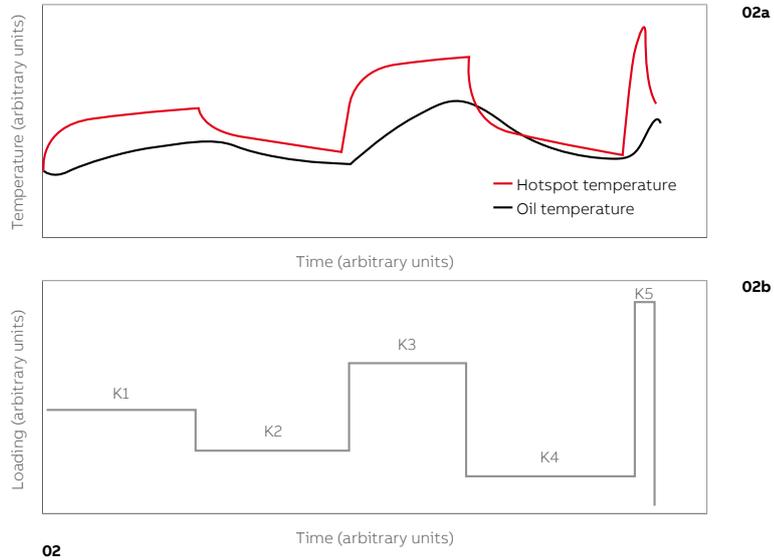
To address this situation, users need actionable information and insights to enable better decision making around, and management of, the asset, and a future-proof technology concept.

—

The technical development of the AAPT was based on a future-proof modular solution.

Therefore, the time has come for transformers to become digital by design. This is why ABB has developed its ABB Ability Power Transformer (AAPT) as a new standard for power transformers. The AAPT is an integrated solution with electronic temperature monitoring and on-board intelligence on load and ageing conditions →3.

Additionally, the AAPT offers a wide range of options, leveraging ABB's broad portfolio of devices, software and services.

Digital power transformer platform and ecosystem – agile development
The technical development of the AAPT was based on a future-proof modular solution. The platform concept covers everything from the basic package with electronic temperature monitoring and indicators, up to a full monitoring package with plug-and-play connectivity including the whole family of ABB eSeries (digitally enabled instrumentation and protection devices), ABB's dissolved gas analyzers (DGA) CoreSense™ and CoreSense M10.

Furthermore, the AAPT was conceived with an agile development approach that allows potential new sensors and instrumentation – such as for the monitoring of partial discharge (PD) and bushings – to be promptly added to the open, vendor-neutral platform →4–5.

Upstream connectivity options range from local devices such as laptops or tablets, control or SCADA (supervisory control and data acquisition) systems, to ABB's own ABB Ability Ellipse asset performance management (APM) software.

Even just the standard AAPT configuration brings the benefit that multiple data points can be trended and stored for future reference or used to compare the relative performance of parallel units and aid in future planning. The AAPT also includes a self-check or watchdog function.

—
02 Typical transformer loading behavior: As transformer loading increases, so too does oil temperature, leading to hotspots.

02a Oil temperature level and hotspot temperature.

02b Transformer loading.

—
03 The standard ABB Ability™ Power Transformer offering.

The AAPT platform has been conceived to be independent of the type and size of the transformer, as the accessories defined for the standard package are typically used in every oil-immersed power transformer.

Last, but not least, the AAPT is fully compliant with industry standards applicable to both power transformers and low-voltage controls for any region of the world.

Connectivity
Many customers now demand actionable information, intelligent asset optimization and the ability to use real-time data to mitigate "nasty surprises". The potential to network the AAPT is, therefore, a driver for many customers. The transformer can easily be physically connected to the station control via a built-in Ethernet cable and fiber-optic interfaces or wirelessly. All connectivity solutions are supported by state-of-the art cyber security and options include connection to ABB Ability cloud-based services. For that purpose, the ABB solution is certified according to IEEE 1686, IEC 62443, etc.

Today, not everybody wants their most critical assets connected to the outside world. So, independent of the onboard cyber security, transformer monitoring can operate on premise and even in standalone mode. All data remains the customer's property [2], should customers prefer, they can simply send ABB any raw data they may want interpreted and translated into useable information. Alternatively, customers can utilize ABB's expertise on site.

—

The AAPT's modern Electronic Temperature Monitoring solution can accurately calculate the transformer's hot spot.

Winding temperature
The beating heart of a power transformer is its windings, but traditional methods for controlling transformer cooling are based on monitoring the oil temperature rather than what is actually happening at the transformer's hot spot. The aging of the insulation at the hottest point in the winding typically determines the life span of a power transformer; an oil temperature just 8°C above nominal could reduce the insulation life by up to 50 percent [3] →6.

03

Top-oil temperature (via resistance temperature detector)

Sensors

Winding temperature (via current transformer)

Electronic temperature monitoring (CoreTec 4)
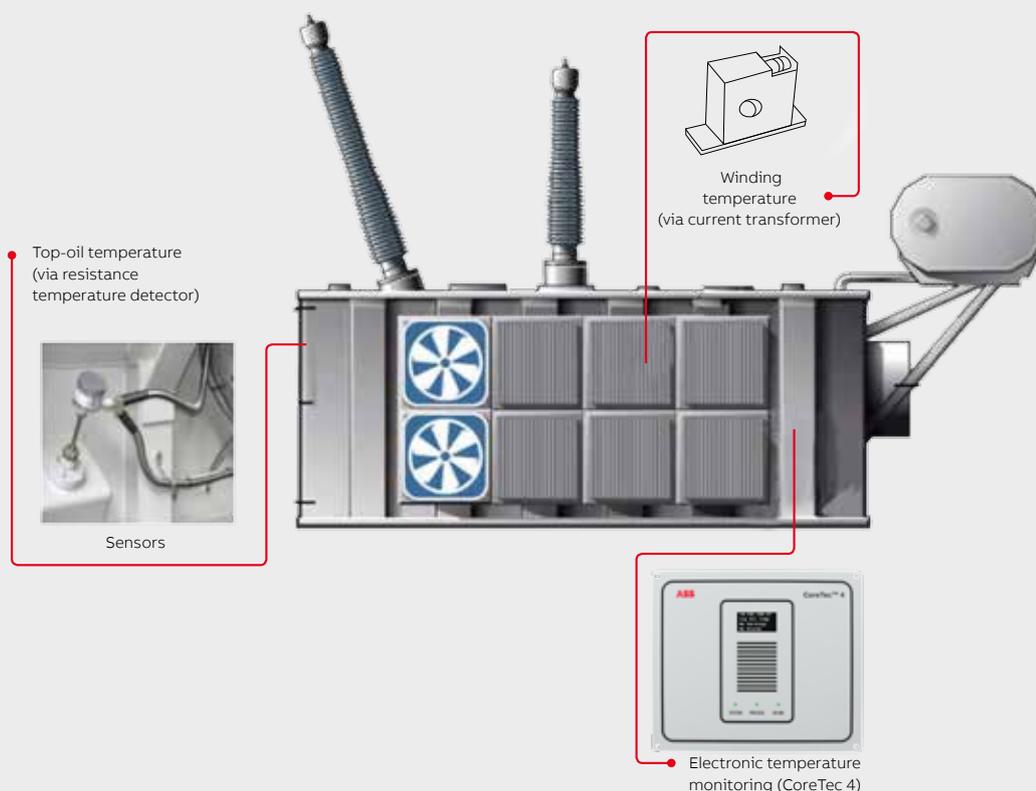
eSeries Devices

Product type	Description
eSDB	Self-drying dehydrating breather
eOTI	Oil temperature indicator
eWTI	Winding temperature indicator
eOLI	Oil level indicator
eVIEWER	Remote viewer for eOLI
eBR	Buchholz relay
ePRD	Pressure release device

Dissolved Gas Analyzers

Product type	Description
CoreSense	Hydrogen and moisture monitor
CoreSense M10	Nine gas and moisture monitor

04

The AAPT's modern Electronic Temperature Monitoring solution can accurately calculate the transformer's hot spot based on design data and factory type-test results, together with dynamic variables such as the loading and oil temperature.

CoreTec™ 4
The brain of the AAPT is the CoreTec 4 module. CoreTec 4 is a digital hub, responsible for collecting and analyzing readings from the different sensors, and processing them to provide an assessment of transformer operation (including cooling equipment governance, if needed) and life expectancy.

For the development of CoreTec 4, ABB was able to leverage existing expertise and experience in transformer monitoring systems, building on developments that go back to the 1980s with first fiber-optic temperature monitoring systems, the 2000s with Transformer Electronic Control (TEC) and the previous CoreTec generations.

Apart from functionality, additional design requirements such as compactness, expandability (by plug-ins), ease of installation and durability were considered in the development process.

The AAPT has been validated as an integrated solution in several new and retrofit applications of different types. The validation included thousands of hours of real on-site conditions, at different

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For the development of CoreTec 4, ABB was able to leverage existing expertise and experience in transformer monitoring systems.

locations and applications around the world. Data gathered during validation demonstrated the reliable performance, with all functional parameters within expected ranges, confirming the benefits of the measurement analysis.

—
04 DGA and
eSeries devices.

—
05 Transformer with
eSeries devices.

Modularity through different packages
With the same philosophy of providing a flexible solution adapted to every customer need, on top of the basic package, AAPT offers additional packages:

Reliability boost: adds the DGA (using, by default, CoreSense), breather status (via self-dehydrating breather) and the oil level from the electronic oil level indicator.

Productivity boost: enhances the information about oil quality by using CoreSense M10, which covers the full spectrum of gas analysis together with moisture.

These packages are well complemented by the Power Care service agreement, a common ABB offer consisting of a matrix of service packages that allow services to be chosen based on customer actual needs – from a single point of contact to full product engineering services.

Case studies
Various use cases were identified and proven in the field. In a transmission network, the information provided on temperature and load enabled the operator to optimize the cooling control in such way that the top oil temperature fluctuation was reduced from over 15 °C to less than 5 °C, under varying ambient and load conditions. This results in stable conditions for the insulation and extends the transformer's lifetime.

