ABB review

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The corporate technical journal

Innovation

Power and productivity for a better world™

More than 120 ago, Thomas Edison's DC lost "the war of the currents" against George Westinghouse's AC. But DC is far from dead. ABB's predecessor company, ASEA, debuted HVDC technology with the Gotland link in 1954 (photo on this page). Today ABB is the world's leading provider of HVDC systems (a modern yard is shown on the front cover). HVDC's advantages include low losses over long distances as well as the possibility of underground or even undersea cables. But the absence of suitable breakers meant that, until now, only single lines were achievable rather than DC networks. In what is possibly the greatest innovation in decades, ABB has filled the gap.

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Innovation

Prith Banerjee

Dear Reader,

Innovations are the changes that propel technical progress forward. They can broadly be classed into three categories: Derivative innovations build on and improve current products, for example by extending existing product families. Platform innovations lead to new products and families of products. The third type, disruptive innovations, are the boldest. They break new ground in a big way, significantly expanding the envelope of the possible and reshaping the way things can be done, so redefining applications, the market and ultimately economic and societal realities.

ABB has recently announced a truly disruptive innovation that will revolutionize the transmission grid on a scale that has maybe not been seen in a century.

Whereas traditional power plants were typically located close to centers of consumption, emerging renewable generation often requires transmission from remote areas. The greatest abundance of renewable sources is in sparsely populated regions where traditional grid infrastructure is weak. Its increased harnessing is thus redefining the requirements placed on transmission grids, with more power having to be transmitted over longer distances – without interfering with local flows. ABB's solution to this challenge is high-voltage DC (HVDC).

ABB's predecessor company, ASEA, pioneered HVDC in the 1950s. Today the technology permits highly efficient bulk transmission over thousands of kilometers as well as the crossing of seas. As early as 1992, ABB proposed a European power supergrid, consisting of an HVDC network connecting centers of consumption to hydro, solar and wind plants, some of them thousands of kilometers away. But the lack of a suitable DC breaker meant that all HVDC links built so far are point-to-point transmissions. ABB has now cleared the final major technical hurdle on the road to a true DC grid with the presentation of its DC breaker.

There is much to be said about the DC breaker, and besides the introduction in this issue, the topic will be revisited in upcoming editions of *ABB Review*.

Further topics covered in the present issue range from data centers to smarter switchgear, and from wireless communications to the better understanding of operator interfaces. All of these innovations will make utilities and industries more efficient, safer and more productive.

I trust that these and other topics presented in this edition of *ABB Review* will increase your understanding of ABB technology and that you will find aspects that are relevant to you.

Enjoy your reading.

Prith Banerjee
Chief Technology Officer and
Executive Vice President
ABB Group

Innovation highlights

ABB's top innovations for 2013

In its research and development labs across the world, ABB is continuously innovating to create the technologies that will shape tomorrow's world. The current selection is but a cross-section of the company's numerous breakthroughs and achievements. Many of these, as well as other innovation successes, are presented at greater length in this and forthcoming issues of *ABB Review*.

Edison's conundrum solved

In its simplest form, the chain of delivery of electrical energy constitutes a cable from the generator to the consumer. In reality, life is rarely that straightforward. The power a household or factory consumes is supplied by different sources distributed over a wide area, with consumers being similarly distributed. Today's electrical grid is a complex mesh built around the concept of redundancy – meaning delivery of power continues even if individual plants or transmission lines are not available. An important ingredient of such a grid is switchgear, permitting the flow of power to be controlled and individual sections disconnected.

In the "war of the currents" of the late 1880s, Thomas Edison's DC and George Westinghouse's AC battled for supremacy – a struggle that AC finally won.

One of the inherent advantages of high-voltage AC lies in its switchgear. When a current is interrupted, it does not stop flowing immediately but a conducting plasma forms between the open contacts of the switchgear. In AC this extinguishes as the current value passes through zero (as it does 100 times a second for 50 Hz, or 120 times for 60 Hz). Interrupting high-voltage DC is a much greater challenge.

Rather than becoming a footnote in history, DC has been making a comeback over the last decades – thanks to HVDC technology pioneered by ABB. HVDC involves converting electricity to high voltages, which can be transmitted over very long distances (up to thousands of kilometers) with very low losses and high controllability. Furthermore, thanks to technologies such as subsea cables, virtually no obstacle is too great for HVDC. But all HVDC links realized so far are point-to-point transmissions. Just as the AC grid benefits from flexibility and redundancy because of its mesh-like structure, so will HVDC's range of application grow if it too can be connected into more sophisticated topologies. Ultimately a new HVDC grid will emerge, reinforcing the traditional grid while relieving it of long-distance bulk power flows, and so redefining the way in which transmission works. The relevance of this has been increased lately by the growth of renewable generation, meaning power must be transmitted from areas of generation where the grid is traditionally weak to centers of consumption hundreds if not thousands of kilometers away. ABB thus embarked on the development of a DC breaker.

In late 2012, the company finally announced its breakthrough. The new breaker uses a combination of power electronic and mechanical switching to safely and speedily interrupt the flow of DC. The technology will be discussed in greater depth in an upcoming issue of *ABB Review*.

Watchful algorithms

ABB MACHsense is a condition monitoring service that uses portable or remote monitoring systems together with intelligent algorithms to assess the condition of motors, generators and other equipment connected to mechanical power transmission elements.

The service focuses on the early identification of defects in the machine being monitored. This enables plant maintenance managers to schedule timely interventions and remedy problems.

These defects include, but are not limited to, bearing problems, motor or generator electromagnetic anomalies and any negative influences on reliability or performance arising from the connected environment.

Measurements are based on configured combinations of data from vibration, voltage, current and temperature sensors. Analysis software consists of libraries of algorithms that are used collectively to achieve the best possible discrimination of defects.

The deployment of these algorithms forms the backbone of the monitoring system, which uses a physics-of-failure approach, combined with sophisticated signal processing of the data, to derive key condition parameters that reflect the development of defects.

In remote-monitoring configuration, an alarm is triggered if a key condition parameter exceeds set limits, giving the plant operator an early warning that maintenance is needed. Customers can access data and observe trends in the operation of their motor, generator or other power transmission elements via the Internet.

Breaking the performance barrier with ELK-3 gas-insulated switchgear

ABB has introduced its latest generation ELK-3 gas-insulated switchgear (GIS) for 420 kilovolt (kV) installations. It is part of ABB's technology and innovation focus, and follows the recent launch of advanced versions of the 245 kV and 72.5 kV range gas-insulated switchgears.

One-third smaller than its predecessor, ELK-3 also needs 40 percent less SF_6 insulating gas, making it more environmentally friendly as well as extremely compact and low-weight. This robust, high-performance GIS enhances grid reliability and efficiency under very harsh conditions.

ELK-3 is factory assembled, tested, and shipped as one bay in a container on a flat rack or low bed truck, reducing transportation, site installation and commissioning time by up to 40 percent compared to traditional designs. Frontal access to drives, position indicators and service platforms improves operation, inspection and maintenance procedures. Standardized modules and connection elements enable flexible substation configurations and optimize building designs.

This new GIS features a fast, single-interrupter dual motion circuit breaker and is designed for current ratings of up to 5,000 amperes (A). It provides protection for power networks with rated short-circuit currents of up to 63 kilo amperes (kA).

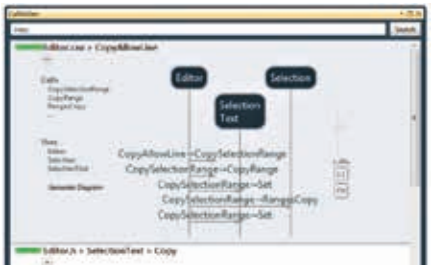
Context searches save time, reduce software maintenance costs

CoMoGen search tool can shrink software maintenance tasks by up to 40 percent

Buying a home requires context, as in what kind of neighborhood is it? Are there schools nearby? Context is equally important when searching software systems. Software developers need more than a snippet of relevant source code; they need to know what object it is in (neighborhood), and what it is linked to (schools). If code search tools provided search results in context, developers could make rational decisions.

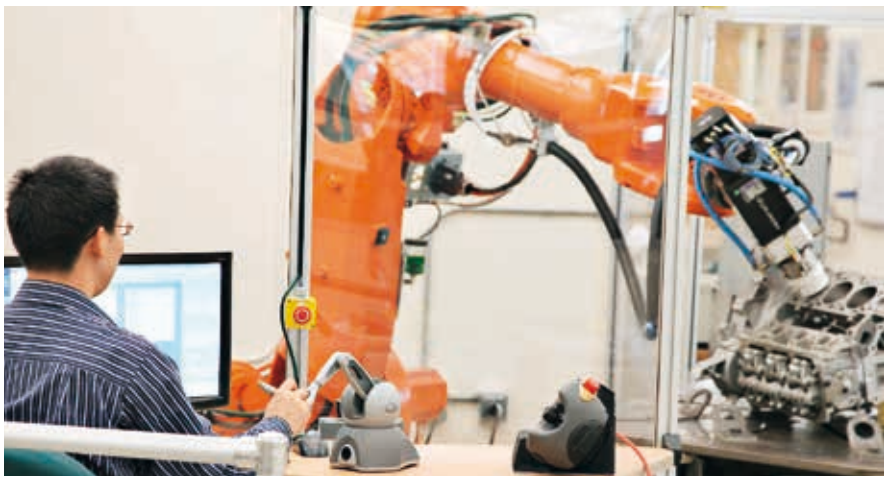
ABB's Industrial Software Systems (ISS) team has developed an advanced search tool called CoMoGen which saves time and money by eliminating manual exploration for context by automatically generating the context for each search result, helping developers make more informed decisions faster. The tool also improves search results.

Software maintenance tasks often begin by identifying search terms in the task description. Source code is then searched for a list of relevant code snippets, much like a Google result page. Interesting links are opened and the "neighborhood" explored, which can easily take several minutes before the result is determined to be irrelevant. ISS estimates CoMoGen can shrink each maintenance task from 5 to 40 percent, potentially saving ABB millions of dollars in software maintenance costs each year.



Human skill, robot strength

ABB Corporate Research and ABB Robotics are collaborating in a research project to allow users to guide the robot from a distance and feel what it feels. When the operator moves a stylus, the robot will synchronously emulate the gestures of the operator and provide force feedback through the stylus. This teleoperation technology will combine the robot's accuracy and strength with the user's skill to provide safe and precise interactive operation for many applications, such as material handling, assembly, and material removal.

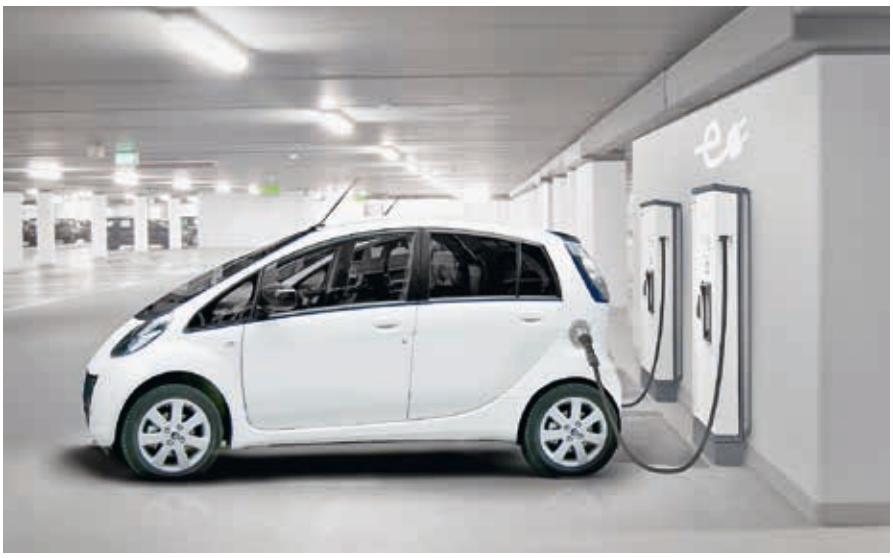


Industrial robots are currently designed for well structured environments to perform repetitive tasks. Automating dynamic and non-repetitive tasks is desirable, but has not been practical or cost effective to date. In these cases a human operator would like to directly operate the robot.

The force sensing capabilities of the robot will give real-time feedback to the operator and strictly maintain process force limits, preventing collisions and ensuring that the quality requirements are met. Operator safety is easily ensured since the operator can be at any distance from the robot. Processes can be optimized by combining user-guided robot motion and automatic operation.

In addition to the haptic feedback, remote teleoperation will also give visual feedback so the operator can see and sense what the robot sees and senses.

Cloud-based connectivity for EV charging



The electric vehicle charging industry is constantly changing. Today, charging operators require safe, secure connectivity solutions that enable their charging networks to run more efficiently and reliably than ever before. ABB's connectivity-based solutions are now part of every charger it produces, resulting in flexibility and cost savings customers can count on.

EV charger connectivity is essential to the future of the charging market, with cloud computing easily eliminating many of the complex constraints from the traditional computing environment, including space, time, power and cost. Connected services via the cloud enable ABB's customers to change the way they use technology to provide service to their own customers, partners and suppliers.

Cloud computing (or SaaS) allows businesses to reduce IT support costs by outsourcing hardware and software maintenance to the SaaS provider. Web applications can be updated and maintained without distributing and installing software on client computers, and the inherent support for cross-platform compatibility is provided.

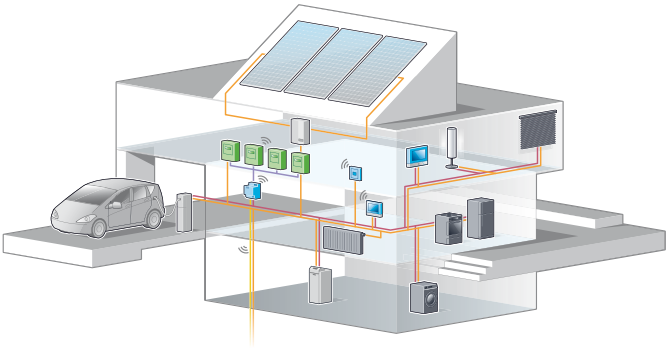
Included in ABB's cloud-based offering are remote maintenance and diagnostics, and interfaces to service providers to enable subscriber man-agement applications. Data protection complies with the highest Internet security standard (ISO 27001).

For more on ABB's cloud-based connectivity solutions for EV charging, please see the article "Cloud-controlled charging" on page 24 in this issue of *ABB Review*.

Residential demand response

In 2010, ABB together with Stockholm City and the utility company Fortum, invited academic and commercial partners to investigate the future urban smart grid in a long-term project.

As a first step the project performed a pre-study resulting in the Active House residential demand response architecture. The architecture is based on existing and emerging smart grid standards and connects the utility's smart grid system with the household's home automation system. ABB implemented and demonstrated a first proof-of-concept of the architecture in 2012 using Ventyx's smart grid system and Busch-Jaeger's and ABB STOTZ-KONTAKT's home automation solutions. (Ventyx is an ABB company and Busch-Jaeger is a member of the ABB Group.) A key component in the architecture is the new Energy Service Interface (ESI), developed by Busch-Jaeger and ABB's researchers, which is an embedded device mounted in the household electrical cabinet. The ESI uses EEBus middleware to communicate over, eg, KNX, ZigBee and IP with home automation components, and a secure communication with the utility and the household



meter. Utility information, in the form of a 24 hour forecast of the electricity price and CO_2 emissions, is sent to the ESI daily. Using household preferences together with meter and utility information, the ESI's energy management system's logic schedules the household's electric loads with the goal of minimizing electrical consumption costs and environmental impacts while still retaining comfort.

I/O to suit

ABB's RIO600 intelligent electronic device (IED) extends the input/output (I/O) of Relion® IEDs and COM600 grid automation devices.

The RIO600 comprises a processor/communication module, a maximum of 10 binary input and output modules (40 channels) and a power supply. It supports the GOOSE communication service, which is based on the IEC 61850 standard. Thus, the RIO600 adds to the I/O capability of a host IED's peripherals by communicating with it over IEC 61850 GOOSE.

The RIO600 IED is based on a modular concept that is standardized in terms of its mechanics, inter-module communication and design of the modules themselves. This makes the modules, to some extent, autonomous and interchangeable. Many variations of functionality can be created by combining various modules. The customer can scale up or down according to application requirements.

As the mechanical form factor is given, no new housing design is required when new functionality is introduced, so development is simplified. All existing modules, eg, the power supply module, communication module and I/O modules, can be used as is. In principle, if

very specific functionality is required, a module can be designed and embedded with standardized modules to create a new, fully functional unit.

You wear it well

Recent advances in mobile computing and communication technologies have enabled innovative solutions in the form of mobile apps and wearable computing. Mobile devices can increase situational awareness when used within factories and plants by providing necessary information on the move. In addition, mobile devices can be used to perform complex tasks due to the introduction of new technologies. Wearable computing, facilitates other efficiency improvements in industrial environments, like hands free interaction and health and safety monitoring of the wearer.

The ABB software research team has been exploring several aspects of mobile and wearable computing. For instance, a wearable safety suit was developed, which integrated various sensors and is operated via a mobile device. Sensors sewn into clothing are able to increase the safety of maintenance and service staff by collecting information related to environmental

conditions such as gas levels or temperature as well as the health of the wearer. Via augmented reality applications on mobile phones, tablets or special glasses, the field technician can get background information to make his work more efficient and safer.

Mine ventilation

Proper ventilation is essential to assure a healthy working environment in an underground mine. It is a support function that interacts highly with production. The purpose is to distribute fresh air to production areas where personnel are. Ventilation consumes a significant amount of energy, typically 100 GWh/year, which can be as a much as 50 percent of a mine's total energy consumption.

Today, main fans on the surface feed the mine with air that is distributed underground by fans or/and air regulators. Modern ventilation technology control is ventilation on demand (VoD); however, many mines are not controlled at all. The drawbacks of VoD are that there is no feedback control and it uses a complex, or weak, fan relationship model. ABB now offers a new and unique method for mine-wide coordinated control of the fans to achieve an energy optimized and reliable solution that automatically feeds the mine with the required air. The solution is based on optimization techniques and relies on feedback from air sensors. Multivariable models describe how changes in the speed of fans affect both the airflows and the pressure over fans. The parameters in the models are obtained empirically from operational data, which makes them adaptable for new conditions.

Light measures current

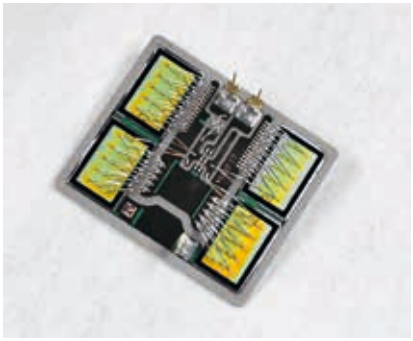
In 2005, ABB introduced a high-performance fiber-optic current sensor (FOCS) for the measurement of DC up to 600 kA, particularly in the area of electro-winning of metals. This sensor – based on the Faraday effect, where the magnetic field caused by the flowing current affects the speed of light in an optical fiber – is now in worldwide use, eg, in aluminum smelters, copper mills and chlorine plants. ABB has now further developed the technology for use in high-voltage substations.

Its advantages over the conventional instrument transformers that are used today for current measurement include higher fidelity (eg, no magnetic saturation), higher safety of operation and smaller environmental impact. The initial product will be integrated into 420 kV or 550 kV live tank breakers (LTBs). This will allow customers to significantly reduce the substation footprint, particularly when implemented in combination with disconnecting circuit-breakers (DCBs).

The sensor is factory-installed in the LTB in a way that does not interfere with the LTB assembly in the field. No extra insulation is needed. An outdoor cubicle near the LTB houses the sensor's three-phase opto-electronics unit. An optical IEC 61850-9-2LE process bus connects the sensor to bay-level control and detection devices. Full redundancy provides a high level of availability: There are two separate sensors for one measurement point and these share a common sensor head housing and fiber cable between the electronics and the housing. A prototype system has been successfully operating at a substation for about three years. First installations of the commercial version of the sensor will occur during 2013.

Integrating for higher power – BIGT

Common topologies in power-electronics feature diodes connected anti-parallel (conducting in the opposite direction) to active switching devices. In order to simplify manufacturing and increase power densities, there is a trend toward integrating the two devices as a single piece of silicon. Due to inherent technical challenges, the approach has so far only been employed for lower power components such as IGBTs (insulated-gate bipolar transistors) and MOSFETs (metal-oxide semiconductor field-effect transistors) and for special applications[1]. ABB has now created a fully integrated high-power IGBT and snubber-diode as a single chip.



The new concept is dubbed BIGT (bimode insulated-gate transistor). The main target application is hard-switching mainstream inverters. First prototype devices with voltage ratings above 3,300 V have demonstrated high power densities and an improved overall performance.

The BIGT was designed in accordance with the latest IGBT design concepts while fully incorporating an optimized integrated anti-parallel diode in the same structure. In addition to the power and size impact of the BIGT, the device provides improved turn-off softness in both operational modes as well as capability for high operating temperatures, higher fault condition performance under IGBT short circuit and diode surge current conditions, and improved current sharing when such devices are operating in parallel. In addition, by utilizing the same available silicon volume in both IGBT and diode modes, the device provides enhanced thermal utilization and hence improved reliability. The BIGT single-chip technology will provide an ideal solution for the next generation of high-voltage applications demanding compact systems with higher power levels.

Footnote

1 Large area bipolar devices such as the IGCT (integrated gate-commutated thyristor) have also featured monolithic integration, but in this case the diode and IGCT utilize fully separate regions on the silicon wafer.

Power packed

Smart modular UPS designs

NICOLE NÄGELE – with its acquisition of the innovative uninterruptible power supply (UPS) company, Newave Energy, based in Switzerland, ABB is now able to offer a complete range of UPS products that suits all flexibility, availability and power needs. Newave is active in the medium- and high-power UPS range, which is the most attractive market segment since it represents a large and fast-growing part of the overall UPS market. Newave's products are the core of ABB's UPS offerings and are based on a robust design philosophy that ensures best performance.

Just over a decade ago, the last Strowger telephone exchange was taken out of service. These stalwarts of the telecom industry were first installed in the 1920s and many of them served for over 50 years. Such longevity expectations for a product being installed today is almost unheard-of. Technology is evolving at such a rate that even forecasting one decade ahead, let alone five, is next to impossible. And this has a direct effect on UPS design. Because UPSs are found in an astonishing variety of industrial, commercial, academic and medical settings, all of which are subject to rapid technological change, they have to be flexible enough to cope with power demands that change over time. Not only is the supported load likely to increase with equipment expansion, but overload conditions may also become more demanding as power quality varies, for whatever reason.

> UPSs are found in an astonishing variety of industrial, commercial, academic and medical settings.

Added to this is the increasing criticality of infrastructure in today's society. As has recently been seen, events such as a bank's IT system dropping out for a few days can have a financial impact that runs into the hundreds of millions of dollars. So, UPS protection must be available at all times – and this creates its own maintenance challenges.

Cost is also an issue. Few organizations will write a blank check for an open-ended power backup solution. Efficiency is demanded, not only for cost reasons, but to ensure that an environmentally friendly approach is taken; there is always pressure to be "green."

This drive for more efficiency, flexibility and availability has been key to the development and uptake of modular UPS solutions. The scalability of modular architecture can deliver major reductions in electricity consumption and CO_2 emissions, and help specifiers make flexible plans for power and space requirements for both immediate and changing future needs → 1.