—

AAPT packages are complemented by the Power Care service agreement, a matrix of service packages covering from a single point of contact to full product engineering services.

In an industrial installation, an operator noticed an increase of temperature and dissolved gases while the load was constant. An investigation found that a mineral buildup had resulted in a blocked fan at a heat exchanger – a situation that could have proven costly in the long run.

eOLI
Liquid level
indicator

eOTI
Liquid
temperature
indicator

SDB
Self-dehydrating
breather

eBR
Buchholz
relay

ePRD
Pressure relief
device

eWTI
Winding
temperature
indicator

CoreTec

CoreSense
Gas sensor

05
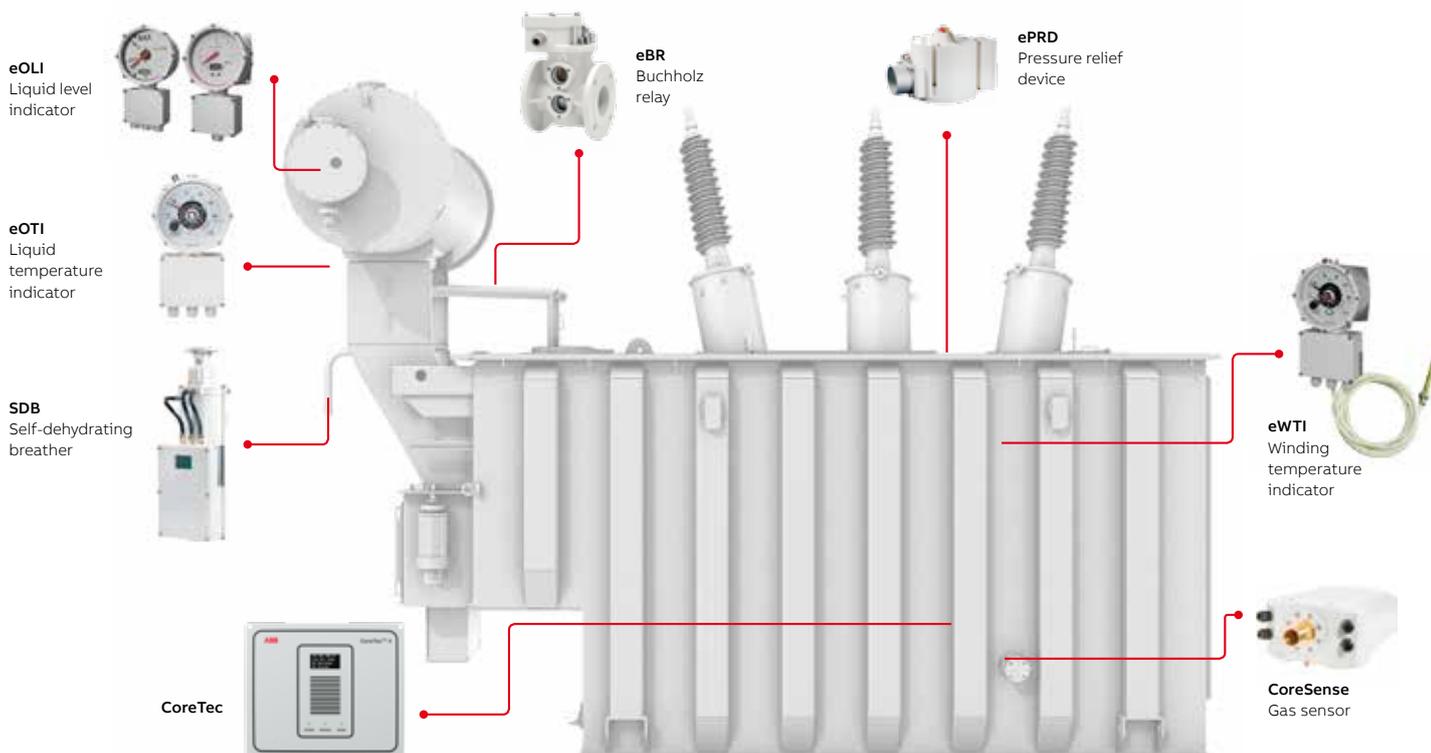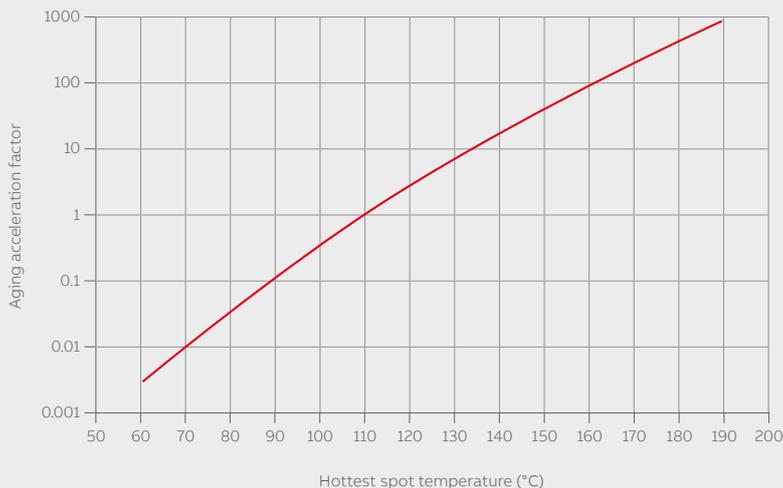
06

In a smelter application, the customer wanted to increase their production capacity by 15 percent. Thanks to the digital capability it was possible to calculate the trade-off in terms of remaining transformer life, and to ensure the asset integrity while running the transformer in overload condition.

—

Those armed with the right data interpretation can benefit from dynamic optimization of the transformer loading and reduce the need for site visits.

In the future, with more data becoming available from an expanded base of installations, and with the advancement of analytics technologies, additional use cases will emerge that further leverage the digital capabilities and the ecosystem that ABB can provide.

The future of power transformers is digital
In the past, transformers were an asset that kept running under stable conditions in a centralized grid. The exact condition of the transformer, especially that of its insulation and aging, were not known but due to stable load conditions many transformers had a long lifetime. Today, however, grid conditions have become more stressful due to the integration of volatile renewables and distributed energy resources, and, for example, the rise in the number of electric-vehicle charging stations.

07

Digital transformer monitoring platform

Monitors vital signals from different sensors
Models and stores data from running algorithms in real time
Controls cooling fans to maintain winding temperature

Plug-and-play capabilities
Digital mechanical sensors
Dissolved gas analyzers
Digital safety devices

—
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Additionally, asset owners feel pressure to ensure competitiveness and effective allocation of capital and operational expenditures. Therefore, better insights are needed in order to ensure sound decisions on transformer maintenance, repair or new investment.

Further, those armed with the right interpretation of data can benefit from dynamic optimization of the transformer loading and reduce the need for site visits. They can make informed decisions and trade-offs between overloading the transformer for immediate financial gains versus shortening transformer life.

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The ABB Ability Power Transformer is a future-proof investment designed to open the world of digital possibilities to asset owners.

ABB is enabling asset owners to meet all these challenges by digitalizing new transformers as a standard feature. The ABB Ability Power Transformer monitors health data and delivers actionable information to enhance grid reliability and the efficiency of load distribution, and increase service and maintenance productivity by enabling condition-based maintenance.

During the lifetime of the transformer, upgrades are easily possible thanks to a modular and scalable architecture.

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The AAPT was introduced to the public at the 2018 Hanover Fair and garnered positive reactions and feedback.

Therefore, the ABB Ability Power Transformer is a future-proof investment designed to open the world of digital possibilities to asset owners and enable them to gain a competitive edge in a changing environment →7.

The AAPT was introduced to the public at the 2018 Hanover Fair and garnered positive reactions and feedback. The market launch of this new product underlined how ABB has, throughout its long history, been able to solve important customer problems, deliver real benefits and spearhead innovation. ●

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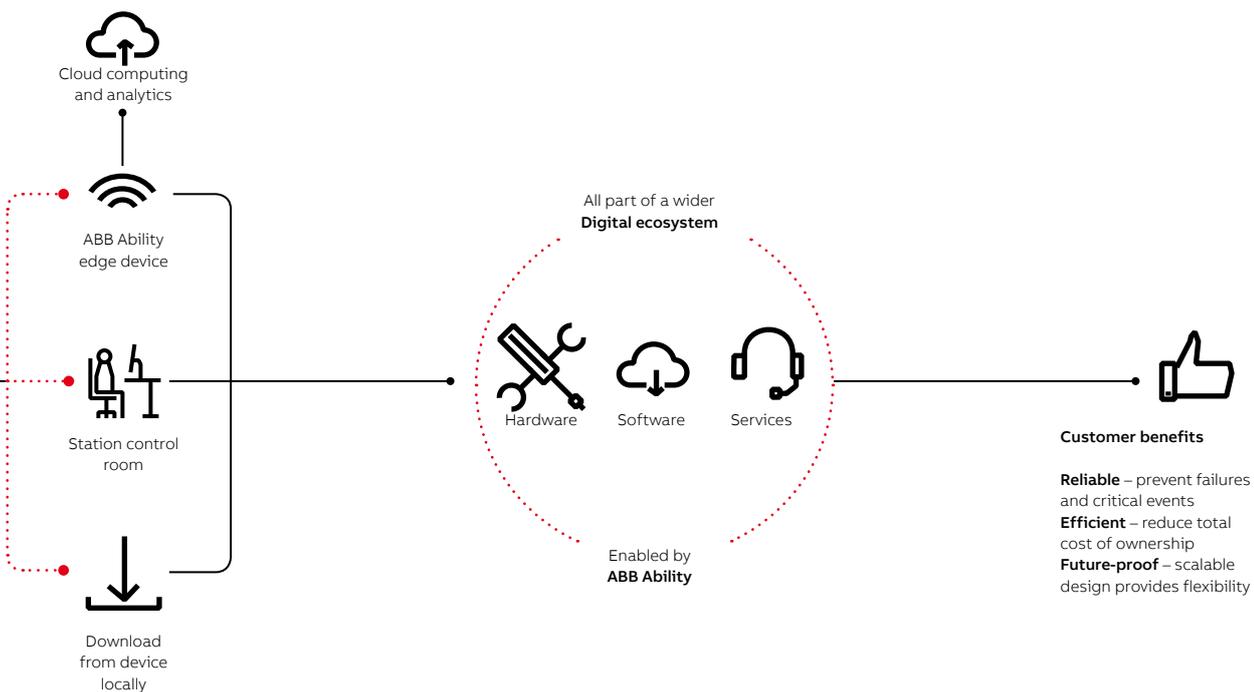
CONNECTED FOR PRODUCTIVITY

ABB's noninvasive temperature measurement creates digitization use cases

A double sensor design for industrial surface temperature measurement uses model calculations to enhance accuracy and strongly reduce response time. Surface temperature estimates are comparable to intrusive methods. This fit-for-industry design provides flexibility without loss of performance.