Full product palette

Newave Energy, a leading manufacturer of uninterruptible power supply solutions,

Title picture
By acquiring Newave Energy, ABB has filled out its UPS product portfolio and can now deliver devices to suit almost any flexibility, availability and power need at a reasonable cost.

1 UPS scalability saves power, reduces emissions and simplifies the designer's job.

2 Modular UPS design brings many advantages.

The drive for more efficiency, flexibility and availability has been key to the development and uptake of modular UPS solutions.

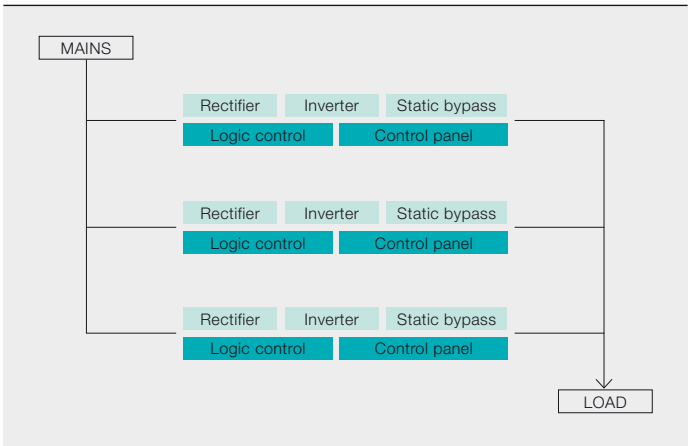
was acquired by ABB in March 2012, thus closing a product gap in core datacenter electrification and industrial power quality. Although ABB has a strong presence in industrial markets and already offers industrial UPS products, Newave is active in the medium- and high-power UPS range. This is the most attractive market segment since it represents 50 percent of the overall UPS market and has a yearly growth rate of 6 to 10 percent. This pioneering company introduced modular and transformer-less UPS technology in 2001. Today, these concepts form the foundation of the most important architectural trends in the UPS market. Although Newave has a comprehensive product portfolio containing both traditional free-standing and modular UPS, the majority of its sales are now of modular three-phase UPS. Today, close to 70 percent of its sales are of modular UPS systems. The UPS market is an exciting one and of huge size: $6 billion to $7 billion annually (the global market for UPS Systems is projected to reach $14 billion by 2017 [1]). Underlining the prospects for this market is the fact that more than half of electricity demand is accounted for by the information technology market. In the United States alone, about 8 percent of the electricity consumed can be attributed to the use of the Internet, ranking it higher than the steel and chemical industries [2]. Combining ABB's and Newave's market presence and technological expertise will allow ABB to offer a complete range of UPS solutions to industrial, commercial and datacenter clients.

Modular UPS

Systems based on a modular UPS topology currently represent the fastest-growing segment of the three-phase UPS market. Scalability, maintainability and availability are the key benefits offered by modular UPSs. Not all modular UPS systems are the same, though: The engineers at Newave have designed their modular, double-conversion three-phase UPS systems using decentralized parallel architecture (DPA), which eliminates single points of failure. Each UPS module contains its own independent control and static bypass switch, meaning each is a UPS in its own right → 2. Clever paralleling schemes allow the modules to work as one system but without interdependence → 3. In the unlikely event that one UPS module were to fail, the overall system will continue to operate normally but with one module fewer of capacity. As it is usual for UPS systems to be over rated, this offers very high reliability.

The Newave DPA concept provides each UPS module with its own independent static switch, rectifier, inverter, logic control, control panel and battery charger. Even the batteries can be configured separately for each module, if required,

3 Clever paralleling systems allow the modules to work as one system but without interdependence.



4 The main application for this kind of UPS technology are data centers.

which makes the parallel system fully and truly redundant. With all of the critical components duplicated and distributed between individual units, potential single points of failure are eliminated. System uptime is further maximized by the true safe-swap modularity of the modules.

Availability

Mean time between failures (MTBF) and mean time to repair (MTTR) are common parameters in the UPS industry and both impact system availability. Modular UPS designs maximize the system's MTBF. Quick and simple repair by swapping modules, which can often be held as spares on site or at a close by service center, minimizes the system's MTTR. Not only does this improve availability but it also reduces cost as service engineers spend less time on site and any risks of data or production loss are minimized. Inventory levels of specialist spare parts is reduced and the need for highly skilled on-site technicians is eliminated. Thanks to the compact design and low weight of the modules, inserting additional modules or replacing existing ones during operation is easy and can often be performed by a single technician.

Modular and transformer-less UPS technology concepts form the foundation of the most important architectural trends in the UPS market.

Efficiency

Electrical efficiency is especially important in UPS applications as the direct waste energy is not only expensive and environmentally unfriendly but, because many UPS systems operate in air-conditioned environments, extra energy and capital expenditure have to be employed to remove excess heat. The modular UPS products available from ABB offer best-in-class energy efficiency. The Newave modular products can operate in voltage-regulating, double-conversion mode where all power is converted from AC to DC and then back to AC. Alternatively, they can be set to an economoy mode (eco mode >99 %) where the load is supplied very efficiently through the static switch and inverter operation is invoked only if the input supply goes out of tolerance.

Cost

Although the initial capital cost of a true modular system is typically slightly higher than that of a legacy UPS design, the picture changes when total cost of ownership (TCO) is taken into account. Improved energy efficiency, as well as other savings, means that the modular system's extra cost will often be recovered within its first year of operation. Floor space is always at a premium and can also be expensive, so the compact design of ABB's UPS products is another economic benefit when compared to legacy UPS designs.

Trying to cater for future power requirements with traditional stand-alone UPS systems can lead to over-specification, creating a wasteful gap between installed capacity and the size of the actual critical load, and making inefficient use of costly floor space. However, rack-mounted configurations can be right-sized by inserting or removing "safe-swappable" modules, enabling power to be added as requirements grow without any footprint penalty. This safe-swap technology, along with significant reductions in repair time, can also achieve the so-called six nines availability (99.9999 percent) – highly desirable for data centers in pursuit of zero downtime.

ABB is now in the fortunate position of having a comprehensive range of power protection products to guard all types of loads from sags, surges and outages.

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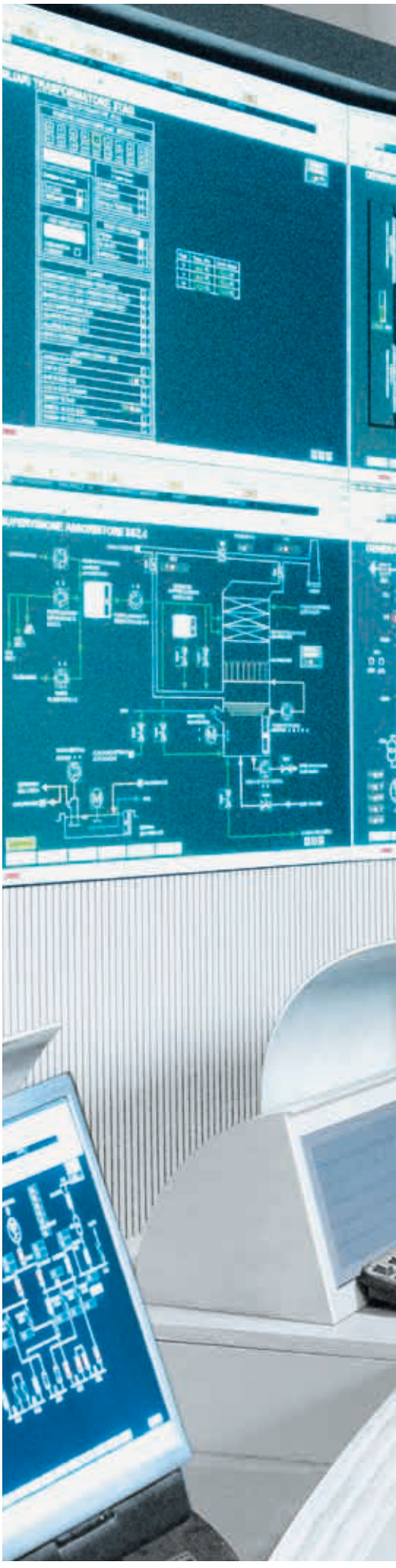
Power factors

Power quality – problems and solutions

NICOLE NÄGELE, SOPHIE BENSON-WARNER – **Modern society has become dependent on a continuous supply of clean electrical power. But the power supplied by the grid is not always clean, or continuous, and measures have to be taken to mitigate this. The first step in designing the power protection solution to do this is to understand the types of power quality problems on the incoming supply and the nature of the loads to be connected.**



Title picture
When problems occur in the supply of electrical power to complex or critical installations, uninterruptible power supplies keep good quality power flowing to essential equipment.

1 PCS100 UPS-I installation

Sophisticated technology has reached into every aspect of our lives to provide enormous benefits in terms of lifestyle, business, infrastructure and health. Accepting these benefits, however, increases reliance on electrical power – and often that power has to be completely free from interruption or disturbance for things to run smoothly.

The consequences of large-scale power disruption can be dramatic. In the United States, considerable analysis regarding the costs of power quality problems has been carried out. Outages and voltage sags, for instance, cost Americans an estimated $150 billion a year in spoiled food, lost productivity and other costs, according to data from the Galvin Electricity Initiative [1]. Outages tend to be relatively infrequent, but expensive. Voltage sags are much more common and, cumulatively, very expensive. Grid investment, of course, can improve grid performance but it is impossible to completely protect against all eventualities.

A power grid is never perfect and it is susceptible to voltage swells and drop-outs as well as sags. Some industrial loads are relatively immune to these voltage fluctuations (switched-mode power supplies, drives, motors, etc.) and may require no additional power protection, especially if they are not critical. Of course, they are vulnerable when the power fails altogether. Others, such as critical systems or continuous process equipment where an outage results in significant restart time, do need protection. Certain loads, such as sensitive measurement or medical equipment, can be sensitive to events even within the normal grid tolerance of +/– 10 percent and these need special consideration.

ABB's PCS100 Power Converter System product portfolio includes products that offer very high efficiency and low ongoing cost of ownership.

Grid upgrades can improve power quality: Overhead cables that are susceptible to interference from trees, lightning and storm damage can be upgraded or routed underground; protection systems can be improved; and grids can be laid out in a ring configuration.

It is often possible to reduce the incidence of voltage outages, but sags are more difficult to eliminate. In a highly connected grid, any grid fault will propagate, impacting negatively on sensitive loads. Even the very best electricity grids in the world have a level of residual power quality issues as there is always an economic limit to what can be achieved. Usually, the most economic solution after the feasible grid upgrades have been completed is for electricity consumers to employ voltage conditioning schemes or uninterruptible power supply (UPS) protection for sensitive loads. The cost of these is often borne by the consumer: It may be that the power quality problems arise in the utility supply, but the consumers, due to the nature of their loads, may be demanding a much higher quality of supply than is practicable. Clearly though, the utility has an obligation to provide voltage at a certain level of quality and there may be some discussion on the cost of customer-specific grid upgrades.

Not only is there the upfront capital cost of mitigation equipment and its installation, but there are also ongoing costs. On top of maintenance costs come efficiency costs, as no equipment is 100 percent efficient. In addition, the equipment must be reliable and maintainable to ensure performance and availability, so care must be taken in its selection.

Historically, the high electrical losses of traditional dual-conversion UPSs (4 to 8 percent) and the high maintenance requirements associated with batteries or other storage media deter industrial and commercial companies from fully protecting their entire load against voltage fluctuations. A trade-off always had to be made between event frequency and consequent financial consequences on the one hand, and the installation and operating costs on the other.

However, ABB's PCS100 Power Converter System product portfolio includes products that offer very high efficiency and low ongoing cost of ownership → 1. These offer shorter payback times and now make it more attractive to install mitigation equipment.

Surges, voltage imbalance and grid frequency variations can be dealt with by ABB's double conversion UPS and PCS100 Static Frequency Converter.

Often, some loads do not require protection whereas others require voltage conditioning and very critical loads require UPS protection. Segregating loads accordingly when designing an electrical system can considerably reduce costs and result in an optimized solution.

Other power quality problems

Voltage sags and outages tend, quite rightly, to be the primary focus of remedial efforts, but they are not the only costly voltage-related power quality problems that can be encountered. In some supplies, particularly in emerging economies, other problems such as surges, voltage imbalance and grid frequency variations can cause major problems with connected loads. Here, ABB's double-conversion UPS and PCS100 Static Frequency Converter (SFC) product would be used to improve supply quality.

Problems can also manifest themselves in the current drawn by the customers' loads. Harmonics and power factor issues are the major areas of concern here and these can also be mitigated by ABB products, including the PCS100 STATCOM-I, which functions rather like a static VAr compensator.

Current harmonics and power factor issues can be mitigated by ABB's PCS100 STATCOM-I, which functions rather like a static VAr compensator.

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Guaranteed power

Smart modular UPS designs provide flexibility and increase availability

SOPHIE BENSON-WARNER – Uninterruptible power supplies (UPSs) have been ensuring a flow of continuous, clean power to industrial and commercial equipment for many years. Few other products find their way into such a huge range of applications: data centers, computer rooms, all kinds of industrial production processes (semiconductor, automotive, etc.) and even sensitive medical equipment. Historically, UPS systems were designed as monolithic devices with limited flexibility, scalability, maintainability and availability. Often, these monolithic designs did not meet customer expectations, so a new UPS design philosophy, based on a modular approach, has been developed in recent years. ABB has a long history in the supply of power and power protection equipment, including modular industrial UPS products. ABB's modular UPS range has been further strengthened by the acquisition of the Swiss company Newave Energy and their range of innovative medium- and high-power UPSs.

The sheer ubiquity of UPSs in so many areas of industry and commerce means that as technological progress drives change, UPSs have to be flexible enough to accommodate the new challenges created. Criticality, cost and energy efficiency are important factors that have to be taken into account. These factors have largely driven the uptake of modular UPS solutions. A modular architecture delivers scalability and the latest high-efficiency designs facilitate major reductions in electricity consumption and CO_2 emissions. Additionally, they provide the flexibility required for planners to design power and space for both immediate and future needs.

Title picture
Much of our modern society depends on critical infrastructure, like this data center. Modular UPS design provides a robust and flexible foundation to keep good, clean power flowing and to maximize availability.

Newave Energy, a leading manufacturer of uninterruptible power supply solutions, was acquired by ABB in March 2012. This pioneering company introduced modular and transformer-less UPS technology in 2001. Today, these concepts form the foundation of the most important architectural trends in the UPS market. Although Newave has a comprehensive product portfolio containing both traditional free-standing and modular UPS, the majority of its sales are now of modular three-phase UPS. Today, close to 70 percent of its sales are of modular UPS systems.

These products complement ABB's range of industrial voltage conditioners and UPSs. Also using a modern and highly efficient modular topology, the PCS100 family of active voltage conditioners (AVCs) and the Industrial UPS (UPS-I) target industrial applications [1, 2].

PCS100 active voltage conditioner

The PCS100 AVC protects sensitive industrial plant and loads against voltage sags, imbalances and regulation issues → 1. By continuously monitoring the incoming supply and comparing it with perfect sinusoidal reference waveforms, voltage vectors can be created using power electronics and injected in real time to provide a conditioned supply. Offering online voltage conditioning performance, ABB's PCS100 AVC has been widely applied in some of the most demanding industrial applications, includ-

Some of the world's largest semiconductor manufacturers rely on this technology to protect their critical loads.

1 The PCS100 active voltage conditioner

2 PCS100 AVC and UPS-I products are found supporting many different load types in many different settings.

ing the automotive and semiconductor industries ➔ 2.

The PCS100 AVC does not include any supercapacitors or batteries for energy storage, but instead takes energy from the remaining supply at unity power factor, with little impact. As voltage sags typically make up more than 90 percent of the problems that impact plant performance, the AVC provides a reliable, efficient and compact solution for industrial plant protection.

Certain critical industrial loads, particularly in process control, warrant outage protection that the AVC cannot supply and this is where the complementary PCS100 UPS-I solution is implemented. Both products can be found supporting different load types in many industries.

The PCS100 AVC contains a redundant bypass that ensures continuity of supply in the unlikely event that the AVC power electronics fail. This ensures very high levels of availability and reliability. Some of the world's largest semiconductor manufacturers, with particularly high demands on plant availability, rely on this technology to protect their critical loads.

The PCS100 AVC ensures quick and full correction of three-phase voltage sags down to 70 percent of the nominal voltage and of single-phase voltage sags down to 55 percent of the nominal voltage. In the case of deeper voltage sags, it undertakes a partial correction, which will often prevent load shedding. In addition, all models are able to continuously correct voltage variations of ±10 percent in the mains voltage. This takes care of imbalances, which are a particular problem for direct online motors and variable speed motor drives.

PCS UPS-I

The PCS100 UPS-I is a highly efficient modular design that utilizes a line-interactive topology ➔ 3. The PCS100 UPS-I product is designed to operate with motors and drives. The very rugged design suits even the most demanding industrial loads. A static switch (utility disconnect) with a high rating powers the load under normal conditions, with the modular inverter supplying the load when the supply voltage goes outside tolerance.

> The PCS100 active voltage conditioner protects sensitive industrial plant and loads against voltage sags, imbalance and regulation issues.

One of the challenges in industrial load protection is to determine appropriate discrimination settings in the protection systems. Due to the unique topology of the UPS-I design and the rugged rating of the static switch, significant fault capacity is available for the electrical system designer to work with. With an efficiency of around 99 percent, the UPS-I has very low losses, which means a low cost of ownership and low cooling requirements, making it both an economic and environmentally friendly solution.

The UPS-I can utilize traditional lead acid batteries as a storage medium, although many of ABB's customers select high-performance supercapacitors that offer up to 500,000 duty cycles and require only minimal preventive maintenance. This means that the lifetime of the storage medium will not be reduced by "real" use of the system, which is often the case with batteries. In many industrial applications, storage is only required to ride through deep voltage sags or power switching events, so many applications need only have a few seconds of storage time.

3 The ABB PCS100 UPS-I

4 The PCS100 UPS-I inverter cabinet

A redundant bypass ensures continuity of supply in the unlikely event that the AVC power electronics fail. This ensures very high levels of availability and reliability.

Whereas the Newave commercial UPS products are based on a highly redundant, decentralized modular design, ABB has selected a centralized modular design topology for their PCS100 UPS-I range of products due to fault clearing requirements in many industrial applications. The static switch is designed to cope with the high level of overloads (motor starting, welders, etc.), harmonics (motor drives, electronic rectifiers, etc.) and faults commonly found in industrial environments. If any inverter module were to fail, the system remains available at reduced capacity. Although the static switch could be seen as a single point of failure, it is backed by a failsafe electromechanical bypass. This means that very high levels of reliability are achieved.

Power factor

Many of the challenges associated with the application of UPSs come from the loads they supply. Load challenges are present even in datacenter and computer room applications: Many of the modern switched-mode power supplies used in computer server loads will cause leading power factor and light-loading conditions when operating in their normal regime. Leading power factor is a major problem for legacy UPS designs and it results in inverter overload and the need for significant de-rating. ABB's commercial UPS technology and industrial PCS100 UPS-I products are designed for a much wider range of load power factors and they thus remove the hidden cost associated with de-rating and the need to oversize the UPS selected.

Leading power factor is also a major problem for the standby diesel generator systems that feed many facilities. The PCS100 UPS-I sister product, PCS100 STATCOM-I, is an economic solution to this problem as it provides fast correction of leading VArs, imbalanced current and low order harmonics – all problems for the alternator systems found on these generator systems.

When selecting an ABB UPS, the particular technical requirements of each application must be looked at very carefully so that the most appropriate UPS can be chosen. Although the raw power requirements, as measured in kilowatts (or kVA), of two applications may be similar, the nature of the loads and the power quality problems present on the supply may be very different. The comprehensive range of power protection solutions and application expertise available from ABB means the correct power protection solution can be applied to ensure reliable and cost-effective protection of critical loads.

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Cloud-controlled charging

ABB's connectivity solutions are changing the electric vehicle charging industry

HANS STRENG, JOOST VAN ABEELEN – Just as apps have added a whole new dimension to mobile device use, so too has cloud-based connectivity changed the face of electric vehicle (EV) charging. It is not enough that a charger simply charges a vehicle – today, charging operators require safe, secure connectivity solutions that allow them to run their charging networks much more efficiently and reliably, while maintaining maximum flexibility in a constantly evolving industry. ABB chargers come complete with a package of connectivity-based services, including remote maintenance and diagnostics as well as interfaces to service providers to enable subscriber management applications. Data protection complies with the highest data security standard (ISO 27001).

The EV charging market is rapidly evolving and so is the evolution of customers' needs.

The benefits of cloud computing are widely recognized in different industries. In the past few years, software as a service (SaaS, also referred to as cloud computing) has been incorporated into the strategy of all leading enterprises. Many businesses allocate as much as 70 to 80 percent of their IT budgets to regular updates and software maintenance for existing infrastructure. SaaS enables businesses to reduce IT support costs by outsourcing hardware and software maintenance to the SaaS provider. Cloud computing also makes it possible to update and maintain Web applications without distributing and installing software on potentially thousands of client computers, and it provides the inherent support for cross-platform compatibility.

Title picture
Electric vehicle charging at a gas station in Estonia

ABB's connected service offerings

EV charger connectivity is essential to the future of the charging market →1, with cloud computing easily eliminating many of the complex constraints from the traditional computing environment, including space, time, power and cost. Utilizing connected services via the cloud enables ABB customers to change the way they use technology to service their own customers, partners, and suppliers. The advantages are numerous, but the most important ones are the resulting flexibility and cost savings.

Cloud computing means that customers can access the data they need anytime and anywhere, even when they are working remotely or outside office hours. With the cloud there is no need for customers to purchase and install expensive software because it is remotely available, generating a huge cost-savings – especially on offerings that require frequent updates to stay competitive. The added flexibility enables ABB customers to quickly and easily scale according to demand. This can be particularly advantageous when there are temporary peaks in demand, such as on holidays or in summer.

Connectivity enables efficient and effective maintenance and support of each charger in the field. At the same time, connectivity also allows ABB to monitor both the development of the market and customer requirements. The EV charging market is rapidly evolving and so is the evolution of customers' needs → 2.

Providing high value–added services via the cloud

Because they are provided via the cloud, ABB connected services are compatible with any charging network or payment and billing platform available today. This means that customers can simply connect to one central point (ABB's Network Operations Center) to gain individual access to each charger in their field as part of their network. Through open-standards-based interfaces, all ABB EV chargers allow remote monitoring, proactive

1 The electric vehicle charging industry is benefitting from cloud connectivity services such as those provided by ABB.

2 ABB's Galaxy online management tool provides access to real-time data and usage statistics from Terra chargers.

Cloud connectivity enables efficient and effective maintenance and support of each charger in the field.

maintenance and functional upgrades to provide its customers with the tools necessary to gather customer-specific usage statistics and reports → 3. This setup benefits both ABB and its customers.

Firstly, most customer-specific configuration is pushed into the cloud and implemented via software. This means that the chargers are essentially identical, which offers tremendous economies-of-scale in the total supply chain as well as in servicing. And managing charger updates and upgrades becomes much simpler, both in terms of hardware and software.

Secondly, the network-based configuration enables future functionality, such as integration into larger smart-grid configuration, without changing anything on the chargers. Finally, by supporting open interfaces and implementing them as cloud interfaces rather than customized charger interfaces, customers can in principle still work with other charger suppliers who have chosen to build stand-alone (unserviced) chargers. Customers are thus offered all the benefits of a cloud-based platform → 4.