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By linking communication between people, services and things, Industry 4.0, appears to offer many opportunities and yet, the disruption poses a threat for some companies. High-flying promises are made about new automation paradigms, but concepts for successful implementation are often lacking. A reasonable digitalization strategy would provide customers with enormous benefits: the reduction of risks for existing processes and flexible answers to the challenges of increased pace and reduced workforce availability.

The "Normenausschuss für Mess- und Regeltechnik" (NAMUR) in the NAMUR Open Architecture provides decision-makers with a reassuring risk-minimizing digitization overview [1]. Sensors play a fundamental role in Industry 4.0 →1, the information they provide at the field level underpin any advanced use of plant data to increase productivity, efficiency and safety by preempting interruptions and failures, thereby making production agile.

Recognizing customers' need to keep a competitive edge, ABB's experts develop accurate sensor products and the theoretical groundwork for enabling algorithms to be combined with artificial intelligence (AI) to allow enterprises to

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Sensors play a fundamental role in Industry 4.0: information underpins any advanced use of data to increase productivity, efficiency and safety.

gain that edge. Existing initially outside of the classical automation pyramid, ie, in condition monitoring, the same methods could produce gains that can be applied to conventional plant operations and process control, once experience and confidence in the novel technology has been gained.

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Title photo:
Process industries like OGC benefit from sensor technology that does not require pipes to be opened.

01
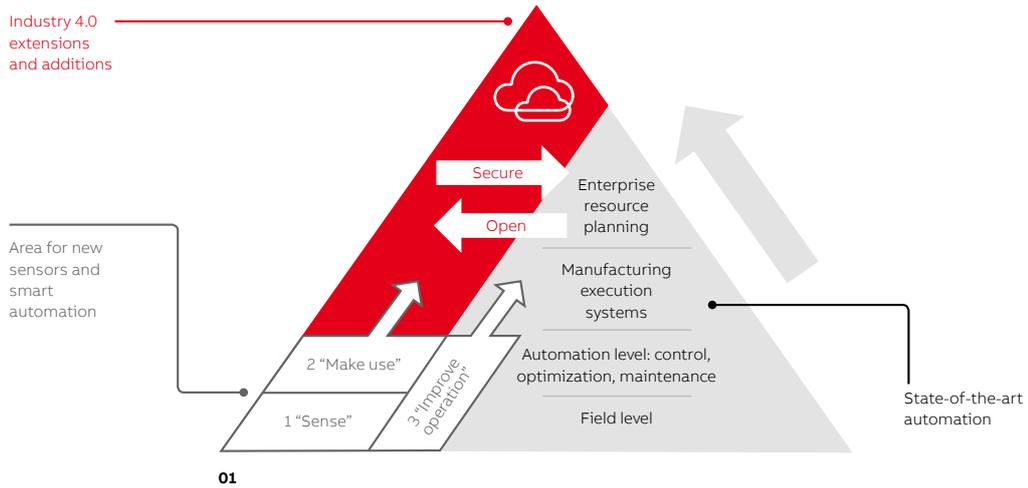
Clearly, the digitization of industrial processes in oil, gas and chemicals (OGC) and the food and beverage industries relies on copious amounts of sensor information to enable recognition of trends, predict problems and, above all, allow strategic decisions to be made [2]. Yet, for companies to accumulate vast data sets, sensing must be accurate, have a rapid response time, and must be cost-efficient to produce and use, it must be non-disruptive to plant processes and able to communicate intelligently with all areas of measurement and analytics.

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ABB's new noninvasive temperature sensor, NiTemp, ensures that process industries like OGC and food and beverage industries can exploit the benefits of Industry 4.0.

ABB's new noninvasive temperature sensor, NiTemp, is just such a device; it is poised and ready to act as a first step – ensuring that process industries can exploit the benefits of Industry 4.0.

Conventional invasive methods
Traditionally, temperature measurements relied on invasive methods. A temperature sensor was inserted with a thermowell through an opening in a pipe or vessel into the medium to be measured, making accurate and rapid response measurements possible. Despite this, such solutions entail enormous risk to employees, and possible damage to the facility. Hot, abrasive or corrosive media can damage thermowells requiring replacement or repair and even the need to shut down facilities or reroute processes. Also, rapidly flowing media can cause thermowells to rupture due to vortex formation and subsequent oscillations; the result can be catastrophic failure [2].

02

03

Noninvasive temperature measurement has been practiced in industry for decades, generally as a fallback option when insertion of a thermowell was either an extreme nuisance to the process or posed unacceptable safety risks. The food and beverage industry avoids the use of thermowells because of the risk of contamination.

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Intrusive measurement techniques with thermowells are expensive to engineer, negatively affect the measurement itself and increase downtime.

In brownfield installations, the facility must be shut down and pipes emptied for invasive measurement devices to be installed – a costly nuisance. Additionally, intrusive techniques affect the measurement itself: the result of the temperature drop induced between the process medium and the sensor [3] – clearly this is suboptimal. Furthermore, thermowells are complicated and expensive to engineer [3,4].
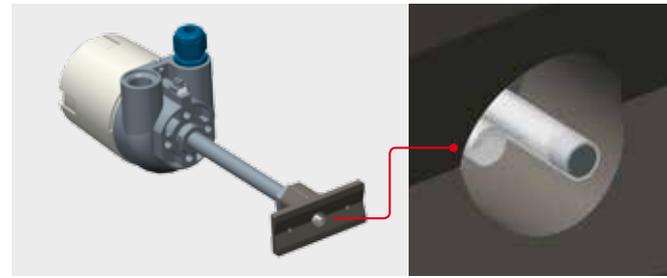
04

A highly skilled workforce is necessary for the realization of the measurement point. In all retrofit use cases the process is shut down and pipes cleared. This can delay the setup process for months. Once the thermometer is inserted and operation begins, there is a real risk of process disturbance, fouling and damage of the equipment. This, in combination with high costs, leads plants to design control instrumentation minimally with as few measurement points as possible, even though more measurements would be useful, eg, for process optimization and, analyses of problem root causes. This is especially true for industries that endeavor to exploit the rich value of Industry 4.0. To be useful for process control, a temperature measurement point must be designed to be noninvasive and compatible with digitization technologies.

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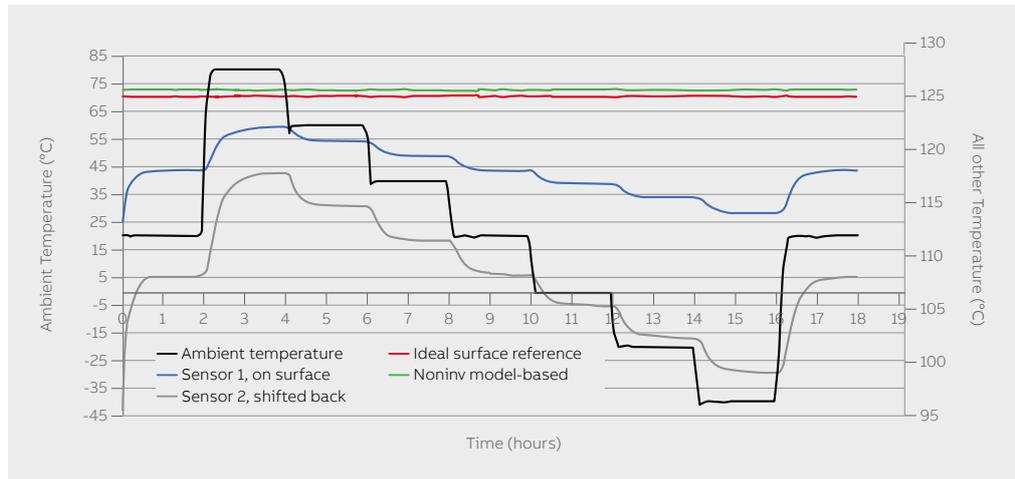
05b

Advantages of noninvasive temperature measurement

ABB's novel design approach to products that generate highly quality-relevant process data, especially for sensors that do not directly influence plant operations, will enable process industries to take full advantage of Industry 4.0. By eliminating the need to open the pipe, installation cost and work time are drastically reduced, especially if the sensors work with wireless communication and an autonomous energy supply method, such as battery or, energy harvesting [5]. The advantages, however, do not come without a cost. Thorough knowledge is required about the thermal behavior of the measurement instrument, the process medium and their connection.

Two-step approach to noninvasive temperature measurement

The main barrier to establishment of noninvasive sensing is the effect of the ambient environment on accuracy and response time. Fluid flow with average temperature, T_m, in a process pipe, may cause a non-trivial thermal field across the flow profile, pipe wall, insulation and ambient air.

Two cases are distinguished:

Case 1: The temperature T_{wa} on the outer surface of the process pipe often very accurately matches T_m. This is particularly true for aqueous solutions in practically all relevant use cases encountered. Consequently, the measurement can be installed without any knowledge of the process or pipe parameters. A first compensation algorithm calculates T_{wa} using only device-internal features.