Significantly reduced investment costs

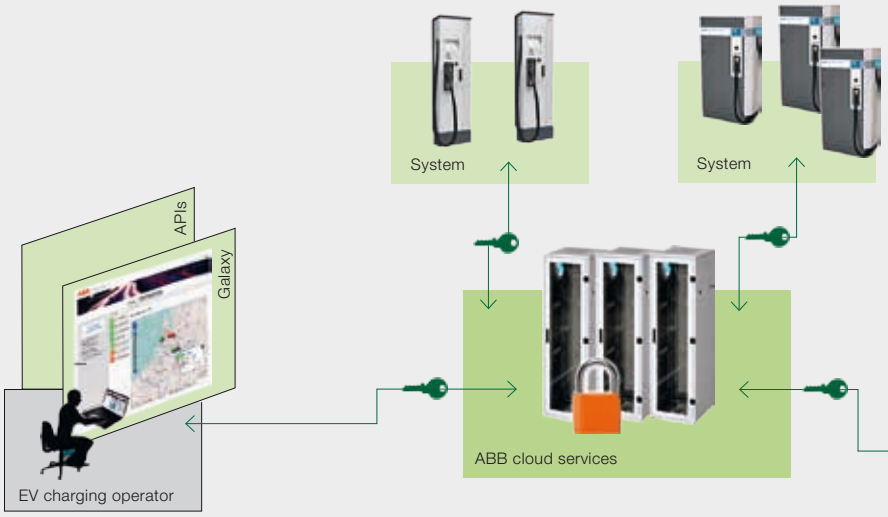
Software developments are capital-intensive investments and, historically, many software development projects fail to achieve their goals. With the cloud-based approach, customers do not need to make costly investments in hardware customization nor must they invest in customization-related software development and IT integration. With ABB's connectivity solutions, customers must simply activate the licenses to use the software. The development and maintenance of the software is covered by a monthly fee.

Access to state-of-the-art services and open standards

The strategy for providing connected services via the cloud allows ABB to pass on huge cost savings to customers via same-time deployment of software services and upgrades. A customer no longer has to worry about updating chargers individually, but can instantly receive upgrades while benefiting from any automated developments courtesy of the cloud. For example, a recently released ABB service pack provided software updates containing both existing as well as new functionality (ie, security updates and language support, respectively).

Supporting open standards and secure protocols, ABB provides the connected services that in turn support the business models of its customers and that generate additional return on investment to their current and growing EV charging infrastructure. Because ABB provides B2B (business-to-business) solutions, it is up to its customers to decide which B2C (business-to-consumer) solution meets their needs. ABB connected services enable customers to easily switch to other B2C offerings – rather than changing the connection for each and

3 ABB's cloud connectivity offering



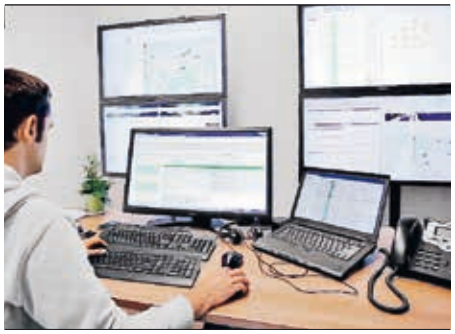
Data transportation and security
Charger data, settings and software updates are transported via TLS and X509 certificates, a security standard widely used to protect classified industrial and governmental information.

Cloud access
Charging operators can access their data via the cloud, a reliable interface enabling connectivity from a back office or user administration system directly to the charging network.

ABB cloud services
Accessible only to the customer, data is stored via independent third-party cloud technology that utilizes strict security standards and professional backup systems.

ABB Network Operations Center
The ABB Network Operations Center (NOC) provides online support and field services 24/7. The NOC monitors networks of chargers and systems, improving overall performance of the EV charging operation.

4 Remote access to charging data is a key advantage of ABB's cloud-based offering.



every charger in their network, they would only need to do so at one location.

Cloud-based platforms have been around for years already: Cars are increasingly developed as connected machines (eg, every Nissan LEAF has a SIM card, making it like a phone on wheels), and smart meters appear in many households and offices. So it is fitting that a connected charging platform also becomes standard. What is more, as the world enters the era of vehicle-to-grid (V2G) where the battery buffer of the car can be used to supply power back through the charger (a practice already mandatory in Japan), then a connected charging platform is essential.

Supporting open standards and secure protocols, ABB provides the connected services that in turn support the business models of its customers.

The next step in EV charging

When it comes to creating a smarter grid, the concept of using electric vehicles to store surplus electricity as a backup power source is particularly interesting. Utilities could potentially use the batteries of parked electric vehicles while they are connected to the grid to store electricity when it is plentiful. When electricity is in short supply, electric vehicles could provide short-notice reserve power (ie, V2G) to meet demand peaks, relieving pressure on utilities to provide reserve generating capacity and evening out the variability incurred by renewables. Connectivity enables the integration with SCADA (supervisory control and data acquisition) and other distribution management systems, putting more analysis and control functions in the hands of grid operators. Some of these technologies can be used, for instance, to ensure that EV charging happens only when energy is available, rather than randomly, mitigating the impact of the additional load on the grid.

ABB has all the elements required for smart grid functionality. The company offers solutions (both hardware and software products, or connected combinations thereof) that enable its customers to make a viable business of selling and operating charging services or load-management services.

For more information about ABB's electric vehicle charging offering, please visit http://www.abb.com/evcharging

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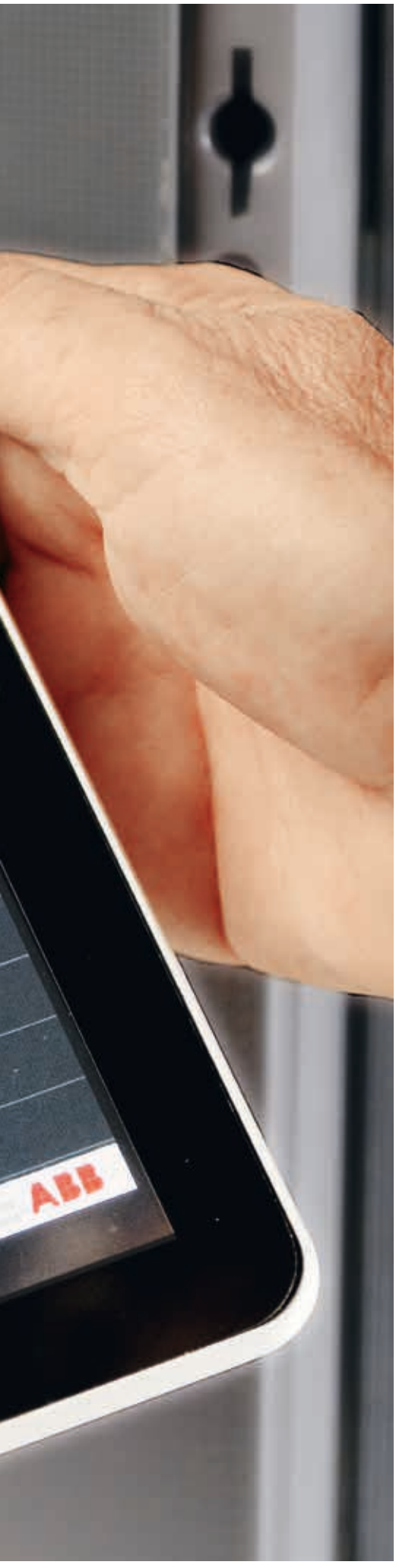

Intelligent workload

A new circuit breaker that reduces breaks by optimizing loads

PIETRO ESPOSTO, PAOLO GRITTI, ENRICO RAGAINI – Humans may feel recharged after a power nap, but a break in electrical power does not provide the same feel-good factor. In an engineer's ideal world, all loads, supplies and environments would be created equal, predictable and reliable. But since the real world differs from the ideal, a new, intelligent automatic circuit breaker from ABB is stepping in to cope with what life throws at it. The first requirements of circuit breakers are about electrical performance (breaking capacity, voltage and current rating). Their use is widespread in electrical installations for protection and switching. In addition, they can now become an active part of the power management system.

Title picture
The Emax 2 circuit breaker also supports remote management via smart devices.

1 The reduction of cubile size possible with Emax 2.

Width of cubicle for breaker installation (mm)

Circuit breaker	Current rating	Emax 2	Emax	reduction
E1.2	1600 A	350	490	29 %
E2.2	2500 A	490	630	22 %
E4.2	4000 A	600	880	32 %
E6.2	6300 A	1200	1260	5 %

Reduction of cubicle width achieved by installation of Emax 2 with respect to Emax. Cubicle depth also shrinks (eg, from 380 mm to 355 mm for current ratings of 2000 A and above).

All consumption demands are not created equal, and yet current supply systems frequently handle connected loads with total equality and no regard for criticality. ABB's Emax 2 is designed, engineered and produced to take all of these considerations onboard, optimizing the use of power, and taking these devices into the realms of intelligent breakers.

ABB is one of the technological and market leaders in low-voltage circuit breakers. A new step toward innovation in low voltage power systems is the new Emax 2 circuit breaker, released in March 2013. Emax 2 is an evolution of the well-established Emax air circuit breaker, which has been one of the top ABB products since 1995 with more than 1 million delivered. Emax 2 gives top performance a significant reduction in size compared to its predecessors ➔ 1.

> The breaker can work as a sensor, an actuator and an active part of the distributed automation system.

High performance, small space, harsh environment

Circuit breakers often have to work in harsh environments: extremely low or high temperatures, humidity and vibrations. The electrical environment is equally harsh. Sometimes power quality will be extremely bad with high harmonic content and frequent interruptions. Extensive electromagnetic compatibility tests are performed to ensure that a breaker is insensitive to these influences.

Circuit breaker dimensions must be kept as small as possible due to the need for more compact switchboards. In some applications, space occupation is critical, for example in data centers and onboard ships, where each square meter occupied by switchgear is at the expense of payload.

In addition to reducing switchboard dimensions, such a compact design and reduction in size also means reduced use of copper, aluminum and steel, optimizing resources even further. The design, product engineering and production of Emax 2 considered the harsh physical and electrical environment in which the circuit breaker will have to operate. Engineering expertise, experience from past product series and new requirements from customers have been taken into account to deliver maximum performance and reliability.

Power systems become smart

Currently a wide-scale evolution is taking place in power systems: cities are evolving into smart cities, where power distribution grids will be intertwined with com-

2 Emax 2 circuit breaker family

Integrating automation into the breaker turns it into a real power management device.

munication networks. Digital “smart” devices will monitor the flow of power, to deliver energy where and when it is required and at maximum efficiency: This of course includes the circuit breaker.

Innovation in electronic technology allows more intelligence to be built into the digital protection unit. The breaker can work as a sensor, an actuator and an active part of the distributed automation system that manages the power distribution. The intelligent breaker is thus capable of processing information, storing information in memory, communicating data, and making decisions in an automated way. Integrating automation into the breaker is an especially significant technological improvement with respect to previous generations of products as it turns the breaker into a real power management device.

Because breakers are deep in the electrical installation, for protection of feeders and loads, making them smart means putting intelligence as close as possible to the loads. This is extremely effective as it allows maximum flexibility and fine granularity in the control of electrical power usage.

Embedding these new functions in the breaker provides additional advantages: Because the circuit breaker is normally installed in power systems for protection and switching, new functions can be added without the need for additional devices. The breaker has built-in current and voltage sensors, so new functions can build on what is already available: Current and voltage measurements data are already available for the purpose of protection, so the unit can use them also for power measurement, statistics, diagnostics, etc. Therefore, the need for compact switchboards can be fulfilled together with the new need for intelligence → 2.

Innovation in electronic technology allows more intelligence to be built into the digital protection unit.

The circuit breaker as a power manager

An electrical installation usually provides power to a large number of independent loads. Some of them absorb energy at a constant rate, but most vary their power consumption with time, for example lights in a building can be switched on or off randomly. HVAC systems turn on and off according to temperature, as do refrigerators.

Each electrical load contributes to the total energy consumption of an installation. However, there is, typically, no coordination among them: Each load switches its power consumption on and

3 Power Manager

1) Power Manager works by measuring the energy absorbed by the electrical installation since the start of the measurement slot (measurement window/ time frame). Total power is the rate of energy increase with time. Based on energy and power, an estimate of consumption at the end of the time frame is calculated.
2) When non controllable loads are turned on, power increases and Power manager estimates whether consumption at the end of the time frame will exceed the limit.
3) Power Manager switches off a controllable load (HVAC) for some minutes.
4) When total power decreases and the estimate is below the limit by some margin, Power Manager reconnects the controlled load.

4 Demand control application

1) Installation is powered by the grid and by local generation (Photovoltaic). Ekip Power controller measures net energy absorbed from the grid (difference between load consumption and local production).
2) If the power produced by PV decreases, Power Manager detects an increase in power flow from the grid. If an excess of energy consumption is estimated, one or more loads are disconnected.
3) Priority loads are kept connected all the time.
4) When PV generation resumes, Power Manager detects a decrease in net power flow from the grid, which eventually triggers a load reconnection.
5) Total load is therefore responsive to the availability of renewable power.

5 Ekip power controller

Ekip power controller controls the maximum power consumed by the installation, utilizing the same method as that used for fiscal metering, thereby achieving savings on the component connected to maximum power ($/kW) on electricity bills. The power consumed is calculated by the energy meter as an average value over pre-determined time periods such as, for example, 5 minutes, or even 2 hours.

Because power is measured as the average of a time slot, a larger consumption in part of a slot can be compensated by a lower consumption in another part, while keeping the total average power within the limits. For example small consumption in the first part of a period allows more tolerance toward larger consumption in the second half.

Ekip power controller uses this principle together with a predictive algorithm that estimates, moment by moment, power at the end of the period in order to decide whether to disconnect or connect loads and generators. This enables brief transient requests for high power to be tolerated, such as, for example, the starting up of motors, without causing the disconnection of loads as soon as the power exceeds the threshold set.

The operations of connection and disconnection therefore depend on the consumption from the beginning of the period up to the present moment. For example, if during the first few minutes of the period of reference consumption was very high, Ekip power controller will disconnect a greater number of loads in the minutes after; if, on the other hand, the initial consumption was low, it will leave a greater number of loads in operation.

Power controller is based on power measurement, which is integrated to obtain the total value of energy consumption. By its internal clock, time elapsed since the beginning of the time slot is known, so the average power can be calculated.

Based on these four quantities (actual instantaneous power, average power in current time slot, total energy and elapsed time), power controller uses a dedicated algorithm to estimate the total consumption at the end of the time slot. Based on such an estimate different actions are taken. If the estimated value is:
- Greater than the power set as a target, Ekip power controller makes the decision to disconnect one of the loads controlled from the power supply, or to connect a generator;
- Equal or slightly less than the average power set as a target, Ekip power controller makes the decision to leave the conditions of the controlled loads and generators unchanged;
- Significantly lower than the average power set as a target, Ekip power controller makes the decision to reconnect one of the loads controlled to the power supply, or switch off a generator if one or more of these have been switched on previously.

The predictive algorithm is run several times at different instants during the time slot, so that the prediction is updated and loads can be connected/disconnected accordingly. The goal is to track actual power consumption and prevent it from exceeding the limit. Meanwhile, whenever power consumption decreases, previously disconnected loads can be reconnected, thus preventing unnecessary off-time.

This operation is carried out cyclically each time by calculating a new estimate: therefore, if the estimate of power consumed continues to be too high despite the fact that a load has been disconnected, Ekip power controller will proceed to disconnect another load and so on, until the power limit is respected. In this way, the number of connected or disconnected loads varies dynamically, and always with the guarantee that only the minimum number needed to respect the power limit are disconnected.

off in an independent way. If several loads are switched on at the same time, sharp peaks can appear. These peaks have several undesirable effects:
- They increase the maximum active power demand and based on the type of contract with the electric utility, additional fees might be applied.
- They might cause overload alarms and even protection trips. In order to avoid this, designers of the installation may consider oversizing, which means more using expensive components.
- On a larger scale, the electrical system will need reserve generating capacity to deal with them.

Power peaks are the result of a lack of coordination between different loads. The presence of a power manager, which prevents too many loads from consuming too much at the same time, can be very effective in limiting, or “shaving”, power peaks. Emax 2 is such a power manager. Its principle is very simple: When power consumption becomes too high, operation of some low-priority loads is delayed by some seconds or minutes, up to a moment when conditions allow them to be reconnected.

In many low-voltage systems, there are often several loads that do not require a continuous power supply and that can be delayed in their operation for a short time without the user even noticing. For example, if an air conditioner is switched off for a minute, the overall effect on the temperature is practically unnoticeable. This delay can however, allow other time critical loads to start and run at peak power for a short time without the total power exceeding the set limit.

Emax 2 Power Manager’s advanced real time control system uses this logic to limit the power absorbed by an electrical installation. It works by disconnecting some “controllable loads” or “delayable loads”, which are then reconnected when it becomes possible without ex-

6 Generator-powered marine installation

1) Several generators are connected in parellel. Installation is operated as a closed loop (all the circuit breakers are closed), for maximum availability. Typical voltage is 690V.
2) When one generator is started, the synchro check embedded in the circuit breaker prevents connection unless its frequency and phase are aligned to the test of the installation. The breaker will signal automatically when conditions are met.
3) In case of a fault, directional protection and digital interlock make each of the breakers in the loop aware of the fault location. Breakers operate as an integrated system, and only those facing the faulty section of the installation trip.
4) Only the section of the plant where the fault is located is put out of service. Power flow to the rest of the plant is maintained throughout the fault.

7 User friendly graphic menus

ceeding the power limit. The power controller constantly optimizes the number of disconnected loads, while continuously trying to supply the largest possible load to the plant. Controllable loads are connected and disconnected by slave breakers, either of Emax 2 or legacy type, which are opened and closed on command. Instead of disconnecting loads, the Emax 2 Power Manager can connect auxiliary generators when load demand requires it. Signaling the connection and disconnection of generators is also managed automatically, as part of the same strategy for dealing with loads. The connection and disconnection of loads is coordinated so that the total power is kept as much as possible below a set limit ➔ 3. This limit is, typically, related to the maximum power demand agreed with the utility.

Another possible application is to make power demands responsive to the availability of renewable power generation ➔ 4. If two power sources are available, perhaps grid and photovoltaic (PV), total power absorbed by the grid will be the load consumption minus the local generation. If PV is not available, the Emax Power Manager will measure an increase of absorbed power and disconnect one or more loads. When PV power becomes available again, a decrease of net power flow will be measured, so the Emax Power Manager will reconnect loads. This kind of demand response application works in real time, based on local power management, and it can be used in stand-alone configurations.

In many low-voltage systems there are often several loads that can be delayed in their operation for a short time without the user even noticing.

The Emax 2 circuit breaker has an integrated electronic unit, that implements all of the protection, measurement , control and communication functions. It is sometimes called the protection unit, or trip unit, or release. The product name for the electronic unit within the Emax 2 is Ekip. The power controller is one of the functions implemented by Ekip, in addition to its other tasks, such as protection. In future applications, the Emax 2 power controller will be used to make power demand responsive to day/night conditions, or energy market price ➔ 5.

When power consumption is high, the storage can be connected in “discharge” mode. When power consumption is low, the available margin can be used to charge the storage system.

8 Touch-screen interface

Finally, it is possible to use the Emax 2 power controller to trigger charge/discharge operations in a storage system. When power consumption is very high, the storage can be connected in – “discharge” – mode to help feed the load. Then, when power consumption is low, the available power margin can be used to charge the storage system.

Applications are packaged as plug and play modules, which makes them extremely easy to put into service.

Protecting local generators

It is becoming increasingly common to see more and more local generators connected to low-voltage distribution grids. The diffusion of PV and small combined heat and power (CHP) generators is apparent and industrial and marine systems already use local generators to a great extent. Protecting local generators from faults is sometimes a technological challenge. Two issues are especially critical:

– When a generator is used to power a microgrid in islanded mode, ie, disconnected from the main grid, frequency variations should be closely monitored. The rate of change of frequency should be used as a fault indicator, so specific protection is required.
– If power is provided by a solid-state generator (eg, the inverter of a PV plant), short circuit currents are typically low. This makes it difficult to detect short circuits for the traditional overcurrent protection. A more sophisticated strategy is to detect current increases associated with a significant drop in voltage, which is typical of short circuit conditions.

Both the above aspects are addressed by Emax 2, which includes specific protection like rate of change of frequency (ROCOF) and 51 V, ie, overcurrent protection controlled by voltage value. Both are implemented here for the first time inside a low-voltage circuit breaker.

Additional Emax 2 features address installations where multiple power sources are present:

– Synchro-check prevents connection of a generator when its voltage is not in phase with that of the system. This function is normally implemented by a separate device, now it is integrated into the breaker.
– Directional protection with logic interlocking (also an exclusive ABB

9 Emax 2's plug and play modules

A large number of terminals and accessories accommodates the maximum variability of connections.

feature for low-voltage breakers) allows maximum availability in multiple power source systems, by automatically detecting the location of a fault and minimizing outages.

An example for a marine power system is shown in ➔ 6.

Easy to use, easy to engineer

As power systems become more and more complex, applications such as those described need quite complex algorithms. In spite of this, Emax 2 remains extremely simple to configure and use. Only the basic parameters have to be set by the user and all tuning is via a specific software that performs all the calculations, meaning the user does not have to be distracted by the complexity. The trip units use graphic menus, either with front panel keypad or touch-screen, which makes it extremely intuitive and user-friendly to use the applications ➔ 7–8.

Most applications are packaged as plug and play modules, which makes them extremely easy to put into service ➔ 9. It is even possible to install such modules in the field. When new functions are added to an existing plant, for example, when a generator is connected to a busbar, the generator protection can be added to the breaker that protects the busbar.

From the engineering point of view, designing the mechanical structure of a switchboard for installation of a breaker is sometimes challenging and Emax 2 includes a large number of terminals and accessories, to accommodate the maximum variability of connections (cables, copper or aluminum busbars, etc.).

In order to save engineering time and effort the product documentation is also innovative. Video manuals and 2-D and 3-D drawings are provided in electronic format. For installation designers, white papers and technical application papers describe the new products and how to correctly select and apply the new Emax 2 breaker.

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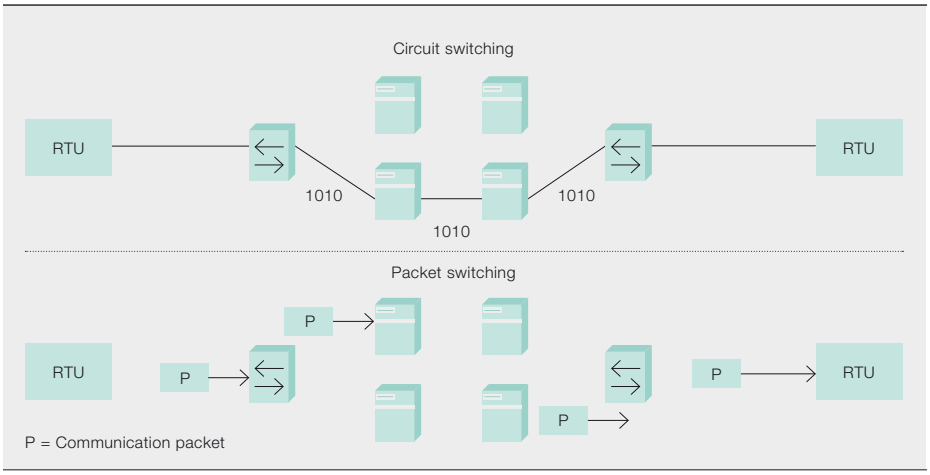
Making the switch

ABB's new multiservice multiplexer, FOX615, meets the new challenges faced by operational communication networks

MATHIAS KRANICH, RAMON BAECHLI, HIMANSHU TRIVEDI – Utilities in electricity, oil and gas, mining, railways, etc. are optimizing their operations with constant reference to real-time data. To obtain these data, they must have access to extremely fast and reliable communication networks. Up to now they have relied on circuit-switched technology to transmit process data to control systems and operators enabling them to keep processes running smoothly. With growing numbers of packet-switched applications, utilities have to deal with new requirements for their communication infrastructure. ABB`s answer to this is the FOX615, a multiservice multiplexer providing a unique combination of SDH (circuit-switched) and Ethernet (packet-switched) functionality, with additional utility-focused features and broadband communication facilities of up to 10 Gbit/s. With its high integration level and flexibility, FOX615 is suitable for a wide variety of applications and an ideal solution for utility communication networks.