Case 2: In the case of more viscous and/or low-heat conductive liquids, such as certain oil, and for gases, T_m can be calculated from T_{wa} online with a second algorithm; some pipe and or process parameters must be provided to the algorithm.

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ABB's nonintrusive sensor eliminates the need to open the pipe; installation cost and work time are drastically reduced.

In both cases, the reliable determination of the pipe surface temperature, T_{wa} is crucial, ie, the performance of the first algorithm mentioned above must occur. In the simplest setup, the algorithm works with signals delivered from:
- a primary sensor that is located as close as possible to the pipe surface, and
- from a secondary sensor that is located in a definite distance from the pipe surface: the reference sensor.

The following section shows how the measurement performance is influenced by the design of the sensing device and the positioning of the primary and reference sensors on the vessel to be measured.
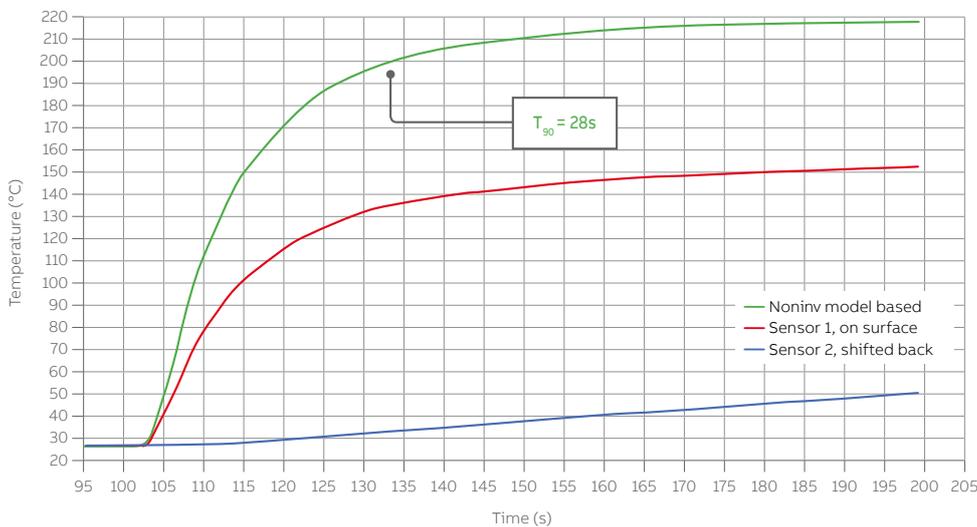
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Design rationale

The temperature of a surface may be inferred from a measurement of two temperatures located within the vicinity using knowledge about the thermal resistance between the points. In practice, this method can be very slow due to the finite velocity of heat waves along the thermal path.

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The NiTemp design consists of two thermometer inset rods, each with a diameter of 3 mm, connected to ensure thermodynamic definiteness.

At an abstract level, the one-dimensional heat equation in a homogeneous material is an illustrative example:

$$\partial_t T = \alpha \partial_x^2 T$$

For the numeric examples below, a stainless steel bar has been taken as example, with a quadratic cross-section $A = 1cm^2$ and length and diffusion constant, respectively:

$$L = 1m, \alpha \approx 4.08 \times 10^{-6} \text{ m}^2/\text{s}$$

A situation of particular relevance is a step heating of one end of a bar, eg, at x=0, up to T_0 = 80 °C, the bar being initially in equilibrium at T_L = 20 °C, which is also kept as a Dirichlet boundary condition at x = L.

Obviously, the bar will approach a linear T-profile over time. The thermal field evolution is given by:

$$T(t,x) = T_0 - T_L \cdot x/L + f(t,x)$$

f is the decaying part, and f(0,x) can be expanded in Fourier components to determine its temporal behavior. Since f(0,0)=f(0,L) = 0 due to boundary conditions, only sine components with wavelength $\lambda = m\frac{L}{2}$ are considered, with corresponding decay rates:

$$f(t,x) = \sum_{m=1}^{n} 2 \frac{A}{\pi m} \sin\left(\frac{\pi m x}{L}\right) e^{\frac{-\alpha \pi^2 m x^2 t}{L^2}}$$

This analytical result is plotted for a number of time points →2.

Obviously, relaxation times for points at a distance of about 1 m from the left end are of the order of one day; whereas, points located closer to the surface reach their equilibrium much faster. These numerical solutions are critical to the system design of noninvasive measurement.

08
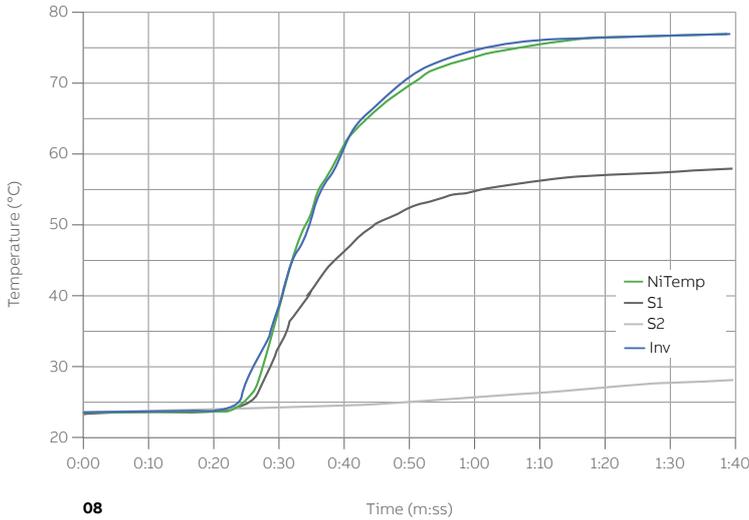
Algorithm performance depends on sensor location

If the primary sensor is assumed to be located at 0.01 m from the heated end of the bar, a number of reference sensor locations at various distances to the primary sensor are considered: x = 0.001; 0.01; 0.1; 1 m. The model-based signal is computed from the primary and reference signals [5].

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Noninvasive temperature measurement has the potential to replace a large number of invasive instruments in green- and brownfield applications.

Typically, the time derivatives of the measurement signal are used in order to invert the delay of heat-conduction signal transfer and reduce response times. However, noise amplification can lead to severe problems. Relying on the analysis and simulation of the dispersive, or dissipative behavior of the heat equation, a derivative-free signal processing is sufficient for practical purposes if the reference sensor is suitably located.

A strong convergence acceleration of the measurement is achieved by shifting the reference sensor towards the surface →3. Consequently, the reference sensor should be located as close as practically possible to the primary sensor.

NiTemp design and validation

The NiTemp design consists of a combination of two thermometer inset rods, each with a diameter of 3 mm →4; these are married in a reproducible way to ensure thermodynamic definiteness. Only the primary sensor inset is pressed directly to the pipe surface.

Design validation

Accuracy and stability were assessed under varying ambient temperature changes →5a using a heatable aluminum block and the two devices situated in a climate chamber. The benchmark surface temperature is measured by a Pt100-resistance sensor that is glued directly on the surface. The accuracy achieved with NiTemp, if the ambient temperature ($T_{ambient}$) changes strongly, is approximately +/− 1 °C →5b.

The step response time of the NiTemp double sensor configuration has been extracted from the behavior observed when the sensor is exposed to a temperature step function, eg, by contacting it to a hot surface at a specific time →6.

A response time of $T_{90} \approx 28$ s was measured, which is a phenomenal value — more than competitive with standard invasive measurement setups in use.

How would the noninvasive sensor compare to an invasive one that is installed, in parallel, in the same process? ABB evaluated the behavior of both invasive and noninvasive measurements when a temperature step change is created in a process pipe to address this question →7.

A water tank was heated to ≈ 80°C; the ambient temperature was ≈ 23°C. The test area examined was a pipe that could be closed by ball valves on both sides. When the tank was heated, a pump started to work against the closed entry valve of the test pipe. The valves of the test pipe opened quickly at a specific time such that a front of hot water entered the pipe at a speed of ≈ 1 m/s.

The test pipe size DN80 was equipped with a state-of-the-art invasive T-measurement with a thin-walled thermowell. The noninvasive device was clamped onto the pipe at a distance of 20 cm from the invasive point.

The measurement response of the two devices to the temperature step of the medium in the pipe →8 shows that the invasive and noninvasive measurement curves are in agreement. Mostly:

$T_{noninv} - T_{inv} < 1°C.$

In practice, all slowly decaying deviations are thus so small that there is no negative influence on the measurement.

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08 ABB's calculated
model-based
noninvasive
measurement (NiTemp),
achieves responses that
agree with those of the
conventional invasive
device (Inv).

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09 Relative
measurement deviation
($T_{surface}$ – T_{medium})/ ($T_{ambient}$ –
T_{medium}) for water (upper
left) and oil (lower left)
The region for the direct
application of NiTemp
shows low deviation for
water (upper right) and
raw oil (lower right).

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Another consideration is the use of more massive thermowells required by regulation today. Hence, in an industrial setting, invasive sensors would show a longer response time than observed in the experiment conducted by ABB [3].

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ABB's advanced noninvasive technology will allow the food and beverage and OGC industries to fully embrace the benefits of Industry 4.0 and be at the vangard of automation.

New applications for noninvasive measurements
ABB's experimental results and physical predictions show that noninvasive temperature measurement can successfully compete with conventional invasive measurement if the application is of a type where $T_m ≈ T_{wa}$ and if the pipe surface is suitably measured: ABB's NiTemp sensor is perfectly designed for this purpose.

So, ABB's NiTemp model-based device can be used in a large number of applications, especially for processes with aqueous solutions, even those with low flow velocities. It is applicable to processes that use liquids, like oils, or for gases, as well. Calculations of expected deviations can be made and compared with results of acceptable use cases such as for water and crude oil →9.