1 Comparison of circuit switching and packet switching



Industrial applications (eg, smart grids) and public telecommunications (eg, mobile high-speed Internet) depend on reliable communication networks. In the past, the wide-area networks (WAN) of public telecom operators and operational networks of utilities were based on the same circuit-switched PDH/SDH[1] technology, which provided the necessary performance level for both segments. Then came the rapid growth of data traffic caused by the switch from simple voice communication to triple-play applications of voice, data and video. To accommodate this change, public telecommunication networks moved to pure packet-switched WANs. An example of such a technology is Ethernet, which was extremely successful in local area networks (LANs) and telecom operators implemented similar solutions for WANs.

However, a connection-less, packet-switched technology does not inherently guarantee the same quality of service as SDH provides. Therefore, utilities stuck to the proven qualities of SDH technology to meet the more stringent requirements for their critical operational networks.

The connection-oriented framework of SDH can generate application-specific communication channels with short and deterministic delay times, as well as low jitter. Packet-switched technology is based on queuing mechanisms, which introduce an additional delay and jitter while allowing variable bandwidth allocation. This makes it ideal for data traffic (eg, computer traffic) ➔ 1. If the different communication technologies are considered in terms of automobile traffic, SDH provides discrete channels for each application, analogous to dedicated lanes for buses, emergency vehicles and other vehicles. Ethernet, by contrast, uses all lanes for all applications, which makes best use of the available infrastructure, but can not guarantee free lanes for high priority traffic. In order to bring some of the benefits of circuit-switched networks to packet-switched networks, various extensions of the original protocols have been developed. These include some of the most important protocols such as IP/MPLS[2], MPLS-TP[3], and PBB[4].

However, even with the new protocols, the quality of service delivered by packet-switched technologies, especially for use in electrical utility applications, remained insufficient. Because of the growing number of Ethernet-based applications and expected future progress in packet-switched technology, utilities now need to incorporate both technologies. They must accommodate the needs of real-time TDM applications (eg, protection) and packet-switched applications (eg, video surveillance, intranet). This means that devices used in the networks must also cater to both technologies, and that is exactly what ABB's hybrid multiplexer, the FOX615, does.

ABB's fundamental aim when designing the FOX615 was to produce a multiplexer that would fulfill the needs of real-time utility applications, while avoiding all technology-imposed performance constraints. To do so, they needed to combine a complete understanding of how future-proof communication networks need to be designed and to identify all of the utility-specific challenges that might arise.

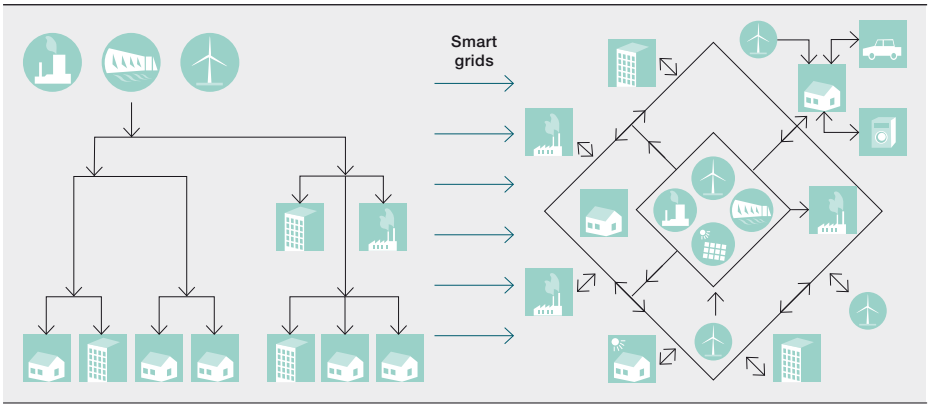
Communication for utilities

Communication networks represent a utility's nervous system. While public telecom companies focus on providing communication services to millions of end-customers, utilities use communication networks to ensure the reliability of their processes. Unlike public telecoms, utility infrastructure is generally a long-term investment, where demand on communication channels is relatively static, comprising high availability (eg, 99.999 percent), coupled with a variety of application-specific requirements, eg, low jitter (for differential protection in electrical grids [1], tolerance of dusty environments (eg, in mining) or high avail-

Title picture
FOX communication cabinets in ABB factory workshop in Baden, Switzerland.

Footnotes
1 Plesiochronous Digital Hierarchy/Synchronous Digital Hierarchy. In North America Sonet is used as equivalent technology to SDH.
2 IP/MPLS: Internet Protocol/Multiprotocol Label Switching
3 MPLS-TP: Multiprotocol Label Switching-Transport Profile
4 PBB: Provider Backbone Bridging

2 Transition from traditional networks to smart grids



In traditional markets energy flow is from power generation to consumers. Smart grids are based on multidirectional power flows in a meshed network.

ability (eg, in railway control systems to ensure passenger safety) [2].

Investment cycles in utilities are much longer than those in the public telecom sector. Protection and control equipment in electrical substations, which is ultimately connected to utility communication equipment, is particularly long-lived. This means that legacy type interfaces need to be provided for many years more and the completely Ethernet/IP-based substation is still in the future.

Instead of the full network refurbishments often seen in public telecommunications networks, utility networks evolve slowly, increasing in size and migrating to new technology step by step. This evolution means that high interoperability between old and new installations is an absolute must.

Operational communication networks play an essential role in a utility's operations, but they are not the utility's main business and are therefore considered a supporting function. In other words, an electrical utility is in the business of supplying power. While absolutely essential, a well-functioning communication network simply helps to run that business. This means that a utility's communication network tends to be operated by relatively small teams of generalists (not communication specialists), who are responsible for large numbers of products and specialized functions. Operational excellence for these networks can be ensured by implementing user-friendly and intuitive tools, all combined with a powerful, centralized network management system. This is what FOX615 offers with its management software FOXMAN.

Utility networks evolve slowly, increasing in size and migrating to new technology step by step.

Utility environment challenges

Utility communication equipment used for operational networks is generally installed in the field and is exposed to harsh environmental conditions, ranging from extreme temperatures to magnetic and electrical fields, which can be particularly severe during short-circuit events. In order to maintain the high levels of availability required, especially in emergency situations, utility communication equipment must be extremely durable and reliable. In dusty and remote environments, where regular maintenance cannot be guaranteed, fan-less designs are preferable.

Electrical utility requirements

Teleprotection is one of the most demanding applications for telecommunications systems in the electrical utilities sector. When short circuits occur on power lines, it is absolutely essential that the fault is cleared within tens of milliseconds. That means the maximum com-

3 Universal multiplexer FOX615 offers up to 21 slots for different user-interface cards.

ABB's new FOX615 can bundle up to 32,000 channels on a single optical fiber link.

munication delay, from one end of the system to the other, must be less than 10 milliseconds. Additional requirements for this sector include symmetrical communication delay times, redundant channel routing, with bidirectional switching and restricted signal jitter [3]. If the application fails to operate correctly (ie. too slowly or not at all), the negative impact in terms of outages and financial losses could be enormous. This is why protection applications are among the most significant in the grid and require communication systems with real-time performance and the highest levels of availability. Packet-switched Ethernet technology cannot inherently provide the necessary performance for these applications.

The fundamental aim when designing the FOX615 was to produce a multiplexer that would fulfill the needs of real-time utility applications, while avoiding all technology-imposed performance constraints.

Supervising the power grid via SCADA[5] is another core requirement of utilities. Grid performance depends on the operator's ability to access accurate, real-time data on the status of the network. Network availability is essential for reliable operations and therefore sophisticated redundancy schemes using different redundancy protocols, are needed at various levels. Since power grids are large installations built up over a number of years, communication demands will differ significantly from substation to substation, depending on the devices used at the time of construction.

Grid challenges of utilities

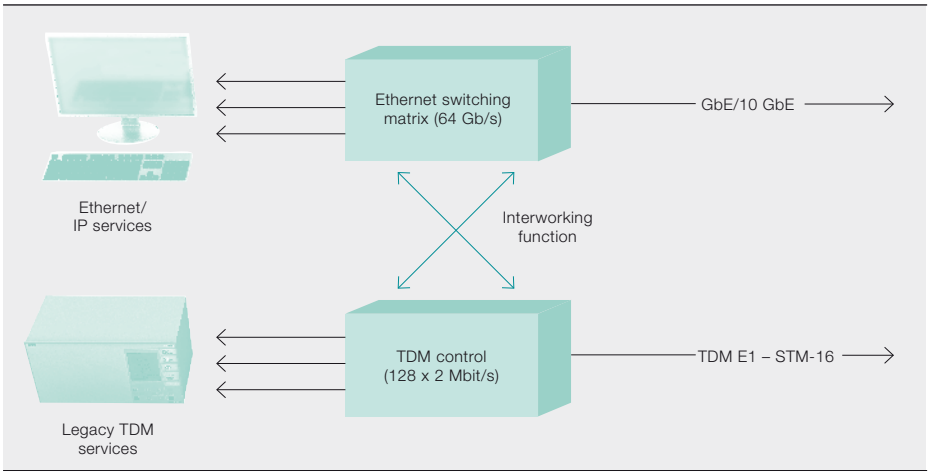
Electrical utilities in particular face enormous changes, driven by demand for smart grid applications. Renewable power generation, more efficient power transmission and automated distribution infrastructure are being installed to meet the increasing demand for power and to comply with environmental legislation. These changes lead to multidirectional power flows, which require reliable, real-time communication to maintain grid stability ➔ 2.

In addition to growing technical complexity, intensified competition and market deregulation in the power sector have led to increased pressure to reduce cost. Capital expenditure (CAPEX) can be optimized and investments protected by an extendable multiservice communication network, covering all requirements for the operation. Furthermore, operational

Footnote

5 SCADA: Supervisory Control and Data Acquisition

4 FOX615 universal multiplexer



FOX615 combines TDM (PDH/SDH) and Ethernet/IP functionality: integrated TDM cross-connect (bottom) as well as Gigabit-Ethernet switching matrix (top).

The integrated access and transport multiplexer function significantly lowers OPEX and space requirements.

expenditure (OPEX) can be lowered by using less equipment in the system, which results in less operational and maintenance work.

FOX – a success story

ABB introduced the first fiber-optic multiplexer (FOX) more than 30 years ago and has since developed it into a full-fledged communication platform. While the first FOX product (FOX6) was a pure time division multiplexing (TDM) communication node with up to six channels, ABB's new FOX615 can bundle up to 32,000 channels on a single optical fiber link – this is equivalent to an annual bandwidth growth rate of 33 percent over the past 30 years.

FOX615 provides the perfect combination of traditional TDM (PDH/SDH) technology and sophisticated Ethernet/IP[6] features to meet all the requirements of utilities. It can be easily integrated into existing PDH/SDH infrastructure, enabling step-wise migration and investment protection ➔ 3.

In contrast to many other solutions, FOX615 views PDH/SDH and Ethernet/IP as complementary technologies, providing a perfect solution for real-time as well as packet-switched based applications. Supporting both TDM and packet-switched technologies in a single device is what allows the user to set up an SDH network that fulfills all performance requirements without needing to replace the communication equipment, and migrate to packet-switched solutions at a later stage. Full migration can be done when the necessary quality of service has been proven. FOX615 provides a powerful switching engine for packet-based communication, as well as a two-stage cross-connect for traditional TDM (PDH/SDH) signals ➔ 4.

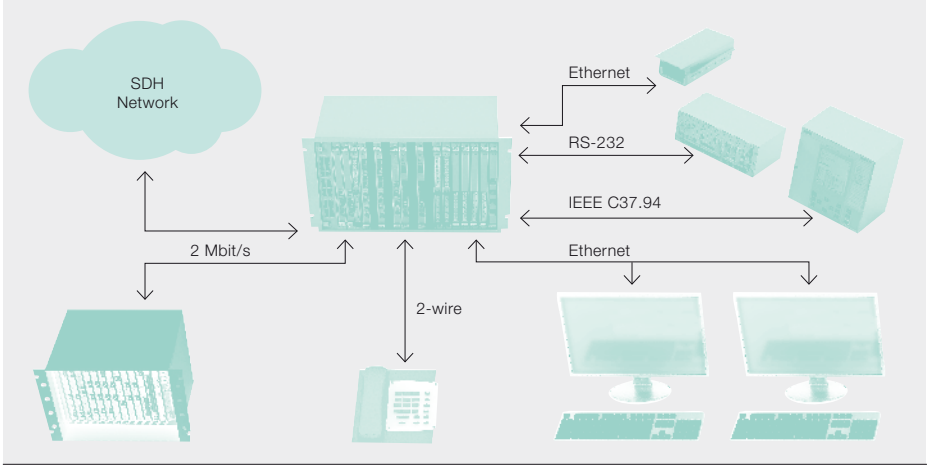
In addition, the integrated access and transport multiplexer function significantly lower OPEX and space requirements; only a single platform with sparse wiring needs to be installed and maintained ➔ 5. Integrated access and transport also makes the management of the communication network easier since all alarms report directly to a single network management system. This ensures easy fault detection and the fastest reaction times.

The FOX615 multiplexer is a utility-grade communication product, capable of operating in electromagnetically polluted environments and across broad temperature ranges (–25°C to 60°C). Very high

Footnote

6 Internet Protocol (IP) allows logical structuring of data networks.

5 FOX615 - multiservice SDH backbone network



FOX615 multiservice node: Different user interfaces can be directly connected to the SDH communication backbone.

FOX615 can be easily integrated into existing PDH/ SDH infrastructure, enabling step-wise migration and investment protection.

MTBF (mean time between failure) figures and exhaustive redundancy options ensure system availability. For a maintenance-free system, FOX615 is also available in a fan-less version.

Applications for electrical utilities

FOX615 is a multiservice multiplexer, which allows direct connection of all utility-specific applications to the multiplexer without external converter boxes. This includes direct connection of distance- and differential- protection relays. A specific interface for protection command signals, including specific functionality such as channel supervision, event recorder or fast protection switching, is available. For optical interconnection to the protection relay an IEEE C37.94 optical interface is available. This enables an all-optical interconnection to be made from relay to relay using the FOX615 multiplexer, reducing the use of fibers and providing enhanced availability through redundant channel routing. FOX615 enables real multiservice networks to be established with protection functions included as an integrated service.

FOX615 is a well-adapted platform providing a vast number of WAN and application interfaces, including teleprotection. Its rugged design with enhanced management functionality ensures long lifetime and easy maintenance.

With FOX615, utilities are not under pressure to change to new, not yet utility-proven technologies. Established technologies will continued to be supported for many years. Migration to new technologies will be possible by upgrading installed FOX615s. ABB is constantly analyzing upcoming communication standards and technologies to assess their applicability for utilities. Future releases of FOX615 are already planned and will enhance FOX615's quality of service for utility WAN implementations using packet-switched technologies.

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Fine mesh

Mesh 802.11 wireless network connectivity

PETER BILL, MATHIAS KRANICH, NARASIMHA CHARI – As the number of intelligent devices used in industry mushrooms, so does the requirement to connect to them. Traditional, wired connections are often no longer appropriate and wireless is now frequently the only cost-effective, reliable and secure way to extend connectivity over wide areas to a large number of devices. With this in mind, ABB has recently acquired the Silicon-Valley-based company Tropos, the market leader in industrial-grade mesh 802.11 systems. Such systems provide many advantages over competing technologies – eg, narrowband private radio systems and cellular mobile data services – and are becoming more and more essential as power grids and other critical infrastructure become increasingly reliant on automation.

1 Comparison of wireless technologies

	Private narrowband radio	Public carrier cellular	Private 802.11 mesh
Latency	Hundreds to thousands of ms	Hundreds to thousands of ms	10-50 ms
Capacity	0.01-0.1 Mbps	0.1-10 Mbps	1-100 Mbps
Security	Medium	Medium-High	High
Reliability	Medium	Medium	High
QoS	Limited	Limited	Yes
Standards-based interoperability	Proprietary	Yes (eg, GPRS, HSPA, LTE)	Yes (IEEE 802.11 and IP)
Manageability	Limited	Very limited	Enterprise-class
Control	Private network	Owned and operated by mobile operator	Private network

Industrial wireless communication products are becoming indispensible for many applications and their use is growing dramatically. With its purchase of Tropos, ABB has acquired important 802.11 Wi-Fi-based mesh technology that has distinct advantages over competing approaches, such as narrowband private radio and cellular mobile data services. Just how do these technologies compare?

Narrowband private radio systems

Examples of narrowband radio systems include microwave radio links, neighborhood-area advanced metering infrastructure (AMI) meshes and licensed VHF/UHF radio systems. By and large, these use vendor-proprietary radio technology and generally offer lower performance (speeds up to hundreds of Kbps and latencies of hundreds of milliseconds and higher) and limited quality of service (QoS) and security functions.

Title picture
Large-scale and widespread wireless networks are proliferating. How is the ABB Tropos industrial-grade mesh 802.11 system superior to competing technologies in this area?

Cellular mobile data services

These offer a different economic model for endpoint connectivity that is based on recurring subscription costs for data services. Several generations of cellular technology have been deployed, including 2G (eg, GPRS) and 3G (eg, HSPA), and 4G LTE now being implemented. These networks are readily available and offer intermediate levels of performance – throughputs of up to a few Mbps and latencies in the range of hundreds of milliseconds. In general, these public networks do not provide the same level of availability, QoS, security and manageability for mission-critical applications that a privately-owned network can provide. Hence, industrial enterprises have always had concerns about their suitability.

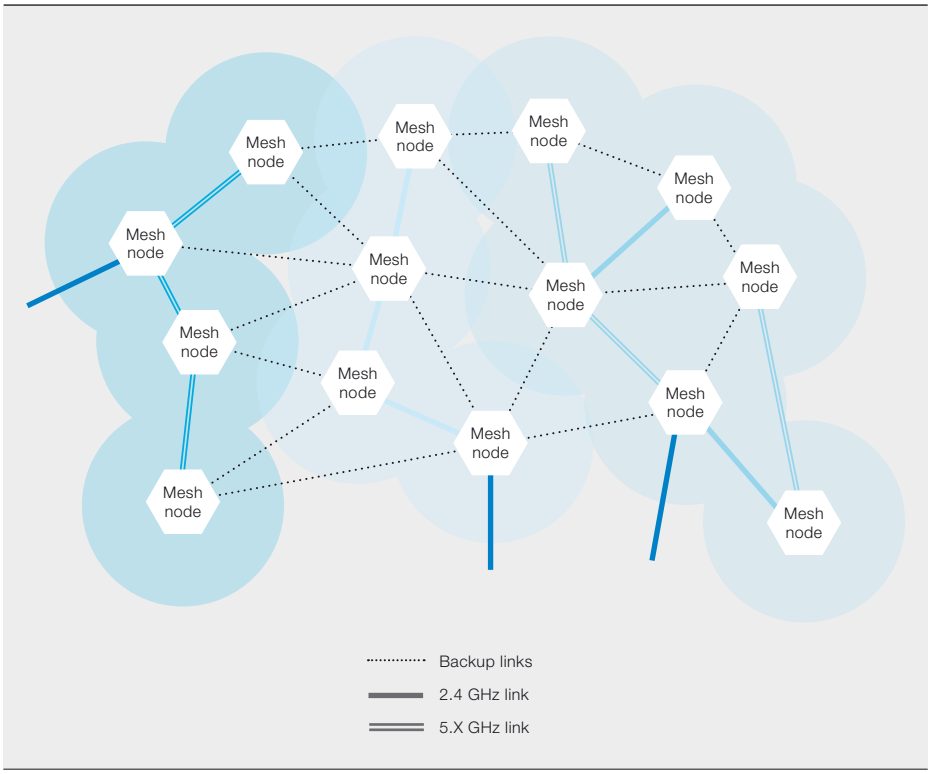
802.11 Wi-Fi-based mesh systems

Wi-Fi-based mesh systems are founded on open standards (IEEE 802.11 and IP) and support standards-based QoS and security mechanisms. Tropos offers the most advanced and market-leading industrial products in this category. They are differentiated from consumer-grade Wi-Fi systems by being hardened for harsh industrial and outdoor environments and by having patented software algorithms that enable a highly resilient and self-organizing mesh network architecture. Mesh routers are typically deployed outdoors on utility poles, streetlights or substations, as well as indoors in buildings and plants. These systems usually operate in an unlicensed spectrum (2.4 GHz and 5 GHz) though they can also be adapted to licensed frequency bands (such as 4.9 GHz). They offer significantly higher levels of performance

They are differentiated from consumer-grade Wi-Fi systems by being hardened for harsh industrial and outdoor environments and by having patented software algorithms.

The mesh structure is robust concerning broken links as there is often more than one path between a source and a destination in the network.

2 Tropos mesh network architecture



(multi-Mbps link speeds and latencies down to a few milliseconds per hop) than the other solutions, enabling implementation of multiservice networks including mission-critical applications ➔ 1.

Industrial applications for meshed Wi-Fi systems

In a mesh network, each node receives and sends its own data – but is also a relay station for other nodes, ie, it collaborates with the rest of the network to ensure data is transmitted successfully. The mesh structure is robust concerning broken links as there is often more than one path between a source and a destination in the network, allowing data to be quickly rerouted around a broken link.

The Tropos product line enables highly reliable industrial-grade mesh 802.11 systems that simultaneously support various applications over one unified network, eg, distribution automation (DA), mobile workforce automation and AMI ➔ 2. This optimizes capital expenditure as well as operational expenditure.

A further product is the Tropos Control software, which provides enterprise-class wireless network management, enabling easy and efficient management of even large-scale networks. Tropos systems have been successfully deployed by many industrial customers including electric utilities, municipal government agencies, public safety departments, transportation systems, oil and gas operators, mining companies, port authorities, etc. Detailed real-world case studies will be described in an upcoming edition of *ABB Review*.