Noninvasive temperature measurement has the potential to replace a large number of invasive instruments in greenfield and brownfield applications. The superior accuracy and rapid response time, in combination with improved safety and lower cost and logistical effort associated with the elimination of the thermowell, make the gathering of vast amounts of field data easier and more efficient. ABB goes one step further by launching this innovative technology as a wireless device, in 2019; this device will be fully integrated in ABB's state-of-the-art connected services. Data will be available for all areas of measurement and analytics, production and decision-making. This advanced technology will allow the food and beverage and OGC industries and others to fully embrace the benefits of Industry 4.0 and be at the vanguard of automation. ●
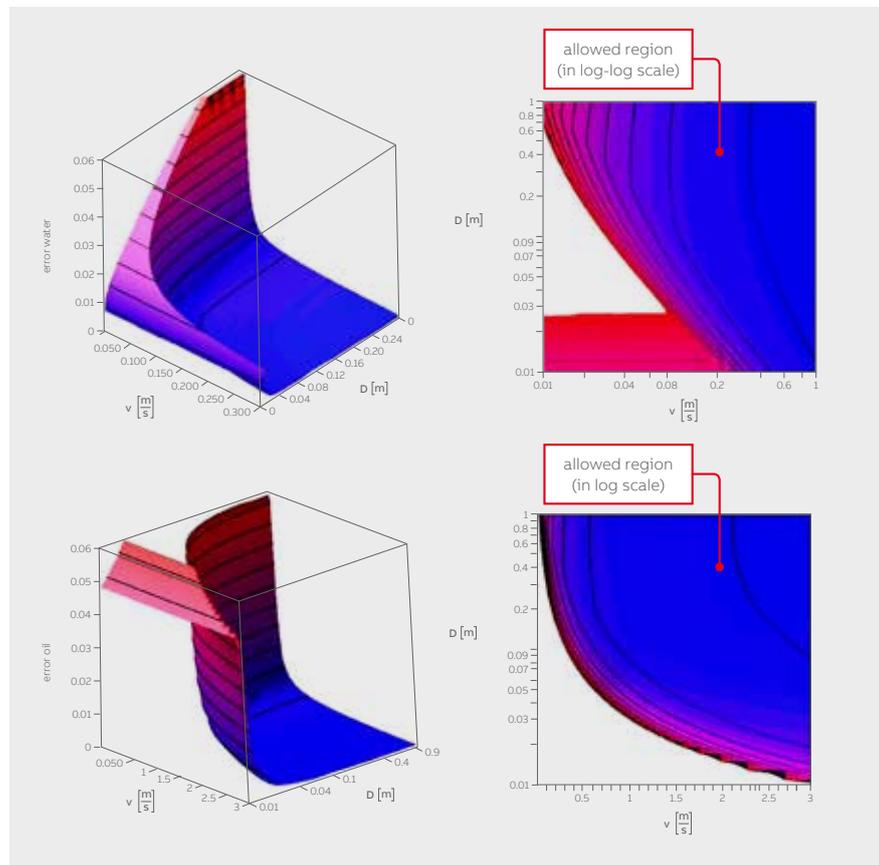
09

ABB's ring bus with static UPS for critical power applications

ABB's new ring bus architecture with static UPS is designed to provide reliable and available power to the most mission critical applications, like data centers, at minimal costs. Currently deployed, this unique system can be expanded at will – without limits to the number of UPSs or distance between them.

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Data centers and other mission critical systems rely on the stable electrical performance of the selected critical power architecture at all times. Technological advances focus on maintaining or improving performance and reliability while reducing total operational costs; this includes lowering the cost of equipment and maintenance, and energy.

Often, energy efficiency is a fundamental driver of innovation in the uninterruptible power supply (UPS) market, together with reliability and preventive maintenance. Improvements in operating efficiency can generate massive savings; an annual energy savings of $13,000 is achieved for every MW of installed UPS power (eg, $0.15/kWh) for each percentage point of improved efficiency. The reduced need to cool the system results in further savings.

Keenly aware of customer's needs, ABB pursues all avenues to maximize efficiency when designing systems. From component selection through the converter topologies and operating modes to the critical power architectures, ABB's novel ring bus configuration with static UPS addresses these needs.

Ring bus architecture basics and evolution
To increase reliability and availability of power supply to critical loads, many and varied UPS configurations have been developed: Paralleled Redundant (N+1 System), Block Redundant (Catcher System), Shared Redundant (4N/3 System), System plus System (S+S) →1. Each configuration has benefits and limitations. Traditionally, the ring bus or ISO (isolated) Parallel Architecture has only been deployed with rotary UPS systems, mainly due to the substantial technical challenges associated with the use of static UPSs.

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Currently, ABB is the sole supplier of the ring bus architecture with static UPS.

The limited fault current capability and the potential back-feed of power from the output of the UPS to the dc link have posed barriers to design engineers. However, in 2014 efforts were made to rectify these difficulties. An initial version of ring bus architecture with static UPS became available to customers. Other design variations have also been explored since 2015. Currently, ABB is the sole supplier of the ring bus architecture with static UPS.

Parallel Redundant – N+1 System

1MW UPS 1MW UPS 1MW UPS 1MW UPS

IT Load 1.2MW IT Load 1.2MW

Block Redundant – Catcher System

1MW UPS 1MW UPS 1MW UPS 1MW UPS

Transfer switch Transfer switch Transfer switch

IT Load 800KW IT Load 800KW IT Load 800KW

Shared Redundant – 4N/3 System

1MW UPS 1MW UPS 1MW UPS 1MW UPS

IT Load 400KW IT Load 400KW IT Load 400KW IT Load 400KW IT Load 400KW IT Load 400KW

System + System – S+S

1MW UPS 1MW UPS 1MW UPS IT Load 1.2MW / IT Load 1.2MW 1MW UPS 1MW UPS 1MW UPS

IP Ring Bus

1MW UPS 1MW UPS 1MW UPS 1MW UPS

IT Load 1.2MW IT Load 1.2MW

Complexity management	How many modules	scalability	Concurrent maintenance	Performance
No Single point of failure	Fault tolerance	reliability	Paralleling switchgears	Reliabiliy
installation cost	energy cost	maintenance cost	utilization rate	...	CapEX OpEX

01

—
01 By analyzing complexity management, number of UPS modules etc, performance and reliability can be mapped.

As configurations increase in their scale of power availability, so typically does cost. Hence, with reliability and power availability paramount, data center operators face a dilemma about architecture choice. These decisions are made more easily by mapping performance, availability and CapEx-OpE based on analyses of multiple factors →1.

Load sharing
A ring bus technology with static UPS in a system with 4 UPSs and two dual corded loads functions so that every UPS can supply its local load cord and also transfer active and reactive power to the ring bus through a choke →2. The intent is to share the local loads equally between the different UPSs without any communication using droop controls, in particular frequency versus active power and voltage versus reactive power. This removes any limitation on

the number of UPSs in the system and the distance between them. Also, the totality of the load is shared across all the UPSs in the ring, even in enormous rings. In large systems with other architectures, blocks of UPSs need to cope with the current limitations of low voltage (LV) breakers. The ring bus chokes are instrumental for the wireless load share as they make the impedance inductive.

—

Because the bypass is the ring, synchronized inputs are not required, nor is there a need for paralleling switchgears.

If the second dual corded load is smaller, then UPS 1 and 2 push active power to the ring while UPS 3 and 4 receive active power from the ring →2. The net result is four UPSs that are equally loaded. In steady-state, the frequency of all UPSs is equal and the phase shift between the various UPS voltages depends on the sign and amount of active power exchanged with the ring bus. If the loads are perfectly balanced and all the UPSs are operational, there is no circulation of power through the chokes.

Fault isolation

The ring bus chokes are essential for the wireless load share and for fault isolation. A fault can occur anywhere in the system, eg, on UPS output (A), on the ring bus (B) →3. No single points of failure should be allowed to cause a partial or total load drop. The worst case scenario is a phase-phase short circuit on the ring bus →3; every UPS needs to provide fault current through its choke while supplying its cord of critical load. The quality of power delivered to the critical load must remain within the defined voltage window (VW) during

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ABB's unique self-healing structure is not only insensitive to an initial fault, but also robust enough to withstand subsequent faults.

faults too. Therefore, VW, fault detection time and fault isolation time are clearly related. When standard relays and breakers are used, fault detection and isolation times are typically one-half and two cycles, respectively. In such cases and during a phase-phase short circuit on the ring bus the UPS output current must remain at the limit of the inverter current limitation regime. This criterion determines the minimal inductance of the ring bus choke. If a fault occurs on the output of one UPS (A), the other UPSs are decoupled from that fault through two chokes →3; clearly a better scenario.

Ring bus architecture protection

To locate and isolate faults (by opening the appropriate breakers) in the system a number of circuit breakers (B_{Ii}, B_{Bi}, B_{Ci}, B_{Li}, B_{RCi}, B_{RLi}, B_{RRi} for every UPS) and the related logic and relays are included. As previously stated, if standard relays and breakers are used for fault detection and isolation, detection and isolation times are typically one-half and two cycles, respectively. This will differ, however, if other switches are used →4.

The bypass is the ring

Even though the most important source of faults in data centers is human error, elimination of errors is impossible; so data centers must be equipped with superior fault tolerant systems.

With the use of breaker B_{Bi} to bypass a choke when a given UPS has failed or is under maintenance, the quality of the voltage on the local load of concern can be improved because the voltage drop on the choke is removed. Because the bypass is the ring, synchronized inputs are not required, nor is there a need for connecting switchgear in parallel. The relays and breaker network make a superior fault tolerance possible, ABB's unique self-healing structure is not only insensitive to an initial fault, but also robust enough to withstand subsequent faults.
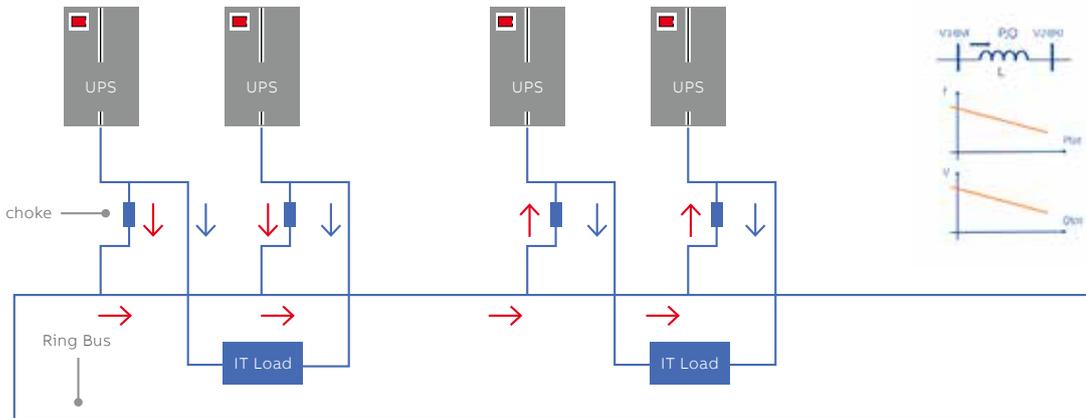

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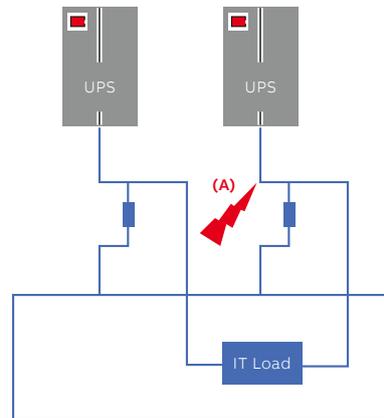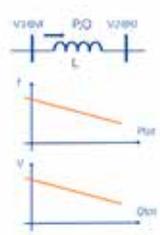
03

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02 Diagram shows how the ring bus architecture allows the load to be shared equally.

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03 Ring Bus architecture illustrating fault decoupling.

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04 Diagram showing the ring bus architecture protection and bypass capability.
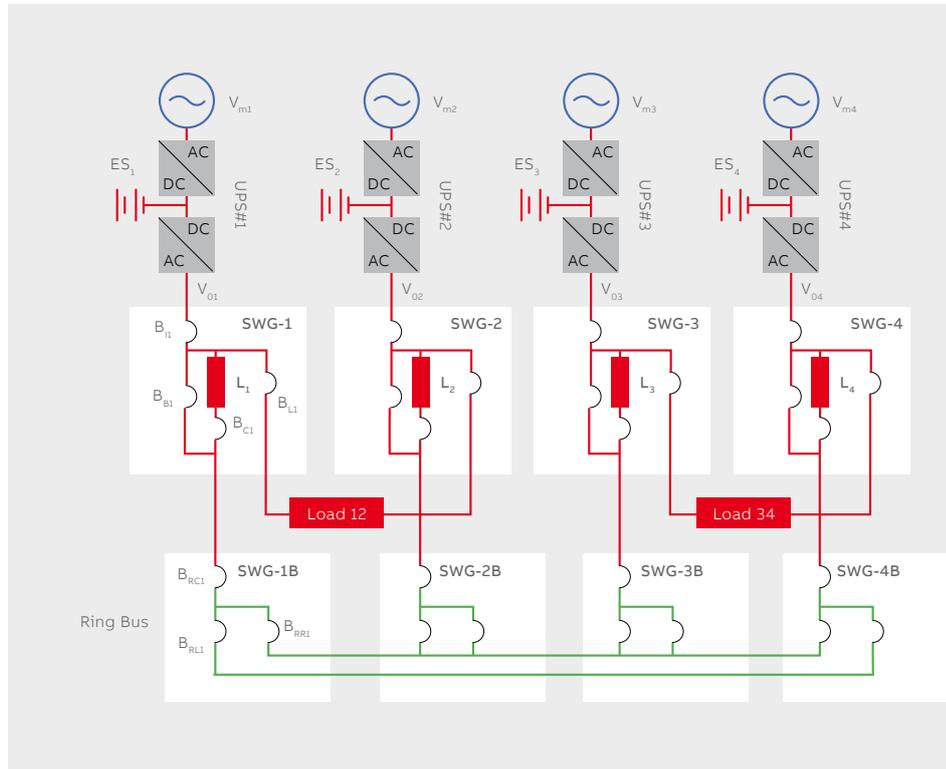
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Measuring performance: the VW pass-fail criteria
Power quality requirements depend on the load; in data centers these are the servers or, more precisely, the power supplies inside the servers. In essence, requirements specify the operating region and prevent interruption of the IT equipment. Depending on the power supplies used, requirements can differ →5.

Starting when a fault is applied, a time of X[ms] of clemency is considered from when the voltage starts to distort, then the rms voltage of the first cycle after clemency is measured and has to be > Y percent of the nominal voltage V_{nom}. As an example, applying the CBEMA requirements to a nominal voltage of 240V, 168V/20ms is obtained,

ie, success is defined by an rms voltage greater than 168V measured on the first cycle 20 ms after the fault →5.

—

The choice of power supply configuration is critical for data center operators because the VW must be fulfilled under any fault condition.

The choice of power supply configuration is critical for data center operators; especially the VW safety margin because the VW must be fulfilled under any fault condition; even the worst case scenario.

The utilization rate (UR) is related to the VW, the tighter the VW, the lower the UR, eg, a UR > 80 percent based on the CBEMA VW (70 percent – 20ms) can typically be reduced to 60 percent based on a VW (86.5 percent – 10ms). Clearly, if faults on the ring bus could be excluded by design, the UR could be increased substantially, but this is not realistic.
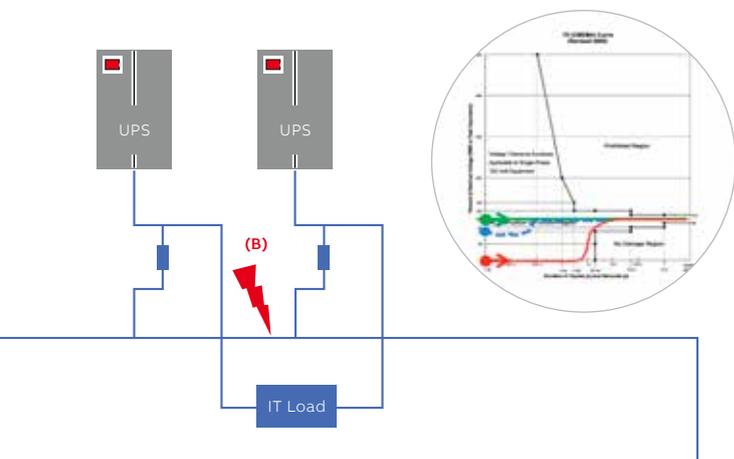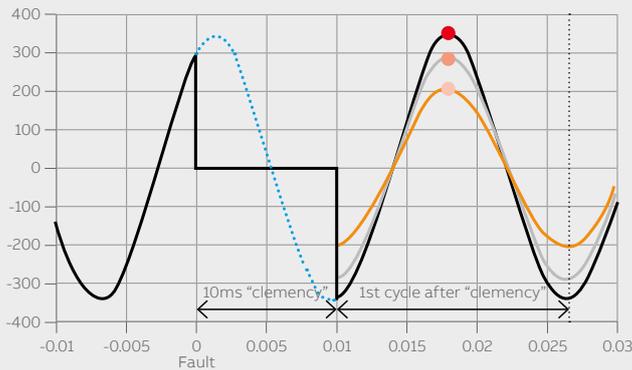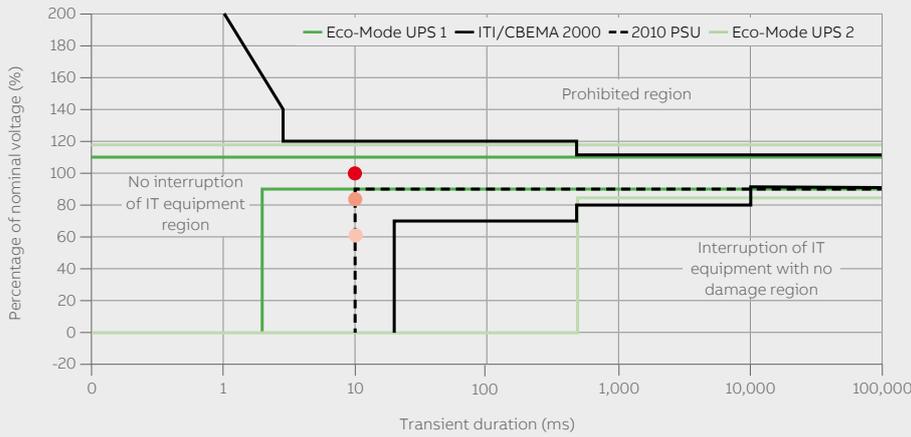
05

Operation modes, validation and results
When one UPS is offline due to maintenance needs or a fault →6, dual UPS power is fed to the loads and the remaining UPS provides balanced power. In steady state, the circulation of power from the ring to one side of the load occurs through the bypass breaker (B$_{B1}$) whereas the instant the fault occurs, the power starts circulating through the first choke (L1), which is then bypassed →4.

If operating conditions exist under unbalanced load →7, the second dual corded load is smaller and UPSs 3 and 4 need to push power to the ring while UPSs 1 and 2 receive power from the ring. Hence, the global load is shared by all four UPSs – a clear benefit.

Developmental process
Seizing on innovation, ABB initiated the development of this unique ring bus architecture with an innovative program in which a few initial patents have been granted; a small power test rig was constructed to verify the hypothesized

wireless load sharing results. The developmental program began with the design of a full scale system of 4 x 200kW UPSs in Riazzino, Switzerland and a 4 x 1000kW UPS in Plano Texas, USA →8.

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Relying on a comprehensive interface system that displays the status of all breakers, UPSs and electrical quantities of interest, ABB delivers a highly functional system.

Taking into account all necessary components (UPS, chokes, breakers, relays, PDU, etc,) these test centers were instrumental during the developmental phase and are still in use today to demonstrate and promote the ring bus architecture to customers and consultants alike. Relying on a comprehensive interface system that includes a synoptic screen that displays the status of all breakers, UPSs and electrical quantities of interest, ABB delivers a highly functional system.