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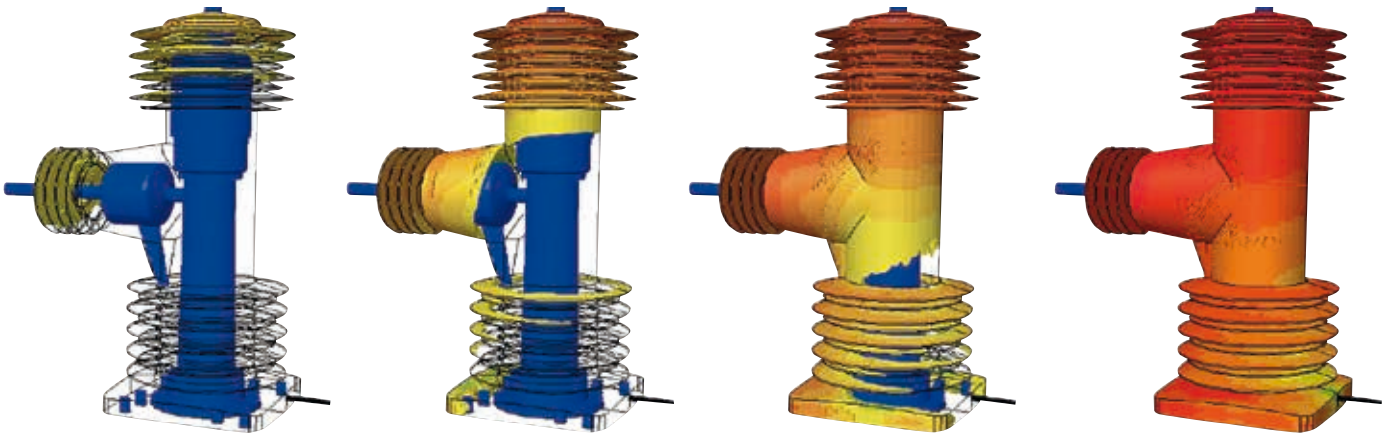
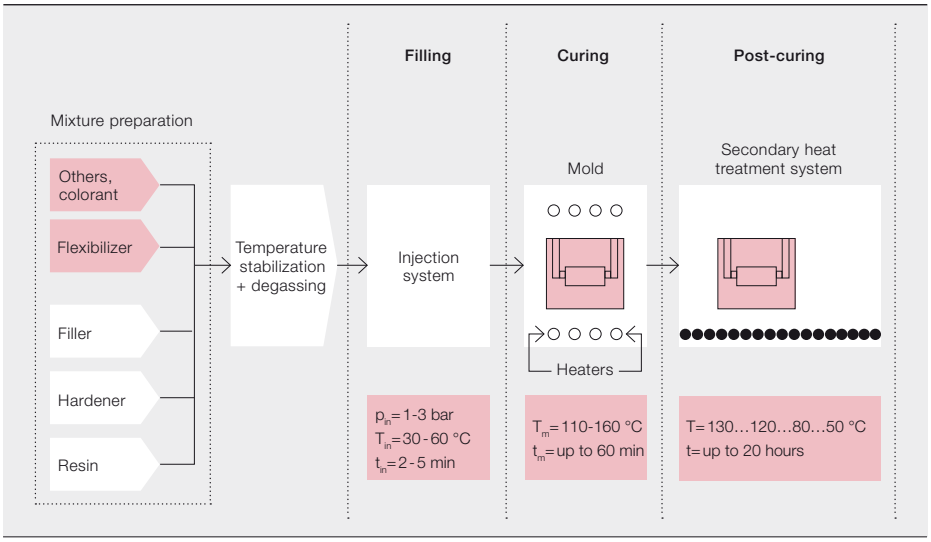


Cast and calculation

eRAMZES – Breakthrough in advanced computer simulations

LUKASZ MATYSIAK, ROBERT PLATEK, MICHAL BANAS, ROBERT SEKULA, HOAN D. LE, ROMAN PERNICA, PETR MICHLICEK – Epoxy resins are the principal insulating material used for encasing most medium- and high-voltage products such as voltage and current transformers, embedded poles, sensors and bushings. They can form a permanently hard protection with excellent electrical, mechanical and thermal characteristics. However, whether or not the cast lives up to these expectations is dependent on the execution of the manufacturing process. For more than ten years now ABB has been developing and using three-dimensional simulations of all stages of the epoxy casting process, including mold filling, curing and post-curing. More than 50 different ABB products have benefitted from these analyses - and their number is growing. The application of computer simulations allowed shorter cycle times, lower scrap rates due to improved products quality and reduced time to market. Recently, ABB developed a new simulation platform called eRAMZES offering-fully-automated reactive molding computations. Thisopens new opportunities in the area of advanced CFD (computational fluid dynamics) and mechanical analyses, giving online and, hence, easy access to complex computer simulations for all ABB designers and process engineers, whether or not they are familiar with numerical modeling.

1 Reactive molding manufacturing process



In the first stage of the APG (automated pressure gelation) process [1] ➔ 3, two or more liquid reactants and additional components are mixed. After homogenization and degassing, the mixture is injected into a heated mold (filling stage). Polymerization of the resinous material taking place during the curing stage results in its solidification and the forming of thefinal product shape. The process is highly exothermic. Subsequently, the product is removed from its mold and typically placed in a tunnel furnace to complete the curing process. Finally, gradual cooling releases thermal and chemical stresses. The complexity of the production process can lead to potential quality challenges such as premature gelation, undesired weld-line locations, air traps and cracks [2, 3, 4].

Thus, it is extremely important to have a comprehensive understanding and control of the manufacturing process. Obtaining such insights purely on the basis of experiments and measurements is both difficult and costly.

ABB has developed and experimentally validated an advanced simulation approach [1, 5, 6], taking into account the complexity of the different stages of the manufacturing technology. In this simulation, each physical phenomenon occurring during reactive molding process is mathematically modeled ➔ 2. The diversity of effects needed to be taken into account has – until now – limited its usage to a narrow group of ABB engineers specialized in this type of industrial simulations.

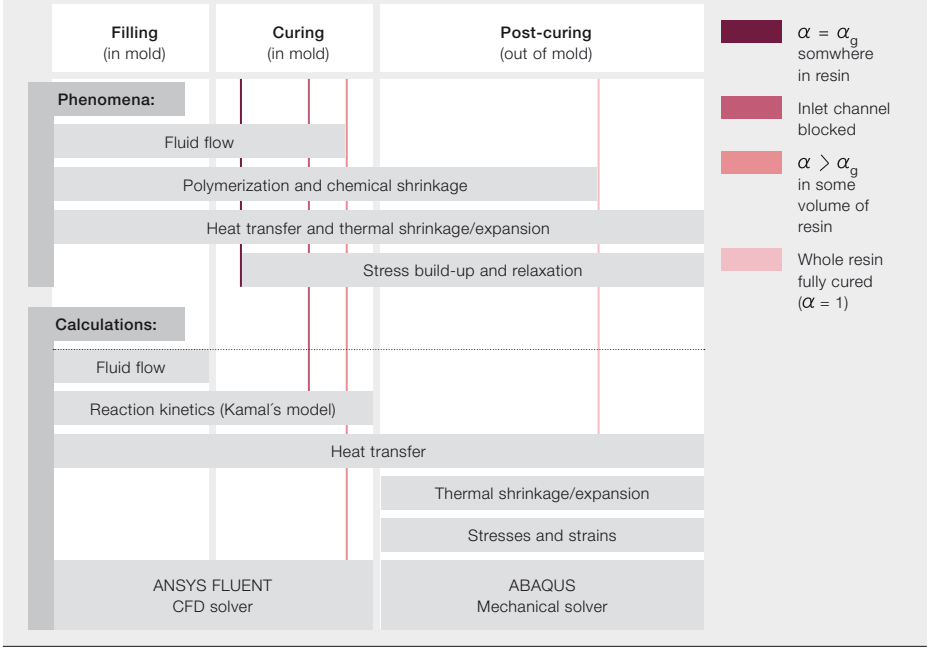
ABB has developed and experimentally validated an advanced simulation approach, taking into account the complexity of the different stages of the manufacturing technology.

A new look at reactive molding simulations

ABB has created a new Web-based, automated and user-friendly tool called eRAMZES to change all this. The tool provides engineers, even those not specialized and experienced in CAE (computer-aided-engineering), online access

Title picture
Curing propagation of a recloser. eRAMZES helps designers understand the thermosetting process and so avoid flaws caused by incorrect setting.

2 Mathematical modeling of the reactive molding manufacturing technology



eRAMZES is controlled by a dedicated multi-functional Web platform linking a number of inter-acting applications.

to advanced reactive molding simulations [7, 8, 9, 10] ➔ 3. The main principle behind eRAMZES is that the company's engineers need only create the CAD (computer-aided-design) model and define the preliminary process parameters. All other operations concerned with numerical modeling are automatically handled by the tool itself. These automated tasks include model discretization (meshing), solver configurations (definition of boundary conditions and materials), computations (solving) and the generation of results.

The architecture of eRAMZES

eRAMZES is controlled by a dedicated multifunctional Web platform linking a number of interacting applications. These include both commercial software (CAD tools, pre-processors, processors and post-processors) and custom-developed software.

The workflow for eRAMZES is presented schematically in ➔ 4. The engineer only defines the geometrical model and process parameters. The remaining computational steps are automated. When the simulation is complete, results are visualized and the user can decide whether the product design and the process parameters fulfill requirements or whether further optimization is needed.

The automation is based on the concept of watcher and launcher programs that are installed on a dedicated high performance computer. In general, a watcher program observes the progress of each task executed by the tool by analyzing the task status in the database ("ready to start", "work in progress" or "finished") and controls the availability ("busy" or "free to run") and operation of launchers. Launchers perform three specific tasks:

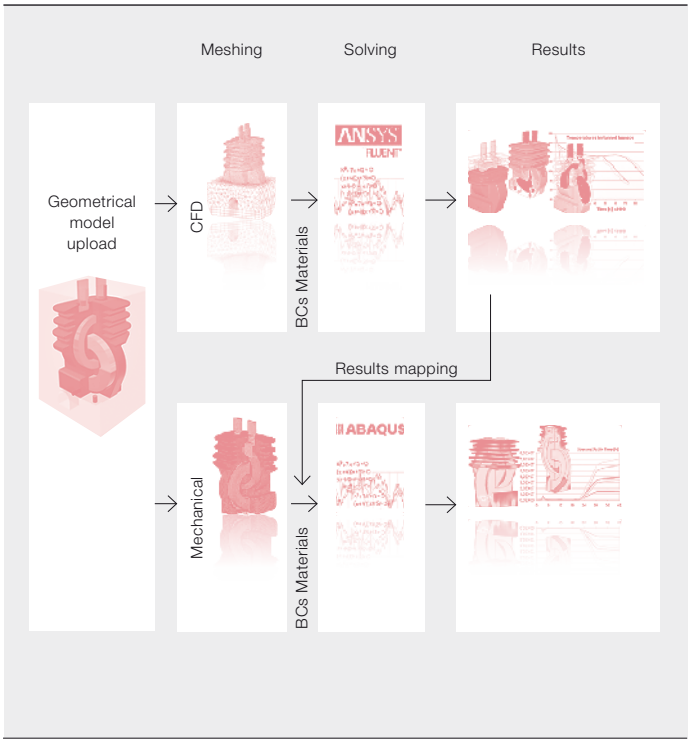
- "Pre" – preparation of the starting directory for the specific program (eg, pre-processor or solver) maintained by a given launcher
- "Launch" – launching that program
- "Post" – cleanup and file management after termination of the program operation.

In case of high demand, this approach allows the running of many simulations in parallel on multiple workstations. These can be customized for the specific needs of different simulation software packages.

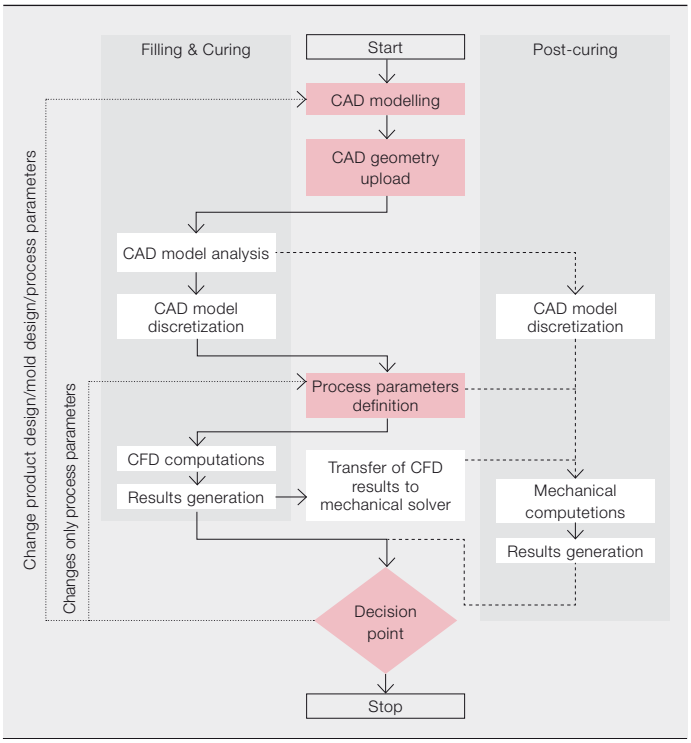
Case creation and CAD model analysis

At the beginning of the analysis, the CAD model ➔ 5 is uploaded using a Web interface ➔ 6. The CAD geometry is automatically analyzed to identify the different parts and to generate data for the later meshing and solving operations. Based on this information, the Web interface is customized so that the relevant process parameters can be entered.

3 The principle of eRAMZES

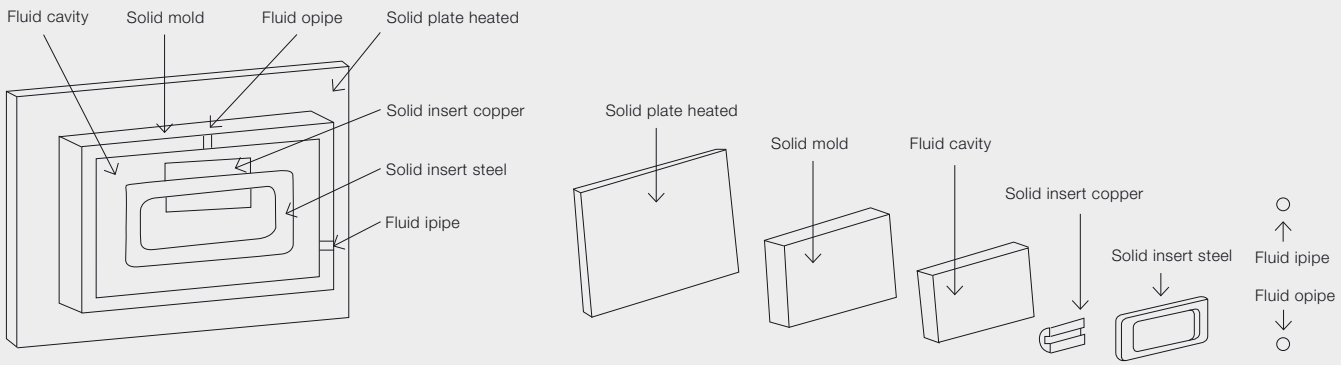


4 Architecture of eRAMZES



Red boxes illustrate steps that require user interaction, while white boxes indicate fully automated operation of the tool.

5 Correct labeling (left) and structure (right) of geometrical parts.



Numerical model preparation

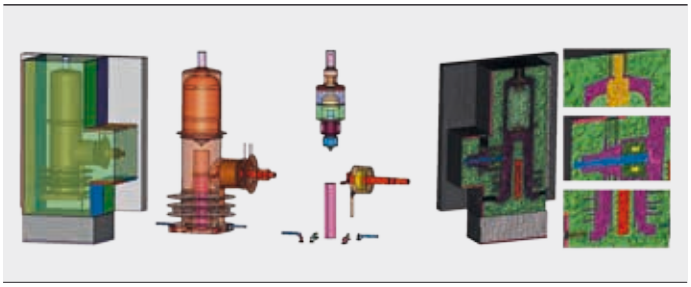
The discretization of the geometry is performed in a fully automatized manner by eRAMZES. This stage was the most challenging part in the tool's development, mainly due to the high complexity and variety of product geometries. Additionally, the differences between CFD and mechanical calculations made it necessary to perform the meshing operations using different meshing tools (pre-processors).

> The optimization shortens cycle times and reduces both scrap rates and time to market.

The launchers initiate and control the discretization procedure in each of the pre-processors. The meshing software simplifies and repairs geometry (removing holes, fillets, intersections, overlapping surfaces, etc) making computations faster and numerically stable. also It alsodiscretizes geometry (different mesh topologies can

6 Case-creation Web page

7 Geometry of outdoor embedded pole (left) and its discretization in HyperMesh (right)



8 Geometry of current transformer (left) and its discretization in ABAQUS (right)

9 Defining of the process parameters

The engineer only defines the geometrical model and process parameters. The remaining computational steps are automated.

be used and consequently either a non-structural or structural mesh can be generated), defines CFD (eg, inlet, outlet, convection etc) and mechanical boundary conditions (eg, constraints, interactions etc). Finally, it exports input files for ANSYS FLUENT and ABAQUS solvers.

The geometrical model of an outdoor embedded pole with its CFD mesh created with eRAMZES is depicted in → 7, and that of a current transformer with its similarly created mechanical mesh in → 8.

One of the greatest benefits of automated mesh creation is time saving. For example, eRAMZES spent only 30 minutes creating almost 3,000,000 CFD mesh elements and 300,000 mechanical mesh elements (using a 2.5 GHz dual-core PC computer with 8 GB of RAM). It would typically take days if not weeks for CAE engineers to manually generate the numerical mesh for comparable geometries. Consequently, eRAMZES users can focus on solving engineering issues rather than on discretization.

Definition of process parameters

The Web application uses information from the CAD model analysis and dynamically creates a Web interface → 9 for the user to enter the required data. This includes process parameters, material properties, materials assigned to product parts and finally, numerical parameters related to mechanical computations.

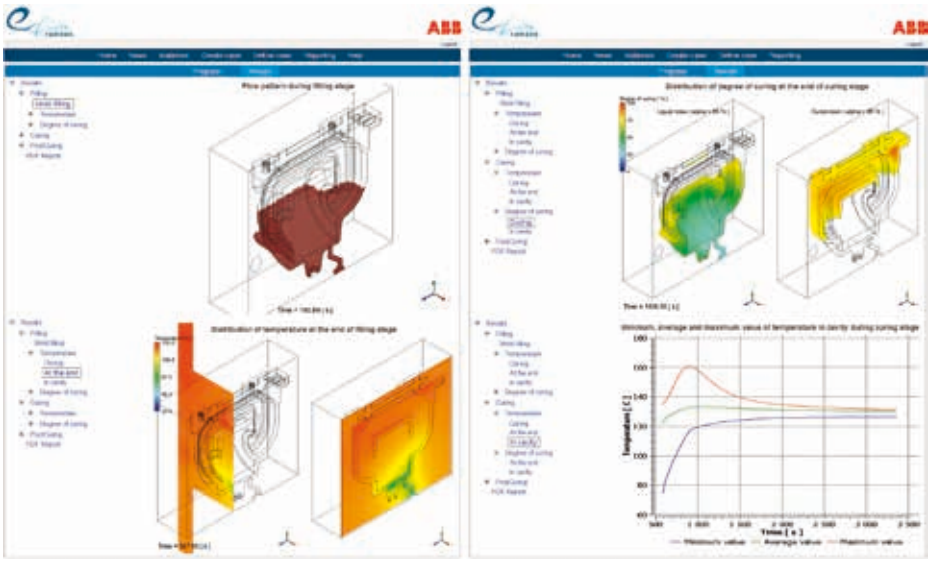
Process parameters include such data as injection parameters (eg, filling time or injection velocity), thermal parameters (eg, temperature of injected material, temperature of heaters, initial temperatures before injection), ambient conditions (eg, air temperature or air convection intensity), post-curing procedure (time and temperature of each cooling stage).

Computations

The tool can now proceed with the processing (or solving) stage. The discretized geometry is imported into the CFD processor – ANSYS FLUENT. Information gathered during the previous steps is transferred to the numerical model to define material assignments, initial conditions, boundary conditions, operating conditions and material properties. The solver is configured by the choice of mathematical models suitable for the reactive molding simulation (both built-in models for turbulence, flow etc, as well as additionally implemented models, eg for curing kinetics) as well as by the definition of numerical parameters. Using these data, the transient numerical computations for the filling and curing stage are conducted and, when complete, results are generated and exported.

The tool allows ABB engineers to observe the influence on the product and its manufacture caused by changes in the product design and its molding as well as by process parameters.

10 Results generated for the filling stage (left) and the curing stage (right)



It is worth noting that reactive molding simulations are known to be numerically instable – even when performed manually – due to the complexity of phenomena involved in the process. In the meantime, eRAMZES monitors and automatically controls the solution convergence ensuring an excellent stability of computations without requiring additional user actions. In this way one of the biggest challenges during the tool's development became one of its most significant achievements.

The computations can be continued if the user decides to include the post-curing simulation. The temperature results obtained for the end of the curing stage are translated using dedicated software (developed for this purpose by ABB) and passed to the mechanical solver ABAQUS as starting point for the post-curing computations.

The ABAQUS software imports and repairs (if needed) the geometrical model. Next, material properties are assigned to the geometrical parts and the analysis steps and time are specified according to the user input provided previously. Boundary conditions (data from ANSYS FLUENT, constraints, etc) and interactions between geometrical parts are set and the mesh is generated based on the user's specification of the mesh density. Finally, the input file is prepared and submitted to the solver for computations and, once finished, results are generated and exported.

Results visualization

Post-processing is the final step of eRAMZES's analysis. The simulation results are further processed in a batch-mode controlled again by specific launchers. The obtained results are presented to the user in different forms such as movies, pictures and charts via the Website or as a printable .pdf document. The way results are visualized can be customized to meet user requirements. Examples of results generated for CFD and mechanical analysis are presented in ➔ 10 and ➔ 11.

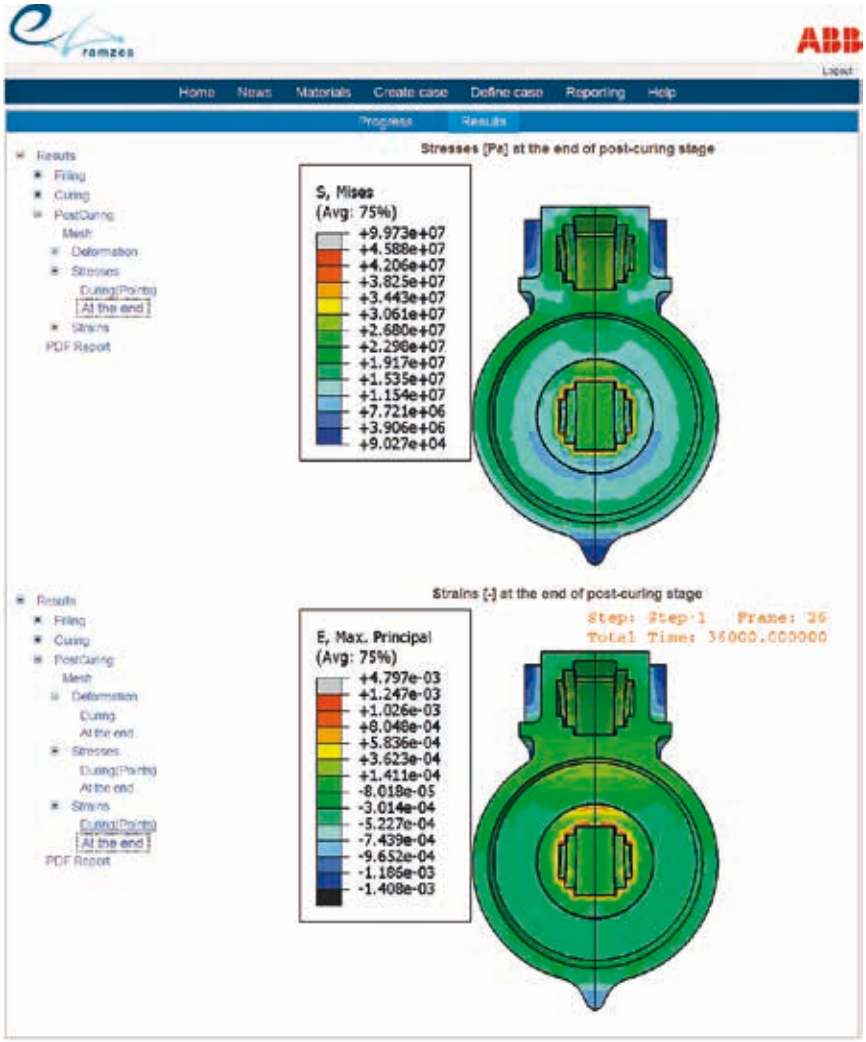
The visualization of results allows users to observe in detail the course of the reactive molding process and observe effects inside the mold and product. These aspects cannot be detected in a normal production process or in an experimental setup. Data includes details of the flow pattern of epoxy resin during the filling stage, distribution of temperature at all times and in all process stages, distribution of the degree of curing during the filling and curing stages, as well as distribution of deformations, stresses and strains during the post-curing stage.

Based on these insights, the engineer can decide whether further process and product optimization is required.

The right cast

The eRAMZES Web-based tool combining CFD and mechanical simulations can be successfully utilized both for the design of new and optimization of exist-

11 Results generated for the post-curing stage



ing products manufactured by reactive molding. The tool allows ABB engineers to observe the influence on the product and its manufacture caused by changes in the design of product and mold as well as by modifications of the process parameters. Furthermore it achieves this without requiring interference in the real production process.

Among the tool's advantages are fully automated discretization and computations ensuring the repeatability of the simulation process (eliminating the error risk inherent to manual processing) as well as the online access to the tool and its user-friendliness extending the potential users of the tool to ABB engineers not expertized in numerical modeling. All aspects mentioned above lead to both shorter development cycles and to an improved quality of epoxy based components. Furthermore, the approach can potentially be adapted to other manufacturing processes.

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Net gain

Keep track of your control system via the Web with ABB's My Control System

MATTHIAS STEIN – ABB has been installing industrial control systems for several decades now and has built up a substantial installed base in a wide variety of industries around the world. Apart from the technical complexity of the control system insofar as it interacts with its particular manufacturing process, there is often non-trivial administrative and support complexity to deal with too: Typically, a control system will require software licenses, up-to-date malware protection, system diagnostic and maintenance tools, training modules, safety monitoring reports and so on. Until now, it was necessary to look in a variety of places to obtain an overview of these. However, ABB's new My Control System Web application now provides control system users with a simple and convenient means of keeping track of many aspects of their system.

Title picture
ABB's My Control System provides users in all industries with an ideal tool to keep track of their ABB control system.

1 Customers can retrieve detailed information about their system from one location and view it using any browser and on nearly any device.

The large installed base of control systems that ABB has built up in many industries over the last 30 years represents a major commitment. ABB looks after this installed base by crafting solutions that ensure the continued productivity, reliability and capability of all ABB assets involved. One important aspect of this is the support ABB offers customers throughout a plant's entire life cycle, even when service requirements change, via a comprehensive spectrum of services – from preventive maintenance through remote monitoring to performance-enhancing assistance. In particular, life cycle services increase the productivity of facilities, minimize costs and extend the life of installed equipment.

My Control System is a secure, Web-based platform that provides comprehensive information about and services for the ABB control system in operation at the customer site.

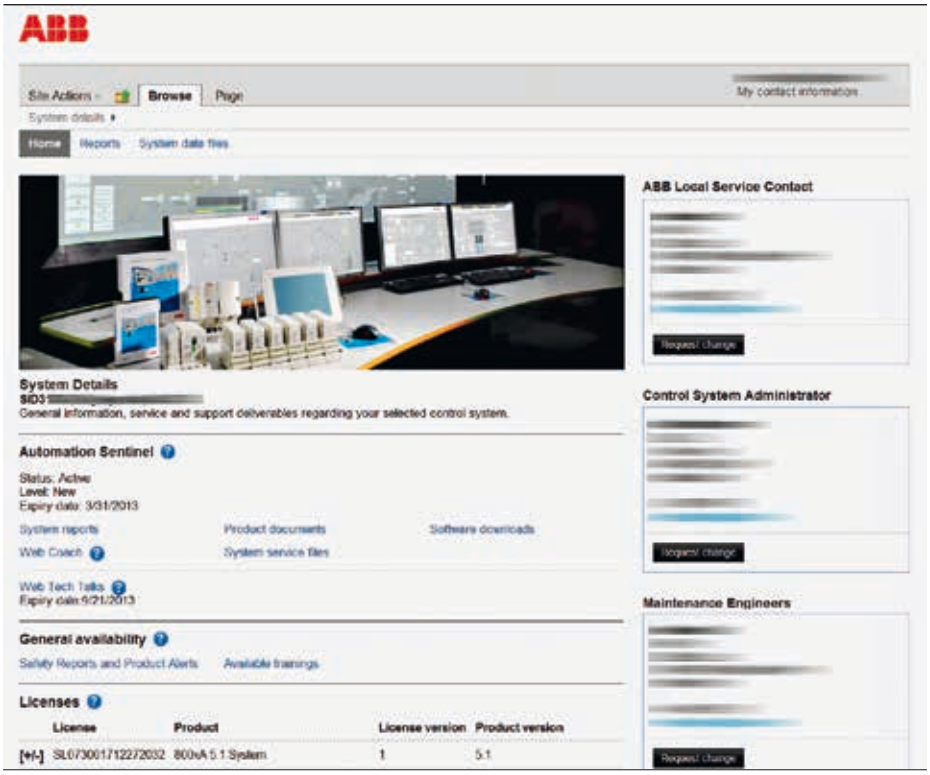
ABB Automation Sentinel Program

Automation Sentinel is ABB's control system life cycle management and support program. With this program, system owners can keep their control system up-to-date and maintain a flexible path to new technology. It provides the basic support required to maintain operation and maximize the life cycle of the ABB control system. The new release builds on the existing Automation Sentinel program and adds new, valuable services, one of which is the newly launched Web-based platform My Control System.

My Control System

My Control System is a secure, Web-based platform that provides comprehensive information about and services for the ABB control system in operation at the customer site. By using a secure log-in at the www.abb.com website, customers can access one easy-to-find location from which they can retrieve detailed information about their system. This data can be viewed using any

2 My Control System starting page



browser and on nearly any device, such as a PC, tablet or, soon, a smartphone ➔ 1.

My Control System presents, in dashboard format, important information about the control system's subscriptions and software licenses in terms of content, expiry dates, tools and license key downloads. All this data is available with just a few clicks. For convenience, the ABB local service contact information is listed on the starting page ➔ 2.

Using My Control System, customers will be able to download documentation and software updates relating to their control system, view online training videos, run system benchmark reports and access all relevant safety reports, alerts or product documents. Rapid problem identification through real-time access to the dashboard is one of the main benefits of My Control System.

Data can be viewed using any browser and on nearly any device, such as a PC, tablet or, soon, a smartphone.

IT security

IT security is more important than ever before for process automation owners as malware is now targeting control systems. Further, many governments are currently developing legislation to regulate the defensive posture of national and commercial enterprises in the face of cyber attacks. In My Control System, a report showing the status of the installed software is available and actions can be taken by the customer to secure the system further.

Benchmark and Fingerprint reports

Other features are also available in My Control System to support ABB control system customers during operation and maintenance: The health status of the control system can be checked with benchmark reports, which indicate optimization possibilities. In addition, Fingerprint reports can show the status of the control system's return on investment (ROI) key performance indicators (KPIs) and suggest what the customer should do to bridge any performance gap.

Customers will be able to download documentation and software updates, view online training videos, run benchmark reports and access all relevant safety reports, alerts or product documents.

3 Customers can lower their total support cost and reduce after-hours phone support or service calls by using My Control System to access pre-filtered information dedicated to their installed control system.

Training

My Control System not only assists ABB's customers to optimize the maintenance of their installed control system, but it also helps plan the training of their operators.

Web Coach is a series of Web-based maintenance training modules for various ABB control systems that is combined with live question and answer sessions to provide cost-effective and convenient training and a valuable technical information resource.

Rapid problem identification through real-time access to the dashboard is one of the main benefits of My Control System.

Web Tech Talks are frequent Web-based meetings for advanced users. These meetings are moderated by ABB product experts and deal with relevant technical topics and issues. Control system users can keep up-to-date with the latest control system technical information and market trends and receive practical tips.

The schedules of Web Coach, Web Tech Talk and other online training opportunities offered by ABB are available in My Control System.

Self-help

Customers can lower their total support cost and reduce after-hours phone support or service calls by using My Control System to access pre-filtered information dedicated to their installed control system. This also reduces the time and effort spent looking for information → 3. My Control System provides ready answers to frequently asked questions, thus reducing the effort spent looking for information. Further, users can download service packs and updates for immediate installation and, thus, shorten software delivery times.

ABB sales and field service personnel will also have access to relevant information via My Control System, giving them improved visibility into customers' control systems. This will help service personnel meet customer needs more proactively and smooth the support process.

4 Features of My Control System

General availability for all control system customers:
- Welcome page
- System details page
- My safety reports/My product alerts
- My training
- ABB local service contact information
- Customer system administrator contact information
- My software/subscription licenses
- Language localization

Additional availability for customers who have an Automation Sentinel program license:
- My product documents (user manuals, Microsoft security update validation reports, System 800xA certified hardware reports)
- My software (software downloads, access to patches, service packs, new software versions)
- Benchmark report: Control system health and performance check and software validation
- Fingerprint report: Advanced diagnostic analysis of the performance of the control system to quickly close performance gaps
- Web Coach/Web Tech Talks

5 My Control System provides a license and service overview of even the most complex installations.

My Control System scope

The development of the My Control System platform started in June 2011. The development program progressed quickly and the platform is now available for all ABB control system users. It has elicited an enthusiastic response. Additionally, when demonstrated at the Hanover Fair in Germany and the Automation and Power World exhibition in Houston, Texas, both in 2012, My Control System evoked a very positive response from customers in general.

A basic version of My Control System with limited access will be provided to all ABB control systems customers. Subscribers to the Automation Sentinel control system life cycle management and support program will enjoy more My Control System benefits ➔ 4.

Through My Control System, both the customer and ABB have an overview of the control systems software licenses and service products that have been purchased (or not) and information regarding validity and expiration dates – even for complex installations ➔ 5. In addition, My Control System is an excellent source of technical information, best practices and expert knowledge.

My Control System brings the customer closer to ABB and ABB closer to the customer, resulting in a solid, long-term and mutually beneficial business relationship.

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My Control System not only assists ABB's customers to optimize the maintenance of their installed control system, but it also helps plan the training of their operators.

In My Control System, the IT security status of the installed control system is always visible on the dashboard.

Conservation of energy

A paper machine fingerprint cuts energy usage

CARL-FREDRIK LINDBERG, NAVEEN BHUTHANI, KEVIN STARR, ROBERT HORTON –
Entering the papermaking machine, the raw material that goes into a single A4 sheet of paper would look like a bucket of slightly dirty water. In fact, the stock furnished to a paper machine contains over 99 percent water and less than 1 percent actual paper fiber. Although most of the dewatering in papermaking is performed mechanically, a significant amount is done thermally – resulting in colossal energy usage and making paper production one of the most energy-hungry processes in industry. But where such large consumptions are in play, there also exist opportunities for significant savings. This is why ABB offers a paper machine energy fingerprint. This assessment quantifies energy flows and benchmarks energy use in the paper machine, enabling energy-saving opportunities to be identified.

In principle, papermaking has changed little over the centuries, though the equipment used has evolved dramatically: A slurry, containing more than 99 percent water and less than 1 percent actual paper fiber, is sprayed onto a traveling, endless wire mesh. Much of the water falls, or is sucked, through the mesh and a wet web of fibers continues to the press section of the paper machine, where it is squeezed between heavy rolls to remove even more water → 1. Water removal here is made more efficient by using a steambox to steam-heat the fiber web before the presses. The web then proceeds to the drying section where it passes partly around, in a serpentine manner, a series of steam-heated drying cylinders. This reduces the moisture content to about 6 percent.

Pressing is a far more efficient means of removing water than heating, but only so much water can be pressed out, so heating is unavoidable – and this is when the energy bills start to mount up. However, where large amounts of energy are consumed, there is also scope for significant energy savings.

Title picture
Paper machines use huge amounts of steam to dry paper. How can a critical analysis of the energy flows in the machine deliver substantial savings?

1 A typical paper machine. The “wet end” is in the foreground; the drying section is at the left.

Where large amounts of energy are consumed, there is also scope for significant energy savings.

Energy flows

In the dryer section, energy is transported by steam, condensate, air, water and paper in a complex flow scheme: The paper dries when it is heated on the steam cylinders and the heat from the moisture released is recouped by a heat exchanger and added to the inlet air, which is further heated by a steam-air heat exchanger. The air going into the machine hall is also heated. Steam heats the steam cylinders and some flash steam[1] is recovered by thermocompressors. Remaining flash steam goes to the condenser where it heats up cold water ➔ 2.

The challenge is to identify where energy is wasted in this complex interplay and what savings can be made.

Measuring and improving paper machine energy performance in this way is not a new idea and several approaches have been suggested [1,2]. It has been found that pocket air ventilation, hood balance and dew point have a significant influence on paper machine efficiency [3,4,5,6,7].

Several aspects can influence energy efficiency:

- The type of equipment (design efficiency and condition)
- Lack of equipment (eg, no heat exchanger, no steambox)
- Plant design (eg, use/waste of flash steam and condensate, heat recovery system)
- Control strategy (eg, no dew point control)
- Operation (manual control, choice of setpoints)
- Maintenance (of heat exchangers, steam traps, valves, sensors, insulation, leaks, tuning control loops, etc.)
- Sensors (calibration, lack of sensors for monitoring and/or control)

Methods

Various methods are used to identify inefficient use of energy.

Energy quantification

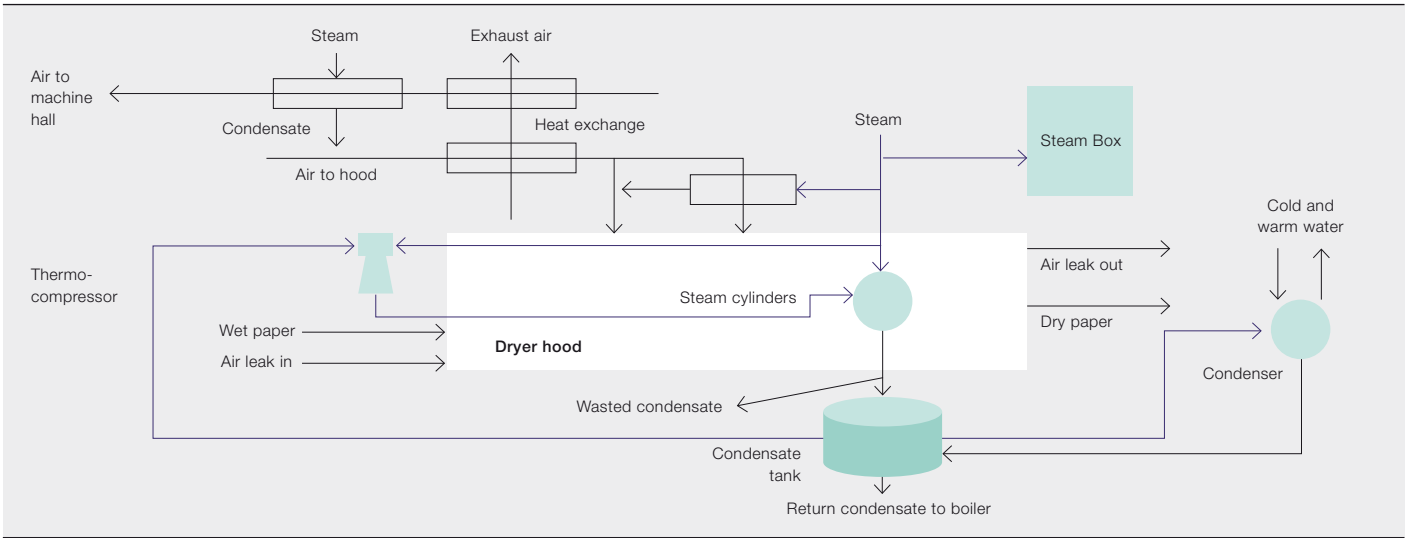
Knowledge of the energy flows inside the paper machine allows waste streams to be identified. Energy flows are more difficult to measure than liquid and gas flows since more measurements are required and very few of the measurements needed for calculating energy are available; steam flow sensors are particularly rare.

The steam flows to the steam groups of a real paper machine were estimated by measuring the rise time in the condensate tanks after switching off the effluent flow from the tanks. The steam consumption in steam-air heat exchangers was, in this case, estimated based on airflow, humidity and temperature measurements. By using energy equations together with measurements, the relative energy consumption was obtained ➔ 3.

Footnote

1 Flash steam is vapor or secondary steam formed from hot condensate discharged into a lower pressure area. It is caused by excessive boiling of the condensate, which contains more heat than it can hold at the lower pressure.

2 Overview of energy flows in a paper machine



The main steam usage is, as expected, in the different steam groups, but, in this paper machine, more than 10 percent of the total steam energy goes to the condenser. An industry-typical value would be under 3 percent, so energy efficiency improvements here are obviously feasible.

Data mining

Historical data can be scanned for operations that influenced the steam consumption per ton of paper ratio. First, data is grouped by paper grade. Then, for each grade group, various signals are plotted against steam consumption per ton of paper. If there is a clear relation between the signal and energy efficiency then a suggestion is given on how to run the paper machine more efficiently. In the future, this search could be automated.

Real data from a paper machine was collected to estimate steam consumption per ton of produced dry paper for some different basis weights. The steam consumption per ton dry paper varied between 1.8 and 2.4 tons → 4. The basis weight has, apparently, a large impact on steam efficiency in this paper machine as heavy basis weights consumed less steam per ton of paper than lighter grades.

Another variable that influenced steam consumption per ton dry paper was machine speed. Generally, the higher this is, the less steam is used → 5. For the lightest basis weights, the velocity relation is weak, perhaps due to condensate rimming in steam cylinders or limited capacity in the press section at higher speeds.

Other parameters that influenced steam efficiency were the differential pressure over steam groups (the lower, the better) and refining (less, if possible).

Steambox optimization

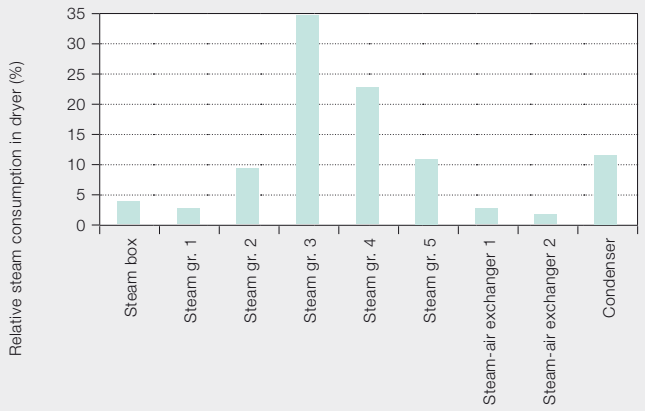
Steam-heating the paper web reduces total steam consumption because hot paper is more easily dewatered in the press section, and the dryer section consequently needs less steam to drive out the remaining moisture. However, feeding too much steam to the steambox does not improve dewatering. Setting the steambox flow to the optimal pressure minimizes total steam flow. It should be noted that the steambox is also used for flattening the moisture profile across the web and dewatering measures should not interfere with this.

An experiment was performed on a steambox → 6. First, the steambox pressure was reduced, then all actuators were set to 80 percent open and the steambox pressure was ramped up slowly and then partly down. The total steam consumption in the paper machine (top curve) reached a minimum after 80 minutes, when it was around one ton per hour (about 2.5 percent) less than in normal operation. The reel velocity was constant during the experiment and the total lower steam consumption at 80 minutes is not a result of higher moisture.

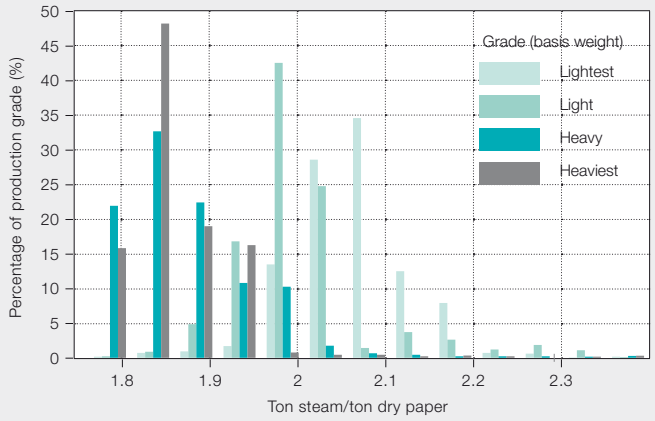
The moisture profile across the sheet (not shown) deteriorated, as expected, with high moisture at the edges when all the actuators were opened. It remains to be seen what steam consumption savings can be achieved when automatic moisture profile control is running.

The challenge is to identify where energy is wasted in this complex interplay and what savings can be made.

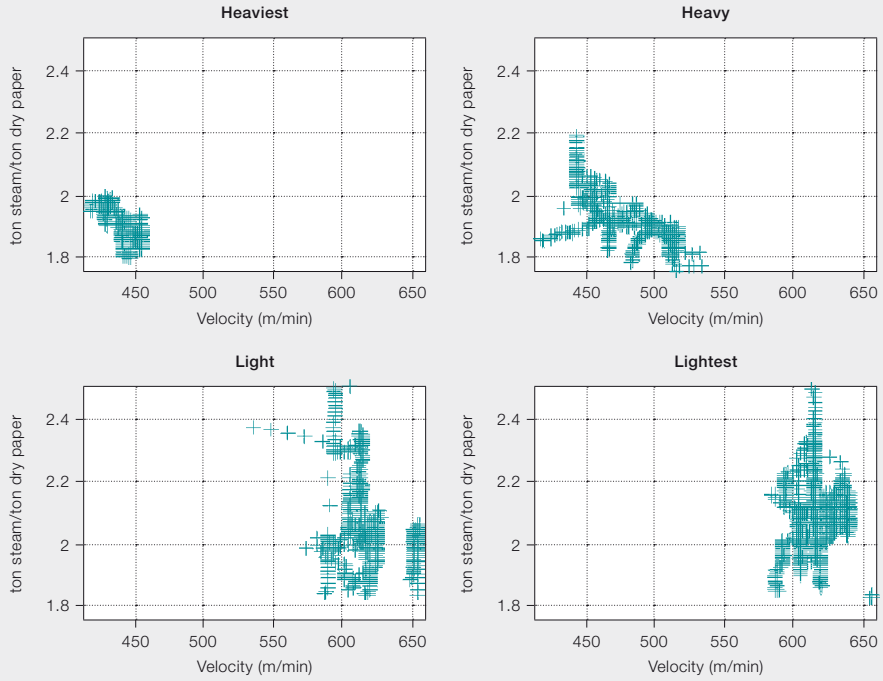
3 Relative steam consumption in the dryer section of a real paper machine



4 Histogram for ton of steam consumption per ton of dry paper produced over 19 days for different basis weights.



5 Ton steam consumption per ton dry paper vs. paper velocity for different basis weights. Higher velocity is more energy efficient for the heavier grades.