—
05 Performance
measurement takes
into account VW and
the pass-fail criteria.
For the two economy
mode UPSs: Eco Mode
UPS 1 fulfills the
requirements while Eco
Mode UPS 2 does not.
The 2010 PSU is a tighter
requirement than the
ITI-CBEMA 2000.

—
06 The system operation
with one UPS offline due
to maintenance or fault.

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07 System operation
is shown under
unbalanced loads.

—
08 Partial view of the
full scale test center at
the ABB test center in
Plano, Texas.

06

07

08
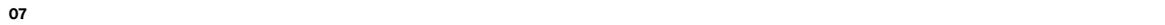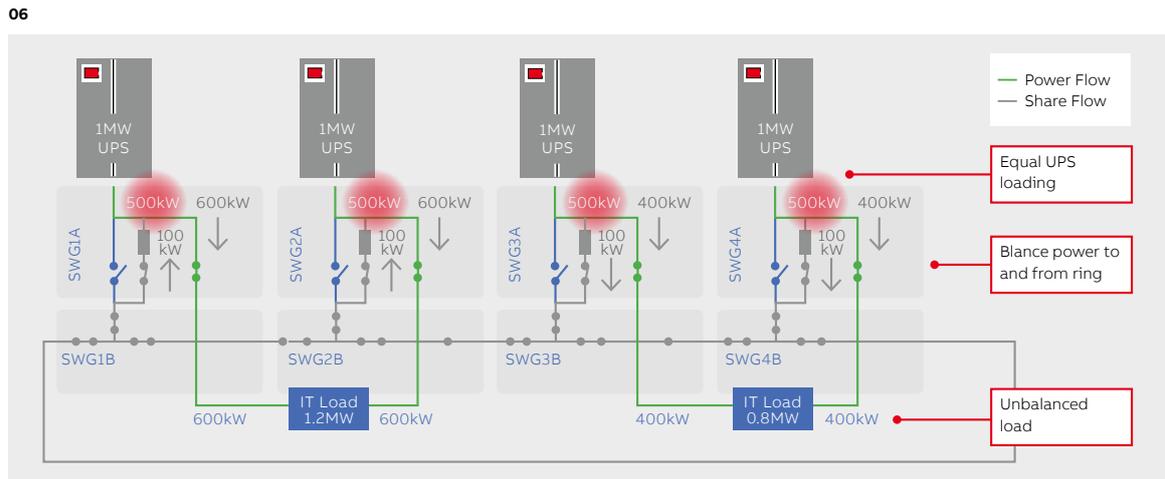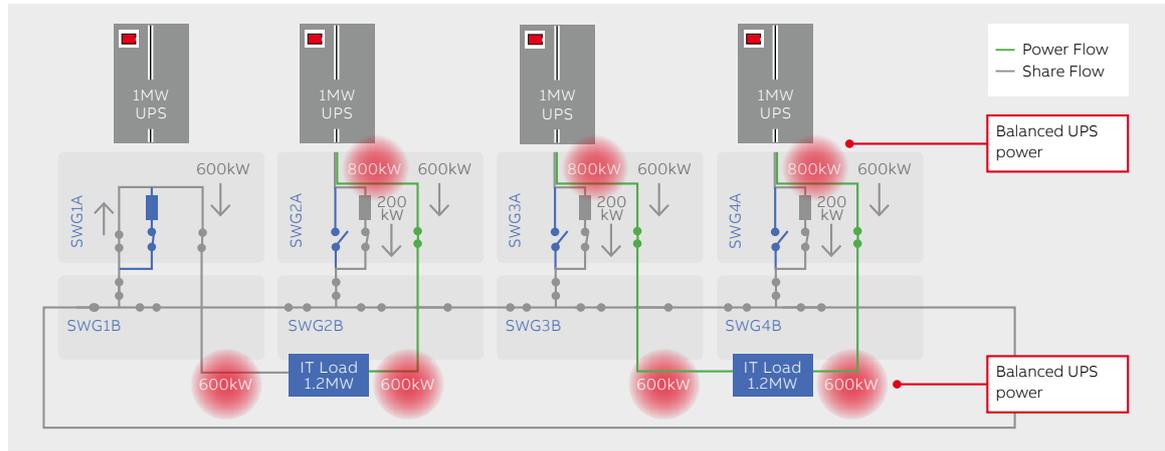
Further advances include the development of a
complete system model that employs transient
simulation software to analyze system performance
in fault and load-shifting events and power transfer
capability for ring bus systems of any size. Other
models have been developed to perform reliability
estimation comparisons of ABB's ring bus system
with those of known architectures, thereby
confirming that isolated parallel configurations
have superior reliability due to the virtual lack
of interaction between UPSs. The UPSs do not
communicate: the only interactions, from a power
connection perspective, are through the extremely
reliable ring bus chokes.

Compelling results were obtained during ABB's
test of a phase-phase short circuit on the ring bus
architecture with 4 UPSs →9. The pass-fail criteria
used in this worst case is a voltage window of 86.5
percent – 10ms. With a nominal voltage of 235V, this
translates into a voltage of 203.3V. Every 1MW UPS
is loaded with 600kW. In this case, the voltages V1,
V2 and V3 on the critical load (downstream from the
PDU) are represented on channels 1, 3 and 5 which
show rms voltages of 218.2V, 205.4V and 230.6V,
respectively, when measured 10ms after the fault →9.
The utilization rate, with this voltage window, is 60
percent – an excellent result.

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09 Experimental results
with a ring bus of 4 UPSs
during a phase-phase
short circuit on the ring.

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10 Comparison of ring
bus architectures using
static versus rotary UPS.

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Static UPS versus rotary UPS

A comparison of a ring bus architecture using rotary UPS with ABB's ring bus →10 highlights the benefits of double conversion UPS: lower initial and maintenance costs and improved load protection.

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Currently, ABB holds several patent families on the ring bus technology and future concepts.

Comparison with known architectures

ABB's novel ring bus architecture with static UPS is more reliable than other solutions, requires less initial investment in materials and installation and consumes less energy during operation. Fewer units are needed and each unit functions at top efficiency; all these features translate to a lower total cost of ownership.

Specifically, the ABB ring bus architecture is a self-healing structure that offers:
- ultimate fault tolerance
- no single points of failure
- lower number of UPS modules
- higher UPS utilization rate and less stranded system capacity
- simple and safe scalability
- optimal utilization of breaker current capabilities
- concurrent maintenance for critical path equipment
- no communication among UPS
- no limitations on the number of UPS and their distance
- total system load shared across all UPS modules
- no need for synchronized inputs
- no needs for paralleling switchgears
- potential fault current limitation

ABB's role as technical leader

Currently, ABB holds several patent families on the ring bus technology that cover the current implementation as well as future concepts. In this way, costs, feasibility and viability of this architecture is optimal today and in the future mission critical system market. These gains will ensure that ABB continues to fulfill its role as a global technical pioneer, supplying customers with the best solutions. By providing power reliably and efficiently, the unique ring bus architecture with static UPS does just that. ●

Standard ring bus with rotary UPS systems	ABB's ring bus with static UPS systems
Rotary UPS systems are line interactive.	Double conversion static UPS are used.
In normal mode (utility available) the loads are fed by the utility with some voltage conditioning provided by the synchronous machine.	In normal mode (utility available) the loads are decoupled from the utility.
One single and common utility is required.	Different utilities can be used for the various UPS, eg, with different amplitudes, frequencies or phases.
In normal mode (utility available) there is no active load share and droop controls are not working.	In normal mode (utilities available) and in energy storage mode the different UPSs share the global load equally by means of droop controls.
Rotary UPS have high short circuit capability (typically 15 In) resulting in small IP chokes (eg, 0.2–0.3 pu).	Static UPS have limited short circuit capability (typically 2.2 In) resulting in large IP chokes (eg, 0.6–0.9 pu). Specific current limiting strategy is required.
Active power back-feed is not a problem.	Active power back-feed into UPS has to be avoided by specific controls.
Reactive power is not necessarily required.	Reactive power sharing is required.

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CONNECTED FOR PRODUCTIVITY

New ABB Tmax XT circuit breakers

A circuit breaker that you can link to your smartphone and connect to analysis tools in the cloud? It might sound far-fetched, but these are just two features of ABB's new low-voltage, molded-case circuit breaker – the SACE Tmax XT.

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The SACE Tmax XT range offers higher performance, better protection and more precise metering than equivalent units, and can handle from 160 up to 1,600 A. Combined with the world's most precise electronic trip units in the smallest frames, the new range builds on the success of the innovative Emax 2, the industry's first smart low-voltage air circuit breaker. In fact, the SACE Tmax XT range has the same logics, features and interfaces as the Emax 2. This commonality, which only ABB can provide on the entire circuit breaker range, delivers significant time savings and enhances installation quality. Reliability is further increased – and time for installation reduced – thanks to Bluetooth and Ekip connectivity for mobile devices.

The XT family's built-in connectivity links smartphones, tablets and PCs to data analysis tools on the ABB AbilityTM cloud platform in real time. The extreme precision of the data measured means users have access to accurate information anywhere and anytime, making it easier to monitor resources and identify savings opportunities. Using the embedded smart power controller can help reduce energy consumption by up to 20 percent.

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The SACE Tmax XT range of circuit breakers can handle from 160 up to 1,600 A.

Upgrading the breakers is straightforward: for the first time, customers can download new functions from the ABB MarketplaceTM, choosing from among more than 50 different protection, metering and automation functionalities. ●

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The proof of successful innovation is revealed when real things happen, like when a system needs to be built or repaired, or every time a gear or bearing is spun into action. ABB is pioneering ways to deliver such innovation.

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DRIVECHAINS AND CONVERTERS

New bearing sensor enhances safety and decision making

ABB has introduced a wireless condition-monitoring bearing sensor that enhances safety and supports evidence-based decision making. Information delivered by the sensor allows customers to quickly assess the health of their bearings and decide when to schedule maintenance. Safety is enhanced since service personnel do not need to get close to operating machinery to assess a bearing's condition.