Infrared thermography

Heat leaks and associated equipment problems reduce energy efficiency. Such issues can be located using thermal imaging. Dryer cylinders, the dryer hood, the thermocompressor, steam and condensate traps, etc. have been studied using this technique.

For example, a thermogram of a section of the hood showed a hot air leak heating the hood on the outside (hot air itself cannot be detected by thermal imaging) → 7. Sealing the leak would save energy and reduce the humidity in the machine hall. This also reduces the amount of moisture to be removed by the ventilation, which, in turn, saves yet more steam by reduced steam heating of outside air.

A thermogram of a thermocompressor was used to detect inefficiency → 8. In the lower part of the figure, cooler flash steam enters at 124.6 °C. High-pressure motive steam enters from the right at 149.9 °C. The mixed flow is at 147.5 °C, which is close to the motive steam temperature, hence very little flash steam is recycled. Energy could be saved by recovering more flash steam and reducing the flow to the condenser.

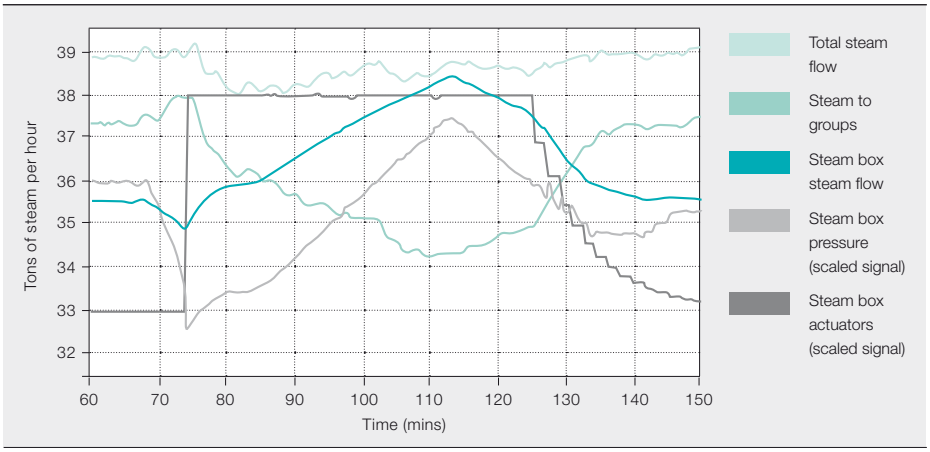
Another way to check the thermocompressor is to study total steam consumption or condenser load when it is switched off. When this was done, no change was observed on total steam consumption or condenser load.

Energy benchmarking

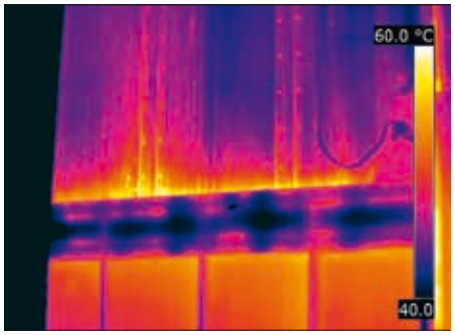
Various benchmarks have been calculated to determine the energy efficiency of the mill, eg:

- Ton steam/ton dry paper
- Steam energy in Joules/evaporated kilogram water
- Electricity kWh/ton paper
- Condensate return ratio to power house
- Dew point in hood (exhaust air)

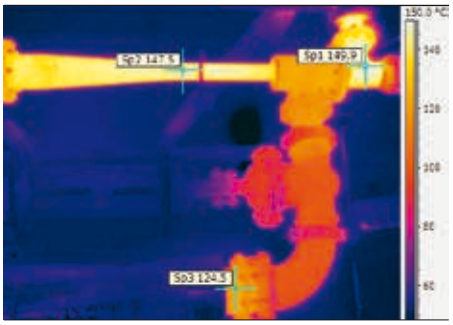
6 Steambox experiment. Note lower total steam consumption (top curve) at t=80.



7 Thermogram of a part of the hood where hot, humid air leaks (above the gap)



8 Thermogram of a thermocompressor



Cooler flash steam enters at 124.6 °C. High pressure motive steam enters from the right at 149.9 °C, giving a 147.5 °C mix, which is close to the motive steam temperature, hence very little flash steam is recycled.

- Sheet consistency after press section
- Availability (uptime/total time)
- Performance (actual speed/maximum for that grade)
- Quality (good tons/total)
- Overall equipment effectiveness

These and other performance indices can be compared with other paper machines producing the same type of paper. Where a benchmark is found to be poor, there exists an opportunity for energy saving.

Other experiments

The discussion above is not exhaustive – there are other experiments that could be performed to identify areas to save steam:

- Increase the wire tension to improve heat transfer rate and reduce steam consumption.
- Reduce over-superheated steam to make the steam cylinders more energy efficient.

Savings all round

Paper machines consume large amounts of energy, but, in most cases, large savings can be also be made. By quantifying steam supply and steam use, inefficiency can be measured, poor energy users can be identified and solutions can be applied.

An audit of a paper machine has identified the following potential steam savings:

- 2.5 percent steam savings by increased reel velocity
- 2.5 percent steam savings by optimization of steambox pressure
- 2 to 8 percent “condenser” savings by repairing and/or improving the operation of thermocompressors, reducing differential pressures over steam groups and improving pressure control in general.
- Plus some more percent steam savings by sealing leaks from hood and ventilation systems, less refining (if possible), increased wire tension, increasing hood dew point, reduced steam superheating, etc.

By simply optimizing control setpoints, steam consumption can be reduced by 5 percent. With limited investments, steam savings of around 10 percent would be possible.

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More power

New ABB motors make their mark

The new additions extend ABB's Ex and safe area portfolio covering different installations and safety and power requirements.

ANDREA CASIRAGHI, ANDREA LAMPUGNANI, SAMI MYLLYKOSKI, DAN STELZNER – The chemical, oil and gas industries face huge challenges: As the source of the basic raw materials that underpin our daily lives, they have to deliver a wide range of highly competitive products at enormous volumes while managing multiple processes in extremely harsh and increasingly difficult environments. All along the production chain, from exploration and extraction to refining and processing, ABB has a wide range of motors and generators, mechanical power transmission products and services that help meet these increasing production demands safely, cost-effectively, and efficiently. ABB's two new motors, the HV flameproof motor AMD 900 and the HV modular induction motor AMI 800 2-pole, were developed to meet the requests of customers for more powerful motors.

Title picture
ABB has a wide range of motors and generators, mechanical power transmission products and services that help meet the increasing production demands of chemical, oil and gas industry safely, cost-effectively and efficiently.

1 New ABB motors

1a The HV flameproof induction motor AMD 900

1b The 2-pole HV modular induction motor AMI 800

ABB motors are powering pumps, compressors and drilling equipment used in all chemical, oil and gas production processes. These industries are seeing a global trend towards large-scale plants requiring motors with higher output to drive bigger machines. This is true for new plants being built in emerging markets as well as for expansion projects in existing plants. In drilling and offshore sectors, keeping size and weight down is essential to keep operating costs down. To meet these trends, motor and generator technical developments are moving towards increased power density; i.e., high voltage, higher output motors that offer the ability to reduce weight and size while delivering more power and speed. And of course all of this has to be achieved while meeting stringent safety standards.

A versatile portfolio

ABB motors meet all national and international standards and requirements – including IEC, European (EN) and NEMA. All withstand demanding process requirements, including onshore or offshore, oil and gas pipelines, refineries or petrochemical plants, floating production storage and offloading oil platforms, or liquefied natural gas (LNG) plants. The motors also operate in harsh environments such as explosive atmospheres, extreme temperatures, corrosive dust or humidity.

ABB develops solutions to improve customers' processes over the entire product lifecycle. The initial purchase price and installation of a motor often represents a small percentage of the overall cost of ownership. Running costs, maintenance and repair bills can outstrip the original costs of a motor, so therefore selection of the right product can lower the total cost of ownership by avoiding downtime.

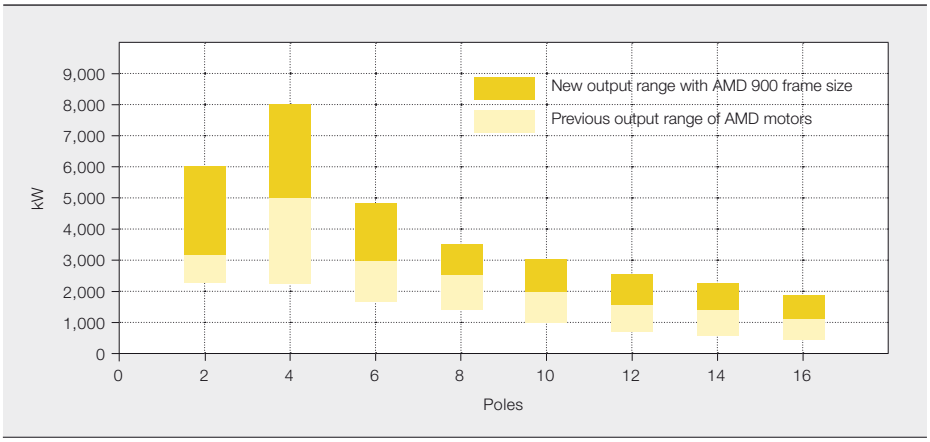
Powerful and cutting-edge motors

To better meet the needs of these industries, ABB has introduced two high-powered motors – the high-voltage (HV) flameproof induction motor AMD 900 and the 2-pole HV modular induction motor AMI 800 → 1. The new additions extend ABB's Ex and safe area motors portfolio covering different installations and safety and power requirements.

The HV flameproof motor AMD 900 is ideal for driving pumps and compressors where higher processing capacity is needed, a refiner, for example. The HV modular induction motor AMI 800 2-pole is designed for driving water injection pumps on floating production, storage and offloading units (FPSOs) and main oil pipeline pumps in addition to other broad applications in chemical, oil and gas installations and wastewater treatment plants.

The HV flameproof motor AMD 900 is intended for fixed and variable speed applications from 333 rpm (18 poles) to 3000 rpm (2 poles), with 20-pole motors

2 AMD output at 6000 V 50 Hz



In drilling and offshore sectors, keeping size and weight down is essential to keep operating costs down.

also available. Operating voltages are 3 to 11 kV, 50 Hz or 60 Hz. The motors are tube cooled either by IC511 or IC516 methods[1] and can be supplied for horizontal or vertical mounting. These motors do not require purging before starting, nor a pressurization system or inert gas. They can also be VSD fed. There is no thermal limitation for the "t_E" time[2], and no need for a system test in VSD applications – individual certification is not required.

Its low vibration levels increases the reliability for an extended lifetime, which, together with its reduced maintenance requirements, means lower cost of ownership. The motor is certified up to IEC frame size[3] 900 and rated up to 8 MW. The HV flameproof motor AMD 900 is an extension of ABB's HV flameproof motor family. The new frame size simply means more power → 2.

Combining higher power with the requirements of flameproof protection (Ex d) involved considerable technical challenges. Internal clearances, referring to the minimum clearance distance between the joints in the frame and the labyrinth seal in mm, were optimized on the labyrinth seals and enclosure. Advanced finite element method (FEM) techniques were used to ensure that the new labyrinth seal design and thicker enclosure met all safety demands. Full compliance with all requirements has been confirmed by extensive testing, and both ATEX and IECEx certifications are available.

Combining higher power with the requirements of flameproof protection (Ex d) involved considerable technical challenges.

The high voltage modular induction AMI 800 2-pole motor expands ABB's Ex and safe area motor range and extends the IEC frame size from 400 to 800 for the 2-pole construction. Because of low vibration levels, rugged construction, low maintenance requirements and excellent reliability, the new motor provides a very low overall cost of ownership. High efficiency, along with a range of ventilation technologies, results in considerable energy savings over the life of the motor.

ABB met the challenge of cooling and stresses in the modular induction AMI 800 2-pole motor when implementing a combination of axial and radial ventila-

Footnotes

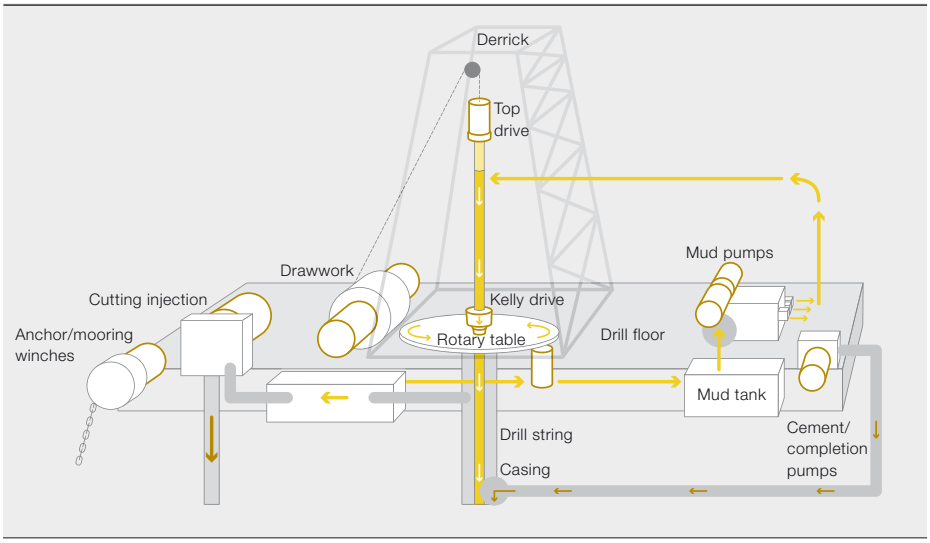
1 http://electrical-engineering-portal.com/cooling-and-ventilation-of-electric-motors-ic

2 t_E = stalled rotor time, in seconds, taken for an a.c. rotor or stator winding, when carrying the initial starting current, to be heated up to the limiting temperature from the temperature reached in rated service at the maximum ambient temperature (IEC 60079-7)

3 Frame size refers to the distance from the center line of the shaft to the bottom of the feet.

By employing VSDs instead of throttling or using by-pass vanes, energy costs can be reduced by as much as 60 percent.

3 ABB's drilling drives system



tion. The rotor has a new bar construction to resist the axial and radial stresses that are generated in such a powerful motor, especially during start-up. The shaft is solid, ensuring the necessary rigidity with the rotor core shrink-fitted on. The motor can be operated with supply voltage from 6 to 13.8 kV and is intended for fixed speed applications up to 3000 rpm, with a direct on line (DOL) connection, and is initially available for 50 Hz. VSD (variable speed drive) operation is possible, but the speed range is fixed on a case-by-case basis for each application. The motor is designed for horizontal mounting and is equipped with sleeve bearings. Available protection types are non-sparking (Ex n) and pressurized (Ex p).

ABB's range of 2-pole HV modular induction motors are available in IEC frame sizes 400, 450, 500, 560, 630 and 710 mm with a maximum output of 8 MW.

AC motors are compact in size, supplied with a flange connection, and are foot supported.

This motor family has a standardized platform with options enabling production efficiency for almost all industrial applications. The addition of the new 800 frame size means more output power. The new target output for the 2 poles is set to 13.5 MW (10 kV – 50 Hz – IC81W) and 12 MW (10 kV – 50 Hz – IC616). The HV modular induction 2-pole motors can be horizontally aligned, and cooling types are weather protected (IPW24) or totally enclosed, equipped with air-to-air (IC611, TEAAC) or with water-to-air (IC81W, TEWAC) heat exchangers.

Comprehensive systems dig deep

A complete AC drilling rig system is a complex mix of transformers, drives and motors. ABB knows the challenges of each application and has the right motor for each one.

ABB supplies Ex certified drilling motors for top drive, mud pump, drawworks (DW), cement pump, rotary table, cutting injection, hex pumps and winches → 3. The motors output extend up to 1,655 kW or 2,250 hp. IEC frame sizes vary from 280, 315, 400, 423, 450 up to 500. Typical operating voltages for VSDs are between 575 and 690 VAC at 50/60 Hz, and the motors are designed to work at ambient operating temperatures that range from –45° C to 55° C.

ABB VSDs, together with ABB's drilling motors, are helping to lower the total cost of ownership through energy savings and reducing environmental impact. By employing VSDs instead of throttling or using by-pass vanes, energy costs can be reduced by as much as 60 percent. ABB electric drives reduce emissions (such as

NO_x and CO_2) onsite that could delay granting of a permit and incur penalties.

The new generation of top drives drilling systems, and the largest ones, rotate by AC motors and typically are connected to a gearing bit without the use of the conventional rotary table and kelly drive. In addition, the top drive can drill at a wider angle than a rotary table with swivel. Generally, top drive motors in drilling rigs need to withstand higher acceleration forces than standard motors in other rugged industry environments. This equipment has to function in hazardous and corrosive environments. For onshore applications, typical power ratings range from 295 to 590 kW (400 – 800 HP), and for offshore are between 660 and 880 kW (900 – 1200 HP), with a speed range of 0 to 2600 rpm. The associated bearing needs to be able to carry the high axial force created by the swivel movement. One or two vertical AC top drive motors are used to drive the gearbox. The top drive is operated from a control console on the rig floor. Usually, top drive motors are controlled by VSDs, using either ducted air or a water cooling solution. The benefits of VSDs are magnified when the driller controls the operating speed and power while enabling motor efficiency, but also keeps tripping pipe downtime smooth and safe. ABB top drive motors are designed, tested and certified for on- and offshore and VSD applications, optimizing total running costs. Together with modern AC technology they provide the optimum solution for drilling extremely deviated wellbores. The foot-mounted and flange-supported construction delivers a mechanically rigid solution. The specially selected bearing solution for vertical motors gives reliable operation and a long lifetime.

Mud pumps circulate the drilling fluid and maintain the correct pressure in the drilling well. Typical installations have two AC motors per pump, or one large AC motor with two shaft extensions. Normally they are VSD driven and suitable for hazardous and corrosive environments. They are mounted horizontally on top of the pump. Power ratings can be between 800 – 1,620 kW (1,100 – 2,200 HP) with typical speeds between 0 – 1,800 rpm and could experience a radial force <80 kN (kiloNewton) at the shaft end, and are either cooled by air or water. The power required to run a pump is roughly proportional to the cube of the speed. So a pump running at half speed can consume as little as one-eighth of the energy compared with one running at full speed. A small reduction in speed can make a big difference in energy consumption. As many pump systems often run at partial load, the use of a VSD can produce huge savings. The high performance and reliability increases plant availability and decreases maintenance costs. Smooth torque over the entire speed range reduces noise and vibration levels, which minimizes mechanical stress.

The DW is the heart of the electrically driven hoisting mechanism on a drilling rig. The DW reels the drilling line in and out to raise and lower the drill stem and bit. This equipment uses a VSD driven motor with a typical intermittent torque duty cycle between 0 and 800 rpm of 12,500 Nm, working in an intermittent speed range that could occasionally be as high as 2,400 rpm. ABB offers a complete drive package with a tested and optimized motor and drive solution for the DW. AC motors are compact in size, supplied with a flange connection, and are foot supported. Special bearing solutions are available for those situations where there are radial forces acting on the motor shaft.

Design, service, savings

ABB motors are engineered with the total running cost of motors as a priority and optimized for the application in which they will be used. They are available both as cast iron or rigid welded steel frame construction; the shaft design is high-fatigue-resistant material; and the special bearings can be either antifriction or sleeve. Both the shaft design and bearings are capable of carrying high radial and axial forces. To withstand harsh weather conditions corrosion treatment is done with the offshore industry's approved painting system.

ABB top drive motors are designed, tested, and certified for on- and offshore and VSD applications, optimizing total running costs.

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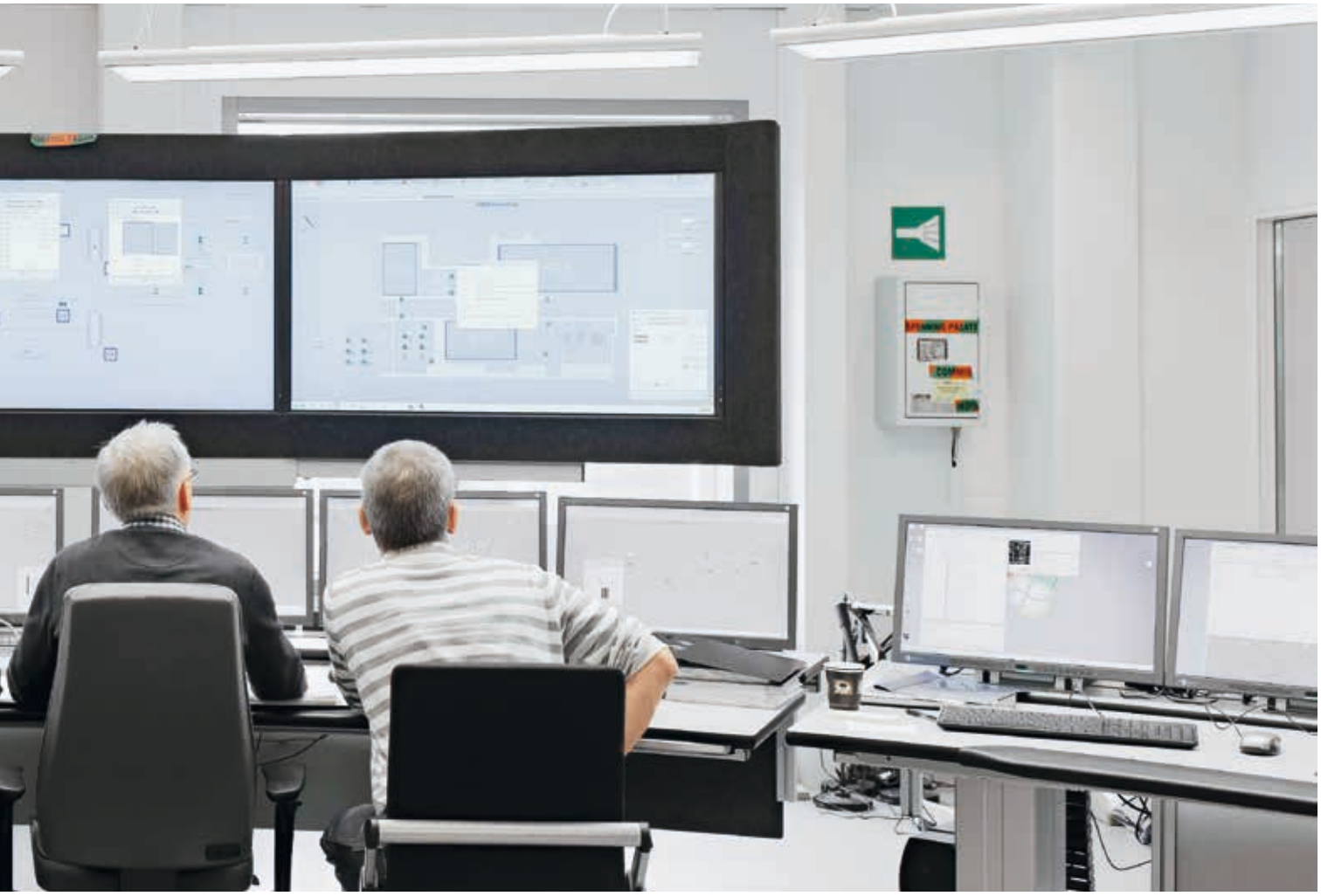
Understanding your user

Ethnography helps deliver better operator interface displays

KRISTOFFER HUSØY, TORGEIR ENKERUD, TONE GRETE GRAVEN – Ever since the Three Mile Island incident, increased attention has been paid to the design of human-machine interfaces. This has led to extensive research in areas such as system design for increased situation awareness and alarm management – and consequent improvements in control system user interfaces. It has also resulted in the emergence of standards and guidelines such as ISO 11064 and EEMUA 191. A focus on the human-machine interface and operator effectiveness is essential not only to ensure safe operation, but also to enable more proactive, and therefore more efficient, production. At the same time, especially in the oil and gas sector, a continuing strong drive towards remotely-sited control rooms and more cost-efficient operation is steadily introducing ever more complex processes and automation that require extensive access to real-time data. These changes impose demands on the designers of operator interfaces. To help tackle these demands, ABB has turned to ethnography-based system design.



Ever since the dawn of the industrial revolution, great ingenuity has been employed to keep the machines that man has devised under control. The engineers in the early days would undoubtedly have wished for ever more dials and levers in their human-machine interface (HMI), but few of them would have foreseen that, in less than two centuries, the steam engine, say, would evolve into the staggeringly complex engine that is a power generation plant. The control demands of such modern installations are fantastically more sophisticated than those of their predecessors. However, modern network technology facilitates the control of such giants by making vast numbers of measurements available in real-time at remote support centers. Some complex facilities can even be controlled remotely via a laptop computer. Unless development in the area of human-machine interfaces is able to keep up with this growing system complexity, the challenges relating to information overload and intricacy in control room operation are likely to become overwhelming. Operator interface design is, therefore, a critical aspect for the safe and effective operation of a modern industrial plant ➔ 1.

ABB's Extended Automation System 800xA, generally considered to be a user-friendly and effective DCS (distributed control system), provides the user interface for many ABB products. To ensure that this interface keeps up with the requirements of even the most complex installations, it is essential to have a deep understanding of the user's current needs and challenges and an insight into future trends. To help achieve this, ABB has introduced ethnography-based system design ➔ 2. By observing firsthand the pain points and day-to-day challenges experienced by novice and expert operators, system designers can tailor future operator interfaces to suit the actual challenges likely to be faced.

The user guides

User-centered design (UCD) methodology – a vital area of research within the software engineering community – postulates that the user must be a central part of the development process, and that a broad and deep understanding of the user and his needs must be acquired early on. The Google search engine, the Amazon website, Microsoft Windows 7

> Unless HMI development keeps up with system complexity, information overload in control rooms may become overwhelming.

Title picture
Control room operators are in charge of ever more sophisticated plants. How does ethnography-based system design help simplify their task?

Ethnography-based methodologies pave the way for game-changing innovations and improvements of control operator effectiveness.

1 The design of the operator interface of complex plants is becoming ever more critical.

and the Apple iPod and iPad have all benefited greatly from such UCD processes. Process control HMI products can also benefit from this focus on the user. However, the process control scenario must be approached somewhat differently as obtaining test personnel and setting up a realistic test environment in complex and time-critical process control situations can be prohibitively expensive and may even be entirely impracticable. This is what led ABB to employ ethnography-based investigative techniques, which are part of the UCD methodology, as a strategy for obtaining a broad and deep understanding of the DCS end-users. By building on knowledge of human factors and situational awareness, and by adapting UCD in this way, ABB has broken new ground in terms of DCS operator interface design methodologies ➔ 3.

Currently, local knowledge of the physical plant being controlled is a necessity.

The methods call for the system designers to observe operators as they perform their normal business in their normal working environment. In this way, the designer can see, firsthand, how operators use the system and what the major and minor difficulties are. It is a key prerequisite that the operators are observed in their normal environment as this allows the observer to obtain detailed accounts of how work is accomplished in practice, rather than how it may be specified, or how workers might report their actions in an interview.

This type of study can be tailored to either gather requirements for improvements to existing solutions, or to collect information that can inspire new solutions. The following discussion summarizes some key findings from a series of ethnographic studies performed by ABB at five oil and gas sites in Norway and India. The sites were: An offshore oil production rig, three gas processing facilities and one oil refinery. They spanned the spectrum of older sites, older sites with major new additions, relatively new sites, and one brand new site that was still partly undergoing commissioning. Two to three researchers visited each site, and spent three or four days in the control room observing the operators at work, and, when possible, encouraging them to speak out loud as to what they were doing and why.

2 Ethnography

Ethnography is a qualitative research method aimed at learning and understanding cultural phenomena that reflect the knowledge and system of meanings guiding the life of a cultural group. Originally pioneered in the field of socio-cultural anthropology, it has also become a popular method in other fields, such as the one described in this article. There are many practical applications of ethnographic methods in commercial contexts, particularly those that involve technology and workplace innovation. Data collection is often done through participant observation, interviews, questionnaires, etc.

3 User-centered design

User-centered design (UCD) is a design philosophy and a process in which the needs, wants, and limitations of end users of a product are given extensive attention at each stage of the design process. The chief difference to other product design philosophies is that UCD tries to optimize the product around how users can, want, or need to use the product, rather than forcing the users to change their behavior to accommodate the product. [1]

User-Centered Design methodology postulates that the user must be a central part of the development process.

Local hero

Currently, local knowledge of the physical equipment being controlled is necessary. The control system's graphical user interface normally implements a high level of abstraction in how the process is presented to the operator in order to remove superfluous detail and highlight crucial information ➔ 4. However, this comes at a price, namely that the operators need to have significant practical experience of the equipment they control. At all the sites visited, the control room operators were required to have prior experience as field technicians and several sites also required them to regularly take shifts as field technicians in order to keep their process knowledge fresh ➔ 5. With the advent of centralized and remote control rooms, one cannot rely on this level of detailed knowledge, so essential for safe and efficient operation, being present. Building up and providing local knowledge is, therefore, a critical aspect that must be catered for when control operators are situated away from the actual plant.

Normal operations involve a high degree of multitasking.

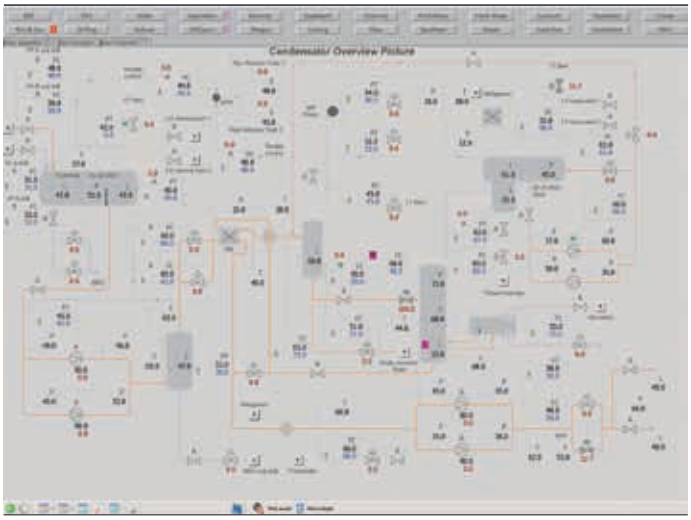
Busy bodies

At all the sites visited, normal operation involved a high degree of multitasking. The operators were continuously engaged in a multitude of parallel tasks that needed attention at irregular intervals. For example, while keeping an overview of the overall plant performance, an operator could be filling a storage tank, starting up two new wells and supporting a field operator in testing gas detectors. In addition, there are many ongoing tasks in the plant in which the operators are not directly involved, but which can be relevant for current or future process decisions. For example, there could be equipment that has been taken out of production for maintenance purposes for a limited time. The operators employ different aide memoires, such as notepads or manual stop watches to remind them of ongoing work tasks. This plethora of activities also involves significant parallel communication and collaboration with different internal and external parties. DCS user interfaces should, therefore, provide ample opportunity for the operators to be able to cancel or postpone operations effectively and smoothly. Some operations are naturally difficult or impossible to postpone due to process constraints, but the current design of the automation system imposes unnecessary constraints on the operators.

In MPC we should trust

Advanced control strategies such as model predictive control (MPC) have been employed at many industrial process sites over the last decade. MPC is a control strategy that utilizes a model of the process to predict how the plant will react to the current input. It is a robust and accurate control strategy that normally performs better than traditional PID control. However, one major challenge with MPC is that it can be difficult for the operators to understand how it works. This reduces the operators' trust in the system and several instances were

4 A typical process graphic, of which there can be thousands



5 Operators need a local knowledge of the plant in order to understand abstract HMI displays.

To improve operator trust, better interfacing with MPC and other advanced control systems is indispensable.

observed where operators switched over to manual mode to steer the process back into a more stable state, before handing control back to MPC. It was clear that they were not comfortable with the course of action being undertaken by MPC.

Even if an advanced control system, like MPC, has a state-of-the-art user interface, operators can still have problems understanding the information presented to them, and they may, therefore, prefer to resolve an issue by switching to manual control, rather than by adjusting parameters to steer the system. Although MPC is a powerful tool for optimizing production, its full potential can only be realized if the collaboration with the operators works effectively and human and system work together as a team.

Alarm processing

A large part of the operators' responsibility is to detect and handle faults and disturbances that occur in the plant. Due to the vast amount of information available and the complexity of the processes, the operators are not able to supervise all parameters at all times. The alarm system, therefore, remains an invaluable tool to detect abnormalities in the process.

At most of the sites visited, incoming alarms continually interrupted the operators' work. The majority were immediately recognized by the operators and acknowledged without any further action. These alarms were mostly due to some known equipment fault or ongoing maintenance work in the plant.

When an alarm was unexpected or unknown, the operators' first response was often to question whether the alarm was related to ongoing maintenance work. After eliminating this cause, the operator would normally move straight to the relevant process graphic to find the exact location of the fault and make a quick estimate of possible cause and consequences. Experience and a good knowledge of the plant topology were then essential for a rapid and accurate evaluation of the situation. Problems were often resolved by referring to successful strategies employed in similar situations in the past.

A second approach was to inquire whether anybody else in the room, or on the radio, had ever seen similar behavior before. If so, the operators would often test or apply the previous solution. Only if the process did not respond as expected would they start to evaluate the situation in more detail, or start looking for a procedure related to the equipment in question. Again, this behavior revealed a heavy reliance on the operators' local knowledge of the plant for safe and efficient operation. When moving towards centralized and remote operations, the system itself will have to provide better support for interpretation of unfamiliar alarm situations.

6 The use of ethnographic studies will increase as industrial systems become more complex and control requirements more sophisticated.

Tying it all together

For any type of software product, it is important to have a solid understanding of the user's role, the intended functionality and the context of use – in other words, a deep insight into the real-life circumstances under which the product will be used. Ethnographic studies gather and structure this type of information.

Having this information gives the development team direction and guidance in making well-founded design decisions, and it increases the probability that the product will be effective in helping the users reach their goals. For DCS development, these factors are particularly important as the context of use is both complex and safety-critical.

The information also makes it possible for the designers to pinpoint areas where a new solution has the best potential to improve operator effectiveness, enable better operational regularity, improve safety aspects and ensure optimum production.

It has been seen that localized knowledge and experience is essential for safe operation of the plant and a need to make experience data and physical information directly available from the user interface has been highlighted. Similarly, it appears that further development regarding visualization and interfaces for advanced control systems is needed to improve operator-system collaboration.

> Ethnography-based methods call for designers to observe operators performing their normal business in their normal working environment.

All in all, ethnographic studies can greatly enhance the effectiveness of HMI design and it is foreseen that their use will increase as industrial systems become more complex and control requirements become more sophisticated ➔ 6.

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Reference

[1] User-centered design. Retrieved April 14, 2012 from http://en.wikipedia.org/wiki/User-centered_design

Reactor reaction

ABB batch management with 800xA comes to Colombia for the first time

RODRIGO VICTORIA – A marked shift in focus has been noted within the chemical industry, with the emphasis moving away from traditional supervisory batch management to production management. To help market players keep pace with this change, ABB has crafted System 800xA Batch Management: a comprehensive, ISA-88 compliant recipe management, batch and procedural control software package for configuring, scheduling, and managing batch operations to improve batch production profitability, consistency and traceability, while ensuring improved regulatory compliance, safety, and security.

System 800xA Batch Management enhances production management by featuring integrated production historian and production schedule interface for batch as well as procedural control applications in continuous and discrete processes. System 800xA Batch Management provides manufacturers the agility, speed, and control to respond to increasing production demands while reducing lifecycle costs and production downtime to enhance performance and overall competitiveness in the marketplace.

Amtex, the largest producer of Sodium Carboxymethylcellulose (CMC) in Latin America, originally looked to a supplier it was already familiar with for the project. However, due to the strong collaboration between ABB Colombia and Automatización S.A., the benefits of going with System 800xA Batch Management became apparent.

CMC is used in food science as a viscosity modifier or thickener, and to stabilize emulsions in various products including ice cream. As a food additive, it is known as E466. It is also a constituent of many non-food products, such as toothpaste, diet pills, water-based paints, detergents, eye drops and various paper products. It is used primarily because it has high viscosity, is non-toxic, and is hypoallergenic [1].

Due to the fact that this was the first batch project of its kind in Colombia, numerous technical issues had to be resolved before the system was stabilized. Amtex considered the system to be very expensive. However, with the solution reinforced by ABB's global expertise, particularly from the Latin American network including ABB Brazil and ABB Argentina, the channel partner and ABB Colombia, the customer was assured that they would have all the technical support needed to meet the demands of the project. As the first ever batch management project developed with ABB System 800xA in Colombia, the contract held particular significance for both ABB Colombia and the channel partner, Automatización S.A.

About Amtex

In Latin America, Amtex is the largest producer of CMC under the brand name of Gelycel® → 1. It operates four production plants in Argentina, Colombia and Mexico, with sales offices and representatives in major cities in the American continent. With an installed capacity of 32,000 metric tons per year, Amtex is ranked among the world's most important producers of CMC, an anionic polymer derived from cellulose used as a thickener in many applications in the food, pharmaceuticals and oil industries. In Colombia Amtex has two facilities: one for the production of 15,000 tons per year of CMC and the other one for the production of 14,000 tons per year of Functional Polymers.

> The solution was reinforced by ABB's global expertise.

Amtex is also involved in manufacturing and providing technical assistance in the application of Gelycel, PAC, compounds and resins, as well as commercialization of raw materials.

Title picture
In Latin America, Amtex is the largest producer of CMC under the brand name of Gelycel®

1 Batch management at Amtex in Colombia

The channel partner

Headquartered in the metropolitan area of Medellin, Colombia, Automatización S.A. carries out its activities throughout Colombia with offices in the cities of Bogotá, Cali and Cartagena. Founded in 1962, Automatización S.A. has a long history of successes in providing automation products and services to various industries in Colombia.

As the system integrator for this Amtex project, Automatización S.A. was in charge of designing the integration of the DCS system, as well as installation, calibration, commissioning and service.

Scope and challenges

Five reactors were automated with the System 800xA control system. In 2010, Amtex realized it needed to automate a reactor at its functional polymers plant and operate under Batch standards. After reviewing tenders from various suppliers, through channel partner Automatización, Amtex selected ABB for its solution's technical advantages in both the control system and batch processing. Amtex's confidence in the contractor's technical knowledge and global support were critical factors in winning the contract.

The scope of the first contract was the automation of one reactor. However, a few months after the implementation on the first reactor, Amtex noted that the quality of the products, produced by the newly automated reactor, were markedly better than those from the remaining reactors. It therefore decided to expand

> “Nowadays customers worldwide seek minimal changes in their process and the only way of managing it is by reducing process variables.”

ABB’s automation to the other five reactors at the plant.

The system was implemented with redundancy at the controller, network control and AC800M Connectivity Server. The system has a Batch Server, Information Management Server, two operator workplaces, one engineering workplace and three controllers. The main controller also has five Profibus DP modules: one for each reactor to connect remote I/O modules, ABB drives and Profibus PA Instrumentation. The elements supplied were:

Batch server

The process operates a total of 50 equipment and two full production management clients. The System 800xA batch management complies with ISA S88 and allows the standardization of production control according to the requirements of customer orders.

Information management server

For the reporting process, Automatización implemented an Information Management Server that generates specific reports for raw materials, electrical consumption, steam and water utilization, batch production, process variables, alarms and events.

Connectivity server

A redundant connectivity server was installed, guaranteeing the availability of the system. The license of this system covers 600 redundant tags.

Operator and engineer workplaces

The control room has two operator workplaces with Batch functionalities: one with four monitors for operating the processes, and another for monitoring batch processes (ie,PFC), editing recipes, accessing data, including making online changes to the recipe ➔ 2.

2 Operator workstations in the control room

The second workstation also features the engineering workplace where the operator can make adjustments, changes and enhancements in the control system.

Controllers

The system has three AC800M controllers: two in redundant configuration, for process control, and one for auxiliary plant equipment which4 connects the plant meters via a Modbus RTU network ➔ 3. This setup prevents the process controllers from being overloaded with data traffic tasks that could affect the performance of the CPUs.

Fieldbus and I/O modules

The system has a control rack for the controllers and DP/PA converters; and four distributed control racks that have remote I/O modules connected by Profibus DP. The I/O modules for hazardous areas are S890. Each reactor has a Profibus DP master module to which the variable-speed drives and I/O modules are connected via remote DP/PA converters. For this project, Profibus PA instruments such as Series 266 pressure transmitters, temperature transmitters and Coriolis mass flowmeters were also supplied.

And the reaction is . . .

Amtex’s primary goals for automating its chemical process were to increase production to around 30 percent and access realtime and accurate information on the production process. Now, with the process fully automated with System 800xA Batch Management, the production in the plant has increased to around 35 percent. In addition, with Information Management capabilities, Amtex now has historical information on which to base decisions in the future.

3 Traffic management with AC800M controllers

Juan Camilo Arango, General Manager of Amtex said, “With the System 800xA, we are completely convinced we may offer our customers reliability and repeatability in our products. Nowadays customers worldwide seek minimal changes in their process and the only way of managing it is by reducing process variables.” Amtex plans to replicate the automation project for its other plant in Colombia, also collaborating with ABB’s channel partner Automatización S.A. Now that really is a great reaction to the project’s success and the client’s satisfaction.

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Reference

[1] Wikipedia. Retrieved December 2012 from http://en.wikipedia.org/wiki/Carboxymethyl_cellulose

Publisher
ABB Review is published by ABB Group R&D and Technology.

ABB Technology Ltd.
ABB Review
Affolternstrasse 44
CH-8050 Zurich
Switzerland
abb.review@ch.abb.com

ABB Review is published four times a year in English, French, German, Spanish and Chinese. *ABB Review* is free of charge to those with an interest in ABB's technology and objectives. For a subscription, please contact your nearest ABB representative or subscribe online at www.abb.com/abbreview

Printer
Vorarlberger Verlagsanstalt GmbH
AT-6850 Dornbirn/Austria

Layout
DAVILLA AG
Zurich/Switzerland

ISSN: 1013-3119

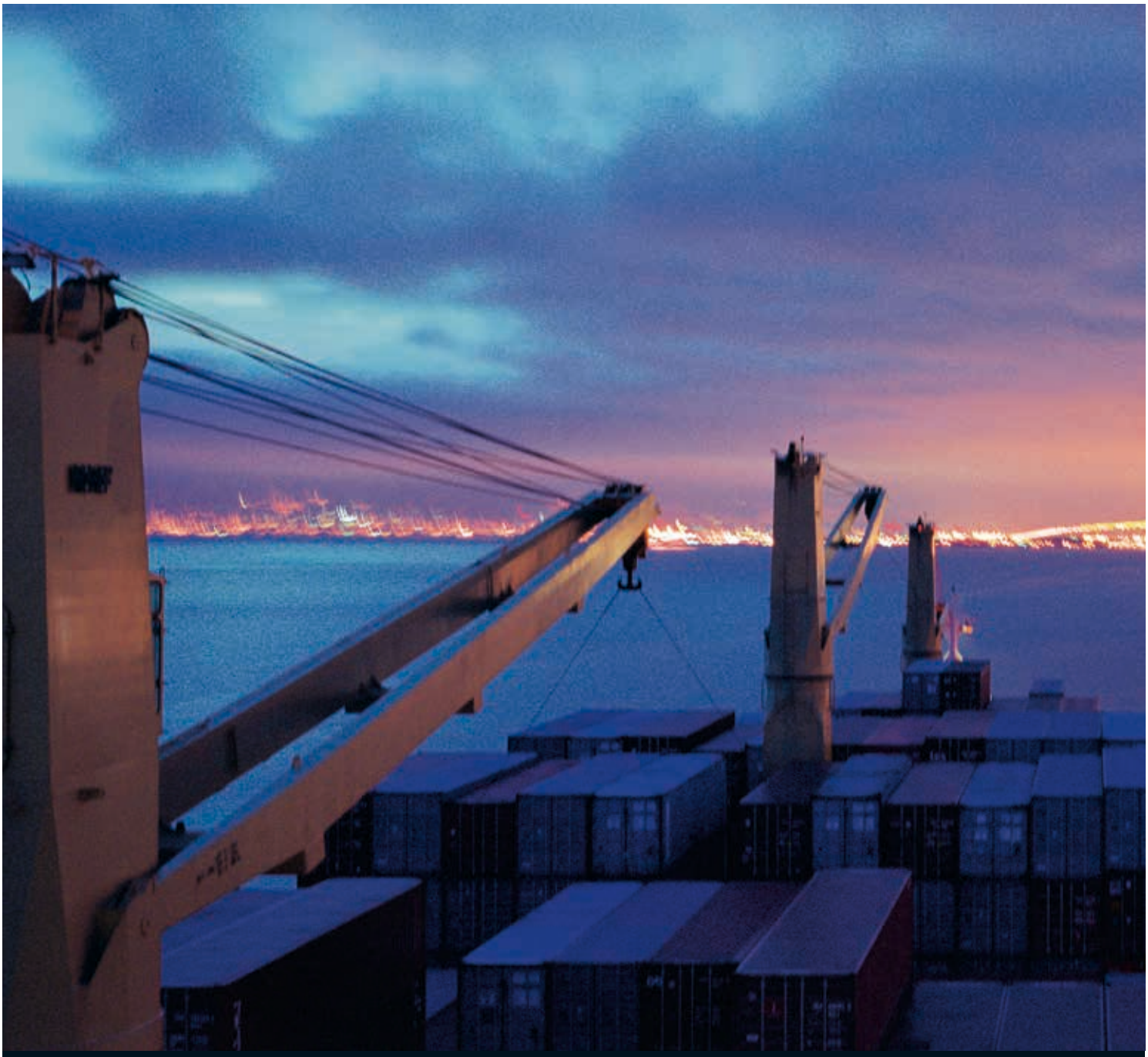
www.abb.com/abbreview

Preview 2|13

ABB's world of technology

The main story of *ABB Review* 2/2013 will be dedicated to the breakthrough that will not just go down in history as the greatest innovation of the year, but possibly that of several decades. The DC breaker will change in a radical way the mode by which power is transmitted and distributed, finally making the DC grid achievable. The present issue already contains some outline information on this breakthrough, but *ABB Review* 2/2013 will take a more detailed look at the technology behind the breaker and explain why it is so important.

Other aspects to be featured in *ABB Review* 2/2013 will include several articles on the company's different activities supporting the mining sector, ranging from ventilation and drives to workforce tracking. A section on marine applications will look at dredgers and lifting vessels. Further articles from across the board of the company' activities will round off this technology-oriented issue.



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