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Mounted bearings play a critical role in many applications, such as material handling in grain storage, the food and beverage industry, and mining. Downtime due to a failed bearing can be quite costly, not only due to lost production but because of secondary damage. Many times, bearings are located in hard-to-access or remote locations, making regular inspections difficult and time consuming. In view of these challenges, ABB has developed the Ability Smart Sensor for

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The sensor provides analytics that open the door to early identification of potential issues with associated equipment.

Mounted Bearings – part of the ABB Ability Digital Powertrain. The sensor allows customers to monitor bearings regardless of their locations; furthermore, it provides analytics that open the door to early identification of potential issues with associated equipment.

What customers want

Although ABB has applied sensors for its mounted bearing products previously, there were many unknowns before starting the development of the current project. To gain more knowledge regarding customer needs and requirements, the company performed an extensive "Voice of the Customer" polling. Over 100 customers of different

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Smart sensors are needed since highly skilled maintenance mechanics are becoming increasingly difficult to replace.

types were interviewed. People interviewed included maintenance managers, operations managers, industrial distributors, reliability engineers, OEMs and others that use mounted bearings. The data from the interviews was aggregated into different buckets based on customer needs and secondary interviews were conducted to validate and prioritize the findings.

The results indicated that customers desire help when it comes to maintaining and troubleshooting bearing products. One of the major reasons for this is that demographics are changing. Highly skilled maintenance mechanics with years of experience, who could often diagnose bearing issues based on small alterations in sounds or temperatures, are nearing retirement age and companies are not generally able to replace them with like-minded workers. Furthermore, when customers do find replacements, the newer workers tend to be computer savvy, but have lower mechanical aptitude.

Also, many customers don't understand condition monitoring technology or how to evaluate condition monitoring data. Some customers outsource this task but doing so is very costly. Often the analysis is performed by people who aren't experts in bearings. While some customers have already adopted a condition monitoring program, many don't have a formal program. They either don't have the resources or consider the current cost of analysis too high.

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Technological advances in electronics, connectivity, sensing, and the Cloud have changed the game.

Most customers, however, see a benefit when it comes to monitoring their asset health and the uptime that results. Also, the Internet of Things is just getting underway and many of the customers who were interviewed believe that it will have a significant impact on reducing the barriers that have prevented condition monitoring solutions from becoming widespread.

The "Voice of the Customer" survey pointed ABB to a solution: an easy-to-use, low cost condition monitoring system would fill most customer requirements. That seems pretty straightforward, but is it possible? As mentioned, ABB had previously had a sensing solution for bearings, but its market acceptance had only been lukewarm. Why would a new solution be any different? The answer is that technological advances in electronics, connectivity, sensing, and the Cloud have changed the game.

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01 The Ability Smart Sensor for Mounted Bearings allows users to monitor hard-to-reach bearings and identify potential issues early. Here the sensor is being used in a fan application.

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02 The Smart Sensor in an aggregate material handling application in a cement plant.

Improved safety and reduced costs

A new bearing sensor was developed as a collaborative effort between ABB and external vendors. ABB now offers a wireless condition monitoring solution that allows customers to quickly assess the health of their bearings. The sensor will let plant operators know when a bearing's performance shows signs of trouble, thus allowing the operator to decide when to replace it to avoid catastrophic failure, all of which provides a significant benefit from a cost and safety standpoint.

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Customers will be able to determine when to order spare parts and how to optimize maintenance and repair schedules.

Because the sensor is wireless, installation costs are lower than is the case with traditional sensor technology. Installed sensors also eliminate the need for maintenance visits to monitor equipment or to take readings with handheld tools, and built-in diagnostic capabilities reduce the need for condition monitoring analysts. Moreover, since machines must be operating to take condition indicator readings, safety is improved for reliability personnel as they don't need to get close to machinery or use their fingers to gauge temperatures. All of this adds up not only to a safer service environment, but one designed to help customers make better decisions. Indeed, thanks to information delivered by the new Ability Smart Sensor, customers will be able to determine how running equipment under different operating conditions influences machine life, when to order spare parts and how to optimize maintenance and repair schedules.

The sensor is very simple to install and mounts directly onto a bearing's housing using simple tools →1–2. Newer bearing housings will be modified to accept the sensor and a retrofit adapter will be available for the installed base as well. The sensor, which is powered by a non-replaceable small lithium battery that has a life expectancy of three years, includes accelerometers to measure vibrations, and temperature sensors to measure bearing temperature as well as temperature inside the sensor. The sensor housing is sealed to maintain its ATEX certification.

From quick views to deep dives

Bluetooth protocol is used to connect to Android or iOS mobile phones using the same app as the Smart Sensor for Motors or through a gateway to connect to ABB Ability or customer reliability systems. Life is made easier for customers since they can log into one ABB Ability interface and check the condition of their bearings or motors. Depending on the capabilities of plant reliability people, there are options for viewing the vibration and temperature data. The mobile app provides a quick view of condition health in a stop light format and also provides some basic information regarding temperature and vibration measurements. If customers want to view more detailed information, the application on ABB Ability allows more sophisticated users to look at trend lines or extract the data in order to perform their own analysis.

Embedded into an on-board microprocessor are advanced algorithms that ABB developed to detect various faults in the bearing. Validation of the algorithms and sensor performance was accomplished through extensive testing in the Greenville Advanced Development Lab on bearings with seeded faults. The true test of performance is how the sensor works under actual operating conditions so several beta test sites at key customer locations were used to further validate the sensor and application.

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Life is made easier for customers since they can log into one ABB and check the condition of their bearings or motors.

Feedback has been very positive. The sensor has 30 days of data storage capacity, so customers can look at trends directly from the sensor. New versions of firmware can be installed by an over-the-air feature built into the sensor.

The Smart Sensor for Mounted Bearings is the latest technology offering in the ABB condition monitoring arsenal and complements the Smart Sensor for Motors. Both sensors provide asset health conditions that can help ABB customers maximize uptime. ●

DRIVECHAINS AND CONVERTERS

Tool-free, push-in wiring

The industry's first range of motor starting solutions with push-in spring terminals speeds up wiring work, minimizes installation and commissioning issues, and provides more reliable long-term operation.

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In motor applications, wiring is both time-consuming and a frequent source of problems – both during installation and later, when terminals must be re-tightened due to vibration.

ABB has launched the industry's first range of motor starting solutions with push-in spring terminals that minimize these issues significantly. The innovative, tool-free connection concept speeds up wiring work and provides a vibration-resistant connection that makes operation more reliable.

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In push-in mode, rigid wires, or wires with ferrules, are simply pushed into the terminals, cutting wiring time by up to 50 percent.

ABB's two-in-one design combines the advantages of push-in and spring technology in a single terminal to enable OEMs, panel builders and machine builders to speed up their installation work and improve reliability.

In push-in mode, rigid wires, or wires with ferrules, are simply pushed into the terminals, cutting wiring time by up to 50 percent compared to a conventional spring solution and making wiring significantly easier. The self-tightening terminals help eliminate problems caused by vibration, eg, terminals being vibrated open. There is no need for routine retightening work, which will positively impact the maintenance and service cycles.

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Spring mode makes it simpler to insert small cross-section wires or wires without ferrules.

Spring mode makes it simpler to insert small cross-section wires or wires without ferrules. The operator simply pushes a standard screwdriver into the clearly marked holes before inserting the wire. The design of the opening mechanism has been optimized with regard to wiring behavior

and ergonomic aspects – eg, a 90° angle for the opening tool insertion. The one-step process makes ABB's solution easier to use and less prone to damage than conventional spring designs.

The clearly marked terminals, an intuitive cable insertion concept and zero-torque connections mean that no special training is required. With easy front access and 90° insertion angles for cables and screwdrivers, automated assembly is facilitated and it is easy to connect accessories.

A wide range of compatible auxiliaries, mounting kits and accessories will be available. 100 percent tool-free mounting connecting kits significantly reduce installation time. Operators can connect devices for direct on-line starters without using any wires. ●

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01 Increasingly
meaningful images
emerge. Shown are
just a few of the many
successive images
on several layers that
demonstrate how
meaningful visual
information is gleaned
by deep learning.

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02 Deep learning
enhances image
recognition, which
allows industrial robots,
like the ABB YuMi shown
here, to perform ever
more complex tasks.

Deep learning

The seventh installment of ABB Review's Buzzword Demystifier delves into the depths of "deep learning."

Deep learning is a way of automatically learning successive layers of increasingly meaningful representations from data. These representations can then be used to detect a pattern or to classify the data. For example, →1 shows just a few of many images from individual layers that learn increasingly refined representations of data. By layer 3, recognizable features can be learned, such as a face. Tens or hundreds of these successive layers may be used to develop such representations.

Successive layers of representations are learned using neural networks – a class of machine learning model. Traditionally, neural networks would learn only a few layers of representations due to inadequate training data or lack of computing power. However, recently, this situation has completely reversed, making it easier to train more layers. The more successive layers, the deeper the network. Hence, "deep learning".

In most traditional machine learning approaches, raw data is not processed automatically. Instead, processing requires considerable domain knowledge to hand-craft certain features.

Deep learning, however, takes raw data as an input and automatically finds the representations needed for pattern detection or classification. This ability to learn features automatically makes deep learning methods very useful in various generalized situations.

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The challenge remains to find the right neural network structure and to identify the variables that determine the training performance of the network. Also, it is not easy to understand which features the deep learning models learn. Moreover, like all machine learning models, deep learning models are also vulnerable to carefully crafted inputs that can lead the models to wrong inferences. These topics are currently the focus of deep learning research.

Recently, deep learning has been tremendously successful in performing tasks such as image and speech recognition →2. The potential impact of deep learning cannot be understated as it will influence many industries and will bring about very visible changes in society as a whole. ●

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Next 02/2019

Simulations and the digital twin

As with people, machines are the sum of their experiences. They are "born" from materials, processes and decisions that then create new data scattered across space and time. What if these touch points could be captured and used to improve performance and model innovation? The next issue of ABB Review will explore the reality of such "digital twins," and how simulation helps machines become better.